Track-Based Alignment Status and Outlook

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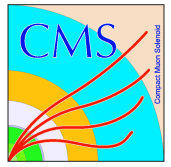
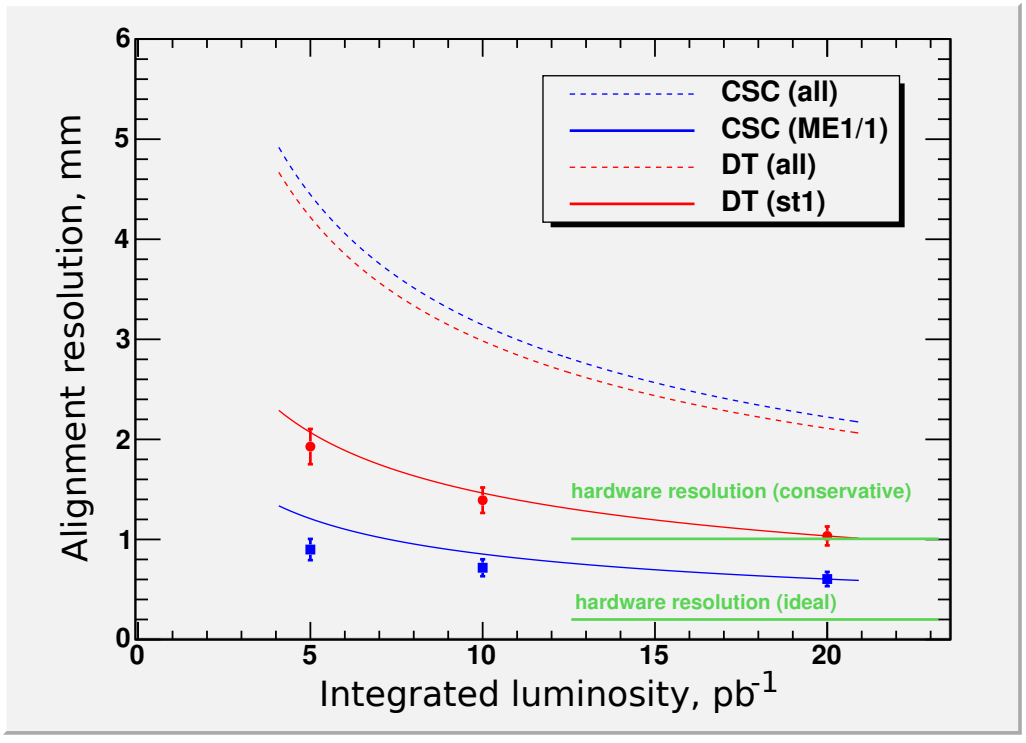
Outline



- Alignment projections with 20–30 pb^{-1}
- Current issue: variation of residuals within a chamber
- Upcoming endcap disk improvements
- Update on track-based vs. hardware "twist"
- Potential method to resolve the twist
- Upcoming sign-off schedule (new constants for re-reco)

Alignment resolution projections

- Below: latest alignment methods, current best understanding, "resolution" = RMS of $x_{\text{aligned}} - x_{\text{true}}$ in simulated alignment
- Collisions muons only: $p_T > 20$ GeV/c (cosmic-ray simulation yields 0.3 mm for top and bottom chambers of barrel)

