Improvement of global alignment of PHENIX muon tracker

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The alignment of tracking chambers is one of the long-standing challenges for nuclear physics experiments. The PHENIX muon system measures the charged-particle momentum using three tracking stations with cathode readout chambers, namely muon tracker (MuTr), implemented in a magnetic field volume[1)]. The precision of the relative alignment between the three tracking chambers directly affects the resolution of momentum measurement. Over the past few years, the PHENIX spin program has been focusing on polarized sea-quark measurements in protons through asymmetry measurements of the W-boson production [2)]. Because of the large mass of W-boson, the muon decayed (which we detect) from the W-boson has a high transverse momentum of $\sim$ 40 GeV/c. Such a high-momentum trajectory is barely bent in the magnetic field, and its sagitta is about a few to several mm in the MuTr volume. The possible misaligment of MuTr chambers will result in further momentum smearing over its intrinsic resolution. The higher the momentum, the more serious the side effect on the charge determination of the traversing particles. The possible charge misreconstruction is a fatal error for the asymmetry measurement, since the opposite charge (either W^+ or W^-) production is predicted to appear in opposite asymmetry. The goal of this study is to achieve the intrinsic resolution of 150 μm as currently, an intrinsic resolution of only $\sim$ 300μm achieved.

We developed a global alignment program that calculates the smallest χ^2 solution of actual hit locations when the straight tracks pass through the three MuTr stations assigning the relative location of chambers as free parameters. In this manner, the program will find the relative alignment of chambers to minimize the residuals. The residual is the distance between the linear interpolation of front- and back-plane hit positions and the actual hit position in the middle plane. The alignment parameters are limited to transverse shifts and rotations. The result of the new alignment demonstrated narrower residual distributions than that previously achieved[3)]; however, it was found that unresolved non linear radial dependences of the residual distributions remain even with the present algorithm.

As a rough quantitative estimate of the misaligment effect, the width of the residual distribution between radial dependent and non-dependent regions were compared. The resulting estimate showed difference of 100 to 500 μm depending on the octants. Note that this indicates a possible room for the improvement of the alignment by fixing the aligment to the radial direction. In order to investigate further problems in the present alignment scheme, of the azimuthal-direction dependence (orthogonal to radial direction) was also checked. Odd dependences were also found in the azimuthal direction. As an overall trend, bad alignment octants are problematic in both radial and azimuthal directions, and thus, a somewhat complicated correlation needs to be addressed. Since there are 16 chamber planes involved simultaneously in the alingment, finding the cause of these dependences is nontrivial. To obtain some hints to disentangle the complication, the local alignment was evaluated. The plane-based local residual was defined using two or three gaps (stations 1 and 2 have three gaps, and station 3 has only two gaps) and two planes (one is a stereo plane; the other is a non-stereo plane). The local residual distributions are again evaluated for radial and azimuthal dependence. Since local residual distributions are independent of other stations, one can expect some localized misalignment in a particular station if the cause of the global misalignment comes from the single plane or station; however, we did not observe that any octant shows such a trend, as shown in Fig. 1. It is interesting to investigate how closely we can reproduce the global residual distribution in comparison with the observed local ones. A toy Monte-Carlo simulation (MC), which includes the multiple scattering effect, is under development. Since the MC assumes perfect alignment, any fraction of the residual width that cannot be explained by the MC can be interpreted as room for the improvement of the alignment.

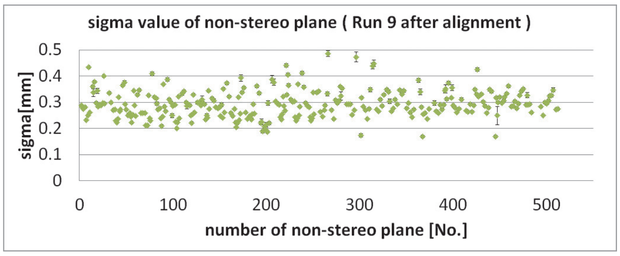

Fig. 1. Standard deviation of local residuals plotted for all non-stereo planes (Run9 after alignment).

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References
1) H. Akikawa et.al., NIM **A499**, 537 (2003).
2) H. Oide, RIKEN Accel. Prog. Rep. **45** (2012).
3) K. Watanabe, Thesis, Rikkyo Univeristy (2012).