Low-x 2021

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Book of Abstracts

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J\psi polarization in high multiplicity hadronic collisions

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High multiplicity events in small collision systems (pp and pA collisions) at hadron colliders have received much attention in recent years. In this talk we will present analysis of J/ψ polarization in high multiplicity hadron collisions using the CGC+NRQCD framework. Predictions both for pp and pA at LHC energies will be presented.

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The LHCspin project

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The goal of LHCspin is to develop, in the next few years, innovative solutions and cutting-edge technologies to access spin physics in high-energy polarized fixed-target collisions, by exploring a unique kinematic regime given by the LHC beam and by exploiting new probes.
This ambitious task poses its basis on the recent installation of SMOG2, the unpolarized gas target in front of the LHCb spectrometer. Specifically, the unpolarized target, already itself a unique project, will allow to carefully study the dynamics of the beam-target system, and clarify the potentiality of the entire system, as the basis for an innovative physics program at the LHC.
The forward geometry of the LHCb spectrometer ($2< \eta <5$) is perfectly suited for the reconstruction of particles produced in fixed-target collisions. This configuration, with center-of-mass energies ranging from $\sqrt{s}$=115 GeV in pp interactions to $\sqrt{s_{NN}}$=72 GeV in collisions with nuclear beams, allows to cover a wide backward rapidity region, including the poorly explored high x-Bjorken and high x-Feynman regimes. With the instrumentation of the proposed target system, LHCb will become the first experiment delivering simultaneously unpolarized beam-beam collisions at $\sqrt{s}$=14 TeV and polarized and unpolarized beam-target collisions.
The status of the project is presented along with a selection of physics opportunities.

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Measurement of charged particle multiplicity distributions in DIS at HERA and its implication to entanglement entropy of partons

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Charged particle multiplicity distributions in positron-proton deep inelastic scattering at a centre-of-mass energy $\sqrt{s} = 319$ GeV are measured. The data are collected with the H1 detector at HERA corresponding to an integrated luminosity of 136 pb^{-1}. Charged particle multiplicities are measured as a function of photon virtuality Q^2, inelasticity y and pseudorapidity η in the laboratory and the hadronic centre-of-mass frames. Predictions from different Monte Carlo models are compared to the data. The first and second moments of the multiplicity distributions are determined and the KNO scaling behaviour is investigated. The multiplicity distributions as a function of Q^2 and the Bjorken variable x_{Bj} are converted to the hadron entropy S_{hadron}, and predictions from a quantum entanglement model are tested.

Eur.Phys.J.C 81 (2021), 212 [arxiv:2011.01812]

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Measurement of Exclusive pi+pi- and rho0 Meson Photoproduction at HERA

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Exclusive photoproduction of $\rho^0(770)$ mesons is studied using the H1 detector at the ep collider HERA. A sample of about 900000 events is used to measure single- and double-differential cross sections for the reaction $\gamma p \to \pi^+\pi^- Y$. Reactions where the proton stays intact ($m_Y = m_p$) are statistically separated from those where the proton dissociates to a low-mass hadronic system ($m_p < m_Y < 10$ GeV). The double-differential cross sections are measured as a function of the invariant mass $m_{\pi\pi}$ of the decay pions and the squared 4-momentum transfer t at the proton vertex. The measurements are presented in various bins of the photon-proton collision energy $W_{\gamma p}$. The phase space restrictions are $0.5 < m_{\pi\pi} < 2.2$ GeV, $|t| < 1.5$ GeV^2, and $20 < W_{\gamma p} < 80$ GeV. Cross section measurements are presented for both elastic and proton-dissociative scattering. The observed cross section dependencies are described by analytic functions. Parameterising the $m_{\pi\pi}$ dependence with resonant and non-resonant contributions added at the amplitude level leads to a measurement of the $\rho^0(770)$ meson mass and width at $m_\rho = 770.8^{+2.6}_{-2.7}$ (tot) MeV and $\Gamma_\rho = 151.3^{+2.7}_{-3.6}$ (tot) MeV, respectively. The model is used to extract the $\rho^0(770)$ contribution to the $\pi^+\pi^-$ cross sections and measure it as a function of t and $W_{\gamma p}$. In a Regge asymptotic limit in which one Regge trajectory $\alpha(t)$ dominates, the intercept $\alpha(t=0) = 1.0654^{+0.0098}_{-0.0067}$ (tot) and the slope $\alpha'(t=0) = 0.233^{+0.067}_{-0.074}$ (tot) GeV^{-2} of the t dependence are extracted for the case $m_Y = m_p$.

