New Trends in High-Energy and Low-x Physics

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Book of Abstracts

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Overview of ATLAS forward proton detectors: status, performance and new physics results

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A key focus of the physics program at the LHC is the study of head-on proton-proton collisions. However, an important class of physics can be studied for cases where the protons narrowly miss one another and remain intact. In such cases, the electromagnetic fields surrounding the protons can interact producing high-energy photon-photon collisions. Alternatively, interactions mediated by the strong force can also result in intact forward scattered protons, providing probes of quantum chromodynamics (QCD). In order to aid identification and provide unique information about these rare interactions, instrumentation to detect and measure protons scattered through very small angles is installed in the beam pipe far downstream of the interaction point.
We describe the ATLAS Forward Proton 'Roman Pot' Detectors (AFP and ALFA), including their performance to date, covering Tracking and Time-of-Flight Detectors as well as the associated electronics, trigger, readout, detector control and data quality monitoring. The physics interest, beam optics and detector options for the extension of the programme into the High-Luminosity LHC (HL-LHC) era are also discussed. Finally, a glimpse on the newest results will be given.

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Unitarity effects in elastic scattering at the LHC

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We study the high-energy behavior of the elastic scattering amplitude using two distinct unitarization schemes: the eikonal and the U-matrix. Our analysis begins with a formalism involving solely Pomerons, incorporating pion-loop insertions in the Pomeron trajectory representing the nearest singularity generated by t-channel unitarity. Subsequently, we explore a scenario that includes the presence of an Odderon. In our analyses, we explore the tension between the TOTEM and the ATLAS measurements for σ_{tot} and $d\sigma/dt$ at 7, 8, and 13 TeV, and the subsequent implications for the properties of both the Pomeron and Odderon. Our results show that the Odderon phase factor $\xi_{\mathbb{O}} = -1$ is favored in both unitarization schemes. More interestingly, this specific phase factor stands as the sole one that aligns with results consistent with a non-zero Odderon coupling.

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Revisit Lepton Flavor Violating Deep Inelastic Scattering

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New physics models allow Lepton Flavor Violating (LFV) reactions which are exactly forbidden in the standard model. Hence search for LFV is a clue to the new physics, which unveil the flavor structure and the symmetries behind it. We revisit LFV lepton-nucleus deep inelastic scattering, $\ell_i N \to \ell_j X$ (ℓ_i and ℓ_j are different flavor lepton, N is nucleus, and X is hadron), which is a leading probe for the LFV. We point out that a new subprocess $\ell_i g \to \ell_j g$ (g represents gluon) via the effective interactions of LFV mediator and gluon gives large contribution. Furthermore, in the light of quark number conservation, we consider quark pair-production processes $\ell_i g \to \ell_j Q\bar{Q}$ (Q denotes heavy quarks) instead of $\ell_i Q \to \ell_j Q$. We discuss model discrimination by analyzing final state distributions.

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Some physics of small collision systems

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In recent years certain experimental results from small collision systems (e.g. p-p, d-Au, p-Pb) at the RHIC and LHC have been reinterpreted as evidence for formation therein of a dense flowing medium (QGP) despite small collision volumes. Systems that had been assigned as simple references (e.g. cold nuclear matter) for larger A-A collisions would then no longer play that role. This presentation examines conventional interpretations of certain data features in the context of a two-component (soft+hard) collision model. Specific topics include centrality determination for p-Pb collisions, interpretation (or not) of nuclear modification factors, significance of claims for strangeness enhancement, and interpretation of the "ridge" in p-p collisions. For p-p and p-Pb data, analysis results indicate that p-Pb collisions are simple linear superpositions of p-N collisions, and N-N collisions within small systems generally follow simple and consistent rules. However, there is more to be learned about "basic" QCD in small systems with improved analysis methods.

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Search for the critical point via intermittency analysis in NA61/SHINE

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The existence and location of the QCD critical point are objects of both experimental and theoretical studies. The comprehensive data collected by NA61/SHINE during a two-dimensional scan in beam momentum and system size allows for a systematic search for the critical point - a search for a non-monotonic dependence of various correlation and fluctuation observables on collision energy and size of colliding nuclei.

Intermittency analysis is a statistical tool used in heavy ion collisions that includes the study of scaled factorial moments (SFMs) of multiplicity distributions in 2D transverse momentum space to detect power-law fluctuations and explore different aspects of the QCD phase diagram. In particular, proton intermittency has been used to locate the critical point of strongly interacting matter, and more recently, it has been used also to study the properties of QCD interactions using charged hadrons.

