Partikeldagarna 2021

Monday 22 November 2021 - Tuesday 23 November 2021

Chalmers Conference Centre

Book of Abstracts

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Svenska fysikersamfundets årsmöte 2022 i Lund

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I am organising the meeting of the Swedish physical society in Lund next year and would like just 5-10 minutes to present it. I hope it can be mixed with partikeldagarna. The theme will be Swedish accelerator based research.

Monday afternoon session 2 / 70

A reappraisal of top-partner hunting

Authors: Avik Banerjee[None]; Gabriele Ferretti[None]; Diogo Buarque Franzosi[1]

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Composite Higgs models together with partial compositeness predict the existence of vector-like top-partners above the TeV scale. A wide class of such models show significant barnching ratio of the top-partners decaying into the third generation quarks and exotic pseudo Goldstone bosons, thus opening up new search topologies at the LHC. We systematically study the exotic decays of the top-partners in the partial compositeness framework. We aim to bridge the gap between the simplified phenomenological models and the full composite Higgs machinery motivated from a 4D strongly coupled gauge theory. We present a Lagrangian at the TeV scale and identify a number of universal features, in particular regarding the spectra of the top-partners. Finally as a proof of principle we discuss the exotic decays of the top-partners in the SU(5)/SO(5) coset.

Monday afternoon session 2 / 60

The colour matrix at next-to-leading-colour accuracy

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In the colour decomposition approach to treating the SU(3) colour gauge group in automated event generators, the size of the colour matrix grows factorially with the number of external particles in the process. As such, the treatment of the colour degrees of freedom becomes the bottleneck for high-multiplicity QCD processes. We propose to utilize the large-N_C expansion to obtain a sparse colour matrix at next-to-leading-colour accuracy which reduces the computation complexity from a factorial to a polynomial scaling at the parton-level. We examine this efficiency for both the fundamental and the colour-flow decompositions for processes with up to two quark pairs. This work is the first step towards an efficient and accurate event generator for processes with 8-9 QCD partons or more.

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Heavy quark momentum diffusion coefficient during the hydrodynamization in heavy-ion collisions

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We compute the heavy quark momentum diffusion coefficient during the initial nonequilibrium evolution using QCD effective kinetic theory after an ultrarelativistic heavy-ion collision. We observe that the diffusion coefficient approaches its thermal value during the hydrodynamization process. We also give an introduction to thermalization/hydrodynamization in the weak coupling framework.

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Simplifying calculations with chirality-flow

Authors: Andrew Lifson[1]; Malin Sjödahl[None]

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In a few recent papers we introduced the chirality-flow formalism for tree-level scattering processes. This method, which builds on the separate SL(2,C) nature of left- and right-chiral states, makes it possible to directly write down the value of a Feynman diagram as a Lorentz scalar.

In this presentation I will review the method and make outlooks towards tree-level implementations, calculations beyond leading order and resummation.

Monday afternoon session 2 / 63

NNLO Positivity Bounds on Chiral Perturbation Theory for a General Number of Flavours

Authors: Benjamin Alvarez[1]; Johan Bijnens[None]; Mattias Sjö[None]

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We present positivity bounds, derived from the principles of analyticity, unitarity and crossing symmetry, that constrain the low-energy constants of chiral perturbation theory. Bounds are produced for 2, 3 or more flavours with equal meson masses, up to and including next-to-next-to-leading order, using the second and higher derivatives of the amplitude. We enhance the bounds by using the most general isospin combinations posible (or higher-flavour counterparts thereof) and by analytically integrating the low-energy range of the amplitude. In addition, we present a powerful and general mathematical framework for efficiently managing large numbers of positivity bounds.

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Towards the precise description of Composite Higgs models at colliders

Author: Diogo Buarque Franzosi[1]

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We present a framework to study the interactions among Nambu-Goldstone bosons (NGB), pseudo-NGB (pNGBs) and gauge bosons in Composite Higgs (CH) models at high energies, including operators of order $\mathcal{O}(p^4)$ and $\mathcal{O}(p^2g^2)$ in the chiral expansion and topological terms.
The set of (p)NGBs comprises the longitudinal modes of electroweak bosons, the Higgs boson, and possibly other scalar states from the dynamical spontaneous electroweak symmetry breaking.
The framework is implemented in a collider simulation tool especially suited for the study of Goldstone Boson Scattering (GBS), which includes vector boson scattering (VBS), di-Higgs production via vector boson fusion (VBF) and the pair production of other pNGBs via VBF.

