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B and c quark production at CDF, $\sqrt{s} = 1.96$ TeV

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Abstract. Measurements of heavy quark production at the Tevatron have previously shown discrepancies with theoretical predictions The increased luminosity of Run 2 will allow CDF to investigate b and c quark production more precisely. In this review three measurements, based on a subset of current data, are presented: charm meson production; J/ψ production; production of an energetic photon in conjunction with a b or c quark jet.

PACS. 12.38.Qk Experimental tests of Quantum Chromodynamics – 13.85.Ni Inclusive production with identified hadrons

1 Introduction

Previous measurements of heavy quark production at CDF have shown discrepancies with theoretical predictions [1]. Both charm and bottom cross-sections are consistently larger than next to leading order estimates. Recent improved predictions [2] have reduced this discrepancy although large theoretical uncertainties still exist [1].

One of the aims of CDF in Run 2 is to test these predictions with much larger event samples, and also using different decay channels to those examined previously. CDF has undergone a series of detector upgrades in readiness for run 2 which help increase sensitivity. For example, a displaced track trigger has been introduced which allows large samples of hadronically decaying b and c quark events to be isolated for the first time. In addition the tracking volume and silicon detectors have been replaced and improved, and the kinematic coverage of J/ψ triggers extended to all transverse momenta.

In this note three measurements sensitive to b and c quark production are presented: a measurement of the charm meson production cross-section (Sect. 2); a measurement of the J/ψ production cross-section (Sect. 3); a measurement of the production cross-section for events containing a photon produced in conjunction with a b or c quark (Sect. 4).

2 Charm meson production cross-section

CDF has made a direct measurement of the charm meson production cross-section, using 5.8 pb^{-1} of data triggered by the displaced track trigger. Over 70 000 D^0, D$^+$, D^{*+} and D$_s^+$ mesons (and charge conjugates) have been fully reconstructed within a rapidity range of ±1. Figure 1 shows the invariant mass of reconstructed D^0 mesons as an example. The fraction of non-prompt events in each sample is estimated by fitting the impact parameter distribution of the reconstructed charm mesons (Figure 2). Once estimated, the charm meson production cross-section can then be calculated and compared to next to leading order predictions [3]. Results for the production cross-section of all four charm mesons are given in Table 1. Figure 3 shows the ratio of measured to predicted cross-section for D^0 production. It can be seen that the data lie slightly above the theoretical prediction.

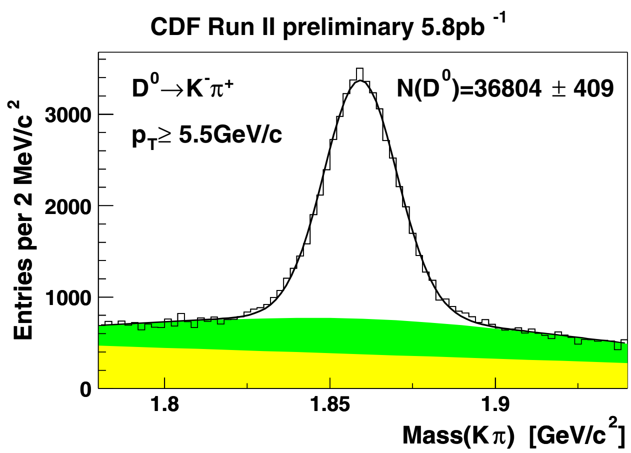

Fig. 1. Invariant mass of the reconstructed D^0 sample. The yellow and green bands show the contribution from combinatoric and wrong kaon-pion assignment respectively

[1] See the proceedings of Douglas Ross's presentation for more details

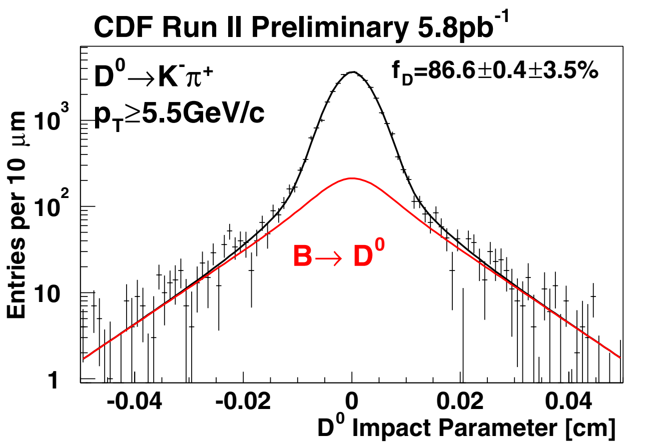

Fig. 2. Impact parameter distribution for reconstructed D^0 mesons. The red line denotes the fitted fraction of non-prompt contributions

