11th International Conference on Hard and Electromagnetic Probes of High-Energy Nuclear Collisions

Sonntag, 26. März 2023 - Freitag, 31. März 2023

Aschaffenburg

Buch der Abstracts

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New constraints on nucleon structure from LHCb

Autor Sara sellam[1]

[1] *University of Santiago de Compostela*

The forward geometry of the LHCb detector provides unprecedented access to both the very high and very low regions of Bjorken x inside the nucleon. With full particle ID and a fast DAQ, LHCb is able to fully reconstruct plentiful charged particles and π^0 mesons, as well as relatively rare probes such as Z bosons and heavy quarks, providing a unique set of constraints on nucleon structure functions. This talk will discuss recent LHCb measurements sensitive to intrinsic charm within the proton, modification of parton distribution functions inside the nucleus, and show the impact of recent LHCb measurements that dramatically reduce nPDF uncertainties at low x.

Experiment/Theory:

LHCb

Affiliation:

on behalf of the LHCb collaboration, speaker to be defined

Parallel: Early-Time Dynamics & nPDFs / 219

Early time dynamics of QCD with conserved charges in heavy-ion collisions

Autoren Travis Dore[1]; Soeren Schlichting[1]; Xiaojian Du[2]

[1] *Universität Bielefeld*

[2] *Galician Institute of High-Energy Physics (IGFAE)*

In the early stages of heavy-ion collisions, at the highest energies, the system begins in a highly anisotropic state which is far from equilibrium. At later times, the dynamic evolution of the system is well described in the framework of relativistic hydrodynamics which requires local thermodynamic equilibrium. The KoMPoST framework has had some success in bridging the gap between these descriptions via a coarse-grained, non-equilibrium evolution of the system assuming a medium dominated completely by gluons. In this work, we present new results in this framework which include quark degrees of freedom in the response of the system to perturbations from the non-equilibrium background.

Experiment/Theory:

Theory/Phenomenology

Affiliation:

Universität Bielefeld
Universidad de Santiago de Compostela

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Condensation and early time dynamics in QCD plasmas

Autoren Lillian de Bruin[1]; Jürgen Berges[1]; Jan Pawlowski[1]; Kirill Boguslavski[2]; Tara Butler[1]

[1] *ITP, Universität Heidelberg*

[2] *TU Wien*

High energy nuclear collisions produce far-from-equilibrium matter with a high density of gluons at early times. We identify for the first time two local order parameters for condensation, which can occur as a consequence of the large density of gluons. We demonstrate that an initial overoccupation of gluons can lead to the formation of a macroscopic zero mode towards low momenta that scales proportionally with the volume of the system—this defines a gauge invariant condensate. The formation of a condensate at early times has intriguing implications for early time dynamics in heavy ion collisions.

Experiment/Theory:

Theory/Phenomenology

Affiliation:

ITP, Universität Heidelberg

Parallel: Early-Time Dynamics & nPDFs / 225

System size dependence of pre-equilibrium and applicability of hydrodynamics in heavy-ion collisions

Autor Clemens Werthmann[1]

Co-Autoren: Sören Schlichting [1]; Victor Amrbus [2]

[1] *Universität Bielefeld*

[2] *West University of Timisoara*

Within a microscopic kinetic description based on the Boltzmann equation, we evaluate the importance of the pre-equilibrium stage in high-energy heavy-ion collisions for final state observables over a large range of viscosity and system size. We use our results to determine the range of applicability of an effective description in relativistic viscous hydrodynamics. We find that hydrodynamics provides a quantitatively accurate description of collective flow when the average inverse Reynolds number is sufficiently small and the early pre-equilibrium stage is properly accounted for. We discuss different possible treatments of the pre-equilibrium phase in kinetic theory, KoMPoST and hydrodynamics and assess their applicability.

Experiment/Theory:

Theory/Phenomenology

Affiliation:

Universität Bielefeld

Parallel: Early-Time Dynamics & nPDFs / 206

Quarkonia Production in Ultraperipheral PbPb collisions at LHCb

Autor Qiuchan Lu[1]

[1] *South China Normal University (CN)*

Measurements of quarkonia production in peripheral and ultra-peripheral heavy-ion collisions are sensitive to photon-photon and photon-nucleus interactions, the partonic structure of nuclei, and to the mechanisms of vector-meson production. LHCb has studied production of the J/ψ and $\psi(2S)$ charmonium states in peripheral and ultra-peripheral collisions using PbPb data at forward rapidity, obtaining the highest precision currently accessible. Here we will present these measurements, along with comparisons with the latest theoretical models and with results from other experiments. Future UPC measurements with the upgraded LHCb detector in Run 3 will also be discussed.

Experiment/Theory:

LHCb

Affiliation:

On behalf of LHCb

Parallel: Early-Time Dynamics & nPDFs / 220

Minijet quenching in a concurrent jet+hydro evolution and the nonequilibrium quark-gluon plasma

Autoren Charles Gale[1]; Sangyong Jeon[1]; Daniel Pablos[2]; Mayank Singh[3]

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[2] *INFN Torino*

[3] *University of Minnesota*

Minijets, created by perturbative hard QCD collisions at moderate energies, can represent a significant portion of the total multiplicity of a heavy-ion collision event. Since their transverse momenta are larger than the typical saturation scale describing the bulk of the equilibrating QGP, they do not in general hydrodynamize at the same pace than the bulk of the collision. In this work we make use of a new concurrent minijet+hydrodynamic framework in which the properties of the fluid QGP are modified due to the injection of energy and momentum from the minijets. In order to achieve a realistic description of charged particle multiplicity, the amount of entropy associated to the low-x initial state needs to be reduced. Moreover, the fact that the injected momentum from the randomly oriented minijets is not correlated with the spatial gradients of the system reduces overall flow, and the value of the QGP transport coefficients needs to be reduced. They are, in effect, an important new source of fluctuations. We avow that their abundance makes it necessary to include their physics in holistic descriptions of heavy-ion collisions. We discuss the impact of the minijets on a number of observables, such as p_T spectra and p_T-differential flow v_n for a wide range of centrality classes.

Based on: *Minijet quenching in a concurrent jet+hydro evolution and the nonequilibrium quark-gluon plasma*, D. Pablos, M.Singh, C. Gale, S. Jeon. *Phys.Rev.C 106 (2022) 3, 034901*

Experiment/Theory:

Theory/Phenomenology

Affiliation:

INFN Torino, University of Minnesota, McGill University

Parallel: Early-Time Dynamics & nPDFs / 127

Measurement of dijet production in UPC with the ATLAS detector

Autor Benjamin Gilbert[1]

[1] *Columbia University (US)*

In relativistic heavy ion collisions, the charged ions produce an intense flux of equivalent photons. Thus, photon-induced processes are the dominant interaction mechanism when the colliding nuclei have a transverse separation larger than the nuclear diameter. In these ultra-peripheral collisions (UPCs), the photon provides a clean, energetic probe of the partonic structure of the nucleus, analogous to deep inelastic scattering. This talk presents a measurement of jet production in UPCs performed with the ATLAS detector using high-statistics 2018 Pb+Pb data. Events are selected using requirements on jet production, rapidity gaps, and forward neutron emission to identify photonuclear hard-scattering processes. The precision of these measurements is augmented by studies of nuclear break-up effects, allowing for detailed comparisons with theoretical models in phase-space regions where significant nuclear PDF modifications are expected but not strongly constrained by existing data.

Experiment/Theory:

ATLAS

Affiliation:

ATLAS Collaboration

Parallel: Early-Time Dynamics & nPDFs / 280

Rapidity-dependent fluctuations in the Trento initial state model

Autor Govert Nijs[1]

Co-Autoren: Wilke van der Schee ; Giuliano Giacalone [2]

[1] *Massachusetts Institute of Technology*

[2] *Universität Heidelberg*

We construct an improved 3+1D version of the Trento initial state model, which includes rapidity-dependent fluctuations. The correlation between the fluctuations at different rapidities is controlled by a new parameter. We then use this improved model to study rapidity-dependent observables for ultracentral collisions. It it known that ultracentral flow at midrapidity is sensitive to fluctuations in the initial state, and it is likewise expected that rapidity-dependent flow will be sensitive to the correlation of these fluctuations between different rapidities in the initial state.

Experiment/Theory:

Theory/Phenomenology

Affiliation:

Massachusetts Institute of Technology

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Simulating hard probes in the early-stages of heavy-ion collisions

Autor Dana Avramescu[1]

Co-Autoren: Virgil Băran [2]; Vincenzo Greco [3]; Andreas Ipp [4]; David Mueller [4]; Marco Ruggieri [3]

[1] *University of Jyväskylä*

[2] *University of Bucharest*

[3] *University of Catania*

[4] *TU Wien*

We study the impact of the Glasma fields, used to describe the very-early stage of heavy-ion collisions, on the transport of hard probes, namely heavy quarks and jets. We perform numerical simulations of the strong classical fields using techniques from *real-time lattice gauge theory*. The resulting fields are used as background for the classical transport of ensembles of particles, described by *Wong's equations*. We develop a numerical solver for the transport of the probes, based on *colored particle-in-cell* methods.

We focus on the dynamics of heavy quarks and jets in the classical colored fields. To quantify the effect of the Glasma, we extract *momentum broadening* of hard probes and evaluate the *anisotropy* transfer from the Glasma to the probes. We investigate other ways to measure the imprint of the Glasma, such as *two-particle angular correlations* of quark pairs or gauge invariant correlators of color Lorentz forces exerted on the probes.

A. Ipp, D. I. Muller, D. Schuh - Jet momentum broadening in the pre-equilibrium Glasma
P. Khowal, S. K. Das, L. Oliva, M. Ruggieri - Heavy quarks in the early stage of high energy nuclear collisions at RHIC and LHC
D. Avramescu, V. Băran, V. Greco, A. Ipp, D. I. Müller, M. Ruggieri - Simulating jets and heavy quarks in the early stages of heavy-ion collisions using the colored particle-in-cell method *(in preparation)*

Experiment/Theory:

Theory/Phenomenology

Affiliation:

University of Jyväskylä

Parallel: Early-Time Dynamics & nPDFs / **51**

J/ψ photoproduction in Pb–Pb collisions with nuclear overlap at ALICE

Autor Ionut Cristian Arsene[1]

[1] *University of Oslo*

Photonuclear reaction is induced by the strong electromagnetic field generated by ultrarelativistic heavy ion collisions. This process has been extensively studied in ultra-peripheral collisions (UPC). Photoproduced quarkonia are used to probe the nuclear gluon distributions at low Bjorken-x. In recent years, the coherent photoproduction of the J/ψ vector meson has also been observed in A-A collisions with nuclear overlap. This observation raises several theoretical challenges, such as the survival of the coherence condition for a nucleus broken during the hadronic interaction or the possible interaction of the produced J/ψ vector meson with a fast-expanding quark-gluon plasma medium. In this presentation, measurements of coherent J/ψ photoproduction cross sections in Pb-Pb collisions for the 40-90$\%$ centrality range, measured by ALICE at midrapidity in the dielectron channel will be presented. In peripheral collisions, the p_{T}-differential cross section is extracted for the first time at midrapidity. Final published results on coherent J/ψ photoproduction cross sections at forward rapidity in the dimuon decay channel in the 10-90$\%$ centrality range will also be shown. Finally, the status of the new rapidity-differential measurement of coherently photoproduced J/ψ at forward rapidity in the centrality range 70-90$\%$ will be discussed. Results will be compared with available theoretical models.

Experiment/Theory:

ALICE

Affiliation:

ALICE

Parallel: Early-Time Dynamics & nPDFs / 248

Far-from-equilibrium slow modes and momentum anisotropy in expanding plasma

Autoren Yi Yin[1]; Jasmine Brewer[2]; Li Yan[None]; Weiyao Ke[None]

[1] *Institute of Modern physics (CAS), China*

[2] *CERN*

We discuss the evolution of initial momentum anisotropy in the early-stage quark-gluon plasma. We use kinetic theory to study the far-from-equilibrium evolution of an expanding plasma with an anisotropic momentum-space distribution. We identify slow and fast degrees of freedom in the far-from-equilibrium plasma from the evolution of moments of this distribution. At late times, the slow modes correspond to hydrodynamic degrees of freedom and are naturally gapped from the fast modes by the inverse of the relaxation time.. At early times, however, there are an infinite number of slow modes. From the evolution of the slow modes we generalize the paradigm of the far-from-equilibrium attractor to vector and tensor components of the energy-momentum tensor, and even to higher moments of the distribution function that are not part of the hydrodynamic evolution. We predict that initial-state momentum anisotropy decays slowly in the far-from-equilibrium phase and may persist until the relaxation time.

Ref: Jasmine Brewer, Weiyao Ke, Li Yan, Yi Yin, ArXiv: 2212.00820

Experiment/Theory:

Theory/Phenomenology

Affiliation:

CERN;Los Alamos National Lab; Fudan University;Institute of Modern Physics, CAS

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Investigation of initial state effects in p+Pb collisions at ATLAS via measurement of both top quark and dijet production

Autor Riccardo Longo[None]

Proton-lead collisions at LHC energies offer unique possibilities to investigate the nuclear modifications of parton distribution functions (PDF) over a wide kinematic range. Several probes can be measured to characterize these effects in different kinematic regimes. The top-quark production is expected to be sensitive to effects at high Bjorken-x values, which are hard to access experimentally using other available probes. Conversely, dijet production can provide constraints on nPDFs over a wide kinematic range that extends down to Bjorken-x~10^{-4}. In 2016 the ATLAS experiment collected 164 nb^{-1} of proton-lead collisions at a centre-of-mass energy of 8.16 TeV per nucleon pair. In this talk, we will present two new results obtained from the analysis of this dataset: the first measurement of the inclusive cross-section for top-quark pair production in dilepton and lepton+jets decay modes with electrons and muons, and the measurement of inclusive dijet cross-section. The results are compared to the NLO and NNLO predictions for dijet production and top-quark production using various PDF sets, respectively.

Experiment/Theory:

ATLAS

Affiliation:

ATLAS Collaboration

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Anisotropic flow in small systems

Autoren Wilke van der Schee[1]; Govert Nijs[2]

[1] *CERN / Utrecht University*

[2] *MIT*

Small systems display large anisotropic flow coefficients that can potentially be interpreted as a hydrodynamic signal. At these moderate multiplicities anisotropic flow is however relatively sensitive to subtle effects. These include the precise experimental procedure, rapidity coverage and gaps as well as effects due to resonance decays. In this talk we quantify these effects for pPb, OO and PbPb collision using the Trajectum framework including systematic uncertainties, so that a reliable hydrodynamic baseline can be attained.

Experiment/Theory:

Theory/Phenomenology

Affiliation:

CERN / Utrecht University

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Dilepton spectra as probes of the early stages of heavy-ion collisions

Autoren Maurice Coquet[1]; Xiaojian Du[2]; Soeren Schlichting[3]; Jean-Yves Ollitrault[4]; Michael Winn[5]

[1] *Irfu/CEA*

[2] *Galician Institute of High-Energy Physics (IGFAE)*

[3] *Universität Bielefeld*

[4] *IPhT/CEA-Saclay*

[5] *Irfu/CEA-Saclay*

The early stages of heavy-ion collisions are largely unexplored experimentally, despite great theory progresses. In such collisions, electromagnetic radiation such as dileptons are produced throughout the history of the medium and probe its quark content. Hence, they are useful tools to investigate the early stages of the quark-gluon plasma, allowing to better understand its chemical and kinetic equilibration. The measurement of such observable is challenging; in particular, one important source of background is the Drell-Yan production of dileptons in the initial hard scatterings. In this contribution we present our estimate of the dilepton spectrum produced by the quark-gluon plasma starting from the early stages, in the intermediate mass range $1 < M < 5$ GeV/c^2, based on QCD kinetic theory. We also estimate the Drell-Yan background in this kinematic range using a state-of-the-art perturbative computation. Our calculation takes into account the anisotropy of the quark and gluon momentum distributions at early times, as well as the under-population of quarks relative to gluons. We investigate different characteristics of this spectrum, in particular its sensitivity to the equilibration time of the quark-gluon plasma, and its approximate scaling with transverse mass. Finally we investigate to what extent can the polarization of dilepton pairs provide a handle to separate the Drell Yan contribution from later dilepton production.

Experiment/Theory:

Theory/Phenomenology

Affiliation:

Irfu/CEA-Saclay, IPhT/CEA-Saclay, Bielefeld University, Santiago de Compostela

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Probing a new regime of ultra-dense gluonic matter using high-energy photons with the CMS experiment

Autor Wei Li[1]

[1] *Rice University*

In ultraperipheral collisions (UPCs) of relativistic heavy ions, the coherent heavy-flavor vector meson production via photon-nuclear interactions is of particular interest, since its cross section is directly sensitive to the nuclear gluon density. However, in experimental measurements, because each of the two nuclei in symmetric UPCs can serve both as a photon-emitter projectile and a target, this two-way ambiguity has prevented us from disentangling contributions involving high- and low-energy photon-nucleus interactions, thus limiting our capability of probing the extremely small-x regime, where nonlinear QCD effects are expected to emerge. In this talk, we will present a new measurement of coherent J/ψ photoproduction, where the two-way ambiguity is solved by implementing for the first time a forward neutron tagging technique in UPC PbPb collisions at 5.02 TeV. The coherent J/ψ photoproduction cross section will be presented as a function of the photon-Pb center-of-mass energy in UPCs up to about 400 GeV, corresponding to an extremely low x of $\sim 5 \times 10^{-5}$. We will discuss the physics implications of this new result, as well as exciting opportunities in future LHC heavy ion runs.

Experiment/Theory:

CMS

Affiliation:

CMS

Parallel: Early-Time Dynamics & nPDFs / **227**

Universality of Energy-Momentum Response in Conformal Kinetic Theories

Autor Xiaojian Du[1]

Co-Autoren: Stephan Ochsenfeld ; Sören Schlichting [2]

[1] *Galician Institute of High-Energy Physics (IGFAE)*

[2] *Universität Bielefeld*

Viscous hydrodynamics serves as a successful mesoscopic description of the Quark-Gluon Plasma (QGP) on large time and distance scales. Since highly energetic Jets deposit part of their energy into the QGP in a very localized fashion, it is important to understand to what extent the propagation of the deposited energy can be described within hydrodynamics. We investigate this problem by studying the evolution of energy-momentum perturbations in kinetic theories, with varying gradients from microscopic to macroscopic scales. By comparing results for different microscopic theories (QCD, Yang-Mills, RTA, Scalars) we find a remarkable degree of universality, where the evolution of energy-momentum perturbations of the QGP is rather well described by one hydrodynamic mode and one non-hydrodynamic mode. We discuss the implications of our findings for the theoretical description of the medium response to Jets in Heavy-Ion collisions.

Experiment/Theory:

Theory/Phenomenology

Affiliation:

Bielefeld University
Galician Institute of High Energy Physics

Parallel: Early-Time Dynamics & nPDFs / **121**

Early time dynamics far from equilibrium via holography

Autoren Matthias Kaminski[1]; Casey Cartwright[2]; Wondrak Michael[3]; Marco Knipfer[4]; Marcus Bleicher[5]

[1] *University of Alabama*

[2] *Utrecht*

[3] *Nijmegen*

[4] *Alabama*

[5] *Frankfurt*

We investigate the early time dynamics of heavy ion collisions studying the time evolution of the energy-momentum tensor as well as energy-momentum correlations within a uniformly thermalizing holographic QGP. From these quantities, we suggest a far-from equilibrium definition of shear

viscosity, which is a crucial property of QCD matter as it significantly determines the generation of elliptic flow already at early times. During the the initial heating phase of the holographic QGP the shear viscosity of entropy density ratio decreases down to 60%, followed by an overshoot to 110% of the near-equilibrium value, $\eta/s = 1/(4\pi)$. Subsequently, we consider a holographic QGP which is Bjorken-expanding. Its energy-momentum tensor components are analytically shown to have a hydrodynamic attractor to which all time evolutions collapse independent of the initial conditions. Based on this, we propose a definition for a far from equilibrium speed of sound that governs the propagation of sound modes in the holographic QGP. Implications for the QCD QGP are discussed.

Experiment/Theory:

Theory/Phenomenology

Affiliation:

University of Alabama

Parallel: Early-Time Dynamics & nPDFs / **259**

Enhancing the CERN LHC small systems program with bowling-pin-shaped neon isotopes

Autor Giuliano Giacalone[1]

Co-Autoren: Wilke van der Schee ; Govert Nijs [2]

[1] *Universität Heidelberg*

[2] *Massachusetts Institute of Technology*

We demonstrate the unique opportunities for small systems studies offered by complementing the future run of ^{16}O+^{16}O collisions at the CERN LHC with collisions of bowling-pin-shaped ^{20}Ne isotopes.

1. Origin of collectivity: A comprehensive campaign of hydrodynamic calculations (~20 million simulated events) demonstrates that the impact of the extreme shape of neon on elliptic flow survives the large fluctuations due to the small nucleon numbers in the comparison O+O vs. Ne+Ne. Such modifications are robust against variations in hydrodynamic model parameters, and, if observed, will yield conclusive evidence of the geometric (and potentially hydrodynamic) origin of flow in systems presenting $dN/dy \approx 100$.

2. Energy loss in small systems: Due to the extremely elongated ^{20}Ne geometry, Ne+Ne collisions may help reveal hard-probe modification via path-length-dependent effects in the comparison with O+O collisions, without requiring a good centrality resolution. We estimate such effects based on the analysis of the path lengths expected to be traversed by the hard probes at realistic temperatures.

Based on Giacalone, Nijs, van der Schee, *et al.*, arXiv:2212:XXXXX

Experiment/Theory:

Theory/Phenomenology

Affiliation:

Institut für Theoretische Physik, Universität Heidelberg

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A novel saturation-based 3+1D initial state model for Heavy Ion Collisions

Autoren Oscar Garcia-Montero[1]; Sören Schlichting[1]; Hannah Elfner[2]

[1] *Universität Bielefeld*

[2] *GSI Darmstadt*

We present a new 3+1D resolved model for the initial state of ultrarelativistic Heavy-Ion collisions, based on the $k_\perp$-factorized Color Glass Condensate hybrid approach [1-4]. This new model responds to the need for a rapidity-resolved initial-state Monte Carlo event generator which can deposit the relevant conserved charges (energy, charge and baryon densities) both in the midrapidity and forward/backward regions of the collision.
This event-by-event generator computes the gluon and (anti-) quark phase-space densities using the IP-Sat model, from where the relevant conserved charges can be computed directly. In the present work we have included the leading order contributions to the light flavor parton densities. As a feature, the model can be systematically improved in the future by adding next-to-leading order calculations (in the CGC hybrid framework), and extended to lower energies by including sub-eikonal corrections the channels included. We present relevant observables, such as the eccentricities and flow decorrelation, as tests of this new approach.

References:
[1] O. Garcia-Montero, H. Elfner and S. Schlichting. *In preparation.*
[2]T. Lappi and S. Schlichting, Phys. Rev. D 97, 034034 (2018), arXiv:1708.08625 [hep-ph].
[3] T. Lappi and H. Mäntysaari, Phys. Rev. D 88, 114020 (2013), arXiv:1309.6963 [hep-ph]
[4] H. Mäntysaari, *Scattering off the Color Glass Condensate*, Ph.D. thesis, Jyvaskyla U. (2015), arXiv:1506.07313 [hep-ph].

Experiment/Theory:

Theory/Phenomenology

Affiliation:

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Illuminating early-stage dynamics of heavy-ion collisions through photons at RHIC BES energies

Autoren Chun Shen[1]; Abel Noble[2]; Jean-Francois Paquet[3]; Björn Schenke[4]; Charles Gale[5]

[1] *WAYNE STATE UNIVERSITY*

[2] *University of Michigan*

[3] *Vanderbilt University*

[4] *Brookhaven National Laboratory*

[5] *McGill University*

Heavy-ion collisions at $\sqrt{s_{\rm NN}} \sim 10$ GeV probes the QCD phase diagram at large baryon densities. However, because the longitudinal Lorentz contraction is small at these collision energies, understanding the dynamics during the early phase of the collision is essential for the subsequent modeling of the system evolution, and for constraining the QGP transport properties at finite baryon densities. Direct photons are multi-messengers in heavy-ion collisions, providing undistorted information about early-stage dynamics. In this talk, we model relativistic heavy-ion collisions at RHIC Beam Energy Scan energies with a hybrid dynamical approach which consists of a 3D-Glauber initial state followed by viscous hydrodynamics and finally by transport theory (MUSIC + UrQMD). Thermal photon emission takes into account the enhancement from finite baryon chemical potentials. We will show that direct photon spectra and their anisotropic flow coefficients have a strong sensitivity to the early stage of heavy-ion collisions and thus provide constraints on QGP dynamics complementary to those obtained from hadronic observables.

Experiment/Theory:

Theory/Phenomenology

Affiliation:

Wayne State University
University of Michigan
Vanderbilt University
Brookhaven National Laboratory
McGill University

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Dijet azimuthal correlations in p-p and p-Pb collisions at forward LHC calorimeters

Autor Krzysztof Kutak[1]

[1] *IFJ PAN*

I am going to present a state-of-the-art computation for the production of forward dijets in proton-proton and proton-lead collisions at the LHC, in rapidity domains covered by the ATLAS calorimeter and the planned FoCal extension of the ALICE detector. We use the small-x improved TMD (ITMD) formalism, together with collinearly improved TMD gluon distributions and full b-space Sudakov resummation, and discuss nonperturbative corrections due to hadronization and showers using the Pythia event generator. We observe that forward dijets in proton-nucleus collisions at moderately low pT are excellent probes of saturation effects, as the Sudakov resummation does not alter the suppression of the cross section.

Experiment/Theory:

Theory/Phenomenology

Affiliation:

IFJ PAN

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Impact of fully coherent energy loss for nPDF extractions

Autoren Tobie Avez[1]; François Arleo[2]

[1] *Subatech*

[2] *Subatech, Nantes*

Nuclear Parton Distribution Functions (nPDF) are an essential tool to predict hard QCD processes in nuclear collisions. Recently various nPDF sets have been extracted using heavy flavour data (D mesons, quarkonia) in pA collisions in the global fits. However, these measurements should be affected by fully coherent energy loss (FCEL) in nuclear matter, which entails a careful treatment in the nPDF determination. As a case study, we evaluate the impact of J/psi suppression data in pA collisions on gluon nPDF using Bayesian reweighing methods, with and without including FCEL. We show that these measurements dramatically shrink the uncertainty of gluon densities, as mentioned in earlier studies. The magnitude of gluon shadowing at small-x, however, is significantly reduced, by about factor of two, when FCEL is taken into account. This result highlights the importance of a careful separation between nPDF effects and energy loss processes and motivates future studies of global nPDF fits with a proper implementation of FCEL.

Experiment/Theory:

Theory/Phenomenology

Affiliation:

Subatech

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Search for elliptic azimuthal anisotropies in photon-proton and pomeron-Pb interactions using rapidity gaps at pPb collisions with the CMS experiment

Autor SUBASH CHANDRA BEHERA[1]

[1] *Indian Institute of Technology Madras (IN)*

Since 2011 a wide variety of measurements suggest the existence of strong collectivity in collisions of small systems such as proton-proton (pp) and proton-nucleus (pPb) with hydrodynamic models and gluon saturation in the initial state as two theory alternatives showing consistency with the observations. These results raise the question as to whether such phenomena may be present in even smaller systems. Just recently ATLAS, ALEPH, and ZEUS collaborations have extended the studies to photon-Pb, electron-electron (ee), and electron-proton (ep) systems respectively. This talk will summarize the latest CMS results on the study of long-range particle correlations extended to photon-proton and pomeron-Lead interactions using pPb collisions at 8.16 TeV . Such interactions provide unique initial conditions with event multiplicity lower than in pp and pPb systems but comparable with ee and ep systems.

Experiment/Theory:

CMS

Affiliation:

CMS

Parallel: Early-Time Dynamics & nPDFs / **231**

Determination of quark and gluon distributions in nuclei using correlated nucleon pairs

Autoren Aleksander Kusina[1]; Tomas Jezo[2]; Karol Kovarik[3]; Michael Klasen[None]

[1] *Institute of Nuclear Physics PAN, Krakow*

[2] *WWU ITP*

[3] *WWU Münster*

Analyzing data from nuclear lepton Deep-Inelastic Scattering, Drell- Yan processes, and W and Z boson production, we show that factorizing nuclear structure into quasi-free nucleons and universally modified close-proximity Short Range Correlated (SRC) nucleon pairs allows us to fully describe the quark-gluon structure of nuclei down to very-low momentum fractions. This is the first combined extraction of the universal distribution of quarks and gluons inside SRC pairs, and the nucleus-specific fraction of nucleons in SRC pairs. The extracted SRC fractions are in good agreement with previous nuclear structure calculations and measurements. At the same time the obtained nuclear PDFs are in very good agreement with fits using conventional framework of global nuclear PDF analysis. This extraction of nuclear structure information from quark-gluon distributions thus represents a significant development toward understanding the structure of nuclei in terms of their fundamental quark-gluon constituents.

Experiment/Theory:

Theory/Phenomenology

Affiliation:

Institute of Nuclear Physics PAN, Krakow

Parallel: Electromagnetic & Electroweak Probes / **74**

Probing the initial state of nuclear collisions using isolated prompt photons with ALICE

Autor Florian Jonas[1]

[1] *Uni Muenster/ORNL*

Hadronic collisions produce prompt photons that are characterized by a large transverse momentum and absence of event activity in their vicinity. Photons are a robust probe of cold nuclear matter effects in small and large collision systems because they do not interact strongly and are thus insensitive to medium-induced final-state effects. Prompt photon production is dominated by the Compton process ($g\mathrm{q} \rightarrow \mathrm{q}\gamma$), making it sensitive to the gluon parton distribution function (PDF), and provides a test of high momentum pQCD calculations. Recent experimental results indicate the need for corrections beyond NLO to describe their production accurately. This talk presents the measurement of isolated prompt photon production in pp and p-Pb collisions at $\sqrt{s_{\mathrm{NN}}} = 8$ TeV, measured by ALICE. The isolation method is applied to suppresses the background photons produced in the fragmentation process and electromagnetic decays. The production cross sections in both systems will be presented and compared with NLO calculations using recent (n)PDFs and fragmentation functions. In addition, the nuclear modification factor R_{pA} is measured, quantifying possible modifications of the parton distributions inside the nucleus. This is the first time the isolated prompt photon R_{pA} has been measured for low transverse momenta of $p_{\mathrm{T}} < 20$ GeV/c - a regime in which a sizeable suppression is predicted by theoretical calculations.

Experiment/Theory:

ALICE

Affiliation:

CERN

Parallel: Electromagnetic & Electroweak Probes / 125

Dilepton production and BSM physics from photon fusion processes in UPC and non-UPC Pb+Pb collisions with the ATLAS detector

Autor Iwona Grabowska-Bold[1]

[1] *AGH University of Science and Technology*

Relativistic heavy-ion beams at the LHC are accompanied by a large flux of equivalent photons, leading to multiple photon-induced processes. This talk presents a series of measurements of dilepton production from photon fusion performed by the ATLAS Collaboration, which provide strong constraints on the nuclear photon flux, its dependence on the impact parameter and photon energy, and can also probe physics beyond the standard model (BSM) using tau leptons. Recent measurements of exclusive dielectron production in ultra-peripheral collisions (UPC) are presented. Comparisons of the measured cross-sections to QED predictions from the Starlight and SuperChic models are also presented. Furthermore, measurements of muon pairs produced via two-photon scattering processes in hadronic (i.e. Non-UPC) Pb+Pb collisions are discussed. These non-UPC measurements provide a novel test of strong-field QED and may be a potentially sensitive electromagnetic probe of the quark-gluon plasma. These measurements include the dependence of the cross-section and angular correlation on the mean-p_{T} of the dimuon pair, the rapidity separation between the muons, and the pair angle relative to the second-order event-plane, all measured differentially as a function of the Pb+Pb collision centrality. The presented results are compared with recent theory calculations. Tau-pair production measurements can constrain the tau lepton's anomalous magnetic dipole moment (g-2), and a recent ATLAS measurement using muonic decays of tau leptons in association with electrons and tracks provides one of the most stringent limits available to date.

Experiment/Theory:

ATLAS

Affiliation:

ATLAS Collaboration

Parallel: Electromagnetic & Electroweak Probes / 111

Comparative multi-probe study of jet energy-loss in QGP

Autoren Rouzbeh Modarresi-Yazdi[1]; Shuzhe Shi[2]; Charles Gale[1]; Sangyong Jeon[1]

[1] *McGill University*

[2] *Stony Brook*

An important sign of the creation of the Quark-Gluon Plasma in heavy-ion collisions is the observation of jet energy-loss. Energetic, high transverse momentum (p_T) partons produced at the moment of initial hard scattering are influenced by the evolution history of the medium and lose energy via interactions. In this work we compare two models of low virtuality radiative energy loss: MARTINI [1] and CUJET [2] using the JETSCAPE framework. We integrate CUJET into the JETSCAPE workflow and perform full jet simulations using DGLV [3-5] radiative rates, for the first time. We consider strongly interacting probes (charged hadrons, jets, jet shape and jet fragmentation function)

as well as electromagnetic probes; photons from jet-medium interactions have a similar structure to the gluon radiation channel but experience no final state interactions [6]. We present the first realistic calculation of jet-medium photons from CUJET and compare it to jet-medium photons from MARTINI. We find that these photons contribute significantly in the phenomenologically interesting intermediate p_T domain (4-12 GeV).
[1] B. Schenke et al., Phys.Rev.C 80 (2009) 054913
[2] J. Xu et al., JHEP 08 (2014) 063
[3] M. Gyulassy et al., Nucl.Phys.B 571 (2000) 197-233
[4] M. Gyulassy et al., Nucl.Phys.B 594 (2001) 371-419
[5] M. Djordjevic et al., Nucl.Phys.A 733 (2004) 265-298
[6] C. Gale et al., Phys.Rev.C 105 (2022) 1, 014909

Experiment/Theory:

Theory/Phenomenology

Affiliation:

McGill University: Rouzbeh Modarres-Yazdi, Charles Gale, Sangyong Jeon
Stony Brook: Shuzhe Shi

Parallel: Electromagnetic & Electroweak Probes / **44**

Thermal radiation and direct photon production in Pb-Pb and pp collisions with dielectrons in ALICE

Autor Raphaelle Bailhache[None]

Electromagnetic probes such as photons and dielectrons are a unique tool to study the space-time evolution of the hot and dense matter created in ultrarelativistic heavy-ion collisions. At low di-electron invariant mass (m_{ee}), thermal radiation from the hot hadronic phase contributes to the dielectron spectrum via decays of ρ mesons, whose spectral function is sensitive to chiral-symmetry restoration. At larger m_{ee}, thermal radiation from the quark–gluon plasma carries information about the early temperature of the medium. At LHC energies, it is nevertheless dominated by a large background from correlated heavy-flavour hadron decays affected by energy loss and flow in the medium. Complementary to the real photon measurements, dielectron data also allow the extraction of the real direct photon fraction, including thermal photons at low pair transverse momentum $p_{\mathrm{T,ee}}$. In pp collisions, such measurement serves as a fundamental test of perturbative QCD calculations, and as a baseline for the studies in heavy-ion collisions. This talk will present the latest ALICE results on dielectron studies in Pb-Pb, and in minimum-bias and high-multiplicity pp collisions, at $\sqrt{s_{\mathrm{NN}}}$ = 5.02 TeV and 13 TeV, respectively. The measurements are compared to simulations and expectations from theory.
Finally, the status of the Run 3 analysis will be reported.

