# Electro ea an e on the Stan ar Mo el results from HERA

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The latest results from the HERA collider both within the Standard (electroweak) Model and beyond are reviewed. Most of the results are based on the full HERA data sample, which corresponds to an integrated luminosity of about 0 5 fb per experiment (H1 or ZEUS).

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35 GeV are described with an accuracy of 10%. Since the remaining radiation does not exceed 10%, the uncertainty induced by radiative corrections for the high $y$ cross section measurement is estimated to be less than 1%.

Both H1 and ZEUS collaborations performed cross section measurements at high $y$ using large statistics samples collected at $E_p = 920$ GeV. For example, the H1 measurements for $y = 0.825$ [14] are shown in figure 6. Compared to the published

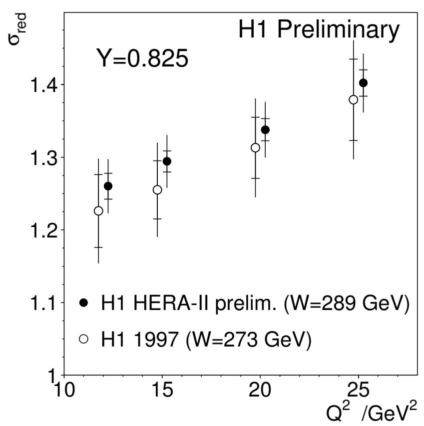


Figure 6. The reduced inclusive DIS cross section measured at $y = 0.825$ and shown as a function of $Q^2$ for the published H1 data [15] taken at $E_p = 820$ GeV (open circles) and the preliminary H1 data at $E_p = 920$ GeV (full circles). The inner error bars show statistical and the outer error bars show statistical and systematic errors added in quadrature. The absolute luminosity uncertainty is not included in the error bars.

H1 result [15], the preliminary H1 measurement improves the statistical uncertainties by a factor of three and the total uncertainties by a factor of two.

The measurements of the reduced double differential cross section at the nominal and reduced proton beam energies by the H1 and ZEUS collaborations are shown in figure 7 and figure 8, respectively. The data are compared to the H1 PDF 2000 [16] and ZEUS-JETS [17] parameterisations. For each $Q^2$ bin and at the lowest $x$, the cross

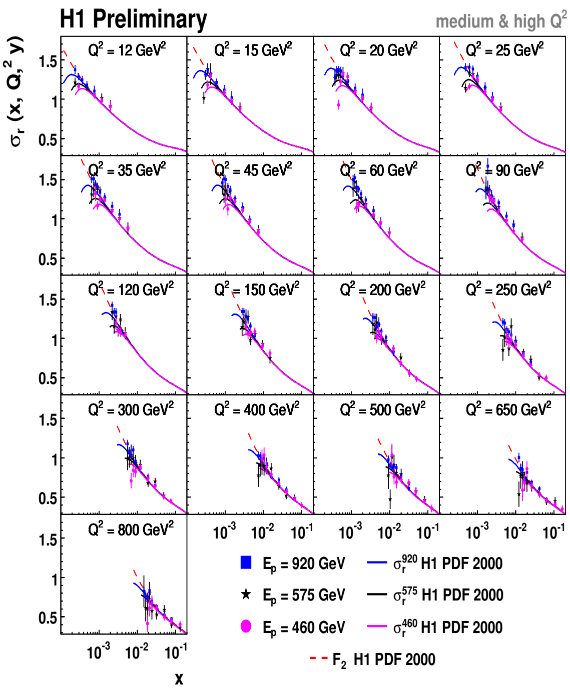


Figure 7. The reduced inclusive DIS cross section measured by the H1 collaboration at different $Q^2$ values and shown as a function of $x$ for the data taken at the three proton beam energies, $E_p = 920$ GeV (squares), 575 GeV (stars) and 460 GeV (circles). The error bars show the statistical and systematic errors added in quadrature. The curves correspond to the H1 PDF 2000 parameterisation and are shown (from top to bottom) for $F_2$ and for $\sigma_r$ at $E_p = 920, 575$ and 460 GeV.

sections show characteristic flattening and turnover, different for different centre-of-mass energies. This behaviour is explained by the influence of the longitudinal structure function $F_L$. Within the uncertainties, the data agree well with the expectations.

