NNV section for (astro)particle physics fall meeting

Friday, 3 November 2023 - Friday, 3 November 2023

Lunteren

Book of Abstracts

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Latest results from the AMS-02 experiment in space

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The Alpha Magnetic Spectrometer (AMS-02) has been in operation on the International Space Station since May 19th, 2011, and it will continue its mission for the duration of the space station's operational lifespan. Throughout its data-taking period in space, AMS-02 has successfully registered a remarkable count of over 200 billion cosmic-ray events.
AMS-02 has been primarily designed to fulfil two significant objectives. Firstly, it aims to explore the presence of antimatter and dark matter within the cosmos. Secondly, it is dedicated to the exquisite measurement of cosmic-ray composition and flux within the energy range of GeV to TeV. The instrument has provided precise data concerning cosmic-ray nuclei, spanning from Hydrogen to Silicon, and even Iron. Furthermore, this data has enabled comprehensive discussions regarding the associated spectral characteristics.

Parallel Sessions (II) / **3**

”Investigating test mass parameters for the Einstein Telescope interferometer ”

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“The ambitious Einstein Telescope (ET) project aims to prove an up-close examination of gravitational waves originating from sources near the birth of the Universe. This study's objective is to investigate parameter specifications for the interferometer's mirrors, including the level of surface distortion necessary for the detector to operate at the required sensitivity.
To achieve this, we start with a suitable set of surface maps from Advanced LIGO and Advanced Virgo as a foundation. These maps are used to generate virtual mirror maps representations, which in turn become the basis for optic simulations representing ET's behavior. The ultimate goal is to refine the mirror requirements and optimize the pathway for ET's mission.”

Parallel Sessions (I) / **4**

Top of the ALPs

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Axion-like particles (ALPs) are pseudo Goldstone bosons that emerge in the low-energy limit of various extensions of the Standard Model. Concrete ALP models include the axion proposed to solve the strong CP problem and can provide a portal to dark matter. In this talk, we focus on searches for ALPs using top quark measurements at the LHC. Since the ALP couples more strongly to heavier fermions, ALPs can leave significant virtual effects in the top kinematic distributions in $t\bar{t}$ production. We show how to constrain the ALP properties from precision measurements of top quark observables. We present a comprehensive calculation that goes beyond the widely used leading-log approximation, and we assess the reliability of this approximation.

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News from ATLAS (tentative title)

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Dark matter studies with long-lived particles

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Quantessence

In this talk I will present a tasty quantum dessert selected from the extensive quantum trilogy – Power of the invisible: the quantessence of reality —a three part book that I have completed and that will appear in December.
I hope to share the pleasure of finding out how this rock solid and yet elusive show piece of physics actually works.

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Panorama views of the ALPs

Author: Susanne Westhoff[1]

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Axion-like particles – ALPs – are predicted in many extensions of the Standard Model with a spontaneously broken symmetry. If ALPs exist in Nature, they leave interesting signatures at colliders and other experiments. In this talk, you will hear about new ideas to probe axion-like particles with GeV-scale masses. I will show how to combine observables with resonant and virtual ALPs to explore their couplings to particles of the Standard Model. Searches for long-lived particles play a prominent role in this endeavor.

Parallel Sessions (II) / 9

DUNE near detector 2x2 prototype

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The Deep Underground Neutrino Experiment (DUNE) is a next-generation neutrino oscillation experiment currently under construction in the United States. The far detector site (at SURF) and near detector site (at Fermilab) are separated by a baseline of 1300 km. At the near detector site, a liquid argon detector (ND-LAr) with 70 optically separated time projection chambers (TPCs) will be constructed. The modular design required the development of new technologies such as a pixelated charge readout and large-area light detectors. A prototype for ND-LAr, with four modules in a 2x2 arrangement, is being installed in the NuMI beam at Fermilab between repurposed MINERvA trackers. This prototype will soon start taking DUNE's first neutrino beam data, and study neutrino-Argon interactions in the few-GeV regime.

