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NEW MEASUREMENT OF THE STRUCTURE FUNCTION $\mathbf{F_2(X,Q^2)}$ AT LOW $\mathbf{Q^2}$ WITH INITIAL STATE RADIATION DATA

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An extension of the inclusive cross section DIS measurements by the H1 Collaboration at low Q^2 based on ISR events is presented. In this analysis the radiated photon is not explicitely detected in the photon detector. The proton structure function $F_2(x, Q^2)$ is measured over a Q^2 range 0.35-0.85 GeV^2 for Bjorken-x values $10^{-4} < x < 10^{-2}$ with a typical total error of 10%.

1 Introduction

The results of the present analysis extend the kinematic range where $F_2(x, Q^2)$ is measured by H1 towards large values of Bjorken-x at low Q^2, below 1 GeV^2, by using of deep-inelastic scattering (DIS) events with a photon collinearly radiated to the incident positron (ISR events). The reconstruction method used in this analysis does not require an explicit detection of the radiated photon. It is based on using ISR events which have effectively a lower initial positron beam energy as compared to ordinary DIS events and thus allow to access to the high x values at a given Q^2. The ISR data thus extend the region to larger x allowing the rise of F_2 at low x to be determined for Q^2 below 1 GeV^2 in the H1 data.

2 Analysis Procedure

The data used in the presented analysis were taken by the H1 detector during the special running period with a minimum bias trigger in August 2000. In order to access values of four momentum transfer squared Q^2 around 1 GeV^2 the interaction vertex was shifted by approximately 70 cm along the proton beam direction. The total luminosity of the data sample is 600 nb^{-1}. Use of the sigma reconstruction method [1] allows to measure the radiative events inclusively. The sigma method includes the radiative effects in the way that the incoming electron energy E_e is replaced by the sum of hadronic and electron $E - P_z$: $2E_e = \Sigma + (E - P_z)_{el}$. The analysis determines Bjorken-x as

$$x = Q^2_\Sigma/(2\Sigma E_p) \tag{1}$$

which is independent of the incoming electron and where E_p is an energy of the proton beam and

$$Q^2_\Sigma = E'^2_e \sin^2\Theta_e/(1 - y_\Sigma), \text{ with } y_\Sigma = \Sigma/(\Sigma + E'^2_e(1 - \cos\Theta_e)). \tag{2}$$

In this equation E'_e and Θ_e denote scattered electron energy and polar angle, respectively. Due to the momentum conservation the method works for events with single and multiple collinear initial state radiation as well as for non-radiative events. The low x behaviour of F_2 at fixed Q^2 was investigated by measuring the derivative $\lambda = (\partial \ln F_2/\partial \ln x)_{Q^2}$. The results presented at this conference are based on preliminary H1 ISR data for $0.35 \leq Q^2 \leq 0.85\,\mathrm{GeV}^2$, preliminary H1 non-ISR data [2] for $0.5 \leq Q^2 \leq 3.5\,\mathrm{GeV}^2$ and published H1 data [3] which cover the range $1.5 \leq Q^2 \leq 150\,\mathrm{GeV}^2$. The method used to get the derivative λ is explained in details at [4].

3 Results

A careful study of the measurement uncertainties was carried out. The hadronic energy scale uncertainty affects F_2 by about 4%. The radiative correction uncertainty is on the level of 3%. The uncertainty of the positron energy scale results in the correlated systematic error contribution of 2% on F_2 (maximum at low energy). The contribution of trigger inefficiency to the uncorrelated systematic error is 0.5%. The uncertainty coming from electron identification efficiency is 0.5%. The total

