Structure function measurement and QCD analysis at medium Q^2

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A preliminary measurement of the proton structure function is presented for $2 \leq Q^2 \leq 120$ GeV^2 and for Bjorken-x values $3 \cdot 10^{-5} < x < 0.1$. The data taken in 1997 by the H1 experiment correspond to a luminosity of 17 pb^{-1}. The results are by a factor of two more accurate than the previous ones due to the higher statistics and the installation of the new backward silicon tracker. A NLO QCD analysis of the cross section combined with fixed target experiments shows to be in good agreement with measured data.

1. Introduction

At medium Q^2 the reduced inclusive neutral current deep inelastic(DIS) cross section $\sigma(ep \to eX)$ can be expressed as [1]

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

where $Y_+ = 1 + (1-y)^2$ and F_2 and F_L are two proton stucture functions. For $y \leq 0.6$ the influence of the F_L on σ_r is negligible.

The variables y and Q^2 can be calculated using electron method [1] which reconstructs them from the energy E'_e and the polar angle θ_e of the scattered lepton. The measurement of the hadronic final state enables to apply the Σ method [2].

2. Strucure function measurement

2.1. Event selection

In 1997 HERA was operated with positrons of energy 27.5 GeV and protons of energy 820 GeV. The positron energy E'_e is measured in the backward electromagnetic lead-fibre scintillator calorimeter (SPACAL [3] [4]) A scattered positron was identified as a SPACAL cluster of radius $\leq$ 4cm matching a track in the preceeding drift chamber (BDC) within 1.5 cm. If geometrically available this cluster had to be associated with a signal in the inner proportional chamber (CIP) or with a track signature in the backward silicon strip detector (BST). Detailed information about further selection criteria can be found in [1]). The new BST [5] which improved the measurement precision towards low y, was used for the first time for the vertex and track reconstruction and for photoproduction background rejection. Hadronic final states were reconstructed with the Liquid Argon (LAr) calorimeter, the tracking detectors (CJC) and the SPACAL.

2.2. Systematic errors

Luminosity has been determined with a precision of 1.5% using elastic bremsstrahlung [6]. The trigger efficiency was larger than 96% and estimated to an accuracy of 0.5-1%. The change of positron identification criteria varied the cross section within 1-2%. The polar angle error is 0.5 mrad as determined from a comparison of the BDC-vertex with the BST measurements. The electromagnetic section of SPACAL was calibrated to 0.5% accuracy at the kinematic peak position and to 3% at low energies. The hadronic scale uncertainty is 4/3/5% for the contributions from LAr, tracks and SPACAL respectively.

2.3. Cross section determination

A standard procedure was applied to determine σ_r [1] from measured number of events which were corrected for the background and the acceptance and the first order radiative contributions. The results obtained with Σ or electron method were found to be in good agreement. The σ_r which is equivalent to F_2 (dashed curve) for $y \leq 0.6$ is shown in Fig. 1. The deviation of σ_r from F_2 at small x has been used to determine F_L [7],[1]. In

Fig. 2 the F_2 is depicted for the range of $x \leq 0.01$ and of $y \leq 0.6$. (F_2 for higher x can be found in [1].) Statistical errors are about 1 %. The total systematic errors are mostly between 3-4% extending up to 8% at the edges of the covered y range. The main sources of uncorrelated systematic errors are listed in Table 1.

Table 1
Effect of systematic errors on the accuracy of σ_r.

source	error [%]
vertex efficiency	1-2
BDC efficiency	0.5
BST efficiency	1-2
trigger efficiency	0.5 - 1
positron identification	0.5-2
noise rejection in LAr	< 3
radiative corrections	1-2
photoproduction background	< 8
charge asymmetry	1
CJC-SPACAL link efficiency	2

3. QCD Analysis

A NLO QCD fit to the reduced cross section was performed in the $\overline{MS}$ renormalization scheme using the DGLAP evolution equations for three light flavours with the charm contribution added according to the NLO calculation of the photon-gluon fusion process [8]. The input distributions of $q = g, u_v, d_v$ and S at the starting scale $Q_o^2 = 2$ GeV^2 were parametrized as:

$$xq(x) = A_q x^{B_q}(1-x)^{C_q}(1 + D_q x + E_q\sqrt{x}) \quad (2)$$

where $S = \bar{u} = \bar{d} = 2\bar{s}$ defines the sea The strong coupling constant was set to $\alpha_s(M_Z^2) = 0.118$. The 1997 H1 and BCDMS [9] and NMC [10] data samples were included in the fit. In Fig. 1 the QCD fit (full line) [1] is compared with the cross section data obtained in this measurement. The dashed curve corresponds to the F_2 determined with this fit. The χ^2 is 1495 for 1095 data points using the uncorrelated errors only. The detailed comparison of F_2 with the data displayed in Fig. 2 shows a good agreement between the fit and the measurements.

4. Summary

A preliminary measurement of the proton structure function F_2 based on the H1 data collected in 1997 has reached better precision as compared to the previous H1 results [11],[12],[13]. The behaviour of the DIS cross section was found to be very well described by a NLO QCD analysis down to $Q^2 = 2\ GeV^2$.

