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DIFFRACTIVE DIJETS IN PHOTOPRODUCTION

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Diffractive dijet processes in photoproduction $ep \to ep + X(jet + jet + X')$ have been measured with the ZEUS detector at HERA. Measured differential cross sections are well described by the predictions from a leading order (LO) Monte Carlo (MC) model which uses the diffractive PDFs extracted from inclusive diffractive DIS measurements. No clear evidence for the suppression of the resolved photoproduction with respect to the direct photoproduction is observed at LO.

1 Introduction

An important question which arises in hard diffractive processes is whether they can be factorized into universal diffractive parton distribution functions (PDFs) and the partonic cross section. At HERA, the diffractive PDFs have been extracted from QCD DGLAP fits to inclusive diffractive deep inelastic scattering (DIS) data [1,2], where factorization is proven to hold [3]. The factorization theorem and the universality of the extracted PDFs can be tested through exclusive processes with different hadronic final states. In particular, diffractive events with dijet production are important as they are sensitive to the gluons (e.g. via $\gamma g \to q\bar{q}$ at HERA), which are known to carry most of the momentum of the diffractive exchange [1,2,4].

The H1 Collaboration has recently presented measurements of diffractive dijets in DIS [5] that support the factorization theorem. However, predictions of diffractive dijet cross sections at the Tevatron using the same PDFs overestimate the measurements by an order of magnitude [6]. The suppression of the Tevatron cross sections can be accounted for by considering rescattering processes between the two hadron beams which create additional particles that destroy the rapidity gap [7]. In one such model, a suppression factor of R=0.34 would also be expected to be observed in the resolved photoproduction of diffractive dijets at HERA [8]. Recent calculations at next-to-leading order (NLO) suggest a suppression of the resolved photon component by R=0.34 [9], using diffractive dijet photoproduction measurements of the H1 Collaboration [10]. This report presents diffractive dijet photoproduction measurements made by the ZEUS Collaboration and their comparison to LO RAPGAP MC [11] with the "H1 Fit 2" diffractive PDFs [1].

2 Measurements

The data used for this analysis was taken with the ZEUS detector at the HERA collider during the $1999-2000$ data-taking period. It corresponds to an integrated luminosity of 77.6 pb^{-1}. A 30-fold increase in luminosity has been achieved com-

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pared to the previous ZEUS analysis [12], which allows precise measurements to be made. In addition, a new forward[a] detector has been added near the beam pipe, allowing measurements to be made in a wider kinematic region. This kinematic region is defined by $0.2 < y < 0.85$, $Q^2 < 1.0$ GeV^2, $x_{I\!P} < 0.035$, $E_T^{jet1(2)} > 7.5(6.5)$ GeV and $-1.5 < \eta^{jet1,2} < 2.0$. The variable y is the inelasticity, Q^2 is the photon virtuality and $x_{I\!P}$ is the longitudinal momentum fraction lost by the proton. The variable E_T is the transverse energy and η is the pseudorapidity. Jets 1 and 2 correspond to the highest and second highest E_T jets, respectively. The jets are reconstructed using the longitudinally invariant k_T algorithm in the laboratory frame. To select diffractive events, a rapidity gap in the forward region, $3 < \eta < 5$, is required. The background from proton dissociation events, with a low-mass proton dissociative system escaping down the beam pipe, is estimated to be $(16 \pm 4)\%$ [13] and is subtracted from all measured cross sections.

The cross sections are measured as a function of y, $x_{I\!P}$, M_X, $z_{I\!P}^{obs}$, E_T^{jet1}, η^{jet1} and x_γ^{obs}. The variable M_X is the invariant mass of the hadronic system X while $z_{I\!P}^{obs}$ and x_γ^{obs} are defined as:

$$z_{I\!P}^{obs} = \frac{\sum_{jets} E_T^{jet} e^{\eta^{jet}}}{2 x_{I\!P} E_p} \tag{1}$$

$$x_\gamma^{obs} = \frac{\sum_{jets} E_T^{jet} e^{-\eta^{jet}}}{2 y E_e} \tag{2}$$

where the sums run over the two highest E_T jets. The observable $z_{I\!P}^{obs}$ (x_γ^{obs}) is an estimator of the longitudinal fractional momentum taken from the diffractive exchange (photon) by the dijet system produced in the hard scattering. The variable $z_{I\!P}^{obs}$ is sensitive to the parton densities in the diffractive exchange, while the ranges $x_\gamma^{obs} > 0.75$ ($x_\gamma^{obs} < 0.75$) correspond to regions enriched with direct (resolved) photon processes. In direct photon processes, the entire photon participates in the hard scatter, whereas in resolved photon processes, the photon acts as a source of partons, with only a fraction of its momentum participating in the hard scatter.

The largest systematic uncertainty on the measured cross sections comes from varying the size of the large rapidity gap requirement. The effect is larger at higher $x_{I\!P}$: approximately 20% in the highest $x_{I\!P}$ bin.

3 Results

The LO predictions from the RAPGAP MC generator, normalized to the data by a factor of 0.59, describe the data well in most variables, as seen in Figs. 1 and 2. The variable $z_{I\!P}^{obs}$, which is sensitive to the diffractive PDFs, is not well reproduced at high $z_{I\!P}^{obs}$. However the shape of the x_γ^{obs} distribution is well described in both the direct and resolved enriched regions, as shown by the flat distribution of the ratio of data to MC (Fig. 2). A reduction of the ratio at lower x_γ^{obs} would suggest

[a] The ZEUS coordinate system is a right-handed Cartesian system, with the Z axis pointing in the proton beam direction, referred to as the "forward direction", and the X axis pointing left towards the center of HERA. The coordinate origin is at the nominal interaction point.

