H1 AND ZEUS RESULTS ON $F_2^{c\bar{c}}$ AND $F_2^{b\bar{b}}$*

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Recent results from the H1 and ZEUS collaborations on the contribution of heavy quarks to the inclusive proton structure function are presented. Measurements of the charm structure function $F_2^{c\bar{c}}$ are made mainly by explicit reconstruction of a D meson. The measurement of the inclusive beauty structure function $F_2^{b\bar{b}}$, and also $F_2^{c\bar{c}}$, is made using precise information from silicon vertex detectors in order to reconstruct the impact parameter of tracks from the decay of the heavy hadron. The results are compared with the predictions of calculations based on perturbative QCD.

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1. Introduction

Measurements of the charm (c) and beauty (b) contributions to the inclusive proton structure function F_2 have been made recently in Deep Inelastic Scattering (DIS) at HERA. Measurements of the open charm cross section in DIS at HERA have mainly been of exclusive D or D^* meson production [1, 2]. From the D^* measurements the contribution of charm to the proton structure function, $F_2^{c\bar{c}}$, has been derived by correcting for the fragmentation fraction $f(c \to D^*)$ and the unmeasured phase space (mainly at low values of transverse momentum of the meson). The results are found to be in good agreement with perturbative QCD (pQCD) predictions at next-to-leading order (NLO). Events containing heavy quarks can also be distinguished by the long lifetimes of c and b flavoured hadrons, which lead to displacements of tracks from the primary vertex. The impact parameter of a track, which is the transverse distance of closest approach (DCA) of the track to the primary vertex point, is reconstructed using precise spatial information from silicon vertex detectors. Measurements using this method have been made at low [3] and high [4] values of Q^2.

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2. Impact Parameter Method

In order to determine a signed impact parameter (δ) for a track, the azimuthal angle of the struck quark $\phi_{\rm quark}$ must be determined for each event. The angle $\phi_{\rm quark}$ is reconstructed from the ϕ of the jet with the highest transverse momentum or, if there is no jet reconstructed in the event, from the properties of the hadronic final state or scattered electron. The direction defined in the transverse plane by $\phi_{\rm quark}$ and the primary vertex is called the quark axis. If the angle between the quark axis and the line joining the primary vertex to the point of DCA of a track is less than $90°$, δ is defined as positive, and is defined as negative otherwise. The δ distribution, shown in Fig. 1, is seen to be asymmetric with positive values in excess of negative values indicating the presence of long lived particles.

To further distinguish between the c, b and light quark flavours the quantities S_1 and S_2 are defined as the significance ($\delta/\sigma(\delta)$) of the track with the highest and second highest absolute significance, respectively, where $\sigma(\delta)$ is the error on δ. In order to substantially reduce the uncertainty due to the resolution of δ and the light quark normalisation, the contents of the negative bins in the significance distributions are subtracted from the contents of the corresponding positive bins. The subtracted distribution for S_2 is shown in Fig. 1.

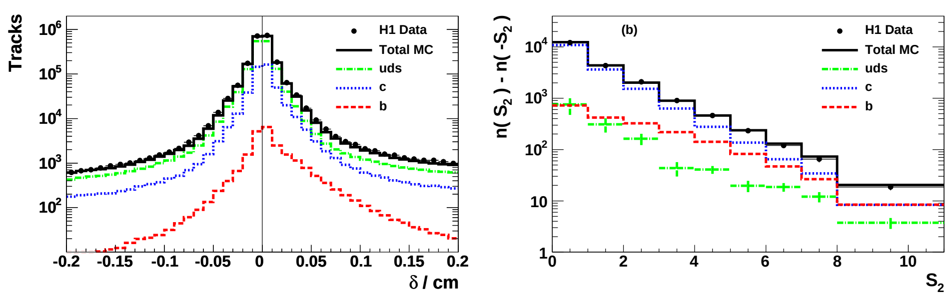

Fig. 1. The signed impact parameter δ of a track (left) and the subtracted significance distribution $S_2 = \delta/\sigma(\delta)$ (right).

The fractions of c, b and light quarks of the data are extracted in each x–Q^2 interval using a fit to the subtracted S_1 and S_2 distributions and the total number of inclusive events. The results of the fit are converted to a measurement of the "reduced c cross section" defined from the differential cross section as

$$\tilde{\sigma}^{c\bar{c}}(x,Q^2) = \frac{\mathrm{d}^2\sigma^{c\bar{c}}}{\mathrm{d}x\,\mathrm{d}Q^2}\,\frac{xQ^4}{2\pi\alpha^2(1+(1-y)^2)}\,.$$

3. Results

The measurements of $\tilde{\sigma}^{c\bar{c}}$ are shown in Fig. 2 as a function of x for fixed values of Q^2. The H1 impact parameter data [3,4] are compared with the results extracted from D^* meson measurements by H1 [1] and ZEUS [2]. The measurements from the impact parameter analysis and the D^* extraction methods are in good agreement. The $\tilde{\sigma}^{c\bar{c}}$ data are compared with two predictions from NLO QCD from MRST [5] and CTEQ [6], and with predictions based on CCFM [7] parton evolution. The predictions provide a reasonable description of the present data, although the data are more precise than the spread in QCD predictions. The measurements of $\tilde{\sigma}^{b\bar{b}}$ are also shown in Fig. 2 and the beauty data are reasonably well described by the QCD predictions. The measurements $F_2^{c\bar{c}}$ and $F_2^{b\bar{b}}$ are shown as a function of Q^2 for various x values in Fig. 3. The measurements of $F_2^{c\bar{c}}$ and $F_2^{b\bar{b}}$ show positive scaling violations which increase with decreasing x.

