9th International Conference on High Energy Particle and Nuclear Physics in the LHC Era

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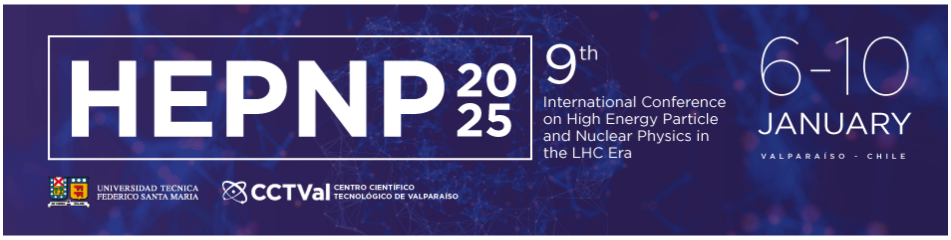

Book of Abstracts

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Welcome Talk

Corresponding Author: brooksw@jlab.org

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Latest News from CMS

Author: Greg Landsberg[1]

[1] *Brown University (US)*

Corresponding Author: greg.landsberg@cern.ch

In this talk, I'll highlight the latest results from the CMS experiment at the LHC, including the recent precision measurement of the W boson mass, numerous searches for beyond the standard model phenomena, and the host of precision measurements in the electroweak and QCD sectors. I'll discuss the latest developments in artificial intelligence techniques in application to CMS physics analysis, as well as the exploration of the quantum science frontier at the LHC.

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New measurement of $K^+ \to \pi^+\nu\bar{\nu}$ branching ratio at the NA62 experiment

Author: Evgueni Goudzovski[1]

[1] *University of Birmingham*

Corresponding Author: evgueni.goudzovski@cern.ch

The $K^+ \to \pi^+\nu\bar{\nu}$ decay is a golden mode for flavour physics. Its branching ratio is predicted with high precision by the Standard Model to be less than 10^{-10}, and this decay mode is highly sensitive to indirect effects of new physics up to the highest mass scales. A new measurement of $K^+ \to \pi^+\nu\bar{\nu}$ decay by the NA62 experiment at the CERN SPS is presented, using data collected in 2021 and 2022. This new dataset was collected after modifications to the beamline and detectors and at a higher instantaneous beam intensity with respect to the previous 2016-2018 data taking. Using the NA62 datasets from 2016-2022, a new measurement of the branching ratio $\mathcal{B}(K^+ \to \pi^+\nu\bar{\nu}) = \left(13.0^{+3.3}_{-2.9}\right) \times 10^{-11}$ is reported, and for the first time the $K^+ \to \pi^+\nu\bar{\nu}$ decay is observed with a significance exceeding 5σ.

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Towards decoding the nature of Dark Matter

Author: Alexander Belyaev[1]

[1] *University of Southampton & Rutherford Appleton Laboratory*

Corresponding Author: a.belyaev@soton.ac.uk

The nature of Dark Matter (DM) remains one of the greatest puzzles in particle physics and cosmology. While overwhelming observational evidence across galactic and cosmological scales confirms its existence, decades of experiments have only verified its gravitational interaction. Key properties of DM – such as its spin, mass, non-gravitational interactions, stabilizing symmetry, number of associated states, and mediating particles linking DM to Standard Model interactions – remain unknown.

To address these challenges, we propose a systematic classification of DM based on DM and mediator multiplets with different spins and weak group charges. Additionally, we introduce a novel class of models – Fermionic Portal Vector Dark Matter (FPVDM) – that extends the Standard Model with an SU(2) dark gauge sector. FPVDM offers important implications for direct and indirect detection experiments, relic density, and collider searches
as well as provides the Gravitational Wave signals from specific regions of the parameter space, where the strong first-order phase transition takes place.

Examples of DM models and their signatures will be discussed, alongside prospects for current and future experiments to test them. This talk will argue that a systematic classification of DM models and their signals provides a robust framework for discovering and identifying Dark Matter in the near future.

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Measurement of the Proton-Nuclear Transverse Analyzing Power with the RHIC Polarized Hydrogen Gas Jet Target

Author: Andrei Poblaguev[1]

[1] *Brookhaven National Laboratory*

Corresponding Author: poblaguev@bnl.gov

In the RHIC spin program, the Atomic Polarized Hydrogen Gas Jet Target (HJET) was constructed to measure the absolute polarization of proton beams. Recoil protons from the vertically polarized proton beam CNI (Coulomb Nuclear Interference) scattering off the vertically polarized proton jet target were detected using left-right symmetric Si detectors. Since the jet polarization is well known, $P_{\text{jet}} \approx 96 \pm 0.1\%$, concurrent measurements of the beam and target spin-correlated recoil proton asymmetries enabled the determination of the beam polarization with low systematic uncertainty, σ_P^{syst}/P $lesssim 0.5\%$.
Additionally, single $A_{\text{N}}(t)$ and double $A_{\text{NN}}(t)$ spin analyzing powers were precisely measured at $|t| < 0.02\,\text{GeV}^2$ for two beam energies, 100 and 255 GeV, allowing for reliable isolation of the corresponding hadronic spin-flip amplitudes. Since HJET also performed well with nuclear beams, $p^\uparrow A$ analyzing powers were routinely studied during heavy ion runs at RHIC without disrupting RHIC operations. For 100\,GeV/nucleon beams, $A_{\text{N}}^{pA}(t)$ was measured for $^2\text{H}^+$ (d), $^{16}\text{O}^{8+}$, $^{27}\text{Al}^{12+}$, $^{96}\text{Zr}^{40+}$, $^{96}\text{Ru}^{44+}$, and $^{197}\text{Au}^{79+}$, providing a detailed test of spin effects within the Glauber model.
The energy dependence of $A_{\text{N}}^{pA}(t)$ was also studied for Au (3.8–100 GeV) and d (10–100 GeV).
These measurements have the potential to determine pp spin-flip amplitudes across a wide range of beam energies, thereby improving the reliability of Regge fits for spin-flip measurements. Preliminary results from the HJET $p^\uparrow A$ data analysis will be discussed.

Plenary session 2 / 539

Exotic searches at ATLAS

Author: Jackson Carl Burzynski[1]

[1] *Simon Fraser University (CA)*

Corresponding Author: jackson.carl.burzynski@cern.ch

Many theories beyond the Standard Model (SM) have been proposed to address several of the SM shortcomings, such as explaining why the Higgs boson is so light, the origin of neutrino masses, or the observed pattern of masses and mixing angles in the quark and lepton sectors. Many of these beyond-the-SM extensions predict new particles or interactions directly accessible at the LHC. This talk will present some highlights on recent searches based on Run 2 data collected by the ATLAS detector at the LHC with a center-of-mass energy of 13 TeV.

Plenary session 3 / 522

PHENIX Overview

Author: Daniel Firak[None]

Corresponding Author: daniel.firak@stonybrook.edu

PHENIX has finished data collection in 2016, but the analysis of the vast amount of unique data are still ongoing, resulting in a steady flow of publications bearing on the most current physics issues related to the nature of QGP and nuclear structure. The versatility of the PHENIX detector, combined with the diversity of collision systems available at RHIC has allowed the exploration of topics as diverse as the gluon spin, jet substructure, MPI at RHIC energies, charmonium and heavy flavor flow, possible mass drop of the eta prime meson, evidence of QGP droplets in small system collisions, thermal photon yield and flow in Au+Au, light and strange neutral meson production in large systems. In this talk we will report on these recent results and their significance.

Plenary session 3 / 528

Baryon Number Flow in High-Energy Collisions

Author: Boris Kopeliovich[None]

Corresponding Author: boris.kopeliovich@gmail.com

Baryon Number (BN) is associated with a specific topology of gluonic fields, rather than with the valence quarks. The BN is frequently confused with the difference between the quark and antiquark distributions in the hadron. However, that they have quite different x-dependences. The BN asymmetry distribution is nearly constant at small x, while valence $q(x) - \bar{q}(x) \propto \sqrt{x}$. The x-independent BN asymmetry leads to the energy independent $\bar{p}p$ annihilation cross section, and to rapidity independent BN stopping at high energies. Measurements of baryon asymmetry at small x in ep collisions at HERA confirms this expectation. The gluonic mechanism of BN stopping also increases the production rate for cascade hyperons in a good accord with LHCb data. The BN asymmetry at mid-rapidities in heavy ion collisions is substantially enhanced by multiple interactions.

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NA64: The dark matter experiment at the CERN SPS

Author: Marco Ayala[1]

[1] *SAPHIR - UNAB*

Corresponding Author: marco.ayala@cern.ch

NA64 is an active target experiment that utilizes high-intensity electron, positron, and muon beams generated by the collision of high-energy protons from the CERN Super Proton Synchrotron (SPS) with a target and subsequently guided to the NA64 detector. The experiment primarily employs the missing energy technique to search for dark matter particles in the sub-GeV mass range and other physics beyond the Standard Model. Recently, NA64 has expanded its physics program to include hadron beams, with the first results published in Phys.Rev.Lett. 133 (2024) 12, 121803. This talk will provide an overview of the NA64 experiment, its current status, and its primary physics goals.

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Science at Jefferson Lab, Today and Tomorrow

Corresponding Author: keppel@jlab.org

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Quarkyonic Matter

Author: Larry McLerran[None]

Corresponding Author: lmcler@uw.edu

I discuss Quarkyonic Matter as an explanation for observed characteristics of neutron star matter. I also argue that the onset of density of Quarkyonic Matter is near that of nuclear matter based on quark distributions measured in deep inelastic scattering. The appearance of Quarkyonic Matter in the phase diagram for QCD at finite temperature and density is quantitatively estimated.

Plenary session 4 / 476

Direct Dark Matter searches with the XENONnT experiment

Author: Johanna Jakob[1]

[1] *University of Münster*

Corresponding Author: j.jakob@uni-muenster.de

The XENONnT experiment is aiming for the direct detection of dark matter in the form of weakly interacting massive particles (WIMPs) by investigating potential interactions with ordinary matter using a liquid xenon (LXe) time projection chamber. The detector, operating at Laboratori Nazionali del Gran Sasso (LNGS) in Italy, contains a total xenon mass of 8.6 tonnes, of which 5.9 tonnes are actively instrumented LXe. Given the elusive nature of possible dark matter interactions, a detection threshold of a few keV nuclear recoil energy as well as establishing an exceptionally low background level are crucial. This enables the pursuit of further rare event searches, as demonstrated by the recent measurement of solar B-8 neutrinos via the nuclear recoil channel (CEvNS) for which the nuclear recoil energy threshold was lowered to 0.5 keV.
XENONnT has completed its first two science runs with a total exposure of approximately 3.5 tonne-years and continues to collect science data. This talk will present the current status and the latest results of the XENONnT experiment.
This work is supported by ErUM-Pro BMBF No 05A23PM1.

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ATLAS ITk Pixel Detector Overview

Author: Anna Raquel Petri[1]

[1] *Università degli Studi e INFN Milano (IT)*

Corresponding Author: anna.raquel.petri@cern.ch

In the high-luminosity era of the Large Hadron Collider, the instantaneous luminosity is expected to reach unprecedented values, resulting in up to 200 proton-proton interactions in a typical bunch crossing. To cope with the resulting increase in occupancy, bandwidth and radiation damage, the ATLAS Inner Detector will be replaced by an all-silicon system, the Inner Tracker (ITk). The innermost part of the ITk will consist of a pixel detector, with an active area of about 13 mˆ2. To deal with the changing requirements in terms of radiation hardness, power dissipation and production yield, several silicon sensor technologies will be employed in the five barrel and endcap layers. As a timeline, it is facing to pre-production of components, sensor, building modules, mechanical structures and services. The pixel modules assembled with RD53B readout chips have been built to evaluate their production rate. Irradiation campaigns were done to evaluate their thermal and electrical performance before and after irradiation. A new powering scheme –serial –will be employed in the ITk pixel detector, helping to reduce thematerial budget of the detector as well as power dissipation. This contribution presents the status of the ITk-pixel project focusing on the lessons learned and the biggest challenges towards production, from mechanics structures to sensors, and it will summarize the latest results on closest-to-real demonstrators built using module, electric and cooling services prototypes.

Plenary session 5 / 467

Extracting Proton 3D structure with AI: Highlights of the EXCLAIM project

Author: liuti simonetta[None]

Corresponding Author: sl4y@virginia.edu

Recent advances in nuclear theory, QCD phenomenology and experiments at the future EIC could soon lead us to both penetrate and visualize the deep structure of visible matter, answering questions that could not even be afforded before. In particular, deeply virtual exclusive experiments are believed to be probes of the orbital angular momentum of the proton's constituents, as well as of its 3D spatial structure. I will present results of the EXCLusives with AI and Machine learning (EXCLAIM) program centered on going beyond simple regression analyses that allow us to gain information from experiment from a quantitative analysis of the underlying correlations in the data.

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Structure Functions at large x

Author: Sebastian Kuhn[1]

[1] *Jefferson Lab*

Corresponding Author: kuhn@jlab.org

Understanding nucleon structure in the valence region, where one quark carries a large fraction x of the nucleon momentum, is a fundamental goal in hadronic physics. Many models and theoretical

predictions exist for the behavior of the ratio $d(x)/u(x)$ of up over down quark densities, and for the intrinsic polarization of up and down quarks inside a polarized nucleon as x approaches x=1. Exploring this regime is one of the central experimental goals of the energy-upgraded CEBAF accelerator at Jefferson Lab. I will present an overview of this experimental program, with an emphasis on recent measurements with the CLAS12 spectrometer in Hall B of Jefferson Lab.

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DUNE: Overview and Status

Author: Luis Mora-Lepin[1]

[1] *Florida State University*

Corresponding Author: lml24d@fsu.edu

The Deep Underground Neutrino Experiment (DUNE) is a next-generation long baseline experiment under construction in the United States. Using a high-intensity neutrino beam produced at Fermilab, DUNE will measure the oscillation of muon (anti)neutrinos into electron (anti)neutrinos with a kilo tonne scale detector located in South Dakota. A near detector will be constructed in Fermilab to constrain the un-oscillated neutrino flux and to reduce detector-associated systematic uncertainties. DUNE will carry out a precision measurement of neutrino oscillations to determine the neutrino mass ordering and whether the CP symmetry is violated in the leptonic sector. The DUNE physics program is not only limited to neutrino oscillations. DUNE will also search for supernova neutrinos, proton decay and BSM particles to list a few. In this talk, I will give an overview of the DUNE experiment and its expected sensitivity. In addition, I will provide an update on the DUNE construction progress.

