CERN Bulletin

Issue No. 32-34/2020-Thursday 13 August 2020
More articles at *http://home.cern/cern-people*

NA62 SEES FIRST SIGNIFICANT EVIDENCE OF RARE PROCESS

The result paves the way for searching for signs of physics beyond the Standard Model of particle physics

The experimental hall where NA62 is located (Image: Julien Ordan/CERN)

Physicists look for new physics phenomena in many ways. One is by observing and measuring processes that are predicted to be extremely rare and looking for differences between data and theoretical predictions. The NA62 detector – the 62nd experiment located in CERN's North Area – is designed to observe with high precision one such process, in which a positively charged particle known as a kaon transforms into a positively charged pion and a neutrino–antineutrino pair (denoted by $K^+ \rightarrow \pi^+\nu\nu$). Yesterday, at the 40th International Conference on High Energy Physics, the NA62 collaboration reported recording 17 candidate events for this particular transformation in data they collected in 2018. By combining the data they collected in 2016 and 2017, NA62 can claim the first evidence for this ultra-rare process, with a statistical significance of three-and-a-half sigma (3.5σ).

Colliding particles – into other particle beams or into fixed targets – at sufficiently high energies can produce heavy, unstable particles, like the kaons sought by NA62. These heavy particles transform (or "decay") almost instantaneously into lighter particles in various combinations.

(Continued on page 2)

A WORD FROM DORIS FORKEL-WIRTH

BY PROTECTING YOURSELF, YOU PROTECT OTHERS

Like the rest of the world, CERN is going through challenging times due to the COVID-19 pandemic. Unfortunately, the virus did not vanish during the summer but is still circulating among the global population. In numerous countries, the number of infections is rising again – resulting in renewed constraints on our professional and private lives.

(Continued on page 2)

In this issue

Published by:
CERN-1211 Geneva 23, Switzerland writing-team@cern.ch
Printed by: CERN Printshop

CERN-ISSN: **Printed version:** 2011-950X
Electronic Version: 2077-9518

A WORD FROM DORIS FORKEL-WIRTH

BY PROTECTING YOURSELF, YOU PROTECT OTHERS

Since the beginning of CERN's gradual restart on 18 May, the Organization has slowly been coming back to life, with more and more colleagues on site each week. And we are all excited to come back and see our colleagues in person, thus restoring the vibrant atmosphere that is so characteristic of CERN.

However, the circumstances are undeniably different and our contacts with colleagues should be reestablished with due consideration for the good health and safety of our community. The updated measures in place will help you understand how to protect yourself and others.

The following three simple gestures are easy to adopt and could save you and your colleagues from COVID-19 infection: wash your hands, keep a two-metre distance and wear face masks (correctly!). Respecting these rules will keep you and others safe; it will show you care and are taking responsibility for your colleagues' health and well-being as much as for your own.

COVID-19 infections are mainly caused through direct or indirect contact with the SARS-CoV-2 virus when it is attached to droplets or to aerosols suspended in the air. There are three main lines of defence: keeping a safe distance of two to three metres, wearing a protective cover like a mask over your mouth and nose to reduce the spread of droplets, and the frequent renewal of ambient air with fresh air to reduce potential airborne viral concentration.

People often simply dislike wearing masks or call their efficiency into question. But there is now confirmed evidence that wearing a mask is one of the most effective ways of protecting against the spread of COVID-19. It has been shown that systematic wearing of face coverings by the community can prevent transmission of the virus, even when a wearer infected with the virus comes into close contact with others. It is therefore important that we can count on the cooperation of the entire CERN community to endorse mask wearing.

Infectious droplets can be released during breathing and speaking, even by asymptomatic infected persons. Not wearing a mask or not doing so in the correct way increases the risk of exposure to the virus for the persons in your vicinity. The wearing of a face mask is a critical barrier against the spread of the infection. At CERN, the general rule is to wear a mask at all times, except in specific settings, i.e. where a two-metre distance from others and proper ventilation can be ensured, whether indoors or outdoors (e.g. in offices or meeting rooms while seated).

Another important measure currently in place is the ventilation of office spaces to reduce the chance of infections by the virus when it is attached to aerosols. Studies show that the virus remains active for at least three hours in the air in common indoor conditions and can travel long distances. Emerging scientific evidence shows that traces of SARS-CoV-2 can be found in aerosols and small droplets even in non-healthcare settings (e.g. public spaces). Therefore proper air ventilation with fresh air should be ensured in office spaces. This may be achieved by natural means, e.g. opening windows and doors for 10 minutes at least every two hours, or by mechanical means via an HVAC system. In offices and meeting rooms where physical distancing and proper ventilation with fresh air are ensured, people may remove their masks while seated.

Our highest priority continues to be to protect the health and well-being of all people on site and those working remotely. Thanks to the measures and recommendations in place, CERN has maintained quite a low infection rate and has successfully managed the situation among the community so far. However, as we return on site, we are now all responsible for protecting the Laboratory and its future and we are all counting on each other to do the right thing.

With the COVID-19 restart plan progressing steadily and more of us returning to CERN, we expect to see the Laboratory becoming increasingly busy, but the circumstances are still unusual and we should avoid becoming complacent. This is why everybody needs to stay informed and respect the measures and recommendations in place – it is the key to a safe return for us all.

Doris Forkel-Wirth
Head of the HSE Unit

NA62 SEES FIRST SIGNIFICANT EVIDENCE OF RARE PROCESS

The Standard Model of particle physics predicts how often a given particle will undergo all possible transformations. In the case of the kaon, only around one in every ten billion are expected to transform into a pion and a neutrino–antineutrino pair, with an uncertainty of about 10%. It is thus one of the rarest processes that can be observed by physicists.

While CERN is famous for the Large Hadron Collider, other accelerators at the laboratory provide particle beams for smaller but highly specialised experiments. The NA62 detector gets its beam from the Super Proton Synchrotron (SPS). Proton beams from the SPS, with an energy of 400 gigaelectronvolts, slam into a fixed target made of beryllium located upstream of NA62. Nearly a billion secondary particles are produced each second as a result and race towards the detector. Of these particles, around 6% are positively charged kaons. The kaons enter the detector, where a dedicated device identifies them before they undergo transformation into lighter particles. The physicists therefore have to first count the kaons produced and identify which of them transformed into a pion and a neutrino–antineutrino pair. Since neutrinos and their antiparticle counterparts leave no trace in the NA62 detector, their presence has to be deduced by calculating the angles between the parent kaon and the daughter pion and by measuring their speed and direction of motion.

