MEASUREMENT OF THE INCLUSIVE DEEP INELASTIC SCATTERING CROSS SECTION AT $Q^2 \sim 1$ GeV^2 WITH THE H1 EXPERIMENT*

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A preliminary measurement is presented of the inclusive ep scattering cross section in the kinematic region of very low Bjorken x and four-momentum transfer squared $Q^2 \sim 1$ GeV^2, in the transition region from the non-perturbative to the deep-inelastic domain. The cross-section measurement is used to obtain new data on the proton structure function $F_2(x, Q^2)$.

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1. Introduction

The data presented here were taken at HERA during a special running period in August 2000. The interaction vertex was shifted by +70 cm in the proton beam direction which allows larger positron scattering angles[1] and thus lower values of Q^2 to be accessed. With a luminosity of 600 nb^{-1} the statistics is about four times higher compared to the previous shifted vertex data taken in 1995 by H1 [1] and ZEUS [2]. Due to higher statistics and improved backward tracking the precision of the measurement as well as the kinematic range coverage was significantly improved.

In the single-photon exchange approximation the reduced neutral current inclusive DIS cross section at low Q^2 is given as

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

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[1] Note that the polar angles θ are defined with respect to the proton beam direction.

where $Y_+ = 1 + (1 - y)^2$. The inelasticity y is related to x and Q^2 as $y = Q^2/sx$, where s is the center of mass energy squared. The influence of the longitudinal structure function F_{L} on the cross section is strongly suppressed for $y < 0.6$ due to the kinematic factor y^2/Y_+ and due to $F_{\mathrm{L}} \leq F_2$.

The kinematic variables Q^2, x and y can be reconstructed making use of various methods. For this analysis the electron and Σ methods [3] are selected. While the electron method employs only the scattered electron measurement, in the Σ method also the hadronic final state information is used.

2. The cross section and $F_2(x, Q^2)$ measurement

2.1. Event selection

A scattered electron was identified in the backward lead scintillating fibre calorimeter (SPACAL) as the highest energetic cluster with a cluster radius of ≤ 4 cm matching a backward silicon tracker (BST) track within 2 cm in the transverse plane. To further suppress the photo-production background a cut on $E - p_z > 35$ GeV was applied.

The BST allows the interaction vertex to be reconstructed from electron track even at large scattering angles. Thus the vertex reconstruction and event identification do not depend on the hadronic final state reconstruction but on the scattered electron measurement only. Along with minimum bias SPACAL trigger it makes the measurement truly inclusive which extends the measurement by one order of magnitude deeper into the low y region than the previous H1 1995 data [1].

For further information about the event selection and about the analysis procedure see the conference paper [3].

2.2. Systematic uncertainties

A careful study of systematic uncertainties was made. The sources can be divided into a number of types:

- The luminosity of the data was determined with a precision of 1.8% using elastic bremsstrahlung. This normalization error is not included in any error bar shown further.
- The statistical uncertainty of the data is typically about 2% in the bulk region.
- Uncorrelated cross-section uncertainties consist of a number of sources. An about 2% is due to Monte Carlo statistics. Further uncertainties are due to the BST track reconstruction efficiency (2%), SPACAL trigger efficiency (0.5%) and radiative corrections (1%).

- Correlated cross section uncertainties are due to E' and E_h measurements (0.5–1%), the θ_e reconstruction (0.5%), the LAr calorimeter noise (4% at low y) and due to the photo-production background (2% at high y).

The total cross section uncertainty is about 4% in the bulk region of the data. Compared to the previous H1 shifted vertex data [1] this is an approximately twofold increase in measurement accuracy.

2.3. Cross section determination

The kinematic region covered by the data was divided into nine intervals in the range $0.3 < Q^2 < 4.2$ GeV^2. The binning in y was adapted to the resolution in the measurement of the kinematic variables.