This contribution will present a summary of results in proton-proton intermittency, as well as the results on negatively charged hadrons intermittency from NA61/SHINE interactions.

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Diagram of high-energy nuclear collisions –new results on Xe+La central collisions from NA61/SHINE at CERN SPS

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NA61/SHINE is a multipurpose fixed-target experiment located at CERN SPS. One of its main goals is to study the onset of deconfinement and the properties of strongly interacting matter. For this purpose, a unique two-dimensional scan in collision energy ($\sqrt{s_{NN}} = 5.1 - 16.8/17.3$ GeV) and system size was performed.
Results on identified hadron spectra produced in nucleus-nucleus collisions, including the first results for Xe+La collisions, will be presented. The kinematic distributions and measured multiplicities of identified hadrons will be compared across various colliding systems and different collision energies. The diagram of high-energy nuclear collisions emerging from this discussion will be introduced along with its possible interpretation based on successful modeling approaches.

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Feasibility studies of Λ transverse polarization in p+p interactions within NA61/SHINE at the CERN SPS

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NA61/SHINE is a fixed-target experiment at the CERN SPS. Its spectrometer has unique properties including large particle acceptance and precise momentum measurement. These properties and high statistics of collected proton-proton collisions at beam momentum 158 GeV/c allow analyzing the transverse polarization of Λ hyperons produced in the primary vertex.

The opportunities for measurements of transverse polarization of Λ hyperons in NA61/SHINE were studied based on Monte-Carlo simulations using EPOS and Fritiof models, and the results will be presented. Especially, the biasing impact of magnetic field on polarization will be discussed in detail. The results show that the bias of Λ polarization due to precession in the magnetic field is limited and less than biases due to limited detector acceptance.

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Speed of sound from ultracentral nucleus-nucleus collisions using the mean transverse momentum

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It has recently been proposed that the speed of sound of the Quark-Gluon Plasma can be experimentally measured using the variation of the mean transverse momentum with the particle multiplicity in ultracentral heavy-ion collisions. In this talk we access this correspondence via hybrid hydrodynamic simulations at zero impact parameter with several equations of state. It is found the correspondence is satisfied for a smooth, boost-invariant fluid and an ideal detector indicating the reliability of extracting the speed of sound from experimental data. Differences between this simplified setup and actual experiments are discussed.

Based on: F. G. Gardim, A. V. Giannini and J. Y. Ollitrault, Accessing the speed of sound in relativistic ultracentral nucleus-nucleus collisions using the mean transverse momentum, arXiv:2403.06052 [nucl-th].

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Recent highlights on collective properties of the nuclear matter from the STAR experiment at RHIC

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The study of flow harmonics provides valuable insights into the dynamics and properties of the Quark-Gluon Plasma (QGP) medium produced in heavy-ion collisions. The directed flow (v_1) slope (dv_1/dy) of protons at mid-rapidity is expected to be sensitive to the first-order phase transition. The number of constituent quark (NCQ) scaling of elliptic flow (v_2) can be regarded as a signature of the formation of QGP. Triangular flow (v_3) typically originates from fluctuations and is expected to provide constraints on the initial state geometry and fluctuations.

In this talk, we focus on the results of collective flow from Au+Au collisions at the top RHIC energy ($\sqrt{s_{NN}} = 200$ GeV), the Beam Energy Scan (BES) program ($\sqrt{s_{NN}} = 3.0$ to 27 GeV). Additionally, we will present results from the data collected for the deformed nuclei, such as Isobars (Ru+Ru and Zr+Zr) and U+U collisions. The transverse momentum (p_T), rapidity (y), and centrality dependence of v_1 and v_2 will be presented. Furthermore, the beam energy dependence of the v_1 and v_3 slopes and the p_T-integrated v_2 will be examined. The experimental results will be compared with model calculations to better understand the underlying physics mechanisms in heavy-ion collisions.

