Structure Function Measurements at HERA

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Abstract. Recent structure function results from the H1 and ZEUS Collaborations are presented. The data cover a wide kinematic range of squared four-momentum transfers Q^2, from $0.2\,\mathrm{GeV}^2$ to $30000\,\mathrm{GeV}^2$, and Bjorken x between $\sim 5 * 10^{-6}$ and 0.65. Data from both experiments have been combined, leading to significantly reduced experimental uncertainties. The combined measurements are analysed using a NLO QCD fit, and a set of parton density functions, HERAPDF1.0, is extracted. New direct measurements of the structure function F_L, making use of dedicated low energy runs of the HERA machine, are also presented.

1. Measurements of the structure function F_2

A new measurement [1] of deep inelastic lepton-nucleon scattering (DIS) is based on data collected by the H1 collaboration in the year 2000 with positrons of energy E_e=27.6 GeV and protons of energy E_p=920 GeV, corresponding to a centre-of-mass energy $\sqrt{s}$=319 GeV. The measurement is performed in the kinematic region of $12\,\mathrm{GeV}^2 \leq Q^2 \leq 150\,\mathrm{GeV}^2$ and of $10^{-4} \leq x \leq 0.1$. The luminosity amounts to 22 pb^{-1}. This measurement is combined with similar H1 data taken in 1996/97 at E_p=820 GeV [2]. The combined data represent the most precise measurement in presented kinematic domain with typical total uncertainties in the range of 1.3-2%. The data are used to determine the structure function $F_2(x, Q^2)$, which is observed to rise continuously towards low x at fixed Q^2. A NLO QCD analysis is performed to obtain a new set of parton distribution functions H1PDF2009 [1] from the inclusive DIS cross section measurements presented here as well as from previously published H1 measurements at low [3] and high [2] Q^2. The data and the NLO QCD fit from H1 data alone are shown in Figure 1.

2. Combined H1 and ZEUS measurements

A combination [4] is presented of the inclusive DIS cross sections measured by the H1 and ZEUS Collaborations in neutral current unpolarised *ep* scattering at HERA during the period 1994-2000. The luminosity amounts to 240 pb^{-1}. The data cover a several orders of magnitude in Q^2, and in Bjorken x. The combination method used takes the correlations of systematic uncertainties into account, resulting in an improved accuracy. The input data from H1 and ZEUS are consistent with each other at $\chi^2/\mathrm{ndf} = 636.5/656$. The total uncertainty of the combined data set reaches 1% in the best measured region, $20\,\mathrm{GeV}^2 < Q^2 < 100\,\mathrm{GeV}^2$. Figure 2 shows the combined HERA results: scaling violations predicted by the theory of QCD and the HERAPDF1.0 fit which will be discussed in the next section.

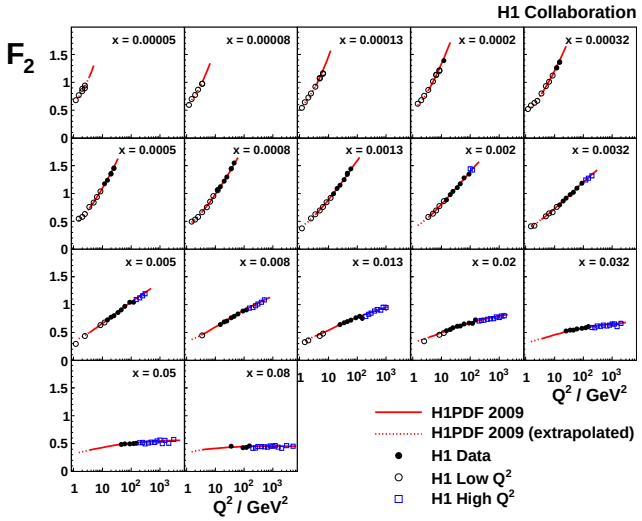

Figure 1. Measurements of the structure function F_2 as a function of Q^2 at various values of x. The new data (closed circles) are complemented by the previously published data at low Q^2 (open circles) [3] and high Q^2 (open boxes) [2]. The error bars represent the total measurement uncertainties. The solid curve represents the NLO QCD fit to H1 data alone for $Q^2 \geq 3.5\,\mathrm{GeV}^2$, which is also shown extrapolated down to $Q^2 = 1.5\,\mathrm{GeV}^2$.

