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A_{LL} FOR JETS AT STAR

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We present an update on the inclusive jet A_{LL} analysis from year 2003 polarized proton collisions at $\sqrt{s} = 200$ GeV. Possible sources of systematic errors are discussed, as well as the statistical precision expected for the final result.

The Relativistic Heavy Ion Collider at BNL (RHIC-BNL) Accelerator complex has begun to provide high energy collisions of polarized protons on polarized protons, with both the luminosity and polarization of these beams under intensive development. At the present time, inclusive jet production and asymmetries are among the measurements with the highest attainable statistical precision. For the STAR experiment, the sensitivity of the longitudinal inclusive jet asymmetry (A_{LL}) to the polarization of the gluon component of the proton makes this the highest priority spin measurement from this new facility. The connection between the total cross section and the leading order partonic processes is given in fig. 1 and is now the subject of theoretical scrutiny (*e.g.*, ref.[1] for calculations up to NLO.)

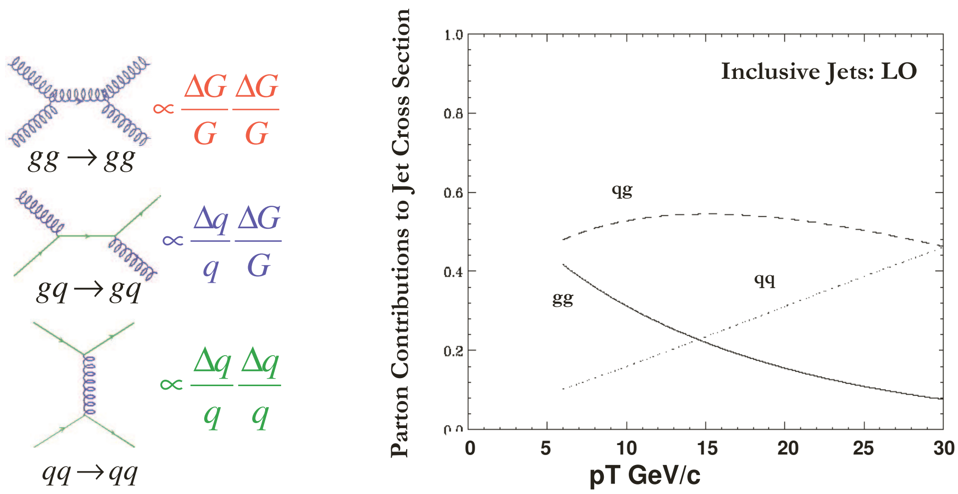

Figure 1. Left diagrams are the highest order partonic contributions to the inclusive jet production cross section. The right plot is the p_T dependence of these partonic contributions as a fraction of inclusive jet production in p-p collisions at $\sqrt{s} =$ 200 GeV.

The Solenoidal Tracker at RHIC (STAR)[2] consists mainly of a large volume TPC placed in a magnetic field to provide comprehensive detection of charged particles emitted in the kinematic region $0 < \phi < 2\pi$ and $-1.6 < \eta < +1.6$. In year 2003, the STAR experiment installed electromagnetic calorimeter coverage (half barrel) in the region $0 < \eta < 1$, allowing significantly improved characterization of jets emitted at central rapidity. This coverage will be increased to $-1 < \eta < +1$ before the next run in 2005.

Of particular interest for spin measurements are the Beam-Beam Counters which are highly segmented scintillator detectors surrounding the beam pipe with coverage from $3.3 < \eta < 5.0$. Single coincidences between subdetector elements on either side of the collision region are sensitive to 87% of the non-singly diffractive cross section for proton-proton collisions, providing the minimum bias trigger and absolute luminosity monitor for our experiment. These coincidences are counted with a high-speed scaler system which provides a high accuracy measurement of the relative luminosity by integrating the yield for each beam bunch crossing. Measurements of longitudinal asymmetries rely on determination of the relative luminosities to statistical precisions much greater than the desired precision of the cross section asymmetry. This is made apparent in the following formula:

$$A_{LL} = \frac{N^{+-}/\ell^{+-} + N^{-+}/\ell^{-+} - N^{++}/\ell^{++} - N^{--}/\ell^{--}}{N^{+-}/\ell^{+-} + N^{-+}/\ell^{-+} + N^{++}/\ell^{++} + N^{--}/\ell^{--}}$$

where the subscripts represent the helicity combinations (parallel and antiparallel) for the colliding beams, N is the number of jets detected for each configuration and ℓ is the luminosity for that configuration.

