ICHEP2018 SEOUL

Wednesday 04 July 2018 - Wednesday 11 July 2018

COEX, SEOUL

Book of Abstracts

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Design study of a Split-Coaxial RFQ for IsoDAR

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The Isotope Decay-At-Rest experiment (IsoDAR) is a proposed experiment to search for sterile neutrinos by measuring neutrino oscillations. The electron-antineutrino generation requires a high intensity primary proton beam impinging on a beryllium target surrounded by lithium . In IsoDAR, H2+ ions are generated and accelerated to avoid space charge effects in the low energy region, which will be stripped into protons after extraction from a cyclotron. As part of the IsoDAR injection system, an RFQ buncher with 32.8 MHz of operation frequency provides 70 keV acceleration and strong bunching of the H2+ beam. The RFQ will be installed halfway inside the iron yoke of the cyclotron to be very close to the median plane. Because the beam starts diverging after the RFQ in both transverse and longitudinal direction, a re-buncher is employed in the end transition cell to re-focus the beam longitudinally. In this paper, we describe in detail the beam dynamics study and RF analysis of the IsoDAR RFQ for direct injection into a compact cyclotron

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An Energy Recovery Linac for energy-frontier DIS at CERN: the LHeC and the FCC-eh

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Energy-frontier DIS can be realised at CERN through an energy recovery linac that would produce 60 GeV electrons to collide with the HL-LHC or later HE-LHC (LHeC) or eventually the FCC hadron beams (FCC-eh). This would create a new laboratory for energy frontier particle and nuclear physics. It provided electron-proton/nucleus collisions with centre-of-mass energies in the range 0.3-3.5 TeV per nucleon, and luminosities exceeding 10^{34} cm^{-2}s^{-1} in ep scattering. Such machine would provide a huge physics programme, as the highest resolution microscope for hadron substructure, through high precision Higgs, top and precision EW physics, and with unique possibilities for BSM searches. With a high luminosity of 5×10^{32} cm^{-2}s^{-1} in ePb scattering, both LHeC and FCC-eh are unique top-energy nuclear physics facilities with eventual access to a new regime of QCD at high partonic densities. All these aspects have strong complementarities with the respective, concurrent pp and AA programmes. In this talk we review the recent accelerator and infrastructure aspects of the LHeC and FCC-eh proposals at CERN, as will be presented to the next European Strategy for Particle Physics in 2019/2020. We also review the progress on the corresponding ERL demonstrator, PERLE, under preparation to be built at LAL Orsay.

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HTS Technology R&D for Future High Energy Accelerators

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R&D of high field HTS magnet technology is ongoing at IHEP (Beijing, China) for future high energy accelerators. A hybrid twin-aperture dipole magnet is under development for SPPC pre-study. The magnet is designed with Common-coil configuration and will be fabricated with Nb3Sn and HTS superconductors. The main field is 12 T with 20% operating margin at 4.2 K. The aperture diameter is 30 mm. The fabrication and experimental test is divided into 3 steps: 1) 4 flat racetrack NbTi coils and 2 flat racetrack Nb3Sn coils are firstly fabricated and tested, to evaluate the fabrication process and stress management of Nb3Sn coils. 2) 2 more Nb3Sn coils are fabricated and tested together with the 1st 2 Nb3Sn coils, to provide 12 T main field in the top and bottom apertures with the diameter of 20 mm. 3) 2 racetrack HTS coils with flared ends are fabricated and inserted into the 4 Nb3Sn coils, to provide 12 T main field in the top and bottom apertures with the diameter of 30 mm. The main design parameters, fabrication process and test results of the magnet will be presented. The R&D plan and steps for next years will also be discussed.

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Status of the FCC-hh design studies

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The Future Circular Collider (FCC) Study aims at developing a large-scale accelerator research infrastructure based on a 100 km tunnel. While the ultimate goal is a proton-proton collider, with 100 TeV centre-of-mass collision energy and unprecedented direct discovery potential. Also ion-ion and ion-proton collisions are possible. The initial project stage could consist of an electron-positron collider.
The talk describes the status of the hadron collider design.

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Heavy resonance searches at the FCC-hh

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The feasibility of a future proton-proton collider (FCC-hh), with center of mass energies up to 100 TeV and unprecedented luminosity is currently being studied.
By delivering an integrated luminosity of few tens of ab-1, such a machine will provide an outstanding discovery potential for new physics, far beyond the reach the high luminosity or high energy LHC. In this talk we will discuss searches of heavy resonances decaying into leptons, tops, bosons and light quarks. Depending on the final state and the assumed model, the discovery reach and exclusion potential for heavy resonances ranges from 20 to 45TeV. We will also discuss why studying heavy resonances provides an important handle to constrain the detector design and performance, such as the muon resolution at high transverse momentum, or the calorimeter containment and granularity.

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Physics at the FCC: a story of synergy and complementarity

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CERN has launched in 2014 the design study of Future Circular Colliders, including a High Luminosity e+e- collider (FCC-ee) running from the Z pole to above the top pair production threshold. Follow a 100 TeV pp and heavy ion collider (FCC-hh) able to reach an unprecedented energy scale and possibly an e-p collider. The FCC-ee offers a broad discovery potential based on a combination of precision Electroweak Measurements, high statistics quark and lepton flavour physics, searches for rare phenomena and new particles, and Higgs model-independent coupling measurements. The FCC-hh can observe the production new particles with Standard Model couplings up to ~30 TeV, but is also an extremely abundant factory for W, Z top and Higgs, allowing searches for rare phenomena and a number of precision measurements including those of the triple Higgs and ttH couplings. The ep option would offer unprecedented reach in structure functions and high statistics of Higgs production. The synergy and complementarity of the FCC machines making the FCC complex a compelling option for the future of Collider Physics.

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R&D status of CEPC Accelerator key technologies

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CEPC is a 100 km circular electron-positron collider operating at 90-240 GeV center-of-mass energy of Z-pole, WW pair production threshold and Higgs resonance. CEPC and its successor SPPC, a 100 TeV center-of-mass super proton-proton collider, will ensure the elementary particle physics a vibrant field for decades to come. To reduce the overall cost, partial double ring scheme was proposed as the alternative, which has a significant impact on the cavity operation and beam dynamics. The conceptual design report (CDR) of CEPC will be completed by the end of 2017 as an important step to move the project forward. In this presentation, the status of CEPC accelerator key technology R&D status will be shown, including SRF system, High efficiency klystron etc.

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Progress on the 650MHz/800kW CW klystron development at IHEP

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The configurations of the CEPC and the SPPC were proposed in September, 2012. To reduce the costs of the construction and the operation, high efficiency klystrons is preferred for the Collider ring. In this scenario, the plan to develop the high efficiency 650MHz/800kW CW klystron with an ultimate goal of 80% is initialized. Since there are no any experiences and infrastructures such as the large baking furnace and the high power testing stand to develop these kind of high power CW klystrons in China, the 1st klystron prototype is based on the conventional 2nd harmonic bunching technology,

then more klystron prototypes will be made with steady improvement of the efficiency. In this paper, the progress on the 1st 650MHz/800kW CW klystron prototype development at IHEP is presented. Till now, the mechanical design of the 1st klystron prototype has been finished; the fabrication will be started soon. In addition, the design of the 2nd klystron prototype and the strategic plan to progressively increase the klystron efficiency will also be shown.

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Super Charm-Tau Factory in Novosibirsk

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A Crab-Waist e+e- collider with the beam energy from 1 GeV to 3 GeV is under development at Budker INP (Novosibirsk, Russia) to study physics in charmonium and tau-lepton sectors. The talk reviews realisation principles, configuration and features of the collider including extremely high luminosity of 10^35 cm^-2s^-1 and longitudinal polarization of electron beam.

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An 3-15 GeV electron beam facility at CERN for particle physics and accelerator R&D

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CERN today operates a small ~200 MeV electron test-facility for accelerator R&D (CLEAR). This facility was put into operation in 2017 and a number of R&D activities were started. The results for accelerator R&D at the CLEAR facility will be reviewed including the plans for 2018-20.

Longer term and in the framework of the Beyond Collider Physics studies at CERN at 3.5 GeV electron linac is proposed. This linac will be used at injector to the SPS where the electron beam can be accelerated to around 15 GeV. This presentation will cover the studies for the 3.5 GeV linac and re-introduction of an electron beam in the SPS.

The potential of such beams for particle physics studies (e.g. Light Dark Matter Searches) and accelerator R&D will be reviewed. The accelerator R&D possibilities cover linear collider studies, general accelerator component R&D (impedance studies, instrumentation, electron guns), novel accelerator technology and more.

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Low energy e+e- collider to search and study of mu+mu- bound state (dimuonium)

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To discover and study a mu+mu- atom (dimuonium) we propose a low energy (410 MeV per beam) e+e- collider with extremely large crossing angle to boost the dimuonium atoms from the collision area and reduce a background. A report describes the collider status and its parameters.

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The CLIC accelerator project status and plans

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The Compact Linear Collider (CLIC) collaboration will present a project implementation plan for construction of a 380 GeV e+e- linear collider for the European Strategy update by the end of 2018. The machine is upgradable in stages to 3 TeV. The CLIC concept is based on high-gradient normal-conducting accelerating structures operating at X-band (12 GHz) frequency.

We present the CLIC accelerator concept and the current status of the project. We report on high-power tests of X-band structures using test facilities across the collaboration, as well as CLIC system verification studies and the technical development of key components of the accelerator, in many cases with the goal of reducing the energy consumption and/or cost of the machine.

We will also summarise developments for application of the X-band technology to more compact accelerators for use e.g. as X-ray FELs and in medicine. A rapidly increasing number of installations are taking the technology in use opening up co-ordinated programmes for further industrial developments in the next phase of the project.

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Recent ILC R&D status

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Key technologies for the ILC are nano-beam and superconducing rf system (SRF). The final beam size at 250GeV ILC, which was announced at ICFA on last November, is ~8nm. In case of 250 GeV ILC, the number of SRF cavities becomes half (compared with 500 GeV). However, the cost of the SRF is still dominant in the ILC accelerator cost. We have started the cost reduction R&D at SRF since last year. The recent progress of these key technologies will be reported.

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Machine-Detector Interface at the CEPC

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Machine-Detector Interface (MDI) represents one of the most challenging topics for the Circular Electron Positron Collider (CEPC), which is proposed as a Higgs Factory to measure Higgs properties with unprecedented precision. MDI involves critical machine and detector components in the constrained interaction region. Performance optimization, often along with considerable trade-offs, can be only achieved with thorough understandings of machine and detector designs and their impacts on each other. In this talk, design progress on the interaction region (IR) layout, the IR superconducting magnets and the luminosity calorimeter will be presented. Predicted radiation backgrounds and their potential impacts will be also discussed.

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CEPC injector linac design

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Circular Electron-Positron Collider (CEPC) is a 100 km ring e+ e- collider for a Higgs factory. The injector of CEPC is composed of linac and booster. The linac is a normal conducting S-band linac and provide electron and positron beam at an energy up to 10 GeV with repetition frequency in 100 Hz. The linac consideration and design will be detailed discussed, including electron linac, positron linac, positron source and damping ring.

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CEPC Accelerator CDR and R&D towards TDR

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In this talk, CEPC CDR status will be reported which relects the CEPC accelerator baeline design status with Higgs, W, and Z operation modes, which includes parameters, collider ring, booster and injection linac designs, including SCRF system, civil engeneering design, cost breakdown and Ac power consumption analysis.
As for CEPC TDR phase, the key R&D issues are addressed with CEPC project timeline.

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The FCC-ee Lepton Collider: Design Status and Operation Concept

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The Future Circular Collider (FCC) Study aims at developing a large-scale accelerator research infrastructure based on a 100 km tunnel. While the ultimate goal is a proton-proton collider, with 100 TeV centre-of-mass collision energy and unprecedented direct discovery potential, the initial project stage could consist of an electron-positron collider, with highest luminosities at collision energies up to 380 GeV, for indirect exploration of the energy scale up to 100 TeV via precision measurements.
The talk provides an overview on the lepton collider design. Special emphasis is given to the parameter and luminosity optimisation, the operation phases and the corresponding evolution of the machine in terms of RF staging for the different physics working points, and the overall duration of the physics program.

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Magnet design studies for future hardon colliders

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Fermilab in collaboration with other members of the US Magnet Development Program (MDP) is working on the development of accelerator magnets for future hadron colliders. A 4-layer, 15-T dipole with 60 mm bore based on Nb3Sn superconductor is under construction with the testing foreseen at the end of the year. At the same time, there are conceptual design studies to evaluate the feasibility of reaching even higher fields with the help of HTS materials. This paper presents the results of these studies and discusses possible options towards higher fields.

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Storage ring proton Electric Dipole Moment Experiment with 10^{-29} $e{\cdot}\mathrm{cm}$ sensitivity

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The electric dipole moment (EDM) of fundamental particles, when induced by the particle internal spin, violates separately the parity (P) and time (T) reversal symmetries. Due to CPT conservation,

T-violation also means CP-violation and it is a sensitive probe of Physics beyond the standard model (SM).
The storage ring EDM (srEDM) collaboration and the Juelich electric dipole investigations (JEDI) collaboration joined forces together with CERN scientists as part of the CERN initiative of Physics Beyond Colliders (PBC) to put together a study of the storage ring proton EDM method under the combined name charged particle EDM (CPEDM). The goal is to evaluate its feasibility, as well as to come up with a cost estimate for a ring with a goal of $10^{-29}\, e{\cdot}\mathrm{cm}$, making it the best sensitivity hadronic EDM experiment, with a mass-scale reach for new, SUSY-like Physics of order 10^3 TeV.
The method requires an all-electric storage ring between 400m-500m in circumference, simultaneous storage of counter-rotating, longitudinally polarized proton beams, magnetic field shielding below 10nT, state of the art SQUID-based beam position monitors, high efficiency with high analyzing power proton polarimeters, high precision beam/spin dynamics tracking simulators, and the development of reliable and cost effective electric field plates capable of sustaining 10MV/m with 3cm plate separation. Several polarimeter and beam polarization concepts have already been tested using polarized beams at the COSY ring in Juelich/Germany. I will present the current status towards the realization of this experiment.

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Status and prospects of the AWAKE experiment

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AWAKE is a plasma wakefield acceleration experiment at CERN, using the 400 GeV proton bunch of the SPS to drive an accelerating gradient in the GV m^{-1} range. AWAKE aims to inject 15–20 MeV electrons into this plasma wakefield and accelerate them to GeV energies over 10 metres. An introduction to AWAKE and its physics will be presented, as well as an overview of the experimental apparatus and the most recent results. Longer term plans, including the future of the AWAKE facility and possible applications of the technology to HEP, will be discussed.

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Van der Meer calibration of the CMS luminosity detectors in 2017

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To guarantee smooth and uninterrupted luminosity measurements the CMS experiment is equipped in Run II with three online luminometers: the Pixel Luminosity Telescope (PLT), the Fast Beam Condition Monitor (BCM1F) and the Forward Calorimeter (HF). For the offline luminosity measurement and a cross check of the online detectors the pixel detector is used (Pixel Cluster Counting, PCC). For the calibration of the luminometers once per year a full program of van der Meer (VdM) scans is performed. It consists of series of standard VdM scans and 4 imaging scans. In the standard VdM scans both beams are moving across each other and the transverse size of the beam overlap is defined. Imaging VdM scans are required to disentangle XY correlation. For steering magnet calibrations, under the special beam conditions during the VdM scan, the length scale (LS) calibration is performed. Detailed studies of the systematic effects of beam-beam deflections, orbit drift, LS calibration and unbunched beam correction allow precise luminosity calibration. The methodology of the luminosity calibration and final uncertainty on the integrated luminosity will be presented.

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LUCID: The ATLAS Luminosity Detector

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The LUCID detector is the main luminosity provider of the ATLAS experiment and the only one able to provide a reliable luminosity determination in all beam configurations, luminosity ranges and at bunch-crossing level.
LUCID was entirely redesigned in preparation for Run 2: both the detector and the electronics were upgraded in order to cope with the challenging conditions expected at the LHC center of mass energy of 13 TeV and with 25 ns bunch-spacing.
An innovative calibration system based on radioactive 207 Bi sources deposited on the quartz window of the readout photomultipliers was implemented, resulting in the ability to control the detectors long time stability at few percent level.
A description of the detector and its readout electronics will be given as well as preliminary results on the ATLAS luminosity measurement and related systematic uncertainties.

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SQUID-based BPM for proton EDM experiment

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The pEDM experiment aims to search for the electric dipole moment (EDM) of proton with 10^{-29} e-cm sensitivity, approximately 5 orders of magnitude better than the current experimental limit. The experiment is designed to store counter-rotating proton beams in an all-electric storage ring. The EDM of the particles will couple with the radial electric field, causing a spin growth around the radial axis in the particle's rest frame. The growth rate of this precession will be proportional to the EDM of the proton.

Magnetic field is a major source of systematic errors as it couples with magnetic dipole moment and dominates the spin precession. Among possible combinations, average radial magnetic field (B_r) is the most critical one. It should be kept at 10aT level. We are developing a novel BPM that is based on SQUID magnetometers for measuring the average magnetic field.

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Superconducting RF Cavities R&D Towards Future High Energy Accelerators

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Modern accelerators for High Energy Physics (ILC, FCC-ee, FCC-he, CEPC) demand efficient operation of SRF cavities. Since low cryogenic losses and high quench fields are essential to save in both capital and operational cost, basic SRF R&D on niobium cavities is focused on increasing the quality factor at the highest accelerating gradient.
The talk will be focused on the description of the strategies adopted to increase quality factor and accelerating gradient in SRF cavities. Innovative surface preparations can allow for future SRF-based accelerators that wouldn't otherwise be feasible, by cutting the capital cost of their realization.
Layered SRF surfaces and smart engineering of the impurities profile at the RF surface are promising technologies that may substantially decrease the cost of accelerators and possibly allow for higher duty cycle operation. The physics behind these new technologies will be described and the impact their application would bring in the accelerator world will be analyzed in detail.
Part of the talk will also address the description of new directions being explored in the SRF community to further increase accelerating gradients beyond the current limitations and on the cost savings they might allow.

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Status of the Fermilab Muon g-2 experiment

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Previous Muon g-2 experiment at BNL measured the anomalous magnetic moment of muon which is $\approx 3\sigma$ away from the Standard Model value. The Fermilab Muon g-2 Collaboration started commissioning runs with an upgraded version of the storage ring. In the first phase, the new experiment aims 4 times more sensitivity thanks to several improvements including muons statistics, pileup reduction, gain changes, lost muons and coherent betatron oscillations. A physics run with significant statistics is expected to take place in 2018.

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LBNF Beamline

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The Long Baseline Neutrino Facility (LBNF) will utilize a beamline located at Fermilab to provide and aim a neutrino beam of sufficient intensity and appropriate energy range toward DUNE detectors, placed deep underground at the Sanford Underground Research Facility (SURF) in South Dakota. LBNF is designed for approximately twenty years of operation, to provide adequate exposure for the DUNE experiment. During its lifetime, the facility must be able to accommodate various target and focusing configurations to enable tuning of the neutrino energy spectrum.

The primary proton beam (60-120 GeV) will be extracted from the MI-10 section of Fermilab's Main Injector. Neutrinos are produced after the protons hit a solid target and produce mesons, which are subsequently focused by magnetic horns into a 194m long decay pipe where they decay into muons and neutrinos. The parameters of the facility were determined by taking into account the physics goals, spatial and radiological constraints and the experience gained by operating the NuMI facility at Fermilab. The Beamline facility is designed for initial operation at a proton-beam power of 1.2 MW, with the capability to support an upgrade to about 2.4 MW. LBNF/DUNE obtained CD-1 approval in November 2015. We discuss here the design status and the associated challenges as well as the R&D and plans for improvements before baselining the facility, and we will present results of a beam optimization algorithm developed to maximize DUNE's sensitivity to neutrino CP violation, yielding substantial improvements to the neutrino flux and physics sensitivities.

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Fermilab Accelerator Complex: Status, Progress, and Near-and Far- Future Upgrade Plans

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We present status of operation and recent progress of the Fermilab proton accelerators, and discuss in our activities toward their near- and far-future upgrades. We also present the spectrum of related accelerator physics and technology R&D activities, including those at the US-leading FAST/IOTA research facility for the intensity frontier beam studies.

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First Muon RF Acceleration for the Muon g-2 Experiment at J-PARC

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The J-PARC E34 experiment aims to measure muon g-2 with a precision of 0.1 ppm and search for EDM with a sensitivity to 10-21 e*cm with a low emittance muon beam. The low emittance muon beam is generated from surface muon beam after thermal muonium production, dissociation of electron by laser, and acceleration by a radio-frequency (RF) linac. One of challenges for the E34 experiment is muon RF acceleration, which has not been demonstrated. Recently we succeeded in demonstrating muon acceleration using a radio-frequency quadrupole linac (RFQ). This talk will describe results of the muon acceleration experiment.

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Status of SuperKEKB phase-2 commissioning

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SuperKEKB is 7GeV electron and 4GeV positron double-ring collider for the B-meson factory, whose design luminosity is $8 \times 10^{35}\mathrm{cm}^{-2}/\mathrm{sec}$. We have already completed the phase-1 commissioning without the interaction point from February 2 to June 28, 2016. The phase-2 commissioning with the interaction point is planed to start from March 19, 2018. We report the preliminary result of the SuperKEKB phase-2 commissioning.

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Progress on stabilising relativistic lepton beams for future colliders

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We report progress on stabilising relativistic electron beams, in terms of their position and arrival time, for achieving high luminosity at future lepton colliders such as the International Linear Collider

(ILC) and the Compact Linear Collider (CLIC). Hardware has been developed and deployed at the Accelerator Test Facility (ATF) at KEK for measuring and stabilising the beam position at the final focus to the nanometre level. We report latest closed-loop feedback tests in which the beam position was stabilised to c. 40 nm. In addition, a beam phase feed-forward system was deployed at the CLIC Test Facility (CTF3) at CERN. We report the results of recent beam tests in which the beam arrival time was stabilised to c. 50 femtoseconds, which meets the requirement for efficient power transfer between the CLIC drive and main beams in the two-beam accelerator complex.

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Recent results from MICE on multiple Coulomb scattering and energy loss

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Multiple Coulomb scattering and energy loss are well known phenomena experienced by charged particles as they traverse a material. However, from recent measurements by the MuScat collaboration, it is known that the available simulation codes (GEANT4, for example) overestimate the scattering of muons in low Z materials. This is of particular interest to the Muon Ionization Cooling Experiment (MICE) collaboration which has the goal of measuring the reduction of the emittance of a muon beam induced by energy loss in low Z absorbers. MICE took data without magnetic field suitable for multiple scattering measurements in
the fall of 2015 with the absorber vessel filled with xenon and in the spring of 2016 using a lithium hydride absorber. In the fall of 2016 MICE took data with magnetic fields on and measured the energy loss of muons in a lithium hydride absorber. These data are all compared with the Bethe-Bloch formula and with the predictions of various models, including the default GEANT4 model.

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First Ever Ionization Cooling Demonstration in MICE

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The Muon Ionization Cooling Experiment (MICE) at RAL has studied the ionization cooling of muons. Several million individual particle tracks have been recorded passing through a series of focusing magnets in a number of different configurations and a liquid hydrogen or lithium hydride absorber. Measurement of the tracks upstream and downstream of the absorber has shown the expected effects of the 4D emittance reduction. This invited talk presents and discusses these results, and projects the
future of ionization cooling.

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The Dark Energy Survey: Cosmological results from the first year of observations

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Since 2013, the Dark Energy Survey (DES) has been mapping an entire octant of the sky to unprecedented depth, measuring the position on the sky, redshift and shape of over 200 million galaxies, together with thousands of galaxy clusters and supernovae. With this data set, DES is studying the properties of dark energy using four main probes: galaxy clustering on large scales, weak gravitational lensing, galaxy-cluster abundance, and supernova distances. The data from the first year of observations (DES-Y1), covering about 1500 sq. deg., have recently been analyzed to derive cosmological constraints from each of these four probes, achieving an unprecedented precision in the determination of the cosmological parameters governing the growth of structure in the Universe. The talk will present these results from the DES-Y1 observations, together with the first public DES data release, and will discuss the expected precision after all the survey data will have been analyzed.

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Revisiting electroweak phase transitions in SM with a singlet scalar: gauge artifact issue

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First-order electroweak phase transition plays a central role in electroweak baryogenesis.
However, it is known that unwanted gauge dependence exists in critical temperature
and Higgs vacuum expectation value in an ordinary perturbative calculation scheme.
In this talk, we revisit the electroweak phase transition in the SM with a singlet scalar
utilizing a gauge-independent method proposed by Patel and Ramsey-Musolf
and make a comparison with previous results. Impact on deviation of triple Higgs coupling
from the standard model is also discussed.

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Low-scale leptogenesis with 3 right-handed neutrinos

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We provide the first systematic study of the low-scale leptogenesis scenario in the minimal Standard Model extended with 3 right-handed neutrinos having masses at the GeV scale.
We highlight and discuss the differences between the 2- and the 3-right-handed neutrino cases, the major qualitative distinction being the possibility, in the latter scenario, of probing part of the parameter space at the LHC. Moreover, 3-right-handed neutrinos allow for the generation of a CP-asymmetry already in the oscillating sterile sector, without the need of relying on flavour asymmetric washout. We quantitatively study the differences between the parameter space of solutions in the two scenarios, highlighting the viability of the models and their testability in current and future experiments, as well as the different impact of the identified solutions in neutrino observables, as for instance in the neutrinoless double beta decay expected rate.

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Statistical Analyses of Higgs- and Z-Portal Dark Matter Models

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I present results from 1711.09912 of frequentist and Bayesian statistical analyses of Higgs- and Z-portal models of dark matter particles with spin 0, 1/2 and 1. Our analyses incorporate data from direct detection and indirect detection experiments, as well as LHC searches for monojet and monophoton events. We find acceptable regions of the parameter spaces for Higgs-portal models with real scalar, neutral vector, Majorana or Dirac fermion dark matter particles, and Z-portal models with Majorana or Dirac fermion dark matter particles.

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Leptogenesis in the minimal Scotogenic Model through annihilation and coannihilation of scalar Dark Matter

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In this letter we have explored the possibility of embedding the genesis
of lepton asymmetry within the well studied *Scotogenic* model. We have shown that in this model one can have a Dark Matter in the TeV scale. The model is highly constrained in the context of dark matter,neutrino mass, Flavor Physics and now also gets an additional
constraint on the relative complex phases from the required lepton asymmetry which eventually

converts to the observed baryonic asymmetry
through the spheleron transition during the electroweak phase transitions.

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Direct Leptogenesis

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It will be pointed out that lepton asymmetry can be generated through CP-preserving inflaton decay into leptons when the Pontecorvo–Maki–Nakagawa–Sakata matrix has proper CP phases. Except for the assumption of the inflaton decay, we do not introduce any new particle.

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The unusual structure detection in Extensive air shower events at Horizon-8T cosmic rays detector system

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Horizon-8T is a detector system aimed to study Extensive Air Showers (EAS) temporal structure in the energy range of the primary above ~10^16 eV. It is constructed at approximately 3340 meters above the sea level at the Tien Shan high-altitude Science Station, part of Lebedev Physical Institute of the Russian Academy of Sciences. Detector system consists of eight charged particle detection points separated by the distance up to one kilometer.
During Physics Run 1 from October 2016 to April 2017, about 8000 total events were detected, a sizable number of which exhibit the unusual spatial and temporal structure of pulses with several maxima (or modes). The separation of the maxima can be from few tens of ns to several hundred ns. The Run 1 dataset suggests that separation between maxima increases with distance from EAS core, which cannot be obtained from simulations, and seem to occur only in events with energy above ~10^17 eV. The overview of Horizon-8T detector system and the details of the unusual events data will be presented.

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Search for Rotational Cross-Correlations in Emergent Space-Time with the Holometer

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We present a new phenomenology for the Fermilab Holometer, a pair of 39m-long, co-located but independent high-power Michelson interferometers. The differential position signals are cross-correlated over a broad frequency band exceeding the inverse light crossing time, attaining sensitivity to both timelike and spacelike correlations across the physical system. The second-generation experiment employs a unique bent-arm configuration to search for rotational correlations associated with the emergence of flat space-time and local inertial frames from a quantum system. A Planck density spectrum in dimensionless strain units is shown to be consistent with causal diamonds of 4-position whose degrees of freedom scale with the holographic information content of black hole event horizons.

A Lorentz invariant framework is constructed to interpret data. Nonlocal entanglements among states in *relational* space-time are statistically modeled as antisymmetric cross-covariances on past and future light cones between world lines of Planck bandwidth in proper time, motivating a distinctive signature: an imaginary broad-band cross-spectrum that is acausal in standard physics, with a frequency response derived from the optical layout and its causal structure.

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Constraining New Physics with high multiplicity

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Having no new physics signals observed at collider experiments, we are motivated to consider a scenario that the new physics scale is higher than the current collider energies but still within the reach of the cosmic ray experiments covering beyond TeV scale. In particular, we focus on the types of new physics interactions accompanying with high multiplicities in their signals from the collision of Ultra-High Energy (UHE) cosmic ray with nucleons in the Earth atmosphere with collision energy E > O(100) PeV or Ecm > O(10) TeV in center-of-mass (CM) frame. The characteristic features of neutrino-induced air-showers and proton-induced air-showers induced by new physics interactions are identified then the experimental constraints on the new physics scale are obtained from the existing and future coming data from Telescope-Array (TA) and Pierre-Auger experiments. As specific examples, we show the results from electroweak sphaleron and TeV scale microscopic black holes in detail.

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The LHCf experiment: recent physics results

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The main aim of the LHC forward (LHCf) experiment 1 is to provide precise measurements of the particles production rate in the forward region. These high energy calibration data are very important for the tuning of hadronic interaction models used by ground-based cosmic rays experiments. LHC is the most suitable place where we can perform these measurements because a proton-proton collision at $\sqrt{s}$ = 14 TeV is equivalent to the interaction of a 10^{17} eV cosmic ray with the atmosphere. In order to do that, two small sampling calorimeters are installed at ±140 m from LHC IP1 (ATLAS Interaction Point), so that they can detect the neutral particles with η > 8.4 produced in p-ion collisions [2].

In the past years, LHCf acquired data from p-ion collisions at different energies (p-p at $\sqrt{s}$ = 0.9, 2.76, 7 and 13 TeV; p-Pb at $\sqrt{s_{NN}}$ = 5.02 and 8.1 TeV). In this talk, we would like to present the analysis results relative to photons [3], neutrons [4] and π^0 [5] differential production cross sections, compared with models predictions. In particular, we will discuss the measurement of the energy distributions of secondary particles produced in $\sqrt{s}$ = 13 TeV p-p collisions (photons, already published [6], and neutrons) and in $\sqrt{s_{NN}}$ = 8.1 TeV p-Pb collisions (photons). In all these cases, no model resulted to be in good agreement with experimental observations in all the regions investigated by the analysis. We will also discuss about the ATLAS-LHCf joint analysis, based on the common data taking that the two experiments had in the last two operations at LHC. This activity is very important because the information of the ATLAS detector in the central region is an useful tag to distinguish between diffractive and non-diffractive events in the LHCf detector. Finally, we will present the measurement relative to the contribution of diffractive dissociation to the production of forward photons in $\sqrt{s}$ = 13 TeV p-p collisions [7], the first result from the ATLAS-LHCf joint analysis.

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Tests of hadronic interactions using the Pierre Auger Observatory

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Ultra-high energy cosmic rays (UHECR) can be used to study hadronic interactions beyond LHC energies. In this contribution we summarize relevant data from the Pierre Auger Observatory.

While the proton-air cross section has been measured at sqrt(s) = 57 TeV and found to be in good agreement with extrapolations from LHC energies, other observables are significantly different to what is predicted using current models. In particular, the predictions from models of showers based on LHC data are in strong contradiction with the observed number of muons. More muons are detected than predicted with the magnitude of the effect being model-dependent. Another observable

from the Auger Observatory, the distribution of the depths of muon production, is also poorly described. Indeed no current model is capable of describing the full range of data from the Observatory, thus highlighting deficiencies in extrapolations beyond LHC energies.

The discrepancy between hadronic models can be examined further by measuring separately the muon and electromagnetic components of the signal recorded by detectors on the ground. The Auger Observatory is being upgraded by the addition of plastic scintillators above the water-Cherenkov detectors to achieve this. The new observations will enable rigorous testing of hadronic models up to sqrt(s) ~100 TeV and are crucial to the quest of determining the composition of UHECR.

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Highlights from the Telescope Array Experiment

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Telescope Array (TA) is the largest cosmic ray detector in the Northern hemisphere, constructed to study ultra high energy cosmic rays (UHECRs) with energies above 10^18 eV. The TA consists of an array of scintillation counters with 1200 m spacing and three fluorescence detectors, each viewing 3 to 30 degrees in elevation. The TA has also added a facility (TALE) to extend the energy threshold down to 10^15.8 eV, by addition of 10 additional fluorescence telescopes increasing the elevation angle up to 59 degrees, and an infill array of plastic scintillation counters with spacing of 400 and 600 m. The TA has accumulated a large UHECR data set which allows us to determine the energy spectrum and chemical composition of the primary particles, and search for anisotropy of UHECR arrival directions and thus sources of cosmic rays. We discuss findings with the latest data about the localized excess of events known as the TA "hotspot". The experiment and its most recent measurements - spectrum, composition, and anisotropy - will be presented.

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Heavy sterile neutrino with large mixing angle does not overclose the Universe

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We study a model of a keV-scale sterile neutrino with a relatively large mixing with the Standard Model sector. Usual considerations predict active generation of such particles in the early Universe, which leads to constraints from the total Dark Matter density and absence of X-ray signal from sterile neutrino decay. These bounds together may deem any attempt of creation of the keV scale sterile neutrino in the laboratory unfeasible. We argue that for models with a hidden sector coupled to the sterile neutrino these bounds can be evaded, opening new perspectives for the direct studies at neutrino experiments such as Troitsk ν-mass and KATRIN.

We estimate the generation of sterile neutrinos in scenarios with the hidden sector dynamics keeping the sterile neutrinos either massless or superheavy in the early Universe. In both cases the generation by oscillations from active neutrinos in plasma is suppressed. In particular, we firstly explore

the hidden sector with the phase transition which makes the sterile neutrinos massless and oscillations inefficient in the early Universe. In the second case, we introduce the feebly interacting scalar field which oscillates at late times and can compose all Dark Matter today avoiding any structure formation constraints.

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The spectrum of the axion dark sector, cosmological observable and black hole superradiance constraints.

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Axions or axion-like particles are ubiquitous in many theoretical extensions of the Standard Model of particle physics, in particular the ''string axiverse" scenario [1-3]. If the phenomenologically defining parameters, the axion mass, m_a, and (effective) decay constant, f_a, fall in specific ranges, then axions contribute to the cosmological dark matter and dark energy densities of the universe [4]. In the framework of string/M theory a systematic construction of the axion decay constant and mass spectrum in explicit realisations of the string axiverse is a daunting task to undertake, often requiring the extensive details of instanton corrections to the superpotential and a detailed knowledge of the full scalar potential for the supersymmetric theory when considering realistic axion/moduli population numbers.

We present the background cosmological (quasi-)observables for a series of random matrix (RMT) models inspired by several axion field alignment mechanisms [5,6], with the associated parameter spectra for a large number of axion fields, $n_{\rm ax} \sim \mathcal{O}(10-100)$, where the masses and decay constants are drawn from statistical distributions [7]. Using the RMT formalism we also consider the spectra of more physically motivated models, specifically a class of G_2 compactified M-theory models [3,8,9] where all the moduli are stabilised in a non-supersymmetric minima. This process effectively reduces the number of parameters from $2n_{\rm ax}$ to a limited number of ''hyperparameters" allowing us to use Bayesian methods to constrain the hyperparameters of the distributions in the context of the cosmological (quasi)-observables.

These methods are also used to constrain the axion parameter space via the black hole superradiance process [10,11]. The presence of multiple fields can enhance the exclusion bounds on both solar and supermassive black holes in the so called Regge spin plane as apposed to considering just a single field. We present an analysis of the statistical likelihoods for each of these models with recorded black hole data in order to provide a picture of the significance of the axion parameter space its phenomenology in effective theories.

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Non-thermal WIMP baryogenesis

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We propose a WIMP baryogensis achieved by the annihilation of non-thermally produced WIMPs from decay of heavy particles, which can result in low reheating temerature. Dark matter (DM) can be produced non-thermally during a reheating period created by the decay of long-lived heavy particle, and subsequently re-annihilate to lighter particles even after the thermal freeze-out. The re-annihilation of DM provides the observed baryon asymmetry as well as the correct relic density of DM. We investigate how wahout effects can affect the generation of the baryon asymmetry and study a model suppressing them. In this scenario, we find that DM can be heavy enough and its annihilation cross section also can be larger than that adopted in the usual thermal WIMP baryogenesis.

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Kaluza-Klein Towers in the Early Universe: Phase Transitions, Relic Abundances, and Applications to Axion Cosmology

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We discuss the early-universe cosmology of a Kaluza-Klein (KK) tower of scalar fields in the presence of a mass-generating phase transition, focusing on the time-development of the total tower energy density as well as its distribution across the different KK modes. We find that both of these features are extremely sensitive to the details of the phase transition and can behave in a variety of ways significant for late-time cosmology. In particular, the interplay between the temporal properties of the phase transition and the mixing it generates are responsible for both enhancements and suppressions in the late-time abundances, sometimes by orders of magnitude. We map out the complete model parameter space and determine where traditional analytical approximations are valid and where they fail. Finally, we apply this machinery to the example of an axion-like field in the bulk, mapping these phenomena over an enlarged axion parameter space that extends beyond those accessible to standard treatments.

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The generation of B-mode and circular polarization of cosmic photons due to NonCommutative space-Time background

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In standard model of cosmology, B-mode polarization of the CMB can be generated due to the tensor perturbation of metric which is related to gravitational effects in the inflation epoch and scalar perturbation can not explain B-mode polarization. We consider Compton scattering in non-commutative framework and show that Compton scattering in presence of non-commutative background and scalar mode of perturbation, beside generating a circularly polarized microwave, can leads to a B-mode polarization of the Cosmic Microwave Background.

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Dark matter assisted Dirac leptogenesis and neutrino mass

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We propose a minimal extension of the standard model with U(1)_B−L × Z_2 symmetry. In this model by assuming that the neutrinos are Dirac (i.e. B − L is an exact symmetry), we found a simultaneous solution for non zero neutrino masses and dark matter content of the universe. The observed baryon asymmetry of the universe is also explained using Dirac Leptogenesis, which is assisted by a dark sector, gauged under a U(1)_D symmetry. The latter symmetry of the dark sector is broken at a TeV scale and thereby giving mass to a neutral gauge boson Z_D . The standard model Z-boson mixes with the gauge boson Z_D at one loop level and thus paves a way to detect the dark matter through spin independent elastic scattering at terrestrial laboratories.

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Cosmological Helical Hypermagnetic Fields and Baryogenesis

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I will show that the baryon asymmetry of the Universe (BAU) is generated from the hypermagnetic helicity decay without being washed out by the sphalerons. Moreover such hypermangetic fields still remain until today as the intergalactic magnetic fields, which will be the smoking gun of the scenario. I will also discuss a possible mechanism to generate such hypermagnetic fields. That is, the chiral instability induced by a large chiral asymmetry in the early Universe thermal plasma, which can be generated by the SU(5) GUT baryogenesis. Although the SU(5) GUT baryogenesis has been thought not to be a viable model for the BAU since the asymmetry is washed out by the sphalerons, it can be indirectly responsible for the BAU through the maximally helical hypermagnetic field generation.

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Leptogenesis in Cosmological Relaxation with Particle Production

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Among cosmological relaxation solutions to the weak-scale hierarchy problem, gauge boson production is a particularly efficient backreaction mechanism for trapping the relaxion. In these models, scanning can even happen after inflation and the relaxion field range can be sub-Planckian, with no extremely small parameters or large e-foldings involved. We consider a model where particle production by the relaxion also reheats the universe and generates the baryonic matter-antimatter asymmetry. Out-of-equilibrium leptons scatter with the thermal bath through interactions that violate CP and lepton number via higher-dimensional operators. Such an effective field theory setup, with no new physics below the cut-off, is sufficient to achieve successful leptogenesis. The baryon asymmetry is thus intrinsically tied to a weak-scale hierarchy.

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Searches for Nucleon Decay at Hyper-Kamiokande

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While grand unified theories offer potential solutions to problems with the Standard Model, such as the origins of charge quantization, their signature prediction, proton decay, has not been observed experimentally. Hyper-Kamiokande is a next-generation water Cherenkov experiment with a 187~kton target volume that will provide unprecedented sensitivity to a variety of nucleon decay modes, including many beyond the so-called flagship modes, $p \to e^+\pi^0$ and $p \to \bar{\nu}K^+$.With improved detector technologies to enhance signal efficiencies and reject backgrounds, Hyper-Kamiokande is expected to search for these processes with sensitivities to proton lifetimes of 10^{35} years and longer, providing opportunities for a discoveries for lifetimes exceeding existing limits by an order of magnitude.This presentation will describe the complete Hyper-Kamiokande nucleon decay physics program and its expected sensitivities.

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Probing the Reheating Temperature with a Gravitational Waves: with application to Gauss-Bonnet Inflation

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In this work, inflationary models with Gauss-Bonnet term is classified into two categories based on their prediction for the tensor spectral index (n_T). We showed that the energy spectrum of the primordial gravitational waves (GWs) induced by a group of models that predict blue-tilted tensor spectrum ($n_T > 0$) can be probed by the future space-based laser interferometer experiment such as DECIGO in frequency ranges of $0.1 - 10$ Hz. If the signals of primordial GW background from our models is detected, it would determine the lower bound of the reheating temperature, which is $T_{\rm re} \geq 10^{-6}$ in our case. Our further analyses on reheating parameters imply that the effect of GB term is significant not only during inflation but also during reheating regardless of the process is instantaneous or lasted for a certain number of e-folds until it completes.

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In between the Observation Runs 2 and 3, a status report on the Advanced LIGO and Advanced Virgo gravitational-wave detectors

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Following a fruitful Observation Run 2 (O2, November 2016 - August 2017) marked by the first three-detector observation of a binary black hole merger and the first ever detection of a binary neutron merger followed by the discovery of the optical counterpart of the gravitational-wave signal, the LIGO and Virgo giant interferometers started a new upgrade phase with a twofold goal: to improve the sensitivity and the duty cycle of the three instruments before starting the Observation Run 3 (O3) next fall, which should last about a year.

After a brief review of the O2 data taking period and a summary of the main results achieved, including the successes of multi-messenger astronomy, we will describe the current upgrade campaign, review the performance achieved to date and conclude by presenting some prospects for O3.

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Relaxion: A Landscape Without Anthropics

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The relaxion mechanism provides a potentially elegant solution to the hierarchy problem without resorting to anthropic or other fine-tuning arguments. This mechanism introduces an axion-like field, dubbed the relaxion, whose expectation value determines the electroweak hierarchy as well as the QCD strong CP violating θ parameter. However, in the original model proposed by Graham, Kaplan and Rajendran (2015), the relaxion does not solve the strong CP problem, and in fact contributes to it, as the coupling of the relaxion to the Higgs field and the introduction of a linear potential for the relaxion produces large strong CP violation. We resolve this tension by considering inflation with a Hubble scale which is above the QCD scale but below the weak scale, and estimating the Hubble temperature dependence of the axion mass. The relaxion potential is thus very different during inflation than it is today. We find that provided the inflationary Hubble scale is between the weak scale and about 3 GeV, the relaxion resolves the hierarchy, strong CP, and dark matter problems in a way that is technically natural.

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Are Cold Dynamical Dark Energy Models Distinguishable in the Light of the Data?

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{In this paper we obtain observational constraints on three dynamical cold dark energy models ,include PL , CPL and FSL, with most recent cosmological data and investigate their implication for structure formation, dark energy clustering and abundance of CMB local peaks. From the joint analysis of the CMB temperature power spectrum from observation of the {\it Planck}, SNIa light-curve, baryon acoustic oscillation, $f\sigma_8$ for large scale structure observations and the Hubble parameter, we find that $\Omega_{\rm DE}=0.6862\pm0.0078$, $\alpha=0.1013\pm0.0031$ and $w_0=-1.3799^{+0.0036}_{-0.0028}$ for the PL model, $\Omega_{\rm DE}=0.6880^{+0.0100}_{-0.0079}$, $w_0=-1.08045^{+0.00041}_{-0.00062}$ and $w_1=-0.12190^{+0.00050}_{-0.00030}$ for the CPL model and $\Omega_{\rm DE}=0.6893\pm0.0078$, $w_0=-0.9994\pm0.0076$ and $w_1=-0.0082^{+0.0044}_{-0.0051}$ for the FSL model at 1σ confidence interval. The PL model has matter-like contribution to the energy content of early universe due to crossing behavior of its Equation of state. Therefore, the PL model has the highest growth of matter density, Δ_m, and matter power spectrum, $P(k)$, compared to ΛCDM and other models. For the CPL on the other hand, the structure formation is considerably suppressed while the FSL has behavior similar to standard model of cosmology. Studying the clustering of dark energy, Δ_{DE}, yields positive but small value with maximum of $\Delta_{DE}\simeq10^{-3}$ at early time due to matter behaviour of the PL, while for the CPL and FSL cross $\Delta_{DE}=0$ several time which demonstrate void of dark energy with $\Delta_{DE}\simeq-10^{-11}$ in certain periods of the history of dark energy evolution. Among these three models, the PL model demonstrate that is more compatible with $f\sigma_8$ data. We also investigated a certain geometrical measure, namely the abundance of local maxima as a function of threshold for three DDE models and find that the method is potentially capable to discriminate between the models, especially far from mean threshold. The contribution of PL and CPL for late ISW are significant compared to cosmological constant and FSL model. The tension in the Hubble parameters is almost alleviated in the PL model.

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Dark matter in the early matter dominated Universe

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In the early Universe, there exists a matter-dominated era, that is driven by inflaton oscillation, curvaton, moduli or long-lived heavy particles. In this early matter domination, dark matter exists and show different behavior from the standard one during radiation domination, from the relics density to the density perturbation, constraints on the reheating temperature and baryogengesis. In this talk, I will present the recent developments.

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Unitarizing SIMP scenario with dark vector resonances

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We investigate a scenario of Strongly Interacting Massive Particles (SIMPs) where the thermal relic density of dark pion dark matter (DM) is determined by number changing 3⟶2 annihilations in a strongly interacting dark sector. In this scenario, including dark vector mesons in the hidden local symmetry scheme, we find that dark vector mesons unitarize the dark chiral perturbation theory (ChPT) efficiently and extend the range of validity of the leading order calculations. In QCD-like theories with SU(3)_L×SU(3)_R/SU(3)_V flavor symmetry, we show explicitly that the inclusion of these dark vector mesons in the 3⟶2 annihilation and 2⟶2 self-scattering of DM eliminates the tension between the Bullet Cluster bound and the relic density condition in a wide parameter space.

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Dark matter and early Universe

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Big-Bang nucleosynthesis (BBN) represents one of the earliest phenomena which can lead to observational constraints on the early Universe properties. Yet, it is well-known that many important mechanisms and phase transitions occurred before BBN. During this talk, I will discuss the possibility to gain insight about the primordial Universe through studies of dark matter in cosmology, astroparticle physics and colliders. For this purpose, we consider that dark matter is a thermal relic, and show that combining collider searches with dark matter observables can lead to strong constraints on the freeze-out period.

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Ultralight Axion Dark Matter and Structure Formation

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The Ultra-Light Axion (ULA) is a dark matter candidate with mass 10^{-22} eV and
de-Broglie wavelength of order kpc. Such an axion, also called the Fuzzy Dark Matter (FDM), thermalizes via the gravitational force and forms a Bose-Einstein condensate. The quantum pressure from FDM can significantly affect the structure formation in small scales, thus alleviating the so-called "small-scale crisis." We develop a new technique to discretize the quantum pressure and use N-body simulations to show the formation of the dark matter halo and its inner structure. We find a constant density solitonic core, which potentially solves the problems of small-scale crisis.
We also investigate the effects of quantum pressure (QP) in cosmological simulations and find that QP leads to further suppression of the matter power spectrum at small scales. We then estimate the flux power spectrum of Lyman-alpha forest, and compare it to the data from BOSS and XQ-100 to set the lower bound on the FDM particle mass to 10^{−23} eV.

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Cosmological search of light dark matter

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A few examples for the light dark matter will be
presented along with their cosmological (e.g. radio astronomy search) and
the particle physics (dark matter search experiments) constraints to illustrate the complementarity between the particle physics and cosmology probes.

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The Evidence of Magnetic Monopoles by Astronomical Observation and Its Astrophysical Implication

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A key observation has been reported in 2013 (Eatough et al., 2013): an abnormally strong radial magnetic field near the GC is discovered.
Firstly, we demonstrate that the radiations observed from the GC are hardly emitted by the gas of accretion disk which is prevented from approaching to the GC by the abnormally strong radial magnetic field and these radiations can't be emitted by the black hole model at the Center.However, the dilemma of the black hole model at the GC be naturally solved in our model of super massive object with magnetic monopoles (MMs) (Peng and Chou 2001). Three predictions in our model are quantitatively in agreement with observations:
1) Plenty of positrons are produced from the direction of the GC with the rate is 6*10(42) e+/sec or so. This prediction is quantitatively confirmed by observation (3.4-6.3)* 10(42) e+/sec. 2) A strong radial magnetic field is generated by some magnetic monopoles condensed in the core region of the super massive object The magnetic field strength at the surface of the object is about 20-100 Gauss at 1.1*10*4 **Rs (Rs is the Schwarzschild radius) or (10-50)mG at 0.12 pc . This prediction is quantitatively in agreement with the lower limit of the observed magnetic field >8mG (Eatough et al.2013); 3) The surface temperature of the super-massive object in the Galactic center is about 120 K and the corresponding spectrum peak of the thermal radiation is at 10**(13)Hz in the sub-mm wavelength regime. This is quantitatively basically consistent with the recent observation (Falcke and Marko, 2013).
The Conclusions are: It could be an astronomical observational evidence of the existence of MMs and no black hole is at the GC .
Making use of both the estimations for the space flux of MMs and nucleon decay catalyzed by MMs (called the RC effect) to obtain the luminosity of celestial objects by the RC effect. In terms of the formula for this RC luminosity we are able to present a unified treatment for various kinds of core collapsed supernovae , SNII, SNIb, SNIc, SLSN (Super Luminous Supernova) and the production mechanism for γ ray burst. The remnant of the supernova explosion is a neutron star rather than a black hole, regardless of the mass of the progenitor of the supernova. Besides, the heat source of the Earth's core as well as the energy source needed for the white dwarf interior are the same mechanism of the energy source as supernova. This unified model can also be used to reasonably explain the possible association of the shot γ ray burst detected by the Fermi γ ray Burst Monitoring Satellite (GBM) with the September 2015 LIGO gravitational wave event GW150914.
Finally, We propose that the physical mechanism of Hot Big Bang of the Universe is also nucleons decay driven by the magnetic monopoles, similar to the supernova explosion.
1Qiu-He Peng, Jing-Jing Liu and Chi-Kang Chou, 2016, "A possible influence on standard model of quasars and active galactic nuclei in strong magnetic field"", Astrophys Space Sci (2016) 361:388
[2] Qiuhe Peng, Jing-Jing Liu and Chi-Kang Chou, 2017,"A unified model of supernova driven by magnetic monopoles"Astrophys Space Sci (2017) 362:222

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A new Paradigm on the TeV-scale Cosmic Rays: Contributions from the local sources

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Recent measurements of cosmic ray proton and helium spectra in CREAM, PAMELA and AMS02 experiments show a hardening above a few hundreds of GeV. This excess is hard to understand in the framework of the conventional models of Galatic cosmic ray production and propagation. We propose here to explain this anomaly by the presense of the local sources as a discrete one. Improving the Green function method for the local sources, we consistently derive these nuclei fluxes by taking into account both local and remote sources for which a unique injection rate is assumed. Finally we found cosmic ray propagation parameters for which the proton and helium spectra remarkably agree with the CREAM, PAMELA, AMS02 measurements. By the similar way, we show that the excess of the position can be explained by a few local sources of pulsar.

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An indirect dark matter search using cosmic ray antiparticles with GAPS

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Experiments aiming to directly detect dark matter (DM) particles have yet to make robust detections, thus underscoring the need for complementary approaches such as searches for new particles at colliders, and indirect searches of DM decay or annihilation signatures in photon and cosmic ray spectra. In particular, low energy ($<$ 0.25 GeV/n) cosmic ray antiparticles such as antideuterons are strong candidates for probing various DM models, as the yield of these particles from DM processes can exceed the conventional astrophysical background by up to two orders of magnitude. The General Antiparticle Spectrometer (GAPS), a balloon borne cosmic ray detector, will exploit this idea and perform a virtually background-free measurement of the cosmic antideuteron flux in the regime $<$ 0.25 GeV/n, which will constrain a wide range of viable DM models. Additionally, GAPS will detect approximately 1500 antiprotons in an unexplored energy range throughout one long duration balloon (LDB) flight, which will constrain $<$ 10 GeV DM models as well as validate the GAPS detection technique. Unlike magnetic spectrometers, GAPS relies on the formation of an exotic atom within the tracker in order to reliably identify antiparticles. The GAPS tracker consists of ten layers of lithium-drifted silicon detectors which record dE/dx deposits from primary and nuclear annihilation product tracks, as well as measure the energy of the exotic atom deexcitation X-rays. A two-layer, plastic scintillator time of flight (TOF) system surrounds the tracker and measures the particle velocity, dE/dx deposits, and provides a fast trigger to the tracker. The nuclear annihilation product multiplicity, deexcitation X-ray energies, TOF, and stopping depth are all used together to discern between antiparticle species. In this presentation, I will give a progress update on the construction of the silicon tracker and TOF system, as well as an update on the simulated performance of the GAPS experiment in light of the upcoming LDB flight from McMurdo Station, Antarctica in 2020.

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The ISS-CREAM Silicon Charge Detector for identification of the charge of cosmic rays up to Z = 26

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The Cosmic Ray Energetics And Mass experiment for the International Space Station (ISS-CREAM) is a space-borne mission designed for the precision measurement of energy and elemental composition of cosmic rays. It was launched and installed on the ISS in August 2017. The Silicon Charge Detector (SCD), placed at the top of the ISS-CREAM payload, consists of 4 layers. Each layer has 2688 silicon pixels and associated electronics arranged in such a fashion that its active detection area of 78 x 74 cm2 is free of any dead area. The 4-layer configuration was chosen to achieve the best precision in measuring the charge of cosmic rays within the constraints on the mass, volume and power allotted to it. The amount of material used for its support structure was minimized as well to reduce the chance of interactions of the cosmic ray within the structure. Given the placement of the SCD, its 4-layer configuration and the minimal amount of material in the cosmic-ray trajectory, the SCD is capable of measuring the charge of cosmic rays ranging from protons to iron nuclei with excellent detection efficiency and charge resolution. We present the design and fabrication of the SCD, and its performance during various ground tests before launch including a heavy-ion beam test. We also present the operation and performance of the SCD on the ISS.

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Cosmic Ray Energetics And Mass (CREAM) Launch and On-Orbit Performance

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The CREAM experiment was launched on a SpaceX Falcon 9 rocket to the International Space Station (ISS) from NASA's Kennedy Space Center on August 14, 2017. The instrument was successfully installed and activated on the ISS Japanese Experiment Module Exposed Facility as an attached payload on August 22, 2017. The CREAM instrument was initially developed to measure cosmic ray elemental spectra using a series of ultra-long-duration balloon flights. The balloon-borne CREAM experiment was flown seven times (12/15/04 - 12/28/16) over Antarctica accumulating ~191 days of flight time, the longest known exposure for a single balloon project. Building on the success of the balloon flights, the payload was transformed for accommodation on the ISS. This version of CREAM, aka ISS-CREAM, is configured with redundant and complementary particle detectors capable of precise measurements of elemental spectra for Z = 1 - 26 nuclei, as well as electrons. The four layers of its finely segmented Silicon Charge Detector provide precise charge measurements, and its ionization calorimeter provides energy measurements. In addition, scintillator-based Top and Bottom Counting Detectors and Boronated Scintillator Detector distinguish electrons from nuclei. At least an order of magnitude increase in data collecting power is expected by utilizing the ISS to reach the highest energies practical with direct measurements. On-orbit performance of the instrument and preliminary results from the ongoing analysis will be presented.

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Precision Measurement of the positron fraction and the combined electron and positron flux in Primary Cosmic Rays with the Alpha Magnetic Spectrometer on the International Space Station

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Precision measurements by AMS of the positron fraction and the combined electron and positron flux in primary cosmic rays in the energy range from up to 1000 GeV based on 25 million positron and electron events is presented. This measurement extends the energy range of our previous observation and increases its precision. The new results show that at ~300 GeV the positron fraction reaches its maximum. This behavior is consistent with a new source of high energy electrons and positrons.

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The cosmic-ray electron spectrum measured with the CALorimetric Electron Telescope

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Direct measurements of cosmic-rays (CRs) are important to understand the sites and the processes of acceleration and propagation of high-energy particles in the interstellar medium. For example, detailed measurements of the high-energy electron+positron (hereafter simply "electron") spectrum can provide information about nearby CR sources. The electron spectrum may also exhibit features from Dark Matter (DM) annihilation.
The CALorimetric Electron Telescope (CALET) is a Japanese-led international space mission promoted by JAXA (Japan Aerospace Exploration Agency) in collaboration with the Italian Space Agency (ASI) and NASA. The apparatus is continuously operating on board of the International Space Station (ISS) since October 2015. Its main objective is to perform precise direct measurements of the electron cosmic-ray spectrum in the energy region above 1 TeV; other scientific objectives are the measurement of hadron spectra, from proton to iron and above, up to several hundreds of TeV and the detection of gamma-ray emissions up to 10 TeV.
The instrument consists of a deep homogeneous calorimeter, a sampling-imaging calorimeter and a

charge detector. The electron measurement is characterized by excellent energy resolution (about 1% at 1 TeV) and good proton rejection power (about 10^5 at 1 TeV). We will discuss the current status of the electron data analysis, mainly focusing on the electron/proton discrimination methods. Also, we will present a comparison between electron spectra measured by CALET and other experiments. The current CALET electron measurement will be extended to higher energies in the next years, with the increase of accumulated statistics.

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First Results from the DAMPE Mission

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DAMPE (DArk Matter Particle Explorer) is a satellite mission of the Chinese Academy of Sciences (CAS) dedicated to high energy cosmic ray detections. Since its successful launch on December 17th, 2015 a large amount of cosmic ray data has been collected. With relatively large acceptance, DAMPE is designed to detect electrons (and positrons) up to 10 TeV with unprecedented energy resolution to search for new features in the cosmic ray electron plus positron (CRE) spectrum. It will also study cosmic ray nuclei up to 100 TeV with good precision, which will bring new input to the study of their still unknown origin and their propagation through the Galaxy.

In this talk, the DAMPE mission will be introduced, together with some details of the construction and on-ground calibration of the detector subsystems. The in-orbit detector commissioning, calibration and operation will be described. First data analysis results will be presented.

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Status of a 3D Imaging Calorimeter of DAMPE for Cosmic Ray Physics on Orbit

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The space experiment of DArk Matter Particle Explorer (DAMPE) developed in China is designed to find the evidence of dark matter particle by observing primary cosmic rays and gamma rays in energy range from 5 GeV to 10 TeV. Since its launch in December 2015, a large quantity of data has been recorded.
The BGO Electromagnetic Calorimeter (BGO ECAL) of the DAMPE is a total absorption calorimeter consisted of 308 BGO crystal bars that allows for a precise three-dimensional imaging of the shower shape. It provides a good energy resolution (<1%@200 GeV) and high electron/hadron discrimination (>10^5). The ECAL also provides a trigger capability for DAMPE. With the data set acquired more than two years of operation in space, a precise time-dependent calibration for energy, shower topologies measured by the BGO calorimeter had been developed.
In this report, the instrumentation and development of the BGO ECAL is briefly described. The calibration on orbit, including the pedestal, minimum ionizing particle (MIP) peak, dynode ratio, and etc. is discussed, and more details about calibration methods and the performance in space are presented.

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Supernova relic neutrino sensitivity study with 2nd Hyper-Kamiokande detector in Korea

Dong-Nyeok Yeum[None]

Neutrino has become a new window to our universe since the observation of neutrinos from the Sun and SN1987A. Hyper-Kamiokande (Hyper-K) is a next-generation neutrino telescope with excellent capabilities in particle physics. The detector will be a water Cherenkov detector of 260 kton water mass with 40 % photo coverage. With about 10 times larger fiducial volume per detector than Super- Kamiokande(SK), sensitivities for the supernova burst and the supernova relic neutrino(SRN) searches will be greatly improved in Hyper-K.
Locating the 2nd detector in Korea will enhance the sensitivity of SRN search thanks to less muon flux and spallation background in deeper (~1km) Korean candidate sites. In this talk, we will present our sensitivity study on SRN search for several candidate sites in Korea and the various theoretical SRN flux models.

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Status of the Supernova Relic Neutrino Search and Atmospheric Neutrino Neutral-Current Quasi-Elastic Interactions Measurement in Super-Kamiokande

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Supernova relic neutrinos (SRN), also called the diffused supernova neutrino backgrounds (DSNB), are emitted from core-collapse supernovae throughout the universe. Super-Kamiokande-IV tags inverse beta interactions by neutrons captured on hydrogen using improved electronics and triggering. Recently, the use of vertex reconstruction of the 2.2 MeV photons emitted by the neutron captures and a neural network improved the discrimination against backgrounds and significantly increased the efficiency. Neutral current quasi-elastic (NCQE) scattering of atmospheric neutrinos on ^{16}O in water-Cherenkov detectors forms an important remaining background in SRN detection. Using neutron tagging technique, the Super-Kamiokande measurement of the NCQE cross section of atmospheric neutrinos will be presented and compared against theoretical predictions.

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GRAND: A Giant Radio Array for Neutrino Detection

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The detection of ultra-high-energy (UHE) neutrinos, with energy in excess of 108 GeV, is an important key to solving the mystery of the origin of UHE cosmic rays. The detection of UHE cosmogenic neutrinos will confirm the photo-dissociation of UHE cosmic rays and the identification of the sources of UHE neutrinos will help to identify the sources of UHE cosmic rays.
The flux of these UHE neutrinos is expected to be low and their detection is a challenge. We present the Giant Radio Array for Neutrino Detection, GRAND, that is based on proven methods of radio

frequency detection of extensive air-showers, which will allow for a huge exposure at a relatively modest price.
On top of discovering UHE neutrinos, GRAND will be able to investigate many other science topics, including neutrino physics, UHE gamma-ray detection, UHE cosmic ray science with very large statistics, the detection of fast radio bursts and giant radio pulses, and a measurement of the epoch of reionisation.
The R&D and different initial phases of development of GRAND, and the physics reach for these research topics will be discussed.

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Latest results of the Antares detector and perspectives for KM3NeT/ARCA

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The ANTARES detector, located 40 km off the French coast, is the largest deep-sea neutrino telescope in the Northern Hemisphere with an instrumented volume of more than 0.01 cubic kilometers. It has been taking data continuously since 2007. The primary goal of such a telescope is to search for astrophysical neutrinos in the TeV-PeV range. The latest results from ANTARES will be presented, including generic searches for diffuse cosmic neutrino fluxes as well as more specific searches for astrophysical sources such as active galactic nuclei or Galactic sources. The rich multi-messenger analysis program based on time and/or space coincidences with other cosmic probes will also be discussed.

The next-generation neutrino telescope in the Mediterranean, KM3NeT/ARCA, is currently under construction and will consist in an instrumented volume several hundred times larger than ANTARES. The first detection lines of KM3NeT have been deployed successfully and the first muons observed. Perspectives for neutrino astronomy with ARCA will also be presented.

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Combined search for dark matter in the Galactic center with ANTARES and IceCube

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To date the neutrino telescopes IceCube and ANTARES have been generating strong limits on the thermally averaged annihilation cross-secttion of WIMP dark matter in the galactic center, with ANTARES yeilding the currently strongest limits at WIMP masses exceeding 30 TeV. At a WIMP mass range of 50 GeV to a few hundred GeV the current limitss from IceCube surpass those of ANTARES offering a good opportunity for a combined analysis. In this presentation the results of a first combined search for dark matter in the galactic center using the data of both these experiments

is presented. As a first step to a combined analysis using both detectors full datasets the 79-string data sample taken from 2012 to 2014 was used from IceCube, while from ANTARES the data sample collected from 2007 to 2015 was taken. The analysis considered dark matter with particle masses between 50 and 100 GeV and a variety of different dark matter halo models and annihilation channels.

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Search for Solar atmospheric neutrinos with the IceCube Neutrino Telescope

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Cosmic ray interactions with the solar atmosphere are expected to generate energetic neutrinos that might be observable with the neutrino telescopes. These so called solar atmospheric neutrinos are expected to have a distinguishable shape in the energy spectrum compared with atmospheric neutrinos generated in the Earth. The difference originates from the lower atmospheric density on the Sun, which allows secondary particles to decay rather than interact with the medium and lose energy. We present the first search for a signal of solar atmospheric neutrinos, using 8 years of data collected with the worlds largest neutrino telescope IceCube, which shows optimal sensitivity for the energetic neutrinos. To distinguish signal from backgrounds we perform a likelihood analysis using directional and energy spectral information. The analysis method and optimization will be introduced and sensitivities presented.

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Search for decaying dark matter with IceCube

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Dark matter particles may be metastable. If they decay into neutrinos, directly or indirectly, the signal is detectable with a neutrino telescope like IceCube, located at the geographic South Pole. IceCube instruments a cubic kilometre of ice with over 5000 optical sensors which detect the Cherenkov light emitted by particles produced in neutrino interactions in the ice. This talk will present recent searches for a decaying dark matter signal. For dark matter mass above 100 TeV, lifetimes below ~10^28 s are excluded for various decay channels, providing the strongest constraints to date.

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IceCube's astrophysical neutrino energy spectrum from CPT violation

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The 6-year dataset of high-energy starting events (HESE) at IceCube indicates a spectrum of astrophysical neutrinos much softer than expected from the Fermi shock acceleration mechanism. On the other hand, IceCube's up-going muon neutrino dataset and Fermi-LAT's gamma-ray spectrum point to an E^{-2} neutrino spectrum. If the HESE data above 200 TeV are fit with the latter flux, an excess at lower energies ensues, which then suggests a multicomponent spectrum. We show that the HESE dataset can be explained by a single E^{-2} power-law neutrino flux from a muon-damped $p\gamma$ source if neutrino interactions are modified by CPT violation. The low-energy excess is naturally explained by the pileup of events from superluminal neutrino decay, and there is no cutoff at high energies due to the contribution of subluminal antineutrinos. The best-fit scenario with CPT violation also predicts the observation of Glashow resonance events in the near future.

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Properties of Elementary Particle Fluxes in Primary Cosmic Rays Measured with the Alpha Magnetic Spectrometer on the International Space Station

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The fluxes and flux ratios of charged elementary particles in cosmic rays are presented in the absolute rigidity range from 1 to 1000 GV. In the absolute rigidity range ~60 to ~500 GV, the antiproton, proton, and positron fluxes are found to have nearly identical rigidity dependence and the electron flux exhibits different rigidity dependence. Below 60 GV, the antiproton-to-proton, antiproton-to-positron, and proton-to-positron flux ratios each reaches a maximum. Particular emphasis is made on new observations of the properties of elementary particles in the rigidity range above 500 GV.

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Anisotropy of Elementary Particle Fluxes in Primary Cosmic Rays Measured with the Alpha Magnetic Spectrometer on the International Space Station

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Analysis of anisotropy of the arrival directions of galactic protons, electrons and positrons has been performed with the Alpha Magnetic Spectrometer on the International Space Station. These results allow to differentiate between point-like and diffuse sources of cosmic rays for the explanation of the observed excess of high energy positrons. The AMS results on the dipole anisotropy are presented along with the discussion of implications of these measurements.

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Precision Measurement of the Monthly Cosmic Ray Fluxes with the Alpha Magnetic Spectrometer on the ISS

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The precision measurements of the monthly cosmic ray fluxes for the period from May 2011 to May 2017 with Alpha Magnetic Spectrometer on the International Space Station are presented. This period covers the ascending phase of solar cycle # 24 together with the reversal of the Sun's magnetic field polarity through the minimum. The detailed variations with time of the fluxes are shown up to rigidities of 60 GV. Impact of the solar polarity reversal is discussed in details.

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Precision Measurement of Electron and Positron Fluxes in Primary Cosmic Rays with the Alpha Magnetic Spectrometer on the International Space Station

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Precision measurements by the Alpha Magnetic Spectrometer on the International Space Station of the primary cosmic-ray electron and positron fluxes in the energy range up to 1000 GeV are presented. The electron flux and the positron flux are significantly different in their magnitude and energy dependence. Their behavior is consistent with the contribution from a new source of high energy particle contributing equally to the fluxes of both electrons and positrons.

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Measurements of Light Nuclear Isotopic Composition in Cosmic Rays with the Alpha Magnetic Spectrometer on the International Space Station

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The spectral shape of the secondary isotopes in cosmic rays is completely determined by the source spectrum of the parent elements and by the propagation process. In particular, 3He in cosmic rays is believed to result from the interaction of primary 4He with the interstellar medium, providing a powerful tool to constrain the parameters of the galactic cosmic rays propagation models. A precise measurement of the helium isotopes ratio (3He/4He) and the individual 3He and 4He fluxes in the kinetic energy per nucleon range from 1.0 GeV/nucl to 10 GeV/nucl based on data collected by AMS during the first 5 years of operation are presented.
The 6Li/7Li ratio, as both isotopes are secondary and stable, is expected to reflect the ratio between the production cross sections and therefore constitute a good check of the reconstruction method. Measurement of the lithium isotopes ratio (6Li/7Li) as a function of the kinetic energy per nucleon from 0.5 GeV/nucl to 10 GeV/nucl based on data collected by AMS during the first 5 years of operation is presented.

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Precision Measurement of Nitrogen flux by AMS

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The nitrogen flux in cosmic rays is expected to contain both primary and secondary components, so the knowledge of their relative contributions is important in understanding the origin, acceleration, and propagation of cosmic rays. A precise measurement of the nitrogen flux with rigidity from 2 GV to 3 TV based on 2 million nuclei collected by AMS during first 5 years of operation is presented.

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Observation of the New Properties of the Secondary Cosmic Rays Lithium, Berillium and Boron with the Alpha Magnetic Spectrometer on the International Space Station¶ 20m¶ 20m

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We report on the observation of new properties of secondary cosmic rays Li, Be, and B measured in the rigidity (momentum per unit charge) range 1.9 GV to 3.3 TV with a total of 5.4 million nuclei collected by AMS during the first five years of operation aboard the International Space Station. The Li and B fluxes have an identical rigidity dependence above 7 GV and all three fluxes have an identical rigidity dependence above 30 GV with the Li/Be flux ratio of 2.0±0.1. The three fluxes deviate from a single power law above 200 GV in an identical way. This behavior of secondary cosmic rays has also been observed in the AMS measurement of primary cosmic rays He, C, and O but the rigidity dependences of primary cosmic rays and of secondary cosmic rays are distinctly different. In particular, above 200 GV, the secondary cosmic rays harden more than the primary cosmic rays.

Astro-particle Physics and Cosmology / 720

Observation of the Identical Rigidity Dependence of the Primary Cosmic Rays Helium, Carbon and Oxygen fluxes by the Alpha Magnetic Spectrometer on the International Space Station

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The precision measurement of primary cosmic rays fluxes (in particular helium, carbon and oxygen) in the rigidity range from 2 GV to 3 TV is presented based on 90 million helium, 8 million carbon and 7 million oxygen nuclei collected by the Alpha Magnetic Spectrometer during its first 5 years of operation.
Unexpectedly, above 60 GV, these three spectra have identical rigidity dependence, moreover they all deviate from a single power law above 200 GV and harden in an identical way.

Beyond the Standard Model / 1135

Searches for electroweak production of supersymmetric gauginos and sleptons at LHC

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Supersymmetry is one of the most searched-for extensions of the Standard Model. In its minimal realization, the Minimal Supersymmetric Standard Model, it predicts a new bosonic (fermionic) partner for each fundamental standard Model fermion (boson), as well as an additional Higgs doublet. The sector of sparticles with only electroweak interactions contains charginos, neutralinos, sleptons, and sneutrinos. Charginos and neutralinos are the mass eigenstates formed by linear superpositions of the superpartners of the charged and neutral Higgs bosons and electroweak gauge bosons. In R-parity conserving models, sparticles can only be produced in pairs and the lightest supersymmetric particle is stable. This is typically the lightest neutralino and can provide a natural candidate for dark matter. When produced in the decay of heavier SUSY particles, a neutralino LSP would escape detection, leading to an amount of missing transverse momentum significantly larger than for SM processes, a canonical signature that can be exploited to extract SUSY signals. In this poster, a set of recent searches for the electroweak production of charginos, neutralinos, sleptons, and gluinos decaying to final states with at least four leptons will be presented. These searches rely on proton-proton collision data delivered by the Large Hadron Collider at a center-of-mass energy of $\sqrt{s}$ = 13 TeV, collected and reconstructed with the ATLAS detector.

Beyond the Standard Model / 1022

Detecting Heavy Charged Higgs boson at the LHC

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Discovery of charged Higgs boson indicates a clear and unambiguous signal of the beyond standard model. The signal of charged boson is well studied for lower mass range in the dominant $\tau\nu$ decay channel. For higher mass range, signal is difficult to probe because of its predominant decays in the top and bottom quark. We attempt to investigate the signature of heavy charged Higgs following its decay mode via top and bottom quark, in both hadronic and leptonic final states, where the main dominant standard model backgrounds are from top quark pair and inclusive QCD production. The jet substructure technique is used to reconstruct the top quark in order to avoid the recombinatorial problem. The cut based analysis is performed constructing various kinematic variables, and signal sensitivity is found to be not promising even for high luminosity options due to the huge SM background cross sections. However, we re analyzed both signal and background employing Multi variate analysis technique. We find an improvement in signal sensitivity in this method. The charged Higgs signal up to the mass of about 500 GeV can be observed with 300 inverse femtobarn(invfb) integrated luminosity option where as this range can be extended to 800 GeV with 3000 invfb integrated luminosity.

Beyond the Standard Model / 704

Monojet signatures at the High-Luminosity and High-Energy LHC

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In some class of BSM models, such as SUSY , DM may be searched using high pT jets + missing ET, where DM (X) may be

produced from the decay of a heavy particle H. If mH is close to mX, the signature is ISR , and may be monojet like, and there are much
information on the nature of H and X. I will discuss leading jet distribution contains the information of both mH, color representation
and spin of the particles, but to extract the information fully, one need to predict the distribution with less than 10% accuracy
for the parameter region that may be studied at HL-or HE-LHC. Then I turn into the theoretical error in the current best NLO MC
based on MC@NLO scheme, such as MG5 and Sherpa, and discuss if such accuracy can be achieved.

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Global fits of the MSSM with GAMBIT

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GAMBIT is an open-source and highly modular tool for performing large-scale global fits of BSM theories. We give a brief introduction to GAMBIT and present results from global fits of seven- and nine-dimensional parameterisations of the Minimal Supersymmetric Standard Model (MSSM). We explore the MSSM parameter space in high detail using an efficient differential evolution algorithm. Among other constraints, our fits incorporate direct simulations of LHC sparticle searches (8 TeV and 13 TeV), an up-to-date set of flavour observables and a detailed treatment of direct and indirect dark matter searches. We identify the different mechanisms responsible for keeping the relic density within the allowed range and discuss the discovery prospects for future collider and dark matter searches in light of the parameter regions preferred in our fits.

Beyond the Standard Model / 320

Exotic signals of heavy scalar bosons through vectorlike quarks

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Heavy vectorlike quarks (VLQs) in many new physics models are very attractive as they can play the key role in the model building and easily fit in with the Higgs measurement as well as the electroweak precision data. We study their **loop level** effects on the phenomenological signatures of a heavy scalar boson S. Under some conditions, loop induced decays of S are significantly enhanced. First, the longitudinal polarization enhancement in the decay of $S \to WW/ZZ$ can happen at loop level, which is shown in a singlet extended standard model with VLQs. We find that the critical condition for the radiative enhancement is large mass differences among VLQs. Secondly, the heavy VLQs running in the loop open new decay channels of the charged Higgs bosons into $W\gamma$ and WZ. In a two Higgs doublet model with VLQs, the branching ratios can be as large as 10^{-3}.

Beyond the Standard Model / 389

Searches for new phenomena in leptonic final states using the ATLAS detector

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Many theories beyond the Standard Model predict new phenomena which decay to well isolated, high-pt leptons. Searches for new physics models with these signatures are performed using the ATLAS experiment at the LHC. The results reported here use the pp collision data sample collected by the ATLAS detector at the LHC with a centre-of-mass energy of 13 TeV.

Beyond the Standard Model / 178

Search for new resonances coupling to third generation quarks at CMS

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We present an overview of searches for new physics with top and bottom quarks in the final state, using proton-proton collision data collected with the CMS detector at the CERN LHC at a center-of-mass energy of 13 TeV. The results cover non-SUSY based extensions of the SM, including heavy gauge bosons or excited third generation quarks. Decay channels to vector-like top partner quarks, such as T', are also considered. We explore the use of jet substructure techniques to reconstruct highly boosted objects in events, enhancing the sensitivity of these searches.

Beyond the Standard Model / 388

Searches for heavy resonances decaying to top quarks with the ATLAS detector

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Searches for new resonances that decay either to pairs of top quarks or a top and a b-quark will be presented. The searches are performed with the ATLAS experiment at the LHC using proton-proton collision data collected at a centre-of-mass energy of 13 TeV. The invariant mass spectrum of hypothetical resonances are examined for local excesses or deficits that are inconsistent with the Standard Model prediction.

Beyond the Standard Model / 176

Beyond-Standard-Model Physics at the High-Luminosity LHC with CMS

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The High-Luminosity Large Hadron Collider (HL-LHC) is expected to deliver an integrated luminosity of up to 3000 fb-1. The very high instantaneous luminosity will lead to about 200 proton-proton collisions per bunch crossing ("pileup") superimposed to each event of interest, therefore providing extremely challenging experimental conditions. The sensitivity to find new physics Beyond the Standard Model (BSM) physics is significantly improved and will allow to extend the reach for heavy vector bosons, for SUSY, dark matter and exotic long-lived signatures, to name a few.

Beyond the Standard Model / 173

Searches for heavy resonances decaying into Z, W and Higgs bosons at CMS

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A summary of searches for heavy resonances with masses exceeding 1 TeV decaying into dibosons is presented, performed on data produced by LHC pp collisions at $\sqrt{s}$ = 13 TeV and collected with the CMS detector during 2016 and 2017. The common feature of these analyses is the boosted topology, namely the decay products of the considered bosons (both electroweak W, Z bosons and the Higgs boson) are expected to be highly energetic and close in angle, leading to a non-trivial identification of the quarks and leptons in the final state. The exploitation of jet substructure techniques allows to increase the sensitivity of the searches where at least one boson decays hadronically. Various background estimation techniques are adopted, based on data-MC hybrid approaches or relying only in control regions in data. Results are interpreted in the context of the Warped Extra Dimension and Heavy Vector Triplet theoretical models, two possible scenarios beyond the standard model.

Beyond the Standard Model / 385

Complementarity of ATLAS Searches for s-channel Resonance Production in Bosonic an Leptonic Final States

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Many theories beyond the Standard Model predict new s-channel resonances decaying into two bosons (WW,ZZ,WZ,WH,ZH) and possibly leptons (ll, lv), such as a new heavy scalar singlet, a new heavy vector-boson triplet, or a heavy spin-2 graviton in the bulk Randall-Sundrum model. This talk will summarize relevant ATLAS searches at the LHC using proton-proton collision data collected at a centre-of-mass energy of 13 TeV and show their complementarity.

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Searches for Long Lived Particles at LHCb

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A flexible trigger system, excellent vertex locator, particle identification detectors, and forward acceptance allow unique searches for long-lived particles to be performed at LHC energies using data collected with the LHCb detector. A summary of results will be presented, including searches for long-lived particles decaying into lepton or jets or coming from B meson decays.

Beyond the Standard Model / 179

Searches for vector-like quarks at CMS

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We present results of searches for massive vector-like top and bottom quark partners using proton-proton collision data collected with the CMS detector at the CERN LHC at a center-of-mass energy of 13 TeV. Single and pair production of vector-like quarks are studied, with decays into a variety of final states, containing top and bottom quarks, electroweak gauge and Higgs bosons. We search using several categories of reconstructed objects, from multi-leptonic to fully hadronic final states. We set exclusion limits on both the vector-like quark mass and cross sections, for combinations of the vector-like quark branching ratios.

Beyond the Standard Model / 384

Search for vector-like quarks with the ATLAS Detector

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Vector like quarks appear in many theories beyond the Standard Model as a way to cancel the mass divergence for the Higgs boson. The current status of the ATLAS searches for the production of vector like quarks will be reviewed for proton-proton collisions at 13 TeV. This presentation will address the analysis techniques, in particular the selection criteria, the background modeling and the related experimental uncertainties. The results and the complementarity of the various searches will be discussed.

Beyond the Standard Model / 584

Flavour Anomalies in Rare Decays at LHCb

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Rare decays are powerful probes for Physics beyond the Standard Model (SM), as new particles can have a large impact on physics observables. Recent results on lepton universality tests and measurements of branching fractions and angular distributions of rare b->sll decays have shown tensions with the SM predictions. The LHCb experiment is ideally suited for the study of the these flavour anomalies, due to its large acceptance, precise vertexing and powerful particle identification capabilities. The latest results from LHCb on the flavour anomalies will be presented and their interpretation will be discussed.

Beyond the Standard Model / 392

Search for New Physics through the Reconstruction of Challenging Signatures with the ATLAS detector

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Many theories of beyond the Standard Model (BSM) physics predict unique signatures which are difficult to reconstruct and the background rates are also a challenge. Signatures from displaced vertices anywhere from the inner detector to the muon spectrometer as well as those of new particles with fractional or multiple value of the charge of the electron or high mass stable charged particles are experimentally demanding signatures. The results of searches using data collected by the ATLAS detector of $\sqrt{s}$ = 13 TeV pp collision is presented.

Beyond the Standard Model / 138

Searches for new physics in lepton+jet final states

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Results of searches for new particles such as leptoquarks, heavy neutrinos, and W bosons with right-handed couplings in final states with leptons (charged or neutral) and jets are presented. The emphasis is given to the recent results obtained using data collected at Run-II of the LHC.

Beyond the Standard Model / 387

Searches for New Phenomena in Dijet Events with the ATLAS Detector

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Events with two hadronic jets in the final state are of particular interest in the search for physics beyond the Standard Model: new phenomena produced in parton collisions are likely to produce final states with (at least) two partons. In this talk several searches performed by the ATLAS collaboration are presented. The very high mass and the low mass regions have both been investigated, by exploiting dedicated signatures and, in case of the latter, new techniques to overcome trigger limitations. Final states with b-jets have also been explored.

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Searches for new physics in dijet and multijet final states

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Results of searches for new physics in the dijet and multijet final states are presented. These include model-independent and model-specific searches using the dijet invariant mass spectrum and the dijet angular distributions, searches for black holes, quantum and microscopic, in multijet events, as well as searches for RPV SUSY in events with paired dijets. This talk focuses on the recent results obtained using data collected at Run-II of the LHC.

Beyond the Standard Model / 383

Dark Matter searches with the ATLAS Detector

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Dark matter could be produced at the LHC if it interacts weakly with the Standard Model. The search for dark matter can be performed either directly, by looking for a signature of large missing transverse momentum coming from the dark matter candidates escaping the detector, or more indirectly by looking for the intermediate mediators which would couple the dark matter particles to the Standard Model. A broad and systematic search program covering these various possibilities with the ATLAS detector is in place: the talk will review the latest results of these searches and show their complementarity.

Beyond the Standard Model / 118

Searches for electroweakly produced supersymmetry with CMS

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In supersymmetry, most solutions to the hierarchy problem feature light higgsinos, since it is the most important ingredient to stabilize the Standard Model higgs mass. Light higgsinos, however, are notoriously difficult to detect due to relatively small mass splittings leading to soft objects in the final state. This talk will outline the challenges of finding higgsinos and present various search results and techniques, that focus on supersymmetric models where colored sparticles are out of reach at the LHC and electroweakino production is the dominant process beyond the Standard Model. The searches are performed on proton-proton collision data at a center of mass energy of 13 TeV, recorded with the CMS detector at the CERN LHC in 2016 and 2017.

Beyond the Standard Model / 400

Searches for sleptons with the ATLAS detector

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Many supersymmetry models feature gauginos and sleptons with masses less than a few hundred GeV. These can give rise to direct pair production rates at the LHC that can be observed in the data sample recorded by the ATLAS detector. The talk presents recent ATLAS results from searches for slepton pair production.

Beyond the Standard Model / 398

Searches for electroweak production of supersymmetric particles involving the Higgs boson and the higgsino with ATLAS

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Fine-tuning arguments suggest the mass of the supersymmetric partner of the Higgs boson, the higgsino, is not too far from the weak scale. The search for higgsinos represents an experimental challenge due to the near mass-degeneracy resulting in soft decay products, and the low production cross section. This talk presents recent ATLAS results of analyses explicitly targeting the higgsino with a variety of experimental techniques, as well as searches for electroweak production of supersymmetric particles in final states involving the Higgs boson.

Beyond the Standard Model / 765

Test of Beyond-Standard-Model Scenarios with sub-keV Germanium Detectors

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The existence of physics beyond the standard model (BSM) is established with the observation of neutrino flavor oscillations. Germanium detectors with their excellent energy response and sub-keV sensitivities 1 provide a unique tool to probe a class of BSM scenarios. The TEXONO Collaboration [2] has been pursuing these studies experimentally, complemented by adaptation of advanced atomic physics theory techniques to derive neutrino interaction cross-sections at atomic-scale energy. We will present highlights of the studies on neutrino electromagnetic interactions [3] as well as constraints on sterile neutrinos, axions and dark photons [4]. Additional subjects along these lines will also be discussed.
1. A.K. Soma et al., Nucl. Instrum. Meth. A 836, 67 (2016).
2. H.T. Wong, The Universe 3 22, 2015.
3. J.-W. Chen et al., Phys. Rev. D 90, 011301(R) (2014); J.-W. Chen et al., Phys.Rev. D 91,013005 (2015).
4. J.-W. Chen et al., Phys. Rev. D93, 093012 (2016); S.K. Liu et al., Phys. Rev. D 95, 052006 (2017); S. Bilmus et al, Phys. Rev. D 92, 033009 (2015).

Beyond the Standard Model / 401

Reconstruction techniques in supersymmetry searches in the ATLAS experiment

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Many supersymmetric scenarios feature final states with non-standard final state objects. The production of massive sparticles can lead to the production of boosted top quarks or vector bosons, high-pt b-jets. At the same time, transitions between nearly mass-degenerate sparticles can challenge the standard reconstruction because of the presence of very soft leptons or jets. The talk will review the application of innovative reconstruction techniques to supersymmetry searches in ATLAS.

Beyond the Standard Model / 140

Searches for long-lived particles and other non-conventional signatures at CMS

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Many extensions of the standard model including SUSY predict new particles with long lifetimes, such that the position of their decay is measurably displaced from their production vertex, and particles giving rise to other non-conventional signatures. We present recent results of searches for long-lived particles and other non-conventional signatures obtained using data recorded by the CMS experiment at Run-II of the LHC.

Beyond the Standard Model / 397

Searches for direct pair production of stops and sbottoms with the ATLAS detector

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Naturalness arguments for weak-scale supersymmetry favour supersymmetric partners of the third generation quarks with masses not too far from those of their Standard Model counterparts. The phenomenology ranges from final states of top or bottom quark pairs and two dark matter candidates, to more complex scenarios involving non-prompt sparticle decays or R-parity violating signatures. This talk presents recent ATLAS results from searches for direct sbottom and stop pair production focusing on the less conventional scenarios.

Beyond the Standard Model / 393

Searches for squarks and gluinos in final states involving dark matter candidates with ATLAS

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Despite the absence of experimental evidence, weak-scale supersymmetry remains one of the best motivated and studied Standard Model extensions. This talk summarises recent ATLAS results on inclusive searches for supersymmetric squarks of the first two generations, and gluinos in R-parity conserving models that predict dark matter candidates. The searches target final states including jets, leptons, photons, and missing transverse momentum.

Beyond the Standard Model / 135

Searches for strongly-produced SUSY at CMS

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Searches for the pair-production of colored supersymmetric particles are presented. The results cover different scenarios of gluino and squark production, including models of split supersymmetry that predict long-lived gluinos. The results are based on proton-proton collisions recorded at sqrt(s) = 13 TeV with the CMS detector.

Beyond the Standard Model / 133

Searches for SUSY with boosted objects at CMS

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Searches for supersymmetry at the LHC have pushed the mass limits for strongly-produced sparticles to the TeV level and make the reconstruction and identification of boosted objects to an essential tool for current and future searches for supersymmetry. These objects can originate from the final stage of a short decay chain, or arise heavy gauge or Higgs bosons produced in a decay chain. The talk summaries the use of large-radius jets and substructure techniques in searches such as the ones for the pair production of gluinos or third generation squarks in proton-proton collisions at 13 TeV.

Beyond the Standard Model / 421

Common exotic decays of top partners

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Many Standard Model extensions which address the hierarchy problem contain Dirac-fermion partners of the top quark at the TeV scale. Searches for these vector-like quarks mostly focus on their decay into electroweak gauge bosons and a Standard Model quark.
In this talk we discuss several classes of composite Higgs models with top partners which have underlying descriptions in terms of a fundamental gauge-fermion dynamics. All of these models contain additional BSM states which are likely to be lighter than the top partners, and which thus provide new decay channels for them. We identify the novel top partner decays which occur most commonly, provide effective Lagrangians and benchmarks, and discuss phenomenological bounds and opportunities for future searches.

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EWBG, alignment and searching for new scalar via triple top signature

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The alignment phenomenon, that the 125 GeV h^0 boson so resembles the Standard Model Higgs boson, can be understood in a two Higgs doublet model without discrete symmetry. The Yukawa couplings ρ_{tt} and ρ_{tc} offer new probes for the extra scalar H^0 and pseudoscalar A^0. We propose to search for $cg \to tH^0$, tA^0 followed by H^0, $A^0 \to t\bar{t}$, $t\bar{c}$, where same-sign dileptons could be the harbinger, with triple-top, in the signature of three leptons plus three b-jets, as confirmation. Discovery could touch upon the origin of baryon asymmetry of the Universe.

Beyond the Standard Model / 253

Probing leptoquark chirality via top polarization at the LHC

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Anomalies in recent LHCb, Belle and Babar measurements of $R_{D(*)}$, and $R_{K(*)}$ in B decays may indicate the new physics beyond the Standard Model (SM). The leptoquarks (LQ) that couple to the 3$^{\text{rd}}$ generation quarks and leptons have been proposed as a viable new physics (NP) explanation. Such left-handed LQs can couple to both bottom and top quarks. Since top particles decay before the hadronization, it is possible to reconstruct chirality of boosted top quarks and consequently the chirality of top coupling to the LQs. We perform analysis on the top quark's chirality in the pair-production channel of the LQ, which can be purely left-handed in comparison to unpolarized $t\bar{t}$ SM background. We study the prospects of distinguishing the chirality of a potential LQ signal for the high luminosity run of the LHC.

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Loop Induced Single Top Partner Production and Decay at the LHC

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Most searches for top partners, T, are concerned with top partner pair production. However, as these bounds become increasingly stringent, the LHC energy will saturate and single top partner production will become more important. We study the LHC sensitivity to single top partner production in a model where the Standard Model (SM) is extended by an SU(2) singlet top partner and a SM gauge singlet scalar, S. In this model, it is possible that the scalar singlet can mediate loop induced gg ⟶ T t production, where t is the SM top quark. In fact, we find that the production rate of this channel can be comparable to top partner pair production at top partner masses of MT > 1.5 TeV. In addition, while most current searches focus on the decays T ⟶ tZ, T ⟶ th, T ⟶ Wb decays, in this model the decay pattern of the top partner can be significantly altered with new decay modes T ⟶ gt, T ⟶ γt, and T ⟶ St. We give an overview of the various production and decay channels of the top partner in this model and classify which modes are dominant in which regions of parameter space. We then project the the sensitivity of the high luminosity LHC to gg ⟶ T t.

Beyond the Standard Model / 60

The MoEDAL Experiment at the LHC - a New Light on the High Energy Frontier

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MoEDAL, is a pioneering LHC experiment designed to search for anomalously ionizing messengers of new physics such as magnetic monopoles or massive (pseudo-)stable charged particles, that are predicted to existing a plethora of models beyond the Standard Model. It started data taking at the LHC at a centre-of-mass energy of 13 TeV, in 2015. Its ground breaking physics program defines a number of scenarios that yield potentially revolutionary insights into such foundational questions as: are there extra dimensions or new symmetries; what is the mechanism for the generation of mass; does magnetic charge exist; and what is the nature of dark matter. MoEDAL purpose is to meet such far-reaching challenges at the frontier of the field. We will present the results from the MoEDAL detector on Magnetic Monopole and highly ionizing electrically charged particle production that are the world's best. In conclusion, progress on the installation of MoEDAL's MAPP (MoEDAL Apparatus for the detection of Penetrating Particles) sub-detector prototype will be very briefly be discussed.

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The unexplored landscape of top-partner decays

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We discuss the LHC sensitivity to top partner production in a model where the Standard Model (SM) is extended by an SU(2) singlet top partner and a SM gauge singlet scalar.
Unlike most searches for top partners which are concerned with three conventional decay modes, Wb, tZ and tH, the decay pattern of the top partner in this model can be significantly altered with new decay modes, gluon + top, photon + top and singlet scalar + top.
We present a new approach to search for a pair-produced top partner that decays to a top quark and a gluon (photon). We give an overview of the various production and decay channels of the top partner and project the sensitivity of the high luminosity LHC.

Beyond the Standard Model / 373

Jet substructure shedding light on heavy Majorana neutrinos at the LHC

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The existence of tiny neutrino masses and flavor mixings can be explained naturally in various seesaw models, many of which typically having additional Majorana type SM gauge singlet right handed neutrinos (N). If they are at around the electroweak scale and furnished with sizeable mixings with light active neutrinos, they can be produced at high energy colliders, such as the Large Hadron Collider (LHC). A characteristic signature would be same sign lepton pairs, violating lepton number, together with light jets – $pp \to N\ell^{\pm},\ N \to \ell^{\pm}W^{\mp},\ W^{\mp} \to jj$. We propose a new search strategy utilising jet substructure techniques, observing that for a heavy right handed neutrino mass M_N much above $M_{W^\pm}$, the two jets coming out of the boosted $W^\pm$ may be interpreted as a single fat-jet (J). Hence, the distinguishing signal topology will be $\ell^\pm\ell^\pm J$. Performing a comprehensive study of the different signal regions along with complete background analysis, in tandem with detector level simulations, we compute statistical significance limits. We find that heavy neutrinos can be explored effectively for mass ranges 300 GeV $\leq M_N \leq$ 800 GeV and different light-heavy neutrino mixing $|V_{\mu N}|^2$. At the 13 TeV LHC with 3000 fb^{-1} integrated luminosity one can competently explore mixing angles much below present LHC limits, and moreover exceed bounds from electroweak precision data.

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Spectral Decomposition of Missing Transverse Energy at Hadron Colliders

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We propose a spectral decomposition to systematically extract information of dark matter at hadron colliders. The differential cross section of events with missing transverse energy (MET) can be expressed by a linear combination of basis functions. In the case of s-channel mediator models for dark matter particle production, basis functions are identified with the differential cross sections of subprocesses of virtual mediator and visible particle production while the coefficients of basis functions correspond to dark matter invariant mass distribution in the manner of the Källén-Lehmann spectral decomposition. For a given MET dataset and mediator model, we show that one can differentiate a certain dark matter–mediator interaction from another through spectral decomposition.

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Tagging "Dark-Jet" at collider

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The phenomenology of dark matter would be complicated if dark matter is a composite particle as a hadron under a dark gauge group. Once a dark parton is produced at a high energy collider, it eventually evolves to a jet-like object and provides a collider signature depending on interactions with the Standard Model particles. For example, a finite lifetime of dark hadron would provide a displaced vertex. Thus by considering features in sub-detectors, one can identify a jet from a dark parton ("dark jet") with analysis methods in conventional exotic searches. However if a lifetime of dark hadron is collider-negligible (too short to manifest a displaced vertex), dark jet would look like a normal QCD jet. In this study, inspired by one-prong jet tagging technologies which have been utilized in a quark- gluon jet discrimination, we propose that a combination of jet substructure variables become useful to tag a dark jet . We study features of several jet substructure variables with a dark jet. As an illustration, we apply jet substructure methods to O(100) GeV dark jet. Our result shows that by combining various jet substructure methods one could get a good discriminant

power for a dark jet over QCD jets. We also discuss about a systematic uncertainty from the choice of parameters in a Monte Carlo simulation in estimating the tagging efficiency of a dark jet.

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Spontaneous CP-violation in the Simplest Little Higgs Model

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We proposed the possiblity of spontaneous CP-violation in the simplest little Higgs (SLH) model. Based on the continuum effective field theory (CEFT) framework, we derived the properties of the scalar potential of this model. We carefully discussed the theoretical and experimental constraints on this model, and showed it is still alive. We also discussed the collider tests of CP-violation in the scalar sector in this model.

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CP violation in B –> D** tau nu

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Current measurements of the branching fractions for b –> c tau nu processes yield results that are more than 4 standard deviations higher than the standard-model expectations. This motivates exploration of potential new physics in these decays, including searches for CP violation. A CP-violating asymmetry requires interference between amplitudes with different CP-violating and CP-conserving phases. We show that these conditions can be satisfied in B –> D** tau nu in the presence of new physics, and describe a new method for measuring the asymmetry at Belle II or LHCb.

Beyond the Standard Model / 525

BSM searches at CLIC

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The Compact Linear Collider (CLIC) is a mature option for a future electron-positron collider operating at centre-of-mass energies of up to 3 TeV. CLIC will be built and operated in a staged approach with three centre-of-mass energy stages currently assumed to be 380 GeV, 1.5 TeV and 3 TeV. This talk discusses the prospects for CLIC to make direct and indirect measurements, or limits, of physics

beyond the Standard Model. New particles can be discovered in a model-independent way almost up to the kinematic limit. Compared with hadron colliders, the low background conditions at CLIC provide extended discovery potential, for example in the case of non-coloured TeV-scale SUSY particles. In addition to studying new particles directly, BSM models can be probed up to scales of tens of TeV through precision measurements. Beam polarisation allows to constrain the underlying theory further in many cases.

Beyond the Standard Model / 756

The Potential of the ILC for Discovering New Particles

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Data from the LHC at 7, 8, and 13 TeV, have, so far, yielded no evidence for new particles beyond the Standard Model Higgs boson. However, the complementary nature of physics with e+e- collisions still offers many interesting scenarios in which new particles can be discovered at the ILC. These scenarios take advantage of the capability of e+e- collisions to observe particles with missing energy and small mass differences, to observe mono-photon events with precisely controlled backgrounds, and to observe the full range of exotic decay modes of the Higgs boson. The searches that an e+e- collider makes possible are particularly important for models of dark matter involving a dark sector with particles of 10–100 GeV mass. In this talk, we will review the opportunities that the ILC offers for new particle discovery.

