Preliminary result of the transverse single spin asymmetry in very forward π^0 production in 510 GeV $p^{\uparrow} + p$ collisions

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The RHICf experiment[1)] measured the transverse single spin asymmetry, A_N, which is defined as the left-right cross section asymmetry of beam polarization, of very forward π^0 in June, 2017. The spin-related interactions between protons and the production mechanism of a particle can be deeply understood by A_N measurement. To date, the non-zero A_N of forward π^0 has been measured by many experiments, and the parton-level interaction between protons has generally been considered to be the origin of the π^0 production. However, recently, larger A_N was observed for more diffractive-like events than the events driven by hard scattering;[2)] therefore, the measurement of A_N in very forward π^0 production by the RHICf experiment will provide a new input to unveil the origin of the non-zero A_N of π^0, especially from the viewpoint of diffractive and non-diffractive interactions.

To measure the very forward π^0, we moved an electromagnetic calorimeter (RHICf detector), which was originally developed for the LHCf experiment,[3)] from CERN to BNL, and installed it at the zero-degree area of the STAR experiment, which was 18 m away from the beam collision point. The RHICf detector consists of two sampling calorimeters; smaller one has a lateral dimension of 20 mm × 20 mm and the larger one has a lateral dimension of 40 mm × 40 mm. Each tower is composed of 16 GSO plates for energy measurement and 4 layers of GSO bars for position measurement. π^0 can be identified and reconstructed by measuring two decayed photons with two towers or even one tower because the position resolution for photons is of the level of a few hundred μm. We measured very forward π^0 with a wide transverse momentum (p_T) coverage of $0 < p_T < 1$ GeV/c and a longitudinal momentum fraction (x_F) range of $0.2 < x_F < 1$. For the correlation study with other STAR detectors, we took the data using the STAR data acquisition system.

Experimentally, A_N is calculated by following equation:

$$A_N = \frac{1}{P}\frac{1}{D_\phi}\Big(\frac{N^{\uparrow} - RN^{\downarrow}}{N^{\uparrow} + RN^{\downarrow}}\Big), \quad (1)$$

where $N^{\uparrow(\downarrow)}$ is the number of detected π^0 in $p^{\uparrow(\downarrow)} + p$ collision and R is the luminosity ratio between two collision types of spin up (↑) and down (↓). P represents the average polarization of the proton beam and D_ϕ is a correction factor for π^0 azimuthal angle distribution because A_N usually depends on the particle's azimuthal angle by $A_N \propto \sin(\phi - \phi_0)$ where ϕ_0 is an offset angle. Typical values of P and D_ϕ is around 0.6 and 0.96 respectively.

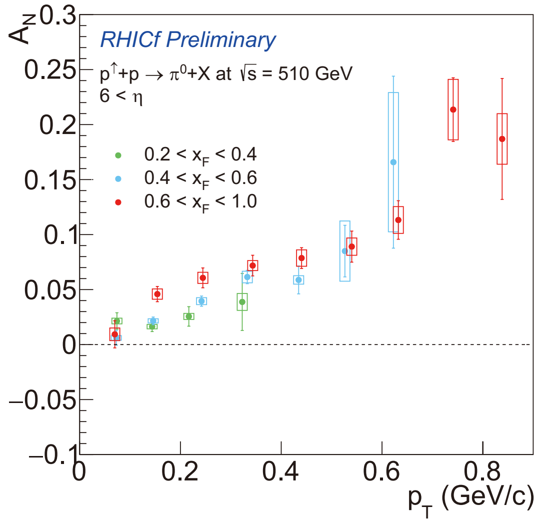

Fig. 1. Preliminary result of the A_N of very forward π^0 production as a function p_T. The three different colors correspond with different x_F ranges.

Figure 1 presents our first result for the A_N of very forward inclusive π^0 production. Surprisingly, non-zero A_N of π^0 was observed even in very forward π^0 production. A_N increases as a function of both x_F and p_T. Because the non-zero A_N in Fig. 1 was driven by the π^0 produced in the very forward region where the diffractive process is dominant, the diffraction can be considered to be a possible contributor of this finite A_N as expected by a recent study.[2)] In order to further study the role of diffraction in the forward π^0 production, we are now analyzing the correlation between RHICf and STAR detectors. STAR forward detectors and Roman pot[4)] can identify diffractive events by observing the rapidity gap or a recoil proton. Therefore, we will be able to understand the relation between diffraction and A_N of (very) forward π^0 with a combined RHICf-STAR analysis.

References
1) RHICf Collaboration, LOI, arXiv: 1409.4860v1.
2) S. Heppelmann (STAR Collaboration), Proc. Sci. **DIS2013**, 240 (2013).
3) O. Adriani *et al.* (LHCf Collaboration), J. Instrum. **3**, S08006 (2008).
4) S. Bültmann *et al.*, Nucl. Instrum. Methods Phys. Res. A **535**, 415 (2004).

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