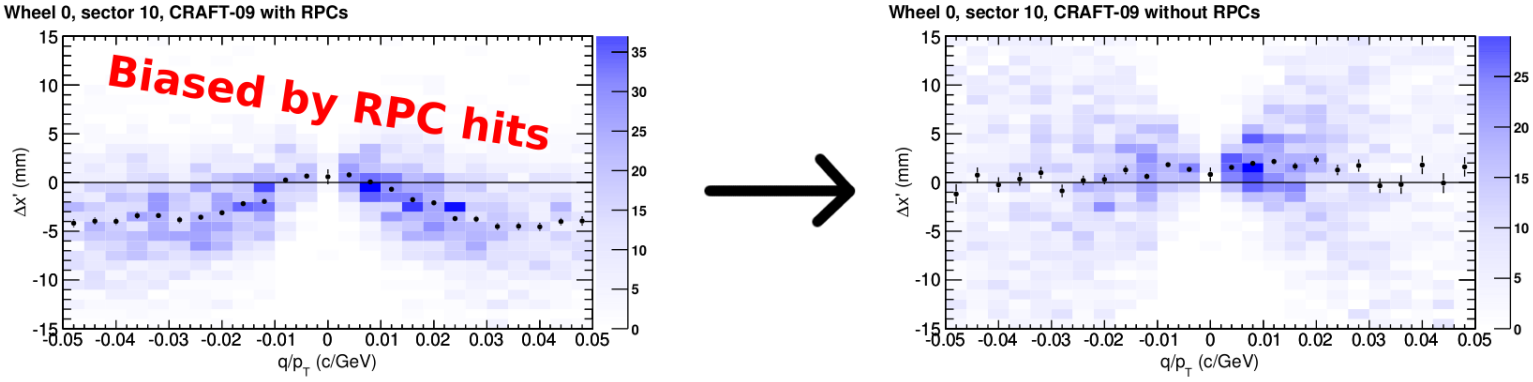


- Only a significant contribution with "*tens* of pb^{-1}" of collisions muons

Alignment resolution projections

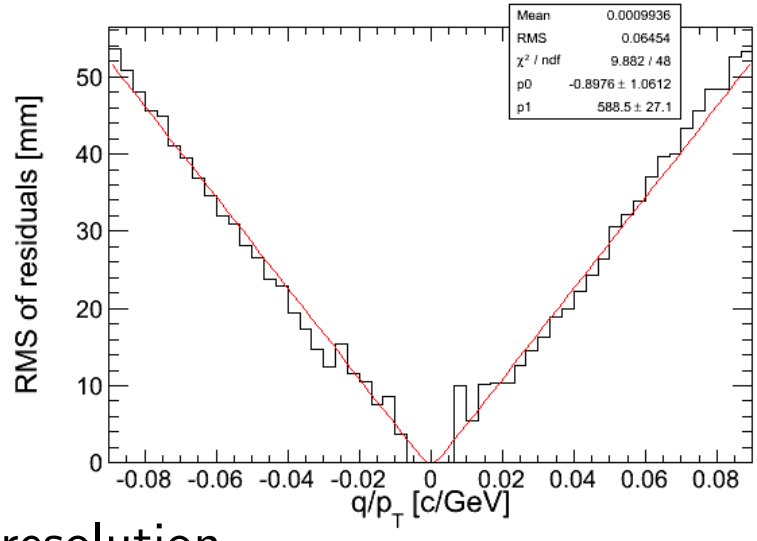
- Question: "I remember seeing more optimistic projections at the end of last year— what happened?"

  Answer: a single bug affected the interpretation of several studies with low-momentum muons by artificially pinching the distributions



