51st International Symposium on Multiparticle Dynamics (ISMD2022)

Sunday 31 July 2022 - Friday 5 August 2022

Book of Abstracts

Contents

Jets and QCD 1 / 1

Exploring quenching features of multi-partonic cascades in expanding medium

Authors: Carlos Albert Salgado Lopez[1]; Souvik Priyam Adhya[2]; Konrad Tywoniuk[3]; Martin Spousta[4]

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[2] *Institute of Nuclear Physics, Polish Academy of Sciences*

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[4] *Charles University (CZ)*

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Quenching features of mullti-partonic cascades in expanding media are important in understanding the complex phenomena of jet quenching. We present results for the inclusive jet R_{AA} by including phenomenologically driven combinations of quark and gluon fractions inside a jet. In addition, we have also studied the effect of the nPDF as well as vacuum like emissions on the jet R_{AA}. Differences among the estimated values of quenching parameter for different types of medium expansions are noted. Next, the impact of the expansion of the medium on the rapidity dependence of the jet R_{AA} as well as jet v_2 are studied in detail. Finally, we present qualitative results comparing the sensitivity of the time for the onset of the quenching for the Bjorken expanding profile on these observables. All the quantities calculated are compared with the recent ATLAS data.

Preferred track:

Jets & QCD at High Scales

Subfield:

Heavy-ion theory

Attending in-person?:

Yes

On behalf of collaboration?:

Poster Session / 2

Multistrange Hyperon Production on Nuclear Targets

Authors: Carlos Merino[1]; Gevorg H. Arakelyan[2]; Yuli M. Shabelski[3]

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[3] *Petersburg Nuclear Physics Institute NCR Kurchatov Institute*

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We consider the experimental data on yields of protons, strange Λ's, and multistrange baryons (Ξ, Ω), and antibaryons production on nuclear targets, and the experimental ratios of multistrange to strange antibaryon production, at the energy region from SPS up to LHC, and compare them to the results of the Quark-Gluon String Model calculations. In the case of heavy nucleus collisions, the

experimental dependence of the Ξ+/Λ, and, in particular, of the Ω+/Λ ratios, on the centrality of the collision, shows a manifest violation of quark combinatorial rules.

Preferred track:

Collectivity & Multiple Scattering

Subfield:

Heavy-ion theory

Attending in-person?:

Yes

On behalf of collaboration?:

High-temperature QCD 1 / 4

How the blast-wave model describes PID hadron spectra from 5 TeV p-Pb collisions

Author: Thomas Trainor[None]

Corresponding Author: ttrainor99@gmail.com

The blast-wave (BW) pt spectrum model has been applied extensively to nucleus-nucleus collision data at a variety of collision energies since commencement of the sulfur-beam program at the SPS. Initially, BW model analysis was intended as one means to demonstrate formation of a dense flowing medium or quark-gluon plasma (QGP) in more-central A-A collisions. In recent years the BW model has also been applied to p-p, d-Au and p-Pb collisions. Results appear to provide supporting evidence that collective flows and possible creation of QGP may occur in smaller collision systems as well. In this talk I consider several variations of the BW model and their supporting assumptions. As a specific example I review results from BW model analysis of identified-hadron (PID) pt spectra from 5 TeV p-Pb collisions. I provide a detailed examination of the shape evolution of model spectra in response to changing collision centrality and hadron species. Finally, I evaluate model fit quality using several conventional statistical measures.

Preferred track:

Collectivity & Multiple Scattering

Subfield:

Heavy-ion experiment

Attending in-person?:

Yes

On behalf of collaboration?:

Flash Talks / 5

Intermittency analysis of charged hadrons generated in Pb-Pb collisions at $\sqrt{s_{NN}}$ = 2.76 TeV and 5.02 TeV using PYTHIA8 / Angantyr

Authors: Ramni Gupta[1]; Salman K Malik[1]

[1] *University of Jammu (IN)*

Corresponding Author: salman.khurshid.malik@cern.ch

The search for the QCD critical point (CP), and the study of quark-hadron phase transition (and vice-versa), at finite baryon density and high temperature, is the main task in contemporary relativistic heavy-ion collision experiments. Fluctuation analysis with global and local measures is the basic tool to achieve this goal. Local density fluctuations are directly related to the critical behaviour in QCD. These fluctuations in the phase space are expected to scale according to universal power-law in the vicinity of critical-point. A search for such power-law fluctuations within the frame-work of the intermittency method is ongoing to locate the critical point of the strongly interacting matter. This method is used to probe the behaviour of these fluctuations through the measurement of normalized factorial moments (NFMs) in (η, ϕ) phase space. Observations and results from the intermittency analysis performed for generated charged hadrons in Pb+Pb collisions, at two different energies, using PYTHIA8/Angantyr for centrality as well as transverse momentum bin width dependence will be presented. We also made a comparison with published EPOS3 results at 2.76TeV.

Preferred track:

Collectivity & Multiple Scattering

Subfield:

HEP theory

Attending in-person?:

No

On behalf of collaboration?:

Hadron structure 3 / **11**

Parton physics of mesons in the limit of large number of colors

Author: Rajamani Narayanan[None]

Corresponding Author: rajamani.narayanan@gmail.com

Continuum reduction can be used to study mesons in the limit of large number of colors with no finite volume effects. We will describe some technical details that are relevant for such a numerical project and present results on the quark parton distribution functions of the pion in this limit.

Preferred track:

Hadron Structure

Subfield:

Nuclear theory

Attending in-person?:

Yes

On behalf of collaboration?:

High-temperature QCD 1 / **12**

Local thermalization of gluons

Author: Georg Wolschin[None]

Corresponding Author: wolschin@uni-hd.de

Fast local thermalization of gluons and quarks characterizes the initial stages of relativistic heavy-ion collisions. For a theoretical description, effective weakly-coupled kinetic theories that rely on the quantum Boltzmann equation have been proposed and solved numerically. In the present work, I aim to account for the time evolution during the rapid equilibration of partons through a nonlinear diffusion equation for the occupation-number distributions in the full momentum range. It is shown that in case of constant transport coefficients, the equation can be solved analytically in closed form through a nonlinear transformation. The occupation-number distribution is then obtained via the logarithmic derivative of a generalized (time-dependent) partition function.

Although the nonlinear boson diffusion equation (NBDE) for the thermalization of gluons had been proposed in [1], the analytical solution had initially been derived only for the free case. In order to obtain the full Bose-Einstein distribution in the stationary limit, however, one has to consider the IR boundary condition [2] at the singularity $p = \mu$ with the initial chemical potential $\mu_i < 0$ for number-conserving elastic gluon scatterings, and $\mu = 0$ for inelastic scatterings. It is shown that analytical solutions of the NBDE can still be obtained [2].

The model is applied to the equilibration of gluons in heavy-ion collisions at LHC energies, where initial central temperatures of $500 - 600$ MeV are reached in the course of local thermalization. Equilibrium is attained through the nonlinear evolution of the distribution functions at short times $t < 0.1$ fm/c in the infrared, whereas it takes more time in the large-momentum region to approach the Maxwell-Boltzmann tail of the distribution function. Thermalization in the IR occurs much faster through inelastic as compared to elastic gluon scatterings, thus preventing the formation of a gluon condensate via number-conserving elastic collisions. These results are consistent with QCD-based numerical findings in [3].

[1] Wolschin, G.: Equilibration in finite Bose systems. Physica A 499, 1 (2018).
[2] Wolschin, G.: Nonlinear diffusion of gluons. Physica A 597, 127299 (2022) .
[3] Blaizot, J.P., Liao, J., Mehtar-Tani, Y.: The thermalization of soft modes in non-expanding isotropic quark gluon plasmas. Nucl. Phys. A 961, 37 (2017).

Preferred track:

High-temperature QCD

Subfield:

Heavy-ion theory

Attending in-person?:

Yes

On behalf of collaboration?:

Hadron spectroscopy 1 / 13

Double charm tetraquark in DD^* scattering from lattice QCD

Authors: Padmanath Madanagopalan[None]; Sasa Prelovsek[1]

[1] *Jozef Stefan Institute, Ljubljana, Slovenia*

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The LHCb collaboration recently discovered a doubly charmed tetraquark T_{cc} with flavor $cc\bar{u}\bar{d}$ just $0.36(4)$ MeV below D^0D^{*+} threshold. This is the longest lived hadron with explicitly exotic quark content known to this date. We present the first lattice QCD study of DD^* scattering in this channel, involving rigorous determination of pole singularities in the related scattering amplitudes that point

to the existence of T_{cc}. Working with a heavier than physical light quark mass, we find evidence for a shallow virtual bound state pole in the DD^* scattering amplitude with $l = 0$, which is likely related to T_{cc}.

Preferred track:

Hadron Spectroscopy

Subfield:

HEP theory

Attending in-person?:

Yes

On behalf of collaboration?:

Collectivity & multiple-scattering 1 / 14

Missing beauty of proton-proton interactions

Authors: Alexander Milov[1]; Iakov Aizenberg[1]; Zvi Citron[2]

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[2] *Ben-Gurion University of the Negev (IL)*

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Multiparton interactions in proton-proton collisions have long been a topic of great interest. A new look at them has begun to emerge from work being done to understand the dynamics of 'small systems', a topic that is taking center stage in the physics of relativistic heavy-ion interactions. Numerous studies conducted at the LHC and lower energies reveal that proton-proton collisions at high energy form a system in which final state interactions substantially impact experimentally observable quantities in the soft sector. However, until recently, no evidence was shown that final state interactions could also affect observables produced in the hard scattering processes. Studies performed by the LHC experiments present strong evidence that the final state interactions in proton-proton collisions have a drastic impact on the b-quark bound states production, whose yields may be reduced by more than a factor of two.

Preferred track:

Hadronic Issues in Heavy-Flavour Physics

Subfield:

HEP experiment

Attending in-person?:

Yes

On behalf of collaboration?:

no, but closely related to ATLAS and CMS results

Jets and QCD 2 / 15

Resolving Extreme Jet Substructure

Author: Michael James Fenton[1]

[1] *University of California Irvine (US)*

Corresponding Author: michael.james.fenton@cern.ch

invited by Jets and QCD at high scales session conveners

Preferred track:

Jets & QCD at High Scales

Subfield:

HEP theory

Attending in-person?:

Yes

On behalf of collaboration?:

Heavy-flavour physics 1 / **16**

Recent results from Belle II

Author: Christian Wessel[1]

[1] *University of Bonn*

Corresponding Author: wessel@physik.uni-bonn.de

The Belle II experiment at the SuperKEKB energy-asymmetric e+e− collider is a substantial upgrade of the B factory facility at the Japanese KEK laboratory. The design luminosity of the machine is 6×1035 cm−2s−1 and the Belle II experiment aims to ultimately record 50 ab−1 of data, a factor of 50 more than its predecessor. With this data set, Belle II will be able to measure the Cabibbo-Kobayashi-Maskawa (CKM) matrix, the matrix elements and their phases, with unprecedented precision and explore flavor physics with B and charmed mesons. we will review the latest results from Belle II, with emphasis on those related to hadronic decay.

Preferred track:

Hadronic Issues in Heavy-Flavour Physics

Subfield:

HEP experiment

Attending in-person?:

Yes

On behalf of collaboration?:

Belle II

Jets and QCD 2 / **17**

Towards discrimination and improved modelling of dark-sector showers

Author: Sukanya Sinha[1]

Co-authors: Andy Buckley [2]; Deepak Kar [3]

[1] *University of Witwatersrand*

[2] *University of Glasgow (GB)*

[3] *University of the Witwatersrand (ZA)*

Corresponding Author: sukanya.sinha@cern.ch

As classic WIMP-based signatures for dark matter at the LHC have found no compelling evidence, several phenomenological studies have raised the possibility of accessing a strongly-interacting dark sector through new collider-event topologies. If dark mesons exist, their evolution and hadronization procedure are currently little constrained. They could decay promptly and result in QCD-like jet structures, even though the original decaying particles are dark sector ones; they could behave as semi-visible jets; or they could behave as completely detector-stable hadrons, in which case the final state is just the missing transverse momentum. In this contribution we will introduce a study performed to explore use of jet substructure methods to distinguish dark-sector from QCD jets in the first two scenarios, using observables in a IRC-safe linear basis, and discuss ways forward for this approach to dark-matter at the LHC, including prospects for estimating modelling uncertainties.

