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Book of Abstracts

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High Transverse Momentum Light and Heavy Flavor Hadrons / **0**

Medium-induced gluon radiation beyond the eikonal approximation

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In this work we improve existing calculations of radiative energy loss by computing corrections that implement energy-momentum conservation, previously only implemented a posteriori, in a rigorous way. Using the path-integral formalism, we compute in-medium splittings allowing transverse motion of all particles in the emission process, thus relaxing the assumption that only the softest particle is permitted such movement. This work constitutes the extension of the computation carried out for $x \longrightarrow 1$ in Phys. Lett. B718 (2012) 160-168, to all values of x, the momentum fraction of the energy of the parent parton carried by the emitted gluon. In order to accomplish a general description of the whole in-medium showering process, in this work we allow for arbitrary formation times for the emitted gluon (the limit of small formation times was previously employed in [J.-P. Blaizot, F. Dominguez, E. Iancu, and Y. Mehtar-Tani, JHEP1301 (2013) 143], for the $g \longrightarrow gg$ splitting). We provide general expressions and their realisation in the path integral formalism within the harmonic oscillator approximation.

High Transverse Momentum Light and Heavy Flavor Hadrons / **2**

Dynamical Evolution, Hadronization and Angular De-correlation of Heavy Flavor in Hot and Dense QCD Matter at RHIC and LHC

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Heavy flavor serves as a valuable probe of the transport properties of the quark-gluon plasma created in relativistic heavy-ion collisions. Within the framework of a Langevin equation coupled to a (2+1)-dimensional viscous hydrodynamic model, we introduce an algorithm that incorporates not only collisional, but also radiative energy loss for heavy quarks by treating the medium-induced gluon radiation as a recoil force term for heavy quarks traversing the QGP matter. The subsequent hadronization process is calculated using a hybrid recombination plus fragmentation model. Within this improved transport framework, our calculation shows significant contributions from gluon radiation to heavy quark energy loss at high energies; the recombination mechanism is found important for heavy flavor meson production at intermediate energies. Our numerical results provide a good description of D meson suppression and flow measured at both RHIC and LHC, as well as predictions for the future measurements of B mesons. In addition, a new observable – the angular correlation function of heavy flavor pairs – is explored in our study and found to be a potential candidate for distinguishing different energy loss mechanisms of heavy quarks inside a QGP.

Keywords:

Heavy flavor, Langevin equation, radiative energy loss, hadronization, angular correlation function.

Hard and Thermal Electroweak Probes / **4**

Photon Signals from Quarkyonic Matter

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This contribution will present a novel way to experimentally investigate quarkyonic matter. In order to do so we calculate the Bremsstrahlung photon spectrum emitted from dynamically evolving quarkyonic matter, and compare this spectrum with that of a high chemical potential quark-gluon plasma as well as to a hadron gas.

We find that the transverse momentum distribution and the harmonic coefficient is markedly different in the three cases.

The quarkyonic elliptic flow coefficient fluctuates randomly from event to event, and within the same event at different transverse momenta. The latter effect, which can be explained by the shape of quark wavefunctions within quarkyonic matter, might be considered as a quarkyonic matter signature.

The corresponding manuscript has been accepted for publication in PRL and can be found at http://arxiv.org/abs/arXiv:1

Keywords:

quarkyonic matter, photons, heavy ion collisions, elliptic flow, transverse momentum spectrum

Initial State and Proton-Nucleus Collision Phenomena / **6**

Color Class Condensate from electron-proton DIS to proton-nucleus collisions

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The Color Class Condensate offers a consistent framework to describe high-energy (small-x) data from various experiments. The non-perturbative input for these calculations, the dipole-target amplitude at initial Bjorken-x, is obtainable from electron-proton deep inelastic scattering processes. Once that is known, one can compute, for example, single and double inclusive particle production in proton-proton and proton-nucleus collisions. Proton-nucleus collisions are especially interesting as the saturation scale is expected to scale as A^1/3, making saturation phenomena easier to observe in pA than pp collisions.

We discuss how tightly the electron-proton DIS data constrains the initial condition for the dipole amplitude and how the LHC single inclusive spectra can be used to further test the CGC picture. Then using only information from DIS experiments we generalize the dipole amplitude to nuclear targets and compute particle production in proton-nucleus collisions [1]. We present predictions for the nuclear suppression factor R_pA at forward rapidities and compare with pQCD calculations. We also discuss how the back-to-back structure of the forward dihadron production cross section is modified when moving from proton-proton to proton(deuteron)-nucleus collisions, as naturally understood in the CGC [2].

References:
[1] T. Lappi, H. Mäntysaari, in progress
[2] T. Lappi, H. Mäntysaari, Nucl. Phys. A908 (2013) 51-72

Keywords:

cgc, nuclear suppression, dihadron correlations, forward particle production

Initial State and Proton-Nucleus Collision Phenomena / **7**

Numerical studies of JIMWLK

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In the CGC framework the initial stages of a heavy ion collision at high energy are described as "glasma" field configurations. The initial condition for these evolving fields depends, in the CGC effective theory, on a probability distribution for color charges. The energy dependence of this distribution can be calculated from the JIMWLK renormalization group equation.

We discuss recent progress in numerically solving the JIMWLK equation in order to understand properties of the glasma initial state. In particular we discuss work on a practical implementation of the running coupling constant in the Langevin method of solving the JIMWLK equation.

Keywords:

Small-x, CGC

Initial State and Proton-Nucleus Collision Phenomena / **8**

Double parton scattering in proton-nucleus and nucleus-nucleus collisions at the LHC

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Multi-parton scatterings are extremely enhanced in interactions involving nuclei at colliders, compared to proton-proton collisions at the same energy. We present the derivation of a simple generic expression to compute double-parton scattering (DPS) cross sections in high-energy proton-nucleus and nucleus-nucleus collisions as a function of the corresponding single-parton hard cross sections and of the event centrality. We apply such DPS formalism to two different final-states at CERN LHC energies: (i) same-sign W-boson pair production in p-Pb [1], and (ii) double-J/psi production in Pb-Pb [2], using NLO predictions with nuclear PDF modifications for the corresponding single-parton scatterings. The first process can help determine the effective sigma_eff parameter characterising the transverse distribution of partons in the nucleon. The second process provides interesting insights

on the event-by-event enhancements and/or suppressions observed in prompt-J/psi production in Pb-Pb collisions at the LHC. Both processes are experimentally measurable and the expected event rates, after acceptance and efficiency losses, for the signal and backgrounds will be discussed.

[1] D. d'Enterria and A.M. Snigirev, Phys.Lett. B718 (2013) 1395; arXiv:1211.0197.
[2] D. d'Enterria and A.M. Snigirev, arXiv:1301.5845.

Keywords:

Hard scattering, double-parton scattering, proton-nucleus, nucleus-nucleus, LHC

Initial State and Proton-Nucleus Collision Phenomena / **10**

Long range two-particle correlations and initial state

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We address the relation between the long range two-particle correlations observed at the LHC and the B-Reggeon. The latter is a four-point generalization of the BFKL Pomeron also emerging as a new element of the QCD Reggeon Field Theory.

Initial State and Proton-Nucleus Collision Phenomena / **11**

Anisotropic flow of thermal photons as a quark-gluon plasma viscometer

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As is well known, photons are a penetrating probe of the dense medium created in heavy-ion collisions. I will present state-of-the-art calculations of viscous photon emission from nuclear collisions at RHIC and LHC. Fluctuating initial density profiles are evolved with event-by-event viscous hydrodynamics. Momentum spectra of thermal photons radiated by these explosively expanding fireballs and their p_T-differential anisotropic flow coefficients $v_n(p_T)$ are computed, both with and without accounting for viscous corrections to the standard thermal emission rates at leading logarithmic order. Viscous corrections to the rates are found to have a larger effect on the v_n coefficients than the viscous suppression of hydrodynamic flow anisotropies. Since photons are found to be more sensitive to the quark-gluon plasma (QGP) shear viscosity than hadrons, their anisotropic flow coefficients v_n serve as a sensitive QGP viscometer.

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Spatially dependent nPDFs and their applications in inclusive pion and prompt photon production

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I will focus on the nuclear PDFs (nPDFs) and their applications in high energy A+A and p/d+A collisions. First, I will introduce our recently published spatially dependent nPDF sets, EPS09s and EKS98s, and discuss the centrality dependence of hard-process cross-sections within the collinear factorization framework. More specifically, I will compare our NLO pQCD calculations for the nuclear modification factor of neutral pion and prompt photon production with the data in d+Au and Au+Au collisions at RHIC and for p+Pb and Pb+Pb collisions at the LHC at midrapidity in different centrality classes. These calculations are found to be well in line with the published data. After this, I will discuss the same observables also at forward rapidities and show to what extent these will probe the small-x gluon densities in p+Pb collisions at the LHC. In addition, we have implemented the spatially dependent nPDFs into a Monte-Carlo Glauber framework to study whether the centrality dependence turns out to be different (stronger) than with the optical Glauber model used so far.

Keywords:

nPDF, proton-lead collisions, prompt photons, nuclear modification factor

Initial State and Proton-Nucleus Collision Phenomena / 14

The onset of hydrodynamical flow in high energy heavy ion collisions

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Real time lattice simulations of the early stages of high energy collisions in the Color Glass Condensate framework indicate a rapid isotropization of the pressure tensor. For realistic values of the saturation momentum, nearly ideal hydrodynamics provides a good description of the bulk evolution of the system after a transient regime that lasts about 1 fermi/c.

Keywords:

color glass condensate, initial state

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Measuring the gluon distribution in nuclei at an Electron-Ion Collider

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Despite the successes of the HERA collider, where much information was gained on the structure of the nucleon, data on the structure of the nucleus at moderate-to-small x remains elusive, as only fixed-target high-x data currently exist. The small-x region, however, is of great interest. The nucleon structure in this region is dominated by gluons which show a rapid rise with decreasing x. At low-x, this growth must be tamed and the gluon distribution will be saturated. This saturation phenomena is expected to be universal, appearing in both nucleons and nuclei. A knowledge of this regime is of vital importance to understanding the underlying physics which governs the initial conditions of heavy-ion collisions at both the LHC and RHIC, where particle production is dominated by gluons from this unknown region.

However, only tantalising hints of this have been observed so far. Therefore, the construction of an Electron-Ion Collider (EIC), colliding polarised electrons with polarised protons and also a wide variety of nuclei, will allow an exploration of the region of small-x in great detail (with luminosities 100x that of HERA), answering questions on both the spatial and momentum distributions of gluons and sea quarks in nuclei. In particular, the saturation region is more accessible in nuclei due to the amplification of the saturation scale with nuclear size (Q_s ~ A^(1/3)).

In this talk I will present the current status of the physics capabilities of e+A collisions at an EIC as outlined in the EIC White paper [1].

[1] A. Deshpande at al, arXiv:1212.1701, (2012)

Heavy Flavor Production and Quarkonia / **16**

Azimuthal Jet Flavor Tomography via CUJET with Running Coupling in 2+1D Viscous QGP Fluids

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We present recent progress with the CUJET pQCD jet tomographic model, which couples running coupling dynamic DGLV opacity series with 2+1D viscous hydro (T, u^μ) fields. We test the consistency of this model with recent RHIC and LHC data on the azimuthal and transverse dependence of $R_{AA\to h}(p_T, \phi, \sqrt{s}, b)$, the nuclear modification of light and heavy open flavor fragments from quenched jets.