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Search for Light Scalars Produced in Association with a Z boson at the 250 GeV stage of the ILC

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In many models with extended Higgs sectors, e.g. in Two Higgs Doublet Models, in the NMSSM as well as in Randall Sundrum models, there exists an additional scalar h, which can easily be lighter than the Standard Model (SM) like Higgs. Its coupling to the Z boson is expected to be small if the 125 GeV Higgs boson is SM like. Such a light scalar with suppressed couplings to the Z boson would have escaped detection at LEP due to its limited luminosity. With a factor of 1000 higher luminosity and polarized beams, the International Linear Collider (ILC) is expected to have substantial discovery potential for such states. Furthermore, searches for additional scalars at LEP and LHC are usually dependent on the model details, such as decay channels. Thus, it is necessary to have a more general analysis with model-independent assumptions. We present a search for a such a light higgs boson produced in association with Z boson at the ILC with a center-of-mass energy of 250 GeV, using the full Geant4-based simulation of the ILD detector concept. In order to be as model-independent as possible, the analysis is performed using the recoil technique, in particular with the Z boson decaying into a pair of muons. Expected exclusion cross section limits for different higgs masses

between 10 and 120 GeV will be given in terms of a scale factor with respect to the Standard Model Higgs-strahlung process cross section.

Beyond the Standard Model / 760

Search for exotic particles at NA62

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The high-intensity setup, trigger system flexibility, and detector performance – high-frequency tracking of beam particles, redundant PID, ultra-high-efficiency photon vetoes — make NA62 particularly suitable for searching new-physics effect from different scenarios. Results from a search for invisible dark photons produced from pi0 decays are given. Fixed target experiments are a particularly useful tool in the search of very weakly coupled particles in the MeV-GeV range, which are of interest, e.g. as potential Dark Matter mediators. The NA62 experiment at the CERN SPS is currently taking data to measure rare kaon decays. Owing to the high beam-energy and a hermetic detector
coverage, NA62 also has the opportunity to directly search for a plaethora of long-lived beyond-the Standard Model particles, such as Axion-like Particles and Dark Photons. In this talk, we will review the status of this searches and give prospects for future data taking at NA62.

Beyond the Standard Model / 635

Search for a heavy dark photon at future e^+e^− colliders

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A coupling of a dark photon A' from a $U(1)_{A'}$ with the standard model (SM) particles can be generated through kinetic mixing represented by a parameter ϵ. A non-zero ϵ also induces a mixing between A' and Z if dark photon mass $m_{A'}$ is not zero. This mixing can be large when $m_{A'}$ is close to m_Z even if the parameter ϵ is small. Many efforts have been made to constrain the parameter ϵ for a low dark photon mass $m_{A'}$ compared with the Z boson mass m_Z. We study the search for dark photon in $e^+e^- \to \gamma A' \to \gamma\mu^+\mu^-$ for a dark photon mass $m_{A'}$ as large as kinematically allowed at future e^+e^- colliders. For large $m_{A'}$, care should be taken to properly treat possible large mixing between A' and Z. We obtain sensitivities to the parameter ϵ for a wide range of dark photon mass at planed e^+ e^- colliders, such as Circular Electron Positron Collider (CEPC), International Linear Collider (ILC) and Future Circular Collider (FCC-ee). For the dark photon mass 20 GeV
$lesssim m_{A'}$
$lesssim 330$ GeV, the 2σ exclusion limits on the mixing parameter are $\epsilon \lesssim 10^{-3} - 10^{-2}$. The CEPC with $\sqrt{s} = 240$ GeV and FCC-ee with $\sqrt{s} = 160$ GeV are more sensitive than the constraint from current LHCb measurement once the dark photon mass $m_{A'}$
$gtrsim 50$ GeV. For $m_{A'}$
$gtrsim 220$ GeV, the sensitivity at the FCC-ee with $\sqrt{s} = 350$ GeV and 1.5 ab^{-1} is better than that

at the 13~TeV LHC with 300 fb^{-1}, while the sensitivity at the CEPC with $\sqrt{s} = 240$ GeV and 5 ab^{-1} can be even better than that at 13~TeV LHC with 3 ab^{-1} for $m_{A'}$
$gtrsim 180$ GeV. We also comment on sensitivities of $e^+e^- \to \gamma A'$ with dark photon decay into several other channels at future e^+e^- colliders.

Beyond the Standard Model / 29

Search for new physics with the SHiP experiment at CERN

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SHiP is a new general purpose fixed target facility, whose Technical Proposal has been recently reviewed by the CERN SPS Committee and by the CERN Research Board. The two boards recommended that the experiment proceeds further to a Comprehensive Design phase in the context of the new CERN Working group "Physics Beyond Colliders", aiming at presenting a CERN strategy for the European Strategy meeting of 2019. In its initial phase, the 400GeV proton beam extracted from the SPS will be dumped on a heavy target with the aim of integrating 2×10^20 pot in 5 years. A dedicated detector, based on a long vacuum tank followed by a spectrometer and particle identification detectors, will allow probing a variety of models with light long-lived exotic particles and masses below O(10) GeV /c2. The main focus will be the physics of the so-called Hidden Portals, i.e. search for Dark Photons, Light scalars and pseudo-scalars, and Heavy Neutrinos. The sensitivity to Heavy Neutrinos will allow for the first time to probe, in the mass range between the kaon and the charm meson mass, a coupling range for which Baryogenesis and active neutrino masses could also be explained. Another dedicated emulsion-based detector will allow detection of light dark matter from dark photon decay in an unexplored parameter range

Beyond the Standard Model / 899

BSM physics in energy-frontier DIS with the LHeC and the FCC-eh

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Energy-frontier DIS can be realised at CERN through an energy recovery linac that would produce 60 GeV electrons to collide with the HL-LHC or later HE-LHC (LHeC) or eventually the FCC hadron beams (FCC-eh). It would deliver electron-proton collisions with centre-of-mass energies in the range 1.2-3.5 TeV, and luminosities exceeding 10^{34} $\text{cm}^{-2}\text{s}^{-1}$. In this talk we present new studies on the possibilities that the LHeC and FCC-eh offer for BSM physics. Among other aspects, we will discuss anomalous top couplings, searches for heavy and sterile neutrinos, contact interactions, FCNC and EWK SUSY particles. We will also demonstrate how the precision PDF and QCD information from ep will empower the search potential of the associated pp facilities, LHC and FCC-hh.

Beyond the Standard Model / 1042

BSM @ Future Colliders

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I will review the ongoing studies on BSM physics at Future Colliders. I will cover a broad range of new physics scenarios for several collider configurations, ranging from High Luminosity LHC, passing through a potential 27 TeV LHC upgrade, the High Energy LHC, and arriving to the FCC collider program, both in its ee and pp configurations. I will report advances from the recent and ongoing CERN Workshops that led to the completion of a Yellow FCC report and will lead, by the end of the year, to a new Yellow report on the physics of HL/HE LHC. These programs are crucial to deliver a coherent input for the next European Strategy, determining the future of european collider physics.

Beyond the Standard Model / 925

(In)dependence of various LFV observables in the non-minimal SUSY

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We investigate the muon anomalous magnetic moment, the $\mu \to e\gamma$ branching ratio and the $\mu \to e$ conversion rate in the nuclei from the point of view of the planned $\mu \to e$ conversion experiments.

In the MSSM these processes are strongly correlated through $\tan\beta$ enhanced contributions. We demonstrate how in the Minimal R-symmetric Supersymmetric Standard Model the $\mu \to e\gamma$ branching ratio and the $\mu \to e$ conversion rate in the nuclei give distinct bounds on the parameter space. We also consider the supersymmetric contributions to the muon anomalous magnetic moment, generated by a subset of topologies contributing to the LFV observables. We briefly discuss the generic implementation of the aforementioned observables into the FlexibleSUSY spectrum-generator generator.

Looking at the current $\mu \to e\gamma$ searches, the analysis points to the need of constructing a dedicated $\mu \to e$ conversion experiment to cover as large parameter space as possible in the non-minimal supersymmetric models.

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Bottom-quark Fusion Processes at the LHC for Probing Z′ Models and B-meson Decay Anomalies

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Anomalies in B-meson decays reported by the LHC experiment suggest a violation of lepton universality. This could be explained by introducing a heavy neutral gauge boson Z' that selectively couples to third generation quarks and second generation leptons. While the performance of experimental searches for such models is good for large Z' masses, the low-mass region sensitivity is aversely affected by large SM background (mostly Drell-Yan).

In this study, we present a novel approach searching for a Z' decaying to muons in association with at least two jets at least one of which is bottom-tagged. We demonstrate that regions of model parameter space can be probed that current inclusive analyses are insensitive to.

Beyond the Standard Model / 803

Search for the forbidden charm meson decays $D^0 \to hh'll$'

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Decay modes with two oppositely charged leptons of different flavor correspond to lepton flavor violating (LFV) decays and are essentially forbidden in the Standard Model (SM) because they can occur only through lepton mixing. Decay modes with two leptons of the same charge are lepton-number violating (LNV) decays and are forbidden in the SM. Hence, decays of the form $D^0 \to hh'll$' provide sensitive tools to investigate new mediators or couplings in physics beyond the SM.
D-mesons were copiously produced in $e^+e^- \to c\bar{c}$ continuum events at the PEP-II e^+e^- collider at the SLAC National Accelerator Laboratory. In this talk, we report on a search for the three LFV and nine LNV decays of the type $D^0 \to hh'll$' (with $h, h' = K/\pi$ and l, l' $= e/\mu$) using data taken by the BABAR experiment which had comparable sensitivity to both muons and electrons in the final state. Upper limits on the branching fractions are improved by up to two orders of magnitude.

Beyond the Standard Model / 758

Search for K+->pi+nunu at CERN

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The decay $K^+ \to \pi^+\nu\nu$, with a very precisely predicted branching ratio of less than 10-10, is one of the best candidates to reveal indirect effects of new physics at the highest mass scales. The NA62 experiment at CERN SPS is designed to measure the branching ratio of the $K^+ \to \pi^+\nu\nu$ with a decay-in-flight technique, novel for this channel. NA62 took data in 2016, 2017 and another year run is scheduled in 2018. Statistics collected in 2016 allows NA62 to reach the Standard Model sensitivity for $K^+ \to \pi^+\nu\nu$, entering the domain of 10-10 single event sensitivity and showing the

proof of principle of the experiment. The analysis data is reviewed and the preliminary result from the 2016 data set presented.

Beyond the Standard Model / 531

Improved studies of B—>D(*) tau nu with vertexing at Belle II

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BABAR, Belle, and LHCb measure the rates for the decays $B \to D^{(*)}\tau\nu$ and $B_c \to J/\psi\tau\nu$ to be higher than the SM expectations, with a combined discrepancy of 4.1σ (for $B \to D^{(*)}\tau\nu$ only) or $\sim 4.3\sigma$ (including all modes). In the coming years, Belle II and LHCb will greatly improve the measurement precision, to the level that systematic uncertainties associated with the background $B \to D^{**}\ell\nu$ become critical. We show how to utilize Belle II's high spatial resolution to obtain a model-independent handle on this background and improve the overall signal-backgroud. We also study the impact of vertexing on Belle II's capability to perform this measurement with the decay $\tau \to 3\pi\nu$, as already demonstrated by LHCb.

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New results on R(D) and R(D*) from Belle

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ndications for lepton flavour violation in the mode B ⟶ D(*) tau nu have triggered substantial interest and could be a hint for New Physics effects such as a charged Higgs or leptoquark current. We report new results from the Belle experiment at the KEKB e+e- collider on R(D), R(D*) and on the longitudinal polarisations of the D*and tau in the decay B ⟶ D* tau nu. Belle results on the purely leptonic modes B ⟶ mu nu and B ⟶ l nu gamma will also be covered. The analyses are based on the full data set recorded by the Belle detector at the Y(4S) resonance containing 772 million BBbar pairs.

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Measurements of $R(D^{(*)}$ and other missing energy decays modes at Belle II.

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The Belle II experiment is a substantial upgrade of the Belle detector and will operate at the SuperKEKB energy-asymmetric e^+e^- collider. The accelerator has already successfully completed the first phase of commissioning in 2016 and first electron positron collisions in Belle II are expected for April 2018. The design luminosity of SuperKEKB is 8×10^{35} $\mathrm{cm}^{-2}\mathrm{s}^{-1}$ and the Belle II experiment aims to record 50 ab^{-1} of data, a factor of 50 more than the Belle experiment. With this amount of data, decays sensitive to physics beyond the Standard Model can be studied with unprecedented precision. In this talk we will present our prospects for studying lepton flavor non-universality with the modes $B \to D^{(*)}\tau\nu$. Prospects for other missing energy modes sensitive to physics beyond the Standard Model such as $B^+ \to \tau^+\nu$ and $B \to K^{(*)}\nu\bar{\nu}$ will also be covered

Beyond the Standard Model / 370

The milliQan experiment: search for milli-charged particles at the LHC

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A recently proposed search for milli-charged particles produced at the LHC is discussed. The experiment, named milliQan, is expected to obtain sensitivity to charges of between 0.1e and 0.001e for masses in 0.1 - 100 GeV range. The detector is composed of 3 stacks of 80 cm long plastic scintillator arrays read out by PMTs. It will be installed in an existing tunnel 33 m from the CMS interaction point at the LHC, with 17 m of rock shielding to suppress beam backgrounds. In the fall of 2017 a 1% scale "demonstrator" of the proposed detector was installed at the planned site in order to study the feasibility of the experiment, focusing on understanding various background sources such as radioactivity of materials, PMT dark current, cosmic rays, and beam induced backgrounds. In this talk I will discuss the general concept of the experiment, the results from the demonstrator, and the plan for the future.

Beyond the Standard Model / 961

The MUonE experiment: measuring the leading hadronic contribution to the muon g-2 via space-like data

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The precision measurement of the anomalous magnetic moment of the muon presently exhibits a 3.5σ discrepancy with the Standard Model (SM) prediction. In the next few years this measurement will reach an even higher precision at Fermilab and J-PARC. While the QED and electroweak contributions to the muon g-2 can be determined very precisely, the leading hadronic (HLO) correction is affected by a large uncertainty which dominates the error of the SM prediction.
We propose a novel approach to determine the HLO contribution to the muon g-2 based on the measurement of the effective electromagnetic coupling in the space-like region at low-momentum transfer. We will discuss the possibility of performing this measurement at CERN by the MUonE experiment, which aims at a very precise determination of the muon-electron elastic differential cross-section, exploiting the scattering of 150 GeV muons (currently available at CERN's North area) on atomic electrons of a low-Z target. We will describe the experimental challenges posed by this

measurement, by the detector able to keep the systematic effects at the required level of 10 ppm and the status of this proposal.

Beyond the Standard Model / 918

Scherk-Schwartz twists in GUT models

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We address the question of whether non-trivial boundary conditions (Scherk - Schwartz twists) acting on fields from the extra compactified dimensions can give a SM low energy spectrum with a “naturally” broken SUSY? We explore a variety of minimal and non-minimal models, confronting current experimental bounds, and discuss progress in formulating more contained and elegant models.

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The absolute maximum and detailed phenomenology of the muon magnetic moment in the 2HDM

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We investigated the muon g-2 in the two-Higgs doublet model (2HDM), employing the recent full two-loop computation and making comprehensive use of experimental constraints from Higgs and flavour physics. In the talk we present the result of detailed analysis in the flavour-aligned 2HDM and
characterize the parameter regions possible to explain the current 3σ deviation. Particularly we present the absolute maximum of the muon g-2 in the 2HDM as a function of the lightest Higgs mass.

We focus on the light CP odd neutral Higgs Boson A, and show that large lepton Yukawa couplings can enhance the muon g-2 in this mass region. We present in detail the maximum possible Yukawa couplings to leptons and quarks of a light A allowed by the LHC and B-Physics results. As a result we find that an overall maximum of 45×10^{-10} for the muon g-2 and large top and tau Yukawa couplings are possible in the parameter region $20 < M_A < 100$ GeV in the 2HDM.

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SModelS - new developments and applications

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ATLAS and CMS have performed a large number of searches for physics beyond the Standard Model (BSM). The results are typically presented in the context of simplified models, containing only a few new particles with fixed decay branching ratios, and yielding generic upper limits on the cross section as a function of particle masses. The interpretation of these limits within realistic BSM scenarios is non-trivial and is best done by automated computational tools. SModelS is such an automatised tool, allowing to decompose models of new physics obeying a Z2 symmetry into simplified model components, and to compare these against a large database of experimental results. The latest release, version 1.1, extended the functionality from comparing to upper limit maps to using also efficiency maps (thus enabling the combination of simplified models), and includes likelihood and chi-square calculations, extended information on the topology coverage as well as an extended database of experimental results. I will present the tool emphasising in particular the new developments. I will then discuss physics applications, including a recent study on the coverage of the pMSSM by the available simplified model results. The discussion illustrates how SModelS can be used to identify important constraints, untested regions and interesting new signatures. An outlook to future developments will also be given.

Beyond the Standard Model / 906

Recent progress with Muon g-2 Experiment at Fermilab

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The muon anomalous magnetic moment can be both measured and computed with high precision, providing a sharp tool in testing the robustness of the Standard Model and searching for new physics. The previous measurement by the Brookhaven E821 experiment found a 3.6 standard deviation discrepancy from the predicted value. The new generation Muon g-2 experiment at Fermi National Laboratory has started to take physics data since early this year. The first physics result is coming soon with expected improvements in both the measurement precision and theory calculation.

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Constraining Right Handed Gauge Boson Mass from Lepton Number Violating Meson Decays in a Low Scale Left Right Model

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We analyze the lepton number violating (LNV) meson decays that arise in a TeV scale Left Right Symmetry model. The right handed Majorana neutrino N along with the right handed or Standard Model gauge bosons mediate the meson decays and provide a resonant enhancement of the rates if the mass of N (M_N) lies in the range $\sim (100\,\mathrm{MeV} - 5\,\mathrm{GeV})$. Using the expected upper limits on the number of events for the LNV decay modes $M_1^+ \to \ell^+\ell^+\pi^-$~($M_1 = B, D, D_s, K$), we derive constraints plausible on the mass of the right handed charged gauge boson by future searches at the ongoing NA62 and LHCb experiments at CERN, the upcoming Belle II at SuperKEK, as well as at the proposed future experiments, SHiP and FCC-ee.
These bounds are complimentary to the limits from same-sign dilepton search at Large Hadron Collider (LHC). The very high intensity of Charmed mesons expected
to be produced at SHiP will result in a far more stringent bound, $M_{W_R} > 18.4$~TeV (corresponding to $M_N = 1.46$~GeV), than the other existing bounds from collider and neutrinoless double beta decay searches.

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Limits on non-Newtonian gravity at 10 μm scale by precision force measurements with optically-levitated microspheres

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The universal law of gravity has undergone stringent tests for a long time over a significant range of length scale, from an atomic scale to a planetary scale 1. Of particular interest is the short distance regime, where modifications to Newtonian gravity may arise from axion-like particles [2] and extra dimensions 1. We have constructed a precision force sensor based on optically-levitated microspheres with a force sensitivity of $\sim 10^{-17}$ N/$\sqrt{\mathrm{Hz}}$ [3] for the purpose of increasing the sensitivity of searches for non-Newtonian forces in the 1-100 μm range. In our scheme, the microsphere interacts with a variable-density attractor mass made by alternating silicon and gold segments with periodicity on the order of 10 μm, which is the same as the distance between the microsphere and the attractor. We report on the performance of this technique, its sensitivity, and some initial results. Further technological developments to reduce background are expected to provide orders of magnitude improvement in the sensitivity, going beyond current constraints [4-8].

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New Precision Measurement of Muonium Hyperfine Structure

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Muonium is the bound state of a positive muon and an electron. MuSEUM (Muonium Spectroscopy Experiment Using Microwave) is a new precise measurement of muonium hyperfine structure (MuHFS)

at J-PARC (Japan Proton Accelerator Research Complex). MuSEUM determines the MuHFS and muon magnetic moment with a ten times better precision than the precursor experiments at Los Alamos Meson Physics Facility (LAMPF) 1.

There are three major motivations for this new measurement.

1. Contribution to the search for BSM physics via muon g-2. Muon anomalous magnetic moment, a_μ, is known for the 3σ tension between the experimental value at BNL and the theoretical value from the standard model[2]. Two new experimental projects to measure muon g-2 more precisely (100 ppb) are ongoing at J-PARC and Fermilab using a muon storage ring. To extract a_μ, these storage ring experiments need an input parameter, μ_μ/μ_p, which can be precisely determined by the MUHFS spectroscopy. MuSEUM determine the parameter with a precision of 10 ppb, a factor of twelve improvement from the precursor experiment at LAMPF, without assuming the bound-state QED is correct.
2. Test of the bound-state QED. Muonium is a purely leptonic system and theoretical calculation of its hyperfine structure is more precise than that of hydrogen. Although free-QED theory is well verified by the electron g-2 experiment[3], for the bound-state situation theorists need to employ different theoretical approach from free QED, so testing its validity is worthwhile.
3. Test of Lorentz invariance. If the Lorentz symmetry is broken, the hyperfine structure is shifted. This causes the sidereal oscillation of MuHFS due to the earth's rotation[4]. By analysing the change of MuHFS in one sidereal day, MuSEUM can test the Lorentz invariance.

Recently, we have succeeded in measuring the MuHFS at J-PARC. This is the first measurement of MuHFS using intense pulsed muon beam, thus this is a promising result for the improvement of the statistics, which was the most dominant source of the uncertainty in the precursor experiments at LAMPF. We are currently working on the measurement at very weak field, which has different sources of systematic uncertainties from precursor experiments at high field (at 1.7T). We also plan a measurement at high field and development of magnetometer using proton NMR in pure water is in progress. The test measurement revealed that the precision of the magnetometer already surpassed the precision of the one used in the LAMPF experiment. A new muon beam line (called H-Line) with ten times more muon intensity is under construction and will be ready for use in a few years.

In this presentation, we report the recent results of the measurement at very weak field and R&D for the high field measurement.

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Beyond the Standard Model / 18

B+L violation at colliders and new physics

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Chiral electroweak anomalies predict fermion interactions that violate baryon (B) and lepton number (L), and can be dressed with large numbers of Higgs and weak gauge bosons. The estimation of the total B+L violating rate from an initial two-particle state –potentially observable at colliders– has been the subject of an intense discussion, mainly centered on the resummation of boson emission, which is believed to contribute to the cross-section with an exponential function of the energy, yet with an exponent (the "holy-grail" function) which is not fully known in the energy range of interest. Focusing instead on the effect of fermions beyond the Standard-Model (SM) in the polynomial contributions to the rate, it is shown that the latter can be enhanced by several orders of magnitude with respect to the SM result, for high centre-of-mass energies and light enough masses. Further calculations hint at a simple dependence of the holy grail function on the heavy fermion masses. Thus, if anomalous B+L violating interactions are ever detected at high-energy colliders, they could be associated with new physics.

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Probing new intra-atomic force with isotope shifts

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In the development of atomic clocks, some atomic transition frequencies are measured with remarkable precision. These measured spectra may include effects of a new force mediated by a weakly interacting boson. Such effects might be distilled out from possible violation of a linear relation in isotope shifts between two transitions, as known as King's linearity, with relatively suppressed theoretical uncertainties. We discuss the experimental sensitivity to a new force in the test of the linearity as well as the linearity violation owing to higher order effects within the Standard Model. The sensitivity to new physics is limited by such effects. We have found that for Yb^+, the higher order effect is in the reach of future experiments. The sensitivity to a heavy mediator is also discussed. It is analytically clarified that the sensitivity becomes weaker than that in the literature. Our numerical results of the sensitivity are compared with other weak force search experiments.

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SuperIso Relic new extensions for direct and indirect detection

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SuperIso Relic is a public computing program for the calculation of flavour observables and relic density in supersymmetry (MSSM and NMSSM). We present new extensions of the code dedicated to the calculation of dark matter direct and indirect detection constraints from the latest experiment results. Contrary to most of the existing programs, this new version allows the user to consider the uncertainties related to nuclear form factors, dark matter density and velocity, as well as cosmic-ray propagation through the galactic medium. The user will thus find a direct way to calculate "conservative", "standard" or "stringent" constraints according to the chosen set of uncertainties. Some examplified results showing the impact of such uncertainties will also be presented.

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Hunting Z/H-resonant Neutralino Dark Mater at High-Luminosity LHC

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In Supersymmetric Standard Models, bino-like or singlino-like neautralino dark matter (DM) can achieve the right thermal relic density through Z boson or Higgs boson resonant annihilations with tiny higgsino component, which makes it very hard to be detected. In this work we focus on the reach for such scenarios at High-Luminosity LHC and their interplay with DM direct detection experiments. We first find that Bino-like DM with $m_{\tilde{\chi}_1^0} \in [41, 46]$ or $[58, 63]$ GeV and $m_{\tilde{\chi}_1^\pm} \in [300, 1500]$ GeV can avoid all current constraints. Then we investigate the searches of such samples at 14 TeV High-Luminosity LHC by chargino neutalino pair production in final states of $3l + E_T^{miss}$, $1l + 2b + E_T^{miss}$ and also two boost jet $+E_T^{miss}$ to make use of the large mass spitting between higgsino and bino. Our simulations indicate that each search mode can exclude higgsino with mass smaller than 800 GeV, and the combination can further push the limit to 1 TeV. Together with expected DM-neutron scattering limit from LUX-ZEPLIN, all the Z/H-resonant DM can be explored.

Beyond the Standard Model / 514

Study of Electroweak Vacuum Stability from Extended Higgs Portal of Dark Matter and Neutrinos

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We investigate the electroweak vacuum stability in an extended version of the Standard Model which incorporates two additional singlet scalar fields and three right handed neutrinos. One of these extra scalars plays the role of dark matter while the other scalar not only helps in making the electroweak vacuum stable but also opens up the low mass window of the scalar singlet dark matter (< 500 GeV). We consider the effect of large neutrino Yukawa coupling on the running of Higgs quartic coupling. We have analyzed the constraints on the model and identify the range of parameter space which is consistent with neutrino mass, appropriate relic density and direct search limits from the latest XENON 1T preliminary result as well as in realizing the stability of the electroweak vacuum upto the Planck scale.

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The Reach of Thermal Supersymmetric Dark Matter

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The three main successes of supernumerary are: naturlaness, gauge coupling unification, and a thermal dark matter candidate. Although experimental constraints on supersymmetry has pushed it to a region of parameter space which is less natural, the other two motivations for supersymmetry are still in tact. I will discuss under what conditions can we still get a good thermal dark matter candidate. The two main ways being gluino coannihilation and stop coannihilation. These methods of generating a thermal dark matter candidate will persist for dark matter masses up to of order 8 TeV, well beyond the reach of the LHC.

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KLOE/KLOE-2 results and perspectives on dark force search

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During the last years several Dark Sector Models have been proposed in order to address striking astrophysical observations which fail standard intepretations.
In the minimal case a new vector particle, the so called dark photon or U-boson, is introduced, with small coupling with Standard Model particles. Also, the existence of a dark Higgs boson h' is postulated, in analogy with the Standard Model, to give mass to the U-boson through the Spontaneous Symmetry Breaking mechanism.

The experiment KLOE, working on the Dafne e+e- collider in Frascati, searched for the existence of the U-boson in a quite complete way, investigating several different processes and final states:

- in dalitz decays of the Phi meson Phi-> eta U, with U->e+e- and eta-> pi+pi-pi0 and p0p0p0
- in e+e- -> U gamma events, with U decaying to electron, muon and pion pairs
- in the dark Higgsstrahlung process, e+e- -> Uh', U-> mu+mu-, h' invisible.

New results in U to muon and U to pion decays, and their combination, will be available at the time of the ICHEP Conference.

Tight limits on the model parameters have been set at 90%CL. Further improvements are expected in terms of sensitivity and discovery potential with the new KLOE-2 detector working on the improved DAFNE e+e- collider.

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Indirect detection of (Late-decoupling) Semi-Annihilating Dark Matter

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Semi-annihilation describes processes with an initial state of two dark matter particles, and a final state of one plus standard model states. It is a generic feature of dark matter whenever the symmetry group enforcing stability is not a discrete Z_2. Semi-annihilation changes the expected signals in current dark matter searches, weakening limits from direct and collider searches, but can still be probed using cosmic ray observations. We discuss generic features of semi-annihilating searches and derive model-independent bounds using effective operators. We additionally discuss the relation between semi-annihilation and kinetic decoupling of the dark and visible sectors. The scattering processes that maintain thermal contact are related by crossing symmetry to dark matter annihilation, which can have an important effect on thermal freeze out. However, interesting parameter space remains where the indirect signals today can be significantly enhanced. We illustrate this general feature using a specific example, a dark matter explanation of the AMS positron flux.

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Hearing the echoes of dark matter and new physics

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Motivated the absence of dark matter signal in dark matter direct detection and
new physics signals at LHC, we study how to hear the echoes of the new physics, especially the dark matter and baryogenesis by new approaches beyond the particle colliders, such as the pulsar timing array experiments (such as SKA) and Laser Interferometer experiments (such as LISA).

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Light Dark Matter Showering under Broken U(1) – Revisited

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The scenario of light dark matter fermion under a massive U(1) group has attracted some attention lately. It was proposed recently that different chiralities of the DM can lead to different showering patterns, resulting in distinguishable signatures in LHC. This can be helpful in understanding the origin of the dark photon mass and the DM mass. Here we study this subject further by examining the dark shower of two simplified models – named Chiral Model and Vector Model. We derive a more complete set of collinear splitting functions by specifying the helicities of the fermion, incorporating all degrees of freedom and splittings arising from symmetry breaking. We implement dark shower with those splitting functions in the two models and analyze the jet profiles after the dark photons decay back the SM particles. The effects of different aspects of splitting functions are demonstrated and discussed.

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The Light Dark Matter eXperiment

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The Light Dark Matter eXperiment (LDMX) proposes a high-statistics search for low-mass dark matter in fixed-target electron-nucleus collisions. Ultimately, LDMX will explore thermal relic dark matter over most of the viable sub-GeV mass range to a decisive level of sensitivity. To achieve this goal, LDMX employs the missing momentum technique, where electrons scattering in a thin target can produce dark matter via "dark bremsstrahlung" giving rise to significant missing momentum and energy in the detector. To identify these rare signal events, LDMX individually tags incoming beam-energy electrons, unambiguously associates them with low energy, moderate transverse-momentum recoils of the incoming electron, and establishes the absence of any additional forward-recoiling charged particles or neutral hadrons. LDMX will employ low mass tracking to tag incoming beam-energy electrons with high purity and cleanly reconstruct recoils. A high-speed, granular calorimeter with MIP sensitivity is used to reject the high rate of bremsstrahlung background at trigger level while working in tandem with a hadronic calorimeter to veto rare photonuclear reactions. This talk will summarize the small-scale detector concept for LDMX, ongoing performance studies, and near future prospects.

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Higgs masses and couplings in a general 2HDM with unitarity bounds

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We investigate a general two Higgs doublet model imposing both the unitarity conditions and the bounded-from-below conditions. In the work we show that these conditions can be written in terms of invariants. Both conditions make restrictions on the ranges of the model parameters. We study model in the Higgs basis, together with the experimental bounds of oblique parameter T, to produce scalar particles with masses and the cubic and quartic couplings of the Higgs in agreement with the phenomenology. The numerical calculations of the model make the prediction that all the extra scalars are heavier (more or less) than 200 GeV.

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The fate of the Littlest Higgs with T parity under 13 TeV LHC data

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Little Higgs models - which can most easily be thought of as a variant of composite Higgs models - explain a light Higgs boson at 125 GeV as an pseudo-Nambu-Goldstone boson of a spontaneously broken global symmetry. The mechanism of collective symmetry breaking shifts the UV scale of these models to the 10 TeV scale and higher. T-parity is introduced as a discrete symmetry to remove tree-level constraints on the electroweak precision data. Still after run 1 of LHC, electroweak precision observables gave stronger constraints than Higgs data and direct searches. We present a full recast of all available 13 TeV searches from LHC run 2 to show that now direct searches supersede electroweak porecision observables. The latest exclusion limits on the LHT model will be presented, as well as an outlook on the full high-luminosity phase of LHC.

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Dilaton-Assisted composite Higgs model at LHC

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We study a recently proposed dilaton-assisted composite Higgs model, which addresses a new solution to the Higgs naturalness problem, relying the scale symmetry of the dilator-Higgs effective theory. The model predicts a heavy U(1) axial vector boson and two massive, oppositely charged, pseudo Nambu-Goldstone bosons. We discuss the phenomenology of new particles, which might be accessible at LHC.

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Search for contact interactions in inclusive ep scattering at HERA

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The high-precision HERA data are used to search for Beyond the Standard Model contributions to electron-quark scattering in the framework of eeqq contact interactions (CI). Combined measurements of the inclusive deep inelastic cross sections in neutral and charged current ep scattering are considered, corresponding to a luminosity of around 1 fb^{-1}. The analysis of the inclusive ep data is based on the simultaneous fits of parton distribution functions together with contributions of CI couplings to ep scattering. Results are presented for different CI scenarios and the resulting 95% CL limits on the CI mass scales extend up to the 10 TeV scale.

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Search for invisible dark photon decay at BABAR

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We report on a search for single-photon events in 53 fb^{-1} of data collected with the BABAR detector. We look for events consistent with production of a dark photon (A') through the process $e^+e^- \to \gamma A'$, $A' \to$ invisible. Such particles are motivated by theories applying a $U(1)$ gauge symmetry to dark matter. We find no evidence for this process and set limits on the A'-photon coupling for a dark photon mass below 8 GeV. These results greatly improve upon previous bounds, and exclude the range of values suggested by the dark-photon interpretation of the muon $(g-2)$ anomaly

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Search for Dark Particles and Dark Sector at Belle

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Dark sector models can explain the relic abundance of our universe and are attractive scenarios after 13TeV LHC results on new physics searches. We are testing two broad categories of theories, those that: couple to electron and that only couple to heavy-flavor muons or taus. In the first category, we are looking for the dark photon that decays into leptons or hadrons in the radiative process. This process is particularly interesting because it allows to search for light dark matter, chi, in the process: e+ e- ⟶ A' gamma, A' ⟶ chi chi. In the later category, we are looking for the dark vector gauge boson Z' and the dark scalar Higgs boson h' ' that decays into dimuons in the following processes: e+ e- ⟶ mu+ mu- Z' and e+ e- ⟶ tau+ tau- h' ', respectively. We report search of these processes using data taken at Belle detector from e+ e- collisions produced by the KEKB collider. We also present search for dark sector particles in meson decays.

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Ultra long-lived particles searches with MATHUSLA

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Many extensions of the Standard Model (SM) include particles that are neutral, weakly coupled, and long-lived that can decay to hadronic and leptonic final states. Long-lived particles (LLPs) can be detected at colliders as displaced decays from the interaction point (IP), or missing energy if they

escape. ATLAS, CMS, and LHCb have performed searches at the LHC and significant exclusion limits have been set in recent years.

The current searches performed at colliders have limitations. An LLP does not interact with the detector and it is only visible once it decays. Unfortunately, no existing or proposed search strategy will be able to observe the decay of non-hadronic electrically neutral LLPs with masses above $\sim$ GeV and lifetimes near the limit set by Big Bang Nucleosynthesis ($c\tau \sim 10^7 - 10^8$ m). Such ultra-long-lived particles (ULLPs) produced at the LHC will escape the main detector with extremely high probability.

In this talk, we describe the MATHUSLA surface detector (MAssive Timing Hodoscope for Ultra Stable neutraL pArticles) 1, which can be implemented with existing technology in time for the turn-on of the high luminosity LHC (HL-LHC). The MATHUSLA detector will consist of an air-filled decay volume surrounded by charged particles detectors (top, bottom, and sides) that provide timing and a robust multilayer tracking system located in the upper region. Ref. 1 proposes covering a total sensitive area of 200×200 square meters on the surface in the region near the interaction point of ATLAS or CMS detectors for the beginning of the HL-LHC run.

We installed a small-scale test stand (~ 6.5 meters tall, covering an area of 2.5×2.5 square meters) on the surface above ATLAS IP in autumn 2017 that consists of three layers of resistive plate chambers used for timing/tracking and two layers of scintillators (top, bottom) for timing measurements to study efficiency of downward cosmic track rejection. The goal is to estimate cosmic background that mimics upward going tracks and the proton-proton collision backgrounds from ATLAS during nominal LHC operations. The test stand will resume operation above the ATLAS IP in April 2018 and collect data with pp collisions until December 2018. This will provide useful information for the design of the main detector and important inputs for the future physics and detector simulations.

We will present preliminary results obtained with data collected in 2017 and the on-going background studies. The sensitivity of MATHUSLA to various ULLP theoretical constructs will be summarized and current design concepts reviewed.

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Search for a Long-Lived Heavy Photon with the Heavy Photon Search Experiment

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The Heavy Photon Search experiment (HPS) at Jefferson Lab seeks to discover evidence for a new dark-force mediator. A new U(1) vector boson could couple to the Standard Model photon through kinetic mixing and could be produced by an electron beam in a dense target in a process similar to bremsstrahlung. Subsequent decays into e+e- pairs, if kinematically allowed, would enable discovery either as a resonance peak on a large Standard Model continuum distribution or as vertices displaced from the target. Small couplings would lead to longer decay times, but also reduced cross sections, requiring high currents (to produce any signal) and large detector acceptance, especially close to the beam (to capture the boosted decay products). The HPS detector is a compact, large acceptance, forward spectrometer consisting of a silicon vertex tracker and lead-tungstate electromagnetic calorimeter. Installed at the Jefferson Lab electron beam facility, it conducted successful engineering runs in the spring of 2015 using a 1.056 GeV, 50 nA beam, and in 2016 using a 2.3 GeV, 200 nA beam. In this talk we will discuss the motivation for this heavy photon search, the detector and its performance during these two engineering runs, as well as present details of the displaced vertex analysis and prospects for discovery in the upcoming physics runs. A separate talk at this conference will present details of a complementary analysis searching for peaks in the invariant mass spectrum of the final-state electron-positron pairs

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Searches for non-resonant new phenomena in final states with leptons and photons

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Many new physics models, e.g., compositeness, see-saw, and extra dimensions models, are expected to manifest themselves in the final states with leptons and photons. This talk presents searches for new non-resonant phenomena in the final states that include leptons and photons, focusing on the recent results obtained using data collected at Run-II of the LHC.

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Searches for new heavy resonances in final states with leptons and photons at CMS

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Numerous new physics models, e.g., theories with extra dimensions and various gauge-group extensions of the standard model, predict the existence of new particles decaying to leptons and photons. This talk presents CMS searches for new resonances in the dilepton, lepton+MET, diphoton, and other final states that include leptons and photons, focusing on the recent results obtained using data collected at Run-II of the LHC.

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Discussion

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Performance of tau and muon leptons reconstruction and identification in the ATLAS experiment using pp collisions at sqrt(s)=13 TeV and their prospects for the HL-LHC

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The ATLAS experiment is a multi-purpose experiment installed at the Large Hadron Collider (LHC) at CERN, designed to study elementary particles and their interactions in high-energy collisions of proton and heavy ion beams.

Muon and Tau leptons play an important role in many physics processes that are being investigated at the LHC. Hadronic decays of the taus are reconstructed from the combined analysis of the calorimeter and inner tracker informations. This contribution details the performance of the identification, trigger, energy calibration and decay mode classification of hadronic decays of the tau leptons with the ATLAS detector using the Run 2 dataset of pp collisions collected at the LHC at a centre-of-mass energy $\sqrt{s}$=13 TeV. The algorithms and the criteria used in ATLAS for the reconstruction and identification of muons with transverse momentum from a few GeV to the TeV scale will also be presented. Their performance is measured with data based on the decays of Z and J/ψ to pairs of muons, that provide a large calibration sample.
Reconstruction and identification efficiencies are evaluated, as well as momentum scales and resolutions, and the results are used to derive precise corrections for the MC simulation of ATLAS events. Isolation selection criteria and their performances in presence of high pileup will also be presented.

For the high-luminosity phase of the LHC (HL-LHC), the instantaneous luminosity will increase up to $L \simeq 7.5{\times}10^{34} cm^{-2}s^{-1}$ leading to an average interactions per bunch crossing of up to 200 and the ATLAS detector will undergo a significant upgrade of its sub-systems, including a complete replacement of its inner tracker.
The prospects of the reconstruction and identification of tau leptons for the HL-LHC are discussed.

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Applying deep learning methods to HEP data

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We apply deep learning methods to various aspects of high energy physics problems, from jet reconstruction to top quark reconstruction at hadron colliders. Various supervised and unsupervised learning method use cases and failure cases are discussed. We describe our setup to make deep learning methods easier for users who are used to analyzing with ROOT data formats.

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Performance of Tau Reconstruction and Identification at CMS

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Since the beginning of LHC Run 2, many improvements have been made to the triggering, reconstruction, and identification of hadronic tau decays at CMS. The standard Hadron Plus Strips (HPS) tau reconstruction algorithm now benefits from a dynamic strip reconstruction. The HPS method

has been extended to a version intended for highly Lorentz-boosted topologies and a version which is used in High Level Triggers. In addition, multivariate discriminators used for tau identification now combine isolation with tau lifetime variables. The excellent performance of the HPS reconstruction is also retained under HL-LHC conditions, with an increased number of concurrent proton-proton interactions and the upgraded CMS detector. The algorithms and performance of the newly developed tau algorithms and discriminators are presented using 35.9 fb-1 of proton proton data collected with CMS from the 2016 run at the LHC.

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Muon performance with the CMS detector in Run2 of the LHC

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The Compact Muon Solenoid (CMS) detector is one of the two multi-purpose experiments at the Large Hadron Collider (LHC) and has a broad physics program. Many aspects of this program depend on our ability to trigger, reconstruction and identify events with final state muons in a wide range of momenta, from few GeV to the TeV scale. Displaced muons can also be used as a benchmark for new new physics searches and do require special reconstruction techinques.

In this talk we present the full process of muon reconstruction in CMS, both offline and online. The identification and isolation strategies to discriminate prompt muons from background, and their performance with 13 TeV data collected with the CMS experiment. Finally, the performance on benchmark channels will be shown.

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Identification of Jets, Missing energy and Boosted Hadronic Resonances in high pile-up conditions with ATLAS

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Accurate measurements and identification of jets, missing energy and boosted hadronic resonances are crucial to most of the ATLAS physics programme both in domain of Standard Model precision measurements and search for beyond the SM physics. The ever increasing LHC luminosity while providing higher statistical sensitivity to rare processes, also leads to more challenging experimental conditions due to multiple simultaneous collisions (pile-up). Additional energy falling inside a jet cone can affect both the jet energy scale and resolution leading to performance which depends on the amount of pile-up. Missing Transverse Momentum, formed from all reconstructed objects, is particularly affected by high pile-up. New techniques are developed and presented to improve immunity to the effects of pile-up and maintain or improve resolution and identification capabilities despite more challenging conditions.

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Measurements of the CMS jet energy scale and resolution at 13 TeV

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Jets are the experimental signatures of energetic quarks and gluons produced in high energy processes and they need to be calibrated in order to have the correct energy scale. A detailed understanding of both the energy scale and the transverse momentum resolution of jets at the CMS is of crucial importance for many physics analyses. In this talk, we present the measurements of CMS jet energy scale and resolution using the data sample collected in proton-proton collisions at a center-of-mass energy of 13 TeV.

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PID strategy and performance at LHCb in Run 2

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The LHCb particle identification (PID) system is composed of two ring-imaging Cherenkov detectors , a series of muon chambers and a calorimeter system. A novel strategy has been introduced in Run 2, where the selection of PID calibration samples for charged particles and neutrals is implemented in the LHCb software trigger. A further processing of the data is required in order to provide samples for the determination of PID performance, which is achieved through a centralised production that makes highly efficient use of computing resources. This talk covers the major steps of the implementation, and highlights the PID performance achieved in Run 2.

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Reconstruction and study of hadronic showers with highly granular calorimeters

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Prototype imaging electromagnetic and hadronic calorimeters developed and operated by the CALICE collaboration provide an unprecedented wealth of highly granular data of hadronic showers for a variety of active sensor elements and different absorber materials. In this presentation, we discuss the reconstruction and energy resolution of single hadrons in individual detectors and combined electromagnetic and hadronic systems using software compensation and semi-digital energy reconstruction. We report on the performance of particle flow algorithms, both in terms of improved energy resolution with software compensation techniques for simulated particle jets and for the separation of nearby particles. A prototype scintillator-based hadron calorimeter provides time information at the few nanosecond level, extending previous studies of the time structure of hadronic showers in steel and tungsten absorbers to larger detector volumes. These measurements, together with studies

of the spatial structure of hadronic showers with different active elements, provide four-dimensional information for hadronic showers which are confronted with GEANT4 simulations using different hadronic physics models.

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HEPfit: The Analysis Toolkit

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HEPfit is a computational tool for the combination of indirect and direct constraints on High Energy Physics models. The code is built in a modular structure so that one can select observables and models of interest. It can be used to build customized models and customized observables. It has a statistical framework based on Markov Chain Monte Carlo (MCMC) driven Bayesian analysis. However, any statistical framework can be used as an option. The goal of HEPfit is to implement electroweak, Higgs and flavour physics observables to the highest degree of precision with minimum theoretical assumptions built in. This has been done in the Standard Model and in several models beyond the Standard Model, such as MSSM, THDM, L-R symmetric models, and several EFTs. Since the statistical treatment in HEPfit is based on MCMC, optimized computational time is of utmost importance, HEPfit is massively parallelized to run over a large number of CPUs using openMPI.

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ALICE Analysis Framework for the LHC Run III

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In LHC Run 3, the ALICE experiment will record 100 times more events than in the runs before. This is achieved with a continuous detector readout. To cope with such a huge amount of data, a new integrated Online-Offline (O2) computing infrastructure is created. Part of this development is a new analysis framework.
In Run 1 and Run 2 a large fraction of the time to analyze a dataset has been used to read the data from disk and to deserialize it. Consequently a main focus of the new development is on this step. A new flat data structure is developed which supports growing, skimming and pruning of the data. Only the absolutely necessary information for an analysis will be read. Uninteresting event or track information should not be processed. The important parts of the dataset will be read at dedicated analysis facilities which are themselves optimized for a quick data access.
The new framework should be built on open source implementations to reduce the required work within ALICE and to benefit from synergies with industry. By using open source implementations, new code can be contributed and no dependency on proprietary software is created.

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Exploitation of heterogeneous resources for ATLAS Computing

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LHC experiments require significant computational resources for Monte Carlo simulations and real data processing and the ATLAS experiment is not an exception. In 2017, ATLAS exploited steadily almost 3M HS06 units, which corresponds to about 300 000 standard CPU cores. The total disk and tape capacity managed by the Rucio data management system exceeded 350 PB.

Resources are provided mostly by Grid computing centers distributed in geographically separated locations and connected by the Grid middleware. The ATLAS collaboration developed several systems to manage computational jobs, data files and network transfers. ATLAS solutions for job and data management (PanDA and Rucio) were generalized and now are used also by other collaborations.

More components are needed to include new resources such as private and public clouds, volunteers' desktop computers and primarily supercomputers in major HPC centers.
Workflows and data flows significantly differ for these less traditional resources and extensive software redesign was needed for some components of the ATLAS distributed computing software stack. High Performance Computers might not allow internet connection directly from/to computing nodes. Some provide hundreds of thousands cores each several times slower than a standard Grid core, others require jobs running in parallel on many cores using MPI, still others allow ATLAS jobs only as a backfill.
The newly developed and commissioned ATLAS software framework called Event Service has been put in place to exploit these highly volatile resources.

The volunteer computing project ATLAS@Home is based on the BOINC platform. Virtualization technologies enabled usage of various platforms and simplified installation. The project adds up to several tens of thousands computing cores used for ATLAS simulations and serves as a unique tool for outreach activities. Not only desktop computers are used; servers from computing clusters too can increase total utilization by running ATLAS@Home on top of standard jobs.

We will discuss current usage of ATLAS pledged and opportunistic resources, evolution of the software used for the management of the huge number of distributed jobs and need for a significant upgrade of computational infrastructure for HL-LHC.

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Turbo: the flexible reduced data format for real-time analysis at the LHCb experiment

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In 2015, the LHCb experiment implemented a unique data processing model that allows for reconstructed objects created in the trigger to be persisted and analysed offline, without a loss in physics performance. This model has recently evolved such that arbitrary additional objects, in addition to those used in the trigger decision, can also be persisted. This allows for a more inclusive approach, where persisted objects may or may not be required for present analyses but are available for future study, whilst still reducing the average event size with respect to saving the raw detector data. This talk motivates and describes the updated data model, and presents a study on the performance of this triggering technique in the context of the LHCb upgrade detector, running from 2021, where it is expected to be the de facto trigger strategy.

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A palette of fast simulations in LHCb

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LHCb is one of the major experiments operating at the Large Hadron Collider at CERN. The richness of the physics program and the increasing precision of the measurements in LHCb lead to the need of ever larger simulated samples. This need will increase further when the upgraded LHCb detector will start collecting data in the LHC Run 3. Given the computing resources pledged for the production of Monte Carlo simulated events in the next years, the use of fast simulation techniques will be mandatory to cope with the expected dataset size. A number of fast simulation options are already available or under development to complement the full simulation of the LHCb detector based on Geant4. They include simulating a subset of the generated particles, simplifying the detector geometry, re-using the underlying event, replacing the detailed simulation of the calorimeter with a faster version based on hit libraries, or using a fully parametric simulation of the detector. We present the available options, describe their applications and discuss the future developments. We also mention how we intend to make the different options transparently available in the LHCb simulation framework.

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Simulating fix-target and heavy-ion collisions in LHCb

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The LHCb experiment is a fully instrumented forward spectrometer designed for precision studies in the flavour sector of the standard model with proton-proton collisions at the LHC. As part of its expanding physics programme, LHCb collected data also during the LHC proton-nucleus collisions in 2013 and 2016 and during nucleus-nucleus collisions in 2015. These datasets provide access to unique kinematic coverage due to the forward pseudo-rapidity of LHCb. Furthermore, in 2015 LHCb commissioned the internal gas target SMOG, becoming the only LHC experiment with a programme of fixed target physics. Any of these particular collision conditions required a different operational setup, as well as dedicated simulation production based on heavy-ion Monte-Carlo event generators and interface extensions of the standard LHCb simulation framework. In this talk, we present the work done to implement such a variety of simulation productions for heavy-ion collisions, and to validate the produced samples. The future perspectives of the heavy-ion collision simulations at LHCb will also be discussed.

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First assessment of new Evaluated Data Libraries for Monte Carlo particle transport

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Evaluated data libraries are the foundation of physics modeling in Monte Carlo particle transport codes, such as Geant4, FLUKA and MCNP, which are used in high energy and nuclear physics experiments, accelerator studies and detector development. They encompass recommended cross sections, nuclear and atomic parameters, which may derive from theoretical calculations, evaluations of experimental data or a combination of both. New versions of major, widely used evaluated data libraries were released in early 2018 by the IAEA (International Atomic Energy Agency) and the NNDC (National Nuclear Data Center, BNL); among them, the new data libraries for electron-photon transport represent substantial evolutions with respect to those currently in use, which date back to more than 20 years ago. The changes concern both the physics content and the data structure, which in turn affect the reliability and the computational performance of simulations. We review the main features of the new data libraries with emphasis on what has changed, and present a first assessment of their physics quality and of their effects on computational performance in the Geant4 environment. These results provide quantitative and objective elements for developers and users of Monte Carlo codes to evaluate the impact of migrating simulations to new data libraries on sound grounds. The assessment also highlights opportunities for improvement in future releases.

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Geant4 Detector Simulations for Future HEP Experiments

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The experimental programs planned for the next decade are driving developments in the simulation domain; they include the High Luminosity LHC project (HL-LHC), neutrino experiments, and studies towards future facilities such as Linear Colliders (ILC/CLIC) and Future Circular Colliders (FCC). The next-generation detectors being planned for long-term future programs will have increased granularity. Detector simulation plays a crucial role in their design and conception. In order to achieve the desired precision in physics measurements, whilst avoiding that the simulation dominates the systematic uncertainties, more accurate simulations and larger Monte Carlo samples will be needed. This presents major challenges both for the development of more accurate models of physics interactions and for the performance of the software used to implement them. In this paper, we will discuss the status of the most widely used detector simulation toolkit, Geant4, in the context of detector R&D for present and future facilities. We highlight, in particular, the need to review some of the physics models' assumptions, approximations and limitations in order to increase precision, and to extend the validity of models up to FCC-hh energies (100 TeV). Results will be shown of recent major improvements in the multiple scattering model of electrons and positrons and a more accurate theoretical description of the Landau-Pomeranchuk-Migdal effect, which plays a significant role at high energies. We will outline the ambitious plans that are foreseen for the further theoretical review of major processes that are a high priority for future HEP experiments.

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An Introduction of DAQ system for CUP experiments

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CUP, Center for Underground Physics, is one of the research centers belonging to Institute for Basic Science (IBS), Korea. CUP is conducting several experiments in the field of neutrinoless double beta decay, direct WIMP search, and neutrino oscillation, such as COSINE-100, AMoRE, and NEOS experiment. CUP has developed the DAQ system for these experiments including hardware and software. In this talk, DAQ system for CUP experiments is introduced focusing on electronics, online DAQ software, and monitoring system.

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CMS High Level Trigger performance at 13 TeV

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The CMS experiment selects events with a two-level trigger system: the Level-1 trigger (L1) and the High Level Trigger (HLT). The HLT is a farm made of approximately 30k CPU cores that reduces the rate from 100 kHz to about 1 kHz. The HLT has access to the full detector readout and runs a dedicated online event reconstruction to select events. In 2017, LHC instantaneous luminosity during standard operations was about $1.5 \cdot 10^{34} cm^{-2} s^{-1}$ with pile-up of 55, well above the design values, and it is expected to exceed $2.0 \cdot 10^{34} cm^{-2} s^{-1}$ in 2018 by increasing the number of proton bunches. In these conditions, the online event selection is very challenging.

We present the most recent HLT performance results and the methods used at HLT to cope with a high pile-up environment.

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The LHCb Run 2 trigger as a benchmark for the upgrade

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The LHCb upgrade trigger represents a new paradigm in high energy physics: A fully software trigger operating at the LHC bunch crossing frequency with a triggerless readout. The existing level-0 hardware trigger in Run 2 has allowed us to test much of the upgrade strategy at 1MHz. In this talk, we will describe the performance of the Run 2 trigger in pp and special data taking configurations, and the implications for the deployment of the upgrade trigger at 30MHz.

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Automated Monitoring Tools for the CMS Muon System Based on Machine Learning Algorithms

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Monitoring the quality of the data being collected by the CMS Muon system to ensure that it fulfills the requirements needed to be used for physics analyses is a time-consuming and labor-intensive task. The CMS Muon group is developing a reliable and robust tool that will make use of automated statistical tests and modern machine learning algorithms to reduce the resources needed to run and monitor the muon sub-detectors. The challenge in the development of such a tool is that the running conditions of the LHC experiments are not static, causing the quantities used for data monitoring to evolve. Furthermore, the tool must be applicable to the monitoring of all four muon sub-detectors (Cathode Strip Chambers, Drift Tube chambers, Gas Electron Multiplier chambers, Resistive Plate Chambers), which all depend on different detector technologies and are located in different geometrical areas of the detector. We will present an overview of the current tools and workflows used for monitoring, together with the status of the state-of-the-art developments towards the automated monitoring that we will implement for the future LHC runs.

Computing and Data Handling / 1027

Machine Learning on Datacenter Operations

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Google said it has reduced electricity bills by introducing machine learning into its data center operations. And what else is there?

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New approaches using machine learning for fast shower simulation in ATLAS

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Modeling the detector response to collisions is one of the most CPU expensive and time-consuming aspects in the LHC. The current ATLAS baseline, GEANT4, is highly CPU intensive. With the large collision dataset expected in the future, CPU usage becomes critical. During the LHC Run-1, a fast calorimeter simulation (FastCaloSim) was successfully used by ATLAS. FastCaloSim parametrizes the energy response of particles in the calorimeter cells, accounting for the lateral shower profile and the correlation of the energy deposition among various calorimeter layers. It significantly speeds up the calorimeter simulation. An improved version of FastCaloSim is currently under development to reduce CPU and memory requirements and to improve the physics description. The new

FastCaloSim implements machine learning techniques, such as principal component analysis and neural networks. Other new ideas being investigated include using deep generative models such as Variational Auto-Encoders (VAEs) and Generative Adversarial Networks (GANs). These models take into account the complex geometry of the ATLAS calorimeter and reproduce the shower characteristics. They are enhanced to handle different particle types and energy level variations simultaneously. This talk will describe these fast simulation methods, quantify the performance and discuss physics applications.

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Fast calorimeter simulation in LHCb

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In HEP experiments CPU resources required by MC simulations are constantly growing and become a very large fraction of the total computing power (greater than 75%). At the same time the pace of performance improvements from technology is slowing down, so the only solution is a more efficient use of resources. Efforts are ongoing in the LHC experiments to provide multiple options for simulating events in a faster way when higher statistics is needed. A key of the success for this strategy is the possibility of enabling fast simulation options in a common framework with minimal action by the final user. In this talk we will describe the solution adopted in Gauss, the LHCb simulation software framework, to selectively exclude particles from being simulated by the Geant4 toolkit and to insert the corresponding hits generated in a faster way. The approach, integrated within the Geant4 toolkit, has been applied to the LHCb calorimeter but it could also be used for other subdetectors. The hits generation can be carried out by any external tool, e.g. by a static library of showers or more complex machine-learning techniques. In LHCb generative models, which are nowadays widely used for computer vision and image processing are being investigated in order to accelerate the generation of showers in the calorimeter. These models are based on maximizing the likelihood between reference samples and those produced by a generator. The two main approaches are Generative Adversarial Networks (GAN), that takes into account an explicit description of the reference, and Variational Autoencoders (VAE), that uses latent variables to describe them. We will present how both approaches can be applied to the LHCb calorimeter simulation, their advantages as well as their drawbacks.

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Particle identification at LHCb: new calibration techniques and machine learning classification algorithms

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Particle identification (PID) plays a crucial role in LHCb analyses. Combining information from LHCb subdetectors allows one to distinguish between various species of long-lived charged and neutral particles. PID performance directly affects the sensitivity of most LHCb measurements. Advanced multivariate approaches are used at LHCb to obtain the best PID performance and control systematic uncertainties. This talk highlights recent developments in PID that use innovative machine learning techniques, as well as novel data-driven approaches which ensure that PID performance is well reproduced in simulation.

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Application of machine learning techniques at BESIII experiment

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The BESIII detector is a general purpose spectrometer located at BEPCII. BEPCII is a double ring e+e− collider running at center of mass energies between 2.0 and 4.6 GeV and has reached a peak luminosity of $1 \times 10^{33}\mathrm{cm}^{-2}\mathrm{s}^{-1}$ at $\sqrt(s) = 3770$ MeV. As an experiment in the high precision frontier of hadron physics, since 2009, BESIII has collected the world's largest data samples of J/ψ , $\psi(3686)$, $\psi(3770)$, $\psi(4040)$ and $\psi(4260)$ decays. These data are being used to make a variety of interesting and unique studies of light hadron spectroscopy, charmonium spectroscopy and high-precision measurements of charmed hadron decays.
Machine learning techniques have been employed to improve the performance of BESIII software. Novel approaches for "particle identification of lepton" and "track segment building for the CGEM (Cylindrical Gas Electron Multiplier Inner Tracker)" will be discussed. The comparison of performances with traditional approaches will be given.

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TrackML : a tracking Machine Learning challenge

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To attain its ultimate discovery goals, the luminosity of the Large Hadron Collider at CERN will increase so the amount of additional collisions will reach a level of 200 interaction per bunch crossing, a factor 7 w.r.t the current (2017) luminosity. This will be a challenge for the ATLAS and CMS experiments, in particular for track reconstruction algorithms. In terms of software, the increased combinatorial complexity will have to harnessed without any increase in budget.

To engage the Computer Science community to contribute new ideas, we organized a Tracking Machine Learning challenge (TrackML) running on the Kaggle platform from March to June 2018, building on the experience of the successful Higgs Machine Learning challenge in 2014.
The data were generated using [ACTS] (http://acts.web.cern.ch/ACTS/latest/doc/index.html), an open source accurate tracking simulator, featuring a typical all silicon LHC tracking detector, with 10 layers of cylinders and disks. Simulated physics events (Pythia ttbar) overlaid with 200 additional collisions yield typically 10'000 tracks (100'000 hits) per event.

The task to be performed by participants in the challenge is the "pattern recognition": associate the hits to tracks corresponding to the original charged particles. The participants are given 100'000 events (including truth information) to train their algorithm, while the evaluation by Kaggle is run on 100 other events. The score used to rank the candidates is the fraction of hits correctly assigned, with a weighting mechanism to favor higher momentum tracks and hits in the innermost and outermost detector layers. In this challenge, there is no CPU constraint, however a second phase of the challenge to be run during the summer will have strong computational constraints.
The emphasis of the challenge is to explore innovative Machine Learning approaches, rather than hyper-optimising known combinatorial approaches. In preliminary discussions with the ML community, Convolutional Neural Network, LSTM, Deep Neural Nets, Monte Carlo Tree Search, geometric Deep Learning have been mentioned. A very simplified 2D version of the challenge (see reference) was successfully run as a two day hackathon in March 2017.

In this talk, the first lessons from the challenge (which will just have been completed) will be discussed. What algorithms have emerged and are the most promising ? How robust is the score, compared to deeper performance evaluations ?

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Machine learning at CERN: ATLAS, LHCb, and other developments

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Machine learning is of increasing importance to high energy physics as dataset sizes and data rates grow, while sensitivity to standard model and new physics signals are continually pushed to new extremes. Machine learning has proven to be advantageous in many contexts, and applications now span areas as diverse as triggering, monitoring, reconstruction, simulation, and data analysis. This talk will discuss a subset of the applications of machine learning in the ATLAS and LHCb experiments, as well as other areas of more general use in high energy physics at CERN.

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Machine learning at CERN: ALICE, CMS, and other developments

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Machine learning is of increasing importance to high energy physics as dataset sizes and data rates grow, while sensitivity to standard model and new physics signals are continually pushed to new

extremes. Machine learning has proven to be advantageous in many contexts, and applications now span areas as diverse as triggering, monitoring, reconstruction, simulation, and data analysis. This talk will discuss a subset of the applications of machine learning in the ALICE and CMS experiments, as well as other areas of more general use in high energy physics at CERN.

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Resonance Search for a Heavy Photon with the Heavy Photon Search Experiment

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The Heavy Photon Search (HPS) experiment at Jefferson Lab is searching for a new $U(1)$ vector boson ("heavy photon", "dark photon" or A') in the mass range of 20-500 MeV/c^2. An A' in this mass region is natural in hidden sector models of light, thermal dark matter. The A' couples to the ordinary photon through kinetic mixing, which induces its coupling to electric charge. Since heavy photons couple to electrons, they can be produced through a process analogous to bremsstrahlung, subsequently decaying to an e^+e^-, which can be observed as a narrow resonance above the dominant QED trident background. For suitably small couplings, heavy photons travel detectable distances before decaying, providing a second signature. Using the CEBAF electron beam located at the Thomas Jefferson National Accelerator Facility incident on a thin tungsten target, along with a compact, large acceptance forward spectrometer consisting of a silicon vertex tracker and lead tungstate electromagnetic calorimeter, HPS is accessing unexplored regions in the coupling parameter space.

HPS conducted successful engineering runs in the springs of 2015 using a 1.056 GeV, 50 nA beam and 2016 using a 2.3 GeV, 200 nA beam. This talk will present the results of a resonance search for a heavy photon using the 1165 nb^{-1} (7.29 mC) of data collected during the 2015 engineering run.

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Searches for dark matter with CMS

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Searches in CMS for dark matter in final states with invisible particles recoiling against visible states are presented. Various topologies and kinematic variables are explored, including jet substructure as a means of tagging heavy bosons. The focus of the talk is the recent results obtained using data collected at Run-II of the LHC.

Dark Matter Detection / 942

The investigation on the dark sector at the PADME experiment.

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Among the theoretical models addressing the dark matter problem, the category based on a secluded sector is attracting increasing interest. The PADME experiment, at the Laboratori Nazionali di Frascati (LNF) of INFN, is designed to be sensitive to the production of a low mass gauge boson A' of a new U(1) symmetry holding for dark particles. This 'dark photon' is weakly coupled to the photon of the Standard Model, and it provides an experimental signature for one of the simplest implementations of the dark sector paradigm. The DAΦNE Beam-Test Facility of LNF will provide a high intensity, mono-energetic positron beam impacting on a low Z target. The PADME detector will measure with high precision the momentum of a photon, produced along with A' boson in e+e- annihilation in the target, thus allowing to measure the A' mass as the missing mass in the final state. This technique, particularly useful in case of invisible decays of the A' boson, will be exploited for the first time in a fixed target experiment. Simulation studies predict a sensitivity on the interaction strength (ε**2 parameter) down to 10−6, in the mass region 1 MeV<M_A'<22.5 MeV, for one year of data taking with a 550 MeV beam.
In 2018 the first run will take place, and early data will give the opportunity to compare the detector performance with the design requirements. Intense activity is taking place to deliver and commission the PADME experimental apparatus on site.
This talk will review the status of the experiment and the prospects.

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Dark Sector Physics with Belle II

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The Belle II experiment is a substantial upgrade of the Belle detector and will operate at the SuperKEKB energy-asymmetric e^+e^- collider. The accelerator has already successfully completed the first phase of commissioning in 2016 and first electron positron collisions in Belle II are expected for April 2018. The design luminosity of SuperKEKB is 8×10^{35} cm^{-2}s^{-1} and the Belle II experiment aims to record 50 ab^{-1} of data, a factor of 50 more than the Belle experiment. This data set offers the possibility to search for a large variety of dark sector particles in the GeV mass range complementary to LHC and dedicated low energy experiments. These searches will profit both from the size of the Belle II data, and from specifically designed triggers for the early running of Belle II. This talk will review planned dark sector searches with a focus on the discovery potential of the first data.

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Status and prospects of the China Dark Matter Experiment

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There is compelling evidence that about one-quarter of the energy density of the Universe is made up of Dark Matter, the identification and study of which are among the most important goals in

basic research. The China Dark Matter Experiment (CDEX) pursues direct searches of light Weakly Interacting Massive Particles (WIMPs) at the China Jinping Underground Laboratory (CJPL), which is the deepest operating laboratory for astroparticle research in the world. Recent results from a prototype CDEX-1 pPCGe (p-type Point Contact Germanium) detector and CDEX-10 array detector system are reported. The CDEX-10 experiment with a PCGe array of 10 kg target mass range is still taking data. The CDEX program evolves into the targets of "CDEX-1T Experiment" with ton-scale germanium detector arrays, which will compose of thousands of kg-mass prototype germanium detectors and further contribute to the studies of Dark Matter search and neutrinoless Double Beta Decay. The key technologies including HPGe detector fabrication, crystal growth and so on has been pursued. A new large space in CJPL-II will be ready by the end of 2018 for CDEX experiment. Also, the recent status of CJPL phase-II with deepest rock overburden and largest underground space in the world will be introduced briefly.

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Synchrotron Emission from a Flavored Dark Matter Model as An Explanation of ARCADE-2 Excess

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We explore the synchrotron signals generated by flavored Dark Matter candidate with mass region between 10-20 GeV annihilating into the leptonic channels e^+e^- and $\mu^+\mu^-$. In these models, the interactions are skewed in flavor space, so that a dark matter particle never couples directly to the Standard Model matter fields of the same flavor, but only to the other two flavors. So, these models can bring interesting results when analyzed as an attempt to explain the Radio observations at multiple frequencies, especially in the region between 22 MHZ and 10 GHz, the well known ARCADE-2 Excess. We present the signal brightness temperature for a sort of frequencies considering the mass region of 10-20 GeV for the dark matter candidate and show that the analysed model can fit such excess. We also explore the model concerning the 21 centimetre-wavelength transition of atomic hydrogen around redshift 20, detected by the 21-centimetre signal as a dark matter explanation.

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Dark matter search with the SABRE experiment

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The SABRE (Sodium Iodide with Active Background Rejection) experiment will search for an annually modulating signal from Dark Matter (DM) using an array of ultra-pure NaI(Tl) detectors surrounded by an active scintillator veto to further reduce the intrinsic background. The expected rate of interactions between DM particles and the detector in fact modulates due to Earth's changing velocity relative to the DM halo.
The first phase of the experiment is the SABRE Proof of Principle (PoP), a single 5kg crystal detector operated in a liquid scintillator filled vessel at the Laboratori Nazionali del Gran Sasso (LNGS). The PoP installation is underway with the goal of running in 2018 and performing the first in situ measurement of the crystal background, testing the veto efficiency, and validating the SABRE concept.
As part of this effort, GEANT4-based Monte Carlo simulations have been developed to estimate the

background in the PoP based on radio-purity measurements of the detector components. The most recent simulations include detailed versions of the detector part geometries.
The second phase of SABRE will be twin arrays of NaI(Tl) detectors operating at LNGS and at the Stawell Underground Physics Laboratory (SUPL) in Australia. By locating detectors in both hemispheres, SABRE will minimize seasonal systematic effects.
In this talk, the status report of the SABRE PoP activities at LNGS will be presented as well as results from the most recent Monte Carlo simulation.

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A dark matter search with NaI(Tl) crystals by using a pulse shape discrimination analysis

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KIMS-NaI is an experiment aimed at directly detecting Weakly Interacting Massive Particle (WIMP) via weak interactions with the nuclei in low-background NaI(Tl) crystals. Underground data for the WIMP search were obtained in the Yangyang underground laboratory with two NaI(Tl) crystals that have unprecedentedly high light-output. Since the scintillation characteristics of nuclear recoils from WIMP interactions and electron recoils produced by many background processes are different, it is possible to distinguish between the two types of events by means of pulse shape discrimination (PSD) methods. We characterized the pulse shapes produced in an NaI(Tl) test crystal by neutrons from a deuteron-based generator and gamma rays from a radioactive source. Surface nuclear recoils that could be misidentified as candidates for WIMP-induced events were also investigated and taken into account in the analysis. Preliminary results based on a PSD analysis of a 2967 kg*day data exposure will be presented.

Dark Matter Detection / 659

Recent results in the COSINE-100 experiment

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The COSINE-100 experiment searches for dark-matter interactions using an array of scintillating NaI(Tl) crystals, that serve both as a WIMP-interaction target and detector, in the low-background environment of the Yangyang underground laboratory. The main goal is to check the annual modulation signal observed by DAMA/LIBRA in an NaI(Tl) crystal array. The experiment has been running for more than 1.5 years stably and several analyses were performed based on the current energy threshold of ~2 keV with a background rate of roughly 3 counts/day/kg/keV in the energy region between 2 and 6 keV. The performance of the detector and recent results will be presented.

Dark Matter Detection / 888

Direct dark matter search with the CRESST-III experiment

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Detecting dark matter particles is one of the most exciting experimental challenges in modern astroparticle physics. Despite many naturally motivated theoretical models for light dark matter, a large part of the parameter space for spin-independent scattering off nuclei remains untested for dark matter particles with masses below few GeV/c^{2}. The CRESST-III experiment (Cryogenic Rare Events Search with Superconducting Thermometers), located at the underground facility Laboratori Nazionali del Gran Sasso in Italy, uses detectors designed to probe the dark matter low-mass region of the parameter space with a sensitivity never achieved before.
The CRESST-III experiment employs scintillating CaWO_{4} crystals as target material for dark matter interaction. Each detector consists of one ~25 g CaWO_{4} crystal coupled with a smaller crystal made of Silicon-On-Sapphire for the detection of the scintillating light. Both crystals are equipped with Transition Edge Sensors (TES) and operated as cryogenic calorimeters down to temperatures of ~10 mK. The double read-out of scintillating light and total energy deposition allows an event-by-event particle identification, which is used for background suppression.
CRESST-III, whose Phase 1 started data taking in August 2016, extends further the reach of a direct search to the sub-GeV/c^{2} mass region.
In this contribution the achievements of the CRESST-III will be discussed focusing on the latest results and the perspectives of future stages of the experiment.

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PICO Bubble Chambers for Dark Matter Searches

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The PICO collaboration uses bubble chambers to search for dark matter, with world-leading sensitivity to spin-dependent (SD) WIMP-proton couplings via direct detection. The bubble chambers are operated in a moderately superheated state, providing excellent rejection of the dominant gamma background, and are located in the deep underground facility SNOLAB in Canada. The PICO-60 detector has set the most stringent limits to date for SD WIMP-proton couplings using C3F8. The collaboration is currently installing PICO-40L, a new detector that will incorporate several design improvements to reduce backgrounds from neutrons and particulate contamination; and is also preparing PICO-500L, a ton-scale bubble chamber designed to cover a large range of mass and cross section parameter space, proving a variety of theoretical models. The PICO collaboration has built a well established technology, easily scalable and relatively inexpensive with flexibility to easily exchange targets following a discovery. The technology, latest results from the PICO-60 detector, recent progress in PICO-40L and future plans towards PICO-500L will be presented in this talk.

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Directional Search for Dark Matter Using Nuclear Emulsion

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A variety of experiments have been developed over the past decades, aiming at the detection of Weakly Interactive Massive Particles (WIMPs) via their scattering in an instrumented medium. The sensitivity of these experiments has improved with a tremendous speed, thanks to a constant development of detectors and analysis methods. Detectors capable of reconstructing the direction of the nuclear recoil induced by the WIMP scattering are opening a new frontier to possibly extend Dark Matter searches beyond the neutrino background. Exploiting directionality would also give a proof of the galactic origin of dark matter making it possible to have a clear and unambiguous signal to background separation. The NEWSdm experiment, based on nuclear emulsions, is a new experiment proposal intended to measure the direction of WIMP-induced nuclear recoils with a solid-state detector, thus with a high sensitivity. We discuss the discovery potential of a directional experiment based on the use of a solid target made of newly developed nuclear emulsions and novel read-out systems achieving nanometric resolution. We also report results of a technical test conducted in Gran Sasso.

Dark Matter Detection / 551

DANAE - a new experiment for direct dark matter detection with DEPFET silicon detectors

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The sub-GeV mass region of WIMPs as a dark matter candidate is foreseeably to be explored intensively in the next generation of direct detection experiments.
Essig and others 1 recently discussed the feasibility of detecting the energy deposit from the dark-matter electron recoil using low-noise semiconductor detectors as the active target. With a readout noise level below 1 electron RMS, the sensitivity allows us to test several theoretical models that account for dark matters with sub-GeV mass.
One of the two silicon-based archetectures that are capable of reaching such noise level, is the DEPFET (Deeply-depleted P-channel Field Effect Transistor) with Repetitive Non Destructive Readout (RNDR). The prototype of this detector has been developed by the Semiconductor Laboratory of the Max Planck Society. and the readout of a single pixel has successfully reached the expected sub-electron noise level as reported in [2].
In this presentation, we will first introduce the working concept of the DEPFET-RNDR based on the recent publication [2]. Then we present a new project DANAE - Direct dArk matter detection using DEPFET with reptitive Non-destructive readout Application Experiment, that plans to apply this type of detector for the direct detection of dark-matter electron recoil.
We started in late 2017 the R&D for the experiment, with the following two objectives in the near future. The first one is to build a setup including the readout for a 64 pixel × 64 pixel matrix with 75 μm × 75 μm pixel size, and to reach the noise level achieved in the single pixel measurement. The second one is to measure the temperature dependence of the leakage current, which is crucial to determine the operating temperature of the detector and to further optimize the number of repetitive readout cycles to reach an optimal noise level. Ongoing efforts to reach the above goals and future perspectives will be discussed.

Dark Matter Detection / 834

Dark matter searches in XMASS

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XMASS is a multi-purpose experiment using a single-phase liquid-xenon scintillator detector located underground at Kamioka Observatory in Japan. We are continuously taking data since November 2013 for more than four years.
With these long-term data, we conducted not only standard WIMP search, but also search for annual modulation caused by dark matter, and various dark matter searches such as light WIMPs, WIMP-129Xe inelastic scattering,and bosonic super-WIMPs.
The XMASS detector is also capable of pursuing various researches in particle and astroparticle physics such as supernova neutrino observation, solar axion search, and double electron capture search.
In this talk, we will present recent dark matter searches in XMASS.

Dark Matter Detection / 717

Ultra-light dark matter in NEWS-G experiment using a gaseous spherical detector

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NEWS-G experiment is using a new type of radiation detector based on the spherical proportional counter. The detector consists of a large spherical gas volume with a central electrode forming a radial electric field. A small spherical sensor located at the center is acting as a proportional amplification structure.
Combination of sub-keV energy threshold and versatility of the target (Ne, He, H) opens the way to search for ultra light dark matter WIMPs down to 100 MeV. Recent results obtained with a low radioactivity detector, 60 cm in diameter operated in LSM underground laboratory will be presented.
First NEWS-G results with Ne as target nuclei, exclude above 4.4⊠1037 cm2 for a 0.5 GeV/c2 WIMP.
The next project NEWS-G, under study, is a larger detector that consists in a selected pure copper sphere of 1.4 meter of diameter to be installed at SNOLAB. This will allow benefiting from a larger volume, relative to the current detector and a much lower background level.
I will discuss the status of the project and prospects for the future.

Dark Matter Detection / 974

Low radioactivity Argon for rare event searches

Pietro Giampa[None]

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The DarkSide-50 two-phase liquid argon (LAr) detector has been searching for weakly interacting massive particle (WIMP) dark matter for more than three years, and during the last two and a half years has been successfully operating the detector with argon that was extracted from underground CO_2 wells in Cortez, Colorado in the USA. This source of argon is shielded from cosmic rays entering Earth's atmosphere, and thus has a concentration reduced by more that a factor 1000 of the cosmogenically produced isotope of ^{39}Ar that beta decays with an endpoint energy that causes the beta spectrum to entirely cover the LAr WIMP search region. This talk will focus on the details of two new projects called Urania and Aria. Urania aims to extract up to 250 kg/day of UAr from the same source of gas as that used to extract the UAr for DS-50. Aria will then further purify by cryogenic distillation in a 350 m tall column the extracted UAr to produce >35 tonnes of detector grade UAr for use in a 20-tonne fiducial volume detector called DarkSide-20k, set to begin operations at the beginning of the next decade. Both projects require industrial scale plants with potential applications outside basic research.

Dark Matter Detection / 969

Development of SiPM based photosensors operating at cryogenic temperature for dark matter searches

Pietro Giampa[None]

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DarkSide-20k is a proposed 20 tonne fiducial mass liquid argon TPC that will perform an instrumental background-free search for WIMP dark matter. The TPC will be outfitted with more than 100,000 specifically designed silicon photomultipliers (SiPM) grouped into several thousands single-channel, $25\ \mathrm{cm}^2$ photosensors that are sensitive to single photoelectrons. We will present the recently achieved performances of the photosensor and associated low-noise electronics at liquid argon temperature and discuss the strategy for the mass production for DarkSide-20k.

Dark Matter Detection / 966

Darkside latest results and future prospects

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DarkSide uses a dual-phase Liquid Argon Time Projection Chamber to search for WIMP dark matter. The talk will present the latest result on the search for low mass ($M_{WIMP} < 20\,GeV/c^2$) and high mass ($M_{WIMP} > 100\,GeV/c^2$)
WIMPs from the current experiment, DarkSide-50, running since mid 2015 a 50-kg-active-mass TPC, filled with argon from an underground source. The next stage of the Darkside program will be a new generation experiment involving a global collaboration from all the current Argon based experiments.
DarkSide-20k, based on a >20-tonne fiducial mass TPC with SiPM based photosensors, is designed to have a background well below that from coherent scattering of solar and atmospheric neutrinos. Like its predecessor DarkSide-20k will be housed at the Gran Sasso (LNGS) underground laboratory, and it is expected to attain a WIMP-nucleon cross section exclusion sensitivity of 10^{-47} cm^2 for a WIMP mass of 1TeV/c^2 in a 5 yr run.

Dark Matter Detection / 842

On the Calibration of the DEAP-3600 Experiment

Pietro Giampa[None]

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The DEAP-3600 experiment is a single phase liquid argon (LAr) dark matter detector, capable of holding up to 3,6 tonnes of LAr. The target material is contained within an ultra-radiopure acrylic vessel 85 cm in radius. Particle interactions within the active volume are observed via 255 HQE 8 inches Hamamatsu room-temperature PMTs, which are coupled to the detector via 50 cm long acrylic light guides (LGs). The inner detector is sealed inside a stainless steel vessel, which is immersed in a 400 meter-cube water tank that functions as a muon veto. The experiment has been operational since May 2016 and stable physics trigger data-taking has been underway since November 2016. In this talk, we will report on the full (multi-year) calibration campaign completed for the PMTs response, the energy response, and the pulse-shape discrimination, all necessary to achieve the ultimate WIMP-nucleus sensitivity.

Dark Matter Detection / 488

Dark Matter Search with the DEAP-3600 experiment

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DEAP-3600 is a single-phase liquid argon (LAr) dark matter direct detection experiment sensitive to spin-independent scattering of Weakly Interacting Massive Particles (WIMPs) on nucleons. The experiment is located two kilometres underground at SNOLAB, in Canada, with a sensitivity of 10^-46 cm^2 for a spin-independent WIMP-nucleon cross section at 100 GeV/c^2 WIMP mass for a background-free exposure of 3 tonne-year. The LAr is contained in an acrylic vessel (85 cm radius) viewed by 255 HQE 8 inches Hamamatsu PMTs, separated by 50 cm acrylic light guides. The detector was designed and built to reach a background level of less than 0.6 events in 3 tonne-year exposure. DEAP-3600 has been taking physics data since late 2016 and first results were recently published which demonstrated stable detector operations and the power of pulse shape discrimination to distinguish electron recoil backgrounds from nuclear recoils, leading to the most sensitive WIMP search to date using a LAr target. Results from the current analysis and future plans will be presented in this talk.

Dark Matter Detection / 862

The LUX-ZEPLIN Dark-Matter Experiment

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Cosmological and astrophysical evidence for the existence of dark matter in the universe and in the Milky Way itself is compelling, with weakly interacting massive particles (WIMPs) being a leading dark-matter candidate. The LUX-ZEPLIN experiment will search for nuclear recoils from dark matter particles incident on 5.6 tonnes of liquid xenon contained within the fiducial volume of a two-phase time projection chamber. The detector will operate at the Davis Cavern at 4850 ft depth at the Sanford Underground Research Facility in Lead, South Dakota. The baseline spin-independent cross-section sensitivity for 40 GeV WIMPs is 1.6 x 10^{-48} cm^2 in 1000 days of livetime. An overview and the status of the project will be presented.

Dark Matter Detection / 667

Lastest results from the XENON Dark Matter Project

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The XENON1T experiment for the direct detection of dark matter is located at the Laboratori Nazionali del Gran Sasso in Italy. The detector uses 3.2 tons of liquid xenon with ~2 tons being inside the dual phase time projection chamber (TPC).

A first dark matter search conducted between November 2016 and January 2017 in a 5-40 $\mathrm{keV_{nr}}$ energy window did not yield evidence for dark matter interactions within the 35.6 (ton $\times$ day) exposure. This allowed to set the most stringent limits so far on the spin-independent scattering cross section of Weakly Interacting Massive Particles (WIMP) on nucleons for WIMP masses above 10 GeV/c^2. The limit features a minimum of $7.7 \times 10^{-47}\mathrm{cm}^2$ for 35 GeV/c^2 WIMPs at 90% confidence level. Since this science run 0 result a total exposure of 1 (ton$\times$year) has been acquired allowing a significant step in sensitivity of direct dark matter search. Additionally to the large exposure, XENON1T's sensitivity relies on an electronic recoil background below 2×10^{-4} events/(kg $\times$ day $\times$ $\mathrm{keV_{ee}}$) - the lowest ever achieved for a dark matter detector.

This talk will describe the XENON1T detector, the data analysis and the results of the new science run 1.

Dark Matter Detection / **1020**

Recent PandaX-II Results on Dark Matter Search and PandaX-4T Upgrade Status

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PandaX experiment, located at China JinPing underground Laboratory (CJPL), is a 500kg scale liquid xenon dark matter direct detection experiment. With recent data, PandaX-II experiment obtained stringent upper limits on the spin-independent (SI) and spin-dependent (SD) WIMP-nucleon elastic scattering cross sections. Alternative models of dark matter are also explored using this data. Meanwhile, PandaX collaboration has launched an upgrade plan to build PandaX-4T detector with 4-ton liquid xenon in the active volume. The PandaX-4T experiment will be relocated to CJPL-II and is expected to run after 2020. Detailed simulation indicates that the sensitivity on SI WIMP-nucleon scattering cross section could reach 10^{-47} cm^2 after two-year's running.

Dark Matter Detection / **917**

Search for Boosted Dark Matter at ProtoDUNE

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We propose, for the first time, the potential of beyond the standard model opportunities at the ProtoDUNE experiment in the context of dark matter physics. We explore various experimental signatures at the cosmic frontier, arising in boosted dark matter scenarios, i.e., inelastic scattering of a relativistic dark matter particle often created by the annihilation of its heavier component which usually constitutes the dominant relic density. Although signal features are unique enough to isolate signal events from potential backgrounds, vetoing an enormous amount of cosmic background is rather challenging as the detectors are located on the ground. Nevertheless, we argue, with a careful estimate, that such backgrounds can be well under control via performing dedicated analyses after data acquisition. We then discuss some phenomenological studies which can be achieved with the ProtoDUNE detectors, employing a dark photon scenario as our benchmark dark-sector model.

Dark Matter Detection / 865

A frequentist analysis of proton-philic spin-dependent inelastic Dark Matter (pSIDM) as an explanation of the DAMA effect

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In the proton-philic spin-dependent inelastic Dark Matter (pSIDM) scenario, the yearly modulation effect in the DAMA experiment is consistent with other available constraints: from the latest experimental bounds from XENON1T, PANDAX-II, SuperCDMS, PICO-60 and CDMSlite, we obtain updated ranges of its parameters by constructing their approximate frequentist confidence intervals both in a halo-independent approach and adopting a truncated Maxwellian for the Weakly Interacting Massive Particles (WIMP) velocity distribution. In our halo−independent analysis we have implemented the WIMP halo function in terms of a step−wise parameterization. Our results confirm the present viability of the pSIDM scenario as a possible explanation of the DAMA effect.

Dark Matter Detection / 853

Present and future sensitivity of WIMP direct detection in EFT

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There are many underground experiments which are currently looking for Weakly Interacting Massive Particles (WIMPs) that are the most popular candidate of dark matter. In these direct detection experiments, the signal are recoil events of WIMP elastic scattering off target nuclei. The effective field theory (EFT) provides a general and efficient way to characterize experiment results. In particular, for non-vanishing momentum transfer, in addition to the standard spin-independent and spin-dependent interactions, new operators arise giving rise to non-standard interactions.
Guided by non-relativistic EFT, we classify the most general interactions between scalar or fermionic WIMP and nuclei. We study exclusion plots for different types of interactions which in WIMPs direct detection are the measure of the relative sensitivity of different experiments. In this work, we study exclusion plots for newly arising non-standard interactions for existing experiments including the effects of isospin violation. We also discuss the spectral shape in WIMPs effective models and

present the exclusion plots for current as well as future experiments. In our analysis, the velocity distribution of dark matter is fixed to a Maxwellian.

Dark Matter Detection / 750

Dark Matter Direct Detection with Spin-2 Mediators

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We consider models where a massive spin-two resonance acts as the mediator between Dark Matter (DM) and the SM particles through the energy-momentum tensor. We examine the effective theory for fermion, vector and scalar DM generated in these models and find novel types of DM-SM interaction never considered before. We identify the effective interactions between DM and the SM quarks when the mediator is integrated out, and match them to the gravitational form factors relevant for spin-independent DM-nucleon scattering. We also discuss the interplay between DM relic density conditions, direct detection bounds and collider searches for the spin-two mediator.

Dark Matter Detection / 325

Prospects of Higgs portal DM models at future colliders

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My talk will base on Higgs portal DM models with fermion, vector and scalar DMs.
I will show that the LHC is unable to probe any parameter space of these models. On the other hand, in terms of four benchmark points, those model will be not only probable but also distinguishable at 500 GeV electron-positron collider and 100 TeV proton-proton collider.

Dark Matter Detection / 252

Heavy quarks flavored scalar dark matter

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The absence of confirmed signal in dark matter (DM) direct detection (DD) may suggest weak interaction strengths between DM and the abundant constituents inside nucleon, i.e. gluons and valence light quarks. In this work we consider a real scalar dark matter S interacting only with $SU(2)_L$ singlet Up-type quarks $U_i = u_R, c_R, t_R$ via a vector-like fermion ψ. The DM-nucleon scattering can proceed through both h-mediated Higgs portal (HP) and ψ-mediated vector-like portal (VLP), in which HP can receive sizable radiative corrections through the new fermions. We find that the constraints of XENON1T results are strong on y_1 from VLP scattering and on y_3 from its radiative contributions to HP scattering. Then we focus on DM-heavy quark interactions via y_2, y_3 in terms of DM-gluon scattering at loop level. We find that renormalization group equation (RGE) and heavy quark threshold effects are important. For the benchmarks $y_3 = 0.5, y_2 = 0.5, 1, 3$, combined results from $\Omega_{\rm DM}h^2 \simeq 0.12$, XENON1T, Fermi-LAT, 13 TeV LHC data have almost excluded $m_S < m_t/2$ when only DM-$\{c, t\}$ interactions are considered. FCNC of top quark are usually below 10^{-9} after passing the other constraints, which are still safe from the current top quark width measurements.

Dark Matter Detection / 16

Dark photons in the decay of a scalar

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The couplings of the Standard Model sector to the scale invariant degrees of freedom can open the possibility to study dark photons (DP). The model for the DP particle solvable in 4-dimensional space-time is studied at the lowest order of perturbative theory using canonical quantization. The model is gauge and scale invariant and these symmetries are spontaneously broken with the following properties: the DP field is massive. The Dalitz-like decay of the (Higgs-like) scalar boson into a single photon and DP is studied. The interaction between DP and quarks is mediated by the derivative of the scalar field - the dilaton. The mass of the dilaton does not enter the final solutions. The limits are set on the DP mass, the mixing strength between the standard photon and DP. This study can be used to probe the DP sector since the emitted energy of the single photon is encoded with measuring of the missing of the recoil DP.

Dark Matter Detection / 819

The Beam Dump eXperiment

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The Beam Dump eXperiment (BDX) is an electron-beam thick-target experiment aimed to investigate the existence of Light Dark Matter (LDM) particles in the MeV-GeV mass range. The experiment has been conditionally approved and is expected to run in a dedicated underground facility located 20 m downstream of the JLab-Hall A beam-dump, receiving up to 10^{22} electrons on target in 1 year time. The detector consists of two main components: a CsI(Tl) electromagnetic calorimeter (Ecal) and a veto system used to suppress the background. The expected signature of the DM interaction in the Ecal is a $\sim$ GeV electromagnetic shower paired with a null activity in the surrounding active veto counters. A complete small-scale prototype of the final detector has been constructed in order to validate the proposed technology and demonstrate the capability to reject the cosmogenic background. Beam-related background was estimated by means of Monte Carlo (MC) simulations. In order to benchmark our simulation tools with on site data, we recently measured, with JLab support, the muon background produced by the 10.6 GeV e^--beam on the Hall-A dump at the location of

the proposed BDX facility with present shielding configuration. A hodoscope made by a BDX ECal CsI(Tl) crystal sandwiched between a set of segmented plastic scintillators was used to measure the muon rate.
This talk will present an overview of the BDX experiment with a particular focus on the results of the recent muon-flux measurements and the comparison with the corresponding simulations.

Dark Matter Detection / 183

New Physics searches at BESIII

BESIII Collaboration[None] ; Shenjian Chen[1]

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Many models of physics beyond the SM, motivated by the recent astrophysical anomalies, include the possibility of a new types of weak-interacting degrees of freedom. Typical models, such as Next-to-Minimal Supersymmetric SM and Light Hidden Dark-sector model,predict a low-mass Higgs and a Dark Bosons, respectively. The masses and decay modes of these particles are expected to be accessible at the BESIII experiment. BESIII has recently performed searches of light Higgs and Dark Bosons in several decay modes using the data collected at $J/\psi, \psi(2S)$ and $\psi(3770)$ resonances. In the data sample at the J/ψ a search of possible invisible decays of light vector mesons V and pseudo-scalar mesons via $J/\psi \to VP$ decays ($V = \omega, \phi$ and $P = \eta, \eta'$)has also been performed. This talk will summarize BESIII recent results on these searches for new physics.

Dark Matter Detection / 859

CAPP's axion data with mass range from 2.45 to 2.75 GHz

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CAPP's flagship axion experiment, CULTASK, employs dilution refrigerators to lower the physical temperature of resonant cavities to less than 40 mK - the coldest ever for axion search. We prepared a complete set of the microwave axion detector (CAPP-PACE) equipped with an 8 T superconducting magnet with 12 cm inner bore in order to search for axions with mass around 2.5 GHz. The frequency tuning system installed in a split-design resonant cavity with a high Q-factor utilizes piezoelectric actuators with interchangeable sapphire and copper rods and performs flawlessly in searching a wide range of axion mass. The feeble signal (10^{-24} W) from the cavity is amplified and transmitted through the RF receiver chain, specially designed to minimize the noise temperature of the system employing an 1 K HEMT or a quantum-limited SQUID (Superconducting Quantum Interference Device) amplifier in order to raise the sensitivity and eventually speed up the axion search. I will present the results of CAPP's first physics data runs in the axion mass range from 2.45 to 2.75 GHz and discuss our future plans and R&D projects.

Dark Matter Detection / 520

MAGIS-100 at Fermilab

Jonathon Coleman[1] ; Joseph Lykken[2] ; Swapan Chattopadhyay[3] ; Rob Plunkett[2] ; Jason Hogan[4] ; Steve Geer[2] ; Peter Graham[4] ; Phil Adamson[2] ; Roni Harnik[2] ; Steve Hahn[2] ; Mark Kasevich[4] ; Jeremiah Mitchell[5] ; Surjeet Rajendran[6] ; Linda Valerio[2] ; Arvydas Vasonis[2]

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The Matter-wave Atomic Gradiometer Interferometric Sensor (MAGIS) collaboration seeks to connect two quantum sensors across a long baseline. The phase in each device is compared across this baseline, enabling broad applications for basic science. The science is enabled by the ongoing advances in atomic clocks and atom interferometry.

The experiment is sensitive to the distortion of the space-time between the sensors, and can be used to answer basic science questions in quantum mechanics, dark sector physics, and 'mid-band' gravitational wave detection. It will be able to detect well-motivated ultra-light dark matter candidates several orders of magnitude beyond current bounds, via time-varying signals. It can also probe hitherto unconstrained parts of parameter space in the search for new fundamental forces.

This scheme is physically implemented in the configuration of MAGIS-100 by taking two atom interferometers and separating them across the baseline of the vertical 100-meter-deep NuMi access shaft at Fermilab.

The Status and plans for the experiment will be presented.

Dark Matter Detection / 839

Cold Dark Matter Axion Search with a Dipole Magnet

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The CAST-IBS/CAPP experiment is a joint effort between the CERN Axion Solar Telescope (CAST) collaboration 1 and the Center for Axion and Precision Physics Research (IBS/CAPP) [2], searching for cold dark matter axions.
In this project, tunable rectangular cavities are inserted in the 9T CAST dipole magnet, an LHC prototype, at CERN.
The traditional haloscope technique first suggested by Sikivie [3] is, for the first time, applied in a rectangular geometry configuration, rather than the common cylindrical geometry. The status and expected sensitivity of the experiment are presented.
1 CAST Collaboration, K. Zioutas et al., Phy. Rev. Lett. 94 (2005) 121301.
[2] http://capp.ibs.re.kr/html/capp_en/
[3] P. Sikivie, Phys. Rev. Lett. 51, 1415 (1983).

Dark Matter Detection / 833

Dark matter axion search experiments using 18T HTS magnet at CAPP/IBS in KAIST

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The presence of dark matter had profound consequences on the evolution of the Universe. The Standard Model does not accommodate a suitable dark matter candidate. Therefore, the existence of dark matter is a crucial phenomenological evidence for physics Beyond the Standard Model. The pressing goal of current and future dark matter experiments is to answer the question of whether dark matter interacts with normal matter other than gravity; i.e. if dark matter is detectable. Among the plethora of dark matter candidate particles, the Weakly Interacting Massive Particles (WIMPs) and the Axions are the most outstanding contender. In this talk, we will discuss about the dark matter axion search projects at the Center for Axions and Precision Physics Research at CAPP/IBS in KAIST, especially focused on the CAPP18T axion dark matter search experiment which utilizes a 18T High Temperature Superconducting solenoid magnet, resonant cavity, dilution refrigerator and linear amplifier system.

Dark Matter Detection / 1045

First Results from the ADMX G2 dark matter axion search

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The axion is a well-motivated dark matter candidate inspired by the Peccei-Quinn solution to the Strong-CP problem. After decades of work, the US DOE flagship axion dark matter search, ADMX G2, is the first experiment to be sensitive to dark matter axions from the plausible DFSZ coupling model, and has begun to search the theoretically-favored axion mass region 2-40 micro-eV. ADMX G2 could now discover dark matter at any time. I will report the first results from exploring the range around 2.7 micro-eV last year, discuss this year's operations and review the ADMX G2 plans to continue the search to cover the entire mass range.

Detector: R&D for Present and Future Facilities / 130

Performance of missing transverse momentum reconstruction at the CMS detector in 13 TeV data

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The precise measurement of the missing transverse momentum (MET) observable is critical for standard model measurements involving W, Z, and the Higgs bosons, and top quarks. In addition, MET is one of the most important kinematic observable used in searches for physics beyond the standard model targeting new weakly interacting neutral particles. A detailed understanding of various effects due to the high collision rate at the CMS detector during the 13 TeV data-taking period of the LHC both in data and simulation is important to achieve the most optimal MET performance. In this talk, we will present the studies of MET reconstruction algorithms using the CMS detector at the LHC.

Detector: R&D for Present and Future Facilities / 278

The upgraded trigger system and di-τ trigger strategies of the ATLAS detector at the HL-LHC

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When LHC enters the High Luminosity (HL-LHC) phase, the instantaneous luminosity will increase from the current 2 x 10^34 cm-2 s-1 (Run II) to a maximum expected value of 7.5 x 10^34 cm-2 s-1, equivalent to 200 interactions per bunch crossing, and the estimated integrated luminosity will reach 3000 fb-1.
New strategies are needed in order to make triggers more selective and to keep pT thresholds for leptons close to the current ones.
The current trigger system is based on a Level-1 hardware trigger plus a High Level Trigger (HLT) implemented in software, two scenarios are being considered for the HL-LHC phase.
The first one is a single Level-0 which will do a preliminary selection of data to reduce the rate to 1 MHz with a latency of 6 μs followed by a High Level Trigger. This corresponds to a 200 kHz target for a di-τ trigger.
The second scenario would reduce the event rate to 2-4 MHz at Level-0, then a Level-1 trigger will further reduce it to 600-800 kHz, followed again by a High Level Trigger.
The new trigger system will rely on better spatial resolution of the LAr calorimeter of ATLAS, whose granularity will be 4 times improved at Level-0 and 16 times at Level-1. This will improve the turn-on curves and the matching between tracks and clusters, it will make transverse energy measurements of reconstructed objects more accurate and it will allow the use of more sophisticated jet algorithms.
Physics motivations for the trigger upgrade at HL-LHC together with an overview of the new trigger system will be given.
The current status of the di-τ trigger at the future HL-LHC Level-0 will then be shown. This study has been performed through simulations of the hadronic decay of the Higgs boson into two taus at a center of mass energy of 14 TeV under a pile-up conditions corresponding to 200 interactions per bunch crossing.
In particular, results on the performance (in terms of turn-on curves and rejection power of the algorithm) will be shown along with the challenges related to the development of this trigger in such a very high pile-up environment.

