7th IDPASC/LIP PhD Students Workshop

Wednesday, July 6, 2022 - Thursday, July 7, 2022

Book of Abstracts

Contents

Scientific session / 1

Cosmic Rays Outreach

Author: Luis Afonso[1]

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Cosmic rays outreach existing practices and their potential are analyzed. It is intended to build innovative means of cosmic rays outreach through participatory design method. Outreach means are developed by LIP cosmic rays researchers, Lousal science center promoters and science center potential users. All participants proposed hypotheses for two museological modules construction one on "Muons" and another on "Muography" and for a web page on "Lousal Muography". Shortly, specific will be formed to refine the initial hypotheses and subsequent construction of the respective prototypes. Participatory design mechanisms, output, outcome, and impact will be evaluated.

Scientific session / 2

Modeling the radiobiological effects of gold nanoparticles in proton therapy of glioblastomas

Author: Joana Antunes[1]

[1] *LIP/FCUL*

Several studies show that the combination of high-Z nanoparticles and external radiotherapy leads to an increased radiation effect in tumoral cells without an increase of the patient dose.
However, it is not yet clear how the sequence of physical, chemical, and biological mechanisms contributes to the observed synergic effect.The objective of this work is to develop simulation tools that allow the analysis and interpretation of radiobiology studies with multifunctional nanoparticles (NPs). To do that, we will develop realistic simulations of the irradiation of monolayer human glioblastomas multiforme (GBM) cell cultures, taking into consideration different concentrations and cellular and subcellular distributions of the gold nanoparticles (AuNPs). The simulations will be implemented based on TOPAS [1] software more specifically the extension TOPASn-Bio [2] that includes models of the physical and chemical processes induced by radiation at the DNA scale.
Several incident beam configurations will be considered (X-rays, Co-60 source and proton beams). So far, simulations of Cobalt-60 irradiation mimicking the one used in the experiments at C2TN were performed.
Based on these simulations, the dose distributions at the subcellular scale were obtained for different AuNPs concentrations. The microdosimetric distributions in cells were used to predict cell survival fractions, using standard mathematical models of the biological effects of radiation as Local Effect Model (LEM) [3] and Microdosimetric Kinetic Model (MKM) [4].
The results obtained in the simulations were compared with the biological in vitro experimental results, and a good agreement between them was verified.

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Scientific session / 3

Dynamics of hadron formation

Author: Mariana Araujo[1]

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The dynamics of hadron formation are still not fully understood due to the complex nature of QCD and the difficulty of studying it through analytical perturbative calculations. Quarkonia are the simplest possible bound states and thus provide the ideal window through which to study this open problem.
Exploiting the large volume of quarkonium data produced at the LHC, we are working, within CMS, to provide a precise measurement of the J/psi polarization, one of the cleanest probes of the quarkonium production mechanism and a challenge to current QCD calculations. At the same time, we are performing a phenomenological study of the existing LHC quarkonium data from ATLAS, CMS and LHCb, which will provide valuable information on the global panorama of quarkonium production and insight into the mechanisms of hadron formation.

Scientific session / 4

N-body simulations of primordial dark matter halos

Author: Joan Bachs Esteban[1]

[1] *CENTRA - IST*

In the standard ΛCDM model, bounded structures would not have formed until the late universe because of the following premises: gravity is the dominant force responsible for matter clustering, and primordial density perturbations follow a nearly scale-invariant spectrum at all scales. Still, it should not be like that in an alternative cosmology. We consider a light scalar field - which can be regarded as dynamical dark energy - and a beyond the SM fermion as our cold dark matter particle. These two species are coupled to each other. If the strength of the coupling is strong enough, the system approaches an attractor solution in which their density parameters and that for radiation remain constant. This scaling solution induces such a rapid growth of the fermionic density perturbations that it quickly becomes nonlinear and may lead to the formation of primordial dark matter halos. To explore whether these structures form, we have modified AX-GADGET, a module of the N-body code P-GADGET3.

Scientific session / 5

Muons acceleration in plasma-based accelerators

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Muon colliders are being currently considered as a next step for HEP [1]. Since muons, as electrons, are fundamental particles, their full energy is available in collisions, in contrast to protons. Nonetheless, the finite mean lifetime of muons (2.2 μs at rest) means that the muons must be collected, cooled, and rapidly accelerated before a significant number of them decay. Plasma accelerators could in principle accelerate muons to relativistic energies much faster than traditional RF accelerators, thereby greatly reducing the loss of muons.
Already well established and studied plasma-based acceleration methods [2,3] are applicable only to particles whose velocities are close to the speed of light (relativistic particles). Heavier particles, e.g.

muons, are thus excluded from the acceleration mechanism. State-of-the-art techniques to sculpt the spatio-temporal spectrum of electromagnetic wave-packets leading to pulses with arbitrary group velocities have been recently developed [4]. These pulses are able to propagate with a subluminal group velocity, making them suitable candidates to drive acceleration wakes for heavier particles.
In this work, we propose a plasma-based acceleration technique for non-relativistic particles using pulses with non-relativistic group velocities and discuss the role of the evolution of these pulses in a plasma on the acceleration. As a first step, we investigated the acceleration using an external field with a non-relativistic group velocity analytically and in 2D particle-in-cell simulations using OSIRIS [5].
Subsequently, the evolution and wakefield properties using optical space-time wave-packet drivers, traveling with group velocities smaller than the speed of light were explored. We have found that these pulses are able to drive plasma wakes that travel slower than the speed of light. If this innovative approach for the acceleration of muons is successful, this work may become a step towards a plasma-based injector for a future muon collider.

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Scientific session / 6

Searching for dark matter with the ATLAS detector using unconventional signatures

Author: Maura Barros[1]

[1] *LIP/Minho University*

The Standard Model (SM) can be considered an effective low-energy expression of a more fundamental theory. There are some observed phenomena not explained by the SM the existence of dark matter (DM) being one of them.
The monotop signature with one top quark and missing transverse energy in the final state can be a powerful probe of specific DM signals. The search for DM can also be done targeting another rare signature, pairs of soft leptons with scattered protons tagged at very small polar angles using the ATLAS Forward Proton tagging detectors (AFP). A search for DM with the ATLAS detector using these unconventional signatures is aimed for.