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Modified Characteristics of Hadronic Interactions in Ultra-high-energy Cosmic-ray Showers

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Data from multiple experiments suggest that the current interaction models used in Monte Carlo simulations do not correctly reproduce the hadronic interactions in air showers produced by ultra-high-energy cosmic rays (UHECR), in particular –but not limited to –the production of muons during the showers. We have created a large library of UHECR simulations where the interactions at the highest energies are slightly modified in various ways –but always within the constraints of the accelerator data, without any abrupt changes with energy and without assuming any specific mechanism or dramatically new physics at the ultra-high energies. We find that even when very different properties –cross-section, elasticity and multiplicity –of the interactions are modified, the resulting changes in some air-shower observables are still mutually correlated. Thus not all possible combinations of changes of observables are easily reproduced by some combination of the modifications. Most prominently, the recent results of the Pierre Auger Observatory, which call for a change in the prediction of both the muon content at ground and the depth of the maximum of longitudinal development of the showers, are rather difficult to reproduce with such modifications, in particular when taking into account other cosmic-ray data. While some of these results are related to the assumptions we place on the modifications, the overall lessons are general and provide valuable insight into how the UHECR data can be interpreted from the point of view of hadronic physics.

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Ultra-high-energy hadronic physics at the Pierre Auger Observatory

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The Pierre Auger Observatory, the world's largest observatory of ultra-high-energy cosmic rays (UHECR), offers a unique insight into the properties of hadronic interactions occurring in air showers at energies well above those reached at human-made accelerators. The key probe into the hadronic interactions has, for a long time, been the number of muons arriving at the ground, which can be directly measured at Auger for energies up to 10 EeV using dedicated underground muon detectors or estimated through the observation of highly inclined showers using the surface detector of the Observatory. Further information can be obtained using the hybrid character of the Observatory, which allows the simultaneous observation of the longitudinal development of the shower with the fluorescence (and lately also radio) detector and the ground signal with the surface detector. Several different analyses using hybrid data show a discrepancy between the predictions of simulations based on the latest hadronic interaction models and data when a complex view of the UHECR air showers is obtained. This discrepancy has been long interpreted as a deficit in the number of muons predicted by the simulations with respect to the data. A new analysis using a global fit of the data on selected hybrid showers has shown that the disagreement between models and data is more complex and also involves the predictions for the depths of the maxima of the longitudinal shower development. At the same time, measurements of shower-to-shower fluctuations using inclined hybrid events show good agreement with the predictions, suggesting that the observed muon discrepancy is rather the result of a gradual accumulation of small changes during the shower development than of a major change in the properties of the first interaction. Recently, the Observatory has undergone a significant upgrade, which includes several components aimed at a significant improvement in the measurement of the muon content of the air showers.

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ILC beam dump experiment and new physics search

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We study capability of the ILC beam dump experiment to search for new physics, comparing the performance of the electron and positron beam dumps.
Firstly, the dark photon, axion-like particles, and light scalar bosons are considered as new physics scenarios. We find that the ILC beam dump experiment has higher sensitivity than past beam dump experiments, with the positron beam dump having slightly better performance for new physics particles which are produced by the electron-positron pair-annihilation.
We also propose an experimental setup to search for sub-GeV dark matter, the Beam-Dump eXperiment at the ILC (ILC-BDX). We study the production, decay and scattering of sub-GeV dark matter particles in several models with a dark photon mediator. Taking into account beam-related backgrounds due to neutrinos produced in the beam dump as well as the cosmic-ray background, we evaluate the sensitivity reach of the ILC-BDX experiment. We find that the ILC-BDX will be able to probe interesting regions of the model parameter space and, in many cases, reach well below the relic target.
This talk is based on the following papers: arXiv: 2105.13768 [hep-ph] and 2301.03816 [hep-ph].

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News on identified hadron production from NA61/SHINE

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NA61/SHINE is a multipurpose, fixed-target experiment located at the CERN Super Proton Synchrotron that has been designed to investigate the phase diagram of strongly interacting matter. This is achieved through a two-dimensional scan of the diagram by varying the beam momentum (13A-150(8)A GeV/c) and the system size (p+p, p+Pb, Be+Be, Ar+Sc, Xe+La, Pb+Pb). The purpose of these measurements is to understand the onset of deconfinement and to locate the critical point of strongly interacting matter.

In this talk, I will introduce the NA61/SHINE's experimental facility, the methods used for particle identification and finally, I will present the latest measurements on identified hadron production. In particular, I will review the anomaly in charged/neutral kaon-ratio production, as well as the new data on K*(892)0 production. The NA61/SHINE results will be compared with worldwide experiments and predictions of various theoretical models, like EPOS, PHSD, UrQMD, and others.

