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Book of Abstracts

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Importance of separated efficiencies for positively and negatively charged particles for cumulant calculations

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At star experiment, average sfficiency of positively and negatively charged particles had been used for cumulants calculation because of thge small efficiency difference between positively and negatively charged particles. However, there is finite difference in the detecting efficiency for positively and negatively charged hadrons. The difference is also dependent on collision energy. In addition, we don't know quantitatively the effect on cumulants and cumulant ratios compared to the case of separated efficiencies.

In this talk, we will show the Monte Carlo toy model assuming Poisson distribution where input parameters are taken from proton(anti-proton) multiplicity distributions at STAR experiment. Results of MC toy model were also checked by analytical calculations. Deviations are proportional to the sum of multiplicity for odd order cumulants, while they are proportional to the difference of multiplicity for even order cumulants. This is also studied as a function of beam energy. The deviation becomes $\sim 20\%$ for odd order cumulants at $\sqrt{s_{NN}}$ = 200 GeV in the most peripheral collisions and $\sim 10\%$ in the most central collisions, while less than 5% at the beam energy of 7.7GeV to 27GeV. The deviations of $S\sigma$ is also as large as the odd order cumulants at high beam energies. But $S\sigma/Skellam$ and $\kappa\sigma^2$ have little deviation($\sim 1\%$) at all over the BES energies. These results would suggest that it is important for us to use separated efficiencies instead of average efficiency.

Session 8 / **59**

Identified Particle Production in Au+Au Collisions at $\sqrt{s_{NN}}$ = 14.5 GeV in STAR

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One of the main goals of relativistic heavy-ion collision experiments is to explore the QCD phase diagram and hence to search for the QCD critical point. The study of the bulk properties of the system formed in high-energy heavy-ion collisions shed light on the evolution of the system and on the particle production mechanism. Keeping this in view, the Beam-Energy Scan (BES) program took place in the years 2010 and 2011 at RHIC, where Au+Au collisions were recorded at $\sqrt{s_{NN}}$ = 7.7, 11.5, 19.6, 27, 39, and 62.4 GeV. In the year 2014, Au+Au collisions at $\sqrt{s_{NN}}$ = 14.5 GeV were also recorded by the STAR experiment at RHIC under the same BES program. In this analysis we present the transverse momentum spectra of $\pi^{\pm}, K^{\pm}, p(\bar{p})$ in Au+Au collisions at $\sqrt{s_{NN}}$ = 14.5 GeV. The bulk properties of the system, dN/dy, mean transverse momentum ($< p_T >$), kinetic freeze-out and chemical freeze-out properties are also studied in detail. All the results are compared with other BES energies.

Collaboration:

for the STAR Collaboration

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Effects of phase transition induced density fluctuations on pulser dynamics

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We show that density fluctuations during phase transitions in pulsar cores may have non−trivial effects on pulsar timings, and may also possibly account for glitches and anti−glitches. These density fluctuations invariably lead to non-zero off−diagonal components of the moment of inertia, leading to transient wobbling of star. Thus, accurate measurements of pulsar timing and intensity modulations (from wobbling) may be used to identify the specific pattern of density fluctuations, hence the particular phase transition, occurring inside the pulsar core. Changes in quadrupole moment from rapidly evolving density fluctuations during the transition, with very short time scales, may provide a new source for gravitational waves.

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Probing color superconducting phases and neutron superfluidity via hydrodynamic evolution at FAIR and NICA.

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High baryon density regions of the cores of neutron stars are expected to
have exotic phases such as color superconducting phases. The symmetry breaking pattern of these phases allows for topological vortices. Even in the lower density region of neutron star, neutron superfluid and associated topological vortices play important role in the dynamics of neutron star, e.g. in pulsar timings and glitches. We consider the possibility of formation of these superfluid phases in heavy−ion collision experiments, e.g. at FAIR and NICA, by carrying out Hydrodynamic simulation. Our result shows that existence of superfluid phases can be
detected by studying the effect of vortices on power spectrum of flow fluctuations.

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Transverse mass scaling of identified hadrons in pp collisions at RHIC and LHC

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The phase transition predicted by Quantum Chromodyamics (QCD) from ordinary matter to a deconfined Quark−Gluon Plasma (QGP) is being studied in high−energy heavy−ion (AA) collisions at different experiments. The identified hadron spectra provide insight into the particle production mechanism and interaction in the hadronic and QGP phases. Measurements in smaller collision systems such as proton-proton (pp) and proton−nucleus (pA) constitute a fundamental reference for

the interpretation of the heavy−ion results. Understanding the mechanism of particle production in elementary pp collisions is one of the major goals of the experiments at the Relativistic Heavy Ion Collider (RHIC) and the Large Hadron Collider (LHC). The production of particles in pp collisions can be roughly categorised into two dominating mechanisms, soft and hard processes. The soft, thermal−like processes populate the low momentum part of the particle spectra and is called underlying event whereas the high momentum region is dominated by hard processes described by fragmentation. In this scenario, an exponential function is used to describe the low part of the transverse momentum (p_T) spectrum while a power−law is used for the high p_T. We will present a systematic study of m_T and $m_T - m_0$ spectra of mesons and baryons at RHIC and LHC energies. The m_T scaling of hadron production in pp collisions at LHC energies seems to hold at lower m_T and breaks down at higher m_T showing a difference in the shape of the m_T spectrum between baryons and mesons which was first observed at RHIC. In order to understand the underlying physics mechanism, a Monte Carlo study has been done using the PYTHIA event generator with two different fragmentation scheme, the string fragmentation (SF) and independent fragmentation (IF). The simulation results demonstrate that this difference exists in both SF and IF scheme. We will also show that the shape of $m_T - m_0$ spectra for pions is different from other hadrons at RHIC and LHC energies. From the PYTHIA simulation it is observed that this difference is due to the contamination of pions from the resonance decay.

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Search for critical parton density fluctuations through baryon clustering

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Phase transitions and/or critical phenomena are known to lead to local density fluctuations. In the coalescence mechanism of particle production, the baryon formation probability can be influenced by these local parton density fluctuations, thereby leading to clusters and voids in the phase-space distribution of hadrons. In order to probe the density fluctuation in heavy ion collisions, we study the angular distribution of a self-normalized distribution of the produced particles. We expect the shape of the distribution to be sensitive to clustering in phase space.\\
We study the effect of clustering of produced particles by employing a simple Monte-Carlo model assuming a Poisson distribution of protons for reference. We also introduce elliptic flow in the model and study its effects. We compare our model results with the STAR Beam Energy Scan data to understand the quantitative sensitivity of our observable and probe baryon density fluctuations.

Collaboration:

for the STAR Collaboration

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Properties of net−baryon number cumulant ratios in the strong coupling limit of lattice QCD at finite density

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Critical phenomena in quantum chromodynamics (QCD) have been attracting attention to find features of chiral symmetry breaking (or restoration) in QCD. QCD critical point (CP) is one of the cornerstones to deduce the QCD phase structure. Theoretically, higher than 3rd order cumulants can be negative [1] due to Z(2) criticality around CP [2] and the remnant effect of O(4) criticality in the crossover region [3] at finite mass and nonzero chemical potential. These sign flips are useful tools to investigate the phase transition, so we need explicit calculations to see actual critical behaviors beyond universality arguments.
The strong coupling approach of lattice QCD provides an efficient method to investigate the QCD phase diagram by virtue of a milder sign problem. We have recently investigated higher-order cumulant ratios of the net-baryon number in the strong coupling and chiral limits with fluctuations of auxiliary fields [4]. We find that the finite volume effect smears the divergence of cumulant ratios and gives rise to the negative kurtosis region [4] while it positively diverges in the chiral and thermodynamic limits [3]. In the presentation, we will give results of the cumulant ratios and discuss the relations to the scaling function analysis discussed in [3]. We will also discuss finite size scaling analyses.

