# INCLUSIVE AND DIJET DIFFRACTIVE PRODUCTION AT HERA

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The results of two methods of identifying of diffractive events, Large Rapidity Gap method and measuring of proton in forward spectrometers, were compared by H1 and ZEUS experiments. The HERA combined diffractive double-diffrential reduced cross sections in events with a leading proton were obtained. The diffractive dijet production in events with a leading proton was measured and compared to NLO QCD calculations.

## 1 Introduction

The bulk of the cross section of hadrons is dominated by long range forces, where a satisfactory understanding of quantum chromodynamics ( QCD) still remains a challenge. The first observed events in deep inelastic scattering (DIS) at HERA containing a large gap in the pseudorapidity distributions of final state hadrons [1,2] were identified as diffractive ep interactions. In diffractive interactions the proton stays intact or dissociates into a low mass state ($Y$), while the photon may dissociate into a hadronic state $X$, $\gamma^* p \to Xp'(Y)$. The systems are separated by a large rapidity gap (LRG). The diffractive exchange object (pomeron) has vacuum quantum numbers and carries a fraction $x_{I\!P}$ of the initial proton longitudinal momentum and a momentum transfer $t$ from the incoming to the outgoing proton. Another possibility which was used by both H1 and ZEUS experiments to identify diffractive interactions was detection of the forward proton by proton spectrometers - roman pots, placed close to the beam pipe.

HERA has made it possible to study diffraction in a wide range of exchanged photon virtualities $Q^2$ from the region of photoproduction, $Q^2 \sim 0\ GeV^2$, to the DIS region with $Q^2 \gg 0\ GeV^2$, and also for many processes like jet- or vector meson-production. Here we will concentrate to diffractive inclusive and dijet measurements.

## 2 Comparison of the selection methods

Methods used for the identification of diffractive events - LRG and measuring of the forward proton in the forward spectrometers (FS) have different systematics. The FS method selects events in which the proton scatters elastically, whereas the LRG method does not distinguish between the case where the scattered proton remains intact or where it dissociates into a system of low mass $M_Y$. In the case of H1 measurements are corrected to $M_Y < 1.6\ GeV$ while in ZEUS case to $M_Y = m_p$. It is therefore natural to ask if both selection methods and both

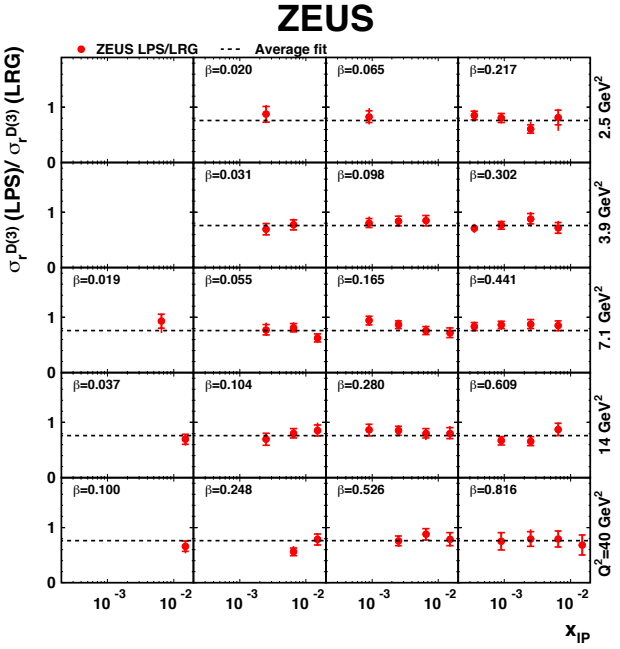


Figure 1: The ratio of the reduced diffractive cross sections as obtained with the LPS and LRG methods, before the subtraction of the proton dissociative background.

