RECENT RESULTS ON PROTON STRUCTURE FUNCTIONS MEASUREMENTS AT LOW Q^2 AT HERA*

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Recent results on F_2 and $F_{\rm L}$ proton structure functions measurements in e^+p deep inelastic scattering (DIS) at low Q^2 at HERA are presented.

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1. Introduction

At low Q^2, in the one-photon exchange approximation, the neutral current DIS cross section can be written as:

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

where $Y_+ = 1+(1-y)^2$, Q^2 is the squared four-momentum transfer, x denotes the Bjorken scaling variable, $y=Q^2/sx$ is the inelasticity and s is the ep center of mass energy squared.

Since $F_{\rm L}\leq F_2$ and because its contribution in the low y region is suppressed by the kinematic factor y^2/Y_+ the measurement of σ_r at low y directly determines F_2 with a small correction for $F_{\rm L}$. At high y, the $F_{\rm L}$ contribution becomes significant and the longitudinal structure function $F_{\rm L}$ can be extracted.

2. F_2 measured in QED Compton scattering

The QED Compton process (QEDC) is the scattering of a quasi real photon off an electron. For the inelastic QEDC, *i.e.* when the proton breaks

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up, the $\gamma^* p$ cross section is defined through the proton structure functions F_2 and $F_{\rm L}$. In the following results data collected in 1997 by the H1 experiment were used. The measurement was performed at very low Q^2 (down to 0.1 GeV^2) and at relatively high x region, thus in the kinematic domain of fixed target experiments.

The details concerning this analysis can be found elsewhere [1]. The F_2 values measured in this process are shown in Fig. 1.

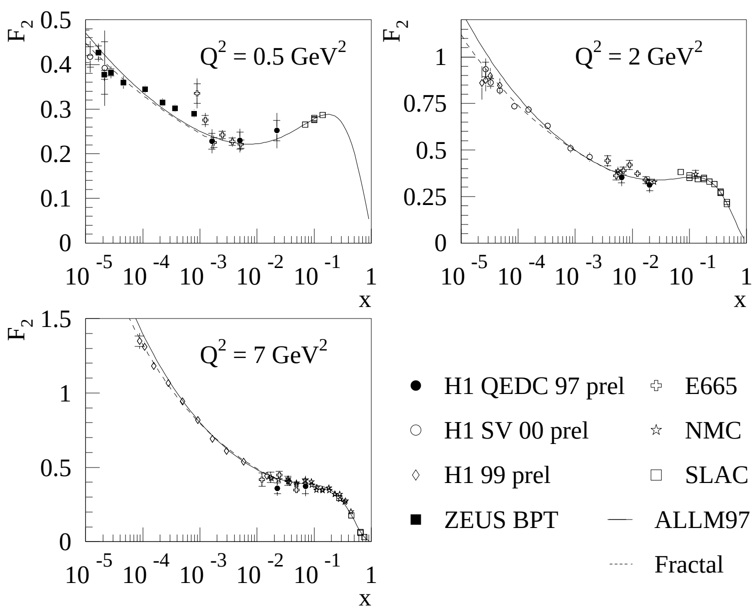

Fig. 1. F_2 measured using QEDC events by H1 compared to other HERA measurements and to fixed target results.

The results of this analysis extend the kinematic range of HERA at very low Q^2 towards higher x values, thus complementing inclusive measurements. A good agreement with fixed target data is observed.

3. Cross section and F_2 at low Q^2 and low x

In order to investigate the transition region between perturbative and non perturbative DIS a dedicated e^+p run was performed during 2000, in which the interaction vertex was shifted by 70 cm in the proton beam direction. The shift of the vertex allows larger positron scattering angles and thus lower Q^2 to be accessed. Details of the analysis can be found in [2]. The measured reduced cross section, shown in Fig. 2, represents the most accurate low x inclusive DIS data in the transition region ($Q^2 \sim 1$ GeV^2)

obtained so far. The results are in agreement with previous measurements in the region of overlap.

