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HEAVY FLAVOUR PRODUCTION IN *ep* COLLISIONS*

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A short overview of recent results on charm and beauty production from the H1 and ZEUS Collaborations at the *ep* collider HERA is presented. The heavy quark contribution to the proton structure function F_2 as well as differential cross-sections are shown. Results on the charm fragmentation are compared to measurements at e^+e^- colliders.

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1. Introduction

At HERA, 27.5 GeV electrons (or positrons) are collided with 920 GeV protons providing a center-of-mass energy of $\sqrt{s} = 318\,\mathrm{GeV}$. The H1 and ZEUS experiments each collected data corresponding to an integrated luminosity of about $500\,\mathrm{pb}^{-1}$. The dominant production process for heavy quarks at HERA is photon-gluon fusion, in which a photon emitted from the electron fuses with a gluon in the proton producing a quark antiquark pair. Thus the study of heavy flavour production offers a more direct sensitivity to the gluon density in the proton than the scaling violations of the inclusive structure function F_2. In addition, predictions of perturbative Quantum Chromodynamics (QCD) are expected to be reliable because of the hard scale provided by the heavy quark mass. The measurements are performed in two kinematic regimes: photoproduction where the exchanged photon is quasi-real ($Q^2 \approx 0\,\mathrm{GeV}^2$) and deep-inelastic scattering (DIS) at larger photon virtualities ($Q^2 \gtrsim 2\,\mathrm{GeV}^2$).

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2. Cross-section measurements

2.1. Charm measurements

Most experimental results for charm production at HERA use $D^{*\pm}$ mesons to identify the presence of charm quarks, exploiting the well known mass difference method. Next-to-leading order (NLO) QCD calculations [1, 2] agree with the measurements in photoproduction as well as DIS. The differential D^* cross-section as a function of the photon virtuality Q^2 [3] is described well over more than four orders of magnitude (Fig. 1 left). In order to study the charm production process further the correlation of the D^* with other particles is measured. A second parton in the event can be reconstructed as a jet. At small azimuthal differences between the D^* and the jet, where higher order processes are expected to contribute, the NLO prediction lies below the data [4] (Fig. 1 right).

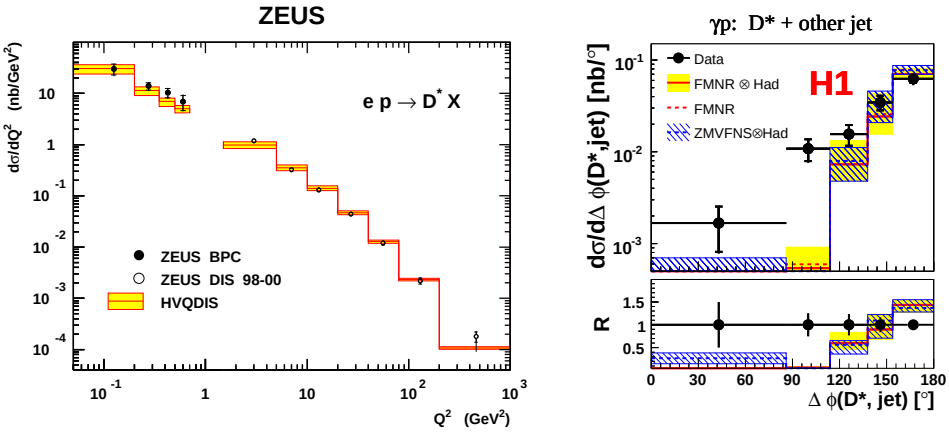

Fig. 1. D^* cross-section as a function of the photon virtuality Q^2 (left) and D^*+jet cross-section as a function of the azimuthal difference $\Delta\phi$ between the D^* and the jet (right).

2.2. Beauty measurements

Since the beauty cross-section at HERA is very small, reconstruction of exclusive hadrons is very difficult. Therefore, more efficient tagging methods which exploit either the long lifetime of B hadrons using precise silicon vertex detectors (displaced track method) or the large b quark mass using the transverse momentum of leptons with respect to jets ($p_{\mathrm{t,rel}}$ method), are used instead. These measurements are reasonably described by NLO calculations. The results in photoproduction, as a function of the transverse momentum of the b quark [5], are shown in Fig. 2.

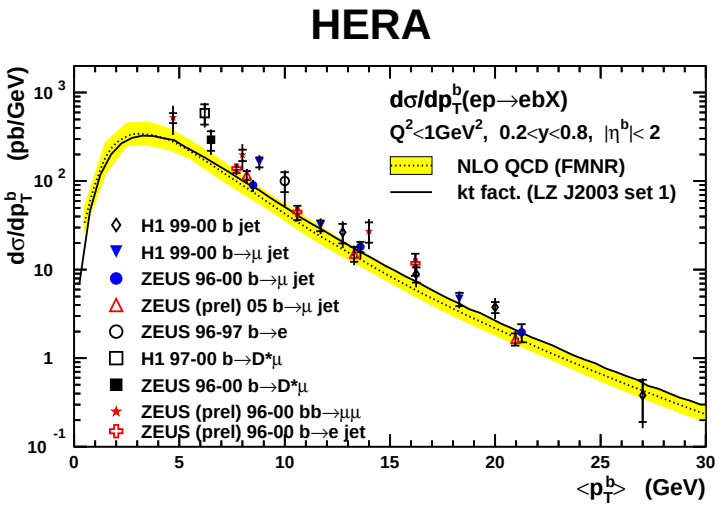

Fig. 2. Compilation of beauty cross-sections measured in photoproduction as a function of the mean transverse momentum of the b quark $< p_{\mathrm{T}}^{b} >$.

