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Measurement of Diffractive Dijet Production at the H1 Experiment

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Abstract. The new results on measurement of dijet production in diffractive deep inelastic ep scattering, ep → eXY, obtained with the H1 detector are presented. The system X contains at least two jets. Measurements are performed using two approaches. One approach is based on detection of the diffractive processes with Y being a proton or its low mass excitation. Diffractive events are selected by demanding a large empty rapidity gap interval separating the final state hadronic systems X and Y. In another approach, the leading final state proton from the process ep → eXp is detected in the H1 Very Forward Proton Spectrometer. The measurements are compared with predictions from NLO QCD calculations based on diffractive parton densities.

INTRODUCTION

The processes of the type ep → eXY in deep inelastic scattering (DIS) at low Bjorken x at the HERA collider provide a very well controlled environment for studying the QCD properties and structure of diffraction. Here, X is a high-mass hadronic state and Y is the elastically scattered proton or its low-mass excitation, emerging from the interaction with almost the full energy of the incident proton. To interpret the dynamics of diffractive DIS, a general theoretical framework is provided by the QCD collinear factorisation theorem [1]. According to this, calculations of diffractive cross sections factorise into process dependent hard scattering coefficient functions and a set of process independent diffractive parton distribution functions (DPDFs). The DPDFs have to be determined from QCD fits to the measured inclusive diffractive cross sections assuming DGLAP evolution of the DPDFs. Experimental determination of the DPDFs is based on assumption of an additional factorisation of the DPDFs dependence on the scattered proton momentum from the dependence on the other variables, ascribed to the structure of the colorless exchange - vertex factorisation. A pomeron flux in the proton is introduced and universal parton densities are attributed to the diffractively exchanged object.

At high energy, diffractive ep scattering has two specific signatures. A leading proton carrying most (> 90%) of the beam energy may be directly detected (proton tagging measurement) in the final state using proton spectrometers. Diffraction may also be identified by a final state with no hadronic activity in a large rapidity region, called Large Rapidity Gap (LRG). The LRG separates the outgoing (untagged) proton, or (untagged) low mass hadronic system Y originating from proton dissociation, from the rest of the hadronic system X.

In this paper measurements of dijet production in diffractive ep scattering obtained by the H1 collaboration are presented. The results are obtained with the LRG method [2] and with a proton tagged in the Very Forward Proton Spectrometer VFPS [3]. It was shown in several measurements that Next-to-leading order (NLO) QCD predictions using DPDFs describe processes such as jet and heavy quark production in diffractive DIS (DDIS) at HERA. However, in diffractive hadron-hadron interactions, the production of jets is found to be suppressed by about one order of magnitude as compared to predictions based on HERA DPDFs. The issues of DPDF applicability and "factorisation breaking" can also be studied in hard diffractive photoproduction (γp), where the virtuality of the exchanged photon Q^2 is close to zero. In this regime, because of the small photon virtuality, partonic fluctuations $\gamma \rightarrow q\bar{q}$ last long enough to interact with the partons in the proton and the photon can be treated as a quasi-real target exhibiting hadronic structure. Since events with two jets are readily produced in gluon-induced processes, measurements of diffractive dijet cross sections are sensitive to the value of the strong coupling α_s and to the gluon content of the pomeron.

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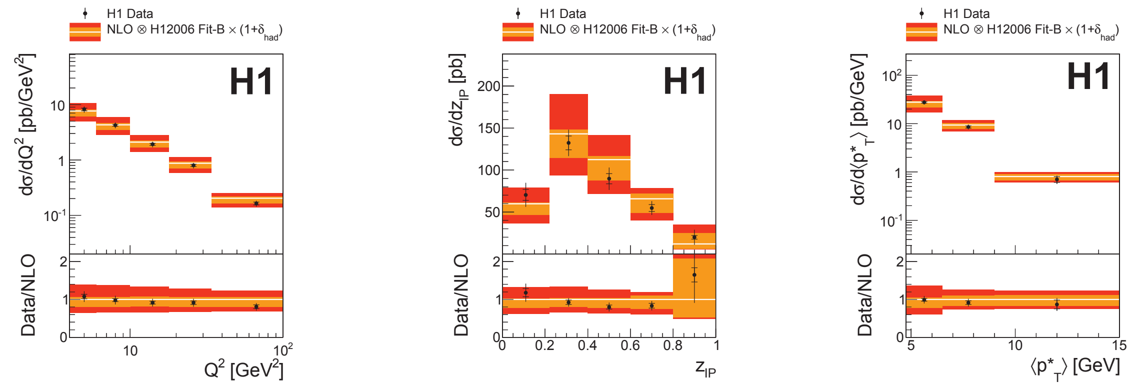