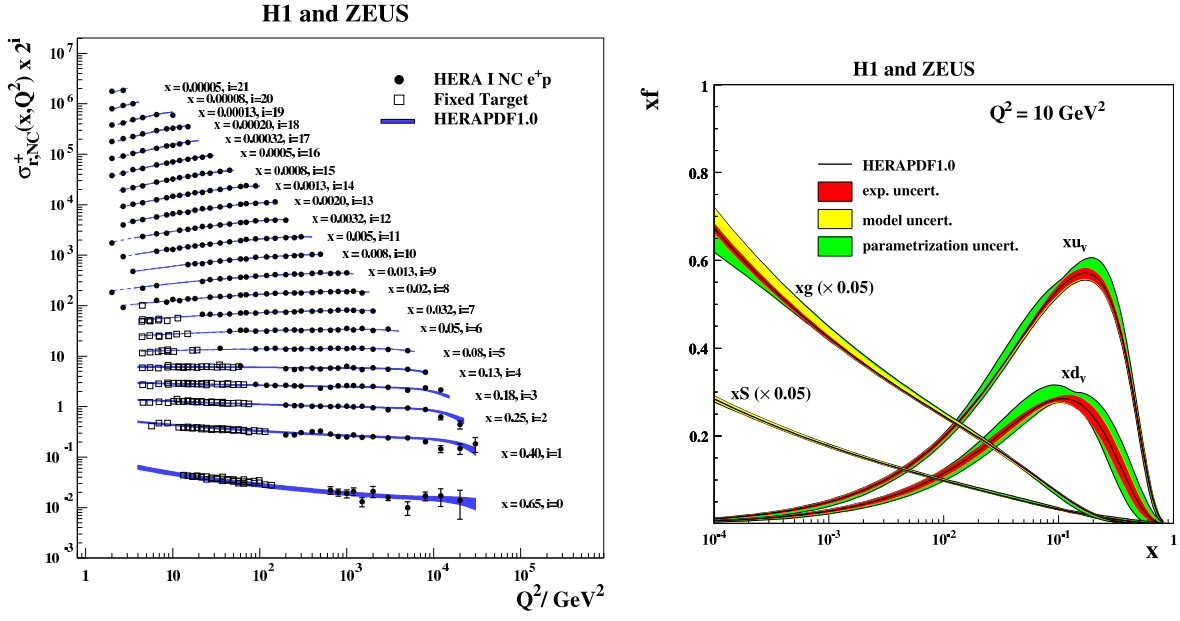

Figure 2. Left: HERA combined neutral current reduced cross section [4] and fixed-target data compared to the HERAPDF1.0 fit. The bands represent the total uncertainty of the fit. Right: the parton distribution functions from the HERAPDF1.0 at $Q^2 = 10\,\mathrm{GeV}^2$. The gluon and sea distributions are scaled down by a factor 20. The experimental, model and parametrisation uncertainties are shown separately (see [4]).

3. QCD analysis of the combined data

The combined data set on inclusive cross sections is used as the sole input for a next-to-leading order QCD analysis which determines a new set of parton distributions HERAPDF1.0 with small experimental uncertainties. This set includes an estimate of the model and parametrisation uncertainties of the fit result as explained in [4]. The HERAPDF1.0 fit results are shown in Figure 2. Due to the precision of the combined data set, the parametrisation HERAPDF1.0 has total uncertainties at the level of a few percent at low x.

4. Measurements of the structure function F_L

Figure 3 shows the first measurements of the the structure function F_L performed by the H1 [5] and ZEUS [6] Collaborations. The measurement of F_L requires several sets of DIS cross sections at fixed x and Q^2 but at different values of inelasticity y. This was achieved at HERA by variations of the proton beam energy whilst keeping the lepton beam energy fixed. The current measurements are based on inclusive deep inelastic e^+p scattering cross section measurements with a positron beam energy of 27.5 GeV and proton beam energies of 920, 575 and 460 GeV. Employing the energy dependence of the cross section, F_L is measured in the range of $12 \leq Q^2 \leq 130\,\mathrm{GeV}^2$ and low Bjorken x of $0.00024 \leq x \leq 0.007$. The F_L values agree with higher order QCD calculations based on parton densities obtained using cross section data previously measured at HERA.