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Explaining the cosmological dark matter coincidence in asymmetric dark QCD

Author: Raymond Volkas[1]

[1] *The University of Melbourne*

Corresponding Author: raymondv@unimelb.edu.au

Observations have established that the dark matter mass density is about five times that of ordinary matter, rather than being orders of magnitude different. This coincidence is potentially explained by asymmetric dark matter. In almost all such models, however, while the number density asymmetries of ordinary and dark matter are related, the mass of the dark matter particle is left as a free parameter. That means the coincidence is not explained. I discuss an approach to justifying why the dark matter was scale is related to the proton mass that uses an infrared fixed point in the renormalisation group evolution of the ordinary and dark QCD coupling constants. The dark matter particle is a stable baryon of dark QCD, just as the proton is a stable baryon of ordinary QCD.

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K-Long Beam Facility at Jefferson Lab

Author: Hovanes Egiyan[1]

[1] *Jefferson Lab*

Corresponding Author: hovanes@jlab.org

Study of hadron spectrum provides one of the best avenues for understanding properties of the strong interactions in the non-perturbative regime. The spectrum of hadronic states containing one or more constituent strange quarks has not been well established compared to the spectrum of hadrons with lightest u- and d-quarks. In order to advance our knowledge of the hyperon spectrum, a new experimental facility is being designed and built in Hall D at Jefferson Lab that will provide a high intensity K_L-beam impinging on fixed hydrogen and deuterium cryo-targets. The experiments will use existing GlueX detector for identifying the final states produced in the reactions. During this talk, I will introduce the physics motivation for proposed experiments, present the conceptual design of the facility, and show the current status of the project.

Plenary session 6 / 469

ALICE Highlights

Author: Jun Takahashi for the ALICE collaboration[1]

[1] *University of Campinas UNICAMP (BR)*

Corresponding Author: jun@ifi.unicamp.br

ALICE is a dedicated experiment built to probe and explore the high-density, deconfined QCD matter produced in relativistic heavy-ion collisions at the Large Hadron Collider (LHC). The complexity of these collisions—featuring numerous competing physics processes that influence the final detected particles—requires a vast amount of data and diverse measurements to unravel the properties of strongly interacting matter at the highest temperatures ever achieved in the laboratory. To that end, ALICE measures a wide array of particles, different observables, and has collected data from Pb–Pb, Xe–Xe, p–Pb and pp collisions at multi-TeV center-of-mass energies. Following major upgrades implemented during Long Shutdown 2, ALICE has been collecting data since the start of Run 3 in 2022. These upgrades, which include increased readout rates and improved vertex resolution, enable ALICE to record a much larger integrated luminosity in Pb–Pb, pp, and p–Pb collisions during Runs 3 and 4. A summary overview of recent ALICE experimental physics results will be discussed with a selection of few representative measurements, with particular attention to developments led by groups in South America.

Parallel session 2: Neutrino Physics (1/2) / 575

Left-Right model with radiative double seesaw mechanism

Author: Antonio Enrique Cárcamo Hernández[1]

[1] *Universidad Técnica Federico Santa María*

Corresponding Author: antonio.carcamo@usm.cl

We propose an extended Left-Right symmetric model with an additional global symmetry U(1)X, which after spontaneous symmetry breaking collapses to a residual subgroup Z2, ensuring that the light active neutrino masses are generated via a double seesaw mechanism at two loop level, with the Dirac submatrix arising at one loop. It also guarantees one loop level masses for the SM charged fermions lighter than the top quark and protects Dark Matter (DM) candidates of the model. To the best of our knowledge our model has the first implementation of the radiative double seesaw mechanism with the Dirac submatrix generated at one loop level. We show that the model can successfully accommodate the observed pattern of SM fermion masses as well as mixings and is compatible with the constraints arising from neutrinoless double beta decay and DM.

Parallel session 1: Particle Detectors and Instrumentations/Future Experimental Facilities (1/2) / 541

Technical challenges and performance of the new ATLAS LAr Calorimeter Trigger

Author: Adriana Milic[1]

[1] *CERN*

Corresponding Author: adriana.milic@cern.ch

The Liquid Argon Calorimeters are employed by ATLAS for all electromagnetic calorimetry in the pseudo-rapidity region |η| < 3.2, and for hadronic and forward calorimetry in the region from |η| = 1.5 to |η| = 4.9. They also provide inputs to the first level of the ATLAS trigger. In 2022 the LHC started its Run-3 period with an increase in luminosity and pile-up of up to 60 interactions per bunch crossing.

To cope with these harsher conditions, a new trigger readout path has been installed. This new path significantly improved the triggering performances on electromagnetic objects with lower pT thresholds, but also lower rates. This was achieved by increasing the granularity of the objects available at trigger level by up to a factor of ten.

The installation of this new trigger readout chain also required the update of the legacy system. More than 1500 boards of the precision readout have been extracted from the ATLAS cavern, refurbished and re-installed. The legacy analog trigger readout that will remain during the LHC Run-3 as a backup of the new digital trigger system has also been updated.

For the new system, 124 new on-detector boards have been added. Those boards that are operating in a radiative environment are digitizing the calorimeter trigger signals at 40MHz. The digital signal is sent to the off-detector system and processed online to provide the measured energy value for each unit of readout. In total up to 31Tbps are analyzed by the processing system and more than 62Tbps are generated for downstream reconstruction. To minimize the triggering latency the processing system had to be installed underground. The limited available space imposed a very compact hardware structure. To achieve a compact system, large FPGAs with high throughput have been mounted on ATCA mezzanine cards. In total no more than 3 ATCA shelves are used to process the signal from approximately 34000 channels.

Given that modern technologies have been used compared to the previous system, all the monitoring and control infrastructure is being adapted and commissioned as well.

This contribution will present the challenges of the commissioning and operation, the performance and the milestones still to be achieved towards the full operation of the new digital trigger system.

Parallel session 2: Neutrino Physics (1/2) / 472

Dimuon production predictions for high energy neutrino detectors using the color dipole model

Author: Caetano Ternes[1]

Co-authors: Daniel Almeida Fagundes [1]; Edgar Huayra ; Emmanuel Gräve de Oliveira [1]

[1] *UFSC, Brazil*

Corresponding Author: yuberth022@gmail.com

Interactions of high-energy neutrinos with matter can be studied through the angular separation observed in dimuon production, an observable particularly sensitive to the transverse momentum

dynamics of partons. In this work, we utilize the color dipole model, in conjuction with Pythia8 Monte Carlo shower and hadronization simulations, to predict dimuon production cross sections within the energy range relevant to IceCube and future detectors.

Parallel session 1: Particle Detectors and Instrumentations/Future Experimental Facilities (1/2) / 481

Endcap Timing Layer of the CMS MIP Timing Detector for HL-LHC

Authors: Claudio Ariel San Martin Valenzuela[1]; Hongbo Liao[2]

[1] *Federico Santa Maria Technical University (CL)*

[2] *Chinese Academy of Sciences (CN)*

Corresponding Author: claudio.sanmartinval@gmail.com

The High-Luminosity Large Hadron Collider (HL-LHC) will enable a more detailed exploration of new physics phenomena by significantly increasing collision rates, leading to pileup levels of approximately 200 simultaneous interactions. The CMS experiment will add a new detector, the MIP Timing Detector (MTD) to cope with these challenges. The MTD is designed to mitigate pileup effects by providing a precise timestamp with a resolution of 30-40 picoseconds for each particle, thereby ensuring sustained detector performance under HL-LHC conditions. The MTD is divided into two sections: the Barrel Timing Layer (BTL) and the Endcap Timing Layer (ETL), each utilizing different sensor and ASIC technologies to address the varying active surfaces, irradiation conditions, and installation requirements. The ETL, comprising two double-sided disks, utilizes Low-Gain Avalanche Diode (LGAD) sensors and the Endcap Timing Readout Chip (ETROC) to meet the unique demands of its environment. Prototyping of ETL modules is underway, with extensive validation tests including the ETROC system test and module assembly. This presentation will provide an overview of the ETL, focusing on module and sensor performance, recent achievements, and the project status.

Parallel session 2: Neutrino Physics (1/2) / 452

Determining the leading-order contact term induced by sterile neutrinos in neutrinoless double β decay

Author: Sebastián Urrutia Quiroga[1]

Co-authors: Vincenzo Cirigliano ; Wouter Dekens

[1] *Institute for Nuclear Physics, University of Washington, USA*

Corresponding Author: suq90@uw.edu

Sterile neutrinos are present in multiple extensions to the Standard Model and participate in neutrino mass mechanisms, from simple type-I seesaw models to UV complete theories like left-right symmetry. In total analogy to the case of light neutrinos, the neutrinoless double β decay amplitude induced by the exchange of sterile neutrinos requires the introduction of a leading-order, short-range operator. Knowing this contribution is essential to correctly interpret positive experimental results in light of disentangling the underlying physical mechanism. In the absence of any data from experiments or lattice QCD, we present a method to determine the low-energy constant associated with this contract term.

Parallel session 1: Particle Detectors and Instrumentations/Future Experimental Facilities (1/2) / 488

ATLAS Upgrades for the High Luminosity LHC

Authors: Huacheng Cai[1]; Marco Lisboa Leite[2]

[1] *University of Pittsburgh (US)*

[2] *Universidade de Sao Paulo (BR)*

Corresponding Author: huacheng.cai@cern.ch

While the on-going Run-3 data-taking campaign will provide twice the integrated proton-proton luminosity currently available at the LHC, most of the data expected for the full LHC physics program will only be delivered during the HL-LHC phase. For this, the LHC will undergo an ambitious upgrade program to be able to deliver an instantaneous luminosity of 7.5×10^{34} cm^{-2} s^{-1}, allowing the collection of more than 3 ab^{-1} of data at $\sqrt{s}$ =13.6 (14) TeV. This unprecedented data sample will allow ATLAS to perform several precision measurements to constrain the Standard Model Theory (SM) in yet unexplored phase-spaces, in particular in the Higgs sector, a phase-space only accessible at the LHC. To benefit from such a rich data-sample it is fundamental to upgrade the detector to cope with the challenging experimental conditions that include huge levels of radiation and pile-up events. The ATLAS upgrade comprises a completely new all-silicon tracker with extended rapidity coverage that will replace the current inner tracker detector; a redesigned trigger and data acquisition system for the calorimeters and muon systems allowing the implementation of a free-running readout system. Finally, a new subsystem called High Granularity Timing Detector will aid the track-vertex association in the forward region by incorporating timing information into the reconstructed tracks. An important ingredient, relevant to almost all measurements, is a precise determination of the delivered luminosity with systematic uncertainties below the percent level. This challenging task will be achieved by collecting the information from several detector systems using different and complementary techniques. This presentation will describe the ongoing ATLAS detector upgrade status and the main results obtained with the prototypes, giving a synthetic, yet global, view of the whole upgrade project.

Parallel session 2: Neutrino Physics (1/2) / 498

Searches for CEvNS and BSM physics at CONNIE

Author: Nicolás Avalos[1]

[1] *Instituto Balseiro (Universidad Nacional de Cuyo, Comisión Nacional de Energía Atómica), CONICET*

Corresponding Author: nicolas.avalos@ib.edu.ar

CONNIE (COherent Neutrino-Nucleus Interaction Experiment) utilizes high-resistivity silicon CCDs to measure coherent elastic neutrino-nucleus scattering (CEvNS) of reactor antineutrinos on silicon nuclei at the Angra-2 reactor in Brazil. In 2021, the setup was enhanced with two Skipper CCDs, pushing the sensitivity threshold to 15 eV and demonstrating the potential of Skipper CCDs in reactor neutrino detection. 300 days of data were acquired between 2021 and 2022, corresponding to a total exposure of 18.4 g-days. No significant excess was observed in the comparison of reactor-on and reactor-off data, leading to 95\% CL upper limits on CEvNS. I will present these results and discuss the capability of Skipper CCDs in three novel searches for new physics: constraints on neutrino interactions through light vector mediators, dark matter-electron scattering via diurnal modulation, and the detection of relativistic millicharged particles from reactors. Lastly, I will outline future plans to scale up the detector mass for enhanced sensitivity.

Parallel session 1: Particle Detectors and Instrumentations/Future Experimental Facilities (1/2) / 482

The CMS Muon System Upgrade for High Luminosity LHC

Authors: Gabriella Pugliese[1]; Hongbo Liao[2]

[1] *Universita e INFN, Bari (IT)*

[2] *Chinese Academy of Sciences (CN)*

Corresponding Author: gabriella.pugliese@cern.ch

To address the demanding conditions of increased luminosity and higher pileup expected during the high-luminosity phase of the LHC (HL-LHC), the muon spectrometer of the CMS experiment will undergo significant upgrades. These enhancements aim to ensure robust operation under challenging data-taking conditions while improving the tracking and triggering performance of the system.

The electronics upgrades will target the Drift Tubes (DT) in the barrel, Cathode Strip Chambers (CSC) in the endcaps, and Resistive Plate Chambers (RPC) across the barrel and endcaps of the current muon system. Additionally, new detector stations will be deployed in the endcaps, where background rates are anticipated to be higher. These new stations will utilize advanced technologies, including triple Gas Electron Multiplier (GEM) and improved RPC (iRPC) detectors, which provide superior timing, spatial resolution, and enhanced rate capabilities.

This presentation will provide an overview of the CMS Muon System upgrades, highlighting ongoing activities, progress, and future plans as we prepare for HL-LHC operations.

Parallel session 4: QCD (1/2) / 521

Reggeon Field Theory at One loop improved Wilsonian regulator and ϵ-expansion

Author: Carlos Contreras[1]

[1] *UTFSM*

Corresponding Author: carlos.contreras@usm.cl

We study multifield extensions of Reggeon Field Theory (also equivalent to Directed Percolation model) at criticality in the improved one-loop perturbative expansion using Wilsonian regulator and ϵ-expansion below the upper critical dimension Dc = 4 at one loop. Analyzing all the fixed points of the renormalization group flow for two flavors, we were able to find different interactions between the 2 Pomerons [1, 2].

In high energy scattering quantum properties of the particles involved imply the need to have several reggeon fields in the description. First even in the QCD Pomeron analysis one may encounter a set of Pomeron states, which will eventually translate in an effective multifield RFT. More in general the so-called Pomeron and the Odderon give the dominant contributions at high energies. These objects have their perturbative counterpart in simplified analysis in QCD, but in full interacting QCD, theory is difficult to formulate a reliable description. Because of that, an idea of considering an effective RFT for these two fields with all the possible specific interactions. Then we need to study the behavior at criticality both perturbatively and non perturbatively.