Scientific session / 7

New Radiobiological and Nanodosimetric Insights into Proton Therapy

Author: João Canhoto[1]

[1] *IST/C2TN*

While the number of patients treated with Proton Therapy (PT) has largely increased, associated and unexpected late effects have been observed over the last few years, which could be related to the uncertainties in the increased relative biological effectiveness (RBE) of protons stopping in organs at risk. The accepted clinical practice is the use of a constant RBE value equal to 1.1, derived from in vitro and in vivo experiments at the early days of PT. However, we now know that this value

disregards experimental evidence that, in fact, RBE is a quantity that depends on many factors, such as dose per fraction, tissue type, Linear Energy Transfer (LET) and biological endpoint.
The main goal of this project is to go beyond the state-of-the-art approach and replace the use of the constant RBE value with a nanodosimetric approach, proving the hypothesis that ionisation detail (ID) at the nanometer scale can predict, better then LET, RBE and microdosimetric quantities, the biological effects associated with proton radiation. ID is a unique nanodosimetric characteristic of ionizing radiation that can be calculated using Monte Carlo Track Structure (MCTS) simulations and measured using a compact gas-based nanodosimeter. To achieve this, we propose to systematically study the frequency of larger ionisation clusters in small target volumes of DNA-size experimentally with low-pressure gas based nanodosimetry and with MCTS simulations (Geant4-DNA/TOPAS-nBio) and correlate them with radiobiological studies.

Scientific session / 8

Probing CP couplings in $\bar{t}t$X production at the Run 3 of the LHC

Author: Esteban Chalbaud[1]

[1] *LIP-Coimbra*

In this talk, we present simplified Dark Matter (DM) models for particle mediators between the Dark Sector and the Standard Model of particle physics. We focus on DM mediators produced in the s-channel together with a top quark pair, which are expected to be within experimental reach of the LHC.
We explore the experimental sensitivity obtained from CP-sensitive variables used in Higgs analyses (e.g. b2 and b4) in the context of DM mediator simplified models. We explore how these variables could be useful for constraining the parity of the mediators coupling with Dark Matter, in the context of a top quark event reconstruction at the parton level. Several mediator spin scenarios and mass scales are studied, compatible with a wide variety of astrophysical scenarios.
Finally, we briefly discuss future approaches to constraining such mediator couplings, using CP-sensitive variables and exploring new observable variables constructed from Parton-level kinematic distributions. We argue for the future employment of Machine Learning techniques and traditional maximum likelihood estimators that could allow probing the CP nature of these DM simplified mediators.

Scientific session / 9

Destructive potential of low-dose proton therapy (LDPT) on neurodegeneration disorders

Author: Carina Coelho[1]

[1] *LIP-Lisboa*

Radiotherapy (RT) is a safe and well-established medical treatment modality, defined by decades of clinical application, used alone or in combination with surgery and/or chemotherapy. It's used especially in cancer treatment, with the aim to destroy tumour growth while minimising damage to the surrounding healthy tissue[1-3]. One of the most important effects of RT, at a cellular level, is the ability to induce DNA damages leading directly or indirectly (through the induction of oxidative stress) to cell death[2,4]. Additionally, this therapy showed some successful results in the treatment of amyloidosis[5,6], a superfamily of chronic degenerative disorders caused by deposits of toxic protein aggregates in cells and tissues, especially regarding extra-cranial amyloidosis[1,2,7,8]. With that in mind researchers started to investigate the use of ionising RT against amyloid pathologies associated with AD[7,8]. Recently, low-dose RT (LDRT), with photons, has shown positive results

on incurable neurodegenerative disorders such as Alzheimer's disease (AD) or Parkinson's disease (PD)[2,8].
Neurodegenerative disorders are the fourth most common cause of death in developed countries, and could surpass cancer by 2040, as predicted by the World Health Organization (WHO)[9]. They have no cure, and current treatments are merely symptomatic.
RT mechanism of action on systemic amyloid deposits is still not well understood[2], and a large amount of uncertainty remains regarding the impact of ionising radiation in the central nervous system[10]. Radiation-induced brain injury is a continuous and dynamic process and the mechanisms of its correspondence with the clinical manifestations are not fully understood[11]. The literature refers that is still necessary a more comprehensive understanding of the molecular and cellular processes underlying radiobiological responses of the brain[10]. The brain's tolerance to RT has been study for human brain tumours, giving privilege to the risk assessment of severe encephalopathy induced by radiation and trying to prove the relevance of parameters such as overall dose, overall treatment time, number and magnitude of dose-fractions[12] but it's also important to consider the volume that is irradiated and the radiation dose rate[11].
The cognitive effects are minimal when compared with the cognitive decline associated with AD and the probability of improving patients quality of life, especially if the total radiation dose is kept low, if we use a fractionated scheme and if critical brain structures are spared[7,12]. The literature suggest that the use of low-dose RT may not induce effects in cognition, cell functioning, DNA and gene expression, apoptosis, or pathological signs and that it can stimulate molecular and cellular protective mechanisms[10]. The use of low-dose RT can reduce amyloid load in the brain while the levels of oxidative stress and neuroinflammation are reduced, influencing cell function and neuronal survival, and helping to maintain cognitive abilities or even improve the cognitive performances of patients in AD advanced stages[2]. It is also important to keep in mind the ability of RT to overcome the blood-brain barrier, which is one of the most limiting factors of many pharmaceutics[2,8].
To improve the beneficial and therapeutic applicability of RT in human specific neurodegenerative conditions there is still a need of more studies to precisely define important factors such as: minimal necessary effective dose, best fractionated scheme, the genetic background-based response, the age-related effects and other possible factors not yet determined[13]. The overall aim of this PhD project is to analyse the destructive potential of low-dose proton therapy (LDPT) on the accumulation of toxic protein aggregates associated with these neurodegeneration disorders. Monte Carlo (MC) simulations will be confronted with experiments on purified amyloidogenic protein solutions and live-cell models of neurodegenerative disorders. Simulations will be validated by state-of-the-art spectroscopy and microscopy methods both in vitro and on cell models of some of these neurodegenerative disorders. The biochemical and biophysical mechanisms underlying the optimal proton therapy conditions for disruption of amyloid deposits will be characterized in close collaboration between LIP/BioISI (FCUL) researchers and the CMAM laboratory (Universidad Autónoma de Madrid - UAM). The results of this multidisciplinary project will lay the groundwork for possible applications of proton therapy on a wide spectrum of neurodegenerative disorders.

