# Quark Matter 2015 - XXV International Conference on Ultrarelativistic Nucleus-Nucleus Collisions


# Report of Contributions

http://indico.cern.ch/e/355454

Contribution ID : **515** Type : **Contributed talk**

# Quarkonium production in proton-proton and proton-lead collisions with ATLAS at the LHC

*Monday, 28 September 2015 11:15 (0:20)*

## On behalf of collaboration:

ATLAS

## Abstract Content

The suppression of heavy quarkonium states such as J/psi, psi(2S) and Upsilon(nS) in heavy-ion collisions, with respect to proton-proton collisions, plays an important role in studying the hot and dense medium formed in the larger collision systems. A full assessment of this suppression requires understanding of nuclear effects which may affect the production of quarkonium states even in the absence of the medium. The study of quarkonium production in proton-nucleus collisions serves as a baseline for understanding heavy-ion collisions and furthers our knowledge of such nuclear effects. Using proton-lead and proton-proton collision data collected at the LHC in 2013, the ATLAS experiment measures J/psi, psi(2S) and Upsilon(nS) production. The yields of charmonium states are separated into contributions from b-hadron decays and prompt production. The nuclear modification factors and excited-to-ground state ratios are presented. All quarkonium states are reconstructed via the dimuon decay channel and the yields are shown differentially in intervals of transverse momentum, rapidity and event activity.

**Primary author(s) :** HU, Qipeng (University of Science and Technology of China (CN))

**Presenter(s) :** HU, Qipeng (University of Science and Technology of China (CN))

**Session Classification :** Quarkonia I

**Track Classification :** Quarkonia

Contribution ID : **564** Type : **Contributed talk**

# J/psi and psi(2S) production in p-Pb collisions with ALICE at the LHC

*Monday, 28 September 2015 11:35 (0:20)*

## On behalf of collaboration:

ALICE

## Abstract Content

The ALICE Collaboration has studied the inclusive J/$\psi$ and $\psi$(2S) production in p-Pb collisions at the nucleon-nucleon centre of mass energy $\sqrt{s_{NN}} = 5.02$ TeV at the CERN LHC. The strongly bound J/$\psi$ and the loosely bound $\psi$(2S) are detected through their decays to muon pairs in two configurations with inverted beam directions, with the following rapidity coverages:$-4.46 < y_{cms} < -2.96$ (Pb-going direction) at backward rapidity and $2.03 < y_{cms} < 3.53$ (p-going direction) at forward rapidity. The J/$\psi$ production is also studied in the mid-rapidity interval $-1.37 < y_{cms} < 0.43$ in the dielectron decay channel. The J/$\psi$ and $\psi$(2S) nuclear modification factors, $R_{pA}$, will be presented as a function of transverse momentum, rapidity and collision centrality; the J/$\psi$ forward-to-backward ratios and the average $p_T^2$ values will be also reported. Notably, the $\psi$(2S) suppression is larger than the one observed for the J/$\psi$ and is not described by theoretical models including only nuclear shadowing and coherent energy loss as cold nuclear matter effects. Moreover, results show that the relative $\psi$(2S) suppression relative to J/$\psi$ grows towards central collisions (especially at backward rapidity). We will also show the $\psi$(2S)/J/$\psi$ ratio as a function of transverse momentum, rapidity and centrality. Our measurements will be discussed together with results of recent theoretical calculations.

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**Session Classification :** Quarkonia I

**Track Classification :** Quarkonia

Contribution ID : **23** Type : **Contributed talk**

# LHCb results from proton ion collisions

*Monday, 28 September 2015 11:55 (0:20)*

## On behalf of collaboration:

LHCb

## Abstract Content

Proton-lead and lead-proton data taking during 2013 has allowed LHCb to expand its core physics program into the regime of heavy ion physics. Results include the first forward measurement of Z production in proton-lead collisions as well as a measurement of the nuclear modification factor and forward-backward production of prompt and displaced J/psi, psi(2S) and Upsilons. Angular particle correlations have also been measured for events of varying charged particle activity.

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**Session Classification :** Quarkonia I

**Track Classification :** Quarkonia

Contribution ID : **53** Type : **Contributed talk**

# Cold Nuclear Matter Effects on J/psi and Upsilon production in p+Pb collisions at 5 TeV and Pb+Pb collisions at 5.1 TeV

*Monday, 28 September 2015 12:15 (0:20)*

## On behalf of collaboration:

None

## Abstract Content

We make a systematic study of the modifications of $J/\psi$ and $\Upsilon(1S)$ production in $p$+Pb collisions at $\sqrt{s_{NN}} = 5$ TeV at the LHC. We compare the uncertainties in the EPS09 shadowing parameterization to the calculated mass and scale uncertainties obtained employng the EPS09 NLO central set. We study the dependence of the results on the proton parton density and the choice of the nuclear modifications. We check whether the results obtained are consistent at leading and next-to-leading order. The calculations are compared to the available ALICE and LHCb data on the nuclear modification factors, $R_{pA}(y)$ and $R_{pA}(p_T)$, as well as the forward-backward asymmetries, $R_{FB}(y)$ and $R_{FB}(p_T)$. Finally, we make predictions for the next Pb+Pb run at $\sqrt{s_{NN}} = 5.1$ TeV in Run 2 of the LHC.

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**Session Classification :** Quarkonia I

**Track Classification :** Quarkonia

Contribution ID : **179** Type : **Contributed talk**

# Forward $J/psi$ production in pA collisions at the LHC

*Monday, 28 September 2015 12:35 (0:20)*

## On behalf of collaboration:

None

## Abstract Content

Inclusive production of $J/\psi$ mesons, especially at forward rapidities, is an important probe of small-x gluons in protons and nuclei. In this work we re-evaluate the production cross sections in the Color Glass Condensate framework, where the process is described by a large x gluon from the probe splitting into a quark pair and eikonally interacting with the target proton or nucleus. Using a standard collinear gluon distribution for the probe and an up to date dipole cross section fitted to HERA data to describe the target we achieve a rather good description of the cross section in proton-proton collisions, although with a rather large normalization uncertainty. More importantly, we show that generalizing the dipole cross section to nuclei in the Glauber approach results in a nuclear suppression of $J/\psi$ production that is much closer to the experimental data than claimed in previous literature.

**Primary author(s) :** DUCLOUE, Bertrand; LAPPI, Tuomas (University of Jyvaskyla); Dr. MÄNTYSAARI, Heikki (University of Jyväskylä)

**Presenter(s) :** DUCLOUE, Bertrand

**Session Classification :** Quarkonia I

**Track Classification :** Quarkonia

Contribution ID : **190** Type : **Contributed talk**

# Chiral Kinetic Theory

*Monday, 28 September 2015 11:15 (0:20)*

## On behalf of collaboration:

NONE

## Abstract Content

A significant body of recent research is aimed towards understanding the anomalous parity-odd response of chiral media, such as chiral magnetic and vortical effects, with applications to heavy-ion collisions and Dirac semimetals. Remarkable progress has been achieved in the non-equilibrium kinetic approach to such phenomena. The chiral kinetic theory features novel properties implementing non-trivially the physics of quantum anomaly and Lorentz invariance.
Based on: PRL 109(2012)162001; PRL 113(2014)182302; PRL 115(2015)021601.

**Primary author(s) :** STEPHANOV, Misha (UIC)

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**Presenter(s) :** STEPHANOV, Misha (UIC)

**Session Classification :** New Theoretical Development I

**Track Classification :** New Theoretical Developments

Contribution ID : **18** Type : **Contributed talk**

# Chiral drag force

*Monday, 28 September 2015 11:35 (0:20)*

## On behalf of collaboration:

None

## Abstract Content

We provide a holographic evaluation of novel contributions to the drag force acting on a heavy quark moving through strongly interacting plasma. The new contributions are chiral in that they act in opposite directions in plasmas containing an excess of left- or right-handed quarks and in that they are proportional to the coefficient of the axial anomaly. These new contributions to the drag force act either parallel to or antiparallel to an external magnetic field or to the vorticity of the fluid plasma. In all these respects, these contributions to the drag force felt by a heavy quark are analogous to the chiral magnetic effect on light quarks. However, the new contribution to the drag force is independent of the electric charge of the heavy quark and is the same for heavy quarks and antiquarks. We show that although the chiral drag force can be non-vanishing for heavy quarks that are at rest in the local fluid rest frame, it does vanish for heavy quarks that are at rest in a frame in which there is no local entropy current. In this frame, the heavy quark at rest sees counterpropagating momentum and charge currents, both proportional to the axial anomaly coefficient, but feels no drag force. This provides strong concrete evidence for the absence of dissipation in chiral transport, something that has been predicted previously via consideration of symmetries. Along the way to our principal results, we provide a general calculation of the corrections to the drag force due to the presence of gradients in the flowing fluid in the presence of a nonzero chemical potential. We close with a consequence of our result that is at least in principle observable in heavy ion collisions, namely an anticorrelation between the direction of the CME current for light quarks in a given event and the direction of the kick given to the momentum of all the heavy quarks and antiquarks in that event.

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**Presenter(s) :** SADOFYEV, Andrey (Massachusetts Inst. of Technology (US))

**Session Classification :** New Theoretical Development I

**Track Classification :** New Theoretical Developments

Contribution ID : **653** Type : **Contributed talk**

# Third order relativistic dissipative fluid dynamics in heavy-ion collisions and astrophysics

*Monday, 28 September 2015 11:55 (0:20)*

## On behalf of collaboration:

NONE

## Abstract Content

The development of relativistic dissipative fluid dynamics is a very important scientific achievement of the last two decades. It has inspired many authors to apply its methodology to lots of possible applications in physical problems. For example it allows to derive hydrodynamical like equations for relativistic heavy-ion collisions, astrophysics, cosmology and plasma physics. So far a symmetric hyperbolic system of evolution equations for the independent field variables has been obtained up to second order with respect to thermodynamic equilibrium. However the exploitation to third order is desirable in order to study the couplings between the three major dissipative fluxes which contribute to the entropy generation in a single-component fluid. In this paper the development of relativistic fluid dynamics is carried through to third order with respect to thermodynamic equilibrium. The set of obtained field equations is closed by imposing the relativity principle and the entropy principle up to third order. Imposing these conditions up to third order affects and restricts the lower order terms. This, in turn, affects the equilibrium expressions which are already explicitly known.

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**Presenter(s) :** MURONGA, Azwinndini (University of Johannesburg)

**Session Classification :** New Theoretical Development I

**Track Classification :** New Theoretical Developments

Contribution ID : **182** Type : **Contributed talk**

# Hydrodynamics with chiral anomaly and charge separation in relativistic heavy ion collisions

*Monday, 28 September 2015 12:15 (0:20)*

## On behalf of collaboration:

None

## Abstract Content

Chiral Magnetic Effect (CME) is a phenomenon that for systems with chiral fermions, in the presence of external magnetic field and chirality imbalance, a charge current is generated along the magnetic field direction. The CME predicts that for quark-gluon plasma (QGP) created in relativistic heavy ion collisions, there would be a charge separation perpendicular to the collisional reaction plane. Charge correlation measurements designed for the search of such signal have been done at RHIC and the LHC for which the interpretations, however, remain unclear due to contamination by background effects that are collective flow driven, theoretically poorly constrained, and experimentally hard to separate. Using anomalous (and viscous) hydrodynamic simulations, we make a first attempt at quantifying contributions to observed charge correlations from both CME and background effects in one and same framework. The implications for the search of CME are discussed.

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**Presenter(s) :** HUANG, Xu-Guang (Fudan University)

**Session Classification :** New Theoretical Development I

**Track Classification :** New Theoretical Developments

Contribution ID : **544** Type : **Contributed talk**

# What flows in the chirally anomalous transport?

*Monday, 28 September 2015 12:35 (0:20)*

## On behalf of collaboration:

None

## Abstract Content

The chirally anomalous transport including the chiral magnetic effect seems to get established from the theoretical side, but some theorists address serious concerns about the physical interpretation of $\langle\Omega|j|\Omega\rangle$. In my talk I will emphasize how the conventional scenario can be verified from the dynamical process of the particle production.
If $|\Omega\rangle$ is an equilibrated static state, a current which is a real-time phenomenon, cannot flow and $\langle\Omega|j|\Omega\rangle$ is not a current but should be a polarization. Such an interpretation is manifest for the chiral separation effect. Besides, in a quick derivation of the chiral magnetic effect using the Chern-Simons-Maxwell theory, the anomalous current appears in the same way as the Maxwell's displacement current, and we all know that the displacement current is a source of the magnetic field but there is no flow of electric carriers. Logically, it is possible that $\langle\Omega|j|\Omega\rangle$ is also such a current containing no flow of charged particles, which is actually the case if the chiral magnetic current is formulated in the chiral perturbation theory.
I would however, emphasize that the genuine current generation occurs at the same time as the particle production with glasma flux tubes that locally violate P- and CP-symmetries together with an external magnetic field. The distribution function in momentum space is dynamically determined by microscopic processes of the particle production and I will present some results from the numerical simulation. A non-trivial observation found in the numerical simulation includes a quantitative estimate of the response time of the system until the anomalous current starts growing up after the switch-on of the background fields, which has a practically important implication for the detection of the physical observables sensisive to the chrally anomalous transport in experiments.

**Primary author(s) :** FUKUSHIMA, Kenji (The University of Tokyo)

**Presenter(s) :** FUKUSHIMA, Kenji (The University of Tokyo)

**Session Classification :** New Theoretical Development I

**Track Classification :** New Theoretical Developments

Contribution ID : **606** Type : **Contributed talk**

# Identified light and strange hadron spectra at $\sqrt{s_{NN}}$=14.5˜GeV and systematic study of baryon/meson effect at intermediate transverse momentum with STAR at RHIC BES I

*Monday, 28 September 2015 11:15 (0:20)*

## On behalf of collaboration:

STAR

## Abstract Content

With the recently measured Au+Au collisions at $\sqrt{s_{NN}}$= 14.5˜GeV, STAR completed its first phase of the Beam Energy Scan (BES) program at RHIC. The main motivation of the BES program is the study of the QCD phase diagram and the search for a conjectured critical point. Amongst the various collision energies of 7.7, 11.5, 19.6, 27, and 39˜GeV, that have been previously presented by STAR, collisions at 14.5˜GeV will provide data set in the relatively large chemical potential gap between the 11.5 and 19.6˜GeV center-of-mass energies. In this contribution, we report new STAR measurements of Au+Au at $\sqrt{s_{NN}}$=14.5˜GeV that involve identified light particle $R_{CP}$ and spectra, as well as measurements of the strange hadrons ($K^0_s$, $\Lambda$, $\Xi$, $\Omega$ and $\phi$). The spectra from both light and strange particles cover a significant range of the intermediate transverse momentum ($2 < p_T < 5$˜GeV/c) in all beam energies. This provides a unique set of data for a systematic study of the baryon-to-meson ratio at intermediate $p_T$ from BES Phase I. We will discuss its physics implications and whether hadronic interactions at late stage dominate the collision dynamics.

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**Presenter(s) :** BRANDENBURG, James (Rice University)

**Session Classification :** Open Heavy Flavors and Strangeness I

**Track Classification :** Open Heavy Flavors and Strangeness

Contribution ID : **693** Type : **Contributed talk**

# Multiplicity and rapidity dependence of strangeness and multi-strangeness production in pp, pPb and PbPb at CMS

*Monday, 28 September 2015 11:35 (0:20)*

## On behalf of collaboration:

CMS

## Abstract Content

Measurements of transverse momentum ($p_T$) spectra for strange ($K^0_s$ and $\Lambda$) and multi-strange ($\Xi^-$) hadrons are presented over a wide range of multiplicity and particle rapidity in pp, pPb and PbPb collisions. The data were recorded using the CMS detector at the LHC, with an implementation of high-multiplicity triggers for pp and pPb collision data. The particle ratios, the total strangeness yields and average $p_T$ of particle spectra for each species are extracted as a function of multiplicity and compared among different collision systems. Motivated by collective flow phenomena from a fluid-like QGP system, a blast-wave model is employed to explore the system size dependence of radial flow strength among various systems. Furthermore, the wide acceptance coverage of the CMS detector enables a study on rapidity dependence of strange particle $p_T$ spectra, especially in asymmetric high-multiplicity pPb collisions, which places stringent tests on theoretical models interpreting particle production mechanism in these collisions. The new results presented provide key insights to understand the underlying dynamics in high-multiplicity small systems.

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**Session Classification :** Open Heavy Flavors and Strangeness I

**Track Classification :** Open Heavy Flavors and Strangeness

Contribution ID : **519** Type : **Contributed talk**

# $\phi$ production at forward rapidity in pp, pPb and PbPb collisions with ALICE

*Monday, 28 September 2015 11:55 (0:20)*

## On behalf of collaboration:

ALICE

## Abstract Content

Light vector meson ($\rho$, $\omega$, $\phi$) production provides key information on the hot and dense state of strongly interacting matter produced in high-energy heavy-ion collisions. In particular, strangeness production can be accessed through the measurement of the $\phi$ meson, while the detailed description of the full dimuon mass spectra can be used to reveal in-medium modifications of hadron properties and thermal emission arising from the medium. The detection of vector mesons through their decay in dileptons has the advantage, with respect to hadronic channel, that the decay products are not affected by final state interactions. Measurements in pp and p-A systems, where hot nuclear matter effects are not expected, are used as a reference.

The ALICE experiment at the LHC can access vector mesons produced at forward rapidity through their decays in muon pairs. We present results on vector meson production in p-Pb collisions at $\sqrt{s_{\rm NN}} = 5.02$ TeV, pp and Pb-Pb collisions at $\sqrt{s_{\rm NN}} = 2.76$˜TeV. In pp collisions the $\phi$ differential cross section as a function of $p_{\rm T}$ was measured in the range $1 \leq p_{\rm T}$ 5 GeV/$c$ and compared with the calculations from PHOJET and PYTHIA. In p-Pb collisions, measurements of the $\phi$ yield and the nuclear modification factor in the rapidity ranges $2.03 \leq y \leq 3.53$ (p-going direction) and $-4.46 \leq y \leq -2.96$ (Pb-going direction) are shown. An asymmetry between the cross section at forward and backward rapidity is observed. Results are compared to the predictions provided by commonly used event generators. In Pb-Pb collisions, the $\phi$ yield and the nuclear modification factor are obtained as a function of centrality in the intermediate $p_{\rm T}$ region ($2 \leq p_{\rm T} \leq 5$ GeV/$c$) and for $2.5 \leq y \leq 4$. Differences are observed between these results and those measured in the same $p_{\rm T}$ range at midrapidity in the KK channel.

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**Session Classification :** Open Heavy Flavors and Strangeness I

**Track Classification :** Open Heavy Flavors and Strangeness

Contribution ID : **195** Type : **Contributed talk**

# Violation of mass ordering for multi-strange hadrons at RHIC and LHC

*Monday, 28 September 2015 12:15 (0:20)*

## On behalf of collaboration:

NONE

## Abstract Content

We study effects of hadronic rescattering on final observables for multi-strange hadrons in high-energy nuclear collisions within an integrated dynamical model. We simulate the whole collision process on an event-by-event basis by using a fully (3+1)-dimensional ideal hydrodynamic description for the quark gluon plasma (QGP) and a subsequent kinetic transport description for the hadron resonance gas.

The QGP created in a collision expands, cools down and then turns into hadron gas. In the last stage of the collisions, hadrons continue to scatter with each other. Therefore observed hadron spectra are, in general, contaminated by the hadronic rescatterings. In order to probe the QGP more directly, multi-strange hadrons, in particular $\phi$-meson and $\Omega$-baryon, can be utilized since multi-strange hadrons have small scattering cross-sections and less scatter with non-strange hadrons. Thus final observables of $\phi$-mesons and $\Omega$-baryons are expected to reflect the properties of the system just after hadronization.

Some years ago, violation of mass ordering in $v_2(p_{\rm T})$ was predicted by using a hydro + cascade hybrid model and thereafter observed by the STAR collaboration. Following this work, we scrutinize multi-strange hadron spectra at both RHIC and LHC energies by using a more sophisticated integrated dynamical model towards comprehensive understanding of this phenomenon. In addition to $v_2(p_{\rm T})$, we investigate the hadronic rescattering effects on mean transverse momenta ($\langle p_{\rm T} \rangle$) and $p_{\rm T}$-averaged $v_2$ of hadrons including heavier multi-strange hadrons such as $\Xi$- and $\Omega$-baryons. We also discuss the collision energy dependence of the hadronic rescattering effects on the violation of mass ordering behavior and show that multi-strange hadrons can be used as "penetrating probes" of the QGP.

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**Session Classification :** Open Heavy Flavors and Strangeness I

**Track Classification :** Open Heavy Flavors and Strangeness

Contribution ID : **458** Type : **Contributed talk**

# Results from (anti-)(hyper-)nuclei production and searches for exotic bound states with ALICE at the LHC

*Monday, 28 September 2015 12:35 (0:20)*

## On behalf of collaboration:

ALICE

## Abstract Content

The high collision energies reached at the LHC enable significant production rates of light (anti-)(hyper-)nuclei in proton-proton, proton-lead and, in particular, lead-lead collisions. The excellent particle identification capabilities of the ALICE apparatus, based on the specific energy loss in the time projection chamber and the velocity information from the time-of-flight detector, allow for the detection of these (anti-)nuclei. Furthermore, the high tracking resolution provided by the inner tracking system enables the separation of primary nuclei from those coming from the decay of heavier systems. This allows for the reconstruction of decays such as the hypertriton mesonic weak decay ($^3_\Lambda$H $\rightarrow ^3$He + $\pi^-$), the decay of a hypothetical bound state of a $\Lambda$ with a neutron into a deuteron and pion or the H-dibaryon decaying into a $\Lambda$, a proton and a $\pi^-$. Results on the production of stable nuclei and anti-nuclei in Pb–Pb and lighter collision systems will be presented. Hypernuclei production rates in Pb–Pb will also be shown, together with upper limits estimated on the production of hypothetical exotica candidates. The results will be compared with predictions for the production in thermal (statistical) and coalescence models.

**Primary author(s) :** SHARMA, Natasha (University of Tennessee (US))

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**Session Classification :** Open Heavy Flavors and Strangeness I

**Track Classification :** Open Heavy Flavors and Strangeness

Contribution ID : **309** Type : **Contributed talk**

# Recent progress in understanding gauge topology, confinement and chiral symmetry breaking

*Monday, 28 September 2015 11:15 (0:20)*

## On behalf of collaboration:

NONE

## Abstract Content

Instantons for a long time were associated with breaking of U(1) and SU(Nf) chiral symmetries in QCD-like theories. Monopoles, on the other hand are related to dual superconductor picture and confinement. Instanton-dyons are instanton constituents, discovered in 1998 by van Baal and others: they incorporate properties of both instants and monopoles. Recently several papers, both analytic and numerical simulations, have studied ensemble of the instanton-dyons. The results indeed show that in this way one can explain BOTH confinement and chiral symmetry breaking, when the ensemble is dense enough (at strong enough coupling or small temperature). The details can be found in the references below.
Interacting Ensemble of the Instanton-dyons and Deconfinement Phase Transition in the SU(2) Gauge Theory Rasmus Larsen, Edward Shuryak (SUNY, Stony Brook). Apr 13, 2015. 11 pp. e-Print: arXiv:1504.03341
Confining Dyon-Anti-Dyon Coulomb Liquid Model I Yizhuang Liu (Stony Brook U.), Edward Shuryak, Ismail Zahed (SUNY, Stony Brook). Mar 10, 2015. 17 pp. e-Print: arXiv:1503.03058
Light Quarks in the Screened Dyon-Anti-Dyon Coulomb Liquid Model II Yizhuang Liu, Edward Shuryak, Ismail Zahed (SUNY, Stony Brook). Mar 31, 2015. 16 pp. e-Print: arXiv:1503.09148

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**Presenter(s) :** LARSEN, Rasmus (Stony Brook University)

**Session Classification :** QCD at High Temperture

**Track Classification :** QCD at High Temperature

Contribution ID : **646** Type : **Contributed talk**

# The topological structures in strongly coupled QGP with chiral fermions on the lattice

*Monday, 28 September 2015 11:35 (0:20)*

## On behalf of collaboration:

None

## Abstract Content

The nature of chiral phase transition for two flavour QCD is an interesting but unresolved problem. One of the most intriguing issues is whether or not the anomalous U(1) symmetry in the flavour sector is effectively restored along with the chiral symmetry. This may determine the universality class of the chiral phase transition. Since the physics near the chiral phase transition is essentially non-perturbative, we employ first principles lattice techniques to address this issue. We use overlap fermions, which have exact chiral symmetry on the lattice, to probe the anomalous U(1) symmetry violation of 2+1 flavour dynamical QCD configurations with domain wall fermions. The latter also optimally preserves chiral and flavour symmetries on the lattice, since it is known that the remnant chiral symmetry of the light quarks influences the scaling of the chiral condensate [1] in the crossover transition region. We observe that the anomalous U(1) is not effectively restored in the chiral crossover region. This effectively means that the eta' excitations remains distinct from the pion excitations well into the QGP medium. We perform a systematic study of the finite size and cut-off effects since the signals of U(1) violation are sensitive to it. We also provide a glimpse of the microscopic topological structures of the QCD medium that are responsible for the strongly interacting nature of the quark gluon plasma phase. We study the effect of these microscopic constituents through our first calculations for the topological susceptibility of QCD at finite temperature, which could be a crucial input for the equation of state with a finite chiral chemical potential.
Reference: [1] S. Ejiri et. al., Phys. Rev. D 80, 094505 (2009).

**Primary author(s) :** Mr. DICK, Viktor (Bielefeld University); Prof. KARSCH, Frithjof (BNL & Bielefeld University); Prof. LAERMANN, Edwin (Bielefeld University); MUKHERJEE, Swagato (Brookhaven National Laboratory); Dr. SHARMA, Sayantan (BNL)

**Presenter(s) :** Dr. SHARMA, Sayantan (BNL)

**Session Classification :** QCD at High Temperture

**Track Classification :** QCD at High Temperature

Contribution ID : **214** Type : **Contributed talk**

# QCD phase diagram from analytical continuation

*Monday, 28 September 2015 11:55 (0:20)*

## On behalf of collaboration:

NONE

## Abstract Content

We extrapolate the QCD cross-over temperature from imaginary to real chemical potentials. Our calculations are based on new continuum extrapolated lattice simulations using the 4stout staggered actions with a lattice resulution up to Nt=16. The simulation parameters are tuned so that the strangeness neutrality is maintained, as it is in a heavy ion collision. We see a consistency between the Taylor expansion and the analytical continuation method. We also use the lattice data to extrapolate the equation of state to real chemical potentials.

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**Session Classification :** QCD at High Temperture

**Track Classification :** QCD at High Temperature

Contribution ID : **248** Type : **Contributed talk**

# Energy loss and shear viscosity at NLO in a high-temperature QGP

*Monday, 28 September 2015 12:15 (0:20)*

## On behalf of collaboration:

NONE

## Abstract Content

We present a set of kinetic equations which extend the AMY energy loss formalism to NLO in the strong coupling constant. A novel aspect of the NLO analysis is a consistent description of wider-angle bremsstrahlung (semi-collinear emissions) which smoothly interpolates between 2to2 scattering and collinear bremsstrahlung. Similarly, the NLO treatment describes how the soft collinear emissions can be incorporated into the drag coefficient at NLO. We describe how many of the ingredients of the NLO transport equations (such as the drag coefficient) can be computed using a Euclidean formalism pioneered by S. Caron-Huot. In the second part of the talk we show how the same framework can be used to address the shear viscosity at NLO, up to a coefficient which cannot be determined using the Euclidean formalism. By treating this coefficient as an unknown parameter (within an estimated range) we can however estimate the NLO corrections to $\eta$.
Refs: J. Ghiglieri, G. Moore, D. Teaney, "Towards the shear viscosity at NLO in high temperature plasmas", in preparation. J. Ghiglieri, G. Moore, D. Teaney, "Energy loss at NLO in high temperature plasmas", in preparation. J. Ghiglieri and D. Teaney, "Parton energy loss and momentum broadening at NLO in high temperature QCD plasmas", arXiv:1502.03730 [hep-ph]. J. Ghiglieri, et al, "Next-to-leading order thermal photon production in a weakly coupled quark-gluon plasma", JHEP 1305, 010 (2013) [arXiv:1302.5970 [hep-ph]].

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**Presenter(s) :** Dr. GHIGLIERI, Jacopo (Universitaet Bern (CH))

**Session Classification :** QCD at High Temperture

**Track Classification :** QCD at High Temperature

Contribution ID : **632** Type : **Contributed talk**

# Confronting fluctuations of conserved charges in central nuclear collisions at the LHC with predictions from Lattice QCD

*Monday, 28 September 2015 12:35 (0:20)*

## On behalf of collaboration:

None

## Abstract Content

We construct net baryon number and strangeness susceptibilities as well as correlations between electric charge, strangeness and baryon number from experimental data on the particle production yields at midrapidity of the ALICE Collaboration at CERN. The data were taken in central Pb-Pb collisions at $\sqrt{}$sNN=2.76 TeV and cover one unit of rapidity. The resulting fluctuations and correlations are consistent with Lattice QCD results at the chiral crossover pseudocritical temperature Tc $\simeq$ 155 MeV. This agreement lends strong support to the assumption that the fireball created in these collisions is of thermal origin and exhibits characteristic properties expected in QCD at the transition from the quark gluon plasma to the hadronic phase. Since Lattice QCD calculations are performed at a baryochemical potential of mu$_B$ = 0, the comparisons with LHC data are the most direct due to the vanishing baryon transport to midrapidity at these high energies. As an outlook, we will also present the applicability of our approach to RHIC data thus extending the comparisons to non-zero baryochemical potentials.

**Primary author(s) :** BRAUN-MUNZINGER, Peter (GSI - Helmholtzzentrum fur Schwerionenforschung GmbH (DE)); KALWEIT, Alexander Philipp (CERN); REDLICH, Krzysztof (University of Wroclaw (PL)); STACHEL, Johanna (Ruprecht-Karls-Universitaet Heidelberg (DE))

**Presenter(s) :** KALWEIT, Alexander Philipp (CERN)

**Session Classification :** QCD at High Temperture

**Track Classification :** QCD at High Temperature

Contribution ID : **153** Type : **Contributed talk**

# Higher moments of net-proton and net-charge multiplicity distributions at 14.5 GeV measured in Au+Au collisions at mid-rapidity with STAR at RHIC

*Monday, 28 September 2015 14:30 (0:20)*

## On behalf of collaboration:

STAR

## Abstract Content

Studying fluctuations of conserved quantities, such as baryon number (B) and charge (Q), provides insight into the properties of matter created in high-energy nuclear collisions. Lattice QCD calculations suggest that higher moments of these quantities are sensitive to the phase structure of the hot and dense nuclear matter created in such collisions.
The Beam Energy Scan (BES)-I program at RHIC, spanning center-of-mass energies of $\sqrt{s_{\rm NN}}$ = 7.7 to 200 GeV of Au+Au collisions, provided measurements at different baryochemical potentials, $\mu$B, to map the QCD phase diagram. In the years 2010 and 2011, STAR collected data of Au+Au collisions at 7.7, 11.5, 19.6, 27, 39 and 62.4 GeV, leaving a wide gap of about $\mu_{\rm B}$ ˜110 MeV between 19.6 ($\mu_{\rm B}$ ˜206 MeV) and 11.5 GeV ($\mu_{\rm B}$ ˜316 MeV).
In this talk, we present first experimental results of higher moments and their products of net-charge and net-proton distributions in Au+Au collisions at 14.5 GeV, measured with the STAR detector at RHIC at mid-rapidity and a transverse momentum up to $p_{\rm T}$ = 2 GeV/c. Their pseudo-rapidity and rapidity dependence will be shown as well. The corresponding value of the chemical potential from the top 5% central collisions is about $\mu_{\rm B}$ ˜260 MeV, so that these results fill the largest gap of previous measurements, in $\mu_{\rm B}$, to complete the BES I program.
Moreover, the energy dependence of higher moments of net-proton distributions in Au+Au collisions at $\sqrt{s_{\rm NN}}$ = 7.7 - 200 GeV in a much larger $p_{\rm T}$ range, utilizing the PID capabilities of the Time-of-Flight detector, are shown. Detector effects, including tracking efficiency, are taken into account. Implications of these results will be discussed in light of the recent Lattice QCD calculations.

**Primary author(s) :** Dr. THAEDER, Jochen (Lawrence Berkeley National Laboratory)

**Presenter(s) :** Dr. THAEDER, Jochen (Lawrence Berkeley National Laboratory)

**Session Classification :** Correlations and Fluctuations I

**Track Classification :** Correlations and Fluctuations

Contribution ID : **482** Type : **Contributed talk**

# Longitudinal Asymmetry and its Measurable Effects in Pb-Pb Collisions at 2.76 TeV

*Monday, 28 September 2015 14:50 (0:20)*

## On behalf of collaboration:

ALICE

## Abstract Content

In a collision of identical nuclei, the extended size and the finite number of nucleons lead to fluctuations in the number of participating nucleons from each nucleus at any impact parameter. This is akin to collisions of unequal-mass nuclei and corresponds to a non-zero momentum of the participant zone in the laboratory frame. Event-by-event fluctuations are estimated by measuring the asymmetry in the energy deposited by spectator neutrons in the zero-degree calorimeters on either side of the interaction vertex. The effect of these fluctuations on the pseudorapidity distributions of produced particles in Pb-Pb collisions at 2.76 TeV is investigated for the first time. The results from the ALICE detector will be presented for different centralities and compared with results from models.

