Measurements of the Structure Functions $F_2(x,Q^2)$ and $F_L(x,Q^2)$ at low Q^2

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Abstract. Recent measurements of the proton structure function F_2 and determination of the structure function F_L in e^+p deep inelastic scattering (DIS) by the H1 Collaboration are summarized. The F_2 results presented here extend the previous measurements at HERA into the Q^2 region below 1 GeV^2 by also using Initial State Radiation (ISR) events. The F_L structure function determined in the current analysis is more precise and accesses lower Q^2 values as compared to previous determinations published by H1.

Keywords: F_2 proton structure function, longitudinal proton structure function, DIS, HERA, H1, initial state radiation, low Q^2, low x
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INTRODUCTION

At low Q^2 the DIS double-differential cross section can be expressed as:

$$\frac{d^2\sigma}{dx\,dQ^2}\cdot\frac{Q^4 x}{2\pi\alpha^2 Y_+} = \sigma_r = F_2(x,Q^2) - \frac{y^2}{Y_+}\cdot F_L(x,Q^2), \qquad (1)$$

where Q^2 is the squared four-momentum transfer, x is the Bjorken scaling variable, $Y_+ = 1+(1-y)^2$. The inelasticity $y = Q^2/sx$ is a fraction of the lepton's energy loss and s denotes the center of mass energy squared of the lepton-nucleon system. For $y < 0.6$ the contribution of F_L is supressed by the kinematic factor y^2/Y_+. Therefore the measurement of σ_r at low y determines F_2 with a small correction for F_L. At high y the contribution of the longitudinal structure function becomes significant which allows to determine F_L.

MEASUREMENT OF THE CROSS SECTION

The data used in the analysis are taken by the H1 detector during special running periods with open triggers for inclusive DIS events. In order to access low values of Q^2 around 1 GeV^2 the interaction vertex for the 2000 data was shifted by approximately 70 cm along the proton beam direction. This data sample is also used for accessing larger values of x with ISR events. Data collected in 1999 with a nominal position of the interaction vertex are used for measurements in the high y region and 1997 data for accessing of low values of y using QED Compton events (QEDC). A new ISR analysis method is applied where the radiative photon is not required to be measured in the photon detector. Details concerning the ISR analysis can be found in [1].

The kinematic reconstruction was done with two methods. The sigma method [2] has been used for medium and low y and the electron method was prefered at highest y due to better y resolution in this region. The H1 and ZEUS inclusuve cross sections measurements at low Q^2 are shown in Fig. 1 together with the fixed target data.

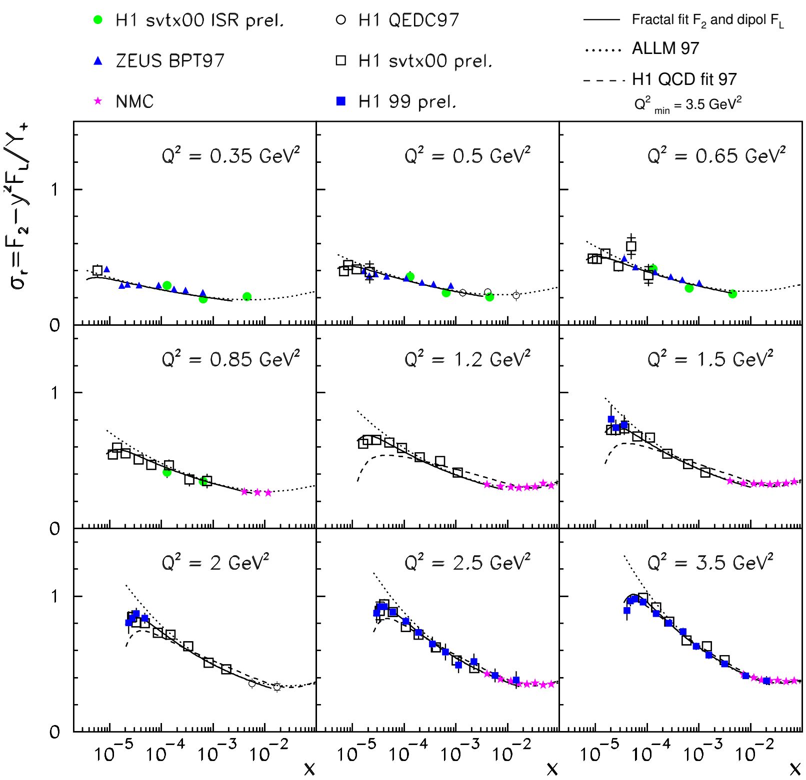

FIGURE 1. Measurements of the cross section - H1 shifted vertex ISR data 2000 (closed points) [1], data from ZEUS BPT97 (closed triangles) [3], NMC (stars) [4], H1 QEDC97 (open points) [5], H1 shifted vertex preliminary data 2000 (open boxes) [6] and H1 preliminary data 1999 (closed boxes) [7]. The data are compared to the Fractal fit F_2 [8] and dipol model F_L [9] (solid curve), to the ALLM97 [10] parameterization (dotted curve) and also to the H1 QCD fit [11] (dashed curve)

The preliminary results of the ISR analysis and the QEDC results from H1 extend the measured kinematic range at low Q^2 towards higher x values.

