First Pan-African Astro-Particle and Collider Physics Workshop

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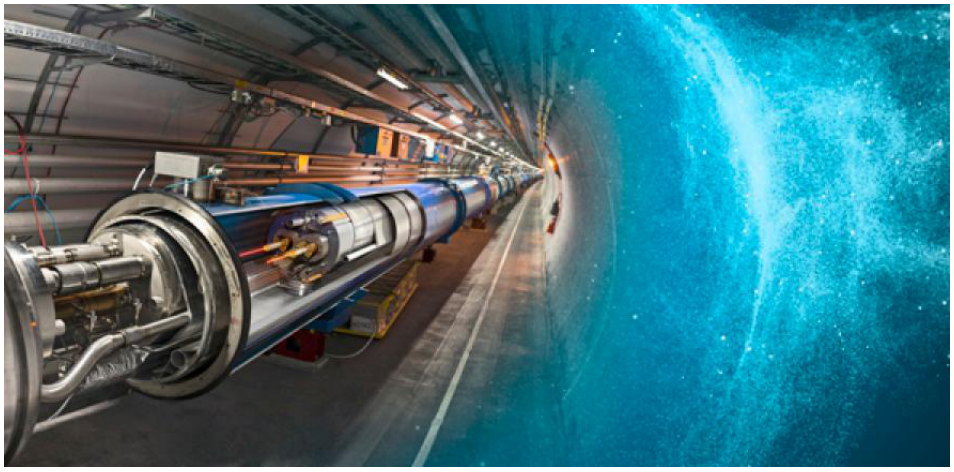

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Parallel Session II / 1

Laser-assisted processes beyond the standard model

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In this work, we have theoretically studied the neutral Higgs pair production in Two Higgs Doublet Model (THDM) in the presence of a circularly polarized laser field. The laser-assisted differential partial cross section is derived in the centre of mass frame at the leading order including Z diagram. The total cross section is computed numerically by integrating the differential cross section over the solid angle dΩ. Two benchmark points are discussed for the THDM parameters. In the first step, we have analyzed the total cross section of e+e− ⟶ h0A0 by considering H 0 as the standard model-like Higgs boson. Then, the process e+e− ⟶ H0A0 is studied by taking h0 as the Higgs boson of the standard model. For both benchmark points, the laser-assisted total cross section of the studied processes depends on the produced neutral Higgs masses, the centre of mass energy and the laser field parameters. In addition, the maximum cross section occurs at high centre of mass energy for the process e+e− ⟶ H0A0 as compared to that of e+e− ⟶ h0A0 .

Parallel Session II / 2

Overview on laser-assisted decay processes

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This work focuses on the controversial debate that has arisen over the last two decades about the possibility that the electromagnetic field affects the lifetime or decay width of an unstable particle. In this presentation, we highlight the possible effect of the electromagnetic field on the decay of particles through the theoretical study of some decay processes such as those of the pi (pion) meson and the intermediate vector bosons W and Z in the presence of an electromagnetic field. Expressions for the decay width and lifetime in the presence of the field have been derived in the framework of the standard electroweak model. The numerical results obtained are presented and discussed.

Parallel Session I, Astro-Particle / 5

T2K Status and Plans

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T2K is a long baseline experiment providing world-leading measurements of the parameters governing neutrino oscillation.

T2K data enable first 3sigma exclusion for some intervals of the CP-violating phase δ_{CP} and precision measurements of the atmospheric parameters Δm^2_{32}, $\sin^2(\theta_{23})$.
T2K exploits a beam of muon neutrinos and antineutrinos at the Japan Particle Accelerator Research Centre (JPARC) and it measures oscillations by comparing neutrino rates and spectra
at a near detector complex, located at JPARC, and at the water-cherencov detector SuperKamiokande, located 295 Km away.
The T2K beam will be upgraded with increased power in 2022 and an upgrade of the ND280 near detector, located 2.5 degrees off-axis, is being assembled to exploits the increased statistics.
Moreover the SuperKamiokande detector has been loaded with 0.01% of Gadolinium in 2020, enabling enhanced neutron tagging.
In preparation for the exploitation of such data, the T2K collaboration is working on an updated oscillation analysis to improve the control of systematic uncertainties
A new beam tuning has been developed, based on an improved NA61/SHINE measurement on a copy of the T2K target and including a refined modeling of the beam line materials.
New selections at ND280, with proton and photon tagging, and at Super Kamiokande, extending pion tagging to muon neutrino samples, have been developed.
After reviewing the latest measurements of oscillation parameters, the status of such new developments and the plan to deploy the beam and ND280 upgrade will be presented.

Parallel Session V, Collider - Experiment / 6

The use of GANs in the search for new resonances at the LHC using semi-supervised machine learning techniques

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In the search for new physics, beyond the standard model, the use of semi-supervised machine learning techniques provides a methodology to extract signal processes while minimizing potential biases caused by prior understanding. When using semi-supervised techniques in the training of machine learning models, over-training can lead to background events incorrectly being labeled as signal events. The extent of false signals generated must therefore be quantified before semi-supervised techniques can be used in resonance searches.

In searches for resonances within a given mass range, the significance of observing a local excess of events, must consider the probability of observing the excess elsewhere within the range. This is known as the “look elsewhere effect” and must be controlled for resonance searches. The semi-supervised technique has additional “look elsewhere effects” which need to be calculated. Generative adversarial networks are used in conjunction with Monte Carlo event generation to produce scalable datasets while minimizing inefficiencies in event weighting. The Wasserstein GAN with gradient penalty is evaluated in the expansion and un-weighting of Z⊠ Monte Carlo data in order to calculate the “look elsewhere effect” within the semi-supervised studies.

Parallel Session VI, Instrumentation / 7

The development of Strontium-90 Tile scanning table for TileCal at the ATLAS experiment

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During Phase I upgrade of the Tile Calorimeter of the ATLAS experiment, the characterization and qualification of assembled E3 and E4 scintillator counters (Crack) was conducted through manual scans using a strontium-90 radioactive source and a small scanbox containing a photomultiplier tube. The Crack counter, clear optical fiber cable and connections were exposed making transmitted scintillation light vulnerable to contamination by external light. This necessitated the development of an automated scanning system and appropriate size of scanbox to allow housing of all components. The one-coordinate positioning system of the scanner is driven by a powerful 103H5210-5240 Bipolar Stepper Motor. The motor is controlled by an X-NUCLEO-IHM02A1 two-axis stepper motor driver expansion board based on the L6470 component, which is plugged onto the Arduino Uno R3 microcontroller to enable correct functionality. The boards are accessible via a ttyACM0 serial port using a Universal Serial Bus cable connection and a software to control the movement and data acquisition. The new scanning box will be employed after Run 3 of the Large Hadron Collider.

Parallel Session IV, Collider / 8

The Production of a Singlet Scalar at Future e+ e- Colliders

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Motivated by the multi-lepton anomalies, a search for narrow resonances with $S \to \gamma\gamma$, $Z\gamma$ in association with light jets, b-jets or missing transverse energy was reported in the paper arXiv:2109.02650. The maximum local (global) significance is achieved for $m_S = 151.5$\,GeV with 5.1σ (4.8σ). In this paper we compute the production cross-section of this scalar candidate in e^+e^- collision by assuming that the couplings to Electro-Weak bosons are loop induced. We find that the cross-section could be large enough for S to be detected at future e^+e^- colliders. The leading production mechanism is $e^+e^- \to Z^\star \to S\gamma$, which offers the opportunity of isolating S through the missing mass method.

Parallel Session IV, Collider / 9

the Mu2e experiment

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The Mu2e experiment at Fermi National Accelerator Laboratory (Batavia, Illinois, USA) searches for the charged-lepton flavor violating neutrino-less conversion of a negative muon into an electron in the field of an aluminum nucleus. The dynamics of such a process is well modelled by a two-body decay, resulting in a mono-energetic electron with energy slightly below the muon rest mass (104.967 MeV). Mu2e will reach a single event sensitivity of about 3x10−17 that corresponds to four

orders of magnitude improvement with respect to the current best limit. We will describe the physics motivations, the underlying experimental technique and the experiment construction status.

Parallel Session I, Astro-Particle / 10

Deflection angle of light rays by accelerating black holes with cosmological constant

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Using the Gauss-Bonnet formalism, the deflection angle of light rays by accelerating black holes is computed and investigated. The effect of the accelerating parameter is inspected. Then, the influence of the cosmological effect is also discussed.

Parallel Session I, Astro-Particle / 12

Thermodynamic of black holes in a cavity from shadow formalism

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Using the Hamilton-Jacobi formalism, we investigate the shadow behaviors of the black holes in a cavity. We approach such behaviors from the thermodynamic quantities. Among others, we establish a possible interplay between the thermodynamic and shadow aspects of such balck hole solutions.

Parallel Session V, Collider - Experiment / 13

Searches for heavy scalar resonance through hadronic jet reconstruction at electron-proton colliders

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A search for the CP-even scalar H in a SM + real singlet scalar field ϕ_H model is presented. A proposed high energy Future Circular Hadron-Electron Collider (FCC - LheC) would provide sufficient energy in a clean environment to probe the heavy scalar H resonance, $m_H \approx 270$ GeV in deep

inelastic scattering (DIS) charged current (CC) and neutral current (NC) process.
Here we investigate the decay of the heavy Higgs like scalar $H \to WW^*$ in DIS electron-proton collision with an integrated luminosity of 1.0 ab^{-1} and centre of mass energy of $\sqrt{s} = 1.3(1.8)$ TeV at FCC-LHeC.
We estimate the likelihood of detecting a resonance signal of H from its final state jets by imposing cut based and machine learning optimization methods to select candidate jet pairs and reconstruct the mass of H.

Parallel Session VI, Instrumentation / 14

Response of gap/crack scintillators of the Tile Calorimeter of the ATLAS detector to isolated muons from $W \to \mu\nu$ events.

