



Track-based Alignment Status

Jim Pivarski

Aysen Tatarinov

Vadim Khotilovich

Alexei Safonov

Texas A&M University

6 December, 2009



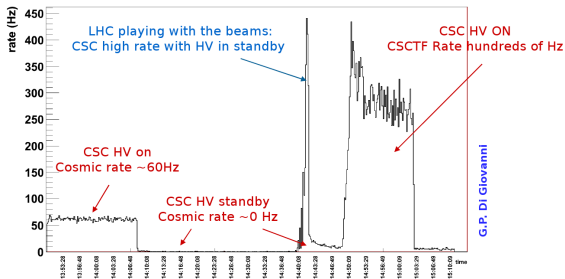
- ▶ The big news: beam-halo! But not much of it.
- ▶ Evolution of alignment procedures from low to high luminosity
- ▶ Comparison of new beam-halo data with Monte Carlo
- ▶ Step 2: alignment of wheels to the tracker with cosmics or collisions
- ▶ New alignment expert: Aysen Tatarinov

Beam-halo events!

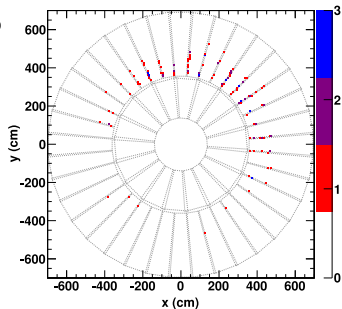
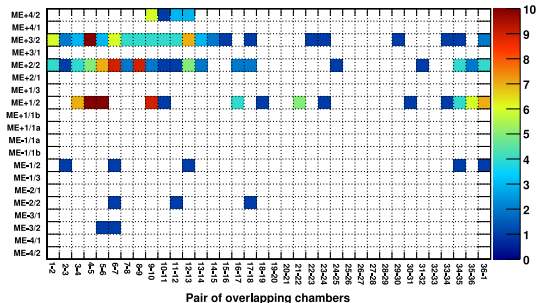
Jim Pivarski 3/15



Total CSC Rate vs Time

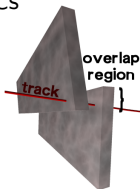


- ▶ Longest period of true beam-halo: 13 min in run 122294
- ▶ Overlaps track yield: 229 in outer ring after sensible cuts
- ▶ Not enough for alignment



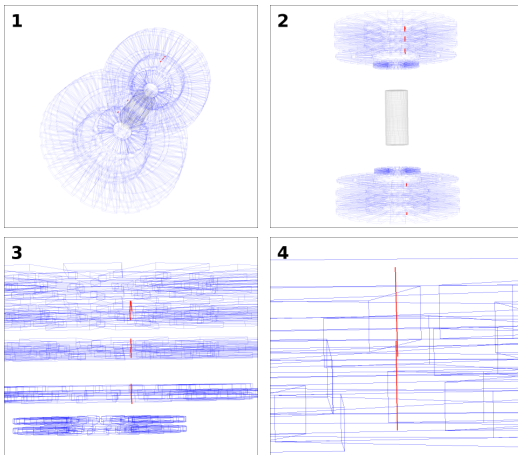


- ▶ Soon: select beam-halo tracks in overlaps between CSCs and propagate relative corrections around the ring
- ▶ Now: connect aligned rings to tracker using cosmic rays propagated from the tracker
 - ▶ step 1: overlaps method gives relative positions of chambers within rings
 - ▶ step 2: propagated tracker tracks give positions of the rings in the tracker's coordinate frame
- ▶ Early collisions ($\sim 5 \text{ pb}^{-1}$):
 - (a) add low- p collisions muons to overlaps method
 - (b) add high- p collisions muons to ring-finding procedure
- ▶ More collisions ($\gtrsim 10 \text{ pb}^{-1}$): propagate tracker tracks to CSCs and determine the position of each chamber individually (Reference-Target)
 - ▶ validate Reference-Target results using overlaps results
 - ▶ two track-based techniques with very different systematics



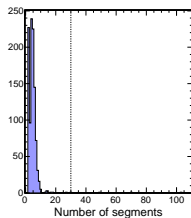


- ▶ Investigating the events we already have
- ▶ 121964 and 122294 are almost purely beam-halo/gas; the rest (up to this weekend) are almost purely cosmic rays and splashes
- ▶ Zooming into a nice event:

