Strangeness in Quark Matter 2024 (SQM 2024)

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Measurement of the full-event energy-energy correlator, including the back-to-back region using the archived ALEPH e+e- data at 91.2 GeV

Auteurs: Austin Baty[1]; Gian-Michele Innocenti[2]; Hannah Bossi[2]; Yen-jie Lee[2]; Yi (Luna) Chen[3]; Yu-chen Chen[2]

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This talk presents the latest result on the energy-energy correlator using the archived ALEPH e+e- data taken at the LEP at a center of mass energy of sqrt(s) = 91.2 GeV. The energy-energy corrector presents a different way to study QCD concerning other approaches utilizing jets and (sub)structures, garnering recent increased interest in this observable in hadronic collision systems at the LHC and RHIC. It allows a natural separation of length scales, which probe various aspects of QCD. In addition to studying the smaller scale behavior where most of the focus in the field has been thus far, thanks to the unique topology of e+e- collisions, the energy-energy correlators for nearly back-to-back particles are measured experimentally for the first time. They are also compared with predictions from various generators. We also discuss potential extensions and synergy with future studies at EIC and FCC.

Track4-Bulk&Phase / **60**

Entropy production and dissipation in spin hydrodynamics: Relativistic quantum-statistical approach

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Motivated by the evidence of spin polarization of matter produced in relativistic heavy ion collisions, there is a growing interest in developing relativistic hydrodynamics for spin-polarized media. This interest is mostly inspired by the previous successes of relativistic hydrodynamics in describing the collective behavior of the quark-gluon plasma. In this talk, I will present the preliminary outcomes of a quantum-statistical-based approach to relativistic spin hydrodynamics and discuss key findings in comparison to standard spin hydrodynamics, along with its future potential (arXiv:2309.05789).

Track6-SmallSyst / **61**

Tantalizing Structure in Long Range Correlations in High Multiplicity e+e- Collisions And Fourier Decomposition Using Archived ALEPH Data at 91-209 GeV

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We present measurements of two-particle angular correlations of charged particles emitted in high-energy e^+e^- collisions using data collected by the ALEPH detector at LEP between 1992 and 2000. The correlation functions are measured over a wide range of pseudorapidity and azimuthal angle as a function of charged particle multiplicity. Previous measurement with LEP1 data at 91 GeV shows no significant long-range correlations in lab coordinate or thrust coordinate analyses, with associated yield distributions in agreement with predictions from the archived PYTHIA v6.1 event generator. Higher collision energy LEP2 data allows access to higher event multiplicity and additional production channels beyond the $Z \to q\bar{q}$ process. The highest multiplicity bin suggests an intriguing deviation from archived MC and implies the potential to search for collective phenomena in small systems. This measurement is pushing the studies of long-range correlation to the smallest collision system limit. It includes the first flow coefficient measurement and a Fourier decomposition analysis in e^+e^- collisions to quantify the anisotropy in the azimuthal two-particle correlation as a function of charged particles' transverse momentum. It is also compared with modern MC generators. This work supplements our understanding of small-system references to long-range correlations observed in proton-proton, proton-nucleus, and nucleus-nucleus collisions.

Track4-Bulk&Phase / **62**

4D-TExS: A new 4D lattice-QCD equation of state with extended density coverage

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Although calculations of QCD thermodynamics from first-principle lattice simulations are limited to zero net-density due to the fermion sign problem, several methods have been developed to extend the equation of state (EoS) to finite values of the B, Q, S chemical potentials. Taylor expansion around $\mu_i = 0$ ($i = B, Q, S$) enables to cover with confidence the region up to $\mu_i/T < 2.5$. Recently, a new method has been developed to compute a 2D EoS in the (T, μ_B) plane. It was constructed through a T-Expansion Scheme (TExS), based on a resummation of the Taylor expansion, and is trusted up to densities around $\mu_B/T = 3.5$. We present here the new 4D-TExS EoS, a generalization of the TExS to all 3 chemical potentials, offering a larger coverage than the 4D Taylor expansion EoS. After explaining the basics of the T-Expansion Scheme and how it is generalized to multiple dimensions, we will present results for thermodynamic observables as functions of temperature and all chemical potentials.

Posters / **63**

Collision-energy dependence of the Breit-Wheeler process in heavy-ion collisions and its application to nuclear charge radius measurements

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In ultra-relativistic heavy-ion collisions, strong electromagnetic fields arising from the Lorentz-contracted, highly charged nuclei can be approximated as a large flux of high-energy quasi-real photons that can interact via the Breit-Wheeler process to produce e^+e^- pairs. The collision energy dependence of the cross section and the transverse momentum distribution of dielectrons from the Breit-Wheeler process in heavy-ion collisions are calculated with lowest-order EPA-QED. Within a given experimental kinematic acceptance, the cross section is found to increase while the pair transverse momentum decreases with increasing beam energy. The corresponding results are also compared with STAR measurements, which are consistent with each other and found to be sensitive to the nuclear charge distribution and the infrared-divergence of the ultra-Lorentz boosted Coulomb field. Following this approach we demonstrate that the experimental measurements of the Breit-Wheeler process in ultra-relativistic heavy-ion collisions can be used to quantitatively constrain the nuclear charge radius. The extracted parameters show sensitivity to the impact parameter dependence, and can be used to study the initial-state and final-state effects in hadronic interactions.

Track6-SmallSyst / **65**

Observation of hydrodynamic behavior with few strongly-interacting fermions: a zero-temperature small system puzzle

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Co-auteurs: Aleksas Mazeliauskas [1]; Andrea Dubla [2]; Carl Heintze [1]; Ilya Selyuzhenkov [2]; Maciej Galka [1]; Philipp Lunt [1]; Sandra Brandstetter [1]; Selim Jochim [1]; Silvia Masciocchi [3]; Stefan Floerchinger [4]; Tilman Enss [1]

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Approaching zero temperature, a gas of strongly-interacting fermions undergoes a transition to a superfluid phase amenable to an ideal hydrodynamic description. At trillion-kelvin temperatures, hadronic matter melts into a quark-gluon plasma (QGP) that flows similarly as a near-perfect fluid. Collider experiments indicate that the signals of QGP formation are mysteriously persistent, emerging down to p-p collisions producing only a few dozen final-state hadrons. Here, we perform experiments to assess whether a similar behavior is displayed as well in small systems at the other end of the temperature spectrum.

States of strongly-interacting ultra-cold fermions are released from elliptical harmonic traps to investigate the emergence of elliptic flow, a smoking-gun of collective behavior. Borrowing techniques from high-energy collisions [1], we study the build-up of momentum anisotropy in the elliptical clouds and the inversion of their initial aspect ratios. Elliptic flow is then observed for systems with as few as 10 fermions and in absence of any separation between microscopic and macroscopic scales [2], opening a new small system puzzle outside heavy-ion collisions. We discuss prospects for future cross-disciplinary research aimed at elucidating further the apparent hydrodynamic behavior of mesoscopic quantum gases.

[1] Floerchinger et al., Phys.Rev.C 105 (2022) 4, 044908
[2] Brandstetter et al., arXiv:2308.09699

Track4-Bulk&Phase / **66**

Spin alignment of vector mesons by glasma fields

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Recent measurements of large spin alignment of vector mesons beyond the expectation from vorticity may imply substantial spin correlation of the constituent quark and antiquark led by fluctuating strong-interaction forces. We explain how spin alignment of vector mesons can be induced by background color fields. Our study is based on the quantum kinetic theory of spinning quarks and antiquarks and incorporates the relaxation of the dynamically generated spin polarization. The spin density matrix of vector mesons is obtained by quark coalescence via the Wigner function and kinetic equation. We estimate the magnitude of such local correlations in the glasma model of the preequilibrium phase of relativistic heavy ion collisions. The dominant longitudinal chromo-magnetic fields from the glasma intrinsically break the rotational symmetry of spin polarization for quarks and antiquarks, which yield $\rho_{00} < 1/3$ for ρ_{00} being the 00-th component of the spin density matrix of vector mesons. It is also found that the strength of the resulting spin alignment could be greatly enhanced and may be comparable to the experimental measurement in order of magnitude. We further propose new phenomenological scenarios to qualitatively explain the transverse-momentum and centrality dependence of spin alignment in a self-consistent framework. Our approach may be applied to not only the light mesons but also heavy mesons such as J/ψ with small momenta especially in high-energy collisions.

Posters / **67**

The effect of charm quark on chiral phase transition in holographic QCD

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Studying the thermal QCD phase transition and the critical endpoint is crucial for understanding the hot environment relevant to the initial stage of heavy-ion collisions and the early universe. The nature of the QCD chiral phase transition in the limit of massless quarks has been a longstanding, open problem.
The discrepancy between the lattice QCD estimation and the effective model results appears for the order of the chiral phase transition in the case of a multi-flavor system. In this talk, We present a study on the thermal chiral phase transition in a four-quark flavor system using the soft-wall holographic QCD model. Our study reveals that in the massless limit, the thermal chiral phase transition is of the second order in the four-quark flavor system. However, in the case of the massive charm quark and the massless light and strange quarks, the order of the phase transition changes to the first order.
We also map the order of the phase transition on a phase diagram in the quark mass plane where the light- and strange-quark masses degenerate but differ from the value of the charm quark mass.

Track4-Bulk&Phase / 68

Critical point fluctuations in heavy-ion collisions within molecular dynamics with expansion

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We analyze particle number fluctuations in the crossover region near the critical endpoint of a first-order phase transition in baryon-rich matter by utilizing microscopic molecular dynamics simulations of the classical non-relativistic Lennard-Jones fluid. We extend out previous studies by incorporating longitudinal collective flow to model the expansion dynamics in heavy-ion collisions.

In heavy-ion experiments it is possible to observe fluctuations in the momentum space only, so we are concentrating our current research around this topic. Using as a beginning result of our previous article about the momentum space fluctuations without the collective flow, where the scaled variance appears to be close to the ideal gas without interaction, we apply shift in one of the space directions to the thermal momentum of the particles.

The scaled variance of particle number distribution inside different coordinate and momentum space acceptances is computed through ensemble averaging and found to agree with earlier results obtained using time averaging, validating the ergodic hypothesis for fluctuation observables in considered system. The presence of a sizable collective flow is found to be essential for observing large fluctuations from the critical point in momentum space acceptances. We find that the enhancement of baryon number fluctuations due to critical point is visible at collision energies between 3 and 10 GeV in realistic rapidity space acceptances. We discuss our findings in the context of the ongoing measurements of proton number cumulants in heavy-ion collisions.

Track6-SmallSyst / 69

Heavy flavor production and collectivity in high energy proton-proton collisions

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The creation of a quark-gluon plasma (QGP) is expected in ultrarelativistic heavy ion collisions. It came as a surprise that proton-proton collisions at ultrarelativistic energies show as well a "QGP-like" behavior and signs of the creation of a nearly perfect fluid, although the corresponding system size is not more than a few cubic femtometers. Even more surprisingly, also heavy flavor particles seem to be part of the fluid or at least interact with it. Recently, we investigated this "collective behavior" of heavy flavor in a quantitative way~[1], by employing the newly developed EPOS4HQ approach, which has been used to describe both heavy and light flavor hadrons in relativistic heavy ion collisions~[2,3]. In this talk, I will show the detail of the EPOS4HQ framework, which contains gluon splitting, flavor excitation, and flavor creation as elementary processes for the creation of heavy quarks. This allows us to disentangle initial state effects, those being due to interactions between charm quarks and plasma partons, and final state effects. Finally, I will show all observables, which may manifest collectivity, such as particle spectra, elliptic flow, baryon-to-meson ratios, and two-particle correlations, and compare the results with experimental data.

Refs:
[1].arXiv:2310.08684.
[2].arXiv:2401.11275.
[3].arXiv:2401.17096.

Track2-HF&Q / 70

Quarkonium production in pp and heavy-ion collisions

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Quarkonium is considered as a probe, which may expose properties of the expanding QGP, produced in ultra-relativistic heavy-ion collisions. The theoretical description of the formation and the propagation of such a bound state of $c\bar{c}$ or $b\bar{b}$ quark-antiquark pairs is a challenging task.

Here we propose a model, which realizes quarkonium production in pp and AA collisions with help of quantal density matrices. This identification is embedded in a quantum-mechanical description of heavy quark propagation and interaction.

The Quarkonium production is realized in two steps:
1) The heavy quark production in pp collisions is given by the PYTHIA event generator;

2) The formation of a quarkonium from a $c\bar{c}$ or $b\bar{b}$ pair is described by the Wigner projection in momentum space with a spatial separation based on the uncertainty principle~\cite{Song:2017phm} . With this formalism we find a good agreement with the experimental rapidity and transverse momentum distributions for the ground states as well as for the excited states of $c\bar{c}$ and $b\bar{b}$ mesons in pp collisions from RHIC to LHC energies.

In a second step we test whether the quantal Remler formalism to describe bound state production in an expanding medium can be realized in a Monte Carlo approach for a QGP. For this study we use a box of thermalized QGP and investigate the time evolution of the c and $\bar{c}$, which are initially not in equilibrium with the QGP, either by localizing them in a smaller box and/or by giving them initially a different temperature. Comparing numerical and analytical results we demonstrate that, if there is no potential interaction between the c and $\bar{c}$, the original Remler formalism has to be modified by introducing a spatial diffusion rate to compensate for the expansion of the system~[1].

As a third step we study bottonium production in heavy-ion collisions, where the properties of bottonium in a QGP, the dissociation temperature and the temperature-dependant radius, are obtained by solving the Schr\"{o}dinger equation with the free energy from lattice QCD calculations as heavy quark potential. The elastic scattering of heavy (anti)quarks with light plasma partons is described by the dynamical quasi-particle model (DQPM). %It turns out that the bottonium is too much suppressed during the expansion as compared to the experimental results for Pb+Pb collisions at $\sqrt{s_{\rm NN}} = 5.02$ TeV.
%To take into account the small size and color neutrality of bottomonium, we introduce a suppression of its scattering rate in a QGP to 10 \% of bottom and antibottom quarks.
%Such a suppression of the scattering rate brings the centrality dependence of the yields as well as the rapidity and transverse momentum distributions to a good agreement with the experimental findings~[2].
Considering that the two (anti)bottom quarks interact independently with QGP partons - as in the Remler formalism - and underestimate bottomonium yield, color neutrality has to be taken into account for agreement with the experimental results~[3].

[1] T.~Song, J.~Aichelin and E.~Bratkovskaya, Phys. Rev. C 96, no.1, 014907 (2017).
[2] T.~Song, J.~Aichelin and E.~Bratkovskaya, Phys. Rev. C 107, no.5, 054906 (2023).
[3] T.~Song, J.~Aichelin, J.~Zhao, P.~B.~Gossiaux and E.~Bratkovskaya,
Phys. Rev. C 108, no.5, 054908 (2023).

Track3-Res&Hyp / 71

Antihelium identification and antihypertriton observation with LHCb

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The production of helium and anti-helium nuclei is studied for the first time with the LHCb detector in pp collisions at $\sqrt{s} = 13\,TeV$. The used dataset was collected between the years 2016 to 2018 and corresponds to an integrated luminosity of $L = 5.5 fb^{-1}$. The helium nuclei are identified using ionization losses in the silicon sensors of the VELO and ST detectors, alongside timing measurements in the OT drift tubes. A total of 10^5 prompt helium and anti-helium are identified with negligible background contamination. First application of this method is the reconstruction of hypertritons via the 2-body decay into Helium-3 and a charged pion. A total of 10^2 hypertriton candidates are found. This example proves the feasibility of a rich program of measurements of QCD and astrophysics interest involving light nuclei.

Posters / 72

Mass degeneracy of chiral partners at finite density and its discovery potential at present facilities

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The spectral functions of chiral partners should become degenerate when the QCD chiral symmetry is restored. The axial-vector spectra are experimentally more challenging to construct than those of vector mesons that directly couple to virtual photons and then to dileptons. Chiral mixing of the vector with axial-vector mesons is thus a key phenomenon to probe in-medium modifications of vector spectrum due to the onset of chiral symmetry restoration carried by the axial-vector counterpart. The mixing effect is expected to be stronger at higher density due to a mechanism driven by chiral anomalies [1], in striking contrast to the vanishing mixing at chiral crossover driven by thermal pions [2]. This feature encourages us to perform the experimental search in the high-density regime, where the recent experimental trend has begun to shift toward.

We propose that experiments at medium energies with paying attention to the new mixing mechanism, may provide a direct evidence of the chiral symmetry restoration. In this presentation, we focus on the density-induced mixing and the spectral functions of ϕ and its chiral partner $f_1(1420)$. We present the invariant mass distribution of dileptons using a transport approach developed in [3, 4] under the conditions of the J-PARC E16 experiment as a prime example. A potential to discover the mass degeneracy of chiral partners at finite density as a signature of the partial chiral symmetry restoration is advocated.

References

[1] C. Sasaki, Anomaly-induced chiral mixing in cold and dense matter, *Phys. Rev.* D 106, 054034 (2022).
[2] A. Sakai, M. Harada, C. Nonaka, C. Sasaki, K. Shigaki, and S. Yano, Probing the QCD phase transition with chiral mixing in dilepton production, 2308.03305, *arXiv*, nucl-th(2023).
[3] W. Cassing, and E. L. Bratkovskaya, Parton transport and hadronization from the dynamical quasiparticle point of view, *Phys. Rev. C* 78, 034919 (2008).
[4] P. Gubler, E. L. Bratkovskaya, and T. Song, ϕ meson properties in nuclear matter from dilepton spectra in a transport approach, *EPJ Web Conf.* 274, 07015 (2022).

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Systematics of yields of strange hadrons produced in heavy-ion collisions at a few AGeV

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After four decades of measurement of strange hadrons produced in nucleus-nucleus collisions we are now at disposal of over 100 yields of $\mathrm{K}^{\pm,0}$, ϕ and Λ. It's a good time to systematize them as function of available energy, $\sqrt{s_{NN}}$ and number of participant nucleons, $\langle A_{\mathrm{part}}\rangle_{\mathrm{b}}$.

However, as different collaborations used different models for estimations of $\langle A_{\rm part}\rangle_{\rm b}$, considerable systematic biases were generated. Therefore, we applied an unified Glauber Monte Carlo approach to all the dataset.With that, we provide the parametrizations of yields with covariance matrices [1]. We also studied the behaviour of $\langle A_{\rm part}\rangle_{\rm b}$ with $\sqrt{s_{NN}}$, which may carry interesting hints on the strangeness production mechanism.

We also found that for a benchmark point (Ar+KCl at $\sqrt{s_{NN}}$ ~2.61~GeV), in terms of practical use, our parametrization currently provides the best predictions of yields comparing to those from public versions of tested transport models.
This encouraged us to present predictions of strangeness yields from Ag+Ag collisions at $\sqrt{s_{NN}}$ = 2.4 and 2.55 GeV (HADES), STAR data from Au+Au at 3 GeV and future CBM data from Au+Au collisions at lower energies.

[1] K. Piasecki, P. Piotrowski, Eur. Phys. Jour. A {\bf 59}, 272 (2023),
https://doi.org/10.1140/epja/s10050-023-01182-6

Track4-Bulk&Phase / **74**

Dependences of directed flow on the net electric charge, strangeness, and baryon number from quark coalescence

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Recently the rapidity-odd directed flow v_1 of produced hadrons has been studied [1]. Seven hadron species, K^-, ϕ, $\bar{p}$, $\bar{\Lambda}$, $\bar{\Xi}^+$, Ω^- and $\bar{\Omega}^+$, have been used to construct multiple hadron sets with a small mass difference but given difference in the net electric charge (Δq) and strangeness (ΔS) between the two sides. A nonzero directed flow difference Δv_1 has been proposed as a consequence of the electromagnetic field produced in relativistic heavy ion collisions [1,2],especially if Δv_1 increases with Δq.

In this study [3], we examine the consequence of quark coalescence on Δv_1 of the hadron sets. We point out that quark coalescence leads to $\Delta v_1 = c_q \Delta q + c_S \Delta S$; therefore, in general $\Delta v_1 \neq 0$ for a hadron set with nonzero Δq and/or ΔS. The coefficients, $c_q = v_{1,\bar{d}} - v_{1,\bar{u}}$ and c_S that contains $v_{1,\bar{s}} - v_{1,s}$, reflect the v_1 difference of produced quarks, which may be caused by the strong interaction and/or the electromagnetic field. Equivalently, one can write $\Delta v_1 = c_q \Delta q + c_B \Delta B$ that involves the difference in the net-baryon number (ΔB), where quark coalescence gives $c_B = -3c_S$. We then propose two methods to extract the coefficients for the Δq- and ΔS-dependences of Δv_1 (or the v_1 slope difference $\Delta v_1'$).

[1] A.I. Sheikh, D. Keane, P. Tribedy, Phys. Rev. C 105 (2022) 014912.
[2] STAR Collaboration, arXiv:2304.02831.
[3] K. Nayak, S. Shi, Z. W. Lin, Phys. Lett. B 849 (2024) 138479.

Posters / **75**

Beauty production in pp collisions at √s = 13 TeV using the ALICE detector at the LHC

Auteur: Binti Sharma[1]

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The measurement of the production of hadrons containing charm or beauty quarks in proton–proton (pp) collisions provides an important test for perturbative quantum chromodynamics calculations (pQCD).
The ALICE detector allows us to perform precise measurements of non-prompt D-meson production, which are an excellent tool to investigate the production of beauty quarks in pp collisions. In this contribution, recent results on the p_T-differential production cross section of D mesons originating from beauty-hadron decays (i.e. non-prompt D mesons) and their comparison with the equivalent results for prompt D mesons in pp collisions at a centre-of-mass energy of $\sqrt{s} = 5.02$ and $\sqrt{s} =$ 13 TeV, will be presented. In addition, the non-prompt D^+/D^0 and $\{D_s^+\}/(D^0+D^+)$ p_T-differential production yield ratios and the measurements of fragmentation fraction ratio of beauty quarks into strange and non-strange B mesons in pp collisions, to test their universality across different collision systems, will be presented. The results will also be compared with pQCD predictions and other theoretical models. To perform these measurements a machine-learning multiclass classification algorithm for the selection of the D mesons coming from beauty-hadron decays is employed.

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Hadronic Phase Dynamics in van der Waals Model

Auteur: Sameer Ahmad Mir[1]

Co-auteurs: Iqbal Mohi Ud Din [2]; Nasir Ahmad Rather [2]; Saeed Uddin [2]

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In this work, we have extensively studied unlike mass ratios of K^+/π^+, also referred as strangeness to entropy (s/S) as a function of temperature (T) and baryon chemical potential (μ_B) of the system in the framework of a van der Waals hadronic resonance gas (vdW-HRG) model at various center-of-mass energies ($\sqrt{s_{NN}}$). We have incorporated an essential feature of the baryonic interaction viz. the hard-core repulsion at high densities leading to a finite size effect in the baryonic (anti-baryonic) sectors. On the other hand we have treated mesons as point like particles. The theoretical results overestimate the experimental values of these ratios in almost the entire energy regime. To take this into account we have introduced a strangeness suppression factor (γ_s). This can be used a corrective factor to define the above said ratio.

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Non-perturbative resummation at finite temperature field theory

Auteur: Najmul Haque[1]

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Non-perturbative resummation at finite temperature via the Gribov gluon propagator was proposed by D. Zwanziger in 2005 [1]. Later, in 2013, it was used by K. Fukushima and N. Su [2] to study gluon thermodynamics. In 2015, N. Su and T. Tywoniuk showed that a novel massless excitation is ascribable to the magnetic scale in quark dispersion relations.

We recently used the non-perturbative resummation via the Gribov gluon propagator to calculate various quantities relevant to hot and dense nuclear matter. We have studied share and bulk viscosities [4], heavy quark diffusion coefficient[5], meson screening mass[6], heavy quarkonium potential[7], et. al. In all the cases, we get an improvement over the perturbative result near the transition temperature. In this talk, I will discuss the recent findings we obtained using the non-perturbative resummation.

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4. Phys.Lett.B 811 (2020) 135936; arXiv:2401.08384
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6. Phys.Lett.B 845 (2023) 138143
7. arXiv: 2305.16250

Posters / **79**

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

Auteur: Alexandru Manea[1]

Co-auteurs: Alexandru Florin Dobrin [1]; Andrea Danu [1]; Catalina Diana Brandibur [1]

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Measurements of azimuthal correlations provide valuable information on the properties of the system created in collisions of hadrons and nuclei at high energy. They revealed an unexpected collective behaviour in small collision systems similar to the one exhibited by the quark–gluon plasma in heavy-ion collisions. In this talk, the origin of collectivity in small collision systems, which is still not understood, is addressed by confronting different tunes of PYTHIA8 and EPOS4 event generators using measurements of azimuthal correlations for inclusive and identified particles focusing on strange and multi-strange particles. In particular, anisotropic flow coefficients measured using two- and four-particle correlations with various pseudorapidity gaps and balance functions are reported in different multiplicity classes of pp collisions at $\sqrt{s} = 13.6$ TeV and p–Pb collisions at $\sqrt{s_{\rm NN}} = 5.02$ TeV. The results are compared with the available experimental data.

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Hadronic J/ψ Regeneration in Pb+Pb Collisions

Auteur: Joseph Lap[1]

Co-auteur: Berndt Mueller [2]

[1] *Yale University*

[2] *Duke University*

We make use of published yields for D-mesons and J/ψ in Pb+Pb collisions at ALICE and a schematic description of the expansion of the hadron gas to study D-meson collisions during the hadronic break-up phase as a production mechanism for charmonium in relativistic heavy ion collisions at the Large Hadron Collider. Our calculation is based on chemical reaction rates with thermal cross sections for an effective meson interaction among pseudoscalar and vector mesons. We find that due to regeneration, the newly measured J/ψ yields are consistent with anywhere from roughly 25% to 110% of the total yield present at hadronization time. This allows us to bound the fractional abundance of

J/ψ immediately after hadronization: $0.28 \leq \frac{dN_0^{J/\psi}/dy}{dN_{\text{eq}}^{J/\psi}/dy} \leq 1.13$. Our results are robust under the relaxation of the particulars of our schematic description and imply that it will be difficult to distinguish regeneration during hadronization from regeneration by final-state hadronic interactions. Therefore, regeneration must be taken into account when modelling.

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Clocking the particle production and tracking of strangeness balance and radial flow effects at top LHC energy with ALICE

Auteur: Collaboration ALICE[None]

Balance functions have been used extensively to elucidate the time evolution of quark production in heavy-ion collisions. Early models predicted two stages of quark production, one for light quarks and one for the heavier strange quark, separated by a period of isentropic expansion. This led to the notion of clocking particle production and tracking radial flow effects, which drive the expansion of the system. The evolution of the azimuthal widths of the balance function has been later associated to the diffusivity of the light quarks.

In this talk, balance functions of identified particles in different multiplicity classes of pp Run 3 collisions at $\sqrt{s} = 13.6$ TeV recorded by ALICE are reported. The results are compared with different models as well as with previously published results on pp and Pb–Pb collisions at different energies. The results enable tracking the balancing of electric charge and strangeness by measuring how the widths and integrals of the charge and strangeness balance functions evolve across the collision energies.

Track4-Bulk&Phase / 82

Studying (anti)nucleosynthesis via event-by-event fluctuations at the LHC with ALICE

Auteurs: Collaboration ALICE[None]; Mario Ciacco[None]

Auteur correspondant mario.ciacco@cern.ch

The production of light (anti)nuclei in heavy-ion collisions has been extensively studied both experimentally and theoretically. Different phenomenological descriptions of (anti)nucleosynthesis differ in the predicted rapidity range over which the conservation of baryon number is realized. Recent studies of the event-by-event Pearson correlation between the antideuteron and antiproton numbers suggest that the baryon number is conserved over a smaller rapidity range than that observed for ordinary hadrons. These observations can be explained by invoking nuclear coalescence mechanisms, which require small rapidity gaps between the nucleons merging into nuclei. In this contribution, the most recent results obtained by the ALICE Collaboration from the study of antideuteron–antiproton and antideuteron–Λ correlations in Pb–Pb collisions are reported. The antideuteron–antiproton correlation provides a benchmark for (anti)nucleosynthesis models, while the antideuteron–Λ correlation arises from baryon-number conservation in the processes underlying the formation of (anti)nuclei since antideuterons do not contain Λ-baryons, providing a crucial complementary test of the coalescence hypothesis. The presented comparison between experimental results and an extensive array of phenomenological models provides new insights into (anti)nucleosynthesis mechanisms.

Track4-Bulk&Phase / 83

Study of baryon-strangeness and charge-strangeness correlations in Pb–Pb collisions at 5.02 TeV with ALICE

Auteurs: Collaboration ALICE[None]; Swati Saha[None]

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In the quest to unravel the mysteries of the strong force and the underlying properties of the quark-gluon plasma, the ALICE collaboration at CERN has carried out a comprehensive study focusing on the correlations between net-conserved quantities such as net-baryon, net-charge and net-strangeness. These correlations play a crucial role in the study of QCD phase structure as they are closely related to the ratios of thermodynamic susceptibilities in lattice QCD (LQCD) calculations. Recent LQCD results also suggest a significant influence of the magnetic field on the susceptibility ratios, paving the way for the use of net-conserved charges to study the magnetic field produced in peripheral heavy-ion collisions.
This presentation introduces new results focusing on the first-order correlations between net-kaon and net-proton as well as net-kaon and net-charge. Here, the net-proton and net-kaon serve as proxies for the net-baryon and net-strangeness, respectively, and measurements are performed as a function of centrality in Pb–Pb collisions at 5.02 TeV using data recorded by the ALICE detector. A comparative analysis is presented, drawing connections with corresponding results at lower collision energies from the STAR experiment at RHIC. Theoretical predictions from the hadron resonance gas model, HIJING and EPOS event generators are also compared with experimental results, providing insights into the effects of resonance decays and charge conservation laws. This comprehensive study attempts to bridge experimental data to LQCD calculations and contribute to our understanding of the complex dynamics inherent in high-energy nuclear collisions.

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Chasing the onset of QCD thermalisation with ALICE

Auteur: Collaboration ALICE[None]

Deciphering the hadronization process has long been a formidable challenge, in part due to its non-perturbative nature. Over the years, various phenomenological models have emerged, all attempting to unravel the complexity of hadron production. Despite their different theoretical foundations, many of these models successfully account for the average yield of hadrons. This has spurred the scientific community to search for innovative observables capable of discerning the fundamental principles governing these models. In pursuit of this goal, the ALICE Collaboration has studied an extensive set of Pearson correlations between hadrons with different quantum numbers. Conducting a system size scan of these measurements unveils a powerful means to identify and analyze emerging QCD phenomena in small collision systems. In this presentation, the latest findings on antiproton-antideuteron and net-kaon-net-Ξ correlations in different collision systems (pp, p–Pb and Pb–Pb) will be reported. These observables offer the unique advantage that they are not affected by resonances or weak decays. The measurements are compared with different hadronization models to investigate the intriguing topic of the onset of thermalization in QCD matter. Furthermore, the correlations are employed to estimate the correlation volume between hadrons stemming from the conservation of baryon and strange quantum numbers.

Track1-LF / 85

Differential measurement of the common particle emitting source using p–p and p–Λ correlations in pp collisions at 13.6 TeV with ALICE

Auteurs: Anton Riedel[1]; Collaboration ALICE[None]

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Using data collected in high-multiplicity pp collisions at 13 TeV with the ALICE detector during the Run 2 period of the LHC, the femtoscopy technique has been successfully employed to extend the boundaries of known hadron-hadron interactions to the S=-3 sector and to initiate studies of charmed and three-body systems. The key element of these analyzes is the precise modeling of the common particle-emitting source, whose size was found to scale with the average transverse mass m_{T} of the studied particle pair. During the ongoing Run 3 data-taking period, the ALICE experiment collected the largest minimum bias dataset in its history, consisting of about 500 billion events at 13.6 TeV. This provides for the first time the opportunity to additionally investigate the common source as a function of event multiplicity.
In this contribution, the measurement of the size of the common particle-emitting source from p–p and p–Λ pair correlations as a function of event multiplicity and m_{T} of the particle pairs are presented. This is achieved by modeling the final-state interaction of p–p pairs with realistic potentials anchored to scattering data, whereas the p–Λ interaction is modeled using state-of-the-art EFT calculations. The presented results will be the basis for all further femtoscopic studies with ALICE in Run 3.

Track7-OthTop / 86

Shedding light on strong interactions in three-baryon systems with ALICE Run 3 data

Auteurs: Collaboration ALICE[None]; Laura Serksnyte[1]

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The interactions of Λ hyperons with nucleons are of high interest for the studies of the composition of the inner core of neutron stars. Their equation of state requires a precise knowledge of the two- and three-body interactions at small distances which are not yet well constrained by the existing experimental data. ALICE has introduced a novel approach to investigate such interactions by measuring femtoscopic correlation functions of particles emitted with distances of around 1 fm in high-energy pp collisions. This method allows the study of various hadron-nucleus pairs and, for the first time, direct access to the 3->3 free scattering process.

In this talk, ALICE measurements of p-d, p-p-p and p-p-Λ correlation functions are presented in pp collisions at √s = 13.6 TeV, with a sevenfold increase in the statistical sample compared to Run 2. Moreover, the first-ever measurement of Λ-d pairs in pp collisions will be presented. The measured correlation functions will be compared to theoretical predictions showing sensitivity to the three-body dynamics.

Track1-LF / 87

Investigating the nature of the K_0^*(700) state with $\pi^{\pm}$ K_S^0 correlations with ALICE at the LHC

Auteurs: Collaboration ALICE[None]; Thomas Humanic[None]

Auteur correspondant thomas.humanic@cern.ch

The first measurements of femtoscopic correlations with the particle-pair combinations $\pi^{\pm}$ K_S^0 in pp collisions at $\sqrt{s}$ = 13 TeV are reported by ALICE. It is shown that it is possible to study the elusive $K_0^*(700)$ particle that has been considered a tetraquark candidate for over forty years. Boson source parameters and final-state interaction parameters are extracted by fitting a model assuming a Gaussian source to the experimentally measured two-particle correlation functions. The final-state

interaction is modeled through a resonant scattering amplitude, defined in terms of a mass and a coupling parameter, decaying into a $\pi^{\pm}$ K_S^0 pair. The extracted mass and Breit-Wigner width, derived from the coupling parameter of the final-state interaction are found to be consistent with previous measurements of the $K_0^*(700)$. The small value and increasing behavior of the correlation strength with increasing source size support the hypothesis that the $K_0^*(700)$ is a tetraquark state. This latter trend is also confirmed via a simple geometric model that assumes a tetraquark structure of the $K_0^*(700)$ resonance.

Track1-LF / 88

Novel constraints for the multi-strange meson-baryon interaction using correlation measurements with ALICE

Auteurs: Collaboration ALICE[None]; Valentina Mantovani Sarti[None]

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This talk presents unprecedented correlation measurements involving Λ, Ξ, kaons and pions obtained by ALICE in pp collisions at $\sqrt{s}$ = 13 TeV. Several measurements are presented for the first time, constituting new experimental constraints on the S = −1, −2 meson-baryon interactions and the nature of exotic states. The strong interactions involving mesons and baryons with strangeness content deliver a rather broad spectrum of interesting states, arising from the rich interplay between the elastic and inelastic QCD dynamics. The Λ(1405) in the S = −1 sector is an example of such molecular state, but in order to build a solid description of its inner structure more data are needed, particularly below the K⁻N energy threshold. Much less experimental data are currently available on another potential molecular state, the Ξ(1620), predicted and observed in the S = −2 meson-baryon sector. The presented correlation data put new constraints on these sectors and deliver a better understanding on such states.

Track4-Bulk&Phase / 89

Probing the speed of sound in QGP with multi-particle $[p_{\mathrm{T}}]$ cumulants in ALICE

Auteurs: Collaboration ALICE[None]; Emil Gorm Nielsen[None]

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The speed of sound squared, c_s^2, one of the properties of the quark-gluon plasma (QGP) connected to the QCD equation of state, can be extracted from ultra-central heavy-ion collisions, where the medium mostly maintains a fixed size and fluctuations in the initial state and thermal fluctuations dominate. We present the first ALICE measurements of the event-by-event mean transverse momentum, $\langle[p_{\mathrm{T}}]\rangle$, in particular its average and higher-order fluctuations as a function of multiplicity using particle spectra and multi-particle $\langle[p_{\mathrm{T}}]\rangle$ cumulant techniques, in ultra-central Pb–Pb collisions at $\sqrt{s_{\mathrm{NN}}} = 5.02$ TeV. The pronounced rise in $\langle[p_{\mathrm{T}}]\rangle$ and the sudden transition in higher-order fluctuations at high multiplicities are used to extract the speed of sound in QGP, c_s^2, and to probe the thermalisation of the QGP, respectively. Our approach yields valuable insights into the thermalized nature of the deconfined state resulting from heavy-ion collisions, contributing to a deeper understanding of the QCD equation of state.

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Studying the dynamics of particle-emitting sources in p–Pb and Pb–Pb collisions with ALICE at LHC energies using femtoscopy

Auteur: Collaboration ALICE[None]

Space–time properties of quark–gluon plasma (QGP), a state of matter with unbound partons produced in heavy-ion collisions, can be studied using femtoscopic correlations of particle pairs emitted after the hadronization.

In this talk, results of 1D and 3D femtoscopic analyses of identical charged kaon pairs are reported in p–Pb and Pb–Pb collisions at $\sqrt{s_{\rm NN}}$ = 5.02 TeV measured by ALICE. The multiplicity dependencies of the obtained 1D radii, compared to other collision systems at different energies, disfavor models suggesting similar evolution for matter created in small and large collision systems. The obtained 3D radii allowed to extract maximal emission times for kaons in a wide centrality range. It will be shown that a new 1D and 3D femtoscopic analysis of identical proton pairs in Pb–Pb collisions at $\sqrt{s_{\rm NN}}$ = 5.36 TeV, recently collected by ALICE, can provide further understanding of the physical processes occurring in heavy-ion collisions.

Track6-SmallSyst / 91

Unraveling the origin of collectivity in high and low multiplicity pp and p–Pb collisions in ALICE at the LHC

Auteurs: Collaboration ALICE[None]; Debojit Sarkar[1]

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We investigate the possibility of a partonic phase in small systems by measuring the elliptic flow of mesons (π^{+-}, K^{+-}, K^0) and baryons ($p+\bar{p}$, $\Lambda+\bar{\Lambda}$) in high-multiplicity p–Pb collisions at $\sqrt{s_{\rm NN}}$ = 5.02 TeV and pp collisions at $\sqrt{s}$ = 13 TeV measured by ALICE. The results show a grouping (with 1σ significance) and splitting (with 5σ confidence) behavior of v_2 at intermediate pt. This phenomenon, reminiscent of partonic flow in heavy-ion collisions, has been observed with such high precision for the first time in small collision systems. Comparison with the hydrodynamic model with hadronization via quark coalescence indicates the formation of a deconfined partonic medium in small systems at high multiplicity. We further extend these measurements down to the lowest possible multiplicity in pp collisions employing the largest pseudorapidity separation ($5.0 < |\Delta\eta| < 6.0$) to explore the limits to the formation of the collective medium and presence of partonic degrees of freedom in small systems.

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Anomalous kaon correlations in Pb–Pb collisions at the LHC with ALICE

Auteur: Collaboration ALICE[None]

Two-particle correlation functions provide critical information about the medium created in heavy-ion collisions. Recent ALICE measurements have demonstrated large dynamical correlations between produced neutral and charged kaons in Pb–Pb collisions at $\sqrt{s_{\rm NN}} = 2.76$ TeV. These integrated correlations cannot be described by conventional heavy-ion models, such as EPOS and AMPT. On the other hand, the ALICE measurements can only be described by invoking the presence of strange-quark condensates. Two candidates for such a condensate are the Disoriented Chiral Condensate (DCC) and Disoriented Isospin Condensate (DIC). They both arise from chiral symmetry restoration in the QGP, which breaks during the phase transition to form a condensate that coherently emits hadrons.

To investigate these anomalous kaon correlations further, we will present a differential analysis of two-particle angular correlation functions of charged and neutral kaons as a function of $\Delta\varphi$ and $\Delta\eta$ in Pb–Pb collisions at $\sqrt{s_{\rm NN}} = 5.02$ TeV. Such an analysis is expected to shed light on the origin of the observed large dynamical fluctuations experimentally, as these have contributions from single-particle fluctuations and two-particle correlations. In particular, the results from this differential study will help disentangle the contributions from resonances and possible contributions from condensates.

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Lambda baryon production in heavy-ion collisions at the NA61/SHINE experiment

Auteur: Yuliia Balkova[1]

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Strangeness production in heavy-ion collisions is a longstanding and actively researched topic, offering crucial insights into the properties of strongly interacting matter. The NA61/SHINE experiment at CERN SPS North Area is one of the leading experiments in this field, focusing on measuring hadron production in a wide range of collision energies and system sizes.

