RECENT RESULTS ON HIGH-Q^2 NEUTRAL AND CHARGED CURRENT CROSS SECTIONS AT HERA

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High-Q^2 NC and CC DIS cross sections have been measured by H1 and ZEUS at HERA. Both NC and CC results based on data taken during the year 1994-2000 are in good agreement with Standard Model expectations. The structure function xF_3^{NC} is extracted from the NC cross sections and the mass of the $W^\pm$ propagator is extracted from the CC cross sections. Valence quark distributions are derived by means of an NLO QCD fit.

1 Deep Inelastic Scattering at HERA

HERA collides a positron or electron beam with a proton beam. From 1994 to 1997 HERA operated as an e^+p collider with a centre-of-mass energy $\sqrt{s} = 300$ GeV. In 1998 it started in the e^-p mode with $\sqrt{s}$ raised to 318 GeV, and then switched to e^+p at the same energy in July 1999. The H1 and ZEUS experiments have collected 102 and 114 pb^{-1} of e^+p and 16.4 and 16.7 pb^{-1} of e^-p integrated luminosity, respectively. The available Q^2 of the experiments can reach as high as 10^5 GeV^2, which corresponds to a spatial resolution of about 10^{-3} fm. This paper presents results on neutral (NC, $e^\pm p \to e^\pm X$) and charged current (CC, $e^\pm p \to \overset{(-)}{\nu} X$) high-$Q^2$ deep inelastic scattering (DIS) based on 81.5 (47.7) pb^{-1} of H1 (ZEUS) e^+p data [1,2,3,4] and on the full luminosity of the e^-p data [5,6,7].

The Born cross section for NC DIS is written as:

$$\frac{d^2\sigma_{NC}^{e^\pm p}}{dxdQ^2} = \frac{2\pi\alpha^2}{xQ^4}\left[Y_+F_2^{NC}(x,Q^2) \mp Y_- xF_3^{NC}(x,Q^2) - y^2F_L^{NC}(x,Q^2)\right] \tag{1}$$

where α denotes the electromagnetic fine structure constant, x the Bjorken scaling variable, y the elasticity parameter and $Y_\pm = 1 \pm (1-y)^2$. The reduced cross section, $\tilde{\sigma}_{NC}$, is often used,

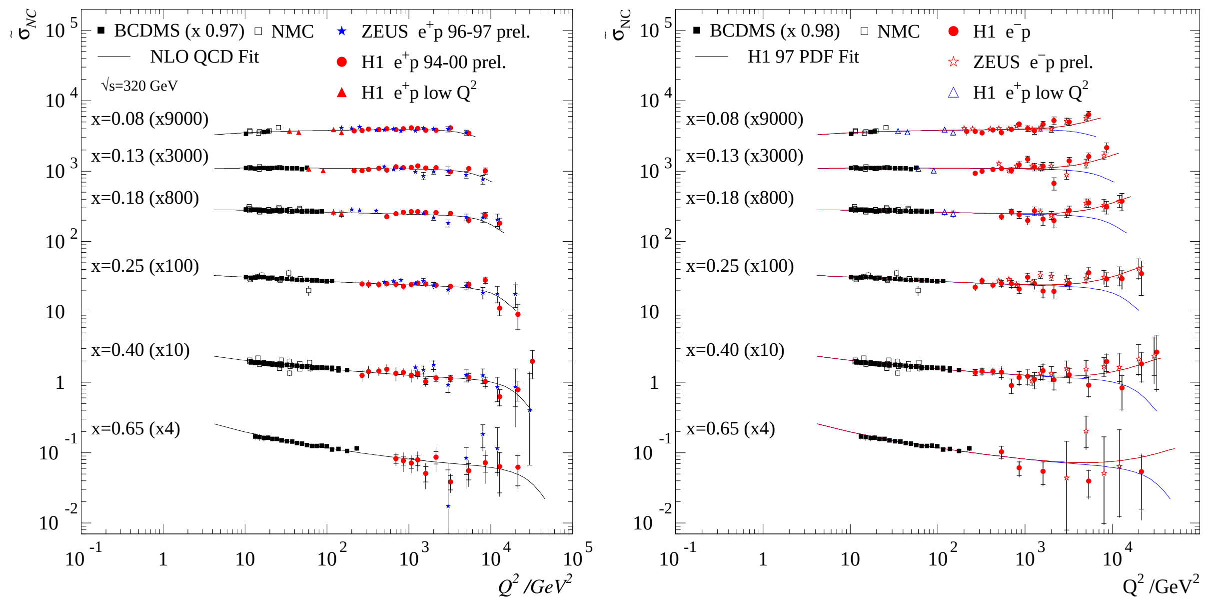


Figure 1: The reduced NC cross sections, $\tilde{\sigma}_{NC}$, compared to the SM predictions for e^+p (left) and e^-p (right).

