ABSTRACT BOOK

PARALLEL SESSION

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Latest flow results from PHENIX at RHIC

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At the Relativistic Heavy Ion Collider (RHIC), key insights into the bulk properties of the hot and dense partonic matter arise from the study of azimuthal anisotropy (v_2) of the produced particles. The v_2 values indicate that the matter undergoes rapid thermalization and behaves hydrodynamically at low p_T. Furthermore, the quark scaling of v_2 for different particle species suggests that thermalization occurs at the quark level and that v_2 is the same for all quark flavors. Recently, higher order harmonic measurements (v_3, v_4) have shown the potential for insights into the medium's initial geometry and fluctuations. This talk will present the latest flow results from PHENIX and discuss their implications.

Comparative analysis of the harmonic flow measured by the event plane and two-particle correlation methods in lead-lead collisions at $\sqrt{s_{NN}} = 2.76$ TeV using the ATLAS detector at LHC

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Differential measurements of charged particle azimuthal anisotropy will be presented for Pb+Pb collisions at $\sqrt{s_{NN}} = 2.76$ TeV with the ATLAS detector at the LHC, based on an integrated luminosity of approximately $8\mu b^{-1}$. This anisotropy is characterized via a Fourier expansion of the distribution of particles in azimuthal angle measured with respect to the event reaction plane. The coefficients v_n, representing the magnitude of the harmonic flow at a particular angular scale, are measured as a function of transverse momentum ($0.5 < p_T < 20$ GeV), pseudorapidity ($|\eta| < 2.5$) and centrality. The measurement of the harmonic values up to $n = 6$ obtained via the two particle correlation method are compared with those from the event plane analysis. The behavior shown by this comparison suggests a connection between these observables and fluctuations in the geometry of the initial state. A large pseudorapidity gap between the tracking system and forward calorimeters is seen to significantly reduce contributions from short-range non-flow effects, permitting analyses of the collective flow component of the harmonic coefficients.

Collective flow and charged hadron correlations in 2.76 TeV PbPb collisions at CMS

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We report on the CMS measurements of charged hadron anisotropic azimuthal distributions from PbPb collisions at $\sqrt{s_{NN}} = 2.76$ TeV. The results are presented as a function of transverse momentum, centrality and pseudorapidity and cover a broad kinematic range. Long range in pseudorapidity di-hadron azimuthal correlations are also studied and discussed in terms of the possible influence of the initial collision geomety. These results can provide constraints on the theoretical description of the early dynamics in the hot and dense medium created at the LHC and the transport properties through this medium.

Shear viscosity of the quark-gluon plasma from relativistic heavy ion collisions

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We report an extraction of the ratio of shear viscosity to entropy density (η/s) of the medium created in relativistic heavy-ion collisions at the LHC. With a significant improvement of one of the main sources of theoretical uncertainty, we are able for the first time to quote a precise average value with robust error bars, systematically accounting for all known sources of systematic error (theoretical and experimental).

Shear viscosity in superfluid neutron stars

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The contribution of phonons to the shear viscosity η in superfluid neutron stars is studied assuming neutron pairing in a ${}^1S_0$ channel. We use a Boltzmann equation amended by a collision term that takes into account the binary collisions of phonons. We use effective field theory techniques to extract the phonon scattering rates, written as a function of the equation of state (EoS) of the system. We find that $\eta \propto 1/T^5$, the proportionality factor depending on the EoS of the system. Our results indicate that the phonon contribution to η cannot be ignored and might have relevant effects in the dynamics of the different oscillation modes of the star [1].

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Medium-induced soft gluon radiation in the quark scattering process without color transfer in t-channel

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We study coherence effects on the medium-induced soft gluon radiation off an "asymptotic quark " traversing a hot and dense QCD medium. The transverse momentum spectrum of the emitted gluon is computed at first order in opacity expansion. The interference effects between the initial and final state radiation modify the soft gluon radiation when a finite angle between the initial and final quarks is considered. The spectrum presents a soft divergence. We comment on possible implications on observables in heavy ion collisions which are sensitive to the initial state radiation.

