


Muon Alignment Progress

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In a nutshell

- The last time I presented was in November

  I had optimized existing code for 10 pb^{-1} alignment

- Since then, I have scaled up to 100 pb^{-1} and see only marginal improvement in alignment quality (not $\sqrt{10}$)

- Re-tuning parameters for 100 pb^{-1} helps

- So do new tools: track filter and alignment-specific refitter, but these are still experimental

- Currently parallelizing the baseline procedure so that I can study improvements in a controlled and timely fashion

Reminder of the method

- First pass: align whole wheels and disks with loose muon hit weights in track refits (Alignment Parameter Error or APE = 2 cm)
- Second pass: align chambers in inner stations with large APEs
- Third pass: set inner station APEs = 0, align chambers in next station
- Et cetera...
- Eighth pass: re-align all chambers with small APEs
- Ninth pass: re-align chambers in all but first stations with small APEs

Scaling up to 100 pb^{-1}

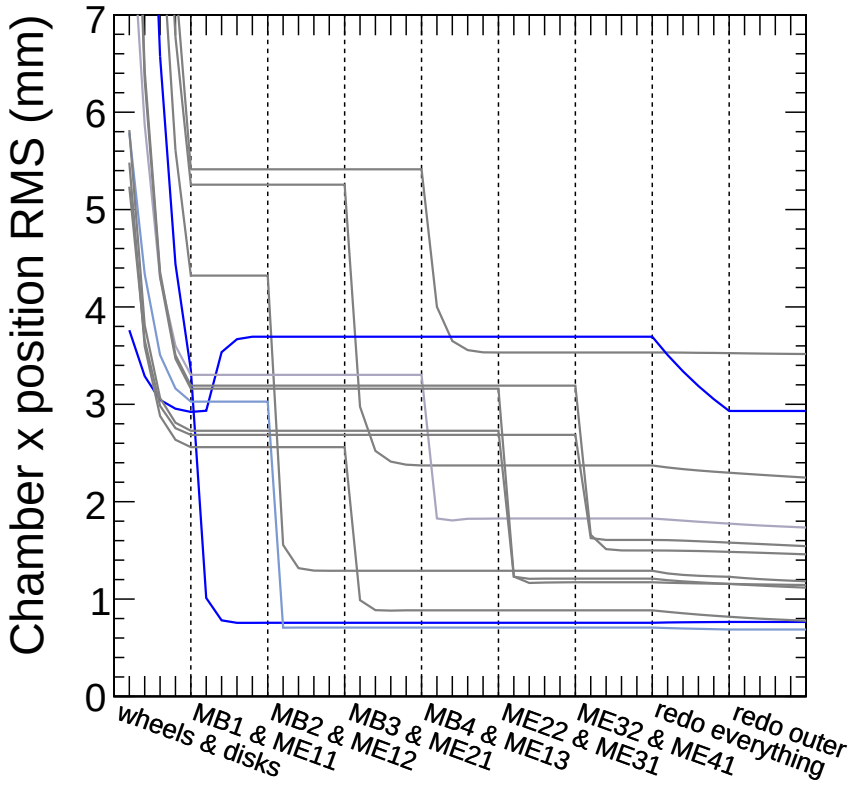
- CPU-intensive: 9 alignment passes $\times$ 5 iterations each = 45 iterations
- Developed "the easy way" as a single CPU process
- 100 pb^{-1} took 8 days to process
  (fortunately, this could run over the winter break)
- Parallelizing to 50 CPUs (= 4 hours) is possible,
  but takes some work to get right (see end of this talk)

Side-by-side comparison (alignment position error)

