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NEW AND RECENT MEASUREMENTS OF $\mathbf{F_2}$ AND $\mathbf{F_L}$ AT LOW $\mathbf{Q^2}$

EWELINA MARIA ŁOBODZIŃSKA
DESY, Platanenallee 6, D15738 Zeuthen, Germany
INP PAS, Radzikowskiego 152, 31-342 Cracow, Poland
E-mail: ewelina@mail.desy.de

New and recent results on F_2 and F_L proton structure functions measurements in e^+p deep inelastic scattering (DIS) at low Q^2 by the H1 Collaboration at HERA are summarized. The F_2 results discussed here extend the kinematic region covered by previous structure functions measurements at HERA into very low Q^2 ($\sim$ 1 GeV) area and also by means of the QED Compton events into the medium x region. The F_L results from H1 are found to be compatible with previously published values, but are more precise and access lower Q^2.

1 Introduction

Accurate measurements of the differential cross section, F_2 and F_L structure functions are vital in testing perturbative QCD. At low Q^2, in the one-photon exchange approximation, the neutral current DIS cross section can be written as:

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

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 $F_L \leq F_2$ 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_L. At high y, the F_L contribution becomes significant and the longitudinal structure function F_L can be extracted. Therefore, at high y the standard procedure of extracting F_2 from the DIS cross section, by subtracting the theoretically computed F_L contribution, can be reversed such that the F_L contribution is extracted from the measured cross section by subtracting a calculation of F_2.

2 $\mathbf{F_2}$ 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 up, the $\gamma^* p$ cross section is defined through the proton structure functions F_2 and F_L. In this anlysis data collected by the H1 experiment in 1997 were used. The measurement was performed at low Q^2 (down to 0.5 GeV^2) and at relatively high x (up to 0.06), approaching the kinematic domain of fixed target experiments. The dominant background for this process arises from inclusive DIS events, in which one of the hadronic final state particles (typically π^0) fakes the outgoing photon. At high y this kind of background dominates the QEDC signature and therefore the analysis is constrained to the low y region.

For the purpose of this analysis the simulation package SOPHIA [1] was adapted, which provides a simulation of the hadronic final state at low Q^2 and low W. The details concerning this analysis can be found in [2]. The F_2 values measured in this process are shown in Fig. 1.

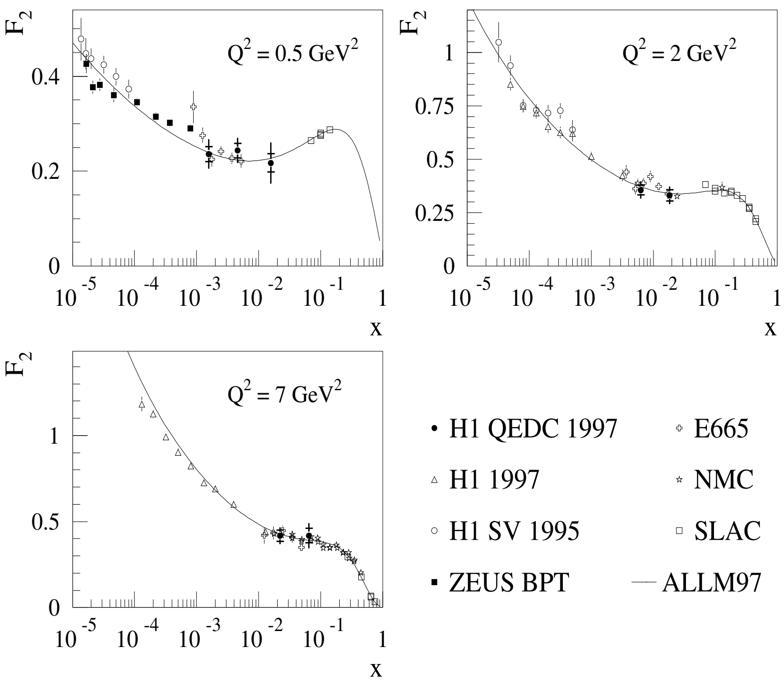

Figure 1. F_2 measured using QEDC events by H1 compared to other HERA measurements and to fixed target results.