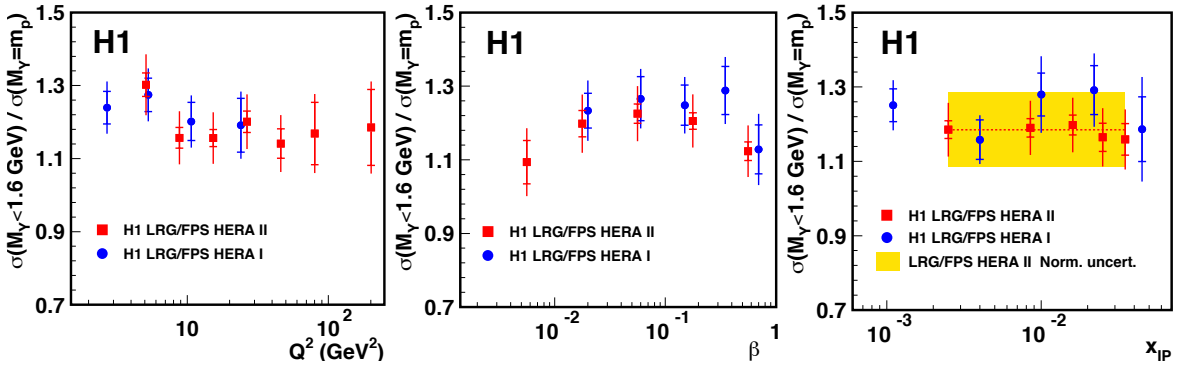


Figure 2: The ratio of the reduced diffractive cross section for $M_Y < 1.6\ GeV$ and $|t| < 1\ GeV^2$ obtained using the H1 LRG data to that for $M_Y = M_p$ and $|t| < 1\ GeV^2$. Results are shown as a function of $Q^2$, $\beta$ and $x_{I\!P}$.

experiments give a compatible results. The selection methods were compared by both ZEUS [3] and H1 [4]. In Fig. 1 the ratio of the reduced cross sections values obtained with ZEUS forward proton spectrometer LPS to those obtained with the LRG method is shown. The ratio is independent of $x_{I\!P}$, $Q^2$ and $\beta$, where $\beta = x/x_{I\!P}$. The normalisation difference is ascribed to about 25% proton-dissociative contribution in the LRG sample. The opposite ratios (reduced cross sections measured with LRG divided by those measured with FPS forward spectrometer) of experiment H1 are shown in Fig. 2. The contamination of dissociation events in the sample of LRG interactions is about 20% not depending on the variable plotted. It is however evident that the precise knowledge and corrections for proton dissociation processes are a key factor in understanding and comparing of results obtained by both experiments.

The double differential reduced cross sections measured using proton spectrometers of H1 (FPS) and ZEUS (LPS) were compared and combined to a HERA reduced cross section shown in Fig.3. The good agreement of both data samples in shape in normalisation is observed. This way two experiments calibrate each other resulting in a significant reduction of the systematic