Eur.Phys.J.C80 (2020), 1189 [arxiv:2005.14471]

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Jet-based TMD measurements with H1 data, unfolded using machine-learning techniques

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Recently, jet measurements in DIS events close to Born kinematics have been proposed as a new probe to study transverse-momentum-dependent (TMD) PDFs, TMD fragmentation functions, and TMD evolution. We report measurements of lepton-jet momentum imbalance and hadron-in-jet correlations in high-$Q62$ DIS events collected with the H1 detector at HERA. The jets are reconstructed with the kT algorithm in the laboratory frame. These are two examples of a new type of TMD studies in DIS, which will serve as pathfinder for the Electron-Ion Collider program.

H1prelim-21-031, https://www-h1.desy.de/psfiles/confpap/DIS2021/H1prelim-21-031.pdf

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Search for collectivity in ep collisions at HERA with the H1 experiment

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Measurements of two- and multi-particle angular correlations in DIS and photoproduction ep collisions at $\sqrt{s} = 319$ GeV are presented as a function of charged particle multiplicity. The data were collected using the H1 detector at HERA. Since no long-range ridge structure is observed in the correlation functions over the full multiplicity range, upper limits of ridge yield are provided as functions of particle multiplicity. The second-order ($V_{2\Delta}$) and third-order ($V_{3\Delta}$) azimuthal anisotropy Fourier harmonics of charged particles are extracted from long-range two-particle correlations as functions of particle multiplicity. The $C_2\{4\}$ signals are also extracted from four-particle correlations for the first time in ep collisions, which are positive or consistent with 0. These observations do not indicate the kind of collective behavior observed at the RHIC and LHC in high-multiplicity hadronic collisions.

H1prelim-20-033 https://www-h1.desy.de/psfiles/confpap/IS2021/H1prelim-20-033.pdf

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Measurement of 1-jettiness in deep-inelastic scattering at HERA

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A first measurement of the 1-jettiness event shape observable in neutral-current deep-inelastic electron-proton scattering is presented. The 1-jettiness observable τ_{1b} is defined such that it is equivalent to the thrust observable in the Breit frame, following momentum conservation. The data were taken with the H1 detector at the HERA ep collider at a center-of-mass energy of 319 GeV in the years 2003 to 2007 and correspond to an integrated luminosity of about 351pb^{-1}. The triple-differential cross sections are presented as a function of the 1-jettiness τ_1, the event virtuality Q^2 and the Bjorken-variable x_{Bj} in the kinematic region $Q^2 > 150$ GeV^2. The data have high sensitivity to the parton

distribution functions of the proton, the strong coupling constant and to resummation and hadronisation effects. The data are compared to selected predictions.

(preliminary result)

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Forward dijets in proton-nucleus collisions at next-to-leading order

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Using the CGC effective theory together with the hybrid factorisation, we study forward dijet production in proton-nucleus collisions beyond leading order. In this paper, we compute the "real" next-to-leading order (NLO) corrections, i.e. the radiative corrections associated with a three-parton final state, out of which only two are being measured. To that aim, we start by revisiting our previous results for the three-parton cross-section presented in our previous paper. After some reshuffling of terms, we deduce new expressions for these results, which not only look considerably simpler, but are also physically more transparent. We also correct several errors in this process. The real NLO corrections to inclusive dijet production are then obtained by integrating out the kinematics of any of the three final partons. We explicitly work out the interesting limits where the unmeasured parton is either a soft gluon, or the product of a collinear splitting. We find the expected results in both limits: the B-JIMWLK evolution of the leading-order dijet cross-section in the first case (soft gluon) and, respectively, the DGLAP evolution of the initial and final states in the second case (collinear splitting).

