ZEUS High Q^2 e^+p and e^-p cross sections

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Neutral-current and charged-current deep inelastic scattering has been studied using 47.7 pb^{-1} of e^+p data and 6.3 pb^{-1} of e^-p data, collected by the ZEUS experiment in 1994-99. Differential cross sections for high Q^2 scattering ($Q^2 > 400$ GeV^2 for e^+p NC, $Q^2 > 200$ GeV^2 for e^+p CC and $Q^2 > 1000$ GeV^2 for e^-p CC) are presented. For e^+p charged-current scattering double differential cross section in x and Q^2 is also measured. The W boson mass is evaluated from the Q^2 dependence of the CC e^+p DIS cross section.

1. INTRODUCTION

The measurements of e^+p neutral-current (NC) and charged-current (CC) DIS cross sections are based on 47.7 pb^{-1} of data collected by the ZEUS experiment from 1994 to 1997. During this period HERA collided 820 GeV protons with 27.5 GeV positrons, yielding a center of mass energy $\sqrt{s} = 300$ GeV.

The measurement of e^-p CC DIS cross sections are based on 6.3 pb^{-1} of data, taken in 1998 and the beginning of 1999, when HERA collided 920 GeV protons with 27.5 GeV electrons.

NC and CC DIS events are simulated using HERACLES with the DJANGO6 2.4. The hadronic final states are simulated using the color dipole model of ARIADNE 4.08 and, for systematic studies, the MEPS model of LEPTO 6.5.

Measured cross sections are corrected for radiative effects and the electroweak Born-level results are presented.

2. e^+p NC CROSS SECTION MEASUREMENT

The NC DIS analysis is described in detail in [1]. The essential requirements to select high Q^2 NC DIS events are an isolated electromagnetic cluster in the calorimeter with an energy greater than 10 GeV and an associated track with momentum above 5 GeV measured in the central tracking detector. The total $E - P_Z$ has to be greater than 38 GeV and less then 65 GeV. For electromagnetic clusters beyond the forward tracking acceptance, the transverse momentum of the cluster must be greater than 30 GeV and $E - P_Z > 44$ GeV. The reconstructed vertex z position must be within ± 50 cm of the nominal position. The kinematic variables are reconstructed using the Double-Angle method.

The differential cross sections $d\sigma/dQ^2$ and $d\sigma/dx$ for NC e^+p scattering for $Q^2 > 400$ GeV^2 are presented in Figs. 1 and 2. The predictions of the Standard Model give a very good description of all measured cross sections, with the possible exception of $d\sigma/dQ^2$ at $Q^2 > 36200$ GeV^2 where 2 events are observed while 0.27 are predicted by the SM.

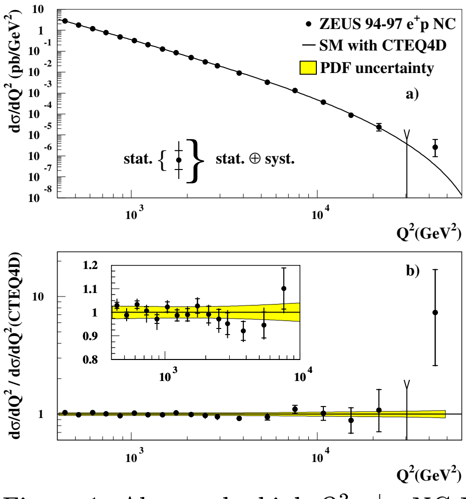

Figure 1. Above: the high Q^2 e^+p NC DIS cross section $d\sigma/dQ^2$ for data (points) and the Standard Model predictions (line). Below: the ratio of the measured $d\sigma/dQ^2$ to the SM expectations, evaluated using CTEQ4D.

