Magnetic field maps and forward tracker alignment

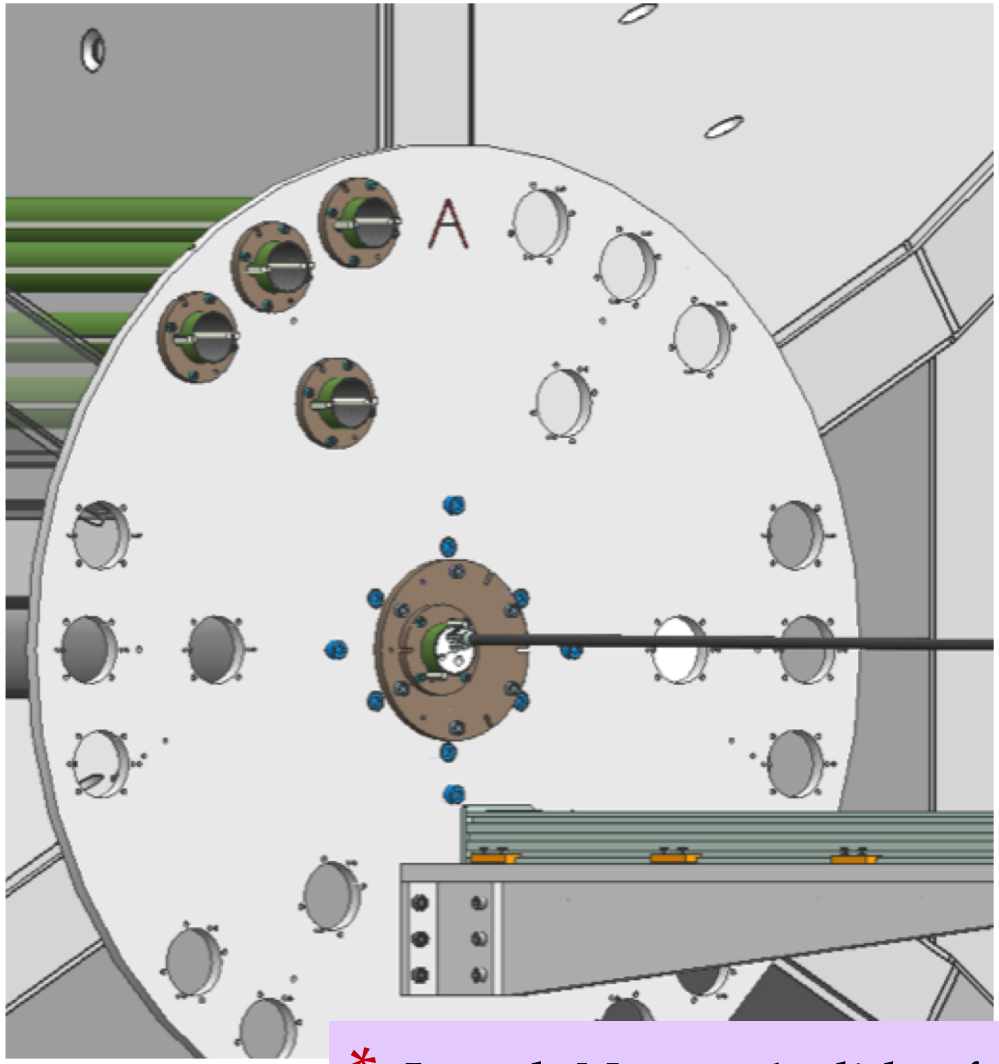
CLAS Collab. Meeting - June, 2019

Mac Mestayer

Forward Track Resolution: Status

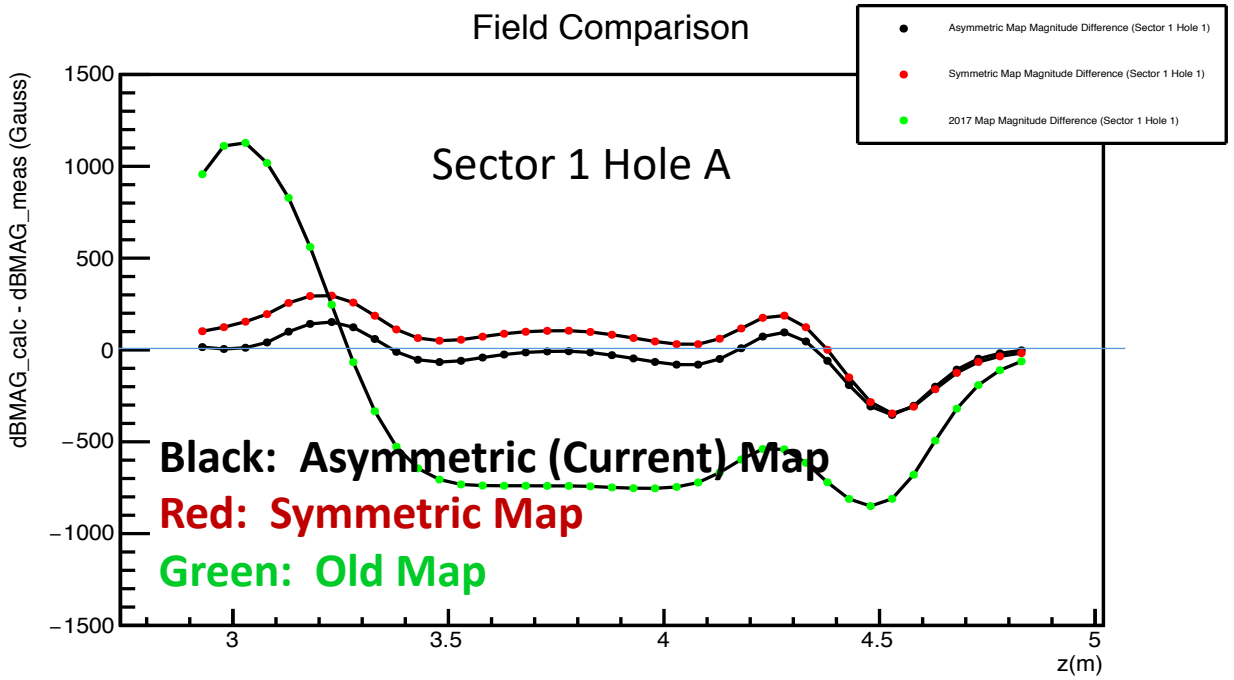
Project	Method	Project Status / Results	Who*
Measure torus B-field → improve **model** (original disagreements of ~ 2 – 3%)	**Fit (model vs. measurement) differences** to a **weighted sum** of pre-calculated differences caused by **"unit displacements"** of coils	**Done** • **next slides → a few details**	JN, Engineers
Align Drift Chambers → improve **tracking** (original misplacements of ~2mm)	**Fit residual mean offset patterns from "straight-track" data** to a **weighted sum** of pre-calculated offset patterns caused by **"unit displacements"** of chambers	**Done** • **nest slides → a few details**	TH