Experiment/Theory:

ALICE

Affiliation:

ALICE

Parallel: Electromagnetic & Electroweak Probes / **214**

Enhancement of photon momentum anisotropies during the late stages of relativistic heavy-ion collisions

Autoren Hannah Elfner[1]; Oscar Garcia-Montero[2]; Anna Schäfer[3]; Jean-Francois Paquet[4]; Charles Gale[5]

[1] *GSI Darmstadt*

[2] *Universität Bielefeld*

[3] *Frankfurt Institute for Advanced Studies*

[4] *Vanderbilt University*

[5] *McGill University*

We present a consistent photon production calculation from hadronic cross sections, including bremsstrahlung and 2-to-2 reactions, matching the usually employed thermal rates [1,2]. Using the hadronic transport approach SMASH as the afterburner for the hadronic stage at RHIC and LHC energies, we find a significant increase in the calculated momentum anisotropies of these photons due to microscopic non-equilibrium dynamics. This enhancement is found in comparison to standard calculations, which rely on the folding of equilibrium rates to a hydrodynamical evolution. Once combined with photons produced above the particlization temperature in the hydrodynamical evolution, the differences between the two approaches are modest regarding $p_\perp$-differential spectra, but are clearly noticeable at low for the elliptic flow: non-equilibrium dynamics enhance the photon v_2 below $p_\perp \approx 1.5$ GeV.

References
[1] A. Schäfer, O. G-M., J-F. Paquet, H. Elfner, and C. Gale. Phys.Rev.C 105 (2022) 4, 044910, arXiv: 2111.13603
[2] A. Schäfer, J. M. Torres-Rincon, J. Rothermel, N. Ehlert, C. Gale and H. Elfner. Phys.Rev.D 99 (2019) 11, 114021. arXiv: 2111.13603

Experiment/Theory:

Theory/Phenomenology

Affiliation:

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HE: GSI Helmholtzzentrum für Schwerionenforschung, Planckstraße 1, 64291 Darmstadt, Germany
CG: Department of Physics, McGill University, 3600 University Street, Montreal, QC, H3A 2T8, Canada

Parallel: Electromagnetic & Electroweak Probes / 41

Recent ALICE results on photon-lead interactions

Autor Roman Lavicka[1]

[1] *Stefan Meyer Institute of the Austrian Academy of Sciences*

Photon-induced reactions in ultra-peripheral collisions (UPCs) of heavy nuclei at the LHC have been studied using the ALICE detector for several years. The ALICE detector can measure the photoproduction cross section for vector mesons at various rapidities, centre-of-mass energies and collision systems. Beyond the recent ALICE studies of the rapidity and momentum transfer dependence of coherent J/ψ photoproduction, new results on incoherent J/ψ photoproduction will be discussed. These results complement coherent J/ψ measurements and provide additional sensitivity to probing nuclear gluon effects including the presence of subnucleon gluon fluctuations. Additionally, new measurements of the coherent and incoherent J/ψ polarization will be shown. These new results serve for testing the s-channel helicity conservation hypothesis.

Experiment/Theory:

ALICE

Affiliation:

CERN

Parallel: Electromagnetic & Electroweak Probes / 250

Using direct γ production to disentangle contributions from centrality biases and final state effects to high pt π0 production in d+Au collisions at 200 GeV.

Autor Axel Drees[1]

[1] *Stony Brook University*

PHENIX presents the simultaneous measurement of high pt (8-18 GeV/c) direct γ and π0 production in d+Au collisions at 200 GeV. The analysis is performed for different events samples selected by event activity. The direct γ-to-π0 ratio is independent of event activity, except for events with the highest activity where the ratio is slightly enhanced. Final state effects are expected to be small for direct photons and initial state effects are expected to be similar for direct γ and π0. Therefore, the new PHENIX results suggest that π0 production is suppression in the final state of the most central d+Au collisions. Expressed as nuclear modification factor RxA, this suppression is about 20%. Here RxA is determined in a model independent way, by quantifying the effective number of binary collisions from the ratio of direct photons measured in d+Au compared to p+p collisions. To establish if the suppression is linked to energy loss, PHENIX is currently analyzing p+Au and 3He+Au collisions. In this talk the latest results will be presented.

Experiment/Theory:

PHENIX

Affiliation:

Stony Brook University

Parallel: Electromagnetic & Electroweak Probes / 126

BSM physics using photon-photon fusion processes in UPC in Pb+Pb collisions with the ATLAS detector

Autor Agnieszka Ogrodnik[1]

[1] *Prague CU*

Relativistic heavy-ion beams at the LHC are accompanied by a large flux of equivalent photons, leading to multiple photon-induced processes. This talk presents searches for physics beyond the standard model enabled by photon-photon processes in both di-tau and di-photon final states. The tau-pair production measurements can constrain the tau lepton's anomalous magnetic dipole moment (g-2), and a recent ATLAS measurement using muonic decays of tau leptons in association with electrons and tracks provides one of the most stringent limits available to date. Similarly, light-by-light scattering proceeds via loop diagrams, which can contain particles not yet directly observed. Thus, high statistics measurements of light-by-light scattering shown in this talk provide a precise and unique opportunity to investigate extensions of the Standard Model, such as the presence of axion-like particles.

Experiment/Theory:

ATLAS

Affiliation:

ATLAS Collaboration

Parallel: Electromagnetic & Electroweak Probes / 169

Thermal photon measurements at PHENIX

Autor Roli Esha[1]

[1] *Stony Brook University*

Photons are emitted at all stages of relativistic heavy-ion collisions and do not interact with the medium strongly. With access to the versatility of RHIC, measurements of low momentum direct photons are made possible across different system size and beam energies. An excess of direct photons, above prompt photon production from hard scattering processes, is observed for a system size corresponding to $dN_{ch}/d\eta$ of 20-30, with a large azimuthal anisotropy and a characteristic dependence on collision centrality. After subtracting the prompt photon component, the inverse slope of the spectrum is continuously increasing with the effective temperature ranging from 250 MeV/c at p_T of 1-2 GeV/c to about 400 MeV/c at 2-4 GeV/c. Within the experimental uncertainty, there is no indication of a system size dependence of the inverse slope. In this talk, results from Au+Au collisions from the PHENIX experiment will be presented.

Experiment/Theory:

PHENIX

Affiliation:

Stony Brook University

Parallel: Electromagnetic & Electroweak Probes / 81

Electroweak-boson measurements from small to large collision systems with ALICE at the LHC

Autor Shingo Sakai[1]

[1] *Univ. of Tsukuba*

Electroweak bosons produced in hard-scattering processes at the early stage of the collision, are efficient probes of the initial state of the collision. While the W measurements in pp collisions are a stringent test of perturbative QCD-based calculations and production mechanisms, they can constrain the nuclear parton distribution functions in p-Pb and Pb-Pb collisions.

Electroweak bosons are studied with ALICE in pp collisions at $\sqrt{s}$ = 13 TeV, p-Pb collisions at $\sqrt{s_{\rm NN}}$ = 8.16 TeV and Pb-Pb collisions at $\sqrt{s_{\rm NN}}$ = 5.02 TeV via their leptonic decays in the muon and electron channels at forward rapidity ($-4.0 < \eta < -2.5$) and midrapidity ($|\eta| < 0.8$), respectively. The observations in p-Pb and Pb-Pb collisions at forward rapidity give access to low Bjorken-x values, a phase-space region poorly constrained by heavy-ion experiments.

The latest W-boson results concerning differential measurements of the normalised production yields, production cross sections, nuclear modification factors and lepton-charge asymmetry as a function of rapidity, transverse momentum, collision centrality and charged-particle multiplicity are presented. The production of W bosons in association with hadrons as a function of the charged-particle multiplicity in pp collisions is reported as well. Comparisons with model calculations are discussed.

Experiment/Theory:

ALICE

Affiliation:

ALICE

Parallel: Electromagnetic & Electroweak Probes / **247**

Thermal photon production rate from Transverse-Longitudinal(T-L) mesonic correlator on the lattice.

Autor Dibyendu Bala[1]

Co-Autoren: Sajid Ali [1]; Olaf Kaczmarek [1]; Anthony Francis [2]; Greg Jackson [3]; Tristan Ueding [1]

[1] *Bielefeld University*

[2] *National Yang Ming Chiao Tung University (NYCU)*

[3] *INT, University of Washington*

Thermal photons are vital tool to study Quark-Gluon Plasma The photon production rate from the plasma at some temperature T is proportional to the transverse spectral function $\rho_T(\omega = |\vec{k}|, \vec{k})$. One can calculate the photon production rate also from the difference between $\rho_T(\omega, \vec{k})$ (transverse) and $\rho_L(\omega, \vec{k})$ (longitudinal) correlator as ρ_L vanishes at the light cone. The UV part of $\rho_T - \rho_L$ is suppressed; therefore, the corresponding Euclidean correlator receives most of its contribution from the IR part of $\rho_T - \rho_L$. We also calculate the T-L correlator on $N_f = 2 + 1$ flavor HISQ configurations with $m_l = m_s/5$ at temperature ~1.15T_c and 1.3 T_c. We have used two ansätze of the spectral function, which are 1) Polynomial ansatz of the spectral function connected to the UV region compatible with OPE expansion and 2) Hydro-inspired spectral function. We have also used the Backus-Gilbert method to estimate the spectral function. We will compare the photon production rate estimated from all these different methods.

Experiment/Theory:

Theory/Phenomenology

Affiliation:

Bielefeld University

Parallel: Electromagnetic & Electroweak Probes / **46**

Direct-photon production and HBT correlations in Pb–Pb collisions at 5.02 TeV with the ALICE experiment

Autor Ana Marin[1]

[1] *GSI*

Measurements of direct photons can provide valuable information on the properties and dynamics of the quark-gluon plasma (QGP) by comparing them to model calculations that describe the whole evolution of the system created in heavy-ion collisions, from the initial conditions to the pre-equilibrium, QGP, and hadronic phases. In the ALICE experiment, photons can be reconstructed via conversion photons using the excellent tracking capabilities, or via direct measurements in the two different types of calorimeters. Combining these different methods we can measure the direct-photon production from lower momentum of 0.4 GeV/c. Exploring the Hanbury Brown and Twiss (HBT) correlation measurement, we can correlate one conversion photon and one calorimeter photon with near-zero opening angle.
In this talk, we will present the first measurements in selected centrality classes of the direct-photon production in Pb—Pb collisions at 5.02 TeV collision energy, as well as the measurements of the photon HBT correlation. The ALICE upgrades will allow us to measure direct photons in the upcoming Run 3 of the LHC and further improve the direct-photon measurements in the ALICE experiment.

Experiment/Theory:

ALICE

Affiliation:

ALICE

Parallel: Electromagnetic & Electroweak Probes / 85

Vector and Axial-Vector Mesons in Nuclear Matter

Autoren Ralf-Arno Tripolt[1]; Lorenz von Smekal[1]; Jochen Wambach[2]

[1] *Justus Liebig University Giessen*

[2] *TU Darmstadt*

We present recent results on the in-medium spectral function of the rho(770) vector meson and the a1(1260) axial-vector meson in nuclear matter, as well as on the resulting thermal dilepton rate. As an effective description of the thermodynamics and the phase structure of nuclear matter we use a chiral baryon-meson model, taking into account the effects of fluctuations from scalar mesons, nucleons, and vector mesons within the Functional Renormalization Group (FRG) approach. Our results show strong modifications of the spectral functions in particular near the chiral critical endpoint which suggest an enhanced dilepton yield at lower energies. Such an enhancement is also found in GiBUU transport simulations for C+C at 1A GeV when including effects of chiral symmetry restoration in the kinetic equations for baryon propagation. Our results may therefore well be of relevance for electromagnetic rates in heavy-ion collisions and help to identify phase transitions and the critical endpoint.

Experiment/Theory:

Theory/Phenomenology

Affiliation:

[1,2] Justus Liebig University Giessen
[1,2] Helmholtz Research Academy Hesse for FAIR (HFHF), Campus Giessen
[3] TU Darmstadt

Parallel: Electromagnetic & Electroweak Probes / 232

Measuring pressure anisotropy of the quark-gluon plasma through photon polarization

Autoren Sigtryggur Hauksson[None]; Charles Gale[1]

[1] *McGill University*

Photons are radiated throughout heavy-ion collisions, including from the hot and dense quark-gluon plasma (QGP). In this talk, we consider the polarization of QGP photons. The polarization gives detailed information about how the pressure anisotropy of the QGP medium evolves and thus how the medium isotropizes during the initial stages of collisions. We calculate for the first time the emission of polarized photons through quark-antiquark pair annihilation and bremsstrahlung in an anisotropic QGP medium. Our calculation includes the Landau-Pomeranchuk-Migdal effect fully. We show that the polarization goes directly as the anisotropy of the soft gluon cloud radiated by quarks and gluons and thus measures pressure anisotropy. Finally, we discuss the size of these effects in heavy-ion collisions and the feasibility of measuring the photon polarization.

Experiment/Theory:

Theory/Phenomenology

Affiliation:

IPhT, CEA-Saclay

Parallel: Electromagnetic & Electroweak Probes / 292

Pre-equilibrium photon production in QCD Kinetic Theory

Autoren Aleksas Mazeliauskas[1]; Oscar Garcia-Montero[2]; Philip Plaschke[None]; Sören Schlichting[2]

[1] *ITP Heidelberg*

[2] *Universität Bielefeld*

We use QCD kinetic theory to compute photon production in the chemically equilibrating out-of-equilibrium Quark-Gluon Plasma created in the early stages of high-energy heavy-ion collisions. We compare the non-equilibrium rates to the production in a thermal QGP and extract the dependence of pre-equilibrium photon production on the kinetic and chemical equilibration time. This allows us to include realistic pre-equilibrium photon production in heavy-ion collisions.

Experiment/Theory:

Theory/Phenomenology

Affiliation:

Oscar Garcia-Montero: Bielefeld University
Aleksas Mazeliauskas: ITP Heidelberg
Philip Plaschke: Bielefeld University
Sören Schlichting: Bielefeld University

Parallel: Electromagnetic & Electroweak Probes / 241

Characterising the hot and dense fireball with virtual photons at HADES

Autor Niklas Schild[1]

[1] *TU Darmstadt*

Electromagnetic probes (γ, γ^*) offer a unique opportunity to study the conditions during heavy-ion collisions. They are produced throughout the whole evolution of the colliding system and can penetrate the strongly interacting medium to bring direct information from their origins to the detector. In this manner, it is possible to not only probe freeze-out, but also earlier stages of maximum temperature and density.

In this contribution, we present measurements of dielectrons from Ag+Ag collisions, collected at the High-Acceptance-DiElectron-Spectrometer (HADES), at $\sqrt{s_{NN}} = 2.55$ GeV and $\sqrt{s_{NN}} = 2.42$ GeV. A particular focus is set on collectivity studies with a multidifferential analysis of the directed flow v_1 and elliptic flow v_2 in terms of centrality, rapidity, transverse momentum and invariant mass.

Experiment/Theory:

HADES

Affiliation:

TU Darmstadt

Parallel: Future Experimental Facilities / **164**

New opportunities for understanding high-density QCD matter with CMS Phase II detector at the High-Luminosity LHC era

Autor Yen-Jie Lee[1]

[1] *Massachusetts Institute of Technology*

The intriguing phenomena emerging in the high-density QCD matter are being widely studied in the heavy ion program at the LHC and will be understood more deeply during the high luminosity LHC (HL-LHC) era. The CMS experiment is under the Phase II upgrade towards the HL-LHC era. A new timing detector is proposed with timing resolution for minimum ionization particles (MIP) to be 30ps. The MIP timing detector (MTD) will provide the particle identification (PID) ability with a large acceptance covering up to $\eta < 3$ through time-of-flight (TOF). Combining MTD with the other new sub-detectors, a tracker with acceptance $\eta < 4$, high granularity calorimeters with acceptance covering $\eta < 5$, will enable the deep studies of high-density QCD matters in ultra-relativistic heavy ion collisions. In this presentation, the performances of a broad range of measurements in heavy ion programs will be discussed using TOF-PID. These include the (3+1)D evolution of heavy flavor quarks, QGP medium response to high-p_{T} parton energy loss at wide jet cone angles, collectivity in small systems, fluctuations and transport of initially conserved charges, and light nuclei physics.

Experiment/Theory:

CMS

Affiliation:

CMS

Parallel: Future Experimental Facilities / 56

ALICE 3: a next-generation heavy-ion detector for LHC Run 5 and 6

Autor Alessandro Grelli[1]

[1] *Utrecht*

ALICE 3 is proposed as the next-generation experiment to address unresolved questions about the quark-gluon plasma by precise measurements of heavy-flavour probes as well as electromagnetic radiation in heavy-ion collisions in LHC Runs 5 and 6. In order to achieve the best possible pointing resolution a concept for the installation of a high-resolution vertex tracker in the beam pipe is being developed. It is surrounded by a tracker based on monolithic active CMOS pixel sensors covering roughly 8 units of pseudorapidity. To achieve the required particle identification performance, a combination of a time-of-flight system and a Ring-Imaging Cherenkov detector is foreseen. Further detectors, such as an electromagnetic calorimeter, a muon identifier, and a dedicated forward detector for ultra-soft photons, are being studied. In this presentation, we will explain the detector concept and its physics reach as well as discuss the R&D challenges.

Experiment/Theory:

ALICE

Affiliation:

ALICE

Parallel: Future Experimental Facilities / 195

Heavy flavor physics at the sPHENIX experiment

Autor Antonio Carlos Oliveira da Silva[1]

[1] *Iowa State University*

In Spring 2023, the sPHENIX detector at BNL's Relativistic Heavy Ion Collider (RHIC) will begin measuring a suite of unique heavy flavor and quarkonia observables with unprecedented statistics and kinematic reach at the RHIC energies using combined EM and hadronic calorimeters and high precision tracking. A MAPS-based vertex detector upgrade to sPHENIX, the MVTX, will provide a precise determination of the impact parameter of tracks relative to the primary vertex in high multiplicity heavy-ion collisions and polarized proton-proton/proton-nuclei collisions. It will enable precision measurements of open heavy-flavor observables, covering an unexplored kinematic region at RHIC. The physics program, its potential impact, and the recent detector development will be discussed in this talk.

Experiment/Theory:

Other

Affiliation:

Iowa State Univerisity

Parallel: Future Experimental Facilities / 183

Measurement of a caloric curve and chiral symmetry restoration with the NA60+ experiment at the CERN SPS

Autor Gianluca Usai[1]

[1] *University of Cagliari and INFN*

The high-intensity beams provided by the CERN SPS in a wide energy interval offer a unique opportunity to investigate the region of the QCD phase diagram at high baryochemical potential. The NA60+ experiment, proposed for taking data with heavy-ion collisions at the SPS in the next years, has a strong potential for investigating the QCD phase diagram via measurements of rare probes in a beam-energy scan of Pb-Pb and p-A collisions in the interval $\sqrt{s}_{NN}$ = 6-17 GeV.
In this talk the physics program of the NA60+ on thermal dimuons will be described.
At beam energies below top SPS energy, the baryon density becomes maximal and its effect on ρ meson broadening can be measured by NA60+ with utmost precision.
NA60+ will have sensitivity to the ρ—a_1 chiral mixing mechanism, which provides access also to the properties of the a_1 by exploring the thermal dimuon mass spectrum in the range 1 < M < 1.4 GeV.
For dimuon masses above 1.5 GeV, the temperature of the emitting source can be directly extracted by a fit of the mass spectrum. The experimental program of NA60+ plans to determine for the first time a caloric curve by measuring the temperature vs beam energy, with particular focus on $\sqrt{s}_{NN}$ < 10 GeV, which is believed to be essential to map out the phase transition regime at high μ_B.
Finally, the competitiveness and complementarity of NA60+ in the landscape of the experiments foreseen at other facilities in the next decade will be discussed.

Experiment/Theory:

Future facility

Affiliation:

University of Cagliari and INFN

Parallel: Future Experimental Facilities / 58

The ALICE Forward calorimeter

Autor Tatsuya Chujo[1]

[1] *University of Tsukuba*

The addition of a Forward Calorimeter (FoCal) to the ALICE experiment is proposed for LHC Run 4 to provide unique constraints on the low-x gluon structure of protons and nuclei via forward measurements of direct photons. A new high-resolution electromagnetic Si-W calorimeter using both Si-pad and Si-pixel layers is being developed to discriminate single photons from pairs of photons originating from π^0 decays. A conventional sampling hadron calorimeter is foreseen for jet measurements and the isolation of direct photons. In this presentation, we will report on results from recent test beam campaigns at CERN with Si-pad and pixel modules, a first prototype for the hadronic calorimeter, as well as the physics prospects.

Experiment/Theory:

ALICE

Affiliation:

ALICE

Parallel: Future Experimental Facilities / 57

ITS3: A truly cylindrical inner tracker for ALICE

Autor Jory Sonneveld[None]

After the successful installation and first operation of the upgraded Inner Tracking System (ITS2), which consists of about 10 m^2 of monolithic silicon pixel sensors, ALICE is pioneering the usage of bent, wafer-scale pixel sensors for the ITS3 for Run 4. Sensors larger than typical reticle sizes can be produced using the technique of stitching. At thicknesses of about 30 µm, the silicon is flexible enough to be bent to radii of the order of 1 cm. By cooling such sensors with a forced air flow, it becomes possible to construct a detector with minimal material. The reduction of the material budget and the improved pointing resolution will allow new measurements, in particular of heavy-flavour decays and electromagnetic probes. In this presentation, we will report on the sensor developments, the performance of bent sensors in test beams, and the mechanical studies on truly cylindrical layers.

Experiment/Theory:

ALICE

Affiliation:

ALICE

Parallel: Heavy Flavours & Quarkonia / 204

Open heavy flavor production in pPb and PbPb collisions at LHCb

Autor Roman Litvinov[1]

[1] *INFN Cagliari*

Heavy quarks are produced in the early stage of heavy ion collisions due to their large mass, and experience the entire evolution of the QCD medium. The baryon-to-meson ratio, in particular, the Λ_c^+/D^0 ratio, provides valuable information on charm hadronization mechanisms, testing the role of coalescence in the Quark-Gluon Plasma created in PbPb collisions. In pPb collisions, heavy quarks are essential to study cold nuclear matter effects, which include the modification of nuclear parton distribution functions, energy loss in the nucleus, and other effects, providing a crucial baseline for interpreting PbPb measurements. In this talk, the first LHCb open charm measurement in PbPb collisions, the Λ_c^+/D^0 ratio, will be presented. Moreover, this presentation will show precision measurements of open charm production from a rich set of charmed hadrons in pPb collisions at 5.02 and 8.16 TeV, including the first measurement of Ξ_c^+ baryons in heavy ion collisions. The nuclear modification factor $R_{p\mathrm{Pb}}$, forward-backward ratio R_{FB} and particle production ratios of charm baryons and mesons will be discussed and compared to models.

Experiment/Theory:

LHCb

Affiliation:

On behalf of LHCb

Parallel: Heavy Flavours & Quarkonia / 312

Higher orders in opacity in QGP tomography

Autoren Magdalena Djordjevic[None]; Stefan Stojku[None]; Bojana Ilic[None]

We consider the problem of including a finite number of scattering centers in dynamical energy loss and classical DGLV formalism. Previously, either one or an infinite number of scattering centers were considered in energy loss calculations, while attempts to relax such approximations were largely inconclusive or incomplete. In reality, however, the number of scattering centers is 4-5 at RHIC and the LHC, making the above approximations inadequate and this theoretical problem important for QGP tomography.

We derived explicit analytical expressions for dynamical energy loss and DGLV up to the 4th order in opacity, resulting in complex mathematical expressions that were, to our knowledge, obtained for the first time. These expressions were then implemented into an appropriately generalized DREENA framework to calculate the effects of higher orders in opacity on a wide range of high-pt light and heavy flavor predictions. Results of extensive numerical analysis, including their intuitive interpretations, will be presented.

Experiment/Theory:

Theory/Phenomenology

Affiliation:

Institute of Physics Belgrade, Serbia

Parallel: Heavy Flavours & Quarkonia / **33**

Intrinsic Charm Production in Fixed-Target Experiments at the LHC

Autor Ramona Vogt[1]

[1] *LLNL and UC Davis*

A nonperturbative charm production contribution, known as intrinsic charm, has long been speculated. While it has yet to be satisfactorily proven, there have been recent tantalizing hints. Several experiments, either taking data or
planned, could proivde definitive evidence in the next few years. Experiments that have taken J/ψ and D meson data include SeaQuest at Fermilab and SMOG at LHCb, see Refs. [1,2] and references therein. Future experiments such as NA60+ are in an energy regime where the intrinsic charm quark signature could be large and unmistakeable, as discussed in recent work [3]. These predictions are discussed and compared to previous fixed-target data.

R. Vogt, Limits on Intrinsic Charm Production from the SeaQuest Experiment, Phys. Rev. C **103** (2021), 035204.

R. Vogt, Contribution from Intrinsic Charm Production to Fixed-Target Interactions at the LHC, to be submitted.

R. Vogt, Energy dependence of intrinsic charm production: Determining the best energy for observation, Phys. Rev. C **106** (2022) 025201.

This work was performed under the auspices of the U.S.\ DoE by LLNL under Contract DE-AC52-07NA27344 and supported by LDRD projects 21-LW-034 and 23-LW-036.

Experiment/Theory:

Theory/Phenomenology

Affiliation:

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Parallel: Heavy Flavours & Quarkonia / **293**

Radiative energy loss of heavy quark through soft gluon emission in QGP

Autoren Taesoo Song[1]; Ilia Grishmanovskii[2]; Olga Soloveva[3]; Elena Bratkovskaya[4]

[1] *GSI*

[2] *ITP, Frankfurt*

[3] *Helmholtz Research Academy Hesse for FAIR*

[4] *GSI, Darmstadt & Goethe University, Frankfurt*

The Low's theorem is applied to the soft gluon emission from heavy quark scattering in quark-gluon plasma (QGP). The QGP is described by the DQPM (Dynamical QuasiParticle Model) which reproduces the EoS from lQCD at finite temperature and chemical potential. We show that if the emitted gluon is soft and of long wavelength, the scattering amplitude can be factorized into the scattering part and the emission part and the Slavnov-Taylor identities are satisfied in the leading order. Imposing a proper upper limit on the emitted gluon energy, we obtain the scattering cross sections of charm quark as well as the transport coefficients (momentum drag and diffusion) in the QGP with and without gluon emission.

Experiment/Theory:

Theory/Phenomenology

Affiliation:

GSI

Parallel: Heavy Flavours & Quarkonia / **302**

A microscopic model of charmonia production in heavy ion collisions

Autoren Pol Gossiaux[1]; Joerg Aichelin[2]; Jiaxing Zhao[2]

[1] *Subatech*

[2] *SUBATECH*

Charmonia production in RHIC is one of the best probes of the QGP state of matter which is created in those collisions. However, the genuine origin of such charmonia is under debate: statistical hadronisation (SH) model considers them as formed at the freeze out while transport models contain 2 components : the primordial charmonia, produced early and subject to decay rate as well as the continuous regenerated component enabled once the local temperature falls below the dissociation temperature. While the SH and transport models can describe the present data, they suffer from some shortcomings.
In our new approach (arxiv 2206.01308), we take strong inspiration from the open quantum system

method and propose a microscopic model based on the evaluation of a creation/destruction rate (following Remler's model) from the set of all c and cbar correlated trajectories generated by combining c and cbar scatterings with the QGP and c-cbar potential estimated from lQCD calculations. This allows to describe the continuous generation of charmonia over time while preserving essential features of the quantum transport.
Comparison with LHC data demonstrates that our model is able to reproduce the global trends. In a 2nd version of our model to be presented at HP, we implement our approach in the newly relased EPOS4 and study in particular the role of c-cbar corrrelations in the initial stage as well as the contribution of the excited states, missing in the 1rst version of our model.

Experiment/Theory:

Theory/Phenomenology

Affiliation:

Subatech

Parallel: Heavy Flavours & Quarkonia / 59

The measurements of J/ψ production in Pb-Pb collisions at $\sqrt{s_{\rm NN}}$ = 5.02 TeV with ALICE

Autor Pengzhong Lu[None]

Quarkonia are excellent probes of deconfinement in heavy-ion collisions. For J/ψ, a bound state of $c\bar{c}$ quarks, its production yield is sensitive to color screening and dissociation in the medium. However, at LHC energies, the charmonium regeneration is expected to be significantly larger than at RHIC and SPS energies, since the density of uncorrelated charm-anticharm ($c\bar{c}$) pairs in the medium is larger. On the other hand, the determination of the non-prompt component of the J/ψ production, originating from b-hadron decays, allows one to access the interaction of b-quarks with the QGP. It enables as well for prompt J/ψ measurements a direct comparison with prompt charmonium models.

In this talk, new published inclusive J/ψ yield and nuclear modification factor results at midrapidity and forward rapidity, will be shown in Pb–Pb collisions at $\sqrt{s_{\rm NN}}$ = 5.02 TeV. The J/ψ-to-D^0 meson ratio, obtained in central and semicentral collisions, will also be discussed. The preliminary measurements of prompt and non-prompt J/ψ yields and nuclear modification factors, performed at midrapidity in Pb–Pb collisions at $\sqrt{s_{\rm NN}}$ = 5.02 TeV, will be presented. The determination of the non-prompt J/ψ fraction extends down to very low $p_{\rm T}$ with a significantly improved precision compared to previous publications. Results will be compared with available calculations.

Experiment/Theory:

ALICE

Affiliation:

ALICE

Parallel: Heavy Flavours & Quarkonia / 154

Measurement of heavy quarkonia elliptic flow in pPb collisions with the CMS detector

Autor Kisoo Lee[1]

[1] *Korea University (KR)*

The second-order Fourier coefficients (v_2) of Υ(1S) and J/ψ mesons in high-multiplicity pPb collisions is studied using data collected by the CMS experiment at a nucleon-nucleon center-of-mass energy 8.16 TeV. The dimuons used to reconstruct the heavy quarkonium states are correlated with charged hadrons using long-range two-particle correlation techniques. The measurement of the Υ(1S) v_2 is reported for the first time in small collision systems. The results are discussed in the context of collectivity and modification of heavy quark dynamics.

Experiment/Theory:

CMS

Affiliation:

CMS

Parallel: Heavy Flavours & Quarkonia / 153

New approach of charmonium medium response using elliptic and triangular flow of J/ψ and ψ(2S) with CMS

Autor Geonhee Oh[1]

[1] *University of Illinois at Chicago*

The second- and third-order Fourier coefficients of charmonium states are measured in PbPb collisions with CMS. With this new analysis, extending to a higher p_{T} region, we investigate further the high-p_{T} J/ψ v_2 in heavy ion collisions. The nonprompt J/ψ v_2 probes the different behavior of charm and bottom quarks induced by interactions with the QGP medium. The v_3 flow coefficient values, for the separated prompt and nonprompt J/ψ as well as the prompt ψ(2S), are reported for the first time.

Experiment/Theory:

CMS

Affiliation:

CMS

Parallel: Heavy Flavours & Quarkonia / 188

Quarkonium transport in strongly coupled plasmas

Autoren Bruno Scheihing Hitschfeld[1]; Govert Nijs[1]; Xiaojun Yao[2]

[1] *Massachusetts Institute of Technology*

[2] *University of Washington*

Suppression of open heavy flavors and quarkonia in heavy-ion collisions is among the most informative probes of the quark-gluon plasma. Interpreting the full wealth of data obtained from the collision events requires a precise understanding of the evolution of heavy quarks and quarkonia as they propagate through the nearly thermal and strongly coupled plasma. Only in the past few

years, systematic theoretical studies of quarkonium time evolution in the QGP have been carried out in the regime where the temperature of the QGP is much smaller than the inverse of quarkonium size.

Such calculations require the evaluation of a gauge-invariant correlator of chromoelectric fields dressed with Wilson lines, which is similar to, but different from, the correlation used to define the well-known [1] heavy quark diffusion coefficient. The origin of this difference has been explained in [2-4]. In this talk, we will show a calculation of the analogous correlator in strongly coupled $\mathcal{N} = 4$ SYM using the AdS/CFT correspondence at a finite temperature [5]. While it resembles the open heavy quark case, it has some crucial differences that highlight the relevance of quantum color correlations. We will also discuss the results for the quarkonium transport coefficients obtained from this correlator, thereby establishing the first analytic results at strong coupling in this context.

[1] Phys. Rev. D 74 (2006) 085012; [2] JHEP 01 (2022) 137; [3] arXiv:2205.04477; [4-5] in preparation

Experiment/Theory:

Theory/Phenomenology

Affiliation:

Massachusetts Institute of Technology, University of Washington

Parallel: Heavy Flavours & Quarkonia / 132

Υ(nS) meson production in Pb+Pb and pp collisions with ATLAS

Autor Zvi Citron[1]

[1] *Ben-Gurion University of the Negev*

Measurements of bottomonium states in heavy-ion collisions provide a powerful tool to study both initial-state effects on heavy-quark production and final-state interactions between heavy quarks and the quark-gluon plasma (QGP). The ATLAS experiment at LHC has measured the production of bottomonium states Υ(1S), Υ(2S), and Υ(3S), in Pb+Pb and pp collisions at a center-of-mass energy per nucleon pair of 5.02 TeV. The data correspond to integrated luminosities of 1.38 nb^{-1} of Pb+Pb data collected in 2018, 0.44 nb^{-1} of Pb+Pb data collected in 2015, and 0.26 fb^{-1} of pp data collected in 2017. The final ATLAS result on the production of three bottomonium states will be reported. The measurement in Pb+Pb collisions is compared to that in pp collisions to extract the nuclear modification factor, R_{AA}, as a function of event centrality, p_{T} and rapidity, and compared to several theoretical models. We will also present a new measurement studying the relationship between the production of hard and soft particles through the correlation of Upsilon meson states with the inclusive-charged particle yields. The analysis is performed using the full-luminosity ATLAS Run-2 13 TeV pp data. A description of the technical challenges associated with a heavy-ion style analysis in high-pileup pp data will be shown, as well as the results and their physics implications.

Experiment/Theory:

ATLAS

Affiliation:

ATLAS Collaboration

Parallel: Heavy Flavours & Quarkonia / 211

Exclusive quarkonium photoproduction in nucleus-nucleus UPCs at the LHC in NLO QCD

Autoren Vadim Guzey[1]; Kari J Eskola[1]; Christopher Flett[2]; Topi Löytäinen[1]; Hannu Paukkunen[1]

[1] *University of Jyvaskyla*

[2] *University of Jyvaskyla & University Paris-Saclay and CNRS, IJCLab*

We present the first study of coherent exclusive quarkonium (J/psi, Upsilon) photoproduction in ultraperipheral nucleus-nucleus collisions (UPCs) at the LHC in the framework of collinear factorization and next-to-leading order (NLO) perturbative QCD. We make predictions for the J/psi and Upsilon rapidity distributions for the cases of lead (Pb) and oxygen (O) beams and quantify their dependence on the choice of the hard scale, nuclear PDFs and their uncertainties, and models for nuclear generalized parton distribution functions (GPDs). We demonstrate that our approach provides a simultaneously good description of all available Run 1 and Run 2 LHC data on J/psi photoproduction in Pb-Pb UPCs and makes definite predictions for photoproduction of heavy quarkonia in heavy-ion UPCs at the LHC.