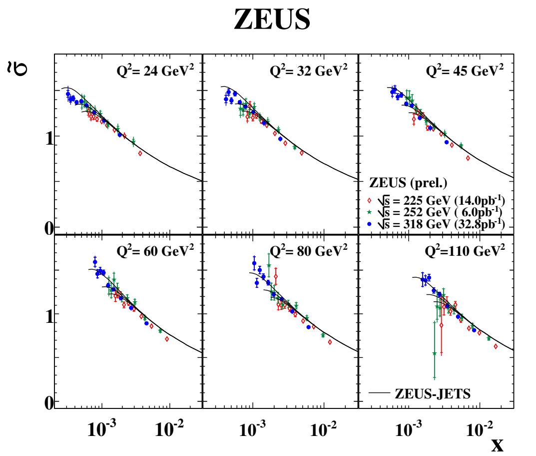


Figure 8. The reduced inclusive DIS cross section measured by the ZEUS collaboration at different $Q^2$ values and shown as a function of $x$ for the data taken at the three proton beam energies, $E_p = 920$ GeV (full circles), 575 GeV (stars) and 460 GeV (open circles). The inner error bars show the statistical and the outer error bars show the statistical and systematic errors added in quadrature. The curves correspond to the ZEUS-JETS parameterisation.

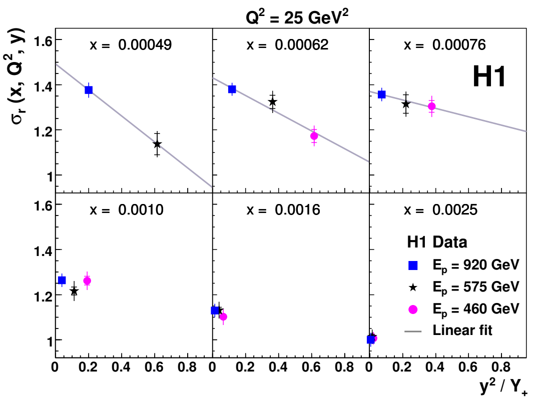


Figure 9. The reduced inclusive DIS cross section measured by the H1 collaboration and plotted as a function of $y^2/Y_+$ for six values of $x$ at $Q^2 = 25$ GeV$^2$ and $E_p = 920$, 575 and 460 GeV. The inner error bars denote the statistical error, the full error bars include the systematic errors. The luminosity uncertainty is not included in the errors. For the bins used to extract $F_L$, a straight line fit is shown where the slope determines $F_L$. The other bins are used for the relative normalisation of the data sets at different $E_p$.

## 3. Measurement of $F_L$

The structure function $F_L$ is determined using the reduced cross section measurements at the three proton beam energies. This procedure consists of two main steps and is illustrated in figure 9.

A large uncertainty on $F_L$ stems from the relative normalisation of the data sets at different $E_p$. This uncertainty can be significantly reduced by demanding the measurements to agree at low $y$, where $f(y)$ is small, and the reduced cross section is almost equal to $F_2$. This regime is reached in figure 9 for the bins at $x = 0.0016$ and $x = 0.0025$. The uncertainty on the relative normalisation is then defined by the statistics at low $y$, a small residual dependence on $F_L$ and non-perfect cancellation of the systematic uncertainties. A rather large systematic error arises from the energy scale uncertainty. The total uncertainty of the relative normalisation between different data sets is about 1.5%.

The structure function $F_L$ is measured as a slope of a linear fit of $\sigma_r(x, Q^2, f(y))$ versus $f(y)$. These fits are shown in figure 9 for the bins in $x$ at 0.00049, 0.00062 and 0.00076. For the lowest $x$ bin the measurement with $E_p = 460$ GeV is not possible, since it would lie beyond the kinematic limit $y = 1$. Here $F_L$ is determined using data with $E_p = 920$ and 575 GeV only. For the other bins all three energies are used. The uncertainties on $F_L$ arise from statistics, from the uncertainty of the relative normalisation of the data sets and from the systematic uncertainties. Similar to the determination of the relative normalisation, there is a cancellation of the systematic uncertainties. However, this cancellation is not complete since the uncertainties typically increase at high $y$.

Figure 10 shows the first preliminary measurements of $F_L$ performed by the ZEUS collaboration [18]. The data are compared to the ZEUS-JETS PDF parameterisation which is based on other ZEUS data. The data cover the range from $24 \leq Q^2 \leq 110$ GeV$^2$. A good agreement between the data and the expectation is observed.

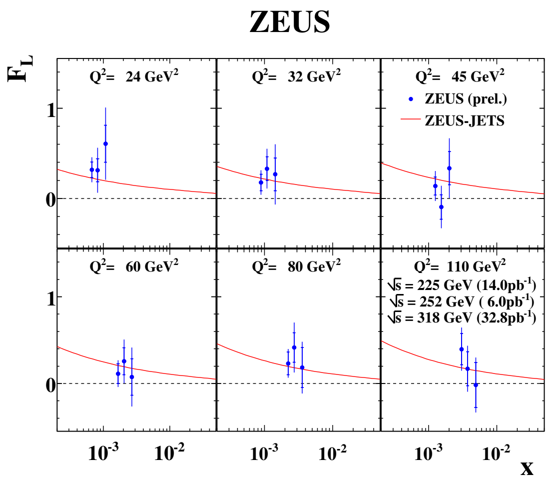


Figure 10. The longitudinal structure function $F_L(x, Q^2)$ measured by the ZEUS collaboration. The inner error bars denote the statistical error, the full error bars include the systematic errors. The curves represent the ZEUS-JETS PDF fit.