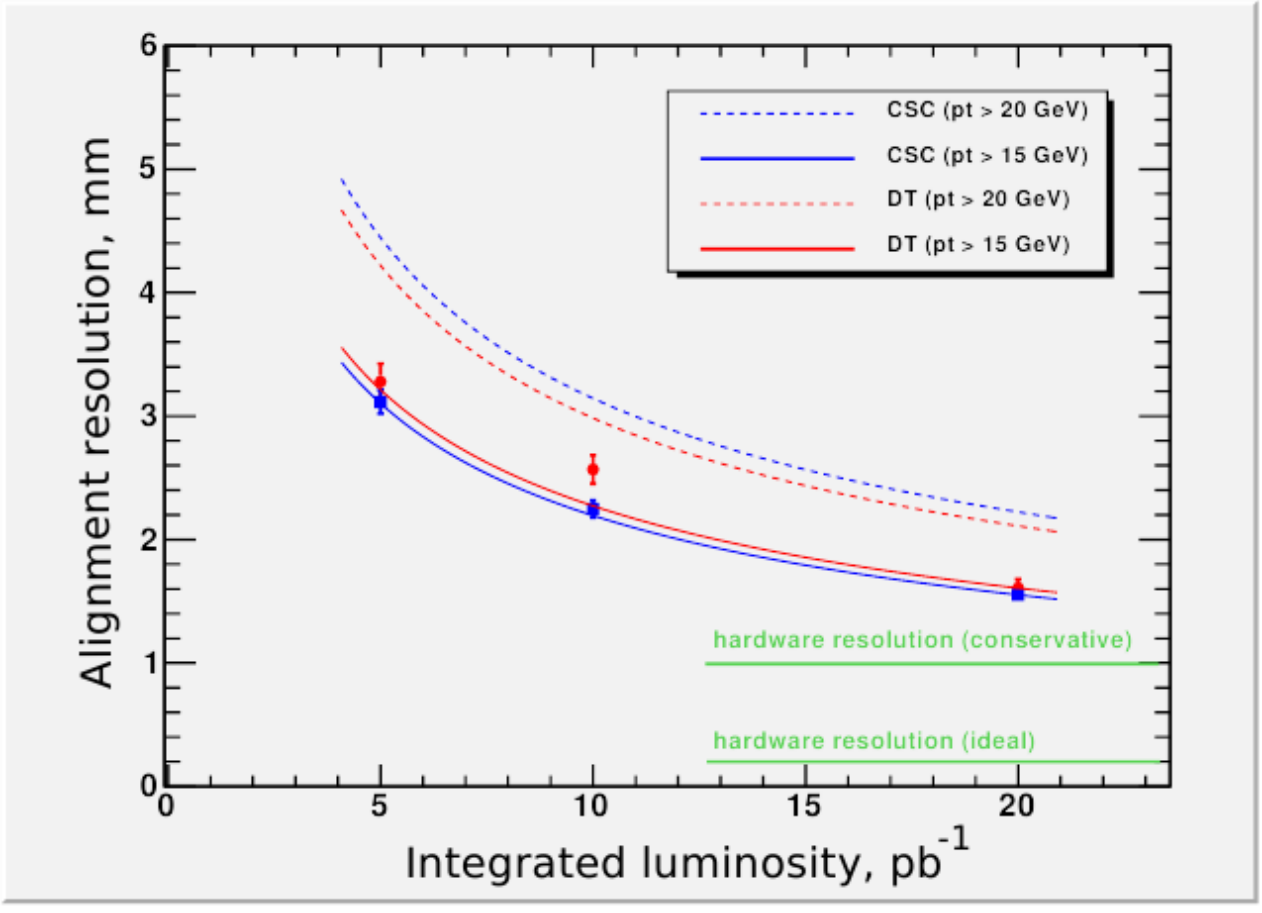
- Resolving this issue results in residuals distributions consistent with Molière theory and brings resolution projections more in line with CSA08 and the "50 pb^{-1} simulation" studies of 2009

