Muon Alignment Quality on the Eve of the CSA08 Exercise

Jim Pivarski, Alexei Safonov, Károly Banicz*

Texas A&M University, *FermiLab

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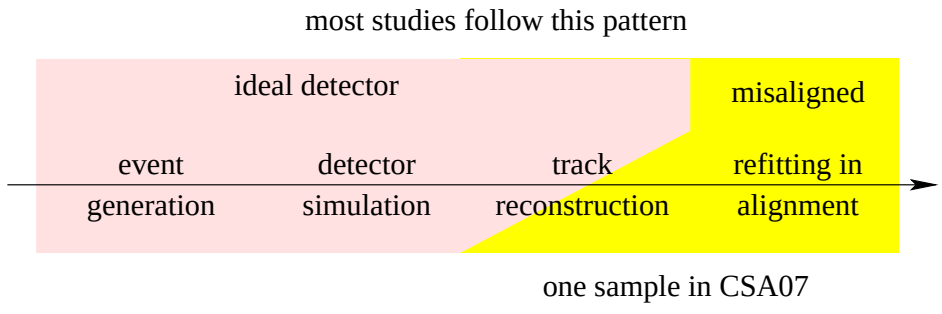
Outline

- Nutshell history since CSA07
- Which "baseline" procedure is best (which should we use in CSA08)?
- Dependence of alignment quality on initial misalignment
- Status of the overlap procedure for beam-halo and cosmic rays
- Workflows in CSA08

Quick history (1/2)

- Last year, we developed an "infinite APE" technique for aligning the muon system:
  1. refit globalMuons with unphysically large Alignment Position Errors on the muon hits
  2. resulting track is dominated by tracker information, but we can calculate muon residuals
  3. converges in one iteration because we're using external information
- CSA07 exercise included an event sample which was misaligned at the RECO level



  - revealed that apparent prior success was due to an incomplete re-fit, and the track deviously carried information about the ideal detector (except in CSA07)

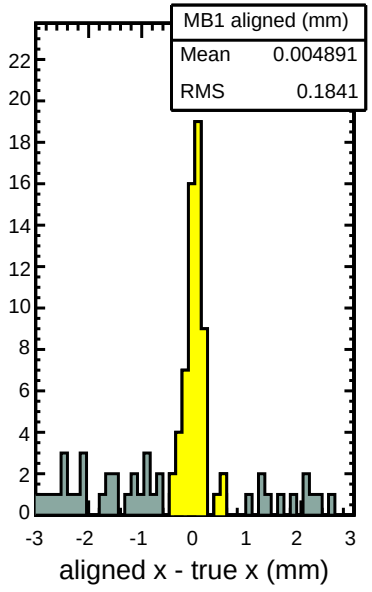
Quick history (2/2)

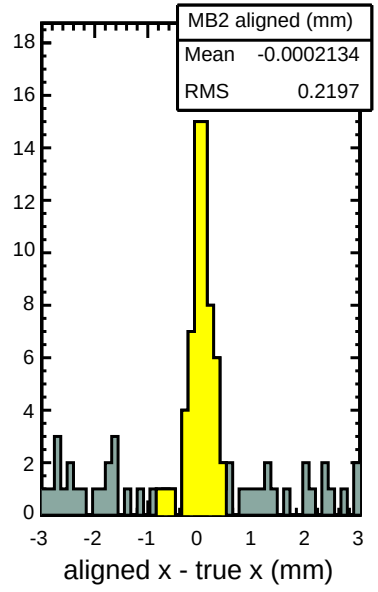
- Correcting that mistake led to poor alignment results because we were dealing with the full alignment problem for the first time, including extrapolation errors due to multiple scattering
- We quickly modified our procedure to take advantage of local information:
  1. align only station 1 in the first stage
  2. fit tracks with tighter APEs in station 1 and align station 2...
- In early tests, "staged procedure" did better than "infinite APE", so I developed this procedure in earnest, yielding 0.4–1.6 mm resolution on chamber resolution in most stations
- In my early tests, I conflated "infinite APE" with "track propagated from tracker" which naively should be the same thing, but there are differences which lead to alignment error
- Many bug-fixes later (both procedures improved), I find that the real "infinite APE" yields the best results: 0.2–0.7 mm
- But it also depends on degree of initial misalignment

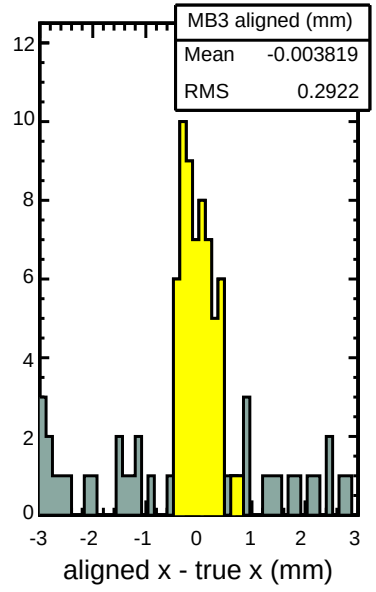
New results

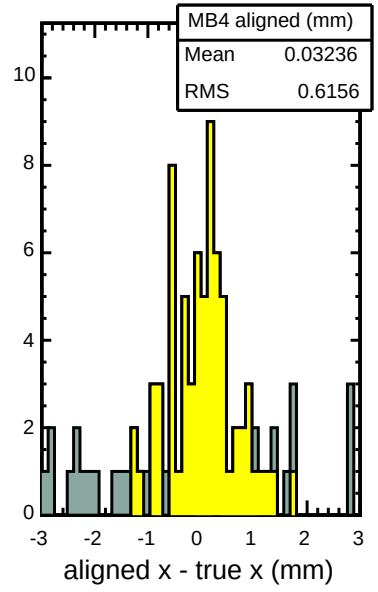
- First, I want to show are the new results with the real "infinite APE" technique.
- These come from a pre-CSA test (1_8_4 FastSim) with 7 pb^{-1} of $W \to \mu\nu$
- Chambers start with the 0 pb^{-1} misalignment scenario and no misaligned layers
- (These are in publicity-plot form, which will be filled with CSA08 results in two weeks)

