LONGITUDINAL DOUBLE-SPIN ASYMMETRY AND CROSS-SECTION MEASUREMENT FOR INCLUSIVE JETS AT $\sqrt{S}$=200 GEV IN POLARIZED PP COLLISIONS

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We present the STAR 2005 preliminary inclusive jet longitudinal double-spin asymmetry for polarized protons collisions with $\sqrt{s} = 200$ GeV. Comparison of these measurements with theory calculations based on deep inelastic scattering (DIS) results show that the 2005 asymmetry measurement provides significant new constraints on the gluon contribution to the proton's spin. We also present the 2003/2004 inclusive jet cross-section. Interpretation of this asymmetry within the next-to-leading order (NLO) perturbative Quantum Chromodynamics (pQCD) framework is motivated by the agreement between the 2003/2004 inclusive jet cross-section and theory over seven orders of magnitude.

1. Introduction

One of the goals of the Solenoidal Tracker at RHIC (STAR) collaboration is to measure the gluon contribution to the proton's spin. The contribution, ΔG, is accessed through longitudinal double-spin asymmetry measurements which are defined as

$$A_{LL} = \frac{\sigma_{++} - \sigma_{+-}}{\sigma_{++} + \sigma_{+-}}$$

where σ_{++} is the cross-section for same helicity state of the protons and σ_{+-} is for opposite helicity states.

Extraction of ΔG from the asymmetry measurement requires that at least one gluon participate in the collision. In the kinematic region of STAR, gluon-gluon collisions dominate at low p_T[1], while quark-gluon collisions contribute more at mid p_T ranges (10-30 GeV/c). Quark-quark collisions are only a small fraction of events for the p_T range attained so far at STAR.

2. Experimental Setup and Jet Analysis

The Relativistic Heavy Ion Collider (RHIC) located at Brookhaven National Lab (BNL) collides heavy ions and polarized protons with energies up to $\sqrt{s} = 500$ GeV. The main parts of the STAR detector[2] used in jet reconstruction are the time projection chamber (TPC), the lead-scintillator barrel electro-magnetic calorimeter (BEMC) and plastic-scintillator beam-beam counters (BBC). The BBC covers the pseudorapidity (η) range of $3.3 < |\eta| < 5.0$ and serves as a minimum bias trigger (MB), sampling $\sim 87\%$ (26.1 ± 2.0 mb[3]) of the non-singly diffractive cross-section. Spin dependent relative luminosity measurements and non-longitudinal spin components of the beam are also made with the BBC. Charged particle tracking is provided by the TPC for $-1.3 \leq \eta \leq 1.3$. Although the BEMC is designed to measure transverse energy from $-1 < \eta < 1$, only half was fully commissioned in 2005 limiting total jet reconstruction in 2005 to $0 < \eta < 1$. Full jet reconstruction was made from a combination of neutral BEMC tracks and charged TPC tracks. All detectors cover the full azimuthal angle.

The higher p_T jet sample was enhanced by implementing two types of calorimeter based triggers, high tower (HT) and jet patch (JP), in coincidence with the MB condition. The HT trigger required one BEMC tower, measuring $\Delta\eta \times \Delta\phi = 0.05 \times 0.05$, to contain transverse energy $(E_T) > 2.9$ GeV (3.7 GeV). In contrast, the JP triggers require patches roughly the size of a jet ($\Delta\eta \times \Delta\phi = 1 \times 1$) have $E_T > 4.6$ GeV (7.9 GeV).

Jets are defined using a mid-point Cone algorithm[4] with a radius of 0.4. Edge effects were minimized by restricting the jet axis to lie within 0.2 units of eta from the edge of the BEMC. To help eliminate beam background, jets were required to deposit 80% or less of their energy in the BEMC. A requirement on the BBC timing equivalent to restricting the event vertex to within 60 cm of the TPC center was also applied to obtain uniform tracking efficiency.

3. Cross-section

The extraction of ΔG from spin asymmetries proceeds through NLO pQCD. The inclusive jet differential cross-section[5], shown in Fig. 1, is used to confirm the agreement between pQCD theory and the differential cross-section defined as:

$$\frac{1}{2\pi}\frac{d^2\sigma}{d\eta dp_T} = \frac{1}{2\pi}\frac{N_{jets}}{\Delta\eta\Delta p_T}\frac{1}{\int Ldt}\frac{1}{c(p_T)}$$

where N_{jets} is the number of jets and $c(p_T)$ is the correction factor. Fig.

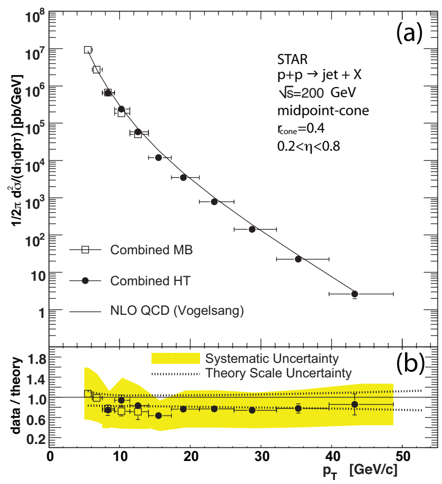

Figure 1. (a) inclusive jet cross-section for polarized protons at $\sqrt{s} = 200$ GeV for 2003/2004 versus jet p_T. Jets from min bias and high tower triggers are shown. Horizontal bars give the jet p_T binning. Vertical bars are the statistical error and are generally smaller than the plotted symbol. The continuous line is the NLO pQCD prediction. (b) Data Theory Comparison. The error band is the experimental systematic uncertainty. The dashed lines indicate the relative change in the NLO calculation for $\mu = p_T/2$ (upper line) and $\mu = 2p_T$ (lower line).

