INCLUSIVE JET A_{LL} MEASUREMENTS AT STAR

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We report STAR's preliminary measurement of the inclusive jet longitudinal spin asymmetry A_{LL} using data from the RHIC 2006 run. The 2006 data set was taken with 200 GeV polarized proton-proton collisions and represents 4.7 pb^{-1} of data. Typical beam polarizations were $\sim 55 - 60\%$. The data are compared with theoretical calculations of A_{LL} based on various GRSV models of the polarized parton distribution functions in the nucleon. Previous STAR inclusive jet A_{LL} and cross section measurements are also presented, as is a discussion of constraints these data place on the allowed theoretical models.

1. Introduction

The Relativistic Heavy Ion Collider (RHIC) is unique among the world's high energy physics laboratories by being the first and only accelerator complex to collide beams of polarized protons. The RHIC Spin Program[1] aims to use polarized p-p collisions to measure the gluon spin contribution, ΔG, to the proton's spin. As measured by polarized Deep Inelastic Scattering (DIS) over three decades, the quark and anti-quark spin contributions to the spin of the proton are known to be only $\sim 20 - 30\%$[2]. The deficit must be made up from the gluon spin and/or the quark and gluon orbital angular momentum contributions, all of which are relatively unconstrained by data.

The ΔG contribution is accessed at RHIC by measuring the double longitudinal spin asymmetry $A_{LL} = \Delta\sigma/\sigma = (\sigma^{++} - \sigma^{+-})/(\sigma^{++} + \sigma^{+-})$, where $++$ and $+$- refer to the helicity states of the two incoming proton beams. A_{LL} can be measured at RHIC in a variety of processes[1]. The results presented here will be from the inclusive jet channel at the Solenoidal Tracker At RHIC (STAR[3]) experiment only. The inclusive jet channel has the advantages of a relatively large cross section and little sensitivity to frag-

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mentation functions. Additionally, STAR's large tracking and calorimeter coverage ideally suits full jet reconstruction.

2. Experimental Setup

Jets are reconstructed at STAR with a midpoint cone algorithm[4] using a cone radius of 0.4(0.7) in 2005(6) and data from the Barrel and Endcap Electro-Magnetic Calorimeters (BEMC, EEMC) and the Time Projection Chamber (TPC). The BEMC and EEMC measure the neutral energy deposited by each event in the full eta range of $-1 < \eta < 2$. The BEMC consists of 4800 towers of alternating layers of lead and scintillator each 0.05×0.05 in η, ϕ; the EEMC consists of 720 towers with varying coverage $(0.05 - 0.1) \times 0.1$ in η, ϕ. Charged track momenta are measured in the 0.5 T STAR solenoidal magnetic field by the TPC for $-1.3 \lesssim \eta \lesssim 1.3$. For triggering and beam luminosity monitoring, Beam Beam Counters (BBCs) are used in the range $3.4 < |\eta| < 5$ on both sides of the collision point. Each BBC consists of two concentric arrays of hexagonal scintillator tiles, and a coincident signal between any tiles from the East and West detectors forms STAR's Minimum Bias (MB) trigger.

The data presented here were taken during two extended p-p runs in 2005 and 2006. In order to increase the relative population of the higher p_T jets in our samples, we heavily prescale events that pass the MB trigger alone and add additional BEMC trigger conditions. The 2005 results shown utilized High Tower (HT) triggers and Jet Patch (JP) triggers, while 2006 results shown are from JP only. The low(high) HT trigger in 2005 required each accepted event to have a single BEMC tower with transverse energy $E_T \geq 2.6(3.5)$ GeV. The JP trigger in 2005 required $E_T \geq 4.5(6.5)$ GeV within a BEMC region 1×1 in η, ϕ, and in 2006 required $E_T \geq 7.8(8.3)$ GeV within the JP per accepted event.