The measurements of $F_L$ obtained by the H1 collaboration [19] are shown in figure 11. This result is obtained using cross section data measured in the SpaCal and LAr calorimeters. The $F_L$ measurement based on the SpaCal data only is published in [20]; it is a subset of the results shown here. The SpaCal based measurements cover the range $12 \leq Q^2 \leq 90$ GeV$^2$, while the LAr data cover $35 \leq Q^2 \leq 800$ GeV$^2$. Use of the LAr data significantly improves the precision in the overlap region. The H1 measurements agree well with those obtained by the ZEUS collaboration.

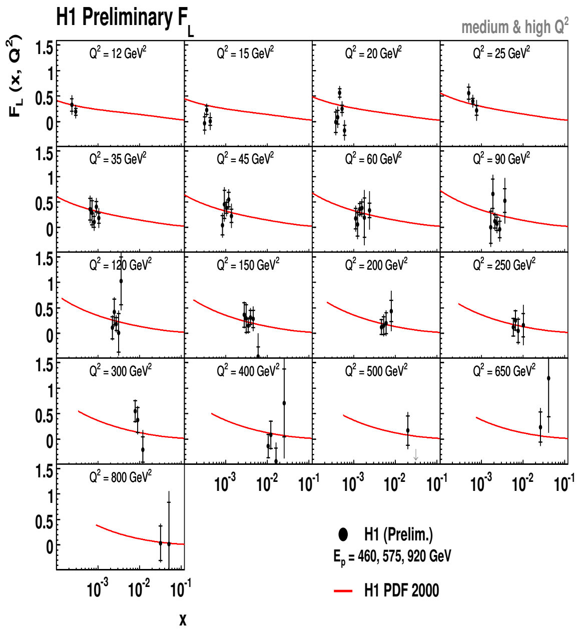


Figure 11. The longitudinal structure function $F_L(x, Q^2)$ measured by the H1 collaboration. The inner error bars denote the statistical error, the full error bars include the systematic errors. The curves represent the H1 PDF 2000 fit.

The measurements of $F_L$ performed by the H1 collaboration have large statistical uncertainties, which at low $Q^2$ stem from the background subtraction. The $x$ range covered by the measurements for each $Q^2$ bin is limited, and for this range the expected variation of $F_L$ is small. Therefore, the measurements are averaged for each $Q^2$ bin in order to obtain a more compact representation of the data. The averaged $F_L$ measurements are shown in figure 12 and are compared to various predictions. The models coincide at $Q^2 > 100$ GeV$^2$, but start to diverge at low $Q^2$ due to differences in the gluon density. The data agree with all predictions within the experimental uncertainties. It is thus important to extend the measurement to low $Q^2$. This can be done using the backward silicon tracker.

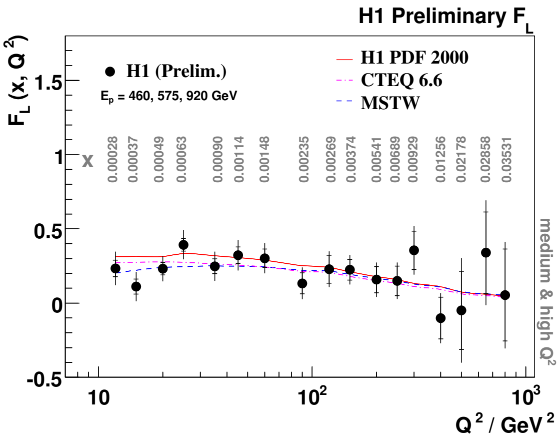


Figure 12. The H1 measurement of $F_L$ averaged over $x$ at fixed values of $Q^2$. The $x$ values of the averaged $F_L$ are shown above the data points. The theoretical predictions are calculated at the corresponding $x, Q^2$ points and connected by lines.

## 4. Summary

The H1 and ZEUS collaborations performed the first measurement of the longitudinal structure function $F_L$. The measurement is obtained using dedicated runs with reduced proton beam energies performed for the last three months of HERA operation. The experimental data agree well with each other and with the expectations based on the standard DGLAP evolution for which the parton densities are obtained from the DGLAP fits to the HERA reduced cross section data.

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