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JET CROSS SECTIONS IN D^* PHOTOPRODUCTION

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Inclusive jet cross sections in D^* photoproduction have been measured using $78.6\ \mathrm{pb}^{-1}$ of data collected by the ZEUS detector. The measurement was performed in the kinematic region $Q^2 < 1\ \mathrm{GeV}^2$, $130 < W < 280$ GeV, $p_T(D^*) > 3$ GeV, $|\eta(D^*)| < 1.5$, $E_T^{\mathrm{jet}} > 6$ GeV and $-1.5 < \eta^{\mathrm{jet}} < 2.4$. Differential cross sections as functions of E_T^{jet} and η^{jet} are compared to a next-to-leading-order (NLO QCD) calculation where the charm quark is treated as a massive parton. Shapes of the cross sections are well described by the NLO QCD predictions after applying the hadronization correction. The normalization of the cross section is higher than the NLO QCD prediction but agrees within the theoretical uncertainty.

1 Introduction

Heavy quark production can be calculated using perturbative QCD (pQCD), where the hard scale is provided by the heavy quark mass or the large transverse momentum. Charm photoproduction has been studied by the ZEUS experiment by reconstructing the D^* meson to tag charm events. Differential cross sections of inclusive D^* photoproduction measured by ZEUS [1] show an excess of data over the NLO QCD prediction in a wide kinematic region. The discrepancy is largest in the medium transverse momentum ($p_T(D^*)$) and positive $\eta(D^*)$ region.

Measurements of jet cross sections in D^* explore a wider kinematic region by making use of the calorimeter rather than just the central tracking detector. They are also expected to have reduced theoretical uncertainties due to hadronization.

2 Analysis

The measurement of inclusive jet cross sections in D^* photoproduction has been performed using $78.6\ \mathrm{pb}^{-1}$ of e^-p and e^+p data measured by the ZEUS detector in the years 1998 - 2000.

The measurement was performed in the photoproduction regime characterized by $Q^2 < 1\ \mathrm{GeV}^2$, where Q^2 is the virtuality of the quasi-real photon emitted from the incoming electron. The center of mass energy of the photon-proton system, W, was restricted to $130 < W < 280$ GeV.

Charm tagging was performed by reconstructing a $D^{*\pm}$ meson in its decay mode, $D^{*+} \to D^0\pi_s^+ \to (K^-\pi^+)\pi_s^+$ and the charge conjugate. Tracks in the pseudorapidity region $|\eta^{\mathrm{track}}| < 1.75$ with transverse momentum $p_T > 0.4$ GeV for the pion and kaon forming the D^0 candidate and $p_T > 0.12$ GeV for the slow pion were required. D^0 candidates were selected if the invariant mass of the track pair was within $1.80 < m(K\pi) < 1.92$ GeV. The mass difference between the D^* and the D^0 candidates, ΔM, was required to be in the region $0.143 < \Delta M < 0.148$ GeV and the signal was extracted by subtracting the background estimated by the wrong charge combinations of kaon and pion which form the D^0, in this region. After all selections, 4861 ± 113 events were selected.

Jets were reconstructed by using the inclusive k_T algorithm in the p_T recombination scheme. The algorithm was run over energy flow objects (EFO), which represent final state particles using combined information from the tracks and the calorimeter clusters.

3 Inclusive jet cross section in D^* photoproduction

Differential cross sections have been measured for the process $ep \to D^* + \text{jet} + X$ as functions of E_T^{jet} and η^{jet}. With this definition, D^* mesons from beauty production is also included, though this contribution is small.

The measurements are compared to the NLO QCD calculation performed in the "massive" scheme by Frixione et al. (FMNR) [2]. The jet algorithm is run over final state partons in the NLO calculation and the D^* momentum is simulated using the Peterson function ($\epsilon = 0.035$) [3] for charm fragmentation. The correction from parton-level to hadron-level jets was done by multiplying the NLO QCD prediction by hadronization correction factors, evaluated using Monte Carlo (MC) simulations, HERWIG [4] and PYTHIA [5]. The average and difference of the two factors from the two MC programs were used as the central value and its uncertainty; the uncertainty was added in quadrature to the other theoretical uncertainties estimated as follows. The central theoretical prediction was calculated using a charm mass of $m_c = 1.5$ GeV and renormalization and factorization scales, $\mu_R = \mu_F = m_T$, where $m_T = \sqrt{m_c^2 + < p_T^c >}$ and $< p_T^c >$ is the average transverse momentum of the charm quark. Upper and lower bounds were estimated by changing the charm mass and the renormalization scale simultaneously to $m_c = 1.3$ GeV and $\mu_R = m_T/2$ (upper), or $m_c = 1.7$ GeV and $\mu_R = 2m_T$ (lower).

The inclusive jet cross sections as functions of E_T^{jet} and η^{jet} are presented in fig. 1 and fig. 2 respectively. The beauty contribution as estimated using PYTHIA, which reproduce ZEUS beauty photoproduction results, is generally small, contributing most at high E_T^{jet}. The measured cross sections are generally higher than the central values of NLO QCD predictions. The normalization is reproduced by taking the extreme values for mass and scales. The shapes of the cross-sections $d\sigma/dE_T^{\text{jet}}$ are well described by the NLO QCD predictions in all bins of η^{jet}. There is, however, some indication that the NLO QCD prediction underestimates the data at the very highest E_T^{jet}. The shapes of the cross-section $d\sigma/d\eta^{\text{jet}}$ are also described by the NLO QCD after applying the hadronization correction. Predictions of NLO QCD without the hadronization correction have a different shape such that the prediction is higher in the rear and lower in the forward direction.

