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

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The transverse single spin asymmetry, A_N, of very forward ($\eta > 6$) π^0 was first measured in the RHICf experiment[1)] in June, 2017 from polarized $p + p$ collisions at $\sqrt{s} = 510$ GeV. The A_N is defined as $(d\sigma_{\mathrm{Left}} - d\sigma_{\mathrm{Right}})/(d\sigma_{\mathrm{Left}} + d\sigma_{\mathrm{Right}})$, where $\sigma_{\mathrm{Left(Right)}}$ is the particle production cross sections in the left (right) side of the polarization direction of the proton beam. The A_N of very forward π^0 is a powerful observable to investigate the contribution from the non-perturbative process to the non-zero A_N of π^0, which has been measured in many experiments[2–4)] thus far.

In order to measure the very forward π^0 precisely, an electromagnetic calorimeter, the RHICf detector, was installed at the zero-degree area of the STAR experiment at Relativistic Heavy Ion Collider, which was 18 m away from the beam collision point. The configuration of the RHICf detector can be found in Ref. 5). The RHICf detector has an energy resolution of 2.5–3.5% for 100–250 GeV π^0 and a transverse momentum (p_T) resolution of 0.005–0.025 GeV/c for 0.0–0.8 GeV/c π^0.

The experiment was conducted for 28 h with three vertical detector positions, where the beam propagated towards the center of the large tower, center of the small tower, and a point 24 mm below the center of the small tower of the detector before the collisions. With the three detector positions, we requested radial polarization, which was the direction at an angle of 90° from the usual vertical polarization at RHIC, and a large β^* = 8 m so as to measure the wide p_T range with higher resolution. The kinematic coverage of the measured π^0 is $x_F > 0.25$ and $0.0 < p_T < 1.0$ GeV/c, where the non-perturbative process was expected to mainly contribute to the π^0 production.

Figure 1 shows our preliminary result for the A_N of very forward π^0 as a function of x_F for five different p_T ranges. The line and box error bars represent statistical and systematic uncertainties, respectively. The estimation; of the polarization; beam center, which is defined as the extrapolated zero-degree position of the beam to the detector; and background (mostly from the two-photon coincidence of different π^0) were the three main systematic sources. See Ref. 6) for more details on the analysis procedure and systematic study.

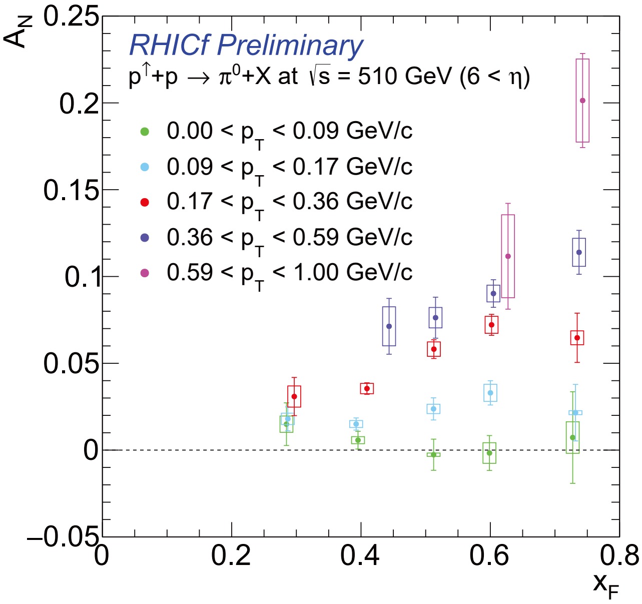

Fig. 1. Preliminary result of the A_N of very forward π^0 production as a function x_F. The five different colors correspond to different p_T ranges.

In Fig. 1, the A_Ns are consistent with zero at a very low $p_T < 0.09$R GeV/c. However, its slope with respect to the x_F-axis becomes steeper as p_T increases. When $p_T > 0.36$ GeV/c, the increasing A_N shows the same slope with the previous forward ($2 < \eta < 4$) π^0 measurements[2–4)] even in the low-p_T region where only the non-perturbative process is expected to be dominant. It might be possible that the non-perturbative process can contribute to the non-zero A_N of π^0 at a higher p_T.

The result also raises the necessity of further experimental efforts to compare the roles of the perturbative and non-perturbative processes in the A_N of π^0 and the measurement of the intermediate kinematic region where both processes possibly contribute ($0.8 < p_T < 2.0$ GeV/c). Combined analysis with STAR forward and Roman pot[7)] detectors is useful to separate each process by measuring the rapidity gap or tagging a proton scattered at a very low angle, which are the characteristics of the diffraction of the non-perturbative process.

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