Submitted to

Europhysics Conference on High Energy Physics, EPS2007, July 19-25, 2007, Manchester
Abstract: **372**
Parallel Session **Strong Interactions**

Electronic Access: www-h1.desy.de/h1/www/publications/conf/conf_list.html

Measurement of Jet Production Deep-Inelastic ep Scattering at Low and Medium Q^2

H1 Collaboration

Abstract

Jet production is studied in deep-inelastic positron-proton scattering over a range of four momentum transfer squared $5 < Q^2 < 100\ \mathrm{GeV}^2$. The data were taken with the H1 detector at HERA in the years 1999-2000 and correspond to an integrated luminosity of 43.5 pb^{-1}. Jets are defined in the Breit frame with the inclusive k_T algorithm and have a minimum transverse momentum of 5 GeV. Inclusive jet cross sections are measured differentially in Q^2 and E_T of the jets and compared to the predictions of perturbative QCD calculations in next-to-leading order of the strong coupling α_s.

1 Introduction

Measurements of inclusive multijet cross-sections in the Breit frame at low Q^2 values ($5 < Q^2 < 100\ \mathrm{GeV}^2$) are presented. Jets are identified using the inclusive k_t algorithm applied in the Breit frame. Compared to previous H1 publications [2, 3], this measurement contains twice the statistics and has reduced systematic errors. In addition the total center of mass energy $\sqrt{s}$ is slighly higher in the new data (320 GeV compared to 300 GeV) due to higher proton beam energy. The measurements of inclusive jet production are presented in both single differential cross sections as a function of Q^2 and E_T, respectively, and in double differential cross sections in these variables.

2 Event kinematics and selection

The kinematic range of this analysis is defined by $5 < Q^2 < 100\ \mathrm{GeV}^2$ and $0.2 < y < 0.7$. Hera the kinematic variables Q^2 and y are determined using the information from the scattered electron and the hadronic final state [1]. Further cuts are applied to ensure the quality of data and remove non-DIS events: the event vertex is required to be within 35 cm from the nominal vertex, energy and angle of scattered electron to be $E_e > 7.5\ GeV$, $156^\circ < \theta_e < 175^\circ$, respectively.

Jets are defined using the inclusive k_t cluster algorithm in the Breit frame in which the virtual photon and the parton collide head on. In this frame the transverse energies of jets are closely related to the transverse energies of the partons emerging from the hard scattering. Jets are selected by requirung the transverse energy to be larger than 5 GeV in that frame. To ensure that jets are fully contained in the calorimeter, the pseudorapidity of jets in the laboratory frame is required to be $-1 < \eta^{Lab} < 2.5$.

The analysis use the data sample collected in positron-proton interactions during 1999-2000. The final data sample contains 151,500 events. The total integrated luminosity of the data sample is 43.5 pb^{-1}.

3 Monte Carlo Models and Correction procedure

For the the calculation of correction factors due to detector effects and the influence of initial state radiation and hadronization the RAPGAP 3.1 and DJANGOh 1.4 Monte Carlo generators are used.

The data distributions are corrected for effects of limited detector acceptance and resolution and for higher order QED effects using bin-to-bin corrections. The bin sizes were chosen as to ensure sufficient statistics and sufficiently high stability and purity in each bin. The corrections for each distribution are defined as the ratio of cross section at hadron level using the Monte Carlo sample which is generated without QED corrections to that at detector level with QED corrections included. The correction factor is taken as the average of the values obtained with DJANGOh and RAPGAP, respectively.

The data is compared with the NLO pQCD predictions obtained with the NLOJET++ [5] program. The parton level predictions are corrected for hadronisation effects using the Monte Carlo samples. The hadronisation correction factors are calculated as the ratios of cross sections on the parton level to that on the hadron level. The average of the corrections obtained from the two Monte Carlo programs is taken as the correction factors.

