Dijet production in diffractive deep inelastic scattering using the VFPS at HERA

J. Delvax

On behalf of the H1 Collaboration
Université Libre de Bruxelles
jdelvax@ulb.ac.be

Abstract. The diffractive dijet cross section has been measured using the Very Forward Proton Spectrometer in Deep Inelastic Scattering. The VFPS allows to measure the leading proton in the range $0.009 < x_{IP} < 0.024$, where x_{IP} is the energy fraction lost by the proton, with an acceptance above 90 % and negligible background contamination. The data have been collected in 2006-2007 and correspond to an integrated luminosity of 127 pb^{-1}. The cross section has been measured for virtualities of the exchanged photon in the range $5 < Q^2 < 80\,GeV^2$ and for values of the inelasticity, y, in between $0.1 < y < 0.65$. The jets are reconstructed in the $\gamma^* - p$ center of mass using a K_T algorithm. The jets are required to have a transverse momentum, P_T, in the $\gamma^* - p$ frame above $P^*_{T,j1} > 5.5\ GeV$ for the first jet and $P^*_{T,j2} > 4\ GeV$ for the second. The jets must be well contained in the central detector asking for the pseudo-rapidity of the two jets in the $\gamma^* - p$ frame to be in between $-3 < \eta^*_{j1,j2} < 0$. Single differential cross sections are compared to NLO predictions obtained using the H1 2007 Jets DPDF.

Keywords: HERA, Diffraction, Jets, QCD
PACS: 13.60.-r,13.85.-t

INTRODUCTION

The diffractive interaction is characterized by a final state composed of two distinct hadronic systems. In the present case, the scattered proton is separated by a large rapidity gap (LRG) from the hadronic final state X (see Fig. 1). The diffractive process can be described by the exchange of a colour singlet, called "Pomeron" IP, between the photon and the proton.

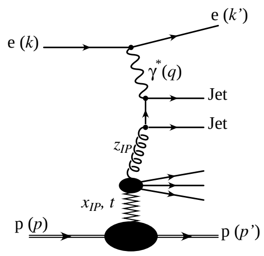

FIGURE 1. Diagram of diffractive dijet production in ep collisions.

The high energies available at the ep collider, HERA, allowed for the first time to study diffraction in terms of perturbative QCD where the hard scale is given by the high virtuality of the exchanged photon Q^2.

The inclusive diffractive cross section at HERA, $ep \rightarrow eXp$, can be described using four kinematic variables. The kinematic variables defined in includive DIS : $x_{Bjorken}$ and Q^2 which can be related to the inelasticity, y, through $Q^2 = sxy$, where s is the center of mass energy squared and two variables specific to diffraction : the longitudinal momentum fraction of the proton carried by the Pomeron, x_{IP} and the momentum transfer squared at the proton vertex, t.

Using the collinear theorem of factorization in QCD [2], the diffractive cross section can be written in terms of Diffractive Parton Distribution Functions, DPDF, which correspond the quark and gluon content of the Pomeron [1].

JET PRODUCTION

The parton distribution functions extracted from measurements in inclusive diffraction can be used to predict the diffractive dijets cross section in deep inelastic scattering (see diagram of Fig. 1).

Previous measurements of diffractive jets in DIS done by the H1 Collaboration [3] showed a good agreement between data and NLO predictions confirming the validity of the factorization theorem.

Based on jet measurements, a new set of DPDF, the H1 2007 Jets DPDF [3], was extracted and allowed to further constrain the gluon density, especially at high value of the fraction of $I\!P$ momentum carried by the parton entering in the hard interaction, $z_{IP} = \frac{x_{Bjorken}}{x_{IP}}(\frac{Q^2+M_{12}^2}{Q^2})$, where M_{12} is the mass of the jet system.

THE VERY FORWARD PROTON SPECTROMETER

In most of the analysis made by the H1 Collaboration, diffractive events were selected on the basis of the Large Rapidity Gap (LRG) method. Using this method, diffraction can be studied with a high statistic but suffers from the presence of an important background coming from proton dissociation. An other method consists on tagging the outgoing proton with proton spectrometers. The diffractive variables can then be precisely determined but with a limited statistic due to low acceptance of such detectors.

In 2004, the Very Forward Proton Spectrometer (VFPS) was installed at the H1 experiment with the aim of a direct measurement of the scattered proton with a high acceptance (above 90 %) and a low background contamination (below 1 %).

The VFPS is composed of two stations, based on the Roman Pot technology, located at 220 meters from the interaction point. Each station is equipped with two scintillating fiber detectors to measure track coordinates from the leading proton.

A complete information on the VFPS construction and installation can be found in [4]. A study of the VFPS performances (acceptance, efficiency, resolution in x_{IP} and background contributions) is detailed in [5].

NLO PREDICTIONS

The dijet cross section predictions at NLO, to be compared to the data, were obtained at the parton level using the $NLOJET++$ [6] program. The hadronization corrections evaluated with the RapGap Monte Carlo [7] were used to correct the predictions to the level of stable hadrons and to estimate the hadronization uncertainties. The estimation of the scale uncertainties was determined by varying the factorization and renormalization scale $\mu_{f,r}$ by a factor 2. The diffractive parton distribution function used in the NLO predictions is the H1 2007 Jets DPDF scaled by a factor 0.83 to correct for proton dissociation background [8].

RESULTS

The data were collected with the H1 detector in 2006-2007 and corresponds to an integrated luminosity of $L = 127\ pb^{-1}$.