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Scientific session / 10

Phase-2 Tracking for ITk based on ACTS and Higgs self-coupling

Author: Luis Coelho[1]

[1] *CERN, LIP-Coimbra*

The reconstruction of trajectories of charged particles is one of the the most complex and CPU consuming stages of event reconstruction in particle physics experiments. At the High Luminosity Large Hadron Collider (HL-LHC), up to 200 proton-proton collisions happen during a single bunch crossing, which leads on average to tens of thousands of particles emerging from the interaction region. Reconstructing the trajectories of track particles is therefore a computational challenge at HL-LHC, motivating the development of more performant track reconstruction algorithms for the LHC experiments. A Common Tracking Software toolkit (ACTS) has been developed based on the track reconstruction algorithms of the ATLAS experiment. This contains a set of algorithms that are agnostic to the details of the detection technologies and magnetic field configuration, which makes it applicable to many different experiments, and are designed for modern computing architectures and multi-threaded event processing. The ATLAS Collaboration has therefore decided to migrate the reconstruction code to use ACTS and directly profit of thread-safety and high-performing software. During my stay at CERN and the rest os my PhD, I will work within the international environment of the ATLAS collaboration on a first Phase-2 track reconstruction prototype based on the ACTS. I will write software using modern C++ standards and carry out R&D on state-of-the-art pattern recognition and track reconstruction algorithms. The proposed thesis also intends to increase our knowledge of the Higgs boson self- coupling and the shape of the Higgs potential, and search for new physics at the CERN Large Hadron Collider within the ATLAS experiment.
The Higgs boson became a prime tool to search for physics beyond the Standard Model (SM). At the current level of precision, the Higgs boson is compatible with SM expectations. A number of open questions indicate the existence of new physics that could be unveiled as we explore the LHC data. A wealth of experimental results from the ATLAS and CMS experiments, probe the region around the minimum of the Higgs potential, or vacuum. But the shape of this potential is not constrained experimentally.
This shape is intimately connected to the breaking of the electroweak gauge symmetry, which resulted in the fundamental forces we experience today. To experimentally constrain this shape we must measure the Higgs boson self-coupling, which is accessible at the LHC through the simultaneous production of two Higgs bosons. This is an extremely rare process that has not yet been observed, and has an expected production rate approximately 1000 times smaller than that for the production of a single Higgs boson. Possible production modes for Higgs boson pairs, HH, at the LHC are gluon- gluon fusion (ggF), vector boson fusion (VBF) and associated production with vector bosons or top quarks. Modifications of the EWSB potential are predicted by several beyond the SM (BSM) theories. Some BSM anomalies on the Higgs boson couplings and interactions could enhance the production rate of Higgs boson pairs by more than one order of magnitude.
The searches for Higgs boson pair production conducted by the ATLAS and CMS collaborations are usually divided into resonant and non-resonant searches. Resonant searches are conducted considering that a new massive intermediate particle is produced, which subsequently decays to pairs of Higgs bosons, creating a distinct peak in the Higgs boson pair invariant mass. For a new heavy particle to decay to a pair of Higgs bosons, it must be either a scalar (spin-0) itself or a massive spin-2 particle to preserve the total angular momentum along the decay axis. Several BSM models with extended Higgs sectors, e.g. MSSM and 2HDM, predict the existence of several Higgs bosons, some areneutral and can mix with the observed 125 GeV Higgs boson.
With this project, I also expect to contribute to enhancing our current knowledge in this important area, focusing on the search for di-Higgs production in VBF HH⟶4b, in both the resonant and non-

resonant channels, which will become one of the most important measurements of the HL-LHC and future colliders. The long-term goal is to measure fundamental properties of the Higgs boson, as a way to explore the SM at a deeper level. Due to a very low HH production cross section, properties such as the trilinear Higgs coupling and the quartic coupling between two Higgs and two weak vector bosons (VVHH) are very difficult to achieve experimentally, in SM-like scenarios.
On the other hand, it is crucial to prepare such measurements in all relevant channels, such as VBF HH. In addition, there are many BSM scenarios, such as the 2HDM model, in which a heavy resonance will result in HH production. So the for HH resonant production in the VBF channel will bring crucial benefits in the development of techniques and expertise needed for the understanding of fundamental properties of the Higgs boson.

Scientific session / 11

Jetography in Heavy Ion Collisions

Author: André Cordeiro[1]

[1] *LIP-Lisbon*

Quantum Chromodynamics (QCD), the theory describing strong interactions, is known to exhibit collective behaviour at high temperature and density, as in the Quark-Gluon Plasma (QGP) - a rapidly expanding, nearly perfect liquid that filled the early universe. Due to its unique properties, the QGP is the main object of study in ultra-relativistic heavy ion colliders, such as RHIC (at Brookhaven National Laboratory) and the LHC (at CERN).
Owing to its short lifetime, on the yoctosecond (10 ^{2} s) scale, the QGP must be studied^{-} ^{4}through probes constructed from the products of the collision, such as jets – clusterings of final state hadrons with a common partonic origin – whose substructure encodes information about the parton cascade unfolding from the hard collision scale (TeV) to the hadronisation scale (MeV).
In this talk, the need for a consistent description of parton interactions with an expanding medium will be motivated in an accessible form.

Scientific session / 12

Astroparticle multi-messenger physics

Author: Pedro Costa[1]

[1] *LIP/IST*

My PhD work focuses primarily on astroparticle multi-messenger physics. Thus far, a particular emphasis has been placed on strategies for expanding the limits of the detection capabilities of ground-based observatories to maximise signal background discrimination efficiency and to encompass more messengers.
More specifically, one of the objectives of my PhD work is to determine whether a gamma-ray observatory located at the Earth's surface is capable of measuring VHE- UHE neutrinos, and its expected performance. This implies the study of highly inclined extensive air showers induced by descending and ascending neutrinos, which are taken as signal events. Conversely, the background is composed of very steep showers induced by cosmic rays. The strategy employed to discriminate between signal and background is based on the balance between the total electromagnetic signal and the total muonic signal registered at the ground.
In addition to this, my PhD work also aims to create and evaluate the performance of new variables in relation to signal-background discrimination efficiency. These analyses entail the simulation of extensive air showers and of the detector response, followed by the parsing of the large amounts of data generated.

Scientific session / 13

Top quark physics and search for physics beyond the Standard Model at the Large Hadron Collider

Author: Giacomo Da Molin[1]

[1] *LIP*

The aim of this PhD thesis is to measure the lepton flavour universality (LFU) in CMS at the Large Hadron Collider (LHC). LHC is a proton-proton collider built in Geneve, where protons collide at about $\sqrt{s}$ = 13 TeV, producing a great amount of data used to study physical processes in detectors such as CMS.
In this presentation, I will present as motivation for my thesis a brief review of some LFU tests in the decays of W: I will describe the discrepancy found by LEP, and the following studies made by ATLAS and CMS. I will then propose my strategy to reduce the uncertainty and produce an high precision LFU test between τ and μ at CMS, exploiting also the new statistics to be provided by Run3.

Scientific session / 14

Using Machine Learning to Scan Beyond Standard Model Parameter Spaces

Author: Fernando Souza[1]

[1] *LIP*

When trying to test models of new physics against experimental results, the customary approach is to simply sample random points from the parameter space of the model, calculate their predicted values for the desired observables and compare them to experimental data. However, due to the typically large number of parameters in these models, this process is highly time consuming and inefficient. We propose a solution to this problem by adopting sampling algorithms which make use of Machine Learning methods in order to improve the efficiency of this validation task. The efficiency and exploratory capacity of these algorithms were tested using the parameter space of the cMSSM and pMSSM models and constrained experimentally by the Higgs mass and Dark Matter relic density. The results show a massive improvement in efficiency with only minor sacrifices in parameter space coverage.

