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The Dijet Mass Spectrum with the DØ Detector

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Abstract

We present preliminary results from an analysis of dijet data collected during the 1994-1995 Tevatron Collider run with an integrated luminosity of 91 pb^{-1}. Measurements of dijet mass spectrum distributions in $\bar{p}p$ collisions at $\sqrt{s} = 1.8$ TeV are compared with next-to-leading order QCD theory.

Predictions for the inclusive jet cross section and hence the inclusive dijet cross section have been made using next–to–leading order (NLO) QCD [3,2,3]. These $\mathcal{O}(\alpha_S{}^3)$ calculations, which include the possibility of a third radiated parton, reduce theoretical uncertainties to 10–20%. We measure the inclusive dijet mass spectrum in the DØ detector at the Fermilab Tevatron Collider at $\sqrt{s} =$ 1.8 TeV. Such a measurement, when compared to NLO, constitutes a rigorous test of QCD.

The data sample was collected during the 1994–95 data taking period and corresponds to a luminosity of 91 pb^{-1}. A complete description of the data selection can be found elsewhere [4]. For each event the dijet mass can be calculated (assuming massless jets): $M_{jj}^2 = 2 \cdot E_T^1 \cdot E_T^2 \cdot (\cosh(\Delta\eta) - \cos(\Delta\phi))$, where E_T^1 and E_T^2 are the transverse energies of the two leading E_T jets, $\eta = -\log(\tan\theta/2)$, where θ is the angle from the direction of proton beam at the vertex and ϕ is the azimuthal angle. Cone size of $\mathcal{R}$=0.7 is used. Each event is weighted by the efficiency of the quality cuts applied to the data. The data were collected using four triggers with E_T thresholds of 30, 50, 85 and 115 GeV with integrated luminosities of 0.36, 4.6, 52 and 91 pb^{-1}. These trigger samples were used to measure the dijet mass spectrum above mass thresholds of 200, 270, 370 and 500 GeV where each of the triggers is 100% efficient. The relative normalizations of the four trigger sets is established by requiring equal cross sections in the regions where two trigger sets overlap and are efficient.

The inclusive dijet mass cross sections are computed for two partially overlapping pseudorapidity ranges: $|\eta|_{1,2} < 1.0$, $\Delta\eta < 1.6$ ($|\eta|_{1,2} < 0.5$). The final observed cross section corrected for jet and event selection efficiency is shown in Fig. 1. The combined systematic errors are also shown in Fig 1, ranging from $\sim$13% at 200 GeV to $\sim$55% at 950 GeV. The systematic error is dominated by the uncertainty due to the energy scale with smaller contributions due to jet selection (1%), vertex selection (1%), the vertex cut (1%), the luminosity scale (8%) and the luminosity matching (0–1.6%).

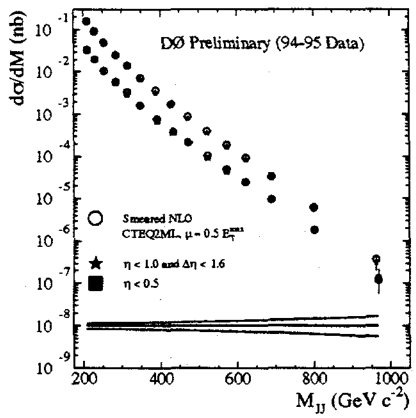

Figure 1: $d\sigma/dM_{jj}$ for $|\eta|_{1,2} < 1.0$, $\Delta\eta < 1.6$ ($|\eta|_{1,2} < 0.5$). The inset solid (dash–dot) curves represent the plus and minus 1σ systematic errors (the dotted lines show the 0, ±25% levels).

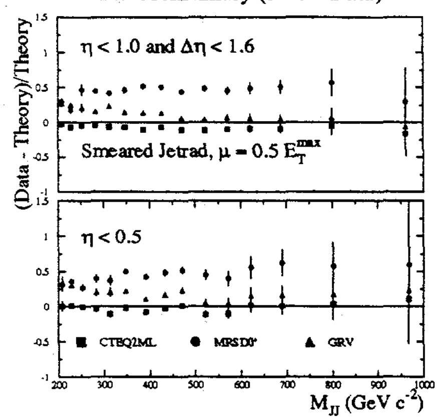

Figure 2: The difference between the data and the smeared NLO QCD predictions normalized to the theoretical prediction ($(D-T)/T$). The symbols represent the calculation using the CTEQ2ML, MRSD0′ and GRV pdf's.

Figure 1 also shows a prediction for the inclusive dijet mass spectrum from the NLO parton event generator JETRAD [3]. The NLO calculation of the dijet mass spectrum has been smeared by the measured jet resolutions. There is good agreement between the prediction and the data over seven orders of magnitude. The data and theoretical calculation are binned identically in M_{jj} bins. The NLO calculation requires specification of the renormalization and factorization scale ($\mu = E_T/2$ where E_T is the maximum jet E_T in the generated event), parton distribution function (pdf) (CTEQ2ML [6]), and a parton clustering algorithm. Partons within 1.3 $\mathcal{R}$ of one another were clustered if they were also within $\mathcal{R}$=0.7 of their E_T weighted η, ϕ centroid. The value of 1.3 $\mathcal{R}$ was determined by overlaying jets in data from separate events and determining the separation at which the jet reconstruction algorithm could resolve the individual jets. Variation of the pdf can alter the prediction by up to 20% depending on M_{jj}. Variation of μ between $0.25E_T$ to E_T can alter the predictions normalization by 10–20% with some M_{jj} dependence. In addition the choice of parton clustering between 1.3 $\mathcal{R}$ and 2.0 $\mathcal{R}$ alters the normalization by $\sim 5\%$ with a small (2–3%) M_{jj} dependence.

Figure 2 shows the ratio, $(D-T)/T$, for the data (D) and the NLO theoretical predictions (T) based on the CTEQ2ML [6], MRSD0′ [7] and GRV [8] pdf's. Given the experimental an theoretical uncertainties the predictions are in excellent agreement with the data. The CTEQ2ML pdf gives the best agreement for the absolute normalization.

In conclusion, we have measured the inclusive dijet mass spectrum for $|\eta|_{1,2} < 1.0$, $\Delta\eta < 1.6$ ($|\eta|_{1,2} < 0.5$) and $200 < M_{jj} < 1100$ GeV at $\sqrt{s} = 1.8$ TeV. The QCD NLO model, using different pdf's is in excellent agreement with the M_{jj} dependent shape of the observed inclusive dijet mass spectrum.

Acknowledgments

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