**Primary author(s) :** RANIWALA, Rashmi (University of Rajasthan (IN))

**Presenter(s) :** RANIWALA, Rashmi (University of Rajasthan (IN))

**Session Classification :** Correlations and Fluctuations I

**Track Classification :** Correlations and Fluctuations

Contribution ID : **502** Type : **Contributed talk**

# Measurement of the correlation between flow harmonics of different order in lead-lead collisions at sqrt(sNN)=2.76 TeV with ATLAS

*Monday, 28 September 2015 15:10 (0:20)*

## On behalf of collaboration:

ATLAS

## Abstract Content

ATLAS measurements of correlations between elliptic or triangular flow, vm (m=2,3), and other flow harmonics vn (n=2−5), in Pb+Pb collisions at sqrt(sNN)=2.76 TeV are presented. The vm-vn correlations are measured as a function of centrality, and as a function of varying event-geometry but fixed centrality using the "event-shape" selection technique. The measurements show that the effects of viscosity in heavy-ion collisions depend only on the collision centrality and not on the collision geometry. These measurements comprehensively demonstrate that a significant fraction of the higher order flow (n>3), is in fact generated from the hydrodynamic response to lower order eccentricities. The separation of the higher order flow harmonics into linear and non-linear components that are directly related to the same- and lower-order eccentricity of the initial geometry is done and their centrality dependence is measured. Comparisons to previous event-plane correlations that probe the non-linear hydrodynamic response are also presented.

**Primary author(s) :** RADHAKRISHNAN, Sooraj Krishnan (State University of New York (US))

**Presenter(s) :** RADHAKRISHNAN, Sooraj Krishnan (State University of New York (US))

**Session Classification :** Correlations and Fluctuations I

**Track Classification :** Correlations and Fluctuations

Contribution ID : **547** Type : **Contributed talk**

# Thermal blurring effects on fluctuations of conserved charges in rapidity space

*Monday, 28 September 2015 15:30 (0:20)*

## On behalf of collaboration:

NONE

## Abstract Content

We study the effect of the difference between momentum- and coordinate-space rapidities on the experimental measurements of fluctuation observables in relativistic heavy ion collisions. In theoretical studies on fluctuation observables, observables in fixed coordinate-space rapidity windows are concerned because the analyses are usually performed in finite volume. The experimental measurements, however, can be performed only for momentum-space (or pesudo-) rapidity. The latter is usually used as a proxy of the former implicitly. However, thermal motion blurs this one-to-one correspondence.
We investigate this effect quantitatively, and show that thermal motion gives rise to significant effects, which should be carefully taken into account in the interpretation of the experimental results of fluctuation observables.
It is argued that this modification can be estimated by the study of the rapidity window dependences of the cumulants and implemented in the description of the time evolution of fluctuations.

**Primary author(s) :** ASAKAWA, Masayuki (Osaka University)

**Co-author(s) :** Prof. KITAZAWA, Masakiyo (Osaka University); Mr. ONISHI, Yutaro (Osaka University); SAKAIDA, Miki

**Presenter(s) :** ASAKAWA, Masayuki (Osaka University)

**Session Classification :** Correlations and Fluctuations I

**Track Classification :** Correlations and Fluctuations

Contribution ID : **201** Type : **Contributed talk**

# Influence of conservation laws on higher moments of the net proton and net charge distribution

*Monday, 28 September 2015 15:50 (0:20)*

## On behalf of collaboration:

None

## Abstract Content

The higher moments of the net baryon and net charge distributions, e.g. the skewness and kurtosis, are studied within an infinite hadronic matter calculation in a transport approach. By dividing the box into several parts, the volume dependence of the fluctuations is investigated. After confirming that the initial distributions follow the expectations from a Poisson distribution, the influence of quantum number conservation like the net baryon number and the net charge in the system on the higher moments is evaluated. For this purpose, the composition of the hadron gas is adjusted for different scenarios, only baryons are simulated to study the net baryon conservation or only pions and $\rho$ mesons to investigate the charge conservation effect. In addition, the effect of imposing kinematic cuts in momentum space is analysed. The role of resonance excitations and decays on the higher moments can also be studied within this model. This work is highly relevant to understand the experimental measurements of higher moments obtained in the RHIC beam energy scan and their comparison to lattice results and other theoretical calculations assuming infinite matter.

**Primary author(s) :** PETERSEN, Hannah

**Co-author(s) :** Dr. STEINHEIMER, Jan; BLEICHER, Marcus (Uni Frankfurt)

**Presenter(s) :** PETERSEN, Hannah

**Session Classification :** Correlations and Fluctuations I

**Track Classification :** Correlations and Fluctuations

Contribution ID : **55** Type : **Contributed talk**

# Nonlinear hydrodynamic response confronts LHC data

*Monday, 28 September 2015 16:10 (0:20)*

## On behalf of collaboration:

NONE

## Abstract Content

Higher-order harmonics of anisotropic flow ($v_n$ with $n \geq 4$) can be measured with the direction of lower-order harmonics, e.g., $v_4$ with respect to the $v_2$ plane. We show that one can scale these measurements by quantities involving lower-order harmonics in such a way that the ratio is independent of initial conditions, and solely involves the medium nonlinear response. The resulting ratios allow to directly confront hydrodynamics with experimental data [1].

We construct four independent such ratios involving $v_4$, $v_5$ and $v_6$ and extract their values from LHC data on Pb+Pb collisions, as a function of centrality. We then calculate these ratios using single-shot hydrodynamics and using the transport model AMPT [2]. Model calculations are in very good agreement with data. We point out that hydrodynamics predicts simple scaling relations between these response coefficients, which can be read off directly from data.

A substantial response ratio in the seventh harmonic is found in theoretical calculations (both in AMPT and in hydrodynamics), from which we argue that a nonzero $v_7$ signal should be seen when measured with respect to elliptic and triangular flow. We present predictions for $v_7$ versus centrality in Pb+Pb collisions at the LHC.

Finally, we point out that combined measurements of higher-order harmonics with their own plane and with respect to lower-order planes can be quantitatively related to event-plane correlations. As an illustration, we show that CMS data on $v_4$ and $v_6$ are compatible with ATLAS data on event-plane correlations.

[1] L. Yan and J. Y. Ollitrault, Phys.Lett. B **744**, 82 (2015) [arXiv:1502.02502 [nucl-th]].

[2] L. Yan, S. Pal and J. Y. Ollitrault, in preparation

**Primary author(s) :** YAN, Li (CNRS)

**Co-author(s) :** OLLITRAULT, Jean-Yves (CNRS); PAL, Subrata (Tata Institute of Fundamental Research, Mumbai, India)

**Presenter(s) :** YAN, Li (CNRS)

**Session Classification :** Correlations and Fluctuations I

**Track Classification :** Correlations and Fluctuations

Contribution ID : **513** Type : **Contributed talk**

# Charged particle production in proton-lead collisions measured by the ATLAS detector

*Monday, 28 September 2015 14:30 (0:20)*

## On behalf of collaboration:

ATLAS

## Abstract Content

Measurements of the centrality dependence of low-$p_T$ and high-$p_T$ particle production in proton-lead collisions at the LHC can provide unique insight into the dynamics of soft and hard scattering processes and the initial state of ultra-relativistic nuclear collisions. Recent results have shown that both soft and hard processes may be significantly influenced by event-to-event fluctuations (variations) in the structure of the proton. In this talk, the latest measurements of the centrality dependence of charged particle, jet, and Z boson production with the ATLAS detector at the LHC will be used to explore these questions. In particular, the sensitivity of the charged particle pseudorapidity distribution in proton–lead collisions to the choice of centrality variable will be discussed. Separately, the strong centrality dependence of jet production in proton–lead collisions has raised questions about energy production at large rapidities in collisions involving a large proton-$x$. To address this, measurements of the correlation between the initial-state hard scattering kinematics in dijet events and forward transverse energy in proton-proton collisions will be presented.

**Primary author(s) :** SHULGA, Evgeny (National Research Nuclear University MEPhI (RU))

**Presenter(s) :** SHULGA, Evgeny (National Research Nuclear University MEPhI (RU))

**Session Classification :** Jets and High pT Hadrons I

**Track Classification :** Jets and High pT Hadrons

Contribution ID : **680** Type : **Contributed talk**

# Decomposing energy balance contributions for quenched jets with CMS

*Monday, 28 September 2015 14:50 (0:20)*

## On behalf of collaboration:

CMS

## Abstract Content

Jet quenching is one of the established signatures of the Quark Gluon Plasma, and this phenomenon has been studied extensively in high energy heavy ion experiments over the last decade. Despite significant progress made in those studies, the specifics of the energy loss mechanisms and the details of jet-medium interactions require further quantitative understanding. Studies of two-dimensional angular correlations of charged hadrons with respect to reconstructed jets make it possible to experimentally assess the energy radiation patterns of an energetic parton traversing the medium as well as its fragmentation function. In this talk, we will present new differential measurements of charged particle densities and energy flow about the jet direction as a function of relative azimuth and relative pseudorapidity from 2.76 TeV PbPb and pp collisions recorded by the CMS Collaboration. With a sample of back-to-back dijets, previously used to reconstruct the event-wise momentum imbalance (missing $p_T$), we explore modifications to correlated charged hadron distributions for both the leading and the subleading sides of the dijet. With this technique, we can individually assess the contribution of the medium-induced modifications to each side of the dijet and explore the extent of potential medium response to the jet propagation, while also extending these measurements to large angular and radial distances.

**Primary author(s) :** EVDOKIMOV, Olga (University of Illinois at Chicago (US))

**Presenter(s) :** EVDOKIMOV, Olga (University of Illinois at Chicago (US))

**Session Classification :** Jets and High pT Hadrons I

**Track Classification :** Jets and High pT Hadrons

Contribution ID : **681** Type : **Contributed talk**

# Angular distributions of the quenched energy flow from dijets with different radius parameters in CMS

*Monday, 28 September 2015 15:10 (0:20)*

## On behalf of collaboration:

CMS

## Abstract Content

One of the first observations of the flow of the quenched energy in imbalanced dijet events has been through the studies of transverse vector sum of particles with the CMS detector, namely the missing $p_T$ measurement. The results have led to new theoretical insights to order to explain the wide angle radiation, such as "jet collimation", "color decoherence", "turbulence cascade" and "hydrodynamical expansion of quenched energy". These mechanisms could give different angular distribution of quenched energy. In this talk, the missing $p_T$ technique has been improved so that it allows the study of angular distribution of the energy flow with respect to the dijet axis. Moreover, in order to get insights about the number of particles which carry the quenched energy, charged particle multiplicity differences in the leading and subleading jet hemispheres are measured. In addition, the measurements are performed using different resolution parameters in anti-$k_T$ clustering algorithm, which provide information about how the angular distribution of the quenched energy depends on the jet width.

**Primary author(s) :** MC GINN, Christopher (Massachusetts Inst. of Technology (US))

**Presenter(s) :** MC GINN, Christopher (Massachusetts Inst. of Technology (US))

**Session Classification :** Jets and High pT Hadrons I

**Track Classification :** Jets and High pT Hadrons

Contribution ID : **161** Type : **Contributed talk**

# Interplay between Mach cone and radial expansion in jet events

*Monday, 28 September 2015 15:30 (0:20)*

## On behalf of collaboration:

NONE

## Abstract Content

As we see expansion of bulk quark-gluon plasma (QGP) created in high-energy nuclear collisions is well described by relativistic hydrodynamics, fluidity is one of the key properties of the QGP. At the same time, the QGP has a large stopping power against propagation of jets: The jets lose a large amount of their energies while traversing the QGP fluid due to strong interactions between them. The deposited energy of the jet induces a shock wave, a.k.a. Mach cone, in the QGP as a hydrodynamic response. Such a hydrodynamic response is also a clear manifestation of the fluidity of the QGP. Since the structure of shock wave is characterized by various properties of the QGP, e.g., sound velocity, stopping power, and viscosity, we have a great opportunity to extract the property of the QGP by analyzing this phenomenon.

We study the hydrodynamic response to jet propagation in the expanding QGP and investigate how it reflects the particle spectra after the hydrodynamic evolution of the bulk QGP. We perform simulations of the bulk dynamics of the QGP specifically in di-jet and gamma-jet events by solving (3+1)-dimensional ideal hydrodynamic equations with source terms. Mach cones are formed and largely develops in the QGP fluid. However, the double peak in the azimuthal particle distribution, which is believed to be an intuitive signal of the Mach cone, is smeared out by the diffusion wake, the distortion by the radial flow and freeze-out processes. Instead, we find a novel phenomenon of the interplay between the Mach cone and radial expansion when the jets travel through the off-central trajectories: Propagation of Mach cone pushes back the radial flow. As a result, the particle production is suppressed in the direction perpendicular to the jet propagation. This is the direct signal of hydrodynamic response to jet propagation and even includes the information about the jet passage in the expanding QGP fluid.

**Primary author(s) :** Dr. TACHIBANA, Yasuki (Nishina Center, RIKEN); HIRANO, Tetsufumi (Sophia Univ)

**Presenter(s) :** Dr. TACHIBANA, Yasuki (Nishina Center, RIKEN)

**Session Classification :** Jets and High pT Hadrons I

**Track Classification :** Jets and High pT Hadrons

Contribution ID : **395** Type : **Contributed talk**

# Thermalization of mini-jets in a quark-gluon plasma

*Monday, 28 September 2015 15:50 (0:20)*

## On behalf of collaboration:

NONE

## Abstract Content

We complete the physical picture for the evolution of a high-energy jet propagating through a weakly-coupled quark-gluon plasma by investigating the thermalization of the soft components of the jet. We argue that the following scenario should hold: the leading particle emits a significant number of mini-jets which promptly evolve via quasi-democratic branchings and thus degrade into a myriad of soft gluons, with energies of the order of the medium temperature T. Via elastic collisions with the medium constituents, these soft gluons relax to local thermal equilibrium with the plasma over a time scale which is considerably shorter than the typical lifetime of the mini-jet. The thermalized gluons form a tail which lags behind the hard components of the jet. We support this scenario, first, via parametric arguments and, next, by studying a simplified kinetic equation, which describes the jet dynamics in longitudinal phase-space. We solve the kinetic equation using both (semi-)analytical and numerical methods. In particular, we obtain the first exact, analytic, solutions to the ultrarelativistic Fokker-Planck equation in one-dimensional phase-space. Our results confirm the physical picture aforementioned and demonstrate the quenching of the jet via multiple branching followed by the thermalization of the soft gluons in the cascades.

**Primary author(s) :** IANCU, Edmond (CEA/IRFU,Centre d'etude de Saclay Gif-sur-Yvette (FR)); WU, Bin (CEA-Saclay)

**Presenter(s) :** WU, Bin (CEA-Saclay)

**Session Classification :** Jets and High pT Hadrons I

**Track Classification :** Jets and High pT Hadrons

Contribution ID : **407** Type : **Contributed talk**

# Energy flow in gamma-jets events of heavy-ion collisions

*Monday, 28 September 2015 16:10 (0:20)*

## On behalf of collaboration:

NONE

## Abstract Content

We use the Linear Boltzmann Transport model for jet propagation to study gamma-triggered jets in high-energy heavy-ion collisions. Since recoiled partons from both elastic scattering and induced gluon radiation processes and their further propagation are specifically considered, the simulations can provide a realistic description of not only the medium modification of the reconstructed jets but also the energy flow in the underlying hydrodynamic background. In this talk, we will discuss the energy flow of the jet-induced medium excitation. By subtracting the same 3+1D hydrodynamic background without gamma-jets, we can calculate the azimuthal angular distribution of both soft and hard particles respect to the triggered gamma and the reconstructed jets. We also show the sensitivity of such angular distributions to the jet-medium interaction strength in particular the jet transport parameters within the LBT model.
[1] Y. He, T. Luo, X. N. Wang and Y. Zhu, Linear Boltzmann Transport for Jet Propagation in the Quark-Gluon Plasma: Elastic Processes and Medium Recoil, Phys. Rev. C 91, 054908 (2015). [2] X. N. Wang and Y. Zhu, Medium Modification of $\gamma$-jets in High-energy Heavy-ion Collisions," Phys. Rev. Lett. 111, no. 6, 062301 (2013).

**Primary author(s) :** LUO, TAN (CCNU/LBNL)

**Co-author(s) :** Prof. WANG, Xin-Nian (LBNL/CCNU)

**Presenter(s) :** LUO, TAN (CCNU/LBNL)

**Session Classification :** Jets and High pT Hadrons I

**Track Classification :** Jets and High pT Hadrons

Contribution ID : **622** Type : **Contributed talk**

# Charm degrees of freedom above deconfinement

*Monday, 28 September 2015 14:30 (0:20)*

## On behalf of collaboration:

NONE

## Abstract Content

The heavy quarks are one of the most versatile probes of the strongly coupled QCD medium created in the heavy ion collision experiments. However, the interactions of the heavy quarks or heavy quark bound states with the strongly coupled medium is still not well understood. One of the ways to look at such interactions is to study the behaviour of open charm hadrons in the thermalized medium. In our earlier study [1] we have shown that open charm hadrons are the relevant degrees of freedom below the QCD transition temperature. However, very little is known about the excitations of the charm degrees of freedom above the QCD transition temperature. In this work we study the nature of the excitations carrying charm in deconfined QCD medium from first principles using the lattice data on fluctuations of charm and its correlations with baryon number and strangeness. Assuming that the total charm pressure can be written as the sum of the partial pressures of charm mesons, charm baryons and charm quarks we extract the corresponding partial pressures from the lattice data. We observe that the partial meson and baryon pressures are significant till temperatures of about 200 MeV, implying that meson and baryon excitations survive well beyond the QCD transition temperature till about 200 MeV. Above that temperature quark like excitations start dominating. We also probe the relative importance of excitations carrying different quantum numbers, specifically we show that possible diquark excitations carrying a charm quantum number are not important for thermodynamics. Our studies could be important in understanding the energy loss mechanism and flow of the heavy quarks in the QGP as well as the hadronization mechanism of the open charm states.
Reference: A. Bazavov, et.al., Physics Letters B 737, 210 (2014) .

**Primary author(s) :** Dr. PETRECZKY, Peter (Brookhaven National Laboratory); Dr. MUKHERJEE, Swagato (Brookhaven National Laboratory); Dr. SHARMA, Sayantan (Brookhaven National Laboratory)

**Presenter(s) :** PETRECZKY, Peter (BNL)

**Session Classification :** Open Heavy Flavors and Strangeness II

**Track Classification :** Open Heavy Flavors and Strangeness

Contribution ID : **364** Type : **Contributed talk**

# PHENIX measurement of single electrons from charm and bottom decays at midrapidity in Au+Au collisions

*Monday, 28 September 2015 14:50 (0:20)*

## On behalf of collaboration:

PHENIX

## Abstract Content

PHENIX has measured single electrons from charm and bottom decays at midrapidity in Au+Au collisions at $\sqrt{s_{NN}}$=200 GeV. Previous heavy-flavor electron measurements have indicated substantial modification of the momentum distribution of the parent heavy-flavor hadrons. Using the PHENIX barrel silicon-vertex tracker (VTX) to measure displaced vertices precisely, the relative contributions from charm and bottom hadrons to these electrons have been measured as a function of transverse momentum in Au+Au collisions at $\sqrt{s_{NN}}$=200 GeV. The heavier bottom quarks significantly extend our probes of the quark-gluon plasma, and the results are compared with theoretical calculations.

**Primary author(s) :** MCGLINCHEY, Darren (University of Colorado)

**Presenter(s) :** MCGLINCHEY, Darren (University of Colorado)

**Session Classification :** Open Heavy Flavors and Strangeness II

**Track Classification :** Open Heavy Flavors and Strangeness

Contribution ID : **523** Type : **Contributed talk**

# Nuclear Modification Factors of D Meson Production in Au+Au Collisions at $\sqrt{s_{NN}} = 200$ GeV

*Monday, 28 September 2015 15:10 (0:20)*

## On behalf of collaboration:

STAR

## Abstract Content

The mass of charm quarks is larger than the scales of the medium created in heavy-ion collisions at RHIC energies (mc » ΛQCD, T, mu,d,s ). Therefore, charm production is mainly feasible in the primordial nucleon-nucleon collisions and experience all the subsequent stages of the medium evolution. The modification of charm quark production in heavy -ion collisions and signatures of their interactions with the created medium are imprinted on the final kinematics of charmed mesons which can be studied experimentally using Nuclear Modification Factors (NMFs). Recent measurement of D0 NMFs has shown rich enhancement and suppression structures in different transverse-momentum regions that shed light on the intricate interplay of Cold Nuclear Matter effects, collectivity with the bulk matter, hadronization mechanisms and energy loss of charm quarks in heavy-ion collisions. Higher precision measurements of NMFs are instrumental for accurately delineating the roles of these different mechanisms, their system size and kinematics dependencies, and can ultimately help in extracting medium parameters.

To this end, we will discuss the topological reconstruction of D mesons via their hadronic decay channels (D0 → Kπ, D+/-→ K π π and D*+/- →D0 π → K π π) utilizing STAR's recently installed Heavy Flavor Tracker for secondary vertex identification. We will also discuss transverse-momentum and centrality dependence of D meson productions and NMFs and compare them with published data from RHIC and the LHC experiments as well as with model calculations for heavy quark production and energy loss in heavy -ion collisions.

**Primary author(s) :** XIE, Guannan (LBNL/USTC)

**Presenter(s) :** XIE, Guannan (LBNL/USTC)

**Session Classification :** Open Heavy Flavors and Strangeness II

**Track Classification :** Open Heavy Flavors and Strangeness

Contribution ID : **433** Type : **Contributed talk**

# Measurements of heavy-flavour nuclear modification factor and elliptic flow in Pb–Pb collisions at $\sqrt{s_{\rm NN}}$ = 2.76 TeV with ALICE

*Monday, 28 September 2015 15:30 (0:20)*

## On behalf of collaboration:

ALICE

## Abstract Content

Heavy quarks, i.e. charm and beauty, are sensitive probes of the medium produced in high-energy heavy-ion collisions. They are produced in the early stage of the collisions and are expected to experience the whole history of the collision evolution interacting with the medium constituents via both elastic and inelastic processes.
The nuclear modification factor ($R_{\rm AA}$) and the elliptic flow ($v_2$) are two of the main experimental observables that allow us to investigate the interaction strength of heavy quarks with the expanding medium. $R_{\rm AA}$ accounts for the modification of heavy-flavour hadron yields in Pb–Pb collisions with respect to pp collisions, after the proper binary collision scaling is applied on the latter system. The comparison of the $R_{\rm AA}$ of charm, beauty and light-flavour hadrons can provide information about the colour-charge and parton-mass dependence of the parton energy loss. $v_2$ is the second Fourier coefficient of the azimuthal distribution of particle momenta in the transverse plane with respect to the reaction plane. At low $p_{\rm T}$ it is sensitive to the degree of thermalization of heavy quarks in the deconfined medium, and at high $p_{\rm T}$ it carries information on the path-length dependence of in-medium parton energy loss.
The ALICE collaboration has measured the production and elliptic flow of open heavy-flavour hadrons via their hadronic and semi-leptonic decays to electrons at mid-rapidity and to muons at forward rapidity in Pb–Pb collisions.
Recent results will be discussed, and model calculations including the interaction of heavy quarks with the hot, dense, and deconfined medium will be confronted with the data.

**Primary author(s) :** DUBLA, Andrea (Nikhef National institute for subatomic physics (NL))

**Presenter(s) :** DUBLA, Andrea (Nikhef National institute for subatomic physics (NL))

**Session Classification :** Open Heavy Flavors and Strangeness II

**Track Classification :** Open Heavy Flavors and Strangeness

Contribution ID : **692** Type : **Contributed talk**

# Beauty production in heavy ion collisions with CMS

*Monday, 28 September 2015 15:50 (0:20)*

## On behalf of collaboration:

CMS

## Abstract Content

The study of beauty production in heavy-ion collisions is considered one of the key measurement to address the flavour-dependence of in-medium energy loss in PbPb collisions. In pPb collisions, studies of b-quark production can also provide insights into the relevance of cold nuclear matter effects in the heavy-flavour sector. The CMS experiment has excellent capabilities for measuring b-quark production thanks to the excellent performances of its muon and tracker system. In this talk, we will present the measurement of fully reconstructed B mesons in pPb collisions at 5.02 TeV as a function of transverse momentum and rapidity. The measurement of nuclear modification factor of $J/\psi$ produced in B meson decays as a function of transverse momentum and centrality will also discussed. The measurement of fully reconstructed B meson in PbPb collisions at 2.76 TeV and prospective for the Run II analysis at 5 TeV will be presented.

**Primary author(s) :** SUN, Jian (Purdue University (US))

**Presenter(s) :** SUN, Jian (Purdue University (US))

**Session Classification :** Open Heavy Flavors and Strangeness II

**Track Classification :** Open Heavy Flavors and Strangeness

Contribution ID : **292** Type : **Contributed talk**

# event by event correlations between light and heavy mesons

*Monday, 28 September 2015 16:10 (0:20)*

## On behalf of collaboration:

None

## Abstract Content

Heavy mesons are one of the few probes which allow for studying the properties of a plasma of quarks and gluons (QGP) created in ultra-relativistic heavy ion collisions. To do this we have to follow the heavy quarks from their production point through the QGP up to the final rescattering of heavy mesons with hadrons after the hadronization. The interaction of heavy quarks in the QPG is calculated in pQCD with a running coupling constant and including elastic as well as radiative collisions (arXiv 1307.5270). Due to event by event fluctuations the interaction of heavy mesons in the hadronic phase depends on the light quarks/mesons which are produced simultaneously with the heavy quarks during the initial phase of the heavy ion reaction. Therefore the observables of the heavy and light hadrons are correlated and both have to be studied simultaneously. Combining the event generator EPOS with our Heavy Quark approach we can for the first time present event-by-event results simultaneously for the light and heavy meson sector and overcome by this uncertainties of the heavy quark observables due to the ambiguities in the plasma expansion (arXiv:1102.1114). We will present detailed studies for pA in which also a (small) plasma is created to explore cold nuclear matter effects and an analysis of AA collisions, simultaneously in the light and heavy mesons sector to show which information about the elementary interaction between heavy quarks and partons is contained in the presently available data.

**Primary author(s) :** Mr. AICHELIN, joerg (subatech); Mr. GOSSIAUX, Pol (subatech)

**Presenter(s) :** AICHELIN, joerg (Subatech/CNRS)

**Session Classification :** Open Heavy Flavors and Strangeness II

**Track Classification :** Open Heavy Flavors and Strangeness

Contribution ID : **22** Type : **Contributed talk**

# Re-weighting at the LHC: the p-Pb data impact

*Monday, 28 September 2015 14:30 (0:20)*

## On behalf of collaboration:

None

## Abstract Content

One of the goals of the proton-lead run at the LHC is to produce a benchmark for heavy-ion collisions. Preliminary analyzes hint that nPDFs fail to give a proper description for certain observables. Here we present a full study of the compatibility between current sets of initial state nuclear distributions and data from the LHC p-Pb run. By means of reweighting techniques [1,2] we give a quantitative estimate of the modification of nPDFs due to the novel proton-lead data, and also determine wether or not performing a new extraction of nPDFs is mandatory at this point.
[1] H. Paukkunen and P. Zurita. JHEP 1412 (2014) 100. [2] N. Armesto, J. Rojo, C.A. Salgado and P. Zurita. JHEP 1311 (2013) 015.

**Primary author(s) :** ZURITA, Maria (Universidade de Santiago de Compostela); PAUKKUNEN, Hannu (University of Jyväskylä); ARMESTO PEREZ, Nestor (Universidade de Santiago de Compostela (ES)); Mr. PENÍN, José Manuel (University of Santiago de Compostela)

**Presenter(s) :** ZURITA, Maria (Universidade de Santiago de Compostela)

**Session Classification :** Initial State Physics and Approach to Equilibrium I

**Track Classification :** Initial State Physics and Approach to Equilibrium

Contribution ID : **396** Type : **Contributed talk**

# Charged-Particle Multiplicity Distributions over Wide Pseudorapidity Range in Proton-Proton Collisions with ALICE

*Monday, 28 September 2015 14:50 (0:20)*

## On behalf of collaboration:

ALICE

## Abstract Content

The distribution of charged particles produced in high energy pp collisions, $P(N_{ch})$, as a function of $N_{ch}$, is sensitive to the number of collisions between quarks and gluons contained in the colliding systems and to the mechanisms underlying particle production. In particular, it is a good probe for the saturation density of gluons in the colliding hadrons.

For the first time, the multiplicity distributions for pp collisions are measured over a wide kinematic range at the LHC (pseudorapidity coverage of $-3.4 < \eta < +5.1$). The $P(N_{ch})$ are obtained at LHC Run 1 energies: from $\sqrt{s}$ =0.9 to 8 TeV, and at the highest available energy $\sqrt{s}$ =13 TeV from Run 2. The distributions are measured using the Forward Multiplicity Detector (FMD) and the Silicon Pixel Detector (SPD) of ALICE at LHC.

The results are compared, where possible, with the results of other LHC experiments and with Monte Carlo simulations. Moreover, data are compared using the Koba–Nielsen–Olesen (KNO) model, where it appears that the scaling predicted by this model is broken at energies from 0.9 TeV.

**Primary author(s) :** ZACCOLO, Valentina (University of Copenhagen (DK))

**Presenter(s) :** ZACCOLO, Valentina (University of Copenhagen (DK))

**Session Classification :** Initial State Physics and Approach to Equilibrium I

**Track Classification :** Initial State Physics and Approach to Equilibrium

Contribution ID : **689** Type : **Contributed talk**

# Centrality and pseudorapidity dependence of transverse energy flow in pPb collisions at 5.02 TeV with CMS

*Monday, 28 September 2015 15:10 (0:20)*

## On behalf of collaboration:

CMS

## Abstract Content

The CMS Collaboration has measured the pseudorapidity and centrality dependence $dET/d\eta$ for 5.02 TeV pPb collisions over 10 units of pseudo-rapidity. This was carried out in a systematic way by measuring centrality using different experimental definitions. As the centrality increases the mean pseudorapidity moves backwards and the $1/NdE_T/d\eta$ distribution widens. For the most central pPb collisions the maximum $1/NdE_T/d\eta$ reaches 25 GeV. The rate of change of dEt/deta with eta and centrality is characterized by the ratio $S_{pc}(eta, centrality) = E_T(\eta, centrality)/E_T(\eta, centrality = 0 - 10\%)$. This ratio depends very strongly upon the definition of centrality and shows strong auto-correlations if a particular eta region is used to define centrality. For the most central events there is a large overlap in the event classes selected by different centrality measurements, but for peripheral events different centrality measures select quite different. This is quite different to the situation in PbPb and suggests that event-by-event fluctuations in the pseudorapidity distribution of particles are much stronger in pPb than in PbPb.

**Primary author(s) :** EDWARDS-BRUNER, Christopher Ryan (University of Kansas (US))

**Presenter(s) :** EDWARDS-BRUNER, Christopher Ryan (University of Kansas (US))

**Session Classification :** Initial State Physics and Approach to Equilibrium I

**Track Classification :** Initial State Physics and Approach to Equilibrium

Contribution ID : **319** Type : **Contributed talk**

# Initial state from holography

*Monday, 28 September 2015 15:30 (0:20)*

## On behalf of collaboration:

NONE

## Abstract Content

Through holography we can collide arbitrary lumps of energy in strongly coupled gauge theories, where we assume transverse gradients are small in the very first moments of the collision. This can be applied to off-central collisions and subsequently evolved using the MUSIC 3+1D hydrodynamic code. This allows us to compare to experimental observables, where we focus on the multiplicity and directed flow as a function of rapidity. These show qualitative agreement with data, although the multiplicity profile at our very strong coupling calculation is significantly narrower than the data, both at RHIC and especially at LHC energies.

Lastly, we will present new results, using the holographic model to study initial anisotropy and entropy when including event-by-event fluctuations, but without hydrodynamics.

References: arxiv:1507.xxxx, WS and B. Schenke, Directed flow in holographic heavy ion collisions

**Primary author(s) :** VAN DER SCHEE, Wilke (MIT); SCHENKE, Bjoern (Brookhaven National Lab)

**Presenter(s) :** VAN DER SCHEE, Wilke (MIT)

**Session Classification :** Initial State Physics and Approach to Equilibrium I

**Track Classification :** Initial State Physics and Approach to Equilibrium

Contribution ID : **159** Type : **Contributed talk**

# Initial state azimuthal anisotropies in small collision systems

*Monday, 28 September 2015 15:50 (0:20)*

## On behalf of collaboration:

None

## Abstract Content

Recent experimental results have revealed a surprisingly rich structure of multiparticle azimuthal correlations in high energy proton-nucleus collisions. Final state collective effects can be responsible for many of the observed effects, but it has recently been shown that a part of these correlations are present already in the wavefunctions of the colliding particles. A domain structure at length scales of the inverse saturation scale, present in the classical color field of a high energy nucleus, naturally leads to such multiparticle correlations. This talk discusses recent work on azimuthal anisotropy coefficients originating from the initial stage color fields. In particular, we describe a recent calculation [1] of the momentum space 2-particle cumulant azimuthal anisotropy coefficients v_n{2}, n=2,3,4 from fundamental representation Wilson line distributions describing the high energy nucleus. These would correspond to the flow coefficients in very forward proton-nucleus scattering. This calculation finds significant differences between Wilson lines from the MV model and from JIMWLK evolution. The talk also discusses the relation [2] of this calculation to earlier work on the ridge correlation obtained in the "glasma graph" approximation [3], and to the "field domain model" [4] where the correlations would originate from a novel nongaussian fluctuation structure in the nuclear color field.

[1] T. Lappi, Phys. Lett. B744 (2015) 315-319

[2] T. Lappi, S. Schlichting, B. Schenke and R. Venugopalan, in preparation

[3] K. Dusling and R. Venugopalan, Phys. Rev. Lett. 108 (2012) 262001, Phys. Rev. D87 (2013) 054014, Phys. Rev. D87 (2013) 051502, Phys. Rev. D87 (2013) 094034

[4] A. Dumitru and A. V. Giannini, Nucl. Phys. A933 (2014) 212, A. Dumitru, L. McLerran and V. Skokov, Phys. Lett. B743 (2015) 134, A. Dumitru and V. Skokov, Phys.Rev. D91 (2015) 7, 074006

**Primary author(s) :** LAPPI, Tuomas (University of Jyvaskyla)

**Presenter(s) :** LAPPI, Tuomas (University of Jyvaskyla)

**Session Classification :** Initial State Physics and Approach to Equilibrium I

**Track Classification :** Initial State Physics and Approach to Equilibrium

Contribution ID : **625** Type : **Contributed talk**

# Azimuthal Harmonics at RHIC and LHC energies: Competition between Initial State Bremsstrahlung and Final State Hydrodynamics

*Monday, 28 September 2015 16:10 (0:20)*

## On behalf of collaboration:

None

## Abstract Content

Recent azimuthal correlation data from d+Au and Au+Au collisions at RHIC energies and cumulant azimuthal harmonics in p+Pb and PbPb at LHC energies display very similar size and characteristics challenging the uniqueness of local equilibrium hydrodynamical interpretation of these data. We show that in p+A collisions the azimuthal harmonics arising from initial-state non-abelian interference effects associated with multiple projectile and target beam jets are remarkably similar to the measured data in experiments and predictions from final state perfect fluid models. The corresponding GLVB model description for pA collisions [1] and its numerical interpretation and inclusion will be shortly summarized and discussed.