Scientific session / 15

Generalizing models with variations of the fine-structure constant driven by scalar fields: extended Bekenstein model coupled to the dark sector

Author: João Dias[1]

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Seeking for the variation of fundamental constants is a crucial step in our quest to go beyond our standard models of fundamental physics. Implementing such variations in a self-consistent way can be achieved by coupling a scalar field to the theory. In the generalized Bekenstein model the

field is coupled to both dark matter and the cosmological constant, leading to variations of the fine-structure
constant and subsequent EP violations. In this work we constrain this model by treating the full cosmological evolution of the field using a synergy between astrophysical, cosmological, and local measurements. We show that couplings of order unity are excluded, imposing strong restrictions on theoretical frameworks aiming to deal with variations of the fundamental constants.

Scientific session / 16

Searching for new particles with astrophysical compact objects

Author: Etevaldo Filho[1]

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Dark matter remains a central mystery of modern-day science. The elusiveness of dark matter candidates in colliders suggests we further search for its true nature where it was first unveiled
- in astrophysics via its gravitational effects. In particular, the new golden age in strong gravity
- with the gravitational wave era and remarkable new electromagnetic observations of compact objects -
is providing intriguing hints on fuzzy dark matter. Such phenomenological studies start from the construction of appropriate compact objects where such fuzzy dark matter plays a key role, both new types of black holes and horizonless compact objects. The goal of this thesis is to go beyond the simplest fuzzy dark matter models, based on Abelian fields. A dark sector, like the visible one, may contain non-Abelian fields. The impact of such fields on the phenomenology of compact objects, connecting it to gravitational waves and electromagnetic observations, is the central goal of this thesis.
Then, the main goal of this thesis is two-fold: construction of new solutions describing bosonic stars and hairy black holes, to construct new bosonic star solutions, both static and spinning, based on non-Abelian (nA) global or gauge symmetries suggested by simple BSM extensions and study their basic mathematical and physical properties and phenomenology. Also, we intend to study hairy black hole solutions in the same models, which are counterparts of the spinning bosonic stars and the phenomenon of superradiance in this context. In particular, we shall consider models that copy the electroweak sector of the standard model and could thus, be interpreted in that context.

Scientific session / 17

Enhanced Searches with the Pierre Auger Observatory in the Era of Multi-messenger Astrophysics

Author: Alexandra Fernandes[1]

[1] *LIP / University of Minho*

The discovery of ultra-high energy (UHE) photons, whose production is expected through cosmic-ray interactions with the source environment, would allow the identification of the astrophysical sources of UHE cosmic rays and unveil many of the mysteries surrounding their production and propagation. The field of high energy photons has had, in the last year, a couple of exciting findings with detections up to a few PeVs. These detections both motivate the search of higher energy photons, further complete the galactic picture for high energy sources and make future multi-messenger studies that more promising. Above these energies, o photon has ever been detected. Fast radio bursts (FRBs) are mysterious radio signals, typically from extragalactic origin, with energy densities upon emission that are predicted to exceed 104^{2} erg . A theoretical model for FRB emission by a flaring magnetar, also predicts the emission of high energy photons with energies between $10\sim^{12}$-$10^{1}7$ eV. This research work intends to explore the field of high energy photon detection for Eγ >$10^{1}6$ eV to

help to complete the multi-messenger picture of the most powerful accelerators of the galaxy and study the never before assessed association between FRBs and photons with energies higher than 10^16 eV.

Scientific session / 18

Accelerating the ATLAS Trigger system with Graphical Processing Units

Author: Nuno Fernandes[1]

[1] *LIP - IST*

The Large Hadron Collider (LHC) is the highest energy particle accelerator ever built. The High Luminosity LHC Upgrade, expected for the years 2026-2028, will increase the LHC collision rate up to a factor 7 with respect to the nominal values, to allow acquiring a huge amount of data and pushing the limits of our understanding of Nature. The ATLAS experiment, which records the proton and ion collisions produced by the LHC to study the most fundamental matter particles and the forces between them, will need to improve its online event selection system (trigger) to accommodate the estimated increase in the collision rate, which leads to longer event reconstruction times due to the higher density of the events. However, the expected growth in computing power at a fixed cost is slower than the projected increase of the event reconstruction times. Thus, improvements to the algorithmic approach in itself are needed to ensure the trigger continues to perform as expected, in particular by considering the use of hardware accelerators, such as Graphical Processing Units (GPUs) or Field Programmable Gate Arrays (FPGAs), to increase performance in a way that could be more cost-effective than the use of the Central Processing Units (CPUs) that are more commonly employed for most computational tasks.
My work has the goal of demonstrating the feasibility of applying hardware acceleration via GPUs to the calorimeter reconstruction algorithms used within the ATLAS trigger. In particular, my work is focused on the Topological Clustering algorithm, which is used to reconstruct the showers generated by the particles that pass through the calorimeter, and its more GPU-friendly counterpart, Topo-Automaton Clustering. The performance and results of both will be compared, and I will give a brief overview of possible directions for
further improvement.

Scientific session / 19

The Smallest Warm Little Inflaton

Author: Paulo Ferraz[1]

[1] *Universidade de Coimbra*

In this work in progress, we consider a modified version of the Warm Little Inflaton inflationary model by eliminating one of the fields interacting with the inflaton field. At a first instance, this appears to preclude the slow-roll dynamics by introducing large corrections to the slow-roll eta parameter. However, we show that this behaviour is fictitious and, in reality, the temporal average of such corrections describes its true behaviour and slow-roll is possible. Then, we analyse the spectrum of the inflaton perturbations and notice that parametric resonance may occur, leading to an additional particle production mechanism during warm inflation. Finally, we discuss the influence of such a mechanism in the inflaton perturbations and related CMB observables.

Scientific session / 20

Going to the light-front with contour deformations

Author: Eduardo Ferreira[1]

[1] *LIP - IST*

We present a novel method for the calculation of Light-Front Wavefunctions (LFWF) from the hadronic Bethe-Salpeter Wavefunctions.
This problem is of great importance, for example, in the study of hadrons — the particles composed of quarks and gluons described by Quantum Chromodynamics (QCD). The study of hadrons on the light-front allows for the calculation of several hadronic structure functions that encode, for example, the momentum and spin distributions of their constituents, like the parton distribution functions (PDFs) which describe the momentum distribution inside the hadron.
We propose a new method to calculate the valence LFWF for a system of two interacting particles based on the use of contour deformations in the solution of the Bethe-Salpeter equation, combined with analytic continuation methods for projecting of the obtained BSWF onto the light front.
We show that the contour deformation method is capable of handling the introduction of particles of different masses and complex conjugate mass poles in the propagators of the particles. Finally, we go through ways of calculating parton distributions from non-perturbative functional methods.

