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Book of Abstracts

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QCD, spin physics and chiral dynamics / 70

Spin Physics Detector project at JINR

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The Spin Physics Detector at the constructing NICA collider (JINR, Dubna) is a universal facility to investigation the spin structure of the proton and deuteron and the other spin-related phenomena with polarized proton and deuteron beams at a collision energy up to 27 GeV. Comprehensive study of the unpolarized and polarized gluon content of the nucleon at large Bjorken-x using different complementary probes such as: charmonia, open charm, and prompt photon production processes is the central point of the SPD physics program. In the polarized proton-proton collisions, the SPD experiment at NICA will cover the kinematic gap between the low-energy measurements at ANKE-COSY and SATURNE and the high-energy measurements at the Relativistic Heavy Ion Collider, as well as the planned fixed-target experiments at the LHC. The possibility for NICA to operate with polarized deuteron beams at such energies is unique. The SPD experimental setup is planned as a multipurpose universal 4π detector with advanced tracking and particle identification capabilities, electromagnetic calorimeter and muon (range) system. To minimize possible systematic effects, SPD will be equipped with a triggerless data acquisition system. Spin physics program at the SPD is expected to start after year 2025 and to extend for about 10 years.

Neutrino physics / 72

CEvNS nuclear physics aspects

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The recent observation of coherent elastic neutrino nucleus scattering (CEvNS) has opened new opportunities for investigating nuclear structure parameters and other electroweak probes. In this talk I will present the current status of constraints on the nuclear neutron rms radii of CsI and Argon, placed by the COHERENT data. I will also review the implications of advanced nuclear structure models, such as the deformed shell model and the quasiparticle random phase approximation (QRPA), on the interpretations of new physics signals with a special focus on electromagnetic neutrino interactions.

QCD, spin physics and chiral dynamics / 74

Measurement of charged particle multiplicity distributions in DIS at HERA and its implication to entanglement entropy of partons

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Charged particle multiplicity distributions in positron-proton deep inelastic scattering at a centre-of-mass energy $\sqrt{s} = 319$ GeV are measured. The data are collected with the H1 detector at HERA corresponding to an integrated luminosity of 136 pb^{-1}. Charged particle multiplicities are measured as a function of photon virtuality Q^2, inelasticity y and pseudorapidity η in the laboratory and the hadronic centre-of-mass frames. Predictions from different Monte Carlo models are compared to the data. The first and second moments of the multiplicity distributions are determined and the KNO scaling behaviour is investigated. The multiplicity distributions as a function of Q^2 and the Bjorken variable x_{Bj} are converted to the hadron entropy S_{hadron}, and predictions from a quantum entanglement model are tested.

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Hot and dense matter physics - QGP and heavy ion collisions / 76

Results on exclusive pi+pi- and rho(770) photoproduction and on collectivity in small systems obtained in ep collisions at HERA

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Exclusive photoproduction of Ï�0(770) mesons is studied using the H1 detector at the ep collider HERA. A sample of about 900000 events is used to measure single- and double-differential cross sections for the reaction $\gamma p \to \pi^+\pi^- Y$. Reactions where the proton
stays intact ($m_Y = m_p$) are statistically separated from those where the proton dissociates to a low-mass hadronic system ($m_p < m_y < 10$ GeV). The double-differential cross sections are measured as a function of the invariant mass $0.5 < m_{\pi\pi} < 2.2$ GeV of the decay pions and the squared
4-momentum transfer at the proton vertex $|t| < 1.5$ GeV^2, in bins of the photon-proton energies $20 < W_{\gamma p} < 80$ GeV. Cross sections for $\rho(770)$ production are extracted as a function of t and $W_{\gamma p}$. The available energy range bridges the gap between
fixed-target experiments and LHC central exclusive production.
The Regge trajectory $\alpha(t)$ is extracted from these H1 data alone.

Measurements of two- and multi-particle angular correlations are presented in both ep deep-inelastic scattering at $\sqrt{s} = 319$ GeV and in photoproduction off protons at energies $W_{\gamma p} = 270$ GeV, as a function of charged-particle multiplicity. No long-range ridge structure is observed in the correlation functions. The second-order ($V_{2\dagger}$) and third-order ($V_{3\dagger}$) azimuthal anisotropy
Fourier harmonics are extracted. Further, $C_2\{4\}$ signals are extracted from four-particle correlations for the first time in ep collisions and are found to be positive or consistent with 0. In summary, collective behavior has not been observed in collisions of protons with virtual or quasi-real photons at HERA energies.

QCD, spin physics and chiral dynamics / 77

The structure of the proton at 1% precision: NNPDF4.0

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We present a new release of the NNPDF family of global analyses of parton distribution functions: NNPDF4.0. It includes a wealth of new experimental data from HERA and the LHC, from dijet cross-sections to single-top and top-quark pair differential distributions. The NNPDF4.0 methodology benefits from improved machine learning algorithms, in particular automated hyperparameter optimisation and stochastic gradient descent for neural network training, which has been validated extensively by means of closure tests and future tests. We demonstrate the stability of the result with respect to the choice of parameterisation basis. We compare NNPDF4.0 with its predecessor NNPDF3.1 as well as to other recent global fits, and study its phenomenological implications for representative collider observables. We assess the impact of representative datasets on specific PDF combinations, such as the dijet and top quark data on the gluon, the Drell-Yan and neutrino DIS data on strangeness, and electroweak measurements on charm and quark flavour separation.

Standard model physics at the TeV scale / 78

Combined SMEFT interpretation of Higgs, diboson, and top quark data from the LHC

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We present a global interpretation of Higgs, diboson, and top quark production and decay measurements from the LHC in the framework of the Standard Model Effective Field Theory (SMEFT) at dimension six. We constrain simultaneously 36 independent directions in its parameter space, and compare the outcome of the global analysis with that from individual and two-parameter fits. Our results are obtained by means of state-of the-art theoretical calculations for the SM and the EFT cross-sections, and account for both linear and quadratic corrections in the $1/\Lambda^2$ expansion. We demonstrate how the inclusion of NLO QCD and quadratic EFT effects is instrumental to accurately map the posterior distributions associated to the fitted Wilson coefficients. We assess the interplay and complementarity between the top quark, Higgs, and diboson measurements, deploy a variety of statistical estimators to quantify the impact of each dataset in the parameter space, and carry out fits in BSM-inspired scenarios such as the top-philic model. Our results represent a stepping stone in the ongoing program of model independent searches at the LHC from precision measurements, and pave the way towards yet more global SMEFT interpretations extended to other high-p_T processes as well as to low-energy observables.

Neutrino physics / 79

Particle physics implications of coherent elastics neutrino-nucleus scattering

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Detection of coherent elastic neutrino nucleus-scattering (Cevns) has been recently confirmed. The low-energy region of this process and its neutral current character, allows to explore beyond the Standard Model particle physics in complementary regions to other searches. In this talk I will review the current status and future perspectives of such constraints with a special focus on non-standard interactions.

Poster Session I / 81

Study of tau neutrino production with nuclear emulsion at CERN-SPS

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The data on tau neutrino is very scarce, only a few experiments have detected its interactions. At FNAL beam dump experiment DONUT, tau neutrino interaction cross-section was directly measured with a large systematical (~50%) and statistical (~30%) errors. The main source of systematical error is due to a poor knowledge of the tau neutrino flux. The effective way for tau neutrino production is the decay of Ds mesons, produced in proton-nucleus interactions. The DsTau experiment at CERN-SPS has been proposed to measure an inclusive differential cross-section of a Ds production with a consecutive decay to tau lepton in p-A interactions. The goal of experiment is to reduce the systematic uncertainty to 10% level. A precise measurement of the tau neutrino cross section would enable a search for new physics effects such as testing the Lepton Universality (LU) of Standard Model in neutrino interactions. The detector is based on nuclear emulsion providing a sub-micron spatial resolution for the detection of short length and small "kink"decays. Therefore, it is very suitable to search for peculiar decay topologies ("double kink") of Ds→τ →X. After successful pilot runs and data analysis, CERN had approved the DsTau project as a new experiment NA65 in 2019. During the physics runs, 2.3×10^8 proton interactions will be collected in the tungsten target, and about 1000 Ds→τ decays will be detected. In this talk, the results from the pilot run will be presented and the prospect for physics runs in 2021-2022 will be given.

Dark matter and cosmology / 82

The PADME Scientific Program

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In spite of the variety of attempts to create dark matter at accelerators, up-to-now, none of the conducted experiments has produced any evidence.
This elusiveness of dark matter has then triggered innovative and open-minded approaches spanning a wide range of energies with high-sensitivity detectors. In this scenario is inserted the Positron Annihilation into Dark Matter Experiment (PADME) ongoing at the Frascati National Laboratory of INFN. PADME is searching a Dark Photon signal [1] by studying the missing mass spectrum of single photon final states resulting from positron annihilation events on the electrons of a fixed target. After commissioning and beam-line optimization, PADME collected in 2020 about 5×1012 positrons on target.
Actually, the PADME approach allows to look for any new particle produced in e+e− collisions through a virtual off-shell photon such as long lived Axion-Like-Particles (ALPs), proto-phobic X bosons, Dark Higgs … In the talk, the scientific program of the experiment, and its current status will be illustrated.

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Development of accelerators and detectors / 83

The PADME Detector

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The Positron Annihilation into Dark Matter Experiment (PADME) [1] aims to search for a dark photon (A') produced in the process e+ e− ⟶ A'γ. It uses the positron beam provided by the DAΦNE LINAC, maximum energy 550 MeV, at the Frascati National Laboratory of INFN [2].
The aim of the experiment is to evaluate the missing mass of single-photon final states following the positrons annihilation on the electrons of a thin target. To measure such a reaction, the PADME apparatus has been built. It consists of a small-scale detector composed of the following parts:
• a diamond active target, to measure the position and the intensity of the beam in each single bunch;
• a beam monitor system consisting of two different silicon-pixel detectors;
• a spectrometer, to measure the charged particle momenta in the range 50-400 MeV;
• a dipole magnet, to deflect the primary positron beam out of the spectrometer and calorimeter and to allow momentum analysis;
• a finely segmented, high resolution electromagnetic calorimeter, to measure 4-momenta and/or veto final state photons.
Each element has specific requirements that are stringent and sometimes at the limit of present technology.

In the talk will be given an overview of each component, and a description of the chosen technical solutions implemented to accomplish the experiment needs. Results of the commissioning data taking, will be illustrated.

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[2] http://www.lnf.infn.it/acceleratori/btf/

Poster Session I / 84

Unstable states in fragmentation of relativistic nuclei (overview)

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In the events of peripheral dissociation of relativistic nuclei in the nuclear track emulsion, it is possible to study the emerging ensembles of He and H nuclei, including those from decays of the unstable 8Be and 9B nuclei, as well as the Hoyle state [1-3]. These extremely short-lived states are identified by invariant masses calculated from the angles in 2α-pairs, 2αp- and 3α-triplets in the approximation of conservation of momentum per nucleon of the primary nucleus. In the same approach, it is possible to search for more complex states. This paper explores the correlation between the formation of 8Be nuclei and the multiplicity of accompanying α-particles in the dissociation of relativistic 16O, 22Ne, 28Si, and 197Au nuclei. On this basis, estimates of such a correlation are presented for the unstable 9B nucleus and the Hoyle state. An enhancement in the 8Be contribution to dissociation with the α-particle multiplicity is found. Decays of 9B nuclei and Hoyle states follow the same trend.

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3. A.A. Zaitsev et al. https://arxiv.org/abs/2102.09541.

Neutrino physics / 85

Latest results from the CUORE experiment

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The Cryogenic Underground Observatory for Rare Events (CUORE) is the first bolometric experiment searching for 0νββ decay that has been able to reach the one-tonne mass scale. The detector, located at the LNGS in Italy, consists of an array of 988 TeO2 crystals arranged in a compact cylindrical structure of 19 towers. CUORE began its first physics data run in 2017 at a base temperature of about 10 mK and in April 2021 released its 3rd result of the search for 0νββ, corresponding to a tonne-year of TeO2 exposure. This is the largest amount of data ever acquired with a solid state detector and the most sensitive measurement of 0νββ decay in 130Te ever conducted, with a median exclusion sensitivity of 2.8×10^25 yr. We find no evidence of 0νββ decay and set a lower bound of 2.2 ×10^25 yr at a 90% credibility interval on the 130Te half-life for this process. In this talk, we present the current status of CUORE search for 0νββ with the updated statistics of one tonne-yr. We finally give an update of the CUORE background model and the measurement of the 130Te 2νββ decay half-life, study performed using an exposure of 300.7 kg·yr.

Poster Session I / 86

Dark matter search with the DarkMESA electron beam-dump experiment

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A search for sub-GeV dark matter (DM) will be performed by the DarkMESA experiment behind the beam dump of the MESA external electron beam in Mainz, Germany. Various dark sector models motivate the existence of sub-GeV scalar and Majorana or pseudo-Dirac DM, accessible in this type of beam-dump experiment, e.g. by coupling to a dark photon mediator A'. In the presence of light DM in the dark sector with masses $m_\chi < m'_A/2$,, the A' would predominantly decay invisibly into those χ particles provided that the dark coupling constant α_D is not too small. Re-interpretations of null results in a multitude of other models are possible [1].

The experiment makes use of the high intensity electron beam available at MESA and will run parasitically to the scheduled program with the P2 apparatus. The experiment is based on a solid and reliable detection technology and will collect an unprecedented accumulated charge in a few years time, that will extend current limits on light DM [2].

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Development of accelerators and detectors / 87

The SHERPA experiment

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The SHERPA ("Slow High-efficiency Extraction from Ring Positron Accelerator") project aim is to develop an efficient technique to extract a positron beam from one of the accelerator rings composing the DAΦNE accelerator complex at the Frascati National Laboratory of INFN, setting up a new beam line able to deliver positron spills of O(ms) length, excellent beam energy spread and emittance.
The most common approach to slowly extract from a ring is to increase betatron oscillations approaching a tune resonance in order to gradually eject particles from the circulating beam.
SHERPA proposes a paradigm change using coherent processes in bent crystals to kick out positrons from the ring, a cheaper and less complex alternative [1]. This non-resonant technique, already successfully used and still developed mainly in hadron accelerators, will provide a continuous multi-turn extraction of a high quality beam [2, 3, 4, 5].
Realizing this for sub-GeV leptons is challenging, however would provide the world's first primary positron beam obtained with crystal extraction. An immediate application of this new extracted beam line would be the PADME ("Positron Annihilation into Dark Matter Experiment") experiment [6], currently strongly limited by the duty cycle. Using the proposed extraction, PADME could increase the statistics by a factor 10^4 and its sensitivity by a factor 10^2.
This technology can be applied in general for both negative and positive leptons, including muons, providing a know how that can be applied for several accelerating machine aspects in the next future, as collimation, extraction and beam splitting, contributing to a general improvement in the particle accelerator field.
In the talk will be given an overview of the whole experiment, describing in particular the crystal extraction principle, the accelerator optics studies, the crystal prototype and the characterization apparatus. First simulation and experimental results will be reported.

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Dark matter and cosmology / 88

The Light Dark Matter eXperiment, LDMX

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The constituents of dark matter are still unknown, and the viable possibilities span a very large mass range. Specific scenarios for the origin of dark matter sharpen the focus on a narrower range of masses: the natural scenario where dark matter originates from thermal contact with familiar matter in the early Universe requires the DM mass to lie within about an MeV to 100 TeV. Considerable experimental attention has been given to exploring Weakly Interacting Massive Particles in the upper end of this range (few GeV –~TeV), while the region ~MeV to ~GeV is largely unexplored. Most of the stable constituents of known matter have masses in this lower range, tantalizing hints for physics beyond the Standard Model have been found here, and a thermal origin for dark matter works in a simple and predictive manner in this mass range as well. It is therefore a priority to explore. If there is an interaction between light DM and ordinary matter, as there must be in the case of a thermal origin, then there necessarily is a production mechanism in accelerator-based experiments. The most sensitive way, (if the interaction is not electron-phobic) to search for this production is to use a primary electron beam to produce DM in fixed-target collisions. The Light Dark Matter eXperiment (LDMX) is a planned electron-beam fixed-target missing-momentum experiment that has unique sensitivity to light DM in the sub-GeV range. This contribution will give an overview of the theoretical motivation, the main experimental challenges and how they are addressed, as well as projected sensitivities in comparison to other experiments.

Poster Session I / 89

Heavy Neutrinos at Future Linear e+e- Colliders

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Neutrinos are probably the most mysterious particles of the Standard Model. The mass hierarchy and oscillations, as well as the nature of their antiparticles, are currently being studied in experiments around the world. Moreover, in many models of the New Physics, baryon asymmetry or dark matter density in the universe are explained by introducing new species of neutrinos. Among others, heavy neutrinos of the Dirac or Majorana nature were proposed to solve problems persistent in the Standard Model. Such neutrinos with masses above the EW scale could be produced at future linear e+e- colliders, like the Compact LInear Collider (CLIC) or the International Linear Collider (ILC).

We studied the possibility of observing production and decays of heavy neutrinos in qql final state at the ILC running at 500 GeV and 1 TeV and the CLIC running at 3 TeV. The analysis is based on the WHIZARD event generation and fast simulation of the detector response with DELPHES. Dirac and Majorana neutrinos with masses from 200 GeV to 3.2 TeV are considered. Estimated limits on the production cross sections and on the neutrino-lepton coupling are compared with the current limits coming from the LHC running at 13 TeV, as well as the expected future limits from hadron colliders. Impact of the gamma-induced backgrounds on the experimental sensitivity is also discussed. Obtained results are stricter than other limit estimates published so far.

QCD, spin physics and chiral dynamics / 90

The LHCspin project

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The goal of LHCspin is to develop, in the next few years, innovative solutions and cutting-edge technologies to access spin physics in high-energy polarized fixed-target collisions, by exploring a unique kinematic regime given by the LHC beam and by exploiting new probes.
This ambitious task poses its basis on the recent installation of SMOG2, the unpolarized gas target in front of the LHCb spectrometer. Specifically, the unpolarized target, already itself a unique project, will allow to carefully study the dynamics of the beam-target system, and clarify the potentiality of the entire system, as the basis for an innovative physics program at the LHC.
The forward geometry of the LHCb spectrometer (2<▯<5) is perfectly suited for the reconstruction of particles produced in fixed-target collisions. This configuration, with center-of-mass energies ranging from $\sqrt{} = 115$ GeV in pp interactions to $\sqrt{} = 72$ GeV in collisions with nuclear beams, allows to cover a wide backward rapidity region, including the poorly explored high x-Bjorken and high x-Feynman regimes. With the instrumentation of the proposed target system, LHCb will become the first experiment delivering simultaneously unpolarized beam-beam collisions at $\sqrt{} = 14$ TeV and polarized and unpolarized beam-target collisions.
The status of the project is presented along with a selection of physics opportunities.

Development of accelerators and detectors / 91

Opportunities of Si-microstrip LGAD for next-generation Space detectors

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Low Gain Avalanche Diodes (LGAD) is a consolidated technology developed for particle detectors at colliders which allows for simultaneous and accurate time (<100 ps) and position (< 10 µm) resolutions with segmented Si-pixel sensors. It is a candidate technology that could enable for the first time 4D tracking (position and time) in space using LGAD Si-microstrip tracking systems. The intrinsic gain of LGAD sensors may also allow to decrease the sensor thickness while achieving signal yields similar to those of Si-microstrips currently operated in Space.

In this contribution we discuss the possible applications and breakthrough opportunities in next generation large area cosmic ray detectors and sub-GeV gamma-ray detectors that could be enabled by LGAD Si-microstrip tracking detectors in Space. We propose the design of a cost-effective instrument demonstrator on a CubeSat platform to enable and qualify the operation of LGAD Si-microstrip detectors in Space.

Neutrino physics / 92

Short-Baseline neutrino oscillation searches with the ICARUS detector

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The ICARUS collaboration employed the 760-ton T600 detector in a successful three-year physics run at the underground LNGS laboratories studying neutrino oscillations with the CNGS neutrino beam from CERN, and searching for atmospheric neutrino interactions. ICARUS performed a sensitive search for LSND-like anomalous νe appearance in the CNGS beam, which contributed to the constraints on the allowed parameters to a narrow region around 1 eV^2, where all the experimental results can be coherently accommodated at 90% C.L. After a significant overhaul at CERN, the T600 detector has been installed at Fermilab. In 2020 cryogenic commissioning began with detector cool down, liquid Argon filling and recirculation. ICARUS has started operations and is presently in its commissioning phase, collecting the first neutrino events from the Booster Neutrino Beam and the NuMI off-axis. The main goal of the first year of ICARUS data taking will then be the definitive verification of the recent claim by NEUTRINO-4 short baseline reactor experiment both in the ν_μ channel with the BNB and in the ν_e with NuMI. After the first year of operations, ICARUS will commence its search for evidence of a sterile neutrino jointly with the SBND near detector, within the Short Baseline Neutrino (SBN) program. The ICARUS exposure to the NuMI beam will also give the possibility for other physics studies such as light dark matter searches and neutrino-Argon cross section measurements. The proposed contribution will address ICARUS achievements, its status and plans for the new run at Fermilab and the ongoing developments of the analysis tools needed to fulfill its physics program.

Poster Session II / **93**

The NP06/ENUBET experiment: a monitored neutrino beam

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The ENUBET experiment, included in the CERN Neutrino Platform effort as NP06/ENUBET, is developing a new neutrino beam based on conventional techniques in which the flux and the flavor composition are known with unprecedented precision ($\mathcal{O}(1\%)$). Such a goal is accomplished monitoring the associated charged leptons produced in the decay region of the ENUBET facility. Positrons and muons from kaon decays are measured by a segmented calorimeter instrumenting the walls of the decay tunnel, while muon stations after the hadron dump can be used to monitor the neutrino component from pion decays. Furthermore, the narrow momentum width (<10%) of the beam provides a precise measurement ($\mathcal{O}(10\%)$) of the neutrino energy on an event by event basis, thanks to its correlation with the radial position of the interaction at the neutrino detector. ENUBET is therefore an ideal facility for a high precision neutrino cross-section measurement at the GeV Scale, that could enhance the discovery potential of the next-generation of long baseline experiments, and for the study of non-standard neutrino models.
We report here a new improved design of the proton target and of the meson transfer line, that ensures a larger neutrino flux while preserving a purity in the lepton monitoring similar to the one previously achieved. The final design of the ENUBET demonstrator for the instrumented decay tunnel, that is due by end 2021, will be also discussed. It has been determined on the basis of the results of the 2016-2018 testbeams and will prove the scalability and performance of the selected detector technology. Progress on the full simulation of the ENUBET facility and of the lepton reconstruction, towards the full assessment of neutrino flux systematics, will be also reported.

Nuclear and particle astrophysics / **95**

Results overview from the DAMPE space mission in orbit

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The Dark Matter Particle Explorer (DAMPE), is a space–borne detector designed for precise galactic Cosmic Ray (CR) studies in a wide energy range (up to 100 TeV), along with detailed measurements of high–energy gamma–rays and indirect searches of Dark Matter (DM) annihilation/decay to detectable particles. The satellite was successfully launched into a sun–synchronous orbit at 500 km, on December 17th 2015 and has been successfully acquiring data ever since. The instrument consists of four sub-detectors, namely: a Plastic Scintillator Detector (PSD), a Silicon TracKer-converter (STK), a deep Bismuth Germanate (BGO) calorimeter (32 X_0, 1.6 λ_I) and a NeUtron Detector (NUD). DAMPE provided valuable insight on the cosmic-ray electron+positron (CRE) spectrum, unveiling a clear spectral break at ~0.9 TeV with unprecedented energy resolution. Moreover, recent results regarding CR protons reveal a spectral hardening (at few hundred GeV) followed by a softening feature at ~10 TeV. These features are well described by a smoothly-broken power law (SBPL), which differs from the paradigm of a unique power law (PL) spectrum extending up to PeV energies, hence necessitating a careful reconsideration of prevailing CR models. Additional insights concerning spectral measurements of helium, medium (i.e, boron, carbon, nitrogen, oxygen) and heavier mass nuclei (iron), will be presented in this work. Preliminary results on secondary-over-primary ratios (i.e., B/C and B/O) detrimental in deciphering the nature of CR propagation in the Galaxy, will also be discussed, including a general synopsis of the mission status.

Nuclear and particle astrophysics / 96

First results from the ARTIE experiment

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A measurement of the transmission coefficient for neutrons through a thick ($\sim$ 3\,atoms/b) liquid natural argon target in the energy range 30-70\,keV was performed by the Argon Resonance Transmission Interaction Experiment (ARTIE) using a time of flight neutron beam at Los Alamos National Laboratory.
In this energy range theory predicts an anti-resonance in the ^{40}Ar cross section near 57\,keV, but the existing data, coming from an experiment performed in the 90s (Winters. et al.), does not support this.
This discrepancy gives rise to significant uncertainty in the penetration depth of neutrons through liquid argon, an important parameter for next generation neutrino and dark matter experiments.
In this talk, the first results from the ARTIE experiment will be presented.
The ARTIE measurement of the total cross section as a function of energy confirms the existence of the anti-resonance near 57\,keV, but not as deep as the theory prediction.

Tests of symmetries and conservation laws / 97

A new limit on the permanent electric dipole moment of the neutron

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The measurement of a permanent electric dipole moment of the neutron (nEDM), as a CP-violating observable, is one of the main priorities at the low energy frontier of particle physics. A discovery or a highly improved constraint could contribute to our understanding of the baryon asymmetry of the universe. Our international collaboration obtained a new limit on the nEDM with an apparatus connected to the UCN source of the Paul Scherrer Institut in Switzerland. This experiment was based on the Ramsey method of separated oscillatory fields in vacuum and at room temperature. An important gain compared to previous experiments was a much-advanced control of the homogeneity and stability of the magnetic field. To this end, the method of mercury co-magnetometry was further optimized, and cesium magnetometers were employed to suppress field gradients of higher orders. A blinding scheme in two steps was developed in order to exclude any bias in the work of two distinct analysis groups. In this talk, we present our new result and the steps which led to this novel constraint on the nEDM.

Neutrino physics / 98

Neutrino oscillations: current status and future opportunities

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In this talk, I will present the current status of global analyses to neutrino oscillation data in the three-flavor framework. I will discuss the recent hints in favor of normal mass ordering and maximal CP violation and the tensions that appear from the combination of different data samples. I will also comment on future opportunities to improve our knowledge of the oscillation picture as well as on its robustness in the presence of new physics beyond the Standard Model.

Nuclear and particle astrophysics / 99

Neutrino flavor evolution in dense environments and the r-process

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In the last two decades atmospheric, solar, reactor and accelerator experiments have precisely measured neutrino squared mass differences and mixings, responsible for neutrino vacuum oscillations. An intense experimental program will keep addressing unknown neutrino properties including neutrino mass ordering and mass scale, the neutrino nature, the existence of sterile neutrinos, of CP violation and also non-standard interactions.

Neutrinos play an important role in astrophysics. Beyond the established Mikheev-Smirnov-Wolfenstein effect, novel neutrino flavor mechanisms are uncovered in particular in dense environments such as core-collapse supernovae and binary compact mergers remnants, where elements heavier than iron can be synthetised through the r-process. In this talk, I will highlight the importance of flavor

evolution in dense media, in connection with future observations and with GW170817. I will also stress the interplay with non-standard physics.

Poster Session I / 100

Slow control and data acquisition systems in the Mu2e experiment

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The muon campus program at Fermilab includes the Mu2e experiment that will search for charged-lepton flavor violating processes where a negative muon converts into an electron in the field of an aluminum nucleus. The conversion process results in a monochromatic electron with an energy of 104.97 MeV, slightly below the muon rest mass. The goal of the experiment is to improve the previous upper limit by four orders of magnitude.
Mu2e's Trigger and Data Acquisition System (TDAQ) uses {\it otsdaq} as its solution. Developed at Fermilab, {\it otsdaq} uses the {\it artdaq} DAQ framework and {\it art} analysis framework, under-the-hood, for event transfer, filtering, and processing.
{\it otsdaq} is an online DAQ software suite with a focus on flexibility and scalability. It provides a multi-user, web-based interface, accessible through a web browser.
A Detector Control System (DCS) for monitoring, controlling, alarming, and archiving has been developed using EPICS (Experimental Physics and Industrial Control System) open-source Platform. The DCS System has also been integrated into {\it otsdaq}, providing a multi-user GUI, web-based control, and monitoring dashboard that communicates with EPICS using an interface specifically designed and developed.

Poster Session I / 101

Status of the Short-Baseline Near Detector at Fermilab

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The Short-Baseline Near Detector (SBND) will be one of three liquid Argon Time Projection Chamber (LArTPC) neutrino detectors positioned along the axis of the Booster Neutrino Beam (BNB) at Fermilab, as part of the Short-Baseline Neutrino (SBN) Program. The detector is currently in the

construction phase and is anticipated to begin operation in the second half of 2022. SBND is characterised by superb imaging capabilities and will record over a million neutrino interactions per year. Thanks to its unique combination of measurement resolution and statistics, SBND will carry out a rich program of neutrino interaction measurements and novel searches for physics beyond the Standard Model (BSM). It will enable the potential of the overall SBN sterile neutrino program by performing a precise characterisation of the unoscillated event rate, and by constraining BNB flux and neutrino-Argon cross-section systematic uncertainties. In this talk, the physics reach, current status, and future prospects of SBND are discussed.

Poster Session II / 102

Development, construction and qualification tests of the mechanical structures of the electromagnetic calorimeter of the Mu2e experiment at Fermilab

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The "muon-to-electron conversion"(Mu2e) experiment at Fermilab will search for the Charged Lepton Flavour Violating neutrino-less coherent conversion of a muon into an electron in the field of an aluminum nucleus. The observation of this process would be the unambiguous evidence of physics beyond the Standard Model. Mu2e detectors comprise a straw-tracker, an electromagnetic calorimeter and an external veto for cosmic rays. The calorimeter provides excellent electron identification, complementary information to aid pattern recognition and track reconstruction, and a fast calorimetric online trigger. The detector has been designed as a state-of-the-art crystal calorimeter and employs 1340 pure Cesium Iodide (CsI) crystals readout by UV-extended silicon photosensors and fast front-end and digitization electronics. A design consisting of two identical annular matrices (named "disks") positioned at the relative distance of 70 cm downstream the aluminum target along the muon beamline satisfies the Mu2e physics requirements.
The hostile Mu2e operational conditions, in terms of radiation levels (total ionizing dose of 12 krad and a neutron fluence of 5x1010 n/cm2 @ 1 MeVeq (Si)/y), magnetic field intensity (1 T) and vacuum level (10^-4 Torr) have posed tight constraints on the design of the detector mechanical structures and materials choice. The support structure of the two 670 crystal matrices employs two aluminum hollow rings and parts made of open-cell vacuum-compatible carbon fiber. The photosensors and service front-end electronics for each crystal are assembled in a unique mechanical unit inserted in a machined copper holder. The 670 units are supported by a machined plate made of vacuum-compatible plastic material. The plate also integrates the cooling system made of a network of copper lines flowing a low temperature radiation-hard fluid and placed in thermal contact with the copper holders to constitute a low resistance thermal bridge. The data acquisition electronics is hosted in aluminum custom crates positioned on the external lateral surface of the two disks. The crates also integrate the electronics cooling system as lines running in parallel to the front-end system.
In this talk we will review the constraints on the calorimeter mechanical structures design, the development from the conceptual design to the specifications of all the structural components, including the mechanical and thermal simulations that have determined the materials and technological choices and the specifications of the cooling station, the status of components production, the components quality assurance tests, the detector assembly procedures, and the procedures for detector transportation and installation in the experimental area.

Neutrino physics / 103

Status and Prospects of the SNO+ Experiment

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SNO+ is a large volume liquid scintillator experiment for neutrino physics located at SNOLAB, Canada. Using the 12 m diameter acrylic vessel and the PMT array of the SNO detector, SNO+ has the primary physics goal of searching for the neutrinoless double-beta decay of the 130Te isotope. Data collected will also be used to explore additional physics topics such as reactor antineutrino oscillations, solar neutrinos, geoneutrinos, and to search for exotic physics.
As a multipurpose neutrino detector, SNO+ must have a very good understanding of its response characteristics, including the optical properties of the detector media and the PMTs. A complete optical calibration of the detector was performed during the initial water phase using a deployed source. Currently, the detector is completely filled with liquid scintillator, to which 1.3 tons of Te-130 is expected to be loaded later next year. I will present the prospects for the search of neutrinoless double beta decay in the Te phase and discuss the current status and results of the experiment, including the results of calibration and backgrounds.

Development of accelerators and detectors / 104

Forward silicon vertex/tracking detector design and R&D for the future Electron-Ion Collider

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The proposed high-luminosity high-energy Electron-Ion Collider (EIC) will provide a clean environment to precisely study several fundamental questions in the high energy and nuclear physics fields. To realize the proposed physics measurements at the EIC, a high granularity detector, which can cover pseudorapidity range from -3.5 to 3.5, provide percentage momentum/energy resolution and be able to separate nanosecond bunch crossings, is required. Within the EIC general detector, a low material budget silicon vertex/tracking detector with fine spatial resolution is critical to carry out a series of hadron/jet measurements at the EIC especially for the heavy flavor product reconstruction/tagging. We will present designs of a proposed forward silicon tracking detector (with pseudorapidity coverage from 1 to 3.5) integrated with different magnet options and the other detector sub-systems for the EIC. The evaluated performance of this detector meets the EIC detector requirements. The detector R&D work for the silicon technology candidates: Low Gain Avalanche Diode (LGAD) and radiation hard Monolithic Active Pixel Sensor (MALTA) will be shown as well.

Neutrino physics / 105

Neutrino mixing from flavour symmetry

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It is known that the lepton mixing angles are completely different from the quark mixing angles. The fundamental principle behind the flavor mixing structure remains unknown. I will review the different approaches to predict the lepton mixing angles and the Dirac and Majorana CP violation phases from theory, commenting also on their experimental tests. Their implications in neutrino oscillation, neutrinoless double decay and cosmology will be discussed. I will also discuss how to explain the quark mixing matrix from flavor symmetry.

Poster Session I / 106

Design and construction status of the Mu2e crystal calorimeter

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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.
The calorimeter plays an important role to provide excellent particle identification capabilities and an online trigger filter while aiding the track reconstruction capabilities, asking for 10% energy resolution and 500 ps timing resolution for 100 Mev electrons. It consists of two disks, each one made by 674 un-doped CsI crystals, read out by two large area UV-extended SiPMs. In order to match the requirements of reliability, a fast and stable response, high resolution and radiation hardness (100 krad, 10^12 n/cm^2) that are needed to operate inside the evacuated bore of a long solenoid (providing 1 T magnetic field) and in the presence of a really harsh radiation environment, fast and radiation hard analog and digital electronics has been developed. To support these crystals, cool the SiPMs and support and cool the electronics, a sophisticated mechanical and cooling system has been also designed and realized.
In this paper, we present the status of construction and QC performed on the produced crystals and photosensors, the development of the rad-hard electronics and the most important results of the irradiation tests done on the different components. Production of electronics is also started and we summarize the QC in progress on the analog electronics and on the integrated SIPM+FEE units. Construction of the mechanical parts are also well underway. Status and plans for the final assembly are also described.
Moreover, a large calorimeter prototype (dubbed Module-0) has been tested with an electron beam between 60 and 120 MeV at different impact angles and the obtained results are summarized. Finally, a full vertical slice test with the final electronics is in progress on Module-0 at the Frascati Cosmic Rays test setup. First calibration results are shown.

Poster Session II / 107

Prospects of studying the production of hypernuclei in heavy-ion interactions at the NICA collider at JINR

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New acceleration complex NICA (Nuclotron-based Ion Collider fAcility) as well as MultiPurpose Detector (MPD) for the study of heavy ion collisions is underway at Joint Institute for Nuclear Research (Dubna, Russia). Strangeness and hypernuclei production is presently under active experimental and

theoretical investigation and is of particular interest of the NICA/MPD program. We combine several dynamical transport models and the MST cluster finding procedure to calculate the production of light nuclei and hypernuclei in heavy-ion collisions at NICA energies. The emphasis will be put on the NICA prospects for the study of the production of hypernuclei and detector performance in the reconstruction of numerous hypernuclei species.

Dark matter and cosmology / 109

Capture of DM in Compact Stars

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Neutron stars harbour matter under extreme conditions, providing a unique testing ground for fundamental interactions.
Dark matter can be captured by neutron stars via scattering, where kinetic energy is transferred to the star.
This can have a number of observational consequences, such as theheating of old neutron stars to infra-red temperatures.
Previous treatments of the capture process have employed various approximation or simplifications.
We present here an improved treatment of dark matter capture, valid for a wide dark matter mass range, that correctly incorporates all relevant physical effects.
These include gravitational focusing, a fully relativistic scattering treatment, Pauli blocking, neutron star opacity and multi-scattering effects.
We provide general expressions that enable the exact capture rate to be calculated numerically, and derive simplified expressions that are valid for particular interaction types or mass regimes and that greatly increase the computational efficiency.
Our formalism is applicable to the scattering of dark matter from any neutron star constituents, or to the capture of dark matter in other compact objects.
We apply these results to scattering of dark matter from neutrons, protons, leptonic targets, as well as exotic Baryons.
For leptonic Targets, a relativistic description is essential. Regarding Baryons, we outline two important effects that are missing from most evaluations of the dark matter capture rate in neutron stars.
As dark matter scattering with nucleons in the star involves large momentum transfer, nucleon structure must be taken into account via a momentum dependence of the hadronic form factors.
In addition, due to the high density of neutron star matter, we should account for nucleon interactions rather than modeling the nucleons as an ideal Fermi gas.
Properly incorporating these effects is found to suppress the dark matter capture rate by up to three orders of magnitude.

We find that the potential neutron star sensitivity to DM-lepton scattering cross sections greatly exceeds electron-recoil experiments, particularly in the sub-GeV regime, with a sensitivity to sub-MeV DM well beyond the reach of future terrestrial experiments.
We present preliminary results for DM-Baryons scatterings in Neutron stars, were the sensitivity is expected to greatly exceed current DD experiments for the spin-dependent case in the whole masse range, and for spin-independent in the low and high mass range.
Regarding White Dwarfs, for dark matter-nucleon scattering, we find that white dwarfs can probe the sub-GeV mass range inaccessible to direct detection searches, with the low mass reach limited only by evaporation, and can be competitive with direct detection in the 1 − 104 GeV range.
White dwarf limits on dark matter-electron scattering are found to outperform current electron recoil experiments over the full mass range considered, and extend well beyond the ~ 10 GeV mass regime where the sensitivity of electron recoil experiments is reduced.

Poster Session I / 110

Development of a new beam position detectors for NA61/SHINE experiment.

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NA61/SHINE is a fixed-target experiment located at CERN Super Proton Synchrotron (SPS). The development of new beam position detectors is part of the ongoing upgrade of the detector system.

Two types of detectors have been manufactured and tested. The first one is a scintillating fibers detector with photo-multiplayer as a readout. The scintillating fibers detector consists of two ribbons, which are arranged perpendicularly to each other. Each ribbon is made of two layers of 250 μm diameter fibers. The grouping of fibers method was used, which allows using of a single multichannel photo-multiplayer for one detector.

The second type of detector is based on the single-sided silicon strip detector (SSD). In this project, Si strips produced by Hamamatsu (S13804) were used, where each strip has a width equal to 80 μm.

The developed detectors must meet several requirements: should work efficiently with proton and lead beams with beam intensity on the level of 100 kHz, the detector's material on the beamline should be minimized, the detectors should be able to determine the position of X and Y hit of each beam particle with maximum possible accuracy.

During the poster session I will present the results of our work.

Standard model physics at the TeV scale / 111

Probing Higgs couplings to light quarks via Higgs pair production

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One of the puzzles of the SM is the large hierarchy between the Yukawa couplings of different flavours. Yukawa couplings of the first and the second generation are constrained only very weakly so far. However, one can obtain large deviations in the Yukawa couplings in several New Physics (NP) models, such as e.g new vector-like quarks, or new Higgs bosons that couple naturally to individual fermion families. \\ In this talk, I will talk about the potential bounds on the NP Higgs Yukawa couplings modification, and new $hh\bar{f}f$ coupling for light quarks from double-Higgs at the LHC, starting from a model independent formalism, to studying specific models. We have looked at the Higgs's' final states $b\bar{b}\gamma\gamma$, and the relevant experimental cuts to reduce backgrounds and estimated the potential exclusion bounds for light quark couplings with the Higgs. I will also talk about the potential for double Higgs production to probe non-linearity between Yukawa and $hh\bar{f}f$ couplings

Flavour physics - CKM and beyond / 112

Standard Model prediction of the Bc lifetime (17+3)

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Applying an operator product expansion approach an updated Standard Model prediction of the B_c lifetime is presented. The non-perturbative velocity expansion is carried out up to third order in the relative velocity of the heavy quarks. The scheme dependence is studied using three different mass schemes for the $\bar{b}$ and c quarks, resulting in three different values consistent with each other and with experiment. Uncertainties resulting from scale dependence, neglecting the strange quark mass, non-perturbative matrix elements and parametric uncertainties are discussed in detail. The resulting uncertainties are still rather large compared to the experimental ones, and therefore do not allow for clear-cut conclusions concerning New Physics effects in the Bc decay.

Development of accelerators and detectors / 113

Polystyrene-based scintillator production process involving additive manufacturing

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Plastic scintillator detectors are widely used in high-energy physics, often as active neutrino target, both in long and short baseline neutrino oscillation experiments. They can provide 3D tracking with 4π coverage and calorimetry of the neutrino interaction final state combined with a very good particle identification, sub-nanosecond time resolution. Moreover, the large hydrogen content makes plastic scintillator detectors ideal for detecting neutrons. However, new experimental challenges and the need for enhanced performance require the construction of detector geometries that are complicated using the current production techniques. The solution can be found in additive manufacturing, able to quickly make plastic-based objects of any shape. The applicability of 3D-printing techniques to the manufacture of polystyrene-based scintillator will be discussed. We will report on the feasibility of 3D printing polystyrene-based scintillator with light output performances comparable with the one of standard production techniques. The latest advances on the R&D aim at combining the 3D printing of plastic scintillator with other materials such as optical reflector or absorber. The status of the R&D and the latest results will be presented.

Nuclear and particle astrophysics / 114

Constraints on the fermionic dark matter from observations of neutron stars

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We study an impact of asymmetric dark matter on properties of neutron stars and their ability to reach the two solar masses limit, which allows us to present a new range of masses of dark matter particles and their fractions inside the star. Our analysis is based on the observational fact of the existence of two pulsars reaching this limit and on the theoretically predicted reduction of the neutron star maximal mass caused by the accumulation of dark matter in its interior. We also demonstrate that light dark matter particles with masses below 0.2 GeV can create an extended halo around the neutron star leading not to decrease, but to increase of its visible gravitational mass. By using recent results on the spatial distribution of dark matter in the Milky Way, we present an estimate of its fraction inside the neutron stars located in the Galaxy center. We show how the detection of a 2 Msun neutron star in the most central region of the Galaxy will impose an upper constraint on the mass of dark matter particles of ~60 GeV. Future high precision measurements of the neutron stars maximal mass near the Galactic center, will put a more stringent constraint on the mass of the dark matter particle. This last result is particularly important to prepare ongoing, and future radio and x-ray surveys.

Neutrino physics / 115

Electrons for Neutrinos

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The ability of current and next generation accelerator based neutrino oscillation measurements to reach their desired sensitivity requires a high-level of understanding of the neutrino-nucleus interactions. These include precise estimation of the relevant cross sections and the reconstruction of the incident neutrino energy from the measured final state particles. Incomplete understanding of these interactions can skew the reconstructed neutrino spectrum and thereby bias the extraction of fundamental oscillation parameters and searches for new physics.
In this talk I will present new results of wide phase-space electron scattering data, collected using the CLAS spectrometer at the Thomas Jefferson National Accelerator Facility (JLab), the reconstruction of the incoming lepton energy from the measured final state is being tested. Disagreements with current event generators, used in the analysis of neutrino oscillation measurements, are observed which indicate underestimation of nuclear effects.

Tests of symmetries and conservation laws / 118

The muon to electron conversion process and the Mu2e experiment at Fermilab

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The Mu2e experiment aims to measure the charged-lepton flavour violating (CLFV) neutrino-less conversion of a negative muon into an electron in the field of an aluminum nucleus. The conversion process results in a monochromatic electron with an energy slightly below the muon rest mass (104.97 MeV). The Mu2e goal is to improve the world's best limit by SINDRUM II of four orders of magnitude and reach a single event sensitivity of 3.0 x 10^{-17} on the conversion rate with respect to the muon capture rate.
In many Beyond the Standard Model (BSM) scenarios, rates for CLFV processes are within the reach

of the next generation experiments and their searches have a sensitivity to new physics that exceeds the LHC reach bringing the reach of new mass scale up to 10^4 TeV. In this context, indirect measurements of CLFV could provide crucial evidence for new physics.
Mu2e exploits a very intense pulsed negative muon beam on an aluminum target for a total number of 10^{18} stopped muons. Production and transport of the muons is performed with a complex and sophisticated magnetic system composed by a production, a transport and a detector solenoid.
The improvement with respect to previous conversion experiments is based on four main elements: the muon beam intensity, the beam structure layout, the extinction of out of time particles and the precise electron identification in the detector solenoid. The conversion electron will be reconstructed and separated from the Decay in Orbit (DIO) background by exploiting the very high resolution (120 keV) tracking system based on straw technology. The crystal calorimeter system will confirm that the candidates are indeed electrons by performing a powerful mu/e rejection while granting a tracking independent HLT filter. A Cosmic Ray Veto system will surround the entire detector solenoid and contribute to minimize the backgrounds due to cosmic muons.

Poster Session II / 119

Experimental tests of QCD scaling laws at large momentum transfer in exclusive light-meson photoproduction

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We evaluated CLAS Collaboration measurements for the 90-deg meson photoproduction off the nucleon using a tagged photon beam spanning the energy interval s = 3 −11 GeV2. The results are compared with the "quark counting rules"predictions. The role of the Sudakov form-factor and Vector-Meson Dominance model is considered.

Hadrons in medium - hyperons and mesons in nuclear matter / 120

HAPG mosaic crystal Von Hamos spectrometer for high precision exotic atoms spectroscopy

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Von Hamos spectrometers are widely used in several fields, ranging from pure physics applications to very different types of practical ones. However, these type of Bragg spectrometers are usally implied in high rate –high resolution experiments, where the typical source size can be as low as few tens of microns.
These limitations prevented them to be used as X-ray detectors for high precision exotic atoms spectroscopy.
Recently, the VOXES collaboration at the INFN Laboratories of Frascati INFN recently developed a VH spectrometer, making use of HAPG mosaic crystals and a X-ray beam optics optimization, which could be used for source sizes up to few mm, (in the Bragg plane), some tens of mm in the sagittal plane and, if gaseous sources are used, of several tens of cm in the X-ray propagation direction. Such kind of a spectrometer could be used, for example, to open a new era in the field of exotic (kaonic) atoms precision measurements, delivering data with unprecedented precision to the

(strangeness) nuclear physics community. In order to foreseen the possible capabilities of this apparatus in terms of signal collection efficiency, reliable ray tracing simulations are necessary, whose consistency with experimental data has to be preliminary checked. We present the main results obtained with the VOXES spectrometer, as well as a comparison of ray tracing simulations. For both of resolutions and reflection efficiencies, the simulations and the experimental results are found to be well in agreement within the errors.

Poster Session I / 121

Causal Equation of State of Hadron Resonance Gas with Relativistic Excluded Volumes and Its Relation to Morphological Thermodynamics

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Here we present a solution to the long-standing problem of constructing the causal equation of state of hadron resonance gas model (HRGM) with Lorentz contracted eigenvolumes of particles with the hard-core repulsion. It is based on the concept of Induced Surface and Curvature Tension (ISCT) [1] to treat the excluded volumes of hard spheres in the high-pressure region. Its mathematically sound and extensive derivation is obtained according to principles of morphological thermodynamics [2]. Practically an exact formula for the relativistic second virial coefficient (excluded volume) is obtained and investigated for various equations of state and a wide range of temperatures T and is shown that it reproduces a close packing of equal spheres limit $v_{exc} = 1-\pi/(3\sqrt{2}) \approx 0.26$ in case of high temperatures with sufficient accuracy without any prior knowledge about such system configuration. We as well propose an ansatz to take into account the effect of Lorentz contraction for higher-order virial coefficients of Boltzmann particles with hard-core repulsion. Such an ansatz allows us to obtain the expected vanishing limit for the effective relativistic excluded volume for high temperatures $T \gg m$. The proposed relativistic ISCT equation of state is applied to hadron mixtures to obtain a temperature dependence of the speed of sound c_S for nucleons, pions, and light hadrons. It is shown that consideration of Lorentz contraction of only the second virial coefficient does not lead to a fully causal equation of state, since the speed of sound exceeds the speed of light by about 10%, but the inclusion of relativistic contraction of higher-order virial coefficients makes the ISCT equation of state causal on a wide range of temperatures even far above the temperatures of hadrons existence.
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Nuclear and particle astrophysics / 122

Study of Short-Range Correlations using a 48 GeV/c carbon beam

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Understanding the structure of strongly-interacting quantum mechanical systems such as atomic nuclei is a formidable challenge in physics. We recently demonstrated the feasibility to access nucleon-nucleon Short-Range Correlations (SRCs) in nuclei using hadronic probes in inverse kinematics [1].

The experiment was carried out at the JINR (Russia), a ^{12}C beam at 48 GeV/c impinged on a liquid hydrogen target where the reaction products were measured kinematically complete with the BM@N detector setup. At first, by measuring the fragment in the $^{12}\text{C}(p,2p)^{11}\text{B}$ reaction limitations posed by final-state interactions are overcome and single nucleon properties are shown to be probed in a distinct single-step knockout reaction. The extracted ground-state distributions are in agreement with theoretical calculations. We probe SRCs in the same way by the break up of SRC nucleon pairs in $^{12}\text{C}(p,2pN)^{10}\text{B}/^{10}\text{Be}$ reactions. SRCs are not only identified for the first time in such kinematical conditions but also their properties like factorization are deduced in this direct measurement. This experimental technique opens the pathway for SRC studies in short-lived nuclei at upcoming accelerator facilities like FAIR. We will also perform a follow-up experiment at JINR end of 2021, which will take advantage of a new proton-detection system.

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QCD, spin physics and chiral dynamics / 124

Gauge-invariant TMD factorization for Drell-Yan hadronic tensor at small x.

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The Drell-Yan hadronic tensor is calculated in the Sudakov region $s \gg Q^2 \gg q_\perp^2$ with $\frac{1}{Q^2}$ accuracy, first at the tree level and then with the double-log accuracy. It is demonstrated that in the leading order in N_c the higher-twist quark-quark-gluon TMDs reduce to leading-twist TMDs due to QCD equation of motion. The resulting tensor for unpolarized hadrons is EM gauge invariant and depends on two leading-twist TMDs: f_1 responsible for total DY cross section, and Boer-Mulders function $h_1^\perp$. The corresponding qualitative and semi-quantitative predictions seem to agree with LHC data for Z-boson production at transverse momentum of DY pair $\sim$ few tens GeV.

Tests of symmetries and conservation laws / 125

Short-distance constraints in hadronic-light-by-light for the muon $g-2$

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We have made recent progress in studying the short-distance properties of the hadronic light-by-light contribution to the muon $g-2$. The intermediate and short-distance part is a major contributor to the error of the hteoretical prediction, see the white paper [arxiv:2006.04822, Physics Reports 887 (2020) 1-166]. We have recently shown that the massless quark-loop is the first term in a systematic expansion at short-distance [arxiv:1908.03331, Phys.Lett. B798 (2019) 134994].This result already helped in the white paper in bringing down the error. Since then we have shown that both nonperturbative [arxiv:2008.13487, JHEP 10 (2020) 203] and the perturbative corrections [arxiv:2101.09169, JHEP 04 (2021) 240] are under control. The talk will describe these developments and how they fit in the total theopretical prediction for the muon $g-2$.

Nuclear and particle astrophysics / 127

Experimental investigations of proton-capture reactions with ^{112,114}Cd at energies of astrophysical interest

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The reaction network in the neutron-deficient part of the nuclear chart around A∼100 contains several nuclei of importance to astrophysical processes, such as the *p*-process. This work reports on the results from recent experimental studies of the radiative proton-capture reactions ^{112,114}Cd(p,γ)^{113,115}In. Isotopically enriched ^{112}Cd and ^{114}Cd targets have been used for the determination of the cross sections, for proton beam energies residing inside the respective Gamow windows for each reaction. Two different techniques, the in-beam γ-ray spectroscopy and the activation method have been implemented, where the latter is considered mandatory to account for the presence of low-lying isomers in ^{113}In (E≈392 keV, $t_{1/2}$ ∼100 min), and ^{115}In (E≈336 keV, $t_{1/2}$ ∼4.5 h). Following the measurement of the cross sections, the astrophysical *S* factors have been subsequently deduced. The experimental results are compared to detailed Hauser-Feshbach theoretical calculations carried out with TALYS v1.95. The results are expected to shed light in the nucleosynthetic mechanisms of the *p*-process in neutron-deficient nuclei, where scarce experimental data exist.

Poster Session II / 128

A study of the nuclear structure in the even-even Yb isotopes

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The medium-to-heavy mass ytterbium isotopes ($_{70}$Yb) in the rare-earth mass region are known to be well-deformed nuclei, which can be populated to very high spin. Spectroscopic information becomes scarcer as the neutron number increases, impeding the understanding of nuclear structure in this mass region, where interesting phenomena, such as shape coexistence, have been predicted. The lack of any experimental information on the structure of the neutron-rich ^{180}Yb isotope and the lifetime of the 2_1^+ state of ^{178}Yb have greatly motivated this study inlaying the path for near-future experimental endeavors. In this work, energy levels, deformation parameters β_2, reduced transition probabilities $B(E2)$ and transition quadrupole moments Q for even-even Yb isotopes have been calculated using a Phenomenological Model and the Interacting Boson Approximation 1. Additional results are presented using the following theoretical models: the Finite-Range Droplet Model, the Hartree-Fock BCS Model with MSk7 force, the Hartree-Fock-Bogoliubov Model with Gogny D1S force, the Relativistic Hartree Bogoliubov Model with the covariant energy density functional NL3*, the Hartree-Fock-Bogoliubov Model with UNEDF1, the Proxy SU(3) and the Pseudo

SU(3) models. Also, numerical results for energy ratios for the Yb isotopes, with the Exactly Separable Davidson (ESD), Exactly Separable Morse, Exactly Separable Woods-Saxon, Deformation Dependent Mass Davidson (DDMD) and Deformation Dependent Mass Kratzer (DDMK) analytical solutions of the Bohr Hamiltonian have been obtained. Along these lines, the results for even-even $^{164-178}$Yb isotopes are compared to available experimental data, serving as benchmarks. An overall good agreement was found between available adopted data and theoretical predictions.

Flavour physics - CKM and beyond / 129

Structure-dependent electromagnetic finite-size effects on the lattice (17+3)

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The systematic effect associated to the finite-volume constraint in lattice calculations has to be corrected for in order to make physical predictions and from these precision tests of the Standard Model. For (sub-)per cent precision one has to include also electromagnetic effects on the lattice, which can lead to particularly large finite-size effects. The finite-size scaling depends not only on properties such as particle masses, but also on structure-dependent form-factors. Examples of the latter are the electromagnetic charge radii of pions and kaons. In this talk we present how to analytically derive these electromagnetic finite-size effects in a relativistic, model-independent and systematic approach, with particular focus on leptonic decays of pions and kaons. The finite-size scaling in leptonic decays allows for improved numerical control in extractions of light-quark CKM-matrix elements from lattice simulations.

Nuclear and particle astrophysics / 130

Heavy-ion collisions and the low-density neutron star equation of state

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The present new and very exciting multi-messenger era for the astronomy, nuclear, gravitational and astrophysics community was set by the detection of gravitational wave signals from the collision of two neutron stars (NS) by the LIGO and Virgo interferometers in 2017, followed up by the detection of the gamma-ray burst GRB170817A and the electromagnetic transient AT2017gfo. Later, in 2019, a second and third signals, GW190425 and GW190814, were detected, the first one a larger system than those of any binary NS known to date, and the latter a system involving the collision of a black hole with a 2.5-2.67 Msun compact object, that has not been ruled out yet to be a NS. The NICER collaboration has published new radius and mass measurements from PSRJ0030+0451 [1], and very recently from PSRJ0740+6620 [2], which have been able to set new constraints in NS matter.