Preferred track:

Jets & QCD at High Scales

Subfield:

HEP theory

Attending in-person?:

Yes

On behalf of collaboration?:

No

Hadron structure 1 / 18

Recent advances in PDF determination: methodology and framework

Author: Alessandro Candido[None]

Corresponding Author: alessandro.candido@mi.infn.it

In the past year, several new achievements have been obtained by the NNPDF collaboration: the release of the 4.0 PDF set, the publication of the fitting code, the PDF4LHC20 combination, and a dedicated study on the intrinsic charm content of the proton.

I will review these progresses, and present the topics that are currently being investigated, to outline the future directions of interest for PDF extraction.

Preferred track:

Hadron Structure

Subfield:

HEP theory

Attending in-person?:

Yes

On behalf of collaboration?:

NNPDF

Hadron spectroscopy 1 / **19**

Hadron resonances from lattice QCD

Author: David Wilson[1]

[1] *University of Cambridge*

Corresponding Author: d.j.wilson@damtp.cam.ac.uk

Studying the spectroscopy of hadrons from lattice QCD, much like in experiment, involves determining hadronic scattering amplitudes and investigating enhancements due to resonances. Lattice QCD offers a method for first-principles computation of hadronic scattering amplitudes and thus enables resonance properties to be determined directly from the fundamental theory. I will present several recent examples of hadronic resonances determined from lattice QCD involving light and charm quarks.

Preferred track:

Hadron Spectroscopy

Subfield:

HEP theory

Attending in-person?:

Yes

On behalf of collaboration?:

the talk could be given on behalf the Hadron Spectrum Collaboration

Hadron structure 1 / **20**

MSHT20 PDFs review and recent developments

Author: Thomas Cridge[1]

[1] *University College London*

Corresponding Author: t.cridge@ucl.ac.uk

The MSHT20 PDFs represented a significant step forward in terms of the accuracy and precision of the resulting PDFs, and followed substantial progress on the experimental, methodological and theoretical fronts. I will review the MSHT20 PDFs before detailing several of the subsequent studies

we have undertaken within the MSHT collaboration, both completed and ongoing work. This will range from studies of the strong coupling and heavy quark mass sensitivity of the PDFs, to the production of MSHT20qed PDFs including QED effects and a photon PDF, through recent work on theoretical uncertainties and approximate N3LO PDFs, and finally the investigation of the impact of new data on the PDFs. I will also briefly outline the PDF4LHC21 combined PDFs, which include MSHT20 as an input along with the CT18 and NNPDF3.1 PDF sets.

Preferred track:

Hadron Structure

Subfield:

HEP theory

Attending in-person?:

Yes

On behalf of collaboration?:

Heavy flavour / hadron structure / **21**

Nucleon matrix elements using lattice QCD

Author: Rajan Gupta[None]

Corresponding Author: rajan@lanl.gov

This talk will provide a summary of the calculations of matrix elements of quark bilinear operators and CP violating Theta term between a nucleon state. Results for isovector and flavor diagonal charges, axial, electric and magnetic charges will be presented. A status of the contribution of CP violating operators from the standard model and BSM will be givn.

Preferred track:

Hadron Structure

Subfield:

HEP theory

Attending in-person?:

Yes

On behalf of collaboration?:

PNDME and NME collaborations

Heavy flavour / hadron structure / **23**

Lattice calculation of semileptonic B-meson decays

Author: Antonio Smecca[None]

Co-authors: Paolo Gambino [1]; Shoji Hashimoto [2]; Sandro Mächler [3]; Marco Panero [1]; Francesco Sanfilippo [4]; Silvano Simula [4]; Nazario Tantalo [5]

[1] *University of Turin*

[2] *KEK, SOKENDAI*

[3] *University of Turin, University of Zurich*

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We present the first results for the inclusive calculation of the B_s-meson decay rate and other related observables. The calculation is based on a recently proposed method for the study of inclusive decays on the lattice through the analysis of smeared spectral functions extracted from Euclidean correlation functions computed on the lattice. Here we present one possible route to perform such analysis which consists in reconstructing the smeared spectral function numerically. Furthermore, we show a comparison between the lattice QCD results and the theoretical predictions from the operator-product expansion.

Preferred track:

Hadronic Issues in Heavy-Flavour Physics

Subfield:

HEP theory

Attending in-person?:

Yes

On behalf of collaboration?:

Jets and QCD 1 / 24

Dynamically groomed jet radius in heavy-ion collisions

Authors: Adam Takacs[1]; Alba Soto-Ontoso[None]; Paul Caucal[2]

[1] *University of Bergen*

[2] *Brookhaven National Laboratory*

Corresponding Author: adam.takacs@uib.no

Jet substructure is a powerful tool to probe the perturbative regime of jet evolution in proton-proton and heavy-ion collisions. Over the past few years, a wide variety of substructure observables have been proposed in order to understand specific aspects of jet dynamics in a quark-gluon plasma (QGP).

In this talk, based on [1,2], we will explore the ability of such an observable, called Dynamical Grooming [3], to pin down the properties of the QGP. In particular, we will present the computation via analytic resummation techniques and Monte-Carlo simulations, of the opening angle θ_g of the hardest splitting in the jet as defined by Dynamical Grooming. This calculation, grounded in perturbative QCD, accounts for the factorization in time between vacuum-like and medium-induced processes in the double logarithmic approximation.
Our main result is that the dominating scale in the θ_g-distribution is the decoherence angle θ_c which characterizes the resolution power of the medium to propagating color probes, which makes this observable particularly interesting to measure ⌧⌧ experimentally. To that aim, we will highlight a suitable combination of the Dynamical Grooming condition and the jet radius that leads to a pQCD dominated observable with a very small sensitivity to medium response.

Refs:
[1] P. Caucal, A. Soto-Ontoso and A. Takacs, JHEP07(2021)020
[2] P. Caucal, A. Soto-Ontoso and A. Takacs, arXiv:2111.14768
[3] Y. Mehtar-Tani, A. Soto-Ontoso and K. Tywoniuk, Phys.Rev.D101,034004(2020)

Preferred track:

Jets & QCD at High Scales

Subfield:

Heavy-ion theory

Attending in-person?:

Yes

On behalf of collaboration?:

Hadron structure 2 / **25**

MSHT20 Approximate N3LO Parton Distribution Functions with Theoretical Uncertainties

Author: Jamie W McGowan[None]

Co-authors: Thomas Cridge [1]; Lucian Harland-Lang [2]; Robert Samuel Thorne [3]

[1] *University College London*

[2] *University of Oxford*

[3] *University College London (UK)*

Corresponding Author: j.mcgowan.18@ucl.ac.uk

The standard for parton distribution function (PDF) fits is at next-to-next-to-leading order (NNLO) in the strong coupling constant (α_s). However, as we move into a new era of high precision phenomenology, experimental physics is pushing the need for a robust understanding of theoretical uncertainties to new levels. Due to the perturbative nature of calculations in Quantum Chromodynamics (QCD) with respect to α_s, the leading theoretical uncertainty in PDFs arises from the truncation of perturbative expansions. We demonstrate how using the currently available knowledge about N^{3}LO (an order above the standard NNLO) can provide consistent, justifiable and explainable estimates for missing higher order uncertainties (MHOUs). Using an expanded Hessian procedure from previous MSHT fits, we present the first approximate N^{3}LO PDF fit with theoretical uncertainties. The phenomenological impact of using the approximate N^{3}LO PDFs is then assessed and compared with NNLO results.

Preferred track:

Hadron Structure

Subfield:

HEP theory

Attending in-person?:

Yes

On behalf of collaboration?:

No

Collectivity & multiple-scattering 2 / **27**

Can quantized fragmentation replace colour reconnection models ?

Author: Sarka Todorova[1]

[1] *Charles University (CZ)*

Corresponding Authors: todorova@cern.ch, sarka.todorova@cern.ch

A brief overview of properties of the model of quantized fragmentation of a helical QCD string followed by the discussion of the evolution of average transverse momentum in hadronic events, as function of leading particle pT and particle multiplicity. Reference to experimental data is included.

Preferred track:

Jets & QCD at High Scales

Subfield:

HEP theory

Attending in-person?:

Yes

On behalf of collaboration?:

Collectivity & multiple-scattering 2 / 29

Directed flow of identified particles in Au+Au collisions at $\sqrt{s_{NN}}$ = 14.6 and 19.6 GeV from RHIC Beam Energy Scan

Author: Zuowen Liu[None]

Co-author: STAR Collaboration

Corresponding Author: liuzw@mails.ccnu.edu.cn

Determination of equation of state for nuclear matter at high baryon density region is one of the most important motivations for RHIC Beam Energy Scan program. Directed flow (v_1), which is the first harmonic coefficient in the Fourier expansion of the final state azimuthal distribution of produced particles relative to the collision reaction plane, is one of good probes to early stage of collision dynamics for its high sensitivity.
STAR Beam Energy Scan program phase I (BES-I) covers collision energies from $\sqrt{s_{NN}}$ = 7.7 GeV to 200 GeV. We observed that v_1 slopes ($dv_1/dy|_{y=0}$) at mid-rapidity for net-proton and net-Λ show a double sign change with minimum when collision energy is around $\sqrt{s_{NN}}$ = 10-20 GeV. The slope of ϕ mesons has a hint of sign change at 11.5 GeV. With large statistics from BES-II, we will present v_1 results of $\pi^{\pm}$, $K^{\pm}$, $p(\bar{p})$, $\Lambda(\bar{\Lambda})$, and construct corresponding net-particles. Their v_1 slopes will be studied as a function of centrality and collision energy. The precise data will help to constrain the model calculations and offer information about equation of state for nuclear matter.

On behalf of collaboration?:

STAR

Preferred track:

Collectivity & Multiple Scattering

Subfield:

Heavy-ion experiment

Attending in-person?:

No

Forward & diffractive physics 1 / 31

Anomalous coupling studies with intact protons at the LHC

Authors: Andrea Bellora[1]; Christophe Royon[2]; Cristian Baldenegro Barrera[3]; Michael Pitt[4]

[1] *Universita e INFN Torino (IT)*

[2] *The University of Kansas (US)*

[3] *Laboratoire Leprince-Ringuet*

[4] *CERN*

Corresponding Authors: christophe.royon@cern.ch, c.baldenegro@cern.ch

We describe the gain on sensitivities to quartic $\gamma\gamma\gamma\gamma$, $\gamma\gamma WW$ and $\gamma\gamma\gamma Z$ anomalous couplings and to the search for Axion-Like Particles by two or three orders of magnitude with respect to standard methods at the LHC by tagging intact protons in the final state, and matching the information from the intact protons and the WW, ZZ, γZ, $\gamma\gamma$ in the main CMS and ATLAS detectors. We will also describe the sensitivity to $\gamma\gamma t\bar{t}$ that was recently submitted for publication.

Preferred track:

Jets & QCD at High Scales

Subfield:

HEP theory

Attending in-person?:

Yes

On behalf of collaboration?:

Forward & diffractive physics 2 / 32

All-Order Merging of High Energy and Soft-Collinear Resummation

Authors: Hitham Hassan[1]; Jeppe Andersen[1]; Sebastian Jaskiewicz[1]

[1] *IPPP, Durham University*

Corresponding Author: hitham.t.hassan@durham.ac.uk

We present a method of merging the exclusive LO-matched high energy resummation of High Energy Jets (HEJ) with the parton shower of Pythia which preserves the accuracy of the LO cross sections and the logarithmic accuracy of both resummation schemes across all of phase space. Predictions produced with this merging prescription are presented with comparisons to data from previous experimental studies and suggestions are made for further observables and experimental cuts which highlight the importance of both high energy and soft-collinear effects.