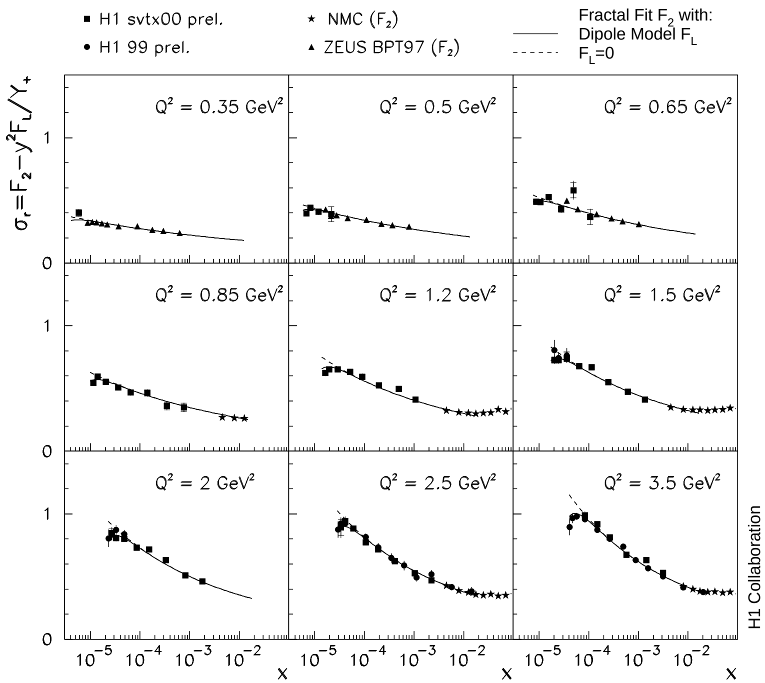

Fig. 2. Inclusive DIS cross section as measured by H1 using new low Q^2 data sets ("99 minimum bias" and "2000 shifted vertex"-squares), compared to larger x data by ZEUS (triangles), at low Q^2, and NMC (stars) at higher Q^2.

From the measured cross section new $F_2(x, Q^2)$ results were determined. The x dependence of F_2 was analyzed as described in [4]. It was found that in the low Q^2 region of this measurement $F_2(x, Q^2)$ still rises towards low x at fixed Q^2 like $F_2(x, Q^2) = c(q^2)x^{-\lambda(Q^2)}$. The variables $c(Q^2)$ and $\lambda(Q^2)$, however, deviate [2,3], from the linear dependence of c and λ on $\ln Q^2$ which was found to be characteristic in the DIS region.

4. $F_{\rm L}$ determination in H1

For fixed Q^2 the reduced DIS cross section rises with decreasing x — Fig. 2. However, at very low x (high y) a characteristic turnover of the cross section is observed. This occurs at all Q^2 values at $y \sim 0.5$ and is attributed to the contribution from the longitudinal structure function $F_{\rm L}(x, Q^2)$ (Eq. 1). In order to extract $F_{\rm L}$ from the reduced cross section the shape method, introduced in [5], was used. The method assumes, in agreement with [4], that F_2 behaves like $x^{-\lambda}$. It also assumes that the shape of the cross section at high y is due to the kinematic factor y^2/Y_+ while F_{L} is considered to be constant in the narrow x range accessible in the measurement. Thus, the reduced cross section distributions are parametrised as: $\sigma_r = cx^{-\lambda} - y^2/(1+(1-y)^2)F_{\mathrm{L}}$. The F_{L} value for a given Q^2 bin is then extracted by fitting the corresponding data. In Fig. 3 the F_{L} values obtained with this method are plotted together with previously published H1 results and compared with higher order QCD fits from H1 [6], ZEUS [7], MRST [8] and Alekhin [9].