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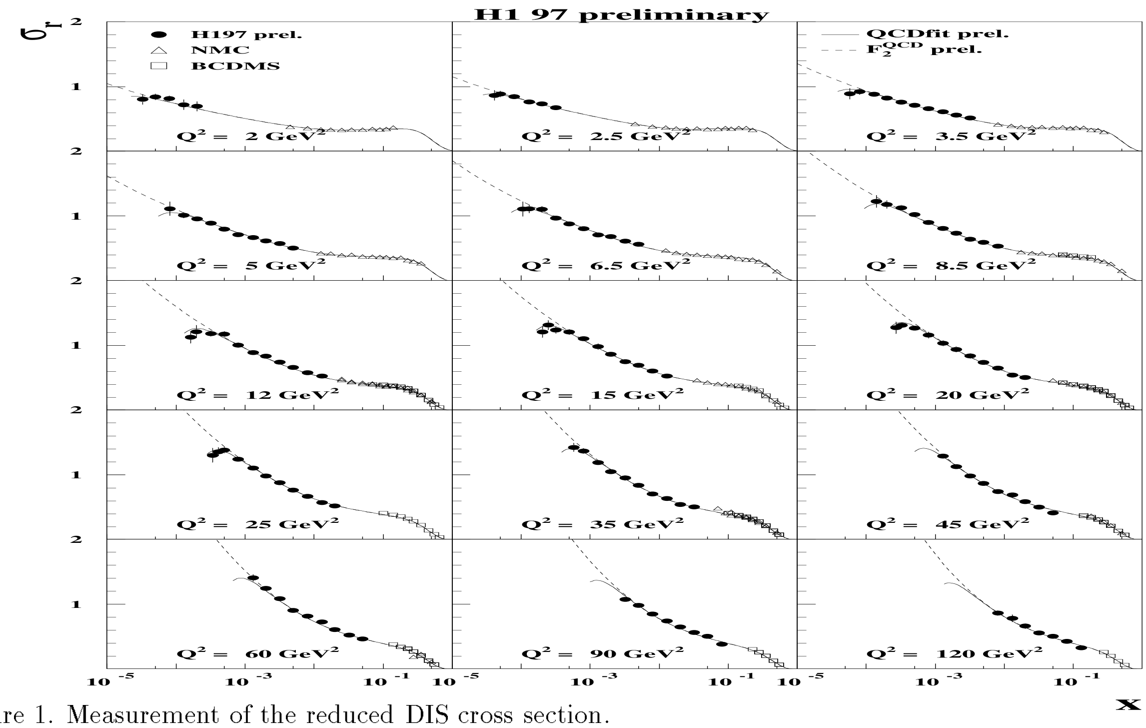

Figure 1. Measurement of the reduced DIS cross section.

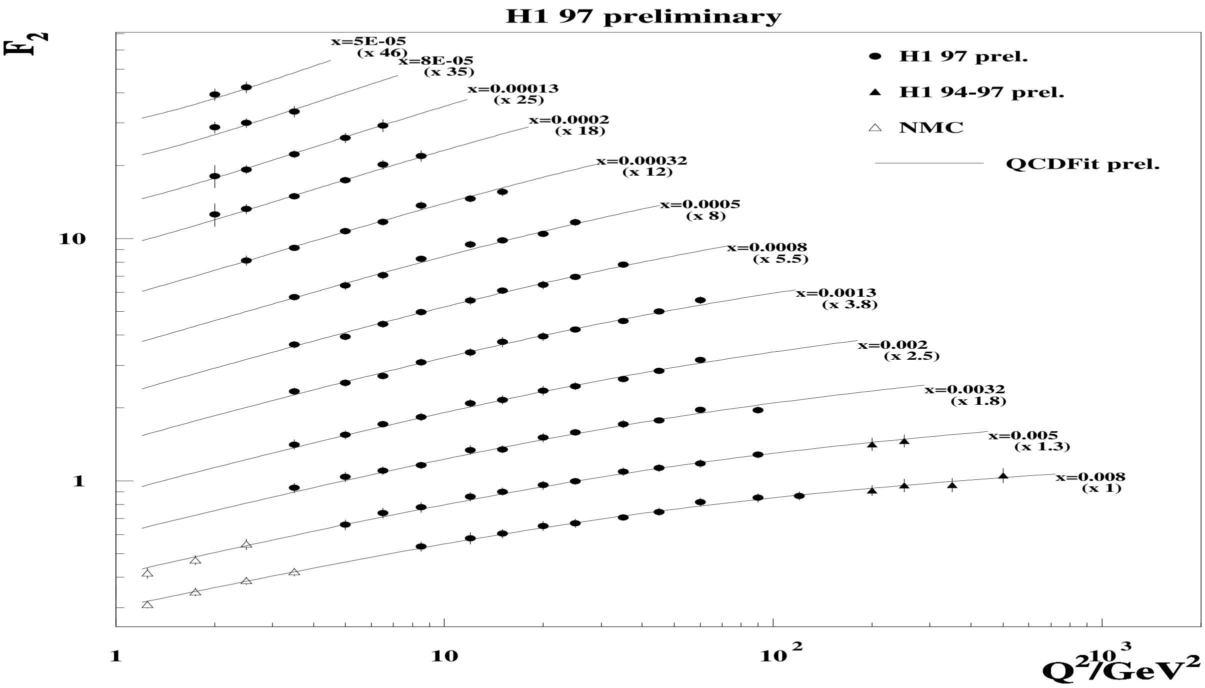

Figure 2. F_2 measurement in the range of $y \leq 0.6$