Workshop on forward physics and high-energy scattering at zero degrees 2017

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Book of Abstracts

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2

Overview of the latest physics results of the LHCf experiment

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The LHC-forward (LHCf) experiment, situated at the LHC accelerator, has measured neutral particles production in a very forward region (pseudo-rapidity $\eta > 8.4$, including zero degree) in proton-proton and proton-lead collisions.
The main purpose of the LHCf experiment is to test the hadronic interaction models used in ground based cosmic rays experiments to simulate cosmic rays induced air-showers in the Earth atmosphere.

The experiment is composed of two independent detectors located at 140 metres from the ATLAS interaction point (IP1) on opposite sides along the beam axis; each detector is composed by two sampling and position sensitive calorimeters.

In this talk, the latest physics results compared with the predictions of DPMJET, EPOS, PYTHIA, QGSJET and SIBYLL event generators will be presented.
In particular, the transverse and longitudinal momentum spectra of neutral pions in different rapidity regions in p-p and p-Pb collisions (at $\sqrt{s}$ = 2.76, 7 TeV and $\sqrt{s_{NN}}$ = 5.02 TeV, respectively), and the photon and neutron inclusive energy spectra in p-p collisions at 13 TeV will be shown.

Relevant topics:

cosmic ray

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PHENIX overview

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The PHENIX experiment at the relativistic heavy ion collider RHIC has been taking data related to the study of the quark-gluon plasma and the spin structure of the nucleon. For the spin structure measurements we have shown that the gluon spin contribution to the total spin of the nucleon is substantial at intermediate x and several ongoing measurements at forward rapidities access even lower x.
Single longitudinal spin asymmetries in real W production access the spin of sea quarks in the nucleon. These measurements indicate that the light quark sea is polarized and asymmetric.
For transverse spin effects there have been many surprises such as the large single spin asymmetries for hadrons at forward rapidities as well as the nuclear dependence of neutron asymmetries at zero degrees. The origins of these effects is being investigated in more detail.
Also the possibility of nonlinear effects at high gluon densities is investigated in the forward region.
The recent results and the status of the ongoing measurements related to these topics will be presented. Also an outlook of measurements with future upgrades will be presented.

Relevant topics:

Spin structure of the nucleon; low x

4

ALICE goes forward

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At the LHC, collision final states have been studied principally in the central kinematic region, where, generally, perturbative QCD can be used. However, there is rich soil for measurements in the forward direction, which probe the nucleon structure at small Bjorken-x values where saturation effects are expected.

A full set of saturation probes in the forward rapidity region of ALICE will be presented, starting from global event observables, like multiplicity and energy measurements, to cross section results and studies of inelastic and diffractive processes. Recent results in ultraperipheral collisions will be shown, focusing on heavy-ion results, where the strong electromagnetic fields of the nuclei provide a significant flux of high-energy photons. Several other measurements will be described, giving a comprehensive overview of ALICE capabilities. Theoretical models are particularly challenged in the forward rapidity region, where we deal with softer processes. Therefore, particular attention to model comparisons will be paid during the presentation.

Finally, the hardware upgrades of ALICE in the forward rapidity region will be described towards the end of the talk.

Relevant topics:

multiplicities, energy measurements in forward region, saturation, total cross section, diffraction, heavy ions, cosmic ray, hardware and future projects

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Forward di-jet production in p+Pb collisions in the small-x improved TMD factorization framework

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I am going to report on study the production of forward di-jets in proton-lead and proton-proton collisions at the Large Hadron Collider. Such configurations, with both jets produced in the forward direction, impose a dilute-dense asymmetry which allows to probe the gluon density of the lead or proton target at small longitudinal momentum fractions. Even though the jet momenta are always much bigger than the saturation scale of the target, Qs, the transverse momentum imbalance of the di-jet system may be either also much larger than Qs, or of the order Qs, implying that the small-x QCD dynamics involved is either linear or non-linear, respectively. The small-x improved TMD factorization framework deals with both situation in the same formalism. In the latter case, which corresponds to nearly back-to-back jets, we find that saturation effects induce a significant suppression of the forward di-jet azimuthal correlations in proton-lead versus proton-proton collisions.