[1] M. Gyulassy, P. Levai, I. Vitev, T.S. Biro, Phys. Rev. D90 (2014) 054025.

**Primary author(s) :** LEVAI, Peter (Hungarian Academy of Sciences (HU))

**Co-author(s) :** GYULASSY, Miklos (Columbia University); BIRO, Tamas Sandor (MTA Wigner RCP)

**Presenter(s) :** LEVAI, Peter (Hungarian Academy of Sciences (HU))

**Session Classification :** Initial State Physics and Approach to Equilibrium I

**Track Classification :** Initial State Physics and Approach to Equilibrium

Contribution ID : **238** Type : **Contributed talk**

# NA61/SHINE results on fluctuations and correlations in p+p and Be+Be interactions at CERN SPS energies

*Monday, 28 September 2015 17:00 (0:20)*

## On behalf of collaboration:

NA61

## Abstract Content

The aim of the NA61/SHINE strong interaction programme is to explore the phase diagram of strongly interacting matter. The main physics goals are the study of the onset of deconfinement and the search for the critical point of strongly interacting matter. These goals are pursued by performing an beam momentum (13A - 158A GeV/c) and system size (p+p, p+Pb, Be+Be, Ar+Sc, Xe+La) scan.

This contribution presents results on transverse momentum and multiplicity fluctuations from the Be+Be and p+p energy scan. Also, results on two-particle correlations in pseudorapidity and azimuthal angle obtained in p+p interactions will be shown. The influence of conservation laws and resonance decays on multiplicity and chemical fluctuations of identified particles in p+p interactions will be discussed. Obtained results will be compared with other experiments and with model predictions.

**Primary author(s) :** MACKOWIAK-PAWLOWSKA, Maja Katarzyna (Warsaw University of Technology (PL))

**Presenter(s) :** MACKOWIAK-PAWLOWSKA, Maja Katarzyna (Warsaw University of Technology (PL))

**Session Classification :** Correlations and Fluctuations II

**Track Classification :** Correlations and Fluctuations

Contribution ID : **46** Type : **Contributed talk**

# Indications for a Critical End Point in the Phase Diagram for Hot and Dense Nuclear Matter

*Monday, 28 September 2015 17:20 (0:20)*

## On behalf of collaboration:

NONE

## Abstract Content

Excitation functions for the Gaussian emission source radii difference ($R^2_{out} - R^2_{side}$) obtained from two-pion interferometry measurements in Au+Au ($\sqrt{s_{NN}} = 7.7^{\sim}200\,\mathrm{GeV}$) and Pb+Pb ($\sqrt{s_{NN}} = 2.76\,\mathrm{TeV}$) collisions are studied for a broad range of collision centralities. The observed nonmonotonic excitation functions validate the finite-size and finite-time scaling patterns expected for the deconfinement phase transition and the critical end point (CEP), in the temperature versus baryon chemical potential ($T, \mu_B$) plane of the nuclear matter phase diagram [1]. A Dynamic finite-size scaling (DFSS) analysis of these data suggests a second order phase transition with the estimates $T^{cep} \sim 165$ MeV and $\mu_B^{cep} \sim 95\,\mathrm{MeV}$ for the location of the critical end point. The critical exponents ($\nu \approx 0.66$ and $\gamma \approx 1.2$) extracted via the same DFSS analysis place this CEP in the 3D Ising model universality class.
[1] Roy. A Lacey, Phys.Rev.Lett. 114, 142301, (2015)

**Primary author(s) :** LACEY, Roy (Stony Brook University)

**Presenter(s) :** LACEY, Roy (Stony Brook University)

**Session Classification :** Correlations and Fluctuations II

**Track Classification :** Correlations and Fluctuations

Contribution ID : **618** Type : **Contributed talk**

# Systematics of higher order net-baryon number fluctuations at small values of the baryon chemical potential: A comparison of lattice QCD and beam energy scan results

*Monday, 28 September 2015 17:40 (0:20)*

## On behalf of collaboration:

[Other]

## Abstract Content

Fluctuations of and correlations among conserved charges of strong interactions have long been considered sensitive observables for the exploration of the structure of the phase diagram of QCD. Cumulants of conserved charge fluctuations are the most promising experimental observables in the search for a critical point in the phase diagram of QCD performed in the beam energy scan (BES) at RHIC. The published data on cumulants of net-proton number fluctuations and, in particular, the still preliminary data set on net-proton fluctuations which covers a larger transverse momentum range show obvious deviations from the thermodynamics of a hadron resonance gas (HRG). This naturally raises the question whether ratios of cumulants of net-proton number fluctuations, and the relation between them and net electric charge cumulants measured by STAR and PHENIX can be understood in terms of equilibrium thermodynamics obtained from lattice QCD calculations.

We present results for cumulants of net-baryon number and net electric charge fluctuations calculated in a next-to-leading order (NLO) Taylor series in the baryon chemical potential ($\mu_B$). We discuss the resulting pattern of ratios of cumulants, e.g. $\kappa_B\sigma_B^2 \equiv \chi_4^B/\chi_2^B$ and $S_B\sigma_B^3/M_B \equiv \chi_3^B/\chi_1^B$. We note that both quantities are identical at $\mu_B = 0$ and that the curvature of the latter is about three times larger than the former. Comparing this generic structure with STAR results on net-proton number fluctuations we conclude that current BES results at energies $\sqrt{s} \geq 19.6$˜GeV are compatible with QCD thermodynamics and can be understood in a NLO Taylor expansion. We also discuss changes of freeze-out parameters that arise from the new, preliminary STAR data on net-proton fluctuations compared to the published data and the recent PHENIX data on electric charge fluctuations.

**Primary author(s) :** Mr. KARSCH (ON BEHALF OF THE BIELEFELD-BNL-CCNU COLLABORATION), Frithjof (Brookhaven National Laboratory and Bielefeld University)

**Presenter(s) :** Mr. KARSCH (ON BEHALF OF THE BIELEFELD-BNL-CCNU COLLABORATION), Frithjof (Brookhaven National Laboratory and Bielefeld University)

**Session Classification :** Correlations and Fluctuations II

**Track Classification :** Correlations and Fluctuations

Contribution ID : **356** Type : **Contributed talk**

# Modeling chiral criticality and its consequences for heavy ion collisions

*Monday, 28 September 2015 18:00 (0:20)*

## On behalf of collaboration:

None

## Abstract Content

Considering effective models constructed to be in the same universality class as QCD, we discuss the role of critical fluctuations in the vicinity of the chiral transition.
In recent lattice calculations [Ejiri et al., Phys. Rev. D 80 (2009) 094505 ] QCD with physical quark masses is found to be in the scaling regime of the O(4) universality class. We examine the O(4) scaling in the context of effective models at small net baryon density and discuss differences and similarities with lattice QCD results and their consequences. Moreover, we explore the critical fluctuations near the chiral critical endpoint (CEP), which belongs to the Z(2) universality class, in a chiral effective model and discuss possible signals of the CEP, recently explored in nuclear collision experiments [Adamczyk et al., Phys. Rev. Lett. 113 (2014) 092301]. Particular attention is attributed to the dependence of such signals on the location of the phase boundary and the CEP relative to the hypothetical freeze out conditions in nuclear collisions.

**Primary author(s) :** ALMASI, Gabor (GSI); WOJCIECH, Tarnowski (Jagiellonian University); REDLICH, Krzysztof (University of Wroclaw); FRIMAN, Bengt (GSI)

**Presenter(s) :** ALMASI, Gabor (GSI)

**Session Classification :** Correlations and Fluctuations II

**Track Classification :** Correlations and Fluctuations

Contribution ID : **623** Type : **Contributed talk**

# Correlated fluctuations near the QCD critical point

*Monday, 28 September 2015 18:20 (0:20)*

## On behalf of collaboration:

None

## Abstract Content

Recently, STAR beam energy scan (BES) measured the multiplicity distributions of net protons with the maximum transverse momentum extended from 0.8 GeV to 2 GeV. The related higher cumulants (moments) present large deviations from the poisson baselines, showing the potential of discovery the QCD critical point in experiment.
In this talk, we introduce a freeze-out scheme for the dynamical models near the QCD critical point through coupling the classical particles with the correlated fluctuating sigma field [2]. For an infinite and stationary medium, such freeze-out scheme can reproduce the standard Staphanov formulas for cumulants presented in Ref[3].
Within this framework, we calculate the correlated fluctuations of net protons emitted from the hydrodynamic freeze-out surface at various collision energies. A comparison with recent STAR BES data shows that our model could reproduce kurtosis (and C4) through tuning the related parameters. However, the critical fluctuations in our model (also in the Stephanov formula) always give positive contributions to the cumulants C2 and C3, which over-predicts the data with poisson expectations served as the thermal fluctuation baselines[2]. In order to qualitatively /quantitatively describe these cumulants data, the effects from dynamical evolution and the deviations from poisson thermal fluctuations should be investigated in the near future.
[1] X. Luo PoS CPOD2014, 019 (2014)
[2] Lijia Jiang, Pengfei Li, Huichao Song, in preparation
[3] M.Stephanov Phys. Rev. Lett. 102, 032301 (2009)

**Primary author(s) :** Prof. SONG, Huichao (Peking University)

**Presenter(s) :** Prof. SONG, Huichao (Peking University)

**Session Classification :** Correlations and Fluctuations II

**Track Classification :** Correlations and Fluctuations

Contribution ID : **202** Type : **Contributed talk**

# Heavy-light flavor correlations and the QCD phase boundary

*Monday, 28 September 2015 18:40 (0:20)*

## On behalf of collaboration:

NONE

## Abstract Content

Modifications in magnitude of fluctuations for different observables are an excellent probe of a phase transition or its remnant. In heavy-ion collision, fluctuations related to conserved charges carried by light and strange quarks play an important role to identify the QCD chiral crossover and deconfinement properties.
Recent Lattice QCD simulations have revealed that the charmed mesons are deconfined together with light-flavor mesons in the temperature range where the chiral symmetry is partially restored. This result strongly suggests that the light-flavor dynamics interferes non-trivially with the heavy flavors.
We discuss correlations between the light and heavy-light flavored mesons at finite temperature within a chiral effective theory implementing heavy quark symmetry. We show that the heavy quark dynamics is tied to the light flavor physics, and the thermodynamics is strongly dragged by the chiral crossover dominated by the non-strange flavors. Consequently, the fluctuations carried by the states with strangeness can be used to characterize the onset of the chiral symmetry restoration.
References:
[1] C. Sasaki, Phys. Rev. D 90, no. 11, 114007 (2014).
[2] C. Sasaki and K. Redlich, Phys. Rev. D 91, no. 7, 074021 (2015).

**Primary author(s) :** Dr. SASAKI, Chihiro (FIAS & Uni of Wroclaw)

**Co-author(s) :** Prof. REDLICH, Krzysztof (University of Wroclaw)

**Presenter(s) :** Dr. SASAKI, Chihiro (FIAS & Uni of Wroclaw)

**Session Classification :** Correlations and Fluctuations II

**Track Classification :** Correlations and Fluctuations

Contribution ID : **684** Type : **Contributed talk**

# Fragmentation patterns of jets in pPb collisions in CMS

*Monday, 28 September 2015 17:00 (0:20)*

## On behalf of collaboration:

CMS

## Abstract Content

The nuclear parton distribution function and flavor composition of hard scattering processes can be accurately studied using the jet fragmentation functions. Recent measurements of the pPb nuclear modification factor ($R_{pPb}$), with diverging values for inclusive jets and charged hadrons, have raised question on jet fragmentation properties in pPb collisions. These spectra measurements are performed with pp reference at 5.02 TeV constructed by interpolation or extrapolation from different $\sqrt{s}$, and on steeply falling power-law spectra. As the jet fragmentation function is only evolving logarithmically with $\sqrt{s}$, this further underscores the importance of a direct measurement. Together with the CMS results in pPb inclusive jets and charge hadron $R_{pPb}$, we introduce the new CMS measurement of fragmentation function in pPb collisions, where within our uncertainties, jets in pPb is found to have identical fragmentation property vs. pp jets. We will further discuss the consistency and tension among the results, and their possible origins. This measurement also gives important reference for the interpretation of the fragmentation function in PbPb collisions.

**Primary author(s) :** BATY, Austin Alan (Massachusetts Inst. of Technology (US))

**Presenter(s) :** BATY, Austin Alan (Massachusetts Inst. of Technology (US))

**Session Classification :** Jets and High pT Hadrons II

**Track Classification :** Jets and High pT Hadrons

Contribution ID : **343** Type : **Contributed talk**

# Exploring jet sub-structure in Pb-Pb collisions at 2.76 TeV with ALICE

*Monday, 28 September 2015 17:20 (0:20)*

## On behalf of collaboration:

ALICE

## Abstract Content

We explore the possible modification of the inclusive charged jet substructure due to jet quenching in Pb-Pb collisions at 2.76 TeV by measuring a set of jet shapes. The set of shapes includes the first order angularity, the pTD and the difference between the leading and subleading tracks of the jet. The shapes are measured with a constituent cutoff of 0.15 GeV and small jet resolution $R = 0.2$. New techniques for background subtraction are applied and a 2D unfolding is performed to correct the shapes to particle level. We further present differential studies of jet suppression measured via full jet $R_{\mathrm{AA}}$ as function of sub-jet structure. We systematically study the jet $R_{\mathrm{AA}}$ by selecting jets with different sub-jet structure (using collinear and infrared safe observable(s) that are robust against heavy-ion background) and present comparison to a variety of jet quenching Monte Carlo models.

**Primary author(s) :** CUNQUEIRO MENDEZ, Leticia (CERN)

**Presenter(s) :** CUNQUEIRO MENDEZ, Leticia (CERN)

**Session Classification :** Jets and High pT Hadrons II

**Track Classification :** Jets and High pT Hadrons

Contribution ID : **633** Type : **Contributed talk**

# Subjet structure as a discriminating quenching probe

*Monday, 28 September 2015 17:40 (0:20)*

## On behalf of collaboration:

NONE

## Abstract Content

Jets have proven to be a powerful experimental tool to ascertain the properties of the QGP. In this work, we propose a new class of jet substructure observables which, unlike fragmentation functions, are largely insensitive to the poorly known physics of hadronization. We show that intra jet sub-jet structures provide us with a large discriminating power between different jet quenching Monte Carlo implementations. Further, this new class of observables proves instrumental to isolate with high purity samples of strongly modified jets where the competing mechanisms of energy loss can be more easily disentangled.

**Primary author(s) :** APOLINARIO, Liliana (Instituto Superior Técnico); TEIXEIRA DE ALMEIDA MILHANO, Guilherme (Instituto Superior Tecnico (PT)); ZHANG, Xiaoming (Lawrence Berkeley National Lab. (US)); PLOSKON, Mateusz (Lawrence Berkeley National Lab. (US))

**Presenter(s) :** ZHANG, Xiaoming (Lawrence Berkeley National Lab. (US))

**Session Classification :** Jets and High pT Hadrons II

**Track Classification :** Jets and High pT Hadrons

Contribution ID : **590** Type : **Contributed talk**

# Jet Hadronization via Recombination of Parton Showers in Vacuum and in Medium

*Monday, 28 September 2015 18:00 (0:20)*

## On behalf of collaboration:

JET

## Abstract Content

We have developed a hadronization model for jet parton showers based on the quark recombination model. Gluons at the end of a perturbative shower evolution undergo a non-perturbative splitting into quark and antiquark pairs, then a Monte-Carlo version of instantaneous quark recombination is applied. Finally remnant quarks (those which have not found a recombination partner) are connected by color strings and subjected to Lund string fragmentation. When applied to parton showers from the PYTHIA Monte Carlo generator, the final hadron spectra from our calculation compare quite well to PYTHIA jets that have been hadronized with the default Lund string fragmentation. This hadronization model readily generalizes to jet showers emerging from a quark gluon plasma by allowing recombination of shower partons with thermal partons, sampled from fluid dynamics or blast wave models. We find that the recombination of shower and thermal partons leads to a significant enhancement of intermediate transverse momentum pions and protons at both RHIC and LHC. Our results thus suggest that medium modification of jet fragmentation provides a plausible explanation for the enhanced production of intermediate transverse momentum hadrons and the changed hadron chemistry observed in experiments. A computer code based on this vacuum and medium hadronization model has been developed within the JET collaboration and can be combined with existing jet shower Monte Carlo codes.

**Primary author(s) :** FRIES, Rainer (Texas A&M University)

**Co-author(s) :** Prof. KO, Che-Ming (Texas A&M University); HAN, Kyongchol (Texas A&M University)

**Presenter(s) :** FRIES, Rainer (Texas A&M University)

**Session Classification :** Jets and High pT Hadrons II

**Track Classification :** Jets and High pT Hadrons

Contribution ID : **384** Type : **Contributed talk**

# Modification of reconstructed jets in heavy-ion collisions

*Monday, 28 September 2015 18:20 (0:20)*

## On behalf of collaboration:

NONE

## Abstract Content

Modification of reconstructed jets in high-energy heavy-ion collisions is studied within a Linear Boltzmann Transport (LBT) model. In the LBT model both elastic scattering and induced gluon radiation processes are simulated within a pQCD approach to jet-medium scattering and high-twist approach to medium induced gluon radiation in a 3+1D hydrodynamic medium. Effects of thermal recoiled partons from jet-induced medium excitation on jet energy loss and transverse profiles of the reconstructed jets are discussed in detail. We also discuss the effect of full energy-momentum conservation in the 2→ 3 inelastic process and the multiple-gluon emission on the total parton energy loss. We further investigate the jet suppression and the medium modification on jet shape and fragmentation function as well as their centrality and rapidity dependence in high-energy heavy ion collisions and compare our results with the RHIC and LHC data.
[1] Y. He, T. Luo, X. N. Wang and Y. Zhu, Linear Boltzmann Transport for Jet Propagation in the Quark-Gluon Plasma: Elastic Processes and Medium Recoil, Phys. Rev. C 91, 054908 (2015). [2] X. N. Wang and Y. Zhu, Medium Modification of $\gamma$-jets in High-energy Heavy-ion Collisions," Phys. Rev. Lett. 111, no. 6, 062301 (2013).

**Primary author(s) :** Dr. WANG, Xin-Nian (Lawrence Berkeley National Laboratory)

**Co-author(s) :** Mr. LUO, Tan (Central China Normal University)

**Presenter(s) :** Dr. WANG, Xin-Nian (Lawrence Berkeley National Laboratory)

**Session Classification :** Jets and High pT Hadrons II

**Track Classification :** Jets and High pT Hadrons

Contribution ID : **350** Type : **Contributed talk**

# Consequences (and a possible explanation) of the $R_{pA}^{\mathrm{jet}}$ - $R_{pA}^{\mathrm{hadron}}$ puzzle

*Monday, 28 September 2015 18:40 (0:20)*

## On behalf of collaboration:

None

## Abstract Content

The experimental finding that in pA collisions at the LHC, $R_{pA}^{\mathrm{jet}}$ is consistent with unity at high transverse energies, while $R_{pA}^{\mathrm{hadron}}$ exceeds unity above $p_T \sim 30$ GeV poses a fundamental problem for our understanding of high-$p_T$ processes in nuclear collisions. It can neither be accounted for in a collinear factorized formalism with process-independent fragmentation functions, nor can it be understood as a final state modification of the final state parton shower (on which standard jet quenching models in nucleus-nucleus collisions are based). We argue that these findings, point to a process-dependent element in the high-$p_T$ fragmentation mechanism. We note that the color recombination mechanisms implemented in general purpose event generators like SHERPA provide for such a process-dependent mechanism, since they imply that single inclusive hadron production depends not only on the factorized hard partonic interaction, but also on the density of the underlying event within which this hard process color recombines during hadronization. We demonstrate both on the level of qualitative arguments and with Monte Carlo simulations that by simply accounting for the factor 3 higher underlying event activity in pA collisions as compared to pp collisions, this mechanism can account for the observed nuclear modification factors of jet and hadron spectra in pA collisions. We emphasize that if the proposed mechanism is confirmed, it has interesting consequences for the understanding of high-pT hadron spectra in proton-proton collisions, since it allows one to quantify the size of a process-dependent correction to the standard collinearly factorized framework.

**Primary author(s) :** ZAPP, Korinna Christine (CERN)

**Co-author(s) :** TEIXEIRA DE ALMEIDA MILHANO, Guilherme (Instituto Superior Tecnico (PT)); WIEDEMANN, Urs (CERN)

**Presenter(s) :** WIEDEMANN, Urs (CERN)

**Session Classification :** Jets and High pT Hadrons II

**Track Classification :** Jets and High pT Hadrons

Contribution ID : **554** Type : **Contributed talk**

# Direct photon production and jet quenching in small systems

*Monday, 28 September 2015 17:00 (0:20)*

## On behalf of collaboration:

NONE

## Abstract Content

Signatures usually associated with hydrodynamic behavior have been recently observed in high and intermediary multiplicity proton-nucleus (pA) collisions at the LHC. Even though these signals suggest the creation of a strongly coupled quark-gluon plasma (QGP) in such collisions, they do not represent concrete proof. In order to better address this problem, other signals must be investigated.

In this work we calculate the thermal photon radiation produced by a small and rapidly expanding QGP droplet [1] and evaluate how much energy jets can loose when penetrating through such a small system. We find that a significant amount of thermal radiation is produced in proton-nucleus collisions, with thermal photons accounting for ˜50% of the direct photons produced in high multiplicity pA collisions at low $p_T$. Furthermore, we show that despite the small system size, jets still loose a significant fraction of their initial energy, leading to a charged hadron Raa of 0.7–0.8 at a transverse momentum of ˜10 GeV. If these two signatures can be accessed by the experiments, they will serve as additional evidence that a strongly coupled QGP is being produced in proton-nucleus collisions at the LHC. To complete the analysis, we study direct photon production and jet quenching in other small systems, such as d-Au and He-Au collisions at RHIC energies.

[1] C. Shen, J.-F. Paquet, G. S. Denicol, S. Jeon and C. Gale, arXiv:1504.07989 [nucl-th].

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**Presenter(s) :** Prof. GALE, Charles (McGill University)

**Session Classification :** QGP in Small Systems I

**Track Classification :** QGP in Small Systems

Contribution ID : **188** Type : **Contributed talk**

# Flow in small systems from parton scatterings

*Monday, 28 September 2015 17:20 (0:20)*

## On behalf of collaboration:

NONE

## Abstract Content

We show that the incoherent elastic scattering of partons, as present in a multi-phase transport model (AMPT), with a modest parton-parton cross-section of $\sigma$=1.5-3 mb, naturally explains the long-range two-particle azimuthal correlations as observed in p+p and p+Pb collisions for all measured $N_{track}$ and $p_T$ bins by the LHC-CMS experiment [1]. We calculate the elliptic, $v_2$, and triangular, $v_3$, Fourier coefficients of the two-particle azimuthal correlation function in p+Pb and peripheral Pb+Pb collisions. Our results for $v_3$ are in a good agreement with the CMS data. The $v_2$ coefficient is very well described in p+Pb collisions and is underestimated for higher $p_T$ in Pb+Pb collisions. The characteristic mass ordering of $v_2$ in p+Pb is also reproduced whereas for $v_3$ such ordering is not observed [2]. An escape mechanism has been proposed recently to explain these successful model results [3]. We investigate this issue in detail and show that collisions between active partons are directly responsible for generating the final $v_n$.
References:

1. Guo-Liang Ma and Adam Bzdak, Phys. Lett. B 739, 209 (2014) [arXiv:1404.4129].
2. Adam Bzdak and Guo-Liang Ma, Phys. Rev. Lett. 113, 252301 (2014) [arXiv:1406.2804].
3. Liang He, Terrence Edmonds, Zi-Wei Lin, Feng Liu, Denes Molnar, Fuqiang Wang, arXiv:1502.05572.

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**Presenter(s) :** MA, Guo-Liang (Shanghai INstitute of Applied Physics (SINAP), CAS)

**Session Classification :** QGP in Small Systems I

**Track Classification :** QGP in Small Systems

Contribution ID : **410** Type : **Contributed talk**

# Effects produced by multi-parton interactions and color reconnection in small systems

*Monday, 28 September 2015 17:40 (0:20)*

## On behalf of collaboration:

None

## Abstract Content

Multi-parton interactions (MPI) and color reconnection (CR) have raised special interest due to the fact that they can produce QGP-like effects in small systems, specifically, flow-like patterns. Now we will show that the same mechanisms produce an explicit dependence of the $p_{\mathrm{T}}$ spectra with the number of constituent quarks. In addition, a Cronin-like peak, at intermediate transverse momentum ($2 < p_{\mathrm{T}} < 10$ GeV/$c$), and a sort of binary scaling, at higher $p_{\mathrm{T}}$, are also observed in events with large number of MPI in pp collisions. While those effects have been revealed in pA collisions at RHIC and at LHC. In pp collisions, the last two effects have not been reported. This suggests that if MPI and CR are the mechanisms which originate the observed effects, then, the conditions for jet quenching would not be satisfied in small systems.

In addition, we will discuss the experimental challenges to select on MPI. Specifically, the limitations and the biases of the event multiplicity, when, it is calculated in certain kinematic regions. We will show that such a selection can be improved using new approaches based on event shapes. Among the findings we will report that the multiplicity selection bias may affect the average \pt at high multiplicity, producing the so-called second rise of $\langle p_{\mathrm{T}} \rangle$ as reported by the ALICE Collaboration. Also, it will be argued that the average expansion velocity extracted from the analysis of the $p_{\mathrm{T}}$ spectra can be increased by the same kind of bias. Results for pp collisions at $\sqrt{s} = 7$ and 13 TeV, and comparisons with the available experimental data will be presented.

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**Presenter(s) :** PAIC, Guy (Universidad Nacional Autonoma (MX))

**Session Classification :** QGP in Small Systems I

**Track Classification :** QGP in Small Systems

Contribution ID : **694** Type : **Contributed talk**

# Differential multi-particle correlation measurements for pPb collisions at CMS

*Monday, 28 September 2015 18:00 (0:20)*

## On behalf of collaboration:

CMS

## Abstract Content

Previous CMS measurements have demonstrated the collective nature of multiparticle correlations in high-multiplicity pPb collisions at the LHC. This collectivity is consistent with a hydrodynamic flow origin. However, it can also be interpreted in terms of initial state effects arising from gluon saturation. The pseudorapidity dependence of the azimuthal Fourier coefficients ($v_n$) is expected to be sensitive to the underlying mechanism with, in the hydrodynamic picture, the longer lifetime of the fireball on the Pb-going side expected to lead to a larger flow signal than found on the p-going side. To investigate the detailed properties of the observed collectivity, differential $v_n$ values in transverse momentum ($p_T$) and pseudorapidity ($\eta$) are presented over the full range of the CMS tracker detector ($-2.4 < \eta < 2.4$) for pPb collisions at a nucleon-nucleon center-of mass energy of 5.02 TeV. Results based on multiparticle analyses involving four or more particles are shown. An event plane analysis is presented where the influence of recently demonstrated event-plane de-correlation is considered. Comparisons are made with peripheral PbPb collisions measured at similar mid-rapidity particle multiplicities. The results will be discussed in the context of current models of the longitudinal dependence of the multiparticle correlations.

**Primary author(s) :** WANG, Quan (University of Kansas (US))

**Presenter(s) :** WANG, Quan (University of Kansas (US))

**Session Classification :** QGP in Small Systems I

**Track Classification :** QGP in Small Systems

Contribution ID : **457** Type : **Contributed talk**

# Light flavour results in p-Pb collisions with ALICE

*Monday, 28 September 2015 18:20 (0:20)*

## On behalf of collaboration:

ALICE

## Abstract Content

Particle ratios provide insight into the hadrochemistry of the event and the mechanisms for particle production. In Pb-Pb collisions the relative multi-strange baryon yields exhibit an enhancement with respect to pp collisions, whereas the short-lived $K^{*0}$ resonance is suppressed in the most central events due to re-scattering. Measurements in p-Pb allow us to investigate the development of these effects as a function of the system size.

We report comprehensive results on light-flavour hadron production measured with the ALICE detector in p–Pb collisions at $\sqrt{s_{\rm NN}} = 5.02$ TeV, covering a wide range of particle species which includes long-lived hadrons, resonances and multi-strange baryons. The measurements include the transverse momentum spectra and the ratios of spectra among different species, and extend over a very large transverse momentum region, from ˜100 MeV/$c$ to ˜20 GeV/$c$, depending on the particle species.

**Primary author(s) :** ORTIZ VELASQUEZ, Antonio (Universidad Nacional Autonoma (MX))

**Presenter(s) :** ORTIZ VELASQUEZ, Antonio (Universidad Nacional Autonoma (MX))

**Session Classification :** QGP in Small Systems I

**Track Classification :** QGP in Small Systems

Contribution ID : **369** Type : **Contributed talk**

# PHENIX results on collectivity in $^3$He+Au collisions

*Monday, 28 September 2015 18:40 (0:20)*

## On behalf of collaboration:

PHENIX

## Abstract Content

Collisions of light with heavy ions have been considered control experiments for heavy ion collisions, but measurements of long-range azimuthal correlations of light hadrons in $p(d)$+A collisions at RHIC and LHC challenge this assumption. Hydrodynamic model calculations have been successful in describing experimental results, though alternative explanations involving initial-state Glasma diagrams have not been not ruled out. Further understanding of the origin of the observed anisotropies can be achieved in $^3$He+Au collisions at $\sqrt{s_{NN}}$=200 GeV, which change the shape and size of the initial reaction zone compared to $p(d)$+A. We present PHENIX results for $^3$He+Au collisions at $\sqrt{s_{NN}}$=200 GeV. Production of neutral pions is measured in a wide transverse-momentum range and is used to study centrality dependence of the cold-nuclear-matter effects. Azimuthal correlations for rapidity separated ($\Delta\eta > 3.5$) particles are measured in a wide transverse-momentum range and compared to that in $p$+$p$ collisions. Elliptic and triangular flow coefficients are measured for charged hadrons and their dependence on particle mass and rapidity is reported. The experimental results are compared theoretical predictions, including to models where three hot spots created by the impact of the three $^3$He nucleons on the Au nucleus expand hydrodynamically to generate triangular flow. The agreement of data with these models may indicate the formation of low-viscosity quark-gluon plasma, even in these small collision systems.

**Primary author(s) :** HUANG, shengli (PHENIX Collaboration)

**Presenter(s) :** HUANG, shengli (PHENIX Collaboration)

**Session Classification :** QGP in Small Systems I

**Track Classification :** QGP in Small Systems

Contribution ID : **263** Type : **Contributed talk**

# Charge-dependent anisotropic flow in Cu+Au collisions

*Monday, 28 September 2015 17:00 (0:20)*

## On behalf of collaboration:

STAR

## Abstract Content

At the early stages of non-central heavy-ion collisions, a strong magnetic field perpendicular to the reaction plane is created. In asymmetric Cu+Au collisions, due to the difference in the number of spectators, not only the magnetic field but also a strong electric field (E-field) would be created along the reaction plane and pointing from the Au-nucleus to Cu-nucleus. The lifetime of the E-field would be short, of the order of a fraction of a fm/c. The quarks and antiquarks that have been already produced at this time would experience the Coulomb force, which result in charge separation of directed flow. Thus, the measurement of the charge-dependent directed flow in Cu+Au provides an opportunity to test different quark (charge) scenarios, e.g Pratt's two-wave quark production, and shed light on the (anti-)quark production mechanism in heavy-ion collisions in general. Understanding the time evolution of the quark densities in heavy-ion collisions is also very important for detailed theoretical predictions of the Chiral Magnetic Effect and Chiral Magnetic Wave, which various experiments are actively searching for. [U+FFFC]The transverse-momentum dependence of the directed (dipole) flow in Cu+Au collision is also very sensitive to the system initial density gradients in the transverse plane, which can only be observed in symmetric systems as a result of density fluctuations. Measurements of the higher-harmonic flow also allows further study of hydrodynamics and the properties of QGP. In this talk, the charge-dependent directed flow in Cu+Au collisions at sqrt{s_{NN}} =200 GeV measured in the STAR experiment will be presented. The results are compared with existing model predictions and implications for the dynamics of quarks production and system evolution will be discussed. Higher-harmonic flow will be also presented and compared with A+A collisions.

**Primary author(s) :** Dr. NIIDA, Takafumi (Wayne State University)

**Presenter(s) :** Dr. NIIDA, Takafumi (Wayne State University)

**Session Classification :** Initial State Physics and Approach to Equilibrium II

**Track Classification :** Initial State Physics and Approach to Equilibrium

Contribution ID : **374** Type : **Contributed talk**

# PHENIX results on flow observables in asymmetric Cu+Au collisions

*Monday, 28 September 2015 17:20 (0:20)*

## On behalf of collaboration:

PHENIX

## Abstract Content

Asymmetric collisions of large nuclei at high energy offer a unique window into many aspects of excited medium formation and evolution. Unlike symmetric collisions, an asymmetric system can have non-zero odd-order moments in its average transverse distribution of participants, and the pattern of participants from the two nuclei can have different shapes on average. In 2012, PHENIX measured particle production in Cu+Au collisions at $\sqrt{s_{NN}} = 200$˜GeV, and we report measurements of the azimuthal anisotropies $v_1$, $v_2$, and $v_3$ (directed, elliptic, and triangular flow) for inclusive and identified charged hadrons produced at midrapidity. Implications for a variety of unique initial-state geometry effects will be discussed.

