NEUTRAL CURRENT CROSS SECTIONS WITH POLARISED LEPTON BEAM AT ZEUS

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Measurements of the neutral current cross sections for deep inelastic scattering in $e^{\pm}p$ collisions with longitudinally polarised lepton beams are presented. The single differential cross section $d\sigma/dQ^2$ is presented for $e^{\pm}p$. For the $e^{-}p$ data set, the double differential cross section in Q^2 and x is shown and the structure function xF_3 is extracted using previously measured unpolarised $e^{+}p$ measurements. The polarised $e^{+}p$ measurements are based on an integrated luminosity of $23.8\,\mathrm{pb}^{-1}$ taken by the ZEUS detector in 2004. The polarised $e^{-}p$ data has an integrated luminosity of $122\,\mathrm{pb}^{-1}$ taken in 2004 and 2005. During both running periods, leptons and protons were collided at HERA with a centre-of-mass energy of 318 GeV. The Standard Model agrees well with all measurements, with the $d\sigma/dQ^2$ measurement showing clear evidence of parity violation.

Introduction

Deep inelastic scattering (DIS) of leptons off nucleons is a key tool to probe the structure of matter at small distance scales. The neutral current (NC) DIS interaction at HERA, $e^{\pm}p \to e^{\pm}X$, proceeds via the exchange of a photon or a Z^0 boson.

The kinematics of NC DIS can be defined in terms of the variables x, y and Q^2. The variable Q^2 is defined to be $Q^2 = -q^2 = -(k - k')^2$ where k and k' are the four-momenta of the incoming and scattered lepton, respectively. Bjorken x is defined by $x = Q^2/2P \cdot q$ where P is the four-momentum of the incoming proton. The variables x, y and Q^2 are related by $Q^2 = sxy$, where $s = 4E_eE_p$ is the square of the lepton-proton centre-of-mass energy (neglecting the masses of the incoming particles).

The Standard Model (SM) predicts that the cross section for $e^{\pm}p$ NC DIS should exhibit a dependence on the polarisation of the incoming lepton due to the parity violating nature of the weak interaction. Therefore, this polarisation effect should be most significant at high Q^2 where the Z^0 boson

exchange becomes important.

These proceedings present the cross section measurements for $e^{\pm}p$ NC DIS with longitudinally polarised lepton beams. The $e^{+}p$ measurements [1] are based on data with an integrated luminosity of $23.8\,\mathrm{pb}^{-1}$ collected at a mean luminosity weighted polarisation of $+0.32$ and -0.41 with the ZEUS detector in 2004. The $e^{-}p$ data has an integrated luminosity of $122\,\mathrm{pb}^{-1}$ with a mean luminosity weighted polarisation of $+0.33$ and -0.27 collected in 2004 and 2005. During both running periods HERA collided protons of energy 920 GeV with positrons or electrons of energy 27.5 GeV, yielding collisions at a centre-of-mass energy of 318 GeV.

Cross sections

The unpolarised electroweak Born-level cross section for the $e^{\pm}p$ NC interaction can be written as

$$\frac{d^2\sigma(e^{\pm}p)}{dxdQ^2} = \frac{2\pi\alpha^2}{xQ^4}H^{\pm} \tag{1}$$

where α is the fine-structure constant and $H^{\pm}$ is defined by

$$H^{\pm} \equiv Y_{+}F_2(x,Q^2) \mp Y_{-}xF_3(x,Q^2)$$

where $Y_{\pm} \equiv 1 \pm (1-y)^2$. The structure functions F_2 and xF_3 contain the sums and differences of the quark and anti-quark parton density functions (PDFs). The longitudinal structure function F_L is ignored as it is small in the kinematic region considered.

The reduced cross section is defined as

$$\tilde{\sigma}^{e^{\pm}p} = \frac{xQ^4}{2\pi\alpha^2}\frac{1}{Y_{+}}\frac{d^2\sigma(e^{\pm}p)}{dxdQ^2} = F_2(x,Q^2) \mp \frac{Y_{-}}{Y_{+}}xF_3(x,Q^2)$$

which is used in this analysis to extract xF_3.

The NC cross section is modified when the incoming lepton beam is longitudinally polarised. The longitudinal polarisation is defined as

$$P_e = \frac{N_R - N_L}{N_R + N_L}$$

where N_R and N_L are the numbers of right and left-handed leptons in the beam. By including the polarisation, the Born $e^{\pm}p$ NC cross section defined by Eq. (1) can be generalised as

$$\frac{d^2\sigma(e^{\pm}p)}{dxdQ^2} = \frac{2\pi\alpha^2}{xQ^4}[H^{\pm} + P_e H^{\pm}_{P_e}]$$

where $H^{\pm}_{P_e}$ contains the polarised structure functions.