Relevant topics:

forward physics

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Status of the RHIC forward experiment

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RHICf is an experiment to measure neutral particles emitted around the zero degree in the 510GeV proton-proton collisions at RHIC. The detector was installed in the interaction point of STAR and physics operation was carried out from 25 to 27 June, 2017. Introduction to the experiment and the first results are presented in the workshop. Forward particle cross sections are useful to constrain the hadronic interaction models used in the cosmic-ray physics at the cosmic-ray energy of 10^{14}eV. Single-spin asymmetry measured with the polarized proton beam is also an important topics because RHICf has a wider p_T coverage than the previous measurements at RHIC.

Relevant topics:

minimum bias, cosmic-ray, spin

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On the one loop $\gamma(*)\to q\bar{q}\gamma(*)\to q\bar{q}$ impact factor and the exclusive diffractive cross sections for the production of two or three jets

Authors: Andrey Grabovskiy[1]; Samuel Wallon[None]; Lech Szymanowski[None]; Renaud Boussarie[2]

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We present the calculation of the impact factor for the $\gamma(*)\to q\bar{q}\gamma(*)\to q\bar{q}$ transition with one loop accuracy in arbitrary kinematics. The calculation was done within Balitsky's high energy operator expansion. Together with our previous result for the $\gamma(*)\to q\bar{q}g\gamma(*)\to q\bar{q}g$ Born impact factor it allows one to derive cross sections for 2- (one loop) and 3-jet (Born) difractive electroproduction. We write such cross sections for the 2 and 3 jet exclusive diffractive electroproduction off a proton in terms of hadronic matrix elements of Wilson lines. For the 2-jet cross section we demonstrate the cancellation of infrared, collinear and rapidity singularities. Our result can be directly exploited to describe the recently analyzed data on exclusive dijet production at HERA and used for the study of jet photoproduction in ultraperipheral proton or nuclear scattering.

Relevant topics:

multiplicities, energy measurements in forward region and very forward jets, BFKL and saturation

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Accessing the gluon Wigner distribution in ultraperipheral pA collisions

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We propose to constrain the gluon Wigner distribution in the nucleon by studying the exclusive diffractive dijet production process in ultraperipheral proton-nucleus collisions (UPCs) at RHIC and the LHC. Compared to the previous proposal to study the same observable in lepton-nucleon scattering, the use of UPCs has a few advantages: not only the cross section is larger, but also the extraction of the Wigner distribution from the data becomes simpler, including its elliptic angular dependence. We compute the corresponding cross section and evaluate the coefficients using models which include the gluon saturation effects

Relevant topics:

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Diffractive Physics at the HERA Collider

Author: Paul Richard Newman[1]

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An extensive programme of diffractive studies was carried out by the H1 and ZEUS collaborations using data from the full 15 year lifetime of the HERA electron-proton collider. This talk will review the results from that programme, particularly where they relate to studies at the LHC. The main topics will be quasi-elastic vector meson photoproduction and electroproduction and soft and hard single diffractive dissociation.

Relevant topics:

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The CT-PPS project

Authors: Fabio Ravera[1]; The CMS and TOTEM Collaborations[None]

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The CMS-TOTEM Precision Proton Spectrometer allows the extension of the LHC physics program by detecting scattered protons in the very forward region of CMS. The detector includes tracking and timing stations installed along the beam pipe at $\sim$ 210 m from the CMS interaction point on both sides. The tracking detector is presently constituted by one silicon strip and one silicon 3D pixel station per arm, ensuring a track resolution of 10 μm along the most interesting direction. The future goal is to replace the present strip stations with pixel ones in order to ensure better performance of multi-track event reconstruction. Each LHC arm is equipped with a timing station hosting three planes of diamond detectors plus one of Ultra-Fast Silicon Detector (UFSD) with a global timing resolution of a few tens of picoseconds. This constitutes the first application of UFSD in a high energy physics experiment. A large R&D effort is ongoing on this technology and on diamond detectors in order to reach the final goal of 10 ps target resolution. This contribution will describe the present status of the CT-PPS project, as well as the operational experience in the 2017 data taking.

