RECENT RESULTS on HARD DIFFRACTION at HERA

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Abstract. Recently measured differential cross sections of diffractive processes with dijets and prompt photons in the final state of ep collisions at the HERA collider are reviewed. Results are compared to QCD calculations based on different models of diffraction.

1 Introduction

The HERA collider experiments H1 and ZEUS recently presented new results on diffractive processes with dijets and prompt photons in the final state of ep collisions at $\sqrt{s} = 318\ GeV$ [1–4]. The measurements were performed in the range of photon (γ^*) virtualities running from the photoproduction region at $Q^2 < 1.0\ GeV^2$ to the deep inelastic scattering (DIS) region with $Q^2 \gtrsim 2.0\ GeV^2$. Diffractive events were identified either by a large rapidity gap (defind with pseudorapidity η_{max}) in the final state (LRG method) or by tagging the leading scattered proton (LP method). Both detectors were designed for measurements in a wide range of the kinematic variables of diffractive events such as $x_{I\!P}$, the fraction of the proton momentum carried by the Pomeron ($I\!P$) and fractions of the photon, x_γ, and of the Pomeron, $z_{I\!P}$, momenta, participating in the hard process. Hadronic and photon jets were reconstructed with the k_T algorithm [5]. Hard diffraction data were compared to pQCD calculations with the Resolved-Pomeron [6] and the Two-Gluon-Exchange [7] models of the diffraction mechanism.

2 Dijet Production in Diffractive ep Collisions

New H1 measurements (LRG and LP methods) [1, 2] of diffractive dijet cross sections in DIS and in photoproduction and also the ZEUS earlier measurements (LRG method) [8] were compared to the Resolved-Pomeron model [6]. The measurement ranges of both experiments mostly overlap, but they are not identical. Good agreement within experimental and theoretical uncertainties in both shape and normalization between measured distributions (Fig.1,a,b) and pQCD calculations based on HERA DPDFs [8–10] supports QCD factorization validity for diffractive dijet processes in DIS. In diffractive dijet photoproduction H1 and ZEUS observations are different. While the ZEUS cross sections are in agreement with the calculations, the new H1 distributions, as well as H1 earlier ones, are systematically below the calculations with a factor of $\sim 0.55 \pm 0.21$. The H1 data alone indicate factorisation violation for diffractive

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dijet photoproduction. New proof of this indication was obtained with a quotient $\mathcal{R} = (DATA/NLO)_{\gamma^* p}/(DATA/NLO)_{DIS} = 0.51 \pm 0.09(exp) \pm 0.02(th)$ (double ratio of data to NLO) [2] where the errors are somewhat reduced due to the cancellation of some experimental systematic and theoretical uncertainties.

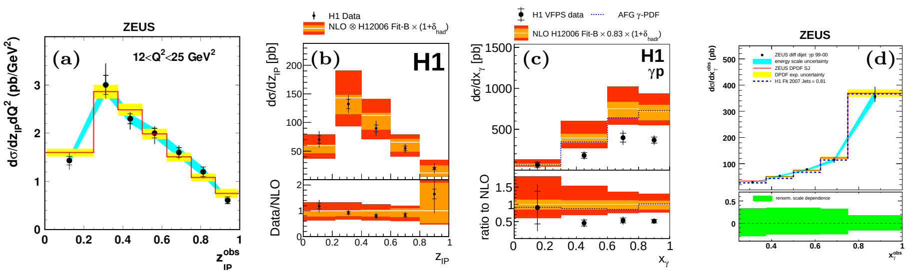

Figure 1: Differential cross-sections in $z_{I\!P}$ (a,b) for diffractive DIS production and in x_{γ^*} (c,d) for diffractive photoproduction of dijets compared to NLO QCD calculations with HERA DPDFs [8–10].