The measured cross section, shown in Fig. 1, represents the most accurate low x inclusive DIS data in the transition region, $Q^2 \sim 1$ GeV^2, obtained so

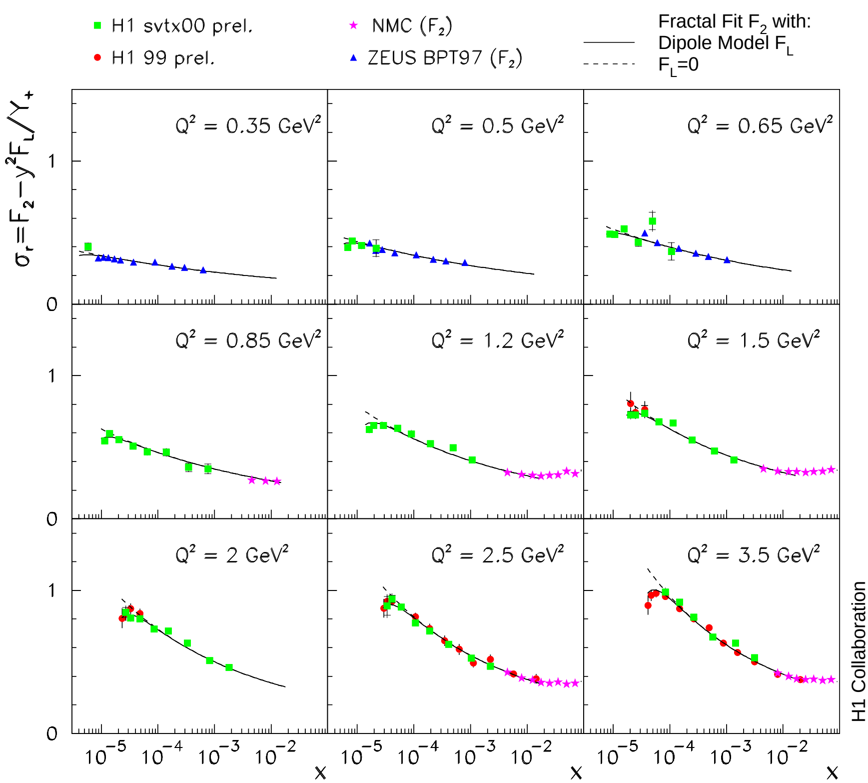

Fig. 1. The new preliminary H1 inclusive DIS cross-section measurement (squares) as function of x in bins of Q^2 compared to further data from H1, ZEUS and NMC.

far. It is seen that the presented data agree well with the recently presented H1 1999 nominal vertex data [4] and that they are consistent with the ZEUS 1997 [5] and NMC [6] measurements at higher x.

The region covered in terms of inelasticity y extends up to $y = 0.75$. At large y the longitudinal structure function $F_{\rm L}$ is observed to tame down the cross section.

The solid curves in Fig. 1 represent the reduced cross section calculated from the fractal model F_2 [7,8] while the effect of $F_{\rm L}$ at high y was estimated using the dipole model prediction for $F_{\rm L}$ [9].

The cross section measurement, corrected for the $F_{\rm L}$ predicted by the dipole model, is used to determine the proton structure function $F_2(x, Q^2)$. The result is shown in Fig. 2 for $0.003 < y < 0.6$. The data are compared with phenomenological parameterizations and with the extrapolated H1 NLO QCD fit [10].