Relevant topics:

Forward physics at LHC, tracking detector, timing detector

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Single diffractive particle production with dipoles

Authors: Boris Kopeliovich[1]; Roman Pasechnik[2]

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The color dipole approach enables us to evaluate the diffractive particle production observables beyond the concept of diffractive factorisation. In this talk, I will overview the current status of research in this direction and present preliminary results on single-diffractive non-Abelian Bremsstrahlung processes with di-jets and quarkonia final states.

Relevant topics:

Medium mass diffraction and the structure of Pomeron

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Extension of Pythia8 to high energy nuclear colisions

Author: Yasushi Nara[1]

[1] *Akita international university*

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We report a current status of a new Monte-Carlo event generator for high energy nuclear collisions based on the Pythia8 event generator:nPythia.
Nuclear collisions are modeled by the successive nucleon-nucleon (NN) collisions based on the Glauber type model.
For each NN collision, we use Pythia8, but taking account of conservation laws for a whole system.
It is found that incoherent sum of NN collision picture based on Pythia8 describes the rapidity distributions of produced hadrons at SPS energies in Pb+Pb, d+Au at RHIC, and p+Pb at LHC.
However, this picture significantly overestimates hadron yield in Au+Au at RHIC and Pb+Pb at LHC, indicating strong nuclear suppression effects.
We introduce a simple model to simulate such nuclear suppression effect motivated by the Color Glass Condensate (CGC).

Relevant topics:

heavy ions at RHIC and LHC

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Exclusive light meson production at the LHC

Author: Maciej Trzebinski[1]

[1] *Polish Academy of Sciences (PL)*

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GenEx - a new Monte Carlo tool for exclusive light meson production will be presented. This tool is being developed by our group and is complementary to the existing MC generators. The generator is self-adapting to the provided matrix element and acceptance cuts. The modular structure of the code, designed for easy process implementation, will be shown. As an example, the exclusive production of pions (continuum plus resonances) will be discussed. This includes predictions for polarized (LHC energies) and non-polarized (RHIC) proton-proton collisions for scalar, vectorial and tensorial Pomeron models.

Relevant topics:

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Atlas Forward Protons: measurements and prospects for exclusve diffractions, BSM physics and Pomeron structure

Author: Carla Sbarra[1]

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The installation of the second arm of the Atlas Forward Proton (AFP) detector system has been completed in time for the 2017 running of LHC, opening the road for measurements of processes with two forward protons. This talk will describe the status of the project, its rich physics programme, as well as first perfomance and measurements with beams. Further ATLAS results with just one or without proton tags will be presented as well.

Relevant topics:

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Single spin asymmetry in RHICf

Author: Junsang Park[1]

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Since single spin asymmetry(AN) was measured, AN has been useful physical observable value in searching intrinsic structure of nucleon and interactions among nucleons. In case of forward region, One Pion Exchange model and Reggeon exchange model have shown good consensus with AN from inclusive neutron measurement via PHENIX Zero Degree Calorimetry(ZDC) at RHIC. One of goals in RHICf experiment is to measure AN in higher pT region more precisely. In this talk, I will present latest results related with AN measurement, especially AN of forward neutron.

Relevant topics:

Single spin asymmetry of forward neutron

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Hadronic interactions at ultra-high energies

Author: felix riehn[1]

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The observation of ultra-high energy cosmic rays by the current leading air shower detectors, the Pierre Auger Observatory and the Telescope Array offer the unique possibility to study hadronic interactions at the highest energies. From the observation of the development of air showers in the atmosphere, for example, the experiments can determine

the interaction cross section of protons at five times the LHC energy. Through the measurement of the muons produced in air showers additional hadronic properties can be estimated. An overview of the different measurements and their interpretation in terms of hadronic interaction will be presented.

Relevant topics:

Cosmic rays, hadronic interactions, muons, LHC, Pierre Auger Observatory, Telescope array

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Transverse single spin asymmetries for very forward neutrons in ultra-peripheral p-A collisions

Author: Gaku Mitsuka[None]

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I will present the transverse single spin asymmetries for very forward neutrons in polarized p-A ultra-peripheral collisions. These asymmetries are about 35 % and the cross section of p-Au ultra-peripheral collisions is comparable with that of hadronic interactions. Thus such asymmetries are central to the AN for very forward neutrons measured by the PHENIX zero-degree calorimeters (ZDCs) in high-energy polarized proton–nucleus (p–A) collisions at RHIC.
In this talk, I will present that the Monte Carlo simulation results involving both ultra-peripheral collisions and hadronic interactions can successfully reproduce the PHENIX measurements.