Quick summery:
https://www.youtube.com/watch?v=yBjd2HA51yE&ab_channel=DIS2021

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Recent ALICE results on vector meson photoproduction

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Ultra-peripheral collisions (UPC) are events characterised by large impact parameters between the two projectiles, larger than the sum of their radii. As a consequence, the protons and ions accelerated by the LHC are beyond the reach of the strong interaction and they can be considered as photon sources.

Vector mesons produced in UPC i.e. \rhozero, \jpsi, and \psip, are of particular interest: vector meson photoproduction in UPC is sensitive to the low-x gluon parton density.
As the photons involved in the interactions are \textit{quasireal}, the vector mesons should retain the polarisation of the photon, as postulated by the s-channel helicity conservation hypothesis.

ALICE has provided measurements of the production cross section at forward rapidity for \jpsi and at mid-rapidity for coherent \jpsi, \psip and \rhozero. The collaboration has also measured the t-dependence of coherent \jpsi production and compared it with models incorporating nuclear shadowing effects, thus providing a new tool to investigate the gluon structure at low Bjorken-x. The measurement of photoproduction accompanied by neutron emission allows us to use a new technique to resolve the ambiguity in Bjorken-x which arises in symmetric A–A UPC collisions.

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Parton distribution functions and intrinsic charm at LHCb

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LHCb is a spectrometer that covers the forward region of proton-proton collisions, in the pseudo-rapidity range from 2 to 5. At LHCb, proton Parton Distribution Functions (PDFs) can be studied in a unique phase space complementary to that accessible by ATLAS and CMS, corresponding to low and high Bjorken-x. In this talk, the measurements of vector boson production in the forward region, with and without an associated jet, will be presented. These measurements can be used to constrain the proton PDFs. In particular, the production of a Z boson in association with a c-jet can be studied to measure the intrinsic charm content of the proton.

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Medium induced cascades and transverse momentum dependence of gluon distribution

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I would like to present recently obtained results for distribution of soft gluons that are produced by hard jet propagating through quark gluon plasma.
The results are based on the papers:
https://link.springer.com/article/10.1007/JHEP04(2021)014
https://journals.aps.org/prc/abstract/10.1103/PhysRevC.102.044910

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Charmonia photo-production in ultra-peripheral and peripheral PbPb collisions with LHCb

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In 2018, LHCb recorded $\sim 210\mu b^{-1}$ integrated luminosity of PbPb collisions at $\sqrt{s_{NN}}$ = 5.02 TeV. With an increase of the luminosity by a factor 20 compared to the previous 2015 PbPb dataset, precise measurements on photo-produced charmonia in ultra-peripheral collisions are foreseen. Moreover, the great momentum resolution of the detector allows to study photo-produced J/psi in collisions with a nuclear overlap. This new type of probe is sensitive to the geometry of the collisions but also to the electromagnetic field of the Pb nuclei. In this talk, we present the latest results on photo-production obtained by LHCb measurements in peripheral and ultra-peripheral PbPb collisions.

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Hard Diffraction at the LHC - Feasibility Studies and Experimental Aspects

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Diffractive processes possible to be measured at the LHC will be briefly discussed. This includes soft (elastic scattering, exclusive meson pair production, diffractive bremsstrahlung) and hard (single and double Pomeron exchange jets, γ+jet, W/Z, jet-gap-jet, exclusive jets) processes as well as Beyond Standard Model phenomena (anomalous gauge couplings, magnetic monopoles).

Feasibility studies, on example of the ATLAS detector, will be presented. Finally, a brief discussion about possibility of having proton detectors in the vicinity of the LHCb Interaction Point (IP8) for the LHC Run 4 will be held.

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Welcome

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Recent results on PDFs and alpha_s from HERA (remote)

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Parton distribution functions and intrinsic charm at LHCb

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From small to large x: toward a unified formalism for particle production in high energy collisions

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Precision QCD measurements from CMS

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The Diffractive Contribution to Deep Inelastic Lepton-Proton Scattering: Implications for QCD Momentum Sum Rules and Parton Distributions

Corresponding Author: sjbth@slac.stanford.edu

PDFs and QCD session II / 20

Determination of proton parton distribution functions using ATLAS data

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PDFs and QCD session II / 21

A model description of spin-averaged and spin-dependent structure functions F (remote)