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Open charm production in heavy-ion collisions at CERN SPS

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The study of open charm hadron production provides an efficient tool for detailed investigation of the properties of hot and dense matter formed in relativistic nucleus-nucleus collisions. In particular, charm mesons are of vivid interest in the context of the phase transition between confined hadronic matter and the quark-gluon plasma as well as for the interpretation of data on J/ψ production measured by the NA38/NA50 and NA60 experiments. Also, such a study gives a unique opportunity to test the validity of theoretical models based on perturbative Quantum Chromodynamics and Statistical approaches for nucleus collisions at the top SPS energy. Such models provide predictions for charm yields that differ by up to two orders of magnitude.

The first measurements of open charm production were conducted using NA61/SHINE data from 2017 and 2018. However, only 95% CL limits on the yields could be established. During the CERN Long Shutdown 2, the detector underwent numerous upgrades, including the installation of a new high-acceptance vertex detector, crucial for the reconstruction of the short-lived open-charm hadrons. The new setup of the experiment is estimated to provide over a ten-fold increase in event statistics, allowing for a first conclusive measurement of charm production at the top SPS energy.

The contribution will introduce our approach to open-charm measurements, the results of our previous measurements, and the status of the ongoing analysis based on the newly acquired data.

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Contribution of Majoron and new gaage boson to Hubble tension in a realistic gauged U(1)⊠⊠−⊠⊠ Model

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In this paper, we analyze parameter regions that can alleviate the Hubble tension in the U(1)Lμ−Lτ model with the broken lepton number U(1)L symmetry. As new particles, this model has a U(1)Lμ−Lτ gauge boson Z′ and a Majoron ϕ, which can affect the early universe and the effective number of neutrino species Neff. If Z′ and ϕ simultaneously exist in the early universe, Z′ −ϕ interaction processes such as Z′να ↔ ϕν¯β occur. The comparison of Neff between the cases with and without the Z′ −ϕ interaction processes shows that these processes make a small contribution of O(10−4) to Neff, and it does not need to be considered for the alleviation of the Hubble tension. Based on these facts, we calculated Neff for various Majoron parameters without the Z′ −ϕ interaction processes to search parameters that could alleviate the Hubble tension. As a result, we found that the U(1)Lμ−Lτ gauge boson and Majoron can alleviate the Hubble tension in some parameter regions, and there is a non-trivial synergy contribution between Z′ and ϕ. Moreover, the parameter region with a lighter mass mϕ ⊠ 2 MeV and a larger coupling λ ⊠ 10−8 is excluded because it predicts too large Neff, i.e. Neff ⊠ 3.5. The favored and restricted regions of the Majoron parameters depend on the Z′ parameters because of the presence of the Z′contribution and synergy one.

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Signals from the early Universe

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The cosmic microwave background (CMB) has been measured with the COBE, WMAP and Planck space missions. Its black-body Planckian spectrum as determined by COBE-FIRAS corresponds to a mean temperature of T_{CMB} = (2.725 ± 0.001) K, and Planck accurately mapped the spatial temperature fluctuations at the level of T/T 6×10^{-6}, thus allowing for conclusions about structure formation in the early universe. However, it has not yet been possible to observe residual spectral lines from the recombination phase some 380,000 years after the Big Bang when the first elements hydrogen and helium were formed [1].

As the most prominent spectral line emitted during recombination, the time-evolution of the hydrogen Lyman-alpha line has recently been investigated in a nonlinear diffusion model that can be solved analytically [2]. The shift of this line emitted at 2466 THz towards lower frequencies in the course of scattering with free electrons and other damping processes, as well as its simultaneous broadening is considered in the model together with the expansion and cooling from $T \simeq 3000$ K at recombination, to 2.725 K now. The thermalization of the Lyα line remains incomplete, such that it could in principle be observable in today's CMB. Based on the calculation [2] in a non-linear model, the signal from the hydrogen Lyman-alpha line is likely to be about seven orders of magnitude lower than the CMB signal –too weak to be detectable with today's technology, as is evidenced by the recent Planck measurement [1].

The result is in accordance with numerical models [3] that have also been compared with CMB observations. Both approaches call for more sensitive equipment in future space missions to actually measure remnants of recombination lines in the CMB.

[1] Aghanim, N., et al.: Planck 2018 results: VI. Cosmological parameters. Astron. Astrophys. 641, 6 (2020).

[2] G. Wolschin: Partial Lyα thermalization in an analytic nonlinear diffusion model. Scientific Reports 14, 4935 (2024).

