MEASUREMENT OF F_2 IN DIS AT HERA

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H1 COLLABORATION

1 Introduction

We measured the inclusive differential cross section of deep inelastic positron proton scattering at HERA with the H1 detector[1]. The structure function $F_2(x, Q^2)$ is defined by the formula

$$\frac{\partial^2\sigma}{\partial x \partial Q^2} = \frac{2\pi\alpha^2}{xQ^4}(2 - 2y + \frac{y^2}{1+R})F_2(x, Q^2) \qquad (1)$$

where only the one photon exchange has been taken into account. Effects due to Z boson exchange are smaller than 2%. The structure function ratio $R = F_2/2xF_1 - 1$ has not been measured yet at HERA and is calculated using the QCD prediction and the GRV structure function parametrisation.

The H1 data presented here were taken in 1994 runs and span a wide kinematical range of $1.5 < Q^2 < 5000$ GeV^2 and $5 \times 10^{-5} < x < 0.32$, which is a significant increase specially towards lower x and lower Q^2 compared to earlier measurements[2] at HERA.

Most interesting is the behaviour of F_2 at very low x. The crucial questions here are: Can conventional perturbative QCD describe the structure functions in terms of parton density evolutions for quark and gluons over such a huge kinematical range? Can we confirm the steep rise of F_2 towards low x, or do we see already saturation effects, which are expected due to parton recombination? Is there any indication, that we reach at the lowest Q^2 = 1.5 GeV^2 already the photoproduction regime, where only a weak rise of total cross section with the invariant mass squared of the photon proton system, $W^2 \approx Q^2/x$, is observed?

2 Data Samples

The analysis presented here is based on data taken during the running period of 1994, where positrons and protons were colliding in HERA at a center of mass energy of 300 GeV. From the total available integrated luminosity of about 3.4 pb^{-1} we selected good quality runs for the standard analysis covering a integrated luminosity of 2.2 pb^{-1} corresponding to about 180,000 events. Furthermore we tried to extend the kinematical range towards lower Q^2 by two different methods:

At the end of 1994 during a short period of data taking the interaction vertex was moved by about 65 cm in positron upstream direction resulting in an increase of the geometrical acceptance of our detector for the final state positrons towards lower scattering angles (bigger angles θ_e). An integrated luminosity of 0.058 pb^{-1} in this setup made 12,000 events mainly in the region $Q^2 \leq 6.5$ GeV^2 available.

In addition we searched a total sample of 2.9 pb^{-1} for events, which had a photon seen by a photon detector situated about 90 m downstream in the positron direction of H1 and which are kinematicaly compatible with QED inital state radiation events. The reduced center of mass evergy of the about 8,000 events of this type allows to access even lower Q^2 values.

3 Determination of Kinematics and Systematic Uncertainties

Four basic quantities are measured for each deep inelastic neutral current event in the H1 detector, namely the energy of the scattered positron E'_e, its scattering angle θ_e, the total energy deposited by the hadronic final state E_{had} and the energy weighted average scattering angle of the hadronic final state γ_{had}. From these four values the two Lorentz-invariant variables x and Q^2 are in principle overdetermined, a feature which is being used to cross check the measurements and estimate systematic errors.

For a most unbiased inclusive cross section measurement the *energy* method is preferable, which uses E'_e and θ_e only. However it has the disadvantage that its accuracy of determining y deteriorates with $1/y$, so we used this method for $y \geq 0.15$ only. Over the full kinematical region we get reasonable good results using the so called Σ method[2], which makes mainly use of E_{had} and γ_{had}. For determining systematic errors in the energy measurment of the calorimeters we make use of the double angle method, which is independant of any absolute energy measurement.

We reached in this preliminary analysis systematic errors in the positron energy measurement of 1.5 % in the backward calorimeter and 3 % in the liquid argon main calorimeter, which influence the final F_2 by 7 %. About 5 % systematic effects have to be expected each from the positron angle measurement, the hadronic energy scale (Σ method only), the background subtraction and the hadronic fragmentation model dependance. Further smaller uncertainties come from the assumed structure functions for the Monte Carlo generators (3 %), the QED radiation corrections (3 %) and the vertex determination efficiency (4 %). Combining all these x, Q^2 bin dependant contributions we get in general a total systematic uncertainty below 10 % and up to 20 % in a few corners of the kinematical plane and for all data points obtained from the initial state radiation sample. A global uncertainty of 1.5 % due to the luminosity measurement has to be added.