  The baseline is "tens of pb^{-1}", exact value depending on desired resolution



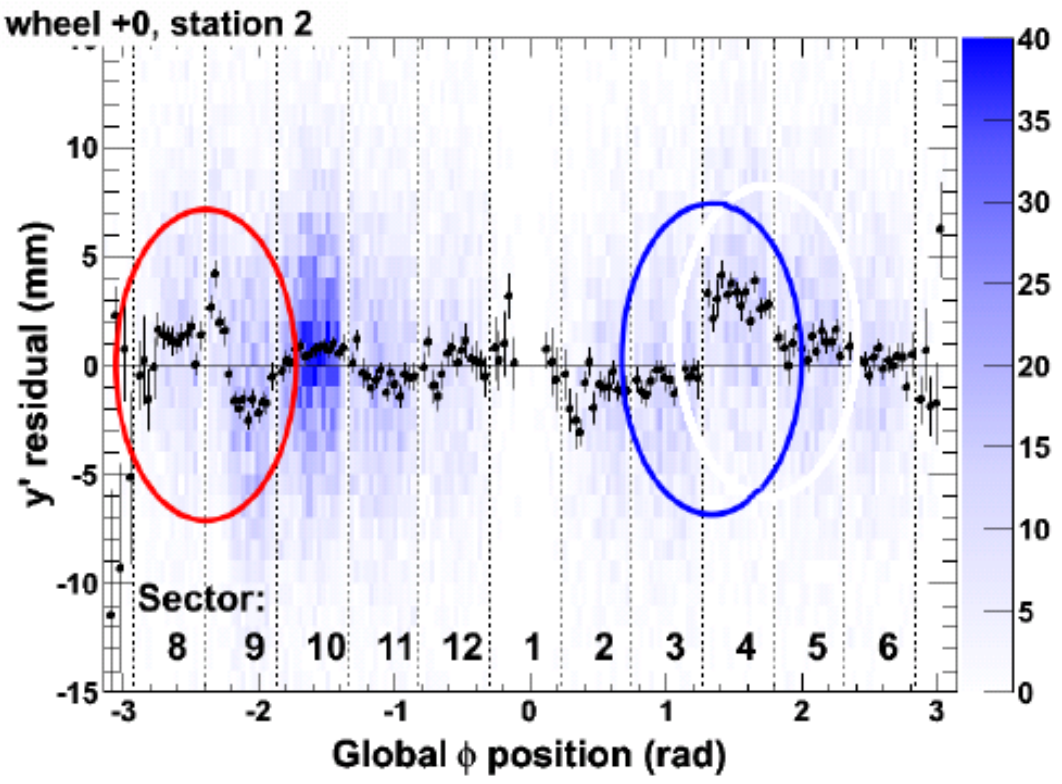
Alignment resolution projections

- Lowering momentum cuts improve resolution (here: $p_T > 20$ GeV/c $\rightarrow$ $p_T > 15$ GeV/c)
- But low-momenta are more susceptible to sources of bias, must be checked in data



Residuals within a chamber

- Standard tool: subdivide residuals distribution into bins smaller than the chambers to be sure that sharp changes in residuals are only at the chamber borders
- Blue ellipse: example of a discontinuity at a chamber border
- Red ellipse: unexpected discontinuity inside of a chamber (observed in local y residuals, which corresponds to global z (parallel-to-beamline) positions)