Acknowledgments: Fondecyt Project Grant: #1231829

References:
[1] J. Bartels, C. Contreras and G. P. Vacca, JHEP 05, 032 (2024)
[2] J. Bartels, C. Contreras and G. P. Vacca, to be appeared (2025) arXiv

Parallel session 3: Beyond The Standard Model (1/2) / 494

Completing the Exploration of the Minimal Dark Matter Paradigm

Author: Alfonso Zerwekh[1]

[1] *Universidad Tecnica Federico Santa Maria*

Corresponding Author: alfonso.zerwekh@usm.cl

The Minimal Dark Matter idea postulates that the dark matter can be the neutral component of an $SU(2)_L$ multiplet. This idea has been intensively studied for the case of fermion and scalar fields. For many years, our group have extended this paradigm to the case of massive vector fields. We have studied the phenomenology of vector dark matter for vector fields in the fundamental, adjoint and 5-dimensional representations of $SU(2)_L$, completing the exploration of the Minimal Dark Matter paradigm. In this talk, we will recapitulate on the main results of these models, discuss their limitations and possible extensions, including some ultraviolet completions.

Parallel session 4: QCD (1/2) / 542

Highlights on top quark physics with the ATLAS experiment at the LHC

Author: James Alfred Mueller[1]

[1] *University of Pittsburgh (US)*

Corresponding Author: mueller@pitt.edu

The large top quark samples collected with the ATLAS experiment at the LHC have yielded measurements of the production cross section of unprecedented precision and in new kinematic regimes. They have also enabled new measurements of top quark properties that were previously inaccessible, enabled the observation of many rare top quark production processes predicted by the Standard Model and boosted searches in the Top sector. In this contribution the highlights of the ATLAS top quark physics program are presented.

Parallel session 3: Beyond The Standard Model (1/2) / 475

Dynamical String Tension Theories with target space scale invariance SSB and restoration

Author: Eduardo Leon Guendelman[1]

[1] *Ben Gurion University*

Corresponding Author: eduardoleonguendelman@gmail.com

The string and brane tensions do not have to be put in by hand, they can be dynamically generated, as in the case when we formulate string and brane theories in the modified measure formalism. Then string and brane tensions appears, but as an additional dynamical degree of freedom . It can be seen however that these string or brane tensions are not universal, but rather each string and each brane generates its own tension, which can have a different value for each string or brane. The consequences of this for the spectrum of these string and brane theories is profound both in the ultraviolet behavior as in the low energy physics. There should be also a considerable effect for the effective gravity theories derived from these theories. We consider new background fields that can couple to these new types of extended objects, one of them, the ¨tension scalar¨ is capable of changing locally along the world sheet the value of the tension of the extended object. When many strings probing the same region of space are considered this tension scalar is constrained by the requirement of quantum conformal invariance. For the case of two strings probing the same region of space with different dynamically generated tensions, there are two different metrics, associated to the different strings, that have to satisfy vacuum Einsteins equations and the consistency of these two Einstein´s equation determines the tension scalar. The universal metric, common to both strings generically does not satisfy Einstein´s equation . The problem is analyzed in the case of a Schwarzschild background and for the cosmological case of a Kasner type solution. In the case of the flat space for the string associated metrics, in the Milne representation, for the case of two types of string tensions, there are solutions with negative string tension at the early universe that whose tension approaches zero in the late universe and a positive string tension type of strings appears for the late universe with its tension approaching a constant value at the late universe. The universal metric is not flat, instead it represents a non singular bounce cosmology. The case in a warped space time where positive and and negative string tensions are separated by a spontaneously generated wall is also studied, the construction of dynamical tension string theories, where the string tension appears as an integration constant. We also find that the construction of brane world scenarios in the context of these dynamical tension string theories, we discuss avoidance of the Hagedorn temperature possible relaxation of string swampland constraints in dynamical tension string theories, and that the dynamical string theories can bridge between the low and high energy quantum gravity effects, The dynamical modified string theory has target space scale invariance and this target space scale invariance can be restored at the points where the string tension approaches infinity. These models suggest the swampland constraints could be avoided.

Parallel session 4: QCD (1/2) / 531

Homotopy approach for scattering amplitude for running QCD coupling

Authors: Carlos Contreras[1]; Eugene Levin[2]; José Garrido[1]

[1] *Universidad Técnica Federico Santa María*

[2] *Tel Aviv University*

Corresponding Author: jose.garridom@sansano.usm.cl

In this talk, I will present the development of the homotopy method for solving the nonlinear Balitsky-Kovchegov (BK) equation with a running QCD coupling. I will show how an analytic solution is obtained for a simplified equation with a leading-twist BFKL kernel, satisfying initial and boundary conditions. In the second stage, we calculate the corrections to this solution. These corrections were computed numerically, but the equation remains analytic, avoiding uncertainties. The first iteration achieves 5% accuracy, while the second iteration improves the accuracy to ≤ 1%. At high energies, the solution approaches the unitarity limit, reproducing key features such as "ζ-scaling" and its breakdown at low $l-l_s$.

Parallel session 3: Beyond The Standard Model (1/2) / 458

Displaced ALPs from top decays at the LHC

Author: Giovanna Cottin[1]

[1] *Pontificia Universidad Católica de Chile (CL)*

Corresponding Author: gfcottin@gmail.com

I will present a study on axion-like particles (ALPs) with quark-flavor-violating couplings at the LHC. The ALPs can originate from decays of top quarks which are pair produced, and then decay to jets. If these couplings to the quarks are tiny and the ALPs have masses of the order of 10 GeV, they are long-lived, leading to signatures of displaced vertex plus multiple jets. We recast a recent ATLAS search for the same signature and reinterpret the results in terms of bounds on the long-lived ALP in our theoretical scenario. We find that the LHC with the full Run 2 dataset can place stringent limits, while at the future high-luminosity LHC stronger sensitivities are expected.

Parallel session 4: QCD (1/2) / 459

Proton structure using lattice QCD

Author: Constantia Alexandrou[1]

[1] *University of Cyprus*

Corresponding Author: alexandrou.constantia@ucy.ac.cy

Recent results will be presented on the Mellin moments of parton distributions as well as on generalised parton distribution functions of the proton. We will show results using twisted mass fermion ensembles simulated with physical values of the light quark mass.

Parallel session 3: Beyond The Standard Model (1/2) / 545

Using ultraperipheral collisions of lead ions to find signals of a new charged vector boson decaying into heavy neutral leptons.

Author: Yohan Mauricio Oviedo Torres[1]

[1] *SAPHIR*

Corresponding Author: mauricio.nitti@gmail.com

In this study, we present the potential of discovering new physics associated with a new charged vector boson decaying into heavy neutral leptons, using ultraperipheral lead ion collisions. We identify the optimal kinematic cuts that increase the statistical significance, which would allow us to detect signals of the possible existence of these particles, as predicted by the Vector Scotogenic Model. In addition, we calculate the necessary luminosity that the ATLAS experiment should reach in this type of collisions to achieve a statistical significance of 2σ and 5σ related to the existence of this new physics.

Plenary session 7 / 536

Hyperasymptotic expansions in QCD

Author: Antonio Pineda[None]

Corresponding Author: pineda@ifae.es

We show how to apply hyperasymptotic expansions to QCD observables. This allows, in principle, to achieve exponential ($\sim exp(-1/\alpha)$) accuracy in their determination with a well defined parametric

error. A selected set of applications we will discuss are heavy quark mass expansions, the static potential and the gluon condensate.

Plenary session 7 / 455

BCM' system for beam abort and luminosity monitoring in ATLAS

Authors: Andrej Gorisek[1]; Harris Kagan[2]; Marko Mikuz[1]

[1] *Jozef Stefan Institute*

[2] *Ohio State University*

Corresponding Authors: andrej.gorisek@cern.ch, kagan@mps.ohio-state.edu, marko.mikuz@cern.ch

The High Luminosity upgrade of the Large Hadron Collider (HL-LHC) at CERN will significantly increase the collider's particle density, presenting new challenges for the ATLAS experiment's detectors. To address these challenges, a new radiation-hard beam monitoring system has been developed to protect the inner silicon detectors and accurately monitor the increased luminosity. This system employs polycrystalline Chemical Vapor Deposition (pCVD) diamond sensors, coupled with a newly designed radiation-hard front-end ASIC, to ensure high performance under the HL-LHC's extreme conditions.
The upgraded system, known as BCM', will replace the existing beam protection system and be integrated into the retractable part of the new all-silicon Inner Tracker (ITk) of the ATLAS experiment. BCM'will not only safeguard the ITk by monitoring background activity and aborting the LHC beam in case of hazardous particle showers but will also serve as a luminosity meter for ATLAS. In addition, a slower Beam Loss Monitoring (BLM) system, developed by the LHC machine, will act as a backup to the BCM'.
Given the HL-LHC's more intense radiation environment, the BCM'system must meet much stricter radiation tolerance requirements, including higher neutron equivalent fluence, total ionizing dose, and charged particle flux. Preliminary results from the prototype detectors using the new ASIC have shown promising performance in beam tests at CERN, indicating that the system is on track to meet the demanding specifications of the upgraded collider.

Plenary session 7 / 499

Recent ALICE results on quarkonium

Author: Martino Gagliardi[1]

[1] *Universita e INFN Torino (IT)*

Corresponding Author: martino.gagliardi@cern.ch

ALICE (A Large Ion Collider Experiment) at the LHC aims at investigating the hot and dense QCD matter formed in ultra-relativistic heavy-ion collisions, and the transition to the Quark-Gluon Plasma (QGP). The suppression of charmonium and bottomonium states by color screening, and its hierarchy resulting from differences in binding energy, is a signature of QGP formation. Moreover, early ALICE results on J/ψ production in Pb-Pb collisions at the LHC were found to be compatible with a scenario where charmonium regeneration occurs in the hadronization phase or at the phase boundary. More recently, it was shown how measurements of quarkonium azimuthal anisotropies and polarization can provide insights into the properties of deconfined nuclear matter. Quarkonium photoproduction in peripheral and ultra-peripheral heavy-ion collisions provides a powerful tool to investigate the gluon structure of the colliding nuclei. Measurements of quarkonium production in small systems, such as proton-proton and proton-nucleus collisions, are also part of the ALICE physics program as they help constrain production models and cold-nuclear matter effects. Measurements as a function of the event multiplicity are particularly interesting, as they probe the interplay

between hard and soft particle production and enable the investigation of a potential common origin for observations made in small and large (such as Pb-Pb) systems. The recent ALICE results on quarkonium, exploiting the full data sample from the LHC Run 2, will be reviewed. The status and first results from the ongoing Run 3 data-taking with an upgraded apparatus will also be discussed.

Plenary session 8 / 520

Overview of the T2K experiment

Author: Grzegorz Żarnecki[1]

[1] *Polska Akademia Nauk, Instytut Fizyki Jądrowej im. Henryka Niewodniczańskiego*

Corresponding Author: grzegorz.zarnecki@ifj.edu.pl

T2K is a long baseline neutrino experiment in Japan producing a beam of (anti-)neutrinos at an accelerator complex and studying their oscillations by comparing the measured (anti-)neutrino spectrum at the near detector ND280 and at the water Cherenkov detector Super Kamiokande (Super-K), located 295 km away. Over the recent years, significant updates were applied to the T2K oscillation analysis, including: improved neutrino interaction modelling, updated flux predictions, and new selection samples in both ND280 and Super-K. In 2024 the technical upgrade of the near detector was finalised and T2K entered the second phase of the experiment. This presentation covers the current oscillation analysis results, recent cross section measurements and the experimental advantages of the ND280 upgrade.

Plenary session 8 / 470

Axion-Induced Patchy Screening of the CMB

Author: Cristina Mondino[1]

[1] *Perimeter Institute for Theoretical Physics*

Corresponding Author: cmondino@perimeterinstitute.ca

Cosmic Microwave Background (CMB) photons can undergo resonant conversion into axions in the presence of magnetized plasma distributed inside non-linear Large-Scale Structure (LSS). This process leads to axion-induced patchy screening: secondary temperature and polarization anisotropies with a characteristic non-blackbody frequency dependence that are strongly correlated with the distribution of LSS along our past light cone. First, I will discuss the modeling and computation of the axion signal contribution to different correlation functions, involving both CMB and and LSS observables. I will then show that a search using Planck temperature maps cross-correlated with the unWISE galaxy catalogue is already competitive to the most sensitive existing astrophysical axion searches, for axion masses around a few times 10ˆ-13 eV. Observations from future surveys could extend this reach by almost an additional order of magnitude.

Plenary session 8 / 540

Beyond the Standard Model in the Higgs sector

Author: Adriana Milic[1]

[1] *CERN*

Corresponding Author: adriana.milic@cern.ch

The discovery of the Higgs boson with the mass of about 125 GeV completed the particle content predicted by the Standard Model. Even though this model is well established and consistent with many measurements, it is not capable to solely explain some observations. Many extensions of the Standard Model addressing such shortcomings introduce additional Higgs bosons, beyond-the-Standard-Model couplings to the Higgs boson, or new particles decaying into Higgs bosons. In this talk, the latest searches in the Higgs sector by the ATLAS experiment are reported, with emphasis on the results obtained with the full LHC Run 2 dataset at 13 TeV.

Plenary session 9 / 576

The SHiP Experiment

Author: Albert De Roeck[1]

[1] *CERN*

Corresponding Author: albert.de.roeck@cern.ch

The BDF/SHiP collaboration has proposed a general-purpose intensity-frontier experimental facility operating in beam-dump mode at the 400 GeV CERN SPS accelerator to search for feebly interacting GeV-scale particles and to perform measurements in neutrino physics. CERN is uniquely suited for this programme owing to the proton energy and yield available at the SPS. In March 2024 the facility got approved at CERN and the final TDRs for the BDF and the SHiP detectors are under preparation. In this talk we will discuss the experimental methods, the SHiP detector set-up, the different sub-detectors, and sensitivities to new particles such as axion-like particles, dark scalars, heavy neutral leptons, light dark matter particles and more, as well as the presently foreseen schedule towards first data.

Plenary session 9 / 461

Fermion self-energy and effective mass in a noisy magnetic background

Author: Enrique Munoz[1]

Co-author: Jorge Castano-Yepes [1]

[1] *Pontificia Universidad Catolica de Chile*

Corresponding Author: munoztavera@gmail.com

In this work[1], we consider the propagation of QED fermions in the presence of a classical background magnetic field with white-noise stochastic fluctuations. The effects of the magnetic field fluctuations are incorporated into the fermion and photon propagators[3] in a quasiparticle picture, which we developed in previous works [2] using the replica trick. In the very strong-field limit, we explicitly calculate the fermion self-energy involving radiative contributions at first order in α, in order to obtain the noise-averaged mass of the fermion propagating in the fluctuating magnetized medium. Our analytical results reveal a leading double-logarithmic contribution ~ ln (eB/m2) to the mass, with an imaginary part representing a spectral broadening proportional to the magnetic noise autocorrelation Δ. While a uniform magnetic field already breaks Lorentz invariance, inducing the usual separation into two orthogonal subspaces (perpendicular and parallel with respect to the field),

the presence of magnetic noise further breaks the remaining symmetry, thus leading to distinct spectral widths associated with fermion and antifermion, and their spin projection in the quasiparticle picture.

