Measurement of Differential Cross Sections for Dijet Production in Neutral Current DIS at High Q^2 and Determination of α_s

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Dijet production has been studied in neutral current Deep Inelastic ep Scattering for $470 < Q^2 < 20000$ GeV^2 with the ZEUS detector at HERA using 38 pb^{-1}. The jet search is performed in the Breit frame using the longitudinally invariant K$_\perp$-cluster algorithm. Dijet differential cross sections and rates have been measured in a kinematic region where both theoretical and experimental uncertainties are small. NLO QCD calculations describe in shape and magnitude the measured differential cross sections. A QCD fit to the dijet rate as a function of Q^2 allows a precise determination of the strong coupling constant.

1. INTRODUCTION

The sizeable data sample collected by the ZEUS experiment during the 1996-97 running period (amounting to an integrated luminosity of approximately 38 pb^{-1}) and the large center-of-mass energy ($\sqrt{s} \approx 300$ GeV) available at HERA allow now to study with improved precision events with a dijet structure in the hadronic final state. On the theoretical side next-to-leading order (NLO) QCD calculations, available in the form of very flexible Monte Carlo programs, can be used in order to test the QCD dynamics of the underlying partonic processes (up to $O(\alpha_s^2)$) and extract useful information on the strong coupling constant and the gluon density in the proton.

In this contribution we report preliminary results on the measurement of differential cross sections for dijet production and a determination of the strong coupling constant via a QCD fit to the measured dijet rate. The analysis is restricted to a high Q^2 phase space region in order to minimize experimental and theoretical uncertainties.

2. DIJET CROSS SECTIONS

The high Q^2 neutral current DIS events used in this analysis are selected according to criteria described in full detail in [1]. Jets are then searched in the Breit frame and defined using the longitudinally invariant K$_\perp$-cluster algorithm [2]. The measured differential cross sections are corrected for detector, QED radiation and hadronization effects and refer to the following phase space region:

- $470 < Q^2 < 20000$ GeV^2,
- $E^{jet}_{T_{BREIT}} > 5$ GeV,
- $E^{jet1}_{T_{BREIT}} + E^{jet2}_{T_{BREIT}} > 17$ GeV,
- $-1 < \eta^{jet}_{LAB} < 2$.

We have measured differential dijet cross sections for a large set of jet variables. As a representative sample we show in Fig. 1 the dijet cross section as a function of the dijet invariant mass M_{jj}, the fraction $\xi = x_{Bj}(Q^2 + M_{jj})/Q^2$ of the proton momentum carried by the incoming parton and the jet variables z_{p1} and z_{p2} determined from the jet energies and polar angles in the laboratory frame according to: $z_{p(i)} = E_i(1 - \cos\theta_i)/\sum_{k=1,2} E_k(1 - \cos\theta_k)$. These cross sections are compared to the NLO predictions obtained with the DISENT [3] program using the CTEQ4M [4] proton parton density functions (PDFs) and Q^2 as renormalization and factorization scale, $\mu_R^2 = \mu_F^2 = Q^2$. A very good agreement both in shape and magnitude is observed between the data and the calculations. An equally good description is obtained for the

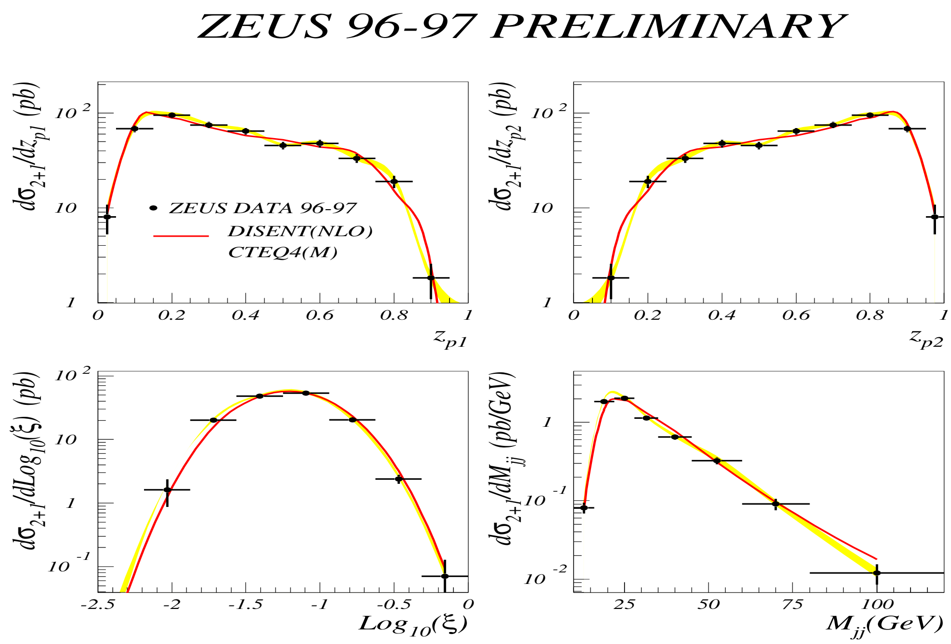

Figure 1. Dijet cross section as a function of z_{p1} (most backward jet), z_{p2} (most forward jet), ξ and dijet mass M_{jj}. The data points include only the statistical errors. The shaded band indicates the uncertainty (3%) on the jet energy scale.

jet transverse energy and pseudorapidity distributions.