1, which includes minimum bias and high tower triggers and extends from 5 GeV/c $< p_T <$ 50 GeV/c, shows good agreement to NLO pQCD over 7 orders of magnitude.

The raw jet yields were corrected for detector resolution and trigger inefficiencies using the STAR simulation framework which consists of the PYTHIA 6.205[6] monte carlo generator and a GEANT3[7] implementation of the STAR detector.

4. Asymmetry Measurement

The asymmetry was calculated as

$$A_{LL} = \frac{\sum P_1 P_2 (N_{++} - R N_{+-})}{\sum (P_1 P_2)^2 (N_{++} + R N_{+-})}$$

where P is the polarization of the two beams, N is the number of jets and R is the relative luminosity between the two spin states. The sum is over runs lasting around 20 minutes. Fig. 2 shows the 2005 preliminary inclusive jet asymmetry measurement, which was taken from 1.6 pb^{-1} of

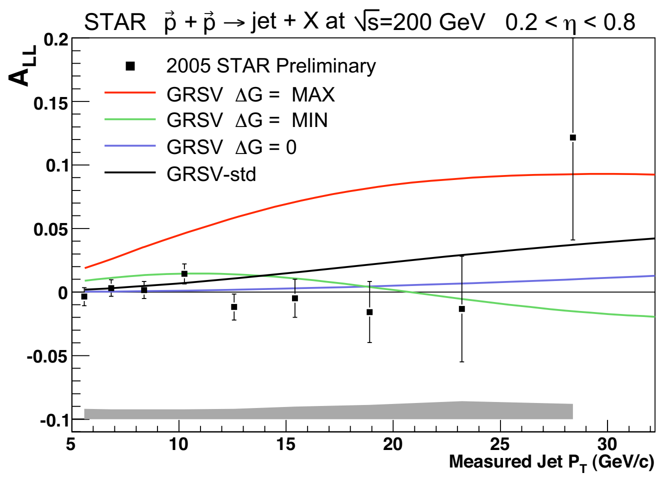

Figure 2. Preliminary inclusive jet double-spin asymmetry for 2005 for polarized protons at $\sqrt{s} = 200$ GeV. The error bars on the points are from statistical errors. The gray error band is total systematic errors. Curves are theory predictions based on DIS data.

sampled luminosity and an average beam polarization of 45% - 50%. The leading systematic error is from reconstruction and trigger bias which is p_T dependent and ranges from 0.002-0.012. Other systematics are from non-longitudinal polarization effects, relative luminosity, backgrounds and parity violating single-spin asymmetries. Polarization error is not included in the systematic error band. The 2003/2004 asymmetry[5] has been plotted along with the 2005 results in Fig. 3 for comparison. Results for 2003/2004 and 2005 are consistent with each other.

The curves in Fig. 2 are from NLO pQCD predictions[1]. The GRSV-std curve is based upon the best fit value to DIS data. The other curves represent $\Delta g(x, Q_0^2) = 0$ (zero gluon polarization) and $\Delta g(x, Q_0^2) = \pm g(x, Q_0^2)$ (maximum and minimum gluon polarization) at $Q_0^2 = 0.4$ GeV^2/c^2 input scale. While the 2003/2004 data disfavored the maximum gluon polarization scenario, the 2005 data is inconsistent with a broader range of GRSV models having a ΔG significantly larger than GRSV-std. With present statistics we are sensitive to polarization of gluons with Bjorken x in the range $0.01 < x < 0.5$.

The 2006 inclusive jet sample will have an improved figure of merit due to increased average polarization and statistics. Additionally, enough di-jet events are available in 2006 data to make an initial di-jet double-

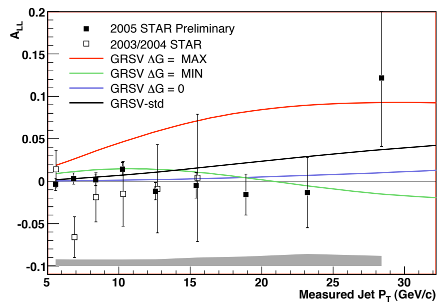

Figure 3. Comparison of 2003/2004 and 2005 inclusive jet double-spin asymmetry. The error bars on the points are from statistical errors. The 2005 jet p_T range has been extended compared to 2003/2004 and the statistical errors have shrunk due to increased statistics and polarization for 2005. Results for 2003/2004 and 2005 are consistent with each other.

spin asymmetry measurement which can be used to determine the partonic kinematics.

5. Conclusion

We presented the STAR 2005 preliminary inclusive jet longitudinal double-spin asymmetry for polarized protons collisions with $\sqrt{s} = 200$ GeV. The asymmetry is inconsistent with large ΔG within the GRSV model framework. It is expected that when included in global fits with DIS data, our measurements will provide a significant contribution to the global understanding of ΔG. The cross-section agrees with NLO pQCD over seven orders of magnitude, and motivates the interpretation of the inclusive asymmetry results within the framework of NLO pQCD.

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