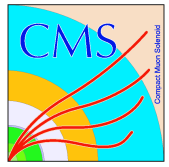


Magnetic Field from Position Residuals

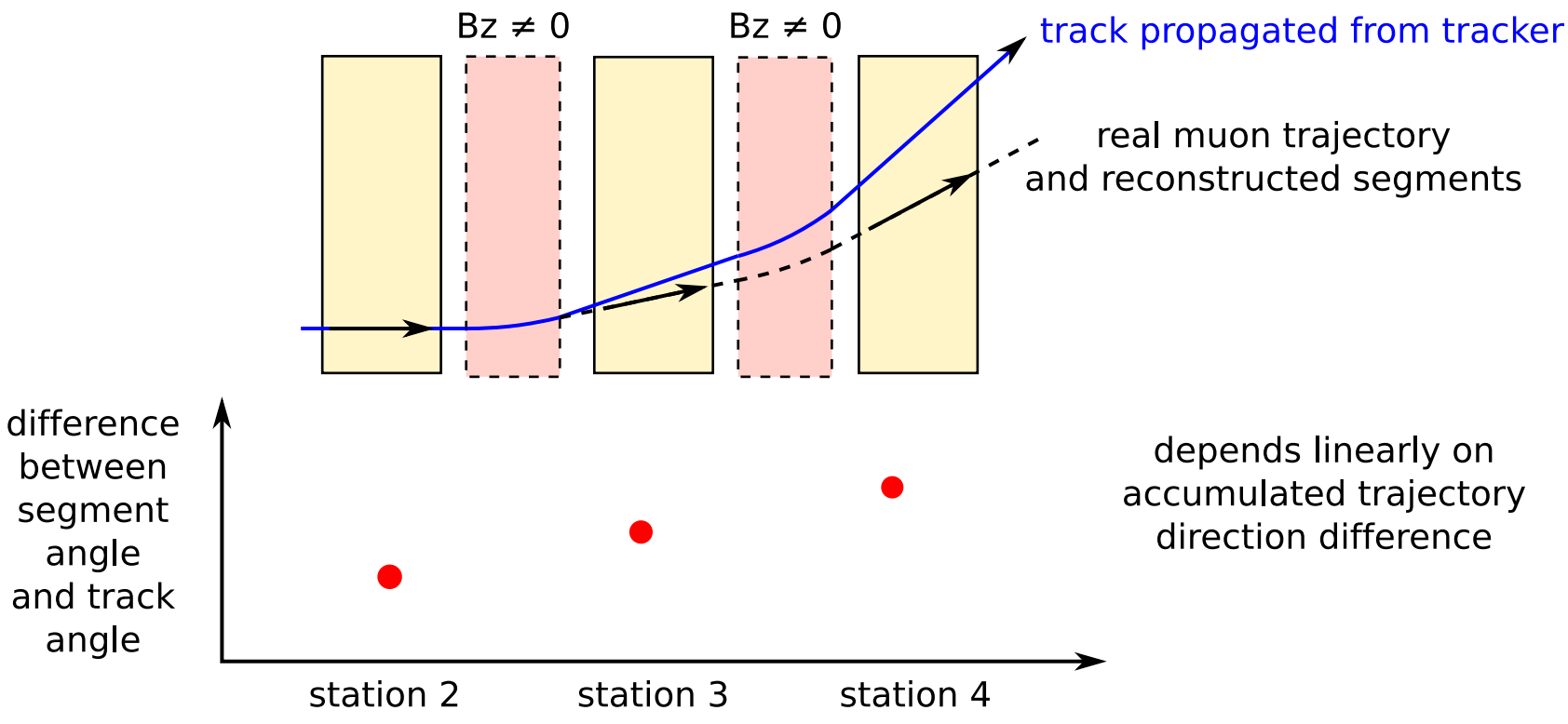
Jim Pivarski

Texas A&M University

30 June, 2009

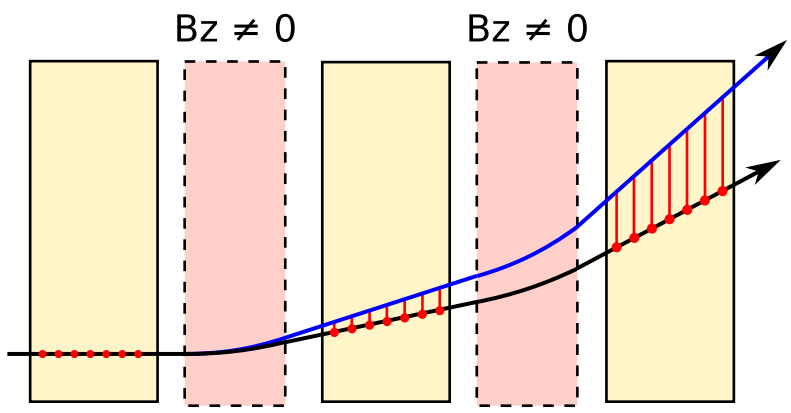
Reminder

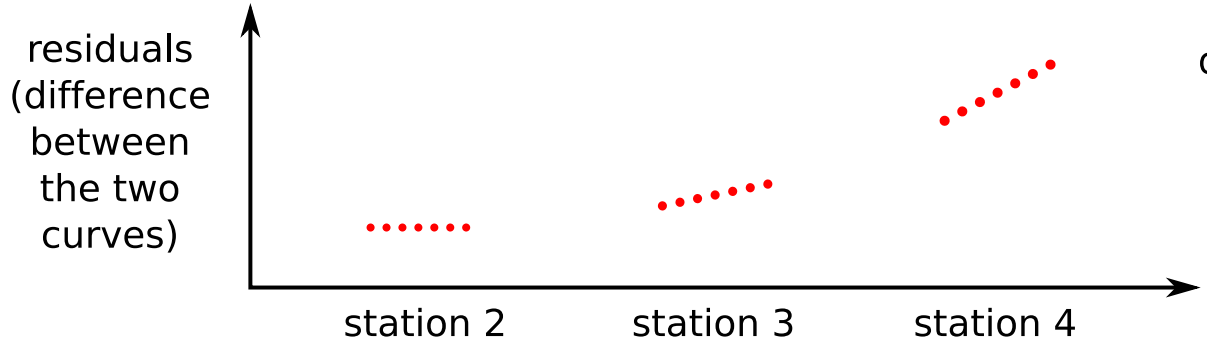
- Easiest to measure magnetic field from *angle* residuals
- Deviation between propagated track and true muon path grows linearly in regions of wrong $\vec{B}(\vec{x})$



Reminder

- Also possible to see the effect in *position* residuals
- Deviation in position is an integral of the deviation in angle
- More sensitive, but more difficult to interpret

