T 71: Supersymmetry: Theory and searches

Time: Thursday 16:30–19:00 Location: H-HS VI

T 71.1 Thu 16:30 H-HS VI

Study of thesensitivity of the ATLAS experiment to the phenomenological MSSM afterRun 2 — •Christoph Ames and Alexander Mann — Ludwig-Maximilians-Universität, Munich

Supersymmetry (SUSY) is a framework that can be used to solve many problems that cannot be explained with the Standard Model, such as the hierarchy problem or the existence of dark matter. SUSY can be implemented in many different models, one of which is the phenomenological Minimal Supersymmetric Model (pMSSM), a simplified version of the MSSM. In this model, it is assumed that all parameters are real, which eliminates the possibility of CP violation through SUSY. Flavour-changing neutral currents are excluded and the first and second generations of supersymmetric fermions are considered to be degenerate. Also, the Yukawa couplings for the first two generations are assumed small and negligible. Therefore, the pMSSM can be described with only 19 parameters and it is feasible to run scans over the phase space to learn more about the behaviour of supersymmetric particles. We evaluate ATLAS analyses that use the Run 2 data of the LHC by performing such scans. With this information, regions of phase space to which current analyses are not sensitive can be identified. The final goal is a statement about the combined sensitivity of ATLAS analyses in the pMSSM.

T 71.2 Thu 16:45 H-HS VI

Phenomenology in the μNMSSM — •Steven Paasch[1], Li Cheng[1], Gudrid Moortgat-Pick[2], and Wolfgang Hollik[1,3,4] — [1]Deutsches Elektronen-Synchrotron — [2]Deutsches Elektronen-Synchrotron, Universität Hamburg — [3]IKP — [4]TTP

The Next-to-Minimal Supersymmetric Standard Model (NMSSM) with an additional singlet in the Higgs sector is a well motivated extension to the Minimal Supersymmetric Standard Model (MSSM). The additional singlet in the Higgs sector relaxes constraints within the Higgs sector. It also provides several candidates for cold dark matter. We will discuss the so-called μNMSSM model that can be embedded consistently into inflation models. Compared to the NMSSM it offers an additional parameter that originates from a non-minimal coupling to gravity. We performed a phenomenological study for the LHC and a future linear collider and analyzed in detail scenarios that are in accordance with current experimental constraints. In particular, we focussed on developing strategies for distinguishing the models in experiment and performed a multi-parameter scan in these models.

T 71.3 Thu 17:00 H-HS VI

Phenomenology of inflation-inspired supersymmetric models — •Cheng Li[1], Steven Paasch[1], Wolfgang Hollik[2], and Gudrid Moortgat-Pick[3] — [1]DESY, Hamburg, Germany — [2]KIT, Karlsruhe, Germany — [3]University Hamburg, Hamburg, Germany

The Next-to-Minimal Supersymmetric Standard Model (NMSSM) with an additional singlet of Higgs sector is a well-motivated extension of the Minimal Supersymmetric Standard Model (MSSM). This additional singlet relaxes constraints within the Higgs sector and enlarges the parameter space. In the talk we discuss the μNMSSM model which in addition can be embedded consistently into inflation models. Within in the μNMSSM, we study the scenarios which are intrinsically different from the normal NMSSM. After that we try to replace some input parameters for adapting `NMSSMTools` to μNMSSM model, and compute the whole spectrum including particles masses, decay widths and mixing matices for specific μNMSSM scenarios. By using the Monte Carlo simulation we check whether the discussed scenarios may be excluded by the experimental limit with `CheckMATE`. For the allowed scenarios, we focus on the process of the light singlet-like Higgs production, and predict the cross sections with different center-of-mass energy and polarization of initial state at the future electron-positron colliders.

