# Jet Physics and PDFs at the Tevatron

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**Abstract.** During Run II of Fermilab's Tevatron collider, the CDF and DØ experiments have collected over 1 $fb^{-1}$ of data. The collaborations made several jet measurements relevant to determining the proton's particle density functions, which are presented here.

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Run II of Fermilab's Tevatron collider and its upgraded detectors started on April 2001, with a proton-antiproton center of mass energy of 1.96 TeV. The detectors are CDF and DØ[1], both general-purpose detectors containing silicon micro-vertex detectors, a central tracking system, and extensive calorimetry and muon systems. The Tevatron allows us to probe the proton's parton density functions (PDFs) in regions of phase space inaccessible elsewhere. Hard collisions often result in collimated particle sprays, which are clustered into jets using various jet algorithms. The jet algorithms are applied to partons, particles, tracks and calorimeter towers.

The primary impact of PDFs on jet physics is through the gluon PDF, which at the Tevatron is strongly related to the inclusive jet and dijet cross sections. These results are presented in the next section. It is also possible to probe the b-quark PDF at the Tevatron, and such measurements from both collaborations are presented. It should be noted that these are the first experimental probes of the b-quark PDF in this region of phase space. Also briefly mentioned are recent Tevatron results that can serve to verify the hard-scattering matrix elements and aspects of the simulation used to extract the PDFs from the measured cross sections.

Due to space limitations, only a few of the plots shown at the conference will be included here. Further plots, details and updates are available on CDF's [2] and DØ's [3] public results web pages, and on the conference's web page [4].

## JET CROSS SECTION MEASUREMENTS

Both the CDF and the DØ collaborations have recently updated their inclusive cross sections measurements as a function of the transverse jet momentum, $p_T$. The most recent measurement is from CDF and uses the $k_\perp$ jet algorithm as described in [6]. The measurement includes jets with $p_T > 54$ GeV in the rapidity region $0.1 < |y_{jet}| < 0.7$. The jets were reconstructed with the $k_\perp$ algorithm's D parameter set to 0.5, 0.7 and 1.0. The results for D=0.5 are shown in Figure 1. The measured cross sections were corrected to the hadron level and compared to perturbative QCD (pQCD) calculations in next-to-leading order (NLO) as implemented in JETRAD [5], and additional parton-to-hadron

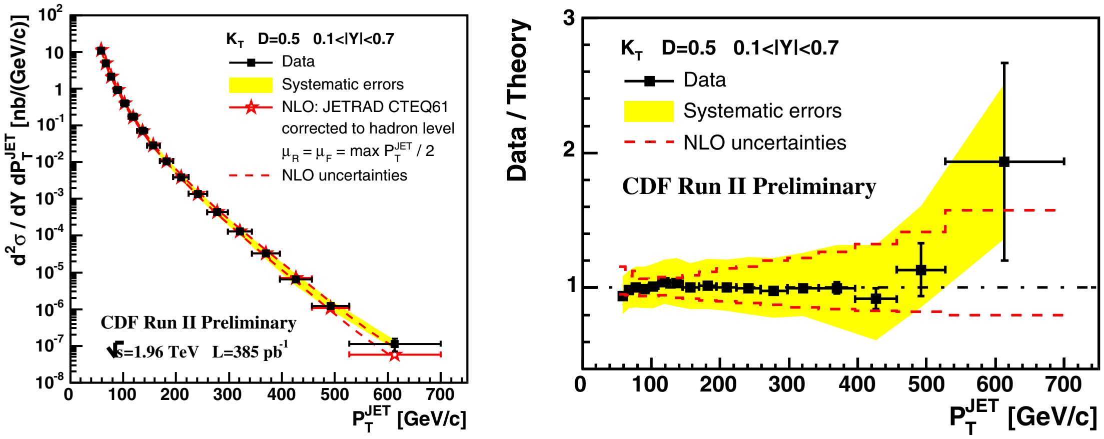


**FIGURE 1.** CDF's $k_\perp$-jet inclusive cross section measurement and its ratio over the NLO prediction

corrections were applied. Larger values of D include particles at larger distances into the jets and hence make the jet cross section more sensitive to soft contributions from the underlying event. This measurement achieved a precision similar to that of the NLO calculations. The NLO calculations and the measured cross section are consistent.