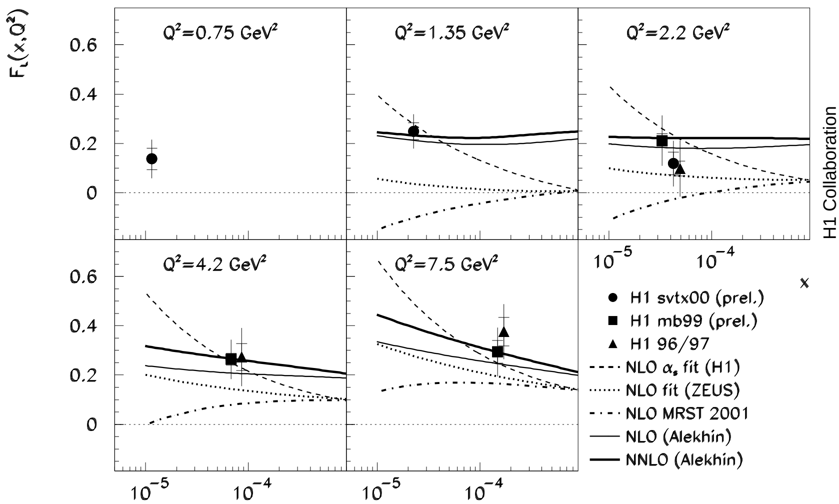

Fig. 3. F_{L} from H1 low Q^2 data compared to different QCD calculations.

The new values of $F_{\mathrm{L}}(x, Q^2)$ are consistent with previous H1 results, but are more precise and extend the kinematic region, in which F_{L} is determined. The H1 data favour positive, not small F_{L} at low x and low Q^2, as preferred by H1's and Alekhin's QCD fits while the MRST prediction tends to be low. ZEUS prediction is also rather low but still consistent with the data for Q^2 greater than 2 GeV^2. A negative F_{L} in the measured area is ruled out.

5. F_{L} from initial state radiation in ZEUS

F_{L} can be measured directly using events with a range of y values for fixed x and Q^2. In principle, such a measurement can be performed using events with QED initial state radiation (ISR), where the emission of a hard photon from the initial state positron leads to a variation in the centre-of-mass energy, and hence y for fixed x and Q^2. The ISR events coming from the data collected by the ZEUS experiment in 1996 and 1997 were analyzed. F_2 was measured and found to be consistent with previous ZEUS measurements. A direct determination of F_{L} was then performed, using the method described in [10]. Fig. 4 shows the F_{L} result. Although the F_{L} result is not very precise, it is clearly consistent with the expectations of perturbative QCD.

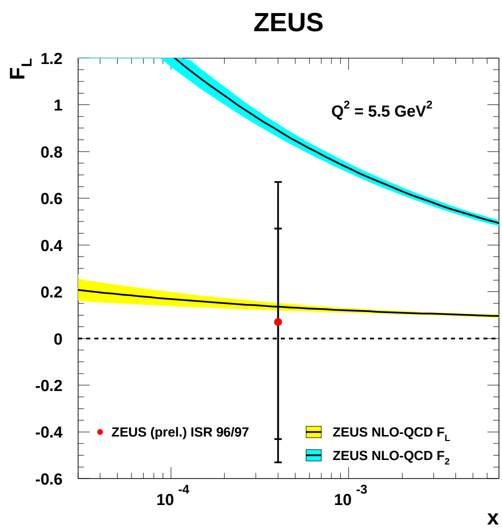

Fig. 4. The longitudinal structure function F_{L} extracted from ISR events by ZEUS.

6. Summary

Recent high precision inclusive cross section and F_2 measurements extend the kinematic region covered by HERA at low Q^2. QEDC scattering allows medium x values to be accessed. For the first time events with ISR were used by ZEUS to directly determine F_{L}. The extraction of F_{L} by H1 is precise enough to constrain theoretical predictions. However, for high precision F_{L} measurements and the determination of the x dependence of F_{L} reduced proton energy running at HERA is required.

REFERENCES

[1] H1 Collaboration, contributed paper 799 to EPS 2003, Aachen.

[2] H1 Collaboration contributed paper 082 to EPS 2003, Aachen.

[3] ZEUS Collaboration contributed paper 770 to ICHEP 1998, Vancouver.

[4] H1 Collaboration, C. Adloff *et al.*, *Phys. Lett.* **B520**, 183 (2001).

[5] H1 Collaboration contributed paper 083 to EPS 2003, Aachen.

[6] H1 Collaboration, C. Adloff *et al.*, *Eur. Phys. J.* **C21**, 33 (2001).

[7] ZEUS Collaboration, S. Chekanov *et al.*, *Phys. Rev.* **D67**, 012007 (2003).

[8] A. Martin, R.G. Roberts, W.J. Stirling, R.S. Thorne, *Eur. Phys. J.* **C23**, 73 (2002).

[9] S. Alekhin, *Phys. Rev.* **D68**, 114002 (2003).

[10] ZEUS Collaboration, contributed paper 502 to EPS 2003, Aachen.