Basil Schneider

contact

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languages

German (native)
English (fluent)
French (moderate)
Croatian (beginner)
Norwegian (beginner)

computing

Linux
C++, Python, Rust
Root, RooFit, RooStats
bash, sed, awk
git, svn
HTML, CSS
LaTeX

besides physics

Cycling
Hiking
Music

education & employment

Nov '15 - now **Research Associate** at the **CMS experiment** — Fermilab

Nov '14 - Oct '15 **Postdoctoral Fellow** at the **ATLAS experiment** — TRIUMF

Jan '11 - Jul '14 **Ph.D.** at the **ATLAS experiment** — University of Bern
Ph.D. Thesis: A general approach to search for supersymmetry at the LHC by combining signal enhanced kinematic regions using the ATLAS detector (Supervisor: Prof. A. Ereditato)

Sep '08 - Mar '10 **Master** of Science in **Theoretical Physics** — ETH Zurich
Master Thesis: The partition function of meromorphic conformal field theories at higher genus (Supervisor: Prof. M. Gaberdiel)

Oct '04 - Sep '08 **Bachelor** of Science in **Experimental Physics** — ETH Zurich
Bachelor Thesis: Untersuchung der Cluster-Struktur von Elastomerpartikeln durch Simulation des Aggregationsvorganges und Partikelgrössen mittels dynamic light scattering (Supervisor: Dr. Cornelius Gauer)

Sep '04 **Comprehensive entrance exam** — ETH Zurich
Exam at the level of a Matura

awards

Mar '15 **Faculty award winner of the University of Bern**
Award for the best PhD thesis in physics at the University of Bern in the year 2014

leadership

Jan '18 - now **SUSY Leptonic subgroup co-convener**

Oct '16 - May '17 **Coordinator of the Single Lepton dPhi Analysis group**

conferences

Jul ’18 **Conference on Supersymmetry and Unification of Fundamental Interactions**
Speaker: “Searches for chargino, neutralino and slepton production with CMS” Barcelona, Spain

Oct ’17 **IEEE Nuclear Science Symposium and Medical Imaging Conference**
Poster: “A new DAQ solution: *otsdaq*” Atlanta, GA, USA

Aug ’17 **Meeting of the Division of Particles and Fields of the American Physical Society**
Fermilab, Batavia, IL, USA
Speaker: “Searches for electroweakly produced supersymmetry with CMS”

May ’17 **Phenomenology 2017 Symposium** Pittsburgh, PA, USA
Speaker: “Searches for supersymmetry in single or opposite-charged dilepton final states with CMS”

Jun ’16 **49th Annual Fermilab Users Meeting** Fermilab, Batavia, IL, USA
Poster: “Characterization of the pixel ASIC with a laser beam in the Outer Tracker upgrade of the CMS detector”

May ’15 **Mitchell Workshop on Collider and Dark Matter Physics**
Texas A&M University, College Station, TX, USA
Speaker: “Supersymmetry searches in ATLAS”

May ’13 **1st LHC Physics Conference (LHCP)** Barcelona, Spain
Poster: “Search for direct production of charginos and neutralinos in events with three leptons and missing transverse momentum in 21 fb^{-1} of pp collisions at $\sqrt{s}$ = 8 TeV with the ATLAS detector”

Jun ’12 **Swiss Physical Society** ETH, Zurich, Switzerland
Speaker: “New Optical receiver modules for the insertable B-Layer at the ATLAS project”

Jun ’11 **Physics at LHC** Perugia, Italy
Poster: “SUSY Searches at ATLAS in Multilepton Final States with Jets and Missing Transverse Energy”

Jun ’11 **Swiss Physical Society** EPF, Lausanne, Switzerland
Speaker: “Insertable b-Layer: A new layer for the ATLAS detector at CERN”

journal publications

I am co-author of 475 ATLAS publications and 111 CMS publications; for a full list, see
http://inspirehep.net/author/profile/B.Schneider.1
Publications with substantial contributions from me:

2018	Performance of the Prototype CBC3-based Outer Tracker Module for the Phase-2 Upgrade of CMS — in preparation
2018	Performance of Prototype Silicon Detectors for the Outer Tracker for the Phase-2 Upgrade of CMS — in preparation
Jan '18	Search for new physics in events with two soft oppositely charged leptons and missing transverse momentum in proton-proton collisions at $\sqrt{s}$ = 13 TeV — 10.1016/j.physletb.2018.05.062
Sep '17	Search for supersymmetry in events with one lepton and multiple jets exploiting the angular correlation between the lepton and the missing transverse momentum in proton-proton collisions at $\sqrt{s}$ = 13 TeV — 10.1016/j.physletb.2018.03.028
Sep '16	Search for supersymmetry in events with one lepton and multiple jets in proton-proton collisions at $\sqrt{s}$ = 13 TeV — Phys. Rev. D 95, 012011 (2017)
Sep '15	Search for the electroweak production of supersymmetric particles in $\sqrt{s}$ = 8 TeV pp collisions with the ATLAS detector — Phys. Rev. D 93, 052002 (2016)
May '14	Search for supersymmetry in events with four or more leptons in $\sqrt{s}$ = 8 TeV pp collisions with the ATLAS detector — Phys. Rev. D. 90, 052001 (2014)
Feb '14	Search for direct production of charginos and neutralinos in events with three leptons and missing transverse momentum in $\sqrt{s}$ = 8 TeV pp collisions with the ATLAS detector — JHEP04(2014)169
Aug '12	Search for direct production of charginos and neutralinos in events with three leptons and missing transverse momentum in $\sqrt{s}$ = 7 TeV pp collisions with the ATLAS detector — Phys.Lett. B718 (2013) 841-859

