Journées de Rencontre Jeunes Chercheur·se·s 2024

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Type Ia supernova spectrophotometric standardisation and application to the ZTF spectra sample

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Type Ia Supernovae (SNe Ia) are reliable standard candles for measuring cosmic distances due to their nearly constant maximum luminosity. Standardisation methods have been developed to reduce intrinsic scatter and improve distance estimates. Traditional photometric method reaches a 8% precision in distance, but the SNFactory (SNf) [1] survey has suggested that a spectroscopic approach can reach 4%.

In this study, we attend to validate this spectroscopic method called the Twins Embedding [2] [3] (TE) using an other survey. The Zwicky Transient Facility (ZTF) spectra sample [4] has around 700 spectroscopic SNe, four times larger than SNf for the same selection cuts, but with lower Signal-to-Noise ratio. We will also study the robustness of TE under different observational conditions and data qualities.

During the talk, I will present the Twins Embedding method, his performance dependancy on different data sample qualities, and the first results of ZTF spectral standardisation.

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Theory / 2

Axion emission from strange matter in core-collapse SNe

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The duration of the neutrino burst from the supernova event SN 1987A is known to be sensitive to exotic sources of cooling, such as axions radiated from the dense and hot hadronic matter thought to constitute the inner core of the supernova. We perform the first quantitative study of the role of hadronic matter beyond the first generation – in particular strange matter. We do so by consistently including the full baryon and meson octets, and computing axion emissivity induced from baryon-meson to baryon-axion scatterings as well as from baryon decays. We consider a range of supernova thermodynamic conditions, as well as equation-of-state models with different strangeness content.

We obtain the first bound on the axial axion-strange-strange coupling, as well as the strongest existing bound on the axion-down-strange counterpart. Our bound on the latter coupling can be as small as O(10^−2) for fa=10^9 GeV.

Astroparticle / **3**

Towards highest and lowest energies for the High Energy Stereoscopic System (H.E.S.S.) in Namibia

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Abstract : The High Energy Stereoscopic System (H.E.S.S.) is a gamma-ray observatory located in the highlands of Namibia, operational since 2002. It has undergone several upgrades to maintain scientific relevance and withstand the desert environment. H.E.S.S. houses CT5, the largest gamma-ray telescope, which has been equipped since 2019 with FlashCAM, a new prototype camera designed to replace the H.E.S.S. II camera and for future deployment at the Cherenkov Telescope Array Observatory (CTAO) in Chile.

FlashCAM is a fully auto-calibrating camera with a progressive gain channel, introducing challenges for integration into the H.E.S.S. software due to its novel operational principles. The camera has been adapted for use in one of H.E.S.S.'s two primary analysis frameworks, HAP Analysis, while its integration into the second analysis software, ParisAnalysis, is still pending. ParisAnalysis'semi-analytical reconstruction model, Model++, requires full characterization of the camera's electronics noise from dark and observational runs, necessitating significant modifications to the calibration pipeline and its advanced algorithms.

The complete integration of FlashCAM into the ParisAnalysis software and Model++ is essential, as it will expand the analysis capabilities to lower energies for extragalactic science, unlocking five years of previously unanalyzed CT5 data. Additionally, this integration will enable cross-analysis using both ParisAnalysis and HAP pipelines, a requirement for the H.E.S.S. collaboration, facilitating the release of the first FlashCAM results and validating the camera's performance for the future CTAO.

TAGS : High Energy Astrophysics, IACT, Gamma-rays, High Energy Stereoscopic System , Instrument calibration.

Standard Model / **4**

FAIR UNIVERSE - Higgs Uncertainty Challenge

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The Fair Universe project organised the HiggsML Uncertainty Challenge, which took place from September to October 2024. This groundbreaking competition in high-energy physics (HEP) and machine learning was the first to place a strong emphasis on uncertainties, focusing on mastering both the uncertainties in the input training data and providing credible confidence intervals in the results.