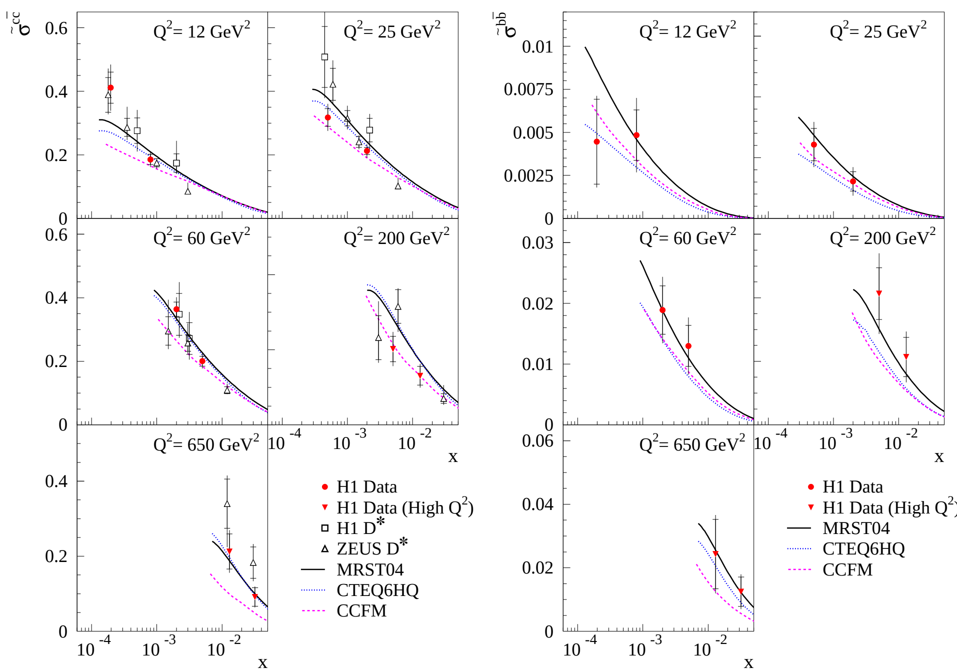

Fig. 2. The measured reduced cross section $\tilde{\sigma}^{c\bar{c}}$ (left) and $\tilde{\sigma}^{b\bar{b}}$ (right) shown as a function of x for 5 different Q^2 values.

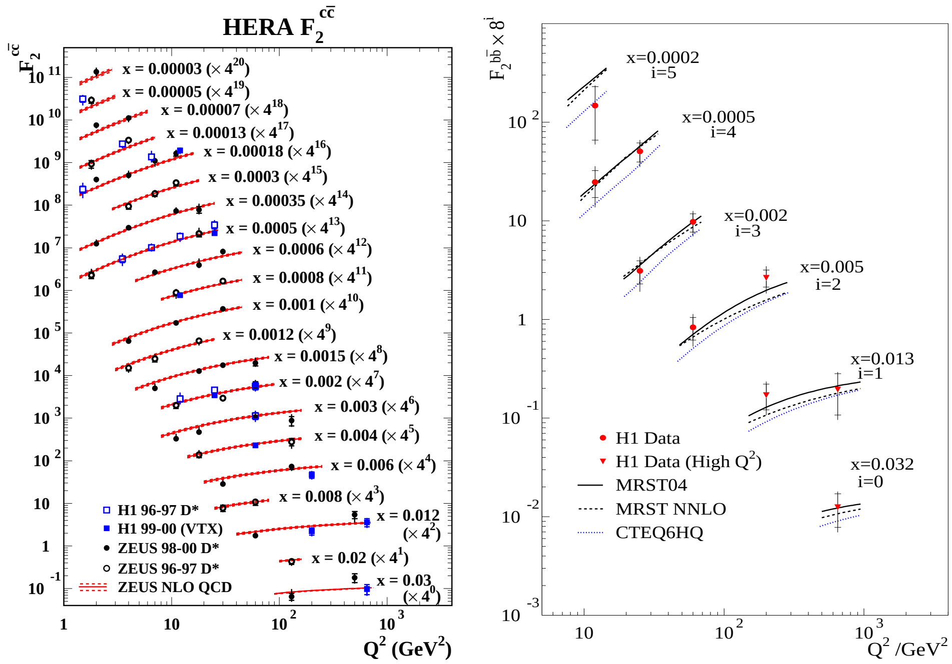

Fig. 3. The measured structure function $F_2^{c\bar{c}}$ (left) and $F_2^{b\bar{b}}$ (right).

4. Conclusion

The differential charm and beauty cross sections in DIS are measured by reconstructing D mesons or using the impact parameters of tracks from the decays of heavy hadrons. The cross sections and derived structure functions $F_2^{c\bar{c}}$ and $F_2^{b\bar{b}}$ are found to be well described by the predictions of perturbative QCD.

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