Keywords:

Jet Flavor Tomography, Viscous Hydro, CUJET

Jet Quenching and Observables / **19**

A hybrid strong/weak coupling approach to jet quenching

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We study the modification of jet properties in a heavy ion environement by the presence of strongly coupled quark gluon plasma. We explore a hybrid approach, in which the high virtuality splitting processes that dominate the QCD shower proceed as in vacuum while the partons of the shower interact with the system as dictated by strongly coupled computations via the AdS/CFT correspondence. We incorporate this approach into an event Monte Carlo and study multiple jet observables, such as jet suppression, di-jet asymmetry, etc. We show that this approach is in qualitative agreement with the available jet measurements at the LHC, but a quantitative description may require additional sources of energy loss, such as radiative processes.

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From full stopping to transparency in a holographic model of heavy ion collisions

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We numerically simulate planar shock wave collisions in anti-de Sitter space as a model for heavy ion collisions of large nuclei. We uncover a cross-over between two different dynamical regimes as a function of the collision energy. At low energies the shocks first stop and then explode in a manner approximately described by hydrodynamics, in close similarity with the Landau model. At high energies the receding fragments move outwards at the speed of light, with a region of negative energy density and negative longitudinal pressure trailing behind them. The rapidity distribution of the energy density at late times around mid-rapidity is not approximately boost-invariant but Gaussian, albeit with a width that increases with the collision energy.

Keywords:

AdS/CFT, Initial state, Thermalization, out-of-equilibrium, hydrodynamic flow

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Studies of production in the forward region at LHCb

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LHCb experiment performs multiple studies at 0.9TeV and 7TeV proton-proton interactions. Results on Energy flow, charge particle multiplicities, particle production ratios, charm production studies are presented and discussed. The comparison with the predictions of different models indicates that more efforts are needed for better understanding of physical processes.

Initial State and Proton-Nucleus Collision Phenomena / **24**

JIMWLK evolution for multi-particle production in Langevin form

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We study multi-particle production with rapidity correlations in proton-nucleus collisions at high energy in the Color Glass Condensate framework. The high-energy evolution responsible for such correlations is governed by a generalization of the JIMWLK equation describing the simultaneous evolution of the strong nuclear color fields in the direct amplitude and the complex conjugate amplitude. This functional equation can be used to derive ordinary evolution equations for the cross-sections for particle production but the ensuing equations appear to be too complicated to be useful in practice, even at large Nc. We propose an alternative formulation based on a Langevin process, which is better suited for numerical implementations, and we present the stochastic equations appropriate for two gluon production.

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Radiative p_T broadening of high energy quarks and gluons in QCD matter

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In this talk I report our results on radiative transverse momentum broadening of high energy quarks passing through hot and cold QCD matter. With L the length of the matter and l_0 the size of constituents of the matter we find p_T^2 has both double logarithmic terms, ln^2(L/l_0), and single logarithmic terms, ln(L/l_0), coming from gluon radiation induced by the matter. We also carry out a resummation of the double logarithmic terms. Our results may indicate a double logarithmically enhanced qhat from gluon radiation and energy loss from two gluon radiation.

Keywords:

transverse momentum broadening, qhat, QCD matter, double logarithmic resummation

Initial State and Proton-Nucleus Collision Phenomena / **29**

Elliptic Flow from Non-equilibrium Initial Condition with a Saturation Scale

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A current goal of relativistic heavy ion collisions experiments is the search for a Color Glass Condensate (CGC) as the limiting state of QCD matter at very high density. In viscous hydrodynamics simulations, a standard Glauber initial condition leads to estimate $4\pi\eta/s \sim 1$, while employing the Kharzeev-Levin-Nardi (KLN) modeling of the glasma leads to at least a factor of 2 larger η/s.
Within a kinetic theory approach based on a relativistic Boltzmann-like transport simulation, our main result is that the out-of-equilibrium initial distribution reduces the efficiency in building-up the elliptic flow. At RHIC energy we find the available data on v2 are in agreement with a $4\pi\eta/s \sim 1$ also for KLN initial conditions. More generally, our study shows that the initial non-equilibrium in p-space can have a significant impact on the build-up of anisotropic flow.

Keywords:

Heavy ion collisions, Color Glass Condensate, Shear Viscosity, Elliptic Flow, Transport Theory

Jet Quenching and Observables / **30**

Understanding Jet Modifications at the LHC

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Jets are collimated QCD multi-particle states that are abundantly produced in heavy-ion collisions at the LHC. Their description in the vacuum is governed by hardest scale of the problem, typically the jet virtuality. In the presence of a background color field, e.g. such as expected in a quark-gluon plasma, one also has to consider a hard scale arising from the medium interactions. It was recently shown that due to the collinear nature of QCD splittings, high-energy jets are typically quite collimated and are not resolved by the medium, i.e. they are only seen as a total charge and lose energy coherently. Assuming this scenario holds for all jets, we show how a factorization of small-angle jet evolution and large-angle medium-induced emissions can be realized and calculate three key observables: the jet RAA, modification of the intra-jet structure and the amount of out-of-cone radiation. Medium-induced radiation is accounted for using the established factorization of multiple branchings leading to the probabilistic rate equation - which we presently improve upon by introducing finite-size effects and a proper regularization prescription in the infrared. This mechanism is particularly important for the transport of energy away from the jet axis up to large angles. For the intra-jet structure, on the other hand, we find the striking importance of so-called “antiangular ordered radiation,” resulting from the slight decoherence of the jet during the passage through the medium.

Keywords:

jet physics, jet quenching

Hard and Thermal Electroweak Probes / **31**

Measurements of direct photons in AuAu collisions with PHENIX

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The PHENIX experiment has published direct photon yields and elliptic flow coefficients (v2) from Au+Au collisions at RHIC energies. These results have sparked much theoretical discussion. The measured yields and flow parameters are difficult to reconcile in current model calculations of thermal radiation based on hydrodynamic time evolution of the collision volume. New sources of photons, e.g. initial state emission related to strong magnetic fields, have been proposed as alternatives.

Our latest analyses which use high statistics data from Run-7 and Run-10 allow to determine yields and harmonic coefficients (v_n) with finer granularity in centrality and photon momentum and down to p_T as low as 400 MeV/c. In this talk we will summarize the current status and present new results from PHENIX.

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Di-jet asymmetric momentum transported by QGP fluid

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High energy partons propagating through the QGP medium are subject to deposit their energy and momentum into the medium. The dynamics of the QGP fluid would be affected by the energy-momentum deposition from these energetic partons. We study the collective flow of the QGP fluid induced by the jets using a (3+1)-dimensional QGP-fluid+Jet model. We simulate the propagation of jets together with expansion of the QGP fluid and calculate the transverse momentum distribution of the particles originated from the medium. As a result, a large fraction of the momentum imbalance of the di-jet is compensated by low-pT particles at large angles from the jet axis. This result is consistent with the one observed by the CMS Collaboration [1].

References
[1]S. Chatrchyan et al. [CMS Collaboration], Phys. Rev. C 84, 024906 (2011); C. Roland, J. Phys. G 38, 124020 (2011) .

Initial State and Proton-Nucleus Collision Phenomena / **35**

Ridge correlations from initial state.

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I describe several mechanisms that lead to ridge like correlations in the produced particle spectrum in p-p and p-A collisions at high energy. The discussion is within the Color Glass Condensate framework, but the physics involved is not directly tied with saturation.

High Transverse Momentum Light and Heavy Flavor Hadrons / 37

The parton cascade BAMPS with the improved Gunion-Bertsch matrix element

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An updated version of the partonic transport model Boltzmann Approach to MultiParton Scatterings (BAMPS) is presented, which allows interactions among all partons: gluons, light quarks, and heavy quarks with elastic and inelastic collisions. We introduce the improved Gunion-Bertsch matrix element, which cures problems of the original Gunion-Bertsch result in characteristic regions of the phase space. Verified by extensive numerical calculations, the improved matrix element agrees well with the exact calculation. With the new matrix element, important properties of the quark-gluon-plasma in heavy-ion collisions such as the thermalization time of the plasma and the shear viscosity over entropy density ratio are calculated within the microscopic transport model BAMPS. Furthermore, we compare our results of the nuclear modification factor and elliptic flow to experimental data at RHIC and LHC.

High Transverse Momentum Light and Heavy Flavor Hadrons / 43

Shooting string holography of jet quenching at RHIC and LHC

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Previous holographic models of jet quenching in AdS/CFT via "falling strings" were found to be incompatible with the recent LHC data in arXiv:1208.0305. A new set of "shooting string" holographic jet initial configurations with finite momentum at string endpoints was proposed in arXiv:1306.6648 that suggests a more natural scheme for determining the instantaneous rate of energy loss of jets in SYM plasmas with longer stopping distances. We apply this framework to predict nuclear modification factors RAA of jets, and compare to recent data at RHIC and LHC. Phenomenological consequences of non-conformal deformations of AdS geometry and Gauss-Bonnet quadratic curvature corrections will be discussed.

Keywords:

Jet quenching, AdS/CFT correspondence, RAA, light quark energy loss

Initial State and Proton-Nucleus Collision Phenomena / **44**

EIC: New Scientific and Technology Frontiers for Parton Femtoscopy

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Our understanding of the structure of nucleons is described by the properties and dynamics of quarks and gluons in the theory of quantum chromodynamics. With advancements in theory and the development of phenomenological tools we are preparing for the next step in subnuclear tomographic imaging at a future electron-ion collider. High center-of-mass energies (up to 150 GeV) in combination with extremely high luminosities (up to 10^34 /s/cm^2) will provide the precision and a kinematic reach well into the gluon dominated regime of very low parton momenta where a saturation of the gluon density is expected, in particular in collisions of electrons with heavy nuclei. In addition, highly polarized nucleon and electron beams (70% polarization) can probe the parton polarizations in previously unexplored kinematic regions and with unprecedented accuracy, as well as address the role of orbital angular momentum with respect to the nucleon spin. This talk will summarize the theoretical, experimental and technical challenges of such a versatile experimental endeavor as planned for the Electron Ion Collider.

Hard and Thermal Electroweak Probes / **47**

Dileptons in d+Au Collisions at sqrt(s)=200 GeV measured by PHENIX and its implications on heavy flavor

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The dielectron mass spectrum is a unique probe to directly access the different stages of a heavy-ion collision. The low mass region (m_ee < 1 GeV/c^2) reflects the Quark Gluon Plasma (QGP) temperature and thermalization phase, while the low vector meson resonances probe chiral symmetry restoration. The intermediate (1< m_ee<3 GeV/c^2) and high (4<m_ee<8 GeV/c^2) mass regions are dominated by semi-leptonic decays of open charm and beauty respectively and so provide information about the heavy flavor dynamics.

The PHENIX experiment at RHIC has studied the dielectron mass spectrum in different collision systems, ranging from p+p to d+Au to Cu+Cu to Au+Au at sqrt(s) = 200 GeV. While the mass spectrum in p+p collisions is well understood in terms of expectations from various sources and serves as a baseline for other collision systems, the low mass excess seen in the Au+Au mass spectrum is still a challenge to theory. The d+Au data thus serves as a control experiment to isolate any cold nuclear matter effects coming from the intial state of the collision.

PHENIX collected a large data set of d+Au collisons in 2008, reaching to high mass (m_ee< 14 GeV/c^2) and high transverse momentum (p_T< 8 GeV/c). The large range in mass and p_T covers the phase space dominated by heavy flavor and so can be used to test next-to-leading order

pQCD calculations for such processes. This talk will summarize the d+Au dielectron mass spectrum studied as a function of p_T and centrality. We will also show the charm and beauty cross-section extracted using several models, utilizing a double differential fit in mass and p_T.