The challenge revolved around measuring the Higgs to tau+ tau- cross section, similar to the HiggsML challenge held on Kaggle in 2014, using a dataset representing the 4-momentum signal state. Participants were tasked with developing advanced analysis techniques capable of not only measuring the signal strength but also generating confidence intervals that included both statistical and systematic uncertainties, such as those related to detector calibration and background levels. The accuracy of these intervals was automatically evaluated using pseudo-experiments to assess correct coverage.
Techniques that effectively managed the impact of systematic uncertainties were expected to perform best, contributing to the development of uncertainty-aware AI techniques for HEP and potentially other fields. The competition was hosted on Codabench, an evolution of the Codalab platform, and leveraged significant resources from the NERSC infrastructure to handle the thousands of required pseudo-experiments.The Competition is part of the NeurIPS 2024 competitions. Link : "https://blog.neurips.cc/2024/06/04/neurips-2024-competitions-announced/ ".
Link to the competition : https://www.codabench.org/competitions/2977/
Link to white paper : https://arxiv.org/abs/2410.02867

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Testing the performance of the LISA (Laser Interferometer Space Antenna) space based gravitational wave observatory

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Impact of Nickel Cryostats in the nEXO Detector

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Neutrino physics / 45

Vertex reconstruction at DUNE experiment

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The Deep Underground Neutrino Experiment (DUNE) is a next-generation neutrino oscillation experiment that will examine neutrino interactions to ultimately address some of the most fundamental questions in particle physics. To study neutrinos is very difficult and a more sophisticated reconstruction approach must be developed to fully exploit the high-resolution detection technology used by the DUNE Collaboration. The goal of this project is to develop innovative algorithms to optimize the reconstruction of neutrino interactions in the DUNE 'Far Detector'(FD), while exploiting the full potential of the detector design to maximize the sensitivity to neutrino oscillation parameters. Building on existing efforts in the DUNE Collaboration, the researchers plan to develop a Machine Learning (ML) based framework to perform neutrino event reconstruction in the FD of the DUNE experiment. As such, this project holds great potential to improve techniques crucial to the reconstruction of neutrino energy, which is the key challenge when performing neutrino oscillation analysis with DUNE' s wide spectrum of neutrino energies.

Neutrino physics / 46

Study of Ar^{39} Beta Decays in DUNE's Prototypes

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The Deep Underground Neutrino Experiment (DUNE) is a next generation long baseline neutrino experiments. It is a Liquid Argon Time Projection Chamber (LArTPC) detector. While its main physics goals (measuring the $\delta_{\rm CP}$ phase, resolving θ_{23} octant and the mass hierarchy) are focused on a GeV-scale physics DUNE has also a low energy (MeV-scale) program. This includes observing for the first time hep solar neutrino or measuring a SuperNova Burst (SNB). To successfully detect these low-energy events, a precise understanding and quantification of the background is needed. This background is mainly Ar^{39} beta decays with an activity of 1 Bq/kg but also other radiologicals (K^{40}, Rn^{222}, Th-chain …) and neutrons. It can provide a variety of different information: like testing the

reconstruction of point-like events (useful for SNB) or measuring some of the detector characteristics (purity, space charge effect, recombination). Here is a study on reconstructing Ar^{39} beta decays in the ProtoDUNE-HD (PDHD) detector, the obtained spectrum is compared to Monte-Carlo simulations. Additionally, a Bi^{207} source, introduced for charge response calibration, is used to test the spatial and energy reconstruction capabilities of the algorithm.

Cosmology / 47

Masking bright objects with LSST

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The Legacy Survey of Space and Time (LSST) is an ambitious project with the objective of mapping the observable universe over a ten-year period. This will be achieved through the utilisation of the Simonyi telescope, which is equipped with six distinct filters. The telescope will survey the entire visible sky in three days. However, the presence of bright objects, particularly stars, represents a significant obstacle to the extraction of valuable insights from LSST data. The presence of these objects will saturate the LSST sensors, resulting in the introduction of biases in object detection and flux measurement within a radius that is dependent on the magnitude of the objects in question. The creation of masks to cover the most affected regions is necessary, yet it is a challenging task due to the difficulty in identifying and characterising these objects. Our method, based on that used for HSC-SSP, has been applied to a catalogue derived from simulated LSST images. The resulting masks cover approximately two percent of the area under study. Their impact is currently being investigated in the Dark Energy Science Collaboration (DESC), particularly within galaxy cluster detection algorithms such as AMICO and redMaPPer. This approach will be used with the first on-sky LSST data, scheduled for 2024-2025.