Scientific session / **21**

The motion of S2

Author: Arianna Foschi[1]

[1] *IST*

The motion of S2, one of the closest star to the Galactic Center, has been largely studied and used to set constraints on the compact object at the center of the Milky Way, which is well established to be a supermassive black hole.
However, the nature of the environment around Sgr A* is still an open issue, leaving the intriguing hypothesis that it is made of dark matter open. In this talk I will present how we can use the astrometric and spectroscopic measurements of S2 to constrain the properties of an ultralight scalar field that has clustered around Sgr A*. I will explain the theoretical model and how we performed the analysis to find the best-fit estimates for the parameters describing a toroidal- shaped scalar field cloud. Finally, I will show some preliminary results.

Scientific session / **22**

Measurement of PeVatrons with the future Southern Wide-field Gamma-ray Observatory (SWGO)

Author: Lucio Gibilisco[1]

[1] *LIP - IST*

The focus of my PhD thesis at LIP is the measurement of PeVatrons with the future Southern Wide-field Gamma-ray Observatory (SWGO), which will have the ability to survey the Galactic centre. Currently, I am working on the exploration of extended air shower characteristics, looking in particular for quantities that can improve SWGO's gamma/hadron separation capabilities, in the effort of reaching a cost-effective solution for SWGO's detector.
The first part of my work led to the definition of the and variables, which quantify the azimuthal fluctuations of the shower footprint at the ground.
The first promising results show that these variables have a discrimination power similar to the one that can be obtained by counting the muons at the ground. Their usage will be tested with real data

from LHAASO and Auger and their capability of measuring the shower mass composition will be explored.

Scientific session / 23

Muography for Underground Geological Surveys: ongoing application at the Lousal Mine (Portugal)

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The LouMu Project is an ongoing collaboration between the Laboratory of Instrumentation and Experimental Particle Physics (LIP), the Institute of Earth Sciences (ICT) – University of Évora and the Lousal Ciência Viva Center which is evaluating the muography potential in the Lousal Mine, with the general aim to create the conditions to use muography as a novel method for geophysical surveys in Portugal.
The use of muons for geophysical surveys has been proved successful in numerous projects around the planet. Muon detection in underground environments is protected from the background radiation measured on the surface, but the number of muons arriving far depths is much lower. Geological and underground conditions should be considered when defining the required exposure time and developing suitable muon telescopes for the observation.
The Lousal Mine (Iberian Pyrite Belt) was exploited until 1988 and is presently an excellent European example of environmental rehabilitation and social improvement based on museum, scientific and educational activities. The observations are done from the Waldemar mine gallery, about 18 m below the surface. The telescopes, developed by LIP, use robust RPC detectors to observe the crossing muons in real time. The aim is to do a first geological survey of the region with muography, mapping already known structures and ore lenses and measuring their densities. The new data will then be used to improve the existing information, but the full process also serves to test the performance of the muon telescope and of the muography analysis tools.
A reference 3D model is being created by joining pre-existing geological and geophysical information and new measurements, done namely with seismic refraction and Ground Penetrating Radar (GPR). This model provides a reference against which to compare the muography results. Ideally, muography could be used to produce an equivalent 3D map of densities. This reference 3D model constructed with independent methods will be used to cross-check the muography results.

Scientific session / 24

RADIATION HARDNESS OF PLASTIC SCINTILLATING MATERIALS FOR SCINTILLATOR CALORIMETERS

Author: Rudnei Machado [1]

[1] *LIP*

Plastic scintillators are currently one of the most economical commercial options for use in particle detection. They are characterized by producing scintillation (detectable photons in the visible part of the light spectrum) when struck by a photon or charged particle. They also have as important characteristics an extremely fast light signal and a high light response. Scintillator plastics are widely used in various fields of science, such as high-energy physics, medicine, dosimetry, and others. Plastic scintillators have a natural material degradation, accentuated when subjected to radiation environments, so materials that are more resistant to radiation play an important role in all these applications. In this sense, PEN (Polyethylene Naphthalate) and PET (Polyethylene Terephthalate) may be one of the options for new scintillator materials, since preliminary studies indicate that PET appears to have more resistance to radiation, while PEN presents a higher light response compared to PET. Another point of great relevance is that PET and PEN scintillate without the need to use dopants. In this context, research on the feasibility of PEN/PET as a development base for new scintillator plastics is pertinent. This study aims at R&D of new scintillating materials based on PET and PEN, as well as composite blends of PET/PEN, aiming to select the blend that results in a higher luminous yield through optical characterization of the produced samples. Initially, samples of blends of PEN, PET, and PEN/PET in various proportions will be produced at the Institute of Polymers and Composites (IPC) of the University of Minho. Subsequently, these samples will be characterized at the Laboratory of Optics and Scintillating Materials (LOMaC) of LIP. In the next step, larger plates will be produced, allowing a more complete characterization of the samples. In this presentation the first results of the light response for PEN and PET samples developed at IPC will be presented. The next steps of this study will also be discussed.

Scientific session / 25

Tweaking gravity

Author: Tiago Gonçalves[1]

[1] *IA-U.Lisboa*

I explore the modified gravity theory which goes by the name of f(R,T) gravity, and study possible cosmological background evolutions and sudden singularities, as well, as constraints from big bang nucleosynthesis.

Scientific session / 26

Extending the SMEFT

The lack of evidence of new physics so far leads us to pursue the model-independent approach encoded in the Standard Model Effective Field Theory (SMEFT). In this talk I will go
over certain directions in which to extend our predictions within the SMEFT. Firstly by considering the contribution of dimension-8 terms; these terms are important not only from the experimental point of view, since certain observables receive their main contribution at this order, but also because dimension-8 Wilson coefficients are the first ones on which purely theoretical bounds can be placed. Furthermore, we consider the extension of the SMEFT with an extra light pseudo-scalar, a motivated scenario within composite Higgs models. Finally, we use the SMEFT approach to connect experimental results with particular Standard Model extensions by classifying models which can

generate the effective operators possibly responsible for the anomalous magnetic moment of the muon.

