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Book of Abstracts

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Optimally sensitive observables for global EFT fits

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Global interpretations of particle physics data in the context of the Standard Model Effective Field Theory (SMEFT) rely on the combination of a wide range of physical observables from many different processes. A key open question to inform such global SMEFT fits is how one can construct new classes of measurements that bring in, in a well-defined statistical sense, a maximal amount of information into the EFT parameter space. We present ongoing work towards assembling optimally-sensitive LHC observables for EFT fits based on unbinned deep-learning parametrisations of the extended log-likelihood ratio, with the ultimate goal of integrating such observables as building blocks of future global EFT fits. We validate them with explicit analytic calculations, and devote particular attention to the role played by systematic and theory errors. As a proof of concept, we study the constraints on the SMEFT parameter space provided by top quark pair production and by Higgs boson production in association with vector bosons at the HL-LHC. Furthermore, we study to what degree binned analyses can achieve sensitivity approaching the optimal limit.

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Studies of Generalized Transverse Momentum Dependent gluon distributions at EIC and LHC

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Generalized Transverse Momentum Dependent parton distributions (GTMDs) encode information about both the transverse momentum and the coordinate dependence of quarks and gluons inside hadrons. GTMDs are hard to probe in experiments, but a few possibilities have been suggested. Gluon GTMDs are accessible via diffractive dijet production which can be explored at the Electron-Ion Collider (EIC), a future accelerator for high precision hadron tomography to be constructed in the U.S. Gluon GTMDs can also be accessed in Ultra-Peripheral Collisions (UPCs) at LHC. To facilitate the experimental study of GTMDs, we consider a model for gluon GTMDs based on an impact parameter dependent McLerran-Venugopalan model within the color glass condensate (CGC) framework. By introducing two free parameters, we fit the model to HERA's H1 data of diffractive dijet production in electron-proton collisions. We find that the model is consistent with the data with a small error band, allowing us to predict diffractive dijet in leptoproduction and photoproduction processes at the EIC. Conditions for UPC studies at the LHC will also be discussed.

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Constraining Neutron-Star Matter with Microscopic and Macroscopic Collisions

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Interpreting high-energy, astrophysical phenomena, such as supernova explosions or neutron-star collisions, requires a robust understanding of matter at supranuclear densities.
However, our knowledge about dense matter explored in the cores of neutron stars remains limited. Fortunately, dense matter is not only probed in astrophysical observations, but also in terrestrial heavy-ion collision experiments.
In this work, we use Bayesian inference to combine data from astrophysical multi-messenger observations of neutron stars and from heavy-ion collisions of gold nuclei at relativistic energies with microscopic nuclear theory calculations to improve our understanding of dense matter.
We find that the inclusion of heavy-ion collision data indicates an increase in the pressure in dense matter relative to previous analyses, shifting neutron-star radii towards larger values, consistent with recent NICER observations.
Our findings show that constraints from heavy-ion collision experiments show a remarkable consistency with multi-messenger observations and provide complementary information on nuclear matter at intermediate densities.
This work combines nuclear theory, nuclear experiment, and astrophysical observations, and shows how joint analyses can shed light on the properties of neutron-rich supranuclear matter over the density range probed in neutron stars.

Parallel 1B / 54

Angular analysis of the B0->K*0ee decay with the LHCb detector

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Recent results in high energy physics experiments highlighted the importance of the heavy flavour processes in searching for clues of new physics. Indeed, hints of new physics can be found in semileptonic decays of B particles that occur via flavor-changing neutral currents (FCNC). The LHCb (CERN, Geneva) detector plays a very important role in these measurements, since it is designed for the study of particles containing b or c quarks. The Standard Model of particle physics states that electron, muon and tau have the same electroweak coupling strength, a concept known as "lepton flavour universality", while experimental results point towards the violation of the universality. Confirmation of these results would pave the way to the discovery of new physics scenarios in these decays, for instance the observation of new heavy mediators. One of the golden channels is the rare $B^0 \to K^{*0}ee$ decay. This is a FCNC decay, hence only proceed through loop-level processes, therefore it is sensitive to possible contributions from heavy mediators, inaccessible to direct searches. The presence of electrons in the final state together with the low available statistic make this channel extremely challenging. Angular analyses on this decay channel have been previously performed by the LHCb, however a new analysis using improved analysis techniques and the full Run1 and Run2 datasets is being currently developed. These ongoing activities, that will lead to the "legacy" LHCb $B^0 \to K^{*0}ee$ angular analysis, will be discussed in this talk.