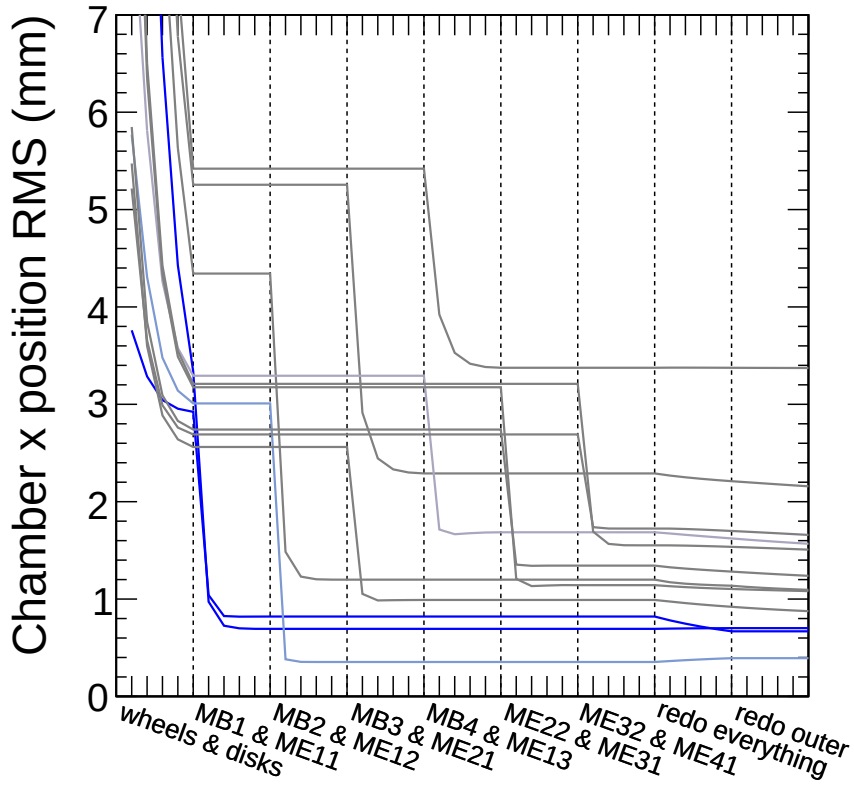
"Chamber x position RMS" is $\sqrt{\overline{(x_{\text{true}} - x_{\text{aligned}})^2}}$, includes offsets

(these are with no tracker misalignment, but the story is the same)