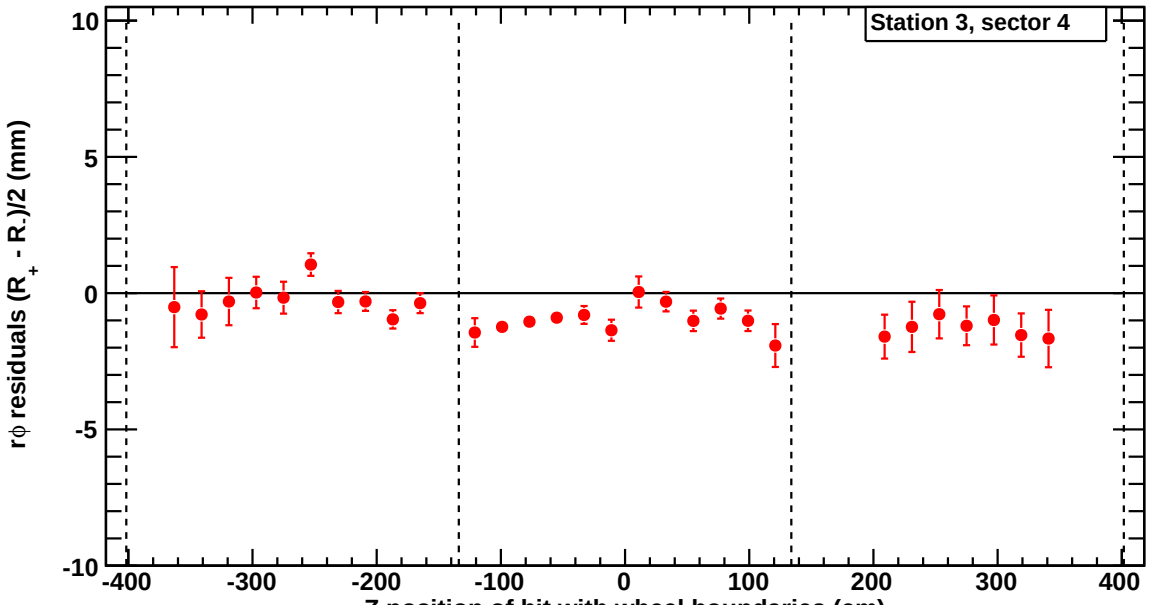




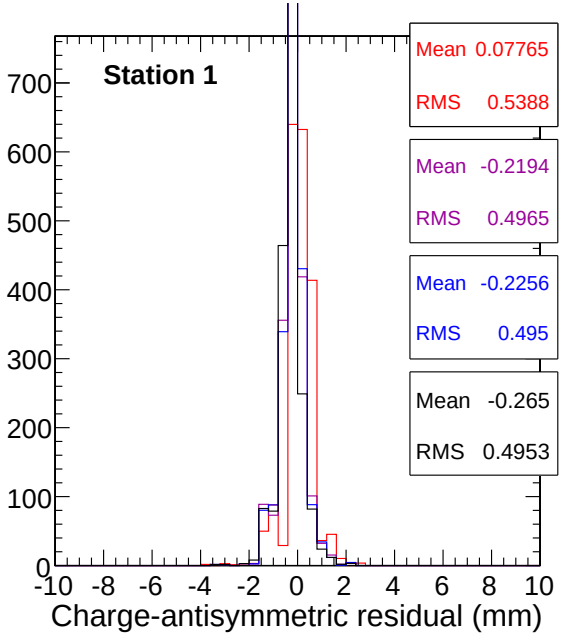
depends quadratically on Bz difference between stations and linearly on accumulated trajectory direction difference

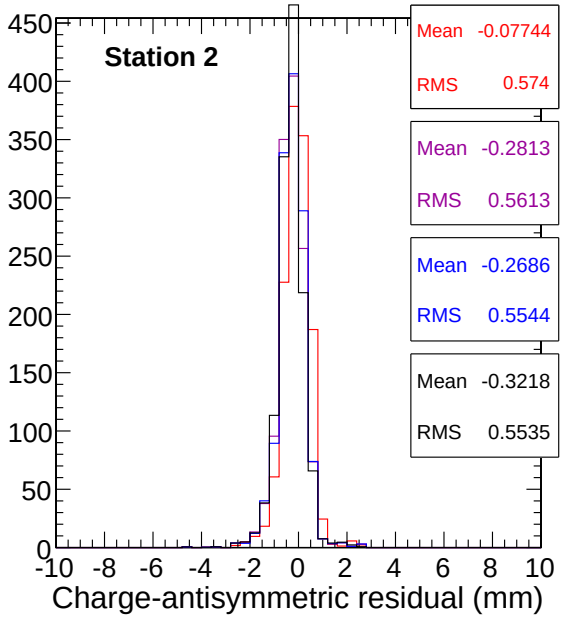
Reminder

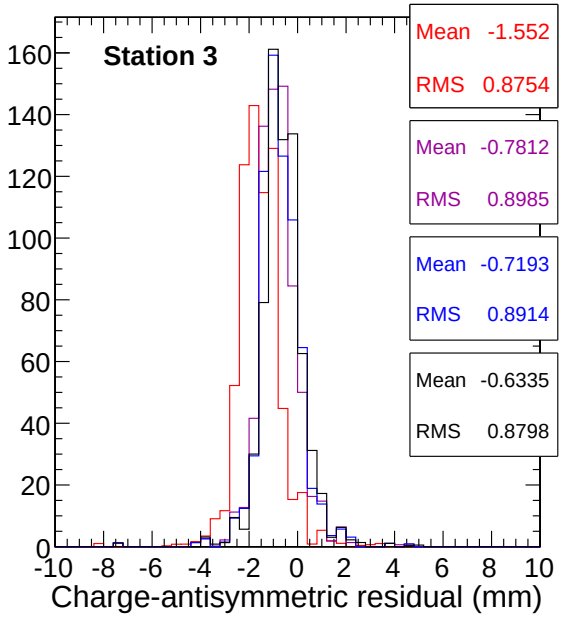
- In either case, magnetic field affects positively and negatively-charged particles in opposite ways, while misalignment affects both equally
- To be insensitive to any misalignment, we plot residuals from positively-charged tracks (R_+) minus residuals from negatively-charged tracks (R_-) over 2
- This can't be performed on individual tracks: it must be binned into geographical regions
- 1 region = $1/12^{\text{th}}$ of a single chamber in z (22 cm)