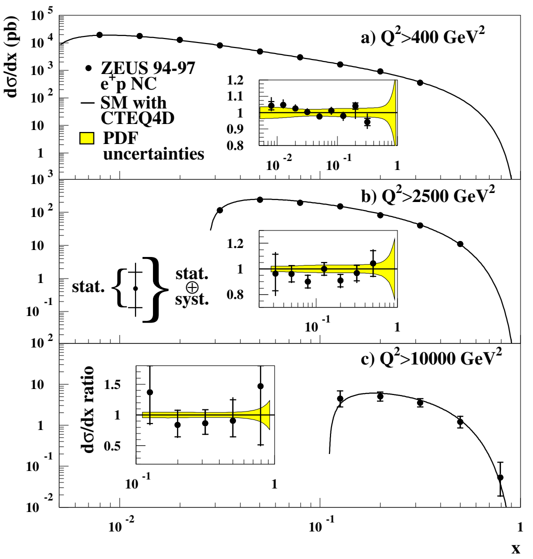

Figure 2. The high Q^2 e^+p NC DIS cross section $d\sigma/dx$ for data (points) and the Standard Model predictions (curve) for $Q^2 > 400$, 2500 and 10000 GeV^2.

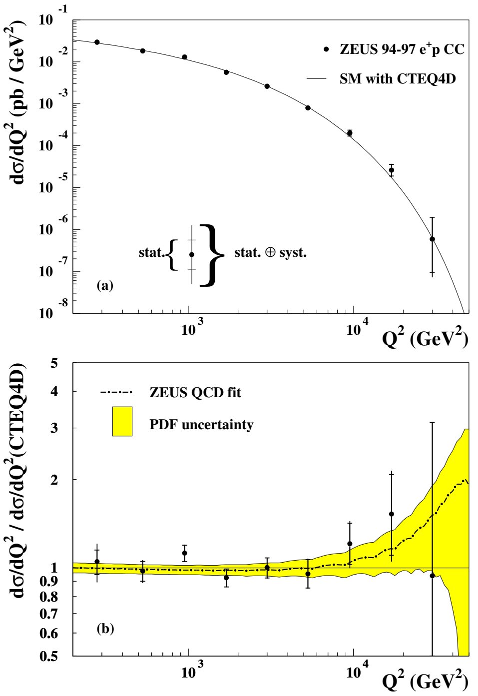

Figure 3. Above: the high Q^2 e^+p CC DIS cross section $d\sigma/dQ^2$ for data (points) and the Standard Model predictions. Below: the ratio of the measured $d\sigma/dQ^2$ to the SM expectation evaluated using CTEQ4D. Also shown by the dashed-dotted line is the result of the ZEUS NLO QCD fit.

3. e^+p CC CROSS SECTION MEASUREMENT

CC DIS events selection cuts depend on the hadronic polar angle γ_h, reconstructed following the Jacquet-Blondel approach [2].

For $\gamma_h > 23^o$ selection procedure requires a tracking vertex within the interaction region. The missing transverse momentum, P_T, as measured in the calorimeter must be greater than 12 GeV (greater than 10 GeV when excluding calorimeter cells closest to the beam line). The $P_T/E_T > 0.4$ is required for 20 GeV $< P_T <$ 30 GeV and $P_T/E_T > 0.55$ for $P_T < 20$ GeV. When $\gamma_h < 23^o$ the vertex is reconstructed from time of flight as measured in the forward calorimeter, and stricter cuts are used: $P_T > 14$ GeV (12 GeV) and $P_T/E_T > 0.6$ cut is imposed when $P_T < 30$ GeV. Topological cuts are applied to reject cosmic and halo muons.

The kinematic variables are reconstructed with the Jacquet-Blondel method and the final selection requires $Q^2_{JB} > 200$ GeV^2 and $y_{JB} < 0.9$.

The differential cross sections $d\sigma/dQ^2$ and $d\sigma/dx$ for CC e^+p scattering are shown in Figs. 3 and 4. While the SM describes the data well over most of the kinematic range, the data tend to lie above the SM predictions at high x. The ZEUS QCD fit [3] gives a better description of ZEUS data for high Q^2 and high x region than CTEQ4D.

The reduced double differential cross section $\tilde{\sigma}$:

$$\tilde{\sigma} = \left[\frac{G_F^2}{2\pi x} \left(\frac{M_W^2}{M_W^2 + Q^2} \right)^2 \right]^{-1} \frac{d^2\sigma}{dx dQ^2}$$

is plotted as a function of Q^2 for several values of x in Fig. 5. The SM gives a good description of data, although at high x measured cross sections tend to lie above CTEQ4D predictions for a wide range of Q^2.

