



CRAFT09 Track-Based Alignment

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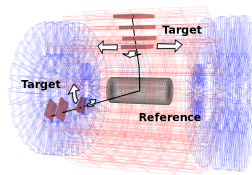
5 October, 2009



- ▶ Reminder of workflows
- ▶ Timeline: from CRAFT to 50 pb^{-1}
- ▶ CRAFT alignment performance
- ▶ DT systematics studies:
 - ▶ time dependence
 - ▶ tracker dependence
 - ▶ global distortions
- ▶ Update on CSC alignment

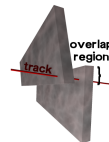


- ▶ **Reference-Target (R-T)**: align a Target set of chambers using globalMuon tracks from a fixed Reference (tracker)



- ▶ **Millepede (future)**: combine local segment and globalMuon data into one fit. **(Now)**: reproduce R-T with globalMuons only

- ▶ **CSC-Overlaps**: reconstruct CSC ring geometry using local segments that overlap along the CSC edges



- ▶ **CSC ring alignment**: align each ring relative to the tracker using globalMuons (averages over all chambers in ring for statistics)

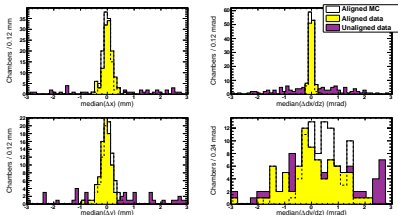


- ▶ CRAFT08: optimized and studied procedures with real data
- ▶ CRAFT09: made procedures routine, studied systematics
 - ▶ deliver DT chamber and CSC ring alignment for 2nd reco
- ▶ October exercise: Reference-Target
 - ▶ automate and document (twiki SWGuideMuonAlignReferenceTarget), such that exercise can be carried out by new users
 - ▶ walk through alignment of chambers relative to tracker with cosmic rays and 50 pb^{-1} V. Khotilovich, A. Tatarinov (TAMU)
- ▶ October exercise: CSC-Overlaps
 - ▶ revive procedure from 2008 LHC run to be ready for Nov. 2009
- ▶ November beam-halo: CSC-Overlaps (DT alignment from cosmics)
- ▶ First 5 pb^{-1} of collisions: align CSC rings to tracker (DT from cosmics)
- ▶ First 50 pb^{-1} of collisions: align all DTs and CSCs relative to tracker with one procedure, improving upon cosmics alignment
 - ▶ cross-check globalMuon methods with CSC-Overlaps



Several different data-driven tests

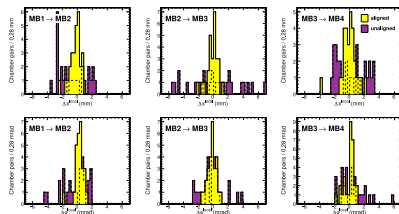
- Distribution of median of residuals demonstrates internal consistency of alignment



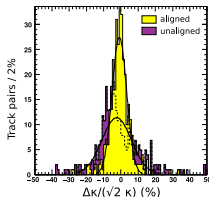
- Aligned data (yellow) is as internally consistent as aligned MC (white)
- $\Delta \frac{dy}{dz}$ (alignment parameter δ_{ϕ_x}) is not improved by tracks: it will be taken from prior geometry in '09 (photogrammetry)

- Segment extrapolation is a partially independent cross-check

A. Calderon



- Track reconstruction: sensitive to before-vs-after alignment, but not fine differences; bottom line



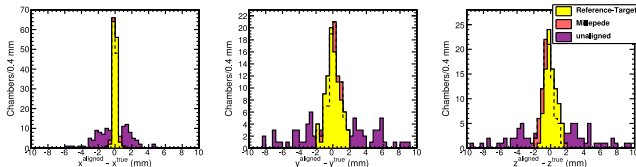
J. Tucker



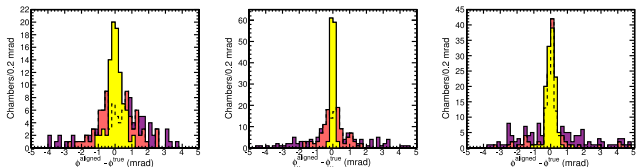
- ▶ Two bug-fixes in Millepede algorithm
 - ▶ loosened residuals cut
 - ▶ corrected tracker-track χ^2 calculation (used as a quality cut)
- ▶ Millepede (red) now reproduces R-T (yellow) accuracy in δ_x , δ_y , δ_z below: MC aligned-minus-true positions and orientations

