RHIC Polarimetry

1. RHIC Polarimetry

Polarimetry is a crucial component of the RHIC Spin Program. Measurement of the absolute proton beam polarization to a precision of 5% is the goal for all high precision spin dependent measurements at RHIC. Two types of polarimeters are used at RHIC, which are based on small angle elastic scattering, with sensitivity to the proton beam polarization coming from interference between electromagnetic and hadronic amplitudes in the Coulomb-Nuclear Interference (CNI) region.

One type of polarimeter(p-Carbon) uses an ultra-thin (5 μg/cm^2) and 10 micron wide carbon ribbon target, and provides fast relative polarization measurements with a few percent statistical uncertainty in 20–30 sec. Repeated measurements during a fill also provide a handle on the beam polarization decay vs time as well as measurements of beam polarization profiles in the transverse plane. The latter directly enters the average beam polarization observed in collisions at the interaction regions of the RHIC experiments.

The second polarimeter (H-Jet) uses a polarized hydrogen gas target and utilizes the analyzing power in proton-proton elastic scattering in CNI region (Fig. 1). It accumulates data over the entire fill and provides absolute polarization measurements, with $\sim$ 10% statistical uncertainty in a fill (6–8 hours).

H-Jet data accumulated over several fills are used for the absolute calibration of the p-Carbon polarimeters. The calibration goal of $\Delta P/P < 5\%$ was reached in the 2005 run. Fig. 2 demonstrates the normalized pC polarization measurements in fills of the 2006 run.

In addition, the two experiments STAR and PHENIX employ local polarimeters which are primarily sensitive to transverse beam polarization, which are used to set up and to monitor the spin directions at collision.

For the near term, we have embarked on an upgrade program to replace the current p-Carbon polarimeters vacuum vessels with longer ones that accommodate two polarimeter set ups and associated targets in each ring. This a) doubles the number of targets and minimize the need to open the vessels during a long run, b) reduces the time required for successive measurements of the horizontal and vertical polarization profiles and thus experiment downtime, c) allows installation and testing in situ new photo-diode detectors with higher rate capabilities, and d) improves the pumping and vacuum system. We are also investigating the possibility of using nano technology to produce carbon targets for the RHIC polarimeters. While promising work has been done, the challenge is to produce 30 mm long filaments or strands to be tested to assess durability and heat dissipation under realistic beam conditions.

In addition we plan a testing program using carbon beams from the Tandem spanning the carbon recoil energies to better calibrate the silicon and photo-diode detectors