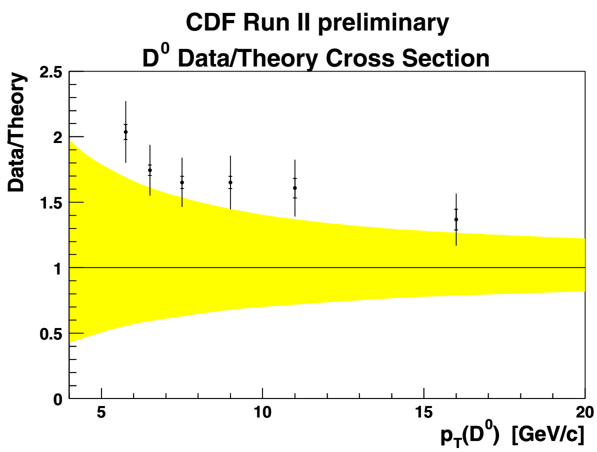

Fig. 3. Ratio of measured to theoretical D^0 production cross-section. The yellow band represents the theoretical uncertainty due to the choise of the renormalisation scale

Table 1. Measured charm meson cross-sections. The first error quoted is statistical, the second systematic

$\sigma(D^0, p_T \geq 5.5 \text{ GeV})$	=	$13.3 \pm 0.2 \pm 1.5\ \mu$b
$\sigma(D^{*+}, p_T \geq 6.0 \text{ GeV})$	=	$5.2 \pm 0.1 \pm 0.8\ \mu$b
$\sigma(D^+, p_T \geq 6.0 \text{ GeV})$	=	$4.3 \pm 0.1 \pm 0.7\ \mu$b
$\sigma(D_s^+, p_T \geq 8.0 \text{ GeV})$	=	$0.75 \pm 0.05 \pm 0.22\ \mu$b

3 J/ψ production cross-section

J/ψ mesons can be produced promptly, or via b hadron decay. A measurement of the J/ψ production cross-section is thus sensitive to both b and c quark production, and was used in Run 1 to extract the b quark production cross-section. So far in Run 2 39.7 pb^{-1} of data have been analysed to isolate a sample of 300 000 events containing a J/ψ meson within a rapidity region of ± 1. Due to improvements in the CDF muon trigger system, a sample of J/ψ mesons has been amassed over the full transverse momentum distribution. The J/ψ cross-section has been measured to be

$$\sigma(J/\psi) = 240 \pm 1(\text{stat})^{+35}_{-28}\ (\text{sys})\ \text{nb}$$

(see Fig. 4), which is consistent with that measured previously [4]. Comparisons to theoretical predictions are forthcoming.

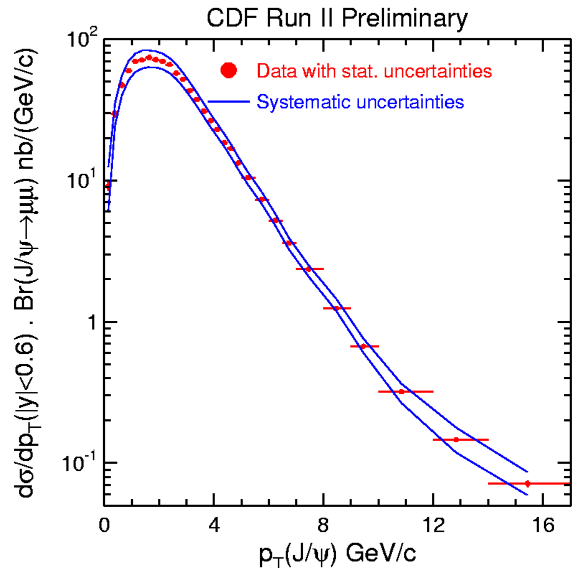

Fig. 4. Differential J/ψ production cross-section as a function of J/ψ pt

4 Photon + heavy flavour production

Studying photon + b and photon + c quark production is interesting from a number of QCD and new physics standpoints. The individual cross-sections are sensitive to general b and c production, and a measurement of the cross-section ratio between photon + b and photon + c events can be related to the charm quark content of the proton. In addition, many new physics channels (gauge mediated SUSY and technicolor, for example) can contribute to these two topologies.