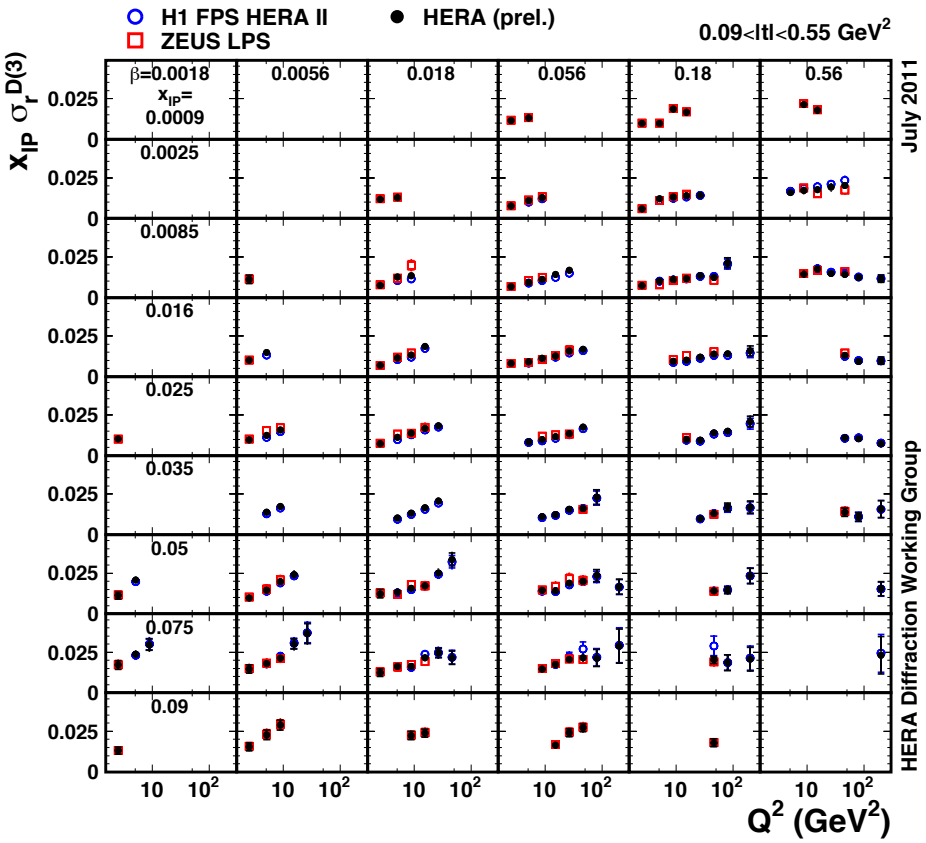


Figure 3: The reduced cross section measured by ZEUS with LPS spectrometer, H1 with FPS spectrometer and HERA combined reduced cross section.

uncertainties.

## 3 Dijets in events with a leading proton.

In previous dijet analyses at HERA, diffractive events have been selected on the basis of the presence of LRG.

H1 collaboration measured the cross section for the diffractive DIS processes $ep- > jjX^{'}p$ , with two jets and a leading proton measured in the FPS [8]. The dijets with transverse momenta in the CMS system $P^*_{t1} > 5\ GeV$ and $P^*_{t2} > 4\ GeV$, in the central pseudorapidity region $-1. < \eta < 2.5$, were compared with next-to-leading (NLO) QCD predictions based on DPDFs H1 fit 2006 B and H1 fit 2007 Jets previously measured by H1 [5,6]. The NLO QCD calculations (program NLOjet++ [7]) were corrected for the hadronization. The results for the $P^*_{t1}$ cross section of the leading jet and $z_{I\!P}$ (where $z_{I\!P}$ is the longitudinal momentum entering the hard subprocess) shown in Fig. 4 a) and b) agree within errors with NLO calculations in shape and normalization very well.

Using the same sample of difractive central dijets [8], the distribution of the momentum transfer from the incoming to outcoming proton, $|t|$, was measured and fitted by the formula $exp(Bt)$. The value of $B = 5.89 \pm 0.50\ GeV^2$ agrees with the previous inclusive $|t|$ measurements[4] satisfactorily, as it is shown in Fig. 4 c).

Two central jets in events with a leading proton measured with the Very Forward Proton Spectrometer (VFPS) were analysed by experiment H1 [9]. The mean value of the $P^*_t$ of two central jets ($P^*_{t1} > 5.5\ GeV$ and $P^*_{t2} > 4\ GeV$) and $z_{I\!P}$ is compared with NLO QCD calculations in Fig. 5. It is seen that within errors agree the data with model quite well.

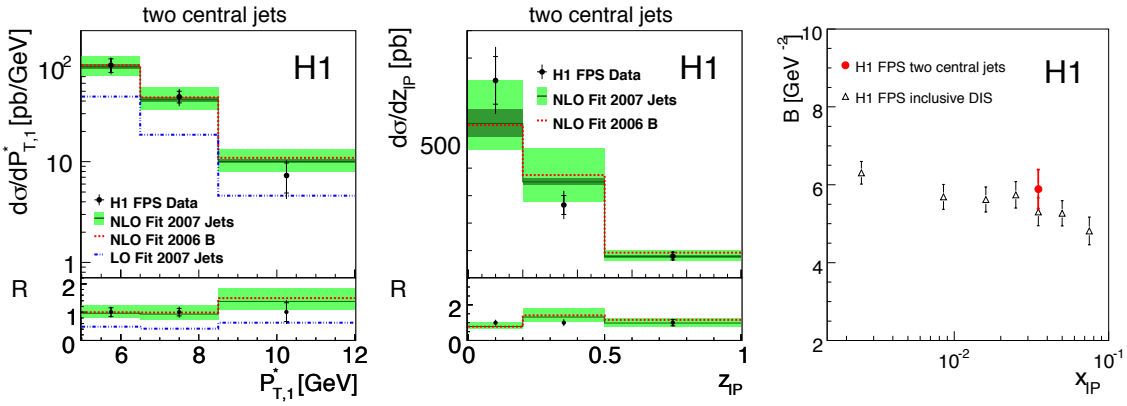


Figure 4: The differential cross section for two central jets shown as a function of $P^*_{t1}$ and $z_{I\!P}$. The $|t|$ slope compared to the H1 inclusive diffractive DIS data as a function of $x_{I\!P}$.