In 2018, the NA62 detector collected data for 217 days, at the expense of around a billion billion (10^{18}) protons. By sifting through these data, the collaboration was able to identify 17 new events that fit the $K^+ \to \pi^+\nu\nu$ profile, in addition to the first candidate event observed in data from 2016 and the two candidates from 2017. Combining these data allowed NA62 to experimentally determine that the rate at which kaons undergo this rare transformation is around one in ten billion, with an uncertainty of about 35%. The experimental value is compatible with the Standard Model's prediction at the current level of precision.

This is an important milestone for the experiment. NA62 is now on track to reach the threshold of 5σ statistical significance to claim observation of the process. The detector will receive new batches of kaons when the SPS resumes operations in 2021, following the second long shutdown of CERN's accelerator complex.

Achintya Rao

LS2 REPORT: FURTHER UPGRADES FOR THE PS

Two new internal beam dumps and a new septum magnet have been installed in the PS as part of the LIU project

The new PS internal beam dumps, sheathed in layers of steel and concrete shielding (in green), have been installed inside the accelerator in June (Image: CERN)

The Proton Synchrotron (PS) now boasts two new internal beam dumps. Installed inside the accelerator in June, they are the result of five years of development work in the framework of the LHC Injectors Upgrade (LIU) project. The size of a shoebox, the core of the dump comprises two absorbing elements – isostatic graphite and a copper, chrome and zirconium compound – through which the beam will pass in turn. Each dump is sheathed in layers of steel and concrete shielding, which will help to absorb the beam. “The dump itself absorbs only 8% of the energy of the beam”, explains François-Xavier Nuiry, the project leader from the EN-STI group. “This represents a power of up to 2.2 kW, which will need to be evacuated. We chose the hot isostatic pressing technique for the core of the dump as it allows optimum heat removal.”

The new beam dumps operate differently to all the other beam dumps at CERN: in order to stop the beam, they place themselves across its path in a rapid (300 ms) oscillation movement. This technique, which was first developed back in 1973 and was then redesigned and modernised for the LIU project, provides a major advantage in terms of reliability. Two ball bearings, springs and an electromagnet are all it takes to trigger the oscillation. “Thanks to their specific design and the careful selection of each of the components that make up the oscillation mechanism, these dumps require very little maintenance and have a high resistance to radiation,” adds François-Xavier Nuiry. Each dump will have to perform 200,000 oscillations a year for 15 years.

The two new dumps are already operational and will undergo oscillation tests in situ until the PS is closed in October.

A new injection line has also been installed. The Booster, which has undergone a complete transformation, will henceforth supply the PS with particles accelerated to up to 2 GeV, compared with 1.4 GeV previously. The old magnets of the injection line, in particular the septum magnet, have thus had to be replaced. “In the 'septum magnet' section of the Accelerator Beam Transfer (ABT) group, we have developed a new magnet that's based on the principle of eddy currents”, explains Michael Hourican, work package leader. “This is the first time that this type of septum magnet has been used at CERN.”

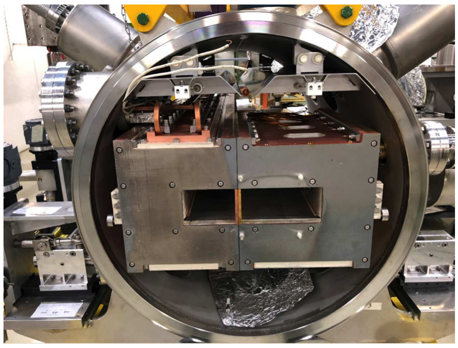
The injection septum magnets will deflect the beams of particles coming from one accelerator and inject them into the next without perturbing the beams that are already circulating. The magnetic field inside the magnet has a tendency to “leak”, which can interfere with the circulating beams, hence the use of eddy currents. “The eddy currents induced in the magnet create a secondary magnetic field that opposes the leaking magnetic field and helps to cancel it out, thus reducing the impact on the circulating beams," explains Michael Hourican.

In the PS, the septum magnet is accompanied by five bumper magnets and an injection kicker magnet, which together make up the injection system. The septum magnet deflects the trajectory of the beam coming from the PSB and directs it to the PS ring. The bumper magnets modify the orbit inside the PS so that its position and angle correspond to those of the beam coming out of the septum. Finally, the injection kicker magnet, located downstream, places the injected beam onto the normal orbit.

It's a bit like a car (the beam) taking a slip road (the injection line) to enter a motorway (the PS): on the slipway, the car takes a bend (the septum magnet), then enters a lane of the motorway. The only difference here is that the motorway lane itself physically moves (under the influence of the bumper magnets) in order to "receive" the car.

For reasons of space and geometry, one of the five bumper magnets has been attached to the new septum magnet (see photo). The two magnets are located inside a vacuum tank, which can be positioned remotely from the CERN Control Centre (CCC) in order to optimise the injection. The assembly was installed inside the PS at the end of June and is currently undergoing tests.

The new septum and bumper magnets during installation in the PS injection line (Image: CERN)



The new septum magnet (left) and the bumper (right) have been clamped together and inserted inside a vacuum tank (Image: CERN)

Anaïs Schaeffer

ICHEP SURVEY TO COLLECT DATA ON IMPACT OF COVID-19

The survey, aimed at the high-energy physics community and prepared by the Diversity and Inclusion panel at ICHEP2020, will be open until 31 August

During the ongoing COVID-19 pandemic, we all face new challenges daily. The effects of temporary and long-term confinement on families, teleworking, job contracts, career development, travel constraints and working conditions can be complex. The "Diversity and Inclusion" panel at ICHEP 2020 organised a discussion about conducting scientific research during a pandemic, and a diverse range of impacts, including personal testimonies, were shared. The panel has prepared a survey to assess the difficulties faced by researchers across different HEP collaborations, subfields of research and countries. The intention is to gauge the global impact of the pandemic on the HEP community, with a focus on personal and professional issues. As an outcome of the survey, the panel plans to highlight difficult circumstances, to propose actions to funding agencies to mitigate them in the near future and to comment on the long-term impacts.

