

Normal fitting method

- ▶ One chamber at a time, use all information for all degrees of freedom (except δ_{ϕ_x})
- ▶ Resolution limited by the small ranges of $\frac{dy}{dz}$ and $\frac{dx}{dz}$
- ▶ $\Delta x / \frac{dx}{dz}$ is antisymmetric with charge, hard to distinguish from \vec{B}

Single chamber fit:

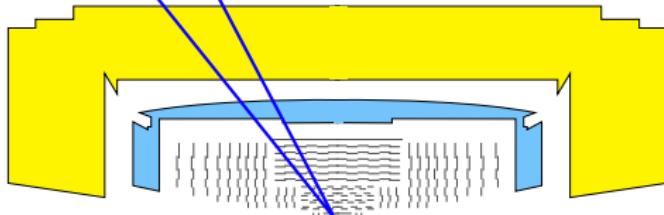
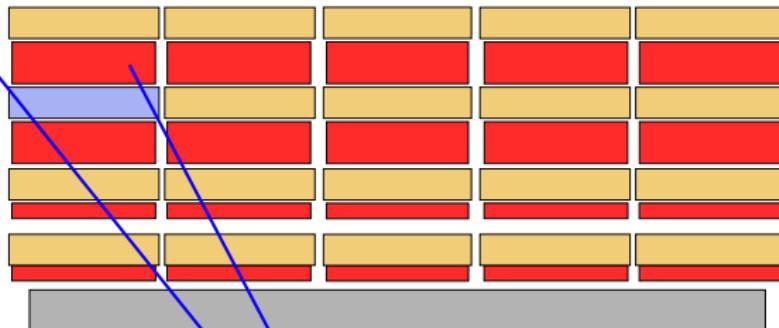
dy/dz range: about 0.15 rad
and can be asymmetric
 dx/dz range: about 0.5 rad
but symmetric

$$\Delta z = \Delta y / (dy/dz) \text{ from SL2}$$

$$\Delta z = \Delta x / (dx/dz) \text{ from SL1&3}$$

Overconstrained: final z position is a weighted average
of z determined from SL2
and z determined from SL1&3

Local coordinates
for chambers depicted



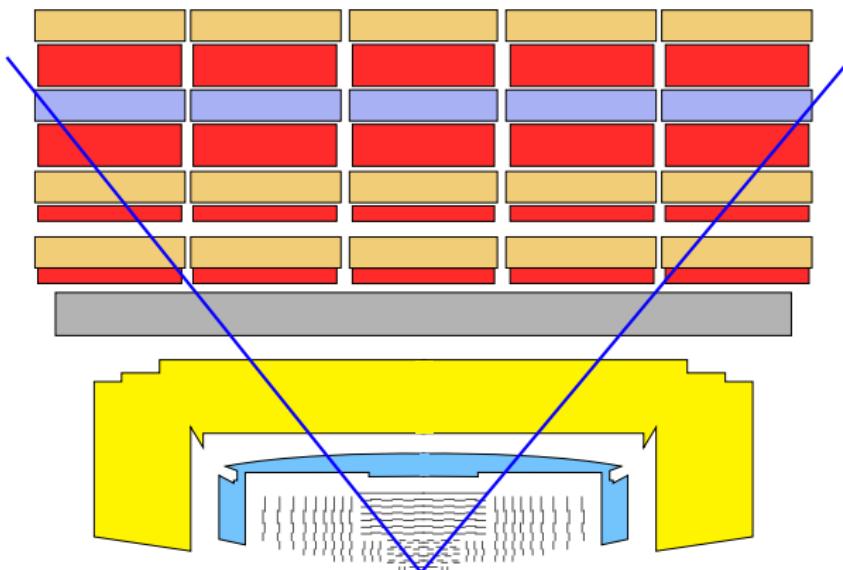
Alternative under consideration

- ▶ First fit δ_z for all wheels in same sector and station (SemiSuperSector)
- ▶ Then align one chamber at a time, keeping δ_z (and δ_{ϕ_x}) fixed
- ▶ Huge range in $\frac{dy}{dz}$ would yield more precise result
- ▶ Assumes hardware alignment has made all five δ_z values consistent!

SemiSuperSector fit:
dy/dz range: about $\pi/2$
and symmetric

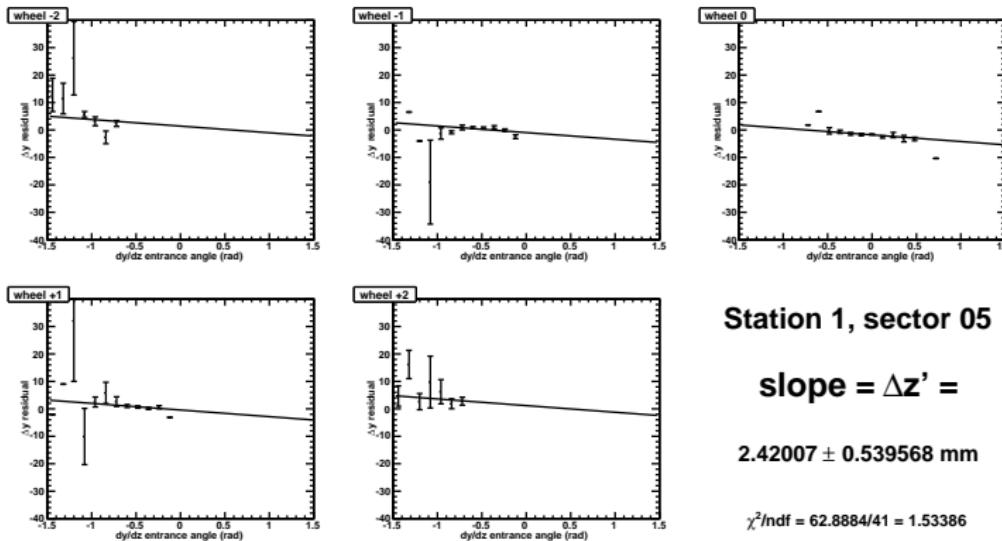
$\Delta z = \Delta y / (dy/dz)$ from SL2

Final z position comes from
SL2 only. Correct placement
of SL1&3 depends on
internal DT alignment.



Fit method

- ▶ Start with Δy residual vs. $\frac{dy}{dz}$ entrance angle plots with only hardware alignment and global adjustment applied: at most 5 plots (some plots are not available; they're taken from other diagnostics)
- ▶ Fit them all with a single function: linear with the same slope (same δ_z), but potentially different intercepts (different δ_y)
- ▶ Careful with signs! (y and $\frac{dy}{dz}$ flip for wheels +1, +2 and some wheel 0)



Station 1, sector 05

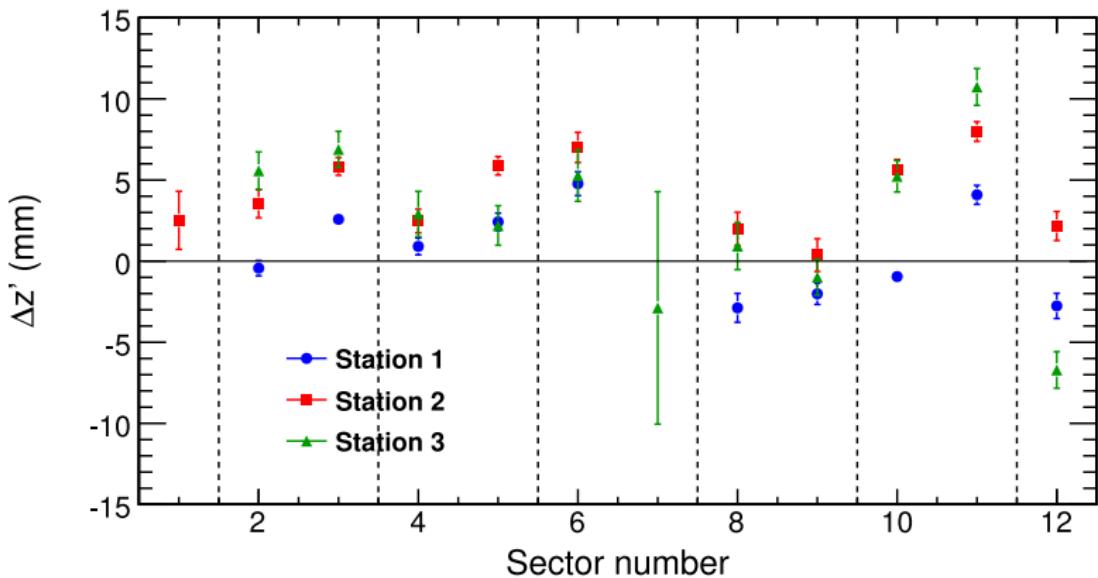
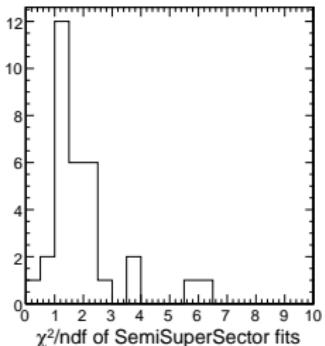
$$\text{slope} = \Delta z' =$$

$$2.42007 \pm 0.539568 \text{ mm}$$

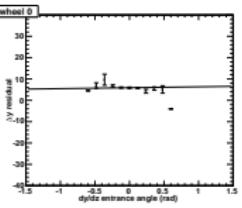
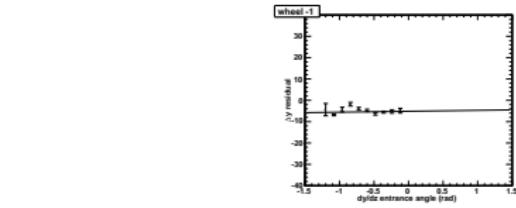
$$\chi^2/\text{ndf} = 62.8884/41 = 1.53386$$

Summary of fit results

- ▶ χ^2 are reasonable (all wheels in each sector are roughly consistent)
- ▶ Semi-regular pattern inside all of the SuperSectors (dashed lines)
- ▶ Individual fits on the pages that follow



Station 1, sector 2

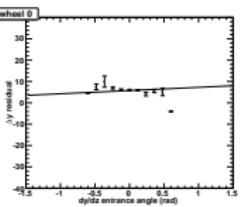
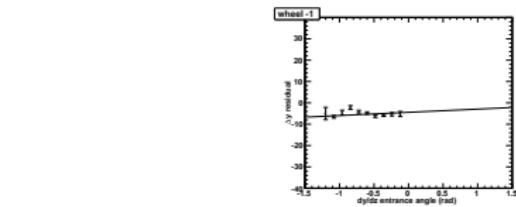
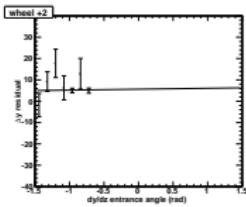
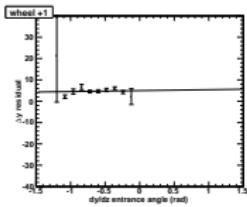


Station 1, sector 02

$$\text{slope} = \Delta z' =$$

$$-0.434594 \pm 0.469855 \text{ mm}$$

$$\chi^2/\text{ndf} = 76.5946/36 = 2.12763$$



Station 1, sector 02

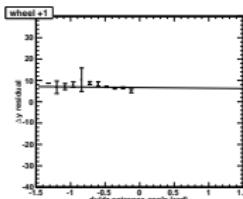
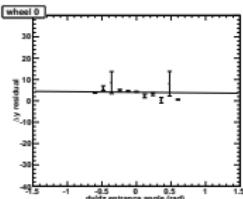
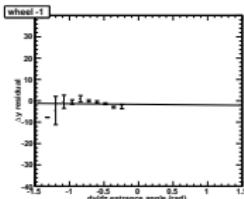
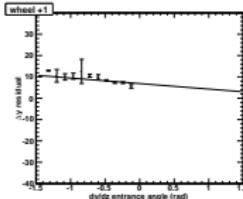
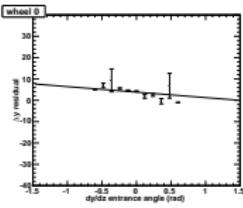
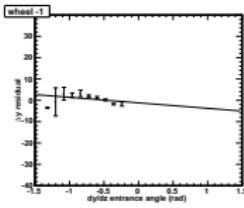
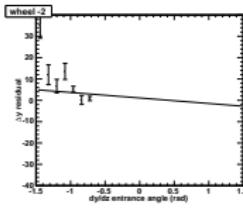
$$\text{slope} = \Delta z' =$$

$$-1.50812 \pm 0.28411 \text{ mm}$$

$$\chi^2/\text{ndf} = 92.0944/37 = 2.48904$$

- ▶ Top: before
Bottom: after
- ▶ Five panels are wheels in the same SemiSuperSector (some are missing)
- ▶ Fit requires all to have the same slope (δ_z), but allows different offsets (δ_y)
- ▶ This first one is a weak fit: keep going (to page 37)

Station 1, sector 3



Station 1, sector 03

$$\text{slope} = \Delta z' =$$

$$2.57632 \pm 0.287216 \text{ mm}$$

$$\chi^2/\text{ndf} = 132.094/36 = 3.66929$$

Station 1, sector 03

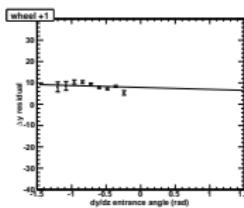
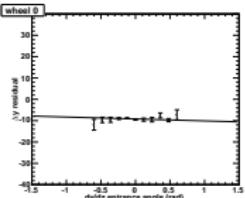
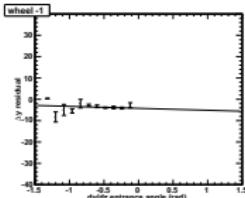
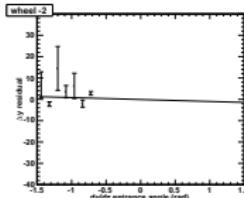
$$\text{slope} = \Delta z' =$$

$$0.29923 \pm 0.313135 \text{ mm}$$

$$\chi^2/\text{ndf} = 91.2257/29 = 3.14571$$

- ▶ Top: before
Bottom: after
- ▶ Five panels are wheels in the same SemiSuperSector (some are missing)
- ▶ Fit requires all to have the same slope (δ_z), but allows different offsets (δ_y)

Station 1, sector 4

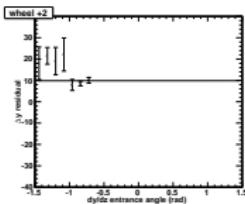
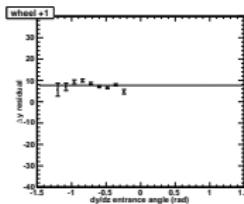
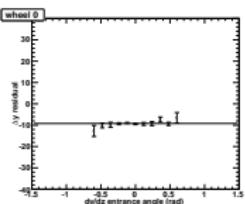
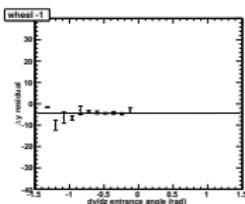
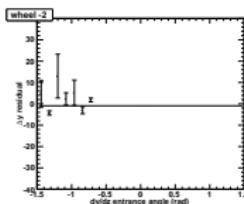


Station 1, sector 04

$$\text{slope} = \Delta z' =$$

$$0.908499 \pm 0.521405 \text{ mm}$$

$$\chi^2/\text{ndf} = 77.3101/37 = 2.08946$$



Station 1, sector 04

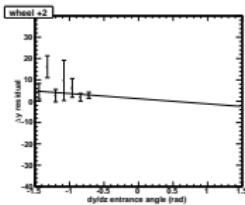
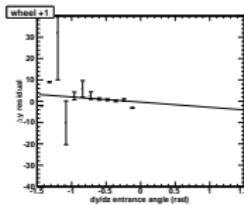
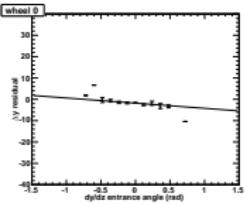
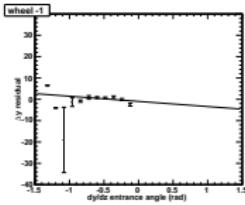
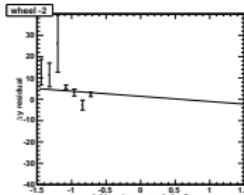
$$\text{slope} = \Delta z' =$$

$$-0.00283526 \pm 0.517298 \text{ mm}$$

$$\chi^2/\text{ndf} = 104.58/44 = 2.37683$$

- ▶ Top: before
Bottom: after
- ▶ Five panels are wheels in the same SemiSuperSector (some are missing)
- ▶ Fit requires all to have the same slope (δ_z), but allows different offsets (δ_y)

Station 1, sector 5

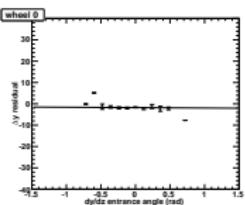
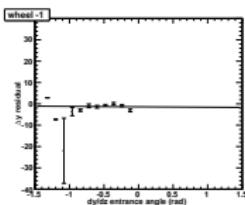
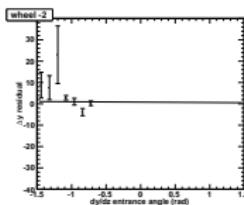


Station 1, sector 05

$$\text{slope} = \Delta z' =$$

$$2.42007 \pm 0.539568 \text{ mm}$$

$$\chi^2/\text{ndf} = 62.8884/41 = 1.53386$$



Station 1, sector 05

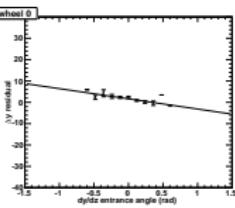
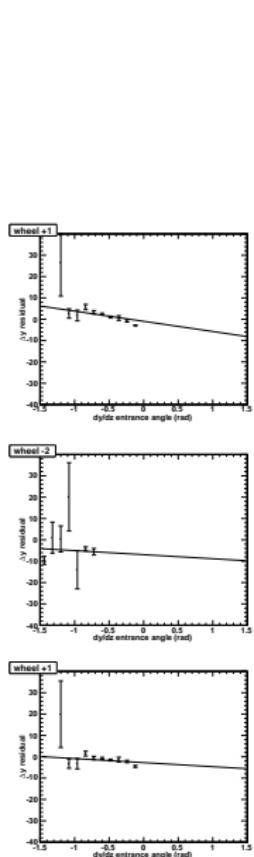
$$\text{slope} = \Delta z' =$$

$$0.190278 \pm 0.533261 \text{ mm}$$

$$\chi^2/\text{ndf} = 66.9834/41 = 1.63374$$

- ▶ Top: before
Bottom: after
- ▶ Five panels are wheels in the same SemiSuperSector (some are missing)
- ▶ Fit requires all to have the same slope (δ_z), but allows different offsets (δ_y)

Station 1, sector 6



Station 1, sector 06

$$\text{slope} = \Delta z' =$$

$$4.77264 \pm 0.735628 \text{ mm}$$

$$\chi^2/\text{ndf} = 34.0875/27 = 1.2625$$

- ▶ Top: before
Bottom: after
- ▶ Five panels are wheels in the same SemiSuperSector (some are missing)
- ▶ Fit requires all to have the same slope (δ_z), but allows different offsets (δ_y)
- ▶ In general, fits are poor near the horizontals (sectors 1 and 7)

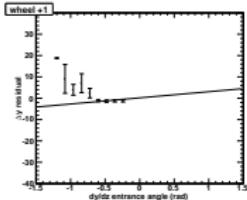
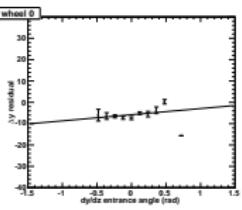
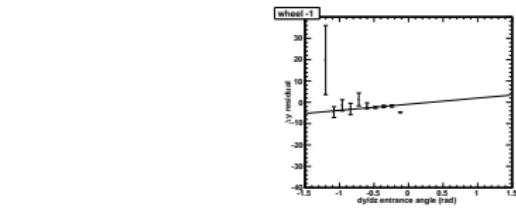
Station 1, sector 06

$$\text{slope} = \Delta z' =$$

$$1.90158 \pm 0.625639 \text{ mm}$$

$$\chi^2/\text{ndf} = 74.6173/35 = 2.13192$$

Station 1, sector 8

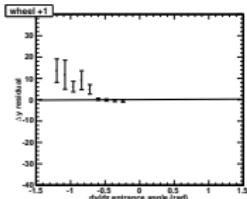
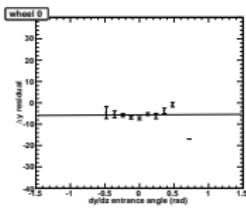
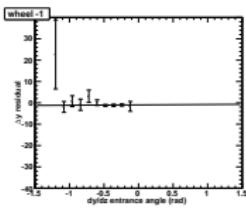


Station 1, sector 08

$$\text{slope} = \Delta z' =$$

$$-2.87993 \pm 0.892183 \text{ mm}$$

$$\chi^2/\text{ndf} = 58.1213/26 = 2.23543$$



Station 1, sector 08

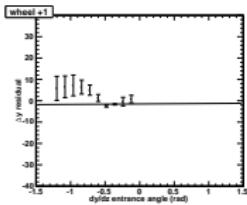
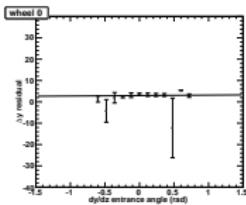
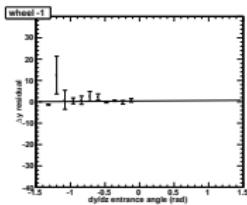
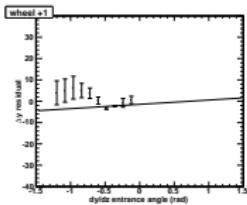
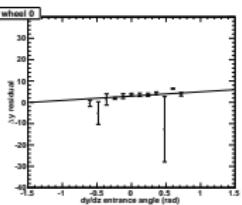
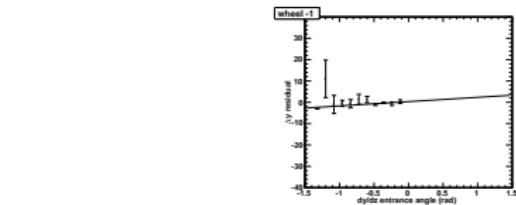
$$\text{slope} = \Delta z' =$$

$$-0.175058 \pm 0.862482 \text{ mm}$$

$$\chi^2/\text{ndf} = 66.6412/28 = 2.38004$$

- ▶ Top: before
Bottom: after
- ▶ Five panels are wheels in the same SemiSuperSector (some are missing)
- ▶ Fit requires all to have the same slope (δ_z), but allows different offsets (δ_y)

Station 1, sector 9



Station 1, sector 09

$$\text{slope} = \Delta z' =$$

$$-2.01531 \pm 0.654374 \text{ mm}$$

$$\chi^2/\text{ndf} = 49.6764/31 = 1.60247$$

Station 1, sector 09

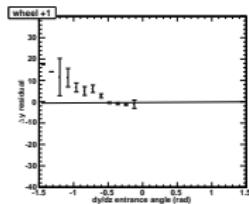
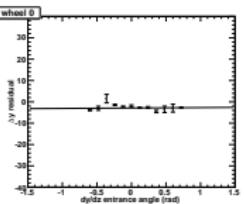
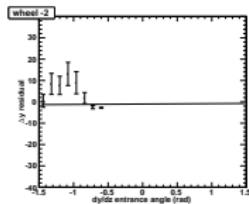
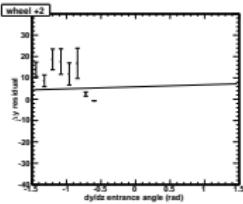
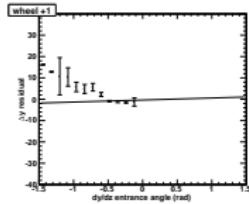
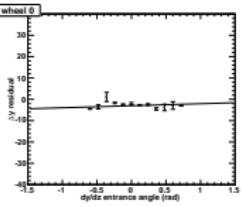
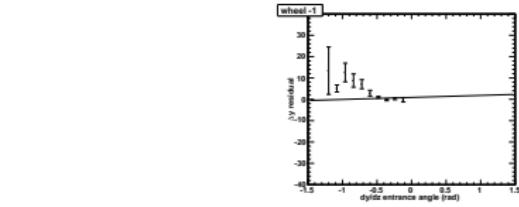
$$\text{slope} = \Delta z' =$$

$$-0.213737 \pm 0.653511 \text{ mm}$$

$$\chi^2/\text{ndf} = 45.8388/31 = 1.47867$$

- ▶ Top: before
Bottom: after
- ▶ Five panels are wheels in the same SemiSuperSector (some are missing)
- ▶ Fit requires all to have the same slope (δ_z), but allows different offsets (δ_y)

Station 1, sector 10



Station 1, sector 10

$$\text{slope} = \Delta z' =$$

$$-0.952277 \pm 0.298596 \text{ mm}$$

$$\chi^2/\text{ndf} = 224.395/38 = 5.90513$$

Station 1, sector 10

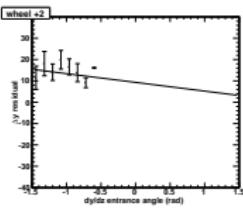
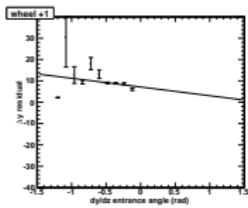
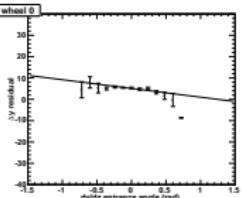
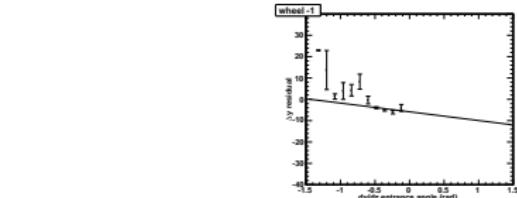
$$\text{slope} = \Delta z' =$$

$$-0.195354 \pm 0.303695 \text{ mm}$$

$$\chi^2/\text{ndf} = 214.8/38 = 5.65264$$

- ▶ Top: before
Bottom: after
- ▶ Five panels are wheels in the same SemiSuperSector (some are missing)
- ▶ Fit requires all to have the same slope (δ_z), but allows different offsets (δ_y)

Station 1, sector 11

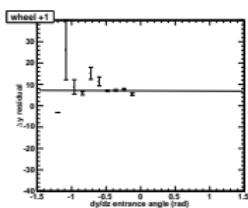
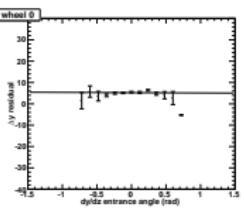