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Speed of sound and systematic study of hadron spectra in Tsallis Statistics

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Tsallis non-extensive thermodynamics has been successfully used to describe the transverse momentum distributions from RHIC to LHC energies. Assuming the non-extensive parameter q$\sim$1, Taylor expansion of Tsallis Boltzmann distribution function is performed up to first order in (q-1), which has an explicit radial flow dependence and an analytical result for the Tsallis distribution in the presence of collective flow is provided. The transverse momentum spectra at RHIC and LHC for A+A and p+p collisions are studied with this explicit radial flow dependent function along with Tsallis Boltzmann distribution function and Tsallis distribution including chemical potential. The information on the freeze-out surface in terms of freeze-out volume, temperature, chemical potential and radial flow velocities for different particle species are obtained. These parameters are studied as a function of particle mass and a differential freeze out scenario is observed. Also it is observed that the system formed in peripheral A+A and p+p collisions are of similar thermodynamic nature. Further, In the present work we extend the q-statistics for the physical resonance gas to examine the basic thermodynamical quantities for systems having different "q" parameters. The speed of sound is studies in the frame work of non-extensive statistics and the effect of q-parameter is observed on the mass cut-off behaviour.

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Identified particle production in $p + p$ collisions at $\sqrt{s}$ = 62.4 GeV in STAR

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It is important to study the particle production as a function of both transverse momentum (p_T) and particle species which provide crucial input for modeling of hadronic interactions and the hadronization process in high-energy collisions [1]. In this contribution, we will present the results on $\pi^{\pm}$, $K^{\pm}$, p and $\bar{p}$ in $p + p$ collisions at $\sqrt{s}$ = 62.4 GeV from STAR experiment at the Relativistic Heavy Ion Collider. The results are obtained for the midrapidity region in the range $\mid y \mid< 0.1$. Charged hadrons are identified by using specific ionization energy loss at the low momentum region (about 1 GeV/c) with STAR's Time Projection Chamber detector [2,3]. We will present the final corrected p_T spectra, particle yields (dN/dy), various particle ratios and mean p_T. The results will be compared with different models namely PYTHIA and PHOJET.

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Collaboration:

STAR Collaboration

Session 9 / 4

Beam energy dependence of specific heat in Ultra-relativistic Heavy-Ion Collisions

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Experiments at RHIC and LHC are on the quest to unearth the nature of the QCD phase transition and to get a glimpse of how matter behaves at such extreme conditions. Phase transitions are governed by a set of thermodynamic parameters, like, temperature (T), pressure, entropy and energy density (E), and can be further characterized by their response functions, like, specific heat,compressibility, and susceptibility. In thermodynamics, the heat capacity (C) is defined in terms of the ratio of the event-by-event fluctuations of the energy of a part of a finite system in thermal equilibrium to the energy $(\Delta E^2) = T^2 C(T)$. This can be applied for a locally thermalized system produced during the evolution of heavy-ion collisions. But for a system at freeze-out, specific heat can expressed in terms of the event-by-event fluctuations in temperature of the system where volume is fixed: $\frac{1}{C} = \frac{(\langle T^2\rangle - \langle T\rangle^2)}{\langle T\rangle^2}$. We define the specific heat as the heat capacity per pion multiplicity within

the experimentally available phase space in rapidity and azimuth. For a system in equilibrium, the mean values of temperature and energy density are related by an equation of state. However, the fluctuations in energy and temperature have quite different behavior.
Energy being an extensive quantity, its fluctuations have a component arising from the volume fluctuations, and not directly suited for obtaining the heat capacity. Here, we obtain the specific heat for heavy-ion collisions at SPS, RHIC beam energy scan energies and for LHC energy. Experimental results from NA49, STAR, PHENIX, PHOBOS and ALICE are combined to obtain the specific heat as a function of beam energy. The results are compared to results from AMPT event generator, HRG model and lattice calculations. We also present local hot spot search at LHC energy for better understanding the collision dynamics.

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Chemical freeze-out study in proton-proton collisions at RHIC and LHC energies

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Particle multiplicities measured at Relativistic Heavy Ion Collider (RHIC) and Large Hadron Collider (LHC) facilities can be used to understand the chemical freeze-out dynamics. At chemical freeze-out (CFO), inelastic collisions cease and the freeze-out parameters can be determined using measured particle multiplicities within the framework of a statistical model.The statistical model has proven to be quite successful in describing the particle production from elementary $p - p$ and e^+e^- collisions up to heavy-ion collisions [1,2]. It helps to do a systematic study of the centrality and energy dependence of freeze-out parameters in heavy-ion collisions from lower SPS to higher LHC energies [3]. The new data at LHC along with the RHIC data can be used to do such a systematic study in proton-proton collisions.

Here, we will present the particle production in proton-proton collisions within a statistical model at RHIC center-of-mass energy $\sqrt{s}$ = 200 GeV and at LHC center-of-mass energy $\sqrt{s}$ = 900 GeV and 7 TeV. In this model, particle production is described by a set of thermal parameters like the temperature, the volume and the set of chemical potentials corresponding to different conserved quantities such as baryon number, strangeness and charge. Two different freeze-out schemes have been used for this study. One is single freeze-out (1CFO) [4] where all hadrons freeze-out together. Other one is double freeze-out (2CFO) [5] where strange and non-strange hadrons freeze-out separately giving two different sets of parameters. We will discuss the energy dependence of different chemical freeze-out parameters in 1CFO. The freeze-out parameters are also extracted in 2CFO and compared with 1CFO. The non-strange temperature is found to be lower than that of strange temperature in 2CFO for all energies studied here which can be interpreted as the early freeze-out of strange hadrons. The freeze-out parameters from 1CFO found to lie intermediate to the corresponding strange and non-strange values of 2CFO.

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Strange hyperon productions at Relativistic Heavy Ion Collisions

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To investigate the possibility of successive freeze out scenario in heavy ion collisions, we have studied the production of strange hadrons microscopically, assuming the non strange hadrons to be in thermal bath. Various hadronic interactions have been considered to investigate the production of strange hyperons, such as Λ, Σ, Ξ and Ω, along with the strange mesons. Basically, their production and evolution is studied using transport equation for different colliding energies. Coupled differential equations for comoving particle densities of these strange hadrons are solved simultaneously with the evolution equations for temperature and chemical potential.

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Studying Tsallis distribution at LHC energies

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A thermodynamically consistent form of the Tsallis distribution at y = 0 has been used for fitting the transverse momentum spectra $d^2N/dydp_T$ and to study the yields of particles measured by the ALICE and CMS experiments at the CERN Large Hadron Collider (LHC). The Tsallis distribution describes the p_T spectra very well. The values of $dN/dy|_{y=0}$ obtained from the Tsallis distribution are in agreement with the values measured by the ALICE and CMS experiments. The data to fit ratio and centre-of-mass energy dependence of $dN/dy|_{y=0}$ will be presented and discussed. An attempt will be made to study the particle ratios using Tsallis distribution at LHC energies.