The survey will be available until 31 August at: surveymonkey.com/r/ICHEP2020-COVIDSurvey.

BREAKING NEW GROUND IN THE SEARCH FOR DARK MATTER

Our fourth story in the LHC Physics at Ten series discusses the LHC's hunt for the hypothetical particle that may make up dark matter

The Large Hadron Collider (LHC) is renowned for the hunt for and discovery of the Higgs boson, but in the 10 years since the machine collided protons at an energy higher than previously achieved at a particle accelerator, researchers have been using it to try to hunt down an equally exciting particle: the hypothetical particle that may make up an invisible form of matter called dark matter, which is five times more prevalent than ordinary matter and without which there would be no universe as we know it. The LHC dark-matter searches have so far come up empty handed, as have non-collider searches, but the incredible work and skill put by the LHC researchers into finding it has led them to narrow down many of the regions where the particle may lie hidden – necessary milestones on the path to a discovery.

"Before the LHC, the space of possibilities for dark matter was much wider than it is today", says dark-matter theorist Tim Tait of UC Irvine and theory co-convener of the LHC Dark Matter Working Group. "The LHC has really broken new ground in the search for dark matter in the form of weakly interacting massive particles, by covering a wide array of potential signals predicted by either production of dark matter, or production of the particles mediating its interactions with ordinary matter. All of the observed results have been consistent with models that don't include dark matter, and give us important information as to what kinds of particles can no longer explain it. The results have both pointed experimentalists in new directions for how to search for dark matter, and prompted theorists to rethink existing ideas for what dark matter could be – and in some cases to come up with new ones."

Read the full feature (http:///news/series/lhc-physics-ten/breaking-new-ground-search-dark-matter).

Ana Lopes

BACK TO SCHOOL IN A NEW BUILDING

The Jardin des Particules, the crèche and nursery school run by the Staff Association, is moving into a new building

CERN Staff Association's new crèche and nursery school, located in Building 664, will open at the end of August (Image: CERN)

The *Jardin des Particules*, the crèche and nursery school run by the Staff Association, will welcome children back after the summer break in a brand-new building. Located a stone's throw from the CERN Reception, the building has a surface area of 1336 m^2spread over two floors: the crèche, for children from 4 months to 4 years old, is on the ground floor, and the school, for older children up to 6 years old, is on the first floor. Each floor has a kitchen and a refectory. Children will be able to spend their break times playing in a playground in front of the school.

"The building was designed to be highly energy efficient," says Pierre Cardon, the leader of the project, which was carried out by the SMB department. "Triple glazing, a reversible heat pump, dual-flow ventilation, solar panels... the new *Jardin des Particules* combines comfort with energy savings."

The work, which began in January, is now almost complete, just in time for the start of the school year on 25 August.

The former *Jardin des Particules* building will be demolished in the coming weeks in preparation for work on the *Science Gateway*, which will begin this autumn. "We had to move both the school and the CERN Mobility Centre (which was located in the Globe car park) to make way for the future Science Gateway," says Frédéric Magnin, who is in charge of the construction work for the latter project. The new Mobility Centre, which is also currently under construction, will open at the end of September in a dedicated building near Entrance A on the Meyrin site (Route Bohr).

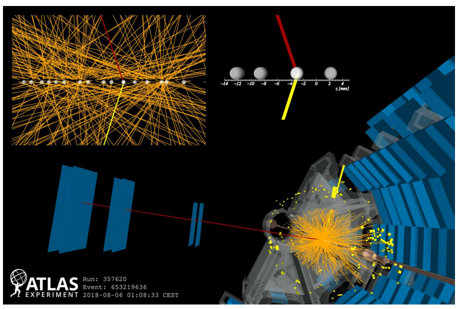
_____

There are still places available at the* Jardin des particules *for the new school year! For more information, go to: http://nurseryschool.web.cern.ch/en.

Anaïs Schaeffer

RARE PHENOMENON OBSERVED BY ATLAS FEATURES THE LHC AS A HIGH-ENERGY PHOTON COLLIDER

The ATLAS experiment reports the observation of photon collisions producing weak-force carriers and provides further insights into their interactions



A 2018 ATLAS event display consistent with the production of a pair of W bosons from two photons, and the subsequent decay of the W bosons into a muon and an electron (visible in the detector) and neutrinos (not detected). (Image: CERN)

During the International Conference on High-Energy Physics (ICHEP 2020), the ATLAS collaboration presented the first observation of photon collisions producing pairs of W bosons, elementary particles that carry the weak force, one of the four fundamental forces. The result demonstrates a new way of using the LHC, namely as a high-energy photon collider directly probing electroweak interactions. It confirms one of the main predictions of electroweak theory – that force carriers can interact with themselves – and provides new ways to probe it.

According to the laws of classical electrodynamics, two intersecting light beams would not deflect, absorb or disrupt one another. However, effects of *quantum electrodynamics* (QED), the theory that explains how light and matter interact, allow interactions among photons.

Indeed, it is not the first time that photons interacting at high energies have been studied at the LHC. For instance, light-by-light "scattering", where a pair of photons interact by producing another pair of photons, is one of the oldest predictions of QED. The first direct evidence of light-by-light scattering was reported by ATLAS in 2017, exploiting the strong electromagnetic fields surrounding lead ions in high-energy lead–lead collisions. In 2019 and 2020, ATLAS further studied this process by measuring its properties.

The new result reported at this conference is sensitive to another rare phenomenon in which two photons interact to produce two W bosons of opposite electric charge via (among others) the interaction of four force carriers[1]. Quasi-real photons from the proton beams scatter off one another to produce a pair of W bosons. A first study of this phenomenon was previously reported by ATLAS and CMS in 2016, from data recorded during LHC Run 1, but a larger dataset was required to unambiguously observe it.

The observation was obtained with a highly significant statistical evidence of 8.4 standard deviations, corresponding to a negligible chance of being due to a statistical fluctuation. ATLAS physicists used a considerably larger dataset taken during Run 2, the four-year data collection in the LHC that ended in 2018, and developed a customised analysis method.