Station 1, sector 11

$$\text{slope} = \Delta z' =$$

$$4.08622 \pm 0.58441 \text{ mm}$$

$$\chi^2/\text{ndf} = 82.1895/38 = 2.16288$$



Station 1, sector 11

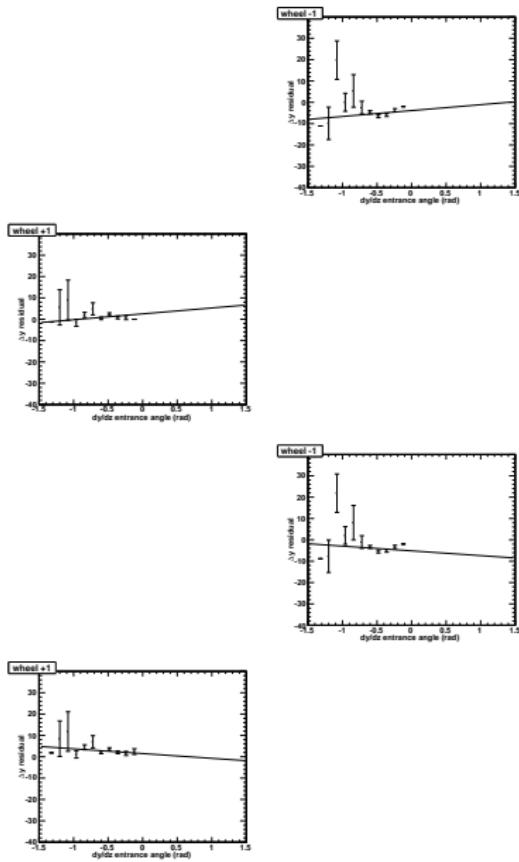
$$\text{slope} = \Delta z' =$$

$$0.127537 \pm 0.572981 \text{ mm}$$

$$\chi^2/\text{ndf} = 78.1685/31 = 2.52156$$

- ▶ Top: before
Bottom: after
- ▶ Five panels are wheels in the same SemiSuperSector (some are missing)
- ▶ Fit requires all to have the same slope (δ_z), but allows different offsets (δ_y)

Station 1, sector 12



Station 1, sector 12

$$\text{slope} = \Delta z' =$$

$$-2.7606 \pm 0.776937 \text{ mm}$$

$$\chi^2/\text{ndf} = 46.375/27 = 1.71759$$

Station 1, sector 12

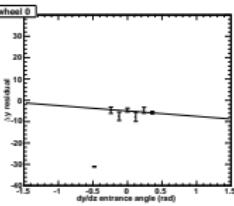
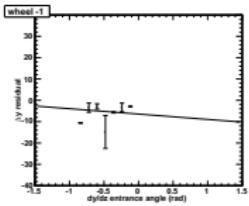
$$\text{slope} = \Delta z' =$$

$$2.22775 \pm 1.30432 \text{ mm}$$

$$\chi^2/\text{ndf} = 31.4639/19 = 1.65599$$

- ▶ Top: before
Bottom: after
- ▶ Five panels are wheels in the same SemiSuperSector (some are missing)
- ▶ Fit requires all to have the same slope (δ_z), but allows different offsets (δ_y)

Station 2, sector 1

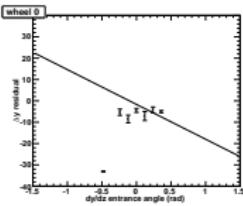


Station 2, sector 01

$$\text{slope} = \Delta z' =$$

$$2.51437 \pm 1.79013 \text{ mm}$$

$$\chi^2/\text{ndf} = 10.3635/11 = 0.942133$$

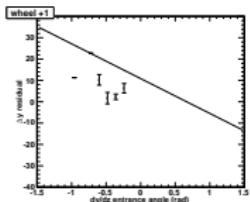


Station 2, sector 01

$$\text{slope} = \Delta z' =$$

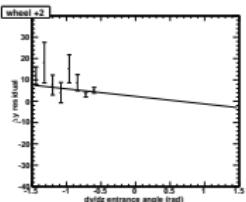
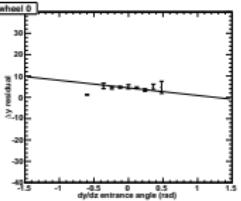
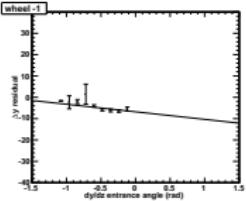
$$16.2998 \pm 1.58382 \text{ mm}$$

$$\chi^2/\text{ndf} = 284.236/11 = 25.8397$$



- Top: before
Bottom: after
- Five panels are wheels in the same SemiSuperSector (some are missing)
- Fit requires all to have the same slope (δ_z), but allows different offsets (δ_y)

Station 2, sector 2

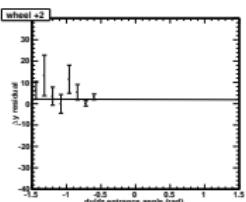
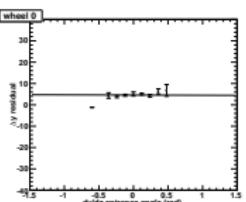
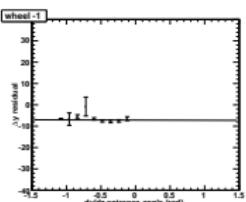


Station 2, sector 02

$$\text{slope} = \Delta z' =$$

$$3.54316 \pm 0.868119 \text{ mm}$$

$$\chi^2/\text{ndf} = 26.5607/24 = 1.10669$$



Station 2, sector 02

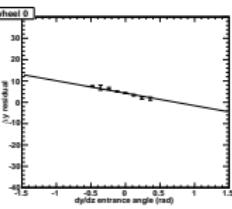
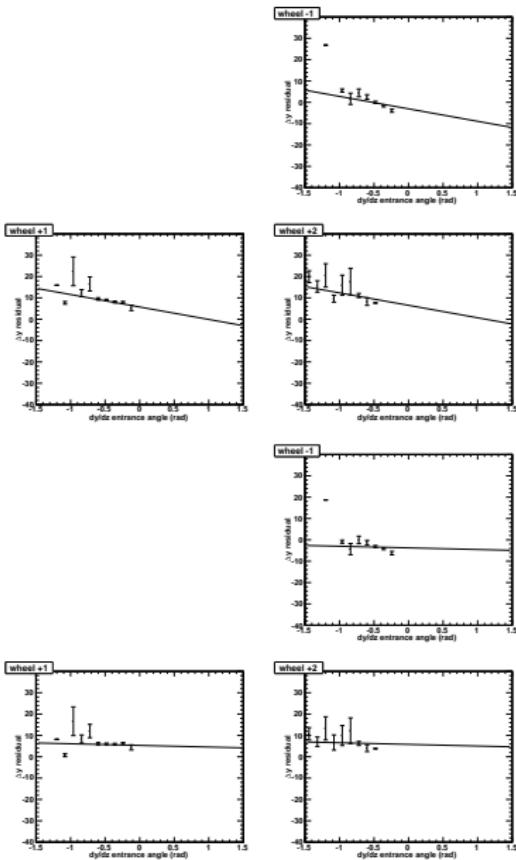
$$\text{slope} = \Delta z' =$$

$$0.094574 \pm 0.861871 \text{ mm}$$

$$\chi^2/\text{ndf} = 23.9063/24 = 0.996095$$

- ▶ Top: before
Bottom: after
- ▶ Five panels are wheels in the same SemiSuperSector (some are missing)
- ▶ Fit requires all to have the same slope (δ_z), but allows different offsets (δ_y)

Station 2, sector 3

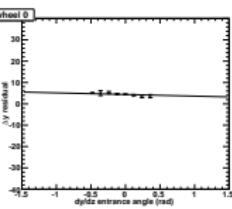


Station 2, sector 03

$$\text{slope} = \Delta z' =$$

$$5.83527 \pm 0.545298 \text{ mm}$$

$$\chi^2/\text{ndf} = 115.137/31 = 3.71409$$



Station 2, sector 03

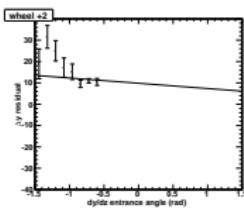
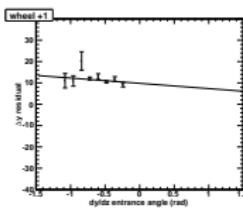
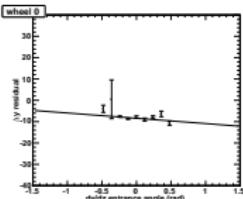
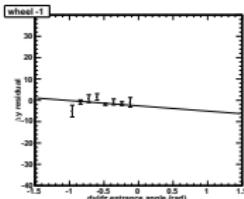
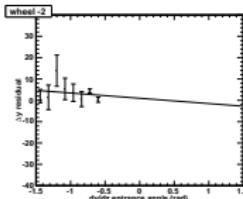
$$\text{slope} = \Delta z' =$$

$$0.767072 \pm 0.558168 \text{ mm}$$

$$\chi^2/\text{ndf} = 111.634/31 = 3.6011$$

- Top: before
Bottom: after
- Five panels are wheels in the same SemiSuperSector (some are missing)
- Fit requires all to have the same slope (δ_z), but allows different offsets (δ_y)

Station 2, sector 4

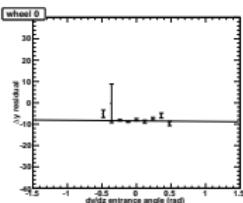
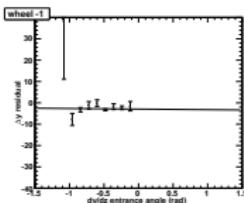
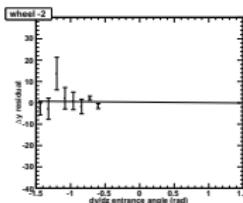


Station 2, sector 04

$$\text{slope} = \Delta z' =$$

$$2.47401 \pm 0.729157 \text{ mm}$$

$$\chi^2/\text{ndf} = 74.2187/41 = 1.81021$$



Station 2, sector 04

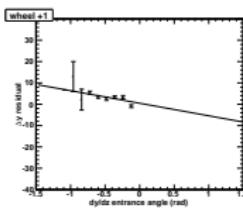
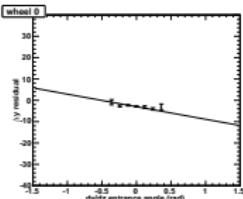
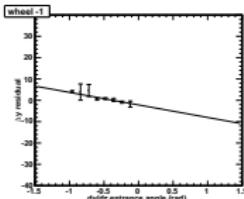
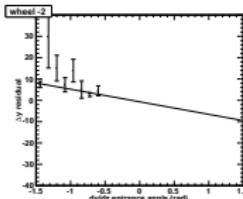
$$\text{slope} = \Delta z' =$$

$$0.276828 \pm 0.722121 \text{ mm}$$

$$\chi^2/\text{ndf} = 77.2557/42 = 1.83942$$

- ▶ Top: before
Bottom: after
- ▶ Five panels are wheels in the same SemiSuperSector (some are missing)
- ▶ Fit requires all to have the same slope (δ_z), but allows different offsets (δ_y)

Station 2, sector 5

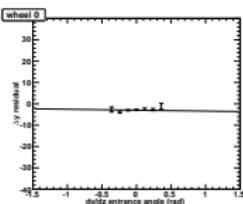
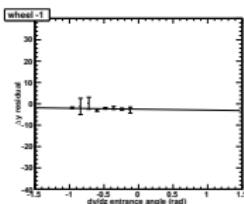
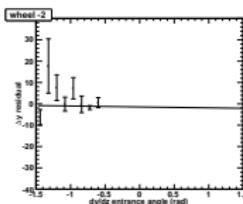


Station 2, sector 05

$$\text{slope} = \Delta z' =$$

$$5.87748 \pm 0.570468 \text{ mm}$$

$$\chi^2/\text{ndf} = 46.4638/31 = 1.49883$$



Station 2, sector 05

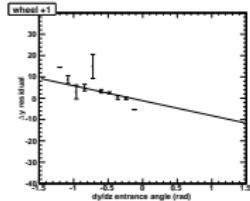
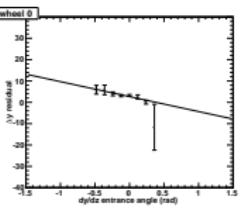
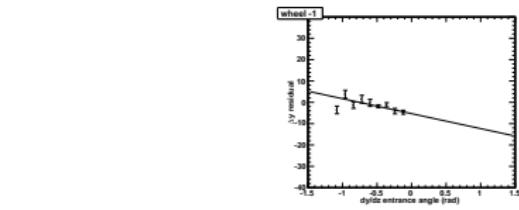
$$\text{slope} = \Delta z' =$$

$$0.434366 \pm 0.514702 \text{ mm}$$

$$\chi^2/\text{ndf} = 53.4815/32 = 1.6713$$

- ▶ Top: before
Bottom: after
- ▶ Five panels are wheels in the same SemiSuperSector (some are missing)
- ▶ Fit requires all to have the same slope (δ_z), but allows different offsets (δ_y)

Station 2, sector 6

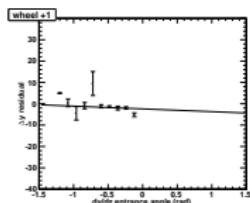
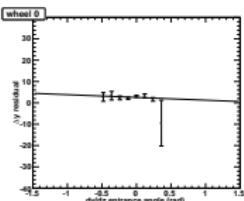
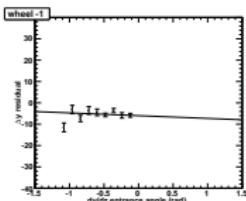


Station 2, sector 06

$$\text{slope} = \Delta z' =$$

$$7.0107 \pm 0.927952 \text{ mm}$$

$$\chi^2/\text{ndf} = 32.4696/25 = 1.29878$$



Station 2, sector 06

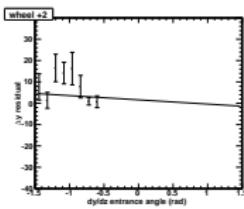
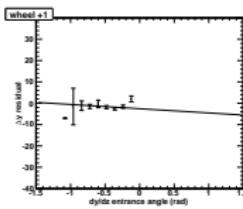
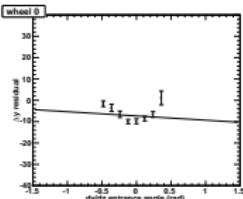
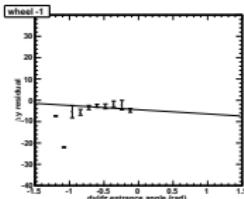
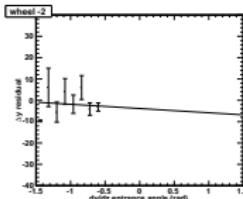
$$\text{slope} = \Delta z' =$$

$$1.28925 \pm 0.880518 \text{ mm}$$

$$\chi^2/\text{ndf} = 43.7277/26 = 1.68184$$

- ▶ Top: before
Bottom: after
- ▶ Five panels are wheels in the same SemiSuperSector (some are missing)
- ▶ Fit requires all to have the same slope (δ_z), but allows different offsets (δ_y)

Station 2, sector 8

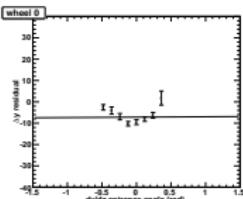
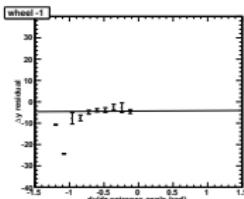
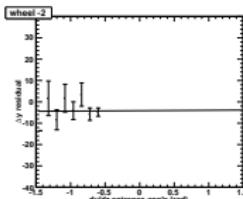


Station 2, sector 08

$$\text{slope} = \Delta z' =$$

$$1.98795 \pm 1.02251 \text{ mm}$$

$$\chi^2/\text{ndf} = 79.9526/39 = 2.05007$$



Station 2, sector 08

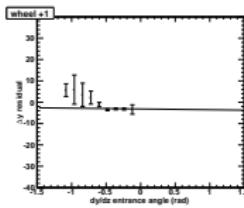
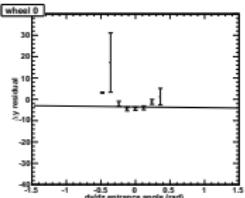
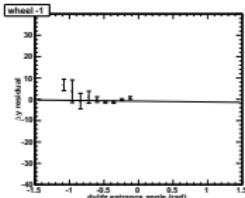
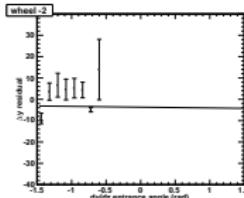
$$\text{slope} = \Delta z' =$$

$$-0.187277 \pm 1.00472 \text{ mm}$$

$$\chi^2/\text{ndf} = 84.2466/39 = 2.16017$$

- ▶ Top: before
Bottom: after
- ▶ Five panels are wheels in the same SemiSuperSector (some are missing)
- ▶ Fit requires all to have the same slope (δ_z), but allows different offsets (δ_y)

Station 2, sector 9

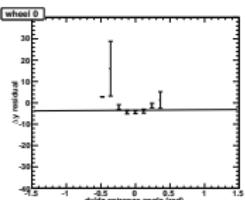
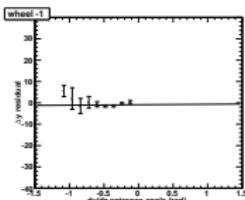
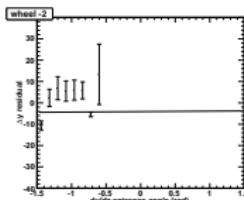


Station 2, sector 09

$$\text{slope} = \Delta z' =$$

$$0.371145 \pm 1.00728 \text{ mm}$$

$$\chi^2/\text{ndf} = 77.8135/33 = 2.35798$$



Station 2, sector 09

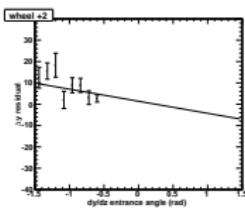
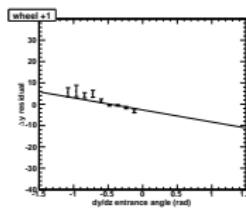
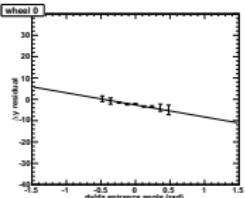
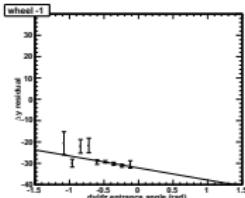
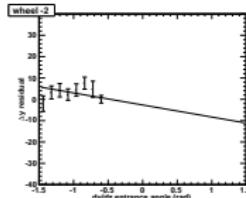
$$\text{slope} = \Delta z' =$$

$$-0.212102 \pm 0.987481 \text{ mm}$$

$$\chi^2/\text{ndf} = 83.198/33 = 2.52115$$

- ▶ Top: before
Bottom: after
- ▶ Five panels are wheels in the same SemiSuperSector (some are missing)
- ▶ Fit requires all to have the same slope (δ_z), but allows different offsets (δ_y)

Station 2, sector 10

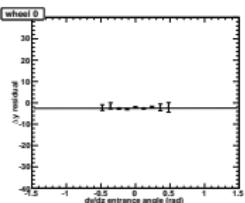
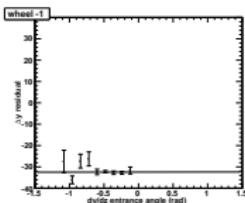
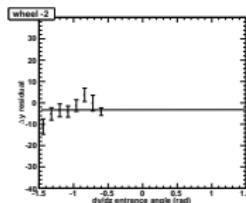


Station 2, sector 10

$$\text{slope} = \Delta z' =$$

$$5.65296 \pm 0.614076 \text{ mm}$$

$$\chi^2/\text{ndf} = 55.9142/43 = 1.30033$$



Station 2, sector 10

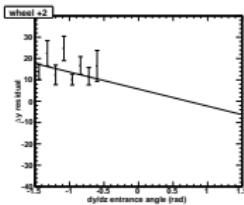
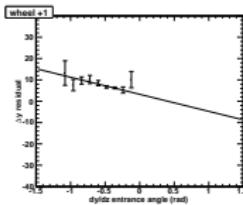
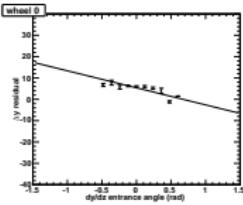
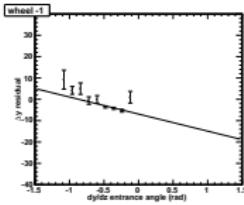
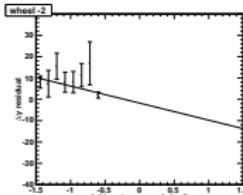
$$\text{slope} = \Delta z' =$$

$$-0.0355865 \pm 0.623822 \text{ mm}$$

$$\chi^2/\text{ndf} = 48.4672/35 = 1.38478$$

- ▶ Top: before
Bottom: after
- ▶ Five panels are wheels in the same SemiSuperSector (some are missing)
- ▶ Fit requires all to have the same slope (δ_z), but allows different offsets (δ_y)

Station 2, sector 11

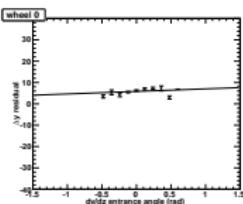
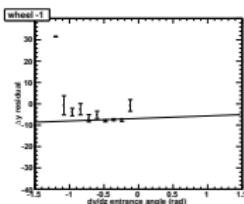
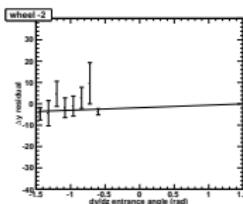


Station 2, sector 11

$$\text{slope} = \Delta z' =$$

$$7.98753 \pm 0.605413 \text{ mm}$$

$$\chi^2/\text{ndf} = 115.311/43 = 2.68165$$



Station 2, sector 11

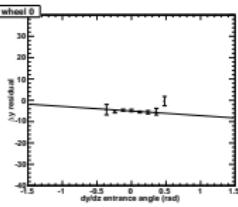
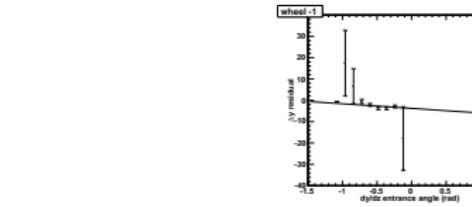
$$\text{slope} = \Delta z' =$$

$$-1.19017 \pm 0.669314 \text{ mm}$$

$$\chi^2/\text{ndf} = 84.0106/43 = 1.95373$$

- ▶ Top: before
Bottom: after
- ▶ Five panels are wheels in the same SemiSuperSector (some are missing)
- ▶ Fit requires all to have the same slope (δ_z), but allows different offsets (δ_y)

Station 2, sector 12

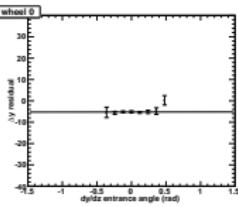
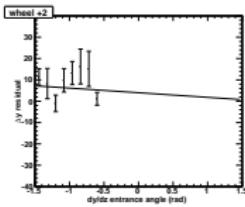
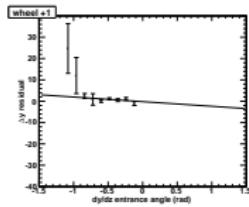


Station 2, sector 12

$$\text{slope} = \Delta z' =$$

2.16418 ± 0.893548 mm

$$\chi^2/\text{ndf} = 42.5265/33 = 1.28868$$



Station 2, sector 12

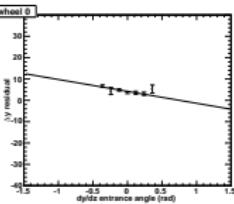
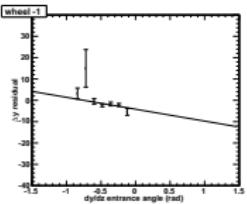
$$\text{slope} = \Delta z' =$$

-0.0232243 + 0.886183 mm

$$\chi^2/\text{ndf} = 42.2738/33 = 1.28102$$

- ▶ Top: before
Bottom: after
 - ▶ Five panels are wheels in the same SemiSuperSector (some are missing)
 - ▶ Fit requires all to have the same slope (δ_z), but allows different offsets (δ_y)

Station 3, sector 2

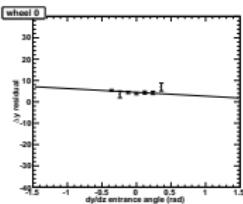
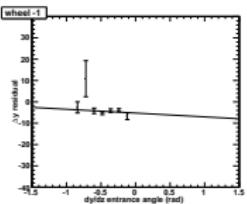


Station 3, sector 02

$$\text{slope} = \Delta z' =$$

$$5.57086 \pm 1.16088 \text{ mm}$$

$$\chi^2/\text{ndf} = 14.0177/14 = 1.00126$$

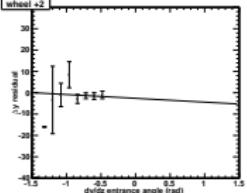


Station 3, sector 02

$$\text{slope} = \Delta z' =$$

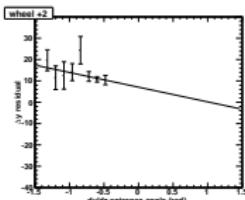
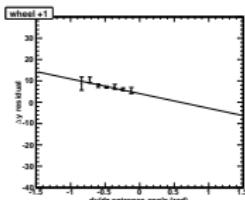
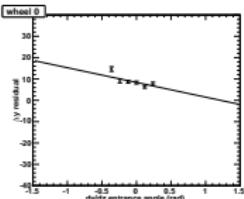
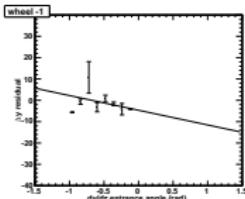
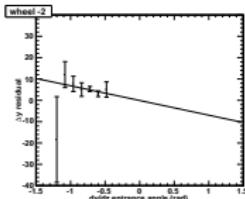
$$1.78362 \pm 0.912481 \text{ mm}$$

$$\chi^2/\text{ndf} = 19.3961/21 = 0.923622$$



- ▶ Top: before
Bottom: after
- ▶ Five panels are wheels in the same SemiSuperSector (some are missing)
- ▶ Fit requires all to have the same slope (δ_z), but allows different offsets (δ_y)

Station 3, sector 3

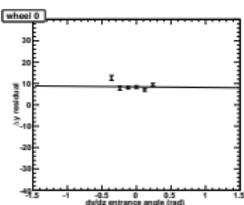
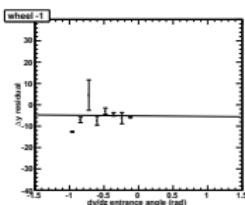
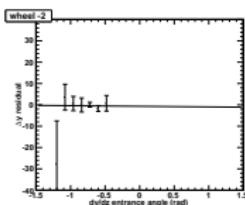


