Stability for the Run05 Operation of the pC-Polarimeter

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The Relativistic Heavy Ion Collider (RHIC) at BNL provides a unique opportunity to collide polarized protons. The decompsition of the nucleon spin in terms of the contributions from its constituents has been studied through various observed asymmetries.

The 2005 run (RUN05) was the first extended operation of polarized RHIC-pp program. During the running period, continuous efforts were made to improve the accelerator performance, for example, intensity, emittance, backgrounds, and so on, while polarization measurements were regularly executed every 2 to 3 hours for both beams using RHIC pC-polarimeters[1]. The stability and reliability of the polarization measurements under various beam/detector conditions are the major concern in evaluating the average polarization, which provides a normalization for the experiments. One of the dominant sources of uncertainties in the pC-polarimetry has been the absolute energy determination for the low energy recoil carbon ions[2].

We detect elastically recoiling carbon ions at the scattering angle of 90° with kinetic energy E in the range 400 keV $< E <$ 900 keV using 6 silicon detectors mounted at azimuth angles 45°, 90° and 135° on both sides of the beam axis. Each detector is segmented into 12 strips (72 strips in total). These low energy carbons stop at very shallow depths ($< 1.3\mu$m) in the silicon sensor and the response of the detector is quite sensitive to the surface structure of the silicon. A 400 keV carbon ion loses about 1/3 of its energy in the typical dead region followed by partially inefficient charge collection region before it reaches fully active region. There are two main difficulties in correcting for the unobserbed energy loss. First we have been unable to separate the energy-dependent energy loss in the dead-layer from the charge collection inefficiency near the surface region. Second, it is non-trivial to model the inefficiency as a function of the depth. It is initially characterized by the Landau distribution of the implanted Boron atoms in the doping process. In reality the efficiency depends on many other conditions such as the radiation damages, event rates, and so on. They make the efficiency function rather complicated.

In order to avoid such a complication which is not sufficiently under control, here we consider the net energy correction by introducing *"effective dead-layer thickness"*, which can be determined from a fit to the measured timings and pulse height using the kinematic correlation between the time-of-flight and carbon energy. A time offset with respect to the beam clock and the effective thickness of the dead-layer are treated as free parameters.

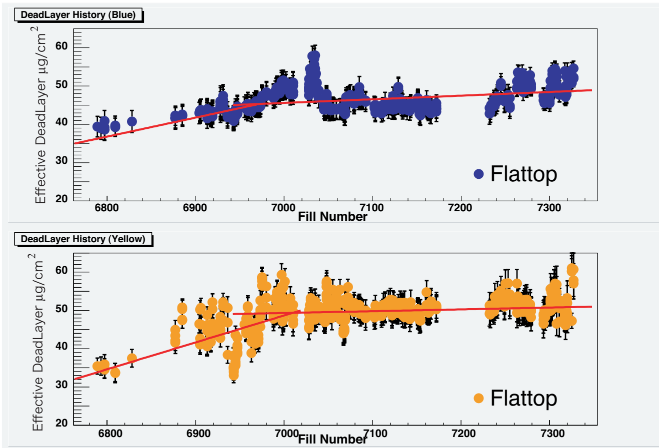

Fig. 1. Stability of the *effective dead-layer thickness* averaged over 72 strips plotted as a function of fill number for blue (top) and yellow (bottom) polarimeters.

Shown in Fig. 1 are the estimated *effective dead-layer thickness* in units of μg/cm^2 averaged over 72 strips. Data points represent individual measurements performed at a beam energy of 100 GeV. As illustrated by the solid line in the figure, the effective thickness of the dead-layer grows with time. This growth of the inefficiency can be interpreted as the deteriorated charge collection efficiency due to the accumulated radiation damages in the surface region. Besides the fitting error, the cause of varying *effective dead-layer thickness* is not known, except for a small average rate dependence (data points in the figure are already corrected for this). These fluctuations are thus accounted for by uncertainties in the absolute energy determination. Taking 1σ of the fluctuations in effective dead-layer thickness, ~ 3 μg/cm^2, corresponds to a few percent uncertainty in the beam polarization.

References

1) I. Nakagawa *et al.*, RIKEN Accel. Prog. rep. **39**, 186 2005, and references are therein.
2) O. Jinnouchi *et al.*, RHIC/CAD Accelerator Physics Note (2004), Vol.171.

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