Parallel 2A / 55

Feasibility studies of multi-charm baryons in perspective of the ALICE 3 upgrade

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Measurements of charm hadrons in pp collisions typically provide insights into the production process of charm in the initial scattering, while those measurements in Pb-Pb collisions aim to understand the role of charm in the equilibration process of the hot and dense medium. Especially states of multi-charm baryons are expected to offer a unique sensitivity to these phenomena, but so far, extensive studies by current experiments are not available.

The upgrade strategy for a future heavy-ion experiment called "ALICE 3" emphasizes an excellent tracking performance as well as a large acceptance and will result in a layout which offers the possibility to implement a new approach in the reconstruction of particles called strangeness-tracking. Its physics program includes the study of multi-charm baryons and the feasibility of such a measurement is studied in simulations, which indicate that a significant measurement of the
Ξ_{cc}^{++} and Ω_{cc}^{+} yield in both pp and Pb-Pb collisions is possible.

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Theoretical study of properties of AcF – Canceled

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Heavy diatomic molecules are currently considered to be among the most sensitive systems used in the search for the P,T-violating effects and in probing of the Standard Model of particle physics. In certain molecules effects resulting from both parity violation and time-reversal violation (P,T- odd effects) are considerably enhanced with respect to atomic systems. The strength of these interactions grows with atomic number, nuclear spin and nuclear deformation. Molecules with atomic nuclear octupole deformation are sensitive for investigating of parity and time-reversal violating effects, in particular nuclear EDM. Diatomic molecule AcF has been proposed to be sensitive to the Schiff moment of the Ac nucleus[1,2]. Nowadays different laboratories plan to perform experimental study of radioactive AcF in aim to measure isotopologue shifts and hyperfine structure and achieve first successful measurements of the Schiff moment.
Pursuing studies on AcF can also provide insight into dynamics of molecular extraction of Ac, as a pathway to delivering a wider range of actinium isotopes for experiments.
This work aims to determine AcF molecular properties at the highest possible level of computational accuracy using the couple cluster in relativistic framework.
The ionization potential, excitation energies, and spectroscopic constants of AcF will be presented and the uncertainty of the predicted values will be discussed.

References:

1. D. Cho, K. Sangster, and E. Hinds. Phys. Rev. A, 44:164–164, 1991.
2. V. Flambaum and V. Dzuba. Phys. Rev. A, 101:42504, 2020.

Parallel 2B / 57

Laboratory and testbeam characterization of ALICE MAPS

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In view of the LHC upgrade to high-luminosity LHC, trackers need to be upgraded to comply new stringent requirements in terms of position (~5um) and time (~10ps) resolution. These properties are required for dealing with an extremely high event rate, identifying particles and reconstructing originating collision and vertex positions.
MAPS are good candidates for present and future trackers thanks to their property of embedding sensor and electronics in the same layer, thus greatly reducing the material in particle tracks.

Within the presented context, ALICE has already installed the ALice PIxel DEtector (ALPIDE) MAPS in the new detector Inner Tracking System and further developments are foreseen for the innermost tracker upgrade in 2025.
By exploiting its reduced thickness (50um), the ALPIDE can be bent in cylindrical shape with radius of 18 mm without degradation of efficiency or spatial resolution. This minimizes the achievable distance from the beam pipe and gives the structure an intrinsic stability, removing the need of considerable support structures, with further reduction of the material budget.
At the same time, new chips based on 65nm CMOS technology are being tested in laboratories and testbeams.

In this talk, some results of my work at Nikhef, as member of the Detector R&D group with focus on fast timing for ALICE, are presented. A laboratory timing characterization of 180nm CMOS technology (on which the ALPIDE is based), recent testbeam results with bent ALPIDE and some preliminary timing measurement results of testbeams with the newly arrived 65nm CMOS chips are discussed.