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[2] J.D. Castano-Yepes, M. Loewe, E. Munoz, J.C. Rojas and R. Zamora, Phys. Rev. D 107, 096014 (2023)
[3] J.D. Castano-Yepes and E. Munoz, Phys. Rev. D 109, 056007 (2024)

Plenary session 9 / 535

Overview of the ATLAS ITk Strip Detector System for the Phase-II LHC Upgrade

Author: Katie Walkingshaw Pass[1]

[1] *University of Glasgow (GB)*

Corresponding Author: katie.louise.mary.walkingshaw.pass@cern.ch

The inner detector of the present ATLAS experiment has been designed and developed to function in the environment of the present Large Hadron Collider (LHC). At the ATLAS Phase-II Upgrade, the particle densities and radiation levels will exceed current levels by a factor of ten. The instantaneous luminosity is expected to reach unprecedented values, resulting in up to 200 proton- proton interactions in a typical bunch crossing. The new detectors must be faster, and they need to be more highly segmented. The sensors used also need to be far more resistant to radiation, and they require much greater power delivery to the front-end systems. At the same time, they cannot introduce excess material which could undermine tracking performance. For those reasons, the inner tracker of the ATLAS detector was redesigned and will be rebuilt completely. The ATLAS Upgrade Inner Tracker (ITk) consists of several layers of silicon particle detectors. The innermost layers will be composed of silicon pixel sensors, and the outer layers will consist of silicon microstrip sensors. This contribution focuses on the strip region of the ITk. The central part of the strip tracker (barrel) will be composed of rectangular short (2.5 cm) and long (5 cm) strip sensors. The forward regions of the strip tracker (end-caps) consist of six disks per side, with trapezoidal shaped sensors of various lengths and strip pitches. After the completion of final design reviews in key areas, such as Sensors, Modules, Front-End electronics, and ASICs, a large-scale prototyping program has been completed in all areas successfully. We present an overview of the Strip System and highlight the final design choices of sensors, module designs and ASICs. We will summarize results achieved during prototyping and the current status of pre-production and production on various detector components, with an emphasis on QA and QC procedures.

Plenary Session 10 / 574

Probing Diquark Structure via Lambda Fragmentation Studies at Jefferson Lab

Author: Lamiaa El Fassi[1]

[1] *Mississippi State University*

Corresponding Author: le334@msstate.edu

Studies based on employing hard probes and pioneering processes such as semi-inclusive deep inelastic scattering (SIDIS) on atomic nuclei are cogent in accessing medium modifications of their underlying structure, exploring the hadronization mechanisms, and studying confinement dynamics in cold nuclear matter. Indeed, carrying out such studies in a clean environment effectively probes the fragmentation mechanisms related to color propagation and hadron formation and, thus, its associated time-distance scales. In this talk, I will highlight recent hadronization results from Jefferson Lab, focusing on the first-ever SIDIS study of Lambda hyperon in the current and target fragmentation regions. These new results, alongside the lately collected CLAS12 quark propagation data, will effectively enhance our understanding of quark-diquark correlations in the nucleon, light, and strange baryon structures.

This work is supported in part by the U.S. DOE award #: DE-FG02-07ER41528

Plenary Session 10 / 518

Advances in extracting x-dependent PDFs and GPDs from Lattice QCD

Author: Martha Constantinou[None]

Corresponding Author: marthac@temple.edu

Calculating the x-dependence of partonic distribution functions from lattice QCD has become feasible in the last decade due to novel approaches. In this talk, I will present selected advances for extracting PDFs and GPDs at leading twist and beyond. Such progress demonstrates the potential of lattice QCD calculations to complement other theoretical and experimental efforts toward a better understanding of the partonic structure of hadrons.

Plenary Session 10 / 506

Experimental overview of Generalized Parton Distributions

Author: Silvia Niccolai[1]

[1] *CNRS*

Corresponding Author: silvia.niccolai@ijclab.in2p3.fr

Generalized Parton Distributions (GPDs) are nowadays the object of an intense effort of research, in the perspective of understanding nucleon structure. They describe the correlations between the longitudinal momentum and the transverse spatial position of the partons inside the nucleon and they can give access to the contribution of the orbital momentum of the quarks and gluons to the nucleon spin.
Deeply Virtual Compton scattering (DVCS), the electroproduction on the nucleon, at the partonic level, of a real photon, is the process more directly interpretable in terms of GPDs of the nucleon. Depending on the target nucleon (proton or neutron) and on the DVCS observable extracted (cross sections, target- or beam-spin asymmetries, ⋯), different sensitivity to the various GPDs for each quark flavor can be exploited. Gluon GPDs can also be accessed by probing specific kinematic regimes. And, besides DVCS, other exclusive reactions, such as Timelike Compton Scattering, Double DVCS, or the exclusive electroproduction of mesons, can provide information on GPDs.
This talk will provide an overview on recent and new, promising, GPD-related experimental results, mainly obtained at Jefferson Lab on fixed target experiments with a 12-GeV electron beam, for various target types and final states. These data open the way to a "tomographic"representation of the structure of the nucleon, allowing the extraction of transverse space densities of the quarks at fixed longitudinal momentum, as well as paving the way to the quarks'angular momentum contribution to the spin of the proton.

Plenary Session 10 / 562

Selected highlights from the STAR experiment at RHIC

Corresponding Author: sonja.kabana@cern.ch

Parallel session 7: Beyond The Standard Model (2/2) / 547

Displaced Vertices of a Light Neutralino at Belle II

Author: Juan Carlos Helo Herrera[1]

[1] *Universidad de La Serena (CL)*

Corresponding Author: juan.carlos.helo.herrera@cern.ch

I will present ongoing work on light neutralinos with baryon-number-violating R-parity-violating (RPV) couplings at Belle II. Neutralinos can be produced in B-meson decays and subsequently decay into baryon-meson pairs, leading to displaced-vertex (DV) signatures. We employ partial reconstruction techniques to enhance signal efficiency and suppress backgrounds. Using Monte Carlo simulations, we determine Belle II's sensitivity to RPV couplings for GeV-scale neutralinos, surpassing current bounds. These preliminary results complement collider searches and explore new regions of parameter space for physics beyond the Standard Model.

Parallel session 6: Neutrino Physics (2/2) / 514

Neutrino Experiments at the Large Hadron Collider

Author: Albert De Roeck[1]

[1] *CERN*

Corresponding Author: albert.de.roeck@cern.ch

The forward direction of particle production in
proton-proton interactions at the Large Hadron Collider can serve as an
intense source of high energy neutrinos of all neutrino-flavours, that stem
from hadron decays. Two experiments located
at a distance of 480 m away from the ATLAS experiment, along the beam line
of sight, FASER(Nu) and SND@LHC, have been installed during the last LHC
shutdown and have been taking data since the start of the Run 3 in 2022.
We will discuss the most recent results from these experiments and give a brief
outlook of recent ideas for future neutrino experiments at the high
luminosity LHC.

Parallel session 5: Particle Detectors and Instrumentations/Future Experimental Facilities (2/2) / 543

The CONDOR Observatory project

Authors: Luis Navarro[1]; Sebastian Tapia Araya[2]; Nicolás Viaux[1]; Raquel Pezoa Rivera[1]

[1] *Universidad Técnica Federico Santa María*

[2] *Federico Santa Maria Technical University (CL)*

Corresponding Author: luis.navarrof@usm.cl

The COmpact Network of Detectors with Orbital Range (CONDOR) Observatory is dedicated to advancing the study of cosmic rays, with a particular focus on the low-energy regime (~150 GeV). Located in the Atacama Desert, Chile, at 5300 meters above sea level, the observatory benefits from optimal conditions for detecting and analyzing cosmic ray events. In this initial study, we present a detailed analysis of angular reconstruction and primary particle differentiation based on simulated cosmic ray showers. Using data generated with the CORSIKA simulation software, we develop methods for accurately reconstructing the incident angles of cosmic ray showers and distinguishing between gamma-ray and proton-induced events. These results provide critical insights into the composition and directional properties of cosmic rays at lower energies, demonstrating the observatory's capability to address fundamental questions in astroparticle physics. This work lays the groundwork for future observational efforts and experimental validation at the CONDOR site.

Parallel session 7: Beyond The Standard Model (2/2) / 495

New parameter region in sterile neutrino searches: a scenario to alleviate cosmological neutrino mass bound and its testability at oscillation experiments

Author: Toshihiko Ota .[1]

[1] *Universidad de La Serena*

Corresponding Author: toshihiko.ota@userena.cl

Recent high-precision cosmological data tighten the bound to neutrino masses and start rising a tension to the results of lab-experiment measurements, which may hint new physics in the role of neutrinos during the structure formation in the universe. A scenario with massless sterile neutrinos was proposed to alleviate the cosmological bound and recover the concordance in the measurements of neutrino masses. We revisit the scenario and discuss its testability at oscillation experiments. We find that the scenario is viable with a large active-sterile mixing that is testable at oscillation experiments. We present a numerical estimation of the sensitivity reach of the IceCube atmospheric neutrino observation to a sterile neutrino with a mass lighter than active neutrinos for the first time. IceCube shows a good sensitivity to the active-sterile mixing at the mass-square difference with a size of ~ 0.1 eV^2 in the case of the "inverted-mass-ordering sterile neutrino", which is forbidden under the assumption of the standard cosmology but is allowed thanks to the alleviation of the cosmological bound in this scenario.

Parallel session 6: Neutrino Physics (2/2) / 534

Connecting Neutrino Mass and Dark Matter via Low-Scale Radiative Seesaw and Phenomenological Implications

Author: Vishnudath K N[1]

[1] *Universidad Técnica Federico Santa María, Valparaíso, Chile*

Corresponding Author: vishnudathkn@gmail.com

I will discuss a TeV-scale extension of the Standard Model in which a dark sector facilitates neutrino mass generation radiatively within the context of the linear seesaw mechanism. Since the symmetries of the model prevent tree-level contributions, tiny neutrino masses are generated at one loop due to spontaneous lepton number violation by the expectation value of a Higgs triplet. I will discuss the implications for charged lepton flavor violation, dark matter phenomenology and collider searches.

Parallel session 5: Particle Detectors and Instrumentations/Future Experimental Facilities (2/2) / 483

The CMS Tracker Upgrade for High Luminosity LHC

Authors: Hongbo Liao[1]; Marco Riggirello[2]

[1] *Chinese Academy of Sciences (CN)*

[2] *Scuola Normale Superiore & INFN Pisa (IT)*

Corresponding Author: marco.riggirello@cern.ch

The High Luminosity phase of the Large Hadron Collider (HL-LHC) will significantly increase its instantaneous luminosity by one order of magnitude, thus enabling unprecedented precision studies of the Standard Model (SM) and searches for Physics beyond the Standard Model (BSM).

To capitalize on this opportunity and address the challenges posed by high pile-up environments, the Compact Muon Solenoid (CMS) experiment is developing a completely new silicon-based tracking system. The Inner Tracker (IT), featuring 3D pixel sensors, will provide excellent secondary vertex discrimination resolution. The Outer Tracker (OT), utilising novel "pT modules" sensors, will reconstruct particle tracks at 40 MHz and feed them into the Level 1 (L1) trigger system, allowing increasing the L1 selection capabilities in a fashion that was not possible before in CMS.

This presentation will provide an overview of the CMS Tracker Upgrade project, focusing on ongoing and future activities essential for achieving the required Tracker performance to target the HL-LHC goals.

Parallel session 7: Beyond The Standard Model (2/2) / 502

Lepton Flavour Violating Higgs decays at the Compact Linear Collider (CLIC) and Future Colliders

Authors: Francisca Garay Walls[1]; Gabriel Andres Vega Hernandez[None]; Philipp Roloff[2]

[1] *Pontifical Catholic University of Chile (CL)*

[2] *CERN*

Corresponding Author: francisca.garay.walls@cern.ch

This talk provides an update on the current status of future collider projects, like the Compact Linear Collider (CLIC), the Future Circular Collider (FCC). It briefly outlines their progress and ongoing developments, while also addressing the European Strategy for Particle Physics recommendations. I this context, Lepton flavour violating Higgs decays could appear in models beyond the Standard model of particle physics. In this talk I will present a sensitivity study of the Compact Linear Collider (CLIC) for this processes were the final states can be electron-muon pairs, tau-muon pairs or tau-electron pairs. Limits at 95% CL on the branching ratios of these processes were calculated at $2.5\,ab^{-1}$ of data at $\sqrt{s} = 1.4$ TeV and $\sqrt{s} = 3$ TeV. We obtained $BR(H \to e\mu) < 7.2 \times 10^{-3}\%$, $BR(H \to \tau\mu) < 0.024\%$ and $BR(H \to e\tau) < 0.036\%$ for $\sqrt{s} = 1.4$ TeV, and, $BR(H \to e\mu) < 0.8 \times 10^{-3}\%$, $BR(H \to \tau\mu) < 0.007\%$ and $BR(H \to e\tau) < 0.019\%$ for $\sqrt{s} = 3$ TeV.

Parallel session 6: Neutrino Physics (2/2) / 560

A common framework for fermion mass hierarchy, leptogenesis and dark matter

Author: Antonio Enrique Cárcamo Hernández[1]

[1] *Universidad Técnica Federico Santa María*

Corresponding Author: antonio.carcamo@usm.cl

In this talk I will describe an extension of the Standard Model designed to elucidate the fermion mass hierarchy, account for the dark matter relic abundance, and explain the observed matter-antimatter asymmetry in the universe. Beyond the Standard Model particle content, the model introduces additional scalars and fermions. Notably, the light active neutrinos and the first two generations of charged fermions acquire masses at the one-loop level. The model accommodates successful low-scale leptogenesis, permitting the mass of the decaying heavy right-handed neutrino to be as low as 10 TeV. I will also discuss its phenomenological consequences in dark matter, charged lepton flavor violation, as well as the constraints arising from electroweak precision observables, and implications for collider experiments.