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Development of the Silicon Tracker for CEPC

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The Circular Electron Positron Collider (CEPC) has been proposed as a Higgs/Z0 (flavor) factory, which would allow precision measurements of the Higgs boson properties, as well as of W±/Z0 bosons. The baseline design of CEPC tracking system consists of a vertex detector with three concentric double-sided pixel layers and a silicon tracker with some layers on both barrel and end-cap regions, besides a large volume time projection chamber (TPC). Driven by physics studies and experimental conditions, the silicon tracking system has similar performance requirements to the ILC detectors, such as a single point resolution of a few micrometers, very low material budget (0.15%X0 per layer for the vertex region and <1%X0 per layer for the outer tracker) and power consumption, but without power-pulsing, which leads to significantly additional constrains on detector specifications, especially for the case of machine operating at Z-pole energy region with high luminosity. In this presentation, I will give an overview of the CEPC tracker design, the requirements and challenges for each sub-system with possible technologies. The on-going R&D activities will also be reported on silicon pixel detector, based on monolithic CMOS pixel sensor (CPS) and Silicon on Insulator (SOI) technologies.

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Upgrade of ALICE forward detectors

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In 2019-2020 the upgrade of CERN LHC will increase the luminosity and the collision rate beyond the design parameters of several of the key ALICE detectors 1. To benefit from the improved performance of the LHC, ALICE will install two new forward detectors: the Fast Interaction Trigger (FIT) [2][3] and the Muon Forward Tracker (MFT) [4]. A further upgrade opportunity might arise during the shutdown between Run 3 and Run 4 when the Forward Calorimeter (FoCal) may be added to the ALICE setup.

The presentation will contain a short description of the new forward detectors. The required functionality and the main physics goals will be given together with the main highlights concerning the design and performance of the detector prototypes.

The main focus will be on FIT. It will replace existing trigger and multiplicity detectors: T0, V0 and FMD. FIT will consist of two Cherenkov detector arrays and a large sectored scintillator ring on opposite sides of the interaction point (IP). FIT will be capable of operating at the sustained Pb-Pb interaction rate of 50 kHz in a continuous readout mode. It will provide the collision time with resolution better than 40 ps and trigger with maximum latency of 400 ns. Several online triggering modes will be available, including multiplicity (centrality) trigger and vertex position trigger. FIT will be able to reconstruct the collision centrality and reaction plane with resolution similar to that of the present ALICE apparatus, while the trigger efficiency for pp collisions will be improved.

The main role of MFT is to add secondary vertex reconstruction capabilities for muon tracks at forward rapidity and to supplement the acceptance of the already operating Muon Spectrometer. The MFT will consist of a stack of 5 disks mounted in front of the hadron absorber shielding the Muon Spectrometer from the IP. The active part is made of custom-designed Monolithic Active Pixel Sensors (MAPS). Most prominent properties of MFT include radiation hardness, low material budget, high granularity of pixels and readout speed.

A SiW electromagnetic calorimeter, FoCal, is considered as a possible upgrade to the ALICE detector. It should be characterized by a very high granularity allowing for γ/π_0 discrimination, especially for very high momenta. The main candidates to instrument the sensitive area are CMOS pixel sensors.

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Status Report on Inner Tracking System Upgrade of ALICE

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The ALICE Collaboration is preparing a major upgrade of the ALICE detector, planned for installation during the second long LHC shutdown. The construction is expected to be completed by 2020 for data taking until 2029. A key element of the ALICE upgrade is the construction of a new, ultra-light, high-resolution Inner Tracking System (ITS).
With respect to the current ITS, this upgrade is aiming at a better position resolution (5 micron), a lower material budget (0.3% X0 for the three innermost layers) and a faster readout (up to 100 kHz in Pb-Pb collisions). This will be obtained by seven concentric detector layers based on an advanced Monolithic Active Pixel Sensor (MAPS) chip, with a pixel pitch of 30x30um^2.
I will present the general layout and main components of the new ITS, a summary of the R&D activities, the current status and outlook.

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The ATLAS FastTracker: Pioneering the next era of hardware track triggers

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Though hardware-based trackers were a crucial element of the triggering systems for both D0 and CDF, no such system has yet been incorporated into either ATLAS or CMS. The ATLAS FastTracKer (FTK) is a first step towards this goal, and will soon provide full tracking information for all events passing ATLAS's Level-1 trigger. This system massively reduces the CPU required to identify track-based signatures like b-jets and taus, and allows for the suppression of pile-up effects on missing energy and jet triggers. This talk will present an overview of FTK commissioning and future plans, along with updated projections for FTK performance.

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Level1 Calorimeter Trigger: from Xilinx Virtex7 to Ultrascale+

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With the restart of the LHC in 2021 the ATLAS experiment will cope with high luminosity beams (2.5 x 10 34 cm -2 s -1). A new Level-1 Calorimeter trigger system (see Fig.1) will be introduced exploiting a finer calorimeter readout granularity. The new system consists of three Feature EXtractors (FEXs), electron (eFEX), jet (jFEX) and global (gFEX), that use FPGAs to reconstruct different physics objects used for the trigger selection and that gather data from the calorimeters through a Fibre Optical Plant.

The Trigger Objects produced by the algorithms running on the FEXs are optically sent to the Level-1 Topological Trigger where interesting physics events are selected by applying kinematic and angular requirements on electromagnetic clusters, jets and total energy.

This contribution will focus on the new jFEX system and on the upgrade of the L1Topological trigger giving an overview of the hardware as well as the algorithmic firmware.

The jFEX (see Fig. 2) and the upgraded L1Topological Trigger are Ultrascale+ based ATCA boards that cope with input data rates of up to 3.6 Tb/s for a maximum of 120 Multi Giga Transceivers (MGTs) per FPGA. To achieve the high transmission speed and high component density for these boards, a number of challenges in power management, voltage distribution and signal integrity had to be addressed in the design.

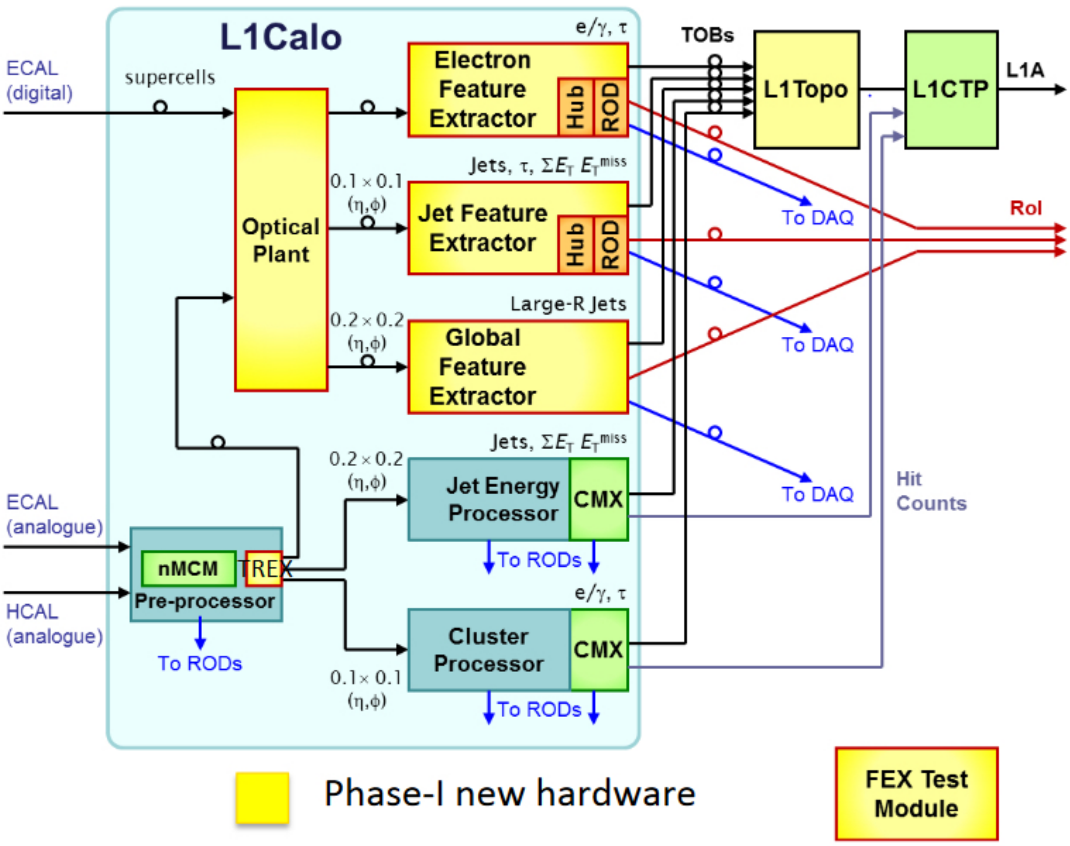

Figure 1: Figure 1

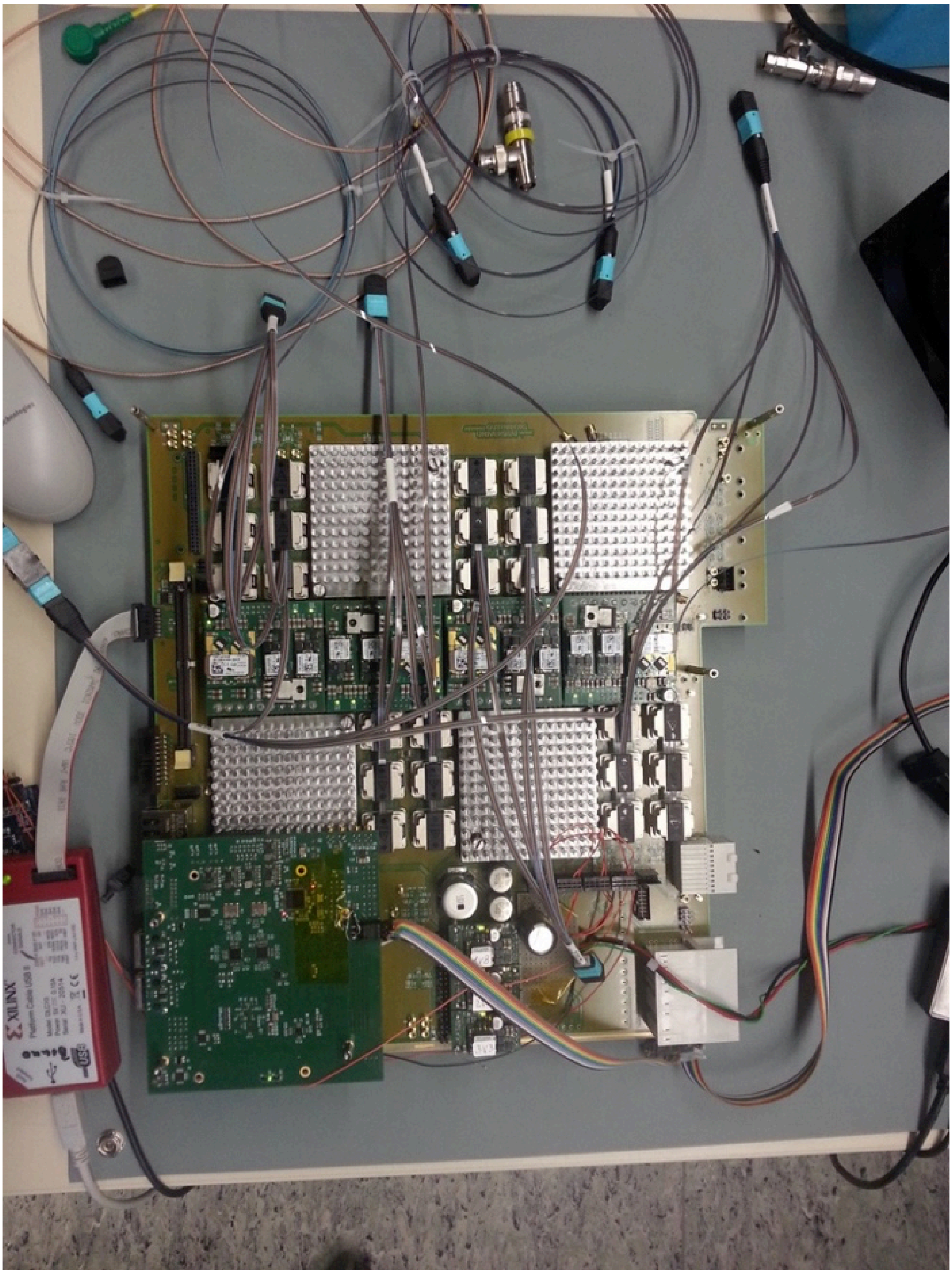

Figure 2: Figure 2

The latest generation Ultrascale+ FPGAs provide large processing resources for sophisticated trigger algorithms. The jFEX will allow to reconstruct small- and large-area jets including high-granularity substructure observables. Energy from pile-up interactions can be determined on an event-by-event basis and subtracted for jets and MET. On the L1Topological Trigger, kinematic reconstruction of full events will be performed within 50ns, and even exotic triggers mixing information from different bunch crossings will be possible.

This contribution will present the design, integrated tests programming of the jFEX and L1Topological Trigger modules.

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Fast timing measurement for CMS RPC Phase II upgrade

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With the increase of the LHC luminosity foreseen in the coming years many detectors currently used in the different LHC experiments will be dramatically impacted and some need to be replaced. The new ones should be capable not only to support the high particle rate but also to provide time information to reduce the data ambiguity due to the expected high pileup.

RPC using low-resistivity Bakelite are proposed to equip the very forward region of the CMS detector. In their single-gap version they can stand rates of few kHz/cm2. New electronics equipped with excellent timing precision measurement (<150ps) are being developed to read out the RPC detectors from both side of the strips to allow good spatial resolution along them. The absolute time measurement, determined by RPC signal (around 1 ns) will also reduce the data ambiguity due to the highly expected pileup at the Level 1 trigger and help to identify Heavy Scalar Charged Particles (HSCP).

Principle of the measurement, implementation in front-end electronic boards (Petiroc front-end ASIC, wave-union TDC and PCB design) will be discussed. First results from cosmic tests and test beams at Gamma Irradiation Facility (GIF) and SPS at CERN would also be presented.

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Frontend and backend electronics for the ATLAS New Small Wheel Upgrade

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The Phase-I and Phase-II upgrades of the LHC accelerator will increase the LHC instantaneous luminosity to 2×1034 cm−2s−1 and 7.5×1034 cm−2s−1, respectively. The luminosity increase drastically impacts the ATLAS trigger and readout data rates. The present ATLAS small wheel muon detector will be replaced with a New Small Wheel (NSW) detector in 2019. The NSW will feature two new detector technologies, Resistive Micromegas (MM) and small strip Thin Gap Chambers (sTGC) conforming a system of ~2.4 million readout channels. Both detectors will be used for muon triggering and precision tracking. A common readout path and two separate trigger paths are developed for these two detector technologies. The frontend electronics will be implemented in about 8000 boards including the design of 4 custom ASICs capable of driving trigger and tracking primitives to the backend trigger processor and readout system. The readout data flow is designed through a high-throughput network approach. The large number of readout channels, short time available to prepare and transmit trigger data, large volume of output data, harsh radiation environment, and the need of low power consumption all impose great challenges on the system design. We will present the overall design along with the status of all ASIC and board prototypes.

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Performance and Calibration of 2m^2 -sized 4-layered Micromegas Detectors for the ATLAS Upgrade

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The increased luminosity of the HL-LHC requires a new, high rate capable, high resolution detector technology for the inner end cap of the muon spectrometer of the ATLAS experiment. For this purpose the Micromegas technology is chosen as precision tracker. The SM2 modules are 2 m^2 -sized micromegas quadruplets. This large size requires a sophisticated construction to provide a spatial resolution better than 100 µm. The first series SM2 modules were investigated using 120 GeV pions and muons at SPS/CERN as well as with cosmic muons in a precision facility.

During the testbeam in August 2017 at the H8 beamline of the SPS 4 small size micropattern detectors were used as tracking reference. The spatial resolution of the SM2 detector is analyzed using two different methods. A charge weighted position reconstruction, the so-called centroid method, achieves a spatial resolution of about 80 µm for perpendicular particle incident. A time projection chamber like approach, the so-called µTPC method, yields a similar resolution for tracks inclined to the active area of the module.

To investigate and calibrate the full active area of SM2 quadruplets a Cosmic Ray Facility (CRF) is used. It uses two ATLAS Monitored Drift Tube chambers (MDT) to provide precise muon track information in the order of 100 µm. A segmented trigger hodoscope provides additional position information in the order of 10 cm along the wires of the MDTs. The angular acceptance of the CRF is between −30 ◦ and +30 ◦ to the zenith angle over an area of about 8 m^2 .

We present results for the first series SM2 quadruplets with 12288 channels read out fully by 96 APVs connected to six FEC cards. A segmentation of the active area into smaller partitions enables a detailed analysis of local detector properties, for example geometrical quality, homogeneity in efficiency, in pulse height and in spatial resolution.

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The Micromegas construction project for the ATLAS New Small Wheel

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In order to meet the requirements of the upcoming luminosity upgrade of the LHC, the Micromegas (MM) technology was selected to be adopted for the New Small Wheel (NSW) upgrade, dedicated to precision tracking. A large surface of the forward regions of the Muon Spectrometer will be equipped with 8 layers of MM modules forming a total active area of 1200 m2. The NSW is scheduled to be installed in the forward region of $1.3 < |\eta| < 2.7$ of ATLAS during the second long LHC shutdown. The NSW will have to operate in a high background radiation region, while reconstructing muon tracks as well as furnishing information for the Level-1 trigger. The project requires fully efficient MM chambers with spatial resolution down to 100 µm, a rate capability up to about 15 kHz/cm2 and operation in a moderate (highly inhomogeneous) magnetic field up to B=0.3 T. The required tracking is linked to the intrinsic spatial resolution in combination with the demanding mechanical accuracy. An overview of the design, construction and assembly procedures of the Micromegas modules will be reported. Results and characterization with cosmic rays of the first series module will also be presented.

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Electron and photon energy measurement calibration with the ATLAS detector

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An accurate calibration of the energy measurement of electron and photon is needed for many ATLAS physics analyses. The calibration of the energy measurement is performed in-situ using a large statistics of Z->ee events. A pre-requisite of this calibration is a good understanding of the material in front of the calorimeter and of the inter-calibration of the different calorimeter layers. The Z->ee sample is also used to measure the energy resolution.
The results obtained with the pp collisions data at sqrt(s)=13 TeV in 2015-2017 corresponding to an integrated luminosity of 80 fb-1 are presented as well as the corresponding uncertainties on the electron and photon energy scales.

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CMS electron and photon performance at 13 TeV

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The Compact Muon Solenoid (CMS) detector is one of the two multi-purpose experiments at the Large Hadron Collider (LHC) and has a broad physics program. Many aspects of this program depend on our ability to trigger, reconstruction and identify events with final state electrons, positrons, and photons with the CMS detector with excellent efficiency and high resolution.

In this talk we present the full process of electron and photon reconstruction in CMS, starting from tracker hits and energy deposits in the electromagnetic calorimeter, the method to achieve the ultimate precision in Run II energy measurements, the trigger and identification strategies (based both on cut based approach and on multivariate analysis) to discriminate prompt electrons and photons from background, and the methods to estimate the associated systematic uncertainties. Finally the performance on benchmark channels (such as H->gamma gamma and Z->ee) will be shown.

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Experimental Setup to capture high resolution images for Quality Control of GEM Foils

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We present an experimental setup developed at the Detector Laboratory at Antonio Nariño University to automatically and precisely capture high resolution images of GEM foils. These high resolution images are then used for quality control of the corresponding GEM foils through an automatic determination of defects and geometry changes of the thousands of the micro-holes contained in

a GEM foil. The setup consists of one 30 x 30 centimeters dual axis linear stepper with a camera with a CMOS sensor to capture the high resolution images, and finally a software, SOFA Software for Foils Analysis for the automatic quality control of the foils through image analysis. With this set up and software, we can identifies variations in the geometry of the micro-holes of a GEM-foil up to one pixel = 1.25 µm. The automatization of image capture and image analysis improve the present quality control of GEM foils in accuracy, efficiency and cost reduction.

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Scintillation crystal growth at the Center for Underground Physics

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The Center for Underground Physics (CUP) at the Institute for Basic Science (IBS) has been conducting two major experiments, the COSINE experiment for dark matter search and the AMoRE experiment for neutrinoless double beta decay search. The COSINE experiment is using NaI:Tl scintillation crystals and the AMoRE is studying the 100Mo based scintillation crystals such as CaMoO4 and Li2MoO4. To minimize the internal background from the crystals, both experiments require ultra-pure scintillation crystals grown from highly purified powder.
For the COSINE experiment upgrade with more amount of NaI:Tl crystals, we had set up a small-size grower for an R&D of the crystal growth and a full-size grower for growing large size crystals for the final detectors. We have been growing a few pure NaI crystals and a few Tl doped NaI crystals (NaI:Tl) at the small-size grower and optimizing the growth condition of the NaI:Tl crystals before trying the full-size grower.
For the AMoRE experiment, we grew the CaMoO4 and Li2MoO4 crystals successfully by a Czochralski grower. The Li2MoO4 crystals were grown by using the purified MoO3 powders. We also succeeded in the double-crystallization growth of the Li2MoO4 which was grown by two of single-crystallized Li2MoO4 crystals as raw materials.
Purities of the grown crystals (NaI, CaMoO4, Li2MoO4) were confirmed by ICP-MS measurements and the Li2MoO4 crystals were measured further by a HPGe detector. The XRD patterns of the crystals were also checked with references to confirm the compositions of the grown crystals. In this study, we will present the growths and measurements results of crystals at the CUP.

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Performance of the 3x1x1 m3 Dual Phase Liquid argon TPC

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Liquid Argon Time Projection Chamber (LAr TPC) is currently the most attractive technology for neutrino oscillations studies. Not only LAr TPCs are cost-effective and scalable to multi-ton scales, but they are also excellent calorimeters and are able to 3D reconstruct the tracks of ionising particles arising from neutrinos decay products. Future giant liquid Argon TPCs, at the ten-kiloton level, are now at the design and prototyping stage in the context of the Deep Underground Neutrino Experiment (DUNE). DUNE will comprise four 10 kton LAr TPC modules placed at the Sanford Underground Research Facility (SURF) in South Dakota (USA). Two different technologies will be tested: single phase and dual phase. The dual phase operation allows to amplify and readout the signal offering several advantages over the single phase. The first step towards large scale Dual-Phase LAr TPCs has been the commissioning and operation of a 3x1x1 m3 detector at CERN with 4.2 tons of Argon. The construction, commissioning, performance and first results achieved with this detector will be addressed in this talk.

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Performance in heavy -ion beam tests of a high time resolution and two-dimensional position sensitive MRPC with transmission line impedance matched to the FEE

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We report on the result of the R&D activity focused on the development of a Multi-Gap Resistive Plate Chamber with Multi-Strip readout architecture, for high counting rate and multiplicity environment, specific for high interaction rate experiments.
An innovative chamber design which fulfills simultaneously two requirements for strip readout MRPCs, i.e. the granularity and the impedance matching to the front-end electronics, will be presented.
The results obtained with this prototype in two in-beam tests performed at CERN-SPS in both triggered and trigger-less/free streaming readout mode operations will be reported.
The performance in terms of efficiency, time resolution, cluster size, and two-dimensional position resolutions in conditions of exposure of the whole active area of the chamber to high flux and high multiplicity reaction products will be discussed. The obtained results recommend such an architecture as solution for large area detectors with accurate simultaneous measurement of time and position in high energy experiments.

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High rate performance of Small-pad Resistive Micromegas. Results of different resistive protection concepts

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Micromegas resistive detectors have already proven to be suitable for precision tracking at rates up to few kHz/cm^2. Rate capability up to few MHz/cm^2 and low occupancy can be achieved by using few mm2 readout pads. Such a rate capability will be required in upgrades of forward muon detectors of LHC experiments as well as in experiments at future colliders.
We present the development of resistive micromegas with O(mm^2) pad readout aiming at precision tracking without efficiency loss up to several MHz/cm^2. To achieve this goal the miniaturization of the readout elements is a key element of the project.

A series of small-pad micromegas detectors have been built with the spark protection resistive layer realised with different techniques: a pad-patterned embedded resistor with screen printing, and a uniform DLC (Diamond Like Carbon structure) layer by sputtering. All detectors consist of a matrix of 48x16 pads. Each pad has a rectangular shape with a pitch of 1 and 3 mm in the two coordinates. The active surface is 48x48 mm^2 with a total number of 768 channels, routed off-detector for readout.
Characterization and performance studies of the detectors have been carried out by means of radioactive sources, X-Rays guns, cosmic rays and high energy particle beam. The response under high irradiation, high rate exposure, is compared with low irradiation performances. A comparison of performance with different resistivity values will be presented.

A new prototype with integrated electronics readout, with front-end IC chip mounted (or bonded) on the back side of the readout plane, is currently under assembly. Such a configuration guarantee full scalability to large size detectors, overcoming the challenging problem (unsolvable for large size) of routing off detector the pad readout lines. The design, the construction and preliminary data of this new detector, will also be reported.

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Characteristics of MCP-PMTs in magnetic field

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Performance of the microchannel plate photomultiplier (MCP-PMT) in magnetic field is an important aspect for its application in the proposed electron ion collider (EIC). The motivation of this paper is to explore the critical parameters that affect the performance of MCP-PMT in magnetic field, and to guide the design optimization of MCP-PMTs for high magnetic field tolerance. MCP-PMTs with two different designs were examined in magnetic field and the results were compared. The magnetic field tolerance of MCP-PMT with new independent biased voltage design shows significant improvement (up to 0.8 T) compared to that of the MCP-PMT with resistor chain design (up to 0.2 T), indicating that optimization of the individual MCP voltage is an important parameter for magnetic field tolerance improvement. The effects of other parameters such as the rotation angle relative to the magnetic field direction and the bias voltage between photocathode and entrance MCP were thoroughly studied with the independent biased voltage design. The gain of the MCP-PMT

exhibits enhanced performance at ± 8 degree tilt angle due to the original MCP 8 degree bias angle. Maximum gain values are observed dependent on the optimal bias voltages in different magnetic field strength.

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Prototype Production of Large Area Picosecond Photodetectors

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We report prototype production results achieved for fully functional sealed Large Area Picosecond Photodetectors (LAPPD™). The LAPPD™ is a microchannel plate (MCP) based photodetector, capable of imaging with single-photon sensitivity at high spatial and temporal resolutions in a hermetic package with an active area of 400 square centimeters. In December 2015, Incom Inc. completed installation of equipment and facilities for demonstration of early stage pilot production of LAPPD™. Initial fabrication trials commenced in January 2016. The "baseline" LAPPD™ employs an all-glass hermetic package with top and bottom plates and sidewalls made of borosilicate float glass. Signals are generated by a bi-alkali Na2KSb photocathode, amplified with a stacked chevron pair of "next generation" MCPs produced by applying resistive and emissive atomic layer deposition coatings to glass capillary array (GCA) substrates. Signals are collected on RF strip-line anodes applied to the bottom plates which exit the detector via pin-free hermetic seals under the side walls. Fully functional, sealed LAPPD™s tested to date have shown electron gains > 7.5 x10^6 @ 850/950 V (entry/exit), low dark rates (9.5 Cts/s cm^2), space resolution along strips of 2.9 mm RMS for single photoelectrons, cross strip spatial resolutions of 1.6 mm RMS, and along-strip time difference resolutions of 33.4 psec RMS. Many of these devices also had very high QE photocathodes that were uniform over the full 8"X 8" window area (#15 QE% @ 365nm Max/Avg/Min = 25.8/22.3±3/15.7). LAPPD™ performance results and test methods for product produced and delivered to early adopter customers during the first half of 2018 will be reviewed. In addition, recent advances in the development of LAPPD™ will also be reviewed as the baseline design is adapted to meet the requirements for a wide range of emerging applications including DOE-supported R&D for the Deep Underground Neutrino Experiment (DUNE), nuclear physics applications such as EIC, homeland security, medical imaging applications including for proton therapy and astronomical applications for direct and indirect photon detection.

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The R&D, Mass Production of the 20 inch MCP-PMT for neutrino detector

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Researchers at IHEP have conceived a new concept of MCP-PMT several years ago. The small MCP units replace the bulky Dynode chain in the large PMTs. In addition the transmission and reflection photocathode in the same glass bulb to enhance the efficiency of photoelectron conversion. After three years R&D, a num-ber of 8 inch prototypes were produced in 2013. The 20 inch prototypes were followed in 2014, and its' per-formance were improving a lot in 2015. This type of PMT has large sensitive area, high QE, and large P/V for good single photoelectron detection. Compensating the PMT performances, cost, radioactivity, the JUNO ordered 15000 pic 20-inch MCP-PMT from the NNVT in Dec.2015. The MCP-PMT collaboration group finished to build the mass production line in Nanjing, and finished the batch test system in the same place in 2016. From 2017 to 2019, all the 20-inch PMTs will be produced and tested one by one in NNVT for JUNO. This presentation will talk about the R&D, the mass production and batch test result of the 5K pieces of MCP-PMT prototypes for JUNO.

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The TORCH time-of-flight detector

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The TORCH detector is a time-of-flight based system that is being developed for use in particle physics experiments with the aim of providing particle identification in the momentum range 2–10 GeV/c over a wide area. The detector exploits prompt Cherenkov light produced by charge particles traversing a 10 mm thick quartz plate. Photons propagate via total-internal reflection and are focussed onto a detector plane comprising position-sensitive micro-channel plate (MCP) detectors. The goal is to achieve a resolution of 15 ps per particle by combining information from around 30 detected photons, given a single-photon resolution of 70 ps. The MCP-PMT detectors have been developed with a commercial partner (Photek), leading to the delivery of a 53 by 53 mm square tube, with 8 by 128 pixels. A small-scale demonstrator of the TORCH has been tested in beam tests and preliminary results indicate a single photon-resolution better than 100 ps. Progress towards a larger-scale system with a 10 MCP-PMTs, and the possible impact on the physics programme of a future LHCb upgrade, will be presented.

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Ageing and high rate studies on resistive Micromegas at the CERN Gamma Irradiation Facility

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Two resistive-strip bulk Micromegas detectors have been installed in the Gamma Irradiation Facility at CERN in 2015.
The primary goal was to assess the performance of the detectors after long term irradiation. This study is particularly relevant in view of the adoption of the Micromegas technology for future upgrades, as in the ATLAS inner muon system. In this region the expected accumulated charge in 10 years of HL-LHC operation has been estimated in 0.2 C/cm^2. After 3 years of continuous irradiation more than 0.3 C/cm^2 have been accumulated, allowing to draw clear conclusions concerning ageing effects on the detectors. During this period, the detector currents have been monitored and the performance of the detectors has been studied by combining the photon background with muon beam available at the facility. In particular, the spatial resolution and detector gain have been studied up to about 70 kHz/cm^2. Complementary to these, a precise estimation of the detectors sensitivity to photons has been obtained by a Geant4 simulation.

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Scalability of technologies for highly granular calorimeters

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After the successful demonstration of the performance of highly granular electromagnetic and hadronic calorimeters by the CALICE collaboration, emphasis has shifted to system issues and large scale production. These are addressed by varied technological prototypes currently in production. We present work on silicon, scintillator, and gas-detector based imaging calorimeters for future electron-positron colliders, pointing out the relevance also for LHC upgrades and other applications. Emphasis will be placed on techniques developed for mass production, such as automatic testing of active detector elements; packaging, wrapping, and mounting of scintillators; and automatised assembly chains as well as on solutions for large-size detector components, precision mechanics and services. We also report results from recent laboratory and beam tests of electromagnetic and hadronic calorimeter prototypes using these production and testing techniques.

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Four dimensional calorimetry with both-side readout of the CsI calorimeter in the $K_L \to \pi^0 \nu \bar{\nu}$ search

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The aim of the KOTO experiment 1 is the first observation of $K_L \to \pi^0 \nu \bar{\nu}$ which is sensitive to CP-violating new physics beyond the standard model (SM). The experimental signature is only two photons from the π^0. To detect this simple signature, the KOTO detector consists of a pure cesium iodide (CsI) calorimeter and hermetical veto counters. The calorimeter is made of 50 cm long CsI

crystals stacked in a cylinder of 1.9 m diameter. Each crystal is read out with a PMT. $K_L \to \pi^0\nu\bar{\nu}$ is a rare decay: its SM prediction of the branching fraction is $(3.0 \pm 0.3) \times 10^{-11}$. One of the major backgrounds is caused by a single neutron generating two clusters in the calorimeter. We are developing multiple countermeasures to reject such events. One of the methods is to distinguish photon clusters from neutron clusters with the depth of their interactions in the CsI crystals. To this end, we plan to install 4000 silicon photomultipliers (SiPMs) on the front surface of the crystals, and locate the depths of interactions by measuring the timing difference between SiPMs and PMTs on the back surface of the crystals.

I will report:
1) beam test results on the neutron rejection power of this method,
2) expected background suppression in the KOTO experiment, and
3) effect of expected radiation damage on the SiPM.

Reference
1 J. K. Ahn $et\ al.$, Prog. Theor. Phys. 021C01 (2017).

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Fast Timing Detectors towards a 4-Dimensional Tracking

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In this contribution, I will review the growing interest in implementing larga area fast timing detectors with a time resolution of 30-50 ps, based on Low-Gain Avalanche Detectors.
Precise time information added to tracking brings benefits to the performance of the detectors by reducing the background and sharpening the resolution; it improves tracking performances and simplify tracking combinatorics.
Large-scale high-precision timing detectors have to face formidable changes in almost every aspect: sensors performance, segmentation and radiation tolerance, very low-power and low-noise electronics, cooling, low material budget, and large data volumes.
I will report on the current status and new development of such detectors for high energy physics, in view of their possible use in the experiment upgrades at the High Luminosity LHC.

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Test Beam Results of 3D Detectors in CVD Diamond

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Detectors based on Chemical Vapor Deposition (CVD) diamond have been used extensively and successfully in beam conditions/beam loss monitors as the innermost detectors in the highest radiation areas of Large Hadron Collider (LHC) experiments. Over the last two years the RD42 collaboration

has constructed a series of 3D detectors using CVD diamond as the active material and laser fabricated columns in the bulk and characterized them in test beams. As a result, the 3D geometry in diamond has been measured to collect more than two times the charge of a standard planar diamond device. 3D cell sizes from 100um x 150um down to 50um x 50um have been tested. The electrical properties and beam test results of the latest 3D devices will be presented.

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Latest Results on Radiation Tolerance of Diamond Detectors

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At present most experiments at the CERN Large Hadron Collider (LHC) are planning upgrades in the next 5-10 years for their innermost tracking layers as well as luminosity monitors to be able to take data as the luminosity increases and CERN moves toward the High Luminosity-LHC (HL-LHC). These upgrades will most likely require more radiation tolerant technologies than exist today. As a result this is one area of intense research. Chemical Vapor Deposition (CVD) diamond is one such technology. CVD diamond has been used extensively in beam condition monitors as the innermost detectors in the highest radiation areas of BaBar, Belle, CDF and all LHC experiments. This talk will describe the recent radiation tolerance measurements of the highest quality polycrystalline CVD (pCVD) material for a range of proton energies, pions and neutrons obtained with this material with the goal of elucidating the issues that should be addressed for future diamond based detectors. The talk will also present the evolution of various semiconductor parameters as a function of dose.

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Commissioning of liquid Xe detector with VUV-MPPC readout for MEG II experiment

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MEG II experiment is an upgrade of the MEG experiment which searches for the charged lepton flavor violating decay of muon, $\mu \to e\gamma$. Target sensitivity of MEG II is 6×10^{-14}, which is one order of magnitude better than MEG 1. The engineering run of the MEG II detectors is planned in 2018.

Liquid xenon (LXe) detector is designed to measure the hit position, energy, and timing of 53MeV gamma-ray from $\mu \to e\gamma$ decay, and its resolutions must be good enough to achieve the target sensitivity.

For the upgrade of LXe detector, 216 PMTs (2-inch) on the gamma-ray entrance face were replaced to 4092 MPPCs ($12 \times 12\mathrm{mm}^2$), aiming to achieve better granularity and uniformity of the scintillation readout. The position and energy resolution are expected to be improved by a factor of two. For this purpose, a large area VUV-sensitive MPPC was developed in collaboration with Hamamatsu Photonics 2.

In 2017, the construction of the detector was finished and the first operation of the LXe detector was carried out. The control and purification of LXe were successfully performed, and good stability of the light yield (i.e. purity) was demonstrated. The properties of the MPPCs operated in LXe was measured. Gamma-rays around the signal energy from muon decay were successfully detected, and the position and timing resolutions were being estimated. In this talk, the performance of the LXe detector including the performance of the MPPCs will be presented.

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The KLOE-2 experiment at DAPHNE

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The KLOE-2 experiment at the INFN Laboratori Nazionali di Frascati has concluded the data-taking at the e+e- DAPHNE phi-factory with more than 5 fb-1 of integrated luminosity collected. Record performance in terms of 2.4 x 10^32 cm-2s-1 peak luminosity and 14 pb-1 maximum daily integrated luminosity were achieved with the crab waist scheme of beam collisions.

KLOE-2 represents the continuation of KLOE with a new physics program mainly focused on the study of K short, η rare and decays as well as on kaon interferometry, test of discrete symmetries, and search for physics beyond the Standard Model. The collected data sample will allow to perform CPT symmetry and quantum coherence tests using entangled neutral kaons with an unprecedented precision, studies of γγ-physics processes, and the search for signals of a hidden dark-matter sector, among the fields to be addressed.

The general purpose KLOE detector, composed by one of the biggest Drift Chamber ever built surrounded by a lead-scintillating fiber Electromagnetic Calorimeter among the best ones for energy and timing performance at low energies, undergone several upgrades including State-of-The-art cylindrical GEM detector: the Inner Tracker. To improve its vertex reconstruction capabilities near the interaction region, KLOE-2 is the first high-energy experiment using the GEM technology with a cylindrical geometry, a novel idea that was developed at LNF exploiting the kapton properties to build a transparent and compact tracking system. To γγ-physics the detector has been upgraded with two pairs of electron-positron taggers: the Low Energy Tagger (LET), inside the KLOE apparatus, and the High Energy Tagger (HET) along the beam lines outside the KLOE detector.

An overview of the KLOE-2 experiment will be given including present status and achievements together with physics plans.

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Ultra-Fast Hadronic Calorimetry

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Calorimeters for particle physics experiments with integration time of a few ns will substantially improve the capability of the experiment to resolve event pileup and to reject backgrounds. In this paper time development of hadronic showers induced by 30 and 60 GeV positive pions and 120 GeV protons is studied using Monte Carlo simulation and beam tests with a prototype of a sampling steel-scintillator hadronic calorimeter. In the beam tests, scintillator signals induced by hadronic showers in steel are sampled with a period of 0.2 ns and precisely time-aligned in order to study the average signal waveform at various locations w.r.t. the beam particle impact. Simulations of the same setup are performed using the MARS15 code. Both simulation and test beam results suggest that energy deposition in steel calorimeters develop over a time shorter than 3 ns providing opportunity for ultra-fast calorimetry. Simulation results for an ideal calorimeter consisting exclusively of bulk tungsten or copper are presented to establish the lower limit of the signal integration window.

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Flavour Physics at the High Luminosity LHC: LHCb Upgrade II

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The LHCb Collaboration is planning an Upgrade II, a flavour physics experiment for the high luminosity era. This will be installed in LS4 (2030) and targets an instantaneous luminosity of 1 to 2 x10^34 cm-2 s-1, and an integrated luminosity of at least 300fb-1. Modest consolidation of the current experiment will also be introduced in LS3 (2025). Physics goals include probing new physics scenarios in lepton flavour universality, obtaining unprecedented precision on CKM tests, and expanding the LHCb programme into new measurement areas such as Higgs decays to charm. The detector design options include the introduction of timing information, with opportunities in vertexing and tracking, electromagnetic calorimetery, and RICH particle identification. Preliminary studies for the LHC suggest that the luminosity goals will be achievable. The collaboration produced an Expression of Interest in 2017 and will issue a physics case document in May 2018, with Technical Design Reports planned for 2020.

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The Mu2e Tracker

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The Mu2e experiment will search for neutrinoless conversion of muons into electrons
In the field of an aluminum nucleus. The signature of this process is an electron with
energy nearly equal to the muon mass. Precise and robust measurement of the outgoing
electron momentum, combined with other background rejection methods, is essential to the
experiment. We rely on a low-mass straw tube tracker to achieve these goals. The tracking
system must operate in a vacuum and a 1 Tesla magnetic field. We have chosen to use about
20,000 thin-wall Mylar straws held under tension to avoid the need for supports within
the active volume. In addition to measuring distance from the wire by drift time,

subnanosecond measurement of signal propagation time will be used to measure position along the wire. Charge will be measured using ADCs to provide particle identification capability.

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Construction and performance tests of the COMET CDC

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The COMET experiment at J-PARC searches for the neutrinoless coherent transition of a muon to an electron in the field of an aluminum nucleus, which violates the lepton flavor conservation and has never been observed yet so far. The conversion rate is predicted to be enhanced in new physics models beyond the Standard Model, while the process is extremely suppressed in the Standard Model. The goal of the COMET Phase-I is to explore the muon-to-electron conversion with a single event sensitivity of 3×10^{-15}, which is 100 times better than the current limit.

In the COMET Phase-I, the converted electrons, which possess monochromatic momentum of 105 MeV/c, are detected with a cylindrical drift chamber (CDC) in a solenoidal magnetic field of 1 T. An inevitable physical background is the decay-in-orbit electrons emitted from the normal 3-body muon decay in an atomic orbit. The momentum distribution of the decay-in-orbit electrons has a high-momentum tail which is able to reach nearly 105 MeV/c. In order to distinguish the signal from the background, good momentum resolution of 200 keV/c is required. Therefore the CDC is designed to reduce material thickness to suppress the multiple scattering effect. We adopt a gas mixture of He:i-C_4H_{10} (90:10) as well as unplated 126-μm aluminum field wires and a 0.5-mm thin plastic inner wall. In addition, an alternated all stereo layer configuration for 20 layers in total is adopted to achieve good spatial resolution for the axial direction.

The wire stringing for 19548 wires in total was conducted. The wire tension was constrained so that the gravitational sag difference in between wires should be less than 100 μm. The construction of the CDC was successfully completed, and thereafter performance tests using cosmic rays are being carried out. We have achieved spatial resolution of 170 μm and efficiency of 95% so far. A future commissioning plan of the CDC will also be presented in this talk.

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The Mu3e scintillating fiber tracker R&D

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The Mu3e experiment searches for a rare lepton flavour violating μ+ ⟶ e+e+e− decay and it aims at reaching an ultimate sensitivity of 10^−16 on the branching fraction of the μ+ ⟶ e+e+e− decay, four orders of magnitude better than the current limit B(μ+ ⟶ e+e+e−) < 10^−12. The experiment will be hosted at the Paul Scherrer Institute (Villigen, Switzerland) which delivers the most intense low momentum continuous muon beam in the world (up to few ×10^8 μ/s). In order to be sensitive to the signal at this so high level, to reject the background and to run at the intensity beam frontier excellent detector performances are needed. To match those requests the experiment has been design based on completely new technologies, one of that given by a tracker made of the thinnest available scintillating fibers coupled to silicon photomultipliers (SiPMs).

We will report in detail the status of the scintillating fiber tracker R&D, from the fiber through the photosensors up to the electronics and the data acquisition, and we will discuss the results obtained with our current prototypes. The final aim would be to provide a fiber tracker detecting minimum ionizing particles (m.i.p.) with a minimal amount of material (the detector thickness below 0.4 % of radiation length X0) with full detection efficiency, timing resolutions below 1 ns and spatial resolution below 100 μm. While expertise on scintillating fibers and SiPMs has been around for a while, nobody has ever built a detector that matches these demands. Current measurements show very promising results: a very high detection efficiency for m.i.p. with a single fiber layer (≥ 95%), and a full efficiency for multilayer configurations (≥ 99%); timing resolutions of the order of 500 ps (multi-layer configuration); optical cross-talk between coated fibers at a negligible level (< 1%), for which spatial resolutions < 50 μm are foreseen (multilayer configuration). We will also discuss the very good agreement between data and Monte Carlo simulation predictions.

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Silicon Strip Detector for J-PARC Muon g-2/EDM Experiment

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The muon anomalous magnetic moment $(g-2)_\mu$ and electric dipole moment (EDM) are sensitive to new physics beyond the Standard Model. J-PARC muon g-2/EDM (E34) experiment 1 aims to measure $(g-2)_\mu$ with a precision of 0.1 parts per million and search for EDM with a sensitivity of $10^{-21}e\cdot$cm with different concept from the muon g-2/EDM experiment at BNL and FNAL. We utilize high intensity proton beam at J-PARC and newly developed technique of ultra-cold muon beam, which is produced by thermal muonium productions 2 followed by laser ionization [3] and muon linear acceleration [4]. The ultra-cold muon beam accelerated up to 300 MeV/c are injected into the storage magnet with a 3 Tesla magnetic field [5]. The positron from muon decay is detected by the silicon strip detector.

The 40 silicon strip vanes are placed radially inside the storage ring. Each vane has single-sided p-on-n type silicon strip sensors on both sides with mutually orthogonal strips. Two-dimensional position of a positron track is detected by two layers of the silicon strip sensor. The silicon strip sensor has 1024 readout strips at a constant strip pitch of 190 μm pitch [6]. The active area is 97.28 mm$\times$ 97.28 mm with 320 μm thickness. We started to fabricate the silicon strip sensors with Hamamatsu photonics and estimate its characterization. The readout ASIC is required to tolerate a high hit rate of 1.4 MHz per strip, to be stable to the change of hit rate by a factor of $1/150$, and to have deep memory for the period of $\sim$ 40 μs with 5 ns resolution. The prototype readout ASIC "SliT128A" has been fabricated using the Silterra 0.18-μm CMOS process. We connected the SliT128A with a silicon strip sensor thorough signal fan-out flex circuit (i.e., pitch adapters) made by Fujikura Ltd. and tested them with a pulsed muon beam at J-PARC.

We developed software tools for our silicon strip detector. The timing stability is important for the precise measurement of the $(g-2)_\mu$. Therefore, we implemented the behavior of the ASIC into the simulation, and estimated the timing shift due to the pileup. Track reconstruction efficiency should be high and stable against change of hit rate. We developed a track finding tool based on Hough transform method and confirmed the track reconstruction efficiency keeps greater than 90% even at the expected highest hit rate.

In this talk, we present the design of the silicon strip detector, development status of the each component, and the expected tracking performance based on simulation.

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The micro-Resistive-WELL detector for the phase 2 upgrade of the LHCb muon detector

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A phase 2 upgrade is proposed for the LHCb experiment in order to take full advantage of the flavor physics opportunities at the HL-LHC. This upgrade could be installed during Long Shutdown 4 of the LHC (2030) and is targeting a luminosity of 2x10^34 cm-2s-1, ten times that of the phase 1 upgrade. Hence it would require a completely revised detector strategy. One of the primary importance physics requirements will be a robust and efficient muon detection. The detector technology suited for the upgrade muon detector should reach a stable and efficient operation up to particle fluxes of several MHz/cm2 in the most illuminated region of the apparatus. It has to guarantee a radiation hardness and effective spark quenching up to integrated charges of C/cm2, and have a high granularity pixel readout to operate efficiently at high rate. In addition, it will be needed to replace large area of the external region of the apparatus designed to operate a much lower particle fluxes. The micro-Resistive-WELL (muRWELL) is one of the detector candidates to be used in the LHCb phase 2 upgrade. The muRWELL has been conceived as a compact, simple and robust Micro-Pattern Gaseous Detector (MPGD) for large area HEP applications requiring operation in harsh environment. The detector amplification stage is realized with a polyimide structure micro-patterned with a blind-hole matrix, embedded through a thin Diamond Like Carbon (DLC) resistive layer with the readout PCB. it is possible to achieve large gains (> 10^4) in very safe operation, thanks to the insertion of the resistive layer with surface resistivity typically in the range 10÷200 MOhm/square, mitigating the transition from streamer to spark. Different detector layouts are studied: the simplest one, based on a single-resistive layer with edge grounding, is designed for low-rate applications (up to 30-40 kHz/cm2), while more sophisticated schemes are under study for high-rate purposes (up to 2-3 MHz/cm2). The single-resistive layer scheme, under development with industrial partners, was extensively validated, and it is ready for applications in HEP. The high-rate versions of the muRWELL, based on different current evacuation schemes such as the double resistive layer, and the single-resistive layout with conductive/resistive-grid grounding, are object of an intense R&D phase, with the goal of optimizing the performances and the constructive process. Both of these detector layouts are suitable for the phase 2 upgrade of the LHCb muon detector: the single-resistive layer scheme aims at representing a cost-effective solution for the replacement of the external region of the apparatus, the high-rate scheme is a perfect candidate for the much more challenging inner region. After an introduction on the principle of operation of the detector, we will discuss the status of the R&D, giving an overview of the different architectures under study.

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The Mu2e crystal calorimeter

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The Mu2e experiment at Fermilab will search for the charged-lepton flavour violating
neutrino-less conversion of a negative muon into an electron in the field of an aluminum nucleus.
The Mu2e detector is composed of a tracker and an electromagnetic
calorimeter and an external veto for cosmic rays.
The calorimeter plays an important role in providing excellent particle identification capabilities,
a fast online trigger filter while aiding the track reconstruction capabilities.
The calorimeter requirements are to provide a large acceptance for ~100 MeV electrons and reach:
1) a time resolution better than 0.5 ns @ 100 MeV;
2) an energy resolution O(10\%) @ 100 MeV;
3) a position resolution of 1 cm.

The calorimeter consists of two disks, each one made of 674 undoped CsI
crystals readout by two large area 2×3 array of UV-extended
SiPMs of 6x6 mm^2 dimensions.
A large scale prototype has also been constructed and tested at the beam test facility in Frascati.
It consists of 51 pre-production crystals readout by two Mu2e SiPM.
We present the progresses done to complete the calorimeter design as well as
a summary of results obtained in the production of components and on the test beam
of the prototype.

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A new particle identification method with the Belle II calorimeter using pulse shape discrimination in CsI(Tl)

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We will present studies on the development and first implementation of a novel technique to improve particle identification at high energy physics experiments through the use of pulse shape discrimination (PSD) with CsI(Tl) scintillators used for electromagnetic calorimeters. Using $5 \times 5 \times 30$ cm^3 CsI(Tl) crystals, such as those used in the electromagnetic calorimeter of the Belle II experiment, we will discuss a new method 1 for characterizing and simulating the CsI(Tl) scintillation response for hadronic energy deposits developed with neutron and proton testbeam data collected at the TRIUMF Proton Irradiation Facility. By implementing the measured pulse shape differences between electromagnetic and hadronic energy depositions into GEANT4 simulations of an array of CsI(Tl) crystals,

we demonstrate the potential for PSD to separate electromagnetic and hadronic showers in CsI(Tl) calorimeters. In particular we show the potential for using PSD to distinguish between calorimeter clusters originating from high energy photons and K_L^0 mesons or neutrons. In addition, progress on the implementation of PSD for the Belle II experiment's CsI(Tl) calorimeter will be outlined and initial performance results using first Belle II collision data will be reported.

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The LHCb RICH Upgrade

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The LHCb RICH detectors have been operating successfully since 2010 and proven to be an essential element of the experiment thanks to their excellent particle identification performance. During the Long Shutdown II of the LHC in 2019-2020, the two detectors will be upgraded in order to maintain their PID performance while operating at significantly increased luminosity, aiming to collect 5 fb-1 per year. This will allow to greatly enhance the statistical precision of physics measurements and to advance the search for very rare B- and D-meson decays. To cope with the challenges of the 40 MHz readout rate and increased occupancy the two detectors will undergo a major upgrade. The Hybrid Photon Detectors will be replaced by multi-anode PMTs together with new front-end electronics capable of reading out every bunch crossing of the LHC. Additionally, the optics of the upstream RICH detector will be modified. Following many tests with particle beams and simulations, the LHCb RICH Upgrade is now in its final stage. The current status of the upgrade will be presented.

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The LHCb Velo Upgrade

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The Large Hadron Collider Beauty detector is a flavour physics detector, designed to detect decays of b- and c-hadrons for the study of CP violation and rare decays. At the end of Run-II, many of the LHCb measurements will remain statistically dominated. In order to increase the trigger yield for purely hadronic channels, the hardware trigger will be removed and the detector will operate at 40 MHz. This, in combination with the five-fold increase in luminosity necessitates radical changes to LHCb's electronics with entire subdetector replacements required in some cases. The Vertex Locator (VELO) surrounding the interaction region is used to reconstruct the collision points (primary vertices) and decay vertices of long-lived particles (secondary vertices).

The upgraded VELO modules will each be equipped with 4 silicon hybrid pixel tiles, each read out with by 3 VeloPix ASICs. The silicon sensors must withstand an integrated fluence of up to $8{\times}10^{15} 1 MeV n_e q/cm^2$, a roughly equivalent dose of 400 MRad. The highest occupancy ASICs will have pixel hit rates of 900 Mhit/s and produce an output data rate of over 15 Gbit/s, with a total rate of 1.6 Tbit/s anticipated for the whole detector. The detectors are located in vacuum, separated from the beam vacuum by a thin custom made foil. The foil will be manufactured through a novel milling process and possibly thinned further by chemical etching.

An additional challenge is the non uniform nature of the radiation damage, which results in requiring a guard ring design with excellent high voltage control. In addition, the n-in-p design requires the guard ring to be on the chip side making the high voltage reach the vicinity of the ground plane (about 30 μm apart). This requires a high voltage tolerant setup for irradiated assemblies which can be achieved using a vacuum chamber. The performance of the prototype sensors has been investigated in a test beam in which a dedicated telescope system was created read out by Timepix3 ASICs. Several different tests of the of the sensor prototypes were performed before and after irradiation. A collection of preliminary results will be presented, as well as a comparison of the performance of the different sensor prototypes.

The VELO upgrade modules are composed of the detector assemblies and electronics hybrid circuits mounted onto a cooling substrate, which is composed of thin silicon plates with embedded micro-channels that allow the circulation of liquid CO_2. This technique was selected due to the excellent thermal efficiency, the absence of thermal expansion mismatch with silicon ASIC's and sensors, radiation hardness of CO2, and very low contribution to the material budget. An alternative and more conservative approach is also under development. The front-end hybrid hosts the VeloPix ASICs and a GBTx ASIC for control and communication. The hybrid is linked to the opto-and-power board (OPB) by 60 cm electrical data tapes running at 5 Gb/s. The tapes must be vacuum compatible and radiation hard and are required to have enough flexibility to allow the VELO to retract during LHC beam injection. The OPB is situated immediately outside the VELO vacuum tank and performs the opto-electrical conversion of control signals going to the front-end and of serial data going off-detector. The board is designed around the Versatile Link components developed for high-luminosity LHC applications. From the OPB the detector data are sent through 300 m of optical fibre to LHCb's common readout board (PCIe40). The PCIe40 is an Altera Arria10-based PCI-express control and readout card capable of 100 Gb/s data throughput. The PCIe40 firmware is designed as a series of common components with the option for user-specific data processing. The common components deal with accepting the input data from the detector over the GBT protocol, error-checking, dealing with reset signals, and preparing the data for the computing farm. The VELO-specific code would, for example, perform clustering of hits and time reordering of the events scrambled during the readout.

The design of the complete VELO upgrade system will be presented with the latest results from the R\&D. The LHCb upgrade detector will be the first detector to read out at full LHC rate of 40 MHz. The VELO upgrade will utilise the latest detector technologies to read out at this rate using while maintaining the necessary radiation hard profile and minimising the detector material.

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LHCb Upgrade Detector

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This year, at the end of LHC Run 2, LHCb will start replacing major parts of the detector and installing new detector components in the underground cavern of LHC Interaction Point 8, thus realizing the long-planned upgrade I of the LHCb experiment. The new detector is designed to operate at the instantaneous luminosity of 2·10^33 cm-2s-1, more than five times higher than in Run 2. All sub-detectors are in production, some close to completion. This talk will present a status overview of the new detector and highlight performance results of a few key sub-systems, such as the silicon pixel vertex detector, the silicon-strip tracker, the scintillating-fibre tracker and the ring-imaging Cherenkov system. A crucial part of the upgrade lies in the software-only trigger, which is facing the extreme challenge to select the desired events at 30MHz input rate with around five to six visible interactions per bunch crossing. Recent R&D progress on the trigger strategy and benchmarking will be presented. In addition, the continuous expansion of the LHCb physics programme (in particular, using fixed targets) and preparation for future challenges will be briefly outlined.

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Belle II iTOP Particle Identification Detector: Construction, Operation and Commissioning

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The imaging Time Of Propagation (iTOP) counter is the primary Particle IDentification (PID) system in the barrel region of Belle II. It contains 16 identical modules between the tracking detectors and the calorimeter. The key elements of each module are the quartz radiator, the Micro-Channel Plate PhotoMultiplier Tubes (MCP-PMTs), and the front end readout electronics. The Cherenkov photons produced by the passage of charged particles through the quartz propagate through the quartz radiator. After multiple internal reflections they reach the MCP-PMTs. Multi-gigasample per second (GSa/s) waveform sampling Application Specific Integrated Circuits (ASICs) are used in readout to provide precise photon timing. Arrival times and positions of the photons are used to identify particles. The construction and installation of the iTOP detector was completed successfully in 2016. The iTOP counter has been in the Phase 2 commissioning together with the other Belle II sub-detectors since February 2018. This talk presents the construction, general principles of operation, and commissioning of the Belle II iTOP detector.

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SciFi - A large Scintillating Fibre Tracker for LHCb

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The LHCb detector will be upgraded during the Long Shutdown 2 (LS2) of the LHC in order to cope with higher instantaneous luminosities and to read out the data at 40MHz using a trigger-less read-out system. The current LHCb main tracking system, composed of an inner and outer tracking detector, will not be able to cope with the increased particle multiplicities and will be replaced by a single homogenous detector based on scintillating fibres. The new Scintillating Fibre (SciFi) Tracker covers a total detector area of 340 m2 and should provide a spatial resolution for charged particles better than 100 µm in the bending direction of the LHCb spectrometer. The detector will be built from individual modules (0.5 m × 4.8 m), each comprising 8 scintillating fibre mats with a length of 2.4 m as active detector material. The fibre mats consist of 6 layers of densely packed blue emitting scintillating fibres with a diameter of 250 µm. The scintillation light is recorded with arrays of state-of-the-art multi-channel silicon photomultipliers (SiPMs). A custom ASIC will be used to digitize the SiPM signals. Subsequent digital electronics performs clustering and data-compression before the data is sent via optical links to the DAQ system. To reduce the thermal noise of the SiPM in particular after being exposed to a neutron fluence of up to 10^{12} neq /cm^2, expected for the lifetime of the detector, the SiPMs arrays are mounted in so called cold-boxes and cooled down by 3D-printed titanium cold-bars to -40o C. Modules together with cold-boxes and readout electronics are mounted on so-called C-frames which will provide the mechanical support structure and the necessary services to power, read out and cool the detector elements. A proto-type frame is currently being built. The serial assembly of these detector elements will start in summer 2018. The detector installation is foreseen to start end of 2019. The talk will give an overview of the detector concept and will present the experience from the series production complemented by most recent test and quality assurance results.

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The Belle II Experiment: Status and Prospects

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The Belle II experiment is a substantial upgrade of the Belle detector and will operate at the SuperKEKB energy-asymmetric e^+e^- collider. The accelerator has already successfully completed the first phase of commissioning in 2016. First electron positron collisions in Belle II are expected for April 2018. The design luminosity of SuperKEKB is 8×10^{35} cm^{-2}s^{-1} and the Belle II experiment aims to record 50 ab^{-1} of data, a factor of 50 more than the Belle experiment. This large data set will be accumulated with low backgrounds and high trigger efficiencies in a clean e^+e^- environment. This talk will review the detector upgrade, the achieved detector performance and the plans for the commissioning of Belle II

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Luminosity measurement at the Circular electron-positron collider CepC

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Abstract

The very forward region at CepC will be instrumented with a luminometer aiming to measure integral luminosity with a precision of 10-3 and 10-4 in e+e- collisions at 240 GeV center-of-mass energy and at the Z0 pole, respectively. Present understanding of the technology solutions for the measurement, and an assessment of the systematic uncertainties are presented.

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Status of CEPC-ECAL R&D

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Circular Electron Position Collider (CEPC) is proposed as a Higgs or Z factory. One option of CEPC-ECAL(Electromagnetic calorimeter), designed based on the Particles Flow Algorithm(PFA), consists of tungsten and scintillator coupling with SiPM as active sensor. A advanced study of the gain with single photon and the responding curve of SiPM will be presented. Scintillator module also had be

studied, different degrees of polishing and different ways of coupling with SiPM, to make light yield meet the dynamic range requirements and improve the uniformity of output light. A 20☒☒×20☒☒ single layer prototype had be produced and the cosmic-ray test results also will be presented.

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R&D progress of CEPC HCAL

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Circular Electron Position Collider (CEPC) is proposed as a Higgs or Z factory. This work introduce the R&D progress of CEPC HCAL. Three detector technologies including RPC detector, GEM detector and plastic scintillator were researched for CEPC HCAL sensitive detector. For RPC detector, we corporation with CALICE collaboration and do some analysis on beam test result. For GEM detector, some module was tested. For plastic scintillator, different size detector cell was tested by Sr-90 source and cosmic ray. In general, some progress of CEPC HCAL has been made.

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Development of TPC detector module and prototype with laser calibration for CEPC

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In the baseline design of the Circular Electron Positron Collider (CEPC) tracking system, the high position resolution(~100μm) Time Projection Chamber(TPC) would be as the main tracker detector integrated with silicon tracker and ECAL. Unlike the detector at International Linear Collider (ILC), the beam structure of CEPC is the continous mode, which determines the detector's operation without the 'power-pulsing', on both Higgs and Z-pole energy regions with the high rating.
To meet the critical physics requirements of the tracker, the new concept structure gaseous detector module as one option for the tracer detector has been developed and tested. In this talk, the deviation of position resolution was calculated by the space charge causing the track distortions in the drift chamber at Z pole run in CEPC, and the value was less than 10μm in the inner diameter of TPC detector. Some performance of the conceptual detector module was obtained. The energy resolution is better than 20% for 5.9 keV X-rays and it indicates that the continuous suppression of ions backflow ratio about 0.1% can be reached at the gas gain of about 5000. Aimed to the calibration and alignment of TPC module, the TPC prototype integrated with laser calibration system has been designed with 5000mm drift length and 200mm*200mm active readout. The on-going R&D activities and some preliminary results will also be briefly reported.

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Performance of the SoLid reactor neutrino detector

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The SoLid collaboration is currently operating a 1.6 ton neutrino detector near the Belgian BR2 reactor, with as main goal the observation of the oscillation of electron anti-neutrinos to previously undetected flavor states. The highly segmented SoLid detector employs a compound scintillation technology based on PVT scintillator in combination with a LiFZnS screens containing 6Li isotopes. The experiment has demonstrated a channel-to-channel response that can be controlled
to the level of a few percent, and energy resolution of better than 14% at 1 MeV, and a determination of the interaction vertex with a precision of 5cm.

In this contribution we will highlight the major outcomes of the R&D program that preceded the construction of the full-scale detector, the quality control during component manufacture and integration, as well as the current performance and stability of the full-scale system. The possibilities for in-situ calibration of the detector with various radioactive sources will be discussed as well.

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Construction and performance of the Top and Bottom Counting Detectors for the ISS-CREAM experiment

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The Cosmic Ray Energetics And Mass experiment for the International Space Station, ISS-CREAM, aims to study the origin, acceleration and propagation mechanisms of high-energy cosmic rays. The ISS-CREAM detector was launched in August 2017 to the ISS aboard the SpaceX-12 Dragon spacecraft. The Top Counting Detector (TCD) and Bottom Counting Detector (BCD) are parts of the ISS-CREAM instrument and they are designed for electron and gamma-ray physics. The TCD/BCD can distinguish electrons from protons using differences in shape between electromagnetic and hadronic showers. In addition, the TCD/BCD can provide a complementary trigger to that from the calorimeter and a low energy trigger to the ISS-CREAM instrument. For these purposes, the TCD/BCD are designed as 2-dimensional detectors, which consist of a plastic scintillator attached to 20 x 20 photodiodes. The sizes of the TCD and BCD detectors are 500 mm × 500 mm × 5 mm and 600 mm × 600 mm × 10 mm, respectively. The ISS-CREAM experiment has many critical requirements for space launch qualification. Thus the mechanical safety and performance in response to vibration and thermal vacuum tests have been studied under various conditions prior to launch. In this presentation, we report the design and construction of the TCD/BCD and the performance of the detector before and after launch.

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Development of Superconducting Tunnel Junction Far-Infrared Photon Detector for Cosmic Background Neutrino Decay Search - COBAND experiment

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We present the status of development of the Superconducting Tunnel Junction (STJ) detector for the COsmic BAckground Neutrino Decay search (COBAND) experiment. The signal of the cosmic background neutrino decay is identified as a sharp cutoff at high energy end in a far-infrared region ranging from 15meV to 30meV in the energy spectrum of the photons from the space1. The COBAND experiment will be done as rocket and satellite experiments in order to detect the far-infrared photons from the space.
For a photon detector of the COBAND experiment, we are developing the STJ detectors2[3]. We will use a combination of the diffraction grating and the array of Nb/Al-STJ pixels with cryogenic amplifier for the rocket experiment[4], and use Hf-STJ as a micro-calorimeter[5] for the future satellite experiment. The present status of the detector R&D and the experimental design for the COBAND experiment is reported in
more detail.

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An ultra-low radioactivity measurement HPGe facility at the Center for Underground Physics

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The Center for Underground Physics (CUP) at Institute for Basics Science (IBS) has been conducting and preparing a few ultra-low background rare decay experiments at the Yangyang underground laboratory (Y2L). In order to keep the background levels in the experiments low enough, it is critical to screen raw materials or detector components to be used in the detectors. For the screening, a number of ultra-low radioactivity detectors are developed and installed. Among the detectors installed, we have a number of HPGe (High Purity Germanium) detectors in the Y2L for measurements of gammas from the background nuclei. Two of 100% p type coaxial single HPGe detectors were installed and have been running from 2016 for the measurement of samples with close to 100% running time. In addition, an array of 14 HPGe detectors was installed in 2017 spring after screening the array detector materials with the single HPGe detectors for an efficient measurement of gamma rays from samples with bigger volumes. Various scintillation crystals such as CaMoO4, Li2MoO4, and NaI(Tl) have been grown with purified raw materials and tested for their radioactivity background levels. In this contribution, a summary of their developments and performances will be presented.

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Design, construction and performance of magnetised mini-ICAL detector module

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India-based Neutrino Observatory (INO) has proposed to build a 51kton magnetised Iron Calorimeter (ICAL) in an underground laboratory to be constructed near Madurai, South India. ICAL is aimed to precisely study the atmospheric neutrino oscillation parameters and determine the ordering of neutrino masses. ICAL will be built by stacking 151 layers of 56mm soft iron plates, spanning essentially a lateral area of 48m x 16m. The detector will deploy about 28,800 glass Resistive Plate Chambers (RPCs) of approximately 2m x 2m in area, inserted between the iron layers. About 3.6 million detector channels are required to be instrumented to read data.

During the detector R&D phase, many RPC detector stacks were constructed and operated by the collaboration for prolonged periods of time - several years, mainly studying long term performance of the RPC detectors. But a magnetised 'mini-ICAL' was proposed to be built, essentially exactly of the same design as that of ICAL and also using same detector components. This was expected to serve the purpose of understanding the engineering issues in constructing the ICAL, and at the same time provide important inputs on the ICAL's operating parameters and physics measurement capabilities. A veto wall is also being planned around the m-ICAL, to explore possibility of building ICAL like detectors on surface or at shallow depths. The veto wall will be made of extruded scintillator tiles and coupled to SiPMs through WLS fibres.

The mini-ICAL currently is in commissioning phase. It was built using 11 layers of 56mm soft iron plates, spanning a lateral area of 4m x 4m. A nominal magnetic field of 1.5 Tesla will be produced inside the iron plates, by passing about 650Amps current through two, 18-turn OFHC copper coils which are water-cooled. A total of 20 RPCs of about 2m x 2m in area - two per gap in the central region, will be inserted between the iron layers and readout using the electronics of the same design as that of ICAL. A software framework for analysis of mini-ICAL data is already in place.

We will describe design and construction details of the m-ICAL magnet, RPC detectors and electronics. We will also present performance of ICAL electronics in magnetic field, including its timing, track reconstruction and momentum resolutions etc.

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Large Area SiPM Readout and Signal Processing for nEXO

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The EXO programme is a two-phase experiment to search for neutrinoless double beta decay. The first phase, EXO-200, yielded the first measurement of two neutrino double beta decay in Xenon and one of the most sensitive searches for neutrinoless double beta decay. The second phase, nEXO, is a proposed 5 tonne liquid xenon time projection chamber (TPC) that will implement several improvements over EXO-200. One such improvement is the usage of silicon photomultipliers (SiPMs) instead of avalanche photodiodes (APDs) as scintillation light detectors. By optimizing the light collection, reducing electronic noise and improving the SiPM performance, we can achieve a 1% energy resolution at the Xe-136 double beta decay end point. In this presentation, I will discuss the electronics readout of large area FBK UV sensitive SiPMs at liquid xenon temperatures and the digital filtering of SiPM waveforms.

Detector: R&D for Present and Future Facilities / 937

Status of the PTOLEMY project for CNB detection and directional direct detection of MeV dark matter

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The PTOLEMY project aims to develop a scalable design for a Cosmic Neutrino Telescope, the first of its kind and the only telescope conceived that can look directly at the image encoded in neutrino density fluctuations of the Universe in the first second after the Big Bang. The past two years of developments have established a compelling case to proceed to telescope design. The cryogenic calorimeters aim to reach 0.05eV energy resolution, an order of magnitude beyond the original target and the highest resolution of any calorimeter. The graphene substrate is stable under 40% loading fraction of hydrogen, the highest on record. The Simons prototype at Princeton has become the basis of a new world-wide collaboration consisting of seven countries (Netherlands, Spain, Sweden, Israel, Italy, UAE, USA) and 29 institutions. The scope of work for the next three years is to complete the design of the Cosmic Neutrino Telescope and to to validate with direct measurement that the non-neutrino backgrounds are below the expected signal from the Big Bang by extrapolating broad backgrounds that span over keV into the 0.1eV window of the signal under the operation of a newly designed high stability HV system with MAC-E filter and TES calorimeter. A proposal to install the PTOLEMY prototype at the LNGS is currently under review. By implementing high radio-pure carbon-12 graphene, we will exploit a concurrent program in directional MeV dark matter searches with 2D targets and CNTs. The number and deployment of CNB telescopes around the world will depend on the next phase of PTOLEMY developments.

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Design and construction of, and physics results from an INO RPC detector stack

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India-based Neutrino Observatory (INO) has proposed a 50kton magnetised Iron Calorimeter (ICAL) in an underground laboratory to be constructed near Madurai. Main aims of this project are to precisely study the atmospheric neutrino oscillation parameters and to determine the ordering of neutrino masses. The detector will deploy about 28,800 glass Resistive Plate Chambers (RPCs) of approximately 2m x 2m in area. About 3.6 million detector channels are required to be instrumented.

A detector stack comprising of 12 layers of 2m x 2m RPCs was designed and commissioned in Madurai. These RPCs are readout through 60 pickup strips (of pitch 3cm) on the x-plane and 63 on y-plane. The signals which are induced on strips due to passage of charged particles through RPC detectors are processed by a series of electronic elements such as Analog-Front End (AFE), Digital-Front End (DFE) and backend data acquisition (DAQ) system. On an event trigger mostly caused by passage of atmospheric muon through the detector stack, the coordinates of all strip hits and their timing with reference to the global trigger signal are recorded by the DAQ system. The entire electronics, data acquisition and trigger systems were developed in-house using preamplifier, discriminator and TDC ASICs as well as high-end FPGAs.

Apart from characterising and long term performance of RPC detectors and electronics, this stack was utilised even to study a few physics problems such as integrated muon flux, polar and azimuthal distribution of incident cosmic ray muons as well as multiplicity of muons passing through the stack. Design, construction and performance features of the detector and electronics will be described in this paper. We will also present a few results from the physics studies that we carried out using this detector stack.

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Detector status of AMoRE-Pilot Experiment

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Advanced Molybdenum-based Rare-process Experiment (AMoRE) aims to search for the neutrinoless double beta decay (0nbb) of Mo-100 in scintillating molybdenum-based crystals using cryogenic metallic magnetic calorimeters (MMCs) at millikelvin temperature. Its commissioning phase, the AMoRE-Pilot, is currently running in the 700-meter-deep Yangyang underground laboratory (Y2L) with six 40Ca100MoO4 crystals weighing in total 1.9 kg. Throughout the pilot phase, the vibrational noise coming from the pulse tube refrigerator, which is the main source of the noise, has been reduced by installing vibration dampers in the dilution refrigerator. The origins of the main background have also been tentatively identified, and the highly contaminated components have been replaced. Detector modules for AMoRE-I, the first phase of AMoRE experiment, is currently in preparation using the results of AMoRE-Pilot. In this presentation, we describe the current status of AMoRE experiment.

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the 20-inch PMT system for the JUNO experiment

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The Jiangmen Underground Neutrino Observatory (JUNO) is a multi-purpose neutrino experiment under construction. The primary goal is to determine the neutrino mass hierarchy and precisely measure the oscillation parameters by detecting reactor anti-neutrinos. There will be around 20000 PMTs with a large photo-cathode of 20-inch equipped for the JUNO experiment, which includes 15000 MCP PMTs from a Chinese company and 5000 Dynode PMTs from Hamamatsu company. To achieve the designed 3% energy resolution, the PMTs are required to have high detection efficiency as well as very tight positioning in the JUNO detector. The 20-inch PMT system for JUNO includes PMT performance testing, design of high voltage divider, waterproof potting, chain implosion protection, and installation on the detector. Testing of the PMTs will use a device developed in a container for batch test and a scanning station for sampling test. Since the PMTs are required to work for 20 years in water with a depth up to 45 m, the PMTs need to be potted to keep the high voltage divider away from water. And in a situation that the PMTs will be closest possible arranged with the spacing only a few mm to achieve a coverage larger than 75%, the protection for chain implosion and also the installation are very challenging. In this talk, all aspects mentioned above for the JUNO 20-inch PMT system will be addressed.

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A multi-PMT photodetector system for the Hyper-Kamiokande experiment

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Hyper-Kamiokande (Hyper-K), a proposed one-megaton water Cherenkov detector to be built in Japan, is the logical continuation of the highly successful Super-Kamiokande experiment. Its broad physics programme includes neutrinos from astronomical sources, nucleon decay, with the main focus the determination of leptonic CP violation.
To detect the weak Cherenkov light generated by neutrino interactions or proton decay, the employment of the multi-PMT concept, first introduced in the KM3NeT detector, is considered as possible solution. A multi-PMT Optical Module based on a pressure vessel instrumented with multiple small diameter photosensors, readout electronics and power, offers several advantages as higher sensitive surface, weaker sensitivity to Earth's magnetic field, increased granularity and
directional information with an almost isotropic field of view. In this contribution the development of a multi-PMT module for Hyper-K is discussed.

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Development of 50 cm Photo-Detectors for Hyper-Kamiokande

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Hyper-Kamiokande is a large water Cherenkov detector planned in Japan. It requires a large aperture photo-detector with a high photon detection efficiency to explore various neutrino physics and discover a nucleon decay. A photomultiplier tube (PMT), R12860 by Hamamatsu Photonics K.K., was developed with a box-and-line dynode to achieve high resolutions of charge and timing, compared with an R3600 PMT for Super-
Kamiokande. Compared with the R3600 PMT, a single photon detection efficiency of the new R12860 PMT is doubled due to the high collection efficiency of 95% and a higher quantum efficiency of 30% at 390 nm wavelength. Recently the output dynamic range was improved and a dark count rate is being reduced. We evaluated an individual difference of the performance measuring 140 PMTs. Using an avalanche diode with a single structure inside of the bulb, we developed a 50 cm hybrid photo-detector (HPD), R12850 by Hamamatsu. The timing resolution was improved to be 3.6 ns (FWHM) by developing a preamplifier with a fast time response. A waterproofed HPD was prepared and installed into a 200-ton water Cherenkov detector at Kamioka, Japan. Several designs of a shockwave prevention cover by an implosion of the PMT in deep water were developed and tested. It enables a light weight or low cost. The recent development and improved performance of the 50 cm photo-detectors will be presented.

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Commissioning of the Baby MIND detector

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The Baby MIND (Magentized Iron Neutrino Detector) is characterized by its original magentization design, as well as by the presence of air gaps allowing muons to be reconstructed down to 300 MeV/c and their charge identified. The detector was completed, assembled and tested at the neutrino platform at CERN, and delivered to the T2K ND280 pit in December 2017. First results from test beam at CERN and commissionning in the neutrino beam at T2K will be presented.

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Characterization of the 20-inch Photomultiplier Tubes for the JUNO Central Detector

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The primary physics goal of the Jiangmen Underground Neutrino Observatory (JUNO) is to resolve neutrino mass hierarchy, taking the advantage of the copious antineutrinos from two powerful nuclear power plants at distances of ~53 km in Guangdong Province, China. To meet this goal, JUNO has designed a 20 kt underground liquid scintillator (LS) detector which deploys 20,000 high quantum efficiency (HQE) photomultiplier tubes(PMTs) to reach an energy resolution of 3%/√(E/MeV) and an energy scale uncertainty better than 1%. Such performance numbers on such a massive LS detector are unprecedented, which places stringent requirements on the two types of the 20-in PMTs used by JUNO, the Hamamatsu HQE PMT and the newly developed micro-channel plate (MCP) PMT. To select qualified PMTs and to supply the detector simulation with precise PMT performance data, we have developed two PMT characterization systems, an industrial container-based mass PMT testing system and a PMT photocathode uniformity scanning station. This talk will explain the requirements on the two types of JUNO PMTs in connection to its physical goals, the technical designs of

the two PMT evaluation systems, the PMT testing strategy and the preliminary JUNO 20-inch PMT characterization results.

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The upgrade project of the T2K near detector

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The upgrade project of the T2K near detector

The T2K neutrino oscillation experiment established the $\nu_\mu \to \nu_e$ appearance with only 10\% of the original beam request of 7.8×10^{21} 30 GeV protons on target (p.o.t.). In view of the J-PARC program of upgrades of the beam intensity, the T2K-II proposal requires to run up to 20×10^{21} p.o.t., i.e. an increase in the exposure by more than a factor 10 aimed at establishing CP violation at 3 σ level for a significant fraction of the possible δ_{CP} values. The Hyper-K proposal consists in a further increase by a factor 10 of the far detector mass. Facing the potential increase of statistics by two orders of magnitude, it is of great importance to undertake a vigorous program of near detector upgrades, with the aim of reducing the overall statistical and systematic uncertainties at the appropriate level of better than 4\%.

The T2K collaboration has launched in 2017 the upgrade project for its near detector ND280. In January 2018 the proposal has been submitted to the CERN SPSC (CERN-SPSC-P357) and to the JPARC PAC. The project aims at installing innovative detectors to significantly increase the physics capabilities. It includes two High-Angle TPCs, a highly segmented Scintillator Detector built with the Super-FGD technology (arXiv:1707.01785, 2018_JINST_13_P02006), and TOF detectors.

The rectangular TPCs will be built with a light field cage and resistive Micromegas detectors for the charge readout. The SuperFGD is based on small plastic scintillator cubes (appr. 1cm side) read-out by three WLS fibers, providing detailed informations for tracking and PID. TOF will complement the TPC and SuperFGD PID information and determine the track direction. With these detectors we will reach a full polar angle coverage for Charged Current Neutrino interactions, improve the tracking performance for low energy pions and protons, and select a clean electron neutrino sample.

We will report on the goals of the project and its development program including prototypes, beam tests at CERN and in Japan in 2018, and projected performances.

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Near Detectors for Hyper-Kamiokande

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The proposed Hyper-Kamiokande experiment (Hyper-K) is a next generation large water Cherenkov (WD) detector with a broad physics program consisting of neutrino beam measurements in search of leptonic CP violation, astrophysical measurements and a search for proton decay. Hyper-K will act as the far detector to measure the oscillated neutrino flux from the long-baseline beam of 0.6 GeV neutrinos/anti-neutrinos produced by a 1.3 MW proton beam at J-PARC in Japan. To minimise

systematic uncertainties, particularly due to flux and cross-section uncertainties, detailed measurements of the unoscillated flux are required with a suite of near detectors. This talk will review the challenges, and present the planned components of the near detector measurement suite, including a new intermediate Water Cherenkov Detector.

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Status of single phase and dual phase DUNE prototype detectors at CERN

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Liquid Argon Time Projection Chamber (LAr TPC) is currently the most attractive technology for neutrino oscillations studies, proton decay studies and Supernova explosions. Not only LAr TPCs are cost-effective and scalable to multi-ton scales, but they are also excellent calorimeters and can 3D reconstruct the tracks of ionising particles arising from neutrinos interaction products. Future giant liquid Argon TPCs, at the ten-kiloton level, are now at the design and prototyping stage in the context of the Deep Underground Neutrino Experiment (DUNE). DUNE will comprise four 10 kton LAr TPC modules placed at the Sanford Underground Research Facility (SURF) in South Dakota (USA). To gain experience in building and operating such large-scale LAr detectors two prototypes are currently under construction in the extension of CERN north experimental hall area (EHN1) which eventually will be exposed to the SPS beam. The prototypes consist of a single-phase LAr TPC, called ProtoDUNE Single-Phase (SP), and a dual-phase LAr TPC, called ProtoDUNE Dual- Phase (DP). The cryostats hosting the detectors have been already completed, and construction of the TPCs is already ongoing. The detectors will be assembled by 2018. An overview of the status and progress of both detectors and how they fit in the general context of DUNE will be addressed in this talk.

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Status of DUNE experiment

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The Deep Underground Neutrino Experiment (DUNE) provides a rich science program with the focus on the neutrino oscillation physics, proton decay studies and Supernova explosions. The high-intensity wide-band neutrino beam will be produced at Fermilab and will be directed to the 40 kt Liquid Argon far detector at the Sanford Underground Research Facility (SURF), 1300 km from Fermilab. One of the most important goals of the experiment is to determine the neutrino mass ordering and the measurement of the CP violating phase. The underground location of the large DUNE far detector and its excellent energy and spatial resolution will allow also conducting non-accelerator physics programs predicted by GUT models, such as nucleon decay or n-nbar oscillations. Moreover, it will be sensitive to measure of the electron neutrino flux from a core-collapse supernova providing valuable information on the mechanism of a supernova. This ambitious project involves worldwide contribution and extensive prototyping and testing program to guarantee that all parts of the technology are fully understood and well tested. Two such prototypes, in both single phase (ProtoDUNE-SP) and dual phase (ProtoDUNE-DP) technologies, are under construction and will be operated at the CERN Neutrino Platform (NP) starting in 2018.

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Design and performance studies of the calorimeter system for a FCC-hh experiment

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The physics reach and feasibility of the Future Circular Collider (FCC) with centre of mass energies up to 100 TeV and unprecedented luminosity is entering its final phase before releasing a Conceptual Design Report. The new energy regime opens the opportunity for the discovery of physics beyond the standard model. 100 TeV proton-proton collisions will produce very high energetic particle showers in the calorimeters from both light jets and boosted bosons/top. The reconstruction of such objects sets the calorimeter performance requirements in terms of shower containment, energy resolution and granularity. Furthermore, high-precision measurements of photons and electrons over a wide energy range are crucial to fully exploit the FCC-hh physics potential, especially given the large amount of collisions per bunch crossing the detectors will have to face (pile-up of $\langle \mu \rangle =$ 1000).
We will present the current reference technologies for the calorimeter system of the FCC-hh detector: Liquid Argon (LAr) as the active material in the electromagnetic calorimeters, and the hadronic calorimeters for $|\eta| > 1.3$ (Endcap and Forward region), and a Scintillator-Steel (Tile) calorimeter as hadronic calorimeter in the Barrel region. The talk will focus on the performance studies for single particles and jets in the combined calorimeter system. We will introduce the simulation framework and the reconstruction chain, that includes the calibration and clustering of calorimeter cells and the estimation of pile-up induced, and electronics noise. In conclusion, the achieved performances will be compared to the physics benchmarks of the FCC-hh experiment.

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Moliere radius measurement using a compact prototype of Lumi-Cal in a test set-up

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The FCAL collaboration has performed a design study for luminometers at future electron-positron colliders. Compact sampling calorimeters with precisely positioned silicon sensors and a fast readout will reach the necessary performance even in the presence of background from beamstrahlung and two-photon processes. A prototype calorimeter has been built with special focus on ultra-thin fully instrumented sensor planes to ensure a very small Moliere radius. Results of a measurement in a 5 GeV electron beam on the performance will be presented.

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The CLIC detector

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The proposed Compact Linear Collider (CLIC) will provide electron-positron collisions at centre-of-mass energies from a few hundred GeV up to 3 TeV. CLIC offers a rich precision physics program, and a high sensitivity to a wide range of possible new phenomena. The precision required for such measurements and the specific conditions imposed by the CLIC beam structure put strict requirements on the detector design and technology developments. This includes ultra-low mass vertexing and tracking systems with small cells, highly granular imaging calorimeters, and a precise hit-timing resolution for all subsystems. Ambitious R&D programs for silicon tracking detectors and calorimeters are pursued, addressing the challenging detector requirements with innovative new technologies. A variety of detector optimisation studies have been carried out to establish the overall detector performance and to assess the impact of different technology options. The resulting optimised detector model has been integrated in the CLIC full-detector simulation framework. This contribution reviews the optimisation studies performed for critical parameters of the CLIC detector, presents the detector performance achieved in full-detector simulations, and gives an overview of the ongoing hardware R&D.

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Level-1 track finding with an all-FPGA system at CMS for the HL-LHC

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The CMS experiment at the LHC is designed to study a wide range of high energy physics phenomena. It employs a large all-silicon tracker within a 3.8 T magnetic solenoid, which allows precise measurements of transverse momentum (pT) and vertex position.

This tracking detector will be upgraded to coincide with the installation of the High-Luminosity LHC, which will provide up to about 10^35 cm^2 /s to CMS, or 200 collisions per 25 ns bunch crossing. This new tracker must maintain the nominal physics performance in this more challenging environment. Novel tracking modules that utilise closely spaced silicon sensors to discriminate on track pT have been developed that would allow the readout of only hits compatible with pT > 2-3 GeV tracks to off-detector trigger electronics. This would allow the use of tracking information at the Level-1 trigger of the experiment, a requirement to keep the Level-1 triggering rate below the 750 kHz target, while maintaining physics sensitivity.

This talk presents a concept for an all FPGA based track finder using a time-multiplexed architecture. Hardware demonstrators have been assembled to prove the feasibility and capability of such a system. The performance for a variety of physics scenarios will be presented, as well as the proposed scaling of the demonstrators to the final system and new technologies.

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Upgrade of the ATLAS Monitored Drift Tube Frontend Electronics for the HL-LHC

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To cope with large amount of data and high event rate expected from the planned High-Luminosity LHC (HL-LHC) upgrade, the present ATLAS monitored drift tube (MDT) readout electronics will be replaced. In addition, the MDT detector will be used at the first-level trigger to improve the muon transverse momentum resolution and reduce the overall trigger rate. A new trigger and readout system has been proposed. Prototypes for two frontend ASICs and a data transmission board have been designed and tested, and detailed simulation of the trigger latency has been performed. We will present the overall design and focus on latest results from different ASIC and board prototypes.

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The ATLAS Muon Trigger

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Events containing muons in the final state are an important signature for many analyses being carried out at the Large Hadron Collider (LHC), including both standard model measurements and searches for new physics. To be able to study such events, it is required to have an efficient and well-understood muon trigger. The ATLAS muon trigger consists of a hardware based system (Level 1), as well as a software based reconstruction (High Level Trigger). Due to high luminosity and pile up conditions in Run 2, several improvements have been implemented to keep the trigger rate low while still maintaining a high efficiency. Some examples of recent improvements include requiring coincidence hits between different layers of the muon
spectrometer, improvements for handling overlapping muons, and optimised muon isolation. We will present an overview of how we trigger on muons, recent improvements, and the performance of the muon trigger in Run-2 data.

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ATLAS level-1 calorimeter trigger: Phase-I Upgrade Performance

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Following the Run 2 LHC data taking, the ATLAS experiment at CERN will enter the first phase (Phase-I) of the planned detector subsystem upgrades. Several systems, in particular, the hardware-based Level-1 calorimeter trigger (L1Calo) will be significantly enhanced to provide improved selectivity at the higher expected pileup in Run 3. During the second long shutdown (LS2) in 2019-2020, the existing L1Calo
electronic processor modules will be replaced with new, advanced boards, called feature extractors, which will receive higher-granularity information from the calorimeters and will support the implementation of more sophisticated algorithms to select electrons or photons, jets, met and large-radius jets.

This presentation will summarise the anticipated functionality of the upgraded L1Calo trigger system. In particular, the performance of the preliminary trigger-level algorithms and a comparison to the operation of the Run 2 L1Calo system will be described.

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The ATLAS trigger in 2017 and 2018 – developments and performance

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The ATLAS Trigger system has been operating successfully during LHC Run-2, between 2015 and 2017. Its excellent performance has been vital for the ATLAS physics program, selecting interesting collision events for a wide variety of physics signatures with high efficiency.

The trigger selection capabilities of ATLAS during Run-2 have been significantly improved compared to Run-1, in order to cope with the higher event rates and with the large number of simultaneous proton-proton interactions (pile-up). At the Level-1 trigger these improvements resulted in more pile-up-robust selection efficiencies and event rates, as well as in a reduction of fake candidate particles. A new hardware system, designed to analyse event-topologies, supports a more refined event selection at Level-1. Exemplary are the application of angular and invariant mass cuts in low momentum di-lepton and di-jet triggers, keeping the Level-1 rate of such selections, which are essential for many physics analyses, at an affordable level. A hardware-based, high-rate track reconstruction, currently being commissioned, enables the high-level software trigger to make use of tracking information at its full input rate. Such full-scan tracking has an important role in reducing the pile-up dependence of triggers based on isolated single leptons and those selecting on total transverse energy. Together with an upgrade of the high-level trigger selections to deploy more offline-like reconstruction techniques, these changes dramatically improve the performance of the trigger selection to nearly that of the offline reconstruction.

At the beginning of 2017 more than 1000 different ATLAS trigger selections had been carefully compiled into a "trigger menu", covering all aspects of the ATLAS physics program and allowing for the expected rise in LHC luminosity. An unexpected change in the LHC conditions in the middle of 2017 toward an environment with much higher pile-up resulted in a much-increased CPU usage of the software trigger and reduced performance, requiring adaptation of the selection software and the general trigger menu design.

This presentation gives a comprehensive review of the ATLAS trigger system in 2017, covering briefly the changes compared to 2016, operational aspects, and encountered constraints. The trigger menu strategy for 2018, the last year of Run-2 will be shown. Focus will be put on the new event-topology-based selections at the Level-1 trigger, and on the trigger performance at high pile-up seen in 2017. The improvement measures taken for 2018 will be discussed and substantiated with first 2018 trigger performance plots.

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Design of the CMS upgraded trigger from Phase I to Phase II of the LHC

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The CMS experiment implements a sophisticated two-level triggering system composed of the Level-1, instrumented by custom-design hardware boards, and the High Level Trigger, a streamlined version of the offline reconstruction software running on a computer farm (more than 30k CPU cores). In 2017, the LHC delivered proton-proton collisions at a centre-of-mass energy of 13 TeV with a peak instantaneous luminosity larger than $2 \cdot 10^{34} cm^{-2} s^{-1}$, more than twice the peak luminosity reached during Run1 and far larger than the design value. The CMS Level-1 trigger was upgraded during the end-of-the year technical stop between 2015 and 2016, to improve its performance at high luminosity and large number of simultaneous inelastic collisions per crossing (pile-up). All the electronic boards have been replaced and the upgraded electronics tested and commissioned with data. Smarter, more sophisticated, and innovative algorithms are now the core of the first decision layer of CMS: the upgraded trigger system implements pattern recognition and MVA (Boosted Decision Tree) regression techniques in the trigger boards for p_T assignment, pile-up subtraction, and isolation requirements for electrons and tau leptons. In addition, the new global trigger is capable of evaluating complex selection algorithms such as those involving the invariant mass of trigger objects. The High Level Trigger features a trade-off between the offline complexity of the algorithms and the available computing power, and between the selection efficiency the maximum sustainable output rate. The trigger selections used in Run-2 will be presented, ranging from simpler single-object selections to more sophisticated algorithms combining different objects and applying analysis-level reconstruction and selection. This presentation will cover the design and performance of the Phase I trigger and how it influences the path towards the Phase II upgrade necessary for the LHC run at a center-of mass energy of 14 TeV with luminosity of $5 - 7 \cdot 10^{34} cm^{-2} s^{-1}$, corresponding to 140–200 pile-up events. The addition of the tracker information at Level-1 and the enhanced computing resources at HLT will maintain the trigger efficiency at a similar level as the present one.

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Design and performance of the upgrade of the CMS L1 trigger

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During its second run of operation, the LHC delivered proton-proton collisions at a centre-of-mass energy of 13 TeV with a peak instantaneous luminosity larger than $2 \cdot 10^{34} cm^{-2} s^{-1}$, more than double the peak luminosity reached during Run1 and far larger than the design value. The upgraded CMS Level-1 trigger is designed to improve the performance at high luminosity and large number of simultaneous inelastic collisions per crossing (pile-up). During the technical stop at the beginning of 2016, all the electronic boards of the CMS Level-1 trigger have been replaced and the upgraded electronics tested, and commissioned with data. Smarter, more sophisticated, and innovative algorithms are now the core of the first decision layer of CMS: the upgraded trigger system implements pattern recognition and MVA (Boosted Decision Tree) regression techniques in the trigger boards for p_T assignment, pile-up subtraction, and isolation requirements for electrons and taus. In addition, the new global trigger is capable of evaluating complex selection algorithms such as those involving the invariant mass of trigger objects. The upgrade reduces the trigger rate and improves the trigger efficiency for a wide variety of physics signals. In this presentation the upgraded CMS Level-1 trigger design and its performance are described.

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Upgrade of the CMS muon spectrometer in the forward region with the GEM technology

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The Large Hadron Collider (LHC) will be upgraded in several phases that will allow to significantly expand its physics program and sustain the requirements to maintain sensitivity for the electroweak and TeV scales. After the expected long shutdown in 2018 (LS2) the accelerator luminosity will be increased to 2 − 3 × 10^34cm−2s−1 exceeding the design value of 1 × 10^34cm−2s−1 allowing the CMS experiment to collect approximately 100 fb−1/year. A subsequent upgrade in 2022-23 will increase the luminosity up to 5 × 10^34cm−2s−1.

To cope with the corresponding increase in background rates and trigger efficiency requirements, the installation of additional muon detectors is a necessity. Three major upgrades are planned for the CMS muon endcap regions, referred to as GE1/1, GE2/1 and ME0. Each of the additional set of detectors is based on the Gas Electron Multiplier (GEM) technology, a choice based on many past R&D activities. While the installation of the GE1/1 chambers has been already approved and scheduled by 2019/20, the GE2/1 project is in an advanced phase of design and the ME0 project is now in the final phase of review.

We present an overview of the muon spectrometer upgrade based on GEM technology, the details of the ongoing GE1/1 chamber production with the first results of the quality assurance tests. Moreover, preliminary results obtained for the GE2/1 single module M4 will be shown along with the design and the technical solution adopted for the foreseen GE2/1 and ME0 chambers.

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Results of quality control of large size GEM detector based on Korean GEM foil for future upgrades of the CMS muon system

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GEM detectors have been developed for the Phase II upgrade and will be installed in the endcap stations of the CMS muon system. In detail, the detector station called GE1/1 will be installed during long shutdown 2 scheduled in 2019 and the other detector stations, called GE2/1 and ME0, later. This upgrade will improve the muon trigger and tracking performance in the high-eta region. The Korea CMS group and Mecaro, a company in Korea, have developed large GEM foils using a double-mask technique. Compared to the single-mask technique used so far, the production process is more simple and the more symmetric shape of the GEM holes improves the amplification process. We have built the first GEM chamber with such foils in double-mask technique and present results of several quality control tests on this GEM chamber.

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Upgrades of the CMS muon system in preparation of HL-LHC

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The present CMS muon system operates three different detector types: in the barrel drift tubes (DT) and resistive plate chambers (RPC), cathode strip chambers (CSC) and RPCs in the forward regions. In order to cope with the challenging conditions of increasing luminosity, several upgrades are planned to the trigger and muon systems. For the existing DT and CSC detectors, the electronics will be upgraded to handle higher rates. Accelerated ageing tests are being performed to study the behaviour of these detectors under conditions which are one order of magitude beyond the design values. New micro-pattern gas detectors will be added to improve the performance in the critical forward region. Those detectors - large-area triple-foil gas electron multiplier (GEM) detectors - will already be installed in upcoming long shutdown in the pseudo-rapidity region 1.6 < eta < 2.4. Only with those additional high resolution detectors, the rate of background triggers can be controlled while maintaining high trigger efficiency for low transverse momentum muons. For the HL-LHC operation the muon forward region should be enhanced with another large area GEM based station, called GE2/1, and with two new generation RPC stations, called RE3/1 and RE4/1, having low resistivity electrodes. These detectors will combine tracking and triggering capabilities and can stand particle rates up to few kHz/cm2. In addition to take advantage of the pixel tracking coverage extension a new detector, ME0 station, behind the new forward calorimeter, covering up to $|\eta| = 3$.

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Small-Strip Thin Gap Chambers for the Muon Spectrometer Upgrade of the ATLAS Experiment

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The instantaneous luminosity of the Large Hadron Collider at CERN will be increased up to a factor of five with respect to the design value by undergoing an extensive upgrade program over the coming decade. Such increase will allow for precise measurements of Higgs boson properties and extend the search for new physics phenomena beyond the Standard Model. The largest phase-1 upgrade project for the ATLAS Muon System is the replacement of the present first station in the forward regions with the so-called New Small Wheels (NSWs) during the long-LHC shutdown in 2019/20. Along with Micromegas, the NSWs will be equipped with eight layers of small-strip thin gap chambers (sTGC) arranged in multilayers of two quadruplets, for a total active surface of more than 2500 m^2. All quadruplets have trapezoidal shapes with surface areas up to 2 m^2. To retain the good precision tracking and trigger capabilities in the high background environment of the high luminosity LHC, each sTGC plane must achieve a spatial resolution better than 100 µm to allow the Level-1 trigger track segments to be reconstructed with an angular resolution of approximately 1mrad. The basic sTGC structure consists of a grid of gold-plated tungsten wires sandwiched between two resistive cathode planes at a small distance from the wire plane. The precision cathode plane has strips with a 3.2mm pitch for precision readout and the cathode plane on the other side has pads for triggering. The position of each strip must be known with an accuracy of 30 µm along the precision coordinate and 80 µm along the beam. The mechanical precision is a key point and must be controlled and monitored all along the process of construction and integration. The sTGC detectors are currently being produced and tested in five countries and assembled into wedges at CERN for integration into ATLAS. The sTGC design, performance, construction and integration status will be discussed, along with results from tests of the chambers with nearly final electronics with beams and cosmic rays.