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

3 Cross section and $\mathbf{F_2}$ at low $\mathbf{Q^2}$ 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 [3]. 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.

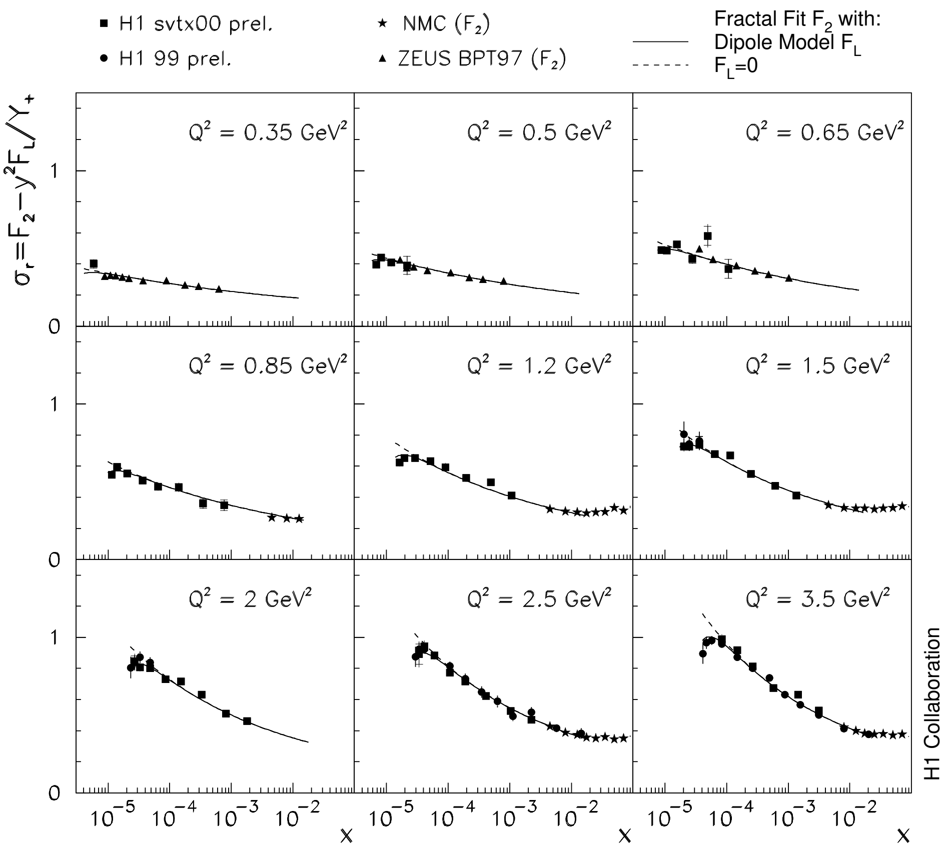

Figure 2. Inclusive DIS cross section as measured by H1 using new low Q^2 data sets ("99 minimum bias" and "2000 shifted vertex"-squares), compared to larger x data by ZEUS (triangles), at low Q^2, and NMC (stars) at higher Q^2.

Using the dipole model [4] predictions for the longitudinal structure function $F_2(x, Q^2)$ were obtained in the range $0.003 < y < 0.6$ and found to be in good agreement with earlier measurements, Fig. 3. The x dependence of F_2 was analyzed as described in [5]. 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 $F_2(x, Q^2) = c(q^2) \cdot x^{-\lambda(Q^2)}$. The variables $c(Q^2)$ and $\lambda(Q^2)$, however, deviate [3] from the linear dependence of c and λ on $\ln Q^2$ which was found to be characteristic in the DIS region.