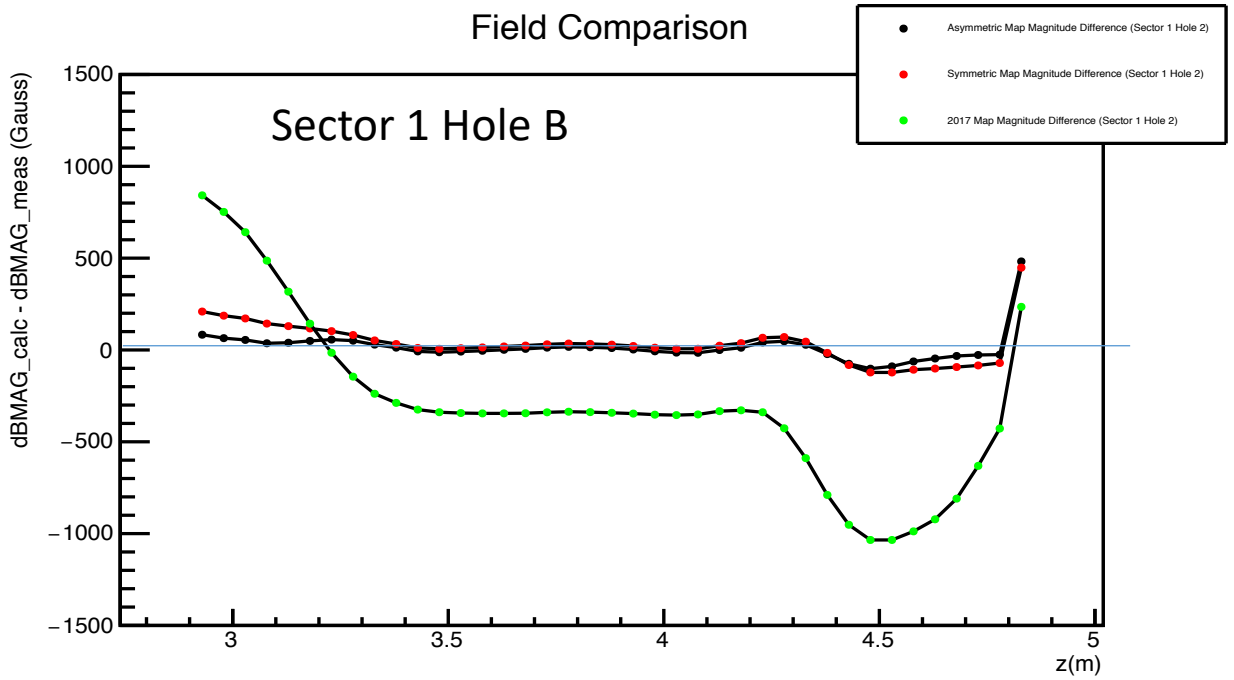
Location of Measurement Points*

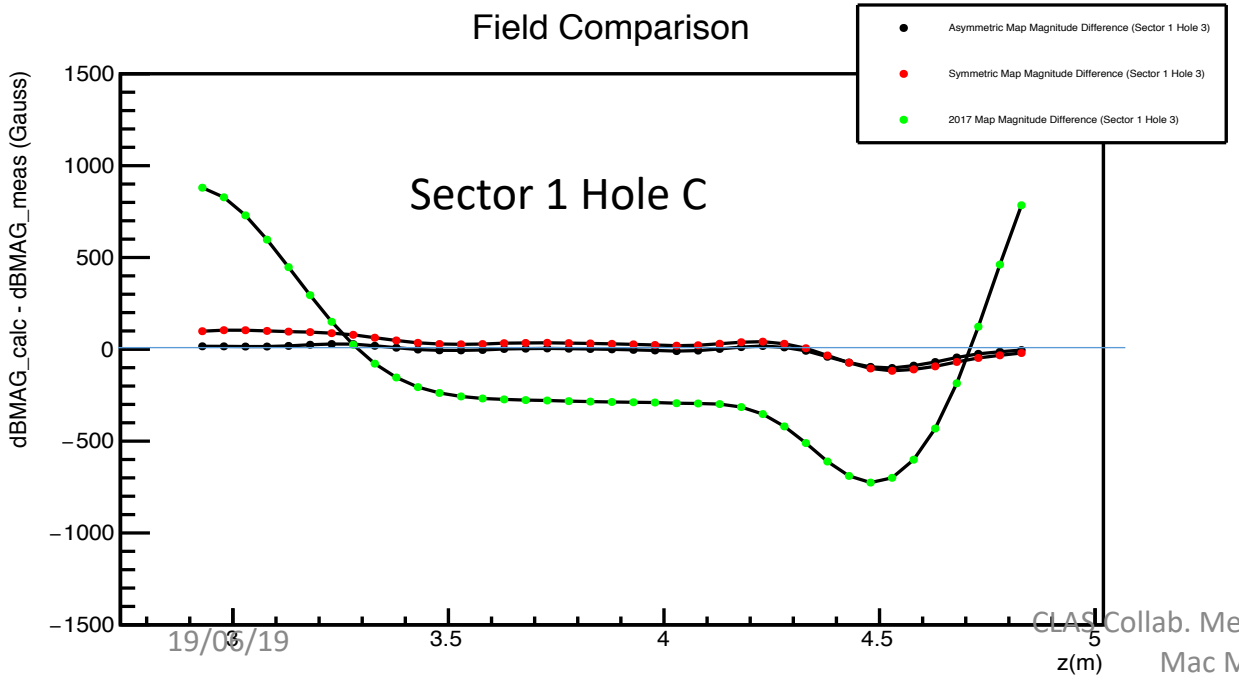