Scientific session / 28

Scintillation dosimetry with plastic optical fibres

Author: Duarte Guerreiro[1]

[1] *LIP*

Radiobiology is a multidisciplinary area where the effects of radiation in cells, tissues and organs are studied. To understand the biological effects of radiation it's important to have a measurement of the energy deposition at the micro or even nano-scale. This project is focused in the development of a detector that offers radiobiology researchers the possibility to achieve real-time dose measurement at the submillimiter scale. The technique chosen resorts to scintillation dosimetry with plastic optical fibres. The optical fibres offer a very good spatial resolution down to 0.25 mm and good tissue equivalence. The detector is built as an irradiation box with a sensitive area composed of an array of plastic optical fibres with the possibility of mapping the dose in one plane or in two orthogonal planes with a spatial resolution of 1×1 mm2, 0.5×0.5 mm2 and 0.25×0.25 mm2 depending on the optical fibres used.

Scientific session / 29

Diluting quark flavor hierarchies using dihedral symmetry

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We present a D4 flavored extension of the SM which provides an intuitive reasoning for the masses and mixing patterns in the quark sector. In our model, the Cabibbo mixing angle becomes related to the ratio of two vacuum expectation values. In fact, the orders of magnitude of the CKM matrix elements are readily obtained from the hierarchical nature of the vacuum expectation values. Moreover, we also show that the smallness of the off-Cabibbo elements in the CKM matrix is strongly connected to the heaviness of the third generation of quarks.

Scientific session / 30

Implementation of a portable PET scanner for proton therapy beam quality assessment

Author: Catarina Magalhães[1]

[1] *I3N/University of Aveiro*

In Proton Therapy (PT), the highly conformal dose irradiation of the tumors makes this technique very powerful, resulting in better treatment outcomes, survival rates, and overall quality of life for cancer patients. However, the characteristics of the depth-dose profile (Bragg-Peak) demands for an extremely precise beam control since the dose profile is much more sensitive to spatial uncertainties than in conventional radiotherapy, potentially delivering unwanted doses to healthy tissues if the treatment is unproperly planned and controlled. Therefore, it is mandatory to measure the beam profile during PT quality control and treatment procedures. Several imaging techniques have been proposed to that purpose based on secondary particle detection originated from the interaction of the beam particles in the tissues. One of the most promising ones is Positron Emission Tomography (PET) which is being widely studied for clinical practice and real-time assessment of beam interaction in the body. EasyPET is a cost-effective benchtop PET system using an innovative and patented acquisition method, with a spatial resolution of less than 1 mm. Its major advantages are its high compactness and portability, contrary to typically bulky PET scanners, allowing the mobility and integration in different Proton Therapy Centers (PTC) locations. This work aims to develop a benchtop, portable, and high-performance PET prototype based on easyPET technology for 3D quality assessment of proton beam delivery in PTCs.
In this talk an introduction to the framework of the phD project will be presented, as well as its state of the art and work plan. The project is being developed in collaboration with the Center for Proton Therapy at the Paul Scherrer Institute (PSI – Switzerland).

Keywords: Positron Emission Tomography, easyPET, Proton Therapy, proton beam quality control, range uncertainties.

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Scientific session / 31

Proton Therapy - Bragg Peak monitoring through Prompt-Gamma: Detection and Instrumentation

Author: José Venâncio[1]

[1] *LIP*

Radiotherapy, one of the techniques used to treat cancer, can be divided into conventional (gamma and electrons) and particle or ion beam therapy. The latter, realized mainly with protons or carbon nuclei, has been highly anticipated due to its dose deposition profile with a monoenergetic beam characterized by a high deposition region at a particular depth - the Bragg Peak.
Dose deposition profile affects the risk to the surrounding healthy tissues and the existence of a Bragg Peak allows to increase the dose in the target region, whilst minimizing the dose to surrounding healthy tissues, reducing the risk of the technique.
There are advantages and disadvantages in the use of protons or carbon nuclei. The lateral spreading and straggling are more influent in lighter ions, such as protons, but in heavier ions, like carbon, we have a high Linear Energy Transfer (LET) which does more biological damage. Also, we see the presence of a tail after the Bragg Peak due to nuclear interactions which cause fragmentation. For that reason, we need better shielding and technical components in the hardware used in those treatments, which increases the final price when using heavy ions in this type of therapy.
In a typical treatment with this kind of therapy, a multienergetic beam is used and we will have a Spread-Out Bragg Peak (SOBP) instead of the typical Bragg Peak. The control and monitoring of the Bragg Peak location can further increase the precision of the treatment. One way to perform this monitoring is to measure the prompt-gamma detected perpendicular to the incident proton beam. The prompt-gamma detection in the orthogonal direction to the proton beam allows a more precise determination of the position of the Bragg Peak. For that purpose, a detector with a GSO scintillator crystal connected to a SiPM is being studied. A set of blades in front of the sensor will act as a collimator to ensure that only perpendicular photons to the sensor are detected. Currently SiPM

coupled to GSO crystals time and amplitude response are being studied to design a data acquisition (DAQ) for the full prototype with a number of sensors in the order of magnitude of 100.

Scientific session / 32

Higgs-Dilaton inflation in Einstein-Cartan gravity

Author: Matteo Piani[1]

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We study the phenomenology of the Higgs-Dilaton model in the context of EinsteinCartan gravity, focusing on the separate impact of the Holst and Nieh-Yan terms on the inflationary observables. Using analytical and numerical techniques, we show the predictions of these scenarios to display an attractor-like behavior intrinsically related to the curvature of the field-space manifold in the metric formulation of the theory. Beyond that, the analysis of the Nieh-Yan case reveals the existence of an additional attractor solution induced by a cubic pole in the inflaton kinetic term that becomes relevant at large dilaton couplings. This constitutes a unique feature of the Einstein-Cartan formulation as compared to the metric and Palatini counterparts.

Scientific session / 33

Radiation damage of the optical components in Scintillator Detector: from the ATLAS/LHC Tile Calorimeter to future experiments

Author: Beatriz Pereira[1]

[1] *LIP*

TileCal, a sampling hadronic calorimeter, is an essential component of the ATLAS detector at the LHC. The active material, made of plastic scintillating tiles, produces light when traversed by ionising particles. The light is transmitted to photomultiplier tubes by wavelength shifting fibres.
The High Luminosity-LHC (HL-LHC) program will extend the TileCal lifetime for 20 years more than originally designed. The detector performance is affected by the increased exposure to radiation that will degrade the TileCal optics and by natural ageing. Since the TileCal's optical components cannot be replaced, their radiation hardness must be evaluated with precision. In addition, the experience gained with a real detector under harsh radiation conditions for long time and the search for new material more capable to handle the radiation will be invaluable for the design of future detectors at FCC or other detectors.
Keywords: LHC, ATLAS, TileCal, Radiation Hardness, Scintillator Detector

Scientific session / 34

Central Exclusive Production at the LHC within the CMS Collaboration

Author: Matteo Pisano[1]

