INCLUSIVE JET CROSS SECTIONS AT THE DØ DETECTOR

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ABSTRACT

The DØ calorimeter has uniform response and hermetic coverage for detection of jets produced in $p\overline{p}$ collisions out to a pseudo–rapidity $|\eta| = 4.1$. Based on a 13 pb^{-1} data sample recorded during the 1992 – 1993 run, we present a measurement of the inclusive differential jet cross section as a function of the jet transverse energy for $|\eta| \leq 3$. The experimental results are compared to the next–to–leading order (NLO) theoretical predictions currently available.

1. Introduction

The availability of a QCD theoretical prediction in the next–to-leading order approximation,[1,2] has increased the interest in the measurement of the inclusive jet cross sections. The inclusive differential jet cross section is defined as:

$$\frac{d^2\sigma}{dE_T d\eta}(\overline{p}p \rightarrow jet + X)$$

and has been measured accurately by the CDF collaboration[3] in the central pseudo–rapidity region ($0.1 < |\eta| < 0.7$). There is also a measurement by the UA2 collaboration[4] in the pseudo–rapidity range $|\eta| < 2$. Using its excellent calorimetry and rapidity coverage, DØ has extended the measurement to previously unexplored rapidity regions ($|\eta| < 3$) allowing a more complete test of the QCD predictions.

2. DØ Calorimetry

The DØ calorimetry[5] consists of three liquid argon calorimeters divided into several electromagnetic, fine hadronic and coarse hadronic modules. The calorimeters are $7 - 9$ interaction lengths deep and provide uniform and hermetic coverage out to $|\eta| = 4.1$. The energy and position resolution for particles passing the calorimeters is excellent, due to the fine transverse segmentation, 0.1×0.1 in $\eta - \varphi$ space. The energy response is linear within 0.5% and the e/π response ratio is $1.02 - 1.09$. The energy resolutions for electrons and pions are $15\%/\sqrt{E}$ and $50\%/\sqrt{E}$ respectively.

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3. Data Selection and Reconstruction

Jets are reconstructed with a fixed cone algorithm (cone size $R = 0.7$) in this analysis. Every 0.1×0.1 tower with more than 1 GeV is used as a seed to find a jet. All the neighbor towers with $E_T > 1$ GeV are joined to the seeds and a cone of $R = 0.7$ is drawn around the center ($\eta_\circ$, $\varphi_\circ$) of the energy cluster. The E_T of the jet is calculated as the sum of the E_{T_i}'s deposited in each tower inside the cone and the position ($\eta_\circ$,$\varphi_\circ$) is obtained from the x, y, and z components of the energy in each tower:

$$E_x = \sum_i E_{x_i} \qquad E_y = \sum_i E_{y_i} \qquad E_z = \sum_i E_{z_i}$$

$$tan\,\varphi_\circ = \frac{E_y}{E_x} \qquad cos\,\theta_\circ = \frac{E_z}{\sqrt{E_x^2+E_y^2+E_z^2}} \qquad \eta_\circ = -ln\left(tan\,\frac{\theta_\circ}{2}\right)$$

$$E_T = \sum_i \sqrt{E_{x_i}^2 + E_{y_i}^2}$$

A new cone is drawn around the new center, the jet variables are recalculated and the process is repeated until the centroid ($\eta_\circ, \varphi_\circ$) becomes stable. If two jets share more than 50% of the E_T of the smaller one, they are merged. In addition, the minimum possible E_T for a jet is 8 GeV. Jet finding efficiency is $> 99\%$ above 20 GeV in all η regions.

Three different trigger levels are involved in the online selection of jet events. The level Ø (LØ) consists of a set of scintillator counters which fire the trigger when a non–diffractive interaction takes place. Level 1 (L1) is a hardware trigger which does a fast sum of the transverse energy deposited in a 0.2×0.2 trigger tower. The event passes the L1 trigger if there is a minimum amount of E_T in a specified number of trigger towers. The level 2 (L2) is a software trigger which runs a fast version of the fixed cone algorithm and sets a condition on the jet E_T. In the inclusive jet analysis, five different thresholds were used at L2: 20, 30, 50, 85 and 115 GeV. In all the cases except the highest E_T threshold and sometimes the second highest one, a cut on the z coordinate of the interaction vertex ($|z| < 10.5$ cm) was applied to take advantage of the calorimeters pseudo–projective geometry. In addition, low E_T triggers are heavily prescaled to lower the event rates and avoid bandwidth saturation. The trigger information was used in the E_T, η ranges where they are more than 95% efficient.

