PHENIX local polarimetry analysis status

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One of the main goals of the PHENIX experiment at the Relativistic Heavy Ion Collider (RHIC) is to study the proton spin structure through spin asymmetry measurements of production cross sections using various probes from polarized $p + p$ collisions. In 2013, we ran longitudinally polarized $p+p$ collisions at $\sqrt{s} = 510$ GeV. Since the stable polarization direction of proton beams circulating in the ring is perpendicular to the ground, the polarization direction is kept perpendicular except in the experimental hall during longitudinally polarized beam collision runs.

Measuring proton beam polarization along the longitudinal direction at the collision is important in double longitudinal spin asymmetry A_{LL} measurements. The polarization in RHIC is measured by RHIC polarimeters at the position where the spin vector is vertical; however, once the polarization direction is changed to be longitudinal, some transverse component of the beam polarization can remain. This should be accounted as a systematic error in the A_{LL} calculation.

The PHENIX local polarimeter measures the transverse component of proton beam polarization at the collision point with single transverse spin asymmetry A_N in forward neutron production. A large A_N for the neutron production was measured in the PHENIX experiment.[1)] For forward neutron production, which has a small transverse momentum p_T, the large A_N cannot be explained by perturbative QCD, but the One Pion Exchange (OPE) models explain it well. In the OPE model, finite A_N is accompanied by the interference of the spin-flip amplitude of pion-exchange and the spin-nonflip amplitude of other Reggeon exchange. A detailed theoretical study is still ongoing.

The PHENIX local polarimeter consists of Zero Degree Calorimeters (ZDCs) and Shower Max Detectors (SMDs) and is located downstream of the beam dipole-bending-magnet outside of the interaction region. ZDC is a hadron calorimeter, and SMD is a hodoscope composed of plastic scintilator strips. The neutron's position is calculated by centroid method using energy deposited in the SMD.

For obtaining the local polarimeter data, a transversely polarized commissioning fill, a longitudinally polarized commissioning fill, and physics fills are used. 81M events were taken for the transverse commisioning fill, and 280M events were taken for the longitudinal commissioning fill. During physics runs, the local polarimeter trigger was used with a prescale, and the scaled trigger rate was about 100-200 Hz.

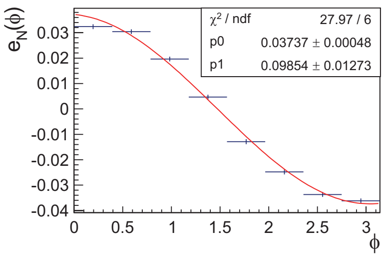

Fig. 1. e_N fitting

Events with 70-300 GeV energy are considered in order to avoid background photons; beam scraping backgrounds from the beam pipe, which deposit low energy in ZDC; and events that directly hit the optical fibers for ZDC readout. Further, only the events with at least two hits in the SMD scintillator strips in both x, y coordinates are considered in order to reject the photon background. A fiducial acceptance cut with radius = 0.5-4.0 cm from the SMD center is applied in order to avoid shower leakage or the smearing effect at the center caused by the SMD with about 1 cm position resolution. After the event selection, 19M events are used for the transverse run analysis.

The measured analyzing power ${A_N}^{measured}$ is defined as

$${A_N}^{measured} = \frac{1}{sin(\phi - \phi_0)} \frac{e_N(\phi)}{p}.$$

e_N is the raw asymmetry calculated with the square root formula,[1)] and its values for the south detector (counter-clockwise direction from the collision point) in the transverse run are plotted in Fig.1. Only the statistical error is calculated for the error bars. p is the proton beam polarization, and it is 0.369 ± 0.061 for the yellow beam (beam runs counter-clockwise direction) during the transverse run. The calculated ${A_N}^{measured}$ is 0.101 ± 0.018. For the transverse component calculation, we calculate ${A_N}^{measured}$ of longitudinal runs in the same manner, then divide that by ${A_N}^{measured}$ of the transverse run. The transverse component is about 1% or less during the commissioning run.

Currently, modification of the pedestal and gain parameters for ZDC and SMD is ongoing. After these are finialized, the codes with new parameters will be rerun. Further, the systematic errors will be estimated.

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References

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