10 pb^{-1} alignment

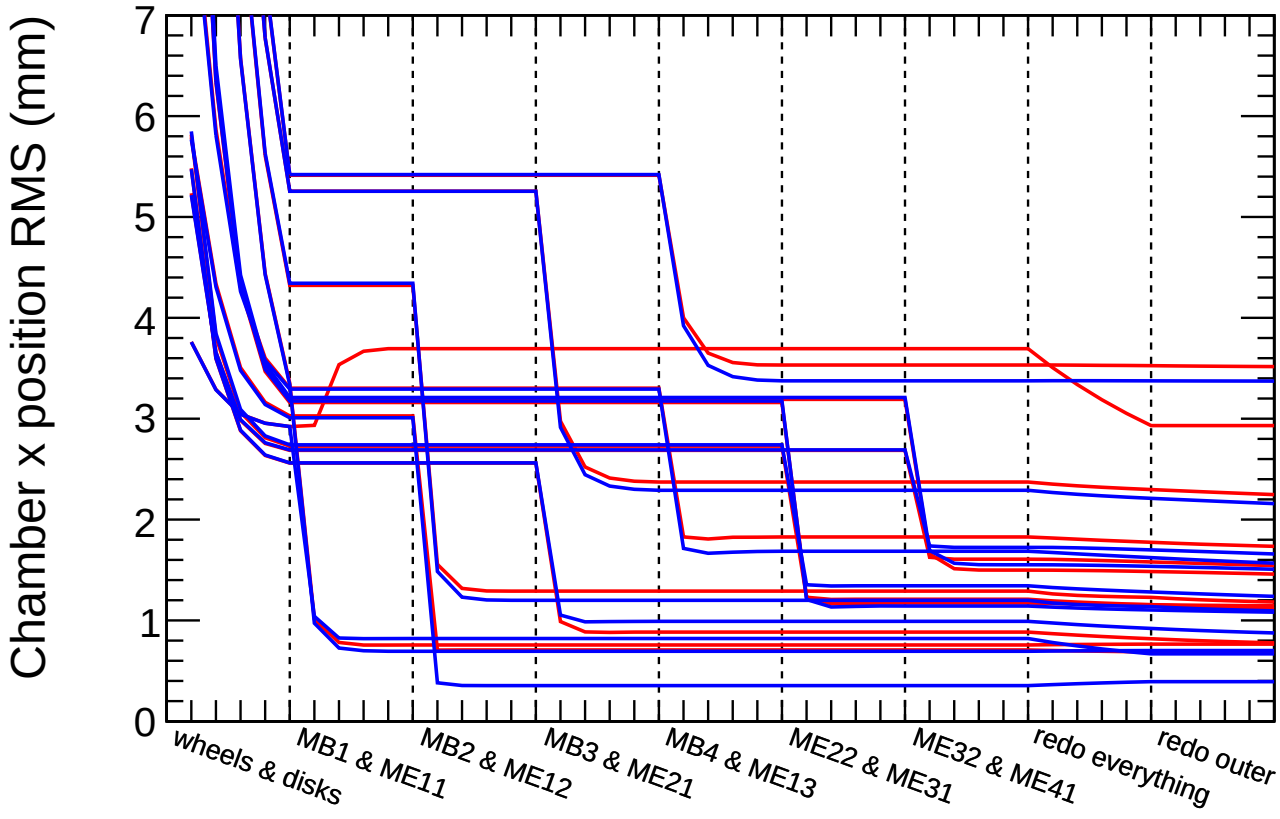


100 pb^{-1} alignment



Overlaid comparison (alignment position error)

red: 10 pb^{-1} blue: 100 pb^{-1}

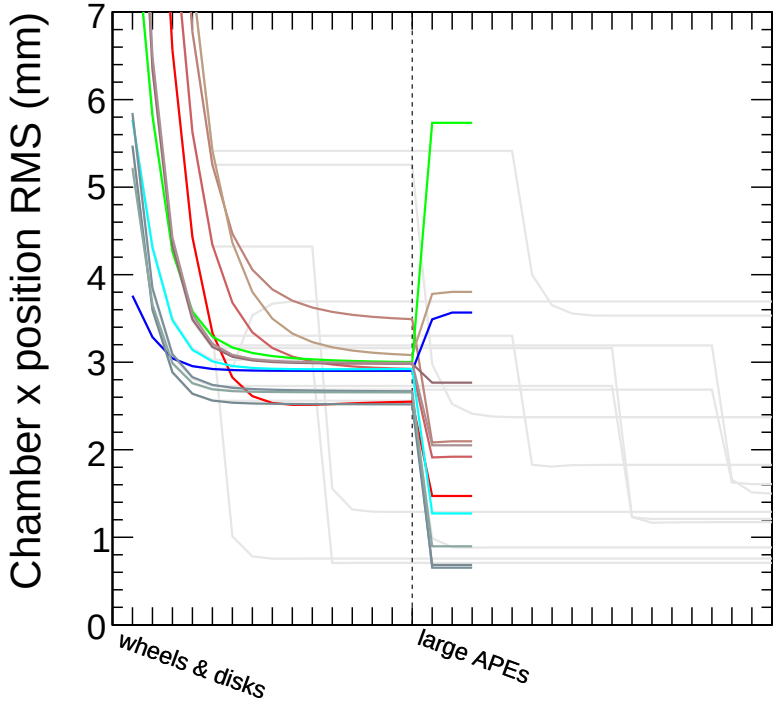


- Wheel/disk alignment hasn't converged! 5 → 15 iterations

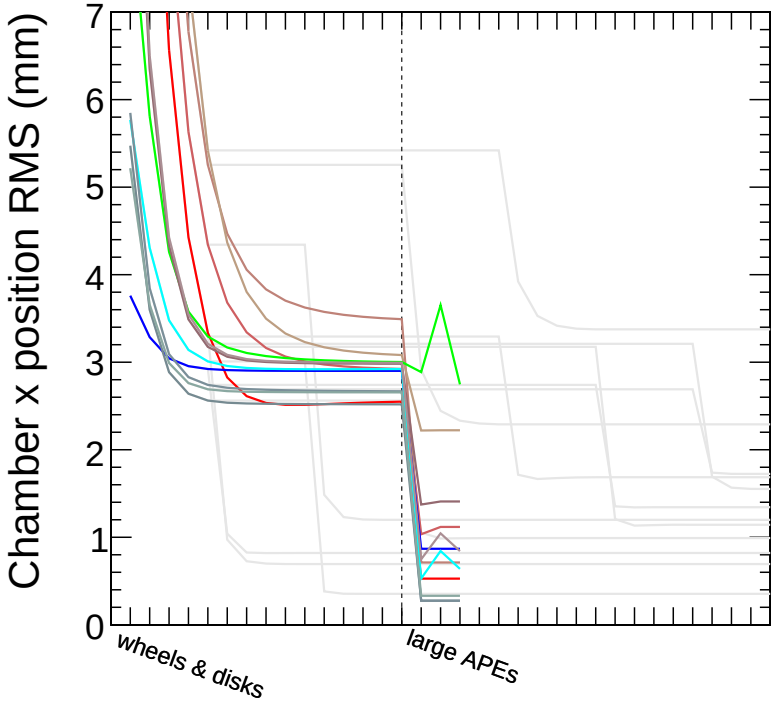
Why doesn't it scale with statistics? (1)

