



# Proposed Muon Alignment Constants

Muon Alignment Group

6 August, 2010



- ▶ Not a polished version of the Muon DPG talk for Monday!
- ▶ Just a list of what we plan to show (our internal sign-off)

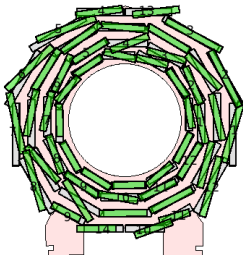
## Basic statement

- ▶ Proposing DT hardware alignment (what was signed-off May 12)
  - ▶ there are systematic discrepancies between track-based (TB) and hardware (HW) geometries
  - ▶ we do not have a compelling argument that either is more correct or trustworthy than the other
  - ▶ we therefore provide the HW–TB difference as a systematic uncertainty
- ▶ Proposing CSC track-based alignment plus HW for  $\phi_x$  and  $Z$  (what was signed-off May 19 with some  $Z$  updates from HW)
  - ▶ HW–TB comparisons are not at the same level as in the barrel
  - ▶ but TB–PG (photogrammetry) are  $\sim 0.6$  mm
- ▶ Proposing Sasha's global position for all systems (good agreement between Sasha's method, TB, and HW)

- ▶ First: it's important to emphasize that TB and HW agree with each other much better than either does with ideal geometry
- ▶ Two independent techniques have “found” the muon chambers
- ▶ Now we're working on the 4 mm-scale differences. . .

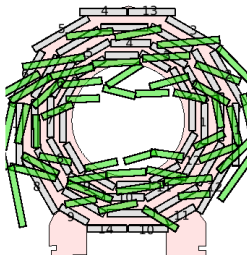
TB – HW

Wheel 0 (length x200, angle x200)



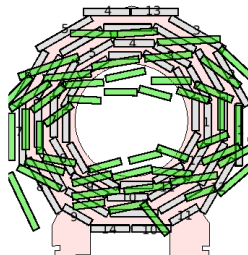
TB – IDEAL

Wheel 0 (length x200, angle x200)



HW – IDEAL

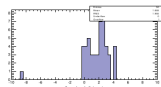
Wheel 0 (length x200, angle x200)



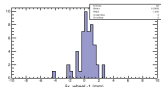
**N.B.** in this picture, displacements and angle differences have been exaggerated by 200×

## ► Primary differences:

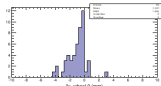
- 5-chamber groups from wheel  $-2$  to wheel  $+2$  seem to be coherently rotated: about 4 mm end-to-end
- barrel compressed in  $z$  by about 4 mm end-to-end
- $\mathcal{O}(1.3 \text{ mm})$  individual-chamber variations after that



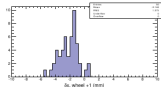
$\delta x = (1.7 \pm 2.0) \text{ mm}$



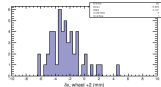
$\delta x = (0.3 \pm 1.2) \text{ mm}$



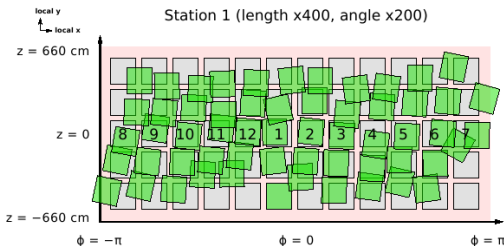
$\delta x = (-1.0 \pm 1.3) \text{ mm}$

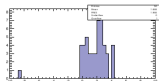


$\delta x = (-2.2 \pm 1.3) \text{ mm}$

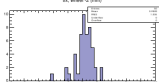


$\delta x = (-2.5 \pm 2.1) \text{ mm}$

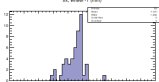




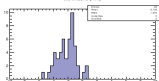
DT wheel -2  
 $\delta x = (1.7 \pm 2.0)$  mm



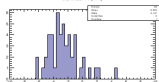
DT wheel -1  
 $\delta x = (0.3 \pm 1.2)$  mm



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



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

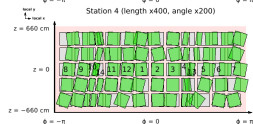
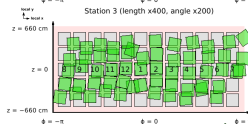
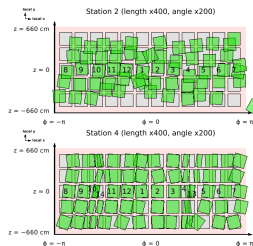
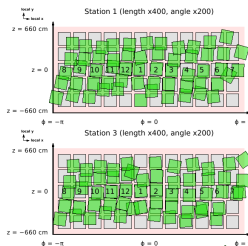


