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Poster Presentation

Three-Particle correlations from PHENIX to investigate the properties of the QGP at RHIC

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There is now a consensus of opinion that in heavy ion collisions at RHIC energies a strongly interacting state of matter resembling a near-perfect liquid (termed sQGP) is formed. Attention is now being focused on elucidating the properties of this medium e.g. size, shape, collectivity, viscosity, closeness to the critical point etc. In this work we describe the efforts in the soft and hard sectors to quantify these properties. In particular, the study of jet-medium interactions are described via correlation based studies. Details of three particle correlation studies of RHIC data will be discussed. Such studies are important as they provide an avenue for estimates of the viscosity and the sound speed of the medium.

Systematic Study of the Optimization Potential for Di-Lepton Measurements in the CBM Experiment

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CBM (Compressed Baryonic Matter) will be the dedicated heavy-ion experiment at the future FAIR (Facility for Antiproton and Ion Research) complex at GSI in Darmstadt, Germany. With CBM we will explore the QCD phase diagram in the region of moderate temperatures but very high baryon densities with A+A collisions of 10-45 AGeV beam energy. A key goal will be the search for the phase transition between hadronic and partonic matter and a possible critical endpoint of this transition. Moreover, CBM will aim for an understanding and the characterization of the high density baryonic matter created in these A+A collisions.

A central observable for these studies are lepton pairs, emitted from the hot and dense phase of the heavy-ion collisions. Since leptons leave the fireball without further interaction, their study can provide information on in-medium properties of vector mesons or on a possible restoration of the chiral symmetry.

Currently the design of the CBM experiment is being optimized for precision measurements of these observables. In this presentation we will focus on the electron decay channel of the vector mesons. The main challenge in this process is to effectively reduce the combinatorial background. Potential contributions to the background as Dalitz-decays or gamma conversion have to be studied in detail and strategies have to be developed to increase the

signal-to-background ratio.
In this presentation, a systematic study on the development of an optimized detector setup for a high precision di-electron measurement will be presented. This includes modifications of the proposed setup of the CBM detector, the introduction of new detector components, establishing of necessary purity levels and particle identification strategies.

Neutral pion production with respect to reaction plane in Au+Au collisions at RHIC-PHENIX

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It has been observed that the yield of neutral pions at high transverse momentum (pT > 5 GeV/c) region is strongly suppressed in central Au+Au collisions at Relativistic Heavy Ion Collider (RHIC), compared to the one expected in p+p collisions. This suppression may be due to an energy loss of hard scattered partons in the medium (jet quenching), that results in a decrease of the yield at a given pT. The magnitude of the suppression would depend on the path length of scattering partons in the medium, and therefore is associated with azimuthal angle from reaction plane in non-central collisions. Studying the path length dependence of energy loss would give additional information on understanding the energy loss mechanism. We discuss the parton energy loss mechanism using the nuclear modification factor (R_{AA}) of neutral pion with respect to reaction plane. A new reaction plane detector was installed in the PHENIX detector in RHIC Year-7 run, and improved the reaction plane resolution. More precise measurement of the hadron suppression with respect to path length is expected using the detector. I will report about analysis status of neutral pion production in Au+Au collisions at $\sqrt{s_{NN}} = 200$ GeV.

Lattice Thermodynamics of phi^4 theory in 4 space-time dimensions

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Perturbative calculations for QCD in the deconfined phase are problematic. A naive perturbation expansion runs into infrared singularities, which can be taken care of by a suitable resummation, taking into account the thermal mass of the electric gluon, and the fact that the very long distance physics is non-perturbative. The resulting resummed perturbation series, however is non-analytic in $\alpha_s = \frac{g_s^2}{4\pi}$ where g_s is the strong coupling constant and has bad convergence properties at temperatures of interest to heavy-ion collision experiments.

Similar problems also occur in perturbative calculations of massless scalar field. A simpler system where some of the problems can be studied is a real scalar field at finite temperature. Infra-red divergences also appear in the small mass limit, and resummation schemes are called for, but, the resulting perturbation series for the thermodynamic quantities is, again, non-analytic in the coupling and possess bad convergence properties. The dependence of the thermodynamic quantities can be studied as a function of the mass parameter in the theory, especially in the limit of small mass, where the divergence structure of the theory would show up. Various resummation schemes are available in the literature for this.

In this work, we carry out a non-perturbative evaluation of the pressure and energy density on the lattice for a real, single component ϕ^4 theory. In our work, we calculate the thermodynamic quantities for two different physical masses, each of which determine a renormalisation group trajectory in the space of the couplings. By starting from the broken phase, and staying on the RG trajectory, we determine the critical temperature, T_c, when we run into the symmetric phase. The relevant thermodynamic quantities are evaluated at temperatures upto 3 T_c. In such a limit, comparisons can be made with the results available from the perturbation theory.

SELF-CONSISTENT QUASI-PARTICLE MODEL FOR QGP

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Quasi-particle model (qQGP) for QGP seems to be a successful phenomenological model to explain the non-ideal behaviour seen in the lattice simulation of QCD (LGT) and the relativistic heavy ion collisions (RHICs) experiments. Here, one replaces the system with real quarks and gluons, interacting via QCD, by non-interacting quasi-partons, having additional thermal masses. There are verities of qQGP models [1] with few system dependent adjustable parameters. Recently, we proposed a new formulation of qQGP, with a **single** system dependent adjustable parameter, which explains very well the LGT results on pure gauge, 2f, 3f and (2+1)f QGP systems. In many works, the thermal masses were taken from the finite temperature QCD perturbative calculations which is based on the temperature dependent propagators appropriate to ideal system and valid for very high temperature. But the system is **non-ideal** and also **not** very high temperature so that the perturbation theory is valid. Here we present and compare 3 models based on our new formulation [2] of qQGP which does not need the reformulation of statistical mechanics (SM) [3], but use the standard SM where one generally obtain the energy density and number density from the definition of grand canonical ensemble and derive all other thermodynamic (TD) functions, including the pressure without any TD incosistency. Model-I is based on the perturbative thermal masses usually used in all qQGP calculations. In Model-II, we assume that thermal masses depend on density (not ideal gas) which itself is a functional of thermal masses and one need to solve the problem self-consistently. But we asssume the same approximate dispersion relation (ω Vs k) used in other qQGP which is appropriate for $T \gg T_c$, which is again questionable. Hence, in Model-III, we redo our self-consistent qQGP, but with the exact dispersion relation obtained in QCD perturabtive and resummation methods. We see that, for all systems (pure gauge, 2f, 3f and (2+1)f), results improve as we go from Model-I to Model-III. At high temperature, all 3 models matches but differ as we go near $T = T_c$. All 3 models have only one system dependent adjustable parameter and explain surprisingly well the LGT results.

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Measurement of High p_T Identified Charged Hadron Spectra in Au+Au $\sqrt{s_{NN}} = 200$ GeV Collisions by the PHENIX Experiment

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In Run-7 of RHIC operations the PHENIX experiment collected over 5 billion minimum bias Au+Au $\sqrt{s_{NN}} = 200$ GeV events. The large dataset and new detector capabilities greatly extend the transverse momentum (p_T) range of identified charged hadron measurements in PHENIX. The Time-of-Flight West detector, one of the new detectors used in PHENIX during the latest run, allows for seamless track-by-track particle identification of π/K/p/d up to $p_T \approx 9$ GeV/c when used in conjunction with the Aerogel Cherenkov Counters. The nuclear modification factors (central-to-peripheral ratios) for π/K/p/d and baryon/meson ratios will be presented. These measurements, coupled with two-particle correlations and flow measurements, can contribute to a more detailed understanding of the partonic energy loss mechanism and the baryon anomaly observed at RHIC.

SEARCHING FOR THE COLOR GLASS CONDENSATE WITH THE STAR FMS

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The first runs at the RHIC collider operated at $\sqrt{s_{NN}} = 200GeV$ have demonstrated the possibility to probe the gluon distribution in heavy nuclei using forward electromagnetic calorimeters. In particular, early results from the Solenoidal Tracker At RHIC (STAR) using prototype calorimeters (FPD/FPD++) have shown general agreement of inclusive yields of forward π^0 mesons from p+p collisions at $\sqrt{s} = 200GeV$ with NLO pQCD calculations. In d+Au collisions, on the other hand, a stronger suppression of forward π^0 yield is observed than would be expected from shadowing effects. Exploratory measurements of azimuthal correlations of the forward π^0 with charged hadrons at $\eta \sim 0$ show a recoil peak in p+p that is suppressed in d+Au at low pion energy. It is shown here how these observations can be qualitatively interpreted using the Color Glass Condensate (CGC) model, an effective field-theory for the saturation behavior of the small-x component of the nuclear wave function. A new detector, the Forward Meson Spectrometer, has been built to measure forward pion and photon production to quantify gluon suppression at low x in heavy nuclei over a large range in x and pt. Using CGC calculations, we show that the detector probes x down to $x \approx 10^{-4}$ for inclusive particle production at $\eta \sim 4$ at $\sqrt{s_{NN}} = 200GeV$. This is well into the x-range where gluon saturation effects are expected to set in. The wide electromagnetic coverage ($2.5 < \eta < 4.0$) will play a crucial role in mapping the boundaries for signatures of saturation (CGC) effects. The granularity of the FMS will allow discrimination of prompt photons from photons produced by neutral meson decays at large rapidity.

Matter induced charge symmetry breaking

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The isospin symmetry is only an approximate symmetry of strong interaction. In nature, for example, light quark masses are non-degenerate. At the hadronic level a mass splitting is observed between the proton (p) and neutron (n) or between the various charge states of the isospin meson multiplets. At the QCD level the symmetry breaking effects can be paramatrized in terms of a small parameter $\epsilon = (m_d - m_u)/(m_u + m_d)$ [1]. Consequently, in the low energy limit of QCD, mixing of various isospin resonance states like ρ-ω mixing or π-η mixing can be expressed in terms of similar parameter involving n and p masses [2]. This, clearly, is an explicit symmetry breaking by the Hamiltonian itself. Such mixings of various isospin states are responsible for charge symmetry violation (CSV) in nucleon-nucleon (NN) interactions. In fact, there exist lot of calculations directed towards the construction of various CSV NN interactions which can be classified as class III and IV potentials. In addition, even the mass difference of various charged states of mesons, like π^0, $\pi^{\pm}$ can break isospin symmetry which is responsible for the breaking of charge independence of NN interaction even if nucleon masses are taken to be degenerate.

In the present work, we consider another mechanism of such symmetry breaking phenomenon which unlike the explicit symmetry breaking term in the Hamiltonian, involves the ground state of nuclear matter containing unequal densities of neutron and proton. This is akin to the spontaneous symmetry breaking (SSB) where the Hamiltonian respects the symmetry but it is broken implicitly by the ground state. Cleary this is a density induced effect. The possibility of such mixing was discussed first in ref.[3] and subsequently in [4]. However all these calculations were limited in the time-like domain, while we extend to formalisms to the space-like region and construct density dependent CSV potential.