Parallel session 5: Particle Detectors and Instrumentations/Future Experimental Facilities (2/2) / 507

New large area Micromegas detector and readout ASIC for the AMBER experiment at CERN

Authors: Chiara Alice[1]; Maxim Alexeev[1]; Oleg Denisov[2]; Rui De Oliveira[3]

[1] *Universita e INFN Torino (IT)*

[2] *INFN, sezione di Torino*

[3] *CERN*

Corresponding Author: maxim.alekseev@cern.ch

The Apparatus for Mesons and Baryon Experimental Research (AMBER, NA66) is a high-energy physics experiment at CERN's M2 beam line. Its broad physics program presently extends beyond 2032 and comprise measurement of the anti-proton production cross-section on He, proton and Deuterium, charge-radius of the proton and Kaon and Pion PDFs using Drell-Yan process. Several major upgrades of the spectrometer are planned for the medium and long-term AMBER program. Among those several resistive bulk MICRO-MEsh-GAseous Structure (MM) detectors designed together with the CERN MPT workshop are planned. Detectors having an active area of 1x0.5 m^2 will be used to substitute aging MWPCs of the spectrometer. Each Micromegas have two readout planes in a face-to-face configuration with a common cathode providing a combined XUV track measurement. Resistive layer is a uniform Diamond-Like Carbon (DLC) of 10 MΩ/
$square$. Present prototypes are the largest resistive bulk MM under test. To have achieve an optimal integration with the new detectors and native integration into the new trigger less DAQ a closely tailored to the MM specifications custom 64 channel fully digital front-end ASIC ToRA (Torino Readout for AMBER) providing timing and energy measurements is designed at INFN sez. Torino. Simultaneous design of the ASIC and associated detector aims to achieve an optimum performance of the system.
The production of the first detector was completed in October 2024, a test campaign is underway at AMBER experiment.

Design aspects of the MM detector and ToRA ASIC together with the first test results of the MM prototype will be presented.

Parallel session 6: Neutrino Physics (2/2) / 533

Models of radiative linear seesaw with electrically charged mediators

Author: Antonio Cárcamo[1]

Co-authors: Nicolas Perez [1]; Sergey Kovalenko [2]; Yocelyne Hidalgo [1]

[1] *UTFSM*

[2] *UNAB*

Corresponding Author: nicolas.perezj@usm.cl

We propose two versions of radiative linear seesaw models, where electrically charged scalars and vector-like leptons generate the Dirac neutrino mass submatrix at one and two loop levels. In these models, the SM charged lepton masses are generated from a one loop level radiative seesaw mechanism mediated by charged exotic vector-like leptons and electrically neutral scalars running in the loops. These models can successfully accommodate the current amount of dark matter, lepton and baryon asymmetries observed in the Universe, as well as the muon anomalous magnetic moment.

Parallel session 7: Beyond The Standard Model (2/2) / 500

Effective Field Theory and Scalar Triplet Dark Matter

Authors: Carolina Arbelaez[None]; DIEGO ALEJANDRO RESTREPO QUINTERO[None]; MARTIN KONRAD HIRSCH Not Supplied[None]; Marcela González[1]; Nicolas Neill[None]

[1] *Universidad Técnica Federico Santa María*

Corresponding Author: nicolasnhhep@gmail.com

We discuss an extension of the standard model with a real scalar triplet, T, including non-renormalizable operators (NROs) up to $d = 6$. If T is odd under a Z_2 symmetry, the neutral component of T is a good candidate for the dark matter (DM) of the universe. We calculate the relic density and constraints from direct and indirect detection on such a setup, concentrating on the differences with respect to the simple model for a DM T with only renormalizable interactions. Bosonic operators can change the relic density of the triplet drastically, opening up new parameter space for the model. Indirect detection constraints, on the other hand, rule out an interesting part of the allowed parameter space already today and future CTA data will, very likely, provide a decisive test for this setup.

Parallel session 5: Particle Detectors and Instrumentations/Future Experimental Facilities (2/2) / 503

Boosting HEP computing: the "Fundamental Research & Space Economy"Italian strategy within the National Center for HPC, Big Data, and Quantum Computing.

Author: Tommaso Diotalevi[1]

[1] *Universita e INFN, Bologna (IT)*

Corresponding Author: tommaso.diotalevi@cern.ch

The need to interject, process and analyze large datasets in an as-short-as-possible amount of time is typical of big data use cases. The data analysis in High Energy Physics at CERN for instance will require, ahead of the next phase of high-luminosity at LHC, access to big amounts of data (order of 100 PB/year). To address this challenge, together with other key strategic sectors essential for the country's development, the ICSC Foundation has recently established the High-Performance Computing, Big Data, and Quantum Computing Research Centre (funded by the NextGenerationEU

recovery plan). The main goal is to maintain and upgrade the national HPC and Big Data infrastructure, developing at the same time advanced methods and numerical applications to integrate computing, simulation, collection, and analysis of data of interest for fundamental research, also through cloud and distributed approaches.
In this context, within a hub-and-spoke framework, "Spoke 2" focuses on cutting-edge research in theoretical and experimental physics, primarily in experimental particle physics, conducted with or without accelerating machines, as well as detectors studying gravitational waves, and more.
This talk will outline the organization and current activities of this spoke, highlighting its scientific and technological contributions to the broader innovation ecosystem.

Parallel session 10: Dark Matter Particles Searches / 480

Search for Long-Lived Particles via Muon Detector Shower at the CMS Experiment

Authors: Hongbo Liao[1]; Matias eduardo Barria Lopez[2]

[1] *Chinese Academy of Sciences (CN)*

[2] *Federico Santa Maria Technical University (CL)*

Corresponding Author: matias.edouardo.barria.lopez@cern.ch

Long-lived particles are predicted by many Beyond the Standard Model (BSM) theories, such as the Supersymmetry and Hidden Valley Models, and can serve as a viable candidate for the Dark Matters (DM). We have searched for Long-Lived Particles (LLPs) that decays in the muon chambers in the Compact Muon Solenoid (CMS) experiment at the Large Hadron Collider with Run 3 Data. The search targets LLPs that decays in the muon detector, creating a large-multiplicity muon detector shower (MDS) that is not matched to muons or punch-through jets. The search will utilize a new dedicated Level 1 high multiplicity trigger developed in Run 3 to target a new low missing transverse momentum (MET) phase space as well as boosted LLPs that are associated with a high MET greater than 200 GeV. The search is sensitivity to a large LLP mass range of 1 —55 GeV. In this talk, we will present the current status and an estimated sensitivity of the search.

Parallel session 9: Nuclear Physics / 493

Cross Section Measurements for large angle fragments production in the nuclear interaction of ^{12}C on C, CH and PMMA thin targets.

Author: ILARIA MATTEI[1]

[1] *INFN - National Institute for Nuclear Physics*

Corresponding Author: ilaria.mattei@mi.infn.it

The study of the nuclear fragmentation of ^{12}C at the Particle Therapy beam energies is important for the development of even more specific treatment plans and also for the development of range monitoring techniques based on charged secondary particles. In this contribution, the fragmentation cross sections of 115 – 353 MeV/u kinetic energy carbon ion beams impinging over thin targets of graphite (C), PMMA ($C_2O_5H_8$) and polyethilene (C_9H_{10}) will be presented, for fragments measured at 90^o and 60^o at the CNAO particle therapy center (Pavia, Italy) by the FOOT collaboration. Thin plastic scintillator detectors have been exploited for the measurement of fragments time-of-flight and energy loss. The deposited energy in thick LYSO crystals has been combined with thin plastic scintillators measurements to perform the fragment identification in charge and mass (Z=1, M=^{1}H, ^{2}H, ^{3}H). The preliminary results of the differential cross sections have been expressed as a function of the kinetic energy of the fragments at production thanks to an unfolding technique applied

to data. The analysis strategy has been successfully validated against the true Monte Carlo (MC) cross sections, computed by means of the FLUKA code. The experimental cross sections have been compared to the MC predictions and results will be presented.

Parallel session 8: QCD (2/2) / 478

ζ-function for a model with spectral dependent boundary conditions

Author: Marcelo Loewe[1]

Co-authors: Enrique Muñoz [2]; Horacio Falomir [3]; Juan Cristóbal Rojas [4]

[1] *Universidad San Sebastian*

[2] *Pontificia Universidad Católica de Chile*

[3] *Univeridad Nacional de La Plata*

[4] *Universidad Católica del Norte*

Corresponding Author: marcelo.loewe@uss.cl

Abstract. We explore the meromorphic structure of the ζ-function associated to the boundary eigenvalue problem of a modified Sturm-Liouville operator subject to spectral dependent boundary conditions at one end of a segment of length l. We find that it presents isolated simple poles which follow the general rule valid for second order differential subject to standard local boundary conditions. We employ our results to evaluate the determinant of the operator and the Casimir energy of the system it describes, and study its dependence on l for both the massive and the massless cases.

Parallel session 10: Dark Matter Particles Searches / 491

Signatures of Fermion Dark Matter in the Vector Scotogenic Model

Authors: Paulo Areyuna C[1]; Jilberto Zamora-Saa[2]; Alfonso R Zerwekh[3]

[1] *ULS*

[2] *UNAB*

[3] *UTFSM*

Corresponding Author: paulo.areyuna@sansano.usm.cl

In this study, we explored the Vector Scotogenic Model in the context of addressing the Dark Matter problem. Guided by unitarity considerations, our focus was directed toward the scenario involving fermionic dark matter. We found that co-annihilations play a crucial role in achieving the observed dark matter relic abundance. Furthermore, the effects of co-annihilation divide the parameter space into two distinct regions with differing phenomenology. Additionally, we examined the detection prospects for each region individually, emphasizing potential signatures in lepton flavor-violating decays, indirect and direct detection methods, and the production of these new particles at collider experiments.

Parallel session 9: Nuclear Physics / 516

QCD Running in Lepton Number Violating Meson and Tau Decays

Authors: Marcela González[1]; Nicolas Neill[None]

[1] *Universidad de Valparaíso*

Corresponding Author: marcela.gonzalezpi@uv.cl

Below the electroweak scale, new physics that violates lepton number in two units ($\Delta L = 2$) and is mediated by heavy particle exchange can be parameterized by a dimension-9 low-energy effective Lagrangian.
Operators in this Lagrangian involving first-generation quarks and leptons contribute to the short-range mechanism of neutrinoless double beta decay ($0\nu\beta\beta$) and therefore they are strongly constrained.
On the other hand, operators with other quark and lepton families are bounded by the non-observation of different lepton number violating (LNV) meson and tau decays, such as $M_1^- \to M_2^+ \ell_1^- \ell_2^-$ and $\tau^- \to \ell^+ M_1^- M_2^-$.
In this work, we calculate RGE-improved bounds on the Wilson coefficients involved in these decays.
We calculate QCD corrections to the dimension-9 operator basis and find RG evolution matrices that describe the evolution of the Wilson coefficients across different energy scales. Unlike the running of operators involved in $0\nu\beta\beta$-decay, the general flavor structure leads to the mixing of not only different Lorentz structures but also of different quark-flavor configurations. Additionally, operators that vanish for the identical lepton case need to be added to the operator basis.
We find new constraints on previously unbounded operators and the enhancement of bounds for specific Wilson coefficients.
We also find new bounds coming from the mixing between operators with different quark-flavor configurations.

Parallel session 8: QCD (2/2) / 456

Valence and sea parton correlations in double parton scattering from data

Authors: Edgar Huayra[None]; Emmanuel Gräve de Oliveira[1]; Joao Vitor[2]

[1] *UFSC, Brazil*

[2] *Universidade Federal de Santa Catarina*

Corresponding Author: joaovitorcl1000@gmail.com

The effective cross section of double parton scattering in proton collisions has been measured by many experiments with rather different results.

Motivated by this fact, we assumed that the parton correlations in the transverse plane are different whether we have valence or sea partons.

With this simple approach, we were able to fit the available data and found that sea parton pairs are more correlated in the transverse plane than valence–sea parton pairs.

Parallel session 10: Dark Matter Particles Searches / 497

The search for MeV-scale Dark Matter at the DAMIC-M experiment

Author: Nicolás Avalos[1]

[1] *Instituto Balseiro (Universidad Nacional de Cuyo, Comisión Nacional de Energía Atómica), CONICET*

Corresponding Author: nicolas.avalos@ib.edu.ar

DAMIC-M (Dark Matter in CCDs at Modane) is a leading experiment that searches for sub-GeV Dark Matter (DM) using Skipper CCDs under the French Alps at the Laboratoire Souterrain de Modane (LSM). The capability of single-electron detection, combined with an extremely low dark current, results in an energy threshold of a few eV. A first prototype phase, the Low Background Chamber (LBC), has been taking data since 2023, and world-leading limits were obtained. In this talk I will discuss the constraints on DM particles interacting with electrons for a mass range between 0.5 and 1000 MeV/c^2. I will also present results of a search for diurnal modulation in the measured single-ionization charge rate and comment on the next years perspective for DAMIC-M.

Parallel session 9: Nuclear Physics / 546

Exploring hadronization in nuclear media: Double-Target experiment with CLAS12

Author: antonio radic[None]

Corresponding Author: antonio.radic@alumnos.usm.cl

On behalf of CLAS collaboration.
The hadronization process can be studied across nuclei of different atomic sizes to understand how the nuclear medium influences this phenomenon.
Recently, an experiment was conducted using the CLAS12 detector at Jefferson Lab to study nuclear hadronization, among other phenomena. This experiment employed a dual-target system, which contained two fixed targets at the same time, a liquid deuterium target and an interchangeable solid nuclear foil exposed at an electron beam of 10.5 GeV. The solid target could be swapped remotely with high precision and quickly.
In this presentation, an overview of the experiment, the innovative double-target system, the physics observables to study, and online reconstructed results will be shown.

Parallel session 8: QCD (2/2) / 463

Photo- and hadroproduction of heavy meson pairs

Author: Marat Siddikov[None]

Corresponding Author: marat.siddikov@usm.cl

In this talk we present our results on the inclusive photo- and hadroproduction of heavy charmonia-bottomonia pairs in the color glass condensate framework. For the photoproduction, we found that the cross section of the process is sensitive only to dipole and quadrupole forward scattering amplitudes (2- and 4-point correlators of Wilson lines). Using the phenomenological parametrizations of these amplitudes, we estimated numerically the production cross sections in the kinematics of the ultraperipheral collisions at the LHC and the future Electron Ion Collider. We found that the contribution controlled by the quadrupole amplitude is dominant, and for this reason, the suggested channel can be used as a gateway for studies of this nonperturbative object. The hadroproduction cross-section has more complicated structure and is sensitive to commingled contributions from dipole, quadrupole, sextupole and octupole forward scattering amplitudes. Using the parametrizations of the sextupoles and octupoles available from the literature, we found that the contributions of sextupoles and octupoles numerically is comparable to contributions of dipoles and quadrupoles.