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Study of jet properties in lead-lead collisions at $\sqrt{s_{NN}} = 2.76$ TeV using the ATLAS detector at LHC

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The centrality dependence has been determined for charged particles and for single jets of different jet sizes in lead-lead collisions in ATLAS at a per-nucleon center of mass energy of 2.76 TeV. In a sample of lead-lead collisions corresponding to an integrated luminosity of 7 μb^{-1}, jets are reconstructed calorimetrically using the anti-kt algorithm with varying radius parameter values. The underlying event, including elliptic flow modulations, is measured and subtracted event-by-event, yielding measurements of jet energies above the ambient background. The lead-lead collision centrality is characterized using the per-event total transverse energy measured in the ATLAS forward calorimeters which cover the pseudorapidity range $3.2-4.9$ for both positive and negative pseudorapidities. The number of nucleon-nucleon collisions, Ncoll, corresponding to the chosen centrality bins, is estimated using standard Glauber Monte Carlo methods. The centrality dependence of the jet yield is characterized by the jet R_{cp}, the ratio of the jet per-event yields divided by Ncoll in a given centrality bin to the same quantity in a peripheral centrality bin. Using this measure, jet production at transverse momenta, $p_T > 60$ GeV is found to be suppressed by more than a factor of two in the 10% most central collisions. The single jet results complement measurements of the dijet asymmetry and the observed suppression of charged particle spectra, and can be compared to the behavior of other hard probes.

Hard probes in 2.76 TeV PbPb collisions at CMS

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We will present an overview of CMS results at $\sqrt{s}$=2.76 TeV using hard probes to study quark and gluon matter in high-energy density. PbPb collisions. The capabilities of the CMS apparatus allows us to investigate these various hard probes using the calorimetry, muon and tracking systems covering a large range in pseudorapidity. The energy loss of fast partons traversing the strongly interacting matter produced in high-energy nuclear collisions is one of the most interesting observables to probe the effects of the hot and dense medium. In the first PbPb collisions at the LHC, the medium properties were studied using back-to-back dijets as a function of collision centrality, and significant momentum imbalance was observed. Studies of the angular distribution of jet fragments indicate a softening and widening of the subleading jet fragmentation pattern. As a complementary study for jet quenching and fragmentation properties, the transverse momentum spectra of charged particles have also been measured in pp and PbPb collisions. The inclusive production cross section of isolated prompt photons has also been studied in pp and PbPb collisions, which provide a direct test of perturbative quantum chromodynamics (pQCD), and constrains the proton and nuclear parton distribution functions (PDFs). CMS is also well equipped to measure muons and dimuons in the high multiplicity environment of heavy ion collisions. Inclusive and differential measurements of the Z boson yield show no sign of modification with respect to NLO pQCD calculations. So the direct photons and Z bosons constitute particularly clean probes of the initial state of the collision. Dimuon decays of the J/Ψ particle and the Υ family are also investigated and comparisons with results in pp collisions will be shown to illustrate suppression in PbPb collisions for quarkonia states.

Lessons from RHIC for the LHC and Vice Versa

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For the past decade, measurements of semi-inclusive single identified particle spectra and two-particle correlations in p-p and A+A collisions at RHIC have produced a treasure trove of results which indicate a suppression of hard-scattered partons in the medium produced in A+A collisions. A suppression $R_{AA} \approx 0.2$ has been measured in the range $5 \leq p_T \leq 20$ GeV/c in central Au+Au collisions at $\sqrt{s_{NN}} = 200$ GeV for π^0 [1] and surprisingly for single-electrons from the decay of heavy quarks [2]. Both these results have been confirmed at LHC [3, 4]. Interestingly, in this p_T range the LHC results for pions nearly overlap the RHIC results [5]. Thus, due to the flatter p_T spectrum, the energy loss in the medium at LHC must be larger than at RHIC in this p_T range. New at the LHC are the beautiful measurements of the fractional transverse momentum imbalance A_J of di-jets [6]. When corrected for the large fractional imbalance in p-p collisions required to obtain a clean jet sample in Pb+Pb, the relative fractional jet imbalance in Pb+Pb/p-p for ~ 200 GeV jets becomes smaller [7], a good topic for discussion. This is compared to the same quantity derived at RHIC from two-particle correlations of di-jet fragments, with a trigger π^0 with $p_T \approx 10$ GeV/c, which appear to show a larger fractional jet imbalance in this lower p_T range [7]. Among other lessons learned from RHIC which will be discussed is the need for p-p and p-A (or d-A) comparison data at the same $\sqrt{s_{NN}}$ in the same detector; and how the heavy-ion results may influence the search for the Higgs particle in p-p collisions at the LHC.