[3] R.A. Sunyaev, J. Chluba: Signals from the epoch of cosmological recombination. Astron. Nachr. 330, 657–674 (2009); J. Chluba, R.A. Sunyaev: Cosmological hydrogen recombination: influence of resonance and electron scattering. Astron. Astrophys. 503, 345–355 (2009)

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The status of the Compressed Baryonic Matter experiment at FAIR

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The Compressed Baryonic Matter (CBM) experiment is currently under construction at the Facility for Antiproton and Ion Research (FAIR). Its goal is to explore the phase structure of strongly interacting (QCD) matter at high net-baryon densities and moderate temperatures through heavy-ion and hadron collisions in the energy range of \sqrt{s_{NN}} = 2.9 - 4.9 GeV using the SIS100 beams. As a fixed-target experiment, CBM is equipped with fast, radiation-hard detector systems and an advanced trigger-less data acquisition scheme. CBM will operate at interaction rates of up to 10 MHz by performing online space-time reconstruction and event selection, enabling the measurement of rare probes such as multi-strange hadrons and their antiparticles, multi-strange hypernuclei, and di-leptons, which have not been extensively studied so far. This presentation will provide an overview of the CBM physics goals, including the investigation of the equation-of-state of compressed nuclear matter, the potential phase transition from the hadronic to the partonic phase, and chiral symmetry restoration. The discussion will cover CBM's physics performance in areas such as (multi-)strange particle production, di-lepton spectroscopy, collective phenomena, and femtoscopy.

Additionally, the status of preparations for CBM's construction will be reviewed, including performance evaluations of CBM components in FAIR Phase-0 experiments and the latest results from a CBM demonstrator test setup operating with SIS18 beams (mCBM).

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Highlights of Recent Spin Physics Results from STAR

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The unique capability of the Relativistic Heavy Ion Collider (RHIC) to collide polarized protons provides an ideal testing ground for exploring a wide range of topics in spin physics. This, along with the excellent coverage and particle identification provided by the STAR detector, has opened new avenues for investigating the proton spin structure.

This overview talk will encompass recent highlights from the STAR experiment. It will begin with investigations into unpolarized parton densities, establishing robust procedures for reconstructing various observables measured at STAR. Measurements of inclusive jet production investigate unpolarized gluon density and provide proper tuning for simulations. Weak bosons ($W^{\pm}/Z$) reconstructed from their decay leptons can be used to probe the sea quark ($\bar{u}$ and $\bar{d}$) densities.

The talk will then delve into explorations of the longitudinal spin structure of the proton. Longitudinal double spin asymmetries, A_{LL}, of inclusive and dijet events provide access to gluon helicity distribution, supplemented by measurements of A_{LL} with charged hadrons within jets. Furthermore, the longitudinal single spin asymmetries, A_L, of $W^{\pm}$ bosons probe the sea quark helicity contribution, clearly demonstrating asymmetric contribution of the $\bar{u}$ and $\bar{d}$ quarks to the proton spin.

The largely unknown transverse spin structure of the proton will be explored next. Spin-dependent shifts in the azimuthal separation between two jets in a dijet event can be used to extract the initial state parton transverse momentum. The transverse single spin asymmetry, A_N, of $W^{\pm}/Z$ bosons reconstructed from the leptonic decay channel pins down the transverse partonic motion to the initial state and tests the non-universality of the Sivers effect. Additionally, the A_N of charged hadrons within jets can be used to probe quark transversity and investigate the universality of fundamental TMD functions.
The dihadron A_N provides an independent measurement of quark transversity in the collinear framework. Measurements of A_N of diffractive processes investigate the contribution of these processes to the unexpectedly large A_N in the forward ($2.5 < \eta < 4$) regime.

Finally, prospects for the recent STAR data-taking periods, with enhanced forward tracking and calorimetry delivered by the STAR forward upgrade, will be discussed.