STRUCTURE FUNCTION F_2 AT LOW Q^2

The proton structure function F_2 obtained from the inclusive cross section measurements rises towards low x for all measured Q^2 bins. The detailed analysis of the x dependence of F_2 is described in [12]. It was found that the x dependence of F_2 at fixed Q^2 exhibits a power law behaviour $F_2 = c \cdot x^{-\lambda(Q^2)}$. The result of fitting this form to the shifted vertex data [1] and [6], compared to published H1 [13] and ZEUS [3] data, is presented in Fig. 2.

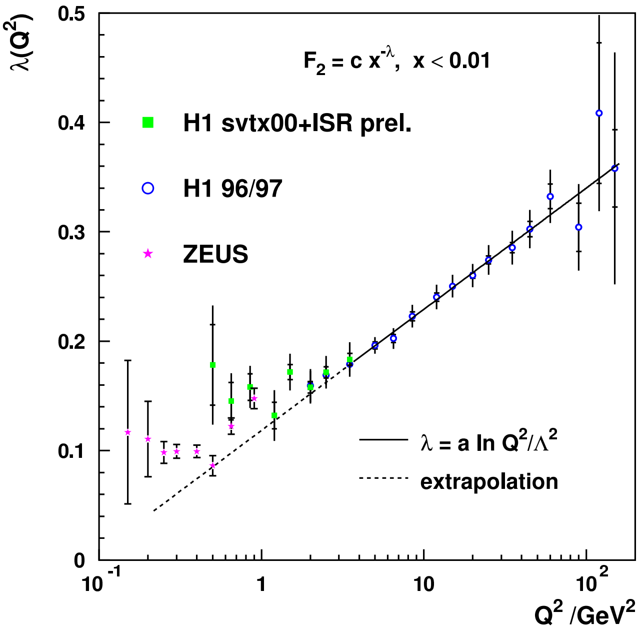

FIGURE 2. The slope $\lambda(Q^2)$ from the fit $F_2 = c \cdot x^{-\lambda(Q^2)}$ to the H1 and ZEUS data.

One can see that the shifted vertex results are in agreement with previously published data in the regions of overlap. Deviation of $\lambda(Q^2)$ from logarithmic dependence $a \cdot \ln[Q^2/\Lambda^2]$ was observed around Q^2=1 GeV^2.

THE EXTRACTION OF F_L

Fig. 1 shows the rise of the cross section with decreasing x for fixed Q^2. However, for the lowest x, a turnover of the cross section can be seen. Lowest x corresponds to highest y and the contribution of $F_L(x,Q^2)$ to the cross section is not negligible at such values of y. An extraction of F_L was done with a "shape method" [14]. It assumes the power behaviour of F_2 and the difference in the shape between the cross section and F_2 to be mostly driven by kinematic factor y^2/Y_+. Using the cross section, parametrised as $\sigma_r = F_2 - y^2/Y_+ \cdot F_L$, F_L for a given Q^2 was extracted by fitting. The results of such an F_L extraction, together with previously published H1 results and different QCD fits, are presented in Fig. 3.

Good agreement of the data and F_L determined by H1 [14], Alekhin's [17] and H1's QCD [11] fits is observed. However, MRST [16] and ZEUS [15] fits tend to be lower.

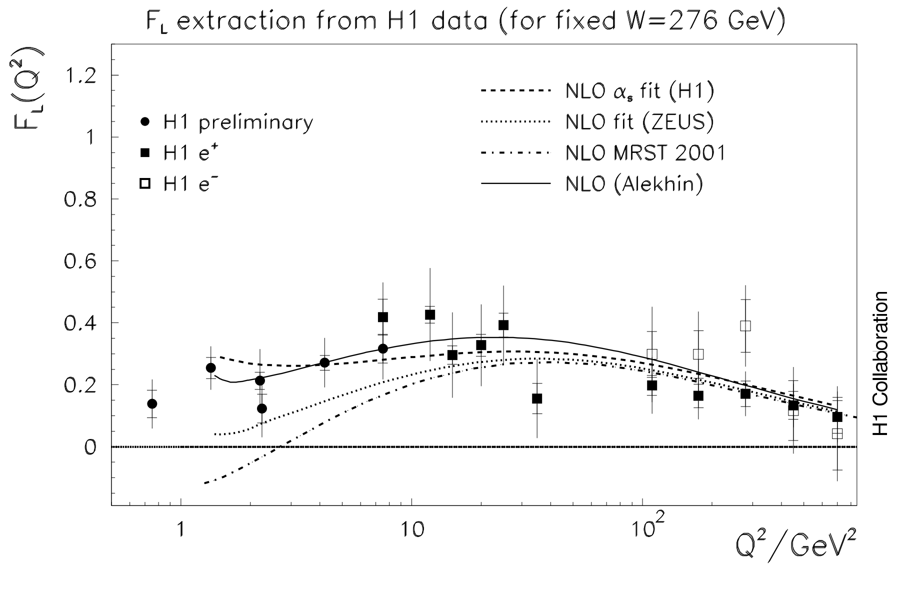

FIGURE 3. F_L obtained from H1 data compared to H1 QCD fit (dashed curve) [11], ZEUS NLO fit (dotted curve) [15], MRST NLO fit (dash-dotted curve) [16], Alekhin's fit (solid curve) [17]

SUMMARY

The inclusive cross section measurements presented here extend the kinematic region covered by HERA at low Q^2. The ISR and QEDC data allow access medium and high x values. The F_L values determined in this analysis are significantly above zero everywhere and already now can discriminate between different predictions.

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