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High-p_T hadrons in heavy ion collisions: from RHIC to LHC

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We study high-p_T hadron production in heavy-ion collisions and analyze several sources of the observed nuclear suppression by experiments at RHIC and LHC. Short production length l_p of a hadron produced during hadronization process causes a relation between the nuclear suppression of high-p_T hadrons and survival probability of a colorless dipole propagating through a dense medium [1, 2, 3, 4]. This leads to a steep rise with p_T of the nuclear modification factor $R_{AA}(p_T)$ due to color transparency effects. In comparison with LHC a dominance of quarks with larger l_p leads to a smaller suppression at RHIC where we include also the suppression factor falling steeply with x_T, related to the energy conservation constraints [5, 6]. This factor is irrelevant at LHC but causes rather flat p_T dependence of R_{AA} at RHIC. Calculations contain only medium density adjustment and we found the transport coefficient to be $\hat{q}_0 = 0.30$-0.45 GeV^2/fm corresponding to $\sqrt{s} = 62$-200 GeV at RHIC and $\hat{q}_0 = 0.60$ GeV^2/fm corresponding to $\sqrt{s} = 2.76$ TeV at LHC. We present a broad variety of predictions in a good agreement with data from experiments at RHIC and LHC.

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Quarkonia and heavy flavour production measurement in Pb-Pb collisions with the ALICE experiment at the LHC

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ALICE (A Large Ion Collider Experiment), one of the four main experiments at the Large Hadron Collider (LHC), was designed and built to perform dedicated research on heavy ion collisions to study the Quark Gluon Plasma (QGP), a deconfined state of strongly interacting QCD matter [1].

As heavy flavours are produced on a very short time-scale in the initial hard scattering processes, they can be used to characterize the hot and dense medium formed in high-energy heavy-ion collisions through their modified yield as compared to pp collisions [2, 3].

In ALICE, quarkonia and heavy flavours are measured via their leptonic decay at central ($|y| < 0.9$) and forward ($2.5 < y < 4$) rapidity. In addition, charmed mesons are also detected at central rapidity via their hadronic decay.

The latest results on quarkonia and heavy flavour production by the ALICE experiment in Pb-Pb collisions at $\sqrt{s_{NN}} = 2.76$ TeV will be presented

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Charmonium production in p-p and Pb-Pb collisions at CERN and comparison with RHIC data

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The review of the experimental data on charmonium states production measured at the CERN SPS and in p-p and Pb-Pb collisions at LHC and comparison with the data obtained at the Brookhaven National Laboratory Relativistic Heavy Ion Collider RHIC is presented. The suppression of J/ψ production was suggested as a possible signal of quark gluon plasma formation in 1986 by Matsui and Satz [1]. But the experimental and theoretical situation is more complicated. The anomalous suppression of J/ψ production at the CERN SPS was discovered in central Pb-Pb collisions by NA50 collaboration at 158 GeV [2]. The effects of J/ψ suppression on cold nuclear matter and feed-down production from higher charmonium states are important in production of J/ψ at SPS energies. The PHENIX experiment at RHIC at $\sqrt{s} = 200$ GeV shows that the J/ψ suppression at these energies is of the same order as the suppression at SPS energies for Pb-Pb. The theoretical models that could reproduce SPS Pb-Pb results at $\sqrt{s} = 17.3$ GeV overestimate the J/ψ suppression at $\sqrt{s} = 200$ GeV. The models that include regeneration of J/ψ agree with the experimental results better. The study of charmonium production at LHC in p-p and Pb-Pb collisions shows the importance of regeneration process. The contribution of B-decay should be taken into account at LHC energy [3]. The future high statistic measurements at LHC could investigate the properties of matter at high energy density and temperature. Also the energy intervals between SPS, RHIC and LHC are very important for study of the mechanism of quarkonium production and suppression, in order to investigate medium effects and conditions for Quark Gluon Plasma formation. If the proton and ion beams will be used at LHC with fixed targets, the energy interval between SPS and RICH in p-A and A-A collisions could be investigated. For 7 TeV proton beam we will get $\sqrt{s} = 114.6$ GeV, for Pb beam at 2.75 TeV $\sqrt{s} = 71.8$ GeV. This is unique possibility to clarify the mechanism of charmonium, J/ψ and ψ' production, particularly to separate two possibilities: i): hard production and suppression in QGP and/or hadronic dissociation or ii): hard production and secondary statistical production with $c\bar{c}$ recombination [4].