In the near future, the large amount of new data that will be made available by SKA will allow us to determine NS properties with much smaller uncertainties and set strong constraints on the equation of state of stellar matter. Neutron stars will, as a consequence, become a real laboratory to

test the nuclear force under extreme conditions of density, proton-neutron asymmetry and temperature.

Light (deuterons, tritons, helions, α−particles), and heavy (pasta phases) nuclei exist in nature not only in the inner crust of neutron stars (cold β−equilibrium matter), but also in core-collapse supernova matter and NS mergers (warm nuclear matter with fixed proton fraction). The appearance of these clusters can modify the neutrino transport, and, therefore, consequences on the dynamical evolution of supernovae and on the cooling of proto-neutron stars are expected. However, a correct estimation of their abundance implies that an in-medium modification of their binding energies is precisely derived.

In this talk, we will address not only from the theoretical point of view how these clusters are calculated for warm stellar matter in the framework of relativistic mean-field models with in-medium effects [3], but also how these models are calibrated to experimental data from heavy-ion collisions [4, 5], measured by the INDRA Collaboration [6]. We show that this in-medium correction, which was not considered in previous analyses from heavy-ion collisions, is necessary, since the observables of the analyzed systems show strong deviations from the expected results for an ideal gas of free clusters. It turns out that the resulting light cluster abundances come out to be in reasonable agreement with constraints at higher density coming from heavy ion collision data. Some comparisons with microscopic calculations are also shown.

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Dark matter and cosmology / 131

Dark-sector physics at Belle II

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The Belle II experiment at the asymmetric e^+e^- collider, SuperKEKB, is a substantial upgrade of the Belle/KEKB experiment. Belle II aims to record 50 ab^{-1} of data over the course of the project. During the first physics runs in 2018-2020, around 100 fb^{-1} of data were collected. These early data include specifically-designed low-multiplicity triggers which allow a variety of searches for light dark matter and dark-sector mediators in the GeV mass range.

This talk will present the very first world-leading physics results from Belle II: searches for the invisible decays of a new vector Z', and visible decays of an axion-like particle; as well as the near-term prospects for other dark-sector searches. Many of these searches are competitive with the data already collected or the data expected in the next few years of operation.

Hadron spectroscopy and exotics / 132

Quarkonium at Belle II

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The Belle II experiment at the SuperKEKB energy-asymmetric e^+e^- collider is an upgrade of the B factory facility at KEK in Tsukuba, Japan. The experiment began operation in 2019 and aims to record a factor of 50 times more data than its predecessor. Belle II is uniquely capable of studying the so-called "XYZ" particles: heavy exotic hadrons consisting of more than three quarks. First discovered by Belle, these now number in the dozens, and represent the emergence of a new category within quantum chromodynamics. We present recent results in new Belle II data, and the future prospects to explore both exotic and conventional quarkonium physics.

Flavour physics - CKM and beyond / 134

Measurements of hadronic B and D decays at Belle and Belle II (20+5)

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[This talk is a combination of several submitted abstracts, including the following.]

In the Belle II experiment, we have accumulated integrated luminosity of more than 100 fb^{-1} after starting the physics data taking in 2019. It is comparable to the data sets used for the B^0 lifetime τ_{B^0} and mixing Δm_d measurements in the BABAR and Belle. To demonstrate high accuracy measurements using the decay time difference of the B^0-$\bar{B}^0$ system which is one of the most essential inputs of the time-dependent CP violation study at the B-factory experiment, we measure τ_{B^0} and Δm_d with resolution function refined for the high-statistics data. Since most of the CP-eigenstates are not flavor non-specific, we determine the flavor of B^0 meson using the remnants based on multi-variable analysis after reconstructing the signal. It is validated using the control samples of hadronic decays $B \to D^{(*)}h$ ($h = K$ or π) and effective tagging efficiency is estimated. We present results of these studies related to the CP violation measurements with high-statistics data samples. We also report about the reconstruction of the decays used for the CP violation and a measurement of the time integrated mixing parameter, χ_d.

Flavour physics - CKM and beyond / 135

Flavour physics with electroweak-penguin and semileptonic decays at Belle and Belle II (20+5)

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[This talk is a combination of several submitted abstracts, including the following.]

In the recent years, several measurements of B-decays with flavor changing neutral currents, i.e. $b \to s$ transitions hint at deviations from the Standard Model (SM) predictions. These decays are forbidden at tree-level in the SM and can only proceed via suppressed loop level or box diagrams. Rare decays of B mesons are an ideal probe to search for phenomena beyond the SM, since contributions from new particles can affect the decays on the same level as SM particles.

The Belle II experiment is a substantial upgrade of the Belle detector and operates at the SuperKEKB energy-asymmetric e^+e^- collider. Radiative $b \to s\gamma$ decays is already been observed and inclusive photon spectra is also obtained with only a small dataset of Belle II. Early measurements related to the electro-weak penguin $b \to s\ell\ell$ and $b \to s\nu\bar{\nu}$ decays has also been performed. We will discuss the results obtained with the current dataset along with the prospects for the searches of these radiative and electroweak penguin decays with the expected $50\ ab^{-1}$ full dataset of Belle II.

Tests of symmetries and conservation laws / 140

Tau physics prospects at Belle II

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The Belle II experiment is a substantial upgrade of the Belle detector and will operate at the SuperKEKB energy-asymmetric e+e− collider. The design luminosity of the machine is 8 × 1035 cm−2s−1 and the Belle II experiment aims to record 50 ab−1 of data, a factor of 50 more than its predecessor. From February to July 2018, the machine has completed a commissioning run and main operation of SuperKEKB has started in March2019. Belle II has a broad τ physics program, in particular in searches for lepton flavour and lepton number violations (LFV and LNV), benefiting from the large cross section of the pair wise τ lepton production in e+e− collisions. We expect that after 5 years of data taking, Belle II will be able to reduce the upper limits on LF and LN violating τ decays by an order of magnitude. Any experimental observation of LFV or LNV in τ decays constitutes an unambiguous sign of physics beyond the Standard Model, offering the opportunity to probe the underlying New Physics. In this talk we will review the τ lepton physics program of Belle II.

Poster Session I / 141

Unitarity, thermal corrections, and higher-order CP asymmetric reaction rates in leptogenesis

Authors: Peter Matak[1]; Tomas Blazek[1]

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We present novel diagrammatic methods for perturbative asymmetry calculations and the inclusion of thermal corrections. Unlike the standard approach based on Cutkosky rules, the unnatural splitting of the amplitude into couplings and imaginary parts of the loop integrals is avoided. Moreover, the presented framework allows for a unified treatment of the usual asymmetries and real-intermediate-state-subtracted reaction rates (traditionally introduced to avoid double-counting in the Boltzmann equation). The S-matrix unitarity and CPT symmetry constraints between the asymmetries of different reactions are derived systematically at any order in coupling constants. They remain valid even when thermal corrections are taken into account via winding the propagators in Feynman diagrams on a cylindrical surface before the cutting is performed. The resulting thermally corrected source-term for the lepton number asymmetry is equivalent to the outcome of the closed-time-path formalism of non-equilibrium quantum theory. As an example, we use the asymmetric reaction rates in the seesaw type-I leptogenesis to demonstrate how the method works. The talk is primarily based on arXiv:2104.06395, arXiv:2102.05914.

Flavour physics - CKM and beyond / 142

Lepton Flavor in Composite Higgs Models (17+3)

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In this talk, we will present the status of lepton flavor physics in composite Higgs models with partial compositeness in the light of recent data in the lepton sector. We will consider anarchic flavor setups, scenarios with flavor symmetries, and minimal incarnations of the see-saw mechanism that naturally predict non-negligible lepton compositeness.
The focus will be on lepton flavor violating processes, dipole moments, and on probes of lepton flavor universality, all providing stringent tests of partial compositeness. We discuss the expected size of effects in the different approaches to lepton flavor and the corresponding constraints, including 'UV complete', effective and holographic descriptions.

Poster Session II / 143

The Triple Nuclear Collisions Method opens a new frontier to investigate the QCD matter properties at ultrahigh baryonic charge densities

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In a few years the experiments with high luminosity (HL) beams will start at the Large Hadron Collider (LHC). Among the other opportunities for such experiments, there are plans to exploit the fixed target mode for HL beams [1]. Using this opportunity, here we suggest to perform the entirely new experiments by means of utilizing the scattering of the two colliding beams at the nuclei of a solid target which is fixed at their interaction region. An original feature of the suggested experiments is a usage of the super-thin solid target operated in the core of colliding beams [2, 3, 4]. Such an approach is based on the successful data-taking process in the LHCb experiment in which the colliding and fixed gaseous target modes are running simultaneously.
Our estimates show that for the instantaneous luminosity of colliding proton beams at HL LHC of L= 10^{36} 1/cm^2/s and the fixed carbon target of the geometrical thickness of 3.3 μm that fills the interaction region of two colliding beams one can expect the triple nuclear collision rate to be about 2 events per 1000 s. For the luminosity of lead beams L= 10^{33} 1/cm^2/s hitting the lead fixed target of similar characteristics one can find that the number of triple nuclear collisions is about 3.4 per 10000 s.
To elucidate the distinctive features of the triple nuclear collisions, we used the UrQMD 3.4 model [5, 6] for the beam center-of-mass collision energies $\sqrt{s}$ = 2.76 TeV and $\sqrt{s}$ = 200 GeV. Our simulations show that in the most central and simultaneous triple nuclear collisions the initial baryonic charge density is about 3 times higher than the one achieved in the usual binary nuclear collisions at these energies. Contrary to the binary nuclear collisions, we found that the high value of baryonic charge density leads to a strong enhancement of proton and Λ-hyperon production at the midrapidity and to a sizable suppression of their antiparticles. Also in such experiments an entirely new kind of scattering reactions, namely a nucleus-fireball interaction, can be studied. Our preliminary simulations shown that the triple nuclear collision method at lower energies of collisions can be of principal importance to discover the (tri)critical endpoint of the QCD phase diagram [4].

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Search for lepton number and flavour violation in K+ and pi0 decays

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The NA62 experiment at CERN collected a large sample of charged kaon decays into final states with multiple charged particles in 2016-2018. This sample provides sensitivities to rare decays with branching ratios as low as 10-11.
Searches for the lepton number violating K+⟶π−μ+e+ decay and the lepton flavour violating K+⟶π+μ−e+ and π0⟶μ−e+ decays are reported. No evidence for these decays is found and upper limits of the branching ratios are obtained at 90% confidence level. These results improve by one order of magnitude over previous results for these decay modes.

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Search for K+ decays to a lepton and invisible particles at NA62 (12+3)

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The NA62 experiment at CERN reports searches for K+ ⟶ e+N, K+⟶μ+N and K+⟶μ+νX decays, where N and X are massive invisible particles, using the 2016-2018 data set.
The N particle is assumed to be a heavy neutral lepton, and the results are expressed as upper limits of O(10−9) and O(10−8) of the neutrino mixing parameter |Ue4|2 and |Uμ4|2, improving on the earlier searches for heavy neutral lepton production and decays in the kinematically accessible mass range.
The X particle is considered a scalar or vector hidden sector mediator decaying to an invisible final state, and upper limits of the decay branching fraction for X masses in the range 10-370 MeV/c2 are reported for the first time, ranging from O(10−5) to O(10−7).
An improved upper limit of 1.0×10−6 is established at 90% CL on the K+⟶μ+νν¯ branching fraction.

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Searches for decays with invisible particles in the final state at NA62 (17+3)

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New measurement of the radiative decay Ke3g at the NA62 experiment at CERN

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The NA62 experiment at CERN reports new results from the study of the radiative kaon decay K+ -> pi0 e+ nu g (Ke3g), using a data sample recorded in 2017–2018. The sample comprises O(100k) Ke3g candidates with sub-percent background contamination. Preliminary results with the most precise measurement of the Ke3g branching ratio, and a T-asymmetry measurement in the Ke3g decay, are presented.

Poster Session I / 149

Future sensitivity on unitarity, light-sterile neutrinos and neutrino magnetic moment from low-energy experiments

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We study the future sensitivities to a non-unitarity neutrino mixing matrix for different short-baseline coherent elastic neutrino-nucleus scattering (CEvNS) proposed experiments. We also identify the best configuration for measuring the oscillation parameters on the (3+1) scheme for light sterile neutrinos and find the estimated sensitivity for their parameters. Finally, we study the conversion to massive sterile neutrinos (in the keV-MeV energy mass) through transition magnetic moments and find the sensitivites for actual COHERENT results as well as future experiments of CEvNS and electron neutrino scattering with a proposed Cr-51 neutrino source experimental setup.

Hadrons in medium - hyperons and mesons in nuclear matter / 150

Four-body Faddeev-type calculation of the $\bar{K}NNN$ system

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The attractive nature of $\bar{K}N$ interaction has stimulated theoretical and experimental searches for K^- bound states in different systems. In particular, many theoretical calculations devoted to the lightest possible system $\bar{K}NN$ have been performed using different methods: Faddeev equations with coupled channels, variational methods, and some others, see a review [1] and references therein. All of them agree that a quasi-bound state in the K^-pp system exists but they yield quite diverse binding energies and widths. The experimental situation is unsettled as well: several candidates for the K^-pp state were reported by different experiments, but the measured binding energies and decay widths of such state differ from each other and are far from all theoretical predictions.

Detection of the heavier four-body $\bar{K}NNN$ system could be easier than in the case of $\bar{K}NN$ since direct scattering of K^- on three-body nuclei can be performed. Some theoretical works were devoted to the question of the quasi-bound state in the $\bar{K}NNN$ system with different quantum numbers, but more accurate calculations within Faddeev-type equations are needed. The reason is that only these dynamically exact equations written in momentum representation can treat energy dependent $\bar{K}N$ potentials, necessary for the this system, exactly.

We are solving four-body Faddeev equations in AGS form [2] in order to search for
the quasi-bound state in the $\bar{K}NNN$ system. We are using our experience with the three-body AGS calculations, described in [1], and our two-body potentials, constructed for them. Namely, three models of the $\bar{K}N$ interaction are being used: two phenomenological potentials and a chirally motivated one. All three potentials describe low-energy K^-p scattering and $1s$ level shift of kaonic hydrogen with equally high accuracy. This will allow us to study the dependence of the four-body results on the two-body input.

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Tests of symmetries and conservation laws / 152

A new experimental approach to search for free neutron-antineutron oscillations based on coherent neutron and antineutron mirror reflection

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An observation of neutron-antineutron oscillations, which violate both baryon and baryon-lepton conservation, would constitute a scientific discovery of fundamental importance to physics and cosmology. A stringent upper bound on its transition rate would make an important contribution to our understanding of the baryon asymmetry of the Universe by eliminating the postsphaleron baryogenesis scenario in the light quark sector.

We show [1-5] that one can design an experiment using slow neutrons that in principle can reach the required sensitivity of 10^10 s in the oscillation time, an improvement of 10^4 in the oscillation probability relative to the existing limit for free neutrons. The improved statistical accuracy needed

to reach this sensitivity can be achieved by allowing both the neutron and antineutron components of the developing superposition state to coherently reflect from mirrors.

We present a quantitative analysis of this scenario and show that, for sufficiently small transverse momenta neutrons/antineutrons and for certain choices of nuclei for the neutron/antineutron guide material, the relative phase shift of the neutron and antineutron components upon reflection and the antineutron annihilation rate can be small enough to maintain sufficient coherence to benefit from the greater phase space acceptance the mirror provides.

The values of the antineutron-nucleus scattering lengths, and in particular their imaginary parts, are needed to evaluate the feasibility of using neutron and antineutron mirrors to search for neutron-antineutron oscillations as well to evaluate the resulting experimental sensitivity. We analyze existing experimental and theoretical constraints on these values with emphasis on low-A nuclei and use the results to suggest materials for the neutron-antineutron guide and to evaluate the systematic uncertainties in estimating the neutron-antineutron oscillation time.

As examples, we discuss scenarios for future neutron-antineutron oscillation experiments at the European Spallation Source or the Institut Laue-Langevin. We show that for the lengths of neutron/antineutron guides and the cold neutron spectra, which can be considered presently at these facilities, the theoretical uncertainties associated with the interaction of antineutrons with the guide walls are negligible, and the gain in sensitivity compared to the existing bounds can be large.

Even better gain factors of up to 10^4 can be hypothetically obtained with longer neutron/antineutron guides and/or softer neutron spectra from dedicated sources of very cold neutrons.

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Nuclear and particle astrophysics / 153

Axion Production in Pulsar Magnetosphere Gaps

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Pulsar magnetospheres admit non-stationary vacuum gaps that are characterized by non-vanishing $\mathbf{E} \cdot \mathbf{B}$. The vacuum gaps play an important role in plasma production and electromagnetic wave emission. We show that these gaps generate axions whose energy is set by the gap oscillation frequency. The density of axions produced in a gap can be several orders of magnitude greater than the ambient dark matter density. In the strong pulsar magnetic field, a fraction of these axions may convert to photons, giving rise to broadband radio signals. We show that dedicated observations of nearby pulsars with radio telescopes (FAST) and interferometers (SKA) can probe axion-photon couplings that are a few orders of magnitude lower than current astrophysical bounds.

Standard model physics at the TeV scale / 154

Precise predictions for photon pair production

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In this talk I will present a new NNLO calculation for the photon pair production process at the LHC where the 0-jettiness resolution variable is resummed to NNLL' accuracy.This higher-order resummation is based on a factorisation formula derived within Soft-Collinear Effective in the small 0-jettiness region.
Then I will discuss the implementation of this process within the Geneva Monte Carlo framework by focusing on the photon isolation algorithm to remove final-state QED singularities. The partonic events are then showered and hadronised using Pythia8 while retaining the NNLO QCD accuracy for observables which are inclusive over the additional radiation.I will finally show comparisons of our predictions to LHC data at 7 TeV.

Hadrons in medium - hyperons and mesons in nuclear matter / 155

<p_T> geometrical scaling for light flavor hadrons

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Color Glass Condensate is a powerful theoretical tool that is able to describe the dynamical properties of partons in the QCD non-perturbative regime, characterized by strong color fields and high parton density.
A previous study, performed for a wide range of energies measured at the Relativistic Heavy Ion Collider (RHIC) and at the Large Hadron Collider (LHC), has shown that observables characteristic for the dynamics of the collision, i.e. the mean transverse momentum ($< p_T >$), the slope of the $< p_T >$ dependence on the mass of the particles and the average transverse flow velocity obtained from the simultaneous fits of the p_T spectra of the detected particles with the Boltzmann-Gibbs Blast Wave expression, scale rather well as a function of the square root of the ratio of the particle density over unit of rapidity and the overlapping area of the colliding nuclei ($\sqrt{\frac{dN/dy}{S_\perp}}$), the relevant scale in the gluon saturation picture.
This study was extended to strange and multi-strange hadrons, for both proton-proton (pp) and heavy-ion (A-A) collision systems. The dependence of the $< p_T >$ and its slope as a function of particle mass on $\sqrt{\frac{dN/dy}{S_\perp}}$, for K_0^S, Λ, Ξ^- and Ω^-, are presented. The comparison with the results obtained for non-strange light flavor hadrons is discussed.

Development of accelerators and detectors / 156

Detector Challenges of the strong-field QED experiment LUXE at the European XFEL

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The LUXE experiment aims at studying high-field QED in electron-laser and photon-laser interactions, with the 16.5 GeV electron beam of the European XFEL and a laser beam with power of up to 350 TW. The experiment will measure the spectra of electrons and photons in non-linear Compton scattering where production rates in excess of 10^9 are expected per 1 Hz bunch crossing. At the same time positrons from pair creation in either the two-step trident process or the Breit-Wheeler process will be measured, where the expected rates range from 10^{-3} to 10^3 per bunch crossing, depending on the laser power and focus. These measurements have to be performed in the presence of low-energy high radiation-background. To meet these challenges, for high-rate electron and photon fluxes, the experiment will use Cherenkov radiation detectors, scintillator screens, sapphire sensors as well as lead-glass monitors for backscattering off the beam-dump. A four-layer silicon-pixel tracker and a compact electromagnetic tungsten calorimeter with GaAs sensors will be used to measure the positron spectra. The layout of the experiment and the expected performance under the harsh radiation conditions will be presented.

Hot and dense matter physics - QGP and heavy ion collisions / 157

Electroweak-boson production in pp, p–Pb and Pb–Pb collisions with ALICE

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Electroweak-boson production in hadronic processes is a clean tool for the investigation of the parton distribution functions (PDFs). This is especially true in heavy-ion collisions at the LHC, where the initial state is still poorly constrained by measurements and important for the interpretation of the system evolution. The ALICE experiment can measure W and Z bosons via their leptonic decays in the electron channel at midrapidity ($|\eta_{\rm lab}| < 0.8$) and in the muon channel at forward rapidity ($2.5 < \eta_{\rm lab} < 4$). The observations at large $\eta_{\rm lab}$ are especially important investigating a phase space region that is largely unconstrained by heavy-ion experiments.

This contribution will present the recent ALICE results on electroweak boson measurements in p–Pb collisions at $\sqrt{s_{\rm NN}} = 8.16\ \rm TeV$ and Pb–Pb collisions at $\sqrt{s_{\rm NN}} = 5.02\ \rm TeV$. They include production yields and nuclear modification factors as a function of rapidity and collision centrality. The results are compared to pQCD calculations; those showing a clear evidence of nuclear modification of the PDFs will be highlighted. Finally, the status and progress of the analysis on W boson production in pp collisions at $\sqrt{s} = 13$ TeV will be presented.

Dark matter and cosmology / 158

Probing new physics at the LUXE experiment

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The proposed LUXE experiment (LASER Und XFEL Experiment) at DESY, Hamburg, using the electron beam from the European XFEL, aims to probe QED in the non-perturbative regime created in collisions between high-intensity laser pulses and high-energy electron or photon beams. This setup also provides a unique opportunity to probe physics beyond the standard model. In this talk we show that by leveraging the large photon flux generated at LUXE, one can probe axion-like-particles (ALPs) up to a mass of 350 MeV and with photon coupling of 3x10^{-6} GeV^{-1}. This reach is comparable to FASER2 and NA62. In addition, we will discuss other probes of new physics such as ALPs-electron coupling.

Tests of symmetries and conservation laws / 159

LUXE: A new experiment to study non-perturbative QED in electron-LASER and photon-LASER collisions

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The LUXE experiment (LASER Und XFEL Experiment) is a new experiment in planning at DESY Hamburg using the electron beam of the European XFEL. LUXE is intended to study collisions between a high-intensity optical LASER and 16.5 GeV electrons from the XFEL electron beam, as well as collisions between the optical LASER and high-energy secondary photons. The physics objective of LUXE are processes of Quantum Electrodynamics (QED) at the strong-field frontier, where the electromagnetic field of the LASER is above the Schwinger limit. In this regime, QED is non-perturbative. This manifests itself in the creation of physical electron-positron pairs from the QED vacuum, similar to Hawking radiation from black holes. LUXE intends to measure the positron production rate in an unprecedented LASER intensity regime. An overview of the LUXE experimental setup and its challenges will be given, followed by a discussion of the expected physics reach in the context of testing QED in the non-perturbative regime.

QCD, spin physics and chiral dynamics / 160

Measurement of Lepton-Jet Azimuthal Decorrelations and of the 1-Jetttiness event shape at High Q^2 using the H1 detector

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First measurements of the 1-jettiness event shape observable in the Breit Frame and of jet production in the laboratory frame, close to the Born-level configuration, are performed in neutral-current deep-inelastic scattering at HERA. The data were recorded with the H1 detector in the years 2003-2007 and are restricted to high momentum transfer $Q^2 > 150$ GeV^2. The 1-jettiness observable τ_{1b} is defined such that it is equivalent to the thrust observable defined in the Breit frame. Triple-differential cross sections are presented as a function of τ_{1b}, Q^2, and the inelasticity y. The data are compared to selected Monte Carlo predictions and to perturbative QCD calculations. The cross sections are sensitive to parton distribution functions of the proton, the strong coupling constant and to resummation and hadronisation effects. Jet production is measured differentially as functions of the jet transverse momentum, jet pseudorapidity, lepton-jet momentum imbalance, and lepton-jet azimuthal angle correlation. The jets are reconstructed in the laboratory frame with the k_T algorithm and a distance parameter of 1.0. The data are corrected for detector effects using the OMNIFOLD method, which incorporates a simultaneous and unbinned unfolding in four dimensions using machine learning. The results are compared with leading order Mont Carlo event generators and

to higher order calculations performed within the context of collinear or transverse-momentum-dependent (TMD) factorization in Quantum Chromodynamics (QCD). The measurement probes a wide range of QCD phenomena, including TMD parton-distribution functions (PDFs) and their evolution with energy.

Nuclear and particle astrophysics / 163

Cross section of the ^{13}C(α,n)^{16}O reaction at low energies in the framework of LUNA collaboration

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The Laboratory for Underground Nuclear Astrophysics (LUNA) is an experiment located in deep underground at Gran Sasso National Laboratories (LNGS). Its mission is to study charged-particle induced nuclear reactions of astrophysical interest.
This is an unique experiment that combines low environmental background and an intense and long term stable proton or alpha beam. The combination of these two peculiarities allowed in the last decades to provide valuable contributions to our present understanding of primordial nucleosynthesis, as well as stellar hydrogen and helium stellar burning.
In this framework, very recent measurements were performed for the direct measurement of the ^{13}C(α,n)^{16}O reaction cross section.
This process constitutes the dominant neutron source for the main s process, responsible of nucleosynthesis of half on nuclides heavier that iron, in low mass stars of thermally pulsing Asymptotic Giant Branch.
For the first time, the LUNA experiment developed a low intrinsic background neutron detector that combined with a detailed Low Level Counting analysis and an accurate target monitoring allowed to measure the ^{13}C(α,n)^{16}O cross section with unprecedented results, reaching the edge of the Gamow peak with an overall uncertainty of 20% at maximum.

In this talk I will present the LUNA experiment, focusing the attention techniques that led the cross section results of the ^{13}C(α,n)^{16}O reaction, illustrating the new reaction rate and its astrophysical implications.

Dark matter and cosmology / 164

Low Mass Black Holes from Dark Core Collapse

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Unusual masses of black holes being discovered by gravitational wave experiments pose fundamental questions about the origin of these black holes. Black holes with masses smaller than the Chandrasekhar limit $\approx 1.4\ M_{\odot}$ are essentially impossible to produce through stellar evolution. We propose a new channel for production of low mass black holes: stellar objects catastrophically accrete nonannihilating dark matter, and the small dark core subsequently collapses, eating up the host star and transmuting it into a black hole. The wide range of allowed dark matter masses allows a smaller effective Chandrasekhar limit and thus smaller mass black holes. We point out several avenues to test our proposal, focusing on the redshift dependence of the merger rate. We show that redshift dependence of the merger rate can be used as a probe of the transmuted origin of low mass black holes.

Hadron spectroscopy and exotics / 165

: Decay modes of the pseudoscalar glueball and its first excited state

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We study several chiral Lagrangians that describe the two- and three-body decays of a pseudoscalar glueball, $J^{PC} = 0^{-+}$, with a mass of 2.6 GeV and its first excited state with a mass of 3.7 GeV. Their masses were predicted by lattice QCD simulations. We compute the decay of the pseudoscalar glueball into (pseudo)scalar and (axial-)vector mesons as well as their excited states. We calculate also the decay of the first excited state into light mesons, charmonia, excited states, and into a scalar and pseudoscalar glueball. These states and channels are in reach of the ongoing BESIII, Belle II, LHCb, and NICA experiments and the upcoming PANDA experiment at the FAIR facility. The various branching ratios are parameters-free predictions.

Standard model physics at the TeV scale / 167

Full NLO QCD corrections to Higgs-pair production in the Standard Model and beyond

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Higgs-pair production is one of the targets of the high-luminosity LHC and of future hadron colliders, as it allows for a direct probe of the trilinear Higgs coupling and hence of the mechanism behind electroweak symmetry breaking. This talk will present the impact of the full next-to-leading order QCD corrections to Higgs-pair production via gluon fusion, the main production mechanism at hadron colliders, in the Standard Model and in Two-Higgs-Doublet models of type II. The uncertainties due to the top-mass scale and scheme choice will be discussed.

Nuclear and particle astrophysics / 168

Supernova constraints on dark flavoured sectors

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I will present a recent application of the SN 1987A cooling bound to set a constraint on dark flavoured sectors. This is possible thanks to the fact that the protoneutron stars are hot and dense environments where hyperons can be efficiently produced. Therefore a decay of the form $\to nX^0$, where X^0 is a new bosonic dark particle, will be severely constrained. I will explain the ingredients required and the application to flavoured (massless) dark photons, axions and ALPs.

Poster Session I / 169

Neutrino mass and phenomenology from a super-weak U(1) symmetry

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The super-weak force is a minimal, anomaly-free U(1) extension of the standard model (SM), designed to explain the origin of (i) neutrino masses and mixing matrix elements, (ii) dark matter, (iii) cosmic inflation, (iv) stabilization of the electroweak vacuum and (v) leptogenesis. We discuss the neutrino sector of this model in detail and study the allowed parameter space of the neutrino Yukawa matrices and mixing matrix elements. The model generates nonstandard neutrino interactions, whose allowed experimental limits are used to constrain the parameter space of the model. We provide benchmark points in the relevant parameter space that fall within the sensitivity region of the SHiP and MATHUSLA experiments.

Standard model physics at the TeV scale / 171

Status of NNLO QCD corrections for process with one or more jets in the final state at the LHC

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The abundant amount of data to be collected by the ATLAS and CMS collaborations in future runs of the Large Hadron Collider at CERN opens up a new era of precision physics. Some of the most prominent precision observables are related to processes with one or more jets in the final state. In order to fully exploit the potential of the LHC and the HL-LHC, it is imperative to make theoretical predictions at the level of accuracy that matches or even exceeds that of the upcoming measurements. In this talk we present a review of the status and future prospects for theoretical predictions including NNLO QCD corrections for process with one or more jets in the final state at the LHC.

QCD, spin physics and chiral dynamics / 172

Overview of recent HERMES results on transverse-momentum dependent spin asymmetries

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The HERMES experiment has collected a wealth of data using the 27.6 GeV polarized HERA lepton beam and various polarized and unpolarized gaseous targets. This allows for a series of unique measurements of observables sensitive to the multidimensional (spin) structure of the nucleon, in particular semi-inclusive deep-inelastic scattering (SIDIS) measurements, for which the HERMES dual-radiator ring-imaging Cherenkov counter provided final-hadron identification between 2 GeV to 15 GeV for pions, kaons, and (anti)protons. In this contribution, longitudinal and transverse single- and double-spin asymmetries in SIDIS will be presented. The azimuthally uniform longitudinal double-spin asymmetries using longitudinally polarized nucleons constrain the flavor dependence of the quark-spin contribution to the nucleon spin. For a first time, such asymmetries are explored differential in three dimensions in Bjorken-x and the in the hadron kinematics z and $h\perp$ (which respectively represent the energy fraction and transverse momentum of the final-state hadron) simultaneously. This approach increases the quark-flavor sensitivity and allows one to probe the transverse-momentum dependence of the helicity distribution. The measurement of hadron charge-difference asymmetries allows, under certain simplifying assumptions, for the direct extraction of valence-quark polarizations. The azimuthal modulation of this double-spin as well as of the single-(beam)spin asymmetry probe novel quark-gluon-quark correlations through twist-3 distribution and fragmentation functions. Also here, asymmetries are explored in several dimensions. Furthermore, in case of the beam-spin asymmetry, results for electro-produced protons and antiprotons have become available. The beam-spin asymmetries for pions are compared to similar measurements for pions at CLAS and unidentified hadrons at COMPASS. Last but not least, a review of similar measurements using a transversely polarized target will be given, providing information on the novel Sivers and Collins effects, among others.Those go beyond the earlier measurements, which were restricted to mainly one-dimensional projections and to mesons, by a first three-dimensional extraction of transverse spin asymmetries for identified pions, charged kaons, as well as protons and antiprotons, and including all single- and double-spin modulations allowed for lepton scattering on a transversely polarized proton target.

Neutrino physics / 173

The Scattering and Neutrino Detector at the LHC

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SND@LHC is a compact and stand-alone experiment to perform measurements with neutrinos produced at the LHC in a hitherto unexplored pseudo-rapidity region of $7.2 < \eta < 8.6$, complementary to all the other experiments at the LHC. The experiment is to be located 480 m downstream of IP1 in the unused TI18 tunnel. The detector is composed of a hybrid system based on an 800 kg target mass of tungsten plates, interleaved with emulsion and electronic trackers, followed downstream by a calorimeter and a muon system. The configuration allows efficiently distinguishing between all three neutrino flavours, opening a unique opportunity to probe physics of heavy flavour production at the LHC in the region that is not accessible to ATLAS, CMS and LHCb. This region is of particular interest also for future circular colliders and for predictions of very high-energy atmospheric neutrinos. The detector concept is also well suited to searching for Feebly Interacting Particles via signatures of scattering in the detector target. The first phase aims at operating the detector throughout LHC Run 3 to collect a total of 150 fb^{-1}. The experiment was recently approved by the Research Board at CERN. A new era of collider neutrino physics is just starting.

Nuclear and particle astrophysics / 174

Neutron Star Cooling on Strong Magnetic Field : Neutrino -Antineutrino Pair Emission and Direct Urca Processes

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We study cooling neutron-stars with strong magnetic fields through neutrino emissions from neutrino and antineutrino pair emission [1] and the Direct urca (DU) processes. We perform exact relativistic quantum calculations by introducing the Landau levels and anomalous magnetic moments [2]. Strong magnetic fields supply energy and momentum and make these processed even in the conditions where these processes do not occur in no magnetic field.
Then, we find that when the strength of the magnetic field is B = 10^14-10^16 G, these contributions are much larger than the modified Urca process.

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Poster Session I / 175

Higgs boson production in the high-energy limit of pQCD

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With the advent of TeV-energy colliding machines, such as the Large Hadron Collider (LHC), the possibility has opened up to test predictions of Quantum Chromodynamics (QCD) and, more in general, of the Standard Model (SM), in new, and so far unexplored, kinematical regimes. Among the many reactions that can be investigated at LHC, the Higgs production is one of the most important and challenging for the entire high-energy physics Community. Beside usual studies in the Higgs sector, it has recently been highlighted how differential Higgs distributions can be effectively used as "stabilizers" of the high-energy dynamics of QCD. The definition and the study of observables sensitive to high-energy dynamics in Higgs production has the double advantage of (i) allowing us to clearly disentangle the high-energy dynamics from the fixed-order one and (ii) providing us with an auxiliary tool to extend Higgs studies in wider kinematical regimes.
In this talk, I will show how a general hybrid collinear/high energy factorization can be built up for the inclusive production of a Higgs in association with a jet. Then, I will present some phenomenological analyses that corroborate the underlying assumption that this reaction can be used to investigate the semi-hard regime of QCD. Finally, I will focus on more formal developments, such as the inclusion of subleading corrections to previous studies, via the calculation of the forward next-to-leading order Higgs impact factor.

Neutrino physics / 176

Final Results of GERDA on the Search for Neutrinoless Double-β Decay

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The search for neutrinoless double-beta decay is generally quoted as the only practical way to establish the nature of the mass of neutrino, one of the most elusive and intriguing elementary particles in the Standard Model. The detection of this rare nuclear decay would attribute to neutrino special properties, described for the first time by Ettore Majorana at the beginning of the last century. A discovery would decisively prove the inadequacy of current fundamental physics theories, in favor of more general formulations. According to some of these novel theories, it might even contribute to solve the mystery of the asymmetry between matter and anti-matter in our universe. For more than 50 years, neutrinoless double-beta decay has been unsuccessfully searched for in the germanium isotope with 76 nucleons.

The GERDA experiment, officially concluded in November 2019, has pioneered the technique of submerging enriched high-purity germanium detectors in liquid argon, at the underground Laboratori Nazionali del Gran Sasso (LNGS) in Italy. During its second experimental phase, GERDA has achieved a world-record background level in the region of interest of $5.2 \cdot 10^{-4}$ cts/(keV kg yr), making the $0\nu\beta\beta$ search effectively background-free. The collaboration has scrutinized 127.2 kg yr of exposure and found no evidence for for $0\nu\beta\beta$. This observation converts to a lower limit of $1.8 \cdot 10^{26}$ yr at 90% C.L., in terms of decay half-life –the most stringent ever set by a $0\nu\beta\beta$ experiment.

The GERDA collaboration has demonstrated the maturity of the germanium experimental technology to realize a background-free tonne-scale experiment with a target discovery sensitivity of 10^{28} yr on the $0\nu\beta\beta$ half-life. This is the ambitious goal of the LEGEND collaboration. The first phase of the experimental project, LEGEND-200, is currently being commissioned at LNGS and will start data taking by the end of this year.

Hot and dense matter physics - QGP and heavy ion collisions / 177

Deep learning jet modifications in heavy-ion collisions

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Jet interactions in a hot QCD medium created in heavy-ion collisions are conventionally assessed by measuring the modification of the distributions of jet observables with respect to the proton-proton baseline. However, the steeply falling production spectrum introduces a strong bias toward small energy losses that obfuscates a direct interpretation of the impact of medium effects in the measured jet ensemble. In this talk, we will explore the power of deep learning techniques to tackle this issue on a jet-by-jet basis.

Toward this goal, we employ a convolutional neural network (CNN) to diagnose such modifications from jet images where the training and validation is performed using the hybrid strong/weak coupling model. By analyzing measured jets in heavy-ion collisions, we extract the original jet transverse momentum, i.e., the transverse momentum of an identical jet that did not pass through a medium, in terms of an energy loss ratio. Despite many sources of fluctuations, we achieve good

performance and put emphasis on the interpretability of our results. We observe that the angular distribution of soft particles in the jet cone and their relative contribution to the total jet energy contain significant discriminating power, which can be exploited to tailor observables that provide a good estimate of the energy loss ratio.

With a well-predicted energy loss ratio, we study a set of jet observables to estimate their sensitivity to bias effects and reveal their medium modifications when compared to a more equivalent jet population, i.e., a set of jets with similar initial energy. Then, we show how this new technique provides unique access to the initial configuration of jets over the transverse plane of the nuclear collision, both with respect to their production point and initial orientation. Finally, we demonstrate the capability of our new method to locate with unprecedented precision the production point of a dijet pair in the nuclear overlap region, in what constitutes an important step forward towards the long term quest of using jets as tomographic probes of the quark-gluon plasma.

[1] Yi-Lun Du, Daniel Pablos, Konrad Tywoniuk, Deep learning jet modifications in heavy-ion collisions, arXiv:2012.07797 [hep-ph], JHEP. 2021, 206 (2021)

Hot and dense matter physics - QGP and heavy ion collisions / 178

N = 4 supersymmetric Yang-Mills thermodynamics to order λ^2

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We calculate the resummed perturbative free energy of $calN = 4$ supersymmetric Yang-Mills in four spacetime dimensions through second order in the ‘t Hooft coupling λ at finite temperature and zero chemical potential. Our final result is ultraviolet finite and all infrared divergences generated at three-loop level are canceled by summing over $calN = 4$ supersymmetric Yang-Mills ring diagrams. Non-analytic terms at $calO(\lambda^{3/2})$ and $calO(\lambda^2 \log \lambda)$ are generated by dressing the A_0 and scalar propagators. The gauge-field Debye mass m_D and the scalar thermal mass M_D are determined from their corresponding finite-temperature self-energies. Based on this, we obtain the three-loop thermodynamic functions of $calN = 4$ supersymmetric Yang-Mills to $calO(\lambda^2)$. We compare our final result with prior results obtained in the weak- and strong-coupling limits and construct a generalized Pad\'{e} approximant that interpolates between the weak-coupling result and the large-N_c strong-coupling result. Our results suggest that the $calO(\lambda^2)$ weak-coupling result for the scaled entropy density is a quantitatively reliable approximation to the scaled entropy density for $0 \leq \lambda \leq 2$.
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Hadron spectroscopy and exotics / 179

Hamiltonian effective field theory in elongated or moving finite volume

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We extend previous work concerning rest-frame partial-wave mixing in Hamiltonian effective field theory to both elongated and moving systems, where two particles are in a periodic elongated cube

or have nonzero total momentum, respectively. We also consider the combination of the two systems when directions of the elongation and the moving momentum are aligned. This extension should also be applicable in any Hamiltonian formalism. As a demonstration, we analyze lattice QCD results for the spectrum of an isospin-2 $\pi\pi$ scattering system and determine the s, d, and g partial-wave scattering information. The inclusion of lattice simulation results from moving frames significantly improves the uncertainty in the scattering information.

Hot and dense matter physics - QGP and heavy ion collisions / 180

Latest results of hadronic resonance production with ALICE at the LHC

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Resonances with very short lifetimes can be used to probe the rescattering and regeneration ~ processes in the hadronic phase of the system produced after a high-energy collisions. These processes are studied by measuring resonance yields as a function of the system size and collision energy and comparing them to model calculations with and without the hadronic cascades. We present measurements of transverse momentum spectra, integrated yields ($\mathrm{d}N/\mathrm{d}y$), mean transverse momenta ($\langle p_{\mathrm{T}}\rangle$), and angular distributions for light flavour hadronic resonances in pp, p–Pb, Xe–Xe, and Pb–Pb collisions at LHC energies.
The $\langle p_{\mathrm{T}}\rangle$ of resonances as a function of event multiplicity in central Pb–Pb collisions follow the same mass ordering as for other hadrons, expected from the hydrodynamic expansion of the system.
At high p_{T} ($>$ 8 GeV/c), nuclear modification factor (R_{AA}) of light flavor hadrons in central Pb–Pb collisions shows strong suppression, whereas the nuclear modification factor in p–Pb collisions, known as R_{pPb} is consistent with unity. This parton energy loss effect is independent of the particle species.

Further, in non-central heavy-ion collisions, the vector mesons can be polarized due to spin-orbital-angular-momentum interaction or hadronization from polarized quarks due to their significant initial angular momentum. Recent measurements of spin alignment for K^{*0} and ϕ mesons produced at midrapidity in pp and Pb–Pb collisions will be presented.

Nuclear and particle astrophysics / 181

ANTARES & KM3NeT: High Energy Astrophysical Neutrino Telescopes in the Mediterranean Sea

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The first deep-sea neutrino telescope, ANTARES, located in the Mediterranean, close to the coast of Toulon (France), has been continuously taking data since 2007. Its primary aim is to detect astrophysical neutrinos in the TeV–PeV in order to contribute to the effort of identifying astrophysical sources of Cosmic Rays and better understand their nature. The next-generation Neutrino Telescope, the Kilometre Cube Neutrino Telescope (KM3NeT ARCA and ORCA), is currently under construction and deployment in the Mediterranean Sea. ARCA (Astroparticle Research with Cosmics in the

Abyss) in its final configuration will instrument 1 GTon of seawater, using more than 100,000 PMTs with a 3"diameter, and it is optimized to detect cosmic neutrinos within an energy range of 1 TeV–10 PeV. The optical properties of the deep-sea water allow for a large effective area and good pointing accuracy in all neutrino flavour channels, leading to an unprecedented sensitivity in the searches for neutrino sources in the Southern Sky. These properties have allowed to ANTARES to constrain the origin of the cosmic neutrino flux discovered by the IceCube detector and to participate, in a multi-messenger context, to the study of astrophysical sources. ANTARES data have been analysed searching for neutrino emission from transient sources, for neutrino correlations with transient events detected at different wavelengths, gravitational wave events, and neutrino events detected by the IceCube observatory. Many other physics topics are also covered by ANTARES: searches of dark matter annihilation or decay in massive objects; the search for relic massive magnetic monopoles and nuclearites; the study of atmospheric neutrinos and neutrino oscillations. An overview of the latest results from all these analyses in ANTARES, as well as the ARCA status and science program will be presented.

Hot and dense matter physics - QGP and heavy ion collisions / 182

Measurements of jet quenching via hadron+jet correlations in Pb-Pb and high-particle multiplicity pp collisions with ALICE

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Interactions of high-p_{T} partons with quark-gluon plasma (QGP) result in jet quenching, which is manifest by the suppression of high-p_{T} jet yields and the modification of jet substructure and di-jet acoplanarity distributions. Several jet quenching phenomena can be measured precisely over a wide range of jet p_{T} using semi-inclusive distributions of charged jets recoiling from a high-p_{T} trigger hadron, which incorporate data-driven suppression of the large uncorrelated background produced in heavy-ion collisions.

In this talk we report semi-inclusive measurements of hadron-jet acoplanarity in Pb-Pb collisions at $\sqrt{s_{\mathrm{NN}}} = 5.02$ TeV and high-particle multiplicity pp collisions at $\sqrt{s} = 13$ TeV. In the Pb-Pb system, where QGP formation is established, narrowing of the acoplanarity is observed relative to a reference distribution from pp collisions. In contrast, pp events with high-particle multiplicity exhibit a broadening of the acoplanarity relative minimum bias events. In this case, however, qualitatively similar features are also seen in pp collisions generated by the PYTHIA 8, which does not include jet quenching or other QGP effects. We will discuss the current status of these analyses, and prospects to understand the origin of these striking phenomena.

QCD, spin physics and chiral dynamics / 183

Global Analysis of SSAs from Current and Future Data

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The analysis of single transverse-spin asymmetries (SSAs) gives us tremendous insight into the internal structure of hadrons. For example, the Sivers and Collins effects in semi-inclusive deep-inelastic scattering (SIDIS), Sivers effect in Drell-Yan, and the Collins effect in electron-positron annihilation have been widely investigated over many years in order to perform 3D momentum-space tomography. In addition, observables like AN in proton-proton collisions are of interest due to their sensitivity to quark-gluon correlations. In this talk I will discuss results, and give an update on, our global fit of SSA data from SIDIS, Drell-Yan, e+e− annihilation into hadron pairs, and proton-proton collisions. I will also report on a study based on these results of the impact the EIC at Brookhaven National Lab and SoLID at Jefferson Lab will have on extracting the nucleon tensor charge. This is an important quantity that sits at the intersection of TMD studies, beyond the Standard Model physics, and lattice QCD.

Hadrons in medium - hyperons and mesons in nuclear matter / 184

Studying the structure of a bound proton through polarization-transfer measurements

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Knowledge of whether the proton's electromagnetic (EM) structure changes when it is bound inside an atomic nucleus is important for a better understanding of nuclear matter and its behavior. If such change is present it is expected to be relatively small and therefore difficult to experimentally determine.

The ratio of the transverse to longitudinal polarization-transfer components in the $\mathrm{A}(\vec{e}, e'\vec{p})$ reaction is proportional to the proton electromagnetic form factor (FF) ratio G_E/G_M. Experiments searching for in-medium modification of EM FF ratio were carried out on protons from different nuclei (^{2}H, ^{4}He, ^{12}C, and ^{16}O). Although the observed polarization transfer ratios deviated significantly (especially for those with higher Fermi momenta) from those of free proton, these differences could be accounted for with the inclusion of different nuclear effects. We observed that deviations in the measured polarization ratios from those of free-proton scattering have a similar dependence on virtuality (a measure of off-shellness) in all measured nuclei.

In our last experiment, instead of comparing results between different nuclei or comparing them against a free-proton scattering, we evaluated polarization transfer to protons extracted from s and p shell of ^{12}C nucleus and examined the differences. This was motivated by theoretical predictions that local nuclear densities experienced by protons in these two shells differ approximately by a factor of two, which could lead to significant changes in the proton EM FF ratio. Comparing protons from the same nucleus has also the advantage of reducing the influence of various experimental uncertainties. We will present these new data and the results in form of individual polarization components as well as their ratios that we obtained both as a function of the missing momentum (related to proton Fermi momentum) and proton's virtuality.

Nuclear and particle astrophysics / 185

Novel Focal-Plane Detector Concepts for PID at the FRIB S800 Spectormeter

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The FRIB S800 superconducting spectrograph is used for studying nuclear reactions induced by high-energy radioactive beams. The spectrometer was designed for high-precision measurements of small scattering angles (within ±2 msr), combined with the large acceptance of the solid angle (20 msr) and momentum (6%). The high-resolution (1/10,000) is optimized for energies up to 200 MeV/u. The S800 has been an indispensable apparatus for the wide physics program of the NSCL with fast rare isotope beams, being the most heavily used experimental device at NSCL. The S800 spectrograph will continue to serve the nuclear physics/astrophysics community for experiments with rare isotope beams also during FRIB operation.
A crucial component for the performance of the S800 spectrometer is the focal plane detector system, which consists of an array of various detector technologies for trajectory reconstruction as well as particle identification (PID). This includes two x/y drift chambers for tracking, an ionization chamber for atomic number identification by energy loss measurement, and a plastic scintillator for timing (as well as energy loss). Downstream the plastic scintillator, a CsI(Na) hodoscope is deployed to identify atomic charge states of the implanted nuclei via total kinetic energy (TKE) measurement. In this work, the operational mechanism and performance of novel detector concepts planned for the upgrade of the S800 focal plane are described for the first time. In particular, we will present the design of the new drift chamber (DC) readout based on a hybrid Micro-Pattern Gaseous Detector structure. Performance evaluations under irradiation with small lab source (5.6 MeV alpha–particle emitted by an Am-241 source) as well as with test heavy-ion beams will be presented and discussed in detail. In the latter case we the detector was irradiated by a 78Kr36+ beam at around 150 MeV/u, as well as by a heavy-ion fragmentation cocktail produced by the 78Kr beam impinging on a Be target.
In addition, I will present the development of a heavy-ion particle identification (PID) device based on an energy-loss measurement (ΔE) within a novel optical scintillation scheme. The new instrument consists of a multi-segmented optical detector (ELOSS) filled with high-luminescence yield gas (e.g. pure Xenon). Its operational principle is based on recording the fast scintillation light emitted along an ion's track. This developing technology allows for high-resolution ΔE measurements at a high counting rate, unlike traditional ionization chambers. Both high energy resolution and high counting rate capabilities are needed to take full advantage of the future FRIB's rare-isotope beam portfolio and anticipated high intensity. The proposed detector presents a significant advance in both instrumentation and capabilities in the field of experimental nuclear physics, providing new opportunities for experiments with rare isotope beams.

Poster Session II / 186

The System for on-Axis Neutrino Detection at the DUNE Near Detector complex

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The Deep Underground Neutrino Experiment Near Detector complex aims at constraining the systematic uncertainties and deconvolving the neutrino beam flux and cross-section models. The System for on-Axis Neutrino Detection (SAND) is the Near Detector component permanently on-axis. SAND is based on the 0.6 T superconducting magnet and electromagnetic calorimeter previously used in the KLOE experiment. The 40 m3 magnetic volume will be filled with an active target/tracker system. One considered option foresees an upstream liquid Argon active target (about 1.5 t) and a Straw Tube Tracker (about 5 t). In this talk the design of SAND will be described and its performances discussed in view of the SAND primary goals, namely the beam monitoring and neutrino flux measurements.

QCD, spin physics and chiral dynamics / 187

First analysis of world polarized DIS data with small-x helicity

evolution

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We present the first-ever description the world data on the $g_1^{p,n}$ structure function at small Bjorken x using evolution equations in x derived from first principles QCD. This is a Monte-Carlo analysis within the JAM global framework that allows us to fit all existing polarized DIS data below $x < 0.1$ as well as predict future measurements of small x $g_1^{p,n}$ at the EIC. This is a necessary step in determining the quark helicity PDFs and, ultimately, the quark contribution to the proton spin.

Hadron spectroscopy and exotics / 188

Extraction of S-matrix pole structure using deep learning

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We developed a deep neural network (DNN) to determine the pole configuration of a coupled-channel scattering with near-threshold enhancement. The trained DNN takes the partial wave amplitude as input and gives the number of nearby poles in any of the unphysical sheets. To avoid any possible model bias, we generate a training dataset using an S-matrix where the relevant pole parameters are independent of any coupling strength. The inclusion of limited energy resolution to the training dataset requires curriculum-type training. We apply our method to probe the pole structure of the πN elastic amplitude and find that the enhancements seen between the ηN and $K\Sigma$ thresholds are due to one pole in each adjacent Riemann sheet and at most two poles in the distant sheet. The output of our method can be used as a guide in designing an appropriate parametrization to extract and pinpoint the pole positions.

Hadrons in medium - hyperons and mesons in nuclear matter / 189

hidden charm mesons in nuclear matter and nuclei

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Recent results for the η_c- and J/ψ-nucleus bound state energies for various nuclei are presented. Essential input for the calculation, namely the medium-modified D and D^* meson masses, as well

as the density distributions in nuclei, are calculated within the quark-meson coupling model. The attractive potentials for the η_C and J/ψ mesons in the nuclear medium originate, respectively, from the in-medium enhanced DD^* and $D\bar{D}$ loops in the η_c and J/ψ self energies. Our results suggest that the η_c and J/ψ mesons should form bound states with all the nuclei considered. Some of the results presented were recently published in J.J. Cobos-Martinez et al, Phys. Lett. B 811 (2020) 135882

Poster Session II / 190

A combined fit to the Higgs Branching Ratios at ILD

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We introduce here a new method to measure the Higgs decay branching ratios at future e^+e^- Higgs factories, by directly exploiting class numeration. Given the clean environment at a lepton collider, we build an event sample highly enriched in Higgs bosons and essentially unbiased for any decay mode. The sample can be partitioned into categories using event properties linked to the expected Higgs decay modes. The counts per category are used to fit the Higgs branching ratios in a model independent way. The result of the fit is directly the set of branching ratios, independent from any measurement of a Higgs production mode. Special care is given to an appropriate treatment of the statistical uncertainties. In this contribution, the current status of our implementation of this analysis within the ILD concept detector is presented.

Poster Session II / 192

Minimal Froggatt-Nielsen Textures

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The flavour problem of the Standard Model can be addressed through the Froggatt-Nielsen (FN) mechanism. In this work, we develop an approach to the study of FN textures building a direct link between FN-charge assignments and the measured masses and mixing angles via unitary transformations in flavour space. We specifically focus on the quark sector to identify the most economic FN models able to provide a dynamical and natural understanding of the flavour puzzle. Remarkably, we find viable FN textures, involving charges under the horizontal symmetry that do not exceed one in absolute value (in units of the flavon charge). Within our approach, we also explore the degree of tuning of FN models in solving the flavour problem via a measure analogous to the Barbieri-Giudice one. We find that most of the solutions do not involve peculiar cancellations in flavour space.

Poster Session II / 193

Low Mass Straw Tube Tracker for the Mu2e Experiment

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A low mass straw tube tracker is at the heart of the Mu2e experiment, tasked with precisely measuring monochromatic electrons from μ^- N$\rightarrow$ e^- N conversion as a signal for charged lepton flavor violation (CLFV). The goal of the Mu2e experiment is to discover CLFV and new physics through improving the current limit on the sensitivity of the neutrino-less muon to electron conversion rate by 10^4. The Mu2e tracker is one of the lowest mass trackers in particle physics with 3.4×10^{-4} g/mm linear mass density in the tracking volume made from 96000 15 μm thick aluminized Mylar straws. The straw tube tracker is key to suppressing background electrons from processes like decay-in-orbit and radiative pion capture by measuring conversion electrons with a momentum precision of less than 180 keV/c. The Mu2e tracker is in production now and construction will wrap up by 2023. Multiple tracker planes have been produced and we will show results from the first plane that has been under test since the beginning of 2021.

QCD, spin physics and chiral dynamics / 194

GPDs of sea quarks in the proton from nonlocal chiral effective theory

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We calculate the spin-averaged generalized parton distributions (GPDs) of sea quarks in the proton at zero skewness from nonlocal covariant chiral effective theory, including one-loop contributions from intermediate states with pseudoscalar mesons and octet and decuplet baryons. A relativistic regulator is generated from the nonlocal Lagrangian where a gauge link is introduced to guarantee local gauge invariance, with additional diagrams from the expansion of the gauge link ensuring conservation of electric charge and strangeness. Flavor asymmetries for sea quarks at zero and finite momentum transfer, as well as strange form factors, are obtained from the calculated GPDs, and results compared with phenomenological extractions and lattice QCD.