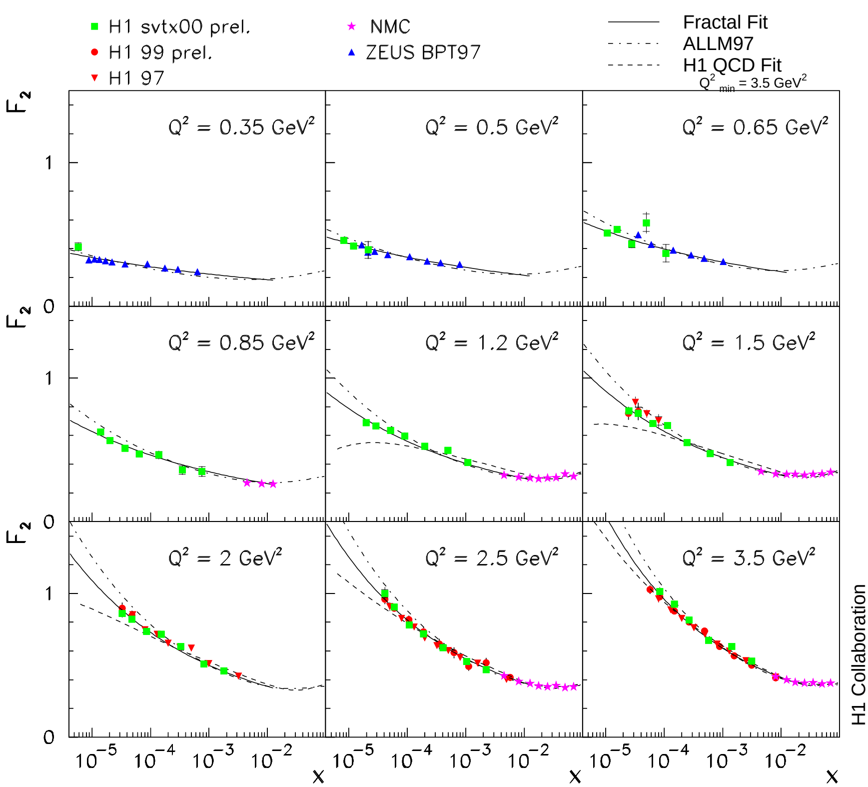

Fig. 2. Measurement of the structure function $F_2(x, Q^2)$ for $y < 0.6$ from H1 shifted vertex data (squares) as function of x in bins of Q^2 compared to further data from H1, ZEUS and NMC.

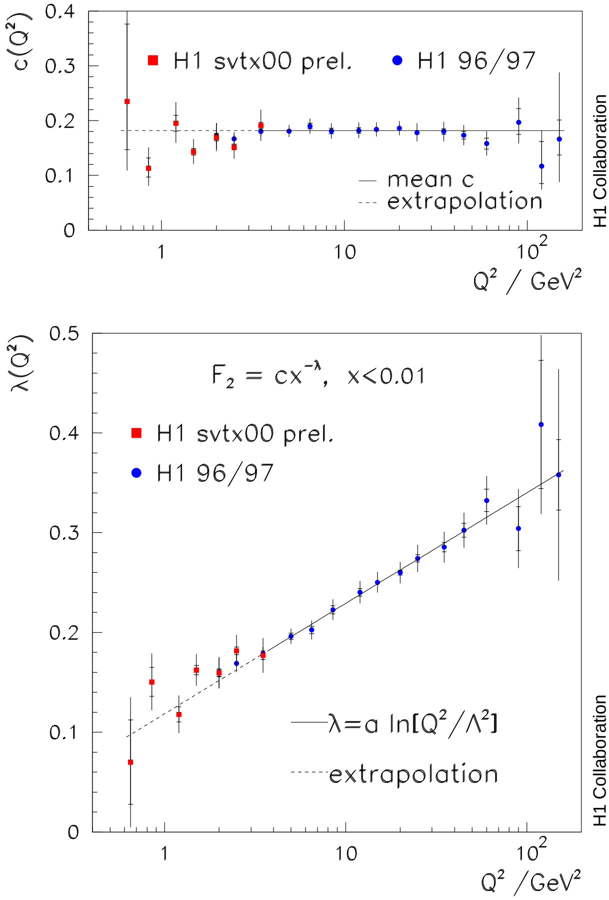

Fig. 3. Determination of the exponents $\lambda(Q^2)$ from fits of the form $F_2(x,Q^2) = c(Q^2)\,x^{-\lambda(Q^2)}$: points — previous H1 structure function data [10] for $x \leq 0.01$; squares — present data. The inner error bars illustrate the statistical uncertainties, the full error bars represent the statistical and systematic uncertainties added in quadrature. The straight line represents a fit of the form $a\ln[Q^2/\Lambda^2]$ using data for $Q^2 \geq 3.5$ GeV^2.

As it is seen from the presented figures, F_2 continues to rise towards low x at all accessed values of Q^2. Following the recent H1 analysis [11] the exponent $\lambda(Q^2)$ was determined from fits of the form $F_2(x,Q^2) = c(Q^2)\,x^{-\lambda(Q^2)}$. The result is shown in Fig. 3. The data were further used, in combination with other measurements, to obtain more precise values of $\lambda(Q^2)$ and $c(Q^2)$, see these proceedings [12].

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