Hard and Thermal Electroweak Probes / **49**

On loop corrections to the dilepton rate

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A novel next-to-leading order analysis of the dilepton production rate from a hot QCD plasma is reported. The photon invariant mass is taken to be in the range K^2 ~ (pi T)^2; subsequently the results are compared with an OPE computation in a hard regime K^2 » (pi T)^2, with an LPM resummed computation in a soft regime K^2 « (pi T)^2, as well as with recent lattice simulations in the Euclidean domain.

High Transverse Momentum Light and Heavy Flavor Hadrons / **53**

Elastic vs. radiative heavy quark energy loss within a transport model

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The full space-time evolution of heavy quarks and light partons in ultra-relativistic heavy-ion collisions is studied within the partonic transport model Boltzmann Approach to MultiParton Scatterings (BAMPS). We discuss in detail for all flavors the influence of elastic and radiative energy loss with a running coupling. Radiative processes, in particular, are implemented through an improved version of the Gunion-Bertsch matrix element, which is derived from comparisons to the exact result. In this calculation the finite heavy quark masses are explicitly taken into account, leading to the dead cone effect. Consequently, we present results of this updated version of BAMPS and compare them to experimental data at RHIC and LHC. In detail, the nuclear modification factor and elliptic flow of charged hadrons, heavy flavor electrons as well as muons, D mesons, and non-prompt J/psi are discussed. The latter two are especially sensitive to the mass difference of charm and bottom quarks. Furthermore, we make predictions where no data is available yet.

High Transverse Momentum Light and Heavy Flavor Hadrons / **54**

Radiation spectrum of a massive quark-gluon antenna in a QCD medium

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We derive the radiation spectrum of a massive quark-gluon antenna in a QCD medium. The calculation is done in the formalism of the classical Yang-Mills (CYM) equations and interactions with the medium are handled in the harmonic oscillator approximation, valid for soft gluon emissions. We discuss the effect produced by the presence of a mass scale and compare the results with the massless case. We put our findings in relation with the energy loss of heavy quarks in heavy ion collisions, one of the phenomenological puzzles of RHIC and LHC data.

Initial State and Proton-Nucleus Collision Phenomena / **56**

Multiplicities, p_T spectra and v_2 in A+A collisions at LHC and RHIC from NLO-improved pQCD + saturation + hydrodynamics model

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We report the results from the recent studies [1,2], where we have brought the EKRT framework [3] to next-to-leading order (NLO) in pQCD, and shown the viability of the model in describing the produced initial QGP energy densities at the LHC and RHIC.

Our updated framework [1] combines a rigorous NLO pQCD computation of the minijet transverse energy production with the saturation of gluons and fluid dynamics. Latest knowledge of NLO nuclear parton distributions (nPDFs) is utilized. Identifying the key parameters and charting the uncertainties of the model, we obtain an encouragingly good agreement with the charged-particle multiplicities and identified bulk hadron p_T spectra measured in 5% most central Au+Au collisions at RHIC and Pb+Pb at the LHC [1].

To obtain the initial QGP energy-density profiles dynamically in non-central collisions [2], we supplement the calculation by a local saturation condition and impact-parameter dependent nPDFs (EPS09s [4]). We address the main uncertainties associated with the obtained initial states. Using viscous fluid dynamics, we show that a good simultaneous description of the centrality dependence of multiplicity, p_T spectra and elliptic flow is obtained both at the LHC and RHIC.

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Phys. Rev. C87 (2012) 044904.

Ref. [2]
R. Paatelainen, K.J. Eskola, and H. Niemi, work in progress.

Ref. [3]
K.J. Eskola, K. Kajantie, P.V. Ruuskanen, K. Tuominen,
Nuc. Phys. B570 (2000) 379.

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I. Helenius, K.J. Eskola, H. Honkanen and C.A. Salgado,
JHEP 1207 (2012) 073.

Keywords:

initial state, QGP

Initial State and Proton-Nucleus Collision Phenomena / **64**

PHENIX Results on Heavy Flavor at Low-x

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It is becoming increasingly clear that initial state effects inherent to collisions of nuclei play an important role in the interpretation of data from heavy ion collisions at RHIC and the LHC. Such effects are more apparent in kinematic regions where the gluon density is expected to be significantly modified in the nucleus. The PHENIX experiment has studied these effects through the production of heavy quarks at backwards, middle, and forward rapidity, where partonic interactions in the nucleus and changes in the gluon structure function influence heavy quark production in different ways. Comparisons between these different rapidities in d+Au collisions offer us a window into the dynamics of particle production and transport in the nucleus. In this talk, new PHENIX results on heavy quark production at low x values will be discussed, in the context of A+A data from RHIC and the LHC.

Jet Quenching and Observables / **67**

Measurement of jet fragmentation functions and shapes in PbPb collisions at sqrt(sNN)=2.76TeV with CMS

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We present measurements of the jet fragmentation functions and transverse momentum profiles (shapes) in PbPb collisions at 2.76 TeV per nucleon-pair center of mass energy with the CMS detector. Jets are reconstructed by the anti-kT sequential clustering algorithm with a resolution parameter of 0.3, using particle-flow objects that combine tracking and calorimetric information. In this talk the jet properties of inclusive jets with transverse momentum pT > 100 GeV/c in PbPb collisions are measured for reconstructed charged particles with pT > 1 GeV/c in a cone of radius sqrt((Δ φ)^2 + (Δ η)^2)=0.3 around the jet axis. A data sample of PbPb collisions collected in 2011 at a center-of-mass energy of sqrt{sNN}= 2.76 TeV corresponding to an integrated luminosity of 150 μb^-1 is used. The results for PbPb collisions as a function of collision centrality are compared to reference distributions based on the full 2013 pp statistics collected at the same collision energy. Centrality-dependent modifications of the fragmentation functions and shapes are revealed.

Initial State and Proton-Nucleus Collision Phenomena / **68**

Study of dijet momentum balance and pseudorapidity distributions in pPb collisions at sqrt{sNN} = 5.02 TeV with CMS

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Results on dijet production in pPb collisions at a nucleon-nucleon center-of-mass energy of 5.02 TeV are presented. Jets are reconstructed with the anti-kT algorithm, using combined information from tracking and calorimetry. The dijet momentum balance, azimuthal angle correlations and pseudorapidity distributions are studied as a function of forward calorimeter transverse energy and compared to results from PYTHIA reference calculations representing pp collisions. For pPb collisions, the dijet momentum ratio pT,2/pT,1 and the width of the azimuthal angle difference distribution is remarkably insensitive to the forward activity of the collision, and comparable to the same quantity obtained from the simulated pp reference. The pseudorapidity of the dijet system changes monotonically with increasing forward calorimeter activity.

High Transverse Momentum Light and Heavy Flavor Hadrons / 69

Measurement of b-jet fraction and nuclear modification factors in PbPb collisions at sqrt{sNN}= 2.76 TeV with CMS

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Modification to jets in high-energy heavy-ion collisions is expected to depend on the flavor of the fragmenting parton. To disentangle this flavor dependence, jets from heavy quark fragmentation are identified in heavy ion collisions. Jets are first tagged by their secondary vertices and the contribution from bottom quarks is extracted using template fits to their secondary vertex mass distributions. The bottom quark jet to inclusive jet ratio is measured with the CMS detector from PbPb and pp collisions at a center-of-mass energy of 2.76 TeV per nucleon. In this talk, the inclusive b-jet fraction and nuclear modification functions measured in the range of 60 < jet pT < 200 GeV/c, using full 2011 PbPb and 2013 pp data collected at sqrt{s}=2.76 TeV are presented.

Hard and Thermal Electroweak Probes / 71

Isolated photon measurements in pp and PbPb collisions with CMS

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We report new measurements using isolated photons based on the high statistics 2.76 TeV pp reference data collected in 2013. The nuclear modification factors of reconstructed isolated photons, obtained by the comparison of heavy ion collisions and pp data, are presented and provide useful constraints to the nuclear parton distribution functions. For events containing an high pT isolated photon with an associated jet, the photon+jet pT imbalance is studied as a function of collision centrality and compared to pp data and model calculations. These measurements allow an unbiased characterization of the in-medium parton energy loss.

Initial State and Proton-Nucleus Collision Phenomena / **72**

Transverse momentum and pseudorapidity dependence of charged particle production and nuclear modification factor in pPb collisions at sqrt(sNN)=5.02 TeV with CMS

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The charged particle transverse momentum (pT) spectra at midrapidity and forward pseudorapidity ranges up to pT=100 GeV/c are presented for pPb collisions at sqrt(sNN)=5.02 TeV. The nuclear modification factor (RpPb) is measured at midrapidity by dividing the measured pPb spectrum by a pp reference spectrum constructed using interpolation methods. In addition, the asymmetries in the charge particle yields between equivalent positive and negative pseudorapidity ranges in both the laboratory and center-of-mass frames are presented as a function of pT.

Hard and Thermal Electroweak Probes / **74**

Production of W and Z bosons in heavy-ion collisions with CMS

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The Compact Muon Solenoid (CMS) is fully equipped to measure leptonic decays of electroweak probes in the high multiplicity environment of nucleus-nucleus collisions. Electroweak boson production is an important benchmark process at hadron colliders. Precise measurements of W and Z production in heavy-ion collisions can help to constrain nuclear PDFs as well as serve as a standard candle of the initial state in PbPb collisions at the LHC energies. The inclusive and differential measurements of the Z boson yield in the muon decay channel will be presented, establishing that no modification is observed with respect to next-to-leading order pQCD calculations, scaled by the number of incoherent nucleon-nucleon collisions. Measurements of the yield of W bosons decaying into a muon and an (anti)neutrino as a function of centrality, and the W charge asymmetry as a function of rapidity show no modifications beyond the expected effect of isospin when compared to pp collisions and the status of the corresponding analyses on pPb collisions will be given.

Heavy Flavor Production and Quarkonia / **76**

Bottomonium production in pp, pPb, and PbPb collisions with CMS

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The three Y states (1S, 2S, 3S) were measured separately using the Compact Muon Solenoid (CMS) experimental apparatus via their dimuon decays in pp and pPb collisions, in the rapidity range |y|<1.9 in the centre-of-mass of the collision. The datasets used in the analysis correspond to recorded integrated luminosities of about 31/nb (pPb) and 5.1/pb (pp), collected in 2013 by the CMS experiment at the LHC, at a centre-of-mass energy per nucleon-nucleon pair of 5.02 TeV and 2.76 TeV respectively. Results of the production ratios of the excited states, Y(2S) and Y(3S), with respect to the ground state Y(1S) will be presented in the context of the PbPb results.

High Transverse Momentum Light and Heavy Flavor Hadrons / 80

Measurements of Open Heavy Flavor Hadrons in STAR Experiment

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Heavy flavor quarks are dominantly produced in the initial hard interactions in high energy heavy ion collisions at the Relativistic Heavy Ion Collider (RHIC). Their interaction with QCD medium is sensitive to the medium dynamics. Thus heavy flavor quarks are suggested as an ideal probe to study the properties of the hot and dense nuclear matter created at RHIC. In this talk, we will present recent open heavy flavor measurements by the STAR experiment through both hadronic and semi-leptonic decay channels. We will
discuss results of open charm meson and non-photonic electron production cross section measurements in proton-proton and Au+Au collisions at $sqrts_NN$ = 200 GeV. We will also present measurements of open charm mesons in proton-proton collisions at $sqrts$ = 500 GeV and the first result in uranium-uranium collisions at $sqrts_{NN} = 193$ GeV. Finally we will describe the ongoing Heavy Flavor Tracker and Muon Telescope Detector upgrade projects and their anticipated physics reach in the coming years.