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The upgrade of the ATLAS Muon System for High-Luminosity LHC

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The muon spectrometer of the ATLAS detector will undergo a major upgrade during the Long Shutdown 3, in order to cope with the operational conditions at the high-luminosity LHC. The trigger and readout system will be completely redesigned, to support Level-0 trigger rates of 1–4 MHz and a latency of 10 us.
To do so, the readout electronics of all the trigger and precision chambers will be replaced and the precision chambers, that at the moment are not included in the hardware trigger, will be integrated into the Level-0 trigger in order to sharpen the momentum threshold and increase the system redundancy. New-generation RPC chambers will be installed in the inner barrel layer to increase the acceptance and robustness of the trigger. Some of the MDT chambers in the inner barrel layer will be replaced with new small-diameter MDTs. New TGC triplet chambers in the barrel-endcap transition region will replace the current TGC doublets to suppress the high trigger rate from random coincidences in this region. A major upgrade of the power system is also planned. The Phase-II upgrade concludes the process of adapting the muon spectrometer to the ever increasing performance of the LHC, which started with the Phase-I upgrade New Small Wheel (NSW) project that will replace the innermost endcap wheels.

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The design and layout of the Phase-II upgrade of the Inner tracker of the ATLAS experiment

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In the high luminosity era of the Large Hadron Collider (HL-LHC), the instantaneous luminosity is expected to reach unprecedented values, resulting in about 200 proton-proton interactions in a typical bunch crossing. To cope with the resultant increase in occupancy, bandwidth and radiation damage, the ATLAS Inner Detector will be replaced by an all-silicon system, the Inner Tracker (ITk), aiming to provide tracking coverage up to $|\eta|<4$. The ITk consists of an inner pixel and an outer strip detector designed to provide a tracking performance at least as good as the current detector, but in the HL-LHC environment. In this talk, the updated layout of the detector for the pixel technical design report is presented, and the expected detector and tracking performance is discussed.

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The CMS Tracker Upgrade for the High Luminosity LHC

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The LHC machine is planning an upgrade program which will smoothly bring the luminosity at about 5*10^34cm-2s-1 in 2028, to possibly reach an integrated luminosity of 3000fb-1 by the end of 2037. This High Luminosity LHC scenario, HL-LHC, will require a preparation program of the LHC detectors known as Phase-2 upgrade. The current CMS Outer Tracker, already running beyond design specifications, and CMS Phase1 Pixel Detector will not be able to survive HL-LHC radiation conditions and CMS will need completely new devices, in order to fully exploit the high-demanding operating conditions and the delivered luminosity. The new Outer Tracker should have also trigger capabilities. To achieve such goals, R&D activities are ongoing to explore options either for the Outer Tracker, either for the pixel Inner Tracker. Solutions are being developed that would allow including tracking information at Level-1. The design choices for the Tracker upgrades are discussed along with some highlights of the R&D activities.

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ATLAS ITk Strip Detector for High-Luminosity LHC

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The ATLAS experiment is currently preparing for an upgrade of the inner tracking for High-Luminosity LHC operation, scheduled to start in 2026. The radiation damage at the maximum integrated luminosity of 4000/fb implies integrated hadron fluencies over 2x10^16 neq/cm2 requiring replacement of the existing Inner Detector. An all-silicon Inner Tracker (ITk) is proposed with a pixel detector surrounded by a strip detector. The current prototyping phase, targeting an ITk Strip Detector consisting of a four-layer central barrel and forward regions composed of six disks at each end, is described in the ATLAS Inner Tracker Strip Detector Technical Design Report (TDR). With the approval of the TDR by the CERN Research Board, the pre-production readiness phase has started at the institutes involved. In this contribution we present the design of the ITk Strip Detector, current status of R&D on various detector components and preparations for production.

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Expected performance of the upgraded ATLAS experiment for HL-LHC

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The Large Hadron Collider (LHC) has been successfully delivering proton-proton collision data at the unprecedented center of mass energy of 13 TeV. An upgrade is planned to increase the instantaneous luminosity delivered by LHC in what is called HL-LHC, aiming to deliver a total of up 3000/fb to 4000/fb of data per experiment. To cope with the expected data-taking conditions ATLAS is planning major upgrades of the detector.

It is now a critical time for these upgrade projects and during the last year and half ATLAS six Technical Design Reports (TDR) were produced by the ATLAS Collaboration. In these TDRs the physics motivation and benefits of such upgrades are discussed together with details on the upgrade project itself.

In this contribution we review the expected performance of the upgraded ATLAS detector and the expected reach for physics measurements as well as the discovery potential for new physics that is expected by the end of the HL-LHC data-taking. Performance of object reconstruction under the expected pile-up conditions will be shown, including a fully re-optimized b-tagging algorithm. Important benchmark physics projections including di-Higgs boson production sensitivity will be discussed.

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A High-Granularity Timing Detector for the Phase-II upgrade of the ATLAS Calorimeter system: detector concept, description and R&D and first beam test results

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The expected increase of the particle flux at the high luminosity phase of the LHC (HL-LHC) with instantaneous luminosities up to $L \simeq 7.5 \times 10^{34}$ cm^{-2} s^{-1} will have a severe impact on the ATLAS detector performance. The pile-up is expected to increase on average to 200 interactions per bunch crossing. The reconstruction and trigger performance for electrons, photons as well as jets and transverse missing energy will be severely degraded in the end-cap and forward region, where the liquid Argon based electromagnetic calorimeter has coarser granularity and the inner tracker has poorer momentum resolution compared to the central region. A High Granularity Timing Detector (HGTD) is proposed in front of the liquid Argon end-cap calorimeters for pile-up mitigation and for bunch per bunch luminosity measurements.

This device should cover the pseudo-rapidity range of 2.4 to about 4.0. Two Silicon sensors double sided layers are foreseen to provide a precision timing information for minimum ionizing particle with a time resolution better than 50 pico-seconds per hit (i.e 30 pico-seconds per track) in order to assign the particle to the correct vertex. Each readout cell has a transverse size of 1.3 mm × 1.3 mm leading to a highly granular detector with about 3 millions of readout electronics channels. Low Gain Avalanche Detectors (LGAD) technology has been chosen as it provides an internal gain good enough to reach large signal over noise ratio needed for excellent time resolution.

The requirements and overall specifications of the High Granular Timing Detector at the HL-LHC will be presented as well as the conceptual design. Most recent results on the main R&D will be discussed, with emphasis on the LGAD sensors (sensor optimisation as thickness, dead zone…., and radiation hardness) and ASIC. Beam test results of gain,timing resolution and efficiency will be also shown.

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The upgrade of the CMS ECAL Barrel calorimeter at the HL-LHC for high-precision energy and time measurements

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The electromagnetic calorimeter (ECAL) of the Compact Muon Solenoid Experiment (CMS) has been operating at the Large Hadron Collider (LHC) with proton-proton collisions at 13 TeV center-of-mass energy, with a bunch spacing of 25 ns and instantaneous luminosity exceeding 10^34 cm-2s-1. The CMS ECAL design ensures that its superb performance extends over a very wide range of energies, up to electron and photon energies of ~1 TeV, as required for physics searches beyond the standard model. The Run II running conditions give a first impression of the challenging environment we expect at the high luminosity LHC (HL-LHC). We review the design and R&D studies for the CMS ECAL crystal calorimeter upgrade. Particular challenges at the HL-LHC are the harsh radiation environment, the increasing data rates, and the extreme level of pile-up events, up to 200 simultaneous proton-proton collisions. We present test beam results on hadron irradiated PbWO crystals up to the fluences expected at the HL-LHC and the status of the new readout and trigger electronics R&D. The pile-up mitigation may be substantially improved by means of precision time tagging of calorimeter

clusters, by associating them to primary vertices via 4D triangulation. We present test beam results on the precision timing potential of the CMS PbWO crystal calorimeter and discuss how the readout electronics may be adapted to exploit this performance in CMS.

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The CMS HGCAL detector for HL-LHC upgrade

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The High Luminosity LHC (HL-LHC) will integrate 10 times more luminosity than the LHC, posing significant challenges for radiation tolerance and event pileup on detectors, especially for forward calorimetry, and hallmarks the issue for future colliders. As part of its HL-LHC upgrade program, the CMS collaboration is designing a High Granularity Calorimeter to replace the existing endcap calorimeters. It features unprecedented transverse and longitudinal segmentation for both electromagnetic (ECAL) and hadronic (HCAL) compartments. This will facilitate particle-flow calorimetry, where the fine structure of showers can be measured and used to enhance pileup rejection and particle identification, whilst still achieving good energy resolution. The ECAL and a large fraction of HCAL will be based on hexagonal silicon sensors of 0.5 - 1 cm^2 cell size, with the remainder of the HCAL based on highly-segmented scintillators with SiPM readout. The intrinsic high-precision timing capabilities of the silicon sensors will add an extra dimension to event reconstruction, especially in terms of pileup rejection. An overview of the HGCAL project will be presented, covering motivation, engineering design, readout and trigger concepts, and performance (simulated and from beam tests).

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Electron and photon identification with the ATLAS detector

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Excellent electron and photon identification capabilities are crucial for many aspects of the ATLAS physics program, from standard model measurements (including Higgs boson) to new physics searches. The identification of prompt photons and the rejection of backgrounds, mostly coming from photons from hadron decays, relies on the high granularity of the ATLAS calorimeter. Electron identification is
based on a likelihood discrimination to separate isolated electron candidates from candidates originating
from photon conversions, hadron misidentification and heavy flavor decays. Isolation variables are used
as further handles to extract the signal. The measurement of the efficiencies of the identification and isolation cuts are performed using several high-statistics data samples, including Z->ee and J/psi->ee decays, radiative Z decays, and inclusive high energy photon samples. The results of these measurements, performed with pp collision data recorded at sqrt(s)=13 TeV during 2015-2017 and corresponding to an integrated luminosity of 80 fb-1, are presented. The impact of the pile-up, especially
large in the second part of 2017 data taking, is discussed.

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Precision Timing with the CMS MIP Timing Detector

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The Compact Muon Solenoid (CMS) detector at the CERN Large Hadron Collider (LHC) is undergoing an extensive Phase II upgrade program to prepare for the challenging conditions of the High-Luminosity LHC (HL-LHC). In particular, a new timing layer will measure minimum ionizing particles (MIPs) with a time resolution of ~30ps and hermetic coverage up to a pseudo-rapidity of |η|=3. This MIP Timing Detector (MTD) will consist of a central barrel region based on LYSO:Ce crystals read out with SiPMs and two end-caps instrumented with radiation-tolerant Low Gain Avalanche Diodes. The precision time information from the MTD will reduce the effects of the high levels of pile-up expected at the HL-LHC and will bring new and unique capabilities to the CMS detector. The time information assigned to each track will enable the use of 4D reconstruction algorithms and will further discriminate interaction vertices within the same bunch crossing to recover the track purity of vertices in current LHC conditions. For instance, in the analysis of di-Higgs boson production decaying to heavy flavor and two photons, 30 ps timing resolution is expected to improve the effective luminosity by 22% through gains in b-tagging and photon isolation efficiency. We present motivations for precision timing at the HL-LHC and the ongoing MTD R&D targeting enhanced timing performance and radiation tolerance, including test beam results.

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Operational Experience and Performance with the ATLAS Pixel detector at the Large Hadron Collider

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The tracking performance of the ATLAS detector relies critically on its 4-layer Pixel Detector, that has undergone significant hardware and readout upgrades to meet the challenges imposed by the higher collision energy, pileup and luminosity that are being delivered by the Large Hadron Collider (LHC), with record breaking instantaneous luminosities of 2 x 10^34 cm-2 s-1 recently surpassed.
The key status and performance metrics of the ATLAS Pixel Detector are summarised, and the operational experience and requirements to ensure optimum data quality and data taking efficiency will be described, with special emphasis to radiation damage experience.

In particular, radiation damage effects will be showed and signs of degradation which are visible but which are not impacting yet the tracking performance (but will): dE/dX, occupancy reduction with integrated luminosity, under-depletion effects with IBL in 2016, effects of annealing that is not insignificant for the inner-most layers.
In addition, the strategy to contain the readout bandwidth limitation will be discussed, required by the LHC over-performing.
Numbers and strategy will also be discussed.

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ATLAS Calorimeter system: Run-2 performance, Phase-1 and Phase-2 upgrades

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The ATLAS detector was designed and built to study proton-proton collisions produced at the LHC at centre-of-mass energies up to 14 TeV and instantaneous luminosities up to 10^{34} cm^{−2} s^{−1}. A liquid argon-lead sampling calorimeter (LAr) is employed as electromagnetic calorimeter and hadronic calorimeter, except in the barrel region, where a scintillator-steel sampling calorimeter (TileCal) is used as hadronic calorimeter.

ATLAS recorded 87 fb^{-1} of data at a center-of-mass energy of 13 TeV between 2015 and 2017. In order to achieve the level-1 acceptance rate of 100 kHz, certain adjustments have been performed. The calorimetry system performed accordingly to its design values and have played a crucial role in the ATLAS physics programme. This contribution will give an overview of the detector operation, monitoring and data quality, as well as the achieved performance, including the calibration and stability of the energy scale, noise level, response uniformity and time resolution of the ATLAS calorimetry system.

The upgrade projects of the ATLAS calorimeter system will also be presented.

For Run-3, where luminosities around L ⊠ 2 × 10^{34} cm^{−2} s^{−1} will be achieved, an upgrade of the LAr trigger readout is necessary to keep a high signal efficiency. The LAr Trigger Digitizer frontend system will digitize 34000 channels at 40 MHz with 12 bit precision after bipolar shaping. The backend LAr Digital Processing system will compute the energy and time of the signals. Results of ASIC developments including QA and radiation hardness evaluations, performances of the final prototypes and results of the system integration tests will be presented along with the overall system design.

For the high luminosity phase of the LHC (HL-LHC), the luminosity will increase up to L ⊠ 7.5 × 10^{34} cm^{−2} s^{−1} leading to an average pile-up up to 200 interactions per bunch crossing. The electronics of both calorimeters has to be upgraded to cope with longer latencies of up to 35 µs needed by the trigger system at such high pileup levels. The expected radiation doses will also exceed the qualification range of the current readout system.

Low-noise, low-power, radiation-tolerant and high-bandwidth electronics components are being developed in 65 and 130 nm CMOS technologies for the LAr system. First prototypes of the front-end electronics components show good promise to match the stringent specifications. The off-detector electronics will make use of FPGAs connected through high-speed links to perform energy reconstruction, data reduction and buffering.
For the Tile system, the photomultiplier signals will be digitized and transferred off-detector to the TileCal PreProcessors (TilePPr) for every bunch crossing, requiring a data bandwidth of 40 Tbps. The TilePPr will reconstruct, store and send the calorimeter signals to first level of trigger at a rate of 40 MHz. In parallel, the data samples will be stored in pipeline memories and the data of the events selected by the ATLAS central trigger system and transferred to the ATLAS global Data AcQuisition (DAQ) system for further processing.
Results of tests of the first prototypes will be presented, along with design studies and simulations of the performance of the readout system.

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Overview talk on detector performances at CMS

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The performance of CMS detector on early 2018 data will be presented. Special attention will be given to the performance of the recently upgraded components, and in particular to the silicon pixel detector and hadronic calorimeters.

Diversity and Inclusion / 1108

Discussion

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Advancing inclusion through work-life balance policies.

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CERN, as an intergovernmental organisation with twenty-two Member States mainly from across Europe, operates in a very particular environment. Complying with the necessity to promote the geographical representation of Member States among its 4000 employees and students inevitably engenders talent attraction challenges. As a research performing organisation in high-energy physics and related fields, fostering gender diversity also proves to be rather complex.
To remain an attractive employer, CERN regularly updates its financial and social conditions taking into account the prevailing social trends and expectations from the new generation of internationally mobile scientists. However, taking action at the time of recruitment is not sufficient to efficiently promote diversity amongst personnel: long-term support policies covering the different stages of life are necessary to help individuals shape their life with equal opportunities, while overcoming the difficulties that may arise from their career and life choices.
To that aim, CERN has recently upgraded its employment policies through a review of its measures enabling a better balance between professional and personal life, and developing an inclusive approach of family structures. Rather than working on pure gender equality plans, CERN has invested in work-life balance policies.
The presentation will give an overview of the policies, questioning whether they can help demanding institutions like CERN re-think the work environment and change a normative work culture into a more inclusive one.

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ECGD: Supporting early-career physicists, gender equality, and diversity at LHCb

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LHCb is a collaboration of over 800 scientists from 72 institutions based in 16 countries, and representing many more nationalities. We aim to work together on experimental high energy physics, and to do so in the best and most productive and collaborative conditions. The ECGD office exists

to support this goal, and in particular has a mandate to support early-career physicists, and to work towards gender equality and support diversity in the collaboration. In this talk we discuss what we have learned from analysis of the collaboration's demographics and survey responses, share our experiences from efforts to achieve these aims, and consider the broader context and challenges facing the field.

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Regional, Age and Gender Demographics in the ATLAS Collaboration

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The ATLAS Collaboration consists of more than 5000 members, with nearly 100 different nationalities. This study presents updated data showing aspects of the regional, age and gender demographics of the collaboration. In particular the relative fraction of women is discussed, including their share of contributions, recognition and positions of responsibility, and showing how this depends on other demographic measures.

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Using HEP Expertise for Social & Humanitarian Impact

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When humanitarian and social challenges from the United Nations, Red Cross and Non Governmental Organisations meet HEP expertise impactful innovation steps become reality. THE Port association at CERN combines physicists and engineers working on HEP topics in their day job with researchers, refugees, entrepreneurs, artists, designers, humanitarian workers and other creative minds. In 60-hour hackathons they co-create new technology opportunities, identify new methods, materials and processes, that can be used in the humanitarian context and sometimes even feed back into HEP. Examples of the last 5 years of humanitarian hackathons at CERN, their outcomes now utilised by UN, ICRC and others as well as future initiatives for HEP society impact are presented.

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Discussion

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Strategies to improve diversity and inclusion in physics

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The number of physics and astronomy bachelor's and doctoral degrees earned in the US continues to increase. However, the degrees earned by underrepresented minority (URM) groups continues to be a small percentage and is on a downward trend for Black/African American students.

National societies such as the American Physical Society (APS) and the American Institute of Physics (AIP) have acknowledged there must be action taken to improve the situation. APS has started the National Mentoring Network, the APS Bridge Program, sponsored the CUWiP conferences, and published the LGBT climate in physics report. AIP has recently launched the TEAM-UP Task Force to investigate the reasons for the persistent underrepresentation of African American undergraduate students in physics and astronomy.

In this talk, I will recap levels of representation in physical sciences, discuss current national efforts and outline some initiatives at the University of Michigan aimed to improve diversity and inclusion in physics.

Diversity and Inclusion / 691

A scientometric analysis of diversity in HEP over the past three decades

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This study addresses various aspects of diversity through a scientometric analysis of HEP publications spanning three decades – from the late 80's to date. It analyzes physics and technological research pertaining to high energy physics, and compares the evolution of a set of diversity parameters in this field and in other research domains, such as nuclear physics and astrophysics. The scientometric analysis involves a variety of social and scientific characteristics of the data, such as the geographical distribution of scholarly publications and their share among research and academic institutions, the funding agencies, the association of researchers with formal collaborations, the spectrum of journals in pertinent research areas and evidence of interaction with other fields. The data are collected from the Web of Science and are analyzed by means of econometric methods and techniques pertaining to statistical ecology, such as trend tests, inequality measures and diversity indices. Correlations in evolution patterns are identified by means of statistical inference methods. The results document quantitatively and objectively the evolution of the role of entities traditionally active in HEP research as well the appearance of new players on the scene. Different patterns observed in physics and technological research are discussed; specific features of diversity evolution in HEP with respect to other physics research domains are highlighted.

Diversity and Inclusion / 763

Moving towards diversity and inclusion in science: Why it is essential for Physics in Africa

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The challenge of diversity and inclusion in science is not solely about demographics. And although improving the numbers is a necessary start, it is not enough to truly address the challenge. Many institutions in South Africa, for example, are making concerted efforts to recruit students and staff from historically marginalized groups, but this approach will only succeed if academics, administrators, and the scientific community at large also consider the environment that the students and new staff are being recruited into, and how to make those spaces truly inclusive arenas where a diverse group of scholars can thrive.

For an environment to be inclusive, students and staff also need spaces to openly and honestly vocalize their feelings and anxieties related to broader social issues. At the Nelson Mandela University, for example, such spaces are created under the theme of 'Courageous Conversations'.

Creating an inclusive scientific community, particularly within the context of South African academic science, is a challenging and multidimensional issue. Nonetheless, there are efforts that are being championed by the South African Institute of Physics and the physics community of South Africa and Africa as a whole.

This report will highlight efforts aimed at addressing the diversity and inclusion in science challenge. The focus will be on physics as a discipline where the diversity and inclusion challenge is most experienced. Physics, and in particular a diverse programme joining nuclear and particle physics with astrophysics, astronomy, cosmology and theoretical physics, offers a model for driving diversity and inclusion in science.

Diversity and Inclusion / 752

Broadening access to STEM via Gender inclusive teaching

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Various studies have demonstrated that girls are less likely than boys to take up science subjects in high schools, in most countries. This has later repercussions on professional choices. A 2015 study by the OECD demonstrates that the main reason for boys' and girls' education choices is less related to ability than self-perception.
Three years ago, with the initial support of an education researcher, CERN launched an awareness-raising initiative on gender equality in the science classroom within its International High School Teacher Programme. The objective of the initiative is to equip teachers with an understanding of concepts used in diversity management, and explore how they apply to science teaching. This translates into helping them design actions that they will put in place in their classroom, and possibly disseminate in their local education professionals' network. Sharing experience, addressing stereotypes reproduced in physics classes and other aspects that may influence students' motivation are part of the programme, as well as the exploration of collaborative tools to disseminate the lessons learnt. Gender inclusive teaching has been acclaimed by the programme's participants and has become one of its yearly features.

The presentation will explain why and how the programme was set up, and draw an assessment of what was achieved so far. It will also touch on the limits of the initiative and explain its possible dissemination towards a broader network actively developing and promoting ideas and tools.

Education and Outreach / **951**

Engineering Physics : Bridging Basic Sciences Based R&D And Technology Developments And Adaptation.

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Most of the newer emerging technologies have their origin well rooted in the Basic Sciences driven R and therefore requires specialized skills for their adaptations. Engineering Physics is the area that addresses to this gap.

A post-M.Sc. program has been designed, implemented to bridge the gap between research in Basic Sciences, in particular, with physics and mathematics with the latest emerging technologies and it's industrial impact. The curriculum has been designed to acquire skills for critical R&D input to some of the areas like Nano-Technology, Material Sciences for PV Engineering applications, Sensors Bio-medical applications, Nuclear Technologies for civilian purposes, computer science based industries, etc. The program is expected to produce experts with requisite on-hand specialized skills to undertake the Basic Sciences based R&D leading to industrial products for commercial applications in identified areas. The model has been analysed including it's impact. Some of the future guidelines have been identified and discussed.

Education and Outreach / **474**

ATLAS Open Data project

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Exploring the many ways that public High Energy Physics resources are employed to teach and outreach particle physics and computer science.

The current ATLAS model of Open Access to recorded and simulated data offers the opportunity to access datasets with a focus on education, training and outreach. This mandate supports the creation of platforms, projects, software, and educational products used all over the planet. We describe the overall status of ATLAS Open Data (http://opendata.atlas.cern) activities, from core ATLAS activities and releases to individual and group efforts, as well as educational programs, and final web or software-based (and hard-copy) products that have been produced or are under development. The relatively large number and heterogeneous use cases currently documented is driving an upcoming release of more data and resources for the ATLAS Community and anyone interested to explore the world of experimental particle physics and the computer sciences through data analysis.

Education and Outreach / **921**

8 Hours of the NicoNico live webcast from the Belle II experimental hall

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Phase 2 of the Belle II experiment is about to begin. A new super-B factory facility, utilizing the SuperKEKB accelerator and the Belle II detector, is designed to search for as yet unknown "New Physics".

The outreach teams of KEK and the Belle II collaboration worked together for more than a year to make the Belle II/SuperKEKB project better known in Japan as well as in the world.

Significant milestones in our roadmap are:
(1) the start of Phase 1 in Feb. 2016 and first turns in the SuperKEKB accelerator,
(2) "the Belle II roll-in", integration of the detector and the accelerator in Apr. 2017, and
(3) Phase2 and first collisions in the coming months,
the list will go on as the project develops towards its design luminosity.

In this talk, we will focus on "the Belle II roll-in" .
We cooperated with the "Niconico" livestreaming service in Japan and live-casted the roll-in event from the Belle II experimental hall for over 8 hours.

We would like to share know-how on how we collaborated, how we risk-hedged , and how impressive it was, and exchange opinions with other institutions who have tried livecasting important events.

Education and Outreach / 913

Belle2VR – An Interactive Virtual Reality Visualization of Particle Physics

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I describe a novel interactive virtual reality visualization of particle physics, designed as an educational tool for learning about and exploring the electron-positron collision events in the Belle II experiment at the SuperKEKB colliding-beam facility at KEK in Japan. The visualization is designed for untethered, locomotive virtual reality, allowing multiple simultaneous users to walk naturally through a virtual model of the Belle II detector and interact with and gather information about the particles that result from collisions. Belle2VR displays the detailed GEANT4-simulated history of each collision event superimposed on the complete detector geometry; the user can move freely through the scalable detector geometry and manipulate the history timeline with handheld controllers. Developed by an interdisciplinary team of researchers in physics, education, and virtual environments, the simulation will be integrated into the undergraduate physics curriculum at Virginia Tech. I describe the tool, including visualization features and design decisions, and outline our plans for future development.

Education and Outreach / 487

Public analysis of Belle II Data

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A small Belle II data sample will be available to the general public through an interactive graphical application which includes basic particle selection tools for reconstructed particles. The application is using an open source library Blockly running in an HTML5 capable browser. In the application, different particle decays can be described by selecting and combining particles from the data file. The application includes easy histogramming and cutting tools and enables display of the ROOT histograms. After submission, a pseudocode is generated by the user interface. The code is interpreted by the server which then runs back-end analysis and sends back the resolution histograms to the client. The browser app also enables for the interactive fitting of the histograms, thus enabling even more complex analyses. The application can be run on a single public web server aimed at a single access or in a virtual appliance for use in a classroom consisting. The virtual appliance consists of a Linux OS, data sample, an analysis framework and a private web server. In the presentation, I will describe the application, demonstrate its use and outline our plans for future development.

Education and Outreach / 13

The Italian Summer Students Program at the Fermi National Accelerator Laboratory

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Since 1984 the Italian groups of the Istituto Nazionale di Fisica Nucleare (INFN), collaborating with the DOE laboratory of Fermilab (US) have been running a two-month summer training program for Italian university students. While in the first year the program involved only four physics students of the University of Pisa, in the following years it was extended to engineering students. This extension was very successful and the enginering students have been since then extremely well accepted by the Fermilab Technical and Accelerator Division groups.
Since 2004 the program has been supported in part by DOE in the frame of an exchange agreement with INFN. An additional agreement for sharing support for engineers of the School of Advanced Studies of S.Anna (SSSA) of Pisa was established in 2007 between SSSA and Fermilab. In the frame of this program four SSSA students are supported each year. Over its 35 years of history, under the management of the Cultural Association of Italians at Fermilab (CAIF.fnal.gov), the program has grown in scope and size and has involved more than 500 Italian students from more than 20 Italian Universities, Since the program does not exclude appropriately-selected non-italian students, a handful of students of European and non-European Universities were also accepted in the years.
Last year the program was extended to include three students to be trained in neutrino physics, selected concurrently with the University of Oxford (UK), who are supported one month in Oxford before the start of the program at Fermilab.
Each intern is supervised by a Fermilab Mentor who is responsible for performing the program. Training programs spanned from Tevatron, CMS, MicroBooNE, Nova experimental data analysis, development of particle detectors (e.g. silicon trackers, calorimeters, drift chambers, neutrino and dark matter detectors), design of the Muon "g-2" and Mu2e experiments, design of electronic and accelerator components, development of infrastructures and software for tera-data handling, research on superconductive elements and on accelerating cavities, theory of particle accelerators.
Since 2010, within an extended CAIF program supported by the Italian Space Agency and the Italian National Institute of Astrophysics, a total of 25 students in physics, astrophyics and engineering have been hosted for two months in summer at US space science Research Institutes and laboratories.

In 2015 the University of Pisa included these programs within its own educational programs. Accordingly, Summer School students are enrolled at the University of Pisa for the duration of the internship and are identified and insured as such. At the end of the internship the students are required to write summary reports on their achievements, which are saved in the Fermilab web pages and in the CAIF archives, After positive evaluation by a University Examining Board, interns are acknowledged 6 ECTS credits for their Diploma Supplement.
The CAIF program is now part of the outreach activities of the European MUSE (H2020-MSCA-RISE-2015 GA 690835) and NEWS (H2020-MSCA-RISE-2016 GA 734303) projects, and is expected to grow further in the near future.
Information on student recruiting methods, on training programs of recent years and on final student's evaluation process at Fermilab and at the University of Pisa will be given in the presentation.

Education and Outreach / **657**

Phantom of the Universe: A State-of-the-Art Planetarium Show on Dark Matter

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Phantom of the Universe is a planetarium show that showcases an exciting exploration of dark matter, from the Big Bang to the Large Hadron Collider. The show reveals the first hints of its existence through the eyes of Fritz Zwicky. Viewers see the astral choreography witnessed by Vera Rubin in the Andromeda galaxy. They plummet deep underground to see a very sensitive dark matter detector. From there, they end the journey at the Large Hadron Collider, speeding alongside particles before they collide in visually stunning explosions of light and sound, and learning how scientists around the world are collaborating to track down the constituent of dark matter. The show is offered to planetariums worldwide free of charge, and is currently in more than 300 planetariums in 56 countries in 17 languages. It features sound by Skywalker Sound and narration by Academy-Award winning actress Tilda Swinton, as well as the writing and producing talents of award-winning filmmaker, Carey Ann Strelecki. Michael Barnett, Kaushik De, and Reinhard Schwienhorst were the Executive Producers.

Education and Outreach / **812**

The role of nuclear and particle physics, astrophysics, and cosmology in building capacity for Physics in Africa

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In Africa particle physics, nuclear physics, astrophysics, and cosmology have been grabbing our attention, and that of our students for years. In the last decade, the field of a diverse research programme joining nuclear and particle physics with astrophysics, astronomy, cosmology and the enticing 'new worlds' imagined in theoretical physics has become particularly exciting due to the unprecedented scale of modern machinery and the discoveries that come with it. There are so many opportunities for students, teachers, and the public to learn about modern science such as the value of blue-skies research to society and everyday applications. For teachers, students, and academics this is also an opportunity to rethink the African science curriculum.

The South African Institute of Physics has created opportunities for the physics community in Africa to engage in physics education and outreach. The nuclear and particle physics community participates through iThemba LABS and the South Africa-CERN Consortium while the astrophysics and cosmology community participates in the astronomy facilities such as the Southern African Large Telescope (SALT) and the Square Kilometre Array (SKA) and its precursor MeerKAT. Teachers, researchers in education and science communication, professionals who work in engagement and outreach in particle physics, nuclear physics, astrophysics, and cosmology, as well as academics across both areas, collaborate in physics education and outreach programmes.

The aim of this report is to highlight the challenges Africa faces in building capacity in physics and the positive impact particle physics, nuclear physics, astrophysics, and cosmology has on physics education, communication, and outreach in Africa.

Education and Outreach / **473**

Taking science to festivals: engaging the public where they least expect it

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Over the past several years, a team based around the ATLAS Experiment at CERN in Geneva has organised public engagement and education activities at a variety of non-scientific venues. These have included the Montreux Jazz Festival (Montreux, Switzerland), the Bluedot Festival (Jodrell Bank, UK), the WOMAD Festival (Charlton Park, UK), Moogfest (Durham, NC, USA), and the Sofia Music Weeks in Bulgaria, with discussions on-going with a major European music festival as well as a festival in the United States. The goal of this effort is to engage new audiences who normally would not be drawn to science festivals and to investigate our ability to communicate scientific messages to broad, diverse audiences.

The results have been impressive, as measured through attendance (example: the first Physics Pavilion at WOMAD received 4500 visitors over 3 days and such was the success that a return invitation was received immediately for 2017 with additional space, resulting in an increased footfall of ~5500), and enthusiasm of the audience and the scientists hosting the activities. We describe the presentation material and format, the hands-on workshops, and other methods employed, as well as lessons learned on how to best optimise audience engagement. The concept can be reproduced for other festival-type environments, and adapted to suit the particular audience demographic and format of the festival.

Education and Outreach / **52**

The impact of Particle Physics Masterclasses on higher school students' Understanding of Science and Attitudes towards Science

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This paper presents early results from a research into the impact of Particle Physics Masterclasses on the Understanding of Science and the Attitudes towards science of higher school students. The

author has found that science communication efforts in plain science are criticized for being "deficit – style" approaches or ones that seek to educate rather than engage. The literature is lacking when it comes to fields such as Particle Physics Communication whereas much research into public engagement has involved studying fields of research with an immediate impact on human life and society (e.g. climate change, genetically modified organisms, nuclear power). Despite this deficit- style approach into the science communication research field, there is a large Particle Physics researchers community really involved in communication. An example of this engagement are the International Masterclasses, an outreach programme run by IPPOG, International Particle Physics Outreach Group. Each year (in February-March) more than 13.000 high school students in 52 countries were involved; each country has usually several sites and experiments. The global Public Engagement in the field has long been coordinated by IPPOG whereas in Italy the international Masterclasses are coordinated by INFN, National Nuclear Physics Institute, involving in every edition around 3.000 students (aged 15-18). This science engagement format was imported into Italy in 2005 and it involves around 2.500- 3000 higher school students every year.

The sample was extracted from the population of the students that attended the Italian Particle Physics Masterclasses during the 2017, edition that involved 2.700 students (source: Data INFN).
The paper focuses on the quantitative analysis of data which were collected at twice (1) via a paper-based survey distributed to the students before attending the Masterclasses and (2) via an online-based survey distributed to the students after attending the Masterclasses.
In order to measure the Understanding of Science were used variables - consisting of different items - which through a factorial analysis were sum up to create 8 scales: Objectivity, Direct and Indirect Observations, Interpretations, Culture and Society, Communication Findings, Accepting a New theory, Disagree with a Theory, Governments and Politics; with a view to measure the "Attitudes towards science", the reference scale - consisting of several variables - is unique and was defined properly as "attitudes towards science" scale. Futher, the questionnaire provided some open – ended questions to provide more meaningful data as well. To verify any differences in Understanding of Science and in the Attitudes towards Science because of attending the INFN Masterclass, was used a paired samples t-test. The results shown here refer to two topics among all those covered in the survey and relate to a paired comparison between respondents ex ante and ex post:

(1) gender diversity - Concerning Understanding of Science, males appear to have higher scores in "Direct and Indirect Observations" and in "Objectivity" categories; concerning Attitudes towards Science, males in general turn out to have higher scores compared to females.

(2) interest in Physics - Concerning Understanding of Science, students interested in Physics turn out to have higher scores in "Direct and Indirect Observations"; concerning Attitudes towards Science,students interested in Physics appear to have in general higher scores in "Attitudes towards Science" category.

The survey was part of the author's research towards a PhD in Science Communication. This research project for the first time collected data about this outreach format in Italy.

Education and Outreach / **574**

A MOOC on HEP for French high schools

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"Voyages de l'infiniment grand à l'infiniment petit" ("Journeys from the infinitely large to the infinitely small") is a French Massive Online Open Course aimed at promoting nuclear and particle physics as well as astrophysics and cosmology to high-school teachers and pupils. Designed by an editorial team of physicists from CNRS and CEA and edited with the pedagogical and technical support from Ecole Polytechnique, this MOOC is composed of 4 courses (Physics of the infinitely small, physics of the infinitely large, The links between the two, The connections with everyday life), consisting in 10 modules of 10 minutes each, and a dozen of speakers have contributed in the writing of the modules. The MOOC students can follow the 4 courses and test their knowledge through a series of quizzes on the Coursera platform. This MOOC aims at providing an overview of high-energy physics to interested students with a high-school level in physics, and also at giving video and text resources to high-school teachers willing to include high-energy physics in their lectures.

Education and Outreach / **666**

Particle Physics Masterclasses: Sharing LHC Research and Discovery with High School Students

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Masterclasses are a proven tool to engage high school students with particle physics. In a Masterclass, participants learn about high energy physics in a day-long course. Moreover, they can actively take part in cutting-edge research and experience methods and tools used in research by performing a tailor-made physics analysis involving real LHC data under the supervision of physicists. During a Masterclass students not only explore the fundamental forces and building blocks of nature, but they can also improve their understanding of science and the scientific discovery process. Particle Physics Masterclasses offer an authentic experience and add a new dimension to physics education at school, thus stimulating the students´ interest in science.

More than 300 Masterclasses are organized in the framework of the program *International Masterclasses* each year. During a 6-week period spanning roughly February to April, research institutes and universities in more than 50 countries invite high school students for a Masterclass. At the end of each day, the participants join in a videoconference with other student groups and CERN, Fermilab, or TRIUMF. Like an international research collaboration, they share and combine the results of their analyses and can thus experience for themselves an important part of the experimental particle physics working process. The program attracts more than 13,000 high school students each year and is run by IPPOG, the International Particle Physics Outreach Group, and is centrally coordinated at Technische Universität Dresden and University of Notre Dame.

The successful Particle Physics Masterclasses are also arranged in other contexts. In 2017, an extra effort was started by IPPOG to support and promote the access of girls to science. To accomplish this, IPPOG launched Masterclass activities especially for girls on the UN International Day of Women and Girls in Science.

In Germany, the nationwide program *Netzwerk Teilchenwelt*, which includes 30 universities and research labs, has been established. For *Netzwerk Teilchenwelt*, Particle Physics Masterclasses are instrumental as a basic level, but is builds up several higher levels of engagement, e.g. workshops at CERN or research projects at universities and institutes for the most motivated and interested high school students. On total, this program offers activities for 4000 high school students per year on four levels.

In the United States, QuarkNet offers International Masterclasses, a World Wide Data Day with LHC data, and Masterclass preparation activities as important components of a program to bring particle physics to high school teachers and students.

Education and Outreach / **475**

CERN's Education and Education Research Projects

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The CERN educational programme aims for a broad spectrum of educational opportunities from high-school students to professional and well experienced science teachers.
In 2017 three new projects have been launched to complement these efforts. The High-School Students Internship Programme (HSSIP) offers a two weeks national internship experience for students aged 16 to 19, enabling them to strengthen their understanding of science. The S'Cool LAB Summer Camp extends the S'Cool LAB offers by a two weeks residential programme enabling high-school students from around the world to experience hands-on science in an international research laboratory. The International Teacher Weeks is a two weeks programme that enables high-school teachers to develop further in the field of particle physics and exchange knowledge and experience among teachers from all over the world. CERN's Physics Education Research team and its projects and programmes will be presented, and the first experience with the above-mentioned programmes will be discussed together with the future plans to monitor and evaluate these programmes.

Education and Outreach / 555

Status of outreach activities at LHCb

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Status of outreach activities at the LHCb experiment at LHC is presented. LHCb is visible on the web with the public page news, Instagram, Facebook and online event display. Masterclasses activities for school boys and girls cover the whole planet. The surface exhibition above the LHCb proton-proton collision point is being constantly developed. Cameras in the control room allow Virtual Visits of the LHCb experiment. Laser scan of LHCb detector is performed to archive its 3D images as an important heritage for humanity. These images will also be used to develop 3D Virtual Reality files for visitors and schools. New film covering a major LHCb discovery is finalized.

Education and Outreach / 472

The "social content" strategy of the ATLAS Experiment

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Social media is an essential tool for communicating particle physics results to a wide audience. This presentation will explore how the nature of social media platforms has impacted the content being shared across them, and the subsequent effect this has had on the user experience. The ATLAS Experiment has adapted its communication strategy to match this social media evolution, producing content specifically targeting this emerging audience. The success of this approach is examined and the effect on user experience is evaluated.

Formal Theory Development / 1015

D-instantons in Klebanov-Witten model

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I discuss D-instanton solutions in type IIB supergravity on AdS5×T1,1, which has a dual N=1 SU(N)×SU(N) super Yang-Mills theory. Apart from ordinary D(-1)-brane instantons, I consider wrapped D1-branes over minimal 2-cycles and derive explicit solutions preserving half the supersymmetries. These solutions are identified with Yang-Mills instantons which are (anti)self-dual in both gauge group factors with instanton charge (k,k′). By examining the boundary behaviour of the solutions I derive the coupling to the corresponding dual boundary operators, and identify their vacuum expectation values. I also discuss the boundary terms and compute the action for these solutions.

Formal Theory Development / 923

Prediction for the Cosmological Constant and Constraints on SUSY GUTS: Status Report for Resummed Quantum Gravity

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Working in the context of the Planck scale cosmology formulation of Bonanno and Reuter, we use our resummed quantum gravity approach to Einstein's general theory of relativity to estimate the value of the cosmological constant as $\rho_\Lambda = (0.0024 eV)^4$. We show that susy GUT models are constrained by the closeness of this estimate to experiment. We also present various consistency checks on the calculation and use the Heisenberg uncertainty principle to remove a large part of the remaining uncertainty in our estimate of ρ_Λ

Formal Theory Development / 744

\theta=\pi in SU(N)/Z_N Theory

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In SU(N) gauge theory, it is argued recently that there exists a "mixed anomaly" between the CP symmetry and the 1-form ZN symmetry at \theta=\pi, and the anomaly matching requires CP to be spontaneously broken at \theta=\pi if the system is in the confining phase. In this talk, we elaborate on this discussion by examining the large volume behavior of the partition functions of the SU(N)/Z_N theory on T^4 a la 't Hooft. The periodicity of the partition function in \theta, which is not 2\pi due to fractional instanton numbers, suggests the presence of a phase transition at \theta=\pi.

Formal Theory Development / 239

Casimir scaling and Yang-Mills glueballs

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We conjecture that in Yang-Mills theories the ratio between the ground-state glueball mass squared and the string tension is proportional to the ratio of the eigenvalues of quadratic Casimir operators in the adjoint and the fundamental representations. The proportionality constant depends on the dimension of the space-time only, and is henceforth universal. We argue that this universality, which is supported by available lattice results, is a direct consequence of area-law confinement. In order to explain this universal behaviour, we provide three analytical arguments, based respectively on a Bethe-Salpeter analysis, on the saturation of the scale anomaly by the lightest scalar glueball and on QCD sum rules, commenting on the underlying assumptions that they entail and on their physical implications.

Formal Theory Development / 521

Supersymmetrizing the map between W symmetry and affine Yangian

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Higher spin symmetry and integrability are two different types of symmetry structures with strong constraining power. I will explain an interesting and useful map between the two in the example of the W symmetry and affine Yangian of gl(1). Then I will explain how to supersymmetrize this map via gluing. This method then allows us to construct new types of affine Yangian algebras.

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New nonperturbative scales and glueballs in confining supersymmetric gauge theories

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Studying confining gauge theories on a circle
can provide answers to some of the deepest
questions about QCD. In this talk, I start
by summarizing the main characteristics shared

by the compactified theories and their four
dimensional cousins. Next, I show that the
glueball spectrum of the compactified theories
is much richer than what have been thought
before. In particular, new nonperturbative
scales and glueballs emerge in the deep IR
regime of the theory. I discuss the spectrum
in the context of super Yang-Mills and show
that the lightest glueball states fill a
chiral supermultiplet with doubly nonperturbative
binding energy. I end with possible implications
of these findings for the four dimensional
gauge theories.

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Extensive quantum entanglement and localization in quantum spin chains

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Quantum entanglement is the most surprising feature of quantum theory. Ground states of quantum many-body systems typically exhibit the area law behavior in the entanglement entropy, which measures the amount of entanglement between a subsystem and the rest of the system. Recently, a class of solvable spin models with local interactions has been constructed by Mavassagh and Shor and by Salberger and Korepin, in which the ground state is expressed as a superposition of random walks, and has much larger entanglement. Its entanglement entropy is shown to be proportional to the square root of the volume.
In this talk, after a brief review of the models, we construct an extension of these models based on symmetric inverse semigroups, and discuss entanglement properties of ground states and its implications in quantum gravity and string theory. As a feature of the extended models that is not found in the original models, there are excited states corresponding to disconnected paths in decorated random walks. Interestingly, Anderson localization phenomena occur in such excited states.

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Non-orientable surfaces and electric-magnetic duality

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Kapustin and Witten showed that a twisted version of N=4 gauge theory in four dimensions compactifies to a two-dimensional sigma-model whose target space is the Hitchin moduli space. In this talk, I consider the reduction of the gauge theory on a four dimensional orientable spacetime manifold which is not a global product of two surfaces but contains a non-orientable surface. The low energy theory is a sigma-model on a two dimensional worldsheet whose boundary components end on branes constructed from the Hinthin moduli space of a non-orientable surface. I will also compare the discrete topological fluxes in four and two dimensional theories and verify the mirror symmetry on branes as predicted by the S-dualty in gauge theory.

Formal Theory Development / 1037

Modular Constraints with (Super-)Virasoro Algebras

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In this talk, we will discuss how the modular property constraints partition function of two-dimensional conformal field theories(CFT). We apply the semi-definite programming to the modular constraints with assuming the presence of holomorphic/anti-holomorphic currents and twist gap in spectrum. The level-one WZW models with Degline's exceptional series, cousins of extremal CFTs and novel c=8 and c=16 CFTs without Kac-Moody symmetry are reailzed on the numerical boundary. Strikingly, it turns out that the modular constraints determine the degeneracies of primary states, also the partition function of theories on the numerical boundary. We extend the above analysis by imposing W-algebra or N=1, N=2 super-Virasoro algebra.

Formal Theory Development / 312

SSB in tensor theories and matrices

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Counting observables in tensor and in matrix theories reveals a non-trivial relation between them. By means of a SSB mechanism, we explore the connection between tensor theories with symmetry group U(N)^d and symmetrized tensor theories which transform under U(N). We see that, in such a case, the Goldstone boson space precisely organizes itself into a collection of d-1 matrices transforming in the adjoint.

Formal Theory Development / 943

Analyticity Properties of Scattering Amplitude in Higher Dimensional Field Theories

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I consider analyticity properties of scattering amplitude in higher dimensional field theories in the frame works of LSZ Axiomatic field theory. I prove existence of the Lehmann-Martin ellipse and prove generalized Jost-Lehmann-Dyson theorem
to achieve this goal. Here the basis for partial wave expansion is Gegenbaur
polynomial. I also prove analog of the Froissart-Martin bound for such theories.
J. Maharana, J. Math. Phys. (1917)

Formal Theory Development / 1038

On Geometric classification of 5d SCFTs

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We formulate geometric conditions necessary for engineering 5d superconformal field theories (SCFTs) via M-theory compactification on a local Calabi-Yau 3-fold. Extending the classification of the rank 1 cases, which are realized geometrically as shrinking del Pezzo surfaces embedded in a 3-fold, we propose an exhaustive classification of local 3-folds engineering rank 2 SCFTs in 5d. This systematic classification confirms that all rank 2 SCFTs predicted using gauge theoretic arguments can be realized as consistent theories, with the exception of one family which is shown to be non-perturbatively inconsistent and thereby ruled out by geometric considerations. We find that all rank 2 SCFTs descend from 6d (1,0) SCFTs compactified on a circle possibly twisted with an automorphism together with holonomies for global symmetries around the Kaluza-Klein circle.

Heavy Ions / 467

Transverse momentum distributions of charged particles in pp and nuclear collisions with ALICE at the LHC

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The charged-particle transverse momentum spectrum in pp collisions is an important observable for testing perturbative QCD calculations and serves as a reference for heavy-ion collisions to study the properties of deconfined matter created in nucleus-nucleus (AA) collisions. The study of inclusive charged particle spectra gives information on parton energy loss in the medium created in AA collisions, leading to a suppression of hadron production at high transverse momentum (p_{T}). This effect can be investigated by calculating the nuclear modification factor, defined as the ratio between the p_{T} spectrum measured in nucleus-nucleus collisions and a reference spectrum in pp collisions scaled by the number of binary collisions. ALICE has measured pp collisions over a large energy range $\sqrt{s}$ =13, 7, 5.02 and 2.76 TeV, p-Pb at $\sqrt{s_{\mathrm{NN}}}$ =5.02 TeV, Xe-Xe at $\sqrt{s_{\mathrm{NN}}}$ =5.44 TeV and Pb-Pb $\sqrt{s_{\mathrm{NN}}}$ =5.02 TeV and 2.76 TeV. We show the p_{T} spectra in pp and nuclear collisions as well as the nuclear modification factors with a exceptional precision as compared to previous results. Comparisons to theoretical models and event generators will be shown.

Heavy Ions / 481

Low mass dielectron measurements in pp, p-Pb and Pb-Pb collisions with ALICE at the LHC

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Low-mass dielectron pairs are unique experimental tool for the studies of the Quark-Gluon Plasma (QGP) created in ultra-relativistic heavy-ion collisions at the LHC. Such pairs are produced during all stages of the collision and carry the information about the whole space-time evolution of the system unperturbed by final-state interactions. The dielectron continuum is very rich in physics sources: on top of ordinary Dalitz and resonance decays of pseudo-scalar and vector mesons, thermal black-body radiation is of particular interest as it contains the information about the temperature of the hot and dense system created in such collisions. The dielectron invariant-mass distribution is also sensitive to medium modifications of the spectral function of short-lived vector mesons that are linked to the potential restoration of chiral symmetry at high temperatures. Correlated electron pairs from semi-leptonic charm and beauty decays provide complementary information about the heavy-quark energy loss. Such pairs dominate in the intermediate mass region ($1.2 < m_{\rm ee} < 2.8$ GeV/c^2) and can be used for a complementary measurement of the heavy-flavour production cross-section. The studies of the minimum-bias proton-proton and proton-ion collisions provide crucial vacuum and cold-nuclear matter references needed for the interpretation of the heavy-ion results. Recent observations of collective effects in high-multiplicity pp and p-Pb collisions show surprising similarities with those in heavy-ion collisions. Measurements of low-mass dielectrons in such events could provide additional information regarding the underlying physics processes.

In this talk, we present the latest results from the ALICE experiment in all three collisions systems: in pp at $\sqrt{s}$ = 7 TeV and 13 TeV, in p-Pb at $\sqrt{s_{\rm NN}}$ = 5.02 TeV and Pb-Pb at $\sqrt{s_{\rm NN}}$ = 2.76 TeV and 5.02 TeV. This includes analyses making use of impact parameter information to identify dielectrons from heavy-flavour decays as well as machine learning techniques to improve electron identification and combinatorial background rejection. To single out the interesting phenomena, the dielectron spectra are compared to the expectations from known hadronic sources. The implications for the heavy-flavour and direct photon production will be discussed. Furthermore, the results will be shown as a function of the charged-particle event multiplicity and of the centrality of the collision.

Heavy Ions / 172

nPDF studies with electroweak bosons in pPb collisions with the CMS detector

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Yields of W and Z bosons can be used to probe the nuclear parton distribution functions of quarks and antiquarks. Results on W boson and Drell-Yan production in pPb collisions using the CMS detector will be presented. The lepton decay channel is used to study both positive and negative W bosons as a function of lepton pseudorapidity. Rapidity and charge asymmetries in the W yield are studied. The Drell-Yan cross section is extracted as functions of the dimuon mass for the first time in pPb collisions, and both as a function of dimuon transverse momentum and rapidity, in the Z boson mass region.

Heavy Ions / 711

Spin alignment measurements of K*0 vector mesons in ALICE at the LHC

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Spin alignment of K^{*0} vector mesons produced in non-central heavy-ion collisions could occur due to the presence of large angular momentum and large magnetic field expected in the initial stages of the collisions. This phenomenon leads to a non-uniform angular distribution of the decay daughters of K^{*0} with respect to its quantization axis in the rest frame of K^{*0}. This quantization axis can be the normal to the production plane (plane subtended by the K^{*0} momentum and the beam axis) or normal to the reaction plane (defined by the impact parameter and the beam axis) of the system. The study of the angular distribution leads to the estimation of the spin density matrix element ρ_{00}. A significant deviation of the value of ρ_{00} from 1/3 would indicate the presence of spin alignment.
We will present recent ALICE results from the spin alignment study of K^{*0} vector mesons at mid-rapidity in Pb-Pb collisions and in pp collisions at center of mass energies of 2.76 TeV, 5.02 TeV and 13 TeV, respectively. Transverse momentum and centrality dependence of ρ_{00} will be presented and the result will also be compared and discussed together with those obtained for $K_s{}^0$ (spin zero) mesons.

Heavy Ions / 871

Investigating jet modification in heavy-ion collisions at \sqrt{s_{\rm{NN}}} = 5.02 and 2.76 \rm{TeV} with ALICE

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The LHC heavy-ion physics programme aims at investigating the fundamental properties of nuclear matter under extreme conditions of energy density and temperature, where a transition to a Quark-Gluon Plasma (QGP) is expected. Jets, the sprays of hadrons resulting from the fragmentation of high-energy partons, are one of the most powerful probes for QGP transport properties, due to the substantial energy loss of partons while traversing the medium. The modification of jets is confirmed by several experimental observables, such as yield, fragmentation pattern and structure of jets.

In this presentation, charged jet nuclear modification factors at \sqrt{s_{\rm{NN}} = 5.02 \rm{TeV} with different jet resolution from 0.2 to 0.4, which are measured down to few ten GeV/c thanks to optimal tracking capabilities of ALICE detector at low momentum, are compared to that at 2.76 \rm{TeV}. These results will be discussed with the recent results of jet measurements in pp, p-Pb and Pb-Pb collisions for the comprehensive understanding of jet modification at LHC.

Heavy Ions / 869

Soft QCD measurements with ALICE

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Particle production at LHC energies involves perturbative (hard) and non-perturbative (soft) QCD regimes. The charged-particle multiplicity cannot be calculated using purely perturbative methods and is generally described by phenomenological models. In this contribution, we report on soft QCD variables, such as inelastic, single, double and central diffractive cross-sections, charged-particle multiplicities and observables characterizing the Underlying Event. Results are presented for all collision systems (pp, p-Pb, Pb-Pb and Xe-Xe) and for all centre of mass energies from $\sqrt{s}$ = 0.9 to

13 TeV and $\sqrt{s_{\mathrm{NN}}}$ = 2.76 to 8.16 TeV. This covers a large range of energy, system and multiplicities with new results recently measured by ALICE in pp high multiplicity, p-Pb and Xe-Xe events at the LHC. Finally, we investigate the evolution of particle production with energy and system size and compare to models based on various particle production mechanisms and different initial conditions, summarizing the understanding of soft QCD 8 years after the start of data taking at the LHC.

Heavy Ions / 14

The Critical Point and Random Fluctuation Walk

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The critical phenomena of strongly interacting matter are presented in the random fluctuation walk model at finite temperature. The phase transitions are considered in systems where the Critical Point (CP) is a distinct singular one existence of which is dictated by the dynamics of conformal symmetry breaking.
The physical approach to the effective CP is predicted through the influence fluctuations of two-particle quantum correlations to which the critical mode couples. The finite size scaling effects are used to extract the vicinity of deconfinement phase transition.
We obtain the size of the particle emission source affected by the stochastic forces in thermal medium characterized by the Ginzburg-Landau parameter which is defined by the correlation length of characteristic dual gauge field. The size above mentioned blows up when the temperature approaches the critical value as correlation length becomes large enough.
The results are the subject to the physical programs at accelerators to search the hadronic matter produced at extreme conditions.

Heavy Ions / 314

Freeze-out Conditions in Au+Au collisions at $\sqrt{s_{NN}} = 7.7 - 39$ GeV at RHIC

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The exploration of QCD phase diagram and study of the dynamics and mechanism of particle production in heavy-ion collisions is one of the research interests in the field of high energy physics. In addition, the search for the QCD critical point in the phase diagram has been the main motivation to carry out the Beam Energy Scan Phase - I (BES-I) program at the Relativistic Heavy Ion Collider (RHIC) facility at BNL. Under this program in the years 2010 and 2011, Au+Au collisions were recorded at $\sqrt{s_{NN}} =$ 7.7, 11.5, 19.6, 27 and 39 GeV by the STAR detector at RHIC. Later in the year 2014, Au+Au collisions at $\sqrt{s_{NN}} = 14.5$ GeV were added to this BES program.

We will present results of the identified particle production from the BES energies. Our study focuses on the extraction of the chemical and kinetic freeze-out properties of the system and understanding the evolution and dynamics of particle production. This study is also interesting since at the top RHIC energies it was found that the hadron-QGP phase transition occurs close to the chemical freeze-out temperature. With this in mind, we will present the measured transverse momentum (p_T) spectra, particle yields (dN/dy) and average transverse momentum ($\langle p_T \rangle$) of $\pi^{\pm}$, $K^{\pm}$, $p(\bar{p})$. Using these observables, the calculated freeze-out parameters, most importantly the chemical freeze-out temperature (T_{ch}), baryon chemical potential (μ_B), kinetic freeze-out temperature (T_k) and radial

flow velocity (β) will be presented. The variation of all these observables with the collision centrality and center of mass energy will be discussed with the published data from STAR. A comparison of these results with the published results of STAR in Au+Au collision at $\sqrt{s_{NN}} = 62.4$ and 200 GeV and ALICE in Pb+Pb collision at $\sqrt{s_{NN}} = 2.76$ TeV will also be shown.

Heavy Ions / 828

Prompt photon production by gluon fusion in a magnetized medium for heavy-ion collisions

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We compute the prompt photon production by gluon fusion and the v2 harmonic coefficient for a the magnetized medium created in heavy-ion collisions. Our calculation is based in the existence of very intense magnetic fields at the early times of the collisions which varies from 1 to 3 times pion mass squared, and open new channels to the photon production. Our calculation take into account several parameters which are relevant to the description of the experimental transverse momentum distribution, and elliptic flow for RHIC and LHC energies. Also, the high occupation number for gluons and the saturation scale are included as well as the flux velocity and geometrical factors. The results are compared with data from PHENIX, and recent hidrodynamical models.

Heavy Ions / 1001

Exclusive Photoproduction of J/Psi's in Peripheral AA Collisions

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The exclusive photoproduction of the heavy vector mesons
J/ψ
is investigated in the context of
peripheral lead-lead collisions for the energies available at the LHC,
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76
TeV and
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TeV. In order to evaluate the robustness of the light-cone color dipole formalism, previously tested in the ultraperipheral regime, it was calculated the rapidity distribution as well as the nuclear

modification factor for the three centrality classes: 30%-50%, 50%-70% and 70%-90%. In our calculations, three approaches were considered, in which are applied gradually modifications on the components of the cross section of the process. In the comparison with the ALICE measurements, once we corrected for the effective interaction region the photon flux and the photonuclear cross section better agreement with the data is obtained, mainly in the more central regions (30%-50% and 50%-70%) where the incertainty is small.

Heavy Ions / 480

Recent results on hard processes in p+Pb, Pb+Pb, and photon-photon collisions from the ATLAS Experiment at the LHC

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Relativistic heavy-ion collision events containing rare final states involving high transverse momentum objects provide in situ probe which allow characterization of the hot, dense QCD matter formed in these collisions. When compared with comparable yields in proton-lead and proton-proton collisions, hadronic jets and quarkonia (both for charm and bottom quarks) are observed to have significantly modified yields and fragmentation properties in lead-lead collisions. Details of these modifications carry information about the interaction of partons with the medium as well as the properties of the medium. By comparison, yields of photons and massive electroweak bosons in lead-lead and proton-lead collisions are found to be essentially unmodified compared to expectations, including isospin effects. With increasing integrated luminosities, these measurements can be used to measure nuclear parton distribution functions and other geometric aspects of the initial state. This talk will present the most recent results on quarkonia, jet, heavy flavor and electroweak boson production, measured in Pb+Pb and p+Pb collisions. The talk covers also includes recent results on gamma-gamma and photonuclear processes studied in ultraperipheral collisions. This is a growing program, complementary to inelastic heavy ion collisions, which produces hard probes via electromagnetically.

Heavy Ions / 581

Photon production and correlations in pp and pPb collisions with LHCb

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LHCb offers the opportunity to perform unique correlation and production measurements at forward rapidity beyond the heavy-flavour sector: direct photons can be reconstructed with good resolution via conversions in the material of the detector, primary tracks can be exploited to perform precise correlation measurements. Recent measurements including the nuclear modification factor of isolated photons in proton-lead collisions at sqrt(s)=5 TeV and the measurement of the dihadron correlation as function of pseudorapidity eta and azimuthal angle phi in pp at sqrt(s)=13 TeV will be shown. The measurements will be put into context with physics of the saturation scale and and with the collective behaviour observed in small collision systems.

Heavy Ions / 262

A Fixed-Target Program at the LHC (AFTER@LHC): where do we stand ?

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We review the physics opportunities 1 which are offered by a next generation and multi-purpose fixed-target program exploiting the LHC beams in order to study pp, pd and pA collisions at $\sqrt{s_{NN}} \sim 115$ GeV as well as Pbp and PbA collisions at $\sqrt{s_{NN}} \sim 72$ GeV. These opportunities span spin, heavy-ion, nucleon-structure and astroparticle physics.

We propose two possible implementations, namely with an internal (polarised) gas target or with a "splitted" beam by a bent crystal which both provide typical instantaneous luminosities [1,2] for pp and pA collisions which surpass that of RHIC by more than 3 orders of magnitude and are comparable to those of the LHC collider mode.

We also discuss our most recent figures of merit [3,4,5] based on two already existing detector set-ups, the LHCb and the ALICE detectors.

Heavy Ions / 902

Energy frontier electron-ion physics with the LHeC and the FCC-eh

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Energy-frontier DIS can be realised at CERN through an energy recovery linac that would produce 60 GeV electrons to collide with the HL-LHC or later HE-LHC (LHeC) or eventually the FCC hadron beams (FCC-eh). It would deliver electron-lead collisions with centre-of-mass energies in the range 0.8-2.2 TeV per nucleon, and luminosities exceeding 5×10^{32} cm^{-2}s^{-1}. In this talk we will present novel ways for the accurate determination of nuclear PDFs, in a hugely extended space of x and Q^2, and the resulting constraints for the theory of parton dynamics in nuclei. We will then discuss diffractive physics and, finally, the possibilities for establishing the existence of a new non-linear regime of QCD at small x beyond the dilute regime described by collinear factorisation. Furthermore, we will comment on the possibilities at the LHeC and FCC-eh for analysing the transverse partonic structure of hadrons and nuclei and its corresponding fluctuations, with expected strong, direct implications on our understanding of the results obtained in present and future high-energy heavy-ion programmes.

Heavy Ions / 788

Recent results from the strong interaction programme of the NA61/SHINE experiment

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The exploration of the QCD phase diagram (T-μ_B) particularly the search for a phase transition from hadronic to partonic degrees of freedom and the QCD critical point is one of the most challenging theoretical and experimental tasks in present heavy ion physics. Unfortunately the QCD predictions are to a large extent qualitative, as QCD phenomenology at finite temperature and baryon number is one of the least explored domains of the theory. The experimental study of the properties of the onset of deconfinement and the search for the QCD critical point is very challenging because of the rapid expansion of the hot dense medium created in ion-collisions.

The fixed-target NA61/SHINE experiment at CERN SPS is pursuing a rich programme on strong interactions, which covers the study of the onset of deconfinement and the search for the QCD critical point. To obtain these goals NA61/SHINE scans a broad region of the QCD phase diagram by varing the momentum (13A-158A GeV/c) and the size of colliding systems (p+p, p+Pb, Be+Be, Ar+Sc, Xe+La, Pb+Pb). New NA61/SHINE results on particle spectra and event-by-event fluctuations in p+p, Be+Be and Ar+Sc collisions will be discussed together with previous NA49 results. In particular the results concerning the observation of the onset of deconfinement as well as multiplicity fluctuations measurements will be presented. The observation of rapid change of hadron production properties that starts when moving from Be+Be to Ar+Sc collisions will be explained. It is interpreted as the beginning of the formation of large clusters of strongly interacting matter - the onset of fireball. The future ion program of the NA61/SHINE experiment including planned measurements of charm hadrons, mostly D mesons, production in Pb+Pb collisions will be presented.

Heavy Ions / 580

pA collisions in fixed-target mode at LHCb

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LHCb has the unique capability to study collisions of the LHC beams on fixed targets. Internal gas targets of Helium, Neon and Argon have been used so far. Updated results and prospects on soft particle production and open and hidden charm productions will be presented. The measurements are of great interest to cosmic ray physics. The charm production measurements provide crucial constraints on intrinsic charm and nuclear parton distribution functions at moderate and large Bjorken x.

Heavy Ions / 1005

Heavy ion collision experiments at NICA

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The NICA (Nuclotron-based Ion Collider fAcility) project is under realization at the Joint Institute for Nuclear Research (JINR, Dubna). The main goal of the project is an experimental study of hot and dense strongly interacting matter in heavy ion (up to Au) collisions at center-of-mass energies up to 11 GeV per nucleon. The physics program will be performed at two experiments, BM@N (Baryonic Matter at Nuclotron) at beams extracted from the Nuclotron, and at MPD (Multi-Purpose Detector) at the NICA collider. This program covers a variety of phenomena in strongly interacting matter of the highest net baryonic density.

Heavy Ions / **242**

Long-range angular correlations of charged particles in high multiplicity e+e- collisions using archived data from the ALEPH detector at LEP

Yen-Jie Lee[1] ; Austin Alan Baty[1] ; Christopher Mcginn[1] ; Gian Michele Innocenti[1] ; Jesse Thaler[2] ; Marcello Maggi[3] ; Michael Peters[1] ; Paoti Chang[4] ; Tzu-An Sheng[5] ; Anthony Badea[1]

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First results on two-particle angular correlations for charged particles emitted in e^+e^- collisions using 730 pb^{-1} of data collected between 91 and 209 GeV with the ALEPH detector at LEP are presented. With the archived data, the correlation functions are studied over a broad range of pseudorapidity η (rapidity y) and azimuthal angle ϕ with respect to the electron-positron beam axis and the event thrust axis. Short-range correlations in $\Delta\eta$ (Δy), which are studied with e^+e^- annihilations which reveal jet-like correlations. Long-range azimuthal correlations are studied differentially as a function of charged particle multiplicity. Those results are compared to event generators and are complementary to the studies of the ridge signals in high multiplicity pp, pA and AA collisions at the RHIC and the LHC.

Heavy Ions / **479**

Recent results on correlations and fluctuations in pp, p+Pb, and Pb+Pb collisions from the ATLAS Experiment at the LHC

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The azimuthal anisotropies of particle yields observed in relativistic heavy-ion collisions have been traditionally considered as a strong evidence of the formation on a deconfined quark-gluon plasma produced in these collisions. However multiple recent measurements from the ATLAS Collaboration in pp and p+Pb systems show similar features as those observed in Pb+Pb collisions, indicating the possibility of the production of such a deconfined medium in smaller collision systems. This talk presents a comprehensive summary of ATLAS measurements in pp collisions at 2.76, 5.02 and 13~TeV and in p+Pb collisions at 5.02 and 8.16 TeV. It includes measurements of two-particle hadron-hadron and muon-hadron correlations in Δϕ and Δη, with a template fitting procedure used to subtract the dijet contributions. Measurements of multi-particle cumulants c_n{2−8} are also presented. The standard cumulant measurements confirm presence of collective phenomena in p+Pb collisions, but are biased by non-flow correlations and are not able to provide evidence for collectivity in pp collisions. To address this, measurements from a new sub-event cumulant method that suppresses the contribution of non-flow effects are presented. More detailed studies of longitudinal flow decorrelations, and higher-order cumulants in ultra-central Pb+Pb collisions are also presented to provide deeper insight into the details of the geometry of the initial state.

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Multiplicity dependence of azimuthal particle correlations as a probe of collectivity in deep inelastic electron-proton collisions at HERA

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Recent observations at RHIC and the LHC of two- and multi-particle correlations in high multiplicity relativistic proton-proton and proton-ion collisions and similarity of the results to those observed in central heavy-ion collisions are often interpreted as an evidence for collective particle production in small collision systems. These results motivate a study in even smaller systems, such as produced in relativistic electron-proton collisions. We present a measurement of two-particle correlations in collisions of electron beams at 27.5 GeV with beams of protons at 920 GeV, which corresponds to 318 GeV centre-of-mass energy. A sample of events equivalent to the integrated luminosity of 350 pb^{-1} was recorded with the ZEUS experiment in 2003-2007. The correlations are measured for charged hadrons as a function of event multiplicity for the lab pseudorapidity range $-1.5 < \eta_{\mathrm{lab}} < 2$. To probe the possible contribution due to collective effects, the correlations are studied as a function of the particle's pair separation in pseudo-rapidity and the pair mean transverse momentum. The observed correlations are compared to available Monte Carlo models of deep inelastic electron-proton scattering. Observations based on the analysis of the ZEUS data put a limit on the possible collective effects in high multiplicity electron-proton collisions.

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HYDJET++ model for the ultra-relativistic heavy-ion collisions: new results and developments

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HYDJET++ model combines the description of soft processes with the treatment of hard partons propagating medium. The model is employed for the analysis of PbPb collisions at LHC energies, particularly, the azimuthal anisotropy phenomena, flow, femtoscopy, hard probes. The influence of geometric and dynamical anisotropies on the development of flow harmonics and, simultaneously, on the second- and third-order oscillations of femtoscopy radii were studied. The interplay of soft hydro-like processes and jets is able to describe the violation of the mass hierarchy of meson and baryon elliptic and triangular flows at transverse momentum $p_T > 2$ GeV/c, the fall-off of the anisotropic flow harmonics at intermediate transverse momenta, and the worsening of the number-of-constituent-quark (NCQ) scaling of elliptic/triangular flow at LHC compared to RHIC energies. The cross-talk of elliptic and triangular flows leads to emergence of higher order harmonics in the model and to appearance of ridge structure in dihadron angular correlations in a broad pseudorapidity range. Recently, the model was further extended to describe quantitatively the event-by-event fluctuations of the anisotropic flow. The model calculations agree well with the experimental data.

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Elliptic flow of direct photons in Pb-Pb collisions at $\sqrt{s_{NN}} = 2.76$ TeV from ALICE

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Elliptic flow of direct photons in Pb-Pb collisions at $\sqrt{s_{NN}} = 2.76$ TeV from ALICE

Direct photons are produced in all stages of a ultrarelativistic heavy-ion collisions and are sensitive to details of the space-time evolution of the produced medium. The low p_{T} part of the direct photon spectrum is expected to be dominated by thermal direct photons - thermal radiation of hot matter, i.e., of the quark-gluon plasma and the hadron gas. At RHIC energies it is a challenge for hydrodynamical models to simultaneously described the yield and the elliptic flow of direct photons which is often referred to as the direct-photon puzzle.

The ALICE detector is equipped with two electromagnetic calorimeters and a central tracking system that make it well suited to study direct photon production at low and intermediate p_{T}. Photons are also detected via conversions in the ALICE detector material with the e^+e^- pair reconstructed in the central tracking system.

In this talk the final results on the direct photon elliptic flow ($v_2^{\gamma,dir}$) at $\sqrt{s_{\mathrm{NN}}} = 2.76$ TeV from the Pb-Pb run in 2010 will be presented for central and semi-central collisions. This is the first time that the direct photon flow is calculated by combining conversion and calorimetric measurements in the p_{T} range of $0.9 < p_{\mathrm{T}} < 6.2$ GeV/c. Comparisons to PHENIX results and to predictions of several theoretical models will be presented in order to shed light on the direct photon puzzle at LHC energies.

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Anisotropic flow of identified particles in Pb–Pb collisions at $\sqrt{s_{\mathrm{NN}}}$ = 5.02 TeV with ALICE

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Anisotropic flow plays a critical role in understanding the properties of the quark-gluon plasma. In this talk we present the elliptic and triangular flow of identified particles in Pb–Pb collisions at $\sqrt{s_{\mathrm{NN}}}$ = 5.02 TeV. The measurements are presented at mid-rapidity for a wide range of particle transverse momenta. The results are compared to those for elliptic and triangular flow in Pb–Pb collisions at lower energy reported by the LHC experiments and also to theoretical predictions.

Heavy Ions / 499

Strangeness and hadronic resonance production in pp, p-Pb and Pb-Pb collisions measured by ALICE at the LHC

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The measurement of strangeness production is one of the powerful tools to study the thermal properties of the QGP and while strangeness enhancement is a well established experimental observation in heavy ion collisions, its interpretation is still debated.

In particular the study of (multi-)strangeness particle production as a function of the event multiplicity in different collision systems, reported by ALICE, has shown a smooth increase of strange particles relative to the non-strange ones with event multiplicity.

We here present the latest results on multiplicity-dependent strangeness production in all the available colliding systems at the top LHC energy. Furthermore, recent measurements of mesonic and baryonic resonances will be presented to discuss the system size dependence, to investigate how hadronic scattering processes affect measured resonance yields, as well as the interplay between canonical suppression and strangeness enhancement.
The experimental results obtained in pp, p-Pb and Pb-Pb collisions will also be compared with the theoretical predictions.

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Measurements of strange and non strange beauty production in PbPb collisions at 5.02 TeV with the CMS detector

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Beauty quark production in heavy-ion collisions is considered to be one of the key measurements to address the flavour-dependence of in-medium energy loss in heavy-ion collisions. On the other hand, the measurement of the production of strange beauty mesons can provide fundamental insights into the relevance of mechanisms of beauty recombination in the quark-gluon plasma. In this talk, we will present the state of the art of beauty measurements in PbPb collisions in CMS that includes the R_{AA} measurement of fully reconstructed B^+ mesons and the latest measurements of non-prompt D^0 and J/ψ from B decay over a wide transverse momentum range in the same colliding system. The first measurement of the B_s R_{AA} in PbPb collisions will also be presented as well as the ratio between the production yield of B_s and B^+.

Heavy Ions / 145

Bottomonium production in PbPb collisions from CMS

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The relative yields and the nuclear modification factors of the ground and excited Upsilon states were measured via dimuon channels in PbPb collisions at 5.02 TeV. The analysis was performed as functions of collision centrality, rapidity, and transverse momentum. The results in PbPb are compared with the previous ones in pPb collisions. The results are discussed in terms of the sequential melting scenario in dense partonic matter.

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Production of open charm and beauty states in pPb collisions with LHCb

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A rich set of open heavy flavour states is observed by LHCb in pPb collisions data collected at 5 and 8.16 TeV nucleon-nucleon center-of-mass energy. Results include the new measurements of production of beauty hadrons in pA collisions through cleanly reconstructed exclusive decays. Open charm states include the Lambda_c baryon, that was also observed in pA collisions for the first time by LHCb.

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Open heavy-flavour production in Pb-Pb and Xe-Xe collisions measured with ALICE at the LHC

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Heavy quarks (charm and beauty) are effective probes of the properties of the Quark-Gluon Plasma (QGP) formed in high-energy heavy-ion collisions at the LHC. Produced mainly in initial hard parton scatterings on shorter time scales compared to the QGP formation time, they witness the full evolution of the system, interacting with the medium constituents and losing energy. The measurement of open-heavy-flavour hadron and jet production in heavy-ion collisions and the comparison (nuclear modification factor, $R_{\rm AA}$) with what expected from pp collisions give insight into the microscopic processes behind parton in-medium energy loss, in particular on its dependence on quark mass and colour charge, and on the interplay of elastic and radiative processes. At low transverse momentum the measurement of the relative abundances of different particle species, in particular

non-strange D mesons, D_s^+ mesons, and Λ_c^+ baryons, is fundamental to address the possible formation of hadrons via coalescence of charm quarks with medium quarks. The study of the heavy-flavour azimuthal anisotropy (elliptic flow, v_2) allows to constrain the path-length dependence of energy loss and, also thanks to the "Event-Shape Engineering" technique, the level of heavy-quark thermalisation and coupling to the system.

Open-heavy-flavour production is measured with ALICE over a wide rapidity range: at mid-rapidity via the full reconstruction of hadronic decay channels of non-strange D mesons, D_s^+ mesons, and Λ_c^+ baryons, and via the identification of electrons from charm and beauty semi-leptonic decays. At forward rapidity heavy-flavour hadron decay muons are detected. The properties of heavy-flavour jets are investigated with angular correlation of heavy-flavour hadron decay electrons with charged particles, as well as by directly reconstruct charm jets tagged by the presence of a D meson among its constituents.

In this contribution new and most recent ALICE measurements of open heavy-flavour $R_{\rm AA}$ and v_2 in Pb-Pb and Xe-Xe collisions at the LHC will be presented. The comparison with measurements at different collision energies and with available theoretical calculations will be also discussed.

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Open charm measurements in heavy ion collisions with the CMS detector

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Charm mesons are excellent probes for studying the properties of the hot and dense medium created in heavy-ion collisions. The measurement of their nuclear modification factor, elliptic and triangular flow can provide strong constraints for the mechanisms of in-medium energy loss. In this talk, the latest measurements of the D^0 in PbPb collisions at 5.02 TeV will be presented.

Heavy Ions / 144

Charmonium production in pPb and PbPb collisions at 5.02 TeV from CMS

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The nuclear modification factors of the ground and excited states of J/psi were measured via dimuon channels in pPb and PbPb collisions at 5.02 TeV. The analysis was performed as functions of collision centrality, rapidity, and transverse momentum. The results are discussed in the framework of the modified nuclear parton distribution function (for pPb) and the interaction of charmonia with dense partonic matter.

Heavy Ions / 327

Charmonium production in pp collisions with ALICE at the LHC

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In pp collisions at LHC energies, charmonium resonances are predominantly produced in hard scattering processes and a subsequent hadronization of the heavy quark pair into a bound state. The production process involves very different energy scales, with the initial quark pair being produced in a high-Q^2 process that allows for a perturbative treatment while the following formation of the bound state is a soft process. Moreover, recent observations have shown an enhancement of the J/ψ production in high multiplicity pp collisions compared to minimum bias events at LHC energies. This suggests, that multi parton interactions (MPI) may also play a role in hard processes and not only, as initially thought, in soft particle production. The production of inclusive charmonia as a function of the event activity in pp collisions was studied by ALICE in different transverse momentum intervals at mid- and forward-rapidity. Measurements of the angular correlations between J/ψ mesons and associated hadrons produced in the same event can shed light on the production of J/ψ mesons as well as eventual global event correlations hypothesized to appear in high multiplicity events.

In this talk, we will present recent ALICE results on J/ψ production as a function of event multiplicity in pp collisions at $\sqrt{s}$ =13 TeV. These results will be discussed in comparison to measurements at different collision energies and model calculations. Additionally, we will present the current status on J/ψ - hadron angular correlations in pp collisions at $\sqrt{s}$ =13 TeV at mid-rapidity.

Heavy Ions / 579

Quarkonia production in pPb collisions with LHCb

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We present new results on quarkonia production in pPb collisions, using the data collected in 2016 at 8.16 TeV nucleon-nucleon centre-of-mass energy, in the unique forward region (pseudorapidity between 2 and 5) covered by the LHCb detector. Both forward and backward rapidities are covered thanks to the possibility of beam reversal. Measurements include the vector bottomonia states and the J/psi and psi(2S), where the prompt and from-b-decay components can be disentangled. The large increase in size of the heavy flavour sample, compared to 5 TeV sample collected in 2013, allows a remarkable improvement in the accuracy of the determination of nuclear modification factors.

Higgs Physics / 411

Study of the Higgs couplings to leptons and Higgs CP properties at the ILC

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In the Standard Model the many Yukawa couplings between the Higgs and fermions, responsible for the mass generation for fermions, are predicted to be strictly proportional to the masses of fermions. Any deviation from this prediction would clearly signal new physics beyond the SM. Many alternative ways of introducing Yukawa couplings in BSM models can result in quite different characteristics for different types of fermions, e.g. up- or down-type, lepton- or quark-type, 3rd-, 2nd- or 1st-generation. More over, if the SM-like Higgs is an admixture of CP even and CP odd states, as preferred in the electroweak baryon genesis models which can potentially explain the baryon number asymmetry in our universe, the Higgs Yukawa couplings will be modified at the tree level. In particular the Higgs to tau tau decay process provides an ideal place for probing the Higgs CP properties. In this talk, we will give the prospects about the measurements of Htautau and Hmumu couplings at the International Linear Collider (ILC), including the Higgs CP phase measurement in Higgs to tautau process using a novel tau reconstruction method. All the simulation studies are performed based on the full detector simulation for the International Large Detector (ILD).

Higgs Physics / 432

Measurement of cross sections and properties of the Higgs boson in decays to two photons using the ATLAS detector

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Measurements of Higgs boson properties and cross sections measured in Higgs boson decays to two photons based on pp collision data collected at 13 TeV are presented.

Higgs Physics / 168

Searches of Higgs boson rare decays at CMS

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The latest results on searches of Higgs boson rare decays will be presented. The talk includes H to \mu\mu and H to invisible analyses.

Higgs Physics / 440

Search for rare decays of the Higgs boson

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The Standard Model predicts decay channels of the Higgs boson that are rare and have not yet been seen. Searches for Higgs boson decays to two muons or to a Z boson and a photon based on pp collision data collected at 13 TeV are presented.

Higgs Physics / 698

Learning from Higgs Physics at Future Higgs Factories

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Future Higgs factories can reach impressive precision on Higgs property measurements. In this talk, we explore its sensitivity to new physics models at the electron-positron colliders. In particular, we study two categories of new physics models, Standard Model with a real scalar singlet extension, and Two Higgs Double Model as examples of weakly-interacting models, Minimal Composite Higgs Model and three typical patterns of the more general operator counting for strong interacting models as examples of strong dynamics. We perform a global fit to various Higgs search channels to obtain the 95 C.L. constraints on the model parameter space. We also compare the sensitivity of various future Higgs factories, namely Circular Electron Positron Collider, Future Circular Collider-ee and International Linear Collider.

Higgs Physics / 162

Constraints on CP-violating couplings of the Higgs boson using its decay to fermions in the CMS experiment

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A study of anomalous Higgs boson couplings and CP violation is presented using the Higgs boson decay mode with a pair of fermions in the final state. Associated production of the Higgs boson with two jets is used in this analysis, which is driven by the VBF, VH, and gluon fusion production mechanisms. Constraints on the anomalous couplings and CP-violating parameters are obtained by the CMS experiment with the Run-II data.

Higgs Physics / 165

The latest results of the measurement of the Higgs boson decaying to tau lepton pairs at CMS

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The latest results of the measurement of the Higgs boson decaying to tau lepton pairs will be presented. The analysis is performed using data collected with the CMS experiment in 2016 and 2017 at the LHC from pp collisions at centre-of-mass energies of 13 TeV.

Higgs Physics / 435

Higgs boson production in decays to two tau leptons using the ATLAS detector

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Measurements of Higgs boson production in Higgs boson decays to two tau leptons based on pp collision data collected at 13 TeV are presented.

Higgs Physics / 768

Boosted Higgs decay in a pair of light jets

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We study the Higgs boson (h) decay to two light jets at the 14 TeV High-Luminosity-LHC (HL-LHC), where a light jet (j) represents any non-flavor tagged jet from the observational point of view. The decay mode h⟶gg is chosen as the benchmark since it is the dominant channel in the Standard Model (SM), but the bound obtained is also applicable to the light quarks (j=u,d,s). We estimate the achievable bounds on the decay branching fractions through the associated production Vh (V=W±,Z). Events of the Higgs boson decaying into heavy (tagged) or light (un-tagged) jets are correlatively analyzed. We find that with 3000 fb−1 data at the HL-LHC, we should expect approximately 1σ statistical significance on the SM Vh(gg) signal in this channel. This corresponds to a reachable upper bound BR(h⟶jj)≤4 BRSM(h⟶gg) at 95% confidence level. A consistency fit also leads to an upper bound BR(h⟶cc)<15 BRSM(h⟶cc) at 95% confidence level. The estimated bound may be further strengthened by adopting multiple variable analyses, or adding other production channels.

Higgs Physics / 35

Background study of HW production with the Higgs decaying to a b-quark pair

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We present next-to-leading order QCD predictions for $Wb\bar{b}+n$-jet ($n=0,1,2,3$) production at the Large Hadron Collider with $\sqrt{s}=13$ TeV. We work in the four-flavor number scheme with a non-vanishing bottom-quark mass and include all subprocesses at leading electroweak order as well as all heavy-fermion-loop effects. We show the impact of QCD corrections for total as well as differential cross sections and make an assessment of theoretical uncertainties of $Wb\bar{b}$ production viewed as an irreducible background to $H(\to b\bar{b})W$ studies. For the calculations we have employed an upgraded version of the BlackHat library which can handle massive fermions in combination with SHERPA. Our results can be explored through publicly available n-tuple sets.

Higgs Physics / **436**

Evidence for Higgs boson production in decays to two b-quarks using the ATLAS detector

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The analysis that studies VH process with H->bb decays is presented based on the 13 TeV pp collision data. A clear excess of the VH with H->bb process over the predicted background is shown providing evidence for such a process. In addition a search for VBF production in the same decay channel is presented.

Higgs Physics / **164**

The latest results of the measurement of the Higgs boson decaying to bottom quarks pair at CMS

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The latest results of the measurement of the Higgs boson decaying to bottom quark pair will be presented. The analysis is performed using data collected with the CMS experiment in 2016 and 2017 at the LHC from pp collisions at centre-of-mass energies of 13 TeV.

Higgs Physics / **927**

Global constraints on the dimension-6 Standard Model Effective Field Theory

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We derive global constraints on new physics within the framework of the dimension-6 Standard Model Effective Field Theory. Our results include the latest theoretical and experimental updates on the electroweak precision observables, as well as the latest Higgs results from the LHC run 2. We also include in the combination the limits from diboson measurements. The results are presented as limits on the Wilson coefficients of the dimension-6 interactions, discussing the complementarities between the different types of observables. All the results have been obtained using the HEPfit code.

Higgs Physics / 946

Higgs mass from high-scale (split) supersymmetry

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In the high-scale (split) MSSM, the measured Higgs mass sets an upper bound on the supersymmetric scalar mass scale $\tilde{m}$ around 10^{10} (10^8) GeV, for $\tan\beta$ in the standard range and the central value of the top mass. It is demonstrated that $\tilde{m}$ can be pushed up close to the Planck scale while reproducing a correct Higgs mass due to potentially large negative sbottom/stau threshold corrections to the Higgs quartic coupling. This mechanism applies to the split as well as the high-scale MSSM. Also discussed are the vacuum stability constraints.

Higgs Physics / 931

Status of the (p)MSSM Higgs sector

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During this talk, the current constraints on the phenomenological MSSM (pMSSM) will be reviewed, focusing in particular on the Higgs sector. I will discuss the status of the pMSSM parameter space,

and evaluate how future colliders, and higher energies or luminosities, can help probing the pMSSM Higgs sector.

Higgs Physics / 836

Status of the semileptonic B decays and muon g-2 in general 2HDMs with right-handed neutrinos

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We study the extended Standard Model (SM) with an extra Higgs doublet and right-handed neutrinos.
If the symmetry to distinguish the two Higgs doublets is not assigned,flavor changing neutral currents (FCNCs) involving the scalars are predicted even at the tree level. In this talk, we investigate the constraints on the FCNCs at the one-loop level, and especially study the semileptonic B meson decays, e.g.$B \to D^{(*)}$ τν and $B \to K^{(*)}$ ll processes, where the SM predictions are more than 2 σ away from the experimental results. We also consider the flavor-violating couplings involving right-handed neutrinos and discuss if the parameters to explain the excesses of the semileptonic B decays can resolve the discrepancy in the the anomalous muon magnetic moment.
Based on the analysis, we propose the smoking-gun signals of our model at the LHC.

Higgs Physics / 550

Current status of Two-Higgs-Doublet models with a softly broken Z_2 symmetry

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One of the most popular extensions of the Standard Model is the Two-Higgs-Doublet model (2HDM), in which a second Higgs doublet is added to the conventional Standard Model particle content. 2HDM's with a softly broken Z_2 symmetry avoid flavour-changing neutral Higgs currents at tree-level. They also comprise the Higgs sector of the Minimal Supersymmetric Standard Model. Current Higgs observables put strong constraints on these models. We present global fits to these data and combine them with information from theoretical bounds, electroweak precision observables and the most important flavour constraints, using the open-source package HEPfit. The resulting limits on the 2HDM parameters like mixing angles, the heavy Higgs masses as well as the allowed Higgs mass splittings will be discussed.

Higgs Physics / 395

FlexibleSUSY: Precise automated calculations in any BSM theory

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FlexibleSUSY is a software package that can solve boundary value problems and calculate the Higgs and BSM particle masses, as well as other observables such as the anomalous magnetic moment of the muon and EDMs in any BSM model (not just supersymmetric models). FlexibleSUSY is designed to be adaptable, fast, precise and reliable. I will describe FlexibleSUSY with particular emphasis on recent developments and the state of the art Higgs mass calculations it can perform. I will then show some applications to illustrate how it can be used to obtain interesting physics results with the highest precision possible and with remarkable speed.

Higgs Physics / **39**

Phenomenological consequences of Higgs inflation in the NMSSM at the electroweak scale

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It has been shown that the Next-to-Minimal Supersymmetric Standard Model (NMSSM) is a valid theory to describe inflation by Higgs bosons. In this model, the inflaton is a linear combination of the Higgs doublets while the Higgs singlet stabilizes the Higgs potential during inflation. The inflaton has a non-minimal coupling to gravity which appears in the low-energy effective Superpotential. Different from the $\mathbb{Z}_3$-invariant NMSSM an additional bilinear μ parameter is introduced which changes the phenomenology at the electroweak scale.

We investigate the impact of this inflation-inspired model on low-energy physics with the focus set on vacuum stability and Higgs phenomenology. We explore the extended parameter space and point out differences compared to the standard $\mathbb{Z}_3$-invariant NMSSM due to the additional μ term. Thereby, we take into account various experimental constraints.

Higgs Physics / **700**

Phenomenology in a Zee-Babu type model with local $U(1)_{L_\mu - L_\tau}$ symmetry

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We discuss extension of the Zee-Babu model introducing local $U(1)_{L_\mu - L_\tau}$ symmetry with several singly-charged bosons. We find a predictive neutrino mass texture in a simple hypothesis that mixings among singly-charged bosons are negligible. Also lepton flavor violations are less constrained compared with the original model in such a scenario. Then we explore phenomenology of the model focusing on a doubly-charged boson physics at collider experiments such as the LHC and the ILC. This presentation is based on arXiv:1803.04795

Higgs Physics / 682

Heavy resonances and the electroweak effective theory

Author(s): Ignasi Rosell[1]

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Direct searches for New Physics states have given so far negative results, so there is a mass gap between SM fields and possible new fields. This mass gap justifies the use of electroweak effective Lagrangians for current energies. Implications of new, higher scales can be analyzed through next-to-leading order corrections of the electroweak effective theory. There are two main ingredients for this analysis. Firstly, a non-linear realization of the electroweak symmetry breaking with a singlet Higgs and a strongly-coupled UV-completion at low energies is assumed. And secondly, a high-energy Lagrangian which incorporates a set of new heavy states is considered. By integrating out these heavy resonances, we study the pattern of low-energy constants among the light fields, which are generated by these massive states.

Higgs Physics / 427

Gravitational waves from first order electroweak phase transition in models with the U(1)_X gauge symmetry

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In this talk, we consider models with the $U(1)_X$ gauge symmetry, which is spontaneously broken by dark Higgs mechanism. We discuss patterns of the electroweak phase transition and detectability of gravitational waves (GWs) when strongly first order phase transition occurs. We find the collider bounds exclude a part of parameter space that could generate detectable GWs otherwise. We show that GWs produced in the multi-step phase transitions can be detected by future observations such as LISA and DECIGO. In addition, we expect that most of the parameter regions can be covered by direct searches for the singlet scalar boson and prediction measurements of various Higgs boson couplings. Furthermore, we discuss the complementarity of dark photon searches or dark matter searches with the GW observations in the models of the dark gauge symmetry. This talk is based on arXiv:1802.02947 with Hashino, Kanemura, Kakizaki and Ko.

Higgs Physics / 419

Light resonances from fundamental composite Higgs models: LHC and future colliders

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The possibility that the Higgs boson is a composite scalar is still open. In models that enjoy an underlying description in terms of a fundamental gauge-fermion dynamics, light scalars at the electroweak scale are predicted. Their properties can also be calculated starting from the underlying models. This leaves us with a predictive and controllable framework that can be tested at the LHC and at future colliders. I will present the most interesting and characteristic channels, which provide new standard candles to search for signs of compositeness in the electroweak sector. One of them is a singlet pseudo-scalar, associated to a U(1) global symmetry, that decays into a pair of gauge boson via anomalies, or a pair of fermions. I will show how an open window in the mass range 14 to 65 GeV can be closed by searching for boosted di-tau systems.

Higgs Physics / 652

Partially Composite Higgs Models

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We study the phenomenology of partially composite-Higgs models where electroweak symmetry breaking is dynamically induced, and the Higgs is a mixture of a composite and an elementary state. The models considered have explicit realizations in terms of gauge-Yukawa theories and allow for a very SM-like Higgs state.

Higgs Physics / 307

Flavor Changing Neutral Higgs Interactions with Top and Tau at Hadron Colliders

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A general two Higgs doublet model (2HDM) is adopted to study the signature of flavor changing neutral Higgs (FCNH) decay
$\phi^0 \to t\bar{c} + \bar{t}c$ and $\phi^0 \to \tau\mu$, where
ϕ^0 could be a CP-even scalar (H^0) or a CP-odd pseudoscalar (A^0)
as well as $t \to ch^0$.
Measurement of the light 125 GeV neutral Higgs boson (h^0) couplings at the Large Hadron Collider (LHC) favor the decoupling limit or the alignment limit of a 2HDM, in which gauge boson and diagonal fermion couplings of h^0 approach Standard Model values.
In such limit, FCNH couplings of h^0 are naturally suppressed by a small mixing parameter $\cos(\beta - \alpha)$, while the off-diagonal couplings of heavier neutral scalars ϕ^0 are sustained by $\sin(\beta - \alpha) \sim 1$.
We study physics background from dominant processes with realistic acceptance cuts and tagging efficiencies. Promising results are found for the LHC running at 13 or 14 TeV collision energies as well as future pp colliders at 27 TeV, or 100 TeV.

Higgs Physics / 38

Sensitive study of the Higgs-strange coupling at FCC-ee

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Precise measurment of the Higgs couplings is a central part of the energy-frontier physics program. Obtaining the small couplings to light states is particularly difficult. We describe a new technique for studying the Higgs coupling to the strange quark using H –> ssbar events at a 250 GeV e+e- collider. With this method, the sensitivity of the proposed FCC-ee collider is at a level of only a few times the standard-model expectation. This is a large improvement over previous proposals, yielding sensitivity to a variety of new-physics scenarios.

Higgs Physics / 975

Higgs measurements at the Future Circular Colliders

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After the Higgs boson discovery, the precision measurements and searches for new phenomena in the Higgs sector are among the most important goals in particle physics. Experiments at the Future Circular Colliders (FCC) are ideal to study these questions. Electron-positron collisions up to an energy of 350 GeV (FCC-ee) provide the ultimate precision with studies of Higgs boson couplings, mass, total width and CP parameters, as well as searches for exotic and invisible decays. The feasibility of observation of the s-channel production e+e- ⟶ H(125) is reviewed. We conclude by noting the remarkable complementarity of the FCC-ee and FCC-hh colliders, which in combination offer the best possible overall study of the Higgs boson properties.

Higgs Physics / 469

Higgs and Electroweak symmetry breaking at the FCC-hh

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The future circular hadron-hadron collider FCC-hh is expected to produce collisions at the unrivaled center of mass energy of sqrt(s) = 100 TeV and to deliver an integrated luminosity of few tens of ab-1. As a result, billions of Higgs bosons will be produced. Having at disposal such humongous samples opens a wide range of possibilities in the realm of precision Higgs measurements. The Top Yukawa and the Higgs self-coupling can be potentially measured respectively to percent level precision. In addition final states involving Higgs bosons can be studied in highly boosted kinematical regimes where the impact of systematic uncertainties can be reduced. Large statistics also offer the possibility of studying rare decays, in particular the Higgs coupling to light quarks.

Higgs Physics / 898

SM and BSM Higgs physics at the LHeC and the FCC-eh

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Energy-frontier DIS can be realised at CERN through an energy recovery linac that would produce 60 GeV electrons to collide with the HL-LHC or later HE-LHC (LHeC) or eventually the FCC hadron beams (FCC-eh). It would deliver electron-proton collisions with centre-of-mass energies of 1.2 and 3.5 TeV, respectively, at luminosities exceeding 10^{34} cm^{-2}s^{-1}. The SM cross section for charged current (CC) Higgs production in polarised e^{-}p scattering is 0.2 (1) pb, respectively, which offers a unique potential for high precision and novel Higgs physics. A summary will be given on the CC, as well as NC, SM decay fraction and resulting coupling measurements, and different possibilities are presented on BSM Higgs physics, both regarding exotic H decays, such as into DM, and extended Higgs theories.

Higgs Physics / 524

Higgs physics at CLIC

CLICdp Collaboration[None] ; Matthias Artur Weber[1]

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The Compact Linear Collider (CLIC) is a mature option for a future electron-positron collider operating at centre-of-mass energies of up to 3 TeV. CLIC will be built and operated in a staged approach with three centre-of-mass energy stages currently assumed to be 380 GeV, 1.5 TeV and 3 TeV. This contribution discusses the physics potential of CLIC in the area of Higgs physics based on benchmark analyses using full detector simulations 1. The initial stage of operation allows study of Higgs production in Higgsstrahlung and WW-fusion, resulting in precise measurements of the production cross sections and the total Higgs-boson decay width. Operation at high energy will provide high-statistics samples of Higgs bosons produced in WW-fusion enabling tight constraints on Higgs couplings. High-energy operation also gives access to the ttH process and Higgs self-coupling, through the measurement of double Higgs production. Global fits to all possible measurements at CLIC are presented.
1 Eur. Phys. J. C77, 475 (2017)

Higgs Physics / 755

Precision Higgs Measurements at the 250 GeV ILC

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The plan for the International Linear Collider is now being prepared as a staged design, with the first stage at 250 GeV and later stages achieving the full project specifications with 4 ab-1 at 500 GeV. This talk will present the capabilities for precision Higgs boson measurements at 250 GeV and their relation to the full ILC program. It will show that the 250 GeV stage of ILC will already provide many compelling results in Higgs physics, with new measurements not available at LHC, model-independent determinations of key parameters, and tests for and possible discrimination of a variety of scenarios for new physics.