Preferred track:

Forward & Diffractive Physics

Subfield:

HEP theory

Attending in-person?:

Yes

On behalf of collaboration?:

Collectivity & multiple-scattering 1 / 33

An effective theory of medium induced radiation

Authors: Adam Takacs[1]; Johannes Hamre Isaksen[1]; Konrad Tywoniuk[2]

[1] *University of Bergen*

[2] *University of Bergen (NO)*

Corresponding Author: jhisaksen@outlook.com

We revisit the picture of jets propagating in the quark-gluon plasma. In addition to vacuum radiation, related to the high initial virtuality of a jet, jet particles scatter on the medium constituents resulting in induced emissions. Analytical approaches to resumming these interactions have traditionally dealt separately with multiple, soft [1,2], or rare, hard scatterings [3,4]. A full resummation has so far only been available using numerical methods [5,6,7]. Our goal is to achieve full analytical control of the relevant scales and map out the dominant physical processes in the full phase space. To this aim, we extend existing resummation schemes for the medium-induced spectrum [4,8,9] to the Bethe-Heitler regime, to cover the whole phase space from early to late times, and from hard splittings to emission below the thermal scale. Based on the separation of scales, a space-time picture naturally emerges: at early times, jets start to build from both vacuum and rare, hard scattering induced emissions. At a later stage, determined by a resolution criterion, these emissions initiate a turbulent cascade [10] that rapidly degrades their energy down to, and including the Bethe-Heitler regime. We quantify the impact of such an improved picture, compared to the current state of the art factorization that includes only soft scatterings [11], by both analytical and numerical methods for the jet fragmentation function. Our work serves to improve our understanding of jet quenching from small to large systems and for future upgrades of Monte Carlo generators.

[1] R. Baier, Y. L. Dokshitzer, A. H. Mueller, S. Peigne, and D. Schiff, Nucl. Phys. B 483 (1997) 291–320.
[2] B. Zakharov, JETP Lett. 63 (1996) 952–957.
[3] M. Gyulassy, P. Levai, and I. Vitev, Nucl. Phys. B 594 (2001) 371–419.
[4] U. A. Wiedemann, Nucl. Phys. B 588 (2000) 303–344.
[5] S. Caron-Huot and C. Gale, Phys. Rev. C82 (2010) 064902.
[6] C. Andres, L. Apolinario, and F. Dominguez, JHEP 07 (2020) 114.
[7] S. Schlichting and I. Soudi, arXiv:2111.13731.
[8] Y. Mehtar-Tani, JHEP 07 (2019) 057.
[9] J. a. Barata and Y. Mehtar-Tani, JHEP 10 (2020) 176.
[10] J.-P. Blaizot, E. Iancu, and Y. Mehtar-Tani, Phys. Rev. Lett. 111 (2013) 052001.
[11] P. Caucal, E. Iancu, A. H. Mueller, and G. Soyez, Phys. Rev. Lett. 120 (2018) 232001.

Preferred track:

Jets & QCD at High Scales

Subfield:

Heavy-ion theory

Attending in-person?:

Yes

On behalf of collaboration?:

Forward & diffractive physics 2 / 34

One-loop corrections to dihadron production in DIS at small x

Author: Jamal Jalilian-Marian[None]

Co-author: Filip Bergabo [1]

[1] *Baruch College, CUNY*

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We calculate the one-loop corrections to dihadron production in DIS at small x using the Color Glass Condensate effective theory of QCD to describe the target dynamics. We show that UV and soft divergences cancel while collinear divergences are absorbed into hadron fragmentation functions. The rapidity divergences lead to JIMWLK evolution of dipoles and quadrupoles in terms of which the production cross section is given. We discuss the phenomenological implications of our results for dihadron angular correlations in EIC.

Preferred track:

Forward & Diffractive Physics

Subfield:

Heavy-ion theory

Attending in-person?:

Yes

On behalf of collaboration?:

Forward & diffractive physics 1 / 36

Diffractive measurements from CMS

Authors: CMS[None]; Christophe Royon[1]

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Corresponding Authors: c.baldenegro@cern.ch, christophe.royon@cern.ch

Recent results on diffractive measurements will be presented.

Preferred track:

Forward & Diffractive Physics

Subfield:

HEP experiment

Attending in-person?:

Yes

On behalf of collaboration?:

CMS

Hadron spectroscopy / Jets / **38**

Recent results on long lived particle searches at the LHC

Corresponding Author: claudia.gemme@cern.ch

Invited by Jets and QCD at high scales session convener"

Preferred track:

Jets & QCD at High Scales

Subfield:

HEP experiment

Attending in-person?:

Yes

On behalf of collaboration?:

All four LHC experiments

Flash Talks / **39**

Production of Z boson in association with high-pt jet (Z-collinear)

Corresponding Author: alexandre.laurier@cern.ch

Cross-section measurements for a Z boson produced in association with high-transverse-momentum jets (pT > 100 GeV) and decaying into a charged-lepton pair are presented. The measurements are performed using proton-proton collisions at sort(s) = 13 TeV corresponding to an integrated luminosity of 139 fbˆ-1 collected by the ATLAS experiment at the LHC. Measurements of angular correlations between the Z boson and the closest jet are performed in events with at least one jet with pT > 500 GeV. Event topologies of particular interest are the collinear emission of a Z boson in dijet events and a boosted Z boson recoiling against a jet. Fiducial cross sections are compared with state-of-the-art theoretical predictions. The data are found to agree with next-to-next-to-leading-order predictions by NNLOjet and with the next-to-leading-order multi-leg generators MadGraph5_aMC@NLO and Sherpa.

Preferred track:

Jets & QCD at High Scales

Subfield:

HEP experiment

Attending in-person?:

Yes

On behalf of collaboration?:

ATLAS Collaboration

Hadron structure 1 / **40**

Determination of proton parton distribution functions using ATLAS and CMS data

Corresponding Author: paul.richard.newman@cern.ch

We present fits to determine parton distribution functions (PDFs) using a diverse set of measurements from the ATLAS experiment at the LHC, including inclusive W and Z boson production, ttbar production, W+jets and Z+jets production, inclusive jet production and direct photon production. These ATLAS measurements are used in combination with deep-inelastic scattering data from HERA. Particular attention is paid to the correlation of systematic uncertainties within and between the various ATLAS data sets and to the impact of model, theoretical and parameterisation uncertainties.

Preferred track:

Hadron Structure

Subfield:

HEP experiment

Attending in-person?:

Yes

On behalf of collaboration?:

ATLAS Collaboration

Poster Session / **41**

Helix string fragmentation and charged particle correlations with ATLAS

Co-author: Sarka Todorova [1]

[1] *Charles University (CZ)*

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Correlations between charged particles provide important insight about hadronization process. The analysis of the momentum difference between charged hadrons in pp, p-lead, and lead-lead collisions of various energies is performed in order to study the dynamics of hadron formation. The spectra of correlated hadron chains are explored and compared to the predictions based on the quantized fragmentation of a three dimensional QCD helix string. This provides an alternative view of the

two-particle correlation phenomenon typically attributed to the Bose-Einstein correlation, which will also be presented.

Preferred track:

Collectivity & Multiple Scattering

Subfield:

HEP experiment

Attending in-person?:

Yes

On behalf of collaboration?:

ATLAS Collaboration

Flash Talks / **44**

Forward proton measurements with ATLAS

Corresponding Author: mustafa.schmidt@cern.ch

The elastic scattering of protons at 13 TeV is measured in the range of protons transverse momenta allowing the access to the Coulomb-Nuclear-Interference region. The data were collected thanks to dedicated special LHC beta* = 2.5km optics. The total cross section as well as rho-parameter, the ratio of the real to imaginary part of the forward elastic scattering amplitude, are measured and compared to various models and to results from other experiments. The measurement of exclusive production of pion pairs at the LHC using 7 TeV data is also presented. This represents the first use of proton tagging to measure an exclusive hadronic final state at the LHC.

Preferred track:

Forward & Diffractive Physics

Subfield:

HEP experiment

Attending in-person?:

Yes

On behalf of collaboration?:

ATLAS Collaboration

Poster Session / **45**

Precision measurements of jet and photon production at the ATLAS experiment

Corresponding Author: giuseppe.callea@cern.ch

The production of jets and prompt isolated photons at hadron colliders provides stringent tests of perturbative QCD. We present the latest measurements using proton-proton collision data collected by the ATLAS experiment at sqrt(s)=13 TeV. Prompt inclusive photon production is measured for two distinct photon isolation cones, R=0.2 and 0.4, as well as for their ratio. The measurement is sensitive to gluon parton density distribution. In addition, we present the measurements of variables probing the properties of the multijet energy flow and measurements extremely sensitive to the strong coupling constant. If ready, the determination of the strong coupling constant will be presented. The measurements are compared to state-of-the-art NLO and NNLO predictions.

Preferred track:

Jets & QCD at High Scales

Subfield:

HEP experiment

Attending in-person?:

Yes

On behalf of collaboration?:

ATLAS Collaboration

Collectivity & multiple-scattering 1 / **46**

Photon-photon fusion and tau g-2 measurement in ATLAS

Author: Agnieszka Ewa Ogrodnik[1]

[1] *AGH University of Science and Technology (PL)*

Corresponding Author: agnieszka.ogrodnik@cern.ch

Relativistic heavy-ion beams at the LHC are accompanied by a large flux of equivalent photons. New measurements of exclusive dilepton production (electron, muon, and tau pairs) are discussed. We present the photon-induced production of tau pairs and constraints on the tau lepton's anomalous magnetic dipole moment. In addition, measurements of photon-induced electron and muon pair production are presented, which provide strong constraints on the nuclear photon flux and its dependence on the impact parameter and photon energy. Forward neutrons are utilized to provide an experimental handle on the impact parameter range sampled in the events.

Preferred track:

Collectivity & Multiple Scattering

Subfield:

HEP experiment

Attending in-person?:

Yes

On behalf of collaboration?:

ATLAS Collaboration

Hadron spectroscopy / Jets / 47

ATLAS results on exotic hadronic resonances

Co-author: Yue Xu [1]

[1] *Tsinghua University (CN)*

Corresponding Author: yue.xu@cern.ch

Recent results from the proton-proton collision data taken by the ATLAS experiment on exotic resonances will be presented. A search for $J/\psi\, p$ resonances in $\Lambda_b \to J/\psi\, pK$ decays with large pK invariant masses will be reported. Studies of Z_c states in B-meson decays with the Run 2 data at 13 TeV will also be discussed. Searches for exotic resonances in 4 muon final states will be shown.

Preferred track:

Hadron Spectroscopy

Subfield:

HEP experiment

Attending in-person?:

Yes

On behalf of collaboration?:

ATLAS Collaboration

Flash Talks / 50

ATLAS measurements of correlations between Upsilon mesons and inclusive charged particles

Author: Iakov Aizenberg[1]

Co-author: Zvi Citron [2]

[1] *Weizmann Institute of Science (IL)*

[2] *Ben-Gurion University of the Negev (IL)*

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This talk presents 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 in 13 TeV pp collisions. Measurements are made differentially for Upsilon momentum and for different Upsilon states. The analysis is performed using the full-luminosity ATLAS Run-2 13 TeV pp data. This measurement benefits from the heavy-ion style approach to remove the combinatorial and pileup backgrounds leading to increased sensitivity. 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.

Preferred track:

Hadron Spectroscopy

Subfield:

HEP experiment

Attending in-person?:

Yes

On behalf of collaboration?:

ATLAS Collaboration

Flash Talks / 51

The role of the underlying event in the charm-baryon enhancement observed in pp collisions at LHC energies

Authors: Robert Vertesi[1]; Zoltan Varga[1]

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The factorization hypothesis states that the production cross-section of heavy-flavor hadrons can be calculated as the convolution of three independent terms: the parton distribution function of the colliding hadrons, the production cross sections of the heavy-quarks in the hard partonic process, and finally the fragmentation functions of the heavy-flavor quarks into the given heavy-flavor hadron species. The fragmentation function has been traditionally treated as universal, i.e. independent of the collision systems.