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PDFs and QCD session II / 22

Discussion session: PDFs, QCD

Corresponding Authors: krzysztof.kutak@ifj.edu.pl, colferai@fi.infn.it, cyrille.marquet@cern.ch

BFKL, low x, saturation session I / 23

Search for BFKL signatures in CMS (remote)

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BFKL, low x, saturation session III / 24

Phenomenology studies of Mueller-Tang and Mueller-Navelet jets (remote)

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BFKL, low x, saturation session I / 25

Two-particle correlations in multi-Regge kinematics (remote)

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Mueller-Tang jets with Next-to-Leading Order Impact Factors

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Is BFKL factorization valid for Mueller-Tang jets?

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BFKL, low x, saturation session II / 28

Black disk radius constraint from a gray disc model description of the pp cross-section

Corresponding Author: irais.bautista.guzman@cern.ch

BFKL, low x, saturation session II / 29

Phenomenology of the hadronic structure at low-x (remote)

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BFKL, low x, saturation session II / 30

Twist analysis of the Balitsky-Kovchegov equation

Corresponding Author: leszek.motyka@uj.edu.pl

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LHCf experiment: current status and future prospect (remote)

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Discussion session: low x, BFKL

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RFT and Self-duality

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BFKL, low x, saturation session III / 34

On transverse gluon polarization at small x

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Forward dijets in proton-nucleus collisions at next-to-leading order

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Fixed multiplicity studies at the LHC

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Unitarization of the BFKL Pomeron states

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New results on probing limitations of collinear QCD in lepton-jet correlations (remote)

Corresponding Author: benjamin.philip.nachman@cern.ch

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Medium induced cascades and transverse momentum dependence of gluon distribution

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The LHC Spin project

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TOTEM results

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The discovery of the odderon by the D0 and TOTEM collaborations (remote)

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Odderon: Lost or Found? (remote)

Corresponding Authors: vladimir.petrov@cern.ch, vladimir.p@cern.ch, v.petrov@cern.ch, vladimir.g.petrov@gmail.com

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Properties of the Odderon extracted from a meta-analysis of experimental data

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Observation of Odderon Effects at LHC energies - A Real Extended Bialas-Bzdak Model Study

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Single and double phi production at the LHC: the role of odderon exchange (remote)

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FACET: a very forward multiparticle spectrometer from CMS

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On holographics derivation of basic properties of QCD glueballs (remote)

Corresponding Author: melnikov@physics.rutgers.edu

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From soft to hard diffraction in ultraperipheral collisions at the LHC

Corresponding Authors: strikman@phys.psu.edu, mxs43@psu.edu, mark.strikman@cern.ch

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Corresponding Authors: kenneth.osterberg@helsinki.fi, kenneth.osterberg@cern.ch, christophe.royon@cern.ch

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Diffractive results from CMS and TOTEM (remote)

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Diffraction and forward physics session III / 53

The CMS Precision Proton Spectrometer Project for the HL-LHC

Corresponding Authors: mario.deile@cern.ch, mdeile@cern.ch

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Overview of ATLAS forward proton detectors for LHC Run 3 and plans for the HL-LHC (remote)

Corresponding Author: maciej.piotr.lewicki@cern.ch

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Anomalous coupling studies with intact protons

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Study of anomalous exclusive t tbar protduction at the LHC

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Inclusive diffractive production of top quark(s)

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The Precision Proton Spectrometer of CMS: performance and prospects

Corresponding Author: ada.solano@cern.ch

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Photon induced processes results from CMS

Corresponding Author: beatriz.ribeiro.lopes@cern.ch

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Photon-photon fusion measurements at ATLAS

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Hard Diffraction at the LHC - Feasibility Studies and Experimental Aspects

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Discussion session: inclusive and exclusive diffraction

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Collectivity in heavy ion interactions at CMS

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Light hadron and photon production in pPb collisions at LHCb (remote)

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Probing initial state with photons and neutral mesons in ALICE

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Heavy ion session / 66

Top results in heavy ions in CMS

Corresponding Author: l.alcerro@cern.ch

Heavy ion - Vector boson session / 67

Measurement of W and Z boson production in association with jets at ATLAS

Corresponding Author: laura.fabbri@cern.ch

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V+jets results from CMS

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Vector-boson scattering, diboson and triboson production at ATLAS