Experiment/Theory:

Theory/Phenomenology

Affiliation:

University of Jyvaskyla & Helsinki Institute of Physics, University of Helsinki, Finland; University Paris-Saclay & CNRS, IJCLab, Orsay, France

Parallel: Heavy Flavours & Quarkonia / 300

Spin-Induced Interactions and Heavy-Quark Transport in the QGP

Autor Zhanduo Tang[None]

Co-Autor: Ralf Rapp [1]

[1] *Cyclotron Institute and Department of Physics and Astronomy, Texas A&M University*

We extend a previously constructed T-matrix approach for heavy quarks in the quark-gluon plasma (QGP) to include inverse-mass (1/M) corrections, i.e. the spin-orbit, spin-spin and tensor forces, between partons. Based on the vacuum Cornell potential as the interaction kernel for the T-matrix equation, we first confirm that the experimental charmonium and bottomonium spectroscopy in vacuum are much improved by employing a confining potential that is a mixture of vector and scalar interactions, rather than a purely scalar one. We then apply the refined potential to calculate the in-medium single-parton spectral functions at finite temperature self-consistently and constrained by various thermal lattice-QCD data. Finally, we study the consequences for the in-medium charm-quark transport coefficients at different temperatures. It turns out that the mixing effect for confining potential significantly enhances the friction coefficient, A(p), for charm quarks in the QGP over previous calculations with a purely scalar potential. Our results may have significant implications for the microscopic description of heavy-flavor transport in heavy-ion collisions at RHIC and the LHC.

Experiment/Theory:

Theory/Phenomenology

Affiliation:

Cyclotron Institute and Department of Physics and Astronomy, Texas A&M University

Parallel: Heavy Flavours & Quarkonia / 203

New measurements in fixed-target collisions at LHCb

Autor Kara Mattioli[1]

[1] *Laboratoire Leprince Ringuet, CNRS*

The LHCb spectrometer has the unique capability to function as a fixed-target experiment by injecting gas into the LHC beampipe while proton or ion beams are circulating. The resulting beam+gas collisions cover an unexplored energy range that is above previous fixed-target experiments, but below the top RHIC energy for AA collisions. Here we present new results on open charm, J/ψ, and $\psi(2S)$ production from pNe and PbNe fixed-target collisions at LHCb. Comparisons with various theoretical models of particle production and transport through the nucleus will be discussed.

Experiment/Theory:

LHCb

Affiliation:

On behalf of LHCb

Parallel: Heavy Flavours & Quarkonia / 224

A fluid-dynamic approach to heavy-quark diffusion in the quark-gluon plasma

Autor Federica Capellino[1]

Co-Autoren: Andrea Beraudo [2]; Andrea Dubla [3]; Stefan Floerchinger [4]; Eduardo Grossi [5]; Andreas Kirchner [6]; Silvia Masciocchi [3]; Jan M. Pawlowski [6]; Ilya Selyuzhenkov [3]

[1] *Physikalisches Institut Heidelberg*

[2] *INFN Torino*

[3] *GSI - Helmholtzzentrum fur Schwerionenforschung GmbH (DE)*

[4] *Institute for Theoretical Physics at Friedrich Schiller University Jena*

[5] *Università degli Studi di Firenze*

[6] *ITP Heidelberg*

Heavy quarks (i.e. charm and beauty) are powerful tools to characterize the quark-gluon plasma (QGP) produced in heavy-ion collisions. Although they are initially produced out of kinetic equilibrium via hard partonic scattering processes, recent measurements of anisotropic flow of charmed hadrons [1] pose the question regarding the possible thermalization of heavy quarks in the medium. Our recent work [2] provides new insights on the level of thermalization of charm and bottom quarks in the QGP. In particular, exploiting a mapping between transport theory and fluid-dynamics, we will show how a fluid-dynamic description of the dynamics of charm quarks in the QCD plasma is feasible.
We will show results for spectra and flow coefficients of charmed hadrons obtained with a fluid-dynamic code (FluiduM [3]) coupled with the conservation of a heavy-quark - antiquark current in

the QGP. We compare our calculations with the most recent experimental data in order to provide further constraints on the transport coefficients of the QGP [4].
This work is funded via the DFG ISOQUANT Collaborative Research Center (SFB 1225).
[1] PLB 813 (2021) 136054
[2] Phys.Rev.D 106 3, 034021 (2022)
[3] Phys. Rev. C 100, 014905 (2019)
[4] Capellino, Beraudo, Dubla, Floerchinger, Grossi, Kirchner, Masciocchi, Selyuzhenkov; in preparation

Experiment/Theory:

Theory/Phenomenology

Affiliation:

Physikalisches Institut Heidelberg, GSI Helmolzzentrum fuer Schwerionenforschung Darmstadt

Parallel: Heavy Flavours & Quarkonia / **152**

Detailed study of the nuclear modification of Υ states in pPb and PbPb collisions with CMS

Autor JaeBeom Park[None]

Bottomonia, the heaviest known mesons, represent major probes of strongly interacting matter properties. In the context of nuclear collisions, the binding energies separating the Υ(nS) states (n=1, 2, or 3) offer an experimental handle to characterize the medium formed. In this talk, we study the modification of the production of the three Υ mesons in both pPb and PbPb collisions with the latest measurements carried out with the CMS detector. The results are compared with model calculations in order to interpret the data.

Experiment/Theory:

CMS

Affiliation:

CMS

Parallel: Heavy Flavours & Quarkonia / **257**

Comparison of Heavy quark Hadronization Mechanisms in heavy ion collisions

Autoren Jiaxing Zhao[1]; Pol Bernard Gossiaux[1]; Joerg Aichelin[1]

[1] *SUBATECH*

The hadronization process is a well-known non-perturbative process, which is happening in both elementary collisions such as $p+p$, $e^+ + e^-$ collisions, and also the relativistic heavy ion collisions. Studying the hadronization mechanism is crucial for understanding the QCD in low-energy regions. In elementary collisions, the hadronization process is usually described by the fragmentation model, while the recombination plays an important role in quark hadronization in the hot medium, which created in relativistic heavy ion collisions. The state-of-art is mixing the fragmentation and recombination process. The recombination dominates in the low transverse momentum region while fragmentation takes over in the high transverse momentum region.

Due to the large mass, distinguishable, and traceable properties, heavy flavor supplies a unique probe to study the hadronization mechanism in heavy ion collisions.
We convened many theoretical groups to do the comparison of the hadronization models with given initial condition.
In this talk, we will present the differences and connections between different hadronization models. We compare in detail the H_{AA} yield and the elliptic flow v_2 of heavy flavor hadrons obtained in different theoretical models and point out how the different models influence the spectra. A summary will be given at the end of this talk.

Experiment/Theory:

Theory/Phenomenology

Affiliation:

SUBATECH, Universit´e de Nantes, IMT Atlantique, IN2P3/CNRS,

Parallel: Heavy Flavours & Quarkonia / 78

New insights into heavy-quarks hadronisation with charm and beauty hadrons in hadronic collisions with ALICE

Autor Annalena Kalteyer[None]

In this contribution, we present the new measurements of non-prompt D^+ and $\mathrm{D_s}$ in pp collisions at $\sqrt{s}$ = 13 TeV. Together with the final measurements of non-prompt D^0 and Λ_c^+, they are crucial to study the beauty quark hadronisation in proton-proton (pp) collisions and their difference with respect to $\mathrm{e}^+\mathrm{e}^-$ collisions. In addition, the baryon-to-meson ratio in pp collisions compared with that in $\mathrm{e}^+\mathrm{e}^-$ and electron–proton collisions and model predictions, and the measurements of charm fragmentation fraction in pp and pPb collision will be reported as well.

Furthermore, the new non-prompt $\Lambda_\mathrm{c}^+/\mathrm{D}^0$ ratio in p-Pb collisions as well as the first measurement of non-prompt D^0 nuclear modification factor R_pPb at $\sqrt{s_\mathrm{NN}} = 5.02$ TeV will be presented. The status of prompt Ξ_c R_pPb studies will be reported. They provide important information about Cold-Nuclear Matter (CNM) effects and to understand how the possible presence of collective effects could modify the production of heavy-flavour hadrons and the similarities observed among pp, p-nucleus, and nucleus–nucleus systems.

Experiment/Theory:

ALICE

Affiliation:

ALICE

Parallel: Heavy Flavours & Quarkonia / 201

Modification of heavy quark hadronization in high-multiplicity collisions

Autor chenxi gu[1]

[1] *Laboratoire Leprince-Ringuet, École Polytechnique, CNRS*

The total rate of heavy quark production can be calculated with perturbative QCD techniques. However, the fraction of heavy quarks that pair with a light quark (forming mesons) versus the fractions combine with two other quarks (baryons) baryons or 3 or more other quarks (exotic states) is sensitive to the nonperturbative hadronization process. LHCb is uniquely well suited to study such effects in the heavy quark sector, down to very low transverse momentum. Here we will present LHCb results on the production rates of Λ_b^0 baryons and B_s^0 mesons relative to B^0 mesons, and D_s^+ relative to D^+ mesons versus multiplicity in pp and pPb collisions. Potential implications for the hadronization mechanism of heavy quarks and our understanding of the factorization of fragmentation functions will be discussed.

Experiment/Theory:

LHCb

Affiliation:

On behalf of LHCb

Parallel: Heavy Flavours & Quarkonia / 163

Search of hot QCD effects via dynamics and productions of heavy flavor quarks in small systems with CMS detector

Autor Yousen Zhang[None]

The surprising collectivity signal emerging in small hadronic systems for light and heavy quarks raises the question whether a quark-gluon plasma is created in those systems too. The conjectured QGP formation could also enhance baryon production because of coalescence processes. Moreover, strangeness enhancement signals have been observed. Recent measurements show charm baryon-to-meson ratios are enhanced in heavy ion collisions compared to pp collisions. In this talk, the studies of collectivity for charm and bottom mesons in pp and pPb collisions will be presented. New measurements of the multiplicity dependence of charm baryon-to-meson ratios will also be presented over a wide multiplicity range, and compared with those in the strangeness sector. These measurements provide new insights into the origin of heavy flavor hadron collectivity and charm hadronization.

Experiment/Theory:

CMS

Affiliation:

CMS

Parallel: Heavy Flavours & Quarkonia / 80

Heavy-flavour leptons and non-prompt D mesons to investigate beauty-quark interaction in the QGP with ALICE

Autor Martin Völkl[1]

[1] *Unversität Heidelberg*

In this contribution, new results for beauty measurements with ALICE are presented. The production of beauty hadrons can be accessed with measurements of leptons from beauty- and charm-hadron

decays as well as the reconstruction of non-prompt charmed hadrons.
We show the nuclear modification factor of electrons from beauty hadron decays in Pb-Pb collisions at $\sqrt{s_{\rm NN}} = 5.02$ TeV, which gives an insight into the production and momentum distribution of beauty quarks via the decays of the different hadron species. In order to understand the contributions from the different hadrons, we also present the final results for non-prompt $\rm D_s^+$ mesons, which are compared to the prompt contribution as well as the non-prompt $\rm D^0$ measurement.
The azimuthal anisotropy of beauty quarks via the measurement of the non-prompt $\rm D^0$ v_2 is also discussed. It helps to further investigate the degree of themalization of beauty quarks in the hot and dense QCD medium. Additionally, ALICE can measure muons from heavy-flavour hadron decays in the forward direction $-4 < \eta < -2.5$. The new results for the azimuthal anisotropy of heavy flavor muon production in p-Pb collisions at $\sqrt{s_{\rm NN}} = 8.16$ TeV provide new insights into the appearance of collective effects in smaller systems, which will be discussed and compared with measurements in Pb-Pb and pp as well as with model calculations.

Experiment/Theory:

ALICE

Affiliation:

ALICE

Parallel: Heavy Flavours & Quarkonia / 197

Constraining the in-medium heavy quark potential and diffusion coefficient within a unified perturbative and non-perturbative transport approach

Autoren Shanshan Cao[1]; Wen-Jing Xing[1]; Yichao Dang[1]; Guang-You Qin[2]

[1] *Shandong University*

[2] *Central China Normal University*

While perturbative QCD is sufficient for understanding parton energy loss at large transverse momentum ($p_{\rm T}$) in heavy-ion collisions, a simultaneous description of the heavy flavor nuclear modification factor ($R_{\rm AA}$) and elliptic flow coefficient (v_2) at low to intermediate $p_{\rm T}$ still remains challenging due to non-perturbative interactions between heavy quarks and the QGP. We develop a unified perturbative and non-perturbative Boltzmann transport model for studying the heavy quark dynamics inside the QGP. A generalized Cornell-type potential is implemented, which incorporates both the short-range Yukawa interaction and the long-range color confining interaction. By combining this new approach to a (3+1)-dimensional viscous hydrodynamic model for the QGP evolution and a hybrid fragmentation-coalescence model for heavy quark hadronization, we obtain a satisfactory description of $R_{\rm AA}$ and v_2 of heavy mesons and their decayed leptons from low to intermediate to high $p_{\rm T}$. From the model-to-data comparison, we extract the in-medium heavy quark potential from open heavy flavor observables for the first time, which is shown in agreement with the lattice QCD calculation. The mass dependence of the heavy quark diffusion coefficient D_s is systematically explored for the first time as well, which is shown to be smaller for b-quark than for c-quark, and is also consistent with recent results from the lattice calculation.

Experiment/Theory:

Theory/Phenomenology

Affiliation:

Shandong University, Central China Normal University

Parallel: Heavy Flavours & Quarkonia / 255

The heavy quark diffusion coefficient from 2+1 flavor lattice QCD

Autor Olaf Kaczmarek[1]

[1] *Bielefeld University*

We present a novel approach to nonperturbatively estimate the heavy quark momentum diffusion coefficient, which is a key input for the theoretical description of heavy quarkonium production in heavy ion collisions, and is important for the understanding of the elliptic flow and nuclear suppression factor of heavy flavor hadrons. In the heavy quark limit, this coefficient is encoded in the spectral functions of color-electric and color-magnetic correlators that we calculate on the lattice to high precision by applying gradient flow. For the first time we apply the method to 2+1 flavor ensembles with temperatures between 200-350 MeV. Using our experience from quenched QCD, where we performed a detailed study of the lattice spacing and flow time dependence, we estimate the heavy quark diffusion coefficient using theoretically well-established model fits for the spectral reconstruction.

Experiment/Theory:

Theory/Phenomenology

Affiliation:

Bielefeld University

Parallel: Heavy Flavours & Quarkonia / 82

Measurement of ${\rm D_{s1}}^{+}$ and ${\rm D_{s2}}^{*+}$ production, and ${\rm D}^{*+}$ spin alignment in pp collisions at $\sqrt{s} = 13$ TeV with ALICE

Autor Stefano Politano[1]

[1] *Politecnico and INFN Torino (IT)*

The understanding of the charm-quark hadronisation in high-energy hadronic collisions has recently improved. The production of D mesons relative to each other is compatible with those measured in ${\rm e^+e^-}$ collisions. The charm baryon-to-meson yield ratios show an enhancement from those measured at lepton colliders. This modification depends on the charged-particle multiplicity. State-of-the-art QCD-inspired models based on string fragmentation, statistical hadronisation, and hadronisation via recombination reproduce the main features of these measurements. However, several aspects of the transition of heavy quarks to the final-state hadron are not yet settled, such as the spin properties of produced particles. Hadronisation models can be further tested by the measurements of excited charm hadron states and of the polarisation or spin alignment of charm vector mesons. In this contribution, the first measurements of ${\rm D_{s1}}^{+}$ and ${\rm D_{s2}}^{*+}$ mesons and of ${\rm D}^{*+}$-meson spin alignment in pp collisions at $\sqrt{s} = 13$ TeV by the ALICE Collaboration are presented. The measurement of the spin alignment is performed separately for prompt and non-prompt ${\rm D}^{*+}$ mesons, the latter are expected to be longitudinally polarised due to the helicity conservation. It is also shown how the latter coupled with the collective anisotropic expansion of the system may mimic the signal of global spin alignment in heavy-ion collisions.

Experiment/Theory:

ALICE

Affiliation:

ALICE

Parallel: Heavy Flavours & Quarkonia / 106

Resolving the R_{pA} and v_2 puzzle of D^0 mesons in $p-Pb$ collisions

Autor Zi-Wei Lin[None]

Co-Autoren: Liang Zheng ; Shusu Shi ; Chao Zhang

It has been a challenge to understand the experimental data on both the nuclear modification factor and elliptic flow of D^0 mesons in $p-Pb$ collisions at LHC energies. In this work[1], we study these observables with an improved multi-phase transport model. After including the Cronin effect (or transverse momentum broadening) and independent fragmentation for charm quarks, we provide the first simultaneous description of the D^0 meson R_{pA} and v_2 data at $p_T \leq 8$ GeV/c. The model also provides a reasonable description of the D^0 meson p_T spectra and the low-p_T (below ~1.5 GeV/c) charged hadron spectra, R_{pA} and v_2. We find that both parton scatterings and the Cronin effect are important for the D^0 meson R_{pA}, while parton scatterings are mostly responsible for the D^0 meson v_2. Therefore, it is crucial to include the Cronin effect for the simultaneous description of the D^0 meson R_{pA} and v_2. Since the Cronin effect is expected to grow with the system size, this work also implies that it could be important for heavy hadrons in large systems.

Experiment/Theory:

Theory/Phenomenology

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Central China Normal University, Wuhan 430079, China

Parallel: Heavy Flavours & Quarkonia / 166

Quarkonia dynamics in the Quark-Gluon Plasma with a quantum master equation

Autoren Stéphane Delorme[1]; Pol-Bernard Gossiaux[2]; Thierry Gousset[3]

[1] *IFJ Pan*

[2] *IMT Atlantique*

[3] *Nantes Université*

In recent years, a significant theoretical effort has been made towards a dynamical description of quarkonia inside the Quark-Gluon Plasma (QGP), using the open quantum systems formalism. In this framework, one can get a real-time description of a quantum system (here the quarkonium) in interaction with a thermal bath (the QGP) by integrating out the bath degrees of freedom and studying the system reduced density matrix.

We investigate the real-time dynamics of a correlated charm-anticharm pair inside the QGP using novel coupled quantum master equations derived from first QCD principles and based on the work of Blaizot & Escobedo [1]. The equations are solved numerically in 1D to lessen computing costs and

are used to gain insight on the dynamics in both a static and evolving medium following a Björken-like temperature evolution. Several initial conditions will be explored and a study of a possible semi-classical treatment will be presented, in order to see if this approach
can be used to treat multiple charm-anticharm pairs at the same time.

[1]-J. P. Blaizot and M. A. Escobedo, Quantum and classical dynamics of heavy quarks in a quark-gluon plasma, J. High Energy Phys. 06 (2018) 034.

Experiment/Theory:

Theory/Phenomenology

Affiliation:

IFJ PAN
Subatech/CNRS/IMT Atlantique/Nantes Université

Parallel: Heavy Flavours & Quarkonia / 49

Multiplicity dependence of quarkonium production in small systems with ALICE

Autor Ailec de la Caridad Bell Hechavarria[None]

High-multiplicity measurements in pp and p-Pb collisions have revealed the presence of phenomena typically attributed to the creation of a quark-gluon plasma (QGP). Events with multiple parton-parton interactions (MPIs) have been proposed as one possible explanation of this observation. MPIs play a significant role in describing the soft component of the hadronic interactions, and at LHC energies also affect the production of heavy quarks. Multiplicity dependent quarkonium measurements in small systems are therefore crucial for studying the correlation between soft and hard components of high-multiplicity events, as well as to shed light on MPIs or any other possible underlying mechanisms. Moreover, excited quarkonia, more loosely bound than ground states, are more sensitive to any possible dissociation mechanisms taking place in the final state.

In this contribution, new published multiplicity dependent ψ(2S) measurements, carried out at forward rapidity in pp and p-Pb collisions at $\sqrt{s}$ = 13 TeV and $\sqrt{s_{\rm NN}}$ = 8.16 TeV, along with charmonium excited-to-ground state ratios, will be discussed. Similar measurements published recently for $\Upsilon(n\rm S)$ states (n = 1,2,3), performed at forward rapidity in pp collisions at $\sqrt{s}$ = 13 TeV, will be presented. The status of ongoing multiplicity dependent J/ψ measurements at midrapidity in pp and p-Pb collisions will also be shown. Results will be compared to available model calculations.

Experiment/Theory:

ALICE

Affiliation:

ALICE

Parallel: Heavy Flavours & Quarkonia / 205

Quarkonia and exotic hadron production in pPb collisions at LHCb

Autor Clara Landesa Gómez[1]

[1] *IGFAE*

Quarkonia production in hadronic collisions is an important experimental observable that sheds light on the heavy quark interaction with the nuclear medium. While the bound quarkonium states undergo dissociation and recombination in PbPb collisions, in pPb collisions they can suffer from a combination of initial and final state effects such as shadowing and comover breakup. The exotic hadron X(3872), which likely contains a $c\bar{c}$ pair plus two light quarks, may be affected by similar phenomena plus modifications of the hadronization process that emerge in dense systems. This talk will discuss recent results on conventional charmonia from LHCb, and the first measurement of X(3872) production in pPb collisions.

Experiment/Theory:

LHCb

Affiliation:

on behalf of LHCb, speaker to be selected later

Parallel: Heavy Flavours & Quarkonia / 251

Medium-enhanced $c\bar{c}$ production in jets

Autoren Jasmine Brewer[1]; Maximilian Attems[None]; Gian Michele Innocenti[None]; Aleksas Mazeliauskas[2]; Sohyun Park[None]; Wilke van der Schee[None]; Urs Achim Wiedemann[3]

[1] *CERN*

[2] *ITP Heidelberg*

[3] *CERN Theoretical Physics Department*

We show that the same QCD formalism that accounts for the suppression of high-p_T hadron and jet spectra in heavy-ion collisions predicts medium-enhanced production of $c\bar{c}$ pairs in jets. Using the formalism of Baier-Dokshitzer-Mueller-Peigné-Schiff and Zakharov we compute the medium-modifications of the gluon splitting into a quark–anti-quark pair and reveal two phenomena: a medium-induced momentum broadening of quark–antiquark pairs, and a medium-enhanced production of such pairs. We perform a parton shower study to demonstrate that the medium-enhanced production of $c\bar{c}$ pairs leads to enhanced production of jets containing $D^0\bar{D}^0$. We estimate that this novel effect of jet-medium interaction could be measurable in high-luminosity heavy-ion runs at the LHC.

Experiment/Theory:

Theory/Phenomenology

Affiliation:

CERN, Heidelberg

Parallel: Heavy Flavours & Quarkonia / 160

Measurements of D^0 mesons production and collective flow with CMS at 5.02 TeV

Autor Milan Stojanovic[1]

[1] *Purdue University*

The interaction of heavy quarks with the quark-gluon plasma (QGP) affects their azimuthal distribution and p_{T} spectrum, hence measurement of azimuthal anisotropy coefficients (v_n) and nuclear modification factors (R_{AA}) of heavy flavor hadrons turns out to be an important probe of the QGP. However, simultaneous modeling of v_n and R_{AA} is still challenging. This talk reports the first nonprompt D^0 measurements of the azimuthal anisotropy elliptic (v_2) and triangular (v_3) coefficients in large systems, using !PbPb collisions at $\sqrt{s_{\mathrm{NN}}} = 5.02$ TeV, collected with the CMS apparatus. The measurements are performed as a function of transverse momentum, spanning 1–30 GeV /c, in three centrality classes, from central to midcentral collisions. Compared to the prompt D^0 results, the nonprompt D^0 v_2 flow coefficients are systematically lower and show less dependence on p_{T} and centrality. An indication of non-zero v_3 coefficient of the nonprompt D^0 is observed. A wide pT range enables the study of various flow generation mechanisms, like diffusion at low p_{T} and path-dependent parton energy loss at high p_{T}. In addition, measurements of both prompt and nonprompt D^0 mesons cross sections in PbPb and pp collisions, as well as R_{AA}, will be shown. The results will be compared to theoretical predictions.

Experiment/Theory:

CMS

Affiliation:

CMS

Parallel: Heavy Flavours & Quarkonia / 108

heavy quark momentum diffusion coefficient in the hydrodynamizing plasma from effective kinetic theory

Autor Jarkko Peuron[1]

Co-Autoren: Aleksi Kurkela [2]; Boguslavski Kirill [3]; Florian Lindenbauer [4]; Tuomas Lappi [1]

[1] *University of Jyväskylä*

[2] *University of Stavanger*

[3] *Vienna university of Technology*

[4] *TU Wien*

We compute the heavy quark momentum diffusion coefficient using effective kinetic theory for a system going through bottom-up isotropization until approximate hydrodynamization. We find that when matching the nonthermal diffusion coefficient to the thermal one for the same energy density, the observed deviations throughout the whole evolution are withing 30% from the thermal value. When matching for other quantities we observe considerably larger deviations. We also observe that the diffusion coefficient in the transverse direction dominates at large occupation number, whereas for an underoccupied system the longitudinal diffusion coefficient dominates. While the ratio of the diffusion coefficients does not follow the usual hydrodynamical attractor, we observe the emergence of a limiting weak coupling attractor governed by bottom-up scaling.

Experiment/Theory:

Theory/Phenomenology

Affiliation:

University of Jyväskylä

Parallel: Heavy Flavours & Quarkonia / 263

PHENIX Measurements of Azimuthal Anisotropy of Light and Heavy Flavor Hadrons and J/Psi in Au+Au Collisions at Forward Rapidity

Autor Brandon Blankenship[1]

Co-Autor: Julia Velkovska [1]

[1] *Vanderbilt University*

One of the most prominent features of the quark gluon plasma is its near-perfect fluid behavior. An important outstanding question is establishing the degree to which heavy flavor particles flow with the bulk system. Measurements of the Fourier coefficient v2 of light and heavy flavor hadrons and quarkonia can provide insight into the properties of the medium. At low transverse momentum (pT) the mass dependence of v2 is associated with the common flow velocity in the bulk system, whereas at higher pT path length and mass dependencies in the energy loss play a role. Additionally for J/Psi, the equilibration and recombination of charm quarks may produce azimuthal anisotropies. We will present new results measured with the PHENIX muon arms covering 1.2<|η|<2.2 using high statistics Au+Au dataset collected in 2014. The v2 of light hadrons and muons from heavy flavor decays are measured in the range 0.5<pT<7 GeV/c, and v2 of J/Psi in the range 0<pT<5 GeV/c. The results are compared to measurements at mid-rapidity. Different rapidities sample different initial and final state effects and have different densities of cc pairs, and therefore the produced particles may be subject to different pressure gradients and coalescence effects. The measurements will be compared to theoretical calculations.

Experiment/Theory:

PHENIX

Affiliation:

Vanderbilt University

Parallel: Heavy Flavours & Quarkonia / 282

D and B meson Suppression and Azimuthal Anisotropy in a Strongly Coupled Plasma at $\sqrt{s_{NN}} = 5.5$ TeV

Autor Blessed Ngwenya[1]

Co-Autor: Will Horowitz [1]

[1] *University of Cape Town*

We present predictions for the suppression of D and B-mesons at $\sqrt{s} = 5.5$ TeV at the LHC in Pb+Pb collisions. We assume that the QGP is strongly coupled, and show the centrality and momentum dependence of the nuclear modification factor at midrapidity. We quantify the systematic theoretical uncertainties associated with the mapping of parameters in $N = 4$ SYM theory to QCD, as well as the momentum dependence of the diffusion coefficient in AdS/CFT. We also present results of the corresponding $v_2(p_T)$ for D and B-mesons describing this azimuthal anisotropy for central, semi-central and peripheral collisions. We show that the suppression and azimuthal anisotropy predictions are qualitatively consistent with LHC measurements. In addition, we show that coupling energy loss to flow increases v_2 substantially out to surprisingly large momenta, on the order of ~ 25 GeV/c, thus pointing to a possible resolution of the R_{AA} and v_2 puzzle at intermediate p_T for light hadrons.

Experiment/Theory:

Theory/Phenomenology

Affiliation:

University of Cape Town

Parallel: Heavy Flavours & Quarkonia / 175

Multi-scale evolution of heavy flavor in the QGP

Autor Gojko Vujanovic[1]

[1] *University of Regina*

Shower development dynamics for a jet traveling through the quark-gluon plasma (QGP) is a multi-scale process, where the heavy flavor mass is an important scale. During the high virtuality portion of the jet evolution in the QGP, emission of gluons from a heavy flavor is modified owing to heavy quark mass. In-medium stimulated radiation of heavy flavor is sensitive to microscopic processes (e.g. diffusion), whose virtuality dependence is phenomenologically explored in this study. In the lower virtuality part of shower evolution, i.e. when the mass is comparable to the virtuality of the parton, scattering and radiation processes of heavy quarks differ from light quarks. The effects of these mechanisms on shower development in heavy flavor tagged jets in the QGP is explored here. Furthermore, our multi-scale study examines dynamical pair production of heavy flavor (via virtual gluon splittings) and their subsequent evolution in the QGP, which is not possible otherwise. A realistic event-by-event simulation is performed using the JETSCAPE Framework. Energy-momentum exchange with the medium proceeds using a weak coupling recoil approach. Using leading hadron and open heavy flavor observables, differences in various heavy quark energy-loss mechanisms are explored, while the importance of heavy flavor pair production is highlighted along with future directions to study. Preliminary Bayesian constraint of parton momentum diffusion in the QGP is shown using light and heavy flavors.

Experiment/Theory:

Theory/Phenomenology

Affiliation:

JETSCAPE Collaboration

Parallel: Heavy Flavours & Quarkonia / 213

Prospects for open heavy-flavour and quarkonium measurements with NA60+

Autor Roberta Arnaldi[None]

The high-intensity beams provided by the CERN SPS in a wide energy interval offer a unique opportunity to investigate the region of the QCD phase diagram at high baryochemical potential.
The NA60+ experiment, proposed for taking data with heavy-ion collisions at the SPS in the next years, has a strong potential of providing new insights into the QCD phase diagram via measurements of rare probes in a beam-energy scan of Pb−Pb and p−A collisions in the interval $\sqrt{s_{\rm NN}} = 6 - 17$ GeV.

In this talk, the prospects for measurements of hidden and open charm will be presented.
Open charm hadrons will be measured from their decays into charged hadrons, which will be reconstructed from the tracks in the silicon detectors of the vertex telescope.
This will enable high-precision measurements of the yield of D^0, D^+, and D_s^+ mesons, and of Λ_c^+ baryons, thus allowing us to constrain the transport properties of the QGP and the charm-quark hadronisation.
Charmonium states, J/ψ and ψ(2S), will be measured through dimuon decays reconstructed with the muon spectrometer.
By measuring the charmonium yield in p−A and Pb−Pb collisions at different collision energies, NA60+ will provide a unique opportunity to study the threshold energy for the onset of deconfinement.
The competitiveness and complementarity of NA60+ in the landscape of the experiments foreseen at other facilities in the next decade will be discussed.

Experiment/Theory:

Future facility

Affiliation:

INFN Torino

Parallel: Heavy Flavours & Quarkonia / 47

Quarkonium polarization in pp and Pb-Pb collisions from ALICE

Autor Andrea Ferrero[1]

[1] *Université Paris-Saclay (FR) and CEA-IRFU-DPhN*

Polarization measurements represent an important tool for the understanding of particle production mechanisms occurring in proton–proton collisions. When considering heavy-ion collisions, quarkonium polarization could also be used to investigate the characteristics of the hot and dense medium, the quark-gluon plasma (QGP) created at LHC energies. It has been hypothesized that quarkonium states could be polarized by the strong magnetic field, generated in the early phase of the evolution of the system, and by the large angular momentum of the medium in non-central heavy-ion collisions. This kind of information can be assessed by defining an ad hoc reference frame where the quantization axis is orthogonal to the event plane of the collision. In this contribution, the new published result of J/ψ polarization with respect to a quantization axis orthogonal to the event-plane in Pb-Pb collisions at $\sqrt{s_{NN}}$ = 5.02 TeV will be presented. The p_T-differential measurement was performed at forward rapidity ($2.5 < y < 4$) and the results will be shown for different centrality classes. The preliminary Υ(1S) polarization analysis, as well as the status of the new J/ψ and ψ(2S) polarization analyses in pp collisions at $\sqrt{s}$ = 13 TeV as a function of the transverse momentum will also be discussed.

Experiment/Theory:

ALICE

Affiliation:

ALICE

Parallel: Heavy Flavours & Quarkonia / 88

Heavy quarks probe the equation of state of QCD matter in heavy-ion collisions

Autoren Feng-lei Liu[1]; Xiang-yu Wu[1]; Shanshan Cao[2]; Guang-You Qin[1]; Xin-Nian Wang[3]

[1] *Central China Normal University*

[2] *Shandong University*

[3] *LBNL*

We show for the first time that heavy flavor quenching and flow can be utilized to probe the equation of state (EoS) of quark-gluon plasma (QGP) produced in relativistic heavy-ion collisions. Based on our quasi-particle linear Boltzmann transport (QLBT) model that is coupled to a (3+1)-dimensional viscous hydrodynamic simulation of the QGP and a hybrid fragmentation-coalescence approach for heavy flavor hadronization, we perform a detailed analysis on the D meson $R_{\rm AA}$ and v_2 data at RHIC and the LHC using the state-of-the-art Bayesian statistical framework. A simultaneous constraint on the QGP EoS and the heavy quark transport coefficient is achieved, both consistent with the lattice QCD results.

[1] Feng-Lei Liu, Wen-Jing Xing, Xiang-Yu Wu, Guang-You Qin, Shanshan Cao, Xin-Nian Wang, Eur.Phys.J.C 82 (2022) 4, 350.
[2] Feng-Lei Liu, Xiang-Yu Wu, Shanshan Cao, Guang-You Qin, Xin-Nian Wang, to be submitted.

Experiment/Theory:

Theory/Phenomenology

Affiliation:

Central China Normal University

Parallel: Heavy Flavours & Quarkonia / **48**

ψ(2S) production in Pb-Pb in ALICE

Autor Victor Feuillard[None]

Charmonium production is a probe sensitive to deconfinement in nucleus-nucleus collisions. The production of J/ψ via regeneration within the QGP or at the phase boundary has been identified as an important ingredient for the description of the observed J/ψ nuclear modification factor at the LHC. The ψ(2S) production relative to J/ψ is a possible discriminator between the two different scenarios. Studies of ψ(2S) production in central nucleus-nucleus collisions at low transverse momentum ($p_{\rm T}$) are crucial, in particular at the LHC, where regeneration might be dominant. For the first time, a significant ψ(2S) signal is extracted in such a kinematic region at forward rapidity in the dimuon decay channel. This measurement relies on the recently published ψ(2S) cross section measured in pp collisions at $\sqrt{s_{\rm NN}} = 5.02$ TeV with an unprecedent precision compared to previous ALICE results.
In this contribution, we present newly published results on the ψ(2S)-to-J/ψ (double) ratio and the ψ(2S) nuclear modification factor in Pb-Pb collisions at $\sqrt{s_{\rm NN}} = 5.02$ TeV. Results are reported as a function of centrality and $p_{\rm T}$ in the region $p_{\rm T} < 12$ GeV/c and are compared to available NA50 and CMS measurements. Comparisons to transport and statistical hadronization model predictions are also provided to shed light on charmonium states recombination mechanism.

Experiment/Theory:

ALICE

Affiliation:

ALICE

Parallel: Heavy Flavours & Quarkonia / 245

J/psi production in Ru+Ru and Zr+Zr collisions at sqrt{s_{NN}} = 200 GeV with the STAR experiment

Autoren Yan Wang[1]; Leszek Kosarzewski[None]

[1] *University of Science and Technology of China*

J/ψ is an important probe to study the properties of the quark-gluon plasma (QGP) created in heavy-ion collisions. Measurements of J/ψ yield suppression in Au+Au collisions at $\sqrt{s_{\rm NN}}$ = 200 GeV suggest that J/ψ production in heavy-ion collisions is affected by the interplay of several effects, such as dissociation, regeneration in the QGP, and the cold nuclear matter effects. Since all these effects are expected to strongly depend on the system size, varying the collision system provides a promising approach to study J/ψ production in heavy-ion collisions.

In 2018, the STAR experiment collected a high statistics sample of isobaric collisions ($^{96}_{44}Ru$+$^{96}_{44}Ru$ and $^{96}_{40}Zr$+$^{96}_{40}Zr$) at $\sqrt{s_{\rm NN}}$ = 200 GeV. In this talk, we will present the precision measurements of inclusive J/ψ production yields as well as its elliptic flow from this data sample. These results will be compared to the similar measurements in Au+Au and Cu+Cu collisions at $\sqrt{s_{\rm NN}}$ = 200 GeV and physics implications will also be discussed.

