JET CROSS SECTIONS IN NC DIS AND DETERMINATION OF α_s AT ZEUS

M. JIMENEZ *

DESY Group ZEUS
Notkestr.85,
Hamburg, 22607, Germany
E-mail: marcos@mail.desy.com

Inclusive jet differential cross sections have been measured in neutral current deep inelastic ep scattering for boson virtualities $Q^2 > 125 GeV^2$ with the ZEUS detector at HERA using an integrated luminosity of 65 pb^{-1}. Jets were identified in the Breit frame using the longitudinally invariant k_T cluster algorithm. Measurements of differential inclusive jet cross sections are presented as functions of jet transverse energy, $E^{\rm jet}_{T,\rm B}$, jet pseudorapidity and Q^2, for jets with $E^{\rm jet}_{T,\rm B} > 8 GeV$. Next-to-leading-order (NLO) QCD calculations describe reasonably well the measurements. An NLO QCD analysis of the differential cross sections has allowed a precise determination of $\alpha_s(M_Z)$ and a test of its scale dependence.

1. Measurements of Inclusive jet cross sections at ZEUS

Jet production in neutral current deep inelastic ep scattering (NC DIS) at high Q^2, where Q^2 is the negative of the square of the virtuality of the exchanged boson, provides a testing ground for perturbative QCD(pQCD). In DIS, the predictions of pQCD have the form of a convolution of matrix elements with parton distribution functions (PDFs) of the target hadron. The matrix elements describe the short-distance structure of the interaction and are calculable in pQCD at each order, whereas the PDFs contain the description of the long-term structure of the target hadron. The hadronic final state in NC DIS may consist of jets of high transverse energy, $E^{\rm jet}_{T,\rm B}$, produced in the short-distance process as well as the remnant (beam jet) of the incoming proton. In this type of processes, the Breit frame is preferred, since it provides a maximal separation between the products of the beam fragmentation and the hard jets. Furthermore, the contribution due to the

*On behalf of the zeus collaboration.

current jet in events from the Born process is suppressed by requiring the production of jets with high $E_{T,\mathrm{B}}^{\mathrm{jet}}$ in this frame. Jet production in the Breit frame is, therefore, directly sensitive to hard QCD processes, thus allowing direct tests of the pQCD predictions. Jet cross sections in NC DIS have been studied previously at HERA. Inclusive-jet, dijet and multijet production have been used to test pQCD and extract values of the strong coupling constant, α_s. Since from these determinations of $\alpha_s(M_Z)$, the smallest uncertainty was obtained in the analysis on the inclusive-jet cross sections, it is worth pursuing this type of measurements. Furthermore, differential jet cross sections as a function of the jet transverse energy in the Breit frame, $E_{T,\mathrm{B}}^{\mathrm{jet}}$, in different regions of Q^2 have been recently included in a NLO QCD fit to extract the proton PDFs. They helped to reduce the uncertainty of the gluon density in the mid- to high-x region. The results presented consist of new measurements of differential inclusive-jet cross sections as a function of the jet pseudorapidity in the Breit frame, $\eta_{\mathrm{B}}^{\mathrm{jet}}$, $E_{T,\mathrm{B}}^{\mathrm{jet}}$, Q^2 and $d\sigma/dE_{T,B}^{jet}$ in different regions of Q^2. Jets with $E_{T,\mathrm{B}}^{\mathrm{jet}} > 8GeV$ and $-2 < \eta_{\mathrm{B}}^{\mathrm{jet}} < 1.5$ were selected. The data sample used corresponds to $81.7pb^{-1}$, which is a more than twofold increase with respect to previous ZEUS analysis of this type, yielding smaller statistical uncertainties. Lower experimental uncertainties have allowed a more accurate determination of α_s and of its running as well as a better constraint on the proton PDFs. Figure 1 shows the measured differential cross section with respect to Q^2. The measurements are compared with NLO QCD ($O(\alpha_s)$) calculations obtained using the program DISENT. The renormalisation (μ_R) and factorisation (μ_F) scales were chosen to be $\mu_R = E_{T,\mathrm{B}}^{\mathrm{jet}}$ and $\mu_F = Q$, respectively. The strong coupling constant, α_s, was calculated at two loops with $\Lambda_{MS} = 220$ MeV, corresponding to $\alpha_s(M_Z) = 0.1175$. The calculations were performed using the MRST99 parametrisations of the proton PDFs. The k_T cluster algorithm was also applied to the partons in the events generated by DISENT in order to compute the jet cross-section predictions. Since the measurements refer to jets of hadrons, whereas the NLO QCD calculations refer to jets of partons, the predictions were corrected to the hadron level using the MC models. The data points are plotted at the weighted mean in each bin of the corresponding variable. The measured $d\sigma/dQ^2$ exhibits a steep fall-off over five orders of magnitude in the Q^2 range considered. The NLO QCD predictions are compared to the measurements in Figure 1. The fractional difference of the measured differential cross sections to the NLO QCD calculations are shown in the lower part of the figure. The calculations reproduce well the measured differential cross sections. The

