



Preparation for Beam-Halo Alignment: MC test

Jim Pivarski

Texas A&M University

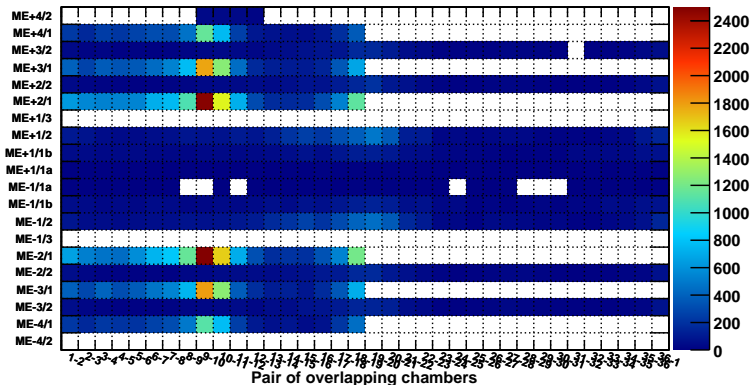
17 November, 2009



- ▶ First circulating beams expected sometime around Nov 20–23
- ▶ Need to prepare the workflow: walk-through with CMSSW_3_2_7 MC
- ▶ MC sample:
 - ▶ requested 10M generated beam-halo events, got 10.6M
 - ▶ R , ϕ distributions not realistic (ATLAS cavern)
 - ▶ 100 000 expected in overlaps region, got 123 888
 - ▶ $3.7\times$ larger than 9-minute sample of Sep 2008
 - ▶ CSC-Overlaps trigger realistically simulated
- ▶ CSCOverlapsAlignmentAlgorithm last tested in 2008
 - ▶ one bug-fix needed to handle new ME4/2 chambers
- ▶ Repeated last year's exercise with similar results
- ▶ Adding new features:
 - ▶ allow for one missing group of consecutive chambers by assuming $\sum_i \text{residuals}_i = 0$ (done)
 - ▶ more monitoring plots (occupancy, raw hits) (done)
 - ▶ combine ME1/1a and ME1/1b chambers (not done)

- ▶ Made to look like CSCValidation plots, for easier comparison
- ▶ Each block is a pair of overlapping chambers, rather than one chamber
- ▶ ME2/1, 3/1, 4/1 have 18 chambers, not 36; no overlaps in ME1/3

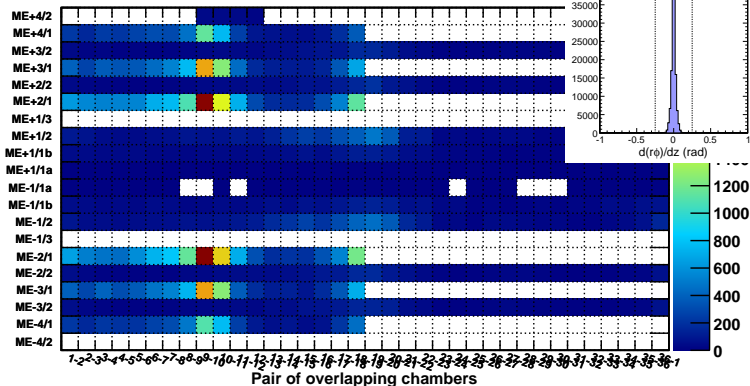
Overlap-track occupancy





- ▶ Made to look like CSCValidation plots, for easier comparison
- ▶ Each block is a pair of overlapping chambers, rather than one chamber
- ▶ ME2/1, 3/1, 4/1 have 18 chambers, not 36; no overlaps in ME1/3
- ▶ Beamline-pointing is $\left| \frac{d(r\phi)}{dz} \right| < 0.25$ rad, to exclude cosmic rays

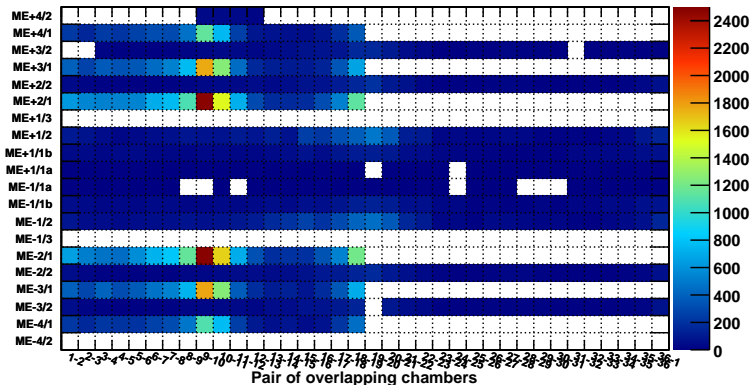
Overlap-track occupancy (with beamline-pointing)