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Inclusive charged hadron elliptic flow v_2 in Au+Au collisions at $\sqrt{s_{NN}}$ = 14.5 GeV

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Quark Gluon Plasma (QGP) is a phase of nuclear matter at high temperature and high energy density formed in relativistic nucleus-nucleus collisions. Azimuthal anisotropy is an important tool for understanding the basic properties of QGP and to characterize the collision dynamics in high energy heavy-ion collisions [1]. These anisotropies are expected to arise due to initial pressure gradients and subsequent interactions of the constituents [2]. The second order azimuthal anisotropy namely elliptic flow is defined as the 2^{nd} harmonic coefficients of the Fourier decomposition of the azimuthal distribution of produced particles with respect to the reaction plane angle (ψ_n), and the azimuthal anisotropy can be expressed as v_2 = $\langle cos(2(\phi - \psi_n))\rangle$, where ϕ is the azimuthal angle of produced particles. Recently, a Beam Energy Scan (BES) program at RHIC has been completed. Its aim is to study the QCD phase diagram [3] by extending the range of chemical potential. The BES program extends the range of baryonic chemical potential (μ_B) from 20 to about 400 MeV at RHIC [4]. The baryon chemical potential increases with the decrease in the beam energy while the chemical freeze-out temperature increases with increase in beam energy [4]. This allows one to study azimuthal anisotropy at midrapidity with varying net-baryon densities. Here we will present a systematic study of the inclusive charged hadron elliptic flow (v_2) as function of transverse momentum (p_T) at midrapidity ($\eta \leq 1.0$) in Au+Au collisions at s N N = 14.5 GeV. The v_2 results will be compared to similar measurements at $\sqrt{(}s_{NN}$ = 7.7, 11.5, 19.6, 27, 39 and 62.4 GeV. We will discuss inclusive charged hadron v_2 from different methods, including η-sub event plane method with a η-gap of 0.15 and 2(4)-particle cumulants method to reduce non-flow correlations. We will also discuss the centrality dependence of v_2, and comparison to calculations from a transport model (AMPT) [5].

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Collaboration:

for the STAR Collaboration

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Dynamical evolution of D meson spectrum in viscous QCD plasma

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We investigate D meson spectrum and nuclear modification factor by incorporating the off-equilibrium distribution function in a dynamic viscous QCD plasma.
The spectrum is determined by heavy quark energy (drag) and momentum relaxation (diffusion) coefficients. We study modifications of these coefficients due to viscous corrections to the bosonic and fermionic thermal distribution functions.
The Fokker-Planck equation is then used to obtain the D meson spectrum within the relativistic viscous hydrodynamic evolution of the medium. We incorporate the many-body interaction effects

via the hard thermal loop technique in the calculation. We also explore the effects of different momentum dependences of the off-equilibrium distribution function on the spectrum as well as on the nuclear modification factor.

Session 13 / 6

Nuclear gluon effects in gamma+Pb collisions at the LHC

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By studying quarkonia photo-nuclear production, the ALICE and CMS collaborations have recently provided experimental evidence of nuclear gluon effects in gamma+Pb interactions at unprecedented low Bjorken-x values in the Pb nucleus. In this talk, an experimental and theoretical review about these studies will be given. The prospect of innovative measurements using the run 2 data will be described.

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Evolution of temperature fluctuation in a thermal bath and, its implications in hadronic and heavy-ion collisions

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The evolution of temperature fluctuations inside an in-homogeneous and an-isotropic medium is derived within the ambit of Boltzmann Transport Equation. Also, taking some existing realistic inputs we have analyzed the Fourier space variation of temperature fluctuation for the medium created after heavy-ion collisions. The effect of viscosity on the variation of fluctuations is investigated. Further, possible implications in hadronic and heavy-ion collisions are explored.

Session 11 / 29

Hadronic resonances production in Pb−Pb collisions with ALICE detector at the LHC

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Resonances are used to study the properties of the strongly interacting hot and dense matter produced in ultrarelativistic heavy−ion collisions. The system produced in such collisions evolves through different stages from early partonic phase to the hadronic one. Resonances can probe the existence of hadron rescattering and regeneration effects after hadronization. These effects can change resonance yields which are measured through their hadronic decay channels. We report the measurements of hadronic resonance production in Pb−Pb collisions at $\sqrt{s_{NN}}$ = 2.76 TeV with ALICE detector at the LHC. Transverse momentum spectra, integrated yields, mean transverse momenta, particle ratios and nuclear modification factors of $K^{*}(892)^{0}$ and $\phi(1020)$ mesons will be discussed and compared to the corresponding measurements in other collision systems. The results will also be compared to theoretical model predictions.

Collaboration:

for the ALICE Colloboratio

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Multiplicity dependence of identified hadron production in pp collisions at $\sqrt{s}$ = 7 TeV in the ALICE at LHC

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Recent measurements in proton-lead (p-Pb) and high-multiplicity proton-proton (pp) collisions show some collective features that are similar to those observed in Pb-Pb collisions. We report the production of charged light flavour, strange and multi-strange hadrons ($\pi, K, p, \Lambda, \Xi, \Omega$) at mid rapidity as a function of event multiplicity in pp collisions at $\sqrt{s}$ = 7 TeV using the ALICE detectors. In the p_T-differential baryon to meson ratios ($p/\pi, \Lambda/K^0_s$)), an enhancement of baryon production at intermediate p_T is observed in high-multiplicity pp collisions. This behavior is qualitatively similar to earlier measurements performed in p-Pb and Pb-Pb collisions as a function of event activity. The production rate of strange and multi-strange hadrons relative to pions exhibits a significant increase with multiplicity in the smaller colliding systems of pp and p-Pb, pointing to similar mechanisms at play in pp and p-Pb collisions. The results are also compared with QCD inspired model calculations.

Collaboration:

for the ALICE Collaboration

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Scaling properties of charged particle multiplicity fluctuations in transport model

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QCD predicts significant fluctuations being associated with quark-hadron phase transition. Studying system that emerges in the relativistic heavy ion collisions, important information on the evolution of the quark-hadron phase tansition can be extracted. Local multiplicity fluctuations of hadrons produced in these collisions may reveal some of the features of the phase transition. A fundamental characteristic of the critical behaviour of a system under-going phase transition is that it exhibits fluctuations of all scales. Scaling properties of the factorial moments of produced particles, more commonly known as intermittency, are used to quantify these fluctuations in a system. We will present observations on the multiplicity flctuations of the charged particles, generated in the Pb-Pb collisions at $\sqrt{s_{NN}}$ = 2.76 TeV using A MultiPhase Transport model. Scaling of the factorial moments with the number of bins will be discussed.

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Wounded quark scenario for charged hadron production in p−p, p−A and A−A collisions

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Various ultra−relativistic high energy collision experiments have been performed at different places to test the predictions of quantum chromo−dynamics (QCD). The charged hadrons produced in these experiments can reveal the nature of hadronic interactions at extreme temperature and/or density and throw light on the role played by the quarks and gluons in the particle production mechanism. Here, we propose a parameterization which is based on a phenomenological model involving the basic quark-quark interactions picture. Our model is based on simple assumptions regarding mean number of participating quarks and average number of collisions suffered by each quark. Model suitably explains the various observed features of charged hadron production such as the pseudo−rapidity density at mid−rapidity and rapidity dependence of pseudo−rapidity density for different colliding system in relativistic heavy−ion collisions. The model satisfactorily describes the role of hard and soft processes involved in the production of charged hadrons. The model also interrelates nucleus-nucleus (A−A) collisions with proton−nucleus (p−A) and proton−proton (pp) interactions. The experimental results for central pseudo−rapidity density and their variations with the mass number of colliding nuclei and center−of−mass energy available till date are well explained by the model results. We also give the predictions for charged hadron multiplicity from our model for A−A collisions at the Large Hadron Collider (LHC) and Compressed Baryonic Matter (CBM) experiments. The model provides a possible universal mechanism of charged hadron production in pp, p−A and A−A collisions and explains various observed features. Any distinct deviation observed in the data from the predictions of the model will provide a hint for QGP formation.