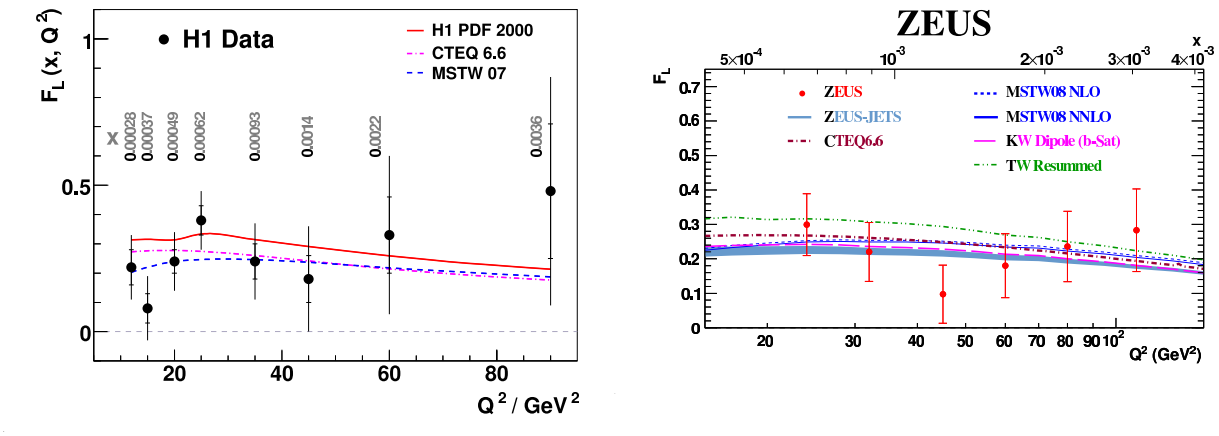

Figure 3. F_L from the H1 data [5] (left) and ZEUS data [6] (right) compared to the different theoretical predictions. The full error bars include the statistical and systematic uncertainties added in quadrature.

Figure 4 shows a new preliminary H1 measurement of the structure function F_L [7]. The measurements of F_L use different parts of the H1 detector covering when combined a wide range of squared four-momentum transfers $2.5 \leq Q^2 \leq 800$ GeV^2 and Bjorken x between 0.00005 and 0.035. The data are compared with higher order QCD prediction H1PDF2009 [1]. The measurements are in a good agreement with H1PDF2009 fit except the lowest Q^2 region.

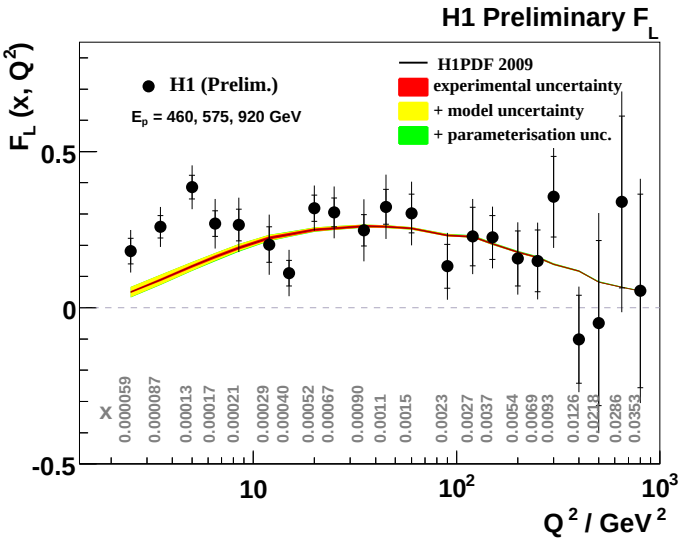

Figure 4. F_L from the H1 data [7] in extended kinematic range of squared four-momentum transfers $2.5 \leq Q^2 \leq 800$ GeV^2 and $0.00005 \leq x \leq 0.035$. The data are compared to NLO QCD fit H1PDF2009. The full error bars include the statistical and systematic uncertainties added in quadrature.

References

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