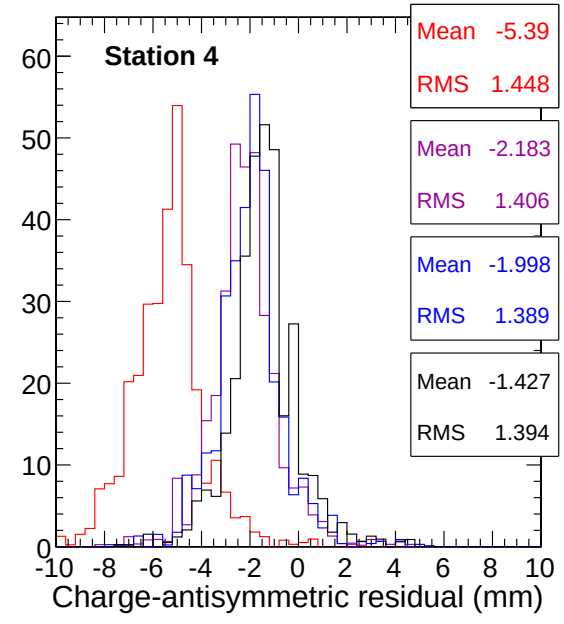


Results for $40 < p_T < 50$ GeV









- Histograms of charge differences (one entry per "geographical region")
- Color code:

  red: original map

  purple: radius $\rightarrow$ 30 m

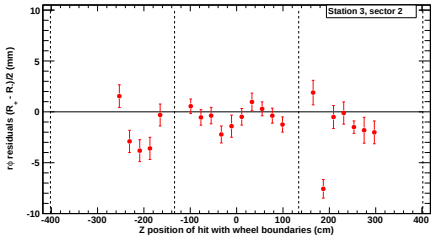
  blue: radius and $|z|$ $\rightarrow$ 30 m

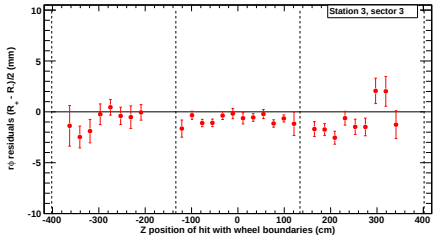
  black: with scaling factors, for 3_1_X
- Final map is not perfectly centered

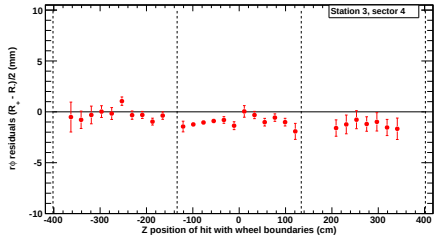
(Calculation includes latest tracker, muon alignment, and CMSSW version)

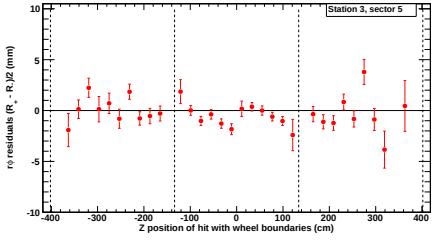
Individual bins vs. z

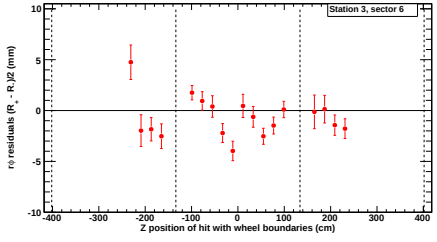
Station 3 (positive − negative)/2 versus z

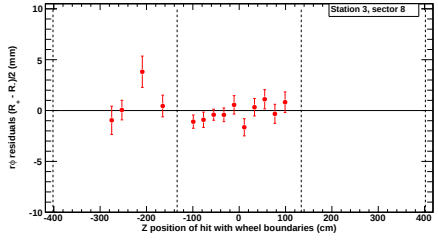
2. 

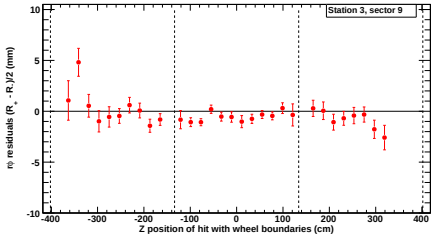
3. 

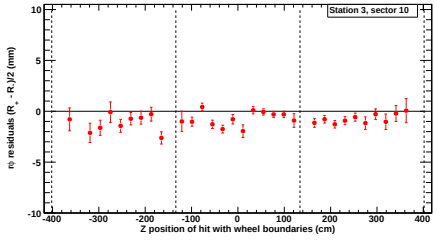
4. 