- ▶ Made to look like CSCValidation plots, for easier comparison
- ▶ Each block is a pair of overlapping chambers, rather than one chamber
- ▶ ME2/1, 3/1, 4/1 have 18 chambers, not 36; no overlaps in ME1/3
- ▶ Quality cuts are loose bounds on maximum residuals, segment χ^2

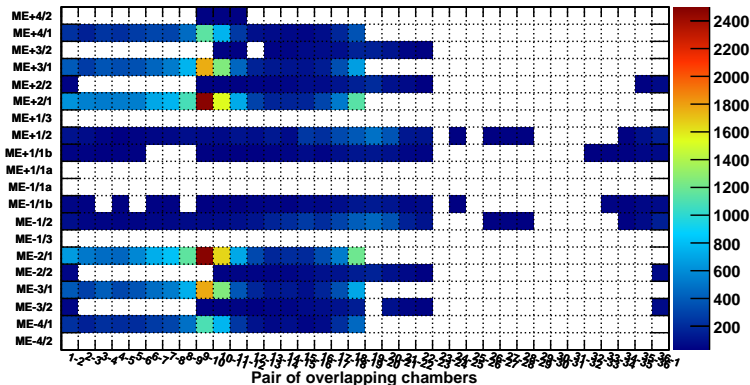
Overlap-track occupancy (beamline and quality cuts)



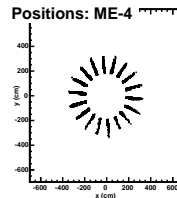
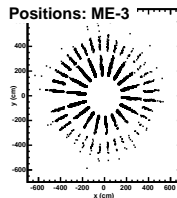
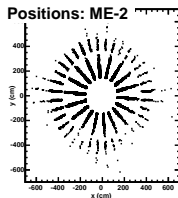
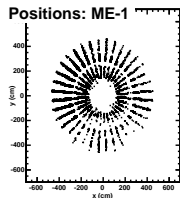
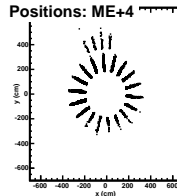
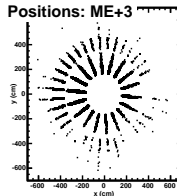
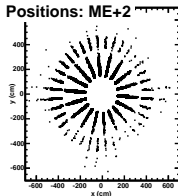
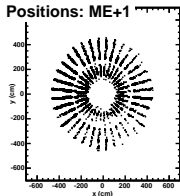


- ▶ Made to look like CSCValidation plots, for easier comparison
- ▶ Each block is a pair of overlapping chambers, rather than one chamber
- ▶ ME2/1, 3/1, 4/1 have 18 chambers, not 36; no overlaps in ME1/3
- ▶ Only $ME\pm 2/1$, $\pm 3/1$, $\pm 4/1$ have more than 30 segments per pair

Overlap-track occupancy (least 30 tracks per pair)



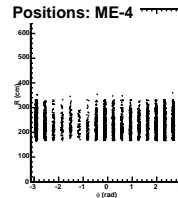
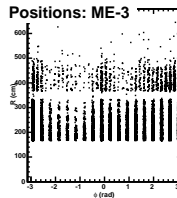
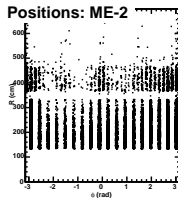
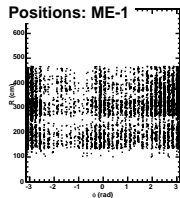
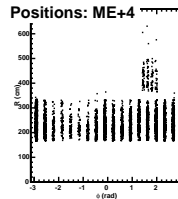
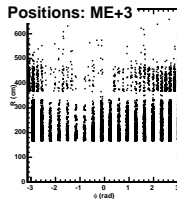
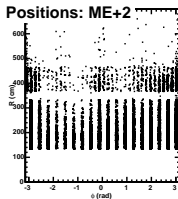
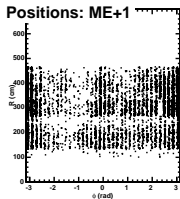
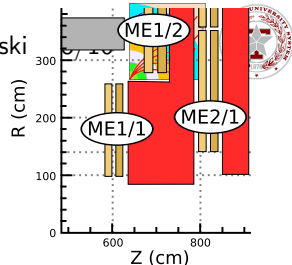
- ▶ Global positions of accepted segments
- ▶ Triggers (L1 and HLT) and offline selection do not explicitly select the overlapping strips (they require activity in neighboring chambers)
- ▶ The fact that we see radial spokes is a nice validation