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The ATLAS Tile Calorimeter is a hadronic sampling calorimeter that plays a major role in jet energy scale measurements. Accurate reconstruction of jets a vital role for precision measurements of the Standard Model and for searches of physics beyond the Standard Model.The jet energy scale is measured assuming uniformity of response in the azimuthal direction of both the Liquid Argon and Tile calorimeters. In this study, the response of the gap/crack scintillators of Tile calorimeter is measured using isolated muons from $W \to \mu\nu$ events. The response of the scintillating cells is quantified by measuring the amount of energy deposited per unit length in both data and Monte Carlo simulation to evaluate the response uniformity over the azimuthal direction.

Parallel Session V, Collider - Experiment / 15

Search for Higgs boson pair production in the bbWW* channel with the ATLAS detector

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Search for resonant Higgs boson pair production, where one Higgs boson decays to bb and the other to WW, using the full Run 2 data of proton-proton collisions collected at a center-of-mass energy of 13 TeV with the ATLAS detector. The trilinear coupling leads to non-resonant pair production of Higgs bosons, where an off-shell Higgs decays to a pair of Higgs bosons. Physics beyond the SM can manifest in the resonant production of new particles that decay into a pair of SM Higgs bosons. This study is potentially sensitive to cases where the decaying particle is a scalar, as in the MSSM and 2HDM models, or a spin-2 graviton, as in Randall–Sundrum models.

Parallel Session V, Collider - Experiment / 16

The Use of a Variational Autoencoder in the Search for Resonances at the LHC

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The Standard Model (SM) of particle physics was completed by the discovery of the Higgs boson in 2012 by the ATLAS and CMS collaborations. However, the SM is not able to explain a number of phenomena and anomalies in the data. These discrepancies to the SM motivate the search for new bosons. In this paper, searches for new bosons are completed by looking for Zgamma resonances in Zgamma (pp > H > Zgamma) fast simulation events.
This research makes use of a neural network, more specifically a Variational Autoencoder (VAE), in the search for new bosons. The functionality of a VAE to be trained as both a generative model and a classification model makes the architecture an attractive option for the search. The VAE is used as a generative model to increase the amount of Zgamma fast simulation Monte Carlo data whilst simultaneously being used to classify samples containing injected signal events that differ from the Monte Carlo data on which the model was trained.
Both the generative capability and classification capability of a single trained VAE model is evaluated. The evaluation of the generative capability is done by assessing how similar the input distributions are to the generated distributions as well as how similar the correlations between individual input variables are to the correlations between individual generated variables.
The classification capability is evaluated by assessing how well the model is able to separate samples with various types and quantities of injected signal events versus samples containing only background events.

Parallel Session III, Astro-Particle / 17

Azimuthal decorrelation between jets at all orders in QCD hard processes

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We study the azimuthal decorrelation $\Delta\phi$ for di-jet production that promise to reveal important information on perturbative and non-perturbative QCD dynamics. This observable has been measured by the H1 collaboration that employed the E_t-weighted recombination scheme whereby our observable is continuously global and sensitive to soft and/or collinear emissions in the back-to-back region, giving rise to single and double logarithms. We now wish to employ the four-vector recombination scheme (E-scheme) that makes our observable falling into the category of non-global QCD observables. Hence the resummation becomes highly non trivial due to the presence of non-global and/or clustering algorithms when the jets are defined using the k_t and anti-k_t clustering procedure. In the present work we carry out this resummation to next to leading logarithmic accuracy including the non-global and clustering logarithms involved in DIS at HERA.

Parallel Session IV, Collider / 18

Explaining a class of multi-lepton excesses at the LHC with a heavy pseudo-scalar of a 2HDM+S model

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The Standard Model (SM) of particle physics is complete after the discovery of a Higgs-like boson at the Large Hadron Collider (LHC) by ATLAS and CMS collaboration. Although the measured properties of it is compatible with the one predicted by the SM, this does not exclude the possible existence of additional scalar bosons as long as the mixing with the SM higgs is small. In fact, in recent years the so called "multi-lepton anomalies" emerged as deviations from the SM precdictions in several analyses of multi-lepton final states from ATLAS and CMS. These excesses are reasonably well described by a 2HDM+S model, where the mass of the heavy scalar $m_H \approx 270$\,GeV, the mass of the singlet scalar $m_S \approx 150$\,GeV. In this talk I will concentrate in describing a new class of multi-lepton excesses that can be explained with the CP-odd particle of the same 2HDM+S model. We have considered the dominant decays of the heavy scalar, $H \to Sh, SS$ and looked at various multi-lepton final states to explain the excess. With this motivation, a candidate for a scalar resonance has been reported with a mass of 151.5\,GeV by looking at the existing SM higgs searches in the $\gamma\gamma$ and $Z\gamma$ channels with associated leptons, di-jets, bjets and missing energy. There are a number of small excesses in searches at the LHC for heavy (pseudo)-scalars in the mass range 400-600\,GeV, here we have assumed that to be the heavy pseudo-scalar of the 2HDM+S model. The region of the parameter space that explains the multi-lepton excesses, the leading decays of the heavy pseudo-scalar are $A \to ZH, t\bar{t}$ producing four top and four lepton final states. Here we will discuss the multi-lepton final state in conjunction with the multi-lepton excesses observed at the LHC.

Parallel Session V, Collider - Experiment / 19

The search for resonances with topological requirements with the Zγ final state at the LHC

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Machine learning techniques have been improving rapidly, and this has seen their
application grow within the high energy particle physics space. In this work, we propose the use of deep neural networks based on full supervised learning to search for heavy resonances at the electroweak scale with topological requirements. This study is carried out in both inclusive and exclusive regions of the phase space tailored for specific production mode. The technique is well situated for collider searches due to its ability to learn more complex functions, and it is evaluated in the Zγ final state using the Monte Carlo simulated signal samples for 139 fb^{-1} of integrated luminosity for Run 2, collected at the LHC. This approach is complemented with semi-supervised learning and used to calculate the limit on the production of Higgs-like to Zγ where the significance of the signal is maximum.

Parallel Session IV, Collider / 20

New charged Higgs boson discovery channel at the LHC

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The ATLAS and CMS experiments have an ambitious search program for charged Higgs bosons. The two main searches for $H^{\pm}$ at the LHC have traditionally been performed in the $\tau\nu$ and tb decay channels, as they provide the opportunity to probe complementary regions of the Minimal SuperSymmetric Model (MSSM) parameter space. Charged Higgs bosons may decay also to light quarks, $H^{\pm} \to cs/cb$, which represent an additional probe for the mass range below m_t. In this work, we focus on $H^{\pm} \to \mu\nu$ as an alternative channel in the context of two Higgs doublet model type III. We explored the prospect of looking $pp \to tbH^{\pm}$, followed by $H^{\pm} \to \mu\nu$ signal at the LHC. Such a scenario appears in 2HDM type-III where couplings of the charged Higgs are enhanced to $\mu\nu$. Almost all the experimental searches rely on the production and decay of the charged Higgs are taken into account. We show that for a such scenario, the above signal is dominant for most of the parameter space, and $H^{\pm} \to \mu\nu$ can be an excellent complementary search. Benchmarks points are proposed for further Monte Carlo analysis.

Parallel Session II / 21

Modular Flavour Symmetries in magnetized toroidal orbifolds

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The major problems in particle physics is the origin of the flavour structure of the quarks, leptons and the generation number, mass hierarchy and mixing angles. One of the candidates for the origin of flavour structure may be in higher dimensional theories such as superstrings; certain compactifications of superstrings, lead to non-abelian discrete flavour symmetries. In this contribution, we consider the 6-D supersymmetric gauge theory compactified on torus orbifold T^2/Z_2 with non-trivial magnetic flux to investigate flavour modular symmetry. The example of flavour symmetry S_4 is given. Other aspects are also described.

Parallel Session II / 22

Influence of the laser field on electron muon neutrino processus

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In view of the great contribution of neutrino-electron scattering to the deep understanding of electroweak interactions, we focus in this paper on the study of elastic scattering of a muon neutrino by an electron ($e - \nu \mu \longrightarrow e - \nu \mu$) in the presence of a circularly polarized electromagnetic field. We perform our theoretical calculation within the framework of Fermi theory using the exact wave functions of charged particles in an electromagnetic field. The expression of the differential cross section (DCS) for this process is obtained analytically in the absence and presence of the laser field. The effect of the field strength and frequency on the exchange of photons as well as on the DCS is presented and analyzed.
keywords: Laser-assisted , Cross Section, Electrweak Interaction

Parallel Session VI, Instrumentation / **23**

A Burn-in test station for the ATLAS Phase-IITile-calorimeter low-voltage power supply transformer-coupled buck converters

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The upgrade of the ATLAS hadronic tile-calorimeter (TileCal) Low-Voltage Power Supply (LVPS) falls under the high-luminosity LHC upgrade project. This presentation serves to provide a detailed overview of the development of a Burn-in test station for use on an upgraded LVPS component known as a Brick. These Bricks are radiation hard transformer-coupled buck converters that function to step-down bulk 200 V DC power to the 10 V DC required by the on-detector electronics. To ensure the reliability of the Bricks, once installed within TileCal, a Burn-in test station has been designed and built. The Burn-in station functions to implement a Burn-in procedure on eight Bricks simultaneously. The Burn-in procedure subjects the Bricks to sub-optimal operating conditions which function to stimulate failure mechanisms within the Bricks. This results in components that would fail prematurely within TileCal failing within the Burn-in station thereby allowing for their replacement which subsequently improves the reliability of the Brick population. The Burn-in station is of a fully custom design in both its hardware and software. The development of the test station will be explored in detail with the presentation culminating in a discussion of preliminary Burn-in results.