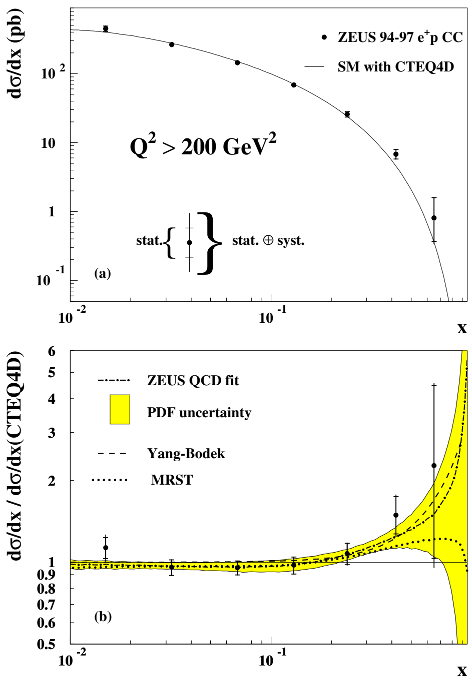

Figure 4. Above: the high Q^2 e^+p CC DIS cross section $d\sigma/dx$ for data (points) and the Standard Model predictions. Below: the ratio of the measured $d\sigma/x$ to the SM expectation evaluated using CTEQ4D. Also shown are the result of the ZEUS NLO QCD fit (dashed-dotted), expectations evaluated using MRST PDF (dotted) and using Yang and Bodek PDF corrections [4] (dashed).

3.1. Determination of the W mass

The Q^2 dependence of the CC cross section can be described by equation:

$$\frac{d\sigma}{dQ^2} = \frac{G_F^2}{4\pi}\frac{M_W^4}{(M_W^2+Q^2)^2}F(Q^2),$$

where the Fermi constant G_F gives normalization and the W mass determines the shape. The value of M_W is extracted from ZEUS data via an unconstrained χ^2 fit of M_W and G_F to the measured differential cross section. The fit yields:

$$M_W = 80.9^{+4.9}_{-4.6}(\text{stat.})^{+5.0}_{-4.3}(\text{syst.})^{+1.3}_{-1.2}(\text{PDF})\text{GeV}$$

The value of M_W can be also determined using the fixed G_F value, $G_F = 1.16626\times10^{-5}$ GeV^{-2},

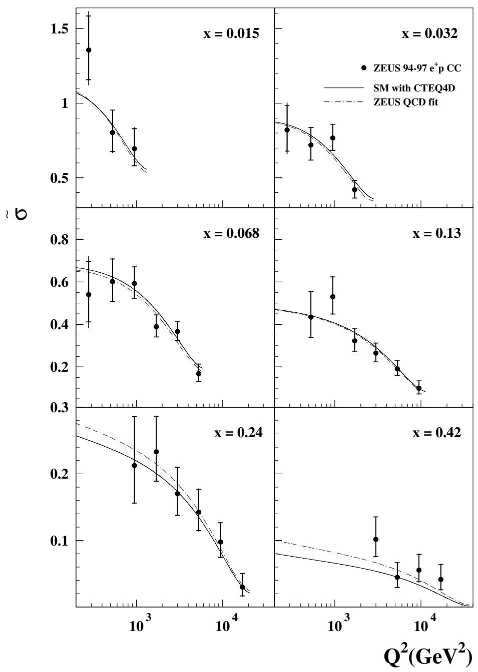

Figure 5. The reduced CC e^+p cross section $\tilde{\sigma}$ as a function of Q^2 at fixed x values. The ZEUS results (points) are compared with the SM expectations calculated using CTEQ4D (solid line) and ZEUS NLO QCD fit (dot-dashed line).

which gives:

$$M_W = 81.4^{+2.7}_{-2.6}(\text{stat.})^{+2.0}_{-2.0}(\text{syst.})^{+3.3}_{-3.0}(\text{PDF})\text{GeV}.$$

The Standard Model imposes the relation between G_F and M_W:

$$G_F = \frac{\pi\alpha}{\sqrt{2}}\frac{M_Z^2}{M_W^2(M_Z^2-M_W^2)}\frac{1}{1-\Delta r},$$

where M_Z is the mass of the Z-boson, α is the fine structure constant and the factor Δr contains the radiative corrections (a function of α, masses of the fundamental bosons and fermions). The model dependent fit based on this relation results in:

$$M_W = 80.50^{+0.24}_{-0.25}(\text{stat.})^{+0.13}_{-0.16}(\text{syst.})^{+0.30}_{-0.31}(\text{PDF})$$
$$^{+0.05}_{-0.06}(\Delta M_t, \Delta M_H, \Delta M_Z)\text{GeV}$$