proceedings

Jun '13	Search for direct production of charginos and neutralinos in events with three leptons and missing transverse momentum in 21 fb^{-1} of pp collisions at $\sqrt{s}$ = 8 TeV with the ATLAS detector — EPJ Web of Conferences 60, 20040 (2013)
Nov '11	The ATLAS IBL BOC Demonstrator — Proceedings, 2011 IEEE Nuclear Science Symposium and Medical Imaging Conference
Oct '11	SUSY Searches at ATLAS in Multilepton Final States with Jets and Missing Transverse Energy — Proceedings, Physics at LHC 2011

public notes

2018 — Search for Supersymmetry at the HL-LHC with the Upgraded CMS Detector — in preparation

Apr ’18 — The Phase-2 Upgrade of the CMS Endcap Calorimeter – Technical Design Report — CERN-LHCC-2017-023

Sep ’17 — The Phase-2 Upgrade of the CMS Barrel Calorimeters – Technical Design Report — CERN-LHCC-2017-011

Jun ’17 — The Phase-2 Upgrade of the CMS Tracker – Technical Design Report — CERN-LHCC-2017-009

Dec ’16 — Search for new physics in the compressed mass spectra scenario using events with two soft opposite-sign leptons and missing transverse momentum at $\sqrt{s}$ = 13 TeV — CMS PAS SUS-16-025

Aug ’16 — Search for supersymmetry in events with one lepton and multiple jets in proton-proton collisions at $\sqrt{s}$ = 13 TeV in 2016 — CMS PAS SUS-16-019

Jul ’15 — First look at proton proton collision data at $\sqrt{s}$ = 13 TeV in preparation for a search for squarks and gluinos in events with missing transverse energy, jets, and an isolated electron or muon — ATL-PHYS-PUB-2015-029

Mar ’15 — Expected sensitivity studies for gluino and squark searches using the early LHC 13 TeV Run-2 dataset with the ATLAS experiment — ATL-PHYS-PUB-2015-005

Jun ’14 — A general approach to search for supersymmetry at the LHC by combining signal enhanced kinematic regions using the ATLAS detector (PhD thesis) — CERN-THESIS-2014-056

Mar ’13 — Search for supersymmetry in events with four or more leptons in 21 fb^{-1} of pp collisions at $\sqrt{s}$ = 8 TeV with the ATLAS detector — ATLAS-CONF-2013-036

Mar ’13 — Search for direct production of charginos and neutralinos in events with three leptons and missing transverse momentum in 21 fb^{-1} of pp collisions at $\sqrt{s}$ = 8 TeV with the ATLAS detector — ATLAS-CONF-2013-035

Nov ’12 — Search for direct production of charginos and neutralinos in events with three leptons and missing transverse momentum in 13.0 fb^{-1} of pp collisions at $\sqrt{s}$ = 8 TeV with the ATLAS detector — ATLAS-CONF-2012-154

Nov ’12 — Search for Supersymmetry in events with four or more leptons in 13 fb^{-1} pp collisions at $\sqrt{s}$ = 8 TeV with the ATLAS detector — ATLAS-CONF-2012-153

organization

Aug ’12 — **Co-organizer of workshop: ATLAS SUSY Statistical Interpretations workshop**
Wrap up lessons learned in previous round of publications and spot possible improvements for next round

Sep ’11 — **Co-organizer of outreach event: Nacht der Forschung** — University of Bern
Performing experiments in public and discussing results

outreach

Jan ’16 **Fermilab Open House**
Explaining the purpose and the mission of Fermilab to the public

Nov ’13 - now **Official ATLAS underground guide**
Showing the ATLAS detector to the public during LHC shutdowns

Mar ’12 - Mar ’13 **Masterclasses** University of Bern
Helping high school students performing measurements on real LHC data

Sep ’11 **Nacht der Forschung** University of Bern
Presenting LHC physics on a poster and answering questions of the public in a research outreach event at the University of Bern

committees

Feb ’18 Analysis Review Committee: Search for supersymmetry in events with two tau leptons and missing transverse momentum in $\sqrt{s}$ = 13 TeV proton-proton collisions with the CMS detector to be submitted to JHEP

Jul ’17 Analysis Review Committee: Search for pair production of tau sleptons in $\sqrt{s}$ = 13 TeV pp collisions in the all-hadronic final state CMS-PAS-SUS-17-003

Jan ’17 Analysis Review Committee: Search for physics beyond the standard model in events with two leptons of same sign, missing transverse momentum, and jets in proton-proton collisions at $\sqrt{s}$ = 13 TeV
Eur. Phys. J. C 77 (2017) 578