Global positions: R - ϕ

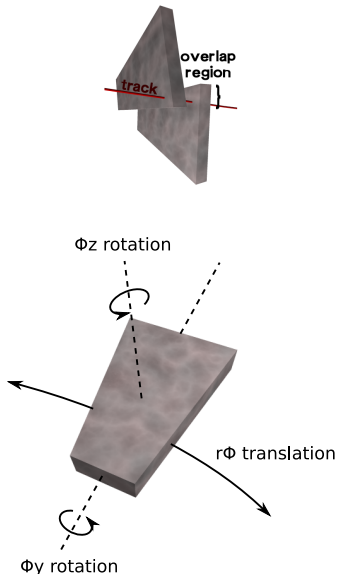
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- ▶ In the R - ϕ projection, we can see why ME1/1 (especially 1/1a) has lower statistics: the triggers are coming from ME2 and ME3
- ▶ I'm trying to find out if there are other trigger lines which would illuminate this better





- ▶ Single muon passing through overlap region leaves segments in two neighboring chambers
- ▶ Any discrepancies in segment slopes $\Delta \frac{d(r\phi)}{dz}$ or intercepts at a plane $\Delta(r\phi)$ imply relative corrections to δ_{ϕ_y} , $\delta_{r\phi}$, and δ_{ϕ_z}
- ▶ Propagate corrections around the ring by solving a system of equations
- ▶ δ_{ϕ_y} , $\delta_{r\phi}$, and δ_{ϕ_z} can be solved independently, as long as they are done in that order



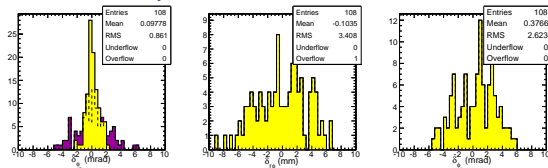
Alignment of ME2/1, 3/1, 4/1

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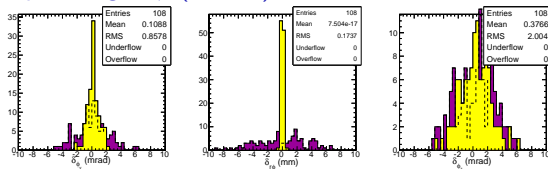
10/16



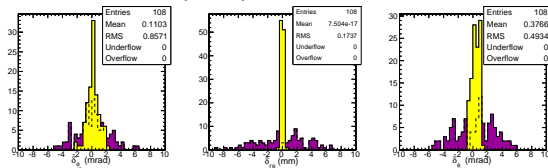
Step 1: align ϕ_y (left)



Step 2: align $r\phi$ (middle)



Step 3: align ϕ_z (right)



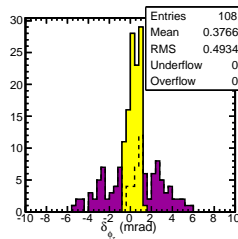
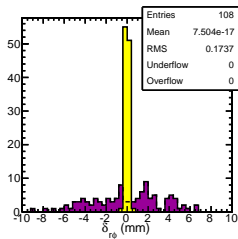
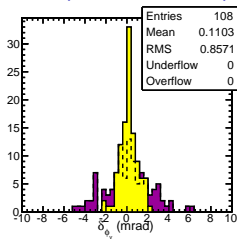
- Differences between aligned and true chamber parameters (2/1, 3/1, 4/1 only)
- Rotation of whole ring in $r\phi$ removed
- Purple: before
Yellow: after
- Final resolution
 - ϕ_y : 0.85 mrad
 - $r\phi$: 0.17 mm
 - ϕ_z : 0.49 mrad
- Depends on MC R and ϕ distributions; not realistic!

Independence of parameters

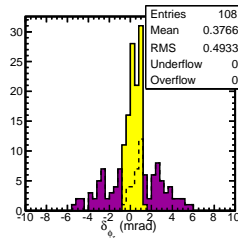
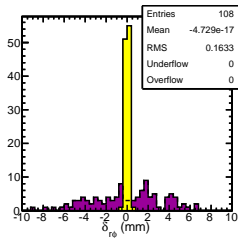
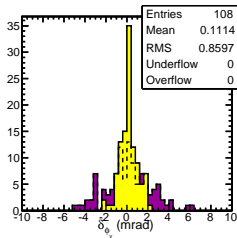
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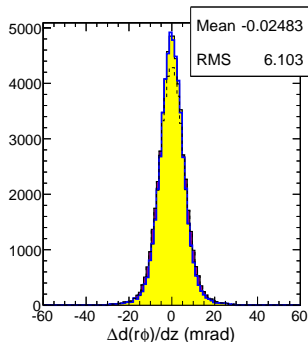
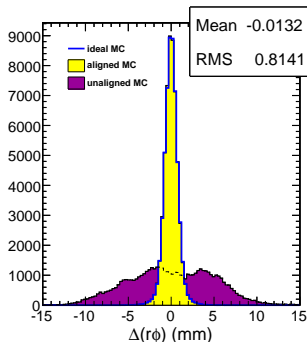
Step 3 (previous page)