This talk emphasizes the significance of measuring strangeness production with respect to the onset of deconfinement. The first results on Lambda baryon production in medium-size systems, such as Ar+Sc, will be presented with a focus on the methodology employed in the analysis. They will be compared with available world data from proton-proton and nucleus-nucleus collisions, and selected theoretical models.

Track2-HF&Q / 94

Study of charm fragmentation with charm meson and baryon angular correlation measurements with ALICE

Auteurs: Antonio Palasciano[None]; Collaboration ALICE[None]

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Fragmentation functions, which describe the fraction of the heavy-quark momentum carried by the heavy-flavour hadron, are one of the key components of the factorisation theorem used to calculate heavy-flavour hadron production cross-sections. Such functions are typically parametrised exploiting measurements performed in $\rm e^+e^-$ and $\rm e^-p$ collisions, under the assumption of fragmentation as a universal hadronisation mechanism across leptonic and hadronic collision systems. However, measurements of charm-hadron spectra and of the ratios of charmed-hadron abundances in pp collisions at LHC have proved that the fragmentation of heavy quarks into the different hadron species differ in hadornic and leptonic collisions.

In this talk, we present measurements of differential observables that consider the surrounding hadronic population in addition to the heavy-flavour hadron itself. These measurements allow for a closer connection to the charm fragmentation functions and put stronger constraints on the properties of hadronisation in hadronic collisions.

In particular, we report the results of angular correlations between D mesons and charged particles in pp collisions, including the first studies with Run 3 data. We will also show the comparison between charm meson angular correlations with charged particles and charm baryon (Λ_c^+) correlations in pp collisions. Such measurement will give insights on the differences of the charm fragmentation between charm baryons and mesons. We also present the final measurement of the fraction of longitudinal momentum of jets carried by Λ_c^+ baryons in pp collisions at $\sqrt{s} = 13$ TeV.

Track2-HF&Q / 95

The role of strangeness in heavy-quark hadronisation from small to large collision systems with ALICE

Auteurs: Collaboration ALICE[None]; Mattia Faggin[1]

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Production measurements of strange hadrons originating from the hadronisation of charm quarks (prompt) and from beauty-hadron decays (non-prompt) offer a unique tool to study the heavy-quark hadronisation across different collision systems. In proton-proton (pp) and p–Pb collisions, they enable quantifying the fragmentation of heavy quarks to strange heavy-flavour hadrons relative to that of heavy-flavour hadrons without strange valence quark. These measurements also provide important tests for perturbative QCD-based calculations and the possible presence of cold nuclear-matter effects. In Pb–Pb collisions, the production of heavy-flavour hadrons with strange-quark content is sensitive to the hadronisation mechanisms of charm and beauty quarks in the quark–gluon plasma (QGP) and to final-state effects. If a fraction of heavy quarks hadronises via recombination with light-flavoured quarks in the medium, the production of heavy hadrons with strange-quark content is expected to be enhanced compared to that of non-strange hadrons, due to the abundant production of (anti)strange quarks in heavy-ion collisions compared to pp and p–Pb collisions.

This contribution discusses the final results of the ALICE Collaboration obtained by measuring strange D mesons in pp, p–Pb, and Pb–Pb collisions collected during the LHC Run 2. It reports the charm-quark fragmentation fraction to strange D mesons in pp and p–Pb collisions. The first measurement of the production of orbitally excited charm-strange mesons in pp collisions is also reported. Additionally, the production measurements of prompt $\mathrm{D_s}^+$ mesons are compared to those of non-strange mesons across the different collision systems, along with the measurement of non-prompt $\mathrm{D_s}^+$ mesons in heavy-ion collisions. Lastly, the first studies of strange and non-strange D mesons using the large data sample of pp collisions at $\sqrt{s} = 13.6$ TeV harvested from the start of LHC Run 3 are presented.

Track2-HF&Q / 96

Investigation of charm-quark hadronisation into baryons in hadronic collisions with ALICE

Auteurs: Collaboration ALICE[None]; JaeYoon Cho[1]

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Charm-baryon production measurements in proton-proton (pp) collisions at the LHC are fundamental to investigate the charm-quark hadronisation, and to test perturbative QCD-based calculations. Measurements in pp collisions showed baryon-to-meson ratios significantly higher than those in $\mathrm{e^+e^-}$ collisions, suggesting that the hadronisation of charm quarks is not universal across collision systems. They challenge the validity of theoretical calculations based on the factorisation approach, which assume universal fragmentation functions across collision systems. Similar measurements in hadronic collisions as a function of the event multiplicity provide sensitive tools to explore how

the formation of charm baryons is influenced by different processes from small to large colliding systems. Lastly, measurements of charm baryon-to-meson yield ratios in p–nucleus and nucleus–nucleus collisions provide crucial information about possible modifications of hadronisation mechanisms in presence of, respectively, cold nuclear-matter effects and final-state effects induced by the formation of a quark–gluon plasma (QGP).

In this contribution, the final results of the ALICE Collaboration obtained by measuring the production of strange ($\Xi_c^{0,+}$, Ω_c^0) and non-strange (Λ_c^+, $\Sigma_c^{0,+,++}$) charm baryons in pp, p–Pb collisions and that of Λ_c^+ baryons in Pb–Pb collisions collected during the LHC Run 2 with the ALICE experiment are shown. A comparison between baryon-to-meson ratios with novel theoretical models implementing hadronisation mechanisms different from the fragmentation in the vacuum will be also discussed. The first studies of charm-baryon reconstruction using the large data sample of pp collisions at √s = 13.6 TeV harvested from the start of LHC Run 3 are presented.

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Studies of beauty-quark production, hadronisation and cold nuclear matter effects via measurements of non-prompt charm hadrons in pp and p-Pb collisions with ALICE

Auteur: Collaboration ALICE[None]

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Measurements of beauty-hadron production in ultrarelativistic hadronic collisions provide a fundamental tool for testing perturbative QCD calculations. In particular, these calculations include a fragmentation function, which models the transition from the quark to a hadron state and is parameterized based on measurements in leptonic collisions. Recent results have shown that the beauty fragmentation function, as well as that of charm, is not universal across different collision systems. An extension of these studies to further energies, rapidities and collision systems has thus become crucial. Additionally, studies in p–Pb collisions allow us to shed light on the role of cold nuclear matter effects on beauty production and their impact on beauty-quark hadronisation.

The ALICE experiment is capable of performing high-precision measurements of non-prompt D mesons and Λ_c^+ baryons, profiting of its excellent tracking, vertexing and particle-identification performance, and exploiting machine-learning techniques for the classification of prompt and non-prompt D mesons.

In this presentation, the final results on non-prompt charm baryon-over-meson and meson-over-meson production yield ratios in pp collisions at $\sqrt{s}$ = 13 TeV will be shown and compared to pQCD predictions, as well as to models with modified hadronisation mechanisms with respect to in-vacuum fragmentation. The final results of non-prompt charm-hadron production yield ratios in p–Pb collisions at $\sqrt{s_{\rm NN}}$ = 5.02 TeV, as well as of nuclear modification factor of non-prompt $\rm D^0$, $\rm D^+$, $\rm D_s^+$, Λ_c^+, will also be discussed. All measurements will be compared with their prompt counterparts. The final results of total $b\bar{b}$ production cross section at midrapidity in pp collisions will also be presented. Finally, the first studies of non-prompt/prompt production yield ratios of charm hadrons in pp collisions at $\sqrt{s} = 13.6$ TeV from the LHC Run3 data taking will be reported.

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Characterisation of heavy-quark propagation and thermalisation in QGP with ALICE

Auteur: Collaboration ALICE[None]

Heavy quarks (charm and beauty) serve as useful probes for investigating the properties of the quark-gluon plasma (QGP) generated in ultra-relativistic heavy-ion collisions. Originating from hard-scattering processes in the early collision stages, heavy quarks traverse the QGP, interacting with its constituents and experiencing energy loss through elastic scatterings and gluon radiation.

Measurements of the nuclear modification factor R_{AA} of charm and beauty hadrons offer a means to characterize the in-medium energy loss of heavy quarks in the QGP. Insights into their diffusion and participation to the medium collective motion are obtained through measurements of elliptic-flow coefficient v_2 of heavy-flavour particles. As heavy quarks traverse the QGP, the internal structure and energy of the resulting jet may be altered, while the parton shower can, reciprocally, modify the plasma itself by injecting energy and momentum. Insights into these effects can be obtained by measuring angular correlations involving heavy-flavour particles.

In this contribution, measurements of charm-hadron R_{AA} and of prompt- and non-prompt D meson v_2 coefficient in Pb–Pb collisions at $\sqrt{s_{\mathrm{NN}}} = 5.02$ TeV will be shown, along with comparisons to model predictions that incorporate various implementations of heavy-quark interaction and hadronisation with the QGP constituents. Additionally, angular correlations of heavy-flavour decay electrons with charged particles, and their alterations in the presence of the QGP will be presented. The latest findings from the LHC Pb–Pb Run3 data will be featured, showcasing the performance of v_2 measurements for both charm mesons and baryons.

Track4-Bulk&Phase / 99

Investigation of early magnetic field and angular momentum in ultrarelativistic heavy-ion collisions via D^{*+}-meson spin alignment with ALICE

Auteurs: Collaboration ALICE[None]; Himanshu Sharma[1]

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Heavy quarks, i.e. charm and beauty, are produced at the initial stage of heavy-ion collisions, on a time scale shorter than the medium formation time, and are sensitive to the initial angular momentum of the system and the magnetic field produced perpendicular to the reaction plane (defined by the impact parameter direction and beam direction) in non-central heavy-ion collisions. In the presence of a large angular momentum and initial magnetic field, the charm quark can be polarised. The quark polarisation is expected to be transferred to the hadron during the hadronisation process. Experimentally, the heavy-flavour polarisation can be probed by measuring the spin density matrix element of spin-1 hadrons (as the D^{*+} meson). Any deviation of the ρ_{00} parameter from ⅓ can be attributed to the spin alignment of the D^{*+} meson.

We will present the first measurement of the ρ_{00} parameter of D^{*+} meson in Pb–Pb collisions at $\sqrt{s_{\mathrm{NN}}} = 5.02$ TeV, exploiting the large data sample collected by the ALICE Collaboration during the LHC Run 2. A comparison with the J/ψ polarisation measurement will also be reported to investigate the effect of the magnetic field.
Moreover, the ρ_{00} parameter of D^{*+} mesons measured in high-energy pp collisions will also be presented, including the first studies with Run 3 data. In this case, the measurement is performed also for D^{*+} mesons originating from B-meson decays. As vector mesons which decay from scalar B mesons, they are expected to be longitudinally polarised due to the helicity conservation in weak decays.

Track2-HF&Q / 100

Study of charm and beauty production in hadronic collisions via muon measurements at forward rapidity with ALICE

Auteurs: Collaboration ALICE[None]; Maolin Zhang[None]

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Measurements of the production of open heavy-flavour hadrons and their semileptonic decays in high-energy heavy-ion collisions give unique access to the transport properties of heavy quarks (charm and beauty) in the quark-gluon plasma (QGP). This includes their mass-dependent in-medium energy loss, their degree of thermalisation and their in-medium hadronisation mechanisms. Charm and beauty measurements in small collision systems, pp and p–Pb, serve as important test of perturbative QCD calculations. They also provide the possibility to investigate cold nuclear matter effects in the nuclear medium and represent the baseline to study the QGP and quantify hot-medium effects in heavy-ion collisions. Measurements in these collision systems gained additional interest due to the possibility of observing, in high-multiplicity collisions, final-state effects typically attributed to the presence of the QGP in Pb–Pb collisions. The origin of these effects is still under active investigation.

Open heavy flavours are also studied with ALICE through the semimuonic decays of charm and beauty hadrons. In this contribution, recent results of the azimuthal anisotropy of open heavy-flavour hadron decay muons in high-multiplicity p–Pb collisions at forward ($2.03 < y_{\rm CMS} < 3.53$) and backward ($-4.46 < y_{\rm CMS} < -2.96$) rapidities are discussed and compared with other experimental measurements, as well as with model calculations. The results provide new insights into the collective-like behaviour observed in small collision systems and impose stringent constraints on models.

In addition, in the LHC Run 3, the new Muon Forward Tracker (MFT) adds vertex capabilities to the forward muon spectrometer, providing a unique way to discriminate muons from charm- and beauty-hadron decays. A first look at the measurement of muons from charm- and beauty-hadron decays, separately, in pp collisions at $\sqrt{s}$ = 13.6 TeV and Pb–Pb collisions at $\sqrt{s_{\rm NN}}$ = 5.36 TeV collected with the upgraded ALICE apparatus is reported.

Track1-LF / 101

Measurement of strange baryon production in charged-particle jets in pp and p-Pb collisions with ALICE

Auteurs: Collaboration ALICE[None]; Gijs van Weelden[1]

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Collective effects similar to those in Pb-Pb collisions have been observed in smaller systems, such as pp and p-Pb collisions. Among these is the increase of the strange to non-strange hadron ratio with charged-particle multiplicity density. Understanding these effects requires a detailed description of the production mechanisms of strange hadrons, which is obscured by large uncertainties in the gluon-initiated particle shower and hadronisation models. Much of our knowledge of particle showers is based on results from ⊠+⊠– collisions, which is sensitive to quark-initated fragmentation patterns, but leaves gluon fragmentation poorly constrained. By studying the production of strange hadrons in hadronic collisions, which are rich in gluon-initiated final states, we can probe these mechanisms and, using data from p-Pb collisions, we can disentangle the contributions in jets from those of the bulk.
In this talk, we present published results on the production of $\rm K^0_S$, Λ(¯), Ξ± and Ω± hadrons in charged-particle jets and the underlying event in pp and p-Pb collisions with ALICE.
In addition, we show a novel measurement of jet fragmentation into Λ and $\rm K^0_S$ hadrons in pp collisions at $\sqrt{s}$=13.6 TeV with ALICE.

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Strangeness production in Au+Au collisions at $\sqrt{s_{NN}}$ = 7.7, 14.6 and 19.6 GeV with the STAR experiment

Auteur: Yi Fang[1]

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One main motivation of the Beam Energy Scan (BES) program at RHIC is to search for the QCD critical point and the onset of deconfinement. Strangeness production has been suggested as a sensitive probe to the early dynamics of the deconfined matter created in heavy-ion collisions. Ratios of particle yields involving strange particles are often utilized to study various properties of the nuclear matter, such as the strangeness and baryon chemical potentials at the chemical freeze-out temperature ($\mu_S/T_{\rm ch}$ and $\mu_B/T_{\rm ch}$).

Measurements from the first phase of the BES program (BES-I) have indicated potential changes in the medium properties with decreasing collision energy. However, the precision of those measurements is not sufficient to draw definitive conclusions. During BES-II, STAR has accumulated high statistics data in Au+Au collisions, which can help reduce the uncertainties in the strange hadron measurements, in particular for the multi-strange hadrons. Benefiting from the iTPC upgrade, the strangeness measurements are now extended from previous rapidity window of |y|<0.5 to |y|<1.5. We also apply the Boosted Decision Trees (BDT) machine learning algorithm to optimize the signal extraction. In this poster, we will present new STAR measurements of strange hadron (K_s^0, Λ, $\bar{\Lambda}$, Ξ, $\bar{\Xi}$, Ω, $\bar{\Omega}$) production in Au+Au collisions at $\sqrt{s_{NN}}$ = 7.7, 14.6, 19.6 GeV from BES-II, including transverse-momentum and rapidity spectra, nuclear modification factors and antibaryon-to-baryon ratios. New insights on the collision dynamics will be discussed.

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Investigating strangeness production in pp collisions using hadron-strangeness correlations with ALICE at the LHC

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One of the key challenges of hadron physics today is understanding the origin of strangeness enhancement in high-energy hadronic collisions, i.e. the increase of (multi-)strange hadron yields relative to non-strange hadron yields with increasing charged-particle multiplicity. The microscopic origin of this phenomenon is still not fully understood: is it related to hard scattering events, such as jets, or instead to particle production mechanisms related to the underlying event? To separate strange hadrons produced in jets from those produced in the underlying event, the angular correlation between high-$p_{\rm T}$ charged particles and strange hadrons has been exploited. The near-side jet yield and the out-of-jet yield of $\rm K^0_S$ and $\Xi^{\pm}$ have been studied as a function of the multiplicity of charged particles produced in pp collisions at $\sqrt{s} = 13$ TeV and $\sqrt{s} = 5$ TeV. The results show that out-of-jet processes give the dominant contribution to strange hadron production and that the relative production of $\Xi^{\pm}$ with respect to $\rm K^0_S$ is favoured in out-of-jet processes. Moreover, the increase with multiplicity of the $\Xi^{\pm}/\rm K^0_S$ yield ratio suggests that strangeness enhancement with multiplicity is observed both in and out of jets. Comparisons with EPOS LHC and PYTHIA 8 model predictions reveal that these models are unable to quantitatively reproduce the measured in- and out-of-jets yields.

Track5-UpFut / 104

Fast timing silicon R&D for the future Electron-Ion Collider

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Co-auteurs: Carlos Solans [2]; Eric Renner [1]; Marcos Vazquez Nunez [3]; Ming Liu [1]; Vicente Gonzalez [3]; Walter Sondheim [1]; Yasser Corrales Morales [4]

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The proposed Electron-Ion Collider (EIC) will utilize high-luminosity high-energy electron+proton ($e + p$) and electron+nucleus ($e + A$) collisions to solve several fundamental questions including searching for gluon saturation and studying the proton/nuclear structure. High granularity and low material budget silicon vertex and tracking detector with fine spatial resolution is essential to perform a series of high precise measurements at the EIC. Complementary to the ongoing EIC project detector technical design carried out by the ePIC collaboration, several new detector R&D, which aims for the ePIC detector upgrade or the EIC detector II development, has started with the support of the EIC generic R&D project. A Depleted Monolithic Active Pixel Sensor (MALTA2) based fast timing silicon tracking detector has been proposed to provide additional hits for track reconstruction in the far-forward and far-backward region at the EIC to improve the overall track reconstruction quality. The fast timing resolution of the MALTA2 technology will help reject background events at the EIC as well. We will present the detector design of the proposed MALTA2 based far forward/backward tracking detector supported by the EIC generic R&D program, progress of the MALTA2 R&D from bench tests and scheduled beam test at CERN and the development of a new MALTA2 stave design with reduced material budgets. The evaluated impacts on the EIC $e + A$ physics will be present as well.

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Resonance production in-and-out of jets in pp collisions @ 13.6 TeV with ALICE

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Recent experimental results on two-particle correlations within jets highlight a strong correlation at extremely large charged-particle jets multiplicities. This has hypothesized the idea of a formation of a hot and dense QCD medium within high-multiplicity jets in pp collisions. This observation suggests a novel aspect of particle interaction dynamics in pp collisions, previously thought to be exclusive to heavy-ion collisions. One notable characteristic of such medium formation is the altered production ratio among different types of particles. This study aims to delve into this phenomenon by analyzing the yields of K*and ϕ mesons within high-multiplicity jets in pp collisions LHC Run 3 data at √s = 13.6 TeV, obtained with ALICE. The analysis utilizes charged jets and the per-trigger yields of K* and ϕ are investigated in-and-out of such jets. The focus on these specific particles is expected to provide valuable insights into the intricate dynamics of QCD medium creation and its influence on particle production patterns.

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Understanding the diffusion and melting of heavy flavor hadrons

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The substantial mass of charm quarks makes them an ideal tool for probing the de-confined medium of quarks and gluons. These charm quarks interact with the medium, thereby carrying vital information about it, before undergoing hadronization to form heavy flavor hadrons.
In this study, we make use of the color string percolation model (CSPM) and the van der Waals Hadron Resonance Gas (VDWHRG) model to examine the diffusion of charm quarks and the D^0 meson in the deconfined and the hadronic phase respectively. CSPM is a QCD-inspired model that assumes colored strings to be stretched between the partons of the colliding nuclei. This is a well-established model which has been used to estimate various thermodynamic and transport properties of the matter formed in ultra-relativistic hadronic and heavy-ion collisions. Conversely, the VDWHRG model is a modified hadron resonance gas model that takes both attractive and repulsive interactions between the hadrons into account. This model successfully explains the lattice QCD data up to temperature, $T \simeq 180$ MeV.
We calculate the drag coefficient (γ) and diffusion coefficients in both momentum (B_0) and coordinate space (D_s) within both CSPM and VDWHRG models. Our observations reveal a minima for the spatial diffusion coefficient around the deconfinement temperature, indicating a phase transition.
Additionally, we investigate the melting of the charmed hadrons by estimating the charm susceptibilities within the VDWHRG model. We found a smooth transition near the deconfinement region at a vanishing chemical potential, hinting at a crossover transition.
The net charm fluctuations can be estimated in experiments by taking the net number fluctuation of $D^{\pm}$ meson. It has not been done in experiments till now. However, with ALICE Run-3 going towards higher luminosity and better detection capabilities, one can perform this study experimentally.
This study offers significant insights into the behavior of charm quarks and open charm hadrons, thereby contributing to the broader understanding of the interaction of heavy flavor with the thermalized medium.

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Measurement of heavy-flavor electron production in Au+Au collisions at $\sqrt{s_{NN}}$ = 54.4 GeV at STAR

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Studying heavy-flavor production in heavy-ion collisions (HIC) can improve our understanding of parton interactions with the Quark-Gluon Plasma (QGP). Due to their significant mass, heavy quarks (charm and bottom) are mainly produced in the initial phase of high-energy HIC, when hard scatterings are prevalent, and thus experience the entire evolution of the QGP. One way to study heavy quarks is to measure Heavy-Flavor Electrons (HFE) - electrons emitted from the semi-leptonic decays of heavy-flavor hadrons.

In this contribution, we will present the HFE measurement at low transverse momentum (p_{T}) in Au+Au collisions at $\sqrt{s_{NN}}$ = 54.4 GeV using data taken in 2017 by the STAR experiment. The strong HFE suppression was already observed in the central Au+Au collisions at $\sqrt{s_{NN}}$ = 200 GeV. The measurement of heavy-flavor quark central-to-peripheral nuclear modification factors below the RHIC top energy will provide new insights into the collisional energy loss that is dominant at low p_{T} and will complement the existing results at $\sqrt{s_{NN}}$ = 200 GeV and the recent HFE elliptic flow measurement at $\sqrt{s_{NN}}$ = 54.4 GeV.

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Strangeness in cosmic ray - air interactions and the Muon Puzzle

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High-energy cosmic ray experiments consistently report an excess of secondary cosmic ray muons at ground level, defying predictions from prevalent high-energy interaction models: a phenomenon known as the "Muon Puzzle". The universal enhancement of strangeness and baryon production in p-p, p-Pb, and Pb-Pb collisions seen by the ALICE collaboration [Nat. Phys. 13, 535 (2017)] could provide an important key to solving the muon puzzle. It has also been shown in [PRD 107, 094031 (2023)] that decreasing the energy fraction lost to photons through π^0 and η decays can increase muon production. Proposed solutions, thus involve exploring increased strange particle yield or hadronic energy fraction during air showers. This study investigates these factors and their cross-correlation in the final state particles across various systems and energies available at the CERN Large Hadron Collider (LHC), utilizing simulation models such as EPOS LHC, SYBILL 2.3d, QGSJET II-04, and PYTHIA 8. Results are presented, accompanied by an outlook on forthcoming Oxygen-Oxygen and proton-oxygen collisions at the LHC.

Track1-LF / 110

Production of light and strange particles as a function of the underlying event activity in small and large collision systems with ALICE

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Measurements of high-multiplicity pp and pA collisions at LHC energies have revealed that these small colliding systems exhibit quark-gluon plasma-like features, such as collective behaviour and strangeness enhancement. A method to narrow down the origin of this phenomenon is to relate the strangeness production to Multi-Parton Interactions (MPIs). Although the MPIs cannot be measured directly, the observable R_T, quantifying the magnitude of the underlying event (UE), can be used as an experimental proxy.

Final results of the charged particle production as a function of R_T in pp, p–Pb and Pb–Pb collisions at $\sqrt{s_\mathrm{NN}}$ = 5.02 TeV will be presented in the toward, away and transverse regions relative to the hard scattering. In addition, results on the production of identified hadrons (π, K, p) and strange particles ($\mathrm{K^0_S}$, Λ and Ξ) as a function of R_T in pp collisions at $\sqrt{s}$ = 13 TeV will be discussed to explore the particle species dependence. All these results will be compared with predictions from QCD-inspired Monte Carlo event generators such as PYTHIA and EPOS.

Track2-HF&Q / 111

J/ψ photoproduction and polarization in peripheral Pb-Pb collisions with ALICE

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Ultrarelativistic heavy-ion collisions generate a powerful electromagnetic field that produces photonuclear reactions. These processes have been extensively studied in ultraperipheral collisions, in which the impact parameter is larger than twice the nuclear radius. Recently, coherent J/ψ photoproduction has been observed in nucleus–nucleus (A–A) collisions with nuclear overlap, based on the measurement of an excess of J/ψ production with respect to hadron-production expectations in the very low transverse momentum (p_{T}). Such quarkonium measurements provide valuable insights on the nuclear gluon distribution at low Bjorken-x and high energy. In addition, they can shed light on the theory behind photon-induced reactions in A–A collisions with nuclear overlap, including possible interactions of the measured probes with the formed and fast expanding quark–gluon plasma. In order to confirm the photoproduction origin of the very low p_{T} J/ψ yield excess, polarization measurement is a golden observable. It is expected that the produced quarkonium would keep the polarization of the incoming photon due to s-channel helicity conservation. ALICE can measure inclusive and exclusive quarkonium production down to p_{T} = 0, at forward rapidity (2.5 < y < 4) and midrapidity ($|y|$ < 0.9). In this contribution, new preliminary measurement of the y-differential cross section and the first new polarization analysis at the LHC of coherently photoproduced J/ψ in peripheral Pb–Pb collisions will be presented. Both measurements are conducted at forward rapidity in the dimuon decay channel. These results will be discussed together with the recent results on coherent J/ψ photoproduction as a function of centrality at both mid and forward rapidities. Comparison with models will be shown when available.

Track6-SmallSyst / **112**

Particle production as a function of charged-particle flattenicity in small collision systems with ALICE

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Event classifiers based either on the charged-particle multiplicity or on event topologies, such as spherocity and underlying event activity, have been extensively used in proton-proton (pp) collisions by the ALICE Collaboration at the LHC. These event classifiers became important tools since the observation of fluid-like behavior in high multiplicity pp collisions as for example radial and anisotropic flow. Furthermore, the study as a function of the charged-particle multiplicity allowed for the discovery of strangeness enhancement in high-multiplicity pp collisions. However, one drawback of the multiplicity-based event classifiers is that requiring a high charged-particle multiplicity biases the sample towards hard processes like multijet final states. These biases blur the effects of multi-parton interactions (MPI) and make it difficult to pinpoint the origins of fluid-like effects.

This contribution exploits a new event classifier, the charged-particle flattenicity, defined in ALICE using the charged-particle multiplicity estimated in 2.8 < η < 5.1 and −3.7 < η < −1.7 intervals. New final results on the production of pions, kaons, protons, and unidentified charged particles at midrapidity ($|\eta|$ < 0.8) as a function of flattenicity in pp collisions at $\sqrt{s}$ = 13 TeV will be discussed. It will be shown how flattenicity can be used to select events more sensitive to MPI and less sensitive to final-state hard processes. All the results are compared with predictions from QCD-inspired Monte Carlo event generators such as PYTHIA and EPOS. Finally, an outlook on using the flattenicity estimator using Run3 data will be shown.

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Studying QCD production mechanisms and medium effects on

quarkonia formation with ALICE

Auteur: ALICE Collaboration[None]

Charmonia is a valuable tool for investigating nuclear matter under extreme conditions, particularly within the strongly interacting medium formed during heavy-ion collisions. At the high energies of the LHC, the regeneration process, driven by the plentiful production of charm quarks, has been found to significantly impact the observed charmonium characteristics. It is important to conduct comprehensive production measurements including both ground and excited states of charmonia to distinguish among various regeneration scenarios considered in theoretical frameworks. In particular, the ψ(2S) production relative to J/ψ is a physical observable with strong discriminating power between the possible regeneration scenarios in Pb-Pb collisions. Additionally, the study of quarkonium production in proton-proton (pp) collisions serves as a crucial tool for exploring both perturbative and non-perturbative aspects of quantum chromodynamics (QCD) calculations. Moreover, it establishes a foundational reference for interpreting results obtained in Pb-Pb collisions and it is a key measurement to distinguish among the available quarkonium production models in pp and p-Pb systems. In this contribution, preliminary findings of the double ratio of ψ(2S)-to-J/ψ as well as the inclusive J/ψ yield in pp collisions at a center-of-mass energy of $\sqrt{s}$ = 13.6 TeV measured by the ALICE Collaboration will be presented and compared with existing model calculations.

Track1-LF / 114

Charged-particle production in pp collisions at 13.6 TeV and Pb-Pb collisions at 5.36 TeV with ALICE

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The pseudorapidity dependence of charged particle production provides information on the partonic structure of the colliding hadrons and is, in particular at LHC energies, sensitive to non-linear QCD evolution in the initial state. For Run3, ALICE has increased its pseudorapidity coverage to track charged particles over a wider range of $-3.6 < \eta < 2$ combining the measurement from the upgraded Inner Tracking System (ITS) and the newly installed Muon Forward Tracker (MFT).

Particle production mechanisms are explored by addressing the charged-particle pseudorapidity densities measured in pp and Pb–Pb collisions, presenting new final results from Run 3. These studies allow us to investigate the evolution of particle production with energy and system size and to compare models based on various particle-production mechanisms and different initial conditions both at mid and forward rapidities.

Track2-HF&Q / 115

Investigating the interplay between initial hard processes and final-state effects measuring prompt and non-prompt J/ψ with ALICE

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Quarkonium production in high-energy hadronic collisions is sensitive to both perturbative and non-perturbative aspects of quantum chromodynamics (QCD) calculations. In fact, the production of the heavy-quark pair is described by perturbative QCD while the formation of the bound state is a non-perturbative process, treated in different ways by available theoretical models. Charmonia cross section can be split into a prompt component, corresponding to the quarkonia directly produced by the charm (anti-charm) quarks, and a non-prompt one, corresponding to the quarkonia originating from the decay of beauty hadrons. The latter can be identified experimentally thanks to its displaced topology and plays an important role in the estimation of the beauty-hadron production cross section. Moreover, non-prompt charmonia is also a valuable tool to investigate the properties of the strongly interacting medium produced in ultra-relativistic heavy-ion collisions. In particular, J/ψ produced in the decay of beauty hadrons can be used to study the mass dependence of heavy-quarks in-medium energy loss mechanism. In this contribution the recent measurement of prompt and non-prompt J/ψ carried out by the ALICE Collaboration in pp and Pb-Pb collisions at midrapidity ($|y|$ < 0.8), at $\sqrt{s}$ = 13 TeV and $\sqrt{s_{\rm NN}}$ = 5.02 TeV respectively, will be presented. Moreover, thanks to the installation of the new muon forward tracker (MFT), the prompt/non-prompt charmonia separation will be possible in LHC Run 3 also at forward rapidity (2.5 < y < 4). The status of the new measurements at $\sqrt{s}$ = 13.6 TeV will be also presented and compared with the existing measurements and the available models.

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System-size dependence of collective phenomena by means of quarkonia measurements with ALICE

Auteur: ALICE Collaboration[None]

Quarkonium production has long been identified as one of the golden probes to study the quark-gluon plasma (QGP). The early production of heavy quarks ($c\bar{c}$ and $b\bar{b}$) make quarkonia an ideal probe to investigate the evolution of the hot and dense medium produced in ultra-relativistic heavy-ion collisions. Among many observables, the measurement of azimuthal anisotropies (expressed as elliptic and triangular flows, v_2 and v_3 respectively) of quarkonia has a special role to shed light on the collective behavior of particles within a strongly interacting medium. In particular, the magnitude of the J/ψ elliptic flow measured at the LHC is interpreted as a signature of the charm quark thermalization in a deconfined medium, supporting the scenario of charmonium (re)generation at low $p_{\rm T}$. Interestingly, the observation of collective-like effects in high-multiplicity pp and p-Pb collisions, provided new insights on the interplay among small and large collision systems. One of the possible scenarios proposed for describing these findings is the presence of multiple parton-parton interactions (MPIs) which affect both the soft component of the event, as well as the hard scales responsible for heavy-quark production at the LHC energies. In this contribution the measurement of the J/ψ flow coefficients in pp and Pb-Pb collisions at mid ($|y|$<0.8) and forward (2.5 < y < 4) rapidity carried out by the ALICE collaboration will be presented. In addition, thanks to the upgraded detector in Run 3 more precise measurements of the same quantities will be possible in pp and Pb-Pb collisions at $\sqrt{s}$ = 13.6 TeV and $\sqrt{s_{\rm NN}}$ = 5.02 TeV respectively. The status of these ongoing measurements and available model predictions will be also discussed.

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Probing of exotic multiquark states in hadron and heavy ion collisions

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The spectroscopy of charmonium-like mesons with masses above the 2_mD open charm threshold has been full of surprises and remains poorly understood [1]. The currently most compelling theoretical descriptions of the mysterious XYZ mesons attribute them to hybrid structure with a tightly bound cc\bar diquark [2] or cq(cq)\bar tetraquark core [3 - 5] that strongly couples to S-wave DD\bar

molecular like structures. In this picture, the production of a XYZ states in high energy hadron collisions and its decays into light hadron plus charmonum final states proceed via the core component of the meson, while decays to pairs of open-charmed mesons proceed via the DD\bar component.
These ideas have been applied with some success to the XYZ states [2], where a detailed calculation finds a cc\bar core component that is only above 5% of the time with the DD\bar component (mostly D0D0\bar) accounting for the rest. In this picture these states are compose of three rather disparate components: a small charmonium-like cc\bar core with r_rms < 1 fm, a larger D+D- component with r_rms = ħ/(2μ+B+)^1/2 ≈ 1.5 fm and a dominant component D0D0 with a huge, r_rms = ħ/(2μ0B0)^1/2 > 9 fm spatial extent. Here μ+(μ0) and B+(B0) denote the reduced mass for the D+D- (D0D0\bar) system and the relevant binding energy |m_D + m_D - M_X(3872)| (B+ = 8.2 MeV, B0 < 0.3 MeV). The different amplitudes and spatial distributions of the D+D- and D0D0 components ensure that the X(3872) is not an isospin eigenstate. Instead it is mostly I = 0, but has a significant (~ 25 %) I = 1 component.
In the hybrid scheme, XYZ mesons are produced in high energy proton-nuclei collisions via its compact (r_rms < 1 fm) charmonium-like structure and this rapidity mixes in a time (t ~ ħ/δM) into a huge and fragile, mostly D0D0, molecular-like structure. δM is the difference between the XYZ meson mass and that of the nearest cc\bar mass pole core state, which we take to be that of the χc1(2P) pure charmonium state which is expected to lie about 20 ~ 30 MeV above M_X(3872) [6, 7]. In this case, the mixing time, cτ_mix 5 ~ 10 fm, is much shorter than the lifetime of X(3872) which is cτ_X(3872) > 150 fm [8].
The experiments with proton-proton and proton-nuclei collisions with √S_pN up to 27 Gev and luminosity up to 10^32 cm^-2s^-1 planned at NICA may be well suited to test this picture for the X(3872) and other XYZ mesons [9]. In near threshold production experiments in the √S_pN ≈ 8 GeV energy range, XYZ mesons can be produced with typical kinetic energies of a few hundred MeV (i.e. with γβ ≈ 0.3). In the case of X(3872), its decay length will be greater than 50 fm while the distance scale for the cc\bar → D0D*0 transition would be 2 ~ 3 fm. Since the survival probability of an r_rms ~ 9 fm "molecular"inside nuclear matter should be very small, XYZ meson production on a nuclear target with r_rms ~ 5 fm or more (A ~ 60 or larger) should be strongly quenched. Thus, if the hybrid picture is correct, the atomic number de-pendence of XYZ production at fixed √S_pN should have a dramatically different behavior than that of the ψ', which is long lived compact charmonium state.
The current experimental status of XYZ mesons together with hidden charm tetraquark can-didates and present simulations what we might expect from A-dependence of XYZ mesons in proton-proton and proton-nuclei collisions are summarized.
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Perspective studies of charmonium, exotics and baryons with charm and strangeness

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The spectroscopy of charmonium-like states together with the spectroscopy of charmed and strange baryons is discussed. It is a good testing tool for the theories of strong interactions, including: QCD in both the perturbative and non-perturbative regimes, LQCD, potential models and phenomenological models [1, 2, 3]. An understanding of the baryon spectrum is one of the primary goals of non-perturbative QCD. In the nucleon sector, where most of the experimental information is available, the agreement with quark model predictions is astonishingly small, and the situation is even worse in the strange and charmed baryon sector. The experiments with antiproton-proton annihilation and proton-proton (proton-nuclei) collisions are well suited for a comprehensive spectroscopy program, in particular, the spectroscopy of charmonuim-like states and flavour baryons. Charmed and strange baryons can be produced abundantly in both processes, and their properties can be studied in detail [1, 2, 3].
For this purpose an elaborated analysis of charmonium and exotics spectrum together with spectrum of charmed and strange baryons is given. The recent experimental data from different collaborations (BaBar, Belle, BES, LHCb,$\cdots$) are analyzed. A special attention was given to the recently discovered XYZ-particles. The attempts of their possible interpretation are considered [4 - 7]. The results of physics simulation are obtained. Some of these states can be interpreted as higher lying charmonium and tetraquarks with a hidden charm [5, 6, 7] and strangeness [8, 9]. It has been shown that charge/neutral tetraquarks must have their neutral/charged partners with mass values which differ by few MeV. This hypothesis coincides with that proposed by Maiani and Polosa [10] and need confirmation nowdays. Many heavy baryons with charm and strangeness are expected to exist. But much more data on different decay modes are needed before firmer conclusions can be made. These data can be derived directly from the experiments using a high quality antiproton beam with √Spp\bar up to 5.5 GeV planned at FAIR and proton-proton (proton-nuclei) collisions with √SpN up to 26 GeV planned at NICA.
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New insights into strange-quark hadronization measuring multiple (multi-)strange hadron production in small collision systems with ALICE

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Among the most important results from Run1 and Run2 at the LHC is the observation of enhanced production of (multi-)strange to non-strange hadron yields, gradually rising from low-multiplicity to high-multiplicity pp and p–Pb collisions, reaching values close to those measured in peripheral Pb–Pb collisions. More insightful information about the production mechanism could be provided by measuring the (multi-)strange particle multiplicity distribution, P(nS), using a novel method based on counting the number of strange particles event-by-event. This measurement extends the study of strangeness production beyond the average of the distribution and represents a unique opportunity to test the connection between charged and strange particle multiplicity production.
In this contribution, new ALICE results on K^0_S, Λ, Ξ and Ω multiplicity distributions in pp collisions at $\sqrt{s}$ = 5.02 TeV as a function of the charged particle multiplicity, together with the average

probability for the production yield of more than one particle are presented. The results are compared to state-of-the-art phenomenological models implemented in commonly-used Monte Carlo event generators, drastically enhancing the sensitivity to the different processes implemented in each approach.

Track4-Bulk&Phase / 121

QCD equation of state, critical point and hydrodynamics of fluctuations

Auteur: Mikhail Stephanov[1]

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Recent theory developments aimed at mapping QCD phase diagram and the search for the critical point in heavy-ion collisions will be discussed. These include understanding of QCD equation of state and the universal properties of fireball trajectories near the critical point, hydrodynamic description of non-Gaussian fluctuations and their freeze-out consistent with conservation laws.

Track3-Res&Hyp / 122

Energy dependence of ϕ(1020) meson production in nucleus-nucleus collisions at the CERN SPS

Auteur: Łukasz Rozpłochowski[1]

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Production of $\phi(1020)$ mesons is expected to play an important role in studies of the transition from confined to deconfined matter. With its zero net strangeness and its valence structure composed predominantly of s and $\bar{s}$ valence quarks, the ϕ meson should not be sensitive to strangeness-related effects in a purely hadronic scenario, but will behave like a doubly-strange particle once partonic degrees of freedom are significant. At the CERN SPS, the energy dependence of the ϕ rapidity distribution is known to display a puzzling behavior. In $p + p$ interactions, the width σ_y of the ϕ rapidity spectrum follows a trend similar to that of other particles(i.e., $\pi^{\pm}$, $K^{\pm}$, and $\bar{\Lambda}$ in both $p + p$ and Pb+Pb collisions), while for central Pb+Pb reactions, it displays a much faster increase as a function of collision energy (EPJC 80, 2020, 199). No information on this phenomenon in any intermediate-size system was available up to now.