Jul ’16 Analysis Review Committee: Search for SUSY in same-sign dilepton events at 13 TeV CMS-PAS-SUS-16-020

teaching

Jan ’11 - May ’14	**Lab Course** Supervising and assisting Physics undergraduate students working on fundamental experiments in mechanics and electronics	University of Bern
Jan ’11 - May ’14	**Physics for Biologists** Assisting 1st year Physics course	University of Bern
Jul ’11 - May ’14	**Private lessons for high-school graduates** Private lessons in Mathematics, Statistics and Physics	Interlink Schulberatung GmbH
Jun ’08	**Exam preparation** Exam preparation for 1st year Physics and Mathematics students	ETH Zurich
2007/2008	**Teaching assistant** Teaching assistant for environmental science students in Calculus	ETH Zurich

supervision

Jul ’16 - Oct ’16	**David Jin** Summer Student at Fermilab, University of Chicago
May ’16 - Aug ’16	**Christian Leefmans** Summer Student at Fermilab, Cornell University
Dec ’14 - Nov ’15	**Felix Cormier** MSc student at CERN, University of British Columbia
Nov ’14 - Nov ’15	**Matthew Gignac** PhD student at CERN, University of British Columbia
Dec ’12 - Mar’ 14	**Benjamin Gerber** MSc student, University of Bern

Analysis activities in ATLAS (up to 2015)

- I was the main analyzer of the search for charginos and neutralinos in events with three leptons and missing transverse momentum based on 8 fb^{-1} of data collected by ATLAS at $\sqrt{s}$ = 8 TeV (JHEP 04 (2014 169)). A large improvement in sensitivity was obtained, compared to previous analyses, by splitting the signal region in multiple bins depending on several kinematic variables and the multiplicity of taus in the final state. In addition to leading the analysis effort, I guided the optimization of the signal region for the final states with at least one tau. I was chosen to present the analysis in front of the collaboration for its approval.
- I carried out the statistical interpretations for four publications in ATLAS, all searching for supersymmetry in either three lepton or four lepton final states (Phys. Rev. D 93, 052002 (2016), Phys. Rev. D. 90, 052001 (2014), JHEP04 (2014) 169, Phys.Lett. B718 (2013) 841-859) and became the reference person for statistical interpretations in ATLAS SUSY EWK searches. In one these searches I also measured the most important background, WZ.
- I combined the three lepton electroweak SUSY search with a search in a final state with two leptons (JHEP 05 (2014) 071).
- During the Long Shutdown 1, I supervised a student and we released a public note (ATL-PHYS-PUB-2015-005) assessing the discovery potential of gluinos as a function of their mass and the integrated luminosity in the final state with one lepton.

Analysis activities in CMS (since 2015)

- I thoroughly studied and compared the software packages that ATLAS and CMS use to carry out their statistical interpretations of analyses to understand the differences in features and scope.
- I carried out a phenomenological study to understand what parts of the SUSY phase space can explain the relic abundance of dark matter, but is not currently covered by SUSY searches.
- I led the search for strongly produced SUSY particles in final states with a single lepton to a publication (10.1016/j.physletb.2018.03.028). I was responsible for organizing and coordinating the analysis, optimizing the analysis strategy and presenting the analysis to the collaboration for approval. The optimization of the search strategy led to an improvement in the exclusion limit for the gluino mass of 100 GeV in the limit of low LSP masses. In addition I was responsible for the measurement of the multijet background.
- I am one of the main analyzers in the soft multilepton group that is targeting light natural higgsinos. I carried out phenomenological studies and added an interpretation, that could solve the hierarchy problem and provide an excellent candidate for dark matter. This analysis is expected to be one of the first SUSY searches to use the combined dataset of 2016 and 2017. I am the contact person for the publication that is submitted to PLB (arXiv:1801.01846 [hep-ex]).
- I assessed the sensitivity of a SUSY search in a final state of two low momentum leptons for the HL-LHC with an integrated luminosity of 3000 fb^{-1} at a center-of-mass energy of 14 TeV and 200 additional pileup events. To develop the analysis itself, I contributed significantly to the validation of Delphes (JHEP 02 (2014) 057) for HL-LHC searches. This in turn enabled the development of

searches for SUSY in the final states with two same-charge leptons and taus. These analyses will be included in the upcoming Yellow Report for the European Strategy for Particle Physics and documented in a PAS that is in preparation.

- I am the SUSY Leptonic co-convener, organizing biweekly meetings, coordinating and reviewing the effort of several analyses that either search for electroweakly produced SUSY or use at least two leptons in their final state.

Detector R&D for the Phase-1 upgrade and MC simulations for HL-LHC on ATLAS (up to 2015)

- I set up the laboratory at the University of Bern that was used for the test of the optical receivers for the read out of the insertable b-layer (IBL), which is the additional pixel detector layer, closest to the interaction point, that was added in the ATLAS experiment during the Long Shutdown 1. I defined the acceptance criteria for the optical receivers, based on the reliability, sensitivity to the input light intensity and frequency range, and then used them to qualify the receivers finally installed in the cavern. I presented the results on this qualification in the ATLAS IBL general meetings. My work has helped establishing the group of the University of Bern as a leader for this kind of measurements in ATLAS.
- While at TRIUMF, I have contributed to the design of the Phase-2 tracker upgrade of the ATLAS detector with Monte Carlo studies of different geometries of the silicon inner detector (ITk), focusing in particular on the benefits, from the point of view of physics analyses, of a possible extension of the rapidity coverage of the tracker. I also studied the impact of using a new tracking algorithm originally developed for Run-2 of ATLAS, called TIDE (Tracking in dense environments) on the proposed ITk layouts. Finally, I supervised a Ph.D. student who was studying the tracking efficiency as a function of the total number of pixel and strip layers in the ATLAS tracker. All these studies have been an important input to the ITk community in defining the best layout of the inner tracker.