Experiment/Theory:

STAR

Affiliation:

STAR

Parallel: Heavy Flavours & Quarkonia / 162

Studies of heavy quark dynamics using B mesons with the CMS detector

Autor Tzu-An Sheng[1]

[1] *MIT*

Heavy quarks are one of the most important probes to study the properties of quark-gluon plasma (QGP). We present new results on nuclear modification factors of $\mathrm{B_s^0}$ and $\mathrm{B^+}$ mesons in pp and PbPb collisions at 5.02 TeV, using data recorded with the CMS detector in 2017 and 2018. The reported B meson nuclear modification factors over an extended transverse momentum range will provide important information about the diffusion of beauty quarks and the flavor dependence of in-medium energy loss. In addition, understanding the hadronization mechanism is crucial for extracting the transport properties of the QGP. The $\mathrm{B_s^0/B^+}$ yield ratio in pp and PbPb can thus shed light on beauty hadronization mechanisms from small to large systems and on the relevance of parton recombination in the medium. We also report the first observation of the $\mathrm{B_c^+}$ meson in nucleus-nucleus collisions. Given the low production cross-section in pp collisions, its production could be significantly enhanced by the recombination of beauty with charm quarks present in the hypothesized medium, providing additional insights into the recombination mechanism.

Experiment/Theory:

CMS

Affiliation:

CMS

Parallel: High-Momentum Hadrons & Correlations / 69

Looking for collective origin of strangeness enhancement in small collisions systems with ALICE at the LHC

Autor Ishaan Ahuja[None]

The main goal of the ALICE experiment is to study the physics of strongly interacting matter, including the properties of the quark-gluon plasma (QGP). The increase of relative production of strange hadrons with respect to non-strange hadrons is historically considered as one of the signatures of QGP formation during the evolution of the system created in heavy-ion collisions. Recent measurements performed in high-multiplicity proton-proton (pp) and proton-lead (p-Pb) collisions have shown features that are reminiscent of those observed in lead-lead (Pb-Pb) collisions. The microscopic origin of this phenomenon is still not fully understood: is it related to soft particle production or to hard scattering events, such as jets? To separate strange hadrons produced in jets from those produced in soft processes, the angular correlation between high-p_{T} charged particles and strange hadrons has been exploited. The near-side jet yield and the out-of-jet yield of K^0_S, Ξ, and ϕ have been studied as a function of the multiplicity of charged particles produced in pp collisions at $\sqrt{s}$ = 13 TeV and p-Pb collisions at $\sqrt{s_{\mathrm{NN}}}$ = 5.02 TeV. New results suggest that out-of-jet processes are the dominant contribution to strange particle production. The results of these measurements are compared to expectations from state-of-the-art phenomenological models implemented in commonly used Monte Carlo event generators.

Experiment/Theory:

ALICE

Affiliation:

CERN

Parallel: High-Momentum Hadrons & Correlations / 68

Charged-particle production in different collision systems up to very high transverse momentum measured with ALICE

Autor Mario Krüger[1]

[1] *Institut für Kernphysik Frankfurt*

The ALICE experiment at the Large Hadron Collider (LHC) is designed to investigate the properties of the quark-gluon plasma created in high-energy heavy-ion collisions. During the successful data-taking campaigns of LHC Run 1 and Run 2 (2009 - 2018), it recorded data for a variety of collision systems and different center-of-mass energies. As particle production at the LHC is driven by a complex interplay of soft and hard QCD processes, finding a consistent model description for all collision systems is challenging. The study of charged-particle production as a function of multiplicity plays a key role in understanding the properties of the matter created in small (pp, p-Pb) and large (AA) collision systems. The precise tracking capabilities from low to high transverse momentum of the

ALICE apparatus give the unique opportunity to measure the evolution of multiplicity-dependent spectral shapes across collision system sizes and energies.

In this contribution, a comprehensive overview of charged-particle production measurements in pp, p-Pb, and AA collisions up to high transverse momentum will be presented. It is obtained by means of a two-dimensional unfolding approach that allows for a detailed correction of detector resolution effects and yields the spectral properties in high-granular multiplicity intervals, maximizing the measurement precision. The results will then be tested against the main theoretical models implemented in commonly used Monte Carlo event generators.

Experiment/Theory:

ALICE

Affiliation:

CERN

Parallel: High-Momentum Hadrons & Correlations / 83

3D structure of jet-induced diffusion wake in an expanding quark-gluon plasma

Autoren Zhong Yang[None]; Xin-Nian Wang[1]

[1] *LBNL*

Diffusion wake accompanying the jet-induced Mach-cone provides a unique probe of the properties of quark-gluon plasma in high-energy heavy-ion collisions. It can be characterized by a depletion of soft hadrons in the opposite direction of the propagating jet. We explore the 3D structure of the diffusion wake induced by γ triggered jets in Pb+Pb collisions at the LHC energy within the coupled linear Boltzmann transport and hydro model. We identify a valley structure caused by the diffusion wake on top of a ridge from the initial multiple parton interaction (MPI) in jet-hadron correlation as a function of rapidity and azimuthal angle. This leads to a double-peak structure in the rapidity distribution of soft hadrons in the opposite direction of the jets as an unambiguous signal of the diffusion wake. Using a two-Gaussian fit, we extract the diffusion wake and MPI contributions to the double peak. The diffusion wake valley is found to deepen with the jet energy loss as characterized by the γ-jet asymmetry. Its sensitivity to the equation of state and shear viscosity is also studied.

Experiment/Theory:

Theory/Phenomenology

Affiliation:

Key Laboratory of Quark and Lepton Physics (MOE) & Institute of Particle Physics, Central China Normal University

Parallel: High-Momentum Hadrons & Correlations / 131

ATLAS measurement of the two-particle correlation sensitivity to jets in pp collisions

Autor Brian Cole[1]

[1] *Columbia University*

Measurements of two-particle correlations in pp collisions show the presence of long-range correlations along $\Delta\eta$ that are strikingly similar to those seen in heavy-ion collisions. The similarity between the pp and heavy-ion measurements raises the possibility that a tiny droplet of the QGP is produced even in pp collisions. However, models that attribute the correlation in pp collisions to semi-hard processes, can qualitatively reproduce the measurements. Performing the pp measurements while distinguishing between the particles from semi-hard processes, such as low-p_{T} jets, and the particles produced from soft interactions, can differentiate between these two origins of the pp ridge. This talk presents measurements of two-particle correlations in pp collisions at $\sqrt{s} = 13$ TeV with two different particle-pair selections. In the first case, tracks associated with jets are excluded from the correlation analysis. This is shown to affect the magnitude of long-range correlations by only a few percent. New measurements of two-particle correlations, measured between tracks that are constituents of jets and tracks from the underlying event are also presented. These measurements can further elucidate the origin of the pp ridge.

Experiment/Theory:

ATLAS

Affiliation:

ATLAS Collaboration

Parallel: High-Momentum Hadrons & Correlations / 180

A multi-messenger Bayesian Inference analysis of QGP jet transport using inclusive hadron and reconstructed jet data by JETSCAPE

Autor Yi Chen[1]

[1] *MIT*

The JETSCAPE Collaboration reports a new Bayesian Inference analysis of jet transport in the QGP, using both hadron and jet inclusive suppression data. The JETSCAPE framework comprises a modular multi-stage modeling of in-medium jet evolution and medium response, together with a statistical framework for rigorous data-model comparison using a Bayesian formalism. The multi-stage approach includes virtuality-dependent in-medium partonic energy loss coupled to a detailed dynamical model of QGP evolution. In this talk we present a new JETSCAPE Bayesian inference analysis that extends the previously published JETSCAPE Bayesian determination of $\hat{q}$, which was based solely on inclusive hadron suppression data. It now incorporates inclusive jet measurements at RHIC and the LHC as well. We explore tension between different datasets considered in the analysis, and report a new, multi-messenger, determination of $\hat{q}$. This study represents the next step in the program toward a comprehensive study of the constraints of the QGP properties from jet quenching data. Future possibilities, including more sophisticated modeling and the inclusion of other types of measurements, will also be discussed.

Experiment/Theory:

Theory/Phenomenology

Affiliation:

JETSCAPE Collaboration

Parallel: High-Momentum Hadrons & Correlations / 191

Study on the energy loss of light and heavy quarks in QGP at PHENIX

Autor maya shimomura[1]

[1] *Nara Women's University*

In studies of the QGP, it has been observed that in high-energy heavy-ion (A+A) collisions, high-momentum hadrons and heavy flavor electrons are suppressed, indicating that QGP is strongly coupled, and that quarks lose energy as they traverse the medium. In order to quantitatively discuss this important energy loss mechanism, for charged hadrons consisting of light quarks, in addition to the conventional fractional momentum losses (Sloss), which uses the comparison with p+p, the angle-dependent fractional momentum losses (S'loss) at different emission angles using azimuthal anisotropy (v_2) are measured at $\sqrt{s_{NN}}$ = 200 GeV. We will report the detailed and new path-length dependent functions obtained from these measurements.
We will also discuss the latest heavy quark measurements in PHENIX for a comprehensive understanding of the energy loss mechanism. Like light quarks, heavy quarks lose energy when interacting with the QGP. The gluon bremsstrahlung by heavy quarks is expected to be suppressed at small angles due to the dead cone effect, and thus the energy loss is expected to be quark-mass-dependent. PHENIX silicon detectors are able to separate single electrons from charm and bottom decays by utilizing the difference of their decay lengths. In this talk, we will report the latest results of heavy flavor productions and their nuclear modifications as a function of p_T and centrality, and discuss the energy loss mechanisms in QGP.

Experiment/Theory:

PHENIX

Affiliation:

Nara Women's University

Parallel: High-Momentum Hadrons & Correlations / 67

Measurement of the deuteron coalescence probability in jets with ALICE

Autor Marika Rasà[1]

[1] *University and INFN Catania*

The microscopic production mechanism of light (anti)nuclei in high-energy hadronic collisions is still mysterious and is a highly debated topic in the scientific community. Two different phenomenological models are typically used to describe the experimental data: the statistical hadronization model and baryon coalescence. In the former, light nuclei are emitted from a source in local thermal and hadrochemical equilibrium. Their yields are calculated using the QCD partition function by imposing the conservation of quantum numbers inside the so-called correlation volume. In the coalescence approach, light nuclei can be formed if the phase-space configuration of nucleons at kinetic freeze-out is compatible with the Wigner density of the bound state. A straightforward prediction of the coalescence model is an enhanced coalescence probability of nuclei inside jets compared to that in the underlying event, measured in small collision systems.

In this contribution, the p_{T}-differential production yields and coalescence probabilities of (anti)deuterons inside jets and in the underlying event measured by ALICE in small collision systems are presented. These results are compared to expectations from coalescence and a reaction-based model. In the

latter approach, implemented in the PYTHIA 8.3 event generator, deuterons are generated using ordinary nuclear reactions.

Experiment/Theory:

ALICE

Affiliation:

CERN

Parallel: High-Momentum Hadrons & Correlations / 71

Strangeness production in jets and underlying event in p-Pb and pp collisions measured with ALICE

Autor Ryan Hannigan[1]

[1] *CERN*

Two-particle jet-like angular correlations with identified strange hadrons allow the measurements of both jet and non-jet components of strange particle production, and in this way to investigate the extent to which the strangeness enhancement observed in small collision systems is a result of soft (medium-like) or hard (jet-like) processes. Relative contributions of these processes to strangeness production mechanisms can be probed by examining changes in the strange hadron over non-strange hadron ratios within jets and in the underlying event separately. In addition, changes to the jet hadrochemistry are studied by measuring strangeness production in the away-side jet.

In this talk, we present the first measurements of the ϕ/h, $(\Lambda+\overline{\Lambda})$/h and $\mathrm{K}^0_\mathrm{S}/(\pi^+ + \pi^-)$, $(\Lambda+\overline{\Lambda})/(\pi^+ + \pi^-)$ ratios in jets and underlying event as a function of charged-particle multiplicity using jet-like di-hadron angular correlations in p-Pb collisions at $\sqrt{s_{\mathrm{NN}}}$= 5.02 TeV and pp collisions at $\sqrt{s}$= 13 TeV measured with ALICE. The results suggest that the strangeness enhancement originates in the underlying event.

Experiment/Theory:

ALICE

Affiliation:

CERN

Parallel: High-Momentum Hadrons & Correlations / 177

A multistage framework for studying the evolution of jets and high-pT probes in small collisions systems

Autor Abhijit Majumder[1]

[1] *Wayne State University*

Understanding the modification of jets and high-p_T probes in small systems requires the integration of soft and hard physics. We present recent developments in extending the JETSCAPE framework to build an event generator, which includes correlations between soft and hard partons, to study

jet observables in small systems. The multi-scale physics of the collision is separated into different stages. Hard scatterings are first sampled at binary collision positions provided by the Glauber geometry. They are then propagated backward in space-time following an initial-state shower to obtain the initiating partons'energies and momenta before the collision. These energies and momenta are then subtracted from the incoming colliding nucleons for soft-particle production, modeled by the 3D-Glauber + hydrodynamics + hadronic transport framework.This new hybrid approach includes non-trivial correlations between jet and soft particle productions in small systems. We calibrate this framework with the measured event activity distributions in p+p and p+Pb collisions at 5.02 TeV. We further compare our results for final state hadron's p_T-spectra from low to high p_T in p+p and p+Pb collisions with experimental results in p+Pb at the LHC. Lastly, we present results of additional observables such as the distributions of jet recoiling from a high-p_T hadron and the nuclear modification factor R_{pPb} as a function of event activity.

Experiment/Theory:

Theory/Phenomenology

Affiliation:

JETSCAPE Collaboration

Parallel: High-Momentum Hadrons & Correlations / 281

Energy Loss in Small Collision Systems

Autor William Horowitz[1]

[1] *University of Cape Town*

We consider some corrections relevant to energy loss in small collision systems, for which the temperature times the size of the system isn't large, $T \times L \sim 1$.

First, we present the derivation of the explicit small path length correction to the DGLV opacity expansion. We then show first results from an energy loss model including these corrections, demonstrating the additional reduction in hadron suppression due to small collision systems (on top of the already reduced energy loss due to smaller pathlengths).

Second, we compute the NLO corrections to $\phi + \phi \to \phi + \phi$ scattering in ϕ^4 theory on a spacetime with finite spatial extent. We show first results for the finite system size corrections to the running coupling, $\lambda(p, L)$: the finite system size reduces the magnitude of the coupling at small scales, $p \sim 1/L$. The origin of the corrections to the running coupling are generic; QCD, with its negative beta function, should thus see an increase in the momentum dependence of hadron suppression from small system corrections to the running coupling.

Deriving the above NLO corrections requires several novel techniques of broader theoretical interest. Most important, we present denominator regularization, a procedure that has all the advantages of dim reg but that has multiple advantages over dim reg, including working in spacetimes of fixed dimensionality and without any symmetries.

Experiment/Theory:

Theory/Phenomenology

Affiliation:

University of Cape Town

Parallel: High-Momentum Hadrons & Correlations / 112

Enhancement of baryon-to-meson ratios around jets as a signature of medium response

Autoren Guang-You Qin[1]; Ao Luo[None]; Ya-Xian Mao[None]; Han-Zhong Zhang[None]; En-Ke Wang[None]

[1] *Central China Normal University*

We present a unique signal of jet-induced medium excitations: the enhancement of baryon-to-meson ratios around the quenched jets. To illustrate this, we study jet-particle correlations and the distributions of jet-induced identified particles with respect to the jet direction in Pb+Pb collisions at the LHC via a multi-phase transport model. We find a strong enhancement of baryon-to-meson ratios for associated particles at intermediate transverse momentum around the triggered jets in Pb+Pb collisions relative to p+p collisions, due to the coalescence of jet-excited medium partons. Since the lost energy from jets can diffuse to large angles, such baryon-to-meson-ratio enhancement is more pronounced for larger relative distance from the jet axis. We argue that the experimental confirmation of the enhancement of jet-induced baryon-to-meson ratios around the jets will provide an unambiguous evidence for the medium response to jet quenching in heavy-ion collisions.

[1] Ao Luo, Ya-Xian Mao, Guang-You Qin, En-Ke Wang, Han-Zhong Zhang, 2109.14314 [hep-ph]

Experiment/Theory:

Theory/Phenomenology

Affiliation:

Central China Normal University

Parallel: High-Momentum Hadrons & Correlations / 172

Pursuing the Precision Study for Color Glass Condensate in Forward Hadron Productions

Autoren Bowen Xiao[None]; Lei Wang[None]; Shuyi Wei[None]; Yu Shi[None]

With the tremendous accomplishments of RHIC and the LHC experiments and the advent of the future electron-ion collider on the horizon, the quest for compelling evidence of the color glass condensate (CGC) has become one of the most aspiring goals in the high energy quantum chromodynamics research. Pursuing this question requires developing the precision test of the CGC formalism. By systematically implementing the threshold resummation, we significantly improve the stability of the next-to-leading-order calculation in CGC for forward rapidity hadron productions in pp and pA collisions, especially in the high p_T region, and obtain reliable descriptions of all existing data measured at RHIC and the LHC across all p_T regions. Consequently, this technique can pave the way for the precision studies of the CGC next-to-leading-order predictions by confronting them with a large amount of precise data.

Experiment/Theory:

Theory/Phenomenology

Affiliation:

Shandong University,
Central China Normal University,
The Chinese University of Hong Kong (Shenzhen)

Parallel: High-Momentum Hadrons & Correlations / 295

Excited Hadron Channels in Hadronization

Autoren Rainer Fries[1]; Jacob Purcell[1]; Michael Kordell[1]; Che-Ming Ko[1]

[1] *Texas A&M University*

The proper treatment of hadronic resonances plays an important role for many aspects of heavy ion collisions. We expect this to be the case also for hadronization, due to the large degeneracies of excited states, and the abundant production of hadrons from their decays. We show how a comprehensive treatment of excited meson states can be incorporated into quark recombination, and in extension, into Hybrid Hadronization. We discuss in detail the quantum mechanics of forming excited states, utilizing the Wigner distribution functions of angular momentum eigenstates of isotropic 3-D harmonic oscillators. We describe how resonance decays can be handled, based on a set of minimal assumptions, by creating an extension of hadron decays in PYTHIA 8. Finally, we present a study of hadron production by jets using PYTHIA and Hybrid Hadronization with excited mesons up to orbital angular momentum L=4. We find that states up to L=2 are produced profusely by quark recombination.

Experiment/Theory:

Theory/Phenomenology

Affiliation:

Texas A&M University

Parallel: Jets and their modification in QCD Matter / 35

Measurement of the R dependence of jet quenching in pp and Pb-Pb collisions with ALICE

Autor Christos Pliatskas[None]

Jets are excellent probes for studying the deconfined matter formed in heavy ion collisions. Measurements of jet yield and substructure as a function of jet resolution parameter R over a wide range in jet p_{T} probe the mechanisms underlying the interaction between jets and the QGP, notably the role of opening angle of the hardest jet shower components, and of the angular distribution of medium-induced radiation. In this talk, we will present two measurements of the nuclear modification factor R_{AA} in central Pb-Pb collisions at $\sqrt{s} = 5.02$ TeV with ALICE, addressing the influence of the large uncorrelated background with novel techniques in machine learning and mixed event subtraction. The mixed-event technique, newly introduced in ALICE, enables inclusive jet measurements at low p_{T} with minimal bias, in a previously unexplored energy regime at the LHC. In addition, the machine learning method enables the measurement of the R-dependence of jet suppression for $R = 0.6$ down to 40 GeV/c. Finally, we introduce a new infrared and collinear safe measurement of the jet energy flow within jets reconstructed with different resolution parameters R. Investigating how the energy is distributed for the same jet with different R allows energy loss to be explored on a jet-by-jet basis instead of between different populations of jets as in inclusive measurements. These results are compared to jet quenching models.

Experiment/Theory:

ALICE

Affiliation:

CERN

Parallel: Jets and their modification in QCD Matter / 301

R-dependence of jet observables with JEWEL+v-USPhydro

Autoren Leonardo Barreto de Oliveira Campos[1]; Fabio de Moraes Canedo[1]; Maria M. M. Paulino[1]; Marcelo Munhoz[1]; Jorge Noronha[2]; Jacquelyn Noronha-Hostler[3]

[1] *University of São Paulo (USP)*

[2] *University of Illinois Urbana-Champaign*

[3] *University of Illinois Urbana Champaign*

The R-dependence of jet observables provides a new tool in understanding the interplay between the jet energy-loss mechanism and medium response in heavy-ion collisions. We have coupled the Monte Carlo event generators JEWEL and PYTHIA, with initial conditions from the T_RENTo and the state-of-the-art (2+1)D v-USPhydro, for the simulation of jet quenching phenomena in a more realistic medium formed in lead-lead collisions at LHC energy scales.

In this work, we present one of the first studies of the jet nuclear modification R_{AA} and anisotropic flow coefficients $v_{n=2,3}$ as a function of the jet cone radius R, in the context of anti-k_T jets, in addition to jet shape observables. The calculations indicate the impacts of the hydrodynamic evolution and weakly-coupled medium response, given by recoils, on the distributions. Results are compared to experimental data in a wide range of jet p_T and collision centrality, and displayed along with large jets ($R \geq 0.6$) predictions.

Experiment/Theory:

Theory/Phenomenology

Affiliation:

University of São Paulo (USP), University of Illinois Urbana-Champaign

Parallel: Jets and their modification in QCD Matter / 133

Novel measurements of dijet quenching with ATLAS

Autor Martin Krivos[1]

[1] *Charles University*

High-energy partons are well established to lose energy when traversing the hot and dense medium produced in heavy-ion collisions. This results in a modification to the transverse momentum distributions of jets, producing a phenomenon known as jet quenching. It has been previously established in Pb+Pb collisions at $\sqrt{s_{\mathrm{NN}}} = 2.76$~TeV that jet quenching leads to significant modifications to the transverse momentum balance of dijet pairs. More differential measurements are needed to better understand the observed phenomenon. In this talk, we report new, fully unfolded measurements of the dijet momentum balance in Pb+Pb and pp collisions at $\sqrt{s_{\mathrm{NN}}} = 5.02$~TeV as well as in Xe+Xe collisions at $\sqrt{s_{\mathrm{NN}}} = 5.44$~TeV. These measurements expand upon previous publications, including the per-event yield of dijets as a function of the momentum balance, which provides insight into

the nature of jet quenching. This talk will additionally present a new observable, the d??et pair nuclear modification factors projected along leading and subleading jet transverse momentum, which provides a precise quantification of asymmetric energy loss experienced by dijets.

Experiment/Theory:

ATLAS

Affiliation:

ATLAS Collaboration

Parallel: Jets and their modification in QCD Matter / 170

The gradient tomography of dijet in heavy-ion collisions

Autoren Yayun He[1]; Xin-Nian Wang[2]

[1] *South China Normal University*

[2] *LBNL*

Jet energy loss and transverse momentum broadening are twin consequences of a jet interacting with a hot and dense QCD matter in heavy-ion collisions. The underlying interaction can be represented by jet transport coefficient $\hat{q}$ distributed in the whole phase space of the bulk medium. The gradient of $\hat{q}$ perpendicular to the momentum direction of an energetic parton leads to an asymmetry of the transverse momentum distribution, which can be used for the initial jet production localization. We investigate such an asymmetry caused by the subleading jet by triggering the leading jet propagating in-plane in Pb+Pb 0-10% collisions at $\sqrt{s} = 5.02$ TeV. Simulations are performed in the linear Boltzmann transport model with fluctuating event-by-event 3+1D viscous hydrodynamic backgrounds. We find that the initial jet production vertex can be localized by combining the dijet transverse imbalance $x_J = p_T^{\rm subleading}/p_T^{\rm leading}$ and subleading jet transverse gradient asymmetry for different leading jet p_T regions. The correlation between both quantities is also investigated to illustrate the properties of $\hat{q}$.

Experiment/Theory:

Theory/Phenomenology

Affiliation:

South China Normal University;
Lawrence Berkeley National Laboratory

Parallel: Jets and their modification in QCD Matter / 103

On the momentum broadening of in-medium jet evolution using a light-front Hamiltonian approach

Autoren Meijian Li[1]; Tuomas Lappi[2]; Xingbo Zhao[3]; Carlos Salgado[4]

[1] *University of Santiago de Compostela*

[2] *University of Jyväskylä*

[3] *Institute of Modern Physics, Chinese Academy of Sciences*

[4] *IGFAE*

Following the formalism developed in our preceding works [1], a non-perturbative light-front Hamiltonian approach, we investigated the momentum broadening of a quark jet inside a SU(3) colored medium. We performed the numerical simulation of the real-time jet evolution in the Fock space of |q> + |qg>, at an extensive range of p^+, and various medium densities. With the obtained light-front wavefunctions of the quark jet, we extracted the jet's observables, including its transverse momentum distribution, the quenching parameter, and the gluon emission rate. We analyzed the interplay between the medium-induced gluon emission and the momentum broadening. This work provides an enhanced understanding of jet quenching from non-perturbative perspectives.

[1] M. Li, T. Lappi, and X. Zhao, "Scattering and gluon emission in a color field: A light-front Hamiltonian approach", Phys. Rev. D 104 (2021) no.5, 056014; arXiv:2107.02225 [hep-ph].

Experiment/Theory:

Theory/Phenomenology

Affiliation:

University of Santiago de Compostela; University of Jyväskylä; Institute of Modern Physics, Chinese Academy of Sciences.

Parallel: Jets and their modification in QCD Matter / 100

Hard parton dispersion in the quark-gluon plasma, non-perturbatively

Autoren Jacopo Ghiglieri[1]; Eamonn Weitz[2]; Philipp Schicho[3]; Niels Schlusser[4]; Guy Moore[5]

[1] *SUBATECH, Nantes*

[2] *SUBATECH, Univeristé de Nantes*

[3] *Goethe U. Frankfurt*

[4] *U. Basel*

[5] *TU Darmstadt*

Jet-medium interactions receive large non-perturbative contributions from classical gluons, i.e. infrared gluons with high occupation numbers. These contributions affect transverse jet momentum broadening and medium-induced radiation. Both depend significantly on the in-medium dispersion of hard partons, encoded in their so-called asymptotic mass.
In this talk, I shall show how the analytical properties of thermal amplitudes allow for a non-perturbative determination of the IR classical contribution through lattice determinations in the dimensionally-reduced Effective Theory of hot QCD, EQCD. I will show how these existing lattice determinations need to be complemented by perturbative two-loop matching calculations in EQCD and QCD, so that the unphysical (classical) UV behaviour of EQCD is replaced by its proper quantum QCD counterpart. I will show how lattice and perturbative EQCD are in excellent agreement in the UV and I will discuss the numerical effect of the two-loop quantum QCD contribution, with an outlook on the effect on medium-induced radiation rates.
The talk is based on G.D. Moore, N. Schlusser 2009.06614, J. Ghiglieri, G.D. Moore, P. Schicho, N. Schlusser 2112.01407, J. Ghiglieri, P. Schicho, N. Schlusser, E. Weitz, in preparation

Experiment/Theory:

Theory/Phenomenology

Affiliation:

SUBATECH, Nantes

Parallel: Jets and their modification in QCD Matter / 234

Jet shape observables in p+p and Au+Au collisions at sqrt{s_{NN}} = 200 GeV at STAR

Autor Tanmay Pani[1]

[1] *Rutgers University*

Jets produced from hard scatterings of partons early in heavy-ion collisions traverse through the quark-gluon plasma (QGP) medium and get modified relative to vacuum (p+p collision) baseline. These modifications can change the distributions of jet shape observables, which are related to jet fragmentation and its internal structure, and calculated based on the intra-jet angular energy distribution. LHC results showed medium-induced modifications to differential jet shape ($\rho(r)$, radial distribution of constituents relative to the jet axis) distributions and a prevalence of quark-like fragmentation from Girth (jet angularity), p_T^D (jet momentum dispersion) and LeSub (splitting between leading and subleading jet constituents) measurements. At RHIC, we are able to study lower energy jets, complementary to those measured at the LHC. Hence measurements of jet shapes at RHIC can help constrain models at different energy scales. In this talk, we present measurements of the fully corrected $\rho(r)$ in p+p and Au+Au collisions at $\sqrt{s_{\rm NN}} = 200$ GeV collected by the STAR experiment. We also show fully corrected resutls for Girth, p_T^D and LeSub in p+p collisions. Exploratory studies of these observables in Au+Au collisions will also be discussed.

Experiment/Theory:

STAR

Affiliation:

STAR

Parallel: Jets and their modification in QCD Matter / 36

Exploring medium properties with hard transverse momentum splittings using groomed jet substructure measurements in Pb-Pb collisions with ALICE

Autor Raymond Ehlers[1]

[1] *Lawrence Berkeley National Laboratory/UC Berkeley*

Jet substructure observables provide unique probes of the properties of the quark-gluon plasma (QGP). In this talk, we report new measurements of groomed jet substructure in central Pb-Pb collisions at $\sqrt{s_{\rm NN}} = 5.02$ TeV. We present the first application of Dynamical Grooming in heavy-ion collisions to search for excess $k_{\rm T,g}$ emissions as a signature of point-like scattering, which is sensitive to large-angle scattering of jets off of quasi-particles in the QGP. These results are reported for the first time in central Pb-Pb collisions and over a larger jet $p_{\rm T}$ range than reported previously. Additionally, we present measurements employing both the Soft Drop and Dynamical Grooming algorithms, comparing results in central Pb-Pb, semicentral Pb-Pb, and pp collisions at $\sqrt{s_{\rm NN}} = 5.02$ TeV. Results with grooming methods and parameters will also be compared. The techniques developed for this measurement are more broadly applicable to jet substructure, which we will explore further in this talk. Comparisons to model calculations will also be discussed.

Experiment/Theory:

ALICE

Affiliation:

CERN

Parallel: Jets and their modification in QCD Matter / 115

Recoil-free jet observable in heavy ion collisions

Autoren Yang-Ting Chien[1]; Wouter Waalewijn[2]; Dingyu Shao[3]; Bin Wu[4]; Rudi Rahn[5]

[1] *Georgia State University*

[2] *University of Amsterdam*

[3] *Fudan University*

[4] *Universidade de Santiago de Compostela*

[5] *Manchester University*

We will discuss the use of recoil-free jet observables to systematically benchmark jet modification studies with precision and sensitivity, starting from the hardest components of jets. Here we focus on the recoil-free jet axis in defining di-jet and photon-jet angular decorrelation. This observable is not affected by the huge underlying event background and can be calculated and measured precisely. Also, since the recoil-free axis follow the dominant energy flow within jet, it is sensitive to any partonic energy loss mechanism which can deflect the axis direction. We will present Monte Carlos studies based on simulations with different jet quenching models. Future measurements of this observable will allow us to test the onset of jet quenching in the whole jet evolution history. This paves a path towards precision heavy ion jet modification studies using recoil-free observables.

Experiment/Theory:

Theory/Phenomenology

Affiliation:

Georgia State University
University of Amsterdam
Fudan University
Universidade de Santiago de Compostela
Manchester University

Parallel: Jets and their modification in QCD Matter / 305

Jet evolution in a dense medium beyond multiple soft scattering approximation

Autoren Edmond Iancu[1]; Paul Caucal[2]; Gregory Soyez[3]

[1] *IPhT, CEA-Saclay*

[2] *Subatech, Nantes Université*

[3] *IPhT*

In a series of recent publications [1,2,3], we have proposed a factorized approach, based on perturbative QCD, for the evolution of a jet in a dense quark-gluon plasma, together with its implementation as a Monte-Carlo parton shower and successful applications to the phenomenology of jet quenching.
In the original formulation of the parton shower, the collisions between the jet constituents and

those of the plasma have been treated in the multiple soft scattering approximation, thus neglecting important effects from single hard scattering. In this new work [4], we extend our Monte Carlo by including the effects of single scattering both on the transverse momentum broadening and on the spectrum for medium-induced radiation. To that aim, the medium-induced cascade is simulated in full 3+1 dimensions and collisions are generated dynamically. This allows us to complete the BDMPS-Z sector of the spectrum for medium-induced radiation with the GLV (Gyulassy-Levai-Vitev) tail at high energies and the Bethe-Heitler spectrum at low energies.
Finally, we discuss the impact of single hard scattering on jet substructure observables like the $k_{t,g}$-distribution after Soft Drop, as measured by the ALICE Collaboration.

Refs:
[1] Caucal, Iancu, Mueller, Soyez, PRL 120 (23), 232001
[2] Caucal, Iancu, Soyez, JHEP 2019 (10), 1-55
[3] Caucal, Iancu, Soyez, JHEP 2021 (4), 1-38
[4] Caucal, Iancu, Soyez, in preparation.

Experiment/Theory:

Theory/Phenomenology

Affiliation:

SUBATECH UMR 6457 (IMT Atlantique, Université de Nantes, IN2P3/CNRS)
IPhT, Université Paris Saclay, CNRS, CEA

Parallel: Jets and their modification in QCD Matter / 53

Classical vs. Quantum Corrections to Jet Broadening in a Weakly Coupled Quark-Gluon Plasma

Autor Eamonn Weitz[1]

Co-Autor: Jacopo Ghiglieri [2]

[1] *SUBATECH, Univeristé de Nantes*

[2] *SUBATECH, CNRS*

The transverse momentum broadening coefficient serves as a key ingredient in characterising the quenching of a jet as it propagates through the QGP. While it has recently been understood to receive quantum, radiative corrections featuring potentially large logarithmic enhancements at relative order g^2 [1, 2], it is still not clear how these corrections compare quantitatively with their classical counterparts, i.e, those coming from the exchange of thermal gluons with large occupation number, present at relative order g and higher [3–5].

During the talk, I plan to first motivate the need for a more careful calculation of the aforementioned logarithmic corrections in the case of a weakly coupled QGP. I will then sketch how the argument of the leading logarithm is altered with respect to earlier calculations and furthermore, how the phase space giving rise to these logarithmic corrections is smoothly connected to that from which the classical corrections emerge. Finally, I will conclude by discussing how these findings, detailed in our own work [6] are relevant with respect to the overall goal of determining which class of corrections are quantitatively more important.

[1] T. Liou, A. Mueller and B. Wu 1304.7677
[2] J.P. Blaizot, F. Dominguez, E. Iancu and Y. Mehtar-Tani 1311.5823
[3] S. Caron-Huot 0811.1603
[4] M. Panero, K. Rummukainen and A. Sch¨afer 1307.5850
[5] G.D. Moore and N. Schlusser 1911.13127
[6] J. Ghiglieri and E. Weitz 2207.08842

Experiment/Theory:

Theory/Phenomenology

Affiliation:

SUBATECH, CNRS, Nantes Université

Parallel: Jets and their modification in QCD Matter / 135

Jet quenching studies with new jet substructure and suppression measurements in ATLAS

Autor Martin Rybar[1]

[1] *Charles University*

Measuring the jet substructure in heavy-ion collisions provides exciting new opportunities to study detailed aspects of the dynamics of jet quenching in the hot and dense QCD medium created in these collisions. In this talk, we present new ATLAS measurements of jet substructure performed using various jet (de)clustering and grooming techniques. Measurements of inclusive jet suppression (R_{AA}) in heavy-ion collisions are presented as a function of the jet substructure using both small-radius ($R = 0.4$) and large-radius ($R = 1.0$) jets in Pb+Pb and pp collisions at $\sqrt{s_{NN}} = 5.02$ TeV. The jet substructure is characterized using the Soft-Drop grooming procedure in order to identify subjets corresponding to the hardest parton splitting in the jet. The measurements are performed using different jet constituents such as charged tracks, smaller R calorimeter jets, and novel objects reconstructed using tracker and calorimeter information. The dynamics of jet quenching is measured and presented as a function of the transverse momentum scale ($\sqrt{d_{12}}$) and the angle of the hardest splitting in the jet. These new measurements test the sensitivity of jet suppression in the QCD medium to its substructure and the emergence of a critical angle for the onset of color decoherence.