Owing to the nature of the interaction process, the only particle tracks visible in the central detector are the decay products of the two W bosons, an electron and a muon with opposite electric charge. W-boson pairs can also be directly produced from interactions between quarks and gluons in the colliding protons considerably more often than from photon–photon interactions, but these are accompanied by additional tracks from strong interaction processes. This means that the ATLAS physicists had to carefully disentangle collision tracks to observe this rare phenomenon.

"This observation opens up a new facet of experimental exploration at the LHC using photons in the initial state", said Karl Jakobs, spokesperson of the ATLAS collaboration. "It is unique as it only involves couplings among electroweak force carriers in the strong-interaction-dominated environment of the LHC. With larger future datasets it can be used to probe in a clean way the electroweak gauge structure and possible contributions of new physics."

Indeed, the new result confirms one of the main predictions of electroweak theory, namely that, besides interacting with ordinary particles of matter, the force carriers, also known as gauge bosons – the W bosons, the Z boson and the photon – are also interacting with each other. Photon collisions will provide a new way to test the Standard Model and to probe for new physics, which is necessary for a better understanding of our Universe.

Links, related articles & scientific material:

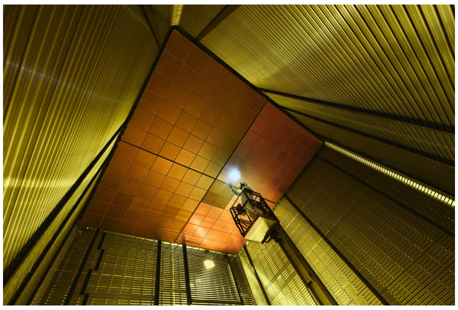
- Observation of photon-induced W^+W^-production in proton–proton collisions at 13 TeV using the ATLAS detector
- ATLAS Physics briefing on the result
- Scientific Plots and Diagrams

---

[1]The four force-carrier interaction is one of the predictions of the electroweak theory that explains how force-carrier particles, also known as gauge bosons, interact not only with matter particles, but also with one another.

CERN'S NEUTRINO SUCCESS STORY

The CERN Neutrino Platform has proved a major success in enabling European participation in long-baseline neutrino projects in the US and Japan



The ProtoDUNE dual-phase prototype being built at CERN (Image: CERN)

The neutrino is the most ethereal of particles. Tens of billions of them emanating from nuclear reactions in the sun's core pass through every square centimetre of Earth's surface each second without notice. They have vanishingly small masses, a trillion times smaller than the top quark, and oscillate weirdly between their three flavours – electron, muon and tau – as they travel.

Since the first direct detection of a neutrino from a nuclear power plant in 1956, a vast and varied experimental programme employing reactor, solar, accelerator, atmospheric, cosmic and geological neutrino sources has grown up to explore its still-mysterious nature.

The latest issue of *CERN Courier* describes the state of the art in experimental neutrino physics, including recent results from the Tokai-to-Kamioka (T2K) facility in Japan that hint at differences in the way neutrinos and antineutrinos oscillate. It also celebrates the key role being played by Europe in contributing to a globally coordinated programme of neutrino research via the CERN Neutrino Platform.

Established in 2013, the CERN Neutrino Platform has enabled significant European participation in the US Long-Baseline Neutrino Facility, which will see neutrinos sent 1300 km from Fermilab in Chicago to the Deep Underground

Neutrino Experiment (DUNE) in South Dakota, and in T2K, which sends neutrinos from Japan's J-PARC accelerator facility to the Super-Kamiokande detector 295 km away. DUNE, T2K and its successor, the Hyper-Kamiokande project, will refine physicists' understanding of neutrino oscillations, while a series of shorter baseline experiments are exploring the existence of a possible fourth, "sterile" neutrino.

For the US-based programme, the CERN Neutrino Platform has provided a large-scale demonstration of DUNE's kilotonne-scale liquid-argon time-projection chambers (TPCs), with the construction and operation of two large-scale single- and dual-phase prototypes. The single-phase ProtoDUNE detector, which has recently completed two years of continuous recording of high-quality data, paves the way for the first DUNE module. At over 70 000 tonnes, the full DUNE detector will be the largest ever deployment of liquid-argon technology, which was first proposed by former CERN Director-General Carlo Rubbia in 1977 and serves as both target and tracker for neutrino interactions.

The first large-scale liquid-argon detector, ICARUS, has also been completely refurbished via the CERN Neutrino Platform. ICARUS was one of two detectors (along with OPERA) at Gran Sasso National Laboratory in Italy that studied neutrinos generated by CERN's Super Proton Synchrotron (SPS) between 2006 and 2012. The refitted detector was shipped to the US in 2017 and is about to take data at Fermilab's short-baseline neutrino facility.

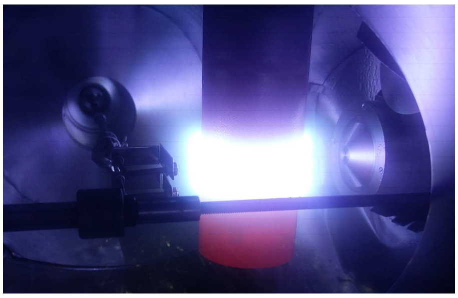
For neutrino projects in Japan, the CERN Neutrino Platform has participated in the development of the BabyMIND magnetic spectrometer and upgrades to T2K's "near-detector", ND280. This detector, which was built inside the magnet from the UA1 experiment at CERN's SPS, is crucial for understanding the neutrino flux prior to oscillations – one of the main measurement uncertainties at T2K and, in the future, at Hyper-Kamiokande. Independently, the SPS Heavy Ion and Neutrino Experiment (NA61/SHINE) at CERN has also contributed to a better understanding of T2K data, and has an important role to play in the future neutrino physics programmes in the US and Japan.

The 2020 update of the European strategy for particle physics, which was released on 19 June, recommends that Europe, and CERN through its neutrino platform, should continue to support neutrino projects in Japan and the US for the benefit of the worldwide neutrino community. "Experimental neutrino physics is back in town at CERN, and it looks like it is there to stay," says Albert de Roeck, leader of the CERN EP-Neutrino group.