Detector R&D for HL-LHC on CMS (since 2015)

- I have worked in two areas related to the R&D program for the CMS Phase-2 Outer Tracker: the development of a data acquisition tool (*otsdaq*) that could be used in all phases of the detector development and construction (from bench tests of individual components to data taking in a beam with multiple detectors), and hardware tests of prototypes of modules and of parts of modules.
- I measured the properties of the first macro-pixel prototype, the MaPSA-Light, that combined a silicon sensor with a dedicated readout chip. In CMS, these macro-pixel detectors will be attached to a strip detector to form the PS modules. Using a laser system to generate charges in the silicon sensor I performed efficiency and time-walk measurements for the first time in a MaPSA-Light prototype.

- Later I measured the properties of all the available (three) Phase-2 2S modules (these are modules with two silicon strip sensors and electronics that form spatial coincidences between hits in the two layers). The characterization studies of these modules led to the discovery of several flaws in the firmware, software and module design, all of which have been later fixed. The results from these tests have been included in the CMS Technical Design Report for the Phase-2 tracking system.
- I have qualified all full-sized hybrids for the 2S modules (these are flexible circuits that are used to connect the two silicon strip layers in a 2S module) that have been commercially manufactured, prior to their use for the construction of prototype modules in different CMS member institutions.
- I have set up several read out systems at CERN and at Fermilab, both to read out Outer Tracker modules and hybrids. The read out system set up at Fermilab has later been used in the test beam, where we measured for the first time the response of version 3 of the CBC ASIC to a particle beam.
- I developed the Outer Tracker part of *otsdaq* (off-the-shelf DAQ), a generic data acquisition tool for particle physics experiments. *otsdaq* has been used in several test beams, both at CERN and at Fermilab. It provides a graphical user interface for simple and efficient data taking, live data quality monitoring and a graphical user interface to configure the detector.
- I participated in several test beams, by setting up the system and allow for efficient data taking. The data from these test beams will be used for a publication that is in preparation.

research proposal

The Large Hadron Collider (LHC) at CERN is the largest particle accelerator built to date and one of the most daring projects accomplished by humankind. The two largest experiments that are analyzing the data of the LHC have a multi-purpose goal: ATLAS and CMS. Both these experiments found a particle in 2012 that was, and to date still is, compatible with the boson associated to the Brout-Engler-Higgs mechanism. Besides the Higgs boson, many measurements have been carried out with previously unseen precision and many searches for particles beyond the Standard Model (SM) of particle physics have been carried out.

The achievements of the LHC and its experiments are impressive. But so far, only about 3 % of the projected data has been taken. Starting with Run-1 in 2010, data has been taken at a center-of-mass energy of 7 and 8 TeV. After a long shutdown of 2 years, Run-2 started in 2015 at a center-of-mass energy of 13 TeV. Until the end of 2017, a total of about 80 fb^{-1} of data has been taken. At the end of Run-3, in 2023, a total of 300 fb^{-1} is expected to be recorded by CMS. The LHC and its experiments will then undergo an upgrade to deliver and record larger instantaneous luminosities. This is referred to as the Phase-2 upgrades, and the LHC will become the High-Luminosity LHC (HL-LHC). At the end of the lifetime of the HL-LHC, a total of 3000 fb^{-1} of data is expected.

Physics

Searches for new physics have so far not revealed any hint of physics beyond the SM. However, it is clear that such new physics must exist. The SM is one of the most successful theories humankind has ever developed, but the theory is not complete. The major deficit of the SM is, that it does not include gravity. It does also not provide a candidate for dark matter, a hypothetical particle that could explain many measurements that we observe in the Universe, among others the rotational curves of galaxies. Another shortcoming of the SM is the naturalness problem: The higgs mass receives radiative corrections to its mass that are many orders of magnitudes larger than the mass itself. This extremely unlikely scenario is called the fine-tuning problem of the Higgs mass.

Before the advent of the LHC era, it was widely expected that Supersymmetric particles would be found, even with little amount of data, as the lightest strongly interacting particles were believed to be not much heavier than 1 TeV. Supersymmetry (SUSY) is an intriguing theory. By effectively doubling the particle content of the SM and exploiting the only Poincaré symmetry left that has not yet revealed itself in nature, many shortcomings of the SM can be explained.

The three popular shortcomings of the SM that can be solved with SUSY are: The naturalness problem, the unification of all interaction strengths at the grand unification energy (GUT scale) and the existence of a dark matter candidate. However, the first two of these three so called shortcomings, the naturalness problem and the unification of energies at the GUT scale, are maybe not real shortcomings of the theory. They only arise because we have a certain pretense for our theories to be beautiful. Fine-tuning might exist and we might just live in a world where the Higgs mass is very small, compared to its corrections, by accident. And there is no reason why we should expect the interaction strengths to unify at a certain energy.

The unsuccessful unification of quantum field theory with general relativity and the non-existence of a dark matter candidate in the SM, on the other hand, cannot be explained away. There must either be a correction to the theory of general relativity, or an additional particle that we haven't accounted for yet. As experimental physicists, it is one of our largest priorities, to search for a dark matter candidate, be it in the context of SUSY or in pure dark matter searches.

The LHC program has also lead to the insight that despite many carefully planned searches, no SUSY particles have been found to date. There are basically three ways to explain this null-result: Either SUSY is a symmetry that is not observed in nature, or SUSY particles are heavy and out of reach by the LHC, or these particles are elusively hiding behind large backgrounds and systematic uncertainties, or in final states that are difficult to trigger on and reconstruct. We cannot know which of these scenarios answers the question why we have not found any SUSY particles. However, while we cannot fully eliminate either of the answers (except by indeed observing SUSY), we can at least refine our searches to make sure to not miss any SUSY particles in our data.