Experiment/Theory:

ATLAS

Affiliation:

ATLAS Collaboration

Parallel: Jets and their modification in QCD Matter / 86

Energy loss effects in EECs at LO

Autoren Joao Barata[1]; Yacine Mehtar-Tani[1]

[1] *BNL*

In recent years, there has been an effort towards establishing a more complete picture for jet substructure in the presence of the quark gluon plasma. Such a program requires not only a more detailed description of medium induced effects, but also the design of novel substructure observables. Very recently, it has been noticed that energy-energy correlators (EECs) might provide one type of such observables. Although the full extent of their sensitivity to the medium has not been completely explored, they are capable to resolve the transverse structure of the jet. In particular, they are sensitive to the critical angle separating coherent and decoherent jet evolution in the medium. In this talk,

we show for the first time the effects of medium induced radiative energy loss in EECs at leading order in the number of vacuum-like emissions. The calculation takes into account all order soft gluon emissions, in the large N_c limit and neglecting subdominant interfering contributions. Similar to other jet quenching observables, energy loss leads to an overall suppression of the EECs. More importantly, this is accentuated in the decoherent regime and results in an important competing effect when trying to extract the critical angle. We further comment on how the current calculation can be extended beyond leading order accuracy, important to compute more complex observables.

Experiment/Theory:

Theory/Phenomenology

Affiliation:

BNL

Parallel: Jets and their modification in QCD Matter / 37

Observation of medium-induced yield enhancement and acoplanarity broadening of low-p_{T} jets in pp and Pb-Pb collisions at $\sqrt{s_{\mathrm{NN}}}$ = 5.02 TeV with ALICE

Autor Yongzhen HOU[1]

[1] *CCNU & IPHC*

The measurement of jets recoiling from a trigger hadron provides unique probes of medium-induced modification of jet production. Jet deflection via multiple soft scatterings with the medium constituents or single-hard Molière scatterings off quasi-particles in the medium are expected to modify the azimuthal correlation between the trigger hadron and recoiling jet. The R-dependence of recoil jet yield also probes jet energy loss and intra-jet broadening. In this talk we present measurements of the semi-inclusive distribution of charged-particle jets recoiling from a trigger hadron in pp and Pb-Pb collisions at $\sqrt{s_{\mathrm{NN}}}$ = 5.02 TeV. We employ precise, data-driven subtraction of the large uncorrelated background contaminating the measurement in Pb-Pb collisions, enabling the exploration of medium-induced modification of jet production and acoplanarity over a wide phase space, including the low jet p_{T} region for large jet resolution parameter R. Hadron-jet acoplanarity in pp collisions will be also presented, which provides a sensitive test of pQCD calculations, as well as a crucial data reference for in-medium jet deflection studies in Pb-Pb collisions. We observe that the jet yield at low p_{T} and at large azimuthal angle between the trigger hadron and jet is significantly enhanced in Pb-Pb collisions with respect to pp collisions. Comparison to theoretical calculations incorporating jet quenching will also be discussed.

Experiment/Theory:

ALICE

Affiliation:

CERN

Parallel: Jets and their modification in QCD Matter / 253

Computing jet transport coefficients on the lattice

Autoren Johannes Heinrich Weber[1]; Abhijit Majumder[2]; Amit Kumar[3]; Ismail Soudi[2]

[1] *Humboldt-University of Berlin*

[2] *Wayne State University*

[3] *McGill University*

The leading jet transport coefficients $\hat{q}$ or $\hat{e}_2$ encode transverse or longitudinal momentum broadening of a hard parton traversing a hot medium. Computing their normalization and temperature dependence from first principles is key to appreciating the observed suppression of high-transverse momentum probes at RHIC or LHC collision energies. We present a first continuum extrapolated result of $\hat{q}$ computed on pure SU(3) lattices with non-trivial temperature dependence different from the weak-coupling expectation.

We discuss the formalism published in Refs [1,2] and its challenges and status in view of obtaining $\hat{e}_2$ or of unquenching the calculation. We consider a hard quark subject to a single scattering on the plasma. The transport coefficients are factorized in terms of matrix elements given as integrals of non-local gauge-covariant gluon field-strength field-strength correlators. After the analytic continuation to the deep-Euclidean region, the hard scale permits to recast these as a series of local, gauge-invariant operators. The renormalized leading twist term in this expansion is closely related to static quantities, and is computed on pure SU(3) lattices (n_τ=4, 6, 8 and 10) for a range of temperatures, ranging from 200MeV < T < 1GeV. Our estimate for the unquenched result in $2+1$-flavor QCD has very similar features.

[1] A. Kumar et al., Phys. Rev. D 106, 034505 (2022).
[2] A. Majumder, Phys. Rev. C87 034905 (2013).

Experiment/Theory:

Theory/Phenomenology

Affiliation:

Humboldt-University of Berlin
Wayne State University
McGill University

Parallel: Jets and their modification in QCD Matter / 303

Exploring jet transport coefficients by elastic and radiative scatterings in the strongly interacting quark-gluon plasma

Autoren Ilia Grishmanovskii[1]; Taesoo Song[2]; Olga Soloveva[3]; Carsten Greiner[4]; Elena Bratkovskaya[5]

[1] *ITP, Frankfurt*

[2] *GSI*

[3] *Helmholtz Research Academy Hesse for FAIR*

[4] *Johann Wolfgang Goethe-Universitat Frankfurt*

[5] *GSI, Darmstadt & Goethe University, Frankfurt*

We study the interaction of leading jet partons in a strongly interacting quark-gluon plasma (sQGP) medium based on the effective dynamical quasi-particle model (DQPM). The DQPM describes the non-perturbative nature of the sQGP at finite temperature T and baryon chemical potential μ_B based on a propagator representation of massive off-shell partons whose properties are adjusted to reproduce the lQCD EoS for the QGP in thermodynamic equilibrium. We present the results for the jet transport coefficients, i.e. the transverse momentum transfer squared per unit length $\hat{q}$ and the energy loss per unit length $\Delta E = dE/dx$ in the QGP and investigate their dependence on the temperature T and baryon chemical potential μ_B as well as on jet properties such as the leading jet parton momentum, mass, flavor, and the choice of the strong coupling constant. In this work both elastic and radiative scattering processes of leading jet parton with the sQGP partons are

considered. We compute the cross sections and transport coefficients and compare the contributions from elastic partonic scattering and radiative processes for the emission of massive gluons. We present a comparison of our results for the elastic energy loss in the sQGP medium with pQCD results as well as with lattice QCD and also with estimates for $\hat{q}$ by the JET and JETSCAPE Collaborations based on a comparison of hydrodynamical calculations with experimental heavy-ion data.

Experiment/Theory:

Theory/Phenomenology

Affiliation:

Institute for Theoretical Physics

Parallel: Jets and their modification in QCD Matter / 167

From perturbative to non-perturbative QCD emissions with jets

Autoren Liliana Apolinário[1]; Raghav Kunnawalkam Elayavalli[2]; Nuno Olavo Madureira[3]

[1] *LIP*

[2] *Vanderbilt University*

[3] *LIP/IST*

In this work, by exploiting jet substructure techniques, we identify the transition from early-time perturbative splittings to late-time non-perturbative emissions and its associated timescale at both RHIC and LHC energies. We introduce three experimentally robust splittings along the jet clustering tree, each related to the perturbative, non-perturbative-like regions and the transition between them. The population of such splittings is quantified via a first phenomenological study of the formation time in a Monte Carlo model to highlight its sensitivities and discuss its experimental feasibility. Finally, we show how these timescales change in a scenario when jet quenching effects, induced by an extended Quark-Gluon Plasma, take place along the parton shower.

Experiment/Theory:

Theory/Phenomenology

Affiliation:

LIP - Laboratory of Instrumentation and Experimental Particle Physics, Lisbon, Portugal;
IST - Instituto Superior Técnico, Lisbon, Portugal;
Vanderbilt University, Tennesse, USA

Parallel: Jets and their modification in QCD Matter / 138

Measurements of the azimuthal anisotropy of jets and high-p_{T} charged particles in Pb+Pb collisions with the ATLAS detector

Autor Xiaoning Wang[1]

[1] *University of Illinois Urbana-Champaign*

The heavy-ion collisions produce a hot, dense medium, and high-momentum partons from the collision traverse this medium while losing energy to it. This talk presents new measurements of the azimuthal dependence with respect to the event plane of single jet yields and high momentum charged particles yields in Pb+Pb collisions at $\sqrt{s_{NN}} = 5.02$ TeV. As the distance traversed by the partons in the medium is dependent on the angle with respect to the event plane at which the partons are produced, these measurements give insight into the path-length dependence of parton energy loss. The magnitude of angular modulation is quantified by the parameter v_n with respect to the n^{th} order event plane. In this talk we will present these two measurements that show v_2, v_3, and v_4 as a function of p_T and collision centrality. In both measurements, a non-zero value of v_2 and v_3 are observed, suggesting that fluctuations in the initial state play a small but distinct role in jet energy loss. Both measurements explore a higher transverse momentum regime and higher-order harmonics than current measurements benefiting from the high statistics 2018 Pb+Pb heavy ion data recorded by ATLAS. These measurements provide new information about the path-length dependence of jet quenching.

Experiment/Theory:

ATLAS

Affiliation:

ATLAS Collaboration

Parallel: Jets and their modification in QCD Matter / 192

Efficient description of medium response to jet energy loss

Autoren Jorge Casalderrey-Solana[1]; Jose Guilherme Milhano[2]; Daniel Pablos[3]; Krishna Rajagopal[4]; Xiaojun Yao[5]

[1] *Universitat de Barcelona*

[2] *Universidade de Lisboa*

[3] *INFN - Sezione di Torino*

[4] *MIT*

[5] *University of Washington*

The injection of energy and momentum from a jet into the QGP generates a wake, which leads to soft and semi-hard particle creation correlated with the jet direction after the QGP hadronizes. As several jet quenching studies have shown, this medium response phenomenon plays a crucial role in our understanding of many jet structure and substructure observables. Nevertheless, a detailed account of the phenomenological consequences of those wakes is still lacking, partly because of the computational complexity of current techniques used to describe their properties. In this work we present a computationally efficient description of the event-by-event, jet-by-jet, determination of the properties of the hadrons coming from QGP wakes. By making use of a single set of universal solutions obtained within linearized hydrodynamics on top of a Bjorken flow, and performing the adequate set of scalings, translations, rotations and boosts, we are able to match the results obtained (with much greater computational cost) using 3+1D hydrodynamics.

Experiment/Theory:

Theory/Phenomenology

Affiliation:

Universitat de Barcelona, Universidade de Lisboa, INFN, Sezione di Torino, Massachusetts Institute of Technology, University of Washington

Parallel: Jets and their modification in QCD Matter / 236

Measurements of Baryon-to-Meson Ratios in Jets in Au+Au and p+p Collisions at sqrt{s_{NN}} = 200 GeV by STAR

Autor GABRIEL DALE-GAU[1]

[1] *University of Illinois at Chicago*

Measurements at RHIC and the LHC show strongly enhanced baryon-to-meson yield ratios at intermediate transverse momenta (p_T) in high-energy nuclear collisions compared to p+p baseline. This enhancement is attributed to the following QGP effects: strong hydrodynamic flow and parton recombination. Jet probes have been used extensively to gain insights into QGP properties, with substantial modifications to jet yields and internal structures seen across multiple measurements. Despite apparent medium-induced changes to jet fragmentation patterns, LHC results indicate that in-jet particle production is significantly different from that of the QGP bulk. To explore this behavior at RHIC, we employ particle identification through time of flight and dE/dx information alongside jet-track correlations to measure in-jet particle production for $p_T < 5.0$ GeV/c. We present the first in-cone baryon-to-meson yield ratios associated with fully reconstructed jets from 200 GeV Au+Au and p+p collisions using the STAR detector at RHIC.

Experiment/Theory:

STAR

Affiliation:

STAR

Parallel: Jets and their modification in QCD Matter / 64

The information content of jet quenching and machine learning assisted observable design

Autor Mateusz Ploskon[1]

[1] *Lawrence Berkeley National Laboratory*

We employ machine learning techniques to identify important features that distinguish jets produced in heavy-ion collisions from jets produced in proton-proton collisions [1]. We formulate the problem using binary classification and focus on leveraging machine learning in ways that inform theoretical calculations of jet modification: (i) we quantify the information content in terms of Infrared Collinear (IRC)-safety and in terms of hard vs. soft emissions, (ii) we identify optimally discriminating observables that are analytically tractable, and (iii) we assess the information loss due to the heavy-ion underlying event and background subtraction algorithms. We illustrate our methodology using Monte Carlo event generators, where we find that important information about jet quenching is contained not only in hard splittings but also in soft emissions and IRC-unsafe physics inside the jet. This information appears to be significantly reduced by the presence of the underlying event. We discuss the implications of this for the prospect of using jet quenching to extract properties of the QGP. Since the training labels are exactly known, this methodology can be used directly on experimental data without reliance on modeling. We outline a proposal for how such an experimental analysis can be carried out, and how it can guide future measurements.

[1] Lai, Mulligan, Ploskon, Ringer [JHEP 10 (2022) 011]

Experiment/Theory:

Theory/Phenomenology

Affiliation:

Lawrence Berkeley National Laboratory

Parallel: Jets and their modification in QCD Matter / 39

Measurement of the jet mass and angularities in Pb-Pb collisions at 5.02 TeV with ALICE

Autor Ezra Lesser[1]

[1] *UC Berkeley*

In recent years jet substructure observables have been used at the LHC as instruments to search for new physics and test perturbative and non-perturbative processes in QCD. In heavy-ion collisions, these jet substructure observables can additionally elucidate the production and evolution of the QCD medium. The jet mass is one such observable that probes the momentum transfer scale of the initial hard scattering. Additionally, the generalized jet angularities summarize the jet substructure using two continuous parameters which differentially weight the jet constituents' relative angle and p_{T}. One jet angularity configuration, the jet thrust, has been compared to the jet mass and has shown surprising differences in comparison with models. ALICE has performed a new measurement for both observables using an identical jet sample to study this difference more closely. The ALICE tracking system's high-precision capability provides a unique opportunity at LHC energies to measure jets at lower p_{T}. We report the generalized jet mass and jet angularities using charged-particle tracks in Pb-Pb collisions at $\sqrt{s_{\mathrm{NN}}}$ = 5.02 TeV with ALICE. Various jet angularity parameters are investigated for the jet resolution parameter R = 0.2. Results are compared to pp collisions and theoretical models.

Experiment/Theory:

ALICE

Affiliation:

CERN

Parallel: Jets and their modification in QCD Matter / 298

A New Model for Jet Energy Loss in Heavy Ion Collisions

Autoren Iurii Karpenko[1]; Alexander Lind[2]; Joerg Aichelin[3]; Pol-Bernard Gossiaux[4]; Martin Rohrmoser[5]; Klaus Werner[6]

[1] *Czech Technical University in Prague, FNSPE*

[2] *Subatech, IMT Atlantique*

[3] *SUBATECH*

[4] *IMT Atlantique*

[5] *Cracow University of Technology*

[6] *Subatech- Nantes University*

We present a new model for jet quenching from coherent radiation in a brick medium. The jet energy loss is simulated as a perturbative final-state vacuum parton shower followed by a medium-induced shower originating from elastic and radiative collisions with the medium constituents. Coherency is achieved by starting with trial gluons that acts as field dressing of the initial jet parton. These are formed according to a Gunion-Bertsch seed. The QCD version of the LPM effect is attained by increasing the phase of the trial gluons through elastic scatterings with the medium. Above a phase threshold, the trial gluon will be realised and can produce coherent radiation themselves.

The model has been implemented in a Monte Carlo code and has been validated by successfully reproducing the BDMPS-Z prediction for the energy spectrum. The realistic case with minimal assumptions are also produced and shown. In particular, we show the influence of various parameters on the energy spectrum and transverse momentum distribution, such as the in-medium quark masses, the energy transfer in the recoil process, and the phase accumulation criteria, especially for low and intermediate energy gluons.

Future studies will allow for the interface with full simulations of the quark-gluon-plasma with hydrodynamic evolution, such as vHLLE, along with subsequent hadronisation of the jet partons in order to produce realistic distributions that can be directly compared to LHC and RHIC data.

Experiment/Theory:

Theory/Phenomenology

Affiliation:

Subatech, Nantes

Parallel: Jets and their modification in QCD Matter / 38

Measurement of the angle between jet axes and energy-energy correlators with ALICE

Autor Reynier Cruz-Torres[1]

[1] *Lawrence Berkeley National Lab*

Modifications of the internal structure of jets through interactions with the QGP produced in heavy-ion collisions, referred to as jet quenching, are used to study the properties of the QGP. In this talk, we present the first measurement of the angle between pairs of jet axes, ΔR_{axis}, in central Pb-Pb collisions at $\sqrt{s_{\mathrm{NN}}}$ = 5.02 TeV with ALICE. We compare this novel jet substructure measurement to a selection of jet quenching models. The data favor models implementing incoherent energy loss of jet constituents in the QGP, but also agree with models invoking an enhancement of quark-initiated jets. On the other hand, our measurement disfavors the intra-jet in-medium p_{T} broadening from the BDMPS formalism. Moreover, to comprehensively study the perturbative and non-perturbative aspects of jet structure, we measured the energy-energy correlators (EEC) that emphasize the angular structure of the energy flow within jets. Defined as the energy-weighted cross section of particle pairs inside jets, the scaling behavior of the EECs as a function of pair distance exposes a distinct separation of the perturbative from the non-perturbative regime, revealing parton-type dependent dynamics of jet formation and their confinement into hadrons. In this talk, we present a new measurement of EEC in pp collisions at the LHC and compare it with pQCD predictions. This measurement serves as a baseline for future measurements in heavy-ion collisions.

Experiment/Theory:

ALICE

Affiliation:

CERN

Parallel: Jets and their modification in QCD Matter / 139

Exploring the QCD color charge dependence of jet quenching with photon+jet events in ATLAS

Autor Christopher McGinn[1]

[1] *University Colorado Boulder, ATLAS and sPHENIX*

As high-energy light quarks and gluons traverse the Quark-Gluon Plasma, they are expected to lose energy mainly via medium-induced gluon bremsstrahlung. Thus, a basic assumption in pQCD-based frameworks of radiative energy loss is that it depends on the QCD color factor of the initiating parton. In this talk, ATLAS presents two measurements in Pb+Pb collisions aimed at constraining the magnitude of this color-charge dependence. First, ATLAS presents the finalized result on the nuclear modification factor RAA for photon-tagged jets. By comparing this measurement to the RAA for inclusive jets, one can exploit the known difference in the quark-/gluon-initiated jet fraction between these two samples and extract the QCD color-charge dependence. Second, ATLAS presents a new measurement of photon plus two jet production in Pb+Pb collisions. In these events, the two jets traverse the same QGP medium, but typically have different color charges (i.e. they are a quark and a gluon). Thus, measurements such as the total jet-to-photon p_{T} ratio, the two-jet p_{T} asymmetry, and the jet opening angle can provide interesting information on the parton-QGP interaction. Both results are compared to a variety of theoretical calculations.

Experiment/Theory:

ATLAS

Affiliation:

ATLAS Collaboration

Parallel: Jets and their modification in QCD Matter / 308

Intra-jet asymmetry and jet-flow coupling in heavy-ion collisions

Autoren Carlos Salgado[1]; Tan Luo[1]; Xin-Nian Wang[None]

[1] *IGFAE*

The interaction between the jet and QGP fluid will deflect particles associated with the jet from their initial direction. Such deflection will depend on the energy of the jet constitutes and the velocity of the flow. The soft particles suffering stronger deflection will drift towards the direction of the flowing medium, away from the center of the jet cone where the hard particles are located, leading to an angular intra-jet asymmetry of particle distribution coupled with flow inside the jet. The intra-jet asymmetry could be obtained by the angular distribution of jet constituents and the angle between the Winner-takes-all(WTA) and standard jet axis. In this work, we first calculate the contributions from jet particles with different pT to the jet shape to get the average effect of the jet-flow coupling. We further explore the intra-jet asymmetry of gamma-jet in both longitudinal and transverse directions and study their dependence on jet path length and fluid viscosity. Together with gamma-jet asymmetry, we can use the difference between the longitudinal and transverse intra-jet asymmetry to extract the velocity of the transverse flow and identify the initial production position of the jet. We also compare the differences between dijet and gamma-jet to investigate the effect of the diffusion wake. The rapidity ordering of particles with different pT shows an explicit picture of the jet-flow coupling effect in the longitudinal direction.

Experiment/Theory:

Theory/Phenomenology

Affiliation:

IGFAE

Parallel: Jets and their modification in QCD Matter / 296

Data-driven $\hat{q}$ in a hard-soft factorized parton energy loss approach

Autoren Tianyu Dai[1]; Jean-Francois Paquet[2]; Steffen A. Bass[1]

[1] *Duke University*

[2] *Vanderbilt University*

Interactions of high-energy partons with the strongly-coupled quark-gluon plasma lead to parton energy loss, as well as broadening of the partons' transverse and longitudinal momentum distributions. Energy loss and momentum broadening resulting from soft parton-plasma interactions can be quantified with transport coefficients, factorizing their effect from hard (perturbative) parton-plasma scatterings. We apply this factorized model of energy loss [1] to perform a Bayesian calibration against RHIC and LHC measurements, finding an enhancement of parton energy loss at low temperature compared to perturbative expectations. We highlight the model's ability to match perturbative calculations while inherently allowing for agnostic non-perturbative energy loss.

[1] T. Dai, J.-F. Paquet, D. Teaney and S.A. Bass, "Parton energy loss in a hard-soft factorized approach," Phys.Rev.C 105 (2022) no.3, 034905

Experiment/Theory:

Theory/Phenomenology

Affiliation:

Duke University;
Vanderbilt University

Parallel: Jets and their modification in QCD Matter / 28

Jet quenching in evolving anisotropic matter

Autoren Andrey Sadofyev[1]; João Barata[2]; Xoán Mayo Lopez[1]; Carlos Salgado[1]

[1] *IGFAE*

[2] *BNL*

Over the last decades, the theoretical picture of how hadronic jets interact with nuclear matter has been extended to account for the medium's finite longitudinal length and expansion. However, only recently a first-principle approach has been developed that allows to couple the jet evolution to the medium flow and anisotropic structure in the dilute limit. In this talk, we will show how to extend this approach to the dense regime, where the resummation of multiple in-medium scatterings is necessary. Particularly, we will consider the modifications of the single particle momentum broadening distribution and single gluon production rate in evolving matter. The resummation is performed by either computing the opacity series or starting from the all order BDMPS-Z formalism. We will also discuss the (novel) resulting modifications to jets' substructure.

Experiment/Theory:

Theory/Phenomenology

Affiliation:

IGFAE

Parallel: Jets and their modification in QCD Matter / 137

ATLAS measurements of b-jet suppression and heavy-flavor azimuthal correlations in 5.02 TeV Pb+Pb collisions

Autor Sebastian Tapia[1]

[1] *Universidad Tecnica Federico Santa Maria*

The suppression of jets in heavy-ion collisions can provide detailed information about the hot, dense plasma formed in these collisions at the LHC. The energy loss mechanism can be studied by measuring differences in the suppression of b-tagged and inclusive jets in pp and Pb+Pb collisions. Besides the b-tagged jet measurements, an alternative method for probing the interactions of heavy quarks with the plasma, is the study of the correlations between heavy-quark pairs, which is sensitive to the relative importance of collisional versus radiative scattering processes. We report new ATLAS measurements of b-tagged and inclusive jet production aND the measurement of the yield of correlated muon pairs from heavy-flavor decays in Pb+Pb and pp collisions at $\sqrt{s_{\rm NN}} = 5.02$~TeV. For b-tagged and inclusive jet, the transverse momentum distributions in Pb+Pb and pp collisions, as well as the nuclear modification factors, R_{AA}, in Pb+Pb collisions are presented togheter with comparisons to theoretical calculations. The measurement of correlated muon pairs from heavy-flavor decays includes per-event yields, scaled by the nuclear thickness function, T_{AA}, measured differentially as a function of centrality. Detailed studies of how the shape of the correlation in azimuthal-angle separation between the two muons, changes from peripheral to central Pb+Pb collisions, and comparison to the corresponding measurements in pp collisions are also presented.

Experiment/Theory:

ATLAS

Affiliation:

ATLAS Collaboration

Parallel: Jets and their modification in QCD Matter / 101

Quantum simulation of jet evolution in a medium

Autoren Carlos Salgado[1]; João Barata[2]; Meijian Li[3]; Wenyang Qian[3]; Xiaojian Du[4]

[1] *IGFAE*

[2] *BNL*

[3] *University of Santiago de Compostela*

[4] *Instituto Galego de Fisica de Altas Enerxias (IGFAE), Universidade de Santiago de Compostela*

In recent years, a lot of effort has been put into expanding established jet-quenching formalisms to account for higher-order or energy-suppressed medium-induced effects. Understanding how such contributions emerge is important to have a more complete picture of jet evolution in the medium

and to extract more detailed properties of the underlying matter. However, such efforts are in general plagued by technical difficulties related to the complexity of the calculations. In this talk, we will argue that quantum computers can be used as alternative theoretical labs to simulate jet evolution in the quark-gluon plasma. Based on the light-front Hamiltonian formalism, we construct a digital quantum circuit that tracks the evolution of a multi-particle jet probe within the $|q\rangle + |qg\rangle$ Fock sectors in the presence of a stochastic color background. Using the quantum simulation algorithm, we show that the jet evolution in the medium can be properly captured employing small lattices. Importantly, the simulations can be run in general stochastic backgrounds, surpassing many of the simplifying assumptions usually taken. We will show that the present strategy can be efficiently expanded to account for the production of multiple gluon radiations.

Experiment/Theory:

Theory/Phenomenology

Affiliation:

Instituto Galego de Fisica de Altas Enerxias,
University of Santiago de Compostela,
Brookhaven National Laboratory

Parallel: Jets and their modification in QCD Matter / 222

Pushing forward jet substructure measurements in heavy-ion collisions

Autoren Alba Soto Ontoso[None]; Daniel Pablos[1]

[1] *INFN Torino*

In this talk, we introduce a novel approach to minimise selection biases associated to the modification of the quark- vs. gluon-initiated jet fraction in order to assess the presence of other medium-induced effects, namely color decoherence. More concretely, we propose to explore the rapidity dependence of jet substructure observables. So far, all jet substructure measurements at mid-rapidity have shown that heavy-ion jets are narrower than vacuum jets. First, we show analytically that if the narrowing effect persists at forward rapidities, where the quark-initiated jet fraction is greatly increased, this could serve as an unambiguous experimental observation of color decoherence dynamics in heavy-ion collisions. Next, we carry out Monte Carlo simulations using the expected statistics of the projected high-luminosity runs and demonstrate that this measurement is within reach of the future detector capabilities that will allow for an extended rapidity coverage both at LHC and RHIC, with STAR.

Based on: *Pushing forward jet substructure measurements in heavy-ion collisions*, D. Pablos, A. Soto-Ontoso. *arXiv:2210.07901*

Experiment/Theory:

Theory/Phenomenology

Affiliation:

INFN Torino, IPhT Saclay, CERN

Parallel: Jets and their modification in QCD Matter / 40

First measurement of jet angularities with D^0-meson tagged jets with ALICE

Autor Preeti Dhankher[1]

[1] *University of California Berkeley*

The properties of partonic fragmentation in QCD are dependent on the flavours of the partons involved in the 1→2 splitting processes underpinning parton showers. These flavour dependencies arise due both to the different Casimir factors of quarks and gluons, as well as the mass of heavy quarks. Heavy-flavour jets provide a unique experimental tool to probe these flavour dependencies, particularly at low and intermediate transverse momenta where mass effects are significant. Here we report the first measurement of the angularity of jets tagged with a reconstructed D^0 meson, in the jet transverse momentum interval of 15-30 GeV/c. Generalised angularities are a set of IRC-safe jet-substructure observables which can be tuned in their sensitivity to the partonic fragmentation and hadronisation processes. Comparisons to angularity measurements in a flavour-untagged jet sample will probe both the flavour depdendences due of the mass of the charm quark, as well as the high purity quark nature of the D^0-tagged jet sample. Further comparisons to different MC generators will assess the role of these flavour dependencies in different parton shower prescriptions.

Experiment/Theory:

ALICE

Affiliation:

CERN

Parallel: Jets and their modification in QCD Matter / 238

Measurement of Two-Point Energy Correlators Within Jets in p+p Collisions at $\sqrt{s}$ = 200 GeV

Autor Andrew Tamis[1]

[1] *Yale University*

Jet substructure is a powerful tool to probe the time evolution of a parton shower. However, many of the analysis methods used to extract splitting formation times from jet substructure, such as Soft Drop grooming and the Lund plane, focus on the hardest radiation of the jet. A complementary observable with growing theoretical and experimental interest, the 2-point Energy Correlator (EEC), re-contextualizes jet substructure study by using the distribution of angular distance of all combinations of two final state particles within a jet. This distribution is weighted by the product of the fractions of jet energy that each of the constituents carry, and thus is infrared-and-collinear safe. The EEC can cleanly reveal the separation between two distinct regimes: effects originating from free hadrons at small opening angles and from perturbative fragmentation of quarks and gluons at large opening angles.

In this talk, the first fully corrected measurement of the EEC at RHIC is presented, using the data taken at $\sqrt{s}$ = 200 GeV $p + p$ collisions by STAR. The EEC will be shown for several full jet p_T selections and compared to predictions from the PYTHIA-6 STAR tune. This work will be useful as a baseline for comparisons to future studies in heavy-ion systems, which will provide information about how the quark-gluon plasma interacts with the jet across different angular scales.

Experiment/Theory:

STAR

Affiliation:

STAR

Parallel: Jets and their modification in QCD Matter / 210

Dead-cone searches in heavy-ion collisions using the jet tree

Autoren Leticia Cunqueiro[1]; Alba Soto Ontoso[None]; Davide Napoletano[None]

[1] *Roma Sapienza*

In this talk, we will discuss the possibility of using the dead cone of heavy quarks as a region of the Lund plane where medium-induced gluon radiation can be isolated and characterised. We propose to use jet grooming techniques to identify a particular splitting in the jet tree that is both perturbative and sensitive to the dead-cone effect. In particular, we introduce a new jet substructure groomer, dubbed Late-k_t, that selects the most collinear splitting in a QCD jet above a certain transverse momentum cutoff. Our observable is then defined as the angular distribution of the splitting tagged by Late-k_t. After discussing the logarithmic resummation structure of this new jet substructure observable, we demonstrate that medium-induced emissions lead to an enhancement of collinear emissions below the dead cone angle for b-initiated jets. Numerically, we demonstrate an excellent resilience of Late-$k_t$against uncorrelated thermal background, thus confirming this observable as a potential candidate to unveil medium dynamics around the dead cone regime.

Experiment/Theory:

Theory/Phenomenology

Affiliation:

CERN

Parallel: Jets and their modification in QCD Matter / 118

Exploring the deadcone effect in heavy ion collisions with energy correlators

Autoren Jack Holguin[1]; Carlota Andres[2]; Ian Moult[3]; Cyrille Marquet[4]; Fabio Dominguez[5]; Raghav Kunnawalkam Elayavalli[6]

[1] *CPHT, Ecole Polytechnique*

[2] *CPHT, CNRS, Ecole polytechnique*

[3] *Yale University*

[4] *CPHT, École polytechnique*

[5] *IGFAE, Universidade de Santiago de Compostela*

[6] *Vanderbilt University*

The dynamics of jet formation in heavy ion collisions (HICs) is influenced by the presence of a quark-gluon plasma (QGP) and is imprinted into a jet's multi-scale substructure. In recent work, we demonstrated that the two-point energy correlator, measured on a massless in-medium jet, provides a sensitive probe of this dynamics and can robustly identify the scales defined by the properties of the QGP. In this talk we present the extension of our work to heavy flavour jets produced in HICs. This introduces new dynamics into the jet formation, namely the deadcone effect. We show that energy correlators allow us to disentangle the dynamics of the deadcone from interactions with the QGP. We identify two limits: the near-massless limit where the deadcone is not affected by the medium

and measurements of medium properties follow similar profiles to the massless case, and the large-mass limit where the medium radiation begins to populate the deadcone producing a zombie cone. Building on our previous work, our study further demonstrates the spectacular ability of energy correlators to disentangle complicated competing jet dynamics.

Experiment/Theory:

Theory/Phenomenology

Affiliation:

CPHT, Ecole Polytechnique

Parallel: Jets and their modification in QCD Matter / 288

Probing the short-length structure of the QGP with jet observables

Autoren Daniel Pablos[1]; Krishna Rajagopal[2]; Zachary Hulcher[3]

[1] *INFN Torino*

[2] *MIT*

[3] *Stanford U.*

High-energy partons are capable of triggering high-momentum exchanges with quark-like and gluon-like QGP quasi-particles that can be observed at sufficiently short length scales. In this work we present an implementation of a central aspect of this physics within the hybrid strong/weak coupling model. Interaction with the quasi-particles results in elastic, Moliere scatterings, leading to deflection of the direction of the jet parton that induced the process as well as the excitation of partons from the thermal medium that recoil after being kicked. Throughout the in-medium evolution, the system of jet partons and recoils, which might further re-scatter, inject energy and momentum into the QGP, producing wakes. Given the large impact of the wakes generated by the hydrodynamic response of the medium on jet observables, finding distinctive signatures of scattering off quasi-particles in the QGP is a challenging task. What makes the hybrid model particularly valuable as a tool for identifying observables that are more/less sensitive to scattering off quasi-particles and less/more sensitive to consequences of wakes in the QGP is that when we turn Moliere scattering off the model contains no effects of scattering —energy loss in the model arises from strongly coupled physics not from scattering. We can therefore use our investigation to suggest observables and strategies that may be followed with a view toward discerning separate consequences of the effects under consideration.

Experiment/Theory:

Theory/Phenomenology

Affiliation:

Stanford U., INFN Torino, MIT

Parallel: Jets and their modification in QCD Matter / 159

Search for medium effects using jets from bottom quarks in PbPb collisions a 5.02 TeV with CMS

Autor Lida Kalipoliti[1]

[1] *LLR*

Jet quenching, one of the signatures of the quark-gluon plasma, is a well established experimental phenomenon at RHIC and LHC. However, a detailed characterization of the expected dependence of jet-medium interactions on the flavor of the parton initiating the shower is yet to be settled. This talk presents the first b jet shapes measurements in 5.02 TeV PbPb and pp collisions collected by the CMS experiment. Comparisons made with jet shapes of inclusive jets, produced predominantly by light quarks and gluons, allow for experimental observations of the "dead cone"effect in suppressing transverse momenta of constituents at small radial distance from the jet axis. A similar comparison for large distances provides insights on the role of parton mass in the energy loss and possible mass dependence of the medium response.