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Intermittency analysis as a measure of multiplicity fluctuations in Pb-Pb collisions at LHC Energies

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Fluctuations in multiplicity of charged hadrons produced in relativistic nuclear collisions are regarded as one of the vital signal of quark-gluon plasma formation and also have a long history back with early cosmic ray observations. The controversial issue of QCD critical point existence may be expected to be solved in current LHC experiments. The presence of local multiplicity fluctuations are considered to shed light on this phenomenon.

Recent theoretical investigation also propose the presence of critical fluctuations exhibitted by chiral condensation in the vicinity of the critical point. These fluctuations are thought to be present in pseudorapidity and transverse momentum distribution of the produced hadrons. In the present study, an attempt has been made to carry out intermittency analysis for the AMPT simulated Pb-Pb collisions at $\sqrt{s_{NN}}$ = 2.76 and 5.02 TeV by calculating scaled factorial moment (SFM) in pseudorapidty and transverse momentum space. We observe eveidence for a power law dependence of SFM. Similar Study for the ALICE experimental data is also under progress. Further, results obtained by applying the proposed method of improved intermittency analysis will also be presented.

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Probing Pb+Pb collisions at $\sqrt{s_{NN}}$ = 2.76 TeV with spectator neutrons in AMPT model

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In high energy heavy-ion collisions a precise knowledge of the initial state is required in order to describe properties of the strongly interacting medium. There is event by event geometric as well as quantum fluctuations in the initial condition of heavy-ion collisions. The standard technique of analyzing heavy-ion collisions in bins of centrality obtained from final state multiplicity averages out the various initial configurations and thus restricts the study to only a limited range of initial conditions. In this work, we propose an additional binning in terms of total spectator neutrons (L+R), which is sum of left (L) and right (R) going spectator neutrons in an event. This offers us a key control parameter to probe events with broader range of initial conditions providing us an opportunity to investigate events with rarer initial conditions which otherwise get masked when analyzed by centrality binning alone.

In this presentation, we will show correlations of initial state observable ε_2 and ε_3 and final state observable v_2 and v_3 in spectator neutron bins. We will present the standard scaling relation between v_2/ε_2 and $\frac{1}{S}\frac{dN_{ch}}{d\eta}$ in bins of spectator neutrons, which seems to break the usual behavior seen in centrality binning alone. The acoustic scaling relation between ln(v_n/ε_n) and transverse system size will also be presented in bins of spectator neutron. We would also discuss about the $< p_T >$ in bins of L+R and centrality, which can be considered as a good probe to study the medium interactions in heavy-ion collisions.

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Resonance production in p-Pb collisions at $\sqrt{s_{NN}}$ = 5.02 TeV measured by ALICE at the LHC

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In order to understand how particle production mechanisms change with system size, proton-lead (p-Pb) collisions, with their charged particle multiplicity that is intermediate between proton-proton (pp) and lead-lead (Pb-Pb) collisions, are of crucial importance. Due to their relatively short lifetimes, resonances are good candidates to probe the existence of particle re-scattering and regeneration in hadronic phase, which may modify the yield of resonances measured in hadronic decay channel. Measurements of resonance particles ($K(892)^0, \Phi(1020), \Sigma(1385)^{\pm}$ and $\Xi(1530)^0$) produced in p-Pb collisions at $\sqrt{s_{NN}}$ = 5.02 TeV have been performed in the rapidity range $-0.5 < y < 0$ with the ALICE detector at the LHC. Resonance reconstruction, transverse momentum spectra, mean transverse momenta and particle ratios are presented and compared to model predictions.

Collaboration:

for the ALICE Collaboration

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Initial condition from the shadowed Glauber model

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We study the effects of nucleon shadowing in the two component Glauber model. The conventional Glauber model predicts a knee-like structure in the centrality dependence of v_2 which has not been observed in experiments. This discrepancy is removed by the inclusion of nucleon shadowing. The model also explains the suppression in fluctuations of initial ε_2 for a given centrality. This result agrees with the dynamical models of initial condition based on gluon saturation physics.

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Entropy scaling and thermalization in relativistic and ultra-relativistic heavy-ion collisions

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Observed dependence of multiplicity distribution on energy and rapidity window reveal that the secondary particles arise from two kind of sources: chaotic and coherent sources. Particles produced through chaotic sources are concentrated in relatively smaller rapidity intervals, while those coming from the coherent sources are spread over entire rapidity space. It has been observed that the scaling based on information entropy holds good for pp collisions in the energy range: from ISR ($\sqrt{s} \sim 19$ GeV) to LHC energy ($\sqrt{s} \sim 2.36$ TeV). Such a scaling of entropy has also been observed in ion-ion collisions at AGS and SPS energies. Furthermore, only a few attempts have been made to extend the entropy studies to evaluate higher generalized fractal dimensions. An attempt is, therefore, made to study Shannon information entropy ($S = -\Sigma(P_n ln P_n)$) scaling, Renyi information entropy ($I_q = \frac{1}{q-1} ln\Sigma(P_n)^q$) and generalized fractal dimensions of order q by analyzing several sets of experimental data on AA collisions at AGS and SPS energies. The findings are compared with the predictions of Monte Carlo model HIJING .

Variation of generalized dimensions, D_q , with q is observed to be expressible in the following form: $D_q \approx (a-c) + cln(\frac{q}{q-1})$. The slope parameter c is found to be nearly independent of beam energy and projectile/target mass; c is often referred to as multifractal specific heat. The value of c is calculated and its dependences on beam energy and target mass are investigated. Variation of entropy with mean charged particle multiplicity in limited rapidity bins is observed to be linear and independent of energy and identity of colliding nuclei, thus indicating a kind of entropy scaling.

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Production of light nuclei and measurement of coalescence parameter in heavy−ion collisions at RHIC

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A strongly interacting medium, namely Quark Gluon Plasma (QGP), is formed in high-energy heavy-ion collisions at RHIC. Light nuclei (anti-nuclei) can be produced in such heavy-ion collisions by the recombination of produced nucleons (anti-nucleons) or stopped nucleons. This formation process is called final-state coalescence. The production of light nuclei is dependent on the baryon density and the correlation (freeze-out) volume. Therefore, by studying the yield and azimuthal anisotropy of light nuclei (anti-nuclei) and comparing them with that of proton (anti-proton) we can gain insight in the particle production mechanism via coalescence and physical properties of the expanding system at the thermal (kinetic) freeze-out. Unlike the quark coalescence phenomena of identified hadrons, nucleonic coalescence is directly measurable as both the light nuclei and nucleons (proton and anti-proton) are measured by the detectors in a given experiment.

In this presentation, we will show the invariant yields of d and $\overline{d}$ for Au+Au collisions at $\sqrt{s_{NN}}$ = 7.7, 11.5, 19.6, 27, 39, 62.4 and 200 GeV from the STAR experiment at RHIC. Light nuclei are identified using the Time Projection Chamber (TPC) and Time-of-Flight (TOF) detector of the STAR experiment. The TOF detector enhances the identification of the light nuclei and extends the p_T reach of light nuclei beyond 1 GeV/c. The p_T spectra of nuclei will be compared with p ($\overline{p}$) to obtain the nuclei to nucleon ratio and B_2 parameter to understand the light nucleus production mechanism in heavy-ion collisions. Light nucleus spectra will also be compared with the prediction from Blast-wave model, using the fit parameters obtained from Blast-wave fit of π, K, p spectra.