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Testing General Relativity with gravitational waves higher-order modes

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Gravitational wave signals from the coalescence of compact objects binaries allow us to test General Relativity in its strong-field regime. The gravitational radiation emitted by these binaries has a multipolar structure, and for systems with high mass ratio and high inclination angles, modes beyond the quadrupolar dominant one are expected to start giving a non-negligible contribution. The improved sensitivity of gravitational-waves detectors yields an increasingly higher chance to detect signals from these systems, and hence to observe higher-order modes. We already had examples of such detections in the last observing run, for events like GW190814 and GW190412. Therefore we need to start taking into consideration higher-order modes in our analyses, including the tests of General Relativity.
We present a new method to probe General Relativity, a test in which we allow for parametrized deviations of the amplitude of higher-order modes from the GR expected values, and we estimate their posteriors with a Bayesian inference analysis. We test our method on simulated binary black holes signals, studying the impact of amplitude deviations on the overall parameter estimation analysis, and we compute Bayes factors differences between the case in which we recover the signal with the GR model or with the non-GR one. Finally, we test our method on the real events GW190412 and GW190814, finding no evidence of deviations from General Relativity.

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A fast and precise method to search for and analyze strongly lensed gravitational-wave events

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Like light, gravitational waves (GWs) can be lensed by massive astrophysical objects such as galaxies or galaxy clusters on their path. Strong gravitational lensing produces several "images" appearing as repeated GW signals in the detectors (doubles, triples, quadruplets), having the same frequency evolution and originating from the same sky position. With Advanced Virgo, Advanced LIGO, and KAGRA at design sensitivity, lensed GWs are forecasted at a rate of 1-2 per year. To search for them, at a minimum one needs to consider all the event pairs present in a gravitational-wave catalog. This leads to a rapidly increasing number of pairs to be looked at, reaching O(10^5) for the detectors at design sensitivity. In order to make searches for lensed events feasible, we have developed a fast and precise methodology to uncover strongly lensed GWs, which relies on the efficient use of the posterior of one image to analyze a potential second image. We show how higher-order modes in the signal can be used for further corroboration of lensing. Finally, we point to applications, such as localizing the host galaxy of a binary black hole merger and probing dark matter around the galaxy acting as a lens.

Parallel 3B / 60

Effective Field Theory and Sterile Neutrinos

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Sterile neutrinos are gauge-singlet fields that can have Majorana masses. They interact with the Standard-Model fields through Yukawa couplings and higher-dimensional gauge-invariant operators. In the framework neutrino extended Standard Model Effective Field Theory (νSMEFT), we study the effect of sterile neutrino on neutrinoless double beta decay ($0\nu\beta\beta$), displaced-vertex searches at LHC and Belle II, and kaon decay with lepton number violation. We find non-standard interactions involving sterile neutrinos have a dramatic impact on the phenomenology and can probe new physics up to the scale of $\mathcal{O}(100)$ TeV.

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Kicker eddy currents in the Fermilab Muon g–2 experiment

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The measurement of the muon magnetic anomaly, aμ = (gμ - 2)/2, is one of the most accurate tests of the Standard Model (SM).
The measurement of aμ by the E989 Muon g-2 experiment was presented last April and confirmed the E821 BNL experimental result of 2004, increasing the significance of the discrepancy between the measured and SM predicted aμ from 3.7σ to 4.2σ.
In the E989 experiment, positive 3.1 GeV/c muons are injected into a 14m diameter storage ring (SR), where both muon's spin and momentum vectors precede. The difference between the spin frequency and the cyclotron frequency is called *anomalous precession frequency*, related to aμ through ωa = aμ B q/m, where B is the dipole magnetic field inside the SR. Therefore, aμ can be extracted by accurately measuring ωa and B.
A kicker system produces a ~ 250G magnetic field parallel to the ring dipole field that steers the muon beam onto the designed orbit. The high voltage of ~ 120kV in the kickers' plates induces *eddy currents* that produce a magnetic field that modifies the main dipole field at the ppm level, thus modifying the measured ωa, if not corrected. I will describe how this field can be measured by a Faraday Magnetometer which I have contributed to build and characterize in the laboratories of the National Optics Institute in Pisa (Italy).

Parallel 3B / **62**

Combined effective field theory interpretation of $$H \rightarrow WW^* and$$WW$ measurements using ATLAS data

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While LHC physics is entering the precision era, no fatal flaws in the standard
model of particle physics have been revealed. In the years to come, direct searches for new particles will continue to play an important role. However, they will be accompanied by precision measurements of known particles and indirect searches. Using the Standard Model Effective Field Theory (SMEFT) these measurements can be combined and interpreted in a coherent theory framework. This framework can be used to describe a variety of beyond the standard model theories that introduce new-physics states at a high mass scale, potentially exceeding the energy reach of the collider.