Parallel Sessions (II) / 10

Improving theoretical predictions for LHC processes by means of resummation

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The precision of experimental measurements continuously increases, which requires the theoretical predictions to improve as well. The problem of including higher order loop calculations in QCD is that large terms appear at all orders in perturbation theory, even though the coupling constant is small. They become for example large in the kinematic limit where the final state particles are produced at threshold, leaving little energy for the radiated gluons. As a consequence, the perturbative description is invalidated. By means of resummation one can find all order expressions for cross sections, restoring the predictive power of the theory. I will demonstrate in a simple example how this can be done. I will then show new results where we find resummed cross sections for QCD-induced diphoton production and the Drell-Yan process. We consider cross sections that are differential in both the invariant mass and the rapidity of (one of the) final state particles.

Parallel Sessions (II) / 11

Study of jet substructure correlations in pp and Pb-Pb collisions at $\sqrt{s_{\mathrm{NN}}} = 5.02$ TeV with ALICE.

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The internal structure of jets is modified in the quark-gluon plasma due to parton-medium interactions.
This has been studied extensively in recent years by various experiments.
Current measurements can be described by a variety of models that implement different physics mechanisms, such as medium-induced radiation, medium response and color coherence

In this new study, we explore correlations of jet substructure observables and their potential to distinguish various phenomena modifying the parton shower.

We focus on correlations of jet substructure observables with varying sensitivity to the angular and momentum structure of the jet.
A study of the correlation of the jet mass and jet girth is presented utilizing pp and Pb-Pb collision data from ALICE at $\sqrt{s_{\mathrm{NN}}} = 5.02$ TeV.

Parallel Sessions (II) / 12

Neutrino astronomy with KM3NeT/ARCA

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The identification of cosmic objects emitting high energy neutrinos provides new insights about the Universe and its active cosmic ray sources. The existence of cosmic neutrinos has been proven by the IceCube
Neutrino Observatory, but the big question of which sources these neutrinos originate from remains largely unanswered. The KM3NeT/ARCA neutrino detector is currently under construction at the bottom of the Mediterranean Sea. The main science objective is the detection of high-energy cosmic neutrinos and discovering their sources. This is achieved by instrumenting a cubic kilometre of seawater with photo-multiplier tubes that detect Cherenkov radiation from neutrino interaction products. This contribution will present the results of the neutrino point source search with KM3NeT/ARCA with data from 2021 and 2022 taken with an evolving detector geometry.

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Quantessence

Author: Sander Bais[1]

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In this talk I will present a tasty quantum dessert selected from the extensive quantum trilogy – Power of the invisible: the quantessence of reality —a three part book that I have completed and that will appear in December.
I hope to share the pleasure of finding out how this rock solid and yet elusive show piece of physics actually works.

Parallel Sessions (II) / 14

Detection of anomalies amongst LIGO's glitch populations with autoencoders

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Non-gaussian, transient bursts of noise in gravitational wave (GW) interferometers, also known as glitches, hinder the detection and parameter estimation of short- and long-lived GW signals in the main detector strain. Glitches, come in a wide range of frequency-amplitude-time morphologies and may be caused by environmental or instrumental processes, so a key step towards their mitigation is to understand their population. Current approaches for their identification use supervised models to learn their morphology in the main strain with a fixed set of classes, but do not consider relevant information provided by auxiliary channels that monitor the state of the interferometers. In this

work, we present an unsupervised algorithm to find anomalous glitches. Firstly, we encode a subset of auxiliary channels from LIGO Livingston in the fractal dimension, which measures the complexity of the signal. For this aim, we speed up the fractal dimension calculation to near-real time. Secondly, we learn the underlying distribution of the data using an autoencoder with cyclic periodic convolutions. In this way, we learn the underlying distribution of glitches and we uncover unknown glitch morphologies, and overlaps in time between different glitches and misclassifications. This led to the discovery of 6.6% anomalies in the input data. The results of this investigation stress the learnable structure of auxiliary channels encoded in fractal dimension and provide a flexible framework for glitch discovery.