T 71.4 Thu 17:15 H-HS VI

An application of neural networks in the phenomenological minimal supersymmetric standard model — Bein Samuel[1], Mrowietz Malte[1], Schleper Peter[1], Prosper Harrison[2], and •Wiederspan Bogdan[1] — [1]University Hamburg, Germany — [2]Florida State University, United States of America

The simplified model approach to interpreting searches for supersymmetry (SUSY) has been extensively used so far in both CMS and ATLAS. In recent times, interpretation have also been done in terms of full models, like the phenomenological minimal supersymmetric standard model (pMSSM). The pMSSM offers the advantages of interpretations in full models, while it contains a manageable number of just 19 degrees of freedom, in contrast to e.g. the over 100 degrees of freedom in the minimal supersymmetric standard model. Neural networks in particle physics have shown their usefulness in the recent past, especially in higher-dimensional problems, where it is hard to detect patterns. A feasibility study for using a neural network to regress on the acceptance of a complex SUSY search is presented.

T 71.5 Thu 17:30 H-HS VI

Search for new physics in final states with hadronically decaying tau leptons in association with *b*-jets — •Ferdinand Krieter and Alexander Mann — Ludwig-Maximilians-Universität München

While the predictions given by the Standard Model (SM) of particle physics show an exceptionally good agreement with experimental data, there are still several questions left unanswered. A search for new physics involving final states with tau leptons, *b*-jets and missing transverse momentum is presented. Such signatures can emerge in multiple extensions of the SM, which try to provide solutions to some of the open questions. The search uses data of pp collision events at a center-of-mass energy of 13 TeV, recorded with the ATLAS detector from 2015 to 2018.

One proposed extension is given by Supersymmetry (SUSY), which predicts superpartners of known SM particles, whose spins differ by one half unit. In many SUSY models the mass of the top squark, the superpartner of the SM top quark, is expected to be low enough to not only be within the reach of the LHC but also to provide an elegant solution to the hierarchy problem.

Besides a search for top squark pair production, another SM extension, leptoquarks, is discussed in this talk. These hypothetical particles are potential candidates to explain the similarities between the quark and lepton sector of the SM as well as the anomalies observed in B-meson decays. Pair-produced leptoquarks of the third generation yield a final state that can be covered by this analysis as well.

T 71.6 Thu 17:45 H-HS VI

Search for Direct Pair Production of Staus with Two Hadronically Decaying Taus in the Final State at the ATLAS Detector in Run 2 — •Clara Leitgeb and Alexander Mann — Ludwig-Maximilians-Universität, München

Supersymmetry is a popular extension of the Standard Model of particle physics. In particular, the search for direct pair production of the supersymmetric partners of left- and right-handed taus (staus) is an important goal of the ATLAS physics program.

Using the full dataset that was taken during Run 2 of the LHC at a center-of-mass energy of 13 TeV, a cut-and-count based analysis of events containing two hadronically decaying taus and missing transverse energy was performed. Despite the low stau production cross section it was possible to exclude degenerate stau masses up to 390 GeV and neutralino masses up to 140 GeV at 95% confidence level. Furthermore, separate exclusion limits for the supersymmetric partners of left-handed taus could be derived.

The analysis will be presented in this talk together with possible improvements of these limits by using machine-learning techniques and studying compressed scenarios.

T 71.7 Thu 18:00 H-HS VI

Search for direct stau production in events with one hadronically and one leptonically decaying tau lepton with the ATLAS detector — •Anna Bertolini and Alexander Mann — Ludwig-Maximilians-Universität, Munich

Supersymmetry (SUSY) provides a solution to many open questions of the Standard Model (SM). It postulates the existence of supersymmetric partners of the elementary particles of the SM. In many SUSY models the mass order of the supersymmetric leptons (sleptons) is reversed compared to the SM, making the supersymmetric tau (stau) the lightest slepton and therefore possibly accessible at the LHC.
Direct stau production has been studied with the ATLAS detector,

assuming that both staus decay into a tau lepton and a stable neutralino. An analysis considering only hadronically decaying taus (HadHad Channel) found no significant excess over the expected SM background.
The presented study looks at a final state with one tau decaying hadronically and one leptonically (LepHad Channel). The advantage of this channel is the possibility to trigger on a light lepton with lower offline thresholds than required for the tau triggers. Therefore, it is possible to search for direct stau production covering a phase-space region to which the HadHad-channel is not sensitive.