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The six-pion amplitude

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Within the framework of the massive O(N) nonlinear sigma model extended to the next-to-leading order in the chiral counting (for $N = 3$ corresponding to the two(-quark)-flavor Chiral Perturbation Theory), we calculate the relativistic six-pion scattering amplitude at low energy up to and including terms $\mathcal{O}(p^4)$. Results for the pion mass, decay constant and the four-pion amplitude in the case of N (meson) flavors at $\mathcal{O}(p^4)$ will be also presented.

Monday morning session / 84

Progress towards a program of searches for neutron conversions at the European Spallation Source with the HIBEAM/NNBAR experiment

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Baryon number violation (BNV) is needed to explain the origin of the matter-antimatter asymmetry and routinely appears in theories which extend the Standard Model of particle physics. However, BNV is yet to be observed. The HIBEAM/NNBAR program is a two stage set of experiments (HIBEAM then NNBAR) to search for neutron conversions to sterile neutrons and anti-neutrons at the European Spallation Source. The ultimate aim of the program is extend the sensitivity of BNV searches by three orders of magnitude compared with previous searches. This talk shows progress on all major aspects of the program: the neutron moderator source, beamline and focusing and detector design. Estimates of the sensitivity of the searches are also given. A focus is placed on the HIBEAM stage.

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Progress on the design of an annihilation detector for the HIBEAM/NNBAR program at the European Spallation Source

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Report from Stockholm university ATLAS group

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Event-structure dependence of light-flavour-hadron production in pp collisions with ALICE

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Updates on the HIBEAM/NNBAR Prototype Calorimeter at Stockholm

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The HIBEAM/NNBAR experimental program will be the cutting-edge free neutron search for n→nbar and n→sterile n oscillations, with an ultimate sensitivity gain of more than three orders of magnitude compared to what was previously achieved. A key component of the program is the annihilation detector which will identify a neutron-antineutron annihilation event within a carbon foil target through the reconstruction of a number pions with kinetic energies below ˜500 MeV. This low energy regime is a challenge for calorimetry due large fluctuations in energy depositions from showers created in traditional sampling calorimeters. A novel, hybrid calorimeter design is proposed for the detector: a hadronic range measurement using scintillating plastic staves and wavelength shifting fibres followed by an energy measurement using lead glass blocks. A prototype calorimeter system is under construction at Stockholm University. The prototype includes 50 scintillator staves and 12 lead glass blocks. Both detectors are read out with silicon photomultipliers. This talk will present the design, construction, and readout electronics of the prototype system. A short description will also be given of plans to supplement the calorimeter prototype with a Time Projection Chamber. The combined system will be studied at test beams at the ESS and elsewhere.

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Search for Dark Matter in events with missing transverse momentum and a Higgs boson decaying into b-quarks with the ATLAS detector

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In hadron colliders, the proton constituents that participate in the hard scatter have almost no momentum in the transverse plane. Any imbalance observed in this plane for the products of the scatter can be interpreted as particles escaping detection. Such events can originate from Standard Model processes involving neutrinos, but might also have a more "exotic"origin. One possible explanation for the nature of Dark Matter is that it consists of stable, weakly interacting, neutral particles that would also escape detection. To be able to study these particles their production has to be accompanied by a visible object like a jet, a photon, a W or a Z boson or a Higgs boson. Compared to the other objects, the Higgs boson offers a significant advantage: it will not be produced from initial state radiation but serves as a direct probe of the interaction with the Dark Matter. The search presented in this contribution is looking for such events through the Higgs decay channel to b-quarks. The final state signature will thus consists of large missing transverse momentum and two b-jets. The signal region is a region of phase space defined to select events of interest while rejecting Standard model background as much as possible. To estimate the remaining background events dedicated phase space regions are defined, the control regions. The corresponding selections are applied to simulated samples to determine the contribution of signal and background events in the total event rate. The estimated yields depend on a number of factors: detector resolution, calibrations, choices made in modeling parameters. These factors contribute to the uncertainty on the estimated yields and are carefully calculated. The signal and control region definitions are applied to the collected data and a profile likelihood fit is performed simultaneously in these regions to extract a possible signal. This contribution will present the results from analyzing the full 13 TeV data set recorded with the ATLAS detector from 2015 to 2018.