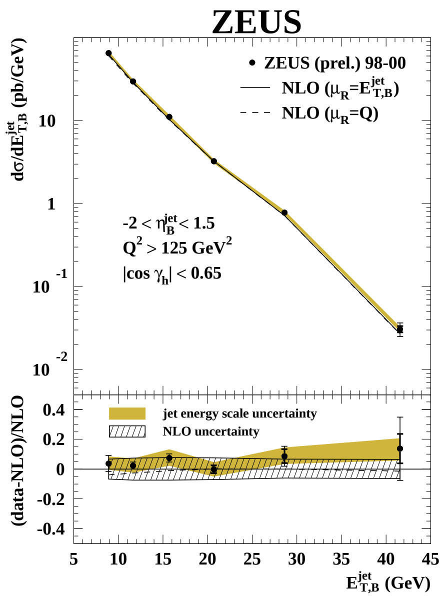

Figure 1. Differential inclusive jet cross section with respect to $E^{\rm jet}_{T,\rm B}$.

measured differential cross-section as functions of $E^{\rm jet}_{T,\rm B}$ and Q^2 were used to determine $\alpha_s(M_Z)$. The NLO QCD calculations were performed using the program DISENT with three different MRST99 sets of proton PDFs, central, MRST99↓↓, and MRST99↑↑; the value of $\alpha_s(M_Z)$ used in each partonic cross-section calculation was that associated with the corresponding set of PDFs. The $\alpha_s(M_Z)$ dependence of the predicted cross sections in each bin i of$E^{\rm jet}_{T,\rm B}$ or Q^2 was parametrised according to a square dependence of the prediction on $\alpha_s(M_Z)$. Figure 2 shows the values of $\alpha_s(M_Z)$ obtained using the different bins of Q^2. The value of $\alpha_s(M_Z)$ obtained for the combined region of $Q^2 > 500GeV^2$ carried the smallest theoretical uncertainties: $\alpha_s(M_Z) = 0.1196 \pm 0.0011(stat.)^{+0.0019}_{-0.0025}(exp.)^{+0.0029}_{-0.0017}(\rm th.)$ The QCD prediction for the energy-scale dependence of the strong coupling constant was tested by determining α_s from the measured $d\sigma/dE^{jet}_{T,B}$ at different $E^{\rm jet}_{T,\rm B}$ values and from the measured $d\sigma/dQ^2$ at different Q^2 values. The method was the same employed for the extraction of $\alpha_s(M_Z)$, but parametrising the α_s dependence of $d\sigma/dE^{jet}_{T,B}$ and $d\sigma/dQ^2$ in terms of $\alpha_s(\langle E^{\rm jet}_{T,\rm B}\rangle)$ and $\alpha_s(\langle Q\rangle)$ in each bin. The results, shown in Figure 3, are in good agreement with the predicted running of the strong coupling constant

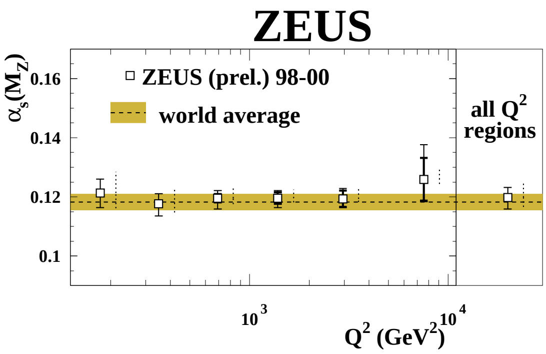

Figure 2. Values of $\alpha_s(M_Z)$ extracted using measured $d\sigma/dQ^2$.

over a large range in $E_{T,\mathrm{B}}^{\mathrm{jet}}$ and Q.

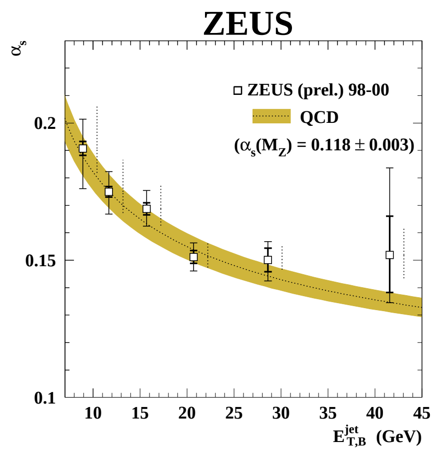

Figure 3. The scale dependence of α_s with respect to $E_{T,\mathrm{B}}^{\mathrm{jet}}$.