Experiment/Theory:

CMS

Affiliation:

CMS

Parallel: Jets and their modification in QCD Matter / 89

Exposing the dead-cone effect and constraining heavy quark splitting functions in heavy ion collisions

Autoren Wei Dai[1]; Ben-Wei Zhang[2]; Enke Wang[None]

[1] *China university of Geosciences*

[2] *Central China Normal University*

When an energetic parton traverses the hot QCD medium, it may suffer multiple scattering and energy losses. The medium-induced gluon radiation for a massive quark will be suppressed relative to that of a light quark due to the dead-cone effect. The development of new declustering techniques of jet evolution makes a direct study of the dead-cone effect in the QCD medium possible for the first time. In this work, we compute the emission angle distribution of the charm-quark initiated splittings in the D0 meson tagged jet and that of the light parton initiated splittings in inclusive jets in p+p and Pb+Pb at 5.02~TeV by utilizing the declustering techniques of jet evolution. When comparing the jet number normalized emission angle distributions of the charm-quark initiated splittings and that of the light parton initiated splittings by directly taking their ratios at the same energy intervals of the initial parton, one can find the charm-quark initiated splittings will be suppressed at smaller emission angle corresponding to the dead-cone effect. The dead-cone effect of the medium-induced gluon radiation can be directly observed. We further find that the dead-cone effect will broaden the emission angle of the splitting and reduce the possibility of such splitting occurring, leading to the massive parton losing less energy. Collisional energy loss will not obscure such observation. Also investigate the possible direct observable that help constrain heavy quark splitting function.

Experiment/Theory:

Theory/Phenomenology

Affiliation:

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Guangdong Provincial Key Laboratory of Nuclear Science, Institute of Quantum Matter, South China Normal University,
Guangzhou 510006, China

Parallel: Jets and their modification in QCD Matter / 289

Unbiased quantification of jet energy loss

Autoren João M. Silva[1]; Liliana Apolinário[2]; Jose Guilherme Milhano[3]; Lénea Luís[4]

[1] *LIP - Lisboa / ULisboa - IST*

[2] *LIP*

[3] *Universidade de Lisboa*

[4] *LIP - Lisboa*

Bin migration effects hinder a direct connection between the nuclear modification factor R_{AA} and the energy lost by jets. R_{AA} compares yields of jets, in pp and AA collisions, that are reconstructed with the same p_T and is thus biased by the steeply falling jet spectrum. To mitigate these effects, Brewer et al. [1] introduced a novel observable to directly quantify average jet energy loss (Q_{AA}), given by the ratio of the transverse momenta that correspond to the same probability quantiles in pp and AA.
This work reinforces the claim that Q_{AA} ratio is a reliable proxy for jet energy loss and, by using it, it shows that energy loss decreases with increasing jet radius when QGP response, as implemented in the JEWEL event generator, is accounted for. Further, our results establish that, contrary to recent claims, the difference in R_{AA} between dijet and boson-jet events is dominated by differences in the spectral shape, leaving the colour charge of the jet initiating parton with a minor role to play.

[1] Brewer, J., Milhano, J. G., & Thaler, J. (2019). Sorting out quenched jets. Physical Review Letters, 122(22), 222301.

Experiment/Theory:

Theory/Phenomenology

Affiliation:

LIP - Lisbon

Parallel: Jets and their modification in QCD Matter / 27

Partonic Critical Opalescence and Its Impact on the Jet Quenching Parameter

Autoren Feng Li[1]; Shanshan Cao[2]; Jing Wu[1]

[1] *Lanzhou University*

[2] *Shandong University*

Jet quenching parameter $\hat{q}$ is essential for characterizing the interaction strength between jet partons and nuclear matter. Based on the quark-meson (QM) model, we develop a new framework for calculating $\hat{q}$ at finite chemical potentials, in which $\hat{q}$ is related to the spectral function of the chiral order parameter. A perturbative calculation up to the one-loop order indicates that the momentum broadening of jets is enhanced at both the high temperature and high chemical potential, and approximately proportional to the parton number density in the partonic phase. We further investigate the behavior of $\hat{q}$ in the vicinity of the critical endpoint (CEP) by coupling our calculation with a recently developed equation of state that includes a CEP in the universality class of the Ising model, from which we discover the partonic critical opalescence (PCO) – a prominent enhancement of the

momentum broadening of jets near CEP, contributed by the scatterings via the σ exchange process. Hence, for the first time, jet quenching is connected with the search of CEP.

Experiment/Theory:

Theory/Phenomenology

Affiliation:

Lanzhou University / Shandong University

Parallel: Jets and their modification in QCD Matter / 290

Jet Measurements with PHENIX

Autor Julia Velkovska[1]

[1] *Vanderbilt University*

Reference measurements in p+p collisions are crucial for understanding jet quenching. PHENIX has a suite of new jets measurements in p+p collisions: fragmentation function, transverse momentum, jt, distribution, the radial profile, and splitting functions.

Jet quenching effects can also be studied with high momentum hadrons and two-particle correlations. The distribution of hadrons opposite a high pt π^0 or photon in Au+Au collisions, reveals how the distribution of hadrons within the opposing jet is modified compared to that in p+p collisions. PHENIX has measured π^0-hadron and γ-hadron angular correlations in Au+Au and p+p collisions with detailed measurements that probe the angular distribution of the modifications.

To fully quantify the quenching effects in heavy ion collision, we must also understand potential modifications in smaller collision systems. Previous PHENIX measurements of jets and π^0s in d+Au collisions revealed possible modifications when dividing the measurements into different event multiplicity or centrality classes. Updated reconstructed jet measurements and the use of direct photons to study possible biases in the event
selection suggest that while peripheral d+Au collisions are consistent with expectations from p+p collisions, some suppression in the most central d+Au events may still exist.
The talk will summarize the latest PHENIX jet-related measurements in p+p, d+Au, and Au+Au collisions.

Experiment/Theory:

PHENIX

Affiliation:

Vanderbilt

Parallel: Jets and their modification in QCD Matter / 90

Impact of pre-equilibrium dynamics on jet quenching observables

Autor Marcos Gonzalez Martinez[1]

Co-Autoren: Carlos Salgado [2]; Carlota Andres [3]; Fabio Dominguez [1]; Liliana Apolinário [4]

[1] *IGFAE - Universidade de Santiago de Compostela (ES)*

[2] *IGFAE*

[3] *CPHT, CNRS, Ecole polytechnique*

[4] *Instituto Superior Técnico (IST), Universidade de Lisboa*

Given recent works showing jet quenching's sensitivity to the dynamics of the pre-hydrodynamic phase of heavy-ion collisions, addressing medium-induced radiation in the initial stages becomes crucial. In this talk, we derive the BDMPS-Z emission spectrum off a hard parton accounting for additional medium-induced emissions arising from its vacuum propagation in the pre-hydrodynamics phase. By comparing this set-up with those where the emitter is created inside the medium, but with different starting points, we isolate the contribution of this initial radiation. We then analyze the impact that this extra radiation may have in the determination of the nuclear modification factor and high-p_T azimuthal asymmetry. Our findings show that replacing in-medium propagation by vacuum propagation prior to hydrodynamization leads to an increase in the high-p_T v_2. However, this increase in the asymmetry is smaller than the one obtained when setting the parton to be created at the hydrodynamization time.

Experiment/Theory:

Theory/Phenomenology

Affiliation:

Instituto Galego de Física de Altas Enerxías (IGFAE), Universidade de Santiago de Compostela

Parallel: Jets and their modification in QCD Matter / 75

First measurements of in-jet fragmentation and correlations of charmed mesons and baryons in pp collisions with ALICE

Autor Antonio Palasciano[1]

[1] *Università & INFN, Bari*

Fragmentation functions are one of the key components of the factorisation theorem used to calculate heavy-flavour hadron production cross sections. The non-perturbative nature of fragmentation functions necessitates their constraint through experimental measurements, commonly performed in the clean environments of $\mathrm{e^+e^-}$ and ep collisions. However, recent measurements of charm hadron spectra and of the ratios of charmed-hadron abundances in pp collisions have questioned the universality of fragmentation functions between leptonic and hadronic collision systems in the baryon sector. In this talk, we present measurements of differential observables that also consider the surrounding hadronic density in addition to the heavy-flavour hadron itself. These measurements provide additional information to the previously reported baryon-to-meson results and allow to obtain a closer connection to the charm fragmentation functions. We report the fraction of longitudinal momentum carried by $\mathrm{D^0}$ and $\mathrm{D_s^+}$ mesons as well as Λ_c^+ baryons. We also report correlations between heavy-flavour decay electrons and charged particles in pp and p-Pb collisions, as well as azimuthal-angle correlations of Λ_c^+ baryons with charged particles in pp collisions, which provide quantitative access to the angular profile, p_{T} and multiplicity distributions of the jets produced by the heavy-quark fragmentation.

Experiment/Theory:

ALICE

Affiliation:

CERN

Parallel: Jets and their modification in QCD Matter / 94

Precise description of medium-induced emissions

Autoren Johannes Hamre Isaksen[1]; Konrad Tywoniuk[None]

[1] *University of Bergen*

We study jet fragmetation via final-state parton splittings in the medium. These processes are usually calculated theoretically by invoking one or two approximations: the large-Nc and the eikonal approximations. We want to develop methods to do the calculations without using these approximations, and to quantify the error that is introduced by employing them.
As partons go through the medium their color continuously rotates, an effect that is encapsulated in a Wilson line along their trajectory. When calculating observables, one typically has to calculate correlators of several Wilson lines. This is usually dealt with in the literature by invoking the large-Nc limit. In an earlier work we showed how correlators of multiple Wilson lines appear, and developed a method to calculate them numerically to all orders in Nc.
However, in our previous paper we made use of the eikonal approximation, meaning that the partons are assumed to travel in straight lines through the medium. This might not be a good approximation for soft and imbalanced splittings, where the produced partons can be kicked around by the medium. We show how the full problem can be transformed into solving a set of coupled Schrödinger equations, with the aforementioned Wilson line correlators acting as the potential term. This system of differential equations is then solved numerically. These results are relevant for high-pT jet processes, multi-gluon emissions in the QGP and initial stage physics at the LHC.

Experiment/Theory:

Theory/Phenomenology

Affiliation:

University of Bergen

Parallel: Jets and their modification in QCD Matter / 243

Medium effects on Hadrons and Jets in $\sqrt{s_{\rm NN}} = 200$ GeV Isobar Collisions at STAR

Autor Tristan Protzman[1]

[1] *Lehigh University*

Partonic scatterings with large momentum transfer occur before the formation of the quark-gluon plasma (QGP) in heavy-ion collisions, resulting in collimated collections of hadrons known as jets. As a jet traverses and interacts with the QGP medium, it loses energy via collisional and radiative processes, known as jet quenching. The magnitude of the energy loss can be quantified by the ratio of hadron or jet yields in A+A and p+p collisions, know as the nuclear modification factor ($R_{\rm AA}$). The high-statistics 2018 STAR isobar data, comprised of Zr+Zr and Ru+Ru collisions, offer the opportunity to study the system size dependence of nuclear modification for hard probes. A measurement of the inclusive charged hadron $R_{\rm AA}$ differentially with the average number of participants ($\langle N_{\rm part}\rangle$) in the isobar collisions will be presented with comparisons to both smaller and larger sized systems. In addition to studying the total energy loss via $R_{\rm AA}$, the path-length dependence of jet quenching processes can be studied by measuring the azimuthal anisotropy of jet yields relative to the event plane, quantified by the second-order Fourier coefficient $v_2^{\rm jet}$. A finite $v_2^{\rm jet}$ is expected in mid-central heavy-ion collisions where a highly ellipsoidal QGP medium is formed, resulting in jets traversing in-plane interacting with less medium than those out-of-plane. Measurements of $v_2^{\rm jet}$ in isobar collisions spanning multiple jet resolutions will be presented. Ongoing work to use event

shape engineering to more precisely control the path length of the initiating partons will also be shown.

Experiment/Theory:

STAR

Affiliation:

STAR

Parallel: Jets and their modification in QCD Matter / 221

Jet suppression and azimuthal anisotropy at RHIC and LHC

Autoren Daniel Pablos[1]; Konrad Tywoniuk[None]; Yacine Mehtar-Tani[2]

[1] *INFN Torino*

[2] *BNL*

Jets are multi-partonic systems that develop before interactions with the QGP set in and lead to energy loss and modifications of their substructure. Jet modification depends on the degree to which the medium can resolve the internal jet structure that is dictated by the physics of coherence governed by a critical angle θ_c. Using resummed quenching weights that incorporate the IOE framework for medium-induced radiation and embedding the system into a realistic heavy-ion environment we compute the R dependence of jet suppression, both at RHIC and the LHC. At RHIC kinematics we see a very mild R-dependence for the range of R studied, similar to what was found at the LHC. We also present results for the jet azimuthal anisotropy v_2 as a function of R. We observe that as centrality is decreased, v_2 for moderate R jets sequentially collapse towards the result for small $R = 0.1$. The reason of this sequential grouping is the evolution of θ_c with centrality due to its strong dependence on the in-medium traversed length. For those jets with $R > \theta_c$, traversing shorter lengths within the medium will make a larger difference than for those jets with $R < \theta_c$, since the size of the resolved phase-space over which quenching weights are resummed will be reduced. For this reason, $v_2(R)$ is quite sensitive to the typical value of θ_c at a given centrality.

[1] Y. Mehtar-Tani, D. Pablos, K. Tywoniuk. Phys.Rev.Lett. 127 (2021) 25, 252301

Experiment/Theory:

Theory/Phenomenology

Affiliation:

BNL, INFN Torino, Bergen U.

Parallel: Jets and their modification in QCD Matter / 249

Thermalization of a jet wake in QCD kinetic theory

Autor Fabian Zhou[1]

Co-Autoren: Aleksas Mazeliauskas [1]; Jasmine Brewer [2]

[1] *ITP Heidelberg*

[2] *CERN*

We study the energy deposition of a high-momentum parton traveling through a Quark-Gluon Plasma using QCD kinetic theory. We show that the energy is first transported to the soft sector by collinear cascade and then isotropised by elastic scatterings. Remarkably, we find that the jet wake can be well described by a thermal distribution function with angle-dependent temperature. This could be used for effective phenomenological descriptions of jet thermalization in realistic heavy-ion collision simulations.

Experiment/Theory:

Theory/Phenomenology

Affiliation:

ITP Heidelberg

Parallel: Jets and their modification in QCD Matter / 117

Determining the onset of color coherence with energy correlators

Autoren Carlota Andres[1]; Cyrille Marquet[1]; Fabio Dominguez[2]; Ian Moult[3]; Jack Holguin[1]; Raghav Kunnawalkam Elayavalli[4]

[1] *CPHT, École polytechnique*

[2] *IGFAE, Universidade de Santiago de Compostela*

[3] *Yale University*

[4] *Vanderbilt University*

We present a new approach to jet substructure in heavy-ion collisions based on the study of correlation functions of energy flow operators (energy correlators). This approach is based on the insight that the dynamics of the QGP is imprinted at specific time scales in the jet, which will be reflected as changes in the shape of the correlator. We analyze the two-point correlator of an in-medium massless quark jet within three jet quenching formalisms: BDMPS-Z with the harmonic oscillator approximation, BDMPS-Z with a Yukawa (Gyulassy-Wang) parton-interaction model, and the first opacity GLV framework. We show that the spectra of correlation functions is sensitive to color coherence, which allows us to robustly identify the *resolution scale* of the QGP: the energy scale at which in-medium emissions start to be resolved by the QGP.

Experiment/Theory:

Theory/Phenomenology

Affiliation:

CPHT, Ecole Polytechnique
IGFAE, Universidade de Santiago de Compostela
Vanderbilt University
CPHT, Ecole Polytechnique
CPHT, Ecole Polytechnique
Yale University

Parallel: Jets and their modification in QCD Matter / 178

Effects of multi-scale jet-medium interactions on jet substructures

Autor Yasuki Tachibana[1]

[1] *Akita International University*

We investigate how the scale-dependent jet-medium interactions affect the jet substructure observables in heavy-ion collisions via event-by-event Monte Carlo simulation using the JETSCAPE framework. Jets are dynamic probes with varying virtualities and energies of partonic constituents in their shower evolution. The various internal medium structures involved in interactions at different scales of the jet parton's virtuality and energy are encoded in the modification of reconstructed jets. Recently, we found that the reduction of jet-medium interaction at the early high-virtuality stage, where the medium is resolved at a very short distance scale and appears more dilute [1], is the key to explaining the different trends in reconstructed jet RAA and single particle RAA in a unified manner [2].
In this study, we focus on jet substructure observables to explore further details of the scale dependence by performing numerical simulations with explicit virtuality dependence in the jet-medium interaction rate within the MATTER+LBT setup of the JETSCAPE framework. We compare results for the Soft Drop groomed observables and jet fragmentation function to data and demonstrate the significant effect of the reduction of jet-medium interaction at the early high-virtuality stage.
[1] Amit Kumar, Abhijit Majumder, and Chun Shen, Phys. Rev. C, 101(3):034908, 2020.
[2] JETSCAPE, arXiv:2204.01163 [hep-ph].

Experiment/Theory:

Theory/Phenomenology

Affiliation:

JETSCAPE Collaboration

Parallel: Jets and their modification in QCD Matter / 165

A unified picture of medium-induced emissions

Autoren Adam Takacs[1]; Johannes Hamre Isaksen[1]; Konrad Tywoniuk[None]

[1] *University of Bergen*

We revisit the picture of jets propagating in the quark-gluon plasma. In addition to vacuum radiation, related to the high initial virtuality, jet particles scatter on the medium constituents resulting in induced emissions. Analytical approaches to resumming these interactions have traditionally dealt separately with multiple, soft, or rare, hard scatterings. A full resummation has so far only been available using numerical methods. We recently achieved analytical control in the full phase space [1]. To this aim, we extended existing resummation schemes to the Bethe-Heitler regime, to cover emissions from early to late times, and from hard splittings to emissions below the thermal scale. Based on the separation of scales, a new space-time picture emerges: at early times, jets start building from both, vacuum and rare, hard scattering-induced emissions. At a later stage, determined by a resolution criterion, these emissions initiate a turbulent cascade that rapidly degrades energy down to, and including the Bethe-Heitler regime. We quantify the impact of such an improved picture, compared to the current factorization that includes only soft scatterings, by analytical and numerical methods for different jet observables. We introduce the concept of accuracy for quenched observables for the first time and show how it improves jet quenching from small to large systems and serves upgrades for Monte Carlo generators.

[1] J. H. Isaksen, A. Takacs and K. Tywoniuk, arXiv:2206.02811.

Experiment/Theory:

Theory/Phenomenology

Affiliation:

University of Bergen

Parallel: Jets and their modification in QCD Matter / 244

Systematic exploration of multi-scale jet substructure in $p+p$ collisions at $\sqrt{s} = 200$ GeV by the STAR experiment

Autor Monika Robotková[None]

Jets are multi-scale objects that connect asymptotically free partons to confined hadrons. Jet substructure measurements in vacuum provide essential insight into the parton evolution and the ensuing non-perturbative processes.

In this study, we use the SoftDrop grooming technique, based on the angular-ordered Cambridge/Aachen reclustering algorithm, to probe correlations between jet substructure variables. This technique provides a correspondence between experimental observables and QCD splitting functions in vacuum. Corrections for detector effects are carried out utilizing either a three dimensional correction procedure or a machine learning based framework called MultiFold, with the latter retaining the correlations across jet substructure observables.

In particular, we explore ensemble level and jet-by-jet correlations between variables such as the shared momentum faction (z_{g}), splitting scale (k_{T}), groomed mass fraction (μ), jet charge (Q, sensitive to the hadronization process) and groomed jet radius (R_{g}) for jets of varying momenta and radii in p+p collisions at $\sqrt{s} = 200$ GeV using the STAR detector. To study the evolution along the jet shower, we present splitting observables at the first, second, and third splits along the jet shower for various jet and initiator prong momenta. Finally, the measurements are compared to leading order Monte Carlo models, such as PYTHIA 6, PYTHIA 8 and HERWIG.

Experiment/Theory:

STAR

Affiliation:

STAR

Parallel: Jets and their modification in QCD Matter / 179

Hybrid Hadronization of Jet Showers from e+e- to AA with JETSCAPE

Autor Cameron Parker[1]

[1] *Texas A&M University*

In this talk we review jet production in a large variety of collision systems using the JETSCAPE event generator and Hybrid Hadronization. Hybrid Hadronization combines quark recombination, applicable when distances between partons in phase space are small, and string fragmentation appropriate for dilute parton systems. It can therefore smoothly describe the transition from very dilute parton systems like e+e- to full AA collisions.
We test this picture by using JETSCAPE to generate jets in various systems. Comparison to experimental data in e+e- and pp collisions allows for a precise tuning of vacuum baseline parameters in JETSCAPE and Hybrid Hadronization. Proceeding to systems with jets embedded in a medium,

we study in-medium hadronization for jet showers. We quantify the effects of an ambient medium, focusing in particular on the dependence on the collective flow and size of the medium. Our results clarify the effects we expect from in-medium hadronization of jets on observables like fragmentation functions, hadron chemistry and jet shape.

Experiment/Theory:

Theory/Phenomenology

Affiliation:

JETSCAPE Collaboration

Parallel: Jets and their modification in QCD Matter / 268

Exploring the time axis within medium-modified jets

Autoren Pablo Guerrero-Rodríguez[1]; Liliana Apolinário[1]; Korinna Zapp[2]

[1] *LIP*

[2] *Lund university*

The fast evolution of the QGP makes its interaction with jets an inherently time-dependent process. However, this crucial dimension is missing from current jet quenching measurements, which hence provide a mere average quantification of the medium properties. In this talk, we propose that jet substructure observables allow access to the QGP time structure. By identifying the recursive steps of a novel jet clustering algorithm (the tau-algorithm) with the sequence of branchings of the parton shower, we obtain an adequate proxy for a time axis within the medium. This technique enables us to label jets according to their formation time and select populations with enhanced sensitivity to quenching effects. By analysing the subsequent splitting, we also explore the possibility of quantifying time-differential properties of the medium. Moreover, we show how this method minimizes the biases stemming from pt- or DeltaR-based selections. The techniques presented here constitute a definite step towards QGP tomographic measurements.

Experiment/Theory:

Theory/Phenomenology

Affiliation:

LIP

Parallel: Jets and their modification in QCD Matter / 237

Measurements of semi-inclusive γ+jet and hadron+jet distributions in heavy-ion collisions at $\sqrt{s_{\rm NN}}$ = 200 GeV with STAR

Autoren Yang He[1]; Maowu Nie[None]

[1] *Shandong University*

We present measurements of the semi-inclusive distribution of charged-particle jets recoiling from γ and π^0 triggers in p+p and central Au+Au collisions, and from charged hadron triggers in smaller

collision systems (Ru+Ru and Zr+Zr) at $\sqrt{s_{\rm NN}}$ = 200 GeV by STAR. The large uncorrelated background in heavy-ion collisions is removed using the event mixing technique, enabling systematically well-controlled measurements at very low jet transverse momentum $p_{\rm T}^{\rm jet}$ and large jet radius R. We report corrected distributions as a function of both $p_{\rm T}^{\rm jet}$ and recoil azimuthal deflection with respect to trigger axis for R = 0.2 and 0.5 jets in p+p and Au+Au collisions. These measurements probe medium-induced jet yield suppression, intra-jet broadening, and jet acoplanarity, as well as their dependence on the color charge in heavy-ion collisions. We also present comparisons to theoretical calculations incorporating Sudakov broadening in vacuum and jet quenching in the medium. Jet yield suppression in central to peripheral collisions is measured in Ru+Ru and Zr+Zr collisions to study the system size dependence of jet energy loss. These together provide a multi-messenger study of the physical processes driving the jet quenching phenomenon.

Experiment/Theory:

STAR

Affiliation:

STAR

Parallel: Jets and their modification in QCD Matter / 246

Parton cascades at DLA: the role of the evolution variable

Autoren André Cordeiro[1]; Carlota Andres[2]; Fabio Dominguez[3]; Jose Guilherme Milhano[4]; Liliana Apolinário[5]; Nestor Armesto[6]

[1] *Laboratório de Instrumentação e Física Experimental de Partículas*

[2] *CPHT, École polytechnique*

[3] *IGFAE, Universidade de Santiago de Compostela*

[4] *Universidade de Lisboa*

[5] *LIP*

[6] *IGFAE (Galician Institute of High Energy Physics)*

While experimental studies on jet quenching have achieved a large sophistication, the theoretical description of this phenomenon still misses some important points. One of them is the interplay of vacuum-like emissions, usually formulated in momentum space, with the medium induced ones that demand an interplay with a space-time picture of the medium and thus must be formulated in position space. A unified description of both vacuum and medium-induced emissions is lacking. In this work, we compute the tree-level probability of a double gluon emission in vacuum, and identify the enhanced phase-space regions for each diagram, corresponding to different configurations of the parton cascade. This calculation provides a parametric form for the formation times associated with each diagram, highlighting the equivalence of various ordering variables at double logarithmic accuracy. This equivalence is further explored by building a toy Monte-Carlo parton shower ordered in formation time, virtuality, transverse momentum, and angle. Aiming at a link with jet substructure, we compute the Lund Plane distributions and trajectories for each ordering prescription. We also compute the distributions in number of splittings and final partons, with the goal of clarifying the differences to be expected from the different ordering variables and the vetoes that must be implemented at Monte Carlo level to conserve energy-momentum, which turn out to have a sizable influence on the shower's evolution.

Experiment/Theory:

Theory/Phenomenology

Affiliation:

CPHT, École polytechnique; IST, University of Lisbon; LIP (Laboratory of Instrumentation and Experimental Particle Physics); IGFAE (Galician Institute of High Energy Physics)

Parallel: Jets and their modification in QCD Matter / 193

Jet shape depending on the gradient of jet transport coefficient in heavy-ion collisions

Autor Han-Zhong Zhang[1]

Co-Autoren: Yayun He [2]; Long-Gang Pang [1]; Xin-Nian Wang [3]; Yu-Xin Xiao [1]

[1] *CCNU*

[2] *South China Normal University*

[3] *LBNL*

Jet shape is studied with a linear Boltzmann transport model for event-by-event simulations of photon-tagged jets in heavy-ion collisions. The transverse momentum asymmetry $A_\perp$ is shown to increase with the initial transverse position when the gradient of jet transport coefficient $\hat{q}$ increases until at the edge of the nonuniform medium. On one hand,the shape of the photon-tagged jet selected by the smaller $A_\perp$ events is "fatter" for the transverse momentum distribution inside the jet due to stronger jet quenching. On the other hand, the jet shape with higher p_T^{jet} is "thinner" due to surface emission of the initial jets. Our numerical results show that the different choices for both final observables $A_\perp$ and p_T^{jet} demonstrate different initial jet creation cites and therefore different jet shapes depending on the gradient of $\hat{q}$.

Experiment/Theory:

Theory/Phenomenology

Affiliation:

Central China Normal University

Parallel: Jets and their modification in QCD Matter / 265

Charge enhancement of parton showers in QCD plasmas

Autoren Chathuranga Sirimanna[1]; ismail soudi[1]; Gojko Vujanovic[2]; wen-jing Xing[3]; Shanshan Cao[3]; Abhijit Majumder[1]

[1] *Wayne State University*

[2] *University of Regina*

[3] *Shandong University*

By scattering with the medium, partons produced by an in-medium shower can change their flavor. At these intermediate energy scales, the rate of gluon conversion to quarks and antiquarks can be more than double the reverse process of quark conversion. Consequently, interactions with the medium lead to a ring of fermions around the hard parton [1]. We present estimates of the range of angles and times where these charge/baryonic rings appear in the angular structure of jets. We discuss the consequences of this dramatic change in the baryon content of the jets, due to the presence of the medium, and how it may contribute to the baryon enhancements observed at intermediate p_T.

[1]- C. Sirimanna et al., arXiv:2211.15553

Experiment/Theory:

Theory/Phenomenology

Affiliation:

Wayne State University, University of Regina, Shandong University.

Parallel: Jets and their modification in QCD Matter / 134

Strong constraints on jet modification in centrality-dependent p+Pb collisions by ATLAS

Autor Jamie Nagle[1]

[1] *University of Colorado Boulder*

Small systems such as pp or p+Pb collisions exhibit evidence of collective behavior strikingly similar to that in Pb+Pb collisions. However, while jet quenching is readily observed in Pb+Pb collisions, no evidence has been found in small systems to date, raising fundamental questions about the nature of the system created in these collisions. This talk reports a measurement by the ATLAS experiment at the LHC which sets new, precise constraints on the possible amount of jet modification in central p+Pb events. To avoid possible biases on the centrality classification of p+Pb events, the collision centrality is categorized by the energy deposited by forward neutrons from the struck nucleus in the Zero Degree Calorimeter (ZDC). The measurement reports the yield of charged hadrons near and opposite in azimuth to reconstructed jets in p+Pb and pp collisions at 5.02 TeV. The ratio between p+Pb and pp, called the I_{pPb}, is consistent with unity within a few percent for hadrons with $p_{\mathrm{T}} > 4$ GeV at all centralities. These data provide new, strong constraints and can be used to set a quantitative limit on jet modification in central p+Pb collisions within a simple model.

Experiment/Theory:

ATLAS

Affiliation:

ATLAS Collaboration

Parallel: Jets and their modification in QCD Matter / 73

Charged-particle jet spectra in event-shape engineered Pb-Pb collisions at 5.02 TeV with ALICE

Autor Caitlin Beattie[1]

[1] *Yale University*

The path-length dependence of jet quenching can help to constrain different jet quenching mechanisms in heavy-ion collisions. However, measuring an explicit value for this dependence has proven challenging. Traditional approaches, which consider anisotropic jet suppression arising from geometric asymmetries, have successfully measured a non-zero azimuthal dependence of jet modification with respect to the event-plane angle of the collision. While such signals improve our qualitative understanding of this topic, extraction of an explicit dependence from these results is limited by fluctuations in the initial state and jet-medium interactions. A new approach to characterize the geometry of the collision is to use event-shape engineering, a technique that classifies events within

a centrality class according to their elliptical anisotropies. By doing so, we gain an improved knowledge of the initial state medium, consequently enabling better constraints on the average path length traversed by the jet. In this talk, new results of jet spectra from event-shape-engineered collisions at ALICE will be presented along with theoretical studies to contextualize the measurement.

Experiment/Theory:

ALICE

Affiliation:

CERN

Plenary Session I / **317**

Welcome Address

Experiment/Theory:

Affiliation:

Plenary Session I / **318**

ALICE Experimental Highlights

Experiment/Theory:

Affiliation:

Plenary Session I / **319**

ATLAS Experimental Highlights

Autor Petr Balek[1]

[1] *AGH Krakow*

Experiment/Theory:

Affiliation:

Plenary Session I / **320**

CMS Experimental Highlights

Autor Georgios Krintiras[1]

[1] *The University of Kansas*

Experiment/Theory:

Affiliation:

Plenary Session II / **321**

LHCb Experimental Highlights

Autor Jiayin Sun[1]

[1] *INFN Cagliari*

Experiment/Theory:

Affiliation:

Plenary Session II / **322**

PHENIX Experimental Highlights

Autor Gabor David[1]

[1] *Stony Brook University*

Experiment/Theory:

Affiliation:

Plenary Session II / **323**

STAR Experimental Highlights

Autoren Joern Putschke[None]; Nihar Sahoo[1]

[1] *Shandong University*

Experiment/Theory:

Affiliation:

Plenary Session II / **324**

HADES Experimental Highlights

Autor Szymon Harabasz[1]

[1] *Technische Universität Darmstadt*

Experiment/Theory:

Affiliation:

Plenary Session III / **325**

Early time dynamics and constraints on medium evolution

Experiment/Theory:

Affiliation:

Plenary Session III / **326**

Electroweak probes: Theory

Experiment/Theory:

Affiliation:

Plenary Session III / **327**

Electroweak probes: Experiment

Experiment/Theory:

Affiliation:

Plenary Session III / **328**

Open heavy flavors: Theory

Experiment/Theory:

Affiliation:

Plenary Session III / **329**

Open heavy flavors: Experiment

Experiment/Theory:

Affiliation:

Plenary Session IV / **330**

Jets medium modifications

Experiment/Theory:

Affiliation:

Plenary Session IV / **331**

Jets substructure

Experiment/Theory:

Affiliation:

Plenary Session IV / **332**

Jet-induced medium response

Experiment/Theory:

Affiliation:

Plenary Session IV / **333**

Monte Carlo modeling of jets

Experiment/Theory:

Affiliation:

Plenary Session IX / **347**

Lattice and EFT for hard probes

Experiment/Theory:

Affiliation:

Plenary Session IX / **348**

Jet quenching with machine learning

Autor YILUN DU[None]

Experiment/Theory:

Affiliation:

Plenary Session IX / **349**

Hard probes at intermediate energies (including fixed-target programs)

Experiment/Theory:

Affiliation:

Plenary Session V / **334**

Quarkonia: Theory

Experiment/Theory:

Affiliation:

Plenary Session V / **335**

Quarkonia: Experiment

Experiment/Theory:

Affiliation:

Plenary Session V / **336**

Nuclear PDFs: new results from global fits

Experiment/Theory:

Affiliation:

Plenary Session V / **337**

Saturation physics at e-p and e-A colliders

Experiment/Theory:

Affiliation:

Plenary Session VI / **338**

UPCs as probes of partonic structure –exclusive and inclusive processes

Experiment/Theory:

Affiliation:

Plenary Session VI / **339**

Hadronization mechanism (via heavy-flavor hadrons): Experiment

Experiment/Theory:

Affiliation:

Plenary Session VI / **340**

Hadronization mechanism (via heavy-flavor hadrons): Theory

Experiment/Theory:

Affiliation:

Plenary Session VI / **341**

Panel discussion: Heavy-flavor production and propagation in QGP - recent achievements and challenges for the next decade

Plenary Session VII / **342**

Future Facilities: sPHENIX and STAR

Experiment/Theory:

Affiliation:

Plenary Session VII / **343**

Future Facilities: Heavy-ion physics at the LHC beyond Run 4

Experiment/Theory:

Affiliation:

Plenary Session VII / **344**

Future Facilities: Electron Ion Collider

Autor Friederike Bock[None]

Experiment/Theory:

Affiliation:

Plenary Session VII / **345**

Future Facilities: SPS

Experiment/Theory:

Affiliation:

Plenary Session VII / **346**

Future Facilities: CBM

Autor Christian Pauly[1]

[1] *Bergische Univgersität Wuppertal*

Experiment/Theory:

Affiliation:

Plenary Session VIII / **367**

Disentangle effects from the initial stage and the evolution stage in heavy ion collisions using EPOS and PHSD

Autor Mahbobeh Jafarpour[None]

Ultrarelativistic heavy-ion collisions at RHIC and the LHC provide a hot and ultra-dense form of matter composed of deconfined quarks and gluons, named QGP. Different models like EPOS and PHSD allow to study the space-time evolution of such heavy-ion collisions. Their dynamics is complicated; hence, various stages should be considered. The first is the primary scattering which defines to a large extent the matter distribution in the phase-space. The second stage concerns the evolution of the partonic system until the system is sufficiently dilute to hadronize. The EPOSi+PHSDe approach is introduced in this thesis, in which the EPOS model is used to determine the initial distribution of matter (partons/hadrons). This part is referred to as EPOSi. Then PHSD is employed to simulate the evolution of the matter in a non-equilibrium transport approach, referred to as PHSDe. The coupling of the two approaches is non-trivial and not straight-forward. Comparing the three models, EPOS, EPOSi+PHSDe, and PHSD, interesting results find concerning their respective space-time evolutions. The results demonstrate considerably different behavior in terms of radial expansion, especially asymmetric expansion, indicating that these three models will provide different results concerning key observables (pT/mT spectra, y/η distribution, v2/3/4) for Au-Au collisions at 200 GeV/A.