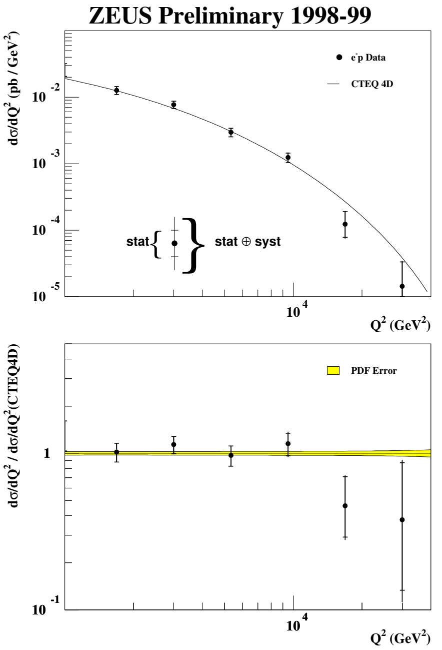

Figure 6. Above: the high Q^2 e^-p CC DIS cross section $d\sigma/dQ^2$ for data (points) and the Standard Model predictions (line). Below: the ratio of the measured $d\sigma/dQ^2$ to the SM expectations, evaluated using CTEQ4D.

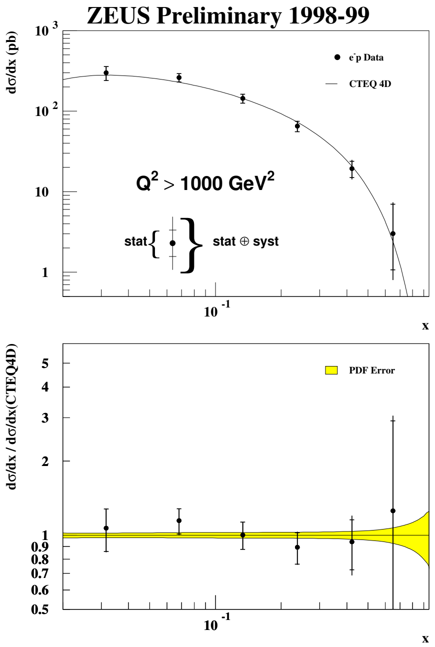

Figure 7. Above: the high Q^2 e^+p CC DIS cross section $d\sigma/dx$ for data (points) and the Standard Model predictions (line). Below: the ratio of the measured $d\sigma/dx$ to the SM expectations, evaluated using CTEQ4D.

This result is in good agreement with both direct and indirect measurements of M_W and demonstrates the consistency of the SM.

4. e^-p CC CROSS SECTION MEASUREMENT

The e^-p CC DIS selection is similar to that used for e^+p data, except for the increased Q^2 cut, $Q^2_{JB} > 1000$ GeV^2.

The differential cross sections for e^-p CC scattering, $d\sigma/dQ^2$ and $d\sigma/dx$ are shown in Figs. 6 and 7. The SM predictions describe the measured $d\sigma/dQ^2$ and $d\sigma/dx$ very well.

5. SUMMARY

The measured cross sections $d\sigma/dQ^2$ and $d\sigma/dx$ for NC DIS e^+p scattering are in very good agreement with the predictions of the Standard Model. Also for the CC DIS e^+p the measured differential cross sections as a functions of Q^2, x, y and the double differential cross section $d\sigma/dxdQ^2$ are reasonably well described by the Standard Model. In the high x region, measured cross sections are somewhat higher then the CTEQ4D PDF. First results for e^-p CC DIS data are presented.

REFERENCES

1. ZEUS Collaboration. DESY 99-056, submitted to the *European Physical Journal*
2. F.Jacquet, A.Blondel, DESY 79-48 (1979) 391.
3. M.Botje, *A QCD Analysis of HERA and Fixed Target Structure Function Data.*, these proceedings.
4. U.K.Yang, A.Bodek, Phys. Rev. Lett. **82** (1999)