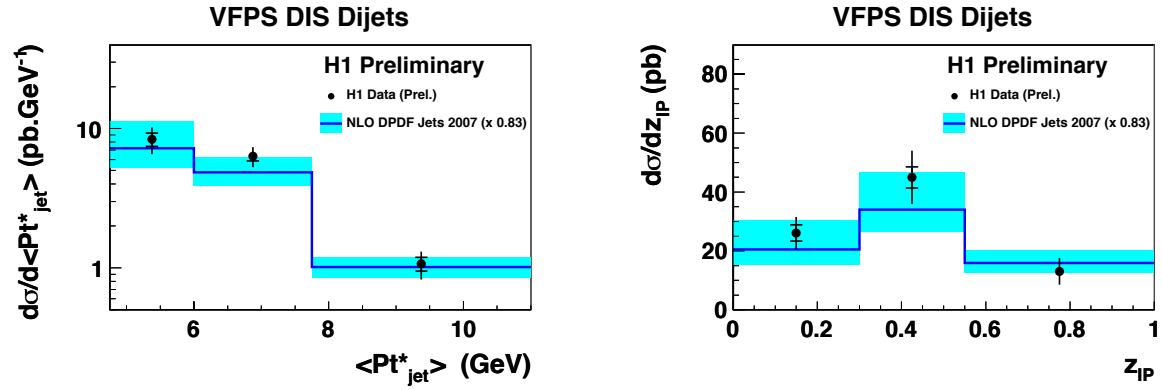


Figure 5: The differential cross section for dijets shown as a function of the mean $Pt^*_{jet}$ and $z_{I\!P}$ as measured using VFPS spectrometer.

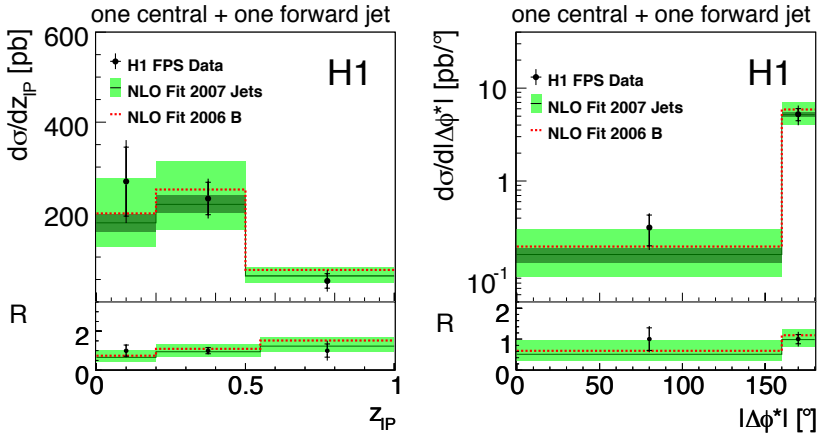


Figure 6: The differential cross section for production ofone cemtral and one forward jet shown as a function of $z_{I\!P}$ and $|\Delta\Phi^*|$.

The search for physics beyond DGLAP evolution was studied by measurement of DIS diffractive forward jets [8]. The selection of events with the proton in the H1 FPS gives a unique opportunity to measure jets in the forward region close to the proton direction. The one central jet with $P_t^* > 3.5$ GeV and one forward jet with $P_t^* > 3.5$ GeV in the forward pseudorapidity region $1. < \eta < 2.8$ were selected. Since the NLO QCD based on the DGLAP approach describes the differential cross section for $z_{I\!P}$ and $|\Delta\Phi^*|$ (where $|\Delta\Phi^*|$ is the difference if azimuthal angles of both jets) well, (see Fig. 6), there is no hint for any observation of beyond DGLAP approach effects.

**Summary**

The ratio of FS to the LRG cross section (ZEUS) or LRG to the FS cross section (H1) is independent of $x_{I\!P}$, $Q^2$ and $\beta$ within uncertainties, confirming that contributions from proton dissociation in the LRG measurement do not significantly alter the measured $x_{I\!P}$, $Q^2$ and $\beta$ dependencies. The amount of diffractive dissociation background in LRG sample is about 20%. The HERA reduced cross section for diffractive production with leading proton was obtained reducing the uncertainties of measurements of both experiments. The cross sections of dijets measured in events with a leading proton agree well with NLO calculations. There is no hint for the observation of beyond DGLAP approach effects in events with leading proton and forward jets.

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