For this work, jets are defined via an iterative, midpoint cone algorithm described in ref. [3], using the sum of all the charged tracks in the TPC. This algorithm uses a seed energy of 0.5 GeV; with a jet being defined as greater than 5 GeV of energy within a cone of radius 0.7. While jets defined this way using the TPC (charged track energies) are relatively unbiased, reliance on the electromagnetic calorimeter as a trigger introduces a serious bias, which is the subject of on-going analysis. An example of the jet bias introduced by a 'high tower' trigger is given in fig. 2. The trigger for these jets is a requirement that a single 'tower' ($\phi \times \eta = 0.05 \times 0.05$) has more than 2.4 GeV of energy. As can be seen at low p_T, this biases us heavily towards jets with a large fraction of electromagnetic (neutral) energy. We are still studying the sensitivity of these biased jets to the parton processes related to the gluon polarization. Full jet reconstruction using the electromagnetic calorimeter, with corrections for hadronic showers and double-counting of electron showers is underway.

STAR data for Year 2003 consists of approximtely 330 nb^{-1} of which 180 nb^{-1} was sampled by the detector (after dead time and trigger efficiencies) taken over a period of about one week. The average longitudinal polarization of the beams was about 25% during this running period. Since the Beam-Beam counters are themselves segmented, it is highly desirable to test the hit distributions in them for asymmetries as a function of the polar angle around the beam axis. Such an asymmetry has already been calibrated directly with these detectors using *transversely* polarized beams and comparing this signal with the accelerator's polarimeters. From these measurements, we can determine that the residual radial component of the

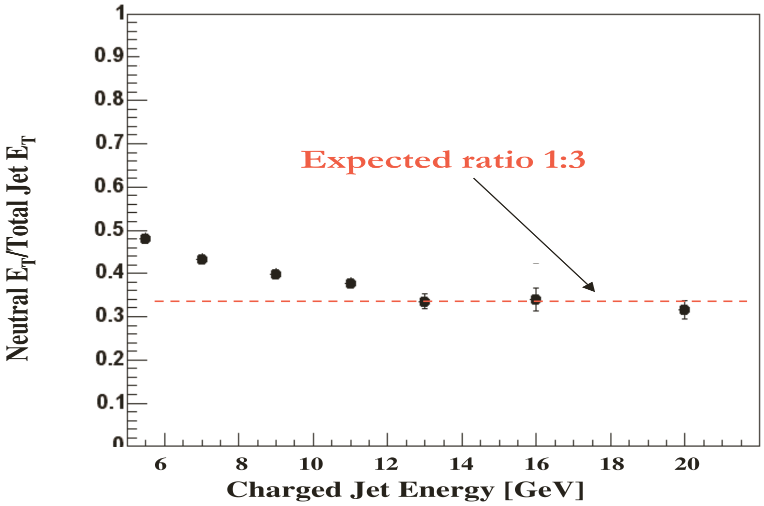

Figure 2. An example of trigger bias as a function of p_T. The trigger here consists of a single Electromagnetic Calorimeter Tower with an energy greater than 2.4 GeV. The points are the ratio of electromagnetic energy to the total energy in the jet cone. For low energy jets, we see an extreme bias towards jets with large amounts of neutral energy, while they proceed smoothly to reasonable values at higher p_T.

polarization is less than 8 degrees (for the worst case).

The major source of systematic error arises from measurements of the relative luminosity. Although the statistical precision of the relative luminosity is on the order of 10^{-4} for measurements over several hours, the accuracy of this measurement can only be tested by comparison to a different measure of the relative luminosity. Such an independent measurement, albeit one of lower statistical precision, is available in the STAR Zero Degree Calorimeters. These calorimeters are designed to be sensitive to single neutrons emitted from heavy ion collisions at zero degrees in the laboratory. They are, thus, only sensitive to about 0.5% of the p-p total cross section; however, this is enough to confirm the difference of the relative luminosity measurements for the two detectors is less than 10^{-3}.

