First measurement of transverse single spin asymmetry (A_N) for very forward π^0 production in polarized p + p collisions at $\sqrt{s} = 510$ GeV

> Minho Kim (Korea Univ./ RIKEN) on behalf of the RHICf collaboration



10 Sep. 2018 SPIN

A_N in forward π^0 production



- Observed non-zero A_N of π^0 ever has been interpreted in only hard process regime theoretically.
- Non-zero A_N comes from an asymmetry of the partonic-level fragmentation process or spin-dependent quark-gluon correlations in the proton.

New question to the A_N of forward π^0



Smaller A_N was observed with increasing multiplicity of photons (closer to hard scattering event topology).

New question to the A_N of forward π^0



• Larger A_N was observed by more isolated π^0 than less isolated one.

- Smaller A_N in more hard scattering-like event and larger A_N in more diffractive-like event?
- Diffractive process may have a finite contribution to the non-zero A_N of π^0 as well as partonic-level one. 4/18

A_N in very forward π^0 production



• Once A_N of very forward π^0 was measured by RHIC IP12 experiment. It was consistent with zero but in very narrow kinematic range.

RHICf experiment will unveil the role of the diffractive process to the A_N of π^0 by measuring the very forward π^0 ($\eta > 6$) in wide kinematic range (0.2 $\langle x_F \langle 1.0 \text{ and } 0.0 \langle p_T \langle 1.0 \text{ GeV/c} \rangle$.

RHIC forward (RHICf) experiment



Operation summary



- RHICf experiment was successfully operated in June 2017.
- Total 110 M events were accumulated for neutral particles (neutron, π^0 , and single photon) during 28 hours.
- Radial polarization.
- **Higher** β^* : 8 m and lower luminosity: 10³¹ cm⁻²s⁻¹ than usual.

RHICf detector & π^0



Small tower: 20/20 mm Large tower: 40/40 mm

Tungsten absorber (44 X₀, 1.6 λ_{int})

16 GSO plates for energy measurement

4 GSO bar layers for position measurement



Triggers of RHICf detector



How did we reconstruct the π^0 ?



How did we reconstruct the π^0 ?



Invariant mass of two photons



- Clear π^0 peak is shown around 135 MeV/c² with ~10 MeV/c² width.
- Invariant mass was fitted by polynomial for background and Gaussian for π^0 .
- Background part usually comes from coincidence of the other particles, not wrong reconstruction.

Energy resolution of π^0 reconstruction



■ Around 2.7% energy resolution is expected to both Type-I and Type-II.

This similar energy resolution is because energy deposit at detector is quite linear to the sum of actual photon energy regardless of the number of photons.

p_T resolution of π^0 reconstruction



• However, p_T resolution of Type-I is much better than Type-II.

p_T resolution of π^0 reconstruction



• However, p_T resolution of Type-I is much better than Type-II.

This different p_T resolution is because peak position is more fluctuated when two photons hit the detector than one.

π^0 kinematics



First, we studied A_N for three different x_F ranges as a function of p_T .

• x_F and p_T resolution of RHICf detector is much better than their binning scale.

Preliminary result of very forward $\pi^0 A_N$



- Systematic uncertainties by polarization, π^0 azimuthal angle distribution, background A_N subtraction, and beam center was included.
- Non-zero A_N was observed even in very forward π^0 production. Diffractive process may contribute to the A_N of π^0 .
- A_N increases by both p_T and x_F , but more sensitive to p_T .

Preliminary result of very forward $\pi^0 A_N$



Summary

- RHICf experiment was successfully operated in June 2017.
- A_N of very forward π^0 was measured over the kinematic range of 0.2 $\langle x_F \langle 1.0 \text{ and } 0.0 \langle p_T \langle 1.0 \text{ GeV/c.} \rangle$
- Because non-zero A_N was observed even in very forward π^0 production, diffractive process may contribute to the finite A_N of π^0 .
- More detailed study with other STAR detectors will precisely unveil the role of the diffractive process to the A_N of (very) forward π^0 production.