Recent charmed-baryon measurements by ALICE and CMS show a low-momentum enhancement over model predictions based on e^+e^- collisions, which challenges this traditional assumption [1,2]. One of the latest measurements also shows that this enhancement depends on the final-state multiplicity of the collision event [3]. Several scenarios have been proposed to explain the emerging pattern, including string formation beyond leading order, the so-called enhanced color re-connection [4], which provides a qualitatively correct description of these findings for pp collisions.

In our contribution, we investigated the charm-baryon enhancement with PYTHIA 8 Monte-Carlo generator and enhanced color-reconnection models. We proposed a method based on several event-activity classifiers to identify the source of the charm-baryon enhancement. We conclude that, within the scenario under investigation, the excess Λ_c production is connected to the underlying event and not to the jet production [5]. We also present studies with several charmed-baryon species that address the role of the quark content and isospin state and allow for the comparison of charm and strange-baryon enhancement mechanisms.
These new observables will provide a unique opportunity in the upcoming measurements from the high-luminosity LHC Run3 phase to understand charm fragmentation mechanisms, and will serve as valuable means for further model development.

[1] CMS Coll., Phys. Lett. B 803 (2020) 135328, arXiv:1906.03322.
[2] ALICE Coll., Physicial Review Letters 127, 202301 (2021), arXiv:2011.06078.
[3] ALICE Coll., Phys.Lett.B 829 (2022) 137065, arXiv:2111.11948.
[4] C., J.R., S., P.Z., JHEP 2015, 3 (2015), arXiv:1505.01681.
[5] Z. V., R. V., Submitted to J.Phys.G. (accepted), arXiv:2111.00060.

Preferred track:

Hadronic Issues in Heavy-Flavour Physics

Subfield:

Nuclear experiment

Attending in-person?:

Yes

On behalf of collaboration?:

Collectivity & multiple-scattering 2 / **52**

Measurements of Proton-Proton Correlation Function in $\sqrt{s_{\rm NN}}$ = 3.0 GeV Au+Au Collisions at RHIC-STAR

Author: fu chuan[None]

Corresponding Author: fuchuan@mails.ccnu.edu.cn

The proton-proton correlation functions are widely used to infer the baryon source spatial and temporal extents in relativistic heavy-ion collisions. Due to the space-momentum correlation, information on collectivity can also be extracted from the correlation functions. There are ample data on the meson source information but results on baryon source are scarce.

In this talk, we will present the first measurement of proton-proton correlation functions in Au+Au collisions at $\sqrt{s_{\rm NN}}$ = 3.0 GeV with a FXT target mode at RHIC. At 3 GeV, the full rapidity coverage of protons is achieved by the STAR detector. The rapidity dependence of the proton source parameters will be discussed for the first time. In addition, collision energy and centrality dependence of the proton correlation functions will be discussed. The experimental results will also be compared with the calculations from UrQMD transport model.

Preferred track:

Collectivity & Multiple Scattering

Subfield:

Heavy-ion experiment

Attending in-person?:

No

On behalf of collaboration?:

STAR collaboration

Poster Session / **53**

Light flavor vector mesons between 2 and 3 GeV at BESIII

Author: Beijiang Liu[None]

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At BESIII, the lineshapes of e+e- ->phi eta', phi eta, KK, omega pi0, eta pipi, omega pipi are measured from 2.0 to 3.08 GeV, where resonant structures are observed in these processes. Multiple lineshapes of intermediate state are obtained by a partial wave analysis of e+e- ->K+ K- pi0 pi0, K+K- pi0 and the structures observed provide essential input to understand the nature of phi2170. These results provide important information for light flavor vector mesons i.e. excited rho, omega and phi, for energy regions above 2 GeV.

Preferred track:

Hadron Spectroscopy

Subfield:

HEP experiment

Attending in-person?:

Yes

On behalf of collaboration?:

BESIII

Hadron structure 2 / 54

R value measurements at BESIII

Author: Beijiang Liu[None]

Corresponding Author: redmer@uni-mainz.de

At BESIII, the R value is measured with a total of 14 data points with the corresponding c.m. energy going from 2.2324 to 3.6710 GeV.
The statistical uncertainty of the measured R is less than 0.6%. Two different simulation models, the LUARLW and a new Hybrid generated, are used and give consistent detection efficiencies and initial-state-radiation corrections. An accuracy of better than 2.6% below 3.1 GeV and 3.0% above is achieved in the R values.

Preferred track:

Hadron Structure

Subfield:

HEP experiment

Attending in-person?:

Yes

On behalf of collaboration?:

BESIII

Hadron spectroscopy 1 / 55

Study of charmonium spectroscopy and decays at BESIII

Author: Beijiang Liu[None]

Corresponding Author: weimin.song@cern.ch

Based on a sample of 448 million psi(2S) events and a scan data sample above 3.7 GeV with an integrated luminosity of 22/fb, charmonium spectroscopy and decays are studied. In the talk the latest results will be presented. The production of psi2(3823) via e+e- -> pi+ pi- psi2(3823) is measured, the most precise measurement of the mass of psi2(3823) is achieved, and the new decay modes of psi2(3823) -> gamma chic2, gamma chic0, pi pi J/psi, eta J/psi, and pi0 J/psi are searched. The new decay modes of hc -> p p-bar eta, p p-bar pi0, p p-bar pi+ pi- pi0, pi0 J/psi are searched for, the mode of p p-bar eta is observed for the first time with significance above 5.0 sigma while evidence of p p-bar pi+ pi- pi0 is found.

Preferred track:

Hadron Spectroscopy

Subfield:

HEP experiment

Attending in-person?:

Yes

On behalf of collaboration?:

BESIII

Hadron structure 3 / **57**

Hyperon physics at BESIII

Author: Beijiang Liu[None]

Corresponding Author: viktor.thoren@physics.uu.se

With the large datasets on □+□−-annihilation at the □/□ and □(3686) resonances collected at the BESIII experiment, multi-dimensional analyses making use of polarization and entanglement can shed new light on the production and decay properties hyperon-antihyperon pairs. In a series of recent studies performed at BESIII, significant transverse polarization of the (anti)hyperons has been observed in □/□ or □(3686) to ΛΛ¯ , ΣΣ¯ , ΞΞ¯, and Ω - anti- Ω + and the spin of Ω− has been determined model independently for the first time. The decay parameters for the most common hadronic weak decay modes were measured, and due to the non-zero polarization, the parameters of hyperon and antihyperon decays could be determined independently of each other for the first time. Comparing the hyperon and antihyperon decay parameters yields precise tests of direct, Δ□ = 1 CP-violation that complement studies performed in the kaon sector.

Preferred track:

Hadron Structure

Subfield:

HEP experiment

Attending in-person?:

Yes

On behalf of collaboration?:

BESIII

Jets and QCD 2 / **59**

Amplitude and colour evolution: From first principles to simulations.

Author: Simon Plätzer[1]

[1] *University of Graz (AT)*

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Colour evolution and parton branching at the amplitude level have become important theoretical frameworks to improve parton showers, and are algorithms in their own right to complement shower development by resummation algorithms capable of including interference effects and subleading-N contributions at an unprecedented level. I will cover recent development in the field, with a focus on soft gluon evolution and the CVolver approach.

Preferred track:

Jets & QCD at High Scales

Subfield:

HEP theory

Attending in-person?:

Yes

On behalf of collaboration?:

Hadron structure 2 / **60**

Transverse single spin asymmetry from gT(x)

Authors: Sanjin Benić[None]; Abhiram Kaushik[None]; Hsiang-nan Li[1]; Yoshitaka Hatta[2]; Eric Andreas Vivoda[3]

[1] *Academia Sinica*

[2] *BNL*

[3] *University of Zagreb*

Corresponding Author: sanjinb@phy.hr

In this presentation I will talk about a novel contribution to the transverse single spin asymmetry (TSSA) from the gT(x) distribution of the transversely polarized proton [1,2]. I will explain how this contribution, absent at the Born level, first appears at two loops and outline the key ideas in the derivation. Next, I will show the detailed results in SIDIS for all possible harmonics of the polarized cross section [2]. This comprehensive numerical computation covers all partonic channels in SIDIS and is focused on the prospects of the gT(x) contribution at the EIC. I will further show some of the very recent computations of the gT(x) contribution in forward pp [3] and pA [4] collisions (where the proton is transversely polarized), notably in connection to the odderon operator that appears in the unpolarized proton (or nuclei) in the high energy limit. One of the main goals of [4] is to shed light on the results from the PHENIX collaboration [5] of a strong (˜Aˆ-1/3) nuclear suppression of TSSA.

[1] S. B., Y. Hatta, H-n. Li, D.-J. Yang, Phys. Rev. D 100 (2019) 9, 094027
[2] S. B., Y. Hatta, A. Kaushik, H.-n. Li, Phys.Rev.D 104 (2021) 9, 094027
[3] S. B., Y. Hatta, A. Kaushik, H.-n. Li, in preparation
[4] S. B., A. Kaushik, E. A. Vivoda, in preparation
[5] PHENIX, Phys.Rev.Lett. 123 (2019) 12, 122001

Preferred track:

Hadron Structure

Subfield:

HEP theory

Attending in-person?:

Yes

On behalf of collaboration?:

Cosmic-ray and astrophysics 1 / 61

Muon measurements at the Pierre Auger Observatory

Authors: Dariusz Gora[None]; for the Pierre Auger Collaboration[None]

Corresponding Author: dariusz.maciej.gora@googlemail.com

The Pierre Auger Observatory is the world's largest detector for the observation of ultra-high-energy cosmic rays (UHECRs) (above the energy of 10ˆ17eV), consisting of a Fluorescence Detector and surface particle detectors known as the Surface Detector (SD). Observations of extensive air showers by the Pierre Auger Observatory can be used to probe hadronic interactions at high energy, in a kinematic and energy region inaccessible to man-made accelerators and to measure muons numbers. Air showers induced by different primaries have different muon contents - with increasing mass of the primary cosmic ray particle, it is expected that the muon content in the corresponding air showers should also increase.Therefore, the determination of the muon component in the air shower is crucial to infer for each event to conclude about the mass of the primary particle, which is a key ingredient in the searches conducted to pinpoint the sources of UHECRs. Recent results obtained from the Pierre Auger Observatory and other experiments indicate that all the simulations underestimate the number of muons in the showers compared to hadronic model expectations, which is the so-called muon deficit. In this talk we will briefly review the muon measurements, and we will present in more detail recent results from the Observatory on fluctuations in the muon number. These results provide new insights into the origin of the muon deficit in air shower simulations and constrain the models of hadronic interactions at ultrahigh energies. With the current design of the surface detectors it is also difficult to straightforwardly separate the contributions of muons to the SD time traces from the contributions of photons, electrons, and positrons. Therefore, we will also present a new method to extract the muon component of the time traces recorded by each SD detector using recurrent neural networks. The combination of such algorithms, with the future data collected by the upgraded Pierre Auger Observatory, will be a major step forward, as we are likely to achieve an unprecedented resolution in mass estimation on an event-by-event basis.