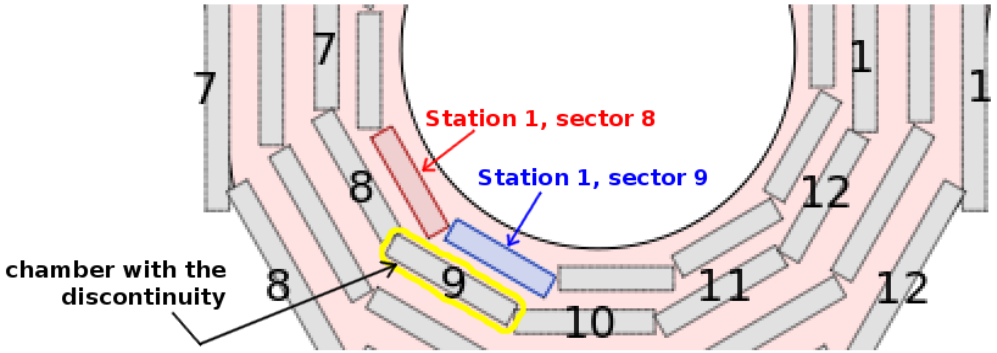
Residuals within a chamber

- Related to which station 1 chamber the track went through before station 2

  red: segment in station 1, sector 8

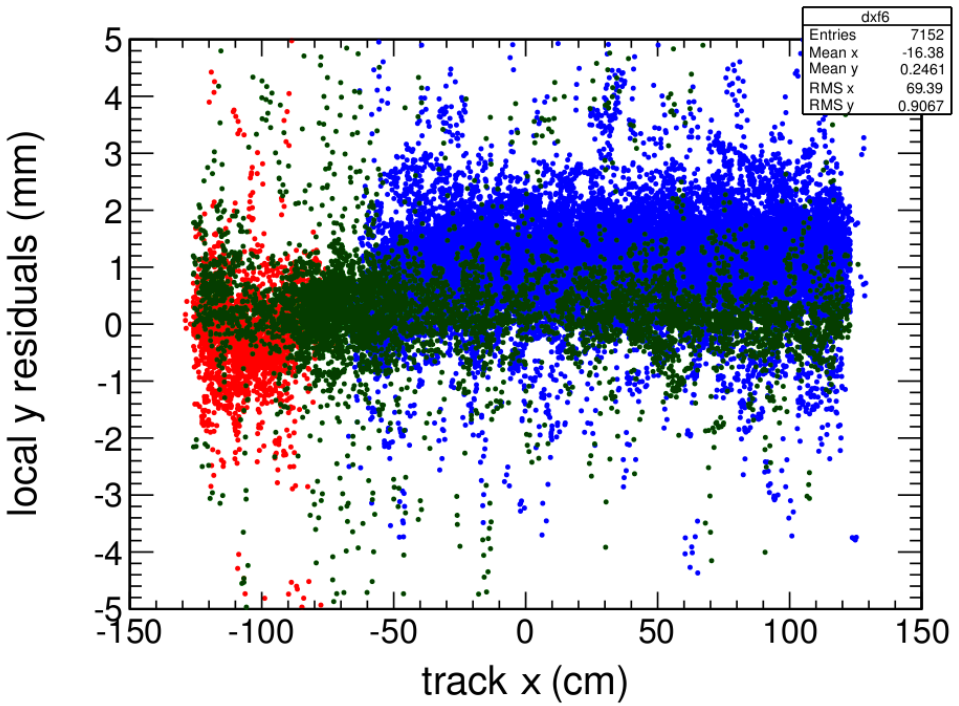
  blue: segment in station 1, sector 9

  green: no segment in either



- Checked for:
  - track-propagation bias from station 1
  - bad trigger geometry
  - dead groups of wires

  None of the above observed



- (Note: even with wide bins, uncertainty in mean local y residual from collisions is ± 5 mm (low-$|p|$))

Endcap disk alignment

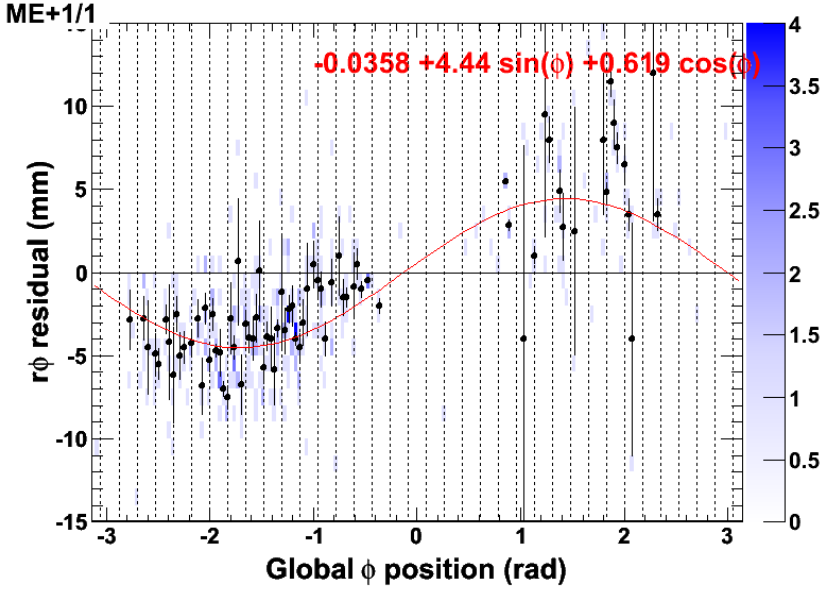
- All track-based alignment procedures will follow this transition:

  high-p_T cosmics $\rightarrow$ medium-p_T cosmics $\rightarrow$ same-p_T collisions