Keywords:

Heavy Flavor, Open Charm Meson, Non-Photonic Electron, STAR Experiment

Heavy Flavor Production and Quarkonia / 81

PHENIX charmonia: what have we learned?

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PHENIX has good quality measurements from Au+Au, Cu+Cu, p+p and d+Au collisions, and the analysis of data from Cu+Au and U+U collisions is nearing completion. The analysis of charmonium data from the 2008 d+Au run has recently been completed, and this talk will focus on what we have learned from the d+Au data about the mechanisms that modify charmonium production in a nucleus.

The d+Au charmonium data from PHENIX consist of 1) J/psi modification versus centrality across the full PHENIX rapidity range, and 2) psi' data at midrapidity only. Both show unexpected features.

The J/psi modification at forward rapidity requires a stronger than linear dependence of suppression on nuclear thickness, while the psi' suppression for central collisions is unexpectedly stronger than that for the J/psi. There will be a discussion of the implications of the rapidity dependence and of the centrality dependence, and also of why we believe that the centrality measurement is reliable.

It has long been assumed that that p(d)+A data provide the baseline for measuring hot nuclear matter effects in A+A collisions by isolating the "cold nuclear matter" effects. However recent results from p+Pb at the LHC and d+Au at RHIC show correlations of soft particles across large rapidity gaps that are consistent with flow. This raises the possibility that there are hot matter effects in d+Au collisions that may affect charmonium production, and evidence for and against
this will be discussed.

Jet Quenching and Observables / 82

Probabilistic picture for in-medium jet evolution

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We study the evolution of a high energy jet triggered by its interactions with a dense QCD medium. We show that the relatively components of the jet which propagate at large angles can be described as the products of a classical branching process, in which successive branchings proceed independently from each other. This exploits the fact that the in-medium rescattering is very efficient in destroying the color coherence between the soft emitted partons: this coherence is washed out already during the branching process, that is, over time scales which are much shorter than the size L of the medium. This allows us to construct a master equation for the generating functional encoding all the intra-jet multi-parton distributions (that is, the distributions in energies and in angles).
The 'jet quenching parameter' $\hat{q}$, which is the only medium-dependent parameter in this description, receives large radiative corrections from a different type of radiation — namely, from hard gluon emissions which are triggered by a single scattering in the medium and occur on time scales much shorter than the typical branching time alluded to above.These radiative corrections, enhanced by a double logarithm $\alpha_s \log^2(LT)$ with T the temperature of the medium, are strongly ordered and overlapping in formation time. We show that these coherent branchings can be absorbed into a renormalization of the jet quenching parameter without spoiling the probabilistic picture mentioned above and which involves only incoherent branchings.

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arXiv:1307.xxxx [hep-ph] In preparation

Initial State and Proton-Nucleus Collision Phenomena / 83

Azimuthal anisotropy v_2 in U+U collisions at STAR

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The azimuthal anisotropy of particle production is commonly used in high-energy nuclear collisions to study the early evolution of the expanding system. The prolate shape of uranium nuclei provides the possibility to study how the initial geometry of the nuclei affects the azimuthal distributions.

It also provides a unique opportunity to understand the initial condition for particle production at mid-rapidity in heavy ion collisions.

In this talk, the two- and four- particle cumulant, v_2($v_2$2 and $v_2$4), from U+U collisions at $\sqrt{s_{NN}}$ = 193 GeV and Au+Au collisions at $\sqrt{s_{NN}}$ = 200 GeV for inclusive charged hadrons will be presented. The STAR Zero Degree Calorimeters resolution allows to further separate more central collisions within 0-1% centrality bin. Differences were observed between the multiplicity dependence of $v_2$2 for most central Au+Au and U+U collisions. The observed $v_2$2 slope results were compared to Monte Carlo Glauber model predictions and it was seen that this model cannot explain the present results on the multiplicity dependence of $v_2$2 in central collisions.

High Transverse Momentum Light and Heavy Flavor Hadrons / 84

Detail study of the medium created in Au+Au collisions with high pT probes by the PHENIX experiment at RHIC

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PHENIX has been measuring high pT identified hadrons such as pi0 or eta since the beginning of the RHIC running. These measurements along with the baseline direct photon measurement led to the discovery of parton energy loss, a final state interaction with a medium, the quark-gluon plasma.

After accumulation of additional statistics in recent RHIC Au+Au runs, we were able to not only reduce uncertainties of golden channel measurements (e.g. pT spectra), but also extend the degree of freedom, such as the yield versus emission angle w.r.t event planes.

Detailed analysis of these measurements provided us deeper insight of the characteristics of the quark-gluon plasma. We have studied the average fractional energy loss (dE/E) of hadrons, as well as the path-length dependence of the energy loss. We have also measured higher order harmonic flows of high pT hadrons that would improve understanding of the medium from hydrodynamic point of view.

In this presentation, the recent high pT hadron results obtained by the PHENIX experiment will be shown, and the physics learned from the results will be discussed in detail.

High Transverse Momentum Light and Heavy Flavor Hadrons / 85

Heavy quark quenching and elliptic flow from RHIC to LHC: can the experimental results be understood by pQCD?

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Recently, we have proposed a microscopic approach for the quenching and thermalisation of heavy quarks (HQ) in URHIC

\cite{Gossiaux:2008,Gossiaux:2009,Gossiaux:2010,Gossiaux:2011}, assuming that they interact with light partons through both elastic and radiative processes evaluated by resorting to some parameterization of the running coupling constant, while those partons are spatially distributed along the hydrodynamical evolution of the hot medium. This approach is able to
explain successfully several observables measured at RHIC and LHC, such as the nuclear modification factor and the elliptic flow of open heavy flavor mesons and non-photonic single electrons. The diffusion coefficient of heavy quarks in the quark gluon plasma – a fundamental property of this state of matter – can thus be extracted and compared with recent lattice calculations.

In this contribution, we provide a general overview of our MC@HQ event generator which can presently be coupled
to the hydrodynamical evolution of the plasma as realized by the KOLb-Heinz approach or by the EPOS model. We discuss the influence of the different hydrodynamical evolution on the predictions for heavy mesons. We confront the results of our model for D and B mesons as well as for the lepton production in URHIC with experimental results obtained so far by the various collaborations at RHIC and LHC. Perspectives for future observables like correlations will be proposed.

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Keywords:

Heavy mesons, Raa and V2

Initial State and Proton-Nucleus Collision Phenomena / **86**

Dihadron azimuthal correlations at large pseudo-rapidity difference in multiplicity-selected d+Au collisions by STAR

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A long-range pseudo-rapidity correlation is unexpectedly observed in pp and p+Pb collisions at the LHC after a uniform background subtraction. It is called the “ridge,” in analogy to the similar phenomenon in heavy-ion collisions after subtraction of an elliptic-flow-modulated background. The heavy-ion ridge has been attributed primarily to triangular anisotropy, resulting from initial geometry fluctuations and subsequent hydrodynamical evolution. The question arises whether the pp/p+Pb ridge is of similar origin, which would be surprising in the small collision systems of pp and p+Pb. Another physics mechanism, the color glass condensate, is also proposed as an explanation for the correlated production of dihadrons forming the ridge.

PHENIX showed, following the method by ALICE and ATLAS, that the difference of dihadron correlations between central and peripheral

collisions can be mostly described by a second harmonic. While it is an open question how much jet contribution remains in the PHENIX result in their limited acceptance, the complementarity between LHC and RHIC can be potentially powerful to distinguish the proposed ridge production mechanisms. In this talk, we present STAR results of dihadron correlations in d+Au collisions as a function of multiplicity, with the large acceptance of |\Delta\eta|<2 by the STAR's Time Projection Chamber (TPC). We also present dihadron correlations using STAR's mid-rapidity TPC and forward TPC, with a |\Delta\eta| coverage of 1.8-4.8. We examine the \Delta\eta dependence of the correlations as well as the difference in the correlations between central and peripheral collisions. We discuss our results in the context of the LHC and PHENIX data.

High Transverse Momentum Light and Heavy Flavor Hadrons / **87**

Heavy-quark azimuthal correlations in heavy-ion collisions

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Besides the traditional heavy-quark observables, like the nuclear modification factor and the elliptic flow, azimuthal correlations of heavy quarks and antiquarks have the potential to give new insight into the interactions with the medium.
Due to the scatterings with the light medium constituents heavy quarks and antiquarks are deflected from their original direction and the initial correlation of the pair is broadened.
We investigate this effect for different transverse momentum classes and find that low-momentum heavy-quark pairs lose their leading order back-to-back initial correlation, while a significant residual correlation survives at large
momenta.
In the study of two different energy loss scenarios, purely collisional and collisional plus radiative corrections, which both describe the nuclear modification factor and the elliptic flow, we observe that the purely collisional energy loss is more efficient in broadening the initial correlations.
This discriminatory feature survives when next-to-leading order production processes are included and offers a fascinating possibility to distinguish the different contributions, collisional and radiative, to the heavy-quark in-medium energy loss once experimental results on azimuthal correlations will be available.

Initial State and Proton-Nucleus Collision Phenomena / **88**

The Initial Flow of Gluon Fields and Its Implications for Heavy Ion Collisions

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We calculate the energy flow of the quasi-classical gluon field at early times in high energy nuclear collisions. We argue that the transverse flow has a rapidity-even component that is similar to collective flow in a fluid and emerges from the QCD analog of Farady's and Ampere's Law, and it has a rapidity-odd component that can be understood from Gauss' Law for gluon fields. While the former leads to the usual radial and elliptic flow phenomena, the rapidity-odd flow term implies directed flow and leads to characteristic flow patterns in asymmetric systems like Cu+Au. A comprehensive study of these unique flow phenomena could lead to novel signatures of color glass. We also discuss a method to calculate initial conditions for a further viscous hydrodynamic evolution from the full energy momentum tensor of the gluon field. This allows us to calculate the phenomenological consequences of the initial gluon field flow. In particular, we show that color glass predicts a rotation of the fireball around the impact vector axis.

Keywords:

Initial State, Color Glass Condensate, Collective Flow

Initial State and Proton-Nucleus Collision Phenomena / **89**

Dynamics of strongly interacting parton-hadron matter

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We study the the non-equilibrium dynamics of heavy-ion collisions from SIS to LHC energies within the Parton-Hadron-String Dynamics (PHSD) transport approach, which incorporates explicit partonic degrees of freedom in terms of strongly interacting quasiparticles (quarks and gluons) in line with an equation of state from lattice QCD as well as the dynamical hadronization and hadronic collision dynamics in the final reaction phase.

We investigate also the equilibrium properties of strongly-interacting infinite parton-hadron matter: the equilibration of different observables on light and strange sector and their fluctuations and also transport coefficients, such as shear and bulk viscosity, electric and heat conductivity are presented.

Heavy Flavor Production and Quarkonia / **90**

Lattice calculation of the heavy quark potential at T>0

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I discuss new results on the extraction of the heavy quark anti-quark potential at non-zero temperature from lattice QCD. Calculations have been performed using Highly Improved Staggered Quark action on lattices with temporal extent Nt=6, 8 and 12. The potential is extracted from the temporal Wilson loops,

largely extending the first preliminary calculations using
Nt=6 lattices [1]. Implications of the findings for
the quarkonium spectral function will be discussed.