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Energy Loss of Heavy Quarks from Single Muon Spectra in Pb-Pb collisions at $\sqrt{s_{NN}} = 5.5$ TeV

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We will present generator-level studies of the effect of radiative energy loss on heavy quarks (charm and beauty) produced in central heavy-ion (Pb-Pb) collisions at $\sqrt{s_{NN}} = 5.5$ TeV. We use PYTHIA and HYDJET Monte Carlos to obtain the nuclear modification factor $R_{AA}(p_T)$ of single muons from semi-leptonic decays of heavy-flavoured mesons (D and B), in the $|\eta^\mu| < 2.5$, $p^\mu_{tot} > 5$ GeV/c kinematic range (typical of LHC detectors like ATLAS or CMS), and discuss its relevance as a signature for medium-induced radiated parton energy loss on charm and bottom quarks. Based on the different suppression levels exhibited by beauty, charm and light-quark channels at intermediate and high p_T, a semi-quantitative dependence of the amount of energy loss on quark mass and flavour can be established from the single inclusive muon spectra.

Measurement of the D^0 meson Production through Hadronic Decay Channel at PHENIX

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The Open Charm production have always been considered as one of the unique and unbiased probes to study the properties of the dense matter produced in Heavy Ion collisions at RHIC. PHENIX experiment at RHIC has done a tremendous job of measuring the production rate of the Heavy Flavor particles through their semi-leptonic decay channels. By studying the production in a different colliding systems (p+p, d+Au, Au+Au) we were able to separate both initial and final state effects in nucleon+nucleon collisions at 200 GeV/N. The unanswered question for those measurements was a relative contribution of Open Charm to the mixture of Open Charm and Open Bottom particle decays that were accessible experimentally in semi-leptonic channel. The results of the direct measurement of D^0 meson production in proton+proton collisions through the hadronic decay channel will be presented. This measurement will should determine the contribution of the Open Charm to the mix and also constrain the theoretical models for the Open Charm production at RHIC energies. The current status of analysis, as well as comparison with the most resent theoretical predictions will be presented.

Decomposition of Awayside Components of Dijet Correlations in Au+Au Collisions at $\sqrt{S_{NN}} = 200$ GeV at PHENIX

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Di-hadron angular correlations offer a powerful method to study the interactions of jets with the hot, dense medium in heavy ion collisions. Since fragments from opposing jets typically form back-to-back pairs, the dihadron angular correlation can also be used to probe the medium response of the energy deposited by parton energy loss. At intermediate transverse momentum (p_T), dijet correlations have a local minimum at $\Delta\phi = \pi$ in Au+Au. The modified shape suggests a medium response to energy deposited by the transiting parton.

We present inclusive photon-hadron angular correlations from $\sqrt{s_{NN}} = 200$ GeV Au+Au collisions in PHENIX. At this intermediate p_T (below 5 GeV/c), these correlations are approximately all from meson-hadron pairs. We decompose the awayside region in the two particle correlation into "head", corresponding to jets which punch through the other side of the medium, and "shoulder", which contains the medium response. We present the per trigger yield in each component and study the transverse momentum and energy balance with the nearside which may also be modified. Au+Au is compared with $\sqrt{s_{NN}} = 200$ GeV p+p collision measured by PHENIX.

PHENIX measurement of centrality dependent charged hadron production in deuteron-gold and nucleon-gold collisions at $\sqrt{S_{NN}} = 200$ GeV

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We present transverse momentum (p_{T}) spectra of charged hadrons measured in deuteron-gold and nucleon-gold collisions in the PHENIX experiment at $\sqrt{S_{NN}} = 200$ for four centrality classes. Nucleon-gold collisions were selected by tagging events in which a spectator nucleon was observed in one of two forward rapidity detectors. The spectra and yields were investigated as a function of the number of binary nucleon-nucleon collisions, ν, suffered by deuteron nucleons. A comparison of charged particle yields to those in $p + p$ collisions show that yield per nucleon-nucleon collision saturates with ν for high momentum particles. We also present the charged hadron to neutral pion ratios as a function of p_{T}.

Determination of the effect of final state energy loss on the acoplanarity and momentum imbalance in jets

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The energy loss of partons leaving the hot media created in the heavy ion collisions has been at the center of the interest of the experimental and theoretical communities of the field. Hence an increase in the transverse momentum imbalance and acoplanarity of dijets may be a way to study the parton energy loss [1]. In order to study the effect, we have made simulations of dijet events where the intrinsic k_t of the partons, the initial and final state radiation are taken into account. The results of these simulations as a function of the center of mass energy of the collision will be presented.

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NEUTRON-ANTINEUTRON OSCILLATION AND ITS IMPLICATION ON A NEUTRON STAR

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The neutron-antineutron ($n\bar{n}$) oscillation is the phenomenon when neutrons change spontaneously to antineutrons and vice versa with an oscillation time $\tau_{n\bar{n}}$. If this process takes place in nature then we have Baryon number oscillation (violation) process with $\Delta B = 2$.

$$n(B=+1) \leftrightarrow \bar{n}(B=-1)$$

In vacuum, the probability of $n\bar{n}$ transition can be calculated to be

$$P(n(t)=\bar{n}) = |\langle\bar{n}|n(t)\rangle|^2 = \sin^2\delta t = \sin^2\frac{t}{\tau_{n\bar{n}}}$$

where t denotes the time. In the presence of magnetic field, this probability can be deduced as

$$P(n(t)=\bar{n}) = \sin^2 2\theta \sin^2\left(\frac{\Delta E \tau_{n\bar{n}}}{2}\right)$$

where

$$\frac{\Delta E}{2} = \sqrt{(\vec{\mu_n}.\vec{B})^2 + \delta^2}$$

and

$$\tan\theta = \frac{\delta}{\left(\vec{\mu_n}.\vec{B} + \sqrt{(\vec{\mu_n}.\vec{B})^2 + \delta^2}\right)} .$$

In the above B is the magnetic field strength, $\vec{\mu_n}$ being the neutron magnetic moment and the transition amplitude $\delta = \frac{1}{\tau_{n\bar{n}}}$. The oscilaltion probability in matter can also be calculated. Neutron stars are dense collapsed core of some massive stars with typical mass of 1.4$M_\odot$ and radius $\sim$ 1.4 Km with a magnetic field around 10^{12} Gauss. At the initial stage the power loss of the neutron star is through the URCA process like $n + n \rightarrow n + p + e + \nu$ producing neutrinos. At a density around 4×10^{11} gm/cc inside the neutron star the neutrons are abundant. The $n\bar{n}$ oscillation, if significant may affect these processes and the stability of a neutron star. In this work, the effect, if any, of such oscillation on neutron star will be investigated.

ON THE NEW POSSIBILITY TO DESCRIBE THE TIME EVOLUTION OF THE CHEMICAL POTENTIAL IN NUCLEAR COLLISIONS AT HIGH ENERGIES

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At the last Quark Matter Meeting (Shanghai 2006 - China) we proposed the introduction of an empirical scale of time for nuclear reactions at high energies, inspired by the HUBBLE Cosmology. The goal of this work is to determine the time evolution of the chemical potentials for charged particles ($p^\pm$, $K^\pm$, $\pi^\pm$) like those obtained in Au+Au at 200 GeV using the blast-wave model.

Studying the sources of high p_T direct photons in Au+Au collisions with the PHENIX detector at RHIC

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In addition to primordial hard scattering at least three other mechanisms are assumed to contribute to the observed high p_T (>5GeV/c) direct photon spectrum in relativistic heavy ion collisions: fragmentation, jet-photon conversion, and Bremsstrahlung. The azimuthal asymmetries are predicted to be different for these mechanisms, notably jet-conversion and Bremsstrahlung photons should exhibit negative "flow". Also, hard scattering and jet-conversion produces photons without any accompanying jet particles, although such "isolation" is blurred by the underlying Au+Au event. We will review current results of high p_T direct photon production at different energies, then using the new, high resolution reaction plane detector of PHENIX and loose isolation criteria we will study the possibility of statistically separating photons from the four basic production sources listed above.

High-p_T Measurement of Azimuthal Anisotropy of Electrons from Semi-leptonic Decay of Open Heavy Flavor Mesons in Au+Au Collisions at $\sqrt{s_{NN}} = 200GeV$ by the PHENIX Experiment

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The azimuthal anisotropy of open heavy flavor mesons at RHIC provides information about the early stages of heavy ion collisions. PHENIX observed a large azimuthal anisotropy parameter v_2 of electrons from heavy flavor decays from RHIC Run4 at low tranverse momentum. Together with the observation of constituent quark scaling of v_2 for light hadrons, the electron v_2 is consistent in coalescense models with charm quarks flowing as much as light quarks. With the addition of a reaction plane detector in PHENIX and the increased statistics of RHIC Run7, v_2 of electrons can be measured with much-improved precision, answering the question of whether heavy flavor continues to flow in the range of p_T in which beauty production is believed to be comparable to that of charm. We studied the p_T and collision centrality dependency of the azimuthal anisotropy of single electrons from open heavy flavor decays from RHIC Run7 data in PHENIX.

Measurement of excited charmonium state and study of J/ψ polarization in PHENIX experiment at RHIC

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Determining the J/ψ polarization will provide constraint on charmonium formation mechanisms. Measuring the feed down of ψ' to J/ψ production is one of the main ingredients

to obtain information on J/ψ prompt production as well as to understand its anomalous suppression observed in AA collisions at RHIC.
The PHENIX Collaboration has studied charmonium production in $p+p$ collisions at RHIC using the sample collected during the 2006 data taking period through its decays into the dielectron channel at mid rapidity. This high statistics data set allowed us to study polarization of the J/ψ and the ψ' to J/ψ ratio at RHIC energies.

A first study of the dimuon mass continuum components in p+p collisions at $\sqrt{s} = 200$ GeV

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The invariant mass distribution of the dimuons produced in heavy ion collisions contains resonances, especially J/psi that has been extensively used as a probe of the Quark Gluon Plasma (QGP). In addition, the dimuon mass distribution above 2 GeV/c^2 includes continuum components such as Drell-Yan, open charm and open beauty. Heavy flavours carry information on the medium properties in which they have propagated and thus a study of the continuum in p+p, d+A and A+A collisions provides complementary signals to understand detailed aspects of matter produced in these collisions. Extracting the continuum components yields from a complex spectrum cannot be done without any knowledge of their mass distributions (line shapes). In a first step, a full PHENIX simulation of the three continuum components is done. Events produced by Pythia are sent into the PHENIX simulation and reconstruction software. The vertex detector resolution was tuned to reproduce the J/psi width measured by PHENIX in p+p collisions at 200 GeV. The relative magnitudes of the components are then obtained by fitting the experimental p+p data. Result from this study will be presented.

Measurement of Electron-Muon Correlations from Semi-Leptonic D Decay in 200 GeV p+p Collisions at RHIC-PHENIX

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Charm production is a valuable probe of the early stages of a heavy ion collision. Correlated electron-muon pairs are a signature of semi-leptonic D decays, and a measurement of D mesons provides information on charm quark energy loss in the hot medium. The energy loss of heavy quarks is still not fully understood, so it is vital to investigate different decay channels of charm mesons to better understand this process. Measurements of electron-muon pairs suffer less from background than e^+e^- or mu^+mu^- pairs since neither direct lepton production nor resonance decays produce this type of correlated signal. Another advantage results from measuring the electrons in the PHENIX central arms and muons in the forward direction, since this probes open charm in a rapidity region different from previous measurements. Studying electron-muon pairs in p+p collisions provides an important baseline for the study of these processes in d+Au and Au+Au collisions. The data in this analysis was obtained during the 2006 RHIC run of p+p collisions at 200 GeV. The current status of this analysis will be presented.

