Overview of track-based alignments proposed for sign-off

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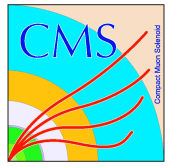
Overview



- Prepared constants:
  - up-to-date track-based alignment of the muon barrel: not proposed for sign-off; studying residuals
    to be presented by Aysen at the end of this meeting
  - internal alignment of the CSC rings (beam-halo overlaps): proposed for sign-off
- Prepared methods:
  - alignment of the CSC rings relative to the tracker: thoroughly tested and cross-checked, needs to be updated with the new tracker geometry and cross-alignment (GlobalPositionRcd)

Endcap constants

The internally aligned CSC geometry can be found here:

`/afs/cern.ch/user/p/pivarski/public/NOV05_PG-HW-phiy-BHPGholes-rings2-BHPGholes2.db`

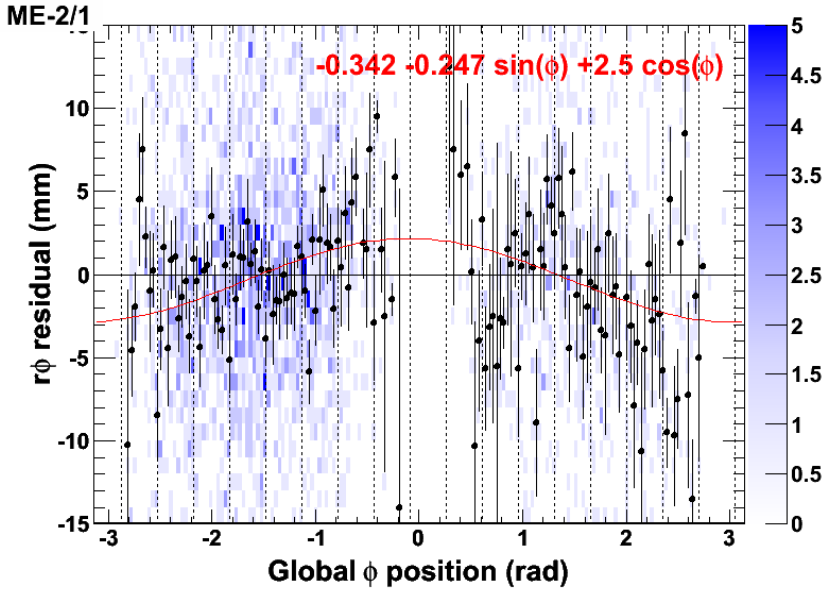
It was created by applying the following, in this order:

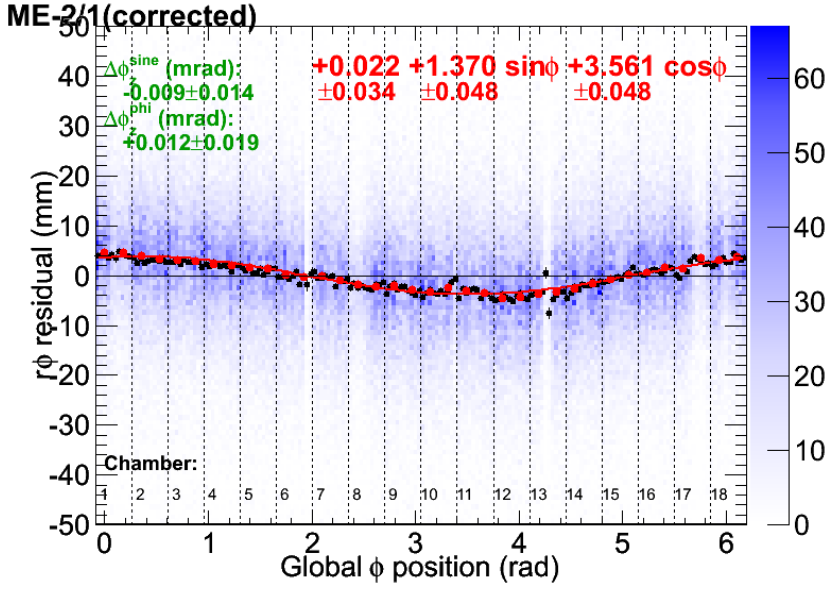
1. Photogrammetry (PG): local x, y, z, ϕ_x, ϕ_z;
2. SLM lines for disk displacement and bending due to magnetic field: local z, ϕ_x (replacing PG);
3. "Missing angle measurement" from collisions relative to the tracker: local ϕ_y;
4. Beam-halo alignment of chambers relative to rings, with PG constraining only the missing beam-halo data (and no PG constraint in ME1/1): $r\phi$ and ϕ_z (replacing PG)
5. Ring alignment using collisions: global x, y, ϕ_z of rings, keeping internal chamber structure intact
6. Beam-halo re-alignment of chambers relative to rings, with only one PG constraint per ring and with ME1/1 constraints derived from collisions