Parallel Session I, Astro-Particle / **24**

Thermal production of early dark matter from van der Waals fluid

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We present a new paradigm for scalar dark matter (DM) particles production in the early Universe. We show the appearance of a new quadratic potential after inflation. This result is due to the stabilization of scalar fields particles. In this case, the mass of this field increases and becomes a candidate for dark matter. We show the van der Waals equation of state for DM, which leads to the Boltzmann equation and the DM number density. We establish the correspondence between the thermodynamic

variables needed to describe simple systems by the van der Waals gas. Particularly, we obtain the relationship between the DM cross-section and the redshifts. Finally, we discuss the local stability of dark matter by the heat capacity.

Parallel Session VI, Instrumentation / 25

Simulation of Monte-Carlo events at the LHC using a Generative model based on Kernel Density Estimation

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We develop a machine learning-based generative model, using scikit-learn to generate a list of particle four-momenta from the Large Hadron Collider (LHC) proton-proton collisions. This method estimates the kernel density of the data using the Gaussian kernel and then generates additional samples from this distribution. As an example of application, we demonstrate the ability of this approach to reproduce a set of kinematic features, that are used for the search of new resonances decaying to Z(ll)γ final states at the LHC. This generative model is constructed to take the pre-processed Zγ events and generate sample data with accurate statistics, mimicking the original distributions and achieving better performances with respect to the standard event Monte-Carlo generators.

Parallel Session IV, Collider / 26

Full next-to-leading-order corrections to the Higgs strahlung process from electron–positron collisions in the Inert Higgs Doublet Model

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We present the cross section of the Higgs strahlung, $e^+e^- \to hZ^0$, at the full next-leading order in the Inert Higgs Doublet Model (IHDM) at the future Higgs factories We systematically calculated both weak and QED corrections by using FeynArts/FormCalc to compute both the weak and the one-loop virtual corrections and Feynman Diagram Calculation (FDC) to evaluate the real photon emission. We evaluated the contribution of the new physics on the radiation corrections in this process for three typical collision energies of future electron-positron colliders :250 GeV, 500 GeV and 1 TeV, taking into account the theoretical and the experimental constraints. We have found a sizeable deviations of the IHDM radiation corrections from the Standard model NLO values, those deviations are within the detection potentials of the future Higgs factories. In the light of these results, we suggest three interesting benchmark points of IHDM for the futures Higgs facilities.

Parallel Session III, Astro-Particle / **27**

Probing 2HDM+S with MeerKAT Galaxy Cluster Legacy Survey data

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Dark matter is believed to constitute the majority of the matter content of the universe, but virtually nothing is known about its nature. Physical properties of a candidate particle can be probed via indirect detection by observing the decay and/or annihilation products. While this has previously been done primarily through gamma-ray studies, the increased sensitivity of new radio interferometers means that searches via the radio bandwidth are the new frontrunners. MeerKAT's high sensitivity, ranging from 3 μJy beam^{-1} for an 8 arcsecond beam to 10 μJy beam^{-1} for an 15 arcsecond beam, make it a prime candidate for radio dark matter searches. Using MeerKAT Galaxy Cluster Legacy Survey (MGCLS) data to obtain diffuse synchrotron emission within galaxy clusters, we are able to probe the properties of a dark matter model. In this work we consider both generic WIMP annihilation channels as well as the 2HDM+S model. The latter was developed to explain various anomalies observed in Large Hadron Collider (LHC) data from runs 1 and 2. The use of public MeerKAT data allows us to present the first WIMP dark matter constraints produced using this instrument.

Parallel Session II / **28**

Asymptotic Grand Unification

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We explicitly test the asymptotic grand unification of a minimal 5-dimensional model with SO(10) gauge theory compactified on an $S^1/Z_2 \times Z_2'$ orbifold. We consider that all the matter fields propagate in the bulk and show that the gauge couplings asymptotically run to a unified fixed point in the UV. However, the Yukawa couplings will typically hit a Landau pole before the GUT scale in this class of $SO(10)$ models.

Parallel Session V, Collider - Experiment / **29**

Search for Higgs boson pair production in the two bottom quarks plus two photons final state in pp collisions at $\sqrt{s}$ = 13 TeV with the ATLAS detector

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From the discovery of the Higgs boson in 2012, most of its properties such as mass, spin, production cross-section and its coupling to fermions and bosons have been measured. However, the trilinear self-coupling λ_{HHH} of the Higgs boson has not been measured yet. This parameter controls the shape of the Higgs potential, explaining the importance of its measurement. Deviation from its Standard Model (SM) predicted value would indicate new physics beyond the SM (BSM). Deviations are quantified through the κ_λ modifier. At the LHC, it is measured through the rate of the rare Higgs boson pair production (HH) process, which is the only direct way to access it. This process is mainly produced at the LHC via gluon-gluon fusion (ggF) through destructive interference of two Feynman diagrams involving quark loops and the triple Higgs boson self-interaction. At the LHC centre-of-mass energy of 13 TeV, the cross-section of the Higgs boson pair production is $31.05^{+2.2\%}_{-5.0\%}$ fb as predicted by the SM. This low cross-section could be enhanced by the presence of BSM physics (non-resonant and resonant), thus the motivation to explore the search for the double Higgs production.
This presentation will focus on the search for the Higgs boson pair production in the two bottom quarks plus two photons final states with the 2015-2018 data recorded by the ATLAS detector recently published (https://arxiv.org/pdf/2112.11876.pdf). This search sets observed (expected) upper limits to the HH cross-section of 4.2 (5.7) times the SM expectation. The observed (expected) constrains on the Higgs boson trilinear modifier κ_λ are determined to be [-1.5, 6.7] ([-2.4, 7.7]) at 95% confidence level. The search explores the resonant production of double Higgs ($pp \to X \to HH$) and sets limits on its cross-section as a function of the m_X. The observed (expected) limits on the cross-section of $pp \to X \to HH$ range from 610 fb to 47 fb (360 fb to 43 fb) over the constrained mass range.
In this presentation, both the search for the resonant and non-resonant double Higgs production will be detailed, in addition to a comparison with other searches f the Higgs pair production with other final states and using data collected between 2015-2016.

Parallel Session II / 30

Flavor changing neutral current in the flipped 341 model

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We present a new chiral gauge anomaly flipped 341 model where lepton families are arranged in different SU(4) gauge group representations leading to a nonuniversal coupling with heavy neutral gauge bosons Z' and Z'' of the model. The resulted flavor-changing neutral current in the leptonic sector is discussed and bounds on some of the flavor changing parameters are derived using the recent experimental data on the muon rare decays.

Parallel Session VI, Instrumentation / 31

Upgrades of the ATLAS muon spectrometer with new small-diameter drift tube chambers

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The goals of the upgrades of the ATLAS Muon Spectrometer with new small-diameter Muon Drift Tube Chambers (so-called sMDT) are to make room to install new triple-Resistive Plate Chambers (tRPC) to increase the trigger efficiency in the inner barrel muon region and to improve the rate capability of the muon chambers in the high background regions corresponding to the HL-LHC project. As a pilot project for the whole replacement of the MDT chambers in the small azimuthal sectors of the barrel inner layer (so-called BIS1-6) by new sMDT-RPC detectors in the long shutdown 3 (LS3), 8 New small diameter (15 mm) Muon Drift Tube chambers (so-called sMDT BIS7A) have been installed in the long shutdown 2 (LS2) in the transition region between Barrel and Endcap of Muon spectrometer $1 < |\eta| < 1.3$. The Author will present an overview of the installation and read-out electronics of the new sMDT BIS7A chambers, their cavern commissioning status and their performance.

Parallel Session VI, Instrumentation / 32

Extraction and analysis of the ATLAS Tile Calorimeter Low Voltage Power Supplies Temperature Data

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Plugin based system for assessing the quality of data and conditions for ATLAS Tile Calorimeters is known as the Tile-in-One (TiO). The TiO is a collection of small sized independent web tools called plugins, designed to make it easier for a user to evaluate Tile Calorimeter (TileCal) data. TiO platform aims to integrate individual TileCal web tools into a single common platform, which will share the same computing infrastructure and access to common services and data, as old interfaces are slowly falling behind and are harder and harder to maintain. The TiO web platform should allow large flexibility and ease of maintenance so that it would be friendly to the plugin developers as well. The Data Control System (DCS) provides temperature data through a dedicated interface called DDV. Based on the possibility to query those data, new TiO plugin is being developed under the following strategy: CentOs 8 was installed inside the virtual box to easily access CERN internal network. The DDV tool is used to query the TileDCS temperature data which are subsequently transformed to a form suitable for the visualizing library. The visualization tool allows user to interact with the plots. Currently the biggest focus is concentrated on finding an intuitive way to display not only the status of one particular module, but the whole detector as well.

Parallel Session I, Astro-Particle / 33

Search for Magnetic Monopoles with ten years of ANTARES data

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This work presents an updated search for magnetic monopoles using data taken with the ANTARES neutrino telescope over a period of 10 years (January 2008 to December 2017). In accordance with some grand unification theories, magnetic monopoles were created during the phase of symmetry breaking in the early Universe, and accelerated by galactic magnetic fields. As a consequence of their high energy, they could cross the Earth and emit a significant signal in a Cherenkov-based telescope like ANTARES, for appropriate mass and velocity ranges. This analysis uses a run-by-run simulation strategy, as well as a new simulation of magnetic monopoles taking into account the Kasama, Yang and Goldhaber model for their cross section with matter. The results obtained for relativistic magnetic monopoles with $\beta = v/c \geq 0.55$, where v is the magnetic monopole velocity and c the speed of light in vacuum, will be presented.

Parallel Session I, Astro-Particle / 34

Solar constraints on captured electrophilic dark matter

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Dark matter captured by interaction with electrons inside the Sun may annihilate via a long-lived mediator to produce observable gamma-ray signals. We utilize solar gamma-ray flux measurements from the Fermi Large Area Telescope and High Altitude Water Cherenkov observatory to put bounds on the dark matter electron scattering cross-section. We find that our limits are four to six orders of magnitude stronger than the existing limits for dark matter masses ranging between GeV to PeV scale.

