# Nucleon Spin Physics with Jets at STAR

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The spin of the nucleon has its origin in quark and gluon polarization, and in angular momenta. Experiments at SLAC, CERN, and DESY, scattering polarized leptons off polarized nucleons, have found that the quark spins account only for ∼25% of the nucleon spin (see e.g. [1]). This is in striking contrast with expectations from constituent quark models, which enjoyed success in describing hadron magnetic moments and spectroscopy, and has motivated the deeper pursuit of the nucleon spin in physics programs around the world.

The spin-physics program at RHIC [2] makes use of collisions of highly energetic polarized proton beams, enabling a series of unique measurements to accurately determine the gluon polarization in the polarized proton and to delineate the flavor composition of quark polarization.

Jets are abundantly produced in proton collisions at RHIC and give sensitivity to gluons via quark-gluon and gluon-gluon scattering contributions. The longitudinal double-spin asymmetry in inclusive jet production,

$$A_{LL} \equiv \frac{\sigma^{++} - \sigma^{+-}}{\sigma^{++} + \sigma^{+-}}, \qquad (1)$$

is thus sensitive to gluon polarization and accessible in experiment while the collider continues to develop its polarized proton capabilities to design specifications. Here, $\sigma^{++}$ and $\sigma^{+-}$ are the inclusive jet production cross sections when the colliding proton beams have equal and opposite helicities, respectively.

The STAR experiment [3], featuring a large acceptance Time Projection Chamber (TPC) and Barrel Electromagnetic Calorimeter (BEMC), is well equipped for jet measurements at RHIC. The jet reconstruction makes use of a midpoint-cone algorithm that clusters charged particle tracks in the TPC and energy deposits in the BEMC within a cone of radius 0.4 in pseudo-rapidity and azimuth.

We have completed the analysis of an event sample of about $0.3\,\mathrm{pb}^{-1}$ of proton collisions at a center-of-mass energy of $\sqrt{s} = 200\,\mathrm{GeV}$ that was collected during 3-week RHIC machine development periods in the years 2003 and 2004 with measured beam polarizations of up to 45%. Figure 1 shows the results versus the reconstructed transverse momentum $p_\mathrm{T}$ of the jet. The differential cross sections were measured as well. They are reasonably well described by next-to-leading order perturbative QCD (NLO-pQCD) evaluation, thus supporting the use of this framework in the transverse jet momenta of the spin data, $5 < p_\mathrm{T} < 17\mathrm{GeV/c}$. The curves in Figure 1 show NLO-pQCD evaluations [4] for commonly used distributions of quark and gluon polarization in the nucleon [5]. They show scenarios in which the gluon polarization is saturated, $\Delta g = \pm g$, in which it vanishes, $\Delta g = 0$, and in which it is based on a best fit to the CERN, SLAC, and DESY data. The $A_{LL}$ data disfavor ($\chi^2 \simeq 3$) large intrinsic gluon polarization $\Delta g = g$, which had been suggested as a possibility to cause the apparent quark polarization deficit via splitting [6].

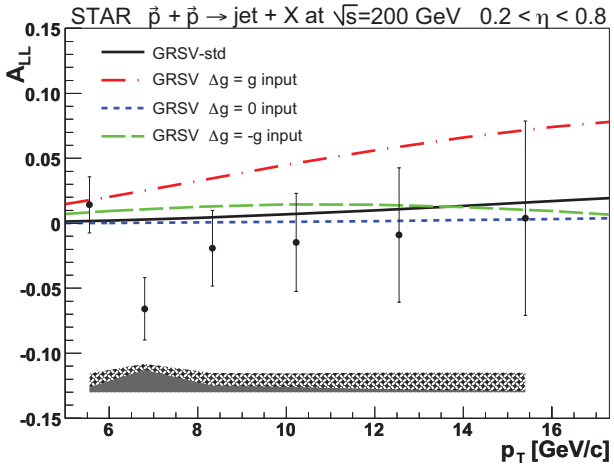


FIG. 1: STAR data on the longitudinal double-spin asymmetry $A_{LL}$ in inclusive jet production versus transverse jet momentum with their statistical uncertainties. The bands indicate the size of systematic uncertainties. The curves are discussed in the text.

In the year 2005, about $\sim 3\,\mathrm{pb}^{-1}$ with average proton beam polarizations of 50% was sampled with improved triggering on jets in STAR. The analysis of these data is being finalized and we expect that the results will conclusively discriminate between the most extreme scenarios for gluon polarization in the polarized nucleon.

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