T 71.8 Thu 18:15 H-HS VI

Search for disappearing tracks with the CMS experiment at $\sqrt{s} = 13$ TeV — •Viktor Kutzner[1], Samuel Bein[1], Seh Wok Lee[3], Isabell Melzer-Pellmann[2], Sang-Il Pak[3], Peter Schleper[1], Sezen Sekmen[3], Akshansh Singh[2], and Alexandra Tews[1] — [1]Institut für Experimentalphysik, Universität Hamburg — [2]DESY — [3]Kyungpook National University

Long-lived particles are often predicted in theories with a small mass splitting between the two lightest particles, for example a chargino and a neutralino. Given a sufficiently small mass splitting in the range of $m_\pi \lesssim \Delta m \lesssim 200$ MeV, the chargino is expected to decay in the CMS tracker volume into soft non-reconstructed leptons or hadrons and a lightest supersymmetric particle, leaving a disappearing track. This signature is characterized by missing hits in the outer layers of the tracker with little or no energy deposited in the calorimeter. In addition to events with one or more disappearings tracks, events with an additional lepton are considered as well to account for a second long-lived chargino, which decays outside the tracker volume. For both topologies events with additional b-quark jets are investigated to account for gluino-/squark-associated chargino production. Data-driven methods are used to determine the dominant backgrounds arising from prompt leptons and fake tracks. Results are presented using proton-proton collision data with $\sqrt{s} = 13$ TeV collected with the CMS experiment during Run-2.

T 71.9 Thu 18:30 H-HS VI

Soft and displaced tracks in searches for compressed Higgsinos at the CMS experiment — Samuel Bein, Viktor Kutzner, Yuval Nissan, Peter Schleper, Alexandra Tews, and •Moritz Wolf — Universität Hamburg

Many supersymmetric extensions to the Standard Model predict the three lightest electroweakinos, χ_2^0, $\chi_1^\pm$ and χ_1^0, to be Higgsino-like with similar masses around the electroweak scale. The lightest chargino and the second-lightest neutralino can be pair-produced and decay to the lightest neutralino. To search for these particles, the best strategy depends on the differences between their masses. For $\Delta m(\chi_2^0, \chi_1^0) > \mathcal{O}(1)\,\text{GeV}$ lepton pairs from the decay of the second-lightest neutralino leave an experimentally distinct signature, whereas $\Delta m(\chi_1^\pm, \chi_1^0) < 0.3\,\text{GeV}$ leads to the chargino in some cases giving rise to a disappearing track or a soft displaced pion. However, mass splittings in the range of $\Delta m(\chi_1^\pm, \chi_1^0) = 0.3 - 1\,\text{GeV}$ are still unexplored by either of those methods.

This study describes how a mono-jet analysis can be made more sensitive to Higgsinos with mass splittings in this range by requiring a soft and displaced track in the event corresponding to the pion originating from the chargino decay.

T 71.10 Thu 18:45 H-HS VI

Search for compressed mass-spectrum long-lived particles using short disappearing tracks with the ATLAS experiment — •Paul Gessinger[1,2] and Stefan Tapprogge[2] — [1]CERN — [2]Johannes Gutenberg-Universität Mainz

In certain Supersymmetry scenarios, the lightest neutalino $\tilde{\chi}_1^0$ and charginos $\tilde{\chi}_1^\pm$ can become nearly degenerate in mass. At mass splittings as low as $\Delta m(\tilde{\chi}_1^\pm, \tilde{\chi}_1^0) \approx 100$ MeV, the chargino obtains lifetimes of $\mathcal{O}(10\text{ ps})$, which causes it to reach sensitive parts of the ATLAS experiment, before decaying mostly to a neutralino leaving the detector without interacting, and a low momentum charged pion that is difficult to detect. This causes the chargino track to *disappear*.

The tracking systems and reconstruction algorithms of the ATLAS detector are designed to efficiently detect and reconstruct charged particles crossing all sensor layers. Using specialized reconstruction techniques, it is possible to reconstruct short *tracklets*, which arise only from hits in the Pixel detector. Previous ATLAS analyses used tracklets consisting of 4 Pixel hits and no hits in the silicon strip detector as disappearing track signatures to search for the aforementioned scenarios in LHC *pp*-collisions at 13 TeV.

Building on efforts to reconstruct even shorter tracklets with only 3 Pixel hits and to reconstruct the soft charged pion, this talk will present the strategy and report on progress towards a dedicated pure-higgsino search, using established analysis techniques and new developments.