FIGURE 1. Diffractive dijet differential cross section as a function of Q^2, z_{IP} and $< p_T^* >$ and its ratio to the NLO prediction based on the H12006 Fit-B DPDF which is displayed as a white line. The inner error bars on the data points represent the statistical uncertainties, while the outer error bars include the systematic uncertainties added in quadrature. The light shaded band indicates the uncertainty arising from hadronisation and the DPDF fit added in quadrature. The outer dark band shows the full theory uncertainty including the QCD scale uncertainty added in quadrature. The lower parts show the the ratio of the data to the NLO prediction.

The differential diffractive DIS cross section is measured in the kinematic variables of the exchanged boson virtuality Q^2, the inelasticity of the process y, the fraction of the momentum of the proton carried by the diffractive exchange x_{IP} , the Bjorken variable defined for the diffractive exchange β, and the four-momentum transfer squared at the proton vertex $|\ t\ |$. For diffractive dijet production additional invariants are introduced, the longitudinal fractions of the photon and of the pomeron momentum entering the hard sub-process, x_γ and z_{IP}.

The simulation of processes ep → eXY is done with the RAPGAP [4] event generator. Assuming the proton vertex factorisation, the parton densities obtained in the previous QCD analysis of inclusive diffractive data (H12006 Fit-B) [5] are convoluted with leading order QCD matrix elements.

DIJETS FROM DIFFRACTIVE EVENTS SELECTED BY THE LRG METHOD

In the LRG analysis the diffractive process ep → eXY, with a proton or its low mass excitation with $M_Y < 1.6$ GeV, is studied. The analysis is restricted to the phase space region with $4 \leq Q^2 \leq 100$ GeV^2, $|\ t\ | < 1$ GeV^2 and $x_{IP} < 0.05$. The events are required to have at least two jets in the pseudorapidity range $1 < \eta_{1,2}^{lab} < 2$ and transverse momenta of the leading and sub-leading jets are required to be larger than 5.5 GeV and 4.0 GeV in the γ-p centre-of-mass frame respectively. Events are selected in a phase space which is somewhat larger than the measurement phase space in order to have better precision of the measurement by accounting for migrations at the phase space boundaries.

The results obtained with LRG method are based on data collected in the years 2005-2007 corresponding to an integrated luminosity of 290 pb^{-1}. This is the full HERA-II data sample with significantly larger statistics with respect to previous analyses. Also, the cross sections are determined using a regularised unfolding procedure which fully accounts for efficiencies, migrations and correlations among the measurements.

The integrated cross section in the measurement phase space is found to be,

$$\sigma_{meas}^{dijet}(epeXY) = 73 \pm 2(stat.) \pm 7(syst.)\ \text{pb},$$

while the NLO QCD prediction of the total diffractive dijet cross section is,

$$\sigma_{theo}^{dijet}(ep \to eXY) = 77^{+25}_{-20}\ (\text{scale})^{+4}_{-14}\ (\text{DPDF}) \pm 3(\text{had})\ \text{pb},$$

which is in very good agreement with the measurement. The experimental uncertainty is found to be significantly lower than the uncertainty on the NLO prediction.

Single differential cross sections as a function of the DIS variable Q^2, of the momentum fractions z_{IP} and as a function of the jet variable $< p_T^* >$ are shown in Figure 1. The figure also include the NLO QCD predictions which