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Assembly and Testing of HGTD Modules

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With the High Luminosity LHC (HL-LHC) upgrade scheduled for 2029, the ATLAS experiment will face increased challenges from higher pile-up and radiation damage. To address this, the High Granularity Timing Detector (HGTD) will be installed in front of the ATLAS end-cap calorimeter, significantly enhancing vertex reconstruction through precise timing information. The HGTD will consist of around 8000 modules, with approximately 2000 being assembled at IJCLab in France. These modules are composed of LGAD sensors, ALTIROC read-out chips, and module flexes, integrated to ensure reliable performance under challenging conditions.
Through extensive R&D, various iterations of the modules have undergone rigorous testing, including electrical validation, verification with radioactive sources, and thermal cycling. These tests contributed to the finalization of the specifications for the preproduction phase. As we approach this critical stage, efforts at IJCLab are also focused on optimizing assembly techniques to improve production rates and ensure the timely delivery of the required modules. Given France's significant role in this international effort, these developments will contribute substantially to the overall success of the HGTD project.

Astroparticle / 49

Study of transient phenomena with the first large CTAO telescope

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Since 2018, the first Large Size Telescope (LST), from the CTAO experiment, is observing various sources in our night sky. To ensure the best pointing possible, it appears mandatory to know the structure effects that affect the pointing of the telescope. The first part of this talk will be dedicated to what is called the bending model, a system which allow correcting the misspointing. Its functioning and potential improvements will be discussed.
The second part of the presentation will focus on data analysis of transient phenomena, such as gamma ray bursts. Those extremely energetic events are among the most important science topics of the collaboration. Until now, none has been detected with the LST. Due to their rapidly varying signal, specific methods can help to improve the chances to detect one of those highly energetic extragalactic sources.

Flavor Physics / 50

Search for charged lepton flavor violation with the COMET experiment at J-Parc

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The Standard Model (SM) of particle physics describes the fundamental particles and the interactions governing the universe. While it has been remarkably successful in providing experimental predictions, several phenomena remain unexplained, such as the matter/antimatter asymmetry, the nature of dark matter, and even the oscillation of neutrinos. In particular, neutrino oscillation experiments have demonstrated that lepton flavor can be violated for neutral leptons, a phenomenon known as **neutral lepton flavor violation**. However, **flavor violation** has not yet been observed in **charged leptons**. In the Standard Model, **charged lepton flavor violation (cLFV)** is strictly forbidden, and even in minimal extensions to account for neutrino oscillation, it is highly suppressed by the large mass of the W boson.

The **COMET experiment** seeks to detect cLFV through a process involving new physics: the **coherent, neutrinoless conversion** of a muon bound to a nucleus into an electron. It targets a single event sensitivity of 10^{-17} over two phases, which is an improvement by four orders of magnitude of the current world limit (SINDRUM-II, 2006).

One of the primary challenges for COMET is mitigating background noise from cosmic rays. Atmospheric muons could enter the detector and produce electrons that mimic signal events or be misidentified themselves as electron candidates. A subsystem known as the **Cosmic Ray Veto (CRV)** is designed to distinguish cosmic ray-induced events from genuine signal events. A detailed study of the radiation environment impacting the CRV has been conducted to optimize its efficiency, exploring various geometric configurations and shielding materials. This analysis was carried out using **ICEDUST**, the simulation software utilized by the experiment.

Theory / 51

Electric dipole response of sd-shell nuclei within the Large-Scale Shell Model approach

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Photo-nuclear reaction rates provide key inputs to various applications of nuclear physics and consist fundamental probes of nuclear structure, from single particle to collective excitations, revealing nature of complicated nucleonic correlations. Among the excitations of nuclei due to the external field, the E1 dipole response is of particular interest. In this talk, I will discuss recent systematic calculations of E1 dipole response of long-lived sd-shell nuclei within the large-scale shell model framework. It will be shown that our theoretical framework permits to reproduce to a good accuracy the position of the GDR peak and the shape of the E1 distributions in the experimentally known cases. If time allows, the analysis of the pygmy-dipole modes in this region will be presented.