In this talk, first results on ϕ meson production in central ^{40}Ar+^{45}Sc collisions are presented. These are obtained through the $\phi \to K^+K^-$ decay channel using the $tag-and-probe$ method adapted from LHCb and ATLAS experiments. The p_T-integrated rapidity distributions, total ϕ multiplicities and hidden strangeness over pion (ϕ/π) ratios are shown as a function of collision energy and system size from $p + p$ up to central Pb+Pb reactions. The puzzling energy dependence of σ_y, and the comparison between ϕ and kaon production including STAR and ALICE data on p+p, d+Au, Cu+Cu, Au+Au, and Pb+Pb reactions will be explicitly addressed in the talk.

Track3-Res&Hyp / 123

Clusters as a prove of the equation-of-state of strongly interacting matter

Auteur: Elena Bratkovskaya[1]

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Authors: S. Gläßel, V. Kireyeu, V. Voronyuk, M. Winn, J. Aichelin, G. Coci, C. Blume, and E. Bratkovskaya

We investigate the influence of the equation-of-state (EoS) of strongly interacting hadronic and partonic matter created in heavy-ion collisions on the light cluster and hypernuclei production within the Parton-Hadron-Quantum-Molecular Dynamics (PHQMD) microscopic transport approach (PHQMD) [1-5]. The PHQMD is a microscopic n-body transport model based on the QMD propagation of the baryonic degrees of freedom, where the clusters are formed via 'potential', i.e. by potential interactions between nucleons and hyperons, and recognized by by the Minimum Spanning Tree (MST) algorithm which is identifying bound clusters by correlations of baryons in coordinate space. Additionally, 'kinetic' mechanisms for deuteron production is incorporated by catalytic hadronic reactions accounting all isospin channels of the various $\pi NN \leftrightarrow \pi d$, $NNN \leftrightarrow Nd$ reactions which enhances deuteron production as well as considering the quantum nature of the deuteron by mean of its finite size modelled by the finite-size excluded volume effect in coordinate space and projection of relative momentum of the interacting pair of nucleons on the deuteron wave-function in momentum space, leads to a strong reduction of d production, especially at target/projectile rapidities [4].

Whereas in the previous PHQMD calculations we employed a static interactions between nucleons we include now a {\bf momentum dependence interaction}. The parameters of momentum dependent potential are fitted to the "optical"potential (i.e. Schr\"odinger equivalent potential U_{SEP}), extracted from elastic scattering data in pA reactions. The potential grows up to $E_{kin} \sim 1.5$ GeV and then decreases.

We observe that a static and a momentum dependent interactions, which yield for cold matter the same equation-of-state, influence the observables in heavy-ion reactions in a quite different way. We discuss the influence on flow coefficients, v_1 and v_2, of different clusters as a function of rapidity, on the p_T- transverse momentum spectra as well as on the fragment yield. Finally we compare our results to the HADES and STAR-BES data and find a strong sensitivity of the flow coefficient, especially of elliptic flow coefficient v_2 on the momentum dependence of the potential.

Moreover, to clarify the origin of the deuteron production in heavy ion collisions from SIS to RHIC energies we propose a method to distinguish experimentally between the different possible production mechanisms.

[1] J. Aichelin, E. Bratkovskaya, A. Le F\'evre, V. Kireyeu, V. Kolesnikov, Y. Leifels, V. Voronyuk and G. Coci, Phys. Rev. C101 (2020) 044905 [arXiv:1907.03860 [nucl-th]].
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Track4-Bulk&Phase / **124**

Modeling spinodal decomposition in a rapidly expanding fluid

Auteurs: Joseph Kapusta[1]; Mayank Singh[2]

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The QCD phase diagram is expected to have a first order phase transition at high baryon densities which will give rise to effects like spinodal decomposition and nucleation in the cooling quark gluon plasma. We expect to probe this region beyond the critical point at the Beam Energy Scan Program at RHIC and the upcoming experiments at the Facility for Antiproton and Ion Research (FAIR). It is crucial to include these effects in our simulations to explain the data. We derive the equations governing spinodal decomposition in an expanding hydrodynamic system. The equations account for surface effects between different phases. The equation of state is extended to the metastable region by interpolation. We numerically solve these equations for a 1D expanding Bjorken fluid and discuss the effects of phase separation.

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Mass spectra of meson nonet (pion, kaon, eta) and the related QCD phase transitions under external magnetic field

Auteur: Shijun Mao[1]

[1] *Xi'an Jiaotong University*

Light mesons (pion, kaon, eta) under external magnetic fields are investigated in temperature-baryon chemical potential plane by using quark model. We observe that there appear mass jumps for mesons at finite magnetic field, temperature and baryon chemical potential, which are induced by the Landau levels of their constituent quarks. Based on the Goldstone's theorem, meson nonet are closely related to the QCD phase transitions. We will discuss the chiral symmetry restoration, pion/Kaon superfluid phase transition and UA(1) symmetry restoration in terms of mesons. (This talk is mainly based our paper: Phys. Rev. D 107, 074018 (2023), Phys. Rev. D 108, 054001 (2023), Phys. Rev. D106, 094017 (2022), Chin. Phys. C 46, 094105 (2022), Chin. Phys. C 45, 021004 (2021), Phys. Rev. D 102, 114006 (2020), Phys. Rev. D 99, 056005 (2019), Phys. Rev. D 96, 034004 (2017))

Track2-HF&Q / **126**

Mass hierarchy of heavy quark energy loss within a perturbative-non-perturbative transport model

Auteur: Yichao Dang[1]

Co-auteurs: Wenjing Xing [1]; Shanshan Cao [1]; Guangyou Qin [2]

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The general intuition that heavier partons suffer weaker energy loss inside a quark-gluon plasma (QGP) medium is critically re-examined. Within a linear Boltzmann transport model that includes both Yukawa and string types of interactions between heavy quarks and the QGP, we find that while the radiative energy loss is suppressed by the parton mass, heavier partons can experience stronger string potential scatterings with the medium. Their competition may result in less energy loss of bottom quarks than charm quarks at low transverse momentum (p_{T}) but an inverse order at high p_{T}. Our model calculation shows a weaker nuclear modification on bottom particles than charm particles

at low p_{T}, as observed by both RHIC and LHC experiments, but predicts an opposite hierarchy at high p_{T}. A larger momentum space transport coefficient ($\hat{q}$) and a smaller spatial diffusion coefficient (D_{s}) are found for bottom quarks than for charm quarks.

Reference: arxiv 2307.14808

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Role of Vorticity and Viscosity on Polarization of Λ-Hyperons in Hot QCD Medium

Auteur: Bhagyarathi Sahoo[1]

Co-auteurs: Captain Rituraj Singh [1]; Jan-e Alam [2]; Raghunath Sahoo [1]

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The recent spin polarization measurement of Λ ($\bar{\Lambda}$) hyperons by the ALICE and STAR Collaborations has created a remarkable interest in the nuclear and high energy physics community to investigate the possible sources for hyperon polarization. It is suggested that in peripheral heavy ion collisions, the initial orbital angular momentum (OAM) manifests the vorticity, which primarily accounts for the spin polarization of the hyperon. Apart from the OAM, there are several other sources of vorticity, such as the shear viscosity, magnetic field, inhomogeneous transverse expansion, etc. In the present study, we couple the vorticity, viscosity, and magnetic field within the ambit of second-order relativistic viscous hydrodynamics and estimate the lifetime of the vortical quark-gluon plasma (QGP) fluid. We observe that the coupling of vorticity and viscosity significantly decreases the QGP evolution rate, and the inclusion of the magnetic field makes the evolution further slower. We observed that the medium evolution becomes highly nonlinear if we consider a coupling between vorticity, viscosity and magnetic field. Using the vortical QGP evolution, we obtain the global spin polarization of Λ-hyperon. Further, we investigate viscosity and magnetic field impact on the polarization of Λ-hyperon. This study provides a qualitative understanding of the QGP medium evolution and spin-polarization of hyperon in heavy-ion collisions. The details of the results will be presented along with the latest experimental developments in this direction.

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The effect of electric and chiral magnetic conductivities on azimuthally fluctuating electromagnetic fields and observables in isobar collisions

Auteur: IRFAN SIDDIQUE[1]

Co-auteur: Uzma Tabassam [2]

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We study the space-time evolution of electromagnetic fields along with the azimuthal fluctuations of these fields and their correlation with the initial matter geometry specified by the participant plane in the presence of finite electric (σ) and chiral magnetic (σχ) conductivities in Ru+Ru and Zr+Zr collisions at √sNN = 200 GeV. We observe the partially asymmetric behavior of the spatial distributions of the electric and magnetic fields in a conducting medium when compared to the Lienard-Wiechert

(L-W) solutions, and deceleration of the decay of the fields is observed in both isobar collisions. While studying the correlation between the magnetic field direction and the participant plane, we see the sizeable suppression of the correlation in the presence of finite
conductivities when compared to the L-W case, reflecting the importance of taking into account the medium properties such as conductivities while calculating the magnetic field induced observable quantities.

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News on identified hadron production in central nucleus-nucleus collisions from NA61/SHINE at CERN SPS

Auteur: Oleksandra Panova[1]

[1] *Jan Kochanowski University*

Auteur correspondant olpanova@cern.ch

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 - 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 system, will be presented. The kinematic distributions and the measured multiplicities of identified hadrons will be compared with NA49 Pb+Pb results, as well as with available world data.

The obtained results, and in particular the ratio of positively charged kaons to pions, are crucial for the understanding of the phenomena of the onset of deconfinement and the onset of fireball, which are some of the main studies in the strong interactions program of the NA61/SHINE experiment.

Track4-Bulk&Phase / 130

Flow and correlation measurements at LHCb

Auteur: Keri Vos[1]

[1] *Maastricht University*

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Particle correlations are powerful tools for studying quantum chromodynamics in hadron collisions. In heavy-ion collisions, azimuthal angular correlations probe collective phenomena in hot, dense, nuclear media, such as QGP. Angular correlations in small collision systems could point to QGP production or potential initial-state correlations. The LHCb experiment has the unique ability to study particle correlations at forward rapidity in high-energy hadron collisions. This talk will present recent results on collective flow from the LHCb experiment.

Track2-HF&Q / 131

Recent conventional and exotic charmonia results from LHCb

Auteur: Youen Kang[None]

Co-auteur: Keri Vos [1]

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Quarkonia production in hadronic collisions is an important experimental observable that sheds light on the heavy quark interaction with the nuclear medium. While the bound quarkonium states undergo dissociation and recombination in PbPb collisions, in pPb collisions they can suffer from a combination of initial and final state effects such as shadowing and comover breakup. With high statistics from pp and pPb datasets, and excellent vertexing capabilities allowing separation of the prompt and b-decay components, LHCb performs precision measurements of J/ψ, $\psi(2S)$, and, for the first time at the LHC, χ_c production and modification. We will discuss these results, along with the first measurement of the nuclear modification factor of the exotic hadron X(3872), in context with recent model calculations.

Track1-LF / 132

Strangeness production in fixed-target collisions at LHCb

Auteurs: Chiara Lucarelli[1]; Keri Vos[2]

[1] *Firenze*

[2] *Maastricht University*

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The LHCb SMOG system provides the unique opportunity to study strangeness production in fixed-target collisions at the LHC. Studies of trangeness production in high-energy fixed-target collisions provides information on hadronization and serve as important inputs to models of particle production in cosmic rays. Recent results on strangeness production in fixed-target proton-nucleus collisions will be presented, including studies hyperon production and polarization.

Track1-LF / 133

Strangeness production in pp and pPb collisions at LHCb

Auteurs: Clara Landesa Gomez[None]; Keri Vos[1]

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Strange hadron production provides information about the hadronization process in high-energy hadron collisions. Strangeness enhancement has been interpreted as a signature of quark-gluon plasma formation in heavy-ion collisions, and recent observations of strangeness enhancement in small collisions systems have challenged conventional hadronization models. With its forward geometry and excellent particle identification capabilities, the LHCb detector is well-suited to study strangeness production in a unique kinematic region. Recent studies of strangeness production with the LHCb detector will be presented, including measurements of strangeness enhancement in the charm- and beauty-hadron systems, as well as studies of hyperon polarization.

Track2-HF&Q / 134

Open heavy flavor production at LHCb

Auteurs: Jianqiao Wang[None]; Keri Vos[1]

[1] *Maastricht University*

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The LHCb experiment is a dedicated heavy-flavor experiment at the LHC and is uniquely well-suited to studying heavy-flavor production in heavy-ion collisions. Open heavy-flavor production studies at LHCb provide strong constraints on nuclear parton densities and probe the hadronization process in the hot, dense, nuclear media produced in heavy-ion collisions. Recent measurements of heavy-flavor production in heavy-ion collisions with the LHCb detector will be presented, including studies of charm and beauty baryon production.

Track1-LF / 135

Ultra-peripheral collisions at LHCb

Auteurs: Hengne Li[None]; Keri Vos[1]

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Ultra-peripheral collisions (UPCs) provide a unique environment to study pomeron- and photon-induced reactions with heavy nuclei. These interactions can produce a wide range of final state particles, from light vector mesons to heavy quarkonia, and probe potentially exotic phenomena. With a fast DAQ, full particle ID, and the ability to reconstruct very low pt particles, LHCb is uniquely well suited to studies of hadronic final states in UPC events. We will present recent LHCb results from ultra-peripheral heavy ion collisions and discuss how these impact our understanding of the partonic structure of nuclei.

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Elliptic flow of deuterons in ultrarelativistic heavy-ion collisions

Auteur: Boris Tomasik[1]

Co-auteur: Radka Vozabova

[1] *Czech Technical University*

We simulate deuteron production in Pb+Pb collisions at 2.76 TeV and focus particularly on the elliptic flow. Two models for the production are compared: direct thermal production and coalescence. In coalescence, the yield of deuterons with certain momentum depends on the size of the region producing the nucleons from which the deuteron is composed. The elliptic flow also depends on how the size of the effective emitting region varies for the emission in different azimuthal directions. Thus the elliptic flow of deuterons from coalescence is expected to be sensitive to the azimuthal anisotropy of the fireball more or at least differently than in case of thermal production. We test this idea by using the blast-wave model to parametrize the emission of hadrons and also deuterons in case of thermal production. We tune the model very carefully on proton and pion data for spectra

and differential elliptic flow, which constrains it quite precisely. It turns out that coalescence leads to higher elliptic flow than the thermal production and is in better agreement with current data.

The presentation is based on https://arxiv.org/abs/2402.06327.

Track5-UpFut / 137

The ALICE 3 particle identification systems

Auteurs: ALICE Collaboration[None]; Giacomo Volpe[1]

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The ALICE Collaboration has proposed a completely new apparatus, ALICE 3, for the LHC Runs 5 and 6, which will enable novel studies of the quark-gluon plasma focusing on low-p_{T} heavy-flavour production, including beauty hadrons, multi-charm baryons and charm-charm correlations, as well as on precise multi-differential measurements of dielectron emission to probe the mechanism of chiral-symmetry restoration and the time-evolution of the QGP temperature.
The detector consists of a large pixel-based tracking system covering eight units of pseudorapidity and including a vertex detector mounted on a retractable structure inside the beam pipe, and a comprehensive particle identification (PID) system, implementing silicon time-of-flight (TOF) detector featuring 20 ps resolution, an aerogel-based ring-imaging Cherenkov (RICH) detector, a muon identification system, and an electromagnetic calorimeter. High-purity separation of electrons with p_{T} as low as 60 MeV/c and up to about 3 GeV/c at midrapidity, and of hadrons over a broad momentum range is achieved by the TOF and RICH, which are arranged in barrel and end-caps for full rapidity coverage.
This contribution will present the PID subsystems conceptual design and technology options, as well as expected performance from simulation studies and first results achieved in ongoing R&D activities.

Track5-UpFut / 138

The silicon tracking system of the future ALICE 3 experiment at the LHC

Auteurs: ALICE Collaboration[None]; Pavel Larionov[None]

ALICE 3 is the next generation heavy-ion experiment proposed for the LHC Runs 5 and 6. Its tracking system will be based on a vertex detector, integrated in a retractable structure inside the beam pipe to achieve a pointing resolution of better than 10 microns for p_{T} > 200 MeV/c, and a very-large-area tracker, surrounding the vertex detector and covering 8 units of pseudorapidity ($|\eta|$ < 4). The tracking system will be based on Monolithic Active Pixel Sensor (MAPS) technology and will leverage the sensor developments carried out for the recently upgraded ALICE Inner Tracking System and for the future ALICE ITS3.

An intensive R&D program has already started to meet the challenging detector requirements: the innermost vertex detector layer, placed at 5 mm from the interaction point, must withstand an integrated radiation load of 9×10^{15} 1 MeV neq/cm^2 NIEL and 288 Mrad TID; the tracker will cover more than 50 m^2 of surface, extending to a radius of 0.8 m and a total longitudinal length of about 8 m.

This contribution will discuss the detector requirements and target sensor specifications, the ideas for mechanics and integration, and the main R&D challenges expected for the implementation of

the ALICE 3 tracking system. In addition, the expected performance for novel heavy-flavour studies, ranging from D-Dbar angular and momentum correlations to the reconstruction of multicharm baryons, will be presented.

Track5-UpFut / **139**

The ITS3 detector and physics reach of the LS3 ALICE Upgrade.

Auteurs: ALICE Collaboration[None]; Chunzheng Wang[1]

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During LHC LS3 (2026-28) ALICE is replacing its inner-most three tracking layers by a new detector, "ITS3". It will be based on newly developed wafer-scale monolithic active pixel sensors, which are bent into truly cylindrical layers and held in place by light mechanics made from carbon foam. Unprecedented low values of material budget (0.07% per layer) and closeness to interaction point (19 mm) lead to a factor two improvement in pointing resolutions from very low p_{T} (O(100 MeV/c)), achieving, for example, 20 $\mu\mathrm{m}$ and 15 $\mu\mathrm{m}$ in the transversal and longitudinal directions, respectively, for 1 GeV/c particles.
After a successful R&D phase 2019-2023, which demonstrated the feasibility of this innovational detector, the final sensor and mechanics are being developed right now.

This contribution will shortly review the conceptual design and the main R&D achievements, as well as the current activities and road to completion and installation. It concludes with a projection of the improved physics performance, in particular for heavy-flavour mesons and baryons, as well as for thermal dielectrons, that will come into reach with this new detector installed.

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Constraining the equation of state with heavy quarks in the quasi-particle model of QCD matter

Auteurs: Feng-Lei Liu[1]; Xiang-Yu Wu[1]; Shanshan Cao[2]; Guang-You Qin[1]; Xin-Nian Wang[3]

[1] *Central China Normal University*

[2] *Shandong University*

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In a quasi-particle model of QCD matter at finite temperature with thermal masses for quarks and gluons from hard thermal loops, the equation of state (EOS) can be described by an effective temperature dependence of the strong coupling $g(T)$. Assuming the same effective coupling between the exchanged gluon and thermal partons, the EOS can also be related to parton energy loss.}
Based on the quasi-particle linear Boltzmann transport (QLBT) model coupled to a (3+1)-dimensional viscous hydrodynamic model of the quark-gluon plasma (QGP) evolution and a hybrid fragmentation-coalescence model for heavy quark hadronization, we perform a Bayesian analysis of the experimental data on D meson suppression R_{AA} and anisotropy v_2 at RHIC and the LHC. We achieve a simultaneous constraint on the QGP EOS and the heavy quark transport coefficient, both consistent with the lattice QCD results.

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Multi-strange hadron production in Run 3 pp collisions with ALICE at LHC energies

Auteur: Upasana Sharma[1]

[1] *University of Jammu*

The ratio between (multi-)strange and non-strange hadron yield increases with the charged particle multiplicity, revealing a smooth transition from low multiplicity pp collisions to central Pb–Pb collisions. Enhanced production of strange hadrons in heavy-ion collisions compared to pp collisions, originally proposed as a signature of QGP formation in nuclear
collisions. Recently, similar enhancement has been also observed in high-multiplicity pp collisions. This increase is observed to be more pronounced for hadrons with a larger strangeness content. In this context, precise measurements of multi-strange hadron production using high statistics pp collision events at √s = 900 GeV and √s = 13.6 TeV, collected by the ALICE experiment during the Run 3 data taking of the LHC will be presented.

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Anisotropic flow, flow fluctuation and flow decorrelation in relativistic heavy-ion collisions: the roles of sub-nucleon structure and shear viscosity

Auteurs: Guang-You Qin[1]; Jie Zhu[1]; Xiang-Yu Wu[1]

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We study the transverse momentum (p_T) differential anisotropic flow and flow fluctuation in Pb+Pb collisions at $\sqrt{s_{NN}}$=5.02 TeV at the LHC. A (3+1)-dimensional CLVisc hydrodynamics framework with fluctuating TRENTO (or AMPT) initial conditions is utilized to simulate the space-time evolution of the quark-gluon plasma (QGP) medium. The effects of shear viscosity and the sub-nucleon structure on anisotropic flow and flow fluctuation are analyzed. Our result shows that shear viscosity tends to suppress both flow coefficients ($v_2\{2\}$, $v_2\{4\}$, $\langle v_2\rangle$) and flow fluctuation (σ_{v_2}) due to its smearing effect on local density fluctuation. The flow coefficients appear to be insensitive to the sub-nucleon structure, whereas for flow fluctuation σ_{v_2}, it tends to be suppressed by the sub-nucleon structure in central collisions but enhanced in peripheral collisions. After taking into account the sub-nucleon structure effect, our numerical result can quantitatively describe the relative flow fluctuations ($v_2\{4\}/v_2\{2\}$, $F(v_2)$) measured by the ALICE Collaboration at the LHC. We further investigate the effects of shear viscosity, sub-nucleon structure and initial condition model on the flow angle and flow magnitude decorrelations (A_2^f, M_2^f) using the four-particle correlation method. We find that the flow decorrelation effect is typically stronger in central collisions than in peripheral collisions. The flow angle decorrelation is found to be insensitive to the shear viscosity and sub-nucleon structure, whereas the flow magnitude decorrelation shows quite different behavior when using TRENTO or AMPT initial condition model. Our study sheds light on the anisotropic flow, transport properties and initial structure of the QGP created in high-energy nuclear collisions.

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Charmonia production by coalescence in heavy ion collisions

Auteur: Sungtae Cho[1]

[1] *Kangwon National University*

We study charmonium states, J/ψ, ψ(2S), and χc1(1P) mesons in heavy ion collisions by focusing on their production from the charm and anti-charm quarks in a quark-gluon plasma by coalescence. Starting from the investigation of the difference in their internal structures or different wave functions of charmonium states, we calculate the yield and transverse momentum distributions of charmonium states produced in heavy ion collisions. Then, we also discuss the flow harmonics, or elliptic and triangular flow of charmonium states using the transverse momentum distribution of charmonium states. We find that the internal structure differences, as well as feed-down contributions of charmonium states, are averaged out for elliptic and triangular flow, resulting in similar elliptic and triangular flow for all charmonium states. We investigate further the elliptic and triangular flow of charmonium states at low transverse momentum regions and also discuss the quark number scaling of elliptic and triangular flow for charmonium states in heavy ion collisions.

S. Cho, arXiv:2307.14765

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Spin-1 quarkonia in a rotating frame and their spin contents

Auteur: Hyungjoo Kim[1]

Co-auteurs: Su Houng Lee [2]; Sungtae Cho [3]

[1] *WPI-SKCM2*

[2] *Yonsei University*

[3] *Kangwon University*

We propose a new way of studying the spin content of a hadron by looking at its response in a rotating frame. By collecting all responses of quarks and gluons in a rotating frame, we describe the spin-rotation coupling of spin-1 quarkonia and thereby reveal their spin contents in a fully relativistic way. We demonstrate that both the perturbative and non-perturbative contributions in the operator product expansion follow a universal formula that identifies the spin-rotation coupling with unit strength. This allows us to recognize the total spin-1 of the vector and axialvector quarkonia in terms of the total angular momentum of quarks and gluons. Specifically, we find the spin contents of J/ψ, χc1, Υ(1S), and χb1 are slightly different from the naive quark model picture.

Track4-Bulk&Phase / 145

Bayesian constraints on the high density QCD EoS from Heavy-ion collision data

Auteurs: Manjunath Omana Kuttan[1]; Jan Steinheimer[1]; Kai Zhou[1]; Horst Stoecker[2]

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The Equation of State (EoS) of QCD matter for baryon densities ranging from 2 to 6 times saturation densities (n_0) is explored using a Bayesian framework [1]. A novel method [2] is employed to introduce any density-dependent EoS in UrQMD, allowing inference on a parameterizable EoS within the molecular dynamics part of the transport model. Au- Au collision data from different heavy-ion

collision experiments in the beam energy range of $\sqrt{s_{\rm NN}}$ =2 - 10 GeV are used to construct the posterior distribution for the density dependence of the EoS. The techniques, challenges and solutions involved in the analyses will be outlined.

It is found that the proton observables used in the study tightly constrain the EoS from 2- 4.5 n_0. However the constraints on the EoS beyond 3 n_0 are highly sensitive to the choice of observations. I will also show new results on how the UrQMD+CMF framework allows us to also study the effect of hyperon interaction, with hyperon flow measurements, which is important for the understanding of the role of strange matter in neutron stars. This highlights the need for accurate measurements by experiments in the collision range of $\sqrt{s_{\rm NN}} = 2$ - 10 GeV which can be achieved through the RHIC BES run and in the HADES+CBM @FAIR Experiments.

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Track1-LF / **146**

Measuring the system size dependence of the strangeness production with ALICE

Auteurs: ALICE Collaboration[None]; Roman Nepeivoda[1]

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Measurements of light-flavour particle production in small collision systems at the LHC energies have shown the onset of features (e.g. collective evolution, strangeness enhancement) that resemble what is typically observed in nucleus-nucleus collisions. These features were shown at the LHC to scale with the charged-particle multiplicity independently on the collision system and energy.
New results on the (multi-)strange hadron production in Pb–Pb collisions at $\sqrt{s_{\rm NN}}$ = 5.02 and 5.36 TeV collected in the Run 2 and Run 3 of the LHC will be presented. These results are discussed in the context of recent measurements of light-flavour hadron production in pp collisions at $\sqrt{s}$ = 0.9 and 13.6 TeV collected by the ALICE experiment during Run 3 of the LHC. With the wealth of data collected with the ALICE upgraded detector, it is possible to bridge the gap in multiplicity between small and large systems, improving the measurement precision and exploring the lowest multiplicity region. The ratios between strange and non-strange hadron yields are measured in pp collisions up to charged-particle multiplicity values comparable to those reached in peripheral Pb–Pb collisions, providing insight into the collision system dependence of strangeness enhancement. Multiplicity, energy and system size dependencies are investigated, comparing with predictions from state-of-the-art models.

Track1-LF / **147**

(TbC) Disoriented Isospin Condensates as source of anomalous kaon correlations at LHC

Auteurs: Joseph Kapusta[1]; Scott Pratt[2]; Mayank Singh[3]

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Heavy-ion collision experiments produce the deconfined state of nuclear matter, the quark-gluon plasma (QGP). At QGP temperatures, the vacuum condensate is expected to melt leading to the restoration of the approximate chiral symmetry of QCD. As the plasma expands and cools, the chiral condensates are formed again. So far, concrete experimental evidence of this widely expected phenomena has proved elusive. The ALICE collaboration has reported anomalous correlations between charged and neutral kaons in Pb-Pb collisions at the LHC. We show that the measurements cannot be explained by usual statistical models but can be explained by invoking domains of flat neutral kaon fraction distribution. Such domains can be related to the fluctuations of the up and down quark condensates as the vacuum refreezes.

Track1-LF / 148

Production of Σ baryons as a function of multiplicity in pp collisions at the LHC with ALICE

Auteurs: ALICE Collaboration[None]; Pavel Gordeev[None]

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The strangeness content of the final state in ultrarelativistic heavy ion collisions has been studied through measurements of kaons, Λ, Ξ and Ω baryons in pp, pA and AA collisions. Σ baryons contain a single strange quark and form a triplet, with the charge (+, 0, -) depending on the light quark content. In a thermal model scenario, these states are abundant enough to carry a significant fraction of the strangeness produced in the collision. However, the experimental measurement is challenging, and to date only Σ^0 in 7 TeV pp collisions have been measured by ALICE, while few other experiments have measured the charged states at lower pp(pp) collision energies.
A number of methods to identify charged Σ have been developed by ALICE during the LHC Run 2. The decay $\Sigma^+ \to$ p π^0 can be reconstructed via the direct detection of the proton and the two gammas from the π^0 decay, either through double conversion into e^+e^- pairs or through one converting and the other being reconstructed in the Photon Spectrometer (PHOS). Additionally, a method to detect anti-neutrons in the PHOS has been developed, allowing the $(anti-\Sigma)^\pm \to$ anti-n + $\pi^\pm$ decays to be reconstructed. We present the transverse momentum spectra of Σ^+ and its charge conjugate anti-particle, in both minimum bias and high-multiplicity triggered pp collisions at $\sqrt{s} = 13$ TeV. These are then compared to the latest MC simulations, including different PYTHIA tunings, which best reproduce the existing hyperon data.
With the advent of Run 3, ALICE has improved the capability of the Inner Tracker, allowing the detection of the charged Σ particle with the reconstruction of its decay after traversing several detector layers. The performance of this novel reconstruction method is discussed. In addition, the prospects for measurements of the interaction between Σ and other baryon species will be discussed together with the implications for constraining the neutron star equation of state.

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New studies on strange quark hadronization: multiple (multi-)strange hadron production and connection to the collision's effective energy

Auteur: ALICE Collaboration[None]

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Among the most iconic results of Run 1 and Run 2 of the LHC is the observation of enhanced production of (multi-)strange to non-strange particles, gradually rising from low-multiplicity to high-multiplicity pp or p-Pb collisions and reaching values close to those measured in peripheral Pb-Pb

collisions.
More insightful information about the production mechanism of strange hadrons is provided by the full Probability Density Function (PDF) for the production of each strange particle species. This is a higher order extension in the study of strange particle production and constitutes a completely new test bench for production mechanisms, probing events with a large imbalance between strange and non-strange content. In addition, the study of strangeness production as a function of the effective energy (the energy available after the collision to produce particles at midrapidity) using the ALICE Zero Degree Calorimeters (ZDC) allows to disentangle the connection of strange hadron production to global and local event characteristics. In this contribution, the full PDFs for the production of $\mathrm{K^0_S}$, Λ, $\Xi^{\pm}$, and $\Omega^{\pm}$ in pp collisions at $\sqrt{s} = 5.02$ TeV and their production yield as a function of effective energy at $\sqrt{s} = 13$ TeV using the ALICE detector will be presented. The measurements will be compared with the predictions from the MC event generators such as PYTHIA and EPOS.

Track3-Res&Hyp / 150

Investigating the hidden strangeness content of exotic resonance with ALICE

Auteurs: ALICE Collaboration[None]; Prottay Das[None]

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The investigation of the quark content of hadrons has been a major focus of nonperturbative strong interaction models. The basic quark model describes baryons as composed of three quarks/antiquarks and mesons as a quark-antiquark pair. However, in the last decade, several resonances have been observed in the mass range 900-2000 MeV/c^2 (e.g. f_0(980) and f_1(1285)) that could have exotic quark compositions. Theory predicts it can be a linear composition of two u and d quarks or can have hidden strangeness to form tetra-quark hadrons or hadrons with hybrid structure.
The excellent particle identification capabilities of the ALICE detector along with the large data sample collected in pp and p–Pb collisions provide an opportunity to explore the high mass resonances. This study reports the first measurement of production cross section of f_1 and f_0 resonances in pp and p–Pb collisions at the LHC energies. The measurements of yields will be presented and will be compared to the statistical hadronization model (SHM) to shed light on the hidden strange content of these resonances. In addition to that, a multiplicity dependent study of f_0 resonances will be presented to search for the possible rescattering effect in the hadronic phase of high multiplicity pp and p-Pb collisions.

Track1-LF / 151

Light-flavour particle production as a function of transverse spherocity with ALICE

Auteurs: ALICE Collaboration[None]; Adrian Nassirpour[None]

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Well established measurements of high-multiplicity proton-proton (pp) and proton-lead (p-Pb) collisions at the LHC have revealed that small collision systems show the onset of phenomena typical of heavy-ion collisions. Some of these signatures, such as strangeness enhancement and collective flow, suggest that light-flavor hadron production arises from a set of complex mechanisms whose relative contributions evolve smoothly from low to high multiplicity collisions. This implies that pp collisions cannot be seen as a simple incoherent sum of parton-parton scatterings, an idea that is common to most Monte Carlo event generators, for example, PYTHIA. Moreover, these signatures have historically been attributed to the formation of a strongly interacting medium in heavy-ion collisions. However, a formation of a medium in these smaller collision systems challanges the current theoretical frameworks.
Studies on multi-differential strange particle production in small systems can be utilized to discriminate among the various final state effects at play and represent an important baseline for heavy-ion

studies. This talk presents new results from ALICE on light-flavor particle production as a function of the transverse spherocity ($S_{\mathrm{O}}^{p_{\mathrm{T}}=1}$) in pp collisions measured at $\sqrt{s}$ = 13 TeV. Utilizing narrow selections in multiplcity and $S_{\mathrm{O}}^{p_{\mathrm{T}}=1}$, the observable allows for a topological selection of events that are either "isotropic" (dominated by multiple soft processes) or "jet-like" (dominated by one or few hard scatterings). The experimental results are compared with predictions from various Monte Carlo generators.

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Investigating the coalescence probability for light nuclei production in jets with ALICE

Auteur: ALICE Collaboration[None]

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The production mechanism of (anti)nuclei in ultrarelativistic hadronic collisions is under intense debate in the scientific community. Two successuful models used for the description of the experimental measurements are the statistical hadronisation model and the coalescence approach. In the latter, multi-baryon states are assumed to be formed by coalescence of baryons that are close in phase-space at kinetic freeze-out. Due to the collimated emission of nucleons in jets, the available phase-space is limited, hence the production of nuclear states by coalescence in jets is expected to be enhanced with respect to the production in the underlying event. In this contribution, the results for the coalescence parameter B_2, that quantifies the formation probability of deuterons by coalescence, in and out of jets measured in both pp and p-Pb collisions are presented in comparison with predictions from the coalescence model.

Track1-LF / **153**

Testing CPT symmetry with multistrange baryons mass precision measurements with ALICE

Co-auteur: ALICE Collaboration

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In any relativistic quantum field theory such as Quantum Chromodynamics or Electroweak theory, the interactions are invariant under the combined operation of Charge conjugation (C), Parity transformation (P) and Time reversal (T). One of the consequences of this (CPT) symmetry is that particles and their corresponding antiparticles must have exactly same mass. While the mass difference bewteen proton and antiproton has been measured to very high precision, the extension to (multi-)strange baryons domain still lacks precise measurements.
The ALICE detector is optimized to reconstruct decays of multistrange baryons (Ξ and Ω). The collected data in pp at $\sqrt{s}$ = 13 TeV during the LHC Run 2 (almost two billion events) together with the particle identification capabilities of the ALICE detector allow to measure the mass of the multistrange hyperons and antihyperons with very high precision. In this contribution, the mass differences between Ξ^- and $\overline{\Xi}^+$ and between Ω^- and $\overline{\Omega}^+$ will be presented, sensibly improving the precision obtained by averaging the results from previous experiments.

Track1-LF / **154**

Studying (multi-)strange hadron angular correlation with associated particles and their production with event topology using the

ALICE detector

Auteurs: ALICE Collaboration[None]; CHIARA DE MARTIN[None]; Chiara De Martin[None]

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The angular correlation between (multi-)strange and associated identified hadrons is measured in pp collisions with the ALICE detector to give insight into the particle production mechanisms and balancing of quantum numbers at the microscopic level. These measurements are expected to be sensitive to whether strangeness is produced through string breaking or in a thermal production scenario. The results are compared to predictions from the string-breaking model PYTHIA 8, including tunes with baryon junctions and rope hadronisation enabled, the cluster hadronisation model HERWIG 7, and the core-corona model EPOS-LHC. In addition, the connection of strange hadron production to hard scattering processes and to the underlying event is also studied. For this purpose, the production of strange hadrons is also measured in each event in the direction of the highest-p_{T} particle (trigger particle), related to hard scattering processes, and in the direction transverse to it, associated with the underlying event, in pp collisions.

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ϕ meson production relative to hard scatterings in pp collisions using the ALICE detector

Auteur: ALICE Collaboration[None]

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Studies of the production of the ϕ meson can serve as a crucial probe in understanding the underlying dynamics of strange hadron production. As the ϕ meson is comprised of a pair of strange-antistrange quarks, it puts implicit constraints on modelling the hadronization procedure itself. General purpose perturbative QCD inspired monte-carlo event generators, such as PYTHIA 8, model hadronization through parton showers where strangeness is conserved on a quark-by-quark basis. In the context of ϕ meson, this would necessarily imply the formation of other strange quarks, subsequently producing hadrons close in phase space. In contrast, quark-gluon plasma (QGP)-inspired models, such as EPOS-LHC and EPOS4, model hadronization by statistical/thermal processes through microcanonical ensembles. As the ϕ meson is inherently neutral in strangeness, it is predicted to have similar dynamics to particles with comparable hadronic masses in the framework of such models.
Measuring the ϕ meson yield in association with a hard scattering can be used to test which paradigm best describes the underlying dynamics of ϕ meson production, as well as putting further constraints on models. This contribution will highlight new results from ALICE comparing the ϕ meson production in-and-out of jets from pp collisions at $\sqrt{s}$ = 13.6 TeV.

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In-medium properties of open strange and open heavy flavour mesons in asymmetric nuclear matter: A QMC model study

Auteurs: Arpita Mondal[1]; Amruta Mishra[1]

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One of the important topics in strong interaction physics is the study of in-medium properties of hadrons, which has direct relevance to Heavy Ion Collision experiments. Several experiments, e.g. CERN-SPS, KEK-PS E325, RHIC-PHENIX, etc., have indicated the influence of the generated medium on the properties of the hadrons. In this work, we investigate the in-medium properties of open

strange (K, $\bar{K}$), open charm (D, $\bar{D}$), and open bottom (B, $\bar{B}$) mesons in the asymmetric nuclear matter (ANM) using Quark Meson Coupling (QMC) model. Within this framework, a direct coupling of scalar (σ, δ) and vector (ω, ρ) mesons to the light quarks and anti-quark constituents of the mesons give rise to the medium modification of the properties of these pseudoscalar mesons. We examine the role of the δ (scalar iso-vector) meson which breaks the isospin degeneracy of the masses of the light quark and antiquark doublets and causes mass splitting between (u, d) as well as ($\bar{d}$, $\bar{u}$) and thus we observe the mass splittings within the isodoublets of K, $\bar{K}$, D, $\bar{D}$, B, and $\bar{B}$ mesons when embedded in ANM. Further, we analyze the excitation energies of the pseudoscalar mesons in the asymmetric nuclear matter. In ANM, due to the interaction of the pseudoscalar mesons with the vector iso-vector ρ meson as well as scalar iso-vector δ meson, there is a splitting in the excitation energies of the mesons within the isospin doublets. The isospin effects become more pronounced at higher baryon densities.

This study indicates a less favourable K^--condensation in the matter with a higher neutron fraction compared to the symmetric case. Additionally, it elucidates the in-medium behaviour of the meson potentials, unveiling the likelihood of substantial absorption for certain mesons that experience strong effective attractive potential within the medium. Such absorption may further lead to the formation of bound states with the nuclei. Therefore, the study of open strange as well as open heavy flavour (charm, bottom) mesons could yield significant observable consequences in terms of particle spectroscopy in the upcoming heavy ion collision experiments at the FAIR project at GSI, where the experiments are planned to be performed using neutron-rich beams to study the compressed baryonic matter.

References

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Phys. Rev. C 109, 025201 (2024).

Posters / **157**

Commissioning of the Intermediate Silicon Tracker at sPHENIX experiment

Auteur: Jaein Hwang[1]

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The sPHENIX experiment represents a novel detector system at the Relativistic Heavy Ion Collider at BNL. Its main goal is to advance our understanding of Quark Gluon Plasma and Cold-QCD by studying jet and heavy-flavor observables with a high-precision tracking system.
The sPHENIX tracking system comprises the MVTX, TPC, TPOT, and Intermediate Silicon Tracker (INTT). This poster aims to introduce INTT, a crucial component of the sPHENIX's tracking system, especially for pile-up separation. Since the launch of sPHENIX in May 2023, starting with AuAu collisions, this poster will present significant results obtained from that time onward.