Parallel Sessions (I) / **15**

The Chiral Magnetic Effect in isobaric nuclei at LHC energies

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Global P and CP invariances seem to be preserved in the strong interaction. However, it is possible to violate locally P and CP invariances due to the chiral anomaly in Quantum ChromoDynamics (QCD), which creates an imbalance in chirality. Heavy ion collisions provide an environment in which this local P and CP violation is expected to create a measurable effect. Under the presence of the strongest magnetic field in nature that we are aware of created in heavy ion collisions, this chirality imbalance will result in a current in the direction of the magnetic field, called the Chiral Magnetic Effect (CME). So far, no conclusive evidence for the CME has been found in experiments due to large background contaminations in the experimental observables. In this talk, I will show how this effect is currently measured and which techniques are used in an effort to disentangle the CME signal from the large backgrounds. Furthermore, I will discuss the potential use of collisions of isobaric nuclei at LHC energies to investigate the CME.

Parallel Sessions (II) / **16**

Inspecting The Higgs sector via H to H(bb)H(tautau) decay at ATLAS

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Double-Higgs (HH) production is one of the most sought-after measurements at the LHC, as it is a direct probe of the Higgs self-coupling coming from the Higgs potential which will shed light on the Higgs sector. I will present the search for HH production in the bottom-quark and tau-lepton pairs decay channel. I focus on the ongoing analysis of the LHC Run-2 dataset, discussing the strategy to distinguish this complex final state from the Standard Model background processes. I also present up-to-date public results on the self-coupling measurement and discuss their relation to an extended Higgs sector and electroweak baryogenesis.

Parallel Sessions (II) / **17**

Searching for new physics using hadronic decays of W and Z bosons in the ATLAS detector

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Fully hadronic decays of diboson (WW, ZZ, WZ) pairs into large-R jets may be more sensitive to currently undiscovered phenomena. As weak bosons are able to interact with spin-0, spin-1 and spin-2 particles, they act as a good tool for probing resonances of new physics beyond the standard model. Due to its large branching fraction, studying the hadronic channels is advantageous, as it can yield a higher energy reach with respect to the semi and fully leptonic channels. In order to distinguish signal events from the large background of standard model dijet events, a machine-learning-based and mass-decorrelated large-R jet tagger, with optimized working points, is used. The fit strategy is validated using a background estimation in signal regions via an ABCD method. This method determines the background in both the low-purity and the high-purity regions, as defined by different boson tagger working points. This analysis, which represents a second pass over the full ATLAS Run 2 dataset, is expected to significantly improve over the previous full Run 2 ATLAS result in this channel. This talk will focus on the background estimation procedure, which plays a crucial role in the success of this analysis.

Parallel Sessions (II) / 18

Dynamical position and orientation calibration of the KM3NeT telescope

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KM3NeT is an underwater neutrino telescope which detects the Cherenkov radiation created by the products of neutrino interactions. To accurately reconstruct neutrino events, a precise determination of the position and orientation of the optical modules, which detect the Cherenkov radiation, is required. As the detector elements sway with the deep sea currents, a continuous tracking of the positions and orientations is necessary. A network of acoustic emitters and receivers is used to position the optical modules. Their orientation is determined by compasses placed in each optical module. In this contribution we want to present the methods to perform the position and orientation calibration of the KM3NeT telescope. The positions of the optical modules need to be resolved with an accuracy of better than 20 cm in order to achieve the envisaged angular resolution of the KM3NeT/ARCA telescope of 0.05 degrees. The orientations of the optical modules need to be resolved with an accuracy of about 3 degrees in order to not compromise the quality of the event reconstruction.

Parallel Sessions (I) / 19

Measurement of 214-Bi beta spectrum in XENONnT

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The XENONnT experiment, situated at the INFN Laboratori Nazionali del Gran Sasso, is a dark matter direct detection experiment with a target of 5.9 tonnes of instrumented liquid xenon. While its primary goal is detecting the faint signals from dark matter particle interactions, it also enables the measurement of high-energy events originating from background radioactive isotopes, including 214-Bi from the radon decay chain. Our study presents a method to select a clean sample of events from the first forbidden non-unique beta decay of 214-Bi to the ground state of 214-Po. This analysis serves two key purposes. Firstly, it provides an internal calibration sample to characterise the detector's response to single beta decays. Secondly, it is the first measurement of the energy

spectrum of this specific decay in its entire energy range. This measurement can be compared with the predictions from nuclear structure models for forbidden beta decays.

