TPC Sector Alignment Report

August 9, 2007

Summary:

* Alignment was last done in 2001 by Bum Choi using zero field data
* Advantages of zero field:
    + no ExB distortions
* Disadvantages of zero field:
    + larger hit errors = poorer track resolution in TPC
    + unknown momentum = unknown multiple scattering / energy loss effects on track extrapolation to primary vertex
    + none taken recently
* Two steps:
    + Inner/outer sector alignment
    + Super-sector alignment
* Super-sector alignment is the most important for extrapolating tracks to the inner tracking and primary vertex
* Ideally, we want to perform the inner/outer sector alignment first, then the super-sector alignment
* Started with using laser-lit central membrane stripes to do inner/outer
    + Abandoned due to insufficient resolution
* Switched to getting the super-sector alignment done so that we could get started on alignment of silicon detectors
* Just starting on using outer-TPC-only tracking to do inner/outer alignment
    + Will require repeat of super-sector alignment

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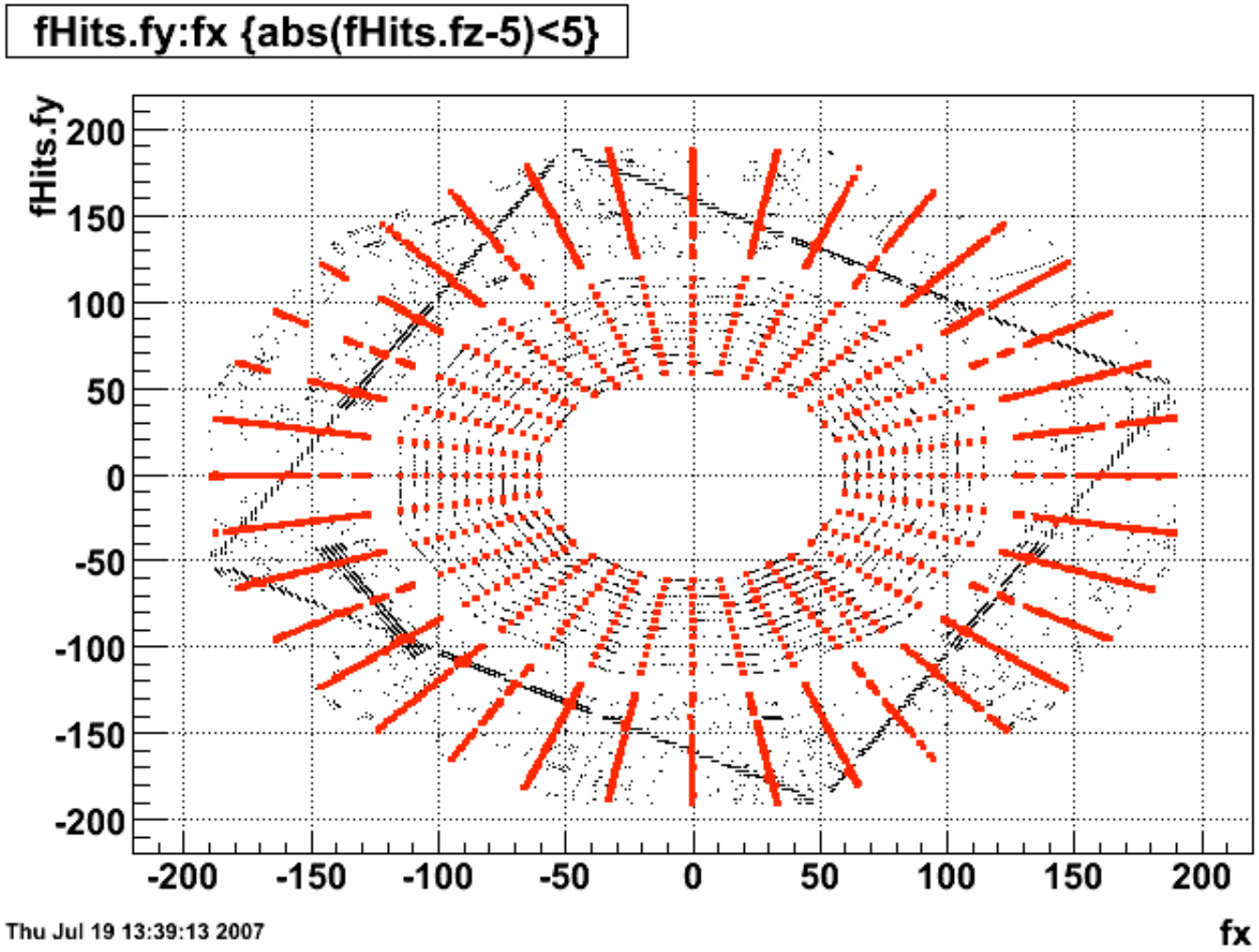
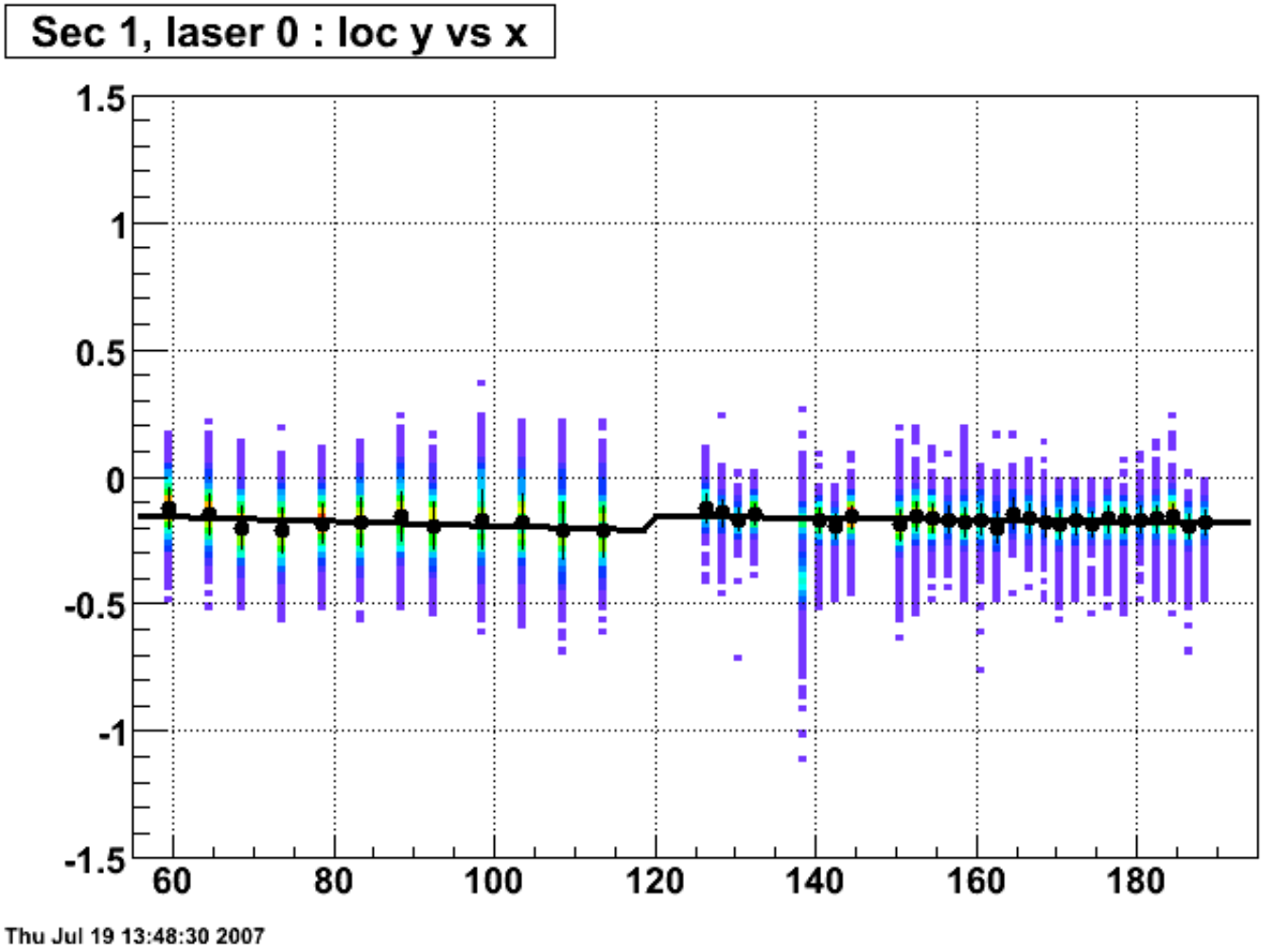
1. CM Stripes