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Proton source measurement in pp collisions at 900 GeV with the femtoscopy technique

Auteur: Neelima Agrawal[1]

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Key aspects in modeling the formation of bound systems such as the deuteron in high-energy collision are the understanding of the strong interaction between nucleons and the characterization of the nucleon-emitting source, which is particularly relevant in models of nucleon coalescence. In this respect, the femtoscopy technique has proven to be a great tool to study both the particle emitting source and the strong interactions in detail.
In this contribution, the femtoscopic method is used to measure proton-proton correlations and to extract the two-particle emission source size in pp collisions at $\sqrt{s}$ = 900 GeV, which is the lowest collision energy at the LHC using data from the Run 3 campaign and the upgraded ALICE detector. Applications of the results as input for the modeling of (anti)deuteron formation by coalescence are discussed.

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Light and strange quark chemical equilibration of the quark-gluon plasma

Auteur: Andrew Gordeev[1]

Co-auteurs: Berndt Mueller [1]; Jean-François Paquet [2]; Pierre Moreau [1]; Steffen Bass [1]

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[2] *Vanderbilt University*

The early stage of a heavy-ion collision is marked by rapid entropy production and the transition from a gluon saturated initial condition to a plasma of quarks and gluons. Even in the early times of the hydrodynamic evolution, the chemical composition of the QCD medium is still largely unknown. Here we study the effects of quark chemical equilibration on the (Q)GP using a novel model of viscous hydrodynamic evolution in partial chemical equilibrium. In this model, we initialize the QCD medium as a completely gluon dominated state, as motivated by the success of gluon saturated initial condition models. Local light and strange quark production during the hydrodynamic phase is simulated through the evolution of time-dependent fugacities for each quark flavor, with the timescales set as free parameters to compare different rates of equilibration. This impacts the system through the equation of state, which we have constructed to depend on the quark flavor content throughout the medium evolution.

In this contribution, we present for the first time the results of complete heavy ion collision simulations using this partial chemical equilibrium model. We find that hadronic and electromagnetic observables are sensitive to the quark equilibration times, and discuss the observed effects. We also examine the impact of quark chemical equilibration on the transport properties of the QGP, and present the framework for a Bayesian model-to-data comparison that will simultaneously constrain the equilibration times and transport coefficients of the QGP.

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Hybrid star are compatible with recent astrophysical observations

Auteur: Anil Kumar[1]

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Compact stars (CS) are stellar remnants of massive stars. Inside CSs the density is so high that matter is in subatomic form composed of nucleons. With the increase in density of matter towards the center of the objects other degrees of freedom like hyperons, heavier non-strange baryons, and meson condensates may appear. Not only that at higher densities, the nucleons may get decomposed into quarks and form deconfined strange quark matter (SQM). If it is so then CSs may contain SQM

in the core surrounded by nucleonic matter forming hybrid stars (HSs). However, the nature and composition of matter inside CSs can only be inferred from the astrophysical observations of these CSs. Recent astrophysical observations in terms of CS mass-radius (M-R) relation and gravitational wave (GW) observation indicate that the matter should be soft in the intermediate density range and stiff enough at the higher density range to attain the maximum possible mass above 2 solar mass which is not compatible with the pure hadronic equation of states (EOSs). Consequently, we study the HS properties with different models of SQM and find that within the vector bag model considering density-dependent bag parameter, the model goes well with the astrophysical observations so far.

Track1-LF / 162

p-ϕ femtoscopic correlation analysis using a dynamical model

Auteur: Kenshi Kuroki[1]

Co-auteur: Tetsufumi Hirano [1]

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Femtoscopic analysis using a two-particle correlation function has attracted significant interest as a method to study hadron interactions. According to the Koonin-Pratt formula [1, 2], the correlation function is interpreted as a convolution of the source function, which reflects the dynamics of the nuclear collisions, and the square of the relative wave function, which reflects the quantum statistical effect and the final state interaction between the pair of interest.

Recently, the ALICE collaboration measured the p-ϕ correlation function [3] in high-multiplicity p+p collisions, revealing a spin-averaged attractive interaction. In Ref. [4], the correlation function was analyzed on a spin channel-by-channel basis using the Gaussian source function. By adopting the lattice QCD potential for the $^4S_{3/2}$ channel [5], the strong attractive potential accommodating a bound state in the $^2S_{1/2}$ channel was extracted from the comparison with the experimental correlation function.

In this study, we analyze the p-ϕ correlation function in high-multiplicity p+p collisions at $\sqrt{s} =$ 13 TeV using the source function from a state-of-the-art hydrodynamics-based model, DCCI2 [6], which can describe the entire process of collision reactions. We find a non-Gaussian long tail in the source function due to hadronic rescattering, leading to deviations in the resulting correlation function compared to that using the Gaussian source function. In addition, we reveal that the correlation function exhibits an intriguing behavior in the small relative momentum regions due to the collectivity of the generated matter. These results emphasize the importance of employing the source function that accurately reflects the collision dynamics for future high-precision studies of hadron interactions via femtoscopy. Finally, from the comparison with the experimental correlation function, we find that the present femtoscopic analysis using the DCCI2 source function also suggests the existence of a p-ϕ bound state in the $^2S_{1/2}$ channel, as in the case using the Gaussian source function.

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Track4-Bulk&Phase / 163

Measurements of Kaon Femtoscopy in Au+Au Collisions at $\sqrt{s_{NN}}$ = 3.0 - 4.5 GeV by the STAR experiment

Auteur: Sooraj Radhakrishnan[1]

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Two-particle correlations are used to extract the space-time and dynamical information of the particle-emitting source created in heavy-ion collisions. The source radii extracted from them characterize the system at the kinetic freeze-out, i.e., the last stage of particle interactions. Kaons can provide a more direct view of the particle-emitting source than pions as they have smaller hadronic cross section and less contribution from long lifetime resonances. It is particularly interesting to study the energy dependence of the extracted kaon source parameters.

In this talk, the measurements of neutral $\mathrm{K_s^0} - \mathrm{K_s^0}$ and charged $\mathrm{K^+} - \mathrm{K^+}$ correlation functions from Au+Au fixed-target collisions at $\sqrt{s_{\mathrm{NN}}}$ = 3.0, 3.2, 3.5, 3.9 and 4.5 GeV, measured by the STAR experiment, will be presented. This is the first such systematic measurement of correlation functions involving strangeness in the high baryon region. These new results will be compared with those from pion femtoscopic measurements and will be discussed with the calculations from hadronic transport model.

Track2-HF&Q / 164

Flavor hierarchy of parton energy loss in quark-gluon plasma from a Bayesian analysis

Auteurs: Guang-You Qin[1]; Shanshan Cao[2]; Wen-Jing Xing[2]

[1] *Central China Normal University*

[2] *Shandong University*

The quenching of light and heavy flavor hadrons in relativistic heavy-ion collisions probes the color and flavor dependences of parton energy loss through a color-deconfined quark-gluon plasma (QGP), and thus offers an important test of QCD-based calculation at extremely high density and temperature. By combining a next-to-leading order perturbative QCD calculation of parton production, a general ansatz of parton energy loss functions and parton fragmentation functions, we calculate the nuclear modification of various hadron species – charged hadrons, D mesons and B-decayed J/ψ – over a wide transverse momentum regime. Comparing our calculations to the experimental data using the Bayesian statistical analysis, we perform a first simultaneous extraction of the energy loss functions of gluons (g), light quarks (q), charm quarks (c) and bottom quarks (b) inside the QGP. We find that the average parton energy loss at high energies follows the expected hierarchy of $\langle \Delta E_g \rangle > \langle \Delta E_q \rangle \sim \langle \Delta E_c \rangle > \langle \Delta E_b \rangle$, while the parton energy loss distribution can further test the QCD calculations of parton interaction with the dense nuclear matter.
We also find that the reduction of experimental uncertainties can significantly improve the precision of the extracted parton energy loss functions inside the QGP.

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Track1-LF / 165

Measurement of Proton-Ξ^- Correlation Function in Isobar Collisions at $\sqrt{s_{\mathrm{NN}}}$ = 200 GeV with the STAR Detector

Auteurs: Boyang Fu[1]; Sooraj Radhakrishnan[2]

[1] *CCNU*

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Femtoscopy is a powerful technique used to investigate the emission source and interaction potential between pairs of particles. The two-particle correlation function, which reveals valuable information about the space-time evolution of the emitting source and final state interaction, is the primary observable of interest. A detailed knowledge of hyperon-nucleon (Y-N) interaction is important for understanding the equation of state of neutron star. In high energy heavy-ion collisions, a large number of particles including hyperons are produced, which offers a great opportunity to study those interactions via femtoscopic measurements.

In this talk, we present the measurements of p-Ξ^- correlations with high statistics in Isobar collisions (Ru+Ru, Zr+Zr) at $\sqrt{s_{\mathrm{NN}}}$ = 200 GeV by the STAR experiment. By employing Lednicky-Lyuboshitz approach, the scattering length (f_0) and effective range (d_0) of proton and Ξ^- interactions are extracted. Results from Au+Au collisions at the same energy will be used for comparison. In addition, these parameters will be compared to those from Lattice QCD calculations.

Posters / **166**

Estimation of the thermodynamic observables from event-by-event fluctuation studies in high-energy experiments

Auteur: Maitreyee Mukherjee[1]

Co-auteur: Vipin Bhatnagar

[1] *Panjab University Chandigarh*

The first estimation of the speed of sound (Cs), specific heat (Cv) and isothermal compressibility (kT) of matter will be presented for a wide range of collision energies from √s_NN = 7.7 GeV to 5.5 TeV. Observables are extracted from the event-by-event multiplicity and temperature fluctuation studies from high energy experiments. Observables will also be estimated from the event generators like UrQMD, EPOS, AMPT and HRG models. The results from the simulations will be compared to published results from the experiments (whichever available). Additionally, an estimation of the thermodynamic observables will be provided for higher energies and future experiments. Possible effects of higher luminosity on the experimental results will be discussed. The formation of the equation of state and universality will also be discussed in this regard. Results will be quite interesting among the theoreticians as well as experimentalists.

Track7-OthTop / **167**

Directed Flow of Λ, ${}^{3}_{\Lambda}\mathrm{H}$, and ${}^{4}_{\Lambda}\mathrm{H}$ in Au+Au collisions at $\sqrt{s_{NN}}$ = 3.2, 3.5, 3.9 and 4.5 GeV at RHIC

Auteurs: Junyi Han[None]; Sooraj Radhakrishnan[1]

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Studying hyper-nuclei production and their collectivity can shed light on their production mechanism as well as the hyperon-nucleon interactions. Heavy-ion collisions from the RHIC beam energy scan phase II (BES-II) provide an unique opportunity to understand these at high baryon densities.

In this presentation, we will show a systematic study on energy dependence of the directed flow for Λ and hyper-nuclei ($^{3}_{\Lambda}$H, $^{4}_{\Lambda}$H) from mid-central Au+Au collisions at $\sqrt{s_{NN}}$ = 3.2, 3.5, 3.9 and 4.5 GeV, collected by the STAR experiment with the fixed-target mode during BES-II. The rapidity (y) dependence of the hyper-nuclei v_1 is studied in mid-central collisions. The extracted v_1 slopes ($dv_1/dy|_{y=0}$) of the hyper-nuclei are positive and decrease gradually as the collision energy increases. These hyper-nuclei results will be compared to that of light-nuclei including p, d, t/$^{3}\mathrm{He}$ and $^{4}\mathrm{He}$. Finally, discussions will be made using comparison to hadronic transport model including coalescence after-burner calculations.

Track4-Bulk&Phase / **168**

Measurement of charge-dependent directed flow in STAR Beam Energy Scan (BES-II) Au+Au and U+U Collisions

Auteurs: Muhammad Farhan Taseer[None]; Sooraj Radhakrishnan[1]

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An ultra-strong magnetic field (B ≈ 10^{18} Gauss) is anticipated during the early stages of heavy ion collisions. Such a strong magnetic field holds significant importance in QCD, including understanding topology of QCD vacuum, QCD phase transition, and nucleon structure. The directed flow or the first harmonic flow coefficient (v_1), serves as a powerful tool not only for detecting the magnetic field but also for understanding its effects in the Quark-Gluon Plasma (QGP) medium (such as electrical conductivity). Additionally, v_1 can capture information from the initial geometry of the system and also offer means to understand baryon transport. Recently, the STAR collaboration reported a substantial splitting of directed flow between positively and negatively charged identified particles in peripheral Au+Au and isobar (Ru+Ru and Zr+Zr) collisions. These results are consistent with the dominance of Faraday induction and Coulomb effect from the initial strong magnetic field 1.

In this presentation, we shall discuss the rapidity dependence of v_1 and dv_1/dy for $\pi^{\pm}$, $K^{\pm}$ and p ($\bar{p}$) in Au+Au collisions at 7.7, 11.5, 14.6, and 19.6 GeV from Beam Energy Scan Phase-II, as well as in U+U collisions at 193 GeV measured by the STAR experiment. The v_1 values will be reported as a function of transverse momentum, rapidity, and centrality. Additionally, the dv_1/dy and the charge dependent difference, $\Delta dv_1/dy$, of identified particles in U+U collisions will be compared to those in Au+Au and isobar (Ru+Ru and Zr+Zr) collisions. These findings will offer further insights into the initial electromagnetic field as well as baryon transport at various system sizes and beam energies.

1. STAR Collaboration, arXiv: 2304.03430

Track4-Bulk&Phase / **169**

Measurement of global and local spin polarization of Λ and $\bar{\Lambda}$ in Au+Au collisions from the RHIC Beam Energy Scan

Auteurs: Qiang Hu[None]; Sooraj Radhakrishnan[1]

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A significant global spin polarization of Λ hyperons in the first phase of RHIC Beam Energy Scan (BES-I) provided evidence of vorticity of the QGP created in heavy-ion collisions. The data also hint at a larger polarization of $\bar{\Lambda}$ than that of Λ, which can be produced by a strong late-stage magnetic field sustained by the medium. A decisive experimental test of this splitting is highly significant, as it could reveal valuable information about the electric conductivity of the QGP 1. On the other hand, the local polarization of Λ and $\bar{\Lambda}$ hyperons are predicted to be different due to the polarization induced by the gradient of baryonic chemical potential (analogous to the electric field) and called baryonic spin Hall effect. This effect is expected to be observable through the energy dependence of the angular modulation of the net polarization [2], $P^{net}_{y,z} = P^{\Lambda}_{y,z} - P^{\bar{\Lambda}}_{y,z}$, as measured by $P^{net}_{z} sin\left(2\phi_{\Lambda} - 2\Psi_2\right)$ and $-P^{net}_{y} cos\left(2\phi_{\Lambda} - 2\Psi_2\right)$, where Ψ_2 is the second-order event-plane.

We present results of Λ global polarization as a function of centrality, transverse momentum, and rapidity in Au+Au collisions at $\sqrt{s_{NN}}$=7.7, 11.5 and 14.6 GeV from second phase of the RHIC Beam Energy Scan (BES-II) with the upgraded STAR detectors. We also present local polarization measurements in Au+Au collisions at $\sqrt{s_{NN}}$ = 7.7 - 27 GeV from BES-II. Our measurements can provide important insights into the late-stage magnetic field sustained by the QGP, as well as spin Hall currents possibly created in a highly dense baryonic environment.

1L. McLerran, V. Skokov, Nucl. Phys. A 922, 184 (2014).
[2]B. Fu et al, arXiv: 2201.12970 (2022).

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Measurements of first-order event plane correlated directed and triangular flow from fixed- target energies at RHIC-STAR

Auteur: Sooraj Radhakrishnan[1]

[1] *Kent State University/Lawrence Berkeley National Laboratory*

Anisotropic flow parameters (v_n) are important observables as they provide insight into the colle-cIve expansion and transport properIes of the medium produced in relaIvisIc heavy-ion collisions. Among these parameters, directed flow (v_1) describes the collecIve sideward motion of produced parIcles in heavy-ion collisions. It is an important probe to study the in-medium dynamics as it is sensiIve to the equaIon of state (EoS) of the produced medium. Minimum in the slope of directed flow (dv_1/dy) as a funcIon of collision energy has been proposed as a signature of the first-order phase transiIon between hadronic maPer and Quark-Gluon Plasma (QGP). Triangular flow (v_3) typically arises from the iniIal state fluctuaIons and is expected to be uncorrelated with the reacIon plane. However recent measurements at lower collision energies show a correlaIon between v_3 and the first- order event plane angle (Ψ_1).

In this presentaIon, we will report the measurements of Ψ_1 correlated v_1 and v_3 for π, K, p, net-kaon, net-proton, d, and t in Au+Au collisions at $\sqrt{s_{NN}}$ = 3.2, 3.5, 3.9, and 4.5 GeV taken in fixed-target mode from the second phase of the beam energy scan (BES-II) program at RHIC-STAR. We will show the dependencies of v_1 and v_3 on rapidity, centrality, and collision energy, and subsequently, discuss their physics implicaIons. The experimental measurements will be compared with the results from the JAM transport model to understand the underlying physics mechanisms at low collision energies.

Track4-Bulk&Phase / 171

Exploring the QCD phase diagram with collective flow at STAR

Auteurs: Shusu Shi[None]; Shusu Shi[1]; Sooraj Radhakrishnan[2]

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Directed and elliptic flow (v_1, v_2) are sensitive to the dynamics of heavy-ion collisions and the equation of state (EoS) of the medium. The v_1 slope with rapidity (dv_1/dy) at mid-rapidity of net-baryons is expected to be sensitive to the first-order phase transition. Studying the flow harmonics for various identified particles at different collision energies provides insights into the medium going through QCD phase transition. In particular, (multi-) strange hadrons with small hadronic cross-sections are cleaner probes of the early stages of heavy-ion collisions. A comprehensive study of light and (multi-) strange hadrons provides valuable insights into the subsequent stages of the medium evolution.

In this talk, the measurements of v_1 and v_2 for both light and (multi-) strange hadrons at $\sqrt{s_{NN}}$ = 3.0 - 19.6 GeV, with the enhanced capabilities of the STAR detector and increased statistics from the second phase of the RHIC beam energy scan (BES-II) program, will be presented. The centrality dependence of anisotropic flow and the test of number of constituent quark (NCQ) scaling will be shown. Also, the energy and centrality dependence of v_1 slope and p_T-integrated v_2 will be presented. The data will be compared with different model calculations, and the inferences on the QCD phase structure and EoS of nuclear matter in the high baryon density region will be discussed.

Track4-Bulk&Phase / **172**

Spin polarization of fermions at local equilibrium: second order gradient expansion

Auteurs: Xin-Li Sheng[1]; Francesco Becattini[2]; Zhong-Hua Zhang[3]; Xu-Guang Huang[3]

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Relativistic heavy-ion collisions provide a unique oppotunity to study spin polarization of fermions. In the past decade, a lot of progress has been made regarding to the spin polarization of Λ hyperon, both at experimental and theoretical level. Polarizations induced by first order gradient quantities, such as the thermal vorticity tensor, have been widely discussed and successfully explained the Λ's global polarization. However, the Λ's polarization along the beam direction still remains a puzzle, which is known as the "spin sign puzzle" in heavy-ion collisions. In this work, we focus on fermions at local equilibrium in a relativistic fluid. We derive, for the first time, the spin polarization induced by second order derivatives of the four-temperature vector. As a consequence, gradients of the thermal vorticity and the thermal shear tensor also have sizable contributions to the polarization, which may provide a solution of the spin sign puzzle.

Track3-Res&Hyp / **173**

Investigating the system size dependence of hypernuclei production with A < 5 using the ALICE detector

Auteurs: ALICE Collaboration[None]; Yuanzhe Wang[None]

Auteurs correspondants: alice-cc-chairs@cern.ch, yuanzhe.wang@cern.ch

The production of (anti)hypernuclei is among the most promising probes for studying the production mechanism of light nuclei in high-energy hadronic collisions. According to coalescence, the production of ^{3}H, ^{4}H, and ^{4}He in small colliding systems (pp and p-Pb) is extremely sensitive to their internal wave function, while in the Statistical Hadronisation Models (SHMs) the nuclear structure does not enter explicitly in the prediction of the yields.
In this contribution, the production measurements of ^{3}H, ^{4}H, and ^{4}He from pp to the most central Pb–Pb collisions are presented. The results are based on the data samples collected by ALICE during the LHC Run 2 and Run 3. For the ^{3}H, in addition, an innovative method to extract its properties starting from the system size dependency of its production yield will also be presented.

Track3-Res&Hyp / 174

Hypernuclei and Ξ^- measurements in Ag+Ag Collisions at $\sqrt{S_{NN}}$ = 2.55 GeV with HADES

Auteur: Simon Spies[1]

[1] *Goethe-University Frankfurt*

In the scope of the FAIR Phase-0 physics program, the HADES collaboration recorded 13.7 billion Ag(1.58A GeV)+Ag events. With an available energy of 2.55 GeV in binary nucleon nucleon collisions, the lightest hadrons containing strangeness are produced at their free nucleon nucleon threshold energy. Therefore, they are ideal probes to investigate medium effects due to their steep excitation function.

In this contribution, we present preliminary results on the production and lifetime measurements of $^{3}_{\Lambda}$H and $^{4}_{\Lambda}$H hypernuclei which are reconstructed via their weak two-body decay channels $^{3}_{\Lambda}$H -> ^{3}He + π^- and $^{4}_{\Lambda}$H -> ^{4}He + π^-. The separation of signals from the combinatorial background is based on the observed weak decay topologies evaluated with the help of an artificial neural network (ANN). For both hypernuclei a lifetime measurement with sophisticated systematic uncertainty estimations is performed to contribute to the world data of hypernuclei lifetimes. Furthermore, we present measurements of multi-strange hyperons which are produced far below their free nucleon nucleon threshold energy and reconstructed using similar analysis techniques. All presented results are discussed with respect to the available world data.

Track7-OthTop / 175

Thermal radiation via dielectrons with ALICE

Auteurs: ALICE Collaboration[None]; Jerome Jung[None]

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Electromagnetic probes such as photons and dielectrons (e^+e^- pairs) are a unique tool to study the space-time evolution of the hot and dense matter created in ultra-relativistic heavy-ion collisions. They are produced at all stages of the collision with negligible final-state interactions. At intermediate dielectron invariant mass ($m_{\rm ee} > 1$ GeV/c), thermal radiation from the quark-gluon plasma carries information about the early temperature of the medium. At LHC energies, it is however dominated by a large background from correlated semileptonic heavy-flavor hadron decays. At smaller $m_{\rm ee}$, thermal radiation from the hot hadronic phase contributes to the dielectron spectrum via decays of ρ mesons, whose spectral function is sensitive to chiral-symmetry restoration. Finally, at vanishing $m_{\rm ee}$, the real direct photon fraction can be extracted from the dielectron data. In pp collisions, such measurement in minimum bias events serves as a baseline for heavy-ion studies and

a fundamental test for perturbative QCD calculations, while studies in high charged-particle multiplicity events allow one to search for thermal radiation in small colliding systems.
In this talk, final ALICE results using the full data sample collected during the LHC Run 2 will be presented. They include measurements of the dielectron and direct-photon production in central Pb-Pb at the center-of-mass energy per nucleon pairs $\sqrt{s_{\mathrm{NN}}}$ of 5.02 TeV, as well as of direct photons in minimum bias and high-multiplicity pp collisions at 13 TeV. Finally, first results with the Run 3 pp data at 13.6 TeV, using the upgraded ALICE detector to disentangle the different dielectron sources, will be reported.

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Direct photon production and correlation at low p_{T} in Pb-Pb collisions with ALICE

Auteur: ALICE Collaboration[None]

Auteur correspondant alice-cc-chairs@cern.ch

Measurements of direct photons can provide valuable information on the properties and dynamics of the quark-gluon plasma (QGP) by comparing them to model calculations that describe the whole evolution of the system created in heavy-ion collisions, from the initial conditions to the pre-equilibrium, QGP, and hadronic phases. In the ALICE experiment, photons can be reconstructed via conversion photons using the excellent tracking capabilities, and via direct measurements in the two different types of calorimeters. Combining these different methods we can measure the direct-photon production from very low transverse momentum of 0.4 GeV/c, where thermal direct photons are expected to be dominant, up to high transverse momenta, where prompt direct photons take over. Additional studies with Hanbury Brown and Twiss (HBT) correlation measurements allow us to constrain the space-time dimensions of the emitting source.
In this talk, we will present measurements in selected centrality classes of the direct-photon production in Pb-Pb collisions at $\sqrt{s_{\mathrm{NN}}}$ = 2.76 and 5.02 TeV, as well as results on direct-photon HBT. The ALICE upgrades will allow us to improve the precision of the direct-photon measurements using the Run 3 data and beyond.

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Feasibility study for the K_1 measurement in pp collisions with ALICE

Auteur: Su-Jeong Ji[1]

[1] *Pusan National University (KR)*

Measuring chiral partners, such as K_1 and K^* mesons, whose vacuum widths are less than 100 MeV, is suitable for investigating chiral symmetry restoration in heavy-ion collisions.
According to a recent theoretical calculation, the $\mathrm{K}_1/\mathrm{K}^*$ ratio in heavy-ion collisions is predicted to be substantially larger than the value obtained using the statistical hadronisation model.
By exploring the $\mathrm{K}_1/\mathrm{K}^*$ ratio as a function of multiplicity across different collision systems, ranging from pp to central heavy-ion collisions, valuable insights into the effects of chiral symmetry restoration can be obtained.
However, K_1 meson has not been measured in hadron-hadron collisions yet.

The ALICE detector has remarkable particle identification capabilities, thereby enabling the measurement of the K_1 meson through its hadronic decay channels like $\mathrm{K}_1^- \rightarrow \rho^0\mathrm{K}^-$ and $\mathrm{K}_1^- \rightarrow \pi^-\mathrm{K}^{*0}$.
In this poster, the feasibility study of the K_1 measurement in pp collisions with ALICE is presented.

Track1-LF / 178

Measurement of charged and neutral kaons in Ar+Sc collisions at NA61/SHINE experiment

Auteur: Tatjana Šuša[1]

[1] *Ruđer Bošković Institute*

NA61/SHINE is a large-acceptance fixed-target experiment located at the CERN SPS. The main physics goals of the NA61/SHINE ion program are the study of the properties of the onset of deconfinement and the search for signatures of the critical point of strongly interacting matter. These goals are pursued by performing an energy (beam momentum $13A$-$158A$ GeV/c) and system size (p+p, p+Pb, Be+Be, Ar+Sc, Xe+La, Pb+Pb) scan. In addition, the experiment performs dedicated hadron production measurements relevant to neutrino and cosmic ray physics.

The experiment has recently reported an unexpected excess of charged over neutral K meson production in central Ar+Sc collisions at 11.9 GeV center-of-mass energy per nucleon pair, which amounts to (23.3 ± 5.5)% at mid-rapidity. In this contribution, rapidity and transverse mass spectra and total multiplicity of K^+, K^-, and K^0_S mesons, as well as charged over neutral K meson production ratio in Ar+Sc collisions will be presented. The obtained results will be compared to the charge and neutral kaon production in different colliding systems measured by the NA61/SHINE experiment, model predictions, and measurements performed by the other experiments.

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K^*/K ratio and the time between freeze-outs for intermediate-mass Ar+Sc system at the SPS energy range

Auteur: Bartosz Kozlowski[1]

[1] *Warsaw University of Technology*

Auteur correspondant bartosz.kozlowski@cern.ch

NA61/SHINE is a multipurpose, fixed-target experiment located at the CERN Super Proton Synchrotron (SPS). The main goal of its strong interaction program is to study the properties of the onset of deconfinement and search for the critical point.

Resonance production is one of the key observables to study the dynamics of high-energy collisions. In dense systems created in heavy nucleus-nucleus collisions, the properties of some of them (widths, masses, branching ratios) were predicted to be modified due to partial restoration of chiral symmetry. The resonance spectra and yields are also important inputs for Blast-Wave and Hadron Resonance Gas models. Finally, the analysis of strange $K^*(892)^0$ resonance allows to better understand the time evolution of high-energy nucleus-nucleus collision. Namely, the ratio of $K^*(892)^0$ to charged kaons is used to determine the time between chemical and kinetic freeze-outs.

In this talk, the first results of the analysis of $K^*(892)^0$ production in central Ar+Sc collisions at three SPS energies ($\sqrt{s_{NN}}$ = 8.8, 11.9, 16.8 GeV) will be presented. The $K^*(892)^0/K^{+/-}$ yield ratios will be compared with corresponding results in p+p collisions, allowing to estimate the time between kinetic and thermal freezouts for Ar+Sc collisions. These first results for intermediate-mass nucleus-nucleus systems at the SPS energy range will be compared with the results of heavier systems at a similar energy range.

Track2-HF&Q / 180

First $D^0+\overline{D^0}$ measurement in heavy-ion collisions at SPS energies with NA61/SHINE

Auteur: Anastasia Merzlaya[1]

[1] *Universitetet i Oslo*

The measurement of open charm meson production provides a tool for the investigation of the properties of the hot and dense matter created in nucleus-nucleus collisions at relativistic energies. In particular, charm mesons are of vivid interest in the context of the study of the nature of the phase-transition between confined hadronic matter and the quark-gluon plasma. Recently, the experimental setup of the NA61/SHINE experiment was upgraded with the high spatial resolution Vertex Detector which enables the reconstruction of secondary vertices from open charm meson decays.

In this presentation the first D^0 meson yields at the SPS energy regime will be shown. The analysis used the most central 20% of Xe+La collisions at 150A GeV/c from the data set collected in 2017. This allowed the estimation of the corrected yields (dN/dy) for $D^0+\overline{D^0}$ via its $\pi^{+/-}+K^{-/+}$ decay channel at mid-rapidity in the center-of-mass system. The results will be compared and discussed in the context of several model calculations including statistical and dynamical approaches.

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Exploring Upsilon Production Mechanisms using PYTHIA Simulation in Proton-Proton Collision

Auteurs: Olena Mezhenska[1]; Jaroslav Bielcik[2]; Leszek Kosarzewski[3]; Jakub Ceska[2]

[1] *Czech technical university in Prague*

[2] *Czech Technical University in Prague, FNSPE*

[3] *Ohio State University*

Due to Debye-like color screening of quarkonium binding potential, quarkonium suppression has been proposed as an important signature of quark-gluon plasma, produced in central heavy ion collisions. However the quarkonium production mechanism is still an unresolved question. The production can happen through hard scattering and an intermediate Color Singlet or Color Octet states, which various production models attempt to describe.

We propose to investigate the production mechanisms of Υ mesons by analyzing Υ-hadron azimuthal correlations at different pseudorapidity ranges. Through this analysis of azimuthal correlations between Υ mesons and hadrons in PYTHIA-simulated pp collisions, our aim is to gain insights into the dynamics governing the formation and evolution of Υ states. This approach allows us to further test the quarkonia production models as well as Upsilon behavior in overall p+p collision at the beam energies of 500 MeV and 14 TeV, which include Multi Parton Interaction (MPI) effects.

This study serves as proof of principle in order to perform such analysis in the STAR experiment at the Relativistic Heavy Ion Collider in BNL

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The high temperature QCD static potential beyond leading order

Auteur: Margaret Carrington[1]

[1] *Brandon University, Manitoba Canada*

The dominant interaction between a heavy quark and antiquark at low energy is described through the static potential. The real part of the potential becomes screened with a screening mass proportional to the temperature, and the imaginary part of the potential gives bound-states a non-zero width. As the temperature increases bound-states can disappear either because they are no longer supported by the screened potential, or because they become wide resonances. We calculate next-to-leading order corrections to the static potential using finite temperature perturbation theory and study their effect on the dissociation temperature of heavy quarkonia. We also study the effect of anisotropy on bound-state energies.

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Study of multiplicity-dependent ρ0(770) production in pp collisions with ALICE

Auteur: Hyunji Lim[1]

[1] *Pusan National University*

Short-lived resonances are ideal probes to study the properties of the hadron gas phase created in heavy-ion collisions in the post-hadronization phase. Since the resonance lifetime is comparable to that of the hadron gas phase, their yields are affected by the competing rescattering and regeneration effects. These can be studied experimentally by measuring the yield ratios of resonances to the corresponding long-lived hadrons as a function of the charged-particle multiplicity, which is a proxy of the system volume. In this context, the $\rho^0(770)$ resonance is particularly interesting due to its very short lifetime of about 1.3 fm/c. The measurement of the $\rho^0(770)$ production yield in low-multiplicity collisions, corresponding to a very short duration of the hadron gas phase, serves as a fundamental reference for measurements in heavy-ion collisions.

In this poster, recent measurements of the $\rho(770)^0$ production in pp collisions with the ALICE detector as a function of multiplicity are presented. The results are discussed together with existing measurements in other collision systems in the context of the state-of-the-art phenomenological models used to describe particle production at LHC energy.

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Genetic Algorithm-Based Optimization of Strangeness Production

Auteurs: Carl Rosenkvist[1]; Hannah Elfner[2]

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[2] *GSI/GU Frankfurt*

In heavy-ion collisions, strange particles are not present before the collision, as they are absent in normal matter. Consequently, strange particles must be produced during or shortly after the collision. Therefore, the production of strange quarks serves as an important probe for the underlying physics of heavy-ion collisions.

In this project, we will investigate strangeness production with the SMASH (Simulating Many Accelerated Strongly-interacting Hadrons) model. At lower collision energies, SMASH incorporates short-lived particles, termed resonances, to describe the production of strange quarks through resonance decay.

The properties of resonance particles are constrained by experimental measurements with unfortunately large uncertainties. Consequently, simulating low-energy observables with SMASH, which are sensitive to strangeness production, inherits these uncertainties.

To address this challenge, we implement a genetic algorithm to simultaneously fit numerous resonance parameters to experimental data, which comprise exclusive elementary cross-sections.

With the best set of resonance parameters, we will investigate pion-nucleus collisions as the second most complicated system before moving on to heavy ions.

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The spin interference effects with photoproduced ρ^0 and J/ψ in Ultra Peripheral Collisions at STAR

Auteur: Barbara Antonina Trzeciak[1]

[1] *Czech Technical University in Prague*

In ultra-peripheral heavy-ion collisions (UPCs), vector meson photoproduction, e.g., ρ^0 and J/ψ, has been considered one of the most sensitive probes for studying the gluonic structure in heavy nuclei. The linear polarization of the photons involved in these processes can help to image the nucleus through the so-called spin interference effect in vector meson photoproduction. Many efforts have been made to study this interference effect in RHIC and LHC experiments. Recently, STAR at RHIC discovered the spin interference effect from the ρ^0 vector meson photoproduction in Au+Au and U+U UPCs. However, the possibility that the interference can happen at the level of vector mesons cannot be falsified using ρ^0 data due to its shorter lifetime. The J/ψ vector mesons, having much longer lifetime and non-localized wave function, bring new insight into these.

In this talk, we will report measurements of the differential cross sections of photoproduced ρ^0 and J/ψ in Au+Au UPCs at $\sqrt{s_{\mathrm{NN}}} = 200$ GeV recorded by STAR. The results will be presented for different combinations of neutron emissions. These data provide important constraints for nuclear parton distribution functions and sub-nucleonic shape fluctuations in heavy nuclei. We also present the latest measurements of angular modulation arising from the spin interference effect for the coherent ρ^0 and J/ψ photoproduction. We observe a large $\cos(2\Delta\phi)$ modulation in the angular separation between the vector mesons and one of its decay daughters, predicted to be a signature of the spin interference effect. Finally, we will discuss the future prospects during the final RHIC runs in 2023-2025.

Track3-Res&Hyp / 186

Measurements of ${}^4_\Lambda$H and ${}^4_\Lambda$He production in $\sqrt{s_{\mathrm{NN}}}$ = 3.0 - 3.9 GeV Au+Au collisions from STAR

Auteurs: Barbara Antonina Trzeciak[1]; Chenlu Hu[None]

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Hypernuclei, which are bound states of nuclei with at least one hyperon, serve as excellent experimental probes for studying the hyperon-nucleon (Y-N) interaction.
The A=4 mirror hypernuclei (${}^4_\Lambda$H(0^+) and ${}^4_\Lambda$He(0^+)) is substantially tighter bound compared to the hypertriton (${}^3_\Lambda$H). The existence of the spin-1 excited states (${}^4_\Lambda$H*(1^+) and ${}^4_\Lambda$He*(1^+)) may also enhance the measured yields through feed-down. As such, their yields allow us to gain insight on

the effects of hypernuclear binding, spin and isospin content on their production in heavy-ion collisions.

In this talk, we will present the first measurements of A=4 hypernuclei (${}^{4}_{\Lambda}$H and ${}^{4}_{\Lambda}$He) production from the RHIC-STAR experiment utilizing the fixed target datasets.
The transverse momentum p_{T} spectra and yields dN/dy as a function of rapidity will be shown from $\sqrt{s_{\mathrm{NN}}}$ = 3.0, 3.2, 3.5 and 3.9 GeV Au+Au collisions.
The dN/dy and $< p_{\mathrm{T}} >$ of ${}^{4}_{\Lambda}$H and ${}^{4}_{\Lambda}$He will be compared between the aforementioned energies to investigate their energy dependencies. The rapidity and energy dependencies of the ratio of ${}^{4}_{\Lambda}$H to ${}^{4}_{\Lambda}$He will also be shown to investigate the isospin dependence.
Furthermore, calculations from thermal model and transport model (JAM) plus coalescence afterburner will be compared to these results and the relevant physics implications will be discussed.

Track3-Res&Hyp / 187

Multiplicity dependence of Hyperon and Hypertriton Production in Zr+Zr and Ru+Ru collisions at $\sqrt{s_{\mathrm{NN}}} = 200\,\mathrm{GeV}$

Auteurs: Barbara Antonina Trzeciak[1]; Dongsheng Li[None]

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In heavy-ion collisions, the production mechanism of hypernuclei, bound states of hyperons and nucleons, is still not fully understood. Recent theoretical model calculations show that a systematic measurement of the multiplicity dependence of yield ratios, such as ${}^{3}_{\Lambda}\mathrm{H}/\Lambda$ and $\mathrm{S}_3 = ({}^{3}_{\Lambda}\mathrm{H}/{}^{3}\mathrm{He})/(\Lambda/\mathrm{p})$, can provide strong distinguishing power between different production mechanisms and offer insights into the possible connection between hypernuclei production yields and their internal structure. In 2018, STAR recorded a huge sample of about 4 billion minimum bias events from Zr+Zr and Ru+Ru collisions at $\sqrt{s_{\mathrm{NN}}}$ = 200 GeV, enabling a detailed investigation of the multiplicity dependence of hyperon and hypertriton production.

In this presentation, we present new measurements on hyperons ($\Lambda, \bar{\Lambda}$ and $\Xi^-, \bar{\Xi}^+$) and hypertriton, including their transverse momentum (p_{T}) spectra and p_{T}-integrated yields ($\mathrm{d}N/\mathrm{d}y$), in four different centrality classes of Zr+Zr and Ru+Ru collisions at $\sqrt{s_{\mathrm{NN}}}$ = 200 GeV. The hyperon yields will be compared to those in Au+Au collisions to study the system size dependence of strangeness production. The yield ratios of ${}^{3}_{\Lambda}\mathrm{H}/\Lambda$ and S_3 will be shown as a function of multiplicity and compared with model calculations. Physics implications on hypernuclei production mechanism as well as Y-N interaction will be discussed.

Track1-LF / 188

Strange Hadron Production at High Baryon Density

Auteurs: Barbara Antonina Trzeciak[1]; Hongcan Li[None]

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Strange hadrons have been suggested as sensitive probes for the medium properties of the nuclear matter created in heavy-ion collisions. At few-GeV collision energies, the formed medium is dense and baryon-rich due to the baryon stopping. Since strange hadrons are produced near or below

the threshold, their yields, especially the excitation function of multi-strange (anti-)hyperons, may provide strong constraints on the equation-of-state (EoS) of high baryon density matter.

In this presentation, recent results on strange hadron production in Au + Au collisions at $\sqrt{s_{\mathrm{NN}}}$ = 3.0, 3.2, 3.5, 3.9 and 4.5 GeV with the fixed-target mode from the STAR experiment will be presented. These results include the transverse mass spectra, rapidity density distributions, particle ratios, and their centrality dependence of strange hadrons ($K^{\pm}$, K^0_S, ϕ, Λ, Ξ^-). These results will be compared with those from higher collision energies and physics implication will be discussed by comparing to the thermal and transport model calculations.

Track6-SmallSyst / 189

Multiplicity Dependent Study of (Multi-)strange Hadrons in d+Au collisions using the STAR detector

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Strangeness enhancement has long been considered a signature of the quark-gluon plasma formation in heavy-ion collisions. Strangeness enhancement has also been observed in small systems at the LHC, but the underlying physics is not yet fully understood. This motivates studies of strange hadron production in small systems at RHIC, where the energy density of system is expected to be smaller than that at the LHC and therefore a hot and deconfined medium is less likely to be created. Investigating the multiplicity dependence of strange hadron production in small systems can naturally connect to peripheral heavy-ion collisions, and contribute to understanding the role of event multiplicity in strange hadron production. Study of rapidity asymmetry and nuclear modifiaction factors in d+Au collisions can also give insight on cold nuclear matter effects.

