BEAUTY PRODUCTION WITH THE ZEUS HERA II DATA

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Beauty production has been measured with the ZEUS detector at HERA II using e^+p data collected in 2003/04. Two preliminary measurements of beauty production in events containing jets and a muon are presented. The first exploits the new ZEUS microvertex detector to measure the b content in photoproduction events by means of the muon impact parameter and its transverse momentum relative to the closest jet. The second measurement determines the b content of DIS events by using the relative transverse momentum of the muon alone. The results of both measurements were found to be in agreement with previous results and with QCD predictions.

1. Introduction

The large increase in luminosity of the HERA collider in its second running period allows for many precise measurements in Quantum Chromodynamics. The centre–of–mass energy of the HERA collider ($\sqrt{s} = 318\,\text{GeV}$) is sufficient for the production of heavy quarks. Here, the b quark is of special interest since its large mass provides an additional hard scale that makes perturbative QCD predictions more reliable and thus allows for thorough QCD tests.

A common signature of heavy quark production events are high–$p_\perp$ jets containing a semi–leptonic decay. Events with jets and muons have previously been observed with the ZEUS detector both in the photoproduction and in the DIS regime.[1,2] The beauty component was extracted by means of the muon momentum transverse to the associated jet, $p_\perp^{\text{rel}}$. Because of the large mass of the b quark this relative momentum of muons from semi–leptonic B decays is on average larger than that of muons from charm or light–flavour decays. In these measurements and in measurements performed by the H1 collaboration agreement with

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next–to–leading order QCD predictions was found. However, the prediction tends to underestimate the data slightly in particular at low $p_\perp$ which is the subject of recent analyses.

Since the HERA upgrade it is also possible to use beauty life–time information, because a micro–vertex detector was installed in the ZEUS detector. This detector is made of silicon strips and provides a precise measurement of three–dimensional vertex position. Preliminary results of the ZEUS collaboration on open beauty production both in photoproduction and DIS are presented here, where in the first case in addition to $p_\perp^{\mathrm{rel}}$ also the signed impact parameter variable of muons, δ, measured with the micro–vertex detector is exploited.

2. Beauty in γp–Scattering

For this measurement all e^+p data taken in the year 2004 were used, corresponding to an integrated luminosity of $33\,\mathrm{pb}^{-1}$. Events with a four–momentum transfer of $Q^2 < 1\,\mathrm{GeV}^2$ containing at least two jets with $p_\perp > 7(6)\,\mathrm{GeV}$, one of which associated to a muon with $p_\perp^\mu > 2.5\,\mathrm{GeV}$ were selected. The beauty, charm and light–flavour contents of this sample were obtained by a simultaneous χ^2–fit to the signed impact parameter, δ, and the relative transverse momentum, $p_\perp^{\mathrm{rel}}$, of the associated muon. Here, templates of $b\bar{b}$, $c\bar{c}$ and light–flavour distributions produced by the PYTHIA event generator (leading order and parton shower) have been used for the fit. In Fig. 1 the results of the fit for both variables together with the 1σ confidence region are shown.) A beauty fraction of $f_b = (16.7 \pm 2.6)\,\%$ was obtained. The impact of the micro–vertex detector information on the combined fit is clearly visible. The measured cross–section for the reaction $ep \to e' + b\bar{b} + X \to e'$ + dijet + μ + X as a function of the muon transverse momentum is depicted in Fig. 2. The result is in good agreement with measurements from the HERA I running period, based on more than three times larger integrated luminosity, as well as with next–to–leading order QCD predictions computed with the program FMNR.[4]

3. Beauty in Deep Inelastic Scattering

This analysis is based on all ep data taken in the running period 2003/04 which means an integrated luminosity of $39\,\mathrm{pb}^{-1}$. DIS events ($Q^2 > 4\,\mathrm{GeV}^2$) containing at least one jet with $E_\perp > 5\,\mathrm{GeV}$ and an associated muon with $p_\perp^\mu > 1.5\,\mathrm{GeV}$ are selected. Here, the amount of $b\bar{b}$ events was determined by a fit to the $p_\perp^{\mathrm{rel}}$ distributions alone (see Fig. 3). The RAPGAP event generator well describes the data after having been scaled by an overall factor 2.49. Figures 4–6 show the singly and doubly differential $b\bar{b}$ production cross–sections together with the leading or-

der+parton shower Monte Carlo scaled by a factor of 2.49. The measurement is consistent in all variables with the scaled Monte Carlo.

References

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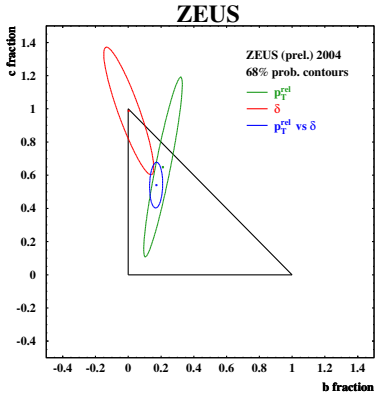


Figure 1. ZEUS analysis of photoproduction data at HERA II. A two–dimensional χ^2–fit of the muon impact parameter, δ and $p_\perp^{\mathrm{rel}}$ is used to obtain the beauty and charm normalisation scales. The small ellipse represents the 1σ confidence region of the two–dimensional fit. The large ellipses result from one–dimensional fits.

