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H1 HIGH Q^2 RESULTS IN NEUTRAL AND CHARGED CURRENT e^+p AND e^-p SCATTERING*

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Inclusive neutral and charged current cross sections in deep inelastic electron proton scattering at high four momentum transfer Q^2 have been measured by the H1 experiment at HERA. The structure functions F_2, xF_3 and F_L are extracted from neutral current cross sections. Charged current cross sections are used to determine the W propagator mass. The valence quark distributions are derived using exclusively H1 data. All results, including those at highest Q^2, are found to be in good agreement with the Standard Model.

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1. Introduction

The precise measurements of the inclusive cross sections in Deep Inelastic Scattering (DIS) provide tests of both the electroweak and the QCD sectors of the Standard Model (SM). The interaction between the proton p and the lepton $e^\pm$ is mediated by the exchange of neutral bosons (γ, Z^0) in the Neutral Current (NC) reactions or charged bosons ($W^\pm$) in the Charged Current (CC) reactions.

The cross sections for $e^\pm p$ scattering presented here are measured in the range of four momentum transfer squared Q^2 between 150 and 30000 GeV^2 and Bjorken x between 0.0013 and 0.65. The e^+p (e^-p) data were taken in 1999–2000 (1998–1999) at a center of mass energy of $\sqrt{s} \approx 318$ GeV and correspond to an integrated luminosity of 45.9 (16.4) pb^{-1}. The e^+p data have been combined with previous H1 measurements [1] at $\sqrt{s} \approx 300$ GeV providing a total e^+p data sample of 81.5 pb^{-1}. The results are compared to SM predictions, calculated with parton densities obtained from the H1 97 PDF fit [1].

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2. Results

The double differential NC cross section for unpolarized $e^{\pm}p$ scattering can be decomposed into three structure functions F_2, xF_3 and $F_{\rm L}$

$$\frac{d^2\sigma^{\pm}_{\rm NC}}{dx\,dQ^2} = \frac{2\pi\alpha^2}{x\,Q^4}\Big[Y_+\,F_2(x,Q^2) \mp Y_-\,xF_3(x,Q^2) - y^2\,F_{\rm L}(x,Q^2)\Big]\,, \qquad (2.1)$$

where α is the fine structure constant and $Y_{\pm} = 1 \pm (1-y)^2$ and y is the inelasticity. The proton structure function $F_2(x,Q^2)$, which in the quark parton model contains the charge squared weighted quark momentum distributions, yields the dominant contribution to the cross section in a large region of the kinematic phase space. The structure function $xF_3(x,Q^2)$ is related to the difference between quark and antiquark densities and contains the parity violating part of the NC cross section. The xF_3 contribution to the cross section depends on the lepton charge and is significant at highest Q^2. The longitudinal structure function $F_{\rm L}(x,Q^2)$ emerges in higher order QCD and is directly sensitive to the gluon distribution in the proton. It is negligible except at highest y. The measurements of the Q^2 dependence of the single differential NC and CC cross sections $d\sigma/dQ^2$ are shown in Fig. 1.

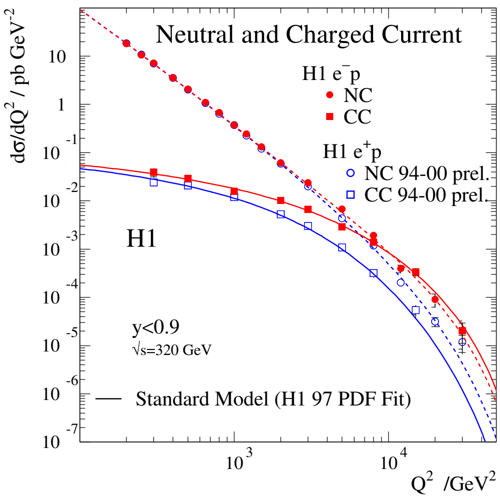

Fig. 1. Measurements of the single differential NC (circles) and CC (squares) cross sections as function of Q^2 for e^-p (solid symbols) and e^+p data (open symbols). The SM predictions are given as dashed (NC) and solid curves (CC). Statistical and total errors are given as inner and outer error bars, respectively.