[1] *LIP*

The Large Hadron Collider (LHC) is a circular particle accelerator located in Geneva (Switzerland). The aim of the accelerator is boosting a beam of protons up to an energy of 6.5 TeV. Subsequently, protons are forced to collide, generating a collection of particles. These particles will interact with a detector located around the interaction point and their kinematic quantities will be measured. The study of the products of the collision can give us relevant information about the
nature of the interaction.
In this seminary, the speaker will give an overview about the so called 'central exclusive production processes' (CEP). In such events, the incoming protons interact without dissociating: as a result of the interaction, protons result deflected from the beam-line and lose energy. The energy lost is used to create a new system of particles in the final state. Therefore, the final state is composed by two protons, slightly deflected from the beam line, and a set of extra particles. In the studies reported, the protons are measured by the Precision Proton Spectrometer (PPS) while the system of extra particles is measured by the Compact Muon Solenoid (CMS).
The seminary will focus on two particular processes: the CEP of quark top-anti/top pairs and of tau-anti/tau pairs. The first study has already been published, while the second one is ongoing.

Scientific session / 35

Polarimeric Studies of Galaxies

Author: João Rino-Silvestre[1]

[1] *CENTRA/IST*

Dust grains are key ingredients in understanding the interstellar medium (ISM) and the largest effects of dust on astronomical observations, the extinction of light in the line of sight and the wavelength dependent reddening it causes, both affecting distance measurements for cosmology when using extragalactic sources such as supernovae. The shape, orientation and distribution of the dust grains may also polarize light as it traverses the ISM. A comprehensive polarization study of galaxies that hosted supernovae is thus justified.
I will describe the reduction steps undertaken to calculate the Stoke parameters in order to yield more reliable and less biased polarimetric estimates. I will then discuss the results obtained from applying this methodology to an ensemble of multi-band polarimetric maps of galaxies observed with VLT's FORS2.

Scientific session / 36

Development of microdosimetric detectors for radiobiology in hadron therapy facilities

Author: Cristiana Rodrigues[1]

[1] *LIP*

The ability to measure the radiation effects on healthy and tumorous tissue at the microscale is essential and still presents a huge challenge. There are some instruments that can make such measurements, but most of these are bigger than the size of a cell, and the measured dose is integrated over a small volume. These instruments are unable to produce microscopic descriptions about how the energy is being distributed on the cells by knock-on electrons and other secondary particles. The development of materials able to describe the particles' interactions at the microscale, namely the interactions of hadrons used in cancer treatment, is the scope of this thesis. Based on micrometric Scintillating Plastic Optical Fibers (SPOF) it is proposed the development of micrometric active dosimeters. Using electrospinning technology, the production of micrometric SPOF two orders of magnitude smaller than those commercially available is now possible. With this dosimeter, the real-time detection of the energy distribution at the cell level can be a reality. We foresee the fabrication procedure's optimization, particularly to achieve the best mechanical properties required to have orderly aligned structures, able to be layered, and produce volumes with tenths of μm (cross-section), able to be read by standard photodetectors. Corundum crystals (Al2O3) have been used to produce passive dosimeters that achieve a more detailed description of the particle's energy deposition. This is a consequence of using specific dopants in the crystals. We aim to use the flux method and carbon and magnesium doping to produce FNTD (fluorescent neutral tracking detectors) dosimeters. The optimization of their characteristics for low mass particles and neutrons could be attained by changing the doping elements. The use of GEANT4/TOPAS simulation will be an essential tool to track the experimental developments and produce the adequate translation of the experimental data into physical quantities.

Scientific session / 37

Shadows of Kerr black holes with Proca hair

Author: Ivo Sengo[1]

[1] *University of Aveiro*

We report the results of the first comprehensive study on the shadows of fundamental Kerr black holes with Proca hair. Some of these solutions show striking non-Kerr features, such as chaotic patterns, non-smooth shadow edges, and ghost shadows. We illustrate how fundamental photon orbits can help us understand some of these features. Nonetheless, a wide range of solutions where deviations from Kerr are small can also be found, which allow us to constrain the amount of hair compatible with the Event Horizon Telescope data.

Scientific session / 38

A next-generation gamma-ray observatory powered by Machine Learning techniques

Author: Borja Gonzalez[1]

[1] *LIP/IST*

The Southern Wide-field Gamma-ray Observatory (SWGO) is the next generation ground-based gamma-ray observatory to survey the Southern hemisphere sky. The experiment, currently in an R&D phase, is expected to have a large array of the order of a few km2 composed of water Cherenkov detectors (WCDs) placed at a high altitude (4.4 km a.s.l. or higher) in South America.
Such an ambitious project requires the design of a high-performance and cost effective WCD able to cope with the observatory needs, particularly the capability to identify shower muons, essential to ensure an excellent gamma/hadron discrimination. Several detector concepts are currently being considered in the SWGO Collaboration. At LIP, we are exploring an innovative WCD concept with reduced surface area and height comprising three PMTs whose signals are analysed by Machine learning techniques. In this talk, a general overview of the SWGO Observatory will be given. Later, I will show that with this method it is possible to achieve an excellent gamma/hadron discrimination and muon counting. Therefore, the proposed WCDs would highly boost the physics capabilities of SWGO, enabling it to cover, with a wide field of view, a wide energy range, from low energies (~ 100 GeV) up to the PeV region.

Scientific session / 39

Towards a yoctosecond imaging tool of the Quark-Gluon Plasma

Author: João Martins Silva[None]

Jets are abundantly produced in collider experiments and they allow for stringent tests of QCD, given that their evolution spans a wide range of scales - from the initial hard scale of the collision to the hadronic scale at which they are detected. When jets are produced in the presence of the Quark-Gluon Plasma which they propagate through, as in heavy ion collisions, this range of scales allows them to be sensitive to the QGP at different timescales. My PhD research aims to endow jets produced in heavy-ion collisions with the ability to serve as yoctosecond-resolution probes of the QGP time evolution.
As a first step towards this goal, an exploration of the Q_{AA}, an observable based on matching probability quantiles between jet transverse momentum (p_T) spectra, is made. This observable is a proxy for medium-induced jet energy loss as a function of p_T and presents an alternative to jet modification studies that compare jet properties in heavy-ion and in proton-proton collisions at the same reconstructed p_T. Its advantage lies in it significantly mitigating biases caused by migration of jets from higher to lower transverse momentum, an effect inevitably convoluted with usual studies. By deconvoluting this effect, conclusions about energy loss mechanisms lie on more firm ground. This presentation goes through an analysis of the behaviour of the Q_{AA} with jet radius and how this behaviour is changed when one includes medium response, an integral part of the measured jet whose importance is non-negligible in jet quenching studies.

