Proposed alignments for barrel and endcap

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- Final studies and validation of the barrel alignment

- Presentation of the endcap disk alignment
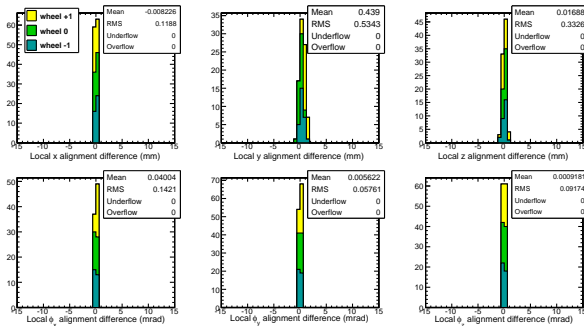
Important corrections

Apr 27 $\xrightarrow{\text{increase } p_T \text{ cut}}$ May 25 $\xrightarrow{\text{use final tracker}}$ May 29

twisted barrel about 0.35 mrad

translated chambers with $\sigma \sim 2$ mm, no rotations

Unimportant corrections

- $\vec{B}(\vec{x})$ correction when $100 < p_T < 200$ GeV
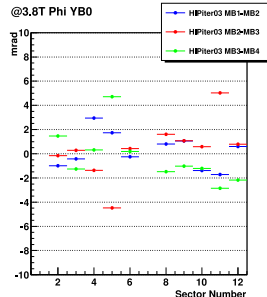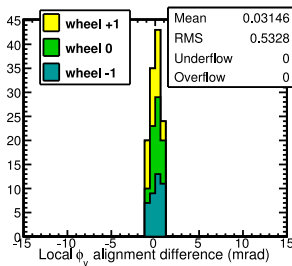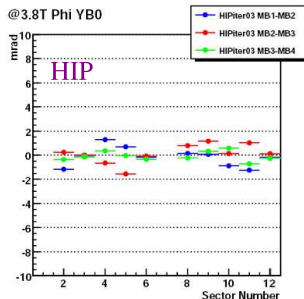- Using the final tracker APEs, in addition to final tracker alignment:

Segment extrapolation

Difference in angle between station *A* and station *B*, measured by segments:

A. Calderon

- ▶ How can segment differences change by more than 2 mrad when no angle was moved in the DB by more than 1 mrad?

- ▶ Something seems to have gone wrong in this test; possibly configured incorrectly (very short timescale)
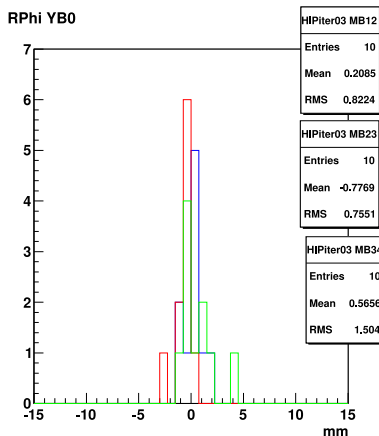
▶ Not admissible because of error observed in ϕ_y plots, but x plots by themselves do not indicate worse resolution

(previously: 0.8 mm in stations 1–3, 1.6 mm station 4 due to internal structure)
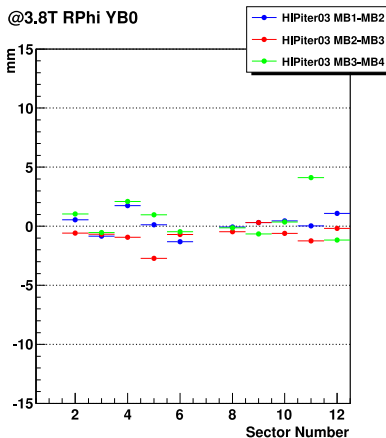
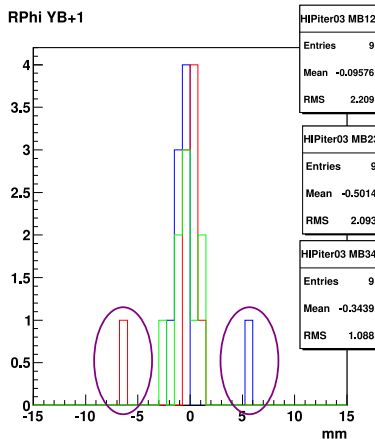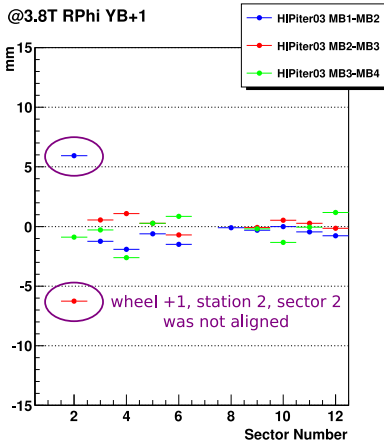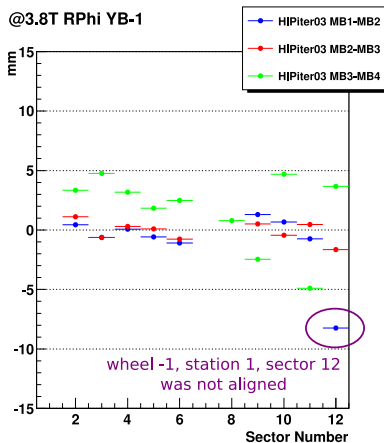- Not admissible because of error observed in ϕ_y plots, but x plots by themselves do not indicate worse resolution

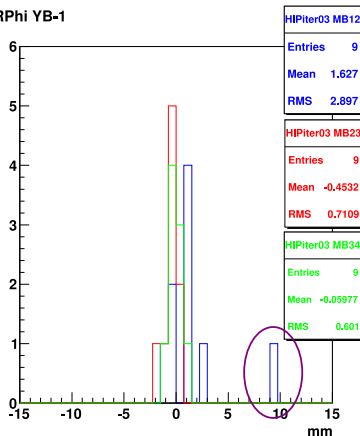 (previously: 0.8 mm in stations 1–3, 1.6 mm station 4 due to internal structure)

- The green points on the left (which do have a worse resolution) do not appear on the right— a mis-match within the set of plots?
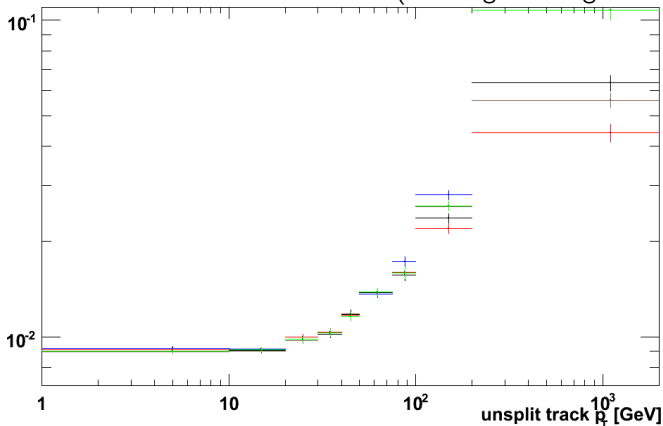
- Sequence of $\frac{(1/p_T)_{top} - (1/p_T)_{bot}}{\sqrt{2}\,(1/p_T)_{bot}}$ (equal to $\frac{(p_T)_{top} - (p_T)_{bot}}{\sqrt{2}\,(p_T)_{bot}}$ if Gaussian)

- Vertical axis is resolution from 1 to 10%

- Key: tracker-only, sometimes with station 1, with station 1, all stations

CRAFT_ALL_V4 (before global alignment)

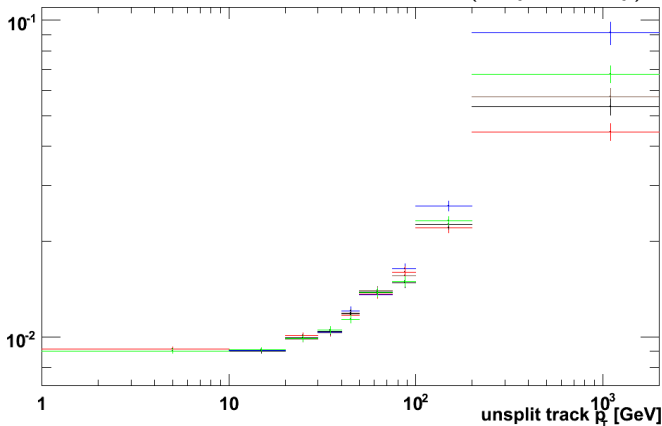Last bin is always statistically independent of tracks used for alignment

J. Tucker

unsplit track p_T [GeV]

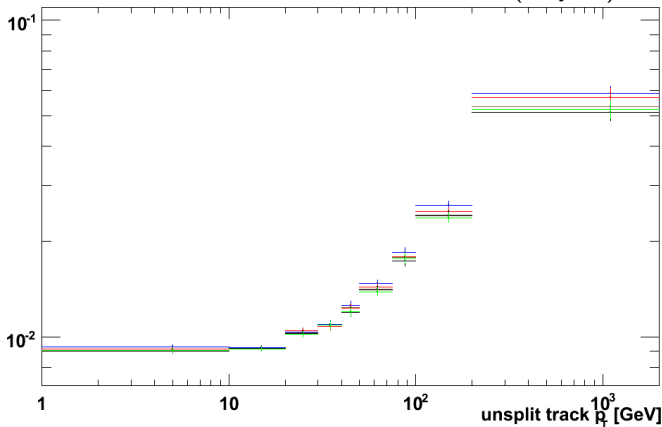# Cosmic splitting (2/4)

- ▶ Sequence of $\frac{(1/p_T)_{\text{top}}-(1/p_T)_{\text{bot}}}{\sqrt{2}\,(1/p_T)_{\text{bot}}}$ (equal to $\frac{(p_T)_{\text{top}}-(p_T)_{\text{bot}}}{\sqrt{2}\,(p_T)_{\text{bot}}}$ if Gaussian)

- ▶ Vertical axis is resolution from 1 to 10%

- ▶ Key: tracker-only, sometimes with station 1, with station 1, all stations

CRAFT_ALL_V5–12 (early February)

Last bin is always statistically independent of tracks used for alignment

J. Tucker

Cosmic splitting (3/4)

- Sequence of $\frac{(1/p_T)_{\text{top}} - (1/p_T)_{\text{bot}}}{\sqrt{2}\,(1/p_T)_{\text{bot}}}$ (equal to $\frac{(p_T)_{\text{top}} - (p_T)_{\text{bot}}}{\sqrt{2}\,(p_T)_{\text{bot}}}$ if Gaussian)

- Vertical axis is resolution from 1 to 10%

- Key: tracker-only, sometimes with station 1, with station 1, all stations

without latest tracker (May 25)

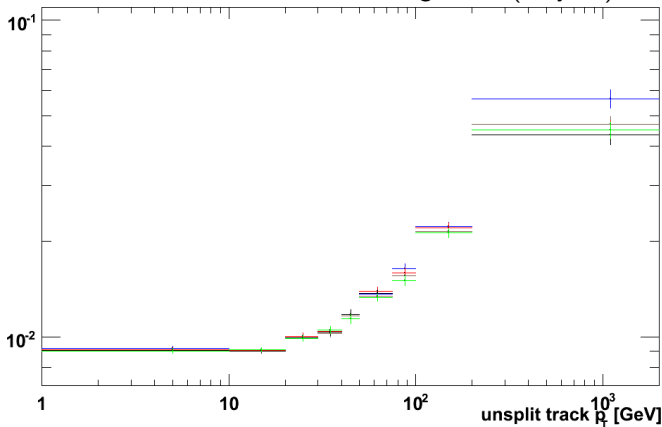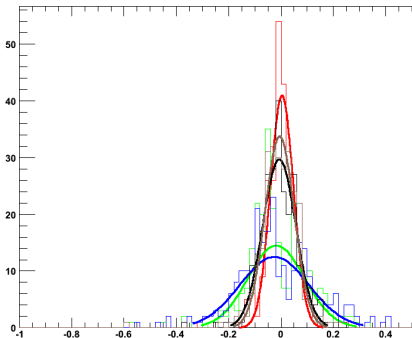Last bin is always statistically independent of tracks used for alignment

J. Tucker

- Sequence of $\frac{(1/p_T)_{\text{top}} - (1/p_T)_{\text{bot}}}{\sqrt{2}\,(1/p_T)_{\text{bot}}}$ (equal to $\frac{(p_T)_{\text{top}} - (p_T)_{\text{bot}}}{\sqrt{2}\,(p_T)_{\text{bot}}}$ if Gaussian)
- Vertical axis is resolution from 1 to 10%
- Key: tracker-only, sometimes with station 1, with station 1, all stations

final muon alignment (May 29)

Last bin is always statistically independent of tracks used for alignment

J. Tucker

Backup: highest bin

- Sequence of $\frac{(1/p_T)_{\text{top}}-(1/p_T)_{\text{bot}}}{\sqrt{2}\,(1/p_T)_{\text{bot}}}$ (equal to $\frac{(p_T)_{\text{top}}-(p_T)_{\text{bot}}}{\sqrt{2}\,(p_T)_{\text{bot}}}$ if Gaussian)

- 200–2000 GeV (these tracks were not used in alignment)

- Key: tracker-only, sometimes with station 1, with station 1, all stations
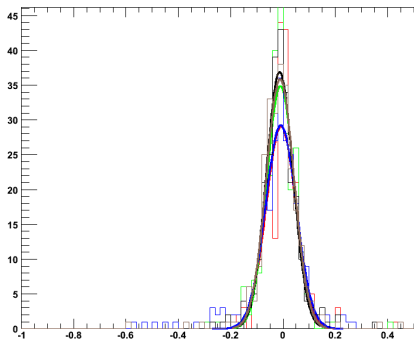

CRAFT_ALL_V4 (before global alignment)

J. Tucker

- Sequence of $\frac{(1/p_T)_{\text{top}} - (1/p_T)_{\text{bot}}}{\sqrt{2}\,(1/p_T)_{\text{bot}}}$ (equal to $\frac{(p_T)_{\text{top}} - (p_T)_{\text{bot}}}{\sqrt{2}\,(p_T)_{\text{bot}}}$ if Gaussian)

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CRAFT_ALL_V5–12 (early February)

J. Tucker

- Sequence of $\frac{(1/p_T)_{\text{top}} - (1/p_T)_{\text{bot}}}{\sqrt{2}\,(1/p_T)_{\text{bot}}}$ (equal to $\frac{(p_T)_{\text{top}} - (p_T)_{\text{bot}}}{\sqrt{2}\,(p_T)_{\text{bot}}}$ if Gaussian)

- 200–2000 GeV (these tracks were not used in alignment)

- Key: tracker-only, sometimes with station 1, with station 1, all stations

without latest tracker (May 25)

J. Tucker

Backup: highest bin

- Sequence of $\frac{(1/p_T)_{\text{top}} - (1/p_T)_{\text{bot}}}{\sqrt{2}\,(1/p_T)_{\text{bot}}}$ (equal to $\frac{(p_T)_{\text{top}} - (p_T)_{\text{bot}}}{\sqrt{2}\,(p_T)_{\text{bot}}}$ if Gaussian)

- 200–2000 GeV (these tracks were not used in alignment)

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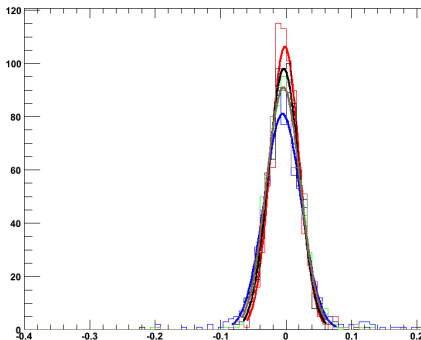
final muon alignment (May 29)

J. Tucker

Backup: second-highest bin

- ▶ Sequence of $\frac{(1/p_T)_{\text{top}} - (1/p_T)_{\text{bot}}}{\sqrt{2}\,(1/p_T)_{\text{bot}}}$ (equal to $\frac{(p_T)_{\text{top}} - (p_T)_{\text{bot}}}{\sqrt{2}\,(p_T)_{\text{bot}}}$ if Gaussian)

- ▶ 100–200 GeV (these tracks were used in the May alignments)

- ▶ Key: tracker-only, sometimes with station 1, with station 1, all stations

CRAFT_ALL_V4 (before global alignment)

Rel. res., 100 < pT [GeV] < 200

J. Tucker

Backup: second-highest bin

- Sequence of $\frac{(1/p_T)_{top} - (1/p_T)_{bot}}{\sqrt{2}\,(1/p_T)_{bot}}$ (equal to $\frac{(p_T)_{top} - (p_T)_{bot}}{\sqrt{2}\,(p_T)_{bot}}$ if Gaussian)

- 100–200 GeV (these tracks were used in the May alignments)

- Key: tracker-only, sometimes with station 1, with station 1, all stations

CRAFT_ALL_V5–12 (early February)

J. Tucker

Backup: second-highest bin
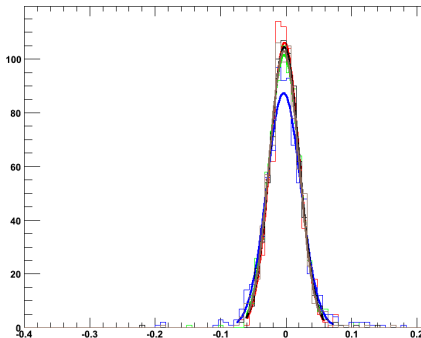
▶ Sequence of $\frac{(1/p_T)_{\text{top}} - (1/p_T)_{\text{bot}}}{\sqrt{2}\,(1/p_T)_{\text{bot}}}$ (equal to $\frac{(p_T)_{\text{top}} - (p_T)_{\text{bot}}}{\sqrt{2}\,(p_T)_{\text{bot}}}$ if Gaussian)

▶ 100–200 GeV (these tracks were used in the May alignments)

▶ Key: tracker-only, sometimes with station 1, with station 1, all stations

without latest tracker (May 25)

J. Tucker

Backup: second-highest bin
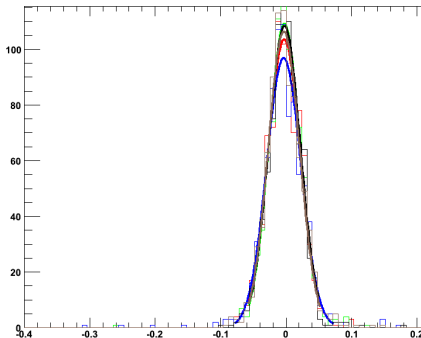
- Sequence of $\frac{(1/p_T)_{\text{top}} - (1/p_T)_{\text{bot}}}{\sqrt{2}\,(1/p_T)_{\text{bot}}}$ (equal to $\frac{(p_T)_{\text{top}} - (p_T)_{\text{bot}}}{\sqrt{2}\,(p_T)_{\text{bot}}}$ if Gaussian)

- 100–200 GeV (these tracks were used in the May alignments)

- Key: tracker-only, sometimes with station 1, with station 1, all stations

final muon alignment (May 29)

Rel. res., 100 < pT [GeV] < 200

J. Tucker

Summary of barrel validation

- ▶ We know that consistency with updated tracker alignment means changing muon chamber positions (not angles) by $\sigma \sim 2$ mm

- ▶ Something happened to the segment extrapolation test: it's not representing the changes we put in (angles change dramatically)
    - ▶ can't use it to test May 29 alignment

- ▶ Cosmic charge splitting indicates improvement with May 29 alignment (based on latest tracker)

An aside, for context

- ▶ 2008 MC $\frac{(1/p_T)_{\text{meas}} - (1/p_T)_{\text{gen}}}{\sqrt{2}\,(1/p_T)_{\text{gen}}}$ first-muon station (FMS) resolution:

  IDEAL: 2%, CSA08 10 pb^{-1}: 3%, STARTUP: 6% at 200 GeV

- ▶ Cosmic splitting FMS: May 25: 5.2% May 29: 4.5% at 200 GeV

Endcap constants

- ▶ Photogrammetry + hardware disk-bending + disk positions from tracks
- ▶ New fits to whole-ring local residuals (next few pages)
- ▶ 3-DOF global corrections to 4 disks:

	δ_ϕ (mrad)	δ_x (mm)	δ_y (mm)
ME+1	0.06	3.3	−0.1
ME+2,3	−0.04	1.7	2.6
ME−1	1.0	3.2	−3.7
ME−2,3	1.44	4.4	−0.1
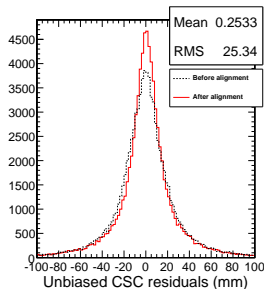
- ▶ "Non-definitive" transfer line numbers from Jim B.

	δ_ϕ (mrad)	δ_x (mm)	δ_y (mm)
ME+2,3 minus ME+1	0.98	1.03	−1.28
ME−2,3 minus ME−1	0.65	3.7	4.32

- ▶ Same rough scale; no wild disagreements
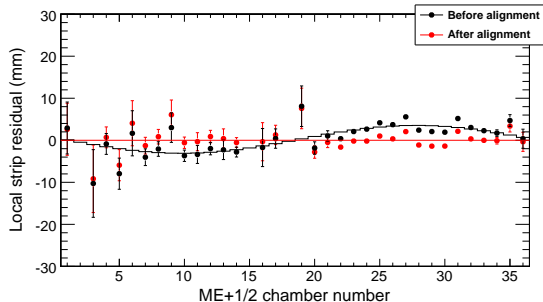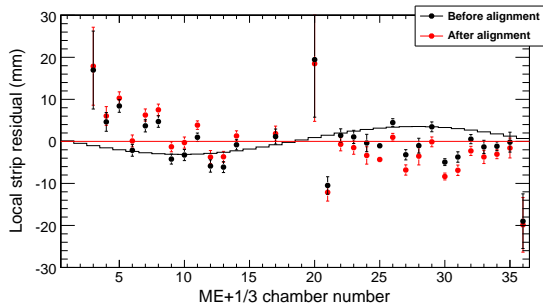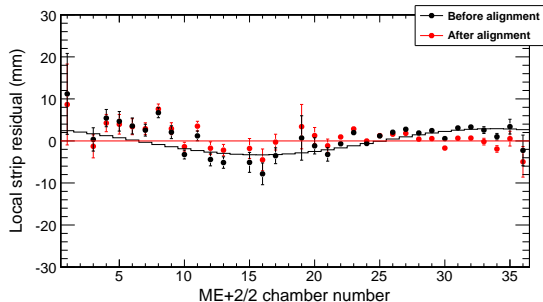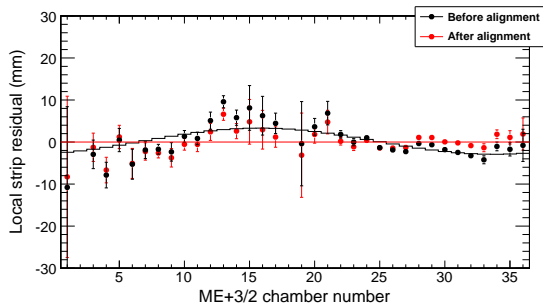
ME+1/2 (fitted)
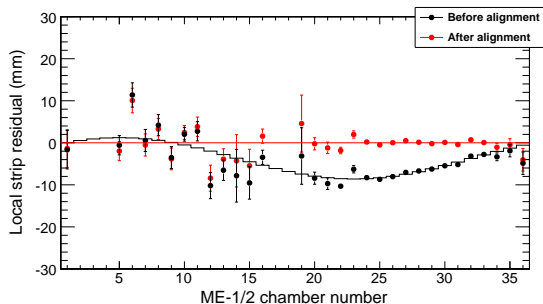
ME+1/3 (overlay
ME+1/2 fit)
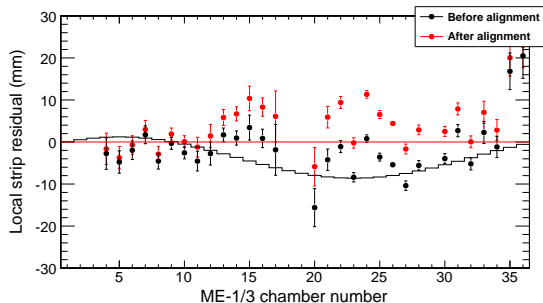
ME+2/2 (fitted)

ME+3/2 (overlay
ME+2/2 fit)

ME−1/2 (fitted)

ME−1/3 (overlay
      ME−1/2 fit)
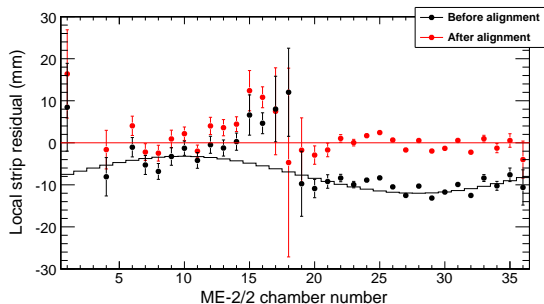
ME−2/2 (fitted)
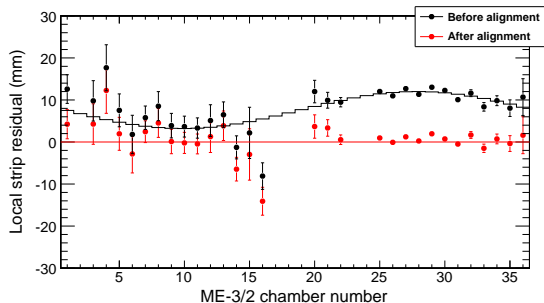
ME−3/2 (overlay
ME−2/2 fit)

Residuals differences

Jim Pivarski 26/28

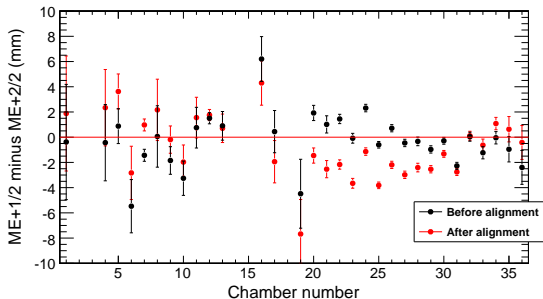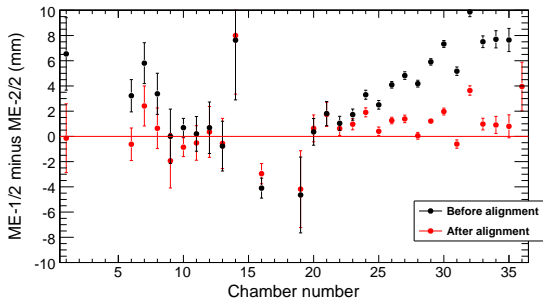Residuals differences are equivalent to segment extrapolation with the CMSSW propagator and a momentum assumption (from tracker)

More precise than absolute residuals and measure relative differences
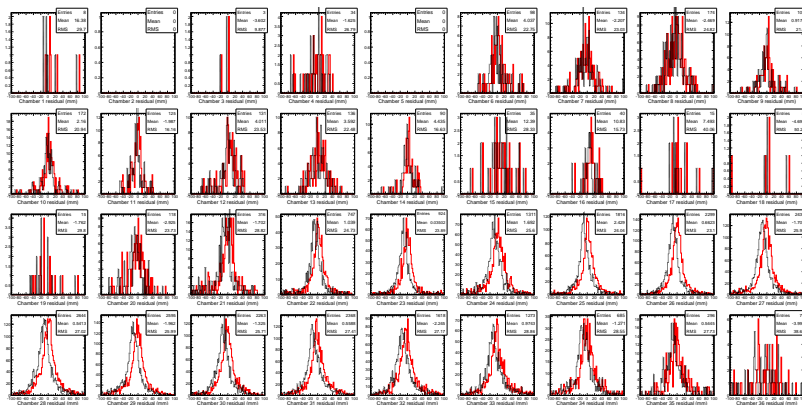
New information: an independent check on alignment

- ME−2/2, before and after alignment (stats box applies to after)
- No weights, no fits, just a mean truncated at ± 100 mm

Summary of constants

- Barrel alignment
    - DT internal alignment with tracks and checked by survey
    - global alignment relative to tracker checked by $1/p_T$ in cosmics splitting
        - aligned using $100 < p_T < 200$ GeV tracks
        - and the current tracker
        - current APEs negligibly affect results

    `/castor/cern.ch/user/p/pivarski/DTCRAFTiter03_withCenteredTracker.db`

- Endcap alignment
    - CSC photogrammetry at 0 T
    - SLM disk-bending measurements at 3.8 T
    - 3-DOF $\times$ 4 disk alignment with tracks

    `/castor/cern.ch/user/p/pivarski/CSCCRAFT_HardwareAndPGAndDisk2.db`