Parallel Sessions (I) / **20**

Measurement of jet quenching cone-size dependence in pp and Pb–Pb collisions with ALICE

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Heavy ion collisions serve as an excellent testing ground to study the strong interaction, described by quantum chromodynamics, under extremely high temperatures. In that environment, a short-lived medium of deconfined matter, called the quark-gluon plasma (QGP), is formed. A hard scattering between partons from the incident nuclei can result in the production of highly energetic partons that will shower into collimated spays of soft particles. These physical objects, called jets, constitute excellent probes for the study of the QGP in heavy ion collisions. In particular, jet substructure measurements can help us understand the interaction dynamics of high-energy partons with the QGP. The effects of these interactions are commonly referred to as jet quenching. In this talk, we discuss two observables which investigate the dependence of jet quenching on the resolution parameter R_{jet}. First, we present a new measurement of the nuclear modification factor R_{AA} using novel machine learning techniques to address the influence of the underlying event in heavy ion collisions. In addition, we introduce a new infrared and collinear safe measurement of the energy flow within jets reconstructed with different resolution parameters R_{jet}. These measurements gauge the relative contribution of competing energy-loss effects such as the dependence on the opening angle of the shower and the generation of large-angle fragments by radiative energy loss, which give opposite trends for the R_{jet}-dependence of R_{AA}.

Parallel Sessions (I) / **21**

Optimization of HLT2 selection algorithms at the LHCb experiment

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The computational challenge posed by Large Hadron Collider(LHC) experiments is a formidable one, and with the advent of the High-Luminosity LHC upgrade, there is an increasing demand for efficient utilization of computational resources. The High-Level Trigger 2(HLT2) at the LHCb experiment is the CPU-based second step of the trigger chain that selects physics objects at offline-quality for long-time storage. A significant fraction of the computational cost(30%) is spent on selections of the physics objects in the trigger lines. The nature of LHCb's physics program necessitates exclusive implementation of algorithms that implement similar selection criteria. This leads to combinations of input particles being iterated over multiple times in separate algorithms. In response to this inefficiency, an optimization framework have been created that identifies combiners with similar inputs, combine them together to remove the duplicate computations and with current work being done towards optimizing the process for best performance. This work represents an important step towards ensuring that the computational resources deployed in the LHCb experiment are effectively implemented to meet the growing demand of High-Luminosity LHC operation.

Parallel Sessions (I) / **22**

Search for the sources of ultra-high-energy cosmic rays

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The arrival directions of ultra-high-energy cosmic rays, with energies above 8 EeV, reveal a dipolar structure pointing away from the center of our Galaxy, thus indicating an extragalactic origin of cosmic rays at the highest energies. In this contribution, it will be demonstrated that the observations can be explained by assuming that the sources follow the large scale structure of the universe. Based on a model that includes the extragalactic propagation and Galactic magnetic field deflections, the source density can be constrained, which allows for valuable conclusions on the possible source types.
At the highest energies, anisotropies at intermediate angular scales arise, which can be interpreted as contributions from individual sources. Promising candidates that can explain all observations are the nearby radio galaxy Centaurus A, as well as local starburst galaxies.
This contribution will provide an overview of the ongoing search for the sources of ultra-high-energy cosmic rays, as well as an outlook to the future.

Parallel Sessions (II) / 23

Charming decay of the Higgs boson

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An important approach to fully understanding the mechanism how particles acquire mass is the coupling between the Higgs boson to first-generation fermions and to second-generation quarks. Among the searches for these types of coupling, the Higgs boson decay to charm quarks is the most promising mode to investigate. This talk will focus on the latest results of the Higgs boson to charm decay analysis from the ATLAS collaboration, discuss the techniques used to identify charm objects, and show the connection between the Higgs Yukawa coupling to the second- and third-generation quarks.