3 Exclusive Dijet Production in Diffractive DIS

The exclusive production of dijets, in diffractive deep inelastic $e^{\pm}p$ scattering was studied with the ZEUS detector using an integrated luminosity of 372 pb^{-1} for the first time [3]. The diffractive DIS range was restricted by $Q^2 > 25\ GeV^2$, $90 < W < 250\ GeV$, $x_{I\!P} < 0.01$, $\eta_{max} < 2$ and $M_X > 5\ GeV$(diffractive mass). Jets with $p_T^{jet} > 2\ GeV$ were selected in $ep \rightarrow e + jet_1 + jet_2 + p$ reaction using the k_T algorithm. The differential cross sections as a function of $\beta = x/x_{I\!P}$, where x is the Bjorken variable, and ϕ which is the angle between the jet and the lepton planes (details in Fig.2 of [3]) are shown in Fig.2. As is seen from Fig.2, both models, the Resolved-Pomeron model [6] (red histograms) based on DPDFs H1 2006 fits A and B [9] and the Two-Gluon-Exchange [7] model (blue histograms) with the GRV gluon density [11] of the proton, underestimate the data. As predicted by both models, the shapes of the measured ϕ distributions are well reproduced by function $(1 + A \cdot cos2\phi)$. As β increases, the parameter A flips sign (Fig.2, lower row) in accord with the Two-Gluon-Exchange model. Such behaviour is inconsistent with an almost constant, positive value of A in the whole β range as expected with the Resolved-Pomeron model.

4 Diffractive Photoproduction of Isolated Photons

Differential cross sections of isolated photon diffractive photoproduction were measured with the ZEUS detector at HERA collider using an integrated luminosity of 374 pb^{-1} inclusively and with at least one accompanying jet [4]. The measurement region was defined by $Q^2 < 1\ GeV^2$, $0.2 < y < 0.7$ and $x_{I\!P} < 0.03$, $\eta_{max} < 2.5$. Photon and hadronic jets were identified in the

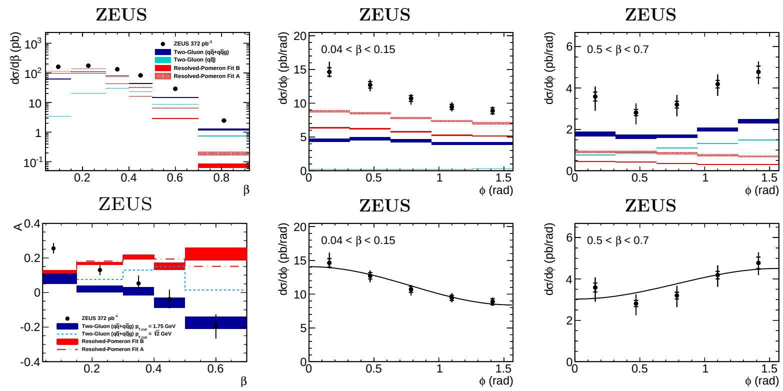

Figure 2: Differential cross-sections in β and ϕ for the diffractive DIS production of exclusive dijets compared to Resolved-Pomeron (red histograms), Two-Gluon-Exchange models (blue histograms) and function $(1 + A \cdot cos2\phi)$ (black lines).

ranges $5 < E_T^{\gamma} < 15\ GeV$, $-0.7 < \eta^{\gamma} < 0.9$ and $4 < E_T^{jet} < 35\ GeV$, $-1.5 < \eta^{jet} < 1.8$. Most photons ($\sim 80\%$) were found to be accompanied by a jet. A proton excitation admixture ($\sim 16\%$) was not subtracted. The shapes of the measured cross sections (Fig.3) are reasonably described by Rapgap (with DPDF-p H1-2006-B [9], PDF-γ SAS-G 1D LO [12]) predictions normalized to data, except for a peak at $z_{I\!P} \sim 1$ (Fig.3f). In diffractive data, direct $\gamma^* p$ processes appeared to be strongly dominated over the resolved ones (Fig.3e): $\mathcal{R}_{diff} = direct/resolved \sim 4/1$ (in non-diffractive case: $\mathcal{R}_{non-diff} \sim 1.17/1$ [13]).