[1] A. Bazavov and P. Petreczky, Nucl. Phys. A904-905 (2013) 599c

Keywords:

Potential at T>0, quarkonium spectral functions, lattice QCD

High Transverse Momentum Light and Heavy Flavor Hadrons / **93**

Identified particle production in sqrt(sNN)=2.76 TeV pp and Pb-Pb collisions with ALICE at the LHC

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ALICE has unique capabilities among the LHC experiments for particle identification (PID) at mid-rapidity over a wide range of transverse momentum (p_{T}). For p_{T} between $\sim$ 100 MeV/c up to 3-4 GeV/c (anti)protons, charged pions and kaons can be separated through the measurement of the specific energy loss ($\mathrm{d}E/\mathrm{d}x$) in gas (silicon) with TPC (ITS) and time of flight (TOF). The identification can be extended to higher p_{T} by
using a Cherenkov detector (HMPID). For $3 < p_{\mathrm{T}} < 20$ GeV/c, statistical PID is possible thanks to the relativistic rise of the $\mathrm{d}E/\mathrm{d}x$ in the TPC.

In this talk results on the transverse momentum distributions ($\sim 0.3 < p_{\mathrm{T}} < 20$ GeV/c) of charged pions, kaons and (anti) protons, measured in pp and $\mathrm{Pb}-\mathrm{Pb}$ collisions at $\sqrt{s_{\mathrm{NN}}} = 2.76$ TeV, will be presented. The evolution of the particle ratios and the nuclear modification factor with the collision centrality will be presented. The comparison of the results with recombination and hydrodynamic models will be shown.

Initial State and Proton-Nucleus Collision Phenomena / **95**

Minijet analysis in pA collisions with ALICE Experiment at LHC

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At LHC energies, several pairs of partons can collide in each pp, p-A or A-A collision. Multiple Parton Interactions (MPI) can affect many physical observables, such as the charged particle multiplicity and the average transverse momentum per event.
In order to include jets down to the lowest energies ("minijets"), a two-particle correlation analysis is performed with the ALICE Experiment. The correlation is expressed as associated yield per trigger particle and allows to extract the number of uncorrelated seed particles which is proportional to the number of MPI.
The quantities are presented for different multiplicity estimators and in different collision systems.

Keywords:

mini-jets, MPI, correlations, LHC, ALICE

Initial State and Proton-Nucleus Collision Phenomena / **96**

Two-particle correlations in pp, p-Pb and Pb-Pb collisions measured in ALICE

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Two-particle correlation studies in high-multiplicity pp and p-Pb collisions at LHC energies have revealed unexpected structures. A symmetric double-ridge correlation pattern was found in p-Pb collisions at sqrt(s_NN)=5.02 TeV that extends to large differences in pseudorapidity. This observation can be attributed to collective behavior in the initial and final state of the collision using saturation and hydrodynamic models.

To further investigate these effects, two-particle azimuthal correlations have been studied for inclusive and identified charged particles in pp collisions at sqrt(s)=7TeV and p-Pb collisions at sqrt(s_NN)=5.02 TeV. The results are compared to those from Pb-Pb collisions.
Saturation effects in p-Pb are expected to be enhanced in the low-x regime of the nucleus that can be probed at forward rapidities. Potential future measurements in this kinematic region are discussed.

Keywords:

forward-central, correlations, p-Pb, LHC, ALICE, low-x, saturation

Initial State and Proton-Nucleus Collision Phenomena / **99**

p-Pb collisions: particle production and centrality determination in ALICE.

Author: Chiara Oppedisano[1]

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Proton-nucleus collisions are studied to disentangle initial state effects,
already present in cold nuclear matter, from final state effects, expected only
when a dense and hot medium is formed as in A-A collisions.
The collisions can be characterized through the number of binary collisions the nucleons undergo.
In p-Pb collisions, the low particle multiplicities
and the large multiplicity fluctuations influence the way collisions are classified into different centrality classes using a particle multiplicity distribution.
ALICE uses different estimators to measure event-by-event the number of
collisions through a Glauber approach.
ALICE results on particle production in p-Pb collisions at sqrt(s_NN) = 5.02 TeV
will be presented, including the pseudo-rapidity and transverse momentum
dependence. The centrality determination will be addressed and its implications will be discussed.

Hard and Thermal Electroweak Probes / **100**

Medium Modification of γ-jets in High-energy Heavy-ion Collisions

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Jet propagation within a strongly coupled medium is described with a Linearized Boltzmann Transport model. In this talk, I will explain two puzzling features in the experimental study of jet quenching in central Pb+Pb collisions at LHC with the LBT model. A γ-tagged jet is found to lose about 15% of its initial energy while its azimuthal angle remains almost unchanged due to rapid cooling of the medium. The reconstructed jet fragmentation function remains almost the same as in vacuum with enhancement at large momentum fraction because of the increased contribution of leading particles to the reconstructed jet energy. A γ-tagged jet fragmentation function is proposed that is more sensitive to jet-medium interaction and jet transport parameter in the medium. Effects of recoiled medium partons on the reconstructed jets are also discussed.

Jet Quenching and Observables / **101**

Measurement of jet production in central Pb–Pb collisions at √sNN = 2.76 TeV using semi-inclusive hadron-jet distributions

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The ALICE collaboration at the LHC presents a measurement of jet production rates recoiling back-to-back from a high pT trigger hadron. The observable is the difference between normalized recoil jet spectra for two hadron pT trigger intervals. This approach allows the removal of the large combinatorial jet background in heavy ion events in a model-independent way, while preserving collinear safety and a low infrared cutoff (150 MeV) for the coincidence recoil jet population. The jet recoil yield is measured over a wide pT range for different choices of jet cone radius. The azimuthal distribution of recoil jets is also explored. The measurements are compared to a calculation of the same observable for pp collisions using Next-to-Leading Order perturbative QCD, and to predictions of Monte Carlo models incorporating jet quenching.

Keywords:

jets, recoil, pQCD, energy loss, Pb-Pb, azimuthal distribution, ALICE, LHC

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Measurements of charged particle jet production cross sections and properties in pp collisions using ALICE at the LHC

Author: Sidharth Prasad[1]

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We present measurements of charged particle jet production cross sections, jet fragmentation, and transverse jet shapes in minimum bias proton-proton collisions at √s = 2.76 and 7 TeV with the ALICE detector. Jets are reconstructed using charged tracks at mid rapidity with the anti-kT jet finding algorithm from the FastJet package at various resolution parameters. Results are compared to predictions from the PYTHIA (tunes Perugia0, Perugia2010, Perugia2011, AMBT1), PHOJET, and HERWIG Monte Carlo (MC) models at √s = 7 TeV. None of the models perfectly explains the measured cross sections. PYTHIA Perugia2011 describes the cross sections
at intermediate and high jet transverse momentum (pTjet) whereas HERWIG reproduces best at low pTjet. Transverse jet shapes are reproduced rather well
by MC generators while the fragmentation functions are relatively well described by the generators in the low momentum region. These measurements will also serve as useful references for similar measurements in A–A collisions where jets are expected to be modified by interactions with the partonic medium.

Keywords:

jets, cross section, fragmentation functions, transverse shapes, pp, PYTHIA, PHOJET, HERWIG, ALICE, LHC

Initial State and Proton-Nucleus Collision Phenomena / 106

Measuring cold nuclear matter effects via di-jets in pPb collisions with ALICE

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We present a measurement of jet correlations in p-Pb collisions at \sqrt{s}=5.02 TeV.
The aim of the measurement is to test whether cold nuclear matter effects and
shadowing are present in p-Pb collisions.
Jets are measured using the central detectors using the anti-kT jet algorithm.
In the analysis the underlying event is subtracted event-by-event.
Corrections for the remaining underlying event contribution and the finite detector resolution are applied on an inclusive basis.
A measurement of the dijet k_{T} as function of the transverse momentum of the
jet, varying jet resolution parameter, and the event multiplicity will be
presented. This observable is a measure of the acoplanarity of dijet
production which is potentially modified.
In addition the correlation in pseudorapidity of jet pairs which is sensitive
to nuclear shadowing will be discussed.

Keywords:

jets, pPb, cold nuclear matter, ALICE, LHC, kt

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Prospects for heavy-flavour angular correlation measurements in heavy-ion collisions at the LHC with the upgrade of the ALICE detector

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A significant suppression of heavy-flavor production in heavy-ion collisions was observed by the ALICE apparatus at the LHC via the measurement of the nuclear modification factor of electrons and muons from heavy-flavor hadron decays and of D mesons reconstructed in hadronic decay channels. This suppression can be, at least partially, attributed to the energy lost by charm and beauty quarks in the interaction with the Quark-Gluon Plasma (QGP) formed in such collisions. The analysis of the angular correlations of heavy-flavour particles with charged hadrons, electrons or displaced secondary vertices can provide further insight into the energy loss process and spot a possible modification of the heavy-flavor parton shower and hadronisation in the presence of the medium.
Pure and abundant heavy-flavour signals are required to measure the properties of angular correlations with a significant precision in heavy-ion collisions: this demands a high resolution on the track spatial position and the collection of large data samples. The feasibility of heavy-flavor correlation measurements after the upgrade of the ALICE detector will be discussed.

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Perspectives on heavy-flavour measurements with the upgrade of the ALICE detector at the LHC

Author: Rosa Romita[1]

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ALICE is the LHC experiment dedicated to the study of the Quark-Gluon Plasma (QGP) in Pb-Pb collisions. Heavy quarks are ideal probes to explore the QGP formation and properties, since they are abundantly produced at the LHC and they experience the entire evolution of the medium.

ALICE measures heavy-quark production both at central and forward rapidity, reconstructing heavy-flavour particles, both exclusively, using a selection of hadronic decay channels, and inclusively, using single leptons. Many important results have been obtained analyzing the data taken over the last three years, however there are still several open questions that are beyond the capabilities of the present detector. For example, a precise measurement of the elliptic flow of charm and beauty hadrons would provide insight on the heavy-quark transport parameters of the medium, and a measurement of heavy-flavour baryons would reveal the role of recombination in the heavy-quark sector.

An upgrade of the ALICE detector, including a new Inner Tracking System (ITS), has been recently approved and is scheduled for the second long shutdown of the LHC. A new Muon Forward Tracker (MFT) is also being proposed. The new ALICE apparatus will provide improved tracking precision (by about a factor of 3) and will collect data with higher rate, thanks to the upgrade of the Time Projection Chamber (TPC). These new features will allow one to measure rare probes in Pb-Pb collisions, such as heavy-flavour baryons and beauty decays and to improve the accuracy of the present measurements, such as elliptic flow and nuclear modification factor for the D mesons. We present the expected performance of the new detector and the perspectives for the new or improved measurements with the upgraded ITS and MFT.

Hard and Thermal Electroweak Probes / 112

Low mass dilepton production in pp, p-Pb and Pb-Pb collisions measured with ALICE at the LHC

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Low mass dilepton production, including light vector mesons ρ, ω, φ, provides key information on the hot and dense state of strongly inter- acting matter produced in high-energy heavy-ion collisions. Among them, strangeness production can be studied through the measure- ment of φ meson production, while the detailed description of the full dilepton mass spectra down to the kinematic threshold can be used to reveal in-medium modifications of hadron properties and the ther- mal emission arising from the medium. Measurements in pp and p-A systems, in absence of hot nuclear matter effects, can be used as a ref- erence to test our knowledge of the processes expected to contribute to dilepton production.
Dilepton production is studied with the ALICE apparatus at the LHC both at central (|y| < 0.9) and forward (2.5 < y < 4) rapidities, respectively in the dielectron and dimuon channel. Results on low mass dilepton production are shown, for various c.m. energies, in pp, p-Pb, Pb-p and Pb-Pb collisions.