- Clearly *some* source of systematic error is drowning out dependence on statistics
- Strong dependence on APE!
  Below, APE $= \infty$ after wheel/disk (dashed line)

10 pb^{-1} alignment



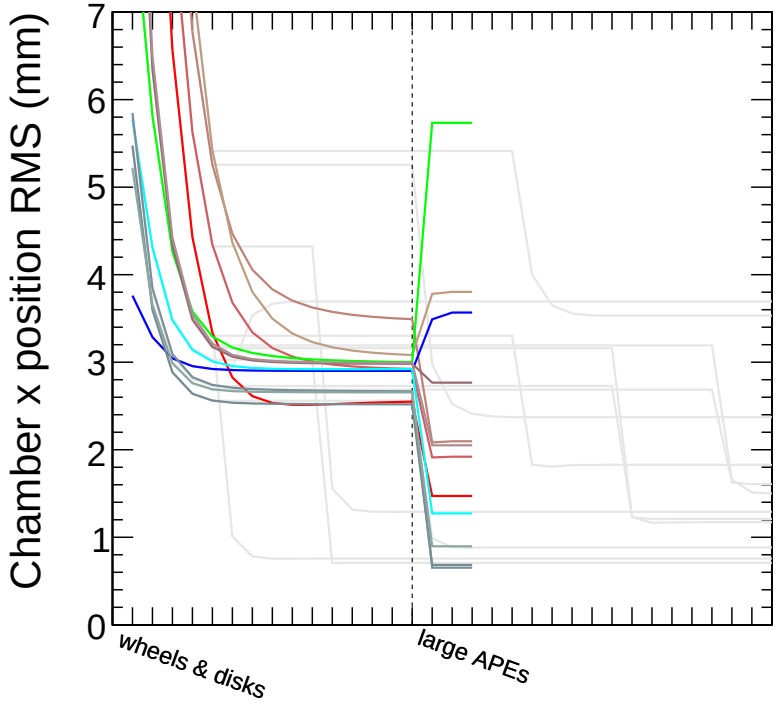
100 pb^{-1} alignment



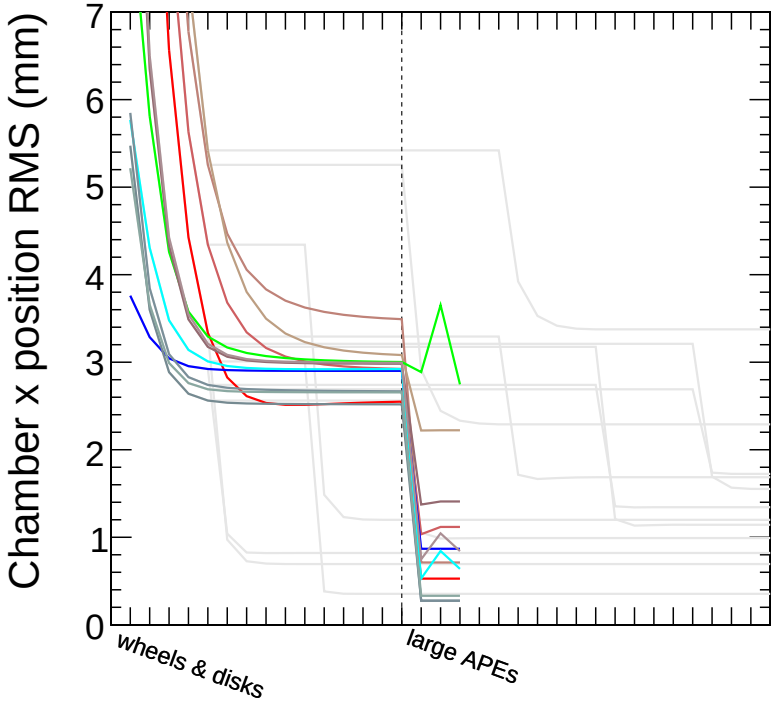
Why doesn't it scale with statistics? (2)

- APE $= \infty$ case improves 100 pb^{-1} alignment and worsens 10 pb^{-1} alignment: scaling is $\sqrt{5}$
- (APEs had been optimized for 10 pb^{-1}...)