In a new combination, using 36.1 fb^{-1} of LHC collision data reconstructed at the ATLAS experiment, effective field theory operators are constrained in a combined analysis of two studies: the measurement of the $H \rightarrow WW^* \rightarrow e^{\pm}\nu_e\mu^{\mp}\nu_\mu$ process and a differential cross-section measurement of the $WW \rightarrow e^{\pm}\nu_e\mu^{\mp}\nu_\mu$ process. For the first time, two conceptually different measurements styles are combined in a coherent statistical framework, increasing the sensitivity of the interpretation and paving the way for future combinations within ATLAS.

Parallel 2C / **63**

Search for Higgs boson pair production in bbll final states

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The discovery of the Higgs boson in 2012 by the ATLAS and CMS collaborations was one of the major achievements of particle physics in recent times.

However, the discovery of this particle was only the first step of its characterization, as the confirmation of the Higgs mechanism requires the determination of its quantum numbers, widths and couplings. Playing such a key role in the the architecture of the SM it is a topic of the utmost importance in understanding the SM as well as a promising portal to BSM physics.

More specifically, measuring the couplings of the Higgs boson can allow us to test the Higgs mechanism and hence the whole electro-weak symmetry breaking (EWSB) mechanism, which is one of the main goals of the LHC.

The SM predicts non-resonant production of Higgs boson pairs (HH) in proton–proton collisions, referred to as non-resonant HH production.

In many BSM theories, HH production can be enhanced by modifying the Higgs boson self-coupling or other Higgs-fermion couplings. One of the possible production modes, where a Higgs decays into two Higgses, would be an ideal probe for determining the trilinear Higgs self-coupling, which is directly linked to the Higgs potential. Measuring it would be a challenge of key importance for the LHC in its high luminosity phase.

A search for HH production in $bb\ell\ell$ final states has been carried out using the full Run 2. Among other decay channels, $bb\ell\ell$ has the advantage of allowing for a better discrimination against background.

Parallel 1C / 64

Ready to address the permanent electric dipole on the electron

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The observation of a CP-violating permanent electric dipole moment of the electron (eEDM) larger than the value predicted by the Standard Model (SM) of particle physics would be direct evidence of new physics, while an upper limit of the eEDM would constrain extensions to the SM. The NL-eEDM experiment has been set up over the last few years, and first measurements demonstrate the working of all its crucial components. It employs the ground state of the barium monofluoride (BaF) molecule [1] which strongly enhances the CP-violating dipole moment. We create and readout a superposition using coherent state transfers, during which the magnetic and electric fields are precisely controlled and measured to reduce the systematic limit that can be achieved. The setup is now ready for a first measurement.

This talk discusses the experimental setup and its performance for a first collection of data. Furthermore, progress on planned upgrades on molecular beam intensity, deceleration and laser cooling will be presented.

[1] The NL-eEDM collaboration, Aggarwal, P., Bethlem, H.L. et al. Eur. Phys. J. D (2018) 72: 197. https://doi.org/10.1140/epjd/e2018-90192-9 and references therein.

Parallel 3C / 65

Ameliorating glitches in gravitational-wave searches for intermediate-mass black holes

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Interferometer data contains numerous noise transients, or "glitches", that can mimic true gravitational waves, reducing the sensitivity of the match-filtering search by increasing the rate at which random coincidences occur. High mass binary black hole mergers are particularly susceptible since they resemble short noise transients. We show that we can use a template bank of compact binary gravitational waveforms as a probe of the frequency evolution of transients in the data. We use the GstLAL detection pipeline to produce matched-filter triggers, under the assumption that short high-mass black hole signals and glitches yield different patterns of GstLAL triggers in time and template parameter. We propose an inexpensive statistic, derived from Random Forest algorithm, based on the triggering patterns, that can easily distinguish between real events and noise, consequently increasing the significance of gravitational-wave candidates.