Heavy Flavor Production and Quarkonia / 113

Upsilon production measurements with ALICE at the LHC

Author: Francesco Bossu[1]

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ALICE (A Large Ion Collider Experiment) is designed to study ultra-relativistic heavy-ion collisions, where strongly interacting matter is produced and a phase transition to the Quark Gluon-Plasma (QGP) is expected. Quarkonia resonances are considered to be one of the most promising probes of the deconfined phase, since the heavy quark pairs are produced in the early stages of the collision and their bound states are sensitive to the QGP temperature. Unlike charmonium, regeneration effects at hadronisation are not expected to play a major role on bottomonium production. Cold nuclear matter effects can be distinguished from the hot nuclear matter ones by studying bottomonium production in proton-nucleus collisions, where no deconfined state is expected to be created.

In ALICE, Υ production can be measured in the muon decay channel with the forward muon spectrometer ($2.5 < y_{\rm lab} < 4$). Recent results in Pb-Pb collisions at $\sqrt{s_{\rm NN}} = 2.76$ TeV, in p-Pb collisions at $\sqrt{s_{\rm NN}} = 5.02$ TeV as well as the cross-section measurement in pp collisions at $\sqrt{s} = 7$ TeV will be presented.

High Transverse Momentum Light and Heavy Flavor Hadrons / 116

Azimuthal Jet Tomography at RHIC and LHC

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Recent data on the azimuthal and transverse momentum dependence of high-pT pion nuclear modification factors in nuclear collisions at RHIC and LHC are analyzed in terms of a wide class of jet-energy loss models, ranging from running coupling pQCD based prescriptions to AdS/CFT-inspired models, considering a variety of transverse expanding collective flow backgrounds. RHIC data are found to be surprisingly consistent with rather different dE/dx models. However, extrapolations to LHC favor running coupling QCD based energy-loss models over fixed coupling QCD, conformal AdS holography, or Tc-dominated jet-energy loss models that tend to overpredict jet quenching at the LHC.

Initial State and Proton-Nucleus Collision Phenomena / **120**

Predictions for p+Pb Collisions at sqrt(s_NN) = 5 TeV: Expectations vs. Data

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Recently a compilation of predictions for charged hadron, identified light hadron, quarkonium, photon, jet and gauge boson production in p+Pb collisions at sqrt(s_NN) = 5 TeV was made available [1]. Here the predictions are compared to the data so far available.

[1] J. Albacete et al., Int. J. Mod. Phys. E22 (2013) 133007.

High Transverse Momentum Light and Heavy Flavor Hadrons / **121**

A transport set-up for heavy-flavour observables in nucleus-nucleus collisions at RHIC and LHC

Authors: Andrea Beraudo[1]; Arturo De Pace[2]; Francesco Prino[2]; Marco Monteno[2]; Mario Sitta[3]; Marzia Nardi[2]; Wanda M. Alberico[4]

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A multi-step setup for heavy-flavour studies in high-energy nucleus-nucleus collisions is presented. The initial hard production of Q-Qbar pairs is simulated with the POWHEG pQCD event generator, interfaced with the PYTHIA parton shower.
Outcomes of the calculations are compared to experimental data in p-p collisions and are used as a validated benchmark for the study of medium effects.
In the nucleus-nucleus case, the propagation of the heavy quarks in the medium is described through the relativistic Langevin equation. The numerical results are compared to experimental data from RHIC and the LHC. In particular we show the comparisons for the nuclear modification factor and for the elliptic flow coefficient v_2 of D/B mesons and heavy-flavor electrons. Besides the results already appeared in Eur. Phys. J. C (2013) 73:2481, we will show a new comparison with data on non-prompt J/psi's from CMS and ALICE, which will are becoming available.
Furthermore, a more systematic study of the effects of heavy-flavor hadronization will be presented.

Keywords:

Heavy-Flavor, Transport theory

Heavy Flavor Production and Quarkonia / **122**

Quarkonium production and polarization, from elementary to Pb-Pb collisions

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Non-relativistic QCD (NRQCD) is commonly expected to describe the production of heavy quarkonium states in elementary collisions. It has been claimed to provide good descriptions of differential production cross sections of several quarkonia, while failing to reproduce the polarization measurements, a problem often attributed to the unreliability of the measurements. In this presentation we show how the very recent LHC measurements, both cross sections and polarizations, compare to NRQCD. We show that different NLO NRQCD approaches lead to seemingly contradictory conclusions and we offer some thoughts regarding what this surprising observation tells about the validity of the NRQCD framework and about quarkonium production. In particular, we explore the possibility that the long-distance matrix elements (LDMEs) describing the transitions from the colour octet states to the observable states, crucial non-perturbative ingredients of the calculations, might not be universal. In that case, the NRQCD framework remains valid, but hadroproduction and photoproduction data are not described by the same set of matrix elements. This observation, while not being as surprising as one might tend to think at first, triggers intriguing questions on the importance of the surrounding hadronic environment in the production of quarkonium states, already in elementary collisions.
This discussion shows that it is not unreasonable to expect different LDMEs in pp and PbPb collisions, where the abundance of gluons may favour otherwise suppressed transitions. Studies of quarkonium production in heavy-ion collisions, to probe QGP melting and/or recombination effects, are therefore remarkably intertwined with the ("cold") nuclear modifications of the LDMEs. We conjecture that accurate results on J/psi and Upsilon(1S) polarizations in Pb-Pb collisions, easily obtainable at the LHC, could provide unique measurements of the long-sought P-wave suppression patterns, thereby reliably probing sequential quarkonium melting, a signature of deconfinement mostly insensitive to "cold nuclear matter" effects.
We finish by proposing measurements of the polarizations of quarkonia in ultra-peripheral Pb-Pb collisions, as a way to study quarkonium production in still another environment, dominated by gamma-gamma interactions instead of gluon-gluon interactions. Such data could provide a clear-cut challenge to LDME universality.

Keywords:

quarkonium production; quarkonium polarization; quarkonium suppression

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A Bayesian approach to identifying D0 mesons produced in pp collisions in ALICE

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The standard particle identification (PID) method in ALICE uses a frequentist, or nσ, approach. In this method, particles are accepted via a cut on the number of standard deviations by which a signal may differ from the expected detector response. In cases where the detector responses for two species become similar, for example at high transverse momenta, or alternatively in some decay channels such as $\Lambda c \longrightarrow pK\pi$, the nσ method becomes less effective, thereby greatly increasing the combinatorial background and making reliable signal extraction difficult.

In this poster, the usage of an alternative Bayesian approach, based on a combination of the measured dE/dx and time-of-flight of the daughter tracks, will be examined. Instead of cutting based on a number of standard deviations from expectation, the Bayesian method bases its response on prior probabilities of a particle being produced with a given momentum. This allows for a calculation of the probability of a daughter particle belonging to each species (π, K, p, etc.) based
on the detector response seen. In order to check the validity of this method, various decay channels were tested and compared to the nσ method. Among these was the channel D0 ⟶ K-π+, which provides a valuable cross-check of both the kaon and pion responses in this approach. In addition to considering the differences in signal-to-background ratio between the various methods, a comparison will be shown between the yield obtained without PID and those found when using Bayesian and nσ approaches after being corrected for their respective PID efficiencies.

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Performance of b-jet tagging algorithms in ALICE

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The interest in studying heavy quarks comes from their characteristics to be initially-produced probes exposed to the collision evolution,
and therefore affected by the presence of the hot and dense medium created in Pb-Pb collisions at LHC energies.

It is expected that heavy quarks traverse the medium losing energy via subsequent elastic scatterings and/or gluon radiation. Theoretical models of energy loss predict a hierarchical dependence on the colour charge and mass of the hard-scattered parton traversing the medium.
This is still one of the main open questions regarding the mechanism of jet quenching in AA collisions.
By comparing the quenching effects on heavy-flavour quarks, with that on light-flavour quarks and gluons we will establish the flavour and colour charge dependence of the energy loss mechanisms.

The high precision tracking, particle identification, and excellent vertexing capabilities of the ALICE detector allow for accurate measurements of particles with charm and beauty in a wide momentum region.
The b-quark production rate can be measured in pp, pA, AA collisions via the full reconstruction of jets originating from the fragmentation of b-quarks, which enables precise measurements of the parton-jet energy scale, reducing the biases in
the study of jet quenching and possibly adding complementary information on the lost energy.
The dependence of the energy loss on the parton type can therefore be assessed by comparing the modification of b-jets with that of light flavour or c-jets in Pb-Pb collisions.

In this poster we present a MC study of the performance of b-jet tagging strategy in ALICE for pp collisions at 7 TeV, exploiting the relatively large mass and long lifetime of B hadrons.
Different b-jet tagging algorithms, based on single tracks, displaced secondary vertices and electron identification will be discussed and compared. The perspectives for the analysis strategy in different collision systems will be presented, together with the performance expected after the ALICE and LHC upgrades in 2018.

Heavy Flavor Production and Quarkonia / 128

Quarkonium production and polarization in pp collisions with the CMS detector

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Studies of the production of heavy quarkonium states are very important to improve our understanding of QCD and hadron formation, given that the heavy quark masses allow the application of theoretical tools less sensitive to nonperturbative effects.

Thanks to a dedicated dimuon trigger strategy, combined with the record-level energy and luminosity provided by the LHC, the CMS experiment could collect large samples of pp collisions at 7 and 8 TeV, including quarkonium states decaying in the dimuon channel. This allowed the CMS collaboration to perform a series of systematic measurements in quarkonium production physics, including double-differential cross sections and polarizations, as a function of rapidity and pT, for five S-wave quarkonia: J/psi, psi(2S), Y(1S), Y(2S), and Y(3S). Some of these measurements extend well above pT~50 GeV, probing regions of very high pT/mass, where the theory calculations are supposed to be the most reliable. Thanks to its high-granularity silicon tracker, CMS can reconstruct low-energy photons through their conversions to e+e- pairs, thereby accessing the radiative decays of the P-wave quarkonium states, with an extremely good mass resolution, so that the J=1 and J=2 1P states can be resolved. This allows CMS to determine cross-section ratios and feed-down decay fractions involving the chi states, in both the charmonium and bottomonium families. Such measurements provide crucial inputs to a better understanding of quarkonium production as a signal of new physics in Pb-Pb collisions.

This talk presents the CMS quarkonium production results, in pp collisions, placing emphasis on the most recent measurements, which include the polarizations of all five S-wave states, the most comprehensive measurement of quarkonium polarization made so far. We will also present brand-new results on P-wave quarkonium production in the bottomonium family. It is likely that other preliminary results on quarkonium production in pp collisions, of particular relevance for the understanding of heavy-ion measurements, will be shown at this conference for the first time.