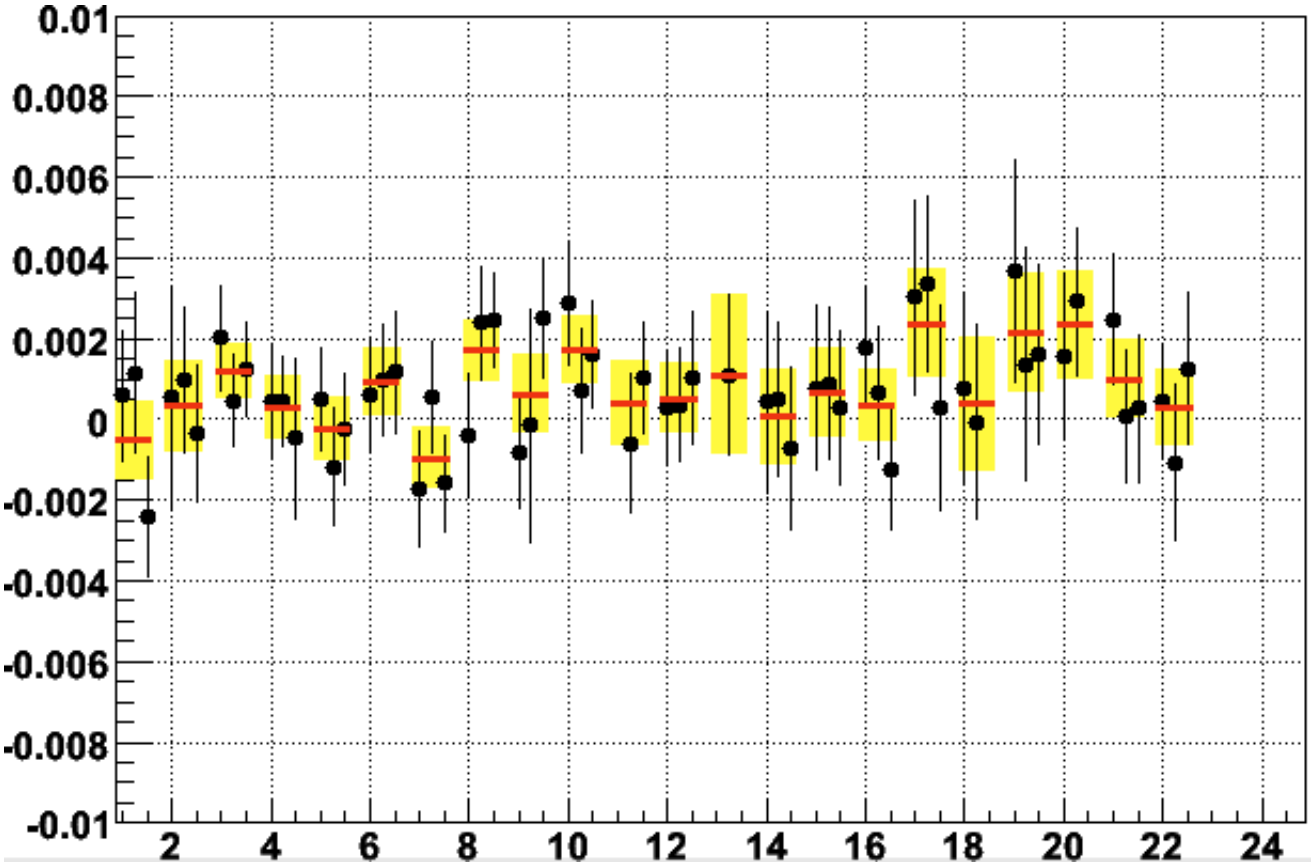
Three stripes per sector.



