Measurement of the Inclusive ep Scattering Cross Section at HERA

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Abstract

Measurements of the inclusive ep scattering cross section are presented in the wide region of four-momentum transfers squared, $0.2 \text{ GeV}^2 \leq Q^2 \leq 30000 \text{ GeV}^2$, and Bjorken x , $4 \cdot 10^{-6} \lesssim x \lesssim 0.8$. The results are based on data sets collected by the H1 and ZEUS collaborations at HERA. The data include the region of high inelasticity y up to 0.9, which is sensitive to the longitudinal proton structure function $F_L(x, Q^2)$.

1 Introduction

At low Q^2 the DIS double-differential cross section can be expressed as:

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

where Q^2 is the negative squared four-momentum transfer, x is the Bjorken scaling variable and $Y_+ = 1 + (1 - y)^2$. The inelasticity $y = Q^2/sx$ is a fraction of the lepton's energy loss and s denotes the center of mass energy squared of the lepton-nucleon system. For $y < 0.6$ the contribution of F_L is suppressed by the kinematic factor y^2/Y_+ , therefore the measurement of σ_r at low y determines F_2 with a small correction for F_L , and only at high y the contribution of the longitudinal structure function becomes significant.

Figure 1: Reduced cross section σ_r measured in the H1 experiment as a function of x compared to the fractal fit [2] result.

2 Measurement of the cross section at low Q^2

The data used in these analyses are taken by the H1 collaboration during special running periods with open triggers for inclusive DIS events. In order to access low values of Q^2 around 1 GeV^2 the interaction vertex for the 2000 data was shifted by approximately 70 cm along the proton beam direc-

tion. The data samples are also used for accessing larger values of x with initial state radiation (ISR) events. Data collected in 1999 with a nominal position of the interaction vertex allows to extend the measurement in the high y region. The kinematic reconstruction is done with two methods. The sigma method [3] is used for medium and low y and the electron method is preferred at highest y due to better y resolution in this region. The data are combined with the previous H1 publication [4] using a special combination procedure [5]. The combined H1 inclusive cross sections measurements at low Q^2 are shown in Figure 1. Typical precision of these data is 1.5% for $Q^2 > 5 \text{ GeV}^2$.

Figure 2: x dependence of the reduced cross section. The new preliminary H1 measurement (circles) presented with other H1 results: a combination of preliminary 97, 99 and 2000 data (triangles) [6], and measurement from 97 data for $y < 0.6$ (squares) [4]. The line is H1 QCD fit [4].

3 Measurements at high y

H1 and ZEUS collaborations performed new measurement of DIS cross section at high in-

Figure 3: Q^2 dependence of H1 preliminary cross section measurement (solid circles) at inelasticity $y = 0.825$ and the published H1 result (open circles) [4]. The published data corresponds to the lower center of mass energy.

elasticity, $0.75 < y < 0.9$ using data collected in HERA-2 running period. The cross section in this kinematic domain exhibits high sensitivity to the longitudinal structure function F_L . The H1 results are based on 96 pb^{-1} data collected in 2003-2006 with about equal luminosities for e^+p and e^-p collisions which allows for high precision control of background processes. The new H1 result is shown in Figure 2, together with the preliminary result at lower Q^2 discussed in Section 2 and the H1 publication [4]. Figure 3 shows the cross section measurement for the highest y bin compared to the publication. The H1 measurement provide about twofold increase in precision compared to the previous HERA results. The new ZEUS measurement is performed at higher Q^2 . It is shown in Figure 4. The data measured by both collaborations serves also as a preparation for the measurement of the longitudinal structure function from the HERA reduced proton energy run.

Figure 4: Measured by ZEUS reduced cross-sections as a function of y for various fixed Q^2 (points) [7] compared to the Standard Model expectations evaluated using CTEQ5D PDFs (red lines) [8] and ZEUS-Jets PDFs (yellow bands) [9].

4 Measurements of structure function F_L

Figure 1 shows the rise of the cross section with decreasing x for fixed Q^2 . However, for the lowest x , a turnover of the cross section can be seen. Lowest x corresponds to highest y where the contribution of $F_L(x, Q^2)$ to the cross section is not negligible and thus the turn over of the cross section may be interpreted as the influence of a sizable F_L structure function. Nevertheless, direct measurement of F_L is not possible without running HERA collider at different centre of mass energies. For this purpose, from March to June of 2007, HERA operated with reduced proton beam energies of 460 GeV and 575 GeV.

Photon 2007

The collected luminosities during this period are 13 pb^{-1} and 7 pb^{-1} respectively. This should allow to measure F_L with a sufficient precision to distinguish between predictions of different models [10].

5 Summary

The inclusive cross section measurements presented here extend the kinematic region covered by HERA at low Q^2 and high y . Low proton beam energy HERA running is finished successfully. That allows the direct measurement of the longitudinal structure function F_L .

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