FERMILAB-CONF-05-626-E

Inclusive and dijet b productions at CDF

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Abstract. This contribution reports recent CDF measurements of the inclusive b-jet and $b\bar{b}$ dijet production cross sections obtained at the Tevatron Run II in $p\bar{p}$ collisions at $\sqrt{s} = 1.96$ TeV. Preliminary results are in reasonable agreement with QCD predictions.

Keywords: Tevatron, CDF, QCD, b-jet, inclusive, dijet, production
PACS: 13.85.Ni, 13.87.Ce

INTRODUCTION

At the Tevatron, the total $b\bar{b}$ cross section is about 50 μb which results to an event rate of few kHz and very high statistics. Beauty production measurements thus provide stringent test of QCD predictions.

In Run I, CDF and D0 have reported large discrepancies between observed and predicted beauty cross sections [1, 2]. This led to many developments both in the theoretical calculations and the experimental approach [3]. From the theoretical side, a major improvement was the implementation of the Fixed-Order with Next-to-Leading-Log (FONLL) calculations [4] in which the resummation of logarithmic terms, with Next-to-Leading-Logarithmic accuracy (NLL), is matched with the Fixed-Order (FO), exact Next-to-Leading-Order (NLO) calculation for massive quarks. There have also been substantial changes in the Parton Distribution Functions (PDFs) and the bottom fragmentation function as extracted from HERA and LEP data. From the experimental side, there have been many improvements in the data treatment for instance avoiding deconvolution and extrapolation to the quark level with Monte Carlo simulations and using only real observables such as b-hadrons and b-jets. CDF has recently reported a measurement of the b-hadron production cross section in Run II in very good agreement with latest theoretical predictions [5].

The b-jet production is also very interesting because it allows to investigate perturbative QCD (pQCD) with rather small theoretical uncertainties from fragmentation processes as b-jets include most of the b quark fragmentation remnants. CDF preliminary measurements of the inclusive b-jet and $b\bar{b}$ dijet production cross sections in $p\bar{p}$ collisions at $\sqrt{s} = 1.96$ TeV are presented in the following.

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[1] Régis Lefèvre is supported by the EU funding under the RTN contract: HPRN-CT-2002-00292, Probe for New Physics.

INCLUSIVE B-JET PRODUCTION

CDF has measured the inclusive b-jet production cross section for jets in the central rapidity region, $|y^{jet}| < 0.7$. The measurement is based on about 300 pb^{-1} of Run II data. Jets were reconstructed with the midpoint algorithm [6]. This iterative seed-based cone algorithm uses midpoints between pair of jets as additional seeds which makes the clusterization procedure infrared safe [7]. The cone radius in the $Y - \phi$ space was set to $R_{cone} = 0.7$, the merging fraction to $f_{merge} = 75$ %.

The analysis exploits the good tracking capabilities of the CDF detector [8] and relies on the reconstruction of secondary vertexes to identify *b*-jets using displaced tracks within the jet cone. Taking advantage of the long lifetime of the *b* hadrons, the tagging is based on the significance of the impact parameter and of the decay length L_{xy}. Furthermore, the sign of L_{xy} is used to reject mis-tagged jets.

To extract the flavor content of tagged jets the shape of the secondary vertex mass distribution is used. Although a full reconstruction of the hadron invariant mass is in general not possible because of the presence of neutral particles, the invariant mass of the tracks used to find the secondary vertex provides a good discrimination between *b*-jets and *c* or light flavor jets. The fraction of *b*-jets is obtained fitting to the data Monte Carlo templates of *b*-jets on one hand and of *c*-jets plus light flavor jets on the other hand. The fit is performed independently for each jet transverse momentum bin considered in the cross section measurement.

Figure 1 (left) shows the distribution of the mass of the secondary vertex for jets with $82 < p_T^{jet} < 90$ GeV/c as an example. The *b*-jet contribution has a quite different shape than the one corresponding to *c*-jets plus light flavor jets. For the fitted fraction of *b*-jets, 34 % in this p_T^{jet} bin, the Monte Carlo reproduces very well the data summing both contributions.

Figure 1 (right) shows the measured inclusive b-jet production cross section. The measurement is fully corrected to the particle level to compensate for inefficiencies, energy losses at the calorimeter level and detector resolution. It extends over p_T^{jet} between 38 and 400 GeV/c. This is a considerable improvement with respect to DØ Run I measurement which was limited to $p_T^{jet} < 100$ GeV/c [9].

The main systematic error comes from the jet energy scale for which a conservative uncertainty of 5 % have been considered, although on going studies are investigating the possibility to reduce it to 3 %. On the last bins, an important contribution to the systematic uncertainties comes from the statistics of the Monte Carlo templates used to fit the data in the extraction of the *b*-jet fraction: bigger Monte Carlo samples are being generated to reduce this error.

The measured *b*-jet cross section is here compared to the prediction from PYTHIA Monte Carlo [10]. This prediction was obtained using CTEQ5L PDFs [11] and a special set of PYTHIA parameters, tuned on Run I data to reproduce the underlying event activity in the transverse region, denoted as PYTHIA-Tune A [12]. A reasonable agreement is observed considering the fact that PYTHIA integrates matrix element calculations at Leading-Order only. A comparison to NLO pQCD [13] is in progress.