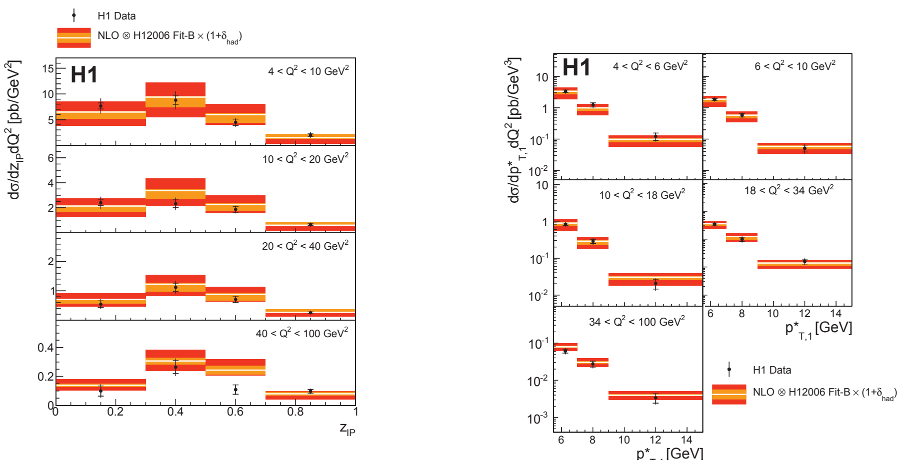

FIGURE 2. Double-differential cross section as a function of z_{IP} and Q^2 (left) and double-differential cross section as a function of $p_{T,1}$ and Q^2 (right). The NLO predictions are also shown. The error bars description the same as in Figure 1.

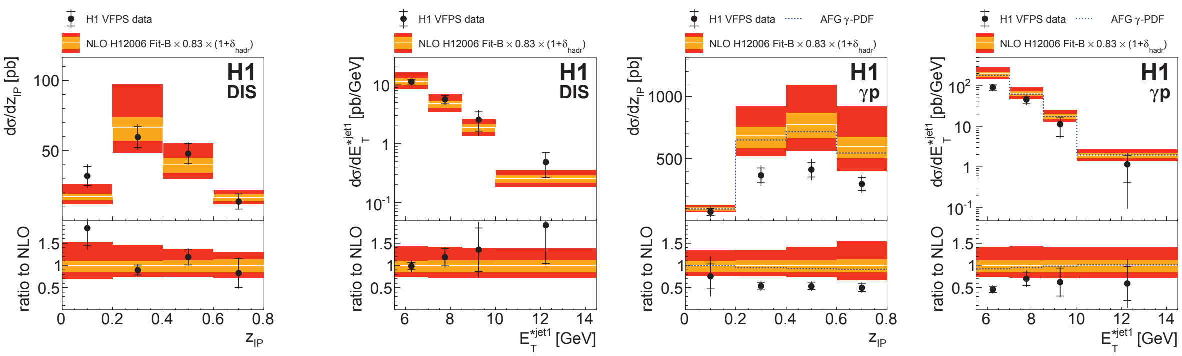

FIGURE 3. Cross sections differential in z_{IP} and E_T^{jet1} for DDIS (two plots on the left side) and for photoproduction sample (two plots on the right side). For photpoproduction, NLO (white line) is based on GRV γ-PDF set used to describe the structure of resolved photons [6]. Dashed line shows the NLO calculation using the AFG γ-PDF [7]. Descriptions for the NLO predictions and the error bars the same as in Figure 1.

describe within their uncertainties the data well both in shapes and normalisation.
Good agreement of the theory with the measurement is also found for the shapes and normalisation of the double differential cross sections measured in bins of z_{IP} and Q^2 and in bins of $p_{T,1}$and Q^2 as shown in Figure 2.

From a fit of the NLO prediction to the the double differential cross cross sections, α_s has been determined in diffractive DIS processes for the first time.

$$\alpha_s(\mathrm{M}_Z) = 0.119 \pm 0.004(\mathrm{exp}) \pm 0.012(\mathrm{DPDF, theo}),$$

which is consistent within the uncertainties with the world average.