Higgs Physics / 174

Prospects for Higgs Boson Measurements at the High-Luminosity LHC with CMS

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The High-Luminosity Large Hadron Collider (HL-LHC) is expected to deliver an integrated luminosity of up to 3000 fb-1. The very high instantaneous luminosity will lead to about 200 proton-proton collisions per bunch crossing (“pileup”) superimposed to each event of interest, therefore providing extremely challenging experimental conditions. Prospects for measurements of the properties of the standard model Higgs boson and searches for beyond the standard model Higgs bosons with the CMS experiment at the HL-LHC are presented.

Higgs Physics / 376

Constraining Sterile Neutrinos from Precision Higgs Data

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We use the LHC Higgs data to derive updated constraints on electroweak-scale sterile neutrinos that naturally occur in many low-scale seesaw extensions of the Standard Model to explain the neutrino masses. We also analyze the signal sensitivity for a new final state involving a single charged lepton and two jets with missing energy, which arises from the decay of sterile neutrinos produced through the Higgs and W, Z boson mediated processes at the LHC. Future prospects of these sterile neutrino signals in precision Higgs measurements, as well as at a future 100 TeV collider, are also discussed.

Higgs Physics / 438

Measurements of Higgs boson properties using a combination of different Higgs decay channels

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Measurements of Higgs boson production and cross sections based on the combination of several Higgs boson decay channels based on pp collision data collected at 13 TeV are presented.

Higgs Physics / 166

Measurements of the Higgs boson mass, production and decay rates and constraints on its couplings at CMS

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Combined measurements of the Higgs boson mass, production and decay rates, as well its couplings to vector bosons and fermions, are presented. The analysis uses the LHC pp collisions recorded by the CMS detector in 2016 at centre-of-mass energies of 13 TeV.

Higgs Physics / 439

Measurement of the Higgs boson mass

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Measurements of the Higgs boson mass in Higgs boson decays to two photons or four leptons, as well as their combination, based on pp collision data collected at 13 TeV are presented.

Higgs Physics / 241

Search for single top + Higgs production with CMS

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We present recent results from searches for the production of a Higgs boson in association with a single top quark (tHq), using data samples collected by the CMS detector in pp collisions at center-of-mass energy of 13 TeV. The searches exploit different top quark and Higgs boson decay modes resulting in final states with photons, bottom quarks, and multiple leptons, and employ multivariate techniques to maximize the sensitivity to the signal. Due to a strong interference between the two main leading-order diagrams, the tHq process is sensitive to the relative sign of the couplings of the Higgs to the top quark and the vector bosons, and thus provides unique information on Higgs boson properties.

Higgs Physics / 437

Evidence for Higgs boson production in association with a ttbar pair

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The search for the production of the Higgs Boson with a pair of top-anti-top quarks is both very important and very challenging. This talks presents the analyses using Higgs boson decays to bbbar pairs, to multi-lepton final states using pp collision data collected at 13 TeV, as well as their combined results including also Higgs boson decays to two photons or Z bosons.

Higgs Physics / 167

Measurements of ttH production at CMS

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The latest results of the measurement ttH production will be presented. The talk includes the search of tHq production.

Higgs Physics / 84

Prospects for measuring Higgs triscalar coupling at the HL-LHC and HL-100 TeV hadron collider

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We perform the most up-to-date comprehensive signal-background analysis for Higgs-pair production in $HH \to b\bar{b}\gamma\gamma$ channel at the HL-LHC with the goal of probing the self-coupling λ_{3H} of the Higgs boson. We simulate all the standard-model signal and background processes with the simulation tools almost as sophisticated as what experimentalists are using. At the HL-LHC, the Higgs boson self-coupling would be constrained to $-1.0\lambda_{3H} < 7.6$ at 95 \% confidence level after considering the uncertainties associated with the top-Yukawa coupling and the estimation of backgrouds. Some crucial kinematic distributions and significance performances are also shown to display our analysis informaitons. Here we also extend the study to the HL-100 TeV hadron collider. We find that, at the SM value, the coupling can be measured with about 20 (7) \% accuracy assuming 3 (30) ab^{-1}.

Higgs Physics / 978

Supervising Deep Neural Networks with Topological Augmentation in search for di-Higgs Production at the LHC

Won Sang Cho[1] ; Chan Beom Park[2] ; Jae-hyeon Park[3] ; Dongsub Lee[1]

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We present a new machine learning technique for the classification of scattering processes which include invisible particles missing in detector. With this purpose, new high-level feature variables are introduced, which can be obtained in the process of topological augmentation – a general reconstruction procedure of invisible missing momenta subject to various hypothetical decay topologies. Given visible particle information, each augmented feature can be used as an optimized event projection basis, and we utilize them all in together for the classification of many hypothetical topologies possibly involved. As an important application, we focus on the (non-resonant) di-Higgs production in the channel of 2 b-jets, 2 leptons + MET, and demonstrate our new multi-class classification analysis using deep neural networks supervised by the topologically augmented features. We provide an update on the future expectation of di-Higgs discovery at the LHC, and discuss on the importance of our method for general scattering processes with missing information, which can even

improve the conventional deep learning technique which works well with full visible low-level information.

Higgs Physics / 766

An Improved Model-Independent Higgs Precision Analysis

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We discuss an improved model-independent Higg precision analysis of d=6 effective operators based on measurements of future lepton colliders. In particular, we focus on how to improve single Higgs couplings and Higgs triple coupling precisions. We identify main obstacles on obtaining sub-percent precisions on them and provide insights on how we may overcome them.

Higgs Physics / 500

Deep learning approaches to the Higgs boson self coupling

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Deep learning has been applied to many studies in high energy physics with substantial improvement over the traditional selection-cut methods. Based on deep-learning approaches, we perform a comprehensive signal-background analysis for Higgs-pair production in $HH \to b\bar{b}\gamma\gamma$ channel at the HL-LHC, with the goal of probing the self-coupling λ_{3H} of the Higgs boson. We show that the multi-class classification using Deep Neural Network can indeed give better performance in disentangling signal and backgrounds.

Higgs Physics / 177

HH production at the High-Luminosity LHC with CMS

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The High-Luminosity Large Hadron Collider (HL-LHC) is expected to deliver an integrated luminosity of up to 3000 fb-1. The very high instantaneous luminosity will lead to about 200 proton-proton collisions per bunch crossing ("pileup") superimposed to each event of interest, therefore providing extremely challenging experimental conditions. CMS prospects on Higgs self-coupling measurements and HH production at the HL-LHC are presented.

Higgs Physics / 171

Searches of double Higgs boson production with CMS

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The search for standard model (SM) double Higgs boson (HH) production using data collected by the CMS detector at the CERN LHC will be presented, using final states from various decay channels: HH->bbbb, bbVV, bbtautau, and bbgammagamma. The HH production serves to measure the self-coupling of the Higgs boson, the rate of which is small in the SM. However, contributions from beyond standard models can significantly enhance the rate. Furthermore, many BSM particles may decay to HH, which are then manifested as a resonance in the HH invariant mass spectrum. Also final state topologies are considered with highly Lorentz-boosted H bosons, which occur for high mass resonance decays, and for large non-SM contributions to the top quark-Higgs boson coupling strength. In this case, jet substructure-based H tagging techniques are used to identify H bosons in the hadronic decay channel. The results showcase the latest upper limits on the production cross sections of the double Higgs boson production, assuming SM and several non-SM Higgs boson self-coupling values. Upper limits are also placed on the production cross sections of massive spin-0 and spin-2 resonances decaying to a HH.

Higgs Physics / 443

Search for di-Higgs production

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Di-Higgs final states can arise through non-resonant production of two Higgs bosons and through potential heavy states decaying to two Higgs boson. This talk presents searches in several Higgs boson decay channels using 36 fb-1 of pp collision data recorded at 13 TeV.

Higgs Physics / 163

The latest results of the measurement of the Higgs boson decaying into two photons at CMS

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The latest results of the measurement of the Higgs boson decaying into two photons will be presented. The analysis is performed using data collected with the CMS experiment in 2016 and 2017 at the LHC from pp collisions at centre-of-mass energies of 13 TeV.

Higgs Physics / 128

Fiducial inclusive and differential Higgs boson cross sections at CMS

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The measurement of fiducial inclusive and differential Higgs boson cross sections allows the study of its properties under a minimal set of assumptions. By defining a fiducial phase-space, the uncertainties due to model dependence and extrapolations are minimized. A new, extended set of measurements performed using 35.9/fb of pp collisions collected by the CMS experiment at LHC in 2016 is presented. The measurements, obtained in the diphoton and ZZ decay channels, cover a wide range of differential observables, describing the kinematic properties of the Higgs boson, of its decay products and of particles produced in association with it. Fiducial measurements targeting individual production mechanisms are also presented.

Higgs Physics / 123

Measurements of Higgs boson production and properties in the ZZ decay channel using the CMS detector

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New results on the on-shell and off-shell Higgs boson production in proton-proton collisions at the LHC are presented. The properties of the Higgs boson are measured in the four-lepton final state using the latest dataset collected at center-of-mass energy of 13 TeV recorded by the CMS detector. The production cross section of the Higgs boson times its branching fraction to four leptons relative to the standard model expectation is measured and constraints on the main Higgs boson production modes are established. Joint constraints are set on the width and mass of the Higgs boson, as well as on the width and parameters that express its anomalous couplings to two electroweak vector bosons.

Higgs Physics / 433

Measurement of cross sections and properties of the Higgs boson in decays to four leptons using the ATLAS detector

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Measurements of Higgs boson properties and cross sections measured in Higgs boson decays to four leptons based on pp collision data collected at 13 TeV are presented.

Higgs Physics / 125

Higgs to WW measurements with CMS

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The latest set of results on Higgs decay to a W boson pair is presented. With a statistics of 36/fb collected by the CMS experiment at the LHC at 13 TeV center of mass energy, the Higgs to WW decay has been observed at CMS with more than 5 sigma for the first time, providing a significant contribution to the current fit of the Higgs boson couplings to fermions and vector bosons. Exploiting the large cross section times branching ratio of this channel, and using 78/fb of data, differential distributions as a function of the Higgs boson transverse momentum and as a function of the number of jets produced in association have been measured. Finally a search for high mass scalar resonances decaying to W boson pairs is performed ranging up to 3 TeV of mass.

Higgs Physics / 434

Measurement of cross sections and properties of the Higgs boson in decays to two W bosons using the ATLAS detector

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Measurements of Higgs boson properties and cross sections measured in Higgs boson decays to two W bosons based on pp collision data collected at 13 TeV are presented.

Higgs Physics / 444

Searches for high-mass resonances

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Several theories beyond the Standard Model predict the existence of new heavy particles decaying into pairs of gauge bosons. In this presentation the latest ATLAS results on searches for resonances decaying into pairs of W or Z bosons or photons, or into a Z boson and a photon, based on 36 fb-1 of pp collision data collected at 13 TeV will be discussed.

Higgs Physics / 169

Searches for extended Higgs boson sectors with CMS

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The latest results on searches of for extended Higgs boson sectors will be presented. MSSM Htautau, Hbb, high mass searches, and charged Higgs will be covered.

Higgs Physics / 445

Searches for additional neutral Higgs bosons in the MSSM

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The MSSM predicts the existence of additional neutral and charged Higgs bosons. This presentation will discuss results from recent searches for neutral Higgs bosons in several leptonic decay channels based on collision data collected at 13 TeV, and their interpretation within the MSSM.

Higgs Physics / 446

Searches for additional charged Higgs bosons in the MSSM

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The MSSM predicts the existence of additional neutral and charged Higgs bosons. This presentation will discuss results from recent searches for charged Higgs bosons in several decay channels based on collision data collected at 13 TeV, and their interpretation within the MSSM.

Higgs Physics / 442

Searches for non-Standard Model decays to two light bosons of the Higgs boson

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Theories beyond the Standard Model predict Higgs boson decays that do not exist in the Standard Model, such as decays into two light bosons (a). This talk presents recent results based on pp collision data collected at 13 TeV.

Higgs Physics / 201

Searches for charged Higgs bosons at CMS

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An overview of the latest results on the charged Higgs boson searches by the CMS collaboration is presented. Different production mechanisms, as well as multiple final states (e.g. tau nu, tb and cb) are covered, as different BSM models predict different dominant production and decay modes. Most of the results presented are based on the dataset of proton-proton collisions at center of mass energy 13TeV, collected with the CMS detector in 2016, corresponding to an integrated luminosity of 36 fb^{-1}.

Higgs Physics / 119

Searches for light Higgs bosons at CMS

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The searches for light pseudoscalar Higgs bosons pair produced from the decay of the 125 GeV Higgs boson and resulting in various final states (4mu, 4tau, 2mu2tau, 2b2tau) and low mass Higgs bosons will be summarised. The analyses are performed using data collected with the CMS experiment at the LHC from pp collisions at centre-of-mass energies of 13 TeV.

Higgs Physics / 441

Searches for non-Standard Model decays to a light meson and a photon of the Higgs boson

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Theories beyond the Standard Model predict Higgs boson decays at a much enhanced rate compared to the Standard Model, e.g. for decays to Z+photon or a meson and a photon. This talk presents recent results based pp collision data collected at 13 TeV.

Neutrino Physics / 122

New Results from Double Chooz

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The reactor neutrino experiment Double Chooz observes electron-antineutrinos from two French power plants at Chooz with two identical detectors at different baselines. From the observed neutrino deficit the mixing angle theta_13 can be determined within the three flavour-scenario and signatures from further generations can be searched for. We will report the status of the experiment and present new results.

Neutrino Physics / 1056

COHERENT constraints on generalized neutrino-quark interactions

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Generalized neutrino-quark interactions can be studied in a fairly model-independent way by considering dimension-six effective operators constructed by only requiring Lorentz invariance. In this talk, following such approach, I will discuss the constraints on generalized neutrino-quark couplings implied by COHERENT data. I will show that some of these interactions can still be sizeable, and that when included provide a better fit to the data that the standard model alone.

Neutrino Physics / 255

Probing the Light Sterile Neutrino Through the Heavy Charged Higgs Decay at the LHC

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We show the 13 TeV proton-proton collider simulation in a ν-two-Higgs-doublet-model (ν-THDM). The heavy charged Higgs bosons are produced in pairs through the electroweak processes and decay to the light sterile neutrinos. The light sterile neutrino further decays into a jet-like object with a muon in it. This helps us discriminate the signal from the backgrounds with the standard model jets.

Neutrino Physics / 306

Discovery potential of light sterile neutrinos with displaced vertices

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Many models of new physics beyond the Standard Model are able to describe massive, long-lived particles with macroscopic decays, which can be reconstructed inside the inner trackers of the LHC detectors. Furthermore, the lack of evidence of any new physics at the LHC motivates to perform these unconventional searches, such as looking for displaced vertices.

In left-right symmetric models, where a mechanism for the unknown origin of neutrino masses is provided via the existence of sterile neutrinos, the production and decay of these new states depends mostly on the unknown mass of the new, heavy right-handed gauge boson, W_R. For neutrino masses much lighter than the mass of W_R, and also below the electroweak scale, the sterile neutrino can be long-lived, and can decay with a displaced vertex signature.

Currently, no public searches at the LHC target sterile neutrinos with masses as low as a few GeV. In this talk, I will comment on the reinterpretation of current displaced vertex searches to a left-right symmetric model. Challenges and current limitations will be highlighted. The proposed search strategy shows that the 13 TeV LHC with 3000 fb^{-1} can probe sterile neutrino masses up to 30 GeV (for W_R masses below 5 TeV) and motivates the experimental collaborations at the LHC to pursue an optimized displaced search to target a broader mass region.

Neutrino Physics / 650

Electromagnetic neutrino properties: present status and future prospects

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Abstract:

A review of theory and phenomenology of neutrino electromagnetic properties is presented. A massive neutrino even in the easiest generalization of the Standard Model inevitably has nonzero electromagnetic characteristics, at least nonzero magnetic moment. Although its value, determined by the neutrino mass, is very small, in other BSM theories much larger values of magnetic moments are predicted.

A short introduction to the derivation of the general structure of the electromagnetic interactions of Dirac and Majorana neutrinos is presented.

A thorough account of electromagnetic interactions of massive neutrinos in the theoretical formulation of low-energy elastic neutrino-electron scattering is discussed on the basis of our recently published paper. The formalism of neutrino charge, magnetic, electric, and anapole form factors defined as matrices in the mass basis with account for three-neutrino mixing is presented.

Then we discuss experimental constraints on neutrino magnetic and electric dipole moments, electric millicharge, charge radius and anapole moments from the terrestrial laboratory experiments. A special credit is done to bounds on neutrino electromagnetic characteristics (including magnetic and electric dipole moments, millicharge and charge radius) obtained by the reactor (MUNU, TEXONO and GEMMA) and solar Super-Kamiokande and the recent Borexino and COHERENT experiments.

The effects of neutrino electromagnetic interactions in astrophysical and cosmological environments are also reviewed. The main manifestation of neutrino electromagnetic interactions, such as: 1) the radiative decay in vacuum, in matter and in a magnetic field, 2) the Cherenkov radiation, 3) the plasmon decay, 4) spin light in matter, 5) spin and spin-flavour precession, 6) neutrino pair production in a strong magnetic field, and the related processes along with their astrophysical phenomenology are also considered.

The best world experimental bounds on neutrino electromagnetic properties are confronted with the predictions of theories beyond the Standard Model. It is shown that studies of neutrino electromagnetic properties provide a powerful tool to probe physics beyond the Standard Model.

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Neutrino Physics / 911

Recent EXO-200 results

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The EXO-200 experiment consists of a time projection chamber filled with ~150 kg of liquid xenon enriched at 80.7% of the 136Xe isotope. The low background level reached within the detector made possible the detection of the two neutrinos double decay of 136Xe, set the most precise measurement of a double beta decay half life to date and provided one of the most sensitive search for the neutrinoless double beta decay. After a brief hiatus in operations, the experiment restarted data taking with upgrades to its front-end electronics and a Rn suppression system. This presentation will cover the recent results of the EXO-200 collaboration published last year,including one year of data with the upgraded detector.

Neutrino Physics / 98

Results from the CUORE experiment

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The Cryogenic Underground Observatory for Rare Events (CUORE) is the first bolometric experiment searching for neutrinoless double beta decay that has been able to reach the 1-ton scale. The detector consists of an array of 988 TeO2 crystals arranged in a cylindrical compact structure of 19 towers. The construction of the experiment and, in particular, the installation of all towers in the cryostat was completed in August 2016 and data taking started in spring 2017. In this talk we present the neutrinoless double beta decay results of CUORE from examining a total TeO2 exposure of 86.3 kg yr, characterized by an effective energy resolution of 7.7 keV FWHM and a background in the region of interest of 0.014 counts/(keV kg yr). In this physics run, CUORE placed a lower limit on the decay half-life of 130Te > 1.3 10^25 yr (90% C.L.). We then discuss the improvements in the detector performance achieved in 2018, the new results on the background model and the latest update on the study of rare processes in Tellurium.

Neutrino Physics / 1046

Searches for Heavy Neutrinos with the ATLAS Detector

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Multiple theories beyond the Standard Model predict the existence of heavy Majorana or Dirac neutrinos. The ATLAS searches presented here focus on models in which these heavy neutral leptons are either produced together with a right-handed W gauge boson, via the Keung-Senjanovic process, or with a heavy charged lepton from the same fermionic triplet, in the context of a type-III seesaw model. The searches focus on final states containing two leptons (of opposite signs or of same signs) and jets, using proton-proton collisions at $\sqrt{s} = 13$ TeV collected with the ATLAS detector at the LHC.

Neutrino Physics / 1044

Search for heavy neutrinos at CMS

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The smallness of neutrino masses provides a tantalizing allusion to physics beyond the standard model. Heavy neutral leptons (HNL), such as hypothetical sterile neutrinos, accommodate a way to explain this observation, through the see-saw mechanism. If they exist, HNL could also provide answers about the dark matter nature, and baryon asymmetry of the universe. Searches for the production of HNL at the LHC, in final states with three leptons or two leptons and jets, are presented. The sample of pp collisions collected by the CMS detector throughout 2016 is used, amounting to a volume of 36/fb.

Neutrino Physics / 955

New results from GERDA Phase II

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GERDA is performing a background-free search for neutrinoless double-beta decay of Ge-76. An observation of this nuclear transition would unambiguously prove that neutrinos are Majorana particles and that the lepton number is violated. Thanks to a factor two increase in statistics, the experimental sensitivity doubled compared to the last data release making GERDA the first experiment exploring neutrinoless double beta decay half-lives at the order of 1e26 years. First results and prospects of this pioneering exploration will be presented.

Neutrino Physics / 823

Search for neutrinoless double-beta decays in Ge-76 in the LEGEND experiment

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The search for neutrinoless double-beta decay is the most sensitive technique to establish the Majorana nature of neutrinos. Two operating experiments that look for such decays in 76Ge — GERDA and MAJORANA DEMONSTRATOR — have achieved the lowest backgrounds and the best energy resolution in the signal region. These are two of the most important detector characteristics for sensitive searches of this undiscovered decay. The Large Enriched Germanium Experiment for Neutrinoless Double Beta Decay (LEGEND) Collaboration has been formed to pursue a tonne-scale 76Ge experiment that integrates the best technologies from these two experiments and others in the field. The Collaboration is developing a phased experimental program that uses existing resources as appropriate to expedite physics results, with the ultimate discovery potential at a decay half-life beyond 1028 years. In this talk, we will present the physics case, R&D efforts and implementation strategies of the LEGEND experiment.

Neutrino Physics / 810

Recent results from the MAJORANA DEMONSTRATOR

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The MAJORANA DEMONSTRATOR is an experiment constructed to search for neutrinoless double-beta decay in ^{76}Ge and to demonstrate the feasibility to deploy a large-scale experiment in a phased and modular fashion. It consists of two modular arrays of natural and ^{76}Ge-enriched germanium detectors totalling 44.1 kg, operating on the 4850' level of the Sanford Underground Research Facility in Lead, South Dakota, USA. Commissioning running began in June 2015, followed by the full detector array acquiring data since August 2016. The ultra-low background and record energy resolution achieved by the MAJORANA DEMONSTRATOR enable a sensitive neutrinoless double-beta decay search, as well as additional searches for physics beyond the Standard Model. I will discuss the design elements that enable these searches, along with our latest results, focusing on the neutrinoless

double-beta decay search. I will also discuss the current status and the future plans of the MAJORANA DEMONSTRATOR, as well as the plans for a future tonne-scale ^{76}Ge experiment.

Neutrino Physics / 780

DOUBLE BETA DECAY WITH NEMO-3 AND SUPERNEMO

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Neutrinoless double beta decay ($0\nu\beta\beta$) is the only practical way to understand the neutrino nature (Dirac or Majorana particle) and to observe full lepton number violation required by most beyond the standard model scenarios.

The goal of the SuperNEMO experiment is to search for $0\nu\beta\beta$ decay. Its technology is based on a successful design approach of the NEMO-3 experiment which was running at the Modane Underground Laboratory in the Frejus Tunnel under the French-Italian Alps in $2003-2011$.
The unique features of this approach are the ability to study almost any $\beta\beta$ isotope and reconstruction of the event topology which produces a "smoking gun" evidence for the process and may allow the underlying physics mechanism to be disentangled.

The latest updates on the final NEMO-3 results obtained with 7 different $\beta\beta$ isotopes are presented.
The physics reach of the SuperNEMO project is discussed and the status of the integration and commissioning of its first module, the Demonstrator, as well as its physics sensitivity are presented.

Neutrino Physics / 317

Spectroscopy of the first electrons from the KATRIN tritium source

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Neutrinos are by far the lightest particles in the Universe. According to the Standard Model of Particle Physics neutrinos should be massless. However, the existence of their mass has been proven experimentally by the observation of neutrino mass oscillations. The KArlsruhe TRitium Neutrino (KATRIN) experiment at the Karlsruhe Institute of Technology aims for a direct neutrino mass determination with a sensitivity of 200 meV/c^2 (90% C.L.).
The measurement will be performed by precise spectroscopy of the tritium-β-decay electrons near the kinematic endpoint of 18.6 keV. That is achieved by employing a high-resolution ($\Delta E < 1$ eV) MAC-E-type high-pass energy filter coupled to a high-luminosity (10^{11} Bq) windowless gaseous tritium source which is supplied by the closed gas processing loop of the Tritium Laboratory Karlsruhe (TLK) at throughput of 40 g of T_2 per day.

In autumn 2016, the First Light commissioning campaign took place, in which photoelectrons generated from KATRIN's rear wall were guided through the complete beamline (source and spectrometers) and were detected successfully on the detector. During the subsequent experimental stage in summer 2018, gaseous metastable Kr-83m was injected into the KATRIN source section. Furthermore, a condensed Kr-83m source was deployed in the transport section. By using both sources, first high-resolution spectroscopy of electrons from radioactive origin has been performed with KATRIN (arXiv:1802.04167). From this campaign, we could demonstrate many aspects of the high-resolution spectroscopy capability of the KATRIN setup and perform a highly accurate calibration of the energy scale of KATRIN from the mono-energetic conversion electrons from Kr-83m (arXiv:1802.05227).

After the demonstration of the high-resolution performance of the KATRIN spectrometers, in spring 2018, the first injection of tritium into the KATRIN source section is scheduled. The principal aim of this campaign is to demonstrate the stability of the tritium source at an activity of about 1% (~10^9 Bq) of the nominal level, which is maintained by a complex tritium loop at the TLK. This stability investigation is crucial in order to operate the tritium source at high isotopic purity (>95%) and a stability of 0.1% during upcoming neutrino mass runs (with a total measurement time of three years).

This talk presents the ambitious goals of KATRIN and the complex setup designed to reach them. The fruitful achievements of the successful Krypton campaign will be summarized and an insight into the results from the first ever high-resolution spectroscopy with tritium beta-decay electrons by KATRIN is given.

Neutrino Physics / 1036

Recent Results from the NOvA experiment

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NOvA is a long-baseline neutrino experiment that uses an upgraded NuMI neutrino source at Fermilab and a 14-kton detector at Ash River, Minnesota. The detector has a highly active, finely segmented design that offers superb event identification capability. The latest results on muon (anti-)neutrino disappearance and electron (anti-)neutrino appearance will be shown, as well as neutral current measurements. The results will include the implications for neutrino oscillation mixing parameters, CP violation and the mass ordering.

Neutrino Physics / 642

Physics Potentials of the 2nd Hyper-Kamiokande Detector in Korea

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Hyper-Kamiokande (Hyper-K) succeeds the very successful Super-K experiment and will consist of a large detector filled with 260 kton water and equipped with 40% photo- coverage. Physics program of Hyper-K is broad, covering from particle physics to Astrophysics.
The 1st Hyper-K detector will be built in Japan, and the 2nd detector is considered to be built in Korea because locating the 2nd detector in Korea improves physics sensitivities in most cases thanks to the longer baseline (~1,100 km) and larger overburden (~1000 m) for Korean candidate sites.

In this talk, we present overview and physics potentials of the 2nd Hyper-K detector in Korea.

Neutrino Physics / 638

Prospects for CP violation measurement with Hyper-Kamiokande

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Three flavor neutrino mixing has been established by the continuous studies of neutrino oscillations since its discovery. Large mixing angles and small neutrino masses, in contrast to those in quark sector, imply new physics at ultra-high energy. In addition, as- yet unmeasured CP violation in neutrino sector is considered as a clue to investigate the origin of matter-antimatter asymmetry of the universe. Hyper-Kamiokande is a next generation large-scale water Cherenkov detector. With the baseline design, its fiducial volume is about an order of magnitude larger than Super-Kamiokande and the detector performance is significantly improved with newly developed photo-sensors. Combination of the Hyper-Kamiokande detector with the upgraded J-PARC neutrino beam will provide unprecedented high statistics of the neutrino and antineutrino signals to measure the CP violation and reveal a full picture of neutrino mixing with high precision. Prospects for the CP violation measurements by the Hyper-Kamiokande
long baseline project will be presented.

Neutrino Physics / 61

Neutrino CP Violation with the European Spallation Source neutrino Super Beam project

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After measuring in 2012 a relatively large value of the neutrino mixing angle θ13, the door is now open to observe for the first time a possible CP violation in the leptonic sector. The measured value of θ13 also privileges the 2nd oscillation maximum for the discovery of CP violation instead of the usually used 1st oscillation maximum. The sensitivity at this 2nd oscillation maximum is about three times higher than for the 1st oscillation maximum inducing a lower influence of systematic errors. Going to the 2nd oscillation maximum necessitates a very intense neutrino beam with the appropriate energy. The world's most intense pulsed spallation neutron source, the European Spallation Source, will have a proton linac with 5 MW power and 2 GeV energy. This linac, under construction, also has the potential to become the proton driver of the world's most intense neutrino beam with very high potential to discover a neutrino CP violation. The physics performance of that neutrino Super Beam in conjunction with a megaton underground Water Cherenkov neutrino detector installed at a distance of about 500 km from ESS has been evaluated. In addition, the choice of such detector will extent the physics program to proton-decay, atmospheric neutrinos and astrophysics searches. The ESS proton linac upgrades, the accumulator ring needed for proton pulse compression, the target station optimization and the physics potential are described. In addition to neutrinos, this

facility will also produce at the same time a copious number of muons which could be used by a muon collider. The ESS neutron facility will be fully ready by 2023 at which moment the upgrades for the neutrino facility could start.
This project is now supported by the COST Action CA15139 "Combining forces for a novel European facility for neutrino-antineutrino symmetry-violation discovery" (EuroNuNet). It has also received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 777419.

Keywords: ESSnuSB, neutrino, CP violation, neutrino oscillations, ESS, COST, EuroNuNet, H2020

Neutrino Physics / 301

The latest oscillation results from the T2K Experiment

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The T2K long-baseline neutrino oscillation experiment has been running since January 2010 and has doubled the data set in both neutrino and anti-neutrino beam mode since results were last reported at ICHEP (2016).
We will present a joint analysis of both the neutrino and anti-neutrino data in the disappearance and appearance channels.
This analysis uses a new event reconstruction algorithm, fiTQun, which provides both improved selections and an increased fiducial volume.
These improvements are used to obtain world-leading measurements of theta_23, Delta m2_23 and delta_CP, as well as to search for the first evidence of nue_bar appearance.

Neutrino Physics / 575

Event Reconstruction Techniques for ANNIE Phase II

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The Accelerator Neutrino Neutron Interaction Experiment (ANNIE), deployed on the Booster Neutrino Beam (BNB) at Fermilab, is planning to use a 26-ton Gd-doped water Cherenkov detector to study the multiplicity of final state neutrons from neutrino-nucleus interactions in water, which provides a unique opportunity to study this physics in an energy range relevant to both atmospheric and long baseline neutrino experiments. The experiment has two main goals: (1) perform the first measurement of the abundance of neutrons from neutrino interactions in water, as a function of momentum transfer in order to constrain neutrino-nucleus interaction models, and (2) demonstrate the power of new fast-timing, position-sensitive detectors by making the first deployment of the Large Area Picosecond PhotoDetectors (LAPPDs) in a physics experiment. The Phase I of ANNIE has successfully measured the neutron background inherent to the BNB. The Phase II of ANNIE will realize the physics measurements by using the arrival time and position of the Cherenkov photons in both PMTs and LAPPDs. The interaction vertices and the charged lepton tracks are reconstructed by using

a maximum likelihood fit. The energies of the charged lepton and the neutrino are reconstructed by using Machine and Deep Leaning algorithms. This presentation will give an overview of the ANNIE Phase II simulation and present the recent development of event reconstruction techniques.

Neutrino Physics / 986

Democratic neutrino mass matrix from generalized Fridberg-Lee model

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We propose a phenomenological model of the Dirac neutrino mass matrix based on the Fridberg-Lee neutrino mass model at a special point. In this case, the Fridberg-Lee model reduces to the Democratic mass matrix with the S_3 permutation family symmetry. The Democratic mass matrix has an experimentally unfavored degenerate mass spectrum on the base of tribimaximal mixing matrix. We rescue the model to find a nondegenerate mass spectrum by adding the breaking mass term as preserving the twisted Fridberg-Lee symmetry. The tribimaximal mixing matrix can be also realized. Exact tribimaximal mixing leads to $\theta_{13} = 0$.
However, the results from Daya Bay and RENO experiments have established a nonzero value for θ_{13}. Keeping the leading behavior of U as tribimaximal, we use Broken Democratic neutrino mass model. We characterize a perturbation mass matrix which is responsible for a nonzero θ_{13} along with CP violation, besides the solar neutrino mass splitting has been resulted from it. We consider this work in two stages: In the first stage, we obtain the perturbation mass matrix with real components which breaks softly the $\mu - \tau$ symmetry and this leads to a nonzero value for θ_{13}. In the second stage, we extend the perturbation mass matrix to a complex symmetric matrix which leads to CP violation. Therefore obtain a realistic neutrino mixing matrix with $\theta_{23} = 45°$. We obtain the solar mass splitting, the ordering of the neutrino masses is inverted. Using only two sets of the experimental data, we can fix all of the parameters of mass matrix and predict the masses of neutrinos and phases. These predictions include the following:
$m_1 \approx (4.82 - 4.93)10^{-2}eV$,
$|m_2| \approx (4.90 - 5.01)10^{-2}eV$, $m_3 \approx 0$ and,
$\phi \approx (0.687° - 10.31°)$ as the origin of the Majorana phases.

Neutrino Physics / 977

Right-Handed neutrino searches at the FCC

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CERN has launched in 2014 the design study of Future Circular Colliders, including a High Luminosity e+e- collider (FCC-ee) running from the Z pole to above the top pair production threshold.

Follow a 100 TeV pp and heavy ion collider (FCC-hh) able to reach an unprecedented energy scale and an e-p collider option. The FCC-ee offers a broad discovery potential based on a combination of precision Electroweak Measurements, high statistics quark and lepton flavour physics, searches for rare phenomena and new particles, and Higgs model-independent coupling measurements. The FCC-hh can observe the production new particles with Standard Model couplings up to ~30 TeV, but is also an extremely abundant factory for W, Z top and Higgs, allowing searches for rare phenomena and a number of precision measurements including those of the triple Higgs and ttH couplings. The ep option would offer unprecedented reach in structure functions and high statistics of Higgs production.

The complementarity of the FCC machines can be illustrated in a spectacular way for particular example of heavy neutral leptons (Right Handed neutrinos), which constitute today one of the most compelling extensions of the Standard Model, if their masses are around the Electroweak scale. While the FCC-ee offers the largest discovery domain by either the very clean observation of long lived particles in Z⟶ νN decays, or by a typical pattern of deviations in a series of precision observables, the FCC-hh (or ep) could detect them in W⟶l N (or e⟶ N Charged current transition) followed by the semileptonic decay of the Heavy Neutral lepton, thus able to observe possible change of lepton flavour or even leptonic number.

Neutrino Physics / 374

Bounds on heavy right handed neutrinos and implications for collider searches

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The neutrino masses and flavor mixings, which are missing in the Standard Model (SM), can be naturally incorporated in the type-I seesaw extension of the SM with heavy Majorana neutrinos being singlet under the SM gauge group. If the heavy Majorana neutrinos are around the electroweak scale and their mixings with the SM neutrinos are sizable, they can be produced at high energy colliders, leaving characteristic signatures with lepton-number violations. Employing the general parametrization for the neutrino Dirac mass matrix in the minimal seesaw scenario, we perform a parameter scan and identify allowed regions to satisfy a variety of experimental constraints from the neutrino oscillation data, the electroweak precision measurements and the lepton-flavor violating processes. We find that the resultant mixing parameters between the heavy neutrinos and the SM neutrinos are more severely constrained than those obtained from the current search for heavy Majorana neutrinos at the LHC. Such parameter regions can be explored at the High-Luminosity LHC and a 100 TeV pp-collider in the future. We will also discuss the scenarios about the inverse seesaw briefly.

Neutrino Physics / 24

Discovery of Massive Sterile Neutrinos at the LHC

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We will discuss all the possibilities of discovering the massive sterile neutrinos at the LHC.

Neutrino Physics / 956

Nuclear Matrix Elements for Neutrinoless Double Beta Decay from Lattice QCD

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While neutrino oscillation experiments have demonstrated that neutrinos have small, nonzero masses, much remains unknown about their properties and decay modes. One potential decay mode — neutrinoless double beta decay ($0\nu\beta\beta$) — is a particularly interesting target of experimental searches, since its observation would imply both the violation of lepton number conservation in nature as well as the existence of at least one Majorana neutrino, in addition to giving further constraints on the neutrino masses. Relating experimental constraints on $0\nu\beta\beta$ decay rates to the neutrino masses, however, requires theoretical input in the form of non-perturbative nuclear matrix elements which remain difficult to calculate reliably. In this talk we will discuss the prospects for a first-principles calculation of the relevant nuclear matrix elements using lattice QCD and effective field theory techniques, assuming neutrinoless double beta decay mediated by a light Majorana neutrino. As a proof-of-principles we will show preliminary results from a lattice calculation of the related $\pi^- \to \pi^+ e^- e^-$ transition amplitude.

Neutrino Physics / 932

Double beta decay search with CUPID-0: results and perspectives

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CUPID-0 is the first large mass experiment based on cryogenic calorimeters (bolometers) that implements the dual read-out of light and heat for background rejection. The detector, consisting of 24 enriched $Zn^{82}Se$ crystals (5.28 kg of ^{82}Se), is taking data in the underground LNGS (Italy) from March 2017.
In this contribution we present the analysis that allowed to set the most stringent limit on the half-life of neutrino-less double beta decay of ^{82}Se.
We prove that the particle identification, enabled by the simultaneous read-out of heat and light, provides an unprecedented background level for cryogenic calorimeters of 3×10^{-3} counts/keV/kg/y.
Finally, we discuss the impact of these results on next generation projects.

Neutrino Physics / 749

CANDLES project to search for neutrino-less double beta decay of ^{48}Ca

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Neutrino-less double beta decay($0\nu\beta\beta$) is acquiring great interest
after the confirmation of neutrino oscillation
which demonstrated nonzero neutrino mass.
Measurement of $0\nu\beta\beta$ provides a test for the Majorana nature of neutrinos
and gives an absolute scale of the effective neutrino mass.

In order to search for $0\nu\beta\beta$ of ^{48}Ca,
we proposed CANDLES project and a detector system by using CaF_2(pure).
The CANDLES III system, which is one of the CANDLES project, aims at a high sensitive measurement
by a characteristic detector system.
The system realizes a complete 4π active shield
by immersion of the CaF_2 scintillators in liquid scintillator.
The active shield leads to a low background condition for the measurement.

Now we have developed the CANDLES III system,
which contained 350 g of ^{48}Ca at the Kamioka underground laboratory.
In 2016, we have installed a shielding system in the CANDLES III system
to reduce background events by the high energy γ-rays,
which were emitted from neutron capture reaction on surround materials.
By the system,
we reduced the background events from neutron capture by two orders of magnitude.
After this upgrade, we started a double beta decay measurement
and obtained result.
Furthermore, we started development of next detector system.
In this system, we will use a CaF_2 scintillating bolometer
and enriched ^{48}Ca.
In this paper,
we will report result of ^{48}Ca double beta decay measurement by using the CANDLES III system
and current status of the CaF_2 scintillating bolometer and enrichment of ^{48}Ca.

Neutrino Physics / 677

Recent results of the AMoRE-pilot experiment, a search for neutrinoless double beta decay of Mo-100

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The Advanced Mo-based Rare process Experiment (AMoRE) is a search for neutrinoless double beta decay of 100Mo in calcium molybdate (CaMoO4) crystals by using cryogenic detectors at a temperature range of tens of millikelvin. The crystals are made of Molybdenum enriched on 100Mo (≥95%) and Calcium depleted on 48Ca isotopes (≤0.002%). The ongoing pilot experiment at the YangYang underground laboratory consists of a number of commissioning runs using six 40Ca100MoO4 crystals of a total mass 1.9 kg. At the same time, the fist phase of the AMoRE experiment with about 5 kg of CaMoO4 crystals is in preparation. The physics data of the AMoRE-pilot were analyzed and fitted with Monte Carlo simulation results to identify their background sources. In this presentation, the fit results will be presented and discussed.

Neutrino Physics / 651

Neutrino properties deduced from the double beta decay study

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Double beta decay (DBD) is a rare nuclear process of great interest due to its potential to provide information about physics beyond the Standard Model (BSM). For example, the discovery of the neutrinoless double-beta ($0\nu\beta\beta$) decay mode could give answers to fundamental issues about possible violation of the CP and Lorentz symmetries in the weak sector, lepton number violation, or about still unknown neutrino properties such as are neutrinos Dirac- or Majorana-like particles?; neutrino absolute masses; what is the correct hierarchy of the neutrino masses?; are there sterile neutrinos?, etc. Theoretically, the DBD study consists in the precisely computation of the nuclear matrix elements (NMEs) and phase space factors (PSFs) entering the DBD half-lives formulas, for different decay modes and transitions to final ground or excited states of the parent nuclei. Reliable computations of these quantities result in reliable predictions of DBD half-lives and constrains of the BSM parameters appearing in the possible mechanisms that may contribute to the $0\nu\beta\beta$ decay. In my talk I give first a short review of the theoretical challenges in the study of $0\nu\beta\beta$ decay. Then I present a new, more reliable, approach to calculate at once the products NMEs x PSFs and I deduce new limits for the neutrino mass parameters for the light and heavy neutrino exchange scenarios.

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Neutrino Physics / 988

Three Neutrino Oscillations in Uniform Matter

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Following similar approaches in the past, the Schrodinger equation for three neutrino propagation in matter of constant density is solved analytically by two successive diagonalizations of 2x2 matrices. The final result for the oscillation probabilities is obtained directly in the conventional parametric form as in the vacuum but with explicit simple modification of two mixing angles (θ12 and θ13) and mass eigenvalues.

Neutrino Physics / 914

Resolving DUNE oscillation parameter ambiguities in the 3+1 sterile neutrino scenario using SBN

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There has been significant interest in the possible effect that one or more light sterile neutrinos, hinted by several short-baseline neutrino oscillation experiments, can have on the measurement of the three-neutrino mixing parameters at the future long-baseline Deep Underground Neutrino Experiment (DUNE), with a particular focus on their effect on CP-violation measurements. By the time DUNE is operational, however, the Short-Baseline Neutrino (SBN) program at Fermilab will have performed high-precision measurements of possible light sterile neutrino oscillations, or will have provided stringent constraints to such scenarios. In this work we will present results on a joint SBN+DUNE light sterile neutrino oscillation analysis, combining both ν_e appearance and ν_μ disappearance oscillation measurements at both long and short baselines. By utilizing a fast MonteCarlo simulation of all SBN and DUNE detectors, we estimate the effects that either a positive or a null observation at SBN could have on DUNE sensitivities.

Neutrino Physics / 838

Phenomenology of minimal seesaw model with S4 symmetry

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We consider a modication of tribimaximal (TBM) mixing matrix which accommodates non-zero mixing angle 13 and CP violation. We show that such a modication of TBM mixing can be achieved in a minimal seesaw model with discrete symmetry S4. This model is very predictive and the undetermined parameters are either mass of heavy neutrinos and a Majorana phase. Possible values of the Dirac-type CP phase D can be predicted with regards to two neutrino mixing angles in the standard parametrization of the neutrino mixing matrix. The unknown parameters are constrained through leptogenesis by imposing the recent experimental neutrino data.

Neutrino Physics / 415

Neutrino mixing in a rephasing invariant parametrization

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Six rephasing invariant combinations can be constructed from elements of the neutrino mixing matrix V: $\Gamma_{ijk} = V_{1i}V_{2j}V_{3k} = R_{ijk} - iJ$, where (i, j, k) is cyclic permutation of $(1, 2, 3)$, R_{ijk} is the real part, and the common imaginary part J is identified with the Jarlskog invariant. In terms of this rephasing invariant parametrization, the squared elements of the neutrino mixing matrix are found to satisfy, as functions of the induced mass, a set of differential equations. They show clearly the dominance of pole terms when the neutrino induced masses cross. Using the known vacuum mixing parameters as initial conditions, it is found that these equations have very good approximate solutions, for all values of the induced mass. The results may be applicable to Long Baseline Experiments (LBL).

Neutrino Physics / 107

Long-range interactions at current and future neutrino oscillation experiments

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The presence of flavoured symmetries like $U(1)_{L_e-L_\mu}$, etc. can affect the propagation of neutrinos by introducing new interactions. If the mediating gauge bosons corresponding to these symmetries are ultra light, then the nucleons and electrons in the sun can generate a long-range potential that can modify the neutrino oscillation probabilities for earth-based experiments. We study the effect of these long-range interactions on long-baseline and atmospheric neutrino experiments. We constrain the parameter space of these new physics scenarios using current oscillation data. We discuss the effect that these interactions can have on future data, and calculate the projected bounds from future experiments. We also discuss the smoking-gun signatures that can distinguish these scenarios from other non-standard interactions.

Neutrino Physics / 43

Neutrino Oscillation Probabilities in Matter

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Recent advances in ways to calculate the neutrino oscillation probabilities in matter will be present as well as their utility for long baseline oscillation experiments. These methods are not only numerically accurate enough for all current and future experiments but provide better analytic understanding then other methods. How accurate an oscillation probability is needed for long baseline experiments will also be discussed as well as the significance of variations in the matter density along the neutrino path line.

Neutrino Physics / 45

Implications of $\mu - \tau$ Reflection Symmetry in Minimal Seesaw Formalism

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We discuss $\mu - \tau$ reflection symmetry embedded in minimal seesaw model which predicts maximal atmospheric mixing angle and Dirac CP phase together with trivial Majorana phases for neutrinos. In this formalism, we add two right-handed neutrinos in the Standard Model which are essential to explain the tiny nature of neutrino mass under the type - I seesaw formalism. Assuming that both the left- and right-handed neutrino fields transform under $\mu - \tau$ reflection symmetry, we obtain the required forms of the neutrino Dirac mass matrix and the Majorana mass matrix for the right-handed neutrinos. To investigate the neutrino phenomenology at low energies, we first consider the breaking of $\mu - \tau$ reflection symmetry due to the renormalization group running. Later, we present a systematical study of different breaking schemes by introducing explicit breaking terms at Dirac and Majorana neutrino mass matrices respectively.

Neutrino Physics / **462**

Average CsI neutron density distribution from COHERENT data

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The coherent neutrino scattering with nuclei provides a novel way to measure the distribution of neutrons in nuclei. This interaction has been theoretically predicted more than 40 years ago 1, but the difficulty of measuring the very small nuclear recoil made possible its experimental observation only in 2017 by the COHERENT experiment 2.

Using the COHERENT data, we are able to determine for the first time the average radius of the neutron distributions of the Caesium and Iodine nuclei [3], which turns out to be of about 5.5 millionths of a nanometer. It was also possible to evaluate the so called "neutron skin", which is the difference between the radii of the neutron and proton distributions. These quantities are crucial ingredients of the nuclear matter equation of state which plays an essential role in understanding several processes, like nuclei in laboratory experiments, heavy ion collisions, and the structure and evolution of astrophysical objects as neutron stars. Moreover, a better understanding of the neutrino-nucleus interaction process is of utmost importance in the direct dark matter searches field, in which this process contributes to an irreducible source of the background.

In this talk, the measurement of the neutron radius and the neutron skin from COHERENT data will be presented, and the implications in nuclear physics, astrophysics and the cosmology will be elaborated.

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Neutrino Physics / **1032**

First observation of coherent elastic neutrino-nucleus scattering and continued efforts of the COHERENT Collaboration

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More than 40 years after its theoretical description, the process of coherent elastic neutrino-nucleus scattering (CEvNS) has been observed for the first time by the COHERENT Collaboration, using a 14.6-kg CsI[Na] detector at the Spallation Neutron Source of Oak Ridge National Lab. COHERENT and other groups continue to work towards additional CEvNS measurements because of the breadth of physics sensitivity shown by the process, including connections to nuclear structure, astrophysics, dark sector physics, and other physics beyond the Standard Model. Details of the initial observation of CEvNS will be presented along with an overview of the physics program within the COHERENT Collaboration, comprised of measurements of both CEvNS on other target nuclei as well as additional neutrino processes, including charged-current interactions on iodine and neutrino-induced neutron production on lead. The complementarity of additional CEvNS measurements will be explored, emphasizing the importance of additional, diverse experimental efforts.

Neutrino Physics / 363

Quasi-elastic-like anti-neutrino production at MINERvA

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Next-generation neutrino oscillation experiments, such as DUNE and Hyper-Kamiokande, hope to measure charge-parity (CP) violation in the lepton sector. In order to do this, they must dramatically reduce their current levels of uncertainty, particularly those due to neutrino-nucleus interaction models. As CP violation is a measure of the difference between the oscillation properties of neutrinos and antineutrinos, data about how the less-studied antineutrinos interact is especially valuable. We present the MINERvA experiment's first double-differential scattering cross sections for antineutrinos on scintillator, in the few-GeV range relevant to experiments such as DUNE and NovA. We also present total antineutrino-scintillator quasi-elastic cross sections as a function of energy, which we compare to measurements from previous experiments. As well as being useful to help reduce oscillation experiments' uncertainty, our data can also be used to study the prevalence of various correlation and final-state interaction effects within the nucleus. We compare to models produced by different model generators, and are able to draw first conclusions about the predictions of these models.

Neutrino Physics / 303

Probing neutrino cross-section models with T2K near-detector data

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The T2K long-baseline neutrino oscillation experiment has been running since January 2010 and collected thousands of neutrino-interaction events at the near detectors (ND280 and INGRID) with different targets. The data collected allow us not only to measure the neutrino-interaction cross sections, but also to probe different nuclear models. T2K is developing new tools for unfolding the data in order to infer unbiased cross sections and exploring new variables which probe ambiguities in the modeling of nuclear effects in neutrino interactions at the energies most relevant for current and future neutrino oscillation experiments.
An overview of methods probing cross-section models which could be used in other neutrino experiments will be presented in this talk. The impact of nuclear effects on the oscillation analysis will be also outlined.

Neutrino Physics / 302

An overview of the neutrino interaction cross-section measurements in the T2K experiment

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In addition to its contributions to our understanding of neutrino oscillation parameters, the T2K long-baseline neutrino oscillation experiment has a complementary program of neutrino interaction cross-section measurements with its near detector complex. With multiple targets (carbon, water, argon, iron), and with on- and off-axis detectors which sample different neutrino spectra from the same beamline, T2K is able to investigate atomic number and energy dependent behavior in a single experiment.
This talk presents an overview of the T2K neutrino cross sections, focusing on the latest results.

Neutrino Physics / 36

First Measurement of Monoenergetic Muon Neutrino Charged Current Interactions

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We report the first measurement of monoenergetic muon neutrino charged current interactions. MiniBooNE has isolated 236 MeV muon neutrino events originating from charged kaon decay at rest ($K^+ \to ^+$) at the NuMI beamline absorber. These signal -carbon events are distinguished from primarily pion decay in flight and backgrounds produced at the target station and decay pipe using their arrival time and reconstructed muon energy. The significance of the signal observation is at the 3.9σ level. The muon kinetic energy, neutrino-nucleus energy transfer ($= E - E$), and total cross section for these events is extracted. This result is the first known-energy, weak-interaction-only probe of the nucleus to yield a measurement of ω using neutrinos, a quantity thus far only accessible through electron scattering.

Neutrino Physics / 30

Neutrino physics with the SHiP experiment at CERN

Collaboration SHiP [None] ; Chunsil Yoon[1]

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SHIP is a new general purpose fixed target facility, whose Technical Proposal has been recently reviewed by the CERN SPS Committee and by the CERN Research Board. The two boards recommended that the experiment proceeds further to a Comprehensive Design phase in the context of the new CERN Working group "Physics Beyond Colliders", aiming at presenting a CERN strategy for the European Strategy meeting of 2019. In its initial phase, the 400GeV proton beam extracted from the SPS will be dumped on a heavy target with the aim of integrating 2×10^20 pot in 5 years. A dedicated detector will allow the study of neutrino cross-sections and angular distributions. $\nu\tau$ deep inelastic scattering cross sections will be measured with a statistics 1000 times larger than currently available, with the extraction of the F4 and F5 structure functions, never measured so far and allow for new tests of lepton non-universality with sensitivity to BSM physics.

Neutrino Physics / 967

Progress on the IsoDAR Antielectron Neutrino Experiment

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IsoDAR is a compact, accelerator-based source for anti-electron neutrinos produced through ^{8}Li decay. When paired with a large scintillator-based detector, IsoDAR allows for a high-precision investigation of the reactor and source-based neutrino oscillation anomalies. This talk will discuss this physics, as well as other beyond Standard Model precision measurements that can be performed. We will also briefly review recent technical developments on the source.

Neutrino Physics / 1018

Neutrino scattering at nuSTORM

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The nuSTORM facility will provide \nu_e and \nu_\mu beams from the decay of low energy muons confined within a storage ring. The instrumentation of the ring, combined with the excellent knowledge of muon decay, will make it possible to determine the neutrino flux at the %-level or better. The neutrino and anti-neutrino event rates are such that the nuSTORM facility serving a suite of near detectors will be able to measure \nu_eN and \nu_\muN cross sections with the %-level precision required to allow the next generation of long-baseline neutrino-oscillation experiments to fulfil their potential. By delivering precise cross section measurements with a pure weak probe nuSTORM may have the potential to make measurements important to understanding the physics of nucleii. The

precise knowledge of the initial neutrino flux also makes it possible to deliver uniquely sensitive sterile-neutrino searches. The concept for the nuSTORM facility will be presented together with an evaluation of its performance. The status of the planned consideration of nuSTORM at CERN in the context of the Physics Beyond Colliders workshop will be summarised.

Neutrino Physics / 486

Hadron Production Measurements for Neutrino Oscillation Experiments with NA61/SHINE

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The uncertainty in the flux of neutrino beams is dominated by our understanding of both the primary interactions of protons and the secondary interactions of protons, kaons and pions with target and beamline material. Hadron production measurements from a comprehensive set of interactions will allow modern neutrino experiments to make more precise neutrino cross section and oscillation measurements. Measurements of charged hadron spectra and total cross sections have recently been obtained by NA61/SHINE, a fixed target experiment at the CERN SPS, for a variety of beam particles, beam momenta and target materials. From the 2010 dataset of 31 GeV/c protons interacting with a T2K replica target, multiplicities of π^+, π^-, K^+, K^- and protons have been obtained. These measurements supplement the results from the 2009 thin target measurements, which have been used to constrain the T2K neutrino flux prediction. The application of the replica target results is ongoing and is expected to further reduce the uncertainties in the flux prediction. Starting in 2015 and continuing through 2018, NA61/SHINE has been recording interactions relevant to the neutrino beams at NuMI and LBNF located at FNAL. These beams are used by the ongoing experiments NOνA and MINERνA and the future experiment DUNE. In 2015, total inelastic and production cross section measurements have been obtained from interactions of K^+ at 60 GeV/c and π^+ at 31 and 60 GeV/c with carbon and aluminum targets. In 2016 and 2017, NA61/SHINE recorded interactions of π^+, π^- and protons with momenta ranging from 31 to 120 GeV/c with carbon, aluminum and beryllium targets. The first of these interactions to be analyzed is 60 GeV/c π^+ with thin carbon and beryllium targets, where multiplicities of π^+, π^-, K^+, K^- and protons are being measured. In the summer of 2018, NA61/SHINE will resume data taking including interactions of 60 GeV/c K^+ with carbon and 120 GeV/c protons on a NOνA replica target.

Neutrino Physics / 417

Study of tau-neutrino production at the CERN SPS

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At the CERN SPS, the DsTau project has been proposed to study tau-neutrino production aiming at providing important information for future ν_τ measurements. Precise measurement of the ν_τ cross section would enable a search for new physics effects in ν_τ-nucleon CC interactions. It also has practical implications for neutrino oscillation experiments. The dominant source of ν_τ is the sequential decay of D_s mesons produced by proton interactions, whose uncertainty dominates current uncertainty in the ν_τ cross section measurement. The project aims at reducing the systematic uncertainty from about 50% to 10% by measuring the D_s differential production cross section. For this purpose, emulsion detectors with a nanometre-precision readout will be used to detect small kinks of the $D_s \to \tau$ decay. An emulsion detector has a position resolution of 50 nm, allowing for

the detection of $D_s \to \tau \to X$ double kinks in a few mm range. Results from the beam tests in 2016-2017 will be presented together with a prospect for a pilot run in 2018 and a physics run in 2021.

Neutrino Physics / 95

The ENUBET neutrino beam

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ENUBET has been designed to monitor lepton production in the decay tunnel of neutrino beams at single particle level and to provide a 1% measurement of the neutrino flux at source. In particular, the three body semileptonic decay of kaons monitored by large angle positron production offers a fully controlled nu_e source at the GeV scale for a new generation of short baseline experiments. The ENUBET Collaboration will present at ICHEP the first end-to-end simulation of the beamline and a complete review of the performance of this non-conventional technique. Special emphasis will be given to the new static focusing system that has been validated in 2018. Beyond positron monitoring, such scheme gives the opportunity to correlate in time the lepton at source and the neutrino at the detector. Time-coincidences enable an unprecedented purity and the possibility to reconstruct the neutrino kinematics at source on an event by event basis. We will also present the performance of the positron tagger tested at CERN in 2017-2018 and the expected sensitivity of ENUBET for nu_e and nu_mu cross section measurements.

Neutrino Physics / 759

Searches for heavy neutral lepton production and lepton flavour violation in kaon decays at the NA62 experiment

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Searches for heavy neutral lepton (HNL) production in charged kaon decays using the data collected by the NA62 experiment at CERN are reported. Upper limits are established on the elements of the extended neutrino mixing matrix for heavy neutral lepton mass in the range 130-450 MeV, improving on the results from previous HNL production searches. The status and prospects of searches for lepton flavour and lepton number violation in kaon decays at the NA62 experiment is also presented.

Neutrino Physics / 305

Search for heavy neutrinos with the near detector ND280 of the T2K experiment

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Heavy Neutral Leptons (HNLs, heavy neutrinos) with masses below the electroweak scale are introduced in some extensions of the Standard Model to address consistently such effects as neutrino oscillations, light neutrino masses, dark matter and baryon asymmetry. In the mass range below 500 MeV/c^2 these heavy neutrinos can be produced in pion or kaon decays, and further decay themselves into charged particles, hence giving a possibility for their detection.
The T2K long-baseline neutrino oscillation experiment utilises an intense neutrino beam, originating mainly from π and K parents. Usage of the K flux allows the study of a wider mass range of heavy neutrinos. The near detector complex ND280, located 280 m from the target and composed of various sub-modules operated inside a magnetic field, provides the tracking capabilities to identify the products of HNLs' decays.
A selection aimed to search for heavy neutrino events in the gas-filled ND280 TPCs was developed and optimised to significantly reduce the background from active neutrino interactions down to few events for the current dataset. After applying the selection to the T2K ND280 data $(12.34\nu + 6.29\bar{\nu}) \times 10^{20}$ protons-on-target, 2010-2017 statistics), no events in the signal region were observed. The results were used to extract limits on the mixing parameters between heavy neutrino and electron-, muon- and tau- flavoured currents in the mass range of 140 < M_{HNL} < 493 MeV/c^2. The T2K data allow an improvement of the limits provided by the previous experiments such as the CERN PS191 which, together with the BNL E949 data, put the most stringent constraints in the mass region studied by T2K.

Neutrino Physics / 304

Search for sterile neutrinos with the T2K far detector

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T2K is a long baseline accelerator neutrino experiment in Japan which studies neutrino oscillations with a narrow-band muon neutrino beam peaked at 0.6 GeV. The large water Cherenkov detector Super-Kamiokande (SK) located 295 km away from the proton target acts as a far detector and provides high quality samples for oscillation analysis. In the present study the T2K setup is used to search for light sterile neutrinos.
Sterile neutrinos are hypothetical particles that do not interact via weak interactions and couple with active neutrinos only through mixing. They are present in many extensions of the Standard Model and can have any masses from 0 to the GUT scale. Light sterile neutrinos of eV masses could modify the standard 3-flavour oscillation pattern and explain anomalies observed in some oscillation experiments.
A sterile neutrino analysis at T2K was developed to constrain θ_{24} and θ_{34} mixing elements in the 3+1 sterile neutrino model. This is the first study of sterile neutrinos at T2K which is based on SK data. To enhance the sensitivity to the effects related to the presence of sterile neutrinos, a joint analysis is done using both charged-current and the

newly implemented neutral-current (NC) oscillation samples (NCπ^0 with 2 rings observed and NC gamma de-excitation) at the far detector. The primary sensitivity for this sterile search comes from NC samples where we are looking for a deficit due to the oscillations to the sterile neutrino.
The analysis strategy and the results obtained for the current T2K data (2010-2017 data taking) are presented.

Neutrino Physics / 772

Status and Prospects of the JSNS^2 experiment

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The JSNS^2 experiment aims to search for the existence of neutrino oscillations with $\Delta\mathrm{m}^2$ near 1 eV^2 at the J-PARC Materials and Life Science Experimental Facility. A 1 MW proton beam (3 GeV) incident on a mercury target produces an intense neutrino beam from muon decay at rest ($\mu^+ \rightarrow e^+ + \bar{\nu}_\mu + \nu_e$). The oscillation to be searched for is $n\bar{u}_\mu$ to $\bar{\nu}_e$, detected via the inverse beta decay reaction ($\bar{\nu}_e + p \rightarrow e^+ + n$), which is then distinctively tagged by gammas from neutron capture of Gadolinium. The first of two detectors with 17 tons fiducial volume is currently under construction at a distance of 24 m from the mercury target. JSNS^2 is expected to provide the ultimate test of the LSND anomaly by replicating nearly identical conditions. The status of the experiment, which is expected to start by the end of this year, will be discussed and its physics potential reviewed.

Neutrino Physics / 519

Latest Results from MicroBooNE

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The MicroBooNE experiment has been taking data in a LArTPC detector at Fermilab since late 2015. This talk will present initial cross-section results from MicroBooNE, alongside our progress on a short-baseline neutrino oscillation analysis in the region of the MiniBooNE low-energy excess. These results will be discussed in the wider context of MicroBooNE's long-term physics goals of neutrino interaction rates, neutrino oscillations, exotic searches and detector research and development.

Neutrino Physics / 979

The MicroBooNE Detector

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MicroBooNE is a large 170-ton liquid-argon time projection chamber (LArTPC) neutrino experiment located on the Booster neutrino beamline at Fermilab. The experiment first started collecting neutrino data in October 2015. The detector serves as a next step in a phased program towards the construction of massive kiloton scale LArTPC detectors for future long-baseline neutrino physics (DUNE) and is
the first detector in the short-baseline neutrino program at Fermilab. We will present results on the performance of the detector, including measurements of cosmic-ray reconstruction efficiencies, on Michel electron and muon momentum reconstruction, on noise characterisation and filtering, processing of ionisation electron signals, and on the use of advanced analysis techniques for event reconstruction.

Neutrino Physics / 545

Physics Programme for the SBND (Short-Baseline Near Detector)

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SBND (Short-Baseline Near Detector) is a 112-ton liquid argon TPC neutrino detector under construction in the Fermilab Booster Neutrino Beam. Together with MicroBooNE and ICARUS-T600 detectors, SBND will search for short baseline neutrino oscillations in the 1 eV2 mass range. SBND will also perform detailed studies of the physics of neutrino-argon interactions, thanks to a data sample of millions of electron and muon neutrino interactions. Finally, SBND plays a vital role in the on-going R&D effort to develop the LArTPC technology, testing several technologies that can be used in a future kiloton-scale neutrino detectors for a long-baseline experiment. We will the physics program, with a particular focus on the neutrino cross-section measurements and search for BSM physics as well as discuss the detector design, its current status.

Neutrino Physics / 546

The Short Baseline Neutrino Program at Fermilab

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The Fermilab Short-Baseline Neutrino (SBN) program, with three liquid argon time projection chamber (LAr-TPC) detectors located along the Booster Neutrino Beam, presents a rich physics and R&D opportunity. SBN will perform sensitive searches for neutrino oscillations in both appearance and disappearance channels at the 1 eV^2 mass- splitting scale, thereby testing the sterile neutrino interpretation of the anomalous excesses of electron (anti)neutrinos observed by LSND and MiniBooNE. Also, the SBN detectors play a major role in on-going R&D efforts aimed at realizing multi-kiloton-scale LAr-TPC detectors in the next generation long-baseline neutrino oscillation experiment DUNE. To form the SBN program, two additional detectors will join MicroBooNE (currently operational at 470m along the beam); the new Short-Baseline Near Detector (SBND) will be installed at 110m, and the largest existing LAr-TPC, the ICARUST600, will be placed at 600m. In this talk, we present the current status of the SBND and ICARUS detectors and review the physics reach of the full three-detector SBN program.

Neutrino Physics / 940

JUNO: A Multipurpose Underground Precision Neutrino Detector

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The Jiangmen Underground Neutrino Observatory (JUNO) is a reactor-based neutrino oscillation experiment primarily aiming at resolving neutrino mass hierarchy (MH) located in South China. There are a few key elements in designing the JUNO detector in order to resolve the neutrino mass hierarchy with high confidence levels. To get sufficient statistics within a reasonable amount of time, JUNO has designed a 20 kilo-tone liquid scintillator detector with an active veto system with good tracking capability; To maximize the hidden MH signal from the multiple reactor cores, the experiment site has been carefully chosen to be at ~53 km so various baselines differ less than 0.5 km; The two key elements in the JUNO central detector's performance are its unprecedented energy resolution, 3%/sqrt(E/MeV), and its high precision absolute energy scale calibration uncertainty, better than 1%, for a LS detector. Such an unprecedented LS detector naturally provides the experiment the ability of measuring \Delta m^2_31 to sub-percent precision. Furthermore, due to its optimized baseline for the solar mass-squared splitting, JUNO is also capable of measuring the solar neutrino mixing parameters sin^2 2\theta12 and \Delta m^2_21 to sub-percent precision. This talk will present the physics potential of the JUNO experiment in resolving neutrino mass hierarchy, measuring oscillation parameters to unprecedented precision, detecting extra-terrestrial neutrinos and searching for other exotic physics.

Neutrino Physics / 631

Latest Reactor Antineutrino Oscillation Results from the Daya Bay

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The Daya Bay experiment is designed to precisely measure the reactor electron-antineutrino oscillation utilizing eight functionally identical detectors placed at three underground experiment halls. The antineutrinos are generated from six reactor cores distributed with baselines from 500 m to 1600 m. In 2012, the Daya Bay experiment observed the reactor antineutrino disappearance and presented a measurement of $\sin^2 2\theta_{13}$ with a significance better than 5σ. Later in 2014, the collaboration reported an effective mass-squared difference $|\Delta m^2_{ee}|$. The Daya Bay collaboration are continuously improving the precision of $\sin^2 2\theta_{13}$ and $|\Delta m^2_{ee}|$ with higher statistics and better systematic uncertainties. In this talk, I will report the latest oscillation results of $\sin^2 2\theta_{13}$ and $|\Delta m^2_{ee}|$ with the neutron-gadolinium capture data sample and the results from another independent oscillation study with the neutron-hydrogen capture.

Neutrino Physics / 494

Searching for a Light Sterile Neutrino at Daya Bay

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Additional generations of neutrinos that do not participate in standard V-A interactions - hence called "sterile" - arise in many extensions of the Standard Model. The existence of light sterile neutrino, with masses at eV or sub-eV scale, could explain several anomalies in short neutrino oscillation experiments as well as discrepancy in cosmological measurements of the Hubble parameter. I will report a search for light sterile neutrino mixing in the electron antineutrino disappearance channel by the Daya Bay Reactor Neutrino Experiment in the $2x10^{-4}$ ⊠ $|\Delta m^2_{41}|$ ⊠ 0.3 eV^2 range. The resulting limits on $sin^2 2_{14}$ constitute the most stringent constraints to date in the
$|\Delta m^2_{41}|$ ⊠ 0.2 eV^2 region. A joint analysis with electron antineutrino disappearance measurements from the Daya Bay and Bugey-3 experiments and the measurement of muon (anti)neutrino disappearance by the MINOS experiment will also be presented. The combined results place stringent constraints on electron neutrino and antineutrino appearance driven by sterile neutrino. The sterile-neutrino mixing parameter space allowed by the LSND and MiniBooNE experiments is excluded for Δm^2_{41} < 0.8 eV^2 at 95% CLs.

Neutrino Physics / 466

Analysis of Gd(n,gamma) reaction with 155, 157 and natural Gd targets taken with JPARC-ANNRI and development of Gd(n,gamma) decay model for Gd-doped neutron/neutrino detectors

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The importance of a good model for the γ-ray energy spectrum from the radiative thermal neutron capture on Gadolinium (Gd) is specially increased in the present era of Gd-enhanced $\bar{\nu}_e$-search detectors. Its an essential prerequisite for MC studies to evaluate the neutron tagging efficiency, in order to enhance signal sensitivity in the Gd-loaded $\bar{\nu}_e$-search detectors.
The γ-ray spectra produced from the thermal neutron capture on enriched gadolinium targets (^{155}Gd, ^{157}Gd and Natural Gd) in the energy range 0.11 MeV to 8.0 MeV, were measured using the ANNRI Germanium Spectrometer at MLF, J-PARC [1, 2, 3]. Based on the data acquired and a GEANT4 simulation of the ANNRI detector, we reported the energy spectrum of ^{157}Gd(n, γ) and
developed a γ-ray emission model of ^{157}Gd(n, γ) in our previous publication 1.
We now present the analysed data of ^{155}Gd(n, γ) and ^{nat}Gd(n, γ) reactions, the energy spectra of γ-rays and an improved model for ^{155}Gd(n, γ), ^{157}Gd(n, γ) and ^{nat}Gd(n, γ) reactions. The consistency of the results from the devised model is checked among all the 14 germanium crystals, at the level of 15% spectral shape deviation at 0.2 MeV binning.

Neutrino Physics / 426

New results from RENO

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The Reactor Experiment for Neutrino Oscillation (RENO) has been taking reactor antineutrinos data from the six reactors at Hanbit Nuclear Power Plant in Korea using two identical near and far detectors since August, 2011. The samllest neutrino mixing angle θ_13 has been successfully measured by observing the disappearance of reactor antineutrinos. In 2016, RENO has published an updated value of θ_13 and its first measurement of dm^2_ee based on energy dependent disappearance probability using 500 live days of data taken until January. RENO has accumulated more data to obtain more precise values of θ_13 and dm^2_ee. A study has been on progress to find changes in the observed reactor antineutrino flux with respect to the reactor fuel evolution. In this talk, we present newly measured values of θ_13 and dm^2_ee and results on the evolution of observed reactor antineutrino yields.

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The measurement of absolute reactor neutrino flux and spectrum, and their evolution at Daya Bay

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The Daya Bay Reactor Neutrino Experiment consists of eight functionally identical detectors placed underground at different baselines from six 2.9 $\mathrm{GW_{th}}$ reactor cores. Since Dec. 2011, the experiment has collected more than 2.2 million inverse beta decay (IBD) candidates to date, enabling a precision measurement of the absolute reactor antineutrino flux and spectrum, and their fuel-dependent evolution. The comparison between measured spectrum and predictions from Huber-Mueller model revealed a 2.9 σ deviation for the whole energy region and mostly pronounced in the region around 4-6 MeV. The measurement of the evolution of the reactor antineutrino flux and spectrum showed a 2.8 σ discrepancy in the antineutrino flux variation with respect to the reactor fuel composition. The discrepancy suggests an overestimation of the predicted contribution from the ^{235}U fission isotope and indicates that this isotope could be primary contributor to the reactor antineutrino anomaly.

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Updated MiniBooNE Neutrino Oscillation Results within the Context of Global Fits to Short-Baseline Neutrino Data

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In its original 2002-2007 run, MiniBooNE observed an anomalous and yet-unexplained excess of electromagnetic events at low energy neutrino energies. This observation is one of several that has pushed the discussion and search for sterile neutrinos. Since 2016, MiniBooNE has been collecting new neutrino-mode data, doubling the statistics from the original 2002-2007 run. We will revisit the originally observed excess, with one analysis treating the new data as stand alone, and another analysis looking at the combined data. We will then discuss the global fits to the world's short-baseline neutrino data, focusing on models with sterile neutrinos and including the updated MiniBooNE results.

Neutrino Physics / 324

Search for Oscillations with a Lithium-6 Detector at the SCK•CEN BR2 reactor

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Several anomalies in the neutrino sector are pointing towards the existence of a new (sterile) neutrino state with a mass around 1 eV. The SoLid experiment is located at the SCK•CEN BR2 research reactor in Belgium and will investigate this possibility. Using the large flux of anti-neutrino generated in the reactor, it will collect a high statistics sample of Inverse Beta Decay (IBD) events. These will be used to study the energy and distance dependence of the neutrino flux, which in turn will be used un-ambiguous support or reject the evidence of sterile neutrinos being the cause of these anomalies.

The measurement is challenging as one has to operate a detector very close to the high radiation environment of a nuclear reactor and on the surface with little overburden to shield against cosmic rays. SoLid is employing a new technology using highly segmented scintillators with excellent particle ID to face these challenges.

The 1.6-tons detector was installed towards the end of 2017 and is taking data since early 2018. We will describe the detector design, the experimental setup at BR2 and the detection principle. This will be followed by a first look at the data.

Neutrino Physics / 1014

STEREO search for a sterile neutrino at the ILL Grenoble reactor

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In the recent period, re-evaluations of the neutrino flux and spectrum emitted by nuclear reactors have led to the so-called Reactor Antineutrino Anomaly (RAA). This anomaly could be caused by the existence of a light sterile neutrino eigenstate participating in the neutrino oscillation phenomenon. This implies the presence of a fourth mass eigenstate, while global fits of reactor experimental data favor oscillation parameters of the order sin^2(2\theta)=0.1 and Delta m^2=1 eV^2.
The STEREO experiment was built to search for eV sterile neutrinos at a short baseline of 10 meters from the compact core of the research reactor of the Institut Laue-Langevin (ILL) in Grenoble, France. The segmentation of the detector in six target cells allows for independent measurements of the neutrino spectrum at multiple baselines. STEREO takes data since end of 2016 and started to produce constraining results on an active-sterile flavor oscillation. The talk will describe the STEREO experiment principles and will detail the status of its data analysis.

Neutrino Physics / 543

PROSPECT, A Precision Reactor Oscillation and SPECTrum Short-Baseline Antineutrino Experiment

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PROSPECT (Precision Reactor Oscillation and Spectrum) is a short-baseline reactor antineutrino experiment. PROSPECT consists of a segmented 4-ton ^{6}Li liquid scintillator antineutrino detector that will precisely measure the ^{235}U fission antineutrino spectrum from the High-Flux Isotope Reactor (HFIR) at Oak Ridge National Laboratory (ORNL). PROSPECT's high statistics and high resolution measurements of the antineutrino energy spectrum and flux from HFIR's ^{235}U core will be vital to understanding the discrepancies between predicted and measured antineutrino spectra and fluxes observed in previous commercial power reactor neutrino experiments; in addition, PROSPECT will search for the existence of sterile neutrino oscillations at the eV^2-scale. PROSPECT's assembly was completed in late 2017 and physics data taking at HFIR began in 2018. This talk will explain PROSPECT's physics objectives, describe its experimental design, and cover its installation and initial data-taking at ORNL.

Neutrino Physics / 843

Status of NEOS

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The NEOS experiment has successfully measured the reactor antineutrino energy spectrum at 24 m distance from Hanbit reactor unit 5 for 180 days of reactor operation and constrained the active-to-sterile oscillation parameters. An extended measurement for a whole burnup cycle by the NEOS Phase-II will be a unique probe for the dependence of the reactor antineutrino flux and spectrum on the fuel composition. Physics goal and schedule of the NEOS-II will be presented in this talk.

Neutrino Physics / 58

Reactor antineutrino physics with DANSS experiment

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DANSS is a solid state scintillation detector of reactor antineutrino, placed just below 3.1 GW industrial light water reactor of Kalininskaya Nuclear Power Plant about 350 km NW from Moscow. A cubic meter sensitive volume of the detector is formed by 2500 scintillator strips with individual SiPM readout. Groups of 50 strips are also readout by conventional PMTs. Reactor antineutrinos are detected by inverse beta-decay (IBD). The sensitive volume has passive shielding of copper (5 cm), borated polyethylene (two layers of 8 cm), lead (5 cm) and active shielding of double layer scintillation counters. The position below reactor provides overburden about 50 m.w.e. A movable platform of the detector

allows to change its distance to the reactor from 10.7 to 12.7 m
(center to center). 5000 IBD events are detected daily in the
position closest to the reactor.
Ratio of the antineutrino spectra at different distances measured
with the DANSS detector is sensitive to neutrino oscillations to sterile
neutrinos in the most interesting region of the oscillation parameters
space (delta m squared ~ 1 eV^2), where the effect is suspected
by Gallium and Reactor antineutrino anomalies. The DANSS collaboration
presents results of 1.5 year detector running with three positions
(10,7, 11.7 and 12.7 m) cycled weekly. The talk covers sterile neutrino
search results as well as analysis details.

Neutrino Physics / 926

Measuring Neutrino Oscillations with KM3NeT/ORCA

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ORCA is the low-energy detector of KM3NeT, the next generation underwater Cherenkov neutrino observatory in the Mediterranean Sea. With ORCA, the primary goal is to resolve the long-standing unsolved question of whether the neutrino mass ordering is normal or inverted, by measuring matter oscillation effects with atmospheric neutrinos. The ORCA design foresees a dense configuration of KM3NeT detection units, optimised for studying the interactions of neutrinos in seawater at energies < 100 GeV. The detector will be deployed at the French KM3NeT site, at 2500 m depth ~40 km offshore Toulon. The excellent optical properties of deep seawater will be exploited by the ORCA's multi-PMT optical modules to accurately reconstruct both cascade events (mostly induced by electron neutrinos) and track events (mostly from muon neutrinos). The construction of the detector has started. In this contribution we will report on the progress of the construction plan and will discuss the potentialities of the ORCA detector both in neutrino mass hierarchy studies and in obtaining new constraints on other key oscillation parameters.

Neutrino Physics / 641

Astrophysical Neutrinos at Hyper-Kamiokande

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Hyper-Kamiokande (Hyper-K) is a proposed next generation underground large water Cherenkov detector with 260 kton of water and 40% photo coverage.
With about 10 times larger fiducial volume than Super-Kamiokande, the sensitivities for astrophysical neutrinos, like solar neutrinos or supernova neutrinos, will be greatly improved in Hyper-K. In this presentation, we will discuss the physics potential of Hyper- K on astrophysical neutrinos and expected performance of the detector.

Neutrino Physics / 639

Oscillation Physics with Atmospheric Neutrinos at Hyper-Kamiokande

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After the initial observation of neutrino oscillations using atmospheric neutrinos, considerable progress has been made in the understanding of the mixing paradigm using long-baseline and reactor neutrinos. Despite these successes, there are several open questions remaining, including the ordering of the neutrino masses, the octant of the atmospheric mixing angle, and whether or not neutrino oscillations violate CP. Hyper-Kamiokande is next-generation water Cherenkov experiment that will observe long-baseline neutrinos from J-PARC as well as atmospheric neutrinos with its 187~kton fiducial volume. While its atmospheric sample is subject to considerable matter effects and provides sensitivity primarily to the neutrino mass hierarchy, its accelerator neutrino sample provides a clean measurement of the CP phase in the PMNS mixing framework, especially when the hierarchy is known.
This talk will discuss Hyper-Kamiokande's oscillation sensitivity using atmospheric neutrinos and demonstrate the power of their combination with the beam sample to realize early resolutions to the open questions in oscillation physics.

Neutrino Physics / 511

The road to SuperK-Gd

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The Super-Kamiokande detector (SuperK) has been running since 1996. In addition to the discovery of neutrino oscillations which led to the Nobel Price in Physics in 2015, it has delivered many important results: the best proton lifetime and Diffuse Supernova Neutrino Background limits to cite two examples. With an extensive physics programme and a long and successful past, the SuperK collaboration has been working to go beyond these limits. Many of our studies could be improved if not only charged particles but also neutrons could be detected.

Gadolinium has the largest cross-section for thermal neutron capture, emitting a gamma cascade of about 8 MeV. This cascade is detected with much higher efficiency than the capture on protons which just produces a single gamma of 2.2 MeV. Thus, by dissolving 0.2% of gadolinium (Gd) sulfate in mass in the otherwise ultra-pure SuperK water, 90% of the neutrons will be captured on Gd. To explore and fulfil this idea the EGADS project was funded in 2009. After the success of this project, the SuperK collaboration approved in 2015 the SuperK-Gd project. This year we will open the detector, refurbish and prepare it for a new era that will bring many new exciting results. In this talk, we will summarise the most important past milestones in the road towards SuperK-Gd as well as the work ahead of us to achieve its goals.

Neutrino Physics / 476

Physics Potential of Super-K Gd

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The next stage of the highly successful Super-Kamiokande experiment is to load gadolinium (Gd) sulphate at 0.2% by mass. Gadolinium has a very large cross section for thermal neutron capture,

which produces a cascade of gamma rays totalling 8 MeV. This is much easier to detect than the 2.2 MeV gamma ray from neutron capture on hydrogen that is currently used for neutron tagging. By tagging events which produce neutrons, background rates are radically reduced for some analyses.
Super-K has published the best limits on the diffuse supernova neutrino background (DSNB, also called supernova relic neutrinos); neutron tagging with Gd will enable detection of the DSNB in 10 years from Gd loading.
In the event of a core collapse supernova in our galaxy, neutron tagging with Gd will give new insight in to the dynamics of the neutrino burst, and a more accurate measurement of the direction to the supernova. Prior to a very close supernova (<1kpc), the late stages of stellar burning would be detected, giving even earlier supernova warning, and probing a never before observed stellar process.
Super-K sets the best limits on proton decay - this will be improved by the addition of gadolinium as the majority of atmospheric neutrino induced backgrounds have one or more neutrons in the final state. Additionally hundreds or thousands of reactor neutrinos will be detected, and spallation induced backgrounds, which create dead-time for many analyses, will be reduced.
The expected benefits of the addition of Gd are explored for these various physics analyses.

Neutrino Physics / 529

Results from Borexino on solar and geo-neutrinos

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Borexino is running at the "Laboratori del Gran Sasso" in Italy since 2007. Its technical distinctive feature is the unprecedented ultralow background of the inner scintillating core, which is the foundation for the outstanding achievements accumulated by this experiment.
In the present talk, after recalling the main features of the detector, the impressive solar data gathered so far by Borexino will be summarized.
Special emphasis will be given to the illustration of the recent release of the fluxes as stemming from the simultaneous real time spectroscopy of the neutrinos from the entire pp nuclear fusion chain in the Sun, opening with the remarkable 2.7% accuracy of the Be7 flux the era of precision measurements also in the realm of the sub-MeV solar neutrinos.
Such results put Borexino in the unique situation of being the only detector able to perform solar neutrino spectroscopy over the entire solar spectrum; the counterpart of this peculiar status, in the flavor conversion interpretation of the solar neutrino data, is the capability of Borexino alone to perform the full validation across the solar energy range of the MSW-LMA paradigm.
The talk will be concluded with an account of the Borexino accomplishments in the geo-neutrino field, marked by the detection of the geo-neutrino signal with a significance as high as 5.9 sigma.

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Directors' Forum & Round-table Discussions

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ICFA Report

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Industry Keynote speech by a CTO of Samsung Electronics

Eunsoo Shim[None]

Plenary / **1081**

Exotics

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BSM Theory

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Special speech

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TBA

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Wrap-up and thanksgiving

Plenary / **1105**

Conference Summary and Outlook

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High-energy cosmic particles

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Plenary / 1103

CMB, cosmology, other astroparticle physics

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Plenary / 1102

Dark matter theory

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Plenary / 1101

Axion searches

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Dark matter searches

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C11 Report

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Heavy ions, theory

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Plenary / 1095

Heavy ions, experimental

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Plenary / 1094

Exotic hadrons

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Strong interactions and hadron physics, experimental

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Plenary / 1092

Strong interactions and hadrons, theory including lattice

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Plenary / 1091

2nd Public Lecture

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Diversity

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Plenary / 1088

Outreach & Education

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Plenary / 1087

Formal theory Development

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Plenary / 1086

Flavor theory & outlook

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Plenary / 1085

charged lepton flavor, experimental (incl. (g-2), EDM, mu & tau LFV)

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Plenary / 1084

Rare decays of B, D, and K mesons, experimental

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CPV and CKM, experimental

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Plenary / **1080**

SUSY

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Plenary / **1079**

Theory (SM Higgs, top, EW)

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Plenary / **1078**

Top/EW/SM

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Plenary / **1077**

Higgs, experimental

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Plenary / **1076**

Industry activities

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Plenary / **1075**

Computing & S/W

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Plenary / **1074**

Future neutrino (DUNE, T2HK)

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Plenary / **1073**

Future e+e- (CEPC, FCC, ILC, CLIC)

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Plenary / **1072**

Accelerators (mainly SuperKEKB)

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Plenary / **1071**

Detector R&D’s

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Plenary / 1070

Neutrino theory including leptogenesis

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Plenary / 1069

non-accelerator-based experiment

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Plenary / 1068

Short baseline experiments

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Long baseline experiments

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Multi-messenger Astrophysics

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Plenary / 1065

CMS+ LHCb highlights

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ATLAS+ ALICE highlights

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Welcome by Mayor of Seoul

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Congratulatory remarks

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Opening remarks by IBS president

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Public lecture 1

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POSTER / 530

Design study of a Split-Coaxial RFQ for IsoDAR

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The Isotope Decay-At-Rest experiment (IsoDAR) is a proposed experiment to search for sterile neutrinos by measuring neutrino oscillations. The electron-antineutrino generation requires a high intensity primary proton beam impinging on a beryllium target surrounded by lithium . In IsoDAR, H2+ ions are generated and accelerated to avoid space charge effects in the low energy region, which will be stripped into protons after extraction from a cyclotron. As part of the IsoDAR injection system, an RFQ buncher with 32.8 MHz of operation frequency provides 70 keV acceleration and strong bunching of the H2+ beam. The RFQ will be installed halfway inside the iron yoke of the cyclotron to be very close to the median plane. Because the beam starts diverging after the RFQ in both transverse and longitudinal direction, a re-buncher is employed in the end transition cell to re-focus the beam longitudinally. In this paper, we describe in detail the beam dynamics study and RF analysis of the IsoDAR RFQ for direct injection into a compact cyclotron.

POSTER / 1128

PROBING OF XYZ-MESON STRUCTURE USING ANTIPROTON BEAM WITH MOMENTUN UP TO 15 GeV/c

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The spectroscopy of charmonium-like mesons with masses above the DD\bar threshold has been full of surprises and remains poorly understood. The currently most compelling the-oretical descriptions of the mysterious XYZ mesons attributes them to higher lying char-monum states, hybrid structure with a tightly bound cc\bar diquark or a cq(cq')\bar tetraquark core that strongly couples to S-wave DD\bar molecule-like structures. In this picture, the production of a XYZ particle in high energy hadron collisions and its decays into light hadron plus charmonum final states proceed via the core component of the meson, while decays to pairs of open charmed mesons proceed via the DD\bar component. Until now charmonium-like spectroscopy represents a good testing tool for the theories of strong inter-actions, including: QCD in both the perturbative and non-perturbative regimes, LQCD, po-tential models and phenomenological models. The experiments with antiproton-proton annihilation are well suited for a comprehensive spectroscopy program, in particular, to test the structure of XYZ mesons. These states can be produced abundantly, and their properties can be studied in detail. For this purpose an elaborated analysis of the main character-istics of charmonium-like spectrum is given. The recent experimental data from different col-laborations (BaBar, Belle, BES, LHCb) are analyzed. A special attention was given to the re-cently revealed XYZ states. The attempts of their possible interpretation are considered. Some of these states can be interpreted as higher lying charmonium and tetraquarks candidates. Much more data on different decay modes are needed before firmer conclusions can be made. These data can be derived from the experiment using a high quality antiproton beam with momentum up to 15 GeV/c.

POSTER / 1127

PERSPECTIVE STUDY OF CHRMONIUM, EXOTICS AND BARYONS WITH CHARM AND STRANGENESS

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The spectroscopy of charmonium-like states together with the spectroscopy of charmed and strange baryons is discussed. It is a good testing tool for the theories of strong interactions, including: QCD in both the perturbative and non-perturbative regimes, LQCD, potential mod-els and phenomenological models [1, 2, 3]. An understanding of the baryon spectrum is one of the primary goals of non-perturbative QCD. In the nucleon sector, where most of the exper-imental information is available, the agreement with quark model predictions is astonishingly small, and the situation is even worse in the strange and charmed baryon sector. The experi-ments with antiproton-proton annihilation are well suited for a comprehensive spectroscopy program, in particular, the spectroscopy of charmonuim-like states and flavour baryons. Charmed and strange baryons can be abundantly produced, and their properties can be studied in detail. For this purpose an elaborated analysis of charmonium and exotics spec-trum together with spectrum of charmed and strange baryons is given. The recent experimental data from different collaborations are analyzed. A special attention was given to the recently discovered XYZ-particles. The attempts of their possible interpretation are considered. The results of physics simulation are obtained. Some of these states can be interpreted as higher-lying charmonium and tetraquarks with a hidden charm. It has been shown that charge/neutral tetraquarks must have their neutral/charged partners with mass values which differ by few MeV. This hypothesis coincides with that proposed by Maiani and Polosa. Heavy baryons with charm and strangeness are expected to exist. But much more data on different decay modes are needed before firmer conclusions can be made. These data can be derived from the experiments using a high quality antiproton beam with momentum up to 15 GeV/c.

POSTER / 371

Electroweakinos with GAMBIT

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We introduce the GAMBIT framework for global scans and its collider physics module ColliderBit, and show results from a recent scan of the electroweak fermion sector of the Minimal Supersymmetric Standard Model (MSSM) in light of LHC searches at 13 TeV and older LEP results. We take particular care to avoid assumptions from specific realizations of the MSSM that automatically prohibit very light neutralinos, and remain agnostic on its relationship with dark matter, in order to focus on the collider implications for the sector. We find that the strict bounds seemingly implied by simplified model interpretations of the LHC data are not borne out in the scan.

POSTER / 1041

Usage of tracking in the CMS Level-1 trigger for the High Luminosity LHC Upgrade

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At the High Luminosity LHC (HL-LHC), the CMS experiment will face a harsh environment with a high instantaneous luminosity up to 5x10^34/cm^2/s corresponding to an average of 140-200 multiple proton-proton collisions per bunch crossing. The main goal of the CMS Level 1 trigger (L1T) upgrade for the HL-LHC is to maintain trigger thresholds that are as low as possible and comparable to those currently in use at the LHC, and to possibly include new triggers that were not feasible at the LHC. This will be achieved by upgrading the detector readout electronics, to allow a much larger L1T rate, and by including, for the first time, tracking information in the L1 trigger. Examples of how this tracking information can be used to reduce the L1 trigger rates are presented here.

POSTER / 958

High Precision Magnetic Field Measurement for the Muon g-2 Experiment

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The Muon g-2 Experiment (E989) at Fermilab will measure the anomalous magnetic moment of the muon, a_μ with a precision of 140 part-per-billion (ppb), aiming at resolving the >3 standard deviations between the previous measurement at Brookhaven (E821) and the Standard Model calculation of a_μ.
The experimental concept uses a polarized muon beam stored in an extremely homogeneous storage ring magnetic field. Parity violation in the weak decay is used as a spin analyzer; the detected rate of the decay electrons oscillates with the frequency, ω_a, in the magnetic field expressed in terms of the free proton Larmor frequency, ω_p. Since a_μ is derived from the ratio of ω_a and ω_p, both are equally important and systematic uncertainties must be kept below 70 ppb for each observable.
A magnetic field measurement system was developed to measure the magnetic field experienced by the muons with an ultimate precision of 70 ppb. 378 new Nuclear Magnetic Resonance (NMR) probes and readout electronics were developed and installed to constantly monitor the field. An upgraded in-vacuum field mapping system scans the muon storage region over the full azimuth of the magnet. A special water-based NMR probe which has a well-measured geometry and low magnetic perturbation was designed to calibrate the probes of the field mapping system. All systems were successfully commissioned, and are currently in full operation for the first physics data taking run that started in February 2018. In this presentation, we will present an overview of the entire field measurement system and show preliminary results from the ongoing physics data taking.

POSTER / 1012

An updated design of the read out link and control board for the Phase-2 upgrade of the ATLAS Tile calorimeter.

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The ATLAS hadronic Tile Calorimeter (TileCal) is being upgraded for the High Luminosity Large Hadron Collider (HL-LHC) that will have a peak luminosity of $5 \times 10^{34}\ cm^{-2}\ s^{-1}$, five times higher than the design luminosity of the LHC. Following the R&D of the new on-detector electronics, we present a redesign of the read out link and control board, so called Daughterboard (DB). The upgraded system will include 1024 DBs that will serve 12 photomultiplier (PMT) channels each, while handling the control and communication between the front-end and off-detector electronics. The DB provides continuous high-speed readout of two gains of digitized PMT data samples to the off-detector, while receiving configuration, control and timing that distributes to the front-end, all over multi-gigabit optic links. Four SFP+ modules service 4×9.6 *Gbps* uplinks and 2×4.8 *Gbps* downlinks, handled respectively by two re-programmable Kintex Ultrascale+ Field Programmable Gate Arrays (FPGAs) and two CERN-developed gigabit link application-specific integrated circuits (GBTx). The GBTx recovers and distributes LHC synchronized phase configurable clocks that drive the FPGAs transceivers and the Analog to Digital Converters readout. Additionally, the GBTx drives a configuration bus that propagates slow control commands to the FPGAs and allows remote access to the FPGAs JTAG chains and configuration memories. Better high-speed uplink timing and improved radiation tolerance have been achieved by migrating the previous design from the Xilinx Kintex-7 FPGAs to the Kintex Ultrascale+ architecture. The new Ultrascale+ FPGAs handle the propagation of clocks and configuration commands while formatting the readout data to be sent off-detector via GTY transceivers. The DB has a double redundant radiation tolerant design that eliminates virtually all possible single failure points, consequently only two uplinks and one downlink are required for nominal running. With the purpose of minimizing radiation-induced errors and enhance data reliability: Triple Mode Redundancy (TMR) is implemented in the FPGA firmware, Cyclic Redundancy Check error verification is used in the redundant uplinks, while Forward Error Correction is handled by each GBTx in each downlink.

POSTER / 1009

Improved determination of d(x) – u(x) flavor asymmetry in the proton by data from the BONuS experiment at JLAB and using an approach by Brodsky, Hoyer, Peterson, and Sakai

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The experimental data taken from both Drell-Yan and deep-inelastic scattering (DIS) experiments suggest a sign-change in $\bar{d}(x) - \bar{u}(x)$ flavor asymmetry in the proton at large values of momentum fraction x.
In this work, we present a phenomenological study of $\bar{d}(x) - \bar{u}(x)$ flavor asymmetry.
First, we extract the $\bar{d}(x) - \bar{u}(x)$ distribution using the more recent data from the BONuS experiment at Jefferson Lab on the ratio of neutron to proton structure functions, F_2^n/F_2^p,
and show that it undergoes a sing-change and becomes negative at large values of momentum fraction x, as expected.
The stability and reliability of our obtained results have been examined by including target mass corrections (TMCs) as well as higher twist (HT) terms which are particularly important
at the large-x region at low Q^2.
Then, we calculate the $\bar{d}(x) - \bar{u}(x)$ distribution
using the Brodsky, Hoyer, Peterson, and Sakai (BHPS) model and show that if one chooses a mass for the down quark smaller than the one for the up quark it leads to a better description for the Fermilab E866 data. In order to prove this claim, we determine the masses of down and up sea quarks by fitting to the available and up-to-date experimental data for the $\bar{d}(x) - \bar{u}(x)$ distribution. In this respect, unlike the previous performed theoretical studies, we have shown that this distribution has a sign-change at $x > 0.3$ after evolution to the scale of available experimental data.

POSTER / 1006

Neutrino mass, Dark Matter and stability of the electroweak vacuum in TeV Seesaw models

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We consider the Standard model extended by fermion and scalar singles.
These singlet can account for the generation of neutrino mass at the
TeV scale and the existence of dark. For the neutrino
sector we consider models with extra singlet fermions which can generate
neutrino mass via the inverse seesaw mechanism whereas
a singlet scalar is introduced as the candidate for dark matter. We show
that although these two sectors are disconnected at low energy, the coupling constants of both the sectors get correlated at high energy scale by
the constraints coming from the perturbativity and stability/metastability
of the electroweak vacuum. In addition, we also discuss a class of U (1) extensions of the standard model with the minimal inverse seesaw mechanism
for neutrino mass generation. We also discuss possibility of a fermionic dark matter candidate within this framework. We obtain constraints on the
U (1) quantum numbers of the Higgs doublet and the additional scalar from
vacuum stability as well as perturbativity considerations.

POSTER / **998**

CMS emittance scans for 2017 luminosity calibration

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Emittance scans are short van der Meer type scans performed at the beginning and at the end of LHC fills. The beams are scanned against each other in X and Y planes in 9 displacement steps and are used for LHC diagnostics and since 2017 for CMS luminosity calibration cross check. An XY pair of scans takes less than 4 minutes elapsed time. BRIL project provides to LHC three independent online luminosity measurement from PLT, BCM1F and HF. The excellent performance of BRIL detectors, fast back-end electronics and CMS XDAQ based data processing and publication allow the use of emittance scans for linearity and stability studies of the luminometers. Emittance scans became a powerful tool and dramatically improved understanding of luminosity measurement during the year. Since each luminometer is independently calibrated in every scan the measurements are independent and ratios of luminometers can strictly be used as a final validation Two independent analyses of emittance scans are launched: offline python based framework and online XDAQ based application. Results are published on the monitoring web-pages in real-time for the XDAQ based analysis and

within typically 15 minutes for the python based framework, which has however the advantage of being rerunnable.

POSTER / **972**

Flavour Physics at FCC-ee

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A possible long-term strategy for high-energy physics at colliders, after the exploitation of the LHC and its High Luminosity upgrade, considers a tunnel of about 100 km circumference, which takes advantage of the present CERN accelerator complex. The Future Circular Collider (FCC) concept follows on the successful experience and outcomes of the LEP-LHC tunnel. A possible first step of the project is to fit in the tunnel a high-luminosity e^+e^- collider aimed at studying comprehensively the electroweak scale with centre-of-mass energies ranging from the Z pole up to beyond the $t\bar{t}$ production threshold. A 100 TeV proton proton collider is considered as the ultimate goal of the project.

Future Circular Collider study groups have been formed in a design study hosted by CERN, aiming at a Conceptual Design Report and a review cost in time for next European Strategy milestone foreseen in 2019.

The unprecedented statistics at the Z pole ($calO(10^{12-13})$ Z decays potentially delivered by the high-luminosity e^+e^- collider can be studied in particular to explore further the Flavour Physics case at large. We will discuss the Physics potential of the measurements of rare decays of b-hadrons, which can complement the knowledge and anticipated results from the current and foreseen b-Physics programs (LHCb upgrade and SuperKEKB B-factory). The large statistics at the Z pole can be used as well to scrutinize Lepton Flavour Violating Z decays, which would serve as an indisputable evidence for Beyond Standard Model Physics if seen. The precision expected for specific rare decays as well as for CP violation phenomena observables, in the current stage of the Design Study, will be reviewed.