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Effect of parton energy loss on quarkonium nuclear suppression

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Quarkonium nuclear suppression in p-A collisions, at sufficiently large quarkonium energy, can be accurately described in a model based on first principles (medium-induced gluon radiation [1]) and depending on a single free parameter. Our results strongly support 'parton energy loss' as a dominant effect in quarkonium nuclear suppression, and moreover give some clue on the quarkonium hadroproduction mechanism.

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Gluon EMC effect and fractional energy loss in Upsilon production in dAu collisions at RHIC

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We discuss the impact of the gluon EMC effect and of the fractional energy loss on the Upsilon production in dAu collisions at RHIC. We show that these effects are needed to describe the experimental data. Our results do not depend on the detail of the nuclear parton distributions. We also argue that this may be the first observation that the gluon EMC effect is stronger than the quark one.

Recent results on heavy quark quenching in ultrarelativistic heavy ions collisions

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Recently, we have proposed a microscopic approach for the quenching and thermalisation of heavy quarks (HQ) in URHIC [1, 2, 3], 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 hydrodynamical evolution of the hot medium. This approach is able to explain successfully several observables measured at RHIC, such as the nuclear modification factor and the elliptic flow of 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 at QNP2012, we would like to discuss the predictions of our model [2] for D and B meson production in URHIC at LHC energies and confront them with experimental results obtained so far by ALICE and CMS collaborations for Pb-Pb collisions at $\sqrt{s} = 2.76$ TeV .

Jointly, we would like to discuss the questions of a) the influence of the medium evolution on the HQ observables as well b) the theoretical influence of a possible gluon damping on our understanding of radiative energy loss. For years, one has often considered that a precise description of the "underlying medium" was of subsidiary importance for the understanding of hard processes. In [4], we have shown that factors as high as 2 in various HQ observables can nevertheless stem from different description of the medium. In our contribution at QNP2012, we will discuss the consequences of a medium evolution originating from fluctuating initial conditions obtained with EPOS [5], considered as one of the approaches which permits to understand the rapidity correlations observed by CMS. In [6], we have studied the consequences of damping mechanisms on standard LPM [7] radiation in electrodynamics and have advocated that the large time needed for the photon formation in Bremsstrahlung from ultrarelativistic charges is not affordable if damping is taken into account. At QNP2012, we would like to address the similar case in QCD, namely the consequences of gluon damping on the standard BDMPS result for gluon radiation spectrum, as well as some phenomenological consequences on HQ quenching.

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Antiproton Nucleus Reactions at PANDA

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The physics program of PANDA[1] comprises the study of antiproton annihilations on nuclear targets [1]. This type of reactions offers a unique tool to study hadron properties in nuclear matter. Hadrons carrying strangeness and/or charm can be produced in the annihilation and eventually their properties (like mass and width) can be investigated making use of the large acceptance and excellent particle detection capabilities of the PANDA spectrometer.
This contribution will give an overview on the planned physics topics to be addressed at PANDA including some lessons learned from past and present experiments looking for in-medium properties of hadrons in the strangeness sector. Simulation results will be presented to demonstrate the expected performance of the PANDA detector.

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Particle Production at High Energy and Large Transverse Momentum

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We revisit the "hybrid formalism" [1] for particle production used recently to study saturation effects in single hadron multiplicities at forward rapidities at RHIC and LHC [2]. We point out that at leading twist there is an extra contribution to the formulae used so far, which corresponds to particle production via inelastic scattering of the projectile partons on the target fields [3].