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Studies of the mass composition of cosmic rays and proton-proton interaction cross-sections at ultra-high energies with the Pierre Auger Observatory

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The Earth's atmosphere is constantly bombarded by charged particles with energies ranging from a few GeV to several hundred EeV. In the latter range, the flux of these so-called ultra-high-energy cosmic rays rapidly decreases, making their observation reliant on large ground experiments that detect their interactions with the atmosphere and the subsequent extensive air showers they produce. Operating for more than twenty years and covering an area of 3000 km² in the Argentine Pampas, the Pierre Auger Observatory offers an unprecedented opportunity to study these elusive particles at the intersection of astrophysics and particle physics. Addressing the mystery behind their origin inevitably raises the question of their composition, which is inferred from the measurement of the depth of the shower maximum by fluorescence detectors and strongly depends on the models used to describe underlying hadronic interactions. Specifically, these interpretations are sensitive to the particle interaction cross-sections at energies several orders of magnitude higher than those reached in terrestrial accelerators. In this contribution, we will first discuss the mass composition measurements obtained from data collected by the Pierre Auger Observatory, before investigating how modifying the proton-proton cross-section may affect their interpretation.

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Correlations and fluctuations measured by STAR experiment

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The STAR (Solenoidal Tracker at RHIC) experiment is conducted at the
Relativistic Heavy Ion Collider (RHIC) at Brookhaven National Laboratory.
Originally designed to study the properties of the Quark-Gluon Plasma (QGP) and the nature of strongly interacting matter under extreme conditions similar to those in the early Universe, STAR' s scope expanded with the initiation of the Beam Energy Scan program. This program broadened the investigation to include the region of high baryonic densities, making STAR an excellent tool for studying the phase diagram of strongly interacting matter.
This talk report focuses on measurements of correlations and fluctuations performed by STAR. The current results of measurements of the fluctuations in net-proton number (including higher-order cumulants), which are crucial for understanding the thermodynamic properties of QGP phase transitions, including the search for the Critical Point, will be presented. Femtoscopic measurements, which utilize correlations between pairs of particles, enable the exploration of collision dynamics and the examination of particle interaction properties. Recent femtoscopic measurements involving kaons, $p-\Lambda$, and $d-\Lambda$ pairs will be discussed.

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Low pT photon spectra and flow in Au+Au at PHENIX

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Direct photons, as electromagnetic probes that do not interact strongly with the medium, provide a unique insight into the properties of quark-gluon plasma formed in high-energy heavy-ion collisions. The PHENIX experiment at RHIC has performed a detailed analysis of the direct-photon spectrum from Au+Au collisions at √sNN = 200 GeV, utilizing the external-photon-conversion technique for a centrality range of 0% - 93% and a transverse-momentum (pT) range of 0.8 to 6.0 GeV/c. An excess of direct photons, above prompt-photon production from hard-scattering processes, is observed for pT < 6 GeV/c. This nonprompt direct-photon component is measured by subtracting the prompt contribution -which is estimated from Ncoll-scaled direct photons in p+p collisions at 200 GeV- from the direct-photon spectra, with a large azimuthal anisotropy and a characteristic dependence on collision centrality. The results indicate an increasing inverse slope from ≈ 0.2 to 0.4 GeV/c with increasing pT, suggesting sensitivity to photons from early collision stages. The pT-integrated nonprompt direct-photon yields follow a power-law scaling with collision system size, with an exponent α ≈ 1.1, independent of pT. Additionally, the inverse slope of the spectrum shows no dependence on system size. These findings will be discussed in detail, highlighting their implications for understanding quark-gluon plasma properties.

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Differential Analysis of High p_T Direct Photon and π^0 Production in small system collisions at $\sqrt{s_{NN}} = 200$ GeV

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In high energy heavy ion collisions, high p_T direct photons emerge from initial hard scattering processes, unaffected by the color-charged medium, unlike jets and final state hadrons. These hadrons suffer energy losses, quantified through the nuclear modification factor, which compares N_{coll}(binary nucleon-nucleon collisions) scaled yields from $p + p$ collisions to those in heavy ion interactions, thereby revealing the influence of the medium on particle yields as a function of collision centrality. Despite longstanding contrary expectations, we observe an unexpected suppression of high-transverse-momentum neutral hadrons in high-activity events in smaller system collisions, and, conversely, an enhancement in more peripheral collisions—a phenomenon not typically seen in larger systems.

Our study, using data of d+Au collisions at $\sqrt{s_{NN}} = 200$ GeV from PHENIX, contrasts the production of direct photons and π^0 in d+Au collisions. This presentation will explore how a new method using direct direct photon production as a measure of N_{coll} corrects this bias.