Preferred track:

Cosmic Rays and Astrophysics

Subfield:

Astrophysics

Attending in-person?:

Yes

On behalf of collaboration?:

Pierre Auger Collaboration

Forward & diffractive physics 1 / 62

Recent ATLAS results on forward physics and diffraction

Corresponding Author: rafal.staszewski@ifj.edu.pl

Invited by the Forward and Diffractive Physics session convener

Preferred track:

Forward & Diffractive Physics

Subfield:

HEP experiment

Attending in-person?:

Yes

On behalf of collaboration?:

ATLAS Collaboration

Poster Session / **63**

Scaling properties of charged particle multiplicity fluctuations at $\sqrt{s_{\rm NN}} = 2.76$ TeV in ALICE at the LHC

Author: Ramni Gupta[1]

Co-author: Sheetal Sharma [2]

[1] *University of Jammu (IN)*

[2] *University of Jammu*

Corresponding Authors: sheetal.sharma@cern.ch, ramni.gupta@cern.ch

Spatial distributions of produced charged particles characterise the system formed in heavy-ion collisions. To learn about the mechanism of particle production and the phase space changes from quarks to hadrons, one of the basic tools is to study fluctuations in particle production. Local charged particle density fluctuations in the phase space are expected to scale with universal scaling exponent for the systems near the critical point.
In this talk, scaling properties of multiplicity fluctuations of the charged particles produced in Pb–Pb collisions at $\sqrt{s_{\rm NN}} = 2.76$ TeV recorded with ALICE detector at the LHC are investigated in the two-dimensional (η, φ) phase space in low transverse momentum region, using Normalized Factorial Moments (NFM). Power-law growth of NFM with increasing number of bins in the phase space region, a feature of bin-to-bin dynamical fluctuations that is consistent with self-similar behaviour [1], is observed. NFM of $q^{\rm th}$ order ($F_{\rm q}$) show linear dependence on the second-order NFM (F_2). The value of the scaling exponent (ν) so determined indicates the order of the phase transition within the framework of Ginzburg-Landau theory [2,3]. Dependence of scaling exponents calculated in the low transverse momentum bins on the $p_{\rm T}$ bin position, width and the centrality of the events will be presented. A comparison of the results with that from the models with no physics of phase transition will also be presented.

References

1. R. C. Hwa and C. B. Yang, Phys. Rev. C **85**, 044914 (2012).
2. R. C. Hwa and M. T. Nazirov, Physical Review Letters, **69**, No. 5, 741 (1992).
3. R.C. Hwa and C. B. Yang, Acta Physica Polonica B, **48**, 23 (2016).

Preferred track:

Collectivity & Multiple Scattering

Subfield:

Heavy-ion experiment

Attending in-person?:

Yes

On behalf of collaboration?:

On behalf of the ALICE Collaboration

Collectivity & multiple-scattering 2 / 65

Strangeness Production in Small Collision Systems at ALICE

Author: Anju Bhasin[1]

[1] *University of Jammu (IN)*

Corresponding Author: anju.bhasin@cern.ch

An enhanced production of strange over non-strange hadrons (strangeness enhancement) was one of the first experimental signatures of the formation of quark-gluon plasma (QGP). The ALICE experiment at the LHC observed such an enhancement in strangeness production in heavy ion collisions at $\sqrt{s_{NN}}$ = 2.76 TeV, contributing to the evidence that a QGP had been formed at LHC energies. Unexpectedly, an enhanced strangeness production was also measured in high multiplicity pp and p-Pb collisions, where some theoretical models do not predict QGP formation. By comparing strangeness enhancement as a function of multiplicity, the ALICE experiment observed smooth transitions going from pp to p-Pb and Pb-Pb collisions.
This contribution, shows new results on the production yield, transverse momentum spectra and nuclear modification factor of (multi) strange hadrons produced in p-Pb collisions at $\sqrt{s_{NN}}$ = 8.16 TeV . New results on multi-differential analyses of strange production in pp collisions that helps in the understanding of strangeness production in small collision systems will also be shown. Finally, we compare the measurements to the available state-of-the-art phenomenological models implemented in Monte Carlo generators.

Preferred track:

Collectivity & Multiple Scattering

Subfield:

Heavy-ion experiment

Attending in-person?:

Yes

On behalf of collaboration?:

ALICE Collaboration

High-temperature QCD 1 / 66

A new insight on mass hierarchy in heavy flavor suppression

Author: Bojana Ilic (Blagojevic)[None]

Co-author: Magdalena Djordjevic

Corresponding Author: bojanab@ipb.ac.rs

The inherent characteristic of parton energy losses, both radiative and collisional, in QGP is the evident flavor dependence. Experimentally observed suppression mass ordering, as well as comprehensively studied dead-cone effect in radiative energy loss, encouraged us to address the mass hierarchy in heavy flavor suppression more thoroughly.

With this goal in mind, we employ the recently developed DREENA framework, which is based on our dynamical energy loss formalism. This enables us [1] to present 1) A novel observable, which is sensitive only to the collisional energy loss. This observable is robust to collision energy, system (size), and centrality, while proposing a new way to utilize high-$p_\perp$ heavy flavor data. 2) Analytical derivation of a direct relation between collisional suppression/energy loss and heavy quark mass; 3) Analytical and numerical extraction of the mass hierarchy in collisional energy loss through this observable, to be more rigorously tested by the forthcoming high-luminosity measurements at the RHIC and the LHC.

[1] Bojana Ilic and Magdalena Djordjevic, arXiv:2203.06646 [hep-ph] (under review in Phys. Rev. C).

Preferred track:

Hadronic Issues in Heavy-Flavour Physics

Subfield:

Nuclear theory

Attending in-person?:

Yes

On behalf of collaboration?:

Poster Session / 69

Study of resonance production in small system collisions with respect to transverse spherocity using EPOS3

Author: Nasir Mehdi Malik[1]

Co-authors: Ranbir Singh ; Sanjeev Singh Sambyal ; Vikash Sumberia

[1] *University of Jammu (IN)*

Corresponding Author: nasir.mehdi.malik@cern.ch

Hadronic resonaces production provide insight into the properties of the hadronic phase. Studying the dependence of the yield of resonances on transverse spherocity and multiplicity allows us to understand the resonance production mechanism with event topology and system size, respectively.In this contribution,we present hadronic resonances production as a function of transverse spherocity using EPOS3 model with URQMD. The results include the transverse momentum spectra.

Preferred track:

High-temperature QCD

Subfield:

HEP experiment

Attending in-person?:

No

On behalf of collaboration?:

Heavy-flavour physics 1 / 70

Challenges with semileptonic B decays to excited charmed mesons

Author: Rusa Mandal[1]

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Less explored from both the theoretical and the experimental sides are the B-meson semileptonic transitions to the lowest lying excited charmed mesons. An accurate knowledge of the form factors of these transitions is important to understand the problem of filling the gap between the inclusive $B \to X_c \ell \bar{\nu}_\ell$ width and the sum of the exclusive semileptonic widths. These exclusive decay modes also serve as the dominant background for $R(D^{(*)})$ extraction. In this talk I will discuss the first calculation of the form factors in $B \to D_1^{(\prime)} \ell \bar{\nu}_\ell$ using QCD light-cone sum rules with B-meson distribution amplitudes.

Preferred track:

Hadronic Issues in Heavy-Flavour Physics

Subfield:

HEP theory

Attending in-person?:

Yes

On behalf of collaboration?:

High-temperature QCD 1 / 71

The chiral magnetic effect and its search in heavy ion collisions

Author: Fuqiang Wang[1]

[1] *Purdue University (US)*

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The strong interaction of quarks and gluons is governed by quantum chromodynamics (QCD). The QCD Lagrangian contains a theta-term that describes the topological feature of the gluon field of the vacuum. Interactions with this term will change the relative numbers of left- and right-handed quarks and antiquarks. This chirality imbalance will yield an electric current along a strong magnetic field because of the (anti-)quark's magnetic moment, either parallel or antiparallel to its spin

dependent of its charge sign. This phenomenon is called the chiral magnetic effect (CME). Such an electric current, or a charge separation, can be experimentally observable in off-center relativistic heavy ion collisions where a magnetic field as strong as 10^14 Tesla can be produced by the passing protons. Because the theta-term explicitly breaks the charge-parity (CP) symmetry, an observation of the CME could provide the large CP-violation needed to explain the matter-antimatter asymmetry in our present universe. In this talk, I will review the status of a decade-long search for this fascinating physics of the CME in heavy ion collisions, from Au+Au collisions at the Relativistic Heavy Ion Collider (RHIC) and Pb+Pb collisions at the Large Hadron Collider (LHC) up to the most recent effort of a blind analysis of isobar collisions at RHIC. I will outlook what may lie ahead in the next 3-4 years regarding the prospect of a CME discovery.

Preferred track:

High-temperature QCD

Subfield:

Heavy-ion experiment

Attending in-person?:

Yes

On behalf of collaboration?:

Hadron structure 2 / 72

Prospects for TMDs & GPDs with Detector 1 at the EIC

Author: John Lajoie[None]

Corresponding Author: daria.sokhan@cea.fr

The Electron Ion Collider (EIC) to be built by JLab and BNL will be unique in colliding polarized electrons off polarized protons and light nuclei, providing the spin degrees of freedom essential to pursue its physics program to study spin structure, multi-dimensional tomographic images of protons and nuclei, and collective effects of gluons in nuclei. The unprecedented luminosity of the EIC, coupled with its flexibility on beam energy and species, will allow detailed three-dimensional imaging of the gluon and sea quark distributions, via both TMDs and GPDs, and to explore correlations amongst them. The hermetic detector will provide the capability to perform similar studies in nuclei, providing precise tomographic images of their quark-gluon landscape, ranging from light few-body nuclei to the heavy nuclei, and could uncover how TMDs and GPDs change when gluons display collective behavior at the high densities. Studies performed by the ECCE and ATHENA collaborations, now working together to develop the first detector at the EIC, will be presented to demonstrate the reach of the upcoming physics program.

Preferred track:

Hadron Structure

Subfield:

Nuclear experiment

Attending in-person?:

Yes

On behalf of collaboration?:

EIC Detector-1

Hadron spectroscopy / Jets / 74

Jets in p+A and e+A Collisions - From RHIC to the EIC

Author: John Lajoie[None]

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The use of jets as a probe in p+A and e+A collisions allows access to the interaction of the hard-scattered partons with the nuclear environment and is sensitive to a wide range of scales. Recent advances in the use of jet substructure offer the potential for an even more finely-grained understanding of this interaction. Measurements of jets and jet substructure in these systems will provide unprecedented access no only to to nuclear PDFs and saturation, but spin-orbit correlations in the nucleon through measurements of the Sivers and Collins asymmetries and how these observables can be modified in a nucleus. The sPHENIX detector currently under construction at Brookhaven National Laboratory's Relativistic Heavy Ion Collider (RHIC) is designed to significantly advance studies of the microscopic nature of nuclear matter. The Electron Ion Collider (EIC), to be built by JLab and BNL, will be unique in colliding polarized electrons off polarized protons and light nuclei, providing the capability to study multi-dimensional tomographic images of protons and nuclei, and collective effects of gluons in nuclei. In this talk we will both present an overview of jet and jet substructure measurements at RHIC and highlight the complementarity between p+A collisions at RHIC and e+A collisions at the future EIC.

Preferred track:

Jets & QCD at High Scales

Subfield:

Nuclear experiment

Attending in-person?:

Yes

On behalf of collaboration?:

Forward & diffractive physics 1 / 75

Exclusive quarkonium photoproduction in ultraperipheral collisions at the LHC

Author: Chris Flett[None]

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We discuss exclusive heavy vector meson photoproduction in proton-proton and lead-lead ultraperipheral collisions (UPCs) at the LHC, initially in conventional collinear factorisation at NLO and then subsequently in a refined approach with a programme of low x resummation and implementation of a crucial low Q subtraction included. We compare and contrast predictions in both frameworks and make a comparison with data from HERA and LHC. Time permitting, we will also discuss asymmetric proton-lead collisions. We conclude by remarking obout the possibility to constrain and ultimately determine the low x and low scale gluon PDF in the proton and heavy nuclei, emphasising the significance of this for future global PDF analyses.

Preferred track:

Forward & Diffractive Physics

Subfield:

HEP theory

Attending in-person?:

Yes

On behalf of collaboration?:

No

Flash Talks / **77**

PHENIX measurements of heavy flavor production and flow in Au+Au collisions

Author: Brandon Blankenship[1]

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Mass ordering is expected for energy loss of quarks traversing the quark gluon plasma (QGP). Gluon bremsstrahlung is the dominant mechanism for light quark energy loss; however, both radiative and collisional energy loss must be considered for heavy quarks. At low transverse momentum these mechanisms have significant quark mass dependence. Therefore, separated charm and beauty measurements are necessary to disentangle these effects. In addition, analysis of the azimuthal anisotropy in the production of heavy flavor particles and quarkonia may give insights in the interactions of the charm and beauty quarks with the medium, e.g. –if they equilibrate with the QGP or if they remain distinct from the bulk system.