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simulation and testing of the Light Dark Matter eXperiment prototype trigger and hadronic calorimeter

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Dark matter is a theorized, yet unknown form of matter that makes up the majority of the mass of the Universe. One compelling explanation for its origin is the thermal freeze-out mechanism, which posits its mass to be somewhere in the MeV to TeV range. While dark matter with mass above 1 GeV is being thoroughly searched for by an ample amount of experiments, very few experiments to date search for light dark matter - dark matter with a mass between 1 MeV and 1 GeV. The Light Dark Matter eXperiment (LDMX) is one of those few. It consists of a 4-16 GeV electron beam shot at a fixed tungsten or aluminium target, the results of which are analysed using missing-momentum techniques to find dark matter creation events. It can therefore conclusively test most models of light dark matter. First commissioning data from the LDMX is expected as early as fall 2023.
In order to build a detector sensitive enough to detect dark matter events, its detecting components - the trigger, trackers, electromagnetic calorimeter, and hadronic calorimeter - must be thoroughly tested and their behavior exactly described. To achieve such precise instrumentation, a prototype of the trigger has been tested this October, and a prototype of the hadronic calorimeter will be tested this coming March. One objective of the test beam measurements was to ensure its proper timing and function of the trigger. Another objective will be to tune the simulation of the hadronic calorimeter. For this purpose, a detailed simulation of each has been developed.
This contribution focuses on the first results from a Geant4 based simulation of the prototype hadronic calorimeter, using different beam characteristics, embedded in the LDMX software framework. Additionally, it focuses on the experimental results of the LDMX trigger prototype that was recently tested under a beam.

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Overview of the Lund ALICE group's activities

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Overview will be presented by me or Alice Ohlson

Title can be tuned to match other overviews.

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Light Dark Matter eXperiment Rejection of Photon Induced Background at 8 GeV

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Viewing dark matter as thermal relics from the early universe necessitates possible dark matter production in accelerator experiments. The dark matter mass range below one GeV, in the "hidden sector", is so far less explored. The Light Dark Matter eXperiment (LDMX) is a proposed fixed target experiment that aims to be sensitive to dark matter around and below the proton mass, where few-GeV electrons will possibly recoil in a thin tungsten target through some dark matter direct production model, yielding measurable missing momentum. At higher energies the production cross-section of some models should increase, motivating the study of running the LDMX at 8 GeV, above the previously studied 4 GeV.

Due to the small and unknown rate of dark matter production, the experiment aims to ideally reject all of the background events out of approximately 10^{14} expected electrons on the target. The electrons will also recoil in the tungsten target through normal bremstrahlung. But through various photo-nuclear interactions, the resulting photon can end up in hard-to-catch hadronic final states that may appear as missing momentum. The forward electromagnetic calorimeter of LDMX can be used to veto these events, using a boosted decision tree trained primarily to distinguish between dark matter signal and such photon induced background events.

Monte Carlo simulations of a first run at 4 GeV showed a 10^{-13} background rejection. Higher energies could expect higher rates of dark matter production in some models, as well as it being easier to measure the energetic by-products of backgrounds events. The rates of some background final states may even decrease at higher energies. This study concerns these possible improvements in background rejection at an 8 GeV second run of LDMX and how the sensitivity to dark matter production is increased, a necessary endeavor when the coupling between dark matter and standard model particles is unknown and at most very small.

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Status and Prospects of Light Dark Matter eXperiment

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An elegant explanation for the origin and observed abundance of dark matter in the Universe is the thermal freeze-out mechanism. Within this mechanism, possible masses for dark matter particle candidates are restricted approximately to the MeV - TeV range. The GeV-TeV mass range is being explored intensely by a variety of experiments searching for Weakly Interacting Massive Particles. The sub-GeV region occurs naturally in Hidden Sector dark matter models, but has been tested much less by experiments to date. Exploring this mass range is imperative as part of a comprehensive Dark Matter search programme, but requires new experimental approaches.

