Log-Log behaviour of F_2 at low x in the Q^2 range from 0.1 to 35 GeV^2

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1. INTRODUCTION

In previous DIS workshops[1] it has been shown that in the low-x region the structure function F_2 is linear in terms of the empirical variable :

$$\xi = \log(x_0/x)\log(1+Q^2/Q_0^2) \quad (1)$$

2. DATA

New data from the H1[2,3] and ZEUS[4] Collaborations are considered (see fig 1). In order to stay safely away from the valence region only data satisfying $x < 0.001$ are selected. The data samples cover nearly the whole phase space with Q^2-values extending up to the HERA kinematic limit which increases with x. The lowest Q^2 value is 0.11 GeV^2[5]. All experiments have carefully studied various sources of systematic errors. Since the F_2 measurements are statistically quite accurate, the account of systematic uncertainties in comparing the 4 data sets is indispensable, when testing the hypothesis

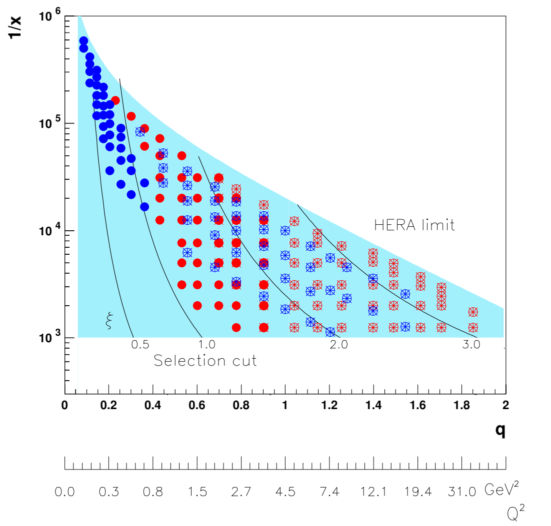

Figure 1. Phase space considered for F_2-analysis.

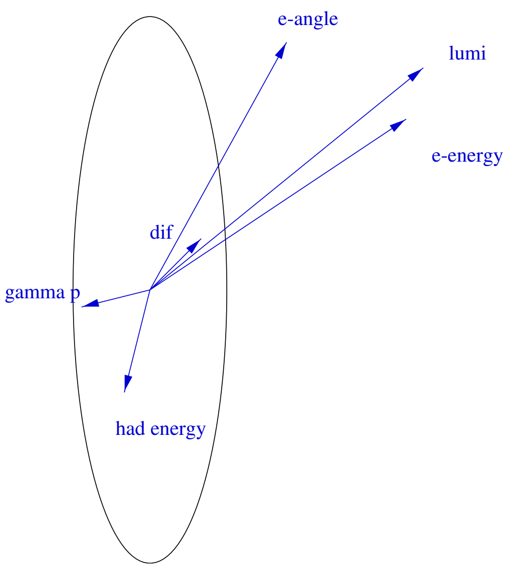

Figure 2. Shift of (u_0, u_1) ellipse due to systematic errors.

$$F_2(x,Q^2) = u_0 + u_1 * (\xi - \langle\xi\rangle) \quad (2)$$

The arrows in fig.2 illustrate the displacement of the (u_0, u_1)-ellipse (uncorrelated errors) due to a 1σ shift induced by each systematic source in the H1-1995 data[2].

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3. Q^2-DEPENDENCE

$F_2(x,q)$ behaves linearly in $q = \log(1+Q^2/Q_0^2)$ with Q_0^2 chosen to be 0.5 GeV^2, as seen in the fig.3 for the 6 low x-bins and in fig.4 for the following 6 x-bins up to x=0.001. A 2-parameter fit of the form $u_0(x)+u_1(x)*(q-\langle q\rangle)$ is performed for each x-bin. The extrapolation of $F_2(x,q)$ towards q=0, and thus Q^2=0, is well consistent with 0 for all x-bins. This is in agreement with the theoretical expectation based on the conservation of the electromagnetic current. The fit quality for the 12 x-bins is good apart from two bins, as seen in fig. 4. The range of the measurements in q is x-dependent (see fig. 1). In particular the lowest x-bins are stongly phase space limited. It is worth noting that the linearity in q is valid down to the smallest measured x-bins. The variable q has the property of interpolating smoothly between Q^2 and $\log Q^2$. The transition region is governed by the value of Q_0^2.

The fitted slopes $u_1(x)$ of the lines in figs. 3, 4 are plotted in fig. 5 and are consistent with a linear logarithmic behaviour, i.e. $u_1(x) = m\ \log(x_0/x)$, where x_0=0.04 and m=0.41. The lines drawn in the two figures. 3,4 correspond to $0.41\ \log(0.04/x)$.

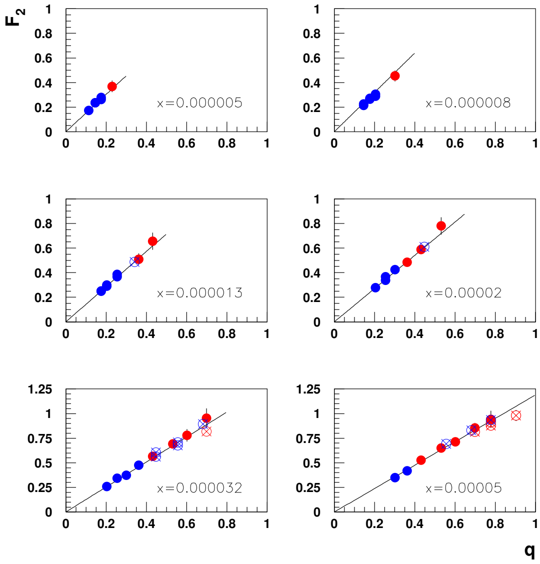

Figure 3. F_2 versus q for fixed lower x-bins in increasing order.