Several offline cuts were applied to remove noise and background. The standard jet cuts are defined as follows:

$$\begin{aligned}&\mathrm{EMF} \in [0.05, 0.95]\\ &\mathrm{HCF} > 0.1\\ &\mathrm{CHF} < 0.4 \quad ,\end{aligned}$$

where EMF and CHF are the fractions of transverse energy deposited in the electromagnetic and the coarse hadronic modules of the calorimeters. HCF is the ratio E_T of the second most energetic cell to the most energetic cell. An additional cut, based on the missing transverse energy of each event, is applied to remove electronic noise and cosmic showers at high E_T. The cut is defined as:

$$\frac{\not{E}_T}{E_T^{leading\,jet}} < 0.7 \quad ,$$

where $\not\!\!E_T$ is the event missing E_T and the leading jet is the one with the highest E_T. The overall efficiency for these cuts is greater than 90% in all pseudo–rapidity regions. The noise rejection is greater than 98%. The data used in this analysis were taken during the 1992 – 1993 run period and correspond to a total luminosity of 13 pb^{-1}.

4. Jet Energy Scale and Resolution Effects

A fraction of the jet energy that enters the calorimeters is lost in uninstrumented areas or leaked outside the cone by showers of particles produced inside the calorimeters. In addition, there is some spurious energy within the jet cone limits coming from the underlying event and uranium radiation. The jet E_T must be corrected back to the parton jet level[1,2] to allow comparison with theoretical predictions. The missing E_T projection fraction method (MPF)[6] was used in a $\gamma - jet$ event sample to obtain the jet calibration with respect to the electromagnetic scale in the central calorimeters. The calibration was extended to the forward η region using energy balance in the transverse plane on a sample of dijet events. The electromagnetic scale was calibrated using LEP results on Z mass and DØ measurements on $Z \rightarrow e^+e^-$. Finally, the underlying event and uranium noise contamination was subtracted.

The fractional jet E_T resolution as a function of E_T is approximately $85\%/\sqrt{E_T}$ and was also determined from collider dijet and $\gamma - jet$ data for each η region in which the jet cross section was measured. The jet E_T spectrum in a particular η region was corrected for resolution smearing by assuming a hypothetical unsmeared cross section which is a function of E_T and η. This function was smeared with the measured E_T resolution and fit to the data. Finally, the data was corrected by the ratio of the hypothetical cross section to the smeared hypothetical cross section.

The η resolution was studied with a Monte Carlo simulation. Within the E_T and η range the cross sections were measured, the η resolution is less than 0.04. No correction was applied to the jet cross sections since the η resolution effect on the jet E_T spectrum is less than 1% in the central region and up to a 2.5% in the forward regions.

5. Inclusive Differential Jet Cross Sections

The inclusive jet cross sections measured with the DØ detector in different pseudo–rapidity regions are shown in Fig. 1. In the most central η bin, $|\eta| < 0.5$, the statistical errors are less than 5% below 300 GeV. The systematic uncertainty due to the energy scale correction and unsmearing procedure is $\approx 35\%$. Other uncertainties from acceptance corrections and contamination contribute a $\approx 7\%$. The error in the luminosity calculation is 12%.

The measurements are compared to EKS[1,2] theoretical predictions in the (NLO) approximation using CTEQ2M parton distribution functions.[7] There is good qualitative agreement between theory and experiment over the whole pseudo–rapidity range that was measured. The predictions are also included within the limits of the total systematic errors associated with the measurement in all the η regions.

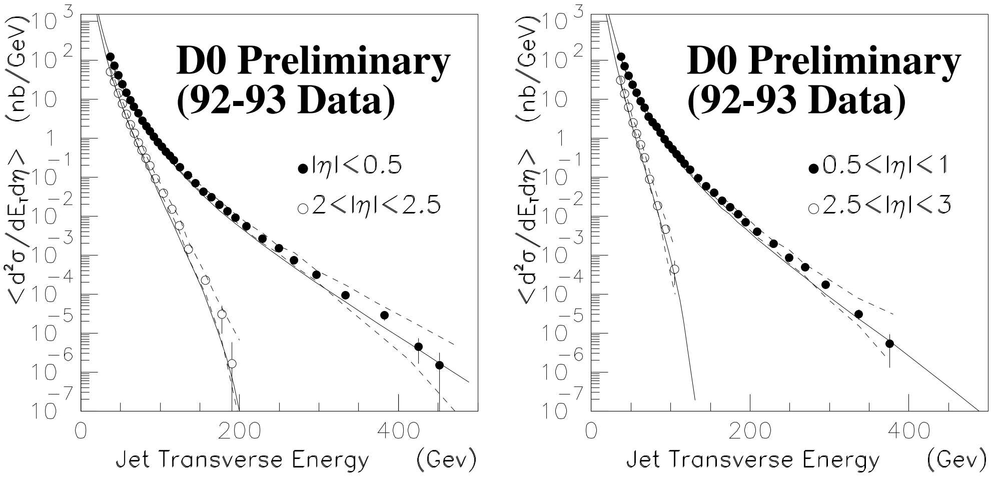

Fig. 1. Inclusive jet cross sections measured with the DØ detector in four different η regions. The bars are statistical errors and the band is the uncertainty from the energy scale correction. The EKS (NLO) predictions using CTEQ2M parton distribution functions are shown in solid lines.

References

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