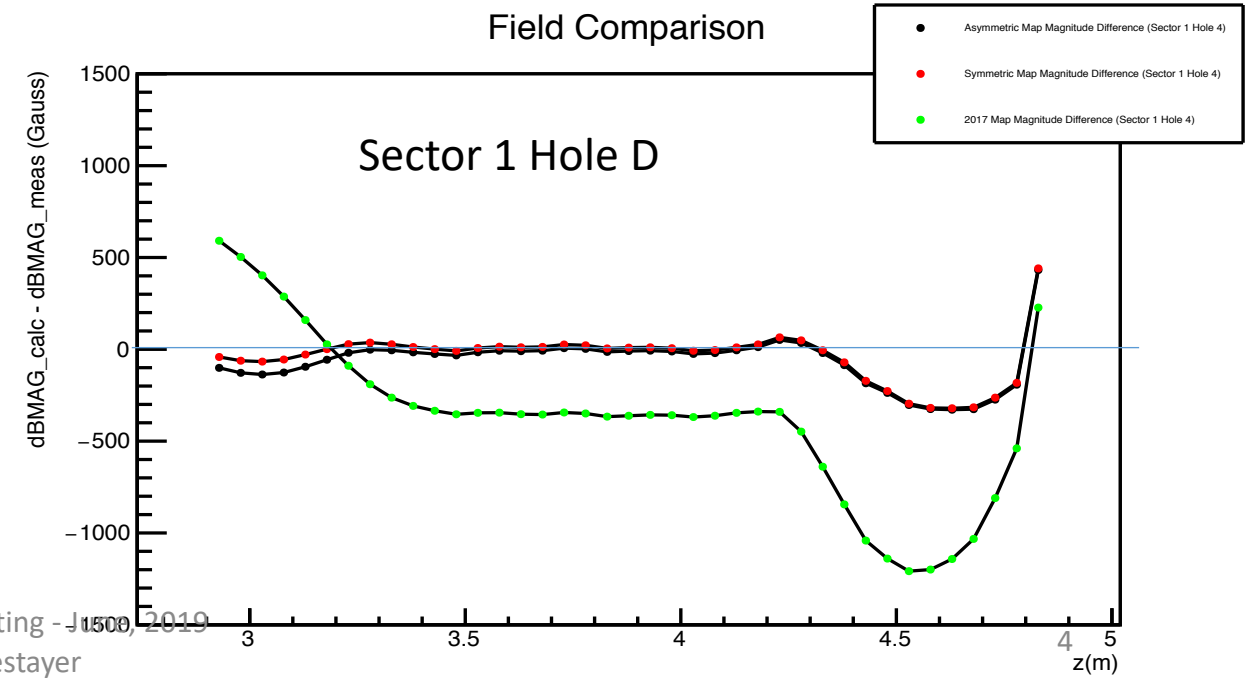
Inner Holes (A): 30 cm From the Center
Outer Holes (B, C, and D): 46.5 cm From the Center