In this talk, we will present new measurements of (multi-)strange hadrons (K^0_S, Λ, Ξ and Ω) in d+Au collisions at $\sqrt{s_{\mathrm{NN}}}$ = 200 GeV, collected by STAR in 2016. We will analyze the multiplicity dependence of strange hadron transverse momentum (p_{T}) spectra, p_{T}-integrated yields dN/dy, average transverse momentum ($\langle p_{\mathrm{T}} \rangle$), and yield ratios to pions. We will also present nuclear modification factors and rapidity asymmetry for these particles. We will discuss implications of our measurements on the possible formation of a hot and deconfined medium and the origin of strangeness enhancement in small systems.

Track7-OthTop / 190

Searching for the baryon number carrier with heavy-ion collisions at the STAR experiment

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Baryon number is a strictly conserved quantum number, which holds the universe as we know it today. In the quark model, each quark is assigned one third of the baryon number. However, string junctions, non-perturbative Y-shaped topology of gluon fields connected to three quarks, are expected to emerge in dynamical processes and have been proposed as an alternative carrier of the baryon number. Neither of these scenarios have been verified experimentally though. In this

contribution, three independent measurements, utilizing heavy-ion collisions recorded by the STAR experiment at RHIC, will be presented, in search for the baryon number carrier. Firstly, the charge and baryon number transport over a large rapidity gap are measured in Ru+Ru and Zr+Zr collisions at $\sqrt{s_{\rm NN}}$ = 200 GeV. The results show significantly more baryon transport than charge transport from beam to midrapidity. The second measurement selects γ+Au collisions from Au+Au collisions at $\sqrt{s_{\rm NN}}$ = 54 GeV. The slope of the baryon number transport distribution against rapidity in γ+Au collisions is found to be smaller than those predicted by PYTHIA and HERWIG event generators, which assign baryon number to valence quarks. Thirdly, the slope measurement is extended to hadronic Au+Au collisions with collision energies ranging between 7.7 and 200 GeV. The rapidity slope of the baryon number transport is found to be independent of centrality and also smaller than event generators. All three measurements are incompatible with the scenario of valence quarks carrying the baryon number.

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Measurements of $K^{*0,\pm}$ mesons in Au+Au (BES-II) and Ru(Zr)+Ru(Zr) collisions at RHIC

Auteur: Barbara Antonina Trzeciak[1]

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The comparison between the production of short-lived resonances (e.g., K^*) to non-resonances (e.g., K) is commonly employed to understand the role of re-scattering and regeneration processes that occur during the late stages of hadronic interactions. Additionally, the neutral (K^{*0} $(d\bar{s})$) and charged (K^{*+} $(u\bar{s})$) vector mesons share similar mass and isospin, but the magnetic moments of their constituent quarks differ by approximately a factor of five. This distinction makes them a unique probe for studying medium effects and particle production.

In this talk, we will present the mass, width, transverse momentum (p_T) spectra, yield (dN/dy), and $\langle p_T \rangle$ of $K^{*0,\pm}$ mesons, utilizing data from the 2^{nd} phase of the RHIC Beam Energy Scan (BES-II) program on Au+Au collisions at $\sqrt{s_{NN}}$ = 7.7 - 19.6 GeV, and isobar collisions (Ru+Ru and Zr+Zr) at $\sqrt{s_{NN}}$ = 200 GeV. The high-statistics sample of isobar collisions will enable precise and differential measurements of particles and anti-particles (K^{*0}, $\overline{K^{*0}}$, and $K^{*\pm}$), separately. The results of the K^{*+}/K^{*0} ratio can be utilized to probe isospin effects. Moreover, comparing the K^{*0}/K^{-} ratio between Au+Au and isobar collisions can provide insights into the energy and system size dependence of hadronic interactions.

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Strangeness production in Au+Au collisions at $\sqrt{s_{NN}}$ = 19.6, 14.6 and 7.7 GeV with STAR

Auteur: Barbara Antonina Trzeciak[1]

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The main goals of relativistic heavy-ion collisions at various energies at RHIC include the study of the QCD phase structure and the properties of the quark gluon plasma. Strange hadrons have been suggested as sensitive probes to the early dynamics of the fireball created in heavy-ion collisions. Ratios of particle yields involving strange particles are often utilized to study various properties of the nuclear mater, such as the strangeness and baryon chemical potentials at the chemical freeze-out temperature (μ_S/T_{ch} and μ_B/T_{ch}). In addition, coalescence model calculations indicate that the Ω/ϕ and $(K^+\Xi^-)/(\phi\Lambda)$ yield ratios are sensitive to strange quark thermodynamic properties and density fluctuations respectively, hence their dependence on the collision energy can potentially probe the onset of deconfinement and the location of the critical end point.

In this talk, we will report on measurements of strange hadron ($\phi, K_s^0, \Lambda, \bar{\Lambda}, \Xi, \bar{\Xi}, \Omega, \bar{\Omega}$) production in Au+Au collisions at $\sqrt{s_{\rm NN}}$ = 7.7-19.6 GeV. The data were taken during the Beam Energy Scan phase-II program (BES-II) by the STAR experiment. The transverse momentum (p_T), centrality dependence of strange hadron yields and the nuclear modification factor will be presented. Additionally, rapidity (y) spectra of strange hardons, as well as the yield ratios (such as antibaryon-to-baryon ratios, $(K^+\Xi^-)/(\phi\Lambda)$ and Ω/ϕ etc.) at $\sqrt{s_{NN}}$ = 7.7-19.6 GeV, will be shown, and the physics implications will be discussed.

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Measurements of di-hadron pairs from QED vacuum excitation in Au+Au ultra-peripheral collisions at $\sqrt{s_{\rm NN}}$ = 200 GeV from STAR

Auteur: Barbara Antonina Trzeciak[1]

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Relativistic heavy-ion collisions generate extremely strong electromagnetic (EM) fields, providing an ideal environment to study the EM excitation of the vacuum. The Breit-Wheeler process, which involves the electron-position pair production via photon-photon interactions, represents the lowest-order decay mode of the QED vacuum excitation. Its expeirmental verification by the STAR experiment has stimulated further exploration into the higher-order decay modes, including the di-hadron pair productions.

In this presentation, we will report the first measurement of di-proton pairs resulting from QED vacuum excitation in Au+Au ultra-peripheral collisions at $\sqrt{s_{\rm NN}} = 200$ GeV by the STAR experiment. The pairs' invariant mass (range from 2.1 to 2.4 $\rm GeV/c^2$), transverse momentum $p_{\rm T}$, and the azimuthal angular modulation caused by the polarized EM field will be presented. The measured results will be compared with theoretical calculations. These measurements will shed new light on the understanding of the QED vacuum.

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Measurement of ${}^4_\Lambda$He lifetime in Au+Au collisions from STAR fixed target mode experiment

Auteur: Barbara Antonina Trzeciak[1]

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Hypernuclei are bound nuclear systems of nucleons and hyperons. The intrinsic properties of hypernuclei, such as their binding energy and lifetime, provide experimental avenues for studying the hyperon-nucleon (Y-N) interaction. The Y-N interaction, as an essential ingredient in the equation of state of high-baryon-density matter, remains poorly constrained. The precise measurement of Λ hypernuclei lifetimes, and its difference to that of the free Λ, will shed light towards the understanding of the Y-N interactions. In particular, the study of isospin mirror hypernuclei, such as (${}^4_\Lambda$H-${}^4_\Lambda$He), may help us gain insight into the isospin dependence of the Y-N interaction. Although there have been numerous measurements of the ${}^4_\Lambda$H lifetime, there is a scarcity of lifetime measurements for ${}^4_\Lambda$He due to its low production rate and low reconstruction efficiency. The high statistics data, collected with the STAR fixed target mode (FXT) Au+Au collisions ($\sqrt{s_{NN}} = 3.0$ - 7.7 GeV), provides a great opportunity to measure the ${}^4_\Lambda$He production with good precision.

In this presentation, we will report the first ${}^{4}_{\Lambda}$He lifetime measurement in heavy-ion collisions with the STAR FXT Au+Au collisions. A comparison of the lifetimes of ${}^{4}_{\Lambda}$H and ${}^{4}_{\Lambda}$He will provide a rigorous test for model calculations, accounting for isospin differences.

Track4-Bulk&Phase / 195

Collision Energy Dependence of Hypertriton Production in Au+Au Collisions at RHIC

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Despite extensive measurements on the production yields of light nuclei in heavy-ion collisions, a consensus on their formation mechanism remains elusive. In contrast to normal nuclei, hypernuclei carries strangeness and can offer an additional dimension for such studies. In particular, the hypertriton ${}^{3}_{\Lambda}$H, a bound state consisting of a proton, neutron and Λ hyperon, is the lightest known hypernucleus with a very small binding energy of $\sim$130 keV. Currently, published measurements of the ${}^{3}_{\Lambda}$H yield are scarce and are limited to very low ($\sqrt{s_{NN}} < 5$ GeV) or very high collision energies (≥ 200 GeV). Precise measurements on the energy dependence of ${}^{3}_{\Lambda}$H production will give invaluable information on hypernuclei production mechanisms due to its unique intrinsic properties.

In this presentation, we will present comprehensive measurements of the collision energy dependence of ${}^{3}_{\Lambda}$H transverse momentum p_T and p_T-integrated yield at mid-rapidity in Au+Au collisions at ten collision energies between 3 and 27 GeV. It is found that thermal model calculations underpredict the ${}^{3}_{\Lambda}$H yield and the ${}^{3}_{\Lambda}$H/ ratio by a factor of $\sim$2 in the reported energy region, while coalescence calculations are closer to data. We will also present the mean p_T of ${}^{3}_{\Lambda}$H as a function of collision energy. The mean p_T of ${}^{3}_{\Lambda}$H is observed to be lower than the Blast-Wave expectation using the same freeze-out parameters from light hadrons. These observations suggest that similar to light nuclei, hypertritons are formed at a later stage than light hadrons possibly through nucleon/hyperon coalescence during these collisions.

Track7-OthTop / 196

Thermal dielectron measurement in Au+Au collisions with STAR BES-II data

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According to lattice Quantum Chromodynamics (QCD) prediction, there exists a phase transition from hadronic matter to Quark Gluon Plasma (QGP) at extreme high temperatures or baryon densities. Thermal dielectrons provide a unique probe to study the properties of the hot QCD medium created in relativistic heavy ion collisions. They can be emitted during the whole evolution of the medium and do not interact strongly with the medium. The invariant mass distribution of thermal dielectrons in different mass regions enables us to extract the temperature of the hot QCD medium in different phases.

The STAR experiment collected high statistic datasets in Au+Au collisions at $\sqrt{s_{\mathrm{NN}}}$ = 7.7 - 19.6 GeV during the Beam Energy Scan program phase II (BES-II). In this talk, preliminary results of the dielectron invariant mass spectra in Au+Au collisions at $\sqrt{s_{\mathrm{NN}}}$ = 9.2 GeV will be presented and discussed in the context of other BES-II dielectron results. Furthermore, the temperature extracted from the spectra at these energies and the physics implications will also be discussed.

Track2-HF&Q / 197

First measurement of heavy flavour femtoscopy using D^0 mesons and charged hadrons in Au+Au collisions at \hbox{$\sqrt{s_{NN}}$ = 200~GeV} by STAR

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Heavy quarks are produced in hard partonic scatterings at the very early stage of heavy-ion collisions and experience the whole evolution of the Quark-Gluon Plasma medium. Femtoscopic correlations, i.e. two-particle correlations at low relative momentum, are sensitive to the final-state interactions and to the space-time extent of the region from which the correlated particles are emitted. A study of such correlations between the charmed mesons and identified charged hadrons could shed light on their interactions in the hadronic phase and the interaction of charm quarks with the medium.

In this presentation, we will show the first measurement of femtoscopic correlations between D^0-charged hadron pairs at mid-rapidity in Au+Au collisions at $\sqrt{s_{NN}}$ = 200 GeV using the data taken in the years 2014 and 2016 by the STAR experiment. D^0 ($\bar{D}^0$) mesons are reconstructed via the $K^- - \pi^+$ (and its charge conjugate) decay channel using topological criteria enabled by the Heavy Flavor Tracker with excellent track pointing resolution. We will present the femtoscopic correlation function for D^0 transverse momentum above 1 GeV/c in the $0-80\%$ centrality. We will compare the experimental results with available theoretical models to discuss their physics implications.

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Systematics of Hidden and Open Strangeness Production in Few GeV HICs

Auteur: Marvin Kohls[1]

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Investigating strangeness production and propagation in heavy-ion collisions in the few GeV energy regime is a sensitive tool for studying the properties of matter at high baryo-chemical potential.
In this contribution, we present results on the production of strange hadrons from a total of 3×10^9 most active Ag(1.58A GeV)+Ag events recorded with HADES and compare the measured multiplicities with results obtained from a hadron resonance gas model realizations with different parameters. Special attention is put to the comparison between different canonical descriptions in the context of strangeness suppression.

With respect to this, the $\phi(1020)/\Xi^-$- and $\phi(1020)/K^-$-ratios are utilized to test the consistency of the corresponding models in describing their relative yields. The significant softening of the K^- transverse spectra due to the $\phi(1020)$ feed-down is also discussed.

Furthermore, we discuss the centrality (A_{part}) dependence of strange-hadron multiplicities, which were found to follow a universal scaling for the collision system Au(1.23A GeV)+Au.

Finally, we present a first glimpse into this year's Au+Au beam energy scan data at energies between 400 and 800 A GeV.

Track2-HF&Q / 199

R_{AA} and v_n: relativistic transport approach for charm and bottom toward a more solid phenomenological determination of $D_s(T)$

Auteurs: Maria Lucia Sambataro[1]; Vincenzo Minissale[1]; Salvatore Plumari[1]; Vincenzo Greco[1]

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Quasi-Particle Model (QPM) allows for a good description of the main features of lattice QCD (lQCD) thermodynamics and for charm quark supplies a satisfying description of $R_{AA}(p_T)$ and $v_2(p_T)$ of D mesons[1,2]. Within an event-by-event full Boltzmann transport approach followed by a hybrid hadronization via coalescence plus fragmentation, we investigate the extension to bottom quark dynamics discussing predictions for $R_{AA}(p_T)$ and $v_{2,3}(p_T)$ of B mesons comparing to the available experimental data by ALICE collaboration on electrons from B meson decay [3]. A sizeable $v_{2,3}$ is found with important implications on bottomonium Υ production. Furthermore, the extension to bottom quark allows to investigate the mass dependence of $D_s(T)$ towards the infinite mass limit assumed in lQCD calculations. We find a significant breaking of the scaling of thermalization time τ_{th} with M_Q/T, entailing a D_s for $M \to \infty$ in agreement with the recent lQCD data with dynamical quarks. Furthermore, we extend our QPM approach to a more realistic model in which partonic propagators explicitly depend on quark momentum (QPMp) following Dyson-Schwinger studies [4]. The QPMp improves the description of lQCD quark susceptibilities, understimated in the standard QPM approach and entails a D_s with a stronger non-perturbative behaviour near to T_c which leads to a better agreement with the recent lQCD data.The implication of QPMp extensions on the $R_{AA}(p_T)$ and $v_n(p_T)$ is under study and hints at a lowering of the global χ^2 toward a more solid extrapolation of $D_s(T)$.

1 M. L. Sambataro, S. Plumari and V. Greco, Eur. Phys. J. C 80 (2020) no.12, 1140.
[2] M.L.Sambataro, Y, Sun, V. Minissale, S.Plumari and V.Greco, Eur.Phys.J.C 82 (2022) 9, 833 .
[3] M.L.Sambataro, V. Minissale, S. Plumari and V. Greco, Phys.Lett.B 849 (2024) 138480.
[4] M.L.Sambataro et al., in preparation.

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Multiplicity dependence of Ξ_c^+ baryon production in pp collisions at $\sqrt{s}$ = 13 TeV with ALICE

Auteur: JaeYoon Cho[1]

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Ratios of production yields of different charm hadron species are a sensitive observable to study the hadronization process.
Recently, the ALICE Collaboration reported the production yield of charm baryons (Λ_c^+, $\Sigma_c^{0,++}$, $\Xi_c^{0,+}$, Ω_c^0) relative to that of D mesons in proton–proton collisions.

The measured baryon-to-meson ratios show significant enhancement compared to those measured in e^+e^- collisions, implying that the hadronization process of charm quark is not universal across the different collision systems.
Various models implementing a modified hadronization of charm quarks in hadronic collisions, which enhance the production of baryons, can describe these enhancements of Λ_c^+ and $\Sigma_c^{0,++}$ which do not include strange quark.

These models predict a similar behaviour for charm baryons with strange-quark content ($\Xi_c^{0,+}$ and Ω_c^0), however they still cannot quantitatively describe the experimental results.

Therefore, more differential measurements, such as a function of charged-particle multiplicity, need to be provided to understand the hadronization process of charm quarks.

The ALICE Collaboration also performed a measurement of Λ_c^+ baryon production as a function of charged-particle multiplicity in pp collisions at $\sqrt{s}$ = 13 TeV.
The measured production yield ratio Λ_c^+/D^0 shows a remarkable modification of the p_T dependence as a function of the charged-particle multiplicity.
A similar measurements for $\Xi_c^{0,+}$ is expected to provide further constraints for understanding the hadronization process of charm quarks.

In this contribution, the production yield of Ξ_c^+ baryons as a function of charged-particle multiplicity at midrapidity in pp collisions at $\sqrt{s}$ = 13 TeV will be shown.
Both minimum-bias and high-multiplicity triggered pp collisions collected by the ALICE detector during the LHC Run 2 data taking period were exploited.
The Ξ_c^+ baryon was reconstructed via its hadronic decay channel, $\Xi_c^+ \to \Xi^- \pi^+ \pi^+$. The production yield ratio between Ξ_c^+ baryons and D^0 mesons as a function of charged-particle multiplicity will be presented as well.

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Dynamical Attractors in Full Boltzmann Transport: system size evolution for conformal and non-conformal plasmas in 3+1D

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We study the emergence of universal behaviour in the early stages of the ultra-relativistic heavy ion collisions by means of a Relativistic Boltzmann Transport (RBT) approach, which solves the RBT equation with the full collision integral in a 3+1D simulation. We look for attractors both in the full distribution function $f(x,p)$ and in its momentum moments.
Firstly, we consider a 0+1D conformal boost-invariant system and compare our results with other approaches, such as kinetic theory in Relaxation Time Approximation and hydrodynamic models. Exploiting the potential of the RBT, we extend this case by studying the appearance of attractors if a more realistic temperature-dependent η/s is introduced, showing a temporary breaking of the universal scaling. Furthermore, we break the system boost-invariance and also in such a case the system evolves towards the attractor 1.
Secondly, we extend this study in two directions. On one hand, we analyse attractors in a non-conformal ($m \neq 0$) system. In such a simulation a bulk viscosity is naturally present, which makes it useful also as a pre-hydrodynamic evolution to which one could properly attach hydrodynamics with a non-conformal equation of state, without suffering from any discontinuity in the bulk viscosity. On the other hand, we explore for the first time universality in the evolution of $f(x,p)$ in a full 3+1D expansion, in which we also focus on collective flows [2]. The RBT lets us study how the attractor behaviour depends on the system size, ranging from typical p-A to A-A radii: we get an insight into the universality also in small systems and not only in highly idealized scenarios, with particular attention to the time needed to lose information on initial conditions [2]. Since such systems are not expected to equilibrate, the emergence of an universal behaviour may clarify the surprising success of hydrodynamical descriptions.

[1] V. Nugara, S. Plumari, L. Oliva, and V. Greco, (2023), arXiv:2311.11921 [hep-ph].
[2] V. Nugara, S.Plumari, V. Greco [in preparation]

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Minijet quenching in non-equilibrium quark-gluon plasma

Auteur: Luyao Fabian Zhou[1]

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We study the energy deposition and thermalisation of high-momentum on-shell partons (minijets) travelling through a non-equilibrium Quark-Gluon Plasma using QCD kinetic theory. For thermal backgrounds, we show that the parton energy first flows to the soft sector by collinear cascade and then isotropises via elastic scatterings. In contrast, the momentum deposition from a minijet reaches the equilibrium distribution directly. For expanding non-equilibrium QGP, we study the time for a minijet perturbation to lose memory of its initial conditions, namely, the hydrodynamisation time. We show that the minijet evolution scales well with the relaxation time $\tau_R \propto \eta/s/T(\tau)$, where $T(\tau)$ is the effective temperature and η/s is the viscosity over entropy ratio.

Track4-Bulk&Phase / **203**

Simulating collectivity in dense baryon matter with multiple fluids

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Fluid-dynamical modelling of heavy-ion collisions in the region of RHIC Beam Energy Scan (BES) and FAIR experiments poses notable challenges. Contraction of the incoming nuclei is much weaker, which results in a long inter-penetration phase and a complex initial-state geometry. Conventional hydrodynamic models, where the fluid phase starts at a fixed proper time τ0, therefore miss the compression stage of the collision. Hence, they miss the key sensitivity to the EoS of the dense medium.

We present a novel multi-fluid approach to simulate heavy-ion collisions in the region of RHIC BES and FAIR. In our approach, we circumvent the issue above by representing the incoming nuclei as two cold, baryon-rich fluids with appropriate energy and baryon densities. The newly produced matter is represented by a third baryon-free fluid, which is generated by the friction between the two colliding fluids. Our MUlti Fluid simulation for Fast IoN collisions (MUFFIN) model is implemented from scratch using a versatile 3+1 dimensional relativistic viscous hydrodynamic code vHLLE. We present benchmark calculations for Au-Au collisions at different RHIC BES energies, discuss the challenges in constructing the approach, and present a study [2] of flow and hyperon polarization observables at RHIC BES energies in MUFFIN. We discuss underlying vorticity development in multi-fluid approach, hyperon - anti-hyperon splitting, and compare our results to the recent data for hyperon polarization from HADES experiment at GSI, and a measurement from fixed-target program at RHIC, in addition to previous measurements within RHIC BES program. We examine directed flow observable at different collision energies, and show its equation-of-state dependence and the effects of final-state hadronic cascade, in a full-fledged dynamical model.

1 Jakub Cimerman, Iurii Karpenko, Boris Tomášik, and Pasi Huovinen, Phys. Rev. C 107, 044902 (2023)
[2] Iu. Karpenko, J. Cimerman, arXiv:2312.11325

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Intertwined chiral restoration and polarization dynamics

Auteurs: Arpan Das[1]; Gowthama K. K.[2]; Radoslaw Ryblewski[3]; Samapan Bhadury[4]; Wojciech Florkowski[4]

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The physics of the recently observed spin polarization of Λ hyperons in heavy-ion collisions is still ambiguous and is under intense investigation. The evolution of the medium is governed by QCD. Thus, it is necessary to incorporate the equation of state (EoS) for the hot QCD medium in our theory. This can be achieved by considering an effective model with a spacetime-dependent mass. Hence, we start from the semiclassical expansion of the Wigner function for spin-1/2 particles, whose kinetic equation is derived from the NJL model. We find the gradient of the effective mass can be interpreted as a source of the spin polarization. This is also consistent with the conservation of total angular momentum. While, under the simple boost-invariant dynamics the effective mass depends only on proper time and consequently decouples from the dynamics of spin, an extension to non-boost invariant expansion, shows a non-trivial dependence of the spin polarization on the effective mass. This implies a possible connection between the spin polarization and chiral restoration.

Based on: PLB 849 (2024) 138464.

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A systematic study on the rescattering of heavy flavor hadrons

Auteur: Renan Hirayama[1]

Co-auteurs: Hannah Elfner [2]; Oscar Garcia-Montero [3]; Sebastian Scheid [4]

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There is currently no agreed-upon description of the interactions that heavy flavored hadrons undergo in the late stages of a heavy ion collision. Although a significant effort is being done to study heavy flavor creation and diffusion during the partonic evolution, the same cannot be said about the hadronic rescattering stage. This leaves open questions such as how much anisotropic flow of heavy hadrons is enhanced, how much quarkonia are suppressed by hadronic processes, and what the consequences on dilepton measurements are. In light of the incoming precision era of measurements, it becomes imperative to understand and quantify the mechanisms that affect such observables also after hadronization.

In this work, we build this understanding step-by-step, in a systematic way: with the hadronic transport approach SMASH, we create the most basic approximation of a hadronic afterburner – a thermalized and expanding sphere of hadron gas –, where we observe the "pion wind" phenomenon and its dependence on the cross section assumption, which we base on the Additive Quark Model but take the proportionality constant of the charm quark as a free parameter. While the cross section is initially only elastic, we later introduce inelastic processes via resonance formation and string excitation, along with fast-moving heavy mesons. These are slowed down nearly independently of the initial momentum, characterizing thermalization. They are also deflected in the medium by an amount

that depends on which cross sections are used, hinting at the mechanism for anisotropic flow generation. Within this setup, we also see a depletion in charmonia due to the $J/\Psi(+N) \to D\bar{D}(+N)$ process. Furthermore, due to the large (semi)leptonic branching ratio, the rescattering of heavy hadrons decrease the phase space of resulting dileptons, so we investigate how this affects their opening angle and invariant mass spectra. This systematic study of hadronic rescattering effects, on a comprehensive set of observables related to heavy flavor hadrons, is the first step for higher precision predictions from full dynamical hybrid approaches.

Track1-LF / **206**

A Deep Learning Based Estimator for Light Flavour Elliptic Flow in Heavy Ion Collisions at RHIC and LHC Energies

Auteurs: Aditya Nath Mishra[1]; Gergely Barnafoldi[2]; Neelkamal Mallick[3]; Raghunath Sahoo[4]; Suraj Prasad[3]

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Recent developments on a deep learning feed-forward network for estimating elliptic flow (v_2) coefficients in heavy-ion collisions have shown us the prediction power of this technique. The success of the model is mainly the estimation of v_2 from final state particle kinematic information and learning the centrality and the transverse momentum (p_T) dependence of v_2. The deep learning model is trained with Pb-Pb collisions at 5.02 TeV minimum bias events simulated with a multiphase transport model (AMPT). We extend this work to estimate v2 for light-flavor identified particles such as $\pi^{\pm}$, $K^{\pm}$, and $p + \bar{p}$ in heavy-ion collisions at RHIC and LHC energies. The number of constituent quark (NCQ) scaling is also shown. The evolution of pT-crossing point of $v_2(p_T)$, depicting a change in meson- baryon elliptic flow at intermediate-pT, is studied for various collision systems and energies. The model is further evaluated by training it for different p_T regions. These results are compared with the available experimental data wherever possible for light hadrons.

See:
1 Physical Review D 105, 114022 (2022)
[2] Phys. Rev. D 107, 094001 (2023)

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The Tsallis-Thermometer as a QGP Indicator For Large And Small Collisional Systems

Auteurs: Gergely Barnafoldi[1]; Gábor Bíró[1]; Tamás Sándor Biró[1]

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Recent experimental results present collectivity also in small systems with high-multiplicity. Today these phenomena are not completely understood: it is an important question whether the presence of the QGP is necessary for the observed collectivity or not. Moreover, the connection between the experimental observables and theories is not trivial. In our phenomenological study we introduce the 'Tsallis-thermometer'as an indicator of quark-gluon plasma, that aims to describe the smooth transition from small to large collisional systems.

The transverse momentum distribution of identified hadrons are analyzed within the thermodynamically consistent formulation of non-extensive statistics. A wide range of center-of-mass energies

and average event multiplicities are studied for various hadron species. We demonstrate that the average event multiplicity is a key variable in the study of high-energy collisions. For this purpose the non-extensive statistical approach is more than appropriate.

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Track2-HF&Q / 209

Charm and Bottom hadron production with a coalescence plus fragmentation hadronization approach: AA system size scan down to pp collisions

Auteurs: Salvatore Plumari[1]; Vincenzo Minissale[2]; Vincenzo Greco[2]

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Heavy baryon production in pp, pA, and AA collisions from RHIC to top LHC energies presents a challenge for the theoretical understanding of heavy-quark hadronization. An hybrid approach of coalescence plus fragmentation has been successful in accurately predicting the large baryon-to-meson ratio $\Lambda_c/D^0 \sim O(1)$ observed in both AA collisions at RHIC and LHC 1, as well as in pp collisions at 5.02 and $13;\mathrm{TeV}$ [2]. Generally, the obtained ratio is significantly larger than those measured and expected in e^+e^- and ep collisions. Additionally, the same approach predicts a significant $\Xi_c/D^0 \sim 0.15$ and $\Omega_c/D^0 \sim 0.05$ enhancement in pp collisions at $5.02;\mathrm{TeV}$, showing promising agreement with early ALICE measurements [2]. Furthermore, we discuss the extension of the hadronization approach to provide the first predictions for the multi-charmed baryon: Ξ_{cc}, Ω_{cc} and Ω_{ccc}. Furthermore, we explore the evolution of the yield over a wide system size scan from $PbPb$ to $KrKr$, $ArAr$ and OO as planned by ALICE3 [3].
This study allow to investigate the impact on the production coming from non-equilibrium in the charm quark distribution. We find that, generally, the predicted yield in $PbPb$ collision are quite similar to SHM if full thermalization is assumed, but on the other hand multi-charmed baryon, especially Ω_{ccc}, are particularly sensitive to the degree of thermalization of the charm quark distribution. Finally, we present the predictions of the hybrid hadronization via coalescence and fragmentation for bottom hadrons B meson Λ_b and $\Xi_b$baryons and their ratios for PbPb and pp collision at top LHC energies [4].
The comparison between charm and bottom hadron production will provide a novel and more powerful insight not only into the hadronization mechanism but also into the charm and bottom quark equilibration dynamics versus the system size of colliding nuclei.

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Stability analyses of spin hydrodynamics and constraints for the spin equation of state.

Auteurs: Arpan Das[1]; Asaad Daher[2]; Radoslaw Ryblewski[3]; Rajesh Biswas[4]; Wojciech Florkowski[5]

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Difficulties with finding a unified interpretation of the local and global spin polarization observables measured in non-central relativistic heavy-ion collisions triggered several theoretical developments, leading, in particular, to an extension of fluid dynamics to spin-polarized systems, known as spin hydrodynamics. Aiming at practical applications, its first- and second-order dissipative extensions 1 were formulated and studied for their stability [2,3]. Based on these and other studies, it was found that the stability of so-called spin modes puts certain constraints, in particular, on the possible forms of spin equations of state [4,5].

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Local spin polarization in a blast wave model with dissipative corrections

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We employ a relativistic kinetic theory model based on the GLW(de Groot - van Leeuwen - van Weert) formalism of the spin hydrodynamics with the Frenkel condition to study the local spin polarization of Λ hyperons. We calculate the Pauli-Lubanski pseudovector with the dissipative correction to the extended phase-space distribution function, obtained within a relaxation-time approximation. This framework naturally incorporates a thermal shear term coupled to thermal vorticity and the derivative of thermal vorticity. We apply our model within a single freezeout thermal blast wave scenario which is qualitatively consistent with experimental observations. We find that the dissipative correction leads to significant local spin polarization for the Λ hyperons which allows us to extract a spin relaxation time by comparing the magnitude of calculated spin polarization with the experimental results.

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Investigating charm quark production in and outside jets using the ALICE detectors at the LHC

Auteur: Josephina Wright[None]

Measurements of correlations between heavy-flavor decay electrons and charged particles are used to study heavy-flavor production in hadronic collisions, and to characterize the heavy-quark in-medium energy loss in heavy-ion collisions, where a quark–gluon plasma is created. We are investigating the charm quark production and interaction in the near and away side of the hadron-triggered jet and comparing it to the underlying event via angular correlations of trigger hadrons and associated electrons from heavy-flavor hadron decays. We exploit a sample of p–Pb collisions at $\sqrt{s_{NN}}$ = 5.02 TeV in order to study the onset of the partonic medium behavior with respect to the medium size. The analysis is performed exploiting the capabilities of the ALICE detectors. The ALICE Time Projection Chamber (TPC) detector is specifically used to identify electrons via ionization energy loss. A heavy-flavor electron sample is obtained after rejecting the background of electrons from photo-conversion and light flavor hadrons. In this contribution we will show a hadron-electron correlation distribution in comparison to a hadron-hadron correlation distribution in a transverse-momentum range of 2 < pT^e < 4 GeV/c in different centralities.

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Collective flow in symmetric and asymmetric collisions of nuclei

Auteurs: Hadi Mehrabpour[1]; Giuliano Giacalone[2]

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In this research, we investigate the influence of nuclear structure parameters on the collective flow observed in symmetric and asymmetric nuclear collisions at ultra-relativistic energies. Our approach involves introducing an approximate yet realistic analytical model for the collision process, which allows us to emphasize the pivotal role played by the structural characteristics of the colliding ions. This versatile model facilitates exploring a broad range of collision scenarios, spanning from light to heavy nuclei.

We leverage the connections between N-particle correlations in the final stages of nuclear collisions and N-nucleon density distributions within the colliding nuclei to discern the impacts. Notably, multi-particle correlations in the final stages of high-energy nucleus-nucleus collisions prove to be sensitive indicators of the collective correlations among nucleons in the wave functions of the colliding nuclei.

Our work sheds light on the intricate interplay between nuclear structure and collision dynamics, offering exciting prospects for advancing our understanding of these fundamental processes.

Track2-HF&Q / 214

Simulating Charm Quarks in IP-Glasma Initial Stage and Quark-Gluon Plasma: A Hybrid Approach for charm quark phenomenology

Auteurs: Manu Kurian[1]; Mayank Singh[2]; Bjoern Schenke[3]; Sangyong Jeon[4]; Charles Gale[4]

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Heavy quarks act as effective probes in relativistic heavy-ion collisions, being generated during the initial phases of the collision event. The accurate modeling of quark-gluon plasma evolution relies on a profound understanding of dynamics in the collision's early phase. We model relativistic heavy-ion collisions at LHC energy with a hybrid dynamical approach consisting of a fluctuating IP-Glasma initial state followed by viscous hydrodynamics.

In this study, we present the first phenomenological findings on charm quark transport spanning from the IP-Glasma initial stage to the quark-gluon plasma. We employed the MARTINI event generator and PYTHIA8.1 to simulate the initial production of heavy quarks and Langevin dynamics to capture the evolution of heavy quarks in the medium. The sensitivity of heavy meson nuclear modification factor and flow coefficient to the early stage of heavy-ion collisions and bulk medium evolution is analyzed for Pb+Pb collision at 5.02 TeV. Our study provides insights into the interaction strength of charm quarks during the early phase and within the quark-gluon plasma.

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Quarkonia Yield Modification in Ultra-relativistic p-p Collisions Questioning the baseline for heavy-ion Collisions: A Quark Gluon Plasma Saga

Auteur: Captain Rituraj Singh[1]

Co-auteurs: Suman DEB [2]; Raghunath Sahoo [1]; Jan-e Alam [3]

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The strongly interacting quarks and gluons plasma (QGP) phase is a must to exhibit the collective behavior. Experimental observations from heavy-ion collisions at the Relativistic Heavy Ion Collider (RHIC) and the Large Hadron Collider (LHC) revealed such collective phenomena. Additionally, intriguing features like strangeness enhancement further support the existence of QGP in these collisions. The p+p collision system has traditionally served as a baseline for heavy-ion collisions due to its lower particle number density. However, the possibility of QGP-like behavior in small systems cannot be entirely dismissed, especially at high collision energies. Recent investigations at LHC energies have even detected collective behavior and strangeness enhancement in p+p collisions. In this context, we focus on charmonia yield modification as a probe for QGP-like effects in p+p collisions at center-of-mass energies 5.02, 7, and 13 TeV. We employ second-order viscous hydrodynamics to the Unified Model of Quarkonia Suppression (UMQS) to interpret experimental data related to normalized charmonium yield with respect to the normalized charged-particle multiplicity. The UMQS model incorporates QGP effects such as color screening, collisional damping, gluonic dissociation, and regeneration, all of which influence the net quarkonia yield in ultrarelativistic collisions. Additionally, we also observe the influence of medium anisotropy on the above-mentioned QGP effects. This investigation sheds light on the intriguing interplay between QGP-like phenomena and small collision systems, offering valuable insights into the fundamental properties of the strong force under extreme conditions.

Track6-SmallSyst / **216**

Signals of initial state quantum entanglement in relativistic particle collision

Auteur: Rene Bellwied[1]

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I will show thermodynamic entropy calculations based on charged particle multiplicity data from proton-proton collisions measured by ALICE at the LHC in comparison to entanglement entropy calculations based on initial state gluon distributions. The relative agreement of these distributions can be quantified by studying their higher order cumulants. The commonalities between the initial and final state suggest
that entanglement could be a possible source for the seemingly thermal and collective behavior in small systems. I will pose the question on when such a picture could and will break down due to decoherence of the initial state. I will also show that rather simple additional final state measurements should be sensitive to gluon saturation, in particular when properly binned in rapidity space.

Track2-HF&Q / 217

A potential approach to the X(3872) thermal behaviour

Auteur: Miguel Angel Escobedo Espinosa[None]

Co-auteurs: Elena Ferreiro [1]; Nestor Armesto [1]; Victor Lopez-Pardo [1]

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We study the potential of X(3872) at finite temperature in the Born-Oppenheimer approximation under the assumption that it is a tetraquark. We argue that, at large number of colors, it is a good approximation to assume that the potential consists in a real part plus a constant imaginary term. The real part is then computed adapting an approach by Rothkopf and Lafferty and using as input lattice QCD determinations of the potential for hybrids. This model allows us to qualitatively estimate at which temperature range the formation of a heavy tetraquark is possible, and to propose a qualitative picture for the dissociation of the state in a medium. Our approach can be applied to other suggested internal structures for the X(3872) and to other exotic states.

Track1-LF / 219

Dependence of net-hyperon production at mid-rapidity on beam energy and its implication on baryon number carrier

Auteur: Chun Yuen Tsang[1]

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The conventional picture of baryon number is that each valence quark inside a baryon carries 1/3 unit of baryon number. However, an alternative picture exists where the center of a Y-shaped topology of gluon fields, called the baryon junction, carries 1 unit of baryon number. Previous analysis of net-proton yield at mid-rapidity from the Beam Energy Scan program phase-I (BES-I) at RHIC showed that it depends on the beam rapidity exponentially, with a slope parameter of 0.64 ± 0.05. Within the baryon junction scenario, the net-hyperon yield at mid-rapidity should show a similar dependence, as junctions are flavor blind. This study aims to test this prediction by analyzing published data from BES-I program. We observe that net-hyperon yields, after correcting for strangeness production suppression, adhere to the expected exponential form. Furthermore, the fitted slope parameters for net-Λ, net-Ξ and net-Ω are similar, in favor of the baryon junction picture. Conventional models, such as Pythia, are unable to reproduce such stopping behavior, highlighting the limitations of existing models, most of which lack the inclusion of baryon junction dynamics.

Track4-Bulk&Phase / 220

Initial conditions and bulk viscosity effects on Λ polarization in high-energy heavy ion collisions

Auteurs: Andrea Palermo[1]; Eduardo Grossi[2]; Francesco Becattini[2]; Iurii Karpenko[3]

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The Λ polarization is a crucial probe of the gradients of velocity and temperature in the quark-gluon plasma generated in heavy-ion collisions. However, it is still not systematically used to tune hydrodynamic models. In this talk, we investigate the influence of different initial conditions and parametrization of the bulk viscosity on Λ polarization, showing that they affect the local polarization significantly. These results highlight the impact that the use of local Lambda polarization can have on refining theoretical models. Finally, we compare our results, including feed-down corrections, with experimental data from high-energy heavy-ion collisions at STAR and ALICE, and demonstrate the crucial role of bulk viscosity in generating the correct sign of longitudinal polarization at LHC energies.

Track4-Bulk&Phase / 221

Magnetic field effect on hadron yield ratios and fluctuations in a hadron resonance gas

Auteur: Volodymyr Vovchenko[1]

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We study the influence of an external magnetic field on hadron yields and fluctuations in a hadron resonance gas by performing calculations within an updated version of the Thermal-FIST package. The presence of magnetic field has a sizable influence of several yield ratios involving both strange and non-strange hadrons. In particular, the enhanced p/π ratio can be probed through centrality dependence in heavy-ion collisions. By attributing the centrality dependence of the p/π ratio in Pb-Pb collisions at 5.02~TeV measured by the ALICE Collaboration entirely to the magnetic field, we estimate its maximal strength at freeze-out. The magnetic field also enhances various conserved charge susceptibilities, which is consistent with recent lattice QCD data and is driven in the HRG model by the increase of hadron densities. We put these results in the context of measurements of hadron fluctuations and correlations.