and is defined as the double differential cross section of Eq. (1) divided by the factor $(\frac{2\pi\alpha^2}{xQ^4})Y_+$, so that the structure function component is extracted. The CC DIS cross section is expressed at leading-order in QCD as:

$$\frac{d^2\sigma_{CC}^{e^+p}}{dxdQ^2} = \frac{G_F^2}{2\pi}\left(\frac{M_W^2}{M_W^2+Q^2}\right)^2 \sum_{i=1}^{2}\left[\overline{u}_i(x,Q^2)+(1-y)^2 d_i(x,Q^2)\right] \quad (2)$$

$$\frac{d^2\sigma_{CC}^{e^-p}}{dxdQ^2} = \frac{G_F^2}{2\pi}\left(\frac{M_W^2}{M_W^2+Q^2}\right)^2 \sum_{i=1}^{2}\left[u_i(x,Q^2)+(1-y)^2 \overline{d}_i(x,Q^2)\right] \quad (3)$$

where G_F denotes the Fermi coupling constant and M_W the mass of the $W^\pm$ boson. The u_i and d_i are u- and d-type quark densities in the proton, respectively, with i running over the first and second generations. As in the NC case, the CC reduced cross section, $\tilde{\sigma}_{CC}$, is defined as Eq. (2) or Eq. (3) divided by the factor $\frac{G_F^2}{2\pi x}(\frac{M_W^2}{M_W^2+Q^2})^2$.

2 Cross Section Measurement

The NC and CC DIS cross sections are both measured for $Q^2 > 200$ GeV^2. Figure 1 shows the NC reduced cross sections $\tilde{\sigma}_{NC}$ as a function of Q^2 for fixed x values. The inner and outer error bars represent the statistical and total uncertainties, respectively. Also shown are the standard model (SM) expectations based on PDFs obtained from an NLO QCD fit [1]. The results are in good agreement with SM predictions over the kinematic range. This illustrates the successful description of the NLO QCD evolution with the DGLAP equation up to $Q^2 \sim 30,000$ GeV^2. Due to the γ-Z^0 interference term, xF_3^{NC}, we observe small differences between the e^+p and e^-p cross sections at high Q^2. We discuss xF_3^{NC} in detail in Section 3.

Figure 2 shows the CC reduced cross sections, $\tilde{\sigma}_{CC}$, as a function of x for fixed Q^2 values, together with the SM predictions based on the NLO QCD fit [1] (left plot) or CTEQ5 [8] (right plot). The measured cross sections are consistent with the SM predictions. The expected contribution from each quark density is also shown. This illustrates that the CC cross section at high x in e^+p collisions is dominated by the d quark, while in e^-p collisions it is dominated by the u quark.