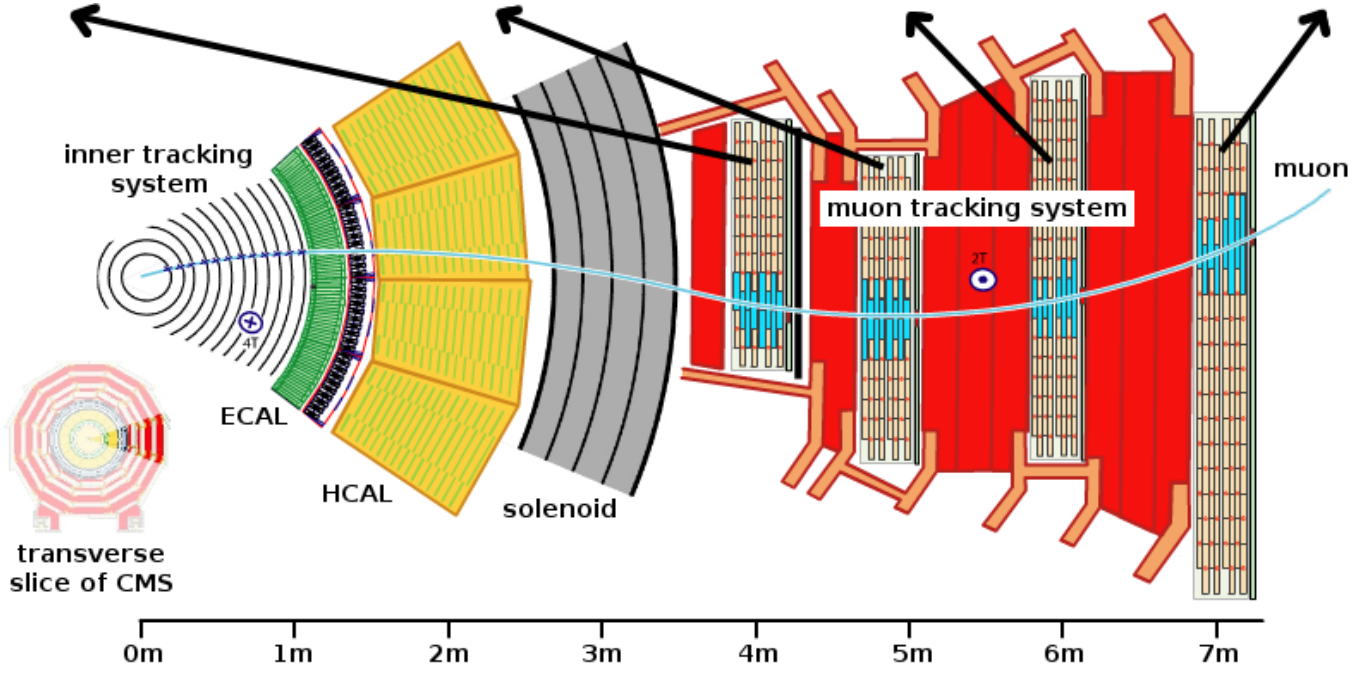
New Barrel aligned positions



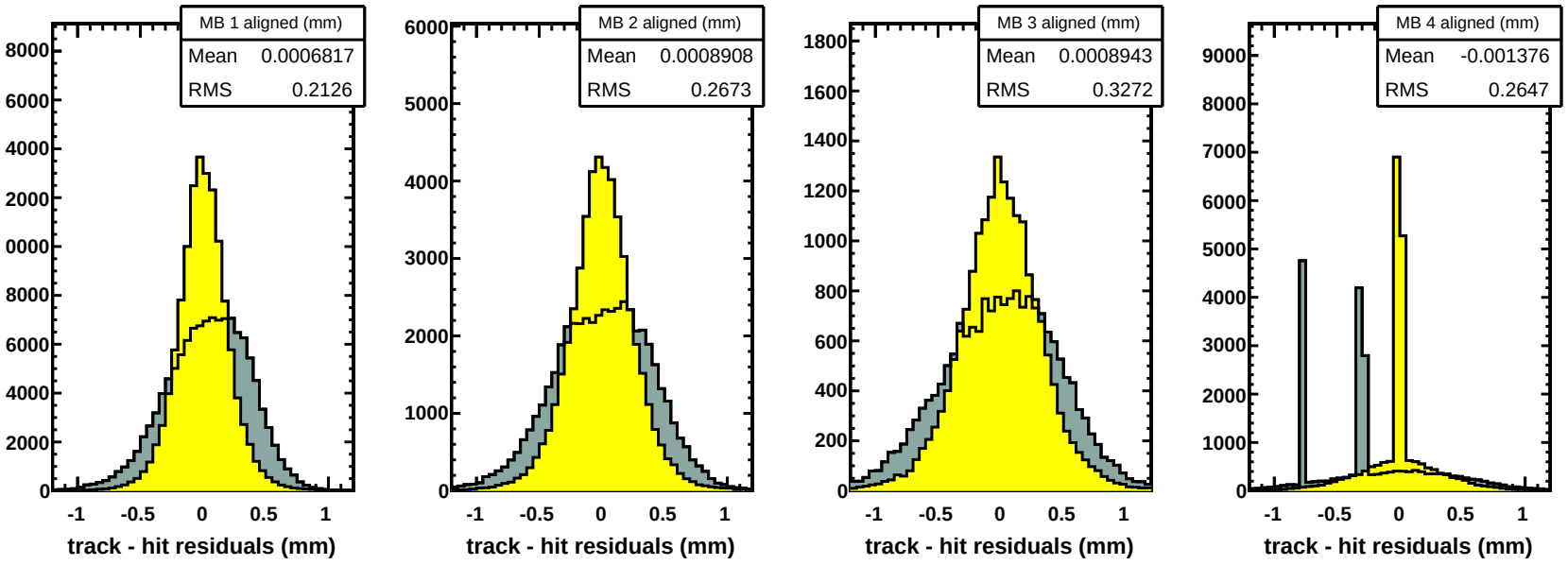


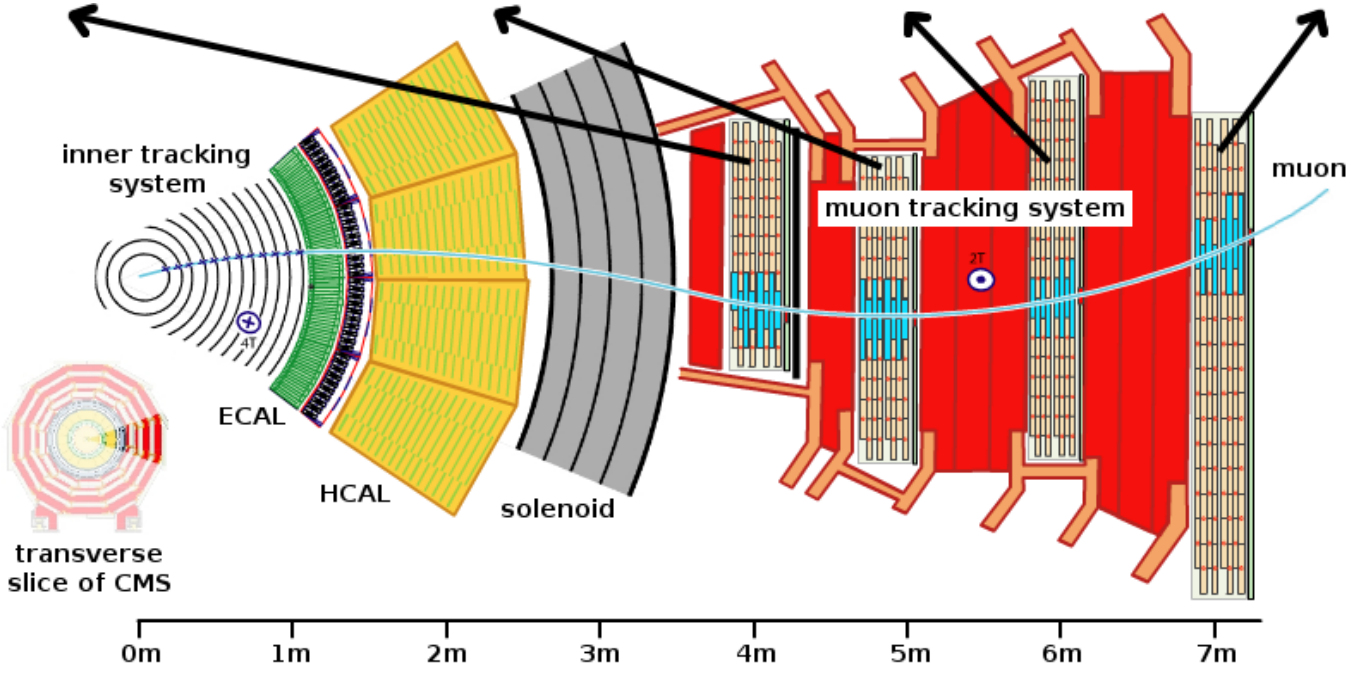




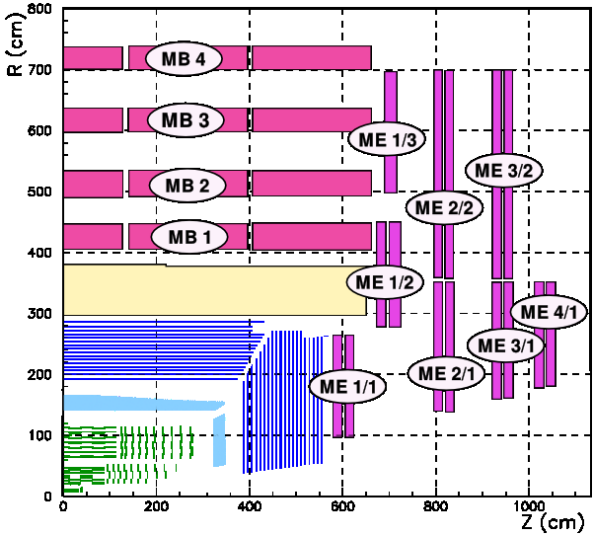


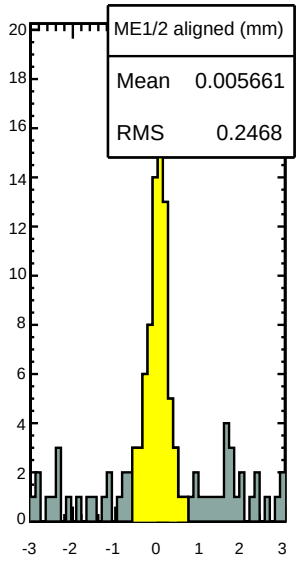
New Barrel track residuals

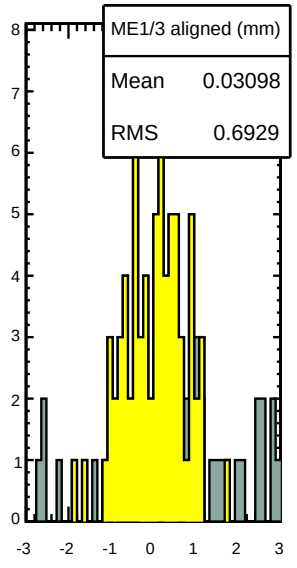