The new data

Comparison of an old cosmic-ray (left) and new collisions (right) plot

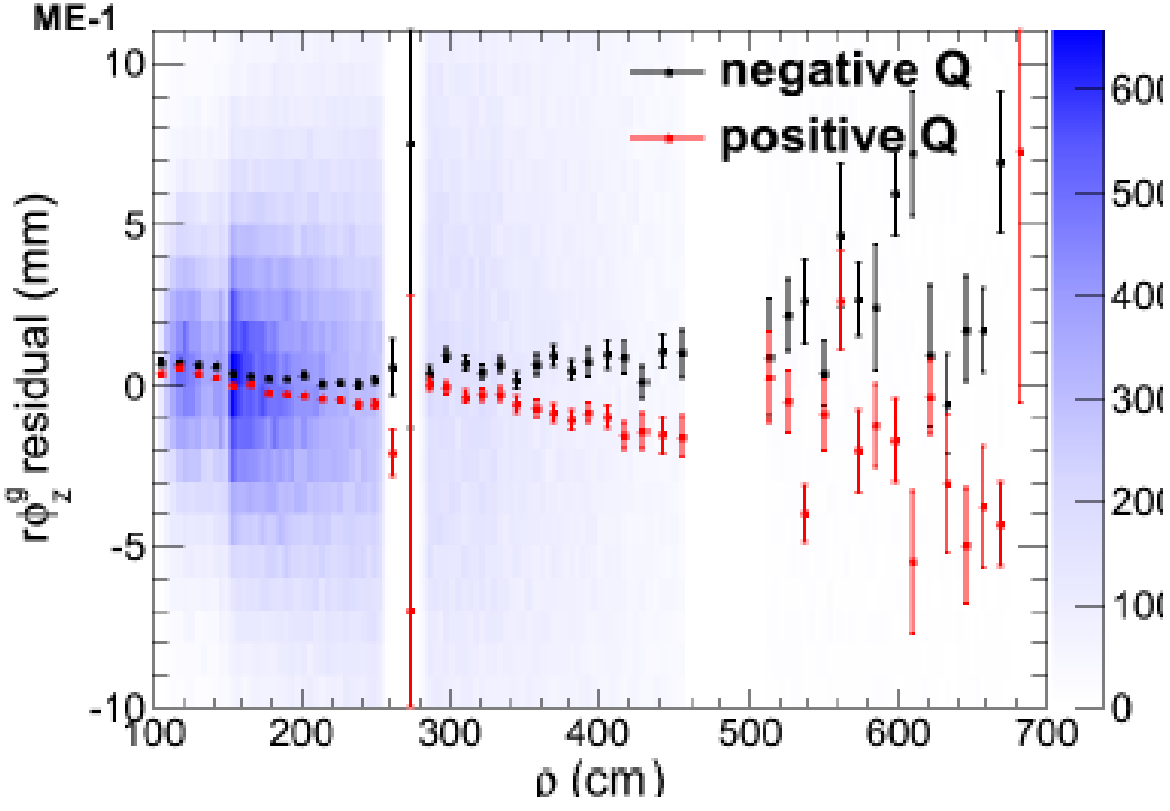
- roughly consistent (note that vertical and horizontal axes are both different: sinusoidal fit provides the best comparison)
- cosmic rays: $p_T > 10$ GeV/c for maximal statistics (this is ME$-$2/1, low statistics due to tracker-pointing geometry)
- 22 pb^{-1} of $p_T > 15$ GeV/c collisions with improved fitting techniques to account for non-Gaussian tails in residuals and splitting between μ^+ and μ^- due to $\vec{B}$-field or material budget errors