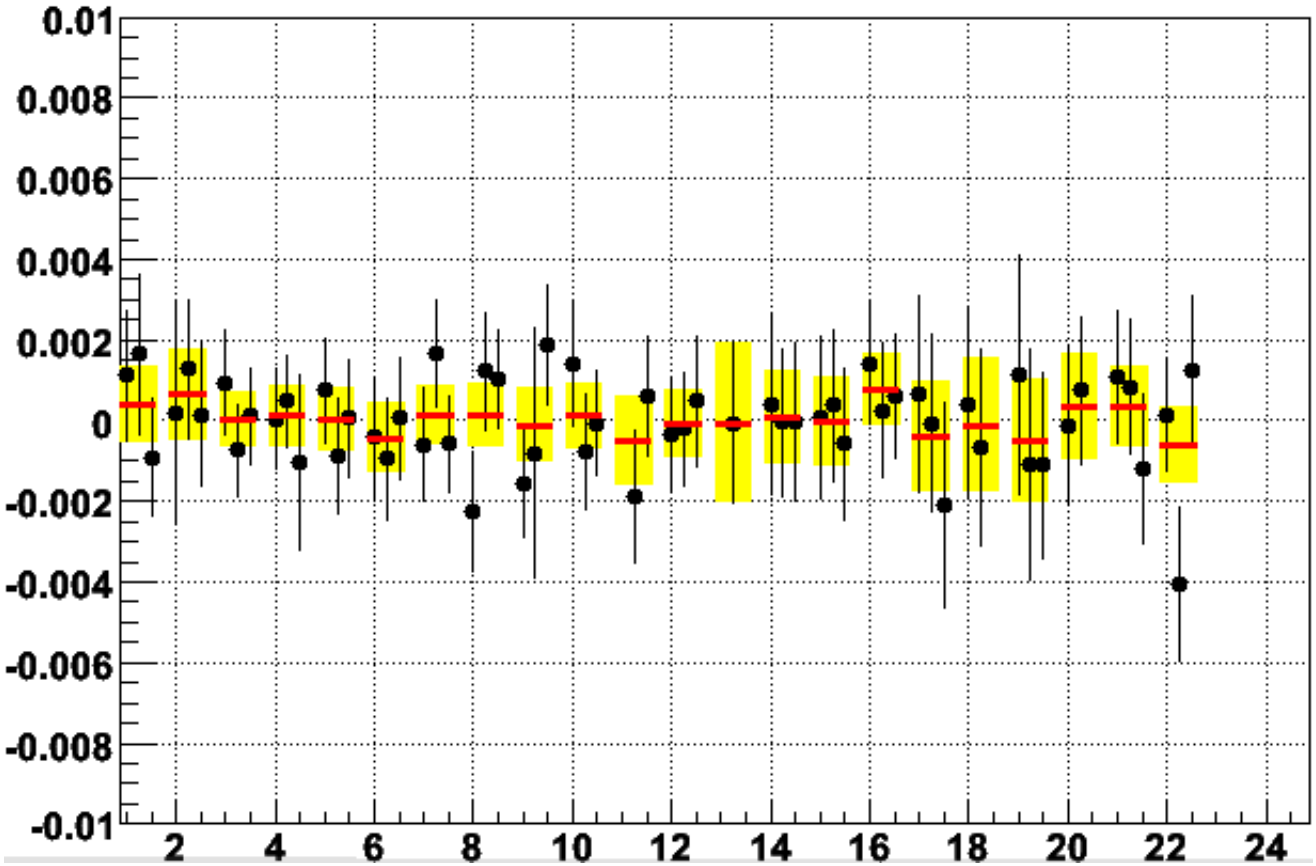
Shown above are hits on west side stripes (in red) with other hits near the central membrane shown in black.



Above: example plot of two-line fits to inner and outer TPC. This is a *good* one! Rotated to sector local x vs. y [cm]. Note the double peak at local y of ~138cm; this is not an uncommon feature in these CM stripe track hit plots.



Above: before calibration difference in line slopes (same as difference in inner/outer rotation angles in radians) vs. sector number.



Above: after calibration pass.

Resolution of angles at the 0.04-0.11 degree level (see the yellow bands above, which are essentially radians). Not good enough, and missing sectors 23 and 24. Translational offset between inner and outer would be tough as well!