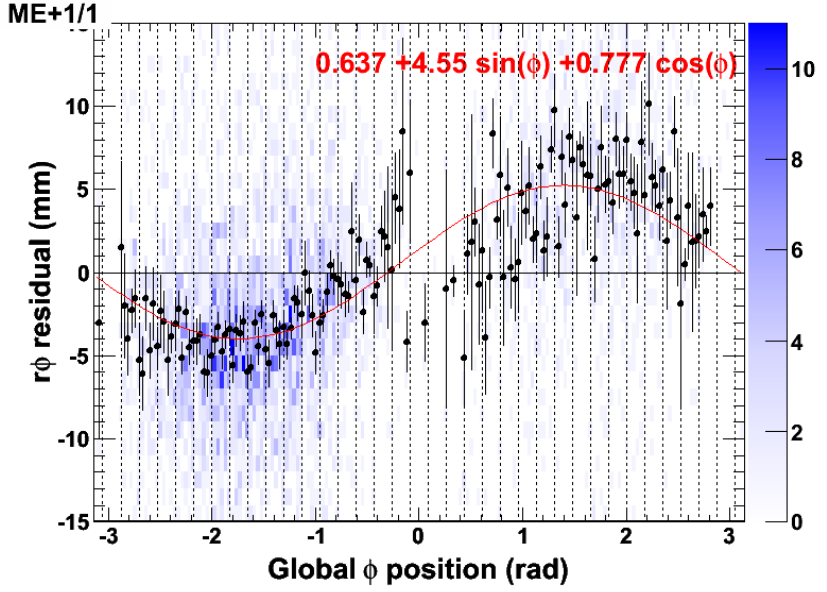
- We can already step forward in endcap disk alignment (in which whole disks are treated as rigid bodies) with some gains in resolution

- Example disk alignment with cosmics (rigid-body disk $\Rightarrow$ sinusoidal):

with $p_T > 100$ GeV/c (current)

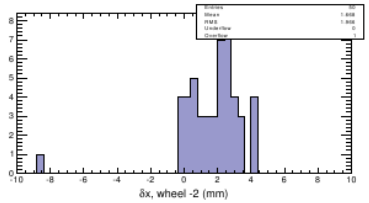


with $p_T > 10$ GeV/c

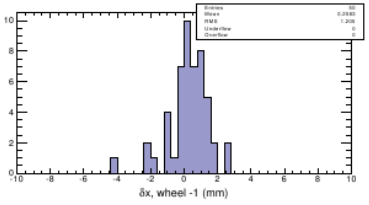


- Switching to collisions would fill in the $\phi = 0$ and π regions

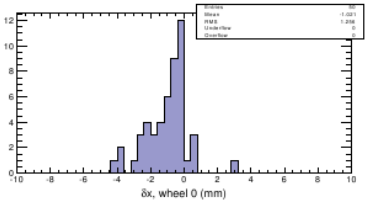
Track-based vs. hardware "twist"



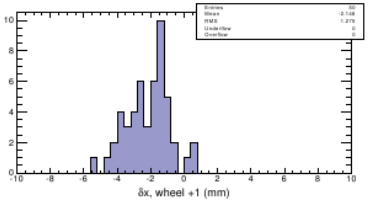
DT wheel -2
$\delta x = (1.7 \pm 2.0)$ mm



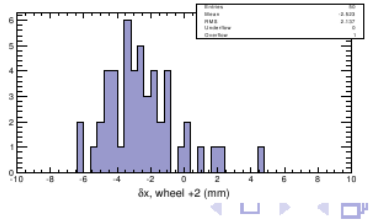
DT wheel -1
$\delta x = (0.3 \pm 1.2)$ mm



