JET RESULTS AT THE DØ EXPERIMENT*

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In this paper I will present a selection of recent results concentrating on the measurement of jets as measured by the DØ experiment at the Fermilab Tevatron $\bar{p}p$ collider. The results presented here are a comparison of the inclusive jet cross-section as measured using the cone and k_{T} jet algorithms, the measurement of sub-jet multiplicity of quark and gluon jets, a measurement of thrust, and a measurement of low p_{T} jets.

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1. Inclusive jet cross-section

DØ has studied the high p_{T} behaviour of the inclusive jet cross section for $|\eta| < 0.5$ at $\sqrt{s} = 1.8$ TeV for different jet algorithms. The measurement of the cross-section using the k_{T} algorithm [1] is compared directly with a previous measurement using a cone algorithm with a radius given by $\mathcal{R} = 0.7$ [2]. The parameter, $D = 1.0$, used to characterise the k_{T} jet has been chosen to give an identical predicted cross section to the cone algorithm using the JETRAD NLO Monte Carlo program [3].

The comparison between the inclusive jet cross-section and theory prediction JETRAD with the CTEQ4HJ distribution is plotted in Fig. 1. Both measurements are in agreement with the predictions. However, the two measurements differ over the measured range of jet transverse energies (E_{T}) with the difference decreasing as E_{T} increases. This is due to the difference in the jet E_{T} measured using the cone and k_{T} algorithm of 1 to 2 GeV depending on the E_{T}. This is caused by several different effects which include hadronic

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showering which is not included in the NLO parton prediction, differing contributions from the underlying event, and effects of particle showering in the detector.

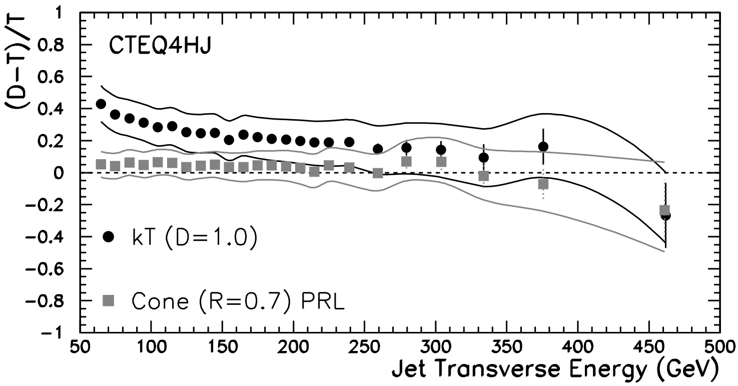

Fig. 1. Inclusive jet cross-sections for $|\eta| < 0.5$ measured using the cone (solid circles) and the $k_{\rm T}$ algorithm (solid squares) compared to the theory prediction JETRAD with the CTEQ4HJ distribution.

If we estimate the effects of hadronisation using the HERWIG [5] shower MC and apply the effect to the JETRAD prediction then the agreement between the cross-section and the theoretical prediction improves from 29% to 44% as estimated using a χ^2 test. The remaining difference between the cross-sections can be explained by the difference in the energy scale corrections for the two algorithms which have several uncorrelated uncertainties.

2. Subjet multiplicity in quark & gluon jets

DØ has investigated the difference in structure between quark and gluon jets. The study was carried out using two samples of jets with $55 < p_{\rm T} < 100\,{\rm GeV}$ at center-of-mass energies of $\sqrt{s} = 630$ and $1800\,{\rm GeV}$. The two samples will have different fractions of jets produced from quarks and gluons since they have a different x range. This fraction can be predicted using a showering MC generator and a parton distribution function.

The structure of the jets is studied by determining the number of sub jets using the $k_{\rm T}$ algorithm at both center-of-mass energies. The distributions are then deconvoluted to obtain the distribution of sub jets for quarks and gluons (see Fig. 2). The difference between quark and gluon jets can be quantified by the ratio $R = (\langle M_g\rangle - 1)\,/\,(\langle M_q\rangle - 1) = 1.84\,^{+0.27}_{-0.23}$, where M_g and M_q are the average number of gluon and quark jets. This value compares well with the HERWIG value $R = 1.91$ which has been tuned using LEP data.