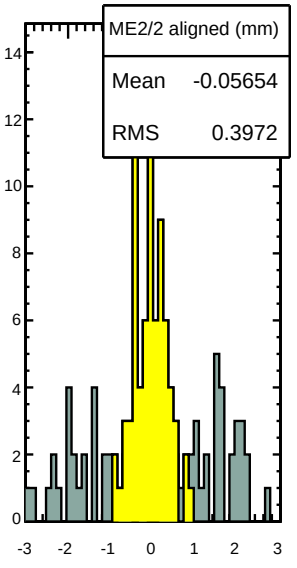


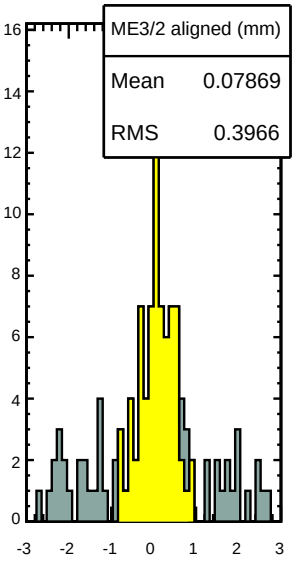
New Endcap aligned positions

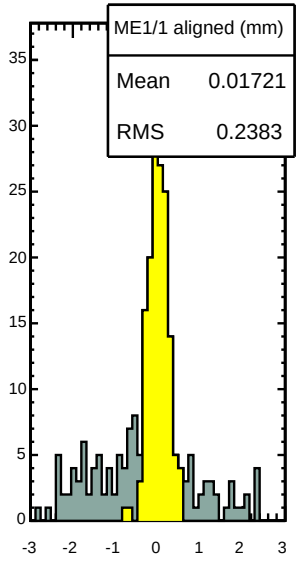


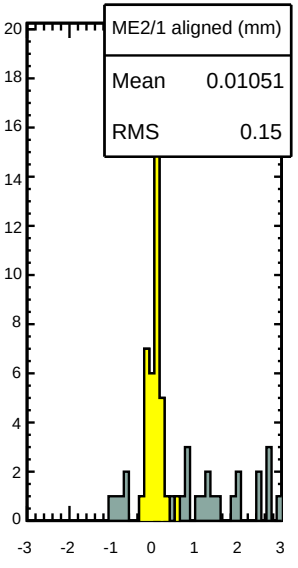


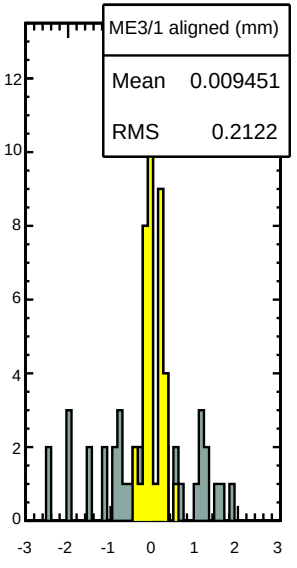


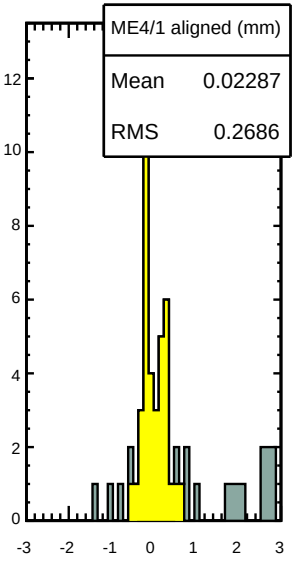




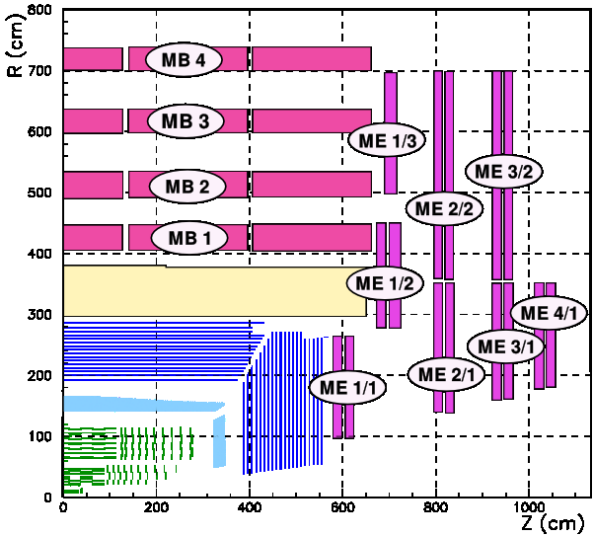