**Primary author(s) :** SCHAEFER, Brennan (Vanderbilt University)

**Presenter(s) :** SCHAEFER, Brennan (Vanderbilt University)

**Session Classification :** Initial State Physics and Approach to Equilibrium II

**Track Classification :** Initial State Physics and Approach to Equilibrium

Contribution ID : **40** Type : **Contributed talk**

# The influence of pre-equilibrium dynamics on heavy-ion collision observables

*Monday, 28 September 2015 17:40 (0:20)*

## On behalf of collaboration:

None

## Abstract Content

In order to bracket the importance of the pre-equilibrium stage on relativistic heavy-ion collision observables at RHIC and LHC energies, we compare simulations in which the pre-equilibrium stage is modeled by free-streaming partons with others where it is modeled fluid dynamically. The first (second) case implements the assumption of extremely weak (strong) coupling in the initial collision stage. We introduce a switching time parameter for the duration of the weakly coupled stage; after this time the system is assumed to stay in the strongly coupled hydrodynamic stage (with a specific shear viscosity that we can vary) until freeze-out. Based on event-by-event simulations of fluctuating initial conditions, we first study observables (radial, elliptic and triangular flow) systematically as a function of the switching time from free-streaming to viscous hydrodynamics ("thermalization time"), leaving other parameters fixed. We then perform a three-dimensional simultaneous parameter fit of the switching time, specific shear viscosity and freeze-out temperature by comparing the numerical results with a set of 5 experimental observables, for four different types of initial conditions. We find that the strongest constraint on the thermalization time does not come of anisotropic flow measurements, as previously thought, but from the mean transverse momentum of hadrons with different masses (i.e. radial flow). First results from a campaign that includes bulk viscous effect and a hadronic afterburner to describe the freeze-out stage, with particular focus on the mass-ordering of the elliptic and triangular flow for protons and Lambda hyperons which is incorrectly described by VISHNU without pre-equilibrium flow, will also be shown.
References: Jia Liu, Chun Shen, U. Heinz, Phys.Rev. C 91 (2015) 064906; and additional work to be published

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**Presenter(s) :** HEINZ, Ulrich (The Ohio State University)

**Session Classification :** Initial State Physics and Approach to Equilibrium II

**Track Classification :** Initial State Physics and Approach to Equilibrium

Contribution ID : **614** Type : **Contributed talk**

# Early Time Dynamics of Gluon Fields in High Energy Nuclear Collisions

*Monday, 28 September 2015 18:00 (0:20)*

## On behalf of collaboration:

NONE

## Abstract Content

Nuclei colliding at very high energy create a strong, quasi-classical gluon field during the initial phase of their interaction. We present an analytic calculation of the initial space-time evolution of this field in the limit of very high energies using a formal recursive solution of the Yang-Mills equations. We provide analytic expressions for the initial chromo-electric and chromo-magnetic fields and for their energy-momentum tensor. In particular, we discuss event-averaged results for energy density and energy flow as well as for longitudinal and transverse pressure of this system. Our results are generally applicable if $\tau < 1/Q_s$. The transverse energy flow of the gluon field exhibits hydrodynamic-like contributions that follow transverse gradients of the energy density. In addition, a rapidity-odd energy flow also emerges from the non-abelian analog of Gauss' Law and generates non-vanishing angular momentum of the field. We will discuss the space-time picture that emerges from our analysis and its implications for observables in heavy ion collisions.

**Primary author(s) :** Prof. KAPUSTA, Joseph (University of Minnesota)

**Co-author(s) :** FRIES, Rainer (Texas A&M University); Dr. CHEN, Guangyao (Iowa State University); Prof. LI, Yang (University of Minnesota-Duluth)

**Presenter(s) :** Prof. KAPUSTA, Joseph (University of Minnesota)

**Session Classification :** Initial State Physics and Approach to Equilibrium II

**Track Classification :** Initial State Physics and Approach to Equilibrium

Contribution ID : **707** Type : **Contributed talk**

# Resumming large radiative corrections in the high-energy evolution of the Color Glass Condensate

*Monday, 28 September 2015 18:20 (0:20)*

## On behalf of collaboration:

NONE

## Abstract Content

The Color Glass Condensate effective theory is the perturbative QCD description of the initial state for proton-nucleus and nucleus-nucleus collisions at RHIC and the LHC. The BK-JIMWLK equations describing the evolution of this theory with increasing energy have recently been extended to next-to-leading order (NLO) accuracy, which should allow for direct comparisons with the phenomenology. However, some of the NLO corrections turn out to be extremely large, since amplified by (double and single) 'collinear' logarithms, i.e. logarithms of ratios of transverse momenta. As a result, the evolution at NLO becomes unstable and void of any predictive power. This difficulty points towards the existence of large radiative corrections to all orders in $\alpha_s$, which must be computed and resummed in order to restore the predictive power of the perturbative expansion.
In Ref. [1], we performed such a resummation for the largest corrections — those where each power of $\alpha_s$ is accompanied by a double transverse logarithm. Subsequently, in Ref. [2], we have extended this resummation by including single transverse logarithms and running coupling corrections. This led us to a 'collinearly improved' version of BK equation, which resums the largest radiative corrections to all orders. Numerical studies of this equation show that the evolution is now stable and also considerably slowed down by the resummation. To demonstrate the usefulness of this equation as a tool for phenomenology, for have used it for fits to the HERA data for electron-proton deep inelastic scattering at high energy [2]. We have obtained excellent fits with a reduced number of free parameters and with initial conditions at low energy taken from perturbative QCD.
[1] "Resumming double logarithms in the QCD evolution of color dipoles", arXiv:1502.05642, Phys. Lett. B744 (2015) 293.
[2] "Collinearly-improved BK evolution meets the HERA data", arXiv:1507.03651

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**Session Classification :** Initial State Physics and Approach to Equilibrium II

**Track Classification :** Initial State Physics and Approach to Equilibrium

Contribution ID : **537** Type : **Contributed talk**

# The non-trivial interplay of elastic and inelastic collisions in the thermalization of the quark-gluon plasma

*Monday, 28 September 2015 18:40 (0:20)*

## On behalf of collaboration:

NONE

## Abstract Content

To understand the approach to equilibrium of a dense system of gluons, such as those produced in the early stages of ultra-relativistic heavy ion collisions, is an outstanding challenge. We study this problem by solving the relevant kinetic equations, including the proper Bose statistics, and using simple approximations that allow for semi-analytic solutions. Both elastic processes and number changing inelastic processes are taken into account. The semi-analytical solutions that we obtain complement discussions based on parametric estimates, or purely numerical solutions, and provide new insights on the interplay of elastic and inelastic collisions during the thermalization of the quark-gluon plasma. In particular, they confirm the rapid growth at early times of soft modes, mostly due to radiation processes, which leads to the almost immediate emergence of an infrared thermal spectrum. They also illustrate the mechanisms by which the system gets rid of the large excess of gluons that it contains initially.

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**Presenter(s) :** Dr. BLAIZOT, Jean-Paul (CEA)

**Session Classification :** Initial State Physics and Approach to Equilibrium II

**Track Classification :** Initial State Physics and Approach to Equilibrium

Contribution ID : **368** Type : **Contributed talk**

# PHENIX measurement of the collision system and multiplicity dependence of heavy quarkonia production

*Tuesday, 29 September 2015 09:00 (0:20)*

## On behalf of collaboration:

PHENIX

## Abstract Content

The system size and multiplicity dependence of heavy quarkonia production in heavy ion collisions can be used to disentangle the effects of hot and cold nuclear matter on quarkonia production. In particular, color screening and recombination, which modify the yields of charmonia in the quark gluon plasma, can be studied in large systems. We present PHENIX results on J/$\psi$ production in U+U collisions. The yield is compared to that in Au+Au collisions as a function of centrality. In peripheral to midcentral collisions the ratio scales as $N_{\rm coll}$, but in central collisions it scales as $N_{\rm coll}^2$. This is consistent with a picture where, for more central collisions, the coalescence mechanism for the production of the J/$\psi$ becomes dominant over the decrease in yield due to the increased energy density.

**Primary author(s) :** FRAWLEY, Anthony (Florda State University)

**Presenter(s) :** FRAWLEY, Anthony (Florda State University)

**Session Classification :** Quarkonia II

**Track Classification :** Quarkonia

Contribution ID : **499** Type : **Contributed talk**

# Charmonium production in Pb-Pb collisions with ALICE at the LHC

*Tuesday, 29 September 2015 09:20 (0:20)*

## On behalf of collaboration:

ALICE

## Abstract Content

Charmonia (for instance J/$\psi$ and $\psi$(2S)) are mesons formed of a charm and anti-charm quark pair. In high-energy hadronic collisions such as those delivered by the LHC between 2010 and 2013, charmonium production results from the hard scattering of two gluons, which occurs very early. In heavy ion collisions, charmonia can thus probe all states of the nuclear matter formed afterward and have therefore been used extensively to study the properties of the Quark-Gluon Plasma (QGP).

In this presentation we will report on published charmonium measurements performed by ALICE in Pb − Pb collisions at a center of mass energy per nucleon-nucleon collision $\sqrt{\text{sNN}} = 2.76$ TeV, at both mid ($|y| < 0.8$) and forward ($2.5 < y < 4$) rapidities. The nuclear modification factor of inclusive J/$\psi$ will be presented as a function of the collision centrality, the J/$\psi$ transverse momentum (pT) as well as its rapidity. The variation of the J/$\psi$ mean transverse momentum and mean transverse momentum squared as a function of the collision centrality will also be discussed. These measurements will be compared to models that include one or several of the following mechanisms: color screening; balance between dissociation and recombination in the QGP; recombination at the QGP phase boundary; interaction with a dense comoving medium. Results on the production of the heavier and less bound $\psi$(2S) meson in Pb − Pb collisions at forward-rapidity will also be presented and compared to both models and measurements performed by other experiments. At mid-rapidity we will also report on ALICE unique capability to separate prompt and non-prompt J/$\psi$ production down to low pT ($\geq 1.5$ GeV/c) and thus provide direct insight on the energy loss of b quarks in the QGP.

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**Session Classification :** Quarkonia II

**Track Classification :** Quarkonia

Contribution ID : **488** Type : **Contributed talk**

# Upsilon production measurements in pp, p-Pb and Pb-Pb collisions with ALICE

*Tuesday, 29 September 2015 09:40 (0:20)*

## On behalf of collaboration:

ALICE

## Abstract Content

Quarkonium, i.e. bound states of heavy quark and antiquarks ($c\bar{c}$ or $b\bar{b}$), are important observables to study the properties of nuclear matter at extreme energy-densities, where Lattice QCD calculations predict a phase transition from hadronic matter to the Quark-Gluon Plasma (QGP). In high energy heavy-ion collisions, the QGP can be studied using the suppression of bottomonium production, due to the color screening, with respect to the proton-proton results scaled by the number of binary collisions. However, this measurement can be biased by the possible presence of cold nuclear matter effects, which can be estimated using proton-nucleus collisions, where the QGP formation is not expected.

ALICE measures bottomonium production at forward rapidity ($2.5 \leq y \leq 4$) down to zero transverse momentum via the dimuon decay channel. In this presentation, the nuclear modification factor of $\Upsilon$ measured in Pb-Pb collisions at $\sqrt{s_{\rm NN}} = 2.76$ TeV and p-Pb collisions at $\sqrt{s_{\rm NN}} = 5.02$ TeV will be discussed. ALICE measurements of the bottomonium production for pp collisions will be also presented. The results will be compared to other LHC experimental measurements and to theoretical calculations.

**Primary author(s) :** DAS, Indranil (Saha Institute of Nuclear Physics (IN))

**Presenter(s) :** DAS, Indranil (Saha Institute of Nuclear Physics (IN))

**Session Classification :** Quarkonia II

**Track Classification :** Quarkonia

Contribution ID : **282** Type : **Contributed talk**

# In-medium quarkonium properties from a lattice QCD based effective field theory

*Tuesday, 29 September 2015 10:00 (0:20)*

## On behalf of collaboration:

None

## Abstract Content

In order to understand the experimental data on quarkonium production in heavy ion collisions at RHIC and LHC it is necessary (though not sufficient) to pinpoint the properties of heavy quarkonium in the deconfined QGP medium, including their dissolution. Studying quarkonium spectral properties at non-zero temperature, directly in lattice QCD, have proven to be difficult and detailed quantitative information on quarkonium in-medium properties is still lacking.
Lattice QCD based effective theories, such as lattice NRQCD, have seen impressive success in the determination of quarkonium properties in vacuum (e.g. their masses and decay widths), with the underlying framework being applicable in principle also at finite temperature. In combination with realistic lattice QCD simulations of the QGP medium with light pion masses by the HotQCD collaboration [1] gaining reliable first-principles insight into in-medium behavior is now is in reach.
Here we present our recent results on the temperature dependence of bottomonium and charmonium correlators, as well as their spectral functions in lattice NRQCD for temperatures 140 MeV $<$ T$<$ 400 MeV [2,3]. The spectra are reconstructed based on a novel Bayesian prescription [4], whose systematic uncertainties are thoroughly tested. We present indications for sequential melting of different quarkonium species with respect to their vacuum binding energies and discuss implications for phenomenology.
[1] A. Bazavov et. al., Phys. Rev. D85 (2012) 054503; Phys. Rev. D90 (2014) 094503
[2] S. Kim, P. Petreczky, A. Rothkopf, Phys. Rev. D91 (2015) 054511
[3] S. Kim, P. Petreczky, A. Rothkopf, work in progress
[4] Y. Burnier, A.R., Phys. Rev. Letters, 111 (2013) 182003

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**Presenter(s) :** ROTHKOPF, Alexander (Heidelberg University)

**Session Classification :** Quarkonia II

**Track Classification :** Quarkonia

Contribution ID : **137** Type : **Contributed talk**

# Strong-Coupling Effects in a Plasma of Confining Gluons

*Tuesday, 29 September 2015 09:00 (0:20)*

## On behalf of collaboration:

NONE

## Abstract Content

For the first time we investigate non-equilibrium dynamic properties of a plasma consisting of confining gluons resulting from Gribov quantization [1]. For this purpose we employ the infrared-improved Gribov dispersion relation of gluons in the kinetic theory setup in the relaxation time approximation and determine the exact in- and out-of-equilibrium evolution of the system. In the static case the resulting equation of state of the studied system provides a good qualitative description of the pure-glue lattice QCD data down to the vicinity of the phase transition [2,3,4], thus permitting a study of the non-equilibrium phenomena in a plasma that exhibits crucial features of the QCD phase transition. In the case of local thermal equilibrium we observe Bjorken-like cooling of the boost-invariant expanding system. Out of equilibrium, by matching to the first order viscous hydrodynamics, we calculate bulk [3] and shear [5] viscosity of the system. We find significant enhancement of the bulk to shear viscosity ratio close to the transition temperature and its universal scaling behavior, in line with the one expected in a strongly-coupled theories [5]. We interpret the onset of strongly-coupled features in the system as the possible explanation of the close to perfect fluid behavior of the quark-gluon plasma.
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4. S. Borsanyi, G. Endrodi, Z. Fodor, S. D. Katz and K. K. Szabo, JHEP 1207, 056 (2012)
5. W.Florkowski, R.Ryblewski, N.Su, K.Tywoniuk, forthcoming

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**Session Classification :** New Theoretical Developments II

**Track Classification :** New Theoretical Developments

Contribution ID : **152** Type : **Contributed talk**

# Matrix model of the semi-QGP with quarks

*Tuesday, 29 September 2015 09:20 (0:20)*

## On behalf of collaboration:

None

## Abstract Content

A matrix model of the semi-QGP, the region near the critical temperature, developed for the pure glue theory is applied to QCD with dynamical quarks. We add new parameters to address the spontaneous breaking of chiral symmetry breaking. The results of the model are compared to the latest results from numerical simulations on the lattice. We compute the interaction measure, the susceptibilities for the light and strange quarks, and quark number susceptibilities to eighth order. We note that a mixed susceptibility, between the Polyakov loop and the chiral order parameter, shows a mild divergence near the chiral transition.

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**Presenter(s) :** PISARSKI, Robert (Brookhaven National Lab.)

**Session Classification :** New Theoretical Developments II

**Track Classification :** New Theoretical Developments

Contribution ID : **28** Type : **Contributed talk**

# Soft-Collinear Effective theory for hadronic and nuclear collisions: The evolution of jet quenching form RHIC to the highest LHC energies

*Tuesday, 29 September 2015 09:40 (0:20)*

## On behalf of collaboration:

NONE

## Abstract Content

Effective field theory (EFT) is a powerful framework based on exploiting symmetries and controlled expansions for problems with a natural separation of energy or distance scales. EFTs are particularly important in QCD and nuclear physics. An effective theory of QCD, ideally suited to jet applications, is Soft-Collinear Effective Theory (SCET). Recently, first steps were taken to extend SCET and describe jet evolution in strongly-interacting matter. In this talk I will demonstrate that the newly constructed theory, called SCETG, allows us for the first time in more than a decade to go beyond the traditional energy loss approximation in heavy ion collisions and unify the treatment of vacuum and medium-induced parton showers. It provides quantitative control over the uncertainties associated with the implementation of the in-medium modification of hadron production cross sections and allows us to accurately constrain the coupling between the jet and the medium. I will further show how SCETG is implemented to present predictions for inclusive hadron suppression in Pb+Pb collisions at the highest LHC energies of 5.1 ATeV and discuss the relative significance of cold and hot nuclear matter effects.

[1] Z.B. Kang, G. Ovanesyan, R. Lashof-Regas, P. Saad, I. Vitev, Phys. Rev. Lett. 114 (2015) 9, 092002

[2] Y.-T. Chien, A. Emerman, Z. Kang, G. Ovanesyan, I. Vitev, JHEP in preparation

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**Session Classification :** New Theoretical Developments II

**Track Classification :** New Theoretical Developments

Contribution ID : **611** Type : **Contributed talk**

# In-medium jet evolution: interplay between broadening and decoherence effects

*Tuesday, 29 September 2015 10:00 (0:20)*

## On behalf of collaboration:

None

## Abstract Content

The description of the modifications of the coherence pattern of the parton shower when in the presence of a QGP has been actively addressed in recent studies. Among the several achievements, finite energy corrections, transverse momentum broadening due to medium interactions and interference effects between successive emissions has been extensively improved as they seem to be essential features for a correct description of heavy-ion collisions results. In this work, based on the insights of our previous work [2], we fully explore the physical interplay between broadening and decoherence, by generalising previous studies of medium-modifications of the antenna spectrum [1] - so far restricted to the case where transverse motion is neglected. The result allow us to identify two quantities controlling the decoherence of a medium modified shower that can be used as building blocks for a successful future generation of Jet quenching Monte Carlos: a generalisation of the $\Delta_{med}$ parameter of the works of [1] - that controls the interplay between the transverse scale of the hard probe and the transverse scale of the medium - and of the $\Delta_{coh}$ in [2] - that dictates the interferences between two emitters as a function of the transverse momentum broadening acquired by multiple scatterings with the medium.
[1] L. Apolinário, N. Armesto, J. G. Milhano, and C. Salgado, JHEP 1502 (2015) 119 [2] Y. Mehtar-Tani, C. A. Salgado and K. Tywoniuk, Phys.Rev.Lett. 106 (2011) 122002 Y. Mehtar-Tani, C. A. Salgado and K. Tywoniuk, JHEP 1210 (2012) 197 J. Casalderrey-Solana and E. Iancu, JHEP 1108 (2011) 015

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**Session Classification :** New Theoretical Developments II

**Track Classification :** New Theoretical Developments

Contribution ID : **493** Type : **Contributed talk**

# Measurement of D Meson Azimuthal Anisotropy in Au+Au Collisions at $\sqrt{s_{NN}}$ = 200 GeV from STAR

*Tuesday, 29 September 2015 09:00 (0:20)*

## On behalf of collaboration:

STAR

## Abstract Content

Heavy quarks are produced through initial hard scatterings and they are affected by the hot and dense medium created in heavy-ion collisions throughout its whole evolution. Due to their heavy mass, charm quarks are expected to thermalize much more slowly than light flavor quarks. As a result, the charm quark flow is a unique tool to study the extent of thermalization of the bulk medium dominated by light quarks and gluons. At high $p_T$, D meson azimuthal anisotropy is sensitive to the path length dependence of charm quark energy loss in the medium, which offers new insights into heavy quark energy loss mechanisms - gluon radiation vs. collisional processes.

In this talk, we present the STAR measurement of elliptic flow ($v_2$) of $D^0$, $D^{\pm}$, $D^{*\pm}$ mesons in Au+Au collisions at $\sqrt{s_{NN}}$ = 200 GeV, for a wide transverse momentum range and different centrality bins. These results are obtained from the data taken in the first year of physics running of the new STAR Heavy Flavor Tracker detector, which greatly improves open heavy flavor hadron measurements by the topological reconstruction of secondary decay vertices. The D meson $v_2$ is compared with those of other particle species at the same energy, measurements at the LHC collision energy and the latest model calculations. Physics implications on charm quark flow as well as the medium transport properties are discussed.

**Primary author(s) :** LOMNITZ, Michael (Kent State University)

**Presenter(s) :** LOMNITZ, Michael (Kent State University)

**Session Classification :** Collective Dynamics I

**Track Classification :** Collective Dynamics

Contribution ID : **398** Type : **Contributed talk**

# Beam-Energy and Centrality Dependence of Directed Flow of $\Lambda$, $\bar{\Lambda}$, $\phi$, $K^0_s$, $K^{\pm}$, $p$, $\bar{p}$, $\pi^{\pm}$

*Tuesday, 29 September 2015 09:20 (0:20)*

## On behalf of collaboration:

STAR

## Abstract Content

The Beam Energy Scan (BES) program at the Relativistic Heavy-Ion Collider aims to study the QCD phase diagram in regions where net baryon density is large, a region where a critical point may exist. Possible signatures of a softening of the QCD equation of state have been reported at BES energies, and directed flow (rapidity-odd $v_1(y)$) is one of the more striking examples in this category. This talk will focus on $v_1$, and its slope $dv_1/dy$, near midrapidity. Ten identified particle types will be presented: $\Lambda$, $\bar{\Lambda}$, $\phi$, $K^0_s$, $K^{\pm}$, $p$, $\bar{p}$, and $\pi^{\pm}$ produced in Au+Au collisions at $\sqrt{s_{NN}}$ = 7.7, 11.5, 14.5, 19.6, 27 and 39 GeV as a function of rapidity. For $\Lambda$, $K^0_s$, $K^{\pm}$, $p$ and $\pi^{\pm}$, all results are presented in the centrality bins $0-5\%$, $5-10\%$, $10-20\%$, $20-30\%$, $30-40\%$, $40-50\%$, $50-60\%$, $60-70\%$ and $70-80\%$.
At intermediate centrality (10-40\%), $dv_1/dy$ shows a minimum near 14.5 GeV for several particle species while $p$ and $\Lambda$ also show a sign change. The $\phi$ meson appears to follow $\bar{p}$ at the higher BES energies, while protons, kaons and pions have a lower magnitude than $\bar{p}$ at 14.5 GeV and above. $\Lambda$ and $p$ are consistent within errors at all energies. $dv_1/dy$ shows a strong centrality dependence, especially for $p$ and $\Lambda$ at the lower beam energies. Results for net kaons and net protons will also be discussed.
The UrQMD model shows a qualitatively similar trend for only a subset of the ten particle types under investigation. This comprehensive set of directed flow measurements for several identified baryons, antibaryons and mesons, spanning BES energies and all centralities, offers a powerful constraint on model calculations.

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**Presenter(s) :** SHANMUGANATHAN, Prashanth (Kent State University, USA)

**Session Classification :** Collective Dynamics I

**Track Classification :** Collective Dynamics

Contribution ID : **460** Type : **Contributed talk**

# (Anti-)deuteron production and anisotropic flow measured with ALICE at the LHC

*Tuesday, 29 September 2015 09:40 (0:20)*

## On behalf of collaboration:

ALICE

## Abstract Content

The high abundance of (anti-)deuterons in the statistics gathered in run 1 of the LHC and the excellent performance of the ALICE setup allow for the simultaneous measurement of the elliptic flow and the deuteron production rates with a large transverse momentum ($p_{\mathrm{T}}$) reach. The (anti-) deuterons are identified using the specific energy loss in the time projection chamber and the velocity information in the time-of-flight detector. For nuclei of higher energies, the High Momentum Particle IDentification (HMPID), a ring-imaging Cherenkov detector, is also utilized. The elliptic flow of (anti-)deuterons could provide insight into the production mechanisms of particles in heavy-ion collisions. While one of the approaches to describe the elliptic flow of hadrons and light nuclei, is given by quark coalescence, the production of light nuclei is also depicted as a coalscence of nucleons, i.e. hadron coalescence. Differences should be visible for those two approaches when the elliptic flow is measured simultaneously with the $p_{\mathrm{T}}$ spectra, especially when they are scaled by the number of nucleons and quarks. The results are compared to expectations from coalescence and hydrodynamic models which aim at describing both the $p_{\mathrm{T}}$-spectra and the elliptic flow.

**Primary author(s) :** LEA, Ramona (Universita e INFN, Trieste (IT))

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**Session Classification :** Collective Dynamics I

**Track Classification :** Collective Dynamics

Contribution ID : **477** Type : **Contributed talk**

# Event shape engineering with the ALICE detector

*Tuesday, 29 September 2015 10:00 (0:20)*

## On behalf of collaboration:

ALICE

## Abstract Content

Event shape engineering (ESE) is a differential technique, which involves selecting events based on their anisotropic flow, and studying other observables with respect to the magnitude of that flow [1]. These studies have been pursued by the ALICE, ATLAS, and PHENIX collaborations, and promise to open up a new paradigm in the era of high statistics heavy-ion data. We will show the latest results from the ALICE collaboration for Pb-Pb 2.76 TeV collisions. In particular, we will show new studies on event by event correlations of radial and anisotropic flow, and discuss how these studies can place extra constraints on the initial conditions. We will demonstrate how the pion, kaon, proton spectra evolve with the event-wise anisotropic flow, and use a blast wave model to determine changes in the radial flow velocity. We will also review the sensitivity of the ESE technique, by comparing results using different ALICE sub-detectors. Finally, we will discuss the feasibility of more statistically demanding ESE studies for the upcoming LHC run 2 and 3 data.
[1] Ultra-relativistic nuclear collisions: Event shape engineering, J. Schukraft, A. Timmins, S. Voloshin, J. Phys. Lett. B **719** (2013) 394–398

**Primary author(s) :** TIMMINS, Anthony Robert (University of Houston (US))

**Presenter(s) :** TIMMINS, Anthony Robert (University of Houston (US))

**Session Classification :** Collective Dynamics I

**Track Classification :** Collective Dynamics

Contribution ID : **375** Type : **Contributed talk**

# PHENIX measurement of $b\bar{b}$ production in $p$+$p$ collisions

*Tuesday, 29 September 2015 09:00 (0:20)*

## On behalf of collaboration:

PHENIX

## Abstract Content

PHENIX has measured the $b\bar{b}$ production cross section in $p$+$p$ collisions at $\sqrt{s} = 500$˜GeV. In the absence of displaced-vertex $b$-tagging, this is made possible by exploiting the properties of $B^0 - \overline{B^0}$ oscillations. Like-sign muon pairs in the PHENIX muon arms are measured in order to extract this signal. We report the $b\bar{b}$ differential cross section in the rapidity range $1.2 < |y| < 2.2$, for dimuon masses in the range 5–10˜GeV/$c^2$, and extrapolate to the total-production cross section.

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**Presenter(s) :** SEN, Abhisek (Georgia State University)

**Session Classification :** Open Heavy Flavors and Strangeness III

**Track Classification :** Open Heavy Flavors and Strangeness

Contribution ID : **455** Type : **Contributed talk**

# Measurements of heavy-flavour production in p–Pb collisions with ALICE

*Tuesday, 29 September 2015 09:20 (0:20)*

## On behalf of collaboration:

ALICE

## Abstract Content

The ALICE experiment's heavy-ion programme allows us to study the hot, high energy-density state of matter formed in ultrarelativistic nuclear collisions. In particular, heavy quarks (charm and beauty) serve as calibrated probes of the medium, since they are predominantly produced during the initial hard scatterings in the collision. ALICE's excellent tracking, vertexing and particle identification capabilities allow it to fully reconstruct the hadronic decays of open-charmed D mesons, as well as enabling the study of leptons stemming from charm and beauty decays at forward and mid-rapidity.

Measurements in p–Pb collisions allow us to disentangle experimental observations arising due to the hot and dense medium from those occurring due to cold nuclear matter effects such as momentum broadening, initial-state energy loss, and the modification of nuclear PDFs in the Pb nucleus. In particular, it is possible to measure nuclear modification factors in p–Pb and Pb–Pb collisions in order to determine whether the observed suppression of particles at high $p_{\mathrm{T}}$ in central Pb–Pb collisions is a medium-induced effect. Further insight into cold nuclear matter effects can be obtained by examining the yields of D mesons as a function of charged-particle multiplicity in p–Pb collisions.

Here we present the most recent results from ALICE for charm and beauty production in p–Pb collisions via heavy-flavour decay electrons at mid-rapidity, heavy-flavour decay muons at forward rapidity, and the hadronic decays of $\mathrm{D}^0$, $\mathrm{D}^+$, $\mathrm{D}^{*+}$ and $\mathrm{D}_\mathrm{s}^+$ mesons at mid-rapidity.

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**Session Classification :** Open Heavy Flavors and Strangeness III

**Track Classification :** Open Heavy Flavors and Strangeness

Contribution ID : **522** Type : **Contributed talk**

# Heavy-flavour correlations and multiplicity dependence in pp and p–Pb collisions with ALICE

*Tuesday, 29 September 2015 09:40 (0:20)*

## On behalf of collaboration:

ALICE

## Abstract Content

The study of heavy-quark production (charm and beauty) in pp collisions at LHC energies allows us to test perturbative QCD calculations and provides a reference for studies in heavy-ion collisions. Measurements in p–Pb collisions help to characterize the effects due to the presence of a nucleus in the collision (cold nuclear matter effects). ALICE has provided measurements of the nuclear modification factor $R_{\rm pPb}$ in the heavy-flavour sector. More differential measurements of charm and beauty production in pp and p–Pb collisions can provide further insight on the above topics.

The analysis of angular correlations between heavy-flavour particles and charged particles allows us to characterize the heavy-quark fragmentation process and is sensitive to their production mechanism. Differences between the measurements in pp and p–Pb collisions can give insight on how cold nuclear matter effects affect the heavy-quark production and hadronisation in p–Pb collisions. In the analysis of hadron-hadron correlations in p–Pb collisions, a double-ridge long-range structure was observed, possibly coming from a collective behavior of the system or gluon saturation in the initial state. This feature can be investigated for heavy quarks as well through heavy-flavour correlation studies. Moreover, the study of heavy-flavour production in pp collisions as a function of the charged-particle multiplicity is a powerful tool to investigate the interplay between hard and soft QCD processes responsible for particle production in hadronic collisions and provides information on the role of multi-parton interactions.

We present ALICE measurements of azimuthal correlations between prompt D mesons and heavy-flavour decay electrons with charged hadrons in pp collisions at $\sqrt{s} = 7$ TeV and p–Pb collisions at $\sqrt{s_{\rm NN}} = 5.02$ TeV. We also show the per-event yields of D mesons as a function of the charged-particle multiplicity in pp collisions at $\sqrt{s} = 7$ TeV.

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**Presenter(s) :** COLAMARIA, Fabio Filippo (Universita e INFN, Bari (IT))

**Session Classification :** Open Heavy Flavors and Strangeness III

**Track Classification :** Open Heavy Flavors and Strangeness

Contribution ID : **328** Type : **Contributed talk**

# Medium-effects on heavy-flavour production in large and small systems

*Tuesday, 29 September 2015 10:00 (0:20)*

## On behalf of collaboration:

NONE

## Abstract Content

Predictions obtained with the up-to-date version of our POWLANG transport code for heavy-flavour production in high-energy nuclear (A-A and now also p-A) collisions will be presented. To the usual Langevin evolution in the plasma we added a new modeling of the hadronization stage including the recombination with thermal partons from the medium at the decoupling hypersurface, to form colour-singlet strings eventually fragmented according to the Lund model implemented in PYTHIA. The additional radial and elliptic flow inherited by the heavy-flavour hadrons from the light quarks will affect the final observables, providing a better agreement with the experimental data for RAA and v2. We will show how, with our setup, it is also possible to study more differential observables like various kind of azimuthal correlations: D-h, e-h – for which experimental data start getting available – but also D-Dbar or e+-e-, not yet experimentally accessible but allowing in principle a more direct information on the decorrelation occurred at the partonic level. If the interaction with the medium tends to partially wash-out the initial Q-Qbar angular correlation, the elliptic flow acquired in the medium and at hadronization will tend to introduce a common correlation of all the heavy-flavour hadrons with the reaction plane, which will also contribute to the experimental signal. Finally we will display the first results of our ongoing study on heavy-flavour observables in small systems, like the ones produced in p-Pb or d-Au collisions, trying to check whether the presence of a hot medium suggested by observables in the light sector (e.g. double ridge, elliptic flow...) can leave its fingerprints also in heavy-flavour signals.

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**Session Classification :** Open Heavy Flavors and Strangeness III

**Track Classification :** Open Heavy Flavors and Strangeness

Contribution ID : **355** Type : **Contributed talk**

# A Comprehensive Analysis of Jet Quenching via a Hybrid Strong/Weak Coupling Model for Jet-Medium Interactions

*Tuesday, 29 September 2015 10:50 (0:20)*

## On behalf of collaboration:

None

## Abstract Content

Within a hybrid strong/weak coupling model for jets in strongly coupled plasma, we explore jet modifications in ultra-relativistic heavy ion collisions. Our approach merges the perturbative dynamics of hard jet evolution with the strongly coupled dynamics which dominates the soft exchanges between the fast partons in the jet shower and the strongly coupled plasma itself. We implement this approach in a Monte Carlo, which supplements the DGLAP shower with the energy loss dynamics as dictated by holographic computations, up to a single free parameter that we fit to data. We confront our model with available single jet, dijet and photon-jet data in Pb-Pb collisons at $\sqrt{s} = 2.76\tilde{}$ATeV and we obtain a satisfactory description after fitting one single parameter. We use our model to predict a broad range of dijet, photon-jet and Z-jet observables for the upcoming LHC Run II, at $\sqrt{s} = 5.02\tilde{}$ATeV. We then augment the model by incorporating the transverse momentum picked up by each parton in the shower as it propagates through the medium, at the expense of adding a second free parameter. We use this model to discuss the influence of the transverse broadening of the partons in a jet on intra-jet observables. In addition, we explore the sensitivity of such observables to the back-reaction of the plasma to the passage of the jet. Finally, we comment on the sensitivity of the different observables we have analyzed to the microscopic dynamics of the jet-plasma interaction.