Experiment/Theory:

Affiliation:

Plenary Session VIII / **368**

Evolution of initial state fluctuations in the hotspot model

Autor Arjun Kumar[None]

The hotspot model has proven to be an efficient tool to study coherent and incoherent diffraction HERA data by modelling the initial state fluctuations of the gluon density of the proton. The hotspot model in its original form is a non-perturbative model applicable for low momentum transfer and underestimates the incoherent cross section in orders of magnitude when extended for large momentum transfer studies for J/ψ photo-production at HERA. We present here a model of hotspot splittings based on the resolution for the evolution of initial state fluctuations in the hotspot model inspired by the DGLAP parton shower approach This is reliable as both the Bjorken limit and the incoherent diffraction at large momentum transfer probes the gluon wave function at smaller length scales as we increase the resolution. In addition to the geometrical fluctuations, we have additional sources of

fluctuations in our model namely the hotspot width, number, and normalisation fluctuations which leads to a good agreement of our model's prediction with data. In the framework developed, we obtain a good description of both the normalization and shape of coherent and incoherent differential cross sections (t-spectrum) simultaneously.

Experiment/Theory:

Affiliation:

Plenary Session VIII / **369**

Dilepton anisotropy at low beam energies in a transport approach

Autor Renan Hirayama[None]

We present calculations of dielectron anisotropic flow in heavy-ion collisions at HADES beam energies from a hadronic transport approach. The collectivity of the electromagnetic radiation produced during the evolution of these collisions has recently been dubbed as a barometer, serving as a probe for the flow velocity of the underlying hadronic matter. In particular, we study the elliptic flow coefficient v_2 of dileptons in different collisions systems, and its relation to the flow of hadrons.

Experiment/Theory:

Affiliation:

Plenary Session VIII / **370**

Measurement of ω meson production in pp and p–Pb collisions at $\sqrt{s_{\rm NN}} = 5.02$ TeV with ALICE

Autor Nicolas Strangmann[None]

The ALICE experiment at the LHC investigates the properties of the hot and dense nuclear matter created in heavy-ion collisions. By comparing the particle production in pp and p–Pb collisions, possible nuclear initial state effects can be isolated. Measurements of the ω meson $p_{\rm T}$-spectra in pp and p–Pb collisions not only allow for a determination of the nuclear modification factor $R_{\rm pA}$, but also provide insights into the fragmentation process and serve as vital input for direct photon cocktail simulations.

The ω mesons can be reconstructed in ALICE via their primary decay channel into three pions ($\omega \rightarrow \pi^+\pi^-\pi^0$). While the two charged pions are being directly identified by the tracking detectors, i.e. the Time Projection Chamber and the Inner Tracking System, the π^0 is reconstructed from its two decay photons. These photons can either be detected in the calorimeters or via tracks in case they convert to an electron-positron pair in the detector material.

In this poster, the measurement of the ω meson production in pp and p–Pb collisions at $\sqrt{s_{\rm NN}} = 5.02$ TeV will be presented. This includes the signal extraction and various corrections of the ω meson yields, as well as comparisons to theory calculations.

Experiment/Theory:

Affiliation:

Plenary Session VIII / **371**

First performance results from upgraded LHCb and SMOG II

Autor Chiara Lucarelli[None]

The LHCb experiment has recently undergone a series of major upgrades: the entire tracking system has been replaced with higher-granularity sensors, the readout electronics have been upgraded, and all hardware triggers have been replaced with a new state-of-the-art streaming readout system. In addition, the gaseous target SMOG system has been upgraded with a dedicated storage cell to greatly increase the rate of fixed target collisions at LHCb. This talk will include the first performance results from the new LHCb tracking system, the streaming readout system, and SMOG II, with a focus on how these upgrades directly impact the LHCb heavy ion physics program. Further upgrades planned for LHC Run 4 and 5 will also be discussed.

Experiment/Theory:

Affiliation:

Plenary Session X / **350**

Highlights, open questions and perspectives: Heavy flavors and quarkonia

Experiment/Theory:

Affiliation:

Plenary Session X / **351**

Highlights, open questions and perspectives: nPDFs and Electroweak Probes

Experiment/Theory:

Affiliation:

Plenary Session X / **352**

Highlights, open questions and perspectives: Jets and high pT

Experiment/Theory:

Affiliation:

Plenary Session X / **353**

Next Hard Probes edition in Japan

Experiment/Theory:

Affiliation:

Plenary Session X / **354**

Goodbye from the local organizing committee

Experiment/Theory:

Affiliation:

Poster Session - Karte: EM-1 / **30**

Shear and bulk viscous coefficients in thermal QCD within the weak magnetic field regime

Autor Shubhalaxmi Rath[1]

Co-Autor: Sadhana Dash [1]

[1] *Indian Institute of Technology Bombay*

We have studied the shear (η) and bulk (ζ) viscosities of hot QCD medium in a weak magnetic field. These viscosities are calculated by using the relaxation time approximation of kinetic theory in weak magnetic field limit, where temperature scale dominates over the energy scale related to magnetic field. It is found that the weak magnetic field reduces both η and ζ, contrary to their enhancement at finite chemical potential. So, the magnetic field decreases the momentum transfer across and along the layer, whereas the density facilitates this. This study sheds light on the sound attenuation through the Prandtl number (Pr), the nature of flow through the Reynolds number (Re), the fluid characteristic and the conformal symmetry of medium through the ratios η/s and ζ/s, respectively. Weak magnetic field increases the Prandtl number, whereas finite chemical potential reduces it. The observation on the Prandtl number also indicates that the energy dissipation due to the sound attenuation is mostly carried out by the momentum diffusion. The Reynolds number gets increased in a weak magnetic field and gets decreased at finite chemical potential, thus explaining that the weak magnetic field makes the medium less viscous, whereas the chemical potential makes the viscous nature of medium more evident. It is observed that, in a magnetic field, η/s gets closer to the lower bound $1/(4\pi)$ and ζ/s gets nearer to the value at conformal symmetry.

Experiment/Theory:

Theory/Phenomenology

Affiliation:

Indian Institute of Technology Bombay

Poster Session - Karte: EM-2 / **52**

Measurement of ω mesons in pp collisions in $\sqrt{s} = 13$ TeV at the LHC with ALICE

Autor Jens Robert Lühder[None]

Measurements of neutral mesons in small collision systems can serve as a baseline to understand modifications in heavy-ion collisions, where a QGP is formed.
These measurements can also be used to test pQCD predictions and to constrain fragmentation functions as well as parton distribution functions.
Furthermore, a precise knowledge of the ω-meson production improves the measurement of direct photons, as photons produced in ω meson decays represent the third largest contribution of decay photon background.

This poster presents the invariant cross section of the ω-meson in pp collisions at a center-of-mass energy of $\sqrt{s} = 13$ TeV measured by ALICE via its dominant decay channel $\omega \to \pi^+\pi^-\pi^0$.
While charged pions can directly be measured by the ALICE central barrel tracking detectors, neutral pions are reconstructed using their decay channel into two photons.
This reconstruction is realized with several complementary methods using the ALICE calorimeters as well as the central barrel tracking detectors.
The combined result covers an unprecedented p_T range with competitive statistical and systematic uncertainties.

Experiment/Theory:

ALICE

Affiliation:

Institut fuer Kernphysik, Münster

Poster Session - Karte: EM-3 / **84**

First results of dielectron analyses with ALICE in Run 3

Autor Florian Eisenhut[None]

The ALICE experiment has been upgraded over the last years during the LHC Long Shutdown 2.
With the new and upgraded detectors ALICE is now capable of reading out the data of the collisions in a continuous way. With a data acquisition rate 100 times larger than before, an integrated luminosity of more than 10 nb^{-1} is expected to be collected for Pb–Pb collisions during the Run 3 (2022-2025) and Run 4 (2029-2032) data taking periods. In these heavy-ion collisions, we produce a quark-gluon plasma which radiates virtual thermal photons which mainly decay into dielectrons (electron-positron pairs).
Since dielectrons do not interact strongly, they are excellent probes of the hot, strongly-interacting matter produced in heavy-ion collisions. Not only the improved readout of the detectors but also the reduced material budget, as well as the improved pointing resolution of the detectors, are crucial for the dielectron analysis. They will help controlling the background from photon conversions and heavy-flavor hadron decays within the dielectron spectra.

This poster will give an overview of the first performance studies for dielectron analyses with the ALICE experiment based on Run 3 data. It will summarize the techniques used to track, identify and select electrons and positrons. Furthermore, first results of the dielectron spectra and their corresponding signal-to-background ratios and significances will be presented together with a comparison to the results in Run 2.

Experiment/Theory:

ALICE

Affiliation:

Goethe University Frankfurt am Main

Poster Session - Karte: EM-4 / **149**

Prompt photon production with up to three jets in POWHEG

Autoren Tomas Jezo[1]; Michael Klasen[None]; Alexander Puck Neuwirth[None]

[1] *WWU ITP*

The production of prompt photons in association with jets is a very sensitive probe of the gluon distribution in light and heavy nuclei as well as of the properties of the quark-gluon plasma. We present a new calculation of prompt photon production with up to three jets at next-to-leading order of (NLO) QCD matched to parton showers with the POWHEG method. As applications, we examine correlations between the photon and the produced up to three jets as well as different approaches to photon fragmentation.

Experiment/Theory:

Theory/Phenomenology

Affiliation:

Institut für Theoretische Physik, WWU Münster

Poster Session - Karte: EM-5 / **174**

$\pi^+\pi^-$ and K^+K^- photoproduction in ultra-peripheral Pb–Pb collisions with ALICE

Autor Minjung Kim[1]

[1] *UC Berkeley*

Ultra-peripheral collisions (UPC) of heavy nuclei provide the opportunity to study interactions between high energy photons induced from the electromagnetic field of ultrarelativistic nuclei and the nuclei from the other beam. The photon fluctuates to a quark-antiquark dipole which then elastically scatters off the nucleus, emerging as vector meson and opposite-charge pseudoscalar meson pair.

The excellent particle identification capabilities of ALICE enable the study of photoproduced $\pi^+\pi^-$ pairs and K^+K^- pairs at midrapidity in Pb–Pb collisions at $\sqrt{s_{\mathrm{NN}}}$ = 5.02 TeV. We will present an analysis of the ρ^0 meson and direct $\pi^+\pi^-$ photoproduction exhibiting the interference, obtained from a fit to the invariant mass spectrum of $\pi^+\pi^-$ pairs. In addition, we will present the prospects of studying the photoproduction of direct K^+K^- pairs in UPCs.

Experiment/Theory:

ALICE

Affiliation:

University of California, Berkeley

Poster Session - Karte: EM-6 / **187**

Electromagnetic fields evolution and heavy flavor probes in relativistic heavy ion collisions

Autor Jiaxing Zhao[1]

Co-Autoren: Zeyan Wang [2]; Hu Jin [2]; Shuzhe Shi [3]; Zhe Xu [2]; Carsten Greiner [4]; Pengfei Zhuang [2]

[1] *SUBATECH*

[2] *Tsinghua University*

[3] *Stony Brook University*

[4] *Johann Wolfgang Goethe-Universitat Frankfurt*

The electromagnetic fields produced by non-central heavy ion collisions are extremely powerful and give rise to a plethora of fascinating subjects in the strongly interacting matter. Their evolution is a significant and unresolved issue.
In this talk, firstly, I will show the electromagnetic evolution in the pre-equilibrium stages which is a gluon-dominated and far-from-equilibrium system after the collisions. Quarks and antiquarks will be produced gradually via inelastic collisions. We find the induced magnetic field is very weak in this stage due to the lacking of quarks.
Next, I will present the new effect we proposed which is called the incomplete electromagnetic response of hot QCD matter.
We examine the validity of Ohm's law and find that the induced electric current increases from zero and relaxes towards the value from Ohm's law. The lower-than-expected electric current significantly suppresses the induced magnetic field and makes the electromagnetic response incomplete. And leads to a strong suppression of the magnetic field.
Considering both these two effects, the magnetic field will decay faster in heavy ion collisions, and which magnitude is much weaker than expected.
Finally, I will show our study on the charmonium dissociation under electromagnetic fields, which can be a sensitive probe for detecting the short-lived electromagnetic fields in heavy-ion collisions.

Experiment/Theory:

Theory/Phenomenology

Affiliation:

Subatech

Poster Session - Karte: EM-7 / **196**

The photon production and the collective flows from magnetic induced fusion and splitting in early stage of high energy nuclear collisions

Autor Moran Jia[1]

Co-Autoren: Defu Hou [1]; Huixia Li [1]

[1] *Central China Normal University*

In early stage of high energy nuclear collisions, the Lorentz contracted colliding nuclei nuclei fly near the light cone, with large-x partons acting as static sources of small-x modes that constitute the Color-Glass Condensate (CGC) fields. By interacting CGC fields, the chromoelectric and chromomagnetic fields are formed, they are the glasma fields. The glasma fields serve as initial condition for the evolution of classical gluon field at early stage which can be studied by Classical Yang-Mills equations. Noteworthily, in non-central collisions at early stage, the strong but short lived magnetic field is generated. Thus, interests of researchers have been triggered toward QCD matter with such extreme background.

As is known, photon is one of the most important probes in high energy nuclear collisions, and all its sources experience such intensive magnetic environment. In this talk, we are going to present our results of event-by-event study through 2+1D glasma simulations for mid-rapidity in overlap region of the two colliding nuclei. The photon can emit through gluon fusion or/and splitting in magnetic field. By including an IR regulator for the gluons, we'll show the non-trivial behavior of the photons' collective flows as well as the improvements (v_2 especially) on parton-hadronstring dynamics (PHSD) computations when comparing to the experiment measurements.

Experiment/Theory:

Theory/Phenomenology

Affiliation:

Central China Normal University

Poster Session - Karte: EM-8 / **270**

Topological separation of dielectron signals in Pb–Pb collisions with ALICE

Autor Jerome Jung[1]

[1] *Goethe University*

Dielectrons are an exceptional tool to study the evolution of the medium created in heavy-ion collisions. In central collisions, the energy densities are sufficient to create a quark-gluon plasma (QGP). Thermal e^+e^- pairs with invariant mass (m_{ee}) around 1.5 GeV/c^2 can be used to estimate the temperature of the QGP.
At LHC energies, the cross section of heavy-flavour (HF) production is large and correlated HF hadron decays dominate the dielectron yield for $m_{ee} > 1.1$ GeV/c^2. Their contribution is modified in the medium compared to elementary collisions to an unknown extent, leading to large uncertainties in the subtraction of known hadronic sources. A topological separation based on the distance-of-closest approach (DCA) to the primary vertex is a promising alternative approach. The decay length of HF hadrons is of the order of $c\tau \approx 100 - 500$ μm, hence their reconstructed decay electrons do not point to the primary vertex. This allows us to disentangle them from the prompt contribution of thermal dielectrons.
In this poster, preliminary results on the DCA_{ee} spectra of dielectrons produced in Pb–Pb collisions at $\sqrt{s_{\mathrm{NN}}} = 5.02$ TeV with ALICE will be presented. The measurements are compared to reference distributions from simulations and expectations from theory. Finally, a first attempt to extract a prompt thermal contribution in the intermediate mass region is performed by fitting the measured DCA_{ee} spectrum.

Experiment/Theory:

ALICE

Affiliation:

Goethe University Frankfurt

Poster Session - Karte: EM-9 / **278**

Dilepton anisotropy at low beam energies in a transport approach

Autoren Renan Hirayama[1]; Hannah Elfner[2]

[1] *FIAS*

[2] *GSI Darmstadt*

We present calculations of dielectron anisotropic flow in heavy-ion collisions at HADES beam energies from a hadronic transport approach. The collectivity of the electromagnetic radiation produced during the evolution of these collisions has recently been dubbed as a barometer, serving as a probe for the flow velocity of the underlying hadronic matter. In particular, we study the elliptic flow coefficient v_2 of dileptons in different collisions systems, and its relation to the flow of hadrons.

Experiment/Theory:

Theory/Phenomenology

Affiliation:

Frankfurt Institute for Advanced Studies (FIAS)

Poster Session - Karte: ET-1 / **42**

J/ψ photoproduction and exclusive dimuon production in p-Pb collisions at $\sqrt{s_{\mathrm{NN}}}$=8.16 TeV at the LHC with the ALICE experiment

Autoren Minjung Kim[1]; Michael Winn[2]

[1] *UC Berkeley*

[2] *Irfu/CEA-Saclay*

Photonuclear interactions are studied in ultra-peripheral p-Pb collisions with the ALICE experiment, where the photon radiated by a Pb nucleus probes the gluon density of the proton at low Bjorken-x. The exclusive J/ψ photoproduction cross section $\sigma(\gamma + \mathrm{p} \to \mathrm{J}/\psi + \mathrm{p})$ is expected to follow a power law trend as x decreases, but it should deviate from this trend at low x due to gluon saturation. In addition, gluon saturation effects are also expected to be visible when studying the dissociative J/ψ photoproduction cross section $\sigma(\gamma + \mathrm{p} \to \mathrm{J}/\psi + \mathrm{X})$ because of reduced quantum fluctuations of the substructure of the proton in the saturation regime. The ALICE collaboration has measured both processes. In this talk, the first measurement of the dissociative J/ψ photoproduction at the LHC will be presented. Finally, we will present the study of dimuon events produced in two-photon interactions. First results for low-mass dimuons will be discussed. Such measurements complement the studies of J/ψ photoproduction and contribute to a better understanding of the photon fluxes generated by the lead nucleus.

Experiment/Theory:

ALICE

Affiliation:

CERN

Poster Session - Karte: ET-2 / **95**

Disentangle effects from the initial stage and the evolution stage in heavy ion collisions using EPOS and PHSD

Autoren Mahbobeh Jafarpour[1]; Klaus Werner[2]

[1] *Subatech*

[2] *Subatech- Nantes University*

Keywords : Heavy-ion Collisions, Event generator, EPOS, PHSD, EPOSi+PHSDe, Quark-Gluon Plasma

Ultrarelativistic heavy-ion collisions at RHIC and the LHC provide a hot and ultra-dense form of matter composed of deconfined quarks and gluons, named QGP. Different models like EPOS and PHSD allow to study the space-time evolution of such heavy-ion collisions. Their dynamics is complicated; hence, various stages should be considered. The first is the primary scattering which defines to a large extent the matter distribution in the phase-space. The second stage concerns the evolution of the partonic system until the system is sufficiently dilute to hadronize. The EPOSi+PHSDe approach is introduced in this thesis, in which the EPOS model is used to determine the initial distribution of matter (partons/hadrons). This part is referred to as EPOSi. Then PHSD is employed to simulate the evolution of the matter in a non-equilibrium transport approach, referred to as PHSDe. The coupling of the two approaches is non-trivial and not straight-forward. Comparing the three models, EPOS, EPOSi+PHSDe, and PHSD, interesting results find concerning their respective space-time evolutions. The results demonstrate considerably different behavior in terms of radial expansion, especially asymmetric expansion, indicating that these three models will provide different results concerning key observables (pT/mT spectra, y/η distribution, v2/3/4) for Au-Au collisions at 200 GeV/A.

Experiment/Theory:

Theory/Phenomenology

Affiliation:

Subatech - Nantes University

Poster Session - Karte: ET-3 / **110**

Thermalization and quark production in a spatially homogeneous system of gluons

Autoren Sergio Barrera Cabodevila[1]; Carlos Salgado[2]; Bin Wu[2]

[1] *Instituto Galego de Física de Altas Enerxías (IGFAE)*

[2] *IGFAE*

We present a full set of the Boltzmann Equation in Diffusion Approximation (BEDA) for studying thermal equilibration of quarks and gluons. Using BEDA, we first analyse thermalization and quark production of spatially homogeneous systems initially made of pure gluons. We observe that soft partons, dominantly produced via medium-induced radiation, rapidly fill a thermal distribution with an effective (time-dependent) temperature and an effective Baryon chemical potential during the entire process. Without allowing quark production, the system is found to establish thermal equalibrium through distict three strages for initially under-populated cases and two stages for initially over-populated cases. Then, we study the production of quarks (and antiquarks) in such a system. The baryonic fermions are produced predominantly due to the $g \to qq$ splitting. We find that the quark production does not modify the early stages for both initially under- and over-populated systems due to Pauli blocking. During such early stages, the quark (and antiquark) number density increases

linearly with time. In contrast, the later stages are modified significantly by quark production. The relation of our studies to those using effective kinetic theory and the jet evolution in QCD medium will also be discussed.

Experiment/Theory:

Theory/Phenomenology

Affiliation:

Instituto Galego de Física de Altas Enerxías (IGFAE)

Poster Session - Karte: ET-4 / **129**

Flow and transverse momentum fluctuations in Pb+Pb and Xe+Xe collisions with ATLAS: assessing the initial condition of the QGP

Autor Ivan Gnesi[1]

[1] *CERN, Geneva (Switzerland), INFN LNF Frascati (Italy), CREF Rome (Italy), UniTo Turin (Italy)*

Constraining the initial condition of the QGP using experimental observables is one of the most important challenges in our field. Recent studies show that the Pearson Correlation Coefficient (PCC) between v_n and event-wise mean transverse momentum $[p_{\mathrm{T}}]$, $\rho_n(v_n, [p_{\mathrm{T}}])$, and $[p_{\mathrm{T}}]$ fluctuations can probe several ingredients of the initial state. This talk presents precision measurements of $v_n - [p_{\mathrm{T}}]$ correlation for n=2,3 and 4 and high order $[p_{\mathrm{T}}]$ fluctuations in ^{129}Xe+^{129}Xe and ^{208}Pb+^{208}Pb collisions, and they are found to be small in the mid-central and central collisions in these systems. The ρ_n and variance and skewness of $[p_{\mathrm{T}}]$ fluctuations show non-monotonic dependence on centrality, p_{T} and η. It was also found that the result depends on the centrality estimator used in the analysis, indicating a strong influence of volume fluctuations. In central collisions, where models generally show good agreement, the v_2–$[p_{\mathrm{T}}]$ correlations are sensitive to the triaxiality of the quadrupole deformation. A comparison of the model with the Pb+Pb and Xe+Xe data confirms that the ^{129}Xe nucleus is a highly deformed triaxial ellipsoid that has neither a prolate nor oblate shape. This provides strong evidence for a triaxial deformation of the ^{129}Xe nucleus from high-energy heavy-ion collisions.

Experiment/Theory:

ATLAS

Affiliation:

ATLAS Collaboration

Poster Session - Karte: ET-5 / **285**

Analytic and Semi-Analytic Results for Color Glass Condensate in the Weak-Field Limit

Autoren Stephen Robicheaux[1]; Rainer Fries[1]

[1] *Texas A&M University*

The classical field approximation to Color Glass Condensate for two colliding nuclei has been solved in the literature using numerical methods and recursive analytic solution. In the weak field limit, analytic solutions in transverse momentum space have also been known for some time. Based on the latter, we derive expressions for the space-time dependence of classical gluon 2-point functions $\langle F^{\mu\nu}(x^\alpha)F^{\kappa\lambda}(y^\beta)\rangle$ in the weak-field limit. For the McLerran-Venugopalan (MV) model, in many cases these expressions are shown to lead to solutions in closed analytic forms valid at all times. We also propose an alternative model which maintains UV-regularity by accounting for local correlations between color charges in the transverse plane. The new model allows for a straight forward calculation of the time dependence of the gluon energy momentum tensor and angular momentum density in early nuclear collisions in the weak field limit. We also discuss the initial motion of the nuclei after the collision.

Experiment/Theory:

Theory/Phenomenology

Affiliation:

Texas A&M University

Poster Session - Karte: ET-6 / **287**

Stabilizing complex Langevin for real-time gauge theory

Autoren Kirill Boguslavski[1]; Paul Hotzy[1]; David Mueller[1]

[1] *TU Wien*

Direct computations of QCD real-time observables like transport coefficients are very difficult due to the infamous sign problem. The complex Langevin (CL) method is a promising approach to overcome it by using a real-time formulation of QCD on a complex time contour. Studying SU(N_c) gauge theories with CL, we find that current stabilization techniques are insufficient to obtain correct results. Therefore, we introduce a novel anisotropic kernel that enables CL simulations on discretized time contours. Applying it to SU(2) pure gauge theory in 3+1 dimensions, we obtain unprecedentedly stable results that may allow us to calculate real-time observables from first principles in the near future.

Experiment/Theory:

Theory/Phenomenology

Affiliation:

TU Wien

Poster Session - Karte: ET-7 / **311**

Nuclear PDF determination using Markov Chain Monte Carlo methods

Autor Nasim Derakhshanian[1]

[1] *Institute of nuclear physics PAN*

Nuclear parton distribution functions (nPDFs) are an essential part in predictions of heavy-ion collisions. nPDFs have been determined via “global QCD analysis” in which nPDF-dependent prediction

of a given process compares with its actual measurement. The challenging part of nPDF extraction is the uncertainty estimation. The most common approach for this purpose is Hessian method which has certain shortcomings, especially in the case of nuclear PDFs. In this presentation I will show a case study for an alternative approach where nPDF uncertainties are estimated using the Markov Chain Monte Carlo (MCMC) methods.

Experiment/Theory:

Theory/Phenomenology

Affiliation:

Institute of nuclear physics PAN

Poster Session - Karte: ET-8 / **314**

Evolution of initial state fluctuations in the hotspot model

Autor Arjun Kumar[1]

[1] *Indian Institute of Technology Delhi*

The hotspot model has proven to be an efficient tool to study coherent and incoherent diffraction HERA data by modelling the initial state fluctuations of the gluon density of the proton. The hotspot model in its original form is a non-perturbative model applicable for low momentum transfer and underestimates the incoherent cross section in orders of magnitude when extended for large momentum transfer studies for J/ψ photo-production at HERA. We present here a model of hotspot splittings based on the resolution for the evolution of initial state fluctuations in the hotspot model inspired by the DGLAP parton shower approach This is reliable as both the Bjorken limit and the incoherent diffraction at large momentum transfer probes the gluon wave function at smaller length scales as we increase the resolution. In addition to the geometrical fluctuations, we have additional sources of fluctuations in our model namely the hotspot width, number, and normalisation fluctuations which leads to a good agreement of our model's prediction with data. In the framework developed, we obtain a good description of both the normalization and shape of coherent and incoherent differential cross sections (t-spectrum) simultaneously.

Experiment/Theory:

Theory/Phenomenology

Affiliation:

Indian Institute of Technology Delhi

Poster Session - Karte: FEF-1 / **194**

The jet physics program with sPHENIX

Autoren Megan Connors[None]; Virginia Bailey[None]

In Spring 2023, the sPHENIX detector at BNL's Relativistic Heavy Ion Collider (RHIC) will begin measuring a suite of unique jet and heavy flavor observables with unprecedented statistics and kinematic reach at the RHIC energies.
The combination of electromagnetic calorimetry, hadronic calorimetry, precision tracking, and the ability to record data at a very high rates enables measurements of jets, jet substructure, and jet correlations at RHIC with a kinematic reach that will overlap with similar measurements at the LHC. Jet

observables are a particularly useful probe of the Quark Gluon Plasma (QGP) formed in heavy-ion collisions since the hard scatted partons that fragment into final state jets are strongly “quenched” , losing energy to the medium as they traverse it. The detection method, physics projection and possible impacts to the field of heavy ion physics will be presented.

Experiment/Theory:

Other

Affiliation:

Iowa State University

Poster Session - Karte: HF-1 / **50**

Quarkonium production and flow in small systems measured with ALICE

Autor Tabea Maria Eder[None]

Quarkonium measurements in hadronic collisions can provide insights into quantum chromodynamics (QCD). The quarkonium formation involves both the perturbative and non-perturbative regimes of QCD and the mechanisms at play are not yet fully understood. In order to get new insights and help constraining model calculations, ALICE has measured several quarkonium observables in proton-proton (pp) collisions at $\sqrt{s}$ = 13 TeV. At this energy, new preliminary Υ cross section measurements, as well as the results of the J/ψ elliptic flow v_2 and double J/ψ production, will be presented. In addition, the contributions of prompt and non-prompt J/ψ can also be measured with ALICE detector.
In this contribution, we present new published results on the prompt and non-prompt J/ψ production at midrapidity in p-Pb collisions at $\sqrt{s_{\rm NN}}$ = 8.16 TeV. Finally, a first look at the quarkonium mass spectrum, produced at both mid and forward rapidity using fresh Run 3 data collected in pp collisions at $\sqrt{s}$ = 13.6 TeV will be shown.

Experiment/Theory:

ALICE

Affiliation:

ALICE

Poster Session - Karte: HF-10 / **202**

First performance results from upgraded LHCb and SMOG II

Autor Chiara Lucarelli[None]

The LHCb experiment has recently undergone a series of major upgrades: the entire tracking system has been replaced with higher-granularity sensors, the readout electronics have been upgraded, and all hardware triggers have been replaced with a new state-of-the-art streaming readout system. In addition, the gaseous target SMOG system has been upgraded with a dedicated storage cell to greatly increase the rate of fixed target collisions at LHCb. This talk will include the first performance results from the new LHCb tracking system, the streaming readout system, and SMOG II, with a focus on how these upgrades directly impact the LHCb heavy ion physics program. Further upgrades planned for LHC Run 4 and 5 will also be discussed.

Experiment/Theory:

LHCb

Affiliation:

On behalf of LHCb

Poster Session - Karte: HF-10 / **218**

Anisotropic quenching of heavy flavor in flowing matter

Autoren Xoán Mayo López[1]; Andrey Sadofyev[2]; João Barata[3]; Carlos Salgado[2]

[1] *Instituto Galego de Fisica de Altas Enerxías - IGFAE*

[2] *IGFAE*

[3] *BNL*

During the last years, there has been an increasing interest in how the quark mass affects the jet quenching phenomena and dynamics of heavy flavor in HIC. Here, we will present a new effect, which consists in anisotropic broadening and gluon radiation sourced by the background flow, transverse to the parton momentum, and sensitive to the quark mass. This effect appears due to a modification of the scattering potential in evolving matter, and scales as second power of mass over the parton energy. We will also discuss how this mass ordered anisotropy affects the overall heavy flavor directionality in HIC and its possible effect in the observed harmonic coefficients from the corresponding momentum anisotropy in both small and large systems.

Experiment/Theory:

Theory/Phenomenology

Affiliation:

Intituto Galego de Física de Altas Enerxías - IGFAE

Poster Session - Karte: HF-11 / **242**

Femtoscopic correlations of D0 mesons with identified hadrons in Au-Au collisions at sqrt{s_{{NN}} = 200 GeV at STAR

Autor Priyanka Roy Chowdhury[1]

[1] *Warsaw University of Technology*

Heavy quarks, like charm quarks, are produced early in the relativistic heavy-ion collisions and probe all stages of the evolution of the created medium –the Quark Gluons Plasma. Two-particle correlations at low relative momentum (the femtoscopic correlations) are sensitive to the interactions in the final state and the extent of the region from which correlated particles are emitted (so-called region of homogeneity). A study of such correlations between charmed mesons and identified hadrons could shed light on their interactions in the hadronic phase and interaction of charm quarks with the bulk partons.

We will present a study of femtoscopic correlations of D^0-π, D^0-K, D^0-proton pairs at mid-rapidity in Au+Au collisions at $\sqrt{s_{\rm NN}}$ = 200 GeV using data taken in the year 2014 by the STAR experiment. D^0 mesons are reconstructed via the K^--π^+ decay channel using topological criteria enabled by

the excellent track pointing resolution provided by the Heavy Flavor Tracker. We will present the femtoscopic correlation function for D^0 transverse momentum $p_{\rm T} > 1$ GeV/c in the 0-80% centrality.

Experiment/Theory:

STAR

Affiliation:

STAR

Poster Session - Karte: HF-12 / **264**

Quarkonium in the QGP from $N_f = 2 + 1$ lattice QCD

Autor Sajid Ali[1]

Co-Autoren: Hai-Tao Shu [2]; Tristan Ueding [3]; Olaf Kaczmarek [3]; Dibyendu Bala [3]

[1] *Bielefeld University, Germany*

[2] *Universität Regensburg*

[3] *Bielefeld University*

We present unquenched correlator data and corresponding reconstructed spectral functions for quarkonium in both pseudoscalar and vector channels. Correlators are obtained using clover-improved Wilson fermions on $N_f = 2 + 1$ HISQ lattices. To be on the constant line of physics bare quark masses are tuned to reproduce the mass spectrum of quarkonium by comparing the mass spectrum obtained from the lattice QCD with experimental values from the particle data group. For the spectral reconstruction, we use models based on perturbative spectral functions from different frequency regions like resummed thermal contributions around the threshold from pNRQCD and vacuum contributions well above the threshold. We show preliminary results of the reconstructed spectral function obtained for the first time in our study for full QCD. In addition, we compare the results with the previous continuum extrapolated results in the quenched approximation.

Experiment/Theory:

Theory/Phenomenology

Affiliation:

University of Bielefeld, Faculty of Physics, Universitätsstr. 25, D-33615 Bielefeld, Germany

Poster Session - Karte: HF-13 / **283**

Charm Meson Production in Relativistic Heavy-Ions Collisions in the context of Non-Extensive Statistics

Autoren Pedro Mariano Marques Mendes[1]; Marcelo Munhoz[1]

[1] *Universidade de São Paulo*

This project aims the application of non-extensive statistics, more specifically that proposed by C. Tsallis, in the study of the transverse momentum distribution of mesons composed of charm quarks produced in collisions between heavy ions at relativistic energies. Non-extensive statistics has been

very successful in the description of transverse momentum spectra of particles produced in hadronic collisions at high energies, whose interpretation of the non-extensive parameter q has been widely discussed. The success of this description might be connected to the degree of equilibrium reached in these collisions, an important condition for a broad understanding of its dynamics. This question is particularly important for heavy quarks in collisions between heavy ions, given its unique character in the investigation of the medium formed in these collisions. We will present some results of a systematic study of charm meson transverse momentum distributions fits, mainly the relative behavior of the temperature and q parameter for different particles and collision centralities, searching for an interpretation for the obtained results regarding the dynamics of charm quarks in these collisions.

Experiment/Theory:

Theory/Phenomenology

Affiliation:

Universidade de São Paulo

Poster Session - Karte: HF-14 / **284**

Measurement of the event multiplicity dependence of J/psi production in p+p collisions at √s = 500 GeV with STAR at RHIC

Autor Brennan Schaefer[1]

[1] *Lehigh University*

We present a new high-statistics measurement of inclusive J/ψ production versus event multiplicity in p+p collisions at $\sqrt{s} = 500$ GeV with the STAR experiment at RHIC. At mid-rapidity, calorimeter-triggered events are selected for candidate J/ψ detection in the dielectron decay channel. Existing measurements at both $\sqrt{s} = 200$ GeV from STAR and $\sqrt{s} = 7$ TeV from ALICE have shown a faster-than-linear rise as a function of mid-rapidity multiplicity. Potential dependence on collision energy is examined, and measurements are made separately for several intervals over a broad J/ψ transverse momentum range. Proposed explanatory mechanisms, including multi-parton interactions, string screening, and high gluon radiation are discussed, along with the guidance this measurement and related probes provide to model calculations.

Experiment/Theory:

STAR

Affiliation:

STAR

Poster Session - Karte: HF-2 / **55**

Measurement of Ξ_c^0 via the semileptonic decay channel in pp collisions and in p–Pb collisions with ALICE

Autor Sanghoon Lim[1]

[1] *Pusan National University*

Recent results of charmed baryon production in pp collisions showed a significant enhancement of the baryon-to-meson ratio compared with the expectation based on e^+e^- collisions. This indicates that the charm fragmentation into hadrons is not an universal process among different collision systems, and different mechanisms may play a role in the hadronic collisions with respect to e^+e^- collisions. Therefore, the measurements of charmed baryon production are crucial to investigate the hadronisation mechanism of charm quarks. The production yield measurement of the Ξ_c^0 baryon has been measured in pp collisions at $\sqrt{s} = 5$ and 13 TeV. Further studies of the multiplicity dependence of the baryon-to-meson yield ratios can provide more information on how the charm hadronisation processes evolve from small to large collision systems. Measurements in p-Pb collisions are important to separate the cold nuclear matter effects from the effects associated with the formation of quark-gluon plasma. In this contribution, the most recent measurements of the Ξ_c^0 production via the semileptonic decay channel $\Xi_c^0 \to \Xi^- e^+ \nu_e$ in pp collisions and the analysis status for the study of multiplicity dependence in pp and p-Pb collisions will be shown.