Neutrino physics / **52**

Neutrino talk #7

Auteur: Matteo Galli[1]

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Astroparticle / **53**

Status report of the Fermi-LAT analysis of VER J0521+211 during the February 25, 2020, flare

Auteur: Samantha López Pérez[1]

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The project that I will describe concerns the study of the gamma-ray source VER J0521+211, an active galactic nucleus of the blazar subclass, using gamma-ray data from the Large Area Telescope (LAT) on board the Fermi Gamma-ray Space Telescope and the Very Energetic Radiation Imaging Telescope Array System (VERITAS). I will first give an overview of the properties of this object and then I will present a status report on the Fermi-LAT analysis during the gamma-ray flare of February 25, 2020. This analysis is part of a joint project between Fermi-LAT, VERITAS and multi-wavelength partners.

Hadronic Physics / **54**

Deeply Virtual Compton Scattering experiment with the Neutral Particle Spectrometer in Hall C at JLab

Auteurs: Carlos Munoz Camacho[None]; Hao HUANG[1]

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The generalized parton distributions (GPDs) embody multiple information about the inner structure of nucleons thus an important topic to investigate. Experimentally, physicists access GPDs through the Compton Form Factor (CFF), and the Deeply Virtual Compton Scattering (DVCS) is the simplest process to look into.

In Hall C at the Jefferson Lab (JLab), we collected DVCS data from the fall of 2023 to the summer of 2024 with our newly installed Neutral Particle Spectrometer (NPS), which was constructed using 1080 lead tungstate (PbWO4) crystals for the detection of emitted photons from DVCS processes and provides us a high energy resolution for the measurement of DVCS cross-section. In this talk, I will present our experimental setup and the preliminary results from our refined offline analysis.

Nuclear Physics / **55**

Étude de la faisabilité industrielle de la technique de transmission par résonance neutronique (NRTA)

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Pour le retraitement du cycle du combustible nucléaire à l'usine Orano de La Hague, la détermination précise de la composition isotopique des matières nucléaires est cruciale pour optimiser leur utilisation et assurer leur gestion. Les méthodes actuelles, comme l'analyse physico-chimique, présentent des limites et sont longues et complexes à mettre en œuvre. L'analyse par transmission de résonances neutroniques (NRTA) émerge donc comme une solution prometteuse grâce à sa spécificité isotopique sur une large gamme d'isotopes.
Cependant, son utilisation reste confinée aux laboratoires de recherche en raison de son besoin de grandes installations pour générer un flux de neutrons avec une haute résolution temporelle. Notre travail vise à évaluer la faisabilité industrielle de la NRTA en développant un système compact et optimisé pour un usage en milieu industriel, en particulier un accélérateur table-top, une base de vol courte, et des échantillons réalistes.
Dans ce travail, seront présentés l'objectif et le contexte de ce projet de recherche, une description détaillée de la technique NRTA et ses défis pour l'industrialisation, ainsi que les résultats des simulations Monte Carlo et la méthode de quantification employée pour analyser les échantillons.

Neutrino physics / **56**

Sterile Neutrino Search with Atmospherics in DUNE

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Being less well-known particles, neutrinos are one of the best starting points for new physics searches in particle physics. In this scope, the hypothesis of the existence of non-weakly interacting "sterile" neutrinos is a promising route to explore to go beyond the Standard Model.

The most direct way to explore this hypothesis is to study the oscillation patterns of active neutrinos, as adding one (or more) extra mixing state will modify the oscillation probabilities and thus the number of events we expect to see in a neutrino detector. As such, most experiments focused on neutrino oscillation studies might be able to constrain the existence of sterile neutrinos.

My work focuses on the possibility for the long baseline Deep Underground Neutrino Experiment (DUNE) to get physical constraints on sterile parameter values using atmospheric neutrinos. In addition to beam neutrinos which are the main focus of DUNE, atmospheric neutrinos allow for a wider range of energies and baselines, which both have an impact on neutrino oscillation probabilities. This, combined with the expected reconstruction performance for both neutrino energy and direction, might give DUNE a particular insight in the search for sterile neutrinos.

Beyond Standard Model / **57**

Search for doubly resonant beyond the Standard Model process with one Higgs boson and one scalar resonance in the final state in the $b\bar{b}\gamma\gamma$ channel in the ATLAS experiment at the LHC

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Physics at the Large Hadron Collider (LHC) at CERN (European Organization for Nuclear Research) is the high priority research field of the Particle Physics community worldwide. ATLAS is one of the two general purpose experiments installed at the LHC that discovered a Higgs boson in July 2012, key piece for the understanding of the fundamental interactions and the origin of elementary particle mass. Its physics program extends beyond Higgs property measurements to the search for signs of physics beyond the Standard Model (BSM) of particle physics.