Hadron spectroscopy and exotics / 195

Range correction in the weak-binding relation for unstable states

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Most of hadrons consist of two or three quarks and they are called mesons and baryons. Those which are not classified into mesons and baryons are called exotic hadrons. The exotic hadrons are considered as, for instance, multiquark states with more than three quarks, or hadronic molecular states which are weakly bound states of hadrons. Many candidates for exotic hadrons are discovered in recent experiments and intensive studies are performed to determine the internal structure of those candidates.
The weak-binding relation is one of the approaches to analyze the internal structure of the candidates for exotic hadrons [1,2]. With the weak-binding relation, we can model-independently determine the compositeness which is the fraction of the hadronic molecular component of hadrons. The compositeness is estimated with the scattering length and the binding energy where the uncertainty arises from the finite interaction range. In Ref. [2], the internal structures of $\Lambda(1405)$, $f_0(980)$ and $a_0(980)$ were investigated by using the weak-binding relation. To apply the weak-binding relation to $\Lambda_c(2595)$ in the charm sector, on the other hand, we need to consider the systems with a large effective range. The effective range is the next to leading length scale in the effective range expansion and it characterizes low-energy hadron scatterings together with the scattering length. We show that the weak-binding relation cannot be applied to the system with a large effective range, because the range correction was neglected in the previous works [1,2].
We introduce the range correction to the weak-binding relation by modifying the correction terms which is the origin of the uncertainty. We perform the numerical calculations to check whether the modification of the weak-binding relation works or not. For the calculation, we consider the effective field theory called effective range model. In this model, the exact value of the compositeness is known by definition, and we can control the scattering length and effective range independently by varying the model parameters such as cutoff and coupling constants. To estimate the compositeness precisely with the weak-binding relation, two conditions need to be satisfied. First one is the validity condition which means that the exact value of the compositeness is contained in the uncertainty region. Second one is the precision condition which means that the uncertainty is sufficiently small. From the numerical calculations, we find the parameter region where only the improved weak-binding relation can be applied, so the modification of correction terms of the relation works well. We further discuss the method of the quantitative evaluation of the uncertainty of the weak-binding relation.

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[2] Y. Kamiya and T. Hyodo, PTEP 2017, 023D02 (2017).

Energy frontier physics beyond the standard model / 196

Search Prospect for Extremely Weakly-Interacting Particles in Gamma Factory

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The Gamma Factory is a proposal to back-scatter laser photons off a beam of partially-stripped ions at the LHC, producing a beam of $\sim$ 10 MeV to 1 GeV photons with intensities of 10^{16} to 10^{18} s^{-1}. This implies $\sim$ 10^{23} to 10^{25} photons on target per year, many orders of magnitude greater than existing accelerator light sources and also far greater than all current and planned electron and proton fixed target experiments. We determine the Gamma Factory's discovery potential through "dark Compton scattering", $\gamma e \to eX$, where X is a new, weakly-interacting particle. For dark photons and other new gauge bosons with masses in the 1 to 100 MeV range, the Gamma Factory

has the potential to discover extremely weakly-interacting particles with just a few hours of data and will probe couplings as low as $\sim 10^{-9}$ with a year of running. The Gamma Factory therefore may probe couplings lower than all other terrestrial experiments and is highly complementary to astrophysical probes. We outline the requirements of an experiment to realize this potential and determine the sensitivity reach for various experimental configurations.

Dark matter and cosmology / 197

Improving the sensitivity to light dark matter with the Migdal effect

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The search for dark matter (DM) weakly interacting massive particles with noble elements has probed masses down and below a GeV/c^2. The ultimate limit is represented by the experimental threshold on the energy transfer to the nuclear recoil. Currently, the experimental sensitivity has reached a threshold equivalent to a few ionization electrons. In these conditions, the contribution of a Bremsstrahlung photon or a so-called Migdal electron due to the sudden acceleration of a nucleus after a collision might be sizeable. We present a recent work where, using a Bayesian approach, we studied how these effects can be exploited in experiments based on liquid argon detectors. In particular we develop a simulated experiment to show how the Migdal electron and the Bremsstrahlung photon allow to push the experimental sensitivity down to masses of 0.1 GeV/c^2, extending the search region for dark matter particles of previous results. For these masses we estimate the effect of the Earth shielding that, for strongly interacting dark matter, makes any detector blind. Finally, given the relevance of the Migdal electrons to the search for low mass DM, we discuss some new ideas on how to possibly measure such an effect with detectors based on a Time Projection Chamber exposed to an high neutron flux.

Hadron spectroscopy and exotics / 198

Covalent hadronic molecules from QCD sum rules

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After examining the Feynman diagrams corresponding to some candidates of hadronic molecular states, we propose a possible binding mechanism induced by shared light quarks. This mechanism is similar to the covalent bond in chemical molecules induced by shared electrons. We use the method of QCD sum rules to calculate its corresponding light-quark-exchange diagrams, and the obtained results indicate a model-independent hypothesis: the light-quark-exchange interaction is attractive when the shared light quarks are totally antisymmetric so that obey the Pauli principle.

Dark matter and cosmology / 201

Dark sector searches at Belle

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The Belle experiment has accumulated close to $1\,\mathrm{ab}^{-1}$ of data in electron-positron collisions at center-of-mass energies around various $\Upsilon(nS)$ resonances. These data can be used to perform a number of new physics searches in the context of dark sector with an unprecedented precision.
We present the results of a search of the dark photon in B-meson decays, the search for dark matter in bottomonium decays, as well as the latest results in the search for dark forces, via direct production, or in the decay of mesons.

Hadron spectroscopy and exotics / 202

Recent results on charmonium and bottomonium states at Belle

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The large data sample accumulated by the Belle experiment at the KEKB asymmetric-energy e^{+} e^{-} collider provides a unique opportunity to perform studies related to hadron spectroscopy utilising various production mechanisms. We studied the two-photon process \gamma\gamma \to \gamma\psi(2S) is studied for the first time and found an evidence for a structure in the \gamma\psi(2S) invariant-mass distribution at 3921.3 \pm 2.4 \pm 1.6\,{\rm MeV}. We report the first measurement of exclusive cross sections for $e^+e^- \to B\bar{B}$, $e^+e^- \to B\bar{B}^*$, and $e^+e^- \to B^*\bar{B}^*$ in the energy range from 10.63 to $11.02\,\mathrm{GeV}$. In addition, we report a search for the $\chi_{bJ}(nP)$ bottomonium states at Belle. Other studies on conventional or exotic charmoniuum and bottomoniuum are also presented.

Hadron spectroscopy and exotics / 203

Recent results on charmed baryon at Belle

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Precision hadron spectroscopy helps in understanding how the matter is made around us. The large data sample accumulated by the Belle experiment at the KEKB asymmetric-energy e^+e^- collider provides us a unique opportunity to perform these studies. We report recent results on charmed baryon spectroscopy from Belle, which include a study on the spin and parity of $\Xi_c(2970)$, mass and width measurements on $\Sigma_c(2455/2520)^+$, $\Xi_c(2790/2815)$ radiative decays, $\Lambda + c \to \Lambda\eta\pi$, $\Omega_c \to \pi\Omega(2012)$. The talk may also cover results on non-charmed baryons at Belle.

Poster Session I / 204

Photo-disintegration of N=Z light nuclei using SRC-based approach

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The outcome of any possible nucleosynthesis scenario is strongly affected by the photodisintegration of nuclei through (γ, N) and (γ, np) channels for Eγ > 10MeV to a few hundred MeV. Though there is a wide range of phenomenological models for the estimation of excitation functions in this energy region, the exact photodisintegration mechanism is not well understood. The shell-model based approaches have not been successful even for the light nuclei of astrophysical importance like 6Li [1]. By extending the Independent PAir Model [2] (IPAM), a SRC-based approach is employed to calculate the photo-disintegration of light nuclei in quasideuteron region. Combining the Gunn-Irving photo-disintegration for α-cluster [3], the proposed approach is used to calculate the total photo-disintegration cross-sections for Eγ between 10 to 140 MeV for many of the N=Z light nuclei from 4He to 40Ca. Contrary to general perception, the quasideuteron photo-disintegration contribution starts in the GDR region itself [4] and dominates at Eγ > 50 MeV. Along with many interesting new insights, the derivation of the Levinger [5] formula is obtained without any additional assumption. A significant fraction of the photo-disintegration cross-section in GDR region may be accounted by contribution of quasi-α degree of freedom which decreases for higher Eγ. The present work suggests an alternative and viable description of photodisintegration for N=Z nuclei in terms of np-SRCs/quasideuteron structures and their paired counterparts.

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Poster Session I / 205

Dark matter searches with mono-photon signature at future e+e- colliders

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In this contribution, recent results on the sensitivity of future lepton colliders to WIMP dark matter (DM) pair production are reviewed. Considered are processes with mono-photon signature, when DM production is accompanied by a hard photon emission from the initial state radiation, through which the process can be identified.
Corresponding study was performed with full detector simulation for the International Large Detector (ILD) concept at the International Linear Collider (ILC), for a centre-of-mass energy of 500 GeV. In the effective field theory (EFT) approach scales of up to 3 TeV can be tested for different operator types and DM masses almost up to half the collision energy. The sensitivity benefits from the polarised beams, which can reduce the main SM background from neutrino pair production substantially. Systematic uncertainties are also significantly reduced when combining data with different polarisation configurations.
Similar study was performed to investigate potential for detecting DM at the Compact Linear Collider (CLIC) running at 3 TeV. When considering the ratio of the mono-photon energy distributions for left-handed and right-handed polarised electron beams, most systematic uncertainties cancel out, resulting in the best limits on the DM pair-production cross section. These limits can be then translated, using simplified DM models, into exclusion limits for DM and mediator
masses for fixed values of the mediator couplings to SM and DM particles.

Finally, pair-production of DM particles at the ILC and CLIC was also studied for scenarios with small mediator masses and small mediator couplings to the SM particles. Limits on the production cross section can be extracted from the two-dimensional distributions of the reconstructed mono-photon events. Limits on the mediator coupling to electrons are presented for a wide range of mediator masses and widths. For mediator masses up to the centre-of-mass energy of the collider,
limits expected from the mono-photon analysis are more stringent than the limits from direct resonance search in SM decay channels.

Hadrons in medium - hyperons and mesons in nuclear matter / 206

Status and perspectives for low energy kaon-nucleon interaction studies at DAFNE: from SIDDHARTA to SIDDHARTA-2

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The study of the antikaon nucleon system at very low energies plays a key role for the understanding of the strong interaction between hadrons in the strangeness sector. The information provided by the low energy kaon- nucleon interaction is accessible through the study of kaonic atoms. The lightest atomic systems, namely the kaonic hydrogen and the kaonic deuterium, provide the isospin dependent kaon-nucleon scattering lengths by measuring the X-rays emitted during their de-excitation to the 1s level. Until now, the most precise kaonic hydrogen measurement and an exploratory measurement of kaonic deuterium were carried out at the DAFNE collider by the SIDDHARTA collaboration, combining the excellent quality kaon beam delivered by the collider with new experimental techniques, as fast and very precise X-ray detectors, like the Silicon Drift Detectors. Today, the most important experimental information missing in the field of the low-energy antikaon-nucleon interactions is the experimental determination of the hadronic energy shift and width of kaonic deuterium, and will be measured by the new SIDDHARTA-2 experiment, which is installed in DAFNE and is ready to start the data taking campaign. The experimental challenge of the kaonic deuterium measurement is the very small x-rays yield, the even larger width (compared to kaonic hydrogen) and the difficulty to perform x-rays spectroscopy with weak signals in the high radiation environment of DAFNE. It is therefore crucial to develop a new large area X-rays detector system to optimize the signal and to control and improve the signal-to-background ratio by gaining in solid angle, increasing the timing capability and as well implementing an additional charge particle tracking veto systems. In the talk I shall review the kaonic atoms measurements performed by SIDDHARTA, the status and plans of SIDDHARTA-2 and future perspectives to measure other kaonic atom systems at the DAFNE collider.

Hadron spectroscopy and exotics / 208

Hadron physics results at KLOE/KLOE2

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KLOE and KLOE-2 experiment, operated at the DAΦNE facility of Frascati, acquired almost 8 fb^{-1} of data at the ϕ peak resonance.
The two samples together represent the largest statistics ever collected at an e^+e^- collider at 1.02 GeV center-of-mass energy.
With about 2.4 $\times 10^{10}$ ϕ and 3.1×10^8 η meson events available for data analysis, KLOE-2 can give an important contribution to hadron spectroscopy and Dark Force research fields. Moreover, thanks to the installation in both DAΦNE arms of two tagger station, KLOE-2 can also investigate the $\gamma\gamma$ fusion.

The $\eta \to \pi^0\gamma\gamma$ decay is considered a ChPT golden mode because of its sensitivity to the p^6 term on both the branching ratio (BR) and the M($\gamma\gamma$) spectrum. There is a 4.5 σ discrepancy between the KLOE preliminary BR measurement, obtained with 450 pb^{-1}, and the most accurate one from Crystal Ball.
By increasing sample statistics KLOE-2 can confirm or solve this discrepancy.

We are also active in the dark force field by testing an alternative model where the Dark Force mediator is an hypothetical leptophobic B boson that can couple only to barions with same quantum numbers of the ω meson. For masses less than 600 MeV the expected dominant decay channel is into $\pi^0\gamma$, thus we are investigated this possibility in the $\phi \to \eta B \to \eta\pi^0\gamma$ channel with $\eta \to \gamma\gamma$.

KLOE-2 aims to precisely measure the π^0 decay width into $\gamma\gamma$ by profiting of the π^0 production through $\gamma\gamma$ fusion. The status of the $\gamma^*\gamma^* \to \pi^0$ analysis will be reported.

We want also to precisely measure the ω cross section in the $e^+e^- \to \pi^+\pi^-\pi^0\gamma_{\rm ISR}$ channel using the Initial State Radiation (ISR) method. Promising results on this item will be also presented.

KLOE-2 searched for the P and CP violating decay $\eta \to \pi^+\pi^-$ by exploiting the radiative $\phi \to \eta\gamma$ process with 1.6~fb^{-1} of KLOE data.
No signal is observed in the $\pi^+\pi^-$ invariant mass spectrum and a limit on the branching ratio at 90\% CL has been extracted.
The limit results to be B($\eta \to \pi^+\pi^-$)$< 4.9 \times 10^{-6}$, three times lower than previous KLOE one, the combination of the two KLOE limits gives a B($\eta \to \pi^+\pi^-$)$< 4.4 \times 10^{-6}$.

Moreover, KLOE-2 perform the search for the double suppressed $\phi \to \eta\,\pi^+\pi^-$ and the conversion $\phi \to \eta\,\mu^+\mu^-$ decays with both $\eta \to \gamma\gamma$ and $\eta \to 3\pi^0$. Clear signal are observed for the first time.

QCD, spin physics and chiral dynamics / 209

Understanding the large transverse momenta in SIDIS

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In recent years the measurements of spin and azimuthal asymmetries (SSAs) in final state hadronic distributions in semi-inclusive processes have been widely used to access the underlying Transverse Momentum Dependent (TMD) parton distributions. The detailed understanding of the orbital structure of partonic distributions, encoded in TMD PDFs has been widely recognized as one of the key objectives of the JLab 12 GeV upgrade, and a driving force behind the construction of the Electron Ion Collider.
Although the interest to TMD PDFs has grown enormously, we are still in need of fresh theoretical and phenomenological ideas, and one of the most challenging items remains the transverse momentum dependence of various observables at relatively large transverse momenta, where the non-perturbative contributions still dominate.
In this talk, we present an overview of the latest studies of hadronic multiplicities and SSAs in SIDIS, and discuss the possible sources of disagreement of experimental data with predictions based on the current TMD formalism.

Tests of symmetries and conservation laws / 210

Precision spectroscopy of RaF molecules for fundamental physics

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Molecular spectroscopy represents a unique tool in the search for physics beyond the Standard Model and exploration of the fundamental forces of nature. Compared to atoms, molecules can offer more than five orders of magnitude enhanced sensitivity to violations of fundamental symmetries, testing energy scales beyond hundreds of TeV. These effects are further enhanced in radioactive molecules, which are particularly sensitive to nuclear parity violating (P-odd) and time-reversal violating (T-odd) effects. A promising candidate for this kind of studies is radium monofluoride (RaF). Containing octupole-deformed nuclei, this molecule is expected to show a high sensitivity for the electron interaction with the P-odd nuclear anapole moment as well as with the P- and T-odd nuclear Schiff and magnetic quadrupole moments. In addition, being laser coolable, RaF is suitable for high-precision studies. In this talk I will present the latest results obtained from a series of laser spectroscopy experiments performed on short-lived RaF isotopologues, at ISOLDE facility at CERN. I will first describe a measurement of the isotope shift of five RaF isotopologues, $^{223-226,228}$RaF. This shows the particularly high sensitivity of radium monofluoride to nuclear size effects, offering a stringent test of models describing the electronic density within the radium nucleus. I will then show preliminary results from a high-resolution laser spectroscopy of ^{223}RaF and ^{226}RaF. Rotational and hyperfine constants of these two isotopologues will be presented. These results represent the first of their kind performed on radioactive, short-lived molecules, opening the way for precision studies and new physics searches in these systems.

Hadrons in medium - hyperons and mesons in nuclear matter / 211

Preparation of the hypertriton binding energy measurement at MAMI

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The hypertriton puzzle concerns the connection between lifetime and binding energy of the simplest yet worst understood hypernucleus consisting of one proton, neutron and Lambda.

A new experiment is prepared at the Mainz Microtron facility to determine the hypertriton Lambda binding energy via decay pion spectroscopy, which was successfully pioneered in the recent years. The experiment makes use of a novel high luminosity lithium target which at the same time minimizes the momentum smearing. Together with a precise beam energy determination via the undulator light interference method a recalibration of the magnetic spectrometers will be done to achieve the goal of a statistical and systematic error of about 20 keV.

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Hot and dense matter physics - QGP and heavy ion collisions / 213

ALICE measurements of inclusive untagged and heavy flavor-tagged jets in pp, p-Pb and Pb-Pb collisions

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Jets emerging from heavy-flavour quark fragmentation represent convenient benchmark probes for perturbative quantum chromodynamics and heavy-flavour fragmentation models. In contrast to light-flavour jets, heavy-flavour jet substructure should be affected by the dead cone effect which suppresses collinear gluon emission off a heavy-flavour quark radiator. This phenomenon may affect also cold nuclear matter effects and in-medium energy loss of heavy-flavour jets in heavy-ion collisions.
The ALICE experiment at the LHC exploits its excellent particle tracking capabilities, which allow for a precise jet reconstruction and identification of heavy-flavour hadron decay vertices, displaced hundreds of micrometers from the primary interaction vertex. In the talk, we will report on heavy-flavour jet measurements done in pp and p-Pb collisions by ALICE. While the presented pp results will focus on discussion of the dead cone effect and D jet substructure measurements, the new b-jet results will be used to constrain cold nuclear matter effects in p-Pb down to jet transverse momentum 10 GeV/c. Finally we will discuss also the new fragmentation distribution measurement done with reclustered subjets.

Hadrons in medium - hyperons and mesons in nuclear matter / 214

Accessing the coupled-channels dynamics using femtoscopic correlations with ALICE at LHC

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Systems as $\mathrm{K^-p}$ and baryon–antibaryon ($\mathrm{B\overline{B}}$) are both characterised by the presence, already at the production threshold, of strong inelastic channels which can affect the properties and the formation of bound states and resonances.\\

In the $\overline{\mathrm{K}}\mathrm{N}$ system, the $\Lambda(1405)$ arises from the interplay between the $\overline{\mathrm{K}}\mathrm{N}$ and the coupled $\Sigma\pi$ channel. Experimental constraints on the different $\overline{\mathrm{K}}\mathrm{N}$ coupled-channels are needed to provide a full description of the nature and properties of the $\Lambda(1405)$. Similarly, baryon–antibaryon systems are characterised by the dominant contribution of several mesonic channels related to the presence of annihilation processes acting below 1 fm. The possible existence of baryon–antibaryon bound states is still under debate due to a limited amount of data for the $\mathrm{p}-\overline{\mathrm{p}}$ system available, and either scarce or absent experimental data for $\mathrm{B}\overline{\mathrm{B}}$ systems containing strangeness.
The femtoscopy technique measures the correlation of particle pairs at low relative momentum. This method applied in small colliding systems, as pp and p–Pb collisions at ALICE provided high-precision data on several baryon–baryon and meson–baryon pairs showing a great sensitivity to the underlying strong potential and to the introduction of the different coupled-channels.\\
In this talk, we will present femtoscopic correlations measured in pp collisions at $\sqrt{s}=13$ TeV by ALICE, separately for data samples obtained with minimum-bias and high-multiplicity triggers.
In particular, we will show results on the $\mathrm{K}^{-}\mathrm{p}$ correlation function which for the first time provide experimental evidence of the opening of the coupled isospin breaking channel $\overline{\mathrm{K}^{0}}-\mathrm{n}$ and on the $\Sigma\pi$ channel contributions. Finally, results from baryon–antibaryon pairs ($\mathrm{p}\overline{\mathrm{p}}$, p- and -) will be shown for the first time. The effect of annihilation channels on the correlation function and a quantitative determination of the inelastic contributions in the three different pairs will be discussed.

Hot and dense matter physics - QGP and heavy ion collisions / 216

Azimuthal correlations in Pb–Pb and Xe–Xe collisions with ALICE

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Measurements of two- and multiparticle azimuthal correlations provide valuable information on the properties of the quark–gluon plasma. In this talk, the latest results for inclusive and identified charged particle azimuthal correlations are reported in Pb–Pb and Xe–Xe collisions recorded by the ALICE detector. These results provide strong constraints on the initial conditions of a collision and hydrodynamic medium response.

Poster Session I / 217

Multi-partonic medium induced cascades in expanding media

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Going beyond the simplified gluonic cascades, we have introduced both gluon and quark degrees of freedom for partonic cascades inside the medium. We then solve the set of coupled evolution equations numerically with splitting kernels calculated for exponential and Bjorken expanding media to arrive at medium-modified parton spectra for quark and gluon initiated jets respectively. Firstly, we have studied the inclusive jet R_{AA} by including phenomenologically driven combinations of quark and gluon fractions inside a jet. The impact of the rapidity dependence of the jet R_{AA} has been studied in detail. Secondly, we have studied the path-length dependence of jet quenching for different types of expanding media by calculating the jet v_2. Additionally, we have qualitatively studied the sensitivity of the time for the onset of the quenching for the Bjorken profile on jet v_2 and comparison with data from ATLAS.

Hadrons in medium - hyperons and mesons in nuclear matter / 219

Exploring strangeness enhancement in pp collisions through strange-hadron correlation studies

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The relative production rate of (multi-)strange hadrons in high-multiplicity hadronic interactions is enhanced with respect to the one measured at lower multiplicities and reaches values observed in heavy-ion collisions. The microscopic origin of this striking phenomenon, originally interpreted as a signature of Quark-Gluon Plasma (QGP) formation, is still unknown: is it related to soft particle production or to hard scattering events, such as jets? Is it related to final particle multiplicity only or does it also depend on initial-state effects? The ALICE experiment has addressed these questions by performing dedicated measurements in pp collisions at $\sqrt{s} = 13$ TeV.
To separate strange hadrons produced in jets from those produced in soft processes, the angular correlation between high-p_{T} charged particles and strange hadrons has been exploited. The near-side jet yield and the out-of-jet yield of K^0_S and Ξ have been studied as a function of the multiplicity of charged particles produced in pp collisions.
Moreover, a multi-differential analysis has been exploited to disentangle the contribution of final-state multiplicity from the one of effective energy available for strange particle production. The effective energy has been estimated by subtracting the energy measured in the Zero Degree Calorimeters (ZDC) from the centre-of-mass collision energy.
The results suggest that soft (i.e. out-of-jet) processes are the dominant contribution to strange particle production and that initial-state properties do not play a significant role in strangeness production, which is mainly driven by final particle multiplicity.

Poster Session II / 221

Backgrounds and sensitivity of the KDK experiment measuring a rare decay of potassium

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40K is one of very few isotopes allowing comparison of a third-forbidden unique decay with first-forbidden unique decay. It is also a source of uncertainty in certain dark matter searches, and in K-based geochronology dating techniques. In particular, one decay branch of 40K has never been experimentally measured: the electron capture directly to the ground state of 40Ar, expected to be of the order of fifty times smaller than the well-known decay to the excited state of 40Ar. In the KDK (potassium decay) experiment (https://arxiv.org/abs/2012.15232), this small decay branch has been investigated by integrating a low-threshold X-ray detector into the high-efficiency Modular Total Absorption Spectrometer (MTAS) at Oak Ridge National Laboratory. We present details of the technique used to measure this small decay branch, with focus on backgrounds, the expected sensitivity, and progress towards unblinding the analysis.

Hadrons in medium - hyperons and mesons in nuclear matter / 222

Measurement of the hypertriton properties and production at the LHC

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The ${}^3_\Lambda$H is a bound state of proton (p), neutron (n) and Λ. Studying its characteristics provides insights about the strong interaction between the lambda and ordinary nucleons. In particular, the ${}^3_\Lambda$H is an extremely loosely bound object, with a large wave-function.
As a consequence, the measured (anti-)${}^3_\Lambda$H production yields in pp and p-Pb collisions are extremely sensitive to the nucleosynthesis models.
Thanks to the very large set of pp, p-Pb and Pb-Pb collisions collected during Run 2 of the LHC the ALICE collaboration has performed systematic studies on the ${}^3_\Lambda$H lifetime, binding energy and production across different collision systems.
The new ALICE results on hypertriton properties have a precision which is comparable with the current world averages and they can be used to constrain the state-of-the-art calculations which describe the ${}^3_\Lambda$H internal structure.
Furthermore, with the precision of the presented production measurements some configurations of the Statistical Hadronisation and Coalescence models can be excluded leading to tighter constraints to available theoretical models.

Nuclear and particle astrophysics / 223

r-Process Radioisotopes from Near-Earth Supernovae and Kilonovae

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The astrophysical sites where r-process elements are synthesized remain mysterious: it is clear that neutron-star mergers (kilonovae, KNe) contribute, and some classes of core-collapse supernovae (SNe) are also likely sources of at least the lighter r-process species. The discovery of the live isotope Fe60 on the Earth and Moon over the past decades implies that one or more astrophysical explosions occurred near the Earth (within ~100pc) within the last few Myr, probably a SN. Intriguingly, several groups have reported evidence for deposits of Pu244, some overlapping with the Fe60 pulse, but pointing to a different origin like KNe. Motivated by the Pu244 observations, we propose that ejecta from a KN enriched the giant molecular cloud that gave rise to the Local Bubble in which the Sun resides. This hypothesis is also consistent with the most recent Pu244 measurements by Wallner et al. (2021).

Accelerator Mass Spectrometry (AMS) measurements of Pu244 and searches for other live isotopes could probe the origins of the r-process and the history of the solar neighborhood, including triggers for mass extinctions, e.g., at the end of the Devonian epoch. Thus, we carried out the nucleosynthesis calculations of the abundances of live r-process radioisotopes produced in SNe and KNe. Given the presence of Pu244, other r-process species such as Zr93, Pd107, I129, Cs135, Hf182, U236, Np237 and Cm247 should be present. Their abundances could distinguish between SNe and KNe scenarios, and we discuss prospects for their detection in deep-ocean deposits and the lunar regolith. With current AMS sensitivities, I129 is the most promising isotope to detect, and we find that the AMS I129 measurements in Fe-Mn crusts already constrain a possible nearby KNe scenario. Thus, we urge searches

for r-process radioisotopes in deep-ocean Fe-Mn crusts, and in the lunar regolith samples brought to Earth recently by the Chang'e-5 lunar mission and upcoming missions including Artemis.

Hadrons in medium - hyperons and mesons in nuclear matter / 224

S-shell Λ and $\Lambda\Lambda$ hypernuclei based on chiral EFT

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The scarcity of hyperon-nucleon (YN) and hyperon-hyperon (YY) scattering data presents an enormous challenge for nuclear physicists in an attempt to derive baryon-baryon (BB) interactions from a microscopic level. Therefore $S = -1$ and $S = -2$ hypernuclei are important laboratories for testing BB interaction models and provide essential information for constructing realistic potentials. In this contribution, we employ the Jacobi no-core shell model (J-NCSM) approach to study the predictions of the two chiral next-to-leading order (NLO) YN interactions, NLO13 and NLO19, for Λ hypernuclei up to the p-shell. We also investigate possible implications of an increased Λ-separation energy of ${}^{3}_{\Lambda}\mathrm{H}$ on the separation energies of $A = 4 - 7$ hypernuclei. Finally, we report our first results for $\Lambda\Lambda$ s-shell hypernuclei based on chiral YY potentials at LO and NLO. The NLO results for ${}^{\;\,6}_{\Lambda\Lambda}\mathrm{He}$ are consistent with experiment. Both interactions also yield a bound state for ${}^{\;\,5}_{\Lambda\Lambda}\mathrm{He}$. The ${}^{\;\,4}_{\Lambda\Lambda}\mathrm{H}$ system is predicted to be unbound.

QCD, spin physics and chiral dynamics / 225

Simultaneous Extraction of Spin-Averaged and Helicity Light Quark Sea Asymmetries

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We present a new global QCD analysis of unpolarized and polarized data, using a Monte Carlo approach to simultaneously extract both the spin-averaged and helicity PDFs. We focus on the light quark sea asymmetries, including new data from the SeaQuest experiment and W-lepton production at RHIC. For the first time we extract a nonzero light quark sea asymmetry for the helicity PDFs through a QCD global analysis using the latest data from the STAR collaboration.

Poster Session II / 226

Luminosity determination in ALICE

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The cross-section in hadronic collisions is crucial information in any physics analysis of ALICE data at the LHC, as it not only provides the baseline for normalization but also is a source of substantial uncertainly by itself. The observable used to determine luminosity in ALICE is the visible cross-section (σ_{vis}), which is measured by using information from the LHC instrumentation and the ALICE detector collected during the van der Meer scan. In this talk, we present a review of the ALICE luminosity determination analysis and the results for Run 2 of the LHC, especially for pp collisions at $\sqrt{s} = 13$ TeV and for Pb-Pb collisions at $\sqrt{s_{\rm NN}} = 5.02$ TeV.

Energy frontier physics beyond the standard model / 227

New physics searches with the ILD detector at the ILC

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Although the LHC experiments have searched for and excluded many proposed new particles up to masses close to 1 TeV, there are many scenarios that are difficult to address at a hadron collider. This talk will review a number of these scenarios and present the expectations for searches at an electron-positron collider such as the International Linear Collider. The cases discussed include the light Higgsino, the stau lepton in the coannihilation region relevant to dark matter, and heavy vector bosons coupling to the s-channel in e+e- annihilation. The studies are based on the ILD concept at the ILC.

Poster Session I / 228

Development of the ATLAS Liquid Argon Calorimeter Readout Electronics for the HL-LHC

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A new era of hadron collisions will start around 2027 with the High-Luminosity LHC, that will allow to collect ten times more data that what has been collected since 10 years at LHC. This is at the price of higher instantaneous luminosity and higher number of collisions per bunch crossing.
In order to withstand the high expected radiation doses, the ATLAS Liquid Argon Calorimeter readout electronics will be upgraded.
The electronic readout chain is made of 4 main parts.
The new front-end board will allow to amplify, shape and digitise on two gains the ionisation calorimeter signal over a dynamic range of 16 bits and 11 bit precision. Low noise below Minimum Ionising Particle (MIP), i.e below 120 nA for 45 ns peaking time, and maximum non-linearity of two per mil are required. Custom low noise preamplifier and shaper are being developed to meet these requirements using 65 nm and 130 nm CMOS technologies. They should be stable under irradiation until 1.4kGy (TID) and 4.1x10^13 new/cm^2 (NIEL). Two concurrents preamp-shaper ASICs have been developed and the best one in term of noise has been chosen. The test results of the new version of this ASIC will be presented. A new ADC chip prototype has been also submitted in June. Integration tests of the different components (including lpGBT links developed by CERN) on a 32-channels front-end board are ongoing, and results of this integration will be also shown.

The new calibration board will allow the precise calibration of all 128000 channels of the calorimeter over a 16 bits dynamic range. A non-linearity of one per mil and non-uniformity between channels of 0.25% with a pulse rise time smaller than 1ns should be achieved. In addition, the custom calibration ASICs should be stable under irradiation with same levels as preamp-shaper and ADC chips. The HV SOI CMOS XFAB 180nm technology is used for the pulser ASIC, while the TSMC 130 nm technology is now used for the DAC part. During second prototype testing, it was found that the DAC part of the calibration system, inserted previously with the pulser in XFAB 180nm technology, was not rad-hard, already after 0.5 kGy. This is why a third version has been designed overcoming this issue, and all results will be presented.
The data are sent off-detector at 40 MHz where FPGAs connected through high-speed links will perform energy and time reconstruction through the application of corrections and digital filtering. The off-detector electronics receive 345 Tbps from front-end readout, which require 33000 links at 10 Gbps. For the first time, online machine learning technics are used in the FPGAs in order to better filter the data. The first test results of the signal processing board will be shown.
Reduced data are then sent with low latency to the first level trigger, while the full data are buffered until the reception of trigger accept signals. The data-processing, control and timing functions are realized by dedicated boards connected through ATCA crates. Design status of this timing boards will be shown too.

Development of accelerators and detectors / **229**

ATLAS LAr Calorimeter Commissioning for LHC Run-3

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The Liquid Argon Calorimeters are employed by ATLAS for all electromagnetic calorimetry in the pseudo-rapidity region $|\eta| < 3.2$, and for hadronic and forward calorimetry in the region from $|\eta| = 1.5$ to $|\eta| = 4.9$. It also provides inputs to the first level of the ATLAS trigger. After successful period of data taking during the LHC Run-2 between 2015 and 2018 the ATLAS detector entered into the a long period of shutdown. In 2022 the LHC should restart and the Run-3 period should see an increase of luminosity and pile-up up to 80 interaction per bunch crossing.

To cope with this harsher conditions, a new trigger readout path have been installed on the during the long shutdown. This new path should improve significantly the triggering performances on electromagnetic objects. This will be achieved by increasing by a factor of ten, the number of available units of readout at the trigger level.

The installation of this new trigger readout chain required the update of the legacy system to cope with the new components. It is more than 1500 boards of the precision readout that have been extracted from the ATLAS pit, refurbished and re-installed. The legacy analogic trigger readout that will remain during the LHC Run-3 as a backup of the new digital trigger system has also been updated.

For the new system it is 124 new on-detector boards that have been added. Those boards are able to digitize the calorimeter signal for every collisions i.e. at 40MHz and in radiative environment. The digital signal is then processed online to provide the measured energy value for each unit of readout an for each bunch crossing. In total this is up to 31Tbps that are analyzed by the processing system and more than 62Tbps that are generated for downstream reconstruction. To minimize the triggering latency the processing system had to be installed underground. There the limited space available imposed the needs of a very compact hardware structure. To achieve a good enough compacity larges FPGAs with high throughput have been mounted on ATCA mezzanines cards. In total no more than 3 ATCA shelves are used to process the signal of approximately 40k channels.

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

This contribution should present the challenges of such installation, what have been achieved so far and what are the milestones still to be done toward the full operation of both the legacy and the new readout paths for the LHC Run-3.

Poster Session II / 230

Machine Learning for Real-Time Processing of ATLAS Liquid Argon Calorimeter Signals with FPGAs

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The Phase-II upgrade of the LHC will increase its instantaneous luminosity by a factor of around 10 leading to the High Luminosity LHC (HL-LHC). At the HL-LHC, the number of proton-proton collisions in one bunch crossing (called pileup) increases significantly, putting more stringent requirements on the LHC detectors electronics and real-time data processing capabilities.

The ATLAS Liquid Argon (LAr) calorimeter measures the energy of particles produced in LHC collisions. This calorimeter has also trigger capabilities to identify interesting events. In order to enhance the ATLAS detector physics discovery potential, in the blurred environment created by the pileup, an excellent resolution of the deposited energy and an accurate detection of the deposited time is crucial.

The computation of the deposited energy is performed in real-time using dedicated data acquisition electronic boards based on FPGAs. FPGAs are chosen for their capacity to treat large amount of data with very low latency. The computation of the deposited energy is currently done using optimal filtering algorithms that assume a nominal pulse shape of the electronic signal. These filter algorithms are adapted to the ideal situation with very limited pileup and no timing overlap of the electronic pulses in the detector. However, with the increased luminosity and pileup, the performance of the filter algorithms decreases significantly and no further extension nor tuning of these algorithms could recover the lost performance.

The back-end electronic boards for the Phase-II upgrade of the LAr calorimeter will use the next high-end generation of INTEL FPGAs with increased processing power and memory. This is a unique opportunity to develop the necessary tools, enabling the use of more complex algorithms on these boards. We developed several neural networks (NNs) with significant performance improvements with respect to the optimal filtering algorithms. The main challenge is to efficiently implement these NNs into the dedicated data acquisition electronics. Special effort was dedicated to minimising the needed computational power while optimising the NNs architectures.

Five NN algorithms based on CNN, RNN, and LSTM architectures will be presented. The improvement of the energy resolution and the accuracy on the deposited time compared to the legacy filter algorithms, especially for overlapping pulses, will be discussed. The implementation of these networks in firmware will be shown. Two implementation categories in VHDL and Quartus HLS code are considered. The implementation results on Stratix 10 INTEL FPGAs, including the resource usage, the latency, and operation frequency will be reported. Approximations for the firmware implementations, including the use of fixed-point precision arithmetic and lookup tables for activation functions, will be discussed. Implementations including time multiplexing to reduce resource usage will be presented. We will show that two of these NNs implementations are viable solutions that fit the stringent data processing requirements on the latency (O(100ns)) and bandwidth (O(1Tb/s) per FPGA) needed for the ATLAS detector operation.

Nuclear and particle astrophysics / 231

LUNA results on deuterium burning and implications for cosmology

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Lightest elements were produced in the first few minutes of the Universe through a sequence of nuclear reactions known as Big Bang nucleosynthesis (BBN).
Although astronomical observations of primordial deuterium abundance have reached percent accuracy, theoretical predictions based on BBN are affected by the large uncertainty on the cross-section of the D(p,gamma;)³He deuterium burning reaction.
I will report on a new measurement of the D(p,gamma;)³He cross section performed by the LUNA collaboration to an unprecedented precision of better than 3%. This result settles the most uncertain nuclear physics input to BBN calculations and substantially improve the use of primordial abundances as probes of the physics of the early Universe.

Hadrons in medium - hyperons and mesons in nuclear matter / 232

Measurement of proton-deuteron correlations in pp collisions at $\sqrt{s}$ = 13 TeV

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The first measurement of p(p)-d(d) two-particle correlations in high-multiplicity pp collisions at $\sqrt{s}$ = 13 TeV will be presented. The studies of source sizes in these collision systems by the ALICE Collaboration enabled the possibility to study final-state interactions using two-particle momentum correlations. The measured correlation functions as well as comparisons with theoretical predictions using the Lednický-Lyuboshits model will be presented. The theoretical correlations include two interaction models using only the Coulomb force as well as both Coulomb and strong interaction. For the later the measured scattering lengths of proton-deuteron pairs from scattering experiments were taken. However both predictions cannot reproduce the measured correlation function. This deviation might give a hint for a different production mechanism of deuterons such as a late formation of these light nuclei in high-energy pp collisions.

Standard model physics at the TeV scale / 234

ILC Higgs Physics Potential

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Higgs factories based on e+e- colliders have the potential to measure the complete profile of the Higgs boson at a level of precision that goes qualitatively beyond the expected capabilities of the LHC. This talk will review the program of Higgs boson coupling measurements expected from the International Linear Collider, including the most recent updates. These measurements span the range of e+e- center-of-mass energies from 250 GeV to 1 TeV and include precision measurements

of the top quark Yukawa coupling and the Higgs self-coupling.
(On behalf of the ILC International Development Team Detector & Physics Speakers Bureau)

Poster Session I / 235

Probing dark matter with ILC

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The International Linear Collider offers a number of unique opportunities for searches for dark matter and dark sector particles. The collider program will offer important capabilities, but also, the ILC will enable new fixed-target experiments using the high-energy electron and positron beams, both beam dump experiments and dedicated experiments using single beams. This talk will describe the expectations for these programs, which address all of the possible dark sector portals.
(on behalf of the ILC International Development Team Speakers Bureau)

Poster Session II / 236

QCD physics measurements at the LHCb experiment

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LHCb is a spectrometer that covers the forward region of proton-proton collisions, corresponding to the pseudo-rapidity range 2<eta<5. In this unique phase space, LHCb can perform tests of perturbative and non-perturbative QCD models, by studying the production of heavy flavor quarks, like charm and top quarks. In this context the production of a Z boson in association with a c-jet can be studied to measure the intrinsic charm content of the proton. Moreover LHCb can test phenomenological models of soft QCD processes, by measuring the production of forward hadrons in pp collisions.

Dark matter and cosmology / 237

Status of the LZ Experiment

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LUX-ZEPLIN (LZ) is a direct detection dark matter experiment located at the Sanford Underground Research Facility in Lead, South Dakota. The experiment consists of three nested detectors; a dual phase xenon TPC, an actively instrumented liquid xenon skin, and an outer detector neutron veto formed by 10 acrylic tanks of gadolinium-loaded liquid scintillator. The active region of the xenon

TPC contains 7 tonnes of liquid xenon with a 5.6 tonne fiducial volume, allowing us to reach a WIMP-nucleon spin-independent cross section sensitivity of 1.4 x 10^{-48} cm^2 for a 40 GeV/c^2 mass in 1000 live days. In this talk I will give an overview of the LZ experiment currently being commissioned, and report on its status.

Development of accelerators and detectors / 238

The BeEST Experiment: A Search for sub-MeV BSM Physics in the Neutrino Sector with Superconducting Quantum Sensors

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The search for sterile neutrinos is among the brightest possibilities in our quest for understanding the microscopic nature of dark matter in our universe. These "mostly sterile"flavors are expected to be accompanied by heavy mass states, and thus their existence can be probed via momentum conservation with SM particles in radioactive decay. One way to observe these momentum recoil effects experimentally is through high-precision measurements of electron-capture (EC) nuclear decay, where the final state only contains the neutrino and a recoiling atom. This approach is a powerful method for BSM neutrino mass searches since it relies only on the existence of a heavy neutrino admixture to the active neutrinos - a generic feature of neutrino mass mechanisms - and not on the model-dependent details of their interactions. In this talk, we describe BeEST concept, which measures the eV-scale radiation that follows the decay of ^{7}Be ions implanted into sensitive superconducting tunnel junction (STJ) quantum sensors, and report the first results in our experimental program.

Hot and dense matter physics - QGP and heavy ion collisions / 239

Charm production and hadronisation in proton–proton, proton–Pb, and Pb–Pb collisions with ALICE at the LHC

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Produced only in hard-scattering processes occurring in the initial stage of the collisions, heavy quarks offer a unique perspective to study the transition from quarks to hadrons in all collision systems. Recently, the ALICE experiment at the LHC measured the Λ_c^+, Ξ_c^0, Ξ_c^+, and $\Sigma_c^{0,++}$ charmed-baryon p_T-differential cross sections at midrapidity in pp collisions, as well as the cross-section times branching ratio of Ω_c^0 baryons, complementing the measurements of D^0, D^+, D^{*+}, and D_s^+ mesons. The baryon-to-meson cross-section ratios are largely enhanced with respect to expectations based on e^+e^- data. The Λ_c^+/D^0 ratio was also studied as a function of the event multiplicity and found to increase towards high multiplicities. These data indicate that the charm-hadronisation process strongly depends on the properties of the collision system and invalidate the assumption of "universality"of charm fragmentation fractions, on which several estimates of the total charm cross section rely on, already for pp collisions. They may also signal the possible onset of effects theoretically anticipated to be relevant in the quark-gluon plasma formed in heavy-ion collisions, like hadron formation via recombination of already formed quarks as a mechanism concurrent to string fragmentation.

In this talk, these results and the measurements of the Λ_c^+/D^0 ratio and Λ_c^+ nuclear-modification factor in p–Pb and Pb–Pb collisions will be presented. The comparison of data with expectations from models implementing different hadronisation processes will be discussed.

Neutrino physics / 240

Project 8: R&D for a next-generationneutrino mass experiment

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Project 8 is a next-generation direct neutrino mass experiment measuring the spectral endpoint region of tritium beta decays. The energy of the beta decay electrons is measured using Cyclotron Radiation Emission Spectroscopy (CRES) which has been demonstrated by the Project 8 collaboration with krypton or molecular tritium confined in a section of a microwave guide. To reach the target sensitivity of 40 meV, major technological development is necessary. Building up on the milestones achieved so far, I will present the next developmental phases of Project 8: In Phase III, atomic tritium will be produced and trapped magnetically, and cyclotron radiation emission spectroscopy (CRES) will be demonstrated in free space which allows larger detection volumes. The knowledge gained from Phase III will enable the design and operation of a large-volume atomic tritium experiment, sensitive to the entire mass range allowed by the inverse neutrino mass hierarchy.

Development of accelerators and detectors / 241

Detector R&D for the International Linear Collider

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The International Linear Collider project develops a linear electron-positron collider with a first "Higgs factory" stage at 250 GeV, followed by an upgrade to higher energy. The precision physics program of the ILC places demanding requirements on the detectors that are to equip the interaction region. Extensive Monte Carlo simulations of complete detector concepts have been used to draw up the main specifications for the detector performance. A global design and R&D effort has addressed these challenging goals with important progress in ultra-transparent vertex detector and tracker solutions, as well as in highly granular calorimeter systems. An overview of the detector requirements will be given and highlights of the R&D effort will be presented in this contribution (on behalf of the International Development Team Detector & Physics Speaker's Bureau).

Hadron spectroscopy and exotics / 242

When heavy-ion collisions help distinguish triangle singularities from actual hadrons

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The hadron spectrum is tangled with threshold and triangle singularities
that difficult the identification of actual resonance states.
We present a thermal-field theory computation in the late hadron stage
of the fireball. Our finding is that such singularities can be filtered
by comparing other data to heavy ion collisions:
peaks therein seem more likely to be hadrons than rescattering effects when
two (easily checkable) conditions are met.
First, the flight-time of the intermediate hadron state in the triangle
must be comparable to the lifetime of the equilibrated fireball
(else, the reaction is delayed until after freeze out, proceeding as in vacuo).
Second, the loop-particle mass or width must be sizeably affected by the medium.
When these conditions are met, the singularity can be vastly reduced:
at T about 150 MeV, even by two orders of magnitude, dropping out of the spectrum.
Based on European Physical Journal C 81, 430 (2021)

Poster Session I / 243

The ESS based neutrino Super Beam Experiment (ESS⊠SB)

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In the search for the CP-violation in the leptonic sector, crucial information has been obtained from neutrino experiments. The measurement of the third neutrino mixing angle, θ13, opened the possibility of discovering the Dirac leptonic CP violating angle, ⊠CP with intense "super"neutrino beam experiments. In the light of these new findings, an urgent need has arisen to improve the detection sensitivity of the current long-baseline detectors, considering proton driver at MW scale with a MegaTon scale detector, with a key modification to place the far detectors at the second, rather than the first, oscillation maximum.

The European Spallation Source neutrino Super Beam (ESS⊠⊠SB) aims to benefit from the high power of the European Spallation Source (ESS) LINAC in Lund-Sweden, to produce the world's most intense second-generation neutrino beam in order to search and measure, with precision, the CP-violation in the leptonic sector, at 5⊠ significance level in more than 60% of the ⊠CP range.

Here I will shed light on the current design study programs running within the collaboration and the physics potential of the experiment.

Development of accelerators and detectors / 244

Rogowski beam position monitors

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Hadrons in medium - hyperons and mesons in nuclear matter / 245

Heavy Ξ^- hyperatoms at $\overline{\text{P}}$ANDA

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In the course of its full lifetime $\overline{\text{P}}$ANDA at FAIR will address the physics of strange baryons with S=-2 in nuclei by several novel and unique measurements. This series of experiments will start with the exclusive production of hyperon-antihyperon pairs close to their production threshold in antiproton-nucleus collisions. This day-one experiment offers a hitherto unexplored opportunity to elucidate the behaviour of antihyperons in nuclei.Within its intermediate stage $\overline{\text{P}}$ANDA will offer the unique possibility to search for X-rays from very heavy hyperatoms as e.g. Ξ^--^{208}Pb. This will complement experiments at J-PARC which attempt to measure X-rays in medium-heavy nuclei. Finally, $\overline{\text{P}}$ANDA will extend the studies on double Λ hypernuclei by performing high resolution γ-spectroscopy of these nuclei for the first time.
This contribution will focus on the hyperatom experiment in all of its facets. Besides its dedicated detector components, the talk will present simulation studies for the expected event rates and how they influence the achievable precision in the estimation of the Ξ^--nuclear potential. Since this estimation is strongly correlated with the shape of the nuclear periphery of the ^{208}Pb nucleus, the systematic uncertainty inherited by the neutron skin thickness of ^{208}Pb is also discussed.
This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 824093.

Poster Session I / 246

Overlap integrals of di-neutron cluster state and shell model state

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Di-neutron correlations are extensively explored in recent experiments, and the enhancement of the spatial localization of the pair of the neutrons (n) has been confirmed at the nuclear surface in the light neutron-excess systems, such as ^{11}Li and ^{19}B. The spatial localization of two neutrons, which is called "the di-neutron correlations", are also investigated theoretically by employing the three-body model with core + n + n. The analysis of the di-neutron correlation gives an important key to elucidate the surface structure of neutron stars. If the di-neutron configuration is stabilized in the nuclear medium, there is a possibility of the formation of new phase with the di-neutron condensation at the surface of the neutron star.

If we consider the three-body system of core plus two neutrons, the spatial localization of two neutrons corresponds to the formation of "di-neutron cluster"around the core nucleus. On the other hand, the valence neutrons usually perform the independent particle motion around the core nucleus, and the ground state of the normal nucleus is explained by the so-called the nuclear shell model. The shell model configuration and the di-neutron one seem to be very different structure

intuitively but these two configurations are non-orthogonal, and there is a finite amplitude of the di-neutron cluster component even if the pure shell model state is realized. Thus, in order to understand the feature of the di-neutron cluster more deeply, it is important to evaluate the overlap integral of the di-neutron cluster state and the shell model state, which is a measure of the non-orthogonal amplitude of these two different states.

We have developed a new formula to evaluate the overlap integral of the cluster and shell-model configurations, and the formula is applied to the core + n + n systems. In this report, we will report the systematic feature of the overlap integrals of the di-neutron cluster state (core + 2n) and the shell model state (core + n + n) with a variation of the core mass number. In particular, we will discuss the enhancements of the overlap integral in connection to the single particle orbits of the valence two neutrons in the shell model states.

Nuclear and particle astrophysics / 247

Extension of Migdal-Watson formula and its application to binary breakup reaction

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Resonance phenomena appearing in low-energy nuclear reactions are very important in studies of nucleosynthesis in cosmos because reaction rates in the synthesis are strongly affected by the resonance parameters: resonance energy and decay width. In particular, the inelastic scattering to the continuum energy states above the particle decay threshold, which is often called breakup reaction, is very useful to explore the resonance parameters.
In order to derive the resonance parameters from the observed strength of the breakup reactions, the evaluation of the non-resonant background strength is indispensable because the resonant enhancement, which has the strong energy dependence, are embedded in the non-resonant background contribution with a broad structure. Since the background strength is structure-less and must have the weak energy dependence, the shape of the non-resonant background strength is often assumed by the simple analytic function or evaluated from the simple reaction mechanism, such as the direct breakup without the final state interaction between the decaying fragments. Unfortunately, there is no theoretical prescription to describe the non-resonant background strength on the basis of the simple analytic formula.
In this report, we propose an analytic formula to evaluate the non-resonant background strength by extending the Midgal-Watson (MW) theory, which was originally considered for the s-wave breakup reaction in the charge neutral systems. In the evaluation of the background strength for the binary breakup, we employ the complex scaling method (CSM), which is a powerful tool to describe the few-body continuum states.
We have calculated the non-resonant breakup strength of ^{20}Ne into α + ^{16}O and ^{12}Be into α + ^{8}He by CSM, and the CSM strength is fitted by the analytic function, which is obtained by the extended MW formula. We will demonstrate that our analytic formula can nicely reproduce the non-resonant strength in these binary breakup reactions. Moreover, we will report the physical meaning of new parameters, which are introduced in extending the original MW formula, in connection to the spatial size of the initial wave function in the breakup reactions.

QCD, spin physics and chiral dynamics / 249

Study of the nucleon structure with the PANDA experiment at FAIR

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The PANDA experiment is a core project of the future Facility for Antiproton and Ion Research (FAIR) at GSI in Darmstadt. It will measure annihilation reactions induced by a high intensity antiproton beam of momentum in the range between 1.5 GeV/c and 15 GeV/c. An important part of the PANDA physics program will be dedicated to the investigation of the nucleon structure using electromagnetic processes. Measurements of the proton electromagnetic form factors in the time-like region, nucleon-to-meson transition distribution amplitudes, generalised distribution amplitudes, and transverse momentum dependent parton distribution functions, are foreseen at PANDA. In the framework of the PANDARoot software, which encompasses PANDA detector simulation and event reconstruction, feasibility studies for the measurement of various electromagnetic processes have been performed. It has been shown that unique studies of the nucleon structure can be experimentally performed at PANDA. In this talk, the physics program of PANDA related to the nucleon structure aspect will be presented with the results of the Monte Carlo feasibility studies.

QCD, spin physics and chiral dynamics / 250

Analysis of isospin symmetry for fragmentation functions

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We make an analysis of the isospin symmetry for fragmentation functions assuming isospin symmetry in strong interactions. Taking hadron decay contributions into account, we show that the isospin symmetry is held for \Lambda hyperon fragmentation functions. Only tiny violations are allowed for other hadrons due to weak decays. We also present a rough estimate for the magnitudes of such violations. For the polarized case, we show that the recent Belle data on the transverse polarization of \Lambda hyperon can be reproduced if the isospin symmetry is kept in the corresponding polarized fragmentation functions. [Ref: Phys.Lett. B816 (2021) 136217]

Hadron spectroscopy and exotics / 252

Recent CMS results in conventional and exotic hadron spectroscopy

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Recent results by the CMS experiment in the hadron spectroscopy field will be discussed. In conventional spectroscopy are included results concerning the excited Lambda_b, Xi_b and B_c states, whereas the exotic one includes searches for YY* states and the production of the X(3872) observed in a new B0s meson decay and evidenced in PbPb collisions.

Hot and dense matter physics - QGP and heavy ion collisions / 253

Medium induced gluon spectrum in the Improved Opacity Expansion

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Over the last decades, analytical calculations of jet quenching observables were force to always make a distinction between jet evolution in dense or dilute mediums. Although there are different theoretical formalisms suited for each one of these scenarios, taking into account multiple soft and single hard interactions between the probe and the background under a single approach has proven to be a difficult task. In this talk, I will introduce the Improved Opacity Expansion (IOE), which extends the well known Opacity Expansion framework beyond the hard momentum transfer tail to the regime captured by the BDMPS-Z/ASW approximation. I will focus on the application of the IOE to the computation of the single gluon medium induced spectrum from a hard parton, which constitutes one of the most important theoretical results in jet quenching theory.

Development of accelerators and detectors / 255

Recent developments of the SDHCAL prototype

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After the construction and the successful operation of the first technological prototype of The Semi-Digital Hadronic CALorimeter (SDHCAL), developed within the CALICE collaboration, new R&D efforts to fully validate the SDHCAL option for future experiments such as those that could equip the ILC and CEPC colliders have been initiated.
The SDHCAL is a sampling hadronic calorimeter using large GRPC as active medium with embedded readout electronics. The GRPC prototype size is 1 m² while future detectors will require GRPC detectors with a scalable length up to 3m long. The readout Printed Circuit Board (PCB) consists of 1 cm² copper pads on one side and 64-channel HARDROC readout chips on the other side, each chip processing the signal arriving on a 64 cm² square.
The design of such large size scalable detectors has been addressed and has required rethinking the gas flow in the GRPC in order to maintain detection efficiency and spatial response homogeneity. The readout PCB was also redesigned and now uses the latest version of the HARDROC readout chips series.
Unlike the previous design, this new PCB design is scalable in length and more tolerant of ASIC readout failures. The PCB clock distribution, slow control and fast control have been redesigned to speed up communication over long chains of ASICs and PCBs. The clock is distributed via the TTC protocol while the slow and fast control use I2C protocol.
The lack of PCB manufacturer, able to produce PCBs larger than 1 m² with 8-layers, necessitated the development of an ingenious scheme with several PCBs connected to each other by tiny, flexible connectors.