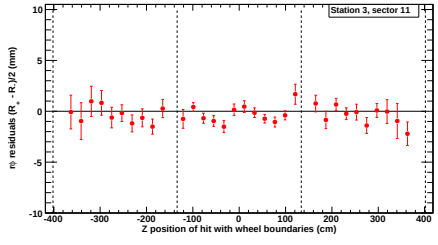
5. 

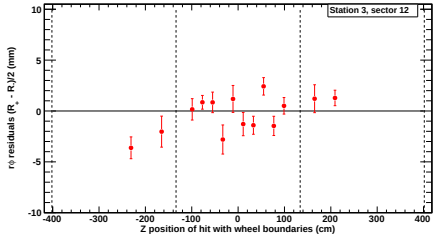
6. 

8. 

9. 

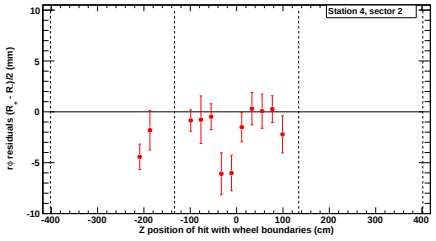
10. 

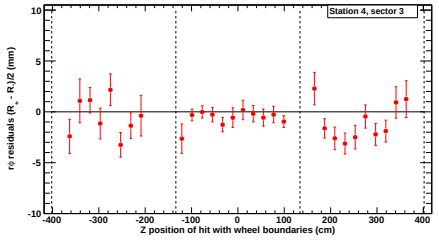
11. 

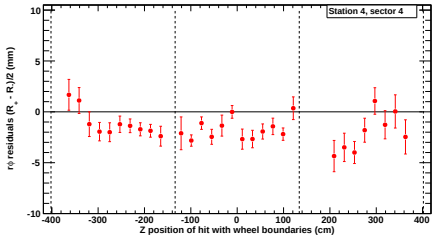
12. 

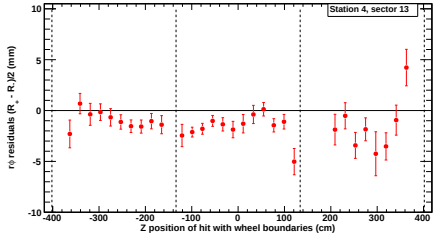
Individual bins vs. z

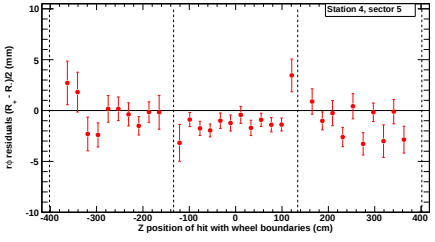
Station 4 (positive − negative)/2 versus z

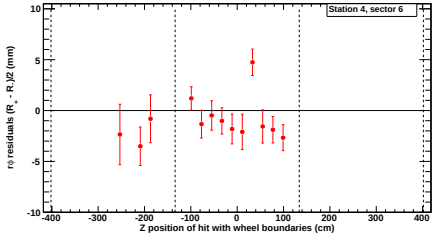
2. 

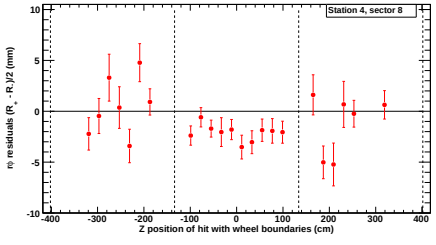
3. 

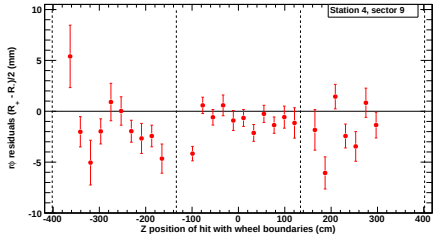
4. 

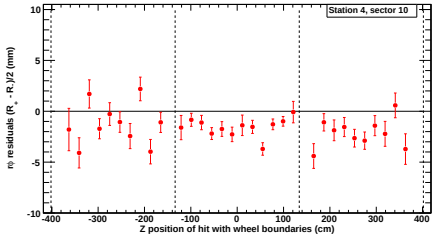
13. 

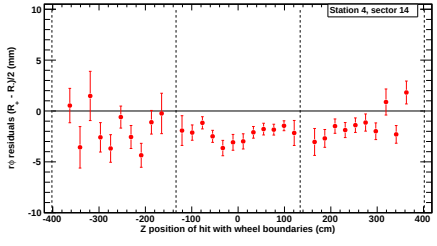
5. 