Scientific session / 40

Measurement of Collider Neutrinos with the SND@LHC Experiment

Author: Guilherme Soares[1]

[1] *LIP*

Neutrinos are produced abundantly at colliders, still collider neutrinos have yet to be detected. The LHC will deliver the highest energies yet of man-made neutrinos, and their detection will be a milestone. This will be achieved at the SND@LHC experiment, which is located 480 meters away from the ATLAS interaction point, near the beam line direction.
The experiment is up and running for the duration of Run3 of the LHC, and features technology from LIP in the Muon Detector system. However, it was assembled last year with a very tight schedule and is currently in the process of commissioning. Due to the aforementioned connection to LIP, the Muon System commissioning is of high interest, and we are currently performing timing corrections in order to meet the stringent timing requirements in order to detect neutrinos. The experiment will be followed throughout, with participation in data taking and analysis towards the first ever observation of collider muon neutrinos, with energies of over 100 GeV.

Scientific session / 41

Double pulse generator for discharge plasmas for particle accelerators

Author: Nuno Torrado[1]

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The AWAKE experiment, running at CERN, investigates particle acceleration in plasma wakefield [1]. Since the current plasma source (10 m long and created in a rubidium vapour by laser field ionization [2]) is applicable only to a limited length, new scalable technologies are being developed, namely a helicon plasma source [3] and direct current gas discharges. The latter is a method that rapidly ignites the plasma and further heats it by applying a current between two electrodes immersed in the gas, inside a glass tube.
To produce the required plasma discharges, a high-power double pulse generator was designed and tested using a 5 m plasma cell setup [4]. The first pulse uses up to 120 kV to ignite the plasma into a relatively low current arc (10 A). The reduction in impedance allows the second pulse to increase the arc current up to 400 A using a lower voltage (up to 10 kV). This raises the ionisation fraction of the plasma to the AWAKE required density range [5]. The scalability is possible due to magnetic circuits (composed of common-mode chokes) that guarantee synchronization of discharges and current uniformity across multiple series tubes with shared electrodes.
In this presentation, I will describe the electrical components of the plasma source and the experimental results obtained from the double pulse generator and the current balancing magnetic circuit.

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Scientific session / 42

Pentaquarks in a Bethe-Salpeter approach

Author: Luis Raul Torres Rojas[1]

[1] *LIP*

In the past two decades there has been tremendous progress in the theoretical and experimental investigation of multiquark states, which has expanded our understanding of what a "hadron" is. Experimental evidence suggests that Nature does not only form "conventional" hadrons such as mesons as quark-antiquark states and baryons as three-quark states, but also more exotic combinations such as tetraquarks and pentaquarks.
From the hadronic point of view, pentaquarks can look like molecules of mesons and baryons, bound states below thresholds, but at the same time they are unstable resonances above other thresholds. How does a molecular picture then arise from the fundamental interactions between five quarks? And how can one distinguish a conventional baryon, which is made of three valence quarks, from a pentaquark with an additional quark-antiquark pair?
The goal of my PhD project is to answer these questions and calculate the properties of pentaquarks in QCD using nonperturbative functional methods, in particular the combination of Dyson-Schwinger equations (DSEs) and Bethe-Salpeter equations (BSEs).

Scientific session / 43

Searches For Higgs Boson Pair Production In Final States With Two Bottom Quarks And Two Tau Leptons At The LHC

Author: Johan Wulff[1]

[1] *LIP*

The large hadron collider (LHC) is a particle accelerator located inside a 27 km circular tunnel near Geneva, Switzerland, primarily built to shed light on the nature of the electroweak symmetry breaking and to examine the mathematical consistency of the standard model (SM) of particle physics at energies above 1 TeV [1]. The two beams of relativistic protons accelerated in the tunnel of the LHC are crossed at 4 locations, one of which is surrounded by the compact muon solenoid (CMS), a multi-purpose detector primarily optimised for muon identification as well as momentum and energy resolution of charged particles [2].
The detection of the Higgs boson by the Atlas and CMS collaborations in 2012 [3, 4] marked the fulfilment of one of the major science goals of the LHC. With the mass of the Higgs determined at 125 GeV, the structure of the Higgs scalar field potential can be calculated precisely within the SM. This theoretical prediction can be compared to experimental results through the measurement of the Higgs pair production cross section, which in turn allows the calculation of the structure of the Higgs scalar field potential [5]. In this contribution, the speaker will present the approaches for both resonant and non-resonant Higgs boson pair production searches with the CMS detector and discuss the possible application of machine-learning methods to the event selection and classification.

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Scientific session / **47**

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Scientific session / **48**

Disentangling and Quantifying the Quark Gluon Plasma with Generative Deep Learning

In heavy-ion collisions in RHIC and at the LHC a nearly perfect fluid state of matter is generated, the QGP, expanding to the surrounding detector in a very short timescale. Jets, collimated sprays of hadrons reconstructed by some clustering algorithm, are very well understood in the absence of this dense medium and are, not only for this reason, amongst the prime tools to study this state of matter. A jet starts as a single parton, with very high virtuality, emerging from a hard scattering in the collision. This parton relaxes its virtuality by fragmenting into more and more partons until these reach the hadronization scale and arrive at the detector, as a spray of color singlets. When the QGP is present this fragmentation is modified, either by extra radiation induced by the extreme color field. either by elastic collisions with the constituents of this medium, which broaden the momenta distribution of the jet. The study of these modifications is the study of Jet Quenching, where we attempt to use the jet as hard probe that transverses the medium to study some of its properties.

Scientific session / 49

Testing Unified Dark matter-energy models in the non-linear regime

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In this talk I will present the work of testing, for the first time, a Unified Dark Matter-Energy model in the non-linear regime. Starting from a linear implementation, which includes a non linear effect named backreaction, in the Boltzmann code CLASS of a UDM Chaplygin Gas model tested against weak lensing, CMB, Sne IA and BAO, we focus on a simpler UDM model lagrangian to be implemented as a first test in an N-Body DM simulation code. I will present a spherical solution for the model as a test in the non-linear regime and the ongoing work in the implementation of the model in the N-Body code.

Scientific session / 50

The ATLAS jet trigger and the search for CP violation in WH production

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The ATLAS jet trigger and the search for CP violation in WH production

Author: Ricardo Barrué[1]

[1] *LIP*

In this talk I will briefly present some of the highlights of my PhD work so far. In the first part, I will introduce the main upgrade done in the ATLAS jet trigger in view of the Run 3 of the LHC and several of the studies done to ensure its readiness and optimal performance. On the second part, I will describe my ongoing work on the optimization of the search for CP violation in the HWW interaction via WH production, including the use of statistical techniques to benchmark different observables and the introduction of multivariate methods to reconstruct (statistically) optimal observables

Summary & Farewell / 52

Summary

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