POSTER / **965**

Indirect search for light charged Higgs bosons through the dominant semileptonic decays of top quark $t \to b(\to B/D+X)+H^+(\to \tau^+\nu_\tau)$

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In this work we introduce a new channel to indirect search for the light charged Higgs bosons, which are predicted in several extensions of the standard model (SM) such as the two-Higgs-doublet models (2HDMs). We calculate the $calO(\alpha_s)$ QCD radiative corrections to the energy distribution of bottom- and charmed-flavored hadrons (B/D) produced in the dominant decays of the polarized top quark in the 2HDM, i.e. $t(\uparrow) \longrightarrow b(\to B/D + \text{jet}) + H^+(\to \tau^+\nu_\tau)$. %This analysis is studied in a specific helicity coordinate system where the polarization vector of the top quark is evaluated with respect to the momentum direction of the bottom quark.
Generally, the energy distribution of hadrons is governed by the unpolarized rate and the polar and

the azimuthal correlation functions which are related to the
density matrix elements of the decay $t(\uparrow) \to bH^+$.
In our proposed channel, any deviation of the B/D-meson energy spectrum from its corresponding SM predictions can be considered as a signal for the existence of charged Higgs at the LHC. We also calculate, for the first time, the azimuthal correlation rate Γ_ϕ at next-to-leading order which vanishes at the Born level.

POSTER / 960

Fast Calorimeter Simulation in ATLAS

ATLAS Collaboration[None] ; Stefan Gadatsch[1]

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Successful physics and performance studies of the ATLAS detector at the Large Hadron Collider rely on a large number of simulated events. The production of these simulated events with the precise detector description using GEANT4 is highly CPU intensive. With the large collision dataset expected to be collected by the ATLAS detector, the development of a simulation tool to reduce CPU requirements is imperative. During the LHC Run-1, a fast calorimeter simulation (FastCaloSim) was successfully used by ATLAS. FastCaloSim utilizes a parametrization of the energy response of particles at the calorimeter read-out cell level, taking into account the lateral shower profile and the correlation of the energy deposition among various calorimeter layers. The tool is interfaced to ATLAS digitization and reconstruction software and provides a calorimeter simulation approximately 500 times faster than GEANT4. An improved version of FastCaloSim is currently under development to further optimize the CPU and memory requirements and to improve the physics description. The new FastCaloSim implements machine learning techniques, such as principal component analysis and neural networks to optimize the amount of information stored in the ATLAS simulation infrastructure. These techniques improve the physics modeling and enhance the performance by reducing the I/O time and the memory usage during simulation. In this talk, the new FastCaloSim parameterization will be described, its performance will be quantified and its physics applications discussed.

POSTER / 915

An improved Pulse Shape Discrimination (PSD) method to detect directly for a non-baryonic dark matter

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For the several decades, the non-baryonic dark matter has been searched in many ways and by many research teams. Non-baryonic dark matter is known as a weakly interaction and neutral particle. In the direct detection ways, it is not easy to identify a non-baryonic dark matter from other particles, such as gamma ray and neutron, due to its electric neutrality. So, the identification of neutral particle is an essential part for the direct detection method of dark matter in a cosmic ray free laboratory with a detector made of radioactive free materials.

A pulse shape discrimination (PSD) method was introduced more than fifty years ago. And it has been used by various elementary particle experiments. We need a more precise PSD method to detect directly dark matter interacting rarely.

We can see the primary and the secondary signals in the scintillation produced by an elastic scattering between an incident particle and a target atom. The primary signal is composed of the scintillations from an excitation process of target nuclear and an ionization process of target atom while the secondary signal is composed of scintillation from ionization process, only. The ratio of scintillations from excitation and ionization processes gives the clue to identify the neutral particles.

Here, we introduce an improved way to separate the primary signal into the scintillations induced by excitation and ionization processes through the elastic scattering between a target atom and a non-baryonic dark matter. This separation of primary signal can provide a big hint to identify a non-baryonic dark matter.

POSTER / 900

Measurements of internal alpha activities in the AMoRE-pilot CaMoO4 crystals

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AMoRE (Advanced Mo-based Rare process Experiment) is an experimental search for neutrinoless double beta decay of Mo-100. A pilot experiment, AMoRE-Pilot, has been operating with six 40Ca100MoO4 (CMO) crystals, total mass 1.9 kg, in a cryostat at the Yangyang underground laboratory (Y2L), with an overburden of 700 m. It is unavoidable that the materials of the crystals suffer from some contaminations of radioactive isotopes such as U-238, Th232, U-235, and their decay particles. They can originate from the chemical powders that were used to grow the crystals and/or may be introduced during the crystal growing and polishing procedures. From fits to the measured energy spectra for background alpha decay events, the levels of contamination from U-238, Th-232, U-235, and their decay particles can be estimated. The estimated information can be used to provide important input to the development strategies for reducing backgrounds in the future crystals. We will present preliminary results of internal alpha activity measurements in the AMoRE-Pilot crystals.

POSTER / 879

The Top Tracker detector of the JUNO experiment

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The JUNO (Jiangmen Underground Neutrino Observatory) experiment is under preparation in China. The project's main goal is to determine the neutrino mass ordering via the precise measurement of the energy spectrum of antineutrinos emitted from nuclear reactors located 53km from the JUNO detector. Data taking is expected to begin in 2021.

In order to achieve JUNO's goals, it is essential to be able to measure the reactor neutrino spectrum with an energy resolution better than 3%. It is also essential to be able to suppress or control the background processes rate, as these processes may produce events with the same signature as those

from the neutrino interactions in the central detector. While there are several sources of background, the most dangerous one is the cosmogenic isotopes produced in nuclear spallation processes by atmospheric muons in the detector volume.

The Veto system of the JUNO detector is designed to measure, and characterize the muon flux in the detector as well as to reduce the cosmogenic isotopes' contribution to the antineutrino spectrum. This system consists of the Top Tracker and the Water Cherenkov detector surrounding the Central Detector which is responsible for measuring the antineutrino energy spectrum. The Top Tracker consists of three layers of two-dimensional detectors made of scintillator strips and will cover about 1/3 of the surface above the Central and Water Cherenkov detectors. The role of the Top Tracker will be to detect atmospheric muons and to reconstruct precisely their trajectory in JUNO in order to study the cosmogenic background production and to supress its contribution.

This poster will discuss the JUNO detector's Top Tracker current design and expected performance.

POSTER / 916

An R&D of Molybdate scintillating crystals for the AMoRE phase-II

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The AMoRE (Advanced Molybdenum based Rare process Experiment) project is an experiment aiming for searching the neutrinoless double beta decay of ^{100}Mo. The planned technique is a combination of 200 kg of X-Molybdates (~100 kg of ^{100}Mo and X candidates are Ca, Li, Na, and Pb.) scintillating crystals as an absorber and metallic magnetic calorimeter (MMC) sensor as a heat and light signal detector at mK temperatures.

1.8 kg of $^{40}Ca^{100}MoO_4$ (^{48}Ca depleted, ^{100}Mo enriched) scintillating crystals are currently installed in the AMoRE-pilot experiment and two candidate crystals, Na_2MoO_7 and Li_2MoO_4, have been being investigated for the large scale experiment with their easiness in crystal growth and internal background control.

The AMoRE phase-II with 200 kg of molybdate crystals aims to reach the range of the inverted neutrino mass hierarchy for an effective Majorana neutrino mass sensitivity of 10~30 meV which can be obtained by a zero background (~1 x 10^{-4} count/keV/kg/y in total) experiment. In order to obtain the mass sensitivity, the internal background levels of the crystal are estimated to be less than 15 μBq/kg for ^{226}Ra and 1.5 μBq/kg for ^{228}Th.

We will report the current status of the R&D of molybdate crystals for the AMoRE phase-II.

POSTER / 876

Phonon simulation of low temperature acoustic waves for rare event detector

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We present a simulation to calculate heat signal spectrum from low temperature bolometer attached to a crystal. This implementation is based on the elementary acoustic wave theory at low temperature, and has been developed using modern Monte Carlo techniques by tracking individual phonon's polarization, wave, and group velocity vectors in anisotropic media. Physical processes include phonon transmission and absorption at the interface, scattering in the bulk, and reflection on the surface. The obtained time dependence of signal is compared against real experimental data to validate our simulation process. Development of this simulation can be used to understand and predict signals from low temperature rare event detector for astro-particle and neutrino physics experiments.

POSTER / 875

Bound eigenstates for Yukawa potential through Matrix representation

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We study the new numerical method to solve the Schrödinger equation with no analytic solution. As an example, we tried the Yukawa potential, which is popular in most areas of physics, especially, quark-quark interaction in high-energy physics. This method is based on the basic principle in quantum physics that all particle states are represented by the complete set of eigenbases.
In this method, we need to select potential which is similar to the real potential with analytic eigenstates. For the Yukawa potential, the Coulomb potential can be a powerful candidate for this basis potential. We study the validity of the method depending on the Coulomb strength and on the number of eigenbases included in the numerical calculation.
The Coulomb strength is controlled by the coupling constant, which is determined to give the smallest energy eingenvalues when the basis potential is similar to the real potential. When the screening parameter less than around 0.02/a0\, *constant coupling constant for a given screening parameter is enough for eigenenergies with 90% accuracy. However, in the opposite case, the coupling constant need to be changed. When screening parameter is 0.2/a0*, the coupling constant needs to be set as 0.983, 0.947, 0.890 for 1s, 2s and 2p, respectively, to keep the accuracy within 90%.
The number of eingenbases is the dimension of matrix to be treated and it affects the calculation time severely. Therefore we cannot choose as many as we want. We study the minimum number of eigenbases to secure the 90% accuracy and find that at least 1.2 times higher states than the ones we target are necessary. Also the set of eigenbases should start from the lowest state even for the intermediate states, because lower states also play quite a role for higher states.
The method is very efficient in a sense that all bound energies and eigenstates are obtained at the same time. The precision in the numerical calculation should be set smaller than the energy differences between states. Our method is very general and can be adopted for other potential cases.

(* a0 is bour radius)

POSTER / 864

Development of Slow Control Package for the Calorimeter Trigger System at the Belle II Experiment

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The Belle II experiment at the SuperKEKB e+e- collider in KEK, Japan does start physics data-taking from early of 2018 with primary physics goal that is to probe the New Physics effect using heavy quark and lepton weak decays. During trigger and DAQ operation upon beam collision, it is important that Belle II detector status have to be monitored during data-taking against an unexpected situation. Slow control system, built in the Control System Studio (CSS) which is a GUI window design tool based on Eclipse, is one of monitoring systems in Belle II operation. NSM(Network Shared Memory) is a core technique of slow control system which make it possible for all systems connected to belle II server share data. With NSM, database and archiver servers are connected to slow control system. Experimental parameters are downloaded to Belle II main database server which is based on PostgreSQL. Real-time results are stored in archiver server which is based on EPICS(The Experimental Physics and Industrial Control System) archiver appliances and tomcat which is open-source java servlet container. In this study, we report the development of slow control system for the Belle II electromagnetic calorimeter (ECL) trigger system.

POSTER / **857**

The tunable microwave cavity for pilot axion experiment at IBS/CAPP

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A Pilot experiment of CULTASK (CAPP's Ultra Low Temperature Axion Search in Korea) started to take axion data in the frequency range between 2.45~2.75GHz with a specially designed microwave cavity. The conventional design, i.e., the open cylinder with two disk shaped endcaps, creates critical reduction on quality factor (Q factor) of the cavity due to the perpendicular crossing between the discontinuity of cavity and the current flow of TM010 mode. We have fabricated the cavity by cutting the copper rod vertically and digging the inside of two halves of the cylinder. The Q factor measurements perfectly agree with the finite difference time domain (FDTD) simulation results whereas conventional horizontal cut cavities have shown near 10% degradation. We have tuned the resonant frequency of the cavity with ~ 1 kHz resolution by changing horizontal position of sapphire or copper rod which is controlled by Attocube piezoelectric actuators. The geometrical factor was more than 0.55 over all frequency range and the Q factor was more than 80,000 with copper rod and more than 100,000 with sapphire rod. I will present the details of the resonant cavity R&D and discuss the future plans.

POSTER / **822**

Probing BSM physics with Recursive Jigsaw Reconstruction

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The recursive jigsaw reconstruction technique provides a powerful way to tackle challenging SUSY final states with multiple missing particles. By altering the input "decay tree" we demonstrate a new approach to considering compressed SUSY signatures from a variety of different sources. The imposition of this decay tree provides a clear way to define which objects are associated with decay states and to partition the visible an invisible objects in a given system. From the imposition of a series of rules, a set of variables emerge, providing a method to distinguish BSM physics cases from the pernicious standard model backgrounds present. These allow sensitivity to signals without having to apply harsh cuts on object momenta or invisible momenta leading to selecting events in unique regions of phase-space.

We introduce this new approach, comparing it briefly to other methods used to probe for BSM physics and demonstrate it's power through application to several final states sensitive to new physics. We will further touch on the applicability of this same method to other physics processes where the use of conventional kinematic handles is challenging.

POSTER / 820

Scattered Kaon Study in the KOTO Experiment at J-PARC

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The KOTO experiment aims to explore physics beyond the Standard Model (SM) by measuring the branching ratio of $K_L \to \pi^0\nu\bar{\nu}$, which is predicted to be $(3.0 \pm 0.3) \times 10^{-11}$ by the SM1. The $K_L \to \pi^0\nu\bar{\nu}$ decay is characterized by a pair of photons from the π^0 decay and no other detected particles. The decay is identified by observing two photons with large transverse momentum on an undoped Cesium Iodide (CsI) electromagnetic calorimeter and no other signals on the hermetic veto detectors.

Kaons decay outside the beam line with final product of two photons, such as $K_L \to \gamma\gamma$ and $K_L \to \pi^+\pi^-\pi^0$, can appear to have large transverse momentum due to kaon scattering and beam interaction with the detectors. These off-axis kaon decay events can impact the upper limit of $K_L \to \pi^0\nu\bar{\nu}$ branching ratio. Aluminum targets located at the upstream of the KOTO detector and inside the decay-volume were used to study kaon beam profile, which provided off-axis kaon decay vertex information. The beam profile provided insights on background contributions to the signal. Studies on the kaon beam profile and background identification from kaon scattering will be presented.

Reference
1 A. J. Buras, D. Buttazzo, and R. Knegjens, "$K^+ \to \pi^+\nu\bar{\nu}$ and $K_L \to \pi^0\nu\bar{\nu}$ in the Standard Model: Status and Perspectives", J. High Energ. Phys. \textbf{2015} 166 (2015)

POSTER / 816

Lattice calculation of form factors for semi-leptonic decays B \to D^(\ast) using improved heavy quark action

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The semileptonic form factors, at zero and non-zero recoil, of $B \to D^{(*)}\ell\nu$ decays are needed to determine the V_{cb}, a Cabibbo-Kobayashi-Maskawa (CKM) matrix element. Typically in the Unitarity Triangle (UT) analysis for the quark flavor mixing angles and the CP violating phase, V_{cb} enters as a normalization of $|V_{ub}|/|V_{cb}|$ or with $\varepsilon_K \propto |V_{cb}|^4$. More precise determination of V_{cb} will make the UT constraints tighter and possibly can reveal a new physics. Other interesting quantity is the ratios of $R(D^{(*)}) = \Gamma(B \to D^{(*)}\tau\nu)/\Gamma(B \to D^{(*)}\ell\nu)$ which can provide a precision test of lepton-flavor universality. A lattice calculation with a non-zero recoils can be used to diagnose the current HQET parameterization of the form factors, which are argued by many of recent articles.

We will present a recent progress in a lattice calculation of these $B \to D^{(*)}\ell\nu$ decays form factors. The calculation has been carried out with the MILC HISQ ensemble which simulates 2+1+1-flavor of dynamical quarks. A preliminary results from two different lattice spacings $a = 0.12, 0.09$ fm with heavy pion mass 310 MeV will be presented. The valence charm and bottom quarks are simulated with the Oktay-Kronfeld (OK) action 1 by which a highly improved lattice heavy quark action reducing discretization errors with $\mathcal{O}(\lambda^3_{QCD}/m^3_{b,c})$ matching to continuum QCD at tree-level. Capturing the loop corrections with a tadpole prescription in a numerical simulation, we reported that this tree-level matched OK action, in practice, shows a significant improvement in the heavy quark discretization errors. 2 Anticipating improved measurements of the decay rates from Belle II experiment, our projected error on the V_{cb} is below 1%. Such an improvement will tighten the constraints on the UT analysis, and help resolve the approximate 3σ discrepancy between estimates using exclusive and inclusive B decays.

POSTER / 950

An Analysis of Bottom Mesons Decaying into Axial-Vector and Pseudoscalar Mesons

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Two body nonleptonic weak decays of bottom mesons to a pseudoscalar meson & an axial-vector meson states have been studied within the overall non-relativistic quark model. For decays involving charmed mesons, these decays have been studied by employing factorization hypothesis in heavy quark symmetry approach. A thorough analysis of charmed meson decays of B-mesons using ISGW model and lattice QCD-extracted form factors has been carried out. The B to D1 form factors have been extracted from lattice QCD based predictions of Γ1/2 and Γ3/2 at zero recoil.
We have calculated various branching ratios and also compared them with existing theoretical analysis. It has been found that the calculated results are in fair agreement with the available experimental data.

PACS Numbers : 13.25.Ft, 14.40.cs, 14.40.Ev

POSTER / **716**

Spectral measurement of sinSq(2theta13) via neutron capture on hydrogen at Daya Bay

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The Daya Bay experiment has measured sinSq(2theta13) and Delta(mSq32) with better than 4% precision using an IBD sample tagged via neutron capture on gadolinium (nGd). A precise and independent measurement of the oscillation parameters can be done with IBDs tagged via neutron capture on Hydrogen (nH), a statistically distinct sample with largely different systematic uncertainties. Effort has gone into developing an energy model that properly handles the extra energy leakage in nH events and that enables a spectral measurement of reactor antineutrino disappearance with this sample. Data-driven methods to precisely estimate the backgrounds and to better control the systematic uncertainties have also been developed. This work will be presented in this poster,alongside the latest nH oscillation results from Daya Bay.

POSTER / **710**

Flavor physics in the multi-Higgs doublet models induced by the Left-Right symmetry

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The matter unification, that is proposed by the Grand Unified theory (GUT),
predicts extra fields that couple to quarks and leptons, in order to realize the realistic Yukawa couplings. In a simple setup, many fields, in which Higgs $SU(2)_L$ doublets are built, are introduced and the realistic Yukawa couplings consist of the many Yukawa couplings between the Standard Model (SM) fermions and the lightest mode among the Higgs doubles. The GUT symmetry breaks down at the very high scale, and we can expect that the heavier Higgs fields do not also gain masses from the GUT symmetry breaking and survive up to the EW scale. Then, we could find the predictions of the matter unification for the low-energy observables. In this talk, we discuss the multi-Higgs doublet models, that could be effectively induced by the extended SM with the matter unification. In particular, we focus on the predictions in the supersymmetric left-right (LR) model. In this model, the down-type and the up-type Yukawa couplings are unified and the Yukawa couplings are expected to be hermitian. Besides, the heavy Higgs doublets have flavor changing couplings with quarks and leptons corresponding to the realization of the realistic fermion mass matrices. The LR symmetry is assumed to break down at high energy, to realize the Type-I seesaw mechanism, and the EW symmetry breaking is radiatively realized. In this case, the flavor-dependent interaction of the Higgs fields is one promising prediction, so that we especially discuss the flavor physics induced by the heavy Higgs fields in my talk.

POSTER / **706**

Recent progress of the ARIADNE experiment

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The purpose of the Axion Resonant InterAction DetectioN Experiment (ARIADNE)1 is to detect axion mediated macroscopic interactions between polarized and unpolarized masses using NMR techniques. This experiment is a collaboration among institutes in Korea, IBS/CAPP and KRISS, and US institutes, Northwestern, Stanford, and Indiana University. Wilczek and Moody2 predicted the possible existence of symmetry violating forces that would be mediated by exotic particles with a very light mass like axions[3]. ARIADNE employs a rotating mass to source the interactions, and a polarized 3He gas as NMR sample to detect axion mediated spin-dependent interactions in sub mm range with high precision. This experiment will investigate a broad mass range of QCD axion from 0.1~10meV. We report the recent progress of this work at IBS/CAPP as well as the other institutes[4].

POSTER / **693**

Research of the 20-inch Microchannel Plate Photomultiplier with Transit Time Spread Improved

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Abstract: The transit time spread (TTS) is an important parameter of photomultiplier tube in the high energy physics field. By the software of CST and Matlab, the theoretical model of the photomultiplier tube structure was established, and the particle sources theoretical model was established according to the M-C integral sampling method of cosine distribution. Based on the establishment of theoretical models, the trajectories of photoelectrons in the 20-inch microchannel plate photomultiplier were simulated. The influence of the focusing electrode structure and the divided voltage ratio between the photocathode and the surface of the first microchannel plate on the TTS was analyzed. The simulation results were that, the transit time spread was improved greatly by adjusting the focusing electrode structure and the divided voltage, and the focusing electrode structure looked like flower. According to the theoretical simulation results, the 20-inch microchannel plate photomultiplier with TTS improved was produced. The TTS of the new 20-inch microchannel plate photomultiplier with the flower-like focusing electrode was about 5 ns (FWHM), and the TTS of the initial 20-inch microchannel plate photomultiplier was about 20ns. The TTS of the new 20-inch microchannel plate photomultiplier was much better than the initial one. The research of improving the TTS was in favor of enlarging the application of 20-inch microchannel plate photomultiplier in the high energy physics field.
Keywords: transit time spread, microchannel plate, photomultiplier tube, focusing electrode.

POSTER / **852**

B-meson Anomalies and New Physics for Flavor Violation

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The LHCb experiment has recently provided several new measurements to test the lepton flavor universality in the Standard Model (SM) and confirmed some of the prevailing anomalies from the B-meson decays in BaBar and/or Belle experiments.
We consider the setup where scalar leptoquarks or extra U(1) gauge bosons have flavor-dependent couplings to the SM. In this work, we discuss the flavor structure for quarks and leptons and various constraints on the model and propose a natural candidate for dark matter.

POSTER / **679**

New readout system for the KOTO CsI calorimeter upgrade

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The purpose of J-PARC KOTO experiment is to search for a rare Kaon decay, $K_L \to \pi^0\nu\bar{\nu}$. This decay violates CP symmetry and is highly suppressed in the Standard Model (SM). The SM predicts its branching ratio as $BR = (3.0 \pm 0.3) \times 10^{-11}$, and the deviation of the measured BR from the prediction signifies the existence of new physics.

The KOTO detector consists of a CsI calorimeter, and veto detectors to suppress backgrounds. The signature of the signal is 2 γs originated from π^0 detected in CsI calorimeter. One of the backgrounds is beam halo neutrons hitting the CsI creating photon-like clusters. These background events are rejected by 2-orders of magnitude based on waveforms and shower shapes of the clusters, but another order of magnitude reduction is needed in order to reach the SM sensitivity.

We have developed a new readout system utilizing MPPCs (Multi Pixel Photon Counter) to discriminate neutrons and γs in the CsI calorimeter.
MPPCs will be installed on the upstream side of the CsI in addition to the PMTs currently used on the opposite side. With timing difference between the MPPC and PMT, we can identify background neutrons because their interaction depths are deeper than those of γs.

We will present the performance of this system measured with e^+ beam at the Tohoku University.

POSTER / **919**

Development of a multi channel silicon avalanche photodiode sensor for low light imaging detection.

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The silicon avalanche photodiode (APD) is a highly sensitive semiconductor photo sensor that converts lights to electrons by using the photoelectric effect with a high gain through avalanche multiplication in its pn junction. It has various preferable characteristics such as operating with high quantum efficiency, large dynamic range, light-weight, robustness, insensitivity to magnetic field, and measuring low amount of lights thanks to the gain of about 100. As a monolithic device, however, it has dimensions of 5 x 5 mm2 ~ 16 x 16 mm2.
We have been developing the APD sensor for measurements of lights from scintillating crystals in particle and nuclear physics experiments. We simulated the pn junction with high electric field of about 400 V on n type substrate. Based on the simulation result, we designed and fabricated APD sensors with arrays of 5 x 5 and 10 x 10 channels in an area of about 5 x 5 cm2 in order to cover a big area with an imaging capability. We will present the simulation, design, and fabrication results of the multichannel silicon APD sensors manufactured in Korea.

POSTER / 847

Low temperature light detectors using metallic magnetic calorimeter

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We developed light detectors to measure scintillation signals from simultaneous phonon-scintillation detection system for rare-event search experiments. The light detector is composed of a two-inch Ge or Si wafer and a low-temperature sensor called Metallic Magnetic Calorimeter (MMC) operated at milli-Kelvin range. The light detector showed promising performance for neutrinoless double beta decay searches. The rise time of the light detectors are as fast as 0.2 ms independent of operating temperatures. An energy resolution of 545 eV of FWHM are found at 40mK with Fe-55 source. Its corresponding rms noise of the light detector is about 30 eV at 10 mK. The performance can be improved even more through optimization of MMC sensors, wafer material selection, and phonon amplifying technique using Neganov-Luke effect. In this poster, we introduce the current status and future studies of light detector development.

POSTER / 754

Oscillations and exact states of neutrinos in a magnetic field

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We further develop recently proposed new approach to description of the relativistic neutrino flavour $\nu_e^L \leftrightarrow \nu_\mu^L$, spin $\nu_e^L \leftrightarrow \nu_e^R$ and spin-flavour $\nu_e^L \leftrightarrow \nu_\mu^R$ oscillations in a constant magnetic field that is based on the use of the exact neutrino stationary states in the magnetic field. The neutrino flavour, spin and spin-flavour oscillations probabilities are calculated. In general, the obtained expressions for the neutrino oscillations probabilities exhibit new inherent features in the oscillation patters that are missing when the customary approach (based on the use of the neutrino helicity states) is used. It is shown, in particular, that in the presence of the transversal magnetic field for a given choice of parameters (the energy and magnetic moments of neutrinos and strength of the magnetic field) the amplitude of the flavour oscillations $\nu_e^L \leftrightarrow \nu_\mu^L$ at the vacuum frequency is modulated by the magnetic field frequency.

POSTER / 708

DAQ Design and Implementation for the HEPS-BPIX 1M Detector

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HEPS-BPIX 1M is a silicon detector with 1 million pixels, which is designed for the High Energy Photon Sources (HEPS) in Beijing, China. It is a high-frame-rate pixel detector working in the single-photon-counting mode. The frame rate is designed to 1 kHz, which leads to ~ 2GB/s high data bandwidth. The data acquisition (DAQ) system need to read out data efficiently. Meanwhile it should provide the functionalities including run control, data transmission, event building, lossless compression, data storage, real-time image display and so on. The DAQ system is deployed in a high performance server, using open source QT framework to develop the user interface. The test results show that the DAQ system is stable and reliable, and the required data bandwidth has been achieved. The detailed design and implementation will be presented, and the results of the performance test will be shown.

POSTER / 1030

EFT for new physics in multi-Higgs final states in hadron colliders

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I will show how to parametrize the Standard Model and generic new-physics contributions by an effective Lagrangian that includes higher-dimensional operators and discuss the constraints from the unitarity of scattering amplitudes for 2 to 2 and 2 to 3 processes. The selected subset of operators is motivated by composite-Higgs and Higgs-inflation models. The new physics effect can be potentially discovered in multi-Higgs final states in both 14 and future 100 TeV colliders.
We study the gluon fusion and vector boson fusion processes at the hadron colliders. The sizable contributions from new effective operators can largely increase the cross section and/or modify the kinematics of the Higgs bosons in the final state. Taking into account the projected constraints from single and double Higgs-boson production, we propose benchmark points in the new physics models for the measurement of the triple-Higgs boson final state for future collider projects.

POSTER / **993**

Inclusive SUSY searches with razor kinematic variables at CMS

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We present an inclusive search for supersymmetry with the razor kinematic variables performed using a data sample of proton-proton collisions corresponding to an integrated luminosity of 35.9 fb-1 collected with the CMS experiment in 2016 at a center-of-mass energy of 13 TeV. The search covers final states with zero or one lepton, and features event categories divided according to the number of jets, the number of b-tagged jets, and the values of the razor kinematic variables in order to separate signal from background for a wide variety of supersymmetric particle signatures. Dedicated search categories containing events consistent with a high-transverse momentum hadronic W boson or top quark decay increase the sensitivity to signal models with large mass splitting between the produced gluino or squark and the lightest supersymmetric particle. The results are interpreted in the context of simplified models of gluino or top squark pair production.

POSTER / **959**

Search for black holes and sphalerons in high-multiplicity final states in proton-proton collisions at sqrt(s) = 13 TeV with CMS

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A search for new-physics signals resulting in energetic, high-multiplicity final states, such as black holes, string balls, and electroweak sphalerons, is presented using a data sample corresponding to an integrated luminosity of 35.9 fb^{-1} collected with the CMS experiment at the LHC in proton-proton collisions at a center-of-mass energy of 13 TeV in 2016. Standard model backgrounds, dominated by multijet production, were determined from control regions in data. No excesses characteristic of new-physics signals resulting in such final states were observed. Model-independent 95% confidence level upper limits on the cross section of new-physics signals in these final states are set and further interpreted in terms of limits on semiclassical black hole, string ball, and sphaleron production.

POSTER / **895**

Electron source of Uniform distribution using deep ultraviolet light excited Au film

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In many applications, there are a lot of needs for uniform distribution of cold cathode electron sources, such as microchannel plate testing, mass spectrometer electron sources that excite some samples to produce ions, etc. We use deep ultraviolet light to excite gold cathodes, or a microchannel plate with a gold cathode, using one or more microchannel plates based on different electron flow densities, to design an electron source with different sizes, different current densities, and uniformly distributed electron flow. In a large area of microchannel plate testing and other fields, we have achieved better experimental results, meet the experimental requirements, of course, we can also according to different user requirements, to design electron source with a maximum current density of sub-milliamp / cm2.

POSTER / 891

Photo production of dijets in ultra-peripheral PbPb collisions at 5.02 TeV with CMS

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Ultra-peripheral collisions (UPCs) of heavy ions involve long-range interactions at impact parameters larger than the sum of their radii, for which the hadronic interactions are largely suppressed. In such UPC events, the jets can be produced in processes such as gamma-nucleus interactions. The study of di-jet photoproduction by gamma-nucleus interactions at high energy offer a unique opportunity to study hadron structure and low Bjorken-x gluon dynamics. The first measurement of photonuclear jets in ultra-peripheral PbPb collisions using data taken in 2015 will be presented, using the CMS detector at the LHC.

POSTER / 882

NaI(Tl) crystal encapsulation with liquid scintillator

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Because of hygroscopic property of NaI(Tl) crystal, meticulous care should be taken when handling and encapsulating the crystal. Encapsulation with little surface radioactive background is critical in building low-background rare search experiment.

One of possible method for the background reduction is encapsulation with active veto counter, such as liquid scintillator. Alpha events from surface of NaI(Tl) crystal and gamma events from external backgrounds are tagged in the liquid scintillator and then such background events can be rejected.

In this poster, we will present the performance a of NaI(Tl) crystal detector encapsulated with liquid scintillator.

POSTER / 873

Non-identical particle femtoscopy in Pb-Pb collisions at $\sqrt{s_{NN}}$ = 2.76 TeV with ALICE at the LHC

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Two-particle femtoscopic correlations between non-identical charged particles for different charge combinations are measured in Pb-Pb collisions at $\sqrt{s_{\mathrm{NN}}}$ = 2.76 TeV with ALICE at the LHC. The three-dimensional two-particle correlation functions and double ratios in the out-side-long pair rest frame as well as in terms of an infinite set of one-dimensional spherical harmonics are studied in different centrality bins. The femtoscopic source size parameter (R_{Out}) and emission asymmetry (μ) are extracted. It is observed that the average source size of the system and emission asymmetry between particles increase from peripheral to central events.

POSTER / 791

Status of $K_L^0 \to \pi^0\gamma\gamma$ in the KOTO Experiment at J-PARC

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$K_L^0 \to \pi^0\gamma\gamma$ has been predicted by $O(6)$ calculation in chiral perturbation theory (ChPT) with the inclusion of the vector meson exchange terms. An effective coupling constant α_V was introduced to incorporate with the vector meson contributions. This decay mode is also crucial for the determination of the direct CP violation amplitude of $K_L^0 \to \pi^0 l^+ l^-$. Fermilab E832 and CERN NA48 had measured the branching ratio and pole parameter α_V around 1.3×10^{-6} and -0.4 respectively.

In 2017, a trigger based on the number of EM-shower clusters by Clock Distribution and Trigger (CDT) module was commissioned to collect $K_L^0 \to \pi^0\gamma\gamma$ events more effectively. The analysis status based on 2017 run data will be presented.

POSTER / 702

An enriched Mo-100 powder measurement by a HPGe array detector

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The AMoRE (Advanced Mo based Rare decay Experiment) phase-II needs ultra pure crystals with low radioactive contamination (< 2 micro Bq/kg of 228Th) to achieve the zero background level in the ROI (Region of Interest) of the neutrinoless double decay from the Mo-100. The raw material of the crystals, enriched Mo-100 powder, has to have low contamination (< 20 micro Bq/kg of 228Th). An array of 14 HPGe detectors (70%) was constructed at the Yangyang underground laboratory in spring 2017 for measuring small amount of radioactive isotopes, such as 238U and 232Th. Activities of various radioactive isotopes in a sample of Mo-100 powders measured with data taken for about 3 months together with background data for about 2 months will be presented in this poster.

POSTER / **787**

Daya Bay energy calibration model

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The Daya Bay Reactor Neutrino Experiment was designed to determine theta13, the smallest mixing angle in the three-neutrino mixing framework, with unprecedented precision. Daya Bay provided theta13 with the best precision and made an independent measurement of the effective mass splitting in the electron antineutrino disappearance channel. Daya Bay also performed a number of other precise measurements, such as a high-statistics determination of the absolute reactor antineutrino flux and spectrum, and study of their evolution, as well as a search for sterile neutrino mixing, among others.

A precision evaluation of the antineutrino energy spectra is a fundament for neutrino oscillation investigation. So an accurate conversion of the detector response to the antineutrino energy is a key attribute of the analysis. This is named as the detector energy response model, which will be presented in the poster. The model involves non-linearity which originates from processes in the liquid scintillator and readout electronics as well as other potential biases related to energy calibration.

POSTER / **774**

Hardening Effects of the TeV-scale Cosmic Ray Proton and Helium Spectra

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We suggest a new way to understand cosmic ray proton and helium by introducing discrete local sources. The source of diffusion equation of cosmic ray propagation is set to be a point source given by delta function, contrary to conventional models which have continuous sources. We calculated the spectrum of proton and helium originated in close and young supernovas. By combining the solutions from discrete source and faraway continuous sources, we found cosmic ray propagation parameters that explain the discrepancy between the conventional models of cosmic ray and recent measurements of CREAM, PAMELA, and AMS-02 experiments.

POSTER / 742

Performance of the KOTO Sampling Calorimeter

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The J-PARC KOTO experiment is searching for the KL->pi0nunubar decay which is sensitive to New Physics. A main feature the signal is that only two photons are observed in a hermetic detector system. Therefore, it is important to detect all decay particles from the KL decay. A 5.5-m long cylindrical Lead/Scintillator sandwich sampling calorimeter surrounds the fiducial KL decay region to detect photons exiting the region. The detection efficiency of the sampling calorimeter is designed to meet with the background elimination capability. We will present the performance of the sampling calorimeter using tagged photons by the KL->3pi0 decay. Especially, the performance of a new sampling calorimeter installed in 2016 will be reported.

POSTER / 713

Search for dark matter production in association with a hadronically decaying vector boson in pp collisions at $\sqrt{s}$ = 13 TeV with the ATLAS detector at LHC

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We present a search for dark matter particles production in association with a hadronically decaying vector boson with 36.1 fb^{-1} of pp collision data at a center-of-mass energy of $\sqrt{s}$ = 13 TeV recorded by the ATLAS detector at the LHC. In addition to hadronic decays of W and Z bosons, also the decays of a new non-Standard-Model vector boson Z' of unknown mass are considered here for the first time. The results of the mono-W/Z search are interpreted in terms of limits on the invisible Higgs boson decays into dark matter particles, constraints on the parameter space of the simplified vector-mediator model and generic upper limits on the visible detector-level cross sections for the W/Z+DM production. The results of the mono-Z' search is shown in the frame of several simplified-model scenarios involving the DM production in association with the Z' boson. No significant excess over the Standard Model prediction is observed.

POSTER / 872

Cosmogenic Neutron Production at the Daya Bay Reactor Neutrino Experiment

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(On behalf of the Daya Bay Collaboration)
Neutrons are an important background for underground experiments studying neutrino oscillations,

searching neutrinoless double beta decay, dark matter, and other rare-event signals. This poster presents a study of neutron production by cosmogenic muons at the Daya Bay Reactor Neutrino Experiment, and gives the measurements of neutron yield for different values of average muon energy at different experimental sites of Daya Bay. The comparisons between the measurements and predictions from Geant4 and Fluka are performed, showing some discrepancies between data and MC. A power-law fit of the dependence of the neutron yield on average muon energy is obtained by including the Daya Bay measurements with those from other experiments.

POSTER / 861

Simulation Studies on Supernova Neutrino Detections in JUNO

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Supernova(SN) 1987A was the first detected neutrino burst in neutrino experiment. The Jiangmen Underground Neutrino Observatory(JUNO) is an upcoming large liquid scintillator detector experiment with an expected 3% energy resolution at 1 MeV and abundant light yield. These properties make JUNO a powerful SN neutrino detector. In this poster, we present our simulation studies on SN neutrino event selection efficiencies and purities for different detection channels involving different flavours of SN neutrinos. We demonstrate that pulse shape discrimination (PSD) technique is effective in JUNO detector for separating different SN neutrino detection channels.

POSTER / 846

A muon simulation study for the AMoRE-II experiment.

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The AMoRE (Advanced Molybdenum based Rare process Experiment) phase-II is an experiment to search neutrino-less double beta decay of Mo-100 which is the later phase of the AMoRE experiment. If the double beta decay is found, it means that the neutrinos are Majorana particles and we can measure their masses. The experiment is going to be carried out in the deep underground in order to observe the extremely rare events free from the backgrounds coming from the cosmic ray particles. However, even in the deep underground, there are still some cosmic ray particles that can affect the measurement and must be excluded as much as possible. A muon veto counter is a sort of detector that can veto cosmic muons coming to the inner space where the CaMoO4 (CMO) crystals and detectors are located. We studied effects of veto materials in the AMoRE-II experiment configuration. In detail, we compared the background values in CKKY unit when the veto material is 3m of water or 30cm of lead. Also, we investigated the effect of thickness of water tank. Detail results with discussions will be shown in the poster.

POSTER / **827**

3-inch PMT system of JUNO experiment

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The JUNO experiment will install 25k 3-inch PMTs (SPMTs) in the gaps between 18k closely packed 20-inch PMTs (LPMTs). Both systems will detect the same IBD signals, but the SPMTs will almost always work in single photoelectron mode. As a result, they will help constrain some of the systematics in the LPMT energy reconstruction, improving the energy resolution and the sensitivity of neutrino mass hierarchy measurement. They will also improve the muon reconstruction resolution, help reduce muon-related isotope backgrounds, provide an independent measurement of the θ12 and Delta_m^{2}_{21} solar parameters with unprecedented precision, and improve the measurement of supernova neutrinos.
SPMT production started in 2018 at a rate of 1000/month by the HZC Company. Performance test data so far indicate that the SPMTs perform as expected. A first version of the electronics has been done and is working well.Testing of the integration will be done at the end of this year. Other areas like the high voltage divider, SPMT potting, cabling, connector and underwater box are all making good progress.

POSTER / **790**

Signal optimization and study of the JUNO 20-inch PMT with high-voltage divider

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The Jiangmen Underground Neutrino Observatory (JUNO) is a 20 kton liquid scintillator detector with primary physics goal of neutrino mass hierarchy determination. One of the key parameters is that the energy resolution of the JUNO should reach 3%@1MeV, totally 20,000 20'' PMTs will be used, including 15000 MCP-PMTs from NNVT and 5000 dynode PMTs from Hamamatsu. For better performances and higher stability, the PMT will be optimized with high-voltage divider. In this work, we will show the design and study of the PMT high-voltage divider and the optimized signal about the overshoot and ringing following the positive HV scheme. We have controlled the overshoot to less than ~1% of the signal amplitude; especially, for MCP-PMTs, we have optimized the HV divider for the collection efficiency, and the time properties of the waveform. More other related parameters also will be presented.

POSTER / **775**

Spin Light of Neutrino in Gamma-Ray Bursts

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The spin light of neutrino (SLν) 1 is the electromagnetic radiation emitted by a neutrino due to its magnetic moment when the particle is moving in external environments, i.e. in the presence of matter and/or electromagnetic or gravitational fields [1-3]. Within the developed quantum theory of SLν in matter [4-6] it has been shown that the efficiency of this radiation increases with increase in both the neutrino energy and the density of matter through which the neutrino is propagating. Therefore, the most suitable astrophysical conditions for this phenomenon to be manifested in are realized in Gamma-Ray Bursts (GRB) where generation of ultra-high energy neutrinos is anticipated and the matter density can reach values on the order of the nuclear density [7]. In the present work we discuss the possibility of the SLν radiation in GRBs during their prompt stage. We search for conditions of the best radiation efficiency within the GRB site and describe the most important radiation characteristics such as the total rate and power, the angular distribution and polarization. On this basis we analyze the possibility to find the imprint of the SLν in the observed gamma-ray flux.

POSTER / **747**

Study of PMT saturation for JSNS2 experiment

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The JSNS2 experiment will search for a sterile neutrino with short baseline (~24m) using a high intensity neutrino beam produced from muon decays at rest at J-PARC MLF (Material and Life science experimental Facility). The experiment considers use of 10-inch Hamamatsu PMTs that are also used by RENO and Double Chooz. A study has been made to understand the PMT saturation behavior with various gains, in order to find a linear-response region of the PMT for the JSNS2. In this presentation, we report the results of the PMT saturation study.

POSTER / **697**

Neutrino evolution accounting for the longitudinal and transversal magnetic fields and matter currents

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We consider neutrino spin oscillations in arbitrary moving matter accounting for the longitudinal $\mathbf{j}_{||}$ and transversal $\mathbf{j}_{\perp}$ matter currents in respect to the direction of the neutrino propagation. From the quasiclassical treatment to the problem, based on the generalized Bargmann-Michel-Telegdi equation that describes the evolution of the three-dimensional neutrino spin vector $\mathbf{S}$ developed earlier 1, it is known that the neutrino spin precession and the corresponding oscillations $\nu_e^L \Leftrightarrow \nu_e^R$ can be engendered by the neutrino weak interaction with the transversal matter current $\mathbf{j}_{\perp}$. We have developed 2 the consistent quantum treatment of this effect based on the direct calculations of the effective Hamiltonian of the neutrino evolution in the presence of the longitudinal $\mathbf{j}_{||}$ and transversal $\mathbf{j}_{\perp}$ matter currents. In addition, we now also account for the neutrino magnetic moment interaction with a constant magnetic field $\mathbf{B} = \mathbf{B}_{\perp} + \mathbf{B}_{||}$. The developed quantum treatment to the neutrino spin oscillations due to weak interaction with the transversal matter current $\mathbf{j}_{\perp}$ has provided proper account for the neutrino mixing effects. The obtained closed expressions for the neutrino spin oscillation probabilities are of interest for the astrophysical applications.

POSTER / 694

Physics Sensitivity Studies at Korean Neutrino Observatory

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The Korean Neutrino Observatory (KNO) is proposed as a next generation underground neutrino detector in Korea. The detector is a 260 kiloton water Cherenkov detector and can serve as the second detector of Hyper-Kamiokande experiment. By detecting J- PARC neutrino beam in these two detectors in Korea and Japan at the same time, the measurement of neutrino oscillation parameters such as leptonic CP phase and the neutrino mass ordering is expected to be improved. Physics sensitivity studies are performed with improved handling of systematic uncertainties compared to the previous study. We present preliminary results on physics sensitivities in various configurations of Hyper-Kamiokande experiment including the KNO configuration.

POSTER / 686

Manifestations of neutrino magnetic moments in spin and flavor oscillations of ultrahigh-energy cosmic neutrinos

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We present a theoretical analysis of possible influence of neutrino magnetic moments on the propagation of ultrahigh-energy (UHE) cosmic neutrinos in the interstellar space under the assumption of two-neutrino mixing. The exact solution of the effective equation for neutrino evolution in the presence of a magnetic field and matter is obtained, which accounts for four neutrino species corresponding to two different flavor states with positive and negative helicities. Using most stringent astrophysical bounds on the putative neutrino magnetic moment, probabilities of neutrino flavor and spin oscillations are calculated on the basis of the obtained exact solution. Specific patterns of spin and flavor oscillations are determined for neutrino-energy values characteristic of, respectively, the cosmogenic neutrinos, the Greisen-Zatsepin-Kuz'min (GZK) cutoff, and well above the cutoff.

POSTER / 771

Boosting the Searches of Gluon Pair Initiated Processes using Deep Learning of ISR Jets

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We introduce new strategy to improve the searches of the signal from gluon-pair-initiated(ggI) processes at the LHC. By the ggI process, we mean the scattering process starting from a pair of gluons

which can be associated with initial-state radiation jets(ISR jets) emitted from various incident parton at hadron collision. The ggI processes include gluon-gluon fusion(ggF) into colour singlet state, Higgs associated top-quark pair productions, which are the important windows of proving the sector of electroweak symmetry breaking.
Focusing on the flavours of associated to each ISR jets, we show that the ISR jets in the ggI processes have distinctive features from background processes. Provided that features, we classified initial states, and discriminated the ggI processes from its backgrounds by using deep neural networks. As a promising example, we demonstrated this new technique on single Higgs production process in dimuon channel. Higgs to dimuon process is elusive because of huge irreducible backgrounds from Drell-Yan and diboson processes. Finally, we provide an enhanced aspect on the Higgs coupling measurements, and discuss on the universality of this technique for probing ggI processes in various channels.

POSTER / 778

Support system for ATLAS distributed computing operations

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The ATLAS distributed computing system has allowed the experiment to successfully meet the challenges of LHC Run 2. In order for distributed computing to operate smoothly and efficiently, several support teams are organized in the ATLAS experiment. The ADCoS (ATLAS Distributed Computing Operation Shifts) is a dedicated group of shifters who follow and report failing jobs, failing data transfers between sites, degradation of ATLAS central computing services, and more. The DAST (Distributed Analysis Support Team) provides user support to resolve issues related to running distributed analysis on the grid. The CRC (Computing Run Coordinator) maintains a global view of the day-to-day operations.

In this presentation, the status and operational experience of the support system for ATLAS distributed computing in LHC Run 2 will be reported. This report also includes operations experience from the grid site point of view, and an analysis of the errors that create the biggest waste of wall-clock time. The report of operations experience will focus on some of the more time-consuming tasks for shifters and grid sites, and on the introduction of new technologies, such as machine learning, to ease the work.

POSTER / 908

A study of cryogenic Li2MoO4 phonon-scintillation detectors for AMoRE-II

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We studied phonon and scintillation properties of Li_2MoO_4 crystals for the AMoRE-II (Advance Molybdenum based Rare process Experiment - phase II), an experiment aiming at detecting neutrinoless double beta decay of ^{100}Mo. The Li_2MoO_4 is one of promising crystal candidates among molybdate crystals containing Mo element for a simultaneous detection of heat and light signals at mK temperatures. It is advantageous to use the crystal in terms of crystal growth and internal background control. We tested Li_2MoO_4 crystals in a low-temperature detection system for high resolution phonon-scintillation measurement based on a metallic magnetic calorimeter (MMC) readout technology. We will present tests results of the Li_2MoO_4 crystals as target material and discuss a feasibility for the large scale experiment, AMoRE-II, with about 200 kg of molybdate crystals.

POSTER / 701

Studies of initial state radiations in Drell-Yan events from ppbar collision at 1.96TeV

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We present the studies of initial state radiations (ISR) in Drell-Yan events from ppbar collisions at sqrt{s}=1.96TeV with CDF Run II data. ISR from hadron collisions plays an important role in jet physics, which has an impact on precision measurements and searches for new physics. We develop a systematic way to study the ISR effect using Drell-Yan events. The truncated mean of the dilepton transverse momentum distribution is found to have a logarithmic slope as a function of dilepton invariant mass square. This logarithmic slope can be used to control ISR effect in the SM processes and new physics processes.

POSTER / 683

Top quark pair production in association with a photon

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Top quark pairs in association with final state particles are produced in large quantities at the LHC due to the high centre-of-mass energy available in proton-proton collisions. One such topology is that of a prompt photon radiated from the top-quark in addition to the final state particles from the top-quark decay. Presented are the results from the ATLAS experiment, which measured the fiducial cross section as well as differential cross sections with respect to kinematic variables of the photon.

POSTER / 714

Study on the Secondary Electron Emission Coefficient of aluminum oxide

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Using the spherical secondary electron emission coefficient measuring device, the primary current and the secondary current of the secondary electron emission process are simultaneously measured by the collection method and the principle of charge conservation, and the surface of the sample is neutralized by charge during the measurement process. Under the small error, the secondary electron emission coefficient of the insulation sample under different incident energy and incident angle was measured, and the result obtained by this measurement method was proved to be stable and reliable. At the same time, the secondary electron emission coefficients of aluminum oxide films with different thicknesses at different incident energies and incident angles were measured by this method, and the energy distribution of the secondary electrons emitted was measured by the grid screening method. Thus, a film having a better secondary electron emission characteristic as a coating solution for an electron multiplier device can be selected and used to enhance the performance of the electron multiplier device.

POSTER / 949

Update on the TowerJazz CMOS DMAPS development for the ATLAS ITk

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The upgrade of the ATLAS tracking detector for the High-Luminosity Large Hadron Collider at CERN requires the development of novel radiation hard silicon sensor technologies. For the development of depleted CMOS sensors for ATLAS we combined small electrodes with minimal capacitance

and advanced processing for fully depleted active sensor volume to achieve radiation hard CMOS sensors in line with ATLAS ITk specifications.

Based on initial studies on the prototype sensor "TowerJazz Investigator" we have now developed, produced and tested a first full-size depleted CMOS sensor based on the 180nm TowerJazz imaging process, the so-called "MALTA" sensor. The sensor combines special low-noise/low power front-end using small electrodes with a novel high-speed asynchronous readout architecture to cope with the high hit-rates expected at HL-LHC. The sensor has been produced end of 2017 and initial measurements have been carried out assessing its analog and digital performance. The poster will show efficiency studies performed with the TowerJazz Investigator chip at the CERN SPS test beam facility in 2017 and first measurement results with the new "MALTA" sensor.

POSTER / 910

Silicon PIN photodiode based radon detectors for an underground experiment environment.

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It is very important to monitor the amount of radon (Rn-222) in the underground experiments such as rare decay search and dark matter experiments with ultra low background requirements. The radioactivity from the radon can be a significant background source to the experiments and need to be measured precisely. We upgraded a radon detector with a volume of ~70 L which was used in the KIMS (Korean Invisible Matter Search) experiment by replacing a Hamamatsu silicon PIN photodiode and a Hamamatsu pre-amplifier. The positively charged radon's daughter particles (Po-214 and Po-218 mostly) produced in the air of the detector chamber are collected by the photodiode in a negative high voltage. The energy resolutions of alpha particles emitted from the decays of the daughter particles are measured to be better than 0.6% with very clean signals to be be identified. In this presentation, We also made two more radon chamber detectors and have been testing them to be used in the underground experiment facility. We will present performances of the radon chamber detectors in the tests.

POSTER / 904

Calibration study of the Electromagnetic Calorimeter Trigger system at the Belle II experiment

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We have developed the Electromagnetic Calorimeter (ECL) trigger system for the Belle-II experiment. The ECL trigger system is based on Trigger Cell (TC) consisting of 16 CsI(Tl) crystal detectors for each. We performed the TC energy calibration using the ECL data, and the TC time-offset calibration as well. We will report the calibration method and performance of the ECL trigger system using beam-collision data from Phase-II run.

POSTER / 903

AMoRE Muon Veto Counter and Event Selection

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The AMoRE (Advanced Mo-based Rare process Experiment) is an experiment searching for a neutrinoless double beta decay of Mo-100. A pilot experiment, AMoRE Pilot, has been running with a total of ~1.8 kg of six 40Mo100MoO4 (CMO) crystals in a cryostat at the Yangyang underground laboratory (Y2L, 700 m overburden from the surface). The AMoRE muon veto counter covers the AMoRE cryostat with 10 plastic scintillator counters (28 PMTs). We have developed several methods to select the muon events in the muon counter and checked the coincident background signals from the crystals. We will present on how to select muons, the muon rate at the AMoRE experiment, and the background level of the crystals by the muons.

POSTER / 893

AMoRE-Pilot background simulation

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The AMoRE (Advanced Mo Rare process Experiment) project is the experiment searching for neutrinoless double beta decay of ^{100}Mo.
Monte Carlo simulation using the Geant4 toolkit was performed to understand background level of detector configuration.
Decays of radioactive isotopes such as ^{232}Th, ^{238}U, ^{40}k, ^{235}U and their daughter nuclei were simulated in six $CaMoO_4$ crystals, and in near-by detector materials.
Background spectra of crystals from the recent pilot measurements were fitted with simulation results to identify dominant background sources.
In this poster, the simulation results and fitting results will be presented.

POSTER / 845

Simulation study for the Electromagnetic Calorimeter Trigger system at the Belle II Experiment

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The Belle II experiment at KEK in Japan start beam collision from early of 2018 to probe a New Physics beyond the Standard Model by measuring CP violation phenomena and rare decays of beauty, charm quark and tau lepton. The experiment is performed at the SuperKEKB e+e- collider with 80×10^{34}cm^{−2}s^{−1} as an ultimate instantaneous luminosity. As a severe beam background environment is highly anticipated, a detail simulation study of the Belle II calorimeter trigger system is very crucial to operate Belle II trigger/DAQ system in stable. We report simulation results on various trigger logic and efficiencies using physics and beam background events upon the Belle II Geant4-based analysis framework called Basf2.

POSTER / 751

Data reconstruction and analysis for the 3x1x1 m^3 dual phase Liquid Argon Time Projection Chamber prototype

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Combining high precision calorimetry with scalability to the multi-kiloton level, the Liquid Argon Time Projection Chamber (LAr TPC) has proven to be an attractive technology for long baseline neutrino oscillation experiments. An extensive R&D program for LAr TPCs at the ten-kiloton level is currently underway in the context of the Deep Underground Neutrino Experiment (DUNE). The DUNE far detector, located at the Sanford Underground Research Facility in South Dakota, USA, will measure the oscillated neutrino flux at a baseline of 1300 km with four 10 kiloton LAr TPC modules. Two different technologies are being explored for this purpose: single phase and dual phase LAr TPCs. The dual phase technology allows to amplify the charge signal in gas argon, offering several advantages over the single phase. The first large scale dual phase LAr TPC with an active volume of 3x1x1 m3 has been operated at CERN in 2017. Another prototype with an active volume of 6x6x6 m3 will be commissioned by the end of 2018, paving the way for DUNE. This poster will give a detailed overview of the different reconstruction stages for dual phase LAr TPC data. Furthermore, results on the liquid argon purity, charge readout uniformity and charge-light matching for the 3x1x1 m3 detector are presented.

POSTER / 709

Measurements of detector material samples with two HPGe detectors at the YangYang Underground Lab.

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Two major experiments, the AMoRE (Advanced Mo based Rare process Experiment) searching for neutrino-less double beta decay and the COSINE searching for dark matter WIMPs (Weakly Interacting Massive Particles), are running in the Yangyang underground laboratory (Y2L). To understand their signals, it is necessary to know the backgrounds from their detector materials like fasteners, crystal, cables, connectors, and etc. By using two 100% HPGe detectors at the Y2L, the background levels of each material samples were measured and analyzed by using efficiencies estimated by a Geant4 simulation tool kit. We will present background measurements of the samples together with an improvement in the efficiency calibration using a mixed source including 10 known radioactive isotopes in this poster.

POSTER / **692**

Status of Korean Neutrino Observatory

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The Korean Neutrino Observatory(KNO) is proposed as a next generation underground neutrino observatory in Korea consisting of 260 ton water Cherenkov detector and can serve as the second detector of Hyper-Kamiokande experiment.
By detecting J-PARC neutrino beam in these two detectors at the same time, neutrino oscillation parameters such as leptonic CP violation phase and the neutrino mass ordering can be definitively measured and the sensitivities are expected to be better than locating the two detectors in Japan. Measuring these oscillation parameters are very important questions to be answered in neutrino physics.
In this work we present such sensitivity studies for various detector configurations as a function of beam exposure time and study of geological candidate sites.

POSTER / **824**

JUNO Calibration System

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The Jiangmen Underground Neutrino Observatory (JUNO), a 20-kton multi-purpose underground liquid scintillator (LS) detector equipped with about 50k PMTs, is under construction at Kaiping, Guangdong Province in China. The primary scientific goal is to determine the neutrino mass hierarchy (MH), which requires the unprecedented energy resolution of $3\%/\sqrt{E}$. Consequently, thorough

calibration of the detector is a must. Accordingly, a comprehensive calibration system, including a Cable Loop System, Guide Tube Calibration System, Auto Calibration Unit, and Remotely Operated Vehicle, has been designed to deploy multiple sources, to cover the entire energy range of reactor neutrinos, and to achieve a full-volume position coverage inside the detector to measure the spatial response function at different calibration energies. The energy linearity can also be studied with different gamma and electron sources. In the presentation, the design and current status of the JUNO calibration system will be introduced, finally it's also presented that the effectiveness of this calibration program is validated by simulation.

POSTER / 849

Overview of the Electromagnetic Calorimeter Trigger System at the Belle II Experiment

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The Belle II at the SuperKEKB collider in Japan has been constructed toward a physics run in early of 2018 with an ultimate target of 40 times higher instantaneous luminosity than the KEKB collider, which was 2.1×10^34/cm^2s.
The main physics motivation is to search for the New Physics from heavy quark/lepton flavor decays. We have upgraded the Electromagnetic Calorimeter(ECL) hardware trigger system in order to select an event of interest efficiently under much higher luminosity and beam background environment than the KEKB.
ECL trigger logic based on two main triggers, the total energy and the number of clusters, would be improved with an FPGA-based flexible architecture and a high speed serial link for the data transfer. In this report, progress of the ECL trigger system development will be outlined and preliminary results from beam collision data in Phase II run will be described.

POSTER / 957

Snowball Chamber: A Super-cooled Approach to Dark Matter Detection

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As higher mass particles are eliminated as possibilities in the search for dark matter, it is important to explore new types of detectors that are more specialized at looking for lower mass particles. For this purpose, I've been exploring super-cooled water as a target material for future detectors. This talk will go over the motivations for a detector of this type, the evidence that has been collected—including the first evidence of radiation induced nucleation of super cooled water, and additional applications beyond searching for dark matter.

POSTER / **892**

Temperature dependent study of NaI(Tl) scintillator and PMT

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The COSINE-100 experiment is searching for the direct detection of weakly interacting massive particles (WIMP) using an array of ultra-low background NaI(Tl) scintillation crystals attached with the PMTs. The next phase of the experiment, COSINE-200, requires crystal background levels that are well below, and light yields are well above, the DAMA/LIBRA detector. Thus, the study of temperature dependent NaI(Tl) light yield and photomultiplier tube(PMT) noise are called to improve confidential level of WIMP detection. The light output of the scintillator and the PMT properties have investigated in the temperature range of -25 C to 30 C. Single photoelectron (SPE) was measured by using LED light source which is independent from the refrigerator. The results of temperature dependent properties of this detector will be presented.

POSTER / **880**

R&D on superconducting cavity at IBS/CAPP

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The IBS Center for Axion and Precision Physics Research (CAPP) explores for dark matter axions with tunable resonant cavities immersed in a strong magnetic field to boost the axion-to-photon conversion when a cavity mode resonates with the axion mass. Deposition of superconducting thin films on the inner surface of the cavity increases Q factor of the cavity and thereby enhances the conversion power. However, in the presence of high magnetic fields, Type II superconductors with high critical regions (> 10 T) should be used. In this study, we present various RF characteristics related to superconducting thin films using cylindrical cavities with NbTi coated using the RF magnetron sputtering method; and with YBCO tapes on the inner surface.

POSTER / **860**

Signal Processing Methods for CAPP's Axion Data

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The IBS center for axion and precision physics research (CAPP) conducts haloscope axion search whose method uses a cavity resonator capable of scanning a range of frequencies using a special tuning system. The relic axions passing through the detector are converted into microwave photons inside the resonator via Primakoff effect. The converted photons are coupled to an RF transmission line from the cavity. The RF signal is transferred through the receiver chain and recorded as an averaged spectrum in a predetermined processing frequency band. This study focuses on the processing aspects of the data obtained from the pilot axion experiments at CAPP (CAPP-PACE) covering the 2.45 - 2.75 GHz frequency range. In this poster, the employed methods of data processing for maximum SNR output are considered.

POSTER / **858**

Low noise Amplifier R&D for CULTASK experiment at CAPP

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IBS/CAPP has launched CAPP-PACE, direct axion detection experiment aimed at the mass range of 2.45~2.75 GHz. In the present detector setup, we utilize 1K (ultra-low noise temperature) HEMT amplifier which is the world-best available commercial silicon-based low temperature amplifier. However, in order to reach QCD axion sensitivity and speed up the experiment, we are currently examining the possibility of replacing HEMT with SQUID amplifier which could reduce the noise temperature drastically. MSA (Microstrip SQUID Amplifier) is a good option for achieving low noise level. This poster includes new behavior of MSA, gain and noise measurement, and test results under magnetic field. Finalized RF receiver chain of our experiment with MSA will be introduced also.

POSTER / **837**

Muon and muon-induced phosphorescence events in the COSINE-100 Dark Matter Searches

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The COSINE experiment has been taking physics data which aim to confirm or refute the annual modulation signal reported by DAMA/LIBRA by using the same technique. In order to tag and suppress cosmic-ray muons, a muon detector was constructed using plastic scintillator panels that completely surround the crystal detector array. High energy muons in the NaI(Tl) crystals and low energy scintillation signals corresponding to muon-induced phosphorescence events with half-lives longer than a few seconds were observed. The muon flux and a study of muon-induced phosphorescence events in the COSINE-100 experiment will be presented.

POSTER / 770

Background assessment and performance of the COSINE-100 detector

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COSINE-100 is a dark matter direct dark matter search experiment that uses an array of scintillating NaI(Tl) crystals as a target/detector. The experiment started taking data in September 2016 and has been running stably since that time. We have fit the measured energy spectra in the NaI(Tl) crystals with a MC model that contains a variety of background components. The background sources will be discussed and preliminary results from a dark matter search analysis will be presented.

POSTER / 741

Exploring high mass regions for axion dark matter at IBS/CAPP

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The Center for Axion and Precision Physics Research (CAPP) of the Institute for Basic Science (IBS) in Korea has completed the construction of the infrastructure for axion dark matter search experiments. An experiment utilizing a 9 T superconducting magnet with a 127 mm bore diameter placed in a He-3 cryogenic system is currently under preparation. This experiment will explore a broad range of axion mass of 10 to 30 μeV (equivalent frequency range of 2.8 to 7 GHz) by employing a new cavity design, dubbed 'pizza-cylinder cavity', which provides a capability of searching relatively high mass regions. We present the status of the experiment and discuss the future prospects.

POSTER / 736

Monitoring System and Detector Stability of COSINE-100

William Thompson[1]

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COSINE-100 is a direct detection dark matter experiment consisting of 106 kg of low-background NaI(Tl) crystal detectors located at the Yangyang Underground Laboratory in South Korea. The primary physics goal of COSINE-100 is to search for a WIMP-induced annual modulation signal to confirm or refute DAMA/LIBRA's claim of dark matter discovery. The search for an annual modulation signal requires a thorough understanding of time-dependent environmental effects and a high degree of detector stability. To help achieve the required level of stability, COSINE-100 has developed a monitoring system to measure operating conditions, such as detector gain, trigger rate, and light yield, over time. Additionally, we monitor several environmental conditions, including temperature, radon levels, and muon rates. Here, I will present the COSINE-100 monitoring system and discuss the achieved stability of the COSINE-100 detector.

POSTER / 826

Measurements of the fast neutron flux at the Yangyang underground laboratory for the COSINE-100 experiment

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Measurements of the environmental neutron flux in the vicinity of dark matter search experiments are important because signals induced by these neutrons can mimic those that are expected from dark matter interactions. In order to establish a systematic understanding of the environmental neutron flux at the location of the COSINE-100 experiment, we developed a liquid scintillator neutron detector and studied its pulse shape discrimination capabilities and background contamination levels. In this poster, the neutron monitoring detector will be described and a measurement of the neutron flux in the COSINE-100 room at the Yangyang underground laboratory will be presented.

POSTER / 844

Study on the noise temperature of Josephson Parametric Amplifier (JPA) used in the axion dark matter search experiment at CAPP/IBS in KAIST

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In an axion dark matter search haloscope experiment, the noise temperature of a linear amplifier is a crucial component that seriously affects the sensitivity of the dark matter axion search. In the CAPP18T experiment at CAPP/IBS in KAIST, we use a cryogenically cooled Josephson Parametric Amplifier (JPA) in order to amplify weak RF signals from a resonant cavity. In this presentation, we describe a method to obtain an accurate and repeatable input noise temperature of the JPA: We use a device with a cryogenic attenuator co-located with the amplifier. A dilution refrigerator (~20mK) and a cryogenic High Electron Mobility Transistor are used for this measurement. We will also discuss the calibration techniques.

POSTER / 675

Measurement of nuclear recoil responses of NaI(Tl) crystal for dark matter search

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In direct detection of WIMP dark matter particles, scintillation crystals such as NaI(Tl) are commonly used as targets/detectors. Interactions between WIMP and the crystal are expected to produce nuclear recoils, while energy calibrations for the crystal are done with gamma sources that produce electron recoils. Since the light yields from electron and nuclear recoils of the same energy are different due to their different fraction of energy transferred to electrons, measurements of these light yield ratios -the so-called quenching factors- are necessary to obtain recoil energies from the light yields from WIMP interactions.

On the other hand, nuclear recoil events and beta/gamma-induced events can be discriminated based on their differences in scintillation characteristics. By using a pulse shape discrimination(PSD) analysis, discrimination between WIMP-induced recoils and the background beta/gamma events can be achived.

In this measurement, the quenching factor of a NaI(Tl) crystal (2 cm x 2 cm x 1.5 cm) were measured from the responses of the crystal to nuclear recoils. The nuclear recoils are produced by 2.43 MeV mono-energetic neutrons from D-D fusion reactions in a neutron generator. Neutron-induced events were selected by the time coincidence of signals in BC501a liquid scintillator neutron detectors and the NaI crystal.

In measurements of the quenching factor for sodium and iodine recoils, energies of the recoiling ions range from 6 to 150 keVnr for sodium and 10 to 75 keVnr for iodine. In these ranges, the quenching factors for sodium are measured at 10 points and vary from 10% to 22% and for iodine are measured at 6 points and vary from 5~6%.

The PSD power of the NaI(Tl) crystal was characterized using quality factors and measured from 1 keVnr to 10 keVee. To measure the quality factor, the responses to nuclear recoils are compared to the response to electron recoils produced by Compton scattering of 662 keV gamma-rays from a 137Cs source.

POSTER / 831

Axion dark matter search experiment with 18T high temperature superconducting magnet at CAPP/IBS in KAIST

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The axion is a hypothetical particle that was introduced to solve the strong CP problem. The U(1) Peccie-Quinn symmetry is spontaneously broken and dynamically produce a slowly oscillating particle axion field. The axion is also a strong candidate for dark matter. In order to search for the axionic dark matter, we use a haloscope technology which is equipped with a strong solenoid magnet and a frequency-tuned resonant cavity system. Our detector is designed to be sensitive to the axion mass range of 14.88-26.88 ueV (3.7-6.5 GHz). In this presentation, we report the CAPP18T axion dark matter search experiment setup which utilizes a 18T High Temperature Superconducting solenoid magnet, resonant cavity, dilution refrigerator and linear amplifier system.

POSTER / **830**

Cosmogenic activation study of the COSINE-100 experiment NaI(Tl) crystals

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The COSINE-100 is a direct dark matter (WIMPs) search experiment with a 106 kg array of NaI(TI) crystals at Yangyang deep underground laboratory. Dark matter search experiments require ultra-low background conditions, thus background understanding and reduction are crucial to improve the sensitivity of the detectors. One of the dominant background contributions on the NaI(Tl) crystals is caused by activated radioisotopes that were primarily produced by previous exposures to cosmic rays. In this presentation, results of cosmogenic activation studies for the NaI(Tl) crystals will be presented based on data from the COSINE-100 experiment.

POSTER / **980**

Magnetic in-vacuum field mapping system for the Muon g-2 experiment

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The Muon g-2 Experiment (E989) at Fermilab will measure the anomalous magnetic moment of the muon, a_μ with a precision of 140 part-per-billion (ppb), aiming at resolving the >3 standard deviations between the previous measurement at Brookhaven (E821) and the Standard Model calculation of a_μ.
The experimental concept requires a precise measurement of the magnetic field of the 45-m long storage ring to better than 70 part-per-billion. One crucial element in achieving this is an in-vacuum magnetic field mapping system (called the trolley) to map the magnetic field over the full storage region of the muons. The former trolley system from the Brookhaven experiment (E821) with 17 NMR probes was refurbished and upgraded with new electronics, probes, and a modern motion control system including the full suite of software modules for the data acquisition and analysis. The precision of the NMR system has been measured to be better than 1 part-per-billion in our highly uniform, and stable solenoid magnet. The in-vacuum mapping system and its motion control system were successfully commissioned at Fermilab and the system is now operating during the first physics data taking run. This poster highlights the systems key components and its overall performance.

POSTER / **867**

Planck scale boundary conditions in extended Higgs sectors

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The Higgs boson quartic couplings and their beta functions appear to be tantalisingly close to zero it the Planck scale. We investigate extended Higgs models, including extra Higgs doublets and/or singlets, to see if the vanishing of quartile couplings can be made exact while still producing the correct Higgs mass and satisfying experimental constraints.

POSTER / **1007**

Probing a singlet scalar in electron- positron colliders

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Large Hadron Collider (LHC) continued studying detail of Higgs boson properties and put bounds on beyond standard models. However electron positron colliders with precise knowledge of the initial-state beams, low backgrounds and sensitivity to small energy depositions would provide a perfect environment to precision study of standard model and discovery of new particles.
We consider a beyond standard model in which SM is extended with a scalar and vector like particles. By considering scalar production associated with photon we perform a direct searches for new particles. We constrain the full parameter space for high luminosity electron- positron colliders. Compare to the constrain obtained combined ATLAS and CMS 125GeV Higgs production and coupling measurements and precision electroweak constrains, the allowed parameter space is more constrained.

POSTER / 992

Search for the Electric Dipole Moment and anomalous magnetic moment of the tau lepton

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Precise measurement of the Electric Dipole Moment (EDM) and anomalous magnetic moment (g-2) of particles is an important test of Beyond Standard Model (BSM) physics. It is generally believed that the tau lepton couples more strongly to BSM due to its large mass, but searching for tau EDM and g-2 has been difficult because it is highly unstable and the neutrinos from its decay are undetected at collider experiments. A new method to approximately reconstruct the neutrinos from the hadronic decays of $\tau^-\tau^+$ pairs produced at e^-e^+ tau factories is proposed. Using the information from the neutrinos, a significant improvement in the related measurements can be achieved. With the matrix element technique, and the estimated 50 ab^{-1} of data to be delivered by the $Belle$-II experiment, a tau EDM search with a 1-σ level precision of $|d_\tau| < 2.09 \times 10^{-19}$ e·cm, and g-2 search with $|\Delta a_\tau| < 1.80 \times 10^{-5}$ (1.5% of the SM prediction), can be expected. It offers an opportunity to search for BSM with tau leptons in current and future tau factories with high precision.

POSTER / 814

Singlet fermionic dark matter and Veltman conditions

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We reexamine a renormalizable model of a fermionic dark matter with a gauge singlet Dirac fermion and a real singlet scalar which can ameliorate the scalar mass hierarchy problem of the Standard Model (SM). Our model setup is the minimal extension of the SM for which a realistic dark matter (DM) candidate is provided and the cancellation of one-loop quadratic divergence to the scalar masses can be achieved by the Veltman condition (VC) simultaneously.
This model extension, although renormalizable, can be considered as an effective low-energy theory valid up to cut-off energies about 10 TeV. We calculate the one-loop quadratic divergence contributions of the new scalar and fermionic DM singlets,and constrain the model parameters using the VC and the perturbative unitarity conditions.
Taking into account the invisible Higgs decay measurement, we show the allowed region of new physics parameters satisfying the recent measurement of relic abundance. With the obtained parameter set, we predict the elastic scattering cross section of the new singlet fermion into target nuclei for a direct detection of the dark matter. We also perform the full analysis with arbitrary set of parameters without the VC as a comparison, and discuss the implication of the constraints by the VC in detail.

POSTER / 868

High frequency axion search cavity using dielectric ring at IBS/CAPP

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In the microwave cavity axion search method proposed by P. Sikkivi, the cavity volume, quality factor of the microwave resonant mode, and average electric potential of the mode in the direction of external magnetic field, so called geometrical factor, greatly affect the detection speed. TM010 mode of cylindrical cavity has been the only option because it promises the maximum axion searching speed. However, the magnet constrained volume also restricts searchable resonant frequency range where the wavelength is about twice the magnet bore size. Therefore, in order to search a relatively high frequency region, the diameter of the cavity must be reduced unnecessarily, which leads to a serious reduction in the search speed due to the volume downsizing. We suggest solution for this by using the TM030 mode to boost the frequency at the same volume, and then devising a way to lock the resulting negative electric field to a high permittivity of dielectric material. I'll show the both simulation and experimental results in conference.

POSTER / 851

Lightweight Dark Matter search in neutrino beam with NOvA Near Detector

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Beyond the Standard Model ideas include lightweight (sub-GeV) Dark Matter candidates. We postulate that they could be produced within the NuMI beam at Fermilab. The NOvA neutrino experiment has recorded ~10e21 protons on target, which correspond to millions of neutrino interaction events in its low-Z, 300-ton, off-axis Near Detector. Among these neutrinos, we search, in a model agnostic attitude, for EM showers signatures from DM candidates scattering or decaying within the detector. We present here the techniques we use to process these events, involving sophisticated particle ID algorithms. We also discuss the progress in understanding the NOvA sensitivity to them as well as projections for the capabilities and sensitivity of the DUNE Near Detector to these models.

POSTER / 835

Study on the tuning mechanism of RF cavity for axion dark matter search experiment at CAPP/IBS in KAIST

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About 23% of the energy density of the universe is considered to be in a form of non-baryonic dark matter. One of the strong candidates of dark matter is a hypothetical particle called the axion. In an axion dark matter search haloscope experiment, axions coherently scatter off the magnetic-field potential in a frequency-tunable resonant cavity. A dynamic frequency tuning in the resonant cavity is essential to effectively scan through the relevant axion mass range. In CAPP18T axion search experiment at CAPP/IBS in KAIST, we use a rotating tuning-rod system. We develop a frequency tuning system using a Proportional Integral Derivative control and precision stepping motor system. In this presentation we report details of the tuning mechanism and accuracy of the setup which are interpreted in the axion mass parameter space.

POSTER / **707**

The IBS/CAPP magnetometer station for the GNOME experiment is running

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The Global Network of Optical Magnetometers to search for Exotic physics (GNOME) is an experiment looking for transient events of axion domain walls from the gradient coupling of axion field with atomic spins 1. GNOME is based on synchronized measurements from multiple GPS-timed magnetometer stations located in geographically separated places on the Earth [3]. While a single magnetometer could detect spin signalsfrom such terrestrial events, it would not be possible to distinguish real physic events from false ones caused by environmental noise sources. GNOME can effectively veto false events by arraying magnetometer stations. One of those stations located at IBS/CAPP in Daejeon, South Korea employs cesium alkali atoms as a primary magnetometer. We present the optimization and characterization of the Cs magnetometer at IBS/CAPP as well as the first preliminary test run results.

POSTER / **878**

Implosion protection and waterproof potting for the JUNO 20-inch PMTs

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The Jiangmen Underground Neutrino Observatory (JUNO), its primary goal is to determine the neutrino mass hierarchy and precisely measure the oscillation parameters by detecting reactor anti-neutrinos, is under construction. 20000 PMTs , including 5000 Hamamatsu dynode PMTs and 15000 NNVT MCP PMTs, are designed to capture photos emitting from the central detector, where the neutrinos enter and react with the liquid scintillator. To reach the physics goal of JUNO, on the one hand, the PMTs should be arranged as close as possible to achieve highest cover rate, so the PMTs should be protected to avoid suffering from chain implosion; On the other hand, the failure rate of the PMT waterproofing should be below than 0.5% for the first 6 years. Design and test of the PMT implosion and waterproof potting have been made and will be shown in this poster.

POSTER / 829

New design of multiple-cavity detector for high mass axion dark matter search

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In cavity-based axion dark matter search experiments exploring high mass regions, arrays of multiple cavities are typically considered to increase the detection volume within a given magnet bore. We, IBS/CAPP at KAIST, introduce a new idea, referred to as pizza-cylinder cavity, which is superior to a conventional multiple-cavity detector in terms of detection volume, simplicity of the experimental setup, and facilitation of the phase-matching mechanism. This design is promising for detecting high frequency axion dark matter with enhanced experimental sensitivities. We present the characteristics of this concept and demonstrate the experimental feasibility using a double-cell cavity.

POSTER / 703

High precision tracking for J-PARC (g-2)/EDM experiment.

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The J-PARC (g-2)/EDM experiment features a novel experimental idea of the anomalous magnetic and electric dipole moments of the muon. The goals of the experiment are to improve the precision of the previous measurement of the E821 experiment at BNL that sets the measurement significantly away from theory; therefore, providing an evidence for new physics. The systematic uncertainties of the experiment vastly differ from E821; thus, it will provide an independent result of the discovered anomaly. In this study, we use a high precision beam and spin dynamics tracking to assess possible systematic uncertainties and relevant corrections for the experiment. We demonstrate the power of the simulation tracking tool and possible areas of using it to further enhance the sensitivity of the experiment. A specific application on so-called pitch effect and momenta distribution will be shown.

POSTER / 990

A Minimal Model For Two-Component FIMP Dark Matter: A Basic Search

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In the multi-component configurations of dark matter phenomenology, we propose a minimal two-component one which is an extension
of the Standard Model with only three new fields; one scalar and one
fermion interact with the thermal soup through Higgs portal mediated
by the other scalar in such a way that the stabilities of dark matter candidates are made simultaneously by an explicit Z2 symmetry. Against
the most common freeze-out framework, we look for dark matter particle signatures in the freeze-in scenario by evaluating the relic density
and detection signals. A simple distinguishing feature of the model
is the lack of dark matter conversion, so the dark matter components
act individually and the model can be adapted entirely to both singlet
scalar and singlet fermionic models, separately. We find dark matter
self-interaction as the most promising approach to probe such feeble
models. Although, the scalar component adopts this constraint, the
fermionic one refuses it even in the resonant region.

POSTER / **794**

Mitigation of the Energy Sawtooth Effects in the Partial Double Ring Scheme of a Circular Higgs Factory

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The energy sawtooth will be significant in the future circular Higgs factory with beam energy as high as 120 GeV. For the partial double ring scheme, unlike the double ring scheme, the effects of energy sawtooth can't be corrected by tapering the magnet strength with beam energy along beamline. In this paper, the energy sawtooth effects in the partial double ring scheme and its mitigation method will be presented.as well as the reduction of dynamic aperture.

POSTER / **792**

Analytical Estimation of Dynamic Aperture for Higgs Factory

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Based on the standard mapping, analytical formula for estimating the dynamic apertures of synchrotron particles has been established for both on-momentum and off-momentum particles. In this paper, we extended the formula of dynamic aperture considering features of a Higgs Factory. As an example, application on the dynamic aperture optimization for the CEPC (Circular Electron and Positron Collider) collider ring will be presented.

POSTER / 705

A non-destructive beam profile monitor for a muon beam of g-2/EDM experiment at J-PARC

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At J-PARC, g-2/EDM experiment will be prepared to measure the anomalous magnetic moment of muon with high precision by producing the ultra-cold muon. The ultra-cold muon beam will be injected into the solenoidal storage magnet after acceleration to 300 MeV/c.
At the injection, it is required for the muon beam to have axisymmetric distribution for a reduction of a systematic error on the precision. The muon spin orientation could be disturbed by the non-symmetric distribution. Therefore, the beam profile monitoring is crucial to enhance the precision by reducing the systematic error.
The non-destructive beam profile monitor has been chosen for the online monitoring to keep the amount of particles where it has to measure the pretty low intensity (~ uA). In this paper a design status of the monitoring system and a reconstruction procedure for transverse profile will be presented.

POSTER / 671

Correction of the Effect of the Coherent Betatron Oscillation by the RF Electric Field for Fermilab Muon g-2 Experiment

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The Fermilab Muon g-2 experiment aims to measure the muon anomalous magnetic moment with a 140 parts-per-billion precision to investigate the greater than 3 standard deviation difference between the Standard Model prediction and the previous measurement by the BNL Muon g-2 experiment. The coherent betatron oscillation (CBO) beam effects must be corrected for in the decay-positron time spectra fits used in high precision muon storage ring based anomalous magnetic moment measurements. This MC simulation study indicates that the application of radio frequency (RF) electric fields to the muon storage ring beam can reduced the CBO amplitude by up to a factor of 10, as well to increase the symmetry of the beam phase space. This is achieved by correcting the mismatched oscillation phases between the high and low momentum muon populations by modulating the muon beam betatron oscillation frequencies with off-resonance RF fields.

POSTER / 890

Photo production of dijets in ultra-peripheral PbPb collisions at 5.02 TeV

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Ultra-peripheral collisions (UPCs) of heavy ions involve long-range interactions at impact parameters larger than the sum of their radii. Therefore, the hadronic interactions are largely suppressed in UPC. Though there are no hadronic processes in UPC, the jets can be produced via some other ways, such as gamma-nucleus interactions. The study of di-jet photoproduction by gamma-nucleus interactions at high energy offer a unique opportunity to study hadron structure and low Bjorken-x gluon dynamics. This presentation shows the first observation of the photonuclear jets analyzed by CMS at the LHC. The CMS experiment has excellent capabilities for the measurements of jets and charged tracks, which are definite advantages for this analysis. The primary result of di-jet photoproduction in ultra-peripheral PbPb collisions using the data taken in 2015 will be presented.

POSTER / **712**

Two-particle correlation via Bremsstrahlung

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An angular correlation between trigger-jet and high-transverse momentum particles observed in AA collisions at the RHIC is well known for ridge structure. This phenomenon is well explained from the hydrodynamical model and it has been a strong evidence of the QGP generation. However, recently the ridge structure has also been reported in high multiplicity pp collisions at LHC. In pp collisions, a sufficiently high-density medium such as QGP is not expected to be produced and therefore, we tried to understand this phenomena through kinematic model between jet particles and partons.
Kinematically, jet particles interact with partons through collisions and lose their energy mostly by emitting gluons and photons. However, unlike photons, gluons carry color charge by themselves and therefore, they interact with other gluons.
In this study, we tried to understand the ridge structure of the correlation between jet particles and partons through only photon Bremsstrahlung process because the gluon radiations are very complicated due to its color degree of freedom. We calculated the scattering cross section between jet particles and medium partons, which leads to two-particle correlation.
During collisions, initial jet particles and partons exchange momenta and the initial distribution of medium partons momentum affect the scattering cross section. In high energy collisions, beams are colliding almost at the speed of light and so the space is contracted in a beam direction. Therefore it is more plausible to use a relativistic statistical distribution for the initial medium parton momentum. However, in the case of non-central collision there is spatial anisotropy which leads to the asymmetry in momentum distribution and therefore, we introduced anisotropic elliptic flows about the azimuthal angle.
We studied the behavior of the correlation depending on the energy losses of initial jets and on the angles between initial and final jets. Collective peak of medium partons moves away from the trigger jet as the energy loss increases or as the angles between initial and final jet decreases.
This study mainly based on the simple calculation such as no color degree of freedom and single photon emission. Also final jets are assumed to be on the perpendicular plane to the beam direction. More solid conclusion should be hold until future studies for realistic situations.

POSTER / 1016

Hadronic wave functions in the extended harmonic oscillator model

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We extend the research task to employ the symmetries of simple harmonic oscillator in canonical (q,p) space to more than the 3 dimensions, based on the solution of Liouville equation. It is possible to obtain some operators in which their eigen values are corresponding to quark
features, including isospin, electric charge, baryon number, hypercharge and ect. Since the extension involve the SU(6) symmetry group, we are able to obtain all the required quantum numbers of heavy quarks. Following that, based on the extended harmonic oscillator model, we are able to get flavor wave functions to characterize and also classify all the baryons and mesons which contain light quarks as well as heavy quarks.

POSTER / 947

The Minkowskian dynamics of hadrons

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The advent of approaches based on the Euclidean space for studying hadron observables, as e.g. by lattice QCD and Schwinger-Dyson equations, has been remarkable and responsible to produce important understanding on non-perturbative physical systems.

However, the quantum field theory formulation in Minkowski space has subtle essential signatures as, for instance, related with spin degrees of freedom, that requires deep understanding by a theoretical framework developed in that space. One important example is the Fock space expansion, which allows one to construct a probabilistic description of the hadron and to explore purely relativistic effects on the dynamics as, for example, through the EM form factors 1.

In recent years, studies based on actual solutions of the homogeneous Bethe-Salpeter equation directly in Minkowski space are becoming available. This makes feasible to start phenomenological investigations of the hadron structure, shedding light on the intrinsic dynamics that is formally and conceptually connected with the physical space, i.e. the Minkowski one [2,3].

Obtaining information on the internal dynamics of the hadrons relies on achieving realistic Bethe-Salpeter amplitudes, making it a necessary step for the calculation of observables. The new framework for solving the Bethe-Salpeter equation has a main ingredient given by the the so-called Nakanishi Integral Representation of the Bethe-Salpeter amplitude, that allows to compute the amplitude for the bound state fully in Minkowski space.

In order to illustrate the phenomenological potential of the approach based on the aforementioned framework, we explore the dynamical observables of the recently observed doubly charmed baryon Ξ_{cc}^{++} [4], by means of a quark-diquark bound state model. By taking the constituents and exchanged-boson masses from lattice calculations, the predicted momentum distributions are shown.
The possibility of understanding the dynamical features also of other possible baryons composed by two-heavy and one-light quarks within the model is another exciting prospect.

The Minkowskian framework is also developed for a quark-antiquark bound state, which is applied for a mock pion. The peculiar features related to the spin degrees of freedom are shown through its Bethe-Salpeter amplitude. That enables the calculation of the EM form factor, the parton distribution functions (PDFs) and transverse amplitudes for the pion, where the comparison with the available data is feasible.

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POSTER / **1000**

The Role of Environment on Void's galaxy Evolution

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The role of environment in galaxies evolution is a highlight knowledge for probing the structure formation and evolution.Because of that, we select two different galaxies categorize for its investigation. In this work, For studying the role of environmental effects on properties of both active galactic nuclei(AGN) and star formation(SFR) galaxies, we have considered two environment subsamples from low (Void) and high (Clusters) density regions with cross matching their details to SDSS DR13. For more precise investigation on the role of environment on Galaxies dynamics, we focus on statistical distribution for Dn4000 and specific star formation rate (sSFR). The results show us that for AGN galaxies, the evolution of these details are related just to Active nuclei and its effect removes all environmental effects. we know that the AGN can be effects on neighbor's galaxies, but the role of its effects on its self is not clear. We analyzed one of these relations: Accretion mass versus sSFR. Our results show the role of AGN accretion mass ejections on sSFR might be very important on Low mass galaxies evolution.

POSTER / **777**

A search for secluded dark matter in the Sun using the IceCube neutrino telescope

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Secluded dark matter is a model for dark matter in which dark matter particles annihilate into baryonic matter via a metastable mediator. In the case of annihilations in the sun sufficiently long-lived mediator particles can escape the solar plasma before decaying, avoiding the absorption of signal particles. This results in significantly amplified neutrino signals at energies beyond 1 TeV promising a high sensitivity for indirect searches using neutrino telescopes. In this talk the results of a search for secluded dark matter in the sun with the IceCube neutrino observatory will be presented. WIMP masses ranging from 100 GeV to 10 TeV and mediators between 1 ns and 10 s decaying directly into

neutrinos are considered. The data taken by IceCube in the in the years from 2011 to 2015 in the 86 string configuration is used in the analysis.

POSTER / 670

Axion dark matter search experiment for the mass range of 6.62 to 7.04 μeV

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The CAPP-8TB axion dark matter search experiment for the mass range of 6.62 to 7.04 μeV is being performed as one of the CULTASK experiments at IBS/CAPP. The experiment utilizes the cavity haloscope technique introduced by Sikivie with a microwave resonant cavity of 3.5 L volume under 8 T superconducting magnet at a cryogenic temperature of less than 0.1 K. In this poster, details of the experiment configurations are presented including the resonant cavity, cryogenics, magnet, a new locomotive frequency tuning mechanism with a dielectric tuning rod, microwave receiver chain with high-electron mobility transistor amplifiers, data acquisition, control, and monitoring system. The target of this effort is to be sensitive to the QCD axion band with a two-month running time.

POSTER / 509

Search for Higgs boson pair production with the ATLAS detector

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The Standard Model (SM) very successfully describes experimental observations, but is known to be an incomplete theory. Measurements of SM parameters and checks of its self consistency are important to improve our understanding of nature. An important parameter to understand electroweak symmetry breaking is the Higgs boson self-coupling, which can be accessed in Higgs boson pair production. These studies are already important now to search for potential effects of physics beyond the SM as well as to prepare for the analysis of the full dataset of the HL-LHC. This poster will present the latest results on the Higgs pair production with the ATLAS detector with a focus on the 4b and bbWW* final states.

POSTER / 508

Search for Higgs boson production in association with a pair of top-quarks with the Atlas detector

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A great success of the Standard Model (SM) was the discovery of a Higgs boson in 2012. Measuring its properties and yet unobserved production and decay modes provides a test of the validity of the SM. The process of Higgs production in association with a pair of top-quarks ($t\bar{t}H$) is still unobserved. Further interest arises from the fact that it provides direct access to the top Yukawa coupling which is possibly sensitive to new physics and therefore provides a crucial test of the SM.
In order to maximize the statistics of the data sample of the $t\bar{t}H$ process the final state of the Higgs decay with the highest branching ratio into a pair of b-quarks has been chosen for this search. This summary is based on the recently published results using $36.1 fb^{-1}$ in pp collisions collected with the Atlas detector in 2015 and 2016. Especially the reconstruction techniques to correctly match the jets originating from b-quarks to their origin, are reviewed. The measurement in the $t\bar{t}H(b\bar{b})$ final state is put in context with the combination of the other Higgs decay modes, resulting in evidence for this process.

POSTER / 661

A low frequency Axion search using the storage ring electric dipole moment method

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The Axion-gluon coupling induces an oscillating electric dipole moment (EDM) in nucleons. The axion induced oscillating EDM can be detected using storage ring EDM method with resonance between g-2 precession frequency and the oscillating EDM. Frequency range from mHz to 100 MHz can be scanned with the resonance method and below mHz down to about 10^{-9} Hz (assuming 4 years of measurement) can be searched using the frozen spin method and by combining many consecutive run data. The estimated sensitivity is at the level of 10^{-30} e.cm or higher. No other experiment has accessed the proposed frequency range at this high sensitivity until now. In this study, we present the experimental method and compare the sensitivity with other experiments. (This work was supported by IBS-R017-D1-2018-a00.)

POSTER / 660

Asymmetry realization of p-Carbon interactions in Geant4 for the storage ring proton EDM experiment

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Our universe appears to break the CP symmetry in the strong interaction within the paradigm of the elementary particle physics. However, no violation has been discovered so far by experiments. To address this question further, a storage ring experiment has been proposed to search for a permanent intrinsic electric dipole moment of proton (pEDM) with the target sensitivity of 10^{-29} e.cm within a year of measurement time. A polarimeter for the proposed storage ring proton EDM (SR pEDM) experiment is being under development using gas electron multiplier (GEM) technology. For an efficient polarimeter design study, we wrote a computer simulation code in the Geant4 frame, which makes the spin-dependent proton-carbon elastic hadronic scattering possible. The cross section of the scattering was implemented with reference from experimental data. The new algorithm of Geant4, its operation, and more details are introduced in this report. Furthermore, the performance of the GEM detector has been demonstrated at Forshungszentrum Juelich (FZJ) in Germany using Deuteron beam generated by Cooler Synctrotron (COSY). (This work was supported by IBS-R017-D1-2018-a00.)

POSTER / **632**

Search for first generation scalar leptoquarks in pp collisions at 13 TeV with CMS

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The quark and lepton sectors of the standard model (SM) are strikingly similar in terms of the number of particles and generations. This hints at a fundamental symmetry existing between the two sectors. Indeed, such a symmetry is part of many beyond-the-SM theories such as composite models, technicolor, grand unified SU(5), Pati-Salam SU(4) and E6 superstring-inspired theories. These models give rise to a new class of bosons called leptoquarks (LQs) that carry both baryon and lepton numbers – a signature of their coupling to quarks and leptons. They are colored objects with fractional electric charge, and could be either scalar or vector particles. An LQ decays into a lepton and a quark, giving rise to a final state of high-momentum leptons and jets. We perform a dedicated search for pair-produced first generation scalar leptoquarks, resulting in a final state of two electrons and at least two jets; and one electron, missing transverse energy and at least two jets, using pp collision data taken at centre-of-mass energy of 13 TeV. The data were recorded with the CMS detector during the 2016 running of the LHC, and correspond to an integrated luminosity of 35.9 fb-1.

POSTER / **629**

Reduction of the radioactive impurities in NaI powder by recrystallization method

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The COSINE project is aimed at direct detection of dark matter experiment1. WIMPs(Weakly Interacting Massive Particles) are one of the most attractive candidates of dark matter[2, 3] but, only DAMA/LIBRA experiment has claimed the detection of a WIMPs[4]. To confirm or exclude the DAMA/LIBRA's modulation results, COSINE is going to achieve ultra-low background and lower energy threshold than DAMA/LIBRA experiment. The NaI scintillating crystal is very suitable material for dark matter searching. In this experiment, radioactive impurities make noise on the peaks and high background. To manufacture the ultra-low background crystal, this presentation will be focused on purification of the NaI powder.
NaI powder was purified by fractional recrystallization from water. The concentration of K, Pb, Th, U and other impurities was measured by ICP-MS. As a result, the recrystallization effectively reduced the concentration of radioactive impurities such as K, Pb, Sr, Ba, Th, and U. Furthermore, based on these experimental methods and results, pilot scale of process were designed and manufactured for COSINE project. It is a recrystallization purify system that can purify 70 kg of NaI powder at one cycle and it takes 3~4 days from purification to drying. This process and result also will be presented.
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POSTER / 625

Development of a 3D highly granular scintillator neutrino detector for the T2K experiment

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The long baseline neutrino experiment T2K has launched the upgrade project of its near detector ND280, crucial to reduce the systematic uncertainty in the prediction of number of events at the far detector to less than 4%. An essential component of this upgrade is a highly segmented scintillator detector, acting as a fully active target for the neutrino interactions.
The baseline concept for it is a novel device, called SuperFGD (arXiv:1707.01785, 2018_JINST_13_P02006), with dimensions of ~200x180x60 cm^3 and a total mass of about 2 tons. It consists of about 2x10^6 small scintillator cubes each of 1 cm^3. Each cube is covered by a chemical reflector and has three orthogonal cylindrical holes of 1.5 mm diameter. The signal readout from each cube is provided by WLS fibers (1.0 mm Kuraray Y11 multiclad fibers) inserted in these holes and connected to micro-pixel avalanche photodiodes MPPCs. We have demonstrated that this detector, providing three 2D projections, has excellent tracking performance, including a 4π angular acceptance, especially important for short proton and pion tracks. Moreover, with its data it will be possible to clearly distinguish between photon conversions and ν_e interactions. Interest in this detector has been expressed by groups of the DUNE and ESS-nu collaboration, proposing it as a component of their near detector complex.

A small prototype of this detector composed of 125 cubes was tested in a beam of charged particles at CERN in 2017. The detector response of this prototype, including the light yield, the cross-talk, and the time resolution has been measured and will be presented. The progress in the R&D of this detector, future plans and results of simulations will be also reported.

POSTER / 544

Study of the differential Drell-Yan cross sections at 13 TeV with CMS

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Studies of the differential Drell-Yan cross sections in the dilepton channel are presented. The analysis is based on data taken with the CMS detector at a proton-proton center of mass energy of 13 TeV. The cross sections are studied as a function of dilepton invariant mass and rapidity. Backgrounds are estimated using data-driven methods, and corrections including detector effects are discussed.

POSTER / 542

Search for Z and Higgs boson decaying into J/psi + photon in pp collisions at 13 TeV with CMS

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Search for the Standard Model Z and Higgs boson decaying into a J/psi and a photon, with subsequent decay of the J/psi into dimuon pair will be presented. The analysis is performed using data recorded by CMS detector from proton-proton collisions at 13 TeV in 2016. The latest results of the limits on the Z/Higgs -> J/psi+photon decay branching fraction will be shown in this poster.

POSTER / 517

Measurement of azimuthal correlations of D mesons with charged particles in pp collisions at sqrt{s}=13 TeV with ALICE at the LHC

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The ALICE (A Large Ion Collider Experiment) detector at the LHC is designed to study the properties of Quark-Gluon Plasma (QGP), a deconfined state of quarks and gluons produced in the ultrarelativistic heavy ions collisions.

Heavy-quarks, charm and beauty, are considered as effective probes for the investigation of the QGP properties. Due to their large masses they are produced almost exclusively during the hard-scattering phase and therefore experience the full evolution of the collision, interacting and losing energy in the hot and dense medium produced.

The study of angular correlations between D mesons and charged particles in different collision systems provides information about the possible medium-induced modification of charm quark fragmentation into jets. The same study in the pp collision system, beside constituting the natural reference to understand the results in p-Pb and Pb-Pb collisions systems, allows investigating charm quark production mechanisms, fragmentation and hadronization.

In this poster, the measurement of azimuthal correlations between D^0 meson and charged particles in pp collisions at $\sqrt{s} = 13$ TeV will be presented. The comparison with results obtained at $\sqrt{s} = 7$ TeV allows investigating the dependence of the result from the energy of the collision. The data will also be compared with simulations results obtained with different event generators.

POSTER / **504**

Study of production of electrons from beauty-hadron decays in pp collisions at √s = 13 TeV and Pb-Pb collisions at √s = 5.02 TeV with ALICE

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Heavy quarks, charm and beauty, are expected to be effective probes for the hot and dense medium (QGP) produced in high-energy heavy-ion collisions. They are produced in the early stage of the collision, almost exclusively in hard partonic scattering, and therefore they experience the full evolution of the QGP allowing to study the in-medium partonic energy-loss. In particular, the medium-induced parton energy loss is expected to depend on the parton mass and colour charge. This results in a reduction of beauty-quark energy loss compared to charm-quark energy loss. Therefore the separate measurement of the beauty-quark production from charm-quark production allows us to test various parton energy loss models. In addition, the measurement provides a crucial testing ground for perturbative QCD calculations and provides a mandatory baseline for corresponding studies in Pb-Pb collisions. The ALICE detector which has excellent particle identification and tracking capabilities allows investigating beauty production via the measurement of beauty-decay electrons. The particle identification is performed by TPC (Time Projection Chamber) and TOF (Time Of Flight). The electrons from beauty-hadron decays are separated statistically from background electrons based on the track impact parameter distribution that result to be wider for the beauty-decay electrons thanks to the long lifetime of the beauty hadrons.
In this poster, we present recent results and analysis status of beauty production in pp collisions at √sNN=13 TeV and in Pb-Pb collisions at √sNN=5.02 TeV.