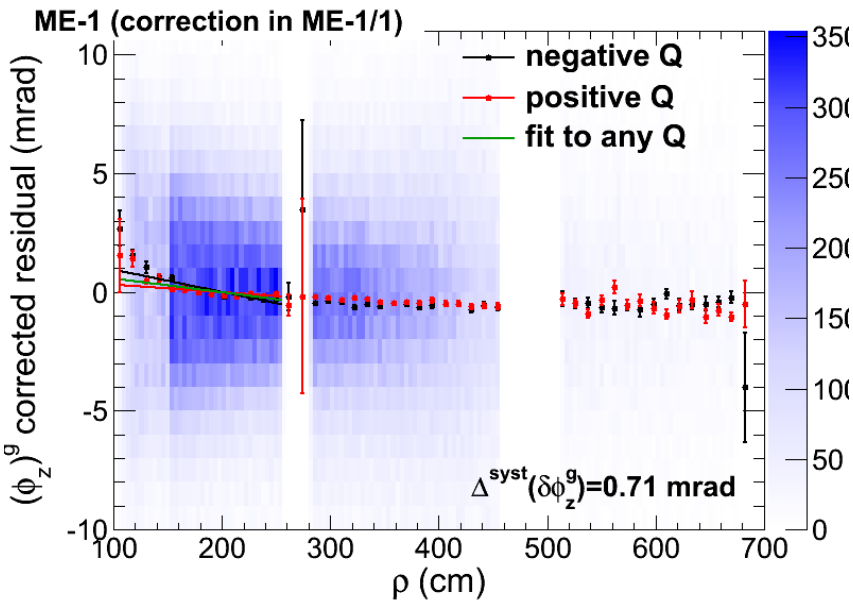
Magnetic field errors?

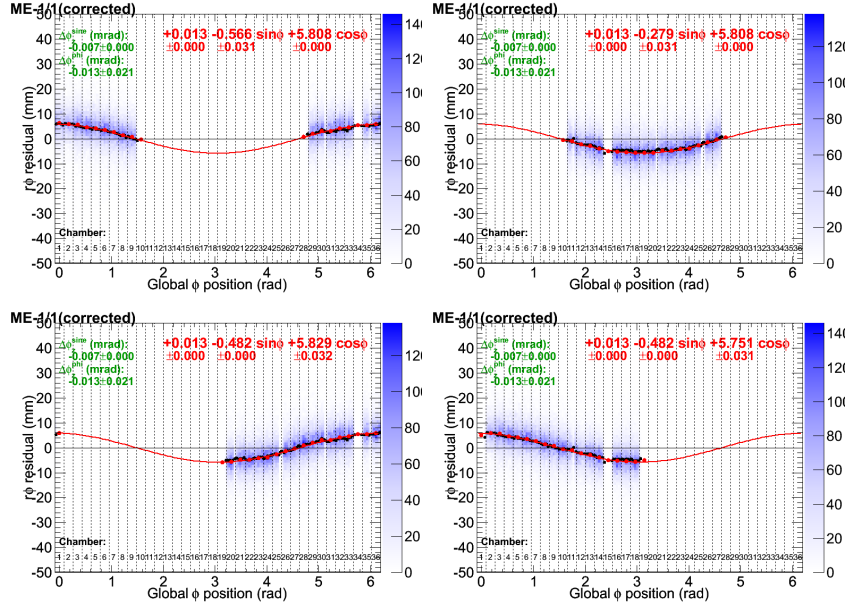
- Observed charge asymmetry at high radius (distance from the beamline ρ); plot below is $r\phi$ residuals vs. ρ for μ^+ and μ^-
- Alignment is protected by residuals vs. $q/|p_z|$ fits
- This splitting could be due to $\vec{B}$-field errors, material budget
- Same pattern in all rings