Step 6: repeated everything, to allow for any interdependence of parameters



► No significant change



- ▶ Toy MC $\Delta \frac{d(r\phi)}{dz}$ distribution is 2 mrad wide: need to find out what is different in the full MC (potential for improvement?)
- ▶ Tracker-to-CSC $\Delta \frac{d(r\phi)}{dz}$ distribution is 5 mrad wide; the above is slightly narrower, accounting for $\sqrt{2}$
- ▶ 6 mrad $\Delta \frac{d(r\phi)}{dz}$ distribution implies 0.76 mm $\Delta(r\phi)$ distribution, so the above is consistent with intercepts dominated by slope error



- ▶ $\sum_i^{18} \Delta(r\phi)_i$ and $\sum_i^{18} \Delta \frac{d(r\phi)}{dz}_i$ must both be zero
- ▶ Independent of alignment: tests consistency of residuals
- ▶ MC results (sum over chambers, not average):

ring	$\Delta(r\phi)$ (mm)	$\Delta \frac{d(r\phi)}{dz}$ (mrad)
ME+4/1	-0.13 ± 0.33	-4.6 ± 2.0
ME+3/1	-0.41 ± 0.22	0.1 ± 1.5
ME+2/1	0.02 ± 0.19	2.4 ± 1.2
ME-2/1	-0.26 ± 0.19	1.6 ± 1.17
ME-3/1	-0.05 ± 0.23	-3.4 ± 1.5
ME-4/1	0.01 ± 0.32	-3.4 ± 2.2

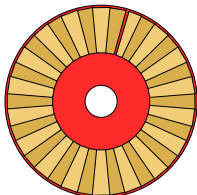


- ▶ New feature: can align incomplete rings by *assuming*

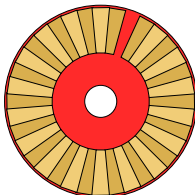
$$\sum_i^N \Delta(r\phi)_i = 0 \quad \text{and} \quad \sum_i^N \Delta \frac{d(r\phi)}{dz}_i = 0$$

- ▶ Closure test is no longer available as a cross-check
- ▶ Only works for certain topologies:

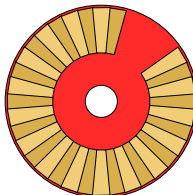
part of a chamber missing
(CLCT problem): okay



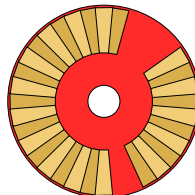
whole chamber missing:
okay



consecutive chambers
missing: okay

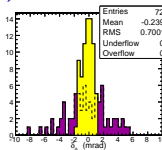
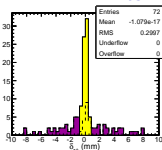
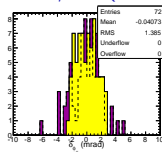


more than one group
missing: **not okay**

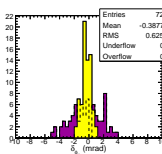
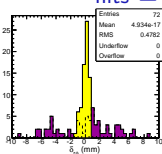
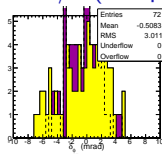




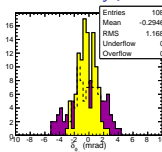
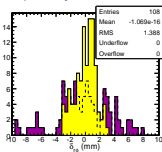
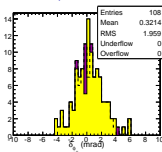
ME $\pm 1/1b$ (complete with $N_{\text{hits}} \geq 5$)



ME $\pm 1/2$ (complete with $N_{\text{hits}} \geq 5$)



ME $\pm 2/2$ and ME $-3/2$ (all incomplete, fix ϕ_y)



- Lowered N_{hits} threshold to 5 to align more rings
- ME2/2, 3/2 (far from beamline) are incomplete, but only +3/2 is missing multiple groups
- Alignment in ME2/2, 3/2 only possible by fixing ϕ_y (due to low statistics)
- Roughly 1/2 hour of circulating beam



- ▶ Last year's software still works, with a minor update
- ▶ New occupancy plots help to monitor trigger/read-out issues
- ▶ Added ability to align incomplete rings, for some topologies
- ▶ Need to combine ME1/1a and 1/1b chambers, especially if 1/1a is shadowed by trigger geometry