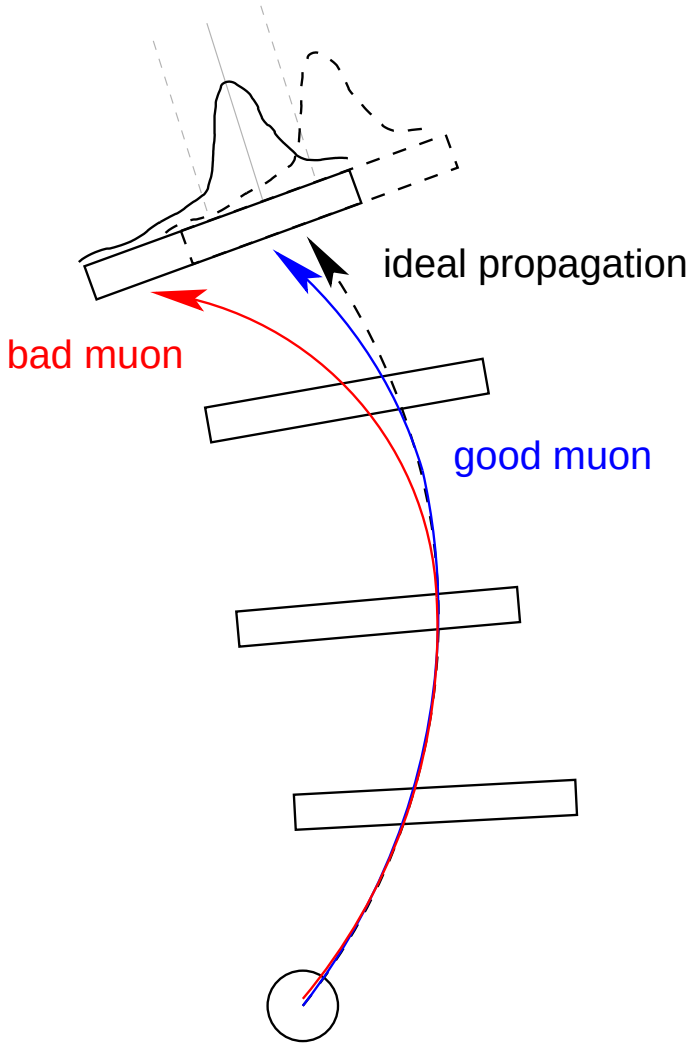
10 pb^{-1} alignment



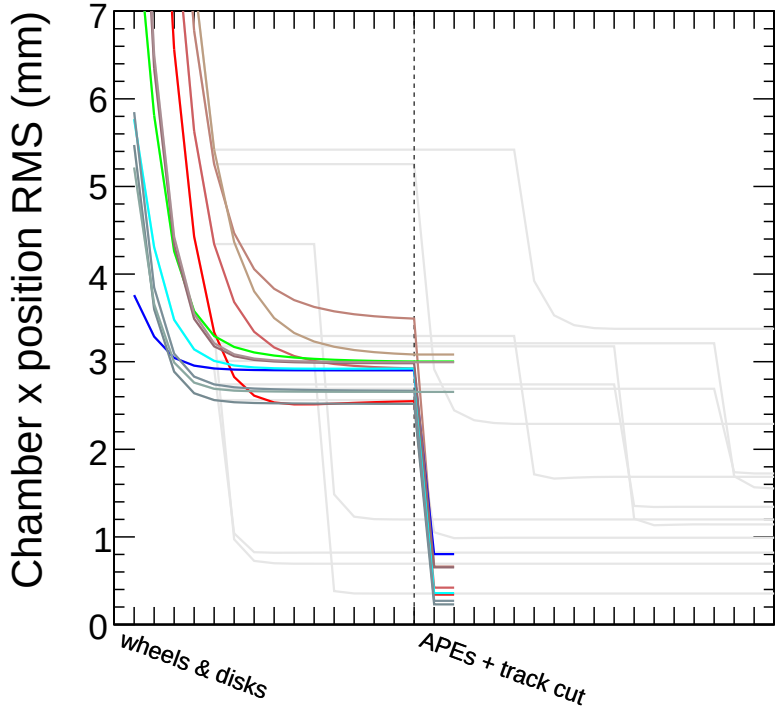
100 pb^{-1} alignment



Something else that helps: cut on tracks



- Keep tracks whose last-station residual is within a $\pm 3\sigma$ window when propagated with APE $= \infty$
- Tests consistency of real muon (hit) with ideal propagation (no scattering)



Considerations for the track-cut

- Windows are defined by APE $= \infty$ propagations, cut must only be applied to APE $= \infty$ propagations
