Muon Alignment: Endcaps

Joint DPG and Physics Muon Workshop, 3 April 2008

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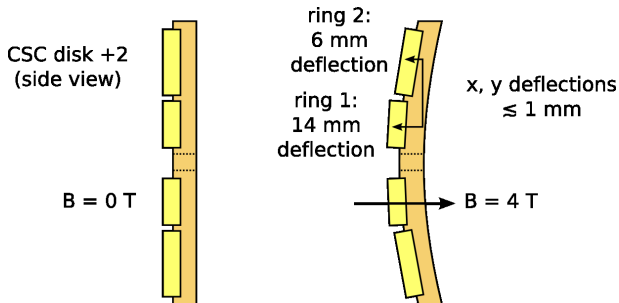Texas A&M University   FermiLab   Florida Inst. of Technology

CSC Alignment Outline

- ▶ Hardware alignment

- ▶ Track-based alignment
  - ▶ Baseline and start-up procedures
  - ▶ iCSA08 exercise

- ▶ Hardware/track-based comparisons

- ▶ Timelines

Hardware alignment

- ME+2 DCOPS alignment finalized in MTCC (field on and off)

- Comparison with photogrammetry in 0T to test accuracy (next two slides)

- Observed expected deformations from 0T to 4T

CSC disk +2 (side view)

B = 0 T

ring 2: 6 mm deflection

ring 1: 14 mm deflection

x, y deflections ≤ 1 mm

B = 4 T

- Now Samir and Marcus are working on other stations

Check Reco against Photogrammetry at B=0T:

- Z_{CMS}
  - PG targets on top of DCOPS box ($\pm$ 300 μm)
  - Coded targets on CSC skins ($\pm$ 300 μm)
  - (Alignment pins only accurate to couple mm)

- $R\varphi$ (X_{CMS}, Y_{CMS})
  - DCOPS reference dowel pin as derived from PG targets on top of DCOPS box ($\sim\pm$ 300 μm)
  - Alignment pins in CSCs ($\pm$ 300 μm)
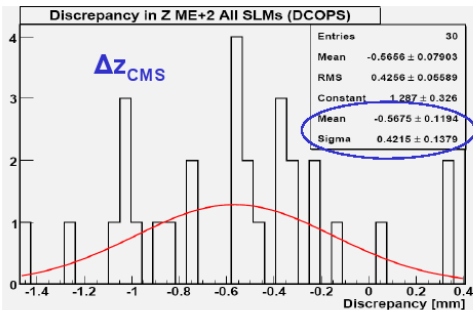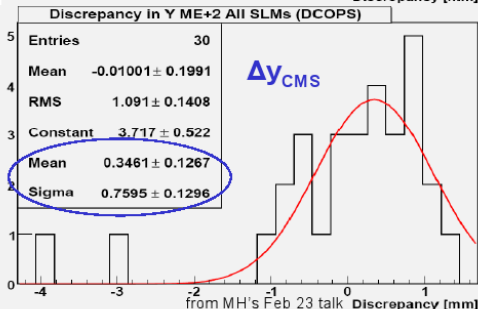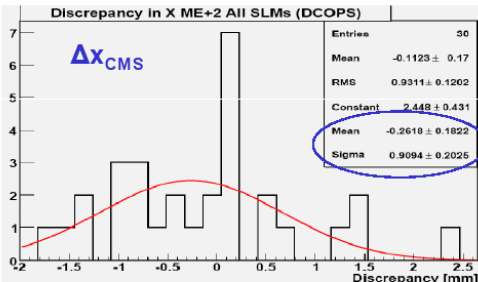
From MH's Feb23 talk

Accuracy Checks with DCOPS

Evaluate the following discrepancies:

For DCOPS targets in all 3 dimensions:

$\Delta x = x_{PG} - x_{reco}$, $\Delta y = y_{PG} - y_{reco}$, $\Delta z = z_{PG} - z_{reco}$