Parallel Sessions (III) / 24

The Eyes of LISA

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The Dutch contribution to the Laser Interferometer Space Antenna (LISA) covers both hardware and data analysis. Focusing on the hardware, the Netherlands will deliver 'The Eyes of LISA', known as the Quadrant Photo-Receivers (QPRs), made up of segmented InGaAs photodiodes with read-out electronics in an ultra-stable housing. Furthermore, The Netherlands is developing the Point Ahead Alignment Mechanism (PAAM), consisting of a nanorad-accurate steerable mirror pointing the outgoing laser beam to meet the advancing opposite spacaecraft during the light travel time. In addition, The Netherlands will provide the Mechanism Control Unit, i.e. special electronics to readout and control the PAAM as well as host electronics for other adaptable optics in LISA. The QPR is a joint development program by Nikhef and SRON, Dutch industry, KU Leuven and the Albert Einstein Institute in Hannover. This talk will focus on the challenges on delivering 120 QPR systems for flight, spares and tests, that meet the requirements that are demanded by the mission.

Parallel Sessions (III) / 25

TCAD Simulations on Monolithic Pixel Sensors: Improving Timing Performance for ALICE at LHC

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During Long Shutdown 4 of the Large Hadron Collider (LHC), ALICE will be replaced by a completely new detector. It will offer unique insights into thermal dielectron production and heavy flavor probes in the quark-gluon plasma. This upgrade involves positioning the inner detector layer 5 mm from the interaction point, minimising scatterings, and enabling large-area curved sensors with the lowest material budget. These requirements are attainable thanks to recent breakthroughs in semiconductor technology and will employ the latest innovations in Monolithic Pixel Sensors (MAPS).

My research is predominantly focused on the advancement of Monolithic Pixel Sensors (MAPS), with a specific emphasis on augmenting their capacity for fast-timing measurements, aiming to attain a 20 ps time resolution and minimize power consumption to align with the objectives of the ALICE project. The performance of these sensors is contingent on numerous parameters, including pixel geometry, pitch size, reverse bias voltage, doping concentrations, and layer thickness. The variation and combination of these parameters are crucial to meet the final specifications.
Leveraging Technology Computer-Aided Design (TCAD) simulations, it becomes feasible to precisely model the electric field within each pixel, thus enabling the calculation of charge trajectories and transit times to the collection electrode. This powerful tool helps to determine the capacitance and power consumption for each proposed configuration, aiding in the selection of the most suitable design. Furthermore, the results obtained will guide the choice of the most radiation-resistant geometry, based on simulations of radiation damage in the sensor. This presentation will showcase recent findings regarding the timing capabilities of MAPS with various geometries.

Parallel Sessions (III) / 26

Commissioning of the NEXT mass separator and spectrometer

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Soon to be located in the North hall of PARTREC, Groningen, the NEXT experiment intends to produce Neutron-rich EXotic heavy nuclei in multi-nucleon Transfer reactions. By measuring the masses of these exotic nuclei to high precision, their internal nuclear structure can be probed. These masses can also be used as input data for nucleosynthesis models.
Once produced, the transfer products will be pre-separated by magnetic rigidity in a solenoid separator before being slowed to thermal energies in a gas catcher and extracted via an RF carpet [1]. The extracted ions are bunched using a novel ion guide consisting of a stack of ring electrodes [2]. The bunched ions can then be accelerated to a few keV and transferred to a Multi-Reflection Time-of-Flight Mass Spectrometer (MR-TOF MS) which separates the prepared ions from their isobaric contaminants and measures their masses to a precision of 10^{-7} after 10 ms [3].
Currently, each component is being commissioned in offline experiments. The extraction performance of the gas catcher has been determined, while an offline set-up has been constructed to commission both the ion-guide and the MR-ToF MS. Early testing with the MR-ToF MS has demonstrated

isotopic separation with a mass precision of 10^{-4} after less than 1 ms of flight time and poor ion bunching. The NEXT ion guide is now being commissioned, it will provide ion bunches <100 ns in width and with an energy spread of 3 eV.
In this contribution, the current status of the NEXT experiment will be discussed, with a focus on NEXT's gas catcher, ion guide, and MR-ToF MS.

