Polarization measurements of 100 GeV proton beams at RHIC by elastic proton-proton and proton-carbon scattering

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The two types of polarimeter have been developed to measure polarizations of proton beams at relativistic heavy-ion collider (RHIC). A pC polarimeter[1)] provides a relative polarization by measuring asymmetries in left-right yields $(N_{\rm L}, N_{\rm R})$ of recoil carbon events through elastic proton-carbon reaction. The absolute beam polarization $P_{\rm beam}$ is given by normalizing the measured asymmetries by the analyzing power for the elastic pC process $A_{\rm N}^{pC}(t)$

$$P_{\rm beam} = \frac{1}{A_{\rm N}^{pC}(t)} \frac{N_{\rm L} - N_{\rm R}}{N_{\rm L} + N_{\rm R}}, \qquad (1)$$

where t is 4-momentum transfer. The silicon strip detectors were implemented around 90° to select the elastic process to be very peripheral ($0.005 < |t| < 0.035$ $(\mathrm{GeV/c})^2$). This is because the t dependent analyzing power is expected to be maximum due to the interference between the electromagnetic and the nuclear strong force amplitudes. This kinematic region is known as Coulomb Nuclear Interference (CNI) region. However, because of the poorly known hadronic spin-flip mechanism at the energy as high as 100 GeV,[2)] the A_N^{pC} is not exactly predictable. Thus the relative A_N^{pC} is experimentally determined from the measured t dependence of the asymmetries and its absolute calibration is obtained from a polarized hydrogen gas jet polarimeter[3)] data which was operated in parallel with the pC polarimeter. Since the target polarization $P_{\rm target}$ is accurately monitored by a Breit-Rabi polarimeter, it can be translated into the absolute beam polarization using a following ratio:

$$\frac{P_{\rm target}}{P_{\rm beam}} = \frac{\epsilon_{\rm target}}{\epsilon_{\rm beam}} \qquad (2)$$

where $\epsilon_{\rm target}, \epsilon_{\rm beam}$ are left-right asymmetries $(N_{\rm L} - N_{\rm R})/(N_{\rm L} + N_{\rm R})$ observed when either the target or the beam is polarized, respectively. The A_N^{pC} employed for Run5 online polarization measurements (see Fig. 1) was calibrated by the preliminary analysis result of the Run4 hydrogen polarimeter data with 8.5% uncertainty. This uncertainty is currently dominated by the statistics and it will be improved cumulatively as increasing data in Run5 and future runs. During Run5, it was attempted for the first time to perform measurements on both blue and yellow beams simultaneously/sequentially and as a consequence the accumulated statistics amounted about factor of 4 of the Run4 data. On the other hand, the signal was somehow suffered from more backgrounds and S/N ratio was deteriorated by factor of 2. The cause of this is under investigation.

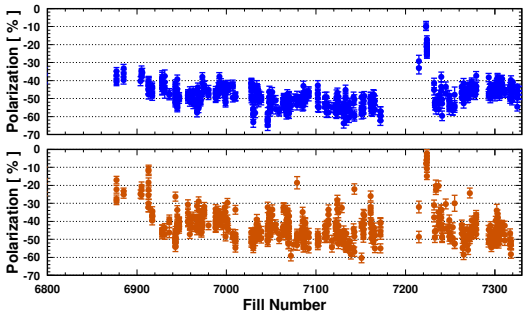

Fig. 1. Results of online (PHENIX physics store) polarization measurements plotted as a function of the fill number for the blue(top) and the yellow(bottom) beams, respectively.

The uncertainty of each pC polarization measurement was estimated to be 12 to 19% as a result of Run3 and Run4 analyses. The RHIC-spin program requires to measure the beam polarization within 5% accuracy. In order to achieve this goal, continuous efforts to improve the polarization measurements have been spent also for Run5. One of the major modifications is in the strip detector of the pC polarimeter. A beam induced pickup noise was significantly suppressed by improving the grounding design of silicon strips. The signal baseline so stabilized is then expected to reduce the uncertainty introduced in the ADC to energy conversion which was one of the largest error sources of Run3 and Run4 data.

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