If all were "perfect", we'd expect Gaussians:
- centered at 0
- $\sigma = \sigma_{PG} \oplus \sigma_{reco} = 300\ \mu m \oplus 250\ \mu m = 400\ \mu m$

Discrepancy in X ME+2 All SLMs (DCOPS)

Δx_{CMS}

Entries	30
Mean	-0.1123 ± 0.17
RMS	0.9311 ± 0.1202
Constant	2.448 ± 0.431
Mean	-0.2618 ± 0.1822
Sigma	0.9094 ± 0.2025

Discrepancy [mm]

Discrepancy in Z ME+2 All SLMs (DCOPS)

Δz_{CMS}

Entries	30
Mean	-0.5656 ± 0.07903
RMS	0.4256 ± 0.05589
Constant	1.287 ± 0.326
Mean	-0.5675 ± 0.1194
Sigma	0.4215 ± 0.1379

Discrepancy [mm]

Discrepancy in Y ME+2 All SLMs (DCOPS)

Δy_{CMS}

Entries	30
Mean	-0.01001 ± 0.1991
RMS	1.091 ± 0.1408
Constant	3.717 ± 0.522
Mean	0.3461 ± 0.1267
Sigma	0.7595 ± 0.1296

from MH's Feb 23 talk Discrepancy [mm]

Track-based alignment

- ▶ Baseline HIP procedure
  - ▶ whole muon system (CSCs *and* DTs)
  - ▶ uses silicon tracker as an external reference
  - ▶ requires at least 10 pb^{-1}
  - ▶ well-studied procedure

- ▶ CSC overlap procedure
  - ▶ tracks through overlap regions measure relative alignment of pairs of neighboring chambers
  - ▶ all CSC chambers except ME1/3 have overlap regions
  1. optimize alignment within each CSC ring
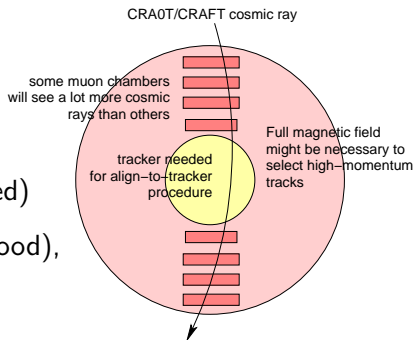 2. follow-up by aligning each CSC ring to tracker (very easy)
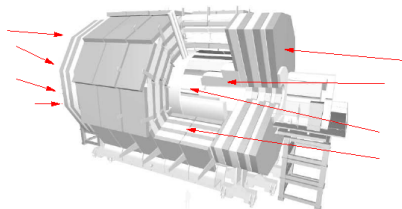
- ▶ CSC layer procedure
  - ▶ align CSC layers relative to layer 1 (similar to above)

Overlap and layer procedures can be done with low-momentum I.P. muons or beam-halo
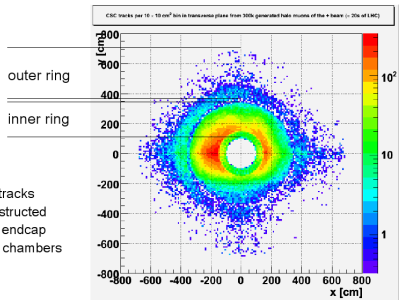
- ▶ Tracks are iteratively re-fit with varying hit-weights
    1. loose hit weights in the muon system: project tracks from tracker and align first station
    2. tight hit weights in first station: align second station
    3. etc.

- ▶ Each chamber is aligned independently of its neighbors

- ▶ Test in CRAFT: full tracker and high statistics for top and bottom chambers

- ▶ Maybe test in CRA0T: how essential is our p_T cut? (to be studied)

- ▶ Estimate 1 million muons in MB0 (good), 10k muons in ME1/3 (fair)

CRA0T/CRAFT cosmic ray

some muon chambers will see a lot more cosmic rays than others

tracker needed for align–to–tracker procedure

Full magnetic field might be necessary to select high–momentum tracks

133k tracks reconstructed in the endcap muon chambers

outer ring

inner ring

- ▶ Beam-halo may be a good source of horizontal muons before first collisions
- ▶ Rate is very uncertain (simulation suggests we'll have enough muons, but uncertainty quoted as factor of 100)
- ▶ Same techniques can be applied to low-energy I.P. muons