POSTER / **458**

Wideband SQUID Amplifiers for Axion Search Experiments

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It was theoretically shown that axions can be detected by converting them to microwave photons inside high-Q cavity resonators in the presence of a strong magnetic field 1. In such experiments, very weak microwave signals should be scanned in a wide frequency range. The best semiconductor amplifiers have a lowest noise temperature plateau of about 1.1 K even at significantly lower ambient temperature. Superconducting quantum interference devices, or SQUIDs, can work as microwave amplifiers with noise temperature close to the standard quantum limit (SQL), TSQL = hf/kB ≈ 50 mK at 1 GHz 2. Previously designed SQUID-based high-frequency amplifiers have narrow bandwidth due to a microstrip resonant input coil [3]. It requires serial replacements of SQUID preamplifiers in order to scan a wide frequency range. This procedure is complex and time consuming because of a large mass of hardware should be cooled down below 100 mK. SQUID-based microwave amplifiers with a suitable amplification should be designed with the smallest possible tunnel junction capacitance, with reasonably low SQUID loop inductance, and maximal transfer function at the working point. Sub-micron size Josephson junctions with a very small capacitance 0.04 pF were used for low-frequency SQUID current sensors [4]. We tested a few of such sensors at high frequencies and found out that they can work as both resonant and wideband microwave amplifiers. In this presentation, we report on SQUID-based wideband microwave amplifiers fabricated using sub-micron size Josephson junctions with very low capacitance. A single amplifier can be used for axion search experiments in a frequency range from about 500 MHz to approximately 5 GHz.

POSTER / 430

Heavy Majorana neutrino pair productions at the LHC in minimal U(1) extended Standard Model

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Heavy Majorana neutrino pair productions at the LHC in minimal U(1) extended Standard Model 2017 In our recent paper 1, we explored a prospect of discovering the heavy Majorana right-handed neutrinos (RHNs) at the future LHC in the context of the minimal non-exotic U(1) extended Standard Model (SM), where a pair of RHNs are created via decay of resonantly produced massive U(1) gauge boson (Z'). We pointed out that this model can yield a significant enhancement of the branching ratio of the Z' boson to a pair of RHNs, which is crucial for discovering the RHNs under the very severe LHC Run-2 constraint from the search for the Z' boson with dilepton final states. In this paper, we perform a general parameter scan to evaluate the maximum production rate of the same-sign dilepton final states (smoking gun signature of Majorana RHNs production) at the LHC, while reproducing the neutrino oscillation data. We also consider the minimal non-exotic U(1) model with an alternative charge assignment. In this case, we find a further enhancement of the branching ratio of the Z' boson to a pair of RHNs compared to the conventional case, which opens up a possibility of discovering the RHNs even before the Z' boson at the future LHC experiment.

POSTER / 428

A Study on the Shielding Ability of Current Aerospace Materials of a Detector against High Energy Cosmic Rays

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High energy cosmic rays are one of the biggest concerns for a detector used in space and manned spaceflight, along with the swift development of the high energy experiments in space and spaceflight enterprise, the research of shielding materials against high energy cosmic rays has become increasingly important. In this study, by using Monte Carlo method, firstly we defined a simple detector in the form of human body, and then we designed the geometry of shielding structures with various shielding materials. At last we comprehensively considered the radiation shielding properties of various materials together with the consideration of mass problems of shielding materials. The radiological protection capability of materials against certain higher energy cosmic ray was appraised from the perspectives of radiation dose. The results concluded that under the same level of mass of shielding materials, it is advantageous to employ the composites and non-metal materials as shielding materials than using metal or alloy. For practical application, the shielding structure is usually consisted with multi-layers. The calculation result shows that a multi-layers shielding structure that has low density layer-high density layer-low density layers structure has a more ideal shielding effect.

POSTER / 403

Search for top squarks with ATLAS at $\sqrt{s} = 13TeV$ in fully hadronic and semi-leptonic final states

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Looking for supersymmetry, the search for a scalar partner of the top quark plays a major part due to its role in stabilising the Higgs boson mass. In the parameter space where a decay of a top squark into a top quark and the neutralino, a Dark Matter candidate, is possible, searches asking for either zero or one charged lepton are most sensitive. Events with an isolated electron or muon simplify event classification, whereas the branching fraction into fully hadronic final states is higher. In both cases b-jets are produced and missing transverse momentum is observed due to undetectable neutralinos. This contribution presents methods used by these searches and the results obtained with data taken in 2015 and 2016 with the ATLAS detector at $\sqrt{s} = 13$ TeV.

POSTER / 358

Measurement of phase-space density evolution in MICE

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The Muon Ionization Cooling Experiment (MICE) collaboration will demonstrate feasibility of ionization cooling, the technique proposed to cool the muon beam at a future neutrino factory or muon collider. The muon beam parameters are measured on a sample built on a particle-by-particle basis, before and after the cooling cell using high precision sci-fibre trackers in a solenoid magnetic field. Position and momentum reconstruction of each muon in MICE allows to developo
several alternative figures of merit in addition to beam emittance. Contraction of the phase-space volume of the sample, or equivalently the increase in phasespace density at its core, is an unequivocal cooling signature. Single-particle amplitude, defined as a weighted distance to the sample centroid, can be used to probe the change in density in the core of the beam. Alternatively, non-parametric statistics provide reliable methods to estimate the entire phase-space density
distribution and reconstruct probability contours. The aforementioned techniques, robust to transmission losses and sample non linearities, are ideal candidates for a cooling measurement in MICE. Preliminary results are presented here.

POSTER / 290

Simulation of the ATLAS New Small Wheel Trigger System

ATLAS Collaboration[None]

The instantaneous luminosity of the Large Hadron Collider (LHC) at CERN will be increased up to a factor of seven with respect to the original design value to explore higher energy scale. In order to benefit from the expected high luminosity performance, the first station of the ATLAS muon end-cap Small Wheel system will be replaced by a New Small Wheel (NSW) detector. The NSW provide precise track segment information to the muon Level-1 trigger to reduce fake triggers. This contribution will summarize a detail simulation of the NSW trigger decision system, track reconstruction algorithm implemented into the trigger processor and results of performance studies on the trigger system.

Summary
The instantaneous luminosity of the LHC will be increased up to a factor of seven with respect to the present design value by undergoing an extensive upgrade program over the coming decade. In order to benefit from the expected high luminosity performance, the first station of the ATLAS muon end-cap Small Wheel system will need to be replaced by a New Small Wheel (NSW) detector, which is used for trigger and precision measurement. The NSW provides precise track segment information to the muon Level-1 trigger to reduce fake triggers arising from particles that are not high pT muons originating from the Interaction Point (IP). The NSW consists of Micromegas (MM) and small-strip Thin Gap Chambers (sTGC). Both systems find a track segment independently and provide a two-dimensional position, ( ), as well as the angle deviation of the NSW track-segment with respect to an infinite momentum track from IP. Eventually, a coincidence by ( ) between the NSW and outer muon system is required to suppress the fake trigger rate.

A detailed study of the final design and validation of the readout electronics for the trigger system that are able to work at high rates with excellent real-time spatial resolution has been performed. A dedicated parametric digitization model based on the exhaustive standalone MC studies and experimental test beam results has been developed to simulate the response of the NSW trigger system. This contribution will summarize a detail simulation of the NSW trigger decision system, track reconstruction algorithm implemented into the trigger processor and results of performance studies of the DAQ trigger logic.

The NSW simulation has been developed to model the actual response of the detector and its fast electronics. The simulation has been used to get a deep understanding of the trigger logic timing, the tracking-segment finding efficiency, track rate and track-pointing resolutions at the high background hit rate expected during the next phases of operation of ATLAS at the LHC. The results of these performance studies will be presented to show that the NSW trigger system is capable of working with good performance compared to the foreseen requirements.

POSTER / 279

Triggering on hadronic signatures in ATLAS – developments for 2017 and 2018

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Hadronic signatures are critical to the ATLAS physics program, and are used extensively for both Standard Model measurements and searches for new physics. These signatures include generic quark and gluon jets, as well as jets originating from b-quarks or the decay of massive particles (such as electroweak bosons or top quarks). Additionally, missing transverse momentum from non-interacting particles provides an interesting probe in the search for new physics beyond the Standard Model.Developing trigger selections that target these events is a huge challenge at the LHC due to the enormous rates associated with hadronic signatures. This challenge is exacerbated by the amount of pile-up activity, which continues to grow. In order to address these challenges, several new techniques were developed to significantly improve the potential of the 2017 dataset.This talk presents an overview of how we trigger on hadronic signatures at the ATLAS experiment, outlining the challenges of hadronic object triggering and describing the improvements performed over the course of the Run-2 LHC data-taking program. The performance in Run-2 data is shown, including demonstrations of the new techniques being used in 2017. We also discuss further critical developments implemented for the rest of Run-2 and their performance in early 2018 data.

POSTER / 268

Identification of very-low transverse momentum muons with the ATLAS experiment

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The standard muon identification of the ATLAS experiment is optimized for muons with transverse momentum (pT) above 5 GeV. However searches for low mass resonances and many B-physics measurements often need to identify muons with lower pT, where standard algorithms suffers from large backgrounds originating from sources such as hadrons decay in flight. A new “LowPt” identification has been developed to allow optimal muon identification down to 2-3 GeV in pT using variables that are sensitive to track kinks in the inner detector and to the imbalance of the momentum measured in the inner detector and in the muon spectrometer. The new “LowPt” identification, analysed in simulation and in data, shows good efficiencies for muons produced in hard collisions and is effective in rejecting backgrounds.

POSTER / 505

Study of the H->tau+tau decay channel with ATLAS

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After the discovery of the Higgs boson, the precision measurements
of its properties and comparison with the Standard Model (SM) predictions
became a crucial part of the LHC physics programme. A potential observation
of deviations may lead to the indirect discovery of physics beyond the Standard
Model (BSM). The direct observation of the coupling of the Higgs boson to
leptons and its measurements is of particular importance to study the mass
generation for leptons. In this contribution, the results of analyses of the
Higgs boson properties in the H->tau tau decay channel are presented. The
measurements of Higgs SM couplings with 36.1 fb^{-1} of data collected by
ATLAS at $\sqrt{s} = 13$ TeV are shown.

POSTER / 250

Interesting Models unifying Neutrino Mass, Dark Matter, Origin of PMNS and CKM, and GUT

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The Standard Model of particle physics have been extremely successful so far, but there are still many unanswered questions like the origin of neutrino mass, nature of dark matter, the source of quark and lepton flavor mixing and their possible correlation, the theory of grand unification of all SM interactions. In this talk I will focus on some interesting models that attempt to answer these questions and possible correlation between them. Embedding a Pati-Salam quark-lepton unification symmetry, SU(4)$_c$$\otimes$SU(2)$_L$$\otimes$U(1)$_R$, into SU(7) GUT with a Scotogenic radiate neutrino mass and LHC phenomenology will be discussed. I will also touch on $G_{SM}$$\otimes$U(1)$_{B-L}$ with residual Z_4 symmetry leading to Scotogenic radiative Dirac neutrino masses with dark matter, $0\nu 4\beta$ and absence of $0\nu 2\beta$ signal and phenomenology of related rare processes. Possible common origin of CKM and PMNS mixings in a complete model. Other possible topics will include chiral dark sector with composite dark matter leading to Scotogenic two loop neutrino mass and neutrino portal to SM.

POSTER / 237

Measurement and simulation of the background in the CMS muon detectors

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The CMS muon system presently consists of three detector technologies equipping different regions of the spectrometer. Drift Tube chambers (DT) are installed in the muon system barrel, while Cathode Strip Chambers (CSC) cover the end-caps; both serve as tracking and triggering detectors. Moreover, Resistive Plate Chambers (RPC) complement DT and CSC in barrel and end-caps respectively and are mostly used in the trigger. Finally, Gas Electron Multiplier (GEM) chambers are getting installed in the muon spectrometer end-caps at different stages of the CMS upgrade programme.

The study of the different backgrounds the muon detectors are exposed to, is fundamental to assess the system longevity and project its performance to the conditions expected for HL-LHC. In this respect, an accurate modelling of the backgrounds in simulation is of prime importance as many studies rely on simulation-based predictions while these future conditions have never been experienced in reality. The state of the art of the work carried out to understand backgrounds observed with data collected during the LHC runs, as well as at CERN high-intensity gamma irradiation facility, (GIF++), will be presented. Furthermore, the effort made to improve the accuracy of Fluka and GEANT4 based simulations of background will be thoroughly described.

POSTER / **233**

Van der Meer calibration of the CMS luminosity detectors in 2017

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To guarantee smooth and uninterrupted luminosity measurements the CMS experiment is equipped in Run II with three online luminometers: the Pixel Luminosity Telescope (PLT), the Fast Beam Condition Monitor (BCM1F) and the Forward Calorimeter (HF). For the offline luminosity measurement and a cross check of the online detectors the pixel detector is used (Pixel Cluster Counting, PCC). For the calibration of the luminometers once per year a full program of van der Meer (VdM) scans is performed. It consists of series of standard VdM scans and 4 imaging scans. In the standard VdM scans both beams are moving across each other and the transverse size of the beam overlap is defined. Imaging VdM scans are required to disentangle XY correlation. For steering magnet calibrations, under the special beam conditions during the VdM scan, the length scale (LS) calibration is performed. Detailed studies of the systematic effects of beam-beam deflections, orbit drift, LS calibration and unbunched beam correction allow precise luminosity calibration. The methodology of the luminosity calibration and final uncertainty on the integrated luminosity will be presented.

POSTER / **235**

Status of Flavour Maximal Non-minimal Universal Extra Dimension

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We consider an $S^1/\mathbb{Z}_2$ compactified flat extra dimensional scenario where all the standard model states can access the bulk and have generalised brane localised kinetic terms. The flavour structure of brane kinetic terms for the standard model fermions are dictated by stringent flavour bounds on the first two generations implying an $U(2)_{Q_L} \otimes U(2)_{u_R} \otimes U(2)_{d_R}$ flavour symmetry. We consider the constraints on such a scenario arising from dark matter relic density and direct detection measurements, precision electroweak data, Higgs physics and LHC dilepton searches. We discuss the possibility of such a scenario providing an explanation of the recently measured anomaly in $R_{K^{(*)}}$ within the allowed region of the parameter space.

POSTER / 230

Searches for dark matter in CMS in non-hadronic final states

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Searches for a weakly interacting particle candidate (WIMP) for dark matter at the Large hadron Collider complement the WIMP direct detection experiments and is one of the major physics goals of the LHC. A series of analyses in CMS (and ATLAS) are aimed at detecting events where a pair of WIMPs may have been produced and recoiled against a visible particle. Such events give rise to final states with large Missing ET and a high pT object, e.g. a jet, a photon, or a weakly interacting gauge boson.Searches for dark matter in final states with invisible particles recoiling against leptons and photons are presented in this talk. Various topologies are explored where several dark-matter production modes are covered. The talk focuses on the recent results obtained using the data collected during 2016 run of the LHC.

POSTER / 208

Search for Heavy Stable Charged Particles at the CMS experiment using the RPC phase II upgrade

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Several theoretical models accomodate the possibility of Heavy Stable Charged Particles (HSCP). With improved data aquisition in the phase-II upgrade of the CMS-RPC system, triggering and identification of HSCPs are expected to be possible using the Time of Flight technique. Moreover, new RPC chambers will be installed to extend the acceptance coverage up to $|\eta|<2.4$ with improved time and spatial resolution which can complement this search. Performance of new Level-1 trigger strategies to detect HSCPs at the High Luminosity LHC will be shown in this poster.

POSTER / 207

Search for Flavor Changing Neutral Higgs at 13 TeV with CMS

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With increasing dataset at the LHC, it is of importance to search for rare processes such as flavor changing neutral current. The search for flavor changing neutral current with the Higgs boson and the top quark has been performed. The Higgs boson decaying to a pair of b jets is considered. To exploit the large dataset, a machine learning technique like deep learning is used.

POSTER / 211

Search for top squarks in the dileptonic final state in CMS

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Latest results on searches for supersymmetric top quarks are presented, focusing on the final states with two leptons. The results are based on a data set of proton-proton collisions, recorded by CMS at a center-of-mass energy of 13 TeV during 2016 and corresponding to an integrated luminosity of 36.5 fb-1. The results are interpreted as exclusion limits on T2tt simplified models.

POSTER / 115

2S Modules for the Phase-2 Upgrade of the CMS Tracker

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An upgrade program is planned for the LHC to increase the instantaneous luminosity up to 5x10^34 /cm^2/s to reach an integrated luminosity of 3000/fb. The CMS experiment will be equipped with an entire new tracking detector in the so-called Phase-2 Upgrade, when LHC will reach the high luminosity phase, HL-LHC. The new tracking detector must be able to fully exploit the demanding operation condition with a high number of pile-up events, withstand 1.5x10^15 n_eq/cm^2 and in addition will have the capability to deliver Level-1 trigger information. The poster shows the concept of so-called 2S modules of the Outer Tracker with two close-by silicon strips sensors able to discriminate high p_t particles from low p_t particles already on module level. The detector components will be described and the necessary production steps and quality checks during the construction phase will be shown.

POSTER / 114

Cross-section measurements and anomalous gauge couplings searches in multileptonic WZ decays with the CMS detector at 13 TeV

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WZ production is one of the dominant multiboson production processes at the LHC energies. Thus, a good understanding of this process improves our understanding of the Standard Model (SM).

Specifically, the all leptonic final state constitutes an irreducible background in multiple SM and beyond the Standard Model (BSM) searches for low cross-section processes in multileptonic channels. Thus, a precise measurement of its total and differential cross-section is needed to increase the reach of general analysis including multiple leptons final states.

Additionally, the proper WZ cross-section measurement is a handle to BSM physics in terms of the hypothesized existence of anomalous gauge couplings which might modify said quantity. The WZ process is expected to provide special sensitivity in the studies of anomalous charged triple gauge couplings (ACTG) as a handle to study the behaviour of the WWZ vertex.

New results with the full 2016 dataset are presented including the inclusive and differential measurement of the WZ cross-sections as well as the computation of precise confidence regions for different configurations of ACTG presence.

POSTER / 108

Triggering on electrons, photons, tau leptons, Jets and energy sums with the CMS Level-1 Trigger

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The Compact Muon Solenoid (CMS) experiment implements a sophisticated two-level triggering system composed of the Level-1, instrumented by custom-design hardware boards, and a software High Level Trigger. A new Level-1 trigger architecture with improved performance is now being used to maintain high physics efficiency for the more challenging conditions experienced during Run II. In this poster, we present the upgraded CMS calorimeter trigger algorithms. The calorimeter trigger system plays a central role in achieving the ambitious physics program of Run II. The upgraded electronics architecture benefits from an enhanced granularity of the calorimeters to optimally reconstruct the trigger objects. Dedicated pile-up mitigation techniques are implemented for the lepton isolation, the jets and the missing transverse energy to keep the rate under control in the intense running conditions of the LHC. The performance of the new calorimeter trigger will be presented, based on proton-proton collision data collected in Run II. The selection techniques used to trigger efficiently on benchmark analyses will be presented, along with the strategies employed to guarantee efficient triggering for new resonances and other new physics signals.

POSTER / 105

Calibration of the CMS preshower detector in LHC Run2

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The preshower detector, part of the CMS endcap electromagnetic calorimeter, is designed to have good spatial resolution to distinguish between different types of incoming particles. The preshower is a sampling detector with two layers of lead absorber, each followed by 1.9mm pitch silicon strip sensors. Each of the 4288 DC-coupled sensors has an active area of 61x61mm^2, making a total surface of around 16m^2. The in-situ calibration is performed using isolated charged hadrons, which are close to minimum-ionizing. The precision required for the calibration of the preshower is largely determined by the fraction of energy deposited in the preshower with respect to that in the CMS endcap crystal calorimeter. The required channel-to-channel calibration precision is 5%. The achieved precision is better than 5%. In this poster, the calibration strategy and results with LHC Run2 data will be described.

POSTER / **99**

Design status of CEPC booster system

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The booster provides electron and positron beams to the CEPC collider for top-up injection at different energy.An 10 GeV linac is adopted as the injector. Then the beam energy is accelerated to specific energy according to three modes of CEPC collider ring (H, W and Z). The booster is in the same tunnel as the collider, placed above the collider ring and has exactly same survey as the collider ring except for the interaction region. Bypasses are arranged to avoid the detectors at IP1 and IP3 from the outer side. The optics/geometry design,injection/extraction scheme and DA study was shown in this paper.

POSTER / **94**

Three dimensional scintillator tracker in the DUNE near detector

Andrew Olivier[1] ; Chang Kee Jung[2] ; Davide Sgalaberna[3] ; Guang Yang[2] ; Hang Su[4] ; Jose Palomino[2] ; Kevin Wood[2] ; Richard Gran[5] ; Steve Manly[1] ; Tejin Cai[1] ; Vittorio Paolone[4] ; Yuri Kudenko[6]

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The main purpose of the Deep Underground Neutrino Experiment is to measure the CP-violation phase in long-baseline neutrino oscillations, proton decay and super nova neutrinos with a liquid-argon detector of unprecedented size.
In order to constrain the systematics including the flux, neutrino interaction cross section, energy scale and so on, a near detector is needed to measure the un-oscillated neutrino spectra. In the near detector complex, a three dimensional scintillator tracker also called 3DST located downstream of the liquid-argon detector is proposed and being studied. The 3DST detector technology will consist of a large amount of 1 cm x 1 cm x 1cm scintillator cubes. We expect this tracker to have full angle coverage for charge particles, as well as precise energy and angular measurements, which, doing a neutrino-electron scattering study will lead to a strong flux constraint. Besides, 3DST gives an unique opportunity to connect carbon target cross sections and flux measurements in DUNE with other experiments, such as T2K and Minerva. In this poster, the simulation and test beam performances of the 3DST will be shown.

POSTER / **86**

DUNENDGGD, a geometry generator for DUNE near detector design

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The main purpose of the Deep Underground Neutrino Experiment is to measure the CP-violation phase in long-baseline neutrino oscillations, proton decay and super nova neutrinos with a liquid-argon detector of unprecedented size. In order to constrain the systematics including the flux, neutrino interaction cross section, energy scale and so on, a near detector is needed to measure the un-oscillated neutrino spectra. The near detector complex will consist of various components since we are aiming to have a good phase space coverage of the neutrino events. A geometry generation tool, DUNENDGGD is developed based on general geometry description (GGD). DUNENDGGD has a great flexibility to generate different
detector and tracker combinations, therefore, the tool has been widely used in the DUNE near detector group, and a large number of studies have been performed based on DUNENDGGD to design the DUNE near detector. In this poster, the concept and examples of DUNENDGGD will be shown.

POSTER / 71

Thermodynamics for pion gas in the large N limit

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We utilize the nonlinear sigma model for large N as an effective theory for low-energy QCD to study the thermodynamical behavior of a pion gas through a virial expansion of pressure. In particular, we determine the entropy density, specific heat, trace anomaly, and the speed of sound, to find a signature of the deconfinament phase transitions. After considering below critical regimes and specifications in the scattering processes, our results show a concordance with lattice and other theoretical results for a light meson gas.

POSTER / 44

Development of profiling system for low energy physics

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The Standard Model in particle physics is refined. However, new physics beyond the standard model, such as dark matter, requires thousand to million times of simulation events compared to those of the Standard Model. Thus, the development of software is required, especially for the development of simulation tool kits. In addition, computing is evolving. It requires the development of the simulation tool kit to accommodate the evolving computing architecture. Therefore, an efficient simulation tool kit is needed. Then, a profiling system is required to confirm it. In Geant4, a typical simulation tool kit, a profiling system in higher-energy physics areas such as the LHC experiment is well developed, contributing to the development of the software. However, profiling systems in the low-energy physics domain are in the beginning stage. Therefore, we develop it and show performances using it. In addition, profiling is performed depending on the development of software. These profiling systems could be used to confirm the development of software for evolving computing architecture.

POSTER / 23

Construction and prototype modules testing of HT-KZ Ultra-high energy cosmic rays detector system for cosmic rays with energies above 10^17 eV

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The HT-KZ is an ultra-high energy cosmic rays detector system that is currently under construction at Nazarbayev University (NU), Kazakhstan. It is designed to study the spatial and temporal structure of Extensive Air Showers with the energy of the primary above ~10 17 eV, and with high time resolution of the shower disk profile and timing synchronization between the detection points (both ~1 ns). Detector system construction at NU is conducted in collaboration with the Tien Shan high-altitude Science Station (TSHSS).

Based on computer simulations, several prototype designs were created, constructed and tested. This poster will present the design features and testing data from prototype modules currently in operation at NU.

POSTER / 213

Search for additional Higgs Bosons in Final States with b-Quarks with the LHC Run II data at CMS

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Properties of the discovered 125 GeV Higgs boson are in good agreement with the predictions of the Standard Model (SM). However, the current precision of these measurements, allows models, such as Supersymmetry, with extended Higgs sectors, in which the discovered Higgs boson is only one of several Higgs bosons. The work focuses on the search for high mass Higgs bosons in a final state with b-quarks will be presented. The analysis was performed with data collected by the CMS experiment at a center-of-mass energy of 13 TeV in the year 2016, corresponding to an integrated luminosity of 36.9 fb-1. Results of this analysis, as well as they interpretation within models, including the Minimal Supersymmetric Standard Model and Two Higgs Doublets Model, will be shown.

POSTER / 498

Lattice Design of the CEPC Collider Ring for the Conceptual Design Report

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CEPC is the future Circular Electron and Positron Collider proposed by China to mainly study the Higgs boson. This paper will present the bean optics design of the collider ring for the concept design report. The compatible beam optics for W and Z mode will be presented as well.

POSTER / 104

Advancements of THGEM in IHEP, China

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Thick Gaseous Electron Multiplier (THGEM) is one of the promising Micro-pattern Gaseous Detectors. It can be applied to Digital Hadron Calorimeter (DHCAL), TPC tracker readout, Muon detector, single photon detector, neutron imaging and so on. The attractive advantages of THGEM are high gain, robust and low cost. The moderate spacial resolution limits its applications but it is acceptable in many cases as listed above. In recent years, we have made continuous effort to improve THGEM performances, develop new types of THGEMs and . The hole pitch and hole diameter can be reached 400 μm and 150 μm by mechanical drilling and 300 μm and 100 μm by laser sputtering respectively. The sensitive area of a single film can be reached 1.0×0.5m^2. The laser sputtering is hopeful to overcome the mass production difficulty of THGEM. Our test results indicated that better substrate, better performance. The specified FR4 substrate for high performance THGEM was made according to more than 10 types of FR4s. Besides FR4 THGEM, the PTFE, Ceramic and Kapton (PI) THGEMs were also developed for low background experiments and neutron imaging. Another attractive direction is the new structure THGEMs, such as Multi-layer THGEM (M-THGEM), Well-THGEM and so on. M-THGEM shows excellent gain performance within a single thin film. The newly progresses will be also presented.

POSTER / 49

Pilot production of RPCs for the SHiP experiment

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Two main aims of the SHiP (Search for Hidden Particles) experiment are the observation of hidden particles and high-statistics study of tau neutrino events. These particles can be produced from the decay of charmed particles in the SHiP hybrid target which is composed of a totally 58-cm long series of TZM slabs followed by Tungsten slabs of the same total length. A major concern for the experimental design is the precise knowledge of the muon flux and the associated charm production cross section. To achieve the physics goals, we plan to carry out a test experiment with SHiP target replica using CERN SPS 400 GeV/c proton beam at H4 area in July 2018. In this test experiment, RPCs will be used for muon identification and their slope measurements. Recently, we have fabricated gas gaps and strip panels to build 6 trigger RPC modules. The module is composed of a 2-mm gas gap and two orthogonal strips of a 10.625-mm pitch. In addition, we constructed a small prototype RPC of a size of 100 x 130cm2 with the same strip pitch to study the fundamental detector performance using cosmic rays. The current construction of the RPC modules is also as a pilot production for the future SHiP experiment in synergy with the present RPC production for the CMS experiment. In the presentation, we report the design of the RPCs for the test experiment and cosmic-ray test results for the small prototype RPC.

POSTER / **64**

A novel water-Cherenkov detector design with retro-reflectors to produce antipodal rings

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Since Kamiokande, the basic design of water-Cherenkov detectors has not changed: the walls of a water tank are lined with photodetectors that capture Cherenkov photons produced by relativistic particles. However, with this design the majority of photons are lost in insensitivie regions between photodetectors, while at the same time most photodetectors are outside the ring and remain dark. To fix both issues at once, we propose fixing retro-reflectors between all photodetectors. These devices will reflect uncollected photons back through their emission point onto photodetectors at the other side of the tank, producing a secondary, delayed Cherenkov ring. Numerical simulations show that, due to the parallax effect of this antipodal ring, our system can yield up to 2x improvement of detector vertex and angle resolutions. This improvement would be beneficial for kinematic selection of multi-ring events and would lower detector costs by decreasing the number of required photodetectors.

POSTER / **269**

Measurement of the tau lepton reconstruction and identification performance in the ATLAS experiment using pp collisions at sqrt(s)=13 TeV

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Tau leptons play an important role in many Standard Model and Beyond the Standard Model physics processes that are being investigated at the LHC. This poster details measurements of the performance of the reconstruction and identification of hadronic tau lepton decays using the ATLAS detector. The measurements include the performance of the identification, trigger, energy calibration and decay mode classification algorithms for reconstructed tau candidates. The performance of these

algorithms is measured with Z bosons and top quark decays to tau leptons and uses the Run 2 dataset of pp collisions collected at the LHC at a centre-of-mass energy sqrt(s)=13 TeV.

POSTER / 623

The Matrix Element Method used in the search for the associated production of the Higgs boson with top quarks and decaying into tau leptons at CMS

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Latest results of CMS searches for a Higgs boson produced in association with top quarks in final states with tau leptons will be presented. The poster will specifically focus on technical aspects related to the Matrix Element Method implementation and on its impact on the sensitivity of the analysis. The analysis presented here uses proton-proton collision data collected at center-of-mass energies of 13 TeV during the Run II of the LHC.

POSTER / 561

The LHCb tracks reconstruction in Run 2: strategy and performance

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In order to accomplish its wide program of physics measurements, the LHCb collaboration has developed in the past years a complex of algorithms for the reconstruction of the trajectories of charged particles, taking into account the heterogeneous structure of the LHCb tracking system. Several data-driven approaches have been conceived to provide a precise evaluation of the tracking efficiency, a crucial ingredient of many physics analysis. These are mostly based on clean samples of muons, but the recent hints of lepton universality violation required the development of robust data-driven techniques specifically dedicated to electrons, in order to reduce the systematic uncertainties. In addition, special data streams with prompt access have been put in place to collect the calibration samples for both muons and electrons. While the end of the Run 2 data taking period is approaching, we provide an overview of the whole reconstruction strategy and of its performances, which have a direct impact on the quality of the current LHCb results and provide the basis for the upgrade era.

POSTER / 360

Track finding with GPU-implemented Runge-Kutta 4th order tracks in the drift chamber

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The track finding with GPU-implemented Runge-Kutta (RK) fourth order tracks is investigated to track the electrons from the muon conversion in the COMET drift chamber. In the COMET drfit chamber, about 40 % of signal events are composed of multiple turns where the right hits assignment to each turn track is significant in the track finding. Scanning all possible initial track parameters can resolve the hit-to-track assignment problem with a high robustness about the noise hits, but requires a huge computational cost because of two reasons: 1) The adaptive RK method to propagate the electron track needs small global errors, corresponding to small step sizes. 2) Initial longitudinal track parameters (z, pz) have broad uncertainties, so many initial seeds of longitudinal track parameters should be tried and compared. In this presentation, these problems of massive computations are mitigated with 1) the parallel computing of RK track propagation, which assigns each track to each GPU unit cell, called thread, 2) a better initial guess on the longitudinal track parameters using the neural network to reduce the uncertainties of parameters. Future aspects on the applicability to other experiments will also be discussed.

POSTER / **669**

A study on high energy gamma intensities in 208Tl decay from a ThO2 powder sample

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The gamma decay intensities for E > 3 MeV from the 208Tl decay have 100% uncertainties in the NNDC database. New measurements with smaller uncertainties are desirable for understanding nuclear decay properties of the nucleus and high energy gamma background in rare decay experiments. A ThO2 powder sample was measured with a 100% High Purity Germanium(HPGe) in the Yangyang underground laboratory (Y2L) at the Center for Underground Physics(CUP) to obtain more accurate numbers of the high energy gamma intensities from the 208Tl. The experimental set-up, Monte Carlo simulation studies for detection efficiencies, and a preliminary result will be presented in this poster.

POSTER / **662**

Neutrino decoherence due to radioactive decay

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The phenomena of neutrino oscillations can proceed only in the case of the coherent superposition of neutrino mass states. An external environment can modify a neutrino evolution in a way that conditions for the coherent superposition of neutrino mass states are violated. Such a violation results in quantum decoherence of neutrino states and leads to suppression of flavor neutrino oscillations. In general, the quantum decoherence can be engendered by three different reasons: 1) dephasing, 2) entanglement with the environment and 3) revelation of "which-path" information. Another type of decoherence due to neutrino wave separation is usually referred to a classic decoherence and it is well studied. In the presented studies we consider the influence of the neutrino radioactive decay in dense media on neutrino oscillations. It is shown that in this case neutrino oscillations undergo all three types of quantum decoherence. The corresponding damping of neutrino oscillations in the presence of an electron media and a magnetic field is calculated. The formalism of quantum electrodynamics of open systems is used in the performed evaluations. The studied phenomena can be significant for description of neutrino oscillations in extreme conditions of astrophysical environments peculiar to supernovae, neutron stars or quasars.

POSTER / 569

Precise measurement of theta13 and dm^2_ee at RENO

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The RENO experiment has measured the neutrino mixing angle θ_13 and dm^2_ee, using reactor antineutrinos from the reactors at Hanbit Nuclear Power Plant since Aug. 2011. In 2016, RENO published results on sin^2(2θ_13) and dm^2_ee using the energy dependent oscillation of reactor antineutrinos in the 500days of data. RENO has accumulated roughly ~2000 days of data with reduced backgrounds and thus decreased systematic uncertainties. Due to the improved statistics and systematic uncertainties we measured sin^2(2θ_13) and dm^2_ee more precisely. In this talk we will present new results from the ~2000 days data.

POSTER / 497

Search for Sterile Neutrinos at RENO

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The RENO experiment has successfully measured $_{13}$ using the disappearance of electron anti-neutrinos in three-flavor neutrino oscillations.We search for sterile neutrinos in four-flavor oscillation model using roughly 1500 days of data collected by the RENO experiment. We have not seen any positive signal and obtain an excluded region of the oscillation parameters. We present an excluded contour plot in $sin^2(2_{14})$–m^2_{41} space.

POSTER / 431

Measured Cosmogenic Background at RENO

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The isotopes of 8He and 9Li produced by cosmic-rays are a main source for backgrounds in reactor neutrino experiments. The isotope decays to a neutron and an electron and mimics an inverse beta decay of an electron antineutrino from reactors. The 8He/9Li background spectrum and rate are measured using the data taken by the RENO experiment, and compared the with Monte-Carlo prediction. In this presentation, we report the measured cosmogenic background spectrum and rate at RENO.

POSTER / 424

Detection of reactor neutrinos with a delayed signal of neutron capture on Hydrogen at RENO

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The RENO experiment has been taking electron antineutrino data from the reactors at Hanbit nuclear power plant in Korea, using two identical detectors since 2011. It has measured the neutrino mixing angle theta13 using inverse beta decay events with a neutron captured on Gadolinium(Gd). A neutron is also captured by Hydrogen. Reactor antineutrinos are detected with a delayed signal of neutron capture by Hydrogen (n-H). The n-H sample provides an independent result amd a consistent check of the n-Gd result. The coincidence time between the prompt and delayed events is longer than that of n-Gd, and results in a larger accidental background. We measure background rates in the 2000 day n-H data sample. In this presentation, we report the n-H selection criteria for reactor antineutrino candidates and remained background rates.

POSTER / 425

Measurement of theta13 in the reactor neutrino events with neutron captures on Hydrogen at RENO

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RENO has been taking data since August, 2011 and successfully measured the smallest neutrino mixing angle, theta13. The measurement values are obtained from the observed reactor antineutrino events with neutron captures on gadolinium (n-Gd) in the target detector region. In addition, RENO has successfully measured the mixing angle as well, using an independent sample with neutron captures on hydrogen (n-H). Because of a large accidental background in the n-H sample, the analysis requires additional reduction of backgrounds. This independent measurement provides a valuable systematic cross-check of the theta13 measurement using the n-Gd sample. In this talk, we will present the results from the 1500 days of n-H data sample.

POSTER / 261

Upgrade plan for RENO

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The more precise measurement of theta13 is valuable for determining the CP violating phase if combined with an accelerator neutrino beam experimental result. We plan to upgrade the RENO facility to make a precise measurement of theta13 and dm_ee^2 and to solve the problem of the 5 MeV excess in the measured reactor neutrino spectrum. We propose to add more identical near and far detectors and to construct further far detectors located at 1.7 km away from the center of reactor array. In this talk, we present the uprade plan for RENO with expected sensitivities.

POSTER / 248

Status of Korean Neutrino Observatory

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The Korean Neutrino Observatory(KNO), consisting of a 260 kton water Cherenkov detector, is proposed to be built in Korea. KNO will be another far detector at a distance of ~1100 km from the J-PARC where an off-axis neutrino beam is produced. Because of the KNO located in the second oscillation maximum, KNO will enhance the sensitivity of determining the leptonic CP violation phase and the neutrino mass ordering. compared to the case of two Hyper-Kamiokande detectors at Kamioka. It will also search for nucleon decays up to a lifetime of 10^35 years. KNO will be the world-largest underground neutrino telescope for a neutrino burst from a core-collapse supernova. A geological survey of candidate sites are complete to estimate the construction cost for a underground facility.

POSTER / 637

Feasibility study for development of a PET device based on Multi-gap Resistive Plate Chambers

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The Multi-gap Resistive Plate Chambers (MRPCs) provide excellent timing as well as position resolutions at relatively lower cost. Therefore, they can be used in medical imaging applications such as PET where precise timing is a crucial parameter of measurement. We have designed and fabricated several six-gap glass MRPCs and extensively studied their performance. In this paper, we describe the
detector, electronics and the data acquisition system of the setup. We present here the data analysis procedure and initial results of our studies to measure the absolute position of a radioactive source (Na-22) using time of flight (TOF) as well as hit position information and hence to demonstrate their potential applications in medical imaging. We also present the Geant4 based simulation results on the efficiency of our detector as a function of number of gaps and the converter thickness.

POSTER / **274**

The ATLAS Electron and Photon Trigger

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ATLAS electron and photon triggers covering transverse energies from 5 GeV to several TeV are essential to record signals for a wide variety of physics: from Standard Model processes to searches for new phenomena. To cope with ever increasing luminosity and more challenging pile-up conditions at a centre-of-mass energy of 13 TeV, the trigger selections need to be optimized to control the rates and keep efficiencies high. The ATLAS electron and photon trigger evolution throughout the Run 2 will be presented, including new techniques developed to maintain their high performance even in high pile-up conditions as well as first efficiency measurements from the 2018 data taking.

POSTER / **375**

Track reconstruction in high-multiplicity environments with the ATLAS Detector at the LHC

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During 2017, the Large Hadron Collider provided record-breaking integrated and instantaneous luminosities, resulting in huge amounts of data being provided with numbers of interaction per bunch crossing significantly beyond initial projections. In spite of these challenging conditions, the ATLAS Inner Detector (ID) track reconstruction continued to perform excellently, and this contribution will discuss the latest performance results covering the key aspects of track reconstruction. Potential areas for improvement will also be highlighted, and planned improvements to track reconstruction techniques for future data-taking periods, in areas such as track ambiguity solving and vertex reconstruction, will be outlined.

POSTER / 668

Dark matter research platform with deep learning

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Theoretical and experimental studies have been consistently performed to search for dark matter. The project of "dark matter research cluster" supported by National Research Council of Science and Technology in Korea has done successfully to collaborate between indirect and accelerator search. Therefore, so-called "dark matter research cluster season II' has been again approved to expand it to including Information and Communication Technology (ICT) based on deep learning.

Through it, we propose to research and develop intellectual information platform and provide a theoretical template to identify the foundation of dark matters. We also propose to perform astronomical and particle experiment-theory-simulation data utilizing integrated research. We also would like to develop a deep-learning software algorithm on dark matter research.

This could enable us to research and develop an intelligent information platform that combines deep-learning-based astronomical and particle experimental data. It could lead in developing ICT, which makes efficient research to search for dark matter.

POSTER / 412

Hough transform based low momentum track finding for the BESIII drift chamber

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A Hough transform based tracking method is introduced for curling track finding of BESIII drift chamber. This track finding algorithm is implemented in the BESIII offline software system and its performance has been checked. The results show that this algorithm improves the reconstruction efficiency for the low transverse momentum tracks.

POSTER / 216

ttH(bb) in leptonic final state with CMS

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We present a search for the standard model Higgs boson decaying into b quarks and produced in association with a pair of top quarks in the leptonic final states. This search has been performed on the full 13-TeV dataset of proton-proton collisions collected by the CMS experiment at the LHC

in 2016. To separate the $t\bar{t}H$ signal from the irreducible $t\bar{t}$ + $b\bar{b}$ background, this analysis takes advantage of several different innovative methods that are a Deep Neural Network (DNN), a Matrix Element Method (MEM), and a Boosted Decision Tree (BDT).

POSTER / **215**

ttH(bb) in the all-hadronic final state with CMS

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We present a search for the standard model Higgs boson decaying into b quarks and produced in association with a pair of top quarks decaying in the all-jet final state. This search is performed on the full 13-TeV dataset of proton-proton collisions collected by the CMS experiment at the LHC in 2016. To separate the $t\bar{t}H$ signal from the irreducible $t\bar{t}$ + $b\bar{b}$ background, this analysis takes advantage of a matrix element method. A data-driven method has been used to estimate the large multijet background.

POSTER / **228**

Search for high mass resonances decaying into four lepton final state at 13 TeV with the CMS detector

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A search for heavy resonances decaying into four-lepton final states in pp collisions is performed. This search is based on the data collected in CMS detector at the LHC. The full 2016 dataset corresponding to an integrated luminosity of 36 /fb at the center-of-mass energy of 13 TeV is used. Benchmark signal samples are generated using Monte Carlo simulation. Event selection takes into account the inefficiency arising from the boosted signature. Data-driven method is used to determine backgrounds with respect to fake muons. Upper limits on the cross section times branching ratio as a function of resonance mass are presented.

POSTER / **227**

Search for Heavy Majorana Neutrinos in the Events with Same-Sign Lepton Pairs and Jets Using the CMS Detector in pp Collisions at sqrt(s) = 13 TeV

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We present searches on Heavy Majorana neutrinos in the events with same-sign lepton paris and jets, using the pp collision data collected from CMS detector at the centre-of-mass energy 13 TeV. The search range is extened to 20 GeV and 1500 GeV, lower and upper bound respectively, compared to the previous analysis using 8 TeV data. Vector boson fusion production channel is considered as well as s-channel, which improves the sensitivities for mass above several hundreds of GeV. We set upper limits on muon mixing squared, electron mixing squared, and muon-electron cross mixing.

POSTER / 226

Search for high-mass resonances decaying into dilepton final state at 13 TeV with CMS

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A search for new high-mass resonances decaying into electron or muon pairs is performed using full data obtained from 2016 proton-proton collisions at 13 TeV. The search exploits data collected by the CMS experiment at a center-of-mass energy of 13 TeV, corresponding to an integrated luminosity of 36 /fb. No significant deviations are observed from the Standard-model expectation. Upper limits on the product of a new resonance production cross section and branching fraction to dileptons are calculated in a model-independent manner. A lower mass limit is set at 95% confidence level for new spin-1 resonance arising in the sequential standard model, superstring-inspired model and spin-2 Kaluza–Klein graviton arising in the Randall–Sundrum model of extra dimensions.

POSTER / 93

Construction of new hybrid CC1π + sample for the SK detector error estimation

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In the energy region of T2K beam, which is peaked around 0.6 GeV, CC1π + is a dominant channel besides CCQE. Consequently, T2K plans to include CC1π + channel as a signal channel. An evaluation of the Super Kamiokande (SK) detector related systematic errors on CC1π + needs to be done. A new hybrid sample is constructed, as it was successfully used for the evaluation of π 0 background in the SK detector in previous oscillation analyses. In this poster, we will describe how the atmospheric neutrino data in SK enabled the construction of a CC1π + hybrid sample and the possibility to apply the results to the systematic error estimation.

POSTER / 229

Search for Zgamma resonances using leptonic and hadronic final states in proton-proton collisions at 13 TeV with the CMS experiment

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A search for Zgamma resonances using leptonic and hadronic final states is presented. The analysis is based on data from proton-proton collisions at a center-of-mass energy of 13 TeV, corresponding to an integrated luminosity of 35.9 /fb, and collected with the CMS detector at the LHC in 2016. The search strategy is to look for an excess above the non-resonant Standard Model background on the Zgamma invariant mass spectrum. Leptonic and hadronic decay modes of the Z boson are investigated and the results are combined and interpreted in terms of upper limits on the product of the production cross sec- tion and the branching fraction to Zgamma.

POSTER / 218

Search for the Standard Model Higgs boson in the dilepton plus a photon channel at 13 TeV with CMS

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This poster presents the search for a Higgs boson decaying into dileptons plus a photon. This topology has contributions from Z boson and a photon or two photons, one of which has an internal conversion into a lepton pair. This is one of the important rare Higgs decay channels and can be used to probe new physics as well. The results with the data collected by the CMS detector at the LHC from proton-proton collisions at 13TeV in 2016 will be shown.

POSTER / 402

Innovative Strategies in the Search for Electroweak Production of Compressed SUSY States with the ATLAS Detector

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The search for electroweakinos and sleptons is a key component of the supersymmetry program at the LHC. In particular, natural SUSY models motivate small mass splittings between the lightest charginos and neutralinos, known as a compressed mass spectrum. Such a scenario presents several experimental challenges, since the decay products are very soft and there is little final state missing energy. In order to build a sensitive analysis around these difficulties, a variety of new techniques are applied, including improvements with ISR-assisted topologies and lepton reconstruction. Here, some of these new strategies are described, and recent results from the search using data at $\sqrt{s} = 13$ TeV from the ATLAS detector are presented.

POSTER / 243

Study of Jet Substructure Variables with the SiFCC Detector at 100 TeV

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We study the performance of jet substructure variables with a detector designed for very high energy proton collisions, the SiFCC detector. The two-prong jets from Z'->WW and three-prong jets from Z'->ttbar are compared with the background from light quark jets at the same energy. The calorimeter geometry is benchmarked in various configurations in order to understand the impact of granularity on variables such as groomed jet mass, Njettiness and energy correlations within the jets. We present results on signal efficiency and background rejection using full GEANT simulations.

POSTER / 120

Heavy flavour identification at CMS

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Most of the CMS studies rely on the identification of b jets (b tagging), which is important for a broad range of analyses at CMS. Identification algorithms of jets from B hadrons heavily rely on machine learning tools and are thus natural candidates for advanced tools like deep neural networks. During the past couple of years, the CMS Collaboration has proven the power of deep neural networks implementing new algorithms, which outperform previous algorithms for b jet identification. While improving b tagging, the CMS Collaboration is pushing the heavy flavor identification beyond the traditional boundaries, with the implementation of b tagging algorithms specialized to the boosted topologies, and the development of c tagging algorithms, used to identify jets originated from charm quarks. With the increased experimentally excluded mass ranges of new particles, in several cases at the TeV scale, searches need to focus more and more on very boosted regimes. Several heavy flavor identification tools specific for boosted topologies have been developed to make these searches possible, such as b tagging of subjets and a double b tagger, aiming at the identification of boosted decays of the heavy particles into pairs of b quarks. This talk will present all this cutting edge developments, together with their performance measurements on CMS data.

POSTER / 665

A Cosmic Ray Detector for the Mu2e Experiment at Fermilab

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The Mu2e experiment is designed to search for the charged-leptonflavor-violating process, μ− to a e−, with unprecedented sensitivity. The single 105-MeV electron that results from this process can be mimicked by electrons produced by cosmic-ray muons traversing the detector. An active veto detector surrounding the apparatus is used to detect incoming cosmic-ray muons. To reduce the backgrounds to the required level it must have an efficiency of about 99.99% as well as excellent hermeticity. The detector consists of four layers of scintillator counters, each with two embedded wavelength-shifting fibers, whose light is detected by silicon photomultipliers. The design and expected performance of the cosmic ray veto detector will be described.

POSTER / **287**

Single Event Upsets in the ATLAS IBL Frontend ASICs

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During operation at instantaneous luminosities of up to 1.5 /s/cm^2 the frontend chips of the ATLAS innermost pixel layer (IBL) experienced single event upsets affecting its global registers as well as the settings for the individual pixels, causing, amongst other things loss of occupancy, noisy pixels, and silent pixels. A quantitative analysis of the single event upsets as well as the operational issues and mitigation techniques will be presented.

POSTER / **286**

Modeling Radiation Damage to Pixel Sensors in the ATLAS Detector

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Silicon pixel detectors are at the core of the current and planned upgrade of the ATLAS detector at the Large Hadron Collider (LHC). As the closest detector component to the interaction point, these detectors will be subjected to a significant amount of radiation over their lifetime: prior to the High-Luminosity LHC (HL-LHC), the innermost layers will receive a fluence in excess of 10^15 neq/cm2 and the HL-HLC detector upgrades must cope with an order of magnitude higher fluence integrated over their lifetimes. Simulating radiation damage is critical in order to make accurate predictions for current future detector performance that will enable searches for new particles and forces as well as precision measurements of Standard Model particles such as the Higgs boson. We present a digitization model that includes radiation damage effects to the ATLAS pixel sensors for the first time and considers both planar and 3D sensor designs. In addition to thoroughly describing the setup, we compare predictions for basic pixel cluster properties on leakage currents, depletion

voltage, charge collection efficiency, Lorentz angle etc. with real data collected at LHC proton-proton collisions.

POSTER / 468

Physics performance of the Particle Flow Oriented detector at the CEPC

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After the Higgs discovery, precise measurements of the Higgs properties and the electroweak observables become vital for the experimental particle physics. A powerful Higgs/Z factory, the Circular Electron Positron Collider (CEPC) is proposed. The Particle Flow oriented detector design is proposed to the CEPC and a Particle Flow algorithm, Arbor has been designed and optimized accordingly.
In this talk, we would like to report the status and progress of the detector design and performance study of the PFA oriented CEPC detector.

POSTER / 630

PURIFICATION TECHNIQUES OF MoO3 FOR AMoRE EXPERIMENT

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The Advanced Mo based Rare process Experiment (AMoRE) is a series of experiments focused on searching for the neutrinoless double beta ($0\nu\beta\beta$) decay of 100Mo. Molybdenum based single crystals of high purity are used as scintillating elements of detector. Sensitivity of the AMoRE detector is limited by the background in the region of the expected peak, the main source of the background forced due to decay chains of natural isotopes, mainly Ra, Th and U presenting as impurities in detector material.
For the all molybdenum-based crystals, molybdenum trioxide powder is used as a main initial material for crystal growth. The MoO3 is volatile at temperatures below melting point, so sublimation at temperature range of 700-720 C under low vacuum allows remove main contamination. By the way, after successive double sublimation raw MoO3 at 720 C Th and U contamination significantly reduced below 20 ppt and 130 ppt levels, respectively. Combination of double sublimation and wet chemistry techniques, like co-precipitation followed by complete precipitation of polyammonium molybdates from acidic media, provides deep removal of many elements. After annealing in air environment Th and U concentration in the purified MoO3 powder decreased below detection limit 10 ppt.
In order to measure lower concentration and decrease the detection limit, development of analytical method for measurement of high purity inorganic materials, like MoO3 and other molybdenum

based crystals, by ICP-MS in tandem with solid-phase separation is going on.
The presented techniques shown high effectiveness for raw MoO3 purification and could be used for purification of enriched powder, moreover, it might be helpful for the other projects which are using pure MoO3.

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POSTER / 25

Dynamical system analysis of agegraphic dark energy in brane-induced gravity

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One of the main aspects of physics beyond the standard model is the concept of extra dimensions. Among many extra dimensional cosmological models the so called DGP model (also called brane-induced gravity) with two branches is of particular interest. In this manuscript we consider the normal branch of the DGP model in which the existence of a dark energy component is necessary to explain the late time acceleration of the universe. For this purpose, we assume agegraphic dark energy (ADE). The best reason for this combination is that both the braneworld theories and the ADE, result from the string theory. We study this model in a dynamical system approach where is a useful tools in investigating cosmological models. By defining a set of suitable new dimensionless variables, we find two critical points for the system and the related eigenvalues. The one which yields to $\omega_{tot} = 0$, represents matter dominated solution and is a repulsive point. But the other which always results $\omega_{tot} < -1/3$, corresponds to de-sitter phases and is a saddle point. Also, we find the effect of extra dimensions in eigenvalues. Finally, the phase trajectories and the evolutionary curves of the dimensionless density parameters will be shown.

POSTER / 646

Electronics for Hyper-Kamiokande

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The Hyper-Kamiokande experiment, aiming to search for nucleon decay and study various properties of neutrinos, is expected to start in 2026. The detector is the ring imaging water Cherenkov type similar to Super-Kamiokande. The newly developed 20inch PMT will be used as photo sensors. They realize better timing resolution but the pulse shape of output signal is slightly different from the PMT currently used in Super- Kamiokande. Because the size of the detector is huge and it is not feasible to run the cable from each PMT to the electronics module located outside of the tank, we are considering to place the front-end electronics module with high voltage system inside the tank. Each front-end module will handle ~24 PMTs and transfer the data to the outside of the detector via an optical data transfer system. One candidate of digitizer is charge-to-time converter (QTC) with FPGA based TDC. In this presentation, we will
review the conceptual design of the front-end electronics module together with the detail of the

R&D status of components, including the basic performance of newly implemented FPGA based TDC.

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High speed trigger system with 4.8Gbps rate for COMET Phase-I experiment

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We report the design and construction of the trigger system for COMET Phase-I experiment of searching for cLFV of muon-electron conversion. A robust, intelligent and flexible trigger system of COMET Phase-I experiment is critical to cope with background hits rating a few MHz in Cylindrical Drift Chamber detector of COMET experiment. To establish robust links between central trigger and timing system with detector readout system, custom serial link rating 4.8Gbps and the receiver board for trigger and timing information are designed and produced. The primary trigger signal will be generated and processed to make intelligent decision using decision tree on conversion signal, through custom-made processing system. The performance of the central trigger system and its test results under beam condition will be reported also.

POSTER / 244

Study of Jet Substructure Variables with the SiFCC Detector at 100 TeV

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We study the performance of jet substructure variables with a detector designed for very high energy proton collisions, the SiFCC detector. The two-prong jets from Z'->WW and three-prong jets from Z'->ttbar are compared with the background from light quark jets at the same energy. The calorimeter geometry is benchmarked in various configurations in order to understand the impact of granularity on variables such as groomed jet mass, Njettiness and energy correlations within the jets. We present results on signal efficiency and background rejection using full GEANT simulations.

POSTER / 507

Search for SM H⟶μμ production in pp collisions with the ATLAS detector at the LHC

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The detection of the SM H⟶μμ decay is important to study the Higgs boson Yukawa couplings to the 2nd generation fermions. Discovering the signal of Higgs boson decay to dimuon is extremely challenging due to the small decay branching fraction (2.2x10-4) and very large irreducible background from Drell-Yan production at the LHC. The search for the H⟶μμ decay has been a high profile analysis in Higgs physics study program. This poster presents the latest search method and results at the time of the conference. Using the combined data sets from LHC Run 1 to Run 2, we present the limit on the signal strength of H⟶μμ.

POSTER / **506**

Search for dark matter candidates in the channel of Mono-H($\to \gamma\gamma$) at the ATLAS experiment

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A search for a dark matter candidate in association with a Higgs boson decaying to two photons based on 36.1 fb^{-1} data collected with the ATLAS detector at the LHC at the energy of 13 TeV will be presented. The results are interpreted in in different benchmark models: a baryonic Z' model and a two-Higgs-doublet-model with a Z' boson.

POSTER / **406**

Search for four-top-quark production in pp collisions at sqrt(s) = 13 TeV with the ATLAS detector

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Recent results on the searches for four-top-quark production are presented. Searches for four-top-quark production, in the single-lepton (1L), opposite and same-sign (2OSL and 2SSL) dilepton and multilepton (3L) final states are summarised. Special focus is given to the 1L and 2OSL channels, where a data-driven method is developed as an estimate for the dominant background from top-quark pair production in association with jets. The combination of these searches is shown and limits on four top-quark production are set in a variety of models.

POSTER / 405

Search for high-mass dimuon resonances using proton-proton collisions at $\sqrt{s}$ = 13 TeV with the ATLAS detector

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This search focuses on high-mass resonances using the latest data collected by the ATLAS detector at the LHC, which has an unprecedented centre-of-mass energy of 13 TeV. The search is conducted for resonant new phenomena in dimuon final states. The dimuon invariant mass spectrum is the discriminating variable used in this search. No significant deviations from the Standard Model expectation are observed. Lower limits are set on the signal parameters of interest at 95% confidence level.

POSTER / 210

Search for ttH production in multileptons final states at 13 TeV with CMS

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A search for top quark pair production in association with a Higgs boson in sqrt(s) = 13 TeV pp collisions is presented. The search, performed in a dataset of 35.9 fb^{-1} collected by the CMS detector along the year 2016, is performed in channels with at least two same-sign leptons and b-jets, targeting the WW^, *ZZ*^ and tautau decay modes of the Higgs boson. A best fit of 1.5 \pm 0.5 times the standard model prediction is obtained, with an observed (expected) significance of 3.3 (2.5) sigma, by the combination of these results with the ones obtained in the 2015 dataset.

POSTER / 205

Measurements of differential top quark pair production cross sections as a function of kinematic event variables at 13TeV with CMS

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Measurements of differential ttbar production cross sections are presented in the single-lepton decay channel, as a function of a number of kinematic event variables. The measurements are performed with proton-proton collision data collected by the CMS experiment at the LHC during 2016 at sqrt(s) = 13 TeV, with an integrated luminosity of 35.9 fbinv. The data are compared to a variety of state-of-the-art leading-order and next-to-leading-order tt simulations.

POSTER / 238

Aging Studies of the triple-GEM detectors for future upgrades of the CMS muon high rate region at the HL-LHC

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The high-luminosity LHC (HL-LHC) upgrade is setting a new challenge for particle detection technologies. In the CMS muon system based on gas detectors, the increased luminosity will yield a ten times higher particle background compared to the present LHC conditions. To cope with the high-rate environment and to maintain the actual performance, new Gas Electron Multiplier (GEM) detectors will be installed in the innermost region of the forward CMS muon spectrometer, 2 < eta < 2.8 (ME0 project). The detailed knowledge of the detector performance in the presence of such a high background is crucial for an optimized design and efficient operation at the HL-LHC. A precise understanding of possible aging effects of detector materials and gases is of extreme importance. For this reason, aging tests of full sized triple-GEM detector operated with an AR/CO2 (70:30) gas mixture at an effective gas gain of 2X10^4, are in course at GIF++, the CERN Gamma Irradiation Facility. One detector is irradiated with 662 keV gamma – rays from a 14 TBq 137Cs source and, in parallel, a second similar detector with 22 keV X - rays at the quality control lab. This contribution describes the performance of triple-GEM detectors during the irradiation test and reports on their state-of-the art.

POSTER / 203

Measurement of normalized differential ttbar cross sections in the dilepton channel from pp collisions at 13 TeV with CMS

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Normalized differential cross sections for top quark pair production are measured in the dilepton (e^+e^-, mu^+mu^-, and $mu^{-+}e^{+-}$) decay channels in proton-proton collisions at a center-of-mass energy of 13\TeV. The measurements are performed with data corresponding to an integrated luminosity of 2.1\fbinv using the CMS detector at the LHC. The cross sections are measured differentially as a function of the kinematic properties of the leptons, jets from bottom quark hadronization, top quarks, and top quark pairs at the particle and parton levels. The results are compared to several Monte Carlo generators that implement calculations up to next-to-leading order in perturbative quantum chromodynamics interfaced with parton showering, and also to fixed-order theoretical calculations of top quark pair production up to next-to-next-to-leading order.

POSTER / 116

A Search for Vector-Like Quark Pair Production using a New Multiclassification Machine Learning Algorithm for Boosted Final State at CMS

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We present a unique search for vector-like T quark pair production, targeting all possible decay modes tH, tZ, and bW, of the T quark at once. We use data collected from the CMS experiment at center of mass energy of 13 TeV. We use a multivariate algorithm, the 'boosted event shape tagger' (BEST), to classify candidate jets as originating from top quarks, W, Z, or Higgs bosons. BEST uses kinematic distributions evaluated in several hypothesized reference frames of the candidate jet as inputs to a neural network-based machine-learning algorithm, to better determine consistency with the decay products of a heavy standard model particle. With this multiclassification algorithm, we categorize candidate events according to multiplicities of heavy objects observed in the final state, and use the sum of all observed jet momenta to better discriminate signal events from the expected QCD multijet backgrounds. With this strategy, we increase signal acceptance relative to standard search techniques, and obtain sensitivities competitive with existing VLQ searches, optimized for specific final states.

POSTER / 357

Recent results from the study of emittance evolution in MICE

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The Muon Ionization Cooling Experiment (MICE) has measured the evolution of beam emittance due to ionization cooling. In MICE, a muon beam is focused onto an absorber using a large aperture solenoid. Lithium hydride and liquid hydrogen absorbers have been studied. Diagnostic devices are placed upstream and downstream of the focus, enabling the phase space coordinates of individual muons to be reconstructed. By observing the properties of ensembles of muons, the change in beam emittance can be measured.
Data taken during 2016 and 2017 are currently under study to evaluate the change in emittance due to the absorber for muon beams with various initial emittances, momenta, and settings of the magnetic lattice. Simulations have been used to estimate the regimes in which heating and cooling are expected and to evaluate the equilibrium emittance, at which neither heating nor cooling is observed. The results of the simulations have been compared to the measured emittance changes. The current status and the most recent results of these analyses will be presented.

POSTER / 285

Measurement of Single Event Upset rates in single pixels of ATLAS IBL

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Techniques have been developed to determine the single upset rates in individual pixels in the innermost layer of the ATLAS pixel detector, called IBL. SIngle pixel SEU cannot be observed directly through error reporting of the pixels as there is no such function, nor is there real time monitoring of configuration during operation. Through analysis of cluster data from physics running and time-over-threshold value distributions the upset rates of individual bits have been extracted and compared to expectation from early beam tests of individual devices. The upset rate is large enough to impact precision measurements, such as luminosity determination from cluster rates, which has a 1% target precision. Corrections for SEU must be developed in order to make such measurements.

POSTER / 112

Probing Dark Matter with the Higgs Boson in the diphoton final state with CMS

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A search for the associated production of dark matter with a Higgs boson which decays into two photons is presented. The search uses data from proton-proton collisions at a center-of-mass energy of 13 TeV, collected with the CMS detector at the LHC in 2016, corresponding to an integrated luminosity of 35.9 fb−1. Results are interpreted in the context of two dark matter models: a two-Higgs-doublet-Z' model where the Z' decays to a pseudoscalar and a standard model-like Higgs Boson and a baryonic Z' simplified model. A combination of these results with a similar search where the Higgs boson decays to two tau leptons is finally presented.

POSTER / 110

Search for supersymmetric partners of the tau lepton with CMS

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Searches for supersymmetry are presented that target the direct and indirect stau pair production. The analyses exploit the final states with two taus of opposite charge and significant missing transverse momentum. The results are based on a data set of proton-proton collisions, recorded by the CMS experiment at a center-of-mass energy of 13 TeV and corresponding to an integrated luminosity of 36 fb-1. Exclusion limits on simplified SUSY models parameters are calculated.

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Measurement of the of $\tau^{\pm} \to \pi^{\pm}e^{+}e^{-}\nu_{\tau}$ branching fraction by Belle

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We present the first measurement of branching fraction for a rare tau decay, $\tau^{\pm} \to \pi^{\pm}e^{+}e^{-}\nu_{\tau}$, using a 562 fb^{-1} dataset collected with Belle detector at the KEKB asymmetric-energy e+e- collider. The $\gamma^{*}W^{*}\pi$ vertex involved in this decay provides unique knowledge to study the dynamics of strong interactions at the energy scale of tau mass. Relevant form factors can serve as an approach to test the validity of the calculation by Resonance Chiral Theory. Meanwhile, a precise measurement of Br($\tau^{\pm} \to \pi^{\pm}e^{+}e^{-}\nu_{\tau}$) also facilitates the searching for LFV modes, e.g., $\tau^{\pm} \to \mu^{\pm}e^{+}e^{-}$, where the decay mode under consideration stands as a notable background.

POSTER / 204

Measurement of ttbb production at 13 TeV with the CMS experiment

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The measurement of the cross section ratio σt̄tbb̄ / σt̄tjj is performed in pp collisions at √s = 13 TeV with the CMS detector at the LHC. Events with two leptons (e or μ) and at least four reconstructed jets, including at least two identified as b quark jets, in the final state are selected. The ratio is measured at the particle in visible phase space and the parton level in the full phase space. The measurement is compatible with the expectation obtained from the POWHEG simulation interfaced with PYTHIA.

POSTER / 111

CMS muon reconstruction and identification performance of Run2 data

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The performance of CMS muon system is crucial for many physics results in CMS. Recently, many upgrades related to muon performance have been carried out such as the installation of new pixel detector and the development of new algorithm in muon high-level trigger. The performance of CMS muon reconstruction and identification has been studied based on the data collected with the CMS detector at sqrt(s)=13 TeV in 2017. Muon reconstruction and identification efficiencies are measured using tag and probe method, and the results are compared to previous performances.

POSTER / 109

The CMS Level-1 muon triggers for the LHC Run II

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The CMS experiment implements a sophisticated two-level triggering system composed of Level-1, instrumented by custom-design hardware boards, and a software High Level Trigger. A new Level-1 trigger architecture with improved performance is now being used to maintain high physics efficiency for the more challenging luminosity conditions experienced during Run II. The CMS muon detector was designed for preserving the complementarity and partially redundant muon detection systems, Cathode Strip Chambers (CSC), Drift Tubes (DT) and Resistive Plate Chambers (RPC), until they were combined at the input to the Global Trigger. The upgraded muon trigger combines information from the three muon detectors in the track reconstruction in order to obtain a better efficiency and lower rates. Advanced pattern recognition and MVA (Boosted Decision Tree) regression techniques implemented directly on the trigger boards allow high-momentum signal muons to be distinguished from the overwhelming low-momentum background. The algorithms for the selection of events with muons, both for precision measurements and for searches of new physics beyond the Standard Model, will be described in detail. The performance of the upgraded muon trigger system will be presented, based on proton-proton collision data collected in Run II.

POSTER / 106

Performance Measurements of B-tagging Algorithms in CMS

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The identification of jets originating from b-quarks is of great importance to many physics analyses. For this reason, a great deal of effort has been put into developing several algorithms that can efficiently distinguish b-jets from light and c-jets. These algorithms typically use information regarding reconstructed objects such as the jet's tracks, secondary vertices and jet-associated leptons. This information is then fed into a multivariate classifier to distinguish whether or not the jet originated from a b-quark. The efficiency with which an algorithm can identify b-jets can differ between simulation and data and therefore correction factors are derived from the ratio of these efficiencies. Several methods have been developed to correct the b-tagging efficiences in MC from the analysis of data events. This poster will focus on the results from techniques that use multijet and ttbar events for the CMS b-tagging algorithms using data collected from 13TeV proton-proton collisions.

POSTER / 81

Design and R&D of CEPC Superconducting RF System

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CEPC is a 100 km double-ring circular electron-positron collider operating at 90-240 GeV center-of-mass energy of Z-pole, WW pair production threshold, and Higgs resonance, with the feasibility of energy upgrade. The conceptual design report (CDR) of CEPC has been published as an important step to move the project forward. Superconducting RF system is one of the most important and challenging accelerator systems due to the wide range of beam energy and current of CEPC operation. In this contribution, the CDR layout design and configuration of CEPC superconducting RF system will be introduced. According to CEPC physics operation model with long Higgs run first, the Higgs, W and Z mode will use the same RF cavity to achieve their luminosity goals, which is different from the FCC-ee approach. The design consideration for beam-cavity interaction with both fundamental and higher order modes are discussed, including the special issue with parking cavities. The operation of Booster fast RF voltage ramp with the narrow-band cavity is discussed. The SRF technology design and R&D progress is also shown at last with some high light on the Fe-based pnictide thin film study.

POSTER / 100

Emittance growth from Beam-Gas Scattering in CEPC

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Large angle beam-gas scattering events are rare but can induce large betatron oscillation amplitudes, which drive particles beyond the core and into the halo region. On the other hand, small angle scattering events have higher probability and will act analogously to quantum excitation. They can dilute core the particle distribution and cause emittance growth. In this paper, numerical estimation and Monte Carlo simulations of this process at CEPC are presented.

POSTER / 461

Performance of Jets at CEPC

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After the Higgs discovery, precise measurements become vital for the experimental particle physics. A powerful Higgs/Z factory, the Circular electron-positron Collider is proposed. Adequate reconstruction and detector design are fundamental to this project. Arbor algorithm has been optimized to fulfill the CEPC physics requirements and is used as the core for the CEPC physics reconstruction. With a particle flow algorithm oriented detector design, we will present the current performance of jets at CEPC. Crucial studies to be covered in the future will also be discussed in this poster.

POSTER / 349

Measurement of the psi(2S) to J/psi cross section ratio in photoproduction with the ZEUS detector at HERA

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The exclusive photoproduction reaction $\gamma p- > \psi(2S)p$ has been studied with the ZEUS detector in ep collisions at HERA using an integrated luminosity of 350 pb^{-1}, in the kinematic range $30 < W <$ 180 GeV, Q^2 < 1 GeV^2, $|t|$ < 5 GeV^2, where W is the photon proton centre-of-mass energy, Q^2 is the photon virtuality and t is the four-momentum transfer at the proton vertex. The $\psi(2S)$ mesons were identified via the decay channels: $\psi(2S)- > \mu^+\mu^-$ and $J/\psi\pi^+\pi^-$ with $J/\psi- > \mu^+\mu^-$. The ratio of the production cross sections $R = \sigma(\psi(2S))/\sigma(J/\psi)$ was measured as a function of W and compared to predictions of the perturbative QCD.

POSTER / 214

Study of hadronic processes in the energy interval from 2 GeV up to 3.08 GeV at BESIII.

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500 pb^{-1} of data have been collected by BESIII between 2.0GeV and 3.08 GeV. Recent results on the line-shape of $e^+e^- \rightarrow \phi\pi\pi, K^+K^-, 2(K^+K^-), \phi\eta, \phi\eta', \omega\pi^0, \omega\eta$ are reported. Possible new resonances in these channels are studied, in particular the $\phi(2170)$, that may be the strange partner of the Y(4260).

POSTER / 92

Exclusive Photoproduction of 2π+2π− Final State at HERA

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Exclusive production of four charged pions at the ep collider HERA is studied at small photon virtualities $Q^2 < 2$ GeV^2. The data were taken with the H1 detector in the years 2006 and 2007 at a centre-of-mass energy of $\sqrt{s} = 319$ GeV and correspond to an integrated luminosity of 7.6 pb^{-1}. The cross section of the reaction $\gamma p \rightarrow 2(\pi^+\pi^-)Y$ is determined in the phase space of $45 < W_{\gamma p} < 100$ GeV, $|t| < 1$ GeV^2 and $M_Y < 1.6$ GeV. The 4π mass spectra indicate that the reaction proceeds predominatly via production and decay of $\rho'(1450)$ and $\rho''(1700)$ resonances. Parameters of these resonances as well as production cross sections times branching ratio into four charged pions are estimated from the mass fit, which includes contributions from non-resonant 4π channel and interference terms.

POSTER / 588

Central Exclusive Production at LHCb

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The installation of scintillating pad detectors (Herschel), bracketing the LHCb detector along the beamline, have significantly enhanced LHCb's sensitivity to central exclusive production. Additionally, dedicated triggers during the early measurement period of Run 2 have produced an extended CEP dataset. A summary of results from Run 1 as well as early results from Run 2 will be shown.

POSTER / 653

: Multi-channel YSO scintillator crystals for the application of low energy X-rays detection in space

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We developed an X-ray detector which consisted of 36-multi-channel Yttrium OxyorthoSilicate (Y2SiO5:Ce,YSO) scintillator crystals and 36-Multi-Anode PhotoMultiplier Tubes(MAPMTs). Both YSO scintillator crystal and MAPMT have 64 channels in an 8×8 array. Therefore the X-ray detector has 2304 channels in total. The reason for choosing YSO scintillator crystal is that it has several advantages in X-ray detection compared to other scintillators. First, it has no intrinsic backgrounds which are crucial to detecting low energy X-rays. Next, it has high light yield and fast decay time. We applied the YSO scintillator crystal X-ray detector to the space mission, which is called Ultra-Fast Flash Observatory(UFFO)/*Lomonosov*, launched into space on Apr. 2016. We confirmed that its stable operation in space to detect X-rays. Here, we will present its design, fabrication, and performances on the detection of low energy X-rays.

POSTER / 313

Light Dark Matter through Assisted Annihilation

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We investigate light dark matter scenarios where annihilation to Standard Model particles at tree-level is kinematically forbidden. In such cases annihilation can be aided by massive Standard Model-like species, called assisters, in the initial state that enhances the available phase space opening up novel tree-level processes. We investigate the feasibility of such non-standard assisted annihilation processes to reproduce the observed relic density of dark matter. We present a simple model where this is realised. We find that if the dark matter and assister are relatively degenerate the required relic density can be achieved for a keV-MeV scale dark matter. We briefly discuss the astrophysical and cosmological constraints on such dark matter scenarios.

POSTER / 260

B_0 and B_{s0} mesons in hot and dense asymmetric nuclear medium

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We investigate the in-medium masses and decay constants of scalar B_0^+, B_0^- and B_{s0} mesons in hot and dense isospin asymmetric nuclear medium, using QCD sum rule approach and chiral SU(3) model. In chiral SU(3) model, using mean field approximation, we calculate the in-medium values of scalar fields σ, ζ, δ and χ. Further, the light quark condensates and gluon condensates needed for the QCD sum rules are expressed in terms of these scalar fields σ, ζ, δ and χ. Furthermore, in-medium values of these condensates are then used in QCD sum rules in order to observe in-medium masses and decay constants of above mentioned mesons. The results of the present investigation may be helpful in order to understand possible outcomes of the future heavy ion collision experiments like CBM and PANDA, at GSI Germany.

POSTER / 1058

Commissioning of Belle II data acquisition

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The Belle II experiment operates at the SuperKEKB e^+ e^- energy-asymmetric collider on or near the \Upsilon(4S) resonance energy. The Belle II experiment is now in the "Phase 2" run and focusing on the search for new physics related with dark sector, axion-like particles, etc. with an intermediate luminosity on the way to reach the challenging target. To accomplish the physics goal of Phase 2, we need to implement a new trigger menu for the single photon and low multiplicity events. A high trigger rate is expected for collecting such data. In this presentation, we describe the data acquisition (DAQ) system of Belle II, focusing on the successful commissioning of the complex DAQ, and the performance of the system for the new physics search mentioned above.

POSTER / 15

Primary (conformal) photons

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We find that an evidence of primary (conformal) photons and their disappearance is a signal of phase transition in the vicinity of the Critical Point. The novel approach to an approximate scale symmetry breaking is developed for this. A scalar dilaton could be the dominant messenger between conformal sector and Standard Model. The origin of primary photons is conformal anomaly through the decays of the dilatons. In the experiments with scanning of the observables, the deviation of the primary photons escape rate Rγγ from about ~ O(0.2), compared to that of π0 ⟶ γγ decay, to its vanishing will indicate the appearance of CP. At the CP no escape of the primary photons are seen.

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Search for Muon to Electron Conversion at J-PARC - COMET Experiment

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Muon to electron conversion in a muonic atom is a process of charged lepton flavor violation (CLFV). It is not allowed in the Standard Model (SM) and known to be one of the best processes to search for new physics beyond the SM. The COMET experiment aims to search for this process at J-PARC with single-event sensitivity of 3×10^{-17}, which is about 10,000 improvement over the current limit. Recently the COMET experiment has taken a staged approach. COMET Phase-I, as the first phase, aims at a single-event sensitivity of 3×10^{-15} with a partial muon beam line and a Phase-I dedicated detector. The construction of COMET Phase-I has started in 2013 and its physics run is expected to start in 2018/2019. The COMET Phase-II will follow immediately afterwards. In this talk, we will describe the physics motivation of CLFV, and the details of COMET Phase-I / Phase-II together with the current status of the experiment preparation.

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Status of the Mu3e experiment

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The Mu3e experiment searches for the charged lepton flavour violating μ+ ⟶ e+e+e− decay and it aims at reaching an ultimate sensitivity of 10^−16 on the branching frac- tion of the μ+ ⟶ e+e+e− decay, four orders of magnitude better than the current limit B(μ+ ⟶ e+e+e−) < 10^−12. The experiment will be hosted at the Paul Scherrer Institute (Villigen, Switzerland) which delivers the most intense low momentum continuous muon beam in the world (up to few ×10^8 μ/s). In order to be sensitive to the signal at this so high level, to reject the background and to run at the intensity beam frontier excel- lent detector performances are needed. To match those requests the experiment has been design based on completely new technologies. Extensive test beams have been performed to validate the detector design. The collaboration is concluding the detector R&D phase and is approaching the pre-engineering phase. A pre-engineering run is foreseen next year with sub-modules of each sub-detector followed by a full assembled pre-engineering run for 2020. The physics runs is expected to start in 2021 followed by at least three years of data taking. A review of the Mu3e experiment and its physics case will be given.

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Testing discrete symmetries with neutral kaons at KLOE-2

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The KLOE-2 experiment is finalizing data taking at the upgraded e+e- DAΦNE collider of the INFN Laboratori Nazionali di Frascati, collecting more than 5 fb^{-1} at the center of mass energy of the ϕ meson. Together with the data sample collected by its predecessor KLOE, the total of almost 8 fb^{-1} integrated luminosity represents the largest existing data sample in the world collected at an e+e- collider at the ϕ meson peak, corresponding to ~2.4 x 10^{10} ϕ mesons produced.

KLOE-2 physics program is mainly focused on K_S, η and η meson rare decays as well as on kaon interferometry, fundamental symmetry tests and physics beyond the Standard Model, including searches for new exotic particles that could constitute the dark matter. The entanglement in the neutral kaon pairs produced at the DAΦNE ϕ-factory is a unique tool to test discrete symmetries and quantum coherence at the utmost sensitivity, in particular strongly motivating the experimental searches of possible CPT violating effects, which would unambiguously signal New Physics.
The lepton charge asymmetry measured in K_S semileptonic decays with 1.7 fb^{-1} of KLOE data, improving the statistical uncertainty of present result by about a factor two, will be presented together with the test of Time reversal and CPT in transitions in $\phi \to K_S K_L \to \pi e \nu, 3\pi^0$ and $\pi e \nu, 2\pi$ decays and the search for the CP violating $K_S \to 3\pi^0$ decay with newly acquired KLOE-2 data.

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KLEVER: An experiment to measure BR(K_L -> \pi^0\nu\bar{\nu}) at the CERN SPS

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Precise measurements of the branching ratios (BRs) for the flavor-changing neutral current decays $K \to \pi\nu\bar{\nu}$ can provide unique constraints on CKM unitarity and, potentially, evidence for new physics. It is important to measure both decay modes, $K^+ \to \pi^+\nu\bar{\nu}$ and $K_L \to \pi^0\nu\bar{\nu}$, since different new physics models affect the rates for each channel differently. The NA62 experiment at the CERN SPS is currently collecting data and will measure BR($K^+ \to \pi^+\nu\bar{\nu}$) to within 10%. We are designing the KLEVER experiment to measure BR($K_L \to \pi^0\nu\bar{\nu}$) to $\sim$20\% using a high-energy neutral beam at the CERN SPS starting in LHC Run 4. The boost from the high-energy beam facilitates the rejection of background channels such as $K_L \to \pi^0\pi^0$ by detection of the additional photons in the final state. On the other hand, the layout poses particular challenges for the design of the small-angle vetoes, which must reject photons from K_L decays escaping through the beam pipe amidst an intense background from soft photons and neutrons in the beam. We present findings from our design studies, with an emphasis on the challenges faced and the potential sensitivity for the measurement of BR($K_L \to \pi^0\nu\bar{\nu}$).

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Study of the normalization modes in search the rare decay of $K_L^0 \to \pi^0 \nu \bar{\nu}$ with the KOTO detector

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The KOTO experiment aims to observe the $K_L^0 \to \pi^0 \nu \bar{\nu}$ decay and measure the branching rate. The Standard Model (SM) prediction for the mode is 2.4 x 10^{-11} with a small theoretical uncertainty. An experimental upper limit of 2.6 x 10^{-8} was set by the KEK E391a collaboration 1. A comparison of experimentally obtained results with SM calculations permits a test of the quark flavor region and a search for physics beyond the SM. The experimental method lies in the detection of two photons and nothing else. KOTO uses a Cesium Iodide (CSI) electromagnetic calorimeter to measure the photon positions and energies. All other detectors compose a hermetic veto system to confirm no extra detectable particle.

A critical part of the blind analysis includes a detailed study of the normalization modes, $K_L^0 \to \pi^0 \pi^0 \pi^0$, $K_L^0 \to \pi^0 \pi^0$, and $K_L^0 \to \gamma\gamma$. These modes are used to calculate the KL flux and efficiencies of kinematic and veto cut requirements. This talk will discuss the analysis results of the normalization modes and provide the framework for our anticipated final branching ratio result which is expected to surpass the sensitivity of the Grossman-Nir limit 2.

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Charm physics prospects at the Belle II experiment

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The Belle II experiment is a substantial upgrade of the Belle detector and will operate at the SuperKEKB energy-asymmetric e^+e^- collider. The accelerator has already successfully completed the first phase of commissioning in 2016 and first electron positron collisions in Belle II are expected for April 2018. The design luminosity of SuperKEKB is 8×10^{35} cm^{-2}s^{-1} and the Belle II experiment aims to record 50 ab^{-1} of data, a factor of 50 more than the Belle experiment. In this presentation, we will discuss the expected sensitivity of Belle II for CPV measurements and New Physics searches in the charm sector. Estimates for several decay channels will be presented, in particular for those with lepton-neutrino, neutral pions and other neutrals in the final state. Alternative flavor-tagging techniques have been developed, a novel flavor-tagging method of prompt D^0s will be presented. Finally, we will present the impact of the improved tracking at Belle II, that will allow to significantly increase the precision of time-dependent measurements.

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Time dependent CP-violation measurements at Belle II

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Time dependent CP-violation phenomena are a powerful tool to precisely measure fundamental parameters of the Standard Model and search for New Physics. The Belle II experiment is a substantial upgrade of the Belle detector and will operate at the SuperKEKB energy-asymmetric e^+e^- collider. The accelerator has already successfully completed the first phase of commissioning in 2016 and first electron positron collisions in Belle II are expected for April 2018. The design luminosity of SuperKEKB is 8×10^{35} cm^{-2}s^{-1} and the Belle II experiment aims to record 50 ab^{-1} of data, a factor of 50 more than the Belle experiment. This dataset will greatly improve the present knowledge, particularly on the CKM angles β and α by measuring a wide spectrum of B-meson decays, including many with neutral particles in the final state. In this talk we will present estimates of the sensitivity to β in the golden channels $B \to c\bar{c}s$ and in the penguin-dominated modes $B^0 \to \eta' K^0$, ϕK^0, $K_S\pi^0(\gamma)$. A study for the time-dependent analysis of $B^0 \to \pi^0\pi^0$, relevant for the measurement of α, and feasible only in the clean environment of an e^+e^- collider, will also be given.

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Determination of the CKM matrix elements $|V_{ub}|$ and $|V_{cb}|$ at Belle II

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The Belle II experiment is a substantial upgrade of the Belle detector and will operate at the SuperKEKB energy-asymmetric e^+e^- collider. The accelerator has already successfully completed the first phase of commissioning in 2016 and first electron positron collisions in Belle II are expected for April 2018. The design luminosity of SuperKEKB is 8×10^{35} cm^{-2}s^{-1} and the Belle II experiment aims to record 50 ab^{-1} of data, a factor of 50 more than the Belle experiment. In this presentation we report our prospects for CKM favoured and suppressed semileptonic B meson decays (with a light lepton) and how they can be used to better understand the CKM matrix element magnitudes $|V_{ub}|$ and $|V_{cb}|$.

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Studies of the CKM matrix with semileptonic decays

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Exclusive semileptonic b-hadron decays are under good theoretical control, which allows precise determinations of the CKM matrix elements, Vub and Vcb. The large production of Lambda_b baryons and Bs mesons at the LHC allows LHCb to provide complementary information with respect to the B-factories in this sector, as well as in the measurement of the shape of the Lambda_b differential decay rates. An alternative approach for measuring Vub, less affected by theoretical uncertainties, is through fully leptonic decay modes. Also this approach is explored at LHCb with the search for the B+->3munu decay. At the same time, novel experimental techniques are used to measure the fraction of semileptonic B+ to charm meson decays, in order to improve the understanding of the inclusive charm semileptonic rate and the background description for analyses exploiting exclusive b -> c and b->u transitions. The latest LHCb results on CKM matrix element determination and related measurements and searches are presented.

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Towards a new paradigm for quark-lepton unification

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The quark and lepton mass patterns upset their naive unification. In this talk, a new approach to solve this problem is described. Model-independently, we find that a successful unification can be achieved. A mechanism is identified by which the large top quark mass renders its third-generation leptonic partner very light. This state is thus identified with the electron. We then provide a generic dynamical implementation of this mechanism, using tree-level exchanges of vector leptons to relate the quark and lepton flavor structures. In a supersymmetric context, this same mechanism splits the squark masses, and third generation squarks end up much lighter than the others. Finally, the implementation of this mechanism in SU(5) GUT permits to avoid introducing any flavor structure beyond the two minimal Yukawa couplings, ensuring the absence of unknown mixing matrices and their potentially large impact on FCNC.

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Radiative B Decays at Belle

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The b⟶s gamma process is sensitive to new physics since the new heavy particles can enter in the loop and thus change the branching fractions, CP asymmetry or other kinetic variables. We present on measurement of the CP asymmetry and isospin asymmetry of B ⟶ Xs gamma and B ⟶ K* gamma, and also their difference of CP asymmetry between charged and neutral modes. The analyses are based on the full data set recorded by the Belle detector at the Y(4S) resonance containing 772 million BBbar pairs from e+ e- collisions produced by the KEKB collider.

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Measurement of hadronic cross sections at CMD-3

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The CMD-3 experiment at the VEPP-2000 collider in Novosibirsk carries out a comprehensive study of the exclusive cross-sections of e+e- -> hadrons in the center-of-mass energy range from the threshold to 2E<2 GeV. The CMD-3 results provide an important input for calculation of the hadronic contribution to the muon anomalous magnetic moment. Currently there are world-wide efforts to improve the accuracy of this calculation to match the expected precision of the Fermilab measurement, which started data taking in 2018. The best precision is still achieved by integrating the measured

total cross-section of e+e- -> hadrons. The calculation is strongly dominated by low-energy data, in particular, by data at 2E<2 GeV. Other interesting topics of the CMD-3 physics program include a study of hadron cross-sections at the nucleon-antinucleon threshold and a search for two-photon production of C-even resonances.

The CMD-3 is the general-purpose particle detector, equipped by a tracking system, two crystal (CsI and BGO) calorimeters, liquid Xe calorimeter, TOF and muon systems. The first round of data taking in the whole available energy range was done in 2011-2013. After a three-year break for collider and detector upgrades, data taking resumed in 2017 with a 2-3 times higher luminosity. Overall, about 120 1/pb have been collected so far.

Here we present the survey of results of data analysis, including various modes of electron-positron annihilation with up to six pions or two kaons and pions in the final state.

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Charged Lepton Flavor Violation in a class of Radiative Neutrino Mass Generation Models

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We investigate charged lepton flavor violating processes $\mu \to e\gamma$, $\mu \to ee\bar{e}$ and $\mu - e$ conversion in nuclei for a class of three-loop radiative neutrino mass generation models with electroweak multiplets of increasing order. We find that, because of certain cancellations among various one-loop diagrams which give the photonic dipole and non-dipole contributions in effective $\mu e\gamma$ vertex and Z-penguin contribution in effective μeZ vertex, the flavor violating processes $\mu \to e\gamma$ and $\mu - e$ conversion in nuclei become highly suppressed compared to $\mu \to ee\bar{e}$ process. Therefore, the observation of such pattern in LFV processes may reveal the radiative mechanism behind the neutrino mass generation.

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Lepton flavor violation and seesaw models at future lepton colliders

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Many new physics scenarios beyond the Standard Model often necessitate the existence of a (light) neutral scalar H, which might couple to the charged leptons in a flavor violating way, while evading all existing constraints. Such scalars could be effectively produced at future lepton colliders like CEPC, ILC and FCC-ee, either on-shell or off-shell, and induce lepton flavor violating (LFV) signals. We find that a large parameter space of the scalar mass and the LFV couplings can be probed, well beyond the current low-energy constraints in the lepton sector. Important implications for some of the well-motivated seesaw models will also be mentioned.

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Recent results on τ-lepton decays with the BABAR detector

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We report on the most recent results of studies of tau-lepton decays, relying on about 430×10^6 $e^+e^- \to \tau^+\tau^-$ events produced at a center-of-mass energy near 10.6 GeV with the BABAR detector at the PEP-II e^+e^- collider.
We present measurements of the branching fractions and the spectral functions for the processes $\tau^- \to K^- K_S(\pi^0)\nu_\tau$, which can be used to determine the hadronic contribution to the muon $g-2$ due to the vacuum polarization.
We present also measurements of the branching fractions of the processes $\tau^- \to K^- n\pi^0\nu_\tau$, with n=1,2,3, which can be used to improve the determination of $|V_{us}|$ from the branching fraction $\tau^- \to X_s\nu_\tau$ computed as the sum of all measured exclusive modes with a method based on finite-energy QCD sum rules.

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Study of the Lorentz structure of tau decays and the rare tau decays from Belle

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We evaluate the Michel parameters of τ decays using the full data sample of Belle. This is important to reveal the Lorentz structure of τ leptonic decays, which includes not only the V - A interaction but also contributions from scalar, tensor and others that may arise from New Physics, thus testing lepton universality as well. We use both tau+ ⟶ l+ nu nu and tau+ ⟶ l+ gamma nu nu. We also measure branching fractions of τ decays into three charged leptons and two neutrinos as well as charged pion, lepton-pairs and a neutrino. Recently, their precise theoretical prediction of the branching fractions are given (O(10^-5 .. -7)) and the statistics of the Belle data allows us to achieve the first observation for them.

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An experiment to search for mu-e conversion at J-PARC MLF in Japan, DeeMe experiment

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Charged lepton flavor violation (CLFV) is a good probe for new physics beyond the
standard model of elementary particle physics.

The DeeMe experiment is going to search for one of the CLFV precesses, mu-e conversion in a nuclear field, with a sensitivity of 10^-14, ten times higher than current limits.
The experiment utilizes a fast-extracted proton beam from a Rapid Cycling Synchrotron (RCS) in J-PARC and a production target in Materials and Life Science Experimental Facility (MLF) as a material that muonic atoms are formed.
The overview of the experiment and the current status will be presented.

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Mu2e: A Search for Charged Lepton Flavor Violation in Muon-Electron Conversion with a Sensitivity < 10^{-16}

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Mu2e will search for coherent, neutrino-less conversion of muons into electrons in the field of a nucleus with a sensitivity improvement of a factor of 10,000 over existing limits. Such a charged lepton flavor-violating reaction probes new physics at a scale unavailable with direct searches at either present or planned high energy colliders. The experiment both complements and extends the current studies at MEG and at the LHC. We present the physics motivation for Mu2e, as well as the design of the muon beamline, tracking spectrometer, and calorimeter. The Mu2e experiment is under design and construction at the Muon Campus of Fermilab. The experiment will begin near the end of 2020 with 3 years of running from 2021 to 2024.

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The MEGII experiment at PSI and the quest for $\mu \to e\gamma$ and its experimental limiting factors at future high intensity muon beams

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The search for the Lepton Flavor Violating decay $\mu \to e\gamma$ exploits the most intense continuous muon beams, which can currently deliver $\sim 10^8$ muons per second. In the next decade, accelerator upgrades are expected in various facilities, making it feasible to have continuous beams with an intensity of 10^9 or even 10^{10} muons per second. We investigate the experimental limiting factors that will define the ultimate performances, and hence the sensitivity, in the search for $\mu \to e\gamma$ with a continuous beam at these extremely high rates. We then consider some conceptual detector designs and evaluate the corresponding sensitivity as a function of the beam intensity.

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CP asymmetries in charm decays into neutral kaons

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We find a new CP-violation effect in charm decays into neutral kaons, which results from the interference between two tree (Cabibbo-favored and doubly Cabibbo-suppressed) amplitudes with the mixing of final-state mesons. This effect, estimated to be of an order of 10^{-3}, is much larger than the direct CP asymmetries in these decays, but missed in the literature. It can be revealed by measuring the difference of the time-dependent CP asymmetries in the $D^+ \to \pi^+ K_S^0$ and $D_s^+ \to K^+ K_S^0$ modes, which are accessible at the LHCb and Belle II experiments. If confirmed, the new effect has to be taken into account, as the above direct CP asymmetries are used to search for new physics.

This work has been published in Phys.Rev.Lett 119.181802(2017).

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Precision measurement of the form factors of semileptonic charged kaon decays

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We present a measurement of the charged kaon semileptonic form factors based on 4.3 million $K^\pm \to \pi^0 e^\pm \nu_e$ and 2.1 million $K^\pm \to \pi^0 \mu^\pm \nu_\mu$ decays collected by the NA48/2 experiment. The single results for the semi-electronic and semi-muonic channel have better and similar precision, respectively, than previous measurements. The combination of both channels yields the most precise measurement of the form factors of semileptonic kaon decays.

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Search for the rare decay of $K_L \to \pi^0 \nu \bar{\nu}$ at J-PARC

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The KOTO experiment is dedicated to observing the rare decay $K_L \to \pi^0 \nu \bar{\nu}$ at the J-PARC 30 GeV proton synchrotron. This decay breaks the CP symmetry directly and is highly suppressed in the Standard Model. Thus this decay mode is sensitive to new physics beyond the SM, in particular the physics related to CP violation.

Data collected in 2013 were analyzed and published in 2017. Several new backgrounds were found in the 2013 analysis, and improvements to the detector were made suppress these backgrounds. Data collection resumed in 2015, increasing the amount of data by a factor of 20, which corresponds to a branching ratio sensitivity of O(10^-9).

In this contribution, we will present analysis results of 2015 data.

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Searches for Flavor Changing Neutral Currents at BESIII

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The Flavor Changing Neutral Current decays(FCNC) are forbidden at tree level in the Standard Model (SM) and could only contribute through loops. Any direct observation beyond the SM expectations could be a good probe of physics beyond the SM. BESIII is the only currently running tau-charm factory with the largest samples of on threshold charm meson pairs, directly produced charmonia and some other unique datasets. It has great potential to probe these FCNC decays from multiple channels.
This talk reviews some recent results on searches for FCNC decays from BESIII. We present searches for the decays of J/ψ, $\psi(3686) \to D^0e^+e^-$, $\psi(3686) \to \Lambda_c^+\bar{p}e^+e^-$, D+ to h e e, $D^+ \to h^+h^0e^+e^-$, $D^0 \to h(h')e^+e^-$. The related searches with same sign electron pairs are also reported. The prospects and challenges with searches of other channels and the impact of future datasets are also discussed.

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Search for the rare decay $D^0 \to K^-\pi^+e^+e^-$

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Flavor-changing neutral current (FCNC) processes are rare within the Standard Model (SM) as they cannot occur at tree level and are suppressed at loop level by the Glashow-Iliopoulos-Maiani (GIM) mechanism. In D-meson decays, the GIM cancellation is almost exact, leading to expected branching fractions for $c \to ul^-l^+$ processes of order $\mathcal{O}(10^{-9})$. However, long-distance effects can raise this to $\mathcal{O}(10^{-6})$. Recently, the LHCb collaboration reported a measurement of the $D^0 \to K^-\pi^+\mu^+\mu^-$ branching fraction $\mathcal{B}(D^0 \to K^-\pi^+\mu^+\mu^-) = (4.17 \pm 0.12 \pm 0.40) \times 10^{-6}$ in the mass range $0.675 < m(\mu^+\mu^-) < 0.875$ GeV/c^2. The LHCb collaboration has also reported on hints for deviation from lepton universality in decays of the type $b \to sl^-l^+$.
In this talk, we report on a search for the FCNC decay $D^0 \to K^-\pi^+e^+e^-$ using data taken by the BABAR experiment at the SLAC National Accelerator Laboratory.

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Rare Charm decays at LHCb

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LHCb is playing a crucial role in the study of rare and forbidden decays of charm hadrons, which might reveal effects beyond the Standard Model. New searches for FCNC mediated processes and first asymmetry measurements in multibody final states with two leptons are presented.

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Λ_c^+ physics with BESIII threshold data

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The BESIII detector accumulated 567 pb^{-1} of data at the center-of-mass energy of 4.6 GeV, which is the world's largest e^+e^- sample at the Λ_c pair threshold. By analyzing this data sample, we report the determinations of the absolute branching fractions of the semi-leptonic decays of $\Lambda_c^+ \to \Lambda e^+\nu$ and $\Lambda\mu^+\nu$, the hadronic decays of $\Lambda_c^+ \to pK_s, pK^-\pi^+, pK_s\pi^0, pK_s\pi^+\pi^-, \Lambda\pi^+, \Lambda\pi^+\pi^0, \Lambda\pi^+\pi^+\pi^-, pK^-\pi^+\pi^0, \Sigma^0\pi^+, \Sigma^+\pi$ and $\Sigma^-\pi^+\pi^+\pi^0$, as well as the inclusive Λ and electron decays. The accurancies of the absolute branching fractions for most decays are improved significantly compared to the previous measurements. We will aslo report cross section measurement of $e^+e^- \to \Lambda_c^+\Lambda_c^-$ near threshold at BESIII.

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Leptonic and semi-leptonic decays of charmed mesons at BESIII

BESIII Collaboration[None]

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BESIII accumulated the world largest samples of e^+e^- collision at $\sqrt(s) = 3.773$ and 4.178 GeV. The purely leptonic decays $D^+_{(s)} \to l^+\nu$, and the semi-leptonic decays of $D^0 \to K(\pi)^-e^+\nu, K(\pi)^-\mu^+\nu$, $\rho^-e^+\nu$; $D^+ \to K^0(\pi^0)e^+\nu$, $K^0(\pi^0)\mu^+\nu$; $D_s^+ \to K^{(*)0}e^+\nu$ and $\eta^{(\prime)}e^+\nu$ have been studied. We will report the improved measurements of the branching fractions of these decays, of the CKM matrix elements $|V_{cs(d)}|$, of the $D^+_{(s)}$ decay constants, and of the form factors of $D_{(s)}$ semi-leptonic decays. These results are important to calibrate the LQCD calculations of $D^+_{(s)}$ decay constants and form factors as well as to test the CKM unitarity.