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Relativistic Hydrodynamics under Rotation: Prospects & Limitations from a Holographic Perspective

Auteurs: Casey Cartwright[1]; Jackson Wu[2]; Markus Amano[3]; Matthias Kaminski[2]

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The AdS/CFT correspondence (holography) has provided numerous important insights into the behavior of strongly-coupled many-body systems. Crucially, it has provided a testing ground for the construction of new effective field theories, especially those in the low frequency, long wavelength limit known as hydrodynamics. We review the study of strongly-coupled rotating fluids using holography and hydrodynamics arising from the study of simply spinning Myers-Perry black holes, and we describe techniques to obtain hydrodynamic and non-hydrodynamic modes. We discuss three regimes in which holographic rotating fluids display: (1) hydrodynamic behavior of a boosted fluid, (2) hydrodynamic behavior distinct from a boosted fluid, and (3) no obvious hydrodynamic behavior. The radius of convergence is computed for the hydrodynamic regimes and discussed along with other limitations of hydrodynamics under rotation.

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Strangeness Production Au+Au collisions at STAR energies using AMPT

Auteur: Ashish Jalotra[1]

Co-auteur: Sanjeev Singh Sambyal [1]

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The production of strange quarks and antiquarks in high-energy collisions of heavy ions is a significant indicator for the creation of a state of matter known as Quark-Gluon Plasma (QGP). The QGP is characterized by the liberation of quarks and gluons from their confinement inside hadrons. Due to their instant decay via weak interactions, strange quarks and antiquarks are not present in normal matter and can only be produced via strong interactions within the QGP. As the mass of strange quarks and antiquarks is close to the temperature at which protons, neutrons, and other hadrons dissolve into quarks, they serve as sensitive probes for studying the conditions, structure, and evolution of the deconfined state of matter.

In this Work, we will report the strange particles (K_s^0, Λ, $\bar{\Lambda}$, Ξ, $\bar{\Xi}$ and Ω) Yields, their rapidity density distribution and also the baryon to meson ratio in Au+Au collisions at $\sqrt{s_{\mathrm{NN}}}$ = 7.2GeV using AMPT model .Their physics implications will also be discussed.

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Constraining Lambda potential in dense nuclear matter from the Lambda directed flow

Auteurs: Asanosuke Jinno[1]; Koichi Murase[2]; Yasushi Nara[3]

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We investigate the possibility of constraining the Lambda (Λ) potential in dense nuclear matter from the Λ directed flow (v_1).

The hyperon puzzle in neutron stars, extensively discussed in recent decades, refers to the problem that most of the equations of state (EOS) with hyperons are not sufficiently stiff to support the observed massive neutron stars. The presence or absence of hyperons in neutron stars is one of the important elements determining the stiffness of EOS with hyperons. The Λ potential at high densities is a key ingredient in discussing the presence of Lambda hyperons, but it is not well constrained by the available experimental data.

In this talk, we investigated the possibility that Λ v_1 can constrain the Λ potential at high densities 1. We use the Lorentz vector version of the relativistic quantum molecular dynamics (RQMDv) model [2] implemented in the JAM2 transport code. By using RQMDv, the rapidity dependence of the proton v_1 at $\sqrt{s_{NN}} = 2 - 20$ GeV is reproduced by a single parameter set [2]. We compare Λ v_1 calculated by using Skyrme-type Λ potentials that are consistent with Λ hypernuclear data [3]. We show that the Λ v_1 is not sensitive to the density dependence of the Λ potential but is sensitive to the momentum dependence. Also, we found that the Σ hyperon and the hyperon resonances are largely produced, and thus, their potentials would largely affect Λ v_1.

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Track3-Res&Hyp / 225

Unveiling the dynamics of little-bang nucleosynthesis

Auteur: kaijia sun[1]

Co-auteurs: Che-Ming Ko ; Chun Shen ; Rui Wang ; Yu-Gang Ma

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High-energy nuclear collisions provide a unique site for the synthesis of both nuclei and antinuclei at temperatures of kT ≈ 100 − 150 MeV. In these little bangs of transient collisions, a quark-gluon plasma (QGP) of nearly vanishing viscosity is created, which is believed to have existed in the early universe within the first few microseconds after the Big Bang. Analyses of identified particles produced in these little bangs based on the statistical hadronization model for the QGP have suggested that light (anti)nuclei are produced from the QGP as other hadrons and their abundances are little affected by later hadronic dynamics. Here, we find a strong reduction of the triton yield by about a factor of 1.8 in high-energy heavy-ion collisions based on a kinetic approach that includes the effects of hadronic re-scatterings, particularly that due to pion-catalyzed multi-body reactions. This finding is supported by the latest experimental measurements and thus unveils the important role of hadronic dynamics in the little-bang nucleosynthesis.

Track2-HF&Q / 226

Detailed study of the production of Υ mesons in PbPb collisions with CMS

Auteur: Prabhat Ranjan Pujahari[None]

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One of the fundamental aspects of the formation and interaction of heavy quark bound states in the quark-gluon plasma is the amount of their suppression, expected to be stronger for quarkonia with smaller binding energies. Indeed, past results show a significant suppression of Υ(1S) mesons in heavy ion collisions, with Υ(2S) mesons being even more suppressed. However, for the Υ(3S)

meson, only upper limits have been reported so far. At the same time, features like polarization of quarkonia or feed-down contributions from excited states remain to be assessed. In this talk, we report the observation of the $\Upsilon(3\mathrm{S})$ meson and a detailed study of the production of Υ mesons in lead-lead collisions recorded by CMS. For the first time, the nuclear modification factor has been extended to the strongly suppressed $\Upsilon(3\mathrm{S})$ state. The results are compared with model calculations describing the dynamics of quarkonia in a hot environment, whereas future prospects are shown too.

Track2-HF&Q / 227

Observation of double J/ψ production in pPb collisions with CMS

Auteur: Stefanos Leontsinis[None]

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The first observation of the simultaneous production of two J/ψ mesons in proton-nucleus collisions will be presented. The analysis is based on a data sample recorded at a nucleon-nucleon center-of-mass energy of 8.16 TeV by the CMS experiment at the CERN LHC corresponding to an integrated luminosity of 174.6 nb^{-1}. The J/ψ mesons are reconstructed in their $\mu^+\mu^-$ decay channel for transverse momenta $p_\mathrm{T} > 6.5$ GeV and rapidity $|y| < 2.4$. The measured inclusive fiducial cross section $\sigma(\mathrm{pPb} \to \mathrm{J}/\psi\mathrm{J}/\psi + \mathrm{X})$ will be compared to perturbative quantum chromodynamics predictions at next-to-leading-order accuracy, including nuclear parton densities effects, for the production of two J/ψ mesons in single- (SPS) and double- (DPS) parton scatterings. A fit of the data to the expected $\mathrm{pPb} \to \mathrm{J}/\psi\mathrm{J}/\psi + \mathrm{X}$ SPS and DPS kinematic distributions of the two J/ψ mesons will provide new constraints on the effective DPS cross section of σ_eff, related to the transverse distribution of partons in the proton.

Track2-HF&Q / 228

Examination of final-state effects in pPb collisions via measurements of the multiplicity dependence of charm hadron production with CMS

Auteur: Austin Alan Baty[None]

The large masses of charm hadrons make them exceptional probes of quantum chromodynamics (QCD), providing quantitative insights into its high-density and temperature phase through their production and interaction in the nuclear medium. Charm hadron production in heavy ion collisions is influenced by several mechanisms, including energy loss, dissociation, and recombination processes. Final-state effects further modify the hadronization of heavy quarks via interactions with nearby particles (co-moving particles, quark coalescence, etc). Studying the modification of hadron production in dense environments enables the investigation of hadronization mechanisms as well as of the origin of the collectivity signals observed in the so-called small systems. We present new measurements of the production rate of charm hadrons as a function of the charged particle multiplicity in proton-lead (pPb) collisions at $\sqrt{s_\mathrm{NN}} = 8.16$ TeV. We report the first study of the prompt and nonprompt (from b-hadron decay) $\psi(2\mathrm{S})$-over-J/ψ cross section ratio. The results are compared with previous measurements in proton-proton (inclusive, prompt, and nonprompt) and pPb (inclusive) collisions, as well as with predictions from a comover-interaction model. In addition, measurements of the production of open charm hadrons such as Λ_c^+ and D^0 will be presented.

Track4-Bulk&Phase / 229

Measurement of strange particle femtoscopic correlations at the CMS experiment

Auteur: Raghunath Pradhan[None]

Particle correlations have been traditionally employed in the study of the collective phenomena observed in hadronic and heavy ion collisions by using azimuthal distributions, while quantum statistical effects and final-state interactions can be accessed by femtoscopic measurements. Femtoscopic correlations of identified hadrons are measured with data recorded by the CMS experiment at the LHC over a broad multiplicity range and different pair transverse momenta. In this talk, results on the femtoscopic correlations of strange particles (K^0_S, Λ and $\bar{\Lambda}$) are reported for proton-lead (pPb) collisions at $\sqrt{s_{NN}} = 8.16$ TeV and lead-lead (PbPb) collisions at $\sqrt{s_{NN}} = 5.02$ TeV using LHC Run 2 data collected by the CMS experiment. The strong interaction scattering parameters, scattering length and effective range, are extracted using the Lednick\'y-Lyuboshitz model for both pPb and PbPb collisions, and compared with other experimental and theoretical results. The measurements are performed in several multiplicity and centrality bins and as a function of of the pair average momentum.

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Measurement of azimuthal anisotropy at high p_T using subevent cumulants in pPb collisions at CMS

Auteur: Sergey Petrushanko[1]

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Measurements at the LHC have provided evidence for collective behavior in high-multiplicity proton-proton (pp) and proton-lead (pPb) collisions through multiparticle correlation techniques. To investigate detailed properties of this collectivity, a comprehensive study of differential Fourier coefficients (v_n) in particle transverse momentum (p_T) and event multiplicity is presented in pPb collisions recorded by the CMS experiment at a nucleon-nucleon center-of-mass energy $\sqrt{s_{NN}} = 8.16$ TeV. In particular, new measurements of p_T-differential multiparticle cumulants using the subevent cumulant method in distinct subevent regions are presented. Relative to past CMS measurements, the new study probes an extended phase space region up to a high particle p_T, putting the observation of nonzero high-p_T v_2 in a small-sized medium into stringent tests.

Track6-SmallSyst / **231**

Using Multivariate Cumulants to Constrain the Initial State in XeXe and PbPb Collisions at the CMS Experiment

Auteur: Aryaa Dattamunsi[None]

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Xenon (Xe) nuclei are deformed and have a nonzero quadrupole moment, whereas lead (Pb) nuclei are considered spherical in shape. The study of XeXe collisions at a center-of-mass energy per nucleon pair of $\sqrt{s_{NN}} = 5.44$ TeV opens up a window to study nuclear deformation using the CMS experiment. When compared to the Run 3 PbPb data at a center-of-mass energy per nucleon pair of $\sqrt{s_{NN}} = 5.36$ TeV, which is very close to that of XeXe, one can explore the dependence of the Fourier flow coefficients on the size and initial-state geometry of the colliding system. For the first time, correlations between higher order moments of two as well as three flow harmonics (v_2 to v_6, up to orders 8 or 10) are measured in XeXe and PbPb collisions as a function of collision centrality. These new measurements have been calculated with multiparticle mixed harmonic cumulants using charged particles in the pseudorapidity region $|\eta| < 2.4$ and the transverse momentum range

$0.5 < p_T < 3.0$ GeV /c. The results have also been compared to theoretical model predictions provided by the IP-Glasma+MUSIC+UrQMD model, which helps us to constrain the initial-state deformation parameters of Xenon nuclei. Furthermore, it has been shown that both hydrodynamic probes $\frac{v_2\{6\}-v_2\{8\}}{v_2\{4\}-v_2\{6\}}$ and $\frac{v_2\{8\}-v_2\{10\}}{v_2\{6\}-v_2\{8\}}$ are centrality dependent, explained by introducing newly measured higher order moments in the Taylor expansion of the corresponding generating function of the cumulants. The higher order moments, skewness, kurtosis, and the superskewness (5th moment) are expressed through the $v_2\{2k\}$ (k = 1, …, 5) harmonics and are shown as a function of collision centrality. Overall, these studies will significantly constrain initial-state model parameters and give us a better understanding of the transport properties of the quark-gluon plasma created in heavy ion collisions at the LHC.

Track4-Bulk&Phase / 232

Hyperon polarization along the beam direction in pPb collision at CMS

Auteur: Chenyan Li[None]

The observation of hyperon polarization along beam direction (P_z) in nucleus-nucleus collisions has revealed the relationship between collective flow and the complex vortical structures of the quark-gluon plasma (QGP). With the high-statistics data collected by the CMS experiment, we present the first P_z results in proton-lead collisions at $\sqrt{s_{NN}} = 8.16$ TeV over a wide transverse momentum range for Λ and $\bar{\Lambda}$ particles at low- and high-multiplicity events. The measured P_z signal can shed light on the mechanism of spin polarization in QGP as well as the origin of collectivity in small collision systems.

Track2-HF&Q / 233

Probing a new regime of ultra-dense gluonic matter using high-energy photons with the CMS experiment

Auteur: Pranjal Verma[None]

In ultraperipheral collisions (UPCs) involving relativistic heavy ions, the production of heavy-flavor coherent vector mesons through photon-nuclear interactions is a key focus due to its direct sensitivity to the nuclear gluon density. Experimental measurements, however, face a two-way ambiguity as each of the symmetric UPC nuclei can act as both a photon-emitter projectile and a target. This ambiguity hinders the separation of contributions from high- and low-energy photon-nucleus interactions, restricting our ability to probe the extremely small-\(x\) regime where nonlinear QCD effects are anticipated. The presentation will unveil the measurement of coherent heavy quarkonium photoproduction, addressing the two-way ambiguity by employing a forward neutron tagging technique in UPC PbPb collisions at 5.02 TeV. Overall these studied focus on the dominance of gluons in nuclear matter probed at higher energies.

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Dependence of two-particle azimuthal correlations on the forward rapidity gap width in pPb collisions at 8.16 TeV with CMS

Auteur: Sergey Petrushanko[1]

[1] *Skobeltsyn Institute of Nuclear Physics, Lomonosov Moscow State University*

The study of proton-lead events that have gaps in the rapidity distribution of particles is sensitive to colorless interactions such as pomeron-lead and photon-lead. The relative contribution of these processes depends upon the size of the rapidity gap. CMS has already studied the cross section of such processes as a function of the rapidity gap. The current analysis extends those studies to the azimuthal correlations of particles produced in the event. Differential studies of the strength of these correlations will be presented as a function of the charged particle transverse momentum, multiplicity, and the rapidity gap magnitude.

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Investigating Bottom Quark Energy Loss, Hadronization, and B Meson Nuclear Modification Factors in B^+ and B_s^0 Decays: Insights from CMS in pp, pPb, and PbPb Collisions

Auteur: Jhovanny Andres Mejia Guisao[None]

The exclusive decay channels $\mathrm{B_s^0} \rightarrow \mathrm{J}/\psi\phi$ and $\mathrm{B}^+ \rightarrow \mathrm{J}/\psi K^+$ are investigated. The differential cross sections of $\mathrm{B_s^0}$ and B^+ mesons as a function of their transverse momenta (p_T) in proton-proton collisions at 5.02 TeV are well-described by fixed-order plus next-to-leading logarithm calculations, using an integrated luminosity of 302.3 pb^{-1}. By utilizing previous lead-lead collision data at the same nucleon-nucleon (NN) center of mass energy, R_AA factors for the B mesons are determined. Additionally, the measurement of the B^+ meson production cross section is presented with respect to meson p_T inclusively and, for the first time, in different charged particle multiplicity ranges. This study is conducted in proton-lead collisions at NN center-of-mass energy of $8.16~\mathrm{TeV}$, utilizing data collected by the CMS detector in 2016 with an integrated luminosity of 175 nb^{-1}. The analysis focuses on the exclusive decay channel $\mathrm{B}^+ \rightarrow \mathrm{J}/\psi K^+$. Inclusive results demonstrate good agreement with fixed-order next-to-leading log calculations, and the ratio of nuclear modification factors is measured for different charged particle multiplicities. These studies provide a comprehensive understanding of $\mathrm{B_s^0}$ and B^+ meson production, shedding light on their behavior in different collision environments and offering insights into the nuclear modification factors associated with these mesons.

Track2-HF&Q / 236

Study of charm quark and QGP medium interactions via Λ_c^+ and D^0 production and collective flow in the CMS

Auteur: Soumik Chandra[None]

Since charm quarks are massive, they are dominantly produced in the early stage of a collision. In heavy ion collisions, they propagate through the quark-gluon plasma (QGP) and provide important information about the initial stages of the collision, and the properties of the QGP medium. The interaction between heavy quarks and the QGP affects the hadronization of heavy quarks and their azimuthal distribution and transverse momentum (p_T) spectrum. By comparing the Λ_c^+ baryon and D^0 meson productions, and measuring the azimuthal anisotropy of the D^0 meson, we can study the charm quark hadronization and the interaction between charm quark and the QGP medium. In this talk, we present the measurements of Λ_c^+ baryon production, the $\Lambda_\mathrm{c}^+/\mathrm{D}^0$ yield ratio at $\sqrt{s_\mathrm{NN}} = 5.02$ TeV in proton-proton collisions and different centrality regions of lead-lead (PbPb) collisions. The results indicate that the production of Λ_c^+ baryons is suppressed for more central events in PbPb, and the coalescence does not play a significant role in the hadronization of Λ_c^+ baryon at $p_\mathrm{T} > 10$~GeV. Furthermore, we present the measurements of the azimuthal anisotropy coefficients (v_2 and v_3), and R_AA of prompt D^0 in PbPb collisions as a function of p_T from central to mid-central collisions. Clear centrality dependencies of prompt D^0 meson v_2 and R_AA are observed. No evidence of the effect of the Coulomb field on the collective flow of charm hadron is found.

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Effects of sub-nucleonic fluctuations on the longitudinal structure of heavy-ion collisions

Auteurs: Jie Zhu[1]; Oscar Garcia-Montero[2]; Sören Schlichting[3]

[1] *Central China Normal University*

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In recent studies, it has been suggested that subnuclear fluctuations in the initial state of heavy-ion collisions impact not only transverse long-range correlations of small systems 1, but also on the creation of longitudinal structure, as seen longitudinal decorrelation observables [2]. In this work, we study the emergence of long-range rapidity correlations in nuclear collisions due to the inclusion of event-by-event subnuclear fluctuations in the initial state. We use the McDIPPER, a novel 3D resolved model for the initial state of ultrarelativistic heavy-ion collisions, based on the $k_\perp$-factorized Color Glass Condensate hybrid approach [3,4]. In this work, we present two extensions to the framework. First, we include the so called hotspot model to account for spatial fluctuations of the dense gluons, dominating the energy deposition at mid-rapidity. Furthermore, we add momentum and spatial fluctuations on the initial energy and the incoming high-x partons by sampling quarks -and anti quarks- from Parton distribution functions (PDFs) [5]. The energy and charge fluctuations will dominate the physics at higher rapidities, in the so-called fragmentation regions. Specially important from the strange sector, the deposition of (anti-) quark pairs allows us to create profiles with local spatial fluctuations of baryon, charge and strangeness profiles. an input needed in the study of 3D charge diffusion in the hydrodynamical stage. We present the effect of the included fluctuations on the rapidity structure on relevant observables, such as the flow decorrelations.

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π, K, and p production in high multiplicity pp collisions at $\sqrt{s}$ =13 TeV with ALICE

Auteur: Navneet Kumar[1]

[1] *Panjab University*

High-multiplicity proton–proton and proton–lead collisions at LHC energies exhibit similar signatures to those observed in Pb-Pb collisions (i.e. strangeness enhancement, collective expansion effects etc.), that are commonly attributed to the formation of the quark–gluon plasma. In this contribution, we will present the measurements of π, K, and p transverse momentum spectra in the rapidity region $|y| < 0.5$ for high multiplicity classes in pp collisions at $\sqrt{s}$ =13 TeV with the ALICE detector at the LHC. These measurements allow to reduce the gap between pp and Pb-Pb collisions. The particles are identified using the specific energy loss and the time of flight information from the TPC and TOF detectors, respectively. Furthermore, the integrated particles yields and particle ratios are also investigated as a function of charged particle multiplicity and compared to the expectation

from QCD-based pp event generators as well as to the production from thermal and hydrodynamic models.

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Study of Nuclear Modification Factor in O-O collisions at LHC energies using a transport model

Auteur: Debadatta Behera[1]

Co-auteurs: Suman DEB [2]; Captain Rituraj Singh [1]; Raghunath Sahoo [1]

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Extensive research at the Large Hadron Collider (LHC) and the Relativistic Heavy Ion Collider (RHIC) on Pb-Pb and Au-Au collisions have helped us develop and understand the properties of the quark-gluon plasma (QGP) in heavy-ion collisions. Recent investigation suggests that QGP-droplets may occur in small collision systems such as high-multiplicity pp collisions. O-O collisions are anticipated in the upcoming run at the LHC. This will provide an important and timely opportunity to investigate the effects seen in high-multiplicity pp and p-Pb collisions with a system having a similar number of participating nucleons and final-state multiplicity but with a larger geometrical transverse overlap, thereby enhancing jet-quenching effects, which depend on path length. In the current work, we have implemented both Woods-Saxon and an α-cluster tetrahedral structure in the oxygen nucleus using a multi-phase transport (AMPT) model. We report the nuclear modification factor (R_{AA}) for all charged hadrons and identified particles for most central, mid-central, and peripheral collisions in the O-O collisions at $\sqrt{s_{NN}}$ = 7 TeV in the case of both Woods-Saxon and α-clustered density profiles. Additionally, we study the rapidity dependence of R_{AA} for all charged hadrons. We have also observed the behavior of R_{AA} with the same multiplicity environment between O-O and Pb-Pb collisions. A study like this will assist us in understanding the implications of nuclear density profiles and provide a realistic baseline measurement to compare experimental results in the future.

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Dissociation of $q\bar{q}$ in the pre-equilibrium Glasma

Auteurs: Marco Ruggieri[1]; Mohammad Yousuf Jamal[2]; Partha Pratim Bhaduri[3]; Pooja -[2]; Santosh Kumar Das[2]; Vincenzo Greco[4]

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In high-energy heavy-ion collision experiments, the study of the pre-thermalization phase known as the Glasma and its subsequent evolution into the Quark-Gluon Plasma has revealed profound insights into Quantum Chromodynamics. The Glasma, arising from the collision of ultra-relativistic heavy ions, is characterized by highly non-equilibrium color fields and huge energy densities, significantly influencing the early-stage dynamics of the collision system. Heavy quarks and their states, being unique probes, play a crucial role in providing valuable insights into the properties of the evolving QCD medium and early-time dynamics. We, for the first time, investigate the interaction of $q\bar{q}$ states with the Glasma phase, particularly $c\bar{c}$ and $b\bar{b}$ using relativistic kinetic theory. We

observe that there is a finite probability of dissociation of these states. An attractive potential, containing Coulomb-like and confinement-like terms, is used to model the strong attractive color force in the pairs, but the strong Glasma fields dominate over it, causing an increase in pair separation and subsequent dissociation. The observed finite probability of dissociation for these states reveals the intricate interplay between QCD dynamics and the suppression of $q\bar{q}$ states during the Glasma phase.

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Probing the spatial dependence of nuclear PDFs using heavy flavor data

Auteur: Stéphane Delorme[1]

[1] *IFJ PAN*

Nuclear parton distributions functions (nPDFs) are essential to link the measurable hadronic cross sections to the perturbatively calculable cross-sections of processes induced by partons in proton-nucleus or nucleus-nucleus collisions. Nowadays, almost all nPDFs are spatially averaged due to the modest amount of available data for nuclear hard processes. However, the collision geometry can significantly affect the nuclear parton densities, in addition to the fact that it is essential to understand the spatial dependence of nPDFs to interpret observables measured in different centrality classes. We present a parametrization of the spatially-dependent nPDFs based on the nucleus thickness function. In this parametrization, only one parameter is used to encode the spatial dependence and is fitted on minimum bias and centrality dependent heavy flavor data from both LHC and RHIC. This represent (to our knowledge) the first attempt at probing the spatial dependence of nPDFs using experimental data.

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Scaling Properties of φ-Meson and Light Charged Hadron Production in Small and Large Systems at PHENIX

Auteur: Rachid Nouicer for the PHENIX Collaboration[1]

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Light hadrons are considerably produced in high-energy heavy-ion collisions and provide a wealth of information about properties of created QCD medium and reaction dynamics. These include, in particular, the implications of collective flow in small and large systems
and the impact of recombination on baryon and strangeness enhancement. The system size dependence studies of different observable are crucial to investigate the properties of Quark Gluon Plasma and hadronization based on initial conditions of the collisions such as nuclear-overlap size, shape of nuclei, and nuclear modification of the parton-distribution functions.

In this talk, we will present recently finalized measurements by PHENIX on the nuclear modification and elliptic flow of φ-meson in Cu+Au, and U+U collisions, and production of identified light charged hadron in small and large system size, p+Al, p/d/3He/Cu+Au, and U+U collisions 1 at RHIC energies as a function of centrality and transverse momentum. The tests of various empirical scaling, and interpretation of the results with respect to the current theoretical model calculations are provided for better understanding of the underlying processes.

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1 N.J. Abdulameer et al. (PHENIX Collaboration), arXiv:2312.09827 [nucl-ex]

Track6-SmallSyst / 245

Multiplicity dependent and inside-jet measurement of light neutral mesons in pp collisions with ALICE

Auteurs: ALICE Collaboration[None]; Joshua Konig[None]

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This talk presents measurements by the ALICE Collaboration of neutral π^0, η, and ω meson production in proton-proton collisions at $\sqrt{s}$ = 13 TeV. Such measurements can constrain the proton parton distribution functions (PDF) and fragmentation functions (FF), and provide input for background corrections of direct photon and dileption analyses. Measurements of π^0 and η meson distributions within and outside of reconstructed jets are reported, which constrain meson FFs. Distributions of inclusive meson production in multiplicity-selected pp collisions are also reported. Phenomena that are characteristic of quark-gluon plasma (QGP) formation, notably strangeness enhancement and the presence of collective flow, have been observed previously in high-multiplicity pp collisions. These new measurements provide additional insight into particle production and hadron chemistry, and the formation of the QGP in small systems.

Track2-HF&Q / 246

Quarkonium dynamics in the quantum Brownian regime with non-abelian quantum master equations

Auteurs: Stéphane Delorme[1]; Aoumeur Daddi Hammou[2]; Jean-Paul Blaizot[3]; pol bernard gossiaux[4]; Thierry Gousset[2]; Roland Katz[4]

[1] *IFJ PAN*

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Being able to deal with the most acurate methods to describe the $Q\bar{Q}$ evolution in a Quark Gluon Plasma is a prerequisite to match the precise quarkonium measurements of all URHIC experiments. Following our recent work 1, we present exact numerical solutions in a one-dimensional setting of quantum master equations previously derived in [2].

We focus on the dynamics of a single $Q\bar{Q}$ pair in a Quark-Gluon Plasma in thermal equilibrium, in the so-called quantum Brownian regime where the temperature of the plasma is large in comparison with the spacing between the energy levels of the $Q\bar{Q}$ system. The one-dimensional potential used in the calculations [2] has been adjusted so as to produce numbers that are relevant for the phenomenology of the charmonium.

The equations are solved using different initial states and medium configurations. Various temperature regimes are studied and the effects of screening and collisions thoroughly analyzed. Distinctive features of the $Q\bar{Q}$ evolution with the quantum master equations are presented. Some phenomenological consequences are addressed by considering evolutions of a single $b\bar{b}$ in both Bjorken scenario and EPOS4 temperature profiles.

Semiclassical approximation has been recently used [1,4] to describe charmonium production in URHIC, where many $c\bar{c}$ are implied. Obtaining an estimate of the systematic error attached to this

approximation is of crucial importance to assess the agreement with experimental data. In the second part of the talk, we investigate the accuracy of the SC approximation by benchmarking the corresponding evolutions on the exact solutions derived with the QME for the case of a single $c\bar{c}$ pair.

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4. D.Y. Arrebato Villar et al., Phys.Rev.C 107 (2023) 5, 054913

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Bridging Nuclear and Quark Matter: A Quantum van der Waals Approach to Quarkyonic Transition

Auteur: Roman Poberezhnyuk[1]

Co-auteurs: Horst Stoecker [2]; Tripp Moss [3]; Volodymyr Vovchenko [3]

[1] *Frankfurt Institute for Advanced Studies*

[2] *Frankfurt Institute for Advanced Studies FIAS Goethe Universitaet Frankfurt am Main and GSI Darmstadt Deutschland*

[3] *University of Houston*

We extend the Quantum van der Waals description of nuclear matter at zero temperature to a high baryon density region by incorporating the continuous transition to quark matter in accordance with the recently proposed quarkyonic approach 1. The nucleon-nucleon interaction parameters are fixed from the empirical properties of the nuclear ground state. The resulting equation of state exhibits the nuclear liquid-gas phase transition at $n_B \leq {}_0$ and undergoes a transition to quarkyonic matter at densities n_B $1.5{-}2\rho_0$ that are reachable in intermediate energy heavy-ion collisions. The transition is accompanied by a peak in the sound velocity. The results depend only mildly on the chosen excluded volume mechanism but do require the introduction of an infrared regulator Λ to avoid an acausal sound velocity. We also consider the recently proposed baryquark matter scenario for the realization of the Pauli exclusion principle, which yields a similar equation of state and turns out to be energetically favored in all the considered setups. The approach is extended to isospin asymmetric matter with applications to neutron star phenomenology [2] and can be generalized to finite temperatures relevant for binary neutron star mergers.

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Track2-HF&Q / **248**

Measurement of D^0 Meson Tagged Jets in Au+Au Collisions at $\sqrt{s_{\mathrm{NN}}} = 200$ GeV

Auteurs: Barbara Antonina Trzeciak[1]; Ondrej Lomicky[None]

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Auteur correspondant lomicond@fjfi.cvut.cz

The Quark-Gluon Plasma (QGP) produced in heavy-ion collisions can be studied using hard probes, such as D^0-meson tagged jets created at the initial collision stage. The jet yield, shape, and its substructure get modified due to interactions with the medium compared with its vacuum propagation. This phenomenon is known as jet quenching.

The transverse momentum (p_T) fraction of the jet, carried by hadrons along the jet axis ($z = \vec{p}_{\mathrm{T,hadron}} \cdot \vec{p}_{\mathrm{T,jet}}/|p_{\mathrm{T,jet}}|^2$), is related to jet fragmentation. The generalized angularities λ_α^κ characterize the jet substructure and they can distinguish jets initiated by light and heavy quarks, and gluons where the different choice of κ and α parameters tunes the sensitivity of the observable to various jet aspects. Measurements of the nuclear modification factor R_{CP} of D^0 jets as a function of the transverse momentum fraction z and the generalized angularities in heavy-ion collisions open ways to investigate modifications of heavy quark fragmentation function and jet substructure in the QGP. In addition, studying radial distribution of D^0 mesons in jets allows one to investigate the charm quark diffusion in the medium.

In this contribution, we report the measurement of D^0 meson tagged jets in Au+Au collisions at $\sqrt{s_{\mathrm{NN}}} = 200$ GeV by the STAR experiment at RHIC. We present R_{CP} as a function of $p_{\mathrm{T,jet}}$ and z, measurements of generalized angularities, and the radial profile of the D^0 mesons for D^0 jets. These results may help distinguish between various models describing jet quenching and heavy flavor quark in-medium energy loss.

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Renormalizing Lattice Spacing Dependence

Auteur: Nadine Attieh[1]

Co-auteurs: Marcus Bluhm ; Marlene Nahrgang ; Masakiyo Kitazawa ; Nathan Touroux ; Taklit Sami

[1] *Subatech*

Heavy ion collisions that aim to probe phase transitions and critical phenomena require robust predictions for fluctuation observables. Today, a major challenge preventing the systematic study of event-by-event stochastic dynamical models for critical fluctuations in heavy-ion collisions is the lattice spacing dependence of physical observables. It arises from discretizating such models, which effectively cuts off the UV modes.
In this presentation, we show the first systematic renormalization of this unphysical lattice spacing dependence in fluctuation observables. In order to study fluctuation dynamics of trajectories near the QCD critical point in heavy ion collisions, we take a stochastic relaxation equation of the chiral field, in the framework of model A in the Hohenberg-Halperin classification, with a Ginzburg-Landau effective potential. We show the noise-induced lattice spacing dependence in the variance and kurtosis of chiral fluctuations. We then introduce an appropriate lattice counterterm to cure this unphysical sensitivity for evolutions not too far from equilibrium. In addition, lattice renormalization recovers expected physics near the critical point during dynamics: a large but finite correlation length and non-zero values of the kurtosis. Finally, we comment on the prospect of extending this approach to stochastic hydrodynamics.

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Multi-particle cumulant J/ψ v_2 measurement in Pb–Pb with the ALICE experiment

Auteur: Victor Valencia[1]

[1] *Subatech - Nantes*

The quark-gluon plasma (QGP) produced in ultrarelativistic heavy-ion collisions has exhibited properties of a mostly perfect fluid. These properties can be observed through the hydrodynamic expansion of the QGP. Experimentally, this was established by measuring azimuthal anisotropies in the final state, known as elliptic flow (v_2) or higher order harmonics such as triangular flow (v_3). These Fourier harmonic coefficients have been extensively measured in past experiments using inclusive charged particles or identified particles in the soft sector. Interestingly, measuring such coefficients using hard probes, such as quarkonia, brings additional information about heavy-quarks production and thermalization in the QGP. While the suppression of loosely bound quarkonia in QGP was observed back to the first measurements at SPS, using LHC Run 1 and 2 data, the J/ψ flow measurements shed new light on quarkonia production through the existence of regeneration mechanisms. Nevertheless, the existing measurements may suffer from non-flow contamination (such as jets or di-jets). Thanks to the new ALICE data-taking strategy in LHC Run 3, new opportunities for more precise and refined measurements are now possible. In particular, multiparticle cumulant analysis can be carried out to extract J/ψ flow with the advantage of further suppressing non-flow contributions. In this poster, the analysis strategy on Run 3 Pb–Pb is described. In addition, preliminary results on J/ψ v_2 in Pb–Pb collisions at $\sqrt{s_{\mathrm{NN}}} = 5.36\ TeV$ at forward rapidity (2.5 < y < 4) will be presented and discussed using various measurement techniques, as multiparticle cumulants.

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Event-by-event Multistage Heavy-ion Collisions with Initial Strangeness

Auteurs: Jan Fotakis[1]; Jie Zhu[2]; Oscar Garcia-Montero[3]; Sören Schlichting[4]; Travis Dore[4]

[1] *Goethe University Frankfurt*

[2] *Central China Normal University*

[3] *Universität Bielefeld*

[4] *University of Bielefeld*

We employ a novel event-by-event multistage framework for simulating heavy-ion collisions which includes finite baryon number, electric charge, and strangeness due to fluctuations in the initial state. This novel framework generates an initial condition using the McDIPPER saturation based event generator which has been upgraded to include charge fluctuations, followed by pre-equilibrium evolution in QCD kinetic KoMPoST with conserved charges. This is then followed with BSQ hydrodynamic evolution including diffusion so that we may compare to relevant observables. We showcase results that are directly related to the finite B, S, and Q charges in the initial state.

Track7-OthTop / 252

Pre-equilibrium photons from the early stages of heavy-ion collisions

Auteurs: Aleksas Mazeliauskas[1]; Oscar Garcia-Montero[2]; Philip Plaschke[3]; Sören Schlichting[4]

[1] *CERN Theoretical Physics Department*

[2] *Universität Bielefeld*

[3] *Bielefeld University*

[4] *University of Bielefeld*

We use QCD kinetic theory to compute photon production in the chemically equilibrating Quark-Gluon Plasma created in the early stages of high-energy heavy-ion collisions. We do a detailed comparison of pre-equilibrium photon rates to the thermal photon production. We show that the photon spectrum radiated from a hydrodynamic attractor evolution satisfies a simple scaling form

in terms of the specific shear viscosity and entropy density. We confirm the analytical predictions with numerical kinetic theory simulations. We use the extracted scaling function to compute the pre-equilibrium photon contribution in central PbPb collisions. We demonstrate that our matching procedure allows for a smooth switching from pre-equilibrium kinetic to thermal hydrodynamic photon production. Finally, our publicly available implementation can be straightforwardly added to existing heavy ion models.

Ref.: Garcia-Montero, Mazeliauskas, Plaschke, Schlichting, 2308.09747

Track7-OthTop / **253**

Bayesian uncertainty quantification of perturbative QCD input to the neutron-star equation of state

Auteurs: Aleksas Mazeliauskas[1]; Aleksi Kurkela[2]; Oleg Komoltsev[2]; Tyler Gorda[3]

[1] *Institute for Theoretical Physics, Heidelberg University*

[2] *University of Stavanger*

[3] *TU Darmstadt*

Auteur correspondant aleksas.mazeliauskas@cern.ch

The equation of state of neutron-star cores can be constrained by requiring a consistent connection to the perturbative Quantum Chromodynamics (QCD) calculations at high densities. The constraining power of the QCD input depends on uncertainties from missing higher-order terms, the choice of the unphysical renormalization scale, and the reference density where QCD calculations are performed. Within a Bayesian approach, we discuss the convergence of the perturbative QCD series, quantify its uncertainties at high densities, and present a framework to systematically propagate the uncertainties down to neutron-star densities. We find that the effect of the QCD input on the neutron-star inference is insensitive to the various unphysical choices made in the uncertainty estimation.

Ref.: Gorda, Komoltsev, Kurkela, Mazeliauskas, 2303.02175, JHEP

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Prompt/Non-prompt J/ψ separation performances with ALICE

Auteur: Emilie BARREAU[1]

[1] *Subatech, Plasma Group*

The ALICE experiment changed its data-taking strategy from triggered to continuous detector readout and underwent several detectors upgrades, in order to cope with the LHC Run3 luminosity increase and maximize the amount of data collected. Among the aforementioned upgrades, the installation of the new muon forward tracker (MFT) enriches the study of quarkonium production previously carried out with the ALICE muon spectrometer at forward rapidity ($2.5 < y < 4$). In particular, thanks to its high spatial resolution, the MFT allows to identify the quarkonia directly produced at the collision (prompt) from those coming from beauty hadron decays (non-prompt). This separation is critical to enlarge our knowledge of heavy-quark production both in pp and heavy-ion collisions. Experimentally, the prompt/non-prompt separation performance relies on highly efficient track matching between the MFT and the muon spectrometer, together with the precise determination of the secondary vertex. In this poster, prompt and non-prompt J/ψ separation performances at forward rapidity ($2.5 < y < 3.6$) in pp collisions at $\sqrt{s} = 13.6$ TeV will be presented.

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How far can we see back in time in high-energy collisions using charm?

Auteurs: Gergely Barnafoldi[1]; Gábor Bíró[1]; Laszlo Gyulai[None]; Róbert Vértesi[1]

[1] *HUN-REN Wigner RCP*

Auteur correspondant gyulai.laszlo@wigner.mta.hu

We use open charm production to estimate how far we can see back in time in high-energy hadron-hadron collisions. We analyze the transverse momentum distributions of the identified D mesons from pp, p–Pb and A–A collisions at the ALICE and STAR experiments covering the energy range from $\sqrt{s_{NN}}$ = 200 GeV up to 7 TeV. While the low-momentum part of the spectra can be associated with particles stemming from a thermal equilibrium, the high-momentum regime follows a power-law-like distribution, resulting from perturbative QCD hadron production. Recent non-extensive thermodynamical models, however, are able to successfully describe the spectra within a unified framework 1. We discuss the consistency of the resulting Tsallis temperature and non-extensivity parameter, and compare them to the ones of light-flavour hadrons. These results allow us to estimate the production time of D mesons in relation to the light-flavour hadrons [2].

1 G. Bíró, G. G. Barnaföldi, T. S. Bíró, J. Phys. G: Nucl. Part. Phys. 47 (2020) 105002
[2] L. Gyulai, G. Bíró, R. Vértesi, G. G. Barnaföldi, preprint: arXiv:2401.14282 [hep-ph]

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b-jet production using heavy flavor tagging in pp collisions at 13.6 TeV with ALICE

Auteur: Hanseo Park[1]

[1] *University of Tsukuba*

This study focuses on measuring b-jet production in pp collisions at 13.6 TeV with the ALICE detector at the LHC. The accurate identification of b-jets is crucial for understanding heavy-flavor quark fragmentation. To achieve this, we apply heavy flavor tagging techniques, including track counting and the secondary vertex method. These techniques significantly enhance the precision of b-jet measurements. Looking forward, we anticipate these methods will be integral in developing machine learning models to further improve detection efficiency. This study highlights the importance of b-jet production measurements and the effectiveness of tagging techniques.