Relevant topics:

RHIC, forward neutrons, ultra-peripheral collisions

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Measurements of hadronic interactions using the nuclear emulsion detector

Authors: Hiroki Rokujo[1]; GRAINE collaboration[None]

[1] *Nagoya University (JP)*

Corresponding Author: hiroki.rokujo@cern.ch

Nuclear emulsion records all trajectories of charged particles with sub-micron spatial resolution and specializes in detailed measurements of topologies of various particle interactions. Remarkable increase in the readout speed of the emulsion scanning system has realized data acquisition from the full volume of emulsion chambers and the minimum-biased analysis. In this talk, we report the current status of measurements of hadronic interactions in the running emulsion experiments: the balloon-borne experiment GRAINE, the fixed target accelerator experiment DsTau at SPS/CERN, etc.

Relevant topics:

hardware and future projects, cosmic ray

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New Hadronic Interaction Models and Air Shower Physics

Author: Tanguy Pierog[1]

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The interpretation of EAS measurements strongly depends on detailed air shower simulations. CORSIKA is one of the most commonly used air shower Monte Carlo program. The main source of uncertainty in the prediction of shower observable for different primary particles and energies being currently dominated by differences between hadronic interaction models even after the update taking into account the first LHC data. As a matter of fact the model predictions converged but at the same type more precise air shower and LHC measurements introduced new constraints.
This year a new generation of hadronic interaction models is released in CORSIKA. Sibyll 2.3c, DPMJETIII-17.1 will be available in 2017 with improved description of particle production and in particular the production of charmed particles. The impact of these hadronic interaction models on air shower predictions will be presented and compared to the first generation of post-LHC models EPOS LHC and QGSJETII-04.
The performance of the new models on standard air shower observable is derived. Due to the various approach in the physics treatment, there is still large differences in the model predictions but it can already be partially resolve by the comparison with the latest LHC data.

Relevant topics:

cosmic ray

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Heavy-flavor production at forward rapidities in the CGC framework,

Author: Hirotsugu Fujii[1]

[1] *University of Tokyo*

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We review and update our current understanding of quarkonium and heavy-meson production at forward rapidities in the CGC framework.

Relevant topics:

heavy ion physics

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Minimum bias at 13 TeV with the ATLAS detector

Author: Nicola Orlando[1]

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The modelling of Minimum Bias (MB) is a crucial ingredient to learn about the description of soft QCD processes and to simulate the environment at the LHC with many concurrent pp interactions (pile-up).
We summarise the ATLAS minimum bias measurements with proton-proton collision at 13 TeV center-of-mass-energy at the Large Hadron Collider.

Relevant topics:

Minimum Bias, soft QCD

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Latest Development of Nuclear Emulsion Technology

Author: Kunihiro Morishima[None]

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Nuclear emulsion is high sensitive photographic film used for detection of three-dimensional trajectory of charged particles. These trajectories are recorded as tracks consist of chain of silver particles. The size of silver particles is less than 1 micrometer, so that nuclear emulsion has sub-micron three-dimensional spatial resolution, which gives us an angular resolution of a few mrad in three-dimension.
In our laboratory, a high-speed three-dimensional read-out system built with optical microscope is still developed. Nowadays the read-out system named Hyper Track Selector (HTS) with scanning speed of approximately 1 square meter per day is being operated. And also, we have the nuclear emulsion production facility in our laboratory. In the facility, we can develop emulsion gel for the purpose by using emulsion gel production machine and we can produce emulsion films in the dark-room for mass production. In this talk, latest development of nuclear emulsion technology will be presented.