Systematics studies

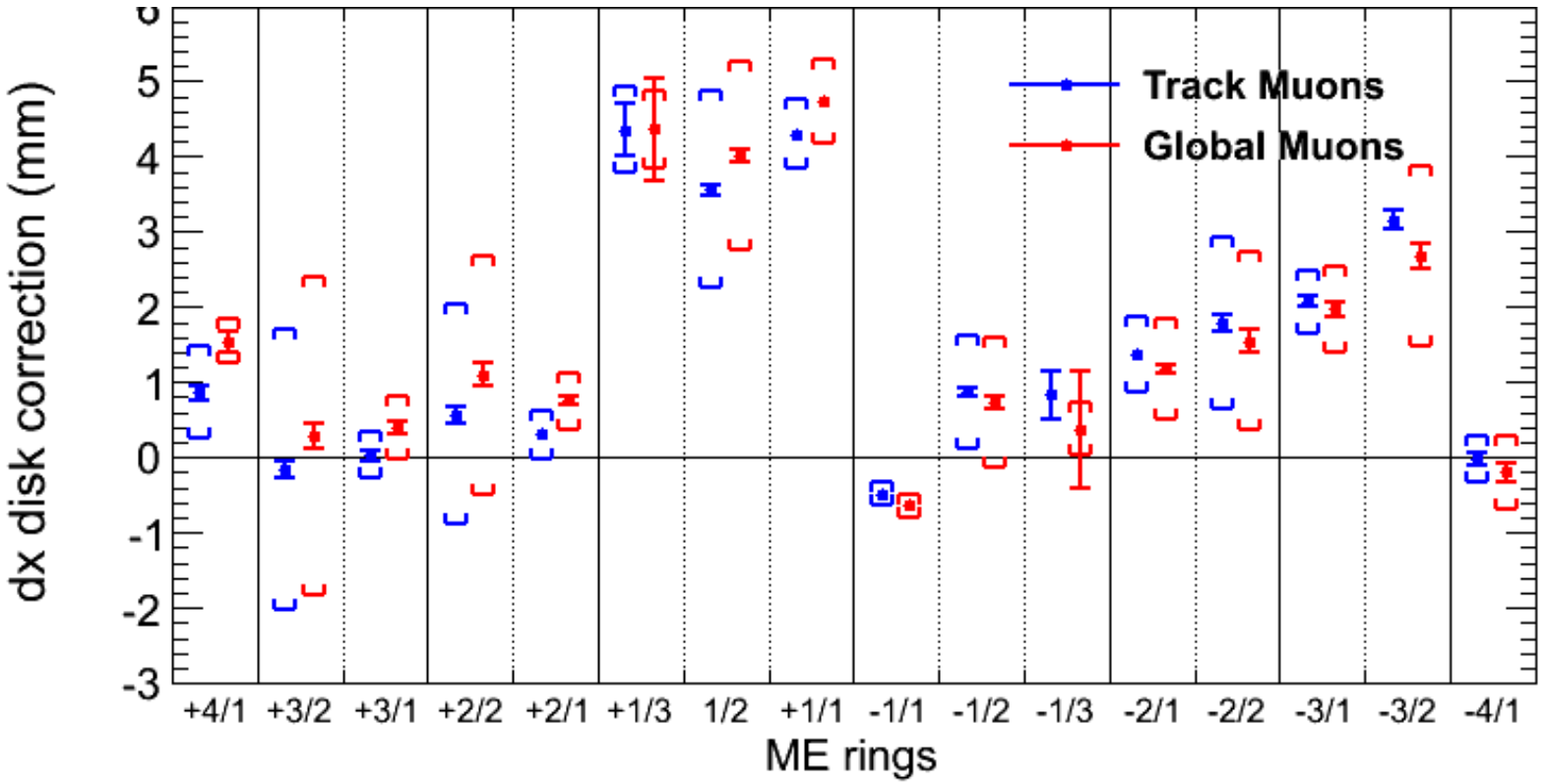
- Detailed systematic error studies quantifying the limits of interpretation of rings as a rigid body
- Two studies shown below (left: variation vs. ρ, right: vs. ϕ)