Events containing an energetic isolated photon (above 25 GeV) are selected within a rapidity of ± 1 from a dataset corresponding to an integrated luminosity of 66.7 pb^{-1}. b and c quarks are identified by requiring a jet containing a separated secondary vertex in addition. The fractions of b and c quarks in the data are determined by fitting the resultant secondary vertex mass to Monte Carlo templates corresponding to different quark types. Neutral pion photon backgrounds are estimated directly from data and subtracted to obtain production cross-sections as a function of photon transverse energy. Results are shown in Figures 5 and 6 for the individual photon + b and photon + c cross-sections, and in Fig. 7 for the cross-section ratio. All measurements are consistent with leading order predictions so far.

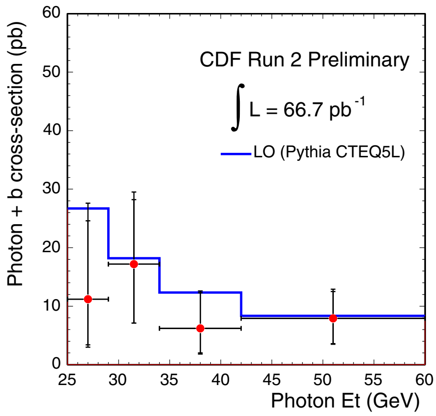

Fig. 5. Measured photon + b quark cross-section (points) as a function of photon Et. The line denotes Pythia LO predictions

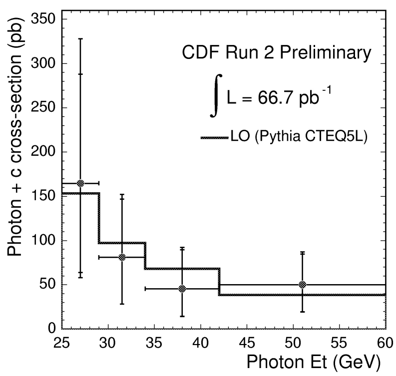

Fig. 6. Measured photon + c quark cross-section (points) as a function of photon Et. The line denotes Pythia LO predictions

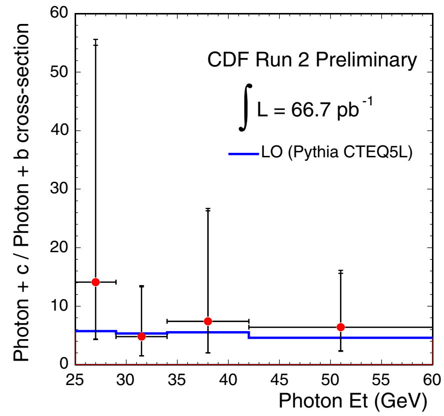

Fig. 7. Ratio of photon+b to photon+c cross-sections. The line denotes Pythia LO predictions

5 Conclusions

Previous measurements of b and c quark production at CDF have shown discrepancies when compared to theoretical predictions. One of the aims of Run 2 is to verify these observations at higher centre-of-mass energies. The charm production cross-section has been measured with a subset of the current dataset, is consistent with Run 1 measurements, and still slightly higher than theoretical predictions. The J/ψ production cross-section has been determined and is also consistent with Run 1 measurements. Finally, a new analysis to measure b and c production in conjunction with an energetic photon is presented. Results are consistent with leading order predictions, although currently statistically limited.

I should like to thank my CDF colleagues for their help in compiling this review, and the organisers for providing such an enjoyable conference.

References

1. See, for example:
   D. Acosta et al., The CDF Collaboration: Phys. Rev. D **65**, 052005 (2002);
   F. Abe et al., The CDF Collaboration: Phys. Rev Lett. **75**, 1451 (1995);
   F. Abe et al., The CDF Collaboration: Phys. Rev. Lett. **71**, 500 (1993);
   F. Abe et al., The CDF Collaboration: Phys. Rev. Lett. **69**, 3704 (1992)
2. M. Cacciari and P. Nason: UPRF-2002-4 (2002)
3. M. Cacciari and P. Nason: hep-ph/0306212 (2003)
4. F. Abe et al., The CDF Collaboration: Phys. Rev. Lett. **79**, 572 (1997)