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Relativistic fluctuating hydrodynamics

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Magneto hydrodynamics

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Theoretical results from hydrodynamical calculations

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Experimental evidences for hydrodynamic flow in heavy-ion collisions

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Experimental results on collective dynamics in heavy ion collisions

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Neutral pion production in pp collisions at LHC energies

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The ALICE experiment at LHC is designed to study very wide p_T range neutral mesons in all collision systems and energies provided by LHC, what is useful to test QCD theory predictions.

ALICE covers the measurement of neutral pions with the photon conversion method (low and intermediate p_T) making use of the ALICE-ITS and TPC, and the electromagnetic calorimeters PHOS and EMCAL (intermediate and high p_T). High p_T can be reached thanks to the triggering capabilities of the calorimeters.

In LHC Run1, the neutral pions were measured in pp collisions at $\sqrt{s}$ = 0.9, 2.76, 7 and 8 TeV by using above detectors. In pp collisions at $\sqrt{s}$ = 8 TeV measurement, not only minimum-bias trigger but also the high energy photon trigger were used. Benefit from the specific trigger, high p_T neutral pion (up to 40 GeV/c) was measured. We will discuss the neutral pion production at LHC energies and compare them.

Session 18 / **46**

Evolution of spatial anisotropies in quark gluon plasma

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Evolution of fluctuations in various thermodynamical quantities have been studied within the framework of Boltzmann transport equation. Spatial anisotropies of the initial state with different geometry have been evolved through Boltzmann equation and shown that these anisotropies decay very fast. This supports the presumption that the measured anisotropies in the data does not originates from the late stage rather it imitate the initial state effects. Relation between thermal fluctuation and transport coefficients have been established. Evolution of fluctuations in energy density and temperature of quark gluon plasma expected to be created in nuclear collisions at relativistic energies has been studied.

Session 16 / **3**

Measurement of leptons from heavy-flavour decays with ALICE at the LHC

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Heavy quarks (charm and beauty) are essential probes of the evolution of the medium created in heavy-ion collisions, because heavy-quark production in high-energy collisions occurs early compared to the formation time of the strongly-interacting partonic matter. To quantify medium effects in AA collisions, one needs to study pp collisions and p−A collisions as references. Apart from providing the crucial reference for Pb−Pb collisions, the measurements of heavy-flavour production in pp collisions provide tests for perturbative QCD calculations. Measurements in p−A collisions can be used to study cold nuclear matter effects, such as modifications to the parton densities in nuclei, k_T broadening and energy loss in cold nuclear matter. The ALICE detector is dedicated to the study

of the strongly- interacting partonic medium, produced in heavy-ion collisions. Thanks to excellent tracking, vertexing and particle−identification capabilities provided by ALICE, we have been able to measure electrons (muons) from semileptonic heavy-flavour hadron decays at mid (forward/ backward) rapidity. Electrons are reconstructed and identified using several detectors at mid rapidity ($< |\eta| <$ < 0.9), namely the Time Of Flight detector, the Time Projection Chamber, the Electromagnetic Calorimeter, and the Transition Radiation Detector. Muons are reconstructed using the muon spectrometer at forward rapidity ($2.5 < \eta < 4$). In this talk, we present measurements of electrons and muons from heavy-flavour hadron decays at mid and forward rapidity with ALICE in pp ($\sqrt{s}$ = 2.76 TeV and $\sqrt{s}$ = 7 TeV), p−Pb ($\sqrt{s_{NN}}$ = 5.02 TeV) and Pb−Pb collisions ($\sqrt{s_{NN}}$ = 2.76 TeV). The measurements of production cross sections of leptons from heavy-flavour decays in pp, p−Pb and Pb−Pb collisions, the nuclear modification factor in p−Pb and Pb−Pb collisions and the azimuthal anisotropy in Pb−Pb collisions will be presented with theoretical model comparisons.

Collaboration:

for the ALICE Collaboration

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Measurement of angular correlations between D mesons and charged particles in pp and p-Pb collisions with ALICE at the LHC

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ALICE (A Large Ion Collider Experiment) is designed and optimised for the study of heavy-ion collisions. The main objective of the ALICE physics programme is to study the Quark-Gluon Plasma (QGP), a strongly-interacting state of matter created at extremely high energy densities and temperatures in heavy-ion collisions. Heavy quarks (charm and beauty) are well suited probes of the QCD matter formed in high-energy nuclear collisions. They are produced in hard partonic scattering processes occurring in the initial stage of the collisions before the QGP is formed. So, they experience the full evolution of the medium and interact with its constituents.

The study of angular correlations between heavy-flavour particles and charged particles can give insight into the mechanisms through which heavy quarks lose energy and help to investigate possible modifications of their hadronisation induced by the presence of the medium. Such correlations in pp collisions serve as reference for nuclear collision systems and provide a testing ground for perturbative QCD calculations. Measurements in proton-lead (p-Pb) collisions are important to investigate cold nuclear matter effects such as the modification of parton densities in nuclei via shadowing or saturation, and k_T-broadening from multiple soft scatterings of partons, or parton energy loss in the initial and final state of the collisions.

In this contribution, the measurements of azimuthal correlations between D^0, D^+ and D^{*+} mesons and charged particles in pp collisions at $\sqrt{s}$ = 7 TeV and p-Pb collisions at $\sqrt{s}$ = 5.02 TeV will be presented along with comparisons with model predictions. D mesons were reconstructed from their hadronic decays in the central rapidity region and in the transverse momentum range $3 \leq p_T \leq 16$ GeV/c, and they were correlated to charged particles reconstructed in the pseudo-rapidity range $|\eta| < 0.8$. We will also discuss prospects of future measurements during Run II with ALICE at the LHC.

Collaboration:

for the ALICE Collaboration

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Two particle correlations in p-Pb collisions at $\sqrt{s_{NN}}$ =5.02 TeV with the ALICE detector

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A measurement of the correlations in the particle production as a function of the azimuthal angle and rapidity is very useful for investigating particle production in high-energy nucleus-nucleus collisions. Possible explanations of the long range correlations in high multiplicity pp and p-Pb collisions are the collective behavior of the created medium and/or the remnants of the strong color fields created by the dense gluonic field (gluon saturation). Long range, near side angular correlations have been observed in high multiplicity pp and p-Pb collisions at the LHC energy. The azimuthal anisotropy parameter, v_2 , of K, π and p shows mass ordering at low p_T and the trend similar to Pb-Pb collisions. The saturation effects are expected to be enhanced at forward rapidity region and the measurements of the particle productions with large rapidity gaps and the centrality dependence are important to quantify saturation and hydrodynamical final state effects. I will review ALICE results of correlations between charged and identified hadrons in p-Pb collisions at mid-rapidity ($-0.8 < \eta < 0.8$) and the correlations between muons at forward rapidity ($2.5 < \eta < 4$) and charged hadrons at mid-rapidity ($-0.8 < \eta < 0.8$).