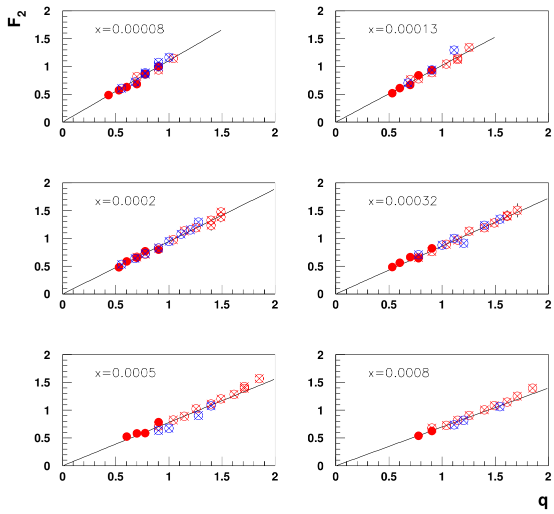

Figure 4. F_2 versus q for fixed higher x in increasing order.

4. RESULTS

The linearity of $F_2(x,q)$ in q implies that the derivative of F_2 with respect to q is a function of x alone. Then, the derivative of F_2 with respect to $\log Q^2$ is bound to exhibit a characteristically different behaviour at low values of Q^2, namely :

$$\begin{aligned}\partial F_2/\partial \log Q^2 &= \partial F_2/\partial q \ \ \delta q/\delta \log Q^2 \qquad (3)\\ &= m \log e \ \log(x_0/x)\frac{Q^2}{Q^2+Q_0^2}\end{aligned}$$

The appearence of the Jacobian factor $\delta q/\delta Q^2$ causes a sharp decrease of $\partial F_2/\partial \log Q^2$ as x decreases, which corresponds to small values of Q^2 (see fig.1), in contrast to the smooth behaviour of $\partial F_2/\partial q$ in x, as seen in fig.5.

The empirical properties of the 2 quantities, average (u_0) and slope (u_1), characterizing the linear fits, show that F_2 actually depends only on

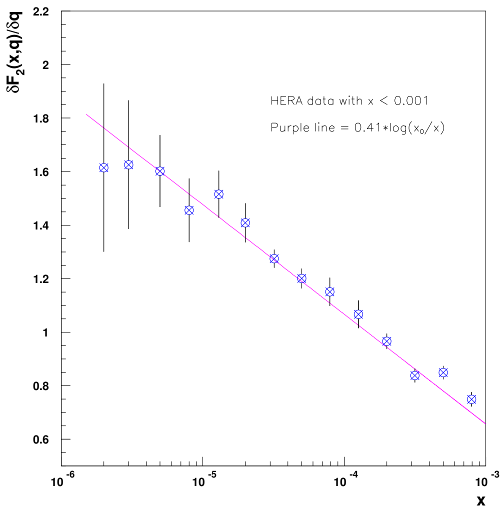

Figure 5. Fitted slopes from 2-parameter fit in q to $F_2(x,q)$ for each x-bin.

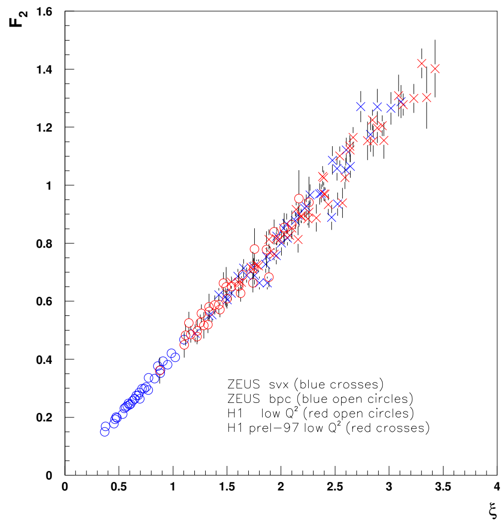

Figure 6. F_2 data from 4 HERA experiments plotted in terms of the scaling variable $\xi = \log(x_0/x)\log(1+Q^2/Q_0^2)$.

the product of $\log(x_0/x)$ and $q = \log(1+Q^2/Q_0^2)$, i.e. on the scaling variable ξ (see eq. 1). All F_2 measurements are plotted in fig. 6 as a function of ξ as calculated from eq. 1. A 2-parameter fit in ξ to the F_2 data yields $\chi^2/\text{dof} = 215/171$ including 2 points contributing 34.1. The extrapolation towards 0 is consistent with 0.

In the kinematic range investigated the structure function $F_2(x,Q^2)$=$F_2(\xi,q)$ has - within experimental uncertainties - no measurable dependence on q, if expressed in terms of ξ. This yields the simple form :

$$F_2(\xi) = 0.41\,\xi \tag{4}$$

This representation holds equally well in the perturbative as in the nonperturbative regime. It has been checked that it is consistent with the prediction of the MRST parametrisation[6], which is based on the QCD evolution and applicable for Q^2 >1.25 GeV^2 and $x > 10^{-5}$.

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