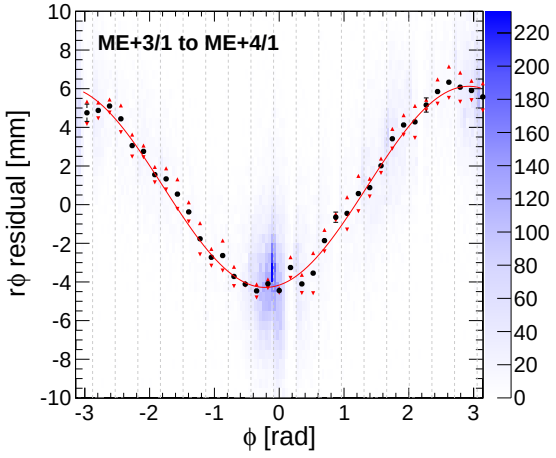
Residuals-calculation method

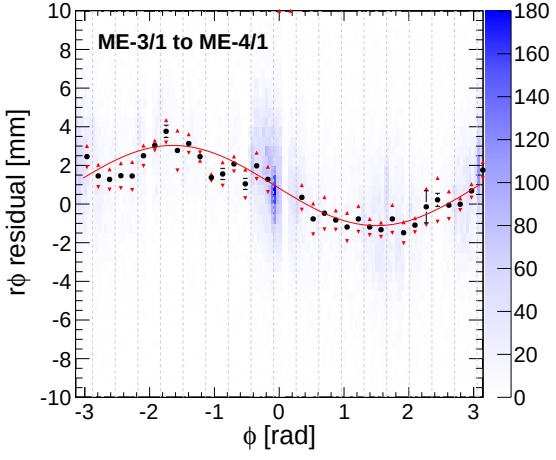
- Statistical and systematic uncertainties
- Comparison of results for different methods of residuals calculation
  - this distinction between "TrackerMuons" and "GlobalMuons" are what Aysen is studying, but while it has noticible effects inside of individual chambers in the barrel, it has less of an effect when finding the average position of a ring