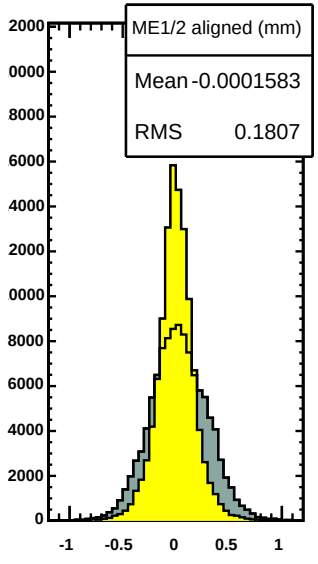


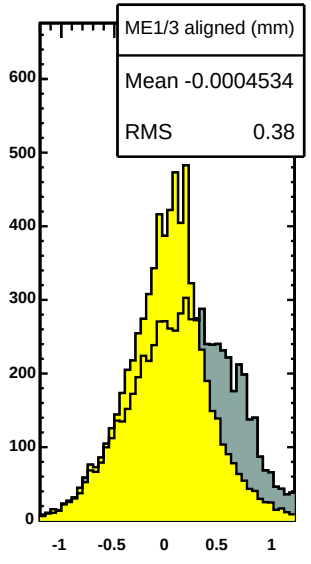


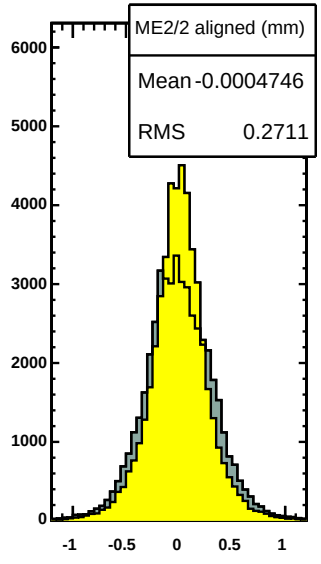


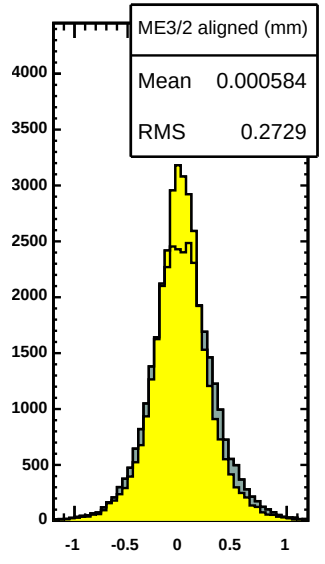
New Endcap track residuals

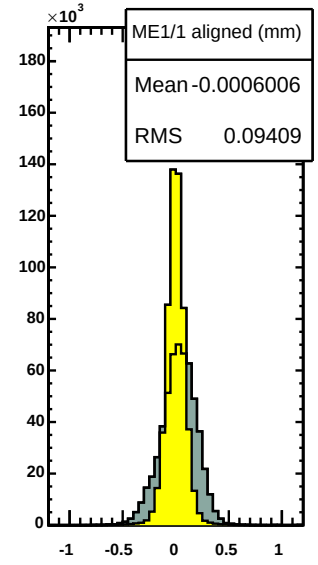


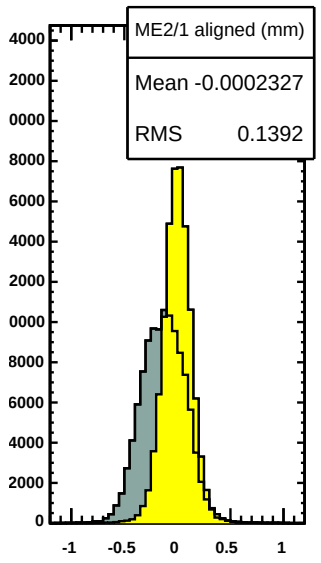


