H1 Measurements at High Q^2

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Abstract

The measurements of the inclusive single and double differential cross sections for neutral and charged current processes with 4−momentum transfer squared Q^2 between 150 and 30000GeV^2 and x-Bjorken values between 0.0032 and 0.65 with the H1 detector at HERA are presented. The final results using e^+p collisions produced between 1994 and 1997 with an integrated luminosity of 35.6 pb^{-1} at a center-of-mass energy $\sqrt{s} = 300$GeV [1], and the preliminary results for e^-p data taken between 1998 and 1999 corresponding to an integrated luminosity of 15.3 pb^{-1} at $\sqrt{s} = 320$GeV [2] are shown.

1. Introduction

Inclusive Deep Inelastic Scattering (DIS) is one of the most powerful tools to study the structure of the proton and its underlying dynamics, QCD. In neutral current (NC) interactions the double differential cross-section for the process $e^\pm p \to e^\pm X$ can be expressed in terms of structure functions as:

$$\frac{d^2\sigma^\pm_{NC}}{dx\, dQ^2} = \frac{2\pi\alpha^2}{xQ^4}\left[Y_+\tilde{F}_2 \mp Y_- x\tilde{F}_3 - y^2\tilde{F}_L\right], \quad (1)$$

where the dominant contribution is $\tilde{F}_2$ and the helicity dependences of electroweak interactions are contained in the functions $Y_\pm \equiv 1 \pm (1-y)^2$. The charged current (CC) cross-section can be written as:

$$\frac{d^2\sigma_{CC}}{dx\, dQ^2} = \frac{G_F^2}{2\pi x}\left(\frac{M_W^2}{M_W^2+Q^2}\right)^2 \phi_{CC}^{e^\pm p}, \quad (2)$$

where the structure function term ϕ_{CC} is given in leading order by the combination of the quark and anti-quark densities as:

$$\phi_{CC}^{e^+p} = x\left[(\bar{u}+\bar{c}) + (1-y)^2(d+s)\right], \quad (3)$$

$$\phi_{CC}^{e^-p} = x\left[(u+c) + (1-y)^2(\bar{d}+\bar{s})\right]. \quad (4)$$

It is convenient to display the reduced cross-sections defined as:

$$\tilde{\sigma}_{NC}(x,Q^2) \equiv \frac{1}{Y_+}\,\frac{Q^4\, x}{2\pi\alpha^2}\,\frac{d^2\sigma_{NC}}{dxdQ^2}, \quad (5)$$

$$\tilde{\sigma}_{CC}(x,Q^2) \equiv \frac{2\pi x}{G_F^2}\left(\frac{M_W^2+Q^2}{M_W^2}\right)^2\frac{d^2\sigma_{CC}}{dxdQ^2}, \quad (6)$$

in order to reduce the strong Q^2 dependence originating from the propagator.

2. The $d\sigma/dQ^2$ cross-sections

Figure 2 shows the single differential cross-sections $d\sigma/dQ^2$ for NC and CC interactions from the e^+p

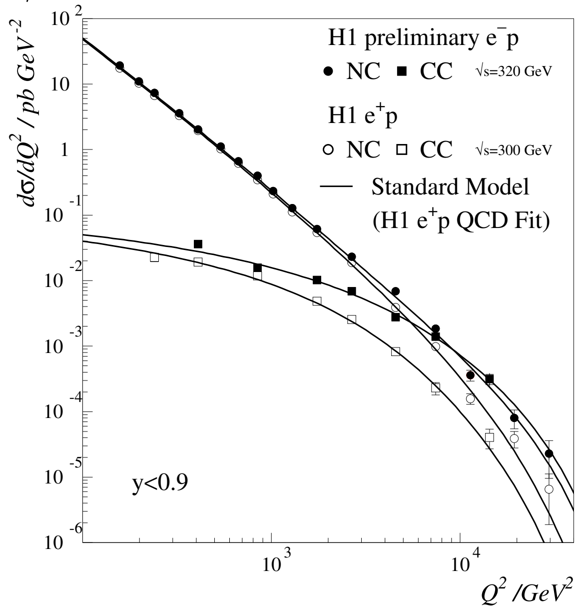

Figure 1. The single differential cross-section $d\sigma/dQ^2$ for NC (circles) and CC (squares) processes in e^+p (open symbols) and e^-p (full symbols) interactions.

and e^-p running. The two NC cross-sections are very similar at $Q^2 \lesssim 3000$GeV^2, where only an increase of $\simeq 7\%$ is expected for e^-p measurement, due to the increased center of mass energy. At high Q^2 this difference is expected to rise to $\simeq 50\%$, but remains small compared to the increase of about an order of magnitude due to the different lepton polarity.