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Study of Hadronization Dynamic with Nuclei

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Hadronization happens at the femtometer scale, therefore comparing nuclei of various sizes is the best way to study this process. Experiments based on a broad range of reactions, like semi-inclusive deep inelastic scattering (SIDIS), Drell-Yan and heavy ion collisions, have already permitted to understand a lot about in-medium hadronization. In this presentation, we will review the models describing nuclear SIDIS and put them into perspective with our analysis of the recent data from Hall B of Jefferson Laboratory (CLAS Collaboration). The impact of these high precision data and their ability to discriminate between existing models, will be discussed. Finally, future prospects and challenges will be addressed.

J/ψ depletion in a nuclear medium

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We have taken into account the main decay channels of J/ψ when travelling inside a nucleus. In analogy to all vector mesons in SU(3), where the main decay channel is to two pseudoscalars, in the case of the J/ψ, the meson meson channel to which it couples strongly is $D\bar{D}$. Taking this into account we study the $J/\psi N \to \bar{D}\Lambda_c$ and $J/\psi N \to \bar{D}\Sigma_c$ mediated by D-exchange. To obtain the couplings we use an extension to SU(4) of the local hidden gauge Lagrangians as done in [1]. Analogously, we consider the mechanisms where the exchanged D collides with a nucleon and gives $\pi\Lambda_c$ or $\pi\Sigma_c$. In addition the coupled system $J/\psi N$, $\bar{D}^*\Lambda_c$, $\bar{D}^*\Sigma_c$, ρN, ωN, ϕN, $K^*\Lambda$, $K^*\Sigma$ is considered with the same extension to the charm sector and a resonance is found around 4425 MeV. The inelastic cross section from transition of $J/\psi N$ to these other channels shows the resonant structure. The sum of all these contributions produces a $J/\psi N$ inelastic cross section which is larger than the elastic one and is responsible for the depletion of $J/\psi N$ when propagating through nuclear matter. The cross section has its peak around $\sqrt{s} = 4425$ MeV, where the resonance appears. We have studied the transparency ratio for electron induced J/ψ production in nuclei at 10 GeV and find that about 20% of the J/ψ produced in heavy nuclei are absorbed inside the nucleus. This ratio is in line with depletions of J/ψ though matter observed in other reactions. Furthermore, the peak of the inelastic cross section around the resonance results in a dip in the transparency ratio that can be used to identify that state in experiments.

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Mueller Navelet jets at LHC: the first complete NLL BFKL study

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Mueller Navelet jets were proposed 25 years ago as a decisive test of BFKL dynamics at hadron colliders. We here present the first next-to-leading BFKL study of the cross section and azimuthal decorrellation of these jets. This includes both next-to-leading corrections to the Green's function and next-to-leading corrections to the Mueller Navelet vertices. The obtained results for standard observables proposed for studies of Mueller Navelet jets show that both sources of corrections are of equal and big importance for final magnitude and final behavior of observables, in particular for the LHC kinematics investigated here in detail. Our analysis reveals that the observables obtained within the complete next-lo-leading order BFKL framework of the present work are quite similar to the same observables obtained within next-to-leading logarithm DGLAP type treatment. There is still a noticeable difference in both treatments for the ratio of the azimuthal angular moments $\langle \cos 2\phi \rangle / \langle \cos \phi \rangle$.

Scanning for changes
PHENIX results from the RHIC low energy scan

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Exploring the the phase diagram of nuclear matter is one of the goals of high energy nucleus nucleus collisions. Data from SPS, RHIC, and LHC have providedinsight into how nuclear matter behaves under the extreme conditions of these collisions. A key feature of the phase diagram is the existence of a critical point where the first order phase transition ends and a smooth crossover between the phases occurs.With data from the RHIC energy scan with a $\sqrt{s}$ from 7.7 to 200 GeV/c PHENIX explores different paths through these transitions to find where e.g. high p_T particles are started to be suppressed or unusual charge fluctuations occur. This presentation will summarize the recent PHENIX results from the RHIC energy scan on particle production, ratios and flow.