- In most passes, tracks must be propagated twice:
  1. once to determine applicability of the cut
  2. again in track-fit with APE $= 0$ on already-aligned chambers
- Windows must be redefined every time last stations are moved
- Mean and stdev are written to a readable-text configuration file for safety

Diagnosis via improvements

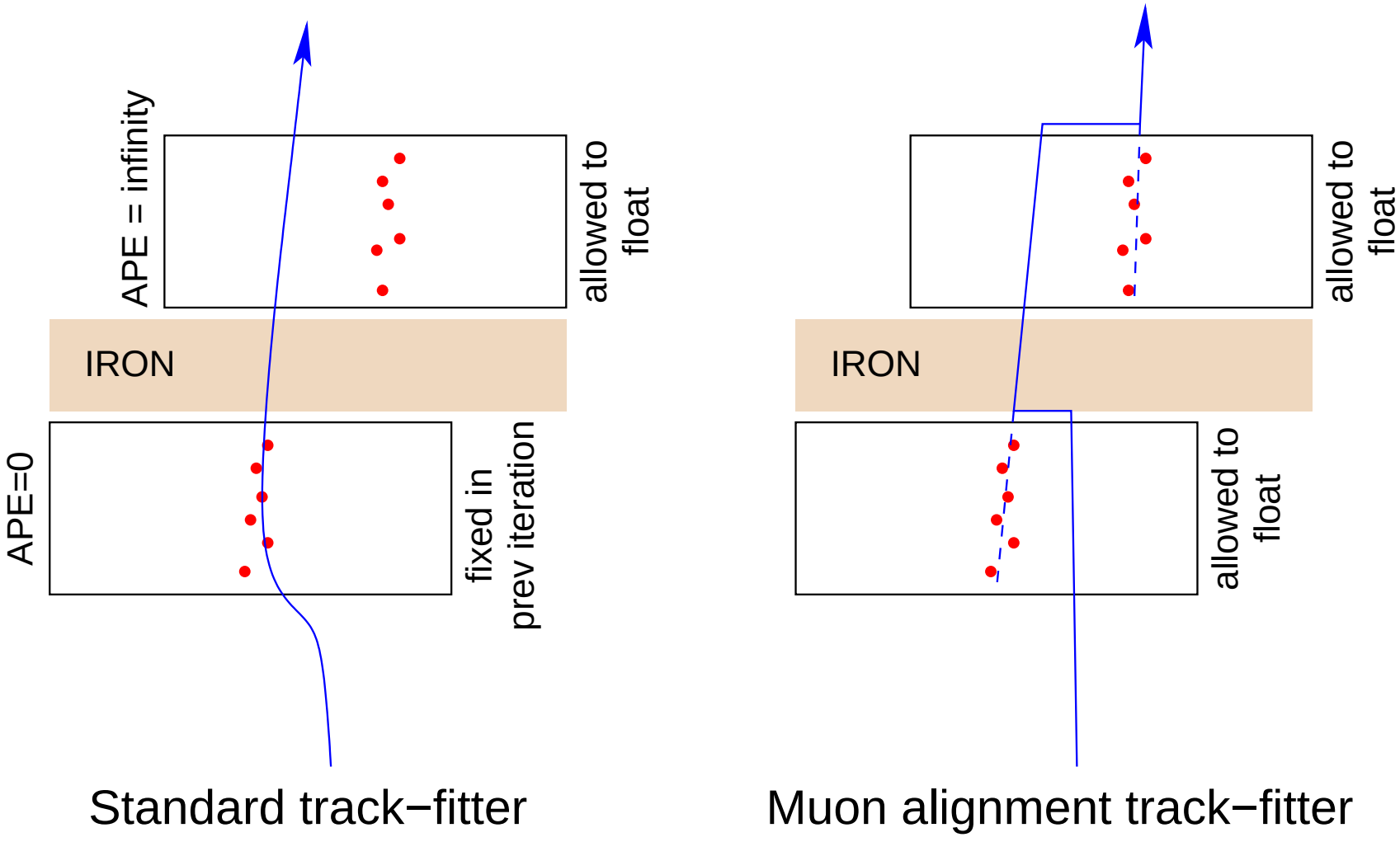
- Finite APEs reduce statistical errors, but exacerbate systematic effect
- Ratio of improvements from track cut in APE $= \infty$ test