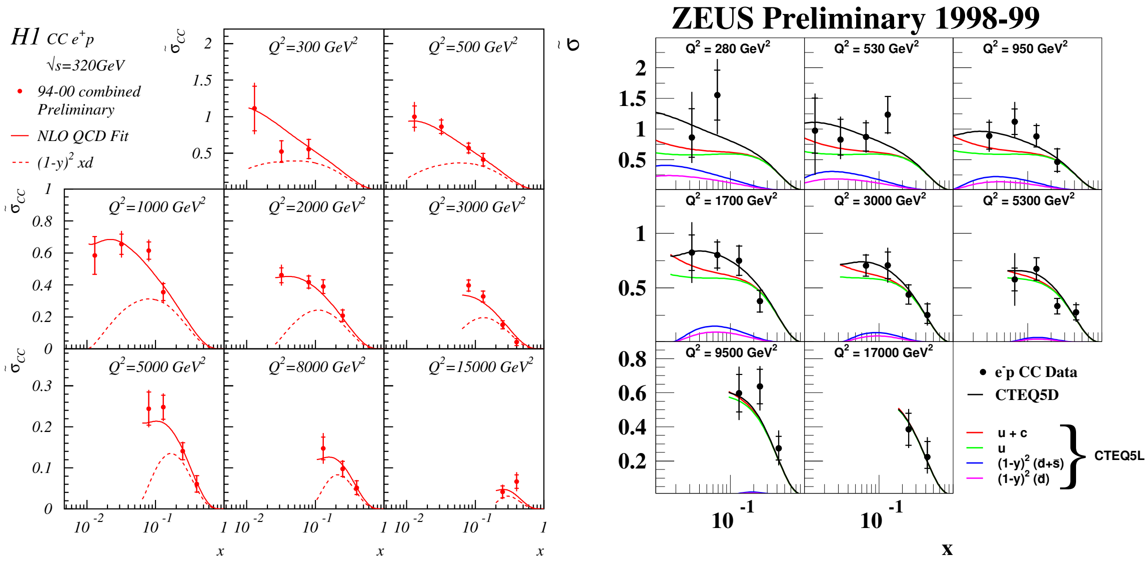


Figure 2: The reduced CC cross sections, $\tilde{\sigma}_{CC}$, compared to the SM prediction for e^+p (left) and e^-p (right).

3 Extraction of xF_3^{NC}, M_W and Valence Quark Distributions

Using the NC double differential cross sections from the 1994-1997 e^+p data at $\sqrt{s} = 300$ GeV and the 1998-1999 e^-p data at $\sqrt{s} = 318$ GeV, xF_3 is determined from:

$$xF_3^{NC} = \frac{xQ^4}{2\pi\alpha^2} \cdot \left(\frac{Y_-^{300}}{Y_+^{300}} + \frac{Y_-^{318}}{Y_+^{318}} \right)^{-1} \cdot \left(\frac{1}{Y_+^{318}} \frac{d^2\sigma_{NC}^{e^-p}}{dxdQ^2} - \frac{1}{Y_+^{300}} \frac{d^2\sigma_{NC}^{e^+p}}{dxdQ^2} \right) - \Delta F_L \tag{4}$$

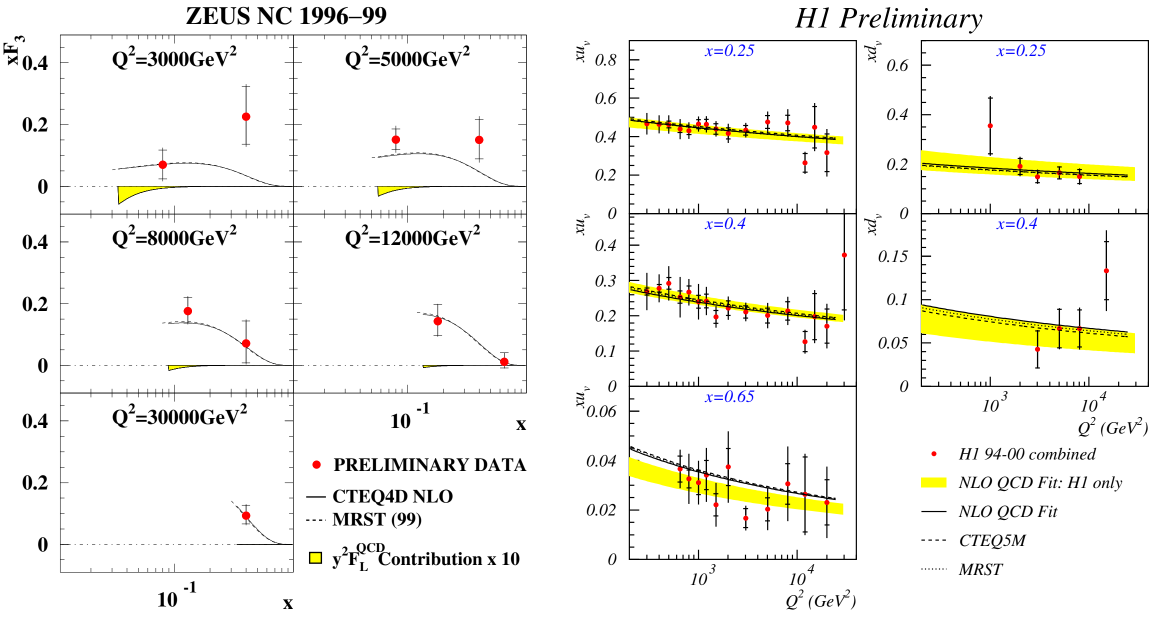
where "300" and "318" denote the different $Y_\pm$ obtained using the different centre-of-mass energies, $\sqrt{s}$. ΔF_L is a correction due to the longitudinal structure function, F_L. The size of ΔF_L obtained by QCD calculations is less than 1% over the kinematic ranges used in this paper, and becomes as large as 10% in the lowest x and Q^2 region. Figure 3(a) shows the results from ZEUS[6]. To reduce the statistical fluctuations, several bins of the double differential measurements are combined. The size of the ΔF_L effect is shown by the shaded bands and is negligible when compared to the size of the statistical uncertainty.