Parallel Session VI, Instrumentation / 35

Extracting and Analysing Data from Detector Control Systems at ATLAS Experiment for Bad Channelling of High Voltage and Low Voltage Power Supplies.

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Tile-in-One (TiO) is web platform to combine all web based offline data quality tools of ATLAS Tile Calorimeter in one web interface. This system is implemented a series of small web applications with main gateway, the applications are called plugins. Plugins run in thier own separate virtual machine to avoid interference and increase platform stability. The aim of this project is to extract data from Detector Control System (DCS) of the ATLAS Experiment and use TiO web platform for visualization and analysis of the data in order to observe behaviour of High volytage and Low voltage power supplies. The data was extracted on the DDV server in a form of text file then converted to comma separated values (csv) file in order to be visualized in the form of plots using plotly.js library. A detailed results for the analysis of the data will be further discussed.

Parallel Session IV, Collider / 36

Leptogenesis, fermion masses and mixings in a flavored SUSY SU(5) GUT

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We propose a a highly predictive 4D SU(5) GUT with a D_4 flavor symmetry to study fermion masses and mixings. The Yukawa matrices of quarks and charged leptons are obtained after integrating out heavy messenger fields from renormalizable superpotentials while neutrino masses are originated from the type I seesaw mechanism. The group theoretical factors from 24- and 45-dimensional Higgs fields lead to ratios between the Yukawa couplings in agreement with data, while the dangerous proton decay operators are highly suppressed. By performing a numerical fit, we find that the model captures accurately the mixing angles, the Yukawa couplings and the CP phase of the quark sector at the GUT scale. The neutrino masses are generated at the leading order with the prediction of trimaximal mixing while an additional effective operator is required to account for the baryon asymmetry of the universe (BAU). An analytical and a numerical study of the BAU via the leptogenesis mechanism is performed where strong correlations between the parameters of the neutrino sector and the observed BAU are obtained.

Parallel Session I, Astro-Particle / 37

Searching for new physics during gravitational waves propagation

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The direct detection of gravitational waves opened an unprecedented channel to probe fundamental physics. Proposed extensions of our current theories predict a dispersion of the gravitational waves during their propagation, leading to a modification of the signals observed by ground-based interferometers compared to their predictions from general relativity. In this talk, I present several analyses probing different alternative models of gravitation with various observables. Using the multimessenger events consisting of gravitational waves and their electromagnetic counterpart, the speed of gravity is measured by comparing the arrival time of the two signals while extra dimensions and scalar-tensor theories are constrained from the comparison of the luminosity distance inferred independently from both signals. Relying only on gravitational wave signals, a large class of proposed theories, including as the existence of massive graviton, predict a frequency-dependent dispersion of the gravitational waves breaking local CPT and/or Lorentz symmetry. Constraints on the modified dispersion relation and effective field theories coefficients are obtained from the analysis of the third LIGO-Virgo detections catalog.

Plenary Session III / 38

Very-high-energy neutrino production in jetted active galactic nuclei

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As the number of tentative associations of very-high-energy neutrinos detected by IceCube with jet-dominated AGN is increasing, also the development of theoretical models for neutrino production in AGN jets is advancing rapidly. This talk will provide a review of the basic physics constraints for VHE neutrino production in AGN jets as well as applications to recent tentative neutrino - blazar associations.

Parallel Session V, Collider - Experiment / 39

Dark photon searches with the ATLAS detector at the LHC

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Many extensions to the Standard Model (SM) introduce a hidden or dark sector (DS) to provide candidates for dark matter in the universe and an explanation to astrophysical observations such as the positron excess observed in the cosmic radiation flux. This hidden sector could rise from an additional U(1)d gauge symmetry. ATLAS has searched for the gauge boson of the DS, which could be a massless or massive dark photon that either kinetically mixes with the SM photon or couples to the Higgs sector via some mediators. If dark photons decay in turn to SM particles with a significant branching ratio, we could either observe measurable deviations in some particular Higgs boson decay channels or new exotic signatures that would be accessible at the Large Hadron Collider (LHC) energies. An overview of searches of dark photon signals with the ATLAS detector, with a particular emphasis on some SM Higgs decay channels will be presented.

Parallel Session II / 40

Scattering amplitude and its soft decomposition

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In the pure scattering theory, the universality of the soft limit has been studied for a long time. In this talk we review the property of soft limit to relate an n-point amplitude to an (n-1)-point amplitude. We show how this property can be used to decompose amplitudes into different complementary soft channel. The existence of such decomposition provides a new way to understand how to construct amplitude solely from them soft limit.

Parallel Session VI, Instrumentation / 41

Single Event Effects qualification of candidate components for the ATLAS Tile Calorimeter Phase-II Upgrade Low Voltage power supply Bricks

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Irradiation campaigns have been carried out in a variety of European facilities to select radiation hard candidates for the upgraded version of the transformer coupled buck converter (Brick). The ATLAS detector is set to undergo a significant upgrade termed the "Phase-II" Upgrade. This talk primarily focuses on the exposure of selected active components (power MOSFETs, MOSFET drivers and isolation amplifiers) to a high energy proton beam at the Proton Irradiation Facility in PSI. A full scale production of nearly 2048 finger Low Voltage power supplies Bricks, with an identical output voltage, is set to be undertaken in the year 2022. The Low Voltage power supply (LVPS) Brick design, which powers the TileCal front-end electronics is currently being finalized. The tested single batch components were selected among candidates suitable to survive the full radiation tolerance in preparation for the HL-LHC. A detailed compilation of the SEE results obtained, along with the relevant set-up and observations will be discussed.

Parallel Session VI, Instrumentation / **42**

Simulation of CMS resistive plate chamber (RPC) performance under different conditions

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The resistive plate chamber (RPC) is a fast gaseous detector that provides a muon trigger system parallel with the drift tubes and cathode strip chambers in the CMS experiment. It consists of two parallel plates, a positively-charged anode and a negatively-charged cathode, both made of a very high resistivity plastic material and separated by a gas volume. It is used in many high-energy physics experiments due to its simple design, construction, good time resolution, high efficiency, and low-cost production.

In this research, we aimed to find the ideal operating conditions of the CMS RPCs using Garfield++ as simulation software. We studied the effect of temperature on various RPC parameters. The electron transport parameters like drift velocity, Townsend coefficient and Diffusion coefficient have been computed under different temperatures and gas mixtures using MAGBOLTZ, while the primary ionization number and energy loss have been studied using HEED. We used the nearly exact Boundary Element Method (neBEM) solver in the calculation of the weighting field and electric field. Finally, we applied Ramo's theorem to calculate the induced signal.

The simulation results showed that temperature affects RPC performance. As the temperature increased, the drift velocity, Townsend coefficient and amplitude of the induced signal increased.

Parallel Session III, Astro-Particle / 43

Lorentz Invariance Violation tests in astroparticle physics

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At energies approaching the Planck energy scale 10^{19} GeV, several quantum-gravity theories predict that familiar concepts such as Lorentz symmetry can be broken. Such extreme energies are currently unreachable by experiments on Earth, but for photons traveling over cosmological distances the accumulated deviations from the Lorentz symmetry may be measurable using the Cherenkov Telescope Array (CTA). Therefore, current and future generation of gamma-ray experiments are expected to improve our understanding of fundamental physics.

Parallel Session IV, Collider / 44

Neutrino masses in the left right symmetric model

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Addressing the question of the small neutrino masses in the LRSM. The results is very appealing as the LRSM leads to the celebrated seesaw mechanism, which ensures the small neutrino masses.\\
In addition the LRSM may have new particles at TeV scale giving a dominant contribution to $0\nu 2\beta\beta$ decay, that can be reached by the future ton-scale experiments.

Parallel Session I, Astro-Particle / 45

MeerKAT and dark matter

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Radio indirect detection has evolved into a promising approach to probe the nature of dark matter. This will only be enhanced by the construction of the full SKA. In the mean-time, MeerKAT's potential as a dark matter detector has largely been ignored. In this work we will present simulations of the sensitivity of MeerKAT to diffuse radio emissions and apply them the dwarf galaxy Reticulum II to determine the potential of MeerKAT to probe the WIMP parameter space. We demonstrate that, by leveraging its angular resolution, MeerKAT has the potential to produce constraints tighter than Fermi-LAT results in dwarf spheroidal galaxies.

Parallel Session II / **46**

On 6D N=(1,0) Supergravity

Authors: Rajae Sammani[1]; Rachid Ahl Laamara[1]; Youssra Boujakhrout[1]

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The main quest of modern physics is to describe all four elementary interactions within the same framework. Our inability to incorporate gravity as a renormalizable quantum field theory is a major motivation for a physics beyond the standard model, the most amazing progress we have made to understand quantum gravity is through local supersymmetry theory: supergravity. We contribute to outlining the most necessary consistency conditions for any quantum gravity theory essentially the anomaly consideration, the moduli space consideration, the BPS space consideration and some geometric conditions. All within the framework of 6D supergravity theories due to their successful landscape analysis.

Parallel Session V, Collider - Experiment / **47**

Minimum bias simulation of parasitic collisions

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Parasitic collisions are proton-proton collisions that happen offset from the nominal ATLAS interaction point. With a 25 ns bunch spacing, the bunches can have parasitic encounters at z = n × 3.75 m, with n < 7. Using MC simulations, it would be possible to observe the distributions of key variables (from tracks and energy deposits) for such events at various distances. The task consisted of the generation of minimum bias MC samples, applying a Z offset to reproduce the effect and simulate the ATLAS detector response in release 21, and reconstructing the observables, based on muon segments, jets topology, Pixels clusters.