Parallel 2B / 66

ALBUS : Anomaly detector for Long-duration BUrst Searches

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Minute-long gravitational-wave transients are an interesting class of events with a high potential for new Science. Comparatively to recent detections of gravitational waves produced from compact binary systems, minute-long transients are expected to originate from a wide range of poorly understood astrophysical phenomena such as magnetars and accretion disk instabilities for which the lack of readily available and accurate gravitational-wave emission models prevents the use of matched filtering methods. Such events are thus probed through an excess of power in time-frequency space correlated between the network of detectors. The problem can be viewed as a search for high-value clustered pixels within an image which has been generally tackled by deep learning algorithms such as convolutional neural networks (CNNs). In this work, we use a CNN as an anomaly detection tool for minute-long gravitational-wave transients. We show that it can reach pixel-to-pixel detection despite training with minimal assumptions while being able to retrieve both astrophysical signals and noise transients originating from instrumental coupling within the detectors. We also note that the neural network can extrapolate and connect partially disjoined signal tracks in the time-frequency plane.

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CNN fo inspiral detection: going down in frequency

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Gravitational waves play an essential role in multi-messenger astronomy. In principle, they could be detected before the other channels. This is particularly important for binary neutron star mergers, where electromagnetic counterparts can be observed. To issue alerts, one would require the detection in the early inspiral part of the signal, well before the maximum frequency is reached. Our previous work showed that machine learning techniques such as convolutional neural networks are well suited to detect this early inspiral. This proof of principle was for a single detector with simulated Gaussian noise. We have shown that our designed neural network architecture performs with similar accuracy as the matched filtering while being much faster. We now extend the search at multiple detectors, and study different possibilities: one network taking the input of all the detectors, or one network by detector. We also evaluate the performance of such a network on different power spectral densities, especially design O4, Gaussian noise O3, and into some real noise of O3. We investigate the efficiency of those techniques for the Einstein Telescope, where the signal should be visible even earlier in the inspiral.

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Sensitivity estimates for diffuse, point-like, and extended neutrino sources with KM3NeT/ARCA

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The identification of cosmic objects emitting high energy neutrinos could provide new insights about the Universe and its active sources. The existence of these neutrinos has been proven by the IceCube collaboration, but the big question from which sources these neutrinos originate is yet unanswered. The KM3NeT detector for Astroparticle Research with Cosmics in the Abyss (ARCA) that is currently being built in the Mediterranean Sea, will excel in the identification of cosmic objects emitting high energy neutrinos because of its precise angular resolution for muon neutrinos (< 0.2 degree for E > 10 TeV events). In order to identify the signature of cosmic sources in the background of atmospheric neutrinos and muons with KM3NeT, statistical methods are being developed and tested with Monte-Carlo pseudo-experiments. This poster presents the most recent results concerning the detection of diffuse, point-like and extended neutrino sources with KM3NeT/ARCA.

Parallel 3C / 69

Commissioning of a setup to develop chemical isobaric separation techniques

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Gas catchers are widely used to slow down energetic particles in order to prepare them for precision measurements. Chemical reactions of the ions with impurities in the gas can affect the extraction efficiency from the gas-catcher. Our aim is to make use of this effect and to explore the potential of

chemical reactions for Chemical Isobaric Separation (CISe)
We want to apply this technique to measure the mass of 100Sn with high precision. 100Sn can be produced in nuclear fusion reactions along with a large amount of unwanted isobaric by-products such as 100Ag, 100Cd, and 100In. In order to develop a suited chemical system, we built a gas-catcher in which stable isotopes of the ions of interest can be produced by laser ablation. The gas-catcher is coupled to a mass-spectrometer which allows us to identify the ablated ions and molecular species created inside the gas-catcher. In this contribution, I will provide an overview of the current status of the project with focus on the performance of the laser ablation source and the optimization of the ion transport efficiency.

Parallel 2A / 70

Simulating Transient Noise Bursts in LIGO with Generative Adversarial Networks

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The noise of gravitational-wave (GW) interferometers limits their sensitivity and impacts the data quality, hindering the detection of GW signals from astrophysical sources. Most problematic are transient noise artifacts, known as glitches, that happen a few times per hour and can mimic GW signals. We employ Generative Adversarial Networks (GANs), a state-of-the-art Deep Learning algorithm inspired by Game Theory, to learn the underlying distribution of various glitch classes and to generate artificial populations of glitches. We reconstruct the glitch waveform in the time-domain, providing a smooth input that the GAN can learn. With this methodology, we can create distributions of ~1000 glitches from Hanford and Livingston detectors in less than one second. This proof-of-concept work will be extended in the future to different hybrid classes of glitches, with the final goal of generating open-source, mock data for better modeling and inclusion in large-scale studies.