Realistic alignment exercise in real-time

- ▶ Baseline alignment (10 pb^{-1}) (minimal goal)
- ▶ CSC overlaps alignment (1 or 10 pb^{-1}, beam-halo)
- ▶ CSC layer alignment (1 or 10 pb^{-1}, beam-halo)

All workflows will be pre-tested

- ▶ iCSA08 conducted in CMSSW_2_0_X
- ▶ Back-ported new features to 1_6_7 and 1_8_X, to test with old CSA07 samples and new FastSim samples

Determined resource requirements for baseline procedure, others are in progress

Hardware/track-based alignments measure some
parameters in common, others are orthogonal

Example:

- ▶ tracks measure CSC x, y
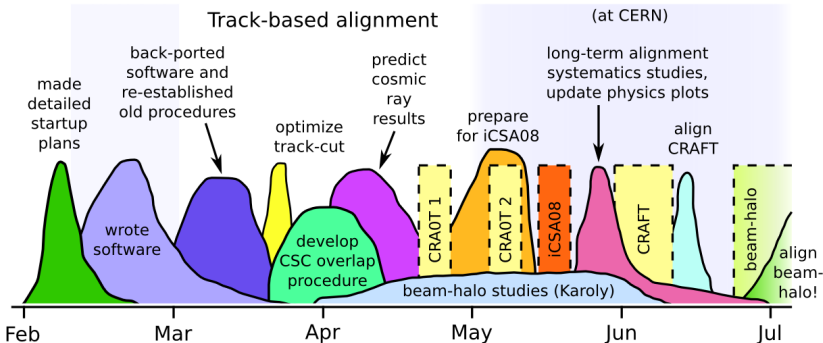- ▶ DCOPS measure CSC x, z

agreement in x lends credence to z

But we need to measure the same dataset

	hardware alignment	track-based alignment
MTCC	done for ME+2	possible testing-ground for beam-halo, if there is time
CRA0T/CRAFT	barrel, link, ME1/3 proximity sensors?	top and bottom chambers in barrel, possibly ME1/3 if enough events
single-beam	full endcap procedure	ring 1 well-measured, ring 2 less so

Timelines

Track-based alignment

(at CERN)

made detailed startup plans

wrote software

back-ported software and re-established old procedures

optimize track-cut

develop CSC overlap procedure

predict cosmic ray results

prepare for iCSA08

CRA0T 1

CRA0T 2

iCSA08

long-term alignment systematics studies, update physics plots

CRAFT

align CRAFT

beam-halo

align beam-halo!

beam-halo studies (Karoly)

Feb   Mar   Apr   May   Jun   Jul

Hardware alignment
(from Marcus's timeline)

...

complete plus-endcap, ME-1, ME-2 in Rφ and Z

incorporate ME±1 Z-sensors and clinometers: integration with link and barrel

ME-3, ME-4 in Rφ and Z

propagate Z-coordinates through entire endcap (6 transfer lines)

redo everything with B=4T in underground 2008 data

Apr   May   Jun   Jul
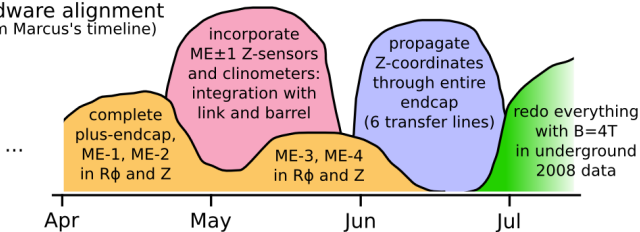
- ▶ Hardware alignment is producing sensible results in MTCC

- ▶ Baseline procedure for whole muon system in good shape

- ▶ Start-up procedures for endcap in development

- ▶ These will be tested in iCSA08

- ▶ Likely date for comparisons: June or July