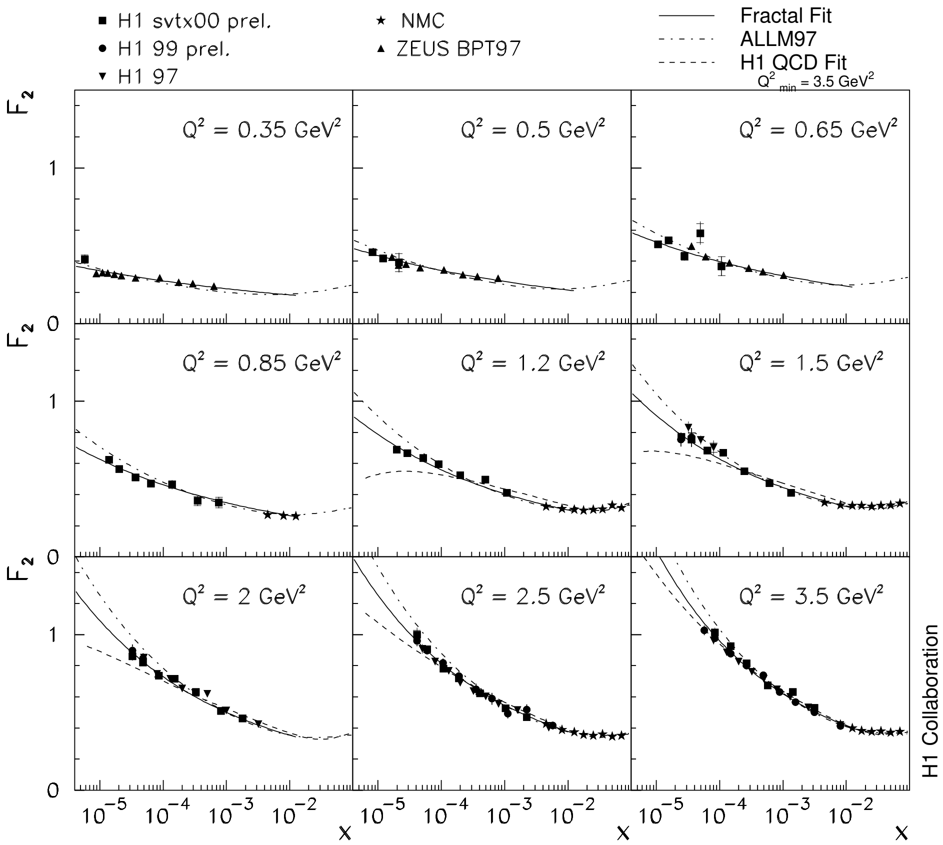

Figure 3. F_2 as measured by H1 using low Q^2 data sets, compared to larger x data by ZEUS and earlier H1 data , at low Q^2, and NMC at higher Q^2.

4 $\mathbf{F_L}$ determination

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 $F_L(x, Q^2)$ (eq.1). In order to extract F_L from the reduced cross section the "shape method", introduced in [6], was used. The method assumes, in agreement with [5], 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 equation: $\sigma_r = c \cdot x^{-\lambda} - y^2/(1+(1-y)^2) \cdot F_L$. The F_L value for a given Q^2 bin is then extracted by fitting the corresponding data. In Fig. 4 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 [7], ZEUS [8], MRST [9] and Alekhin [10] .