The scattered electron is required to be detected in the backward electromagnetic calorimeter with an energy $E_e > 10\ GeV$ which constrained the accessible kinematical range to $5 < Q^2 < 80\ GeV^2$ and $0.1 < y < 0.65$. The scattered proton is measured in the VFPS with $0.009 < x_{IP} < 0.024$. The jets are found using a K_T algorithm in the $\gamma^* - p$ center of mass (all variables reconstructed in this frame are denoted with *). The jet selection requires $P^*_{T,j1} > 5.5\ GeV$ and $P^*_{T,j2} > 4\ GeV$. In order to have jets well contained in the central detector, a cut is applied on the pseudo-rapidity of the two jets $-3 < \eta^*_{j1,j2} < 0$.

Background from coincidences of non-diffractive DIS events with beam-gas protons giving a signal in the VFPS was found to be negligible ($< 1\%$).

Figures 2, 3 and 4 present the cross section differentially measured in $\log x$, y, Q^2, x_{IP}, $< P^*_{T,jets} >$ and in z_{IP} compared to NLO predictions [9].

Within uncertainties the data and predictions are in agreement both in shape and in normalization even in the highest z_{IP} bin where the sensitivity to the gluon distribution and therefore to the different DPDF's is the highest.

REFERENCES

1. H1 Collab., A. Aktas and al., *Eur. Phys. J.* **C48**, 715 (2006).
2. J.C. Collins, *Phys. Rev.* **D57**, 3051 (1998) et erratum ibid. **D61**, 019902 (2000).
3. H1 Collab., A. Aktas and al., *JHEP* **10**, 42 (2007).
4. L. Favart et al,*H1 internal note*, **H1-05/00-582** and **DESY PRC-01/00**
   H1 Collab., Addentum to H1-05/00-582
5. T. Hreus, "Measurement of inclusive diffractive deep inelastic scattering using VFPS at H1", proceedings of DIS10 [arXiv:1008.2725v1]
6. Z. Nagy and Z. Trocsanyi, *Phys. Rev. Lett.* **87** (2001).
7. H. Jung, *Comput. Phys. Commun.* **86**, 147 (1995).
8. H1 Collab., F.D. Aaron et al., *Eur.Phys.J.***C71**, 1578 (2011).
9. J. Delvax, "Etude de la production de jets en diffraction à HERA, à l'aide du spectromètre à protons VFPS", PhD thesis, ULB (2010)

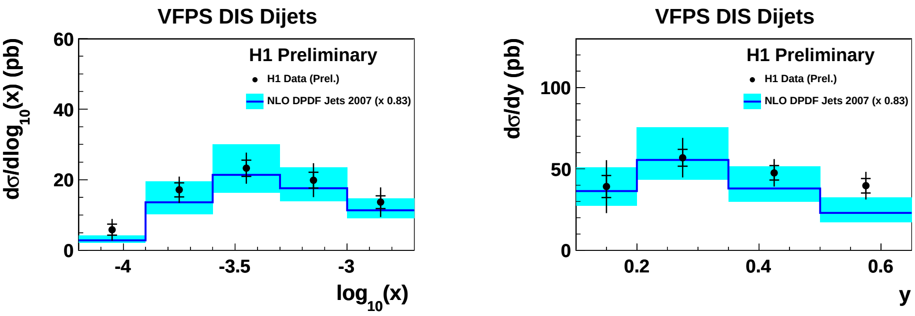

FIGURE 2. The cross section measured differentially in $\log x$ and in y compared with NLO predictions obtained using the H1 2007 Jets DPDF. The black dots present the data shown with statistical and uncorrelated systematics added in quadrature. The blue line presents the NLO predictions with the light blue band being the scale and hadronization uncertainties added in quadrature. Predictions are scaled by 0.83 to correct for proton disscociation background.

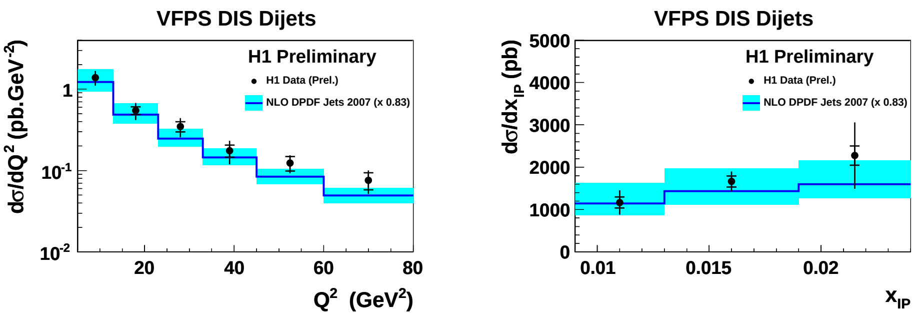

FIGURE 3. The cross section measured differentially in Q^2 and in x_{IP}. See caption of Fig. 2 for more details.

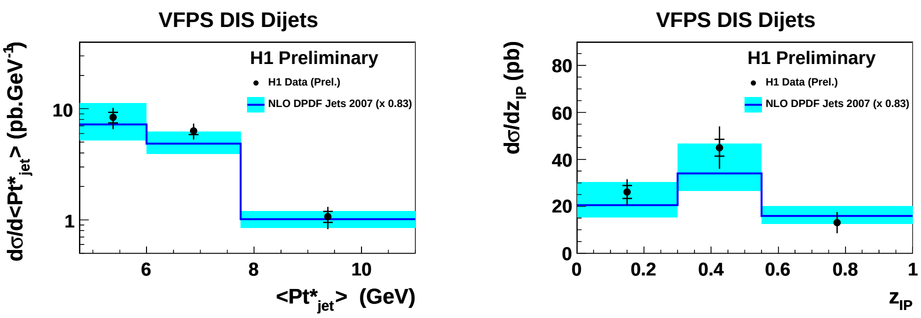

FIGURE 4. The cross section measured differentially in $< P^*_{T;jet} >$ and in z_{IP}. See caption of Fig. 2 for more details.