The theoretical community shows many ways out of the perceived tension between SUSY theory and its non-observation. However, we also have to consider that one of the favorite theories of the particle physics community might not be realized in nature. It is important, though, that CMS continues a broad program for searches beyond the SM, be it in the context of SUSY or not. The SUSY search community in CMS has a wide spectrum of knowledge for searches. It is important to keep this know-how and extend searches to less obvious cases. More emphasis should be laid on less common search strategies. And we should not forget, that so far we only analyzed around 3 % of the data we expect to receive from the LHC.

The current trigger strategies need to be revisited. Currently, most SUSY analyses rely on a trigger that is firing when a sufficient large amount of missing transverse momentum is observed in an event. This has not yet led to the observation of any new particles. Instead we have to introduce triggers that include other objects, like for example the two low momentum muons that my SUSY search in a final state with two low momentum leptons commissioned. Other possibilities should be explored more often already at trigger level, such as angular information or the possibility of using machine learning algorithms. A good trigger strategy is crucial: If SUSY is hiding and we do not trigger its events, we will not find it. Including trigger information from the Outer Tracker during Phase-2 of data taking, will open up many possibilities for new trigger strategies, despite larger rates due to the larger instantaneous luminosity. As an example, it is currently very difficult to trigger on very low momentum electrons, since they are completely dominated by instrumental noise in the electronic calorimeters.

Currently CMS uses data parking and scouting. Parked data are data recorded by firing a trigger that is either a loose version of an existing trigger or a completely different trigger that does not overlap with any others. This data is parked, meaning they are not reconstructed immediately but only when spare computing time is available, for example during a long shutdown. In data scouting, trigger thresholds are lowered as well. To control the bandwidth used by these triggers, only a fraction of information is stored on tape. Currently, non of the SUSY searches use either parked or scouted data. Exploiting these strategies can lead to a substantial increase of sensitivity, especially in the regions of parameter space that are relatively difficult to access.

Also on the reconstruction side we have to refine our analyses. There already has been a lot of work done that aims in this direction. B-jet finding algorithms have been improved lately, using a deep neural network to enhance the efficiency for finding b-jets at the same mistagging rate. Similar approaches are now explored for other objects, like top-tagging or W-tagging. These efforts should be strengthened and exploited in all analyses where its use makes sense.

High energy physics is no longer the field where the most data is analyzed. Other fields in computer science now analyze data sets that are larger than ours. This has led to many advancements in the field of big data processing. Machine learning algorithms have been improved and simplified. Languages and packages exist, that can be relatively easily applied to our field. We have to exploit these technical advancements and further improve the use of the latest technologies. Keeping pace with these developments and an increased exchange with experts from other fields can boost our sensitivity as well. There are efforts ongoing in machine learning, but other parts of technology have a similar potential. The programming language Rust can serve as an example here, since it inherently features concurrency and memory safety, without compromising speed. Moving away from C++ to Rust could lead to more efficient software that is easier to maintain.

We also have to make sure that we systematically cover all possible final states. For example, we currently have a search for electroweakly produced SUSY particles that decay via a W and a Z gauge boson. The final states considered are in two oppositely charged leptons, three leptons and two oppositely charged low momentum leptons. I am part of the analysis groups that exploits the final state with two low momentum leptons and we are in the process of expanding the final state to three low momentum leptons. There is large room for improvement here: Analyses should make sure to cover the whole parameter space. This is not the case right now, as while there are searches for two high momentum leptons as well as two low momentum leptons, there is no search that covers a high momentum and a low momentum lepton. This could be achieved relatively easily and I have defined it as one of my goals during my co-convenership of the SUSY Leptonic subgroup, to make sure that these corner cases are well covered. Second, a final state with leptons had better sensitivity in this model up till now, but this is about to change. Once exclusion limits for electroweak SUSY particles are pushed to high values, purely hadronic final states might become more sensitive. Leptonic final states have the advantage of less background, hadronic ones have the higher branching ratios. Once the SUSY particles become heavy enough, background can be suppressed in the hadronic final states by requiring high momentum jets. At a certain point, the hadronic search will take over in sensitivity from the leptonic searches. We have to explore this new decay mode.

While SUSY theory provides a dark matter candidate, we should also strengthen the pure dark matter searches. There exist already many dark matter searches and some of the pure dark matter searches are covered by SUSY searches. But SUSY often predicts a final state with several high momentum objects, while there is usually less activity in a pure dark matter search. We have to understand what phase space of pure dark matter searches is not covered yet. Dark matter can be searched for in direct detection, indirect detection, or collider experiments. We need to communicate with our colleagues from other fields, and of course also with the theory community, to better understand how we can extend our dark matter searches to cover the maximal possible parameter space.

Phase-2 Inner Tracker

The HL-LHC upgrade implies extreme challenges for the design and the operation of the tracker in terms of radiation tolerance of sensors and readout electronics. This is especially true for the inner part of the tracker, equipped with pixel sensors: the Inner Tracker. Since I have been testing the modules of the Outer Tracker extensively both on a benchtop system and in several test beams, I can bring my expertise on setting up test stands and testing detector components from the CMS Phase-2 Outer Tracker to the pixel system. For the module qualification the plan of CMS is to use dedicated systems. Based on the experience with the previous CMS pixel detectors and with the Outer Tracker, there is a lot to gain from establishing early test stands where the entire chain, from the module to the electrical to optical conversion to the DAQ backend is tested in conditions as close as possible to those expected for the final detector.