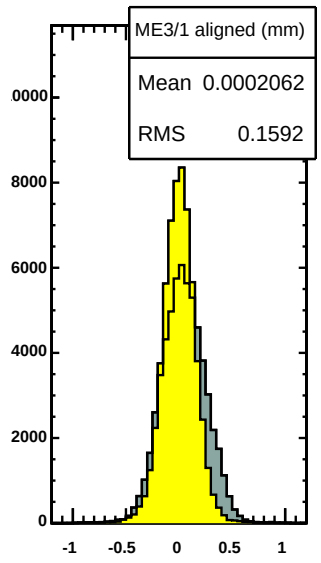


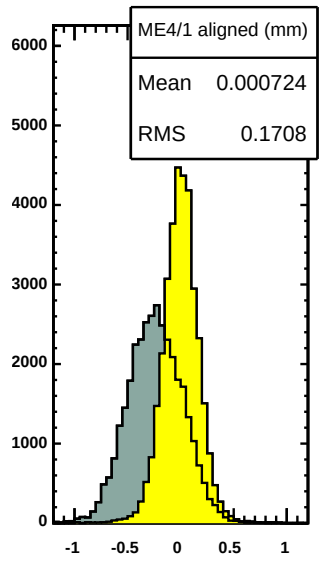






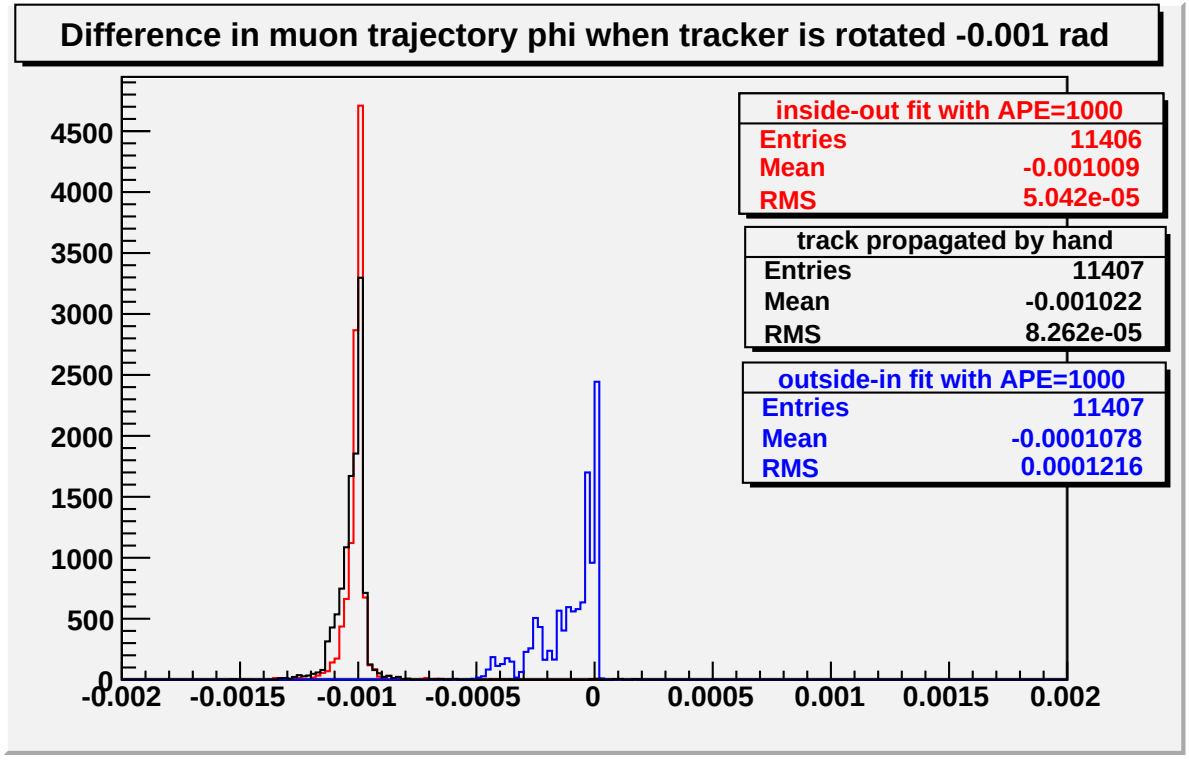






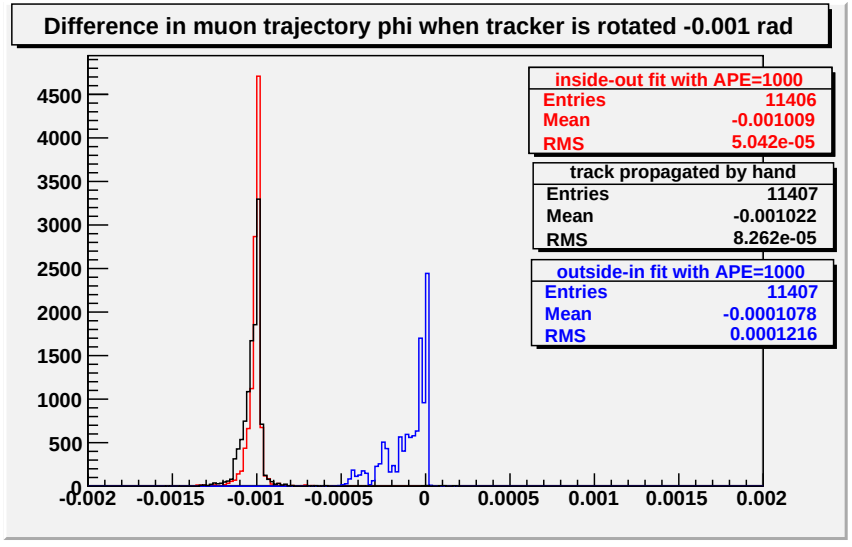
"Infinite APE" is good again?

- High-quality results from "infinite APE" made me suspicious, because this is the procedure that suffered from the "devious tracks" bug