Track5-UpFut / 257

Perspectives on (multi-strange) hypernuclei physics with the CBM experiment at FAIR

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The CBM experiment at FAIR aims to explore dense nuclear matter near the predicted quark-gluon plasma phase transition. Studying the production and decay of (multi-strange) hypernuclei in this

extreme environment offers unique insights into hyperon-nucleon and hyperon-hyperon interactions, crucial for understanding the nuclear equation of state at high densities and the structure of neutron stars.
CBM's unprecedented world-record interaction rate, combined with high-precision tracking and particle identification, enables comprehensive measurements of rare hypernuclei. This capability extends to two and three-body decays with neutral daughters, significantly expanding the accessible decay modes and providing novel constraints on theoretical models.
Feasibility studies demonstrate CBM's ability to measure single and double hypernuclei with high precision. Sophisticated analyses of these data reveal valuable insights into hyperon-hyperon interactions. These studies pave the way for a comprehensive investigation of hypernuclei at FAIR, providing crucial data to unravel the properties of dense nuclear matter.

Track2-HF&Q / 258

Forward rapidity elliptic flow measurements in PHENIX Au+Au collisions at 200 GeV

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Measurements of elliptic flow (v_2) of light and heavy flavor particles can provide key insight into the transport properties and collective behavior of the Quark Gluon Plasma (QGP). The PHENIX experiment at RHIC has a unique coverage at forward rapidity ($1.2 \leq |\eta| \leq 2.2$), and large muon datasets collected during the 2014 and 2016 runs, allowing for statistically significant heavy flavor v_2 measurements in this region at RHIC energies. For J/ψ in this region, smaller charm quark yields are observed hinting that charm quark coalescence, a potential dominating source of J/ψ v_2, may not play a significant role given that the majority of $c\bar{c}$ pairs are produced at mid-rapidity in central collisions. In the forward rapidity region, the v_2 of light hadrons and muons from heavy flavor decays are also measured and the results are compared to measurements at mid-rapidity. Measurements at forward rapidity sample different initial and final state effects and therefore the produced particles may be subject to different pressure gradients. We present final results of J/ψ, open heavy flavor, and charged hadron v_2 measured using the PHENIX muon arms and using the combined high statistic 2014 and 2016 Au+Au datasets. This combination of elliptic flow measurements between various particle species will be the first comprehensive look at heavy flavor dynamics in forward rapidity at RHIC.

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Measurements of neutral meson production and collective flow in Au+Au collisions at 200 GeV with sPHENIX at RHIC

Auteur: Marzia Rosati[1]

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sPHENIX is a next-generation, state-of-the-art particle detector at the Relativistic Heavy-Ion Collider (RHIC) that has recently taken its first dataset of 200 GeV Au+Au collisions during a commissioning run in 2023. From this inaugural dataset, the anisotropic flow (v_n) of neutral pions (pi0's) has been measured for the first time in the sPHENIX detector using the scalar product method. Anisotropic flow is a hallmark signature of the formation of a Quark-Gluon Plasma in ultra-relativistic nucleus-nucleus collisions, and the use of pi0's as the species of interest offers an important opportunity to benchmark the performances of both the sPHENIX Electromagnetic Calorimeter (EMCal) and Minimum Bias Detector (MBD). This talk will present the measurement of pi0 v_2 in different centrality classes with a comparison to previous experimental results at RHIC. Additionally, the status of measuring eta meson production in sPHENIX, important for the further calibration of the EMCal, as well as the charged hadron v_n measured via tracklets reconstructed in the Intermediate Silicon Tracker (INTT), will be reported.

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Measurement of charged-particle multiplicity in Au+Au collisions at 200 GeV with sPHENIX at RHIC

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sPHENIX, the first detector to be built at the Relativistic Heavy-Ion Collider (RHIC) in over two decades, will bring unprecedented measurement capabilities at RHIC energies. One of the initial physics measurements performed by sPHENIX is that of the total charged-particle multiplicity, which utilizes two-point tracklets constructed from clusters in the Intermediate Silicon Tracker (INTT), and is presented for the first time in this talk. This measurement serves to directly validate, based on real collision data, the operational readiness of the INTT readout and clustering methods, as well as the supporting detectors used for event characterization in sPHENIX. Additionally, this measurement provides a key diagnostic tool for acceptance, alignment, and vertex finding, which are critical components of the full tracking system that will enable the entire physics program of sPHENIX. The measurement of charged-particle multiplicity will be presented and discussed in the context of previous measurements at RHIC energies and the latest models of bulk particle production in heavy-ion collisions.

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Measurement of $dE_T/d\eta$ in Au+Au collisions at 200 GeV with sPHENIX at RHIC

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The transverse energy in heavy ion collisions is one of the key observables characterizing global properties of the Quark-Gluon Plasma (QGP). The transverse energy per unit pseudorapidity ($dE_T/d\eta$) probes the energy carried by the medium along the longitudinal direction, providing essential information related to the initial geometry and subsequent hydrodynamic evolution of the QGP. Such studies are facilitated using recent data collected by the sPHENIX detector during the RHIC commissioning run in 2023 with Au+Au collisions at nucleon-nucleon center-of-mass energy of 200 GeV. The sPHENIX calorimeter system, comprising Electromagnetic and Hadronic Calorimeter detectors, covers a wide rapidity acceptance region as well as the full azimuthal phase space. This setup provides the capability for high-resolution measurements of photons, electrons, jets, and hadrons, and also allows particularly detailed $dE_T/d\eta$ measurements with high precision. This talk reports the first measurements of $dE_T/d\eta$ with the sPHENIX detector, which are also the first results for that observable at RHIC using a hadronic calorimeter. The results are presented in various centrality intervals and compared to the latest theoretical models, which will impose strong constraints on centrality-dependent particle production and initial conditions of the collisions at RHIC energies.

Track2-HF&Q / 262

Prospects for heavy flavor physics and commissioning of the tracking system in Run-24 with sPHENIX at RHIC

Auteurs: Huan Huang[1]; Marzia Rosati[2]

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sPHENIX is an exciting new experiment recently constructed at the Relativistic Heavy Ion Collider (RHIC) that will allow for the study of high precision heavy flavor (HF) observables of the Quark-Gluon Plasma (QGP), with capabilities not previously available at RHIC. The tracking system of sPHENIX is made up of four detectors working together in a hybrid streaming mode, which are the MAPS vertex detector (MVTX), intermediate silicon tracker (INTT), time projection chamber (TPC), and TPC outer tracker (TPOT). sPHENIX also includes a large acceptance, hermetic calorimeter system which features the first barrel hadronic calorimeter at RHIC. This state-of-the-art system enables the study of high statistics, unbiased heavy flavor samples, including fully reconstructed heavy flavor jets with high precision. The first sPHENIX physics run is scheduled to begin in April 2024, following a commissioning run in 2023. In this talk, we will present the progress made in the commissioning of the tracking system with collision data, the roadmap towards the first HF physics results at sPHENIX, and performance projections for the entire HF physics program.

Track5-UpFut / 263

Intelligent experiments through real-time AI: Fast Data Processing and Autonomous Detector Control for sPHENIX and future EIC detectors

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This new DOE FOA project, first funded by the DOE Office of Science Nuclear Physics AI-Machine Learning initiative in 2022, focuses on leveraging cutting-edge AI technology to address the data processing challenges posed by high-energy nuclear experiments, such as those at RHIC, LHC, and the future EIC. We first aim to develop a demonstrator to process high-rate data streams from sPHENIX experiment tracking detectors in real-time to identify rare heavy flavor events in p+p collisions. Our approach integrates real-time readouts and an intelligent control system, accelerating AI inference with FPGA hardware. This enables the efficient collection of rare heavy-flavor events in high-rate p+p collisions (~1MHz), optimizing the use of limited DAQ bandwidth (~15kHz). The project employs Graph Neural Network-trigger algorithms, trained with sPHENIX p+p collision simulation data, and leverages the hls4ml package for AI model conversion into Firmware. Real-time AI technologies are deployed on powerful FELIX-712 boards with Xilinx Kintex Ultrascale FPGA. Successful deployment of a demonstrator at sPHENIX promises immediate benefits, minimizing computation resources, and accelerating the end-to-end pipeline from experiments to physics discovery, in particular, heavy-flavor measurements in p+p and possibly p+Au collisions. The approach is transferable to other fields requiring high-throughput data streams and real-time detector control, including future EIC experiments. For the EIC, we are developing a DIS-electron tagger using AI-ML algorithms for real-time identification of DIS electrons and characterization of global kinematics. In this talk, we highlight the latest progress in AI-intelligent heavy-flavor triggering for sPHENIX and DIS electron tagger algorithm development for EIC, demonstrating the transformative potential of AI and FPGA technologies in high-energy nuclear and particle experiments' real-time data processing pipelines.

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Development and Simulation of Backward Hadronic calorimeter for the ePIC detector at EIC

Auteur: Alexandr Prozorov[1]

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The Electron-Ion Collider (EIC) is a future particle accelerator at Brookhaven National Laboratory. It will provide physicists with high luminosity and highly polarized beams with a wide range of nuclei species at different energies, covering an extensive kinematic range, which will provide unprecedented access to the spatial and spin structure of proton, neutron, and light ions. The EIC physics goals include measuring the Generalized Parton Distribution, performing precision 3D imaging of the nuclei structure, and studying color confinement and hadronization mechanisms.

The backward hadronic calorimeter (backward/negative HCal) for the Electron-Proton/Ion Collider (ePIC) is a tail-catcher type calorimeter under development, which is to be located in the electron-going direction. In order to meet the physics goals of the EIC, a high position resolution backward hadronic calorimeter is needed to measure and distinguish charged and neutral hadronic showers coming from jets originating from fragmentation of small-x partons. The planned design type is a sandwich calorimeter with alternating layers of non-magnetic steel and plastic scintillator with wavelength-shifting fibers (Fe/SciFi). The light readout will be provided by Silicon Photomultipliers. It will cover the pseudorapidity range $-3.5 < \eta < -1.2$. A performance study of backward Hcal is ongoing for geometry, material, and energy resolution on the basis of the existing simulation framework for high-energy experiments. We will present a study of position resolution and neutron detection efficiency.

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Jet-soft correlations in event-by-event hydrodynamic evolution

Auteurs: Leonardo Barreto de Oliveira Campos[1]; Fabio de Moraes Canedo[1]; Maria M. M. Paulino[1]; Jacquelyn Noronha-Hostler[2]; Jorge Noronha[2]; Marcelo G. Munhoz[1]

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Collective flow and energy loss are two of the most important tools to study the Quark-Gluon Plasma formed in relativistic heavy ion collisions. Collective flow is usually explored through soft particles correlations while energy loss studies normally uses hard probes, as heavy flavor quarks or jets coming from hard scattering of partons. However, the interplay between these two ways of studying the Quark-Gluon Plasma can have an important role. We expand upon those studies by discussing the dialogue between soft and hard scales via reconstructed jets and their azimuthal flow, as they provide complex insights into medium response and path-length dependence of energy loss.

This contribution employs realistic event-by-event (2+1)D v-USPhydro hydrodynamic profiles with \tr initial conditions, in which JEWEL medium-modified parton showers propagate through. We combine the azimuthal distribution of thermal particles and anti-k_T jets to analyze jet-soft correlations and its features given the event-by-event medium fluctuations and jet quenching. Calculations for jet anisotropic flow coefficients v_n in multiple centralities classes will be shown, providing an extension of established results 1, in addition to jet spectra event-shape engineered collisions compared to newly released ALICE measurements.

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Track1-LF / **266**

Analysis of charged kaon flow in Ag+Ag collisions registered with HADES

Auteur: Jan Orliński[1]

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Charged kaons –mesons containing one (anti)strange quark –are predicted to be good probes of the Equation of State (EoS) of nuclear matter and possible changes of basic properties of kaons (like mass and decay constant) in hot and dense nuclear matter [1, 2]. These effects can be studied by comparing measured data to model calculations and the anisotropies of the azimuthal angle (flow) are expected to be particularly sensitive to them. Previous flow analyses of kaons, K^- in particular, were hampered by limited statistics [3].

The High Acceptance Di-Electron Spectrometer (HADES) [4] Collaboration carried out Ag+Ag collisions at beam energy of 1.58 GeV/nucleon and collected an unprecedented number of 10 billion events. This allows to study the flow of K^+ and K^- mesons with statistical errors smaller than before. Together with the high acceptance of the HADES setup, the analysis could significantly advance our understanding of the properties of hot and dense nuclear matter.

In this contribution, the preliminary results on transverse flow of K^+ and K^- mesons emitted from Ag+Ag collisions measured with HADES will be presented as maps of $v_{1,2}(p_T, y)$. The contribution will also include the corresponding raw (p_T, y) distribution and an overview of efficiency challenges specific to the measurement of flow.

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Track4-Bulk&Phase / **268**

Equilibrium expectations for non-Gaussian fluctuations near a QCD critical point

Auteurs: Jamie Karthein[1]; Krishna Rajagopal[2]; Maneesha Pradeep[3]; Mikhail Stephanov[4]; Yi Yin[5]

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With the highly anticipated results from the Beam Energy Scan II program at RHIC coming soon, an understanding of particle-number fluctuations and their significance as a potential signature of a possible QCD critical point is crucial. Early works that embarked on this endeavor sought to estimate the fluctuations due to the presence of a critical point assuming they stay in equilibrium

[1,2]. From these results came the proposal to focus efforts on higher, non-Gaussian, moments of the event-by-event distributions, in particular of the number of protons. These non-Gaussian moments are especially sensitive to critical fluctuations, as their magnitudes are proportional to high powers of the critical correlation length. As the equation of state provides key input for hydrodynamical simulations of heavy-ion collisions, we estimate equilibrium fluctuations from the BEST equation of state (EoS) that includes critical features from the 3D Ising Model [3,4,5]. In particular, the net-baryon kurtosis and its dependence on non-universal mapping parameters is investigated within the BEST EoS [6]. Furthermore, the correlation length, as a central quantity for the assessment of fluctuations in the vicinity of a critical point, is also calculated in a consistent manner with the scaling equation of state. We propose a new parameterization of the critical correlation length in terms of the same parametric variables (R, θ) used for the BEST EoS, consistent with the ⊠-expansion. Additionally, we study how these parametrizations of the correlation length could be used to calculate critical cumulants, updating the early work of 1. These will be useful for further comparison to estimates of out-of-equilibrium fluctuations in order to determine the magnitude of the observable fluctuations to be expected in heavy-ion collision experiments, in which the time spent near a critical point is short.

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Track4-Bulk&Phase / 269

Bayes-DREENA for QGP parameter inference from unified high and low-pt data

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Abstract: High-pt theory and data are conventionally utilized to examine interactions of high-pt partons with the Quark-Gluon Plasma (QGP). In contrast, bulk QGP properties are typically inferred from low-pt data and models. Our approach unifies these two domains through a finite-temperature dynamical energy loss DREENA framework, enabling a comprehensive assessment of QGP properties using both high-pt and low-pt data. We will demonstrate how the method can constrain the early evolution of the QGP and analyze the temperature dependence of the shear viscosity to entropy density ratio. By incorporating Bayesian inference within the DREENA framework, we show that using high-pt data jointly with low-pt data leads to parameter distributions within the bounds of those inferred only from low-pt data but are much better constrained. Thus, integrating DREENA within a formal statistical framework (Bayes-DREENA) allows more accurate inferences of QGP properties and utilizes a wide range of available data.

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Finite density QCD equation of state: critical point and lattice-based T′-expansion

Auteur: Micheal Kahangirwe[1]

Co-auteurs: Claudia Ratti [1]; Damien Price [1]; Elena Bratkovskaya [2]; Johannes Jahan [1]; Mikhail Stephanov [3]; Olga Soloveva [4]; Paolo Parotto [5]; Pierre Moreau [6]; Steffen Bass [6]

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We present a novel construction of the QCD equation of state (EoS) at finite baryon density. Our work combines a recently proposed resummation scheme for lattice QCD results with the universal critical behavior at the QCD critical point. This allows us to obtain a family of equations of state in the range $0 \leq \mu_B \leq 700$ MeV and $25 \leq T \leq 800$ MeV, which match lattice QCD results near $\mu_B = 0$ while featuring a critical point in the 3D Ising model universality class. The position of the critical point can be chosen within the range accessible to beam-energy scan heavy-ion collision experiments. The strength of the singularity and the shape of the critical region are parameterized using a standard parameter set. We impose stability and causality constraints and discuss the available ranges of critical point parameter choices, finding that they extend beyond earlier parametric QCD EoS proposals. We present thermodynamic observables, including baryon density, pressure, entropy density, energy density, baryon susceptibility and speed of sound, that cover a wide range in the QCD phase diagram relevant for experimental exploration.

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Rapidity scan approach for net-baryon cumulants with a statistical thermal model

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Utilizing rapidity-dependent measurements to map the QCD phase diagram provides a complementary approach to traditional beam energy-dependent measurements around midrapidity. The changing nature of thermodynamic properties of QCD matter along the beam axis in heavy-ion collisions at low collision energies both motivate and pose challenges for this method. In this study, we derive the analytical cumulant-generating function for subsystems within distinct rapidity windows, while accounting for global net-baryon charge conservation of the full system. Rapidity-dependent net-baryon cumulants are then calculated for a system exhibiting inhomogeneity along the beam axis, and their sensitivity to finite acceptances through changing rapidity bin widths is explored. We highlight the non-trivial behaviors exhibited by these cumulants, underscoring their importance in establishing a non-critical baseline for interpreting net-proton cumulants in the search for the QCD critical point. Finally, we discuss the implications of the rapidity scan for mapping the QCD phase diagram within the current context.

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$U_A(1)$ symmetry restoration at high baryon density

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Co-auteurs: Jin Gui ; Pengfei Zhuang [2]

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We study the relation between chiral and $U_A(1)$ symmetries in the quark-meson model. Although quarks and mesons are described in mean field approximation, the topological susceptibility characterizing the $U_A(1)$ breaking comprises two components: one controlled by the condensate and the other by the meson fluctuation. The $U_A(1)$ restoration is governed by the competition of these components. In a hot medium, the condensates melt. However, the fluctuation is enhanced. Therefore, the $U_A(1)$ symmetry cannot be solely restored via the temperature effect. Nevertheless, the baryon density reduces the condensates and fluctuation, and thereby, the $U_A(1)$ symmetry can only be restored in a dense or dense and hot medium. The strange condensate plays a weak role in the susceptibility, and the chiral and $U_A(1)$ symmetry restorations occur almost at the same critical point.

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Non-prompt J/ψ production as a function of charged-particle multiplicity in pp collisions at $\sqrt{s} = 13$ TeV with ALICE

Auteur: Wenda Guo[1]

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The study of the production of non-prompt J/ψ, originating from the decay of beauty hadrons, besides allowing to isolate the prompt J/ψ cross section from the inclusive J/ψ cross section, can be used to estimate open beauty quark production. Heavy-flavour particle production in pp collisions as a function of charged-particle multiplicity can provide insight into the processes occurring in the collision at the partonic level, as well as the interplay between the hard and soft mechanisms in particle production.
In this contribution, the measurements of the non-prompt J/ψ fraction as a function of charged-particle pseudorapidity density ($\mathrm{d}N_{\mathrm{ch}}/\mathrm{d}\eta$) in pp collisions at $\sqrt{s} = 13$ TeV with ALICE are reported. J/ψ mesons are reconstructed at midrapidity ($|y| < 0.9$) in the dielectron decay channel. Events are classified based on the charged-particle multiplicity at midrapidity ($|\eta| < 1$). The multiplicity reach is seven times larger than the average charged-particle multiplicity of inelastic collisions, thanks to the usage of high-multiplicity triggered events. The measurement of the fraction of non-prompt J/ψ is performed via unbinned maximum likelihood fit down to $p_{\mathrm{T}} = 1$ GeV/c. The prompt and non-prompt J/ψ yield extraction as a function of $\mathrm{d}N_{\mathrm{ch}}/\mathrm{d}\eta$, both normalized to the corresponding multiplicity integrated quantities, will also be shown.

Track3-Res&Hyp / 275

Production of light nuclei in Au+Au collisions with the STAR BES-II program

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The production mechanism of light (anti-)nuclei in heavy-ion collisions can be either by the thermal model or the coalescence model. By studying the yields and ratios of light (anti-)nuclei, we can gain insight into their production mechanism and physical properties of the expanding system at freeze-out. Furthermore, the enhancement in the light nuclei compound ratios such as $N_t N_p / N_d^2$ and $N_{^3He} N_p / N_d^2$ from the coalescence baseline, has been suggested as a potential probe to search for the critical phenomena in the QCD phase diagram. This enhancement might be a consequence of the enhanced baryon density fluctuations when the system is in vicinity of the critical point or the first-order phase transition. In the first phase of the Beam Energy Scan (BES-I) program at RHIC, an enhancement relative to the coalescence baseline of the light nuclei yield ratio ($N_t N_p / N_d^2$) is observed in the most central Au+Au collisions at $\sqrt{s_{NN}}$ = 19.6 and 27 GeV with a combined significance of 4.1σ. The large datasets ($\sim$ 10$\times$BES-I) taken by the STAR BES-II with enhanced detector capabilities will greatly improve the precision of the new measurements.

In this talk, we will present the centrality and energy dependence of transverse momentum (p_T) spectra of p, $\bar{p}$, d, $\bar{d}$, and ^3He in Au+Au collisions at BES-II energies of $\sqrt{s_{NN}}$ = 7.7 – 27 GeV. We will also report the centrality and energy dependence of integrated particle yields (dN/dy) and mean p_T ($\langle p_T \rangle$) of light nuclei. We will discuss the centrality and p_T dependence of the coalescence parameters ($B_2(d)$ and $B_3(^3He)$). The physics implications of these results will be discussed.

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Exploring the $\Lambda(1520)$ resonance in high-multiplicity proton–proton collisions at LHC energies with ALICE

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Resonances play a crucial role in probing the characteristic of the hadronic phase, created in ultra-relativistic heavy-ion collisions. Rescattering and regeneration processes influence the measurable resonance yields and p_{T} spectra shapes. Measurements of resonance productions in high-multiplicity pp collisions could provide insight into the possible presence of a hadronic phase in small collision systems. The $\Lambda(1520)$ resonance, with a lifetime of approximately 13 fm/c, provides additional insights into the hadronic phase compared to the K^{*0} (4 fm/c) and ϕ (46 fm/c) resonances. This contribution presents recent measurement of $\Lambda(1520)$ resonance production in high-multiplicity pp collisions, including p_{T} integrated yield ($\frac{dN}{dy}$), mean transverse-momentum ($\langle p_T \rangle$), and particle yield ratios as a function of charged-particle multiplicity.

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Search for the Chiral Magnetic Effect by Event Shape Engineering Differentially in Invariant Mass in Au+Au Collisions at $\sqrt{s_{NN}}$ = 200 GeV from STAR

Auteur: Sooraj Radhakrishnan[1]

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Chiral Magnetic Effect (CME) is a phenomenon in which electric charge is separated by a strong magnetic field from local domains of chirality imbalance and parity violation in quantum chromodynamics (QCD). The CME-sensitive observable, charge-dependent three-point azimuthal correlator

$\Delta\gamma$, is contaminated by a major physics background proportional to the particle elliptic anisotropy (v_2). In this talk, we report a brand-new analysis from STAR on charge separation using the Event Shape Engineering (ESE) approach 1, projecting $\Delta\gamma$ to zero v_2 to obtain the CME-sensitive intercept. Our approach has several novel aspects: (1) we use three subevents to select on dynamical fluctuations of v_2 by separating particles of interest from ESE selection; (2) we apply the ESE method differentially as a function of the pair invariant mass (m_{inv}) since CME is a low-p_{T} phenomenon and hence more sensitive to lower mass; and (3) we consider remaining nonflow contamination in the extracted intercept from two and three-particle correlations using data-driven approach and HIJING simulations [2], and also report measurement using the zero-degree calorimeter that largely supresses nonflow. We validate our differential ESE method with a toy model and simulations by Anomalous-Viscous Fluid Dynamics (AVFD) [3]. We report preliminary results in Au+Au collisions at $\sqrt{s_{\mathrm{NN}}} = 200$ GeV from STAR.

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Exploring inelastic and elastic parton interactions and transport properties of the strongly interacting quark-gluon plasma

Auteurs: Ilia Grishmanovskii[1]; Olga Soloveva[1]; Taesoo Song[None]; Carsten Greiner[1]; Elena Bratkovskaya[2]

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We investigate the role of inelastic processes in the strongly interacting quark-gluon plasma (sQGP) within the effective dynamical quasi-particle model (DQPM). In the DQPM the non-perturbative properties of the sQGP at finite temperature T and baryon chemical potential μ_B are described in terms of strongly interacting off-shell partons (quarks and gluons) with dynamically generated spectral functions whose properties are adjusted to reproduce the lQCD EoS for the QGP in thermodynamic equilibrium. For the first time the massive gluon radiation processes from the off-shell quark-quark ($q+q$) and quark-gluon ($q+g$) scatterings are calculated explicitly within leading order Feynman diagrams with effective propagators and vertices from the DQPM without any further approximations. We present the results for the energy, temperature and μ_B dependencies of the total and differential radiative cross sections and compare them to the corresponding elastic cross sections. Moreover, we present estimates for the transition rate and relaxation time of radiative versus elastic scatterings in the sQGP. We also present the results for the jet transport coefficients such as the transverse momentum transfer squared $\hat{q}$ per unit length as well as the energy loss $\Delta E = dE/dx$ per unit length in the sQGP and investigate their dependence on the temperature T and momentum of the jet parton depending on the choice of the strong coupling constant α_s in thermal, jet parton and radiative vertices. For the latter we consider different scenarios used in the literature and find a very strong dependence of $\hat{q}$ and ΔE on the choice of α_s. Finally, we explore the relation of $\hat{q}/T^3$ to the ratio of specific shear viscosity to entropy density η/s and show that the ratio $T^3/\hat{q}$ to η/s has a strong T dependence – especially when approaching to T_c – on the choice of α_s in scattering vertices.

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Tensor polarization and spectral properties of vector meson in QCD medium

Auteur: Shuai Liu[1]

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We calculate the tensor polarization and the resulted spin alignment of a generic vector meson in local equilibrium up to the first order in hydrodynamic gradients using thermal field theory with dissipative effects incorporated. Several new contributions, including a novel shear-induced tensor polarization (SITP), are discovered and turn out sensitive to the in-medium spectral properties of the vector mesons. The phenomenological study reveals that these contributions, especially SITP, could generate substantial spin alignment in heavy-ion collisions, and potentially helps us to understand the large spin alignment observed in experiments. The talk will be mostly based on our work 1 with several updates on phenomenological implications.

1arXiv:2206.11890

Track2-HF&Q / 281

Heavy flavor production under a strong magnetic field

Auteur: Shile Chen[1]

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The strong magnetic field created in high energy nuclear collisions will affect the dynamical processes in the QCD medium, especially the heavy quark production that happens in the initial stage of the collisions. In this talk, I will discuss the heavy quark production cross section for the elementary process $gg \to Q\bar{Q}$ at leading order and the corresponding transverse momentum distribution in nucleus-nucleus collisions in both strong magnetic field and weak field limit. The main difference between these two extremes is whether dimension reduction of quark phase space happens and this will contains the production concentrated in a very narrow energy region above the threshold. Since the translation invariance is broken, the production becomes anisotropic in magnetic field. It would be interesting to observe these effects in the experiment.
Ref: arXiv 2401.17559

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Correlations of harmonic flow coefficients at large baryon densities

Auteur: Tom Reichert[None]

Co-auteurs: Apiwit Kittiratpattana ; Jan Steinheimer [1]; Marcus Bleicher [2]; Oleh Savchuk [3]

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Correlations between the harmonic flow coefficients v_1, v_2, v_3 and v_4 of nucleons in peripheral Au+Au collisions at 1.23A GeV are investigated with the Ultra-relativistic Quantum Molecular Dynamics model employing different Equations-of-State (hard Skyrme, soft Skyrme, Chiral-Mean-Field). Using an event-by-event selection based on the final state v_2 it is shown that the triangular flow changes its slope around midrapidity while the quadrangular flow changes its curvature in these different v_2-event classes. The correlations of the flow coefficients are explained with the intricate time dependence of spectator shadowing blocking the early in-plane expansion. The results on the flow correlations thus reveal a strong sensitivity to the EoS which will allow to measure the Equation-of-State at large baryon densities more precisely than is usually possible. Finally the model is used to calculate the first and predict the second order flow coefficients of hypernuclei.

Track4-Bulk&Phase / **283**

Bayesian location of the QCD critical point: a holographic perspective

Auteurs: Andrew Manning[None]; Claudia Ratti[1]; Israel Portillo[None]; Jacquelyn Noronha-Hostler[2]; Joaquin Grefa[1]; Jorge Noronha[2]; Mauricio Hippert[None]; Michael Trujillo[None]; Romulo Rougemont[None]

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We present the first prediction of a QCD critical point (CP) from a Bayesian analysis constrained by first principle results at zero baryon density. We employ the gauge/gravity duality to map QCD onto a theory of dual black holes. Predictions for the CP location in different realizations of the model overlap at one sigma. Even if many prior samples do not include a CP, one is found in nearly 100% of posterior samples, indicating a strong preference for a CP.

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Quantum van der Waals quarkyonic matter at non-zero isospin asymmetry

Auteurs: Max Moss[1]; Roman Poberezhnyuk[2]; Volodymyr Vovchenko[1]

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Quarkyonic matter is a possible realization of dense QCD matter, corresponding to a mixture of hadrons and quarks with a mixed phase in momentum space. Recently, the quantum van der Waals theory of quarkyonic matter was developed [Phys. Rev. C 108 (2023) 045202], indicating that quarkyonic regime in symmetric nuclear matter may occur at densities as low as twice the saturation density, achievable in heavy-ion collisions. Here, we extend the framework to non-zero isospin asymmetries by utilizing the two-component van der Waals equation and separate Fermi surfaces for u and d quarks. We utilize constraints on the symmetry energy and its slope, as well as the neutron stars mass-radius relation to fix the isospin dependence of the van der Waals interaction parameters. We also outline the extension to finite temperatures, which will allow direct applications of the proposed framework to heavy-ion collisions.

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Chiral symmetry breaking and restoration for an accelerated and rotated observer

Auteur: Zhibin Zhu[1]

Co-auteur: Xu-Guang Huang [2]

[1] *FUDAN UNIVERSITY*

[2] *Fudan University*

In the relativistic heavy ion collision experiment, there exist a large acceleration and rapid rotation in the non-central collision which can be considered as a system with acceleration and rotation. According to the Hawking-Unruh effect, the accelerated observer sees himself in a system with Unruh temperature $T = a/2\pi$, where a is the proper acceleration. And the color glass condensate picture predicted that in heavy ion collision the particle under a strong color-electric field with strength $E \sim Q_s^2/g$ (Q_S is the saturation scale, and g is the strong coupling) which will provide a typical acceleration $a \sim Q_s \sim 1GeV$ such that the Unruh temperature $T \sim 200MeV$ which is larger than the pseudo-critical temperature for QCD phase transition. It means that the Unruh effect may play an important role in QCD phase transition. The chiral symmetry breaking and restore for an accelerating observer have been discussed in the past study. As the QGP is the most vortical fluid, QCD matter under rotation has attracted many attentions. In this work we study the chiral symmetry for an observer under both acceleration and rotation.

We study the chiral condensate observed by an accelerated and rotated observer using field theory in general spacetime. We develop the formalism to calculate the chiral condensate using the Nambu-Jona-Lasinio model in accelerating and rotating frame. We solve the gap equation and obtain the chiral condensate as a function of proper acceleration and angular velocity. We also defined a critical acceleration a_c where the chiral symmetry restore. As one of our main results, a_c as a function of rotation angular velocity ω was obtained. And we also study the constituent quark mass and neutral pion condensate in the case with the presence of $a \cdot \omega$. Like the case with the presence of parallel electromagnetic field, we also observe a chiral rotation form the σ-direction toward the π-direction.

Track5-UpFut / 286

Physics of heavy flavors and strangeness with a time-of-flight PID upgrade at CMS in the high-luminosity LHC era

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The intriguing phenomena emerging in the high-density quantum chromodynamics (QCD) matter are being widely studied in the heavy ion program at the LHC and will be understood more deeply during the high-luminosity LHC (HL-LHC) era. The CMS experiment is under the Phase 2 upgrade towards the HL-LHC era. Among others, a new timing detector is proposed with its timing resolution for minimum ionization particles (MIP) to be 30 ps. The MIP timing detector (MTD) will also provide the particle identification (PID) ability with a large pseudorapidity acceptance covering up to $|\eta| < 3$ through time-of-flight (TOF). Combining MTD with the other new subdetectors, i.e., a tracker with acceptance $|\eta| < 4$ and high-granularity calorimeters with acceptance $|\eta| < 5$, will enable deeper studies of high-density QCD matters in ultrarelativistic heavy ion collisions. In this presentation, the performances of a broad range of measurements in the future CMS heavy ion programs will be discussed using TOF-PID. Particular emphasis will be given to the future heavy flavor and strangeness program, including the (3+1)-dimensional evolution of heavy flavor quarks, fluctuations and transport of initially conserved quantum charges, and light nuclei physics.

Track4-Bulk&Phase / 287

Measuring the speed of sound in the QGP with the CMS experiment

Auteur: Michael Murray[None]

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A hot and dense matter exhibiting collective flow behavior with almost no viscous dissipation has been discovered in ultrarelativistic nuclear collisions. To experimentally constrain the equation of state of this matter, we present a measurement of its speed of sound using head-on lead-lead collision data collected by the CMS experiment at a center-of-mass energy per nucleon pair of 5.02 TeV. The measurement uses an analysis of the observed charged multiplicity dependence of the average particle transverse momentum in ultracentral events (impact parameter of nearly zero), a variable which probes the system temperature as a function of entropy density at a fixed volume. Results are compared with hydrodynamic simulations and lattice QCD predictions of the equation of state at high temperatures and small chemical potential. Implications for the exploration of the QCD phase structure and the search for a critical point are discussed.

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Real time, non-perturbative quantum simulations in a strong coupling theory —phase structure, jet production, and charge transport in the Schwinger model

Auteur: Shuzhe Shi[1]

Co-auteurs: Dmitri Kharzeev [2]; Kazuki Ikeda [2]

[1] *Tsinghua University, Beijing, China*

[2] *Stony Brook University*

Addressing QCD processes in a first principle manner requires a real-time, nonperturbative method. It is well known that the Schwinger model [QED in (1+1) dimensions] shares many common properties with QCD, including confinement, chiral symmetry breaking, and the existence of vacuum fermion condensate. As a step in developing such an approach, we report here on fully quantum simulations, using classical devices, of a massive Schwinger model.
In three separate but intrinsically connected works, we study three properties of the strong coupling Schwinger model: the phase structure at finite temperature and chemical potential [Phys.Rev.D 108 (2023) L091501], the chiral condensate modification and entanglement entropy caused by jet propagation [Phys.Rev.Lett. 131 (2023) 021902], and the propagation of vector and axial charge, i.e., nonlinear Chiral Magnetic Wave [Phys.Rev.D 108 (2023) 074001].

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Partonic Critical Opalescence and Its Impact on the Jet Quenching Parameter $\hat{q}$

Auteurs: Feng Li[1]; Shanshan Cao[2]; jing wu[3]

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Jet quenching parameter $\hat{q}$ is essential for characterizing the interaction strength between jet partons and nuclear matter. Based on the quark-meson (QM) model, we develop a new framework for calculating $\hat{q}$ at finite chemical potentials, in which $\hat{q}$ is related to the spectral function of the chiral order parameter. A mean field perturbative calculation up to the one-loop order indicates that the momentum broadening of jets is enhanced at both high temperature and high chemical potential, and approximately proportional to the parton number density in the partonic phase. We further investigate the behavior of $\hat{q}$ in the vicinity of the critical endpoint (CEP) by coupling our calculation with a recently developed equation of state that includes a CEP in the universality class of the Ising model, from which we discover the partonic critical opalescence (PCO) – the divergence of scattering rate of jets and their momentum broadening at the CEP, contributed by scatterings via the σ exchange process. Hence, for the first time, jet quenching is connected with the search of CEP.

Track1-LF / 291

Large isospin symmetry breaking in kaon production at high energies

Auteurs: Francesco Giacosa[1]; Herbert Stroebele[2]; Marek Gazdzicki[3]; Mark Gorenstein[4]; Roman Poberezhnyuk[5]; Subhasis Samanta[None]; Wojciech Brylinski[None]

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It is well known that isospin symmetry is fulfilled to a good approximation in strong interactions, as confirmed in low-energy scattering experiments and in mass spectra of both light and heavy hadrons. In collisions of nuclei with an equal number of protons and neutrons, isospin symmetry imposes that the number of produced charged kaons should equal the number of neutral ones. The NA61/SHINE experiment at CERN recently reported an excess of charged over neutral kaon production in high-energy nucleus-nucleus collisions. Here, we argue that the measured charge-to-neutral kaon ratio of about 1.2 indicates an unexpectedly large violation of isospin symmetry. Using well-established models for hadron production, we demonstrate that known symmetry-breaking effects and the initial nuclei containing more neutrons than protons lead only to a small (few per cent) deviation from unity at high energies. Thus, they cannot explain the measurements. The significance of the isospin symmetry violation beyond the known effects is 5.5·σ when errors quoted by the experiments are used and 8.1 ·σ for the PDG-like scaled errors. New systematic, high-precision measurements and theoretical efforts are needed to establish the origin of the observed large isospin-symmetry breaking.

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Wigner function thermalization —- a quantum simulation of QGP based on the Schwinger Model

Auteurs: Li Yan[1]; Shile Chen[2]; Shuzhe Shi[3]

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[3] *Tsinghua University, Beijing, China*

Thermalization of the quark gluon plasma (QGP) created in relativistic heavy-ion collisions is a crucial theoretical question in understanding the onset of hydrodynamics, and in a broad sense, a key step to the exploration of thermalization in quantum systems.
Addressing this problem theoretically, in a first principle manner, requires a real-time, non-perturbative method. To this end, we carry out a fully quantum simulation on a classical hardware, of a massive Schwinger model, which well mimics QCD as it shares the important properties such as confinement and chiral symmetry breaking. We focus on the real-time evolution of the Wigner function, namely, the two-point correlation function, which approximates quark momentum distribution, etc. Starting from a non-equilibrium initial state, the real time evolution of the Wigner functions, as well as the entanglement entropy, both demonstrate that thermalization of the quantum system is approachable. In particular, relaxation to the thermalized state depends on coupling strength, in the presence of quantum fluctuations. We also study the connection of the Wigner function thermalization to the well-known Eigenstate Thermalization (ETH).

Track4-Bulk&Phase / **293**

A Realistic Coalescence Model for Deuteron Production

Auteurs: Laura Fabbietti[1]; Maximilian Horst[2]

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Understanding the formation of (anti)nuclei in high-energy collisions has attracted large interest over the last few years. According to the coalescence model, nucleons form independently and then bind together after freeze-out if they are sufficiently close in phase-space. A recent advancement of the model is the Wigner function formalism, which allows the calculation of the coalescence probability based on the distance and relative momentum of the constituent nucleons, independently of the collision energy or system.
The interest in explaining nuclear formation processes extends beyond standard model physics, with implications for indirect Dark Matter searches. Understanding the production mechanism of antinuclei is crucial for correctly interpreting any future measurement of antinuclear flux in space, as it would allow for the differentiation of the background originating from collisions between high-energy Cosmic Rays and the stationary Interstellar Medium.
In this presentation, we provide a comprehensive overview of the state-of-the-art coalescence formalism, not only for deuterons but also for the more intricate case of A=3 nuclei. This represents a significant advancement, as previous efforts primarily focused on modeling the formation of simpler bounds states, e.g., deuterons. Furthermore, the model is tested for pp collision data and Heavy-Ion collisions measured at STAR. Our approach introduces a novel aspect by implementing this model into a purpose-built Monte Carlo generator called ToMCCA. This generator offers exceptional adaptability while maintaining superior performance compared to traditional general-purpose event generators.

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Insights into Background Effects in Searching for the Chiral Vortical Effect in Experiments

Auteurs: Qiye Shou[1]; Chunzheng Wang[2]

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The Chiral Vortical Effect (CVE), potentially induced by the interplay between chiral anomalies in quark-gluon plasma(QGP) and strong vortical fields in non-central heavy-ion collisions, has been explored using the azimuthal correlations between baryon pairs such as $\Lambda - p$ by the ALICE and STAR experiments. These observations have shown non-trivial behavior that indicates the underlying mechanisms and potential signals. However, the study of CVE is complicated by background effects that are not yet fully understood. This poster presents the latest insights into these background effects. Through the assistance of various models, including the AMPT and the blast wave model, ALICE data have been analyzed and interpreted. Potential sources of background, such as local baryon conservation and coalescence processes are discussed, which provide fresh perspectives on the study of anomalous chiral effects and the collective dynamics of the QGP.