[1] J. Even, X. Chen, A. Soylu, P. Fischer, A. Karpov, V. Saiko, J. Saren, M. Schlaich, T. Schlathölter, L. Schweikhard, J. Uusitalo, and F. Wienholtz, "The NEXT project: Towards production and investigation of neutron-rich heavy nuclides," Atoms, vol. 10, no. 2, p. 59, 2022.
[2] X. Chen, J. Even, P. Fischer, M. Schlaich, T. Schlathölter, L. Schweikhard, and A. Soylu, "Stacked-Ring Ion Guide for Cooling and Bunching Rare Isotopes", International Journal of Mass Spectrometry, vol. 477, 116856, 2022.
[3] M. Schlaich, "Development and Characterization of a Multi-Reflection Time-of-Flight Mass Spectrometer for the Offline Ion Source of PUMA", Master's Thesis, Technische Universität Darmstadt, Darmstadt, Germany, 2021.

Parallel Sessions (III) / 27

Fragmentation of charged-particle jets in pp collisions with ALICE

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In high energy pp collisions, quarks and gluons can scatter as free particles, after which they will radiate away their energy via gluon Bremsstrahlung and quark-antiquark pair production, before hadronising back into bound states. The resulting sprays of energetic particles can be reconstructed as jets and function as probes for studying the strong interaction. The momentum distribution of particles within jets can be described by (jet) fragmentation functions, which is expected to be different for gluon-initiated jets and quark-initiated jets. Our current knowledge of fragmentation functions is almost exclusively based on fits to data from e^+e^- collisions and semi-inclusive deep inelastic scattering processes, both of which are mainly sensitive to quark fragmentation, leaving gluon fragmentation functions poorly constrained. Hadronic collisions at the LHC, however, produce data rich in gluon-initiated final states and offer excellent opportunities to study gluon fragmentation directly. In this talk, we present the potential for ALICE to investigate gluon fragmentation with unprecedented precision by measuring fragmentation into baryons and mesons in pp collisions at $\sqrt{s} = 13.6$ TeV.

Parallel Sessions (III) / 28

Probing the width of the Higgs boson through offshell decays

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Since its discovery just over ten years ago we have learned a lot about the Higgs boson. However, some of its fundamental properties have yet to be confirmed experimentally. One such property is its decay width, or equivalently its lifetime. While it was initially never thought that measurements of the Higgs width could actually be made at the Large Hadron Collider (LHC) due to the detector resolutions of its major experiments ATLAS and CMS falling approximately a factor thousand short, a strategy using a clever interpretation of Higgs decays in the offshell regime does appear to make this possible.

In this talk I will explain the technique that makes this possible, and give an overview of a currently ongoing analysis that is nearing its finalisation which aims to measure the Higgs width through

this strategy, in particular for the case where it decays into two W-bosons. I will also give an expected sensitivity of this analysis on the LHC's full run 2 dataset, along with future plans for further interpretations in the context of Effective Field Theories (EFT). Finally, looking ahead, we will see what sensitivity we can expect with the full high luminosity LHC run which is expected to finalise towards the end of the next decade.

Parallel Sessions (II) / 29

Detecting the Cosmic Neutrino Background with PTOLEMY

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The PTOLEMY collaboration aims to detect the Cosmic Neutrino Background, the signal of neutrino freeze-out 1 second after the Big Bang. The CNB has been predicted, but not yet been measured. In this talk, I will give an overview of the PTOLEMY experiment and the challenges that need to be solved to make this experiment viable. Specifically, I will talk about progress on the development of the target for neutrino interactions. This target will consist of tritium atoms on graphene.

Parallel Sessions (II) / 30

Quantum algorithm for track reconstruction in the LHCb vertex locator

Author: Davide Nicotra[None]

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Using the LHCb vertex locator as a use-case, I will present a new algorithm for particle track reconstruction based on the minimisation of an Ising-like Hamiltonian using a linear algebra approach. This new formulation of the problem is suitable to be solved using the Harrow-Hassadim-Lloyd (HHL) quantum algorithm: if the hypotheses for an efficient implementation are met, this approach can provide an exponential speedup as a function of the number of input hits over its classical counterpart. The algorithm has been validated using LHCb simulated events with a classical linear solver, showing good track reconstruction performances. The quantum implementation has been also tested, using smaller toy-generated events, showing very promising results.