- Are the tracks remembering the RECO geometry now? Test:
  1. Rotate tracker by 1 mrad, refit tracks
  2. Check ϕ of each track extrapolation, track-by-track, surface-by-surface: the difference should always be 1 mrad



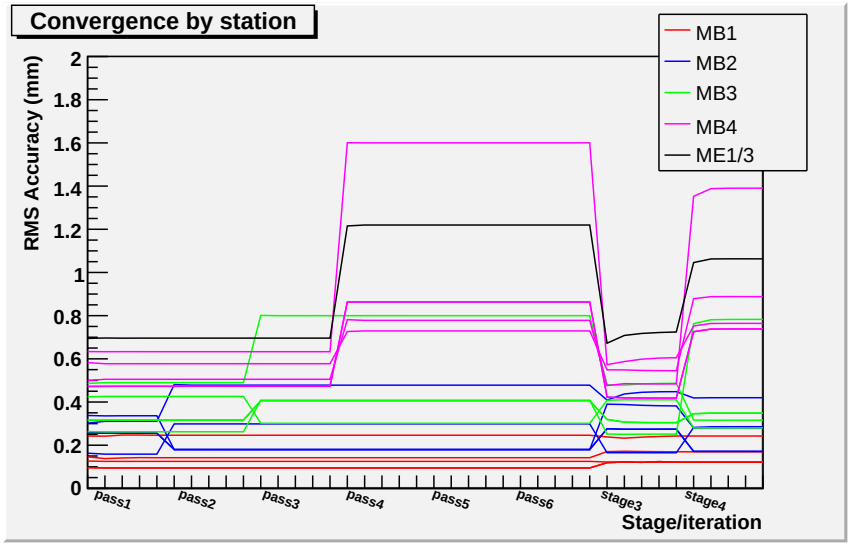
"Infinite APE" is good again?