Experiment/Theory:

ALICE

Affiliation:

Pusan National University

Poster Session - Karte: HF-3 / **77**

Open heavy flavour production from the high mass dilepton spectrum in pp collisions at $\sqrt{s}$ = 13 TeV with ALICE

Autor Michele Pennisi[1]

[1] *INFN Torino*

Production measurements of heavy quark pairs in pp collisions are a known tool to test perturbative quantum chromodynamics calculations. In addition, they provide a reference for the corresponding studies in nuclear collisions. Indeed, in Pb-Pb collisions, the heavy quarks are produced at the early stages of the collision and can then experience full medium evolution. Open heavy flavor hadrons can therefore probe the quark-gluon plasma properties, as they are sensitive to the heavy quark energy loss in medium. A detection technique that was little explored at LHC energies is the analysis of the high-mass (i.e above the J/ψ mass) continuum of the dilepton invariant mass spectrum, which is dominantly populated by semi-leptonic decays of charm and beauty hadron pairs in pp collisions. In this presentation, new preliminary results from ALICE on the extraction of the charm and beauty hadron contributions to the high-mass dimuon continuum, at forward rapidity in pp collisions at $\sqrt{s}$ = 13 TeV, will be presented. Results from Pythia 8 Monte Carlo simulations used as input for the template fit of the data will be discussed.

Experiment/Theory:

ALICE

Affiliation:

ALICE

Poster Session - Karte: HF-4 / **96**

Measurement of non-prompt D^0 production in p-Pb collisions at $\sqrt{s_{\mathrm{NN}}}$ = 5.02 TeV with ALICE

Autor Mingyu Zhang[1]

[1] *Central China Normal University*

Measurements of the production of hadrons containing heavy quarks (charm and beauty) allow a study of cold nuclear matter (CNM) effects such as gluon saturation, shadowing and energy loss in p-Pb collisions. Understanding these effects is important for the proper interpretation of results in Pb-Pb collisions. In addition, the measurements provide the possibility to investigate the hadronisation mechanism.

In this poster, the first measurement of production cross section and nuclear modification factor of the D^0 originating from beauty hadron decays, called non-prompt D^0, at midrapidity in p-Pb collisions at $\sqrt{s_{\mathrm{NN}}}$ = 5.02 TeV with the ALICE detector will be presented. The non-prompt baryon-to-meson yield ratio $\Lambda_{\mathrm{c}}^{+}/\mathrm{D}^0$ will be discussed as well.

Experiment/Theory:

ALICE

Affiliation:

Central China Normal University

Poster Session - Karte: HF-5 / **120**

Longitudinal momentum fraction of heavy flavor meson in jets in high-energy nuclear collisions

Autoren Yao Li[1]; Wei Dai[2]; Ben-Wei Zhang[1]; Sa Wang[3]

[1] *Central China Normal University*

[2] *China university of Geosciences*

[3] *South China Normal University*

Heavy flavor jets are powerful tools to gain insight into the in-medium partonic energy loss mechanisms and the transport properties of the quark-gluon plasma (QGP) in high-energy nuclear collisions. In this work, we present the first theoretical study of the longitudinal momentum fraction $z_{||}$ carried by D^0 meson in jets in Pb+Pb collisions at $\sqrt{s_{\mathrm{NN}}}$ = 5.02 TeV. The p+p baseline is provided by POWHEG+PYTHIA8 which matches the next-to-leading order hard processes with the parton shower. The in-medium evolution of heavy quark jets is employed by a Monte Carlo transport model which takes into account the collsional and radiative partonic energy loss in the expanding QGP. We observe steeper $z_{||}$ distributions of B^0-jet compared to that of D^0-jet at the same kinematics region in p+p collisions, which may be a hint of the harder jet fragmentation function of b-jet compared to c-jet in vacuum. In A+A collisions, it is shown that the jet quenching effect would in general decrease the values of $z_{||}$. In addition, we predict visibly stronger nuclear modifications of B^0-jet $z_{||}$ distributions compared to D^0-jet within the same p_{T} windows, as a result of the much steeper initial $z_{||}$ distribution of B^0-jet in vacuum.

Experiment/Theory:

Theory/Phenomenology

Affiliation:

Central China Normal University

Poster Session - Karte: HF-6 / **141**

Measurement of jet performance in proton-lead collisions in the ATLAS experiment

Autor Patrycja Potępa[1]

[1] *AGH University of Science and Technology / Johannes Gutenberg Universitaet Mainz*

Jets can be copiously produced in heavy-ion collisions at the LHC energies. Their calibration is crucial for precise measurements of various processes, such as top-quark pair production. The poster presents the measurement of jet energy scale and resolution in proton-lead collisions collected at 8.16 TeV in 2016. The balance between Z boson and jet transverse momenta is explored for jet $p_{\mathrm{T}} > 20$ GeV and $|\eta| < 2.5$ to estimate jet performance in both data and simulation. The performance of two jet definitions, referred to as EMPFlow and HIJets, is studied and results are compared including systematic uncertainties. The presented results are a key input to the ongoing analysis of top-quark pair production in p+Pb collisions.

Experiment/Theory:

ATLAS

Affiliation:

ATLAS Collaboration

Poster Session - Karte: HF-7 / **171**

Can Transverse Mass Scaling Shed Light on the Event-Activity Dependence of Y-Mesons Production at LHC?

Autoren Alexander Milov[1]; Zvi Citron[2]

[1] *Weizmann Institute of Science*

[2] *The Ben Gurion University of the Negev*

Recent measurements by the CMS and ATLAS experiments reveal a deficit of charged particles in pp collisions with excited Y(nS) states compared to the Y(1S) ground state. This observation is suggested to be a manifestation of excited bottomonia suppression in pp interactions. The analysis presented in this talk is an independent approach, complementary to the CMS and ATLAS analyses, based on first physics principles that finds a significant suppression in the production of excited bottomonia states in pp collisions at the LHC energies. The analysis uses transverse mass scaling as an empirical tool to quantify the magnitude of the suppression. Based on the analysis of shapes of momentum distributions, one can conclude that the Y(2S) production in pp collisions is suppressed by a factor of approximately 1.6 and Y(3S) by a factor of approximately 2.4 from what would be expected from the momentum distribution of Y(1S). Details of the analysis and striking parallels to the findings of ATLAS and CMS experiments would help shed light on the nature of quarkonia production in pp collisions.

Based on https://arxiv.org/abs/2203.11831

Experiment/Theory:

Theory/Phenomenology

Affiliation:

Weizmann Institute of Science, Israel
The ben Gurion University of the Negev, Israel

Poster Session - Karte: HF-8 / **186**

Study of multiplicity-dependent charmonia production in p+p collisions at PHENIX

Autor Sanghoon Lim[1]

[1] *Pusan National University*

The production of quarkonia in high-energy heavy-ion collisions has been studied extensively to understand their production mechanisms and properties of Quark-Gluon Plasma (QGP). PHENIX has the capability to measure J/ψ with muon arms at forward and backward rapidity ($1.2 < |y| < 2.2$) and charged particle multiplicity with silicon trackers at various acceptance ranges. The recent PHENIX study shows an increasing trend of J/ψ yields versus multiplicity in p+p collisions, which implies that the multi-parton interactions contribute to the J/ψ production at the RHIC energy. $\psi(2S)$ have the same quark contents as J/ψ but different binding energies, so J/ψ and $\psi(2S)$ are expected to be modified differently due to the final-state effect like interaction with nuclear mediums or co-moving particles. Such different modifications can be applied to A+A collisions, even in small systems like p+A collisions; thus, understanding the modification mechanism is crucial for the precise understanding of the whole production mechanism. It will be very interesting to extend the study of the relative production of two states in various multiplicity ranges of p+p collisions. In this talk, we will present the study of multiplicity-dependent production of charmonia in p+p collisions with PHENIX, along with comparisons to the results from other experiments and MC based on PYTHIA8.

Experiment/Theory:

PHENIX

Affiliation:

Pusan National University

Poster Session - Karte: HMHC-1 / **72**

Particle yield modification in jet-like azimuthal V^0 -hadron correlations in Pb-Pb collisions at $\sqrt{s_{NN}}$ = 5.02 TeV with ALICE

Autor Mustafa Anaam[None]

Two-particle azimuthal correlations are a powerful tool to investigate the details of the mechanisms of jet quenching and hadron production. Suitable candidates for these studies are strange mesons (K^0_S) and baryons ($\Lambda/\overline{\Lambda}$), as their relative production rates differ for jets originating from quark or gluon. Measurements of near- and away-side hadron yields associated with these hadrons as trigger particles therefore provide additional constraining power for in-medium energy loss of different high-p_T partons and their fragmentation properties.

In this contribution, we present ratios of per-trigger yields in Pb-Pb collisions with respect to pp collisions, I_{AA} measured at midrapidity in the most central 0-10% collisions with the ALICE detector, with K^0_S, $\Lambda/\overline{\Lambda}$ and charged hadrons as trigger particles. A significant enhancement of I_{AA} for various particle species is found at the lowest associated-particle $p_{T,assoc}$ on both the near- and away-side, while a strong suppression of I_{AA} for $p_{T,assoc} > 3$ GeV/c on away-side is observed, as expected from

strong in-medium energy loss. The data are compared to HIJING, AMPT and EPOS models, where the latter two qualitatively describe the near- and away-side yield modifications at intermediate and high $p_{\mathrm{T,assoc}}$.

Experiment/Theory:

ALICE

Affiliation:

CERN

Poster Session - Karte: HMHC-2 / **105**

Measurement of ω meson production in pp and p–Pb collisions at $\sqrt{s_{\mathrm{NN}}} = 5.02$ TeV with ALICE

Autor Nicolas Strangmann[1]

[1] *Goethe University Frankfurt*

The ALICE experiment at the LHC investigates the properties of the hot and dense nuclear matter created in heavy-ion collisions. By comparing the particle production in pp and p–Pb collisions, possible nuclear initial state effects can be isolated. Measurements of the ω meson p_{T}-spectra in pp and p–Pb collisions not only allow for a determination of the nuclear modification factor R_{pA}, but also provide insights into the fragmentation process and serve as vital input for direct photon cocktail simulations.

The ω mesons can be reconstructed in ALICE via their primary decay channel into three pions ($\omega \rightarrow \pi^{+}\pi^{-}\pi^{0}$). While the two charged pions are being directly identified by the tracking detectors, i.e. the Time Projection Chamber and the Inner Tracking System, the π^{0} is reconstructed from its two decay photons. These photons can either be detected in the calorimeters or via tracks in case they convert to an electron-positron pair in the detector material.

In this poster, the measurement of the ω meson production in pp and p–Pb collisions at $\sqrt{s_{\mathrm{NN}}} = 5.02$ TeV will be presented. This includes the signal extraction and various corrections of the ω meson yields, as well as comparisons to theory calculations.

Experiment/Theory:

ALICE

Affiliation:

Goethe University Frankfurt

Poster Session - Karte: HMHC-3 / **109**

Measurement of neutral meson production as a function of multiplicity in pp collisions at $\sqrt{s}$ = 13 TeV with ALICE

Autor Joshua Koenig[1]

[1] *Goethe-Universität Frankfurt*

The precise measurement of the neutral meson production in pp collisions can be used to constrain fragmentation functions and parton density functions needed by pQCD calculations. Additionally, those measurements serve as input for direct photon analyses.
Moreover, the dependence of the neutral meson cross section on the event charged-particle multiplicity could give further insight into possible final-state effects in high-multiplicity pp collisions, in which other measurements show surprising similarities with those in heavy-ion collisions.

The analysis combines results from several partially independent reconstruction techniques available in ALICE. The decay photons were either detected with the electromagnetic calorimeters, or via the central tracking system using $\mathrm{e}^{+}\mathrm{e}^{-}$ pairs from conversions in the detector material.
The combination of these methods allows for a large p_{T} coverage, as well as small statistical and systematic uncertainties.

In this poster, the invariant cross sections of the π^0 and η meson in pp collisions at $\sqrt{s}$ = 13 TeV, measured with ALICE, for different charged-particle multiplicity classes will be presented. The measurement covers $0.2 \leq p_{\mathrm{T}} < 200$ GeV/c for the π^0 and $0.4 \leq p_{\mathrm{T}} < 50$ GeV/c for the η meson. Furthermore, the results will be compared to predictions from event generators and pQCD calculations.

Experiment/Theory:

ALICE

Affiliation:

Goethe-Universität Frankfurt

Poster Session - Karte: HMHC-4 / **168**

Assessing QGP momentum scales with energy correlators

Autoren Liliana Apolinário[1]; Carlota Andres[2]; Fabio Dominguez[3]; Raghav Kunnawalkam Elayavalli[4]

[1] *LIP*

[2] *CPHT, École polytechnique*

[3] *IGFAE, Universidade de Santiago de Compostela*

[4] *Vanderbilt University*

Correlation functions of energy flow operators have been recently proposed as a tool to identify the onset of colour coherence within the jets. As a promising exploration avenue to unveil the scales of the Quark-Gluon Plasma, it has yet to be demonstrated how the medium back-reaction to the jet propagation will blur such identification. In this work, by using a perturbative prescription to describe the jet-medium interactions and its re-scatterings, we show which weight of the normalised two-point correlator can maximise the separation between the wide range of momentum scales that go into the development of an in-medium jet: in-medium radiation and medium-recoiling particles. Additionally, we also explore the energy correlators' sensitivity to the different medium response momentum scales and their thermalization.

Experiment/Theory:

Theory/Phenomenology

Affiliation:

LIP - Laboratory of Instrumentation and Experimental Particle Physics, Lisbon, Portugal; IST - Instituto Superior Técnico, Lisbon, Portugal; CPHT, École polytechnique, France; IGFAE, Universidade de Santiago de Compostela, Spain; Vanderbilt University, Tennesse, USA

Poster Session - Karte: HMHC-5 / **185**

Anisotropic flow and the valence quark skeleton of hadrons

Autoren Meijian Li[1]; Wenyang Qian[1]; Bin Wu[2]; Hong Zhang[3]

[1] *University of Santiago de Compostela*

[2] *Universidade de Santiago de Compostela*

[3] *Shandong University*

We developed a formalism to study momentum anisotropy, in particular, the collective flow v_2, in the ultra-relativistic onium-onium scattering. We derived the impact-parameter dependent cross section up to the next-to-leading order in the eikonal approximation. With this formalism, we are able to interpret the origin and behavior of v_2 in the dilute limit, by investigating the elementary dipole-dipole scattering, $q\bar{q} + q\bar{q} \to g + X$. We calculated v_2 in the $\pi + \pi \to g + X$ process at a comprehensive coverage of impact parameter and transverse momentum. The valence sector light-front wave function of the π is obtained numerically from the Basis Light-Front Quantization, a non-perturbative light-front Hamiltonian approach, in a holographic basis. For comparison and as a complementary study, we also calculated v_2 in the $J/\psi + J/\psi \to g + X$ process. The J/ψ light-front wavefunction is built analytically from the phenomenological framework of Small-basis Light-Front Wavefunction. With this work, we have shown that momentum anisotropy can develop due to the interference of the valence quarks. This formalism is generic and can be applied to other hadrons and photons in the future.

Experiment/Theory:

Theory/Phenomenology

Affiliation:

Universtiy of Santiago de Compostela, Shandong University

Poster Session - Karte: HMHC-6 / **199**

Collectivity at LHCb

Autor Mateusz Goncerz[None]

Particle correlations are a powerful tool to study the bulk properties in relativistic heavy ion collisions. The momentum correlations between identical particles originating from the same particle-emitting source, referred to as the Bose-Einstein correlations, measure scales that are related to the geometrical size of the source. The two particle azimuthal angular correlations measure the momentum spatial anisotropy of produced particles, providing information on collective phenomena arising in the dense nuclear medium. This poster will discuss new LHCb measurements of Bose-Einstein correlations and collective flow coefficients in pPb and PbPb collisions in the forward rapidity region.

Experiment/Theory:

LHCb

Affiliation:

on behalf of the LHCb Collaboration, speaker to be defined later

Poster Session - Karte: HMHC-7 / **200**

Modification of b quark hadronization in high-multiplicity pp collisions at LHCb

Autor julie napora[1]

[1] *Los Alamos National Laboratory*

The differences in hadron chemistry observed at e^+e^- machines versus hadron colliders may indicate that the mechanisms by which partons evolve into visible matter are not universal. In particular, the influence of the underlying event in hadron collisions requires further study. With full particle ID, precision vertexing, and a high rate DAQ, the LHCb detector is uniquely well suited to study the hadronization of heavy b quarks. This talk will present LHCb data on hadronization of heavy bottom quarks, and discuss the status of a new LHCb analysis of bottom baryon production versus charged particle multiplicity.

Experiment/Theory:

LHCb

Affiliation:

On behalf of LHCb

Poster Session - Karte: HMHC-8 / **235**

Nuclear modification of charged hadrons and jets in isobar collisions at $\sqrt{s_{NN}}$ =200 GeV at STAR

Autor Isaac Mooney[1]

[1] *Yale University*

Partonic scatterings with high momentum transfer occur before the formation of the quark-gluon plasma (QGP) in heavy-ion (A+A) collisions and result in collimated collections of hadrons called jets. The modification of the parton shower in the QGP compared to that in proton-proton (p+p) collisions offers insight into the nature of the medium's interaction with colored probes. Typically, this is measured as a ratio of hadron or jet spectra in A+A and p+p collisions called the R_{AA}. The nominal RHIC A+A collision species is gold (Au) with 197 nucleons, but the high-statistics 2018 STAR isobar data from Zr+Zr and Ru+Ru collisions, each with 96 nucleons, offer the opportunity to study the system size dependence of nuclear modification of hard probes.

In this talk, we present a measurement of the inclusive charged hadron R_{AA} differentially with average number of participants ($<N_{\mathrm{part}}>$) in isobar collisions at STAR. The large available range of $<N_{\mathrm{part}}>$ in these data allows for comparisons to small systems and Au+Au results. We also present ongoing work to control the path length of the partons through the medium via event shape engineering. Events are categorized by their eccentricity, and within a given eccentricity and centrality class, jets traveling in the event plane direction are compared to those traveling perpendicular to it, in order to study the dependence of jet energy loss on the collision geometry.

Experiment/Theory:

STAR

Affiliation:

STAR

Poster Session - Karte: JETS-1 / **34**

Multiplicity dependence of charged-particle jet properties in pp and p-Pb collisions with ALICE

Autor DEBJANI BANERJEE[1]

Co-Autor: Reynier Cruz-Torres

[1] *Bose Institute*

Measurements of jet properties in small systems provide insights into perturbative and non-perturbative QCD aspects of jet structure and cold nuclear matter effects. Additionally, recent studies of high-multiplicity final states in small collision systems exhibit signatures of collective effects that are conventionally associated with the formation of hot and dense, color-deconfined QCD matter. However, no evidence of jet quenching has been observed within present accuracy in small collision systems. In this talk we will present recent ALICE measurements of intra-jet properties in pp collisions at $\sqrt{s} = 13$ TeV and p-Pb collisions at $\sqrt{s} = 5.02$ TeV: mean charged-constituent multiplicity, transverse momentum profile, and fragmentation distributions. These jet properties are compared between high-multiplicity and minimum-bias events in small collision systems. In addition, we will compare these results with various Monte Carlo generators.

Experiment/Theory:

ALICE

Affiliation:

CERN

Poster Session - Karte: JETS-10 / **275**

Data-driven quark and gluon jet modification

Autoren Jasmine Brewer[1]; Yueyang Ying[None]; Yi Chen[2]; Yen-Jie Lee[2]

[1] *CERN*

[2] *Massachusetts Institute of Technology*

Distinguishing between the modification of quark- and gluon-initiated jets in the quark-gluon plasma (QGP) remains an unresolved challenge without a definitive answer from experiment. We demonstrate that a fully data-driven technique, known as topic modeling, may be used to study the separate modification of quark and gluon jets experimentally. Our proof-of-concept study is based on proton-proton and heavy-ion collision events from the Pyquen generator with statistics accessible in Run 4 of the Large Hadron Collider. We use topic modeling to extract the separate modification of quark and gluon jet substructure in the QGP. We show that this data-driven technique is robust to large backgrounds in heavy-ion collisions by smearing our input distributions and obtaining similar results. These results suggest the potential for an experimental determination of quark and gluon jet substructure and their modification.

Experiment/Theory:

Theory/Phenomenology

Affiliation:

MIT, CERN

Poster Session - Karte: JETS-11 / **279**

Identifying quenched jets with machine learning

Autoren Julia Velkovska[1]; Lihan Liu[2]; Marta Verweij[3]; Yilun Wu[1]; Yilun Wu[2]

[1] *Vanderbilt University*

[2] *Vanderbilt*

[3] *Utrecht*

Measurements of jet substructure in ultra-relativistic heavy ion collisions suggest that the jet showering process is modified by the interaction with quark gluon plasma. Modifications of the hard substructure of jets can be explored with modern data-driven techniques. In this study, a machine learning approach to the identification of quenched jets is designed. Jet showering processes are simulated with a jet quenching model Jewel and a non-quenching model Pythia 8. Sequential substructure variables are extracted from the jet clustering history following an angular-ordered sequence and are used in the training of a neural network built on top of a long short-term memory network. We show that this approach successfully identifies the quenching effect in the presence of the large uncorrelated background of soft particles created in heavy ion collisions.

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based on arXiv: 2206.01628

Experiment/Theory:

Other

Affiliation:

Vanderbilt University, Utrecht University

Poster Session - Karte: JETS-12 / **294**

Jet Quenching with JEWEL+vUSPhydro+$\mathrm{T_R ENTo}$

Autoren Maria M. M. Paulino[1]; Fabio de Moraes Canedo[1]; Leonardo Barreto de Oliveira Campos[1]; Jacquelyn Noronha-Hostler[2]; Marcelo Munhoz[3]; Jorge Noronha[4]

[1] *University of São Paulo (USP)*

[2] *University of Illinois Urbana Champaign*

[3] *Universidade de São Paulo*

[4] *University of Illinois Urbana-Champaign*

We have studied the influence of realistic modeling of the medium formed in Relativistic Heavy-Ion collisions on Jet Quenching phenomena. We used JEWEL to simulate the medium modified parton shower and coupled it with vUSP-hydro+$\mathrm{T_R ENTo}$ models. We have studied the influence of these combination of models on jet observables such as R_{AA}, jet mass, x_J and subjet fragmentation. We have benchmarked our method with some of these observables and observed significant differences in these observables behavior when a realistic hydrodynamics is used on them.

Experiment/Theory:

Theory/Phenomenology

Affiliation:

Universidade de São Paulo, University of Illinois Urbana-Champaign

Poster Session - Karte: JETS-13 / **307**

Exploring transverse momentum broadening in expanding medium induced cascades

Autoren Souvik Priyam Adhya[1]; Krzysztof Kutak[2]; Wiesław Płaczek[3]; Martin Rohrmoser[4]; Konrad Tywoniuk[None]

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[4] *Cracow University of Technology*

In this work, we assess the impact of the expansion of the medium on angular distribution of gluons at different kinematical scales in a medium-induced cascade . Firstly, we study the scaling of the gluon spectra at low$-x$ between expanding and static medium profiles and apply them to obtain the transverse momentum broadened spectra. The numerical solutions for the in-medium cascades are obtained from the gluon evolution equations using the Monte Carlo event generator MINCAS. Additionally, we investigate the early and late onset of the initial quenching time for the Bjorken expanding profile. Next, we study the angular distributions for the in-cone radiation for different media and observe that the out-of-cone energy loss proceeds via the radiative break-up of hard fragments followed by an angular broadening of soft fragments. We note that for an effective in-medium path length, the angular distributions for soft fragments are very similar for different media. Also, harder jet fragments within the jets inside a cone are more sensitive to the details of the medium expansion as compared to softer fragments which are responsible for most of the gluon multiplicity in the cascade. Finally, we observe that cascades in the expanding media are relatively more collimated than in a static media and discuss phenomenological implications of our results on jet quenching observables.

Experiment/Theory:

Theory/Phenomenology

Affiliation:

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Poland.

Poster Session - Karte: JETS-2 / **62**

Measurement of the transverse momentum(j_{T}) distributions of charged-particle jet fragments in pp collisions at $\sqrt{s}$ = 5.02 TeV with ALICE

Autor Jaehyeok Ryu[1]

[1] *Pusan National University*

Jet fragmentation allows us to explore the evolution process of the QCD jets. It can be studied using the transverse momentum (j_{T}) and longitudinal momentum fraction (z) of constituent particles. The j_{T} distributions of jet fragments have been measured in pp and p—Pb collisions at $\sqrt{s}$, $\sqrt{s_{NN}}$ = 5.02 TeV with ALICE, and various parton-shower models reasonably describe the pp results. In this analysis, we extend the analysis to more detailed measurements of j_{T} distributions for charged-particle jets in pp collisions, in several z ranges. The z-dependent jT distributions will be compared with the theoretical predictions to test our current understanding of jet fragmentation and hadronisation.

Experiment/Theory:

ALICE

Affiliation:

Pusan National University

Poster Session - Karte: JETS-3 / **113**

Suppression of leading particles and flavor correlation modifications in heavy ion collisions

Autoren Yang-Ting Chien[1]; Isaac Mooney[2]; Roli Esha[3]; Diptanil Roy[4]; Weibin Zhang[3]; Mriganka Mouli Mondal[None]

[1] *Georgia State University*

[2] *Yale University*

[3] *Stony Brook University*

[4] *Rutgers University*

We study the suppression of leading two hadrons within jets and the modifications of their flavor correlations in heavy ion collisions. The di-hadron system is robust against the underlying event background therefore allows its precision measurements. Their suppression is sensitive to any partonic energy loss mechanism and can be used to cleanly test the onset of jet quenching in the evolution history. Also, their flavor correlation probes hadronization in the last stage of jet evolution. We will discuss di-hadron observables in the context of the upcoming RHIC measurements and present studies based on a variety of Monte Carlo simulations, which will lead to realistic measurement in the near future.

Experiment/Theory:

Theory/Phenomenology

Affiliation:

Georgia State University
Yale University
Rutgers University
Stony Brook University

Poster Session - Karte: JETS-4 / **142**

Dijet probes of the initial state in p+Pb collisions with ATLAS

Autor Aric Tate[None]

The measurement of the dijet production cross-section in p+Pb collisions is of great interest to the understanding of initial state effects. The analysis of this channel can provide input to the parameterization of the modification of parton distribution functions (PDFs) in nuclei and to search for the onset of non-linear QCD effects or gluon saturation at low Bjorken-x. In 2016, the ATLAS experiment at the LHC collected 164 nb^{-1} of data from p+Pb collisions at the center-of-mass energy of 8.16 TeV. This poster presents ATLAS preliminary results for the triple-differential inclusive dijet cross-section in p+Pb. The results of this measurement can be used to constrain nuclear PDFs over a broad kinematic range. The events characterized by at least one jet in the forward region are also analyzed as a function of centrality to compare the dijet production in central and peripheral collisions and search for evidence of gluon saturation.

Experiment/Theory:

ATLAS

Affiliation:

ATLAS Collaboration

Poster Session - Karte: JETS-5 / **144**

Studies of large-R jets and their substructure in Pb+Pb and pp collisions with ATLAS

Autor Martin Spousta[1]

[1] *Charles University*

Measurements of the jet substructure in Pb+Pb collisions provide information on the jet quenching in the quark-gluon plasma (QGP) created in these collisions, over a wide range of energy scales. This poster presents ATLAS measurement of the suppression of yields of large-radius jets and its dependence on the jet substructure, characterized by the presence of sub-jets. This measurement is performed using the large Pb+Pb data sample at the center-of-mass energy of 5.02 TeV recorded in 2018 and compared to the result from pp collisions at the same collision energy. Studies of the suppression of inclusive yields of large-R jets probe the angular redistribution of energy in the parton shower and medium response when compared to existing measurements of suppression of smaller jets. Further, this measurement might provide new information about the scales at which jet constituents lose energy coherently or as independent color charges.

Experiment/Theory:

ATLAS

Affiliation:

ATLAS Collaboration

Poster Session - Karte: JETS-6 / **148**

Substructures of heavy flavor jets in pp and Pb+Pb collisions at $\sqrt{s}$ = 5.02~TeV

Autoren Qing Zhang[1]; Wei Dai[2]; Lei Wang[1]; Ben-Wei Zhang[1]

[1] *Central China Normal University*

[2] *China university of Geosciences*

Groomed jet substructure measurements, the momentum splitting fraction z_g and the groomed jet radius R_g, for inclusive, D^0-tagged and B^0-tagged jets in pp and central Pb+Pb collisions at $\sqrt{s} = 5.02$ TeV are investigated. Theoretical results for light-quark initiated and gluon initiated jets are provided as references though experimentally indistinguishable for now. Charged jets are constrained in a relative low transverse momentum interval $15 \leq p_{\mathrm{T}}^{\mathrm{jet\ ch}} < 30$ GeV/c where the QCD emissions are sensitive to mass effects. The mass hierarchy manifests in z_g distributions in both parton showering and jet quenching indicating steeper splitting functions of heavier partons. The flavour differences induced by Casimir factors do not contribute to z_g distributions. Balanced splittings are suppressed due to jet quenching effects. The competition between flavor effects and mass effects to emission-angle distributions is directly observed for the first time. In both pp and Pb+Pb collisions, the mass hierarchy in R_g of inclusive, D^0-tagged and B^0-tagged jets is broken due to contributions from gluon-initiated jets. R_g shift to more broaden distributions due to medium-induced modifications.

Experiment/Theory:

Theory/Phenomenology

Affiliation:

Central China Normal University

Poster Session - Karte: JETS-7 / **181**

Exploring the impact of jet substructure observables on the Bayesian inference of medium properties

Autor Peter Jacobs[1]

[1] *LBNL*

Bayesian inference provides a powerful approach to constrain jet quenching model parameters using experimental measurements. It remains an open question, however, which jet observables provide complementary information in this approach, and in turn which observables the community should focus on measuring and calculating. In this talk we report a first, exploratory study which incorporates jet substructure observables in a Bayesian inference analysis of jet quenching, based on the JETSCAPE framework. We examine the additional information that jet substructure observables provide beyond that contained in inclusive jet and hadron suppression observables. We discuss the implications of these findings on the future experimental and theoretical jet quenching programs, including both opportunities and limitations offered by jet substructure observables.

Experiment/Theory:

Theory/Phenomenology

Affiliation:

JETSCAPE Collaboration

Poster Session - Karte: JETS-8 / **240**

Extended hydrodynamics regime and jet-medium interaction

Autoren Yi Yin[1]; Weiyao Ke[None]

[1] *Institute of Modern physics (CAS), China*

In the context of jet-medium interaction, we consider the response of QCD-like plasma to energy/momentum disturbance as a function of the gradient. For both N=4 super-Yang Mills theory in strong coupling limit and kinetic theory under relaxation time approximation, we find that hydrodynamic modes continue dominating medium's response even in the region where Knudsen number is large. However, in this extended hydrodynamic regime, both the first-order and second-order hydrodynamics fail to characterize medium's behavior. We construct a simple yet not trivial extension of the Muller-Israel-Stewart theory, namely MIS*, and show this novel framework can quantitatively describe hydrodynamic modes in both hydrodynamic and extended hydrodynamic regimes with a suitable choice of model parameters for representative microscopic theories with and without quasi-particle descriptions.We apply MIS* to study how a Bjorken-expanding QGP responds to a moving energetic parton.

[1] Weiyao Ke and Yi Yin, 2208.01046 .

Experiment/Theory:

Theory/Phenomenology

Affiliation:

Institute of modern physics, Chinese Academy of Science; Los Alamos National Laboratory.

Poster Session - Karte: JETS-9 / **271**

JEWEL and jet substructure in any collision system

Autor Isobel Kolbé[1]

[1] *IGFAE*

Understanding the apparent absence of the modification of high-p_T partons in small colliding systems has become critical. A major avenue of investigation that remains largely unexplored is the identification of observables that are experimentally more robust in small colliding systems than the traditional R_{AA}. In recent years the study of jet substructure observables in heavy-ion collisions has accelerated and we now have at our disposal several promising observables that merit investigation in small systems. In order to facilitate the process of comparing analytically viable observables with existing and future experimental results, we have developed a plugin for JEWEL (Jet Evolution With Energy Loss) that allows the user to pass hydrodynamic profiles from any collision system to JEWEL. Code suitable for use with (2+1)D temperature and fluid velocity profiles, fully compatible with the newest available version of JEWEL will be made available publicly, as well as simple RIVET analyses. We briefly detail the particularly careful treatment of the local fluid velocity, and present several jet substructure observables in a variety of collision systems.

Experiment/Theory:

Theory/Phenomenology

Affiliation:

IGFAE

Poster Session - Karte: HF-15 / **161**

Study of charm quark hadronization via Λ_c^+ and D_s^+ production in the CMS experiment

Autoren Soumik Chandra[1]; Milan Stojanovic[None]

[1] *PhD Student*

Measurements of the lightest open-charm baryon, Λ_c^+, production can provide important information about the quark coalescence process of hadronization in the quark-gluon plasma (QGP). With strange quark yields being enhanced in the presence of the QGP medium, the production of D_s^+ is expected to be enhanced in heavy ion collisions if recombination plays an important role in the hadronization process. The high-luminosity data sets collected by the CMS experiment in 2018 have been used to measure Λ_c^+ production via $\Lambda_c^+ \rightarrow p^+K^-\pi^+$ in the p_T range 3–30 GeV /c for pp collisions and 6–40 GeV /c for PbPb collisions in different centrality classes. The D_s^+ production is measured via the decay channel $D_s^+ \rightarrow \phi\pi^+ \rightarrow K^+K^-\pi^+$ in the p_T range 2–40 GeV /c in pp collisions and 6–40 GeV /c in PbPb collisions using the data sets collected by CMS detector in 2015. Results of the differential cross section of Λ_c^+ and D_s^+, the ratios of Λ_c^+ and D_s^+ over D^0 yields in pp and PbPb collisions will be presented along with the nuclear modification factors.

Experiment/Theory:

CMS

Affiliation:

CMS

Student Lectures / **360**

Welcome from the LOC chairs

Autor Chairs[None]

Experiment/Theory:

Affiliation:

Student Lectures / **359**

From high-momentum hadrons and correlations to jets

Autor Jana Bielcikova[None]

Experiment/Theory:

Affiliation:

Student Lectures / **363**

Introduction to GSI/FAIR + Q&A (Groups A+B)

Autor Frank Herfurth[1]

[1] *GSI*

Experiment/Theory:

Affiliation:

Student Lectures / **366**

FAIR Platform Visit (Groups C+D)

Autoren Patrick Dahm[1]; Tetyana Galatyuk[None]

[1] *GSI*

Experiment/Theory:

Affiliation:

Student Lectures / **365**

FAIR Platform Visit (Groups A+B)

Autoren Patrick Dahm[1]; Tetyana Galatyuk[None]

[1] *GSI*

Experiment/Theory:

Affiliation:

Student Lectures / **364**

Introduction to GSI/FAIR + Q&A (Groups C+D)

Autor Frank Herfurth[1]

[1] *GSI*

Experiment/Theory:

Affiliation:

Student Lectures / **358**

Future experimental facilities and detectors

Autor Luciano Musa[None]

Experiment/Theory:

Affiliation:

Student Lectures / **356**

Theory of hard processes in heavy-ion collisions

Autor Carlos Salgado[1]

[1] *IGFAE*

Experiment/Theory:

Affiliation:

Student Lectures / **357**

Heavy flavours and quarkonia

Autor Andrea Dainese[1]

[1] *INFN Padova*

Experiment/Theory:

Affiliation:

362

Registration