MEASUREMENT OF F2CC AND F2BB AT LOW Q2 AND X USING THE H1 VERTEX DETECTOR AT HERA

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Measurements of the structure functions F_2^{cc} and F_2^{bb} derived from inclusive charm and beauty cross sections in e^+p collisions at HERA are presented for values of photon virtuality $12 \leq Q^2 \leq 60$ GeV^2 and of the Bjorken scaling variable $0.0002 \leq x \leq 0.005$. The fractions of events containing charm and beauty quarks are determined using a method based on the impact parameter, in the transverse plane, of tracks to the primary vertex, as measured by the H1 vertex detector. This is the first measurement of F_2^{bb} in this kinematic range. The results are found to be compatible with the predictions of perturbative quantum chromodynamics and with previous measurements of F_2^{cc}.

1. Charm and beauty cross sections at HERA

The reduced charm cross section is related to the measured differential cross section by:

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

where the photon virtuality Q^2, the Bjorken scaling variable x and the inelasticity variable y are related to the centre of mass energy s of the ep collision by $Q^2=sxy$. An analogous equation holds for the reduced beauty cross section. At leading order the main production mechanism of heavy quarks is photon-gluon fusion and at low $Q^2 \sim m_{HQ}^2$ the masses of the heavy quarks must be taken into account; at higher Q^2 the masses of the heavy quarks can be safely neglected. Several predictions exist for the heavy quark cross sections at HERA for the transitional phase space between the massive and the massless regimes and they are compared to the experimentally observed values presented here.

2. Experimental method

2.1. *The signed impact parameter δ and significance distributions*

The analysis method uses the signed impact parameter δ, as a discriminator between light and heavy quarks. This relies on the good *rφ* hit resolution of 12 μm of the H1 vertex detector. For a detailed description of the analysis method along with detector descriptions, etc. the reader is referred to the publication of the results presented here [1]. Dividing the impact parameter by its error results in the significance variable, *S*, and the significance of the first, second and third highest absolute significance tracks, S_1, S_2 and S_3 respectively, can be calculated with caveats found in [1]. In order to further reduce detector resolution effects and the normalisation of the light quark component, the negative component of the significance distribution is subtracted from the corresponding positive bin, further emphasizing the large asymmetry of these "subtracted significance distributions" in the case of heavy quarks (see Fig. 1).

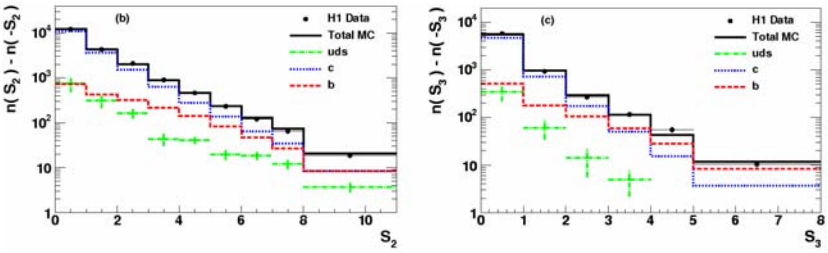

Figure 1. The subtracted significance distributions S_2 and S_3 used to determine the flavour composition in the analysis. The results of the fit to the data of the various simulated flavour components are included.

2.2. *Cross section extraction*

A least squares simultaneous fit is performed to the subtracted significance distributions S_1, S_2 and S_3 and the total number of inclusive events. The simulation components, i.e. contributions from light, charm and beauty quarks, are scaled in the fit in order to achieve the best fit to the data, with the main constraint on the light quarks coming from the total number of inclusive events and the subtracted significance distributions constraining the charm and beauty fractions. The results of this fit can then be used to calculate the heavy quark reduced cross sections defined in Eq. 1. which are related to the heavy quark structure functions F_2^{cc} and F_2^{bb} using the relation:

$$\tilde{\sigma}^{c\bar{c}} = F_2^{c\bar{c}} - \frac{y^2}{1+(1-y)^2} F_L^{c\bar{c}} \qquad (2)$$

3. Results

3.1. *The charm and beauty structure functions F_2^{cc} and F_2^{bb}*

Figure 2 shows the charm structure function F_2^{cc} as a function of Q^2 in bins of x. The structure functions are extracted using the definition in Eq. 2. Also shown are the results obtained from measurements using D^* mesons, an independent technique with different systematic uncertainties and extrapolations; the two experimental techniques agree well. The experimental data are compared to several QCD predictions: two (MRST04 [2] and CTEQ6HQ [3]) based on a variable-flavour number scheme which aims to provide reliable perturbative QCD predictions over the whole kinematic phase space and a third prediction is based on CCFM evolution [4]. All three QCD predictions give a reasonable description of the data.

Also shown in Fig. 2 is the beauty structure function F_2^{bb} as a function of x in bins of Q^2, together with the results of a similar analysis at higher Q^2. Again the three QCD predictions are also shown and, given the current experimental precision, give a good description of the data.

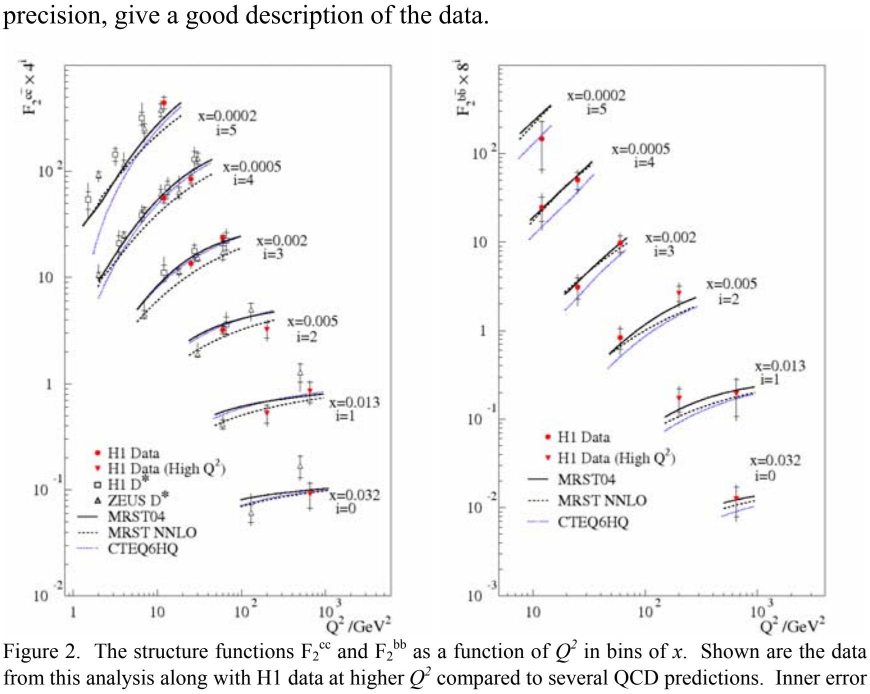

Figure 2. The structure functions F_2^{cc} and F_2^{bb} as a function of Q^2 in bins of x. Shown are the data from this analysis along with H1 data at higher Q^2 compared to several QCD predictions. Inner error bars show the statistical error; outer error bars show the statistical and systematic errors added in quadrature. Also shown in the case of the charm structure function are results obtained from measurements of D^* mesons.

4. Summary

Charm and beauty structure functions F_2^{cc} and F_2^{bb} have been measured in the Q^2 range from 12 to 60 GeV^2 using an analysis technique that exploits the tracking precision of the H1 vertex detector. Both structure functions are reasonably well described by QCD predictions and in the case of the charm structure function the data are in good agreement with measurements using D^* mesons.

References

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