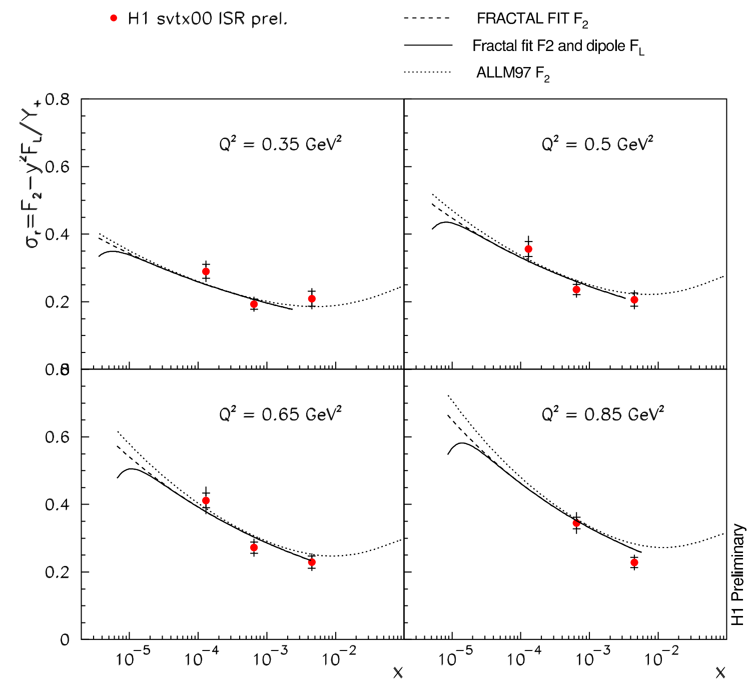

Figure 1. The cross section as determined from ISR events as a function of x for fixed values of Q^2. The inner error bars represent the statistical and outer error bars the total uncertainty of the measurement. The data are compared to the Fractal fit F_2 [6] (dashed curve), to the Fractal fit F_2 and dipol model F_L [7] (solid curve), and also to the ALLM97 [5] parameterization (dotted curve).

accuracy of the presented preliminary results is about 10%.

The preliminary result of the measurement is presented in Figure 1 where the cross section is shown as a function of x in bins of Q^2 for $1.3 \cdot 10^{-4} \leq x \leq 4.5 \cdot 10^{-3}$ and $0.35 \leq Q^2 \leq 0.85\,\mathrm{GeV}^2$. The data points are compared to predictions from the ALLM97 [5] parametrisation and the Fractal fit [6] where self-similar properties of the proton structure are assumed. At all Q^2 bins the data are well described by both parametrisations.

The result of comparison of presented ISR data and preliminary non-ISR shifted vertex data [2] is shown in Figure 2. As it is seen the ISR method complements preliminary shifted vertex data by accessing large x at low Q^2.

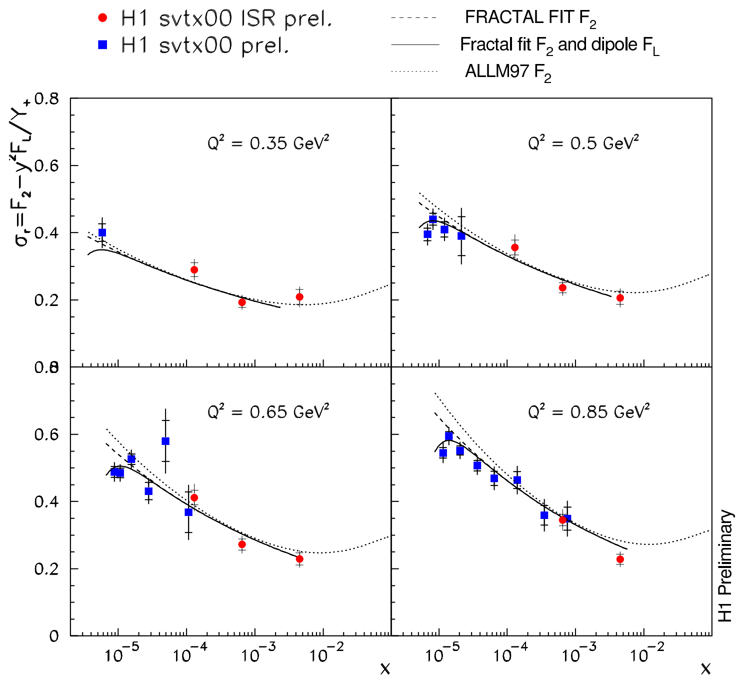

Figure 2. Measurements of the cross section - H1 shifted vertex ISR data 2000, this analysis (closed points), compared to preliminary data from H1 shifted vertex 2000 [2] (squares). The data are compared to the Fractal fit F_2 [6] (dashed curve), to the Fractal fit F_2 and dipol model F_L [7] (solid curve), and also to the ALLM97 [5] parameterization (dotted curve).

The x dependence of F_2 at fixed Q^2 exhibits a power law behaviour [8]

$$F_2 = c \cdot x^{-\lambda(Q^2)}. \tag{3}$$

The result of fitting this form to the ISR data complemented by preliminary shifted vertex data [2] in λ values is presented in Figure 3 along with published H1 data [3]. It shows that the F_2 data in a wide range of x and Q^2 can be well described by Equation 3 using $\lambda(Q^2) = a \cdot \ln[Q^2/\Lambda^2]$. The new shifted vertex data (combined