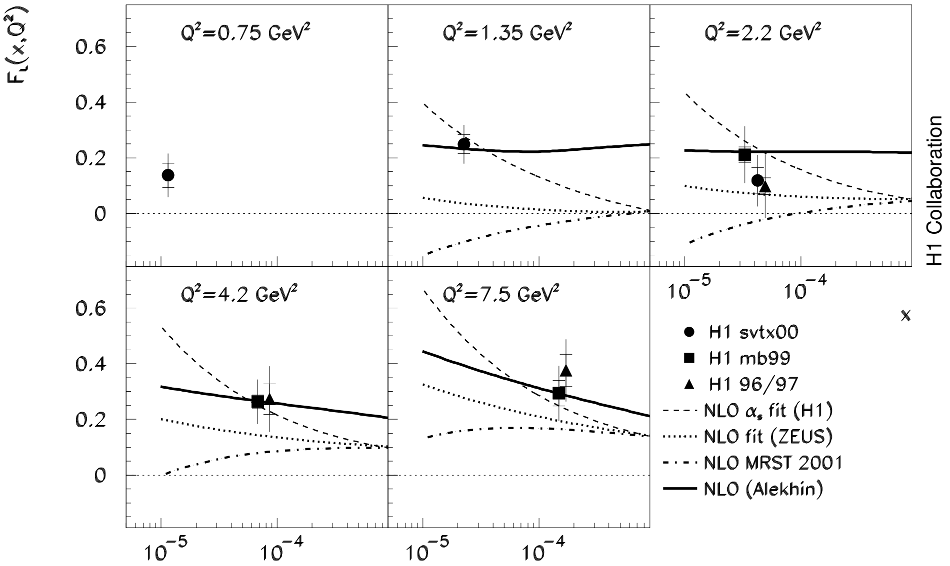

Figure 4. F_L from H1 low Q^2 data compared to different QCD calculations.

The new values of $F_L(x, Q^2)$ 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. The ZEUS prediction is also rather low but still consistent with the data. A negative F_L in the measured region is ruled out.

An overview of the current H1 data on $F_L(x, Q^2)$, from $Q^2 = 0.75$ GeV^2 to $Q^2 = 700$ GeV^2 and for fixed W=276 GeV, is given in Fig. 5. It comprises the preliminary results of the low Q^2 analysis described in this paper, previous results based on data collected in 96/97 [7] and also the recently published high Q^2 results from e^+p and e^-p data [11].

5 Summary

Recent high precision inclusive cross section and F_2 measurements extend the kinematic region covered by HERA at low Q^2. QED Compton scattering allows medium x values to be accessed. 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 [12], [13].

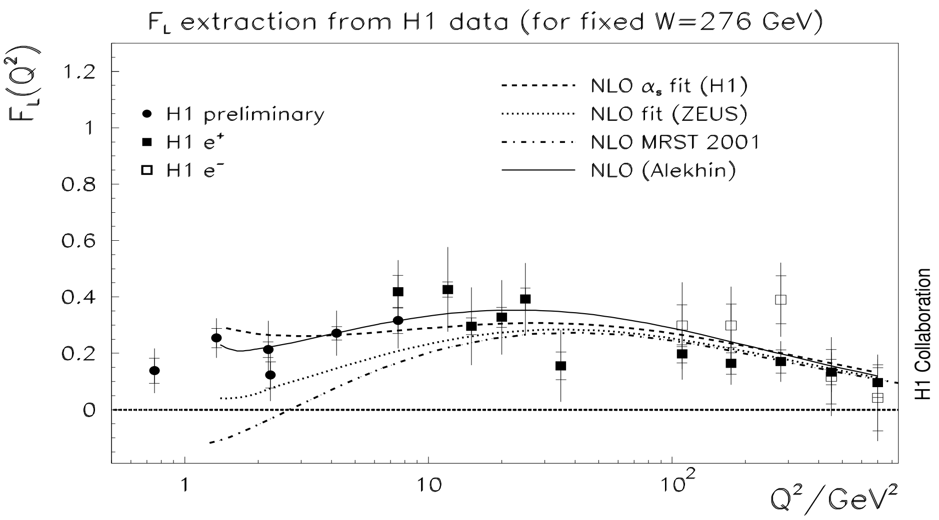

Figure 5. Measurements of F_L from H1 at large W as a function of Q^2 compared to different QCD predictions.

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