The jet data itself was examined for signs of unphysical false asymmetries. In fig. 3 we plot the single (left-right) asymmetries separately for each beam (designated 'Blue' and 'Yellow') by summing over both polarization states of the opposing beam. Such an asymmetry is forbidden in strong interactions by parity violation and is a good test for false asymmetries arising from detector effects. The results are statistically consistent with zero.

The final data sample consists of jets of greater than 5 GeV total energy emitted in the region $0.2 < \eta < 0.8$. While work remains on the characterization of the jet energy scale, we can give the approximate distribution of the errors on the asymmetry as a function of E_T for the fully reconstructed jets (fig. 4). Integrating over the total sample will give an error of ± 0.03 for the total inclusive jet asymmetry.

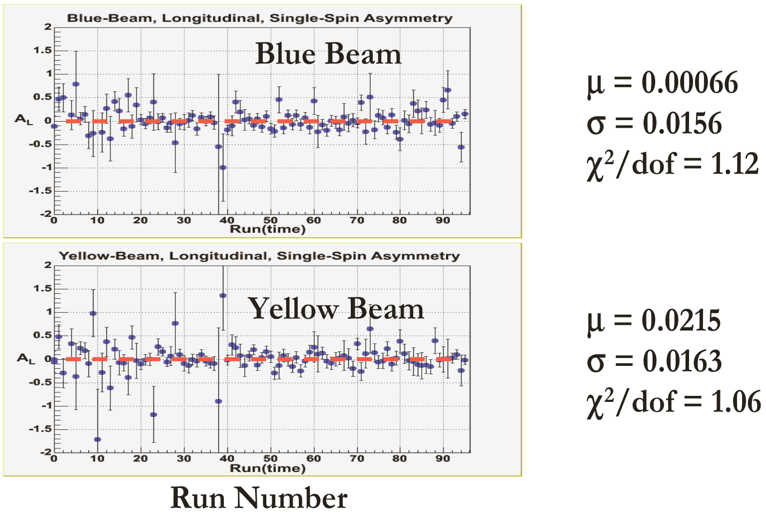

Figure 3. Single (parity-violating) jet asymmetries as a function of time (run number). False asymmetries arising from detector effects are statistically consistent with zero.

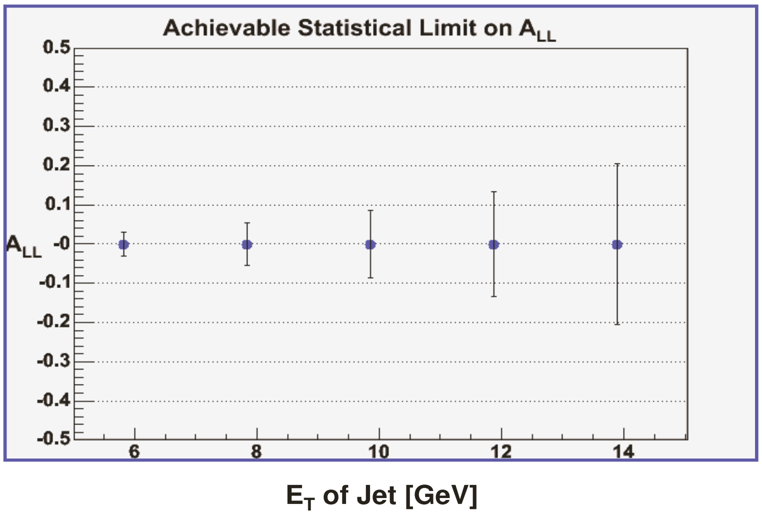

Figure 4. Acheivable statistical errors on the Jet Asymmetry vs E_T for inclusive jets from the STAR 2003 pp data.

References

1. B. Jager, M. Stratmann, W. Vogelsang, hep-ph/0404057.
2. K.H. Ackermann et al, Nucl. Instr. and Meth. **A 499** (2003) 624.
3. G. Blazey et al, hep-ex 0005012.