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Effect of strangeness on the Neutron star f–mode Oscillations in general relativistic calculations

Auteurs: Debanjan Guha Roy[1]; Sarmistha Banik[1]; Tuhin Malik[2]

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[2] *CFisUC, Department of Physics, University of Coimbra*

We study quasinormal $f-$mode oscillations in neutron star(NS) interiors within the linearized General Relativistic formalism. We utilize approximately 9000 nuclear Equations of State (EOS) using spectral representation techniques, incorporating constraints on nuclear saturation properties, chiral Effective Field Theory(χEFT) for pure neutron matter, and perturbative Quantum Chromodynamics (pQCD) for densities pertinent to NS cores. Our study reveals a weak correlation between f–mode frequencies and individual nuclear saturation properties, but a robust linear relationship between the radii and $f-$mode frequencies with extreme masses ($1.34M_\odot$ and $2.0M_\odot$). However, for different masses on the NICER data, it has minimal overlap in the radius domain and differs in the frequency domain with our nucleonic EOS set. Interestingly, the same analysis corresponding a set of EOS with hadron-quark phase transition lie very well within our NICER-derived constraints in the radius as well as the $f-$mode frequency domain, indicating a preference of strange hybrid EOS over the purely nucleonic ones for the first time.

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Determine the unknown hexadecapole deformation of ^{238}U by relativistic heavy ion collisions

Auteurs: Haojie Xu[1]; Fuqiang Wang[2]

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[2] *Purdue University*

The ^{238}U nucleus is well deformed with a large quadruple deformation $\beta_2 = 0.286$. However, its hexadecapole deformation $\beta_{4,\mathrm{U}}$ is not well determined, mainly because it is overshadowed by the large $\beta_{2,\mathrm{U}}$ in experimental observables that are typically sensitive to both. A recent study (Ryssens, et.al., Phys.Rev.Lett. 130, 212302) proposes a smaller β_2 for U to explain the v_2 differences between ^{238}U+^{238}U and ^{197}Au+^{197}Au collisions, and thereby a finite $\beta_{4,\mathrm{U}}$ to compensate the smaller $\beta_{2,\mathrm{U}}$ in order to still describe the experimental quadruple moment. This is, however, rather indirect as v_2 is nearly insensitive to β_4, and the v_2 differences between the two systems can simply be explained by a larger $\beta_{2,\mathrm{Au}}$ as our knowledge of the β_2 of odd-Z nuclei is poor. In this talk, we present three truly β_4-sensitive observables, the flow harmonic correlation $\mathrm{ac}_2\{3\}$, the event-plane correlation $\langle\cos(4\Phi_2 - 4\Phi_4)\rangle$, and the nonlinear response coefficient $\chi_{4,22}$. The $\chi_{4,22}$ observable is even insensitive to the quadruple deformation and the system size, providing an unique opportunity to precisely extract the $\beta_{4,\mathrm{U}}$ from relativistic heavy ion collisions.

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Critical dynamics of non-equilibrium phase transitions

Auteurs: Leon Sieke[None]; Lorenz von Smekal[None]; Mattis Harhoff[1]; Sören Schlichting[None]

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In context of the search for the QCD critical endpoint in heavy-ion collisions, a deep understanding of the out-of-equilibrium dynamics of the system is necessary to make well-grounded predictions for signatures in final states. To this end, we investigate the dynamic critical behavior of a classical scalar field theory with Z_2 symmetry in the dynamic universality class of Model A in two and three spatial dimensions. The critical dynamics of the system are studied under a linear quench protocol, in which the external symmetry breaking field is changed at a constant rate through the critical point. We discuss the connection to the Kibble-Zurek mechanism and determine the dynamic critical exponent � as well as universal scaling functions. These fully describe the non-equilibrium evolution of the system near the critical point for all quench rates under consideration. We find that, while the scaling functions are non-trivial, the corresponding scaling exponents are fully determined by the static critical exponents and the dynamic critical exponent. Finally, we perform a finite-size scaling analysis and observe good collapse of the data onto universal finite-size scaling functions.

Track4-Bulk&Phase / **298**

Differential measurements of ϕ-meson global spin alignment in Au+Au collisions at STAR

Auteurs: Gavin Wilks[None]; Sooraj Radhakrishnan[1]

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The STAR collaboration observed a significant global spin alignment (ρ_{00}) signal for ϕ-mesons in Au+Au collisions using the data from the BES-I1 which cannot be explained by conventional mechanisms, but may be attributable to the influence of a ϕ meson force field [2-6]. In this talk, we present differential measurements of ϕ-meson global spin alignment using the STAR detector in Au+Au collisions at $\sqrt{s_{NN}}$ = 7.7, 14.6 and 19.6 GeV from the second phase of the Beam Energy Scan at RHIC (BES-II). This study aims to clarify the source of the ϕ-meson ρ_{00} signal using increased statistics available from BES-II and detector upgrades to STAR after BES-I. The first rapidity (y) dependent ρ_{00} results for ϕ-mesons will be shown, alongside new centrality and transverse momentum (p_T) dependent measurements. The results presented in this talk will help understand the potential link of global spin alignment to vector meson fields and their roles in the evolution of nuclear matter.

1 STAR Collaboration., Nature \textbf{614}, 244–248 (2023)
[2] X.L. Sheng et al., Physical Review D \textbf{101}, 096005 (2020).
[3] X.L. Sheng et al., Physical Review D \textbf{105}, 099903 (2022).
[4] X.L. Sheng et al., Physical Review D \textbf{102}, 056013 (2020).
[5] X.L. Sheng et al., Physical Review Letters \textbf{131}, 042304 (2023).
[6] X.L. Sheng et al., Physical Review C \textbf{108}, 054902 (2023)

Track4-Bulk&Phase / **299**

Measuring the Global Spin Alignment of ϕ meson in Heavy Ion Collisions by STAR

Auteurs: Charles Robertson[None]; Sooraj Radhakrishnan[1]

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In non-central heavy-ion collisions, a large orbital angular momentum is produced. A part of the orbital angular momentum can polarize the quarks and anti-quarks, hence the vector mesons, inside the medium. Recently, STAR measured the global spin alignment of ϕ(1020) and K^*(892) mesons in Au+Au collisions from the RHIC Beam Energy Scan I (BES I) program 1. The global spin alignment, quantified by the 00^{th} coefficient of the spin density matrix, ρ_{00}, is measured by a fit to the acceptance and efficiency corrected ϕ meson yield versus polar angle (θ^*) between the daughter kaon in the parent's rest frame and the orbital angular momentum direction. In this talk, we present an alternative approach to extract ρ_{00} by utilizing the $\langle \cos^2\theta^* \rangle$ as a function of pair-invariant mass instead of analyzing the ϕ meson yields in $\cos\theta^*$ bins. We use a data-driven method to correct for acceptance and efficiency. We report new analysis from this method and discuss physics implications.

1 M. Abdallah et al. (STAR Collaboration), Nature 614, 244–248 (2022).

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Estimate the magnetic field in heavy-ion collisions by virtual photon polarization and dilepton anisotropy

Auteurs: Li Yan[1]; Minghua Wei[1]

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We assume a relatively weak magnetic field at $0.01 - 0.1m_\pi^2$ level in the QGP. In approximate equilibrium, the quark distribution function is modified by the electromagnetic field. The quark and anti-quark tend to move back to back in the plane. As a consequence, the virtual photons are produced in the polarized states. Virtual photon polarization is characterized by coefficients λ_θ and λ_ϕ, which are sensitive to the magnetic field and hydrodynamic behaviors.

In a static QGP, a magnetic field with an intensity of $0.05m_\pi^2$ enhances the observable quantity λ_θ by 0.07. This implies that within the precision range of heavy-ion collision experiments, the residual magnetic field in the late-stage evolution of the quark-gluon plasma can be probed. Thermal dileptons emitted by the QGP contribute significantly in the intermediate invariant mass region. Our research indicates that λ_θ exhibits good sensitivity to the magnetic field throughout the entire intermediate invariant mass region. In the range of M=0.6-3 GeV, the deviation caused by a nonzero weak magnetic field is $\lambda_\theta\left(M, eB=0\right) - \lambda_\theta\left(M, eB=0.075m_\pi^2\right) \sim 0.06 - 0.07$, and its sensitivity remains stable. Furthermore, we investigated the effects of transverse momentum, rapidity, azimuthal angle, QGP temperature, and electric conductivity on the coefficient λ_θ and λ_ϕ.

Finally, we considered the longitudinal expansion effect of the QGP. In addition to the previous factors, the polarization effect becomes more pronounced. Overall, the current research confirms the sensitivity of virtual photon polarization and dilepton anisotropy to the late-stage magnetic field evolution.

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Chemical Freeze-Out of Hadrons Within the Induced Surface Tension Hadron Resonance Gas Model

Auteur: Elizaveta Zherebtsova[1]

Co-auteur: Oleksandr Vitiuk [1]

[1] *University of Wroclaw*

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Strangeness production in heavy-ion collisions provides crucial insights into strongly interacting matter. The ratio of charged kaons to pions serves as a signature of deconfinement, with experimental observations revealing a distinct horn structure. The Induced Surface Tension (IST) Hadron Resonance Gas Model 1 effectively describes strangeness production and the horn structure, offering valuable information about the thermodynamic conditions at freeze-out.
We present an updated version of this model that allows the fitting of ratios among different hadrons, taking into account both inclusive and exclusive feed-down corrections consistently with experimental analysis. Our study of STAR experimental data on hadron multiplicities emphasizes the essential role of accounting for the contribution of weak decay processes to particle multiplicities and allows us to accurately describe the experimental results. Remarkably, our findings concerning the chemical freeze-out (CFO) parameters, obtained from fits to STAR BES data across collision energies ranging from 7.7 to 200 GeV, closely correspond to those derived from other models for ALICE data at 2.76 TeV and lattice QCD results for the pseudocritical line temperature.

1 O. V. Vitiuk et al., Eur. Phys. J. A 57(2) (2021) 74.

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Phenomenology of Identified Particle Spectra in Heavy-Ion Collisions at LHC Energies

Auteur: Oleksandr Vitiuk[1]

Co-auteurs: David Blaschke [1]; Gerd Röpke [2]; Benjamin Dönigus [3]

[1] *University of Wroclaw*

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[3] *Goethe-Universität Frankfurt*

Auteur correspondant oleksandr.vitiuk@cern.ch

The Zubarev approach of the non-equilibrium statistical operator 1 is used to account for the enhancement of the low-p_T part of pion spectra by introducing an effective pion chemical potential [2]. This is an alternative to the explanation of the low-p_T enhancement by resonance decays. We report on first results obtained with a newly developed thermal particle generator that implements both mechanisms of low-p_T enhancement and applies Bayesian inference methods for these scenarios to find the most probable sets of thermodynamic parameters at the freeze-out hypersurface for the case of the transverse momentum spectra of identified particles measured by the ALICE Collaboration [3]. The Bayes factor is determined for these scenarios. The advantages and limitations of the Zubarev approach are discussed.

References:
1 D.N. Zubarev, V.G. Morozov and G. Röpke, Statistical Mechanics of Nonequilibrium Processes, Akademie Verlag Berlin (1996), vol. I
[2] D. Blaschke et al., Particles 3, 380–393 (2020)
[3] B. Abelev et al., Phys. Rev. C 88, 044910 (2013)

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Differential Study of Λ-hyperon Polarization in Central Heavy-Ion Collisions Within Transport Model Approach

Auteur: Oleksandr Vitiuk[1]

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We present a comprehensive differential study of hyperon polarization in (ultra-)central Au+Au collisions at low and intermediate energies, employing the microscopic transport model UrQMD in conjunction with the statistical hadron-resonance gas model. This study entails a complex analysis of the of the fireball dynamics and thermal vorticity field evolution. The resulting thermal vorticity configuration effectively manifests as the formation of two vortex rings in the forward and backward rapidity regions. We demonstrate that the polarization of Λ-hyperons exhibits oscillatory behaviour as a function of the azimuthal angle, offering a novel means to probe the structure of the fireball in central heavy-ion collisions.

Track7-OthTop / 304

Strange quark nucleation in astrophysics: thermal fluctuations of the composition

Auteurs: Alessandro Drago[1]; Andrea Lavagno[2]; Giuseppe Pagliara[1]; Mirco Guerrini[1]

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[2] *Politecnico di Torino and INFN Torino*

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At the extreme densities reached in the core of neutron stars and related astrophysical phenomena, it is possible that quark deconfined matter takes place.
The formation of this new phase of strongly interacting matter is likely to occur via a first-order phase transition for the typical temperatures reached in astrophysical processes (e.g. quark deconfinement could play a key role in the explosion of core-collapse supernovae from blue supergiants).
The first seeds of quark matter would then form through a process of nucleation within the metastable hadronic phase. I will address the role of the thermal fluctuations in the hadronic composition on the nucleation of three-flavours (strange) quark matter and its implication for the phenomenology of compact stars.
I will discuss in particular under which conditions strange quark stars (namely, stars entirely composed of strange quark matter) could be formed in astrophysical processes.

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Decoding charmonia polarization in pp collisions at LHC energies: PYTHIA8 analysis and future trajectories

Auteurs: Suman DEB[1]; Bhagyarathi Sahoo[2]; Dushmanta Sahu[2]; Captain Rituraj Singh[2]; Raghunath Sahoo[2]

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In this study, we investigate the polarization parameters of J/ψ and ψ(2S) in proton-proton (pp) collisions at LHC energies, utilizing PYTHIA8 to analyze dimuon angular distributions. Our findings reveal intriguing insights: at low transverse momentum (p_T), both particles exhibit longitudinal polarization, transitioning to transverse polarization at higher p_T in both helicity and Collins-Soper reference frames. Moreover, longitudinal polarization is evident across all energies, while transverse polarization is prominent in the Collins-Soper frame. Notably, the degree of longitudinal polarization of ψ(2S) increases with charged particle multiplicity, contrasting the relatively constant polarization observed for J/ψ. Although we find no clear dependence of polarization parameters on rapidity, future studies with wider kinematics acceptance, such as the ALICE 3 setup, could shed light on this aspect. Our results, based on pQCD-based PYTHIA8 simulation, suggest the necessity for comprehensive studies utilizing theoretical models in conjunction with experimental data to fully understand charmonia polarization in ultra-relativistic pp collisions.

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Enhancement of baryon-to-meson ratios around jets as a signature of medium response

Auteurs: Ao Luo[1]; En-Ke Wang[2]; Guang-You Qin[3]; Han-Zhong Zhang[3]; Yaxian Mao[3]

[1] *Shandong University*

[2] *South China Normal University*

[3] *Central China Normal University*

We present a unique signal of jet-induced medium response: the enhancement of baryon-to-meson ratios for associated particles at intermediate transverse momentum around the triggered quenched jets. Since the lost energy from the jets can diffuse to large angles, we expect that such baryon-to-meson-ratio enhancement is stronger for larger distance with respect to the jet axis. Our prediction can be tested by future experiments.

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Lambda hyperon local spin polarization and weak magentic field effect

Auteur: Li Yan[1]

[1] *Fudan University*

Lambda hyperon spin polarization has been recognized in relativistic heavy-ion collisions as a signature that captures the rotational nature of the quark-gluon plasma (QGP). Although the global spin polarization of Lambda hyperon can be well described once QGP collective rotation is characterized by hydrodynamics, the thoretial predication of local spin polarization, namely, polarization along the beam axis, etc., exhibit opposite sign comparing to the experimental results.

To solve the sign puzzle, we propose the weak magnetic effect, which emerges in QGP close to local thermal equilibrium as the dissipative correction to the quark phase space distribution function, as a novel contribution to the observed Lambda hyperon local spin polarization. With a finite field strength, which is consistent with previous estimate of the magnetic field in heavy-ion collisions based on direct photon elliptic flow, one is able to explain the experimentally observed Lambda local spin polarization through all centrality classes. Moreover, the weak magnetic effect plays an unambiguous role in the ordering between the second-order and the third-order modulations of the Lambda local spin polarization observed in experiments.

Track4-Bulk&Phase / 309

Dynamics of the chiral critical point in QCD, diffusion coefficient in Model G

Auteurs: Derek Teaney[1]; EDUARDO GROSSI[2]; Florio Adrien[3]

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We present a detailed study of the finite momentum dynamics of the
$O(4)$ critical point of QCD, which lies in the dynamic universality class of Model G. The critical scaling of the model is analyzed in multiple dynamical channels. For instance, the finite momentum analysis allows us to precisely extract the pion dispersion curve below the critical point. The pion velocity is in striking agreement with the predictions relation and static universality. The pion damping rate and velocity are both consistent with the dynamical critical exponent
ζ=3/2 of Model G. Similarly, although the critical amplitude for the diffusion coefficient of the conserved
O(4) charges are small; it is visible both in the restored phase and with finite explicit symmetry breaking, and its dynamical scaling is again consistent with
ζ=3/2. We determine a new set of universal dynamical critical amplitude ratios relating the diffusion coefficient to a suitably defined order parameter relaxation time. We also show that in a finite volume simulation, the chiral condensate diffuses on the coset manifold in a manner consistent with dynamical scaling and with a diffusion coefficient determined by the transport coefficients of hydrodynamic pions.

Track2-HF&Q / 311

Prospects for open heavy-flavour and quarkonium measurements with NA60+

Auteur: Roberta Arnaldi[1]

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The NA60+ experiment, proposed for data taking in the next years, aims to investigate the high baryochemical potential region of the QCD phase space diagram, exploiting the large intensity of CERN SPS beams.
By studying rare probes via a beam-energy scan with PbPb and p-A collisions in the interval 6.3 < $\sqrt{s_{NN}}$ < 17.3 GeV, NA60+ will have the possibility to access the high μ_B region of the QCD phase diagram.

In this talk, we will focus on the prospects for measurements of hidden and open charm. Open charms will be measured in their decays into charged hadrons, reconstructed from tracks in the silicon detectors of the vertex telescope.
High-precision measurements of the yield of D^0, D^+ and D_s^+ mesons, and of Λ_c^+ baryons, will allow us to constrain the transport properties of the QGP and the charm-quark hadronisation.
Charmonium states will be accessed from their dimuon decay, reconstructed by matching muon tracks in the vertex telescope and in the muon spectrometer. The J/ψ and ψ(2S) measurements at various collision energies will allow us to identify the onset of charmonium suppression in a deconfined medium, correlating this observation with the temperature of the system, as measured, always by NA60+, via thermal dimuons.

NA60+ will also investigate the hadronic decay of strange hadrons and hypernuclei production and the corresponding performance studies will be presented.

Finally, we will discuss the competitiveness and complementarity of NA60+ in the landscape of the experiments foreseen at other facilities in the next decade.

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Spin alignment of K* induced by baryonic inhomogeneity

Auteur: Feng Li[1]

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The difference between the spin alignments of K^* and those of ϕ at the low collisional energies is a puzzle raised by the recent experiments. Unlike ϕ meson, K^*, carrying a unit strange charge, should react to strange potential. In this talk, I shall first convince you that the strange chemical potential is not small in a brayon-rich medium for keeping strange neutrality, and then derive the spin alignment induced by strange, and hence baryon chemical potential gradient using linear response theory, with the transport coefficients expressed, w/o any approximation, in terms of the K^*'s in-medium spectral properties by employing Ward-Takahashi identity. The magnitudes of these coefficients, and hence of the spin alignment, will be further estimated under the quasi-particle approximation.

Track5-UpFut / 313

The NA60+ experiment at the CERN SPS

Auteur: Sabyasachi Siddhanta[1]

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NA60+ is a new experiment designed to study the phase diagram of the strongly interacting matter at high baryochemical potential from 200 to 550 MeV at the CERN SPS. It is focused on precision studies of thermal dimuons, heavy quark and strangeness production in Pb–Pb collisions at center of mass energies ranging from 6 to 17 GeV.

The proposed experimental apparatus is composed of a vertex telescope located close to the target and a muon spectrometer located downstream of a hadron absorber. The vertex telescope will consist of several planes of ultra-thin, large area Monolithic Active Pixel sensors (MAPS) embedded in a dipole magnetic field. The muon spectrometer will utilize large area gaseous detectors for muon tracking and a toroidal magnet based on a new light-weight and general-purpose concept.

An ambitious physics program is foreseen, which includes the search for chiral symmetry restoration effects through the rho-a1 mixing, the study of the order of the phase transition at large baryochemical potential through the measurement of a caloric curve, the onset of the deconfinement through the measurement of J/psi suppression. Finally the measurement of the transport properties of the medium via open charm states and the study of hadrochemistry via detection of strange hadrons and hypernuclei is also part of the physics program.

A letter of intent was submitted at the end of 2022 and the goal is to start data taking in 2029.

This talk will focus on the experimental apparatus, including the technical aspects and the R&D status, as well as the physics program and its competitiveness and complementarity to other experiments.

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Diffusion of heavy quarks in the early stages of high-energy nuclear collisions

Auteurs: Marco Ruggieri[1]; Pooja -[2]; Santosh Kumar Das[2]; Vincenzo Greco[3]

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[2] *Indian Institute of Technology Goa*

[3] *Università degli Studi di Catania-INFN(LNS)*

We study the diffusion of heavy quarks in the early stages of high-energy nuclear collisions. The pre-equilibrium stage of relativistic heavy-ion collisions, commonly known as Glasma, evolves according to the classical Yang-Mills (CYM) equations. Heavy quarks are coupled to the evolving Glasma fields via relativistic kinetic theory.
We compute the momentum broadening as well as the angular momentum fluctuations of charm and beauty quarks in the early stage, which turn out to be anisotropic due to the anisotropy of the background gluon fields. We observe that σ_p ∝ t². This non-Markovian diffusion of heavy quarks in the early stages is explained by the memory effect present in the gluon fields. Furthermore, we also estimate the HQ spatial diffusion coefficient 2πTD_x in the pre-equilibrium phase. The D_x obtained in the pre-equilibrium phase is quite close to the value obtained within pQCD in the QGP phase.
Notably, D_x follows a continuous evolution from the pre-equilibrium phase to the QGP phase.

Track2-HF&Q / 315

Heavy Flavour Energy Loss in Small and Large Systems

Auteur: Coleridge Faraday[1]

Co-auteur: W. A. Horowitz [1]

[1] *University of Cape Town*

Auteur correspondant frdcol002@myuct.ac.za

We present novel predictions for high-p_T heavy flavour D and B meson suppression in $p+p$, $p+A$, $d+A$ and $A+A$ collisions at RHIC and the LHC. These predictions are made using a one-parameter convolved elastic and radiative energy loss model, which receives small system size corrections to both the elastic and radiative energy loss. We simultaneously predict the observed light flavour pion R_{AA} in both Au + Au and d + Au collisions at RHIC, providing additional supporting evidence that QGP is formed in high-multiplicity d + Au collisions at $\sqrt{s} = 200$ AGeV. Our results are also consistent with the suppression of both light and heavy flavours in Pb + Pb collisions at the LHC. We are unable to reproduce the observed lack of suppression in high-multiplicity p + Pb collisions at the LHC. We propose that a system size scan will help separate radiative and elastic dominated suppression, as well as various theoretical uncertainties in HTL-based elastic energy loss. Predictions, along with a detailed theoretical uncertainty analysis, are presented for such a future system size scan including $p+p$, $p+A$, $d+A$, $^3\mathrm{He}+A$, $p+\mathrm{O}$, $\mathrm{O}+\mathrm{O}$, $\mathrm{Xe}+\mathrm{Xe}$, and $\mathrm{Pb}+\mathrm{Pb}$ collision systems.

Track7-OthTop / 319

Implication of Quarkyonic duality to the hyperon puzzle

Auteur: Yuki Fujimoto[1]

Co-auteurs: Toru Kojo [2]; Larry McLerran [1]

[1] *Institute for Nuclear Theory, University of Washington*

[2] *Tohoku University*

Duality between quarks and baryons is one of the most fundamental properties of QCD.
We have recently shown in Ref. 1 that the duality is closely tied to Quarkyonic nature of matter at high baryon density. We have formulated a dual model for cold, dense QCD, which allows a thermodynamic description both in terms of baryons or quarks, i.e., one can simultaneously consider the system in terms of quarks and baryons. The confinement of quarks inside baryons sets the transformation between quark and baryonic descriptions. At low density, the baryonic description is more natural, and at high density, the quark description becomes more natural, but at any density one might use one or the other. The nontrivial feature of this theory is that when we persist with the baryonic picture in the region where the quark description is more natural, the shell structure, which is the notable feature of Quarkyonic matter, appears in the pure baryonic distribution owing to the Pauli exclusions among quarks. This Quarkyonic shell structure is dual to a description in terms of quarks with a filled Fermi sea of quarks with a finite Fermi surface.

In this talk, we discuss the implication of this Quarkyonic duality to the hyperon puzzle [2]. We extend the model to three flavors to consider the combined effect between the duality and the strangeness. We discuss that the Quarkyonic shell structure arising from the duality retains even in the presence of strangeness. As a result, the threshold density for the hyperons are shifted to even higher density compared to the conventional treatment, and the hyperonic softening of the equation of state becomes milder. This will provide a systematic way toward the resolution of the hyperon puzzle from the fundamental aspect of QCD.

References:
1 Y. Fujimoto, T. Kojo, L. McLerran, To appear in Phys. Rev. Lett., arXiv:2306.04304 [nucl-th].
[2] Y. Fujimoto, T. Kojo, L. McLerran, In preparation.

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Thermoelectric transport and the spectra of conserved operators in RTA kinetic theory

Auteur: Alexander Igor Soloviev[None]

Co-auteurs: Matej Bajec [1]; Sašo Grozdanov [2]

[1] *University of Ljubljana*

[2] *University of Edinburgh, University of Ljubljana*

The relaxation time approximation (RTA) of the kinetic Boltzmann equation is likely the simplest window into the microscopic properties of collective real-time transport. Within this framework, we analytically computed all retarded two-point Green's functions of the energy-momentum tensor and a conserved $U(1)$ current in thermal states with classical massless particles at non-zero density, and in the absence/presence of broken translational symmetry. Furthermore, I will discuss the explicit analysis of the analytic structure of the different correlators and the QCD transport properties that they imply, such as the thermoelectric conductivities and the quasihydrodynamic dispersion relations.

Track6-SmallSyst / 321

Collectivity in small systems with the ATLAS detector

Auteur: Blair Daniel SEIDLITZ[None]

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This talk presents the latest ATLAS measurements of collective phenomena in small collision systems, including pp collisions and Ultraperipheral collisions (UPC) of heavy ions. In pp collisions, presented measurements include flow decorrelations in rapidity for probing the longitudinal structure and study of the sensitivity of collective motion in pp collisions to the presence of jets, which aims to distinguish the role that semi-hard processes play in the origin of these phenomena. In UPCs, the measurement of charged hadron production is presented as a function of pseudorapidity and transverse momentum in different categories of event multiplicity. Together with previously measured elliptic flow coefficients, the yields and mean pT results are compared with calculations from DPMJET and hydrodynamic-based models. These comparisons enable detailed characterizations of photonuclear event properties, including the photon energy distribution and whether small QGP droplets may be formed.

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Opening IPHC

Auteur: Sandrine Courtin[1]

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Opening IN2P3

Auteur: Christelle Roy[1]

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Opening Université de Strasbourg

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Opening Alsace

Auteur: Olivier Becht[None]

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Theory Overview / State-of-the-art

Auteur: Jacquelyn Noronha-Hostler[1]

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Experiment Overview / State-of-the-art

Auteur: Maximiliano Puccio[1]

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Recent results on light flavours and correlations from ALICE

Auteur: Mesut Arslandok[1]

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Recent results on heavy flavours and quarkonia from ALICE

Auteurs: Fiorella Fionda[1]; Fiorella Maria Celeste Fionda[1]

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CMS highlights: Recent results from CMS

Auteurs: Florian Damas[1]; Florian Damas[2]

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LHCb highlights: Recent results from LHCb

Auteur: Thomas Boettcher[1]

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ATLAS highlights: Recent results from ATLAS

Auteur: Petr Balek[1]

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ATLAS highlights: Recent results from ATLAS
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This talk presents an overview of recent ATLAS measurements in heavy ion collision systems.
These include multiple measurements of jet production and jet structure, which probe the dynamics of the hot, dense Quark-Gluon Plasma formed in relativistic nucleus-nucleus collisions, and measurements of quarkonia and heavy flavor production to probe the QGP medium properties.
Furthermore, an overview of the latest ultra-peripheral physics measurements performed, including both measurements of photo-nuclear and photon-photon fusion processes, will be discussed.
The photo-nuclear events can provide a clean probe of the partonic structure of the nucleus analogous to deep inelastic scattering while studies of processes in photon-photon interactions constraints the nuclear photon flux, the tau lepton's anomalous magnetic dipole moment (g-2), and provide a unique opportunity to investigate extensions of the Standard Model.

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Strangeness in astrophysics

Auteurs: LAURA TOLOS RIGUEIRO[1]; Laura Tolos[2]

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Over the past decades strangeness has received a lot attention in connection with the study of exotic atoms, the analysis of the production and propagation of strange hadrons in particle research facilities as well as the investigation of the possible strange phases in the interior of compact stars, such as neutron stars. In this talk I will address strange dense matter inside neutron stars, paying a special attention to the consequences for the structure of these compact stellar objects and the dynamics of neutron star mergers.

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STAR highlights: Recent results from STAR

Auteur: Qian Yang[None]

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Qian Yang, for the STAR Collaboration

STAR is a multipurpose detector with excellent particle identification capabilities, operating at Relativistic Heavy Ion Collider (RHIC) at BNL.
Recently, STAR has completed data taking for the second phase of the Beam Energy Scan program at RHIC (BES-II) and the Isobar collisions program. The BES-II program includes dedicated low beam energy runs and a fixed-target program covering the energy range $\sqrt{s_{NN}}$ = 3 -19.6 GeV/c^2, allowing for exploration of the high baryon density region of the QCD physics.
The BES-II program also includes iTPC, EPD and eTOF detector upgrades which will increase STAR's acceptance both in rapidity and low transverse momentum and extent its particle identification capabilities.
With new datasets and dataset from U+U and d+Au collisions, STAR collaboration will present a series of measurements related to charged particles, strange hadrons, heavy quarks, dielectrons, light nuclei as well as hypernuclei. STAR is also taking high statistics p+p and Au+Au data in RHIC runs from 2023-25 with dedicated forward upgrades and the detector upgrades from BES-II. These datasets provide unique opportunities to investigate the microstructure of Quark-Gluon Plasma (QGP) and the unique forward cold QCD physics.
The outlook on these measurements will also be discussed.

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PHENIX highlights: Recent results from PHENIX

Auteur: Maya Shimomura[None]

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sPHENIX highlights: Recent results from sPHENIX

Auteur: Rachid Nouicer[1]

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sPHENIX is a new state-of-the-art detector constructed at Brookhaven National Laboratory's Relativistic Heavy Ion Collider (RHIC). It was commissioned and took first Au+Au collision's data in the RHIC Run-2023.
It seeks to answer fundamental questions on the nature of the quark-gluon plasma (QGP), including its coupling strength and temperature dependence, by using a suite of precision jet and Υ measurements that probe different length scales of the QGP. This is possible with its full acceptance, $|\ \eta\ |<1$ and $0-2\pi$ in ϕ, electromagnetic and hadronic calorimeters and precision tracking enabled by a 1.5 T superconducting magnet. With the increased luminosity afforded by accelerator upgrades, sPHENIX will perform high statistics measurements extending the kinematic reach at RHIC to overlap the LHC's. This overlap will facilitate a better understanding of the role of temperature, density and parton virtuality in QGP dynamics and, specifically, jet quenching.

This talk will discuss the present detector status in the ongoing RHIC Run-2024, as well as highlights on first physics measurements in Au+Au collisions at $\sqrt{s_{NN}}$ = 200 GeV obtained from RHIC Run-2023.

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NA61/SHINE highlights: Recent results from NA61/SHINE

Auteur: Andrzej Rybicki[None]

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News from NA61/SHINE

The NA61/SHINE experiment at the CERN SPS is a multipurpose fixed-target spectrometer for charged and neutral hadron measurements. Its research program includes studies of strong interactions as well as reference measurements for neutrino and cosmic-ray physics. A significant advantage of NA61/SHINE over collider experiments is its extended coverage of phase space available for hadron production. The latter includes the nearly entire forward hemisphere for charged hadrons and additionally, also a large part of the backward hemisphere for specific neutrals.

This talk will summarize the substantial package of new strangeness-related results, obtained by NA61/SHINE since the last Strangeness in Quark Matter conference (Busan, 2022). The latter will include preliminary and final data on strange baryon and strange meson production (Λ, K, K^*, and others) in proton-proton, pion-nucleus and nucleus-nucleus collisions in the collision energy range $\sqrt{s_{NN}}$ =5-17 GeV. Particular attention will be devoted to the difference observed between charged and neutral K mesons production in Ar+Sc reactions, up to now not understood by existing models.

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HADES highlights: Recent results from HADES

Auteur: Manuel Lorenz[None]

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Transport models –State of the art

Auteur: Steffen Bass[1]

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Recent progress on the QCD phase diagram and the equation of state

Auteur: Gergely Endrödi[1]

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Spin polarization in relativistic heavy ion collisions

Auteur: Xu-Guang Huang[1]

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Hadronisation mechanisms

Auteur: Vincenzo Greco[1]

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Strange resonances and exotic states

Auteur: Anders Garritt Knospe[None]

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Nuclei and hypernuclei production at the LHC

Auteur: Chiara Pinto[None]

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Hypernuclei production at RHIC and their properties

Auteur: Yuanjing Ji[1]

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Measurement of nuclei radii in heavy ion collisions

Auteurs: Giuliano Giacalone[1]; Giuliano Giacalone[1]

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Open charm and beauty production

Auteurs: Zaida Conesa del Valle[1]; Zaida Conesa del Valle[2]

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Hydrodynamisation of charm quarks in heavy ion collisions

Auteur: Stefan Floerchinger[1]

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Measurements of quarkonia production

Auteur: Laure Massacrier[1]

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Theoretical aspects of quarkonia production in heavy ion collisions

Auteur: Jiaxing Zhao[1]

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Experimental search on QCD critical point

Auteurs: Yu Zhang[1]; Yu Zhang[1]

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Available theoretical tools in search for the Critical Point of the QCD phase diagram

Auteur: Adam Bzdak[None]

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Study of hadron two-body and three-body interactions with femtoscopy

Auteur: Raffaele Del Grande[1]

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Molecular states with charm: insights from vacuum and finite-temperature analyses

Auteur: Juan Torres-Rincon[1]

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This talk explores recent results in the study of molecular states with both open and hidden charm. Employing effective-field theories that incorporate heavy-flavor degrees of freedom and implement heavy-quark spin symmetry, significant progress has been made in generating bound and resonant states through unitarization techniques. Special attention will be given to the heavy-light sector, elucidating the double pole structure of the $D^{0*}(2300)$ state as well as the $D_s^{0*}(2317)$. In the hidden charm sector, the discussion will delve into exotics, like the X(3872), highlighting differences from the compact state interpretation. Furthermore, the feasibility of extracting relevant information from femtoscopy measurements will be discussed. A final part will cover the properties of molecules at a finite temperature in the context of heavy-ion collision phenomenology and how the molecular states can melt in such a medium.

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Flow in light ion collisions

Auteur: Shengli Huang[1]

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Collectivity in high energy proton proton collisions

Auteur: You Zhou[1]

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Understanding the rapidity dependence of small system flow

Auteur: Bjoern Schenke[1]

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Effects of nuclear matter properties in neutron star mergers (TbD)

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Effect of three body forces on the nuclear equation of state with strangeness

Auteur: Isaac Vidana[1]

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Flash talk 3

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LHC upgrades

Auteur: Jochen Klein[1]

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Plenaries-Highlights / 400

Physics program and detector technologies of ePIC at EIC

Auteurs: Carlos MUNOZ CAMACHO[1]; Carlos Munoz Camacho[None]

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Plenaries-Highlights / 401

Prospects for strangeness and heavy flavour physics at FAIR

Auteur: Yvonne Leifels[1]

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Plenaries-Highlights / 402

SPS upgrades and prospects

Auteur: Piotr Podlaski[None]

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Plenary-Summaries / 403

Summary Talk –Theory

Auteur: Jasmine Brewer[None]

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Plenary-Summaries / 404

Summary Talk –Experiment

Auteur: Javier Castillo Castellanos[1]

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Closing session / 405

Closing speech

Auteurs: Antonin Maire[1]; Boris Hippolyte[2]; christian kuhn[3]

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Closing session / 406

Best experimental talk: Andre Mischke's Award

Auteur: In-Kwon Yoo[1]

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Track1-LF / 407

First physics measurements in Au+Au collisions from sPHENIX at RHIC

Auteur: Marzia Rosati[1]

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sPHENIX, the first new detector to be built at the Relativistic Heavy-Ion Collider (RHIC) in over two decades, will bring unprecedented measurement capabilities at RHIC energies.

sPHENIX collected its first data during the inaugural RHIC commissioning run in 2023 with Au+Au collisions. The data allow for a partial commissioning of multiple key sub-systems of the detector, including the hermetic electromagnetic and hadronic calorimetry (unique at RHIC), elements of the four-component charged-particle tracking system, and the global/forward detectors.

This talk reports the first measurements of a number of "standard candle"properties of heavy ion collisions in commissioning data, including the charged-particle pseudorapidity density, the total transverse energy production, and the production and azimuthal modulation of neutral pions.

The results are compared with theoretical expectations and previous measurements at RHIC, and the lessons learned for the physics data-taking in 2024 are discussed.

Closing session / 408

SQM 2026 in UCLA

Auteur: Huan Huang[1]

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Posters / 409

Measurement of Ξc0 production as a function of multiplicity via hadron decay in pp collisions at $\sqrt{s}$ = 13 TeV with ALICE

Auteur: Tao Fang[None]

Measurements of the production of heavy-flavour hadrons in proton–proton (pp) collisions provide an important test of quantum chromodynamics (QCD). The heavy-flavour production cross section can be calculated, using the factorisation approach, as a convolution of three terms: the parton distribution functions, the partonic cross section, calculated with perturbative QCD calculations, and the fragmentation functions.
Recent measurements of the baryon-to-meson (Λc+/D0, Σc0,++/D0, Ξc0,+/D0 and Ωc0 /D0) pT-differential production yield ratios in pp collisions are inconsistent with corresponding measurements in e+e− collisions, indicating that the hadronisation of charm quarks is not a universal process among different collision systems. From measurements of the pT-differential Λc+/D0 yield ratio as a function of the charged-particle multiplicity in pp collisions, the modification of the hadronisation mechanism is found to be multiplicity dependent, with an enhancement of ratio in high-multiplicity collisions. The measurement of the multiplicity dependence of the Ξc0 /D0 yield ratio can provide further constraints on the study of charm hadronisation.
In this contribution, the production cross section of Ξc0 baryon reconstructed from the hadronic decay channel Ξc0 ⟶ Ξ−π+ and the baryon-to-meson production yield ratio Ξc0/D0 as a function of charged-particle multiplicity measured in pp collisions at √s = 13 TeV at midrapidity with the ALICE detector at the LHC will be discussed.

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Pictures for best poster Awards

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Picture for the Andre Mischke Award

Plenary-Overviews / 412

Precision measurements of net-proton number fluctuations in Au+Au collisions at RHIC

Auteur: Yifei ZHANG[1]

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The main goal of the RHIC beam energy scan program (BES) is to study the strongly interacting nuclear matter phase structure and search for the possible QCD critical point in high-energy nuclear collisions. Over more than a decade, the scan (BES-I and BES-II) covered a wide range of collision energy, from $\sqrt{s_{\rm NN}}$ = 3.0 GeV to 200 GeV corresponding to a wide range of baryonic-chemical potential μ_B = 750 MeV to 25 MeV. The STAR detector, with some crucial upgrades, was the main apparatus used in the scan. Observables, for studying the physics of collectivity, chirality, criticality, involving light/strange hadrons, leptons, correlations, (hyper-)nuclei have been measured with the highest precision to date.

In this talk, we will focus on the physics of phase boundary and QCD critical point. Specifically, new BES-II data on collision energy and centrality dependence of proton, anti-proton and net-proton cumulants, up to the $4^{\rm th}$ order, in Au+Au collisions at $\sqrt{s_{\rm NN}}$ = 7.7, 9.2, 11.5, 14.6, 17.3, 19.6 and 27 GeV, will be presented. The new experimental results will be discussed within the framework of non-critical model calculations.