P. Martinez, L. Scodellaro

translational
degrees of
freedom
 δ_x , δ_y , δ_z

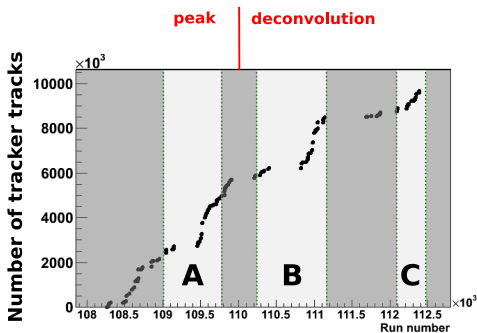


rotational
degrees of
freedom
 $\delta\phi_x$, $\delta\phi_y$, $\delta\phi_z$

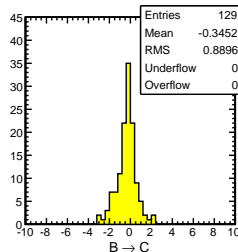
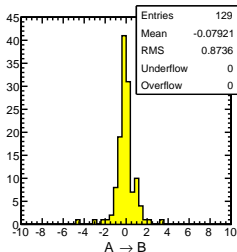
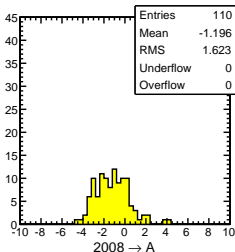


CRAFT09 time dependence

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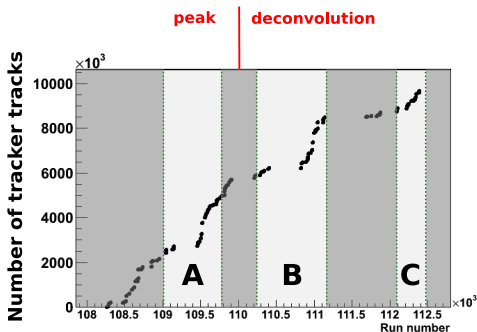


- ▶ Three $B = 3.8$ T periods in CRAFT-2009
- ▶ Align each independently, observe differences
- ▶ Below: differences in $r\phi$ positions (mm)

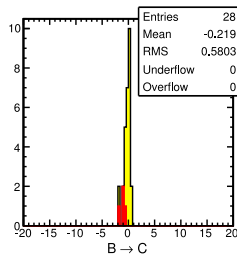
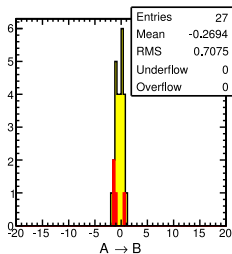
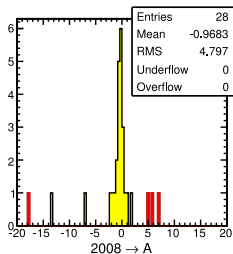


CRAFT09 time dependence

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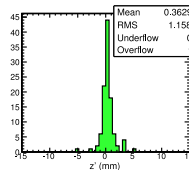
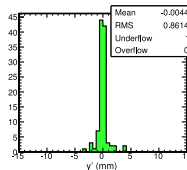
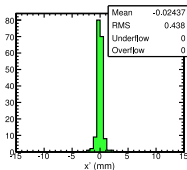
- ▶ Three $B = 3.8$ T periods in CRAFT-2009
- ▶ Align each independently, observe differences
- ▶ Below: differences in z positions (mm)
(red chambers were known to be moved)



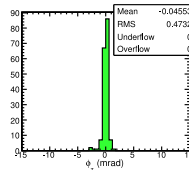
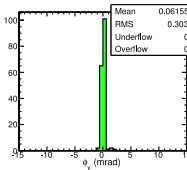
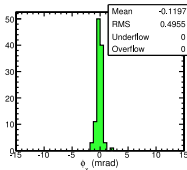


- ▶ Second question: are time-dependencies in the tracker significant?
- ▶ Realign muon chambers with 2008 tracker and 2009 tracker, compute each chamber-by-chamber difference

translational
degrees of freedom
 $\delta_x, \delta_y, \delta_z$



rotational
degrees of freedom
 $\delta\phi_x, \delta\phi_y, \delta\phi_z$

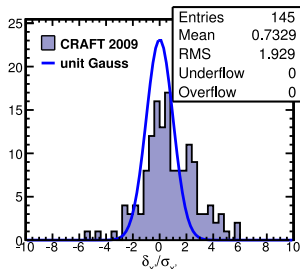
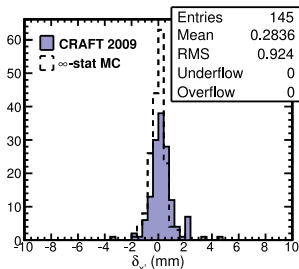