3. MEASUREMENT OF α_s

The very good agreement observed between the measured and NLO dijet cross sections suggest that one can effectively use the measured dijet production to obtain a rather precise measurement of the strong coupling constant. In this section we shortly describe a preliminary determination of $\alpha_s(M_Z)$ obtained via a QCD fit of the dijet rate $R_{2+1}(Q^2) = \sigma_{2+1}(Q^2)/\sigma_{tot}(Q^2)$.

The NLO expression for the dijet rate in DIS is given by:

$$R_{2+1}(Q^2) = \alpha_s(Q^2)c_1(Q^2,\alpha_s) + \alpha_s^2(Q^2)c_2(Q^2,\alpha_s), \qquad (1)$$

where the coefficients c_1 and c_2 depend themselves, via the PDFs evolution equations, on α_s. In order to perform a theoretically consistent fit of $\alpha_s(M_Z)$ one needs to use a set of PDFs obtained for different $\alpha_s(M_Z)$ values.

We have used the CTEQ4A-series [4] for the default QCD fit and the MRST($\alpha_s \downarrow\downarrow, \alpha_s, \alpha_s \uparrow\uparrow$) series [5] for a systematic check. In Fig. 2 we show the measured R$_{2+1}(Q^2)$ and the NLO predictions using the CTEQ4A-series for the same phase space region defined in the previous section. The strong coupling $\alpha_s(M_Z)$ is determined by a χ^2 fit of R_{2+1} (NLO) to the measured dijet rate. The preliminary result for $\alpha_s(M_Z)$ is given by:

$$\alpha_s(M_Z) = 0.120 \pm 0.003\ (stat)\ ^{+0.005}_{-0.006}\ (exp)\ ^{+0.003}_{-0.002}\ (th) \qquad (2)$$

which is in good agreement with the world average value [6]. The individual contributions to the total systematic uncertainty are shown in Fig. 3. The experimental uncertainty is dominated by the uncertainty on the jet energy scale (± 0.005) and contains contributions coming from the dependence on the QCD Monte Carlo models used to unfold the data ($\pm^{0.001}_{0.002}$) and a yet limited Monte Carlo statistics (± 0.002). The theoretical uncertainty includes the dependence on the renormalization scale ($+0.002$) (μ_R^2 is varied by a factor two around the central value $\mu_R^2 = Q^2$), the one coming from the NLO program used ($+0.002$) (the entire fit procedure is repeated using the DISASTER++ [7] program instead of DISENT) and the uncertainty on the PDFs (-0.002) (the CTEQ4A series is replaced with the MRST series).

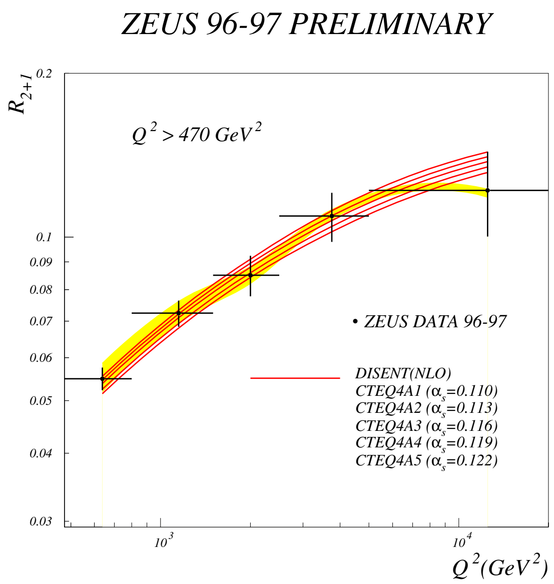

Figure 2. Dijet rate R_{2+1} as a function of Q^2. The data points include only the statistical errors. The shaded band indicates the uncertainty (3%) on the jet energy scale. Also shown are the five NLO predictions for the CTEQ4A-series (see text).

4. SUMMARY

We have measured dijet differential cross sections and rates in a kinematic region where both theoretical and experimental uncertainties are small. NLO QCD calculations describe very well

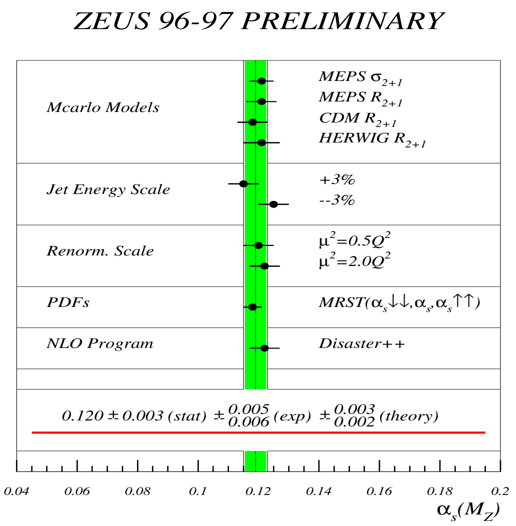

Figure 3. Preliminary $\alpha_s(M_Z)$ value and individual contributions to the total systematic uncertainty. Shaded band: $\alpha_s(M_Z) = 0.119 \pm 0.004$ [6]

in shape and magnitude the measured differential cross sections. The dijet rate when fitted to perturbative QCD predictions allows a precise determination of the strong coupling constant. The preliminary result is (2).

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