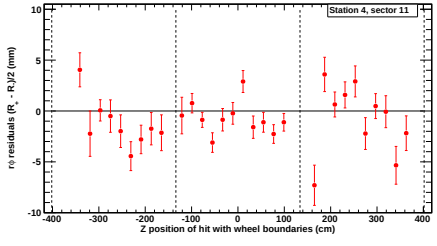
6. 

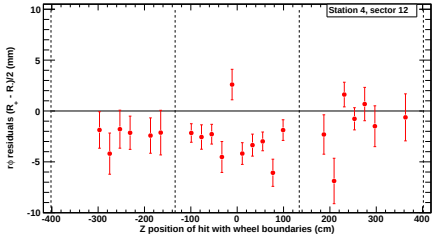
8. 

9. 

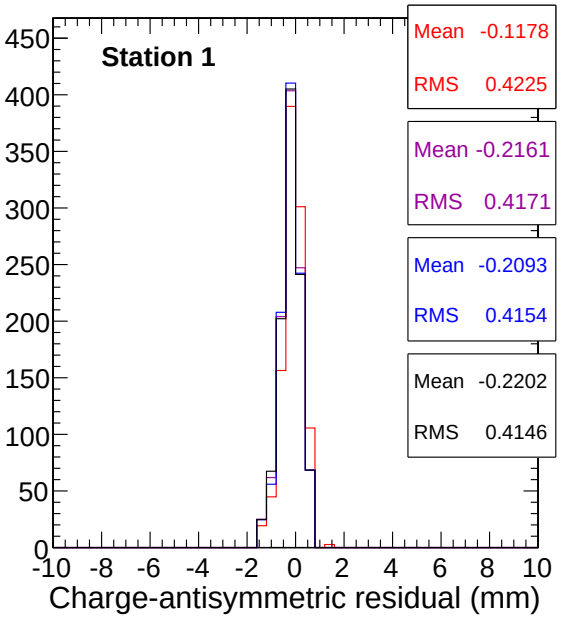
10. 

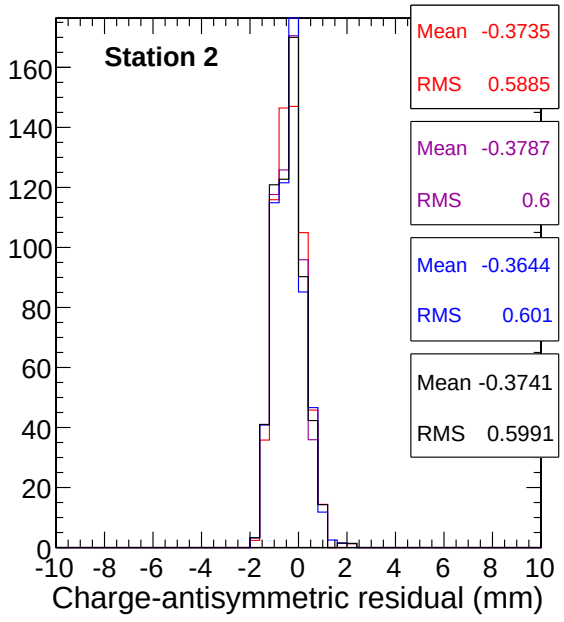
14. 

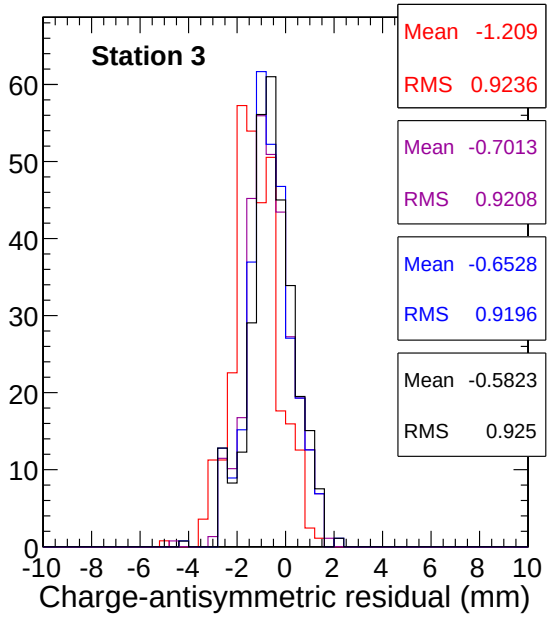
11. 