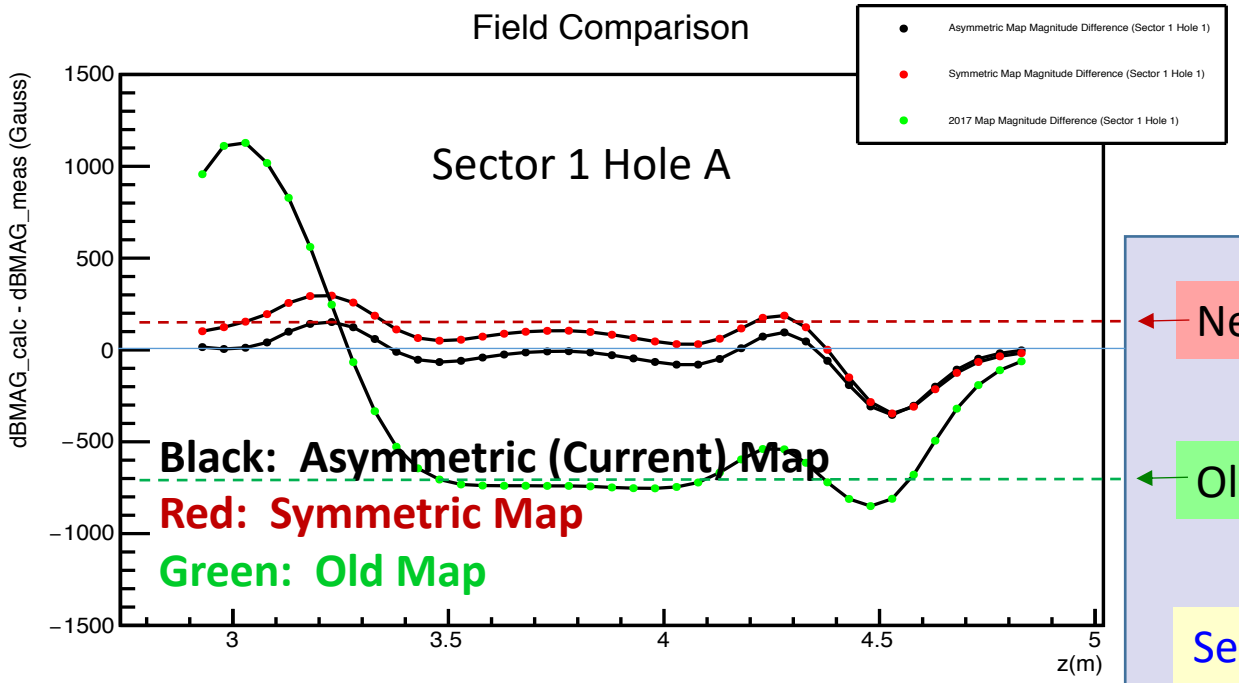
* Joseph Newton's slides from Summer '18 Collaboration Meeting

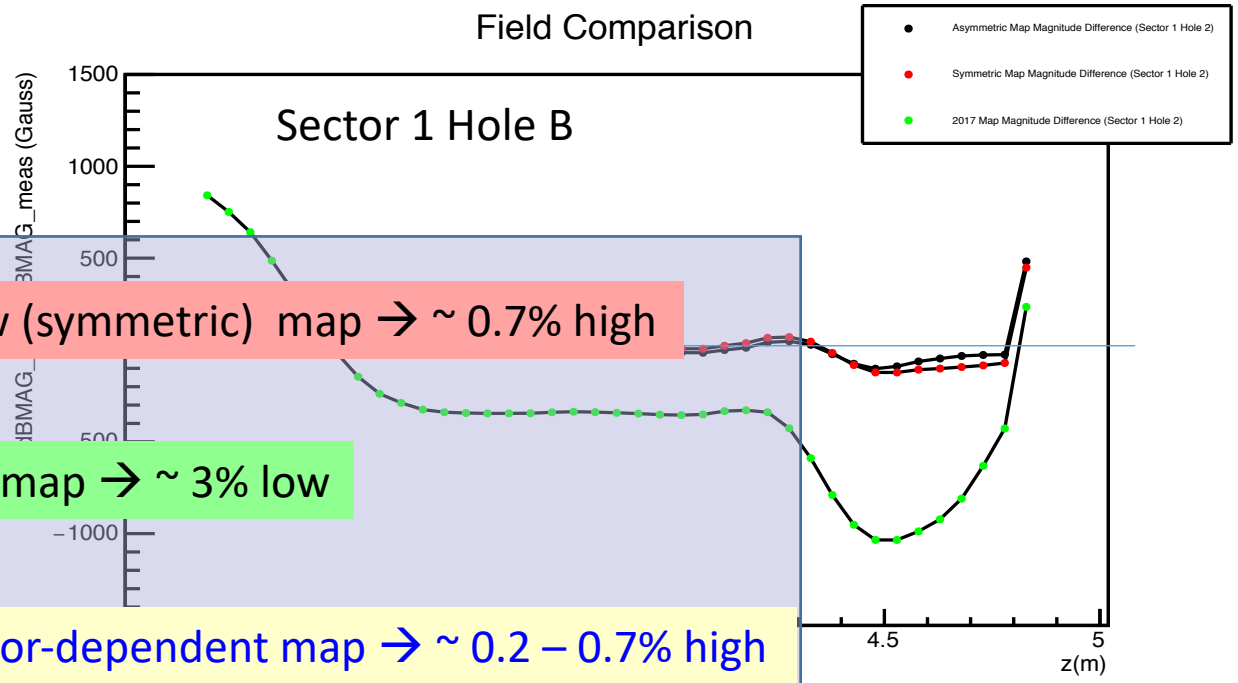

Field Comparison
Asymmetric Map Magnitude Difference (Sector 1 Hole 1)
Symmetric Map Magnitude Difference (Sector 1 Hole 1)
2017 Map Magnitude Difference (Sector 1 Hole 1)
Sector 1 Hole A
Black: Asymmetric (Current) Map
Red: Symmetric Map
Green: Old Map
dBMAG_calc - dBMAG_meas (Gauss)
z(m)