The freeze-out mechanism assumes a non-gravitational interaction between dark and ordinary matter, which necessarily implies a production mechanism for dark matter at accelerator experiments. Recent advancements in particle accelerators and detectors in combination with software developments like machine learning techniques open new possibilities to observe such processes.

The planned Light Dark Matter eXperiment (LDMX) is an electron-beam, fixed- target experiment that exploits these developments, enabling us to observe processes orders of magnitudes rarer than what is detectable today. The key to this is a multi-GeV beam providing a few electrons 46-million times per second, and a detector that monitors how each individual electron interacts in the target —for up to 10^{16} electrons. First beam for commissioning the experiment is expected in early 2024 at SLAC, Stanford, marking the starting point of a first data taking period of about one and a half years. A second phase with higher beam-energy and -intensity is foreseen soon thereafter.

This presentation will give an overview of the theoretical motivation and the different components of the LDMX detector concept, as well as the main experimental challenges and how they are addressed. It will further discuss projected sensitivities and possible future upgrades towards covering a large portion of the viable phase-space for sub-GeV thermal relic dark matter and other models.

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High-school project with open data

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NORNDIP

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GENIE

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Can inelastic dark matter save DAMA?

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Constraining the neutrino flux from cosmic population of Gamma-ray Bursts

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A model-independent analysis of neutrino flares detected in IceCube from X-ray selected blazars

Author: Ankur Sharma[None]

Co-author: Erin O'Sullivan [1]

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Blazars are among the most powerful steady sources in the Universe. Multi-messenger searches from blazars have traditionally focused on their gamma-ray emission, which can be produced simultaneously with neutrinos in photohadronic interactions. However, X-ray data can be equally vital to constrain the SED of these sources, since the hadronically co-produced gamma-rays get absorbed by the ambient photon fields and cascade down to X-ray energies before escaping.
In this work, we test the time-dependent neutrino emission potential of 1000 X-ray bright blazars by performing an untriggered search for neutrino flares from their direction in 10 years of IceCube data. The best-fit flare parameters are obtained using an unbinned likelihood maximization, and the binomial test statistic is used to search for statistically significant emission from a sub-population of the sources.

Tuesday afternoon session 3 / 68

Searching for axion-like particles through the photon disappearance channel

Author: David Marsh[None]

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Axions and axion-like particles (ALPs) comprise theoretically well-motivated extensions of the Standard Model. ALPs can be naturally light, very weakly interacting, and may interconvert with photons in magnetic fields. I will discuss efforts over the past several years that leverage precision observations of X-ray emission from active galactic nuclei in galaxy clusters to search for signals from ALPs through the "photon disappearance channel". These searches have led to world-leading limits on light ALPs, and can be further improved over the coming decade through the launch of the next generation of X-ray telescopes. I will briefly discuss new theoretical results that draw on elementary properties of quantum perturbation theory and Fourier analysis to drastically simplify the analysis of weak axion-photon mixing, leading to new conceptual insights and more robust phenomenology.

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Constraining dark matter annihilation with cosmic-ray antiprotons using neural networks

Author: Michael Korsmeier[1]

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The derivation of indirect constraints on dark matter annihilation in our Galaxy from cosmic-ray antiprotons requires computationally expensive simulations of cosmic-ray propagation. I will present a new method based on Recurrent Neural Networks that significantly accelerates simulations of cosmic-ray antiproton spectra from secondaries and dark matter and achieves an excellent accuracy. Importance sampling is identified as particularly suitable for efficiently marginalizing over the nuisance parameters related to cosmic-ray propagation while ensuring that the networks are only evaluated in well-trained parameter regions. The method allows to investigate a wide range of dark matter models and it speeds up the runtime by at least two orders of magnitude compared to conventional approaches. I will illustrate our method on two examples: First, for a generic dark matter model annihilating into a pair of $b\bar{b}$-quarks and and, second, for the scalar singlet dark matter model.