A new DAQ interface board is currently under development. This new DAQ interface board has an optimized geometry to fit the requirements of the ILD detector.
It can handle up to 432 HARDROC3 chips, covering a PCB area of 2.76 m², which is sufficient to cope with the maximum size of the GRPC in ILD (0.9x3 m²).
Communication with the external environment is via an ethernet connector using the TCP/IP protocol to ensure coherence in data transmission.
A new cassette, as part of the calorimeter absorber, is being designed. The main challenge is to ensure the rigidity and uniform contact between the GRPC and its PCB. For the ILC detector, the ASICs are power-pulsed using the specific time structure of the linear collider beam. This keeps the ASIC power consumption low enough to avoid cooling the PCB. For the CEPC, the continuous operation of the accelerator implies adding cooling capacity to the designed cassette structures.
Finally, the mechanical structure to support 3m long GRPC requires improved flatness of the steel plates used in the structure. Furthermore, to maintain this flatness, usual screw and bolt assembly is not sufficient. A sophisticated method of joining the plates using the electron beam welding technique has been developped.
In addition, new developpements to replace single gap GRPC by multigap GRPC coupled with fast timing electronics are being pursued. A time resolution better than 50 ps is achievable. This will allow to follow the temporal evolution of the hadronic showers developing in the calorimeter.
The first prototypes of the PCB with HARDROC3 chips, the mechanical structure and the DAQ interface board have been manufactured. An improved version of the DAQ interface board and the design of the holding cassettes are being finalized. Tools to handle such large detectors are also being designed. A first fully assembled prototype of 2 m² with 4 layers is expected to be ready in year 2022.
In parallel, the first SDHCAL prototype has been extensively tested in beam test facilities. Refined analysis techniques are being developed to improve the energy and shower reconstruction of the SDHCAL prototype. The latest analysis developments cover techniques to improve the spatial uniformity of the response and a better treatment of the particle incidence angle in the energy reconstruction.

Poster Session I / 256

Search for BSM physics with neutron beta decay in the BRAND project

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Neutron and nuclear beta decay correlation coefficients are sensitive to the exotic scalar and tensor interactions that are beyond the Standard Model (BSM). The BRAND project aims at a test of the Lorentz structure of weak interaction in neutron decay by precision measurements of yet unexplored transverse polarization of electrons in correlation with the neutron spin and electron and recoil proton momenta. The experiment will simultaneously measure eleven neutron correlation coefficients (a, A, B, D, H, L, N, R, S , U, V), where seven of them (H, L, N, R, S, U and V) depend on the transverse electron polarization. Five of these correlations: H, L, S, U and V were never attempted experimentally before. The expected ultimate sensitivity of the proposed experiment respectively BSM couplings will be comparable to that of the ongoing and planned correlation measurements in neutron and nuclear beta decays but offers completely different systematics and additional sensitivity to imaginary parts of the scalar and tensor couplings. In the talk, an overview of the project, physical motivation and applied experimental techniques will be reported. The results of the first pilot run of the experiment performed recently using the cold neutron beam line PF1B at the Laue-Langevin Institute, Grenoble, France will be presented, with an emphasis on the challenges of the proposed proton detection technique.

Poster Session II / 257

Measurement of low mass dileptons in ALICE

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The ALICE experiment is optimized to the study of the quark-gluon plasma (QGP), a state of matter where, due to high temperature and density, chiral symmetry is restored, and quarks and gluons are deconfined. In order to obtain information on its properties, it is particularly valuable to study the lepton pair production, as leptons can decouple from the plasma at any stage of its evolution and carry information about the medium properties at the time of their emission, since they do not interact strongly. In particular, the production of dileptons is a promising tool for the understanding of the chiral symmetry restoration and the thermodynamical properties of the QGP.

To differentiate possible medium contributions to the dilepton yield in nucleus–nucleus collisions from those from hadron decays, studies in pp and p-A collision systems are necessary to obtain a medium-free reference. These studies can also be used to study charm and beauty production, which are an excellent test of perturbative quantum chromodynamics (pQCD) predictions.

In this presentation, we will report on the latest results for low mass dilepton production measured with the ALICE detector in various collision systems at mid- and forward rapidity. All the measurements are compared to the expected dilepton yields from known hadronic sources and model calculations. Finally, we will discuss the prospects and future measurements.

Poster Session I / 258

Dark matter from a complex scalar singlet and the role of the discrete symmetries

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In this talk I will study the case where dark matter emerges from a complex scalar field charged under a U(1) global symmetry, which is spontaneously broken. Our analysis considers different explicit symmetry breaking terms motivated by discrete symmetries. I will show results which demonstrate that in some regions of the parameter space these scenarios may be distinguished by combining different observables, such as direct detection and collider signatures. Finally we discuss the case where the stabilising symmetry may be broken, as well as an effective operator approach valid in the pseudo-Nambu-Goldstone limit.

Poster Session II / 259

Machine Learning for Background Hit Rejection in the Mu2e Straw Tracker

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The Mu2e experiment at Fermilab will search for charged lepton flavor violation (CLFV) via muon to electron conversion, with a goal of improving the previous upper limit four orders of magnitude and reaching unprecedented single-event sensitivities. The signal of CLFV conversion is a ~105 MeV electron, which is detected using a high-precision straw tracker. Protons produced by muon capture can create highly ionizing straw hits. Identifying and removing these hits can enhance the reconstruction efficiency. Through a poster, I will discuss improving the rejection of this background by replacing a simple cut on the energy deposited in the straw with a TMVA-based machine learning algorithm. In particular, it is found that a neural network using the ADC waveform shape and Time-Over-Threshold significantly improves both the signal electron acceptance and proton rejection efficiency.

Nuclear and particle astrophysics / 261

New observation of α decay of ^{190}Pt to the first excited level of ^{186}Os

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The partial half-life of ^{190}Pt for the alpha decay to the first excited level ($E_{exc} = 137.2$ keV) of ^{186}Os was measured using an ultralow-background HPGe-detector system located 225 m underground in the laboratory HADES (Belgium). A sample of high purity platinum (the purity grade is 99.95%) with a mass of 148.122 g was used and measured during 373 days. Preliminary, the partial half-life of ^{190}Pt is estimated as $T_{1/2} = (2.2 \pm 0.4) \times 10^{14}$ yr. Measurements of the ^{190}Pt isotopic concentration in the platinum sample are in progress at the John de Laeter Centre at Curtin University (Perth, Western Australia) aiming to further reduce the half-life value uncertainty.

Standard model physics at the TeV scale / 262

Nailing Higgs Couplings at Future Colliders

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LEP precision on electroweak measurements was sufficient not to hamper the extraction of Higgs couplings at the LHC. But the foreseen permille-level Higgs measurements at future lepton colliders might suffer from parametric electroweak uncertainties in the absence of a dedicated electroweak program. We perform a joint, complete and consistent effective-field-theory analysis of Higgs and electroweak processes. The full electroweak-sector dependence of the $e^+e^- \to WW$ production

process is notably accounted for, using statistically optimal observables. Up-to-date HL-LHC projections are combined with CEPC, FCC-ee, ILC and CLIC ones. For circular colliders, our results demonstrate the importance of a new Z-pole program for the robust extraction of Higgs couplings. At linear colliders, we show how exploiting multiple polarizations and centre-of-mass energies is crucial to mitigate contaminations from electroweak parameter uncertainties on the Higgs physics program. We also investigate the potential of alternative electroweak measurements to compensate for the lack of direct Z-pole run, considering, for instance, radiative return to these energies. Conversely, we find that Higgs measurements at linear colliders could improve our knowledge of the Z couplings to electrons. Our results can be found at: arXiv:1907.04311

Poster Session I / 265

Higgs searches in $t\bar{t}\phi$ production at the LHC

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A new reconstruction method to explore the low mass region in the associated production of top-quark pairs ($t\bar{t}$) with a generic scalar boson (ϕ) at the LHC is proposed, using dileptonic final states of the $t\bar{t}\phi$ system with $\phi \to b\bar{b}$. The new method of mass reconstruction shows an improved resolution of at least a factor of two in the low mass region when compared to previous methods, without the loss of sensitivity of previous analyses. It turns out that it also leads to an improvement of the mass reconstruction of the 125 GeV Higgs for the same production process. We use an effective Lagrangian to describe a scalar with a generic Yukawa coupling to the top quarks. A full phenomenological analysis was performed, using Standard Model background and signal events generated with MadGraph5_aMC@NLO and reconstructed using a kinematic fit. The use of CP-sensitive variables allows then to maximize the distinction between CP-even and CP-odd components of the Yukawa couplings. Confidence Levels (CLs) for the exclusion of ϕ bosons with mixed CP (both CP-even and CP-odd components) were determined as a function of the top Yukawa couplings to the ϕ boson. The mass range analysed starts slightly above the Υ mass up to 40 GeV, although the analysis can be used for an arbitrary mass. If no new light scalar is found, exclusion limits at 95% CL for the absolute value of the CP-even and CP-odd Yukawa are derived. Also, we show that CP-searches are virtually impossible for ϕ boson masses above a few hundred GeV in the dileptonic channel, by computing CLs, as a function of luminosity, for the exclusion of different signal hypotheses with scalar and pseudoscalar bosons with masses that range from m = 40 GeV up to 200 GeV. Finally, we analyse how these limits constrain the parameter space of the complex two-Higgs doublet model (C2HDM).

Hadrons in medium - hyperons and mesons in nuclear matter / 266

Υ} and \boldmath{η_b} mass shifts in nuclear matter and the nucleus bound states

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We estimate for the first time the mass shifts (scalar potentials) in symmetric nuclear matter of the Υ and η_b mesons using an effective Lagrangian approach, as well as the in-medium mass of

the B^* meson by the quark-meson coupling model. The attractive potentials of both Υ and η_b are expected to be strong enough for these mesons to be bound in various nuclei, and we have obtained such nuclear bound state energies. A detailed analysis on the BB, BB^*, and B^*B^* meson loop contributions for the Υ mass shift is made by comparing with the respectively corresponding DD, DD^*, and D^*D^* meson loop contributions for the J/Ψ mass shift, in order to investigate how similar are the strengths of the interactions of bottomonium and charmonium to nuclear matter. In addition, initial studies are made to test the effects of different types of form factors and coupling constant values used in the calculation.

QCD, spin physics and chiral dynamics / 267

Extraction of the worm-gear TMD g_{1T} from COMPASS, HERMES and JLab data on semi-inclusive DIS

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We present the first-ever QCD analysis of the semi-inclusive DIS $A_{LT}^{cos(\phi_h-\phi_S)}$ data using Monte Carlo techniques to extract the worm-gear TMD g_{1T}. The relevant data are available from COMPASS, HERMES and JLab. We compare our results for g_{1T} with different theoretical approaches, including the large-N_c approximation, the Wandzura-Wilczek-type approximation, and lattice QCD.

Tests of symmetries and conservation laws / 269

Lepton-flavour violation in hadronic tau decays and $\mu-\tau$ conversion in nuclei

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Within the Standard Model Effective Field Theory framework, with operators up to dimension 6, we perform a model-independent analysis of the lepton-flavour-violating processes involving tau leptons. Namely, we study hadronic tau decays and ℓ-τ conversion in nuclei, with $\ell = e, \mu$. Based on available experimental limits, we establish constraints on the Wilson coefficients of the operators contributing to these processes. The translation of these constraints into the most general leptoquark framework is also considered. Our work paves the way to extract the related information from Belle II and foreseen future experiments.

Poster Session I / 270

Quasi-Dirac neutrinos in the linear seesaw model

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We implement a minimal linear seesaw model (LSM) for addressing the Quasi-Dirac (QD) behaviour of heavy neutrinos, focusing on the mass regime of $M_N < M_W$.
Here we show that for relatively low neutrino masses, covering the few GeV range, the same-sign to opposite-sign dilepton ratio, $R_{\ell\ell}$, can be anywhere between 0 and 1, thus signaling a Quasi-Dirac regime. Particular values of $R_{\ell\ell}$ are controlled by the width of the QD neutrino and its mass splitting, the latter being equal to the light-neutrino mass m_ν in the LSM scenario. The current upper bound on m_{ν_1} together with the projected sensitivities of current and future $|U_{N\ell}|^2$ experimental measurements, set stringent constraints on our low-scale QD mass regime. Some experimental prospects of testing the model by LHC displaced vertex searches are also discussed.

Hot and dense matter physics - QGP and heavy ion collisions / 271

Warm dense QCD matter in strong magnetic fields

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Finite magnetic field is relevant for both systems where QCD matter can be studied in practice - heavy ion collisions and neutron stars. It was shown recently, that in sufficiently strong magnetic fields and at moderate baryon densities a new phase of QCD matter appears: a crystalline condensate of neutral pions named the chiral soliton lattice. This phase might be relevant for magnetars; however, in order to assess its relevance for heavy ion collisions, finite temperature has to be taken into account. In this talk, I will describe the effects of quantum fluctuations and finite temperature recently calculated within chiral perturbation theory. The obtained results on the QCD phase diagram for varying temperature, baryon chemical potential and magnetic field will be presented.

Flavour physics - CKM and beyond / 272

CP violation and heavy-flavour production results from ATLAS and CMS (20+5)

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The recent CPV measurements from ATLAS and CMS with B0s to J/psi Phi decays will be discussed together with some recent results concerning Heavy Flavour production from both experiments.

Hadrons in medium - hyperons and mesons in nuclear matter / 273

Experimental hint of the genuine three-hadron interactions using femtoscopy in pp collisions with ALICE

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The femtoscopic studies done by the ALICE Collaboration provided results with unprecedented precision for the short-range strong interactions between different hadron pairs. The next challenge is the development of the three-particle femtoscopy which will deliver the first ever direct measurement of genuine three-body forces. Such results would be a crucial input for the low-energy QCD and neutron star studies. In particular, the momentum correlation of p-p-p triplets can provide information about genuine three-nucleon forces while the p-p-Λ interaction is a necessary piece to understand if the production of Λ hyperons occurs in neutron stars. In this talk, the first study of femtoscopic p-p-p and p-p-Λ correlations will be presented. The results were obtained using high-multiplicity pp collisions at $\sqrt{s}$ = 13 TeV measured by ALICE at the LHC. The measured three-body correlation functions include both three- and two-particle interactions. The cumulant method was applied to subtract lower order contributions and infer directly on the genuine three-body forces. The two-particle contributions were estimated both experimentally by applying mixed-event technique, and mathematically by projecting known two body correlation functions on the three-body systems. The measured p-p-p and p-p-Λ correlation functions and the corresponding cumulants will be shown.

Flavour physics - CKM and beyond / 274

Flavour-physics prospects in Run3 and at the HL-LHC at ATLAS and CMS (15+5)

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Flavour physics will play a role of paramount importance also in the foreseen upgrades and developments of the LHC experiments. Run3 and then high-luminosity LHC will allow the ATLAS and CMS experiments to provide results with improved precisions and with an increased sensitivity to new physics scenarios. The talk will provide an overview of expected ATLAS and CMS performances on this topic.

Flavour physics - CKM and beyond / 275

Rare flavour-physics decays at ATLAS and CMS (20+5)

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The ATLAS and CMS experiments have performed measurements of B-meson rare decays proceeding via suppressed electroweak flavour changing neutral currents.
This talk will focus on the latest results from the ATLAS and CMS on B^0_s → mu mu, B^0 → mu

mu, B^0 ⟶ K^*0 mu mu and B^+ ⟶ K^(*)+ mu mu decays. The LHC combined results on the B decays to two muons will also be presented.

Hot and dense matter physics - QGP and heavy ion collisions / 276

Virtual Photon Measurements with the HADES at GSI

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The High Acceptance DiElectron Spectrometer (HADES) is dedicated to the measurement of electromagnetic probes from heavy ion collisions and to study the in-medium behaviour of dileptons in the moderate temperature and high density regime of the QCD phase diagram. The spectral distributions of dileptons reveal the thermal properties of the medium. With the recent upgrade of the HADES RICH detector an unprecedented quality and signal-to-background ratio was achieved in the detection of these extremely rare probes.
In this talk we present preliminary results on the dielectron analysis of the HADES Ag+Ag data at a centre-of-mass energy of $\sqrt{s_{NN}} = 2.55\,GeV$. The high statistics of the HADES data taking in combination with a strongly increased electron detection efficiency allow even for a signal in the Φ-meson mass region. The obtained dielectron signal spectrum will be compared to simulated hadronic cocktail and nucleon-nucleon reference spectra clearly revealing a contribution from the medium.

Energy frontier physics beyond the standard model / 277

Searches for long-lived particles at CMS

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Models beyond the SM predict new particles with a wide range of lifetimes. The weak-scale particles can get a long lifetime which lead to unconventional signatures in the detector with respect to these from prompt decays, often requiring customized techniques to trigger and identify them. The CMS experiment puts a growing effort to expand the reach for long-lived signals. During the talk, recent studies on long-lived particles are be shown.

Applications of nuclear and particle physics technology / 278

Charge identification of fragments in FOOT experiment by nuclear emulsion detector

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Charged Particles Therapy (CPT) is a technique based on the use of charged particle beams for the treatment of deep-seated tumors. The advantages of CPT are due to the energy release occurring mainly at the end of the particles path, in the Bragg peak region, and to the enhanced biological effectiveness of hadron beams, measured in terms of the Relative Biological Effectiveness (RBE). Recent studies indicate the re-assessment of the proton RBE value due to secondary fragmentation as a crucial topic to improve the clinical treatment plans. The FOOT (FragmentatiOn Of Target) experiment is an international project aimed to measure the target fragmentation induced by a proton beam in the human tissues in the energy range relevant for therapeutic applications (150–250 MeV for protons and 200–400 MeV/n for carbon ions).
As fragments generated by a proton beam have few micrometers range, an inverse kinematic approach has been adopted in which a primary beam (carbon or oxygen) impinge on targets made of carbon and hydrogen-enriched carbon materials (C2H4). Therefore, the cross-section on hydrogen is derived from their linear combination.
The aim of the experiment is the measurement of the fragments production cross section in pA interactions with maximum uncertainty of 5%, the fragment energy spectra with an energy resolution of the order of 1–2 MeV/u, and the charge and isotopic identification with at the level of 3% and 5% uncertainty, respectively.
The detector was projected as a "table-top"one, so it could be easily moved and fitted in different experimental rooms where ion beams of therapeutic energies are available. The FOOT detector is based by two complementary setups: an electronic spectrometer, covering a polar angle acceptance up to about 10 degrees with respect to the beam axis, for fragments Z > 3, and an emulsion spectrometer, to measure light fragments (Z < 3) up to 70 degrees with respect to the beam axis.
The electronic setup is composed by a drift chamber, working as a beam monitor upstream of the target to measure the beam direction a magnetic spectrometer, based on silicon pixel and strip detectors, a scintillating crystal calorimeter to stop the heavier produced fragments, and a ΔE detector, with TOF capability, for the particle identification.
In this work we present the results obtained by the first data taking, occurred in 2019 at the GSI facility (Darmstadt, Germany), by exposing the emulsion detector to a 200 and 400 MeV/n oxygen ion beams. The charge identification of fragments and the cross section evaluation produced in interactions of the 16O beam with a C2H4 and C targets will be reported.
The emulsion spectrometers have been realized according the Emulsion Cloud Chamber (ECC) technique which consists of nuclear emulsion films alternated with passive material. Each emulsion spectrometer is composed of three sections: a first section for vertexing composed by alternated emulsion films and passive layers of C or C2H4 acting as target in which secondary fragments are originated; a second section dedicated to ion charge separation consisting of emulsion films underwent to controlled fading treatments; a third section composed by emulsion films alternated with passive materials of increasing density (plastic, lead and tungsten) to measure the particle range and momentum. For this analysis, the second Section has been considered as a stand-alone detector.
The method adopted for the analysis of the charge identification is based on thermal treatments inducing controlled fading of nuclear emulsion films to distinguish the charge of fragments generated by oxygen interactions and separate them from cosmic rays integrated during the detector lifetime. The charge of the fragments was measured or assigned for more than 99% of tracks reconstructed in Section II of the detector. Two complementary methods were adopted for the analysis: a cut-based analysis and the Principal Component Analysis

Development of accelerators and detectors / 279

DarkSide-20k and the Future Liquid Argon Dark Matter Program

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DarkSide run since mid-2015 a 50-kg-active-mass dual-phase Liquid Argon Time Projection Chamber (TPC), filled with low radioactivity argon from an underground source and produced world-class results for both the low mass (M_WIMP<20 GeV/c^2) and high mass (M_WIMP>100 GeV/c^2) direct detection search for dark matter.
The next stage of the DarkSide program will be a new generation experiment involving a global collaboration from all the current Argon based experiments. DarkSide-20k is designed as a 20-tonne fiducial mass dual-phase Liquid Argon TPC with SiPM based cryogenic photosensors and is expected to be free of any instrumental background for exposure of >100 tonne x year. Like its predecessor, DarkSide-20k will be housed at the INFN Gran Sasso (LNGS) underground laboratory, and it is expected to attain a WIMP-nucleon cross-section exclusion sensitivity of 7.4 x 10^{-48} cm^2 for a WIMP mass of 1 TeV/c^2 in a 200 t yr run. DarkSide-20k will be installed inside a membrane cryostat containing more than 700 t of liquid Argon and be surrounded by an active neutron veto based on a Gd-loaded acrylic shell. The talk will give the latest updates of the ongoing R&D and prototype tests validating the initial design.
A subsequent objective, towards the end of the next decade, will be the construction of the ultimate detector, ARGO, with a 300 t fiducial mass to push the sensitivity to the neutrino floor region for high mass WIMPs.

QCD, spin physics and chiral dynamics / 282

Back-to-back di-π^0 correlations at STAR

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Two-particle azimuthal correlation has been proposed to be one of the most direct and sensitive channels to access the nonlinear gluon dynamics in nuclei. Color Glass Condensate (CGC) predicts a suppression of back-to-back correlation in $p(d)$+A collisions compared to p+p collisions. In d+A collisions, the double-parton scattering (DPS) can be an alternative explanation of the suppression \cite{Strikman:2010bg}. A comparison of suppression in d+A and p+A with the same kinematics provides an opportunity to study the impact of DPS. During the 2015 and 2016 RHIC runs, STAR collected data with the Forward Meson Spectrometer (FMS, $2.6 \leq \eta \leq 4.0$) in p+p, p+Al, p+Au and d+Au collisions at $\sqrt{s_{\rm NN}} = 200$ GeV, which enables the measurements of azimuthal correlations of neutral pions in the forward region. In this talk, we will present the preliminary results on forward di-π^0 correlations as a function of event activity and π^0's transverse momenta in p+p, p+Al and p+Au collisions, together with an analysis update of the same measurements in d+Au collisions.

\bibitem{Strikman:2010bg}
M. Strikman and W. Vogelsang, Phys. Rev. D \textbf{83}, 034029 (2011), 1009.6123.

Poster Session II / 283

Background model and science reach of the LUX-ZEPLIN (LZ) experiment

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LUX-ZEPLIN (LZ) is a direct dark matter experiment, primarily designed to search for WIMPs, currently being commissioned 1.5 km underground at the Sanford Underground Research Facility in Lead, South Dakota. It features a 2-phase xenon time projection chamber with an active mass of 7 tonnes, surrounded by an instrumented xenon "skin" and a liquid scintillator outer detector which are used as active vetoes. The entire setup is installed inside a tank of ultra-pure water to shield it from external radiation. An extensive screening and selection campaign for the materials used in the construction of the detector, together with an inline xenon purification system, further ensure an ultra low-background environment. This will allow LZ to reach an unprecedented sensitivity to the WIMP-nucleon spin-independent cross-section of 1.4 x 10^-48 cm^2 for a 40 GeV/c^2 mass WIMP after a 1000 live day run, using an inner fiducial mass of 5.6 tonnes with minimal gamma-ray and neutron backgrounds. This is an improvement of more than one order of magnitude over the current best results. This talk will provide an overview of the background model of LZ and its implication on the scientific reach of the experiment, not only for direct WIMP search but also for other interesting physics topics.

Poster Session I / 284

Effect of finite system size on the thermodynamics of hot and magnetized hadron resonance gas

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Since few decades, considerable amount of research interest has been grown on the study of hot and/or dense 'strongly'interacting matter produced in the heavy ion collision (HIC) experiments at RHIC and LHC. On top of that, recently, another
contemporary research topic is the investigation of the effect of a strong
background magnetic field on various properties of QCD matter at extreme condition of high temperature and/or baryon density. Interestingly, a non-central or asymmetric HIC at RHIC and LHC energies has the potential to create strong magnetic field of the order of 10^18 Gauss or more. As the magnitude of the magnetic field is comparable to QCD energy scale, various novel phenomena owing to the rich vacuum structure of QCD could take place 1 such as chiral magnetic effect, magnetic catalysis, inverse magnetic catalysis etc.

Through the HIC experiments, it is possible to probe the bulk thermodynamic properties or the phase structure of QCD. The non-perturbative aspects of QCD restrict a first principle analytic calculation of the QCD thermodynamics especially in the low temperature region. The numerical lattice QCD (LQCD) based calculations [2] is one of the best alternatives to study the QCD thermodynamics, but is limited to the low baryon density region of the QCD phase diagram due to its 'sign'problem. On the other hand, the hadron resonance gas (HRG) model [3–5] is a statistical thermal model for studying the QCD thermodynamics at finite temperature, baryon density as well as external magnetic field [6–8]. Interestingly, at low temperature and small baryon density, the results from HRG model agrees well with the LQCD.

In the calculation of thermodynamic quantities, one generally assumes the system size to be infinite. However, in the HIC experiments, the created fireball has finite volume (few fm^3). So, it is justified to consider the boundary effects in the calculation of thermodynamical quantities pertaining to the HIC [9]. In this presentation, we will be showing the calculation of various thermodynamic quantities like energy density, longitudinal and transverse pressure and magnetization of an ideal HRG of finite size in presence of external magnetic field. The formalism of generalized Matsubara prescription [10] will be used to incorporate the finite size effect whereas the effect of external magnetic field will enter through the Landau quantization of the dispersion relations of charged hadrons.

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Nuclear and particle astrophysics / 285

Sensitivity of the LUX-ZEPLIN experiment to rare Xenon decays

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LUX-ZEPLIN (LZ) is a direct dark matter experiment with a projected sensitivity to WIMP-nucleon interactions that is more than an order of magnitude better than the current best limits. The design of LZ features a dual-phase time projection chamber (TPC) containing 7 active tonnes of liquid xenon and 5.6 tonnes fiducial, and it has additional instrumented detectors encompassing the TPC for improved background reduction and active shielding. The ultra-low background required for dark matter searches allows LZ to be potentially sensitive to other rare events, such as some not yet observed decays of xenon isotopes. This talk will focus on the latest sensitivity studies of LZ to the decays of 134Xe and 136Xe, considering a total exposure time of 1000 live-days. The projected sensitivity of LZ to the half-life of the neutrinoless double beta decay of 136Xe is 1.06×10^26 years at 90% CL without isotopic enrichment, a result comparable to the current best experimental limit from KamLAND-Zen. The projected sensitivities of LZ to the half-lives of the two-neutrino and neutrinoless double beta decay modes of 134Xe are currently the best in literature, being 1.7×10^24 years and 7.3×10^24 years, respectively, at 90% CL.

Development of accelerators and detectors / 288

The upgrade of the ATLAS experiment: physics potential and new detector features

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With the end of RUN-II, the LHC has delivered only 4% of the collision data expected to be available during its lifetime. The next data-taking campaign – RUN-III – will double the integrated luminosity the LHC accumulated in 10 years of operation. The Run-III will be the herald of the HL-LHC era, an era when 90% of total LHC integrated luminosity (4 ab-1) will be accumulated allowing ATLAS to

perform several precision measurements to constrain the Standard Model Theory (SM) in yet unexplored phase-spaces and in particular in the Higgs sector, only accessible at LHC. Direct searches have so far provided no indication of new physics beyond the Standard Model, however, they can be complemented by indirect searches that allow extending the reach at higher scales. Indirect searches are based on the ability to perform very precise measurements, a highly complex task at a hadron collider that will require tight control of theoretical predictions, reconstruction techniques, and detector operation. Moreover, populating extreme regions of phase-space for multi-differential production cross-section analysis will require the development and validation of Monte Carlo phase-space biasing techniques and efficient integration methods to produce the billions of events needed to cope with higher luminosities.
To answer the quest for high precision measurements in a high luminosity environment, a comprehensive upgrade of the detector and associated systems was devised and planned to be carried out in two phases. The Phase-I upgrade program foresees new features for the muon detector, for the electromagnetic calorimeter trigger system, and for all trigger and data acquisition chain and will operate to accumulate about 350 fb-1 of integrated luminosity during the RUN-III. The RUN-III will mark the debut of a new trigger system designed to cope with more than 80 simultaneous collisions per bunch crossing. After this, ATLAS will proceed with the Phase-II upgrade to prepare for the high luminosity frontier where the ATLAS experiment will face more than 200 simultaneous collisions per bunch crossing and a high radiation level for many subsystems. The Phase-II upgrade comprises a completely new all-silicon tracker with extended rapidity coverage that will replace the current inner tracker detector; the calorimeters and muon systems will have their trigger and data acquisition systems fully redesigned, allowing the implementation of a free-running readout system. Finally, a new subsystem called High Granularity Timing Detector will aid the track-vertex association in the forward region by incorporating timing information into the reconstructed tracks. A final ingredient, relevant to almost all measurements, is a precise determination of the delivered luminosity with systematic uncertainties below the percent level. This challenging task will be achieved by collecting the information from several detector systems using different and complementary techniques.
The presentation will describe physics goals and the status of the ongoing detector upgrades for RUN-III and the HL-LHC era.

This abstract is being submitted by the ATLAS Upgrade Speaker Committee representative. If approved, the speaker will be selected from ATLAS Collaboration and the conference will be informed.

Development of accelerators and detectors / 289

The upgrade on the ATLAS electronic systems in view of the High Luminosity challenge

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To maximize the physics reach, the LHC plans to increase its instantaneous luminosity to 7.5×10^{34} cm^{-2} s^{-1}, delivering from 3 to 4 ab^{-1} of data at $\sqrt{s}$ =14 TeV. In order to cope with this operation condition, the ATLAS detector will require new sets of both front-end and back-end electronics. A new trigger and DAQ system will also be implemented with a single-level hardware trigger featuring a maximum rate of 1 MHz and 10 µs latency. Enhanced software algorithms will further process and select events, storing them at a rate of 10 kHz for offline analysis. The large number of detector channels, huge volumes of input and output data, short time available to process and transmit data, harsh radiation environment and the need of low power consumption all impose great challenges on the design and operation of electronic systems. This talk will focus on these challenges, the proposed solutions and the latest results obtained from the prototypes.

This abstract is being submitted by the ATLAS Upgrade Speaker Committee representative. If approved, the speaker will be selected from ATLAS Collaboration and the conference will be informed.

QCD, spin physics and chiral dynamics / 290

First-time observation of Timelike Compton Scattering, with the CLAS12 detector

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Generalized Parton Distributions (GPDs) describe the correlations between the longitudinal momentum and the transverse position of the partons inside the nucleon. They are nowadays the subject of an intense effort of research, in the perspective of understanding nucleon spin and mechanical properties.

In this talk, we present the first observation of the Timelike Compton Scattering (TCS) process, $\gamma p \rightarrow \gamma^* p' \rightarrow e^+e^-p'$, measured using the CLAS12 detector at Jefferson Lab, with a 10.6 GeV electron beam impinging on a liquid-hydrogen target. The initial photon polarization and the decay lepton angular asymmetries are reported in the range of timelike photon virtualities $2.25 < Q'^2 < 9$ GeV^2 and the squared momentum transferred $0.1 < -t < 0.8$ GeV^2 at the average total center mass energy squared of $\bar{s} = 14.5$ GeV^2. The polarization asymmetry, similar to the beam spin asymmetry in Deeply Virtual Compton Scattering (DVCS), projects out the imaginary part of the Compton Form Factors (CFFs, which are complex quantities linked to the GPDs) and provides a way to test the universality of Generalized Parton Distributions. The angular asymmetry of the decay leptons, on the other hand, accesses the real part of the CFF $\mathcal{H}$ which contain the D-term, a quantity directly linked to the mechanical properties of the nucleon.

QCD, spin physics and chiral dynamics / 291

Searches for Chiral Magnetic Effect and Chiral Magnetic Wave in Xe-Xe and Pb-Pb collisions with ALICE

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An important property of the strong interaction that is potentially observable in heavy-ion collisions is local parity violation which manifests itself as a charge separation along the direction of the magnetic field. This phenomenon is called the Chiral Magnetic Effect (CME). A similar effect in which the presence of a vector charge (e.g., electric charge) causes a separation of chiralities is the Chiral Separation Effect (CSE). Their coupling leads to a wave propagation of the electric charge called the Chiral Magnetic Wave (CMW), causing a charge-dependent elliptic flow.
In this talk, we present results of the charge-dependent two- and three-particle correlators as function of centrality in Xe–Xe and Pb–Pb collisions at $\sqrt{s_{\mathrm{NN}}}$ = 5.44 TeV and 5.02 TeV, respectively. The charge dependence of the three-particle correlator is often employed as evidence for the CME. The interpretation of the experimental results is complicated by possible background contributions, associated with local charge conservation (LCC) coupled to elliptic flow. Comparisons with predictions from Anomalous-Viscous Fluid Dynamics simulations and a Blast-wave parametrisation that incorporates LCC are used to estimate background effects. Furthermore, these measurements combined with Monte Carlo Glauber and T$_{\mathrm{R}}$ENTo simulations of the magnetic field are employed to derive an upper limit on the CME contribution for the first time in Xe–Xe collisions. In addition, recent measurements of charge-dependent flow as a function of charge asymmetry are presented and their implications for observation of CMW are discussed.

Dark matter and cosmology / 292

New Ideas of Probing Sterile Neutrino Dark Matter

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Sterile neutrino is a simple and elegant dark matter candidate. In its minimal incarnation, the original Dodelson-Widrow mechanism that explains the relic abundance has been in strong tension with the indirect detection limits. I present the self interacting neutrino scenario, mediated by a Majoron-like scalar or vector boson, as a novel solution to the above tension. It can accommodate new production mechanisms for sterile neutrino dark matter, open up a wide parameter space, and result in a number of testable signatures from the laboratorie s to the cosmos.

Poster Session II / 293

DANSS Experiment around the Five Year Milestone.

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DANSS detector is composed of plastic scintillator and takes full advantages of its unique location directly below a commercial reactor core. The ability to change the distance to the antineutrino source by means of a lifting platform makes DANSS an ideal apparatus for sterile neutrino searches, while the fine segmentation of the sensitive volume provides an exteremely clean separation of the inverse beta decay process.

Revised approach to the calibration procedure improved the confidence in the energy scale, while numerous refinements in the Monte-Carlo simulations led to much closer agreement between the experiment and the model.

The results of the five year data taking will be presented, including the latest estimates for the exclusion area of the sterile neutrino parameters.

Hadrons in medium - hyperons and mesons in nuclear matter / 294

Electromagnetic form factors of baryons in nuclear medium

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The electromagnetic structure of baryons is modified in the nuclear medium.
The modifications can be inferred from the comparison between the electromagnetic form factors in medium with the respective form factor in vacuum.
Of particular interest is the ratio between the electric and magnetic form factors in medium (G_E^*/G_M^*) and vacuum (G_E/G_M) of octet baryons.
The deviation of the double ratios $(G_E^*/G_M^*)/(G_E/G_M)$ from unity measures the impact of the medium modification of the electromagnetic structure in a nuclear medium.
Measurements of the double ratios $(G_E^*/G_M^*)/(G_E/G_M)$ may become available in a near future using the transfer polarization method developed at Jefferson Lab.
We present estimates of the double ratios of octet baryons for different nuclear densities based on a constituent quark model which take into account meson cloud excitations of the baryon cores.
Our results show different features, namely, enhancement or quenching depending on the octet baryon flavor content.

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In the figure, we present our estimates for the double ratios of the proton and neutron for different nuclear densities.

Hadron spectroscopy and exotics / 297

Recent XYZ studies at BESIII

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In this talk recent XYZ results at BESIII will be reviewed, that includes: Observation of a near-threshold enhancement in the Lambda Lambda-bar mass spectrum from e+ e- -> phi Lambda Lambda-bar at the center-of-mass energies from 3.51 to 4.60 GeV; Observation of e+ e- -> eta psi(2S) at the center-of-mass energies from 4.236 to 4.600 GeV; Cross section measurement of e+ e- -> p pbar eta and e+ e- -> p pbar omega at center-of-mass energies between 3.773 GeV and 4.6 GeV; Search for reaction e+ e- -> chi_cJ pi+ pi- and a charmonium-like structure decaying to chi_cJ pi+/- between 4.18 and 4.60 GeV; Search for the reaction channel e+ e- -> eta_c eta pi+ pi- at center-of-mass energies from 4.23 to 4.60 GeV.

Hadron spectroscopy and exotics / 298

Charmonium Decays at BESIII

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Although the charmonium spectrum seems to be well investigated, charmonia can still be used as benchmarks to test our QCD predictions, as these states lay in the transition region between perturbative and non-perturbative QCD.Despite the need for experimental confirmations, setbacks arise from limited statistics because of the production processes of all non-vector states. The

properties and many decay channels of some charmonium states (such as hc or eta_c(2S)) are still far from being known.
Since 2009, BESIII has been scanning and investigating the charmonium
region to shed light on open questions. Thanks to its unique J/psi; and psi(2S) data sets, BESIII could overcome statistical limitations.
Recent results on charmonium decays from BESIII are presented.

Hadron spectroscopy and exotics / 299

Observation of the first hidden-charm strange tetraquark at BESIII

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In the last ten years, a whole set of new particles not fitting in the constituent quark model has populated the mass region above the
open-charm threshold. The spectrometer BESIII, installed at the Beijing Electron Positron Collider II, can access these states in electron-positron annihilations both by production and by direct formation. It has collected a large dataset at different center-of-mass energies. In this talk, the discovery of the first hidden-charm strange tetraquark with a mass of 3.98 GeV/c^2 will be addressed. The resonance was observed in the analysis of data collected at five center-of-mass energy points in the range [4.628, 4.698] GeV, with a total integrated luminosity of 3.7 fb-1. Due to its properties, the Zcs(3985) is a strong candidate for the predicted open-strange charmonium-like tetraquark with the minimal structure ccbar subar.

Flavour physics - CKM and beyond / 300

Leptonic and semileptonic D decays at BESIII (12+3)

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BESIII has collected 2.9 and 6.3 fb-1 of e+e- collision data samples at 3.773 and 4.178-4.226 GeV, respectively. We report recent measurements of the (semi)leptonic decays D(s) -> l+nu (l=mu, tau) and D(s) -> X l+nu [X=K(*), rho, eta('), a_0, K_1, and l=e, mu]. The decay constants f_D(s), the semileptonic form factors f(0) and the CKM matrix elements |V_cs(d)| are determined precisely. These results are important to verify the LQCD calculations of f_D(s) and f(0) and the CKM matrix unitarity. Precision tests of lepton-flavor universality with (semi)leptonic D decays are also made.

Flavour physics - CKM and beyond / 301

Hadronic decays of charmed hadrons at BESIII (12+3)

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BESIII has collected 2.9, 6.3 and 4.4 fb-1 of e+e- collision data samples at 3.773, 4.178-4.226 and 4.6-4.7 GeV, respectively. We report recent measurements of strong phase differences in D0 and D0-bar

decays of KSpi+pi-, KSK+K-, K-pi+pi+pi- and K-pi+pi0. The obtained parameters are important to reduce the systematic uncertainty in the gamma/phi_3 measurement at LHCb and Belle II. We will also report the amplitude analyses of D+ -> KSK+pi0, Ds -> etapi+pi0, K+K-pi+, pi+pi+pi-, KSpi+pi0, K+K-pi+pi0,and KSK-pi+pi+. In addition, the absolute branching fractions of D0(+), Ds, and Lambda_c decays will also be presented.

Hadron spectroscopy and exotics / 302

Light meson spectroscopy at BESIII

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Due to the high production of light mesons J/ψ radiative and hadronic decays, the largest sample of J/ψ events accumulated at the BESIII detector offers a unique laboratory to study the light mesons spectroscopy and search for the light exotic states. In this talk, we shall report the recent progresses on the light meson spectroscopy achieved at BESIII.

Hadron spectroscopy and exotics / 303

Light meson decays at BESIII

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The world's largest sample of J/ψ 1.3 billion events accumulated at the BESIII dector offers a unique opportunity to study light meson decays. In recent years the BESIII experiment has made significant progresses in eta/eta' decays, including observation of eta'->pi+pi- mu+mu-, search for the rare decays of eta'->4pi0 and eta'->gam gam eta as well as the search for CP violation in eta'->pi+pi-e+e-. In addition, the prospects for the light meson decays with the available 10 billion J/ψ will also be discussed.

Tests of symmetries and conservation laws / 304

Light hyperon physics at BESIII

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The BESIII experiment at the electron positron collider BEPCII in Beijing is successfully operating since 2008 and has collected large data samples in the tau-mass region, including the world's largest data samples at the J/Psi and Psi(2S) resonances. The recent observations of hyperon polarisations at BESIII opens a new window for testing CP violation, as it allows for simultaneous production and detection of hyperon and anti-hyperon pair two body weak decays. The CP-symmetry tests can be

performed in processes like e.g. J/Psi —> Lambda Lambdabar, J/Psi —> Sigma Sigmabar and J/Psi —> Xi Xibar. For the Xi —> Lambda pi decay it is possible to perform three independent CP tests and determine the strong phase and weak phase difference. In this presentation an outline of the methods and recent results achieved at BESIII will be highlighted.

QCD, spin physics and chiral dynamics / 305

Measurements of the R value at BESIII

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The R value, defined as the ratio of the inclusive hadronic cross section and the muon cross section in e+e- collisions, is an important input for the calculation of the Standard Model predictions of the anomalous magnetic moment of the muon a_mu and the running of the QED coupling constant alpha_QED(m_Z) evaluated at Z pole. The BESIII collaboration has collected data with high statistics to measure the R value at more than 130 scan points between 2.0 and 4.6 GeV. In this presentation, the measurement between 2.2324 and 3.6710 GeV is discussed. On average, a total uncertainty of less than 3% is achieved, which is dominated by the systematic uncertainty.

Hadron spectroscopy and exotics / 306

Study of phi(2170) at BESIII

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In e+e- collisions between 2 and 3 GeV, excited states of rho, omega and phi can be produced directly. Especially the resonances around 2GeV like rho(2000), rho(2150) and \phi(2170) are not fully understood yet. Theorists describe the phi(2170) as a traditional s s-bar state, an s s-bar g hybrid, a tetraquark state, a Lambda Lambda-bar bound state, or a phi KK resonance. The predicted decay widths vary strongly depending on the assumed nature of phi(2170). With energy scan data collected by the BESIII collaboration between 2.0 GeV and 3.08 GeV, the properties of phi(2170) are studied systematically in PWAs of its expected decay modes, such as e+e- -> K+K-pi0pi0, phi eta', phi eta, K+K-, and eta' pi+pi-.

QCD, spin physics and chiral dynamics / 307

Recent result of nucleon time-like form factors at BESIII

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Nucleons are one of the most fundamental building blocks of ordinary matter, yet their internal structure and dynamics are still not fully understood. Electromagnetic form factors allow to investigate fundamental properties of the nucleon. The BESIII collaboration has studied the time-like form factors of the proton using the energy scan and the ISR technique. The |GE/GM| ratio is obtained with

a precision comparable to the investigations of the space-like EMFF in electron proton scattering. The effective form factor of the neutron is measured with highest precision using the scan method. For both nucleons, an intriguing periodic behavior of effective form factors lineshape is observed. In this presentation the latest results on nucleon form factors at BESIII are discussed.

Poster Session I / 308

Hyperon pair production at BESIII

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Hyperons provide an unique avenue to study the strong interaction in baryon structure. Due to their limited life time, the production in e+e- annihilations is the only viable way to obtain information on the hyperon structure and internal dynamics through their electromagnetic form factors. With the unique data sets obtained by the BESIII collaboration, the pair production cross sections for Lambda, Sigma, Xi, and Lambda_c are studied from threshold, where some abnormal threshold effects are observed. Using the self-analyzing weak decays of the Lambda and Lambda_c, the relative phase between the electric and magnetic form factors is measured. In this presentation the latest results at BESIII are discussed.

QCD, spin physics and chiral dynamics / 309

Helicity Evolution at Small x: the Single-Logarithmic Contribution

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We calculate single-logarithmic corrections to the small-x flavor-singlet helicity evolution equations derived recently in the double-logarithmic approximation. The new single-logarithmic part of the evolution kernel sums up powers of $\alpha_s \ln(1/x)$, which are an important correction to the dominant powers of $\alpha_s \ln^2(1/x)$ summed up previously by the double-logarithmic kernel at small values of Bjorken x and with α_s the strong coupling constant. The single-logarithmic terms arise separately from either the longitudinal or transverse momentum integrals. Consequently, the evolution equations we derive simultaneously include the small-x evolution kernel and the leading-order polarized DGLAP splitting functions. We further enhance the equations by calculating the running coupling corrections to the kernel.

Poster Session II / 310

Results of Jpsi weak decay searching at BESIII

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Based on the 225 million J/ψ data set accumulated at the 3.097 GeV by the BESIII detector, we show searches for the extremely rare process of J/ψ weak decays. We find no obvious signal event for the processes of $J/\psi \to \bar{D}^0\pi^0, \bar{D}^0\eta, \bar{D}^0\rho^0, D^-\pi^+$ and $J/\psi \to D^-\rho^+$ and present the most stringent constraints of 10^{-6} at 90\% confidence level. Furthermore, the result of $J/psi \to D^-e^+\nu_e + c.c.$ with 10 billion newly collected J/ψ data and some other prospect results are also presented.

Poster Session I / 312

Search for invisible decays at BESIII

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BESIII has collected 448.2 M $\psi(3686)$ data set and 10 B J/ψ data set. The huge clean data sample provide an excellent chance to search for new physics. We report the search for decay $J/\psi \to \gamma + invisible$, which is predicted by next-to-minimal supersymmetric model. Without significant signal found, we gave around 6.2 times better upper limits than previous CLEO-c's results. In addition, we report the preliminary result of the first search for the invisible decay of Λ. This invisible decay is predicted by the mirror matter model which could explain the 4σ discrepancy in neutron lifetime measurement results from the beam method and bottle method.

Poster Session II / 313

Studying chiral imbalance using Chiral Perturbation Theory.

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We analize the most general low-energy effective lagrangian including local parity violating terms parametrized by an axial chemical potential μ_5. This result is obtained following the external source method, up to $\mathcal{O}(p^4)$ order in the chiral expansion for two light flavours. We show that the $\mathcal{O}(p^4)$ lagrangian includes new terms proportional to μ_5^2 and new low-energy constants. Finally, the μ_5 and temperature dependences of several observables related to the vacuum energy density are studied. The same procedure can be followed to incorporate isospin chemical potential.

Flavour physics - CKM and beyond / 314

Subleading contributions in rare semileptonic $B^+ \to \pi^+\ell^+\ell^-$ decay (17+3)

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In the Standard Model (SM), the $b \to s$ and $b \to d$ flavor-changing neutral currents (FCNC) are induced by loop effects. Rare semileptonic B-meson decays originated by these currents are standard channels for testing the SM precisely and searching for possible physics beyond the Standard Model. Differential branching fractions of semileptonic B-decays and angular distributions in some of them are experimentally measured by the LHCb, ATLAS and CMS collaborations at the LHC as well as by BaBar and Belle at the B-factories. We also anticipate significantly improved results from the ongoing Belle-II experiment.
Here, we consider the rare $B^{\pm} \to \pi^{\pm}\ell^{+}\ell^{-}$ decay, where $\ell = e, \mu, \tau$ is a charged lepton, and present its dilepton invariant-mass spectrum and decay rate based on the effective electroweak Hamiltonian approach for the $b \to d\ell^{+}\ell^{-}$ transitions in the SM, taking into account also the weak annihilation diagrams. We present theoretical predictions for total and partial branching fractions for $B^{+} \to \pi^{+}\tau^{+}\tau^{-}$ in dependence on the parameterization type for the $B \to \pi$ form factors. Our prediction for the total branching fraction of $B^{+} \to \pi^{+}\mu^{+}\mu^{-}$ agrees with the LHCb result (Aaij R. et al.,LHCb Collab., JHEP 10 (2015) 34) within the experimental and theoretical uncertainties. Moreover, accounting for the weak annihilation contributions allows us to obtain a better agreement with the experimental data on the distribution in the dimuon invariant mass squared q^2 in the entire kinematically allowed region and, in particular, in its lowest q^2-part. The importance of the long-distance contributions from the light vector mesons on the dilepton invariant-mass spectrum is also discussed. These results are potentially useful in testing the lepton flavor universality in the FCNC $B \to \pi\ell^{+}\ell^{-}$ decays.

Poster Session I / 315

Axion-Dark-Matter Search Using Cold Neutrons

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The current best estimate for the universe's matter content consists of 84% dark matter, and the search for its composition remains of great interest. One possible candidate is a so-far undetected ultra-low-mass axion. Various astronomical observations and laboratory experiments constrain the axion mass and its interaction strength in the allowed phase space. In this talk, we present the idea of a complementary laboratory search for an axion-induced oscillating neutron electric dipole moment using a cold neutron beam Ramsey setup. We show results from recent measurements with the Beam EDM setup at the Institut Laue-Langevin that resulted in further constraints of the axion-gluon coupling.

Dark matter and cosmology / 316

Dark Matter search with the CRESST-III experiment

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The CRESST (Cryogenic Rare Event Search with Superconducting Thermometers) experiment, installed at the Laboratori Nazionali del Gran Sasso (LNGS), is suited for direct detection of dark matter particles via elastic scattering off nuclei of $CaWO_4$.
CRESST uses an array of crystals (24 g each) operated as cryogenic calorimeters, each equipped with a cryogenic light detector.
An interaction in the $CaWO_4$ crystal produces a phonon and light signal: the phonon signal allows a

precise energy measurement, the light signal is used to discriminate the expected dark matter signal (nuclear recoil) from the dominant background (electron/gamma and alpha). In early 2018, CRESST completed an initial data taking campaign reaching nuclear recoil thresholds of 30.1 eV. This unprecedented low threshold allows to probe dark matter particle masses below 500 MeV/c^2 and down to 160 MeV/c^2.
Most recent results are presented and discussed. The perspective for the next phase of the experiment will be also discussed.

Poster Session II / 317

Ultracold neutron production and extraction from solid deuterium at the PSI UCN source

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Ultracold neutrons (UCN) with kinetic energies below 300 neV can be confined for hundreds of seconds in storage volumes made from materials of high Fermi potential. The UCN source at the Paul Scherrer Institut (PSI) delivered UCNs for the measurement of the currently best limit on the permanent electric dipole moment of the neutron and will continue to do so for the follow-up experiment n2EDM.

The source moderates free neutrons from a spallation target, first in room temperature heavy water and then in 5 Kelvin cold solid deuterium (sD_2). Superthermal moderation in solid deuterium by phonon excitation, the last step to obtain UCNs, is a well-known process to convert cold neutrons to ultracold neutrons at high intensity. The deuterium temperature as well as the isotopic and spin-isomeric purity have a strong influence on the UCN output from the moderator. We measured these parameters and deduced the UCN lifetime in the solid deuterium. Furthermore, we estimated the fraction of UCNs that escape the moderator and can be transported to experiments by comparison of detailed Monte Carlo simulations with measurements of the UCN count rates at different deuterium filling levels. Our analysis indicates that the mean free path that the UCN travel in the moderator to reach the surface is shorter than what is expected based solely on the UCN lifetime in deuterium. We attribute the lower than expected UCN extraction to neutron scattering on defects in the solid deuterium, caused by thermal stress during freezing and cooling. Precise control of the temperature and the rate of crystallization of 22'000 cm^3 of solid deuterium poses challenges. With continuous improvements on the cryogenic system as well as operational experience we were able to improve the freezing and cooling procedures. We observe that slow freezing, as well as slow cooling and annealing of the solid deuterium in the moderator increase the UCN output considerably.

QCD, spin physics and chiral dynamics / 318

Twist-3 gluon fragmentation contribution to transversely polarized hyperon production in semi-inclusive deep-inelastic scattering

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We study the transverse polarization of hyperons produced
in semi-inclusive deep inelastic scattering, $ep \to e\Lambda^{\uparrow}X$,
in the collinear twist-3 factorization. This process receives three types of
twist-3 contributions: (i) twist-3 distribution in the initial proton combined
with the transversity fragmentation function (FF) for the hyperon,
(ii) Twist-3 quark FFs for the hyperon, and (iii) Twist-3 gluon FFs for the hyperon.
In this talk, we present the twist-3 cross section for (iii) in the leading order (LO)
with respect to the QCD coupling constant, which completes the LO cross section
for this process. Since gluons are ample in the nucleons, this contribution
representing multi-gluon correlations in the fragmentation process is
potentially as important as other two contributions. We also show that the
QCD equation of motion relations and the Lorentz invariance relations
among the twist-3 FFs are crucial to gurantee the color and electromagnetic
gauge invariance of the cross section. This study is relevant for the future
Electron-Ion Collider experiment.

Poster Session I / 319

Anomalous dilepton production as precursory phenomena of color superconductivity

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One of the key ingredients in hadron physics based on QCD is the notion of diquark
correlations, which in turn could lead to the color superconductivity (CSC) in dense and cold quark matter with a Fermi surface to be realized in a compact star.
One of the main focuses of recent experiments using heavy-ion collision is to reveal possible rich physics in high baryon-density matter at relatively low temperature: Such experiments include the beam-energy scan program at RHIC, and HADES and NA61/SHINE collaborations as well as those to be performed in future experimental facilities such as FAIR, NICA and J-PARC-HI.
In the present report, we show that the diquark correlations or pair fluctuations of the two-flavor superconductivity (2SC) near but above the critical temperature make a well-defined collective soft modes, which may be experimentally confirmed through an anomalous enhancement of the dilepton production rate.
Indeed, on the basis of the two-flavor NJL model, we shall demonstrate that
Aslamazov-Larkin term due to the soft modes, which is known to give rise to anomalous excess of electric conductivity in metals, modify the photon self-energy so greatly that the dilepton production rates is enhanced anomalously at the low energy region.

Poster Session I / 320

The Search for Electric Dipole Moments of Charged Particles in Storage Rings

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The matter-antimatter asymmetry in the universe cannot be explained by the Standard Model of elementary particle physics. According to A. Sakharov, CP violating phenomena are needed to understand the matter-antimatter asymmetry. Permanent Electric Dipole Moments (EDMs) of subatomic elementary particles violate both time reversal and parity asymmetries and therefore also violate CP if the CPT-theorem holds.
Storage rings offer the possibility to measure EDMs of charged particles by observing the influence of the EDM on the spin motion. The Cooler Synchrotron (COSY) at Forschungszentrum Jülich provides polarized protons and deuterons up to a momentum of 3.7 GeV/c and is therefore an ideal starting point for the JEDI - Collaboration (Jülich Electric Dipole moment Investigations) to perform the first direct measurement of the deuteron EDM.
During this talk, recent results of the JEDI physics program are presented.

Hot and dense matter physics - QGP and heavy ion collisions / 321

Study of the phase diagram of strongly interacting matter in the NA61/SHINE experiment

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NA61/SHINE (SPS Heavy Ion and Neutrino Experiment) is a fixed target experiment located at the CERN SPS. Its strong interactions programme is devoted to study properties of the phase diagram of strongly interacting matter. For this goal the two-dimensional scan is performed by measurements of hadron production properties as a function of collision energy (13A - 158A GeV/c) and system size (p+p, p+Pb, Be+Be, Ar+Sc, Xe+La, Pb+Pb). This contribution presents new results on the onset of deconfinement - the transition between the state of hadronic matter and the quark-gluon plasma. Also, new results on fluctuations and correlations devoted to the search for the critical point of strongly interacting matter will be presented. Obtained results will be compared with available data from other experiments and from various theoretical models.