MB1	1.5	MB2	2.7	MB3	1.1
ME1/1	1.1	ME1/2	2.4		
ME2/1	1.2	ME2/2	2.2		
ME3/1	1.0				

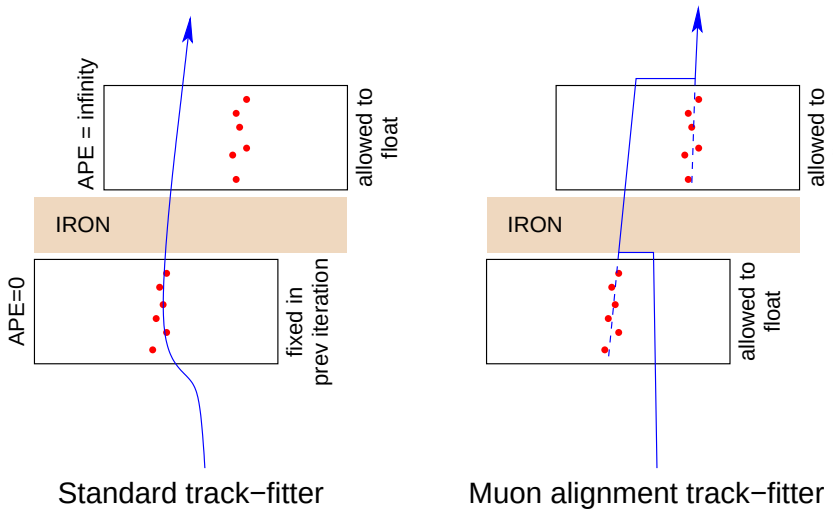
(1.0 is no improvement)

- The effect is probably related to scattering
- But it's not symmetric
- Amplified in outer stations due to our local-propagation method

Potentially useful: new track refitter



New track refitter



- Accomplish same local propagation method in one pass (with more iterations)
- More control over how track is updated:

  Ideally, tracker should fix $|\vec{p}|$, muon chamber should only update position (x, y) and direction (η, ϕ)
- This is a generalization of Gena's suggestion to align with overlap hits
- Implemented, working, but not in "baseline" procedure
- Might only be a convergence-speed improvement; might outperform baseline method when $\rho(x)$, $\vec{B}(x)$ is uncertain

Software: setting up procedure to run in parallel

- Iteration 1 splits into 50 jobs, collected and merged, then on to iteration 2. . .
- 2805 configuration files, all different
- Seems to be working, but CAF stopped accepting my jobs yesterday
- This is the revised CSA exercise (reporting computing requirements tomorrow at Al/Ca)
- With a faster alignment procedure, we can do proper studies of the systematic error and the improvements discussed in this talk

Conclusions

- Alignment error is dominated by a *reducible* component
- Origin is unknown, but probably related to scattering tracks
- New track-level cut helps: added to baseline procedure (width of window is still unoptimized)
- New track fitter (already written) may also help, especially if infinite-APE track-fitting is suspect
  (e.g. uncertain material $\rho(x)$ or $\vec{B}(x)$ field)
- *Baseline* procedure is conventional: what we have been working with for 3 months, with loosened APEs and a track cut that can be wide