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IceCube-Gen2: The Window to the Extreme Universe

Author: Christian Glaser[None]

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IceCube-Gen2 is a planned extension of the IceCube Neutrino Observatory at the South Pole designed to study the high-energy neutrino sky from TeV to EeV energies. IceCube-Gen2 will increase the annual rate of detected neutrinos by a factor of 10 by deploying 120 new strings with attached

optical sensors in the ice sheet, and through the addition of a radio array expand the observed energy range by three orders of magnitude. The radio technique is a cost-effective way to instrument the huge volumes needed for the detection of ultra-high energy neutrinos at the predicted flux levels. IceCube-Gen2 will play an essential role in shaping the new era of multi-messenger astronomy, fundamentally advancing our knowledge of the high-energy universe through the combination of neutrino, electromagnetic, and gravitational wave observations.
I will report on the status of the project and expected sensitivity. I will present the Radio Neutrino Observatory in Greenland (RNO-G) that is currently under construction and serves as a field test for Gen2 radio. I will highlight the areas of Swedish contribution: development of novel optical sensors, intelligent trigger system based on deep learning for the radio array, and wind generators for autonomous operation in harsh polar environments.

Tuesday afternoon session 3 / 78

Probing the neutrino sky with IceCube: latest results

Author: Ankur Sharma[None]

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IceCube is the world's largest neutrino observatory with a km^3 array of optical detectors located at the South Pole in Antarctica. In over a decade of observation, IceCube has exceedingly shaped our understanding of the astrophysical neutrino paradigm. With a near 100% duty cycle, IceCube is a vital tool not only for neutrino astronomy, but also for probing BSM physics, fundamental neutrino physics with the vast volumes of atmospheric neutrinos it collects, and cosmic ray physics with the IceTop surface array. In this talk, I will highlight the most recent physics results from IceCube. I will also provide an overview of the currently underway IceCube upgrade and the contribution of the Sweden group to this effort.

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No sharp spectral features in the local cosmic-ray positron flux

Author: Isabelle John[1]

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The local flux of cosmic-ray positrons has been measured to great precision by the AMS-02 experiment. At high energies, the positron flux is dominated by nearby pulsars that convert their spin-down energy into electron-positron pairs. Interestingly, simple pulsar models predict sharp spectral features in the positron flux, while AMS-02 observations indicate that the positron spectrum is extremely smooth. Recently, however, observations have shown that the positron production of pulsars might be more complex than previously assumed. In this work, we take into account several mechanisms that greatly reduce the sharp spectral features in the positron flux predicted by the simple models, and create a pulsar model that is consistent with the smooth positron flux.

Tuesday afternoon session 3 / 74

Dark matter electron interactions in graphene detectors

Author: Einar Urdshals[None]

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We develop a formalism to describe electron ejections from graphene by dark matter (DM) scattering for general forms of spin 1/2 DM electron interactions. This novel formalism allows for accurate prediction of the daily modulation signal expected from DM in upcoming direct detection experiments employing graphene sheets as target material. The general interaction is captured using non-relativistic effective field theory methods, whereas the physics of the graphene sheet is treated with state-of-the-art DFT.

Tuesday afternoon session 3 / 79

TeV halos and inhibited diffusion around pulsars

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TeV halos have become a new class of astrophysical objects which were not predicted before their recent observation. They offer evidence that diffusion around sources (concretely, pulsars) is not compatible with the effective average diffusion that our models predict for the Galaxy. This directly impacts Galaxy formation, our knowledge of the propagation process throughout the Galaxy and our models of acceleration of charged particles by astrophysical sources like supernova remnants (SNRs) or Pulsar Wind Nebulae (PWN).
The goal of this talk is to overview what is this new class of object and the different theories able to explain the mechanisms leading to its formation and evolution. Finally, we will show the importance of the detection of these sources for our current understanding on galaxy evolution.

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Report from ACCU

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Report from VR

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Report from IUPAP

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Report from IPPOG

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Report from (R)ECFA

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Report from the Lund University ESSnuSB Group

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The ESSnuSB is a proposed long-baseline neutrino-oscillation experiment with neutrino beam production at the ESS in Lund and detection of the oscillated beam in a megaton-scale water-Cherenkov detector 360-540 km downstream. The beam would be measured before oscillation at the near-detector (ND) complex close to the production point in Lund, with the dual purpose of providing a direct neutrino flux measurement as well as measuring the interaction cross-section between nucleons and electron neutrinos. The Lund University ESSnuSB group is leading the development of the kiloton-scale water-Cherenkov component of the ND, including its reconstruction and particle identification performances. In this talk I will present the activity and latest results of the Lund University ESSnuSB group.