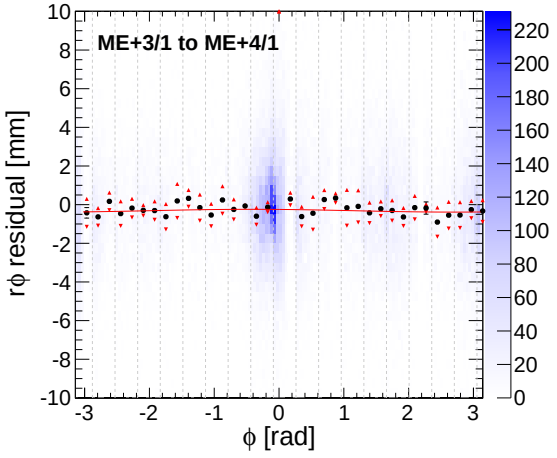
Independent cross-check

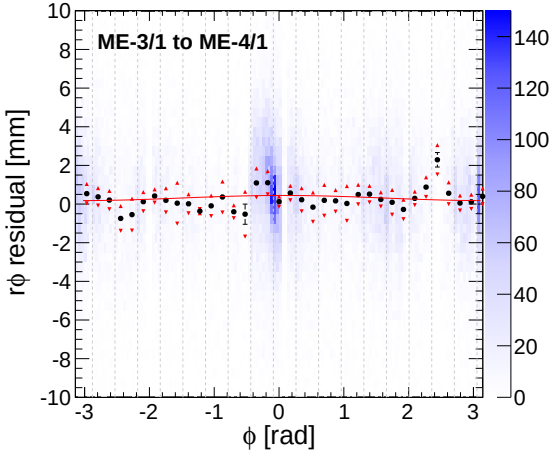
Before alignment





After alignment



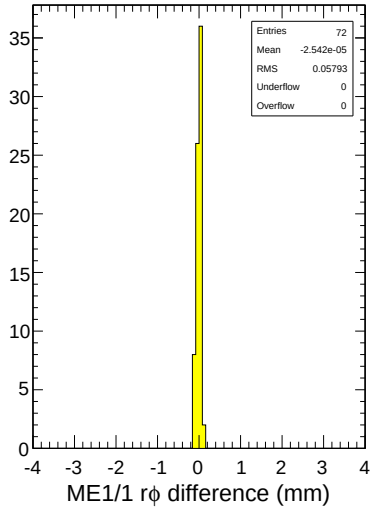


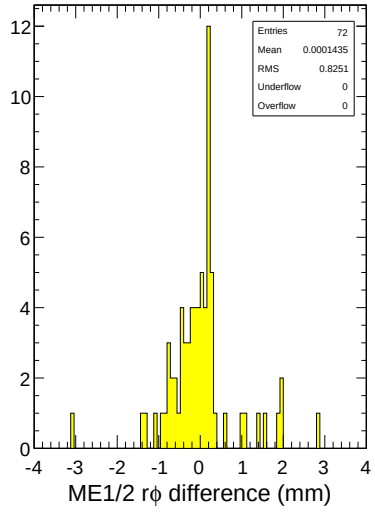
The above plots were not used for the alignment— they are a cross-check

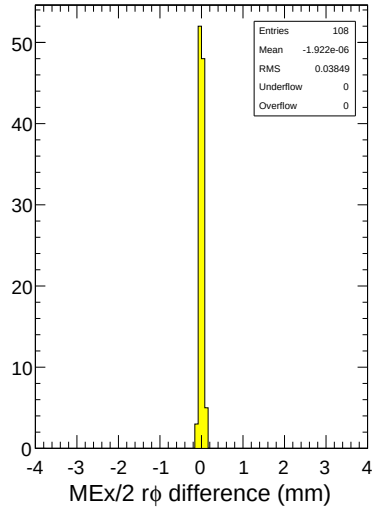
- Ring alignment relative to the tracker verified with ring alignment relative to other rings using beam-halo tracks (note ϕ asymmetry)
- Independent alignment techniques yield the same result within 130 μm (x and y) and 0.14 mrad (ϕ_z) for ME4/1

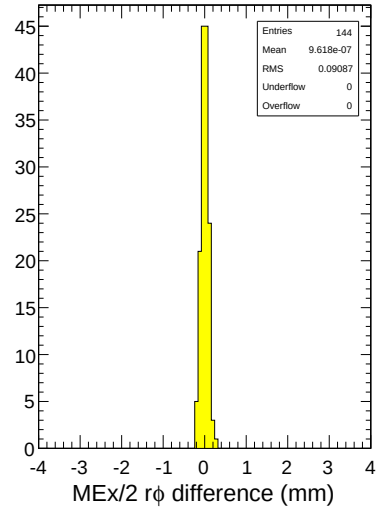
Do internal alignments factorize?

- Reproducibility of internal ring alignment after the whole ring has been re-positioned depends on pattern of photogrammetry constraints
- ME$\pm$1/2 each have two antipodal constraints which pull the ring back toward the photogrammetry's coordinate frame
- The rest of the rings are fine