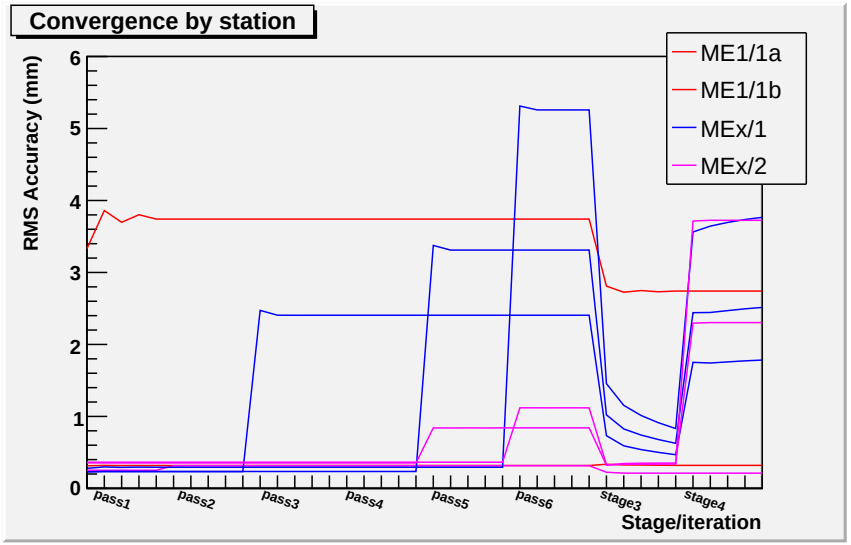
- Tracks remembered RECO geometry when refit from the outside-in
- We now always fit from the inside-out
- Black curve: calling the propagator directly to extrapolate from tracker to muon system
  - Naively, this should be the same as infinite APE
  - There are small differences, even after correcting a firstMeasurement()/lastMeasurement() mistake in my code
  - I based my decision to pursue the "staged approach" on results from the propagator, which is different enough to yield a factor of 2 worse alignment resolution ($\Delta\phi$ of 0.001 $\rightarrow$ $\sim$5 mm)



Staged procedure

Current state of the staged procedure versus iteration (100 pb^{-1}):





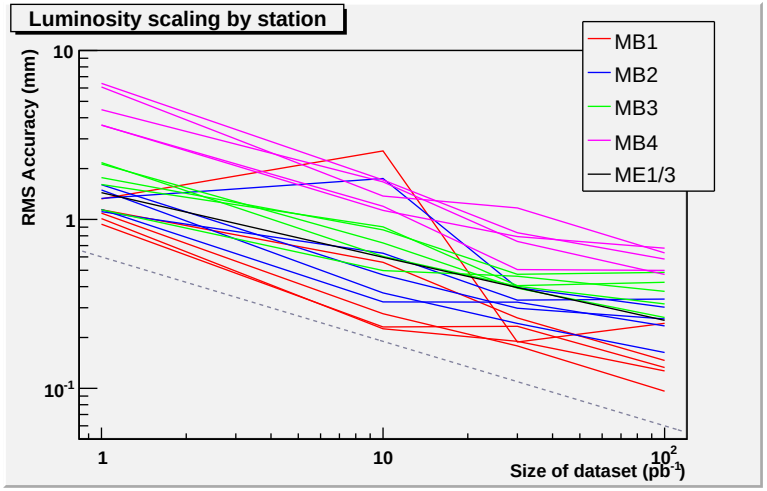
1. Pass1: same as "infinite APEs" (pre-alignment not on this plot)
2. Pass2: fix station 1 and steer tracks toward them, aligning station 2
3. Results in errors that compound as we go out
4. "Stage 3" is "infinite APEs" again (fixes everything)

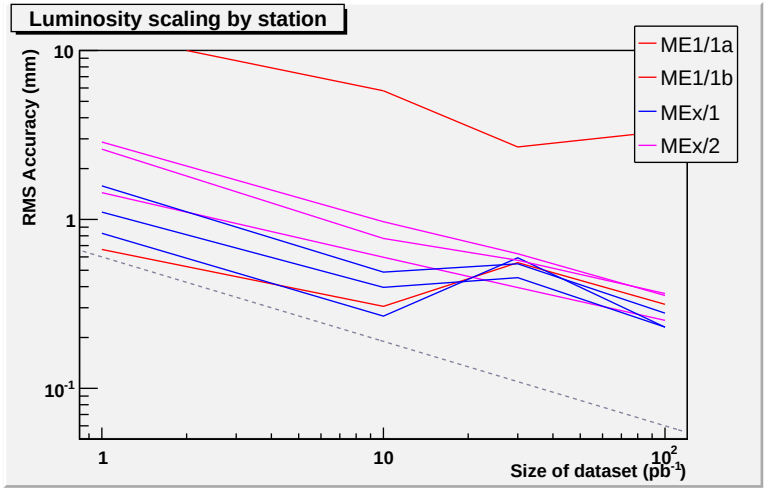
This was the motivation for me to switch back to the "infinite APEs" method as our baseline.

Apples-to-apples comparison (same starting misalignment) on next page.