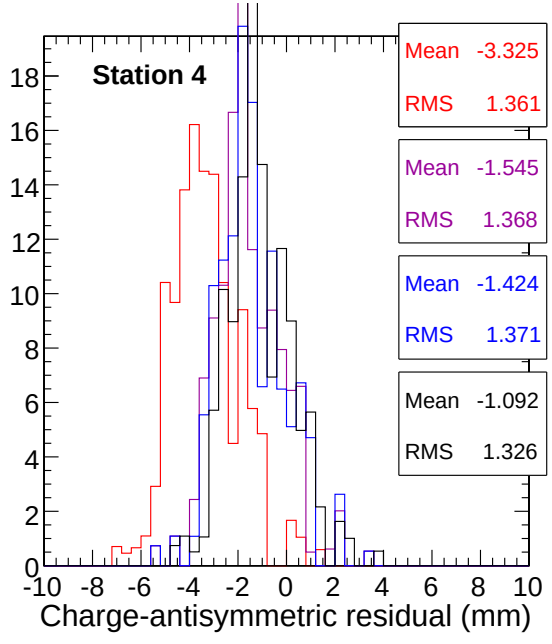
12. 

Results for $90 < p_T < 100$ GeV









- Same as before, with a higher p_T cut
- Color code:

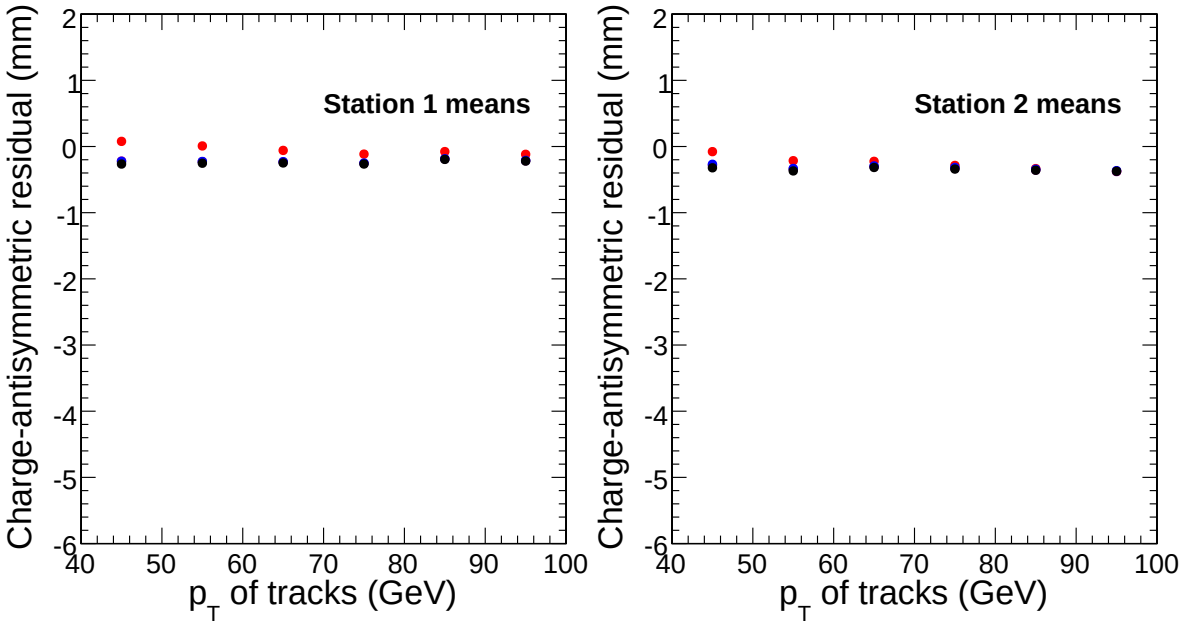
  red: original map

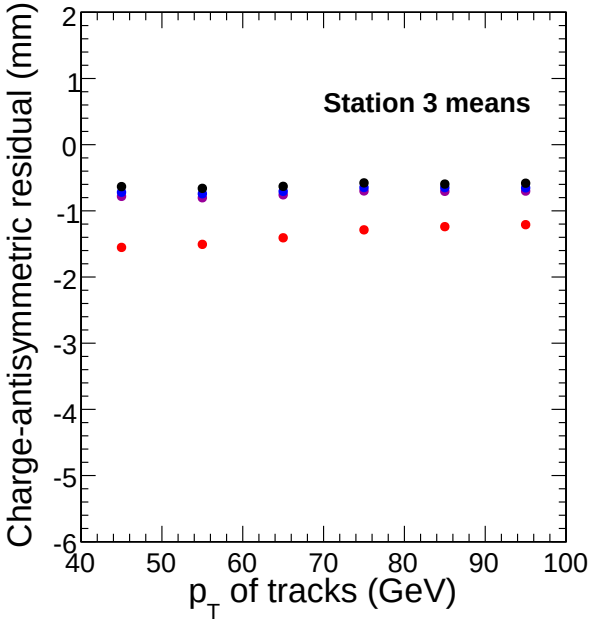
  purple: radius $\longrightarrow$ 30 m

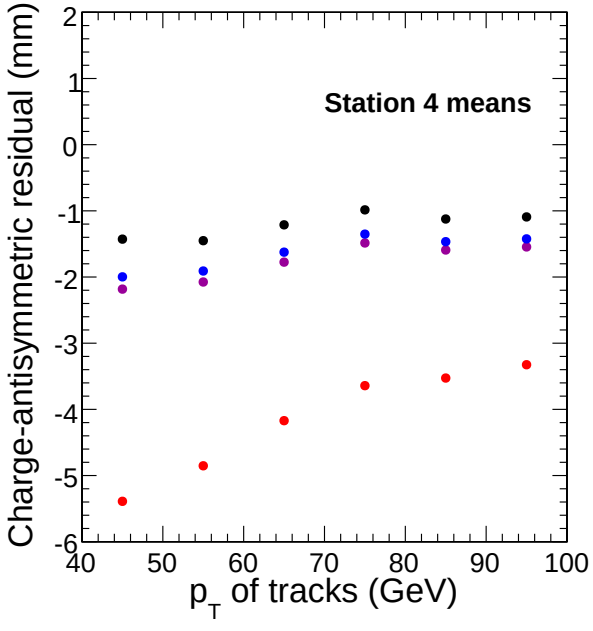
  blue: radius and $|z|$ $\longrightarrow$ 30 m

  black: with scaling factors, for 3_1_X
- Same conclusion: final map not perfectly centered

Results as a function of p_T







- Do the same thing in equally-sized p_T bins, plot the mean of each histogram here
- Color code:

  red: original map

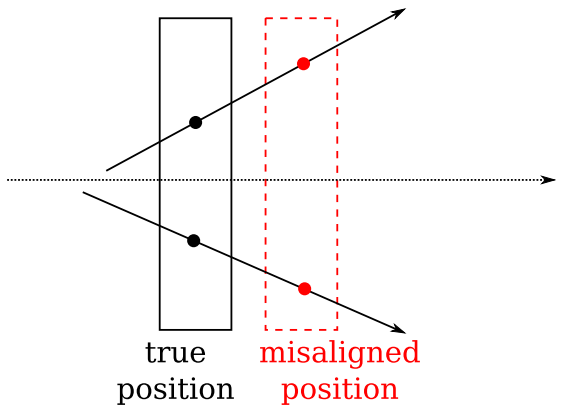
  purple: radius $\longrightarrow$ 30 m

  blue: radius and $|z|$ $\longrightarrow$ 30 m

  black: with scaling factors, for 3_1_X
- $\vec{B}$-field effects must decrease as $1/p_T$, but after original map, everything's flat!
- dE/dx falls off faster: $1/{p_T}^2$

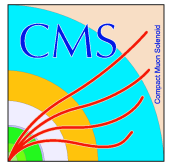
Why the constant offset?

- Difference between R_+ and R_- is 2 mm in station 4, but roughly constant with respect to p_T
  - independence of p_T rules out the usual suspects: $\vec{B}$ and dE/dx
- Charge and entrance angle should be correlated
- Misalignment in local z can yield opposite position residuals for opposite entrance angles



  - local z was corrected for all chambers except station 4
  - local z alignment fit included contributions from y residuals and y entrance angles, as well as x residuals and x entrance angles: in this study, we're only looking at x residuals and angles

Why the constant offset?



- Also, "sawtooth" effect manifests itself as x residuals versus x entrance angles (but not y)
- So perhaps this is something we've seen before; the new part is that entrance angles are correlated with charges, so the biases vs. entrance angle become biases wth respect to charge

Conclusions

- Charge-antisymmetric residuals are not zero with the latest map
- But they do not indicate any problems in the magnetic field
  - sensitive to errors in original map, but not any other maps
- We now have some ideas as to what might be wrong (new manifestation of an old problem?)