Parallel Session V, Collider - Experiment / **49**

Higgs CP measurement with EFT model in lepton collider

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In the Circular Electron Positron Collider (CEPC), a measurement of the Higgs charge and parity (\textit{CP}) mixing through $e^+e^- \to ZH \to \mu^+\mu^- H(\to b\bar{b}/c\bar{c}/gg)$ process is presented, considering a scenario of analyzing $5.6\ ab^{-1}$ e^+e^- collision data with the center-of-mass energy of 240 GeV. In this work, a CP-mixing parameter p is greater (less) than 5.40×10^{-2} (-5.52×10^{-2}) excluded at the 95% confidence level.
This study demonstrates the potential of precise measurement of the hadronic final states of the Higgs boson decay at the CEPC, and will provide key information to look for the \textit{CP}-odd Higgs.

Parallel Session IV, Collider / 50

Searches for new physics using the top-quark pair invariant mass distribution in proton-proton collisions at √s=13 TeV

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A search for new heavy particles that decay into top-quark pairs is performed in proton-proton collisions at the LHC at a center-of-mass energy of 13 TeV using data collected by the ATLAS experiment during the years 2015 and 2018. Events consistent with top-quark pair production are selected by requiring a single isolated charged lepton, missing transverse momentum and jet activity compatible with a hadronic top-quark decay. Jets identified as likely to contain b-hadrons are required to reduce the background from other Standard Model (SM) processes. The observed invariant mass spectrum of the candidate top-quark pairs is investigated to seek for any significant deviation from the SM background expectation.

Parallel Session III, Astro-Particle / 51

The lambda hyperon and the hyperon puzzle

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Neutron stars provide unique conditions to study cold dense nuclear matter at extreme densities. Due to these extreme conditions additional hadronic degrees of freedom are expected to be populated, including hyperons. This talk will focus on the influence of hyperons on the neutron star equation of state. In particular the contribution of the lambda hyperon will be discussed, as a first approximation to describing exotic neutron star equations of state. The system under consideration is where the strong nuclear force is described by the exchange of mesons and applying the relativistic mean field theory to study dense nuclear matter. As expected, the inclusion of the lambda hyperon softens the neutron star equation of state (EoS). A softer EoS will reduce the maximum mass attainable by the modeled neutron star with such EoS. While hyperons are certainly not unexpected in high density systems, but there presence seems to be contradicted by observations of high mass neutron stars. This contradiction is known as the "hyperon puzzle". The expected influx of observational data from massive new radio-telescopes like the Square Kilometer Array (SKA) will provide observations that can be supported and evolve theoretical models of nuclear matter. Therefore, the study of hyperonic matter is not only relevant to nuclear theory, but also locally to Botswana as an African partner country of the SKA.

Parallel Session III, Astro-Particle / 52

Exploring the Impact of Magnetic field on Core-Collapse Supernova Neutrino Light Curves Detection.

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The time profile of neutrino emissions from core-collapse supernovae contains unique information about the dynamics of the collapsing stars and the behavior of particles in dense en- vironments. The observation of neutrinos from the SN1987A supernova, in the Large Magellanic Cloud, marked the beginning of neutrino astronomy. To date, no other supernova neutrino obser- vation has been made. It is therefore essential to investigate the impact of the supernova properties on the neutrino light curves expected in current and future experiments. In this contribution, we study the effect of the magnetic field on the neutrino observations. For certain massive supernovae, strong magnetic fields are expected to change the star's collapse rate, and thus modulate neutrino production. Here, we consider the impact of different magnetic field topologies on neutrino light curves which would be observed at the KM3NeT, DUNE, and DarkSide experiments. We iden- tify areas of complementarity between these three experiments and discuss how to combine their observations to allow to discriminate between different supernova models.

Parallel Session III, Astro-Particle / 53

Thermodynamics of magnetised dense neutron-rich matter

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A neutron star is one of the possible end states of a massive star. It is compressed by gravity and stabilized by the nuclear degeneracy pressure. Despite its name, the composition of these objects are not exactly known. However, from the inferred densities, neutrons will most likely compose a significant fraction of the star's interior. While all neutron stars are expected to have a magnetic field, some neutron stars ("magnetars") are much more highly magnetised than others: the inferred magnetar surface magnetic field is between 10^{14} to 10^{15} gauss. While neutron stars are macroscopic objects, due to the extreme value of the stars' energy, pressure, and magnetic field the thermodynamics on the microscopic scale can be imprinted on the star's large scale behaviour. This talk will focus on describing the thermodynamics of magnetised dense neutron and neutron-rich matter, its equation of state and explore conditions of a possible ferromagnetic state, contributions from the magnetised vacuum, as well as possible observational implications thereof for neutron stars.

Parallel Session V, Collider - Experiment / 54

Search for Dark Matter with the ATLAS detector at the LHC

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Astronomical and cosmological observations support the existence of invisible matter that can only be detected through its gravitational effects, thus making it very difficult to study. Dark matter (DM) makes up about 27% of the known universe. As a matter of fact, one of the main goals of the physics program of the experiments at the Large Hadron Collider of the CERN laboratory is the search of new particles that can explain dark matter. This talk discusses both experimental and theoretical aspects of searches for DM candidates at the LHC as well as exploring the nature of possible interplay between the Standard Model and the Dark Sector. An updated overview of the various experimental search channels performed by the ATLAS experiment is presented in order to pinpoint complementarity among different types of LHC searches and the interplay between the LHC and direct and indirect dark matter searches.

Parallel Session IV, Collider / 55

Weinberg's factor from helicity constraint

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Scattering amplitudes connect theoretical descriptions to experimental predictions. Low energy terms of the scattering amplitude tend to factorize from the high energy. Different methods have already been established to understand the mechanism of such factorization, Weinberg's theorem. With regard to the Weinberg soft factor, calculations have already shown that this factor has a universal character. In this talk, we show that it is possible to calculate this factor independently from the scattering amplitude based on the Wigner constraint. We also show that such constraint leads us to a system partial differential equation to simplify the construction of the Weinberg's soft factor for the case of one particle or two particles.

Parallel Session I, Astro-Particle / 56

KM3NeT: Status and perspectives for neutrino astronomy from the MeV to the PeV

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KM3NeT is a multi-purpose neutrino observatory currently being deployed at the bottom of the Mediterranean Sea. It consists of two detectors: ORCA and ARCA (for Oscillation and Astroparticle Research with Cosmics in the Abyss). ARCA will instrument 1 Gton of seawater, with the primary goal of detecting cosmic neutrinos with energies between several tens of GeV and PeV. Due to its position in the Northern Hemisphere, ARCA will provide an optimal view of the Southern sky including the Galactic Center. ARCA currently has 8 detection units fully operating out of an eventual planned total of 230. ORCA is a smaller (~ few Mtons) and denser array, optimized for the detection of atmospheric neutrinos in the 1 - 100 GeV range. It can also study low-energy neutrino astronomy, such as MeV-scale core-collapse supernovae. ORCA currently has 10 detection units fully operating out of an eventual planned total of 115. I will report on the current status and recent discoveries of ARCA and ORCA as well as a timeline for future developments.

Parallel Session IV, Collider / 57

On 't Hooft lines and Lax operators of SO_{2N} type

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The four dimensional Chern Simons topological gauge theory represents a rich framework allowing to study two-dimensional integrable systems using line and surface defects and Feynman diagrams computations. Relying on this "Gauge/Bethe ansatz" correspondence, one can recover interesting results of the integrable models and generate new ones without reference to the traditional algebraic techniques. For example, the study of the intrinsic properties of interacting Wilson and 't Hooft

line defects in the 4DCS theory yields the oscillator realisation of the Lax operator verifying the RLL equation of integrability. This study focuses on the 4DCS theory with invariance given by the SO_{2N} gauge group, which allows to construct the Lax operator associated to the QQ representation of an XXX spin chain with so_{2N} symmetry. This also allows to interprete the oscillator degrees of freedom in terms of algebras decomposition and field bundles charges.

Parallel Session VI, Instrumentation / 58

The ATLAS Inner Detector trigger design and performance during Run 2 data taking from the 13 TeV LHC collisions

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The ATLAS Inner Detector (ID) trigger is a crucial component in the ATLAS trigger system, and plays a pivotal role in the high quality reconstruction of the physics objects - electron, muon, tau and b-jet candidates. These objects are fundamental for physics studies and analyses at ATLAS. The ATLAS ID trigger was redesigned during 2013-2015 shutdown, this provided the opportunity to improve its performance during Run 2 data taking from the 13 TeV Large Hadron Collider (LHC) collisions. The design and performance of the ATLAS ID trigger during Run 2 data taking from the 13 TeV LHC collisions are discussed, as well as suggested plans and developments during 2019-2021 shutdown for the start of Run 3 and beyond. The results presented here illustrate the superb performance of the ATLAS ID trigger, even in the extreme number of proton-proton interactions per bunch-crossing (pile-up) conditions of Run 2 data taking from the 13 TeV LHC.

Parallel Session III, Astro-Particle / 59

Thermodynamic analysis of the BTZ black hole in f(R) gravity

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The classical Einstein equations in 2+1 dimensions have a black hole solution with a negative cosmological constant. Its solutions are asymptotically anti-de Sitter rather than asymptotically flat. In the context of f(R) gravity theory, we attempt to investigate the thermodynamics of non-rotating Banados, Teitelboim, and Zanelli (BTZ) black holes. The Lagrangian will be modified due to the non-rotating BTZ BH metric, in turn, the associated area law of entropy will be modified too. In addition, the heat capacity and the evaporation time will be examined.