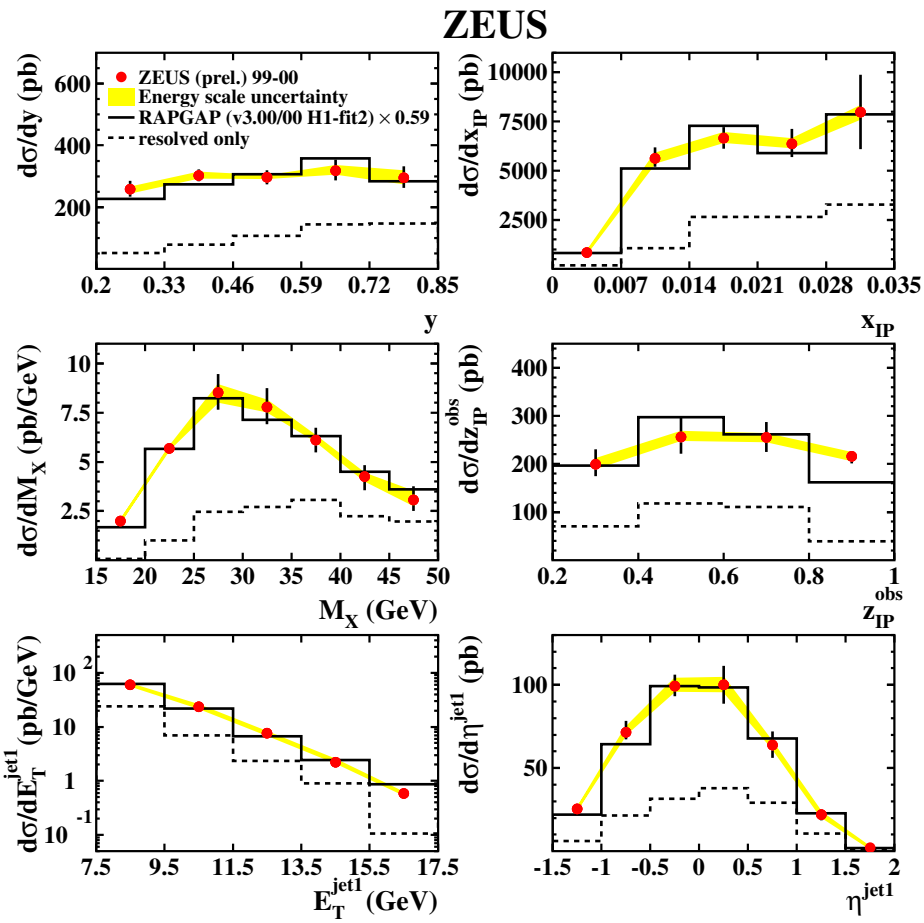

Figure 1. The single differential cross sections in y, $x_{I\!P}$, M_X, $z_{I\!P}^{obs}$, E_T^{jet1} and η^{jet1}. The data are shown as dots, with the corresponding energy scale uncertainty shown as a band; the inner error bars indicate the statistical uncertainty and the outer error bars indicate the statistical and systematic uncertainties added in quadrature. The solid lines show the prediction of the LO RAPGAP MC, normalized to the data by a factor of 0.59; the dashed lines are the resolved photon component from RAPGAP.

a suppression of the resolved photon processes with respect to the direct photon processes, and hence a breakdown of QCD factorization in the resolved photoproduction. No clear evidence of such a breakdown is observed when comparing the data to LO MC.

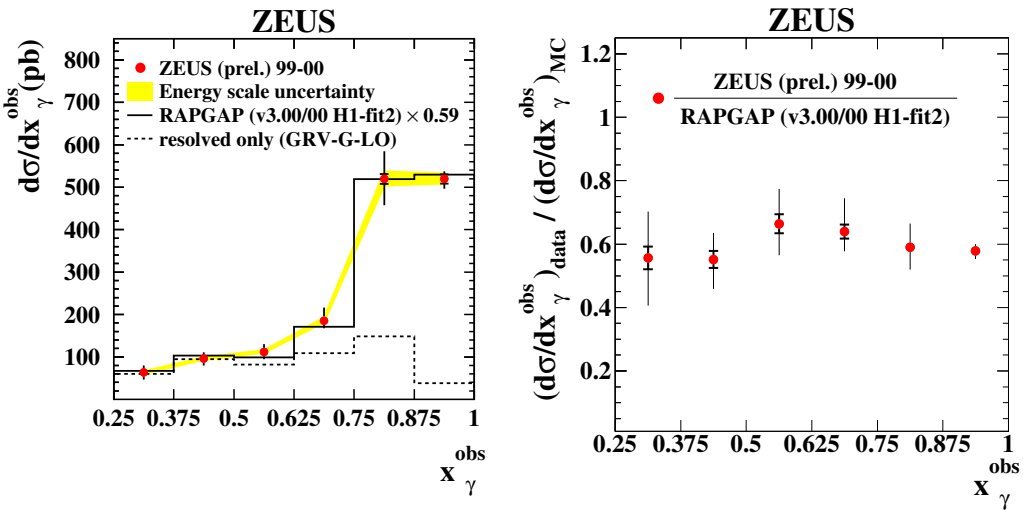

Figure 2. The single differential cross section in x_γ^{obs} and the ratio of the single differential cross sections in x_γ^{obs} between data and RAPGAP. See the caption of Fig. 1 for a description of the data and MC.

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