QCD, spin physics and chiral dynamics / 322

Explicit renormalization of the nucleon-nucleon interaction in chiral EFT with a finite cutoff

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Nucleon-nucleon interaction
is studied within chiral effective field theory with a finite cutoff
at next-to-leading order in the chiral expansion.
The leading order interaction is resummed in a non-perturbative manner,
whereas the next-to-leading-order terms are treated perturbatively.
Some aspects of renormalizability of such a scheme are addressed.
In particular, it is analyzed whether the power-counting
breaking terms originating from the integration regions with momenta of the order
of the cutoff can be absorbed by the renormalization of the
low energy constants corresponding to the leading contact interactions.
The cutoff dependence of the scheme is also studied.

Poster Session II / 323

Non-prompt J/ψ measurements at midrapidity in pp, p–Pb and Pb–Pb collisions with ALICE

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The J/ψ production is sensitive to the presence of the deconfined state of quarks and gluons, quark-gluon plasma (QGP), which is expected to form in the nuclear collisions. Measurements of J/ψ meson originating from the weak decay of b-hadrons, non-prompt J/ψ, can provide an estimate of beauty quark production in the nuclear collisions. It is observed that production of non-prompt J/ψ is modified in Pb-Pb collisions in comparison to that in pp collisions, as quantified by nuclear modification factors ($R_{\rm AA}$). It is related to several effects governed by the QGP in the Pb-Pb collisions. The measurement of nuclear modification factors for p-Pb collisions is used to assess various Cold Nuclear Matter (CNM) effects which can modify the production yields of non-prompt J/ψ. ALICE has excellent capabilities to reconstruct J/ψ in e^+e^- decay channel down to zero transverse momentum ($p_{\rm T}$). In addition, it allows the statistical separation of the non-prompt J/ψ component for $p_{\rm T}$ larger than 1 GeV/c.

In this contribution, ALICE results on b$\bar{\rm b}$ production cross-sections (extrapolated from non-prompt J/ψ cross-sections) in pp collisions will be presented and compared with the theoretical models. Moreover, $R_{\rm AA}$ of non-prompt J/ψ as a function of transverse momentum ($p_{\rm T}$) in p-Pb collisions at the center-of-mass energy per nucleon pair $\sqrt{s_{\rm NN}}$ = 5.02 TeV will be presented and further compared with $R_{\rm AA}$ of non-prompt J/ψ in Pb-Pb collisions at $\sqrt{s_{\rm NN}}$ = 2.76 TeV. The obtained results will be compared with theoretical predictions.

Poster Session I / 324

Chiral Symmetry Restoration, Thermal Resonances and the $U(1)_A$ symmetry

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We review recent work on Ward Identities (WI) and Effective Theories within the context of the QCD transition at finite temperature. On the one hand, WI allow to obtain generic results on the interplay between chiral and $U(1)_A$ restoration, key to understand the nature of the transition, as well as scaling laws verified by lattice screening masses. On the other hand, thermal resonances $f_0(500)$ and $K_0^*(700)$ generated within Unitarized Chiral Perturbation Theory (ChPT) scattering at finite temperature allow to describe scalar susceptibilities around chiral and $O(4)\times U(1)_A$ restoration, in good agreement with lattice results.

Poster Session I / 325

Explaining the MiniBooNE Excess Through a Mixed Model of Oscillation and Decay

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This talk presents a model of the electron-like excess observed by the MiniBooNE experiment comprising of oscillations involving two new mass states: ν_4, at $\mathcal{O}(1)$ eV, that participates in oscillations, and $\mathcal{N}$, at $\mathcal{O}(100)$ MeV, that decays to $\nu + \gamma$ via a dipole interaction.
Short-baseline oscillation data sets, omitting MiniBooNE appearance data, are used to predict the oscillation parameters. We simulate the production of $\mathcal{N}$ along the Booster Neutrino Beamline via both Primakoff upscattering ($\nu A \to \mathcal{N} A$) and Dalitz-like neutral pion decays ($\pi^0 \to \mathcal{N}\nu\gamma$).
The simulated events are fit to the MiniBooNE neutrino energy and visible scattering angle data separately to find a joint allowed region at 95\% CL.
A point in this region with a coupling of 3.6×10^{-7} GeV^{-1}, $\mathcal{N}$ mass of 394 MeV, oscillation mixing angle of 6×10^{-4} and mass splitting of 1.3 eV^2 has $\Delta\chi^2/dof$ for the energy fit of 15.23/2 and 37.80/2. This model represents a significant improvement over the traditional single neutrino oscillation model.

Poster Session II / 328

The Updated SIDDHARTA-2 Apparatus for Kaonic Deuterium X-Ray Spectroscopy

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Kaonic atoms provide an ideal testing ground to precisely study QCD at very low energies. Theoretical models still show significant discrepancies in their descriptions of this regime, and fundamental experimental input to constrain these models is provided by X-ray spectroscopy of light kaonic atoms. This is the goal of the SIDDHARTA-2 experiment located at the DAΦNE collider at LNF, which aims to measure the $2p \to 1s$ transition in kaonic deuterium. In comparison to the previously performed kaonic hydrogen measurement, the K$^-$d measurement is aggravated by the low X-ray yield and an improvement of the signal-to-background ratio of one order of magnitude is essential. This increase will be implemented in the form of three main updates to the apparatus: the newly developed, large-area X-ray detection system consisting of closely packed Silicon Drift Detectors, a cryogenic, lightweight target cell for optimal X-ray transmission to the detectors, and a two-stage veto system for the active suppression of background. The characteristics and implementation of these updates will be presented.

QCD, spin physics and chiral dynamics / 329

TMD cross-section factorization for dijet production at the EIC

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We use soft collinear effective theory (SCET) to study a dijet production process in deep-inelastic-scattering (DIS), measuring the imbalance of the two hard probes in the Breit frame. In order to achieve factorization of the transverse momentum dependent (TMD) cross-section, we need to introduce a new soft function that we calculate at one-loop, regulating rapidity divergencies with the delta-regulator. We use consistency relations with heavy meson pair production in DIS to extend the anomalous dimension of the dijet soft function to three loops. We also provide phenomenological discussion and preliminary plots for this process, which is expected to be measured at the future EIC. The study of these processes could provide new knowledge of the TMD gluon distributions, to which they are sensitive.

Poster Session II / 330

In-situ Cosmogenic Background for LEGEND

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The Large Enriched Germanium Experiment for Neutrinoless double beta Decay (LEGEND) Collaboration aims to develop an experimental program to search for neutrinoless double-beta decay in ^{76}Ge, with a half-life sensitivity of up to 10^{28} years in the second phase. Assuming a light neutrino exchange model, the sensitivity would cover the entire parameter space for neutrinos in the inverted hierarchy, as well as a portion of the normal hierarchy parameter space. Discovery of this decay mode, or exclusion of this decay mode in the case of inverted hierarchy, would have far-reaching consequences for multiple areas of particle physics and cosmology.
The first phase of the project, LEGEND-200, will utilize 200 kg of isotopically enriched Ge detectors and is under construction at the Laboratori Nazionali del Gran Sasso (LNGS). The second phase of the project, LEGEND-1000, will use one tonne of enriched Ge in its search, and aims to operate at an unprecedented background goal of 10^{-5} (keV kg yr)$^{-1}$ around the Q value. Improvements in all areas of background modeling and analysis are being investigated in the pursuit of this goal. One area of active study is the background induced in-situ by atmospheric muons and their secondary particles. Towards this end, a standalone GEANT4 simulation module has been developed for exploring both the prompt and delayed signals generated by the passage of the muons. The two sites primarily investigated in these simulations are LNGS, with a rock overburden of 3400 m.w.e., and SNOLAB, with a rock overburden of 6000 m.w.e. An estimate of the impact of the muon-induced signals over the lifetime of the experiment has been produced, along with the effectiveness of a variety of analysis cuts. Presented here are the results of the baseline simulations to date, as well as the implications for a number of alternative design options which have been considered while planning LEGEND-1000.

Dark matter and cosmology / 331

Dark sector searches with NA64 experiment at CERN

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The existence of dark sectors is an exciting possibility to explain the origin of Dark Matter (DM). In addition to gravity, DM could interact with ordinary matter through a new very weak force. This new interaction could be mediated by a new massive vector boson, called dark photon (A'). If A' exists, it could be produced through the kinetic mixing with a bremsstrahlung photon from a high-energy electron scattering in a target. A' could then decay invisibly into light DM particles, A′→χχ, or visibly, into e+e-. Searching for the former in events with large missing energy allows us to probe the γ−A′ mixing strength and the parameter space close to the one predicted by the relic dark matter density. Motivation for searching visible decays, has been recently enhanced by the anomaly observed in the 8Be and 4He nuclei transitions that could be explained by the existence of a 17 MeV boson also decaying into e+e-. In this talk, we present the latest NA64 results from the combined 2016-2018 data analysis for visible and invisible modes, and the future prospects in 2021. New recent results on axionlike and scalar particles searches produced though Primakoff reaction will also be discussed. Finally, the new NA64 muon program, exploring dark sectors weakly coupled to muons will also be presented.

Flavour physics - CKM and beyond / **332**

Searching for New Physics with $B_s^0 \to D_s^\pm K^\mp$ Decays (17+3)

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Particularly interesting processes to test the Standard Model are non-leptonic $B_s^0 \to D_s^\pm K^\mp$ transitions. As these decays occur via pure tree diagrams, they allow a theoretically clean determination of the angle γ of the unitarity triangle. Considering recent LHCb results, an intriguing picture arises, showing tension with the Standard Model. Utilising the available experimental data, we perform a theoretical analysis in order to shed more light on these puzzling patterns. Do these puzzles actually indicate footprints of New Physics?

QCD, spin physics and chiral dynamics / **333**

Transverse single-spin asymmetries and cross section of weak bosons in p+p collisions at √s = 510 GeV

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The STAR experiment at RHIC has measured transverse single-spin asymmetries of W$^\pm$/Z_0-bosons in proton-proton collisions at a center-of-mass energy $\sqrt{s}$ = 510 GeV (2017 data). These asymmetries probe correlations between parton motion and the proton spin in the initial state which are described in terms of transverse momentum dependent parton distribution functions (TMD), in this case the Sivers function. The Sivers function is of particular theoretical interest because its process dependence can be linked to underlying kinematics, namely the gauge link structure of the scattered parton with the nucleon remnant. This means that the Sivers function is not universal and a sign

change is expected between the asymmetries measured in semi-inclusive deep inelastic scattering compared to those in hadronic collisions. The new STAR preliminary results with an integrated luminosity of about 350 pb^{-1} improve significantly on previous data from 2011. We will discuss details of the full reconstruction of the W-boson kinematics which are required for a true TMD measurement. Comparison with recent global fits will illustrate the potential impact of the new data. In addition, we will present an improved cross section measurement of Z_0-bosons as function of transverse momentum which now comprises an integrated luminosity of about 700 pb^{-1}. The STAR data are complementary to existing LHC results and will provide important input into unpolarized TMD fits.

Dark matter and cosmology / 334

Measurement of the antinuclei nuclear inelastic cross sections with ALICE and implications for indirect Dark Matter searches

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Antinuclei in cosmic rays are considered a unique probe for signals from exotic physics, such as WIMP Dark Matter annihilations. Indeed, these channels are characterised by a very low astrophysical background, which comes from antinuclei produced by high energy cosmic ray interactions with ordinary matter.
In order to make quantitative predictions for antinuclei fluxes near earth, both the production and annihilation cross sections of antinuclei need to be accurately known down to low energies.
In ultra relativistic pp, p-Pb and Pb-Pb collisions at the CERN LHC, matter and antimatter are abundantly produced in almost equal amounts, allowing us to study the production of antinuclei and measure their absorption in the detector material. The antinuclei absorption cross section is evaluated on the average ALICE material. Using this result, we then predict the transparency of our galaxy to anti-3He from both dark matter annihilations and high energy cosmic ray collisions.
In this talk we present the first measurements of the antideuteron and anti-3He absorption cross section with ALICE and we discuss the implications of these results for indirect Dark Matter searches using cosmic antinuclei.

Neutrino physics / 336

Neutrino Oscillation Results from the NOvA Experiment

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The NOvA experiment is a long-baseline accelerator-based neutrino oscillation experiment that uses the upgraded NuMI beam from Fermilab to measure electron-neutrino appearance and muon-neutrino disappearance between the Near Detector, located at Fermilab, and the Far Detector, located at Ash River, Minnesota. NOvA's primary physics goals include precision measurements of oscillation parameters, such as θ_{23} and the atmospheric mass-squared splitting, along with probes of the mass hierarchy and of the CP-violating phase. This talk will cover NOvA's most recent three-flavor oscillation results, based on a neutrino beam exposure of 13.6E20 protons-on-target and an anti-neutrino beam exposure of 12.5E20 protons-on-target.

Nuclear and particle astrophysics / 337

Probing hadronic interactions with the Pierre Auger Observatory

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Cosmic Rays are high-energetic particles of cosmic origin constantly bombarding Earth. Their energies extend beyond 10^{20} eV, 400 TeV in the center of mass system for proton-proton collisions. Such energies are well above those achieved by LHC and therefore hadronic models in this range rely on extrapolations from energies several orders of magnitude lower. Cosmic rays offer therefore the unique possibility to test the hadronic interactions in a range unattainable by accelerators. Moreover, using cosmic rays one can explore the high pseudorapidity regime as well as high-energetic proton-nucleus and nucleus-nucleus interactions, well studied only at lower energy.
The Pierre Auger Observatory is the largest Cosmic Ray observatory ever built (3000 km^2), operating since 2004 in the Argentinian Pampa. In this contribution an overview of the results obtained by our collaboration will be given with a special focus on the particle physics implications. We will show the proton-Air cross section at 38.7 and 55.5 TeV. Our data indicate that hadronic interaction models fail in the predictions of the muon densities on the surface. The activities to investigate this inconsistency will be presented. Current activities for the search of hypothetical Lorentz Invariance Violation will be also briefly discussed.

Poster Session II / 338

CPT symmetry test in positronium annihilations with the J-PET detector

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Discrete symmetry under the combined transformation of charge, parity, and time-reversal (CPT) can be tested in the decays of positronium atom, the lightest bound system built of charged leptons. Jagiellonian Positron Emission Tomograph (J-PET) device constructed from plastic scintillators, detects the photons originating from electron-positron annihilation. This feature enables J-PET to study CPT symmetry in the three-photon annihilations of the triplet state of positronium. Signs of violation of the CPT symmetry can be sought as a non-vanishing expectation value of an angular correlation operator that is odd under CPT transformation. Technique to estimate the spin of ortho-positronium and momenta of annihilation photons for a single recorded ortho-positronium event allows J-PET to measure the expectation value of CPT symmetry odd angular correlation operator. J-PET measures a broad range of kinematical configurations of ortho-positronium annihilation to three photons and is the first experiment to determine the full range of the CPT-odd angular correlation. The presentation will include the methods of performing the CPT symmetry test using an angular correlation operator which involves the spin and momenta of photons originating from o-Ps$\rightarrow 3\gamma$ decay using extensive size positronium production and annihilation chambers with the J-PET detector.

Poster Session I / 339

Mott polarimeter for electrons from neutron decay in BRAND experiment

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Abstract:
The BRAND experiment aims at the search of Beyond Standard Model (BSM) physics via measurement of exotic components of weak interaction. For this purpose, eleven correlation coefficients of neutron beta decay will be measured simultaneously. Seven of them: H, L, N, R, S, U and V, are sensitive to the transverse polarization of electrons from free neutron decay. The correlation coefficients will be derived using Mott polarimetry and completely determined kinematics of products from the polarized neutron beta decay. For this aim the beam of cold polarized neutrons available in PF1B areal at ILL, Grenoble will be utilized.
The electron detection system features both the tracking and energy measurement capability as well as the Mott polarimetry for determination of the electron spin orientation. The 3D tracking is performed with a low density, helium based drift chamber of a hexagonal cell structure which is optimized for beta particles.
The Mott polarimeter is an integral part of the tracker. It consists of a thin Pb foil installed inside, the drift chamber and two plastic scintillators, providing trigger and scattered electron energy measurement.
The results of the first pilot run of the BRAND experiment performed in September '20 will be reported with emphasis on the description and the performance of the electron detection system and the Mott polarimeter.

Neutrino physics / **340**

Search for eV Sterile Neutrinos - The STEREO Experiment

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Search for eV Sterile Neutrinos – The STEREO Experiment

Mathieu Vialat on behalf of the STEREO collaboration\\

In the recent years, the study of reactor antineutrinos has revealed two unsolved anomalies. The first one is related to the neutrino spectral shape where an excess of detected neutrinos compared to the model is observed around 5 MeV. The second anomaly, called Reactor Antineutrino Anomaly (RAA), is a deficit of the detected neutrino flux compared to the expected one. This phenomenon could be explained by an oscillation to a new light sterile neutrino. It can be tested by searching for oscillations at a reactor with very short baselines.

The STEREO experiment was installed at $\sim$ 10 m from the compact core, highly enriched in ^{235}U, of the research reactor of the Institut Laue-Langevin (Grenoble, France). The detector has been designed to search for a new light sterile neutrino in the parameter region of the RAA best fit parameters ($\Delta m^2{}_{41}$ = 2.3 eV^2 and $\sin^2(2\theta_{ee}) = 0.17$), but also to characterize the flux and the shape of the pure ^{235}U spectrum. Data were taken between November 2016 and November 2020. STEREO has been able to exclude a significant part of the parameter space with a dataset of 179 (211) days reactor on (off) data. A measurement of the absolute flux, with the best precision for a single experiment at a reactor with highly enriched ^{235}U, has also been achieved. Finally the STEREO analysis provided a neutrino energy spectrum which shows an excess, compared to the rate-normalized Huber model, around 5 MeV similar to the one reported by other reactor experiments.

In this contribution we will give an overview of the STEREO experiment. Then, updated results obtained with the whole STEREO dataset,
collecting 334 (543) days on (off), will be presented.

Hot and dense matter physics - QGP and heavy ion collisions / 344

Deep Learning for the Classification of Quenched Jets

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Co-authors: Liliana Apolinário [1]; Nuno Castro [2]; Miguel Crispim Romao [1]; Guilherme Milhano [1]

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An important aspect of the study of Quark-Gluon Plasma (QGP) in ultra-relativistic collisions of heavy ions is the ability to identify a subset of jets that were strongly modified by the interaction with the QGP. In this talk, we will show how deep learning techniques can be applied for this purpose. Samples of Z+jet events were simulated in vacuum and medium and used to train deep neural networks with the objective of discriminating between medium- and vacuum-like jets. Dedicated Convolutional Neural Networks, Dense Neural Networks and Recurrent Neural Networks were developed and trained, and their performance will be shown. The results show the potential of these techniques for the identification of jet quenching effects induced by the presence of the QGP.

Dark matter and cosmology / 345

New method to search for axion-like particles demonstrated at the COSY storage ring

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The axion was originally proposed to explain the small size of CP violation in quantum chromodynamics. The axion would have a small mass and be weakly coupled to nucleons. If sufficiently abundant, it might be a candidate for the dark matter in the universe. Axions or axion-like particles (ALPs), when coupled to gluons, induce an oscillating Electric Dipole Moment (EDM) along the nucleon's spin direction. This can be used in an experiment to search for axions or ALPs using polarized charged particles in a storage ring.

In the spring of 2019, at the Cooler Synchrotron (COSY) in Jülich, we performed a first test experiment to search for ALPs using an in-plane polarized deuteron beam with a momentum of 0.97 GeV/c. The field of the ring magnets precesses the deuteron polarization in the horizontal plane relative to the beam velocity at a rate determined by the deuteron anomalous magnetic moment multiplied by the relativistic factor γ. In the frame of the moving beam, the radial electric field due to the ring magnets ($\mathbf{v} \times \mathbf{B}$) rotates the EDM. If the spin precession frequency equals the EDM oscillation frequency, which is proportional to the ALP mass, a resonance occurs that accumulates the rotation of the polarization out of the ring plane. This rotation is detected with a polarimeter that measures the transverse components of the beam polarization while the beam is stored. Since the axion frequency

is unknown, the momentum of the beam was slowly ramped, thus changing γ, to search for a vertical polarization jump that would occur when the resonance is crossed. At COSY, four beam bunches with different polarization directions were used to make sure that no resonance was missed because of the unknown relative phase between the polarization precession and the EDM oscillations. We scanned a frequency window of about a 1 kHz width around the spin precession frequency of 121 kHz. This talk will describe the experiment and show preliminary results.

Poster Session I / 346

Statistical hadronization explaining strangeness-abundant particle yields in pp collisions at $\sqrt{s}$ = 17.3 GeV

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Four yields of strange hadrons (ϕ and $\bar{K}^*(892)^0$ mesons, Ξ and Ξ^- baryons) emitted from p+p collisions at $\sqrt{s}$ = 17.3 GeV have been recently measured by the NA61/SHINE collaboration 1. These results prompted the creation of a unified set of particle yields, combining the data from NA49 and NA61/SHINE in a consistent manner (instead of treating the measurements separately [2,3]).

We used the Thermal-FIST statistical hadronization code with the canonical ensemble required for either hadrons with open strangeness only, or all the particles [4]. With physically unjustified omission of the ϕ meson yield, a satisfactory fit quality is obtained. However, all the particle yields including the ϕ meson might be reproduced with χ^2/NDF $\approx$ 1.5, if the volume of strangeness production is above that for non-strange particles. Newest NA61/SHINE results on Ξ^0(1530) and $\bar{\Xi}^0$(1530) baryons and K_S^0 meson [5] are also discussed.

The larger volume of strangeness emission zone in pp interactions might be revealed via HBT investigations of production volume of strange and non-strange particles. The uncertainties of existing measurements spread over energies above SPS do not allow to verify this conjecture. A precise femtoscopic study is therefore welcome.

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Hadrons in medium - hyperons and mesons in nuclear matter / 347

X-ray spectroscopy experiments on exotic Xi atoms at J-PARC

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X-ray spectroscopy of hadronic atoms is a strong measure
to determine the strong interaction between the hadron and
nuclei. At J-PARC, we have conducted two experiments on
exotic atoms with doubly strange hyperon, Ξ^-, aiming at
the world-first detection of the X rays. One is performed
as a byproduct of J-PARC E07 experiment (search for double
hypernuclei with hybrid emulsion technique) where Ξ^-
is stopped on the emulsion. The other is a dedicated experiement
for the detection of Ξ^--Fe atom X rays (J-PARC E03).
We will show the result of E07 and the status of the ongoing
analysis for E03. We also discuss future prospects of
Ξ-atomic X-ray spectroscopy.

Tests of symmetries and conservation laws / 348

Improved bounds on heavy quark electric dipole moments

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New physics models with additional CP violation sources are currently being constrained by searches for electric dipole moments (EDMs). Using the stringent limits on their chromo-EDMs, new bounds on the EDM of charm and bottom quarks will be derived. The new limits improve the previous ones by about three orders of magnitude. The implications for different Standard Model extensions will be discussed.

Dark matter and cosmology / 349

Signatures of Primordial Black Holes in theories of Large Extra Dimensions

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The addition of spatial dimensions compactified to submillimeter scales serves as an elegant solution to the hierarchy problem. As a consequence of the extra-dimensional theory, primordial black holes can be created by high-energy particle interactions in the early universe. While four-dimensional primordial black holes have been extensively studied, they have received little attention in the context of extra-dimensions. We adapt and extend previous analyses of four-dimensional primordial black holes for the purpose of studying the impact extra-dimensions have on cosmology. We find new constraints on both extra-dimensional primordial black holes, and the fundamental extra-dimensional theories by combining an analysis of Big Bang Nucleosynthesis, the Cosmic Microwave Background, the Cosmic X-ray Background, and the galactic centre gamma-rays. With these constraints we explore to what extent these extra-dimensional primordial black holes can comprise the dark matter in our universe.

QCD, spin physics and chiral dynamics / 350

Angular dependence and target-spin dependent asymmetries in pion-induced collisions at the COMPASS experiment

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The COMPASS experiment, located in the North Area of CERN, has the study of nucleon structure as one of its main physics goals. In 2015 and 2018, COMPASS collected Drell-Yan and J/ψ production data from the collisions of a 190 GeV negative pion beam on a transversely polarized ammonia target, and on a tungsten target. The study of the angular dependence of the dimuons produced provides valuable information on the transverse momentum dependent parton distribution functions (TMD PDFs) of both the nucleon and the pion. The measurement of target-spin dependent azimuthal asymmetries is of particular interest, as it can be used to test the predicted sign change of the Sivers TMD PDF when measured in the Drell-Yan process, as compared to the one measured in semi-inclusive deep inelastic scattering. The COMPASS experiment has the advantage of measuring both processes in very similar phase space. On the other hand, the transverse spin asymmetries measured in J/psi production may give access to the gluon Sivers TMD PDF, while improving our understanding of the charmonium production mechanisms. The most recent COMPASS results on dimuon angular dependences and target transverse spin dependent asymmetries will be presented.

Dark matter and cosmology / 351

Search for New Physics in e+e- Final States With an Invariant Mass of 10-20 MeV Using the ARIEL Electron Accelerator

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The DarkLight Collaboration
Arizona State University, University of British Columbia, Hampton University, TJNAF, MIT, St. Mary's University, Stony Brook University, TRIUMF,
University of Manitoba, University of Winnipeg

Proposal S2134 by the DarkLight collaboration of Canadian and U.S. institutions has been approved with high priority in April 2021 to carry out an experiment to search in the e+e- invariant mass region of 10 - 20 MeV in electron scattering from tantalum for evidence of new physics. The experiment will use the electron accelerator of the Advanced Rare IsotopE Laboratory (ARIEL) at TRIUMF, Vancouver, Canada. The experiment is motivated by anomalies resulting from the muon g-2 determination and reported in the decays of excited 8Be and 4He (ATOMKI anomaly). Initial data taking is anticipated to take place using a beam energy of 31MeV and intensity of 150 µA. It is anticipated that the energy available with the ARIEL electron accelerator will increase, thus providing a definitive experimental constraint on the existence of a dark fifth-force carrier, proposed to explain the reported anomalies. The planned experiment will be described in detail and expected sensitivities projected.

QCD, spin physics and chiral dynamics / 352

Measurements of jet substructure in proton-proton collisions with ALICE

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Jets encode the full evolution between the partonic state immediately following a hard-scattering interaction and the hadronic state measured in particle detectors. While only approximately 60% of the jet content corresponds to charged particles, this content can be measured with significantly higher precision than neutral particles such as photons or neutral hadrons. These measurements can be used to pose stringent tests of perturbative QCD calculations, as well as to study non-perturbative physics such as hadronization and underlying-event effects. In this talk we present an overview of recent charged-jet substructure measurements from pp collisions in ALICE, including generalized angularities, primary jet Lund plane, dynamical grooming, and angular distances between different jet axes for groomed and inclusive jets. These results provide new insights into the evolution of jets by comparing ALICE measurements to predictions from different event generators and pQCD calculations.

Poster Session II / 353

Inclusive Jet Cross-section Measurements in pp Collisions at $\sqrt{s} =$ 200 and 510 GeV with STAR

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Jets, clusters of collimated particles produced in high energy proton-proton (pp) collisions, are an excellent tool to study the internal structure of the proton. According to perturbative QCD calculations, for center of mass energies of $\sqrt{s} = 200$ and 510 GeV at RHIC, jet production in the mid pseudo-rapidity, $|\eta| < 1$, is dominated by quark-gluon and gluon-gluon scattering processes. These jets are sensitive to gluons in the proton with momentum fraction $0.01 < x < 0.5$. The STAR experiment has measured a series of jet double-spin asymmetries within $-1 < \eta < 2$, in longitudinally polarized pp collisions, to constrain the gluon helicity distribution function in the proton. Similarly, jet cross-section measurements from unpolarized pp collisions are effective at constraining the unpolarized gluon distribution in the proton. In this talk, we will present the STAR preliminary results on mid pseudo-rapidity inclusive jet cross-section measurements in pp collisions at $\sqrt{s} = 200$ and 510 GeV as well as the techniques used in this analysis. They include an off-axis cone underlying event correction to the jet transverse momentum, an unfolding procedure to map the measured jet spectra to physical particle jet spectra, and the determination of the leading systematic uncertainties.

Hadrons in medium - hyperons and mesons in nuclear matter / 354

Femtoscopic study of coupled-channel baryon-baryon interactions with $S = -2$

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We investigate the momentum correlation functions of $S = -2$ baryon pairs ($p\Xi^-$ and $\Lambda\Lambda$) produced in high-energy nuclear collisions. The momentum correlation function reflects the baryon-baryon interaction at low energies and the source function. We use the interaction potentials obtained from recent lattice QCD calculations at nearly physical quark masses and the static Gaussian source model. We take account of the Coulomb potential and coupled-channel effects including the threshold difference. Coupled-channel effects generate the cusp structure and high-momentum tail in the $\Lambda\Lambda$ correlation function and enhance the $p\Xi^-$ correlation function at small relative momenta. Recently obtained experimental data of the correlation functions of $p\Xi^-$ and $\Lambda\Lambda$ pairs are simultaneously described by the coupled-channel baryon-baryon interactions from lattice QCD.

Poster Session II / 355

Measurements of quarkonium production in pp, p–Pb and Pb–Pb collisions with ALICE at the LHC

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Lattice Quantum Chromodynamics predicts the existence of dense and hot nuclear matter at high temperature that behaves as a deconfined medium of quarks and gluons, known as Quark-Gluon-Plasma (QGP). Such conditions are created by colliding heavy-ions (Pb–Pb) at ultra-relativistic energies which are then studied by ALICE at LHC. The properties of QGP can be studied by measuring the production of J/ψ, Υ(1S) and Υ(2S) in Pb–Pb collisions with respect to the yield in pp collisions scaled by the number of binary collisions. A suppression of J/ψ, Υ(1S) and Υ(2S) has been observed in Pb–Pb collisions at √s_{NN} = 2.76 TeV and 5.02 TeV mainly due to color Debye screening of quark-antiquark binding in QGP. However, for J/ψ the magnitude of the suppression at LHC energies is smaller than that observed at lower energies at SPS and RHIC, indicating that charmonium (re)generation via the (re)combination of charm and anti-charm quarks plays an important role. The measurement of elliptic flow of J/ψ may further constrain the inter-play between charmonium suppression and (re)generation mechanisms.

In addition to the medium modification of quarkonium resonances, a contribution from cold nuclear matter effects such as shadowing or nuclear breakup in addition to the QGP effects can be present. Such a contribution is evaluated by studying proton-nucleus collisions.

In this presentation, we will report the recent ALICE measurements of quarkonia at mid- and forward rapidity for various energies and colliding systems (pp, p–Pb, Pb–Pb and Xe–Xe). All the measurements are compared to various theoretical predictions.

Development of accelerators and detectors / 356

LHCb ECAL upgrade II

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The aim of the Phase-2 Upgrade of LHCb is to collect up to 300 fb^{-1} of data in a few years, operating at a luminosity of $(1..2) \cdot 10^{34} cm^{-2} s^{-1}$. Because of the significant increase in particle densities and radiation doses, the present LHCb Electromagnetic Calorimeter (ECAL) will require a major revision. The increased instantaneous and integrated luminosity will result in very high particle density and radiation doses in the areas close to the beam pipe. In these conditions, ECAL has to provide high-quality energy and position measurement for electromagnetic showers, as well as separation of two closely lying showers. Another requirement for the whole ECAL, which is aimed to reduce combinatorial background at high luminosity operation, is the ability to measure the time of arrival of the photon or electron with an accuracy of few tens of picosecond. The intrinsic time resolution of the ECAL modules is expected to be sufficient to meet this requirement, although the use of an additional timing layer is not excluded. The expected particle flow and radiation doses strongly depend on the distance from the beam pipe and determine the technology and granularity of the upgraded ECAL modules. The upgraded ECAL will be subdivided accordingly into several zones. The central part, with the highest expected doses, will be a sampling spaghetti calorimeter (SPACAL) based on radiation-hard crystal scintillators and a Tungsten absorber. The peripheral areas will be instrumented with modified Shashlik type modules, similar to the modules of the present ECAL, with modifications aiming to achieve the best time resolution for this technology. The intermediate part will be a spaghetti calorimeter with polystyrene-based scintillating fibres and a moulded lead absorber. The main advantages of using lead-polystyrene spaghetti type are the possibility to modify granularity with minimal intervention and fibres replacement to increase radiation hardness. An extensive R&D campaign is ongoing to optimize the Upgrade 2 ECAL structure. It includes: - studies of scintillating materials, in terms of scintillation kinetics and radiation hardness; - simulation studies to find the optimal detector layout, longitudinal segmentation and granularity; - beam test studies of the performance of various ECAL module prototypes, both for central (SPACAL) and peripheral areas. for the moment, a time resolution for 5 GeV electrons achieved for W-Crystal and Lead-Polystyrene Spacal prototypes is about 20 ps, and better than 40 ps for Shashlik type modules. In this talk, we will present the results of time resolution measurements for all these technologies, as well as predictions from detailed Monte-Carlo simulation.

Poster Session II / 357

The Cygno experiment for Dark Matter direct detection

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Innovative experimental techniques are needed to further search for dark matter weakly interacting massive particles. The ultimate limit is represented by the ability to efficiently reconstruct and identify nuclear and electron recoil events at the experimental energy threshold. Gaseous Time Projection Chambers (TPC) with optical readout are very promising candidates thanks to the 3D event reconstruction capability of the TPC technique and the high sensitivity and granularity of last generation scientific light sensors. The Cygno experiment is pursuing this technique by developing a TPC operated with He(Ar)-CF4 gas mixture at atmospheric pressure equipped with a Gas Electron Multipliers (GEM) amplification stage that produces visible light collected by scientific CMOS camera. A fast photodetector is used to measure the drift time of the primary ionisation electrons and thus reconstruct the third coordinate of the ionisation track. Events are then reconstructed with an innovative multi-stage pattern recognition algorithm based on advanced clustering techniques. In this contribution, we present the performances of prototype detectors assessed by exposing them to radioactive sources. We show that good energy and spatial resolution as well as discriminating power between nuclear and electron recoils is achieved in the KeV energy range. Finally, we discuss the plan to build a 1m3 demonstrator expected to be installed and operated at LNGS in 2021/22. This experimental campaign aims at proving the scalability of such a detector concept to a bigger apparatus able to significantly extend our knowledge about DM and neutrinos.

Poster Session I / 358

Status of ^{48}Ca double beta decay search with CANDLES

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Neutrino-less double beta decay($0\nu\beta\beta$) is acquiring great interest after the confirmation of neutrino oscillation which demonstrated nonzero neutrino mass. Measurement of $0\nu\beta\beta$ can provide a test for the Majorana nature of neutrinos and gives an absolute scale of the effective neutrino mass.

The CANDLE project is the challenge to discovery of ^{48}Ca $0\nu\beta\beta$. Among double beta decay nuclei, ^{48}Ca has an advantage of the highest $Q_{\beta\beta}$-value (4.27 MeV). This large $Q_{\beta\beta}$-value gives a large phase-space factor to enhance the $0\nu\beta\beta$ rate and the least contribution from natural background radiations in the energy region of the $Q_{\beta\beta}$-value. Therefore, good signal to background ratio is expected in a $0\nu\beta\beta$ measurement.

In order to search for $0\nu\beta\beta$ of ^{48}Ca, we have constructed the CANDLES-III system by using CaF_2 scintillators at the Kamioka underground laboratory, ICRR, the University of Tokyo. The CANDLES-III system aims at a high sensitive measurement by a characteristic detector system. The system realizes a complete 4π active shield by immersion of the CaF_2 scintillators in liquid scintillator. The active shield leads to a low background condition for the measurement. And we have also installed a shielding system in the CANDLES-III system to reduce background events by the high energy γ-rays, which were emitted from neutron capture reaction on surround materials. By the system, we reduced the background events from neutron capture by two orders of magnitude. After this upgrade, the system has achieved low background measurement with background level of 10^{-3} events/keV/yr/(kg of $^{nat.}$Ca) at the $Q_{\beta\beta}$-value. This is comparable or less than those of other sensitive experiments for double beta decay. Based on the result, we also started development for a next generation detector system for ^{48}Ca double beta decay measurement. In this system, we will use a CaF_2 scintillating bolometer and enriched ^{48}Ca.

In this paper, we will report result of ^{48}Ca double beta decay measurement by the CANDLES-III system and current status of the CaF_2 scintillating bolometer and enrichment of ^{48}Ca.

Flavour physics - CKM and beyond / 360

Four-quark operators and SU(3): from non-leptonic kaon decays to vacuum matrix elements (17+3)

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Four-quark operators mediate non-leptonic kaon decays and play an important role in inclusive QCD observables. Using their symmetry transformations and the known properties of QCD at low energies, we re-derive and extend generic relations among matrix elements and study their phenomenological implications. They include a determination of the electroweak-penguin contributions to eps'/eps based on hadronic tau-decay data and a study of the interplay of those relations with recent lattice data, which can be used to test the accuracy of large-Nc based estimates of matrix elements and to improve the predictive power in the tau sector.

Tests of symmetries and conservation laws / 361

BeamEDM - A beam experiment to search for the neutron electric dipole moment

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The neutron Electric Dipole Moment (EDM) has always attracted interest as a promising channel for finding new physics. The existence of a neutron EDM would violate CP symmetry given the CPT conservation. This new source of CP violation could explain the baryon asymmetry of the universe. The BeamEDM experiment aims to measure the neutron EDM using a novel technique which overcomes the previous systematic limitation of neutron beam experiments, the relativistic vxE effect. The experiment exploits the time-of-flight technique with a pulsed cold neutron beam which allows to distinguish between time dependent and time independent effects such as the EDM. A proof-of-principle apparatus has been developed to perform preliminary measurements for the future full-scale experiment intended for the European Spallation Source in Sweden.
In this presentation the details of the experimental setup together with the latest results from the data taking in August 2020 at the Institut Laue-Langevin in France will be presented.

Tests of symmetries and conservation laws / 362

Proton decay amplitudes with physical chirally-symmetric quarks on a lattice

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Proton decays are sought as manifestation of baryon number violation predicted by Grand Unification. Their amplitudes depend on nonperturbative QCD, and we calculate them on a lattice with chirally symmetric quarks at the physical point for the first time. Our results largely agree with previous determinations done with heavy quark masses. Therefore, our findings solidify evidence against simple Grand-Unified theories as the absence of observed proton decays cannot be due to chiral QCD dynamics.

Hot and dense matter physics - QGP and heavy ion collisions / 363

A Large-N Expansion for Minimum Bias

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Despite being the overwhelming majority of events produced in hadron or heavy ion collisions, minimum bias events do not enjoy a robust first-principles theoretical description as their dynamics are dominated by low-energy quantum chromodynamics. In this talk I will present a novel expansion

scheme of the cross section for minimum bias events that exploits an ergodic hypothesis for particles in the events, and events in an ensemble of data. This expansion is entirely defined in terms of observable quantities, in contrast to models of heavy ion collisions that rely on unmeasurable quantities like the number of nucleons participating in collision. The expansion parameter that is identified is the number of detected particles N, and as $N \to \infty$ the variance of the squared matrix element about its mean, constant value on phase space vanishes. With this expansion, I will show that the transverse momentum distribution of particles takes a universal form that only depends on a single parameter, with fractional dispersion relation, and agrees with data in its realm of validity. Further I will show that the constraint of positivity of the squared matrix element requires that all azimuthal correlations vanish in the $N \to \infty$ limit, as observed in data. This approach enables unified treatment of small and large system collective behaviour, for instance being equally applicable to collective behaviour in heavy ion collisions and pp collisions. I will also briefly comment on power counting and symmetries for minimum bias events in other collider environments and show that a possible "ridge"in e+e− collisions is highly suppressed as a consequence of its symmetries.

Development of accelerators and detectors / 364

Neutron beam test with a scintillator tracker for long-baseline neutrino experiments

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The long-baseline neutrino oscillation experiments rely on detailed models of neutrino interactions on nuclei. These models constitute an important source of systematic uncertainty, driven in part because detectors to date have been blind to final state neutrons. We are proposing a three-dimensional projection scintillator tracker as a near detector component in the next generation long-baseline neutrino experiments such as T2K upgrade and DUNE.
Such a detector consists of a large number of scintillator cubes with three orthogonal optical fibers crossing through each cube. Due to the good timing resolution and fine granularity, this technology is capable of measuring neutrons in neutrino interactions on an event-by-event basis and will provide valuable data for refining neutrino interaction models and ways to reconstruct neutrino energy. Two prototypes have been exposed to the neutron beamline in Los Alamos National Lab (LANL) in both 2019 and 2020 with neutron energy ranging from 0 to 800 MeV. These beam tests, aimed at characterizing our detector's response to neutrons, is a critical step in demonstrating the potential of this technology. In this presentation, the LANL beam test setup will be described and a neutron total cross section measurement will be shown.

Poster Session II / 365

A strong influence of weak decays on chemical freeze-out parameters of hadrons measured in high energy nuclear collisions found within the advanced Hadron Resonance Gas Model

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The advanced Hadron Resonance Gas Model (HRGM) which correctly accounts for the sequential strong and weak decays is developed. Our analysis of the STAR experiment data on hadronic multi-

plicities demonstrates that taking into account for the weak decays is extremely important to have a model that can describe the data with very high accuracy.
We report our results on fitting the particle yields measured at midrapidity in central nuclear collisions by the STAR Collaboration during the Beam Energy Scan I (BES) program for the center-of-mass collision energies √sNN = 7.7 − 200 GeV using an advanced HRGM based on the induced surface tension equation of state [1, 2] with the multicomponent hard-core repulsion.
Two fitting schemes are used: with and without weak decays. The chemical freeze-out (CFO) parameters extracted from the fit show a significant influence of weak decays on the fit quality. Moreover, their inclusion into the analysis of BES I data leads to decreasing the CFO temperature of hadrons by about 10–15 MeV. For the highest RHIC energies of collision the new CFO temperatures of hadrons, for the first time, are in complete agreement with the ones obtained earlier for the ALICE energy √sNN = 2.76 TeV [2, 3]. Furthermore, it is found that the new CFO temperatures of hadrons practically coincide with the lattice QCD results on pseudocritical temperatures at small values of baryonic chemical potential. Remarkably, it is shown that the CFO parameters of light (anti-, hyper-) nuclei obtained in 3 are not affected by these modifications.

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Poster Session II / 366

A Machine Learning Algorithm for Triggering the Project 8 Neutrino Mass Experiment

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Project 8 is a next-generation neutrino mass experiment that uses Cyclotron Radiation Emission Spectroscopy (CRES) to measure the neutrino mass. CRES is a novel technique for β-decay spectroscopy that measures the frequency of the cyclotron radiation produced by energetic electrons trapped in a magnetic field. The cyclotron frequency can be directly converted into the energy spectrum, which yields the neutrino mass through measurement of the spectrum endpoint. The next phase of Project 8 seeks to measure the energy spectrum of molecular Tritium β- decay in an O(10 cm^3) free space volume, using a multi-channel phased array of antennas. The low signal power (< 1fW) and multi-channel reconstruction place stringent constraints on the triggering and online signal processing algorithms. I present progress on a machine learning triggering algorithm that employs a Deep Convolutional Neural Network (DCNN) to detect the presence of cyclotron radiation signals buried in noise. The network achieves greater than 85% classification accuracy on simulated electron signals, outperforming conventional methods, and rivaling the performance of an optimal matched filter while requiring significantly fewer computational resources for online operation.

Tests of symmetries and conservation laws / 367

Searching for time-varying nuclear electric dipole moments using precision magnetic resonance

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The Cosmic Axion Spin Precession Experiments (CASPEr) search for ultralight axion-like dark matter. CASPEr-e is sensitive to the time-varying nuclear electric dipole moment, induced by the electric-dipole moment (EDM) coupling g_d. The detection scheme is based on a precision measurement of
^{207}Pb solid-state nuclear magnetic resonance in a polarized ferroelectric crystal. We calibrated the detector and characterized the excitation spectrum and relaxation parameters of the nuclear spin ensemble with pulsed magnetic resonance measurements in a 4.4 T magnetic field. We swept the magnetic field near this value and searched for axion-like dark matter with Compton frequency within a 1 MHz band centered at 39.65 MHz. Our measurements place the upper bound $|g_d| < 9.5 \times 10^{-4}$ GeV^{-2} (95% confidence level) in this frequency range. This constraint corresponds to an upper bound of 1.0×10^{-21} e · cm on the amplitude of oscillations of the neutron electric dipole moment, and 4.3×10^{-6} on the amplitude of oscillations of CP-violating θ parameter of quantum chromodynamics. Our results demonstrate the feasibility of using solid-state nuclear magnetic resonance to search for axion-like dark matter in the nano-electronvolt mass range.

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The role of small hard-core radius of (anti-)Lambda-hyperons in resolving the puzzle of (anti-)hyper-triton production in high energy nuclear collisions

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We present a summary of the results obtained with the novel hadron resonance gas model based on the induced surface tension equation of state 1 with the multicomponent hard-core repulsion. This model is used to resolve the long-standing problem to describe the light nuclear cluster multiplicities including the hyper-triton nucleus measured by the STAR Collaboration, known as the hyper-triton chemical freeze-out puzzle 2. Here we discuss an entirely new strategy to analyse the experimental data on light nuclear clusters and employing it in the analysis of hadronic and light (anti-)(hyper-)nuclei multiplicities measured by the STAR Collaboration at the center-of-mass collision energy $\sqrt{s_{NN}} = 200$ GeV and by the ALICE Collaboration at $\sqrt{s_{NN}} = 2.76$ TeV. We got rid of the existing ambiguity in the description of light (anti-)(hyper-)nuclei data and determined the chemical freeze-out parameters of nuclei with high accuracy and confidence. This success is achieved by taking into account the correct excluded volumes of light nuclei in hadronic medium and by using the small value of the hard-core radius of the $\Lambda/\bar{\Lambda}$ hyperons found in earlier work 1.
One of the most striking results is that for the most probable scenario of chemical freeze-out for the STAR energy the obtained parameters allow us to reproduce the multiplicities of hadrons and light (anti-)(hyper-)nuclei and, for the first time, to simultaneously describe the values of the experimental ratios S_3 and $\bar{S}_3$ which were not included in the fit. Our results show that the multiplicities of light nuclear clusters may be frozen prior to the hadrons at temperatures about $170 - 175$ MeV.
The new presented strategy allows one to determine the hard-core radii of other hyperons with high accuracy, if the yields of their hyper-nuclei are known.

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Hadron spectroscopy and exotics / 371

High energy $\pi\eta^{(\prime)}$ production and the double Regge exchange

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The $\pi^- p \to \pi^- \eta p$ and $\pi^- p \to \pi^- \eta' p$ reactions were recently studied by the COMPASS collaboration at CERN. The analysis has shown that for high energies the $\pi\eta^{(')}$ system is produced in two kinematic regimes. In these regimes the laboratory frame direction of $\eta^{(')}$ is either forward or backward. The Gottfried-Jackson frame analysis of the polar angle distribution revealed the characteristic forward-backward asymmetry in the polar angle, with the asymmetry being stronger for the $\pi\eta'$ system. We describe these processes in terms of double Regge exchange, where both meson-meson and meson-baryon invariant masses are large. The multi-Regge processes had been extensively studied in the seventies and the elegant mathematical formulation of the production amplitudes was developed. Nevertheless, the phenomenological status of the multi Regge approach was still not clear even in the simplest case of three particles in the final state. We have shown that applying the double Regge exchange and taking into account the leading 2^{++} Regge trajectories, we are able to explain the forward-backward asymmetry. We have also identified the dominant amplitudes and indicated that the observed asymmetry originates from the interference of the even and odd partial waves (with the latter being exotic). Especially the impact of the strongest odd wave, namely the $P-$ wave, is interesting through its direct relation to the production of the putative π_1 hybrid meson. The high energy amplitudes can be formally related to the production of exotic resonances through the Finite Energy Sum Rules.

Tests of symmetries and conservation laws / 372

Test of new operators of discrete symmetries with J-PET

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Search for possible violation of combined charge, parity, and time-reversal symmetries is yet another approach for a test of New Physics, therefore a bound state of electron and positron (positronium) as the lightest matter-antimatter system and at the same time aneigenstate of the C and P operators is an unique probe in such endeavour. The test is performed by measurement of angular correlations in the annihilations of the lightest leptonic bound system. The J-PET detector is the only device which enables determination of polarization of photons from positronium annihilation together with estimation of positronuium spin axis on the event-by-event basis. This allows exploration of a new class of discrete symmetry odd operators that were not investigated before. With first measurements demonstrating such capabilities we are able to reach the precision of CP and CPT tests at permill level. In the talk we will describe experimental techniques and new results of discrete symmetries tests in the decays of positronium in a whole available phase-space.

Applications of nuclear and particle physics technology / 373

From tests of discrete symmetries to medical imaging with J-PET detector

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The Jagiellonian Positron Emission Tomograph (J-PET) is a multipurpose detector for 1) tests of discrete symmetries, 2) medical imaging by combinig metabolic information collected by standard PET with structural information obtained from Positronium lifetime in a concept of morphometric image and 3) test of quantum entanglement of photons originating from the decay of positronium atoms. The experimental apparatus consists of 192 plastic scintillators read out from both ends with vacuum tube photomultipliers. Signals produced by photomultipliers are probed at four levels in the amplitude domain and digitized on 8 FPGA based readout boards in triggerless mode. Using the TOT (Time Over Threshold) response, as a measure of energy loss instead of charge integration methods, significantly reduces system deadtime, which is especially crucial in case of J-PET, built out of plastic scintillators producing very fast light pulses. System performance and recent results will be presented togehter with the non-linear correlation between input energy loss and TOT of the signal.

Neutrino physics / 375

Status of the Jiangmen Underground Neutrino Observatory

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The Jiangmen Underground Neutrino Observatory (JUNO) is a multi-purpose neutrino experiment currently under construction in South China, expecting to start data taking in 2023. JUNO primary goal is the determination of the neutrino mass ordering and the measurement at a sub-percent level three of the neutrino oscillation parameters and thanks to the detection of reactor antineutrinos at a medium baseline (53 km). The main detector, placed in a cavern 700 m underground, will consist of 20 kton of liquid scintillator contained in a 35.4 m diameter acrylic sphere, becoming the largest detector of its kind ever built in the world. JUNO will be instrumented with 17,612 20”photomultiplier tubes (PMTs), and 25,600 3”PMTs reaching a photo-coverage above 75%, and will achieve an unprecedented energy resolution of $3\%/\sqrt{E(MeV)}$ thanks to a comprehensive calibration system, among others. The acrylic sphere will be submerged in a water pool Cherenkov detector and covered on the top by layers of plastic scintillator to tag cosmic ray muons, a major source of background. During this talk the project's design and status will be presented.

Poster Session I / 376

The NUCLEUS experiment: a search for coherent elastic neutrino-nucleus scattering with reactor antineutrinos

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Coherent elastic neutrino-nucleus scattering (CEνNS) offers a unique way to study neutrino properties and to search for new physics beyond the Standard Model.

The NUCLEUS experiment aims at measuring the CEνNS signal from reactor antineutrinos. The detector will consist of a newly developed 10 g target array of CaWO4 and Al2O3 cryogenic calorimeters with demonstrated ultra-low threshold of ~20 eV, an energy region never explored so far. The experiment will be installed between the two pressurized water reactors of the Chooz B power plant in the French Ardennes. Currently, the experiment is under construction and the commissioning of the full apparatus is expected to start in 2022.

This talk will present the expected sensitivity of the NUCLEUS experiment to the CEνNS signal as well as its physics potential. The current status and the next steps of the experiment will be reported.

Hot and dense matter physics - QGP and heavy ion collisions / 377

Measurements of $D^{\pm}$ meson production and total charm quark production yield at midrapidity in Au+Au collisions at $\sqrt{s_{\rm NN}}$ = 200\,GeV by the STAR experiment

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One of main goals of the STAR experiment is to study the Quark-Gluon Plasma (QGP) produced in ultra-relativistic heavy-ion collisions. Charm quarks are an ideal probe of the QGP, as they are created primarily in hard partonic scatterings at early stage of Au+Au collisions. In this talk, we present the measurements of $D^{\pm}$ meson production in Au+Au collisions at $\sqrt{s_{\rm NN}}$ = 200 GeV by STAR using the data collected in 2014 and 2016. $\rm D^{\pm}$ mesons are reconstructed via a topological reconstruction of the three body hadronic decay $D^{\pm} \rightarrow K^{\mp}\pi^{\pm}\pi^{\pm}$, enabled by the exceptional track pointing resolution of the Heavy-Flavor Tracker. Supervised machine-learning techniques are used to improve the signal significance. The $D^{\pm}$ transverse momentum ($p_{\rm T}$) spectra are then obtained in 0-10\%, 10-40\%, and 40-80\% central Au+Au collisions. The spectra are used to calculate the nuclear modification factor as a function of p_T which reveals a significant suppression of high-p_T $D^{\pm}$ meson production in central and mid-central Au+Au collisions with respect to p+p collisions. The D^+/D^0 yield ratios as a function of $p_{\rm T}$ and centrality have also been extracted and compared to that from PYTHIA calculations. For the first time, STAR has measured the total charm quark production cross section per nucleon-nucleon collision, combining the main open charm hadron ground states ($\rm D^0$, $\rm D^{\pm}$, $\rm D_s$, and Λ_c), at midrapidity in 10-40\% central Au+Au collisions at 200 GeV, which provides insight into the charm quark production in heavy-ion collisions.

Hot and dense matter physics - QGP and heavy ion collisions / 378

A Time Reclustering Algorithm for Jet Quenching Studies

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Ultra-relativistic heavy-ion collisions have unlocked the study of a hot, dense state of QCD matter, the Quark-Gluon Plasma (QGP). However, due to its short lifetime, on the yoctosecond scale, the QGP must be studied with recourse to external probes, such as jets, collimated sprays of particles originated from the hard scattering.

Since jets are multi-scale probes, we can use jet quenching, the collection of medium modifications of the jets'substructure, to study the evolution of medium properties at various times

In this work, we show that one can assign a time structure to jets by using the formation time of a parton's emission. The obtained clustering history can be accurately reconstructed, and the medium modifications can be studied at various timescales, potentiating future tomographic measurements of the QGP.

Further, by classifying jets according to the formation time of the first unclustering step, one can select, out of an inclusive measurement, jet populations that were strongly modified by the QGP. This selection of jet populations by their quenching magnitude can help to distinguish specific features of jet-QGP interaction.

QCD, spin physics and chiral dynamics / 379

A model calculation of T-odd gluon TMD distributions at twist-2

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We perform explorative analyses of the 3D gluon content of the proton via a study of polarized T-odd gluon TMDs at twist-2, calculated in a spectator model for the parent nucleon. Our approach encodes a flexible parameterization for the spectator-mass density, suited to describe both moderate and small-xx effects. All these prospective developments are relevant in the investigation of the gluon dynamics inside nucleons and nuclei, which constitutes one of the major goals of new-generation colliding machines, as the EIC, the HL-LHC and NICA.

Nuclear and particle astrophysics / 380

Bridging the gap between spectroscopy of hot, radioactive ion beams, and cold, precise measurements

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Atomic and molecular ions contained in RF traps are demonstrating to provide some of the most precise measurements possible of electron-nucleon interactions.
Atoms and molecules containing radioactive nuclei are predicted to offer significant enhancements to constrain beyond the Standard Model effects, including searches for time-reversal symmetry, dark matter candidates and yet to be observed nuclear properties.
However, radioactive atoms and molecules present challenges for precision spectroscopy: they are produced at low rates (often <1000 per second), in hot environments (>300 K) and require accelerated

beam energies to isolate (>10 keV).
This contribution presents a setup under construction to efficiently adapt bunches of radioactive ions to a cryogenic ion trapping environment, which will additionally permit electric-field polarisation of molecules to allow for searches of eEDMs, nuclear Schiff moments and magnetic quadrupole moments.