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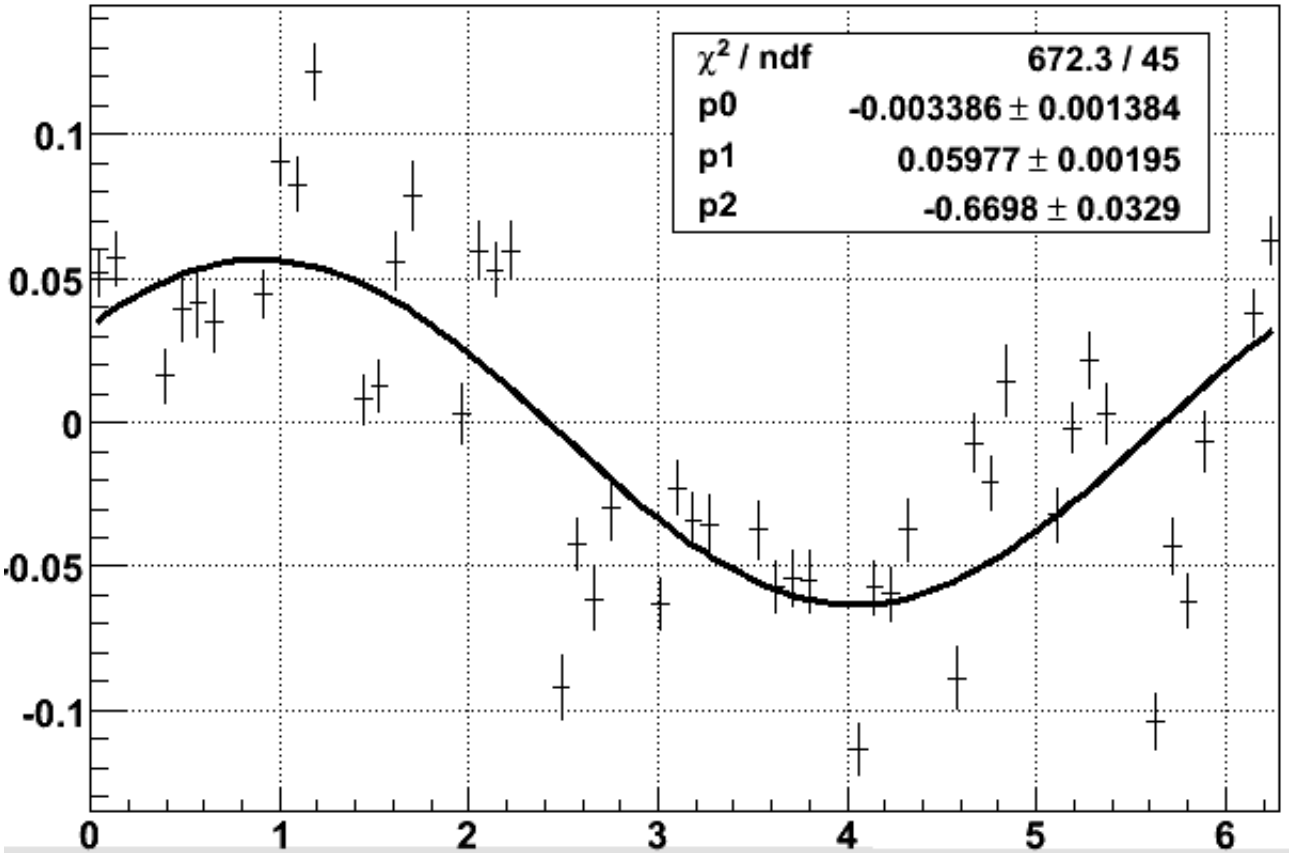