3. A_{LL} Results and Comparison to Theory

Previous p-p inclusive jet results have been published from STAR[5] in which good agreement within systematics was found between the measured cross section for STAR data using two trigger arrangements and an NLO pQCD evaluation[7]. The agreement confirms the applicability of the NLO pQCD framework to STAR's energy regime and supports interpretation of A_{LL} in this framework. Partonic subprocesses including $gg \rightarrow gg$, $qg \rightarrow qg$, and $qq \rightarrow qq$ all contribute in a p_T dependent way to A_{LL} at leading order. Subprocesses including a gluon, gg and qg, dominate in STAR's p_T and
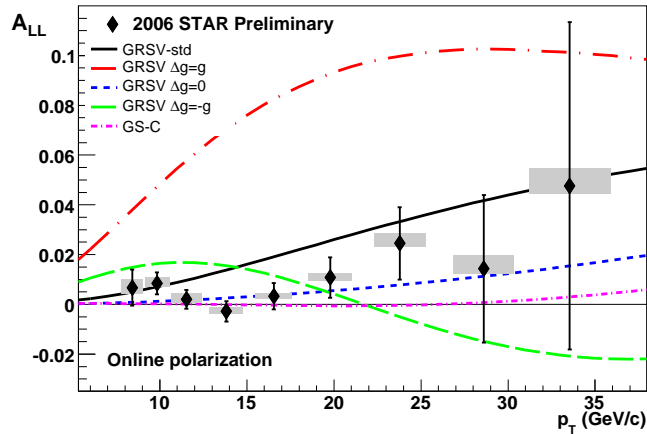
kinematic range[7,1].

Figure 1. A_{LL} as a function of corrected jet transverse momentum for inclusive jet production at $\sqrt{s} = 200$ GeV. The error bars represent statistical uncertainties only. The grey bands represent the systematic uncertainties, excluding an overall uncertainty for beam polarization. Data are shown compared to NLO polarized gluon models from GRSV[7] and GS[10].

Experimentally, A_{LL} is measured as:

$$A_{LL} = \frac{1}{P_1 P_2} \frac{N^{++} - RN^{+-}}{N^{++} + RN^{+-}}, \quad R = \frac{\mathcal{L}^{++}}{\mathcal{L}^{+-}} \tag{1}$$

where $N^{(++),(+-)}$ are the jet yields for the aligned and anti-aligned beam helicity states, R is the ratio of luminosities, and $P_{1,2}$ are the beam polarizations measured with RHIC polarimeters[6]. Figure 1 shows A_{LL} from 2006 JP trigger data representing 4.7 pb^{-1} of data after all cuts. Beam background not associated with the hard scattering occasionally resulted in jet-like signals in the detectors exhibiting an excess of neutral energy. We remove them by placing a conservative upper limit on the fraction of the total energy in a jet coming from our calorimeters; less than 0.80 in 2005 and less than 0.85 in 2006 after shielding was added around the beampipe upstream of STAR's detectors. BBC coincidence timing information is used in 2005(6) to keep events within uniform TPC tracking efficiency for both yield and relative luminosity measurements. A cut is also applied to the

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jet thrust axis in both samples to keep jets within uniform calorimeter acceptance, $0.2 < \eta < 0.8$ in 2005 and $-0.7 < \eta < 0.9$ in 2006. In 2006 the BEMC was fully instrumented and both BEMC and EEMC towers were included in jet finding/reconstruction.
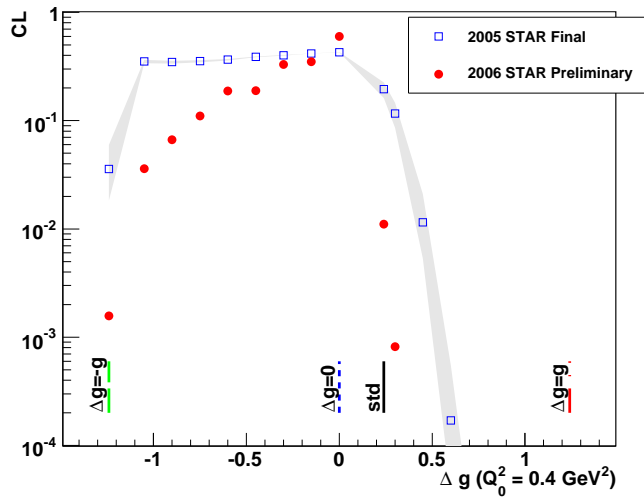

Figure 2.   2005/6 Confidence Levels are shown for GRSV models ranging from $\Delta g = -g$ to g. The quantity Δg represents the integral of x from $0 \to 1$ of $\Delta g(x)$ for that model at the input scale $Q^2 = 0.4\ GeV^2$. The shaded band around 2005 points is the 9.4% scale uncertainty from beam polarization.