Collaboration:

for the ALICE Collaboration

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Quenching parameter in a dual gravity closer to thermal QCD

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The yield of hadrons produced with high transverse momentum at RHIC and LHC has shown to be significantly suppressed in comparison with the cumulative yield of NN collisions. This effect, so called jet quenching was predicted to occur due to the energy loss suffered by hard scattered partons and can be understood in terms of a single "quenching parameter" $\hat{q}$, which can be obtained in a model-independent and nonperturbative way by the holographic set up on the duality of gauge-gravity. Usually in the holographic set up, the geometry in the gravity side at finite temperature was usually taken as the pure AdS black hole metric and hence their dual gauge theory is conformally invariant unlike QCD which depends on scale. Therefore we work on a local metric, known as as Ouyang-Klebanov-Strassler (OKS) model, where the coincident D7 branes as the fundamental quarks were embedded in the Klebanov-Tseytlin background. Later to switch on a finite temperature a black hole is inserted into the OKS background and the Hawking temperature will correspond to the gauge theory temperature, resulting the so-called OKS-BH metric. In the resulting dual gauge theory of OKS-BH metric, the coupling runs with the energy both in UV and infrared limit like QCD and hence proves to be a better background for thermal QCD, thus we obtain a strong-coupling calculations of $\hat{q}$ in terms of a particular light-like Wilson loop. We have calculated $\hat{q}$ for both short-distance and long-distance limit of the dipole, where $\hat{q}$ varies with the temperature as T^4 and depends on the light-cone time L^- both linearly and inversely in former limit and $\hat{q}$ aries linearly with T^4 and L^- in the latter limit.

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Exclusive photoproduction of Upsilon in pPb collisions with the CMS

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Relativistic heavy ions are a copious source of virtual photons, which allow to study the gamma−proton and gamma−gamma interactions in ultraperipheral collisions (UPC). The exclusive photoproduction of heavy vector mesons provide a clean probe of the gluon distribution at very small values of parton fractional momenta (Bjorken x) x≈10^{-2} 10^{-4} at central rapidities ($|y| < 2.5$) and search for saturation phenomena. We present the first measurement of exclusive photoproduction of Υ (1S,2S,3S) states in their dimuon decay channel in ultraperipheral collisions of protons and heavy ions (pPb) with the CMS experiment at $\sqrt{s_{NN}} = 5.02$ TeV for an integrated luminosity $L_{int} = 33$ nb^{-1}. The photoproduction cross−section of Υ (1S) is measured as a function of photon−proton center−of−mass energy $W_{\gamma p}$. The differential cross−section $d\sigma/dt$, where t is the squared four−momentum transfer at the photon−proton vertex, is measured in the range $|t| < 1.0$ (GeV/c)^2 . The results are compared with other measurements and theoretical predictions.

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Thermal effects in the hadronic and photonic multiplicity distributions and correlations: A Thermo-Field Dynamic approach

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The existence of the Quark Gluon Plasma(QGP) requires that in the collision of heavy ions an initial fireball is formed which has a lifetime larger than typical hadronic time scale of 10^{-23} sec and that the temperature and volume of the fireball is sufficient to ensure that the Quark Hadron phase transition predicted by statistical QCD is achieved. Then the pions and photons emitted from this hot fire ball may carry information of the temperature and life time of the emitting region, and this may manifest itself in the correlation functions and multiplicities which can be modified by finite temperature. Thus it is important to find ways of incorporating finite temperature effects in multiplicity distributions and correlations. The Thermo field formalism is particularly useful in the description of parametric dynamical systems in which squeezing of quantum fluctuations is important. Quantum optical systems with Bose - Einstein thermal fluctuation properties are conventionally represented by density matrices and their evolution described by master equations. We apply the formalism of thermofield dynamics can be used to get the thermal counter parts of multiplicity distribution and correlations. We then compare the distribution to the Glauber Lachs distribution and calculate the chaoticity parameter. Comparison with current data is given.

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Characterizing the away-side jet with robust flow background subtraction via two-particle and three-particle correlations in Au+Au collisions at $\sqrt{s_{NN}}$ = 200 GeV in STAR

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Jets are modified in relativistic heavy-ion collisions due to jet-medium interactions. Measurements of jet medium modifications have so far been obscure because of the large underlying anisotropic flow background. In this analysis we devise a novel method to subtract the flow background using data themselves. We select events with a large recoil momentum (P_x) within a pseudorapidity (η) window of $0.5 < |\eta| < 1$ from a high-p_T trigger particle to enhance the away-side jet population. Di-hadron azimuthal correlations are analyzed with associated particles in two η ranges ($-0.5 < \eta < 0$ and $0 < \eta < 0.5$) symmetric about midrapidity, one ("close-region") close to and the other ("far-region") far away from the P_x selection η window. The away-side jet contributes to the close-region but not as much to the far-region due to the large η gap, while the flow contributions are equal. Assuming the $\Delta\phi$ shape of jet-like correlations does not depend on $\Delta\eta$, the correlation difference measures the away-side jet shape where the anisotropic flow background is cleanly subtracted.

The away-side jet correlation width is studied as a function of centrality and associated particle p_T. The width is found to increase with centrality at modest to high associated particle p_T. The increase can arise from jet-medium modifications, event averaging of away-side jets deflected by medium flow, and/or simply nuclear k_T broadening. To further discriminate various physics mechanisms, a three-particle correlation analysis is conducted with robust flow background subtraction also using data themselves. Based on this analysis we discuss possible physics mechanisms of away-side broadening of jet-like correlations.

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Open charm production measurements in pp and PbPb collisions with the ALICE detector at the LHC

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Session 18 / 18

Scale setting with naive staggered quarks

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Scale setting for QCD with two flavors of staggered quarks is examined using Wilson flow. Results are also compared with the scale set by Rho mass measurements.

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Study of direct photon via internal conversion method in Cu+Cu at $\sqrt{s_{NN}}$ = 200 GeV at PHENIX

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Photons and dileptons in high-energy heavy-ion collisions are godd probe to understand space-time evolution of the produced system. The PHENIX experiment has measured direct photons with internal conversion method in p+p, d+Au, and Au+Au collisions at $\sqrt{s_{NN}}$ = 200 GeV. PHENIX has recently measured direct photons in Au+Au central and peripheral collisions with external conversion method. The results on direct photon in Cu+C, however, have not been published yet. DIrect photons via internal conversion method are measured with e^+e^- pairs as an excess compared to hadronic cocktail after subtracting backgrounds. The PHENIX experiment has as excellent electron identification capability, and thus it can be used for such measurements. We will report the current status of direct photon measurement in Cu+Cu at $\sqrt{s_{NN}}$ = 200 GeV at PHENIX.

Collaboration:

for the PHENIX Collaboration

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Reaction−diffusion equations in ultra−high energy heavy−ion and pp collisions: Effective first order quark−hadron transition and DCC formation

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Reaction-diffusion equations with suitable boundary conditions have special propagating solutions which very closely resemble the moving interfaces in a first order transition. We show that the dynamics of chiral order parameter in heavy-ion collisions, with dissipative dynamics, is governed by one such equation, specifically, the Newell-Whitehead equation. The chiral transition is, therefore, completed by a propagating interface, exactly as for a first order transition, even though the transition actually is a crossover for relativistic heavy−ion collisions. Same thing also happens when we consider the initial confinement−deconfinement transition with Polyakov loop order parameter. We next consider the case of high multiplicity pp collisions at LHC energy where a transient stage of quark-gluon plasma, where chiral symmetry is restored, may be achieved. We study the dynamics of chiral field for such an event using reaction−diffusion equation approach and show that the interior of such a rapidly expanding system is likely to lead to the formation of a single large domain of disoriented chiral condensate (DCC).

