HEAVY FLAVOR PRODUCTION IN CDF*

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This paper summarizes results on heavy flavor production at CDF. Heavy flavor production is classified in low and high $p_{\rm t}$. While at low $p_{\rm t}$ it is possible to perform exclusive reconstruction of the final state, at higher $p_{\rm t}$ heavy flavors are identified from jets coming from a secondary vertex.

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1. Introduction: why studying heavy flavors at hadron colliders

Hadron colliders are an hostile environment for studying complex events like those originating from heavy flavor decays, but it is possible to profit from the large cross section and luminosity that for the Tevatron parameters yields a rate for b of a few KHz and much larger for charm. The study of b production is an interesting problem for perturbative QCD. Since the b mass is larger than the QCD scale, perturbative expansion is expected to work quite well in this case.

2. Charm production

One of the first measurements performed in CDF was the cross section of exclusively reconstructed charm states: $D^0 \to K\pi$, $D^* \to D^0\pi$, $D^+ \to K^-\pi^+\pi^+$, $D_s^+ \to \phi\pi^+$. The analysis has been carried on with 5.8 ± 0.3 pb$^-$1 of data, collected during the first months of Run II. Events from prompt charm or from b decays have been distinguished fitting the distribution of the impact parameter of the charm system. This results in a direct charm fractions of about 85%. The measured differential cross section is in good agreement with theory predictions, even if on the upper side of the theory error band.

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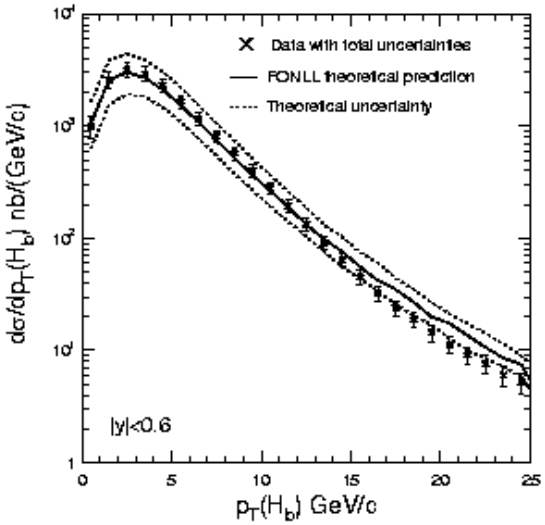

Fig. 1. b production cross section from exclusively-reconstructed J/Ψ decays.

3. b production in J/ψ

This analysis requires two muons of 2 GeV $p_{\rm t}$, but no cut on the total $p_{\rm t}$ of the system. To get the b production component, in every J/Ψ $p_{\rm t}$ bin the distribution of the variable $L_{xy}/p_{\rm t}(J/\Psi)/M(J/\Psi)$ is fitted. The total b cross section is obtained de-convoluting the J/Ψ branching ratio from the b fraction, and is shown in Fig. 1.

4. Inclusive b-jet production

The measurements presented in the next two sections deal with hadronic jets. Heavy flavor production is identified from the presence of a secondary decay vertex in the event. The efficiency of this "b-tagging" algorithm is about 40%, and depends on $p_{\rm t}$; it has been studied from Monte Carlo and cross-checked using b-enhanced samples with isolated leptons. To merge particles in jets, the Midpoint algorithm, infrared and collinear safe, has been used. The b fraction is estimated for every $p_{\rm t}$ bin making a distribution of the reconstructed invariant mass of the secondary vertex, and fitting it using templates coming from Monte Carlo for b and $c+$ light jets.

The differential inclusive b-jet cross section is shown in Fig. 2, compared to leading-order (Pythia) Monte Carlo. The ratio between data and Pythia is about 1.4, giving an estimate of the relevance of higher orders in this measurements.

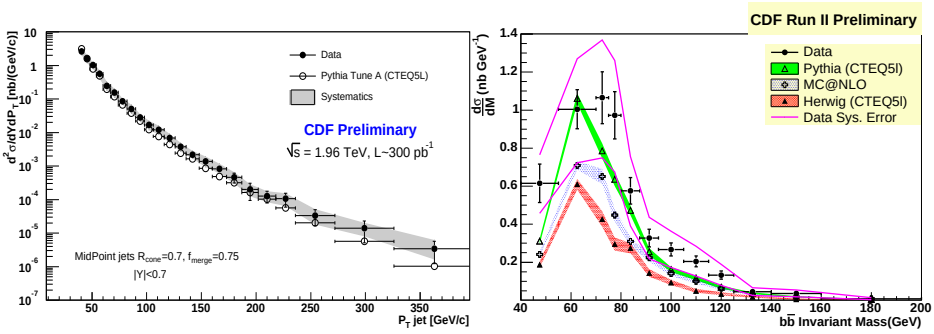

Fig. 2. Left: Differential cross section for b jets. Right: Invariant mass of the b–$\bar{b}$ system in the double b analysis.

5. Production of b-jet pairs

A similar analysis has been carried on to measure production of b–$\bar{b}$ jets. The requirement in this case is to have two tagged jets in the central region ($|\eta| < 1.2$), and also in this case the invariant mass of the secondary vertex is used to determine the b content of the tagged jets. The measured b–$\bar{b}$ invariant mass is shown in Fig. 2, compared with two leading-order and one next-to-leading order Monte Carlo codes. We see that the agreement with the next-to-leading order code is not better than Pythia, probably due to the fact that the latter gives a better description of the underlying event.

6. Associated production of heavy flavors and photons

Photon production in a hadron collider is overwhelmed by a large background due to π^0 decays in $\gamma\gamma$; it is possible to distinguish the two by looking at the shape of the signal in the preshower detector in front of the calorimeter, or in a wire chamber located inside the calorimeter. It is, however, not possible to perform an event-by-event separation of signal and background, so only a distinction on a statistical basis is possible. Also in this case the secondary vertex mass is used to identify the quark type, but instead of just separating the b from the rest, a fit to three distributions, for b- c- and light-quarks is performed. Cross sections as a function of photon $E_{\rm t}$ have been measured, and found to be in good agreement with LO Monte Carlo production.

7. Conclusions

CDF has a broad program in heavy flavor production studies (not to mention decays, oscillations *etc.*) thanks mainly to its tracker. We reported measurement of charm cross section, and b cross section in the J/Ψ channel as well as inclusive studies performed on b jets, b jet pairs and b and c jets associated with photons.