The DØ collaboration measured the inclusive jet cross section using the Run II Cone Algorithm [7] with $R_{cone} = 0.7$. The cross section was measured in two rapidity regions: $|y_{jet}| < 0.4$ and $0.4 < |y_{jet}| < 0.8$, and the results are shown in Figure 2. The measured cross sections were corrected to the hadron level and compared to pQCD NLO calculations made using NLOJET++ [8] and the PDFs from CTEQ6.1M [9] and MRST2004 [10]. Parton-to-hadron corrections were evaluated using PYTHIA [11] and HERWIG [12] and result in uncertainties on the ratio between the observed and the calculated cross sections between 10% (below $p_T = 100$ GeV) and 5% (for $p_T > 100$ GeV). The NLO calculations and the results are consistent.

CDF also measured the inclusive cross section using cone jets in the rapidity region $0.1 < |y_{jet}| < 0.7$, using data with an integrated luminosity of 177 pb$^{-1}$; DØ also measured the dijet cross section using cone jets in the rapidity region $|y_{jet}| < 0.5$, using data with an integrated luminosity of 143 pb$^{-1}$. In both measurements the pQCD NLO calculations and the data were consistent. Further details can be found in [2, 3, 4].

## B-JET MEASUREMENTS

In current PDF fits, the b-PDF is derived from the gluon PDF using theoretical predictions which assume no intrinsic b content and often use the massless gluon splitting approximation. The Tevatron collaborations made the direct experimental probes of the b-PDF necessary to verify these approximations at Tevatron kinematics, using vector-boson plus b-jet final states.

DØ has recently published [13] a measurement of the ratio of inclusive cross sections $\frac{\sigma(Z+\text{bjet})}{\sigma(Z+\text{jet})} = 0.021 \pm 0.004(stat)^{+0.002}_{-0.003}(syst)$, using data with an integrated luminosity of $\approx 180$ pb$^{-1}$. The cross sections were measured in the $Z \rightarrow e^+e^-$ and the $Z \rightarrow$