Quark and Lepton Flavor Physics / 337

Search for CP violation and rare decays in charm sector at Belle

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Using more than 920fb-1 data collected with the Belle detector at the KEKB asymmetric-energy e+e- collider, we report the first measurement of the T-odd moments in the decay D0⟶KS0π0π+π- . We search for CP-violation in decays D0⟶KS0KS0 and D+⟶π+π0 . All the results are consistent with no CP violation. We also report the result from the first search for D0 decays to invisible final states. No significant signal yield is observed and an upper limit is set on the branching fraction at 90% confidence level.

Quark and Lepton Flavor Physics / 611

Direct CPV in charm decays at LHCb

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LHCb has collected the world's largest sample of charmed hadrons. This sample is used to measure direct CP violation in D0 mesons and Lc baryons. New measurements from several decay modes are presented, as well as prospects for future sensitivities.

Quark and Lepton Flavor Physics / 610

Mixing and indirect CPV in Charm decays at LHCb

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LHCb has collected the world's largest sample of charmed hadrons. This sample is used to measure $D^0 - \bar{D}^0$ mixing and to search for indirect CP violation. New measurements from several decay modes are presented, as well as prospects for future sensitivities.

Quark and Lepton Flavor Physics / 198

Hadronic decays of $D^{0(+)}$ and D_s^+ at BESIII

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BESIII collected 2.93 and 3.2 fb^{-1} of data at $\sqrt(s) = 3.773$ and 4.178 GeV, respectively. Many hadronic decays of $D^{0(+)}$ and D_s^+ have been studied. In this talk, the measurements of the branching fractions of $D^{0(+)} \to PP$ (P=Peudecalor) decays, the observations of the baryonic decay $D_s^+ \to p\bar{n}$ and the pure W-annhilation decay $D_s^+ \to \omega\pi^+$ as well as the amplitude analyses of the multi-body decays $D^0 \to K^-\pi^+\pi^0\pi^0, K^-\pi^+\pi^+\pi^-$, $D^+ \to K_s\pi^+\pi^+\pi^-$ and $D_s^+ \to \eta\pi^+\pi^0$ will be presented.

Quark and Lepton Flavor Physics / 1003

Optimising sensitivity to γ with B0→DK+π−, D→K0Sπ+π− double Dalitz plot analysis

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Two of the most powerful methods currently used to determine the angle γ of the CKM Unitarity Triangle exploit B+→DK+, D→K0Sπ+π− decays and B0→DK+π−, D→K+K−, π+π− decays. It is possible to combine the strengths of both approaches in a "double Dalitz plot" analysis of B0→DK+π−, D→K0Sπ+π− decays. The potential sensitivity of such an analysis is investigated in the light of recently published experimental information on the B0→DK+π− decay. The formalism is also expanded, compared to previous discussions in the literature, to allow B0→DK+π− with any subsequent D decay to be included.

Quark and Lepton Flavor Physics / 609

Time-integrated CP violation measurements in B->DD and B->DKK decays at LHCb

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Measurements of CP violation are a core part of the LHCb physics programme to over constrain the CKM matrix and to understand the differences between matter and antimatter. The worlds most precise measurement of ACP in B+->DD0 decays is presented alongside the first measurement of ACP in the B+->DsD0 channel. Results from B(s)->D0KK decays are also shown, including the first observation of the Bs->DKK channel and inspections of the Dalitz plots.

Quark and Lepton Flavor Physics / 336

Recent investigations of direct CP violation in B-meson decays at Belle

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Direct CP violation in B meson decays provides a good probe for New Physics. We report measurement of branching fraction(BF) and direct CP asymmetries (Acp) in charmless B decays B+ → KsKsK+ and B+ → KsKspi+, which proceed through b→s and b→d flavor-changing neutral current transitions, respectively. Another charmless B decay B0 → K-pi+Ks, which proceeds through b→d penguin process, is also studied. Strong evidence of localized Acp was observed in a similar decay B+ → K+K-pi+ by Belle, and in the presentation, differential Acp and BF measurements as a function of K-Ks invariant mass are reported in addition to the total Acp and BF measurements. We also cover Acp of B0bar → D0 (K+pi-) pi0 and B0bar → D0 (K+pi-pi0) pi0 decays, which provide an interesting probe of subtle interference effects via CKM disfavoured transitions. Finally, we report on our latest measurements of B+ → D(*)K+ decay, sensitive to CKM unitarity triangle angle gamma/phi3, involving D decays to K+- pi-+, CP eigenstates and the almost pure CP even state pi+ pi- pi0. The analyses are based on the full data set recorded by the Belle detector at the Y(4S) resonance containing 772 million BBbar pairs.

Quark and Lepton Flavor Physics / 603

Direct CP violation in B decays at LHCb

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Measurements of charge CP asymmetries in the decays of b hadrons with charmonia in the final state are powerful probes to search for physics effects beyond the Standard Model. Recent results in the measurement of direct CP violation of B mesons performed by the LHCb collaboration using Run 1 data will be presented.

Quark and Lepton Flavor Physics / 607

Measurements of the CKM angle gamma at LHCb

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The CKM angle gamma remains the least precisely measured angle of the unitarity triangle, and is the only easily accessible with purely tree level decays, making it a benchmark for Standard Model flavour processes. We present the Run 2 update of the measurement of gamma using the GGSZ method with the golden mode B+->DK+, D->Kshh. The results of the latest LHCb gamma combination are also shown, giving the most precise determination of gamma from a single experiment.

Quark and Lepton Flavor Physics / 599

Charmless three-body meson decays at LHCb

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Charmless three-body decays of B mesons are an ideal place to study CP violation, as contributions from 'loop' diagrams at a similar magnitude to tree-level diagrams, and variation of the strong phase across the so-called 'Dalitz plot', can result in phase-space regions with large CP asymmetries. Furthermore, many of these decays can be used to inform determinations of the angles of the Cabibbo-Kobayashi-Maskawa unitarity triangle. Here, the latest LHCb results on three-body charmless B meson decays are presented.

Quark and Lepton Flavor Physics / 601

CP violation in b-baryon decays to multibody final states at LHCb

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The violation of CP symmetry is well established nowadays in the K- and B-mesons sectors. However CPV has not been observed in the baryonic sector. Charmless b-baryon decays represent a promising opportunity in this respect since their amplitudes receive both contributions from tree level diagrams where the CKM element Vub appears and loop level diagrams which have comparable contirbutions. In addition, these decays are sensitive to possible physics beyond the SM, entering from penguin topologies. We present the most recent measurements of CP violation in charmless b-baryon decays performed by LHCb, including branching ratios and triple-product asymmetries.

Quark and Lepton Flavor Physics / 598

CP violation and polarisation amplitudes in B->VV decays at LHCb

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Decays of b-mesons to charmless multi-body final states are CKM suppressed in the Standard Model, which brings the tree amplitudes to levels comparable with corresponding loop amplitudes. New particles not foreseen in the SM that appear in the loops may alter not only the CP asymmetries of these decays, but also the polarisation fractions and triple-product asymmetries. The latest measurements of these quantities performed by the LHCb experiments are presented, with particular emphasis on B->VV decays, where V indicates a light vector meson.

Quark and Lepton Flavor Physics / 597

CP violation in b-hadron decays to charmless charged two-body final states at LHCb

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The amplitudes governing the decays of neutral b-hadrons to charmless charged two-body final states receive relevant contribution from both b->u tree-level and b->d,s penguin topologies. Hence, these decays are sensitive probes of the CKM paradigm, but also have the potential to reveal new physics beyond the Standard Model. Relevant quantities to measure are time-dependent and time-integrated CP asymmetries, and branching ratios. We present the most recent measurements of these quantities performed by the LHCb experiment.

Quark and Lepton Flavor Physics / 602

CP violation in B decays to charmonia at LHCb

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Precision measurements of CP violating observables in b hadron decays with charmonia in the final state are powerful probes to search for physics effects beyond the Standard Model. The most recent results on CP violation in the decay, mixing and interference of b hadrons obtained by the LHCb Collaboration will be presented, with particular focus on results obtained exploiting the data collected during the Run 2 of LHC. These results represent the world's best constraints, some of which are world-first measurements, of the CP violating phase phi_s.

Quark and Lepton Flavor Physics / 606

Recent improvements and prospects with flavour tagging at LHCb

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Precision measurements of time-dependent CP violation and of mixing parameters in the neutral B meson systems are bound to the ability to identify the production flavour of reconstructed b hadrons. The harsh environment of proton-proton collisions at LHC constitutes a challenging environment for flavour tagging and demand for novel and improved strategies. We present recent progress and new developments in flavour tagging at the LHCb experiment, which will allow for a further improvement of CP violation measurements in decays of B0 and Bs0 mesons.

Quark and Lepton Flavor Physics / 330

Measurements of time-dependent CP violation in charmless B meson decays

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We report measurements of time-dependent CP violation in charmless B meson decays that are sensitive to physics beyond the Standard model or Kobayashi-Maskawa CP violation angle phi_2 in b to s penguin or b to u tree transitions, respectively. The analyses use Belle final entire data sample collected at the Upsilon(4S) resonance containing 772 mullion B meson pairs.

Quark and Lepton Flavor Physics / 608

Time-dependent CP violation measurements in B->DX decays at LHCb

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Time-dependent CP violation in B->DX decays provides sensitivity to angles of the CKM matrix. The excellent time resolution of the LHCb detector provides opportunities to perform precise time-dependent measurements. A summary of recent LHCb results are presented, including the B0->Dpi analysis which profits from the largest flavour tagged sample analysed by LHCb to determine the CKM angle sum (gamma+2beta).

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Measurement of cos2beta = cos2phi_1 in B^0 to D^{(*)0} h^0 with D to K^0_S pi^+ pi^- decays by a time-dependent Dalitz analysis using BaBar and Belle combined data

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We report measurements of sin2beta = sin2phi_1 and cos2beta = cos2phi_1 from a time-dependent Dalitz analysis in B^0 to D^{(*)0} h^0 with D to K^0_S pi^+ pi^- decays using BaBar and Belle combined data sample containing 471 + 772 million B meson pairs collected at the Upsilon(4S) resonance.

The measurement gives a confirmation of the CP violation in this B decay mode and solves the two-fold ambiguity of the angle beta=phi_1 that can not solely be fixed by the sin2beta = sin2phi_1 measurements in B^0 to charmonium K^0 decays.

Quark and Lepton Flavor Physics / 605

B meson mixing parameters and branching fractions at LHCb

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New LHCb results in the measurement of B meson mixing parameters and branching fractions will be presented. The results are obtained using pp collisions collected in Run 1 and Run 2 of the LHC and include a new and world's most precise determination of the decay width difference in the Bs system and the ratio between the decay width of the Bs and Bd mesons.

Quark and Lepton Flavor Physics / 149

Measurements of heavy flavor properties at CMS

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Recent measurements of the properties of heavy flavor particles at CMS, based on data collected at Run 1 and Run 2 of the LHC, are presented. Reported results include, among the others, measurements of lifetimes, masses and branching ratios of B hadrons and heavy quarkonia.

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New results on semileptonic B decays and on the CKM magnitudes |Vub| and |Vcb| from Belle

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The magnitudes of the Cabibbo-Kobayashi-Maskawa (CKM) matrix elements |Vcb| and |Vub|, in combination with the angles of the Unitarity Triangle, are crucial for testing the quark flavour sector of the Standard Model. We report new results on |Vub| and |Vcb| obtained from the Belle data set. This presentation will also cover new measurements of B → pi pi l nu and B → D* * l nu. The analyses are based on the full data set recorded by the Belle detector at the Y(4S) resonance containing 772 million BBbar pairs from e+ e- collisions produced by the KEKB collider.

Quark and Lepton Flavor Physics / 615

Tests of lepton universality with semitauonic b-quark decays

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In the Standard Model, the three charged leptons are identical copies of each other, apart from mass differences. Experimental tests of this feature in semileptonic decays of b-hadrons are highly sensitive to New Physics particles which preferentially couple to the 2nd and 3rd generations of leptons. This talk will review the latest lepton universality tests in semileptonic b->c transitions at LHCb.

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Towards establishing New Physics in $B^0 \to K^{*0}\ell^+\ell^-$ decays

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Rare semileptonic $b \to s\ell^+\ell^-$ transitions provide some of the most promising framework to search for New Physics effects.
Recent analyses have indicated an anomalous pattern in measurements of lepton-flavour-universality observables.
We propose a novel approach to independently and complementary clarify the nature of these effects by performing a simultaneous amplitude analysis of $B^0 \to K^{*0}\mu^+\mu^-$ and $B^0 \to K^{*0}e^+e^-$ decays.
This method allows the direct determination of the difference of the Wilson Coefficients $calC_9$ and $calC_{10}$ between electrons and muons,
and are found to be insensitive to both local and non-local hadronic contributions.
We show that considering the current preferred New Physics scenario a first observation of LFU breaking in a single measurement is possible with LHCb Run-II dataset.

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Connecting b⟶sμμ anomalies to enhanced rare nonleptonic B_s decays in Z' model

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The anomalies recently observed in $b \longrightarrow s\mu\mu$ data could be early signals of physics beyond the standard model (SM) in $b \longrightarrow s$ transitions. Assuming this to be the case, we consider a scenario in which a *Z'* boson is responsible for the anomalies. We further assume that its interactions also affect rare nonleptonic decays of the *B*s meson which tend to be dominated by electroweak-penguin contributions and are purely isospin-violating. Most of these *B*s decays are not yet observed, and their rates are expected to be relatively small in the SM. Taking into account various constraints, we find that the *Z'* effects can enhance the rates of some of these decays, particularly $Bs \longrightarrow \eta\pi$, $\phi\pi$, by up to an order of magnitude. This *Z'* scenario is therefore potentially testable in upcoming experiments at LHCb and Belle II.

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Search for the rare decay $B \to \Lambda\bar{p}\nu\bar{\nu}$

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We search for the rare flavor-changing neutral current process $B^- \to \Lambda\bar{p}\nu\bar{\nu}$ using data from the BABAR experiment. A total of 424fb^{-1} of e^+e^- collision data collected at the center-of-mass energy of the $\Upsilon(4S)$ resonance is used in this study, corresponding to a sample of $(471 \pm 3) \times 10^6$ $B - \bar{B}$ pairs. Signal $B^- \to \Lambda\bar{p}\nu\bar{nu}$ candidates are identified by first exclusively reconstructing a B^+ decay in one of many possible decays to hadronic final states, then examining detector activity that is not associated with this reconstructed B^- decay for evidence of a signal decay. The data yield is found to be consistent with the expected background contribution under a null signal hypothesis, resulting in an estimated branching fraction of
$calB(B^- \to \Lambda\bar{p}\nu\bar{\nu}) = (0.4 \pm 1.1 \pm 0.6) \times 10^{-5}$, where the uncertainties are statistical and systematic, respectively. An upper limit of
$calB(B^- \to \Lambda\bar{p}\nu\bar{\nu}) < 3.0 \times 10^{-5}$ at the 90% confidence level is determined.

Quark and Lepton Flavor Physics / 619

Electroweak Penguin Decays at LHCb

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Rare b->sll decays are flavour changing neutral current processes that are forbidden at the lowest perturbative order in the Standard Model (SM). As a consequence, new particles in SM extensions can significantly affect the branching fractions of these decays and their angular distributions. The LHCb experiment is ideally suited for the analysis of these decays due to its high trigger efficiency, as well as excellent tracking and particle identification performance. Recent results from the LHCb experiment in the area of b->sll decays are presented and their interpretation is discussed.

Quark and Lepton Flavor Physics / 618

Searches for Lepton Flavour Violating decays at LHCb

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Recent hints for lepton-universality violation in b->clnu and b->sll transitions could imply the existence of lepton-flavour violating B decays. The LHCb experiment is well suited for the search for these decays due to its large acceptance and trigger efficiency, as well as its excellent invariant mass resolution and particle identification capabilities. Recent results on searches for lepton-flavour violating decays from the LHCb experiment will be presented.

Quark and Lepton Flavor Physics / 617

Lepton Flavour Universality tests at LHCb

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The coupling of the electroweak gauge bosons of the Standard Model (SM) to leptons is lepton flavour universal. Extensions of the SM do not necessarily have this property. Rare decays of heavy flavour are heavily suppressed in the SM and new particles can give sizeable contributions to these processes, their precise study thus allows for sensitive tests of lepton flavour universality. Of particular interest are rare b->sll decays that are well accessible at the LHCb experiment. Recent results from LHCb on lepton flavour universality in rare b->sll decays are discussed.

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Electroweak Penguin B Decays at Belle

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The electroweak penguin B decay process b → s l+ l- is a sensitive probe to New Physics (NP) Recent measurements of angular variable of B → K*l+ l- by LHCb and Belle indicate a deviation from the standard model, and further measurements on these process are of interest in the search of NP. In this presentation, we report on the measurements of lepton flavor non universality tests and search for the lepton flavor violating decays in B→K(*)*l+l- and B→Xsl+l-. The analyses are based on the full data set recorded by the Belle detector at the Y(4S) resonance containing 772 million BBbar pairs from e+ e- collisions produced by the KEKB collider.

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ATLAS measurements of CP Violation and Rare decays in Beauty mesons

The ATLAS Collaboration[None] ; Iskander Ibragimov[1]

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The ATLAS experiment has performed accurate measurements of mixing and CP violation in the neutral B mesons, and also of rare processes happening in electroweak FCNC-suppressed neutral B-mesons decays. This talk will focus on the latest results from ATLAS, such as rare processes: B^0_s → mu mu and B^0 → mu mu; and CPV in Bs to Jpsi Phi

Quark and Lepton Flavor Physics / 152

Angular analyses at CMS

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Angular analyses of penguin B hadron decays such as B0->K*ll constitute one of the main indirect probes of new physics at LHC, due to the clean theoretical predictions and precise experimental results that can be obtained. In this report we present the most recent results of the CMS experiment on this subject, including the measurement of the P1 and P5' angular variables in B0->K*mumu decays and the angular analysis of the B+->K+mumu process.
Files

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Rare decays at CMS

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With the large integrated luminosity collected and the high efficiency of its di-muon triggers, the CMS experiment is a privileged test bench for rare decays involving heavy flavors. We report about the most recent measurements based on LHC Run 2 data, including decays of B and tau particles to muons and rare vector boson decays to heavy flavors.

Quark and Lepton Flavor Physics / 616

Radiative B decays at LHCb

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Radiative b-hadron decays are sensitive probes of New Physics through the study of branching fractions, CP asymmetries and measurements of the polarisation of the photon emitted in the decay. During Run-1 of the LHC, the LHCb experiment has collected large samples of radiative b-hadron decays. We present here the latest LHCb measurements, which help constrain the size of right-handed currents in extensions of the Standard Model.

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Discussion

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Progress on Reports to be submitted to European Strategy Group

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Messaging to the Japanese Government regarding the ILC Decision

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Welcome and Introduction

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Studies of the $X^{\pm}(5568)$ state and Evidence for Zc±(3900) in b-flavored Hadron Decays at D0

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We study the production of a narrow structure $X^{\pm}(5568)$ decaying to $B_s^0\pi^{\pm}$ produced in 10.4 fb^{-1} of $p\bar{p}$ collisions recorded by the D0 detector at the Fermilab Tevatron collider at $\sqrt{s} = 1.96$ TeV. We report evidence for the production of $X^{\pm}(5568)$ using the semileptonic mode $B_s^0 \to \mu^{\mp} D_s^{\pm} X$ with $D_s^{\pm} \to \phi\pi^{\pm}$. The results are consistent with the previous measurements by D0 of the production of $X^{\pm}(5568)$ using the hadronic decay $B_s^0 \to J/\psi\phi$. The mass and width of this state are measured using a combined fit of the hadronic and semileptonic data.

Strong Interactions and Hadron Physics / 587

Soft QCD at LHCb

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The forward acceptance of LHCb, 2.0 < y < 5.0, provides a complementary reach to the general purpose detectors at the LHC. LHCb measurements of the pp inelastic cross-section, J/psi production in jets, kinematic correlations between b and b-bar hadrons, and Bose Einstein correlations are discussed. Prompt J/psi production is found to be less isolated than predicted in LO NRQCD.

Strong Interactions and Hadron Physics / 185

Light meson decays at BESIII

BESIII Collaboration[None]

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At present the world's largest sample of 1.3 billion J/psi decay has been collected by the BESIII detector, which provides a unique opportunity to investigate light meson decays. The $a^0(980) - f^0(980)$ mixing is an important probe to the nature of those two light scalars. The first observation of $a^0(980) - f^0(980)$ mixing will be reported. The η and η' hadronic decays are sensitive tools for the investigations of $\pi - \pi$ and $\eta - \pi$ interactions, symmetry breaking, and for testing the Chiral Perturbation Theory. In this talk, BESIII presents new results on amplitude analyses of the Dalitz decays $\eta' \to 3\pi; \eta' \to \eta\pi\pi, \eta' \to \gamma\pi\pi$, on the observation of new decay modes and on searches for rare or forbidden decays.

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Study of K^0_S pair production and eta_c(1S), eta_c(2S) and non-resonant eta' pi+ pi- in two-photon collisions at Belle

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We report the measurements of gamma gamma —> eta_c(1S), eta_c(2S)—>eta' pi+ pi- with eta' decay to gamma rho and eta pi+ pi- First observation of eta_c(2S)—>eta' pi+ pi- with a significance 5.5 \sigma including systematic error is obtained. The products of the two-photon decay width and branching fraction of decays to eta' pi+ pi- are determined for the eta_c(1S) and eta_c(2S), respectively. A new decay mode for the eta_c(1S)—>eta' f0(2080) with f0(2080)—>pi+ pi- is observed with a statistical significance of 20 \sigma. The cross section for gamma gamma —> eta' pi+ pi- and eta' f2(1270) are measured for the first time. We also report a measurement of the cross section for K^0_S pair production in single-tag two-photon collisions, gamma*gamma → K^0_S K^0_S for Q^2 up to 30 GeV^2, where Q^2 is the negative of the invariant mass squared of the tagged photon. The measurement covers the kinematic range 1.0 GeV < W < 2.6 GeV and |cos theta*|<1.0 for the total energy and kaon scattering angle, respectively, in the gamma* gamma center-of-mass system. For the first time, the transition form factor of the f'2(1525) meson is measured separately for the helicity-0, -1, and -2 components and also compared with theoretical calculations. Finally, the partial decay widths of the chi_c0 and chi_c2 mesons are measured as a function of Q^2. The results are based on a data sample collected with the Belle detector at the KEKB asymmetric-energy e+ e- collider.

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Baryonic Decays of Charmonium at BESIII

BESIII Collaboration[None] ; Hao Cai[1]

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For the first time the branching ratio and the angular distribution of the decay $\psi(3686) \rightarrow n\bar{n}$ have been measured. At the same time also the branching ratio and angular distribution of the decay $\psi(3686) \rightarrow p\bar{p}$ have been measured with unprecedented precision. It turns out that the two branching ratio are quite close, implying that the phase between strong and electromagnetic part is close to 90 degrees for the "magnetic" part, while since the angular distributions are different very likely the "electric" part behaves in a different way.

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Exotic and Conventional Quarkonium Physics Prospects at Belle II

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The Belle II experiment, now operating at the KEK laboratory in Japan, is a substantial upgrade of both the Belle detector and the KEKB e^+e^-accelerator. It aims to collect 50 times more data than existing B-Factory samples. Belle II is uniquely capable to study the so-called "XYZ" particles: heavy exotic hadrons consisting of more than three quarks. First discovered by Belle, these now number in the dozens, and represent the emergence of a new category within quantum chromodynamics. This talk will present the capabilities of Belle II to explore both exotic and conventional quarkonium physics.

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Searches for exotic baryonic states at LHCb

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With the discovery of two pentaquark candidates at LHCb a new field of baryon spectroscopy has been opened. The unique data samples on beauty baryon decays collected at the LHC during its runs I and II provide opportunities to further study the spectrum of exotic heavy baryons. This presentation will highlight recent progress on establishing new baryonic multiparticle decay modes of beauty hadrons and will summarize the status of the pentaquark searches.

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Studies of meson-like exotic states at LHCb

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LHCb exploits decays of beauty hadrons as well as direct production in proton-proton collisions to investigate exotic mesons, especially in the charmonium mass region. The large data samples collected during Run I and II of the LHC open new possibilities for precision studies of these states. Recent results on exotic meson spectroscopy will be presented.

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Recent results on charmonium(-like) states and search for pentaquark at Belle

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Study of the processes e+e- ⟶J/ψDD and D()+- D-+ by Belle is updated, where a new charmonium(-like) state X*(3860) is observed with a significance of 6.5σ using full amplitude analysis in J/ψDD, and the first angular analysis is performed in D()+- D-+. We present the measurement of the absolute branching fractions of B+⟶Xcc K+ and B+⟶D()*0 π+ decays. Here, Xcc denotes ηc, J/ψ, χc0, χc1, ηc(2S), ψ(2S), ψ(3770), X(3872), and X(3915). We also perform first search for hidden-strangeness penta-quark decay Ps+⟶φp in the Cabibbo-suppressed decay Λc⟶φpπ0. All the results presented here exploit the full data set of Belle.

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Exotic quarkonium states at CMS

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Using large data samples of di-muon events, CMS has performed detailed measurements and searches for new states in the field of exotic quarkonia. We report on several recent results including, among the others: the measurement of the X(3872) properties, the investigation of the B+ to J/ψ φ K+ decay revealing two structures in the J/ψ φ mass spectrum, one of which compatible with the Y(4140) state by CDF, the search for the X(5568) state first seen by the D0 experiment. The study of charged Z charmonium-like states through a full amplitude analysis of 3-body decays of B0 to J/Psi(or Psi(2S)) Kaon Pion is also foreseen to be reported.

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Studies of X Y Z states at BESIII

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With about 12 fb^{-1} of collected data useful for the study of X Y Z resonances, BESIII continues the exploration of these exotic charmonium-like states. In these talk, recent results of the measurements of the line-shape of $e^+e^- \rightarrow \pi^0\pi^0\psi(3686), KKJ/\psi$, and $\pi^+D^0D^{*-}$, as well as the J^P determination of $Z_c(3900)$ and $Z_c(3900)$ observed in $e^+e^- \rightarrow \phi\chi_{c1/2}$ at $\sqrt(s) = 4.6$ GeV will be presented.

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Study of $e^+e^- \rightarrow e^+e^-\eta'$ in the double-tag mode at BABAR

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We study the process $e^+e^- \rightarrow e^+e^-\eta'$ in the double-tag mode and measure for the first time the $\gamma^\star\gamma^\star \rightarrow \eta'$ transition form factor $F_{\eta'}(Q_1^2, Q_2^2)$ in the momentum-transfer range $2 < Q_1^2, Q_2^2 < 60$ GeV^2. The analysis is based on data with an integrated luminosity 469 fb^{-1} collected at the PEP-II e^+e^- collider with the BABAR detector at center-of-mass energies near 10.6 GeV. The results for the form factor are compared with the predictions based on pQCD and VMD.

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Spectroscopy, production and exotica in HF states in ATLAS

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Searches for, and measurements of exotic states are studied with the ATLAS detector. The latest results from ATLAS on exotic (tetra- / pentaquark) states are presented. In addition, recent results on heavy flavour production measurements are reported in the Bu and Bc systems.

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Hyperon studies at BESIII

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Hyperons are a powerful diagnostic tool that sheds light on some of the most challenging questions in contemporary physics. One is how and why the strong force confines quarks and gluons into composite systems, e.g. protons. The central question is: What happens if we replace one of the light quarks in a proton, with a heavier quark? In particular, strange systems probe the strong interaction in the confinement domain which make strange hyperons particularly interesting. Electromagnetic form factors (EMFF's) is currently the best way to study hyperon structure. In the time-like region, the EMFF's can be complex with a relative phase. This phase is a non-perturbative phenomenon and stems from the interference between different production amplitudes, including intermediate states. A non-zero phase polarises the final state even when the initial state is unpolarised. Hyperons have the advantage compared to protons that their polarization is experimentally accessible by the angular distributions of their decay products. However, due to experimental challenges, the studies of hyperon EMFF's are scarce and the phase has not been measured at all until now. A new, dedicated data sample collected by the BESIII experiment therefore provide new insights. In this talk, it will outlined how to measure the phase between the electric and the magnetic form factor and presented the latest results from the BESIII experiment.

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Recent results on charmed baryons at Belle

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We report measurement of the decays of the Ωc0 charmed baryon into hadronic final states and observe excited Ωc charmed baryons in the decay mode Ξc+K- including Ωc(3000) , Ωc(3050), Ωc(3066), and Ωc(3090). In addition, We report the first observation of the Ξc(2930)0 charmed-strange baryon with a significance greater than 5σ in its decay to K-Λc+ in B- ⟶K-Λc+Λc- decays. The branching fractions of the decays Λc+ ⟶ Σ +π -π +, Λc+ ⟶ Σ0 π+π 0 and Λc+ ⟶ Σ +π 0 π 0 are also measured. The analyses are based on a data set recorded by the Belle detector from e+ e- collisions produced by the KEKB collider.

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Study of the e+e- annihilation into hadrons with the SND detector at the VEPP-2000 collider

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Recent results on study of exclusive processes of e^+e^- annihilation into hadrons below 2 GeV obtained at the SND detector are presented. The analyses are based on data collected at the VEPP-2M and VEPP-2000 colliders. In particular, we present the measurements of the $e^+e^- \to \eta\pi^+\pi^-$, $e^+e^- \to \eta K^+K^-$, $e^+e^- \to K_S K_L \pi^0$ cross sections, and the preliminary results on study of the $e^+e^- \to \pi^+\pi^-$, $e^+e^- \to n\bar{n}$ and $e^+e^- \to \pi^0\gamma$.

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Studying parton correlations via double parton scatterings in associated quarkonium production at the LHC and the Tevatron

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Quarkonium production in proton-proton (*pp*) collision provides interesting means to study the parton content and their correlations in the proton. Recent experimental LHC and Tevatron data of $J/\psi + Z$, $J/\psi + W$ and $J/\psi + J/\psi$ production suggest the relevance of double parton scatterings (DPSs) as opposed to single parton scatterings (SPSs). In this talk, we review the corresponding SPS contributions and discuss upper limits set up by quark-hadron duality. These allow us to perform an improved extraction of the DPS yields whose we discuss the implications.

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Measurement of the Minimum Bias, Underlying Events and Double-Parton Scatterings at CMS

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We present recent results on Minimum Bias, Underlying Events and Double Parton Scattering using data recorded by CMS detector at the LHC. The results on the measurement of the underlying event using leading tracks, jets, and Drell-Yan processes are presented. Double parton scattering is investigated in several final states including vector bosons and multi-jets, and the results are compared to other experiments and to MPI models tuned to recent underlying event measurements at CMS.

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New Results on the W Boson Production and Multi-lepton Cross Sections with the ATLAS Detector

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We report on the latest measurement on the production of W bosons in association with jets at 8 TeV and compare our results to the latest theoretical predictions. Differential cross sections for events

with one or two jets are presented for a range of observables, including jet transverse momenta and rapidities, the scalar sum of transverse momenta of the visible particles in the event, and the transverse momentum of the W boson. For a subset of the observables, the differential cross sections of positively and negatively charged W bosons are measured separately.
Moreover, the exclusive muon pair production measurement at 13 TeV is presented and the results are compared to theoretical predictions. The integrated cross-section is determined within a fiducial acceptance region of the ATLAS detector and differential cross-sections are measured as a function of the dimuon invariant mass.
If available, a study of the W and Z boson production in association with 1 or 2 b-jets will be presented.

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V+heavy flavor jets and constraints to PDFs with CMS

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The associated production of vector bosons, W or Z, and jets originating from heavy-flavour quarks is a large background source in measurements of several standard model processes, Higgs boson studies, and many searches for physics beyond the SM. The study of events with one or two well-identified and isolated leptons accompanied by heavy-flavour jets is crucial to refine the theoretical calculations in perturbative QCD, as well as to validate associated Monte Carlo techniques. Using the LHC proton-proton collision data at centre-of-mass energies of 8 and 13 TeV collected by the CMS detector, Wbb, Zb(b), W+c, and Z+c cross sections are measured. Fiducial differential cross sections are measured as a function of several kinematic observables. The study of the associated production of a vector boson with jets from a c-quark is specially interesting to improve the treatment of heavy quarks in PDF-related studies. The production of a W boson associated with a c-quark allows probing and constraining the strange quark content of the proton. T he associated production of a Z boson and c-quark jets may give insight into the existence of an intrinsic charm quark component inside the proton.

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Electroweak and QCD aspects in V+jets from CMS

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The study of the associated production of vector bosons and jets constitutes an excellent testbench to check numerous QCD predictions. Total and differential cross sections of vector bosons produced in association with jets has been studied at both 8 and 13 TeV center-of-mass energies. Differential distributions as function of a broad range of kinematical observables are measured and compared with theoretical predictions. Final states with a vector boson and jets can be also used to study electroweak initiated processes, such as the vector boson fusion production of a Z or W boson that are accompanied by a pair of energetic jets having large invariant mass.

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Studies of HERA deep inelastic scattering data at low Q^2 and low x_Bj

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A phenomenological study of the final combined HERA data on inclusive deep inelastic scattering (DIS) has been performed. The data are presented and investigated for a kinematic range extending from values of the four-momentum transfer, Q^2, above 10^4 GeV^2 down to the lowest values observable at
HERA of $Q^2 = 0.045$ GeV^2 and Bjorken x, $x_{\rm Bj} = 6 \times 10^{-7}$. The data are well described by fits based on perturbative quantum chromodynamics (QCD) using collinear factorisation and evolution of the parton densities encompassed in the DGLAP formalism from the highest Q^2 down to Q^2 of a few GeV^2. The standard DGLAP evolution was augmented by including an additional higher-twist term in the description of the longitudinal structure function, F_L. This additional term, $F_L A_L^{\rm HT}/Q^2$, improves the description of the reduced cross sections significantly. The resulting predictions for F_L suggest that further corrections are required for Q^2 less than about 2 GeV^2. The Regge formalism can describe the data up to $Q^2 \sim 0.65$ GeV^2. The complete data set can be described by a new fit using the ALLM parameterisation. The region between the Regge and the perturbative QCD regimes is of particular interest.

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Parton Distributions, QCD and small-x physics in energy-frontier DIS with the LHeC and the FCC-eh

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Energy-frontier DIS can be realised at CERN through an energy recovery linac that would produce 60 GeV electrons to collide with the HL-LHC or later HE-LHC (LHeC) or eventually the FCC hadron beams (FCC-eh). It would deliver electron-proton collisions with centre-of-mass energies in the range 0.3-3.5 TeV, and luminosities exceeding 10^{34} cm^{-2}s^{-1}. In this talk we will present new studies on the prospects for the precise and complete determination of parton distributions in the proton, both inclusively and in diffractive deep inelastic scattering. We discuss electroweak physics at high scales in ep. We will then embark on the most promising way for establishing the existence of new QCD physics at small x, of BFKL type, through the discovery of a new regime beyond the dilute one described by fixed-order perturbation theory.

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Constraints on the Parton Density Functions of the Proton by Measurements with the ATLAS Detector – QCD Track

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Parton distribution functions (PDFs) are crucial ingredients for measurements at hadron colliders, since they describe the initial states and therefore critically impact the precision of cross section predictions for observables. This talk will review recent precision analyses, where the PDFs play an important role and discuss the impact of several new ATLAS cross-section measurements on PDFs of the proton.

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Investigation of parton densities at very high x

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The knowledge of the proton parton densities for large x is very important in the search for new physics signals at the LHC. For Bjorken-x larger than 0.6 they are however poorly constrained by the data used in extracting the proton parton density functions (PDFs) and different pdf sets have large uncertainties, and differ considerably, in this regime. We compare the pdf sets most widely used by the LHC community to the ZEUS high-x data. This data has not been previously used in pdf set determinations. Due to the small expected and observed numbers of events in this kinematic regime, Poisson statistics is used in the evaluation of the probabilities assigned to the different pdf sets. A wide variation is found in the ability of the PDF sets to predict the observed results.

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QCD analysis of the ATLAS and CMS W and Z cross-section measurements and implications for the strange sea density

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In the present paper, the ATLAS inclusive $W^{\pm}$ and Z boson production data are analysed together with the CMS inclusive $W^{\pm}$ and Z boson production data to investigate any possible tensions between the data sets and to determine the strange sea fraction, within the framework of a parton distribution function fit at next-to next-to leading order in perturbative QCD.

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The CMS-TOTEM Precision Proton Spectrometer and first physics results

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The CT-PPS (CMS-TOTEM Precision Proton Spectrometer) detector system consists of silicon tracking stations as well as timing detectors to measure both the position and direction of protons and their time-of-flight with high precision. They are located at around 200 m from the interaction point in the very forward region on both sides of the CMS experiment. CT-PPS is built to study Central Exclusive Production (CEP) in proton-proton collisions at LHC, including photon-photon production of W and Z boson pairs, high-mass diphoton and dilepton production, high-p_T jet production, as well as searches for anomalous couplings and new resonances.

The CT-PPS detector has taken data at high luminosity while fully integrated to the CMS data acquisition system. The total data collected correspond to around 55 fb^{-1}. In this presentation the CT-PPS operation, commissioning and performance are discussed.

The measurements of dilepton and diphoton production in photon-photon fusion with CT-PPS are presented. For the first time, exclusive dilepton production at high masses have been observed in the CMS detector while one or two outgoing protons are measured in CT-PPS using around 10 fb^{-1} of data accumulated in 2016 during high-luminosity LHC operation. These first results show a good understanding, calibration and alignment of the new CT-PPS detectors. Preliminary results concerning the search for high-mass exclusive diphoton production are presented.

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Deeply Virtual Compton Scattering at Jefferson Lab

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Exclusive processes at high momentum transfer, such as Deeply Virtual Compton Scattering (DVCS) access the Generalized Parton Distributions (GPDs) of the nucleon. GPDs offer the exciting possibility of mapping the 3-D internal structure of protons and neutrons by providing a transverse image of the constituents as a function of their longitudinal momentum.

A vigorous experimental program is currently pursued at Jefferson Lab (JLab) to study GPDs through DVCS and meson production. New results from Hall A will be shown and discussed. Special attention will be devoted to the applicability of the GPD formalism at the moderate values of momentum transfer. In addition, we will report on results for L/T separated pi0 electroproduction cross sections off the proton, the neutron and the deuteron. A large transverse response for both the proton and neutron cases is found, pointing to a possible dominance of higher-twist transversity GPD contributions. For the first time, a flavor decomposition of the u and d quark contributions to the cross section will be shown.

We will conclude with a brief overview of additional DVCS experiments under analysis and planned with the future Upgrade of JLab to 12 GeV.

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Exclusive rho(770) photoproduction at HERA

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Exclusive photoproduction of $\rho(770)$ vector mesons is studied using the H1 detector at HERA. A sample of about 700000 decays $\rho \rightarrow \pi^+\pi^-$ was collected in the years 2006-2007, using the H1 fast track trigger. It corresponds to an integrated luminosity of 1.3 pb^{-1}. The sample is used to study cross-sections as a function of the invariant mass $m_{\pi\pi}$ of the decay pions, the photon-proton collision energy W and the momentum transfer at the proton vertex t. The phase-space restrictions are $0.5 < m_{\pi\pi} < 1.3$ GeV, $20 < W < 80$ GeV and $|t| < 1.5$ GeV^2. Reactions where the proton stays intact are statistically separated from those where the proton dissociates to a low-mass hadronic system. The observed cross-section dependencies are parameterized using fits and are compared to expectations from phenomenological models.

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Measurements of elastic pp interactions and exclusive production with the ATLAS detector

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The total pp cross section is a fundamental observable at the LHC. It can be derived from the measurement of the elastic cross section, using the optical theorem. Measurements of the elastic proton-proton cross section were performed at a center-of-mass energy of 8 TeV at various settings of the beam optics using the ALFA detector.
The ALFA detector is also used to tag forward protons in order to enrich the exclusive diffractive production of pion pairs for first cross section measurements of this process at center-of-mass energies of 7 and 8 TeV.
In the absence of forward proton tagging, exclusive processes can be distinguished in the central part of the ATLAS detector exploiting the absence of charged particles reconstructed in the inner tracking detector.
If available, the talk will also cover the study of the exclusive pion production at 7 and 8 TeV, the total cross section and rho determination from elastic scattering, as well as an inclusive single diffractive study at 8 TeV.

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Measurement of Diffractive and Exclusive processes at CMS

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With excellent performance the Compact Muon Solenoid (CMS) experiment has made a number of key observations in the diffractive and exclusive processes and hence in probing the Standard model in a unique way. This presentation will cover recent results on the measurement of diffractive and exclusive processes using data recorded by CMS detector at the LHC.

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Experimental Investigation of π+π− and K+K− atoms

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The DIRAC experiment at the CERN PS accelerator observed for the first time the long-lived hydrogenlike π+π− atoms. Atoms were produced by PS proton beam on the Be target. Part of the atoms in the long-lived states crossed the gap of 96 mm and then broken in the Platinum foil of 2.1 μm. producing π+π− pairs(atomic pairs). From the analysis of the $n_A^L = 436^{+157}_{-61}$ observed atomic pairs the lifetime of 2p state was evaluated to $\tau_{2P} = 0.22^{+1.55}_{-0.18} \times 10^{-11}$ s. This value of the long-lived atom lifetime is on the three order of magnitude more than our measured value of the atom ground state lifetime $\tau_{1S} = 3.15^{+0.28}_{-0.26} \times 10^{-15}$ s and do not contradicts to the QED value $\tau_{2P} = 1.17 \times 10^{-11}$ s. Further study of long-lived π+π− atoms will allow to measure the energy differences between p and s atomic states, to determine ππ scattering lengths and check the precise QCD predictions for these parameters.

On the same setup there were identified more than 7000 K+K- pairs with effective mass less than 2MK + 5Mev. In the distributions of K+K− pairs there is a strong signature of the Coulomb enhancement: the pairs number is increasing with the decreasing of the relative momentum in the pair c.m.s. The observed number of K+K− pairs with small relative momentum allows us to evaluate for the first time the number of K+K− atoms produced simultaneously with this pairs.

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QCD and gamma-gamma Physics at FCC-ee

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e+e- collisions at a Future Circular Collider with tens of ab^-1 integrated luminosities provide unparalleled conditions to carry out unique high-precision QCD and two-photon-fusion studies. The QCD and gamma-gamma physics perspectives at the FCC-ee will be summarized focusing on high-accuracy measurements of 1) the QCD coupling alpha_s 1, 2) parton radiation and fragmentation 2, and 3) SM and BSM studies in photon-photon collisions [3].

1 http://arxiv.org/abs/arXiv:1512.05194
2 http://arxiv.org/abs/arXiv:1702.01329
[3] http://arxiv.org/abs/arXiv:1510.08141

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IR-Improved results for LHC/FCC physics: Status report

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We present the current status of recent developments in the theory and application of IR-improved QED⊗QCD resummation methods, realized by MC event generator methods, for LHC and FCC physics scenarios.

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Tests of Perturbative QCD with Photon Final States at the ATLAS Experiment

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The production of prompt isolated photons at hadron colliders provides a stringent test of perturbative QCD and can be used to probe the gluon density function of the proton.
The ATLAS collaboration has performed numerous cross section measurements of prompt photon production, among which are a precise measurement of the production of isolated prompt photons in association with heavy flavor jets and a first measurement of the production cross-section of tri-photon final states at a center of mass energy of 8 TeV, as well as a photon plus jet cross section measurement at 13 TeV. If available, a measurement of diphotons in association with jets and a ratio of photon cross sections between 8 and 13 TeV will also be presented. The results are compared with state-of-the-art theory predictions, indicating several interesting discrepancies.

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Combination and QCD analysis of beauty and charm production cross section measurements in deep inelastic ep scattering at HERA

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Measurements of open charm and beauty production cross sections in deep inelastic ep scattering at HERA from the H1 and ZEUS Collaborations are combined. Reduced cross sections are obtained in the kinematic range of negative four-momentum transfer squared of the photon $2.5\ \mathrm{GeV}^2 \leq Q^2 \leq 2000\ \mathrm{GeV}^2$ and Bjorken scaling variable $3 \cdot 10^{-5} \leq x_{\mathrm{Bj}} \leq 5 \cdot 10^{-2}$. The combination method accounts for the correlations of the statistical and systematic uncertainties among the different data sets. Perturbative QCD calculations are compared to the combined data. A next-to-leading order QCD analysis is performed using these data together with the combined inclusive deep inelastic scattering cross sections from HERA. The running charm and beauty quark masses are determined as $m_c(m_c) = 1.290^{+0.046}_{-0.041}(\mathrm{exp/fit})^{+0.062}_{-0.014}(\mathrm{model})^{+0.003}_{-0.031}(\mathrm{parameterisation})$ GeV and $m_b(m_b) = 4.049^{+0.104}_{-0.109}(\mathrm{exp/fit})^{+0.090}_{-0.032}(\mathrm{model})^{+0.001}_{-0.031}(\mathrm{parameterisation})$ GeV.

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Determination of the strong coupling constant $\alpha_s(m_Z)$ in next-to-next-to-leading order QCD using H1 jet cross section measurements

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The strong coupling constant α_s is determined from inclusive jet and dijet cross sections in neutral-current deep-inelastic ep scattering (DIS) measured at HERA by the H1 collaboration using next-to-next-to-leading order (NNLO) QCD predictions. The dependence of the NNLO predictions and of the resulting value of $\alpha_s(m_Z)$ at the Z-boson mass m Z are studied as a function of the choice of the renormalisation and factorisation scales. Using inclusive jet and dijet data together, the strong coupling constant is determined to be $\alpha_s(mZ) = 0.1157(20)_{exp}(29)_{th}$. Complementary, $\alpha_s(mZ)$ is determined together with parton distribution functions of the proton (PDFs) from jet and inclusive DIS data measured by the H1 experiment. The value $\alpha_s(mZ) = 0.1142(28)_{tot}$ obtained is consistent with the determination from jet data alone. The impact of the jet data on the PDFs is studied. The running of the strong coupling is tested at different values of the renormalisation scale and the results are found to be in agreement with expectations.

Eur.Phys.J.C77 (2017) 4, 215 [arxiv:1611.03421]

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Strong coupling from a nonperturbative determination of the QCD Λ-parameter

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We present a first-principle determination of the Λ parameter and the strong coupling at the Z pole mass. Computing the nonperturbative running of the coupling in the range from 200 MeV to 70 GeV, and using experimental input values for the masses and decay constants of the pion and the kaon, we obtain α(mZ)=0.11852(84). The nonperturbative running up to very high energies guarantees that systematic effects associated with perturbation theory are well under control.

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Measurements of event properties and correlations in multijet events in CMS

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We present results on measurements of characteristics of events with jets, from jet-charge over investigations of shapes to jet mass distributions, and angular correlations in multi-jet events. The measurements are compared to theoretical predictions including those matched to parton shower and hadronization.

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Quark jet fraction in multi-jet final states and quark gluon discrimination

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We calculate quark and gluon jet fraction in multi-jet final states at the LHC, which is based on perturbative QCD at next-to-double logarithmic accuracy. We find a measurable scaling pattern of the fraction. This is related to a performance of new physics searches using quark-gluon jet discrimination in multi-jet final states, and would be useful for more understanding of QCD and tuning of Monte-Carlo generators. We also introduce a variable which is related to jet flavors in multi-jet final states, and propose a data-driven method using the variable to reduce systematic uncertainties of the analysis. We show how the background rejection using the method increase for signals which produce many quark jets.

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Probing perturbative QCD at the ATLAS Experiment

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Perturbative QCD calculations at next-to-leading order are available for the jet production in pp collisions since several years and next-to-next-to leading order calculations also became available recently. In this talk, we present the latest results from the ATLAS collaboration for inclusive jets and dijets, measured at center of mass energies of 8 and 13 TeV. All measured cross-sections are compared to state-of-the art theory predictions. Moreover, we present two measurements of dijet correlations allowing to test the renormalization group equation and to extract the strong coupling constant.

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Differential jet cross sections at the CMS experiment

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We present measurements of differential jet cross sections over a wide range in transverse momenta from inclusive jets to multi-jet final states. Studies on the impact that these measurements have on the determination of the strong coupling alpha_s as well as on parton density functions are reported.

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Measurement of Jet Production Cross Sections in Deep-inelastic ep Scattering at HERA

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A precision measurement of jet cross sections in neutral current deep-inelastic scattering for photon virtualities $5.5 < Q^2 < 80$ GeV^2 and inelasticities $0.2 < y < 0.6$ is presented, using data taken with the H1 detector at HERA, corresponding to an integrated luminosity of 290 pb^{-1}. Double-differential inclusive jet, dijet and trijet cross sections are measured simultaneously and are presented as a function of jet transverse momentum observables and as a function of Q^2. Jet cross sections normalised to the inclusive neutral current DIS cross section in the respective Q^2-interval are also determined. Previous results of inclusive jet cross sections in the range $150 < Q^2 < 15000$ GeV^2 are extended to low transverse jet momenta $5 < P_T < 7$ GeV. The data are compared to predictions from perturbative QCD in next-to-leading order in the strong coupling, in approximate next-to-next-to-leading order and in full next-to-next-to-leading order. Using also the recently published H1 jet data at high values of Q^2, the strong coupling constant $\alpha_s(M_Z)$ is determined in next-to-leading order.

Eur.Phys.J.C77 (2017) 4, 215 [arxiv:1611.03421]

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Studies of isolated photon production with a jet in deep inelastic scattering and diffractive photoproduction at HERA.

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Isolated photons with high transverse energy have been studied in deep inelastic ep scattering with the ZEUS detector at HERA, using an integrated luminosity of $326\,\mathrm{pb}^{-1}$ in the range of exchanged-photon virtuality $10 - 350\ \mathrm{GeV}^2$. Outgoing isolated photons with transverse energy $4 < E_T^{\gamma} < 15$ GeV and pseudorapidity $-0.7 < \eta^{\gamma} < 0.9$ were measured with accompanying jets having transverse energy and pseudorapidity $2.5 < E_T^{\mathrm{jet}} < 35$ GeV and $-1.5 < \eta^{\mathrm{jet}} < 1.8$, respectively. Differential cross sections are presented for the following variables: the fraction of the incoming photon energy and momentum that is transferred to the outgoing photon and the leading jet; the fraction of the incoming proton energy transferred to the photon and leading jet; the differences in azimuthal angle and pseudorapidity between the outgoing photon and the leading jet and between the outgoing photon and the scattered electron. Comparisons are made with theoretical predictions: a leading-logarithm Monte Carlo simulation, a next-to-leading-order QCD prediction, and a prediction using the k_T-factorisation approach.

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Measuring jet substructure observables at the ATLAS Experiment

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Jet substructure observables have significantly extended the search program for physics beyond the Standard Model at the Large Hadron Collider. The state-of-the-art tools have been motivated by theoretical calculations, but there has never been a direct comparison between data and calculations of jet substructure observables that are accurate beyond leading-logarithm approximation. Such observables are significant not only for probing the collinear regime of QCD that is largely unexplored at a hadron collider, but also for improving the understanding of jet substructure properties that are used in many studies at the Large Hadron Collider. The ATLAS collaboration has recently performed several measurements of precision jet substructure at 13 TeV that will significantly extend our understanding of both the perturbative and non-perturbative aspects of jet formation. These measurements of jet mass in various topologies as well as other properties of jet fragmentation such as charged-particle multiplicity and the properties of gluon splitting to bottom quarks are unfolded to correct for detector effects and compared with a variety of predictions.

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Forward energy flow and jet production in pp and pA collisions at the LHC with CMS

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The CASTOR calorimeter at CMS measures the energy of particles emitted with pseudorapidity between -5.2 and -6.6. It has been operating since the startup of the LHC in 2009 and has taken data in pp, pPb, and PbPb collisions at various centre-of-mass energies during run 1 and run 2. In this presentation we give an overview of some important and unique results obtained with CASTOR, with emphasis on the forward energy flow and jet production in pp collisions with $\sqrt{s} = 13$ TeV and pA collision with $\sqrt{s} = 5$ TeV. These results are compared to various models for the underlying event and parton shower dynamics. Further, we aim to interpret the results in terms of gluon saturation.

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Probing the charm hadronisation with ALICE at the LHC

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Charm-quark hadronisation can be investigated by measuring the relative abundance of various particle species, in particular non-strange D mesons (D^0, D^+, D^{*+}), D_s^+ mesons, and charm baryons ($^+_\mathrm{c}$, $^0_\mathrm{c}$). The high precision tracking, good vertexing capabilities and excellent particle identification granted by the ALICE apparatus allows measuring hadrons containing charm quarks over a wide momentum range in pp and pA collisions. Measurements of the charmed-baryon production in small systems are also a fundamental reference for heavy-ion collisions, where an enhancement of the baryon-to-meson ratio could derive from hadronisation via coalescence of charm quarks with the quarks of the Quark-Gluon Plasma formed in these collisions.\\

In this talk, recent measurements of charmed meson and baryon production in pp collisions and in p-Pb collisions with the ALICE experiment are presented and compared with theoretical calculations. The results include the p_T-differential cross section of $^+_\mathrm{c}$ and $^0_\mathrm{c}$ baryons, and the $^+_\mathrm{c}/\mathrm{D}^0$ ratio. The measured values of $^+_\mathrm{c}/\mathrm{D}^0$ baryon-to-meson ratio are significantly higher than what expected from model expectations and previous measurements at e^+e^- and e-p colliders.

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Study of inclusive di-hadron and production rates of hyperon and charmed baryon in e+e- colliders

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The inclusive cross sections for di-hadrons of charged pions and kaons (e+e-⟶hhX), hyperons and charmed baryons in e+e- annihilation are reported. For di-hadrons of charged pions and kaons, the cross sections are obtained as a function of the total fractional energy and invariant mass for any di-hadron combination in the same hemisphere and di-hadron fragmentation functions are probed. For hyperons and charmed baryons, the direct production cross sections after subtracting the feed-down contributions from heavy particles are compared for the first time. We also report the first observation of transverse Λ/Λbar polarization in e+e- colliders. The analyses are based on a data set recorded by the Belle detector from e+ e- collisions produced by the KEKB collider.

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Measurement of hadronic cross sections with the BABAR detector

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A program of measuring the light hadrons production in exclusive $e^+e^- \to$ hadrons processes is in place at BABAR, with the aim to improve the calculation of the hadronic contribution to the muon $g-2$. We present the most recent results obtained by using the full data set of about 470 fb^{-1} collected by the BABAR experiment at the PEP-II e^+e^- collider at a center-of-mass energy of about 10.6 GeV. In particular, we report the results on the channels $e^+e^- \to \pi^+\pi^-\pi^0\pi^0$, $e^+e^- \to \pi^+\pi^-\eta$, $K^0_S K^+\pi^-\pi^0$, $\bar{K^0}K^0\pi^0$, $\bar{K^0}K^0\pi^0\pi^0$, and $\bar{K^0}K^0\eta$.
The first reaction is the main source of uncertainty on the total hadronic cross section in the energy region between 1 and 2 GeV, while the other processes, together with previous BABAR results, complete the studies of the final states with two neutral or charged kaons.

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Contribution of QCD Condensates to the OPE of Green Functions of Chiral Currents

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In this talk, basic properties of QCD condensates will be presented, together with theirs relation to the operator product expansion (OPE) and the two-point and three-point Green functions constructed of chiral currents. Next, we will discuss our newest results for contribution of the QCD condensates with dimension D<6 to the Green functions calculated within the framework of chPT/RChT, i.e. chiral perturbation theory or resonance chiral theory. This matching of the OPE and such effective theories can lead to some coupling constants constraints and, therefore, thus allows us to obtain some unknown parameters of the chiral/resonance Lagrangian.

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Charm Quark Mass with Calibrated Uncertainty

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We determine the charm quark mass $m_c(m_c)$ from QCD sum rules of moments of the vector current correlator calculated in perturbative QCD. Only experimental data for the charm resonances below the continuum threshold are needed in our approach, while the continuum contribution is determined by requiring self-consistency between various sum rules, including the one for the zeroth moment. Existing data from the continuum region can then be used to bound the theoretical error. Our result is $m_c(m_c) = 1272 \pm 8$ MeV for $\alpha_s(M_Z) = 0.1182$. Special attention is given to the question how to quantify and justify the uncertainty.

J. Erler, P. Masjuan and H. Spiesberger,
Charm Quark Mass with Calibrated Uncertainty,
Eur. Phys. J. C 77, 99 (2017) [arXiv:1610.08531].

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Lattice Predictions for Bound Heavy Tetraquarks

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We investigate the possibility of $qq'\bar{Q}\bar{Q}'$ tetraquark bound states using $n_f = 2+1$ lattice QCD with pion masses $\simeq$ 164, 299 and 415 MeV. Two types of lattice interpolating operator are chosen, reflecting first diquark-antidiquark and second meson-meson structure. Performing variational analysis using these operators and their mixings, we determine the ground and first excited states from the lattice hadron correlators. Using non-relativistic QCD to simulate the bottom quarks and the Tsukuba formulation of relativistic heavy quarks for charm quarks, we study the $ud\bar{b}\bar{b}$, $\ell s\bar{b}\bar{b}$ as well as $ud\bar{c}\bar{b}$ channels, with $\ell = u, d$. In the case of the $ud\bar{b}\bar{b}$ and $\ell s\bar{b}\bar{b}$ channels unambiguous signals for $J^P = 1^+$ tetraquarks are found with binding energies $189(10)$ and $98(7)$ MeV below the corresponding free two-meson thresholds at the physical point. These tetraquarks are therefore strong-interaction stable, implying they are stable under strong as well as electromagnetic interactions while they can decay weakly. So far these are the first exotic hadrons predicted to have this feature. Further evidence for binding is found in the $ud\bar{c}\bar{b}$ channel, whereby the binding energy broadly straddles the electromagnetic stability threshold.
Studying further the quark mass dependence, we vary the heavy quark mass in $ud\bar{Q}\bar{Q}$, $\ell s\bar{Q}\bar{Q}$ as well as $ud\bar{Q}\bar{b}$, $\ell s\bar{Q}\bar{b}$ between ~ 0.7 and 6.3 times the bottom quark mass. The observed mass dependence closely follows a behaviour argued from phenomenological considerations of the heavy quark potential.

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First-principles lattice QCD calculation of the neutron lifetime

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There is an intriguing discrepancy in the measurements of the neutron lifetime. The almost 4σ difference has recently been highlighted due to new high-precision experiments using ultra cold trapped neutrons and it could indicate the existence of new physics.
Thanks to the Standard Model relation between the lifetime and the axial coupling g_A of the neutron, which governs it's transition to a proton, a first-principle QCD calculation of g_A could shed light on the experimental discrepancy and new physics.
Lattice QCD provides a robust framework to numerically compute inherently non-perturbative quantities from first principles. Starting only from the Lagrangian of QCD and owing to new improved numerical algorithms, we calculate the axial coupling of the neutron with unprecedented precision and thus obtain the neutron lifetime: $\tau_n = 885(15)$ seconds.
This calculation is challenging and the outcome is very promising: it paves the way to understanding nuclear observables directly from QCD degrees of freedom with high accuracy.

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Studies of open charm production and properties at LHCb

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LHCb continues to expand its world-leading sample of charmed hadrons collected during LHC's Run 1 and Run 2. Recent results on charm production and charm hadron lifetimes are presented.

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Measurements of heavy flavor production at CMS

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Recent results on the production of beauty and charm at the CMS detector, based on data collected at Run 1 and Run 2 of LHC are presented. Measurements of single and double quarkonium production, Lambda_b polarization, open charm and B hadrons cross sections and ratios are reported.

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Precise measurement of the $D^*(2010)^+ - D^+$ mass difference

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We measure the mass difference, Δm_+, between the $D^*(2010)^+$ and the D^+, using the decay chain $D^*(2010)^+ \to D^+\pi^0$ with $D^+ \to K^-\pi^+\pi^+$. The data were recorded with the BABAR detector at center-of-mass energies at and near the $\Upsilon(4S)$ resonance, and correspond to an integrated luminosity of approximately $468\,\text{fb}^{-1}$. We measure $\Delta m_+ = (140\,601.0 \pm 6.8\,[\text{stat}] \pm 12.9\,[\text{syst}])$ keV.
We combine this result with a previous BaBar measurement of $\Delta m_0 \equiv m(D^*(2010)^+) - m(D^0)$ to obtain $\Delta m_D = m(D^+) - m(D^0) = (4\,824.9 \pm 6.8\,[\text{stat}] \pm 12.9\,[\text{syst}])$ keV.
These results are compatible with, and approximately five times more precise than, previous world averages.

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ATLAS results on quarkonia and its associated production

The ATLAS collaboration[None] ; Cesare Bini[1]

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The associated production of vector boson with quarkonia is a key observable for understanding the quarkonium production mechanisms, including the separation of single and double parton scattering components.

This talk will present the latest differential measurements from ATLAS of (associated-) quarkonium production

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Open heavy-flavour measurements in proton-proton collisions with ALICE at the LHC.

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In proton-proton (pp) collisions, open heavy-flavour hadrons are valuable tools for testing perturbative Quantum Chromo-Dynamics (pQCD) calculations. Indeed, the large heavy-quark masses (with respect to the QCD scale parameter) allow to calculate the heavy-quark production cross section, as perturbation series in α_S down to $p_{\mathrm{T}} = 0$.

The ALICE experiment has measured D mesons in pp collisions, via the reconstruction of hadronic decay channels at central rapidity, as well as muons (electrons) from semi-leptonic decay of heavy-flavour hadrons at forward (mid) rapidity. These measurements, performed over a wide range of transverse momentum, in several rapidity regions and for different collision energies, have much smaller uncertainties than the typical theoretical ones. Thus, ALICE results challenge state-of-the-art pQCD calculations such as FONLL and GM-VFNS and, besides, add sensitivity to gluon PDF.

More differential measurements help studying further charm production: the analysis of D-meson-tagged jets allows measuring charm jet production, and addressing charm-quark production processes and charm fragmentation properties. Additionally, multiplicity-dependent measurements of heavy-flavour production provide insight into multi-parton interactions and the possible interplay of soft and hard processes.

In this talk, new and most recent ALICE results on open heavy-flavours in pp collisions at $\sqrt{s} = 2.76$, 5, 7, 8 and 13 TeV will be presented and compared with theoretical and model predictions.

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Measurement of D * Production in Diffractive Deep Inelastic Scattering at HERA

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Measurements of $D^*(2010)$ meson production in diffractive deep inelastic scattering ($5 < Q^2 < 100$ GeV^2) are presented which are based on HERA data recorded at a centre-of-mass energy $\sqrt{s} = 319$ GeV with an integrated luminosity of 287 pb^{-1}. The reaction $ep \rightarrow eXY$ is studied, where the system X, containing at least one $D^*(2010)$ meson, is separated from a leading low-mass proton dissociative system Y by a large rapidity gap. The kinematics of D^* candidates are reconstructed in the $D^* \rightarrow K\pi\pi$ decay channel. The measured cross sections compare favourably with next-to-leading order QCD predictions, where charm quarks are produced via boson-gluon fusion. The charm quarks are then independently fragmented to the D^* mesons. The calculations rely on the collinear factorisation theorem and are based on diffractive parton densities previously obtained by H1 from fits to inclusive diffractive cross sections. The data are further used to determine the diffractive to inclusive D^* production ratio in deep inelastic scattering.

Eur.Phys.J.C77 (2017), 340 [arxiv:1703.09476]

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Recent LHCb Results in Charm Spectroscopy

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LHCb continues to expand its world-leading sample of charmed hadrons collected during LHC's Run 1 and Run 2. With this data set, LHCb is discovering many previously unobserved charmed states and making the most precise determinations of the properties of these states. LHCb's latest work on the spectroscopy of charmed hadrons is presented.

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Heavy quark(onia) spectroscopy at LHCb

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The spectroscopy of excited hadronic states in the beauty sector, double heavy hadrons and quarkonia provides a rich proofing ground for effective theories of the strong interaction. The unique data set collected during runs 1 and 2 of the LHC have lead to the observation of several new states, interesting decay modes and has enabled precision mass measurements of known resonances. Here we present recent results from LHCb.

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Search for the B-meson decay to four baryons $B \rightarrow p\bar{p}p\bar{p}$

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B mesons are the lightest mesons which can decay to various final states containing different baryons. Up to now, the discrepancy between the inclusive branching fraction of all B meson decay modes with at least a couple of baryons in the final state, measured by ARGUS to be $(6.8 \pm 0.6)\%$, and the sum of exclusive baryonic channels, averaged on neutral and charged B mesons at less than 1%, represents an open issue. The measurement and comparison of exclusive branching fractions of baryonic B decays, as well as studies on the dynamic of the decay, may allow better understanding of baryon production in B decays and, more generally, hadron fragmentation into baryons. We present here a search for the decay $B \rightarrow p\bar{p}p\bar{p}$, not yet observed, by using a data set consisting of about 470 million $B-\bar{B}$ pairs collected with the BABAR detector at the SLAC National Accelerator Laboratory. We select 11.1 ± 4.6 candidate events, corresponding to a signal significance of 2.9σ, and obtain
the branching fraction of $(1.14 \pm 0.047(stat) \pm 0.17(syst)) \times 10^{-7}$.

Strong Interactions and Hadron Physics / 348

Measurement of beauty production from dimuon events at HERA

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Beauty production in events containing two muons in the final state has been measured with the ZEUS detector at HERA II. A low transverse-momentum threshold for muon identification, in combination with the large rapidity coverage of the ZEUS muon system and the upgraded ZEUS tracker, gives access to almost the full phase space for beauty production. The total cross section for beauty production in ep collisions at $\sqrt{s} = 318$ GeV has been measured. Differential cross sections and a measurement of $b\bar{b}$ correlations are also obtained. All are compared to previous beauty cross-section measurements, Monte Carlo models and next-to-leading-order QCD predictions. The previous ZEUS measurements are confirmed with higher precision.

Strong Interactions and Hadron Physics / 594

Studies of Bc mesons at LHCb

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The Bc meson, the heaviest amongst known meson, decays through the weak interaction. Its double heavy quark content make it an interesting laboratory for test of effective theories of the strong interaction with a unique setting for production, decay and spectroscopy studies. This talk presents recent progress on Bc decays obtained at LHCb.

Strong Interactions and Hadron Physics / 785

Study of radiative decays of the $\Upsilon(1S)$ and of three-body decays of the J/ψ

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We report on recent studies of quarkonium decays performed with the data collected by the BaBar experiment at the PEP-II e^+e^- collider.
In particular, we use the entire BaBar dataset to study the reaction $e^+e^- \to \gamma_{ISR} J/\psi$, with $J/\psi \to \pi^+\pi^-\pi^0$, $J/\psi \to K^+K^-\pi^0$, or $J/\psi \to K_S K^\pm \pi^\mp$, and the photon γ_{ISR} is produced via Initial-State-Radiation. We measure the relative J/ψ branching fractions and perform a Dalitz plot analysis of each J/ψ decay mode using an isobar model and a Veneziano model.
We also present a study of the radiative decays of the $\Upsilon(1S)$ to $\pi^+\pi^-\gamma$ and $K^+K^-\gamma$ final states, performed on the data samples collected at the peak of the $\Upsilon(2S)$ and $\Upsilon(3S)$ resonances. The $\Upsilon(1S)$ is reconstructed from the decay chains $\Upsilon(nS) \to \pi^+\pi^-\Upsilon(1S)$, with $n = 2, 3$. Branching fractions measurements and spin-parity analysis are reported for the $\Upsilon(1S)$ radiative decays to intermediate resonances observed in the $\pi^+\pi^-$ and K^+K^- mass spectra.

Strong Interactions and Hadron Physics / 345

Observation of Y(4S) → eta’ Y(1S) and Y(2S) → gamma eta_b(1S) at Belle

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The hadronic transitions involving an eta meson, thoroughly studied by Belle, are the largest transitions from Y(4S) to the narrow bottomonia. The transition Y(4S)→η′Y(1S) yields insights on the quark content of the pseudoscalar mesons, and on the mechanism of heavy quark spin symmetry breaking, if compared with the eta transitions, We report the first observation of this transition, with the Y(1S) decay in a mu+mu- pair and the eta’ decay in rho gamma or pi+pi-eta decay modes. The analysis is based on 497 /fb data collected on Y(4S) peak by Belle at the KEKB e+ e- collider. We also report on search for Y(2S) → gamma eta_b(1S) decay based on analysis of the inclusive photon spectrum of 24.7 fb^-1 of e+e- collisions at the Y(2S) center-of-mass energy with Belle. This result represents the first significant observation of this decay mode, and provides a new measurement of the eta_b(1S) mass and the branching fraction for this suppressed M1 transition. We also cover other measurements on bottomonia.

Strong Interactions and Hadron Physics / 343

Measurement of Bs and Y(5S) Decays with Belle

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The branching fraction of the decay Bs ⟶ Ds X has been measured by Belle and other experiments, but with indirect methods which have model-dependent limitations. We report a direct measurement of this decay by tagging one Bs from Y(5S) with semi-leptonic decay (Bs ⟶ Ds l nu), where several Ds decay modes are combined to increase the total statics. We also report a search for eta and eta' transitions from Y(5S) resonance to the lower bottomonia. These results are based on data sample of 121 /fb collected at the Y(5S) resonance by the Belle detector at the KEKB asymmetric-energy e+ e- collider. Other analyses on Bs and Y(5S) decays are also covered in this talk.

Strong Interactions and Hadron Physics / 367

Probing the strange content of the proton via charm production in charged-current deep inelastic scattering at HERA

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The production of charm quarks in charged current interactions at HERA is investigated using the ZEUS detector. The present analysis considers measurements taken in HERA II period (2003 - 2007) where major detector upgrades were implemented at ZEUS. With an integrated luminosity of about 350 pb^{-1}), the HERA II data has enough statistics to probe the strangeness in the proton via charm production at high Q^2 in charged current deep inelastic scattering (CC DIS). The life-time tagging method was used to select charm events, suppressing the light-flavour contribution in the CC cross section. The charm cross section measurement in CC DIS at HERA as well as estimation of major systematics is presented and compared with theoretical expectations.

Technology Applications and Industrial Opportunities / 1052

From CERN knowledge to society

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CERN's mission is the pursuit of knowledge through curiosity-driven research. The Laboratory was created to explore the fundamental particles and their interactions, with the goal of helping us to understand how the universe works. Since its beginnings, CERN has also acted as a trailblazer in the technologies related to accelerators, detectors and computing. As a laboratory with a long-term research plan, it is continuously innovating. For more than 60 years, the work of thousands of scientists from all over the world has pushed back the limits of knowledge in fundamental physics, as well as in many fields of technology. It is part of CERN's mission to ensure that our innovations bring practical benefits to society as a whole.

We use a variety of avenues to bring CERN innovation to society, ranging from education, communication and outreach to formal Knowledge Transfer (KT) activities whose aim is to maximise the positive impact of CERN technologies outside the HEP field. CERN's KT activities have led to hundreds of collaboration agreements from the field of medtech and aerospace, and from industry 4.0 to cultural heritage. We have a CERN KT fund to stimulate innovation. It has funded 41 projects since 2011, while our Medical Applications budget has funded 25 projects since 2014. We promote entrepreneurship and we grant licences for companies to develop our technologies. 23 start-ups are now using CERN technology, some hosted in the nine Member State Business Incubation Centres (BICs). All this is done to ensure a strong return on investment for policy makers, industry, and the general public.

Technology Applications and Industrial Opportunities / 1054

Production of GEM foils in Korea and application detectors

MECARO has invested great efforts to produce the large size GEM foils since 2012. The company developed their original production methods including new chemicals for etching and high-tech lithography machine. In this talk, we will summarise the technical details for the large size GEM foil production and review our status on production capability. We will also show some of our new activities on application detector development.

Technology Applications and Industrial Opportunities / 1049

Case Study for the Socio-economic Impact of large Scientific Projects on the Technology Transfer and Technology-driven Startups in KOREA

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In Korea, large scientific facilities started to build in parallel with the economic growth from late 1980s. The 3rd generation synchrotron-based, 2 GeV electron accelerator, the Pohang Light Source (PLS), was the biggest scientific endeavor in Korean history at that time. Few heavy industries for nuclear power with decent technical level, large ship building industries, semiconductor chip makers and a steel company were all engineering and technological resources from the industrial sector. After PLS, consecutive large science projects have been deployed with bigger scales in cost and technical complexities. A few of those are KSTAR, KOMAC, RAON, KSLV, KHIMA and ITER. During the rapid expansion period of last 30 years, there have been a noticeable change in the industrial sector. New startups driven by the advanced technology development have emerged and networked with laboratories as well as themselves, establishing new industrial clusters of companies for developing new and advanced technologies. This change definitely give impacts to the policy and strategy on the large science facilities deployment.
In this presentation, few cases will be shown as an example and some insight will be drawn for the future.

Technology Applications and Industrial Opportunities / 1048

HL-LHC industrialization and procurement. Lessons learnt

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The High-Luminosity LHC (LH-LHC) is a major upgrade of the Large Hadron Collider (LHC) that aims increasing the number of proton-proton collisions, boosting our chances of coming across new and rare physics phenomena. In order to do that, several new technologies will be introduced and heavy civil engineering work is required. Overall, more than 1.2 km of the current LHC ring will need to be replaced with new components.
The engineering concepts behind most part of these components come from our latest R&D and only a few units will be required for each type. From one side producing them at CERN or in the laboratories collaborating in HL-LHC would be nearly impossible considering the production time frame. From the other side, the industry considers that the series are too short, the tolerances too tight and the development too risky to get interested. How to solve this situation?
The talk will give an overview of the sourcing strategy that was put in place for HL-LHC and the results obtained. Particular emphasis will be put on what we think were key success factors and could be useful for other construction projects facing the same challenges.

Technology Applications and Industrial Opportunities / 1055

ALICE ITS production with Korean industry - Status and Outlook

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The ITS (Inner Tracking System) upgrade for the ALICE experiment at the LHC consists of novel monolithic CMOS pixel senosors with a total surface of 10^2. It is foreseen to be installed in the experiment during LS2 in 2019/20. The ITS upgrade encompasses highly advanced industrial technologies, such as CMOS sensor processing, post processing of silicon wafers, custom electronics and precision robotics. This contribution will give and overview of the R&D development carried out with industrial partners in Korea and present the current status of the production as well as an outlook for the future.

Technology Applications and Industrial Opportunities / 1053

Ams' Technology Concepts on Monolithically Integrated Photosensors

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Ams AG is a global leader in the design and manufacture of advanced sensor solutions, which are at the heart of the products and technologies that define our world today – from smartphones and mobile devices to smart homes and buildings, industrial automation, medical technology and connected vehicles. To build global leadership in optical sensing, ams is driving integration of sensor technologies into monolithically integrated solutions. This presentation will provide an overview of ams' integrated photosensor concepts including 3D integration, spectral sensing and radiation hard concepts.

Technology Applications and Industrial Opportunities / 1051

nVIDIA AI Computing

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Technology Applications and Industrial Opportunities / 1050

Chinese industries in technology developments related to high energy physics facilities: Introduction to CIPC

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Facing to future high energy physics large science projects, CEPC-SppC, CEPC Industrial Promotion Consortium (CIPC) has been etablished in Nov 7, 2018 , with companies working in different

key technology domains, such as superconducting cavities, cryo-module, klystron, high field superconducting magnet, civil engineering, etc. Previously, these companies have worked closely with Chinese academic institutions and Universities in ILC collaboration,JUNO, and Jinping Dark matter experiment, European XFEL, LCLSII, FRIB-MSU, and C-ADS, etc.

Top Quark and Electroweak Physics / 971

Top-quark physics at the Future Circular Colliders

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The FCC-ee project includes a running time at and above the top pair production threshold.
The collection of about 0.2 ab-1 at the tt threshold would allow the most precise measurement of the top mass with about 10 MeV of statistical accuracy. The threshold region can also be used to measure the top width and extract an indirect value of the top Yukawa coupling. A second running phase will collect about 1.5ab-1 of data at sqrt(s)=365 GeV with a luminosity of 3x10^34. The million of tops produced will be used for the measurement of the top quark electroweak coupling to the photon and the Z with a precision around or below the per-cent level. This precision can be reached with the sole angular and momentum distributions of the lepton arising from semi-leptonic decays in top anti-top events, and can be further improved with other observables.
New improved estimates of the limits for FCNC processes in top events can also be obtained using both the top pair produced events at 365 GeV along with the anomalous production of single top via FCNC at the sqrt(s)=240 GeV of the Higgs running phase.

Top Quark and Electroweak Physics / 526

Top-quark physics at the first CLIC stage

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The Compact Linear Collider (CLIC) is a mature option for a future electron-positron collider operating at centre-of-mass energies of up to 3 TeV. CLIC will be built and operated in a staged approach with three centre-of-mass energy stages currently assumed to be 380 GeV, 1.5 TeV and 3 TeV. This talk discusses the prospects for precision measurements of the top-quark properties at the first stage of CLIC operation based on benchmark analyses using full detector simulations. The top-quark mass can be determined with a precision of about 50 MeV in a theoretically well-defined manner by using a centre-of-mass energy scan around the top-quark pair production threshold. Other approaches to extract the top-quark mass at CLIC make use of ISR photons or the direct reconstruction of the top quarks. Another key measurement at 380 GeV is the study of the top-quark couplings to electroweak gauge bosons. Expected precisions on Effective Field Theory (EFT) operator coefficients are shown. Finally, searches for Flavour Changing Neutral Current (FCNC) top quark decays, such as t->cH, t->c+photon and t->c+missing energy, are discussed.

Top Quark and Electroweak Physics / 175

Standard Model measurements at the High-Luminosity LHC with CMS

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The High-Luminosity Large Hadron Collider (HL-LHC) is expected to deliver an integrated luminosity of up to 3000 fb-1. The very high instantaneous luminosity will lead to about 200 proton-proton collisions per bunch crossing ("pileup") superimposed to each event of interest, therefore providing extremely challenging experimental conditions. Prospects for selected Standard Model (SM) measurements at the High-Luminosity LHC are presented. In particular, the performance of the upgraded CMS detector at the HL-LHC for precision measurements of the global SM parameters, top mass and electroweak mixing angle is studied. Prospects for flavour changing neutral currents search in single top quark production and also for QCD-oriented measurements are also presented.

Top Quark and Electroweak Physics / 157

First measurements of top quark mass and other properties with Run-2 data in CMS

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Measurements of top quark properties using data collected by the CMS experiment at 13 TeV are presented. The top quark mass is measured in the lepton+jets channel is consistent with the CMS measurements of Run-1. The top quark mass is also studied as a function of the event kinematical properties. For the first time at the LHC, the width of the top quark is directly probed during Run-2, in what constitutes the most precise direct bound of the top quark width performed to date.

Top Quark and Electroweak Physics / 451

Measurements of the top quark mass with the ATLAS detector

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The top quark mass is one of the fundamental parameters of the Standard Model. The latest ATLAS measurements of the top quark mass in top quark pair final states are presented. Measurements use dilepton, lepton+jets and all-hadronic final states and their combination is performed. Measurements of the top quark pole mass based on precision theoretical QCD calculations for lepton kinematic distribution and for ttbar production with an additional jet are also presented, as well as a measurement of the top quark mass using 13 TeV data.

Top Quark and Electroweak Physics / 217

Direct and indirect measurements of the top quark mass in $p\bar{p}$ collisions

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We discuss extractions of the pole mass of the top quark based on measurements of the inclusive and unfolded differential $p\bar{p} \to t\bar{t}$ production cross section as a function of $p_T(t)$ and $M(t\bar{t})$. We use the full Run II (2001–2011) data set of $p\bar{p}$ collisions at $\sqrt{s} = 1.96$TeV collected by the D0 experiment, corresponding to an integrated luminosity of 9.7 fb^{-1}. We compare the indirect extraction to the final combination of direct measurements of the top quark mass at D0 and to the preliminary D0+CDF combination.

Top Quark and Electroweak Physics / 56

Exclusive Top Threshold Matching at Lepton Colliders

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The threshold scan at future lepton colliders is the most precise known method to determine the top quark mass (well below 100 MeV), a fundamental parameter of the Standard Model that co-determines the stability properties of the electroweak vacuum. We present a new method to match the continuum next-to-leading order QCD corrections with the next-to-leading logarithmic resummation of the Coulomb singularities of the quasi-toponium bound state at threshold where fixed-order perturbation theory is invalid. This matching is performed at the level of the fully exclusive WbWb final state. It allows to study all kinds of differential distributions at or close to threshold. The top mass dependence of these distributions opens up new possibilities for the top mass determination that might be competitive with the inclusive threshold scan.

Top Quark and Electroweak Physics / 970

Electroweak Physics at FCC-ee

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The Future Circular Collider with electron-positron beams (FCC-ee) should provide improvements of the electroweak precision measurement concerning Z, W, H and their masses by a large factor over the present status.
The unparalleled experimental precision would open, via Electroweak loop corrections, a broad discovery potential for new, at least weakly interacting particles up to high energy scales.
The Z boson mass and width, as well as the Z ⟶ bb partial width, and the forward-backward asymmetries for leptons and quarks can be measured with high precision with the run at the Z pole, where the instantaneous luminosity is expected to be five to six orders of magnitude larger than LEP. As a result, a precise determination of the effective weak mixing angle, as well as of the running electromagnetic coupling αQED(mZ2) can be extracted directly from the data.

At centre-of-mass energies around 160 GeV, corresponding to the WW production threshold, the W boson mass and width can be determined precisely with high-statistics cross section measurements at several energy points. The key breakthrough for this exceptional performance is the continuous beam energy determination by resonant depolarization of the beams. Considerable improvements of the strong coupling constant determination down to a precision of Δαs(mZ)±0.0001 will be possible with the measurements of the hadronic widths of the Z and W bosons.

Top Quark and Electroweak Physics / 743

Electroweak Physics at CEPC

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Abstract: The Circular Electron Positron Collider (CEPC) project aims to build a circular electron-positron collider capable of precision physics measurements at center-of-mass energies ranging from 90 GeV to 240GeV. The CEPC has a total circumference of at least one hundred kilometers and at least two interaction points. In its 10 years operation at 240 GeV, it will collect more than one million Higgs events. CEPC will also run at Z pole for two years, producing more than 100 billion Z bosons in two year. It will also collect data around WW threshold for one year, in order to perform the W boson mass measurement with high precision. These datasets will boost the precision of electroweak measurements by orders of magnitude. An overview is presented of the potential of CEPC to advance precision studies of electroweak physics with an emphasis on the opportunities in W and Z physics.

Top Quark and Electroweak Physics / 420

3rd Generation Quark and Electroweak Boson Couplings at the 250 GeV stage of the ILC

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The 3rd generation quarks are, due to their large mass, highly sensitive probes for new physics connected to the electroweak symmetry breaking. While top quark pair production requires center-of-mass energies of larger than 350 GeV, the first stage of the ILC at a center-of-mass energy of 250 GeV can perform precision measurements of bottom quark pair production, thereby settling the long standing ~3\sigma tension between the LEP experiments and SLD. For this measurement, the polarised beams of the ILC are of special importance as they enable the separation of the vector and axial-vector couplings of the b quark to Z boson and photon. Another important precision probe for new physics are triple gauge boson coupings (TGCs). Thanks to the polarised beams and the much higher luminosity, a significant increase in precision beyond past and present experiments is expected at the first stage of the ILC for the TGCs involving W bosons. For both measurements, we will report recent projections based on detailed simulations of the ILD detector concept, and highlight the role of important detector performance aspects, e.g. for the separation of b and anti-b jets based on vertex charge measurements and particle ID.

Top Quark and Electroweak Physics / 586

EW physics at LHCb

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A variety of vector boson measurements have been performed at LHCb with Run 1 data, including inclusive Z/W cross-sections, the Z forward-backward asymmetry, Z/W production with jets (including heavy flavor). Additionally, the inclusive Z cross-sections have been measured with Run 2 data. A variety of these results will be presented.

Top Quark and Electroweak Physics / 455

New Results on Z Boson Production with the ATLAS Detector

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Precision measurements of the Drell-Yan production of Z bosons at the LHC provide a benchmark of our understanding of perturbative QCD and electroweak processes and probe the proton structure in a unique way. ATLAS performed a precise triple differential Drell-Yan cross-section measurement as a function of Mll, dilepton rapidity and cosθ* defined in the Collins-Soper frame at a center of mass energy of 8 TeV. We report on this measurement which provides sensitivity to PDFs and the Z forward-backward asymmetry, AFB. In order to test the electroweak sector with single Z boson final states, ATLAS has published a first measurement of the tau-polarization in Z events as well as the cross-section of the electroweak production of Z bosons at 13 TeV. These results will be presented and discussed.

Top Quark and Electroweak Physics / 539

W/Z boson production cross sections with the CMS detector

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Measurements of single W and Z boson inclusive and differential production cross sections with the CMS detector are presented. Measurements of Drell-Yan cross sections in the mass range of 15 to 3000 GeV are also reported. The results are compared to predictions from different Monte Carlo generators.

Top Quark and Electroweak Physics / 221

Measurements and combination of the weak mixing angle at the Tevatron and extraction of the W mass

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We combine four measurements of the forward-backward charge asymmetry A_{FB} in $p\bar{p} \to Z/\gamma^* \to e^+e^-/\mu^+\mu^- + X$ events using $\sim$ 10 fb^{-1} of $p\bar{p}$ data collected at $\sqrt{s} = 1.96$ TeV by the CDF and D0 detectors at the Fermilab Tevatron collider. A_{FB} is measured as a function of

the invariant mass of the dilepton system to extract the effective weak mixing angle $\sin^2\theta^{lep}_{eff}$. We discuss the combination of these measurements and present the indirect extraction of the W mass in the context of the standard model.

Top Quark and Electroweak Physics / 220

Measurements of the effective weak mixing angle in at D0

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We present the measurements of forward-backward charge asymmetry A_{FB} in $p\bar{p} \to Z/\gamma^* \to \mu^+\mu^-$ events using $9.7\ \mathrm{fb}^{-1}$ of $p\bar{p}$ data collected at $\sqrt{s} = 1.96$ TeV by the D0 detector at the Fermilab Tevatron collider. A_{FB} is measured as a function of the invariant mass of the dimuon system to extract the effective weak mixing angle $\sin^2\theta^{lep}_{eff}$. This measurement is combined with a previous measurement performed in the $p\bar{p} \to Z/\gamma^* \to e^+e^-$ channel at D0. In the context of the standard model, using the on-shell renormalization scheme where $\sin^2\theta_W = 1 - M_W^2/M_Z^2$, the measurement of $\sin^2\theta^{lep}_{eff}$ yields an indirect extraction of the W mass.

Top Quark and Electroweak Physics / 527

Top-quark physics at high-energy CLIC operation

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The Compact Linear Collider (CLIC) is a mature option for a future electron-positron collider operating at centre-of-mass energies of up to 3 TeV. CLIC will be built and operated in a staged approach with three centre-of-mass energy stages currently assumed to be 380 GeV, 1.5 TeV and 3 TeV. This talk discusses the prospects for top-quark physics at the two TeV-scale CLIC energy stages based on benchmark analyses using full detector simulations. New studies of top-quark pair production at high-energy CLIC operation make use of jet-substructure techniques originally developed for the LHC. Forward-backward and polarisation asymmetries, as well as so-called optimal observables, are studied. The top Yukawa coupling and the CP properties in the ttH coupling are best probed in 1.5 TeV collisions. CLIC operation at 3 TeV also enables the study of top-quark pair production through Vector Boson Fusion. The BSM sensitivity provided by the top physics program at CLIC is illustrated using Effective Field Theory (EFT).

Top Quark and Electroweak Physics / 310

Charming Top Decays with Flavor Changing Neutral Higgs Interactions at Hadron Colliders

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We investigate the prospects for discovering a top quark decaying into one light Higgs boson along with a charm quark in top quark pair production at the CERN Large Hadron Collider (LHC) and future hadron colliers.

A general two Higgs doublet model is adopted to study the signature
of flavor changing neutral Higgs (FCNH) interactions with $t \to c\phi^0$,
followed by $\phi^0 \to b\bar{b}, ZZ^*$, and WW^*,
where ϕ^0 could be CP-even (h^0) or CP-odd (A^0).
We study the discovery potential for the FCNH signal and physics background
from dominant processes with realistic acceptance cuts and
tagging efficiencies.
Promising results are found for the LHC running
at 13 or 14 TeV collision energies as well as future pp colliders
at 28 TeV, 33 TeV, or 100 TeV.

Top Quark and Electroweak Physics / 449

Top quark properties measurements with the ATLAS detector

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The top quark is the heaviest known fundamental particle. As it is the only quark that decays before it hadronizes, this gives the unique opportunity to probe the properties of bare quarks. This talk will focus on a few recent precision measurements of top quark properties in production and decay by the ATLAS Collaboration at center-of-mass energies of 8 TeV and 13 TeV.

Top Quark and Electroweak Physics / 153

Top modelling and tuning in CMS

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State-of-the-art theoretical predictions accurate to next-to-leading order QCD interfaced with Pythia8, Herwig, and Sherpa event generators are tested by comparing the unfolded ttbar differential data collected with the CMS detector at 8 and 13 TeV. These predictions are also compared with the underlying event activity distributions in ttbar events using CMS proton-proton data collected at a center of mass energy of 13 TeV. In addition, studies of jet shapes in ttbar events at 13 TeV are presented. Studies to derive and test the new CMS event tune obtained through jet kinematics in ttbar events and global event variables are also described.

Top Quark and Electroweak Physics / 968

TopFitter: Fitting top quark Wilson Coefficients to Run II data

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We will describe the latest TopFitter analysis, which uses top quark observables to fit the Wilson Coefficients of the SM augmented with dimension 6 operators. In particular, we will discuss the inclusion of new LHC Run II data, and the implementation of particle-level observables.

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The role of positron polarization for the inital 250 GeV stage of the International Linear Collider

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The International Linear Collider is now proposed with a staged machine design, with the first stage at sqrt(s)=250 GeV and an integrated luminosity goal of 2 ab^-1. One of the questions for the machine design is the importance of positron polarization. In this report, we review the impact of positron polarization on the physics goals of the 250 GeV stage of the ILC and demonstrate that positron polarization has distinct advantages.

Top Quark and Electroweak Physics / 535

Multiboson production at CMS

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Precision measurements of multi-boson production is a validation of the Standard Model. These multi-boson processes are a background to Higgs measurements and searches for Beyond the Standard Model physics. In this talk, we present the recent measurements of multiboson final states performed in CMS, involving W, Z and photon combinations. Inclusive and differential cross sections are compared to different theoretical predictions. Phase space regions that provide sensitivity to anomalous triple or quartic gauge couplings are also investigated. These coupling strengths are directly related to the broken electroweak symmetry and deviations from the SM are a clear signal of new physics.

Top Quark and Electroweak Physics / 457

New Results on Multi-Boson Production with the ATLAS Detector

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Measurements of the cross sections of the production of three electroweak gauge bosons and of vector-boson scattering processes at the LHC constitute stringent tests of the electroweak sector of the Standard Model and provide a model-independent means to search for new physics at the TeV scale. The ATLAS collaboration searched for the production of three W bosons or of a W boson and a photon together with a Z or W boson at a center of mass energy of 8 TeV. ATLAS also searches for the electroweak production of diboson final states, where evidence was found for the exclusive production of W boson pairs. If available also further results on the electroweak production of diboson pairs will be presented. All results have been used to constrain anomalous gauge couplings and have been compared to the latest theory predictions.

Top Quark and Electroweak Physics / 456

Tests of the electroweak sector sector with Diboson final states at the ATLAS Experiment

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Measurements of the cross sections of the production of pairs of electroweak gauge bosons at the LHC constitute stringent tests of the electroweak sector and provide model-independent means to search for new physics at the TeV scale. Similarly, the electroweak production of vector bosons in proton-proton collisions tests the gauge structure of the Standard Model. The ATLAS collaboration has performed detailed measurements of integrated and differential cross sections of the production of ZZ di-boson pairs as well as WZ and WW di-boson pairs at 8 and 13 TeV. The results will be presented and compared to predictions at NLO (and NNLO) in pQCD. Constraints on new physics are provided by setting limits on anomalous triple gauge couplings. If available, a measurement of the unfolded 4-lepton mass at 13 TeV will be presented.

Top Quark and Electroweak Physics / 536

Results of vector boson scattering from CMS

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The production of massive vector boson pairs is a key process for the understanding of the non-abelian gauge structure of the standard model and for the comprehension of the electroweak symmetry breaking mechanism. The study of the production of vector boson pairs with the presence of two jets in the event allows to measure the electroweak production of vector bosons in association with jets, in particular made up through vector boson scattering (VBS) processes. In this presentation, we will report the recent results of the production of diboson in association with two jets. The constraints on anomalous quartic couplings will be presented as well.

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Determination of electroweak parameters using H1 inclusive DIS data

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An improved determination of electroweak (EW) parameters using H1 inclusive neutral current and charged current DIS cross sections is presented. The analysis benefits from the usage of the previously published cross sections using longitudinally polarised lepton beams. The parameters are determined in a combined fit of EW parameters together with PDFs. The predictions include NNLO QCD corrections for the PDF and structure function calculations, and the corrections at the leptonic vertex are obtained in the on-shell scheme including the full set of 1-loop corrections. The analysis determines the weak neutral-current couplings of the light quarks and thus tests potential contributions beyond the SM. The mass of the W-boson is determined and a precision of 115 MeV is achieved.

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A Precision Event Generator for EW Radiative Corrections in Hadron Scattering: KKMC-hh

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KKMC-hh is a precision event-generator for Z production and decay in hadronic collisions, which applies amplitude-level resummation to both initial and final state photon radiation, including perturbative residuals exact through order $\alpha^2 L$, together with exact order α electroweak matrix element corrections. We present some comparisons to other programs and results showing the effect of multi-photon radiation for cuts motivated by a recent ATLAS W -mass analysis. We also show preliminary untuned comparisons of the electroweak corrections of KKMC-hh to those of HORACE, which includes order exact α EW corrections with resummed final-state photon radiation.

Top Quark and Electroweak Physics / 453

Searches for rare top quark couplings with the ATLAS detector

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The top quark is the heaviest known fundamental particle and probing its couplings with the other fundamental particle may open a window to physics beyond the Standard Model. Searches for flavour-changing neutral current top-quark interactions are discussed based on the 13 TeV ATLAS dataset. Searches for rare top quark decays to Higgs and Z bosons are presented in top quark pair production, and searches for rare top quark interactions with gluons and Z bosons are presented in single top quark production.

Top Quark and Electroweak Physics / 159

Anomalous top quark couplings, FCNC, and EFT interpretations in CMS

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Top quark production can probe physics beyond the SM in different ways. Some processes, and especially certain angular correlations, are sensitive to the existence of anomalous top quark couplings. In the SM, flavour-changing neutral currents (FCNC) are forbidden at tree level and are strongly suppressed in loop corrections. Several extensions of the SM incorporate significantly enhanced FCNC behaviour that can be directly probed in top quark processes. Current approaches adopting an EFT framework allow describing effects of new physics in a model independent way. This talks reviews the current limits on possible anomalous couplings of the top quark, FCNC searches in the top sector, and EFT interpretations.

Top Quark and Electroweak Physics / 158

Rare top quark production in CMS: ttW, ttZ, ttgamma, tZ, tgamma, and tttt production

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A comprehensive set of measurements of top quark pair and single top quark production in association with EWK bosons (W, Z or γ) is presented. The results are compared to theory predictions and re-interpreted as searches for new physics inducing deviations from the standard model predictions using an effective field theory approach. The status of the search for four top quark production, to which the LHC experiments are starting to be sensitive, and that has important BSM re-interpretations, is also reported.

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Measurements of ttbar+X using the ATLAS detector

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The large centre-of-mass energy available at the proton-proton collider LHC allows for the copious production of top quark pairs in association with other final state particles at high transverse momenta. The ATLAS experiment has measured several final state observables that are sensitive to additional radiation in top anti-top quark final states. Results on the top production in association with W and Z bosons are presented as well as top pair production with a photon or with b quarks. These measurements are compared to modern Monte Carlo generators based on NLO QCD matrix elements.

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Forward-backward asymmetry in $p\bar{p} \to t\bar{t}$ events at the Tevatron

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We discuss the asymmetry between yields of forward- and backward-produced top and antitop quarks in $p\bar{p} \to t\bar{t}$ events at the Tevatron collider. These measurements use the full Run II data set in lepton plus jets and dilepton channels, recorded in the D0 and CDF detectors, corresponding to an integrated luminosity of $\approx 2 \times 10$ fb^{-1} . The combinations of inclusive and differential asymmetries are presented and compared with recent standard model predictions.

Top Quark and Electroweak Physics / 154

Recent ttbar inclusive cross sections results in CMS

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Latest results on inclusive top quark pair production cross sections are presented using proton-proton collision data collected by CMS at different centre-of-mass energies, including 5 TeV. Final states with at least one charged lepton and one b-jet are explored to measure inclusive production cross sections. The sensitivity of some these measurements to PDFs and extraction of standard model parameters is also described. Moreover, first ttbar cross sections results in proton-lead collisions are discussed.

Top Quark and Electroweak Physics / 452

Single Top quark production and properties measurements using the ATLAS detector

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Measurements of single top-quark production in proton-proton collisions and of angular correlations in single top-quark events are presented based on the 8 TeV and 13 TeV ATLAS datasets. For the production of single top quarks in the t-channel and the tW-channel, measurements of inclusive and differential cross-sections are included. Evidence for s-channel production using 8 TeV data and the measurement of single top quark production in association with a Z boson at 13 TeV are also presented. All measurements are compared to state-of-the-art theoretical calculations. Differential cross-sections are measured as a function of angular variables that are sensitive to anomalous contributions to the Wtb vertex and the top quark polarization.

Top Quark and Electroweak Physics / 156

Single top quark production in CMS

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Recent results on single top quark production are presented, performed using CMS data collected at different centre-of-mass energies. The single top quark analyses investigate separately the production of top quarks via t-channel exchange, in association with a W boson (tW) or via the s-channel. Differential measurements of t-channel production cross sections are also presented.

Top Quark and Electroweak Physics / 585

Top physics at LHCb

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LHCb, while purpose built for b-physics, also functions as a general purpose forward detector, covering the pseudo-rapidity range 2.0 to 5.0. Measurements of top production in the LHCb acceptance have particular sensitivity to high values of Bjorken-x, and offer complementary PDF constraints to measurements at the central detectors. In addition, the higher contribution from quark-initiated production to top pair production in the forward region leads to a larger expected charge asymmetry at LHCb than at the other experiments. The first Run 2 measurement of top pair production at LHCb at 13 TeV will be presented, along with previous Run 1 measurements in final states accessible to both single top and top pair production.

Top Quark and Electroweak Physics / 448

Top quark production cross-section measurements with the ATLAS detector

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Measurements of the inclusive and differential top-quark pair production cross sections in proton-proton collisions with the ATLAS detector at the Large Hadron Collider at center-of-mass energies of 8 TeV and 13 TeV are presented. The inclusive measurements reach high precision and are compared to the best available theoretical calculations. Differential measurements of the kinematic properties of the top-quark production are also discussed. These measurements, including results using boosted tops, probe our understanding of top-quark pair production in the TeV regime.