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"Exclusive and diffractive processes in high energy proton-proton and nucleus-nucleus collisions"

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1 Chung, Suh-Urk
The Status of Diffractive 3-π systems from COMPASS

2 Figiel, Jan, for the H1 and ZEUS Collaborations
Diffraction at HERA

The selected, recent results on diffractive processes observed by the H1 and ZEUS experiments in e-p interactions at the HERA collider are presented. Many results on energy and momentum transfer dependence of the vector meson (VM) production show universal behaviour reflecting transition between soft and hard regime of the Quantum Chromodynamics (QCD). The new, precise measurements of the inclusive diffractive structure finctions are shown as well. They allow to obtain (QCD hard factorisation theorem) the universal diffractive Parton Distribution Functions (dPDF's) which, in turn, are used to predict (QCD factorisation, NLO calculations) cross-sections for other, semi-inclusive diffractive processes. In particular this procedure turned out to be successful for the diffractive dijet production in deep inelastic scattering (DIS) but seems to fail for diffractive dijets in photoproduction, suggesting violation of the QCD factorisation as in hadron-hadron interactions. Despite of closing HERA in 2007 still new experimental results on diffraction are expected to challenge the QCD predictions.

3 Gay Ducati, Beatriz
Higgs Boson Production with QCD and EW Corrections at LHC

4 Giacobbe, Benedetto
Status and Results of ATLAS on Diffractive and Exclusive Reactions

5 Goerlich Lidia, for the H1 Collaboration
Measurement of the Azimuthal Correlation between the most Forward Jet and the Scattered Positron in Deep-Inelastic Scattering at HERA

Deep-inelastic positron-proton scattering events at low photon virtuality, Q^2, with a forward jet, produced at small angles with respect to the proton beam, are measured with the H1 detector at HERA. A subsample of events with an additional jet in the central region is also studied. For both samples, differential cross sections and normalised distributions are measured as a function of the azimuthal angle difference, $\Delta\phi$, between the forward jet and the scattered positron in bins of the rapidity distance, Y , between them. The data are compared to predictions of Monte Carlo generators based on different evolution approaches as well as to next-to-leading order calculations in order to test the sensitivity to QCD evolution mechanisms. Measurements of the cross sections as a function of $\Delta\phi$and Y are best described by the BFKL-like CDM model. Additionally, the shape of the $\Delta\phi$ distributions does not discriminate further between different evolution schemes. The fixed order NLO DGLAP predictions are in general below the data, but still in agreement with the large theoretical uncertainties.

6 Grafstrom, Per
Experimental overview of Bound-Free electron-positron Pair Production in heavy ion collisions

It is defined what is meant with Bound-Free pair production (BFPP) or Electron Capture from Pair Production (ECCP) in the strong electromagnetic field between two nuclei. The analogy with anti-hydrogen production is pointed out. An overview of the experimental program is given starting from the first low energy measurements ending with the recent LHC observations. The measurements of BFPP at the Bevalac in the beginning of the 90ths are described. The

role of radiative and non radiative electron capture is pointed out. Later measurements at Brookhaven using the Alternate Gradient Synchrotron and similar apparatus as was employed at the Bevalac are also described. Some time is devoted to the detailed measurements done at CERN within the CERN fixed target heavy ion program using Pb ions accelerated with the SPS. Due to the big cross section at ultra relativistic energies (hundreds of Barns) BFPP is a limiting factor for high energy heavy ion colliders. Several aspects of those limitations are discussed. BFPP in a heavy-ion collider was first observed at the RHIC and those results are shown. Recently BFPP was also observed at the LHC in Pb-Pb collisions. Those striking observations are also described. The first attempts to estimate the cross section from the observations at the colliders are explained.

7 Gustafson, Gosta
Exclusive final states in diffractive excitation

In this talk I describe a formalism for generating exclusive final states in diffractive excitation. It is here assumed that the production of rapidity gap events is analogous to diffraction in optics, and the formalism is based on the GoodWalker formalism for diffractive excitation. Thus diffraction is visualized as the shadow of absorption, and fully determined by the transition to inelastic states. It is also assumed that the diffractive eigenstates are represented by the virtual parton cascades, specified by a definite absorption amplitude. We emphasize that, although diffractive excitation is basically a quantum-mechanical phenomenon with strong interference effects, it is possible to calculate the different interfering components to the amplitude in an event generator, add them and thus calculate the reaction cross section for exclusive diffractive final states.