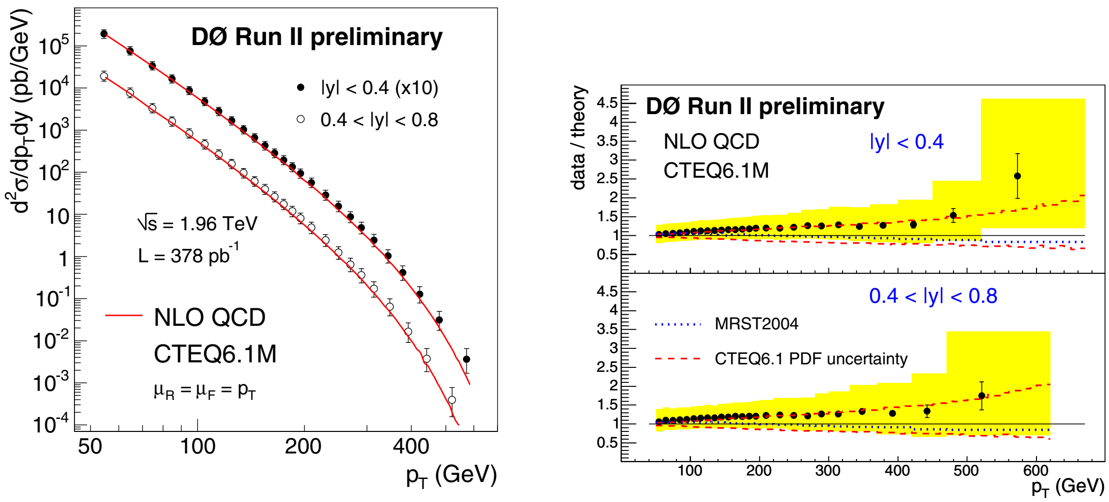


**FIGURE 2.** DØ's cone jet inclusive cross section measurement and its ratio over the NLO prediction

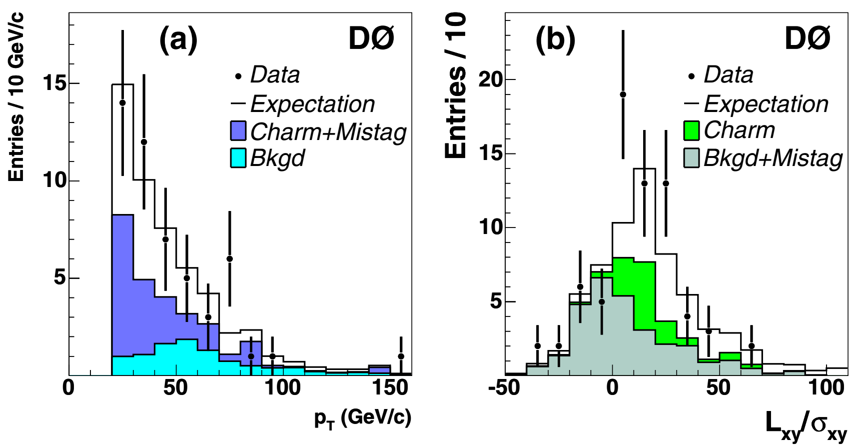


**FIGURE 3.** Decay length significance and $p_T$ distributions from DØ's cross section ratio measurement

$\mu^+\mu^-$ modes, for jets with a pseudo-rapidity $|\eta| < 2.5$ and $p_T > 20$ GeV. The b-jets were tagged with a secondary vertex algorithm, Figure 3 shows the distribution of the transverse decay length significance before requiring $L_{xy}/\sigma_{xy} > 7$. The measurement is in good agreement with the NLO prediction of $0.018 \pm 0.004$, made using the CTEQ6 [9] PDFs.

CDF measured the $\gamma$ b-jet production cross section $\sigma(\gamma + b\text{jet}) = 40.6 \pm 19.5(stat)^{+7.4}_{-7.8}(syst)$pb, using data with an integrated luminosity of $\approx 67$ pb$^{-1}$. The cross sections were measured for electrons with $E_T > 25$ GeV and for jets with $E > 30$ GeV that were tagged with a secondary vertex algorithm. The measurement is in agreement with the LO prediction made using the CTEQ5L PDFs.

## SUPPORTING MEASUREMENTS

To extract information on the PDFs from a jet measurement, the particle-level cross sections must be derived from the measured (detector level) observables. These "hadronic corrections" include the effects of the proton and anti-proton remnants and their subsequent interactions, as well as fragmentation effects. CDF measured the jet shapes for cone jets, in $p_T$ bins from 37 to 380 GeV. This measurement is sensitive to the hadron remnants and to fragmentation effects, and shows that both are well simulated.

Hard scattering matrix elements, computed using pQCD, are used to constrain the PDFs from the particle-level cross sections. DØ published [14] a measurement of dijet azimuthal decorrelations at central rapidities ($|y_{jet}| < 0.5$), which directly probes the matrix elements at orders $O(\alpha_s^3)$ and $O(\alpha_s^4)$. The distribution of the azimuthal angle measured, $\phi$ is given by the differential cross section in $\phi$ normalized by the total cross section. This reduces the systematic effects and uncertainties from the PDFs and jet energy response and allows a check of the matrix elements. The measurements was presented in detail elsewhere in this conference, but is mentioned here since it serves to verify the extraction of PDFs from jet cross section measurements.

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