The leading systematic uncertainties on our A_{LL} data points come from biases introduced by jet reconstruction and triggering. We determine them by combining Pythia[9] generated events with polarized parton weights from GRSV[8] ΔG models and a full Geant[10] STAR detector and trigger simulation. Shifts have been applied to the p_T values of the points in Fig. 1 in order to correct for jet energy scale and resolution effects. A conservative uncertainty is applied to each p_T point individually by taking the maximal deviation of all allowed GRSV A_{LL} theory curves from simulated A_{LL} curves corrected to our detector+trigger. Other systematic effects studied include the possible contribution caused by residual transverse beam polarization components, the uncertainty on relative luminosities, and the uncertainties introduced from beam backgrounds. Single spin asymmetries are also measured and found to be consistent with zero as expected.

The curves in Fig. 1 are NLO pQCD calculations of the inclusive jet A_{LL} from two separate theory groups, GRSV[8] and GS[11]. Within the GRSV framework, GRSV-STD is the best fit to polarized inclusive DIS data as of 2001. GRSV $\Delta g = (-g)g$ are gluon polarization models with all the gluons predicted to be (anti-)aligned with the proton helicity at the initial scale $Q^2 = 0.4\ GeV^2$. GRSV $\Delta g = 0$ represents no net gluon polarization within the proton at the initial scale. GS-C contains a node at $x \sim 0.1$ for $Q^2 = 4$ GeV^2. STAR's kinematic x-range is $0.03 < x < 0.3$, which accounts for $\sim$ 50% of the total ΔG integral for GRSV-STD.

Figure 2 shows the confidence level (CL) of the comparison of the 2005/6 data and theory for each of the GRSV parameterizations. Stratmann and Vogelsang provided STAR with additional ΔG models lying between the 4 major GRSV models shown on Fig. 1. Within the GRSV framework, STD can be excluded based on STAR data with a 99% CL and gluon polarizations $\Delta g < -0.7$ can be excluded with a 90% CL. The 1σ limits for the best fit GRSV-STD are Δg = -0.45 to 0.7. Experimental systematic and statistical uncertainties were accounted for in the CL calculation.

4. Conclusion

Preliminary 2006 inclusive jet A_{LL} results using $\sqrt{s} = 200$ GeV polarized proton-proton collisions with jet p_T up to 35 GeV/c were shown. 4.7 pb^{-1} of data were used with typical beam polarizations ranging $\sim 55 - 60\%$. The data provide significant new constraints as illustrated by a CL analysis using GRSV polarized gluon parameterizations. The central value of the best fit to DIS data, GRSV-STD, can be excluded at 99% CL, and GRSV models predicting $\Delta g < -0.7$ are excluded at 90% CL.

References

1. G. Bunce *et al. Ann. Rev. Nucl. Part. Sci.* **50**, 525 (2000).
2. B.W. Filippone *et al., Adv. Nucl. Phys.* **26**, 1 (2001) and references therein.
3. K.H. Ackerman *et al., Nucl. Instrum. Methods* **499**, 624 (2003).
4. G.C. Blazey *et al. arXiv:hep-ex/0005012.*
5. B.I. Abelev *et al., Phys. Rev. Lett.* **97**, 252001 (2006).
6. O. Jinnouchi *et al.* arXiv:nucl-ex/0412053.
7. B. Jäger *et al., Phys. Rev.* **D70**, 034010 (2004).
8. M. Glück *et al., Phys. Rev.* **D63**, 094005 (2001).
9. T. Sjostrand *et al., Comput. Phys. Common.* **135**, 238 (2001).
10. GEANT 3.21, CERN program library.
11. T. Gehrmann and W.J. Sterling *Phys. Rev.* **D53**, 6100 (1996).