- ▶ About 0.4 mm (δ_x), 0.3 mrad ($\delta\phi_y$): at the level of other systematics



- ▶ Until now, DT alignments have used tracks from the tracker barrel only (TIB and TOB)
- ▶ What is the effect of including the tracker endcap (TID and TEC)?
- ▶ Below: difference (in x) between tracks with zero endcap hits and tracks with one or more endcap hits (“endcap enriched”)

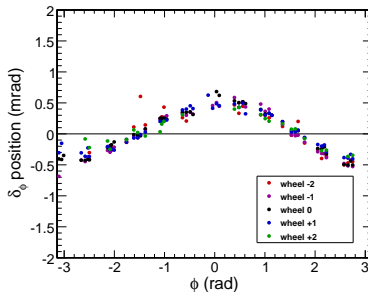
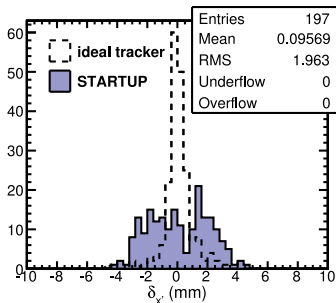
Left: in mm with MC reference, right: divided by statistical error



- ▶ Conclusion: statistically-significant but small (0.3 mm) bias
 - ▶ CSC alignment and future alignments must use tracker endcap
 - ▶ decision: include in next alignment and study further

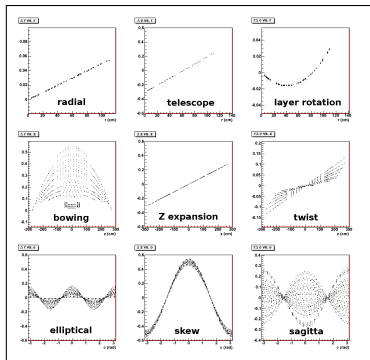


- ▶ Produce MC estimate of CRAFT misalignment by
 1. running tracker alignment procedure with MC cosmic rays
 2. running muon alignment procedure with MC cosmic rays(could be seen as a trial run of October exercise, but in 2_2_X)
- ▶ Result: broad distribution of aligned positions (relative to true positions), strongly dependent on tracker geometry
 - ▶ clear structure ($\delta_\phi = \delta_{x'}/R$ where R is distance to beamline)

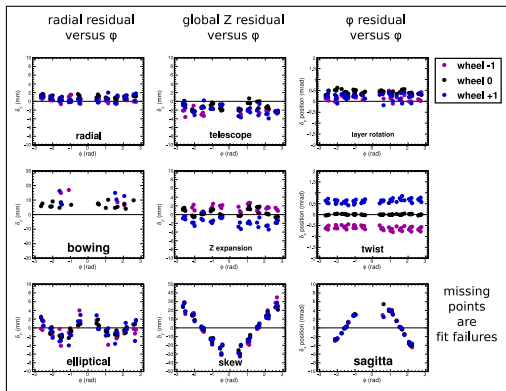


- ▶ 9 canonical modes: $\{R, z, r\phi\}$ displacements vs. $\{R, z, \phi\}$
- ▶ Some of these are weak modes in the tracker
- ▶ Run muon alignment on each one of them (cosmic ray MC) to quantify dependence: STARTUP looks roughly like $0.1 \times$ “sagitta”

Tracker module positions
(set by hand)

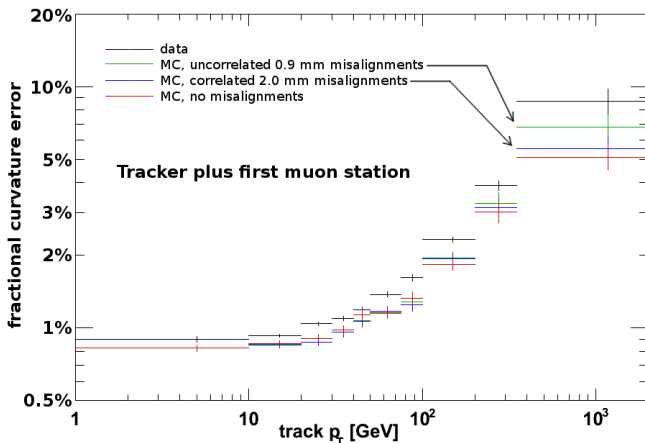


Muon chamber positions (aligned)





- ▶ “Fractional curvature error” = $\left(\frac{q}{p_T}^{\text{top}} - \frac{q}{p_T}^{\text{bottom}} \right) / \left(\sqrt{2} \frac{q}{p_T} \right)$
- ▶ Misalignment with 2.0 mm global distortion is correlated with tracker, hence resolution is actually better than with random 0.9 mm
- ▶ MC underestimates real resolution by 10–35% (non-alignment effects?)