Station 3, sector 03

$$\text{slope} = \Delta z' =$$

$$6.88708 \pm 1.11681 \text{ mm}$$

$$\chi^2/\text{ndf} = 39.4651/34 = 1.16074$$



Station 3, sector 03

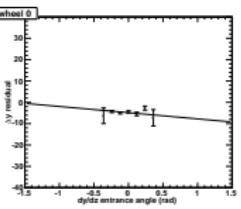
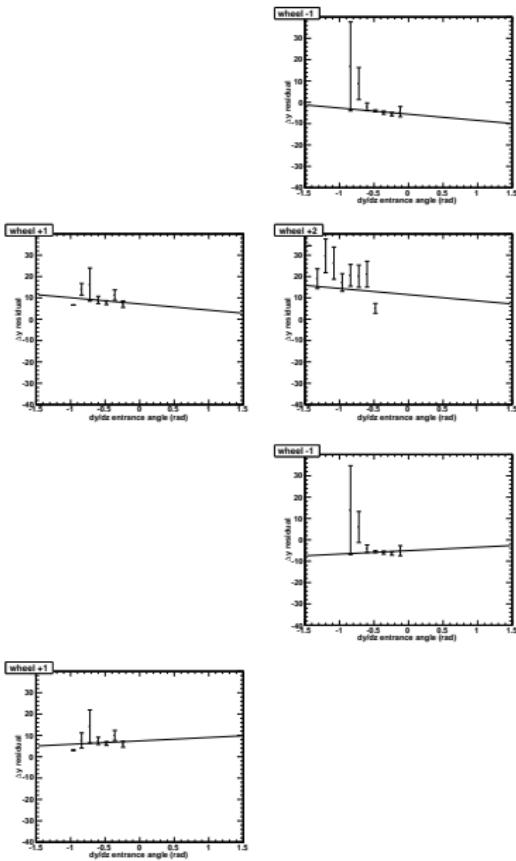
$$\text{slope} = \Delta z' =$$

$$0.285458 \pm 1.12087 \text{ mm}$$

$$\chi^2/\text{ndf} = 39.5471/34 = 1.16315$$

- ▶ Top: before
Bottom: after
- ▶ Five panels are wheels in the same SemiSuperSector (some are missing)
- ▶ Fit requires all to have the same slope (δ_z), but allows different offsets (δ_y)

Station 3, sector 4

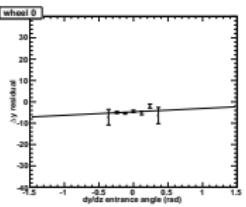


Station 3, sector 04

$$\text{slope} = \Delta z' =$$

$$2.90664 \pm 1.39391 \text{ mm}$$

$$\chi^2/\text{ndf} = 47.6942/28 = 1.70337$$



Station 3, sector 04

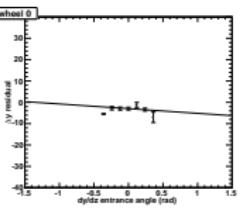
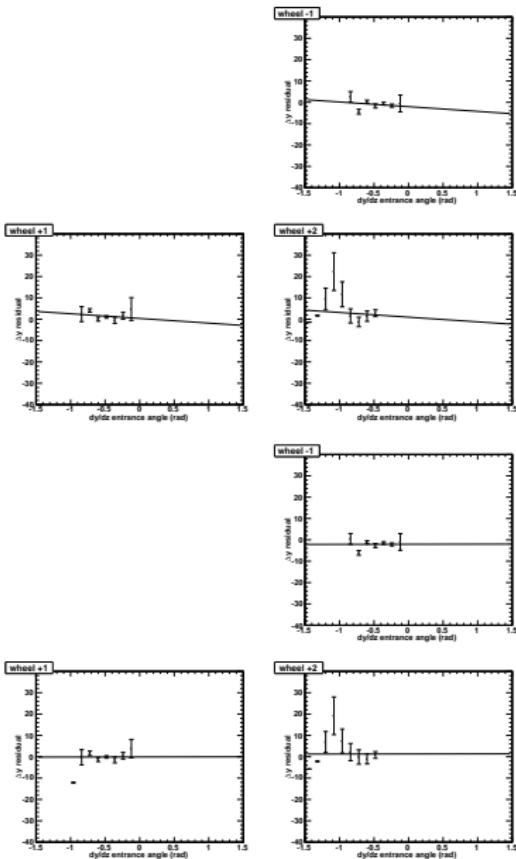
$$\text{slope} = \Delta z' =$$

$$-1.60243 \pm 1.43584 \text{ mm}$$

$$\chi^2/\text{ndf} = 20.636/20 = 1.0318$$

- ▶ Top: before
Bottom: after
- ▶ Five panels are wheels in the same SemiSuperSector (some are missing)
- ▶ Fit requires all to have the same slope (δ_z), but allows different offsets (δ_y)

Station 3, sector 5

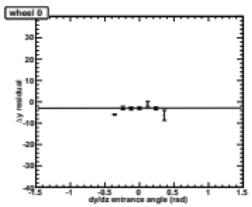


Station 3, sector 05

$$\text{slope} = \Delta z' =$$

$$2.19744 \pm 1.21713 \text{ mm}$$

$$\chi^2/\text{ndf} = 45.6084/27 = 1.6892$$



Station 3, sector 05

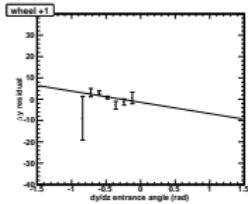
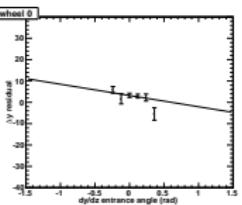
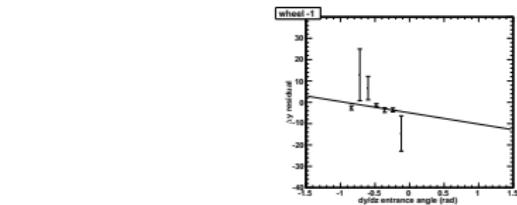
$$\text{slope} = \Delta z' =$$

$$-0.042316 \pm 1.21777 \text{ mm}$$

$$\chi^2/\text{ndf} = 36.4603/27 = 1.35038$$

- ▶ Top: before
Bottom: after
- ▶ Five panels are wheels in the same SemiSuperSector (some are missing)
- ▶ Fit requires all to have the same slope (δ_z), but allows different offsets (δ_y)

Station 3, sector 6

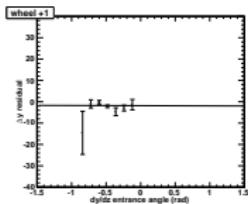
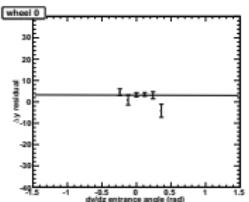
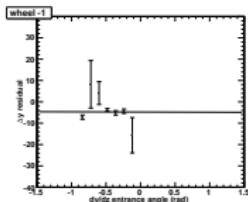


Station 3, sector 06

$$\text{slope} = \Delta z' =$$

$$5.27766 \pm 1.59203 \text{ mm}$$

$$\chi^2/\text{ndf} = 29.3859/20 = 1.4693$$



Station 3, sector 06

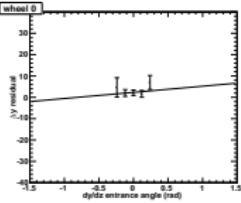
$$\text{slope} = \Delta z' =$$

$$0.0933595 \pm 1.64216 \text{ mm}$$

$$\chi^2/\text{ndf} = 30.7118/20 = 1.53559$$

- ▶ Top: before
Bottom: after
- ▶ Five panels are wheels in the same SemiSuperSector (some are missing)
- ▶ Fit requires all to have the same slope (δ_z), but allows different offsets (δ_y)

Station 3, sector 7

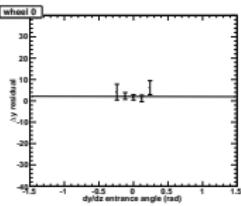


Station 3, sector 07

slope = $\Delta z'$ =

-2.88187 ± 7.16305 mm

$\chi^2/\text{ndf} = 2.35095/5 = 0.47019$



Station 3, sector 07

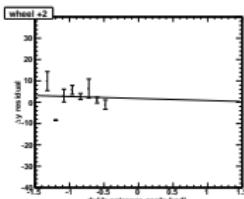
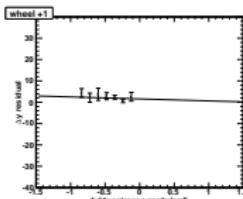
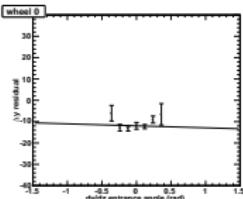
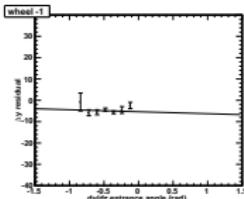
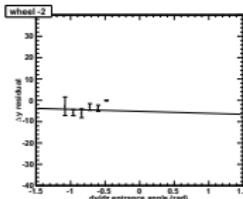
slope = $\Delta z'$ =

0.053982 ± 6.83668 mm

$\chi^2/\text{ndf} = 2.39691/5 = 0.479382$

- ▶ Top: before
Bottom: after
- ▶ Five panels are wheels in the same SemiSuperSector (some are missing)
- ▶ Fit requires all to have the same slope (δ_z), but allows different offsets (δ_y)

Station 3, sector 8

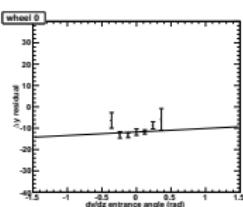
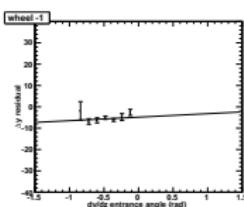
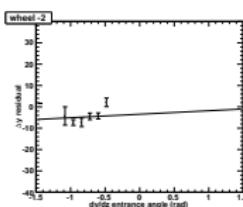


Station 3, sector 08

$$\text{slope} = \Delta z' =$$

$$0.929127 \pm 1.45344 \text{ mm}$$

$$\chi^2/\text{ndf} = 36.1226/34 = 1.06243$$



Station 3, sector 08

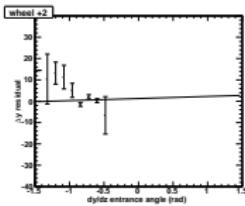
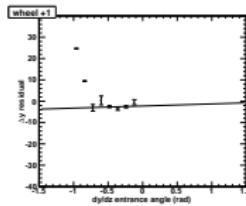
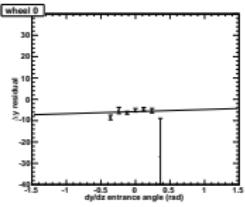
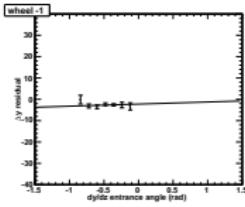
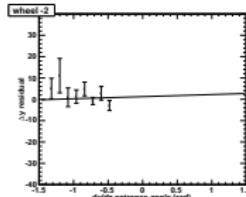
$$\text{slope} = \Delta z' =$$

$$-1.63976 \pm 1.39463 \text{ mm}$$

$$\chi^2/\text{ndf} = 50.3678/36 = 1.39911$$

- ▶ Top: before
Bottom: after
- ▶ Five panels are wheels in the same SemiSuperSector (some are missing)
- ▶ Fit requires all to have the same slope (δ_z), but allows different offsets (δ_y)

Station 3, sector 9

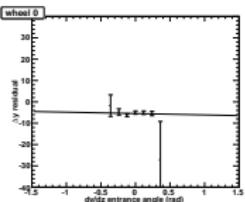
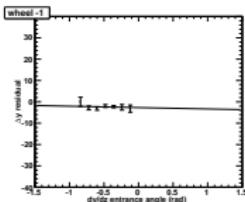


Station 3, sector 09

$$\text{slope} = \Delta z' =$$

$$-0.986135 \pm 1.11186 \text{ mm}$$

$$\chi^2/\text{ndf} = 50.0061/36 = 1.38906$$



Station 3, sector 09

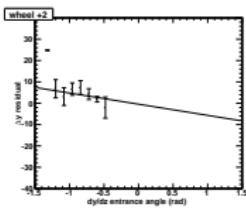
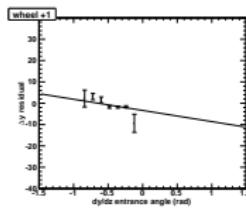
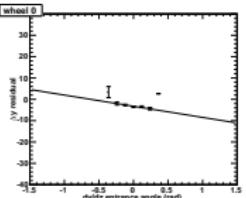
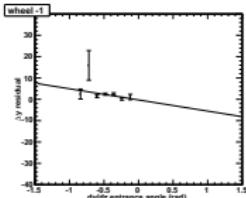
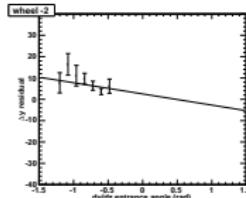
$$\text{slope} = \Delta z' =$$

$$0.642921 \pm 1.21565 \text{ mm}$$

$$\chi^2/\text{ndf} = 31.8323/28 = 1.13687$$

- ▶ Top: before
Bottom: after
- ▶ Five panels are wheels in the same SemiSuperSector (some are missing)
- ▶ Fit requires all to have the same slope (δ_z), but allows different offsets (δ_y)

Station 3, sector 10

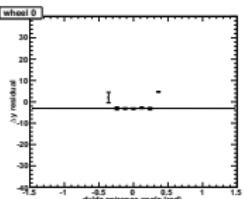
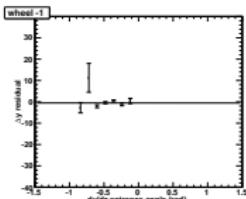
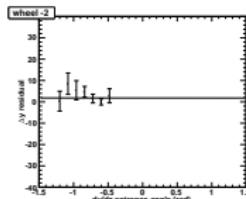


Station 3, sector 10

$$\text{slope} = \Delta z' =$$

$$5.22996 \pm 0.969257 \text{ mm}$$

$$\chi^2/\text{ndf} = 39.113/34 = 1.15038$$



Station 3, sector 10

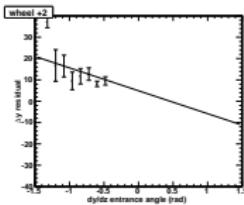
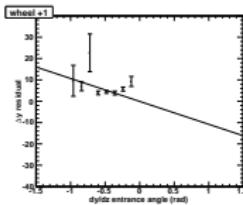
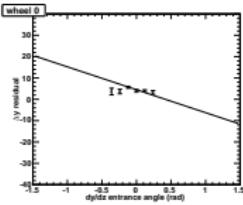
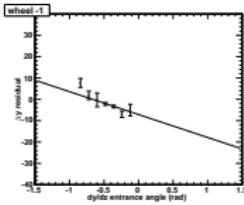
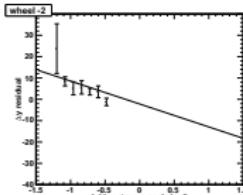
$$\text{slope} = \Delta z' =$$

$$0.00913221 \pm 0.951436 \text{ mm}$$

$$\chi^2/\text{ndf} = 41.4496/34 = 1.21911$$

- ▶ Top: before
Bottom: after
- ▶ Five panels are wheels in the same SemiSuperSector (some are missing)
- ▶ Fit requires all to have the same slope (δ_z), but allows different offsets (δ_y)

Station 3, sector 11

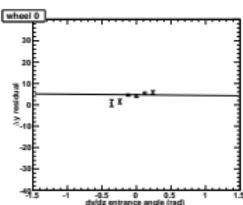
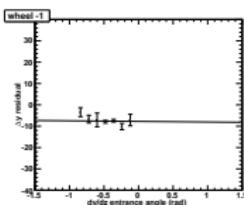
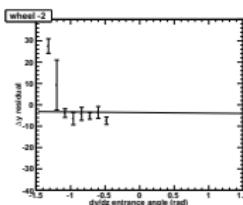


Station 3, sector 11

$$\text{slope} = \Delta z' =$$

$$10.7359 \pm 1.13316 \text{ mm}$$

$$\chi^2/\text{ndf} = 231.626/37 = 6.26017$$



Station 3, sector 11

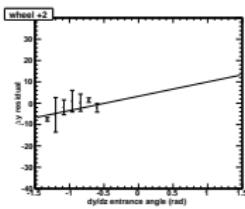
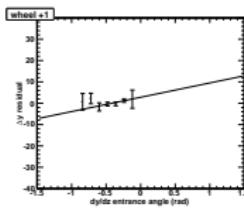
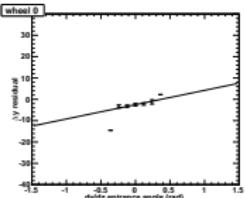
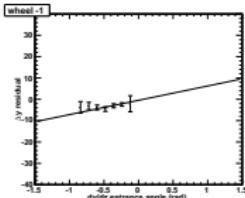
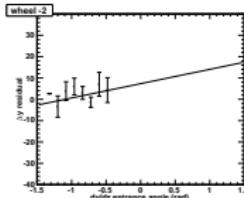
$$\text{slope} = \Delta z' =$$

$$0.287305 \pm 1.11319 \text{ mm}$$

$$\chi^2/\text{ndf} = 215.096/37 = 5.81341$$

- ▶ Top: before
Bottom: after
- ▶ Five panels are wheels in the same SemiSuperSector (some are missing)
- ▶ Fit requires all to have the same slope (δ_z), but allows different offsets (δ_y)

Station 3, sector 12

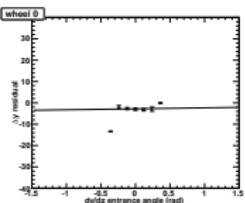
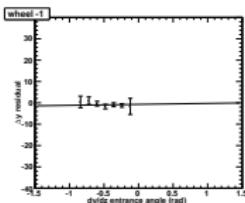
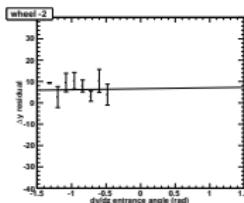


Station 3, sector 12

$$\text{slope} = \Delta z' =$$

$$-6.70632 \pm 1.12894 \text{ mm}$$

$$\chi^2/\text{ndf} = 32.888/33 = 0.996605$$



Station 3, sector 12

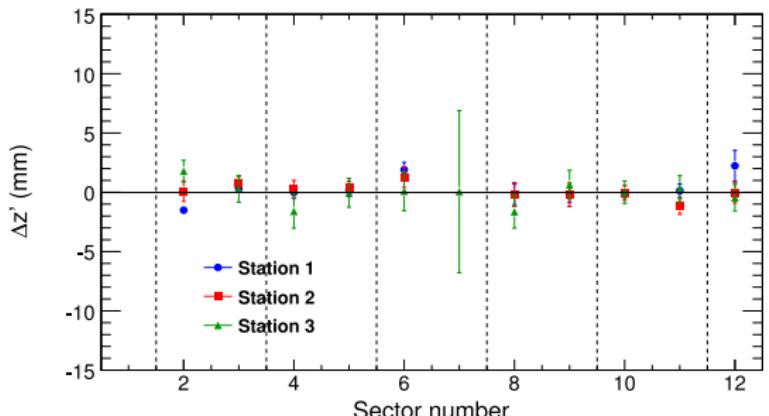
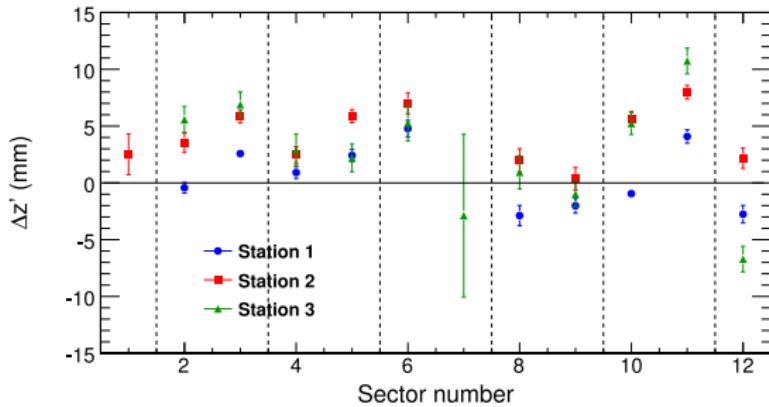
$$\text{slope} = \Delta z' =$$

$$-0.456328 \pm 1.13215 \text{ mm}$$

$$\chi^2/\text{ndf} = 37.4354/33 = 1.13441$$

- ▶ Top: before
Bottom: after
- ▶ Five panels are wheels in the same SemiSuperSector (some are missing)
- ▶ Fit requires all to have the same slope (δ_z), but allows different offsets (δ_y)

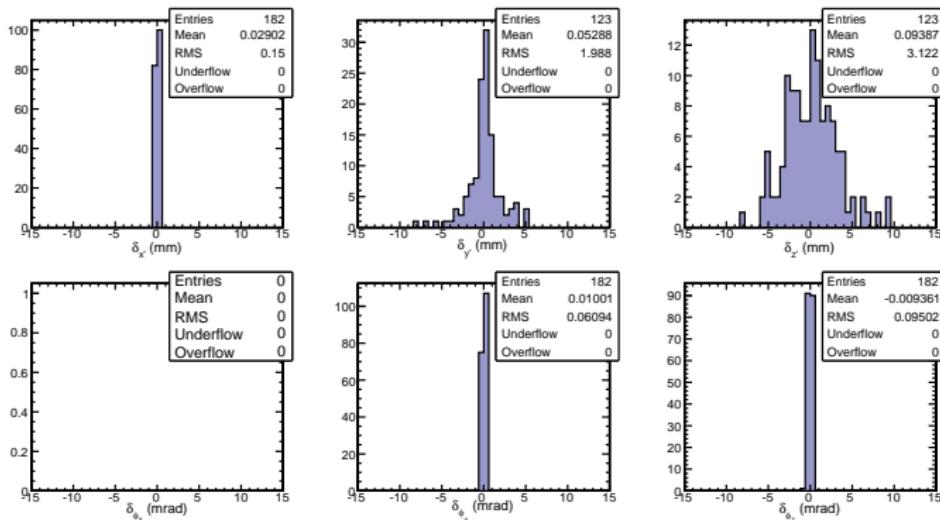
Summary before and after



- Top: plot shown on page 4
- Bottom: same thing after applying correction
- Direction and magnitude are right; could be done with more precision

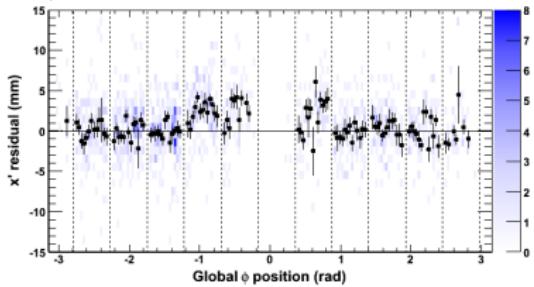
Consequences for other degrees of freedom

- ▶ Fix δ_z to these SemiSuperSector values and run individual chamber alignment. Below: differences with respect to normal alignment
- ▶ δ_z are different (naturally: computed with different constraints)
- ▶ δ_y are different (naturally: alignment matches line-of-sight of tracks and $\frac{dy}{dz}$ is asymmetric in many chambers)
- ▶ Everything else is the same, insensitive to these new δ_z values