Poster Session II / 381

Purification of large volume of liquid argon for LEGEND-200

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The LEGEND-200 experiment is under construction at the Laboratori Nazionali del Gran Sasso (LNGS) in Italy. Its main goal is a background-free search for neutrinoless double beta decay of Ge-76. Up to 200 kg of bare high purity germanium (HPGe) detectors with 76Ge enrichment beyond 86% will be deployed in liquid argon (LAr). The LAr will serve as a cooling medium for the detectors as well as a passive and active shield. The LAr active veto instrumentation will be composed of light guiding optical fibers connected to silicon photomultipliers for detecting scintillation light of argon. It has been already shown in the GERDA experiment that the LAr veto was a very powerful tool for background rejection.
The scintillation properties of LAr (attenuation length, triplet lifetime) are worsened by the presence in the liquid (at a ppm level) of electronegative impurities such as oxygen, water and nitrogen from quenching and absorption processes. Consequently, the efficiency of the LAr veto will be significantly impacted. In order to achieve the best possible performance of the LAr detector LAr will be purified during initial filling of the LEGEND-200 cryostat.
The design, construction and performance of the system capable of purifying 65m3 of liquid argon to sub-ppm level will be presented. The quality of the purified liquid is monitored in real-time by measuring the triplet lifetime and simultaneous direct measurements of the concentrations of impurities such as water, oxygen, and nitrogen with a sensitivity of 0.1 ppm. If needed, the system may also be used later to purify LAr in the cryostat in the loop mode. A dedicated cryogenic pump has been installed on the bottom of the LEGEND-200 cryostat to circulate LAr between the purification system and the cryostat.

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Status of the Majorana Demonstrator Neutrinoless Double-Beta Decay Experiment

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The Majorana Demonstrator is an experiment searching for neutrinoless double beta decay in ^{76}Ge. The Demonstrator consists of 44 kg (30 kg enriched in ^{76}Ge) germanium detectors in two modules operating at the 4850' level of the Sanford Underground Research Facility in Lead, South Dakota. The experiment has recently concluded its primary physics data taking campaign in March 2021, having operated since 2015. Published results with a 26 kg-yr exposure achieved a world-leading energy resolution of 2.5 keV FWHM at the double beta decay Q-value, one of the lowest background indices at the double beta decay Q-value, and a half-life lower limit of 2.7×10^{25} yr (90% C.L.). The low backgrounds, low-energy thresholds, and excellent energy resolution also enable competitive searches for double-beta decay to excited states and beyond the Standard Model physics. In 2020, one module

underwent significant hardware upgrades, which involved replacing several p-type point contact (PPC) detectors with four larger, novel geometry inverted coaxial point contact (ICPC) detectors. In this talk, we present the latest results of the Majorana Demonstrator including, the increased available exposure, improved analysis, and performance since the upgrade.

Poster Session II / 383

TPEX@DESY - Measuring Two-Photon Exchange at the DESY Test Beam Facility

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The striking discrepancy in the proton form factor ratio, $\mu_p G_E^p / G_M^p$, measured using unpolarized and polarized techniques is still not resolved. The leading explanation is hard two-photon exchange (TPE). Hard TPE is difficult to calculate without significant model dependence, and has generally not been included in radiative corrections. Three recent experiments found only a small contribution but were limited to relatively low Q^2 where the discrepancy is not clear. A new proposal, TPEX@DESY, would use an extracted beam at the DESY test beam facility together with a liquid hydrogen target and high precision lead tungstate calorimeters to measure hard TPE at higher beam energies. This would permit measurements in a Q^2 regime where the discrepancy in the proton form factor ratio is significant and where the expected hard TPE contribution is predicted to be large. The motivation and overview of the proposed measurements will be presented.

Poster Session II / 384

QED corrections to charged-current neutrino-nucleon elastic scattering

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Charged-current quasielastic scattering is the signal process in modern neutrino oscillation experiments and the main tool for the reconstruction of the incoming neutrino energy. Exploiting effective field theory, we factorize neutrino-nucleon quasielastic cross sections into soft, collinear, and hard contributions. We evaluate soft and collinear functions from QED and provide a model for the hard contribution with expected infrared and collinear behavior. We account for logarithmically-enhanced higher-order corrections and evaluate cross sections and cross-section ratios quantifying the resulting uncertainty in detail. We present results for various conditions of modern and future accelerator-based neutrino experiments.

Poster Session I / 385

Improved modeling of reactor antineutrino spectra

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Over the last decades, Inverse Beta Decay (IBD) antineutrino experiments conducted at short and long baselines from nuclear reactors have revealed significant discrepancies on both the rate and shape of the measured spectra compared to state-of-the-art predictions. No evidence for an experimental bias has been detected, and the sterile neutrino interpretation of the reactor antineutrino anomaly has been mostly excluded by recent very short baseline reactor experiments. The validity of the predictions is then questioned as the source of the observed discrepancies. This last lead has motivated a revision of reactor antineutrino spectrum modeling as a new generation of reactor experiments investigating Coherent Elastic Neutrino-Nucleus Scattering (CEνNS) will continue to rely on predictions.

In this context, a revisited prediction of reactor antineutrino spectra using the summation method has been developed, including a thorough propagation of the uncertainties associated to both the modeling and the nuclear data. In this talk, I will detail the many improvements this new prediction brings over the previous modelings. I will show a comparison of this new modeling to other state-of-the-art predictions as well as some IBD datasets collected by recent short and long baseline reactor experiments. Finally, the low energy portion of the reactor antineutrino spectrum will be discussed in regards to the current experimental effort aiming at observing CEνNS at reactors.

Poster Session I / 386

Reactor CEvNS with SBC Liquid Argon Bubble Chambers

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The Scintillating Bubble Chamber (SBC) Collaboration is constructing a 10-kg liquid argon bubble chamber with scintillation readout. The goal for this new technology is to achieve a nuclear recoil detection threshold as low as 100 eV with near complete discrimination against electron recoil events. In additional to a dark matter search, SBC is targeting a CEvNS measurement of MeV-scale neutrinos from nuclear reactors. A high-statistics, high signal-to-background detection would enable precision searches for beyond-standard-model physics. I will discuss the status of SBC, the CEvNS physics reach, calibration and background challenges, and new techniques being considered by SBC to realize a precision sub-keV nuclear recoil calibration, such as nuclear Thomson scattering and Ar-40 neutron capture calibrations.

Poster Session II / 387

LEGEND: The 76Ge Neutrinoless Double Beta Decay Program

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The Large Enriched Germanium Experiment for Neutrinoless ββ Decay (LEGEND) is a program searching for neutrinoless double beta decay of ^{76}Ge using high-purity germanium detectors operating in an active liquid argon veto. The first phase, LEGEND-200, is presently under construction at the Laboratori Nazionali del Gran Sasso (LNGS) in Italy and is scheduled to begin data taking in late 2021. This experiment consists of 200 kg of germanium detectors in an active liquid argon shield, and will achieve a half-life sensitivity of 10^{27} years over its 5 year run. LEGEND-1000 is the proposed tonne-scale successor, which will consist of 1000 kg of germanium detectors, achieving a discovery sensitivity exceeding 10^{28} years over its 10 year science operation. The design of LEGEND-1000 builds on the successful technology pioneered by the GERDA and MAJORANA DEMONSTRATOR collaborations, and further refined in LEGEND-200.

Hadrons in medium - hyperons and mesons in nuclear matter / 388

Hypernuclear spectroscopy with extended shell-model configurations

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Hypernuclear studies have played an important role to understand hyperon-nucleon fundamental interaction properties and also to disclose characteristic structures of many-nucleon systems with strange particles which are free from the nucleon Pauli principle. In various theoretical approaches in hypernuclear spectroscopy, different types of production cross sections are often compared in order to elucidate properties of many-body structures. Thus we focus our attention on the understanding of the new results of high-resolution $(e, e'K^+)$ experiments done at the Jefferson Laboratory (JLab) and then we will also discuss possibility of high-resolution (π^+, K^+) and (K^-, π^-) reactions being planned in the upgrade proposal of the J-PARC beamlines.

Recent $(e, e'K^+)$ reaction experiments done at JLab have provided us with remarkably high-resolution data showing p-shell hypernuclear structure details. These experiments have confirmed the major peaks and subpeaks predicted by the DWIA calculations based on the normal-parity nuclear core wave functions coupled with a Λ-hyperon in s- and p-orbits. At the same time, the data also show some extra subpeaks which seem difficult to be explained within the p-shell nuclear normal parity configurations employed so far. In order to describe the extra subpeaks, we have extended the model space by introducing the new configuration which includes non-normal parity nuclear core-excited states. By this extension we emphasize that the Λ-hyperon plays an interesting role to induce inter-shell mixing of the nuclear core-excited states having different parities.

For the ${}^{10,11}{}_{\Lambda}$Be and ${}^{10,11}{}_{\Lambda}$B hypernuclei, we will show the energy levels and the DWIA cross sections of (K^-, π^-), (π^+, K^+), and (γ, K^+) reactions that are calculated within the extended model space. Also, we will discuss the E1 and M1 transtions of these hypernuclei.

Hot and dense matter physics - QGP and heavy ion collisions / 389

Systematic study of energy loss in quark-gluon plasma at RHIC-PHENIX

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The phase transition from hadronic material to quark-gluon plasma (QGP) is a phenomenon that occurs under extreme conditions of high temperature and high density. The QGP causes energy loss of high momentum particles which is observed as a suppression of high momentum hadron production in A+A collisions relative to p+p collisions. PHENIX, one of the relativistic heavy ion collider (RHIC) experiments at Brookhaven National Laboratory, aims to measure various QGP signals from nuclear collision reactions. The study presented in this talk uses PHENIX data to evaluate the energy loss of partons in QGP in various collision systems. We systematically study the energy loss with $\pi^0 s$ in Au+Au and Cu+Au and Cu+Cu at $\sqrt{s_{NN}}$=200 GeV and charged hadrons in Au+Au at $\sqrt{s_{NN}}$=200 GeV using two quantities, S_{loss} and dp_T. S_{loss} represents the percentage of high p_T hadron momentum loss. Previous studies revealed the the scaling properties of S_{loss} on collision system size. The current study uses S_{loss} to quantify energy loss dependence on path-length and measures dp_T which is the difference in momentum loss between the in-plane and out-of-plane directions.
The interpretation of these results and their impact on our understanding of the path-length dependence of energy loss in the QGP will be discussed.

Poster Session I / 390

Electroluminescence yield of He-CF4-isobutane mixtures

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CYGNO is part of the CYGNUS international proto-collaboration for the development of a distributed Galactic Nuclear Recoil Observatory for directional Dark Matter search at low WIMP masses (1-10 GeV/c2) and coherent neutrino scattering measurement. CYGNO is developing a gaseous Time Projection Chamber (TPC), which will be hosted at Laboratori Nazionali del Gran Sasso, Italy. The CYGNO-TPC will rely on a triple Gas Electron Multiplier (GEM) stack for charge multiplication and electroluminescence (EL) production, operating at room temperature and atmospheric pressure. The EL will be collected with a high resolution scientific camera for particle identification and 2D track reconstruction, with the aim of discriminating nuclear recoils and their direction.
To probe the middle energy and mass range of WIMPs (GeV), having a low mass target is essential, hence He will be the main component of the CYGNO-TPC. The addition of CF_4 is also fundamental as it increases gas scintillation and sensitivity to Spin Dependent WIMP-Nucleon Coupling. To further improve the tracking capabilities of the gas mixture (such as electron diffusion and drift velocity), the addition of isobutane and other gases with high H-content is currently under consideration.
This work aims at determining how the addition of small percentages of isobutane to the He-CF_4 (60/40) base mixture influences the EL yield, charge gain and corresponding energy resolution. The detector, operated in continuous-flow mode, was irradiated with low-energy x-rays (5.9-keV) and a Large Area Avalanche Photodiode (LAAPD) was used to readout the EL produced in the avalanches of a single GEM. Increasing concentrations of isobutane, from 1% to 5%, were added to the base mixture of He-CF_4 (60/40), continuously flowing at 4 L/h.
Our results show that the number of avalanche electrons increases with the addition of isobutane, with a 2.7-fold increase for 5% isobutane content relatively to 0%. The energy resolution of the charge signals is independent of the isobutane content and around 12 % (FWHM) for all mixtures. The EL yield decreases with increasing concentration of isobutane. Although a 7.9-decrease in the number of EL photons emitted per avalanche electron was measured for 5% isobutane relative to 0%, there was only a 2.8-fold decrease in the total number of emitted EL photons. The energy resolution of the EL signals was around 20%, showing a slight degradation with increasing isobutane content, which we attribute to low statistics.
These results show that isobutane does not compromise the total amount of EL photons, while maintaining the energy resolution of the base mixture unchanged and is therefore a good option to study for possible applications in the CYGNO-TPC.

Poster Session II / 391

Search for sterile neutrinos in low-energy double-cascade events with the IceCube Neutrino Observatory: a first expected sensitivity

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Sterile neutrinos are a well motivated facet of the new physics landscape. From their role in the mechanism through which Standard Model (SM) neutrinos acquire mass, to their potential explanation of anomalies in oscillation experiments and even as Dark Matter candidates, these hypothetical particles are thought to play a central part in the near future of particle physics. Many models of sterile neutrinos exist, in some of which they are allowed to decay to SM particles. If the sterile neutrino production and subsequent decay happens inside the IceCube detector, this would lead to a double-cascade signature similar to the one known from tau neutrino charged current interactions. However, the lifetime of the sterile neutrino is potentially much longer than that of the tau lepton, depending on its mass. This opens the possibility for a spatial resolution of a double-cascade topology at atmospheric neutrino energies, as opposed to searches for high energy tau neutrinos from astrophysical sources. In this talk, I will present the results of a first study of the IceCube-DeepCore detector sensitivity to such a signal, using simulation only. The strategy of this analysis is to study the topology of such double-cascade events and design a classifier that would help us isolate a sample of signal events over the background from SM processes. We study the sensitivity as a function of the signal parameters to determine in what conditions could IceCube see such a signal. Scanning the two-dimensional tau-sterile mixing parameter and sterile neutrino mass phase-space, we conclude that with the current state of the analysis tools, this search will have to wait for the IceCube Upgrade or a major improvement of the analysis tools in order for a signal to be isolated from the very large neutrino background.

Applications of nuclear and particle physics technology / 392

Measurements of 16O fragmentation cross sections on C target with the FOOT apparatus

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In Particle Therapy (PT), nuclear interactions of the beam with the patient's body causes fragmentation of both the projectile and target nuclei. In treatments with protons, target fragmentation generates short range secondary particles along the beam path, that may deposit a non-negligible dose especially in the entry channel. On the other hand, in treatments with heavy ions, such as C or other potential ions of interest, like He or O, the main concern is long range fragments produced by projectile fragmentation, that release the dose in the healthy tissues downstream of the tumor volume. Fragmentation processes need to be carefully taken into account when planning a treatment, in order to keep the dose accuracy within the recommended 3% of tolerance level. The assessment of the impact that these processes have on the released dose is currently limited from the lack of experimental data, especially for the relevant fragmentation cross sections. For this reason, treatment plans are not yet able to include the fragmentation contribution to the dose map with the required accuracy. The FOOT (FragmentatiOn Of Target) collaboration, funded by INFN (Istituto Nazionale di Fisica Nucleare, Italy) , designed an experiment to fill this gap in experimental data,

aiming the measurement of the differential cross sections of interest with an accuracy better than 10%. The apparatus, shown in figure 1, is composed of several detectors that allow fragment identification in terms of charge, mass, energy and direction. Starting from the incident beam direction, the particles cross a plastic scintillator (Start Counter) and a drift chamber to measure the start for the Time Of flight and to monitor the primary beam respectively. Then the beam interacts with the magnetic spectrometer composed by two pixel detectors, a microstrip detector and a permanent magnet system that provides the required magnetic field in order to measure the fragments momentum. The last part of the FOOT electronic setup is composed by a plastic scintillator wall (ΔE-TOF detector) and a calorimeter that provide the fragments energy loss (ΔE) and the stop of the TOF measurements.The TOF system composed by the SC and after ~ 2 m the ΔE-TOF detector, plays a crucial role as the charge Z of fragments reaching the ΔE-TOF detector can be identified from the energy loss ΔE and the TOF information. The two detectors have been optimized in order to achieve a TOF resolution lower than 100 ps and an energy loss resolution σ(ΔE)/ΔE ~ 5%. For this reason the SC thickness was carefully optimized looking for a good compromise between the out of target fragmentation probability, that called for the smallest possible thickness, and the time resolution, that is directly linked to the light yield requiring a thick detector. The final SC detector layout, that was optimized using MC simulations, foresees a squared EJ −228 plastic scintillator (5 × 5 cm2 active area) arranged in a set of four different thickness (ranging from 250 μm to 1 mm) used depending on the beam projectile and energy range. According to this geometrical proprieties the expected beam fragmentation inside the SC is about 5% of the incident ions. The plastic scintillator readout is performed by means of 48 3 × 3 mm2 SiPMs, 12 per side, bundled in eight electronic channels, each reading a chain of 6 SiPMs. The ΔE-TOF detector consists of a matrix of EJ-200 bars, 3mm thick, orthogonally arranged in two subsequent layers. The thickness of the bars is chosen as a trade-off between the amount of scintillation light produced in the bar (resulting in a better timing and energy resolution), which increases with the deposited energy and therefore with the bar thickness, and the systematic uncertainty induced on the ΔE- TOF measurement by secondary fragmentation in the bars that would worsen the particle identification and tracking. Each layer is composed of 20 bars that are 2 cm wide and 44 cm long, resulting into a 40 × 40 cm2 active area. The light produced in each bar is collected at both the extremities using to 4 SiPMs per side (3 × 3 mm2 active area) biased and read-out by a single electronic channel. The two detectors share the SiPM read-out system: the 88 output signals of the ΔE- ToF and the SC are digitized and recorded by using the WaveDAQ system, capable of a 0.5–5 GS/s sampling speeds.The FOOT TOF system has been tested with 12C and 16O ion beams with energies ranging from 115 MeV/u to 400 MeV/u in March 2019 at the CNAO (Centro Nazionale di Adroterapia Oncologica) experimental room. The measured TOF resolution has matched the expectations (the average resolution σ(ToF) ranges between 55 ps and 80 ps as a function of the beam kinetic energy) and fulfilled the requirements needed for the fragment atomic mass discrimination level needed by the cross section measurement program of the FOOT experiment. In April 2019 a first data taking was done at GSI Laboratory using a 400 MeV 16O beam impinging on a graphite target with a partial FOOT experiment setup including the SC, the Beam Monitor and the ΔE-TOF detectors. In this contribution the two timing detectors and their performance tested at GSI are explained in detail. In addition, preliminary results of the charge changing cross sections for the production of fragments with Z between 2 and 7 for the case of 400 MeV/u 16O beam integrated in the ΔE-TOF detector acceptance will be presented

Poster Session II / 393

Stability and Causality of the relativistic third order hydrodynamics

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The hot and dense QCD medium created in relativistic heavy ion collisions behaves like a fluid system and successfully studied by tools of relativistic hydrodynamics. A theory of relativistic hydrodynamics should be causal and stable. Causality is the restriction imposed by special theory relativity which doesn't allow any information to travel faster than the speed of light. The earliest formulations of relativistic hydrodynamic equations for non-ideal fluids were covariant generalisations of the Navier-Stokes equations of Newtonian non-perfect fluids by Eckart 1 and Landau-Lifshitz 2.

These are first-order theories which involve parabolic differential equations and violate causality and face instability problem. The parabolic character is responsible for the thermodynamic fluxes to react instantaneously to the corresponding thermodynamic forces which leads to the infinite speed of propagation of disturbances.

The attempts to get rid of the acausality and remove the instability of first-order hydrodynamics and to obtain a hyperbolic second-order theory led to the derivation of Israel-Stewart equations. In this generalised theory, dissipative fluxes such as heat flux, shear and bulk stresses are treated as independent variables and their evolution equations are hyperbolic in nature. The second-order theories allows the existence of a relaxation time for dissipative processes so the system doesn't returns to the equilibrium states instantaneously unlike Navier-Stokes theory, which restore causality. Hiscock and Lindblom later showed that the perturbations in the medium evolve causally and do not cause any instability in Israel-Stewart theory around equilibrium states 3.

Despite the success of Israel-Stewart theory in explaining a wide range of collective phenomena observed in heavy-ion collisions, it has resulted in unphysical effects such as reheating of the expanding medium [4] and negative longitudinal pressure [5]. This motivates the improvisation of the relativistic second-order theory by incorporating higher-order corrections. In Ref. [6] a new relativistic third-order evolution equation for the shear stress tensor from kinetic theory is derived. We will be presenting the analysis of the causality and stability properties of the third-order relativistic hydrodynamics and some interesting results about the dispersion relation and group velocity of modes of propagation of disturbances.

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Tests of symmetries and conservation laws / 394

Experiments with mid-heavy antiprotonic atoms in AEgIS

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Antiprotonic atoms have been fundamental in experiments which made the most precise data on the strong interaction between protons and antiprotons and of the neutron skin of many nuclei thanks to the clean annihilation signal. In most of these experiments, the capture process of low energy antiprotons was done in a dense target leading to a significant suppression of specific transitions between deeply bound levels that are of particular interest. In Particular, precise measurements of specific transitions in antiprotonic atoms with Z>2 are missing.
We propose to use the pulsed production scheme for the formation of cold antiprotonic atoms. This technique has been recently achieved experimentally for the production of antihydrogen at AEgIS. The proposed experiments will have sub-ns synchronization thanks to an improved control and acquisition system. The formation in vacuum guarantees the absence of Stark mixing or annihilation from high n states and together with the sub-ns synchronization would resolve the previous experimental limitations. It will be possible to access the whole chain of the evolution of the system from its formation until annihilation with significantly improved signal:background ratio. Moreover, the remaining highly-charged isotope can be trapped if the recoil from peripheral annihilation is sufficiently low. This could become an alternative path for production and measurement of several rare

isotopes.
In the contribution I will discuss the experimental scheme and challenges as well as the opportunities and relevance for atomic, nuclear and particle physics.

Dark matter and cosmology / 395

Bound state formation effects for dark matter beyond WIMPs

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Bound state formation can have a large impact on the dynamics of dark-matter freeze out in the early Universe, in particular for colored co-annihilators. We study their effect for dark-matter freeze out beyond the WIMP paradigm, i.e. for very weak dark-matter couplings. In this case, chemical decoupling is initiated by the break-down of efficient conversions between the co-annihilators and dark matter. This scenario has been dubbed conversion-driven freeze out or co-scattering. It provides a prolonged process of chemical decoupling rendering bound state formation particularly relevant. We investigate the importance of next-to-leading order bound state effects in this scenario and find that corrections to the bound state decay rate have the largest impact on the relic density – around 30%. Bound state excitations and corrections to the ionization rate are subdominant, potentially leading to an effect around 5% and below 1%, respectively. We reevaluate the cosmologically viable parameter space which extends significantly due to the corrections. As the scenario leads to the prominent signature of long-lived particles it provides great prospects to be probed by dedicated searches at the upcoming LHC runs.

Development of accelerators and detectors / 399

Space charge effects in liquid argon detectors and ion feedback experimental evidences

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In a noble gas time projection chamber, the electrons produced in the ionization are drifted to the anode for position reconstruction of the event, while the ions move in the opposite direction. The drift velocity of ions in liquid argon is five orders of magnitude slower than electrons, and a positive volume region is created by the accumulated ions, known as space charge. We studied the effects of the space charge for the next generation of liquid argon multi-tonne experiments for neutrino physics and dark matter searches

The space charge can modify the drift lines, the amplitude of the electric field, and ultimately the velocity of the electrons, thus, a displacement in the reconstructed position of the ionization signal can be produced. The constant recombination between free ions and electrons can produce a quenching of the charge signal and a constant emission of photons, uncorrelated in time and space to the physical interactions. In dual-phase detectors with charge amplification, where the electrons are

extracted to the gas phase and multiplied, these effects can be worsened by the ion feedback from gas to liquid phase.

In this talk, the predictions of the space charge effects for multi-ton argon detectors, with drift lengths of several meters, are presented, evidencing some potential concerns for this kind of detectors particularly when operated on surface. Finally, recent experimental results regarding the direct measurement of the ion feedback from the gas into the liquid phase, obtained with a dedicated setup in our laboratory, will also be discussed.

QCD, spin physics and chiral dynamics / 400

Exclusive cross section measurements at COMPASS

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Deeply Virtual Compton Scattering (DVCS) and Hard Exclusive Meson Production (HEMP) are very promising reactions to study Generalized Parton Distributions (GPDs). GPDs correlate the longitudinal momentum of the partons to their transverse spatial distribution inside the nucleon, and thus provide the 3-dimensional structure of the nucleon in QCD. Following a one-month test run in 2012, exclusive measurements were performed at COMPASS in 2016 and 2017 at the M2 beamline of the CERN SPS. The 160 GeV muon beam impinged on a 2.5m long liquid hydrogen target that was surrounded by a barrel-shaped time-of-flight system to detect the recoiling target proton. The scattered muons and the particles produced were detected by the COMPASS spectrometer, which was supplemented by an additional electromagnetic calorimeter for the large-angle-photon detection.

The DVCS cross section are extracted from the sum of cross-sections measured with opposite beam charge and polarization, with special attention made to separate DVCS from exclusive π^0 production. In the COMPASS kinematic domain, the DVCS cross section is closely related to the GPD H and provide the transverse extension of the partons in the Bjorken-x regime between valence quarks and gluons. On the other hand, the measurement of the cross-section of exclusive π^0 production, and the Spin Density Matrix Elements (SDMEs) of ρ^0 and ω can not only serve as important inputs for the chiral-odd GPDs, together with the chiral-even ones, but also provide insights into their reaction mechanisms. The current progress on the study of these exclusive channels will be presented.

Poster Session I / 401

Directionality for nuclear recoils in a liquid argon Time Projection Chamber

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Liquid argon (LAr) is one of the most promising targets for the search of WIMP-like dark matter. LAr dual-phase time projection chamber (LAr TPC) is a leading technology, able to detect both the scintillation and ionization signal. The correlation in the two signal channels provides a possible handle to measure the recoil direction of the nuclei: if confirmed, this would allow inferring the incident direction of potential dark matter candidates.

Previous work from SCENE resulted in a hint of the existence of a directional effect, which can potentially pave the way for a tonne scale directional WIMP search with LAr TPC. To validate this hypothesis, we conducted the Recoil Directionality (ReD) experiment to measure this correlation in 70 keV nuclear recoils to the highest precision.

The ReD TPC was carefully calibrated and then irradiated with a neutron beam at the INFN Laboratori Nazionali del Sud, Catania, Italy. A model based on directional modulation in charge recombination was developed to explain the correlation. In this contribution, we describe the experimental setup, the theoretical model, and the preliminary results from data analysis.

QCD, spin physics and chiral dynamics / 403

Effect of the pion field on the distributions of pressure and shear in the proton (NO SHOW UP)

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In the light of recent experimental progress in determining the pressure and shear distributions in the proton, these quantities are calculated in a model with confined quarks supplemented by the pion field required by chiral symmetry. The incorporation of the pion contributions is shown to account for the long-range distributions, in general agreement with the experimentally extracted quark contributions. The results of the model are also compared with lattice QCD results at unphysically large quark mass.

Poster Session I / 404

Sensitivity of r-nuclide distributions to the choice of nuclear mass model

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The astrophysical r-process of nucleosynthesis is widely considered to explain the production of stable and neutron-rich isotopes beyond the iron peak. Taking place at temperatures above 1 GK and very high densities, it is believed to occur in extreme astrophysical scenarios (e.g., [1, 2]), such as supernova explosions or neutron star and black hole collisions. In order to study stellar nuclear reactions computer simulations are commonly used. Simulation models of the r-process depend on a very large number of nuclear parameters. Thus, this nucleosynthesis mechanism poses great interest to both astrophysics and nuclear physics.

One of the most important parameters that impacts calculation of the neutron capture rates is the masses of participating nuclei, especially in the little-studied exotic isotope regions of the nuclide chart. Most of such masses were obtained not experimentally, but from theoretical models. For some isotopes different models predict significantly different values, which brings uncertainties to r-process calculations.

It was found in the first part of our research 3, that theoretical r-process yeilds of some isotopes are strongly dependent on the choice of the nuclear mass model. In this study different nuclear mass models were used to create a number of reaction rate libraries, analogous to the REACLIB [4]. Reaction rates and their cross sections calculation was performed using the TALYS package [5].

Following nuclear mass models were considered by us in this scope: the macro-microscopic models FRDM [6] and WS4 [8], the Skyrme interaction-based HFB mass model [7], and our mass evaluation based on local mass relations [9]. The latter is based on a phenomenological approach, assuming that the residual neutron-proton interaction energy behaves smoothly as a function of the mass number.

These reaction rates libraries were subsequently used to carry out simulations of the r-process. For this purpose we have used a nuclear reaction network of about 7000 isotopes and corresponding reactions with macroscopic conditions. Our implementation is based on the SkyNet modular nuclear reaction network library [10].

Final mass distributions of the nucleosynthesis products were obtained in an r-process scenario at 1.2 GK and the sensitivity of the calculation to the choice of the nuclear mass model was estimated. Comparison of the results of different models in the interval A = 60 ÷ 220 was performed. Obtained r-process isotopes yields show the differences of the considered mass models.

Nuclear and particle astrophysics / 405

The Southern Wide-field Gamma-ray Observatory

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The Southern Wide-field Gamma-ray Observatory (SWGO) main scope is the observation of the Galactic centre region and other sky regions not accessible from the Northern hemisphere. The Observatory is being designed to detect atmospheric air showers over a wide energy range, from few hundred MeVs up to PeVs. Therefore, it will detect not only air showers initiated by gamma rays, but also initiated by charged nuclei (hadrons). The SWGO detector design is focusing on improving the gamma/hadron air showers discrimination. For that, water Cherenkov detectors (WCD) with two interior cavities are being designed. Each cavity will have its own photomultiplier. The top cavity is expected to be more sensitive to the electromagnetic component of the air shower, while the bottom cavity will be sensitive to the muonic component. The information of the electromagnetic and muonic air shower components are crucial for understanding the air shower physics. Furthermore, the time resolution will be improved to the order of sub nanoseconds allowing the extraction of information of the air shower atmospheric profile. Such information will improve our ability to discriminate between air showers initiated by different nuclei (i.e. cosmic ray composition). This talk will give an overview of SWGO, highlighting its capabilities for studying high energy hadronic interactions with air showers. SWGO observations analysed in conjunction with observations from even higher energies (such as observations from the Pierre Auger Observatory) will be critical for improving our knowledge at the high energy frontiers of particle and nuclear physics.

Hadron spectroscopy and exotics / 406

Recent Results from the Gluonic eXcitation Experiment (GlueX) at JLab

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The GlueX experiment conducts searches for hybrid mesons, using a linearly polarized photon beam, impinging on a liquid hydrogen target. The GlueX detector provides a close to 4π acceptance and allows to reconstruct both, neutral and charged particle tracks which are produced in the γp reactions.

GlueX is taking data in two phases and has collected $\sim 8.4\,\mathrm{PB}$ of raw data so far. The first phase data has been fully reconstructed and calibrated, whereas the second phase is still running, using a DIRC upgrade.

This talk will give a brief overview of the GlueX physics program, highlighting the latest results obtained from the phase one data analysis. This includes the determination of polarization observables, cross section measurements, as well as an outlook on the first steps towards an amplitude analysis of hybrid meson search channels.

Hadrons in medium - hyperons and mesons in nuclear matter / 408

Experimental status toward the direct lifetime measurement of Hypertriton using the (K-, pi0) reaction at J-PARC

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The hypertriton (3ΛH) is the lightest hypernucleus consisting of a proton, a neutron, and a Λ hyperon. From old emulsion experiments, the Λ separation energy of the hypertriton has been measured as 130 ± 50 keV. Theoretical calculation shows that Λ hyperon is separated by ~10 fm from the deuteron inside hypertriton. Therefore, as a very loosely bound system, the lifetime of the hypertriton has been estimated to be close to that of free Λ particle (τ = 263 ps). However, in recent years, the lifetime of hypertriton in heavy-ion based experiments (ALICE, STAR and HypHI) has been found to be 30-40% shorter than expectation. This has been recognized as the hypertriton lifetime puzzle. In heavy-ion based experiments, the hypertriton events have been identified using invariant mass and the lifetime of hypertriton is derived from decay length. In order to shed light on this puzzling issue, we propose to measure the hypertriton lifetime in time domain directly as an independent and complementary approach.

Our proposal has been approved as the E73 experiment at J-PARC in Japan. The E73 experiment employs the (K-, pi0) reaction to populate hypertriton. This reaction is a novel production method to convert a proton into Λ hyperon by detecting pi0 meson. The high energy gamma-ray (>500 MeV) decayed from the forward projectile pi0 is used to select Λ events with smaller recoiling momentum, which has higher formation probability for hypertriton. These high energy gamma-ray are detected by the calorimeter installed in the downstream of the beamline. Hypertriton events can be identified with mono-energic pi- at ~114 MeV/c from two-body mesonic weak decay, which is measured by Cylindrical Detector System (CDS) composed of a solenoid magnet, a drift chamber and timing counters. The lifetime of hypertriton can then be derived from the time difference between start counter and stop counter after subtracting TOF obtained from tracking. The advantage of this approach is that it allows us to carry out a direct lifetime measurement, which is different from the heavy-ion based experiments. Another merit of the E73 experiment is to selectively populate hypertriton ground state and avoid any contribution from the postulated 3/2 excited state.

We have performed a test experiment with 4He target to demonstrate the feasibility of (K-, pi0) reaction in June 2020.The pilot run with 3He target has been carried out in May 2021. We have successfully identified 4ΛH and 3ΛH events. For case of 4ΛH, our new method allows us to drastically improve the precision of 4ΛH lifetime. For the just completed experiment with 3He target, we will derive the production cross section as a reference for the final data taking run planed in 2022~2023. In this talk, we will describe the details of our experimental method and present the current status of the E73 experiment.

Hot and dense matter physics - QGP and heavy ion collisions / 409

Phenomenological study of quarkonium suppression and the impact of the energy gap between singlets and octets

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The study of heavy quarkonium suppression in heavy-ion collisions represents an important source of information about the properties of the quark-gluon plasma produced in such collisions. The evolution of the reduced density matrix of heavy quarks inside a quark-gluon plasma is described by a master equation. In a previous work, we found that this master equation needs to take into account the finite energy gap between singlet and octet states in order to lead to the correct thermalization at late times. In this talk, we will discuss the phenomenological consequences of taking into account such energy gap when computing the nuclear modification factor. We will do this in two different scenarios, one using Hard Thermal Loop perturbation theory and another inspired by recent lattice QCD results on the static potential.

Poster Session I / 410

Prospects for the measurement of the b-quark mass at the ILC

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This note presents an analysis of the potential of future high-energy electron-positron colliders to measure the b-quark mass. We perform a full-simulation study of the measurement of the ratio of the three-jet rates in events with $b\bar{b}(g)$ and $q\bar{q}(g)$ production, R_3^{bl}, and assess the dominant uncertainties, including theory and experimental systematic uncertainties. We find that the ILC "Higgs factory" stage, with an integrated luminosity of 2 ab^{-1} at $\sqrt{s} = 250$ GeV can measure the b-quark $\overline{MS}$ mass at a scale of 250 GeV ($m_b(250$ GeV) with a precision of 1 GeV. From this result we extrapolate the potential of the GigaZ run
running at $\sqrt{s} = m_Z$. We expect $m_b(m_Z)$ can be determined with an 0.12 GeV uncertainty, exceeding the precision of the LEP and SLD measurements by a factor $\sim$3.

Poster Session I / 411

Methodology of accounting for aQGC effect on background for improvement of EFT coupling constants limits in case of electroweak $Z\gamma$ production at the conditions of run 2 of the ATLAS experiment

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In this report the model-independent effective field theory phenomenology is used to parameterize the anomalous couplings in the Lagrangian with higher dimensional operators. Setting limits on these operator's coefficients (EFT coupling constants) leads to new physics constraints. There are 2 terms of new physics are contained in the model: linear (interference) and quadratic. These terms were generated using decomposition method in MC event generator MG5_aMC.
In the classical version of setting these limits, all background processes are considered as non-depending on coefficients. However in general case one or several backgrounds can be affected by non-zero EFT coupling constants. This report presents the way of accounting such background processes in limits setting. As an example the electroweak $Z\gamma$ production is considered, since this process is extremely sensitive to anomalous quartic gauge couplings.

Neutrino physics / 412

New insight Into nuclear physics and weak mixing angle using electroweak probes

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In this talk we will present the first measurement of the neutron skin of cesium and iodine using electroweak probes, coherent elastic neutrino-nucleus scattering and atomic parity violation. This measurement, differently from hadronic probes, is model-independent and suggests a preference for nuclear models which predict large neutron skin values, with implications that range from neutron stars to heavy ion collisions.

Moreover, we will show a new determination of the low-energy weak mixing angle, with a percent uncertainty, fully determined from electroweak processes and independent of the neutron radius of cesium, allowed to vary in the fit. This will permit to put reliable constraints to theories beyond the standard model.

Hot and dense matter physics - QGP and heavy ion collisions / 413

Deciphering the role of multiple scatterings and time delays in the in-medium emission process

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Medium-induced gluon radiation is known to be an important tool to extract the properties of the QGP created in heavy-ion collisions. I will use a recent approach to evaluate the full in-medium gluon emission spectrum, including the resummation of all multiple scatterings, to analyze the validity of the usually employed analytical approximations. More specifically, by using this all-order result I will determine the kinematic regions in which the effects of multiple scatterings are essential and where, in contrast, a single hard scattering is enough to describe the in-medium emission process. Furthermore, I will compute the effects due to the inclusion of a time delay in the production of the medium has on the emission spectrum.

Poster Session II / 415

Flow fluctuation studies using a multiharmonic/large-order cumulant analysis

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In the past years, significant progress has happened in high-energy nuclear physics models. A more robust and quantitative picture has replaced the qualitative descriptions of heavy nuclei collisions in the earlier days, enabling us to have a clearer picture of different stages of a heavy-ion collision. These models typically have $O(10)$ free parameters that are tuned by Bayesian analysis in recent years. To better understand the free parameter values, it is essential to experimentally probe their phase space by observables, each containing independent information of the model.

In this presentation, our focus is on anisotropic flow observables. We introduce a method to extract anisotropic flow cumulant systematically. Employing a Monte Carlo simulation tuned by Bayesian analysis results, we predict the value of some low-order flow harmonic cumulants with significant signals that have not been reported by the LHC so far. Moreover, we introduce a new method to extract the linear and nonlinear hydrodynamic response coefficients based on our multiharmonic cumulant study. Besides, this systematic study enables us to propose a genuine three-particle correlation function for the first time. This observable is a summation of all third-order flow harmonic cumulants of all harmonics. The large-order flow cumulant ($v_n\{2k\}$ with large k) contains a unique piece of information about the underlying flow distribution. In particular, we discuss the relation between the nonvanishing Lee-Yang zero phase and large-order flow cumulant ratios at ultra-central, ultra-peripheral, large, and small collision systems.

Based on:
1. S. F. Taghavi, (2020), arXiv:2005.04742 [nucl-th] (will be appeared in Eur.Phys.J.C)

Tests of symmetries and conservation laws / 416

Precision measurement of muonium hyperfine structure at J-PARC

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A hydrogen-like atom in which a positive muon (μ^+) and an electron are bound is called muonium (Mu). The MuSEUM collaboration aims to determine the muonium's hyperfine structure (MuHFS) with a precision of 1 ppb, a tenfold improvement in precision compared to previous experimental results 1. Since muonium is a leptonic two-body system, high-precision comparison of experimental and theoretical results is the most rigorous validation of bound- state quantum electrodynamics (QED). In the experiment, the MuHFS is
determined by microwave spectroscopy of the Zeeman-split sublevels in a high magnetic field. The muon-to-proton magnetic moment ratio is obtained simultaneously, which is necessary for the experimental determination of the
muon's anomalous magnetic moment. The experiment is proposed to be performed at J-PARC MLF MUSE, where the world-highest intense pulsed
muon beam is delivered. Since the proposal submission in 2011, we have been developing the apparatus and conducting pilot experiments in a near-zero
magnetic field 3. We are working on high-precision NMR probes and a passive shimming method to obtain a uniform magnetic field in a superconducting
magnet to proceed to high-field experiments. In this contribution, the project overview, results of the zero-field experiments, and preparation status for a high-field experiment will be introduced.
\vspace{10pt}

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Flavour physics - CKM and beyond / 417

Measurement of structure dependent radiative $K^+ \to e^+\nu\gamma$ decays using stopped positive kaons at E36 (12+3)

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The J-PARC E36 experiment is aiming at searching for the lepton universality violation by precisely measuring the ratio of the branching ratio of the $K^+ \to e^+\nu$ (K_{e2}) to $K^+ \to \mu^+\nu$ ($K_{\mu2}$) decays. The E36 experiment was performed at J-PARC employing a stopped K^+ beam in conjunction with a 12-sector iron-core superconducting toroidal spectrometer. Charged particle momenta were calculated by reconstructing the tracks in the spectrometer. Particle discrimination between e^+ and μ^+ was carried out using an aerogel Cherenkov counters and a lead-glass Cherenkov counter, as well as by measuring the time-of-flight between TOF counters.

The peak structure due to the K_{e2} decays was successfully observed in the e^+ momentum spectrum. The structure-dependent radiative $K^+ \to e^+\nu\gamma$ ($K_{e2\gamma}^{\mathrm{SD}}$) events were selected by requiring one photon hit in the CsI(Tl) calorimeter. The experimental spectra were reproduced by the Monte Carlo simulation, which indicates a correct understanding of the detector acceptance. The $Br(K_{e2\gamma}^{\mathrm{SD}})$ value relative to $Br(K_{e2})$ was obtained by calculating the ratio of the $K_{e2\gamma}$ and K_{e2} yields corrected for their detector acceptances. A value of $Br(K_{e2\gamma}^{\mathrm{SD}})/Br(K_{e2}) = 1.22 \pm 0.07_{\mathrm{stat}} \pm 0.04_{\mathrm{syst}}$ was obtained, which is significantly larger than the value inferred from a previous experimental result for $Br(K_{e2\gamma}^{\mathrm{SD}})/Br(K^+ \to \mu^+\nu)$.

Neutrino physics / 418

Discovery of solar neutrinos from the CNO fusion cycle within

the Sun by the Borexino experiment

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Borexino has now been observing the Sun shining in neutrinos since over 14 years. The last and among the most important results obtained with this large liquid scintillator detector at the underground Laboratori Nazionali del Gran Sasso is the discovery of neutrinos from the Carbon-Nitrogen-Oxygen (CNO) cycle of fusion reactions.
Previously unobserved, the CNO cycle is predicted to be a dominant energy production mechanism for massive stars, while it remains secondary for stars of the mass of the Sun. Consequently, its small neutrino flux is hard to detect and poses real challenges for due to cosmogenic (11C) and intrinsic (210Bi) backgrounds within the detector. We present here the strategy adopted by the Borexino experiment to succeed in this challenge, including the extraordinary performance and stability achieved by the detector and the data analysis developed for the task, as well as the implications of this result on solar physics.

Hadrons in medium - hyperons and mesons in nuclear matter / 419

The phi meson in nuclear matter in a transport approach

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While the phi meson vacuum properties, such as mass and width, are well known, it is not clear how these properties will change once it is put in an extremely dense environment such as nuclear matter. To study how the phi meson behaves at finite density has been the goal of several past and near future experiments at multiple facilities [1-3]. Recently, ALICE at LHC has also obtained novel experimental data constraining the phi-N interaction [4].Theoretically, many works have been conducted with the aim of studying the phi meson in nuclear matter. Connecting theoretical results with experimental measurements is, however, not a trivial task, as the phi meson in nuclear matter is usually produced in relatively high-energy pA reactions, which are generally non-equilibrium processes.
In this presentation I will report on an ongoing project [5], attempting to simulate pA reactions in which the phi meson is produced in nuclei, making use of a transport approach [6]. First results of simulations of 12 GeV p+C and p+Cu reactions will be presented and comparisons between obtained dilepton spectra and experimental data of the E325 experiment at KEK 1 will be made.

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Poster Session II / 420

Semi-Exclusive Double Drell-Yan factorization and GTMDs

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In this talk we show how to apply the SCET formalism to factorize Double Drell-Yan process involving a pion and a proton, with four leptons and the proton in the final state. We will show how the factorization of the cross-section leads to the appearance of a Double TMD and two GTMDs. Additionally, we will show how the subsequent zero-bin subtraction leads to the appearance of a new Soft Factor and how the rapidity divergences work out at one-loop level.

Flavour physics - CKM and beyond / 421

Explaining the Cabibbo Angle Anomaly (17+3)

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The first row of the Cabibbo-Cobayashi-Maskawa (CKM) matrix shows a discrepancy of ~3σ with unitarity, known as the "Cabibbo Angle Anomaly"(CAA). After reviewing the origin and status of the anomaly, I investigate the various possibilities to explain it in the context of physics beyond Standard Model (BSM) which can be broadly grouped into three categories: modifications of four-fermion contact operators, modifications of the leptonic W vertices and modifications of the W vertices with quarks. In addition, I also discuss the phenomenological implications in the electroweak (EW) precision observables and low energy observables testing lepton flavour universality (LFU) which have to be taken into account in order to asses the viability of these solutions. Then, I review concrete realizations of BSM physics proposed to solve the CAA, which highlight the correlation with other existing anomalies such as $b \to s\ell\ell$ and $\tau \to \mu\nu\nu$, providing interesting predictions to be tested experimentally in the near future.

Poster Session II / 424

NEWS-G: Search for Light Dark Matter with Spherical Proportional Counters

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The NEWS-G (New Experiments With Spheres-Gas) collaboration is searching for light dark matter candidates using a novel detector concept, the spherical proportional counter. Access to the mass range from 0.05 to 10 GeV is enabled by the combination of a low energy threshold, light gaseous targets (H, He, Ne), and highly radio-pure detector construction. First NEWS-G results obtained with SEDINE, a 60 cm in diameter spherical proportional counter operating at LSM (France), excluded for the first time WIMP-like dark matter candidates down to masses of 0.5 GeV. The construction and on-going commissioning of a new, 140 cm in diameter, spherical proportional counter constructed at LSM using 4N copper with 500 μm electroplated inner layer will be presented, along with the latest developments in detector instrumentation. The detector is scheduled to collect data in SNOLAB (Canada) later this year. The design and construction of ECUME, a 140 cm in diameter spherical proportional counter fully electroformed underground will be discussed. The potential to achieve sensitivity reaching the neutrino floor in light Dark Matter searches, with a next generation detector are also summarised.

Hadron spectroscopy and exotics / 425

Exclusive and Inclusive photoproduction of XYZ

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I'll present estimations of cross sections for the electro- and photoproduction of several exotic candidates, including X(3872), Y(4260) and Z_c(3900)+ based on the publication 10.1103/PhysRevD.102.114010. I also present preliminary results of the inclusive photoproduction of these exotic meson candidates.

Flavour physics - CKM and beyond / 426

A Common Origin of Muon g-2, B-Meson Anomalies, and Fermion Mass Hierarchies (17+3)

Author: Anders Eller Thomsen[1]

Co-authors: Javier Fuentes-Martín [2]; Admir Greljo [1]; Ben A. Stefanek [3]

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Recent years have seen a series of anomalies hinting at lepton universality violation in B-meson decays, which can be explained with a single TeV-scale Pati-Salam leptoquark mediator found in "4321" models. The tension of the muon (g-2) measurement, as recently confirmed at Fermilab, with SM prediction can, however, not be explained with the same mediator. We explore how to explain the muon (g-2) in a "4321" model and find that such a model naturally addresses the fermion mass hierarchies.

Poster Session I / 427

Reducing the risk of proton therapy with prompt-gamma

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Radiotherapy, one of the techniques used to treat cancer, can be divided into conventional (gamma and electrons) and heavy charged particles radiotherapy. The latter, realized mainly with proton or carbon nuclei, has been highly anticipated due to its dose deposition profile, which presents a high deposition region at its end - the Bragg Peak. Dose deposition profile affects the risk to the surrounding healthy tissues and the existence of a Bragg Peak allows to increase the dose in the target region, whilst minimizing the dose to surrounding healthy tissues, reducing the risk of the technique. The control and monitoring of the Bragg Peak location can further increase the precision of the treatment. One way to perform this monitoring is to measure the prompt-gamma detected perpendicular to the incident proton beam. For that purpose a detector with a GSO scintillator crystal, connected to a SiPM is being studied. A set of blades in front of the sensor will act as a collimator to ensure that only perpendicular photons are detected. Currently SiPM coupled to GSO crystals time and amplitude structure is being studied to design a DAQ for the full prototype with O(100) sensors. This poster will focus on the prototype system and its concept.

Poster Session II / 428

Light Collection for the Scintillating Bubble Chamber (SBC)

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The ongoing search for dark matter continues to evolve, and the quest to reach lower cross-sections is leading to new technologies. One of the newer proposals involves the use of a bubble chamber which employs noble elements (such as argon and xenon) as the active mass. Combining recent developments of bubble chambers with liquid noble gases allows additional scintillation data to be collected. Scintillating bubble chamber (SBC) experiment plans to achieve a threshold as low as 100eV using this technology for the detection of dark matter. To maximize light collection, SBC is required to characterize 32 Hamamatsu VUV4 SiPMs (silicon photomultipliers). The characterization includes the dark noise rate, photo detection efficiency, and crosstalk as a function of temperature and breakdown voltage. This talk will show the current progress, and some preliminary results.

QCD, spin physics and chiral dynamics / 429

The chiral anomaly and axion-like dynamic in polarized DIS

Author: Andrey Tarasov[1]

Co-author: Raju Venugopalan [2]

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[2] *Brookhaven National Laboratory*

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I'll discuss the role of the chiral anomaly in deep inelastic scattering (DIS) of electrons off polarized protons employing a worldline formalism, which is a powerful framework for the computation of perturbative multi-leg Feynman amplitudes. I'll demonstrate how the triangle anomaly appears at high energies in the DIS box diagram for the polarized structure function $g_1(x_B, Q^2)$ in both the Bjorken limit of large Q^2 and in the Regge limit of small x_B. I show that the infrared pole of the anomaly appears in both limits. I will introduce an effective action for spin dependent observables at small x that follows from the cancellation of the infrared pole in the matrix element of the anomaly. This effective action, consistent with anomalous chiral Ward identities, is controlled by two dimensionful scales in Regge asymptotics. The first is the color charge squared per unit area, while the second is the pure Yang-Mills topological susceptibility.

Hadron spectroscopy and exotics / 430

Results of polarization observables in photoproduction reactions from the CBELSA/TAPS experiment

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The study of the nucleon excitation spectra allows to better understand the dynamics of the constituents inside the nucleons. Large discrepancies exist between experimentally observed states and predicted states from lattice QCD calculations or from phenomenological quark models. Experimentally, the nucleon excitation spectra can be investigated by studying different meson photoproduction reactions. Partial wave analyses are performed in order to extract the contributing resonances from experimental data. For an unambiguous solution it is not enough to only measure the unpolarized cross section, but several single and double polarization observables are needed in addition.

The CBELSA/TAPS experiment is located at the electron stretcher accelerator ELSA in Bonn, Germany. It offers the possibility to measure polarization observables with a linearly or circularly polarized photon beam and a longitudinally or transversely polarized target. The detection system consists mainly of two calorimeters: the Crystal Barrel and the MiniTAPS detector.

This talk will present recent results of several polarization observables from the CBELSA/TAPS collaboration. This work is supported by the Deutsche Forschungsgemeinschaft (SFB/TR16) and the Schweizerischer Nationalfonds.

Neutrino physics / 431

Atmospheric neutrino oscillation measurements and BSM searches with IceCube and KM3NeT

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Precision measurements of the flavor oscillations of atmospheric neutrinos have the potential to reveal several phenomena beyond the Standard Model. The DeepCore sub-array of the IceCube neutrino telescope is capable of detecting large amounts of atmospheric neutrinos at energies as low as 5 GeV, which allows for observations of neutrino oscillations via muon neutrino disappearance. A new sample of atmospheric neutrino events from 8 years of DeepCore data with improved event selection and reconstruction methods has been created that will be the basis for several highly sensitive analyses of standard oscillations and BSM phenomena. This talk presents a standard oscillation measurement using a sub-selection of highly pure muon neutrino events from the new event sample as well as the sensitivity that will be achieved when the full sample is used. In addition, we will provide an outlook on the capabilities of future low-energy upgrades to IceCube and KM3NeT.

Poster Session I / 432

THEORETICAL STUDIES ON PION PHOTOPRODUCTION ON DEUTERONS

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\documentclass{article}
\usepackage{amssymb,amsmath,gensymb}
\usepackage{graphicx,setspace}
\usepackage[affil-it]{authblk}
\usepackage{xcolor,tikz,fancyhdr}

\begin{document}

\author{Venkataramana Shastri\thanks{venkataramana.shastri@gmail.com}, Aswathi V and S P Shilpashree}
\title{Theoretical Studies on Pion Photoproduction on Deuterons}
\affil{School of Engineering and Technology, CHRIST (Deemed to be University), Bangalore, India}
\date{18/06/2021}
\maketitle
\section{Abstract}
The study of nuclear reactions between elementary particles and atomic nuclei plays an important role in understanding the interdisciplinary area
of Nuclear Physics and Particle Physics.
The study of photoproduction of mesons has a long history going back to 1950's.
It was in the next decade studies on photoproduction of π meson on deuteron started.
Since then coherent and incoherent photoproduction of π meson on deuteron have been studied theoretically and experimentally.
The study of photoproduction of pions describe the coupling among photon, meson and nucleon fields and also gives information about strong interactions
that indirectly hold the nucleus together.
A thorough investigation of the photoproduction process is firmly believed to give first hand information on two important aspects, one being the threshold of
π photoproduction amplitude and the other being propagation of low-energy pions in nuclear medium.
The purpose of the present contribution is to theoretically study pion photoproduction on deuterons using model independent
irreducible tensor formalism developed earlier to study the photodisintegration of deuterons.\cite{gr2006-1}

\begin{thebibliography}{}

\bibitem{gr2006-1}G Ramachandran, S P Shilpashree Phys. Rev. C {\bf 74}, 052801(R) (2006)

\end{thebibliography}
\end{document}

Hadrons in medium - hyperons and mesons in nuclear matter / 433

Light Exotic Λ Hypernuclei

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Hypernuclei with proton or neutron excess are of particular interest in strangeness nuclear physics 1. Such systems are loosely studied experimentally so far. The first attempts to get neutron-rich Λ hypernuclei [2-4] were taken using mesonic projectiles. Exotic hypernuclei can be produced also in heavy ion collisions [5], particularly, at NICA complex developed at JINR. Properties of exotic hypernuclei can shed light on the subtle features of the hyperon-nucleon and hyperon-nucleus interactions. Specifically, density dependence of the ΛN interaction, core polarization can be investigated as factors that may have a significant influence on structure of exotic hypernuclei [6]. The charge symmetry breaking ΛN interaction [1,7,8,9] is also relevant to exotic hypernuclei.

We address the structure of light Λ hypernuclei in the framework of Hartree-Fock approach with effective potentials in the Skyrme form. This phenomenological approach widely used in hypernuclear physics (e.g., [10,11]) allows us to analyze the hypernuclear properties in relation to both nucleon-nucleon and hyperon-nucleon components of the general baryonic interaction. Hyperon binding energies, as well as radii of nuclear cores are calculated using several Skyrme parametrizations. We consider isobaric chains of light Λ hypernuclei and show that the Λ binding energy depends slightly but sizably on $(N-Z)$ at fixed A.

Due to the glue-like role of the Λ hyperon, there is a chance to get bound hypernuclei with unstable cores. We test the possibility of the ^{9}C hypernucleus to be bound, and study its stability against two-proton and four-proton decays. We also examine the stability of exotic boron, nitrogen and oxygen hyperisotopes.

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Poster Session II / 434

Time calibration and monitoring in the ATLAS Tile Calorimeter

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The Tile Calorimeter (TileCal) is the hadronic calorimeter covering the central region of the ATLAS experiment at the LHC. This sampling device uses steel plates as an absorber and scintillating tiles as the active medium and its response is calibrated to the electromagnetic scale by means of several dedicated calibration systems. The accurate time calibration is important for the energy reconstruction, non-collision background removal as well as for specific physics analyses.
The time calibration as performed with collision data is presented. Its monitoring with laser system and collision data is discussed as well and the corrections for various identified problems. Finally, the time resolution as measured with jets in Run 2 is presented.