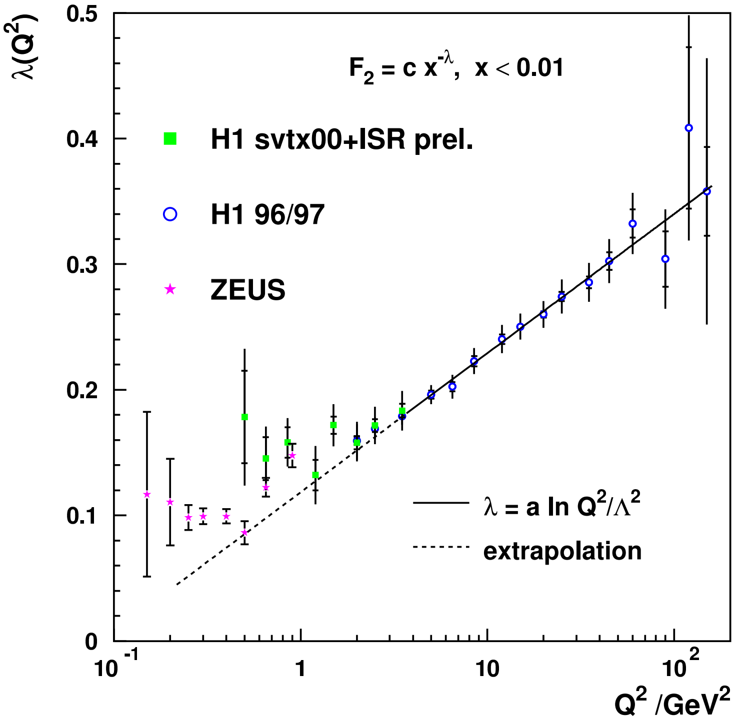

Figure 3. Slope $\lambda(Q^2)$ as a result of fitting $F_2 = c \cdot x^{-\lambda(Q^2)}$ to the H1 and ZEUS data.

ISR and non-ISR H1 preliminary data) are in agreement with the published ZEUS [9] and H1 [3] data in the regions of overlap.

4 Conclusions

Deep-inelastic scattering data with initial state photon radiation are used to measure the structure function F_2 for region of four-momentum transfers $0.35 \leq Q^2 \leq 0.85\,\mathrm{GeV}^2$ and Bjorken-x values of $1.3 \cdot 10^{-4} \leq x \leq 4.5 \cdot 10^{-3}$. At very low Q^2 this new method permits the range of F_2 measurements to be extended to larger x. The obtained cross section is consistent with previous measurements performed at HERA and different experiments in the regions of overlap and also with phenomenological expectations as it is shown in Figure 4. The data bridge the Q^2 gap between previous H1 and ZEUS measurements in terms of the F_2 slope λ.

Acknowledgements

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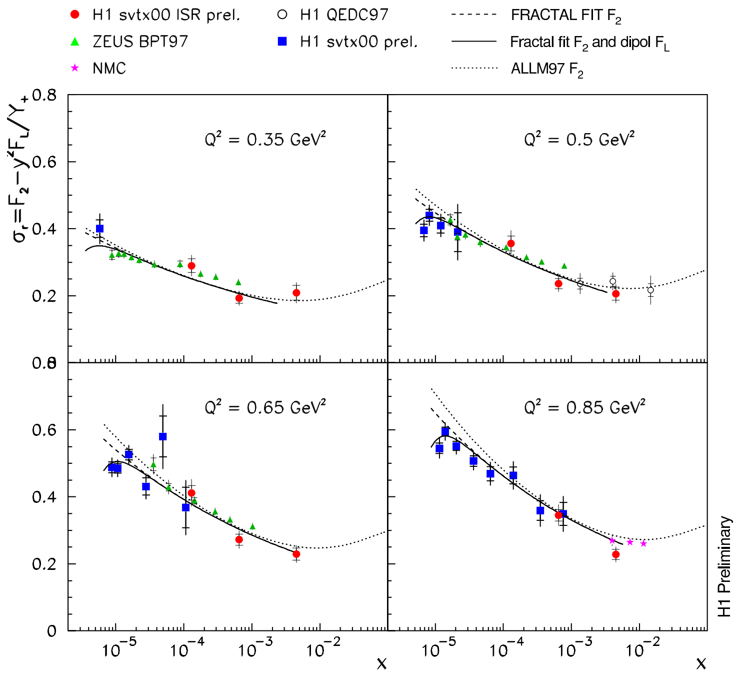

Figure 4. Measurements of the cross section - H1 shifted vertex ISR data 2000, this analysis (closed points), compared to data from ZEUS (BPT97 triangles) [9], NMC (stars) [10], H1QEDC97 (open points) [11], H1 shifted vertex preliminary data 2000 [2]. The data are compared to the Fractal fit F_2 [6] (dashed curve), to the Fractal fit F_2 and dipol model F_L [7] (solid curve), and also to the ALLM97 [5] parameterization (dotted curve).

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