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**Presenter(s) :** Mr. PABLOS, Daniel (Universitat de Barcelona)

**Session Classification :** Jets and High pT Hadrons III

**Track Classification :** Jets and High pT Hadrons

Contribution ID : **83** Type : **Contributed talk**

# Consistency of Perfect Fluidity and Jet Quenching in semi-Quark-Gluon Monopole Plasmas

*Tuesday, 29 September 2015 11:10 (0:20)*

## On behalf of collaboration:

None

## Abstract Content

We utilize a new framework, CUJET3.0, to deduce the energy and temperature dependence of the jet quenching parameter, $\hat{q}(E > 10\ \mathrm{GeV}, T)$, from a combined analysis of available data on the nuclear modification factor and azimuthal asymmetry of high $p_T$ light hadrons and open heavy flavors in high-energy A+A collisions at RHIC and LHC. Extending a previous perturbative QCD based jet energy loss model (known as CUJET2.0) with (2+1)D viscous hydrodynamic backgrounds, this new framework includes three novel features of nonperturbative physics origin: (1) the Polyakov loop suppression of color-electric scatterings and (2) the enhancement of the jet scattering due to emergent chromomagnetic monopoles near $T_c$ and (3) thermodynamic properties constrained by lattice QCD data. CUJET3.0 reduces to CUJET2.0 at high temperatures $T > 400$ MeV, but greatly enhances $\hat{q}$ near the QCD deconfinement transition temperature. This enhancement accounts well for the observed elliptic harmonics of jets with $p_T > 10$ GeV. Extrapolating our data-constrained $\hat{q}$ down to thermal energy scales, $E \sim 2$ GeV, we find for the first time a remarkable consistency between the high energy jet quenching and bulk perfect fluidity with $\eta/s \sim T^3/\hat{q} \sim 0.1$ near $T_c$.

References

[1] Jiechen Xu, Jinfeng Liao, Miklos Gyulassy, arXiv:1411.3673 [hep-ph].

[2] Jiechen Xu, Alessandro Buzzatti, Miklos Gyulassy, JHEP 1408, 063 (2014).

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**Co-author(s) :** Prof. LIAO, Jinfeng (Indiana University); Prof. GYULASSY, Miklos (Columbia University)

**Presenter(s) :** XU, Jiechen (Columbia University)

**Session Classification :** Jets and High pT Hadrons III

**Track Classification :** Jets and High pT Hadrons

Contribution ID : **251** Type : **Contributed talk**

# Direct-photon+hadron correlations to study parton energy loss with the STAR experiment

*Tuesday, 29 September 2015 11:30 (0:20)*

## On behalf of collaboration:

STAR

## Abstract Content

Photons are valuable probes of the QCD plasma due to their lack of color and electric charge. Direct photons ($\gamma_{dir}$), those produced during the collision rather than from decays of hadrons, are not affected by the medium.The study of direct-photon-triggered away-side jets can give information about the energy loss of the away-side parton while traversing through the medium. On the other hand, comparison between the suppression of $\gamma_{dir}$- and $\pi^0$- triggered away-side hadron yields can give information about the path-length and color-factor dependence of parton energy loss.

We report new results of $\gamma_{dir}$+hadron and $\pi^0$+hadron azimuthal correlations as a measure of the away-side jet-like correlated yields in central Au+Au and p+p collisions at $\sqrt{s_{NN}}$ = 200 GeV in the STAR experiment from years 2011 and 2009 of data taking, respectively. The charged-hadron per-trigger yields at mid-rapidity ($|\eta| < 1$) and for transverse momenta $p_T^{assoc} > 1.2$ GeV/c associated with $\gamma_{dir}$ and $\pi^0$ (for triggers $|\eta|$ <0.9, $12 < p_T^{trig} < 20$ GeV/c) in central Au+Au collisions are compared with p+p collisions. With this new low $p_T^{assoc}$ cut, we see evidence for the recovery of the lost energy in the low-momentum range for the constituents of the jet.The $z_T$ ($= \frac{p_T^{assoc}}{p_T^{trig}}$) dependence, now extending down to $z_T$=0.1, of the suppression of the away-side associated yields is presented. The dependence of the suppression on both $p_T^{assoc}$ and $p_T^{trig}$ is also discussed. Finally, these results are compared with various model predictions.

**Primary author(s) :** Dr. SAHOO, Nihar (Texas A & M University)

**Presenter(s) :** Dr. SAHOO, Nihar (Texas A & M University)

**Session Classification :** Jets and High pT Hadrons III

**Track Classification :** Jets and High pT Hadrons

Contribution ID : **377** Type : **Contributed talk**

# PHENIX results on jet correlations via high-$p_T$ hadrons and photons

*Tuesday, 29 September 2015 11:50 (0:20)*

## On behalf of collaboration:

PHENIX

## Abstract Content

Suppression of high $p_T$ hadrons in heavy ion collisions is a well-known phenomenon, understood to be a result of in-medium energy loss of partons. To explore more precisely the underlying energy loss mechanism, PHENIX has measured many complementary observables. Fractional energy loss of single hadrons vs the number of participants in Au+Au and Cu+Cu collisions reveal scaling laws which can constrain models. Back-to-back correlations between direct photons and hadrons provide access to the initial parton energy prior to in-medium interactions. Two-particle correlations with an azimuthal angle selection of the trigger particle with respect to the reaction plane can control for the parton path length inside the medium. Comparing near-side to away-side correlations in $d$+Au collisions to those in $p$+$p$ collisions provides a precise measurement of possible cold nuclear matter effects or other phenomena not yet accounted for. Recent results from PHENIX on high-$p_T$ particle correlations will be presented.

**Primary author(s) :** HANKS, Ali

**Presenter(s) :** HANKS, Ali

**Session Classification :** Jets and High pT Hadrons III

**Track Classification :** Jets and High pT Hadrons

Contribution ID : **340** Type : **Contributed talk**

# Azimuthal anisotropy of charged jet production in $\sqrt{s_{\rm NN}}$ = 2.76 TeV Pb–Pb collisions with ALICE

*Tuesday, 29 September 2015 12:10 (0:20)*

## On behalf of collaboration:

ALICE

## Abstract Content

Jets in heavy-ion collisions are used to probe the QGP, as medium-induced parton energy loss from elastic and radiative interactions between partons and the QCD medium will lead to a modification of the measured jet spectrum. The dependence of the energy loss on the in-medium path length provides deeper insight into the energy loss mechanisms and can be studied by measuring jet production relative to the event plane orientation.
This contribution will show results of measurements of $R = 0.2$ charged jet production in central and peripheral $\sqrt{s_{\rm NN}} = 2.76$ TeV Pb–Pb collisions with respect to the second order event plane, quantified as $v_2^{\rm jet}$. Jet finding is performed with the anti-$k_{\rm T}$ algorithm using charged tracks from the ALICE tracking system. The contribution of hydrodynamic flow to the underlying event energy is taken into account event-by-event; remaining fluctuations are removed on an ensemble basis by unfolding the jet spectra for different event plane orientations separately.
Significant non-zero $v_2^{\rm jet}$ is observed for peripheral collsions for $20 < p_{\rm T} < 100$ GeV/$c$; in central collisions this effect is less pronounced. Comparisons to $v_2$ of charged particles at high momenta and azimuthally dependent jet production studies of ATLAS are given, as well as $v_2^{\rm jet}$ predictions from the JEWEL Monte Carlo, which simulates parton shower evolution in the presence of a dense QCD medium.

**Primary author(s) :** BERTENS, Redmer Alexander (Nikhef National institute for subatomic physics (NL))

**Presenter(s) :** BERTENS, Redmer Alexander (Nikhef National institute for subatomic physics (NL))

**Session Classification :** Jets and High pT Hadrons III

**Track Classification :** Jets and High pT Hadrons

Contribution ID : **365** Type : **Contributed talk**

# PHENIX results on fluctuations and Bose-Einstein correlations in Au+Au collisions from the RHIC Beam Energy Scan

*Tuesday, 29 September 2015 10:50 (0:20)*

## On behalf of collaboration:

PHENIX

## Abstract Content

The RHIC Beam Energy Scan focuses on mapping the QCD phase diagram and pinpointing the location of a possible critical end point. Bose-Einstein correlations and event-by-event fluctuations of conserved quantities, measured as a function of centrality and collision energy, are promising tools in these studies. Recent lattice QCD and statistical thermal model calculations predict that high order cumulants of the fluctuations are sensitive indicators of the phase transition. Products of these cumulants can be used to extract the freeze-out parameters and locate the critical point. Two-pion interferometry measurements are predicted to be sensitive to potential softening of the equation of state and prolonged emission duration close to the critical point. We present recent PHENIX results on fluctuations of net-charge distributions using high-order cumulants and their products in Au+Au collisions at $\sqrt{s_{NN}} = 7.7$–$200$˜GeV, and measurement of two-pion correlation functions and emission-source radii in Cu+Cu and Au+Au collisions at several beam energies. The extracted source radii are compared to previous measurements at RHIC and LHC to study energy dependence of the specific quantities sensitive to expansion velocity and emission duration. The experimental results are compared with different heavy-ion-collision models. Implications for the search of critical point, extraction of freeze-out temperatures, and baryon chemical potentials at various collision energies are discussed.

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**Session Classification :** Correlations and Fluctuations III

**Track Classification :** Correlations and Fluctuations

Contribution ID : **485** Type : **Contributed talk**

# Femtoscopy of identified particles in Pb-Pb collisions with ALICE at the LHC

*Tuesday, 29 September 2015 11:10 (0:20)*

## On behalf of collaboration:

ALICE

## Abstract Content

Femtoscopy allows measurements of the space-time characteristics of particle production using correlations resulting from the effects of quantum statistics and final state interactions. We present the results of femtoscopic analyses for different identified particle systems measured by ALICE in Pb-Pb collisions at 2.76 TeV. Hydrodynamic models predict a decrease of the radii with increasing pair transverse $m_T$ due to radial flow. Correlation measurements of heavy particles extend the range over which the transverse mass dependence of the source radii can be studied and thus can serve, as a tool to learn about the dynamics of he deconfined medium. Particularly, we compare the measured 3D kaon radii with a model where the hydrodynamic phase is succeeded by a hadronic rescattering phase and a purely hydrodynamical calculation. The latter predicts an approximate mT scaling of source radii obtained from pion and kaon correlations. This $m_{\mathrm{T}}$ scaling appears broken in our data, which indicates strong rescattering in the hadronic phase at LHC energies. The emission duration and the decoupling time of the system are also estimated using the three-dimensional femtoscopic analysis for kaons, and compared with such estimates obtained from pions.

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**Session Classification :** Correlations and Fluctuations III

**Track Classification :** Correlations and Fluctuations

Contribution ID : **505** Type : **Contributed talk**

# Femtoscopic measurements in p+Pb collisions at $\sqrt{s_{NN}} = 5.02$ TeV with the ATLAS detector

*Tuesday, 29 September 2015 11:30 (0:20)*

## On behalf of collaboration:

ATLAS

## Abstract Content

Recent measurements in two- and multi-particle correlations in p+Pb collisions suggest collective behavior reminiscent of that observed in Pb+Pb. In addition, the data hint at interesting geometric behavior in ultra-central p+Pb events, where fluctuations in the size of the proton may become significant. Femtoscopic measurements may provide useful insight on both of these problems because they image the spatio-temporal size of the particle emitting region. In particular, the evolution of HBT radii with pair momentum should have a characteristic behavior in the presence of collective expansion. This talk will present identical-pion HBT measurements from ATLAS using one- and three-dimensional correlation functions. Pions are identified using $dE/dx$ measured in the pixel detector. Correlation functions and the resulting HBT radii will be presented as a function of pair momentum ($k_T$) and collision centrality. The contribution to the two-particle correlation function from hard processes is studied in depth, and a new method for completely constraining this background will be described. The measured source sizes are observed to decrease with $k_T$ and increase significantly in more central collisions.

**Primary author(s) :** KOHLER, Markus (Weizmann Institute of Science (IL))

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**Session Classification :** Correlations and Fluctuations III

**Track Classification :** Correlations and Fluctuations

Contribution ID : **118** Type : **Contributed talk**

# Observable consequences of event-by-event fluctuations of HBT radii

*Tuesday, 29 September 2015 11:50 (0:20)*

## On behalf of collaboration:

None

## Abstract Content

One of the major lessons from the field of heavy-ion physics in the past several years has been the significance of the role played by event-by-event fluctuations in the evolution of a heavy-ion collision. Their important effects on many momentum-space observables (particle yields and spectra, anisotropic flows, etc.) have already been studied systematically, and some of the properties of their event-by-event distributions, and their consequences for the extraction of medium properties such as the specific viscosity of the quark-gluon plasma (QGP), are already known.

In this talk it is pointed out that similar event-by-event fluctuations of spatiotemporal observables provide complementary constraints on our understanding of the dynamical evolution of heavy-ion collisions. The relation of Hanbury Brown-Twiss (HBT) radii extracted from ensemble-averaged correlation function measurements to the mean of their event-by-event probability distribution is clarified, and a method to experimentally determine the mean and variance of this distribution is proposed and demonstrated using an ensemble of fluctuating events generated with the viscous hydrodynamic code VISH2+1. The sensitivity of the mean and variance of the HBT radii to the specific QGP shear viscosity $\eta/s$ is studied using simulations with the same code. We report sensitivity of the mean pion HBT radii and their variances to the temperature dependence of $\eta/s$ near the quark-hadron transition at a level similar (10-20%) to that which was previously observed for elliptic and quadrangular flow of charged hadrons.

References:

- Plumberg, C. and Heinz, U. “Interferometric signatures of the temperature dependence of the specific shear viscosity in heavy-ion collisions”, Phys.Rev. C91 (2015) 5, 054905
- Plumberg, C. and Heinz, U. “Probing the properties of event-by-event distributions in Hanbury-Brown–Twiss radii”, (forthcoming)

**Primary author(s) :** PLUMBERG, Christopher (The Ohio State University)

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**Presenter(s) :** PLUMBERG, Christopher (The Ohio State University)

**Session Classification :** Correlations and Fluctuations III

**Track Classification :** Correlations and Fluctuations

Contribution ID : **490** Type : **Contributed talk**

# Measuring baryon-(anti-)baryon interaction cross-sections with femtoscopy in heavy-ion collisions

*Tuesday, 29 September 2015 12:10 (0:20)*

## On behalf of collaboration:

NONE

## Abstract Content

Interaction cross-sections for baryon pairs are of fundamental interest and they are actively investigated theoretically. They are known well for pairs of common (anti-)baryons, however there is a lack of precise data for heavier baryons, including the ones carrying strangeness. The two-particle correlation formalism (femtoscopy) is sensitive to the interaction kernel for a pair of particles, which is related to the pair interaction cross-section [1]. We show how this formalism can be used to extract the cross-sections from the femtoscopic baryon-(anti-)baryon correlation functions [2]. The analysis is complicated by the presence of the so-called "residual correlations" arising from weak decay products in the measured sample. We show how this effect can be exploited to gain further insight into the cross-sections of even heavier baryons. We discuss the limitations of the measurement technique and estimate the discovery potential of currently available and soon-to-be-collected heavy-ion collision datasets at RHIC and at the LHC.

[1] A. Kisiel, H. Zbroszczyk, M. Szymanski; "Extracting baryon-antibaryon strong interaction potentials from p$\Lambda^-$ femtoscopic correlation functions"; Phys.Rev. C89 (2014) 5, 054916
[2] R. Lednicky, V.L. Lyuboshits; "Final State Interaction Effect on Pairing Correlations Between Particles with Small Relative Momenta"; Sov.J.Nucl.Phys. 35 (1982) 770, Yad.Fiz. 35 (1981) 1316-1330

**Primary author(s) :** KISIEL, Adam (Warsaw University of Technology (PL))

**Presenter(s) :** KISIEL, Adam (Warsaw University of Technology (PL))

**Session Classification :** Correlations and Fluctuations III

**Track Classification :** Correlations and Fluctuations

Contribution ID : **24** Type : **Contributed talk**

# Anisotropic hydrodynamics for conformal Gubser flow

*Tuesday, 29 September 2015 10:50 (0:20)*

## On behalf of collaboration:

None

## Abstract Content

We derive the equations of motion for a system undergoing boost-invariant longitudinal and azimuthally-symmetric transverse "Gubser flow" using leading-order anisotropic hydrodynamics. This is accomplished by assuming that the one-particle distribution function is ellipsoidally-symmetric in the momenta conjugate to the de Sitter coordinates used to parameterize the Gubser flow. We then demonstrate that the SO(3)_q symmetry in de Sitter space further constrains the anisotropy tensor to be of spheroidal form. The resulting system of two coupled ordinary differential equations for the de Sitter-space momentum scale and anisotropy parameter are solved numerically and compared to a recently obtained exact solution of the relaxation-time-approximation Boltzmann equation subject to the same flow. We show that anisotropic hydrodynamics describes the spatio-temporal evolution of the system better than all currently known dissipative hydrodynamics approaches. In addition, we prove that anisotropic hydrodynamics gives the exact solution of the relaxation-time approximation Boltzmann equation in the ideal, eta/s -> 0, and free-streaming, eta/s -> infinity, limits.

**Primary author(s) :** STRICKLAND, Michael (Kent State University)

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**Presenter(s) :** STRICKLAND, Michael (Kent State University)

**Session Classification :** Collective Dynamics II

**Track Classification :** Collective Dynamics

Contribution ID : **113** Type : **Contributed talk**

# Effects of the longitudinal event-by-event fluctuations in viscous hydrodynamics.

*Tuesday, 29 September 2015 11:10 (0:20)*

## On behalf of collaboration:

None

## Abstract Content

It has been shown that in the context of ideal hydrodynamics the longitudinal fluctuations affect the flow anisotropies even at midrapidity [1], which implies that in the event-by-event description the deviations from boost invariance are much larger than usually expected. We extend the previous study to dissipative hydrodynamics, and study how different kind of longitudinal fluctuations of energy density and/or longitudinal flow velocity affect the flow anisotropies at different values of eta/s.
[1] L. Pang, Q. Wang and X-N. Wang, Phys. Rev. C86, 024911 (2012)

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**Presenter(s) :** PANG, LongGang (Lawrence Berkeley National Laboratory)

**Session Classification :** Collective Dynamics II

**Track Classification :** Collective Dynamics

Contribution ID : **136** Type : **Contributed talk**

# Hydrodynamic fluctuations and dissipation in an integrated dynamical model

*Tuesday, 29 September 2015 11:30 (0:20)*

## On behalf of collaboration:

NONE

## Abstract Content

Thermal fluctuations arising during hydrodynamic evolution of the system (a.k.a., *hydrodynamic fluctuations*) [1] play an important role in event-by-event hydrodynamic simulations. For example, entropy production fluctuates during the expansion even if we start from a common initial condition in a macroscopic sense [2]. On the other hand, the effect of the fluctuations must be significant in small colliding systems such as p-p, p-A and peripheral A-A collisions [2]. Stability of thermal equilibrium systems is a consequence of an interplay between thermal fluctuations and dissipation. Thus it is indispensable to take the hydrodynamic fluctuations into account in causal dissipative hydrodynamic simulations.
In this study, we develop a new (next-generation) integrated dynamical model to investigate the effects of the hydrodynamic fluctuations on observables in high-energy nuclear collisions. We implement the hydrodynamic fluctuations in a fully 3-D dynamical model consisting of the hydrodynamic initialization models such as Monte-Carlo Kharzeev-Levin-Nardi model and Monte-Carlo Glauber model, causal dissipative hydrodynamics, and the subsequent hadronic cascades. By analyzing the hadron distributions obtained by massive event-by-event simulations with both of the hydrodynamic fluctuations and the initial-state fluctuations, we discuss the effects of the hydrodynamic fluctuations on the flow harmonics, $v_n$, and their fluctuations. This sheds a new light on extracting transport coefficients from observables.

1 K. Murase and T. Hirano, arXiv:1304.3243 [nucl-th].

2 T. Hirano, R. Kurita, K. Murase and K. Nagai, Nucl. Phys. A **931** (2014) 831.

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**Presenter(s) :** MURASE, Koichi (The University of Tokyo)

**Session Classification :** Collective Dynamics II

**Track Classification :** Collective Dynamics

Contribution ID : **320** Type : **Contributed talk**

# The Rapidity Density Distributions and Longitudinal Expansion Dynamics of Identified Pions from the STAR Beam Energy Scan

*Tuesday, 29 September 2015 11:50 (0:20)*

## On behalf of collaboration:

STAR

## Abstract Content

The Beam Energy Scan (BES) at the Relativistic Heavy-Ion Collider was proposed to characterize the properties of the medium produced in heavy-ion interactions over a broad range of baryon chemical potential. The aptitude of the STAR detector for mid-rapidity measurements has previously been leveraged to measure identified particle yields and spectra to extract bulk properties for the BES energies in this kinematic window. However, to extract information on expansion dynamics and full phase space particle production it is necessary to study identified particle rapidity density distributions.

In this talk, we present the first rapidity density distributions of identified pions from Au+Au collisions at $\sqrt{s_{NN}}$ = 7.7, 11.5, 14.5, and 19.6 GeV from the Beam Energy Scan program as measured by the STAR detector. We use these distributions to obtain the full phase space yields of the pions to provide additional information of the system's chemistry. Further, we report the width of the rapidity density distributions compared to the width expected from Landau hydrodynamics. Finally, we interpret the results as a function of collision energy and discuss them in the context of previous energy scans done at the AGS and SPS.

**Primary author(s) :** FLORES, Chris

**Presenter(s) :** FLORES, Chris

**Session Classification :** Collective Dynamics II

**Track Classification :** Collective Dynamics

Contribution ID : **697** Type : **Contributed talk**

# Studies on longitudinal fluctuations of anisotropy flow event planes in PbPb and pPb collisions at CMS

*Tuesday, 29 September 2015 12:10 (0:20)*

## On behalf of collaboration:

CMS

## Abstract Content

Most studies of anisotropy flow phenomena have assumed a global flow phase angle (or event plane angle) that is boost invariant in pseudorapidity ($\eta$). It was realized in recent years that this assumption may not be valid in presence of initial-state fluctuations, especially along the longitudinal direction. The effect of eta-dependent event plane fluctuations would break the factorization relation of Fourier coefficients from two-particle azimuthal correlations into a product of single-particle anisotropy Fourier harmonics as a function of $\eta$. First study of factorization breakdown effect in $\eta$ is carried out using the CMS detector, which covers a wide $\eta$ range of 10 units. A novel method is employed to suppress nonflow correlations at small pseudorapidity gaps of two particles. Significant eta-dependent factorization breakdown is observed in both PbPb and high-multiplicity pPb collisions. The measurements are presented for various orders of flow harmonics as a function of centrality or event multiplicity classes in PbPb and pPb, and are also compared to three-dimensional hydrodynamic calculations with longitudinal fluctuations. The new results presented here provide new insights into the longitudinal dynamics of relativistic heavy ion collisions, and help improve the three-dimensional modeling of the evolution of the strongly-coupled quark gluon medium.

**Primary author(s) :** GUILBAUD, Maxime (Rice University (US))

**Presenter(s) :** GUILBAUD, Maxime (Rice University (US))

**Session Classification :** Collective Dynamics II

**Track Classification :** Collective Dynamics

Contribution ID : **111** Type : **Contributed talk**

# Heavy quark suppression and D-hadron (D-D) correlations in heavy-ion collisions

*Tuesday, 29 September 2015 10:50 (0:20)*

## On behalf of collaboration:

None

## Abstract Content

Heavy quarks are valuable probes of the dense nuclear matter produced in relativistic heavy-ion collisions. We establish a comprehensive framework that describes their entire temporal evolution in the QGP matter and the subsequent hadron gas. The dynamics of open heavy quarks in the QGP is described using either an improved Langevin approach [1,2] or a linearized Boltzmann approach [3] that both simultaneously incorporate the quasi-elastic scattering and medium-induced gluon radiation processes. The hadronization of heavy quarks into their mesonic bound states is calculated utilizing our hybrid model of fragmentation plus heavy-light quark coalescence [1,2]. And the final rescatterings of heavy hadrons inside the hadron gas are described using the UrQMD model.

Within this newly developed framework, we demonstrate that while quasi-elastic scattering dominates heavy quark energy loss in the QGP at low energies, contributions from gluon radiation at high energies are significant; and the coalescence process is found important for heavy meson production at intermediate $p_{\rm T}$. Our numerical results provide a good description of the $R_{\rm AA}$ and $v_2$ of both $D$ meson and $B$-decay non-prompt $J/\psi$ measured at RHIC and LHC.

In addition, two-particle correlation functions of heavy flavor are explored [4]. We show that while the nuclear modification of the $p_{\rm T}$ imbalance of $D-\bar{D}$ pairs reflects the total energy loss of heavy quarks, their angular correlations are sensitive to the detailed energy loss mechanisms. $D$-hadron correlations are also calculated and shown to be a potential observable quantifying the medium response to the energy deposited by hard probe particles.

[1] S. Cao, G.-Y. Qin, and S. A. Bass, Phys. Rev. C88, 044907 (2013). [2] S. Cao, G.-Y. Qin, and S. A. Bass, arXiv: 1505.01413. [3] Y. He, T. Luo, X.-N. Wang and Y. Zhu, Phys. Rev. C91 054908 (2015). [4] S. Cao, G.-Y. Qin, and S. A. Bass, arXiv: 1505.01869.

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**Presenter(s) :** CAO, Shanshan (Lawrence Berkeley National Lab)

**Session Classification :** Open Heavy Flavors and Strangeness IV

**Track Classification :** Open Heavy Flavors and Strangeness

Contribution ID : **221** Type : **Contributed talk**

# Measurements of $D_s^{\pm}$-meson $R_{CP}$ and $v_2$ in Au+Au collisions at $\sqrt{s_{NN}}$ =200 GeV in STAR

*Tuesday, 29 September 2015 11:10 (0:20)*

## On behalf of collaboration:

STAR

## Abstract Content

Heavy quarks are considered as an excellent probe for the early dynamics in heavy-ion collisions. Among all open charm mesons, $D_s^+(c\bar{s})$ and $D_s^-(\bar{c}s)$ mesons play a unique role to quantify heavy quark diffusion and hadronization in heavy-ion collisions, because of their valence quark compositions. Also, like multi-strange hadrons, $D_s^{\pm}$ mesons are expected to freeze out early and have smaller hadronic interaction cross-section compared with other $D$ mesons. Therefore, the elliptic flow ($v_2$) of $D_s^{\pm}$ is considered to be a better measure of the partonic contribution to the charm hadron $v_2$ than that of $D^0$ or $D^{\pm}$. The new Heavy Flavor Tracker detector, which has been installed recently in the STAR experiment, provides a unique opportunity to reconstruct $D_s^{\pm}$ via displaced vertices at RHIC at $\sqrt{s_{NN}}$ =200 GeV. We will present the first measurement of the nuclear modification factor $R_{CP}$ and $v_2$ of $D_s^{\pm}$ in Au+Au collisions at $\sqrt{s_{NN}}$ = 200 GeV. These results will be compared with those of other open charm mesons and strange mesons to determine how the (possibly) strangeness equilibrated partonic matter affects the $D_s^{\pm}$ meson production. They will also be compared with measurements at the LHC energy to study the energy dependence of the above mentioned phenomena.

**Primary author(s) :** MD, Nasim (Uiniversity of california, Los Angeles)

**Presenter(s) :** MD, Nasim (Uiniversity of california, Los Angeles)

**Session Classification :** Open Heavy Flavors and Strangeness IV

**Track Classification :** Open Heavy Flavors and Strangeness

Contribution ID : **496** Type : **Contributed talk**

# Measurements of Open Heavy Flavor Production in Semi-leptonic Channels in p+p, U+U and Au+Au Collisions at STAR

*Tuesday, 29 September 2015 11:30 (0:20)*

## On behalf of collaboration:

STAR

## Abstract Content

Heavy flavor quarks are suggested as excellent probes to study the strongly interacting Quark-Gluon Plasma (QGP) discovered in high-energy heavy-ion collisions. Measurements of heavy flavor production will advance our understanding of the properties of the QGP. Studies in different heavy-ion collision systems and centralities, and separately for charm and bottom quarks can provide new insights in how partons interact with the QGP, and QGP evolution and dynamics. In this talk, we will present the most recent results on Non-Photonic Electron (NPE) production from semi-leptonic decays of open heavy flavor hadrons with the STAR experiment at the Relativistic Heavy Ion Collider. We will first report updated results on NPE production in p+p collsions at $\sqrt{s}$= 200 GeV with much improved precision and wider kinematic coverage than previous ones. These results are instrumental to test the validity of perturbative QCD calculations, and provide precise references for heavy-ion collisions. Calculations suggest that a 20% higher Bjorken energy density may be reached in U+U collisions, which can lead to a stronger suppression for NPE production. We will also report new results on the nuclear modification factor, $R_{AA}$, for NPE production in the 0-5% most central U+U collisions at $\sqrt{s_{NN}}$=193 GeV and compare with those in Au+Au collisions at $\sqrt{s_{NN}}$=200 GeV. Finally we will report the most recent development in measurements of NPE from open bottom and charm hadron decays separately, utilizing the new Heavy Flavor Tracker of the STAR experiment.

**Primary author(s) :** BAI, Xiaozhi (University of Illinois at Chicago)

**Presenter(s) :** BAI, Xiaozhi (University of Illinois at Chicago)

**Session Classification :** Open Heavy Flavors and Strangeness IV

**Track Classification :** Open Heavy Flavors and Strangeness

Contribution ID : **371** Type : **Contributed talk**

# PHENIX results on heavy-flavor yields at forward rapidity

*Tuesday, 29 September 2015 11:50 (0:20)*

## On behalf of collaboration:

PHENIX

## Abstract Content

PHENIX installed and commissioned a forward silicon vertex tracker (FVTX) in 2012. The complete detector covers the rapidity range of $1.2 < |y| < 2.2$, and each arm has full azimuthal coverage. This acceptance matches that of the PHENIX muon arms. With the barrel silicon vertex detector, the FVTX greatly improves tracking to the collision vertex, and is able to identify secondary particles from in-flight decays. We present the current status of the analysis of $c$ and $b$ production in Cu+Au collisions at $\sqrt{s_{NN}} = 200$˜GeV using the distance of closest approach to the event vertex of inclusive decay muons, and of $b$ production from J/$\psi$ decay. We will also show the current status of a study of $\psi'$ production in Cu+Au collisions. Preliminary results on a reference measurement of $\psi'$ in $p$+$p$ collisions at $\sqrt{s} = 510$˜GeV will be shown. The $c$ and $b$ yields in Cu+Au collisions provide insight into the rapidity dependence of energy loss of heavy flavor in hot nuclear matter. The Cu+Au collisions also offer the opportunity to study $\psi'$ dissociation relative to that of the J/$\psi$ as a function of path length in the nuclear medium.

**Primary author(s) :** BROOKS, Melynda (Los Alamos National Laboratory)

**Presenter(s) :** BROOKS, Melynda (Los Alamos National Laboratory)

**Session Classification :** Open Heavy Flavors and Strangeness IV

**Track Classification :** Open Heavy Flavors and Strangeness

Contribution ID : **501** Type : **Contributed talk**

# RAA and v2 of muons from heavy-quark decays in lead-lead collisions at sqrt(sNN)=2.76TeV with the ATLAS detector

*Tuesday, 29 September 2015 12:10 (0:20)*

## On behalf of collaboration:

ATLAS

## Abstract Content

The ATLAS measurement of the nuclear modification factor (RAA) and the elliptic flow (v2) of muons from heavy quark decays in Pb+Pb collisions at sqrt(s_NN)= 2.76 TeV are presented. The measurements are done over the pT range of 4-14 GeV and over the centrality range of (0-60)% within pseudorapidity interval of $|\eta|<1$. A significant elliptic flow is observed over the full pT range for all centralities. The RAA results are consistent with previous measurements but have much better statistical precision. More than a factor of two suppression of the muon yield relative to scaled pp data is observed in the most central collisions. These measurements give an insight into the interaction of heavy quarks with the bulk medium produced in heavy-ion collisions.

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**Presenter(s) :** MILOV, Alexander (Weizmann Institute of Science (IL))

**Session Classification :** Open Heavy Flavors and Strangeness IV

**Track Classification :** Open Heavy Flavors and Strangeness

Contribution ID : **670** Type : **Contributed talk**

# Dynamical energy loss as a novel tomographic tool of QGP at RHIC and LHC

*Tuesday, 29 September 2015 14:00 (0:20)*

## On behalf of collaboration:

NONE

## Abstract Content

High momentum suppression of light and heavy flavor observables is considered to be an excellent probe of jet-medium interactions in QCD matter created at RHIC and LHC. Utilizing this tool requires accurate suppression predictions for different experiments, probes and experimental conditions, and their unbiased comparison with experimental data. With this goal, we developed the dynamical energy loss formalism towards generating predictions for non-central collisions; the formalism takes into account both radiative and collisional energy loss computed within the same theoretical framework, dynamical (as opposed to static) scattering centers, finite magnetic mass, running coupling and uses no free parameters in comparison with experimental data. Within this formalism, we will provide predictions, and a systematic comparison with experimental data, for a diverse set of suppression data: all available light and heavy flavor probes, lower and high momentum ranges, various centrality ranges and various collision energies at RHIC and LHC. We will also provide clear qualitative and quantitative predictions for the upcoming RHIC and LHC experiments. Comprehensive agreement between our predictions and experimental results provides us with a good deal of confidence that our dynamical energy loss formalism can well explain the jet-medium interactions in QGP, which will be further tested by the obtained predictions for the upcoming data. Application of this model, as a novel high-precision tomographic tool of QGP medium, will also be discussed.