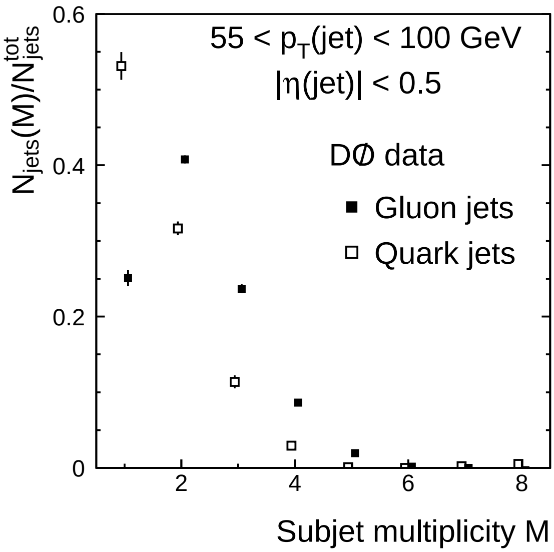

Fig. 2. The number of sub jets for quark and gluon jets.

3. Dijet transverse thrust distribution

Measurement of event shape distributions at e^+e^- colliders have been used to study of hadronic final states, the testing of perturbative QCD predictions, and the measurement of α_S. The thrust distribution measures how collinear the event is, with a value of 1 corresponding to two back-to-back objects and a $\frac{1}{2}$ corresponding to a uniform distribution of particles. The traditional definition of thrust has to be adjusted in two ways for making measurements at a hadron collider due to the underlying event and possibility of multiple $\bar{p}p$ collisions occurring in the same bunch crossing. The first is to calculate the thrust using jets instead of particles since jets are more likely to be associated with the hard process we wish to study. The second is to calculate the thrust only in the transverse direction (as we can only apply conservation of momentum in the transverse direction). The transverse thrust T^2 is given by

$$T^{\mathrm{T}} = \max{}_{\hat{n}} \frac{\sum |\vec{p}_{t_i} \cdot \hat{n}|}{\sum |\vec{p}_{t_i}|} \,. \tag{1}$$

After studies to optimise the signal and reduce the detector effects it was found that the optimum observable is to calculate the thrust using only the two highest p_{T} jets in the events as measured using the k_{T} algorithm, T_2^{T}.

The thrust is measured as a function of scalar sum of the transverse momentum of the three leading jets, H_{T}^3. The thrust is measured in four H_{T}^3 bins corresponding to four different jet trigger thresholds, 160–260 GeV, 260–360 GeV, 360–430 GeV, and 430–700 GeV. The thrust distribution for 430–700 GeV is given in Fig. 3.

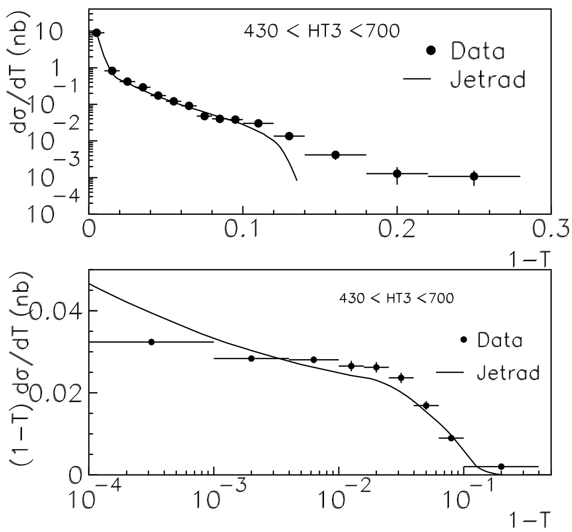

Fig. 3. The transverse thrust distribution T_2^{T} compared to a JETRAD prediction for $430 < H_{\mathrm{T}}^3 < 700$ GeV.

The thrust measurements are compared the NLO parton JETRAD predictions with a renormalization scale of $\mu_{\mathrm{F}} = \mu_{\mathrm{R}} = p_{\mathrm{T}}^{\max}/2$ and the CTEQ4HJ parton distribution function. The NLO prediction agrees with data in the region of $1-T$ from 10^{-3} to 0.12. The NLO prediction disagrees with data in the limit T approaches 1 and resummation calculations are probably needed to get agreement. In regions where T approaches 0.5 the NLO prediction is not expected to provide an adequate description of the data as higher order contributions are required (between $\sqrt{2}/2 \leq T_2^{\mathrm{T}} \leq \sqrt{3}/2$ the LO prediction is order α_s^4).