This talk is partially based on materials published in Phys.Rev.D 109 (2024) 9, 094001

Parallel session 10: Dark Matter Particles Searches / 486

Perturbative Unitarity Constraints in some Spin-1 DM Models under the SU(2)L representation.

Author: Gonzalo Benitez[None]

Corresponding Author: gonzalo.benitezi@usm.cl

The Higgs boson plays a fundamental role in the Standard Model (SM) of particles, one of them, is to unitarize the elastic scattering of the gauge bosons at tree level. Additionally, this analysis impose an upper bound on the Higgs Mass. Despite the extraordinary experimental success, which culminate in the discovery of the Higgs boson in 2012, the SM cannot explain the astrophysical and cosmological evidence of the Dark Matter in our universe.
Given that the spin of the DM candidate is not constrained, some spin-1 DM Models have been proposed. However, introducing massive vector fields, which are not gauge fields, irredeemably induce violations of perturbative unitarity in scattering processes involving these spin-1 particles bosons. This issue manifests itself as scattering amplitudes that do not decrease sufficiently fast with increasing $s = E_{CM}^2$. In this talk, I will discuss the constrains in the parameter space induced by unitarity violation in models of vector DM, where the vector fields are multiplets of $SU(2)_L$. In particular, I will analyze the approximation of the vector polarization at high energies and the scattering process involved in each model.

Parallel session 9: Nuclear Physics / 570

EPOS

Corresponding Author: benjamin.guiot@usm.cl

Parallel session 8: QCD (2/2) / 484

Double Parton Scattering in Ultraperipheral Collisions

Authors: Bruna de Oliveira Stahlhofer[1]; Edgar Huayra[None]; Emmanuel Gräve de Oliveira[2]

[1] *Universidade Federal de Santa Catarina*

[2] *UFSC, Brazil*

Corresponding Author: emmanuel.de.oliveira@ufsc.br

Double Parton Scattering (DPS) is an important mechanism through which we can investigate the parton distributions of the proton and the nucleus. Although we know that such scatterings occur in high-energy collisions, the formalism describing them lacks answers to questions such as: Is there a universal effective cross section? To address such questions, we investigate DPS in ultraperipheral collisions (UPC), where the effective cross section is not constant, as it typically is in central collisions, as demonstrated in our results. Furthermore, when allowing the nucleus to break in an ultraperipheral proton–nucleus collision, we provide insights into the photon distribution of the nucleus. Additionally, since the effective cross section exhibits a complex dependence on the longitudinal energy fraction carried by the photon in the initial state, we evaluate cross sections involving photons and gluons in the initial state, leading to the production of quark–antiquark pairs or dilepton and quark–antiquark states in the final state.

Plenary session 11 / 479

The Southern Wide-Field Gamma-ray Observatory (SWGO)

Author: Ulisses Barres de Almeida[1]

[1] *Brazilian Center for Physics Research (CBPF)*

Corresponding Author: ubarres@gmail.com

SWGO is the international proposal to build a wide-field gamma-ray observatory to explore the Southern Hemisphere sky in the energy range from a few hundred GeV to the PeV. Its objective is to open a new window of astronomical observation, in a domain where observational coverage is currently limited to the northern hemisphere, through the HAWC and LHAASO observatories. SWGO will be installed in the Atacama Astronomical Park, in the Chilean Andes, at an altitude of 4,770 m above sea level, and will be based on an array of Cherenkov water detectors deployed over an area of 1 km2. In this presentation I will give an overview of the SWGO proposal and future plans for the instrument, as well as its financing and construction prospects, and scientific objectives. Some emphasis will be given to aspects related to the Latin American cooperation and participation in the Observatory.

Plenary session 11 / 465

Neutral triple gauge boson vertices, EFT and LHC

Author: MARTIN KONRAD HIRSCH Not Supplied[None]

Corresponding Author: mahirsch@ific.uv.es

Searches for anomalous neutral triple gauge boson couplings (NTGCs) provide important tests for the gauge structure of the standard model. In SMEFT ("standard model effective field theory") NTGCs appear only at the level of dimension-8 operators. While the phenomenology of these operators has been discussed extensively in the literature, renormalizable UV models that can generate these operators are scarce. In this work, we study a variety of extensions of the SM with heavy fermions and calculate their matching to d = 8 NTGC operators. We point out that the complete matching of UV models requires four different CP-conserving d = 8 operators and that the single CPC d = 8 operator, most commonly used by the experimental collaborations, does not describe all possible NTGC form factors. Despite stringent experimental constraints on NTGCs, limits on the scale of UV models are relatively weak, because their contributions are doubly suppressed (being d = 8 and 1-loop). We suggest a series of benchmark UV scenarios suitable for interpreting searches for NTGCs in the upcoming LHC runs, obtain their current limits and provide estimates for the expected sensitivity of the high-luminosity LHC.

Plenary session 11 / 519

The Pierre Auger Observatory: Latest Results and Prospects

Author: Fernando Catalani[1]

[1] *Universidade de São Paulo*

Corresponding Author: fcatalani@usp.br

The Pierre Auger Observatory, the largest and most accurate ultra-high-energy cosmic ray observatory (UHECRs) in the world, located in the province of Mendoza, Argentina, uses a hybrid design composed of two detection systems: a network of 1660 water-Cherenkov detectors, distributed over an area exceeding 3000 km^2, and 27 fluorescence telescopes that monitor the atmosphere above the surface detector array. Since the beginning of its operations, the Pierre Auger Observatory has produced noteworthy results that have expanded our knowledge in the field of astroparticle physics.

Among its main advances, it was discovered that the composition of UHECR becomes lighter for energies up to approximately 2 EeV, shifting towards a heavier composition at higher energies. Furthermore, it has been proven with high significance that the UHECRs above the ankle are predominantly from extragalactic sources. The Observatory is currently undergoing an important upgrade, called AugerPrime, which aims to further expand its capabilities for the next decade of measurements. This upgrade includes the addition of plastic scintillation detectors and radio antennas to the surface Cherenkov detectors, along with an upgrade of electronic systems to accommodate the new detectors and improve experimental efficiency. This contribution will present an overview of the most significant results, including recent spectrum measurements, searches for anisotropies in arrival directions, primary mass composition and an outline of prospects for the coming years of AugerPrime operations.

Plenary session 12 / 515

Development of high precision 4D-trackers for future experiments

Authors: Artur Apresyan[1]; Cristián Peña[1]; Sergo Jindariani[1]; Si Xie[2]; William King Brooks[3]

[1] *Fermi National Accelerator Lab. (US)*

[2] *California Institute of Technology (US)*

[3] *Federico Santa Maria Technical University (CL)*

Corresponding Author: artur.apresyan@cern.ch

We present recent progress towards the development of 4D-trackers with high granularity in position in time. As future colliders move to higher energy collisions, with increased particle occupancy, the need for 4D (spatial and temporal) tracking systems becomes extremely important to maintain the desired particle reconstruction efficiency. Additionally, the use of timing information is critical for particle identification (PID) and meeting future collider physics goals. Tracking detectors capable of achieving timing resolution around 10 ps and 5-10 μm spatial resolution are needed for many proposed future colliders, including the FCC-ee, Muon colliders [5], and the Electron–Ion Collider (EIC). New technologies and advanced manufacturing techniques are required to achieve these ambitious goals. We will present our recent progress towards achieved these target specifications through development of 3D-integrated sensors, advanced ASICs and monolithic active pixel sensors (MAPS). This research program leverages the unique combination of facilities and cross-disciplinary expertise of scientists and engineers at US National labs and USM Chile with industrial partners.

Plenary session 12 / 505

Recent BABAR studies of high-order radiation in ISR e+e− → μ+μ−γ and e+e− → π+π−γ events and their implications on data-driven hadronic vacuum polarization predictions of the muon g-2

Author: José Ocariz[1]

[1] *Université Paris Cité and LPNHE/IN2P3*

Corresponding Author: ocariz@in2p3.fr

The BABAR collaboration has recently presented a dedicated measurement of additional radiation in ISR $e^+e^- \to \mu^+\mu^-\gamma$ and$e^+e^- \to \pi^+\pi^-\gamma$ events. Results are presented at next-to- and next-to-next-to-leading order, with one and two additional photons, respectively, for radiation from the initial and final states. Comparison with predictions from the PHOKHARA and AFKQED simulations, reveal discrepancies in the one-photon rates and angular distributions. While these discrepancies

have a negligible effect on the BABAR measurement of hadronic cross section measurements, they may affect other measurements. The findings are presented in the quickly-evolving context of comparisons between experimental measurements of the muon $g-2$ and the theoretical predictions, including recent evolutions.

Plenary session 12 / 572

Latest insights from MINERvA

Author: Marco Ayala[1]

[1] *SAPHIR - UNAB*

Corresponding Author: marco.ayala@cern.ch

The Main Injector Experiment v-A (MINERvA) at Fermilab is a dedicated neutrino-nucleus scattering experiment that employs the NuMI neutrino beam. The MINERvA detector is composed of a fine-grained scintillator tracker with electromagnetic and hadronic calorimetry regions. Upstream of the central tracker, alternating layers of scintillator strips and passive nuclear targets allow for the study of nuclear medium effects in neutrino-induced interactions. MINERvA performs high-precision measurements of neutrino interactions across a wide range of neutrino energies and target materials. This talk will present an overview of MINERvA, including its beamline, detector, physics program, recent results, and current status.

Plenary session 12 / 513

Superconducting Single Photon Detectors: from quantum networks to dark matter

Author: Cristián Peña[1]

[1] *Fermi National Accelerator Lab. (US)*

Corresponding Author: cristian.pena@cern.ch

Superconducting nanowire single photon detectors (SNSPDs) are low-threshold quantum sensors designed to detect UV, optical and infrared photons. SNSPDs have enabled high-fidelity quantum teleportation, deep space optical communications, exoplanet transit spectroscopy, searches for bosonic and fermionic DM, and have recently been proposed to search for quantum gravity in tabletop experiments. During the first part of this colloquium, I will focus on applications in quantum networking with a emphasis on protocols including quantum teleportation and entanglement swapping using fiber-based infrastructure in the context of the Fermilab Quantum Network Experiment (FQNET) and the Advanced Quantum Network (AQNET) currently deployed at Fermilab and in the Chicagoland area. During the second part, I will cover an emergent research and development program to further decrease the energy threshold of SNSPDs to unprecedented levels and present ideas on how this unique sensor capability will enable new fundamental physics experiments looking for the axions and dark photons.

Plenary session 13 / 490

Low scale seesaw theories and their phenomenology

Author: Antonio Enrique Cárcamo Hernández[1]

[1] *Universidad Técnica Federico Santa María*

Corresponding Author: antonio.carcamo@usm.cl

I will describe theories with low scale seesaw mechanisms implemented to generate the SM fermion mass hierarchy. In the first part of my talk, I will explain an extended 2HDM theory where the tree level Universal seesaw and Zee-Babu mechanisms generate the SM charged fermion mass hierarchy and tiny active neutrino masses, respectively. The theory is consistent with SM fermion masses and mixings, with the muon and electron g−2 anomalies and successfully accommodates the constraints arising from charged lepton flavor violation and meson oscillations. In the second part of the talk I will describe three models where the neutrino masses are generated from a three loop level inverse seesaw mechanism, whose radiative nature is ensured by the preserved discrete symmetries, which also guarantee the stability of the dark matter candidate. I will discuss in detail the lepton sector phenomenology of one of the three-loop inverse seesaw models. The model successfully complies with the constraints imposed by the neutrino oscillation experimental data, neutrinoless double beta decay, dark matter relic density, charged lepton flavor violation, electron-muon conversion, and provides essential means for efficient low-scale resonant leptogenesis. Charged lepton flavor violating decays and the electron-muon conversion processes get sizable rates within future sensitivity reach. In the third part of my talk, I will describe two theories with extended gauge symmetries each incorporating distinct inverse seesaw mechanisms for generating neutrino masses at the radiative level. I will discuss their implications in the muon anomalous magnetic moment, charged lepton flavor violation and leptogenesis.

Plenary session 13 / 567

TBC

Plenary session 13 / 568

TBC

579

Test

Author: ahmed el alaoui[None]

Corresponding Author: ahmede@jlab.org

Test

Plenary session 6 / 563

DUNE: Overview and Status

Corresponding Author: lml24d@fsu.edu

Plenary session 9 / 564

SHiP

Corresponding Author: albert.de.roeck@cern.ch

Poster session / 523

Neutrino portal for vector dark matter

Author: Pablo Solar[None]

Co-authors: Alfonso Zerwekh [1]; Claudio Dib [1]

[1] *Universidad Técnica Federico Santa María, casa central, Valparaíso, departamento de física*

Corresponding Author: pablo.solar@usm.cl

In the Fermion Portal Vector Dark Matter (FPVDM) framework, We study how to connect the standard model with dark matter via neutrinos. In This framework standard model is expand with a $SU(2)_D \times U(1)^g_{Y\,D}$ dark sector, where the $SU(2)_D$ gauge bosons are the dark matter candidates (specifically the $V^{\pm}$ components), this symmetry is broken by a dark scalar Φ_D, giving mass to the gauge bosons and leaving a remanent $\mathbb{Z}_2$ symmetry that ensures the stability of the candidate. The interaction with the standard model is realized through VL-fermions that couple to neutrinos through a Yukawa-like term. We consider two models, with one and two families of VL-fermions for which we calculate parameter-space constraints using relic density, direct detection and indirect detection.

Poster session / 510

Particle Identification for Cosmic Rays at the CONDOR Observatory

Authors: Constanza Valdivieso[1]; Gonzalo Ignacio Munoz Justiniano[2]; Luis Navarro[1]; Nicolas Viaux[1]; Raquel Pezoa[1]; Sebastian Tapia[1]

[1] *Universidad Técnica Federico Santa María*

[2] *Federico Santa Maria Technical University (CL)*

Corresponding Author: gonzalo.munozj@usm.cl

The CONDOR (COmpact Network of Detectors with Orbital Range) project aims to establish the highest-altitude observatory for cosmic rays at the Atacama Astronomical Park in northern Chile. Positioned at 5.300 meters, CONDOR will provide unique sensitivity to low-energy cosmic ray (CR) particles, particularly from ˜100 GeV, contributing to our understanding of cosmic rays and their interactions with Earth's atmosphere. We develop a particle identification tagger using advanced statistical analysis techniques to classify cosmic rays detected by the observatory as either Protons or Photons. Leveraging Monte Carlo simulations from CORSIKA and statistical fitting applied. Our tagger distinguishes between particle showers induced by different types of CR. Preliminary results show high classification accuracy, enhancing our ability to differentiate proton and photon showers. This capability is crucial for studying astrophysical sources such as gamma-ray bursts and active galactic nuclei and understanding cosmic ray composition at high energies. Our work will improve data quality and particle identification at CONDOR, providing an essential tool for future analyses in astroparticle physics.