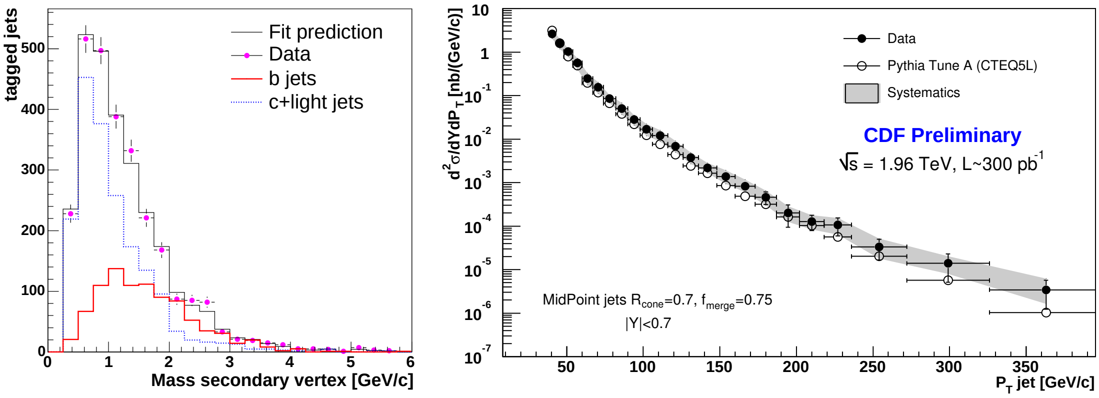

FIGURE 1. *Left:* Mass of the secondary vertex distribution for jets with $82 < p_T^{jet} < 90$ GeV/c. Fitted prediction is overlaid on the data. *b*-jet contribution as well as the one from *c*-jets plus light flavor jets are also reported. *Right:* Differential inclusive b-jet production cross section as a function of p_T^{jet}. The measurement is fully corrected to the particle level. Data points include the statistical errors, the shade band represents the systematic uncertainties. Particle level predictions from PYTHIA-Tune A are overlaid on the data.

INCLUSIVE DIJET B PRODUCTION

A preliminary measurement of the $b\bar{b}$ dijet production cross section has been carried out using a small sample of CDF Run II data. Jets were reconstructed using the JetClu Run I cone algorithm [14] with a cone radius of $R_{cone} = 0.7$ in the $\eta - \phi$ space and a merging fraction of $f_{merge} = 75$ %. As in the previous analysis, the *b*-jet identification is based on the reconstruction of secondary vertexes using displaced tracks within the jet cone and the b-jet content is extracted fitting the secondary vertex mass distribution to the data. Two tagged jets with pseudo-rapidities $|\eta| < 1.2$ and transverse energies $E_T > 30$ GeV for the leading jet and $E_T > 20$ GeV for the second one were required.

Figure 2 shows the differential inclusive $b\bar{b}$ dijet production cross sections measured as a function of the angle between the two jets in the transverse plane $\Delta\phi_{jj}$ and of the invariant mass of the two jets M_{jj}. The $\Delta\phi_{jj}$ distribution shows that the event selection preferentially picks out the leading order flavor creation process when asking for two central b-jets. NLO contributions are however not negligible at small opening angles.

The measurement is compared to predictions from a small MC@NLO [15, 16] sample. In this program, NLO pQCD calculations are matched with parton showers, HERWIG [17] event generator is used. Default MRST2001 PDFs [18] were used. The multiple parton interactions generator JIMMY [19] with default parameters was linked to HERWIG to better take into account the underlying event. Data and theory agree reasonably well.

In the future, the jet clusterization will be done with the midpoint algorithm instead of the JetClu Run I cone algorithm which may compromises meaningful comparisons with pQCD calculations as it is not infrared safe. Work is in progress to include the full data sample as well as bigger MC@NLO samples in order to test QCD predictions more accurately.

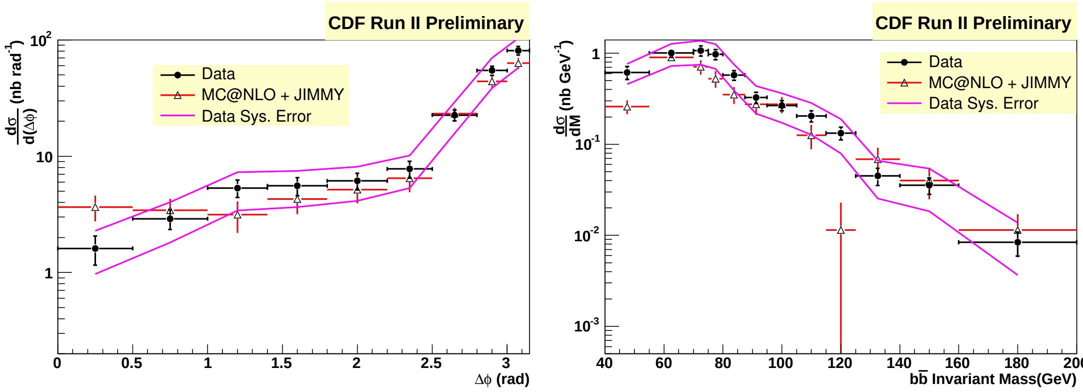

FIGURE 2. Differential inclusive $b\bar{b}$ dijet production cross sections as a function of $\Delta\phi_{jj}$ (left) and of M_{jj} (right). The measurement is fully corrected to the particle level. Data points include the statistical errors, the lines represent the systematic uncertainties. Particle level predictions from MC@NLO using JIMMY in conjunction with HERWIG are overlaid on the data.

ACKNOWLEDGMENTS

I am very grateful to the DIS 2005 organizers for their invitation. I would also like to acknowledge the members of the QCD and *b*-tagging Groups of the CDF Collaboration, especially Monica D'Onofrio and Anant Gajjar, for their works in achieving the results reported here. Finally, I would like to acknowledge the EU for its funding under the RTN contract: HPRN-CT-2002-00292, Probe for New Physics.

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