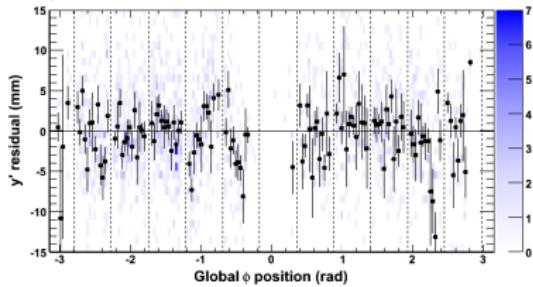


Map plots with SemiSuperSector δ_z

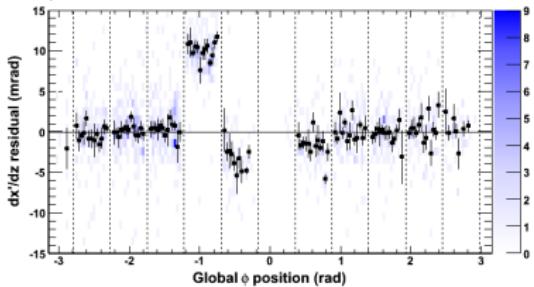
wheel -2, station 1



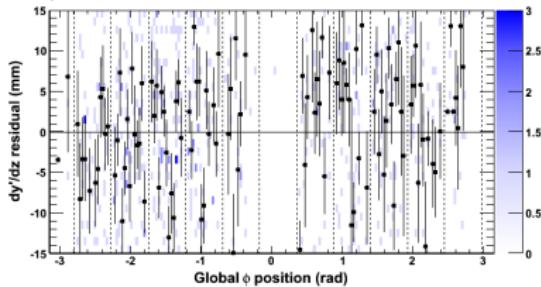
wheel -2, station 1



wheel -2, station 1

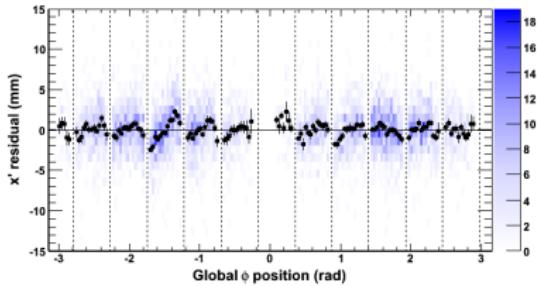


wheel -2, station 1

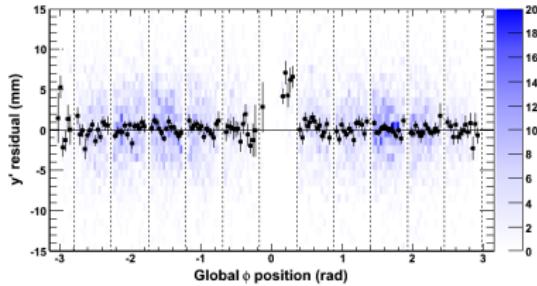


Map plots with SemiSuperSector δ_z

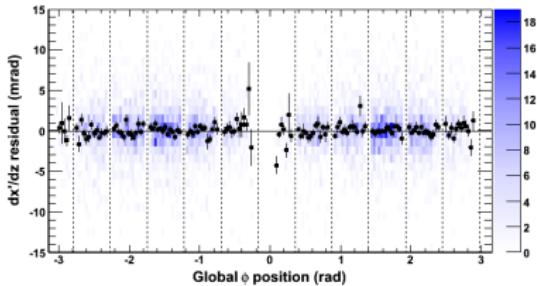
wheel -1, station 1



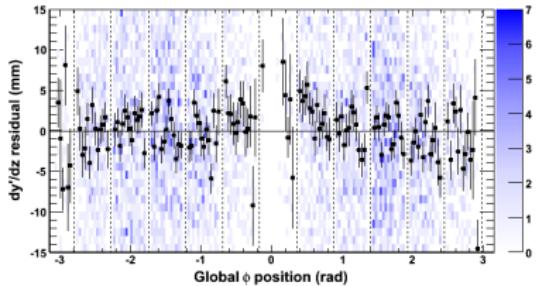
wheel -1, station 1



wheel -1, station 1

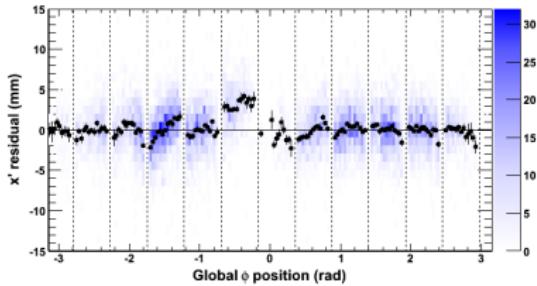


wheel -1, station 1

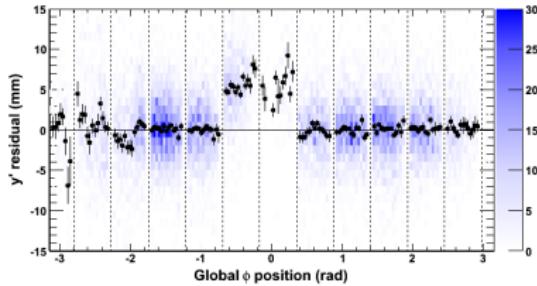


Map plots with SemiSuperSector δ_z

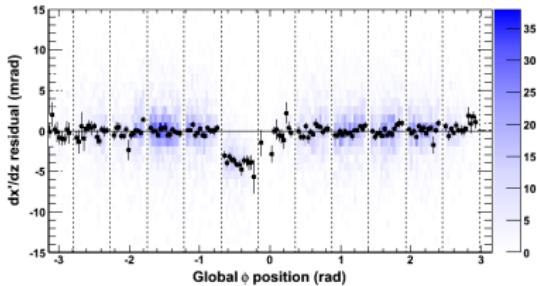
wheel +0, station 1



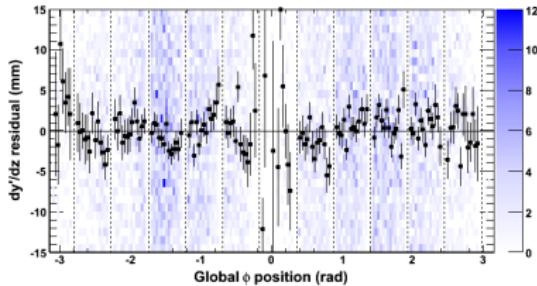
wheel +0, station 1



wheel +0, station 1

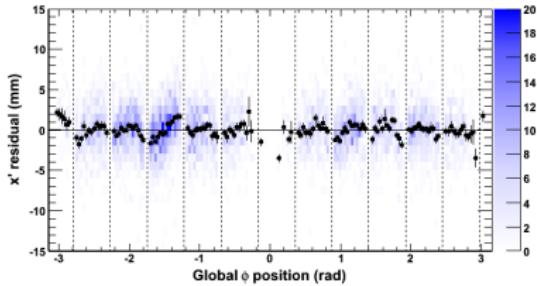


wheel +0, station 1

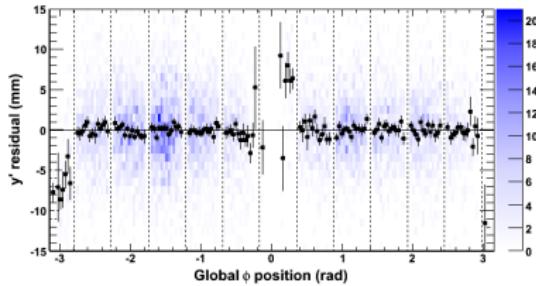


Map plots with SemiSuperSector δ_z

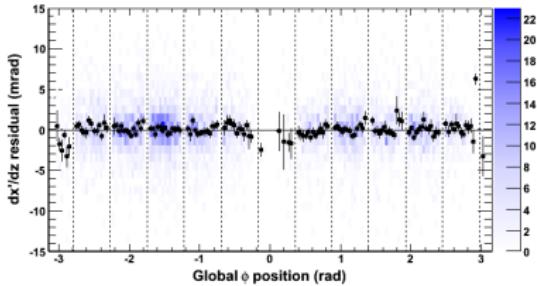
wheel +1, station 1



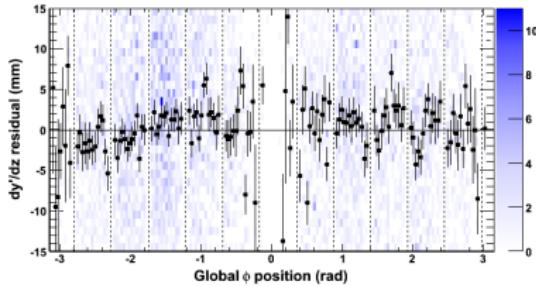
wheel +1, station 1



wheel +1, station 1

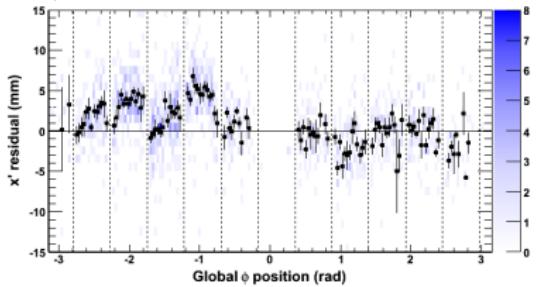


wheel +1, station 1

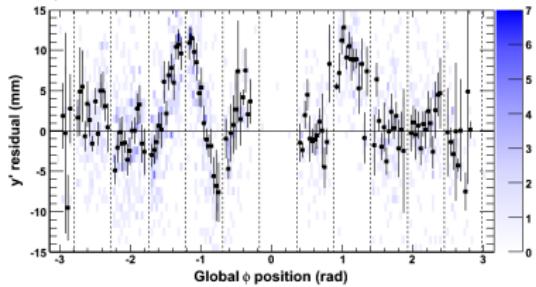


Map plots with SemiSuperSector δ_z

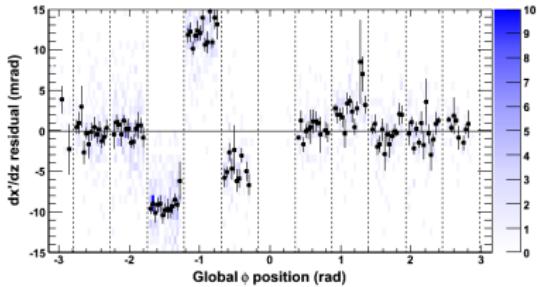
wheel +2, station 1



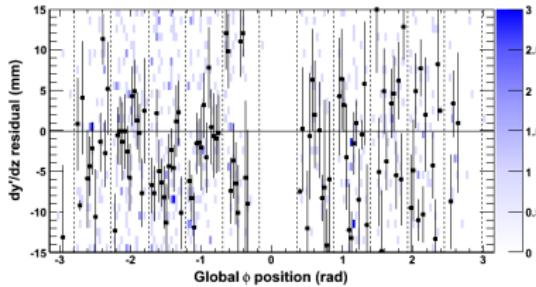
wheel +2, station 1



wheel +2, station 1

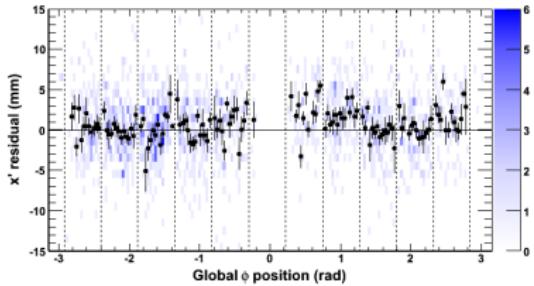


wheel +2, station 1

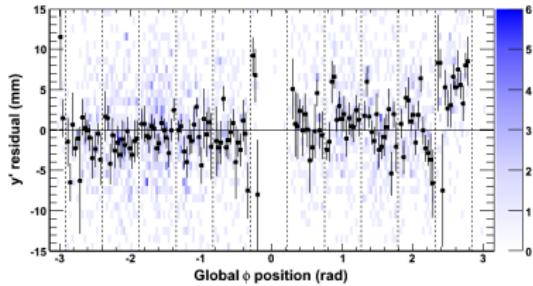


Map plots with SemiSuperSector δ_z

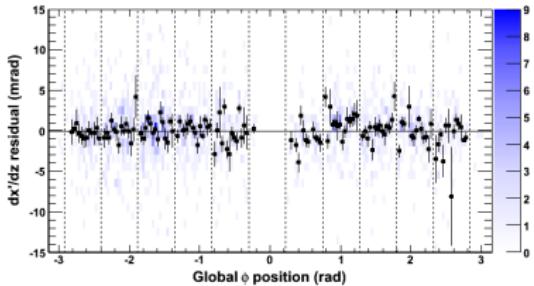
wheel -2, station 2



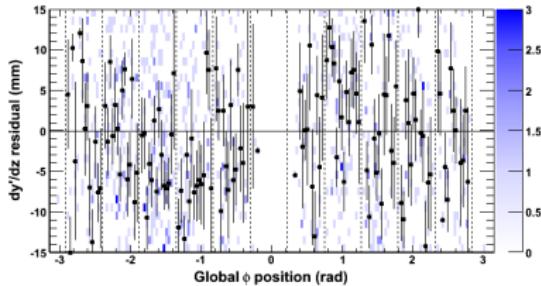
wheel -2, station 2



wheel -2, station 2

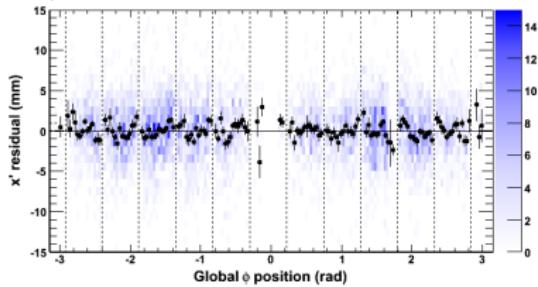


wheel -2, station 2

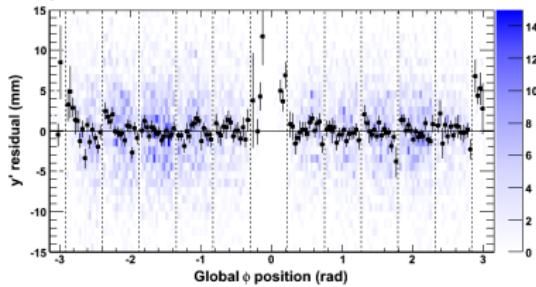


Map plots with SemiSuperSector δ_z

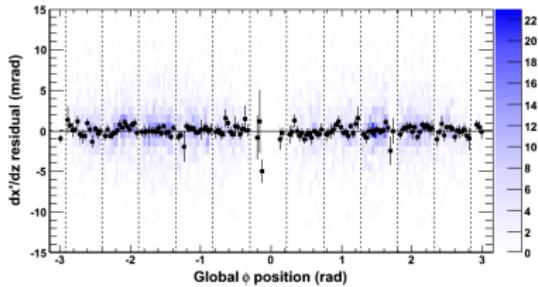
wheel -1, station 2



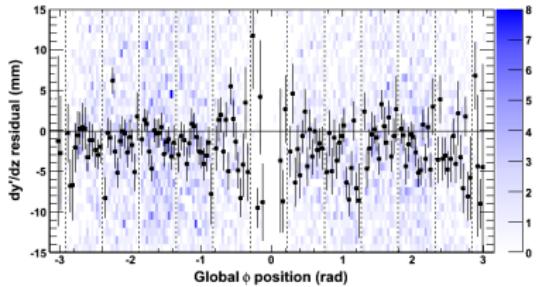
wheel -1, station 2



wheel -1, station 2

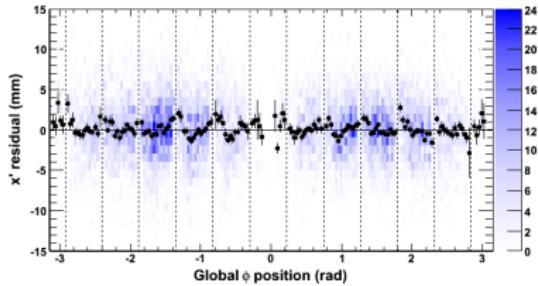


wheel -1, station 2

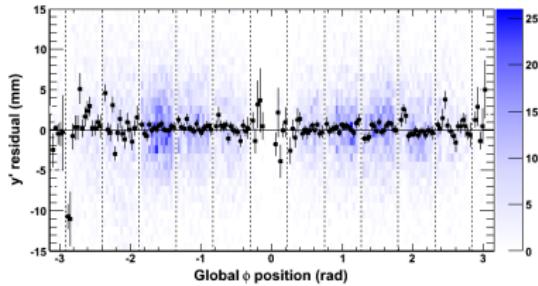


Map plots with SemiSuperSector δ_z

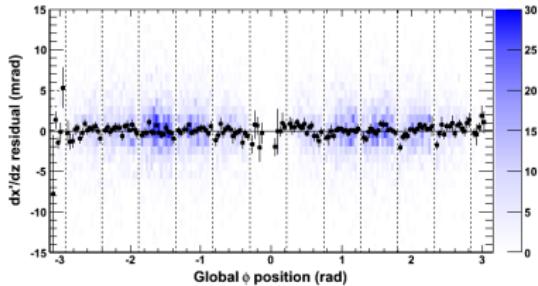
wheel +0, station 2



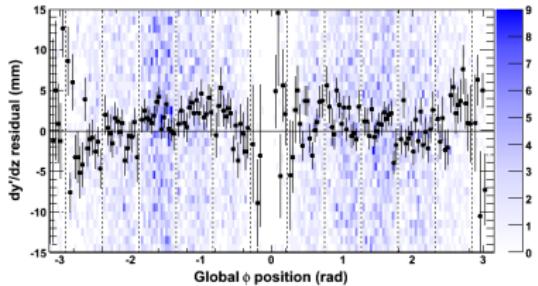
wheel +0, station 2



wheel +0, station 2

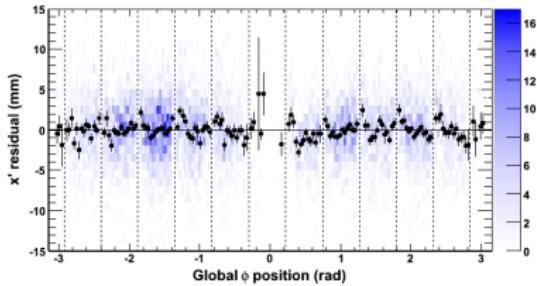


wheel +0, station 2

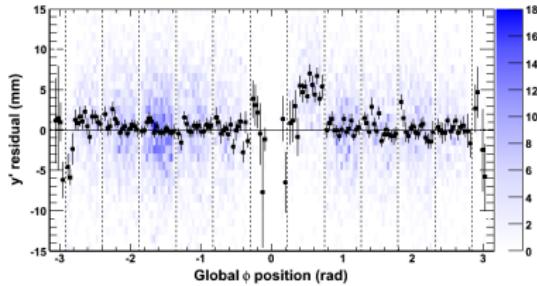


Map plots with SemiSuperSector δ_z

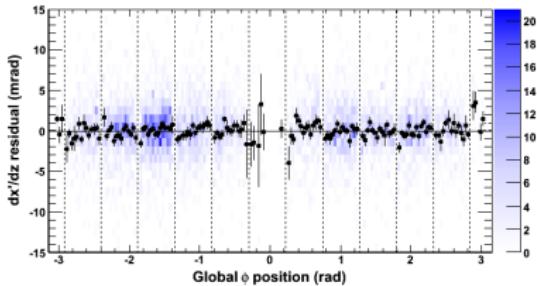
wheel +1, station 2



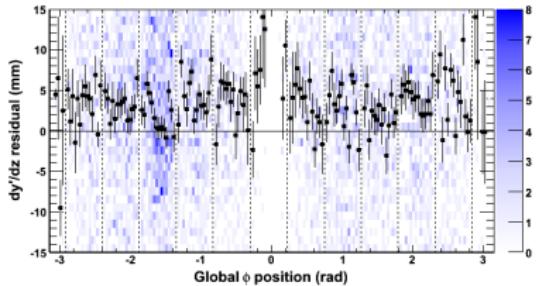
wheel +1, station 2



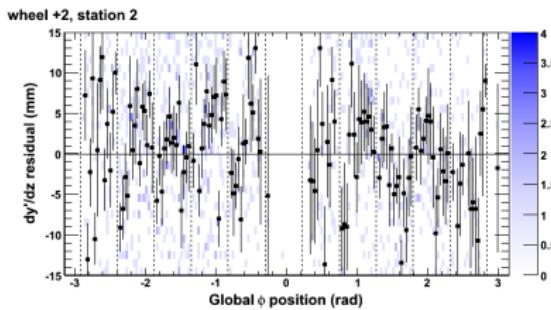
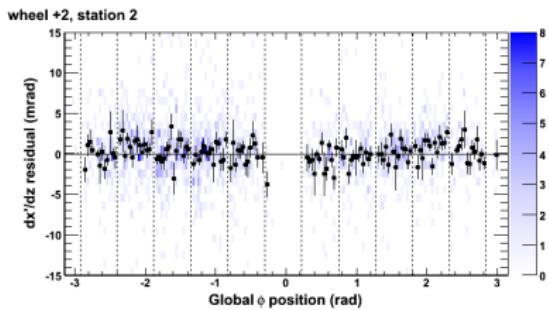
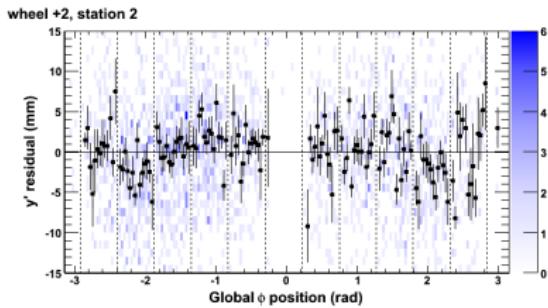
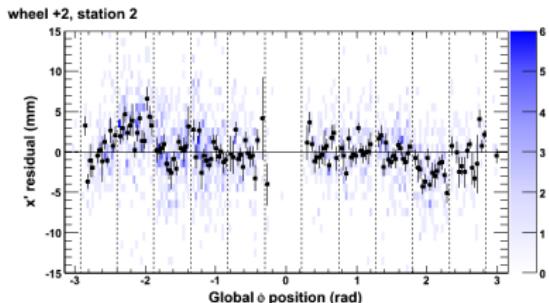
wheel +1, station 2