Probing RHIC Matter with direct-photon Jet and Jet-Jet Correlations in PHENIX[a]

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2-particle correlations from Direct Photon - Jet and Jet-Jet Pairs are important for studying Energy Loss of Hard Probes in the matter created at RHIC. We present details of the Direct Photon-h and pi0-h analyses from p+p and A+A datasets ranging from Run4 to the newest Run7.

Analysis of features of multiplicity distributions of charged hadrons at RHIC

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It is found that Collective Flow Model(CFM)which can successfully analyze charged particle distributions at AGS and lower SPS (less than 20Gev/n) , fails to analyze that of RHIC. The tail of distribution of charged particle at RHIC has a jump away from the collective model calculation as the energy increase. Thermalization Component Model (TCM) is presented basing on collective flow to study the multiplicity distributions at RHIC in this paper. It is realized that the limitation of phase space of collective flow can denote that of thermalization region. By comparing the contributions of particle productions from thermalization region at different energies and different centrality, we can deep our study on the feature of collective movement at RHIC.

Detailed analysis of thermalization relation with centrality and energies at RHIC is presented in this paper. We develop CFM to TCM to discuss the thermalization limitations and contributions at different energy regions and different centrality in this paper.

Collective flow in heavy-ion collisions is an unavoidable consequence of thermalization. It is realized that the limitation of phase space of collective flow can denote that of thermalization

region. We have shown that the Thermalization Component Model gives results consistent with the experimental data for particle production at AGS, SPS and RHIC. Especially we present a detail discussion of Au-Au and Cu-Cu collisions at different centrality at $\sqrt{s} = 62.4$ and $\sqrt{s} = 200$ GeV. The percentage ratios of contributions of particle production from the thermalization region are the largest at AGS, and decrease as collision energies decrease at SPS and RHIC, but seem to reach saturation when $\sqrt{s}$=62.4   200GeV. It is also found that the limitation of the flow show a relation of straight line with $\ln\sqrt{(s)}$. We can predict the thermalization limitation at future LHC experimental data.
It is shown from our study that the percentage ratios of particle production from thermalization regions increase as the increase of the centrality at RHIC. We also study the percentage ratios of contribution from thermalization regions by compare two collision systems(Au+Au with Cu+Cu) and two collision energies at RHIC. It is found that the contribution ratio is larger for the smaller collision system (Cu+Cu) at $\sqrt{s} = 62.4$ GeV , but shows independent of the collision system at $\sqrt{s} = 200$ GeV .

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STAR Multi-Strange Hyperon Elliptic Flow and Parton Collectivity from 200GeV Au+Au and Cu+Cu Collisions

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We will present measurements of elliptic flow (v2) for multi-strange hyperons (Omega and Cascade) from 200GeV Au+Au and Cu+Cu collisions. Both the signal to background ratio and v2 are calculated as a function of invariant mass. For a given pt bin, the observed v2 can be treated as a superposition of background v2 and omega v2. A fit can be made to the v2 vs. mass distribution and the hyperon v2 extracted. This method has successfully been used for STAR phi meson v2 measurements[1]. The physics implications on coalescence models and parton collectivity will be discussed.

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Heavy Quarkonia Production in Heavy Ion Collisions at PHENIX

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It has been suggested that heavy quarkonia suppression could be a strong signature of the existence of QGP color screening effects in high-energy heavy ion collisions. At RHIC, we have observed significant suppressions of J/Ψ production in both CuCu and AuAu collisions relative to the yield in pp system. However, the current model calculations of J/Ψ suppression include several competing physics processes, and it is very challenging to distinguish various suppression scenarios from J/Ψ measurement alone. It is expected that the weakly bound $\Psi^{'}$ should melt at a lower temperature and thus should be suppressed much more compared with J/Ψ. On the other hand, the Υ states which are much more tightly bounded compared with J/Ψ, should melt at higher temperature and hence expected to be less suppressed. So the measurements of higher mass heavy quarkonia states, such as $\Psi^{'}$ and Υ, together with J/Ψ, will help us to further constrain various quarkonium suppression models in heavy ion collisions. In this analysis, we study the production rates of $\Psi^{'}$s and Υs relative to J/Ψ yields in pp and CuCu systems through the dimuon channel. The current status of this study will be presented.

Direct measurement of fragmentation photons in p+p collisions at $\sqrt{s_{NN}} = 200$ GeV with the PHENIX experiment

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In heavy ion collisions direct photons have proven to be an important observable because they are penetrating, and therefore remain largely insensitive to the final state effects that lead to jet quenching. Perturbative QCD calculations predict a contribution to the direct photon yield of up to 30% from photons produced through parton fragmentation. In heavy ion collisions it is expected that this contribution is modified due to additional stimulated photon bremsstrahlung as well as energy loss of the partons through gluon radiation prior to fragmentation. A measure of such bremsstrahlung photons would provide direct observation of the energy loss of jets in the medium. Thus measurements of the fragmentation component to direct photon yields in both p+p and Au+Au collisions provides both an important test of pQCD predictions and of predictions for the nuclear modification factor. A natural way of picking out photons produced through jet fragmentation is to select photons associated with jets on the near side using hadron-photon correlations. However, this signal is small compared to the various contributions to the inclusive conditional yield from photons produced through π^0, η, and other mesonic decays, thereby requiring a very precise determination of these backgrounds. We present new results from the application of this approach to PHENIX p+p data at $/sqrts_{NN} = 200$ GeV and discuss its potential for signal extraction in heavy ion collisions.

Event-by-event fluctuations of identified particles as measured by PHENIX

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Phase transitions are normally associated with fluctuations on many length scales. Thus, fluctuations have been proposed as a signature of the transition of a quark-gluon plasma to normal hadronic matter. These fluctuations may appear as correlations between the observed particles. Studies of these correlations could reveal properties of the phase transition and the hadronization process. We present a systematic study of kaon-to-pion fluctuations for Au+Au collisions at $\sqrt{s_{NN}} = 62.4$ and 200 GeV, as a function of centrality and of the momentum of identified pions and kaons as measured by PHENIX. Proton-to-pion fluctuations are also studied. The robustness of the analysis method will be discussed and comparisons will be made with different fluctuation models using Monte Carlo techniques.

Searching for strong parity violation signals in non-central Au+Au collisions at $\sqrt{s_{NN}}$ = 200 GeV in PHENIX experiment at RHIC

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The participants in non-central Au+Au collisions could have a large orbital angular momentum perpendicular to the reaction plane as determined by spectators. According to a recent prediction [1], it is suggested that a strong parity violation signal could be revealed via preferential emission of charged particles in the direction along the orbital angular momentum. This would mean that positive and negative pions will be produced asymmetrically with respect to the angular momentum. There would be more positive than negative pions in the direction of angular momentum and more negative than positive pions in the opposite direction of angular momentum. We are looking for such a parity violation effect with charged hadron production in the PHENIX muon spectrometer with respect to the reaction plane determined from the directed flow measurement. We present the current status of this analysis.

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Open charm elliptic flow from single muon in Au+Au collisions at $\sqrt{s_{NN}}$ = 200 GeV in PHENIX experiment at RHIC

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Event anisotropy is expected to have sensitivity to the early stage of ultra-relativistic heavy-ion collisions at RHIC. The possible formation of a quark gluon plasma (QGP) could affect how the initial anisotropy in the space coordinate is transferred into the momentum space for the final state. We perform a quantitative analysis of the azimuthal distribution of single muons with respect to the reaction plane with PHENIX muon spectrometer in Au+Au collisions at $\sqrt{s_{NN}} = 200$ GeV. We present the current status of the open charm elliptic flow measurement after subtracting decay muon and punch-through contributions from the inclusive single muon flow at forward rapidity $1.5 < | \eta | < 1.8$.

"Measurement of Azimuthal Anisotropy with the New Reaction Plane Detector in the PHENIX experiment"

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Azimuthal anisotropy of particle emission with respect to the reaction plane is one of the most important global observables in relativistic nucleus-nucleus collisions at RHIC. The observation of a large anisotropy which follows specific scaling relations over a broad range of particle species is considered as evidence for the probable formation of a hot and dense partonic matter in Au+Au collisions at RHIC. The accurate measurement of the reaction plane is a key factor in the study of azimuthal anisotropy. In order to improve the resolution of such measurements in the PHENIX experiment at RHIC, we designed and fabricated a new Reaction Plane Detector (RxNP). RxNP worked very well during the PHENIX Run7 period and demonstrated the design performance. As a result of the upgrade, the reaction plane resolution was improved by a factor of two. This allows us to improve the precision of the measurements of azimuthal anisotropy for particles with high transverse momentum $p_T >$ 4 GeV/c and to perform a more detailed study of rare particles, such as direct photons, non-photonic electrons from D-meson decay, and J/psi. First experimental results of the study of azimuthal anisotropy with the new PHENIX Reaction Plane Detector will be presented and discussed.

INSTABILITIES OF THE GLASMA

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Understanding the mechanism of thermalization of hot QCD matter is one of the most important problems in the physics of heavy ion collisions [1]. Since the standard scenario based on perturbative hard scattering has been challenged by very short thermalization time $t < 0.6$ fm suggested by the successful ideal hydrodynamical simulation for the RHIC data. Some other scenarios are now extensively investigated. One of the possible scenarios will be the plasma (Weibel) instability where the interaction between hard particles and soft gauge field induces rapid enhancement of the soft field. The plasma instability certainly helps to make the matter isotropic, but still requires long time to reach thermalization. In this contribution, we discuss another scenario for the early thermalization.

The initial condition of the heavy ion collision is given by the Color Glass Condensate (CGC), which is a weakly-coupled strong gauge field in each colliding nucleus. The matter just after the collision is still well-described by such coherent Yang-Mills field. This is called the glasma. If there is some instabilities in the glasma, it will help to make the matter isotropic/thermalized. In fact, it is already found in the lattice numerical simulation that there is instability in the glasma [2]. We analytically investigate the classical Yang-Mills equation for an expanding glasma in the rapidity (η) - proper time (τ) coordinates, and find there is indeed instabilities for a very simple configuration of the gauge fields (constant electric field or magnetic field in the beam (z) direction). This is essentially equivalent to the known instabilities in the constant Yang-Mills field in the ordinary space-time coordinates [3]. Therefore, we find that the instability of electric fields is related to the Schwinger mechanism, and that of magnetic fields corresponds to the Nielsen-Olesen instability. We further discuss more realistic case with the CGC initial condition. The CGC is characterized by the gauge field which is randomly distributed on the transverse space with the coherent size being $1/Q_s$. We discuss whether the instability occurs when the transverse extent of the constant gauge field is finite and of the order of $1/Q_s$. We also discuss possible relationship between the glasma instability and the Weibel instability. To clarify it, we need to examine the effects of back reaction in the glasma instability.