It is important to have a working chain to read out existing module components as soon as possible, then extending it with the components as they become available. This should happen in close collaboration with ETH Zurich and PSI. Even though these institutes have different interests and responsibilities, all groups will benefit from an efficient read-out chain. The software needed to communicate with the components needs to be developed in parallel and should be done in close collaboration with the Outer Tracker DAQ group, since a lot of expertise is in this group and already many lessons have been learned in the past years.

I want to pioneer the use of *otsdaq* for the pixel detector read-out system, this can have an impact beyond the extended pixel detector. *otsdaq* is a generic and highly flexible and scalable DAQ solution for high energy physics experiments. I already adopted *otsdaq* to Outer Tracker modules and integrated it in the Outer Tracker DAQ. I intend to do the same for the Inner Tracker hardware.

After getting a broad overview over the current status and the involvement of the group at the University of Zurich in the Inner Tracker upgrade, I want to take over a leading role in the on-detector electronics and the optical data links. For the on-detector electronics I can bring in my expertise from the Outer Tracker upgrade, and on optical data links I worked in the IBL upgrade in ATLAS. As time passes I also want to become a leader in the construction of the mechanics and the integration of the entire detector, and later in commissioning and installation.

In the long term I also would like to understand if an upgrade of the current pixel system design, that goes further than what is currently described in the Technical Design Report is feasible.

research experience

I have been a member of the ATLAS Collaboration between 2011 and 2015. Since 2015 I am a member of the CMS Collaboration.

My research program in both experiments has been driven by the search for SUSY particles. I search for natural SUSY that could solve the hierarchy problem, as well as providing a dark matter candidate that could explain the relic abundance of dark matter particles that we observe in the Universe. I have a strong background in phenomenological SUSY. With this knowledge I can devise searches that are not covered by standard searches. I am also interested in understanding what sensitivity we can expect to have in searches beyond the SM with the Phase-2 detector at the HL-LHC, and later eventually at the HE-LHC.

An essential part for a general purpose detector at the LHC, such as ATLAS or CMS is a robust tracking system to allow best possible position resolution, an efficient matching of tracks to vertices and a performant track separation. I did detector R&D for the insertable b-layer (IBL) upgrade and optimized the detector design, using robustness of physics observables for the Phase-2 upgrade on ATLAS. In CMS I tested several components of module prototypes and developed a data acquisition tool (*otsdaq*) that could be used in all phases of the detector development and operation.

SUSY Leptonic Co-Convener in CMS since January 2018

Since January 2018, I am the co-convener of the SUSY Leptonic subgroup in CMS. The Leptonic subgroup is specialized in SUSY searches with at least two leptons, or targeting electroweak production processes. As a convener, I facilitate and review several different analyses. I co-organize the biweekly meetings, in which new analysis developments are discussed, analyses are reviewed and approved. I read the documentation that the analysts provide, review analysis strategies and make suggestions about how they can be improved. I also read the early paper drafts that are put forward by the analysts. Once we agree that a certain analysis is in a robust state, we allow the previously blind analyses to unblind their signal regions. When an analysis gets approved, the review will be passed on the the Analysis Review Committee. From this point on, we follow the analyses and assist them in every way possible to efficiently lead them to a publication. As Co-convener I will also co-lead one of the sessions at the yearly SUSY workshop.

SUSY Search in two soft oppositely charged lepton final states in CMS

A higgsino-like electroweakino is the most important ingredient to control the mass of the Higgs boson. Its mass is the only SUSY parameter that enters the Higgs boson mass already at tree level. A pure higgsino state leads to four particles, two neutral and two charged ones, that are almost mass degenerate. If they are not accompanied by other light SUSY particles, their detection will pose a challenge, since the small mass splitting leads to low momentum objects. These objects are difficult to reconstruct and trigger on. To be able to control the large background that appears in searches with low momentum objects, our search strategy targets leptonic decays of the neutral higgsinos. In the search for two low momentum oppositely charged leptons, we require triggers to either fire because of their large missing transverse momentum, or because of two very low momentum muons, that additionally have a small amount of missing transverse momentum. The low momentum muons trigger has been specifically introduced by our analysis group. This search strategy was specifically chosen to target higgsinos, but it is also sensitive to other compressed states, like chargino-mediated stop decays.

In our SUSY searches, we usually use Simplified Models that include only the minimal particle content necessary, i.e. the relevant particle masses are the only free parameters. To a certain degree this lets the experimenter decouple the analysis from the theory involved. However, it is not a priori clear that Simplified Models cover all corners of a realistic extension of the SM. To understand if the Simplified Models that we used in our search indeed cover the higgsinos in a more generic SUSY model, I developed a more generic model for additional interpretation. In the current paper, that is using the full 2016 dataset and is now submitted to PLB (arXiv:1801.01846 [hep-ex]) I am the contact person and as such reviewed the paper draft in view of the comments we received from the CMS Collaboration, and also from the journal referees.

We intend to further extend our search regions, by including a three low momentum lepton final state and enhance our sensitivity for signals with a displaced vertex. We plan to have a PAS ready by ICHEP 2018, including the full 2016 and 2017 datasets. We expect to be one of the first analyses to publish a SUSY search with both the 2016 and 2017 datasets combined. A journal publication is planned to follow shortly thereafter.

