Transverse Spin Dependent Azimuthal Correlations of Charged Pion Pairs in $p^{\uparrow} + p$ Collisions at $\sqrt{s} = 200$ GeV

Babu Pokhrel (For the STAR Collaboration)

October 30, 2020









Motivation

Transversity Distribution $(h_q(x))$:

 $h_q(x)$ describes transversely polarized quark in transversely polarized hadron.

- $h_q(x)$ is mostly constrained by e^+e^- and SIDIS data.
- *h_q(x)* is chiral odd, needs to be coupled with another chiral odd PDF.
- In $p^{\uparrow} + p$ collision, $h_q(x)$ can be coupled with interference fragmentation function(IFF), $H_{1,q}^{\triangleleft}$.



Measures probability difference between quark polarized parallel versus antiparallel to the nucleon polarization.

(日) (同) (日) (日)

• $H_{1,q}^{\triangleleft}$ should be measured independently to extract $h_q(x)$.

Motivation



• IFF analysis with run 2015 dataset ($\int L = 52 \ pb^{-1}$) will significantly improve the statistical precision.

Babu Pokhrel

・ ロ ト ・ 同 ト ・ 三 ト ・ 三 ト

STAR Experiment At RHIC



Relativistic Heavy Ion Collider (RHIC) Solenoidal Tracker At RHIC (STAR)

- RHIC is capable of colliding bunched beams of polarized protons up to $\sqrt{s} = 510$ GeV.
- STAR experiment is located at one of the collision points of RHIC.
- Major detectors: TPC ($|\eta| < 1.3$) (provides particle tracking and identification), BEMC($|\eta| < 1$) (electromagnetic calorimeter, provides event triggering).

STAR Kinematic Region



• STAR covers much higher Q^2 than HERMES and COMPASS.

• x > 0.1, where the quark transversity is expected to sizeable.

Run 2015 $p^{\uparrow} + p$ dataset at $\sqrt{s} = 200$ GeV. Beam Polarization: 57.5%(Blue), 58.5% (yellow) Integrated Luminosity: $\sim 52 \ pb^{-1}$ (~ 30 times greater than run 2006!)

Events and Particle Selection Cuts:

- Triggers: JP1, JP2
- Z-vertex: $|V_z| < 60 \text{ cm}$
- $p_T^{\pi} > 1.5 \text{ GeV/c}$
- $-1 < \eta^{\pi^+\pi^-} < 1$
- $2.5 < p_T^{\pi^+\pi^-} < 15 \text{ GeV/c}$
- $0.2 < M_{inv}^{\pi^+\pi^-} < 4 \text{ GeV}/c^2$

Kinematic Observables

- A_{UT} inherits × (fractional momentum of proton carried by parton), z (fractional energy of parton carried by hadron pair), and $M_{inv}^{\pi^+\pi^-}$ dependence.
- Opening angle cut (< 0.7) ensures the hadron-pair from the same jet.



Asymmetry Extraction



- Formation of all possible oppositely charged pion pairs in the final state in an event. Opening angle = $\sqrt{(\eta_{\pi^+} \eta_{\pi^-})^2 + (\phi_{\pi^+} \phi_{\pi^-})^2} < 0.7$
- Construction of observables ϕ_S , ϕ_R , \vec{P}_h and \vec{R} following the reference *Phys.Rev. D70 (2004) 094032.*
- Single Spin asymmetry is achieved by integrating over the polarization of one beam, reducing the effective polarization close to zero.

Babu Pokhrel

DNP Fall Meeting, New Orleans

Asymmetry Extraction

• Asymmetry in geometric mean of hadron yields at opposite azimuthal angle and polarization measured using the cross-ratio formula:

 $A_{UT} \cdot sin(\phi_{RS}) = \frac{1}{P} \cdot \frac{\sqrt{N^{\uparrow}(\phi_{RS})N^{\downarrow}(\phi_{RS}+\pi)}}{\sqrt{N^{\uparrow}(\phi_{RS})N^{\downarrow}(\phi_{RS}+\pi)}} + \sqrt{N^{\downarrow}(\phi_{RS})N^{\uparrow}(\phi_{RS}+\pi)}$

- Count N^{↑↓}(π⁺π⁻) in 16 φ_{RS} bins of uniform bin width. Calculate
 A_{UT} · sin φ_{RS} for each φ_{RS} bins.
- *sine* function is fit to the modulation.
- The asymmetry is extracted from the amplitude of the modulation fit, and the associated error will be assigned as statistical error for the particular bin.



• Asymmetry for *blue* and *yellow* beam will be computed separately (provides consistency check!). The final result will be the average of both.

Statistical Error Projection



• The run 2015 dataset will considerably improve on the statistical precision of the run 2006 ($\int L \sim 1.8 \ pb^{-1}$) dataset.

Babu Pokhrel

DNP Fall Meeting, New Orleans

October 30, 2020 10 / 11

Summary

- $\bullet\,$ Run 2015 integrated luminosity is \sim 30 times larger than Run 2006 data set.
- This analysis is finalizing systematics, expect preliminary results soon.
- Run 2015 IFF analysis results will allow for IFF and transversity extraction.
- IFF analysis with the run 2017 data ($\int L \sim 350 \ pb^{-1}$), much larger dataset, will improve statistical precision of IFF measurements at $\sqrt{s} = 510$ GeV.
- Universality of transversity can be tested in conjuction with e^+e^- and SIDIS result.

< □ > < □ > < □ > < □ > < □ > < □ >