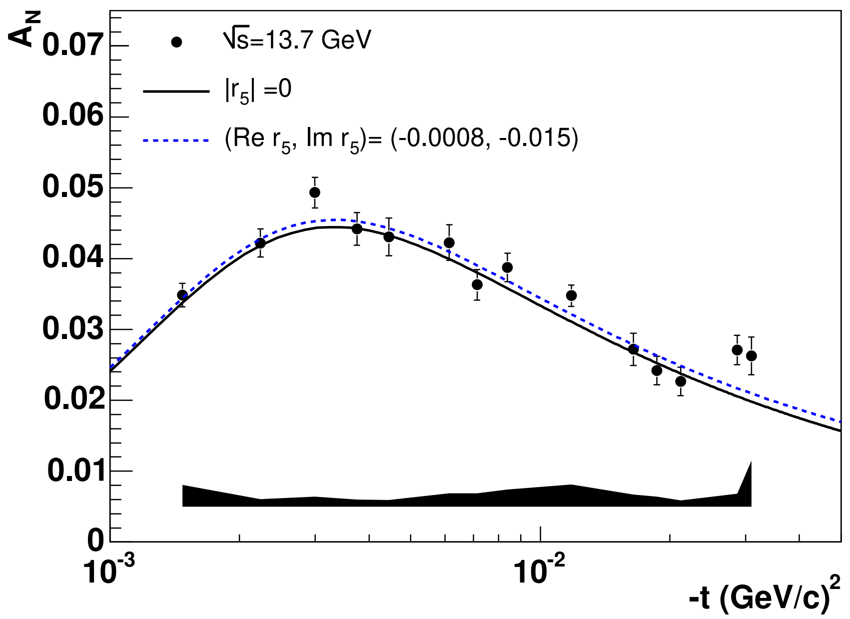

Figure 1. Analyzing power, A_N, in proton-proton elastic scattering as a function of 4-momentum transfer squared, t, measured by H-Jet with 100 GeV/c RHIC proton beam [1]. The errors on the data points are statistical. The lower band represents the total systematic error. Theoretical prediction (solid line) and fit to the data (dashed line) are shown for the comparison.

response.

In Run 2008, the polarized jet target was tested running with the Blue and Yellow beams separated by 5 mm vertically and both incident on the jet. Data analysis is in progress while initial results are encouraging. If deemed successful, this mode would allow the jet to continuously monitor the polarization of both beams in all physics fills instead of alternating between the two beams.

Finally, while the polarized Jet target has calibrated the RHIC polarimeters for the physics runs, primarily at 100 GeV and once at 31 GeV, we have yet to provide a good calibration at RHIC injection. The only such measurement was carried out in a 15-hour run in 2004 which resulted in a meager 12% absolute beam calibration. Since then, the RHIC beam intensity and polarization have increased dramatically to allow a much more accurate calibration. This will serve several goals: a) cross calibrate the AGS and RHIC p-Carbon polarimeters at the same energy, b) provide a good RHIC injection measurement to discern polarization losses, if any, during RHIC ramps.

REFERENCES

1. H. Okada, et al., Phys. Lett B638 (2006), 450.

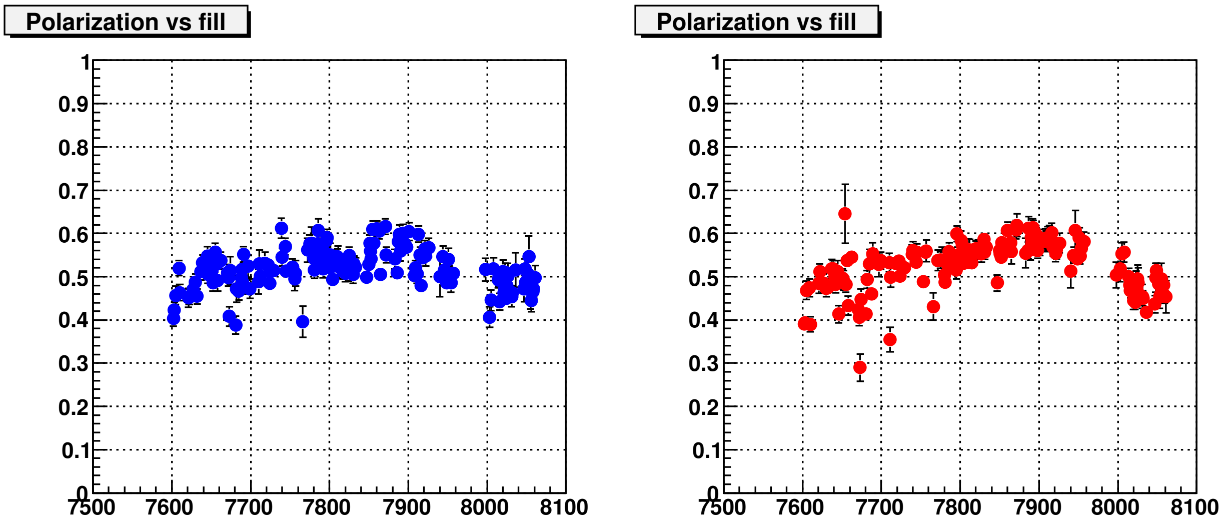

Figure 2. Fill by fill polarizations for "blue" (left) and "yellow" (right) beams in RHIC run 2006, measured by pC polarimeters. Fill numbers < 8000 are for 100 GeV/c beams. Fill numbers > 8000 are for 31.2 GeV/c beams.