Relevant topics:

hardware and future projects

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Small x and multiple scattering effects in forward Drell-Yan scattering

Authors: Leszek Motyka[None]; Mariusz Sadzikowski[1]; Tomasz Stebel[2]

[1] *Jagiellonian University*

[2] *Institute of Nuclear Physics PAN*

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The forward Drell-Yan scattering is an excellent probe of the proton structure down to very small x. In this region effects of BFKL evolution are strong. We study in detail these effects in the Drell-Yan structure functions. At small x and moderate invariant masses of the Drell-Yan pair also effects of higher twist operators and multiple scattering are expected to turn on. We model them using the GBW saturation model.

Relevant topics:

forward scattering, Drell-Yan process, small x resummation, higher twist effects, gluon saturation

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Higher twist and saturation effects in the proton structure at small x

Authors: Leszek Motyka[None]; Mariusz Sadzikowski[1]; Wojtek Slominski[None]; Katarzyna Wichmann[2]

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The DIS data from HERA are analyzed in a framework of the leading twist contributions described by the standard DGLAP formalism (NLO and NNLO) complemented by twist 4 corrections inspired by the saturation model. We fit the data down to $Q^2 = 1$ GeV^2 and find an evidence for the higher twist effects at small x and moderate Q^2. We also study parton saturation effects in the input for the parton density functions and find that inclusion of parton saturation improves the description of data. We discuss in detail the influence of the higher twist corrections in the cross sections on the emerging parton density functions.

Relevant topics:

proton structure, small x, parton saturation, multiple scattering, higher twist effects

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Forward neutrons from polarized proton-nucleus collisions

Authors: Boris Kopeliovich[1]; Irina Potashnikova[1]; Ivan Schmidt[None]

[1] *UTFSM*

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Absorptive corrections, known to suppress proton-neutron transitions with large fractional momentum z⟶1 in pp collisions, become dramatically strong on a nuclear target, and push the partial cross sections of leading neutron production to the very periphery of the nucleus. The mechanism of π-a1 interference, which successfully explains the observed single-spin asymmetry in polarized pp⟶nX, is extended to collisions of polarized protons with nuclei. Corrected for nuclear effects, it explains the observed single-spin azimuthal asymmetry of neutrons, produced in inelastic events, where the nucleus violently breaks up. The single-spin asymmetry is found to be negative and nearly A-independent.

Relevant topics:

Forward spin asymmetry

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Pomeron spin-flip from single-spin asymmetry of forward protons

Authors: Boris Kopeliovich[1]; Michal Krelina[2]

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[2] *UTFSM, Valparaiso Chile*

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Coulomb-Nuclear Interference (CNI) mechanism of single-spin asymmetry in small-angle elastic scattering of polarized protons offers a unique way to measure the spin-flip part of the Pomeron. We analyze recent data from RHIC on single-spin asymmetry in pp and pA elastic scattering in the CNI region, aiming at determination of r_5, the fractional spin-flip component of the hadronic elastic amplitude. Some inconsistency is observed and possible reasons are discussed.

Relevant topics:

Forward spin asymmetry

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Higher twist effects in minimum bias hadronic collisions

Author: Sergey Ostapchenko[1]

[1] *Frankfurt Institute for Advanced Studies (FIAS)*

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Using a phenomenological approach, I investigate the importance of higher twist corrections to parton processes in high energy proton-proton scattering.

Relevant topics:

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Opening remark

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CMS : Minimum bias measurements at 13 TeV

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Recent results on Forward Physics and High-Energy Scattering from CMS

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LHCf-ATLAS common analysis

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IceCube (TBC)

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Diffuse TeV gamma-ray production and hadronic interaction (TBC)

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Atmospheric neutrino production (TBC)

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KMI Colloquium : LHC and Cosmic Rays : the Chicken or the Egg?

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STAR review (TBC)

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Exclusive resonance production via photon exchanges

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Closing remark

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Event-by-event mean p_T fluctuation and transverse size of color flux tube generated in p-p collisions

Author: Takeshi Osada[None]

We propose a novel phenomenological model of mean transverse momentum fluctuations based on the Geometrical Scaling hypothesis. Bose-Einstein correlations between two gluons generated from an identical color flux tube are taken into account as a source of the fluctuation. We calculate an event-by-event fluctuation measure and show that ALICE data observed 0.90 TeV for p+p collisions are reproduced. By fitting our model to the experimental data, we evaluate the transverse size of the color flux tube generated in the initial stage of p+p collisions.