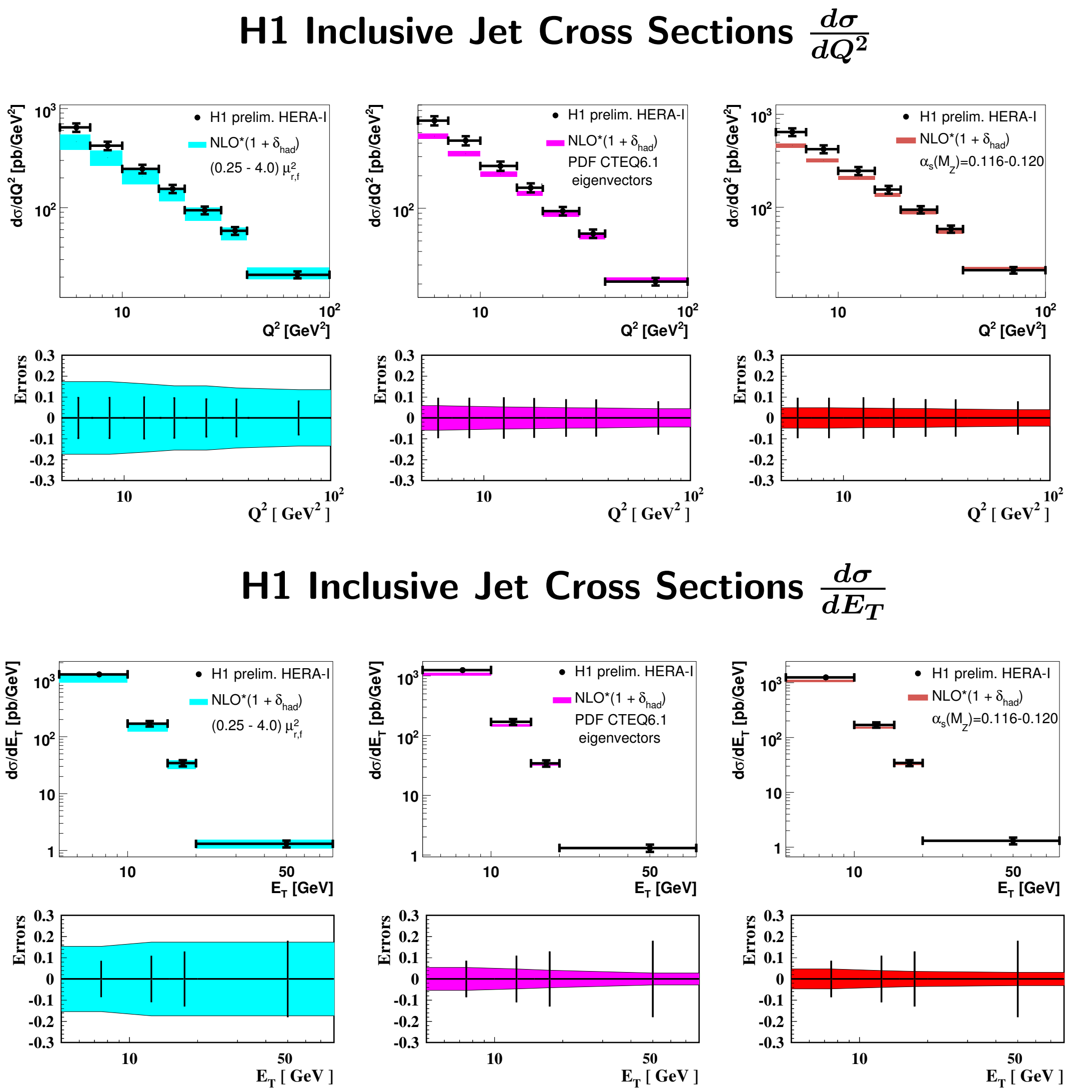

Figure 1: The inclusive cross sections vs Q^2 and E_T of the jets compared with NLO pQCD predictions, corrected for hadronization. The cross sections are shown separately for 3 different sources of theory uncertainties: the uncertainty arising from the scales (obtained by varying the renormalization and factorization scales by a factor 2 up and down), from α_s variation (varying α_s between 0.116 and 0.120) and from the proton PDFs (using 40 eigenvectors of the CTEQ6.1M proton PDF parameterization). The plots also show the relative sizes of experimental and theoretical uncertainties.

