Status of analysis of longitudinal double helicity asymmetry in π^0 production in $\sqrt{s} = 510$ GeV polarized proton–proton collision by PHENIX central arm

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The final goal of this research is to contrain polarized gluon distribution via measurement of the longitudinal double helicity asymmetry of π^0 production ($A_{LL}^{\pi^0}$) with $\sqrt{s} = 510$ GeV RHIC PHENIX data. Based on the results of EMC experiment and other following experiments, the quark-spin component of a proton is only $0.330 \pm 0.011(Theo.) \pm 0.025(Exp.) \pm 0.028(Evol.)$. [1)2)] The remaining spin might be carried by gluons or orbital momentum. However, the gluon-spin component is poorly measured because polarized gluon distribution has not been measured precisely.[2)] However, measurement with $\sqrt{s} = 510$ GeV RHIC PHENIX data can contribute significantly toward constraining polarized gluon distribution. The gluon-spin component can be measured via $A_{LL}^{\pi^0}$ in polarized proton collisions, which is defined as

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

where $\sigma_{++}^{\pi^0}$ and $\sigma_{+-}^{\pi^0}$ denote the π^0 cross section from a collision between same helicity protons and that from a collision between opposite helicity protons, respectively.

Compared to the previous measurement with $\sqrt{s} =$ 200 GeV RHIC data (Run09), the ongoing measurement with $\sqrt{s} = 510$ GeV RHIC data (Run13) will cover a lower momentum-fraction (Bjorken x) kinematic region, where the uncertainty large. The integrated luminosity of Run13 is much higher compared to that of Run09. The figure of merit ($\int L \times P_B^2 \times P_Y^2 dt$) considering beam polarization (P_B and P_Y) is also higher. Table 1 presents a comparison between Run09 and Run13. Thus, this research can contribute toward constraining polarized gluon distribution. The progress of the analysis is presented herein.

Table 1. Measurement with RHIC Run09 and Run13 data

	Run09	Run13
$\sqrt{s}$	200 GeV	510 GeV
Bjorken x region	0.05∼0.2	0.02∼0.08
$\int Ldt$	15 pb^{-1}	145 pb^{-1}
$\int L \times P_B^2 \times P_Y^2 dt$	1.4 pb^{-1}	14.7 pb^{-1}

In this experiment, π^0 is measured via $\pi^0 \rightarrow \gamma\gamma$ decays using a highly segmented electromagnetic calorimeter (EMCal) covering $|\eta| < 0.35$ and $\Delta\phi = \pi$.

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Thus far, event selection and related low-level study, EMCal warnmap generation, and EMCal TOF tower-by-tower correction have been done.

An EMCal warnmap is a map of abnormal EMCal towers. To reject events from the abnormal towers, a warnmap has been generated wherein noisy, dead and uncalibrated towers are marked. EMCal tower-by-tower TOF correction has been performed. Before the correction, there was tower-by-tower TOF deviation, and the deviation depended on time. After the correction, the TOFs of all towers are well aligned.

For event selection, the shower-shape cut, charge-veto cut and TOF cut are applied to reject hadronic, charged and ghost events, respectively. Clusters in an EMCal can survive up to three bunch-crossings. Clusters from previous crossings are called ghost clusters. For the charge-veto cut and TOF cut, cut parameters are optimized by the signal-to-noise ratio. In addition to the three cuts mentioned above, the conventional minimum energy cut and vertex cut are also applied. After event selection, the statistics for remaining π^0 is 6.97×10^7. The results of the event selection are summarized in Fig. 1.

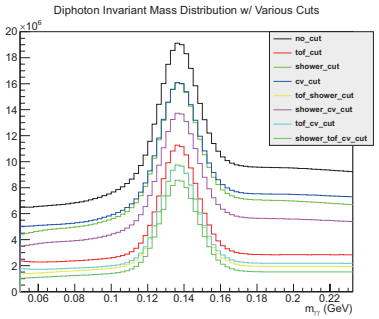

Fig. 1. Diphoton invariant mass distribution with various cuts for all P_T bins. After event selection, 70% of the noise is suppressed, whereas 30% of the signal is lost.

After the completion of event selection, $A_{LL}^{\pi^0}$ calculation has been started. $A_{LL}^{\pi^0}$ calculation is currently in preliminary stage. Estimation of statistical and systematic uncertainties is also being carried on. To validate the analysis, single-spin asymmetry is being calculated.

References

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