Parallel Sessions (III) / 31

Advanced Machine Learning techniques at the service of identifying boosted Higgs-boson decays to heavy-flavours

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The search for boosted Higgs-boson decays to heavy-flavoured quarks constitutes a central aspect of the physics programme of the ATLAS experiment at the Large Hadron Collider (LHC). A high-performance algorithm for tagging such Higgs boson decays can play a crucial role in improving the

sensitivity of searches for new resonances in Beyond the Standard Model scenarios or in the precise measurement of the Higgs boson properties. In this context, the ATLAS experiment has recently harnessed cutting-edge machine learning technique based on Transformer networks to significantly enhance the identification performance of such decays. This presentation will shed light on these latest developments, demonstrating how advanced machine learning techniques are pushing the boundaries of our ability to unravel the secrets of the Higgs-boson at the LHC.

Parallel Sessions (III) / 32

First results from the Timepix4 Telescope

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A beam telescope based on the recently developed Timepix4 ASIC was built in order to perform tests of synchronous multiple-detector readout and track reconstruction with fast timing capability. The Timepix4 is a readout ASIC for hybrid pixel detectors that is designed to record both the time of arrival (ToA) and the time over threshold (ToT) for each discriminated signal. It has a 448×512 pixel matrix with square pixels at a 55 µm pitch. The ToA is digitised by a TDC with time bins of 195 ps. The ToT is proportional to the charge collected by the silicon sensor, and is used to achieve sub-pixel spatial resolution. The ToT is also used to correct for timewalk and thereby improve the ToA resolution. The telescope consists of eight planes with n-on-p silicon sensors. Four of these planes are instrumented with 300 µm thick planar sensors, and they are tilted with respect to the be incidence to provide high quality spatial measurements. The other four planes have 100 µm thick sensors to achieve a better time response. Each detector assembly (sensor + Timepix4 ASIC) is cooled by circulating chilled glycol through a 3D-printed titanium block that is directly attached to the carrier PCB. The cooling block has a circular cut-out to minimise the amount of material traversed by incident particles. The assemblies are readout by SPIDR4 systems. Scintillators and micro-channel plate (MCP) detectors provide precise time-reference signals that are recorded by the PicoTDC chip which has time bins of 3 ps. The time references are used to characterise and calibrate the time measurements of the telescope. First tracks were reconstructed using information from all eight planes, which allows for the assessment of temporal resolution using high energy particles.

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Simulation of high-time-resolution silicon LGAD sensors with Allpix2

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Once the Large Hadron Collider (LHC) enters the high-luminosity phase, the number of proton-proton interactions will increase by an estimated factor of 3, which calls for a detector with very precise timing measurements to distinguish between collisions in time, as well as in space. To that end, the ATLAS detector will be upgraded with a High Granularity Timing Detector (HGTD) consisting of LGAD sensors that are capable of providing a time resolution of 30 to 50 ps per track. The topic of this talk will be the simulation of LGAD sensors in the Allpix^2 framework, where we will focus on the necessary steps involved in generating efficiency plots and how these compare to test beam results.

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Transformers for Particle Track Reconstruction and Hit Clustering

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Track reconstruction is a crucial part of High Energy Physics (HEP) experiments. Traditional methods for the task scale poorly, making machine learning and deep learning appealing alternatives. Following the success of transformers in the field of language processing, we investigate the feasibility of training a transformer to translate detector signals into track parameters. We study and compare different architectures for the task, including an autoregressive transformer model with the original encoder-decoder architecture, and encoder-only architectures for the purpose of track parameter classification and regression. The models are benchmarked on simplified datasets generated by the recently developed simulation framework REDuced VIrtual Detector (REDVID). The performance of the proposed models on noisy linear and helical track definitions shows promise for the application of transformers on more realistic data for particle reconstruction.

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The quest for new particles: ATLAS Experiment Searches Updates and Outlook

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The ATLAS Experiment at the Large Hadron Collider (LHC) continues to push the boundaries of particle physics, seeking to unravel the mysteries of the universe beyond the Standard Model. This talk will provide an overview of the most recent results obtained during Run 2 of the LHC, focusing on our relentless quest for new physics. In addition, I will outline the plans and prospects for Run-3 and the upcoming HL-LHC searches.