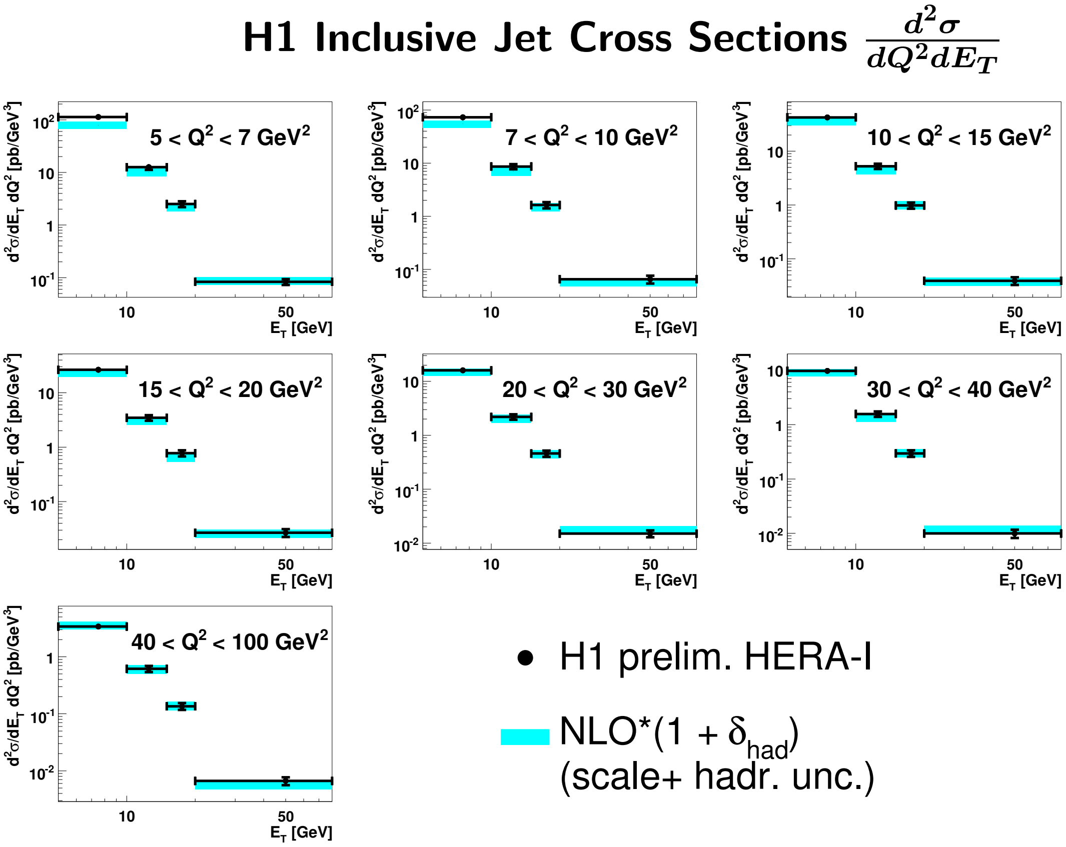

Figure 2: The inclusive double differential jet jet cross sections compared with NLO predictions corrected for hadronization. The error bands reflect the uncertainties in the NLO predictions arising from the variation of the renormalization and factorization scales by a factor 2 up and down and from the hadronization.

4 Results

The measured cross-sections are compared with NLO pQCD predictions obtained with the NLOJET++ [5] program. The calculations are performed in the $\overline{\mathrm{MS}}$ scheme for five massive quark flavours, and the parton PDF of the proton taken from the CTEQ6.1M set [4]. Q^2 is used as factorization scale (μ_F), whereas the renormalization scale (μ_R) is chosen to be the E_T of the jets.

Figure 1 shows the inclusive cross sections as a function of Q^2 and E_T of the jets. The error bars indicate the sum of the statistical and systematical errors added in quadrature. The total systematical errors vary from bin to bin between 8 and 19%, being on the average about 10%. The NLO QCD predictions, corrected for hadronization are compared with the measurements. The cross sections are shown separately for three different sources of theoretical uncertainties in the NLO predictions: the uncertainty arising from the scales (obtained by varying renormalization and factorization scales by a factor 2 up and down), from α_s variation (varying α_s between 0.116 and 0.120) and from the proton PDFs (using 40 eigenvectors of the CTEQ6.1M proton PDF parameterization). The scale uncertainty represents the largest theoretical uncertinty. The figure also compares the experimental and theoretical uncertainties. With the present data, a stringent test of QCD and a precise determination of the strong coupling α_s are possible.

The double differential cross sections as a function of Q^2 and E_T of the jet are shown in Figure 2. The error band on the NLO predictions reflect the variation of the scales μ by a factor of 2 up and down using the NLOJET++. The NLO pQCD calculations corrected for hadronization provide quite reasonable description of the inclusive jet cross sections for relatively high $Q^2 \gtrsim 10\ GeV^2$ and $E_T > 10\ GeV$. At lower Q^2, the comparison indicates the need for higher order QCD corrections.

5 Summary

New measurements of the inclusive jet cross-sections at Q^2 between 5 and 100 GeV^2 performed with the H1 detector are presented. Jets are selected using the inclusive k_T algorithm in the Breit frame and are required to have a minimum transverse energy of $5\ \mathrm{GeV}$. QCD calculations up to second order in the strong coupling constant α_s are compared with the data. The NLO pQCD calculations corrected for hadronization provide quite a reasonable description of the inclusive jet cross sections for relatively high $Q^2 \gtrsim 10\ GeV^2$ and E_T of the jet above 10 GeV.

References

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