wheel +1, station 2

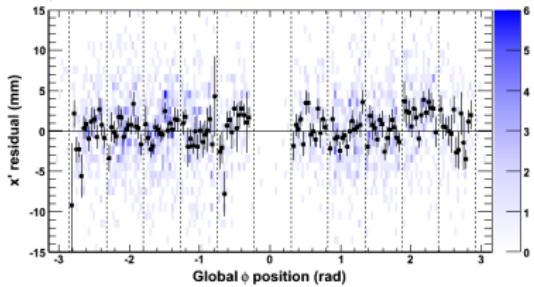


Map plots with SemiSuperSector δ_z

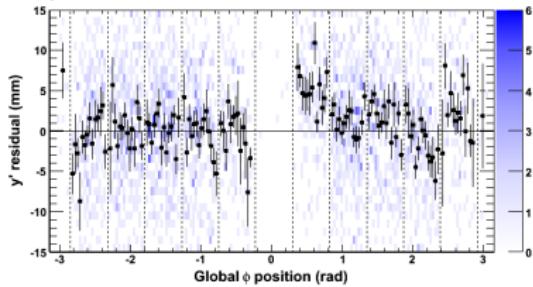


Map plots with SemiSuperSector δ_z

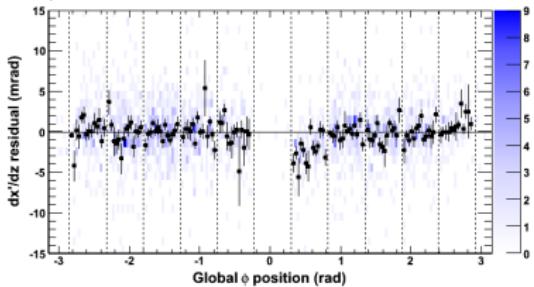
wheel -2, station 3



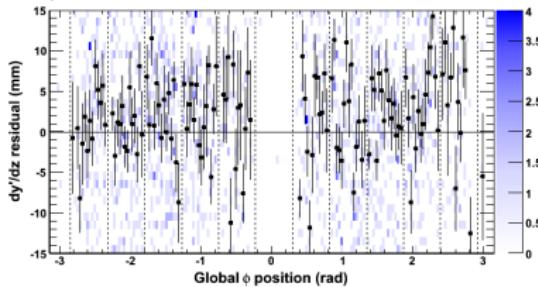
wheel -2, station 3



wheel -2, station 3

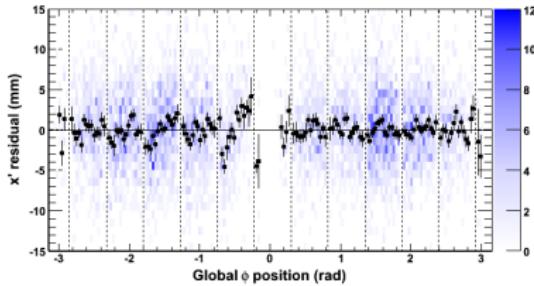


wheel -2, station 3

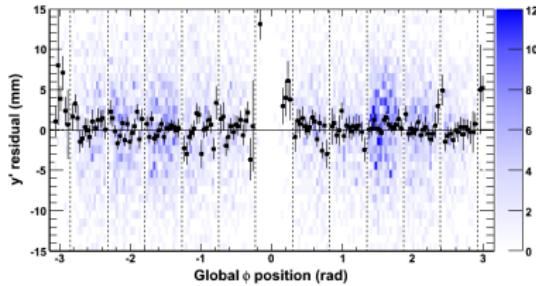


Map plots with SemiSuperSector δ_z

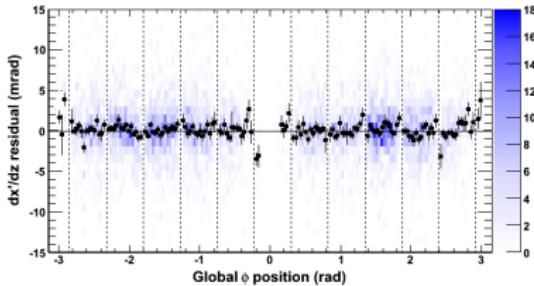
wheel -1, station 3



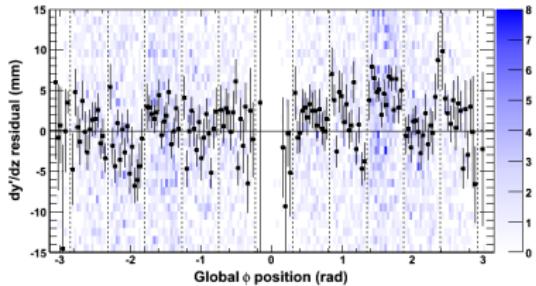
wheel -1, station 3



wheel -1, station 3

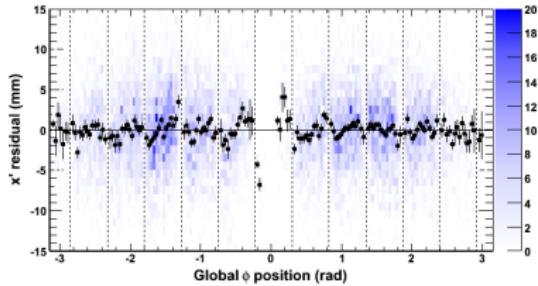


wheel -1, station 3

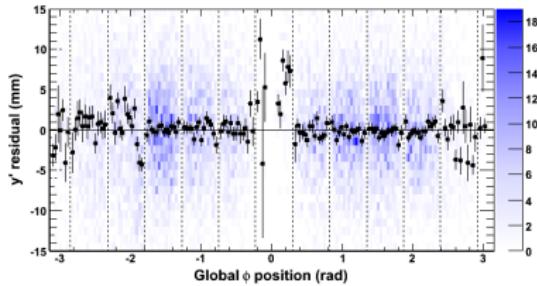


Map plots with SemiSuperSector δ_z

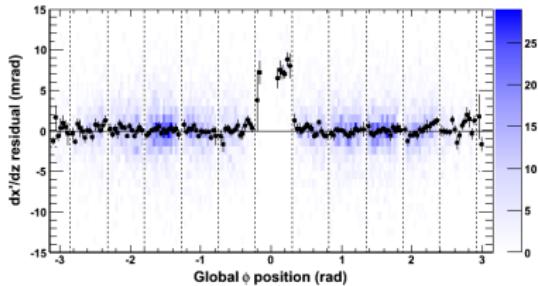
wheel +0, station 3



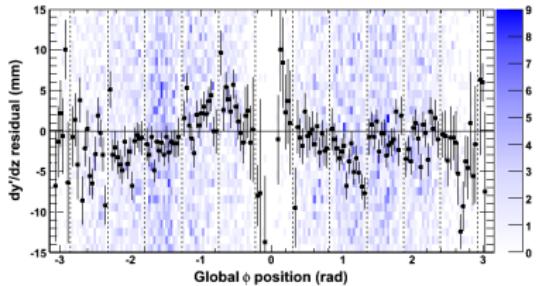
wheel +0, station 3



wheel +0, station 3

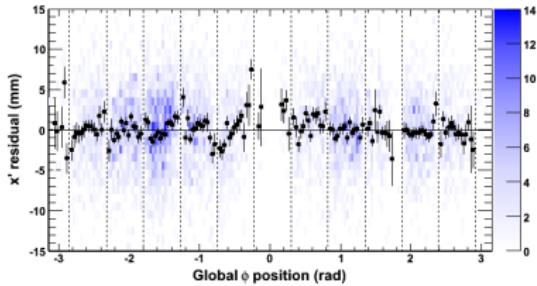


wheel +0, station 3

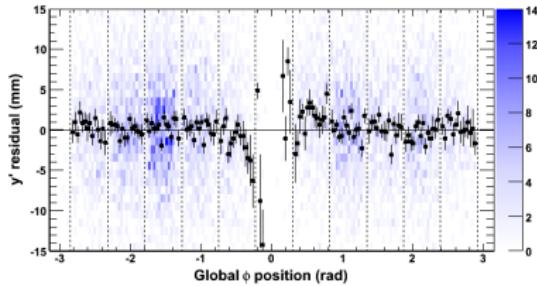


Map plots with SemiSuperSector δ_z

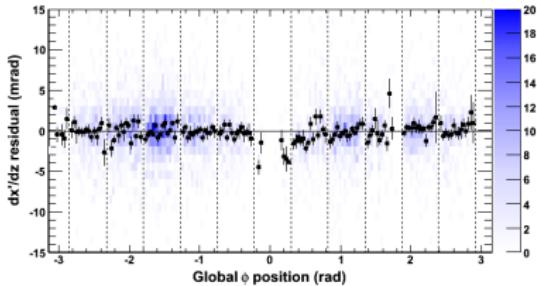
wheel +1, station 3



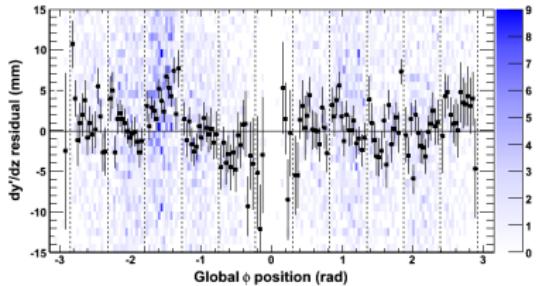
wheel +1, station 3



wheel +1, station 3

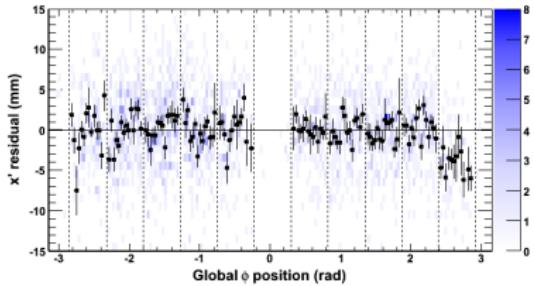


wheel +1, station 3

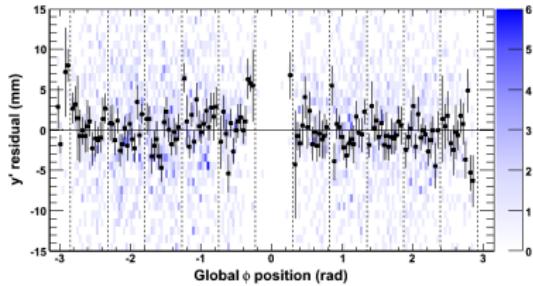


Map plots with SemiSuperSector δ_z

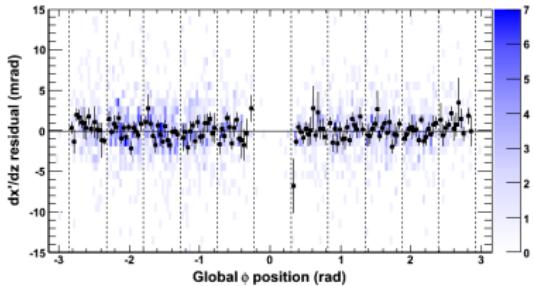
wheel +2, station 3



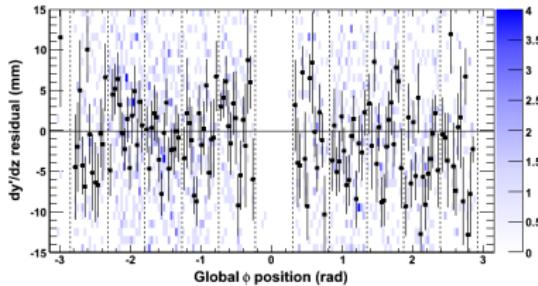
wheel +2, station 3



wheel +2, station 3

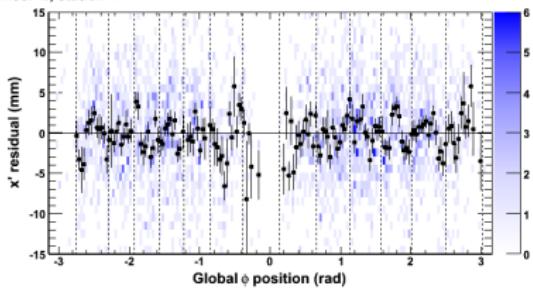


wheel +2, station 3

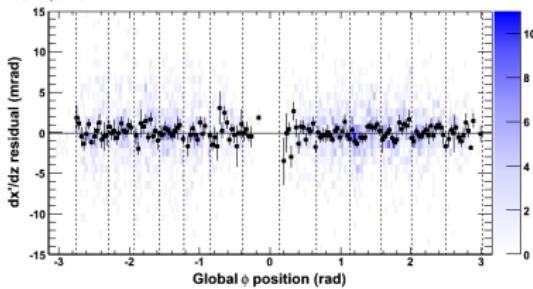


Map plots with SemiSuperSector δ_z

wheel -2, station 4

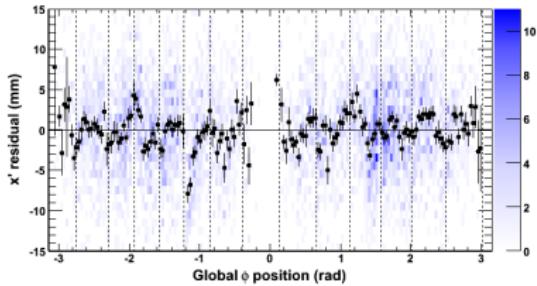


wheel -2, station 4

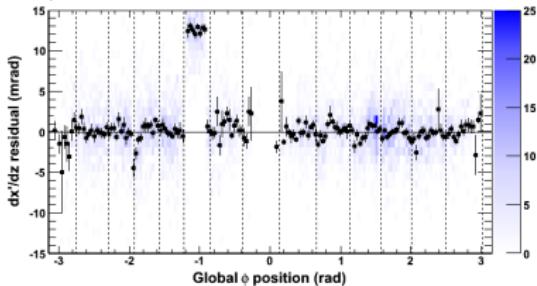


Map plots with SemiSuperSector δ_z

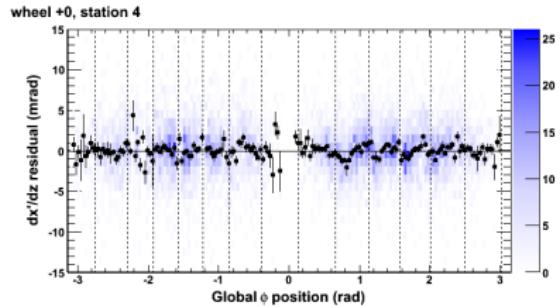
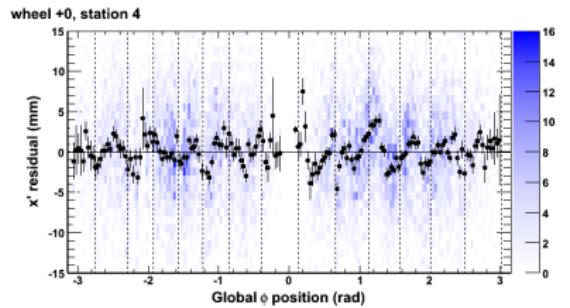
wheel -1, station 4



wheel -1, station 4

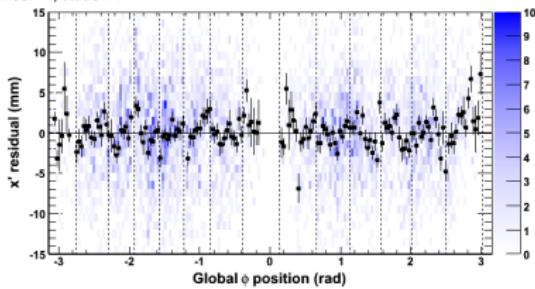


Map plots with SemiSuperSector δ_z

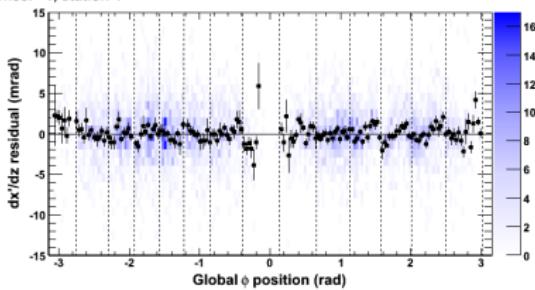


Map plots with SemiSuperSector δ_z

wheel +1, station 4

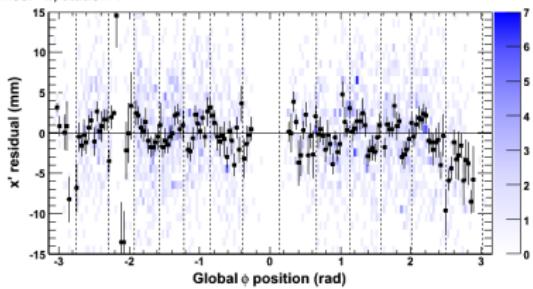


wheel +1, station 4

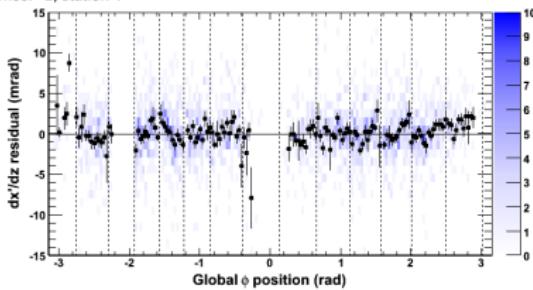


Map plots with SemiSuperSector δ_z

wheel +2, station 4

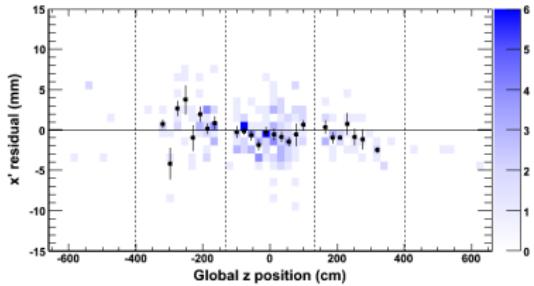


wheel +2, station 4

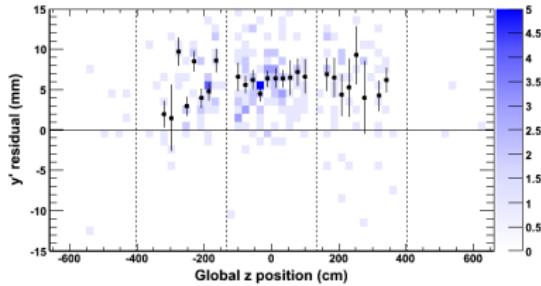


Map plots with SemiSuperSector δ_z

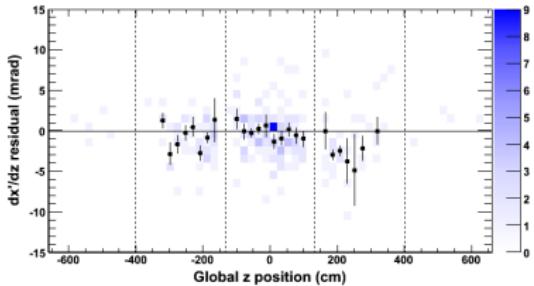
station 1, sector 01



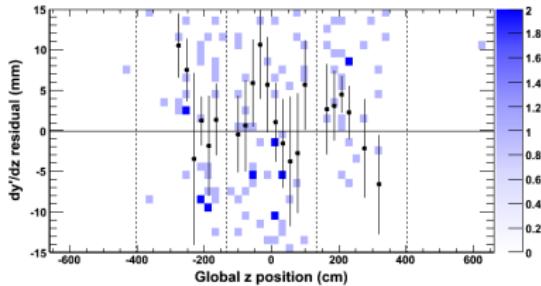
station 1, sector 01



station 1, sector 01

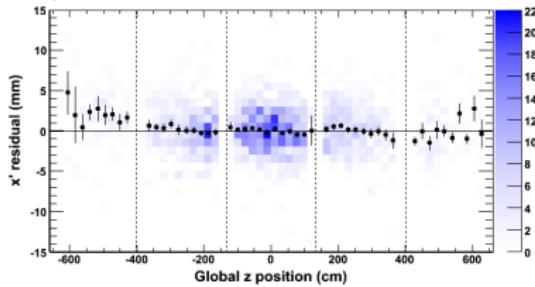


station 1, sector 01

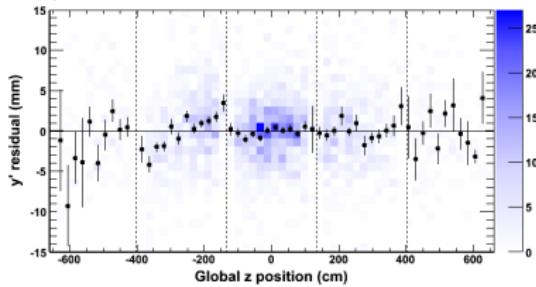


Map plots with SemiSuperSector δ_z

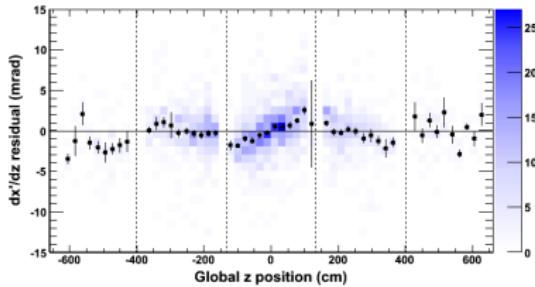
station 1, sector 02



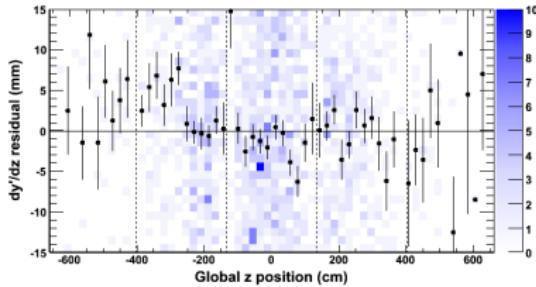
station 1, sector 02



station 1, sector 02

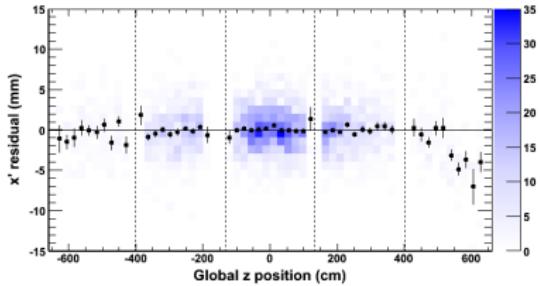


station 1, sector 02

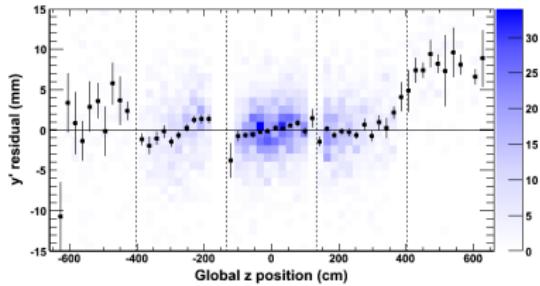


Map plots with SemiSuperSector δ_z

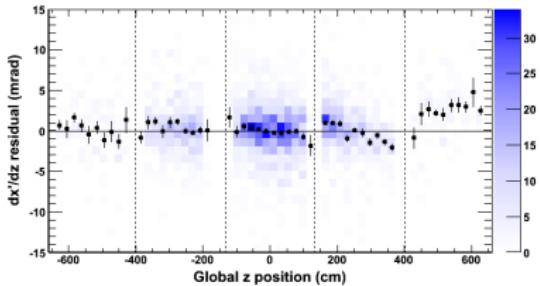
station 1, sector 03



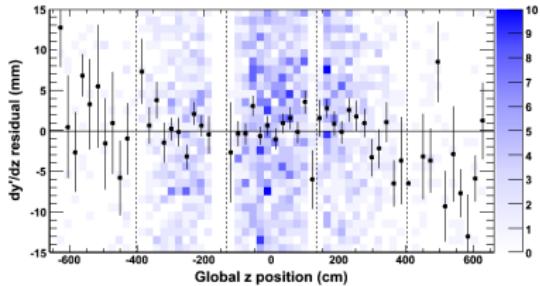
station 1, sector 03



station 1, sector 03

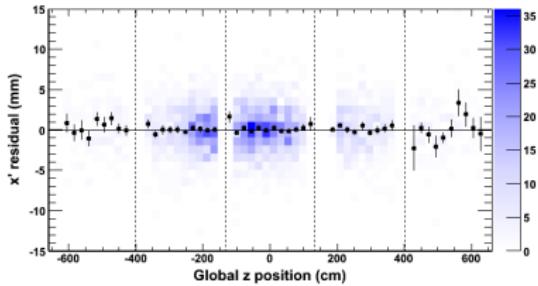


station 1, sector 03

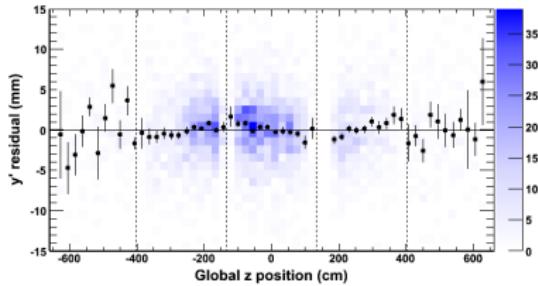


Map plots with SemiSuperSector δ_z

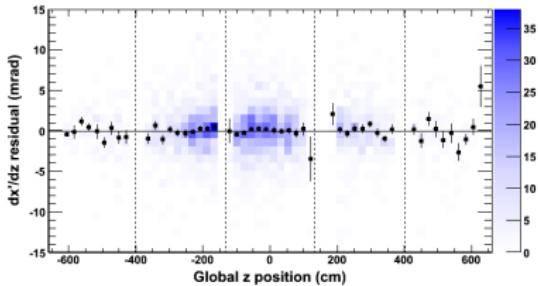
station 1, sector 04



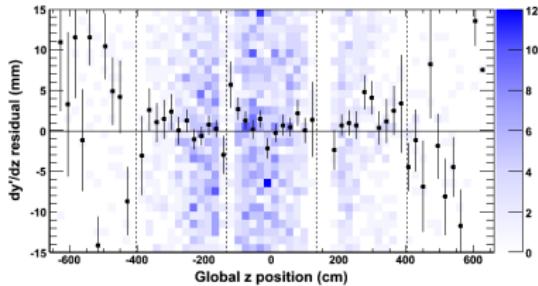
station 1, sector 04



station 1, sector 04

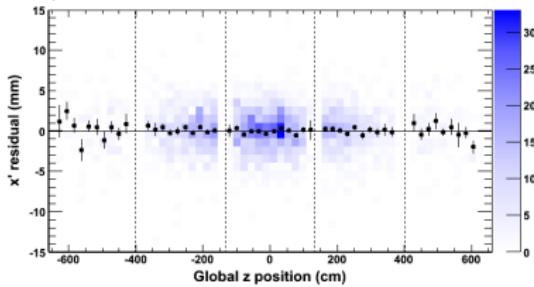


station 1, sector 04

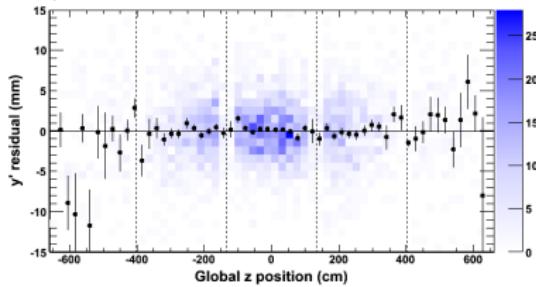


Map plots with SemiSuperSector δ_z

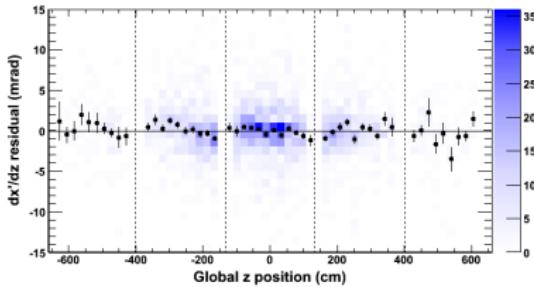
station 1, sector 05



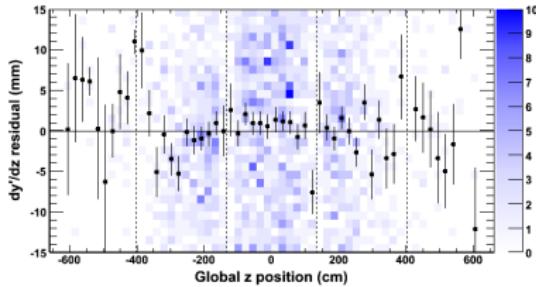
station 1, sector 05



station 1, sector 05

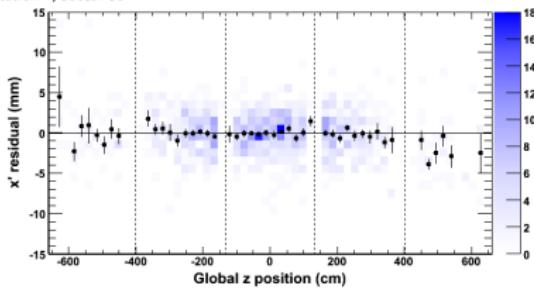


station 1, sector 05

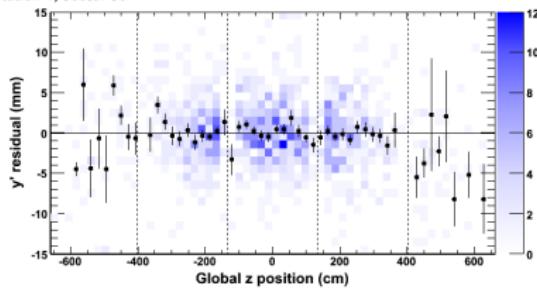


Map plots with SemiSuperSector δ_z

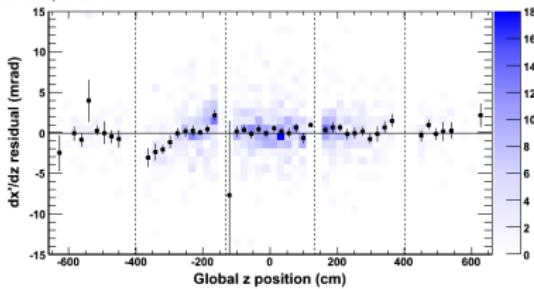
station 1, sector 06



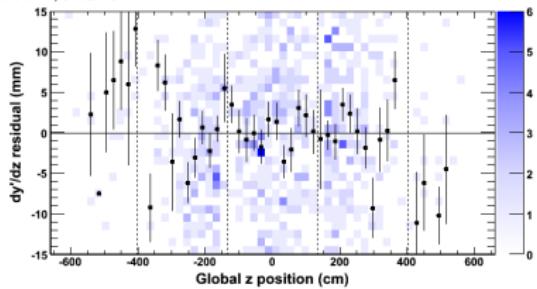
station 1, sector 06



station 1, sector 06

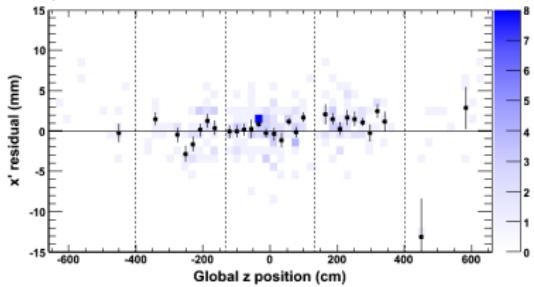


station 1, sector 06

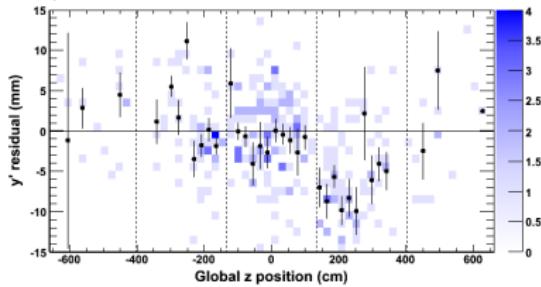


Map plots with SemiSuperSector δ_z

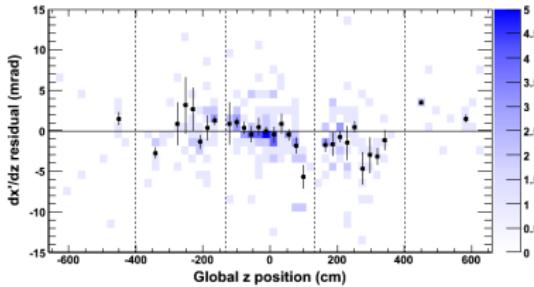
station 1, sector 07



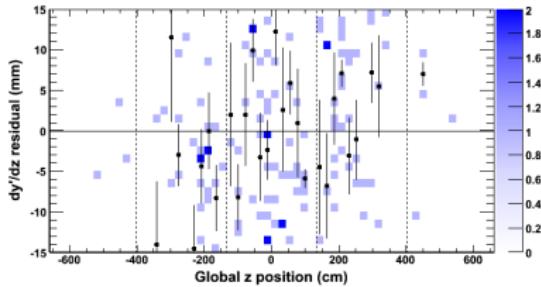
station 1, sector 07



station 1, sector 07

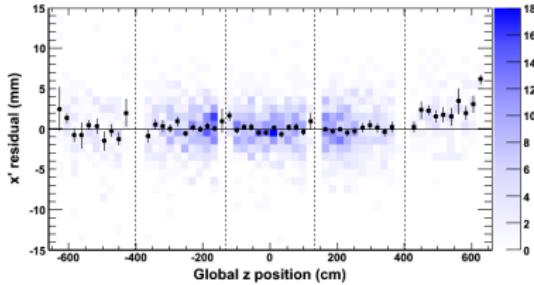


station 1, sector 07

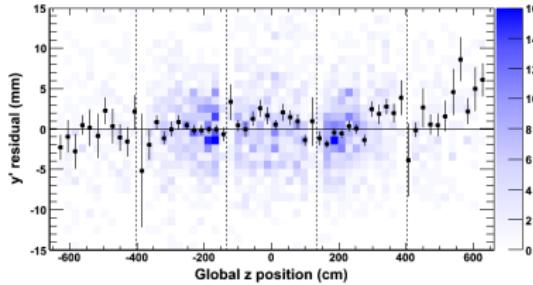


Map plots with SemiSuperSector δ_z

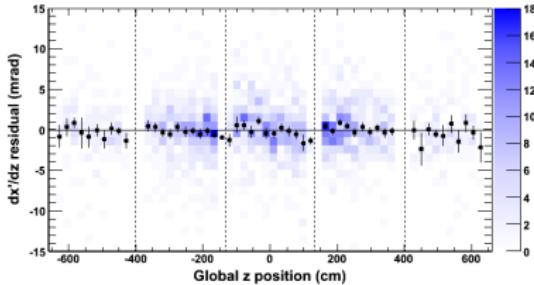
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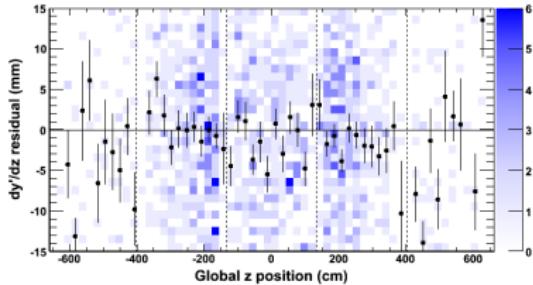
station 1, sector 08



station 1, sector 08

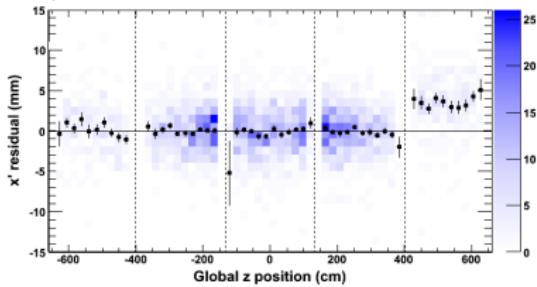


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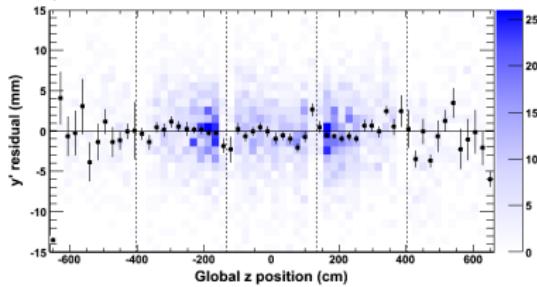