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D-meson production in p-Pb collisions at $\sqrt{s_{NN}}$ = 5.02 TeV with the ALICE detector

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Open heavy-flavour hadrons are a powerful tool to investigate the properties of
the medium created in high-energy nuclear collisions. The relatively large masses of heavy quarks, charm and beauty, ensure that they are predominantly produced
in hard scattering processes during the early stages of the collision and experience the whole evolution of the system. The measurements of D-meson production
in p-Pb collisions are necessary to characterize the initial-state effects due to the presence of a nucleus, such as the modification of parton distribution functions in the nucleus, leading in particular to gluon saturation (shadowing) at low Bjorken-x, transverse momentum broadening due to parton scatterings in the nucleus and partonic energy loss in cold nuclear matter. The measurements of heavy-flavour production as a function of charged-particle multiplicity are sensitive to the interplay between hard and soft mechanisms of particle production, and could provide insight into the role of multi-parton interactions and multiple binary nucleon-nucleon collisions.

In this talk, we will focus on the measurements of D-meson production in p-Pb collisions at $\sqrt{s_{NN}}$ = 5.02 TeV. D mesons (D^0, D^+, D^{*+} , and D^{+s}) are reconstructed via their hadronic decay channels in the central rapidity region with the ALICE detector. The D-meson p_T and y-differential production cross sections in p-Pb collisions will be shown. The nuclear modification factor, R_{pPb}, for minimum bias p-Pb collisions will be shown and compared with theoretical predictions. The D-meson transverse momentum distributions in p-Pb collisions relative to pp collisions (Q_{pPb}), measured in several multiplicity classes, will be presented. The D-meson yields per event, measured in different multiplicity intervals and normalized to their multiplicity-integrated values, will also be discussed.

Collaboration:

ALICE Collaboration

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Model study of two particle correlations with identified trigger particles in p-Pb collisions at LHC energy

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Azimuthally anisotropic collective emission of charged particles commonly known as elliptic flow , mass ordering of the flow coefficient (v_2) and baryon enhancement at intermediate p_T in p-Pb collisions has remained a few of the most remarkable and surprising observations at LHC. However, no general consensus could be reached as ideas based on hydrodynamical evolution of partonic medium or based on incoherent parton scattering along with quark coalescence could reproduce similar results.
In this study, the two particle correlations technique with identified trigger hadrons has been used to study hadronization at intermediate p_T. Baryon production being favoured in coalescence and/or hydro frame work, a suppression in correlation strength has been conjectured for baryon triggered correlation function compared to that of mesons.
The multiplicity dependence of the per trigger yields associated with baryon and meson triggers as obtained from the string-melting version of the AMPT Model has been used to quantify the response of two-particle correlation function towards coalescence formalism. A comparative study on hydro-based model with hadronic cascade in the later stage will also be reported.

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Elliptic flow of thermal photons at RHIC, LHC & FCC

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The upcoming Future Circular Collider (FCC) facility at CERN is aimed to study P+P collisions at centre of mass energy 100 TeV, which is about 7 times higher than the top LHC energy for P+P collisions. Heavy-ion collision at FCC (Pb+Pb at $\sqrt{s_{NN}}$= 39TeV) is expected to produce initial states having much larger initial temperature and energy density than those produced at LHC and RHIC energies. One also expect to have a long lived QGP and larger system volume at FCC. Heavy ion collisions at FCC thus can provide us with much enhanced production of thermal photons and valuable information about the produced system.

We consider an ideal hydrodynamic model with smooth initial density distribution to study the evolution of the system produced at 39A TeV Pb+Pb collisions at FCC. We calculate thermal photon spectra and elliptic flow at FCC and compare those with the results obtained at RHIC and at the LHC energies. We conclude that, calculation of photon anisotropic flow parameters at different centrality bins and at different beam energies would be useful to understand the photon v_2 puzzle.

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Effect of geometrical inhomogeneity on electron and ion transmission of GEM-based detectors: A numerical study

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A Time Projection Chamber (TPC) is an ideal device for three−dimensional tracking, momentum measurement and identification of charged particles. They are being used in many on−going experiments, including ALICE. Owing to the enormous particle multiplicity per event, very specific requirements are made on the performance of the detectors in harsh radiation environments. Different R&D activities are currently concentrated on the adoption of the Gas Electron Multiplier (GEM) as the gas amplification stage of the upgraded version of the ALICE-TPC. For example, to keep distortions due to space-charge at a manageable level, a lower ion feedback in the drift volume is required. Again, for a substantial detector gain, it is important that a large fraction of primary electrons participate in the avalanche process and contribute to the signal generation. Thus, a proper optimization of the detector geometry, field configuration and gas mixtures are required to have a higher electron transparency and lower ion backflow. The manufacturing tolerances, defects, asperities on the material surface, normally arising out of machining and handling processes, are likely to cause distortions in the local field. For example, the results of scanning electron microscope (SEM) analysis give the evidence of the widening of GEM holes, as well as the formation of the non−conductive layer on the copper near the hole edge. Depending on their shape and size amplitude, these imperfections can be responsible for generating local discharges and related fluctuations, which can ultimately affect the performance of the detector. Detailed studies on the effects of such structural inhomogeneity on the performance of GEMs is crucial. In the present work, a numerical study simulation work has been

carried out to investigate the role of geometrical inhomogeneity and surface asperities on the electron transmission and ion backflow of GEM-based detectors. Ideally perfect, as well as single GEM detector with such imperfections have been considered here in order to achieve a comprehensive understanding. Here, we plan to present demonstrate and discuss our detailed numerical results in detail and will try to make an attempt to relate the above studies in the context of the high luminosity experiments, in particular, the ALICE upgrade scenario.

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Third-order viscous corrections to entropy four-current and relativistic hydrodynamics

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Using relativistic kinetic theory, a new expression that has been derived for the entropy four-current up to third order in gradient expansion will be presented. The effects of the higher-order entropy density in the case of Bjorken expansion will be discussed. It will be demonstrated that our results obtained using Chapman-Enskog like iterative solution of Boltzmann equation shows better agreement with the exact solution of Boltzmann equation and with the parton cascade BAMPS, as compared to the widely used Grad's method.

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Track distortion in a micromegas based large prototype of a Time Projection Chamber for the International Linear Collider

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The principal particle tracker at the International Linear Collider (ILC) is planned [1] to be a large Time Projection Chamber (TPC) where different Micro Pattern Gaseous Detector (MPGDs) candidate as the gaseous amplifier. A Micromegas (MM) based TPC can meet the ILC requirement of continuous and precise pattern recognition.
Seven MM modules, working as the end-plate of a Large Prototype TPC (LPTPC) installed at DESY, have been tested with a 5 GeV electron beam. Due to the grounded peripheral frame of the MM modules, at low drift, the electric field lines near the detector edge remain no longer parallel to the

TPC axis. This causes signal loss along the boundaries of the MM modules as well as distortion in the reconstructed track. In presence of magnetic field, the distorted electric field introduces E×B effect [2].

A detailed numerical study has been accomplished to understand the features of this distortion. Three Micromegas modules are simulated resembling the experimental setup. Tracks are allowed to point in different directions. Taking the primary track as reference, residuals are calculated. The field lines, drift lines of the electrons, diffusion of electrons in gas, nature of track distortion, expectations of the residuals are numerically calculated in presence and in absence of magnetic field. The E×B effect has been simulated as well. Simulated results follow the experimental observations. Effect of very small variation in geometrical positions of the modules is being carried out.