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Charmonia photo-production in ultra-peripheral and peripheral PbPb collisions with LHCb (remote)

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Discussion: heavy ions, vector bosons

Corresponding Authors: irais.bautista.guzman@cern.ch, georgios.krintiras@cern.ch

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Jet cross section measurements in CMS (remote)

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Precision measurements of jet production at the ATLAS experiment (remote)

Corresponding Author: francesco.giuli@cern.ch

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Elastic photon-initiated production at the LHC: the role of hadron-hadron interactions (remote)

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Forward hadronization and the muon puzzle in air showers

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J\psi polarization in high multiplicity hadronic collisions

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Direct measurement of short-lived particle dipole moments at the LHC

Corresponding Author: nicola.neri@cern.ch

Vector meson session I / **79**

Measurements of prompt photon production with the ATLAS detector

Corresponding Author: daniel.camarero.munoz@cern.ch

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Recent results on vector meson production, particle multiplicity spectra and particle correlations at HERA

Corresponding Author: ruspa@to.infn.it

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Recent ALICE results on vector meson photoproduction

Corresponding Author: simone.ragoni@cern.ch

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Gluon-gluon fusion for production of light isoscalar mesons (remote)

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Open slot

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tba

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Semiexclusive dilepton production in proton-proton collisions with one forward proton measurement at the LHC (remote)

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Inclusive Higgs-Jet production in high-energy hadron collisions (remote)

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Rho photoproduction in ALICE (remote)

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Discussion: Vector mesons

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Workshop Conclusion

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Direct measurement of short-lived particle dipole moments at the LHC

Authors: Nicola Neri[1]; Fernando Martinez Vidal[2]

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Magnetic and electric dipole moments of fundamental particles provide powerful probes for physics within and beyond the Standard Model. For the case of short-lived particles these have not been experimentally accessible to date due to the difficulties imposed by their short lifetimes. A unique program of direct measurements of electromagnetic dipole moments of strange and charm baryons, and ultimately the tau lepton, at the LHC is proposed. Novel experimental techniques have been developed, along with feasibility studies and projected sensitivities for different luminosity scenarios.

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Twist analysis of the Balitsky-Kovchegov equation

Authors: Leszek Motyka[None]; Mariusz Sadzikowski[1]

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We perform a twist decomposition of the proton structure functions that evolve according to the Balitsky-Kovchegov equation at the LL order. Using the Mellin space technique we isolate the linear (BFKL) effects and the non-linear (BK) corrections for the leading and subleading twist contributions.

Diffraction and forward physics session I / 93

Summary of the odderon discovery (remote)

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Black disk radius constraint from a gray disk model description of the pp cross-section

Author: Irais Bautista Guzman[1]

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We use a two-function interplay model parametrization to describe data of the pp cross-section by the increase of matter density to the black disk saturation limit and the radial expansion through the growth of the overlap area based on a geometric scaling model. We argue two mechanisms responsible for the growth of high energy cross-sections in pp collisions by using data on different species we found a parametrization of the radial expansion as a function of energy consistent with unitarity.

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Elastic photon-initiated production at the LHC: the role of hadron-hadron interactions

Authors: Lucian Harland-Lang[1]; Mikhail Ryskin[2]; Valery Khoze[3]

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We discuss the role of additional hadron-hadron interactions in elastic photon-initiated production at the LHC, both in proton and heavy ion collisions. We in particular assess different sources of uncertainty associated with these cross sections, and compare with other calculations in the literature. A key result of our analysis is that the uncertainty associated with the survival factor is small, and it is only by taking very extreme and rather unphysical variations in the modelling of the survival factor that significant differences in the predicted cross sections. This underlines the basic, rather model independent, point that a significant fraction of elastic photon-initatied scattering occurs for hadron-hadron impact parameters that are simply outside the range of QCD interactions, and hence this sets a lower bound on the survival factor in any physically reasonable approach.