M_W is extracted by a χ^2-fit to the CC $d\sigma/dQ^2$ based on ZEUS 1994-1997 e^+p data with M_W as a free parameter. The fit yielded $M_W = 81.4^{+2.7}_{-2.6}(\text{stat.}) \pm 2.0(\text{syst.})^{+3.3}_{-3.0}(\text{PDF})$ GeV. H1 has applied a similar fit to their CC double differential cross sections and obtained $M_W = 81.2 \pm 3.3(\text{stat.}) \pm 1.7(\text{syst.}) \pm 3.7(\text{PDF})$ GeV from the 1994-1997 e^+p data and $M_W = 79.9 \pm 2.2(\text{stat.}) \pm 0.9(\text{syst.}) \pm 2.1(\text{PDF})$ GeV from the 1998-1999 e^-p data. These space-like measurements are in good agreement with the world average of time-like measurements.

H1 has used[4] their combined e^+p double differential NC and CC cross sections together with the e^-p data in an NLO QCD fit to determine the dominant valence quark distributions xu_v and xd_v at high Q^2 and high x. The H1 low-Q^2 data[9] are also included in order to constrain the gluon and sea quarks. The results are shown as the shaded error bands in Figure 3(b) together with other parametrisations from MRST[10], CTEQ5[8] and the previous H1 fit[1]. Also shown are the valence quark densities determined with the local extraction method defined as:

$$xq_v(x, Q^2) = \sigma_{meas}(x, Q^2) \left(\frac{xq_v(x, Q^2)}{\sigma(x, Q^2)} \right)_{para} \tag{5}$$

where the first factor $\sigma_{meas}(x, Q^2)$ on the right-hand-side is the measured NC or CC double differential cross section, and the second factor is the theoretical expectation from the H1 fit[1].



(a) (b)

Figure 3: (a) xF_3^{NC} extracted from the NC double differential cross sections. (b) Valence quark densities derived from the NC and CC cross sections by means of an NLO QCD fit.

4 Summary

NC and CC DIS cross sections in e^+p and e^-p collisions measured by the H1 and ZEUS experiments are in good agreement with SM predictions over the kinematic range of $200 \lesssim Q^2 \lesssim 30000$ GeV^2 and $0.01 \lesssim x \lesssim 0.65$. xF_3^{NC} is determined from the NC double differential cross sections. M_W has been extracted from the CC cross sections and is found to be consistent with LEP and Tevatron measurements. The valence quark distributions have been extracted by means of an NLO QCD fit to the NC and CC double differential cross sections.

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References

1. H1 Collab., C. Adloff et al., Eur. Phys. J. **C13** (2000) 609.
2. ZEUS Collab., J. Breitweg et al., Eur. Phys. J. **C11** (1999) 427.
3. ZEUS Collab., J. Breitweg et al., Eur. Phys. J. **C12** (2000) 411.
4. H1 Collab., Contribution to ICHEP2000, Paper 309.
5. H1 Collab., C. Adloff et al., DESY-00-187, accepted by Eur. Phys. J. **C**.
6. ZEUS Collab., Contribution to ICHEP2000, Paper 413.
7. ZEUS Collab., Contribution to ICHEP2000, Paper 414.
8. CTEQ Collab., H. L. Lai et al., Phys. Rev. **D55** (1997) 1280.
9. H1 Collab., Contribution to ICHEP2000, Paper 294.
10. A. D. Martin et al., Eur. Phys. J. **C4** (1998) 463.