4. Low p_{T} jets

DØ has carried out a comprehensive comparison of low transverse energy ($E_{\mathrm{T}} > 20$ GeV) jet production with the Monte Carlo generators PYTHIA [6] and HERWIG [5]. The E_{T} and angular distributions of 1, 2, 3, and 4 jet events are measured and compared with the MC predictions. Without tuning the MC generators underestimate the production of low E_{T} 3 and 4 jet events (Fig. 4).

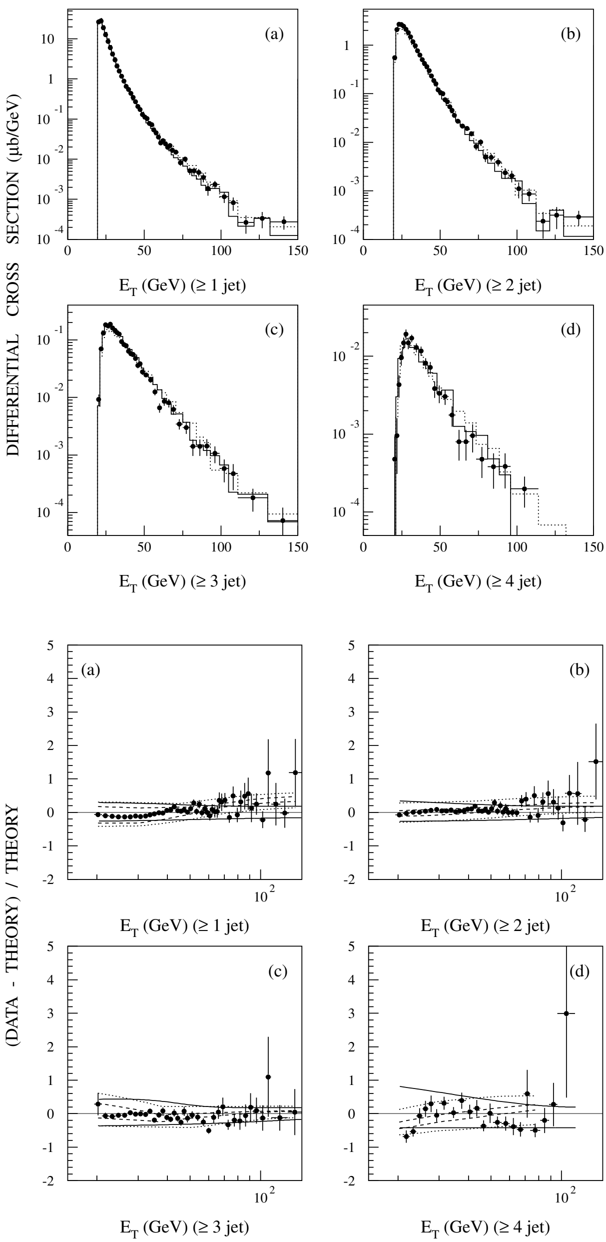

Fig. 4. The inclusive jet cross-sections for 1, 2, 3, and 4 jet events. Both plots compare the measured cross-section with tuned PYTHIA predictions. The lower plot shows (Data–Theory/Theory).

However, if the event generators are tuned to the observed data then excellent agreement can be obtained. For PYTHIA the fraction of energy contained within the core region of the hadronic matter distribution needs to be adjusted to PARP(83) = 0.32 HERWIG requires adjustment of the minimum p_{T} of the hard process to 3.7 GeV to obtain agreement.

5. Conclusion

In Run I DØ has completed several measurements that probe low p_{T} regimes and the structure of jets. Measurement of inclusive jet cross-section depends on the choice of the jet algorithm. Low p_{T} cross-sections, jet substructure measurements, and the thrust distribution probe the event structure and test the predictions of LO shower Monte Carlo programs.

Currently Run II has commenced at the Tevatron and DØ has produced its first preliminary jet results. Over the next year we can expect to see many more intriguing results as the increased luminosity and detector improvements allow us to improve or jet measurements.

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