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PHENIX measurement of dihadron correlation in Au+Au collision at 200 GeV: jet quenching and medium response

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We present a detailed survey of the trigger p_T, partner p_T and centrality dependence of near- and away-side jet shapes and yields in Au+Au collisions at $\sqrt{s_{NN}} = 200$ GeV from RUN4. These measurements provide a broad overview of the different physical features that come into play for different p_T ranges. In particular, the results can be interpreted as the interplay between the jet fragmentation and response of the medium to quenched jets. The former dominates the high p_T region, while the latter dominates the low and intermediate p_T region. These results allow a detailed comparison of the similarities as well as the differences of the correlation pattern between the near- and away-side, and provide new insights into the physical processes of the jet-medium interactions. Together with inclusive hadron production, they also allow us to quantify the role of jets at intermediate p_T, where the particle production was believed to be dominated by the soft processes such as hydrodynamical flow and recombination.

PHENIX measurement of dihadron $\Delta\eta$ correlation in Au+Au collision at 200 GeV

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The observation of a long range $\Delta\eta$ correlation at the near-side has led to many speculations of the underlying physical processes responsible for such novel feature. This include several models advocating the heating of medium by the jets emitted close to the surface. PHENIX can access this so called "ridge" phenomena in a limited pseudo-rapidity of $|\Delta\eta| < 0.7$ in Au+Au collisions. Status of this study and the comparison to $\Delta\phi$ correlation results is presented.

A new type of Time-Of-Propagation (TOP) Cherenkov detecor for particle identification

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The Time-of-Propagation (TOP) Cherenkov detector is a novel technical extension of the Detection of Internally Reflected Cherenkov (DIRC) light for particle identification. In contrast to the BarBar DIRC [1,2], which provides the 2-D space measurement, it measures 1-D time of propagation and 1-D space information. Thus TOP has the advantages of being simple in construction and compact in size as well as its quick time response. It is proposed to be used in the internal target experiment on the Cooling Storage Ring (CSR) at Lanzhou, China [3]. In this presentation, Geant4 toolkit is used to simulate the propagation of Cherenkov photon in thin quartz bar radiator. We estimate various contributions to the time uncertainty, such as the wavelength dependence of the refractive index, the hit position resolution and TTS of the phototube, timing jitter due to the start signal determination, the quartz thickness and the charged particle tracking accuracy [4].

In order to estimate the PID performance, the separability (S_0) is defined as π and K for example. Its dependence on the particle momentum, incident angle and propagation length, are discussed respectively. From Geant4 simulation, we obtain the probability function of the deviation of the time of propagation from correct/incorrect expectation for π and K tracks. A log-likelihood ($\ln L$) is thus defined and calculated for incoming π and K tracks by using this probability function. The clear separation of π and K tracks illustrates the high PID ability of this novel TOP technique.

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r-MODES AND VISCOSITY OF SUPERFLUID QUARK STARS

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We present results from a study of the r-mode instability in compact stars containing color superconducting quark matter. The r-mode is a toroidal pulsational instability that arises for all such rapidly rotating compact stars, causing energy loss from the star in the form of gravitational waves that may be detected by interferometric experiments on Earth. The r-mode instability is damped by the viscosity of quark matter, thereby suppressing the amplitude of the gravitational waves while allowing such compact stars to spin faster than expected.

For stars containing quark matter in the color-flavor-locked phase, we present results for the r-mode frequency, the damping timescale associated to the bulk viscosity, as well as the critical rotation frequency of these stars. Employing recent results on the bulk and shear viscosities of superfluid quark matter, we show that the r-mode instability is active in a window of temperature that is typical of observed compact stars, suggesting that they may be promising candidates for detection of color superconducting quark matter through gravitational waves.

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Measurement of $\omega/\phi \rightarrow e^+e^-$ in proton + proton collisions at $\sqrt{s} = 200$GeV at RHIC-PHENIX

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The light hadron masses are generated due to the spontaneous breaking of the chiral symmetry. Due to the effect of chiral symmetry restoration, the mass of the light vector meson(ρ, ω, ϕ) may be shifted and/or modified in the hot matter created by high energy heavy ion collisions at RHIC. The study of mass modification is an important topic to understand the mechanism of generation of hadron mass.
Unlike hadrons, electrons do not interact strongly with the medium. The measurement of electron pairs from vector meson is therefore a good probe to study chiral symmetry restoration since electrons carry the original information.
The study of the light vector mesons in proton+proton collisions is an important baseline for the various heavy ions collisions such as Au+Au, Cu+Cu and d+Au. The PHENIX experiment measures ω/ϕ meson via their di-electron decays in p+p collisions at $\sqrt{s}$ = 200GeV. We will present and discuss the result.

Two- and three particle correlations of high-p_t charged hadrons in heavy ion collisions at top SPS engery

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The analysis of azimuthal correlations of hadrons with high transverse momenta provide a unique tool to study the interactions of partons with the medium in an early stage of heavy ion collisions.
A detailed analysis of two particle correlations in Pb-Au collisions from the CERES experiment at top SPS energy will be presented for different centralities of the collisions.
The key observation is a non-Gaussian shape on the "away-side" of the two particle correlation function in central collisions indicating significant interactions of partons traversing the medium even at SPS energy. A study of the correlations for different charge combinations of trigger and associate particles reveals charge ordering in the fragmentation process and sensitivity to the charges of the interacting partons. Hence the analysis may reveal properties of the initial as well as the final state of the collision.
To further investigate the pattern of the two particle correlation function an analysis based on three particle correlations is presented. Different scenarios like elastic scattering of the initial partons or the evolution of a mach cone can lead to the same observable shape of the two particle correlation function. The three particle analysis gives strong indications for a cone like emission of hadrons emerging from hard parton-parton interactions in the collisions.

Beam Energy and System Size Dependence of Radial Flow Measured at PHENIX

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Hadron production in high-energy heavy ion collisions shows unique properties such as large radial collective flow, jet quenching in the created matter. Measurement of identified hadron p_T spectra is one of the ways to extract information on hadron production mechanisms and final state interactions between produced hadrons. Especially, we focus on (anti)proton p_T spectra at low to high p_T (<6 GeV/c) to study the beam energy and system size dependences of radial flow strength with the available various data sets; p+p, Cu+Cu, Au+Au at $\sqrt{s_{NN}}$ = 62.4 and 200 GeV. From a different point of view, the so-called intermediate p_T region (2-5 GeV/c) is considered to have relatively large soft contribution affected by radial flow in addition to hard jet component. This may be part of the origin of the baryon enhancement in this p_T region.

We will present π/K/p p_T spectra measured at PHENIX. Several model fits including hydro-inspired one are used to extract freeze-out properties for comparison between different collisions systems. we also discuss relative contributions of radial flow at partonic and hadronic phases with complementary elliptic flow measurement.

Stopping effects in U+U collisions with a beam energy of 520 MeV/nucleon

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The Cooling Storage Ring (CSR) External Target Facility (ETF) at Lanzhou, China[1], delivering the uranium beam up to 520 MeV/nucleon is expected to make significant contribution and provide a good opportunity to systematically study the the nuclear equation of state (EOS)at the high net-baryon density region of nuclear matter phase diagram[2].

Uranium is the largest deformed stable nucleus, and has approximately an ellipsoid shape with the long and short semi-axis given by $R_l = R_0(1 + 2\delta/3)$ and $R_s = R_0(1 - \delta/3)$, respectively, where $R_0 = 7$ fm is the effective spherical radius and $\delta = 0.27$ is the deformation parameter. we consider two extreme orientations: the so-called tip-tip and body-body patterns with the long and short axes of two nuclei are aligned to the beam direction, respectively. With the two extreme collision orientations, some novel stopping effects which are believed responsible for some significant experimental observables, such as particle production, collective motion as well as attainable central densities, can be obtained. The various collision patterns could be selected from random orientation collisions in certain purity and efficiency by cutting On-Line hardware trigger such as mid-rapidity charge multiplicity and forward neutron multiplicity, along with the Off-Line trigger of stopping power ratio.

A Relativistic Transport Model (ART1.0)[3] is applied to simulate the stopping effects in tip-tip and body-body U+U collisions, at a beam kinetic energy of 520 MeV/nucleon. Our simulation results have demonstrated that both central collisions of the two extreme orientations can achieve full stopping, and also form a bulk of hot, dense nuclear matter with a sufficiently large volume and long duration, due to the largely deformed uranium nuclei. The nucleon sideward flow in the tip-tip collisions is nearly 3 times larger than that in body-body ones at normalized impact parameter $b/b_{max} < 0.5$, and that the body-body central collisions have a largest negative nucleon elliptic flow $v_2 = -12\%$ in contrast to zero in tip-tip ones. The Large nucleon sideward flow in tip-tip collisions and the significant negative nucleon elliptic flow in body-body central collisions can provide a sensitive probe to extract nuclear EoS information. Thus the extreme circumstance and the novel collective flow in tip-tip and body-body collisions can provide a good condition and sensitive probe to study the nuclear EoS, respectively. More experimental observables of U+U collision dynamics should be further studied, due to the geometric effects state (EoS).

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PHENIX measurements of $\pi^+\pi^+$ and $\pi^-\pi^-$ 4-momentum correlation functions in Au+Au collisions at $\sqrt{s_{NN}} = 200$GeV

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4-momentum correlation functions of pion pairs in central $Au + Au$ collisions provide an important avenue for study of the spacetime extent of the QCD matter produced at RHIC. In a recent high statistics experimental run, the PHENIX collaboration has performed detailed measurements with improved resolution of the reaction plane. This allows for a detailed correlation analysis of mid-rapidity pions, $0.20 < p_t < 0.40$, Gev/C, in the 10% most central collisions with respect to the reaction plane. These measurements are essential for understanding the reaction plane dependence of the 3D source functions and gaining further insight into the non-Gaussian tails recently observed in the pion pair transverse momentum and beam direction. The latest results from our ongoing analysis will be presented.

Systematics study of Photon production at forward rapidity in STAR

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We present the measurement of multiplicity and pseudorapidity distributions of inclusive photons production at forward rapidity (eta from -2.3 to -3.8) for Au+Au collisions at 200 GeV and Cu+Cu collisions at 200 and 62.4 GeV. Photons are measured using the Photon Multiplicity Detector (PMD) in STAR experiment at RHIC. The distributions of (η_{beam}), where η_{beam} is beam rapidity will be presented. Pseudorapidity distributions of photons at forward rapidities, when observed in the frame of one of the colliding particles show the signature of energy independent scaling at forward rapidities known as Limiting Fragmentation. Measurement of inclusive photons reflect the distribution for pi0s as most of the photons come from pi0 decay. Gluon saturation at initial conditions of the collisions is one of the possible explanations for this scaling. Study of system-size and incident energy dependence of this phenomenon will help to understand the mechanisms better. The system-size and energy dependence of the widths of scaling in pseudorapity and comparison with model predictions will be presented.

Investigation of high p_t events and shear viscosity in Nucleus-Nucleus collisions using the Hijing event generator

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In the recent years lot of interest has been observed in the Nucleus-Nucleus collisions at RHIC energies in phenomena related to high p_t physics[1] that is the suppression of high p_t particles and disappearance of back-to-back jets compared to the scaling with the number of binary nucleon- nucleon collisions indicating that a nearly perfect liquid is produced in these collision. Results on self shadowing of high p_t events will be presented using hadron multiplicity associated to high p_t events and unbiased events in Nucleus-Nucleus collisions[2] obtained from the hijing event generator. The results on shear viscosity using transverse momentum correlations[3] will also be presented.