Parallel Session V, Collider - Experiment / 60

The Spin Physics Detector at NICA

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The Spin Physics Detector (SPD) is planned to run at the NICA collider that is currently under construction at JINR (Dubna). The main goal of SPD is to study the spin structure and other spin-related phenomena of the nucleon. SPD will operate with polarized proton-proton, deuteron-deuteron, and proton-deuteron collisions at energies up to $\sqrt{s} = 27$ GeV and luminosity up to 10^{32} cm^{-2} s^{-1}. The experiment setup is planned to be a universal multipurpose 4π detector. Possible SPD studies with unpolarized proton and deuteron beams, at the first stage of NICA operation, are also being investigated.

Parallel Session IV, Collider / 61

Measurements of W boson properties at √s = 5 and 13 TeV with the ATLAS detector at the LHC.

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After the discovery of the W and Z bosons at the Super Proton Synchrotron (SPS) at CERN, particles responsible for weak interactions, the efforts have been geared towards measuring their properties. A precise measurement of the W boson properties remains a major test for the validation of the standard model.

In this presentation, the measurement of the W boson transverse momentum p_W^T and the differential cross sections are described. Using low pile-up data set, collected with low number of interactions per bunch crossing, by the ATLAS detector in 2017 and 2018.

- **Measurement of the transverse momentum distribution**: One of the most important theoretical sources of uncertainties in the measurement of the W-boson mass, is the extrapolation of the p^T distribution from Z boson to W-boson (≈ 6 MeV), a direct measurement of p_W^T would avoid such an extrapolation and the corresponding theoretical modelling uncertainty.
- **Measurement of the differential cross sections**: The measurement of the differential cross sections for the W boson provides stringent tests of the QCD theory, and is crucial for a deep understanding and modelling of QCD interactions. Also, the rapidity dependence of the W boson production in the Drell–Yan process provides constraints on the parton distribution functions (PDFs), which are currently the dominant uncertainty source in the W mass measurement (9.2 MeV).

source: https://tel.archives-ouvertes.fr/tel-03224873

Parallel Session I, Astro-Particle / 62

Correlation between IceCube neutrinos and X-ray flaring blazars

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Gamma-ray bright blazars are beginning to emerge as a very plausible source of at least some of the very-high-energy neutrinos detected by IceCube. Most searches for a correlation between blazars and neutrino events have so far focused on gamma-ray flaring blazars, motivated by the fact that very-high-energy gamma-rays are co-produced with neutrinos if neutrinos are produced through photo-pion interactions of relativistic protons with dense target photon fields. However, the same target photon fields also act as a source of gamma-gamma opacity, leading to the development of electromagnetic cascades. The energy of the co-produced photons is therefore more likely to emerge in the soft gamma-ray to X-ray regime instead of high-energy and very-high-energy gamma-rays. We are therefore conducting a systematic search for a correlation between IceCube Gold and Bronze alerts and X-ray flaring blazars, utilizing the Swift-XRT blazar monitoring program. First preliminary results of this search will be presented.

Parallel Session VI, Instrumentation / 63

The geometry description of High Granularity Timing Detector with XML-based format

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The main purpose of the ATLAS experiment is to study the proton-proton collisions from the Large Hadron Collider (LHC) in order to exploit the full discovery potential of the LHC. ATLAS' exploration uses precision measurement to push the frontiers of knowledge by seeking answers to fundamental questions.
A new phase called High Luminosity LHC (Run4) will start operation in mid-2026, which aims to deliver an integrated luminosity of up to $4000 fb^{-1}$. To meet the quest for high precision measurements in a high luminosity environment, a new subsystem called High Granularity Timing Detector (HGTD) will be installed to mitigate the pileup effect by providing timing information. It will aid the track-vertex association in the forward region by incorporating timing information into the reconstructed tracks. The Low Gain Avalanche Detector (LGAD) sensors will be used to meet these changing needs.
For the perspective of the HGTD description, ATLAS collaboration is moving towards the use of an XML-based format for defining this subdetector description, this work aims to describe the HGTD geometry using this format, then integrate it with ATLAS software and to the simulation infrastructure.

Parallel Session I, Astro-Particle / 64

Search for nuclearites in nine years of ANTARES data

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Nuclearites are hypothetical heavy particles composed by roughly equal proportions of up, down and strange quarks. These particles loose their energy by atomic collisions and they induce visible light in transparent mediums through black-body radiation from a shock wave.

ANTARES is a neutrinos telescope running at 2475 meters under water in the Mediterranean Sea. Nuclearites with a masses $\geq 4 \times 10^{13}$ GeV/c^2 are able to generate a sufficient amount of visible light to be detected. The nuclearites with a masses $\leq 10^{22}$ GeV/c^2 are not able to cross the Earth diameter, however. In this analysis, we consider a down-going flux of nuclearites with masses ranging from 4×10^{13} to 10^{16} GeV/c^2 penetrating into the Earth with galactic velocities ($\beta = 10^{-3}$).

Parallel Session III, Astro-Particle / 65

ALP-Photon interaction in magnetized environment of a compact star

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The spin zero, very light bosons like scalar (dilaton) and pseudoscalar (axion) collectively grouped into the term axion like particle (ALP). Dilatons are postulated in extended theory of standard model of particles to cure the scale invariance of the field theory while the axions have been introduced to resolve the $U_A(1)$ anomaly in Quantum field theory. These ALPs also show their presence in higher dimensional theories as K K particle in Kaluza Klein theory, moduli in String theory and chameleons in cosmology.

ALPs hold a special place amongst the possible candidates of dark matter therefore their detection as well as identification have become a part of the central theme of particles detector projects. The direct experimental detection of these particles in ground based laboratories are still far from reach of existing–sensitivity of the detectors. However recent advancements in the area of their indirect detection by searching the imprints of their interactions with non-thermal photons coming through the magnetosphere of the compact stars, motivates to carry out the investigations into that direction. Previously the similar kind of investigations had been practiced by several groups [1]-[5] on relevant issues, however our investigation includes another non-trivial aspect that has not been effectively considered important in such investigations; that is background dependence of the mixing dynamics of these particles (dilaton/axion) with electromagnetic radiation.
In this work we focus on evaluating statistically good signal strength of spectro-polarimetric variables like ellipticity angle, linear polarization angle and degree of linear polarization of the photons interacted with ALP using the Stokes parameters.
It has been shown that the obtained magnitudes of the variables fall into the detectable range of the detectors that would be helpful in designing the future detectors. In addition to that we have also looked for the implications of this dimension five interactions to explain the anomalous behaviour in luminosity time relation of stars like Betelgeuse.

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Parallel Session V, Collider - Experiment / **66**

The off-shell Higgs production and measurement of its decay width with the ATLAS experiment

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The measurement of the off-shell Higgs production and its decay width is performed in the Higgs decay channels of $ZZ \to 4\ell$ and $ZZ \to 2\ell 2\nu$. The measurement uses Monte Carlo samples at a centre-of-mass energy of 13 TeV, produced according to the ATLAS detector configurations with an integrated luminosity of 139 fb^{-1}. The results are presented as an expected upper limit on the off-shell Higgs signal strength at 95% confidence levels (CLs). In addition, the ZZ off-shell and on-shell combined results are shown.

Parallel Session I, Astro-Particle / **67**

Dark Matter Direct and Indirect Detection

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dark matter is an essential ingredient for understanding the recipe of the universe's creation. Since it cannot be made of any of the usual standard model particles, therefore the construction of particle-physics models for dark matter has become a huge industry, accelerated quite recently by many studies. The techniques needed to detect these different signatures of dark matter are composed of two major direct and indirect detection. this work intended to provide a brief review of dark matter for the newcomer to the subject beginning with a discussion of the astrophysical evidence for dark matter. Then the standard weakly interacting massive particle (WIMP) scenario and detection techniques are reviewed, as well as mentioning some alternatives (axions and sterile neutrinos).

Parallel Session II / **68**

Tensor Network Theory

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We introduce some basic definitions and concepts of tensor network. We show that the tensor network can be used to represent quantum many-body states, where we explain MPS(Matrix Product States) in 1D and PEPS (Projected Entangled Pair States) in 2D systems, as well as the generalizations to thermal states and operators. The quantum entanglement properties of the tensor network states including the area law of entanglement entropy also be discussed. Finally, we present several special tensor network's that can be exactly contracted, and demonstrate the difficulty of contracting tensor network's in general cases.

Parallel Session III, Astro-Particle / 69

Recoil Kinematics in Radiative Energy Loss

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We investigate the behaviour of particle emission spectra in the large-x region following a rigorous implementation of the kinematic constraints in the simpler framework of a scalar field theory. We find that the small-x kinematic constraints in the simpler theory are identical to those implemented in sophisticated QCD-based energy loss models, but that the exact large-x kinematics are more complicated than those implemented in those same QCD-based energy loss models. We compute the multiplicity distributions for various values of the parent parton energy and see that our spectra respect energy conservation by smoothly vanishing outside the classically allowed $0 < x < 1$ region. We repeat the calculation for the emission of a spin-1 particle and similarly observe that the spectra have support strictly within kinematically allowed regions.

Parallel Session II / 70

On the quantum geometry of gravity

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The quantum algebra of observables of particles in homogeneous space from bicrossed product model $\mathcal{C}[x]$
$blacktriangleright$
$joinrel \triangleleft \mathcal{C}[p]$ forms a Hopf algebra $A(+, \mu, \eta, \Delta, \epsilon)$. Quantum mechanic is formulated algebraically while gravity is more geometric. Quantum geometry which is a non commutative geometry, with Hopf algebra give us an access to an algebraic language of gravity. The duality of Hopf algebra with Von Neuman algebra (Hopf duality) which relates observables and states give a quantification of gravity if one can show that the non commutativity of the coproduct Δ curves the phase space.