Poster session / 511

Angle reconstruction for Cosmic Rays at CONDOR Observatory

Authors: Constanza Valdivieso[1]; Gonzalo Muñoz[1]; Luis Navarro[1]; Nicolás Viaux[1]; Raquel Pezoa[1]; Sebastián Tapia[1]

[1] *Universidad Técnica Federico Santa María*

Corresponding Author: constanza.valdivieso@usm.cl

The COmpact Network of Detectors with Orbital Range (CONDOR) Observatory is a future cosmic ray observatory to be constructed at an altitude of 5300 m a.s.l. in the Atacama Desert, making it the highest detector array in the world. CONDOR observatory aims to detect cosmic rays with energies starting at ˜100 GeV scale, a range crucial for bridging the gap between satellite and ground-based experiments. Currently, this low-energy range is only explored through balloon-based measurements, highlighting CONDOR's unique and much-needed contribution. By focusing on this under-explored region, CONDOR aims to study astrophysical phenomena such as gamma-ray bursts, active galactic nuclei, and other transient and steady gamma-ray sources. This work presents results on cosmic ray angle reconstruction for the CONDOR observatory. Using detailed simulations with CORSIKA, we demonstrate the capability to accurately determine incoming particle angles, laying the foundation for future observations. These results highlight the observatory's potential to advance astroparticle physics by leveraging its unique high-altitude location and focus on an energy range that remains poorly understood.

Poster session / 512

Renormalon-based Resummation of the Bjorken Sum Rule in Holomorphic QCD

Author: Camilo Castro Arriaza[1]

Co-authors: Cesar Ayala [2]; Gorazd Cvetic [2]

[1] *Universidad Técnica Federico Santa María*

[2] *Universidad Tecnica Federico Santa Maria*

Corresponding Author: camilo.castroa@sansano.usm.cl

We evaluate the polarised Bjorken sum rule (BSR) $\overline{\Gamma}_1^{p-n}(Q^2)$ with truncated Operator Product Expansion (OPE) up to the $D = 4$ term 1. Due to the knowledge of the renormalon structure of the BSR, the leading-twist term of dimension $D = 0$ is evaluated using a recently developed renormalon-based resummation [2], in this case with two variants of holomorphic QCD couplings $[a(Q^2) \mapsto \mathcal{A}(Q^2)]$ which have no Landau singularities and thus require, in contrast to the perturbative QCD (pQCD) case [3], no regularisation of the resummation formula. The $D = 2$ and $D = 4$ terms are then included in the OPE of the inelastic BSR, and fits are performed to the available experimental data.

In comparison to applying the renormalon-based resummation method using the pQCD coupling, further advantages we note in our approach are that the Q^2-interval in the fit can be significantly extended to lower Q^2-values and the extracted residue parameter values are more stable, this being reflected in the significantly reduced experimental uncertainties of these values.

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Poster session / 524

Estimates for Bc meson production at LHCb

Author: Franco Barattini[1]

Co-authors: guiot benjamin [2]; Claudio Dib [3]; Boris Kopeliovich

[1] *Universidad Tecnica Federico Santa Maria*

[2] *Universidad frederico santa maria*

[3] *Federico Santa Maria Technical University (CL)*

Corresponding Author: fbarattiniosorio@gmail.com

Among the B mesons, the B_c meson is unique as it is the only one composed of two different heavy flavors, b and c, making its production and detection more challenging than other b-flavored mesons. This results in significant uncertainties in its dynamic properties. Consequently, rather than reporting its differential production cross-section, the LHCb collaboration 1 provides the transverse momentum dependence of the ratio between the production of B_c mesons and the combined production of B^+ and B^0 mesons, showing an increase at small transverse momentum that indicates a violation of heavy-quark symmetry. To constrain the uncertainties and understand better the B_c meson production, we use Non-Relativistic QCD (NRQCD), a non-relativistic effective field theory based on a perturbative expansion in the relative velocity of heavy quarks. Within this framework, we apply two common approaches to calculate the production of heavy-quark bound states, referred to here as the *Fragmentation Approach* and the *Direct Approach*.

The first approach is based on the principles of Collinear Factorization, where fragmentation functions (FFs) are used as tools to describe the hadronization of single partons. Contributions from this method are know as *Leading Power*, because they are dominant at large transverse momentum. While FFs are typically fitted to experimental data, for mesons composed of heavy quarks, NRQCD allows us to estimate their values theoretically. Using the already calculated NRQCD fragmentation functions for the B_c and B_c^* bound states [2], we have found that the contribution from fragmentation alone fails to reproduce the observed increase at small transverse momentum.

To improve our results in this kinematic region, we aim to compare to compare the previous findings with the *Direct Approach*. In this method, hadrons are produced directly from the hard scattering process without relying on a fragmentation function. While this approach performs better at small transverse momentum, it fails at large values due to its inability to resum collinear emissions to all orders, as achieved through DGLAP evolution. Nevertheless, we expect it to provide an accurate description of the behavior at small transverse momentum, complementing the fragmentation approach.

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Poster session / 525

Analysis of the emission spectra of an evaporating Schwarzschild black hole

Author: Miguel Figueroa[1]

Co-authors: Claudio Dib [2]; Oscar Castillo-Felisola [3]

[1] *Universidad Técnica Federico Santa María*

[2] *Federico Santa Maria Technical University (CL)*

[3] *Universidad Tecnica Federico Santa Maria*

Corresponding Author: miguel.figueroavi@usm.cl

Many early universe theories predict the creation of Primordial Black Holes (PBHs) that could have sufficient mass to be expiring today with a final burst of Hawking radiation. A Black Hole (BH) has a Hawking temperature inversely proportional to its mass. Hence, a sufficiently small BH will quasi-thermally radiate particles at an ever-increasing rate as it evaporates and raises its temperature. Detection of this radiation would provide insight into many areas of physics, including the early universe, high-energy physics, and the interplay between gravitation and thermodynamics.

In this work, we analyze the emission spectra of a Schwarzschild black hole using quantum field theory in curved spacetimes. We examine the gravitational effects on particles emitted near the event horizon and demonstrate that the effective emission region extends beyond the black hole's size. This behavior is closely related to the critical impact parameter derived from the geometrical optics approximation, offering deeper insights into the quantum-classical interplay in black hole evaporation.

Poster session / 532

Probing light neutralinos from pair produced sleptons with a displaced vertex at the LHC

Author: Fabián Hernández Pinto[1]

Co-authors: Giovanna Cottin [2]; juan carlos Helo [3]; Nicolas Neill ; Zeren Simon Wang [4]; Abi Soffer [5]

[1] *Universidad Técnica Federico Santa María*

[2] *Pontificia Universidad Católica de Chile (CL)*

[3] *Universidad de La Serena*

[4] *National Tsing Hua University*

[5] *Tel Aviv University (IL)*

Corresponding Author: fabianhernandezpinto@gmail.com

We study light neutralinos ($\tilde{\chi}_1^0$) with masses of the order of the GeV scale in the context of R-parity-violating (RPV) supersymmetry. For such masses, the neutralinos can become long-lived particles and decay with a macroscopic (order cm) displacement inside LHC detectors. Complementing previous works, we focus on their production through a pair of sleptons ($\tilde{e}_L$) with process $pp \to \tilde{e}_L \tilde{e}_L \to e\tilde{\chi}_1^0 e\tilde{\chi}_1^0$. As the neutralino production does not depend on the RPV coupling to sleptons (i.e.˜λ'_{111}) but it is dominated by drell-yan processes, we can access values of the λ'_{111} coupling (neutralino masses) with smaller(highers) orders of magnitude when compared to the sensitivity attainable with displaced vertex searches for singly slepton production. Also, we provide a reinterpretation of our signal in the context of the RPC slepton pair-production with 2 leptons and missing energy final state. This goes to exlusion limits in the RPV coupling - neutralino mass plane and the slepton and neutralino masses plane, where we will expect that our DV 95\% C.L. will be lower than this prompt-search recast.

Poster session / 529

Using optimal observables to probe CP-violation in top-Higgs interactions

Author: Marcel I. Yanez[None]

Corresponding Author: yanezma1@msu.edu

In the context of collider searches for new physics one of the main candidates for extensions of the standard model is the existance of CP violating interactions. In this work, we introduce a CP violating Yukawa interaction between the top quark and the Higgs boson. Utilizing Higgs Effective Field Theory (hEFT) and the optimal observable technique in the heavy quark approximation, we provide a quantitative argument to analyze gluon fusion channel data for two Higgs plus two Jets cross sections to constrain CP odd interactions. We compute Wilson coefficients via matching the NLO order theory and the hEFT amplitudes and then simulate observable data for the CP violating and non CP violating scenarios via MadGraph and Delphes.

Poster session / 561

Real-Time Classification of Higgs Boson Production Mechanisms for the ATLAS Trigger System Using FPGA-Optimized Machine Learning Models

Author: Addles Joshua Castillo Espinosa[1]

[1] *Millennium Institute for Subatomic Physics at High Energy Frontier (CL)*

Corresponding Author: addles.jo@cern.ch

The High-Luminosity Large Hadron Collider (HL-LHC) will demand highly efficient and fast data processing systems to handle unprecedented event rates. In this study, we present a novel approach to real-time classification of Higgs boson production mechanisms—focusing on gluon-gluon fusion (ggF) and vector boson fusion (VBF)—using machine learning (ML) models optimized for deployment on field-programmable gate arrays (FPGAs). Our goal is to enhance the ATLAS Level-0 trigger's ability to identify key physics signatures with minimal latency, improving the prioritization of events for detailed analysis.
We trained and validated lightweight ML models on simulated ATLAS datasets, leveraging high-level features such as jet kinematics, forward jet tagging, and missing transverse energy to distinguish ggF and VBF events. The models were quantized and converted to FPGA-compatible firmware using the hls4ml library. Resource utilization, latency, and accuracy were evaluated, achieving inference times well within the nanosecond-scale budget while maintaining classification performance comparable to traditional algorithms.
This study demonstrates the feasibility of implementing sophisticated ML algorithms in FPGA-based trigger systems, offering significant advancements in real-time event classification. By extending this framework, we aim to support a broader range of Higgs production mechanisms and refine searches for rare processes, contributing to the HL-LHC's discovery potential.

Poster session / 501

Exploring Ultraviolet Complete Extensions of a Vector Dark Matter Model via the so(4) algebra

Authors: Jorge Schifferli Verdugo[1]; Alfonso Zerwekh[2]; Carolina Arbelaez[1]

[1] *Universidad Técnica Federico Santa María*

[2] *Universidad Tecnica Federico Santa Maria*

Corresponding Author: jorge.schifferli@usm.cl

In previous works it has been shown that a minimalist model for vector dark matter surfers from loss of unitarity because of the coupling between the vector field and the Higgs boson 1.

Nevertheless, algebraic manipulation of the vector sector by mixing the weak interaction fields with the vector dark matter fields reveals a possible path towards an ultraviolet completion. The resulting

vector sector constructed by linear combinations of these fields reproduces the gauge sector of a Yang-Mills theory over a group with an $\mathfrak{so}(4)$ algebra [2]. The algebra isomorphism $\mathfrak{so}(4) \simeq \mathfrak{su}(2) \oplus \mathfrak{su}(2)$ implies that an ultraviolet completion can be constructed by using either SO(4) or its cover group SU$(2) \times$ SU(2) to formulate the desired Yang mills theory.

We have managed to construct an SU$(2) \times$ SU(2) based Yang-Mills theory which reproduces the desired gauge sector and we are currently studying the constraints on the parameter space coming from current experimental bounds related to dark matter and standard model mass spectrum. In parallel, we have begun the formulation of the alternative SO(4) model and we aim to compare their differences and ability to maintain a minimal structure once completed.

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Poster session / 473

Optimization in Renormalization Scale and the Principle of Maximum Conformality

Authors: Daniel Salinas-Arizmendi[1]; Claudio Dib[2]

[1] *Universidad Técnica Federico Santa María*

[2] *Federico Santa Maria Technical University (CL)*

Corresponding Author: daniel.salinas@usm.cl

Predictions of processes in perturbative Quantum Chromodynamics (pQCD) critically depend on the appropriate choice of the renormalization scale μ_r to determine the correct running coupling in the perturbative expansion. In conventional scale setting, this scale is set to the characteristic process value, Q, and the uncertainty is estimated by varying μ_r within an arbitrary range $[Q/2, 2Q]$. However, this procedure introduces significant ambiguities in the choice of renormalization scheme and scale, limiting the precision of fixed-order predictions and directly impacting the results of numerous high-energy processes.

In this work, we present the **Principle of Maximum Conformality** (PMC) method as a robust solution to eliminate these ambiguities. The PMC absorbs the non-conformal terms into the effective coupling $\alpha_s(Q_{\text{PMC}})$ and establishes an optimal scale Q_{PMC}, resulting in a completely conformal perturbative series for the process. We apply the PMC method to improve the relation between pole and running heavy quark masses, the electroweak ρ parameter, the determination of the decay width of the W boson in hadrons, and other processes.

Poster session / 474

Phenomenological Implications of an S_3 Symmetric Extended Higgs Doublet Model

Authors: Daniel Salinas-Arizmendi[1]; Antonio Enrique Cárcamo Hernández[1]; Alfonso Zerwekh[2]

[1] *Universidad Técnica Federico Santa María*

[2] *Universidad Tecnica Federico Santa Maria*

Corresponding Author: daniel.salinas@usm.cl

In this work, we propose to explain the mass hierarchy and mixing pattern in the leptonic sector, we explore an extension of the Standard Model whose scalar sector includes one active and two inert doublets as well as some scalar singlets. The model includes a S_3 family symmetry supplemented by extra cyclic symmetries. As a consequence of our construction, a Dark Matter (DM) candidate is predicted and its properties are consistent with the observed cosmic abundances and the constraints imposed by direct and indirect detection experiments. The model allows Charged Lepton Flavor Violation (CLFV) processes like $\mu \to e\gamma$ and $\mu \to 3e$, but the predicted branching ratios align with experimental limits. Additionally, our analysis elucidates the generation of the active neutrino masses through a one-loop radiative seesaw mechanism matching the observed neutrino oscillation data. The model agrees with experimental data on Higgs Diphoton decay rates and on oblique parameters.