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ELLIPTIC FLOW METHODS IN ALICE

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Anisotropic flow is recognized as one of the main observables providing information on the early stage of a heavy-ion collision. Anisotropic flow is characterized by a Fourier expansion of the azimuthal particle distribution. The fist two harmonics, v_1 and v_2, are called directed and elliptic flow respectively. Initial measurements of elliptic flow at RHIC have shown that the system created in the collision to first order can be described as a thermalized fluid which expands hydrodynamically.
It is expected that at the LHC, due to high initial energy densities, all elliptic flow is generated before hadronization takes place; making v_2 a probe of the equation of state of the Quark Gluon Plasma. A detailed measurement of v_2, and higher harmonics, is possible at the LHC because of the expected increase in multiplicity and in the magnitude elliptic flow itself.
For detailed measurements of anisotropic flow there are several methods available; the event-plane, cumulants and Lee-Yang zeroes methods. These methods all have different sensitivities to non-flow and flow fluctuations. Combined they give a better estimate of the flow signal. We present flow analysis using these methods on data simulated within the ALICE framework.
Until recently only the event-plane method was used in ALICE for the second order reaction plane estimation. We present here a new method to extract the reaction plane, based on the Lee-Yang zeros technique. This event plane does not need to be corrected for autocorrelations and is not influenced by non-flow. Therefore it provides a better estimate of the reaction plane. The method is applied on simulated data to test its range of applicability.

Quantitatively Constraining Theory Input from Experimental Data with Statistical and Systematic Errors

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The PHENIX experiment has measured suppression of semi-inclusive single π^0 in Au+Au collisions at $\sqrt{s_N N}$=200 GeV. The present understanding of this suppression is in terms of parton energy loss in a dense color-charge medium. We present a quantitative method for constraining parton energy-loss model parameters from our experimental data that have statistical point-to-point uncorrelated errors and correlated systematic errors. We detail this methodology and apply it to various data sets and models to extract quantities such as medium transport coefficients.

D_{sJ}(2317) meson production at RHIC

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Production of $D_{sJ}(2317)$ mesons in relativistic heavy ion collisions at RHIC is studied [1]. Using the quark coalescence model, we first determine the initial number of $D_{sJ}(2317)$ mesons produced during hadronization of created quark-gluon plasma. The predicted $D_{sJ}(2317)$ abundance depends sensitively on the quark structure of the $D_{sJ}(2317)$ meson. An order-of-magnitude larger yield is obtained for a conventional two-quark than for an exotic four-quark $D_{sJ}(2317)$ meson. To include the hadronic effect on the $D_{sJ}(2317)$ meson yield, we have evaluated the absorption cross sections of the $D_{sJ}(2317)$ meson by pion, rho, anti-kaon, and vector anti-kaon in a phenomenological hadronic model. Taking into consideration the absorption and production of $D_{sJ}(2317)$ mesons during the hadronic stage of heavy ion collisions via a kinetic model, we find that the final yield of $D_{sJ}(2317)$ mesons remains sensitive to its initial number produced from the quark-gluon plasma, providing thus the possibility of studying the quark structure of the $D_{sJ}(2317)$ meson and its production mechanism in relativistic heavy ion collisions.

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Rapidity Dependence of Coalescence in Au+Au Collisions at $\sqrt{s_{NN}} = 200$ GeV.

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The BRAHMS Experiment at RHIC measures charged particles at a wide range of deuteron rapidities, $y \sim 0 - 3$, offering a unique opportunity to study the rapidity dependency of various physical phenomena.
In this presentation deuteron coalescence is used to study the rapidity dependence of the source size. As the fireball cools down and hadronizes it becomes possible for protons and neutrons to coalesce into deuterons. The coalescence parameter,

$$B_2 = \frac{E_d \frac{d^3 N_d}{dp_d^3}}{(E_p \frac{d^3 N_p}{dp_p^3})^2}$$

can be meassured and connected via model calculations, to the volume of the fireball. Thus measurements of B_2 can yield information about the density profile of the emitting source at the time of hadronic freeze-out.
We present here the rapidity, as well as centrality, dependence of B_2 in $\sqrt{s_{NN}} = 200$ GeV Au+Au collisions. The obtained results are compared with similar published measurements from other RHIC experiments. Furthermore an estimate of the source size radius is given.

Measurement of ω mesons via radiative decay mode in $\sqrt{s_{NN}}$ =200GeV Au+Au collisions at RHIC-PHENIX

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Measuring low mass vector mesons in an extreme condition made by relativistic heavy-ion collisions is one of the intriguing study as a quest for the QCD phase transition to Quark-Gluon-Plasma. Properties such as mass and width are expected to be modified at low p_T as a probe of the chiral symmetry restoration. Furthermore, hadron suppression due to the jet quenching should be seen in their spectra.

We report on ω mesons' production via radiative decay mode ($\omega \rightarrow \pi^0\gamma$,$\pi^0 \rightarrow 2\gamma$) in $\sqrt{s_{NN}}$ GeV Au+Au collisions at RHIC-PHENIX. The main challenge of this analysis is to handle the huge combinatorial background inevitable for reconstructing particles from the three-body decay mode. The emphasis is on the feasibility study using both simulation and real data to search the best parameters that improve S/$\sqrt{B}$. For example, momentum and energy range of π^0 and γ is optimized to reconstruct ω. To estimate the remaining background, we consider three background sources; correlated/uncorrelated background and K_s^0 contribution. Then each amount of background is determined by fitting and the total background is subtracted successfully. The result suggests that ω meson production is suppressed in central Au+Au collisions at high p_T region.

ALICE Transition Radiation Detector

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ALICE (A Large Ion Collider Experiment) has been designed as a dedicated heavy-ion experiment and its primary aim is the study of nuclear collisions at LHC. In order to establish and analyse the existence of the quark gluon plasma (QGP), a number of observables have to be studied with ALICE in a systematic and comprehensive ways. Measurements of heavy quarkonia states, such as J/Ψ, Ψ', Υ, Υ', and high p_T charged particles carry important information to characterize the QGP. Transition Radiation Detector (TRD) was developed to improve the electron identification capability and the tracking resolution in the central rapidity region of the ALICE coverage. Using the TRD, reasonable J/Ψ and Υ measurements will be realized[1].

The TRD surrounds the TPC (Time Projection Chamber) in the central barrel of ALICE. It consists of 540 drift chambers with the drift direction perpendicular to the wire planes. Xe,CO_2(15%) gas is used to have ionization energy deposit and absorption of X-rays from transition radiation. The size of the drift chamber is $\sim 1.2 \times 1.4$ m^2 and the total number of readout channels is 1.18 million. Drift chambers are arranged in 18 large scale (7 m length)

modules (super-modules). One super-module contains 5 longitudinal stacks and 6 radial layers of chambers each. With 6 layers, TRD achieves less than 2% pion efficiency with keeping 90% electron efficiency.
The development of custom on-detector front end electronics with ASIC, multi-chip module, and chip-to-chip bonding technologies has been finished and integrated with the detectors. Two super-modules have been assembled and installed into a magnet in ALICE. The cosmic run will be performed in December together with the other ALICE detectors and infrastructures. In addition, the test beam experiment is being performed at CERN PS using electron or pion beam.
The construction technology of TRD super-module, electronics and control system, and the basic performance of the super-module obtained in the test beam experiment and cosmic run are described in this poster.

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Continuum Thermodynamics of $SU(3)$ Gauge Theory in $2+1$ vs $3+1$ Dimensions

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We present the thermodynamical variables in a controlled continuum extrapolation of finite temperature $SU(3)$ lattice gauge theory in $2+1$ dimensions. We have investigated in detail systematic errors that come from finite size and finite lattice spacing. The $2+1$ dimensional theory is easy to simulate on the lattice compared with the $3+1$ dimensional theory, and, of course, QCD with fermions. It is, however, in many aspects similar to pure gauge theory in $3+1$ dimensions, it has linear confinement and a deconfining phase transition at finite temperature. We compare our results with resummed perturbation theory. We also give a simple analytic interpolation of our data in the range $T_c \leq T \leq 10T_c$, which can be used to compare the results with phenomenological models. Finally we discuss the implications of our analysis for the thermodynamics of a strongly interacting quark gluon plasma in 3+1 dimensions.

Muon measurements with the CBM Experiment

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The Compressed Baryonic Matter (CBM) experiment at the Future Facility for Antiproton and Ion Reaseach(FAIR) is aiming at the investigation of strongly interacting matter at high baryon densities. The research program of CBM comprises of the exploration of the equation of state of dense hadronic matter, the search for the deconifinement first order phase transition which is expected to occur at high net-baryon densities and the study of in-meium modifications of hadrons which might signal the onset of chiral symmetry restoration.
The key observables include vector mesons decaying into lepton pairs. In particular J/ψ and ψ' mesons are predicted to be sensitive probes of the deconfined phase. The rare probes will be measured for the first time at FAIR energies. Due to the high reaction rate(up to $10 MHz$) envisaged for the CBM experiment, the recorded charmonium yields will be comparable to measurements at LHC.
Results of feasibility studies will be presented for the identification of charmonium via its dimuon decay in heavy-ion-collision at FAIR energies. Moreover detector requirments and possible technological solutions will be discussed. Initial R&D on detector development will be presented.

Pion form factor in asymmetric nuclear matter

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It is well known that the pion form factor ($F(Q^2)$) plays an important role to describe the photon-hadron interactions in vector meson dominance (VMD) model. $F(Q^2)$ is proportional to the rho spectral function with a peak at the ρ pole mass and a kink near the ω pole indicating the mixing of ρ-ω meson in free space due to explicit symmetry breaking driven by u-d quark mass difference. There exists several models which calculate mixing amplitude of these mesons and their momentum dependence.
In the present work we study the medium modification of pion form factor in asymmetric nuclear matter within the framework of Quantum Hadrodynamical model. It is shown that both the shape and the pole position of the pion form factor in dense asymmetric nuclear matter is different from its vacuum counterpart with ρ-ω mixing. This is due to the density and asymmetry dependent ρ-ω mixing which could even dominate over its vacuum counterpart in matter. Effect of the in-medium pion factor on experimental observables *e.g.*,

invariant mass distribution of lepton pairs has been demonstrated.

First Result of Net-Charge Jet-like Correlations from STAR

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Two-particle jet-like correlations of charged hadrons with a high p_T trigger particle are strongly modified in central Au+Au collisions at RHIC, lending strong support for jet quenching and partonic energy loss. At intermediate p_T the away-side correlation exhibits a double-peak structure which prompted many theoretical investigations of jet-medium interactions. In the same intermediate p_T range the inclusive baryon to meson ratio was found to be strongly enhanced in central Au+Au collisions and is significantly higher than that from jet fragmentation in elementary collisions. Studying jet-like correlations separately for baryons and mesons, therefore, will shed more light on the physics of jet-medium interaction. To this end, we analyze jet-like correlations with associated positive and negative charged particles separately. The net-charge (difference between positive and negative charged particles) may be dominated by net-protons, therefore is primarily sensitive to the baryon content, while the total charge contains all charged particles and has a very different baryon to meson composition than the net-charge. We present the first results from STAR on net-charge jet-like correlations in Au+Au collisions as a function of centrality and compare to total-charge results as well as results from reference d+Au data. Associated p_T spectra of net-charge yields on both the near and away side are obtained, and are compared to those of total charge correlated yields as well as inclusive yields. Ratio of net-charge to total charge correlated yields is presented as a function of associated p_T and centrality, and is compared to the corresponding ratio from inclusive measurements which reflects the medium. The results will be discussed in the context of jet-medium interactions at RHIC.