Keyword: Quantum gravity, Quantum group, Hopf algebra

Parallel Session II / 71

T_{QQ} -like states from QCD Laplace sum rules and Double ratio of sum rules

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Motivated by the recent LHCb-group discovery of an exotic hadron at 3878 MeV interpreted as $J^P = 1^+$
T_{cc} tetraquark state , we improve in this work the existing results from QCD Spectral Sum Rules (QSSR)
at lowest order (LO) by combining the mass determinations from the ratio R of Inverse Laplace sum rules
(LSR) with the double ratio of sum rules (DRSR). In so doing, we start by improving the previous mass and
coupling of the X(3872) which will be used as input in the DRSR method. We extend our analyzes to the
SU3 breaking $T_{cc\bar{s}\bar{u}}$ state and to the bottom sector.

Parallel Session III, Astro-Particle / 72

GEANT4 MONTE-CARLO SIMULATION AND MEASUREMENT OF GAMMA RAY ATTENUATION IN CONCRETE

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Gamma rays have high energy hence they are significantly used in irradiation of food items, diagnosis in nuclear medicine, tracing for radioactive substances like thorium, radiotherapy, sterilization of medical equipment, and among others, the detection of illicit trafficking of radioactive material across international borders. However, gamma rays also pose great danger to individuals working within and around radiation facilities including the linear accelerators used in medicine, nuclear power stations and the nuclear reactors. This is because when gamma rays is absorbed by living organisms, it damages their cells causing delayed division, reproductive failure and mutation among others. This calls for radiation protection for people working near radiation facilities. The study on gamma radiation attenuation through materials is important in Gamma ray shielding hence radiation protection. Most radiation facilities have thick concrete walls. This is because it's a cheap shielding material with good structural advantage. This study employed the use of the GEANT4 Monte-Carlo program to simulate the gamma ray attenuation in concrete. Version ten of the GEANT4 package for Linux platform was used to simulate the linear attenuation coefficient of ordinary concrete for gamma ray photons of energy 662 keV and its mass attenuation coefficient for gamma ray photons within the energy range from 10 keV to 100 MeV. The simulated and the measured data were analyzed with the ROOT program. A comparison was made between the GEANT4 simulated results, the measured data, the NIST XCOM simulated data and the published data. The findings from measurement indicated that the linear attenuation coefficient of ordinary concrete is (0.182±0.006) cm-1 while the GEANT4 simulated value is 0.179 cm-1. The half value layer of ordinary concrete was obtained to be (3.81±0.13) cm and 3.87 cm for the measurement and the GEANT4 simulation respectively. These research findings also showed that the mean free path of ordinary concrete is 5.59 cm and (5.49±0.18) cm for the simulation and the measurement respectively. The variation of mass attenuation coefficient with energy from 10 keV to 100 MeV obtained from GEANT4 was consistent with the one obtained from XCOM program, except at lower energies where the photoelectric effect

mass attenuation coefficient was inconsistent. This was attributed to the adoption of different cross section data sources for the XCOM program and the GEANT4 program. These findings indicated consistency in both the measured results, the GEANT4 evaluated results, the XCOM simulated results and the published data. The results validated the use of the GEANT4 program for the simulation of gamma ray attenuation in materials.

Parallel Session IV, Collider / 73

The comparison study of the ratio between $t\bar{t}\gamma$ and $t\bar{t}$ in the $e\mu$ channel at 13 TeV using the ATLAS detector

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With the goal of increasing the precision of NLO QCD predictions for the $pp \to t\bar{t}\gamma$ process in the di-lepton top quark decay channel we present a study of the ratio of top quarks together with a photon to the top quark pair. Fully realistic LO and NLO computations for $t\bar{t}\gamma$ and $t\bar{t}$ production are employed. Events with exactly one electron and one muon, and at least two jets with one of them being a b-tagged are selected. Multiple observables are related with Monte Carlo simulations at leading-order and next-to-leading-order theoretical calculations. The variables include photon kinematic variables, angular separation between the two leptons, and angular variables related to the photon and the leptons.

Parallel Session II / 74

Big Science for National and Regional Unity

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Big science is characterized by long term multi-lateral engagements and large scale instruments that are used to address fundamental questions in science. The projects in big science work require huge funding and extensive collaborations at the regional and international levels. Experiences elsewhere, for example in Europe and the Middle East, have shown that in addition to technological developments, big science work brings communities of people together to address common scientific goals. Africa will be hosting the Square Kilometer Array (SKA) project. This is the world's largest array of radio telescopes to be operated in Africa and Australia. South Africa is one of the founder members of the global SKA organization. There are eight partner countries of the SKA in Africa. The SKA and the AVN (African VLBI Network) present Africa with a great opportunity for scientists in the region to work together with world scientists. This is a unique opportunity to use big science as a means to attain regional cohesion and unity. This paper focusses on the following: how big science has contributed to unity in the European Middle-Eastern regions; the experiences from particle physics research at the European Organization for Nuclear Research – CERN; the potential for big science to enhance national and regional unity in Africa; and the way forward for Africa.

Parallel Session IV, Collider / 75

Jet substructure and boosted top quark jet tagging

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We discuss varied jet taggers that identify boosted hadronic top quark jets.
These tagging approaches mainly uses jet algorithms to reconstruct the kinematics of fat jets (i.e. jets that includes heavy particles), by analyzing their subjet constituents. We also review the currently available experimental results as well as the crucial QCD aspects with reliable theoretical and algorithmic backgrounds that are useful for developing and enhancing these taggers.

Parallel Session V, Collider - Experiment / 76

Charged Higgs boson production via pp → H ± bj at the LHC

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The charged Higgs searches can be served to probe new physics at the LHC. In this study, we focus on the associated production of the charged Higgs boson with the bottom-quark and jet in 2HDM-type-I as a promising mode for a light H ± , i.e. m H ± < mt . We consider both situations where h(H) are the SM-like Higgs boson discovered with a mass near 125 GeV and investigate their bosonic decays, such as H± → W± h and/or H± → W± A. We explore the possible signals at the LHC taking into account the theoretical and experimental constraints, as a result, we find that, over a substantial region of the 2HDM-I parameter space, the Signal qbW + 2b/2τ /2γ could severe as a promising and alternative signal that might serve to discover
the H± states at the LHC.

Parallel Session IV, Collider / 77

Search for charged Higgs boson via $H^{\pm}W^{\mp}$ at the LHC

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In this work, we investigate the production of charged Higgs bosons via $pp \to H^{\pm}W^{\mp}$ at the LHC in the 2HDM Type-I. By focusing on the case where h or H is identified as the observed Higgs boson of mass 125 GeV, we study the aforementioned Higgs boson production channel and explore their bosonic decays, namely $H^{\pm} \to W^{\pm}h$ and/or $H^{\pm} \to W^{\pm}A$. Our study in this regard shows that the signal can reach several femtobarns in the viable parameter space, especially for $h/A \to b\bar{b}$, $\tau\tau$ and $\gamma\gamma$ decays. We propose six Benchmark Points (BPs) amenable to experimental investigation.

Parallel Session VI, Instrumentation / 78

The Fast Simulation Chain in the ATLAS experiment

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The ATLAS experiment at the large hadron collider relies on very large samples of simulated events that are required in the majority of physics analysis and performance studies in the ATLAS physics program. Producing such a huge number of simulated events using the Geant4 framework consumes the CPU resources. The challenge is that in the high luminosity phase of LHC, the average number of proton-proton collisions per bunch crossing will increase to about 200 collisions, which will have a severe impact on ATLAS computing resources. To meet the simulated sample statistics requirements, ATLAS is developing faster alternatives to the algorithms used in the standard sample production chain. This document describes the new tools for fast simulation chain that have been developed by ATLAS, and shows their physics performance.

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Detector performance and physics reach of at Muon Collider

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A muon collider is very promising for the future of high energy physics and is becoming a realistic option. It combines the high precision of electron-positron machines, with a low level of beam-strahlung and synchrotron radiation, and the high centre-of-mass energy and luminosity of hadron colliders. Beams with an intensity of the order of 10^{12} muons per bunch are necessary to obtain the desired luminosity, which entails a very high rate of muons decay. Among the technological challenges, the treatment of the Beam-induced Background is one of the most critical issues for the detector design.
This contribution will present the detector performance for collider machines working at centre-of-mass energies up to 3 TeV, discussing, in particular, the strategies studied to mitigate the effect of the Beam-induced Background. Moreover, the reach of the most representative physics processes will also be discussed.

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CP-even Heavy Higgs boson at HL-LHC

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We investigate the possibility of observing a havey Higgs boson (H) within the context of type-I 2 Higgs Doublet Model (2HDM). Our study is focused on $gg \rightarrow H \rightarrow hh \rightarrow b\bar{b}\ ZZ \rightarrow bb4\mu$ for H production and decay. The study is done assuming a data-set of size 3000 fb^{-1} of proton-proton collisions at $\sqrt{s} = 14$ TeV at High Luminosity Large Hadron Collider (HL-LHC). According to scans over the parameter space, we consider two promising benchmark points for this analysis. Signal and background samples are produced using MonteCarlo (MC) simulation where the detector response is based on CMS detector PhaseII Upgrade. We find that the mass distributions of our signal are consistent with those obtained by previous experimental study performed on HHbb4l channel where they investigated the self Higgs coupling using the full Run2 data of the CMS detector with $\sqrt{s} = 13$ TeV and $L_{int} = 137 fb^{-1}$.

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Thermal Performance of Developed Carbon Nanotubes and Nanospheres Based Thermal Interface Materials for Heat Dissipation Applications.