Many theoretical BSM (Beyond the Standard Model) models predict the existence of new scalar particles in the Higgs sector, denoted as X and S, which could be produced in proton-proton collisions in association with a Higgs boson: $pp \to X \to SH$. Searches for such particles have been conducted by several analysis teams within the ATLAS and CMS experiments. Notably, one analysis reported a local (global) excess of 3.5σ (2.0σ) for $X = 575$ GeV and $S = 200$ GeV compared to the background-only hypothesis in the decay channel $X \to SH \to b\bar{b}\gamma\gamma$, using 140 fb^{-1} of ATLAS Run 2 data at $\sqrt{s} = 13$ TeV. While this excess is below the discovery threshold of 5σ, it may suggest a possible deviation from the Standard Model prediction.

A search is performed for a new scalar particles, X and S, using ATLAS Run 2 data $\sqrt{s} = 13$ TeV and partial Run 3 data $\sqrt{s} = 13.6$ TeV. That could either allow to confirm the existence of these particles with a higher significance ($> 5\sigma$) or refute their existence.

Beyond Standard Model / **58**

Search of heavy long-lived particles with large ionization energy loss at the CMS experiment

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I will present the current search in the CMS experiment for exotic signatures characteristic of massive particles with a sufficiently long lifetime to be considered stable at the detector scale, and electrically charged. Such particles, among other things, have a special properties: because of their large mass, they deposit more energy in the matter than Standard Model particles.
As a first step, I worked on the reconstruction of saturated charge clusters within the CMS tracker, a useful algorithm within the analysis.
The latest results dealing with data from 2017 and 2018 have recently been published and do not show

any significant excess of events above the background expectation, but they do establish upper cross-section limits for these hypothetical particles produced.
I will present the continuation of this work by looking at possible extensions of research like the focus on missing transverse energy (MET).

Nuclear Physics / 59

Status of the b-STILED project

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Precision measurements in beta decay play an essential role in the search for new physics beyond the standard model (SM), by probing "exotic"phenomena such as scalar and tensor interactions. The existence of such interactions induces deviations on specific observables, away from their SM predictions. The study of the full beta energy spectrum offers a sensitive mean to probe these interactions.
The goal of the b-STILED (b: Search of Tensor Interactions in nucLear bEta Decay) is to perform the most precise measurement of the beta-energy spectrum in 6He decay, in order to extract the Fierz interference term b with a precision in the order of 4.10-3. This term depends linearly on exotic coupling constants, allowing to search for or to constrain the presence of tensor interactions in nuclear beta decay.
The main instrumental effect observed in previous measurements of the beta energy spectrum resides in the energy loss due to electrons backscattering outside the detector volume. Two techniques are used to overcome this effect. They consist of using either a very low energy beam of 6He+ ions (25 keV) deposited between two scintillation detectors, or a high energy beam of 6He+ ions (312 MeV) deposited inside one scintillation detector to form a 4π calorimeter. The use of these techniques ensure the deposition of the entire energy of the detected beta particles. An experiment using the first technique was performed at the Grand Accélérateur National d'Ions Lourds (GANIL) in 2021. A second experiment using the other technique was performed at GANIL again in 2023.
This contribution will introduce the general context of the project, describe the second experimental setup, and report on the status of the data analysis for the latest experiment.

Beyond Standard Model / 60

Recherche d'un boson de Higgs additionnel de masse <110 GeV dans le canal de désintégration diphoton

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En 2012, le modèle standard a été complété après la découverte au LHC, par les expériences ATLAS et CMS, d'un boson scalaire pouvant correspondre au boson de Higgs tel que prédit par le mécanisme BEHHGK. Cependant, des modèles d'extensions du modèle standard comme le 2HDM ou la supersymétrie prédisent des bosons de Higgs additionnels pouvant posséder des masses bien différentes de celui observé et induire une violation de CP permettant d'expliquer l'asymétrie de la baryogénèse . Cette présentation a pour but de montrer les résultats obtenus par CMS dans cette recherche d' un boson de Higgs additionnel ayant une masse <110 GeV dans le canal de désintégration diphoton, ainsi que la recherche actuelle menée avec les données du Run 3 du LHC ayant commencé en 2022. Notamment, je présenterai la partie de l'analyse dans laquelle je suis impliqué correspondant à la discrimination entre le processus Drell-Yan (Z->ee) et un potentiel signal (h->γγ) via des méthodes de réseaux de neurone ainsi que la génération de données par Variational Auto Encoder (VAE) afin de modéliser le bruit de fond n'ayant pu être supprimé.