Simulation of first order deconfinement transition in relativistic heavy-ion collisions

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We have carried out numerical simulation of the first order confinement-deconfinement phase transition to study the formation and evolution of Z(3) domain walls in relativistic Heavy Ion Collision. We use the effective potential for the Polyakov loop order parameter for this transition, proposed by Pisarski. The transition in this model is weakly first order, and we simulate it by first determining the profile of the critical bubble using the bounce technique and then simulating the phase transition by random nucleation of these bubbles. The nucleation probability from the initial confined vacuum to the deconfined state in the confining background is used from the literature to determine the number of bubbles nucleated per unit time in the overlap region of the colliding nuclei. This initial field configuration is evolved using a stabilized leapfrog algorithm of second-order accuracy. Due to Bjorken scaling for the longitudinal expansion, early dynamics of bubble evolution is described using simulation in 2+1 dimensions. As the bubbles expand and coalesce, Z(3) walls and associated strings form due to random choice of Z(3) vacua inside different bubbles. We study the coarsening of the domain wall network and any possibility of scaling solution within the short time available for the system before the hadronization stage when the walls melt away. We also estimate the energy density fluctuations resulting from the decay of walls when temperature drops below Tc. We use this simulation to make a detailed study of observable consequences of the presence of these walls in terms of enhancement of high P_T hadrons, and multiplicity fluctuations resulting from the decay of wall network,as well as presence of novel jet structures.

Transverse Energy Measurement in Au+Au collisions by the STAR Experiment.

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Transverse energy (E_T) has been measured with both of it's components, namely hadronic (E_T^{had}) and electromagnetic (E_T^{em}) at mid-rapidity, for 62.4 GeV and 200 GeV (Run-IV) Au+Au collisions by the STAR experiment. In the common phase space of TPC and BEMC ($0 < \eta < 1$ and full ϕ), we have obtained E_T^{had} from the TPC reconstructed tracks and E_T^{em} from the BEMC tower hits after correcting for the hadronic contaminations in the calorimeter. We present the minimum-bias spectra of E_T and it's components for 62.4 GeV and 200 GeV Au+Au collisions. The centrality behavior of $< dE_T/d\eta > /(0.5N_{part})$ and the excitation function of $< dE_T/dy > /(0.5N_{part})$ has been compared with the final state gluon saturation model (EKRT) along with similar measurements from SPS to RHIC. The centrality behavior of the ratio $< dE_T/d\eta > / < dN_{ch}/d\eta >\equiv E_T/N_{ch}$ has been compared to the corresponding data at other energies. The most striking feature is the observation of a nearly constant value of $E_T/N_{ch} \sim 0.8$ GeV from AGS, SPS to RHIC. It has been shown by the statistical-thermal model that this behavior is related to the freeze-out criteria and is consistent with the single freeze-out model [1]. It is found that the increase in E_T production with energy, comes mostly from the increase in particle multiplicity. The E_T and N_{ch} production has been observed to follow a logarithmic behavior. Based on the boost-invariant Bjorken hydrodynamic model, the estimation of the initial energy density of the produced fireball, when compared with the lattice QCD calculations, suggests that a deconfined phase has been created at RHIC for the central Au+Au collisions. Taking similar colliding species i.e. Au+Au, the $\epsilon_{Bj}.\tau$ has been predicted for LHC, based on the measurements at RHIC. We have also made predictions for $(dE_T/d\eta)/(0.5\ N_{part})$ and $(dN_{ch}/d\eta)/(0.5\ N_{part})$ for the LHC energy. The ratio E_T^{em}/E_T, for top 5% central events is consistent with a final state dominated by mesons and has been found to increase slowly with $\sqrt{s_{NN}}$. E_T^{em}/E_T has been observed to be independent of centrality. Furthermore, we have studied the event-by event fluctuations in E_T and in the ratio of it's components using σ/μ as the fluctuation observable. The fluctuations in $E_T, E_T^{em}/E_T$ have been observed to be 8.4% and 9.7% respectively for top 5% central events. The centrality behavior of E_T-fluctuation has also been studied.

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Track Matching Study from TPC to PHOS in ALICE Experiment

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The Photon Spectrometer (PHOS) designed by ALICE is dedicated to measuring photon spectrum precisely with a large transverse momentum range from 0.5-100GeV/c. We present a study within the frame of software-AliRoot for matching charged tracks reconstructed from the ALICE tracking detectors with the clusters measured in the PHOS. Matching efficiency and contamination due to wrong matches have been deduced for charged pions, muons and protons. For electrons, lower efficiency and more contamination are discovered. And further the study shows that with less additional material in front of PHOS will be much in favor of the photon detection and thermal photon analysis of the middle transverse momentum domain.

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Measurement of High p_T Flow and Jet Correlation in Au+Au Collisions at $\sqrt{S_{NN}} = 200GeV$ from PHENIX

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Single hadron yields at high transverse momentum p_T are observed to be strongly suppressed in central Au+Au collisions. This suppression is thought to be the result of jet quenching, and the observed high p_T hadrons are thought to be dominated by fragmentation of partons emitted from the surface of the overlap region. Although extremely simplistic, this picture would lead to a small but finite v_2 and a relatively unmodified near-side jet shape for these high p_T hadrons. A combined study of the v_2 and near-side jet correlations of leading hadrons can improve our understanding of the particle production mechanism and geometrical bias in this p_T region. PHENIX experiment installed a new reaction-plane detector and collected 5.5 billion Au+Au events in RUN7. The significantly improved ability to determine the reaction-plane and large statistics allow a more detailed study of flow and jet correlation. Results on the elliptic flow and jet correlation for high p_T hadrons are discussed.

Analysis of Low Energy Pion Spectra

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The transverse mass spectra and the rapidity distributions of π^+ and π^- in Au-Au collisions at 2, 4, 6, and 8GeV·A by E895 collaboration are fitted using an elliptically expanding fireball model with the contribution from the resonance decays and the final state Coulomb interaction. The ratio of the total number of produced π^- and π^+ is used to fit the data. The resulting freeze-out temperature is rather low($T_f < 60$MeV) with large transverse flow and thus resonance contribution is very small. The difference in the shape of m_t spectra of the oppositely charged pions are found to be due to the Coulomb interaction of the pions.

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FLOW FLUCTUATIONS AND MEASUREMENT OF ANISOTROPY COEFFICIENTS

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The observation of flow in relativistic heavy ion collisions has led to different analysis techniques to determine flow from experimental data. The standard method determines the coefficients of fourier expansion of azimuthal distribution by obtaining the average cosines of the particle angles with respect to the estimated reaction plane.This method measures essentially two particle correlations, and the coefficients include contributions from non-flow correlations. The methods of obtaining the higher order cumulants and that of finding the Lee-Yang zeroes determine many particle correlations

due to collective effects.

Considering the recent interest in fluctuations in flow we propose to revisit the standard method of analysis. The different implementations of the standard method of analysis yield consistent results. The method purports to determine the mean value of flow, $\langle v_n \rangle$, for any given sample of events, where as it determines $\sqrt{\langle v_n^2 \rangle}$. The two values agree with each other if the values of flow for all events are distributed about a mean with a *small* variance.

We shall argue that the dependence of flow on centrality, rapidity and particle identity introduces an additional uncertainty in the p_T dependence of v_2, manifesting in different values of flow for each event. This mimics fluctuations in flow, and contributes to the variance of the distribution over and above the contribution due to impact parameter and eccentricity fluctuations. The effect of this uncertainty in the p_T dependence will be estimated on the final values of flow determined using the standard method of analysis.

The standard method often decreases the contribution of non-flow correlations by determining the flow of a given set of particles using the estimated reaction plane from another set of particles. We shall also show that fluctuations in the flow of particles used to estimate the reaction plane also contribute to similar behaviour, namely, decreasing the measured values of flow for the first set of particles.

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DILEPTON FROM QGP AND QUARK-HADRON PHASE TRANSITION

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A model of statistical quark-gluon plasma formation is considered. We look the dilepton production at the transition temperature which is obtained around $(150-170)\ MeV$, from this system with the quark mass depending on the coupling parameter used in R. Ramanathan et al$(PRC70, 2004, 027903)$. The rate of dilepton production is shown for the invariant mass M as well as transverse momentum P at the particular value of $E = 2.0, 3.0\ GeV$. It is found that there is significant production of leptons in this process.

Measurement of π^0 and η mesons with PHENIX in sqrt(s)=200GeV Au+Au collisions at RHIC

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The π^0 meson has been a crucial probe for observing jet quenching in ultrarelativistic heavy-ion collisions at RHIC. With the data from the 2004 RHIC run, a first systematic comparison between the precise measurement of the nuclear modification factor (R_{AA}) and theoretical calculations allowed constraining model parameters such as the initial gluon density $\mathrm{d}N^{\mathrm{g}}/\mathrm{d}y$ and the transport coefficient $\hat{q}$. Measurements of the η meson production in the same collisions have also shed light on a possible dependence of the suppression on the particle species.

In the 2007 Au+Au run of RHIC, PHENIX has gathered more than 3 times the events than in 2004, allowing an extension of the particle spectra up to higher transverse momenta. PHENIX has also added new detectors to its setup that allow higher precision e.g. in the measurement of the reaction plane. The latest result on the measurement of the π^0 and η mesons as well as the status of the Run7 data analysis will be shown and discussed.

D^0 production in proton proton collision at $\sqrt{s}$ = 200 GeV

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The charm quarks are a rich probe of QCD matter produced in heavy ion collisions. To understand how the energy loss mechanism and the flow strength depend on quark mass, one has to study charm quark production. A systematic study of charm yield and spectra in pp, pA and AA is a prerequisite to understand the properties of the strongly interacting matter. In this work, we report on the D^0 reconstruction in the $K\pi$ channel in pp collisions at $\sqrt{s}$ = 200 GeV, measured by PHENIX collaboration. D^0-mesons are produced in pairs. While one of them may decay to $K\pi$ the other may decay to electron channel. The electron decay provides a method of tagging the D^0 mesons and helps reducing the hadronic background from pp. The K and π identification is optimized with a combination of time of flights in TOF and EMCAL subsystems. Mixed event technique is used to subtract the background. The simulations are carried out to study the effect of electron tagging on signal to background ratio and to tune the hadron identification. A status of this analysis will be presented.

Azimuthal Correlations of Electrons from Heavy Quark Decay with Hadrons in Au+Au Collisions at $\sqrt{s_{NN}}$=200GeV in PHENIX

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The observed large suppression and elliptic flow of electrons from heavy quark decay has led to a rethinking of the conventional radiative energy loss picture that well describes light quark energy loss. However, substantial ambiguities exist because of uncertainties in the charm/bottom ratio and unknown medium effects on the fragmentation and hadronization of heavy quarks. Two particle hadron correlations have been used extensively to obtain additional information about hadronization, fragmentation and possible medium response in heavy ion collisions. The PHENIX experiment is well suited to electron measurements because of it's excellent electron identification capabilities. We apply techniques developed for direct photon-hadron correlations to statistically subtract correlations from photonic sources from the inclusive electron hadron correlations and we present the current status of two particle correlations between electrons from heavy quark decay and charged hadrons in Au+Au collisions in the PHENIX experiment.