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In this study, the incorporation of 0D and 1D carbon nanomaterials in a commercial thermal interface material is reported to enhance the heat transfer of electronic devices. The investigated thermal interface materials were fabricated following a protocol based on sonication of the carbon nanomaterials and the thermal compound in acetone at 55 ℃. In order to test the applicability of the fabricated thermal interface materials, a setup was designed to simulate the operating conditions of standard electronic components. The experimental setup monitored the heat dissipation and transmission to the heat sink and allowed the acquisition of the data by means of LabVIEW software. The role of the carbon nanomaterials incorporated was studied by varying the mass in the thermal interface materials in a range between 0 and 10 %. The large heat transfer is reported with thermal interface materials containing 1% of carbon nanomaterials, corresponding to a temperature drop of 2 ℃. In addition, the thermal resistance Rth of the thermal interface materials was characterised by the ASTM D5470 approach. The reproducibility and reliability of the reported results were shown as part of the study. These measurements are found to be in accordance with the testing stand results. The new thermal interface material was tested in the low voltage power electronics and a temperature drop of over 5 ℃ was observed. The use of these new thermal interface material as part of the current upgrade of the ATLAS detector at CERN will have good impact, such as protecting the electronics from overheating and will expand their life span.

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Higgs boson couplings at muon collider

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Muon collisions at multi-TeV center of mass energies are ideal for studying Higgs boson properties. Precise measurements of its couplings to fermions and bosons will be allowed by the high production rates that can be reached at these energies. Furthermore the double Higgs boson production rate could be sufficiently high to directly measure the parameters of trilinear self-couplings, giving access to the determination of the Higgs potential.
In this presentation an overview of the results that have been obtained so far on Higgs couplings by studying the $\mu^+\mu^- \to H\nu\bar{\nu}$ and $\mu^+\mu^- \to HH\nu\bar{\nu}$ processes at $\sqrt{s}$ of 3 TeV will be given. All these studies have been performed by fully simulating the signal and physics background samples and by evaluating the effects of the beam-induced background on the detector performances.
Evaluations on Higgs boson couplings sensitivities and most recent results on the uncertainty on double Higgs production cross section and the trilinear Higgs self-coupling, will be presented and discussed.

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NLO Scattering in ϕ^4 Theory Finite System Size Correction

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Previously an equation of state for the relativistic hydrodynamics encountered in heavy-ion collisions at the LHC has been calculated using lattice QCD methods. This leads to a prediction of very low viscosity, due to the trace anomaly. Finite system corrections to this trace anomaly could challenge this calculation, since the lattice QCD calculation was preformed in an effectively infinite system. To verify this trace anomaly it is beneficial to add the finite system corrections that will be encountered. We construct a massive ϕ^4 theory while imposing periodic boundary conditions on n of the 3 spatial dimensions. $2 \to 2$ NLO scattering is then computed, while analytically making sure the optical theorem holds, to ensure unitarity remains intact despite the pathological nature of the finite system. In order to develop a solid mathematical basis that will carry forward into the thermal field theory context, some small and large argument analysis (in terms of the incoming energy as well as the length scales of the finite dimensions) is performed on the s,t and u channels separately. Finally the finite size corrections to the total cross section, running coupling and effective coupling is explored numerically, in order to estimate the size of such finite system corrections in massive field theories.

The size of these effects appears to depend very sensitively on the length scales of the finite dimensions, the number of finite dimensions, the energy of the scattering as well as the size of the renormalized coupling. For parameters comparable to what is found for QCD at the LHC it is unclear if the corrections would be detectable or not. Due to the pathological nature of the system it is also found that there are energies at which the total cross section becomes infinite when there are 2 finite dimensions, and that the cross section is infinite for all physical energies when all three spatial dimensions are finite. This makes interpretation difficult, and suggests the need to consider scattering happening in a finite time-span. It does however suggest that a fuller treatment of finite-system time-independent QCD may reveal detectable finite system effects, possibly challenging or confirming the low viscosity of the relativistic Quark Gluon Plasma generated in heavy-ion collisions, as calculated as a consequence of the numerically calculated lattice QCD equation of state.

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A Study to the Mass Effect due to Variation of Particle Type on the Femtoscopic Correlation Using Therminator2 Event Generator

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Studying the femtoscopic correlation of elementary particles resulting from heavy-ion collisions introduces an identification of the particle's space-time characteristics after the collision, in addition to the determination of how strong particles can interact. In this study, I try to present a femtoscopic analysis of particles with identical charges to check the effect of mass on the correlation factor through THERMINATOR2 which is used to generate events for proton-lead collisions at a center of mass energy of 5.02 TeV.

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A New Monte-Carlo Code System for Particles Transport

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Particles Through Matter (or PTM for short) is a new Monte-Carlo C++ code system, under development by us. The PTM is intended to be a general purpose Monte-Carlo code, simulating all types of particles and their interactions with matter. The current version is still in an early stage of development, although a minimum stuff of electromagnetic interactions is already done, covering a wide energy range from low to high energies (at least collider energy scale). For electron/positron, a minimal package of physical processes is done, e.g., energy loss, bremsstrahlung, ionization, coulomb scattering (single and multiple) and the annihilation for the positron. For photons, the photoelectric effect, Rayleigh and Compton scattering and pair production are implemented with different models. The PENELOPE option is implemented for both electron/positron and photons aside with the standard option. Optical photon and its processes is implemented too, enabling performing simulations of even complex optical systems, e.g., refractive and reflective telescopes. Fresnel lenses which present complex shapes of the surface are taken into account. Further, a minimal functioning package for neutrino propagation and interaction (roughly implemented) through matter with matter effect is done, with three active neutrino scheme and three active plus one sterile neutrino. More details about the design of the code with some validation tests will be presented and discussed through this contribution.

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Are Jets Narrowed or Broadened in e+A SIDIS?

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We compute the in-medium jet broadening to leading order in energy in the opacity expansion. At leading order in α_s the elastic energy loss gives a jet broadening that grows with $\ln E$. The next-to-leading order in α_s result is a jet narrowing, due to destructive LPM interference effects, that grows with $\ln^2 E$. We find that in the opacity expansion the jet broadening asymptotics are—unlike for the mean energy loss—extremely sensitive to the correct treatment of the finite kinematics of the problem; integrating over all emitted gluon transverse momenta leads to a prediction of jet broadening rather than narrowing. We compare the asymptotics from the opacity expansion to a recent twist-4 derivation and find a qualitative disagreement: the twist-4 derivation predicts a jet broadening rather than a narrowing. Comparison with current jet measurements cannot distinguish between the broadening or narrowing predictions. We comment on the origin of the difference between the opacity expansion and twist-4 results.

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Study of muon-induced background in Double Chooz neutrino oscillation experiment.

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The Double Chooz experiment is a reactor antineutrino disappearance experiment located on the site of the Chooz nuclear power plant in the Ardennes region in France. The principal aim of the experiment is a high precision measurement of the oscillation amplitude sin2 2θ13 of the antineutrinos emitted from the two reactor cores of the Chooz power plant. The robustness and accuracy of this measurement depends strongly on a precise knowledge of the rates and spectral shapes of the backgrounds that contaminate the antineutrinos selection over the neutrino oscillation expected region. We study the muon induced background in the Double Chooz experiment. Indeed, cosmic muons crossing the detectors or interacting in the neighborhood constitute the main source of background events encountered in Double Chooz. Dedicated identification techniques have been developed ton tag each of these backgrounds and, consequently, the associated spectral shapes and rates have been determined. The values obtained in our work serve as inputs in the final fit whence the θ13 value is extracted. The latest measurement released by the Double Chooz collaboration is sin^2 θ13 = 0.119 ± 0.016.

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The discovery of the Higgs boson at the LHC

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Extended Scalar Sectors and new Physics Beyond the Standard Model

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Neutrinos and the Invisible Universe

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Physics beyond the Standard Model

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Anomalies in Particle Physics

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Future Colliders

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HyperK status and prospects

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Dark matter in the Universe

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Indirect DM search and Physics Beyond the Standard Model

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A theoretical review of astroparticles

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Formation and the Evolution of Large-Scale Structure in the Universe

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Multi-messenger Astronomy with high-energy Neutrinos

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Optical observations of gamma-ray binaries with SALT

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Searching for Dark Matter Scattering, on Earth and in the Stars

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Search for Dark Matter with the ATLAS detector at the LHC

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Light charged Higgs boson in $H^{\pm}h$ associated production at the LHC

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In this work, we investigate the production of charged Higgs boson via $pp \to H^{\pm}h$ at the LHC in the Two-Higgs Doublet Model (2HDM) Type-I. By focusing on the case where H is identified as the observed Higgs boson of mass 125 GeV, we study the aforementioned Higgs boson production channel and explore their bosonic decays, namely $H^{\pm} \to W^{\pm}h$ and $H^{\pm} \to W^{\pm}A$, which can reach a sizeable Branching Ratio (BR) and often dominate over the fermionic decays in the theoretically and experimentally viable parameter space. In this regard, we demonstrate that the production process $pp \to H^{\pm}h$ followed by $H^{\pm} \to W^{\pm}h$ and/or $H^{\pm} \to W^{\pm}A$ could well be the most promising discovery channel for light $H^{\pm}$ at the LHC.

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Introduction

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Welcome from the Ministry of Higher Education, Scientific Research and Innovation of Morocco

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Welcome from the Network of African Science Academies

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Beyond the Standard Model with Lepton Flavor Universality Violation

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In recent years, exciting (indirect) hints for physics beyond the Standard Model (SM) have been accumulated. In particular, semi-leptonic B decays show deviations from the SM predictions, which, due to the ratios $R(K^{(*)})$ and $R(D^{(*)})$ are obviously related to lepton flavour universality violation (LFUV). However, {we point out} there are more anomalies which admit an interpretation in terms of LFUV: The anomalous magnetic moment of the muon, the Cabibbo angle anomaly, the CMS measurements of non-resonant di-electrons, the difference of the forward-backward asymmetry in $B \to D^* \ell \nu$ and leptonic tau decays. In this letter we discuss the experimental and theoretical status of these anomalies, {compare their strength and weaknesses} and examine {and synthesize} how they can be explained in terms of possible extensions of the SM by new particles and interactions. Even though not all anomalies might be confirmed in the future, this unified view of the anomalies in terms of LFUV significantly strengthens their relevance, which is crucial in order to construct a convincing physics case for future colliders.