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Diffractive Dijet Production at HERA

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Cross sections for events of the type $ep \to eXY$, where the systems X and Y are separated by a large rapidity gap and X contains two jets, are presented for both deep inelastic scattering and photoproduction, measured using data from the H1 experiment at HERA. The corrected cross sections are described by a resolved pomeron model with parton densities for the pomeron which were obtained from a QCD analysis of $F_2^{D(3)}$ from H1.

1. INTRODUCTION

At HERA, the diffractive structure function $F_2^{D(3)}(x_{I\!P},\beta,Q^2)$ for deep inelastic scattering events with a large rapidity gap has been measured [1] and successfully interpreted in terms of a resolved pomeron model [2] with gluon dominated parton densities for the pomeron which evolve according to the DGLAP formalism.

Diffractive dijet events offer the possibility to directly probe the partonic (gluonic) structure of the pomeron and test the universality of the pomeron parton distributions in a different kinematic regime.

The kinematics of such events are visualized in Fig.1. In a resolved pomeron model, $z_{I\!P}$ measures the momentum fraction of the parton from the pomeron which enters the hard scattering. For resolved photoproduction events, x_γ corresponds to the momentum fraction from the photon entering the hard interaction.

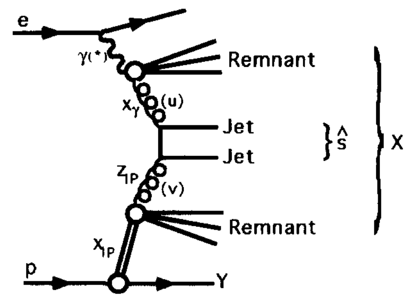

Figure 1. The kinematics of diffractive dijet production at HERA.

2. DATA SELECTION

The presented cross sections [3] are extracted from 1994 data ($L_{int} \approx 2\ pb^{-1}$), where 27.5GeV positrons (e^+) collided with 820 GeV protons. The sample of deep inelastic scattering (DIS) events ($7.5 < Q^2 < 80\text{GeV}^2$, $0.1 < y < 0.7$) is selected by requiring the scattered e^+ to be well measured in the backward calorimeter. The sample of quasi-real photoproduction (γp) events ($Q^2 < 0.01\text{GeV}^2$, $0.25 < y < 0.7$) is obtained by measuring the almost undeflected e^+ 33 m downstream from the interaction point in a low-angle e tagger. Diffractive events are selected by requiring no energy above noise levels in the region of the outgoing p corresponding to $3.2 < \eta < 7.5$ in pseudorapidity. The upper limit restricts the measurement to $M_Y < 1.6\text{GeV}$, $|t| < 1.0\text{GeV}^2$. $x_{I\!P} < 0.05$ is required to reduce background from non-pomeron exchange. A cone algorithm is applied in a frame collinear with the exchanged γ. Exactly two jets are required with $p_T > 5\text{GeV}$. The selection yields ≈ 400 γp and 55 DIS events.

3. QCD MODELS

The Monte Carlo models used are RAPGAP [4] for DIS and POMPYT [5] for γp. Both contain a resolved pomeron model where the diffractive

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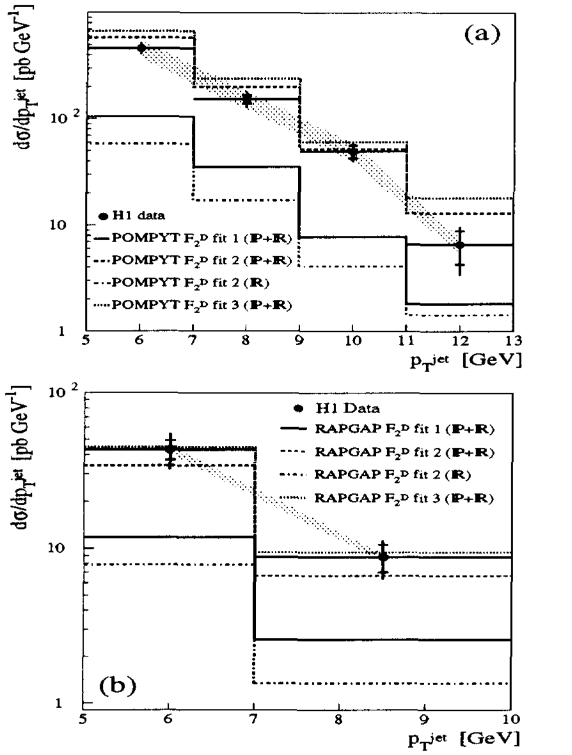

Figure 2. Dijet cross sections for the γp (a) and DIS (b) samples, differentially in p_T^{jet}.

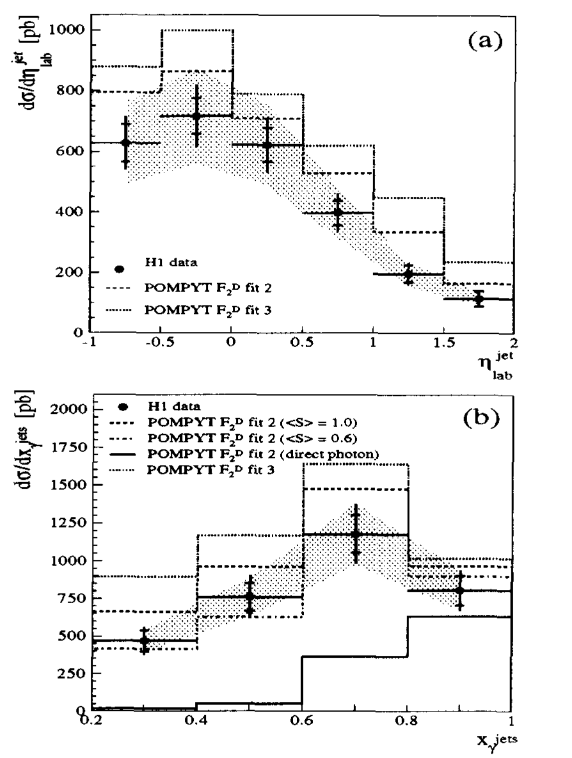

Figure 3. Dijet cross sections for the γp sample, differentially in η_{lab}^{jet} (a) and x_γ^{jets} (b).

