Status of Beam-Halo Alignment with First Beams

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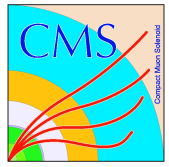
18 September, 2008

In a nutshell



- Idea: tracks passing through overlap of neighboring CSC chambers yield relative position of pairs; use these to reconstruct whole ring
- History: long succession of trial-and-error; a subtle problem!
- Consistency check: ring must "close," residuals must be centered for all pairs of chambers simultaneously
- Methods (now that the dust has settled):
  - Step-by-step: fix one chamber, align its neighbors, align its neighbors' neighbors... check quality with closure
  - Matrix-based: minimize a global χ^2 by solving 18 (or 36) simultaneous equations, check quality with final χ^2
- Advantages/disadvantages: step-by-step can be used when a chamber is missing, matrix-based more evenly distributes error (and therefore typical errors are smaller)
- Status: works in MC, reveals the expected 2.5 mm radial shift in cosmics data (ME+2/2, 3/2), close to working in beam-halo data

Alignment details

- Alignment is in global $r\phi$, rather than local x
  (chambers glued to circle around the beamline, not a polygon)
- Residuals measured perpendicular to strips (always tangent to circle)
- Necessitates a new alignment package, a software issue to be dealt with later

Properties of closure in this framework

- Independent of the alignment state: moving a chamber in $r\phi$ increases residuals on one side and reduces them on the other
- Independent of whether we align chamber N to $N+1$ or align chamber N to $N-1$
- Closure is a property of fitting procedure, misalignments other than $r\phi$, and possibly deeper detector issues

Results, expressed as radial shift

Lack of closure can be interpreted as increase/decrease in radius

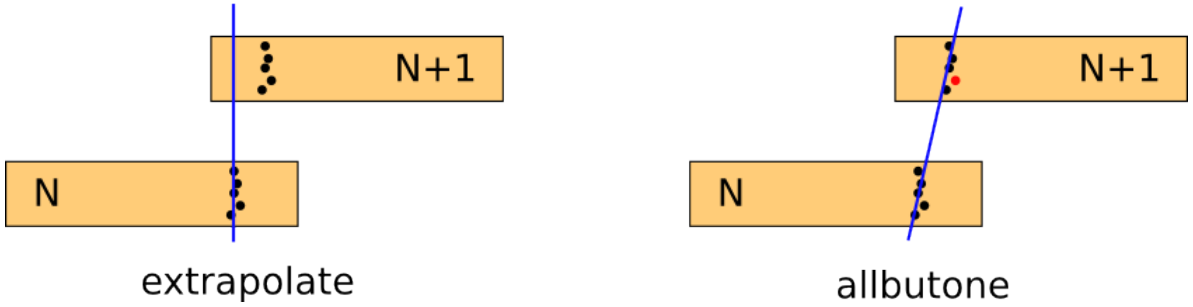
- MC: all rings less than 1 mm, most ∼300 μm (new accomplishment)
- Cosmics data: ME+2/1 wants to shrink 1.8 mm, ME+2/2 and 3/2 want to increase 3.5 and 3.0 mm
  - Good (2/2 and 3/2)! There was an actual radial misalignment of 2.5 mm in ME2/2 and 3/2 (with the right sign)
- Beam-halo data: ME+2/1 wants to shrink 1.6 mm (consistent), ME−2/1 shrink 6.8 mm, ME−3/1 shrink 6.0 mm

We're seeing something real...

- consistency between CRUZET cosmics and 62232 beam-halo is a strong criterion (completely different track angles)
- step-by-step procedure reveals approximately the same underclosure with each step, like a property of the chambers, not location

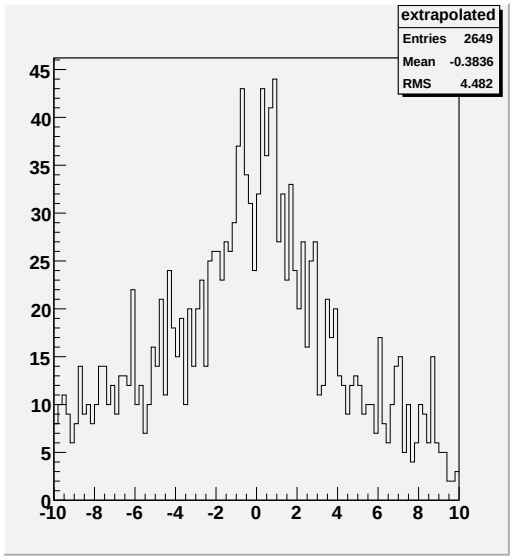
...but it's very likely not radius: rotations around wire axis (ϕ_y)?
shear of layers (i.e. alignment pins are tilted 0.4 mrad)?

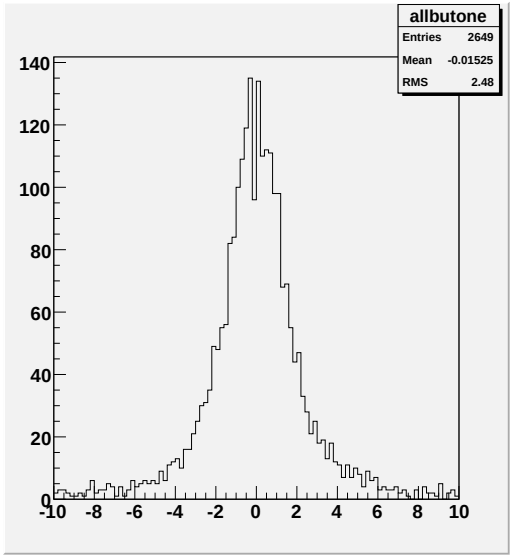
Fitting methods intro



Traditional fitting method (previous page): include hits on chamber N in fit, align chamber $N + 1$

Tentative fitting method: include all hits in fit except the one whose residual we calculate (residuals over uncertainty should be unit Gaussian)





ME+2/1 chamber 1 residual over uncertainty in the two cases: 4.4 $\longrightarrow$ 2.4

Closure results with new fitter

	ME+2/1 wants to shrink	ME−2/1 shrink	ME−3/1 shrink
Old fitter	1600 μm	6800 μm	6000 μm
New fitter	170 μm	420 μm	490 μm

- Resolution improves by a factor of 2, but this bias decreases by a factor of 10— it's not just because the track is more constrained
- *However*, new fit does not yield misalignment, as old "extrapolation fit" did. It will require iteration, and convergence is empirically slow.
- Strike a balance by merely deweighting hits on the aligned chamber? (under study)

What to do?

- Find a deweighting factor that aligns chambers on a reasonable timescale without re-introducing the bias? (hopefully)
- Discover the origin of the bias, and if it's an internal misalignment, correct that too? (too optimistic for a CMS Week timescale)
- Evenly distribute error with matrix algorithm (fallback solution)
- Use step-by-step algorithm with a fudge factor to do the same thing on incomplete rings? (requires a strong assumption that true $r\phi$ misalignment doesn't have a coherent pattern, an assumption I don't want to make)
- Complete rings in run 62232: ME+2/1, −2/1, and −3/1
- Complete rings in whole beam−halo dataset: ME+2/1, +3/2, −2/1, −2/2, −3/1
- CRUZET cosmic rays can add ME+2/2 and +3/2