By associating a D^* and a jet, jets having a specific quark flavour, i.e. charm can be tagged. Such a jet is called *D^* jet* with any other jet in the event, the flavour of which is unknown, called *other jet*. By determining the properties of the other jet, the nature of the partonic sub-process can be explored. In Fig. 3 and 4 the cross-section $d\sigma/dE_T^{\rm jet}$ and $d\sigma/d\eta^{\rm jet}$ are presented for D^* jets and other jets. As in the inclusive case, the shapes of all distributions are well described by the NLO QCD with hadronization correction. This is even true for the other jets in the furthest forward region measured where resolved photon processes are expected to dominate.

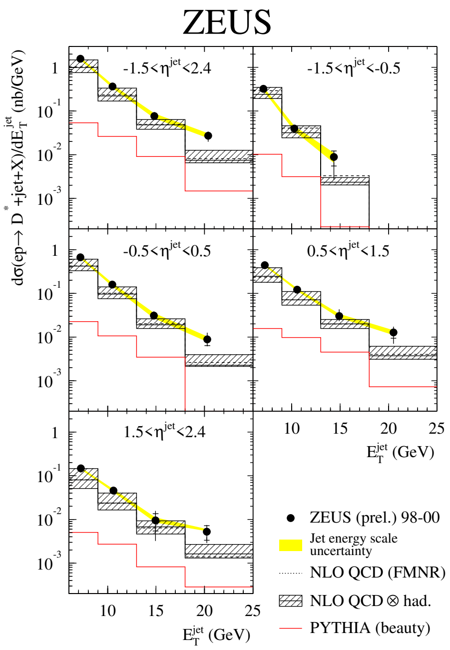

Figure 1. Inclusive $E_T^{\rm jet}$ cross section for $ep \to D^* + {\rm jet} + X$ in different regions of $\eta^{\rm jet}$. The data (dots) with its uncertainty from the jet energy scale (shaded band) are shown compared to the NLO QCD prediction with hadronization corrections (solid line) and its associated uncertainty (hatched band). The parton-level prediction from NLO QCD is also shown (dashed line) and the expected beauty contribution estimated from PYTHIA is also indicated.

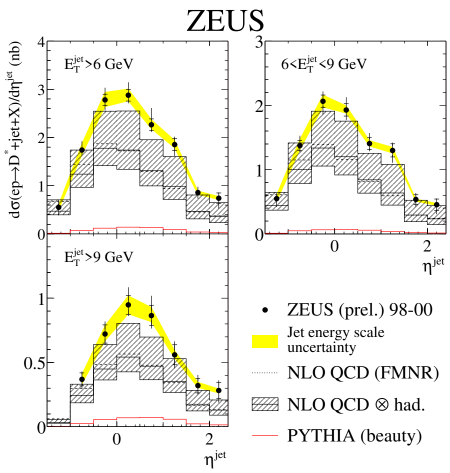

Figure 2. $d\sigma/d\eta^{\rm jet}$ in different $E_T^{\rm jet}$ regions. Lines and bands are the same as fig. 1.

Acknowledgements

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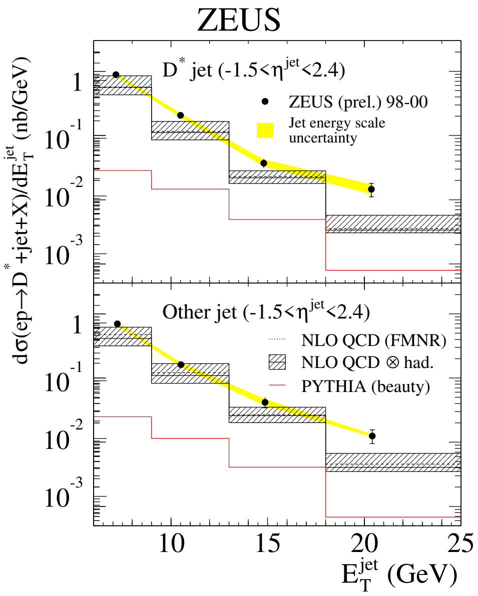

Figure 3. $d\sigma/dE_T^{\rm jet}$ for D^* jet and other jet, in different $\eta^{\rm jet}$ regions. Lines and bands are the same as fig. 1.

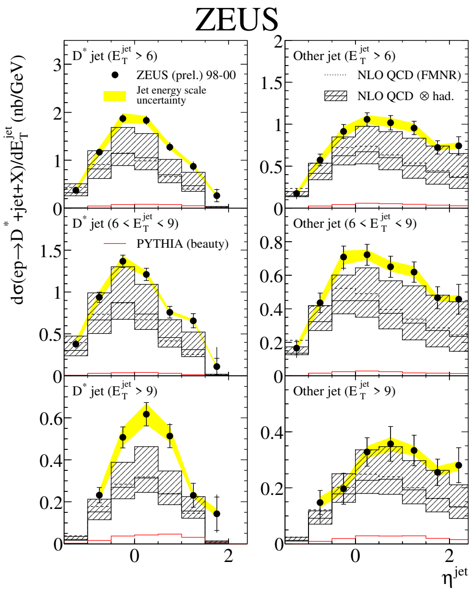

Figure 4. $d\sigma/d\eta^{\rm jet}$ for D^* jet and other jet, in different $E_T^{\rm jet}$ regions. Lines and bands are the same as fig. 1.

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