Map plots with SemiSuperSector δ_z

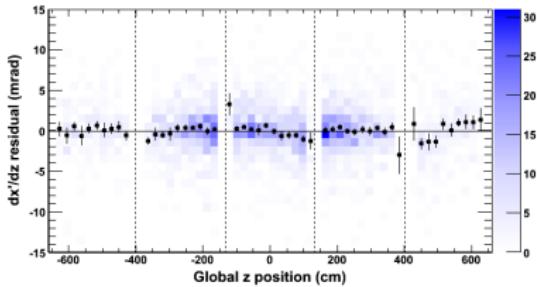
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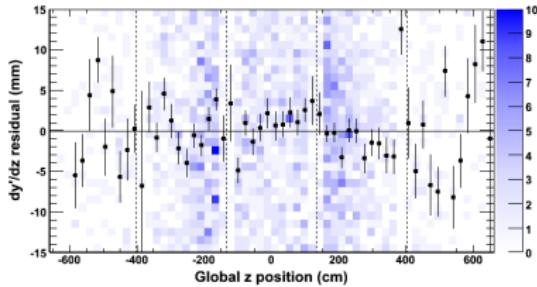
station 1, sector 09



station 1, sector 09

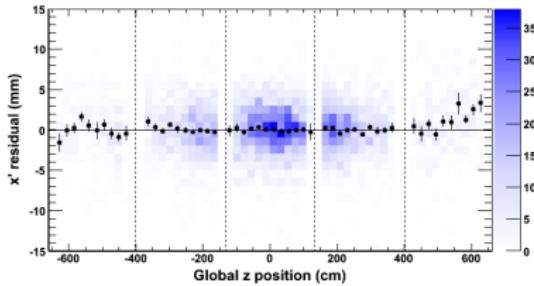


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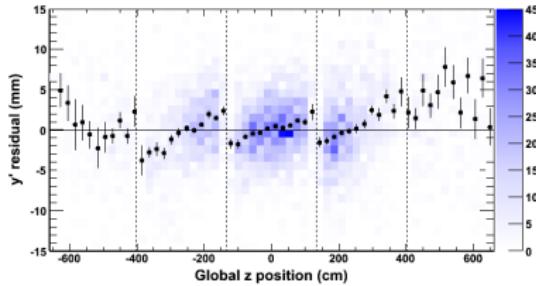


Map plots with SemiSuperSector δ_z

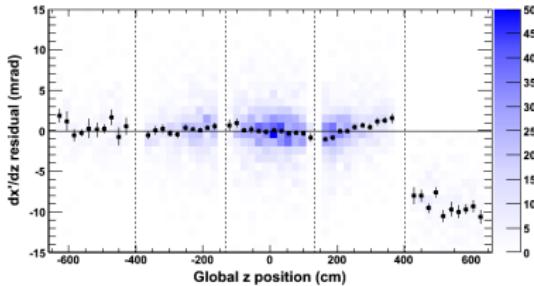
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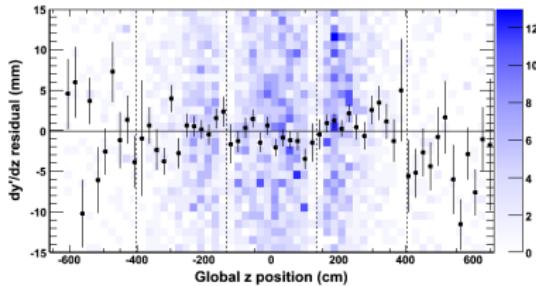
station 1, sector 10



station 1, sector 10

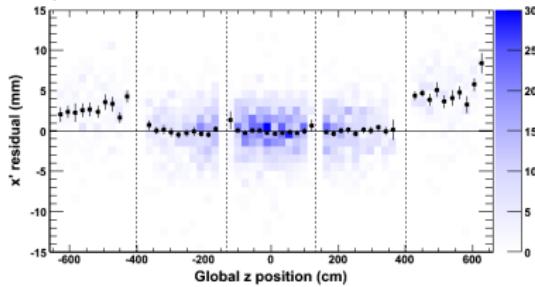


station 1, sector 10

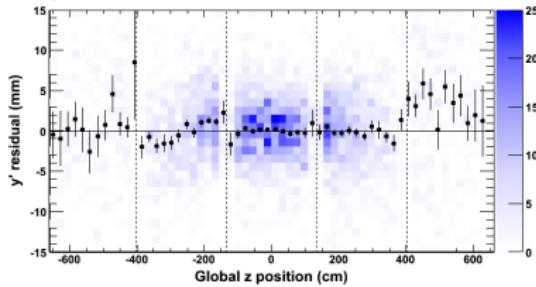


Map plots with SemiSuperSector δ_z

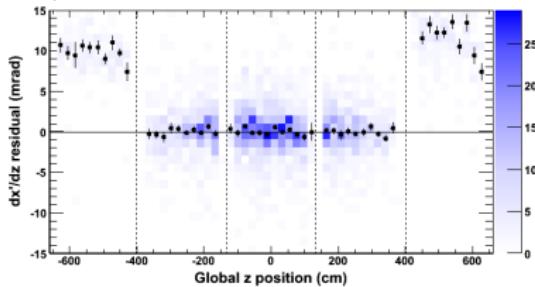
station 1, sector 11



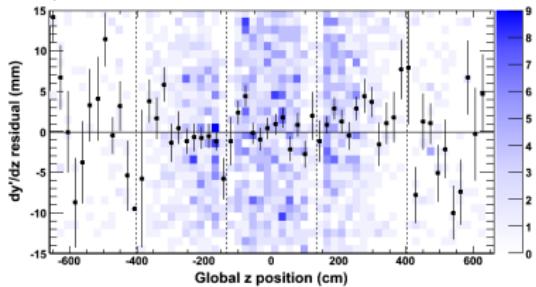
station 1, sector 11



station 1, sector 11

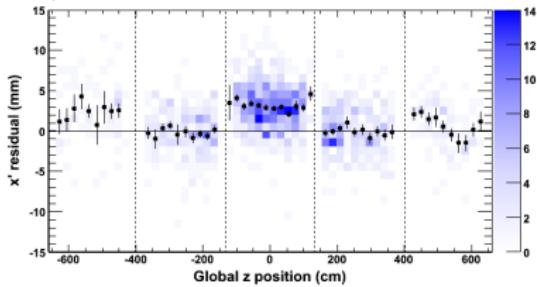


station 1, sector 11

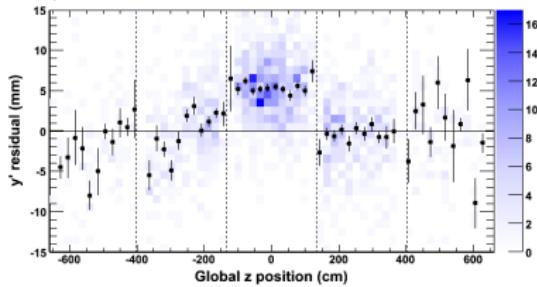


Map plots with SemiSuperSector δ_z

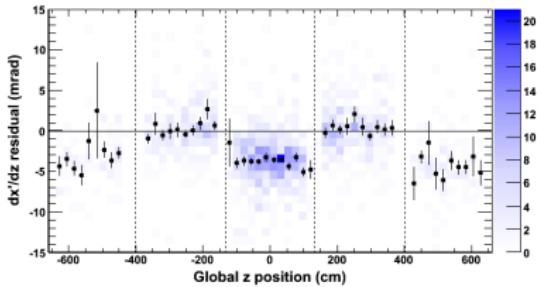
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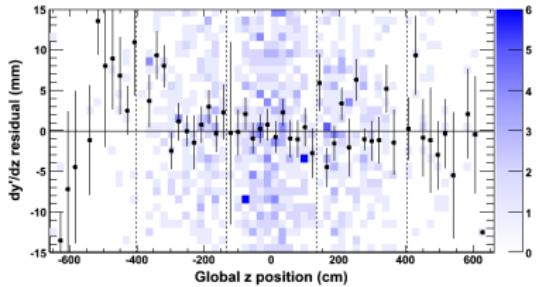
station 1, sector 12



station 1, sector 12

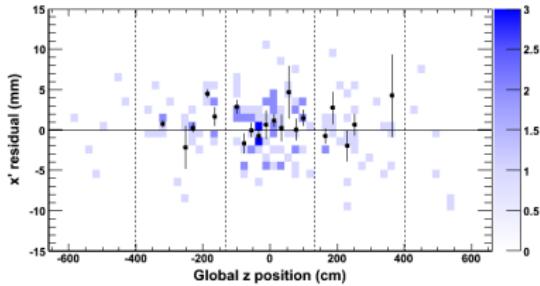


station 1, sector 12

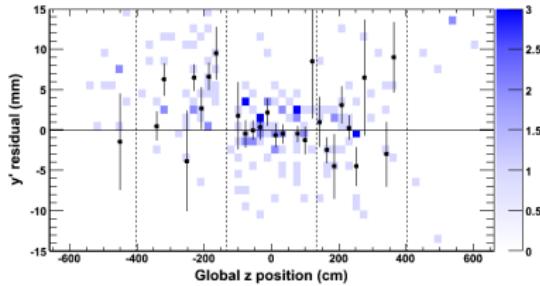


Map plots with SemiSuperSector δ_z

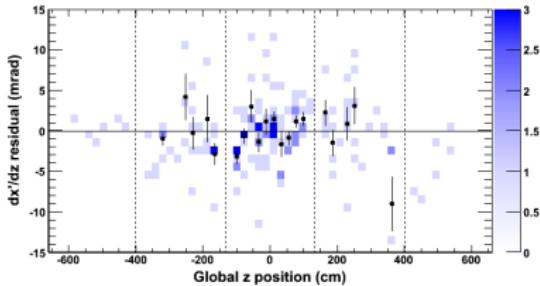
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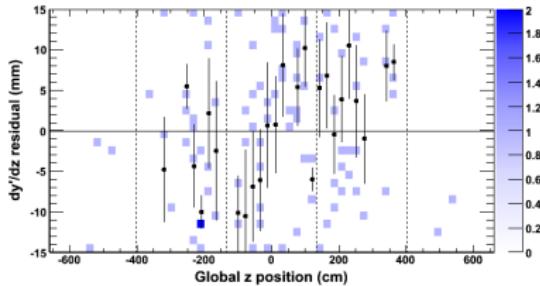
station 2, sector 01



station 2, sector 01

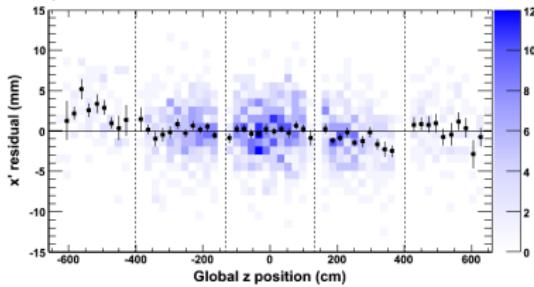


station 2, sector 01

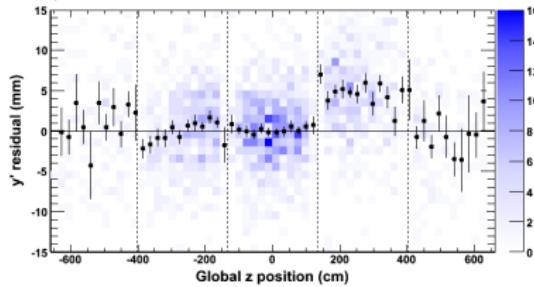


Map plots with SemiSuperSector δ_z

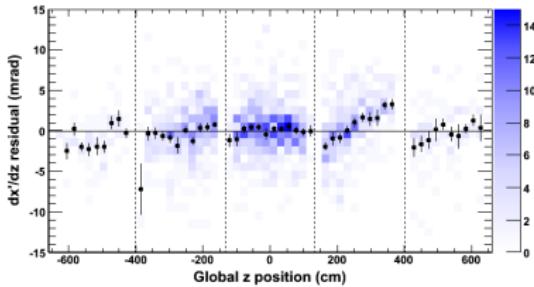
station 2, sector 02



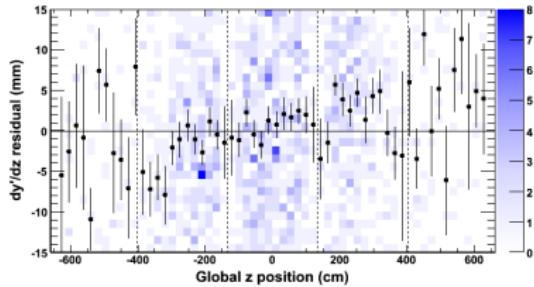
station 2, sector 02



station 2, sector 02

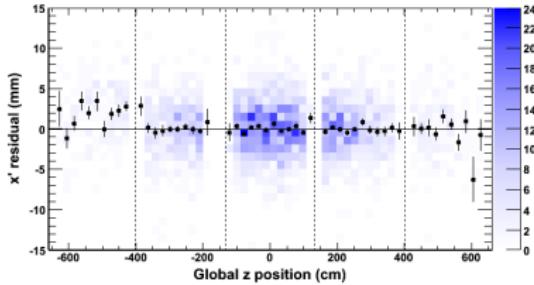


station 2, sector 02

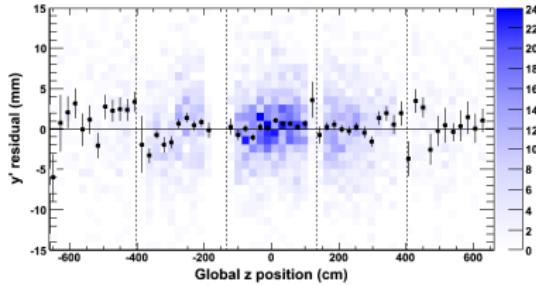


Map plots with SemiSuperSector δ_z

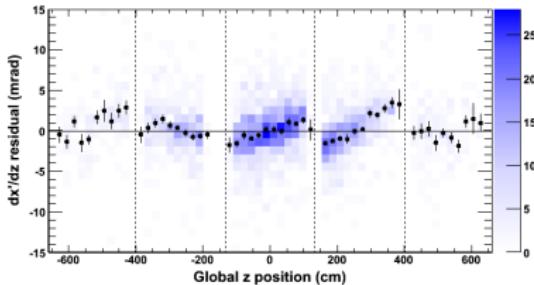
station 2, sector 03



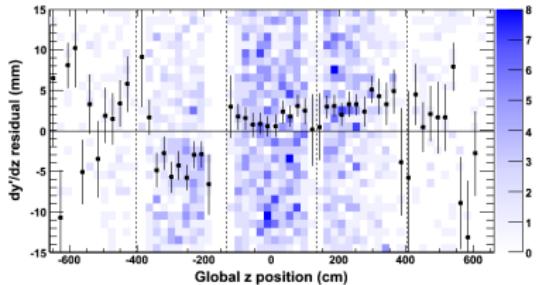
station 2, sector 03



station 2, sector 03

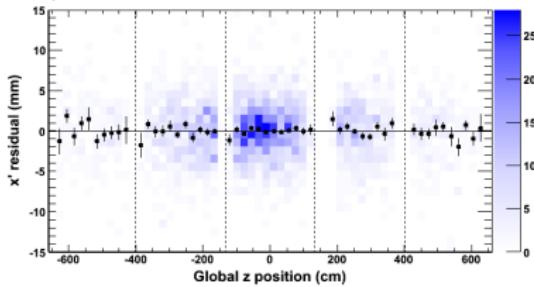


station 2, sector 03

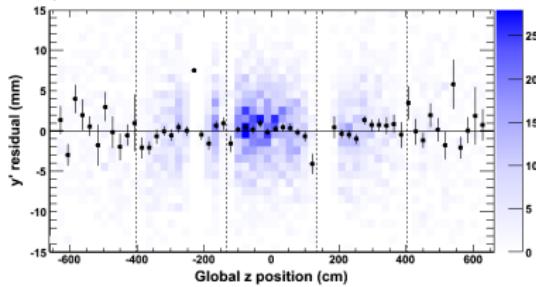


Map plots with SemiSuperSector δ_z

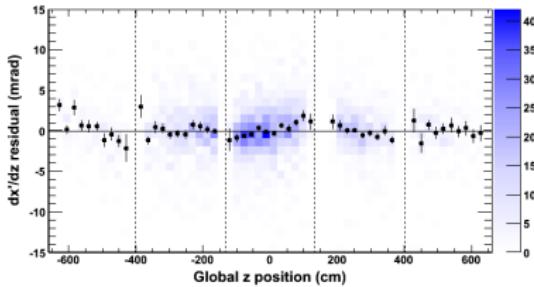
station 2, sector 04



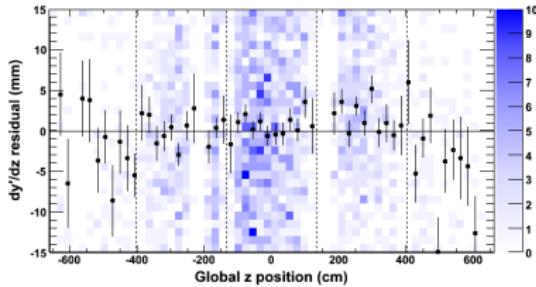
station 2, sector 04



station 2, sector 04

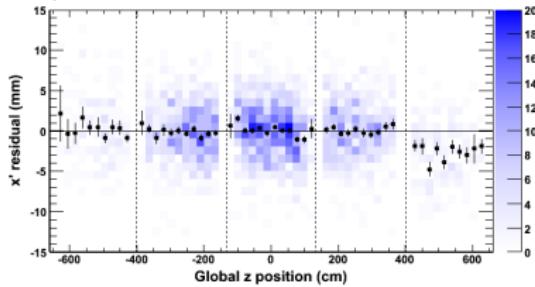


station 2, sector 04

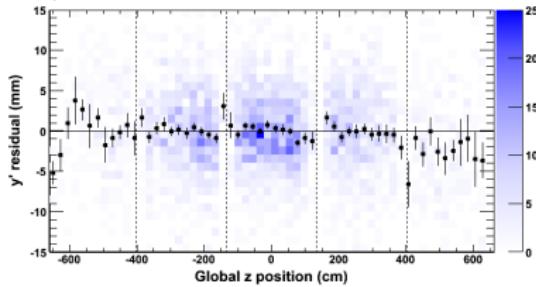


Map plots with SemiSuperSector δ_z

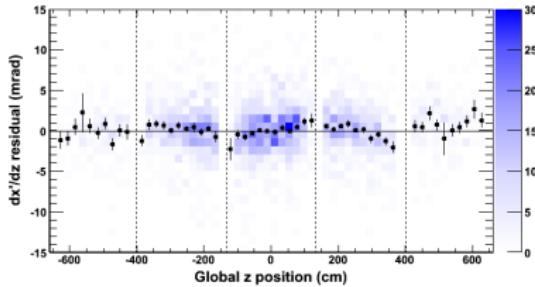
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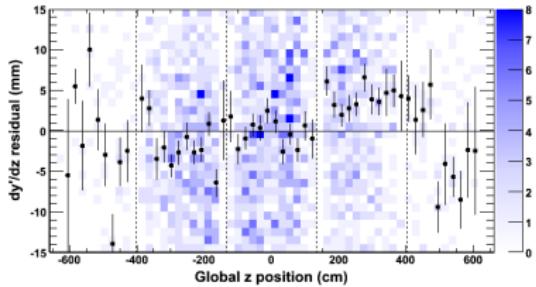
station 2, sector 05



station 2, sector 05

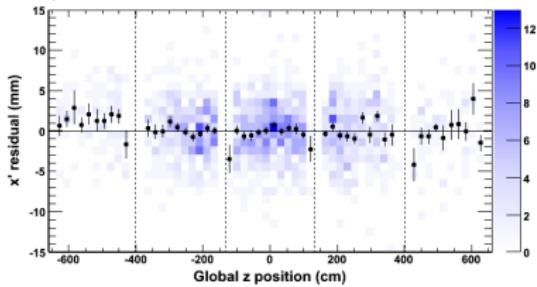


station 2, sector 05

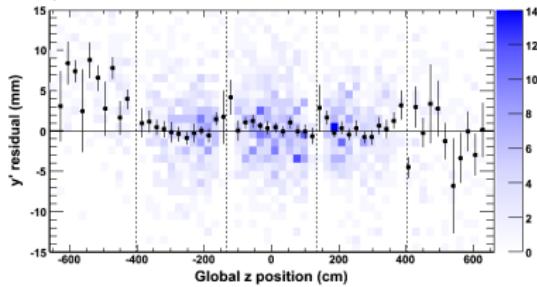


Map plots with SemiSuperSector δ_z

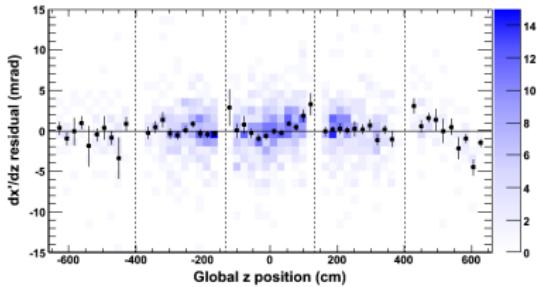
station 2, sector 06



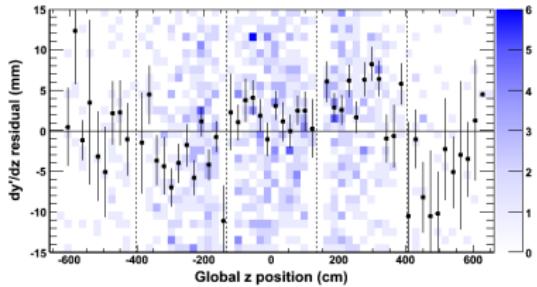
station 2, sector 06



station 2, sector 06

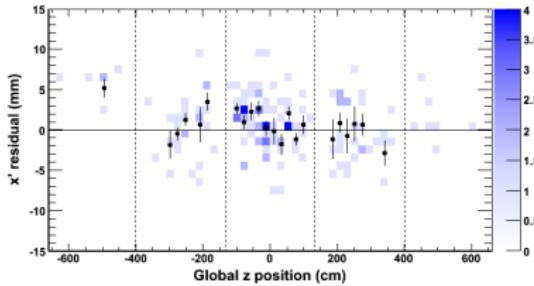


station 2, sector 06

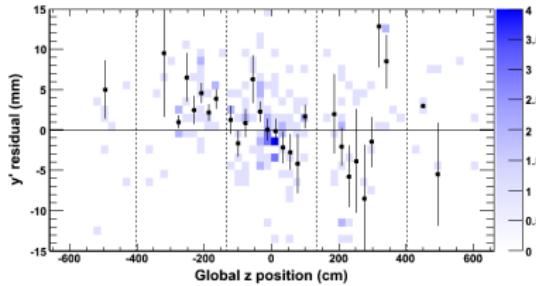


Map plots with SemiSuperSector δ_z

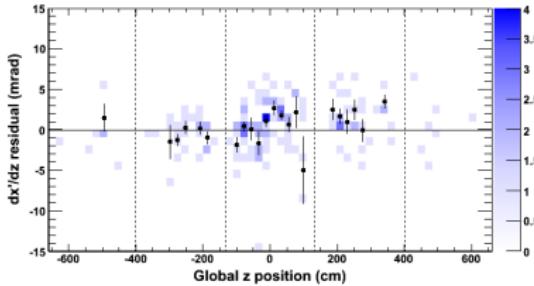
station 2, sector 07



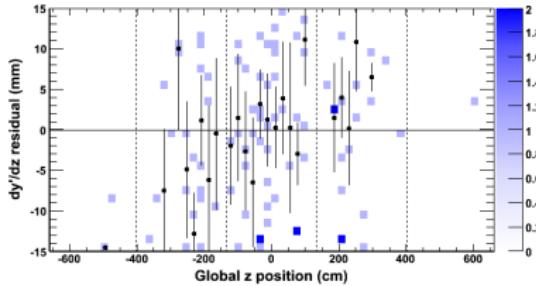
station 2, sector 07



station 2, sector 07

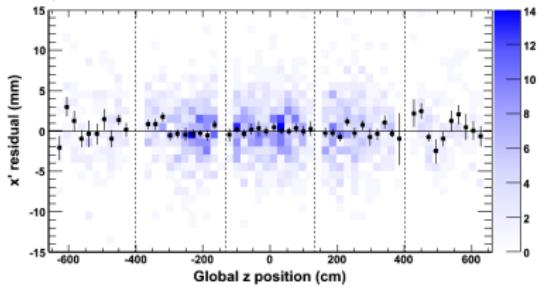


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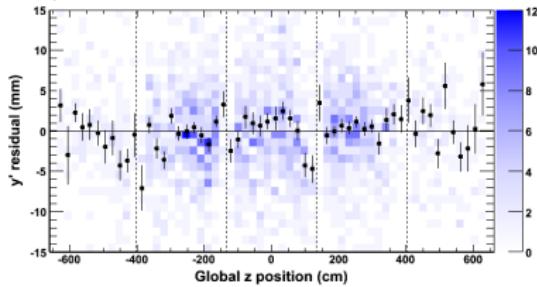