Development of accelerators and detectors / 435

The ATLAS Tile Calorimeter performance and its upgrade towards the High-Luminosity LHC

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The Tile Calorimeter (TileCal) is a sampling hadronic calorimeter covering the central region of the ATLAS experiment. TileCal uses steel as absorber and plastic scintillators as active medium. The scintillators are read-out by the wavelength shifting fibres coupled to the photomultiplier tubes (PMTs). The analogue signals from the PMTs are amplified, shaped, digitized by sampling the signal every 25 ns and stored on detector until a trigger decision is received. The TileCal front-end electronics reads out the signals produced by about 10000 channels measuring energies ranging from about 30 MeV to about 2 TeV. Each stage of the signal production from scintillation light to the signal reconstruction is monitored and calibrated to better than 1% using radioactive source, laser and charge injection systems. The performance of the calorimeter has been measured and monitored using calibration data, cosmic ray muons and the large sample of proton-proton collisions acquired in 2009-2018 during LHC Run-1 and Run-2.
The High-Luminosity phase of LHC, delivering five times the LHC nominal instantaneous luminosity, is expected to begin in 2028. TileCal will require new electronics to meet the requirements of a 1 MHz trigger, higher ambient radiation, and to ensure better performance under high pile-up conditions. Both the on- and off-detector TileCal electronics will be replaced during the shutdown of 2025-2027. PMT signals from every TileCal cell will be digitized and sent directly to the back-end electronics, where the signals are reconstructed, stored, and sent to the first level of trigger at a rate of 40 MHz. This will provide better precision of the calorimeter signals used by the trigger system and will allow the development of more complex trigger algorithms. Changes to the electronics will also contribute to the data integrity and reliability of the system. New electronics prototypes were tested in laboratories as well as in beam tests.
Results of the calorimeter calibration and performance during LHC Run-2 are summarized, the main features and beam test results obtained with the new front-end electronics are also presented.

Poster Session I / 436

Improving spatial resolution in neutron detectors with submicrometric B4C layers: Monte Carlo simulation results

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The physical properties of neutrons make them an excellent probe for the investigation of matter in different scientific fields, such as physics, chemistry and biology as well as for specific medical and industrial applications. Along with neutron imaging, a variety of techniques use neutron irradiation on a sample to characterize it, such as neutron diffraction, reflectometry, spectroscopy, and small angle scattering. All these have a common need: the detection of neutrons that are transmitted or scattered by the sample. Because neutrons are electrically neutral, their detection is usually achieved via nuclear capture reactions, in which the neutron is absorbed by the nucleus of an atom, which becomes unstable and decays into two highly ionizing charged particles. These reactions only occur with significant cross-section for a few isotopes and the ones with practical interest for detection applications are, by decreasing cross-section, 3He, 10B and 6Li. Until recent years, proportional counters filled with 3He gas were considered the golden standard for neutron detection, due to their high efficiency, good gamma-ray discrimination, and non-toxicity. However, when a severe shortage of this gas was acknowledged, prices skyrocketed and heavy acquisition restrictions were implemented, which urged for the pursue of alternative technologies. One additional motivation was given by the fact that 3He detectors were already at the limit of their performance capabilities, namely regarding counting rate and position resolution, which fell short of the requirements of instruments in new neutron facilities such as the European Spallation Source (ESS), that will provide a neutron beam up to one hundred times brighter than currently available in any other existing facility.

Consequently, over the last decade, a great deal of effort and investment was put into the development of 3He-free neutron detectors, and for a wide range of applications, gaseous detectors that rely on the 10B nuclear capture reaction are the most promising. Because elemental boron is a solid at STP conditions, these detectors employ a thin coating of boron or other boron-containing material, such as boron carbide (B4C), surrounded by a proportional gas for charge amplification. These materials are not self-supporting, hence are generally deposited directly on the inner walls of the detector or in aluminium substrates that are then inserted into it.

Due to momentum and energy conservation, the reaction products of the 10B neutron capture (an alpha particle and a 7Li nucleus) are emitted in the same line of action, in opposite directions. Consequently, in conventional boron coated detectors, for each neutron capture, only one of the reaction products can travel towards the gas to generate a signal in the detector, while the other is absorbed by the boron layer or the substrate. Furthermore, depending on the depth in which the nuclear capture occurs and the consequent energy lost to collisions inside the boron layer, the range of the 7Li and alpha particles in conventional proportional gases at atmospheric pressure can extend from virtually zero to about 10 millimetres. This intrinsically limits the spatial resolution of such detectors, which generally calculate the centre of gravity from many neutron detections to estimate with greater precision the neutron capture site. While this position uncertainty can be reduced by increasing gas pressure, which results in shorter particle travel ranges, this poses a mechanical challenge that requires the use of thicker entrance windows, which in term increases the probability of neutrons being scattered or absorbed before reaching the sensitive region of the detector.

Although the range of the 7Li and 4He fission fragments from the neutron capture reaction in solids is only of a few microns, current conventional gaseous neutron detectors based on 10B adopt detection layers with a combined thickness of converter and substrate with, at least hundreds of microns, most frequently extending to many millimetres. In this work, we propose an alternative approach that aims at simultaneously detecting both secondary products of neutron capture reactions which can be achieved if thin enough converter and substrate layers are deployed. By using independent readout systems to detect each particle that emerges on opposite sides of the conversion layer, and crossing the information from these two signals, it is possible to reconstruct the neutron interaction site with greater precision than using the centre of gravity approach of conventional detectors, while also requiring less statistic.

Monte Carlo simulations with GEANT4 were developed to compare the position reconstruction uncertainty of a state-of-the-art boron detector with the novel coincidence detector. An incident point thermal neutron beam at a fixed position was considered, and the estimation of the neutron interaction site for each detected neutron was achieved by weighting the energy deposited along the trajectory of each particle in the x-projection of the track. For the same neutron exposure, the simulation results show an improvement of intrinsic spatial resolution (FWHM) by a factor of approximately 8.

Poster Session I / 437

Recent results on ultra-peripheral collisions at the LHC with ALICE

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The ultra-peripheral collisions (UPCs) of relativistic heavy-ion collisions provide a unique opportunity to study the photon induced interactions
at the LHC in new kinematic regimes.

The ALICE experiment has measured the coherent photo-nuclear production of the ρ^0 and J/ψ vector mesons in UPCs.
The measurement of ρ vector meson is an excellent tool to study nuclear shadowing effects and the

approach to the black-disc limit of QCD, while the J/ψ measurement is also a good tool to study the nuclear shadowing and saturation effects at low-x.

In this contribution, recent results obtained with the data from the LHC Run2 will be presented.
The first measurement of the cross section of the ρ^0 mesons in Xe-Xe at $\sqrt{s_{NN}}$ = 5.44 TeV and Pb-Pb UPCs at $\sqrt{s_{NN}}$ = 5.02 TeV, and the cross section of the J/ψ mesons and its t-dependence in Pb-Pb UPCs at $\sqrt{s_{NN}}$ = 5.02 TeV will be reported.
These results are compared with various model predictions in order to improve our phenomenological understanding of the UPCs.

Nuclear and particle astrophysics / 438

Recent developments in the In-Medium Similarity Renormalization Group

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The ab initio description of nuclear systems has undergone a major renewal due to the use of low-resolution interactions derived from chiral effective field theory in conjunction with many-body techniques admitting for mild computational scaling 1.
Nowadays many-body practitioners are able to target systems with up to one hundred interacting particles from first principles in a systematically controllable way 2.
In this talk I present recent advances in the field of ab initio nuclear theory in the context of the non-perturbative in-medium similarity renormalization group (IMSRG) approach.
While the many-body expansion is commonly built upon a simple Hartree-Fock state, basis optimisation tools have shown to significantly improve the modelsapce convergence of the calculation [3,4].
In addition, by including three-body contributions induced by the RG flow enables for an improved many-body solution using ab initio technology [5].
Optimising the underlying reference state as well as relaxing the many-body truncation will eventually pave the way for high-precision studies in medium-mass systems.

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Poster Session II / 439

NLO Corrections to Di-Jet Production in DIS Using the Color Glass Condensate

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Di-Jet angular correlations serve as a sensitive probe of saturation physics in the Color Glass Condensate (CGC), an effective theory of QCD in which a heavy target nucleus can be modeled as a classical background field. The leading order cross section for di-jet production in Deep Inelastic

Scattering (DIS) is well known, but experiments at the Electron Ion Collider will be sensitive to corrections. Here we present our preliminary results for the calculation of Next to Leading Order (NLO) corrections to di-jet production in DIS at small Bjorken x, where the target nucleus is treated as a CGC. These results have additional utility in providing initial conditions for heavy ion collisions. The Wilson line correlators are averaged according to the gaussian (MV) model, and we use the spinor helicity formalism for efficient calculation of the helicity structure.

Poster Session II / 440

Neutral Bremsstrahlung in xenon unveiled

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Neutral bremsstrahlung emission in noble gases has been neglected in favor of excimer-based VUV emission. This alternative mechanism of secondary scintillation production was only recently unveiled in argon. We have found strong evidence of neutral bremsstrahlung emission in xenon, obtained using both the NEXT-White TPC, at present the largest optical Xe-TPC in operation, and a dedicated setup based on a Gas Proportional Scintillation Counter. The secondary scintillation yield was measured over 5 order of magnitude for a wide range of reduced electric fields. A non-negligible light production signal was detected even for low electric fields, under which drifting electrons have not sufficient kinetic energy to excite Xe atoms. Comparison with first-principle calculations allows us to assign this effect to neutral bremsstrahlung, which is intrinsically broadband and, as confirmed by our measurements, immune to quenching, unlike excimer-based electroluminescence emission.

For photon wavelengths below 1000 nm, the neutral bremsstrahlung yield increases from about 10^{-2} $photon/(cm\,bar\,e^{-})$ to above $3{\times}10^{-1}$ $photon/(cm\,bar\,e^{-})$ for reduced electric fields of about 50 $V/(cm\,bar)$ and 500 $V/(cm\,bar)$, respectively. At higher electric fields, above 1.5 $kV/(cm\,bar)$, the neutral bremsstrahlung intensity, around 1 $photon/(cm\,bar\,e^{-})$, is about two orders of magnitude lower than conventional secondary scintillation.

Despite being fainter than its excimeric counterpart, neutral bremsstrahlung (originated in the 'buffer' and 'veto'regions) can interfere with the ability to measure low primary-scintillation signals in gaseous or liquid Xe TPCs. This new source of light emission opens a viable path towards the development of single-phase liquid Xe TPCs based on secondary scintillation amplification for neutrino and dark matter physics, avoiding the very high electric fields required by conventional electroluminescence.

Poster Session I / 441

Search for TTRIV in the interaction of polarized neutrons with polarized targets

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In this talk, the current efforts of the NOPTREX collaboration to perform TRIV studies in different neutron - compound nucleus systems will be presented. I will describe the experiments we are currently performing and planning for the near future to better characterize PV asymmetries and *s*, *p* wave resonance parameters. The mixing between these energetically close resonances is responsible for the observed amplification in PV effects, and the same mechanism would also enhance any TRIV effect.

Poster Session I / 442

Searches for baryon number violation via neutron conversions at the European Spallation Source

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The observation of neutrons converting to antineutrons and/or sterile neutrons would demonstrate Baryon Number Violation (BNV) for the first time. BNV is an essential condition needed to produce the matter/anti-matter asymmetry in the universe and appears in a number of theories beyond the Standard Model. The existence of sterile neutrons would address the issue of a possible dark sector of particles. The HIBEAM/NNBAR project is a proposed series of experiments for the European Spallation Source (ESS) that can open up a discovery window for BNV by observing free neutrons transforming to antineutrons and/or sterile neutrons. A series of competitive searches are planned with an ultimate improvement in sensitivity of three orders of magnitude compared with the previous free neutron to anti-neutron search at Institut Laue-Langevin. This talk describes the HIBEAM/NNBAR experiment. The motivation for the experiment and theories predicting neutron conversions are described, followed by a description of the ESS and those ESS facilities which can be exploited for the experiment. The set-ups and sensitivities of the neutron conversion searches are shown. Special focus is placed on the annihilation detector which would use a Time Projection Chamber and calorimeter system exploiting scintillators and lead-glass. Geant-based simulations of the annihilation signature within a detector are shown and compared with background predictions. Finally, it is also shown how the program of work benefits from important but lower sensitivity searches ongoing by the Oak Ridge National Laboratory and being performed by many of the same collaborators as those on HIBEAM/NNBAR. Although it is a dedicated particle physics experiment, HIBEAM/NNBAR is a multi-disciplinary milieu, bringing together experts in neutronics, magnetics, detector design, and data analysis.

Poster Session II / 443

WISArD : Weak Interaction Studies with 32Ar Decay

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Nuclear beta decay is a powerful tool to test the Standard Model (SM) in the electroweak sector. The wide variety of nuclei and beta transitions allows us to choose the perfect candidate for specific tests of the SM which are competitive with high energy physics experiments 1. In particular, the beta-neutrino angular correlation coefficient $a_{\beta\nu}$ and the Fierz interference term b are directly sensitive to the possible existence of scalar (resp. tensor) currents in the well-established standard vector−axial-vector $(V - A)$ description of pure Fermi (resp. Gamow-Teller) transitions. These coefficients can be accessed either by directly measuring the energy distribution of the daughter nucleus or the emitted beta, or from the kinematic shift of secondary particles emitted after the decay. One of the best results to date on the modified $\tilde{a}_{\beta\nu}$ coefficient for a pure Fermi transition is at 0.65% 2. It was obtained using ^{32}Ar, from the broadening of the beta-delayed proton group emitted by the isobaric

analogue state of the daughter nucleus ^{32}Cl. In the WISArD experiment, we aim at a precision at the 0.1% level for the Fermi transition of ^{32}Ar from a new approach : we measure the kinematic *shift* of the beta delayed protons emitted in the same or the opposite hemisphere to the beta 3.
The proof-of-principle campaign of the experiment was performed in the fall of 2018 and already yielded the 3rd best precision level on $\tilde{a}_{\beta\nu}$. The precise analysis of this first campaign allowed us to draw a full account of the dominating systematic errors, that have since been tackled in a complete upgrade of the set-up. Four major items were optimized and will be presented : the beam control and monitoring was enhanced and the detection solid angle was maximized, both to increase statistics; the energy resolution of the proton detector was lowered by one order of magnitude and the beta detection threshold and backscattering simulations were validated on dedicated measurements, both to lower the main sources of systematic errors. This upgrade is now in its final stage, on track for the second run of data taking scheduled for the end of 2021. The potential precision at reach for this new campaign will be discussed.

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Neutrino physics / 445

Detecting CEvNS and beyond with CONUS

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The CONUS experiment aims at detecting coherent elastic neutrino nucleus scattering (CEνNS) at the nuclear power plant in Brokdorf, Germany, which has a maximum thermal power of 3.9GW$_{th}$. Four low energy threshold high-purity point contact Germanium spectrometers are set up in an elaborate shield achieving background levels comparable to experiments located much deeper underground.
With the data collected during Run-1 and Run-2 of the experiment and a full spectral analysis it was possible to determine the most stringent upper limit on CEvNS with reactor antineutrino in the fully coherent regime so far. This will be shown in the talk. Moreover, novel limits on physics beyond the standard model can be set such as on non-standard interactions (NSIs) in the neutrino-quark sector and on the neutrino magnetic moment. An overview on the latest results will be presented in the talk.

Flavour physics - CKM and beyond / 446

Ultralight scalars in leptonic observables (17+3)

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Many new physics scenarios contain ultralight scalars, states which are either exactly massless or much lighter than any other massive particle in the model. Axions and majorons constitute well-motivated examples of this type of particle. In this work, we explore the phenomenology of these

states in low-energy leptonic observables. After adopting a model independent approach that includes both scalar and pseudoscalar interactions, we briefly discuss the current limits on the diagonal couplings to charged leptons and consider processes in which the ultralight scalar ϕ is directly produced, such as $\mu \to e\phi$, or acts as a mediator, as in $\tau \to \mu\mu\mu$. Contributions to the charged leptons magnetic and electric moments are studied as well.

Poster Session I / 447

Beta spectrum shape measurements using a multi-wire drift chamber

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Beyond Standard Model (BSM) theories are typically probed in two types of experiments. In collider experiments, such as those carried out at LHC, exotic bosons are directly produced in high-energy proton - proton collisions. Another way to test BSM's, is by studying low-energy observables. This is facilitated by the small effects/currents of the same exotic bosons on these observables1. The shape of the beta spectrum, which is the topic of this research, is sensitive to two exotic currents, scalar and tensor, both prohibited in the SM weak interaction. For allowed transitions, these currents introduce a correction term in the spectrum, called the Fierz term bFierz , which is inversely proportional to the energy.
In addition to BSM's, the beta spectrum shape is a useful tool to probe SM effects. One of those effects is called Weak Magnetism (WM) and is induced by QCD interactions between quarks in the nucleon. For some particular transitions, a measurement of WM can provide a good test for the Conserved Vector Current hypothesis (CVC). Furthermore, the knowledge of WM for high-mass neutron-rich nuclei is crucial in the analysis of reactor anti-neutrino experiments2.
With this in mind, an attempt is made to measure the spectrum shape of the pure Gamow-Teller decay In114 -> Sn114, at the precision level of 10-3. To obtain a spectrum cleared from undesired systematic contributions, a plastic scintillator in combination with a multi-wire drift chamber was designed to measure the beta spectrum shape. The purpose of the drift chamber is to identify certain type of events , e.g. electrons that are backscattered from the scintillator surface, or cosmic muons. In addition to event pattern recognition, the setup allows for several filtering and calibration methods. For example, by requiring coincidence between detector and drift chamber, noise and gamma particles can be filtered. Furthermore, in order to correct for non-uniform light propagation in scintillator and light guide, tracking conversion electrons from a calibration source enables the real-time generation of a 2D-detector surface gain map.

The current results and progress with respect to detector calibration and efforts to tackle systematics in the measured 114In-spectrum will be presented. In addition, the results are compared with Monte-Carlo simulations, mainly based on Geant4 and Garfield++, as the analysis is depending on it. Finally, the preliminary results for WM extraction are shown.

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Poster Session I / 448

Effects of transverse momentum broadening of parton cascades from coherent emissions and scatterings in a medium

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In heavy ion collisions at high energies the hot and dense medium of a quark-gluon plasma (QGP) can be recreated and investigated.
We study how jets that were produced in hard binary collisions propagate and in particular how the jet-particle momentum components k_T transverse to the jet-axis change.
To this end, we evolved jets within a QGP medium, in which they undergo both medium induced coherent radiation as well as scatterings that involve transverse kicks,
using the MINCAS-algorithm 1 that is based on the works of [2,3].
In this framework parton branching occurs simultaneously to scatterings within the medium, leading to the interference effects that reproduce the well known BDMPS-Z emission rates.
In the most general form the resulting parton branchings also give rise to a sizeable k_T broadening.
Thus, it is interesting to compare the relative importances of k_T broadening from the coherent splittings and different types of in-medium scatterings.
We find a clear hierarchy of the influences from different scattering effects and deflections during branchings [4]:
While scattering still yields the largest contributions to broadening, the branching effects are comparable in size.
However, we find that with increasing strength of jet-medium interactions k_T broadening even decreases in some of the studied cases, due to
the interplay of scattering and energy loss due to branching.

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Development of accelerators and detectors / 449

The STAR Forward Upgrade

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The STAR Collaboration is building a Forward Upgrade to supplement the excellent mid-rapidity capabilities of the STAR Detector for the final years of the RHIC program. The Forward Upgrade will utilize tracking and electromagnetic and hadronic calorimetry to trigger on and measure charged and neutral hadrons, photons, jets, and di-electrons over the pseudorapidity region $2.5 < \eta < 4$. The Forward Upgrade will enable critical measurements to test the limits of universality and factorization in QCD when combined with future data from the EIC. In *pp* collisions, it will probe the structure of the nucleon at very high and low *x*, including for example measurements of the Sivers and Collins effects at *x* values higher than have been studied in semi-inclusive DIS. In *p*+Au collisions, it will probe nuclear modifications of the gluon density at low *x* and explore non-linear dynamics characteristic of the onset of gluon saturation. In Au+Au collisions, it will probe the longitudinal dynamics of hot QCD matter. This talk will present the status of the Forward Upgrade construction and describe the physics program that it will enable.

Tests of symmetries and conservation laws / 450

Laser spectroscopy of antiprotonic and pionic helium atoms at CERN and PSI

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The ASACUSA collaboration at CERN's Antiproton Decelerator, and the PiHe collaboration at PSI's 590 MeV ring cyclotron facility have carried out laser spectroscopy of metastable antiprotonic and pionic helium atoms. The latter is a three-body exotic atom composed of a helium nucleus, electron, and negative pion occupying a highly-excited state with principal and orbital angular momentum quantum numbers of n≈l-1≈17, which retains a τ=7 ns average lifetime. The atoms were synthesized by using the πE5 beamline of PSI which provides the world's highest-intensity continuous pion beam. The atoms were irradiated with 800 picosecond-long infrared laser pulses that induced a pionic transition (n,l)=(17,16)⟶(17,15) [1-4]. This triggered an electromagnetic cascade that resulted in the π- being absorbed into the helium nucleus. The nucleus underwent fission and the neutron, proton, and deuteron fragments were detected by an array of 140 plastic scintillation counters surrounding the target. This constitutes the first laser excitation and spectroscopy of an atom containing a meson. By further improving the experimental precision of the π4He+ transition frequencies and comparing them with the results of three-body QED calculations, the pion mass may be determined to a high precision. Similar measurements have been carried out for metastable antiprotonic helium [5-6] which will be pursued at the new ELENA facility. Limits may also be established on exotic forces that arise between pions or antiprotons and helium nuclei [7].

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Tests of symmetries and conservation laws / 451

ASACUSA antihydrogen program: current status and prospects

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The ASACUSA experiment aims at a precise measurement of the ground state hyperfine (GSHFS) splitting of antihydrogen with an initial relative precision of $\leq 10^{-6}$ to test the combined CPT symmetry. The Rabi-type measurement will be carried out in a polarized beam of antihydrogen atoms that is synthesized via three-body-recombination (3BR) of positrons and antiprotons at CERN's Antiproton Decelerator complex 1. A measurement with ground-state hydrogen atoms using the spectroscopy apparatus envisioned for antihydrogen yielded a 3ppb-precise value of the GSHFS 2, improving the previous measurement in a beam by more than an order of magnitude.

Antimatter atoms are produced via 3BR in a wide range of highly excited Rydberg states [3,4]. Thus, compared to hydrogen, the main challenge with antihydrogen lies in the production of GS atoms. Measurements [5,6] indicate that the rate of low-lying states needs to be increased by more than an order of magnitude to make measurements possible. In this view, the ASACUSA-CUSP collaboration is investigating different techniques to increase the GS fraction in the beam relying on stimulated deexcitation. I will present here novel developments on light-stimulated deexcitation [7] employed directly at the antihydrogen formation region that allow driving the formed atoms toward ground-state and thus enable a more efficient beam formation and polarization. As a consequence the ground state fraction at the cavity would be significantly increased. I will conclude on the future ASACUSA-CUSP physics program and it's prospects for antimatter spectroscopy measurements.

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Flavour physics - CKM and beyond / 452

CKM, CPV and mixing results at LHCb (20+5)

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CKM, CPV and mixing results at LHCb

Flavour physics - CKM and beyond / 453

Flavour physics with rare, electroweak-penguin, and semileptonic decays at LHCb (20+5)

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Flavour physics with rare, electroweak-penguin, and semileptonic decays at LHCb

Flavour physics - CKM and beyond / 454

Flavour prospects with the LHCb upgrades (15+5)

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Flavour prospects with the LHCb upgrades

QCD, spin physics and chiral dynamics / 455

Deeply Virtual Compton Scattering off the Neutron with CLAS12 at Jefferson Lab

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A key step towards a better understanding of nucleon structure in terms of generalized parton distributions (GPDs) is the measurement of deeply virtual Compton scattering off the neutron (nDVCS; $ed \to e'n\gamma(p)$). This process emphasizes mainly, in the kinematic range covered at Jefferson Lab, the access to the GPD E of the neutron which is the least constraind GPD up till now. The measurement of E, together with H, provides information on the quark total angular momentum –via the Ji's sum rule - and conveys a more complete picture of nucleon structure. The GPD E is accessed in nDVCS through the Beam Spin Asymmetry (BSA). The measurement of the BSA of nDVCS, combined with observables from pDVCS measurements, will allow to perform the flavor separation of relevant quark GPDs via linear combinations of proton and neutron GPDs. This talk will report on the experiment recently carried out at Jefferson Lab with the upgraded ~11 GeV CEBAF polarized electron beam, the Hall-B CLAS12 detector, and a liquid deuterium target. Details on the data analysis along with preliminary beam-spin asymmetries for nDVCS will be presented.

Tests of symmetries and conservation laws / 456

Searches for exotic physics by comparing the fundamental properties of protons and antiprotons at BASE

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The Standard Model is the most successful theory in physics. However, it does leave several questions open, such as for example the striking matter-antimatter imbalance in the visible Universe, or the origin of dark matter. These questions can be probed by ultra-high precision comparisons of the fundamental properties of protons and antiprotons, like the charge-to-mass ratio or the magnetic moment, which are the specialties of the BASE collaboration at CERN. To this end, BASE is performing spectroscopy of single trapped antiprotons and protons using superconducting detectors in an advanced cryogenic Penning trap system. The flag result of the BASE collaboration is the measurement of the antiproton magnetic moment with a fractional precision of 1.5 parts in a billion 1, which improved previous measurements by more than three orders of magnitude. We also reported a measurement of the antiproton-to-proton charge-to-mass ratio with a fractional precision of 69 p.p.t. 2, which constitutes one of the most stringent tests of the CPT invariance in the baryon sector. Additionally, the sophisticated experimental setup of the BASE experiment allowed us to contribute to searches of dark matter candidates, by constraining the interaction of antiprotons with axion-like particles (ALPs) 3 and recently, by demonstrating a new method of testing the ALP to photon conversion using our ultra-sensitive superconducting single-particle detectors [4].

In my talk, I will review the recent achievements of BASE, will report on recent progress in improving the frequency resolution of the experiment, and will outline strategies to further improve our high-precision studies of matter-antimatter symmetry to anticipated precision at the parts per trillion level.

1 C. Smorra et al., Nature 550, 371 (2017).
2 S. Ulmer et al., Nature 524, 196 (2015).
3 C. Smorra et al., Nature 575, 310 (2019).
[4] J. A. Devlin et al., Physical Review Letters 126.4 (2021): 041301.

Energy frontier physics beyond the standard model / 458

Probing Higgs-portal dark matter with vector-boson fusion

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We constrain the Higgs-portal model employing the vector-boson fusion channel at the LHC. In particular, we include the phenomenologically interesting parameter region near the Higgs resonance, where the Higgs-boson mass is close to the threshold for dark-matter production and a running-width prescription has to be employed for the Higgs-boson propagator. Limits for the Higgs-portal coupling as a function of the dark-matter mass are derived from the CMS search for invisible Higgs-boson decays in vector-boson fusion at 13 TeV. Furthermore, we perform projections for the 14 TeV

HL-LHC and the 27 TeV HE-LHC taking into account a realistic estimate of the systematic uncertainties. The respective upper limits on the invisible branching ratio of the Higgs boson reach a level of 2 % and constrain perturbative Higgs-portal couplings up to dark-matter masses of about 110 GeV.

Poster Session II / 459

The n2EDM experiment at the Paul Scherrer Institute, PSI

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CP violation is a crucial ingredient in the understanding of the matter anti-matter asymmetry of the universe. A measured electric dipole moment of the neutron would signal breaking the CP symmetry and could hint towards new physics.
The n2EDM experiment is currently under construction by the international nEDM collaboration at PSI. It seeks to improve the sensitivity over the recently established new upper limit on the neutron electric dipole moment of $1.8 \cdot 10^{-26} e \cdot$ cm (90% CL) by another order of magnitude. The n2EDM apparatus uses a double-chamber setup in vacuum and at room temperature, exploiting co-magnetometry and an array of accurate external magnetometers. To successfully accomplish its ambitious goal, not only a high number of neutrons but also an adequate control of the systematic effects is important. Different parts of the apparatus contribute to the precise control of the magnetic field which is key in this next generation measurement. The design of the n2EDM apparatus with its various subsystems will be presented and their role in the improvement of the measurement will be discussed.

Energy frontier physics beyond the standard model / 460

Cosmological approaches to the Higgs hierarchy problem

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TBA

Energy frontier physics beyond the standard model / 461

BSM vision

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TBA

Energy frontier physics beyond the standard model / 462

BSM with axions

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TBA

Energy frontier physics beyond the standard model / 463

SM Anomalies and BSM interpretations

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TBA

Hadron spectroscopy and exotics / 464

Resonance studies at JPAC

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I will present the recent studies by the Joint Physics Analysis Center on the tools to extract information about the excited hadron spectrum from data.

Poster Session I / 465

Primary Scintillation Yield in Xenon –Further Experimental Studies

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Xenon scintillation has been extensively used in recent particle physics experiments. However, information on primary scintillation yield is still scarce and dispersed. The mean energy required to produce a VUV scintillation photon (Wsc) in gaseous xenon has been measured in the range of 30-120 eV. Lower Wsc-values are often reported for alpha particles compared to electrons produced by gamma or x-rays, being this difference still not fully understood.
We carried out a systematic study on the absolute primary scintillation yield in xenon at 1.2 bar, using a Gas Proportional Scintillation Counter. A simulation model of the detector's geometric efficiency was benchmarked through the primary and secondary scintillation produced at different distances from the photosensor. Wsc-values were obtained for gamma- and x-rays with energies in the range from 5.9-60 keV and for 2-MeV alpha particles. No significant differences were found between alpha particles and electrons.

Poster Session II / 466

Measurement of the 136Xe ββ2ν half-life with NEXT-White

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The NEXT (Neutrino Experiment with a Xenon TPC) collaboration aims at the sensitive search of the neutrino-less double beta decay (ββ0ν) of 136Xe at the Laboratorio Subterraneo de Canfranc (LSC). The observation of such a lepton-number-violation process would prove the Majorana nature of neutrinos, providing also handles for an eventual measurement of the neutrino absolute mass. A first large-scale prototype of a high-pressure gas-Xenon electroluminescent TPC, NEXT-white, is being operated at the LSC since 2016. This 5-kg radiopure detector has already proven the outstanding performance of the NEXT technology in terms of the energy resolution (<1% FWHM at 2.6 MeV) and the topology-based background rejection. NEXT-White has also measured the relevant backgrounds for the ββ0ν search using both 136Xe-depleted and 136Xe-enriched xenon. In this talk, the measurement of the half-life of the two neutrino mode of the double beta decay (ββ2ν) will be presented. For this measurement, two novel techniques in the field have been used: 1) a Richardson-Lucy de- convolution to reconstruct the single and double electron tracks, boosting the background rejection, and 2) a direct subtraction of the ββ backgrounds, measured with 136Xe-depleted data. These techniques allow for background-model-dependent and background-model-independent results, demonstrating the robustness of the ββ2ν half-life measurement and the unique capabilities of NEXT. The physics program of NEXT-White will be completed in late 2021, when the construction of the NEXT-100 detector at the LSC starts. Holding 100 kg of 136Xe and with a background index below 5×10−4 counts/keV/kg/year, this detector will perform the first competitive ββ0ν search within the NEXT roadmap. As validated with NEXT-White, NEXT-100 will reach a sensitivity to the half-life of 6×10^25 y after 3 years of data taking, paving the way for future ton-scale phases.

Development of accelerators and detectors / 467

The Readout Electronics of the Mu2e Electromagnetic Calorimeter

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Mu2e aims to measure the ratio of the rate of the neutrino-less muon to electron coherent conversion in the field of an aluminum nucleus relative to the rate of ordinary muon capture. In order to do that, Mu2e will exploit a detector system composed of a straw tracker and an electromagnetic calorimeter. The latter has to provide precise information on energy (σE/E <10%), time (σt < 500ps) and position (σx < 1cm) for ~100 MeV electrons. It is composed of 1348 un-doped CsI crystals, each coupled to two large area Silicon Photomultipliers (SiPMs). Each SiPM is connected to a Front End Electronics (FEE) chip, which hosts the shaping amplifier and the high voltage linear regulator. Each group of 20 FEE is controlled by one Mezzanine Board (MB), which passes the amplified signals to the Digitizer ReAdout Controller board (DiRAC). The DiRAC samples the waveforms at 200 MHz with 12-bits ADCs, packs the data according to the Mu2e custom format and transmits them to the event builder through an optical transceiver. In order to limit the number of pass-through connectors and the length of the cables, the readout and digitization electronics will be located inside the detector cryostat, close to the interaction target. The boards are expected to sustain a neutron fluence of about 5x1010 n/cm2 @ 1 MeVeq (Si)/y and a Total Ionizing Dose of about 12 krad, while working into a 1T magnetic field and a vacuum of 10-4 Torr. This harsh operational environment has made the electronics design challenging, requiring an extended campaign of tests to select and qualify the employed electronic components. Moreover, to validate the performances of the system in terms of dynamic, SNR, bandwidth, and linearity, we assembled a full system chain (20 FEE board, one MB and one DiRAC prototype) to read the Module-0 (a medium scale prototype of the calorimeter) during a cosmic rays test. We demonstrated that the readout electronics performs satisfactorily: the signal shape is as expected from the Monte Carlo simulation, with an obtained time resolution of about 350 ps for MIP particles. In this paper we report on the board architecture and design, on the qualification of the prototypes and on the performance tests, as well as on the results of the first vertical slice test of the Mu2e calorimeter.

Poster Session I / 468

Is or is not DAMA/LIBRA's a dark matter signal? No PANIC, the COSINUS experiment is coming

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COSINUS (Cryogenic Observatory for the search of SIgnatures seen in Underground Sites) is a new experiment aiming at the detection of galactic dark matter particles scattering off atomic nuclei. It is based on the employment of cryogenic scintillating calorimeters made up of sodium iodide crystals operated at millikelvin temperature. The construction of the impressive COSINUS infrastructure, whose installation will start soon in the National Laboratory of Gran Sasso, has been strongly motivated by a first specific goal: providing a conclusive statement on the nature of the annually modulated signal detected by the DAMA/LIBRA experiment. Such signal, measured using room temperature scintillators, is compatible with the expectations for the detection of galactic dark matter particles, but it has not been confirmed by any other experiments so far. For this reason, COSINUS is cross-checking the results of the DAMA/LIBRA experiment by using the same target material (sodium iodide) but applying a different technology. Indeed, COSINUS reconstructs the energy released in the target material by measuring both the energy converted into lattice vibrations and into scintillation light. Relying on the particle-dependent light yield, an efficient background rejection can be achieved on an event-by-event basis. In this talk, we will provide an update on the status of the COSINUS experiment and on the last results of our detector design optimisation studies, with a particular focus on the COSINUS phenomenology of detection and on the description of the relevant parameters which enter in the comparison among the several NaI-based experimental results.

Poster Session II / 469

Strange particle production in relativistic nuclear collisions

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One of the main goals of the relativistic nuclear collisions is to investigate the behavior of nuclear matter under extreme conditions of temperature and energy density. The transverse momentum distributions of identified hadrons contain information about the collective expansion of the system and constrain the freeze-out properties of the matter created in these collisions. It is often assumed that different particle species freeze-out from the fireball at different temperatures. A blast-wave analysis on the strange particle pT spectra obtained in Au+Au collisions at the Relativistic Heavy Ion Collider (RHIC) Beam Energy Scan (BES) energies will be presented. The dependence of the freeze-out parameters on collision energy and event centrality will be discussed. These results will be compared with the blast-wave results obtained from the non-strange particle pT spectra analysis.

Tests of symmetries and conservation laws / 470

Overview and status of the PanEDM experiment at ILL

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Searches for permanent electric dipole moments (EDMs) provide important results to constrain model parameters and promising experiments to potentially reveal beyond Standard Model (SM) physics. A non-zero EDM is a direct manifestation of time-reversal (T) violation, and, equivalently, violation of the combined operation of charge-conjugation (C) and parity inversion (P). Identifying new sources of CP violation can help to solve fundamental puzzles of the SM, e.g. the observed baryon-asymmetry in the Universe.
The PanEDM experiment's goal is to measure the EDM of the neutron with a sensitivity at least one order of magnitude below the current best limit of d_n<1.8e-26 ecm (90% C.L.). Located at the new ultra-cold neutron (UCN) source SuperSUN at ILL PanEDM will greatly benefit from high UCN densities with UCN energies below 80 neV. A statistical neutron EDM sensitivity of 3.8e-27 ecm is expected within 100 measurement days with SuperSUN phase-I. With future phase-II improvements in SuperSUN and the PanEDM apparatus an ultimate statistical sensitivity of 7.9e-28 ecm is anticipated.
The already commissioned passive magnetic shield provides highly stable magnetic fields with drifts <10fT over 250s and magnetic field gradient drifts <10fT/m/s, strongly suppressing major systematic effects. Other subsystems addressing systematic effects are being commissioned, e.g. external Hg magnetometer cells, an all-optical Cs magnetometer array and the high-voltage system including a leakage current monitor.
In this presentation I will give an overview of ILL's new UCN source SuperSUN, the PanEDM experiment and its main components and a status report on recent progress including results from ongoing commissioning of SuperSUN.

Nuclear and particle astrophysics / 471

Ultrahigh-energy physics from high altitudes with ANITA

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Over the last 15 years, the Antarctic Impulse Transient Antenna (ANITA) collaboration has flown interferometric radio arrays on long-duration balloon payloads over Antarctica. ANITA seeks to detect the Askaryan radio emission produced from interactions of ultrahigh-energy (>1 EeV) neutrinos in the Antarctic Ice Sheet. Above 10^{19.5} eV, ANITA sets world-leading limits on neutrino flux.

ANITA is also sensitive to radio emission from extensive air showers. In addition to a number of cosmic ray candidates, ANITA has also detected several events consistent with upward-going air showers. While atmospheric tau decays from energetic tau neutrinos interacting in the Earth could produce such event topologies, the implied rate poses challenges for this explanation. If real, these events could be a hint of new physics.

The successor to ANITA is the Payload for Ultrahigh Energy Observations (PUEO), with hardware improvements and a more sensitive triggering technique to improve on ANITA's sensitivity by more than an order of magnitude at 10^19 eV. PUEO is expected to launch in 2024.

Tests of symmetries and conservation laws / 472

Testing Pauli Exclusion Principle for electrons at the LNGS underground laboratory

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The VIP-2 experiment at the Underground Gran Sasso Laboratory (LNGS) aims to perform high sensitivity tests of the Pauli Exclusion Principle (PEP) for electrons, and search for a possible small violation. The PEP violation would be a clear indication of physics beyond the Standard Model.
The VIP-2 collaboration performs tests of PEP violation in various configurations.
A first experimental method consists in circulating a DC current in a copper strip, searching for the X radiation emitted by a PEP prohibited transition (from the 2p level to the 1s evel of copper when this is already occupied by two electrons).
The VIP experiment already set a strong limit on the PEP violation probability for electrons $\frac{1}{2}\beta^2 < 4.7 \times 10^{-29}$.
The goal of the upgraded VIP-2 experiment is to improve this limit by at least two orders of magnitude and explore theories beyond Standard Model allowing for small violations. The VIP-2 experimental apparatus and preliminary results of the analysis of a first set of collected data will be presented.
On the other side, it was recently shown that a large class of Quantum Gravity models embed the violation of PEP as a consequence of the space-time non-commutativity.
High sensitivity tests of PEP violation in closed systems, i.e. without the necessity to circulate current, turn out to be excellent measurements to put strong experimental limits on the energy scale of the non-commutativity emergence in Quantum Gravity. The preliminary results of exploratory studies based a High Purity Germanium (HPGe) detectors and high radio-purity Roman Pb targets will be presented

Energy frontier physics beyond the standard model / 473

EW SUSY production at the LHC

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The direct production of electroweak SUSY particles, including sleptons, charginos, and neutralinos, is a particularly interesting area of search at the LHC. While the lightest neutralino is a well motivated and studied candidate for dark matter in models with R-parity conservation, the small production cross sections of electroweak production leads to difficult searches. This talk will highlight the most recent results of searches performed by the ATLAS and CMS experiments for supersymmetric particles produced via electroweak processes, including analyses with leptonic and hadronic final states.

Energy frontier physics beyond the standard model / 474

Long-lived particles and unconventional signatures at LHC

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Various theories beyond the Standard Model predict unique signatures that are difficult to reconstruct and for which estimating the background rate is also a challenge. Signatures from displaced decays anywhere from the inner detector to the muon spectrometer, as well as those of new particles with fractional or multiple values of the charge of the electron or high mass stable charged particles are all examples of experimentally demanding signatures. The talk will focus on the most recent results using 13 TeV pp collision data collected by the ATLAS and CMS experiments at the LHC.

Energy frontier physics beyond the standard model / 475

Beyond the SM Higgs physics at LHC (Direct and indirect from Higgs couplings)

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The discovery of the Higgs boson with the mass of 125 GeV completed the particle content predicted by the Standard Model. Even though this model is well established and consistent with many measurements, it is not capable to solely explain some observations. Many extensions of the Standard Model addressing such shortcomings introduce additional Higgs-like bosons which can be either neutral, singly-charged or even doubly-charged. Precision measurements of the coupling of the Standard Model Higgs boson can also be used to place constraints on two-Higgs-doublet models. Constraints on the couplings of The current status of searches based on the full LHC Run 2 dataset of the ATLAS and CMS experiments at 13 TeV are presented.

Energy frontier physics beyond the standard model / 476

Search for heavy resonances at the LHC (ED, HVB, etc…)

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Many extensions to the Standard Model predict new phenomena occurring at high mass. These include new scalar or vector resonances, as well as new heavy fermions. This talk will summarize recent searches for such heavy particles based on 13 TeV pp collision data collected by the ATLAS and CMS experiments at the LHC. They cover new heavy resonances decaying into dibosons (including W, Z, photon, or Higgs bosons), vector-like quarks (including both single and pair production), and new heavy leptons. In addition to discussing the main results obtained, this talk will also explain the experimental methods used, including top-quark, vector- and Higgs-boson-tagging techniques used to identify decay products in the highly boosted regime.

Energy frontier physics beyond the standard model / 477

Search for dark matter at the LHC

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The presence of a non-baryonic Dark Matter (DM) component in the Universe is inferred from the observation of its gravitational interaction. If Dark Matter interacts weakly with the Standard Model (SM) it could be produced at the LHC. The ATLAS and CMS experiments have developed a broad search program for DM candidates, including resonance searches for the mediator which would couple DM to the SM, searches with large missing transverse momentum produced in association with other particles (light and heavy quarks, photons, Z and H bosons) called mono-X searches and searches where the Higgs boson provides a portal to Dark Matter, leading to invisible Higgs decays. The results of recent searches on 13 TeV pp collision data, their interplay and interpretation will be presented.

Nuclear and particle astrophysics / 478

Review of Neutrino Astrophysics with IceCube

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IceCube, a kilometer-cubed scale detector operating at the South Pole, has discovered an all-sky isotropic high-energy neutrino flux. A likely astrophyscal neutrino observed in September 2017, was coincident with high-energy and very-high-energy flares from the blazar TXS 0506+056, so revealing the first candidate high-energy neutrino source. A follow-up study by IceCube with archival data revealed a candidate neutrino flare in 2014-2015. Nevertheless, the nature of the classes of objects responsible for neutrino sources remains unclear. IceCube itself has ruled out gamma-ray bright blazars, as being responsible for more than 27% of the diffuse flux.

The diffuse flux has been studied with multiple methods, including tracks, cascades and starting events. The flavor flux ratio is consistent with expectations of standard oscillations for astrophysical baselines. Two recent important results related to the diffuse flux studies are the observation of two nutau candidate events and one Glashow resonance event.
In this presentation, I will discuss the current status of searches for the sources of astrophysical high-energy neutrinos with IceCube. The discussion will include a description of multi-messenger studies conducted with IceCube data as well as a summary of the current knowledge of the diffuse astrophysical flux.

QCD, spin physics and chiral dynamics / 479

Gravitational form factors on the lattice

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Hadronic matrix elements of the QCD energy-momentum tensor can be parametrized in terms of gravitational form factors (GFFs) which, through their dependence on momentum transfer and decomposition into quark and glue contributions, encode information about the distributions of energy, angular momentum, pressure, and shear forces within a hadron spatially and amongst its constituents. GFFs can be constrained indirectly by experiments through their relation with generalized parton distributions, but they are directly and straightforwardly accessible to lattice calculations. We present the results of a recent lattice calculation at unphysically heavy pion masses of the gluonic contributions to the GFFs (and various densities derived from them) of the rho meson and delta baryon, which are as yet unconstrained by experiment, extending previous studies of the gluon GFFs of the pion and nucleon. We discuss further progress in an ongoing program of lattice calculations to determine the GFFs of the physical proton with full control over uncertainties, including both quark and glue contributions, providing access to the physical energy, spin, pressure, and shear force densities.

Development of accelerators and detectors / 480

UCN-Detection System for the PanEDM Experiment

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The PanEDM collaboration prepares a measurement of the Electric Dipole Moment of the neutron (nEDM) at the Institut Laue-Langevin, using its new source for ultracold neutrons (UCN), SuperSUN. The measurement principle relies on Ramsey's spectroscopy method of separated oscillating fields, which is applied to polarized UCNs stored in two chambers placed in a common magnetic field. The envisaged experimental sensitivity of $\mathrm{d_n} = 7.9 \times 10^{-28}$ ecm imposes stringent requirements on performance and stability of the system in general and especially on the detection system. This poster presents limits for the bandwidth, efficiency and background of a detection system suitable for a high precision experiment such as PanEDM. We extensively modified a commercially available system, based on four Gas-Electron-Multiplier detectors with a B10 neutron conversion layer. This enhanced the gas and signal amplification, reduced sparks, lowered the overall electronic noise and improved the usability. Thus we can present an improved system and its first demonstration with UCN which is adapted for the envisaged PanEDM limit.

Nuclear and particle astrophysics / 481

The Scintillation Bubble Chamber (SBC) experiment for dark matter and reactor CEvNS

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The Scintillating Bubble Chamber (SBC) experiment is a novel detection technique aimed at detecting low-mass (0.7-7 GeV/c2) WIMP interactions and coherent elastic neutrino-nucleus scattering (CEνNS) from reactor neutrinos. Using a target volume primarily composed of superheated argon, the nucleation signal from electron recoils (the limiting factor for low-threshold studies in bubble chambers) is suppressed, allowing for the exploration of new parameter space. Particle interactions with the target fluid can lead to the production of heat (bubbles) and scintillation light. By combining these observables, the SBC detector is aiming to reach a threshold for nuclear recoils of 100 eV and a projected WIMP-sensitivity of 1.73x10-43 cm2, for a WIMP mass of 1 GeV/c2.
In this talk, I will present the design of the SBC experiment and provide an update on the ongoing construction and commissioning at Fermilab. I will also discuss the new camera test setup designed and being constructed at the University of Alberta. Finally, I will give an overview of the collaboration's plans for future operations at Fermilab and SNOLAB, including the potential for such a detector to become the leading technology to study CEνNS.

Dark matter and cosmology / 482

Search for Dark Matter signatures from cosmic-ray antinuclei with the GAPS experiment

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The General Antiparticle Spectrometer (GAPS) experiment is designed to perform low-energy cosmic-ray antinuclei measurements searching for indirect signatures of dark matter annihilation or decay. The unprecedented sensitivity at energies <0.25 GeV/n will allow GAPS to detect or set upper limits on the cosmic antideuterium or antihelium nuclei flux in an energy range with a very low astrophysical background. Several beyond-the-Standard Model scenarios predict antinuclei fluxes about two orders of magnitude above the astrophysical background. Furthermore, GAPS will collect the largest statistics of low-energy antiprotons to date, extending the existing measurements to unexplored low energies (< 100 MeV). The GAPS experiment will perform such measurements using long-duration balloon flights over Antarctica, beginning in 2022/23 austral summer. The experimental apparatus consists of ten tracker planes of Si(Li) detectors surrounded by a time-of-flight system made of plastic scintillators. A novel identification technique is used to detect the antinucleus, which employs the production and decay of a short-lived exotic atom. In this contribution, the status of the constructions of the different GAPS subdetectors will be reported, and the latest results of the simulations studies on the detector performance will be summarized.

Energy frontier physics beyond the standard model / 484

Constraints on coloured scalars from global fits

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We consider a simple extension of the electroweak theory, incorporating one $SU(2)_L$ doublet of colour-octet scalars with Yukawa couplings satisfying the principle of minimal flavour violation. Using the HEPfit package, we perform a global fit to the available data, including all relevant theoretical constraints, and extract the current bounds on the model parameters. Coloured scalars with masses below 1.05 TeV are already excluded, provided they are not fermiophobic. The mass splittings among the different (charged and CP-even and CP-odd neutral) scalars
are restricted to be smaller than 20 GeV. Moreover, for scalar masses smaller than 1.5 TeV, the Yukawa coupling of the coloured scalar multiplet to the top quark cannot exceed the one of the SM Higgs doublet by more than 80\%. These conclusions are quite generic and apply in more general frameworks (without fine tunings). The theoretical requirements of perturbative unitarity and vacuum stability enforce relevant constraints on the quartic scalar potential parameters that are not yet experimentally tested.

Poster Session I / 485

Neutron lifetime experiment with pulsed cold neutrons at J-PARC

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A neutron decays into a proton, an electron, and antineutrino in a lifetime of about 880 s. The neutron lifetime is one of the important parameters for particle physics and astrophysics. For instance, it dominates the uncertainty on 4He abundance in the Big Bang Nucleosynthesis and it also determines Vud term in the Cabibbo-Kobayashi-Maskawa quark mixing matrix. Although the neutron lifetime is very important in modern physics, there is a 4-sigma (8.5 s) discrepancy between the results of two typical methods: the beam method and the storage method. The beam method measures the neutron flux and decay protons by different detectors, and the storage method counts survival neutrons after some storage times. The discrepancy is called the neutron lifetime puzzle and is not yet settled. The possibility that unknown systematic errors and new physics such as dark decays are the cause has been discussed.
We have been carrying out a neutron lifetime measurement with a new method at J-PARC to solve the puzzle. In our method, we measure the neutron flux and decay electrons simultaneously by a Time Projection Chamber filled by working gas and 3He. To reduce the background event rate, the neutron beam is shaped to bunches shorter than the length of the sensitive region by the Spin Flip Chopper (SFC) and injected into the TPC. Since the neutron flux and decay rate are counted by the same detector in our method, the systematic uncertainty is different from the typical beam method. Additionally, we can measure dark decays with electrons if it exists. We are aiming for 1 s (0.1%) precision determination of the neutron lifetime to achieve a definitive result.
We have been constructed the experimental and analysis procedure to determine the neutron lifetime by our new method by the last year and the result is 898 +/- 10 (stat.) +15 -18 (sys.) s. Towards 1 s accuracy, we are now installing a new SFC of 3 times flux and it will enable us to analyze more classified events to reduce systematic uncertainties.
This presentation will report the first physics result of our experiment with acquired data during 2014 - 2016, and a detailed status and prospect of upgrades both in the apparatus and the analysis towards 1 s precision.

Poster Session II / 487

Kinematic fitting for ParticleFlow Detectors at Future Higgs Factories

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Many physics analyses in Higgs, top and electroweak physics improve the kinematic reconstruction of the final state by constrained fits. This is a particularly powerful tool at e^+e^- colliders, where the initial state four-momentum is known and can be employed to constrain the final state. A crucial ingredient to kinematic fitting is an accurate estimate of the measurement uncertainties, in particular for composing objects like jets. This contribution will show how the particle flow concept, which is a design-driver for most detectors proposed for future Higgs factories, can – in addition to an excellent jet energy measurement – provide detailed estimates of the covariance matrices for each individual particle-flow object and each individual jet. Combined with information about leptons and secondary vertices in the jets, the kinematic fit enables to correct b- and c-jets for missing momentum from neutrinos from semi-leptonic heavy quark decays. The impact on the reconstruction of invariant di-jet masses and the resulting improvement in ZH vs ZZ separation will be presented, using as an example the full simulation of the ILD detector concept. As an outlook, the expected benefit for the Higgs self-coupling measurement from double Higgs production will be discussed.

Poster Session II / 491

Improvement of systematic uncertainties for the neutron lifetime experiment at J-PARC

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A neutron decays into a proton, an electron, and antineutrino in a lifetime of about 880 s. The neutron lifetime is one of the important parameters for particle physics and astrophysics. For instance, it dominates the uncertainty on 4He abundance in the Big Bang Nucleosynthesis and it also determines Vud term in the Cabibbo-Kobayashi-Maskawa quark mixing matrix. Although the neutron lifetime is very important in modern physics, there is a 4-sigma (8.5 s) discrepancy between the results of two typical methods: the beam method and the storage method. The beam method measures the neutron flux and decay protons by different detectors, and the storage method counts survival neutrons after some storage times. The discrepancy is called the neutron lifetime puzzle and is not yet settled. The possibility that unknown systematic errors and new physics such as dark decays are the cause has been discussed.
To solve the lifetime puzzle, a new neutron lifetime experiment with a different method is in progress at J-PARC. In this method, the neutron flux and decay electrons are measured simultaneously by a Time Projection Chamber (TPC) filled by working gas and 3He to evaluate the neutron flux. The systematic uncertainties are different from the previous beam method because we measure the decay electrons whereas the previous beam experiments measured decay protons. Our goal is to determine the neutron lifetime with accuracy of 1 s (0.1%).
This experiment published the first result of this experiment in 2020 as 898 +/- 10 (stat.) +15/-18 (sys.) s. Towards 1 s accuracy, improvements of the systematic uncertainties are essential. In this presentation, we report on the upgrades we have performed to reduce systematic uncertainties as follows:
1) 3He with pressure of about 100 mPa is used to measure the neutron flux. The 3He gas is injected into a smaller container with high pressure (~ 3 kPa), then released into the vacuum chamber in which the TPC is. The ratio of the small container and the vacuum chamber is necessary to be measured with high accuracy. We developed a measurement method of the volume ratio with higher accuracy by installing a new transducer with larger dynamic range. Working gas we are using is He

and CO2, thus a small amount of 3He contains. To determine the 3He amount in the working gas, we developed a new method using 14N(n,p)14C reaction.
2) Space charges formed by ionized electrons reduce the gain of wire chambers. The space charge effect should be implemented in the Monte Carlo simulation to reproduce the energy loss distributions of the experiment which affect calibration discrepancy between simulation and experiment. We have implemented a new model of space charge effect and improved the reproducibility of energy loss distributions of beta decay and 3He(n,p)3H reaction.

Poster Session II / 493

Charged Hadron Identification with dE/dx and Time-of-Flight at Future Higgs Factories

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The design of detector concepts has been driven for a long time by requirements on transverse momentum, impact parameter and jet energy resolutions, as well as hermeticity. Only rather recently it has been realised that the ability to idenfity different types of charged hadrons, in particular kaons and protons, could have important applications at Higgs factories, ranging from improvements in tracking, vertexing and flavour tagging to measurements requiring strangeness-tagging. While detector concepts with gaseous tracking can exploit the specific energy loss, all-silicon-based detectors have to rely on fast timing layers in front of or in the first layers of their electromagnetic calorimeters. This presentation will review the different options for realising kaon and proton identification, introduce recently developed reconstruction algorithms and present full detector simulation prospects for physics applications using the example of the ILD detector concept.

QCD, spin physics and chiral dynamics / 497

Charged-averaged elastic lepton-proton scattering cross section results from OLYMPUS

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Measurements of the proton's form factor ratio made with polarization transfer show a striking discrepancy relative to the ratio extracted from unpolarized elastic electron-proton scattering cross sections. One hypothesis is that the discrepancy is caused by hard two-photon exchange (TPE), a typically neglected radiative correction that may bias the two approaches differently. This hypothesis has been challenging to confirm. Theoretical estimates of TPE are model-dependent, and recent experimental determinations of TPE lacked the kinematic reach to be conclusive. The possible impact of TPE remains a cloud over our knowledge of the proton's form factors. Recently, the OLYMPUS experiment published new elastic scattering cross sections that are insensitive to the effects of TPE: specifically the average of electron-proton and positron-proton cross sections. The OLYMPUS experiment, conducted at DESY, Hamburg, measured elastic e^-p and e^+p scattering by detecting the scattered lepton and recoiling proton in coincidence in a large-acceptance, toroidal magnetic spectrometer. OLYMPUS was designed to measure the e^+p/e^-p cross section ratio to isolate the effects of TPE. By exploiting the over determined kinematics of the reaction, the absolute efficiency of spectrometer could be verified, allowing cross sections to be extracted from the data. These results can help refine our knowledge of the proton's form factors, especially in the squared momentum-transfer region of 1–2 GeV^2, where some previous measurements are in tension.