3. Contribution to the proton structure function F_2

The measurements using the displaced track method and the $p_{\mathrm{t,rel}}$ method allow the extraction of the fraction of heavy quark events in an event sample [6,7]. In the DIS case, this can be converted to the charm and beauty contributions $F_2^{c\bar{c}}$ and $F_2^{b\bar{b}}$ to the inclusive proton structure function F_2 (Fig. 3). $F_2^{c\bar{c}}$ can also be extracted from D meson cross-sections. The experimental results agree well with each other and with NLO QCD predictions based on proton parton distributions extracted from scaling violations.

4. Fragmentation

One important ingredient to the extraction of the charm production cross-section and the charm contribution $F_2^{c\bar{c}}$ to the proton structure function from measured D meson cross-sections is the fragmentation that describes the transition of a charm quark into a charmed hadron. The measurement of different charmed hadron cross-sections at HERA allows the calculation of fragmentation fractions $f(c \to D)$ [8,9] (Fig. 4 left). Within uncertainties they agree well with the results from e^+e^- annihilation experiments. Also the measured spectrum of the momentum fraction z transferred from the heavy quark to the hadron [10] is similar to the e^+e^- data indicating that fragmentation is universal, when accounting for expected differences in the perturbative part and for different z definitions as listed in Fig. 4 (right).

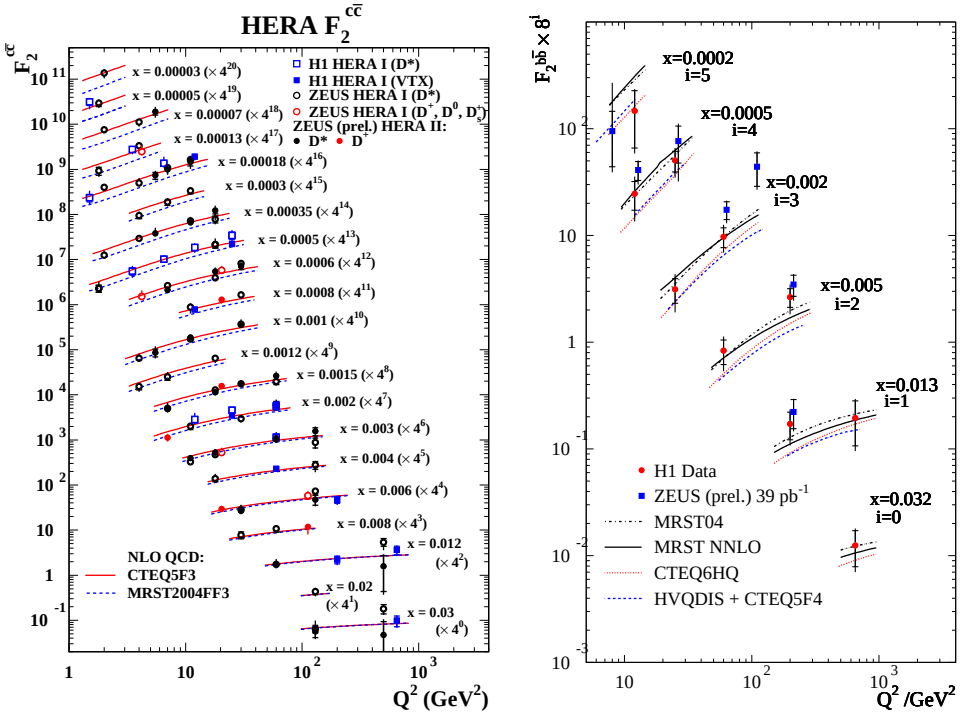

Fig. 3. Charm (left) and beauty (right) contribution to the proton structure function F_2.

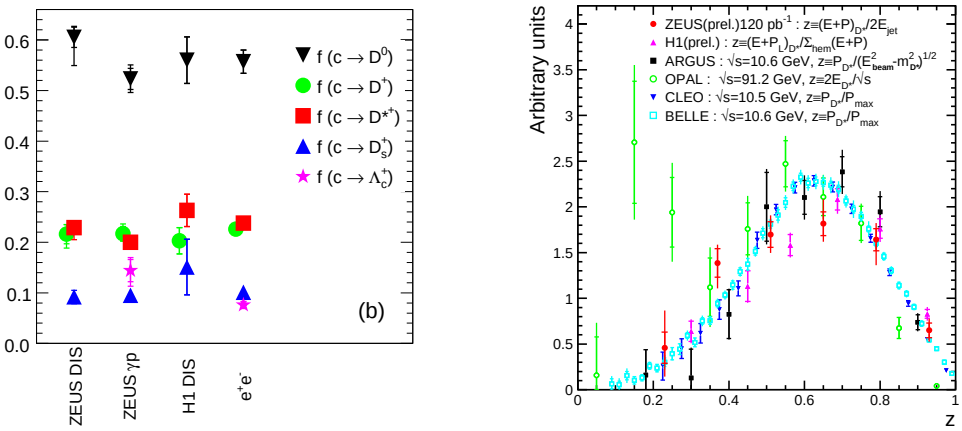

Fig. 4. Comparison of fragmentation fractions (left) and the fragmentation function for D^* mesons (right) between ep and e^+e^- data.

5. Summary

Heavy flavour production at HERA is intensively studied with various tagging methods. The measurements are reasonably well described by next-to-leading order perturbative QCD calculation.

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