Map plots with SemiSuperSector δ_z

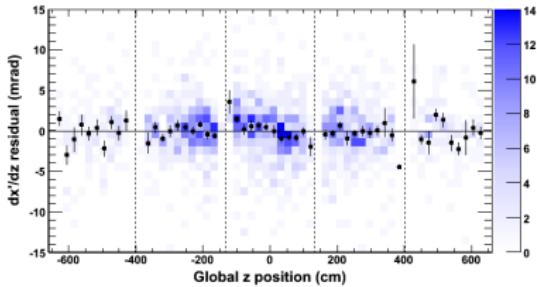
station 2, sector 08



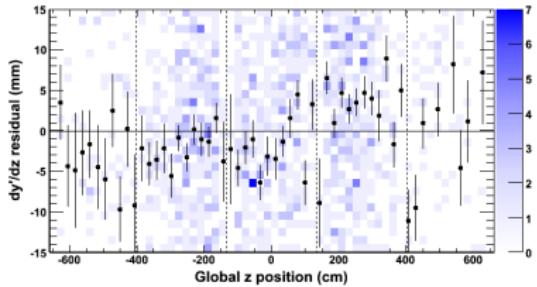
station 2, sector 08



station 2, sector 08

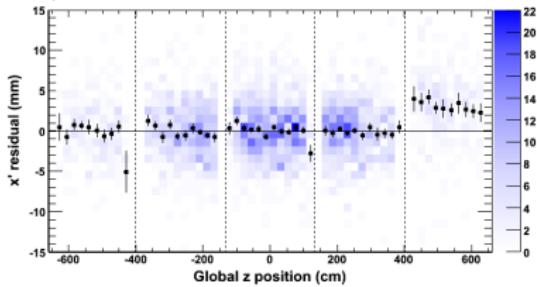


station 2, sector 08

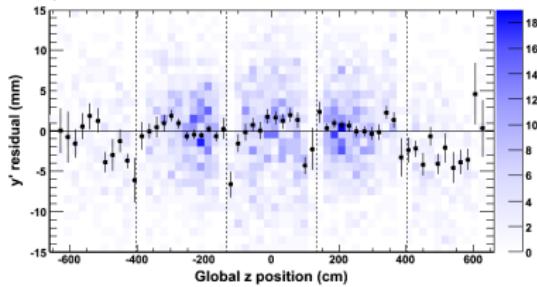


Map plots with SemiSuperSector δ_z

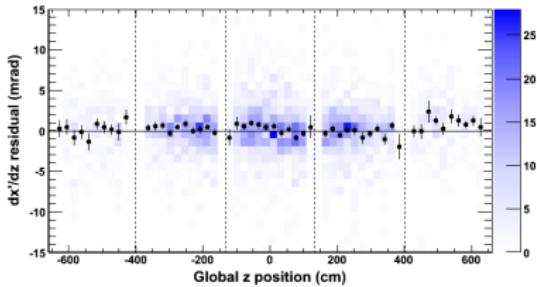
station 2, sector 09



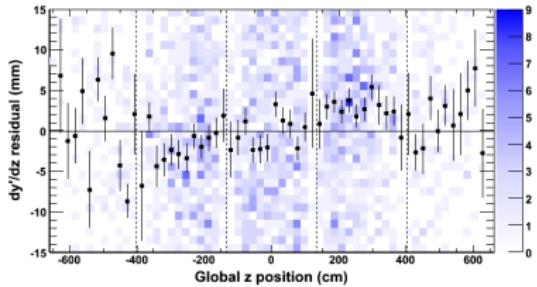
station 2, sector 09



station 2, sector 09

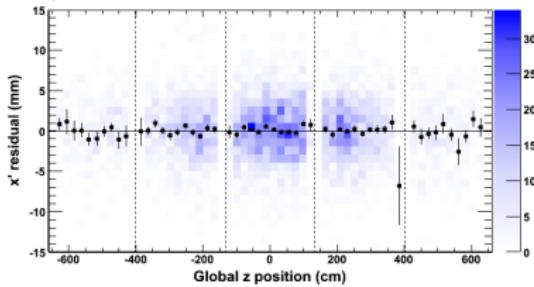


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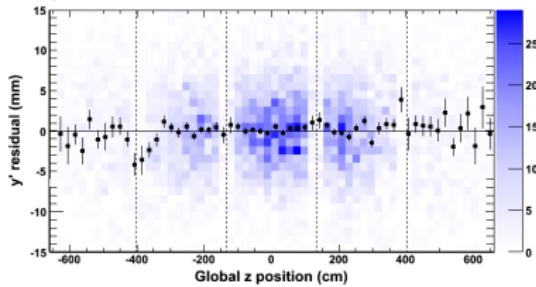


Map plots with SemiSuperSector δ_z

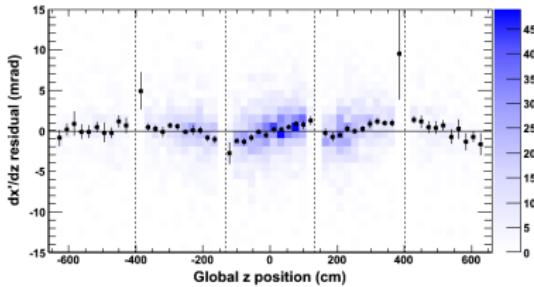
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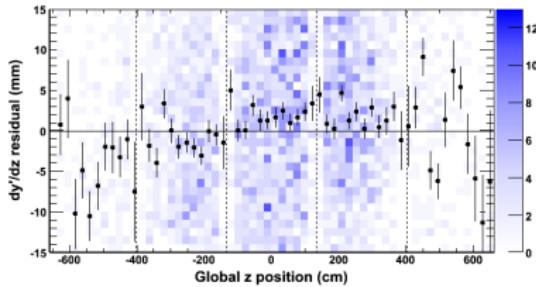
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station 2, sector 10

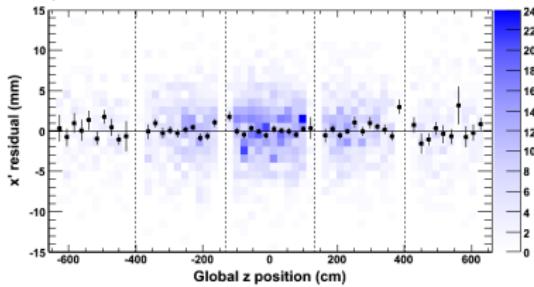


station 2, sector 10

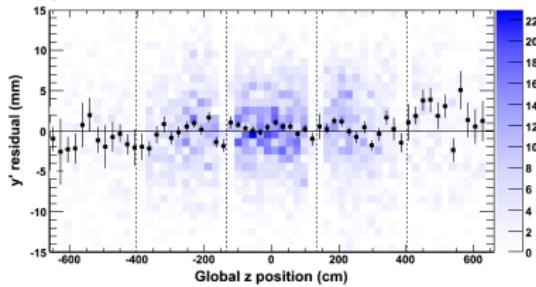


Map plots with SemiSuperSector δ_z

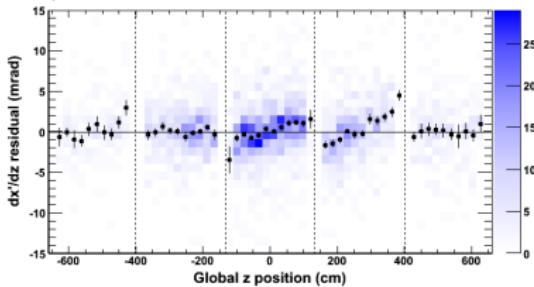
station 2, sector 11



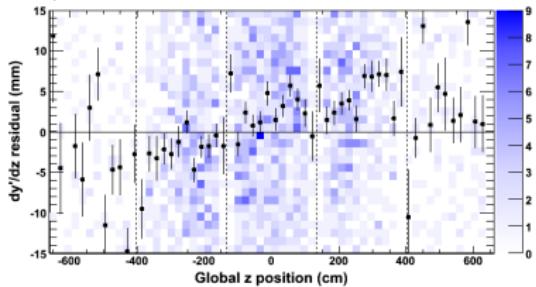
station 2, sector 11



station 2, sector 11

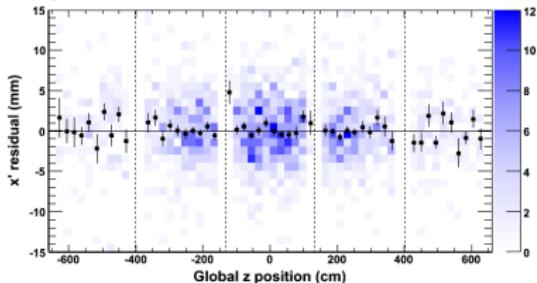


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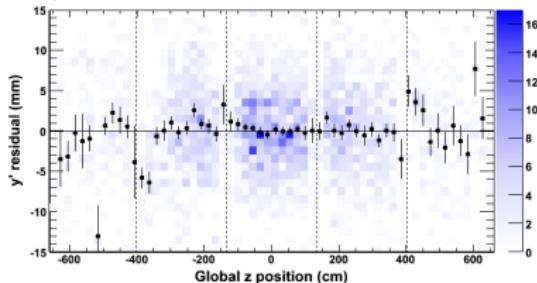


Map plots with SemiSuperSector δ_z

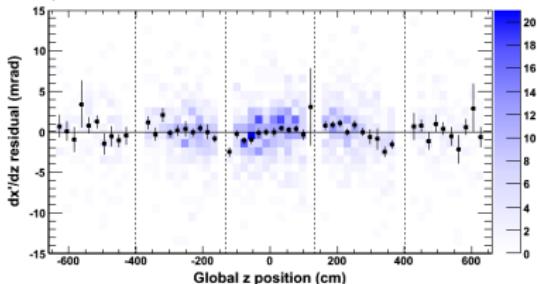
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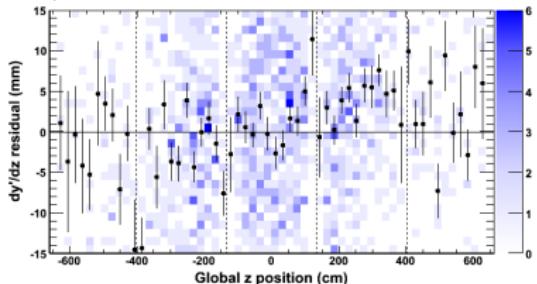
station 2, sector 12



station 2, sector 12

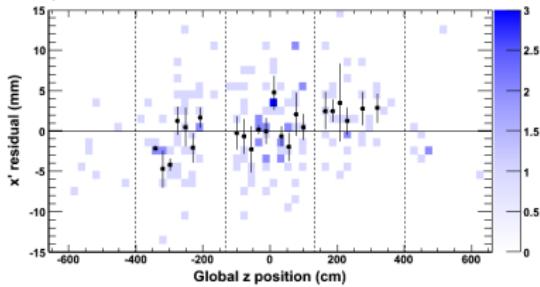


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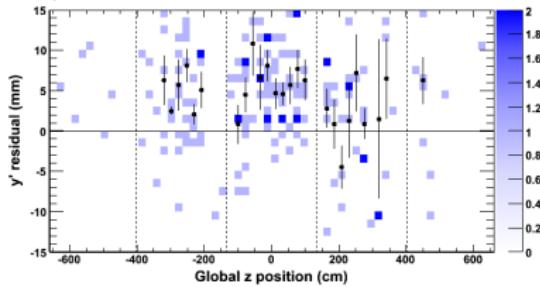


Map plots with SemiSuperSector δ_z

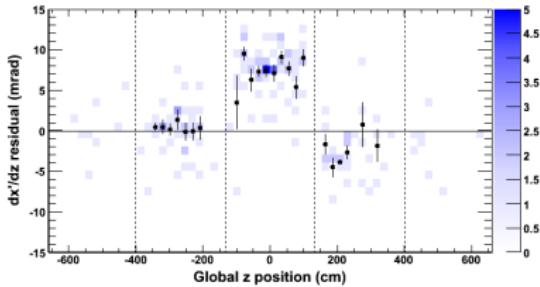
station 3, sector 01



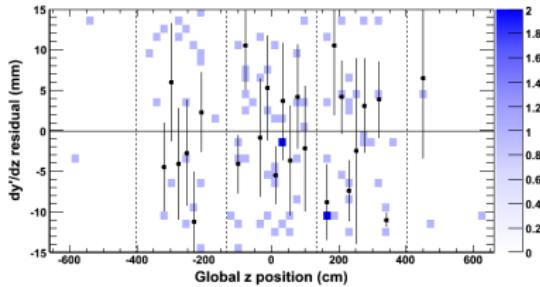
station 3, sector 01



station 3, sector 01

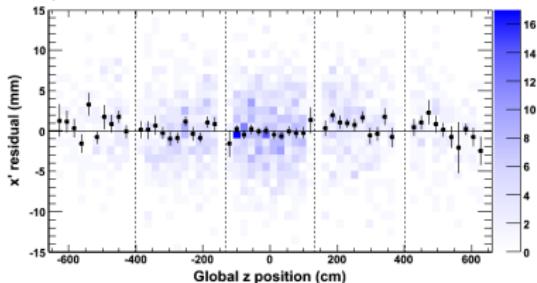


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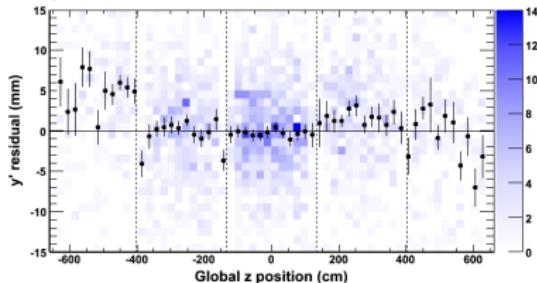


Map plots with SemiSuperSector δ_z

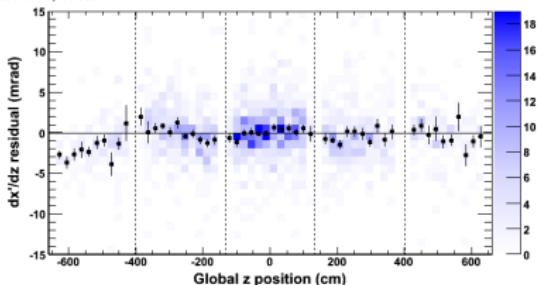
station 3, sector 02



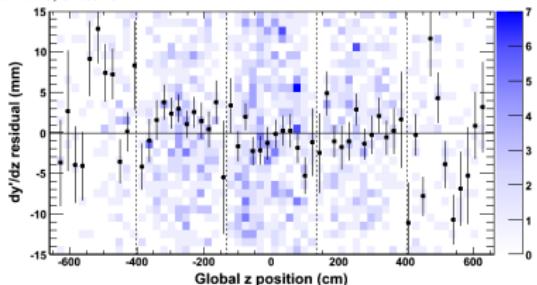
station 3, sector 02



station 3, sector 02

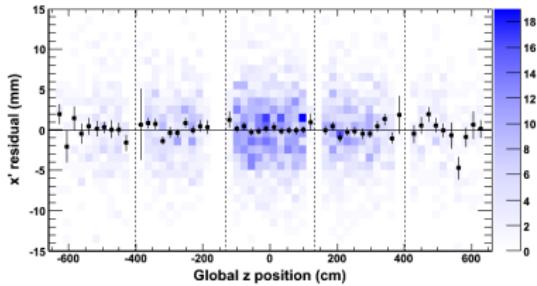


station 3, sector 02

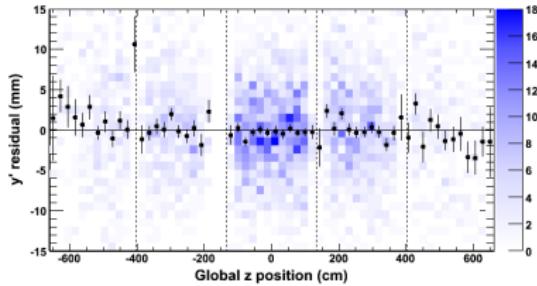


Map plots with SemiSuperSector δ_z

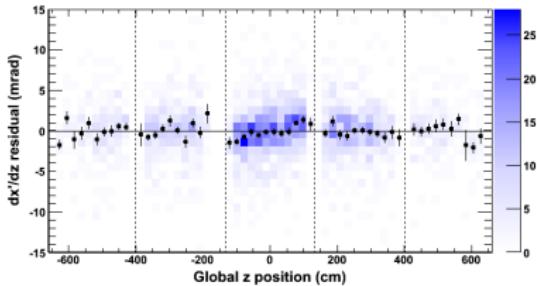
station 3, sector 03



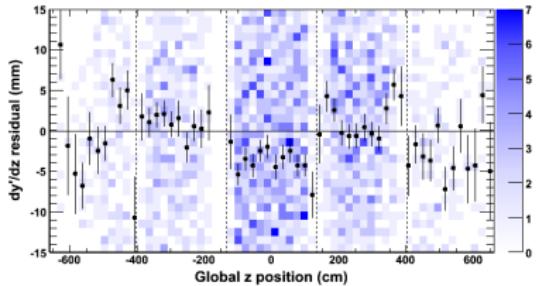
station 3, sector 03



station 3, sector 03

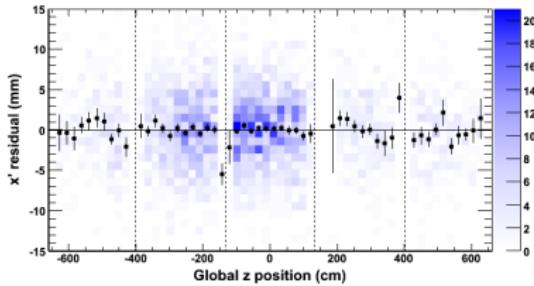


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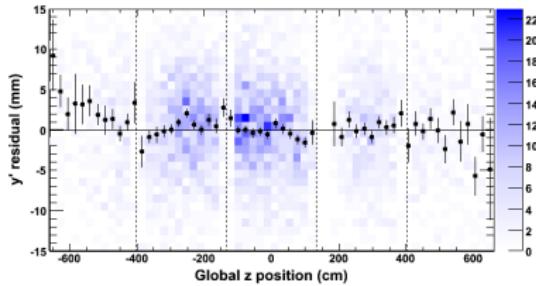


Map plots with SemiSuperSector δ_z

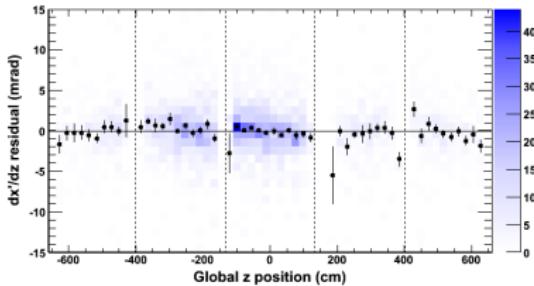
station 3, sector 04



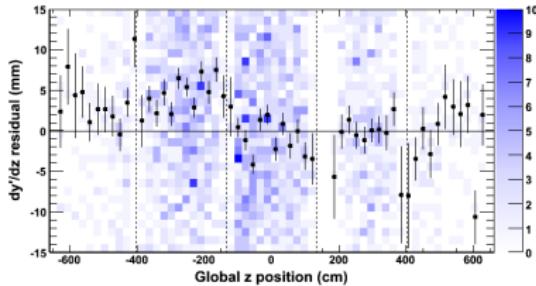
station 3, sector 04



station 3, sector 04

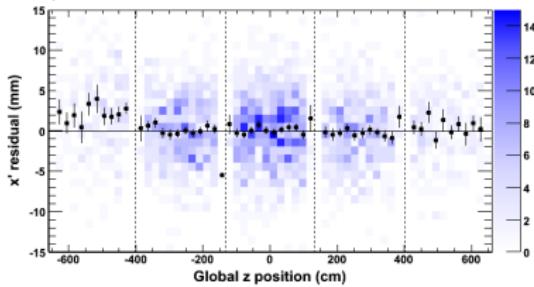


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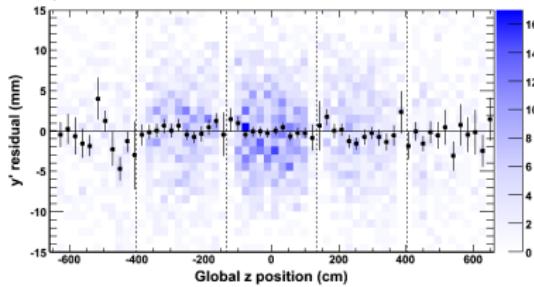


Map plots with SemiSuperSector δ_z

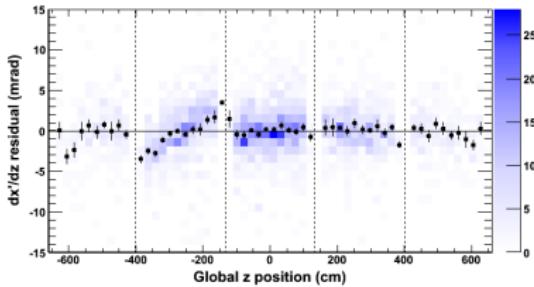
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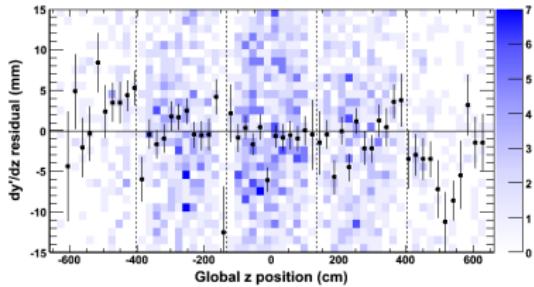
station 3, sector 05



station 3, sector 05

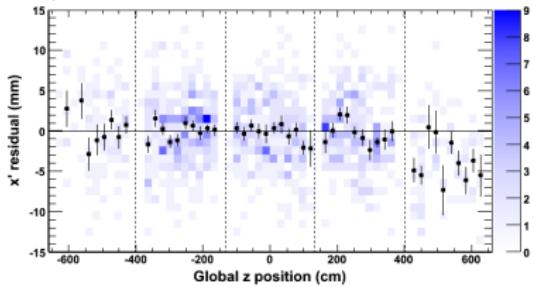


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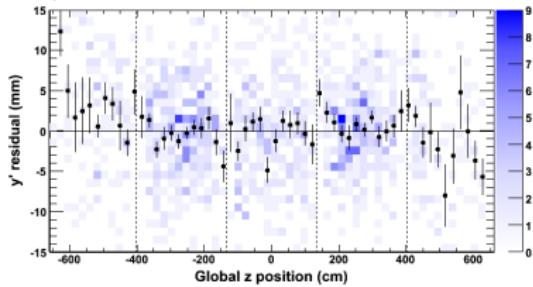


Map plots with SemiSuperSector δ_z

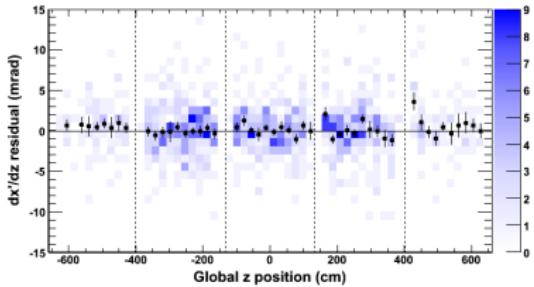
station 3, sector 06



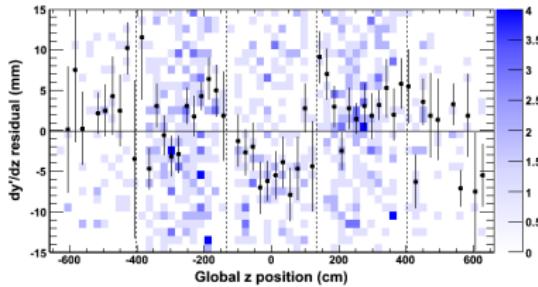
station 3, sector 06



station 3, sector 06

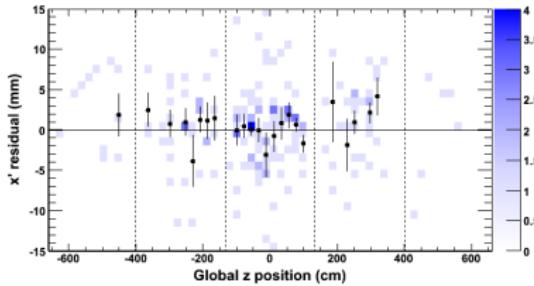


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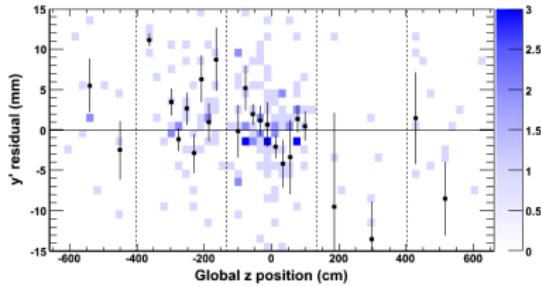


Map plots with SemiSuperSector δ_z

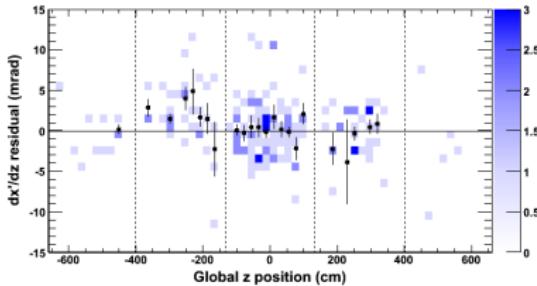
station 3, sector 07



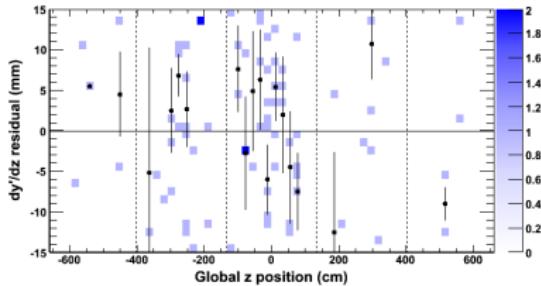
station 3, sector 07



station 3, sector 07

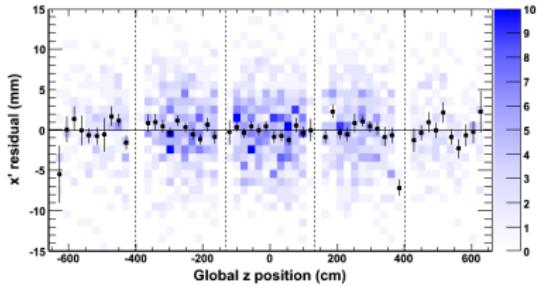


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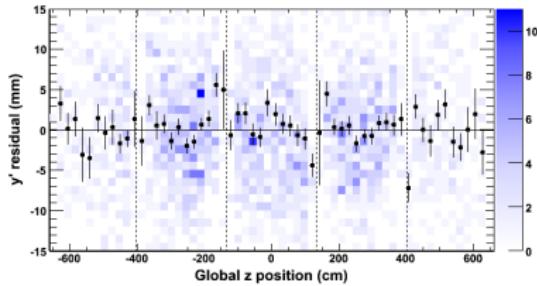