Field Comparison
Asymmetric Map Magnitude Difference (Sector 1 Hole 2)
Symmetric Map Magnitude Difference (Sector 1 Hole 2)
2017 Map Magnitude Difference (Sector 1 Hole 2)
Sector 1 Hole B
dBMAG_calc - dBMAG_meas (Gauss)
z(m)


Field Comparison
Asymmetric Map Magnitude Difference (Sector 1 Hole 3)
Symmetric Map Magnitude Difference (Sector 1 Hole 3)
2017 Map Magnitude Difference (Sector 1 Hole 3)
Sector 1 Hole C
dBMAG_calc - dBMAG_meas (Gauss)
z(m)


Field Comparison
Asymmetric Map Magnitude Difference (Sector 1 Hole 4)
Symmetric Map Magnitude Difference (Sector 1 Hole 4)
2017 Map Magnitude Difference (Sector 1 Hole 4)
Sector 1 Hole D
dBMAG_calc - dBMAG_meas (Gauss)
z(m)

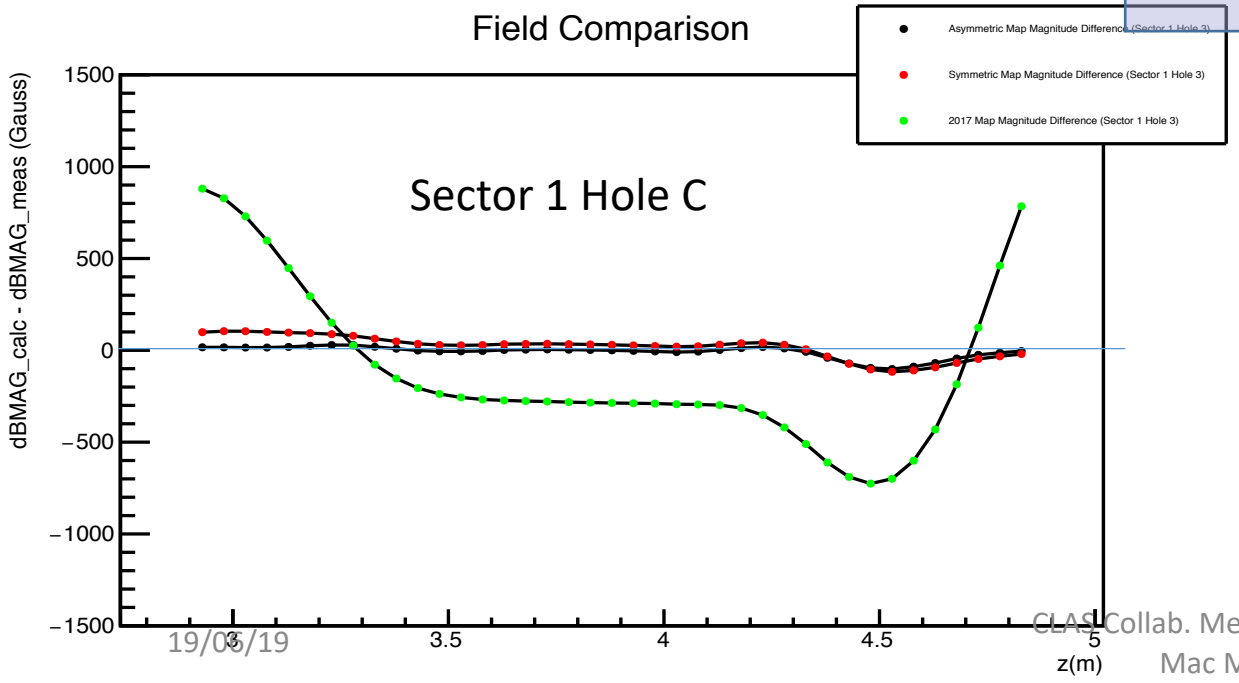


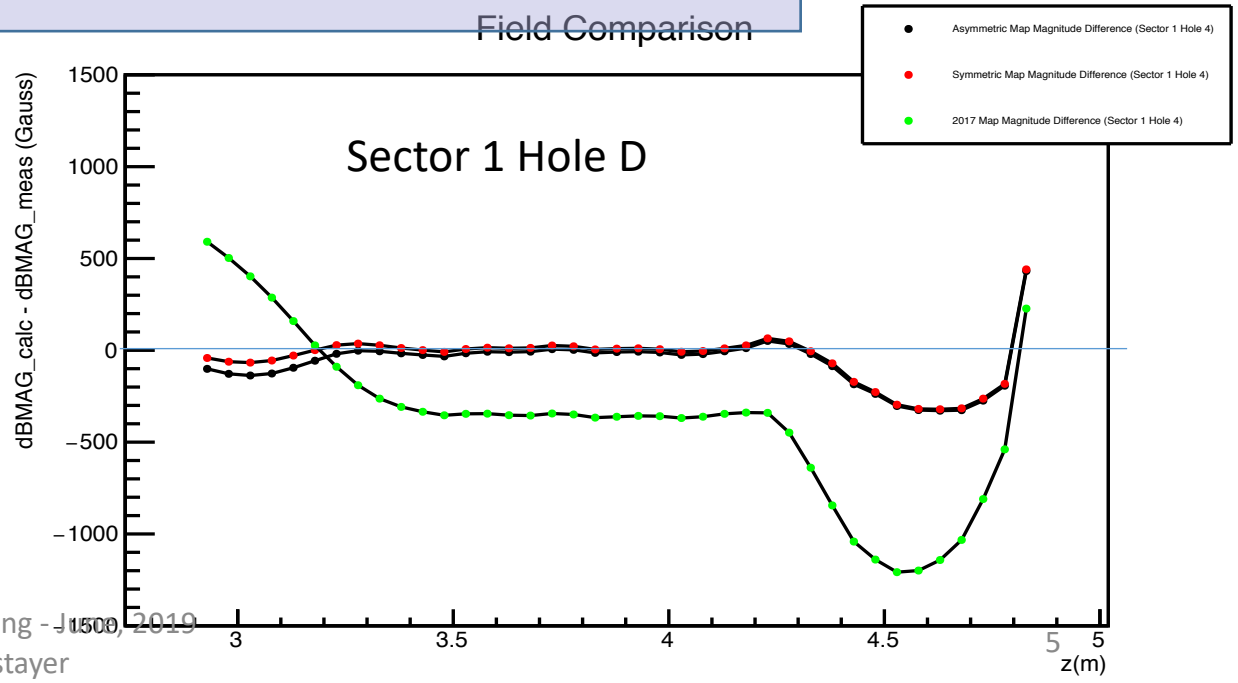


New (symmetric) map → ~ 0.7% high

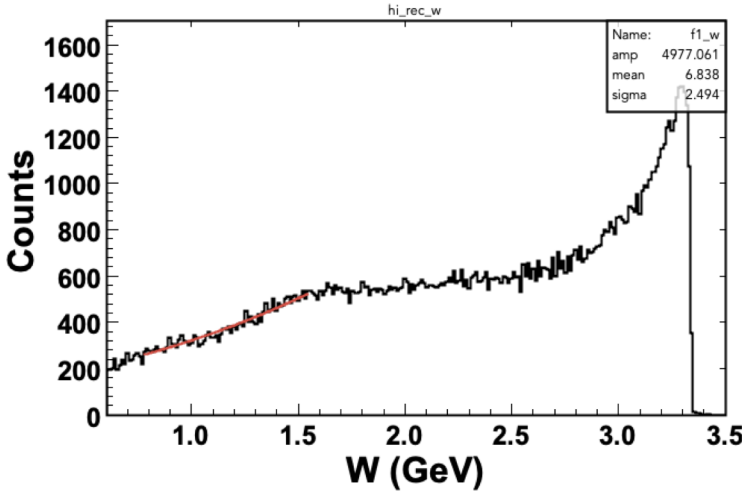
Old map → ~ 3% low

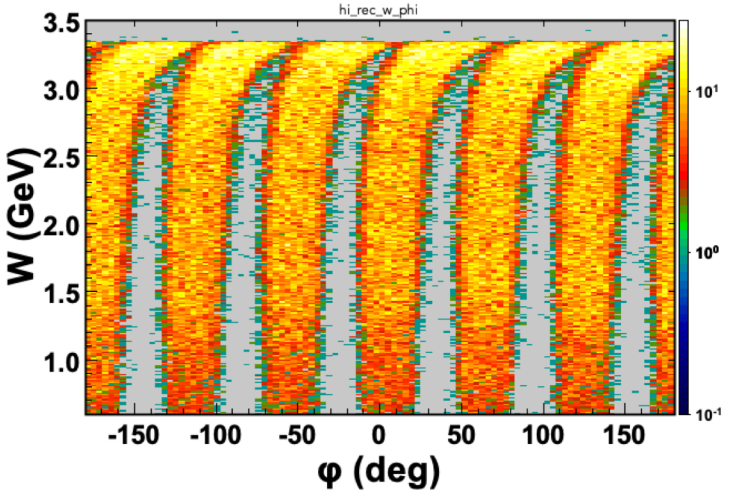
Sector-dependent map → ~ 0.2 – 0.7% high