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D meson production in Pb-Pb collisions at sqrt{s_{NN}} = 2.76 TeV with ALICE

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The ALICE experiment at the LHC studies Pb-Pb, p-Pb and pp collisions with the aim of investigating the properties of the high energy density state of strongly-interacting matter, expected to be produced in Pb-Pb collisions. Heavy quarks are sensitive probes to test the medium properties, since they are formed on a shorter time scale with respect to the strongly-interacting matter. These quarks lose energy passing through the medium via gluon radiation and elastic collisions with other partons. The following interactions with partons of the medium might lead to their thermalization, in spite of their large mass.
The nuclear modification factor (RAA), obtained by comparing heavy flavour production yields in pp and Pb-Pb collisions, allows one to measure the effect of parton in-medium energy loss. In particular, the study of the centrality dependence of the D meson RAA, compared with light flavour and J/psi from beauty hadron decay measurements, can provide information on the colour charge and parton mass dependence of the energy loss. Moreover, the azimuthal anisotropy (v2) of D mesons compared to that of light hadrons is expected to bring insights into the degree of thermalization of charm quarks within the medium.

Charmed mesons have been measured with ALICE, by reconstructing D0, D+, D+ and D+s mesons from their hadronic decay channels, in the central rapidity region in Pb-Pb collisions at sqrt(s_NN) = 2.76 TeV, with data collected in the 2010 and 2011 runs. The centrality and transverse momentum dependence of D meson RAA and v2 will be presented.

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Measurement of W-Boson Production at Forward Rapidity with the ALICE Muon Spectrometer at the LHC

Author: Jianhui Zhu[1]

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W bosons are produced in initial hard scattering processes and they are not affected by the strong interaction. They have been suggested as standard candles for luminosity measurements and to improve the evaluation of the detector performances. In heavy-ion collisions, W bosons, which are not affected by the presence of the hot and strongly-interacting medium formed in such collisions, allow one to check the validity of binary scaling and to study the nuclear modification of quark distribution functions.
Furthermore, W bosons provide a reference for observing QGP induced effects on other probes, like suppression of heavy quark.
The production of W bosons at forward rapidity (2.5 < y < 4) is measured in the single muon decay channel with the ALICE muon spectrometer. After a presentation of the motivations for the study of W bosons and a description of the ALICE muon spectrometer, the latest results on the W boson production at forward rapidity in Pb-Pb collisions at sqrt(s_NN) = 2.76 TeV and p-Pb/Pb-p collisions at sqrt(s_NN) = 5.02 TeV will be discussed.

Jet Quenching and Observables / **138**

Jet quenching in perturbative QCD with JEWEL

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I will discuss the present status and prospects for future developments and applications of the (soon publicly available) JEWEL code. JEWEL is a fully microscopic Monte Carlo event generator for jet evolution in a dense, strongly interacting medium. It employs a consistent perturbative approach using a common framework for all scattering and radiation processes. This construction allows for the consistent treatment of recoils, radiation off recoiling scattering centres, multiple gluon emission, interplay between vacuum and medium induced radiation and interferences. At the same time it is very constrained leaving little room for tuning and allowing for a quantitative assessment of uncertainties related to the basic assumptions. Despite its being based on few minimal assumptions JEWEL results are in reasonable agreement with experimental data for both jets and leading hadrons. JEWEL can be interfaced with any model for the medium and thus offers a tool for studying how models implementing different medium properties can be disentangled with the help of hard probes.

Keywords:

jet quenching

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J/Psi and (2S) Production in p-Pb Collisions at sqrt(sNN)=5.02 TeV with the ATLAS Detector.

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Production rates of bounded c-cbar states in nucleus-nucleus collisions provide a sensitive probe of strongly interacting matter of quarks and gluons created in such collisions. The temperature achieved by the medium defines the color screening length, which has a direct impact on the production rates of different quarkonium states. Studying the production rates of heavy quark states provides a "thermometer" for the medium where they were formed. However, understanding quarkonium production in lead-lead system requires a reference. Proton-lead collisions, where no deconfined state is expected to be created, opens the possibility to untangle the cold nuclear matter effects in heavy-quarkonium states production.

Experimental data of integrated luminosity approximately equal to 30nb-1 obtained by the ATLAS detector in 2013 proton-lead run at sqrt(s_NN)=5.02 TeV to analyse J/Psi and Psi(2S) in bins of transverse momentum, rapidity, and collision centrality.

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Probing the nuclear wave function with photons in proton-lead collisions with ATLAS

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One of the most important questions in heavy ion physics is the role of shadowing and anti-shadowing in the nuclear wave function. Proton-lead collisions at 5.02 TeV at the LHC provide an excellent opportunity to test models of the nuclear parton distribution functions (nPDFs) by means of the measurement of penetrating hard probes, such as photons and electroweak bosons (W & Z) at high pT. Low pT photons, which are challenging to identify amidst diet backgrounds, also provide a channel to access the low-x part of the wave function. ATLAS has taken 30 nb -1 of proton-lead data, and has measured prompt, isolated photons within |eta|<2.5 and at pT up to 200 GeV. The yield of prompt, isolated photons as a function of pT, rapidity and centrality will be presented and compared with the leading nPDF implementations.

Jet Quenching and Observables / 149

Jet quenching effects on the elliptic and triangular flow at RHIC

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In this work we investigate how the energy and momentum lost by partonic jets in the quark-gluon plasma may affect the final elliptic and triangular flow of low p_T hadrons at RHIC energies. The jets are modeled as external sources in the energy-momentum conservation equations of ideal hydrodynamics, which are solved on an event by event basis. We find that the average integrated elliptic (triangular) flow and the participant eccentricity (triangularity) can become significantly less linearly correlated if the energy loss rate is sufficiently large (dE/dx > 10 GeV/fm). We show that the linear correlation between v_3(p_T < 1 GeV) and v_3(2 < p_T < 3 GeV) is particularly sensitive to the magnitude of dE/dx and, thus, this new observable may be used to distinguish between strong and weak coupling scenarios for the jet energy loss in the QGP.

Keywords:

Heavy Ion Collisions, hydrodynamics, jet quenching, flow Fourier harmonics, initial eccentricity.

Hard and Thermal Electroweak Probes / **150**

Boson production in lead-lead collisions in the ATLAS experiment

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Lead-lead collisions at the LHC have are capable of producing a system of deconfined quarks and gluons at unprecedented energy density and temperature. Partonic-level interactions and energy-loss mechanisms in the medium can be studied with the aid electroweak bosons which carry an important information about the properties of the medium. Electroweak bosons form a class of unique high-pT probes because they or their decay products do not interact with the strongly-coupled medium, providing a benchmark for a variety of other phenomena measured with strongly interacting particles.

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The ATLAS experiment measures isolated high-pT photons, W and Z bosons via different decay cha
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Jet Quenching and Observables / **155**

Inclusive jet production in p+Pb collisions at 5.02 TeV with the ATLAS detector at the LHC jet quenching

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Measurements of reconstructed jets in high-energy proton-lead collisions over a wide rapidity and pT range can shed light on the partonic structure of nuclei. Inclusive jet production is sensitive to the nuclear modification of parton distribution functions and, in the forward direction and at small transverse momenta, can provide constraints on the saturation of low Bjorken-x partons in

the high-density Pb nucleus. Furthermore, any modification of jet production in p+Pb collisions requires that the strong suppression seen in central Pb+Pb collisions be understood in the light of these nuclear effects. We present the latest results on inclusive jet production in p+Pb collisions at 5.02 TeV measured in the new high statistics 2013 data with the ATLAS detector at the LHC.

Initial State and Proton-Nucleus Collision Phenomena / 159

Predictions for the Spatial Distribution of Gluons in the Initial Nuclear State

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We demonstrate measurable, falsifiable differences between the DGLAP and CGC predictions for the t-differential cross section of exclusive vector meson production (EVMP) in electron-ion collisions. These predictions permit an experimental determination of the dominant physical processes for low-x gluons in a high-energy nucleus. At eRHIC energies, J/psi photoproduction in e+A collisions provides an ideal experimental probe for the spatial distribution of gluons. EVMP grants experimental access to the edge region of the highly-boosted nuclear wavefunction, where the saturation scale for CGC calculations becomes inaccessible to pQCD. On the other hand, DGLAP evolution requires careful consideration of unitarity effects.

Under these different small-x frameworks we obtain a measurable distinction in both the shape and normalization of the differential cross section predictions. An eRHIC measurement of such an EVMP cross section will therefore constrain the initial state in heavy ion collisions, allowing for a more quantitative study of the properties of the quark-gluon plasma.

Initial State and Proton-Nucleus Collision Phenomena / 160

Applications of JIMWLK Evolution to Exclusive J/Psi Production

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The Large Hadron Collider, located at the European Centre for Nuclear Research, is the most powerful particle collider ever built. The ATLAS experiment at the LHC uses the proton and heavy ion collisions produced in this 27 km long collider to probe the predictions and limitations of the Standard Model. Due to the high energies employed, collisions are able to probe a regime known as the Colour Glass Condensate (CGC): a medium characterized by a part of the hadronic wavefunctions being dominated by nonperturbatively large gluon occupation numbers. The JIMWLK equation is a mathematical tool used to predict some of the physical observables within the CGC framework. By exploiting appropriate exclusive interactions (where at least one of the protons does not break), this work attempts to calculate the exclusive J/Psi production cross-section using a truncation of the JIMWLK equation and to measure this cross-section in the ATLAS experiment.

Jet Quenching and Observables / **164**

Jet propagation within a Linearized Boltzmann Transport Model

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A Linearized Boltzmann Transport model is developed for the study of parton propagation inside quark-gluon plasma. Both leading partons and thermal recoiled partons are tracked so that one can also study jet-induced medium excitation. In this study, we implement the complete set of elastic parton scattering processes and investigate elastic parton energy loss, transverse momentum broadening and their nontrivial energy and length dependence. We further investigate the jet shape and fragmentation functions of reconstructed jets using FASTJET algorithm. Contributions from the recoiled thermal partons are found to have significant influences on jet shape and angular distribution of reconstructed jets.

Keywords:

Jet transport

High Transverse Momentum Light and Heavy Flavor Hadrons / **165**

Interplay between bulk medium evolution and (D)GLV energy loss

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The PHENIX Collaboration has argued that azimuthal angle dependent pi0 suppression in Au+Au at RHIC poses a challenge for perturbative QCD energy loss models. However, recent work by Betz and Gyulassy claims simultaneous reproduction of this set of observables with simple pQCD-motivated energy loss formulas. We study and contrast different bulk medium evolution models (based on hydrodynamics and covariant transport) combined with different implementations of Djordjevic-Gyulassy-Levai-Vitev radiative energy loss to investigate whether, and if yes then how the nuclear-suppression vs elliptic flow puzzle could be resolved in the DGLV framework for light partons and heavy quarks. This is especially interesting in view of our earlier results that showed that realistic transverse expansion of the bulk medium reduces high-pT elliptic flow from GLV energy loss by nearly half compared to transversely frozen evolution scenarios.

Hard and Thermal Electroweak Probes / **169**

Electromagnetic radiation as a probe of the initial state in relativistic nuclear collisions and of viscous hydrodynamics

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The penetrating nature of electromagnetic signals makes them suitable probes to explore the properties of the strongly-interacting medium created in relativistic nuclear collisions. This study investigates thermal electromagnetic radiation production using a 3+1D viscous hydrodynamic simulation (MUSIC). We study the thermal dilepton/photon emission of the medium by using both pQCD and hadronic scattering (and decay) processes. We will examine the effects of the initial conditions, viscosity, and event-by-event fluctuations on the flow coefficients of electromagnetic probes.