Nuclear and particle astrophysics / 498

The use of realistic equations of state in f (R, T) gravity theory and massive neutron stars

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In this work we investigate neutron stars (NS) in f (R, T) gravity for the case R + 2λT , R is the Ricci scalar and T the trace of the energy-momentum tensor. The hydrostatic equilibrium equations are solved considering realistic equations of state (EOS). The NS masses and radii obtained are subject to a joint constrain from massive pulsars and the event GW170817. The pressure gradient inside the star, in this theory of gravity, depends on the inverse of the sound velocity. Since this velocity is quite low in the crust, |λ| need to be very small. The existence of the NS crust demands the |λ| values to be much smaller than the ones used with simpler EOS in the previous works of Neutron Star calculations in this modified gravity theory. The finding that using several relativistic and non-relativistic models the variation on the NS mass and radius is almost the same for all the EsoS in f (R, T) theory, manifests that our results are insensitive to the high-density part of the EOS.
Finally, we highlight that our results indicate that conclusions obtained from NS studies done in modified theories of gravity without using realistic EOS that describe correctly the NS interior can be unreliable.

Hadrons in medium - hyperons and mesons in nuclear matter / 499

π0 production in Ag+Ag collisions at 1.23 AGeV beam energy

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The High Acceptance DiElectron Spectrometer (HADES) is a fixed target experiment which explores the properties of hadronic matter in collisions of pions, protons and nuclei at beam energies 1-2 AGeV. It operates at the SIS18 accelerator in GSI, Darmstadt.
The precise measurements of neutral mesons yield were already carried out by TAPS collaboration. However, their measurements have only one bin in rapidity. Due to the newly built electromagnetic calorimeter ECal, the HADES experiment has the unique possibility to study the dependence of π0 yield on rapidity (in the range 0.8-1.8) and transverse momentum (200-900 MeV/c).
In this talk the preliminary results of measurements of yield of π0-mesons by the HADES experiment in collisions of Ag+Ag nuclei at beam energy 1.23 AGeV are discussed.

Poster Session I / 500

The TUCAN EDM Experiment

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The goal of the TUCAN EDM experiment (TRIUMF Ultra-Cold Advanced Neutron Electric Dipole Moment experiment) is to make a new precise measurement of the neutron EDM, with uncertainty of $1x10^{-27}$ e-cm, a one order of magnitude improvement compared to the current world's best limit. The experiment is unique in using a spallation-driven superfluid helium (He-II) source of ultracold neutrons (UCN). We have been operating a prototype UCN source at TRIUMF since 2017. We are now at the stage of upgrading this source to produce world-leading UCN densities, using a new He-II cryostat that has undergone cryogenic testing at KEK in 2020-21. We are also assembling the experimental components of the EDM experiment, including a magnetically shielded room, coils, and atomic magnetometers. This presentation will report on the data from our prototype UCN source acquired at TRIUMF, and on our recent progress upgrading the UCN source and preparing the EDM experiment.

Poster Session I / 501

Hydrodynamic analyses of nuclear collisions in Landau and Eckart frames

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The quark matter created in relativistic nuclear collisions is interpreted as a nearly-perfect fluid. The recent efforts to explore its finite-density properties in the beam energy scan programs motivate one to revisit the issue of the local rest frame fixing in off-equilibrium hydrodynamics. We first investigate full second-order relativistic hydrodynamics in the Landau and Eckart frames, which are defined with energy and baryonic flows, respectively. Then we perform numerical simulations to elucidate the effect of frame choice on flow observables in nuclear collisions. The results indicate that the flow can differ in the two frames but charged particle and net baryon rapidity distributions are mostly frame independent when off-equilibrium kinetic freeze-out is considered.

Poster Session II / 503

MUSE, the MUon proton Scattering Experiment

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The proton radius puzzle began in 2010 when the CREMA Collaboration released their measurement of the proton radius (Pohl et. al (2010)) from muonic hydrogen spectroscopy: rp=0.84184(67) fm, This was five standard deviations smaller that the accepted CODATA value at that time (0.8768(69) fm), and sparked an enduring and intriguing puzzle. This puzzle has been addressed in repeated electron scattering measurements seeking to go lower in Q2, such as PRad at Jefferson Lab, and the Mainz Initial State Radiation experiment. There have also been a plethora of new atomic hydrogen spectroscopy experiments, and some more muonic atom spectroscopy. MUSE, the MUon proton Scattering Experiment, was first proposed in 2012 to be the first muon proton elastic scattering experiment with sufficient precision to address the proton radius puzzle. MUSE has the capacity to simultaneously measure elastic muon-proton, and electron-proton scattering, and switch polarities to measure with opposite charge states, giving access to cross sections, extracted radii, and two-photon measurements for muons and electrons. As such, MUSE can directly measure the two-photon effect by comparing charge-states, and compare muon and electron scattering. This will allow reduction of the systematic uncertainty due to the partial cancellation of uncertainties by simultaneous and

/ or subsequent measurements within the same apparatus. We will review the motivation for and status of MUSE, which is due to begin production running in 2021.

Development of accelerators and detectors / 504

Precision Timing with the CMS MTD Barrel Timing Layer for HL-LHC

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The Compact Muon Solenoid (CMS) detector at the CERN Large Hadron Collider (LHC) is undergoing an extensive Phase II upgrade program to prepare for the challenging conditions of the High-Luminosity LHC (HL-LHC). A new timing detector in CMS will measure minimum ionizing particles (MIPs) with a time resolution of 30-40 ps for MIP signals at a rate of 2.5 Mhit/s per channel at the beginning of HL-LHC operation. The precision time information from this MIP Timing Detector (MTD) will reduce the effects of the high levels of pileup expected at the HL-LHC, bringing new capabilities to the CMS detector. The barrel timing layer (BTL) of the MTD will use sensors that are based on LYSO:Ce scintillation crystals coupled to SiPMs with TOFHIR ASICs for the front-end readout. In this talk we will present motivations for precision timing at the HL-LHC and an overview of the MTD BTL design, including ongoing R&D studies targeting enhanced timing performance and radiation tolerance.

Development of accelerators and detectors / 505

The CMS MTD Endcap Timing Layer: Precision Timing with Low Gain Avalanche Detectors

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The MIP Timing Detector (MTD) of the Compact Muon Solenoid (CMS) will provide precision timestamps with 40 ps resolution for all charged particles up to a pseudo-rapidity of $|\eta|=3$. This upgrade will mitigate the effects of pile-up expected under the High-Luminosity LHC running conditions and bring new and unique capabilities to the CMS detector. The endcap region of the MTD, called the Endcap Timing Layer (ETL), will be instrumented with silicon low gain avalanche detectors (LGADs), covering the high-radiation pseudo-rapidity region $1.6 < |\eta| < 3.0$. The LGADs will be read out with the ETROC readout chip, which is being designed for precision timing measurements. We present recent progress in the characterization of LGAD sensors for the ETL and development of ETROC, including test beam and bench measurements.

Poster Session II / 506

Tagging large-radius b-jets from Higgs decays dropping unneeded information

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Among the high-energy physics community, there is a growing interest in replacing cut-based selections using different types of multivariate analysis. This transformation made it possible to use high-level variables produced by complex reconstruction algorithms.
Within this context, Deep Learning approaches are rapidly spreading to improve the selection performances by combining all the available information. The development of these algorithms often relies on a brute force approach where all available event features are tested for multiple combinations of the algorithm hyperparameters. Nonetheless, the significance of the prediction does not necessarily increase with the amount of information given as input to the algorithm. The opposite is often true.
Herein, we propose an effective method to choose the most valuable variables to give as input to a Deep Neural Network using a CancelOut layer. Indeed, given a fixed number of variables, the CancelOut layer selects during training only the most relevant features to achieve the best performances. We use as a study case the selection of events where a boosted large and massive jet contains both of the b~quarks originated from H boson decays. We show how the Deep Neural Network classifier performance can be affected by keeping irrelevant variables in input and how our method can naturally get rid of them. The proposed method can be easily implemented in already developed Deep Neural Network classifiers through a retraining campaign.

Hot and dense matter physics - QGP and heavy ion collisions / 508

Hard probes of heavy ion collisions with ATLAS

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This talk gives an overview of the latest hard process measurements in heavy ion collision systems with the ATLAS detector at the LHC, utilizing the high statistics 5.02 TeV Pb+Pb data collected in 2018. These include multiple measurements of jet production and structure, which probe the dynamics of the hot, dense Quark-Gluon Plasma formed in relativistic nucleus-nucleus collisions; measurements of electroweak boson production to constrain the modifications of nuclear parton densities and test the Glauber model and binary scaling picture of heavy ion collisions; and measurements of quarkonia and heavy flavor production to probe the QGP medium properties. A particular focus of the measurements is the systematic comparison of fully unfolded data to state of the art theoretical models.

Hot and dense matter physics - QGP and heavy ion collisions / 509

Collective dynamics of heavy ion collisions in ATLAS

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This talk gives an overview of the latest measurements of collective behavior in a variety of collision systems with the ATLAS detector at the LHC, including pp collisions at 13 TeV, Xe+Xe collisions at 5.44 TeV, and Pb+Pb collisions at 5.02 TeV. These include measurements of vn-[pT] correlations in Xe+Xe and Pb+Pb, which carry important information about the initial-state geometry of the Quark-Gluon Plasma and can potentially shed light on any quadrupole deformation in the Xe nucleus; measurements of flow decorrelations differential in rapidity, which probe the longitudinal structure of the colliding system; and measurements of the sensitivity of collective behavior in pp collisions to the presence of jets, which seek to distinguish the role that semi-hard processes play in the origin of these phenomena in small systems. These measurements furthermore provide stringent tests of the theoretical understanding of the initial state in heavy ion collisions.

Hot and dense matter physics - QGP and heavy ion collisions / 510

Ultra-peripheral physics with ATLAS

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This talk gives an overview of the latest ultra-peripheral physics measurements performed with the ATLAS detector at the LHC. These include differential measurements of the exclusive di-muon production cross-section, which are crucial for setting constraints on the initial photon spectrum for all UPC measurements at the LHC; measurements of light-by-light scattering, which result in an observation of this elusive Standard Model process and set competitive limits on the parameter space for axion-like particles; measurements of electromagnetic di-muon production in non-UPC Pb+Pb collisions, which are sensitive to the structure of the initial EM fields and possibly EM content of the created Quark-Gluon Plasma; and measurements of collective behavior in high-multiplicity photo-nuclear collisions.

Poster Session I / 511

The High Energy Particle Detector for the second China Seismo-Electromagnetic Satellite

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The CSES (China Seismo-Electromagnetic Satellite) is a multi-instrumental scientific space program devoted to study the near-Earth electromagnetic, plasma and particle environment to understand the seismo-associated disturbances in the ionosphere-magnetosphere transition zone. In particular, the mission aims at confirming the existence of possible temporal correlations between the occurrence of medium and large magnitude earthquakes and the observation in space of electromagnetic perturbations, plasma variations and precipitation of bursts of high-energy charged particles from the inner Van Allen belt.
The first satellite (CSES-01) was launched in 2018, while the second one (CSES-02) is currently under development and its launch is expected by 2022. One of the instruments on board the satellites is a particle detector (HEPD-02, High-energy Particle Detector). This high-precision particle detector measures electrons in the energy range between 3 and 100 MeV, protons between 30 and 200 MeV, as well as light nuclei in the MeV energy window.
The HEPD-02 detector will be composed of a tracker made of Monolithic Active Pixel Sensors and a double layer of crossed plastic scintillators for trigger. The actual calorimeter will be constituted by a tower of plastic scintillator and two-segmented planes of inorganic LYSO crystals. The calorimeter is surrounded by five scintillator planes used as a veto system.
This contribution describes the new architecture and the main characteristics of HEPD-02, with a focus on the choices made to meet the challenging scientific objectives of the mission.

Standard model physics at the TeV scale / 513

Status and future prospects of precision computations for Higgs Physics at the LHC

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In this talk, I will review the more important recent theoretical results in the computations and simulations of Higgs-production at the LHC.

QCD, spin physics and chiral dynamics / 516

Recent Spin Results at PHENIX

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There have been numerous results in both longitudinal and transverse spin at PHENIX. The longitudinal double spin asymmetry (A_{LL}) provides insight into the gluon helicity distribution function (\{Delta}G), the contribution of gluon spin to the proton. The A_{LL} of direct photons, jets, and charged pions in polarized pp collisions at \sqrt{s} = 510 GeV have been measured, which are novel PHENIX results. The transverse single spin asymmetry (A_{N}) elucidates the transverse momentum dependent (TMD) distributions and fragmentation functions and their higher twist counterparts. A_{N} for \pi^{0}, \eta, charged pion, open heavy flavor electrons, and direct photons at midrapidity in polarized pp \sqrt{s} = 200 GeV have been measured at PHENIX. In addition, the neutron A_{N} at very forward rapidity has been measured in pA with the explicit pT and xT dependence which will provide more information about the underlying mechanisms that create the asymmetries. This talk will discuss these recent PHENIX results.

Standard model physics at the TeV scale / 517

Four-lepton production in gluon fusion at NLO matched to parton showers

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We present a calculation of the NLO corrections to the gluon-induced
electroweak gauge boson pair production, gg->ZZ and gg->W+W-, matched to the PYTHIA 8 parton shower in the POWHEG approach. The calculation consistently incorporates the continuum background, the Higgs-mediated process, and their interference. We consider leptonic decay modes of the vector bosons and retain offshell and non-resonant contributions. Parton-shower effects are found to
be marginal in inclusive observables and quite sizeable in observables that are exclusive in additional jet radiation. The Monte Carlo generator presented here allows for realistic experimental effects to

be incorporated in state-of-the-art precision analyses of diboson production and of the Higgs boson in the offshell regime.

Poster Session II / 523

Measurement of the ttH production cross-section in multi-leptonic final states in pp collisions at a centre-of-mass energy of 13 TeV with the ATLAS detector

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The Yukawa coupling of the Higgs boson to the top quark is a key parameter of the Standard Model. This coupling can be directly measured from the process of gg/qq -> ttH. And the multilepton channel is the most sensitive channel in this process. A search for ttH production in multilepton final states has been performed with an integrated luminosity of 80 fb-1 at a centre-of-mass energy of 13 TeV. Results will be presented.

Poster Session II / 524

ATLAS measurements of CP violation and rare decays processes with beauty mesons

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The ATLAS experiment has performed measurements of B-meson rare decays proceeding via suppressed electroweak flavour changing neutral currents, and of mixing and CP violation in the neutral Bs meson system.
This talk will focus on the latest results from the ATLAS collaboration, such as rare processes B^0_s → mu mu and B^0 → mu mu, and CP violation in the B_s^0 —> J/psi phi decays. In the latter, the Standard Model predicts the CP violating mixing phase, phi_s, to be very small and its SM value is very well constrained, while in many new physics models large phi_s values are expected. The latest measurements of phi_s and several other parameters describing the B_s^0 —> J/psi phi decays will be reported.

QCD, spin physics and chiral dynamics / 526

ATLAS results on charmonium production and B_c production and decays

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Recent results from the proton-proton collision data taken by the ATLAS experiment on the charmonium production and on the B_c production and decays will be presented. The measurement of the associated production of the J/psi meson and a gauge boson, including the separation of single and double parton scattering components, will be discussed. The measurement of J/psi and psi(2S) differential cross sections will be reported as measured on the whole Run 2 dataset. The measurement of the differential ratios of the B_c+ and B+ production cross sections at 8 TeV will also be shown. New results on the B_c decays to J/psi Ds(*) final states obtained with the Run 2 data at 13 TeV will be detailed.

Hadron spectroscopy and exotics / 527

ATLAS results on J/psi p resonances in the Lambda_b -> J/psi p K decays

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A study of J/psi p resonances in the Lambda_b -> J/psi p K decays with large m(pK) invariant masses is presented by the ATLAS experiment at the LHC. The analysis is based on a combined sample of pp collision data at centre-of-mass energies of 7 TeV and 8 TeV corresponding to integrated luminosities of 4.9 fb-1 and 20.6 fb-1, respectively. Although the data prefer the model with two or more pentaquark states, the model without pentaquarks is not excluded. The pentaquark masses and widths obtained using the model with two pentaquarks are consistent with those from the LHCb experiment.

Poster Session II / 528

Jet flavour tagging for the ATLAS Experiment

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The ability to identify jets stemming from the hadronisation of b-quarks (b-jets) is crucial for the physics program of ATLAS.
The higher pileup conditions and the growing interest for measurements including c-jets and for searches in the high transverse momentum regime make the task more and more complex. The algorithms responsible for establishing the jet's flavour are evolving quickly, exploiting powerful multivariate and deep machine learning techniques. Since the primary input to any such algorithm consists of charged-particle tracks within the jet, the identification of jets from heavy-flavor decays depends strongly on the tracking efficiency and resolution and the robustness of the track-jet association logic. Flavour-tagging techniques in ATLAS will be reviewed, presenting the state-of-the-art in terms of algorithms, with focus on the capability to reconstruct and select the relevant tracks produced in the ATLAS Inner Detector.

Poster Session II / 529

Performance and calibration for the identification of boosted Higgs bosons decaying into beauty quark pairs in ATLAS

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The physics programme at ATLAS involves a variety of Standard Model and Beyond Standard Model resonances decaying to two b quarks, including the Higgs Boson. In order to identify these resonances at high momentum, ATLAS has developed the boosted X⟶bb tagger, a new NN-based tagging algorithm which combines the flavour information of up to three sub-jets associated to the large-R jet capturing the decays of these particles. This talk presents the Monte Carlo performance for the boosted X⟶bb tagger and the corresponding calibration strategy using the full Run-2 dataset gathered by ATLAS and comparing to simulation. Foreseen results include the signal tagging efficiencies derived using Z (->bb)+jets and Z(->bb)+gamma events, and background mistag rates measured using ttbar and g->bb splitting in multi-jet events.

Poster Session I / 534

Search for type-III seesaw heavy leptons in leptonic final states in pp collision at sqrt(s)=13 TeV with the ATLAS detector

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Heavy leptons with masses ranging from the GeV to the TeV appear in several Beyond the Standard Model (BSM) mechanisms, aimed to explain the neutrino mass generation. The seesaw mechanism provides an elegant extension of the Standard Model (SM) explaining the smallness of the neutrino masses. In particular, it introduces at least one extra fermionic triplet field with zero hypercharge in the adjoint representation of SU(2)_L which couples to electroweak gauge bosons. These new charged and neutral heavy leptons could be produced via EW processes at the Large Hadron Collider (LHC).This search is performed using data collected by the ATLAS detector at sqrt(s)=13 TeV with an integrated luminosity of 139^-1 corresponding to the full Run-2 dataset recorded in LHC Run 2 (2015-2018). The analysis is focused on final states with large lepton multiplicity, which allows to reject a significant part of background providing an higher signal significance. For the first time, a result considering a combination of the most important type-III seesaw heavy leptons decay modes is presented.

Standard model physics at the TeV scale / 536

Overview of precision measurements (angular coefficients, charge asymmetry, sin2Θ, mW, etc) at the LHC

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Overview of precision measurements (angular coefficients, charge asymmetry, sin2Θ, mW, etc) at the LHC

Standard model physics at the TeV scale / 537

Multibosons production at the LHC (diboson, triboson)

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Multibosons production at the LHC (diboson, triboson)

Standard model physics at the TeV scale / 538

Status of VBS measurements at the LHC

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Status of VBS measurements at the LHC

Standard model physics at the TeV scale / 539

Single boson production overview (W, Z, ⊠) at the LHC

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Single boson production overview (W, Z, ⊠) at the LHC

Standard model physics at the TeV scale / 540

V+jets/+heavy flavour production at the LHC

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V+jets/+heavy flavour production at the LHC

Standard model physics at the TeV scale / 541

Jet substructure and fragmentation (including TOP) at the LHC

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Jet substructure and fragmentation (including TOP) at the LHC

Standard model physics at the TeV scale / 542

Modelling the data at the LHC: status and issues (overview including soft QCD and TOP)

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Modelling the data at the LHC: status and issues (overview including soft QCD and TOP)

Standard model physics at the TeV scale / 543

Top quark Cross sections overview (including re-interpretation) at the LHC

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Top quark Cross sections overview (including re-interpretation) at the LHC

Standard model physics at the TeV scale / 544

Status of single top measurements at the LHC

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Status of single top measurements at the LHC

Standard model physics at the TeV scale / 545

Associated productions with top (t+X, tt+X with X=W,Z,, heavy-flavours, tt) at the LHC

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Latest measurements of top quark pair production in association with EWK bosons (W, Z or ɣ) and heavy flavoured jets (cc,bb) using data collected by the ATLAS detector in LHCpp collisions at 13 TeV are presented. Inclusive and differential measurements are included. In addition, the most recent results of the very rare four-top-quark production are reported. Where available with full Run-2 data, measurements in single or dilepton final states are combined with the multilepton channel.

Standard model physics at the TeV scale / 546

Top quark properties overview (asymmetries, CP violation, spin correlations, FCNC) at the LHC

Author: Jacob Kempster[1]

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The remarkably large integrated luminosity collected by the ATLAS and CMS detectors during Run2 in proton–proton collisions at a center-of-mass of 13 TeV allows to use the large sample of top quark events to explore a variety of properties of top quark production and decay and to probe the presence on new physics that might break well established symmetries or manifest itself in rare processes. In addition to spin correlation, asymmetry measurements are presented in observables sensitive to CP violation using ttbar events. Furthermore, the electroweak nature of t-channel single top production is exploited to measure the three top (anti)quark polarization vectors. Finally, ttbar and single top productions are used jointly to search for top quark flavor-changing interactions with the Higgs boson, charm or up quarks, and gluons.

Standard model physics at the TeV scale / 547

Top quark mass measurements at the LHC

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Top quark mass measurements at the LHC

Standard model physics at the TeV scale / 548

Measurement of Higgs differential distributions at the LHC

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Recent measurements from the ATLAS and CMS collaborations on Higgs boson fiducial and differential cross sections will be presented. The interpretation of results will also be shown in EFT frameworks wherever possible.

Standard model physics at the TeV scale / 549

Double Higgs production at the LHC

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Double Higgs production at the LHC

Standard model physics at the TeV scale / 550

Higgs couplings to fermions and bosons (including inclusive cross sections, coupling combinations, spin/CP measurements of couplings) at the LHC

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With the full Run 2 pp collision dataset collected at 13 TeV, very detailed measurements of Higgs boson properties can be performed using its decays into bosons and fermions. At the same time, the search for double-Higgs production can profit for the large integrated luminosity to provide more and more stringent limits. This talk presents measurements of Higgs boson properties using decays into bosons and fermions and their combination, including production mode cross sections and simplified template cross sections, as well as their interpretations; and the searches for non resonant di-Higgs production, as well as their combination.

Standard model physics at the TeV scale / 551

Higgs rare and exotic decays at the LHC

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Exotic and rare decays of the Higgs boson provide a unique window for the discovery of new physics, as the Higgs boson may couple to hidden-sector states that do not interact under the Standard Model gauge transformations. Models predicting exotic Higgs boson decays to pseudoscalars can explain the galactic centre gamma-ray excess, if the additional pseudoscalar acts as the dark matter mediator. This talk presents recent searches for decays of the 125 GeV Higgs boson to new particles, and searches for rare decays of the Higgs boson where enhanced rates would be a sign of new physics. These searches use LHC collision data at sqrt(s) = 13 TeV collected by the ATLAS and CMS experiments in Run 2.

Hot and dense matter physics - QGP and heavy ion collisions / 552

Strange, charm and bottom hadron flow in pPb and PbPb

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Waiting for abstract.

Hot and dense matter physics - QGP and heavy ion collisions / 553

Recent heavy ion results from CMS

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Waiting for abstract.

Poster Session II / 555

The MIGDAL experiment: towards the first observation of the Migdal effect

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The Migdal effect predicts the emission of an atomic electron when the respective nucleus is perturbed. The experimental confirmation of this prediction would imply that current direct detection experiments are sensitive to dark matter (DM) particles with mass well below the thresholds typically assumed. In particular, it would have a great impact on the search for sub-GeV DM particles.
The objective of the Migdal In Galactic Dark mAtter expLoration (MIGDAL) experiment is to carry out the first observation of the Migdal effect. To that purpose, MIGDAL will use a neutron beam to induce the Migdal effect in gas atoms contained in a tracking chamber, and will search for events with a recoiling nucleus and a ionization electron originating from a common vertex.

This talk will present an overview of MIGDAL. I will first describe and motivate the design of the experiment. Then I will explain the expected signal, and discuss the respective backgrounds obtained from dedicated Monte Carlo studies.

Standard model physics at the TeV scale / 556

Perspectives for Higgs measurements at Future Colliders

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Nuclear and particle astrophysics / 557

Atomic Structure Calculations in Lanthanide and Actinide ions relevant to kilonovae

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The observation of the near-infrared emission from binary neutron-star merger events, often know as kilonova, has increased the confidence that these astrophysical sources are the potential sites of heavy r-process nucleosynthesis. This emission is present in the observations of the gravitational-wave signal (GW170817) by LIGO/Virgo and is consistent with an electromagnetic transient emission of a kilonova. However, data of opacities, necessary for the interpretation of these observations, relies heavily on atomic structure calculations of both lanthanides and actinides, which is still very sparse. In this work we discuss the details of these calculations and some of the limitations imposed by the complexity of f-shell elements. Besides reviewing some previous results, we compare them with our present calculations based on the the atomic structure codes FAC and MCDFGME. We study the combined effect of transition wavelengths and oscillator strengths on the opacities and how energy precision can be important at lower wavelengths. Finally, we discuss how higher sensitivity of the opacity curve at higher energies can be exploited, looking for features of specific of lantanides and actinides present in kilonovae.

Nuclear and particle astrophysics / 558

Trojan Horse Method for n-induced reaction investigations at astrophysical energies

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Neutron induced reactions play a significant role in the nucleosynthesis of the elements in the cosmos. Its interest ranges from the primordial processes occurred during the Big Bang Nucleosynthesis up to the "stellar cauldrons" where neutron capture reactions could take place via the s-process or the r-process.
In the last years, several efforts have been made to investigate the possibility of applying the Trojan Horse Method (THM) to neutron induced reactions mostly by using deuteron as "TH-nucleus". Here, the main advantages of using THM will be given together with a more focused discussion on the recent 7Be(n,alpha)4He and the 14N(n,p)14C reactions. The former reaction was studied via the THM application to the quasi-free 2H(7Be,aa)p reaction and it represents the extension of the method to neutron-induced reactions in which an unstable beam is present. The 14N(n,p)14C reaction was studied via the 2H(14N,p14C)p experiment performed at INFN-LNS via a 50 MeV 14N beam provided by the TANDEM accelerator. The preliminary data analysis will be also shown.

Nuclear and particle astrophysics / 559

Determination of 118Sn(p,g)119Sb cross-section at astrophysical energies from X-ray emission yields

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Proton capture reactions at sub-barrier energies have significant contributions in explosive nucleosynthesis environments. In particular, they are crucial to determine the reaction rate of the inverse (g,p) reaction in reaction networks describing the production of the stable p-nuclei, a set of 35 naturally occurring nuclei from Se to Hg that cannot be produced in neutron capture processes like the s-process or the r-process.
In this work, we present the measurement for the first time of the radiative proton capture reaction 118Sn(p,g)119Sb using the activation method by detecting the emitted X-rays. The gamma emission associated to the electron capture decay in 119Sb will be used to validate the method. The results are compared to theoretical predictions using the TALYS code, and show the potential of using this technique to further constrain the nuclear input in astrophysical network calculations.

Development of accelerators and detectors / 560

The PANDA Experiment

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The PANDA (Antiproton Annihilation at Darmstadt) experiment is currently being constructed at the High Energy Storage Ring (HESR) and going to be one of the four key experiments at the Facility for Antiproton and Ion Research (FAIR) near Darmstadt/Germany. The PANDA experiment is planned to address a wide range of open questions in hadron physics by studying the interactions between protons and antiprotons with an antiproton beam momentum range from 1.5 GeV/c to 15 GeV/c and a fixed proton target. The PANDA detector contains two different structures to cover almost the full solid angle: the target spectrometer (TS) as an onion shell-like detector that is enclosed in a solenoid magnet with a B-field of 2 T and the forward spectrometer (FS) with a 2 Tm dipole magnet to track and identify particles with small polar angles. The aim is to use modern detector technologies in both spectrometers in order to provide precise tracking in strong magnetic fields, excellent particle identification, calorimetry, and muon identification. This talk will focus on the construction and technical aspects of PANDA detector systems in both spectrometers together with the implemented magnets and two types of foreseen proton targets.

Energy frontier physics beyond the standard model / 561

Leptoquarks and HVB (in scenarios of LFU anomaly)

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Leptoquarks and Heavy Vector Boson searches covering all LHC experiments.

Energy frontier physics beyond the standard model / 564

Searches for Axion-Like Particles

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Searches for Axion-like particles covering all LHC experiments.

Energy frontier physics beyond the standard model / 565

Prospects for BSM at LHC (experimental vision)

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Experimental prospects for BSM searches at the LHC.

Energy frontier physics beyond the standard model / 566

Prospects for searches of new physics at future facilities beyond HL-LHC

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Energy frontier physics beyond the standard model / 567

Strong SUSY and third generation SUSY

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The most recent results of searches for supersymmetric (SUSY) particles produced via strong interaction, as well as for SUSY particles of the third generation, will be presented. The analyses are performed by the ATLAS and CMS Collaborations and are based on the full data set of proton-proton collisions collected during the Run 2 of the LHC.

Neutrino physics / 568

Looking for More New Physics in Long-Baseline Neutrino Oscillation Experiments

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Thanks to the discovery of nonzero neutrino masses, several new neutrino oscillation experiments worldwide are under serious investigation for the current decade and beyond. I provide an overview of the physics of long-baseline neutrino oscillation experiments, concentrating on their ability to reveal more new phenomena in the neutrino sector.

Neutrino physics / 569

Coherent elastic neutrino-nucleus scattering experimental programs

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Coherent elastic neutrino-nucleus scattering (CEvNS) is a process in which a neutrino scatters off an entire nucleus. Measurements will further the search for BSM physics and bring new insights to topics in nuclear physics and astrophysics. CEvNS has now been observed in CsI and Ar by the COHERENT collaboration. A number of experiments are pursuing further measurements, making use of a variety of neutrino sources and detector technologies. This talk will explore the physics reach of CEvNS experiments, the status of the current experimental program, and prospects for the future.

Applications of nuclear and particle physics technology / 570

Proton-range verification in proton radiation therapy using PET

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I will report first performance results for a prototype PET system designed for proton rage verification in proton therapy. This prototype will later be evaluated with phantoms and animals at the proton therapy center of MD Anderson Cancer Centre in Houston, Texas, USA.
The PET system consists of two detector module assemblies in the shape of angular sections of a cylinder with an inner diameter of 325 mm and axial length 105 mm. The two angular sections cover 99 degrees each. Because of the partial angular coverage, optimization the time resolution is essential in this application. Each PET detector module consists of an 8x8 LYSO array with 3x3x15 mm3 pixels in one-to-one coupling to one Hamamatsu MPPC array S14161-3050HS-08 with 3x3 mm2 pixels. The readout electronics is developed by PETsys Electronics and is based on the PETsys TOFPET2 ASIC. The complete PET system will has 96 detector modules and 6144 electronic readout channels. The interface to the DAQ computer is based on a DAQ module using the PXI express bus, and receiving data from the front-end part through two optical links at 6 Gbit/s.
A Clock&Trigger module located near the detectors will distribute clock signals and allow selecting system wide coincidence events selection in the front end firmware. The complete readout can be divided in a configurable number of trigger regions, and events without a coincidence partner in a different trigger region will not be transmitted to the DAQ computer. This will reduce the data rate to the computer by about one order of magnitude.
We will also report the results of a study of radiation damage to the detectors in this application. The study is based on Geant4 simulation.

Applications of nuclear and particle physics technology / 571

Measurements of primary and secondary particle tracks in live cells

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Carbon (C-) ion beams undergo nuclear interactions with tissue, producing secondary nuclear fragments. Thus, at the depth where the tumor and critical structures are located, C-ion beams are composed of a mixture of different particles with different linear energy transfer (LET) values. Indeed,

at the middle of a typical spread-out Bragg peak of a C-ion beam, only about 35% of the particles are primary particles. To understand the biological consequences of C-ions it is important to elucidate how single cells coupe with damage induced by C-ions and their fragments. Particularly, it is important to understand at the molecular level the kinetics of DNA repair proteins after damage from C-ions and their fragments. Here we describe a technique that enables isolation of DNA damage response (DDR) in mixed radiation fields using beam line microscopy coupled with fluorescence nuclear track detectors (FNTDs).
We first constructed a portable confocal microscope that could be transported to and placed in any beam line. We then cultured HT1080-eGFP-53BP1 cells on coverslips made of FNTDs, which in turn where imaged before, during and right after C-ion, proton or photon irradiation using an in-house built confocal microscope placed in the beam path. The HT1080-eGFP-53BP1 cell construct allowed us to monitor the spatiotemporal behavior of 53BP1, a double strand break repair protein. The FNTD allowed us to link single particle track traversals to their damage sites and separate DNA damage induced by primary particles from fragments in the HT1080-eGFP-53BP1 cell nucleus.
We were able to spatially link physical parameters of radiation tracks to DSB sites in live cells to investigate DSB repair induced by a clinical C-ion beam in real time, which was previously not possible. We demonstrated that the lesions produced by the high-LET primary particles associate most strongly with cell death in a multi-LET radiation field, and that this association is not seen when analyzing radiation induced DSB lesions in aggregate without primary/fragment classification.
We report a new method that uses confocal microscopy in combination with FNTDs to provide submicrometer spatial-resolution measurements of radiation tracks in live cells. Our method facilitates expansion of the radiation-induced DNA damage research because it can be used in any particle beam line including particle therapy beam lines.

Applications of nuclear and particle physics technology / 572

Ion beams for the development of radiation resistant semiconductors

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Ion beams are used in a wide range of applications in research and industry including the deliberate modification of functional materials and the characterisation of materials using ion beam analysis techniques. The understanding of ion-solid interactions furthermore allows evaluating the detrimental effects of radiation on materials and devices in different radiation environments. GaN and related semiconductors are currently challenging conventional silicon technology for the next generation of high frequency and high power devices operating in extreme environments such as space. We present recent results demonstrating the extraordinary radiation resistance of GaN upon ion irradiation within a wide energy range. For medium energy (hundreds of keV), GaN shows high amorphisation thresholds, however, the complex defect accumulation processes in the crystal lattice need to be better understood in order to implement ion implantation as a processing tool for nitride electronics. For highly ionising swift heavy ion irradiation (hundreds of MeV), a strong in-track recovery of the crystal damaged during the ion passage keeps permanent damage low. These are promising results for the use of GaN in space. Back on Earth, GaN can find applications in robust detectors for ionising radiation. We will report first results on the development of GaN microwire radiation sensors.

Poster Session I / 573

Characterization and functional test of a micro dosimeter of scintillated optical fibers

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With the growing demand for better and improved technics in treating cancer in Portugal, there is an ongoing discussion of the need to build a proton therapy centre as well as train skilled labour in this field. In result, there is a need for high precision measuring instruments that supply real-time measures of dose (J/kg) at a tissue or DNA level, where the variance values are large enough to create undesirable errors.
The goal of this work is to develop a new detector capable of measuring real-time doses with sub-millimeter resolution, constructed using juxtaposed thin plastic scintillating fibers (PSF, 0.25, 0.5 and 1 mm) coupled with a readout by a multi-anode photomultiplier (MAPMT, 64 channels) and a suitable data acquisition (DAQ) system. In this poster it is discussed the characterization of the full detection chain (optical fibers, MAPMT and DAQ), measuring quantities such as optical and electrical crosstalk, noise, linearity, and stabilization using UV LEDs. To conclude the characterization, several radioactive sources (Cs-137, Co-60, Tl-204 and Am-241) were used.

Poster Session I / 574

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

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Several studies show that the combination of high-Z nanoparticles and external radiotherapy leads to an increased radiation effect in tumoral cells without an increase of the patient dose. However, it is not yet clear how the sequence of physical, chemical, and biological mechanisms contributes to the observed synergic effect.
The objective of this work is to develop simulation tools that allow the analysis and interpretation of radiobiology studies with multifunctional nanoparticles (NPs). To do that, we will develop realistic simulations of the irradiation of monolayer (2D) and spheroid (3D) human glioblastomas multiforme (GBM) cell cultures, taking into consideration different concentrations and cellular and subcellular distributions of the gold nanoparticles (AuNPs).
The simulations will be implemented based on TOPAS 1 software more specifically the extension TOPASn-Bio 2 that includes models of the physical and chemical processes induced by radiation at the DNA scale. These must describe the laboratory experimental conditions of irradiation with X-rays, Co-60 sources and with proton beams considering the cell lines morphology and 2D and 3D

cell culture scenarios. The construction of the computational cell models will be developed based on confocal microscopy images of the biological samples.
Based on the simulations, the dose distributions at the subcellular scale will be obtained, as well as the temporal distribution of the reactive oxygen species (ROS) induced by the different irradiation conditions, AuNPs distribution, and concentrations. The microdosimetric distributions in cells will be used to predict cell survival fractions, using standard mathematical models of the biological effects of radiation as Local Effect Model (LEM) 3, Nanodosimetric Oxidative Stress (NanOx) [4] and Microdosimetric Kinetic Model (MKM) [4].
The results obtained in the simulations will be compared with the biological in vitro and in vivo experimental results, which will include evaluation of cell viability and survival. Moreover, the simulated ROS yields will be also compared with the experimentally determined values.

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3 T. Elsasser, et al., "Quantification of the relative biological effectiveness for ion Beam radiotherapy: direct experimental comparison of proton and Carbon ion beams and a novel approach for treatment planning", Int. J. Radiation Oncology Biol. Phys., Vol. 78, No. 4, pp. 1177–1183, 2010
[4] M. Cunha, et al., "NanOx, a new model to predict cell survival in the context of particle therapy" , Phys. Med. Biol. 62 1248, 2017
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Applications of nuclear and particle physics technology / 575

Scintillating array for real –time high –resolution ion therapy dosimetry –Initial Design and Simulations

Authors: Duarte Guerreiro[1]; Matilde Santos[1]; João Gentil[2]; Luís Peralta[1]; Jorge Sampaio[1]

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Radiobiology is a multidisciplinary area where the effects of radiation in cells, tissues and organs are studied. To understand the biological effects of radiation it is important to be able to have a read of the energy deposition at a micro and nano scales.
Having this in mind, this project is being developed with the aim of building a detector that offers radiobiology researchers the chance to perform their studies with good spatial resolution and real-time dose measurement.
The technique chosen to build this detector is scintillation dosimetry with plastic optical fibers. The optical fibers were chosen because they offer a very good spatial resolution and tissue-equivalence, being able to offer a spatial resolution of 0.25 mm.
In this talk will be presented the initial design of the detector, ready for production: This detector will be developed as an irradiation box with a sensitive area composed of plastic optical fibers with the possibility of mapping dose in one plane or in two orthogonal planes originating a spatial resolution of 1x1 mm, 0.5x0.5 mm and 0.25x0.25 mm depending on the optical fibers used. The detector will be prepared for the possibility of receiving a cell culture plate and moving it in front of the detector's sensitive area. It will be also presented simulations (detector performance and shielding) where it is shown the signal expected when the detector is irradiated with a proton beam and a study of the shielding necessary in the experimental setup.

Poster Session I / 576

Measurements of Nuclear Modification Factor of Inclusive Full Jet Measurements in Pb-Pb Collisions at √sNN = 5.02 TeV with LHC-ALICE

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The quark-gluon plasma (QGP) which emerges in collisions of ultra-relativistic heavy-ions can be probed with jets, collimated showers of hadrons resulting from fragmentation of highly-virtual partons after a hard scattering. The jet shower interacts with the QGP via collisional and radiative processes that lead to a phenomenon known as jet quenching which manifests itself by suppression of high-pT jet yields and jet shape modifications. The observed modifications carry information about the transport properties of the QGP.
In this presentation, we report the nuclear modification factor measurements of full jets in Pb-Pb collisions at √sNN = 5.02 TeV taken with the ALICE experiment at the LHC. The jet energy scale is corrected for the large, fluctuating underlying event with the area based method, where the underlying event density is obtained either with the traditional or machine learning based estimators. The machine learning estimator enables to access lower transverse momenta and larger jet radii than previously possible in ALICE. The potential bias introduced by the machine learning method is investigated and its impact is quantified.

Plenary session / 577

Overview on theoretical issues of standard model and physics at the TeV scale

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Plenary session / 578

Higgs physics results by ATLAS and CMS

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We present in this contribution an overview of the latest Higgs results published by the ATLAS and CMS collaborations. The focus will be on analyses considering the whole Run 2 dataset, showing measurements of the Higgs boson mass and inclusive, fiducial, and differential cross-section measurements in the main decay channels and searches in more challenging phase spaces. Finally, a review of the newest searches for double Higgs production at the LHC is presented.

Plenary session / 579

Highlights of EW and QCD results at the LHC

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Plenary session / 580

Observational multi-messenger physics with neutrinos and beyond

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Plenary session / 581

Theoretical understanding on dark matter

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Plenary session / 582

Experimental searches for dark matter

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Plenary session / 583

New experimental results in the field of neutrino physics

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Plenary session / 584

Theoretical progress in the field of neutrino physics

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Opening

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Plenary session / 586

New theoretical aspects of flavor physics

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Plenary session / 587

LHCb results

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Plenary session / 588

Belle II results

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Plenary session / 589

Theoretical aspects of fundamental symmetries and conservation laws

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Plenary session / 590

Overview on experimental tests of fundamental symmetries and conservation laws

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Plenary session / 591

The muon g-2 experiment at FNAL

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The E989 collaboration has recently published the most precise measurement of the muon anomalous magnetic moment ⊠⊠ with an uncertainty of 460 ppb. The new experimental world average of ⊠⊠ deviates by 4.2 standard deviations from the Standard Model prediction provided by the Muon g-2 Theory Initiative. The emerging results from ab-initio lattice QCD calculations allow to scrutinize this tantalizing hint for physics beyond the Standard Model for the first time in a three way comparison. To extract the value of ⊠⊠ a clock comparison experiment is performed with spin-polarized muons confined in a superbly controlled electric and magnetic field environment. The deviation of the Larmor from the cyclotron frequency, the anomalous spin precession frequency, is determined while a high-precision measurement of the magnetic field environment is performed using nuclear magnetic resonance techniques. I will discuss the most recent result from the first science data run in 2018 and will report on the experimental improvements implemented to achieve the ultimate goal of 140 ppb uncertainty on ⊠⊠.

Plenary session / 592

Theoretical understanding of light and heavy hadrons

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Plenary session / 593

New experimental results on light and heavy hadrons

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Plenary session / 594

New theoretical results on QCD and the structure of the nucleon

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Plenary session / 595

New experimental results on the (spin) structure of the nucleon

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Plenary session / 596

Experimental status of the proton radius

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Plenary session / 597

Status of and plans for the EIC project

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Plenary session / 598

New theoretical results on hot and dense matter physics in heavy ion reactions

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Plenary session / 599

Experimental results on hot and dense matter physics in heavy ion reactions

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The main goal of the relativistic heavy-ion reaction experiments is to study the phase structure of the QCD phase diagram. Experiments at the Relativistic Heavy Ion Collider and Large Hadron Collider Facility have produced a QCD matter with quark and gluon degrees of freedom –quark-gluon plasma (QGP). In this talk, we review the recent measurements related to mapping the phase diagram of QCD, large initial magnetic field, the polarization of QGP, and search for novel phenomena of Chiral Magnetic Effect. We also discuss the observation of significant collectivity in small systems relative to those observed in heavy-ion reactions, new results on investigation of QGP properties through measurements of heavy-flavor hadrons and tagged jets, and exciting possibilities like light-light scatterings in ultra-peripheral heavy-ion reactions. Finally, as an outlook, we discuss the movement of the field towards an experimental investigation of high baryon density matter at lower collision energies and precision measurements of properties of QGP through high luminosity running of facilities at higher energies.

Plenary session / 600

Theoretical understanding of hadrons in hot/dense media

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Plenary session / 601

Overview on experimental results on hadrons in medium

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Plenary session / 602

Overview on progress in theoretical nuclear physics

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Plenary session / 603

Experimental nuclear astrophysics overview

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If there is one thing we learned about the field of nuclear astrophysics in the last 10 years, it's that it is complicated business. While the original processes proposed already in the 1950s are still mostly valid and continue to exhibit important open questions, today we understand that other processes may have significant contributions. In particular, the production of heavy elements, which involves explosive nucleosynthesis processes, is one of the topics where major advances have been made in the last years. These advances are driven by new astronomical observations, sophisticated new astrophysical models, and new developments in radioactive ion beam facilities around the world.
In this talk I will present an overview of the field of nuclear astrophysics, focusing on the recent discoveries and current open questions especially from the experimental point of view. A particular focus will be on heavy element nucleosynthesis and on the new exciting opportunities that will soon be available at the Facility for Rare Isotope Beams (FRIB) at Michigan State University.

Plenary session / 604

Overview on progress in nuclear medical physics

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Plenary session / 605

Accelerator Technologies and Science: Progress and Outlook

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For over half a century, high energy particle accelerators play key role and shape modern nuclear and particle physics, they are also the instruments for the forefront research for the material science and biology. In this talk we briefly overview the most notable accelerator facilities which came into operation since previous 2017 PANIC Conference and now employed for research in nuclear physics, basic energy sciences, neutrinos, high energy particle frontier. We also present upcoming and planned future facilities and outline their main goals, challenges and required R&D. Focus will be given to the core accelerator technologies such as magnets, RF acceleration, and targets as we as leading beam physics developments such as beam cooling, colliding beams and plasma acceleration.

Plenary session / 606

New developments in Physics Data science

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Plenary session / 607

Overview on the energy frontier of particle physics beyond the standard model

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Plenary session / 608

(Astro)physical implications of the O3 gravitational wave detections

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Neutrino physics / 609

The status of T2K and Hyper-K experiments

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T2K is an accelerator-based neutrino experiment providing world-leading measurements of the parameters governing neutrino oscillation. T2K data enabled the first 3sigma exclusion for some intervals of the CP-violating phase \delta_{CP} and precision measurements of the atmospheric parameters \Delta_m^{2}{32}, sin^2(\theta{23}). T2K uses a beam of muon neutrinos and antineutrinos produced at the Japan Particle Accelerator Research Centre (JPARC) and a series of detectors located at JPARC and in Kamioka, 295km away, to measure oscillation from neutrino event rates and spectra. The T2K beam will be upgraded with increased power in 2022 and, combined with an upgrade of the ND280 near detector, will usher in a new important physics period for T2K. In addition, the Super-Kamiokande detector has been loaded with 0.02% of Gadolinium in 2020, enabling enhanced neutron tagging. In preparation for the new physics run, 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 modelling of the beam line materials. New selections have been developed at ND280, with proton and photon tagging, and at Super-Kamiokande, where pion tagging has been extended to muon neutrino samples. After reviewing the latest measurements of oscillation parameters, the status of such new analysis developments and the plan to deploy the beam and ND280 upgrade will be presented.
The Hyper-Kamiokande experiment consists of a 260 kt underground water Cherenkov detector with a fiducial volume more than 8 times larger than that of Super-Kamiokande. It will serve both as a far detector of a long-baseline neutrino experiment and an observatory for astrophysical neutrinos and rare decays. The long-baseline neutrino experiment will detect neutrinos originating from the upgraded 1.3 MW neutrino beam produced at the J-PARC accelerator. A near detector suite, close to the accelerator, will help characterise the beam and minimise systematic errors. The experiment will investigate neutrino oscillation phenomena (including CP-violation and mass ordering) by studying accelerator, solar and atmospheric neutrinos, neutrino astronomy (solar, supernova, supernova relic neutrinos) and nucleon decays. An overview of the Hyper-Kamiokande experiment, its current status and physics sensitivity will be presented.

Neutrino physics / 611

The DUNE experiment

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The Deep Underground Neutrino Experiment (DUNE) is a next generation, long-baseline neutrino oscillation experiment which will utilize high-intensity ν_μ and $\bar{\nu}_\mu$ with peak neutrino energies of ~2.5 GeV produced at Fermilab, over a 1285 km baseline, to carry out a detailed study of neutrino mixing. The neutrino beam has an initial design intensity of 1.2 MW, but has a planned upgrade to 2.4 MW. The unoscillated neutrino flux will be sampled with a near detector complex at Fermilab, and oscillated at the DUNE far detector at the Sanford Underground Research Facility, which will ultimately consist of four modules each containing a total liquid argon mass of 17 kt.

In this talk, the key features of the DUNE experiment will be described. DUNE's long-baseline neutrino oscillation sensitivity will be discussed, including a full simulation, reconstruction, and event selection of the far detector and a full simulation and parameterized analysis of the near detector. Detailed uncertainties due to the flux prediction, neutrino interaction model, and detector effects are included. DUNE is able to resolve the neutrino mass ordering to a 5σ precision, for all values of the CP-phase, after a 66 kiloton-megawattyear exposure (ktMWyr). It has the potential to observe charge-parity violation in the neutrino sector to a precision of 3σ (5σ) after an exposure of 197 (646) ktMWyrs, for 50% of all values of the CP-violating phase. DUNE's sensitivity to other oscillation parameters of interest have been explored.

Flavour physics - CKM and beyond / 612

Belle II hot topic: Precise measurements of the D meson lifetimes (12+3)

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Flavour physics - CKM and beyond / 613

Flavor Physics at the FCC-ee (15+5)

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Dark matter and cosmology / 614

A machine learning approach to the Galactic Center Excess

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A machine learning approach to the Galactic Center Excess

Dark matter and cosmology / 615

The Fermi-LAT GeV excess: from dark matter to point sources

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TBA

Dark matter and cosmology / 616

Axions, strong lensing and deep learning: Towards convincing dark matter discoveries in astrophysical data

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TBA

Dark matter and cosmology / 617

Anomalies and opportunities in indirect searches for Dark Matter

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Anomalies and opportunities in indirect searches for Dark Matter

Dark matter and cosmology / 618

Dark Matter and Long-Lived Particles in Celestial Bodies

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TBA

Dark matter and cosmology / 619

Dark Matter Interpretation of the Fermi-LAT Observations Toward the Outer Halo of M31

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Dark Matter Interpretation of the Fermi-LAT Observations Toward the Outer Halo of M31

Dark matter and cosmology / 620

New Physics and the Black Hole Mass Gap

Author: Sam McDermott[None]

New Physics and the Black Hole Mass Gap

Applications of nuclear and particle physics technology / 621

Adapting a computed tomogram to Geant4 for monitoring proton therapy via prompt-gamma rays and time-of-flight PET

Author: Hugo Simões[1]

Co-authors: Valéria Lopes ; Andrey Morozov [2]; Jorge Sampaio [3]; João Silva ; José Teodoro ; Margarida Simões ; Patricia Gonçalves [2]; Paulo Crespo [2]

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Proton therapy (PT) is growing worldwide due to its ability to provide a very conformational dose to the tumor being irradiated. However, diverse variables may compromise such conformationality and lead to undesirable situations that are suspected of being correlated with tumor recurrence. Several approaches have been suggested for in vivo monitoring of the PT dose delivery and proton beam range verification. One of them, already applied in clinical practice, is based on positron emission tomography (PET) which involves detection of 511 keV gamma rays resulting from positron-emission decay of proton induced radioactive nuclides. Another group of techniques is based on detection of prompt gamma rays (PG) originating from proton-nuclear interactions within the body.
The Laboratory of Instrumentation and Experimental Particle Physics (LIP, Portugal) has been conducting studies on these two topics. In the field of PET, LIP is part of the TPPT (in-beam time-of-flight positron emission tomography for proton therapy) consortium which is thriving efforts in order to construct an in-beam TOF-PET system onto one of the therapeutic proton beam lines in the MD Anderson Cancer Center (MDACC) in Houston, Texas, USA (University of Texas). The team at LIP is responsible for the simulations that will allow a comparison between measured beta+ activity distributions versus the expected ones. Regarding the PG imaging technique, LIP has addressed efforts to develop and test a system with a multi-slat collimator oriented orthogonality to the beam direction in order to detect the PG rays that escape the patient in the perpendicular direction.
A more detailed study of both aforementioned approaches requires simulation of real treatment plans. This task includes, on one hand, the adaptation of patient computed tomograms (which are proportional to electron density) into Geant4 (which includes tissue density and stoichiometry). On the other hand, some irradiation beam parameters (e.g. position, energy, direction, among others) should also be considered in the simulations. In this work, the latest developments on this topic will be presented.

Plenary session / 622

Free falling?: From 21st century Physics to 16th century Physics

Author: Henrique Leitão[1]

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After getting a PhD in Physics, I slowly moved, or drifted, or - according to some colleagues - degraded, into the history of science. In this presentation I will try to justify this curious turn of events. That is, I will show why questions in mathematics and physics of more than 500 years ago can still be interesting and challenging today. I will also show that there are still many open questions in the history of science, waiting for the right researcher to appear - a physicist perhaps?

Plenary session / 623

From the infinitesimal to the infinite with high energy particle colliders

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One of the goals of particle physics is to explain the structure of matter at the smallest distance scales. For decades, the properties of the basic building blocks of matter have been investigated in ever greater detail. However, even today some profound but simple questions, such as the origins of dark matter in the universe, remain unanswered. The attempt to understand the material world around us in the simplest possible terms has involved ingenious feats of scientific sleuthing. Such fundamental questions are being addressed by using high-energy particle colliders. These energetic collisions provide, for a brief instant, the energy necessary to produce new forms of matter, as was done a fraction of a second after the big bang. This presentation will illustrate how we use the very large-scale colliders to probe the incredibly small, which can provide answers to questions on a universal scale!

624

Discussion

625

Discussion

626

Discussion

627

Discussion

Farewell / 628

Farewell

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Plenary session / 630

Best Posters

Authors: Fabio Happacher[1]; Ingo Rienäcker[2]; Maud VERSTEEGEN[3]; Souvik Priyam Adhya[4]

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The best posters in Nuclear Physics and in Particle Physics will be awarded two prizes kindly offered by NuPECC, the Nuclear Physics European Collaboration Committee.
The best poster in the Instrumentation domain will be awarded a prize kindly offered by MDPI - Instruments, the peer-reviewed, open access journal of scientific instrumentation and its related methods and theory.
The best poster authored by a PhD student will be awarded a prize kindly offered by the EPS - European Physical Society.

Neutrino physics / 631

Neutrinoless double beta decays

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Double beta decay tests new physics beyond the standard model. Various theoretical options and methods to unravel which one is realized will be discussed.

Neutrino physics / 632

The Quest for Majorana Neutrinos

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Since neutrinos have no electric charge or color, they may be their own antiparticles, referred to as Majorana neutrinos, and thus violate lepton number conservation. Neutrinoless double beta decay ($0\nu\beta\beta$) would be a direct consequence, and the search for this decay mode is the most sensitive method to unravel the Majorana nature of neutrinos. In this talk, I will high-light recent experimental achievements, the future plans for ton-scale experiments and their experimental challenges to

explore neutrino masses down to the $m_{\beta\beta} \sim 10$ meV scale. The synergies with other neutrino mass observables will be summarized.

Poster Session I / 633

Is there any New Physics?

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In the wake of the recent measurements of the decays B ⟶ J/ψ π(K) and B ⟶ J/ψ lν reported by the LHCb Collaboration we calculate c c l
the form factors for the B ⟶ J/ψ and B ⟶ η transitions in full kinematical region within covariant confined quark model. Then we use the c c c
calculated form factors to evaluate the partial decay widths of the above-mentioned semileptonic and nonleptonic decays of the B meson. c
We find that the theoretical predictions on the ratios of R and R are in good agreement with the last LHCb-data. However, the prediction K+/π+ π+/μ+ν
for the R is found to be underestimated.

Energy frontier physics beyond the standard model / 634

Probing dark matter with ILC

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The International Linear Collider offers a number of unique opportunities for searches for dark matter and dark sector particles. The collider program will offer important capabilities, but also, the ILC will enable new fixed-target experiments using the high-energy electron and positron beams, both beam dump experiments and dedicated experiments using single beams. This talk will describe the expectations for these programs, which address all of the possible dark sector portals.?
(on behalf of the ILC International Development Team Speakers Bureau)