The result is calculated using the Lund Dipole Cascade model, implemented in the DIPSY event generator. This model is based on BFKL evolution to small x, including essential non-leading corrections and effects of saturation. It reproduces well inclusive and elastic cross sections, and gives a fair description of exclusive final states in non-diffractive events. Preliminary results for exclusive diffractive states in DIS are presented. As in this formalism diffraction is determined with the help of the optical theorem, the generation of diffractive excitation is also fully determined, when the parameters of the model are adjusted to non-diffractive and elastic data, with no additional tunable parameters. Work is in progress for application to pp collisions. The results are obtained in collaboration with Christoffer Flensburg and Leif Lönnblad.

8 Harland-Lang, Lucian
Latest Results on Standard Candle Central Exclusive Production within the Durham Model

Work performed as part of the KRYSTHAL collaboration on standard candle central exclusive production (CEP) processes within the pQCD??? based Durham model is presented, which involve the production of systems with sufficiently low masses that observation of these processes is already possible at the Tevatron and in the early LHC low luminosity runs. These processes allow us to test the overall theoretical formalism as well as being of interest in their own right. This talk concentrates on three particular examples of these processes, with emphasis on new experimental results at the LHC and Tevatron, and how these can be used to constrain and test the theory predictions. First, the CEP of chi_c charmonium, via radiative and two-body decay channels, is discussed and comparisons are made with recent potentially exclusive LHCb data. With this in mind, we present initial estimates of the expected background at the LHC from non-exclusive events, where one or both protons dissociates: such processes are poten-

tially important at the LHC, when the outgoing protons are not measured, but only some restricted large rapidity gap conditions can be imposed. Second, the CEP of meson pairs is discussed, considering both the 'non-perturbative' (calculated using Regge Theory) and 'perturbative' (calculated using the pQCD-based Durham model) contributions, and concentrating on the possible continuum background to chi_c → pi+pi- (K+K-). Finally, diphoton CEP is discussed. Theory predictions within the Durham framework using different PDF sets are compared with the recent CDF diphoton results, with particular attention paid to the possibility of using this (and future) data to constrain the gluon PDF at low x and Q^2; predictions for the LHC using a variety of gluon PDFs and updated survival factors to account for the recent TOTEM elastic pp data are given.

9 Hiroaki, Menjo
Recent results from the LHCf experiment

The LHCf experiment is one of the LHC forward experiments and the unique experiment dedicated to the ultra-high energy cosmic-ray physics. The aim is to provide a detailed calibration of hadronic interaction models used in air shower simulations by measurement of energy and transverse momentum spectra of neutral particles (photons, neutrons and neutral pions) at the LHC forward region. The LHCf detectors, which each are composed of two sampling and imaging calorimeter towers, had been installed at 140m far from one LHC interaction point (IP1). The detectors cover the pseudo-rapidity range of more than 8.4 at the beam crossing angle of 140urad. LHCf has completed the physics program at sqrt(s)=900GeV and 7TeV p-p collisions in 2010. In this talk, we presented the recent LHCf results, forward photon energy spectra at 900GeV and 7TeV p-p collisions and forward neutral pions at 7TeV p-p collisions. We found no model is able to reproduce the experimental results and they are located around the middle of predictions of hadron interaction models. Other analyses, for neutral hadrons, transverse momentum spectra of photons and etc, are ongoing. LHCf will have operations again, at p-Pb collisions in the end of 2012, at sqrt(s)=14TeV p-p collisions. Additionally we are discussing with BNL people to have possibility of operation at RHIC with lower collisions energy and icon collisions.