**Primary author(s) :** DJORDJEVIC, Magdalena (Institute of Physics Belgrade)

**Presenter(s) :** DJORDJEVIC, Magdalena (Institute of Physics Belgrade)

**Session Classification :** Jets and High pT Hadrons IV

**Track Classification :** Jets and High pT Hadrons

Contribution ID : **603** Type : **Contributed talk**

# Jet Formation and Interference in Quark Gluon Plasma

*Tuesday, 29 September 2015 14:20 (0:20)*

## On behalf of collaboration:

NONE

## Abstract Content

We study the double inclusive emission of gluons off a hard parton propagating in thin QCD plasma. Within the N=1 opacity approximation, we determine the induced emission pattern of two gluons which are soft compared to the parton energy but hard compared to the medium scale. We assume a wide separation between the energies of those two gluons, but we allow arbitrary ordering of their emission angles. We select the transverse momenta of the induced gluons such that only the softest one may be medium induced. We study the ordering properties of a hard jet forming in the medium by analyzing the interference pattern of the softest gluon with respect to the hard quark-gluon core. We concentrate in the regime in which the formation times of both gluons are comparable and discuss the interplay between interferences and the formation time of the quark-gluon subsystem.

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**Co-author(s) :** TYWONIUK, Konrad (Universitat de Barcelona); Mr. PABLOS, Daniel (Universitat de Barcelona)

**Presenter(s) :** CASALDERREY SOLANA, Jorge (University of Barcelona (ES))

**Session Classification :** Jets and High pT Hadrons IV

**Track Classification :** Jets and High pT Hadrons

Contribution ID : **372** Type : **Contributed talk**

# PHENIX results on reconstucted jets in $p$+$p$ and heavy ion collisions

*Tuesday, 29 September 2015 14:40 (0:20)*

## On behalf of collaboration:

PHENIX

## Abstract Content

PHENIX has measured the inclusive jet cross-section at midrapidity in $p$+$p$ collisions at $\sqrt{s_{NN}}$=200 GeV. Jets were reconstructed from charged particles and electromagnetic calorimeter clusters using the anti-$k_T$ algorithm with $R = 0.3$ and a Gaussian filter reconstruction algorithm. These small radii jet reconstructions are needed as baseline measurements for comparisons with heavy ion collisions. The measurements are unfolded for detector effects and the resulting jet spectra are reported for the transverse momentum range $8 < p_T < 60$ GeV/$c$. These results are compared with theoretical calculations with implications for the sensitivity to the gluon angular emission. Results on reconstructed jets in $d$+Au and Cu+Au collisions at the same $\sqrt{s_{NN}}$=200 GeV are reported and nuclear modification factors $R_{AA}$ compared to those measured via single inclusive hadrons. These results probe the interplay between descriptions of the collision geometry and hard processes, and partonic energy loss in a heavy-ion collision with novel geometry, respectively.

**Primary author(s) :** TIMILSINA, Arbin (ISU)

**Presenter(s) :** TIMILSINA, Arbin (ISU)

**Session Classification :** Jets and High pT Hadrons IV

**Track Classification :** Jets and High pT Hadrons

Contribution ID : **311** Type : **Contributed talk**

# Semi-inclusive charged jet measurements in Au+Au collisions at \sqrt{s_{NN}} = 200 GeV with STAR

*Tuesday, 29 September 2015 15:00 (0:20)*

## On behalf of collaboration:

STAR

## Abstract Content

In this talk we report measurements by the STAR collaboration of the semi-inclusive yield and azimuthal distribution of reconstructed charged jets recoiling from a high p_{T} hadron trigger, in central and peripheral Au+Au collisions at \sqrt{s_{NN}} = 200 GeV. Corrections for the large underlying background to jet observables in heavy-ion collisions are carried out on an ensemble-averaged basis using a novel event-mixing technique, without imposition of a fragmentation bias on the reported jet population. Charged recoil jets with a transverse momentum up to 34 GeV/c are reported without a low-p_{T} cutoff, for jet radii up to R=0.5. We compare the measurements to theoretical calculations and to similar jet measurements at the LHC. These measurements provide insight into the nature of jet quenching, and may probe the quasi-particle degrees of freedom in the Quark-Gluon Plasma.

**Primary author(s) :** SCHMAH, Alexander (Lawrence Berkeley National Lab)

**Presenter(s) :** JACOBS, Peter Martin (Lawrence Berkeley National Lab. (US))

**Session Classification :** Jets and High pT Hadrons IV

**Track Classification :** Jets and High pT Hadrons

Contribution ID : **300** Type : **Contributed talk**

# Measurement of high $p_{\mathrm{T}}$ photons and neutral mesons in $pp$ and Pb-Pb collisions at mid-rapidity with ALICE

*Tuesday, 29 September 2015 15:20 (0:20)*

## On behalf of collaboration:

ALICE

## Abstract Content

The ALICE experiment at the LHC performs measurements of neutral meson and direct photon inclusive spectra at mid-rapidity in a wide $p_{\mathrm{T}}$ range in $pp$, $p$-Pb and Pb-Pb collisions. Photons and neutral mesons ($\pi^0$, $\eta$, $\omega$) are reconstructed via complementary methods, using the ALICE electromagnetic calorimeters, PHOS and EMCal, and by the central tracking system, identifying photons converted into $e^+e^-$ pairs in the material of the inner barrel detectors (TPC and ITS). Prompt direct photons produced in Compton ($q + g \rightarrow \gamma + q$) and annihilation ($q + \bar{q} \rightarrow \gamma + g$) processes can be identified in the EMCal calorimeter combining two techniques: electromagnetic shower shape analysis; and isolation cut analysis (no other particle production along the photon direction in the hard process), making use of the measured particle activity in the EMCal and in reconstructed tracks close to the prompt photon candidate. These methods are efficient in getting rid of photons from neutral meson decays ($\pi^0$ and $\eta$), dominant at high-energy collisions produced at LHC.

Measurements of isolated photons and neutral meson spectra in pp collisions provide valuable data for pQCD calculations and allow us to study scaling properties of hadron production at LHC energies and to constrain the proton parton distribution function. ALICE measured the nuclear modification factor $R_{\mathrm{AA}}$ for the $\pi^0$ production in Pb-Pb collisions at $\sqrt{s_{\mathrm{NN}}}$=2.76 TeV at different collision centralities showing a clear pattern of strong suppression in a hot QCD medium with respect to $pp$ collisions.

In this presentation, we will show $\pi^0$ and $\eta$ spectra in $pp$ and Pb-Pb collisions and isolated photon spectra in $pp$ collisions up to high $p_{\mathrm{T}}$. These results will be compared to state-of-the art theoretical predictions.

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**Presenter(s) :** MORREALE, Astrid (Centre National de la Recherche Scientifique (FR))

**Session Classification :** Jets and High pT Hadrons IV

**Track Classification :** Jets and High pT Hadrons

Contribution ID : **508** Type : **Contributed talk**

# Jet suppression and the flavor dependence of partonic energy loss with ATLAS

*Tuesday, 29 September 2015 15:40 (0:20)*

## On behalf of collaboration:

ATLAS

## Abstract Content

In relativistic heavy ion collisions, a hot medium with a high density of unscreened color charges is produced. One manifestation of the energy loss of jets propagating through the medium is a lower yield of jets emerging from the medium than
expected in the absence of medium effects. Therefore modifications of the jet yield are directly sensitive to the energy loss mechanism. Furthermore, jets with different
flavor content are expected to be affected by the medium in different ways. Parton showers initiated by quarks tend to have fewer fragments carrying a larger fraction of
the total jet energy than those resulting from gluons. Jets containing heavy quarks may lose less energy as the large quark mass suppresses the amount of medium-induced
radiation. This would lead to different relative contributions of inelastic and elastic energy loss. In this talk, the latest ATLAS results on single jet suppression will
be presented. Measurements of the nuclear modification factor, RAA, for fully reconstructed jets are shown. The rapidity dependence of jet suppression is discussed, which
is sensitive to the relative energy loss between quark and gluon jets. New measurements of single hadron suppression out to pT˜150 GeV are also presented, which provide
complementary information to the jet suppression measurements. Finally, a new measurement of the RAA for b-tagged jets is presented. At low b-jet pT, the role of the
heavy quark mass is expected to be maximal and b-jets are dominated by hard scattering processes where the b quark carries most of the momentum. As the jet pT increases,
the flavor dependence of the energy loss is expected to be reduced and a significant contribution to b quark production develops from gluon splitting in the parton shower.
This measurement covers a kinematic range including both regimes and the interplay between the various effects is discussed.

**Primary author(s) :** KOSEK, Tomas (Charles University (CZ))

**Presenter(s) :** KOSEK, Tomas (Charles University (CZ))

**Session Classification :** Jets and High pT Hadrons IV

**Track Classification :** Jets and High pT Hadrons

Contribution ID : **509** Type : **Contributed talk**

# New results on inclusive and reaction plane dependent dijet asymmetry in Pb+Pb collisions with ATLAS

*Tuesday, 29 September 2015 16:00 (0:20)*

## On behalf of collaboration:

ATLAS

## Abstract Content

The phenomenon of events containing highly asymmetric dijet pairs is one of the most striking results in heavy ion physics. It has provided the first direct observation of in-medium jet energy loss at the LHC. Detailed measurements of centrality-dependent dijet imbalance in $\sqrt{s_{NN}} = 2.76$ TeV PbPb collisions using data collected in the 2011 LHC heavy ion run are presented. The new analysis fully corrects to the particle level. The results show a centrality-dependent modification of the dijet asymmetry distribution accompanied by an unmodified angular correlation between two jets in the dijet system. Detailed studies of the dijet asymmetry as a function of the leading jet transverse momentum and jet radius are presented. The reference measurement of the dijet asymmetry in the pp collisions at the same center of mass energy is also shown. The dijet asymmetry measurements are also done while selecting the leading jet at different angles with respect to the second order event-plane. This effectively probes the path-length dependence of the dijet asymmetry at fixed centrality. The variation of the dijet asymmetry with the soft particle $v_2$, at fixed centrality are also measured. To further constrain the energy loss models, the measurement of the correlations between jets that are at small relative angles was performed. The measured neighbouring jet pairs result primarily from hard radiation by the parton that occurs early in the process of the shower formation. These dijet and multijet measurements can provide a better understanding of the correlation of the parton energy-loss with the underlying geometry, help elucidating the role of the fluctuations in the energy loss as well as put some constrains to models in which a part of the parton shower radiates coherently in the response of the medium.

**Primary author(s) :** PEREPELITSA, Dennis Vadimovich (Brookhaven National Laboratory (US))

**Presenter(s) :** PEREPELITSA, Dennis Vadimovich (Brookhaven National Laboratory (US))

**Session Classification :** Jets and High pT Hadrons IV

**Track Classification :** Jets and High pT Hadrons

Contribution ID : **335** Type : **Contributed talk**

# Magnetihydrodynamics and charged flow in non-central heavy ion collisions

*Tuesday, 29 September 2015 14:00 (0:20)*

## On behalf of collaboration:

None

## Abstract Content

Strong magnetic fields produced in any non-central heavy ion collision are expected to affect the dynamics of the hot QCD matter produced in this collision. The magnetic field is time-dependent and the conducting medium is expanding, which leads to the induction of charged currents due to the combination of Faraday and Hall effects. We extend our previous work by studying the imprint of the magnetic fields produced in non-central heavy ion collisions on the azimuthal distributions and correlations of the produced charged hadrons by employing a hydrodynamic description of the expanding cooling droplet of liquid produced in a heavy ion collision combined with the electromagnetic effects in a perturbative fashion. We use the Cooper-Frye freeze-out procedure to obtain the azimuthal hadron distributions. We find that the charged currents induced by the presence of the electromagnetic fields result in a charge-dependent directed flow $v_1$, elliptic flow $v_2$ and triangular flow $v_3$ that is respectively odd, even, odd in rapidity and always odd under charge exchange. It can be detected by measuring correlations between the directed, elliptic and triangular flow of charged hadrons at different rapidities, $\langle v_i(y_1)v_{i(y_2)}\rangle$. We also investigate the dependence of our model on the various parameters and make estimates of the magnitude of the charge-dependent flow observables expected at RHIC and the LHC.

**Primary author(s) :** RAJAGOPAL, Krishna (Massachusetts Inst. of Technology (US)); KHARZEEV, Dmitri (Stony Brook University); GURSOY, Umut (Utrecht University)

**Presenter(s) :** GURSOY, Umut (Utrecht University)

**Session Classification :** Correlations and Fluctuations IV

**Track Classification :** Correlations and Fluctuations

Contribution ID : **156** Type : **Contributed talk**

# Charge-dependent correlations from event-by-event anomalous hydrodynamics

*Tuesday, 29 September 2015 14:20 (0:20)*

## On behalf of collaboration:

None

## Abstract Content

The chiral magnetic effect (CME) has received considerable attention in recent years, particularly in the context of heavy-ion collisions. The anomaly-induced transport effects like the CME are macroscopic and are incorporated into hydrodynamic equations giving rise to "anomalous hydrodynamics". Theoretically, the CME is expected to occur in heavy-ion collisions. The data reported by STAR[1] and PHENIX[2] collaborations at RHIC and ALICE collaborations [3] at the LHC show a behavior consistent with the CME, but the quantitative understanding is still lacking. In order to reach a definitive conclusion, a reliable theoretical tool that can describe the charge-dependent observables is indispensable.
In this contribution, we report our recent attempt of quantitative modeling of the CME for heavy-ion collisions. We develop an event-by-event hydrodynamic model which includes the anomalous transport effects. We perform 3+1 dimensional anomalous hydrodynamic simulations, with constitutive equations that contain the anomaly-induced effects. We also develop a model of the initial condition for the axial charge that captures the statistical nature of random chirality imbalance created by color flux tubes. Basing on the event-by-event hydrodynamic simulations for hundreds of thousands of collisions, we calculate the correlation functions that are measured in experiments, and discuss how the anomalous transports affect the observables.
[1] B. I. Abelev et al. [STAR Collaboration], Phys. Rev. Lett. 103, 251601 (2009); B. I. Abelev et al. [STAR Collaboration], Phys. Rev. C 81, 054908 (2010).
[2] A. Ajitanand, S. Esumi, R. Lacey [PHENIX Collaboration], Proc. of the RBRC Workshops, vol. 96, 2010.
[3] P. Christakoglou [ALICE Collaboration] 2011 J. Phys. G: Nucl. Part. Phys. 38 124165.
[4] Y. Hirono, T. Hirano, and D. E. Kharzeev, [arXiv:1412.0311]

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**Co-author(s) :** HIRANO, Tetsufumi (Sophia Univ); KHARZEEV, Dmitri (Stony Brook University)

**Presenter(s) :** HIRONO, Yuji (Stony Brook University)

**Session Classification :** Correlations and Fluctuations IV

**Track Classification :** Correlations and Fluctuations

Contribution ID : **258** Type : **Contributed talk**

# The ridge and di-hadron correlations from the Beam Energy Scan at RHIC

*Tuesday, 29 September 2015 14:40 (0:20)*

## On behalf of collaboration:

STAR

## Abstract Content

Di-hadron correlations are a key observable in heavy-ion collisions, and play a critical role in establishing the equation of state for hot and dense matter. Long range di-hadron correlations, also known as the ridge, have been observed at the top RHIC energies and the LHC in A+A, p+A, and d+A collisions and are crucial to probing the collectivity of the various systems. We will present the first set of results of 2D di-hadron correlations ($\Delta\phi, \Delta\eta$) for Au+Au collisions with center-of-mass energies 7, 11.5, 14.5, 19.6, 27, and 39 GeV from the STAR experiment. Measurements of these correlations will utilize both the TPC and FTPC to provide extensive coverage in azimuth and pseudo-rapidity, where the ranges extend to $0 < \phi < 2\pi$ and $0 < |\eta| < 4$ respectively and are integrated over $0.2 < p_T < 2.0$ GeV/c. We will obtain anisotropy coefficients of orders 2-5 ($v_{2-5}\{2\}$) from the ridge, and show how they depend on energy and centrality. In particular, when scaled by the multiplicity, we find $v_3\{2\}$ shows a non-monotonic behavior as a function of energy. Hints of similar behavior are observed when $v_3\{2\}$ and $v_4\{2\}$ are scaled by $v_2\{2\}$. We will discuss the relevance of this observation in terms of a possible pressure minimum, and how such a minimum might relate to critical point searches in the Beam Energy Scan. Finally, we will analyze the near-side peak, which could be narrowed in the presence of radial flow, via studying its beam-energy and centrality dependence.

**Primary author(s) :** SONG, Liao (University of Houston)

**Presenter(s) :** SONG, Liao (University of Houston)

**Session Classification :** Correlations and Fluctuations IV

**Track Classification :** Correlations and Fluctuations

Contribution ID : **184** Type : **Contributed talk**

# Forward-backward multiplicity fluctuation and longitudinal harmonics in high-energy nuclear collisions

*Tuesday, 29 September 2015 15:00 (0:20)*

## On behalf of collaboration:

NONE

## Abstract Content

One of the largest uncertainties in the modeling of heavy-ion collision arises from present poor understanding of the early-time dynamics especially in the longitudinal direction. Forward-backward (FB) multiplicity correlation has been regarded as a power observable on the early time dynamics since it probe directly the initial state density fluctuations in pseudorapidity. Previous studies of FB multiplicity correlation were primarily based on two-bin or multi-bin correlation method in selected $\eta$ ranges, whose connection to underlying dynamics is complicated by statistical smearing due to finite multiplicity and residual centrality or volume effects. In a recent paper (1506.03496), we have developed a data-driven two-particle correlation method which overcome both limitations and hence allow direct connection between the correlation function and underlying heavy-ion collision dynamics. The robustness and physics potential of the method are demonstrated using the AMPT and HIJING simulation. We found that the long-range component of the FB correlation is captured by a few longitudinal harmonics, with the first component driven by the asymmetry in the number of participating nucleons in the two colliding nuclei and the second component reflecting the EbyE fluctuation of nuclear-stopping. The higher-order longitudinal harmonics are found be strongly damped in AMPT compare to HIJING, due to weaker short-range correlations as well as the final-state effects present in the AMPT model. Two-particle pseudorapidity correlation reveals interesting charge-dependent short-range structures in AMPT model that are absent in HIJING model. The proposed method opens a new avenue to elucidate the particle production mechanism and early time dynamics in heavy-ion collisions. Future analysis directions and prospects of using the pseudorapidity correlation function to understand the centrality bias in p+p, p+A and A+A collisions are discussed.

**Primary author(s) :** JIA, Jiangyong (State University of New York (US)); RADHAKRISHNAN, Sooraj Krishnan (State University of New York (US)); ZHOU, Mingliang (State University of New York (US)); HUO, Peng (State University of New York (US))

**Presenter(s) :** HUO, Peng (State University of New York (US))

**Session Classification :** Correlations and Fluctuations IV

**Track Classification :** Correlations and Fluctuations

Contribution ID : **500** Type : **Contributed talk**

# Measurement of two-particle pseudorapidity correlations in proton-lead and lead-lead collisions with the ATLAS detector

*Tuesday, 29 September 2015 15:20 (0:20)*

## On behalf of collaboration:

ATLAS

## Abstract Content

Two-particle pseudorapidity correlations are measured using charged particles from sqrt(s_NN)=2.76 TeV Pb+Pb collisions by the ATLAS experiment at the LHC. The correlation function CN($\eta$1, $\eta$2) is measured for different centrality intervals for | $\eta$1, $\eta$2|<2.4 and transverse momentum pT>0.5 GeV. An enhancement is observed along $\eta$- =$\eta$1-$\eta$2 ≈0 and a suppression is observed at large $\eta$- values. The correlation function is expanded in Legendre polynomials, and root-mean-square values of the Legendre coefficients at the single particle level an are measured. Significant values are observed for an, which decrease quickly for larger n. The leading coefficient a1 is compared to that estimated from a fit to CN($\eta$+) for different $\eta$- slices, as well as to the asymmetry of the number of participating nucleons between the two colliding nuclei ANpart = (NpartF-NpartB)/ (NpartF+NpartB). The centrality dependence of a1 show a very similar shape as ANpart in mid-central collisions (20-50%), but show faster increase in more central and more peripheral collisions. The latter behavior suggests additional forward-backward multiplicity fluctuations that may arise from fluctuations at the sub-nucleonic level. The status of a similar measurement in proton-lead collisions will be reported. The implications of these measurements for constraining the early time dynamics of high-energy nuclear collisions are discussed.

**Primary author(s) :** JIA, Jiangyong (State University of New York (US))

**Presenter(s) :** JIA, Jiangyong (State University of New York (US))

**Session Classification :** Correlations and Fluctuations IV

**Track Classification :** Correlations and Fluctuations

Contribution ID : **478** Type : **Contributed talk**

# Forward-central two-particle correlations in p-Pb collisions at $\sqrt{s_{NN}}$ = 5.02 TeV

*Tuesday, 29 September 2015 15:40 (0:20)*

## On behalf of collaboration:

ALICE

## Abstract Content

A double-ridge structure has been observed in two-particle correlations in p-Pb collisions at midrapidity and its origin is actively debated. Measurements at larger relative pseudorapidity can further improve our understanding of this phenomenon. The results on two-particle angular correlations between trigger particles in the forward pseudorapidity range ($2.5 < |\eta| < 4.0$) and associated particles at mid-rapidity ($|\eta| < 1.0$) in p-Pb collisions at a nucleon-nucleon center-of-mass energy of 5.02 TeV are reported in the talk. The trigger particles are detected by the ALICE muon spectrometer, and the associated particles by the ALICE central barrel tracking detectors. The reconstructed trigger particles mainly originate from weak decays of primary pions and kaons at low transverse momentum ($p_T$), and heavy-flavor particles at high $p_T$. The ridge is found to persist to the pseudorapidity ranges studied here, and the second-order Fourier coefficients for these measured trigger particles are extracted after subtracting the correlations obtained in low-multiplicity events from those in high-multiplicity events. The Fourier coefficients have a similar pT dependence in the p-going and Pb-going directions, and the ratio of Fourier coefficients in the two directions is calculated as a function of $p_T$. The results are compared with calculations from a parton-cascade model.

**Primary author(s) :** KRYSHEN, Evgeny (CERN)

**Presenter(s) :** KRYSHEN, Evgeny (CERN)

**Session Classification :** Correlations and Fluctuations IV

**Track Classification :** Correlations and Fluctuations

Contribution ID : **479** Type : **Contributed talk**

# Multiplicity and transverse momentum dependence of electric charge balance functions

*Tuesday, 29 September 2015 16:00 (0:20)*

## On behalf of collaboration:

ALICE

## Abstract Content

We report comprehensive results on the balance function as a function of the pseudorapidity and azimuthal angle difference, $\Delta\eta$ and $\Delta\varphi$ respectively, between two charged particles. Results on the multiplicity and transverse momentum ($p_T$) dependence measured with ALICE in pp, p-Pb, and Pb-Pb collisions at 7 TeV, 5.02 TeV, 2.76 TeV are presented. The balance function in both $\Delta\eta$ and $\Delta\varphi$ becomes narrower with increasing multiplicity in all three systems for particles with $0.2 < \mathrm{pT} < 2.0$ GeV/c. The experimental findings favor models that either incorporate some collective behavior (e.g. AMPT) or mimic this using different mechanisms (e.g. PYTHIA8 with color reconnection). For higher values of transverse momenta the balance function becomes even narrower but exhibits no quantitative difference between the three systems. The results add constraints to models that describe collective effects down to small systems (for low values of $p_T$), and particle production mechanisms such as coalescence and fragmentation processes (for inter- mediate and high values of $p_T$).

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**Presenter(s) :** CHRISTAKOGLOU, Panos (Nikhef National institute for subatomic physics (NL))

**Session Classification :** Correlations and Fluctuations IV

**Track Classification :** Correlations and Fluctuations

Contribution ID : **378** Type : **Contributed talk**

# PHENIX results on collectivity tests in high-multiplicity $p$+$p$ and $p$+Au collisions

*Tuesday, 29 September 2015 14:00 (0:20)*

## On behalf of collaboration:

PHENIX

## Abstract Content

Observations of possible collective effects in high-multiplicity $p$+$p$ collisions at the LHC and in $p$+Pb and $d$+Au collisions at the LHC and RHIC challenge our understanding of the requirements for quark-gluon plasma formation. To further investigate this, PHENIX recorded high statistics $p$+$p$ and $p$+Au data sets in 2015. In both cases, high-multiplicity triggers were implemented using the forward silicon detector (FVTX) and the beam-beam counter (BBC) covering pseudorapidity $1.0 < |\eta| < 3.0$ and and $3.1 < |\eta| < 3.9$, respectively. The large high-multiplicity event samples enable highly differential analyses to look for collective effects. We report results on large pseudo-rapidity-separation correlations investigating whether the near-side ridge is seen in high-multiplcity $p$+$p$ events at RHIC. We also report the extraction of flow coefficients from azimuthal anisotropies in $p$+Au and compare the results with theoretical expectations, including viscous hydrodynamics where the elliptic flow strength is expected to be substantially smaller than in $d$+Au and $^3$He+Au at the same energy.

**Primary author(s) :** NAKAGAWA, itaru (RIKEN)

**Presenter(s) :** NAKAGAWA, itaru (RIKEN)

**Session Classification :** QGP in Small Systems II

**Track Classification :** QGP in Small Systems

Contribution ID : **222** Type : **Contributed talk**

# To Be (Collective) or Not to Be (Collective) - Different Theoretical Approaches to Describing Small Collisions System Observables

*Tuesday, 29 September 2015 14:20 (0:20)*

## On behalf of collaboration:

NONE

## Abstract Content

We have investigated the hypothesis that small collision systems (p+A, d+A, 3He+A) at RHIC and the LHC form small droplets of nearly inviscid quark-gluon plasma within the context of hydrodynamic models (Phys.Rev.Lett. 113 (2014) 11, 112301) and with an extension of the AMPT model (arXiv:1501.06880). We explore the constraints on such pictures and the geometric scaling by varying the hydrodynamic viscosity and transition to hadronic cascade, and in AMPT by varying the initial geometry and parton-parton interaction strength. These studies also motivate a beam-energy scan of small systems that may be carried out at RHIC in 2016. We detail predictions for the various observables in this new energy regime. These studies can provide experimental and theoretical handles for elucidating the relevant physics behind small system collectivity with important implications on such observations in large system collisions.

**Primary author(s) :** NAGLE, jamie (University of Colorado)

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**Presenter(s) :** NAGLE, jamie (University of Colorado)

**Session Classification :** QGP in Small Systems II

**Track Classification :** QGP in Small Systems

Contribution ID : **503** Type : **Contributed talk**

# Measurement of the long-range azimuthal correlations in pp collisions at sqrt(s)=13TeV with the ATLAS detector at the LHC

*Tuesday, 29 September 2015 14:40 (0:20)*

## On behalf of collaboration:

ATLAS

## Abstract Content

The ATLAS measurement of azimuthal correlations between particle pairs at large pseudorapidity separation in pp collisions at sqrt(s)=13 TeV are presented. The data were collected using a combination of the minimum-bias and high track-multiplicity triggers. A detailed study of the dependence of two-particle correlations on the charged particle multiplicity, transverse momentum of the pair constituents and the pseudorapidity separation between particles forming a pair is shown. Measurements of multi-particle cumulants in the azimuthal angles of produced particles in wide pseudorapidity ($|\eta|<2.5$) and multiplicity ranges, with the aim to extract a single particle anisotropy coefficient, v2, are also presented. These measurements can help to understand the origin of the long-range correlations seen in high-multiplicity pp and p+Pb collisions.

**Primary author(s) :** ZHOU, Mingliang (State University of New York (US))

**Presenter(s) :** ZHOU, Mingliang (State University of New York (US))

**Session Classification :** QGP in Small Systems II

**Track Classification :** QGP in Small Systems

Contribution ID : **695** Type : **Contributed talk**

# Azimuthal anisotropy harmonics from long-range correlations in high multiplicity pp collisions at CMS

*Tuesday, 29 September 2015 15:00 (0:20)*

## On behalf of collaboration:

CMS

## Abstract Content

Observation of a long-range, near-side, two-particle correlation (known as the "Ridge") in high-multiplicity pp and pPb collisions opened up new opportunities of exploring novel QCD dynamics in small collision systems. While extensive studies of this long-range correlation phenomenon in pPb collisions have revealed its collective properties, the nature of the ridge in pp collisions still remains unknown. New measurements of two-particle angular correlations for charged particles, and identified $K^0_s$ and $\Lambda$ particles emitted in 7 TeV pp collisions are presented using the CMS detector. With the implementation of a high-multiplicity trigger during the 2010 LHC pp run, CMS is capable of probing the most exotic high multiplicity pp collisions. The second-order ($v_2$) and third-order ($v_3$) anisotropy harmonics of charged particles, $K^0_s$ and $\Lambda$ particles are extracted from long-range correlations as a function of particle multiplicity and $p_T$, after correcting for the contribution of back-to-back jet correlations. Four-particle cumulants ($c_2\{4\}$) are also measured for charged particles as a function of multiplicity. The results are compared to 5.02 TeV pPb data covering a similar range of particle multiplicity. These new studies will provide stringent constraints on the possible origin of long-range correlations observed in small collision systems.

**Primary author(s) :** CHEN, Zhenyu (Rice University (US))

**Presenter(s) :** CHEN, Zhenyu (Rice University (US))

**Session Classification :** QGP in Small Systems II

**Track Classification :** QGP in Small Systems

Contribution ID : **463** Type : **Contributed talk**

# Strangeness production as a function of charged particle multiplicity in proton-proton collisions

*Tuesday, 29 September 2015 15:20 (0:20)*

## On behalf of collaboration:

ALICE

## Abstract Content

Recent measurements performed in high-multiplicity proton-proton (pp) and proton-lead (p-Pb) collisions have shown features that are reminiscent of those observed in lead-lead (Pb-Pb) collisions. These observations warrant a comprehensive measurement of the production of identified particles.

We report on the production of $K^0_{\rm S}$, $\Lambda$, $\bar{\Lambda}$, $\Xi^-$, $\bar{\Xi}^+$, $\Omega^-$ and $\bar{\Omega}^+$ at mid-rapidity measured as a function of multiplicity in pp collisions at $\sqrt{s} = 7$ TeV with the ALICE experiment. Spectral shapes studied both for individual particles and via particle ratios such as $(\Lambda/K^0_{\rm S})$ as a function of $p_{\rm T}$ exhibit an evolution with event multiplicity and the production rates of hyperons are observed to increase more strongly than those of non-strange hadrons. These phenomena are qualitatively similar to the ones observed in p-Pb and Pb-Pb collisions.

**Primary author(s) :** BIANCHI, Livio (University of Houston (US))

**Presenter(s) :** BIANCHI, Livio (University of Houston (US))

**Session Classification :** QGP in Small Systems II

**Track Classification :** QGP in Small Systems

Contribution ID : **228** Type : **Contributed talk**

# Causal hydrodynamic fluctuation in Bjorken expansion

*Tuesday, 29 September 2015 15:40 (0:20)*

## On behalf of collaboration:

None

## Abstract Content

We investigate effects of causal hydrodynamic fluctuation on dynamics of the quark gluon plasma (QGP) in Bjorken expansion in high-energy nuclear collisions. The space-time evolution of the QGP can be well described by relativistic hydrodynamics. In the recent hydrodynamic analyses, effects of event-by-event (e-by-e) initial fluctuation on final flow observables have been focused. Moreover, it is hotly debated whether the same hydrodynamic models can be applicable even in small systems such as p-p, p-A, and peripheral A-A collisions. In this study, we focus on thermal fluctuation during hydrodynamic evolution which must be also important on an e-by-e basis of hydrodynamic description, in particular, in small systems. We first introduce causal hydrodynamic fluctuation, namely the thermal noises arising during the hydrodynamic evolution, into the boost invariant Bjorken expansion. We next perform hydrodynamic simulations of the Bjorken model with hydrodynamic fluctuation on an e-by-e basis.

We find the final entropy fluctuates around the mean value even if the initial condition is fixed in a macroscopic sense. We also find the entropy can temporally decreases during the time evolution, which is allowed by the fluctuation theorem in non-equilibrium statistical physics. Fluctuation of entropy results in multiplicity fluctuation as an observable. Through the fluctuation-dissipation relation, hydrodynamic fluctuation is intimately related with dissipation. Thus final multiplicity fluctuation contains transport properties of the QGP. The fluctuation effect would be significant in small system such as p-p, p-A and peripheral A-A collisions. Therefore we may have a chance to constrain the transport properties in such small systems.

We further discuss rapidity [U+3000] dependent hydrodynamic fluctuation on top of boost-invariant Bjorken expansion to see whether long-range rapidity correlation can be contaminated by hydrodynamic fluctuations.

**Primary author(s) :** NAGAI, Kenichi (Sophia university); HIRANO, Tetsufumi (Sophia Univ)

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**Presenter(s) :** NAGAI, Kenichi (Sophia university)

**Session Classification :** QGP in Small Systems II

**Track Classification :** QGP in Small Systems

Contribution ID : **466** Type : **Contributed talk**

# Saturation or collectivity in p+A collisions at RHIC and LHC?

*Tuesday, 29 September 2015 16:00 (0:20)*

## On behalf of collaboration:

NONE

## Abstract Content

I will discuss recent experimental results in proton-proton, proton-lead and deuteron-gold collisions at the LHC and RHIC, and explain how they influence our understanding of non-perturbative QCD at high energy density. Several ideas that may help to disentangle between initial state effects, e.g., the color glass condensate, and final state effects such as hydrodynamics or transport models will be presented. In particular I will discuss the measurement of mean multiplicity vs the number of participants in p+A, the average transverse momentum of produced particles and the elliptic flow as a function of rapidity in p+A, and relations between two-, four-, six- and eight-particle azimuthal anisotropies in p+A and A+A interactions.

**Primary author(s) :** BZDAK, Adam (AGH University of Science and Technology)

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**Presenter(s) :** BZDAK, Adam (AGH University of Science and Technology)

**Session Classification :** QGP in Small Systems II

**Track Classification :** QGP in Small Systems

Contribution ID : **133** Type : **Contributed talk**

# Prospects for the dense baryonic matter research at NICA

*Tuesday, 29 September 2015 14:00 (0:20)*

## On behalf of collaboration:

None

## Abstract Content

The NICA (Nuclotron-based Ion Collider fAcility) project is under preparation at the Joint Institute for Nuclear Research (JINR, Dubna). The main goal of the project is a study of hot and dense strongly interacting matter in heavy ion collisions (up to gold) in the energy range up to $\sqrt{s}\_NN = 11$ GeV. Two modes of operation are foreseen, collider and extracted beams, with two detectors: MPD and BM@N. In the collider mode the designed average luminosity is 10E27 cm-2 s-1 for Au(79+). The proposed experimental program allows one to search for manifestations of the phase transitions and critical phenomena.