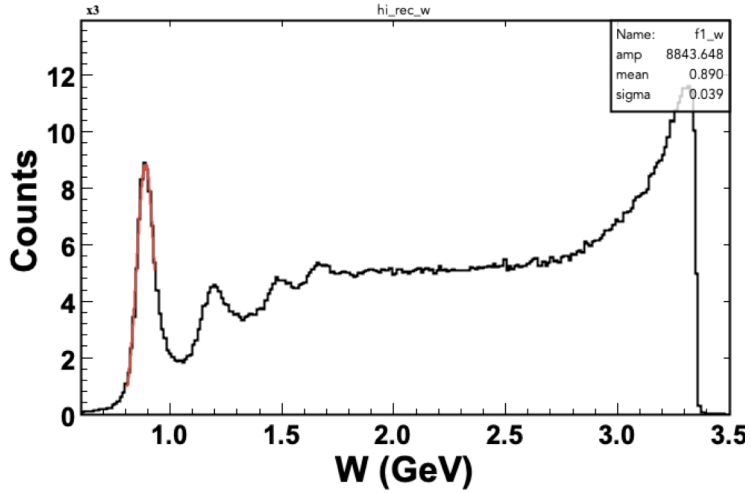


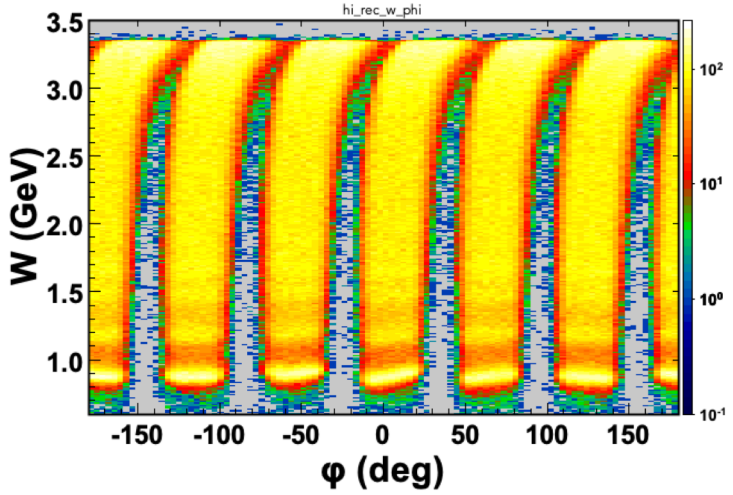


From the old to the new symmetric map

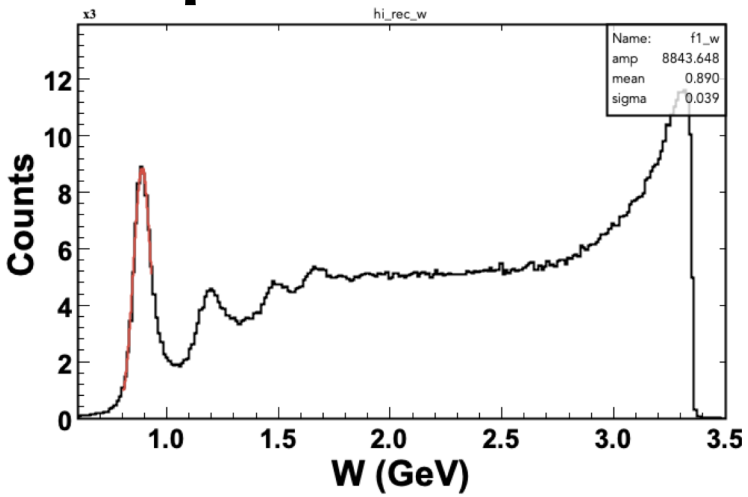


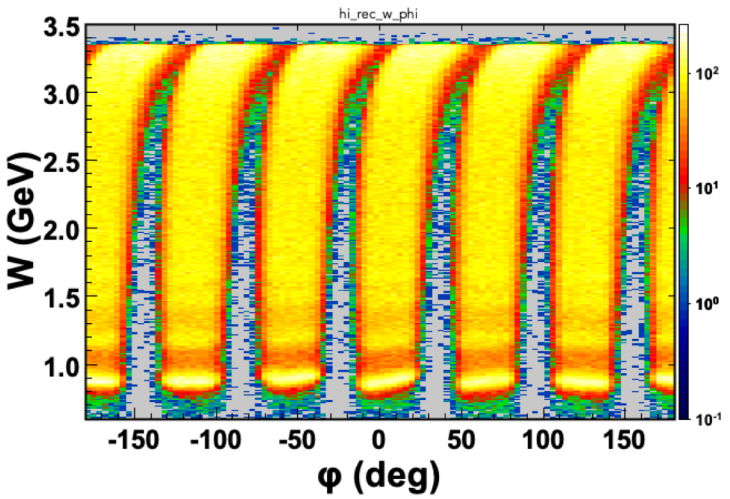


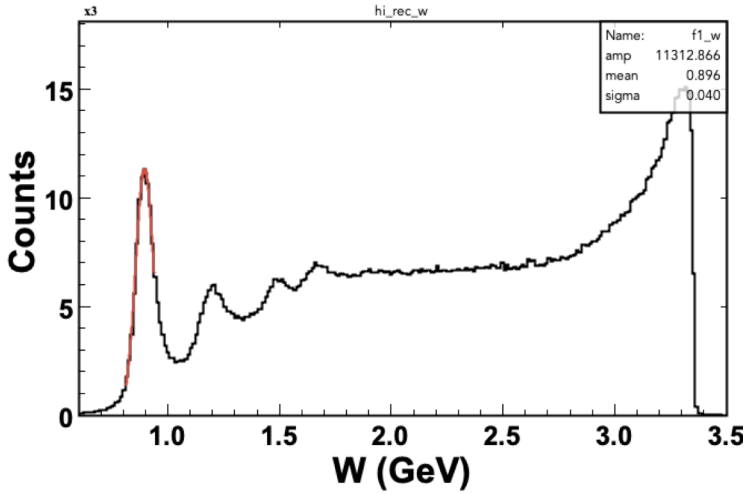