The CC cross-sections are about 3 orders of magnitude smaller than the NC ones at low Q^2, but become of similar order at $Q^2 \simeq M_W^2$. As in the NC case, the increase in cross-section due to the higher beam energies is rather small, compared to the difference due to the coupling of $W^\pm$ to different quark flavors.

All measured cross-sections are in good agreement with the Standard Model expectation, obtained from a NLO QCD fit to DIS data at $Q^2 < 150\mathrm{GeV}^2$, which described in [1]. No significant excess is visible at very high Q^2.

3. The NC cross-sections at high x

At high Q^2 cross-section measurements at high x become kinematically accessible at HERA. This region is particularly interesting, as new informations about α_S and the parton densities may be obtained with high precision measurements. In figure 3 the behavior at high x of the reduced cross-sections $\tilde{\sigma}_{NC}(x,Q^2)$ is compared for e^+p and

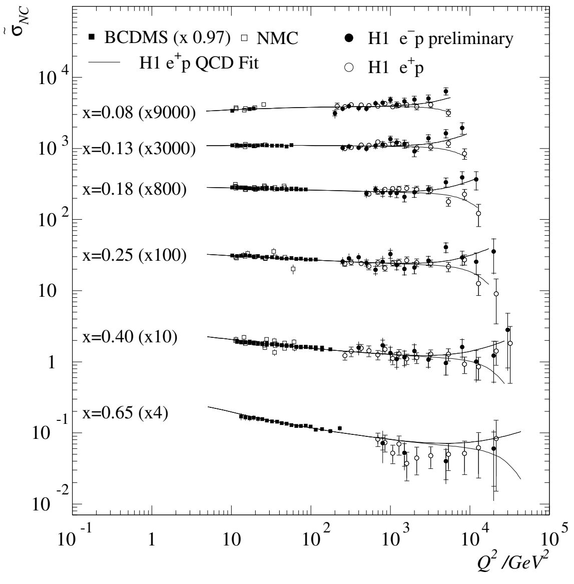

Figure 2. The reduced neutral current cross-section $\tilde{\sigma}_{NC}(x,Q^2)$ at high x for e^+p (open points) and e^-p (full points) interactions.

e^-p interactions. The effect of the constructive (destructive) effect of the $\gamma - Z$ interference term in e^-p (e^+p) interactions is clearly visible for $Q^2 \gtrsim 3000\mathrm{GeV}^2$ for all measured x-values. At $x = 0.65$ the measurement is still largely dominated by statistical errors, but shows a tendency to be slightly below the expectation from the NLO QCD Fit [1], driven in this kinematic region by the high precision BCDMS measurement.

4. The CC cross-sections

At high x the proton is dominated by the valance quark densities. The CC cross-section, displayed in figure 4, is higher for e^-p scattering than for e^+p, not only due to the u-density being twice the d-density in this kinematic region, but also due to the additional suppression of the Wd interaction by the helicity factor in $(1-y)^2$. A precise determination of the d-density from CC interactions would therefore need an important increase in statistics.

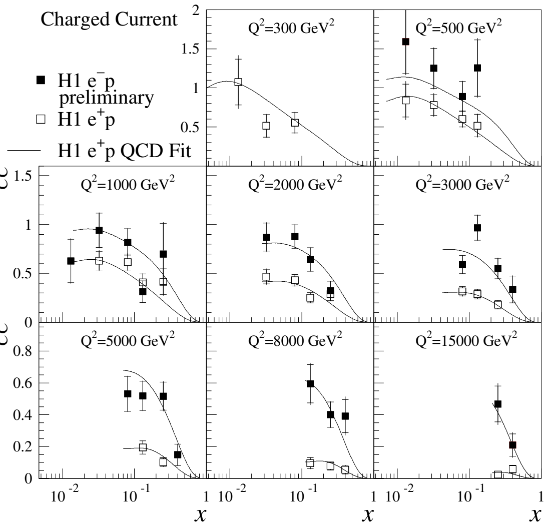

Figure 3. The reduced charged current cross-section $\tilde{\sigma}_C(x,Q^2)$ for e^+p (open squares) and e^-p (full squares) interactions.

As the shpae of the CC cross-section is determined from the propagator term, M_W can be extracted at HERA in the t-channel. The result obtained from a fit to the e^+p cross-section measurement is

$$M_W = 80.9 \pm 3.7(exp.) \pm 3.7(theo.)\mathrm{GeV}\ . \qquad (7)$$

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References

[1] H1 Collab., C. Adloff et al., DESY-99-107 (1999). *submitted to Eur. Phys. J.*

[2] H1 Collab., "Measurement of the Neutral and Charged Current Cross-Sections in Electron-Proton Collisions at High Q^2 at HERA", ICHEPS 99-Tampere (1999), pa-157b.