PHENIX has lepton identification and silicon vertex detectors both in the central and forward/backward rapidity regions, which allow for displaced vertex analysis of the charm and bottom hadron decays, and the reconstruction of quarkonia. We will present measurements of the nuclear modification factors and elliptic flow of heavy flavor particles and the J/psi mesons. These results will be put in the context of energy loss mechanisms and heavy flavor dynamics in the QGP.

Preferred track:

Hadronic Issues in Heavy-Flavour Physics

Subfield:

Heavy-ion experiment

Attending in-person?:

Yes

On behalf of collaboration?:

PHENIX

Hadron spectroscopy / Jets / **78**

Validation of the Glauber Model for centrality determination in small system collisions

Author: Niveditha Ramasubramanian[1]

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The RAA of pions in small system collisions like p/d/He+Au at high pT show suppression in central collisions and enhancement in peripheral collisions. Although the suppression can be understood by probable formation of Quark Gluon Plasma (QGP) in central collision, there is no known physics mechanism to understand the observed enhancement.

As direct photons are transparent to the QGP and thus travel unaffected through them, its RAA at high pT will be unity in all centrality classes. Any deviation from this will shed light on the observed centrality dependent trend in RAA of Pi0s and thus could help us detangle true final state effects on these collisions.

In this talk, we show that the centrality binned RAA of direct photons show similar trends of suppression and enhancement as RAA of Pi0s for all centralities except the events with the highest multiplicity. This indicates that the centrality determination is biased affecting both Pi0s and direct photons. We also show a new way to define the RAA of Pi0s using the RAA of direct photons, thus removing any dependence on the Glauber Model. By this new definition, we note that there appears to be supresion in events with high multiplicity, which indicates final state effect on the Pi0 production.

Preferred track:

Jets & QCD at High Scales

Subfield:

Nuclear experiment

Attending in-person?:

Yes

On behalf of collaboration?:

PHENIX Collaboration

Flash Talks / 79

Intermittency analysis of charged particles generated in Xe-Xe˜collisions at $\sqrt{s_{NN}}$ = 5.44 TeV using AMPT Model

Authors: Ramni Gupta[1]; Zarina Banoo[2]

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The Multiplicity fluctuations are sensitive to QCD phase transition and to the presence of of critical point in QCD phase diagram. At critical point a system undergoing phase transition is characterized by large fluctuations in the observables. Fluctuation study is thus one of the important techniques to explore phases of the QCD matter and to search for the critical end point of hadron-quark or quark-hadron phase boundary. Scaling of the observables from heavy ion collision experiments may reveal a many of the properties of the system created, as it expands from quark-gluon plasma phase to hadronic phase. The study of scaling behaviour of the normalized factorial moments (F_q) of multiplicity fluctuations with the number of bins (M) in the phase space is one of such observables. Using scaling exponent obtained from the normalized factorial moments of the number of charged hadrons in the two dimensional (η, ϕ) phase space, the system created in these collisions can be characterized quantitatively. Here we will present observations and results from the analysis performed

for charged particle multiplicity distributions obtained from Xe-Xe collisions at $\sqrt{s_{NN}} = 5.44$ TeV with the string melting mode of the AMPT model. Observations, results on the behaviour of the normalized factorial moments and the dependence of the scaling exponent on the transverse momentum bin width will be presented.

Preferred track:

High-temperature QCD

Subfield:

HEP experiment

Attending in-person?:

Yes

On behalf of collaboration?:

Forward & diffractive physics 2 / 80

Recent LHCb results on forward physics and diffraction

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The LHCb detector at the LHC offers unique coverage of forward rapidities for studies of Central Exclusive Production (CEP) and soft QCD. CEP measurements allow the investigation of the nature of pomerons, and provide constraints on low-x gluon phenomenology, probing potential saturation effects. Moreover LHCb can test phenomenological models of soft QCD processes, by measuring the production of forward hadrons in pp collisions. In this talk the latest results from the LHCb experiment will be presented.

Preferred track:

Forward & Diffractive Physics

Subfield:

HEP experiment

Attending in-person?:

Yes

On behalf of collaboration?:

LHCb

Flash Talks / 81

Multiplicity dependence of charged-particle jet production in pp collisions at 13 TeV with ALICE

Author: Debjani Banerjee[1]

[1] *Bose Institute (IN)*

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Measurements of jet production and jet properties in pp collisions provide a test of perturbative quantum chromodynamics (pQCD) and form a baseline for similar measurements in heavy ion (A–A) collisions. Recent studies of high-multiplicity final states of small collision systems exhibit signatures of collective effects that could be associated with hot and dense, color-deconfined QCD matter, which is known to be formed in collisions of heavier nuclei. The modification of the jet fragmentation pattern and jet properties is expected in the presence of such QCD matter. In this contribution, we report recent ALICE measurements of charged-particle jet production and intra-jet properties, including mean charged-constituent multiplicity and fragmentation distribution for leading jets, in minimum bias pp collisions at √s = 13 TeV. In addition, the event multiplicity dependence of jet production and jet properties in pp collisions at √s = 13 TeV will also be presented. Results will be compared with theoretical model predictions.

Preferred track:

Jets & QCD at High Scales

Subfield:

HEP experiment

Attending in-person?:

Yes

On behalf of collaboration?:

ALICE

Hadron structure 3 / **82**

Accessing target fragmentation at CLAS12 with multidimensional ep to e$'$pX SSAs

Authors: Fatima Benmokhtar[1]; harut avakian[None]

[1] *Duquesne University*

Corresponding Author: timothy.hayward@uconn.edu

Studies of properties such as the azimuthal modulations of hadrons produced in the target fragmentation region serve as a test of our complete understanding of the different production mechanisms in SIDIS and provide additional information on QCD dynamics that are not accessible with hadron production in the current fragmentation region. We present the first multidimensional studies of beam single-spin asymmetries for semi-inclusive protons, $ep \rightarrow e'pX$, produced in the target fragmentation region that can be related to higher-twist fracture functions dictating the formation of protons out of the target remnant. The data were taken using the CLAS12 spectrometer at JLab with a longitudinally polarized 10.6˜GeV electron beam incident on an unpolarized hydrogen target. A clear sign change has been observed in preliminary results that captures the transition between the target and current fragmentation regions and provides a possible criteria for the experimental separation of both hemispheres, opening a new avenue for studies of nucleonic structure.

Preferred track:

Hadron Structure

Subfield:

Nuclear experiment

Attending in-person?:

Yes

On behalf of collaboration?:

CLAS12

Cosmic-ray and astrophysics 1 / 83

Probing hadronic interaction models with the hybrid data of the Pierre Auger Observatory

Author: Tanguy Pierog[1]

[1] *KIT*

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The Pierre Auger Observatory is the world's largest extensive air shower detector. Based on two detection techniques, namely fluorescence telescopes for the observation of the longitudinal development and water Cherenkov detectors for particles at ground, this experiment can be used not only as a cosmic ray observatory, but also to study the basic properties of hadronic interactions leading the development of air showers initiated by these primary cosmic rays. We will show that by using careful data selection it is possible to extract the proton-air inelastic cross-section at energies much higher than that accessible at man-made accelerators. Taking advantage of both detection techniques we will demonstrate that it is also possible to test hadronic interaction models using correlations between different air shower observables, like shower maximum and muons at ground, to reduce the uncertainty due to the unknown beam of cosmic rays.

Preferred track:

Cosmic Rays and Astrophysics

Subfield:

Astrophysics

Attending in-person?:

Yes

On behalf of collaboration?:

Pierre Auger

Jets and QCD 1 / 84

Recent results on jet suppression at the LHC

Author: Roberta Arnaldi[1]

[1] *Universita e INFN Torino (IT)*

Corresponding Author: reynier.cruz.torres@cern.ch

Jets in relativistic heavy-ion collisions interact with the quark-gluon plasma (QGP), leading to effects such as a suppression of jet yields and modification of internal jet structure that are used to measure the properties of the QGP. The dependence of jet suppression on the cone size (R) and jet p_{T} is

a useful observable to disentangle competing energy loss mechanisms with a high discriminating power when compared to models. In this talk we discuss the various jet suppression measurements from LHC experiments and its implications. In addition to inclusive jet suppression measurements, results from semi-inclusive event topologies which allow to explore the lowest p_{T} regions to track the radiated energy will also be presented.

Preferred track:

Jets & QCD at High Scales

Subfield:

Heavy-ion experiment

Attending in-person?:

Yes

On behalf of collaboration?:

ALICE

Cosmic-ray and astrophysics 1 / 85

Air showers and hadronic interactions with CORSIKA 8

Author: Maximilian Reininghaus[1]

[1] *Karlsruhe Institute of Technology (KIT)*

Corresponding Author: maximilian.reininghaus@kit.edu

The CORSIKA 8 project is a collaborative effort aiming to develop a versatile C++ framework for the simulation of extensive air showers, intended to eventually succeed the long-standing FORTRAN version. I present an overview of its current capabilities, focusing on aspects concerning the hadronic and muonic shower components. In particular, I demonstrate the "cascade history" feature and its application to quantify the importance of certain phase-space regions in hadronic interactions for muon production. Additionally, I show first results using Pythia 8.3, which as of late is usable as interaction model in cosmic-ray applications and has recently been integrated into CORSIKA 8.

Preferred track:

Cosmic Rays and Astrophysics

Subfield:

Astrophysics

Attending in-person?:

Yes

On behalf of collaboration?:

Jets and QCD 1 / 86

Recent measurements of heavy flavour jet production at the LHC

Co-author: Sebastian Neubert [1]

[1] *University of Bonn (DE)*

Corresponding Author: kara.mattioli@cern.ch

The LHCb experiment at the LHC is suited for studying how hadrons are formed from scattered quarks and gluons, in energetic proton-proton collisions. The hadronization and fragmentation processes can be studied via measurements such as those involving jet substructure. Equipped with a forward spectrometer, the LHCb experiment achieves an excellent transverse momentum for charged tracks, that along with excellent particle identification capabilities offers a unique opportunity to measure with great precision hadronization variables and the production of heavy flavor jets.

Preferred track:

Jets & QCD at High Scales

Subfield:

HEP experiment

Attending in-person?:

Yes

On behalf of collaboration?:

LHCb

Heavy-flavour physics 1 / 87

Heavy quark spin partners of the ψ(4230) and their decay properties

Author: Muhammad Naeem Anwar[1]

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The charmoniumlike state ψ(4230)1 is now widely considered as predominantly a D1¯D hadronic molecule. The heavy quark spin symmetry (HQSS) thus implies the possible emergence of its heavy quark spin partners with molecular configuration as D1¯D∗ and D∗2¯D∗ below these charmed mesons' thresholds. Similar heavy quark spin patterns are already identified for instance for recently observed LHCb pentaquarks and for charged exotic states in the bottom sector, namely Zbs.

Studying the spin partners of the ψ(4230) leads to explore the full heavy quark spin multiplet involving one P- and one S-wave charmed mesons. A remarkable feature is that the
mψ(4360) − mψ(4230) ≈ mD∗ − mD , (1)
mψ(4415) − mψ(4360) ≈ mD∗2 − mD1 , (2)
which is a natural consequence of HQSS if ψ(4230), ψ(4360), and ψ(4415) are identified as the isoscalar molecules of D1¯D, D1¯D∗ and D∗2¯D∗, respectively.

We analyze the probabilities of various intermediate charmed meson components for JP C = 1−− exotic state ψ(4360) and find that the channel D1¯D∗ couples more strongly around its mass regime, and the coupling behavior remains the same even if the mass of ψ(4360) is pushed closer to D1¯D∗ threshold. This enlightens that the most favorable molecular scenario for the ψ(4360) could be D1¯D∗, and hence it can be interpreted as HQSS partner of the ψ(4230). We also find the strong coupling behavior of D∗2¯D∗ channel with the ψ(4415), which makes it a good candidate for a dominant D∗2¯D∗ molecule.

