Photoproduction - DIS Transition

A. Petrukhin

*DESY, Notkestrasse 85, 22607 Hamburg, Germany
ITEP, Bolshaja Cheremushkinskaja 25, 117218 Moscow, Russia*

Abstract. Recent measurements of the proton structure function F_2 at low Q^2 in e^+p deep inelastic scattering (DIS) by the H1 Collaboration are summarized. This measurements are performed in the region of low squared four-momentum transfers, $0.2 \text{ GeV}^2 \leq Q^2 \leq 12 \text{ GeV}^2$, and low Bjorken x , $5 \cdot 10^{-6} \leq x \leq 0.02$.

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INTRODUCTION

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

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

where Q^2 is the squared four-momentum transfer and x is the Bjorken scaling variable, $Y_+ = 1 + (1 - y)^2$. The inelasticity $y = Q^2/sx$ is a fraction of the lepton's energy loss and s denotes the squared center of mass energy of the lepton-nucleon system. The double-differential cross section is governed by two independent proton structure functions, F_2 and F_L . For low y the contribution of F_L is suppressed due to 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 .

MEASUREMENT OF THE STRUCTURE FUNCTION F_2

The data used in the recent analysis were taken by the H1 detector 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 short period of H1 2000 data taking was shifted by approximately 70 cm along the proton beam direction. This data sample is also used for accessing larger values of x with Initial State Radiation (ISR) events. Data collected by the H1 collaboration in 1999 with a nominal position of the interaction vertex are used for measurements in the high y region. The data collected by ZEUS collaboration with BPT calorimeter extends the HERA measurements to $Q^2 < 1 \text{ GeV}^2$.

The kinematic reconstruction by H1 was done with two methods. The sigma method [1] has been used for medium and low y and the electron method was preferred at highest y due to a better y resolution in this region. The H1 and ZEUS measurements of the

proton structure function F_2 at low Q^2 are shown in Fig. 1 together with the fixed target data.

FIGURE 1. Measurements of the F_2 : H1 97-00 preliminary data (red points) [2], data from ZEUS BPT97 (closed triangles) [3], NMC (stars) [4], H1 QEDC97 (black squares) [5], H1 97 data (upturned triangles) [6]. The data are compared to the Fractal fit F_2 (solid curve) [7] and Dipole models GBW (dashed line) [8] and IIM (dotted line) [9].

The preliminary results from H1 97-00 extend the measured kinematic range at low Q^2 towards higher x values. All fits presented in Fig. 1 are performed to H1 preliminary data only, however all data are reasonably well described by the fits.

RISE OF F_2 AT LOW x

The proton structure function F_2 obtained from the inclusive cross section measurements rises towards low x for all measured Q^2 bins. A detailed analysis of the x dependence of F_2 is described in [10]. It was found that the x dependence of F_2 at fixed Q^2 exhibits a power law behaviour $F_2 = c \cdot x^{-\lambda(Q^2)}$. The result of fitting this form to the H1 preliminary data [2] is presented in Fig. 2 and compared to published ZEUS BPT [3] data.

One can see that new H1 preliminary results are in agreement, in the regions of overlap, with the previously published data, where deviation of $\lambda(Q^2)$ from the logarithmic dependence $\ln[Q^2/\Lambda^2]$ was observed.

FIGURE 2. The slope $\lambda(Q^2)$ from the fit $F_2 = c \cdot x^{-\lambda(Q^2)}$ to the H1 97-00 preliminary data [2] and ZEUS BPT data [3].

EFFECTIVE VIRTUAL PHOTON-PROTON CROSS SECTION

The reduced cross section σ_r can also be re-expressed as

$$\sigma_r = \frac{Q^2(1-x)}{4\pi^2\alpha} \sigma_{\gamma^*p}^{\text{eff}} \quad (2)$$

with the fine structure constant denoted as α and the effective virtual photon-proton cross section $\sigma_{\gamma^*p}^{\text{eff}}$

$$\sigma_{\gamma^*p}^{\text{eff}} = \sigma_T + \left[1 - \frac{y^2}{Y_+}\right] \sigma_L. \quad (3)$$

The sum $\sigma_L + \sigma_T$ is referred to as the total virtual photon-proton cross section, $\sigma_{\gamma^*p}^{\text{tot}}$, which is often expressed as a function of Q^2 and of the invariant mass of the virtual photon-proton system, W . The total and the effective virtual photon-proton cross sections are approximately equal to each other for the $W \leq 200$ GeV. The measurement of the virtual photon-proton effective cross section $\sigma_{\gamma^*p}^{\text{eff}}$ as a function of Q^2 at various values of W is presented in Fig. 3. The new precise H1 preliminary results cover the kinematic area around $Q^2 \sim 1$ GeV² which was not measured previously.

FIGURE 3. Measurement of the virtual photon-proton cross section $\sigma_{\gamma^*p}^{\text{eff}}$ as a function of Q^2 at various values of W . The cross sections for consecutive W values are multiplied with the factors indicated in the figure. The new preliminary H1 results [2] are compared to data obtained by the ZEUS experiment [3], [11] and to the Fractal [7] and Dipole model fit [8], [9] results.

SUMMARY

The inclusive cross section measurements presented here extend the kinematic region covered by HERA at low Q^2 and high x . The new preliminary H1 results at $Q^2 \sim 1 \text{ GeV}^2$ cover the gap in kinematic plane between published H1 and ZEUS data. The achieved precision of this new measured DIS cross section is on the level of 2-3%.

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