DIJETS FROM DIFFRACTIVE EVENTS WITH A LEADING PROTON

In the analysis where a proton is detected in the VFPS is required, diffractive dijet production is measured in photoproduction and DIS. VFPS allows for a measurement of protons with energies between 895 and 912 GeV ($0.008 < x_{IP} < 0.028$) and with transverse momenta up to about 0.8 GeV ($|\ t\ | < 0.6$ GeV^2).
Diffractive dijet production is measured in photoproduction and DIS in the same kinematic range, $0.2 < y < 0.7$ and

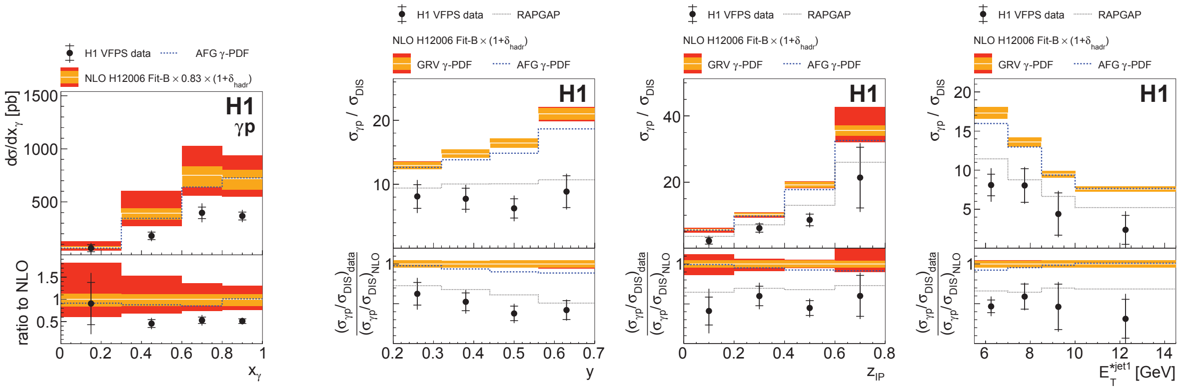

FIGURE 4. Diffractive dijet ep cross sections in the photoproduction kinematic range differential in x_γ (leftmost plot). Ratios of diffractive dijet photoproduction to DIS cross sections differential in y, z_{IP} and E_T^{jet1}. Descriptions for the NLO predictions and the error bars the same as in Figure 1 and 3.

$0.010 < x_{IP} < 0.024$ for jets with $E_T^{jet1} > 5.5$ GeV, $E_T^{jet2} > 4$ GeV and with photon virtuality $Q^2 < 2$ GeV^2 for photoproduction and 4 GeV$^2 < Q^2 < 80$ GeV^2 for DIS.

The obtained results are based on data collected in the years 2006 and 2007 with a total integrated luminosity of 30 pb^{-1} for diffractive photoproduction and 50 pb^{-1} for diffractive DIS.

Two leftmost plots in Figure 3 show the measured differential DIS cross sections as a function of the momentum fractions z_{IP} and as a function of the jet variables $p^*_{T,1}$. Two rightmost plots in Figure 3 show the same for photoproduction sample. The plots also contain the NLO calculations based on the H12006 Fit-B DPDFs which within the uncertainties describe the DIS diffractive dijet data. This result is consistent with previous H1 measurements and the new data may be used in future DPDF fits. In photoproduction the NLO predictions overestimate the measured total cross sections confirming the previous H1 results obtained with the LRG method. The shapes of the cross sections are described within the uncertainties.

The observed suppression depends neither on the variable x_γ which is sensitive to the DPDF and to the presence of a diffractive exchange remnant as shown in the leftmost plot of Figure 4.

Ratios of photoproduction to DIS cross sections and double ratios of data to NLO are analysed in order to profit from cancellations of theoretical uncertainties and the results are shown in Figure 4. Integrated over the analysis phase space the double ratio is found to be 0.51 ± 0.09 which means that within the theoretical framework based on diffractive parton densities, factorisation is broken in diffractive dijet photoproduction. This result is consistent with the previous measurements from H1 obtained with other techniques.

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REFERENCES

[1] L. Trentadue and G. Veneziano, Phys. Lett. B **323**, 201 (1994).
[2] V. Andreev et al. [H1 Collaboration], JHEP **1503**, 092 (2015).
[3] V. Andreev et al. [H1 Collaboration], JHEP **1505**, 056 (2015).
[4] H. Jung, Comput. Phys. Commun. **86**, 147 (1995).
[5] A. Aktas et al. [H1 Collaboration], Eur. Phys. J. C **48**, 715 (2006).
[6] M. Gluck, E. Reya and A. Vogt, Phys. Rev. D **45**, 3986 (1992).
[7] P. Aurenche, M. Fontannaz and J. P. Guillet, Eur.Phys.J. C **44**, 395 (2005).