At Q^2 beyond M_Z^2, the NC data show a clear effect of the xF_3 contribution which enters with a different sign for e^+p and e^-p. The double differential NC cross section measurements are presented in Fig. 2 in the form of the reduced cross section

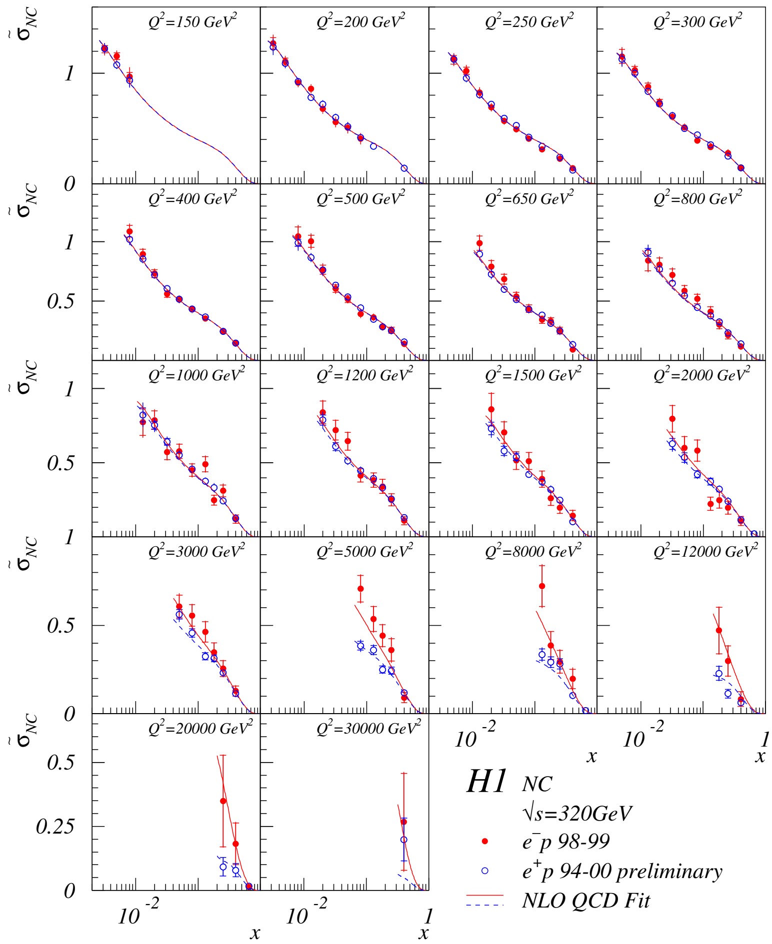

Fig. 2. Measurements of the NC reduced cross sections for e^-p (solid points) and e^+p data (open circles). The SM predictions are given as full (e^-p) and dashed lines (e^+p). Statistical and total errors are given as inner and outer error bars, respectively.

$$\tilde{\sigma}^{\pm}_{\mathrm{NC}}(x,Q^2) = \frac{x\,Q^4}{2\pi\alpha^2\,Y_+}\,\frac{d^2\sigma^{\pm}_{\mathrm{NC}}}{dx\,dQ^2}\,. \tag{2.2}$$

The NC measurements are in good agreement with the SM predictions. The proton structure function F_2 has been extracted from the reduced cross section in the kinematic phase space where the xF_3 and F_{L} contributions are small and can be corrected for [1]. The results are consistent for e^+p and e^-p data. The structure function xF_3 is extracted from the difference between the e^-p and e^+p cross sections [2] as shown in Fig. 3(a). The measurement