DT wheel +2  
 $\delta x = (-2.5 \pm 2.1)$  mm

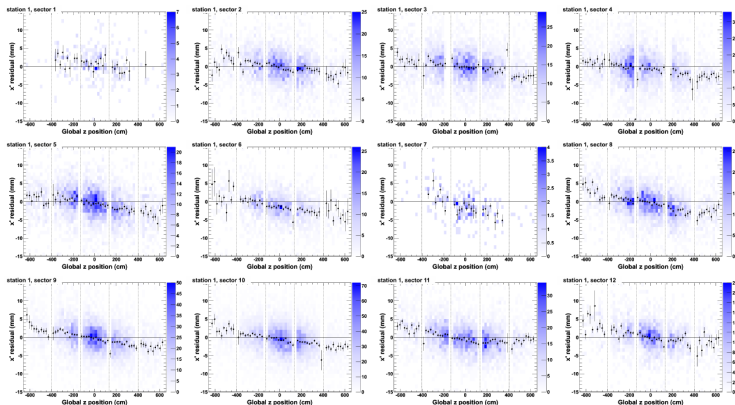
## ► Primary differences:

- 5-chamber groups from wheel -2 to wheel +2 seem to be coherently rotated: about 4 mm end-to-end
- barrel compressed in  $z$  by about 4 mm end-to-end
- $\mathcal{O}(1.3$  mm) individual-chamber variations after that

## ► Same for all stations

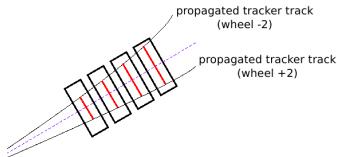


- ▶ Also seen at the level of residuals: these are  $r\phi$  residuals vs.  $z$  in each 5-chamber group; dashed lines are boundaries between chambers
- ▶ Smooth transitions between chambers could be due to a coherent rotation in HW or a tracking bias in TB

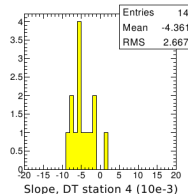
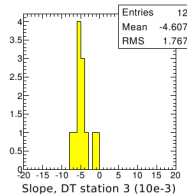
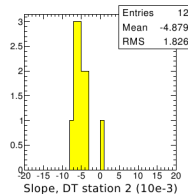
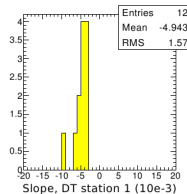
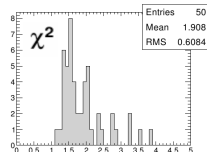
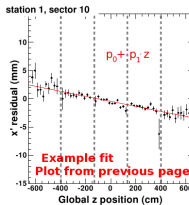


N.B. Vertical scales are  $\pm 15$  mm

- If the effect were due to a bias in input tracks, e.g. a global distortion of the tracker leading to  $z$ -dependent  $\Delta\phi$  errors, then its magnitude would scale from distance from the tracker

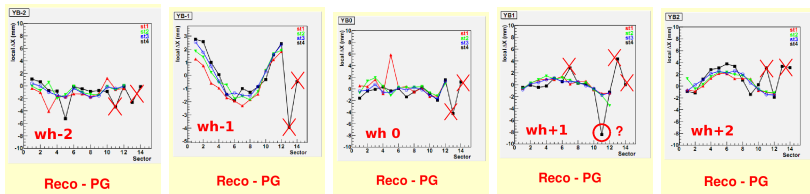


- Test: fit each 5-chamber group of residuals to a straight line (50 in all) and make histograms of the resulting slopes
- Result: strongly peaked at the same slope in all four stations





- ▶ If the trend were a weak mode of the HW alignment procedure, it would be present in 0 T data as well
- ▶ Photogrammetry (PG) data are available for 0 T, with **x mm** for inside-of-wheel resolutions and **y mm** for between-wheel resolutions
- ▶ No evidence of 4 mm systematic trend from wheel  $-2$  to wheel  $+2$



N.B. Vertical scales are  $\pm 10$  mm except wheel  $-1$ , which is  $-5$  to  $3$  mm.



- Each MAB is equipped with a tiltmeter which measures the angle wrt gravity:
  - One can combine PG orientation of YB2 wheels with tiltmeter variation between OT and 3.8T:

$\Delta\phi_Z$ Tilt ( $\mu\text{rad}$ )	MAB195	MAB255	MAB315	MAB15	MAB75	MAB135
YB+2	+48.8	+78.6	-69.9	-57.8	-56.5	--
YB-2	--	100.3	12.8	-40.3	-57.3	--

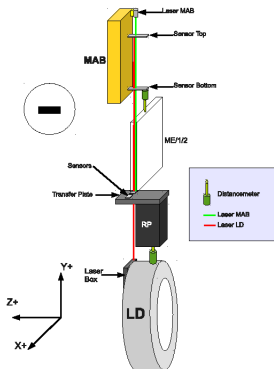
$\Phi_Z$ Angle ( $\mu\text{rad}$ )	YB+2	YB-2
Absolute PG	227	169
$\Delta\phi_Z$ from tilts compatible with 0	$0 \pm 100^*$	$0 \pm 100^*$
Total = PG + $\Delta$ from OT to 3.8T	$227 \pm 100$	$169 \pm 100$
Link Fit @ 3.8T	349	244