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Bulk viscosity of hadronic gas

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The bulk viscosity of the hadronic medium has been estimated within a hadron resonance gas (HRG)model approach including the Hagdorn density of states. The fluctuation in the chemical composition of the hadronic medium within the ambit of the grand canonical ensemble can result in non-zero divergence of the hadronic fluid flow velocity, allowing us to estimate the hadronic bulk viscosity upto a relaxation time. The correlation of bulk viscosity with the conformal symmetry breaking (CSB) measure has been studied. The bulk viscosity along the chemical freezeout curve has been estimated and shown that at FAIR energies the bulk viscous coefficient can be enhanced by a factor of five as compared to LHC energies.

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R_{AA} and v_2 of heavy flavour decay muons at forward rapidity at relativistic heavy ion collisions

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Heavy flavours are produced in the initial stage of relativistic heavy ion collisions. While traversing the quark gluon plasma, they will loose energy by colliding with quarks and gluons and also by radiating gluons. After their production, they may get fragmented into heavy mesons by picking up light quarks/antiquarks and in turn may decay through leptonic channels. These leptons would carry information of the initial stage of heavy ion collisions and also the evolution of the plasma.

In this work, we have made a detailed study for the nuclear modication factor, R_{AA} and azimuthal anisotropy, v_2 of muons from heavy flavours decay at forward rapidities in Pb+Pb collision at 2.76 ATeV at LHC. The p_T distribution of heavy quarks produced from the initial fusion of partons, is obtained from FONLL (Fixed Order Next−to−Leading Logarithms) approach. We consider both the radiative and collision energy loss along with a boost−invariant expansion of the plasma for the prediction of R_{AA} as well as v_2. We compare our result of muon R_{AA} from heavy flavour in Pb+Pb collisions at 2.76A TeV with the ALICE data and found that our result can satisfactorily explain the experimental data. The muon R_{AA} at $0-10\%$ centrality, calculated by the present formalism has shown very good agreement with the ALICE data. We also compare our result of muon v_2 from heavy flavours for Pb+Pb collisions at 2.76A TeV with the ALICE data.

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Mass modification of pions in presence of weak magnetic field

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In this work, the self energies of π^0 and $\pi^{\pm}$ up to one loop order have been calculated in the limit of weak external magnetic field. The effective masses get an explicit magnetic field dependence which are modified significantly for the pseudoscalar coupling due to weak field approximation of the external field. However, for the pseudovector coupling, only a modest reduction in the effective masses are noted. These theoretical developments are relevant for the study of the phenomenological aspect of mesons in the context of neutron stars as well as heavy ion collisions.

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Transport coefficients of a two component hadronic gas consisting of pions and nucleons

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We derive the transport coefficients of a two component Hadronic gas consisting of Pions and Nucleons. We solve the relativistic Boltzmann equation with binary collision ($\pi\pi$, πN and NN) employing the relaxation time approximation method. In medium effects are introduced through one loop self-energies in the propagator of the exchange of ρ and σ for the $\pi\pi$ cross-section, and one loop self-energy in the propagator of the exchange of Δ for the πN cross-section. We use phenomenological amplitude for NN collisions. The effect of early freeze-out in heavy collision is implemented through temperature dependent pion chemical potential. The temperature dependence of the transport coefficients are studied.

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Characterisation of pALPIDE-2 chips at Pusan

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A new ITS (inner tracking system) is currently being developed as a core upgrade project of the ALICE (A Large Ion Collider Experiment) setup for increasing luminosity beam at LHC in 2020.
The new ITS is designed to have reduced pixel size and material budget for improved vertexing and tracking capabilities and data taking rate, in particular for low momentum particles.
In order to satisfy the requirements of the new ITS, ALPIDE(ALice Pixel DEtector) is developed with MAPS(Monolithic Active Pixel Sensors) technology. A pALPIDE-2 is the second prototype of ALPIDE which includes the full size chip and the same circuitry as new ITS.
We have tested the pALPIDE-2 chip with 60MeV electron in PAL(Pohang Accelerator Laboratory) for checking the performance with low momentum particles. In the presentation, its recent results of detector performance will be presented.

Collaboration:

ALICE Inner Tracking System Upgrade Project

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Quark number density and susceptibility calculation with one correction in mean field potential

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We calculate quark number density and susceptibility of a model which has one loop correction in mean field potential. The calculation shows continuous increasing in the number density and susceptibility up to the temperature T = 0.4 GeV. Then the value of number density and susceptibility approach to the lattice result for higher value of temperature. The result indicates that the calculated values of the model fit well and the result increase the temperature to reach the lattice data with the one loop correction in the mean field potential.

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Large revealing similarity in multihadron production in nuclear and particle collisions

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The dependencies of charged particle pseudorapidity density and transverse energy pseudorapidity density at midrapidity as well as of charged particle total multiplicity on the collision energy and on the number of nucleon participants, or centrality, measured in nucleus-nucleus collisions are studied in the energy range spanning a few GeV to a few TeV per nucleon.

The model in which the multiparticle production is driven by the dissipating effective energy of participants is considered. The model extends the earlier proposed approach, combining the constituent quark picture together with Landau relativistic hydrodynamics shown to interrelate the measurements from different types of collisions. Within this model, the dependence of the charged particle pseudorapidity density and transverse energy pseudorapidity density at midrapidity on the number of participants in heavy-ion collisions are found to be well described in terms of the effective energy defined as a centrality- dependent fraction of the collision energy. For both variables the effective energy approach reveals a similarity in the energy dependence obtained for the most central collisions and centrality data in the entire available energy range. The total multiplicity dependencies on the collision energy and on the centrality reveals different behaviour at energies up to RHIC top energy compared to the LHC data. The total multiplicity dependencies measured at RHIC are found to be well reproduced as soon as the fragmentation area of the pseudorapidity distribution is taken into account within the limiting fragmentation approach. The measurements at the LHC are well described by the model demonstrating no fragmentation in the data. Given the total multiplicity dependence on centrality is well described, the most central collision data on the multiplicity and the multiplicity centrality data show their complementarity in the energy dependence similar to the charged particle and transverse momentum densities. Predictions are made for the investigated dependencies for the forthcoming higher energy measurements in heavy-ion collisions at the LHC.

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Charm quark energy loss and its consequences

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Charm quarks are mostly produced in the pre-equilibrium phase of relativistic heavy ion collisions and primarily due to prompt gluon fusion and interactions among high energy partons. The produced charm quarks undergo modification while moving through quark gluon plasma. Consequently studies of charm spectra via its mesonic channels and their decay product give information on the medium properties. We present results on the modification of heavy quark energy and momentum spectra due to hot and dense medium (QGP) at LHC collider energies

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Recent developments in effective field theory at finite T and mu

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Lattice: Results and Prospects

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Jet medium interactions

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Dilepton production in heavy ion collisions

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Quarkonia and heavy flavour procession in heavy ion collisions

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Beam energy dependence of anomalous baryon enhancement in central heavy−ion collisions

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An unprecedented large baryon enhancement at the intermediate p_T (2−5 GeV/c) in the central heavy ion collisions at RHIC still lacks unambiguous understanding. In−spite of qualitative agreement with models based on recombination/coalescence of quarks from the de−confined medium of quarks and gluons, contemporary ideas based on mass dependent radial boost and baryon formation from gluon junctions ostensibly reproduces similar result. In this presentation we will report beam energy dependence of baryon anomaly based on hadronic and partonic versions of A Multi Phase Transport model. Such a study would be helpful in extending our in−sight on the origin of anomalous baryon generation particularly at lower energies where partonic activity ceases.