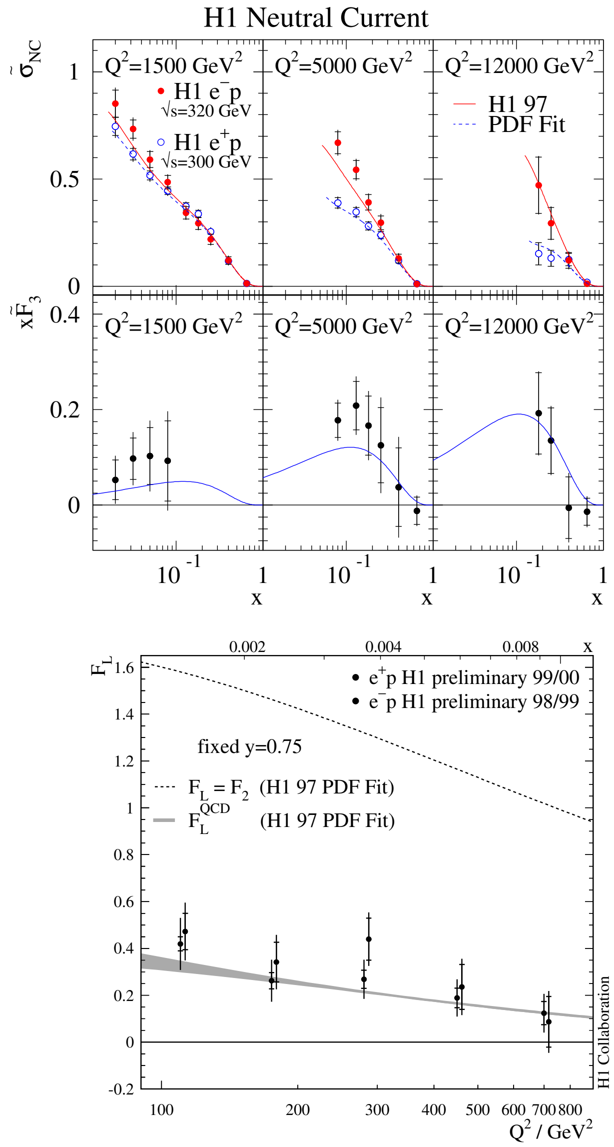

Fig. 3. (a) Structure function xF_3 (lower plots) in three bins of Q^2, extracted from the difference of the reduced cross sections (upper plots) of e^-p and e^+p data. (b) The longitudinal structure function F_{L} for $y = 0.75$ derived from e^+p and e^-p data. For displaying purposes, the e^-p results are slightly shifted to the right.

reveals direct sensitivity to the valence quark distributions. To get access to the longitudinal structure function F_{L}, the cross section measurements were extended to highest y, *i.e.* lower energies of the scattered electron. F_{L} is

