

# RHIC polarization for Run 13

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## 1 Introduction

This note describes the RHIC polarization measurements for use by the collider experiments for the Run13 255 GeV polarized proton running period. The measurement procedure is largely identical to that followed for Runs 9-12, described in a previous note [1]. That note should be referred to for details of the polarimetry system and measurement, use of tabulated results [2], and uncertainties, all of which apply to the Run13 results. This note describes improvements and additions made for the Run13 analysis.

## 2 Spin tilt correction

As described in the previous note [1], the polarized hydrogen jet polarimeter (H-jet) provides an absolute polarization measurement, used to normalize the asymmetries measured in the more detailed proton carbon (pC) polarimeter measurements. It is important to note the measurement capabilities of the pC and H-jet polarimeters:

- The pC polarimeters have six detectors arranged azimuthally around the proton beam. This allows a measurement of the spin vector in the plane transverse to the beam; thus, the polarization may be expressed as a magnitude  $P$  and tilt angle at the pC polarimeters  $\phi_{\text{pC}}$ , where  $\phi_{\text{pC}} = 0$  for a vertical spin vector.
- The H-jet has only two detector stations in the horizontal plane of the beam. Thus, asymmetries between these two detector stations measure only the vertical component of the spin vector at the H-jet,  $P \cos \phi_{\text{H-jet}}$ .

The normalization procedure followed in previous analyses [1] assumed  $\phi_{\text{H-jet}} = 0$ .

Careful analysis of the Run13 255 GeV polarization measurements showed that there were nonzero tilt angles in both beams, with  $\phi_{\text{pC}} = 16^\circ$  for the Blue beam and  $\phi_{\text{pC}} = 9^\circ$  for the Yellow beam [3]. Also, spin tracking analysis shows that the spin vector tilt does not change significantly in the 71 m between the pC and H-jet polarimeters [4], *i.e.*  $\phi_{\text{H-jet}} = \phi_{\text{pC}}$ . Thus, the H-jet measurements under-measured the Blue beam polarization

magnitude by  $\approx 4\%$  and the Yellow beam by  $\approx 1\%$ . The normalization procedure for the Run13 255 GeV data was corrected for this effect <sup>1</sup>.

### 3 $P_0$ from H-jet

As described in the previous note [1], the principal results for use by the experiments are the initial polarization and decay rate:

$$P_{SSA}(t) = P_{0,SSA} - P'_{SSA} \cdot t. \quad (1)$$

Here the subscript  $SSA$  indicates the polarization for single-spin asymmetry measurements with colliding beams. It is determined from the transverse intensity averaged polarization measured by the the polarimeters,  $P$ , and the transverse polarization profile,  $R$ , to lowest order in  $R$ :

$$P_{SSA} \approx \left(1 + \frac{1}{2}R\right)P. \quad (2)$$

In most cases the measured quantities  $P$ ,  $P'$  and  $R$  come from multiple pC measurements throughout a fill. For the many short fills, due e.g. to beam loss, with only one pC measurement, the Run13 average of  $P'$  is used to determine the parameters in Eq. (1).

In Run13 the pC polarimeters experienced a high loss of carbon ribbon targets, requiring two replacements of the target sets during the run. This resulted in a few periods when there were no viable targets and thus no pC measurements for one of the beams. Many fills in these periods were long enough to provide a statistically significant H-jet measurement. As described in the previous note [1], the H-jet measures the beam intensity averaged polarization throughout a fill:

$$P_{H-jet} = \frac{\int dt I(t) P(t)}{\int dt I(t)} = P_0 + P' \cdot \frac{\int dt t I(t)}{\int dt I(t)}, \quad (3)$$

where  $I(t)$  is the beam intensity throughout a fill. This allows a determination of the initial polarization for experiments:

$$P_{0,SSA} = \left( P_{H-jet} - \overline{P'} \cdot \frac{\int dt t I(t)}{\int dt I(t)} \right) \cdot \left( 1 + \frac{1}{2} \overline{R_0} \right). \quad (4)$$

Here  $\overline{P'}$  is the Run13 average of polarization decay, and  $\overline{R_0}$  the Run13 average of initial profile parameter. RHIC archive values of beam intensities are used to numerically evaluate the term involving  $I(t)$ . The values of  $P_{0,SSA}$  so determined are included in the tabulated results, highlighted in red.

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<sup>1</sup>Subsequent analysis of the older data sets showed that the Run12 255 GeV period had similar spin tilts in both beams; the tabulated polarization results for this period have not been corrected for this effect. The other periods studied, Run9 100 GeV, Run11 250 GeV, and Run12 100 GeV, did not have significant spin tilts.

## References

- [1] [http://public.bnl.gov/docs/cad/Documents/RHIC polarization for Runs 9-12.pdf](http://public.bnl.gov/docs/cad/Documents/RHIC%20polarization%20for%20Runs%209-12.pdf).
- [2] The results are available at <https://wiki.bnl.gov/rhicspin/Results>; there, for each year click on 'Fill by fill results'.
- [3] <http://www.cadops.bnl.gov/AP/spinmeeting.htm>, see Feb. 25, 2015 meeting minutes and presentation 'Tilt Spin?'.
- [4] *Ibid.*, see Feb. 25, 2015 meeting minutes and presentation 'Is It Possible?'.