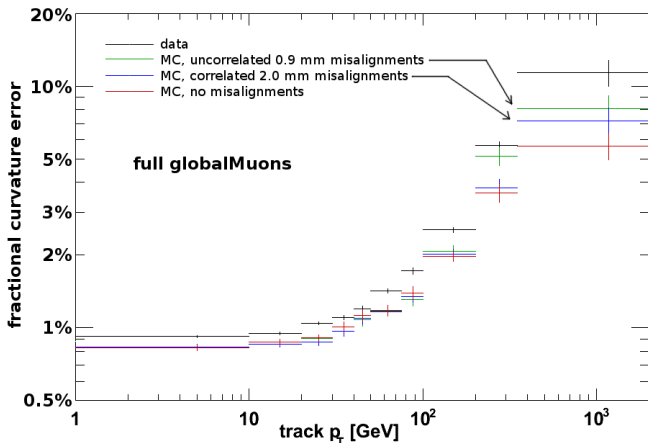
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Cosmic splitting test

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- ▶ “Fractional curvature error” = $\left(\frac{q}{p_T}^{\text{top}} - \frac{q}{p_T}^{\text{bottom}} \right) / \left(\sqrt{2} \frac{q}{p_T} \right)$
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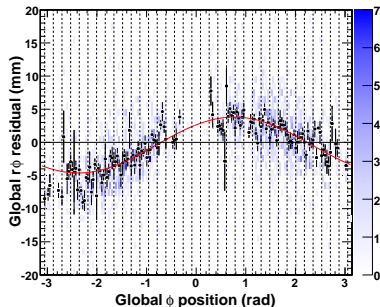


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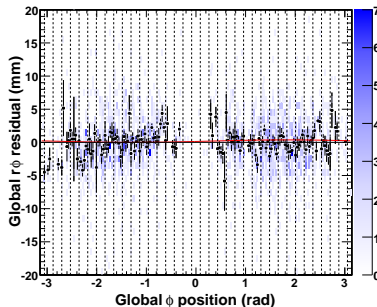


- ▶ Translate/rotate CSC disks using ring-1 chambers
- ▶ Example below: $\delta_x = 2.9$ mm, $\delta_y = 3.0$ mm, $\delta_{\phi_z} = 0.22$ mrad
 $r\phi$ residuals versus ϕ ; dashed lines are chamber boundaries

ME-1/1 before



ME-1/1 after

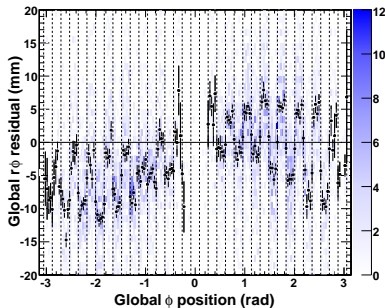


- ▶ Still investigating ring-2 residuals (even-odd chambers alternate 5 mm)
 - ▶ not reproduced at the level of RecHits in the overlap region. . .

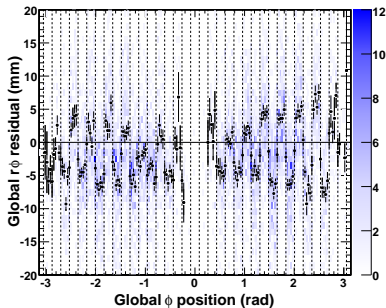


- ▶ Translate/rotate CSC disks using ring-1 chambers
- ▶ Example below: $\delta_x = 2.9$ mm, $\delta_y = 3.0$ mm, $\delta_{\phi_z} = 0.22$ mrad
 $r\phi$ residuals versus ϕ ; dashed lines are chamber boundaries

ME-1/2 before



ME-1/2 after



- ▶ Still investigating ring-2 residuals (even-odd chambers alternate 5 mm)
 - ▶ not reproduced at the level of RecHits in the overlap region. . .



- ▶ Reference-Target algorithm is sufficiently routine that it can be run under different conditions to study alignment systematics
 - ▶ time dependence makes sense (biggest change between CRAFTs)
 - ▶ most large changes have been identified as moved chambers
 - ▶ tracker didn't change significantly between CRAFTs to affect muon alignment
 - ▶ small effect seen in including tracker endcap
 - ▶ effect of tracker global distortions visible in MC
- ▶ Muon system with chamber positions matched to tracker yields better resolution than smaller, uncorrelated errors
 - ▶ but ideally both ought to be minimized
- ▶ CSC bug-hunt continues, but we can produce a disk alignment even if the problem isn't found