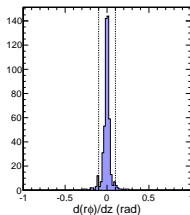


► Top plots: data, bottom plots: beam-halo Monte Carlo

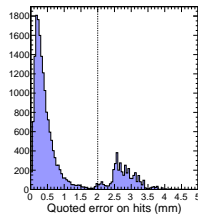
Anti-beam-splash:
segments < 30



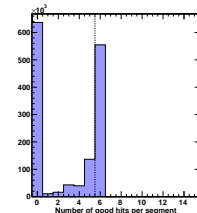
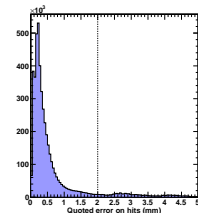
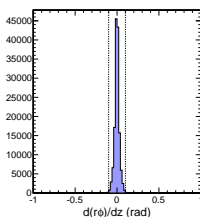
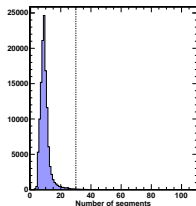
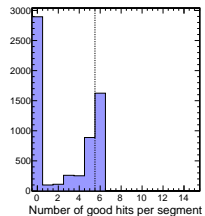
Anti-cosmic:
point to beamline
(± 0.1 rad)



Exclude last
cathode strip: hit
error < 2 mm

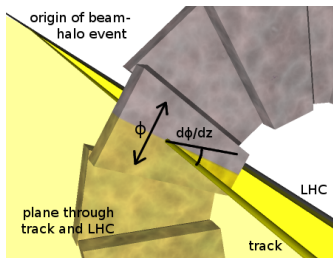


Fiducial segments:
#hits/segment ≥ 6



Discriminant for beam-halo

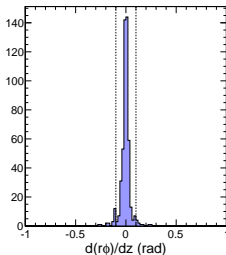
Jim Pivarski 7/15



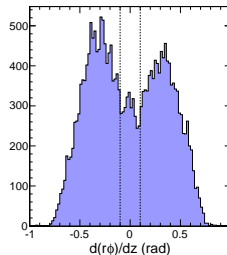
- ▶ $\frac{d(r\phi)}{dz}$ is the degree to which the track is out of the plane formed by the track intersection point and the LHC beamline

- ▶ Strongly correlated with run number
- ▶ Almost all beam-halo events are in two runs (before this weekend)

121964 and 122294

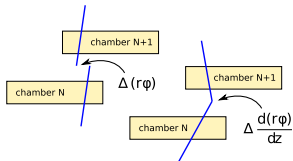


All other large runs since Nov 23

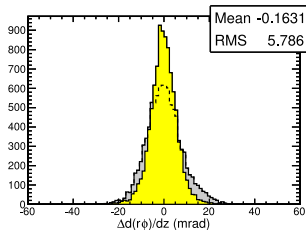
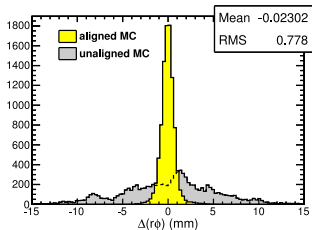
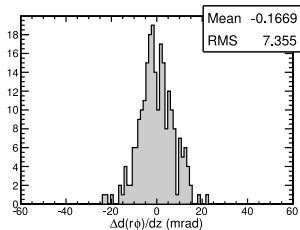
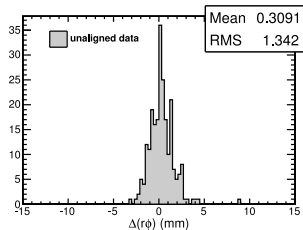


Residuals from new data

Jim Pivarski 8/15



- ▶ Two types of residuals: continuity ($\Delta r\phi$) and differentiability ($\Delta \frac{d(r\phi)}{dz}$)
- ▶ Outer ring consistent with ~ 1 mm RMS misalignment

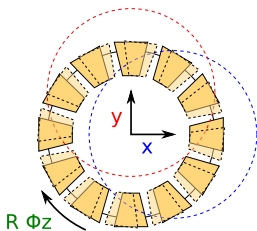
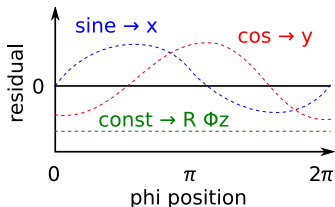