Matthew Chalmers

A NEW COATING TECHNIQUE FOR DEFLECTING CRAB CAVITIES

A team from the Vacuum, Surfaces and Coatings group is studying a method of niobium coating by sputtering for use in future accelerators



Magnetron for niobium sputtering on crab cavities, comprised of a negatively charged niobium cylinder (the bright part) surrounding a magnet (Image: CERN)

Research being done as part of the Future Circular Collider (FCC) study is already bearing fruit, as the development of a new sputtering method for manufacturing crab cavities shows. These cavities, which are located on either side of the collision points, tilt the particle bunches so that their overlap area is as large as possible when they cross each other, making it possible to increase and control the accelerator's luminosity. This technique is in its infancy, as the first crab cavities are being developed for the High-Luminosity LHC (HL-LHC). They will be made of bulk niobium, a superconducting material that is traditionally used for radiofrequency cavities. However, bulk niobium is very expensive, which is why alternatives are being sought for use in colliders of the future. To reduce costs, the scientists intend to use copper coated with a thin layer of niobium instead of bulk niobium.

Copper has previously been coated with niobium for the LHC 's radiofrequency cavities, using a technique called magnetron sputtering. A magnet surrounded by a negatively polarised niobium cylinder (the "magnetron") is inserted into the cavity in order to generate an argon plasma. The electrons present in the plasma, excited around the magnetic field lines, ionise the positively charged argon atoms, which are accelerated towards the niobium cathode. The argon ions hit the niobium, whose atoms are sprayed out and scatter around the cavity before settling on the copper walls.

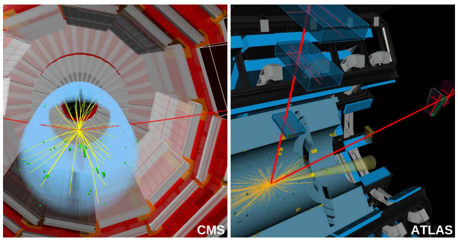
The constant negative polarisation technique suits the LHC's elliptical radiofrequency cavities, but the more complex inner shape of the crab cavities prevents a uniform layer from being deposited on the walls. This is where teams from the BE-RF, EN-MME and TE-VSC groups came in, developing a new WOW ("Wide Open Waveguide") crab cavity that is compatible with the sputtering technique, as well as a new technique for depositing the coating, namely High-Power Impulse Magnetron Sputtering (HiPIMS), a sputtering method using voltage modulation that makes it possible to reach fairly high power levels in order to ionise a significant fraction of the sputtered niobium atoms. The potential of the niobium target is periodically reversed in order to repel the positive niobium ions, thereby increasing the speed of the scattered particles. They are thus projected more efficiently onto the cavity walls and the coating becomes denser and more homogenous.

Following three years of R&D, the first test on a cavity will take place this winter, having been postponed due to CERN moving to safe-mode. Fabio Avino of the VSC group is raring to go: "I witnessed the very beginnings of the project, three years ago, and since then, I've been delving into the principles of physics and engineering, and I've come up with a satisfactory result. The team and I hope that our work will one day be useful for an accelerator like the FCC." Beyond high-energy physics, the depositing technique studied at CERN also has applications in the automobile, aerospace and medical industries, which use HiPIMS to coat objects with complex shapes and to obtain layers with challenging properties.

Thomas Hortala

CERN EXPERIMENTS ANNOUNCE FIRST INDICATIONS OF A RARE HIGGS BOSON PROCESS

The ATLAS and CMS experiments at CERN have announced new results which show that the Higgs boson decays into two muons



Candidate event displays of a Higgs boson decaying into two muons as recorded by CMS (left) and ATLAS (right). (Image: CERN)

Geneva. At the 40th ICHEP conference, the ATLAS and CMS experiments announced new results which show that the Higgs boson decays into two muons. The muon is a heavier copy of the electron, one of the elementary particles that constitute the matter content of the Universe. While electrons are classified as a first-generation particle, muons belong to the second generation. The physics process of the Higgs boson decaying into muons is a rare phenomenon as only about one Higgs boson in 5000 decays into muons. These new results have pivotal importance for fundamental physics because they indicate for the first time that the Higgs boson interacts with second-generation elementary particles.

Physicists at CERN have been studying the Higgs boson since its discovery in 2012 in order to probe the properties of this very special particle. The Higgs boson, produced from proton collisions at the Large Hadron Collider, disintegrates – referred to as decay – almost instantaneously into other particles. One of the main methods of studying the Higgs boson's properties is by analysing how it decays into the various fundamental particles and the rate of disintegration.

CMS achieved evidence of this decay with 3 sigma, which means that the chance of seeing the Higgs boson decaying into a muon pair from statistical fluctuation is less than one in 700. ATLAS's two-sigma result means the chances are one in 40. The combination of both results would increase the significance well above 3 sigma and provides strong evidence for the Higgs boson decay to two muons.

"CMS is proud to have achieved this sensitivity to the decay of Higgs bosons to muons, and to show the first experimental evidence for this process. The Higgs boson seems to interact also with second-generation particles in agreement with the prediction of the Standard Model, a result that will be further refined with the data we expect to collect in the next run," said Roberto Carlin, spokesperson for the CMS experiment.

The Higgs boson is the quantum manifestation of the Higgs field, which gives mass to elementary particles it interacts with, via the Brout-Englert-Higgs mechanism. By measuring the rate at which the Higgs boson decays into different particles, physicists can infer the strength of their interaction with the Higgs field: the higher the rate of decay into a given particle, the stronger its interaction with the field. So far, the ATLAS and CMS experiments have observed the Higgs boson decays into different types of bosons such as W and Z, and heavier fermions such as tau leptons. The interaction with the heaviest quarks, the top and bottom, was measured in 2018. Muons are much lighter in comparison and their interaction with the Higgs field is weaker. Interactions between the Higgs boson and muons had, therefore, not previously been seen at the LHC.