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**Session Classification :** Future Experimental Facilities, Upgrades, and Instrumentation

**Track Classification :** Future Experimental Facilities, Upgrades, and Instrumentation

Contribution ID : **714** Type : **Contributed talk**

# Studies of high density baryon matter with high intensity heavy-ion beams at J-PARC

*Tuesday, 29 September 2015 14:20 (0:20)*

## On behalf of collaboration:

[Other]

## Abstract Content

We are developing a future heavy-ion program at J-PARC, which is one of the world's highest intensity proton synchrotrons. In heavy-ion collisions at J-PARC, matter whose density is 8-10 times as high as the normal nuclear density, comparable to that of the neutron star core will be created. There, we aim at exploring QCD phase structures such as the critical point and phase boundaries, and studying modifications of the strong interaction at high baryon density through the investigation of hadron properties and production of exotic hadrons and nuclei. Ions up to U will be accelerated to 1-19 AGeV ($\sqrt{s_{NN}} = 2 - 6.2$ GeV) at the beam rate up to $10^{11}$ ions per cycle of Main Ring synchrotron (MR). We have designed a heavy-ion acceleration scheme with a new linac and a booster as the injector, combined with the existing 3-GeV Rapid-Cycling Synchrotron (RCS) and 50-GeV MR that have been proven to accelerate high-rate proton beams. In heavy-ion experiments, we will measure electrons and muons to study the chiral restoration of vector mesons, and the event-by-event fluctuations of conserved charges to search for the critical point in addition to the conventional systematic studies of various hadrons in the wide energy range. We will also measure particle correlations to study the properties of particle interactions. Last but not least, we will also search for exotic hadrons and nuclei such as dibaryons, kaonic nuclei, and measure hypernuclei at high density, which is one of the important topics in hadron physics. We are designing a large acceptance heavy-ion spectrometer based on a Toroidal magnet to measure hadrons, lepton pairs, and event-by-event fluctuations. We are also designing a closed geometry spectrometer to measure hypernuclei to study weak decays and magnetic moments. In this presentation, the preliminary version of the designed acceleration scheme, as well as the spectrometers and their expected performance and physics results are presented.

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**Session Classification :** Future Experimental Facilities, Upgrades, and Instrumentation

**Track Classification :** Future Experimental Facilities, Upgrades, and Instrumentation

Contribution ID : **45** Type : **Contributed talk**

# Nuclear collisions at the Future Circular Collider

*Tuesday, 29 September 2015 14:40 (0:20)*

## On behalf of collaboration:

None

## Abstract Content

The Future Circular Collider (FCC) is the project for an electron and hadron collider in a new 80-100 km tunnel in the Geneva area. In hadron mode, a centre-of-mass energy of order 100 TeV would be achieved in pp collisions. A design study is under development to be concluded in 2018, with the target start of operation of the machine in 2035-40.

The FCC could operate with heavy ions, providing Pb-Pb and p-Pb collisions at centre-of-mass energies of 39 and 63 TeV, respectively, with monthly integrated luminosities of order 5-10/nb. We will present the updated studies on the physics opportunities with heavy ions at the FCC, emphasising the new developments since last Quark Matter, on four topics: bulk observables with focus on the new degrees of freedom (charm) that can be active; hard probes that are produced more abundantly than at the LHC and offer possibilities for new kinds of studies through boosted heavy objects (such as top quarks) or for quarkonia; small-x studies in p-Pb with the large enlargement of the kinematic x-Qˆ2 plane that the huge collision energy implies; and ultra-peripheral collisions where small-x and electro-weak studies can be performed. Implications on other fields like the physics of very high-energy cosmic rays, will also be presented.

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**Session Classification :** Future Experimental Facilities, Upgrades, and Instrumentation

**Track Classification :** Future Experimental Facilities, Upgrades, and Instrumentation

Contribution ID : **254** Type : **Contributed talk**

# The STAR Heavy Flavor Tracker and Upgrade Plan

*Tuesday, 29 September 2015 15:00 (0:20)*

## On behalf of collaboration:

STAR

## Abstract Content

The Heavy Flavor Tracker (HFT) of the STAR experiment at RHIC is the first application of the state-of-the-art thin Monolithic Active Pixel Sensors (MAPS) technology in a collider environment. The HFT, composed of two silicon PiXeL detector (PXL) layers, an Intermediate Silicon Tracker (IST) and a Silicon Strip Detector (SSD), greatly improves the impact parameter resolution of STAR tracking and enables reconstruction of hadronic decays of heavy flavor mesons and baryons in the heavy ion collision environment, providing unique probes for studying the Quark-Gluon Plasma. In this talk we will discuss the HFT hardware design, and current detector status and performance.

The HFT was successfully commissioned during the 2014 RHIC run, taking data in Au+Au collisions at 200 GeV. The HFT performance during this run matches the expected performance, most significantly for track pointing resolution. We will show preliminary results from 2014 Au+Au data analyses, demonstrating the capabilities of charm reconstruction with the HFT. We will also describe recent modifications to HFT subsystems to improve its reliability, material budget, and tracking in the 2015 run, when the HFT has been taking data in p+p, p+Au and p+Al collisions at $\sqrt{s_{NN}}$ =200 GeV.

In order to extend these capabilities of measuring bottom quark hadrons at RHIC energies, a faster heavy flavor tracker (HFT+) is needed to collect data at higher luminosity with good efficiency. The proposed HFT+ will be equipped with new generation of MAPS sensors with a much shorter integration time ($\leq 20$ μs) and possibly extend the current PXL detector acceptance with minimal modification to the original mechanical and air cooling infrastructure. Requirements for the upgraded HFT+ detector and expected performance will be also presented in this talk.

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**Presenter(s) :** CONTIN, Giacomo (Lawrence Berkeley National Lab. (US))

**Session Classification :** Future Experimental Facilities, Upgrades, and Instrumentation

**Track Classification :** Future Experimental Facilities, Upgrades, and Instrumentation

Contribution ID : **373** Type : **Contributed talk**

# sPHENIX calorimeter design and jet performance

*Tuesday, 29 September 2015 15:20 (0:20)*

## On behalf of collaboration:

PHENIX

## Abstract Content

The PHENIX collaboration is planning a major detector upgrade, sPHENIX, consisting of large acceptance calorimetry and precision tracking in conjunction with the recently acquired BaBar 1.5˜T superconducting solenoid. The sPHENIX calorimeter system consists of an inner layer of tungsten-scintillating fiber electromagnetic calorimeter surrounded by two layers of sampling hadronic calorimeters made of scintillator tiles and metal plates. The calorimeters provide full azimuthal coverage for $|\eta| < 1$ for calorimetry-based jet measurements and low bias jet triggering, enabling a very rich jet physics program at RHIC. We present the current state of the sPHENIX calorimeter design along with studies of their expected performance for jet measurements.

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**Session Classification :** Future Experimental Facilities, Upgrades, and Instrumentation

**Track Classification :** Future Experimental Facilities, Upgrades, and Instrumentation

Contribution ID : **360** Type : **Contributed talk**

# Upgrade of the ALICE Inner Tracking System

*Tuesday, 29 September 2015 15:40 (0:20)*

## On behalf of collaboration:

ALICE

## Abstract Content

During the long shutdown of the LHC in 2018/19 (LS2) the present Inner Tracking System (ITS) of the ALICE experiment based on silicon pixel, silicon drift and silicon strip detectors, will be entirely replaced by a new tracker using novel monolithic silicon pixel chips. This new tracker will significantly enhance heavy flavor measurements, which are out of reach for the present system, e.g. charmed baryons, such as the ΛC, and will allow studying hadrons containing a beauty quark. The new tracker will provide an improved pointing resolution in r-[U+2010] φ and z, decreasing the present values by a factor 3 and 5, respectively, to about 40 microns for a pT of 500 MeV/c. Each of the seven layers will be constructed using 50 micron thin silicon chips on a very light weight carbon fiber based support structure, allowing to achieve a very low material budget for the first three layers of 0.3% X0/layer and 0.8% X0/layer for the four outer layers. The innermost layer will be placed at 23 mm radius, compared to presently 39 mm. Furthermore, the readout rate of the new ITS will increase from presently 1kHz to 50 kHz for Pb-[U+2010]Pb collisions and 400 kHz for p-[U+2010]p collisions, thus matching the expected event rate for Pb-[U+2010]Pb collisions after LS2. This presentation will provide an overview of the upgrade of the ALICE ITS and the expected performance improvement. It will present the actual status of the R&D and give an outlook on the construction phase starting in 2016.

**Primary author(s) :** RIEDLER, Petra (CERN)

**Presenter(s) :** RIEDLER, Petra (CERN)

**Session Classification :** Future Experimental Facilities, Upgrades, and Instrumentation

**Track Classification :** Future Experimental Facilities, Upgrades, and Instrumentation

Contribution ID : **361** Type : **Contributed talk**

# The ALICE TPC: from wires to GEMs

*Tuesday, 29 September 2015 16:00 (0:20)*

## On behalf of collaboration:

ALICE

## Abstract Content

The ALICE Time Projection Chamber, the largest of its kind, has been operated during the LHC RUN 1 and is being operated during RUN 2, with Multi-Wire Proportional readout Chambers. These chambers feature a Gating Grid which is pulsed at a maximum frequency of about 3 kHz and allows one to amplify the charge produced in triggered events and prevents ions to invade the drift region, such that space-charge distortions are minimized. Analysis of data from LHC Run1 and first look at data from Run2 had demonstrated excellent performance both for particle identification via dE/dx and tracking. A summary of the performance will be presented. For RUN 3 and RUN 4, where collision rates of 50 kHz are expected, our aim is to preserve this excellent performance while removing the inherent rate limitation imposed by the gating grid, such that 50 kHz read-out rate can be achieved. To this end, a new concept for continuous readout at a minimum of space-charge build-up in the drift volume will be adopted. A novel configuration of GEM detectors has been developed that allows one to maintain excellent particle identification and effective ion trapping, by stacking four GEM foils with different hole pitches and operated under an ad hoc field configuration. Results of intensive R&D to achieve this goal will be summarized, including the demonstration of robustness against discharges. We will also discuss the detector production phase, which is just starting, and includes extensive and repeated quality assurance to ensure the reliability of the chambers once they are installed in the TPC.

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**Session Classification :** Future Experimental Facilities, Upgrades, and Instrumentation

**Track Classification :** Future Experimental Facilities, Upgrades, and Instrumentation

Contribution ID : **158** Type : **Contributed talk**

# Does non-monotonic behavior of directed flow signal the onset of deconfinement ?

*Wednesday, 30 September 2015 09:00 (0:20)*

## On behalf of collaboration:

NONE

## Abstract Content

Yes, it does! We investigate the effects of nuclear mean-field on the directed flow $v_1$ in high energy nucleus-nucleus collisions from $\sqrt{s_{NN}} = 2.7$ GeV to 27 GeV incident energies within a transport theoretical model based on the framework of the relativistic quantum molecular dynamics. Specifically, we use the JAM transport model with potentials. Our approach reproduces the rapidity dependence of directed flow data up to $\sqrt{s_{NN}} \approx 9$ GeV showing the significant importance of mean-field. However, the slopes of $dv_1/dy$ at mid-rapidity are positive at $\sqrt{s_{NN}} = 11.7$ and 19.6 GeV, and becomes negative above 27 GeV. Thus the result from a JAM hadronic transport model with nuclear mean-field approach is incompatible with the data. Therefore within our approach, we conclude that the excitation function of the directed flow cannot be explained by the hadronic degree of freedom alone.

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**Session Classification :** Collective Dynamics III

**Track Classification :** Collective Dynamics

Contribution ID : **246** Type : **Contributed talk**

# Bulk evolution of heavy ion collisions in the beam energy scan: New developments and first results

*Wednesday, 30 September 2015 09:20 (0:20)*

## On behalf of collaboration:

NONE

## Abstract Content

The beam energy scan (BES) and upcoming BESII at the Relativistic Heavy Ion Collider (RHIC) aims at pinning down the detailed phase structure of QCD and locate the critical point that marks the transition from a cross-over to a first order phase transition. In order to do this, fundamental theory needs to be linked to experimental observables, and sophisticated dynamical modeling becomes necessary.

We present important advancements in the fluid dynamic description of heavy ion collisions needed to account for the relevant physics of heavy ion collisions with center of mass energies ranging from 7 to 200 GeV. In particular, we present the latest developments in the 3+1 dimensional viscous relativistic simulation MUSIC, including bulk viscosity and finite baryon chemical potential. We construct an equation of state for finite baryon chemical potential, using Taylor expanded lattice QCD data and a hadron resonance gas model. Further we present a new model of the initial state using an extension of the conventional Monte Carlo Glauber model to three spatial dimensions, which provides fluctuating initial distributions of net baryon and entropy densities.

We use this model to compute a wide range of observables, including multiplicity and net-baryon rapidity distributions, as well as directed and higher order flow as functions of rapidity and beam energy. We discuss the sensitivity of various observables to the details of the equation of state, the transport parameters of the produced medium, and transverse and longitudinal geometric fluctuations, which will help guide experimental efforts in the BESII.

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**Session Classification :** Collective Dynamics III

**Track Classification :** Collective Dynamics

Contribution ID : **492** Type : **Contributed talk**

# Study of the Bulk Properties of the System Formed in Au+Au Collisions at $\sqrt{s_{NN}}$ = 14.5 GeV Using the STAR Detector at RHIC

*Wednesday, 30 September 2015 09:40 (0:20)*

## On behalf of collaboration:

STAR

## Abstract Content

The main goal of the Beam Energy Scan (BES) Program at RHIC is to study the structure of the QCD phase diagram. In the years 2010 and 2011 data were collected for Au+Au collisions at $\sqrt{s_{NN}}$ = 7.7, 11.5, 19.6, 27, 39, 62.4, and 200 GeV. The corresponding baryonic chemical potential ($\mu_B$) ranged from 420 to 20 MeV, leaving a gap of about 100 MeV in the phase space between $\mu_B$ = 315 MeV and 205 MeV for $\sqrt{s_{NN}}$ = 11.5 and 19.6 GeV, respectively. This happened to be the region of phase space where several interesting observations related to bulk properties of the system were reported. In the year 2014, Au+Au collisions at 14.5 GeV (corresponding $\mu_B$ for central collisions $\approx$ 264 MeV) were recorded by the STAR detector.

In this talk we present the first measurements of the transverse momentum spectra and azimuthal anisotropy of all the identified hadrons ($\pi^+$, $\pi^-$, $K^+$, $K^-$, $p(\bar{p})$, $K^0_s$, $\Lambda(\bar{\Lambda})$, and $\phi$) at midrapidity in Au+Au collisions at 14.5 GeV for various collision centralities and compare the results with those from other BES energies. The bulk properties of the system, like the chemical freeze-out conditions and the collectivity extracted from the measured yields of the produced particles will also be presented. A clear centrality dependence in the difference between baryon and anti-baryon elliptic flow is observed. Furthermore, the new data taken at 14.5 GeV show that the baryon-meson splitting of elliptic flow is of the similar order as for the higher beam energies. The energy and centrality dependence of the measurements on the bulk properties will be discussed systematically.

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**Session Classification :** Collective Dynamics III

**Track Classification :** Collective Dynamics

Contribution ID : **476** Type : **Contributed talk**

# Measurements of Correlations between Anisotropic Flow Harmonics in Pb–Pb Collisions in ALICE

*Wednesday, 30 September 2015 10:00 (0:20)*

## On behalf of collaboration:

ALICE

## Abstract Content

Anisotropic flow is one of the key observables used to probe the properties and evolution of the hot and dense matter produced in heavy-ion collisions. It was recently realized that event-by-event initial fluctuations lead to correlations between different harmonics (correlations of $v_n$ and $v_m$ when $n \neq m$), present also in transport model calculations. The strengths of some of these correlations are much more sensitive to QGP transport properties (e.g. $\eta$/s) compared to standalone $v_n$ measurements [1]. In this talk, we report the first ALICE measurements of the correlation strength between various anisotropic flow harmonics. The correlation strength is characterized with multi-particle cumulants of mixed harmonics, which by construction depend only on the fluctuations of magnitudes of the anisotropic flow vectors. A detailed comparison to Monte Carlo models, including AMPT and HIJING, is also presented. These studies further constrain initial conditions, the properties and the evolution of the system in theoretical calculations of heavy-ion collisions.

[1] H. Niemi, G. S. Denicol, H. Holopainen and P. Huovinen, Phys. Rev. C **87** (2013) 054901

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**Session Classification :** Collective Dynamics III

**Track Classification :** Collective Dynamics

Contribution ID : **713** Type : **Contributed talk**

# Charmonium and bottomonium spectral functions from lattice QCD at finite temperature

*Wednesday, 30 September 2015 09:00 (0:20)*

## On behalf of collaboration:

NONE

## Abstract Content

Dissociation of heavy quarkonia is expected to happen in the quark-gluon plasma due to the Debye screening, which causes suppression of quarkonium yields in relativistic heavy ion collisions. Actually the $J/\psi$ suppression in SPS, RHIC and LHC as well as the sequential $\Upsilon$ suppression in LHC have been observed. However, since there are not only the medium effect but also other processes, e.g. cold nuclear matter effects, to contribute to the quarkonium suppression and production, the experimental results are still not fully understood. Therefore theoretical understanding of in-medium quarkonium properties plays an important role to explain the experimental data. Moreover, since the elliptic flow suggesting collective motion of heavy quarks due to the hydrodynamic effects has been observed, in-medium behavior of a single heavy quark is also of great theoretical interest.

In this talk we report our study on charmonium and bottomonium in lattice QCD at finite temperature. Similarly to a previous study [1] simulations have been performed on large and fine isotropic lattices by using quenched gauge field configurations. A couple of lattice spacings towards the continuum limit were also chosen. At temperatures in a range from $0.73T_c$ to $2.2T_c$ we construct charmonium and bottomonium spectral functions from temporal Euclidean meson correlators which have been computed in our previous studies [2,3]. From the temperature and quark mass dependence of the spectral functions we discuss the dissociation of the quarkonium states. We will also extract the transport properties of heavy quarks from the spectral function in the vector channel and estimate the heavy quark diffusion coefficient for both charm and bottom.

[1] H.-T. Ding, A. Francis, O. Kaczmarek, F. Karsch, H. Satz and W. Soeldner, Phys. Rev. D **86**, 014509 (2012).

[2] H. Ohno, PoS LATTICE **2013**, 172 (2014).

[3] H. Ohno, H.-T. Ding and O. Kaczmarek, PoS LATTICE **2014**, 219 (2014).

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**Session Classification :** Quarkonia III

**Track Classification :** Quarkonia

Contribution ID : **612** Type : **Contributed talk**

# Spectral Functions from anisotropic Lattice QCD.

*Wednesday, 30 September 2015 09:20 (0:20)*

## On behalf of collaboration:

[Other]

## Abstract Content

The FASTSUM collaboration has been carrying out lattice simulations of QCD for temperatures ranging from one third to twice the critical temperature, investigating the chiral and deconfining aspects of the transition, as well as the properties of the Quark Gluon Plasma. In this contribution we concentrate on spectral functions and on some of the associated transport coefficients. We work in a fixed scale scheme and use anisotropic lattices which help achieving the desirable fine resolution in the temporal direction, thus facilitating the (ill posed) integral transform from imaginary time to frequency space. We study the pattern of sequential dissociation for charmonium and bottomonium, and analyse the temperature dependence of the masses and width of the surviving states. The results are obtained with a physical strange mass, a pion mass of 400 MeV, and a lattice spacing of 0.12 fm. Simulations at the physical pion mass and with a finer lattice spacing are in progress and their status might be reported as well.

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**Presenter(s) :** LOMBARDO, Maria Paola (INFN)

**Session Classification :** Quarkonia III

**Track Classification :** Quarkonia

Contribution ID : **497** Type : **Contributed talk**

# Measurements of Quarkonium Polarization and Production versus Charged-Particle Multiplicity in p+p Collisions at $\sqrt{s}$ = 500 GeV in the STAR experiment

*Wednesday, 30 September 2015 09:40 (0:20)*

## On behalf of collaboration:

STAR

## Abstract Content

Good knowledge of quarkonium production mechanism in p+p collisions is crucial for interpretation of the heavy-ion results. However, it is still not well understood after decades of effort. Simultaneous measurement of quarkonium spectrum and polarization in a wide kinematic range, notably at high transverse momentum, is suggested as a necessary step towards determination of quarkonium production mechanism. Moreover, an intriguing trend of a sharp increase of the quarkonium yields as a function of charged-particle multiplicity was observed in p+p collisions at $\sqrt{s}$= 7 TeV at the LHC. Such a behavior could be qualitatively explained in the framework of multiparton interactions, hydrodynamic evolution, or the percolation model and the latter two assume the formation of a high density medium. Therefore it is very interesting and important to study if such effects are also present at much lower energies in order to discriminate among these theoretical interpretations.
In this talk, we will present new J/$\psi$ and $\Upsilon$ measurements in p+p collisions at $\sqrt{s}$= 500 GeV with the STAR experiment. The J/$\psi$ polarization is extracted in both helicity and Collins-Soper reference frames and compared with results from other experiments at other energies. Both J/$\psi$ and $\Upsilon$ production as a function of transverse momentum and charged-particle multiplicity are also measured and compared with model calculations.

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**Presenter(s) :** TRZECIAK, Barbara (Czech Technical University in Prague)

**Session Classification :** Quarkonia III

**Track Classification :** Quarkonia

Contribution ID : **686** Type : **Contributed talk**

# CMS Charmonia results from Run I

*Wednesday, 30 September 2015 10:00 (0:20)*

## On behalf of collaboration:

CMS

## Abstract Content

A multi-dimensional analysis of charmonia in pp, pA, and AA collisions with the CMS detector will be presented. The prompt J/psi results are obtained using the $L_{int} = 5.4pb^{-1}$ pp, the $L_{int} = 35nb^{-1}$ pPb, and the $L_{int} = 150\mu b^{-1}$ PbPb data recorded between 2011 and 2013. The prompt J/psi nuclear modification factors ($R_{AA}$) and azimuthal anisotropy ($v_2$) in PbPb will be presented, and their impact on the understanding of the charmonium production will be discussed. In addition, the suppression pattern of prompt psi(2S) and J/psi in pp and PbPb collisions will be compared, addressing the phenomenology of the charmonium excited state versus ground state in a medium. The pPb differential cross-sections of prompt J/psi will be shown in a wide kinematic region, for transverse momentum spanning from 2 to 30 GeV /c and a rapidity interval between -2.87 to 1.93 in the center of mass of the collision. The ratio of yields in forward (p-going beam) and backward (Pb-going beam) directions, $R_{FB}$, is measured, to quantify the asymmetry of cross-sections as a function of $p_T$, rapidity, and event activity. A significant asymmetry is observed for $2 < p_T < 10$ GeV/c region, with no rapidity dependence, and with the effect monotonically increasing for higher event activity.

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**Presenter(s) :** KIM, Yongsun (Korea University (KR))

**Session Classification :** Quarkonia III

**Track Classification :** Quarkonia

Contribution ID : **173** Type : **Contributed talk**

# Thermal photons from a modern hydrodynamical model of heavy ion collisions: status of the direct photon puzzle

*Wednesday, 30 September 2015 09:00 (0:20)*

## On behalf of collaboration:

NONE

## Abstract Content

Early fluid-dynamical calculations of direct photon spectra and momentum anisotropy were found to be systematically smaller than measurements from the RHIC and the LHC, an observation that became known as the "direct photon puzzle". It is shown in this work that the use of a modern hydrodynamical model of heavy ion collisions [1] together with more complete photon emission rates greatly improves agreement with both ALICE and PHENIX data, supporting the idea that thermal photons are the dominant source of direct photon momentum anisotropy in heavy ion collisions. The event-by-event hydrodynamical model used includes, for the first time, both shear and bulk viscosities, along with second order couplings between the two viscosities. Different photon emission rates are investigated, including one that takes into account the effect of confinement on photon emission [2]. The effect of both shear and bulk viscosities on the photon rates is studied and is shown to have a measurable effect on the photon momentum anisotropy. The inclusion of parton energy loss on prompt photons and its importance for comparisons of direct photon calculations with experiments is discussed.
[1] Ryu, Paquet, Shen, Denicol, Schenke, Jeon and Gale. (2015) [arXiv:1502.01675] [2] Gale, Hidaka, Jeon, Lin, Paquet, Pisarski, Satow, Skokov and Vujanovic. (2015) Phys. Rev. Lett. 114, 072301

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**Presenter(s) :** PAQUET, Jean-Francois (McGill University)

**Session Classification :** Electromagnetic Probes I

**Track Classification :** Electromagnetic Probes

Contribution ID : **545** Type : **Contributed talk**

# Jet fragmentation photons in ultrarelativistic heavy-ion collisions

*Wednesday, 30 September 2015 09:20 (0:20)*

## On behalf of collaboration:

None

## Abstract Content

Electromagnetic probes have been expected to be penetrating probes of the early-time dynamics and quark-gluon plasma. Indeed, the photon spectra measured in the recent RHIC and LHC experiments provide us with an opportunity to deepen understanding of the photon emission mechanism, as they have significantly larger anisotropies compared to theoretical estimates by the hydrodynamic modeling of the bulk properties, implying a missing photon production mechanism giving rise to the large anisotropy. This also implies that the sensible production mechanism should be able to provide a good amount of photons so the anisotropy survives in averaging over various photon sources.

We discuss a photon production mechanism associated with the fragmentation of jets of quarks and antiquarks. We show theoretical estimates of the photon yield obtained from a convolution of the phenomenological jet distribution and the photon emission rate by the bremsstrahlung after the hard parton scatterings at the impact of heavy-ion collisions.

Our estimate shows a significant photon yield in a few GeV transverse momentum range and a power low behavior. This transverse momentum dependence may be consistent with a recent observation that the photon spectra measured in distinct collision energies can be fitted by power low exponents and the saturation momentum which characterizes the energy scale before and just after the collisions [Klein-Boesing, McLerran, Phys. Lett. B 741 (2015)]. An implication from this observation is the early-time emission of photons before other scales come into play. As a possible interpretation of the early-time emission, we argue that the power low behavior of the phenomenological jet distribution with an infrared cutoff by the saturation momentum is taken over by the photon spectrum. We also discuss anisotropy of the photon spectrum due to the jet energy loss which captures the anisotropic spatial geometry of the matter.

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**Presenter(s) :** HATTORI, Koichi (RIKEN-BNL Research Center)

**Session Classification :** Electromagnetic Probes I

**Track Classification :** Electromagnetic Probes

Contribution ID : **366** Type : **Contributed talk**

# PHENIX measurements of thermal photon production in Au+Au collisions

*Wednesday, 30 September 2015 09:40 (0:20)*

## On behalf of collaboration:

PHENIX

## Abstract Content

Photons are unmodified once produced in heavy ion collisions, so they provide information about the entire thermal evolution of the medium. PHENIX measured photon yields exceeding that expected from initial hard scattering and observed a large azimuthal anisotropy, $v_2$, of these soft photons with respect to the reaction plane. The large yield and $v_2$ continue to challenge simultaneous quantitative descriptions and raise important questions about the early time dynamics in the medium. More differential measurements provide information to help distinguish various potential explanations for this thermal photon puzzle. We present yields of direct photons from Au+Au collisions at $\sqrt{s_{NN}}$=62.4 GeV and the yield, $v_2$, and $v_3$ from Au+Au collisions at $\sqrt{s_{NN}}$=200 GeV.

**Primary author(s) :** Dr. PETTI, Richard (Brookhaven National Lab)

**Presenter(s) :** Dr. PETTI, Richard (Brookhaven National Lab)

**Session Classification :** Electromagnetic Probes I

**Track Classification :** Electromagnetic Probes

Contribution ID : **287** Type : **Contributed talk**

# Direct Photons in Pb-Pb collisions with ALICE

*Wednesday, 30 September 2015 10:00 (0:20)*

## On behalf of collaboration:

ALICE

## Abstract Content

Direct photons produced in the hot fireball of a heavy-ion collision leave the medium unscathed. Therefore, they are believed to provide information about the very early stage of the collisions. In particular, the direct photon pT spectrum at low pT ($1 < \mathrm{pT} < 4$ GeV/c) might contain information about the initial temperature of the quark-gluon plasma and its space-time evolution. With current state-of-the-art hydrodynamic models a simultaneous description of the yield and flow of low pT direct photons is difficult to achieve, a finding which is referred to as "photon puzzle". In this talk direct photon spectra measured in Pb-Pb collisions at 2.76 TeV are presented. Two independent methods were used, the photon conversion method based on the reconstruction of electron-positron pairs from converted photons and the reconstruction in the electromagnetic calorimeter PHOS. With both methods direct photon spectra were obtained for three centrality classes. The statistical significance of the direct excess is quantified in each case taking into account correlated systematic uncertainties.

**Primary author(s) :** SAHLMUELLER, Baldo

**Presenter(s) :** SAHLMUELLER, Baldo

**Session Classification :** Electromagnetic Probes I

**Track Classification :** Electromagnetic Probes

Contribution ID : **87** Type : **Contributed talk**

# Lattice QCD for Baryon Rich Matter – Beyond Taylor Expansions

*Wednesday, 30 September 2015 09:00 (0:20)*

## On behalf of collaboration:

[Other]

## Abstract Content

Lattice QCD is believed to have limited power for baryon rich QCD matter because of the notorious sign problem. There have been several approaches to circumvent the problem, such as the multi-parameter reweighting method and the pure imaginary chemical potential approach, which can not provide us information beyond $\mu/T = 1$ where $\mu$ is the quark baryon chemical potential and $T$ is temperature. Here we report our recent studies, the canonical approach and the pinning one. We first review the previous methods, and study why we cannot go into large $\mu/T$ regions. Then we present our results which catch the hadron/QGP transition line, although our lattice is still small and the quark mass is heavy.

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**Presenter(s) :** NAKAMURA, Atsushi (RCNP, Osaka Univ)

**Session Classification :** Quark Matter in Astrophysics

**Track Classification :** Quark Matter in Astrophysics

Contribution ID : **122** Type : **Contributed talk**

# QCD constraints on the equation of state for compact stars

*Wednesday, 30 September 2015 09:20 (0:20)*

## On behalf of collaboration:

None

## Abstract Content

In recent years, there have been several successful attempts to constrain the equation of state of neutron star matter using input from low-energy nuclear physics and observational data. We demonstrate that significant further restrictions can be placed by additionally requiring the pressure to approach that of deconfined quark matter at high densities. Remarkably, the new constraints turn out to be highly insensitive to the amount - or even presence - of quark matter inside the stars.
In this framework, we also present a simple effective equation of state for cold quark matter that consistently incorporates the effects of interactions and furthermore includes a built-in estimate of the inherent systematic uncertainties. This goes beyond the MIT bag model description in a crucial way, yet leads to an equation of state that is equally straightforward to use.

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**Presenter(s) :** FRAGA, Eduardo (Universidade Federal do Rio de Janeiro)

**Session Classification :** Quark Matter in Astrophysics

**Track Classification :** Quark Matter in Astrophysics

Contribution ID : **299** Type : **Contributed talk**

# Hot Neutron Stars with Hadron-Quark Crossover

*Wednesday, 30 September 2015 09:40 (0:20)*

## On behalf of collaboration:

NONE

## Abstract Content

Recent observations of 2-solar-mass neutron stars (NSs) give us the problem, ''to be or not to be" for the exotic components such as deconfined quarks in dense matter of NS cores. This is because the first-order phase transition to exotic matter leads to a softening of the equation of state (EOS) so that 2-solar-mass NSs cannot be sustained. In our previous works [1,2], we have constructed the EOS, "CRover-C" EOS (EOS with crossover for cold NSs), assuming a hadron-quark crossover transition from a view that hadrons are not point-like particles but are composed of quarks and a quark percolation would occur when hadrons come near with each other. We have shown this EOS can sustain the massive NSs in spite of the participation of quark degrees of freedom. The point is that the EOS with crossover is made stiff, contrary to the conventional first-order transition, as far as the percolation begins at rather low-density.

The purpose of the present work [3] is to discuss the properties of hot NSs at birth by extending CRover-C EOS to the finite temperature case. Hot NSs are composed of supernova matter characterized by an isentropic nature and a constant lepton fraction owing to a neutrino trapping. In a manner analogous to the cold case, we construct a new EOS of supernova matter, ''CRover-H" (EOS with crossover for hot NSs) and obtain hot-NS models. It is found that the crossover has important effects not only on generating the stiff EOS to sustain 2-solar-mass hot NSs, but also on lowering the internal temperature. It is remarked that during the thermal evolution from hot to cold NSs, the gravitational energy of amount 0.04 solar-mass is released due to the contraction and the spin up of about 14% occurs, in the case of the canonical mass NSs.

[1] K.Masuda, T.Hatsuda and T.Takatsuka, Astrophys. J. 764, 12 (2013)
[2] K.Masuda, T.Hatsuda and T.Takatsuka, PTEP. no.7, 073D01 (2013)
[3] K.Masuda, T.Hatsuda and T.Takatsuka, arXiv:1506.000984[nucl-th]

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**Presenter(s) :** MASUDA, Kota (The Univ. of Tokyo / RIKEN)

**Session Classification :** Quark Matter in Astrophysics

**Track Classification :** Quark Matter in Astrophysics

Contribution ID : **88** Type : **Contributed talk**

# Phenomenological QCD equations of state for massive neutron stars

*Wednesday, 30 September 2015 10:00 (0:20)*

## On behalf of collaboration:

None

## Abstract Content

We construct an equation of state for massive neutron stars based on QCD phenomenology, with special attention to the behavior at density larger than twice of saturation density. Our primary purpose is to delineate the relevant ingredients of equations of state that simultaneously have the required stiffness and satisfy constraints from thermodynamics and causality. We construct the equations of state following the 3-window description proposed by Masuda-Hatsuda-Takatsuka: at low density, we use the APR equation of state; at high density we use the NJL model with supplemental vector and diquark interactions that are inferred from the hadron spectroscopy and nuclear physics; at intermediate density we interpolate the low and high density equations of state. The 3-window approach allows us to consider a class of quark equations of state which have been implicitly omitted in the conventional hybrid construction. In particular, quark matter equation of state can be stiff in this approach. We will argue how the neutrons star mass-radius curves can be related to the microscopic effects in the QCD dynamics.