In this contribution, we plan to present the extended version of our study in which we explore the full HQSS multiplet of P - and S-wave charmed mesons. Along with the predictions for the mass spectrum, we intend to provide predictions for the important decay patterns of these resonances in hadronic configurations to disentangle their long- and short-distance structures. Once the predicted patterns are confirmed by future experiments, it will enrich our understanding of QCD and its facet of forming hadronic matter by arranging multiquarks.

Preferred track:

Hadron Spectroscopy

Subfield:

HEP theory

Attending in-person?:

Yes

On behalf of collaboration?:

Cosmic-ray and astrophysics 1 / 89

Sub-TeV hadronic interaction model differences and their impact on air showers

Author: Michael Schmelling[1]

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In the sub-TeV regime, the most widely used hadronic interaction models disagree significantly in their predictions of particle spectra from cosmic ray induced air showers. We investigate the nature and impact of model uncertainties, focussing on air shower primaries with energies around the transition between high and low energy hadronic interaction models, where the dissimilarities are largest and which is well within the energy range probed by accelerator measurements. Our studies underline the importance of interactions in the energy regime where the switching between models occurs. We also show the effect of the choice of model on the number of hadronic interactions within cosmic ray induced air showers of higher energies.

Preferred track:

Cosmic Rays and Astrophysics

Subfield:

Attending in-person?:

Yes

On behalf of collaboration?:

Cosmic-ray and astrophysics 1 / 90

Generic hadronic collisions in Pythia

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In order to accurately simulate hadronic cascades through a medium, it is necessary to model hadron-ion collisions with generic hadron species. Pythia has recently added support for hadron-nucleon collisions, along with a simplified toy model for generalizing this to the hadron-ion case. In this talk, I present these developments, including ongoing work to interface it with CORSIKA8, and discuss how the Angantyr framework (Pythia's module for heavy ion collisions) can be extended to give a more accurate description of hadron-ion collisions. I also present some new features of the Angantyr framework that may be relevant to cosmic rays, such as rope formation, which has been shown to give rise to strangeness enhancement.

Preferred track:

Cosmic Rays and Astrophysics

Attending in-person?:

Yes

On behalf of collaboration?:

Subfield:

Heavy-ion theory

Cosmic-ray and astrophysics 1 / 91

Probing hadronic interaction models with IceTop and IceCube

Authors: Agnieszka Leszczyńska[1]; Dennis Soldin[2]; Dennis Soldin[None]; Stef Verpoest[None]; Stef Verpoest[None]; Stef Verpoest[3]

[1] *KIT, Karlsruhe*

[2] *University of Wuppertal*

[3] *Ghent University*

Corresponding Author: agnieszka.leszczynska@kit.edu

Cosmic rays that enter the Earth's atmosphere interact with air nuclei, initiating a cascade - an air shower. The secondary particles that reach the ground can be measured with large detector arrays. Understanding the air-shower development is crucial for the interpretation of cosmic-ray observables and strongly depends on our knowledge of high-energy hadron production. During the air-shower development, hadronic cascades decay into muons in a broad range of energies. The IceCube Neutrino Observatory together with its surface array, IceTop, provide unique possibilities to detect these muons. The in-ice array of optical modules can detect air-shower muons in the TeV energy range. IceTop, an array of ice-Cherenkov tanks, measures the dominant electromagnetic component as well as GeV muons. These measurements allow us to probe hadronic multiparticle production at different stages of the air-shower development. In this contribution we will focus on the density of low-energy muons obtained with IceTop, as well as on the high-energy muon multiplicity from the in-ice data. We will show these studies for different hadronic interaction models and discuss resulting differences.

Preferred track:

Cosmic Rays and Astrophysics

Subfield:

HEP experiment

Attending in-person?:

Yes

On behalf of collaboration?:

IceCube

Hadron spectroscopy 1 / **92**

Experimental hadron spectroscopy: an overview

Authors: Wolfgang Gradl[1]; Wolfgang Gradl[1]; Wolfgang Gradl[2]

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[2] *Uni Mainz, Inst.f.Kernphysik*

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Hadron spectroscopy, the study of states bound by the strong interaction, has received renewed interest in recent years, motivated by the discovery of states that to not conform to the usual classification of mesons (q qbar) or baryons (qqq). This opens up a new field of spectroscopy for these unconventional states. In this talk I will give a short overview of the field and present several recent observations of unconventional states containing heavy quarks found at LHCb and BESIII.

Preferred track:

Hadron Spectroscopy

Subfield:

Nuclear experiment

Attending in-person?:

Yes

On behalf of collaboration?:

Heavy flavour / hadron structure / **93**

Recent CP violation results in heavy flavour involving multibody decays

Author: Jeremy Peter Dalseno[1]

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CP violation, as one of the key ingredients necessary to explain the dominance of matter over antimatter in our Universe, has been very well established experimentally in heavy-flavour decays. Nevertheless, the CKM mechanism within the Standard Model predicts an interdependence between several CP-violating observables governed by unitarity, which motivates their continued study. We discuss some of the latest results on CP violation coming from the heavy-flavour experiments, with a particular focus on measurements facilitated by the presence of multibody decays.

Preferred track:

Hadronic Issues in Heavy-Flavour Physics

Subfield:

HEP experiment

Attending in-person?:

Yes

On behalf of collaboration?:

Poster Session / 94

Finite system size correction to NLO scattering in ϕ^4 theory

Authors: Jean Du Plessis[1]; William Alexander Horowitz[2]; William Horowitz[3]; William Horowitz[3]

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We compute for the first time the finite size corrections to NLO $2 \to 2$ scattering in ϕ^4 theory on a $\mathbb{R}^{1,(3-n)} \times \mathrm{T}^n$ spacetime. In order to do so we developed multiple novel techniques, including denominator regularization, a generalization of a formula by Ramanujan using the sum of squares function, and an analytic continuation of the generalized Epstein Zeta function. We show that our calculations pass all consistency checks, and numerically as well as analytically examine the behaviour of the scattering amplitude as well as the effective coupling. We discuss the implications for critical exponents in condensed matter systems as well as how denominator regularization might be further employed to simplify calculations involving fermions and curved spacetimes.

Most important, our results form a first step in quantifying analytically the finite size system effect on the trace anomaly in QCD, which may lead to significant corrections to the extracted viscosity to entropy density ratio in small systems. Implications for heavy-ion collision measurements are discussed.

This talk is based on https://doi.org/10.1103/PhysRevD.105.L091901 (preprint: arXiv:2203.01259) and W.A. Horowitz & JFDP in preparation.

Preferred track:

High-temperature QCD

Subfield:

HEP theory

Attending in-person?:

Yes

On behalf of collaboration?:

Hadron structure 1 / 95

Lattice and PDFs overview

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TBA

Preferred track:

Hadron Structure

Subfield:

HEP theory

Attending in-person?:

Yes

On behalf of collaboration?:

Poster Session / **96**

Studies of Time-Like Compton Scattering with CLAS12 at Jefferson Lab and at the EIC with the Detector-1 Reference Detector

Authors: Daria Sokhan[1]; Kayleigh Gates[2]; Rachel Ann Montgomery[3]; Rachel Montgomery[None]; Rachel Montgomery[2]

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Time-Like Compton Scattering (TCS) is a hard, exclusive process, involving the elastic scattering of a real photon from a nucleon, and the production of a virtual photon that decays to a heavy lepton pair in the final state. Studies of TCS observables are used to broaden our understanding of Generalised Parton Distributions (GPD's) which can offer insights into the internal structure of the nucleon.

TCS is currently being studied at Jefferson Laboratory (JLab) and is planned for the upcoming Electron Ion Collider (EIC).

The EIC will be built on the Brookhaven National Laboratory site, and will collide polarised electrons with polarised protons, polarised light ions, and a range of unpolarised ions, with a projected collision luminosity of up to 10^{34} cm^{-2} s^{-1}. The EIC is therefore the ideal next-generation facility to probe nucleon structure.

In this presentation, I show a feasibility study for measuring Time-like Compton Scattering (TCS) on the proton at the EIC, via a full Geant4 simulation of the Detector-1 reference design. Data is also currently being taken with CLAS12, Run Group C at Jefferson Laboratory, on a polarised proton target, and I will also present some preliminary work on the measurement of TCS with this data.

Preferred track:

Hadron Structure

Subfield:

Nuclear experiment

Attending in-person?:

Yes

On behalf of collaboration?:

CLAS12 + EIC/ECCE

Poster Session / **97**

Performances of electron reconstruction + identification in Run 2 and preparation for Run 3

Authors: Sulman Younas[1]; Sulman Younas[2]

[1] *National Centre for Physics (PK)*

[2] *Horia Hulubei National Institute of Physics and Nuclear Engineering (RO)*

Corresponding Authors: sulmanyounas93@gmail.com, sulman.younas@cern.ch

In the ATLAS detector, electrons and positrons, collectively referred to as electrons, leave characteristic signatures which allow them to be reconstructed and identified. The poster will present measurements of electron reconstruction and identification in Jpsi->ee and Z->ee events using Run2 data collected at centre-of-mass energy of 13 TeV in p-p collisions. The poster will also show the development of a new identification algorithm based on a deep neural network targeting Run3.

Preferred track:

Jets & QCD at High Scales

Subfield:

HEP experiment

Attending in-person?:

Yes

On behalf of collaboration?:

ATLAS

98

Excursion briefing

Corresponding Author: a.g.buckley@gmail.com

Keynote talks / **99**

CDF measurement of the W-boson mass

Corresponding Author: mark.lancaster@cern.ch

On behalf of collaboration?:

Attending in-person?:

Subfield:

Preferred track:

Jets and QCD 2 / 100

Jet substructure and hadronization

Authors: Barbara Jacak[1]; Barbara Jacak[1]; Barbara Jacak[2]

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Experiments measure hadrons, but pQCD calculations deal with quarks and gluons. While there are several prescriptions for relating the two, the actual process of hadronization is not well understood. I will discuss different descriptions of the hadron formation process, and what we can learn from jet substructure measurements about hadronization. Insights from current LHC data and future measurements at the EIC will be summarized.

Preferred track:

Jets & QCD at High Scales

Subfield:

HEP theory

Attending in-person?:

Yes

On behalf of collaboration?:

Flash Talks / 101

Quantum computing approaches for simulating parton showers in high energy collisions

Authors: Simon Williams[1]; Simon Williams[2]

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[2] *CERN*

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The interpretation of measurements from high energy collisions at experiments like the Large Hadron Collider (LHC) relies heavily on the performance of full event generators, specifically their accuracy and speed in simulating complex multi-particle final states. With the rapid and continuous improvement in quantum computers, these devices present an exciting opportunity for high energy physics.

Dedicated quantum algorithms are needed to exploit the potential that quantum computers can provide. In this talk, I will present general and extendable quantum computing algorithms for the simulation of the parton shower in a high energy collision. The algorithms utilise the quantum characteristics of the quantum device to efficiently perform the parton shower simulation. Furthermore, I will show that, by reframing the parton shower in the quantum walk framework dramatically improves the performance of the parton shower simulation, increasing the number of shower steps that can be simulated, whilst reducing the required Quantum Volume required on the device. These algorithms are the first step towards simulating a full and realistic high energy collision event on a quantum computer.

Preferred track:

Subfield:

HEP theory

Attending in-person?:

Yes

On behalf of collaboration?:

Jets and QCD 2 / **102**

Recent results on jet-based anomaly detection at the LHC

Corresponding Author: santiago.paredes@cern.ch

Recent results on jet-based anomaly detection at the LHC

On behalf of collaboration?:

LHC collabs

Attending in-person?:

Yes

Subfield:

HEP experiment

Preferred track:

Jets & QCD at High Scales

Poster Session / **103**

Intermittency analysis of charged hadrons generated in Pb-Pb collisions at $\sqrt{s_{NN}}$ = 2.76 TeV and 5.02 TeV using PYTHIA8 / Angantyr

Authors: Ramni Gupta[1]; Salman K Malik[1]

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The search for the QCD critical point (CP), and the study of quark-hadron phase transition (and vice-versa), at finite baryon density and high temperature, is the main task in contemporary relativistic heavy-ion collision experiments. Fluctuation analysis with global and local measures is the basic tool to achieve this goal. Local density fluctuations are directly related to the critical behaviour in QCD. These fluctuations in the phase space are expected to scale according to universal power-law in the vicinity of critical-point. A search for such power-law fluctuations within the frame-work of the intermittency method is ongoing to locate the critical point of the strongly interacting matter. This method is used to probe the behaviour of these fluctuations through the measurement of normalized factorial moments (NFMs) in (η, ϕ) phase space. Observations and results from the intermittency analysis performed for generated charged hadrons in Pb+Pb collisions, at two different energies, using PYTHIA8/Angantyr for centrality as well as transverse momentum bin width dependence will be presented. We also made a comparison with published EPOS3 results at 2.76TeV.