Upgrade study to assess the sensitivity to SUSY models at the HL-LHC

The HL-LHC upgrade implies extreme challenges for the design of the detector, but also for the reconstruction and identification of particles. With the increase of the instantaneous luminosity, more and more soft proton-proton collisions (pileup) will be contaminating the hard process we are interested in. The expected average number of additional pileup events will reach 200 on average during the HL-LHC. This unprecedented large number of simultaneous collisions will pose challenges, especially for soft objects, as for example in the search for SUSY in two soft oppositely charged lepton final states. It is therefore extremely important to study how much the improved detector and the large dataset benefits the search and how much the additional pileup events hurt the sensitivity.

I carried out a study to assess the sensitivity of a search for higgsinos with two soft leptons and missing transverse momentum with the Phase-2 detector in an environment with up to 200 pileup events. Since we need a large number of background Monte Carlo events for a search with 3000 fb^{-1} and since SUSY searches additionally require a large number of signal events, both the CMS full and fast detector simulation take too much computing time to be produced for a sensitivity study. We therefore rely on Delphes, a fast multipurpose detector response simulation (JHEP 02 (2014) 057).

I have compared the performance of the CMS Full Detector Simulation with the ones from Delphes, measured reconstruction and identification efficiencies in FullSim samples and improved the Delphes detector simulation to match the one obtained by FullSim. I assessed the performance of the missing transverse momentum in both detector simulations and compared how much they degrade compared to Run-2, due to additional pileup events.

My validation studies on Delphes objects in turn enabled the search for wino-like electroweakinos in a final state with two leptons of same charge and searches for staus, both in hadronic and leptonic decay channels. The two searches for electroweakinos will be combined in a larger framework: the radiatively driven natural SUSY (10.1007/JHEP12(2013)013).

The results of the studies for HL-LHC that I have performed have been included in the TDRs for the upgrade of the Barrel calorimeters (CERN-LHCC-2017-011) and for the HGCAL (CERN-LHCC-2017-023). These studies, and the other ones that have benefited from my improvements to Delphes, will also be included in a CERN Yellow Report on the physics reach of the HL-LHC, that will also be used as input document for the European Strategy Planning for Particle Physics. Prior to their inclusion in the Yellow Report these analyses will also be made public as CMS PAS.

Given my leadership role for SUSY analyses within the CMS HL-LHC studies group, I have also been invited to give presentations at the Future Higgs Workshop at CERN and the HL/HE-LHC Meeting at FNAL (the latter I had to decline due to conflicting commitments).

SUSY Search exploiting angular information in single lepton final states in CMS

The transition from 8 to 13 TeV in the center-of-mass energy of the LHC offered an unprecedented increase in sensitivity for colored SUSY particles in the vicinity of 1.5 TeV.

During the Long Shutdown 1, when I still was a member of the ATLAS collaboration, I supervised a student and we released a public note (ATL-PHYS-PUB-2015-005) assessing the discovery potential of gluinos as a function of their mass and the integrated luminosity in the final state with one lepton. We found that with already a small amount of data, we could surpass the exclusion limits from the searches carried out at a center-of-mass energy at 8 TeV and given the right mass of the gluinos, we could have expected a discovery with a relatively small dataset.

After my transition to CMS and Fermilab, I continued to work on this analysis in the same final state. At the beginning of Run-2, I focused on light gluinos, considering both decays mediated by light stops or light squarks. In this search in a final state with exactly one lepton, I exploited the angle between the reconstructed W and the lepton to search for SUSY events. I coordinated the analysis by organizing the group meetings, assessing the analysis strategy and leading the group to a publication in PLB (10.1016/j.physletb.2018.03.028).

I measured the QCD background and assessed the systematic uncertainty on its yields. I optimized the binning of the signal of this search, to maximize the sensitivity for a given signal. Due to my optimizations, the sensitivity improved by 100 GeV for heavy gluinos in the limit of massless neutralinos. I was chosen to present the analysis in front of the collaboration for approval.

SUSY Search in three lepton final states in ATLAS

During my PhD I searched for electroweakly produced SUSY in final states with three leptons. In the search we considered gauge boson as well as light sleptons mediated decays of associated neutralino-chargino production.

A large improvement in sensitivity was achieved by splitting the signal region in multiple bins depending on several kinematic variables, such as the missing transverse momentum, the invariant mass of a lepton pair and the transverse mass. This was one of the first SUSY searches in ATLAS that introduced such a binning of the signal region covering a large parameter space that is sensitive to many different SUSY signals. By exploiting the difference in kinematics in the individual signal regions I improved the sensitivity in the gauge boson mediated decay by 180 GeV, and in the slepton mediated decay by 200 GeV.

In this search we also included final states with taus and interpreted results in associated neutralino-chargino production with stau mediated decays. I also optimized the signal regions in final states of three leptons including one tau.