Poster session / 496

Cosmic Ray Simulations for CONDOR Observatory and Angular Reconstruction via Machine Learning

Authors: Constanza Valdivieso[1]; Gonzalo Muñoz[1]; Luis Navarro[1]; Nicolás Viaux[1]; Raquel Pezoa Rivera[1]; Sebastián Tapia[1]

[1] *Universidad Técnica Federico Santa María*

Corresponding Author: luis.navarrof@usm.cl

The COmpact Network of Detectors with Orbital Range (CONDOR) Observatory is an upcoming cosmic ray detection facility set to be constructed at an altitude of ˜5000 meters a.s.l. in the Atacama Desert, making it the highest cosmic rays detector in the world, designed to observe gamma and cosmic rays at the low-energy range (˜GeV-Tev). By focusing on this relatively unexplored range, CONDOR is poised to make significant contributions to astroparticle physics. In this study, we present advances in the reconstruction of cosmic ray arrival angles using detailed simulations performed with CORSIKA. Data preprocessing techniques were employed to extract meaningful features from the simulated particle shower footprints, which were then analyzed using machine learning models. These models were trained to predict the incoming particle angle with high precision, utilizing the rich spatial and temporal information available in the simulated datasets. Our results demonstrate the feasibility of accurately reconstructing the directionality of cosmic rays, a key requirement for studying astrophysical sources. These findings not only validate the proposed capabilities of the CONDOR observatory but also highlight the potential of integrating machine learning methodologies in cosmic ray research.

Poster session / 477

Electric field fluctiations in a self interacting scalar theory

Author: Melanie Martínez Villarreal[1]

Co-authors: Enrique Munoz ; Marcelo Loewe [2]

[1] *Pontificia Universidad Católica de Chile*

[2] *Pontificia Universidad Catolica de Chile*

Corresponding Author: mimartinez1@uc.cl

The aim of this project is to study the effects of a noisy electric field in a complex scalar field $\lambda\phi^4$ theory, in the context of ultrarelativistic heavy ion collisions. The bosonic propagator in presence of a constant electric field is derived using the Schwinger-Fock proper time method. To consider the fluctuations of the electric field the statistical average of the generating functional of the theory is derived using the replica trick. The fluctuations are modeled as classical white noise following a

gaussian probability distribution, which depends on the correlation lenght Δ_E of the fluctuations. The self energy and the vertex correction function are found in order to study the renormalization group equations of the theory.

Poster session / 487

Predictive linear seesaw model with $\Delta(27)$ family symmetry.

Authors: Antonio Cárcamo Hernández[1]; Ivo de Medeiros Varzielas[2]; juan manuel marchant gonzalez[1]

[1] *Universidad Técnica Federico Santa María*

[2] *Universidade de Lisboa*

Corresponding Author: juan.marchantgonzalez@gmail.com

This work aimed to create a model where the smallness of the neutrino masses has been considered. To achieve this, we have chosen to extend the symmetry group of the SM, which is based on the group $SU(3)_C \times SU(2)_L \times U(1)_Y$, by adding an extra symmetry based on the discrete group $\Delta(27)$, due to the success that this group has presented in the literature and because it is the smallest group that has as irreducible representation a triplet and anti-triplet. In addition to extending the symmetry of the SM to generate the masses of the particles, a Linear Seesaw mechanism was applied, which allows us to generate masses for the neutrinos due to the insertion of a heavy exotic neutrino, which explains the smallness of the masses of the active light neutrinos. The model is predictive in the leptonic sector and allows obtaining correlations between observables in the neutrino sector, predicting an effective mass for neutrinoless double beta decay (m_{ee}) less than 2.35 [meV]. In addition, the model provides restrictions to processes that violate the leptonic flavor, such as the $\mu \to e\gamma$ process, obtaining values below the experimental limit.

Poster session / 504

Exclusive Vector Meson Production in Ultraperipheral Proton-Nucleus Collisions

Author: OTAVIO DA SILVA ABRAAO[None]

Corresponding Author: otavio.abraao@ufrgs.br

We analyze the production of vector mesons ρ and J/Ψ in ultraperipheral proton-nucleus collisions with center of mass energies √
s = 5, 02 TeV and √
s = 8, 16 TeV. We calculate
the differential cross sections using three phenomenological models that take into account the effects of parton saturation, and we present predictions for pCa and pP b collisions. We compare our predictions with the latest data from the CERN-LHC CMS collaboration. We demonstrate that the models are able to describe the data at small values of t. However, we observe a suppression compared to the limited available data at large values of t. We conclude that a future experimental analysis of the region of large t values is necessary for a more precise comparison between different approaches for the saturation regime.

Poster session / 508

Constraining the Higgs Potential via Di-Higgs searches with ATLAS at the LHC

Author: Sebastian Julio Fuenzalida Garrido[1]

[1] *Federico Santa Maria Technical University (CL)*

Corresponding Author: sebastian.fuenzalida.garrido@cern.ch

The 2012 discovery of the Higgs boson (H) by the ATLAS and CMS collaborations at the Large Hadron Collider (LHC) marked the beginning of an extensive program aimed at understanding the properties of this fundamental particle. A key aspect still under investigation is the Higgs boson self-interaction, which governs the shape of the Higgs potential, $V(\phi)$. In the Standard Model (SM), non-resonant Higgs boson pair (HH) production is predicted, with the dominant production mechanism at the LHC being gluon-gluon fusion (ggF), which has a cross-section of $\sigma_{\text{ggF}}^{\text{SM}} = 31.1\,\text{fb}$ at NNLO, followed by vector boson fusion (VBF) with $\sigma_{\text{VBF}}^{\text{SM}} = 1.73\,\text{fb}$ at tree level, both at $\sqrt{s} = 13\,\text{TeV}$. The coupling modifiers κ_λ (which parametrizes the triple Higgs coupling, relevant for both ggF and VBF processes) and κ_{2V} (which governs the interaction of two Higgs bosons with two vector bosons, specific to the VBF process) are defined as the ratio of the observed coupling to the SM prediction. Deviations from $\kappa_\lambda = 1$ and $\kappa_{2V} = 1$ would suggest deviation from the SM predictions. The signal strength parameter $\mu_{HH} = \frac{\sigma_{\text{ggF}}+\sigma_{\text{VBF}}}{\sigma_{\text{ggF}}^{\text{SM}}+\sigma_{\text{VBF}}^{\text{SM}}}$ is also used to evaluate the consistency of the measured HH production rate with the SM prediction. Among the most sensitive final states for probing the Higgs self-coupling and constraining κ_λ, κ_{2V}, and μ_{HH} are HH→bbbb, HH→bb$\tau\tau$, and HH→bb$\gamma\gamma$. Recent analyses of the HH→bb$\tau\tau$ final state have provided key insights into the sensitivity to κ_λ, κ_{2V}, and μ_{HH}, setting limits that approach the SM predictions. These results are further enhanced by the combination of constraints from all major Di-Higgs final states, significantly improving the precision on these parameters. Projections for the high-luminosity LHC (HL-LHC) indicate substantial sensitivity improvements, especially when combining the bb$\tau\tau$ and bb$\gamma\gamma$ channels. Such combinations are expected to provide stringent constraints on κ_λ, κ_{2V}, and μ_{HH}. These advances underscore the critical role of multi-channel analyses in understanding the Higgs boson self-interaction and the shape of the Higgs potential.

Poster session / 509

Simulation of High-Energy Particle Showers for SWGO

Author: Tamara Petrosillo Lago[1]

Co-authors: Claudio Dib [2]; Sebastian Tapia Araya [2]

[1] *Universidad Técnica Federico Santa María*

[2] *Federico Santa Maria Technical University (CL)*

Corresponding Author: tamarapetrosillo@gmail.com

The reconstruction of atmospheric showers produced by high-energy gamma rays is an essential point in order to determine the effectiveness and optimize the design and layout of the Southern Wide-field Gamma-ray Observatory (SWGO). While SWGO is dedicated to studying gamma rays from astrophysical sources, cosmic rays introduce significant noise into the data, making it essential to accurately distinguish them. This work focuses on simulating the interactions of various particles with SWGO's Cherenkov detectors, which use photomultiplier tubes (PMTs), to model the expected light signals produced by them.

At very high energies, simulation of the detector response due to the entire particle shower is computationally expensive. To address this, we simulate the arrival of particles at the detectors and construct a lookup table of detector responses. This table serves as a resource-efficient tool to predict Cherenkov light signals under various conditions. Comparisons between this method and full shower simulations will be discussed, along with potential impacts on gamma-to-cosmic ray separation.

Poster session / 468

Phenomenological aspects of the fermion and scalar sectors of a S4 flavored 3-3-1 model.

Authors: maria mora urrutia[1]; antonio carcamo[1]; juan manuel marchant[1]; Daniel Salinas-Arizmendi[2]

[1] *USM*

[2] *Universidad Técnica Federico Santa María*

Corresponding Author: maria.morau@usm.cl

We proposed a viable and predictive model based on the SU(3)_C × SU(3)_L × U(1)_X gauge symmetry, supplemented by the global U(1)_Lg symmetry, the S_4 family symmetry and several auxiliary cyclic symmetries, which successfully reproduces the experimentally observed SM fermion mass and mixing pattern. The tiny active neutrino masses are generated through an inverse seesaw mechanism mediated by right-handed Majorana neutrinos. The model is consistent with the SM fermion masses and mixings and successfully accommodates the current Higgs diphoton decay rate constraints as well as the constraints arising from oblique S, T and U parameters and we studied the meson mixing due to flavor changing neutral currents mediated by heavy scalars, finding parameter space consistent with experimental constraints.

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Exploring the $B \to K\,E_{\rm miss}$ anomaly: Signatures of light new particles

Author: Martin Novoa-Brunet[1]

[1] *IFIC, U. Valencia, CSIC*

Corresponding Author: martin.novoa.b@gmail.com

Motivated by the remarkable Belle II experimental result on $B \to K\,E_{\rm miss}$ I review the scenarios that could accomodate the observed deviation and how this correlate with constraints coming other observables induced by flavour changing neutral currents. I discuss the phenomenological difficulties in accommodating it exclusively in terms of processes with SM neutrino final state and systematically investigate possibilities that $E_{\rm miss}$ comes not only from the SM neutrinos but also from other light undetected particles. I exhaustively explore the possible new scalar, fermion or vector particles final states and their viability. Since several of these possibilities significantly alter the phase space and kinematical distributions of events in the experiments, I consider not only the branching fractions of but also all available event distributions presented in the Belle II and BaBar analyses, and construct a likelihood for different NP scenarios using the data from both $B \to K^{(*)}E_{\rm miss}$ and $B_s \to E_{\rm miss}$ processes.

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The Planck scale, the nuclear scale and 4G model of final unification

Authors: Satya Seshavatharam Utpala Venkata[None]; Lakshminarayana S[1]

[1] *Andhra University, Visakhapatnam-03,AP, India*

Corresponding Author: seshavatharam.uvs@gmail.com

Considering our 4G model of final unification, we have noticed a great correlation between the Planck scale and the nuclear scale. If one is willing to consider Plank scale radius as, $R_{pl} \cong \frac{2G_N M_{pl}}{c^2}$ where $M_{pl} \cong \sqrt{\frac{\hbar c}{G_N}}$, based on the the observed nuclear radius of $R_0 \leq 1.2$ fm, quantitatively it is possible to show that, $\frac{R_{pl}}{R_0} \cong \frac{2G_N M_{pl}}{c^2 R_0} \cong \left(\frac{m_e}{m_p}\right)^6$. Thus, $G_N \cong \left(\frac{m_e}{m_p}\right)^{12} \left(\frac{R_0^2 c^3}{4\hbar}\right)$. Refining this observation with our 4G model of the strong coupling constant and fine structure ratio, Newtonian gravitational constant can be estimated as, $G_N \cong \left(\frac{m_e}{m_p}\right)^{12} \left(\frac{\hbar c}{\alpha_s m_p^2}\right) \cong \left(\frac{m_e}{m_p}\right)^{14} \left(\frac{16\pi^4 \hbar c}{\alpha^2 m_p^2}\right) \cong$ $6.679855347 \times 10^{-11}$ m^{3}kg^{-1}sec^{-2}. This obtained value can be considered as a reference value for the past and future experimental values of G_N . With further study- background physics can be understood, and accuracy can also be improved.

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Ultraheavy multiscattering dark matter: DUNE, CYGNUS, kilotonne detectors, and tidal streams

Author: Harsh Aggarwal[1]

Co-author: Nirmal Raj [2]

[1] *Indian Institute of Technology, Kharagpur*

[2] *Indian Institute of Science*

Corresponding Authors: harsh2002@kgpian.iitkgp.ac.in, nraj@iisc.ac.in

For scattering cross sections large enough to make the detector in direct searches optically thick to the incident dark matter, dedicated multi-scatter signatures are being sought. We provide some significant updates to the multi-scatter program. First, we refine earlier treatments of the dark matter flux through detectors, generalizing to arbitrary geometries and velocity distributions. Using this and considerations of energy deposition, we derive the reaches in cross section and mass of various proposed large volume-detectors. These include a kilotonne fiducial mass "module of opportunity" at DUNE, a kilotonne xenon detector suggested for neutrinoless double beta decay, the gaseous detector CYGNUS, and the dark matter detectors XLZD and Argo. We show that where the velocity vector can be reconstructed event-by-event, key properties of the local velocity distribution such as the mean speed can be marked, and tidal streams can be picked up if they make up about 10% of the local dark matter density.

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Effect of Magnetic Field on Urca Processes in Neutron Star mergers

Author: Pranjal Tambe[1]

Co-authors: Debarati Chatterjee [1]; Mark Alford [2]; Alexander Haber [2]

[1] *Inter-University Centre for Astronomy and Astrophysics*

[2] *Washington University*

Corresponding Author: pranjaltambe32@gmail.com

Isospin-equilibrating weak processes, called "Urca" processes, are of fundamental importance in astrophysical environments like (proto-)neutron stars, neutron star mergers, and supernovae. In these environments, matter can reach high temperatures of tens of MeVs and be subject to large

magnetic fields. We thus investigate Urca rates at different temperatures and field strengths by performing the full temperature and magnetic-field dependent rate integrals for different equations of state. We find that the magnetic fields play an important role at temperatures of a few MeV, especially close to or below the direct Urca threshold, which is softened by the magnetic field. At higher temperatures, the effect of the magnetic fields can be overshadowed by the thermal effects. We observe that the magnetic field more strongly influences the neutron decay rates than the electron capture rates, leading to a shift in chemical equilibrium.