First observation of J/ψ elliptic flow parameter v_2 and new results of suppression in Au+Au collisions.

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Understanding the J/ψ suppression and possible recombination mechanisms at RHIC is one of the outstanding challenges for theorists and experimentalists. Recent results provided by PHENIX showed a stronger suppression at forward rapidities, while at mid-rapidity the suppression is similar to lower energy collision experiments. A large sample of Au+Au collisions at $\sqrt{S_{NN}}$=200 GeV was collected during 2007 data taking run with PHENIX detector at RHIC. Using this sample, J/ψs were identified in the di-electron decay channel. We studied the J/ψ nuclear modification factor and the first determination of its v_2 elliptic flow parameter at mid-rapidity.

K*(892) RESONANCE PRODUCTION IN PB+PB COLLISIONS AT CERN SPS ENERGIES

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Production of the K*(892) resonance in the $K^+\pi^-$ decay channel was studied by the NA49 experiment in central Pb+Pb collisions at 158A GeV beam energy. The signals of the K*(892) mesons are extracted from the invariant mass spectra of $K^+\pi^-$ pairs using particle identification by dE/dx measurements in the NA49 TPCs. The mixed event background subraction technique was optimised for dealing with the overwhelming combinatorial background. The mass and width of the resulting mass peak are consistent with the PDG table values. Preliminary K*(892) yields are presented as a function of rapidity and transverse momentum.

Jet Quenching in Relativistic Heavy Ion Collisions

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Quantum chromo dynamics (QCD) calculations on space-time lattice predict a transition from confined state in hadrons to a deconfined state of quarks and gluons above a temperature of 170 MeV or an energy density above 1GeV/fm^3. In the relativistic heavy ion collisions at RHIC at BNL, where the initial energy density is around 5GeV/fm^3, such a transition to a deconfined state of matter is formed as shown by experimental measurements of several observables [1,2]. It is currently believed that this deconfined state consists of a strongly interacting Quark Gluon Plasma (sQGP), behaving nearly like a perfect liquid, see [1,2] . Among many observables, jet-quenching phenomenon is so far an undisputed and important signal for a hot dense medium formed in relativistic heavy ion collisions. We are calculating the energy loss of partons while traversing the QGP medium due to the gluon bremsstrahlung processes. The coherent radiation processes involve multiple scatterings of the partons in the QGP medium during the gluon formation time. This leads to the interference effects known as Landau-Pomeranchuk-Migdal effect (LPM) [3]. For this purpose, we follow the Arnold Moore Yaffe (AMY) formalism discussed in detail in [3,4,5]. The bremsstrahlung integral equations determine the gluon emission amplitude given by $\mathbf{F}_s(\mathbf{h},\text{p},\text{k})$ function. In terms of this $\mathbf{F}_s(\mathbf{h},\text{p},\text{k})$ function, the emission rate is determined as given in Eq. 1 (for details see Eq.5 given in Ref.4). In our recent works, we used the iterations method and the variational method for solving similar integral equations for virtual photon emission from QGP [6]. For the case of gluon emission, we are using the iterations method to solve AMY integral equation to obtain $\mathbf{F}_s(\mathbf{h},p,k)$ function. The work is in progress and in the conference; we will present results for $\mathbf{F}_s(\mathbf{h},p,k)$ distributions.

$$\frac{d\Gamma_g^{LPM}}{d^3\mathbf{k}} = \frac{\alpha_s}{4\pi^2 k^2}\sum_s N_s d_s C_s \int_{-\infty}^{+\infty}\frac{dp}{2\pi}\int\frac{d^2\mathbf{h}}{4\pi^2} n_s(p+k)[1\mp n_s(p)]\otimes [1+n_b(k)]\frac{1}{k^3}|\Gamma^s_{p\to p+k}|^2 2\mathbf{h}\cdot\Re\mathbf{F}_s(\mathbf{h};p,k) \quad (1)$$

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PHENIX measurements of particle species dependent flow correlations in Au+Au and Cu+Cu collisions at $\sqrt{s_{NN}}$=200 GeV

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Flow correlation measurements constitute a central pillar in the body of evidence in support of the creation of the quark gluon plasma (QGP) in RHIC collisions. Such momentum anisotropy is now routinely characterized at mid-rapidity, by the even order Fourier coefficients,

$$v_n = \left\langle e^{in(\phi_p-\Phi_{RP})}\right\rangle, n = 2, 4, .., \quad (2)$$

where ϕ_p is the azimuthal emission angle of a particle, Φ_{RP} is the azimuth of the reaction plane and the brackets denote statistical averaging over particles and events.

At RHIC energies, momentum anisotropy is believed to result from frequent particle interactions which drive pressure gradients in an "almond-shaped" collision zone. However, the question of whether or not particle collisions are frequent enough to achieve full local equilibrium is still under debate. Similarly, a consensus on the detailed dynamical evolution of the QGP has not been reached.

In recent experiments, the PHENIX collaboration has made detailed measurements of flow correlations and their fluctuation, for several particle species produced in Au+Au and Cu+Cu collisions at $\sqrt{s_{NN}}$=200 GeV, with an eye toward resolving these issues.

We will present a detailed set of harmonic flow correlation results and discuss their implication for local thermalization and the dynamical evolution of the QGP, as reflected by its equation of state and transport properties.

Probing the Quark-Gluon Phase Transition using Energy and System-Size Dependence of Long-Range Multiplicity Correlations in Heavy Ion Collisions from the STAR Experiment

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Long-range forward-backward multiplicity correlations have been measured in heavy ion collisions at RHIC. Results for short and long-range multiplicity correlations (forward-backward) are presented for several systems (Au+Au, Cu+Cu, and pp) and energies (e.g. $\sqrt{s_{NN}} = 200$ and 62.4 GeV). A strong, long-range correlation is seen for central heavy ion collisions at $\sqrt{s_{NN}} = 200$ GeV that vanishes in semi-peripheral events and *pp* collisions. There is no apparent scaling with the number of participants (N_{part}) involved in the collision. These correlations provide information about the longitudinal behavior of the system formed in heavy ion collisions. To access the transverse behavior, the clusters produced in the same heavy ion collisions have been characterized by a study of the energy and system size dependence of the percolation density parameter (ρ) [1]. The relationship between the long-range correlation and ρ has been explored to characterize the hadron-quark/gluon phase transition and rapid thermalization of the system.

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Properties of the ϕ meson at high temperatures and densities

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We calculate for the first time the mass shift, the width broadening, and the spectral density of the ϕ meson in a hot bath of nucleons and pions using a general formalism relating self-energy to the forward scattering amplitude (FSA) [1,2]. In order to describe the low energy FSA, we use experimental data along with a background term. For the high energy FSA, a Regge parametrization is employed. We verify the resulting FSA using dispersion techniques. We find that the position of the peak of the spectral density is a little shifted from its vacuum position, but its width is considerably increased due to collisional broadening. Properties of the spectral density are also investigated in various physical limits [3]. Finally, we study the implications of our findings for measurements at SPS and at RHIC.

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Centrality dependence of charged kaon spectra from Au+Au collisions at 200 GeV

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Strangeness enhancement is a useful signal to study Quark Gluon Plasma in relativistic heavy ion collisions. Kaons created in the collisions carry a large fraction of strangeness, which is not in the initial colliding nucleus. Measurements of kaon spectra over a wide centrality range will allow us to study the freeze-out dynamics. In particular at the intermediate transverse momentum, centrality dependence of kaon spectra will allow us to study the hadron formation mechanism via coalescence. In this talk, we present the charged kaon spectra at mid-rapidity from Au+Au collisions at 200 GeV measured by the STAR experiment at RHIC. With Time-of-Flight detector to identify kaon, the centrality dependence of kaon spectra is presented at 0.3 GeV/c $< p_T <$ 5GeV/c. The freeze-out dynamics indicated by kaon spectra measurements are discussed. The comparison with 62.4 GeV Au+Au results are also discussed.

Full jet reconstruction in $\mathrm{p+p}$ at $\sqrt{s} = 200\,\mathrm{GeV}$ and in $\mathrm{Cu+Cu}$ at $\sqrt{s_{NN}} = 200\,\mathrm{GeV}$ with the PHENIX detector

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Acceptance-limited detectors, such as the PHENIX Experiment, are an especially challenging environment to perform full jet reconstruction. The heavy ion background further limits the usefulness of traditional jet reconstruction schemes when applied at RHIC energies. Yet the information derived from reconstructed jets could provide effective means to study in-medium energy loss and medium-induced modification of fragmentation.

We introduce a new jet reconstruction algorithm based on filtering that is suitable for both acceptance-limited and large acceptance detectors, and is in part inspired by pQCD energy flow variables [1]. We will discuss the jet reconstruction performance in both PHENIX and full acceptance detectors, and will present the status of first results from this general method for jet production in both hadronic and heavy ion collisions at RHIC.

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Study on the γ ray and neutron sensitivity of MRPC

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The multi-gap resistive plate camber (MRPC) has good time resolution (less than 100ps) and high detection efficiency (higher than 95and will be used to construct a full barrel time-of-flight (TOF) detector for the STAR experiment at RHIC. In this paper we try to use MRPC technology to detect γ rays and fast neutrons. DPF neutron source and flash x-ray source were used to measure the γ ray and neutron sensitivity. The results show that MRPC has good response to x-ray and it can discriminate the γ ray peak and neutron peak of DPF source.
In the mean time, we studied the method to improve the neutron sensitivity of MRPC. Thin polyethylene layer is placed on the surface of electrode glass, when neutron interact with polyethylene, proton is produced and it can ionize working gas. Electron and ions will produce avalanche by strong electric field and charges is induced on collect electrodes. This kind of neutron detector not only has high neutron- γ resolution capability, but also has good spatial resolution.

Measurement of direct photon via internal conversion in $\sqrt{s} = 200$ GeV p+p collisions at RHIC-PHENIX

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Direct photons are unique probes to investigate properties of Quark Gluon Plasma (QGP) since photons are not influenced by the strong interaction. Photons are emitted at many different stages of the collisions, from the initial interaction to the final hadron-gas phase. However thermally emitted photons from QGP phase are considered to be the primary contributor in the low energy region.

A measurement of 'real' direct photon using an electromagnetic calorimeter is notoriously difficult in the low energy region due to large systematic errors. There are three main reasons why the errors can not be reduced:

1. It is essentially very difficult to measure the photon energy with high resolution in the low energy region using an EMCal.
2. The uncertainty in estimating hadron contamination becomes larger in this region.
3. There is large irreducible π^0 background in the real photon spectrum.

On the other hand, it is possible to measure 'virtual' direct photons via internal conversion with small systematic errors in the low energy region since the hadron contribution can be estimated using the Kroll-Wada formula.

It has been shown that this method of measuring 'virtual' photons can reduce the systematic errors of the photon yield in Au+Au collisions. Thus the same method is applicable to the direct photon yield in p+p collisions, which serves as a vital comparison to the direct photon yield in Au+Au collisions. The comparison of direct photon yield between in p+p and Au+Au collisions can be performed to discuss the production of thermal photon in QGP phase. In this work, we present the results of the measurement of the direct photon yield via internal conversion in p+p collisions at $\sqrt{s} = 200$ GeV.