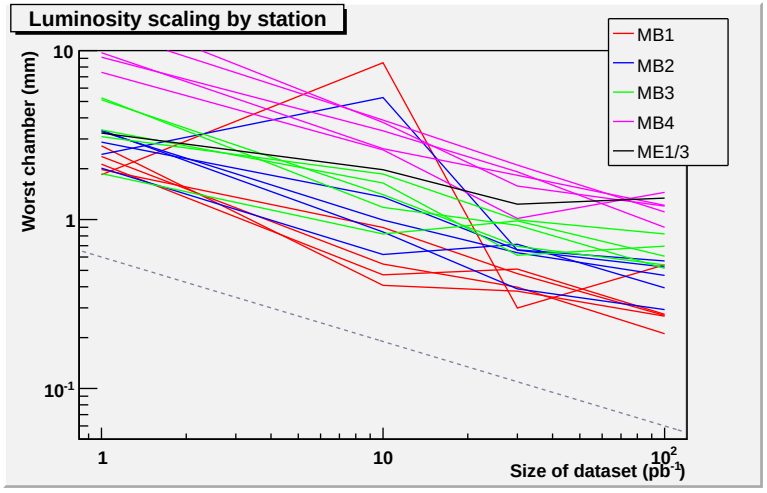
Scaling with $\int$luminosity

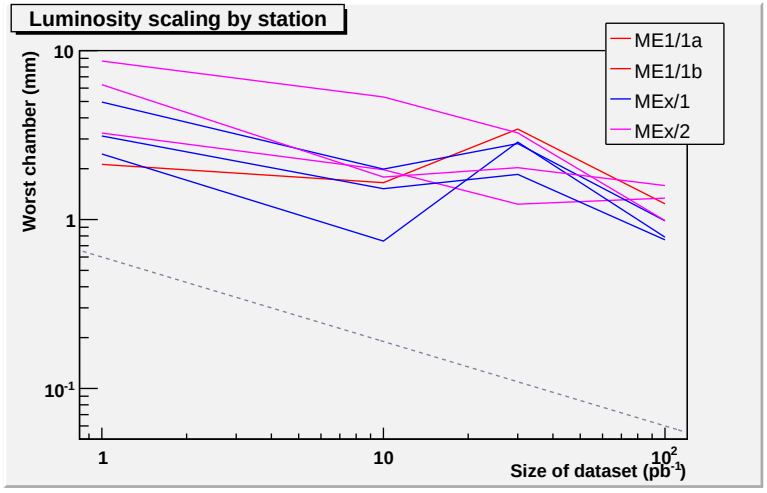
RMS of chamber residual misalignments within each station
(dashed grey line is $1/\sqrt{N}$ for comparison)





Worst chamber within each station





Consistency

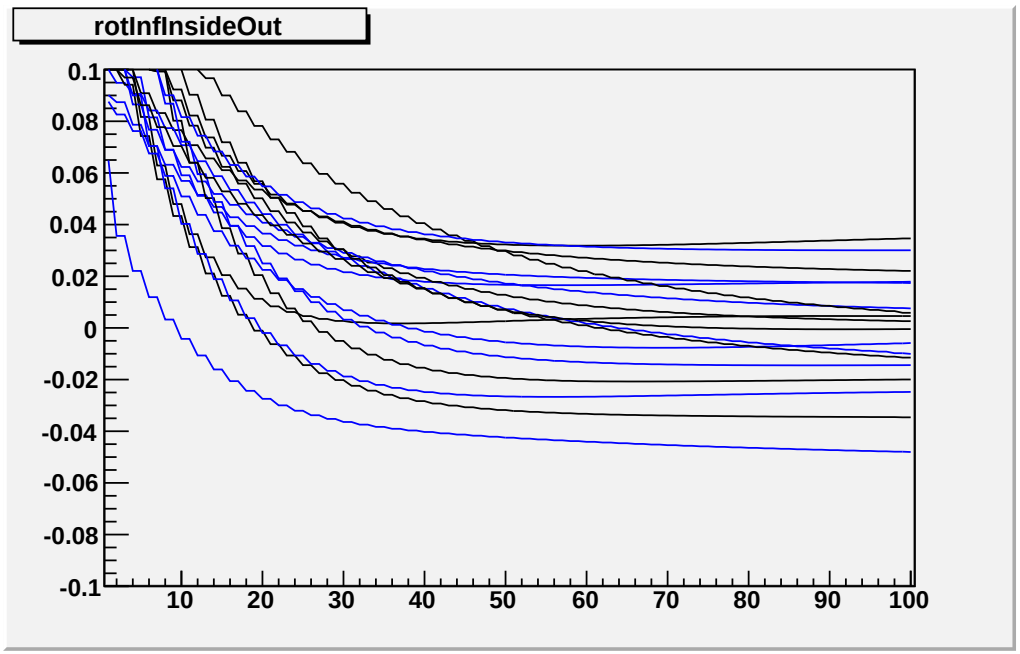
- Within the "infinite APE" method, I still see differences (compare slide 13 with slides 6–9)
- My old studies used huge misalignments as a starting misalignment ($\sim$cm), and so do the last two slides
- iCSA08 starting point is 0 pb^{-1} scenario, which is closer to reality, but has no layer misalignments (neither did the old starting point, it turns out)
- Quick study: RMS resolution per station with varying layer misalignment

station	with perfect layers (mm)	with 1$\times$ expected (mm)	with 2$\times$ expected (mm)
MB 1	0.184	0.188	0.212
MB 2	0.220	0.219	0.239
MB 3	0.294	0.318	0.357
MB 4	0.613	0.608	0.621
ME1/1	0.227	0.216	0.247
ME1/2	0.245	0.262	0.308
ME1/3	0.679	0.678	0.686
ME1/4	0.235	0.259	0.299
ME2/1	0.149	0.171	0.218
ME2/2	0.397	0.400	0.422
ME3/1	0.213	0.224	0.260
ME3/2	0.396	0.391	0.395
ME4/1	0.267	0.302	0.358

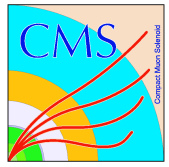
(DTs assumed to be 100 μm (guess), CSCs known from MTCC)

Overlaps procedure

- Reminder: using tracks from CSC overlap regions, we fit to even-numbered chambers, align odds, then alternate
- Problem: this is affected by devious tracks! (small region of hits with non-infinite APEs, inward-out versus outward-in is not as well defined. . .)
- Test: rotate muon system; procedure should *not* be able to find its way back to ideal because the procedure only knows about relative information



Conclusions



- Baseline procedure is in good shape: it should be the "infinite APEs" version.
- This is what will go into iCSA08, and I've done many tests to be sure it will be a successful and realistic test.
- Overlaps procedure is still a work in progress: triggers, AlCa paths, are all in place* and will deliver events in CSA and data, but we don't know how to use them yet
- (* caveat: CSA will deliver overlap globalMuons instead of standAloneMuons, the mistake was caught too late)
- Working on a track refitter that is immune to "devious tracks" bug, and uses only information I understand well (linear fits in the overlap region, which Gena recommends); I would say it's 80% there
- Overlaps will be important for beam-halo *and* cosmic rays, so it's something to fix very soon. However, we never said that success in iCSA08 depends on this part of the procedure (I made that clear a month ago...)