Step 2: align rings to tracker

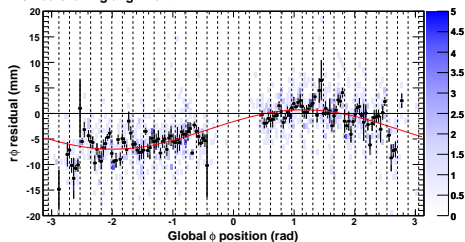
Jim Pivarski 9/15



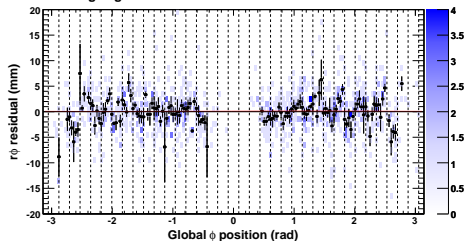
- ▶ Internal alignment of rings using beam-halo is step 1, not done yet
- ▶ Aligning rings to tracker has been performed with cosmic rays (CRAFT-09)



ME-1/2 before ring alignment



ME-1/2 after ring alignment





- ▶ Track-based corrections with respect to design geometry
- ▶ Grouped items are physically connected to the same disk; values are correlated but not exactly equal within fitting errors

ring	δ_x (mm)	δ_y (mm)	δ_{ϕ_z} (mrad)
ME-4/1	5.00 ± 0.14	-1.30 ± 0.22	1.57 ± 0.05
ME-3/2	2.25 ± 0.04	-0.62 ± 0.06	1.85 ± 0.01
ME-3/1	4.16 ± 0.12	0.06 ± 0.18	2.12 ± 0.04
ME-2/2	1.66 ± 0.04	1.29 ± 0.05	1.68 ± 0.01
ME-2/1	3.77 ± 0.09	-1.96 ± 0.13	2.18 ± 0.03
ME-1/3	2.41 ± 0.06	1.43 ± 0.09	0.26 ± 0.01
ME-1/2	3.52 ± 0.05	-1.56 ± 0.07	0.85 ± 0.01
ME-1/1	2.93 ± 0.09	-2.90 ± 0.13	0.66 ± 0.04
ME+1/1	4.95 ± 0.08	-1.93 ± 0.11	0.17 ± 0.04
ME+1/2	5.05 ± 0.05	0.81 ± 0.07	0.13 ± 0.01
ME+1/3	4.36 ± 0.06	3.22 ± 0.08	0.02 ± 0.01
ME+2/1	4.56 ± 0.08	2.30 ± 0.12	0.18 ± 0.03
ME+2/2	4.28 ± 0.04	3.86 ± 0.05	-0.11 ± 0.01
ME+3/1	5.06 ± 0.10	4.42 ± 0.17	-0.05 ± 0.03
ME+3/2	4.01 ± 0.04	4.88 ± 0.06	-0.37 ± 0.01
ME+4/1	5.58 ± 0.15	8.24 ± 0.24	0.40 ± 0.05

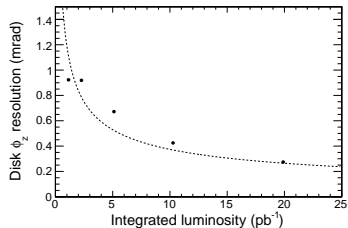
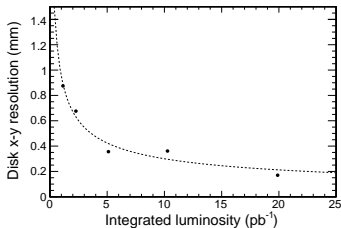
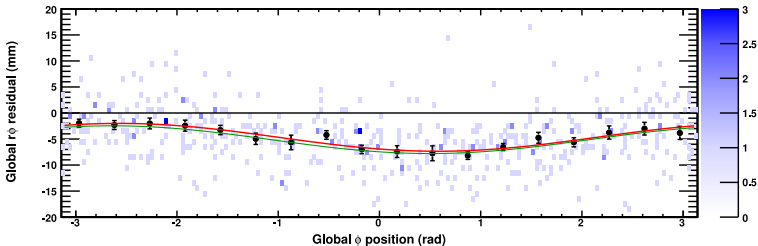
Ring fits with collisions