A Simplified Model for Calculating R_{AA} and R_{CP} of Cold Nuclear Matter Effects

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Understanding the behavior of QCD matter under different temperature and density conditions is a subject of intense experimental and theoretical work in nuclear physics. Recent results at RHIC suggest the formation of an ultradense form of matter [1]. However, in order to properly interpret these results, methods for analyzing background nonequilibrium processes need to be developed so that these processes may be separated from those that occur at equilibrium. For example, although the quark-gluon plasma (QGP) is not expected to be formed in p+p, p+A, or d+A collisions, these collisions result in effects which must also be ascertained separately from those that may be associated with the QGP [2]. These cold nuclear matter effects, as well as the modification of initial parton distribution functions, such as shadowing, gluon saturation, etc., need to be understood before firm conclusions can be drawn on the nature of the hot nuclear medium that has been produced at RHIC.

An incoherent binary nucleon-nucleon collision model of AA collisions for simulating particle production in cold nuclear matter is presented, which with a simple phenomenological parameter, the mean nucleon energy loss fraction, yields results that match experimental data [3], as well as those of HIJING [1,4], rather well. The model's simulation program extracts particle production data from pp collisions that are simulated using the PYTHIA program. The nuclear geometry is described through the Glauber Model. The preliminary R_{AA} and R_{CP} results will be presented in this poster.

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Meson-baryon femtoscopy in AuAu collisions at 200GeV measured by STAR experiment

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Correlations between non-identical particles at small relative velocity probe asymmetries in the average space-time emission points at freezeout [1]. Such asymmetries may arise from long-lived resonances, bulk collective effects, or differences in the freezeout scenario for the different particle species. STAR has extracted pion-proton correlation functions from a high-statistics dataset of

Au+Au collisions at $\sqrt(s_{NN})$ GeV. We present a femtoscopic analysis of this data for all combinations of pions and (anti-)protons, for collisions of different centrality. The measurements are compared with calculations of a simple Blast-wave model, in which asymmetries are driven only by collective flow, as well as with Therminator [2], which also accounts fully for resonance effects.

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Proton femtoscopy in STAR

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Femtoscopy of two particles investigates the properties of matter produced in heavy-ion collisions. It allows to study the space-time characteristics of the baryon-emitting medium. The distinctions in the scattering cross sections, the production of resonances and collective motion can create differences between space-time properties of proton and anti-proton emission. We present the latest results on baryon-(anti-)baryon femtoscopy performed by STAR for Au+Au collisions at $\sqrt{s_{NN}} = 200$ AGeV and analyze the centrality dependence of such observables. Hydrodynamics and similar models predict no emission asymmetry between particles of same masses, while models including rescattering in the final stage (UrQMD) show a small asymmetry. Using our data we attempt to distinguish between the two scenarios, using proton - anti-proton femtoscopy as a direct probe for the existence of final state rescattering.

EOS of QGP using Screened Cornell Potential

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Equation of State [EOS] of Quark Gluon Plasma [QGP] using Screened Cornell potential based on Mayer's cluster expansion is presented here[1-4]. The Cornell potential $V(r_{ij})$ [5] is defined here for gluon plasma as

$$V(r_{ij}) = \left(\frac{3\alpha_s}{r_{ij}} - \sigma r_{ij}\right) e^{-m_D r_{ij}}$$

and for quark-antiquark plasma

$$V(r_{ij}) = \left(\frac{4}{3}\frac{\alpha_s}{r_{ij}} - \sigma r_{ij}\right) e^{-m_D r_{ij}}$$

where α_s , σ and m_D are strong coupling constant , string tension and De bye mass (inverse De bye screening length) respectively. In the QGP, the De bye mass of a chromoelectric charge follows from the static limit of the longitudinal polarization tensor which in the high temperature limit is given by

$$m_D^2 = \alpha_s^2 T^2 (1 + \frac{n_f}{6})$$

where n_f is the number of light quark flavors in the QGP [6]. In our numerical analysis, we adjusted the two parameters σ and α_s such that we get qualitatively good fit to the EOS of LGT (Lattice Gauge Theory). For all the flavors at high temperatures EOS figures coincide. At $T \approx T_c$ our results donot match with the lattice results. This may be due to perturbative effects.

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Systematics of cut-off effects in lattice calculations with chemical potential

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Recent lattice calculations have attained accuracies of 10% or more. Two factors are respon- sible for this success: The discovery of new, powerful algorithms such as the Rational Hybrid Monte Carlo (RHMC) algorithm, and the use of improved actions. In particular, at high temperature and non-vanishing chemical potential, where todays lattice calculations are forced to be performed on rather coarse lattices, the use of improved actions is mandatory. While improvement schemes for thermodynamic calculations have been used for quite some time, little is known about the systematics of these effects in the presence of a non-vanishing chemical potential as well as in chiral fermion formulations. The latter eliminate another problem in todays lattice studies of QCD thermodynamics, the explicit chiral symmetry breaking inherent in the staggered and Wilson fermion formulations. With the rapid im- provement in computing resources chirally invariant discretization schemes also become more and more attractive to be used for thermodynamic calculations. Recently it has been questioned whether a non-vanishing chemical potential may introduce additional cut-off errors in the chirally invariant overlap fermion formalism [1]. We will show here that this is not the case and explicitly calculate the cut-off induced errors in the high temperature, Stefan-Boltzmann limit of QCD [2]. We extend this study to the case of do- main wall fermions as well as truncated perfect actions of Wilson type. In this poster, we present explicit results for the size of cut-off effects at finite temperature and non-vanishing chemical potential that arise in various discretization schemes used for the fermion sector of QCD in lattice calculations.

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Multi-strange hadron production measured by the STAR detector in Cu+Cu collisions at $\sqrt{s_{NN}} = 62.4$ GeV

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The study of particle production in relativistic heavy ion collisions is an important tool to understand the fireball dynamics and the various process present in such physical system. The production of strange hadrons is of special interest given the particular value of the strange quark mass and the abundance of these hadrons in such collisions, allowing for a statistical interpretation of the results. The transverse momenta spectra and the total yields of strange hadrons have been measured by the STAR experiment for Au+Au collisions at center of mass energies of 62.4 GeV, 130 GeV and 200 GeV per nucleon pair. All these measurements allowed not only a systematic study of particle production dependence on collision energy but on system size as well due to the different collision centralities that can be probed. In 2005, STAR has measured Cu+Cu collisions at 62.4 and 200 GeV in order to enhance these systematic studies on the energy and the system size dependence of particle production. The results for 200 GeV were already presented in previous conferences. We will present details and preliminary results of the analysis of Ξ and Ω and their anti-particles production for Cu+Cu collisions at $\sqrt{s_{NN}} = 62.4$ GeV. These particles are identified through the reconstruction of their weak decay topology. The data presented in this poster enriches the systematic study of energy and system size dependence of yields and ratios between the AGS experiments to the top RHIC energy measurements.

Strange Hadron Elliptic Flow v_2 from 200 GeV Cu+Cu Collisions

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Elliptic flow allows us to probe early dynamics in high-energy nuclear collisions. Previous studies of elliptic flow, in particular its pt dependence, of all charged particles and identified hadrons [1,2] from 200 GeV AuAu collisions at RHIC suggest that, the system has gone through early thermalization with partonic collectivity before expansion and freeze-out. It is expected that as the system size decreases and energy decreases, the condition for a complete thermalzation are no longer met, and this change of condition may result in change in elliptic flow. Thus it becomes important to measure elliptic flow in smaller systems and at different energies. In this analysis, we present STAR's preliminary results of v_2 for K_S^0, Φ, and Λ from 200 GeV CuCu collisions. We will compare the results with those from AuAu collisions at a similar number of participants or similar eccentricity. Hydrodynamic model results will also be used to compare with the data.

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Systematic Study of Low-p_T Direct Photons via π^0 Tagging Method at PHENIX

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Direct photons are an excellent penetrating probe to study the formation of the Quark-Gluon Plasma (QGP) since they are not influenced by the strong interaction and hadronization processes. While at high p_T they constitute a crucial reference for the medium modification of high-p_T hadron production, at low and intermediate p_T direct photons, which are expected dominated by thermal photons, can provide important information about temperature of QGP at the early stage of heavy-ion collisions. But the huge background from meson decay makes the measurement of thermal photons very challenging.

Among all the different efforts to measure low-p_T direct photons production at PHENIX, π^0 tagging method is a promising approach to minimize the systematic errors. The analysis utilizes two different Electromagnetic Calorimeter (EMCal) detectors installed at PHENIX that provides an important cross checks and increases the confidence level of physics results. Methods, results and comparison with the latest measurements of PHENIX will be presented.

Three Body Force for investigation of Hadron in Hypercentral Harmonic and Anharmonic Potentials

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We present a theoretical approach to the internal motion of a system based on 3-body forces among particles in a special case. Using 3-body potentials. The 3body-forces are more easily introduced and treated within the hyperspherical harmonic formalism. The internal particle motion is usually described by means of the Jacobin relative coordinates ρ , λ and R . The problems related to three body nonhypercentral potentials in three-dimension are investigated.

While the difficulties that arise in the study of nonhypercentral potentials are explicitly shown, we discuss some results obtained using nonhypercentral harmonic and anharmonic and some inverse power terms; however the potential can be easily generalized in order to allow a systematic analysis. Which admit an exact solution of the wave equation. The method is also applied to some other types of potentials.

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Di-electron spectroscopy in CBM

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The Compressed Baryonic Matter (CBM) experiment at the future Facility for Antiproton and Ion Research (FAIR) at GSI in Darmstadt will be a dedicated heavy-ion experiment exploring the QCD phase diagram in the region of moderate temperatures and high baryon densities with A+A collisions at 10-45 AGeV beam energy. This region of the phase diagram attracted strong attention in recent years because several interesting features of QCD can be addressed experimentally. An experimental observation of a first order phase transition or the critical end point would be a milestone in our understanding of the quark-hadron phase diagram.

One key aspect of the CBM physics program is to look for the signal of chiral symmetry restoration by studying the in-medium properties of low mass vector mesons created inside the fireball. The leptonic decay channels of these mesons are of special interest as the leptons leave the hot and dense fireball without further interaction and may reveal information on the characteristics of the matter created in the collisions. Along with this, the measurement of charmonium, also in its leptonic decay channel, will provide important insight into the subject of charm production at threshold, charmonium formation in hot and dense matter and deconfinement phase transition.

The vector mesons can be reconstructed from di-electron or di-muon channel. Here we will present the feasibility studies investigating the di-electron channel, within the proposed CBM setup. The electrons are identified using information from the Ring Imaging Cherenkov (RICH) detector and the Transition Radiation Detectors (TRD). A further clean up of the identified electron sample is also done using the Time Of Flight (TOF) signal. Momentum information is provided from a set of Silicon Tracking Stations (STS) located inside a dipole magnetic field immediately behind the target. For the low mass vector mesons the special challenge is to reduce the combinatorial background coming from random combinations of electrons and positrons. In CBM this becomes further difficult because of the fact that electron identification is provided only after the magnetic field required for tracking. Several topological cuts have been developed to reduce the background coming from π^0 Dalitz decay and conversion of γ in various materials in the detector systems. Results from these feasibility studies will be presented and compared with those from existing experiments. Similar effort has been put forward to reconstruct J/ψ through the di-electron channel and results of this analysis will also be discussed.