Neutrino physics / 61

Refining Sterile Neutrino Exclusion through Joint Analysis: STEREO Phase 2 Reproduction and Analytical Response Modeling

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Motivated by the Reactor Anti-neutrino Anomaly (RAA, an experimental 6% flux deficit), recent reactor anti-neutrino experiments have explored the existence of a fourth, sterile neutrino. Its experimental signature is oscillations induced over short baselines. The STEREO and PROSPECT experiments have excluded the RAA's best-fit oscillation parameters at over 4σ and produced exclusions contours for other areas of the parameter space.
A joint analysis combining STEREO, PROSPECT, and Daya Bay is currently underway to improve the exclusion contours.
This talk will present my work in this context on reproducing STEREO Phase 2 results, focusing on numerical optimizations to improve computational efficiency. I will also discuss the development of an analytical response model, used to enhance flexibility in fitting procedures and better handle systematic uncertainties.

Theory / 62

Confront resonant s-wave dark matter to cosmological and astrophysical constraints

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There are strong cosmological and astrophysical constraints for thermal dark matter below the GeV scale: CMB excludes s-channel annihilation cross-sections for thermal dark matter below 10 GeV.
What kind of special properties dark matter should have to evade such strong constraints ?
Resonant annihilation is one possibility.
First, I will explain the effects of resonances on the formation of the dark matter relic with a model-independent approach.
Then, I will focus on light dark matter interacting with quarks and gluons, introducing the Chiral Lagrangian, and discussing if resonant s-wave models can evade the constraints that are obtained from CMB and indirect detection.

Instrumentation / 63

Amelioration of noise burst mitigation measures in the ATLAS Liquid Argon calorimeter

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The ATLAS detector is one of the four main experiments near the Large Hadron Collider (LHC) at CERN. The Liquid Argon Calorimeter (LAr) is an essential part of ATLAS, its primary purpose being the measurement of electrons and photons, but also providing important input for the measurement of jets and transverse impulses. Since LHC Run 1, the LAr is affected by a coherent noise phenomenon so-called Noise Bursts (NB), which reduces its efficiency. This noise must therefore be identified and removed with minimal loss of physics data. The current method for identifying NB candidates relies on cells connected to the Front-End Board (FEB), which shapes the energy deposition signals. In this work, we explore an alternative identification method based on the coherent behavior of cells supplied by the same High Voltage Line (HV Line). This HV Line-based flag identifies events as NB only when the energy deposition is significant. Additionally, it identifies certain NB events that were not caught by the FEB-based flag despite considerable energy deposition. The HV Line-based flag more effectively identifies NB candidate events, thereby reducing possible losses of physics data. A detailed study of this HV Line-based flag is presented in this work, and a perspective on identifying the partition origin of noisy event is proposed.

Standard Model / 64

Electron Reconstruction in the CMS Phase-2 High Granularity Calorimeter

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The high-luminosity era of the LHC will pose unprecedented challenges to the detectors. To meet these challenges, the CMS detector will undergo several upgrades, including the replacement the current endcap calorimeters with a novel High-Granularity Calorimeter (HGCAL). To make optimal use of this innovative detector, new and original algorithms are being devised. A machine-learning based electron superclustering algorithm is presented, designed to recover bremsstrahlung photons to collect the entire electron energy whilst limiting pile-up contamination. The granularity of HGCAL allows for many cluster variables to be computed, fed into a Deep Neural Network to determine whether two clusters should be linked. Groups of clusters thus formed, known as superclusters, are used to seed electron track reconstruction. The superclustering is developed within The Iterative Clustering Framework (TICL).

The new neural-network based superclustering shows improved performance over the current geometrical algorithm used in Phase-1, by collecting less pile-up induced clusters.