10 Hollar, Jonathan
CMS Results on Exclusive and Diffractive Reactions

11 Ivanov, Dmitry
Mueller-Navelet jet production in proton-proton collisions

12 Jenkovszky, Laszlo
Diffractive production of resonances

Low-mass single diffraction dissociation (SDD) will be among the first measurements at the LHC. While high-mass diffractive scattering receives much attention - mainly due to its relatively straightforward interpretation through triple Regge formalism and successful measurements at the ISR,

HERA and Tevatron - low-mass SDD still lacks both experimental measurement and theoretical understanding. A dual-Regge model with a nonlinear proton Regge trajectory in the missing mass channel, describing the experimental data on low-mass single diffraction dissociation, is constructed.Predictions for the LHC energies are given. The expected resonance structure for the low-mass single diffractive states from a Regge-dual model is predicted. Estimates for the observable low-mass single diffraction dissociation cross sections and efficiencies

for single diffractive events simulated by PYTHIA 6.2 as a function of the diffractive mass are given. Model calculations for the low mass SDd process were corrected by the experimental efficiencies. The forward detector systems T1 and T2 (or equivalently the HF and CASTOR calorimeters) facilitate detection of forward diffractive masses down to about 4 GeV, far above the three dominating N^* states.

An approximate calculation of the diffractive mass was made through its relation to the size of the rapidity gap adjacent to the scattered proton. The adjacent rapidity gap was defined as the gap between the diffractive proton (close to the beam rapidity) and the nearest particle in rapidity.

The correspondence between the diffractive mass and the pseudorapidity gap was established. To provide for a more precise (although model-dependent) measurement, the PYTHIA program has been used to determine the correlation between the diffractive mass and the size of the rapidity gap.

We present the actual (generated) diffractive mass together with that calculated by the above method, for two cases:

(a) for full eta coverage, and

(b) for a limited eta range $|\eta| < 4.7$, i.e., the nominal CMS coverage.

The efficiency of the Forward Shower Counters for detecting forward diffractive systems is high. For low-mass single diffraction one relies largely on the FSC's. Measurement of the content (off-line) of individual FSC counters, which cover different eta-ranges, provides more differential tests of the diffractive event simulation. From the various rates, with knowledge of the FSC efficiencies, the background contributions can be estimated and subtracted from different situations. Correlations between the FSC counters can be determined and compared with expectations. These will be used to make more precise determinations of the mass of the diffractive system. The ultimate uncertainties to be achieved will come from work which is in progress. Another valuable check will be the independence of all the measured cross sections on the instantaneous luminosity.

In the model presented here, there is no significant contribution from the so called Roper resonance. For completeness, the case where it dominates the low SDD masses was considered. This mass region would be efficiently covered by the additional Forward Shower Counters

13 Kaiser, Norbert
Chiral symmetry and low-energy pion-photon reactions

14 Kowalski, Henri
A New Way to Physics beyond the Standard Model

15 Kroll, Peter
Exclusive wide-angle processes

It is reported on an analysis of recent BELLE data on two-photon annihilations into pairs of pseudoscalar mesons. The analysis is based on a QCD inspired model of the handbag type in which the process factorizes in a hard subprocess $\gamma\gamma \to q\overline{q}$ and soft $q\overline{q}$ transitions to the meson pair. It is shown that the latter transitions appear as form factors which represent second moments of 2-meson distribution amplitudes (or time-like generalized parton distributions). With the help of SU(3) flavor symmetry combined with the absence of isospin-2 states in the handbag approach one can show that there are only two independent form factors, one for valence and one for non-valence quarks, which represent the soft physics information for the six pseudoscalar meson channels. This handbag approach describes well all BELLE data for energies larger than 3 GeV. Comparison with other approaches and the application of the

handbag approach to other wide-angle processes, as for instance two-photon annihilation into baryon-antibaryon pairs, are also briefly discussed. The talk is based on Refs. [1, 2].

References

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[2] M. Diehl and P. Kroll, Phys. Lett. B683, 165 (2010).

16 **Kus, Vlastimil**
Rapidity gaps in diffractive dijet events

17 **Lebiedowicz, Piotr**
Exclusive diffractive production of π^+ and π^- and K^+ K^- in pp-collisions

18 **Luszczak, Marta**
Diffractive production of charm in pp-collisions

19 **Maciula, Rafal**
Exclusive production of dijets in pp-collisions

20 **Mayer, Christoph**
Exclusive pair production in ultra-relativistic heavy ion collisions

21 **Mesropian, Christina**
Status and Results from the Tevatron

22 **Mieskolainen, Mikael**
Advanced Multivariate Methods in HEP

23 **Moran, Dermot**
Measuring Exclusive Dimuon Production at LHCb

Central Exclusive Production is of interest as it may allow a precise measurement of the Higgs mass and quantum numbers. The theoretical predictions for Central Exclusive Production may be tested and the current models constrained by measuring exclusive cc production. Exclusive J=y and y(2S) photoproduction are of interest as they allow a search for the odderon and provide a means to constrain the unintegrated gluon distribution functions. The cross-section for exclusive dimuon production from diphoton exchange has a small theoretical uncertainty. Therefore a measurement of this process provides a test of the experimental methods used to identify exclusive events. The exclusive production processes involve colourless exchanges between the protons resulting in regions devoid of particles called rapidity gaps. Exclusive candidates are identified at LHCb through the use of Vertex Locator defined rapidity gaps. This talk presents preliminary results for the measurement of exclusive dimuon production at LHCb using the data collected throughout the running period of 2010.