The agreement of both the *electron* and the Σ method in all data points within error bars gives us confidence, that the above estimations are correct. Figure 1 shows all data points of the analysis of the standard and the shifted vertex samples using the combined results of the *electron* and the Σ method. The systematic

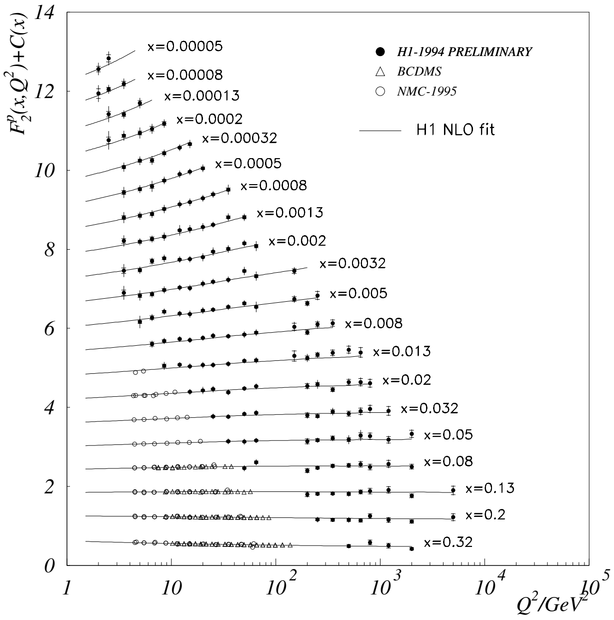

Figure 1: Preliminary measurement of the proton structure function $F_2(x, Q^2)$ of H1 and some fixed target results for comparison. The curve shows the result of a next-to-leading order QCD fit as described in ref. 3. All contributions are included in the error bars plotted, except the global normalisation.

errors dominate over the statistic errors for $Q^2 \leq 500$ GeV^2. The smooth transition from the fixed target to the HERA data points shows, that the absolute normalisation between these very different type of experiments is consistent.

4 Discussion

The NLO QCD fit applied to the H1 data (using data points with $Q^2 \geq 5$ GeV^2 only, see figure 1) shows in fact, that perturbative QCD in a DGLAP type approach describes the evolution of F_2 in the full kinematical range. The scaling violations at low x demonstrate the influence of the gluon density on the proton structure function.

Figure 2 shows the data points for the eight lowest bins of Q^2, including now the results obtained from the radiative data sample. We can see that F_2 is still rising towards low x even at Q^2 as low as 1.5 GeV^2. However, as requested by pQCD, the steepness becomes smaller at lower Q^2, but no additional flattening which could result from saturation effects can be seen yet and also we observe, that we did not reach the photoproduction regime yet, where the cross section changes only smoothly with the center of mass energy[4].

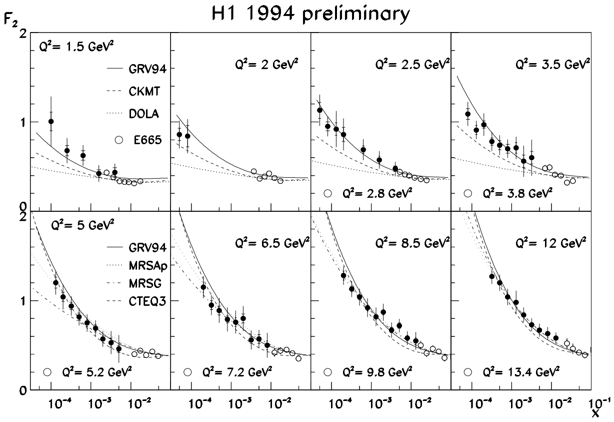

Figure 2: The results in the low Q^2 region (closed circles) including the data points obtained from the radiative sample, together with E665 data (open circles). Different predictions are shown and are discussed in the text.

Some theoretical predictions and extrapolations are also shown. The CTEQ and MRS parton density evolutions are defined for $Q^2 \geq 4$ GeV^2 and follow the data nicely. Very interesting is the fact that the GRV 94 parametrisation, which starts from valence like distribution of quarks at $Q^2 = 0.34$ GeV^2, with some additional gluon contribution and other corrections added, describes the data also at the lowest Q^2 bins within the sizeable error bars rather well. The DOLA predictions, using a soft pomeron type of approach, however fail to describe the data.

References

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3. H1 Collaboration, S. Aid et al., *Phys. Lett.* **B354** (1995) 494.
4. H.P. Beck, H1 Collaboration, *Total photoproduction cross section at $W_{\gamma p}$ of 200 GeV and its decomposition,* these proceedings.