Preliminary results of $A_{LL}^{\pi^0}$ measurement at $\sqrt{s} = 510$ GeV at mid-rapidity through a PHENIX experiment

I. Yoon[*1,*2] for the PHENIX collaboration

One of the important functions of the relativistic heavy ion collider (RHIC) longitudinally polarized proton program is to constrain the gluon-spin component of the proton (ΔG) by measuring the double helicity asymmetry (A_{LL}) of π^0 and jet production. Based on the results of deep inelastic scattering experiments, the quark-spin component of proton is only $0.330 \pm 0.011(Theo.) \pm 0.025(Exp.) \pm 0.028(Evol.)$.[1] The remaining spin might be carried by gluons or orbital momentum. However, ΔG has not been measured in detail as yet.[2)]

The measurement of A_{LL} for π^0 production ($A_{LL}^{\pi^0}$) at $\sqrt{s} = 200$ GeV has been successfully published and has contributed to constraining ΔG.[3)] To explore the lower Bjorken x region, where dominant uncertainty remains, longitudinally polarized proton-proton collisions in 2013 (Run13) were successfully carried out with increased energy, i.e. $\sqrt{s} = 510$ GeV. Because of the increased energy, the measurement at $\sqrt{s} = 510$ GeV can reach a lower x range, $0.01 < x$, while the previous measurement could reach only $0.02 < x$. The measurement at $\sqrt{s} = 510$ GeV is ongoing and preliminary results have been released.

$A_{LL}^{\pi^0}$ can be defined in terms of differences in cross-sections as

$$A_{LL}^{\pi^0} = \frac{d\Delta\sigma^{\pi^0}}{d\sigma^{\pi^0}} = \frac{d\sigma_{++}^{\pi^0} - d\sigma_{+-}^{\pi^0}}{d\sigma_{++}^{\pi^0} + d\sigma_{+-}^{\pi^0}} \quad (1)$$

where $\sigma_{++(+-)}$ stands for π^0 cross-section with the same(opposite) helicity proton collisions. Because σ^{π^0} can be described by the parton distribution function, the partonic reaction cross-section and fragmentation function and most of π^0s are from quark-gluon or gluon-gluon scattering at mid-rapidity region, gluon helicity distribution (Δg) is accessible by measuring $A_{LL}^{\pi^0}$. This description is verified by comparing the π^0 cross-section between theoretical and experimental data.

Equation 1 can be rewritten in terms of experimental observables as

$$A_{LL} = \frac{1}{P_B P_Y} \frac{N_{++} - RN_{+-}}{N_{++} + RN_{+-}}, R = \frac{L_{++}}{L_{+-}} \quad (2)$$

where $P_{B(Y)}$ is the polarization of RHIC's "Blue (Yellow)" beam, $N_{++(+-)}$ is the yield of the π^0 candidate from the same (opposite) helicity collisions, and R is the relative luminosity of the same and opposite helicity collisions.

As the collision rate increases in Run13, the effect of multiple collisions on one beam crossing becomes sizable. The effect of multiple collisions is fully taken into account for the relative luminosity measurement. Luminosity miscount by the finite resolution of the vertex width of luminosity detector is also considered. The uncertainty of the relative luminosity is a dominant systematic uncertainty of the measurement.

To reduce the combinatorial background in diphoton invariant distribution, several cuts are applied. Hits by a charged track, hadron, and previous crossings are rejected. To evaluate A_{LL} for the remaining background, A_{LL} of the background is also measured and is subtracted to obtain physical asymmetry.

Fig. 1 shows preliminary results of $A_{LL}^{\pi^0}$ measurement at $\sqrt{s} = 510$ GeV. The result covers 2 GeV/c $< P_T <$ 20 GeV/c ($0.008 < x_T < 0.08$, where $x_T = 2P_T/\sqrt{s}$). The DSSV14 theory curve is shown and it agrees with experimental data within uncertainty. The measurement at $\sqrt{s} = 200$ GeV is also shown for comparison. Larger asymmetry is observed at higher collision energy.

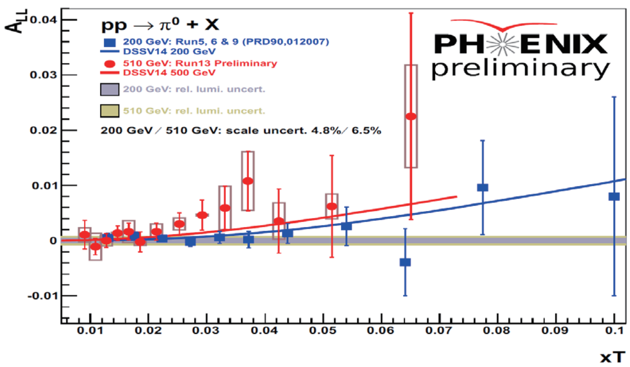

Fig. 1. Preliminary result of $A_{LL}^{\pi^0}$ measurement at $\sqrt{s} =$ 510 (red line) and comparison with $A_{LL}^{\pi^0}$ at $\sqrt{s} = 200$ GeV[3)] (blue line). DSSV14 theory curves[2)] are shown. The grey and yellow bands indicate systematic uncertainty due to the uncertainty of relative luminosity. Global-scale uncertainty due to systematic uncertainty of polarization is not shown. Open boxes denote point-to-point systematic uncertainty.

Further analysis is ongoing to obtain the final result.

References

1) A. Airapetian et al.: Phys. Rev. D **75**, 012007 (2007).
2) D. de Floran, R. Sassot, M. Stratmann and W. Vogelsang: Phys. Rev. Lett. **113**. 012001 (2014).
3) A. Adare et al.: Phys. Rev. D **90**, 012007 (2014).

*1 RIKEN Nishina Center
*2 Seoul National University