DT wheel 0
$\delta x = (-1.0 \pm 1.3)$ mm

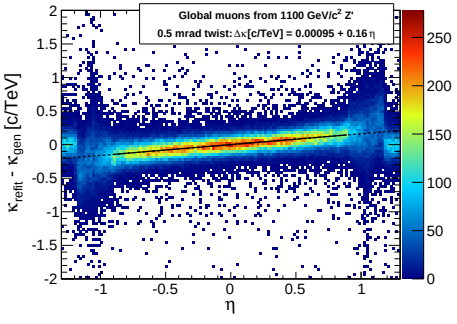


DT wheel +1
$\delta x = (-2.2 \pm 1.3)$ mm

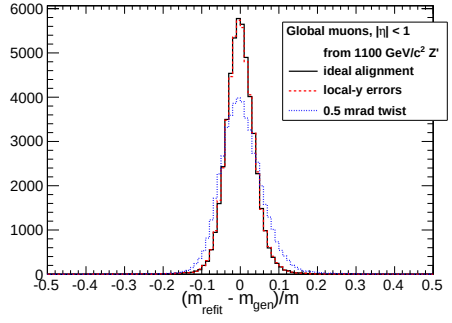


DT wheel +2
$\delta x = (-2.5 \pm 2.1)$ mm

- Reminder: primary difference between barrel track-based and hardware geometries is a twist of one relative to the other
- Plots on left: track-based minus hardware by wheel
- Effect on track curvatures (versus η):

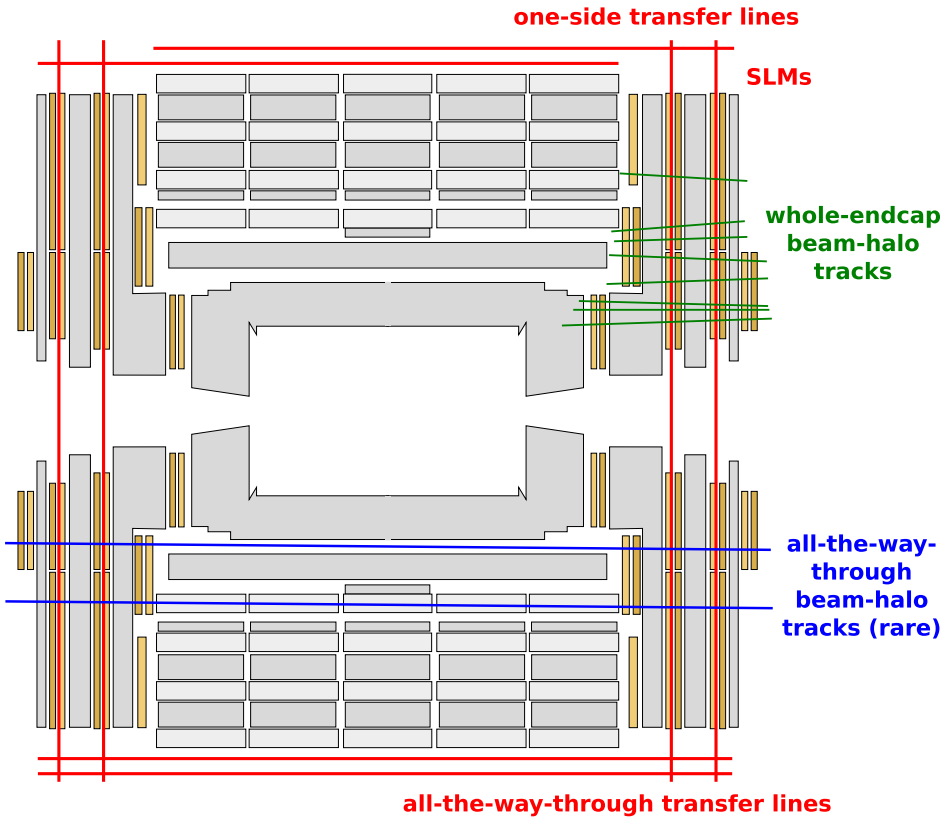


- Effect on Z' mass resolution:



