Quality assurance of PHENIX spin database for Run 15 at RHIC

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The PHENIX collaboration at Brookhaven National Laboratory takes advantage of the spin-polarized proton beam at RHIC in order to perform spin dependent analyses. All spin relevant information are stored in a spin database accessible to the collaboration. All the information were obtained over the 10.9 weeks of proton-proton collisions, 5.1 weeks of proton-Gold collisions, and 1.9 weeks of proton-Aluminum collisions at RHIC in 2015.

Due to some glitch of the accelerator control system, there are some occasions when incorrect or null information are recorded in the database. The following is a review and status of the quality assurance (QA) analysis of the database of all physics runs taken in Run 15. This QA was necessary to ensure sufficient accuracy of the data available to the collaboration in this database for data analyses.

The first step of the QA was to check if any of the physics runs were missing from the database. In the first pass over the database there were a total of 24 missing runs. The reasons for missing runs included the following: PHENIX magnet trips midway while collecting data, unsuccessful crossing shift calibrations, and issues with the data acquisition system. Of these 24 missing runs, two have been recovered and likely 13 will be recoverable since these runs were not included as a result of an unsuccessful calibration. Those remaining, for which there was a magnet trip, will not be used for physics analyses.

Next, it was necessary to check that each run was assigned to the proper RHIC fill number so the spin patterns and polarizations for each run could be cross-checked with the polarimetry group. The initial fill time is provided by the Collider Accelerator Department (CAD) as the time of beam injection and the PHENIX data acquisition system recorded the begin and end run times. In order to verify that a run was assigned the proper RHIC fill number, it was checked that the begin run time was after its associated begin fill time and before the begin fill time for the next fill. This method proved that all physics runs were originally assigned to the proper RHIC fill number.

The spin patterns and crossing shifts in the spin database were checked for consistency across all runs in each fill. The spin pattern is a record of the spin direction for each bunch of protons in the collider for a given fill. The crossing shift is a PHENIX specific quantity that defines the shift in the bunch number from the zeroth bunch along the bunch train. This was necessary because within a fill the crossing shift or spin pattern should not change, but in the spin database this occurred occasionally. The spin patterns were also checked for consistency with the CAD database. For inconsistencies in the crossing shift throughout a fill, the Global Level 1 scalars were assessed to indicate the reason for the anomaly. These scalars are scaled down numbers of triggered events, which indicate the presence of unfilled bunches for this QA. If no reason was found and the bunch crossings were normal, the anomalous run(s)'s crossing shift was changed to the crossing shift of all other runs in that fill. In addition, there were some fills that indicated an abnormal crossing shift and were addressed on a fill-by-fill basis. There were 7 fills for which one or more crossing shifts were inconsistent and 5 of those have been resolved. The remaining fills are still under investigation. Two fills had inconsistent spin patterns with CAD. These were corrected on a run-by-run basis.

The polarization of the beam is the percentage of each proton bunch that is spin polarized in the designated spin direction. It is known that the polarization gradually decays while the polarized beam is stored in the ring for 6 to 7 h. While several physics runs are taken during this period, assigning a simple average polarization of the fill to each run is not necessarily representative of the actual polarization of the run. We introduce 'dynamic polarization' to reflect the polarization decay for later runs in the fill by solving the following formula:

$$P_{dyn} = P_{init} + P_{slope} * (brt - bft) \quad (1)$$

where P_{dyn} is the dynamic polarization, P_{init} is the initial fill polarization, P_{slope} is the slope of the fill polarization provided by the polarimetry group, bft is the begin fill time, and brt is the begin run time. The uncertainty for the dynamic polarization was calculated by simple error propagation.

$$\Delta P_{dyn} = \sqrt{(\Delta P_{init})^2 + (\Delta P_{slope} * (brt - bft))^2} \quad (2)$$

The dynamic polarizations will be re-calculated once the final polarization values are released after thorough offline analysis is carried out by the polarimeter group.

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