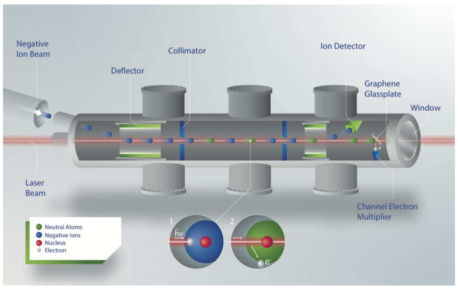
"This evidence of Higgs boson decays to second-generation matter particles complements a highly successful Run 2 Higgs physics programme. The measurements of the Higgs boson's properties have reached a new stage in precision and rare decay modes can be addressed. These achievements rely on the large LHC dataset, the outstanding efficiency and performance of the ATLAS detector and the use of novel analysis techniques," said Karl Jakobs, ATLAS spokesperson.

What makes these studies even more challenging is that, at the LHC, for every predicted Higgs boson decaying to two muons, there are thousands of muon pairs produced through other processes that mimic the expected experimental signature. The characteristic signature of the Higgs boson's decay to muons is a small excess of events that cluster near a muon-pair mass of 125 GeV, which is the mass of the Higgs boson. Isolating the Higgs boson to muon-pair interactions is no easy feat. To do so, both experiments measure the energy, momentum and angles of muon candidates from the Higgs boson's decay. In addition, the sensitivity of the analyses was improved through methods such as sophisticated background modelling strategies and other advanced techniques such as machine-learning algorithms. CMS combined four separate analyses, each optimised to categorise physics events with possible signals of a specific Higgs boson production mode. ATLAS divided their events into 20 categories that targeted specific Higgs boson production modes.

The results, which are so far consistent with the Standard Model predictions, used the full data set collected from the second run of the LHC. With more data to be recorded from the particle accelerator's next run and with the High-Luminosity LHC, the ATLAS and CMS collaborations expect to reach the sensitivity (5 sigma) needed to establish the discovery of the Higgs boson decay to two muons and constrain possible theories of physics beyond the Standard Model that would affect this decay mode of the Higgs boson.

ISOLDE REVEALS FUNDAMENTAL PROPERTY OF RAREST ELEMENT ON EARTH

The finding is significant for both fundamental and medical research, as the element is a promising candidate for cancer treatment by targeted alpha therapy



The set-up used to measure the electron affinity of astatine. A beam of negative astatine ions is sent to a device comprising several components. Laser light (red) is shone on the ions to measure the energy required to extract the extra electron of the ion (inset 1) and turn the ion into a neutral atom (inset 2). (Image: D. Leimbach et al.)

A team of researchers using the ISOLDE nuclear-physics facility at CERN has measured for the first time the so-called electron affinity of the chemical element astatine, the rarest naturally occurring element on Earth. The result, described in a paper just published in *Nature Communications*, is important for both fundamental and applied research. As well as giving access to hitherto unknown properties of this element and allowing theoretical models to be tested, the finding is of practical interest because astatine is a promising candidate for the creation of chemical compounds for cancer treatment by targeted alpha therapy.

The electron affinity is the energy released when an electron is added to a neutral atom in the gas phase to form a negative ion. It is one of the most fundamental properties of a chemical element. Together with the ionisation energy, the energy it takes to remove an electron from the atom, it defines several other traits of an element, such as its electronegativity – the ability of the element to attract shared electrons in chemical bonds between atoms.

Although astatine was discovered in the 1940s, knowledge of its properties has mostly been based on theoretical calculations or on extrapolation from the properties of its relatives in the periodic table; astatine is a member of the halogen family, which includes chlorine and iodine. This is because astatine is scarce on Earth, and the tiny amounts of the element that can be produced in the lab prevent the use of traditional techniques to measure its properties. One notable exception was a previous measurement at ISOLDE of the element's ionisation energy.

In the new ISOLDE study, astatine atoms were first produced along with other atoms by firing a high-energy beam of protons from the Proton Synchrotron Booster at a thorium target. The astatine atoms were then negatively ionised, and ions of the isotope ^{211}At were extracted and sent to a special measurement device in which laser light of tunable energy was shone on the ions to measure the energy required to extract the extra electron of the ^{211}At ion and turn the ion into a neutral atom.

From this measurement, the ISOLDE researchers obtained a value of 2.41578 eV for the electron affinity of astatine. This value, which agrees with the value that the authors derived using state-of-the-art theoretical calculations, indicates that the electron affinity of astatine is the lowest of all halogens but is nonetheless greater than that of any other elements outside the halogen family that have been measured so far. If that wasn't enough, the researchers went on to use the derived electron affinity and the previous measurement of the ionisation energy to determine several other properties of astatine, such as its electronegativity.

These properties are relevant for studies investigating the possible use of ^{211}At compounds in targeted alpha therapy, a treatment that delivers alpha radiation to cancer cells. Astatine ^{211}At is an ideal source of alpha radiation but most of the ^{211}At compounds under investigation suffer from the rapid release of ^{211}At negative ions, which could damage healthy cells before the compounds reach the cancer cells.

“Our results could be used to improve our knowledge of this release reaction and the stability of the ^{211}At compounds being considered for targeted alpha therapy,” says lead author of the study David Leimbach. “In addition, our findings pave the way to measurements of the electron affinity of elements heavier than astatine, potentially of the superheavy elements, which are produced one atom at a time.”

“With the present result, we conclude a 10-year research effort at ISOLDE to determine the fundamental properties of astatine, the ionisation energy and the electron affinity, which together finally enabled us to derive the electronegativity of astatine,” adds Sebastian Rothe, lead author of the earlier ISOLDE study.

Ana Lopes

COVID-19 AND HEATWAVES: A DOUBLE CHALLENGE

The Medical Service outlines the preventive measures to be taken in with the event of a heatwave during the COVID-19 pandemic

Summer has arrived and may bring with it another heatwave at a time when, unfortunately, COVID-19 is still with us.

The World Meteorological Organization (WMO) recently published a warning about the health risks posed by the double challenge of a heatwave and the pandemic, especially for vulnerable people. Some of the measures usually recommended during a heatwave, such as the use of air conditioning, contradict those in place to combat the novel coronavirus.