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Mueller-Tang jets with Next-toLeading Order Impact Factors

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We present, the results of a phenomenology analysis at Next-to-Leading accuracy for the Mueller-Tang jet process, where two jets separated by a large rapidity interval and no other radiation are observed. This process is of high interest, as one might be able to investigate Balitsky-Fadin-Kuraev-Lipatov (BFKL) dynamics which emerges in the high-energy limit of quantum chromodynamics (QCD).
Two are the key ingredients in the BFKL framework. The Gluon-Green 4-point function (GGF) a, process independent, universal object that is exchanged in the collision and the Impact-Factors (IF) which couple the GGF with the external probes.
The novelty in this study consists in including in the analysis also the NLO corrections of the IFs. Aside from the expected complications due to the NLO IF enriched topology, a more puzzling problem emerged during this study. The precise observable definition enforced also at experimental level preclude a construction featuring the high-energy factorization, namely the separation of IF and GGF so that all the BFKL resummed enhancing factors can be cast into the GGF alone.
On the experimental side, fair agreement has been found between BFKL predictions and Tevatron data. The CMS experiment has presented results at collision energies of 7 and 13 TeV. However, no clear-cut evidence of the BFKL dynamics can be claimed yet. To confirm and distinguish the role of the underling BFKL dynamics a complete analysis at NLO is needed. In this talk, we present progress toward such a task. We recall some of the difficulties encountered along the way, with emphasis on the mentioned breaking of the high-energy factorization and compare the predictions to the CMS findings at 13 TeV.

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Precision QCD measurements from CMS

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Jet production is an important probe of both QCD and new physics. Recent CMS measurements involving jet production are presented. In particular, the CMS 13 TeV inclusive jet data are used in a QCD analysis together with HERA inclusive deep inelastic scattering and CMS 13 TeV triple-differential top quark-antiquark pair production cross sections. The parton distributions and the strong coupling constant are extracted simultaneously. Further, a standard model effective field theory analysis is performed, in which the standard model is extended with 4-quark contact interactions, resulting in a first-ever simultaneous extraction of the contact interactions' Wilson coefficient together with the standard model parameters using the LHC data.

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From soft to hard diffraction in ultraperipheral collisions at tLHC

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We review a number of coherent phenomena which are studied in the ultraperipheral collisions (UPC) at the LHC. In particular, we demonstrate that much larger shadowing for coherent rho-meson production than in the Glauber model naturally emerges in the color fluctuation picture of high energy hadron –nucleon interaction. We also demonstrate that the theory of the leading twist gluon shadowing correctly predicted large suppression of the γ A->J/ψA production as compared to the impulse approximation as well as the increase of the slope of the cross section. We explain that in long run studies of the UPC processes would probe x at least as small as x=10-4. Such studies would allow to test proximity of the scales of the onset of black disk regime for protons and heavy nuclei. Several other UPC processes will be considered as well.

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Inclusive Higgs-Jet production in high-energy hadron collisions

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We present recent BFKL phenomenological results for the inclusive production of a Higgs in association with a jet, as a testfield for the semi-hard regime of QCD. We show how the large energy scales provided by the emission of a Higgs boson stabilize the BFKL series, and discuss the possible extension of this work in the full NLA BFKL analysis, by including the NLO jet impact factor, with a realistic implementation of the jet selection function, and the NLO forward-Higgs impact factor.

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Speeding up machine learning-based inference for Hadronic physics via Hadamard matrices

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Recent research by CERN has revealed machine learning-driven capabilities for the identification of proton-proton collisions at LHC for reanalysis. While this work and other previous works also work on speeding up inference via the machine learning algorithm, in this work we propose harnessing Hadamard matrices for faster inference at the model level. Machine learning algorithms for classification tasks have a variety of use cases and applications. One model type, the artificial neural network, has become increasingly popularized over the last decades, with fascinating applications in computer vision and elsewhere. Such classifier algorithms have a number of parameters and yield a per-class value. In this work, we discuss the use of a Hadamard matrix to initialize the classifier,

which in turn speeds up inference. The aforementioned matrix is positioned at the final classification transform, which yields two primary benefits. Firstly, it is a deterministic, low-memory, and easily generated matrix that can be used to classify. Secondly, it removes the need to perform matrix-matrix multiplication. By speeding up performance, we can enable further state-of-the-art results on many tasks that have immense applicability in Hadron physics at LHC.

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