sPHENIX silicon tracker alignment

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The sPHENIX experiment is a high-energy particle physics experiment at RHIC. To resolve short lived exotic particles, which decay in-flight, it requires a highly-tuned tracking reconstruction workflow. One requisite to achieve this is to align active areas of sPHENIX silicon tracking subsystems using real data. In this case, the subsystems are the Maps-based VerTeX detector (MVTX) and the INTermediate Tracker (INTT).[1)] The goal of the process is to optimize the global alignment parameters via an iterative process.

This process involves fitting clusters of hits to tracks over a set of runs. In addition to parameters for each track (local parameters), shared alignment parameters (global parameters) are used to define the position and orientation of silicon sensors. One iteration comprises computing the track residuals in the sensor plane, computing their derivatives with respect to local and global parameters, and writing these to a binary file. Parameters which minimize the sum of squares of these residuals are identified using Millepede,[2)] and used for the next pass. The process is finished when the residual distribution approaches the dimensions of a subsystem's silicon pixels or silicon strips.

A dramatic example of the improvement to track residuals is shown in Fig. 1. In this figure, the distribution of track residuals in the local $\hat{x}$ direction of the sensors are shown as a function of global azimuth angle ϕ, or angle about the global $\hat{z}$ (beam) axis. Sensors are roughly oriented so that the local $\hat{x}$ axis is pointed exactly along $\hat{\phi}$, the unit vector pointed in the direction of $\partial\vec{r}/\partial\phi$, where $\vec{r}$ is the global position. This pairing is suitable for identifying translations in detector geometry, as misalignments in the x-y plane appear as sinusoidal dependencies. Notice that in Fig. 1, the qualitatively sinusoidal behavior is reduced after applying the alignment correction.

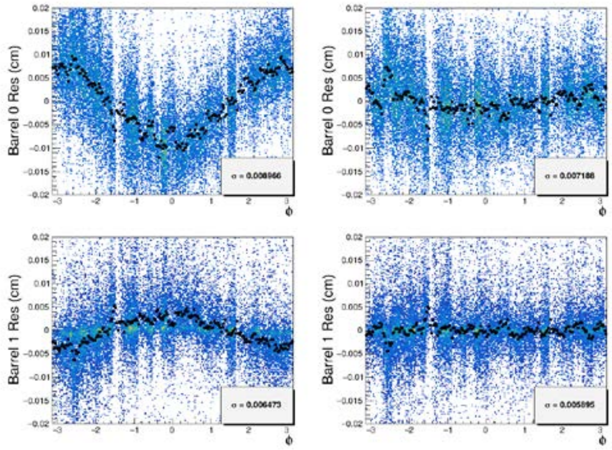

Fig. 1. The distribution of track residuals as a function of global azimuth angle ϕ before (left) and after (right) applying an alignment shift obtained using the iterative process described. "Barrel 0" referrs to the INTT inner barrel, and "Barrel 1" referrs to the INTT outer barrel. The shown standard deviations σ correspond to the residual distribution, integrated over all ϕ, and are in units of cm.

Much progress has been made toward aligning the sPHENIX silicon trackers. Most workflows use a fitting module implemented by sPHENIX collaborators which specializes in performing either helical fits or straight line fits. The advantage of this module is that it integrates some Millepede functionality directly. However, a workflow using A Common Tracking Software (ACTS)[3)] is being revisited and developed. In fact, the alignment corrections that produce the improvement shown in Fig. 1 were obtained tracks fitted using the ACTS direct navigator.

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