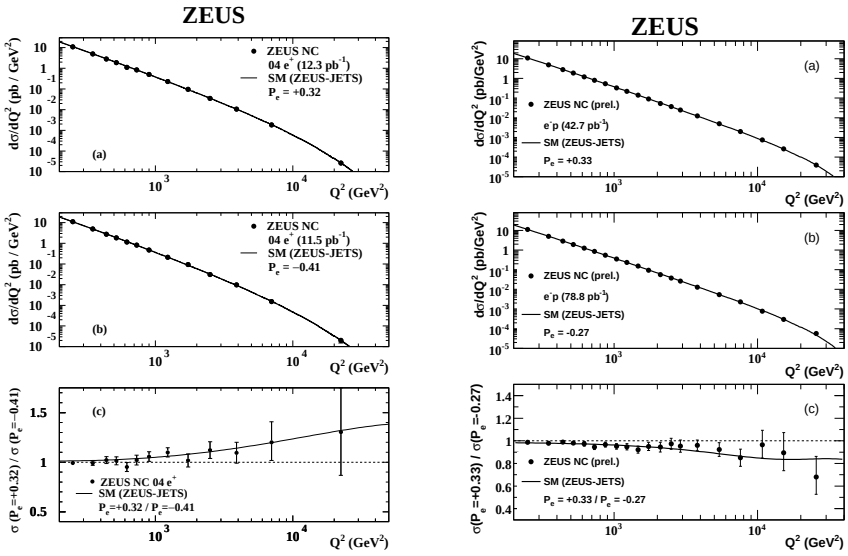

Figure 1. The e^+p cross section $d\sigma/dQ^2$ is shown on the left and the e^-p cross section $d\sigma/dQ^2$ is shown on the right. Both plots present $d\sigma/dQ^2$ for (a) positive polarisation data, (b) negative polarisation data, and (c) a ratio of the two. The curves show the predictions of the SM evaluated using the ZEUS-JETS PDFs.

Results

The cross section $d\sigma/dQ^2$ for $e^{\pm}p$ NC DIS is shown in Fig. 1 for positively and negatively longitudinally polarised lepton beams. Only statistical uncertainties were considered when taking the ratio of the cross sections with the two polarisations. A clear indication of parity violation is seen as the cross section ratio deviates from unity and is well described by the SM evaluated using the ZEUS-JETS PDFs.

Figure 2 presents the reduced cross sections for unpolarised $e^{\pm}p$ and the xF_3 measurements. The unpolarised e^-p reduced cross sections are measured by combining the positive and negative polarisation samples, and correcting the residual polarisation of -0.06. The reduced cross sections are compared with previously measured unpolarised e^+p reduced cross sections taken in 1999 and 2000 [2]. A significant difference between the two data sets is seen at high Q^2 due to the xF_3 contribution. The structure function xF_3 is extracted using the unpolarised $e^{\pm}p$ reduced cross sections and is reproduced well by the SM.

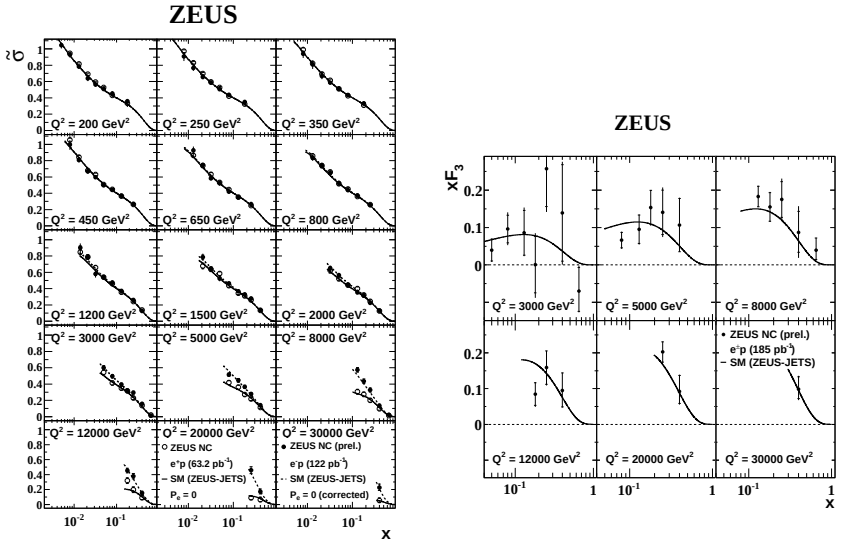

Figure 2. The $e^{\pm}p$ unpolarised reduced cross section, $\tilde{\sigma}$, plotted as a function of x in fixed Q^2 bins is shown on the left. On the right is the structure function xF_3 plotted as a function of x in fixed Q^2 bins. The curves on both plots show the SM prediction evaluated using the ZEUS-JETS PDFs.

Summary

The single differential cross section $d\sigma/dQ^2$ is presented for $e^{\pm}p$ NC DIS separately for positively and negatively longitudinally polarised leptons. The e^-p reduced cross sections corrected to zero polarisation are presented and have been combined with previously measured unpolarised e^+p reduced cross sections to extract xF_3. The SM predictions describe the measurements well and this is the first time at ZEUS that parity violation can clearly be seen in the $d\sigma/dQ^2$ measurement.

References

1. ZEUS Collab., S. Chekanov *etal.*, Preprint hep-ex/0402026, 2006. Accepted by Phys. Lett. B
2. ZEUS Collab., S. Chekanov *etal.*, Phys. Rev. **D 70**, 052001 (2004)