I was also responsible for the statistical interpretations of results by calculating discovery p-values, exclusion contours and upper limits on model cross-sections. I helped implementing a data driven estimate of the most important background, WZ, in the three lepton final state. I also carried out the statistical interpretations of a search for R-Parity violating models in a final state with four leptons. This effort has led to a total of 4 papers (Phys. Rev. D 93, 052002 (2016), Phys. Rev. D. 90, 052001 (2014), JHEP04(2014)169, Phys.Lett. B718 (2013) 841-859), of which I have been a driving analyst. During this process I became the reference person for statistical interpretations in ATLAS SUSY EWK searches

Electrical tests of several prototypes of the CMS Phase-2 Outer Tracker upgrade

To cope with the large radiation and the high number of pileup events expected at the HL-LHC, the CMS detector will need to be upgraded. One of the most important aspects of the CMS HL-LHC upgrade is the complete replacement of the tracking system. There are multiple reasons for this. First of all the performance of the current detector will start degrading due to radiation damage, and the current detector could not operate efficiently for a time long enough. The new silicon tracker needs to be able to withstand much higher doses compared to the current one. Then, an increase in granularity and the capability of resolving tracks that are close in space are required to cope with the increase in the number of pileup collisions, which is expected to reach up to 200 per bunch crossing. To extend the physics reach of CMS an increase in the acceptance of the tracking volume up to |eta|=4 is also necessary. Finally, the trigger thresholds for single leptons should not increase relative to the current values in order to retain, for example, sensitivity to SUSY final states with low momentum objects. This requires the use of tracking information already at the first level of the trigger system.

In order to provide the tracking information for the L1 trigger decision the CMS Phase-2 outer tracking system is designed in such a way that local track segments are built in doublets of closely spaced sensors that form modules. Two kind of modules are foreseen for the CMS Outer Tracker: a module with two strip sensors (2S) and a module with a strip sensor and a pixel sensor (PS). The PS modules with their granularity allow for high resolution, while keeping the occupancy low. The 2S modules on the other hand limit the bandwidth and power consumption and subsequently the material needed in the tracking volume. The different modules are built around different kind of ASICs that are used to read out the silicon sensor information and form the local track segments. In the PS module there are two different types of ASICs. The MPA is bump-bonded onto a pixelated layer, while the SSA is wire-bonded to connect the strip layers. The 2S modules use the CBC ASIC.

The first prototype assembly for the MPA ASIC covers only a fraction of the sensor size planned for the PS modules and was named MPA-Light, and its module assembly MaPSA-Light. I set up a laser system at Fermilab, that triggered the data taking and measured the timewalk for this device for the first time with a sensor attached.

For the CBC ASIC, I characterized all three full-sized prototype modules that were available at the time. The resulting measurements of the mean noise were released in the Technical Design Report of the CMS Phase-2 tracking system. For this measurements I have set up a readout system that is based on a GLIB readout card. In the bump-bonding lab at CERN, I have set up the same readout system, in order to test and measure the newly produced modules during and right after production. Since this was the first time the modules have been thoroughly characterized, I discovered several flaws in the firmware, software and module design, all of them have been improved by now.

The same read-out setup has also been used to test the flexible circuits that are used to connect the two silicon strip layers in a 2S module. These hybrids have been commercially manufactured and I have done electrical tests to assure the quality of the prototypes. I automated the testing procedure completely by software, significantly speeding up the process. Also the generation of a test report was automated. The hybrid circuits that passed the quality assurance tests as well as the visual inspection, were shipped to various CMS member institutions for the construction of prototype modules. Thanks to the automatization of the quality assurance test process, the results can easily be reproduced by the institutes.

At Fermilab I have set up a crate based read out, that was first used to read out a smaller prototype of the CBC chip and later to test version 3 of the CBC chip for the first time in a test beam. The crate based read out used a uTCA card developed at CERN called FC7. Since the FC7 based read-out offers more flexibility in terms of reading out module prototypes, I have set up the same FC7 based read out at CERN.

I have contributed to several test beams by setting up the systems and allow for efficient data taking. The measurements obtained during these test beams are to be published in two separate publications, both are in preparation right now.

Data acquisition with otsdaq

I also contributed to the development of *otsdaq*, which is an off-the-shell DAQ solution for high energy physics experiments. I adopted the software to be used for the Phase-2 Outer Tracker modules and implemented the existing Phase-2 Outer Tracker software framework into *otsdaq*. I have introduced the tool to the Phase-2 Outer Tracker community by giving presentations and a hands-on session at the Phase-2 Outer Tracker Workshop.

Some of the highlights of *otsdaq* are the finite state machine of the detector, a graphical user interface that allows for simple and easy to learn data taking, but also detector configuration, and live data quality monitoring, as well as smaller subsystems, like an integrated e-log, messaging service or macro maker.

otsdaq has been commissioned in several test beams. At the last CMS Phase-2 Outer Tracker test beam at Fermilab, it has been the standard tool for data taking.

Test optical receivers for suitability with IBL detector

The insertable b-layer (IBL) is an addition to the pixel detector from Run-1 in ATLAS and was installed during the Long Shutdown 1. It is the layer closest to the interaction point and allows for more precise vertex finding and track separation. I have tested the commercial optical readout components to be used off-detector. For this I have set up the laboratory at the University of Bern. The acceptance criteria for the optical receivers with form factor SNAP 12 I have defined to be reliability, sensitivity to the input light intensity and frequency range. For testing the reliability, I have put them into a climate chamber for accelerated aging and monitored them with a logic analyzer and self programmed FPGA. I tested the receivers for efficiency as function of the input sensitivity and the frequency and found that two of the three different vendors matched all quality criteria. One of the two vendors was then chosen by the community, also depending on external factors like availability and price. I have presented my measurements in several IBL General Meetings and my results have been an important decision factor in choosing the right product. The receivers were later installed in the cavern and are still in operation. I also replaced optical transmitters that ceased to function during operation in Run-1.