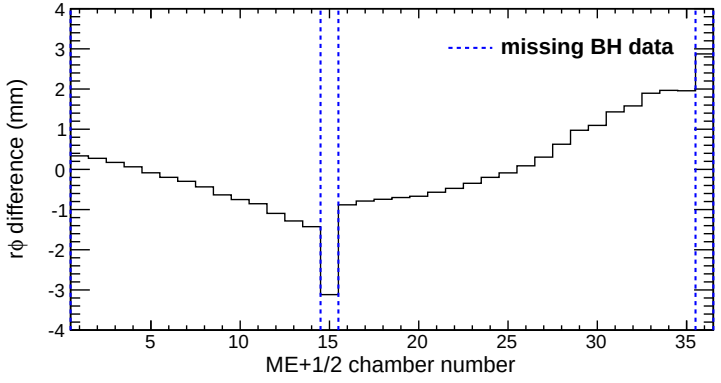


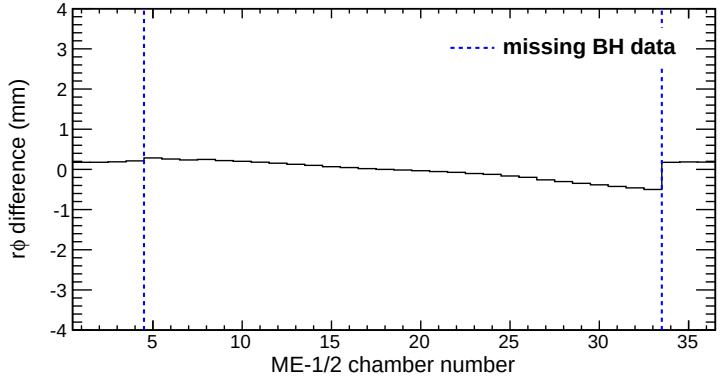




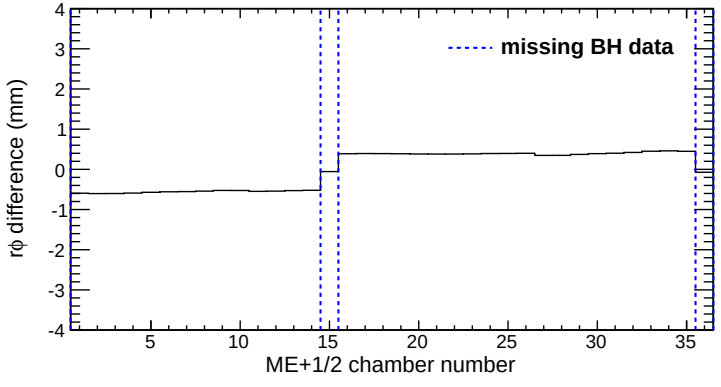
Change in internal alignment

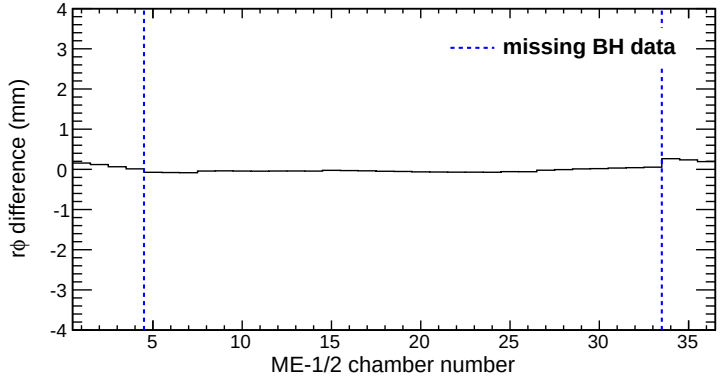
- To solve this problem, never use more than one photogrammetry constraint per ring
- Before (this is the "spread" in ME±1/2 chamber positions):





- After: PG only constrains the relative positions of ME+1/2/15 (and neighbors) and ME−1/2/33,34





For full details

see the "Endcap ring alignment note" on Indico

Next steps

1. Proposing new internal ring constants for sign-off
2. Proposing ring alignment relative to tracker method for sign-off
3. Must repeat ring alignment relative to tracker with the updated tracker description and cross-alignment before Nov. 12
4. Will likely finish much, much sooner because all of the pieces are already in place
5. When those constants are signed-off (via HyperNews), they need to be uploaded to the database and the Muon POG should be pointed to their location and how to use them