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Spin Physics Program of New Generation sPHENIX Detector at RHIC

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The sPHENIX experiment is a new experiment and its new detector of Relativistic Heavy Ion Collider (RHIC) in the Brookhaven National Laboratory. It is an upgrade of the PHENIX experiment. The sPHENIX is to complete the scientific mission of RHIC in study of QGP and the spin structure of the proton. The sPHENIX detector will provide precision vertexing, tracking and electromagnetic and hadronic calorimetry in the central pseudorapidity region |η| < 1.1, with full azimuth coverage, at the full RHIC collision rate, delivering unprecedented data sets for hard probe tomography measurements at RHIC. ⊠ The sPHENIX was commissioned using Au+Au collision in 2023, and currently taking physics data with transversely polarized proton+proton collisions at the the collision energy of 200 GeV. The status of detector commissioning and possible physics targets of the proton spin program using the sPHENIX detector will be discussed.

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The future of experimental measurements of light-by-light scattering

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Light-by-light scattering is a relatively new area in experimental physics. Since its first observation in 2017 by the ATLAS collaboration, which was reported in Nature [1], only three studies have been published with new results [2-4], all within a similar kinematic range. Our recent research [5] shows that studying two-photon measurements in regions with lower transverse momentum ($p_{t,\gamma}$) and invariant mass ($M_{\gamma\gamma}$) allows us to observe not only the main contribution of photon scattering, known as fermionic loops but also weaker mechanisms like the VDM-Regge.
In addition, examining two-photon measurements in low-mass regions is crucial for researching light meson resonances to $\gamma\gamma \to \gamma\gamma$ scattering. We have begun investigating the interference between different contributions. For future experiments with the ALICE FoCal detector [6] and ALICE 3 [7], we have calculated background estimates and explored possibilities to minimize their impact. Our predictions suggest that these new mechanisms are challenging both theoretically and their experimental verification is difficult. However, the planned upgrades to existing detectors and the development of new ones present a unique opportunity to verify this complex picture.

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Overview of the Past, Present, and Future of the Pierre Auger Observatory: Advantages and limitations concerning accelerator data

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The Pierre Auger Observatory is the world's largest facility for detecting ultrahigh-energy cosmic rays that has been operating for nearly 20 years. The hybrid concept of the detector allows accurate estimations of the energy spectrum, mass composition, and arrival directions of cosmic rays, which are crucial for identifying the origin and nature of the highest energy particles arriving at Earth. With the data from the Auger Observatory, it is possible to explore particle physics in regions of phase space inaccessible by the existing man-made accelerators and probe the hadronic interactions at energies nearly two orders of magnitude higher than those attainable at the Large Hadron Collider. In this contribution, we review the current status and a selection of the key results of the Pierre Auger Observatory. We discuss the existing limitations in exploring the universe's most energetic phenomena and the future perspectives, including the ongoing enhancements provided by the upgrade of the Observatory.

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Recent results from precision measurements at the NA62 experiment

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The NA62 experiment at CERN collected the world's largest dataset of charged kaon decays in 2016-2018, leading to the first measurement of the branching ratio of the ultra-rare $K^+ \to \pi^+\nu\bar{\nu}$ decay, based on 20 candidates.

In this talk NA62 reports new results from the analyses of rare kaon and pion decays, using data samples collected in 2017-2018. A sample of $K^+ \to \pi^+\gamma\gamma$ decays was collected using a minimum-bias trigger, and the results include measurement of the branching ratio, study of the di-photon mass spectrum, and the first search for production and prompt decay of an axion-like particle with gluon coupling in the process $K^+ \to \pi^+ A$, $A \to \gamma\gamma$. A sample of $\pi^0 \to e^+e^-$ decay candidates was collected using a dedicated scaled down di-electron trigger, and a preliminary result of the branching fraction measurement is presented. Recent results from analyses of $K^+ \to \pi^0 e^+\nu\gamma$ and $K^+ \to \pi^+\mu^+\mu^-$ decays using 2017–2018 datasets are also presented. The radiative kaon decay $K^+ \to \pi^0 e^+\nu\gamma$ (Ke3g) is studied with a data sample of O(100k) Ke3g candidates with sub-percent background contaminations. Results with the most precise measurements of the Ke3g branching ratios and T-asymmetry are presented. The $K^+ \to \pi^+\mu^+\mu^-$ sample comprises about 27k signal events with negligible background contamination, and the presented analysis results include the most precise determination of the branching ratio and the form factor.