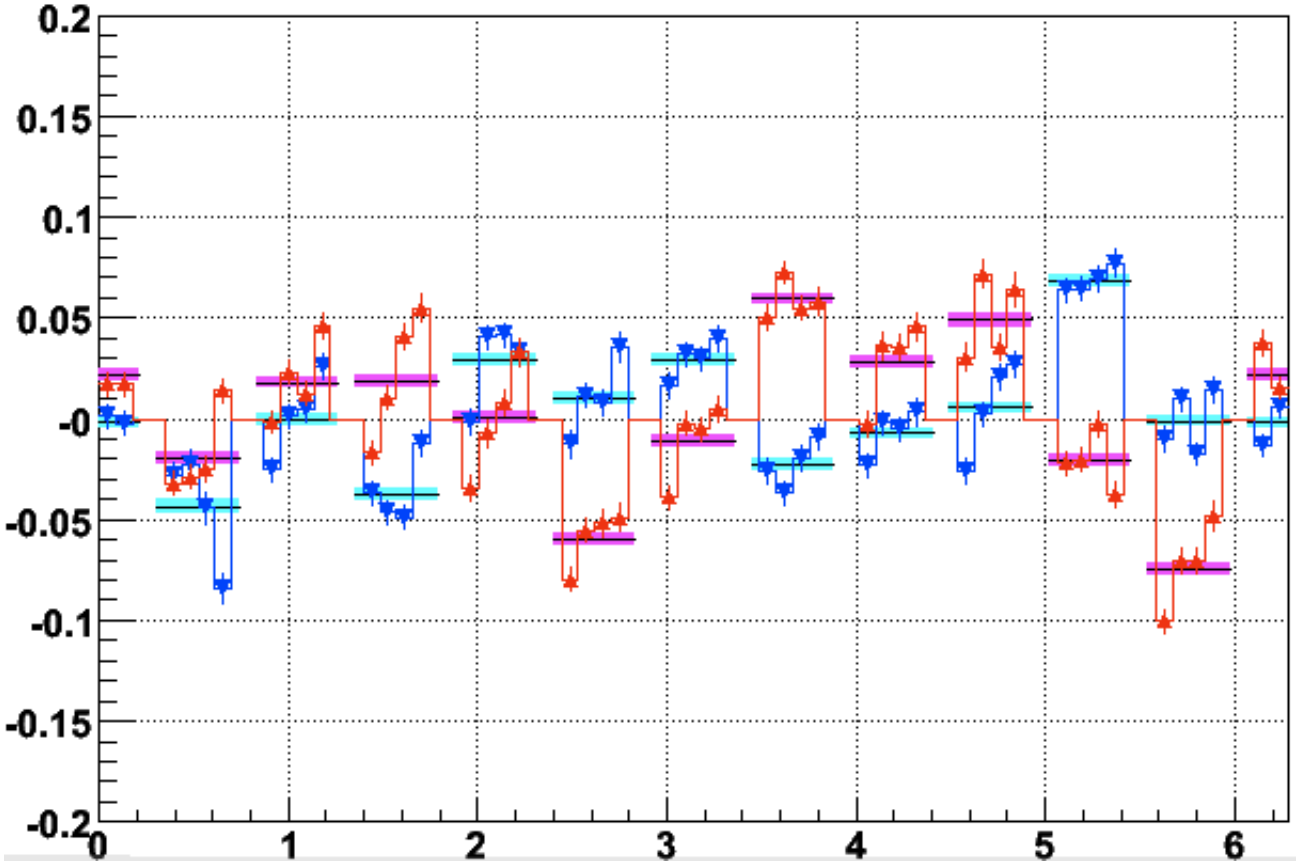
2. Super-sector alignment