Relevant topics:

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Evidence for GeV Cosmic Rays from White Dwarfs in the Local Cosmic Ray Spectra and in the Gamma-ray Emissivity of the Inner Galaxy

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Evidence for GeV Cosmic Rays from White Dwarfs in the Local Cosmic Ray Spectra and in the Gamma-ray Emissivity of the Inner Galaxy

Relevant topics:

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Hadronic interaction model at 1–10 TeV for atmospheric neutrino flux calculation from muon observations

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The hadronic interaction model at 1–10 GeV for the calculation of atmospheric neutrino is studied with the atmospheric muon data in 1 GeV – 1 TeV for vertical directions and in 100 GeV – 10 TeV for horizontal directions. Some preliminary result on the calculation of atmospheric neutrino flux are also shown.

Relevant topics:

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Forward Physics with tagged protons at the LHC: from the Pomeron structure to the search for quartic anomalous couplings

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Forward Physics with tagged protons at the LHC: from the Pomeron structure to the search for quartic anomalous couplings

Relevant topics:

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Contributions of diffraction on the forward particle production in \sqrt{s} = 13 TeV proton-proton collisions with ATLAS-LHCf detectors

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Collider experiment is an efficient way to verify and improve the hadronic interaction models. Abundant of energy flow in the forward region of the collisions are believed to have large influence to the development of air-shower. LHCf is the experiment dedicate to verify the hadronic interaction models by measuring the forward neutral particle production at the LHC. According to the LHCf results, no simulation model can predict the LHCf data perfectly. Thus, it is necessary to classify the LHCf observables into specific interaction types; diffraction and non-diffraction. Several Monte Carlo simulation samples in p-p collisions at \sqrt{s} = 13 TeV were analyzed for studying the presence of differences among specific interaction types on the LHCf observables. Combining the information of ATLAS, LHCf can identify these specific interaction types experimentally, especially, the low mass diffraction. LHCf and ATLAS have succeed the common data-taking in p-p collisions at \sqrt{s} = 13 TeV. If the we finish the necessary review progresses, the recent joint analysis result will be reported.

Relevant topics:

Cosmic ray, Hadronic interactions, Diffraction

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Exclusive diffraction results from CMS

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Exclusive diffraction results from CMS

Relevant topics:

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Exclusive resonance production via photon exchanges

Author: Jordan Scharnhorst[None]

With the usage of proton tagging at the LHC arises the possibility of detecting broad resonances. Without proton tagging, it is difficult to find broad resonances within the statistical and systematic uncertainties on the invariant mass due to the high SM backgrounds. We seek to establish bounds on the widths of broad resonances produced exclusively by diphoton exchanges with and without proton tagging.

Relevant topics:

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Welcome address

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Overview of the workshop series

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A Forward Calorimeter Upgrade in LHC-ALICE

Author: Toma Suzuki[1]

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In high-energy heavy-ion collisions at the Relativistic Heavy Ion Collider (RHIC) and at the Large Hadron Collider (LHC) strongly interacting matter is produced in which quarks and gluons are deconfined. The ALICE experiment studies the properties of this so-called Quark-Gluon Plasma at the LHC. However, there are still many unanswered questions with regards to the initial state of these heavy ion collisions. Measurements in the forward region at high energy such as at the LHC are expected to access the initial state more clearly, e.g. addressing gluon saturation such as the Color Glass Condensate (CGC).
There is an upgrade plan to implement a Forward Calorimeter in the ALICE experiment at the LHC, covering $3.3< \eta <5.3$. FoCal is composed of an electro-magnetic calorimeter (FoCal-E) , which will be used for the measurement of direct photons and π^0 ,while a hadron calorimeter (FoC al-H), will be used for jet measurements in the forward region. In addition, FoCal-E consists of a low granularity layer(LGL) for the measurement of photon energy and a high granularity layer(HGL) with pixel readout for a precise hit position measurement.
In this presentation, we will discuss the physics motivations of FoCal and the current status of the FoCal research and development. We will also show recent results of the physics and detector simulations on the FoCal performance.

Relevant topics:

hardware and future projects

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Memory of Prof. Lev Lipatov

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