THE INCLUSIVE JET CROSS SECTION FROM STAR

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We present preliminary measurements of the inclusive jet cross section in the transverse momentum region $5 < p_T < 50$ GeV/c from 0.16 pb^{-1} of polarized p+p data at $\sqrt{s}$=200 GeV. The data were corrected for detector inefficiency and resolution using PYTHIA events processed through a GEANT simulation. The measured jet cross section agrees well with NLO pQCD calculations over seven orders of magnitude. By applying these techniques to ongoing analyses of higher statistics data already collected, we hope that STAR can ultimately contribute to global parton distribution analyses.

The relativistic heavy ion collider (RHIC) is the first high energy polarized proton-proton collider. A primary motivation is the study of QCD spin physics, although high luminosity running may provide access to new TeV scale physics[1]. The solenoidal tracker at RHIC (STAR) is capable of direct jet reconstruction in p+p collisions for $5 < p_T^{jet} < 50$ GeV, corresponding to the interval $0.05 < x_T < 0.5$ ($x_T \equiv \frac{2p_T}{\sqrt{s}}$). Next to leading order (NLO) QCD calculations under various assumptions show that the inclusive jet cross section at RHIC is sensitive to high-x gluons. For example, the predicted cross section at $p_T = 40$ GeV/c differs by 13% depending on whether one uses the CTEQ6.1M or CTEQ6M distributions, which differ in the treatment of high-x gluons by an amount that is "well within the specified uncertainty."[2] Thus a high statistics measurement of unpolarized jet cross sections at STAR may provide significant constraints to previously measured large-x parton distribution functions, which directly impact searches for new physics at both the Tevatron and the LHC [3]. We present a preliminary measurement of the inclusive jet cross section from STAR. The measurement, limited by systematic uncertainties, agrees reasonably well with a NLO pQCD calculation.

The data were collected during a short 2004 p+p commissioning run at

200 GeV. STAR, a large acceptance collider detector with precision tracking and electromagnetic calorimetry, is described in detail elsewhere [4]. The detector subsystems of principle interest to this analysis were the large acceptance time projection chamber (TPC) and the partially commissioned (2400 of 4800 towers) barrel electromagnetic calorimeter (BEMC). Both have full azimuthal coverage, and the TPC (BEMC) covers $|\eta| < 1.2$ ($0 < \eta < 1$). The *in situ* calibration of the BEMC, along with various analysis details, are presented elsewhere[5]. The data presented here were collected in two trigger configurations: minimum bias (MB) and high tower (HT). The highly pre-scaled MB trigger selected 87% ± 8% of the non-singly diffractive interactions. The HT trigger required the MB condition as well as a single tower above an E_T threshold corresponding to ∼3.0 GeV. The HT trigger was efficient for energetic γ, π^0 and e candidates. It also significantly enhanced the population of high p_T jets, but with strong energy-dependant efficiency. In this analysis we correct for the jet-p_T dependent trigger efficiency using simulation. In total ∼0.16 pb^{-1} was sampled.

Jet finding was performed using a STAR implementation of the midpoint-cone algorithm [7]. For each event, a list of four momenta was constructed from TPC tracks and BEMC towers with p_T >0.2 GeV. For tracks (towers) the π^+ (γ) mass was assumed. The algorithm parameters used were r_{cone}=0.4, p_T^{seed}=0.5 GeV/c, and f_{merge}^{split}=0.5. Reconstructed jets were restricted to $0.2 < \eta < 0.8$ to minimize edge effects in the partially commissioned BEMC. Fake "neutral energy" jets originating from accelerator backgrounds were discarded [8]. After all cuts approximately 10k (55k) jets remained from the MB (HT) sample. We attempt to correct the measured jet yield to the particle level, i.e. the energy of the r_{cone}=0.4 cluster immediately after hadronization but before any detector effects. Detector efficiency and finite resolution were evaluated by studying PYTHIA (v6.205-CDF tune A) [9] events passed through the STAR simulation and reconstruction software. The "true" properties of jets were defined by running the same clustering algorithm on the final state PYTHIA event record. The "accepted" properties of jets were defined by clustering the simulated track and tower output of the full simulation/reconstruction chain. The jet p_T resolution was found to be ∼25%. We define a "generalized efficiency" via the correction factor $c(p_T) = \frac{M^{acc}(p_T^{acc})}{N^{true}(p_T^{true})}$ that convolutes effects from jet reconstruction efficiency, resolution induced bin sharing, and trigger efficiency. The correction factor is evaluated separately for MB and HT modes, where the Monte Carlo events are subject to the same trigger requirements as the data. Note that bin-migration can yield $c > 1$.