Using signed DCAs to primary vertex. Divide each sector into six azimuthal bins. Track cuts:
number of TPC hits >= 25
number of inner TPC hits >= 5
0.3 < pt < 2.0 GeV/c
-1 < eta < 1
|sDCA| < 4.0cm

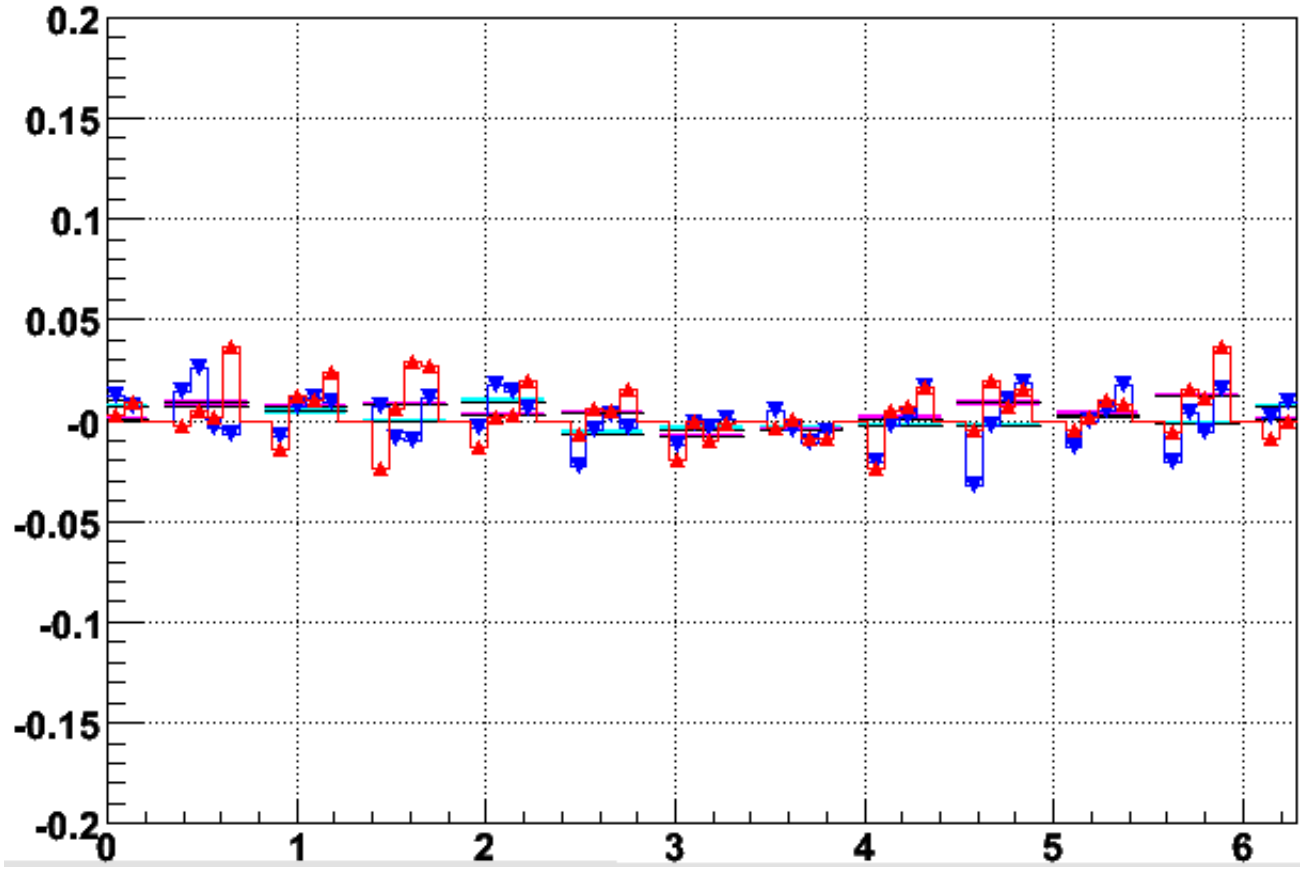
Dropping outer sixths of each sector for calibration. Contributions to sDCA from primary vertex bias and SpaceCharge. Seen here by taking east sDCAs plus west vs. phi.



Above: sDCA west + sDCA east vs. phi. Offset (p0 in the above fit) of about 34 microns from SpaceCharge. Primary vertex position bias (p1 in the fit) of 600 microns. The latter was alleviated by relaxing cuts used by Minuit vertex finder, but still about 150 microns of position bias remained. Subtracting out these components (I don't want the sector alignment to absorb these effects!) in each calibration pass. Several passes required because changing sector alignments changes found vertex position, necessitating iterations.



Above: Before calibration, sDCA [cm] vs. phi, red is east, blue is west.



Above: after a few iterations of calibration.

Resolution down to 0.005-0.006 degrees! Can improve even more with more stats, but requires bookkeeping of the subtracted-out SpaceCharge and primary vertex bias effects for data covering larger periods of time.

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3. Outer-TPC-only tracking

Nothing to report yet.