On behalf of collaboration?:

Attending in-person?:

No

Subfield:

HEP theory

Preferred track:

Collectivity & Multiple Scattering

Poster Session / 104

Production of Z boson in association with high-pt jet (Z-collinear)

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Cross-section measurements for a Z boson produced in association with high-transverse-momentum jets (pT > 100 GeV) and decaying into a charged-lepton pair are presented. The measurements are performed using proton-proton collisions at sort(s) = 13 TeV corresponding to an integrated luminosity of 139 fbˆ-1 collected by the ATLAS experiment at the LHC. Measurements of angular correlations between the Z boson and the closest jet are performed in events with at least one jet with pT > 500 GeV. Event topologies of particular interest are the collinear emission of a Z boson in dijet events and a boosted Z boson recoiling against a jet. Fiducial cross sections are compared with state-of-the-art theoretical predictions. The data are found to agree with next-to-next-to-leading-order predictions by NNLOjet and with the next-to-leading-order multi-leg generators MadGraph5_aMC@NLO and Sherpa.

On behalf of collaboration?:

ATLAS Collaboration

Attending in-person?:

Yes

Subfield:

HEP experiment

Preferred track:

Jets & QCD at High Scales

Poster Session / 105

Forward proton measurements with ATLAS

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The elastic scattering of protons at 13 TeV is measured in the range of protons transverse momenta allowing the access to the Coulomb-Nuclear-Interference region. The data were collected thanks to dedicated special LHC beta* = 2.5km optics. The total cross section as well as rho-parameter, the ratio of the real to imaginary part of the forward elastic scattering amplitude, are measured and compared to various models and to results from other experiments. The measurement of exclusive production of pion pairs at the LHC using 7 TeV data is also presented. This represents the first use of proton tagging to measure an exclusive hadronic final state at the LHC.

On behalf of collaboration?:

ATLAS Collaboration

Attending in-person?:

Yes

Subfield:

HEP experiment

Preferred track:

Forward & Diffractive Physics

Poster Session / 106

ATLAS measurements of correlations between Upsilon mesons and inclusive charged particles

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This talk presents 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 in 13 TeV pp collisions. Measurements are made differentially for Upsilon momentum and for different Upsilon states. The analysis is performed using the full-luminosity ATLAS Run-2 13 TeV pp data. This measurement benefits from the heavy-ion style approach to remove the combinatorial and pileup backgrounds leading to increased sensitivity. 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.

On behalf of collaboration?:

ATLAS Collaboration

Attending in-person?:

Yes

Subfield:

HEP experiment

Preferred track:

Hadron Spectroscopy

Poster Session / 107

The role of the underlying event in the charm-baryon enhancement observed in pp collisions at LHC energies

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The factorization hypothesis states that the production cross-section of heavy-flavor hadrons can be calculated as the convolution of three independent terms: the parton distribution function of the colliding hadrons, the production cross sections of the heavy-quarks in the hard partonic process, and finally the fragmentation functions of the heavy-flavor quarks into the given heavy-flavor hadron species. The fragmentation function has been traditionally treated as universal, i.e. independent of the collision systems.

Recent charmed-baryon measurements by ALICE and CMS show a low-momentum enhancement over model predictions based on e^+e^- collisions, which challenges this traditional assumption [1,2]. One of the latest measurements also shows that this enhancement depends on the final-state multiplicity of the collision event [3]. Several scenarios have been proposed to explain the emerging pattern, including string formation beyond leading order, the so-called enhanced color re-connection [4], which provides a qualitatively correct description of these findings for pp collisions.

In our contribution, we investigated the charm-baryon enhancement with PYTHIA 8 Monte-Carlo generator and enhanced color-reconnection models. We proposed a method based on several event-activity classifiers to identify the source of the charm-baryon enhancement. We conclude that, within the scenario under investigation, the excess Λ_c production is connected to the underlying event and not to the jet production [5]. We also present studies with several charmed-baryon species that address the role of the quark content and isospin state and allow for the comparison of charm and strange-baryon enhancement mechanisms.
These new observables will provide a unique opportunity in the upcoming measurements from the high-luminosity LHC Run3 phase to understand charm fragmentation mechanisms, and will serve as valuable means for further model development.

[1] CMS Coll., Phys. Lett. B 803 (2020) 135328, arXiv:1906.03322.
[2] ALICE Coll., Physicial Review Letters 127, 202301 (2021), arXiv:2011.06078.
[3] ALICE Coll., Phys.Lett.B 829 (2022) 137065, arXiv:2111.11948.
[4] C., J.R., S., P.Z., JHEP 2015, 3 (2015), arXiv:1505.01681.
[5] Z. V., R. V., Submitted to J.Phys.G. (accepted), arXiv:2111.00060.

On behalf of collaboration?:

Attending in-person?:

Yes

Subfield:

Nuclear experiment

Preferred track:

Hadronic Issues in Heavy-Flavour Physics

Poster Session / 108

PHENIX measurements of heavy flavor production and flow in Au+Au collisions

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Mass ordering is expected for energy loss of quarks traversing the quark gluon plasma (QGP). Gluon bremsstrahlung is the dominant mechanism for light quark energy loss; however, both radiative and collisional energy loss must be considered for heavy quarks. At low transverse momentum these mechanisms have significant quark mass dependence. Therefore, separated charm and beauty measurements are necessary to disentangle these effects. In addition, analysis of the azimuthal anisotropy in the production of heavy flavor particles and quarkonia may give insights in the interactions of the charm and beauty quarks with the medium, e.g. –if they equilibrate with the QGP or if they remain distinct from the bulk system.

PHENIX has lepton identification and silicon vertex detectors both in the central and forward/backward rapidity regions, which allow for displaced vertex analysis of the charm and bottom hadron decays, and the reconstruction of quarkonia. We will present measurements of the nuclear modification factors and elliptic flow of heavy flavor particles and the J/psi mesons. These results will be put in the context of energy loss mechanisms and heavy flavor dynamics in the QGP.

On behalf of collaboration?:

PHENIX

Attending in-person?:

Yes

Subfield:

Heavy-ion experiment

Preferred track:

Hadronic Issues in Heavy-Flavour Physics

Poster Session / 109

Intermittency analysis of charged particles generated in Xe-Xe˜collisions at $\sqrt{s_{NN}}$ = 5.44 TeV using AMPT Model

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The Multiplicity fluctuations are sensitive to QCD phase transition and to the presence of of critical point in QCD phase diagram. At critical point a system undergoing phase transition is characterized by large fluctuations in the observables. Fluctuation study is thus one of the important techniques to explore phases of the QCD matter and to search for the critical end point of hadron-quark or quark-hadron phase boundary. Scaling of the observables from heavy ion collision experiments may reveal a many of the properties of the system created, as it expands from quark-gluon plasma phase to hadronic phase. The study of scaling behaviour of the normalized factorial moments (F_q) of multiplicity fluctuations with the number of bins (M) in the phase space is one of such observables. Using scaling exponent obtained from the normalized factorial moments of the number of charged hadrons in the two dimensional (η, ϕ) phase space, the system created in these collisions can be characterized quantitatively. Here we will present observations and results from the analysis performed for charged particle multiplicity distributions obtained from Xe-Xe collisions at $\sqrt{s_{NN}} = 5.44$ TeV with the string melting mode of the AMPT model. Observations, results on the behaviour of the normalized factorial moments and the dependence of the scaling exponent on the transverse momentum bin width will be presented.

On behalf of collaboration?:

Attending in-person?:

Yes

Subfield:

HEP experiment

Preferred track:

High-temperature QCD

Poster Session / 110

Multiplicity dependence of charged-particle jet production in pp collisions at 13 TeV with ALICE

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Measurements of jet production and jet properties in pp collisions provide a test of perturbative quantum chromodynamics (pQCD) and form a baseline for similar measurements in heavy ion (A–A) collisions. Recent studies of high-multiplicity final states of small collision systems exhibit signatures of collective effects that could be associated with hot and dense, color-deconfined QCD matter, which is known to be formed in collisions of heavier nuclei. The modification of the jet fragmentation pattern and jet properties is expected in the presence of such QCD matter. In this contribution, we report recent ALICE measurements of charged-particle jet production and intra-jet properties, including mean charged-constituent multiplicity and fragmentation distribution for leading jets, in minimum bias pp collisions at √s = 13 TeV. In addition, the event multiplicity dependence of jet production and jet properties in pp collisions at √s = 13 TeV will also be presented. Results will be compared with theoretical model predictions.

On behalf of collaboration?:

ALICE

Attending in-person?:

Yes

Subfield:

HEP experiment

Preferred track:

Jets & QCD at High Scales

Poster Session / 111

Quantum computing approaches for simulating parton showers in high energy collisions

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The interpretation of measurements from high energy collisions at experiments like the Large Hadron Collider (LHC) relies heavily on the performance of full event generators, specifically their accuracy and speed in simulating complex multi-particle final states. With the rapid and continuous improvement in quantum computers, these devices present an exciting opportunity for high energy physics. Dedicated quantum algorithms are needed to exploit the potential that quantum computers can provide. In this talk, I will present general and extendable quantum computing algorithms for the simulation of the parton shower in a high energy collision. The algorithms utilise the quantum characteristics of the quantum device to efficiently perform the parton shower simulation. Furthermore, I will show that, by reframing the parton shower in the quantum walk framework dramatically improves the performance of the parton shower simulation, increasing the number of shower steps that can be simulated, whilst reducing the required Quantum Volume required on the device. These algorithms are the first step towards simulating a full and realistic high energy collision event on a quantum computer.

On behalf of collaboration?:

Attending in-person?:

Yes

Subfield:

HEP theory

Preferred track:

Flash Talks / 112

Studies of Time-Like Compton Scattering with CLAS12 at Jefferson Lab and at the EIC with the Detector-1 Reference Detector

Authors: Daria Sokhan[1]; Kayleigh Gates[2]; Rachel Ann Montgomery[3]; Rachel Montgomery[None]; Rachel Montgomery[2]

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Time-Like Compton Scattering (TCS) is a hard, exclusive process, involving the elastic scattering of a real photon from a nucleon, and the production of a virtual photon that decays to a heavy lepton pair in the final state. Studies of TCS observables are used to broaden our understanding of Generalised Parton Distributions (GPD's) which can offer insights into the internal structure of the nucleon.

TCS is currently being studied at Jefferson Laboratory (JLab) and is planned for the upcoming Electron Ion Collider (EIC).

The EIC will be built on the Brookhaven National Laboratory site, and will collide polarised electrons with polarised protons, polarised light ions, and a range of unpolarised ions, with a projected collision luminosity of up to 10^{34} cm^{-2} s^{-1}. The EIC is therefore the ideal next-generation facility to probe nucleon structure.

In this presentation, I show a feasibility study for measuring Time-like Compton Scattering (TCS) on the proton at the EIC, via a full Geant4 simulation of the Detector-1 reference design. Data is also currently being taken with CLAS12, Run Group C at Jefferson Laboratory, on a polarised proton target, and I will also present some preliminary work on the measurement of TCS with this data.

On behalf of collaboration?:

CLAS12 + EIC/ECCE

Attending in-person?:

Yes

Subfield:

Nuclear experiment

Preferred track:

Hadron Structure

Organisation / 113

Introduction

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Keynote talks / 114

The Trouble with MW

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On behalf of collaboration?:

CDF

Attending in-person?:

Yes

Subfield:

Preferred track: