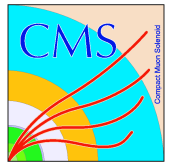

Diagnosing Tracker Global Modes with Muon Chamber Residuals

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5 November, 2009

Motivation

- There are ways to resolve weak modes using tracker data only
  - different topologies: cosmics, beam-gas, and collisions
  - resonance mass constraints
  - direction of flight of displaced vertices (e.g. $K_s \to \pi^+\pi^-$)?
- But we also have a detector outside of the tracker: muon system
- A study of the tracker using muon chamber residuals could reveal new information or complement studies that require collisions
- This talk is an advertisement: I'd like to interest someone in this as a new project

Challenges and solutions

- Problems with using the muon system to diagnose the tracker:
  - less precise hit resolution by about a factor of 10
  - complicated magnetic field, many radiation lengths of material
  - tracks correlate tracker regions with muon system regions
  - muon alignment determined from tracker: must avoid making circular conclusions

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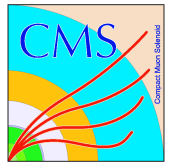

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- Partially resolve these issues with three ingredients:
  1. study muon residuals as a function of p_T (or curvature q/p_T)
     - errors in curvature grow quadratically with propagation distance (in a small-error approximation)
     - magnetic field/material budget errors have an antisymmetric signature in q: "muons err to the left, antimuons to the right"

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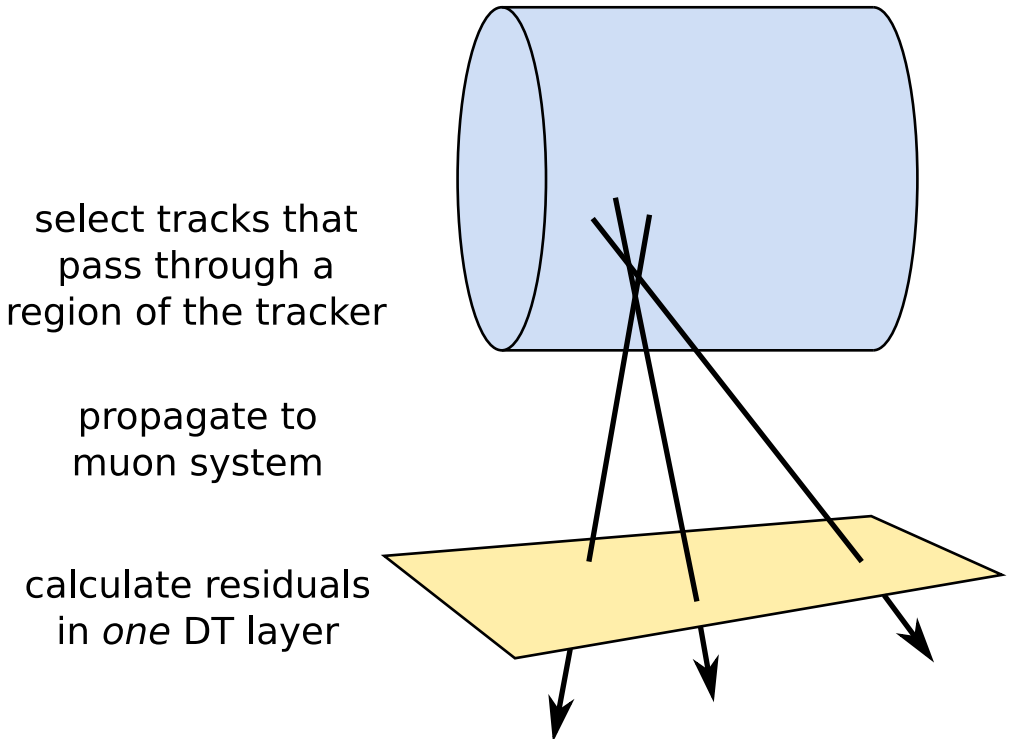
  3. focus on only one muon alignable: a single DT layer
     - a layer is 2 or more meters wide and long, depending on station
     - can ignore effect of its own misalignment: constant and linear trends in residuals vs. position, entrance angle

Method used in this talk

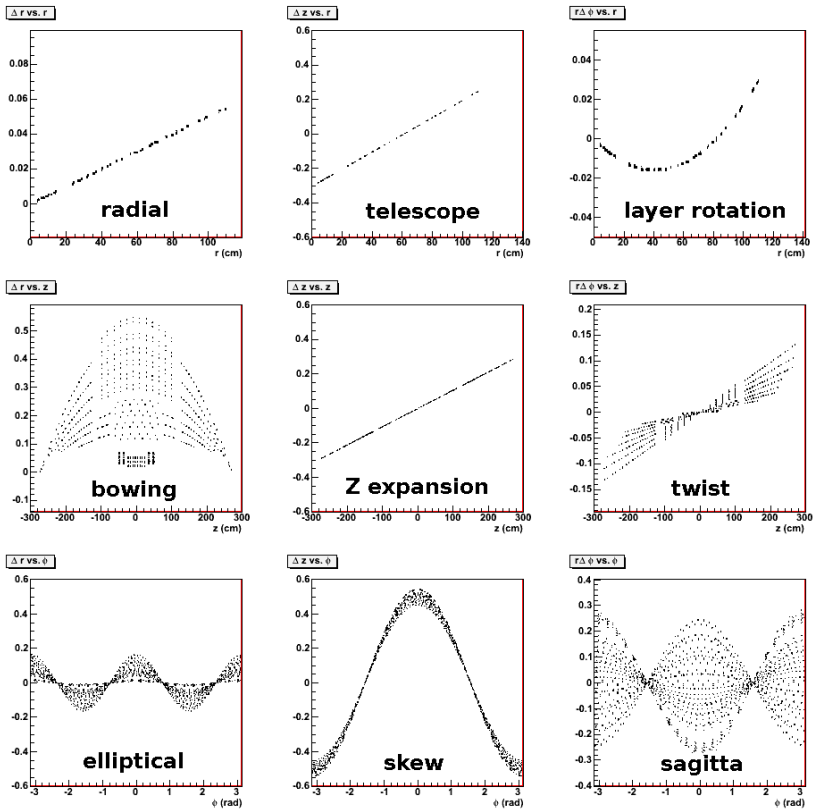


- Tracker-only fits, propagate to muon system
- Tracker hits ≥ 5
- Tracker $\chi^2/\text{ndf} < 20$
- Exactly 12 hits on DT segment in wheel 0, station 1, sector 10
- Look at x residuals on layer 2 of this chamber (arbitrarily chosen)
- Segment $\chi^2/\text{ndf} < 20$

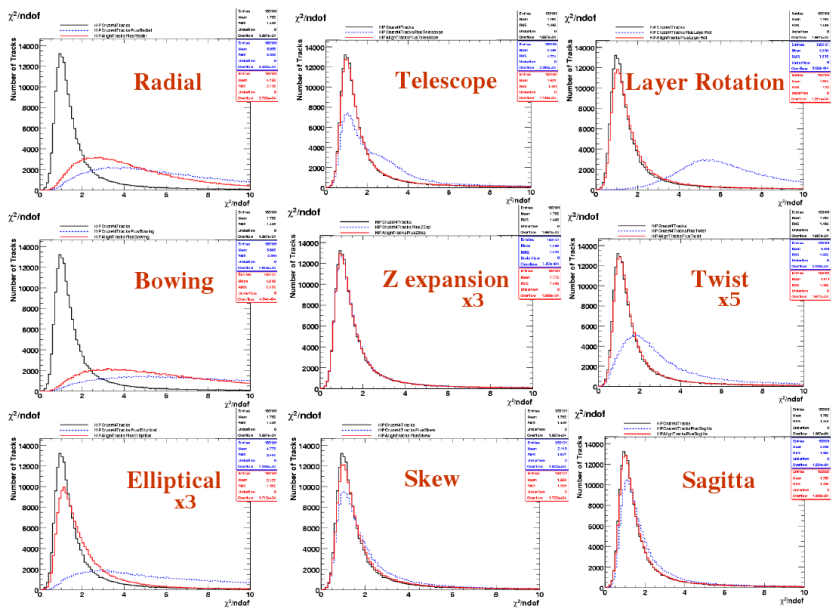
- Characterize "a region of the tracker" by d_{xy}, d_z, ϕ, $\cot\theta$, ...
  - integrates over a region: only useful for studies of global shape
- In this talk, I only look at d_{xy}, ϕ, and q/p_T (transverse plane)

Tracker global distortions

- 9 sample modes: $\{R, z, r\phi\}$ displacements vs. $\{R, z, \phi\}$
- Left: tracker module positions in each mode
- Right: χ^2 sensitivity of each mode



- Blue: sensitivity to distortion
  Red: recovery (may be outdated)
- Cosmic rays are less sensitive to sagitta than layerRotation

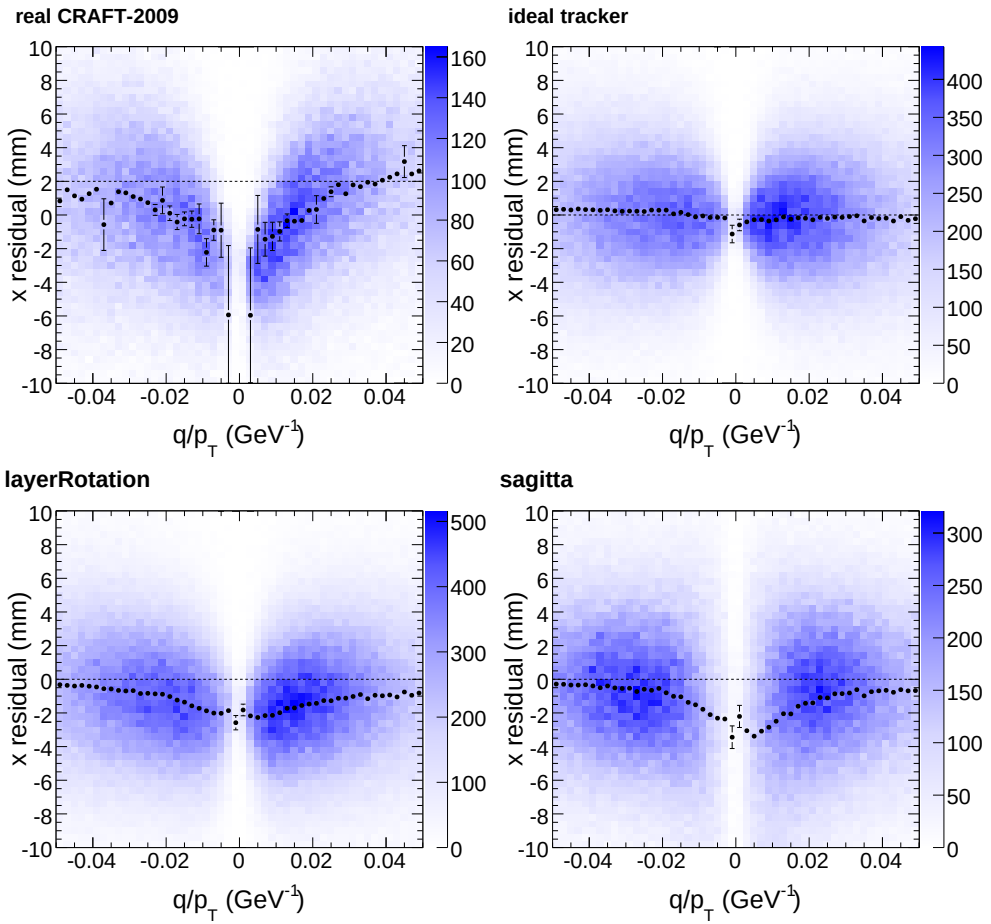


Zijin Guo Nov 13, 2008

Evidence for an effect

- DT x residuals depend ∼symmetrically on q/p_T: not a $\vec{B}(\vec{x})$ error
- MuonPOG May 11, 2009: reasoned from geometry that it could be layerRotation ("curl"), but this was ruled out by tracker χ^2

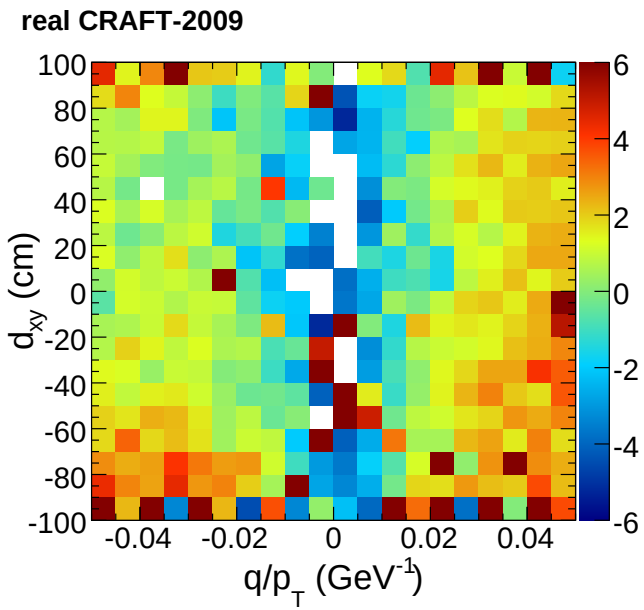
`http://indico.cern.ch/contributionDisplay.py?contribId=3&confId=55713`

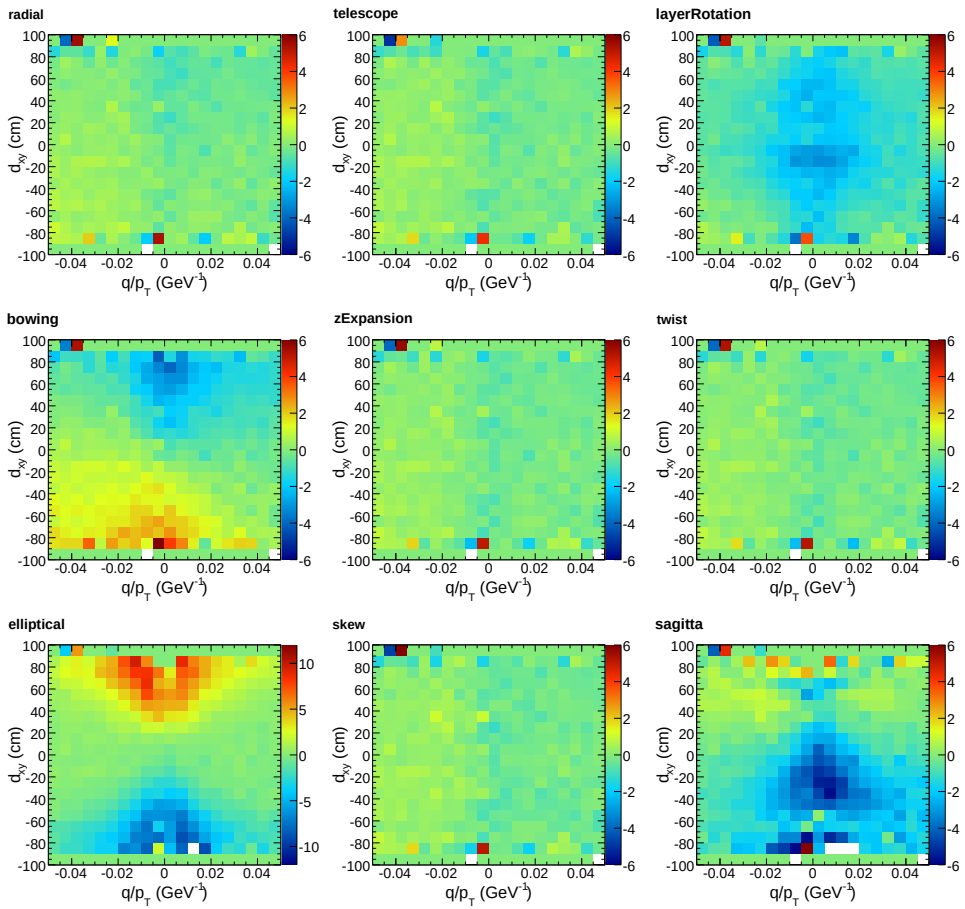


- Top-left: real data, CRAFT-2009 in 3_2_7 with the latest tracker alignment
- Others: Monte Carlo with different tracker geometries
- blues: 2-D distribution of residuals vs. q/p_T
- black points: profile (vertical mean by bin)

Residual vs. d_{xy} and q/p_T

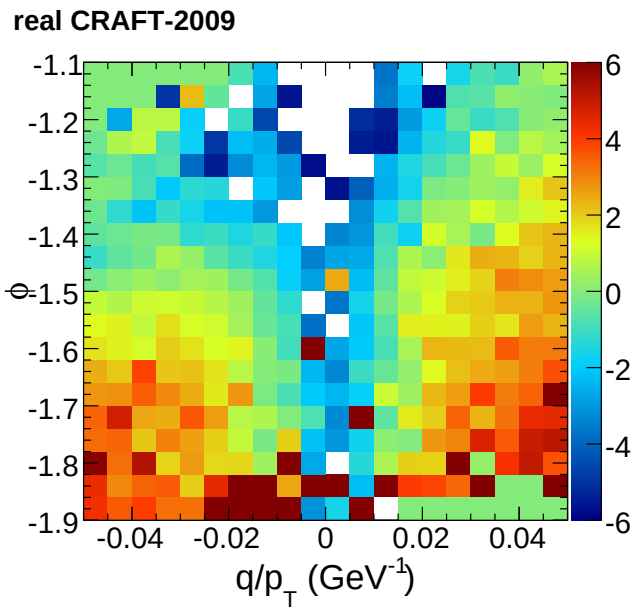
- Try to get a global picture with 2-D profiles
- Color scale is mean x residual (mm) in each 2-D bin
- Not one of the 9 sample modes has exactly the same shape as data

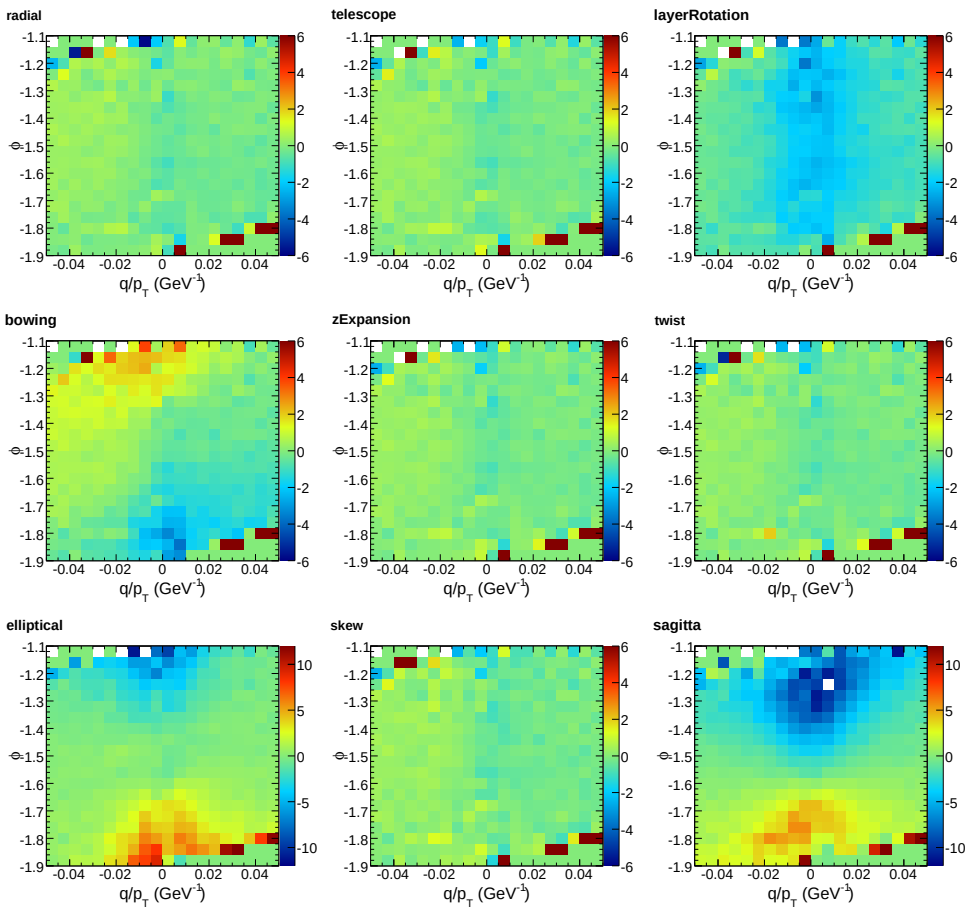




Residual vs. ϕ and q/p_T

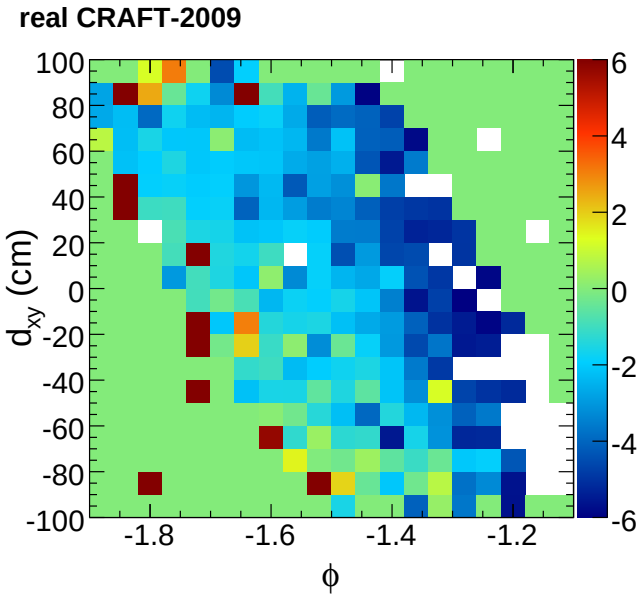
- Try to get a global picture with 2-D profiles
- Color scale is mean x residual (mm) in each 2-D bin
- Not one of the 9 sample modes has exactly the same shape as data

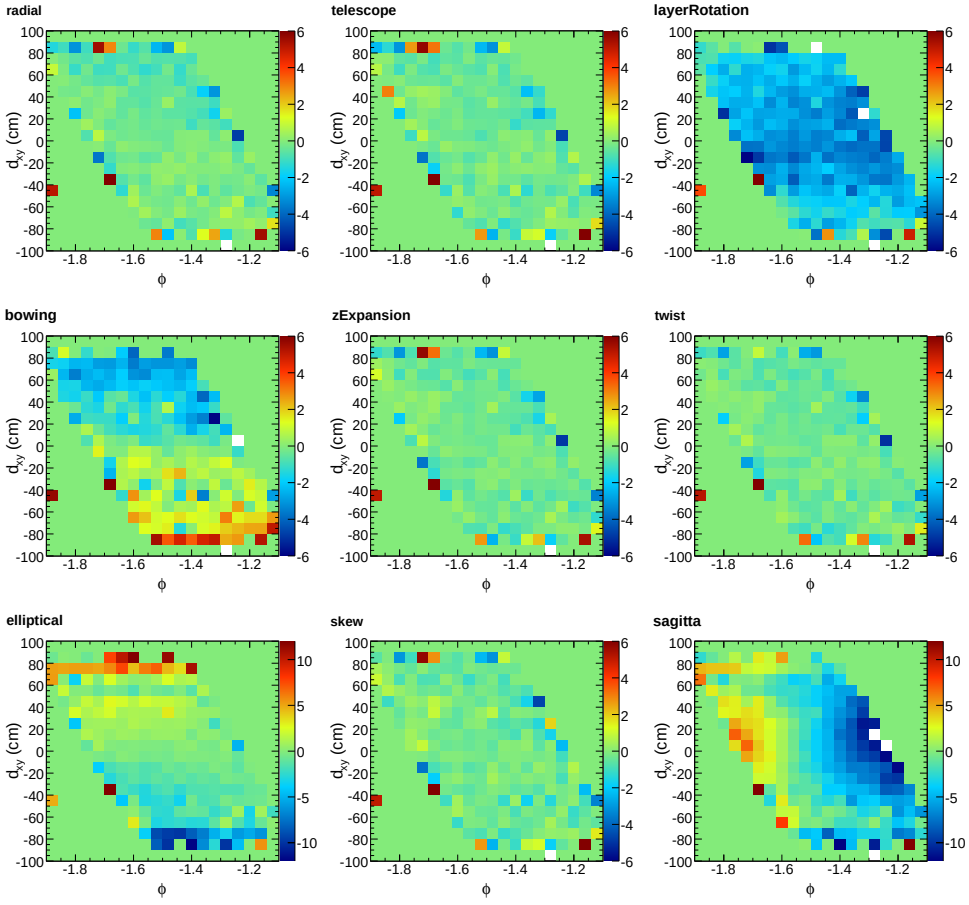




Residual vs. d_{xy} and ϕ (high p_T)

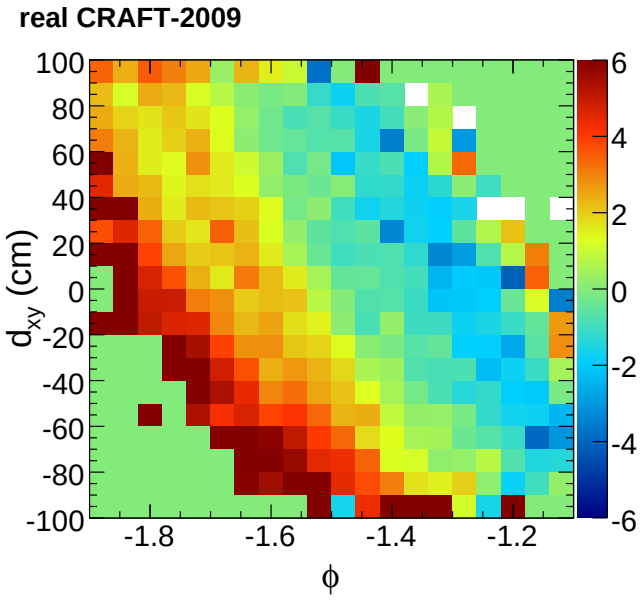
- "High p_T" means $p_T > 100$ GeV
- Looks similar to sagitta in this projection, but from the previous two pages, we know that the real distribution is not exactly sagitta

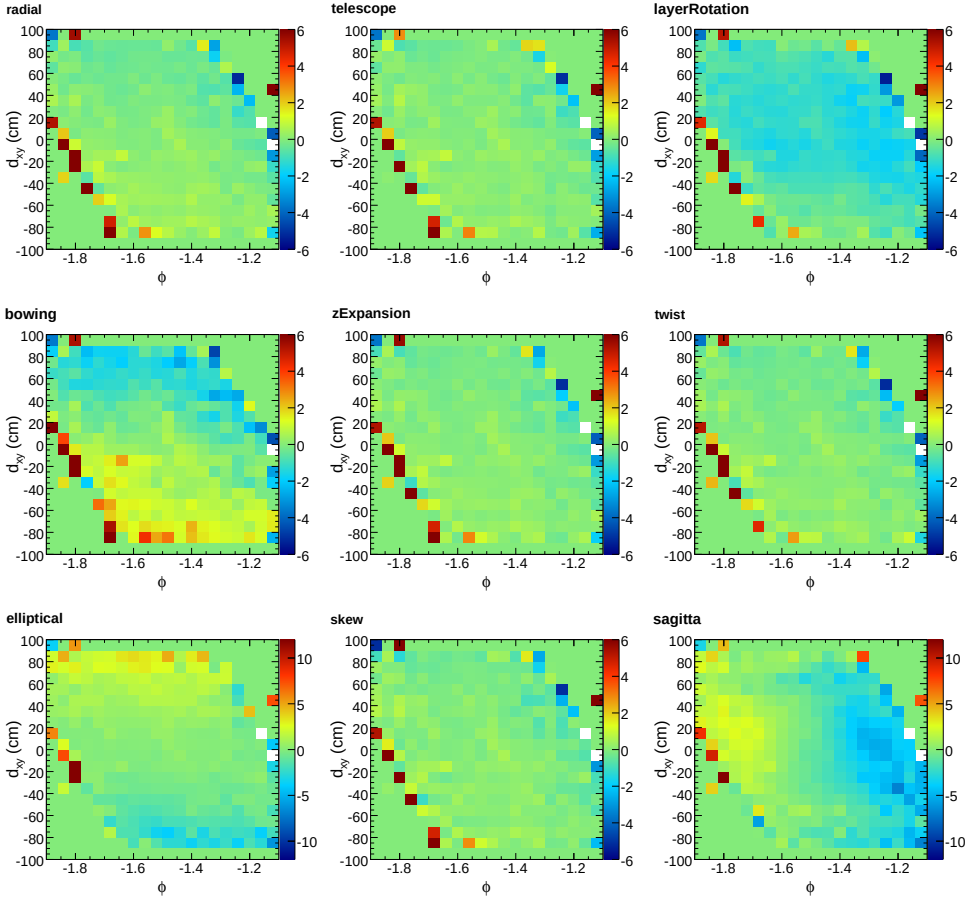




Residual vs. d_{xy} and ϕ (low p_T)