Cosmology / 65

The application of modular neural networks in CMB reconstruction

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In this presentation, we will explore the application of machine learning techniques in cosmology, focusing on the analysis of Cosmic Microwave Background (CMB) maps. Accurately calculating the tensor-to-scalar ratio from CMB data is a crucial yet challenging task, as it holds the key to understanding primordial gravitational waves and the early universe's inflationary period. I will discuss the use of informed learning with the goal of precise reconstruction, which can be readily reapplied in other areas of cosmology and astrophysics studies. These methods offer robust tools for dealing with the complexities and high-dimensional nature of data. By leveraging machine learning, we can enhance our ability to simulate, analyze, and interpret CMB observations, providing deeper insights into the universe's fundamental properties. The versatility and potential of machine learning in advancing our understanding of the cosmos will be highlighted, by showing data analysis techniques applicable in all scientific disciplines. A special focus is given to the application of physics-quided networks, their advantages and integration into the works of scientists.

Beyond Standard Model / 66

Quantum magnetometry for the search of the neutron electric dipole moment.

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The neutron electric dipole moment (nEDM) is the coupling of the neutron spin to an external electric field. A non-zero electric dipole moment would violate time reversal symmetry, source of charge-parity violation.
The n2EDM experiment aims to lower the nEDM upper limit by one order of magnitude, increasing the sensitivity to beyond standard model physics and to processes leading to baryon asymmetry.
This talk will present the apparatus that is being commissioned at the Paul Scherrer Institute (PSI), focusing on quantum magnetometry that provides an in situ monitoring of time fluctuations of the magnetic field.

Neutrino physics / 67

Impact of Nickel Cryostats in the nEXO Detector

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Keywords: nEXO, neutrinoless double beta decay, rare events, liquid xenon, shielding, hydrofluoroether, radioactivity, background reduction, nickel cryostats

Presentation Type: Oral presentation

The nEXO experiment aims to detect neutrinoless double beta decay ($0\nu\beta\beta$), a rare nuclear process that, if observed, would show that neutrinos are their own antiparticles and could provide insights into the universe's matter-antimatter asymmetry. The experiment uses 5 tonnes of liquid xenon enriched in the ^{136}Xe isotope as both the decay source and the detection medium within a Time Projection Chamber (TPC), kept in liquid form by nested cryostat vessels.

A key challenge for nEXO is minimizing radioactive background, particularly gamma radiation from uranium and thorium decay chains in detector components, which could mimic the $0\nu\beta\beta$ signal. Initially, a 32 tonnes liquid hydrofluoroether (HFE-7200) shield was planned around the TPC. Recent design changes propose switching the carbon fiber composite (CFC) cryostat vessels to chemical vapor-deposited (CVD) nickel, significantly reducing background interference by a factor of approximately 300.

Simulations and background analyses suggest that this background reduction could allow a smaller inner cryostat vessel and thinner HFE shielding, decreasing the HFE mass from 32 tonnes to 7.5 tonnes while maintaining the same background suppression. This modification could lower costs, reduce storage needs, and shorten cooling time, although thermal stability and external background effects would need close monitoring.

Standard Model / 68

Search for Higgs Pair Production Decaying into 2 Photons and 2 b Quarks at the High-Luminosity LHC

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The Standard Model (SM) is currently the most predictive framework for describing interactions among the fundamental constituents of matter. It includes 19 free parameters, which are measured experimentally, notably with the ATLAS detector at the Large Hadron Collider (LHC) at CERN. These parameters encompass particle masses, phases, and coupling values. One of these couplings, the Higgs boson self-coupling, stands out due to its unique nature: only a scalar can possess a self-coupling and it is a key parameter in shaping the Higgs potential, explaining the origin of particle masses. This coupling is involved in the simultaneous production of two Higgs bosons via a virtual Higgs boson, a rare process with a cross-section 1,000 times smaller than that of single Higgs boson production. This process presents a detection challenge, as the two Higgs bosons decay into various types of particles with different probabilities. A particularly sensitive signature for this measurement is the decay of a pair of Higgs bosons into two b-quarks and two photons ($HH \to b\bar{b}\gamma\gamma$). Although currently limited by the amount of collected data, this analysis has provided the best existing constraint on this value. An upgrade to the LHC, called the High Luminosity LHC (HL-LHC), aims to increase the data produced by a factor of 20 compared to the current measurement. A sensitivity projection study for this coupling measurement allows us to determine the expected constraint at the end of the HL-LHC program.