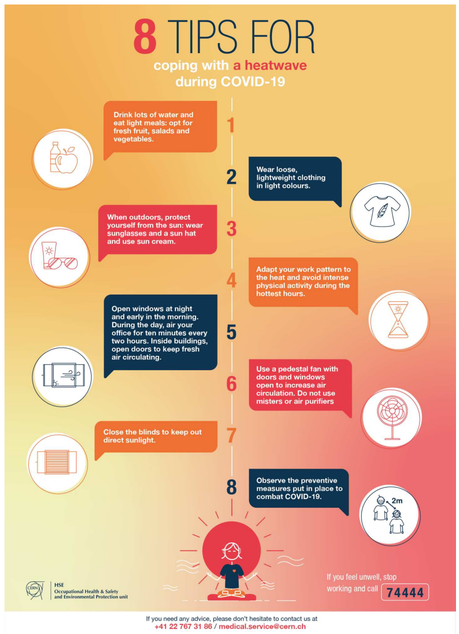
Here are a few tips to help you stay safe during this time, without increasing the risk of spreading the virus:

- **Stay hydrated** : drink water regularly throughout the day (at least 1.5 litres in total). At work, use your own bottle or flask. In addition, plan meals based primarily on fruit and vegetables, either raw or cooked. Opt for vegetables with a high water content, such as cucumbers, lettuce, radishes, tomatoes, courgettes and peppers, and fruits that aren't too high in sugar, such as watermelon, melon, peaches and strawberries.
- **Dress appropriately** : choose loose, lightweight clothes (preferably in light colours) to allow sweat to evaporate. If you work outdoors, remember to protect your skin and your head from the sun (sunglasses, sun hat, sun cream).
- **Know your limits** : adapt your work pattern to your heat tolerance; avoid intense physical activity during the hottest hours of the day. Work in the shade as much as possible.
- **Ventilate** : to keep fresh air circulating, it is essential to air or ventilate offices and work spaces. If possible, leave windows open overnight and early in the morning. During the day, open windows for at least ten minutes every two hours. In addition open inside doors if possible to help air circulate. If you have a pedestal fan, use it with the windows and doors open to increase the air circulation.
- **Protect yourself** : the protective measures put in place to combat COVID-19 still apply!

In the event of a medical emergency, call 74444!

If you need support on a specific issue, the following services are available to you:

- The COVID-19 helpline: +41 22 766 77 77
- The Medical Service: +41 22 767 31 86 / medical.service@cern.ch.



(Image: CERN)

CERN Medical Service

COMPUTER SECURITY: PRESENTING IMAGES THAT ARE NOT YOURS. . .

Once you download a photo from the Internet, beware that it might be subject to copyright

Conference season is coming up again – maybe in a different setting to what we are used to, but still with lots of interesting results to present and share. And with lots of presentations being made, lots of images will be shown to embellish the content and act as a visual aid, since inter-human communication is 20% oral and 80% visual. . . But beware, not every image is a good choice.

The good ones, of course, are those that you have created yourself. Your plots. Your graphs. Your sketches. Photos taken by you. But once you download a photo from the Internet, a nice image you found through a Google search or on Instagram, beware that it might be subject to copyright. It is not unknown for a researcher to receive a cease-and-desist notification from the copyright holder asking to take down the photo and pay compensation fees. And these can get quite expensive!

As with music, films and videos, images and photos displayed on a webpage can be subject to copyright. So be careful. Make sure that you have the proper rights when using visual content, be it graphics, photos or videos. Whether you are a presenter, webmaster or editor, please ensure you hold the correct rights when using visual content and music in your presentations, webpages or publications. . . Check whether the image is published under a Creative Commons licence (see, for example, Wikimedia) or consider paying a royalty fee to a photo repository such as BigStockPhoto.com or iStockPhoto.com. It takes an investment of just a few francs to be on the safe side. If you are really keen on using a particular photo or graphic, contact its author/owner and ask for permission (and keep written proof!). And, of course, take some time to browse the CERN Document Server (CDS) for images and footage from CERN. If you can't find what you are looking for, why not roam around the CERN site, take the photo yourself and make it available on CDS?

Do you want to learn more about computer security incidents and issues at CERN? Follow our Monthly Report. For further information, questions or help, check our website or contact us at Computer.Security@cern.ch.

The Computer Security Team

Announcements

APPLY NOW FOR ISOTDAQ 2021

(Image: CERN)

The 12th International School of Trigger and Data Acquisition (ISOTDAQ) will introduce those with an education in physics, engineering or computing (ranging from undergrads to postdocs) to the arts and crafts of triggering and acquiring data for physics experiments. The school will be held from 10th - 19th February 2021, at INFN & DFA "E. Majorana" in Catania, Italy.

The school will provide an up-to-date overview of the basic instruments and methodologies used in high-energy physics, spanning from small experiments in the lab to the gigantic LHC experiments, presenting the main building blocks, as well as the different solutions and architectures at different levels of complexity.

The main topics of the school include the basics of Data Acquisition (DAQ) programming concepts (e.g. threaded programming, data storage, networking, I/O programming, FPGA programming), hardware bus systems (VMEbus, PCIe, MicroTCA), basic Trigger Logic and Hardware (NIM) as well as intelligent trigger systems based on Associative Memories and GPUs. PC based readout and trigger design will also be covered with reviews of modern TDAQ systems from LHC and fixed target experiments.

The school consists of 50% lectures (given mainly by physicists and engineers working daily on complex TDAQ systems) and 50% of practical exercises where students will be able to work in small groups on a wide variety of electronics components of TDAQ systems. The main aim of the school is to provide students with a wide but introductory level of the TDAQ domain. It will also be of interest to students from other research domains such as astrophysics or nuclear physics.

Please find more information (including application instructions) at our website: https://indico.cern.ch/e/isotdaq2021.

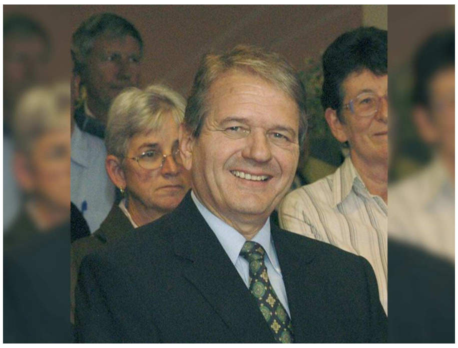
Application deadline is November 1st, 2020.