Resolving the twist

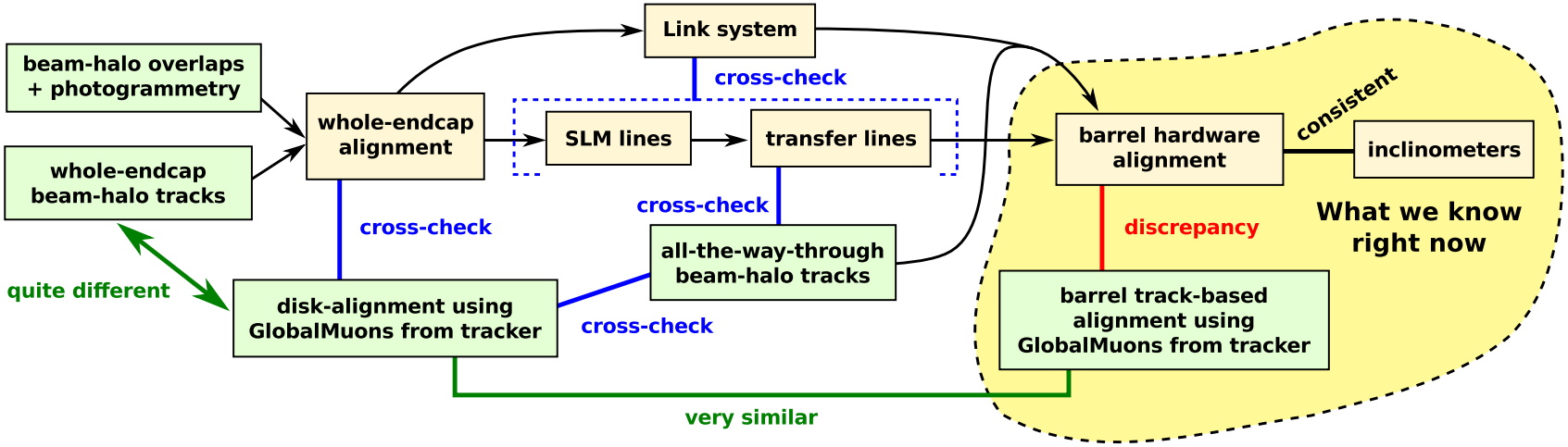
- Follow-up tests (pattern of residuals, cross-check with inclinometers) were performed, but they didn't isolate the problem and lead to a diagnosis
- More decisive test:
  1. align endcap disks with beam-halo (instead of global muons from tracker)
  2. use SLM/transfer lines to propagate measurement to the barrel (instead of an independent fit)
  3. check for barrel twist relative to transfer lines, which are fixed by endcap tracks



- CSC beam-halo tracks are very unlikely to have a twist of their own with the same magnitude as tracker-to-DT GlobalMuons

Resolving the twist

- This new test would provide a tighter network of cross-checks, with track-based checks between hardware steps and vice-versa
- When there is a discrepancy at some step (and there must be one), it will isolate the problem, hopefully leading to a solution



- Incidentally, this brings all hardware alignment systems and all track-based techniques into a single round of comparisons

New constants for re-reco

- Schedule of the next sign-off:
  1. Friday, Oct N ($N = 15$?): finalized alignment *procedures*, decision about track-based vs. hardware in barrel
  2. same day: tracker alignment is frozen
  3. following week: re-align with new tracker geometry
  4. next Friday: finalized *constants* (no discussion about procedures or track-based vs. hardware)
  5. constants passed on to Muon POG for testing...
- Targeted for next sign-off:
  - barrel track-based with understood/controlled residuals-inside-of-chambers, possibly lower p_T cut in cosmics
  - barrel hardware with all-at-once fit
  - endcap disk with lower p_T cut, possibly using collisions muons
  - endcap hardware improvements in z of chambers/disks
  - endcap beam-halo $\rightarrow$ transfer lines $\rightarrow$ barrel method to resolve track-based vs. hardware twist issue

Conclusions

- Track-based alignment with 20–30 pb^{-1} of collisions muons is marginal; best track-based alignment still from cosmics
- Continuing to study systematic errors with cosmics
- Improvement to endcap disk alignment is in development
- We may be able to resolve the "twist" issue by using all alignment subsystems (barrel, endcap, link), and tracks from different sources (tracker-to-muon chambers, endcap beam-halo)
- Several improvements targeted for next reprocessing