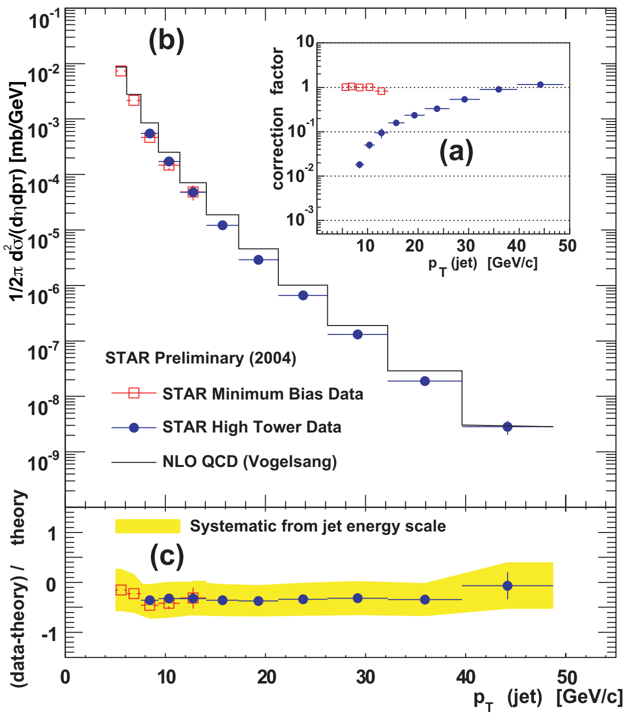

Figure 1. (a) The correction factor for MB and HT data derived from simulation. Statistical errors are shown. (b) Preliminary inclusive jet cross section compared to NLO pQCD calculation. Statistical uncertainties are plotted but are smaller than the markers. (c) Ratio comparison of data vs. theory. The shaded band represents the dominant systematic uncertainty, and an 8% uncertainty on the overall normalization is not shown. See text for details.

Figure 1a shows the correction factor for MB and HT data. Whereas the MB correction is nearly unity, the HT correction varies by two orders of magnitude. The primary difference between the MB and HT corrections is the inclusion of the HT trigger efficiency, which varies strongly with jet-p_T due to the weak correlation between p_T of the trigger photon (via π^0 decay) and p_T of the parent jet. Figure 1b shows the corrected jet cross section. The MB and HT data show good agreement in the three overlapping bins, where the MB and HT efficiencies differ by at least a factor of ten. The data are compared to results from a fast (small-cone approximation) NLO pQCD calculation incorporating CTEQ6M PDFs and r_{cone}=0.4, with a scale of $\mu \equiv \mu_F = \mu_R = p_T$ [10]. The NLO prediction varies by a maximum of 23% if μ is varied by a factor of two. It was verified that the calculation agrees with a standard full NLO calculation[11]. We find good shape agreement between data and theory over seven orders of magnitude. Figure 1c shows the ratio between data and theory. Non-perturbative corrections to the predicted jet yield due to the underlying event and hadronization are beyond the scope of the NLO calculation. Using PYTHIA we estimate these would reduce the NLO prediction by 26% for $p_T > 10$ GeV/c, improving the agreement between data and theory. The shaded band represents the dominant systematic uncertainty (50% change in yield) on the measured cross section from the 10% uncertainty on the jet energy scale. Given the steeper slope of the jet cross section at RHIC energies we expect the cross section measurement to show increased sensitivity to uncertainties in the jet energy scale when compared to the Tevatron. A major challenge for future RHIC runs will be the use of smaller cross section processes such as di-jet and photon-jet final states to hopefully reduce the uncertainty on the jet energy scale to below 5%.

We have presented preliminary measurement of the inclusive jet cross section from 0.16 pb^{-1} of polarized $p{+}p$ collisions at $\sqrt{s} = 200$ GeV. We correct for a high tower trigger efficiency that changes by two orders of magnitude over the range of the measurement. The reasonable agreement with NLO pQCD calculations over seven orders of magnitude motivates the application of perturbative QCD to interpret the spin dependent jet asymmetries recently reported from STAR. These measurements pave the way for ongoing analyses of $15pb^{-1}$ of data already collected.

References

1. J. Bunce *et al.*, Ann. Rev. Nucl. Part. Sci. 50 (2000) 525.
2. D. Stump *et al.*, JHEP 10 (2003) 046.
3. J. Pumplin, 13th International Workshop on Deep Inelastic Scattering (2005) arXiv:hep-ph/0507093.
4. K.H. Ackerman *et al.*, Nucl. Instrum. Methods Phys. Res., Sect. A 499 (2003) 624.
5. M.L. Miller, arXiv:hep-ex/060400
6. J. Adams *et al.*, Phys. Rev. Lett. 91 (2003) 172302.
7. Gerald C. Blazey *et al.*, arXiv:hep-ex/0005012.
8. J. Kiryluk, arXiv:hep-ex/0512040.
9. T. Sjostrand, P. Eden, C. Friberg *et al.*, Comput. Phys. Commun. 135 (2001) 238.
10. B. Jager, M. Stratmann, W. Vogelsang, Phys. Rev.D 70 (2004) 034010.
11. M. Wobisch, these proceedings.