Tuesday morning session 2 / 93

Report from the ATLAS groups on the ATLAS HL-LHC hardware work

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The Plasma Axion Haloscope and the ALPHA Collaboration

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The plasma haloscope is a novel method for the detection of the resonant conversion of axions to photons. Traditional cavity haloscopes compensate for the momentum mismatch between the axion and the massless photon by breaking translational invariance, for instance through implementing

physical structures on the order of the axion Compton wavelength. This makes reaching higher axion masses a challenge due to the very small structures needed. Plasma haloscopes instead use a tunable plasma frequency to match the axion mass. Using a wire metamaterial plasma haloscope, the plasma frequency can be tuned to match the axion mass by changing the interwire spacing, allowing for large conversion volumes.

The newly formed ALPHA collaboration has begun work towards building a tunable, cryogenic, plasma haloscope. A wire metamaterial has been chosen as the target plasma, and is expected to reach competitive sensitivity for axion masses between $8-400$ μeV. This talk will give an overview of the plasma haloscope concept and the ongoing experimental effort of the ALPHA collaboration.

Tuesday morning session 2 / **71**

The SHIFT project

Authors: David Anthony Milstead[1]; Elin Bergeaas Kuutmann[2]; Sara Strandberg[1]; Gabriele Ferretti[None]; Joergen Sjoelin[1]; Rikard Enberg[3]

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In the SHIFT project, funded by the Knut and Alice Wallenberg foundation, experimental and theoretical physicists at Chalmers, Stockholm and Uppsala collaborate in the search for top partners that could potentially solve the Higgs fine-tuning problem. The work includes phenomenological studies of models with top partners, direct searches for top partners in compositeness and supersymmetry as well as indirect searches via precision measurements of processes involving top quarks. In this talk we will present the project and its latest results.

Tuesday morning session 2 / **77**

Status of the Light Dark Matter KAW project

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This contribution provides an overview of the status of the Knut and Alice Wallenberg project "Light Dark Matter", a collaboration between experimental and theoretical particle and nuclear physicists from Lund University, Chalmers and Stockholm University. The project addresses the possible existence of sub-GeV dark matter in a very comprehensive way. Its activities range from the setup of a new, highly sensitive experiment, LDMX, to discover such particles, over the development of software tools for simulations and statistical interpretation of the data, to connections and input to other existing and future experiments including direct detection. In this talk, we will review the motivation and goals of the project, report on recent activities and progress, and give an outlook on the next steps.

Tuesday morning session 2 / 61

HIPPO —HIggs Pairs and POtential

Author: Arnaud Ferrari[1]

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Picoseconds after the Big Bang, the Universe experienced a phase transition into a state of lower energy, in which nearly all fundamental particles became massive by interacting with the Higgs field. About 13.8 billion years later, the 2013 Nobel Prize in physics was awarded to Englert and Higgs for discovering this mass-generating mechanism, confirmed by the observation of a spin-0 neutral boson with a mass of 125 GeV by ATLAS and CMS at the Large Hadron Collider (LHC) in 2012. The shape of the Higgs potential and the Higgs boson self-coupling are among the most important open questions in particle physics: establishing and measuring Higgs boson pair (HH) production is central to the LHC physics program, both as the experimental signature of the Higgs boson self-coupling and as a sensitive probe of several BSM scenarios. The Higgs boson self-coupling is also strongly related to cosmology and the aforementioned phase transition in the early Universe, which may have given rise to gravitational waves that appear as a background today. We are therefore at a historic junction, where a single measurement in the terrestrial LHC experiments can shed light on the early Universe and its behaviour as a whole. A dozen particle physicists in Sweden recently formed the HIPPO project to coherently tackle these questions. Via regular meetings, the corresponding research topics progress along two inter-connected tracks, one theoretical and one experimental, which exploit the interplay between directly probing the Higgs boson self-coupling and BSM physics at colliders and indirectly probing the phase transition in the early Universe through the gravitational-wave background. An application to the Wallenberg foundation is currently in preparation, aiming at injecting funding resources into the project and creating a world-leading research environment across four academic nodes in Lund, Stockholm and Uppsala.

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Introduction