Nuclear dependence of transverse single-spin asymmetry of charged hadrons in polarized p+p, p+Al and p+Au collisions in PHENIX

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Jeongsu Bok (Inha University / New Mexico State University) for the PHENIX collaboration

**Unique capability of RHIC : polarized p+p and p+A**

The world’s only machine capable of colliding high-energy beams of polarized protons, and a unique tool for exploring the proton’s spin. Also studying collisions of polarized protons with nuclei: p+Al and p+Au

**Charged hadron A_N Analysis**

- PHENIX Muon Spectrometers covers 1.2<|η|<2.4
- 3 Stations of Muon Tracker located behind the absorber measures momentum of charged tracks (muon, hadron) and provides LL1 trigger
- Additional electronics provides momentum dependent triggering
- Muon Identifier (MuID) discriminates muons and hadrons
- Hadrons which stopped in the middle of MuID are selected with momentum cut (p_T>3.5GeV/c) while high momentum muons penetrate.

**Transverse Single Spin Asymmetry**

Transverse Single Spin Asymmetry (TSSA) describe the azimuthal-angular dependence of particle production relative to the transverse spin direction of the polarized proton in proton-proton collisions

- Unexpected large TSSA were observed in hadron production in the forward direction (at large Feynman-x) in p+p collisions up to 500 GeV over 40 years
- A_N(η+) and A_N(η−) have opposite sign. A_N(K+) and A_N(K−) have same sign.

**Mechanisms for A_N**

- Sivers mechanism
- Collins mechanism

**A_N in Polarized p+A collisions**

- The first polarized p-A collision at RHIC 2015
- Novel opportunities to study nuclear effects on parton dynamics
- A_N in inclusive hadron production at forward rapidity in polarized p+A helps us to understand underlying mechanisms of A_N because different mechanism have different A-dependence on A_N
- Recent theories: Hybrid approach (Twist-3 in polarized p, CGC in A side)

**Surprising nuclear dependence of A_N**

- cosine modulation in p+p disappeared in p+Au collisions at 0.1<p_T<0.2
- Nuclear dependence of A_N for positively charged hadron at 0.1<p_T<0.2
- Fit function to quantify the A-dependence, A_N(1/L3) dependence and <N_{h-ad}> dependence
- Favors A_N(1/L3) dependence and <N_{h-ad}> dependence

**Comparison with Theory and Outlook**

- A-dependence is expected for high p_T>Qs
- Current hybrid framework cannot explain this result
- A-dependent term is responsible for nonzero A_N
- Nuclear effect? Multiple scattering?
- More data is needed to pin down the origin of TSSA
- Future experiments (pPHENIX, EIC, STAR forward upgrade) will shed light on the 3D nucleon structure including the true origin of Transverse Single Spin Asymmetry