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Study of mean transverse momentum scaling with m/nq in relativistic heavy-ion collisions

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Heavy-ion collisions at relativistic energies offer an unique opportunity to investigate the properties of highly excited dense nuclear matter in the laboratory. The transverse momentum distributions of identified hadrons contain information about the collective expansion of the nuclear matter created in these collisions. In this work, a study of the average transverse momentum <pT> of bulk and strange hadrons (K^0_S, , -, $^-$, -$^+$, ϕ, $^-$, and -$^+$) as a function of system centrality and reduced hadron mass in Au-Au collisions at RHIC-BES energies (7.7 - 39 GeV) is presented. For the peripheral events, there is an approximate scaling of average p_T with the reduced hadron mass, i.e., mass divided by the number of quark constituents (m/n_q). The scaling is broken in central Au-Au collisions, where <p_T> is higher for baryons than that for mesons, although they increase linearly with m/nq. These results will be compared with AMPT simulations, based on different hypotheses related to the evolution of the system formed in these collisions.

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Characterisation of the Atmosphere for Imaging Atmospheric Cherenkov Telescopes

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Ground-based observations of Very-High-Energy (VHE) gamma rays from extreme astrophysical sources are significantly influenced by atmospheric conditions. This is due to the atmosphere being an integral part of the detector when utilizing Imaging Atmospheric Cherenkov Telescopes (IACTs). Clouds and dust particles diminish atmospheric transmission of Cherenkov light, thereby impacting the reconstruction of the air showers and consequently the reconstructed gamma-ray spectra.
Precise measurements of atmospheric transmission above Cherenkov observatories play a pivotal role in the accuracy of the analysed data, corrections of the reconstructed energies and fluxes of incoming gamma rays, establishing observation strategies for different types of gamma-ray emitting sources, and provide valuable data for studies of climate changes.

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Welcome

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Standard Model Measurements at the LHC

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Jet measurements at the LHC

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V+heavy flavour measurements at ATLAS

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Extension of the Standard Model with Chern-Simons type interaction

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This extension has a new vector massive boson (Chern-Simons boson) that couples to electroweak gauge bosons by the so-called effective Chern-Simons interaction. There is no direct interaction between the Chern-Simons bosons and SM fermions. We consider the effective loop interaction of a new vector boson with SM fermions and consider the possibility of the manifestation of the GeV-scale Chern-Simons bosons in collider experiments. These results are presented in detail in arXiv:2110.14500 and arXiv:2405.00164.
The work of V.G., I.H., and O.Kh. was supported by the National Research Foundation of Ukraine under project No. 2023.03/0149.

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Overview of EIC and its ePIC detector

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Recent results from the FASER experiment at the LHC

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Expected (predicted) dip-bump structures in diffraction dissociation at the LHC

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Unitarity effects in elastic scattering at the LHC

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Investigation of single proton dissociation

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Beyond the Standard Smash: Decoding the Quark-Gluon Plasma at the LHC

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Recent results from the ALICE experiment at the LHC

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Exploring the nuclear structure with vector mesons in UPCs

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UPC events în CMS run III

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Open charm production in heavy-ion collisions at CERN SPS

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Heavy ions and small-x physics at CMS

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Centrality dependent Levy HBT analysis in $\sqrt{s_{NN}}$=200 GeV Au+Au collisions with PHENIX

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Thermal model interpretation of particle production in pp interactions around sˆ1/2˜=10 GeV

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Some physics of small collision systems

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Recent results from precision measurements at the NA62 experiment

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Equations for particles with spin S=0 and S=1 in spinor representation

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Workshop conclusion

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Constraints on the neutrino extension of the Standard Model and baryon asymmetry of the Universe

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Heavy neutral leptons (HNLs) leave behind effective interactions of Standard Model particles, leading in particular to charged lepton flavor violation (cLFV) processes. Non observation of cLFV processes puts therefore constraints on the parameters of the HNLs. We find the relations between the effective operators in the realistic case when neutrino masses are non-zero and the HNLs are non-degenerate. This allows us to strengthen the existing cLFV constraints. We also link the baryon asymmetry of the Universe to the same higher-dimensional effective operators, providing complementary bounds on these parameters. These results are presented in detail in arXiv:2408.02107.
The work of V.G. and O.Kh. was supported by the National Research Foundation of Ukraine under project No. 2023.03/0149.

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Collective effects in PYTHIA8 and EPOS4 simulations of pp and p-Pb collisions

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Forward-backward Correlations with the Σ Quantity in the Wounded-Constituent Framework at Energies Available at the CERN LHC

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