cross section factorizes into a pomeron flux (taken from Regge fits to $F_2^{D(3)}$ [1]) and pomeron parton distributions (obtained by a QCD analysis of $F_2^{D(3)}$), evolved with a scale p_T. The hard scattering process is modelled by leading order QCD matrix elements. Factorization-breaking effects at high $x_{I\!P}$ are taken into account by adding a sub-leading meson-exchange, which is parametrised in terms of the pion structure function. POMPYT contains resolved γ contributions.

4. RESULTS AND DISCUSSION

The cross sections are corrected for detector effects. The main systematic errors arise from detector calibration and model dependencies.

4.1. Jet rates and p_T spectra

Fig. 2 shows dijet cross sections as a function of p_T^{jet}, the jet transverse momentum relative to the photon axis in the rest frame of X. The contribution of sub-leading exchange is only of the order of 15%. Models in which the pomeron consists only of quarks at the starting scale (*fit* 1 from [1]) undershoot the data by a factor of 5. In contrast, models where the pomeron is dominated by gluons (*fits* 2, 3 from [1]) give a reasonable description. This demonstrates how the dijet events are sensitive to the gluon content of the pomeron.

4.2. Photoproduction and factorization breaking

Fig. 3 (a) shows the γp cross section as a function of the pseudorapidity of the jets η_{lab}^{jet}. This

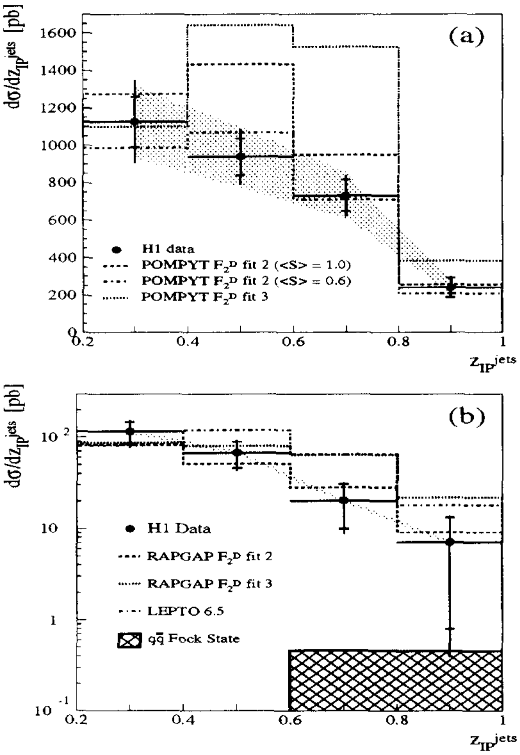

Figure 4. Dijet cross sections for the γp (a) and DIS (b) samples, differentially in $z_{I\!P}^{jets}$.

distribution is sensitive to the decomposition of the data in x_γ^{jets} and $z_{I\!P}^{jets}$. The shape is well described by both gluon dominated models, whereas the normalization is too high.

Fig. 3 (b) shows the γp cross section differentially in x_γ^{jets}, which is defined as

$$x_\gamma^{jets} = \Sigma_{jets}(E - P_z) \ / \ \Sigma_X(E - P_z) \ . \qquad (1)$$

The data show direct and resolved photon components. The gluon dominated models are too high in normalization for resolved photon events with $x_\gamma^{jets} < 0.8$. This can be interpreted in terms of additional soft interactions between the photon and the pomeron remnants which may destroy the rapidity gap and thus break diffractive factorization. Applying an a-posteriori weight of 0.6 for resolved γ events improves the description. If this is compared to results from the Tevatron [6], there is an indication of an energy dependence of factorization-breaking effects.

4.3. Dependence on the fractional momentum from the pomeron

In Fig. 4, cross sections as a function of $z_{I\!P}^{jets}$, defined as

$$z_{I\!P}^{jets}(\gamma\mathrm{p}) = \Sigma_{\mathrm{jets}}(\mathrm{E} + \mathrm{P_z}) \ / \ \Sigma_{\mathrm{X}}(\mathrm{E} + \mathrm{P_z}) \qquad (2)$$

$$z_{I\!P}^{jets}(\mathrm{DIS}) = \beta \cdot \left(1 + \mathrm{s^{jets}}/\mathrm{Q^2}\right) \qquad (3)$$

are presented for γp (a) and DIS (b). The gluon dominated resolved pomeron models give a reasonable description of the distributions with the flat gluon model (*fit* 2) being better than the peaked gluon model (*fit* 3).

In DIS, the data are also compared with the model of Bartels et al. [7] of the virtual γ fluctuating into a $q\bar{q}$ pair coupling to the proton by the exchange of two hard gluons. This model is not expected to describe the region of large M_X (low $z_{I\!P}^{jets}$) because there, additional contributions like $q\bar{q}g$-states are becoming important [8].

5. CONCLUSIONS

This article presented the first measurement of diffractive dijet cross sections in γp and DIS from H1. The data are described by a resolved pomeron model with gluon dominated parton densities for the pomeron which were obtained from QCD fits to $F_2^{D(3)}$ and evolved with DGLAP using a scale p_T.

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