E-mail: isotdaq.schools@cern.ch

Obituaries

HORST WENNINGER (1938 – 2020)

Former CERN director Horst Wenninger played key roles in the approval of the LHC and in firmly establishing knowledge transfer at CERN



(Image: CERN)

A newly promoted middle manager at CERN was angry. Some of the personnel he had inherited were not performing well and he would not be able to deliver equipment on time and on budget as he had promised. Irate, he had to complain. Twenty minutes later he came out from his boss Horst Wenninger's office, calm and content. There were good reasons that Horst earned the epithet “Mr Valium”.

Top-flight physicists and those aspiring to be so would seek Horst out to get advice and help. He was universally trusted, because he was not going to steal their ideas and was therefore not considered a threat. He knew his way around CERN like no one else, and knew whom to contact to get things done (and crucially how to get them to do it).

Before becoming a physicist, Horst had considered becoming a diplomat. Somehow, he managed to combine the two professions, all in the interest of CERN. He cultivated the art of connecting scientists, engineers and administrators – always with the aim of achieving a goal.

Horst was born in Wilhelmshaven in 1938, the third child of a naval officer. His early childhood was spent with his mother and three siblings near Dresden. When the war ended, the family settled in Heilbronn (Baden Württemberg). He met his wife and started his family while studying at Heidelberg University, where he earned his PhD in nuclear physics in 1966. In 1968 he joined CERN to participate in the Big European Bubble Chamber (BEBC).

From the outset Horst was inspired by CERN. It satisfied both his interest in physics and his penchant for diplomacy. He saw the importance of the Laboratory for establishing peaceful worldwide collaboration and relished participating in the adventure.

Unsurprisingly, Horst was soon identified as a leader, first as physics coordinator for the BEBC programme in 1974. In 1980 he went to DESY to work on electron–positron collider physics in preparation for LEP, returning to CERN in 1982 to lead the BEBC group. In 1984 he became head of the Experimental Facilities division, providing support for Omega, UA1 and UA2. For the R&D and construction of the LEP detectors Horst needed to implement a new style of collaboration: for the first time, major parts of the detectors had to be financed, developed and provided by outside groups with central CERN coordination. In 1990 he became leader of the Accelerator Technologies division, comprising the major technology groups working on LEP2, R&D on superconducting magnets for LHC, and LHC-specific technologies such as vacuum and cryogenics. In 1993 as LHC deputy project leader, his profound knowledge of CERN, and what would be possible in the way of cost reductions and inevitable personnel cuts, was vital for the reassessment of the LHC project.

Horst was CERN's Research and Technical director from 1994 to 1999. LHC approval was expected in 1994. However, the day before the crucial vote by the CERN Council in December that year, the German delegation was still not authorised to vote in support of the project. In a late-night action Horst managed to arrange contact with the office of the German chancellor, with the mission to sway the minister responsible for the decision. His cryptic reaction was conveniently interpreted by the supportive German delegate as a green light, a determined move for the good of CERN. Horst was later awarded the Order of Merit (First Class) of the German Republic.

In 2000 he helped launch the CERN Technology Transfer division and chaired the Technology Advisory Board. He was also instrumental in the execution at CERN of the Italian LAA initiative for LHC detector R&D. Thanks largely to Horst's drive the 2017 book “Technology Meets Research – 60 Years of CERN Technology: Selected Highlights” was published, a tribute to the importance he associated with technology in the life of CERN.

Horst retired from CERN in 2003, but he continued to make major contributions thanks to his broad physics, technology and management experience and his international network. GSI in Darmstadt had recently embarked on the FAIR project, which was much larger than any previous undertaking at that laboratory. Horst was asked to help: his singular talents were immensely valuable, even vital, in charting a common way forward at a time when science, technology and politics pulled in different directions. He was instrumental in arranging the help of substantial CERN accelerator expertise, and later, as the facility relied on major international “in-kind” contributions, it naturally fell to Horst to take on the associated complex and delicate organisation and procurement. When in 2019 the EU approved the “South-East European International Institute for Sustainable Technologies” (SEEIIST), Horst was appointed to coordinate Phase 1.

Horst left his mark on CERN. The wider community also benefited immensely from his contributions in advisory roles throughout his active life. We have lost an outstanding colleague and a good friend from whose enthusiasm, advice and wisdom we all benefited tremendously.

His friends and colleagues

Ombud’s corner

HOLIDAYS: THE TONIC YOU NEED TO BOUNCE BACK

“I'm caught up in a serious conflict with a colleague. I'm really worried about it and I don't know how to sort it out. Luckily, I'm going on holiday for three weeks, which will help me step back and see things more clearly when I return.”

Paid holidays were introduced at the start of the 20th century, beginning in Germany in 1905. Since then, their benefits have been abundantly clear. Paid holidays relieve pressure and give us a chance to shake off the stress and anxiety that accumulate at work. Released from our usual obligations, we can recharge our batteries and take care of ourselves.

One effect holidays have is to break the routine that is useful for structuring our daily lives but leads in the long term to a loss of creativity and curiosity. When we go away on holiday, we often leave our comfort zone and experience new things. This gives us new ideas and helps us see things in a different light when we return. The most famous example of this is George de Mestral, the inventor of Velcro, who found his inspiration in nature when he noticed burdock flowers clinging to his trousers during a walk in the mountains.

Holidays also give us the opportunity to reduce the time we spend on the internet, or even stop using it altogether. Quitting the habit may be a bit painful at first, but ultimately helps us rediscover a feeling of freedom and relaxation, allowing us to discover new places and sensations and experience new things.

Finally, taking a break gives us the chance to get to know ourselves better. Through encounters, conversations and discoveries, we can gain a better appreciation of our possibilities and our limits. And what's more important in our interactions with others than knowing ourselves well, so that we feel better and our relationships improve? Making the most of our holidays isn't a luxury, but a necessity. Taking a brief break from our professional activities does us the world of good and contributes to the well-being of those around us, in both our professional and our private lives. So, off you go and don't look back – enjoy your holidays!

Pierre Gildemyn

If you'd like to comment on any of my articles or suggest a topic that I could write about, please don't hesitate to e-mail me at Ombuds@cern.ch.