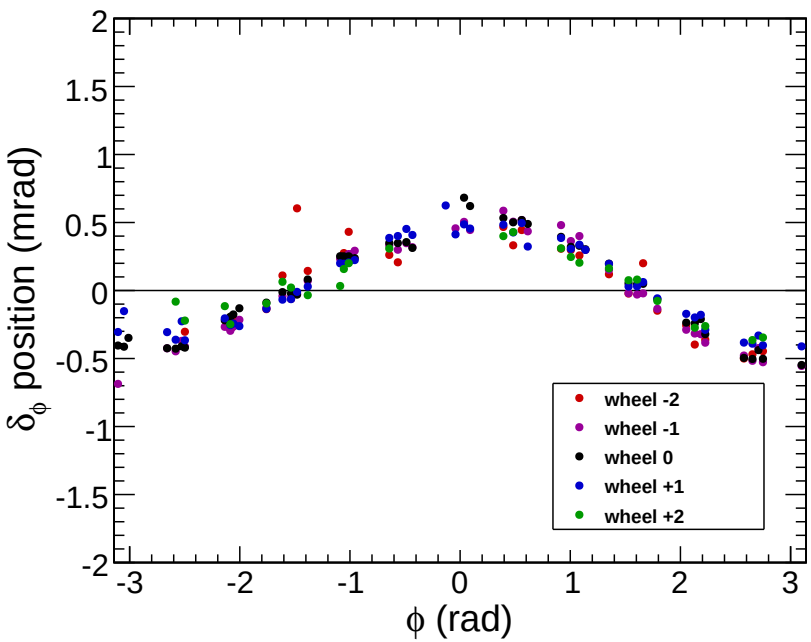
- "Low p_T" means $p_T < 100$ GeV
- This is a simple pattern: does it suggest a geometric interpretation?

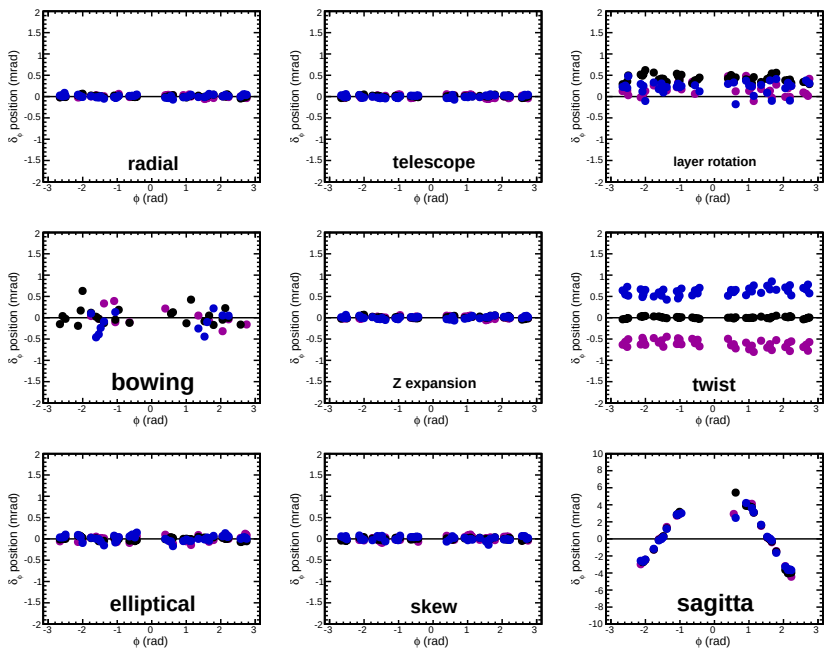




Clue from MC study

- When we conducted the MC cosmic ray alignment exercise, the combined system acquired a global distortion resembling sagitta, too
- Left: muon chamber ϕ positions relative to MC-truth, aligned using TrackerAlignment_CRAFT08Realistic_mc
- Right: same thing for the 9 globally-distorted tracker modes
  - at the extremes of the bottom-right plot, muon chamber misalignments were too large to recover, but the shape is $\cos\phi$





Conclusions

- Muon chamber measurements are sensitive to some global distortions of the tracker
  - q/p_T is especially useful for characterizing tracker: independent of DT misalignment, propagation errors must be antisymmetric in q, and sensitivity grows with distance
  - avoid dependence on muon alignment by selecting only one alignable, ignore the simple trends that may be due to its own misalignment

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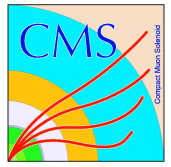

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  - tracker alignment with cosmics is insensitive to this mode
  - residuals distributions *most closely* resemble sagitta (of the 9)
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  - MC misalignments also resemble sagitta (but also not exact)
- This will likely be a long-term project
  - first identify the pattern (possibly not unique), then cross-check data from other sources, like resonances
  - method for applying constraint: Markus's talk?
  - DT wire endpin measurements exist; can verify DT layer rigidity
  - anyone interested?