This presentation aims to introduce the challenge of detecting events with this unique signature and to show the expected results for the high-luminosity program. Precisely knowing the value of this coupling is crucial, either to strengthen the predictive power of the SM and constrain the shape of the Higgs potential, which has a direct impact on the stability of our universe, or to open the door to new physics.

Neutrino physics / 69

Search of reconstructed Michel-electrons in DUNE

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The Deep Underground Neutrino Experiment (DUNE) is a long baseline experiment that wants to answer questions like: the preponderance of matter over antimatter, the dynamics of the supernova neutrino bursts and whether protons decay, using a neutrino beam.
The experiment exploits Liquind ArgonTime Projection Chamber (LArTPC) technology.
DUNE consists of 4 modules of 17 kton located 1300 km away in an underground facility in South Dakota.
DUNE will also be able to look at neutrinos from other sources: supernovae and atmospheric, which have a different energy range.
My work focuses on improving the performance of the detector for neutrinos from atmospheric sources. In particular, I'm studying the ability to distinguish the charge of the neutrino that can increase the sensitivity in the mass hierarchy measurement.
In order to distinguish the charge of neutrinos, we take advantage of charge detection of muon events by going to observe the electrons that are products of the muon decay (called Michel-electrons)
My final goal is to optimise the Michel-electron tagging efficiency using reconstruction information of atmospheric neutrinos.

Astroparticle / 70

Pulsars in Gamma-ray Astronomy with H.E.S.S.

Auteur: Maxime Regeard[1]

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Pulsars are rapidly rotating neutron stars for which we detect pulsed emission. Pulsars have been detected from radio (more than 3000 sources detected) to gamma-rays (300 sources detected in 3PC).
In the last 2 decades, Imaging Atmospheric Cherenkov Telescopes (IACTs), such as H.E.S.S., MAGIC or VERITAS, have drastically enhanced the very high energy (VHE) astronomy, with several hundreds of sources detected. In the case of pulsars, four pulsars have been detected in the high energy domain. However, the major breakthrough was the discovery by H.E.S.S. of pulsed emission up to tens of TeV from the Vela pulsar. This detection open the path towards TeV pulsar astronomy.
We will present new results from H.E.S.S.:
One of the major questions regarding pulsar emission models is whether the High Energy (HE) end of their spectra displays a tail extending beyond tens of GeV, as is the case for the Crab. We investigate this matter on both Vela and PSR B1706-44 through a joint-analysis using H.E.S.S. CT5 and Fermi-LAT data.
We report also on the detection of a new pulsar, PSR J1509-5850, by H.E.S.S. which displays a multi-TeV component, similar to Vela. However, its unexpectedly high TeV luminosity, as compared to the latter, opens even more the path towards TeV pulsar astronomy.

Neutrino physics / 71

Development of a muon reconstruction algorithm for JUNO using all the sub-detectors

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JUNO is an experiment designed to resolve the mass ordering of the neutrinos. It consists of a main detector containing 20 kt of Liquid Scintillator with which the neutrinos will interact, and two other veto detectors.

Cosmogenic isotopes, produced by the passage of cosmic muons, are one of the biggest sources of background for JUNO. To reject these events, without missing any neutrino events, we need to know when a muon enters the detector, and what is its trajectory. To this end, several methods have already been put in place, but all using only one detector. This presentation will therefore explore the construction of a method allowing us to use all detectors at the same time, and thus increase our precision.

Instrumentation / 72

Quad module assembly and quality control for the ITk Pixel Detector upgrade fo the high luminosity phase of LHC

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The ATLAS experiment is preparing for the high-luminosity phase of the LHC (HL-LHC) with a complete upgrade of its inner detector to an all-silicon inner tracker (ITk). Designed for enhanced granularity, radiation hardness, readout speed and low material budget, the ITk aims to maintain high performance in tracking and data acquisition under the challenging conditions of increased pile-up and radiation.
The final assembly of ITk quad sensor modules involves the integration of a carbon-fiber mechanical wirebond protection element, installed in the wire bond region of the Outer Barrel modules. To support this process, a mechanical wirebond protection tooling developed collaboratively by Japan and CERN is being incorporated into the assembly workflow at LPNHE and other outer barrel assembly sites.
ITK pre-production phase is expected to transition to full production by the end of 2024, data and experience from pre-production will support optimizations in the module production process, enhancing efficiency and refining quality control procedures.

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General information talk

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Conclusion talk

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