Parallel 1C / 71

Inclusive four lepton measurement with the ATLAS experiment at 13 TeV

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The Standard Model (SM) is a successful theory capable of describing observations across many physics processes. Nevertheless, the SM can not be the complete picture as it lacks to explain phenomena such as the matter-antimatter asymmetry, the behaviour of the cosmic microwave background, and others. Therefore, a presence of new physics is needed.

Various SM measurements, and their combinations, can be used to put constraints on models describing phenomena beyond the SM. This approach is useful in particular in the cases where new physics is expressed by many parameters, such as the effective field theory (EFT). An example of the measurement, which allows to probe phenomena within the SM and beyond, is an analysis of events with at least four leptons produced in proton-proton interactions at the LHC. I will present the latest ATLAS four lepton measurement at $\sqrt{s} = 13$ TeV and show, how the results can be used to systematically look for new physics within the SMEFT framework.

Parallel 2A / 72

The Nikhef two photon absorption setup

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To be able to separate different vertices after the High Luminosity upgrade at the LHC, timing information about the measured particles is needed. This presentation describes the characterization and first measurements of a TPA setup, build to test if future sensors reach the timing requirements needed for future use in the HL-LHC. The first part of this presentation describes the setup and its characterisation. A beam waist of 0.995 ± 0.035 μm was found. Next I will present how the stability of the TPA signal was characterised and corrected, resulting in a standard deviation of 3.6\%, and a maximum deviation of 11.7\% of the corrected signal. The second part of the presentation describes the first intrapixel timing measurements on three different assemblies with the new setup. These measurements show the advantages of the TPA setup, by making it possible to observe the metalization layer of the sensor, and showing the timing resolution of the sensor at different depths inside the silicon. A timing resolution of $\pm$ 0.6 ns for a 200 μm thick n-on-p Timepix3 assembly was found, and a timing resolution of $\pm$ 0.55 ns for a 300 μm thick p-on-n Timepix3 assembly. These results show that the setup can perform the necessary timing measurements, offering a reliable testing facility next to test beam measurements.

Parallel 2C / 73

Investigating exotic decays of the radon-222 chain with a contaminated liquid xenon detector

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In the search for dark matter, detectors have been built using liquid xenon as a detection medium. One of their most crucial background source is radon-222 and its daughter nuclides, as they can cause signals which look like those expected from dark matter particles. Consequently, it is important to understand how the radon-222 decay chain signals can be identified and suppressed from the dark matter signature. However, within the known radon-222 chain, there are some candidates for exotic decays which are theoretically allowed but have never been observed. One example of these exotic decays is the double-beta decay of the radon-222 into radium-222 which has a current limit on the half-life of $t_{1/2}$ > 8.0 years (at 90% C.L.). The radium-222 subsequently decays with a half-life of $t_{1/2}$ = 38s in a unique 3-fold alpha decays signature, which can be used for tagging the radon-222 double beta decay. In order to search for this signature, the R&D dark matter facility at Nikhef designed a customized liquid xenon detector called XAMSL (Xenon AMsterdam Liquid) in order to contaminate the xenon in the setup with high amount of radon-222, using a radium-226 source of 22.2kBq of activity. Using the known decay signals from the daughter nuclei of radon-222, it is possible to perform an energy calibration on its spectrum and measure the sensitivity required for the exotic decays.

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Improved Neutrino Shower Reconstruction with KM3NeT

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The IceCube Neutrino observatory has established the existence of a high energy cosmic neutrino flux. The origin of this flux remains elusive, and its discovery is instrumental in understanding cosmic particle accelerators. KM3NeT ARCA is a water cherenkov neutrino telescope aiming at finding high energy cosmic neutrino sources. The new multi-pmt optical module design and water medium gives an opportunity for improved reconstruction methods. When electron neutrinos interact through charged current in KM3NeT, they cause shower-type events. Current reconstruction algorithms for showers already reach a 1.5 degree resolution. We develop a new algorithm which fits the time profile of neutrino showers. An angular resolution of below 1 degree is achieved for electron neutrino charged-current events above 300 TeV. A small improvement in energy resolution is also found. Finally, results of computational optimization efforts are presented.

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Detecting Cosmic Neutrinos for Astronomy and Physics

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The inner workings of the quark-gluon plasma

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Plenary 2 / 77

Perspectives of Quantum Gravity

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Plenary 3 / 78

Symmetries in Machine Learning, from Images to Molecules

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