Heavy Flavor Production and Quarkonia / **170**

Inclusive J/ψ and ψ(2S) production in p-Pb collisions at √sNN = 5.02 TeV with ALICE at the LHC

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Charmonia are considered as a key observable for deconfinement in nucleus- nucleus (A-A) collisions at LHC energies. Measurements in proton-nucleus (p-A) collisions provide important information to investigate nuclear effects, which are commonly not attributed to the Quark-Gluon Plasma.
In ALICE, J/ψ production has been measured in proton-proton, p-A and A-A collisions down to pT = 0 GeV/c both via their dimuon decay in the forward muon spectrometer and with dielectrons in the central barrel. √
In this talk, results on the J/ψ nuclear modification factor RpA at sNN = 5.02 TeV as a function of rapidity, covering the forward (2.03 < ycms < 3.53), central (-1.37 < ycms < 0.46) and backward range (-4.46 < ycms < -2.96), will be presented as well as RpA(pT). Results on ψ(2S) at forward and backward rapidity will also be discussed. Finally, comparisons with theoretical models will be carried out.

Heavy Flavor Production and Quarkonia / **171**

Investigating Jet Quenching on the Lattice

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Due to the dynamical, real-time, nature of the phenomenon, the study of jet quenching via lattice QCD simulations is not straightforward. In this talk, however, it will be shown how it is possible to extract information about the momentum broadening of a hard parton moving in the quark-gluon plasma, from lattice simulations. After discussing the basic idea (originally proposed by Caron-Huot), we will present a recent study, in which we estimated the jet quenching parameter non-perturbatively, from the lattice evaluation of a particular set of gauge-invariant operators.

Jet Quenching and Observables / **172**

Jet suppression in Pb+Pb collisions with the ATLAS detector

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High Transverse Momentum Light and Heavy Flavor Hadrons / **173**

D-meson production in pp, p-Pb, and Pb-Pb collisions with ALICE at the LHC

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Heavy quarks, i.e. charm and beauty, are considered calibrated probes of the strongly interacting deconfined medium (Quark Gluon Plasma) formed in heavy-ion collisions. Produced in hard scattering processes in the initial stages of the collision, they interact with the medium, lose energy and, depending on the coupling strength to the medium, take part in the collective motion of the QGP matter. ALICE measured the production of D0, D*+, D+ and Ds mesons at central rapidity in pp, p-Pb and Pb-Pb collisions at the LHC. The study of the modification of the transverse-momentum differential yields of charm particles in Pb-Pb collisions with respect to pp collisions, quantified by the nuclear modification factor (RAA), can unravel details of the energy loss mechanism, such as its dependence on the quark mass and on the path length the parton travels through the medium. A similar comparison between pp and p-Pb collision data (RpPb) is fundamental to disentangle effects related to the presence of the hot medium from cold nuclear matter effects, among which nuclear shadowing, suppressing the gluon PDF at low Bjorken-x, is the most important for charm at LHC energies. The degree of thermalization and coupling to the medium is investigated in semi-peripheral Pb-Pb collisions by measuring the elliptic flow coefficient (v2), which quantifies the angular dependence of the particle production with respect to the reaction plane of the collision and, at high pT, is sensitive to the path-length dependence of the energy loss. The latter dependence can be also addressed by studying the modification to the azimuthal correlation distribution of D mesons and charged hadrons in central Pb-Pb collisions with respect to pp collisions.
Results on the transverse momentum and centrality dependence of the D-meson elliptic flow and RAA will be presented. The comparison with the RAA of non-prompt J/ψ from B decay measured with CMS will be discussed. The preliminary results on D-meson RpPb and the dependence of D-meson yields on rapidity in p-Pb collisions will be shown. As an outlook, the analysis and the preliminary results on the azimuthal correlations between D-mesons and charged hadrons in pp collisions will be described.

High Transverse Momentum Light and Heavy Flavor Hadrons / **174**

Measurements of electrons from heavy-flavour decays in pp, p-Pb and Pb-Pb collisions with ALICE at the LHC

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Heavy-ion collisions at the LHC provide an opportunity to investigate the properties of QCD matter at high temperatures and energy densities, where a transition to a Quark- Gluon Plasma state is expected to occur. In order to study the QGP properties, a given observable is often measured in different collision systems (pp, p-Pb and Pb-Pb) and multiplicity classes.

Heavy quarks, i. e. charm and beauty, are a powerful probe for this state of matter. Due to their large masses, they are produced in initial hard parton scattering processes, and they propagate through the hot and dense medium created in the collision of heavy ions. Heavy-flavour hadrons can be studied via the measurement of electrons from their semi-electronic decays.

ALICE has excellent capabilities for heavy-flavour measurements employing several sub- systems providing high resolution vertex and track reconstruction, as well as particle iden- ti□cation in a wide momentum range.

In this contribution, measurements of the nuclear modification factors (RpPb and RAA) and of the elliptic flow v2, of heavy-flavour decay electrons, will be presented as a function of pT. The nuclear modification factor is the ratio of the electron transverse momentum spectrum measured in Pb-Pb (p-Pb) collisions to that in pp collisions, scaled by the number of binary nucleon-nucleon collisions. The elliptic flow v2 is the second Fourier coefficient of the azimuthal distribution of particle momenta in the transverse plane with respect to the reaction plane.

Furthermore, studies of the correlation between these electrons and unidentified charged particles in pp (√s = 2.76 TeV), p-Pb (√sNN = 5.02 TeV) and Pb-Pb (√sNN = 2.76 TeV) collisions will be reported.

High Transverse Momentum Light and Heavy Flavor Hadrons / **175**

Nuclear Modification Factor and Elliptic Flow of Muons from Heavy-Flavour Hadron Decays in Pb-Pb Collisions at sqrt(s_NN)=2.76 TeV with ALICE

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The LHC heavy-ion physics program aims at investigating the properties of strongly- interacting matter in extreme conditions of temperature and energy density, where the formation of the Quark Gluon Plasma (QGP) is expected. In high-energy heavy-ion collisions, heavy quarks are regarded as efficient probes of the properties of the QGP as they are created on a very short time scale in initial hard parton scattering processes and subsequently interact with the medium.

In the high transverse momentum region, the suppression of the yield of heavy- flavoured hadrons, quantified by means of the nuclear modification factor, RAA, defined as the ratio of the yield measured in Pb–Pb to that observed in pp collisions scaled with the number of binary nucleon-nucleon collisions, is used to study the heavy quark in-medium energy loss mechanisms. The heavy-flavour elliptic flow, the second order coefficient of the Fourier expansion of particle azimuthal distributions (relative to the reaction plane), pro- vides insight into the degree of thermalization of heavy quarks in the deconfined medium and carries information on the path-length dependence of parton energy loss in the low and high transverse momentum region, respectively.

With ALICE, the detector designed and optimized for heavy-ion physics at the LHC, open heavy flavours are measured at forward rapidity ($2.5 < y < 4$) using semi-muonic decays. The latest results on the nuclear modification factor and elliptic flow of muons from heavy-flavour decays in Pb–Pb collisions at √sNN = 2.76 TeV will be presented. Comparisons with theoretical predictions will be discussed.

Initial State and Proton-Nucleus Collision Phenomena / **177**

Centrality dependence of charged particle spectra in Proton-Lead collisions at sort(s_NN) = 5.02 TeV with the ATLAS detector

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To Be Completed

Initial State and Proton-Nucleus Collision Phenomena / **178**

Gluon Saturation Beyond Leading Logs

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Opening

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Theory: What Have Hard Probes Taught Us about the Quark-Gluon Plasma?

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ALICE: What Have Hard Probes Taught Us about the Quark-Gluon Plasma?

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ATLAS: What Have Hard Probes Taught Us about the Quark-Gluon Plasma?

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CMS: What Have Hard Probes Taught Us about the Quark-Gluon Plasma?

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STAR: What Have Hard Probes Taught Us about the Quark-Gluon Plasma?

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PHENIX: What Have Hard Probes Taught Us about the Quark-Gluon Plasma?

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Jet Physics Theory

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Fully Reconstructed Charged Jets in Central Au+Au Collisions at sqrt(s_NN)=200 GeV from STAR

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Jet production and structure in pp, p-Pb and Pb-Pb collisions measured by ALICE

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From Jet Quenching to Wave Turbulence

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Measurement of jet structure in Pb+Pb collisions using the ATLAS detector

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Jet measurements from the CMS Collaboration

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ALICE results on the production of light-flavor hadrons at the LHC

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Light and heavy flavor energy loss phenomenology

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ALICE Heavy Flavor Results

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Quark Energy Loss in a Strongly Coupled Fluid Close To and Far From Equilibrium

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Electromagnetic Fingerprints of the Little Bang

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Dielectron production in Au+Au collisions at $\sqrt{s_{NN}}$ = 19.6, 27, 39, and 62.4 GeV from STAR

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Direct-photon hadron correlations and jets in heavy-ion collisions at PHENIX

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Next-to-leading order thermal photon production in a weakly coupled quark-gluon plasma

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Jet Correlations Theory

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Measurements of long-range angular correlations and anisotropy in d+Au collisions at 200 GeV from PHENIX

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Study of the long-range correlation in high multiplicity p+Pb collisions with the ATLAS detector

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Theoretical Overview of Initial State and Flow Physics

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Azimuthal correlations with ALICE

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Correlations and flow phenomena in pPb and PbPb at CMS

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The Search for Gluon Saturation in pA Collisions

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Hard Probes Lattice Theory

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Quarkonia results from the PHENIX experiment

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Quarkonium measurements in the STAR experiment

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Quarkonia Theory

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Quarkonium production in ALICE at the LHC

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Onia production in pA and Ap collisions at LHCb

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Charmonium and bottomonium production in heavy-ion collisions with CMS

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Experimental Wrap-Up: Energy Loss

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Experimental Wrap-Up: p(d)A - Jets and Correlations

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Experimental Wrap-Up: Onia, Thermal and Electroweak Probes

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Theory Wrap-Up

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Closing

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Andreas: Experimental Wrap-Up: p(d)A - Particle Production and Nuclear Modification Factors

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Multiplicity dependence of J/psi production in p-Pb collisions with ALICE at the LHC

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The study of the production of charmonia, bound states of c and cbar quarks, is an intense research activity, both experimentally and theoretically. The peculiar properties of some of the charmonium states, like their small size (< 1 fm) and strong binding energy (several hundred MeV), make them ideal probes of the strongly interacting matter, the so-called Quark-Gluon Plasma (QGP), formed in heavy-ion collisions.

ALICE is dedicated to the study of QGP properties in heavy-ion collisions at the LHC. It measured J/psi suppression in Pb-Pb collisions at sqrt(s_NN)=2.76 TeV. At the beginning of 2013, p-Pb collisions at sqrt(s_NN)=5.02 TeV have been studied at the LHC, in order to measure the effects on charmonia related to cold nuclear matter, which include gluon shadowing (or gluon saturation), energy loss and nuclear absorption. Their evaluation is important in order to be able to disentangle, in Pb-Pb collisions, hot and cold nuclear matter effects.

Several observables (cross-section, nuclear modification factor and forward-to-backward ratio) on J/psi production in p-Pb collisions have been measured as a function of the transverse momentum and rapidity in the dimuon decay channel which covers 2.5<y_lab<4. In this poster, I will present a study of the multiplicity dependence of the J/psi production in p-Pb collisions.

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Video Presentation

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Memorial for Bob Thews and Vesa Ruuskanen / 222

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Memorial for Bob Thews and Vesa Ruuskanen / 223

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Memorial for Bob Thews and Vesa Ruuskanen / 224

Bob, Vesa and Hard Probes

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Johnnie Thews