24 **Nachtmann, Otto**
A model for high-energy soft reactions

25 **Orava, Risto**
Measuring Diffraction at the LHC

26 **Pasechnik, Roman**
Gap survival effects from soft color screening

27 **Pilkington, Andy**
A new model for minimum bias in Sherpa

28 **Pinfold, James**
The MoEDAL experiment and its physics program

29 **Royon, Christophe**
The ATLAS Physics Project

30 **Royon, Christophe**
Anomalous couplings studies and the ATLAS Forward Physics project

31 **Sandacz, Andrzej**
Diffractive physics at STAR - present and future

32 **Schaefer, Wolfgang**
Diffractive production of heavy vector mesons in pp and AA collisions

33 **Schicker, Rainer**
Electromagnetic interactions, introduction to the session

The process of (free) lepton pair production in electromagnetic interactions of protons and nuclei is reviewed in Born approximation. The process of bound-free pair production in Pb-beams is introduced, where the electron is captured in an atomic bound state of the Pb-nucleus. At the high energies of the Large Hadron Collider (LHC), the very strong photon fluxes of Pb-beams lead to a cross section of bound-free pair production which exceeds the geometrical cross section by a factor of about 70. This session is devoted to the process of bound-free pair production, starting with an experimental overview, and continuing with a presentation of the prospects of such measurements at the LHC. The following talks are then focusing on possible physics measurement by using the tagged outgoing Pb(81+) beam as an impact parameter filter for selecting purely electromagnetic interactions at the LHC.

34 **Schicker, Rainer**
Prospects of bound-free pair production measurements at LHC energies

The very strong photon fluxes of Pb-beams at the Large Hadron Collider (LHC) lead to a range of electromagnetic interactions in the regime $Z\alpha \sim 0.6$. Corrections to the Born approximation are therefore needed for an exact prediction of experimentally measurable cross sections. As a example, the process of free pair production in Pb-Pb beams at the LHC is presented where the Coulomb and unitarity corrections reduce the Born cross section by 14% and 3%, respectively. The concept of tagging the Pb(81+) for selecting electromagnetic interactions at the LHC is presented. Multiple pair production is then discussed where the second pair can be either free or bound-free. As an example of two pair production, photoproduction of pion or kaon pairs is

presented. As an additional application of bound-free pair tagging, the feasibility of measuring the energy dependence of the total $\gamma\gamma$-hadronic cross section is discussed.

35 **Staszewski, Rafal**
Diffractive W production at the LHC

36 **Szczurek, Antoni**
Exclusive diffractive production of W+W- pairs in pp-collisions

37 **Tasevsky, Marek**
Central Exclusive Higgs Production im MSSM

38 **Teryaev, Oleg**
Possible dualities between different mechanisms of hadronic exclusive processes

39 **Trzebinski, Maciej**
Diffractive Jet-Gap-Jet Production

40 **Werder, Dominik**
Monte Carlo study of soft color screening effects in diffractive DIS

41 **Wagner, Jakub**
Exclusive lepton pair production in ultra-peripheral collisions

Generalized Parton Distributions (GPDs) offer a new way to access the quark and gluon nucleon structure. We advocate the need to supplement the experimental study of deeply virtual Compton scattering by its crossed version, timelike Compton scattering (TCS) i.e. the exclusive photoproduction of a lepton pair with large invariant mass. We review recent progress in this domain, emphasizing the need to include NLO corrections to any phenomenological program to extract GPDs from experimental data. We also stress that data on TCS at very high energy should be available soon thanks to the proposed experimental program at JLab at 12 GeV, and study of ultraperipheral collisions at the RHIC and LHC which opens a window on quark and gluon GPDs at very small skewness.