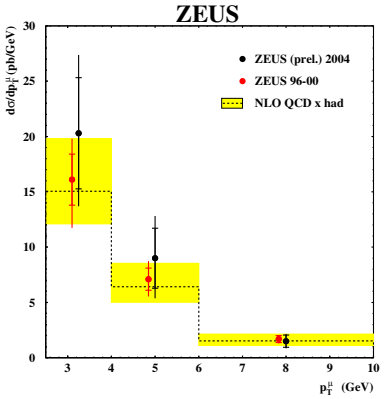


Figure 2. Cross–sections for open beauty production in γp–scattering as a function of the relative transverse momentum of the muon, $p_\perp^{\mathrm{rel}}$, for events with $Q^2 < 1\,\mathrm{GeV}^2$, $0.2 < y < 0.8$, $p_\perp^{\mathrm{jet}} > 7(6)\,\mathrm{GeV}$, $|\eta|^{\mathrm{jet}} < 2.5$, $p_\perp^{\mu} > 2.5\,\mathrm{GeV}$ and $-1.6 < \eta^{\mu} < 2.3$. Next–to–leading order QCD predictions and results of HERA I measurements are also shown.

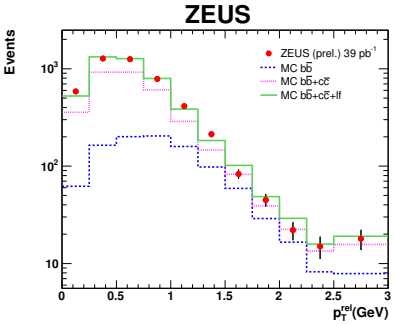


Figure 3. Determination of the $b\bar{b}$ amount in DIS events by a fit of the $p_\perp^{\rm rel}$ distributions.

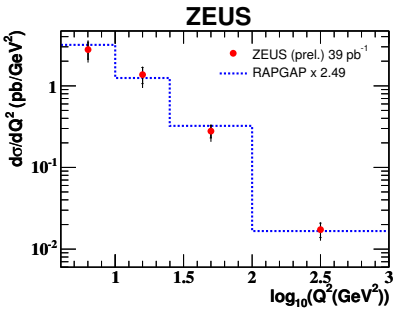
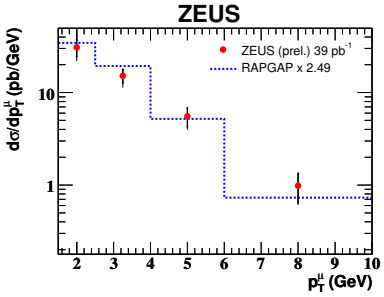
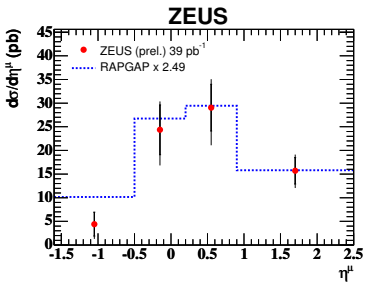


Figure 4. Differential cross–section in deep inelastic scattering as a function of the momentum transfer, Q^2.

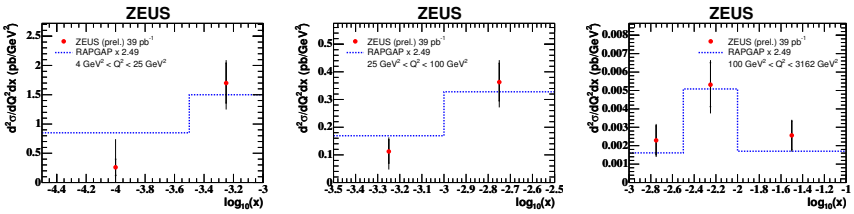


(a)



(b)

Figure 5. Differential $b\bar{b}$ production cross–section in DIS events with $Q^2 > 4\,\mathrm{GeV}^2$ containing least one jet with $E_\perp^{\rm jet} > 5\,\mathrm{GeV}$, $-2.0 < \eta^{\rm jet} < 2.5$ and an associated muon with $p_\perp^\mu > 1.5\,\mathrm{GeV}$ as function of (a) $p_\perp$ and (b) η of the muon. The line shows the scaled RAPGAP Monte Carlo.



(a) $4 < Q^2 < 25\,\mathrm{GeV}^2$ (b) $25 < Q^2 < 100\,\mathrm{GeV}^2$ (c) $100 < Q^2 < 3162\,\mathrm{GeV}^2$

Figure 6. Double–differential cross–section for open beauty production in deep inelastic scattering at ZEUS as function of Q^2 and x.