Identified-particle production and spectra with the ALICE detector in pp and Pb–Pb collisions at the LHC

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Unique capabilities of the ALICE experiment allow for measuring the production of identified particles over a wide momentum range both in pp and Pb–Pb collisions at the LHC. In this report, the particle-identification detectors, techniques and the achieved performance are shortly reviewed. The current results on hadron transverse momentum spectra measured in pp collisions at $\sqrt{s} = 900$ GeV and 7 TeV, and in Pb–Pb collisions at $\sqrt{s_{\rm NN}} = 2.76$ TeV are discussed. In particular, the proton-proton results on particle production yields, spectral shapes and particle ratios are presented as a function of the collision energy and compared to previous experiments and commonly-used Monte Carlo models. The particle spectra, yields and ratios in Pb–Pb are measured as a function of the collision centrality and the results are compared with published RHIC data in Au–Au collisions at $\sqrt{s_{\rm NN}} = 200$ GeV and predictions for the LHC.

Theoretical and experimental evidence for hadron formation above the QCD critical temperature.

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Recent work on in-medium hadronization in the non-equilibrated fragmentation process [1, 2] has been followed up by studies on bound state formation in the equilibrated deconfined matter as described by lattice QCD [3]. Through the comparison to PNJL model calculations we find evidence for an extended phase of mixed degrees of freedom. The extracted hadron formation probability exhibits flavor and baryon number dependencies which are experimentally verifiable. We confront the calculations of the non-equilibrium and equilibrium particle production in heavy ion collisions with measurements from RHIC and LHC.

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Diffraction on Nuclei: Effects of Nucleon-Nucleon Correlations and Inelastic Shadowing Within an Improved Glauber-Gribov Approach

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The cross sections for a variety of diffractive processes in proton-nucleus scattering, associated with large gaps in rapidity, are calculated [1] within an improved Glauber-Gribov theory, where the inelastic shadowing corrections are summed to all orders by employing the dipole representation [2] and the effects of nucleon-nucleon correlations, leading to a modification of the nuclear thickness function [3], are also taken into account. Numerical calculations are performed for the energies of the HERA-B experiment, and the RHIC and LHC colliders, and for several nuclei. It is found that whereas the Gribov corrections generally make nuclear matter more transparent, nucleon correlations act in the opposite direction and have important effects in various diffractive processes. The number of inelastic hadron-nucleus and nucleus-nucleus collisions $n_{coll}(b)$ at impact parameter b [4], and its integral value N_{coll}, which are used to normalize the measured fractional cross section of a hard process, are also calculated [5] within the same approach. The results for relativistic heavy ion scattering will also be shown.

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Photoproduction of vector mesons in ultra-peripheral Pb+Pb collisions at ALICE

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The ALICE experiment at the CERN's Large Hadron Collider allows the study of vector meson production in ultra-peripheral heavy-ion collisions (UPC). Thanks to the large electromagnetic field of the nucleus, two-photon and photonuclear interactions can be studied in a yet unexplored kinematic regime. In 2010, ALICE recorded UPC events in Pb+Pb collisions at a centre-of-mass energy of 2.76 TeV. Dedicated triggers that make use of the Time-of-Flight, Silicon Pixel and VZERO detectors were prepared to study $\rho^0$and J/ψ production at central rapidity; the VZERO detectors consists of two arrays of 32 scintillator hodoscopes each, which are placed around the beam pipe on either side of the interaction region. In addition, UPC events were also collected by requiring at least a muon candidate at forward rapidity in coincidence with VZERO-C, but having VZERO-A vetoed, which is opposite to the muon system. To ensure the exclusive process, this analysis considered the information from other sub-detectors to extend the rapidity gap up to 8 units of pseudo-rapidity, *i.e.* the pseudo-rapidity region where no hadrons are detected. In this way, vector mesons were measured at both central and forward rapidities. The rapidity dependence of J/ψ mesons produced in UPC reactions is particularly interesting as is expected to constrain theoretical models that differ in the relative weight attributed to the coherent and incoherent components. Furthermore, it might provide a measure of the nuclear gluon shadowing. In this talk, results on J/ψ and ρ^0 photoproduction using the 2010 and 2011 UPC heavy-ion data will be presented. The prospects of measuring such exclusive processes in proton-lead collisions will also be mentioned.