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**Presenter(s) :** KOJO, Toru (University of Illinois, Urbana-Champaign)

**Session Classification :** Quark Matter in Astrophysics

**Track Classification :** Quark Matter in Astrophysics

Contribution ID : **370** Type : **Contributed talk**

# PHENIX results on centrality dependence of yields and correlations in $d$+Au collisions

*Wednesday, 30 September 2015 10:50 (0:20)*

## On behalf of collaboration:

PHENIX

## Abstract Content

Measurements of the $v_2$ of identified hadrons and of azimuthal correlations between rapidity separated soft particles strongly suggest the presence of collective effects in central $d$+Au collisions at $\sqrt{s_{NN}}$=200 GeV. The good agreement between low viscosity hydrodynamic calculations and experimental results also suggests a close relationship between the effects observed in high multiplicity $d$+Au and heavy-ion collisions. This relationship can be further explored by extending the measurements to higher transverse momentum where physical effects such as jet fragmentation and energy loss begin dominating particle production. Another handle is provided by a detailed study of centrality dependence of the observed phenomena to pinpoint momentum versus centrality domain where the collective effects manifest themselves. Intermediate and high-$p_T$ particle measurements also contribute to the systematic study of the baryon anomaly and jet quenching by placing constraints on cold-nuclear-matter effects. PHENIX has unique capabilities for measuring azimuthal correlations between high $p_T$ neutral pions at midrapidity ($|\eta| < 0.35$) and clusters measured in the muon piston calorimeter (MPC) at forward rapidity ($-3.7 < \eta < -3.1$), providing effective separation of jet bias contributions. We present new PHENIX results on rapidity separated $\pi^0$-MPC azimuthal correlations measured over a wide $p_T$ range in different centrality $d$+Au collisions at $\sqrt{s_{NN}}$=200 GeV. We also report recent PHENIX results on intermediate and high $p_T$ hadron production.

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**Presenter(s) :** SAKAGUCHI, Takao (BNL)

**Session Classification :** Collective Dynamics IV

**Track Classification :** Collective Dynamics

Contribution ID : **475** Type : **Contributed talk**

# Higher harmonic anisotropic flow of identified particles in Pb-Pb collisions with the ALICE detector

*Wednesday, 30 September 2015 11:10 (0:20)*

## On behalf of collaboration:

ALICE

## Abstract Content

Anisotropic flow plays a critical role in establishing the equation of state for the Quark Gluon Plasma. The results at the LHC have demonstrated that the matter created in heavy-ion collisions behaves as a nearly perfect fluid reflected in the low value of the shear viscosity over entropy density ratio ($\eta$/s). The higher flow harmonics are particularly sensitive to the value of $\eta$/s in hydrodynamic calculations. In this talk, we present the first ALICE results on $p_{\mathrm{T}}$ differential $v_2$, $v_3$, $v_4$ and $v_5$ for $\pi^{\pm}$, $\mathrm{K}^{\pm}$, $\mathrm{p}(\overline{\mathrm{p}})$ from the high statistics 2011 heavy-ion run. We investigate how all $v_n$ coefficients evolve with particle mass and centrality for 0-1%, 20-30% and 40-50% centrality percentiles. These new measurements aim at differentiating between models that use different initial conditions, constraining further the value of $\eta$/s and allowing to decouple the influence of the late hadronic stage from the hydrodynamic evolution of the system.

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**Presenter(s) :** MOHAMMADI, Naghmeh (Nikhef National institute for subatomic physics (NL))

**Session Classification :** Collective Dynamics IV

**Track Classification :** Collective Dynamics

Contribution ID : **698** Type : **Contributed talk**

# Principle Component Analysis of two-particle correlations in PbPb and pPb collisions at CMS

*Wednesday, 30 September 2015 11:30 (0:20)*

## On behalf of collaboration:

CMS

## Abstract Content

A Principle Component Analysis (PCA) of two-particle azimuthal correlations as a function of transverse momentum ($p_T$) is presented in PbPb collisions at 2.76 TeV and high-multiplicity pPb collisions at 5.02 TeV. The data were recorded using the CMS detector at the LHC. It has recently been shown that factorization breaking of two-particle azimuthal correlations can be attributed to the effect of initial-state fluctuations. Using a PCA approach, Fourier coefficients of observed two-particle azimuthal correlations as a function of both particles' $p_T$ are characterized into leading and subleading mode terms. The leading modes are essentially equivalent to anisotropy harmonics ($v_n$) previously extracted from event-plane or two-particle correlation methods as a function of $p_T$. The subleading modes represent the largest sources of factorization breaking. In the context of hydrodynamic models, they are a direct consequence of initial-state fluctuations, particularly providing new insights on the radial excitations of initial-state eccentricity. The results are presented over a wide range of centrality and event multiplicity, and are compared to hydrodynamic predictions. Connection to the measurement of $p_T$-dependent flow factorization breaking is also discussed.

**Primary author(s) :** MILOSEVIC, Jovan (University of Belgrade (RS))

**Presenter(s) :** MILOSEVIC, Jovan (University of Belgrade (RS))

**Session Classification :** Collective Dynamics IV

**Track Classification :** Collective Dynamics

Contribution ID : **119** Type : **Contributed talk**

# Pinning down QCD-matter shear viscosity in A+A collisions via EbyE fluctuations using pQCD + saturation + hydrodynamics

*Wednesday, 30 September 2015 11:50 (0:20)*

## On behalf of collaboration:

None

## Abstract Content

We compute the initial fluctuating QCD-matter energy densities produced in ultrarelativistic heavy-ion collisions from NLO perturbative QCD using a saturation conjecture to control soft particle production [1], and describe the subsequent space-time evolution of the system with dissipative fluid dynamics [2], event by event [3]. The resulting centrality dependence of hadronic multiplicities, $p_T$ spectra, and flow coefficients from this pQCD + saturation + hydro ("EKRT") framework are then compared simultaneously to the LHC and RHIC measurements. We also show that the computed probability distributions of relative event-by-event fluctuations of the flow coefficients, that mostly constrain the initial conditions, match well with the LHC measurements. With such a systematic multi-energy and multi-observable analysis we can test the initial state calculation and applicability of hydrodynamics, and also constrain the temperature dependence of the shear viscosity-to-entropy ratio of QCD matter in its different phases. Furthermore, we demonstrate that correlations of two and three event-plane angles provide additional constraints to the temperature dependence of the shear viscosity. As shown in [3], we can describe all these different flow coefficients and correlations remarkably consistently with the shear viscosity that is independent of the collision energy. Using these constraints from the current RHIC and LHC measurements we then predict the charged hadron multiplicities, $p_T$ spectra, flow coefficients and event-plane correlations for the forthcoming 5 ATeV Pb+Pb collisions.

[1] R. Paatelainen, K. J. Eskola, H. Holopainen and K. Tuominen, Phys. Rev. C 87 (2013) 044904.
[2] R. Paatelainen, K. J. Eskola, H. Niemi and K. Tuominen, Phys. Lett. B 731 (2014) 126.
[3] H. Niemi, K. J. Eskola and R. Paatelainen, arXiv:1505.02677 [hep-ph].

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**Presenter(s) :** NIEMI, Harri (Johann Wolfgang Goethe-Universität)

**Session Classification :** Collective Dynamics IV

**Track Classification :** Collective Dynamics

Contribution ID : **90** Type : **Contributed talk**

# Elliptic Anisotropy $v_2$ May Be Dominated by Particle Escape instead of Hydrodynamic Flow

*Wednesday, 30 September 2015 12:10 (0:20)*

## On behalf of collaboration:

NONE

## Abstract Content

It is commonly believed that azimuthal anisotropies in relativistic heavy ion collisions are generated by hydrodynamic evolution of the strongly interacting quark-gluon plasma. Recently, apparent anisotropy signals have been observed in small systems of proton- and deuteron-nucleus collisions, and the signals can again be described by hydrodynamics. A natural question is why hydrodynamics still seems to be applicable to such small systems. Since A Multi-Phase Transport (AMPT), like hydrodynamics, has been quite successful in describing a large amount of experimental data, we investigate the generation of anisotropies in AMPT by analyzing the complete parton collision history. We also use another transport model, the MPC/Cascade, to check the model dependence of our results.

To our surprise, we find [1] that the majority of $v_2$ comes from the anisotropic escape of partons, not from the parton collective flow, for semi-central Au+Au collisions at 200A GeV. Hydrodynamic-type collective flow will eventually dominate over the escape mechanism at unrealistically large parton cross sections. However, even at the parton cross section of 40 mb, the escape mechanism still contributes to about one-third of the final parton $v_2$. The picture is qualitatively the same from both transport models, and for the smaller d+Au system the escape mechanism is more dominant as expected. Our results thus show that elliptic anisotropy $v_2$ is dominated by particle escape instead of hydrodynamic flow in transport models. If confirmed, our finding could change the paradigm of anisotropic flow. Our results also suggest the need for hydrodynamics to include the escape mechanism, without which the extracted viscosity to entropy density ($\eta/s$) ratio would be severely underestimated.

[1] L. He, T. Edmonds, Z.W. Lin, F. Liu, D. Molnar, F.Q. Wang. ArXiv:1502.05572 [nucl-th].

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**Presenter(s) :** Prof. LIN, Zi-Wei (East Carolina University)

**Session Classification :** Collective Dynamics IV

**Track Classification :** Collective Dynamics

Contribution ID : **274** Type : **Contributed talk**

# $J/\psi$ and $\Upsilon$ measurements in the di-muon channel in Au+Au collisions at $\sqrt{s_{NN}}$ = 200 GeV with the STAR experiment

*Wednesday, 30 September 2015 10:50 (0:20)*

## On behalf of collaboration:

STAR

## Abstract Content

Measurements of quarkonium production in heavy-ion collisions have played an essential role in understanding the properties of the Quark Gluon Plasma (QGP) created in such collisions. In particular, $J/\psi$ suppression in the medium has been proposed as a direct probe of the QGP formation, where quarks and gluons are the relevant degrees of freedom. However, regeneration of $J/\psi$ from uncorrelated $c$ and $\bar{c}$ quarks in the medium adds extra complications to the interpretation of $J/\psi$ suppression. The measurement of the second order harmonic coefficient ($v_2$) for $J/\psi$ would help disentangle different production mechanisms since the regenerated $J/\psi$ is expected to inherit the flow of the charm quarks while the primordial $J/\psi$ should have almost zero $v_2$. On the other hand, the contribution from regeneration to $\Upsilon$, $b\bar{b}$ bound states, is much smaller at RHIC energies, making them ideal probes to study the color-screening feature. In early 2014, the Muon Telescope Detector (MTD), designed to trigger on and identify muons based on precise timing information, was fully installed in STAR at mid-rapidity. Due to the low trigger threshold on muon $p_{\mathrm{T}}$, the MTD trigger has a relatively high efficiency for low $p_{\mathrm{T}}$ $J/\psi$, where the regeneration contribution is expected to be the largest. Moreover, the MTD opens the door for separating different $\Upsilon$ states for the first time at STAR as the Bremsstrahlung radiation for muons is much smaller compared to electrons. In this talk, we present the measurements of $J/\psi$ suppression, quantified as the nuclear modification factor $R_{\mathrm{AA}}$, and $v_2$ in Au+Au collisions at $\sqrt{s_{NN}} = 200$ GeV down to zero $p_{\mathrm{T}}$. These measurements bring extra insights into the $J/\psi$ production mechanism in heavy-ion collisions. Furthermore, the measurement of different $\Upsilon$ states is explored within the precision of the available statistics.

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**Session Classification :** Quarkonia IV

**Track Classification :** Quarkonia

Contribution ID : **583** Type : **Contributed talk**

# Observation of a J/psi yield enhancement at very low pT in Pb-Pb collisions at 2.76 TeV

*Wednesday, 30 September 2015 11:10 (0:20)*

## On behalf of collaboration:

ALICE

## Abstract Content

We report on the first measurement of an excess in the yield of J/psi at very low transverse momentum with respect to expectations from hadronic production, performed by ALICE at the LHC in Pb-Pb collisions at 2.76 TeV. Remarkably, the measured nuclear modification factor of J/$\psi$ in the rapidity range $2.5<y<4.0$ reaches about 7 (2) for Pb-Pb collisions in the $p_{\rm T}$ range 0-300 MeV/$c$ and in the 70–90% (50–70%) centrality class. The excess is observed at very low $p_{\rm T}$, below 300 MeV/c, evoking the $p_{\rm T}$ distribution of J/$\psi$ coherent photoproduction measured in ultra peripheral Pb-Pb collisions. The J/$\psi$ production cross section associated with the observed enhancement in the yield is obtained under the hypothesis that coherent photoproduction is the underlying physics mechanism. If this hypothesis is confirmed, the observation of J/$\psi$ coherent photo-production in Pb-Pb collisions at impact parameters smaller than twice the nuclear radius opens new theoretical and experimental challenges. Furthermore, such a new quarkonium production mechanism could become a novel probe of the QGP at LHC energies.

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**Session Classification :** Quarkonia IV

**Track Classification :** Quarkonia

Contribution ID : **687** Type : **Contributed talk**

# CMS bottomonia results from Run I

*Wednesday, 30 September 2015 11:30 (0:20)*

## On behalf of collaboration:

CMS

## Abstract Content

Bottomonia are important probes of the quark-gluon plasma since they are produced at early times and propagate through the medium, mapping its evolution. The production cross section of the three Y states (1S, 2S, 3S) was measured separately using the Compact Muon Solenoid (CMS) experimental apparatus, in pp and PbPb collisions at 2.76 TeV. A strong suppression is observed in PbPb collisions, by up to a factor of 2 and 10 for the Y(1S) and Y(2S) respectively. The Y(3S) was not observed in PbPb collisions, being suppressed by more than 7 at the 95% confidence level. This suppression was seen to also depend on centrality, but not significantly on transverse momentum or rapidity. A similar suppression pattern of the excited states (2S and 3S) as compared to the ground state (1S), though less pronounced than in PbPb data, was observed also when analyzing the pPb data at 5.02 TeV center of mass collision energy. A surprising dependence of the excited over the ground state ratio, as a function of the global event activity, was also found in pPb data. The three states are also observed to be individually more produced in events with more activity, for the three collision systems. In this talk we will present the final CMS results on bottomonium production in the three collisions systems.

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**Session Classification :** Quarkonia IV

**Track Classification :** Quarkonia

Contribution ID : **71** Type : **Contributed talk**

# Upsilon suppression in the QGP at the LHC

*Wednesday, 30 September 2015 11:50 (0:20)*

## On behalf of collaboration:

NONE

## Abstract Content

Heavy quarkonia and in particular, the Upsilon meson as observed by CMS [1] and ALICE [2] have proven to be a very useful tool to investigate the quark-gluon plasma that is likely created in heavy-ion collisions at RHIC and LHC energies.
Here it is suggested that the combined effect of gluon-induced dissociation, collisional damping, screening, and reduced feed-down explains [3,4] most of the suppression of Upsilon states that has been observed in PbPb relative to pp collisions at $\sqrt{s_{NN}} = 2.76$ TeV at the CERN LHC. The formulation includes hydrodynamic expansion of the medium, the relativistic Doppler effect on the dissociation, and the running of the strong-coupling constant. For the centrality-dependent Y(1S) suppression agreement with the CMS data is found. The momentum dependence of the nuclear modification factor is calculated.
The suppression is a clear, albeit indirect, indication for the presence of a Quark-Gluon Plasma at LHC energies. A prediction for the centrality-dependent Y(1S) suppression at the forthcoming LHC energy of 5.125 TeV is presented. Regarding the suppression of the Y(2S) state, additional mechanisms have to be considered.
[1] S. Chatrchyan et al., CMS Collab., Phys. Rev. Lett. 107, 052302 (2011); 109, 222301 (2012).
[2] B. Abelev et al., ALICE Collab., Phys. Lett. B 738, 361 (2014).
[3] F. Nendzig and G. Wolschin, Phys. Rev. C 87, 024911 (2013); J. Phys. G 41, 095003 (2014).
[4] F. Vaccaro, F. Nendzig, G. Wolschin, Europhys. Lett. 102, 420001 (2013)

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**Presenter(s) :** WOLSCHIN, Georg (Heidelberg University)

**Session Classification :** Quarkonia IV

**Track Classification :** Quarkonia

Contribution ID : **711** Type : **Contributed talk**

# Dynamical upsilon-suppression in the Schroedinger-Langevin approach

*Wednesday, 30 September 2015 12:10 (0:20)*

## On behalf of collaboration:

NONE

## Abstract Content

The suppression of upsilon Y(1S) states in AA collisions, observed by the STAR collaboration at RHIC and by the CMS and ALICE collaboration at LHC, is one of the most convincing evidence for the creation of the quark gluon plasma. The precise survival of excited Y(2S) and Y(3S) states vs ground state could even allow to measure the highest temperature reached in those collisions, according for instance to the sequential suppression scenario which is substantiated by calculations of the dissociation temperature based on lattice potentials evaluated at finite temperature.

In our contribution, we address the question of upsilon dissociation resorting to a dynamical approach, i.e. the non-linear Schroedinger-Langevin equation (SLE). In this scheme, the time-dependent real potential implements the Debye-screening while the stochastic forces express the (hard) interactions between the QGP and the $b\bar{b}$ state, possibly leading to instantaneous dissociation. The SLE preserves unitarity and enables to treat the transitions between bound and open quantum states, which are mocked up resorting to imaginary potential in other treatments. It allows to consider a realistic compact initial state, made of a linear superposition of upsilon eigenstates and to preserve quantum coherence in the time-evolution of the $b\bar{b}$ pair. In a stationary QGP, our SLE naturally leads to asymptotic distributions of {Y(1S), Y(2S),...} following correct statistical weights, which allows to make the link with models based on the hypothesis of statistical recombination. This sanity check is a unique feature of our approach.

We will describe the main ingredients of our SLE as well as some of its most important properties. We will then present the suppression prediction resulting from SLE embedded in state-of-the-art evolution scenario of the QGP background, both for RHIC and LHC energies. The relations with other theoretical frameworks will also be described.

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**Session Classification :** Quarkonia IV

**Track Classification :** Quarkonia

Contribution ID : **363** Type : **Contributed talk**

# PHENIX results on low-mass dileptons in Au+Au collisions with the Hadron Blind Detector

*Wednesday, 30 September 2015 10:50 (0:20)*

## On behalf of collaboration:

PHENIX

## Abstract Content

Dileptons are an important probe of the dense medium created in heavy-ion collisions, with sensitivity to chiral symmetry restoration, thermal radiation and in-medium effects. The PHENIX Hadron-Blind Detector (HBD), which took data during RHIC runs 2009–2010, is a proximity-focusing \v{C}erenkov detector operated with pure CF4, directly coupled to a triple GEM readout in a windowless configuration. The HBD was designed to improve the measurement of low-mass dileptons with the aim of confirming or refuting the earlier PHENIX measurement of a strong excess of low-mass di-electrons in central Au+Au collisions. A new, significantly improved analysis procedure has been developed that enables a quantitative understanding of the background in the low-mass region at a sub-percent level. We present the final di-electron results obtained with the PHENIX HBD for Au+Au collisions at $\sqrt{s_{NN}}$=200 GeV, including invariant mass spectra, transverse momentum distributions, and centrality dependence. The results will be compared to published results and to model calculations.

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**Session Classification :** Electromagnetic Probes II

**Track Classification :** Electromagnetic Probes

Contribution ID : **290** Type : **Contributed talk**

# System-size and energy dependences of dielectron excess invariant-mass spectra at STAR

*Wednesday, 30 September 2015 11:10 (0:20)*

## On behalf of collaboration:

STAR

## Abstract Content

Dilepton measurements play an essential role in the study of hot and dense nuclear matter, created in heavy-ion collisions. Dileptons are produced in the whole evolution of the system and escape with minimum interaction with the strongly interacting medium. Thus, they provide information about the various stages of the system during the evolution. In the low mass region ($M_{ee} < 1.1\ GeV/c^2$), they retain information about the in-medium modifications of vector mesons which are considered as a link to chiral symmetry restoration. Recently, it is found in a model calculation that the charged particle multiplicity normalized dilepton excess yield in the low mass region is proportional to the lifetime of the hot, dense medium created in heavy-ion collisions at $\sqrt{s_{NN}}$ = 6-200 $GeV$ [1]. The energy density created in U+U collisions at $\sqrt{s_{NN}}$ = 193 $GeV$ is expected to be higher by about 20% and the medium created might have a longer lifetime compared with the Au+Au collisions at $\sqrt{s_{NN}}$ = 200 $GeV$. Thus it would be interesting to compare the normalized dielectron excess yields in U+U and Au+Au collisions.
In this talk, we will present the invariant mass, transverse momentum, and centrality dependent measurements of dielectron production in U+U collisions at $\sqrt{s_{NN}}$ = 193 $GeV$. With the acceptance correction applied, we will report the invariant dielectron excess mass spectra in U+U collisions at $\sqrt{s_{NN}}$ = 193 $GeV$ and in Au+Au at $\sqrt{s_{NN}}$ = 27, 39, and 62.4 $GeV$. Comparisons with the NA60 results and the STAR measurements in Au+Au collisions at $\sqrt{s_{NN}}$= 19.6 and 200 $GeV$ will be shown. System-size and energy dependences of low mass excess yield will be discussed together with model comparisons.
[1] R. Rapp and H. van Hees, arXiv: 1411.4612.

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**Session Classification :** Electromagnetic Probes II

**Track Classification :** Electromagnetic Probes

Contribution ID : **566** Type : **Contributed talk**

# Low-Mass Dielectron Measurements in pp, p-Pb and Pb-Pb Collisions with ALICE

*Wednesday, 30 September 2015 11:30 (0:20)*

## On behalf of collaboration:

ALICE

## Abstract Content

The measurement of electron-positron pairs (dielectrons) in the low invariant mass region allows to study the vacuum and in-medium properties of light vector mesons. Additionally, dielectrons from semileptonic decays of correlated heavy quark mesons carry information on the heavy-flavour production in the different collision systems. To quantify modifications of the dielectron production in heavy-ion collisions, measurements in pp collisions serve as a reference, while the analysis of p-A collisions allows disentangling cold from hot nuclear matter effects. In the ALICE apparatus at the LHC, electrons at mid-rapidity are identified by their specific energy loss in the Inner Tracking System (ITS) and Time Projection Chamber (TPC), combined with time-of-flight information from TOF. The dielectron invariant mass distributions will be compared to those from the expected hadronic sources in pp collisions at $\sqrt{s} = 7$ TeV and in p-Pb collisions at $\sqrt{s_{\rm NN}} = 5.02$ TeV. From these ones and from pair transverse momentum distributions, we discuss constraints on the heavy-flavour contributions. The status of the analysis of Pb-Pb collisions at $\sqrt{s_{\rm NN}} = 2.76$ TeV will also be presented. Also future prospects of low-mass dielectron measurements with an upgraded ALICE detector after the second LHC long shutdown in 2018 will be discussed.

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**Session Classification :** Electromagnetic Probes II

**Track Classification :** Electromagnetic Probes

Contribution ID : **516** Type : **Contributed talk**

# Vector boson production in p+Pb and Pb+Pb collisions measured with ATLAS at the LHC

*Wednesday, 30 September 2015 11:50 (0:20)*

## On behalf of collaboration:

ATLAS

## Abstract Content

Electroweak boson production processes (W, Z and photon) provide access to the earliest moments of heavy ion collisions. Furthermore, because they do not undergo strong interactions, they are sensitive to the initial-state geometry of the collision and potentially the details of the nuclear parton distribution functions (PDF). ATLAS results on vector boson yields have demonstrated binary collision scaling in Pb+Pb collisions. In p+Pb collisions, the measurement of vector bosons provides possible constraints on the nuclear PDF and insights into the details of the initial collision geometry. We report on the latest results of vector boson production in p+Pb collisions at sqrt(sNN)=5.02 TeV and Pb+Pb collisions at sqrt(sNN)=2.76 TeV. In p+Pb collisions, production yields and lepton charge asymmetry of W bosons are presented as a function of pseudorapidity of the charged lepton and centrality. Photon and Z yields are presented differentially as a function of transverse momentum, rapidity and centrality. The vector boson yields are compared to calculations incorporating different PDF sets, as well as different centrality calculations.

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**Session Classification :** Electromagnetic Probes II

**Track Classification :** Electromagnetic Probes

Contribution ID : **685** Type : **Contributed talk**

# W and Z bosons in pp, pPb and PbPb with CMS

*Wednesday, 30 September 2015 12:10 (0:20)*

## On behalf of collaboration:

CMS

## Abstract Content

Electroweak boson production is an important benchmark process in high-energy heavy-ion collisions at the LHC. W and Z bosons do not participate in the strong interaction and their leptonic decays provide medium-blind probes of the initial state of the collisions. The final results on the W and Z production in pPb collisions at 5.02 TeV, combining both the muon and electron channels, will be presented. When compared to theory calculations that include nuclear modifications to the parton distributions, data show a clear sensitivity to this type of effects. The final results in PbPb collisions at 2.76 TeV, compared to pp collisions at the same center of mass energy, will also be presented. The centrality dependence confirms the binary scaling of hard probes in heavy-ion collisions, while the differential cross sections points to initial state effects small compared to the statistical precision of the available data.

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**Session Classification :** Electromagnetic Probes II

**Track Classification :** Electromagnetic Probes

Contribution ID : **572** Type : **Contributed talk**

# Critical point search from an extended parameter space of lattice QCD at finite temperature and density

*Wednesday, 30 September 2015 10:50 (0:20)*

## On behalf of collaboration:

[Other]

## Abstract Content

Aiming to understand the phase structure of lattice QCD at nonzero temperature and density, we study the phase transitions of QCD in an extended parameter space, where the number of flavor, quark masses, complex chemical potentials and so on are considered as parameters. Performing simulations of 2-flavor QCD with improved staggered and Wilson fermions and using the reweighting method, we calculate probability distribution functions in various systems. An interesting system is (2+Nf)-flavor QCD at finite density, where two light flavors and Nf massive flavors exist. For large Nf, we can easily investigate the critical surface terminating first order phase transitions in the parameter space of the light quark mass, the heavy quark mass and the chemical potential. We determine the critical surface by looking at the shape of distribution functions. Another interesting system is QCD with a complex chemical potential. We investigate the singularities where the partition function vanishes, so-called Lee-Yang zeros, and possible Stokes lines. Through the studies of these systems, we discuss the phase structure of QCD at finite density.

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**Presenter(s) :** EJIRI, Shinji (Niigata University)

**Session Classification :** Baryon Rich QCD Matter

**Track Classification :** Baryon Rich QCD Matter

Contribution ID : **573** Type : **Contributed talk**

# Real time evolution of non-Gaussian cumulants in the QCD critical regime

*Wednesday, 30 September 2015 11:10 (0:20)*

## On behalf of collaboration:

None

## Abstract Content

Enhanced near critical fluctuations can be quantified by the variance of the critical field (the Gaussian cumulant), as well as higher non-Gaussian cumulants such as skewness and kurtosis. These non-Gaussian cumulants are accessible through measurements of event-by-event fluctuations of various particle multiplicities. Non-Gaussian event-by-event fluctuations of multiplicities are generically expected to show nonmonotonic behavior in the proximity of the critical point. These expectations are entirely based on the assumption that the soft modes responsible for critical fluctuations are in equilibrium with the medium. However, the expanding medium created in heavy-ion collisions only spends a limited amount of time in the QCD critical regime and it is unlikely the critical modes remain in equilibrium in this duration.

We derive a coupled set of equations that describe the non-equilibrium evolution of cumulants of critical fluctuations for space-time trajectories on the cross-over side of the QCD phase diagram. In particular, novel expressions are obtained for the non-equilibrium evolution of non-Gaussian Skewness and Kurtosis cumulants. Utilizing a simple model of the space-time evolution of a heavyion collision, we demonstrate that, depending on the relaxation rate of critical fluctuations, Skewness and Kurtosis can differ significantly in magnitude as well as in sign from equilibrium expectations. Memory effects are important and shown to persist even for trajectories that skirt the edge of the critical regime. We use phenomenologically motivated parameterizations of freeze-out curves, and of the beam energy dependence of the net baryon chemical potential, to explore the implications of our model study for the critical point search in heavy-ion collisions.

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**Presenter(s) :** MUKHERJEE, Swagato (Brookhaven National Laboratory)

**Session Classification :** Baryon Rich QCD Matter

**Track Classification :** Baryon Rich QCD Matter

Contribution ID : **73** Type : **Contributed talk**

# Estimation of the shear viscosity at finite net-baryon density from A+A collision data at $\sqrt{s_{NN}} = 7.7 - 200$ GeV

*Wednesday, 30 September 2015 11:30 (0:20)*

## On behalf of collaboration:

NONE

## Abstract Content

We present the first application of state-of-the-art 3D viscous hybrid model to heavy ion collisions at RHIC Beam Energy Scan (BES) energy range $\sqrt{s} = 7.7 \ldots 200$ GeV. The model employs the hadron transport approach UrQMD for the early and late non-equilibrium stages of the reaction, and 3+1 dimensional viscous hydrodynamics for the hot and dense quark-gluon plasma stage. It includes the equation of motion for finite baryon number, and employs an equation of state with finite net-baryon density to allow for calculations in a large range of beam energies. The parameter space of the model is explored, and constrained by comparison with the experimental data for bulk observables from SPS and the phase I BES at RHIC. The favored value of the shear viscosity coefficient over entropy density ratio $\eta/s$ in the fluid phase depends on collision energy. It increases with decreasing collision energy, which may indicate that $\eta/s$ of the quark-gluon plasma increases with increasing baryochemical potential $\mu_B$.
Ref: Iu.A. Karpenko, P. Huovinen, H. Petersen, M. Bleicher, Phys. Rev. C 91, 064901 (2015)

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**Presenter(s) :** KARPENKO, Iurii (Frankfurt Institute for Advanced Studies)

**Session Classification :** Baryon Rich QCD Matter

**Track Classification :** Baryon Rich QCD Matter

Contribution ID : **323** Type : **Contributed talk**

# Measurement of hadron suppression at 14.5GeV and study of its connection with the disappearance of other QGP signatures at low $\sqrt{s_{NN}}$ in Au+Au collisions with STAR at RHIC in BES I

*Wednesday, 30 September 2015 11:50 (0:20)*

## On behalf of collaboration:

STAR

## Abstract Content

At top RHIC energies and at the LHC, the suppression of high transverse momentum ($p_T$) hadrons provides evidence for partonic energy loss in a QGP. We study jet quenching in the RHIC BES by investigating the centrality dependence of the binary-collision-scaled high-$p_T$ yields. In this representation we can see if the scaled yield decreases as we go to larger overlap regions and higher energy densities. Phenomena like radial flow that increase the yield in this measurement are all expected to become stronger for more central collisions. Measurement of a decrease in the scaled yield while studying more central collisions can serve as possible evidence for jet quenching if initial state effects can be accounted for. One such effect is the suppression of per nucleon cross sections in heavier nuclei relative to lighter nuclei for Bjorken $x$ >0.3 first measured by the European Muon Collaboration (EMC). Even at energies and centralities where this signature is lost a QGP may still be formed since the suppression caused by energy loss must overpower all the phenomena responsible for enhancement. Measurements will be shown for several ranges of $p_T$ for 7.7, 11.5, 14.5, 19.6, 27, 39, and 62.4 GeV data showing that relative hadron suppression persists for collisions at least down to 14.5 GeV.

Models have also shown that the development of $v_3$ and a ridge requires the presence of a low viscosity QGP phase. To further investigate the presence of the QGP at these lower energies and whether the observed hadron suppression coincides with onset of other QGP signatures, we cross-examine the energy and centrality dependence of $v_3$. We find that for collisions with $N_{\rm part}$ <50, the ridge and $v_3$ disappear for energies below 14.5 GeV, suggestive of a turn-off of the QGP. But for $N_{part}$ >50, $v_3$ and the ridge persist down to the lowest energies, consistent with the hadron suppression defined in the new variable at the lower beam energies.

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**Presenter(s) :** HORVAT, Stephen (STAR)

**Session Classification :** Baryon Rich QCD Matter

**Track Classification :** Baryon Rich QCD Matter

Contribution ID : **379** Type : **Contributed talk**

# PHENIX results on global observables and flow in Au+Au collisions from the RHIC Beam Energy Scan

*Wednesday, 30 September 2015 12:10 (0:20)*

## On behalf of collaboration:

PHENIX

## Abstract Content

The RHIC Beam Energy Scan explores the high baryon density region of the QCD phase diagram to find signatures of the critical point. PHENIX has measured global observables such as $dN_{ch}/d\eta$ and $dE_T/d\eta$ at midrapidity in Au+Au collisions at $\sqrt{s_{NN}}$=7-200 GeV as well as elliptic ($v_2$) and triangular ($v_3$) flow coefficients for identified charged hadrons at midrapidity in Au+Au collisions at $\sqrt{s_{NN}}$=39-200 GeV. The charged particle and transverse energy densities normalized by number of participants ($N_{\rm part}$) stay constant within uncertainties as a function of $N_{\rm part}$ for collision energies $\sqrt{s_{NN}} < 39$˜GeV. At higher energies the global observables scale with number of quark participants ($N_{qp}$), where $N_{qp}$ is estimated using a modified Glauber model that replaces each nucleon participant with quark participants. This observation is consistent with universal number of constituent quarks scaling of flow coefficients measured for identified hadrons at higher collision energies. Both observations can indicate onset of parton degrees of freedom in the fireball. Elliptic and triangular flows were measured for identified hadrons as a function of transverse momentum and collision centrality. An energy dependent difference of the measured $v_2$ and $v_3$ values between particles and corresponding anti-particles is observed. The difference increases with decreasing beam energy and centrality of collisions. The quality of universal number of quark scaling observed for $v_2$ and $v_3$ at $\sqrt{s_{NN}}$=200 GeV deteriorates with decreasing collision energy.

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**Track Classification :** Baryon Rich QCD Matter