PG+Tilt is compatible with lasers (lasers more precise)

\* VERY conservative uncertainty

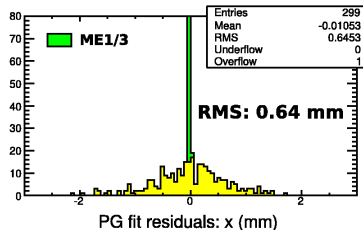
2

- Link system between barrel and endcap connects to end of barrel hardware alignment devices (MAB) 4.5 m from the beamline
- Constraint from gravity direction + PG:  $110 \pm 140 \mu\text{rad} \rightarrow 0.47 \pm 0.63 \text{ mm}$  at barrel ends, in contraction with TB's 4 mm
- Independent of barrel alignment (Does it assume that the MABs are rigid and ideal? I still don't understand the comment in HyperNews)

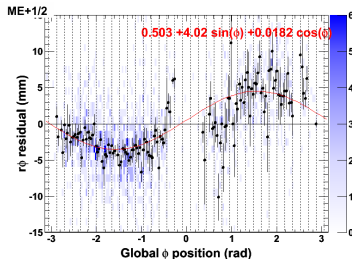


- ▶ Several different sources of information:
  - ▶ tilting ( $\phi_x$ ) and motion toward magnet: straight line monitors (HW)
  - ▶ chambers-within-disks ( $r\phi$ ,  $\phi_z$ ): beam-halo tracks and PG, weighted to prefer tracks where available
  - ▶ disks-relative-to-tracker (global  $x$ ,  $y$ ,  $\phi_z$ ): cosmic  $p_T > 100$  GeV/ $c$  tracks\*
  - ▶ final  $z$  positions: transfer lines (HW)
- ▶ All are unaffected by RPC-bias or GPR-removal bugs, except \*, which was re-run: see browser

Beam-halo vs. PG:

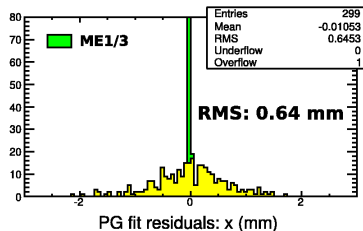


Disk position from cosmic GlobalMuons (before alignment):

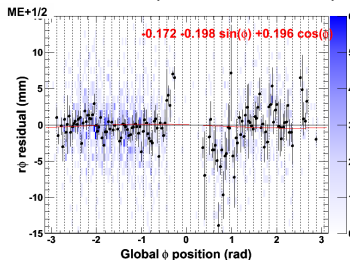


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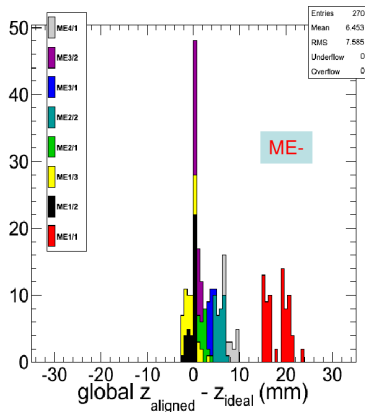
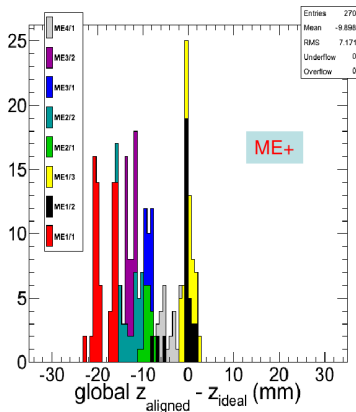
Beam-halo vs. PG:



Disk position from cosmic GlobalMuons (after alignment):



- ▶ Still need to be applied
- ▶ Is this the latest distribution? Why does it have this pattern?
- ▶ Shouldn't it be approximately
  - ▶ 14 mm for ME1/1 (inward)
  - ▶ 7 mm for all other stations (same global direction)





- ▶ DT HW alignment: ?
- ▶ CSC HW  $\phi_x$  + beam-halo + cospics-disk:  
`/afs/cern.ch/user/p/pivarski/public/JUN5_CSC.beamhalo-PG-diskXYphiZ.db`  
Updated cospics-disk plots in browser:  
<http://hepr8.physics.tamu.edu/mual/browser/> “ring\_data\_gprsasha”
- ▶ CSC HW  $\phi_x$  + beam-halo + cospics-disk + HW Z: needs to be created from the above + the latest HW SQLite file
- ▶ Sasha's GlobalPositionRcd: ?