Jim Pivarski 11/15



- ▶ Collisions muons will cover the inner rings better than cosmics
- ▶ MC resolution estimate:

ME-1/2 collisions MC with 5 pb^{-1} , fitted (red) and compared with truth (green)

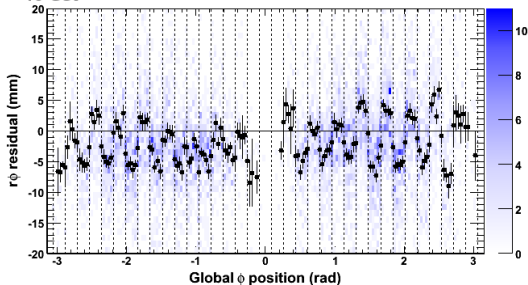


Problem in tracker-to-CSC

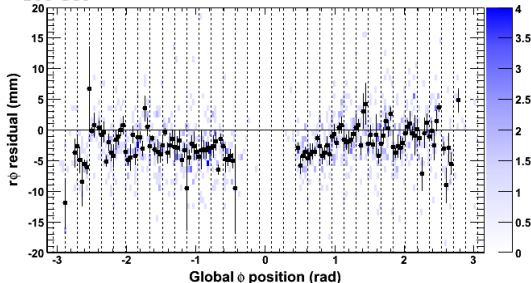
Jim Pivarski 12/15



$p_T > 40 \text{ GeV}$



$p_T > 100 \text{ GeV}$



- ▶ Residuals on low- p_T tracks alternate unphysically between chambers; not so for high- p_T tracks
- ▶ Dashed lines are chamber boundaries (4 bins per chamber)
- ▶ Corresponding effect *not* seen in overlaps
- ▶ This is a very weird effect: defies most explanations (full detective story not shown here)
- ▶ Continued next page...

New alignment expert

(in training)

Jim Pivarski 13/15



- ▶ **Aysen Tatarinov**, new grad student at Texas A&M, will be taking on alignment responsibilities
- ▶ Current status: I've documented all of the tools on twiki pages

<https://twiki.cern.ch/twiki/bin/view/CMS/SWGuideMuonAlignment>

SWGuideMuonAlignReferenceTarget

SWGuideMuonAlignFrameworkDetails

SWGuideMuonGeometryConversion

SWGuideMuonGeometryDBComparison

SWGuideMuonAlignValidationPlots

FindQualityFilesPy

SWGuideMuonAlignStandAloneTest

SWGuideMuonAlignCustomGeometry

and he is successfully using them to produce MC alignment results

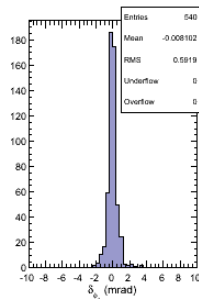
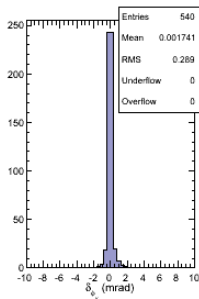
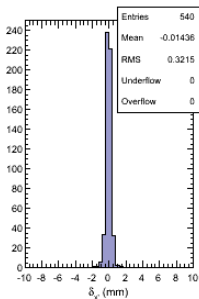
- ▶ First major project will be to solve the CSC residuals problem shown on the previous page (with help from me)
- ▶ **Vadim Khotilovich** is also still developing infrastructure
Completed: FindQualityFiles, next project: unified monitoring system

Step 3: Reference-Target

Jim Pivarski 14/15



- ▶ High-luminosity: align each chamber individually using tracks from the tracker
- ▶ Any discrepancies between this and overlaps alignment will tell us a lot about tracker or track-propagation errors
- ▶ Simulation produced by Aysen: 50 pb^{-1} yields $320 \mu\text{m}$ in $r\phi$, comparable to beam-halo resolution, enough to make a good test
 - ▶ now trying 5, 10, and 20 pb^{-1}





- ▶ Beam-induced muons have arrived, but not yet in great numbers like last year (clean beams, cautious with inner-ring CSC voltage)
- ▶ The events that we do have look very promising
- ▶ We have aligned rings relative to the tracker using CRAFT-09 cosmic rays; extends naturally to early collisions
- ▶ Ring alignment revealed a very strange feature
- ▶ Aysen is joining us in the alignment effort: his first major task will be understanding the very strange feature