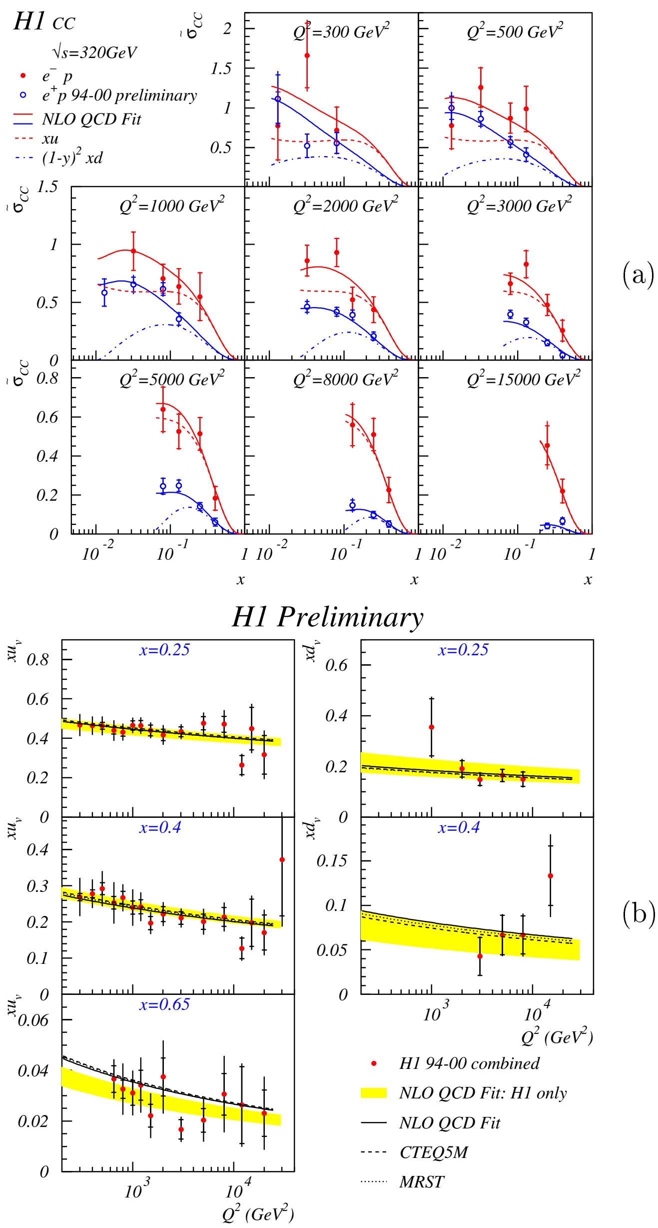

Fig. 4. (a) CC reduced cross sections for e^-p (solid points) and e^+p data (open circles). SM predictions are given as full curves, dashed lines represent corresponding valence quark contributions. (b) Valence quark distributions xu_{v} (left) and xd_{v} (right) at highest x, derived using the local extraction method (points) and from a QCD fit to H1 data only (bands). Lines show results from global QCD analysis.

extracted by subtracting the F_2 contribution, which is extrapolated into the high y region using the QCD fit [1], from the measured cross sections. The results for e^-p and e^+p data are presented in Fig. 3(b). Both measurements are consistent and in agreement with the QCD fit, showing the overall consistency of the parton decomposition of the proton.

The CC cross section for unpolarized $e^{\pm}p$ scattering is given by

$$\frac{d^2\sigma^{\pm}_{\rm CC}}{dx\,dQ^2} = \frac{G_{\rm F}^2}{2\pi x}\left(\frac{M_W^2}{Q^2+M_W^2}\right)^2 \tilde{\sigma}^{\pm}_{\rm CC}\,. \tag{2.3}$$

$G_{\rm F}$ is the Fermi coupling constant and M_W the propagator mass. In leading order QCD, the CC reduced cross section $\tilde{\sigma}^{\pm}_{\rm CC}$ is given by quark momentum distributions with helicity dependent weights

$$\begin{aligned} \tilde{\sigma}^{+}_{\rm CC} &= x[(\overline{u}+\overline{c}) + (1-y)^2(d+s)]\,, \\ \tilde{\sigma}^{-}_{\rm CC} &= x[(u+c) + (1-y)^2(\overline{d}+\overline{s})]\,. \end{aligned} \tag{2.4}$$

The measurements of the single differential CC cross sections $d\sigma/dQ^2$, shown in Fig. 1, are still statistically limited. The shape of the cross sections is sensitive to the propagator mass, which has been derived from a fit to the e^-p data [2], $M_W = 79.9 \pm 2.2(\text{stat.}) \pm 0.9(\text{syst.}) \pm 2.1(\text{pdf})$ GeV. The CC reduced cross sections $\tilde{\sigma}_{\rm CC}$ are presented in Fig. 4(a) and reveal the sensitivity to individual parton densities.

All H1 NC and CC $e^{\pm}p$ cross section measurements are used to determine the $u_{\rm v}$ and the $d_{\rm v}$ valence distributions at high x. Fig. 4(b) shows the results obtained with the local extraction method [1]:

$$xq_{\rm v}(x,Q^2) = \sigma_{\rm meas}(x,Q^2)\left[\frac{xq_{\rm v}(x,Q^2)}{\sigma(x,Q^2)}\right]_{\rm QCDfit}\,.$$

Fig. 4(b) also shows the valence quark distributions obtained from a NLO QCD fit to the H1 data alone. Both methods are consistent with global analysis but not yet competitive to global PDF fits due to limited statistics.

3. Conclusions

The H1 data at high Q^2 provide a rich testing ground for both the electroweak theory and QCD evolution. Presently, the SM predictions are in good agreement with the data. At HERA II, increased luminosity and effects of the polarized lepton beam will improve the precision of such tests.

REFERENCES

[1] C. Adloff *et al.* [H1 Collaboration], *Eur. Phys. J.* **C13**, 609 (2000).
[2] C. Adloff *et al.* [H1 Collaboration], *Eur. Phys. J.* **C19**, 269 (2001).