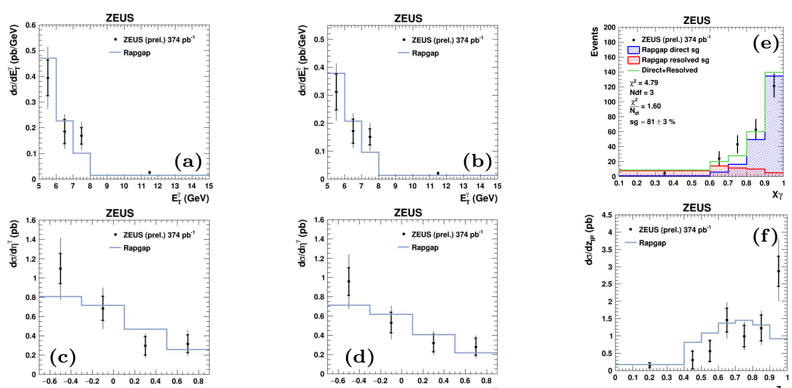

Figure 3: Differential cross sections of diffractive photoproduction of isolated photonin E_T^{γ}, η^{γ} without (a,b) and in E_T^{γ}, η^{γ}, $z_{I\!P}$, x_{γ} with (c,d,e,f) an accompanying jet compared to Rapgap MC model.

Summary

The HERA collider experiments recently presented new results on diffractive processes with dijets and prompt photon in final states of *ep* collisions. The NLO pQCD calculations with HERA DPDFs agree with the new H1 data on diffractive dijet cross sections in DIS, whereas in photoproduction they overestimate the new H1 measurements, as well as H1 earlier, independent ones, indicating possible factorisation violation in these processes. However, earlier ZEUS diffractive dijet data are compatible with NLO pQCD calculations in photoproduction and DIS, suggesting that the QCD factorisation holds in both ranges. The first measured cross sections of diffractive production of exclusive dijets in DIS from the ZEUS detector are underestimated by QCD based models of diffraction. The Two-Gluon-Exchange model reproduces the shape of the ϕ distributions whereas the Resolved-Pomeron model does not. The diffractive photoproduction of isolated photons with and without an accompanying jet has been measured with the ZEUS detector. The RAPGAP model reasonably describes the shape of differential cross sections in the transverse energy and pseudorapidity of the photon and of the jet. A prominent peak near $z_{I\!P}^{meas} = 1$ is not described by this model and requires further study.

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[1] H1 Coll., V. Andreev et al., JHEP **03** (2015) 092.
[2] H1 Coll., V. Andreev et al., JHEP **05** (2015) 056.
[3] ZEUS Coll., H. Abramowicz et al., Eur. Phys. J. **C 76** (2016) 1.
[4] ZEUS Coll., ZEUS-prel-15-001.
[5] S. Catani, Y. L. Dokshitzer, M. H. Seymour, B. R. Webber, Nucl. Phys. **B 406** (1993) 187.
[6] G. Ingelman and P. E. Schlein, Phys. Lett. **B 152** (1985) 256.
[7] J. Bartels et al., Phys. Lett. **B 386** (1996) 389 and refs. therein V.M. Braun and D. Yu. Ivanov, Phys. Rev. **D 72** (2005) 034016.
[8] ZEUS Coll., S. Chekanov et al., Nucl. Phys. **B 831** (2010) 1.
[9] H1 Coll., A. Aktas et al., Eur. Phys. J. **C 48** (2006) 715.
[10] H1 Coll., A. Aktas et al., JHEP **10** (2007) 042.
[11] M. Glück, E. Reya and A. Vogt, Z. Phys. **C 67** (1995) 433.
[12] G. A. Schuler and T. Sjöstrand, Phys. Lett. **B 376** (1996) 193.
[13] ZEUS Coll., H. Abramowicz et al., JHEP **08** (2014) 023.