Map plots with SemiSuperSector δ_z

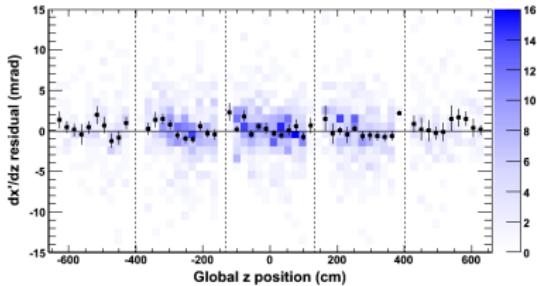
station 3, sector 08



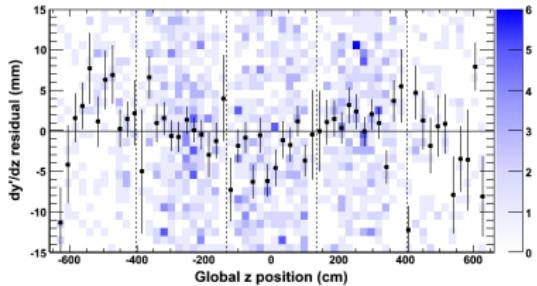
station 3, sector 08



station 3, sector 08

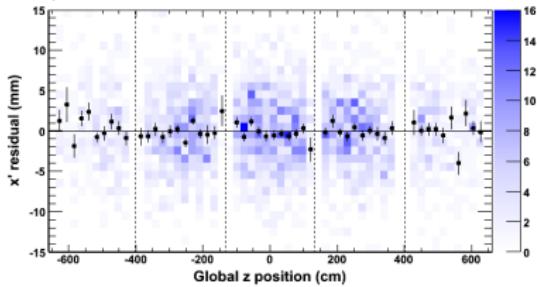


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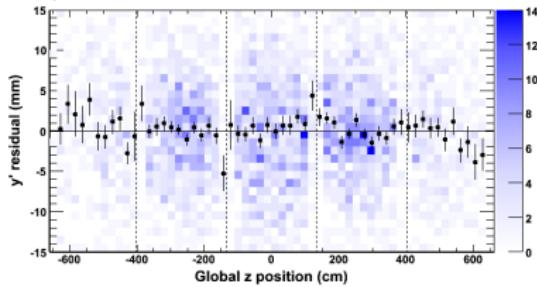


Map plots with SemiSuperSector δ_z

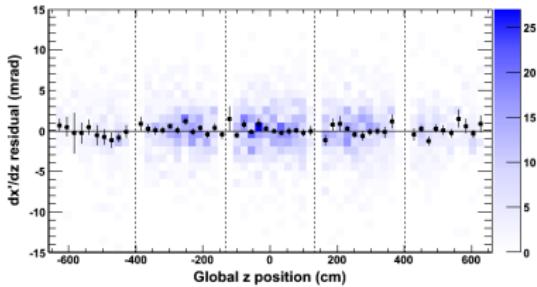
station 3, sector 09



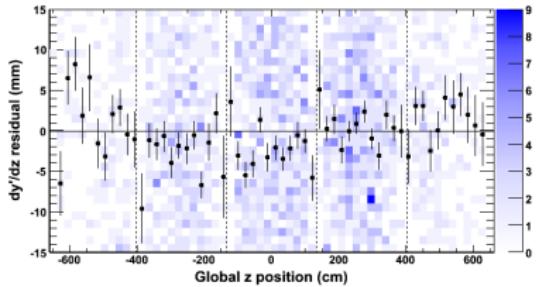
station 3, sector 09



station 3, sector 09

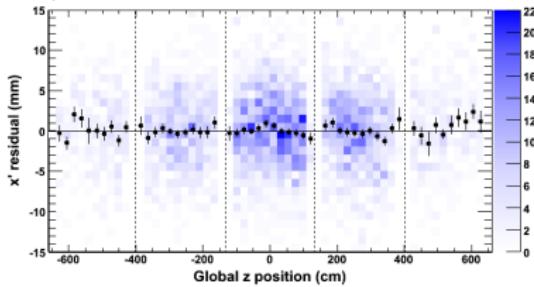


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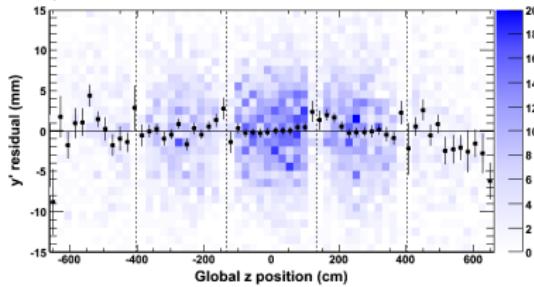


Map plots with SemiSuperSector δ_z

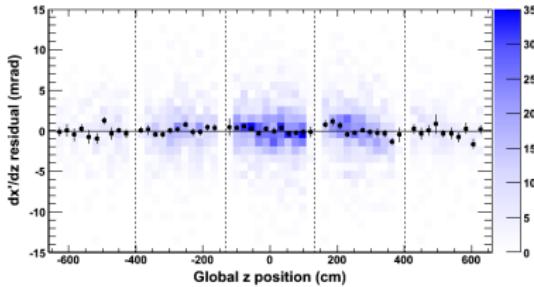
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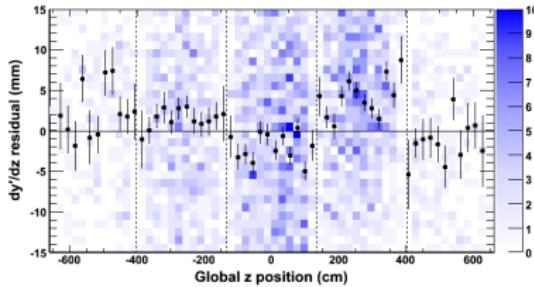
station 3, sector 10



station 3, sector 10

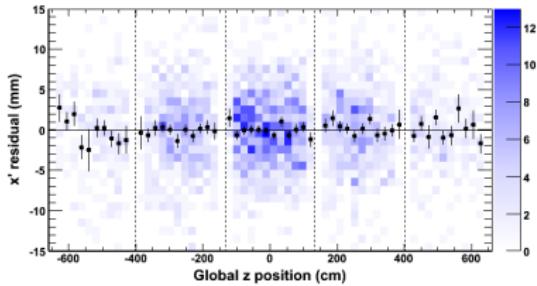


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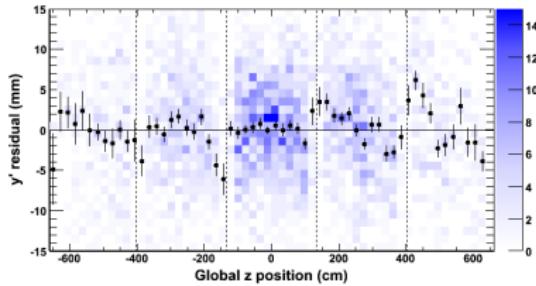


Map plots with SemiSuperSector δ_z

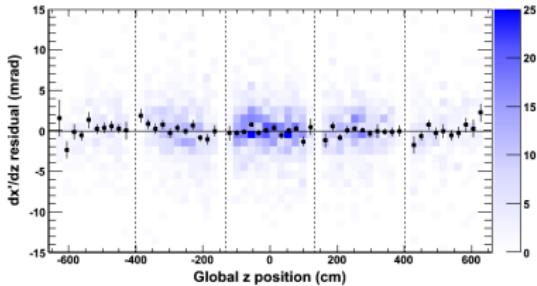
station 3, sector 11



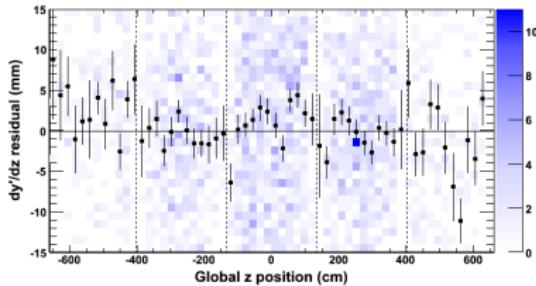
station 3, sector 11



station 3, sector 11

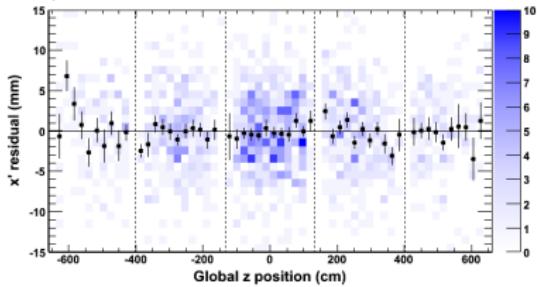


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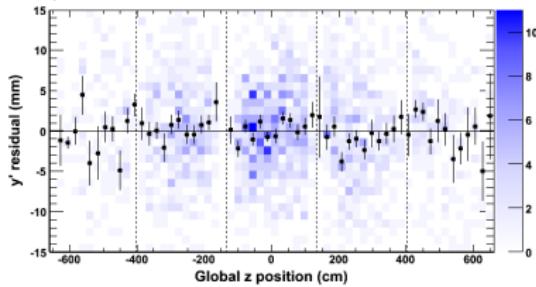


Map plots with SemiSuperSector δ_z

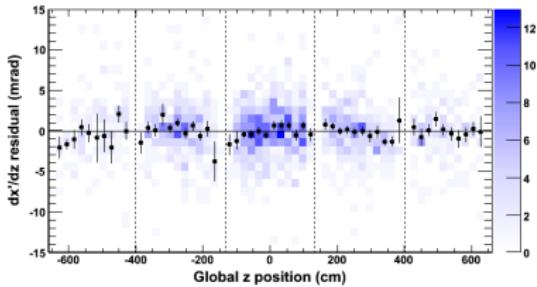
station 3, sector 12



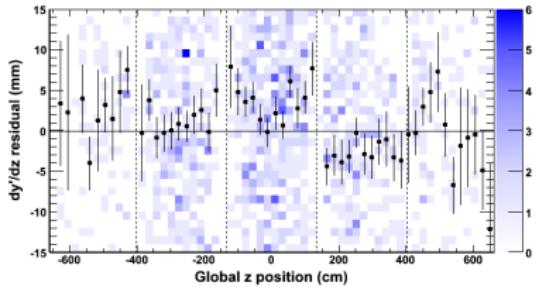
station 3, sector 12



station 3, sector 12

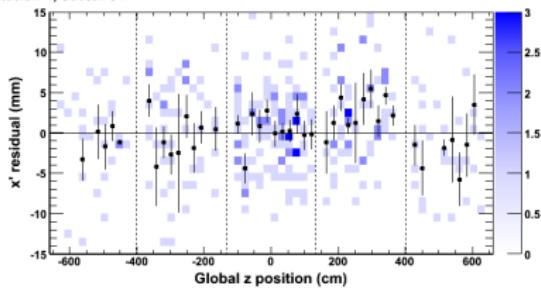


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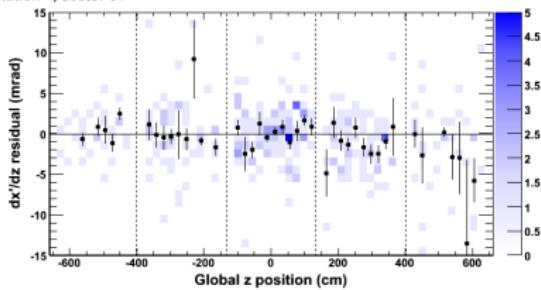


Map plots with SemiSuperSector δ_z

station 4, sector 01

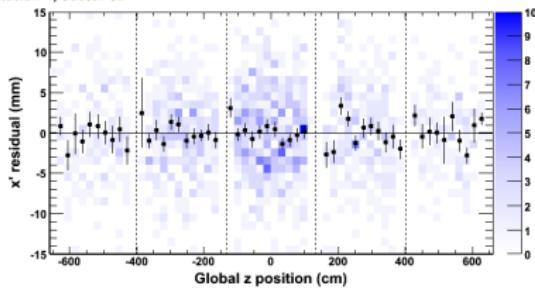


station 4, sector 01

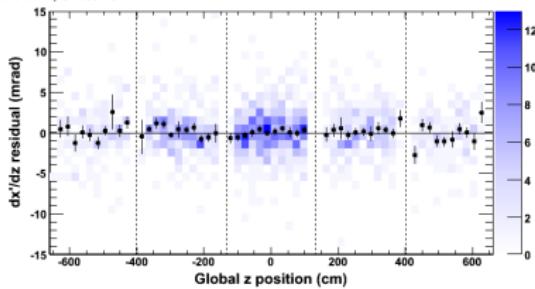


Map plots with SemiSuperSector δ_z

station 4, sector 02

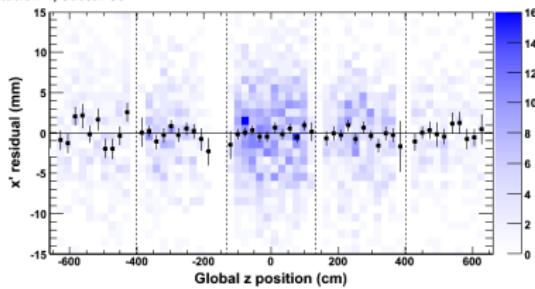


station 4, sector 02

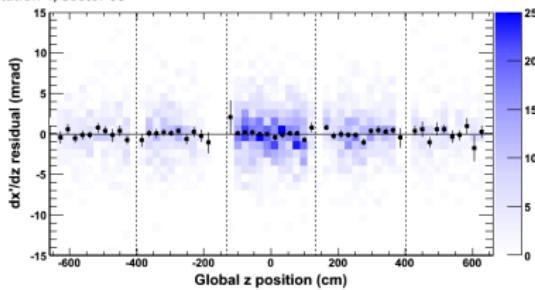


Map plots with SemiSuperSector δ_z

station 4, sector 03

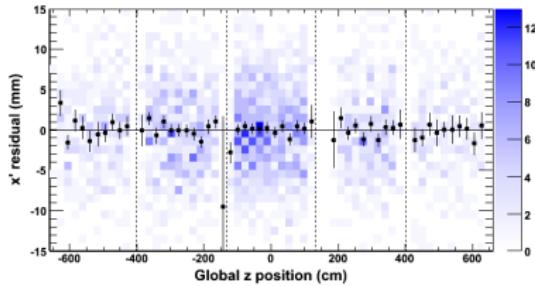


station 4, sector 03

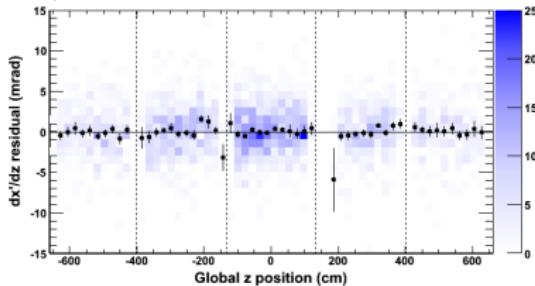


Map plots with SemiSuperSector δ_z

station 4, sector 04

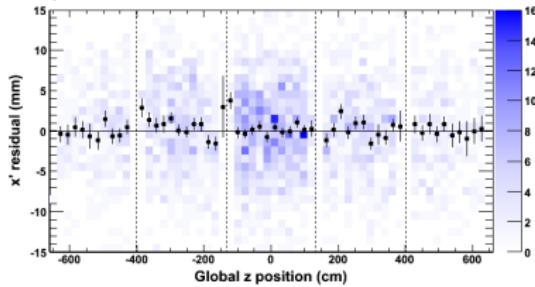


station 4, sector 04

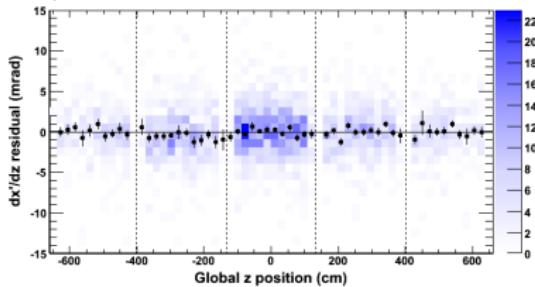


Map plots with SemiSuperSector δ_z

station 4, sector 05

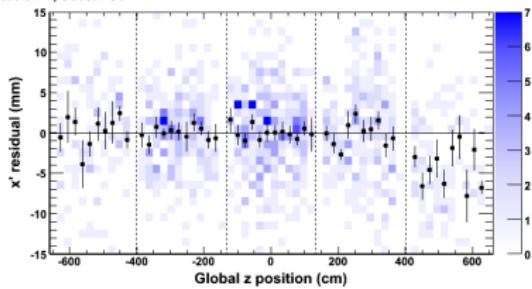


station 4, sector 05

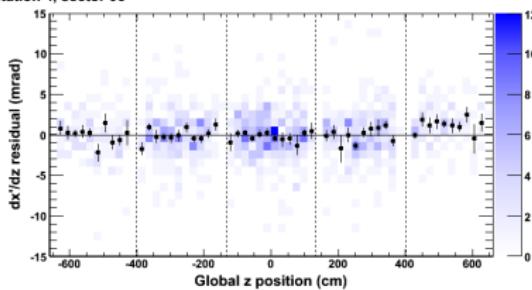


Map plots with SemiSuperSector δ_z

station 4, sector 06

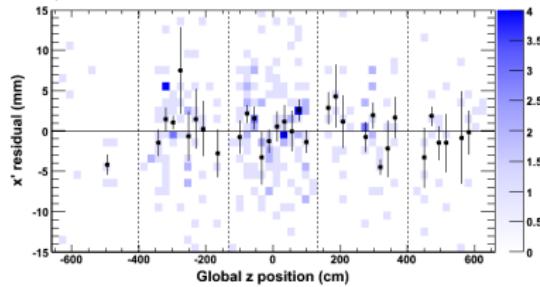


station 4, sector 06

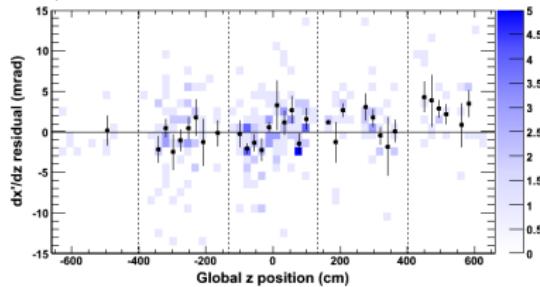


Map plots with SemiSuperSector δ_z

station 4, sector 07

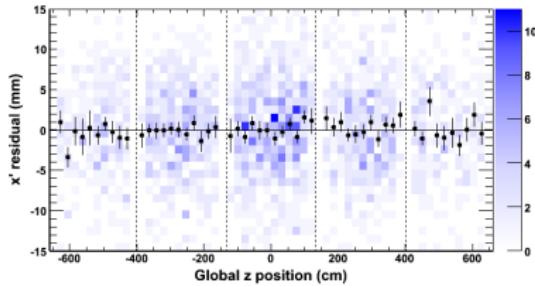


station 4, sector 07

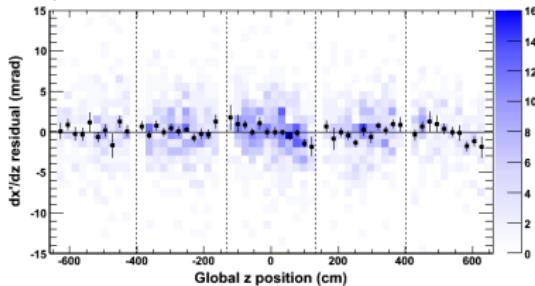


Map plots with SemiSuperSector δ_z

station 4, sector 08

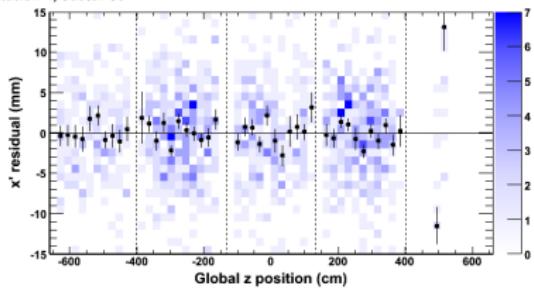


station 4, sector 08

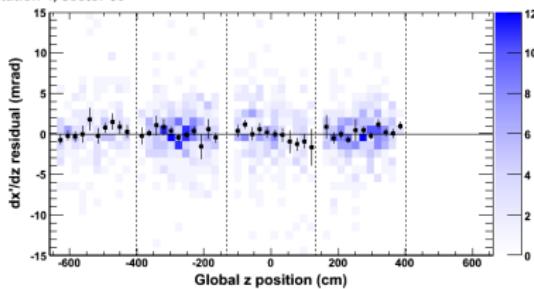


Map plots with SemiSuperSector δ_z

station 4, sector 09

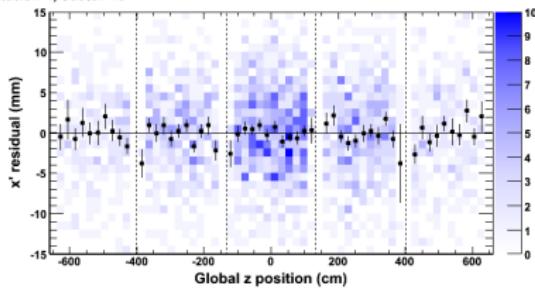


station 4, sector 09

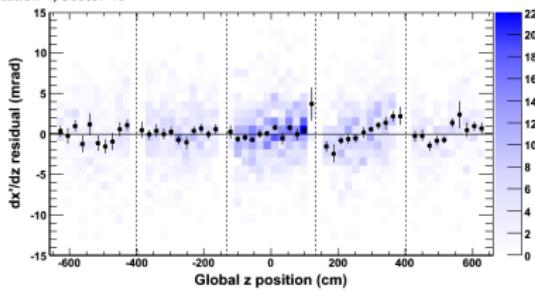


Map plots with SemiSuperSector δ_z

station 4, sector 10

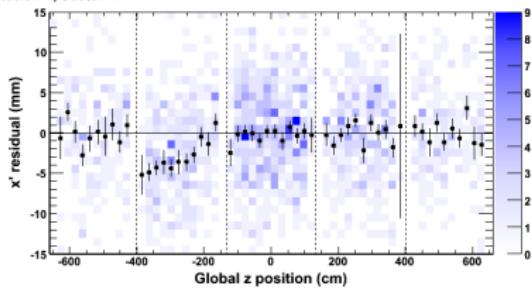


station 4, sector 10

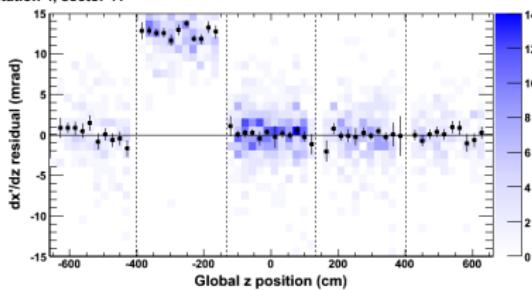


Map plots with SemiSuperSector δ_z

station 4, sector 11

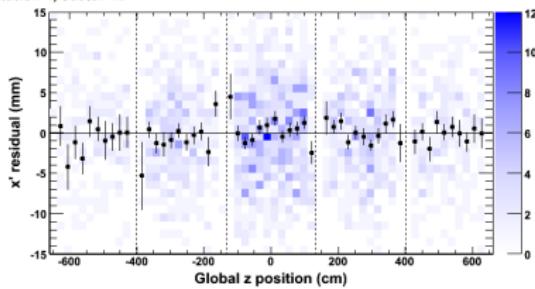


station 4, sector 11

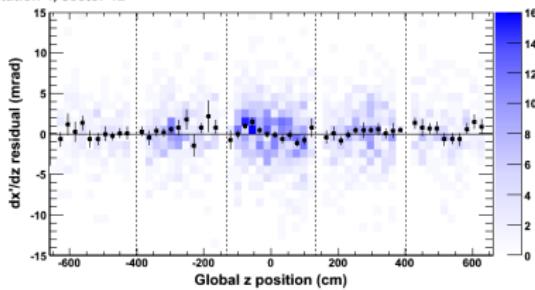


Map plots with SemiSuperSector δ_z

station 4, sector 12

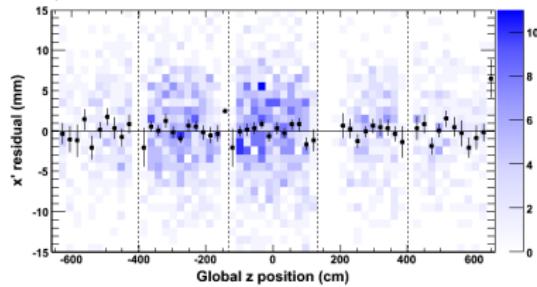


station 4, sector 12

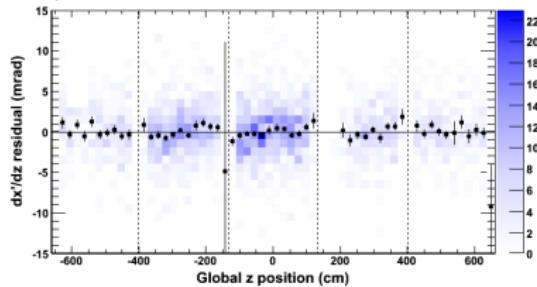


Map plots with SemiSuperSector δ_z

station 4, sector 13

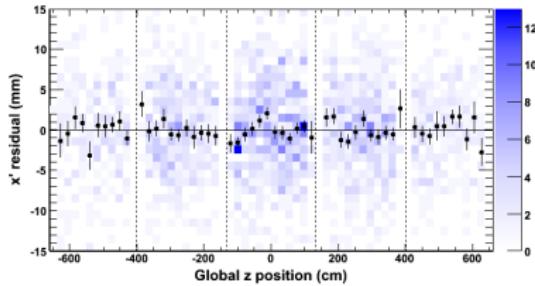


station 4, sector 13



Map plots with SemiSuperSector δ_z

station 4, sector 14



station 4, sector 14