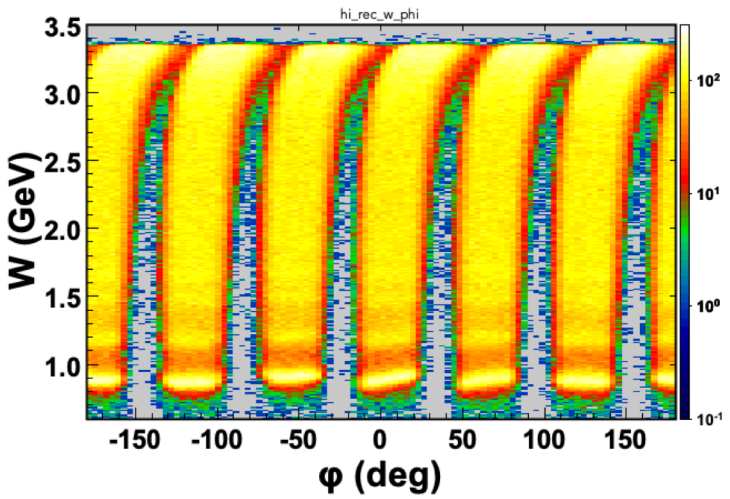


From the symmetric to the asymmetric map





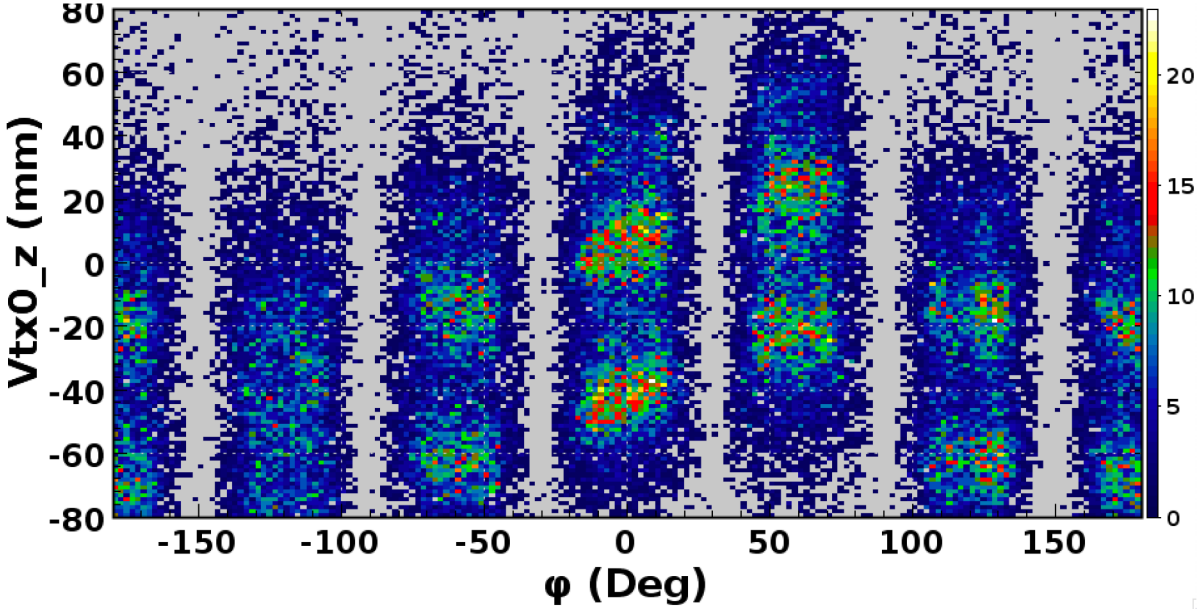




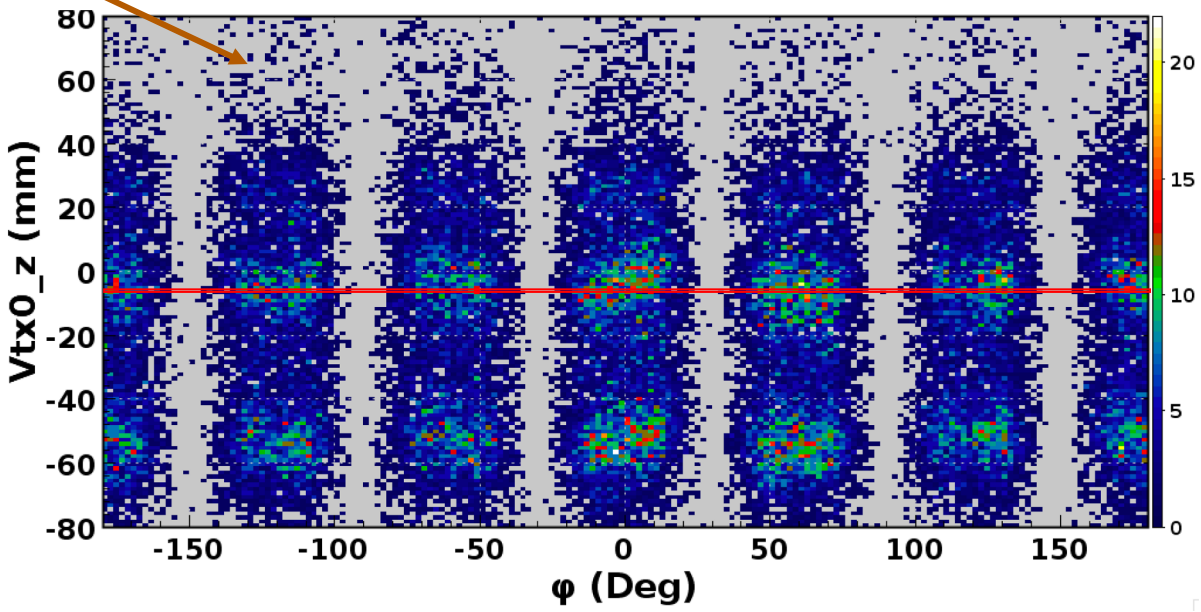
run 5297, Fall Alignment Vertices *

Vertices same for all sectors

Unaligned



Aligned



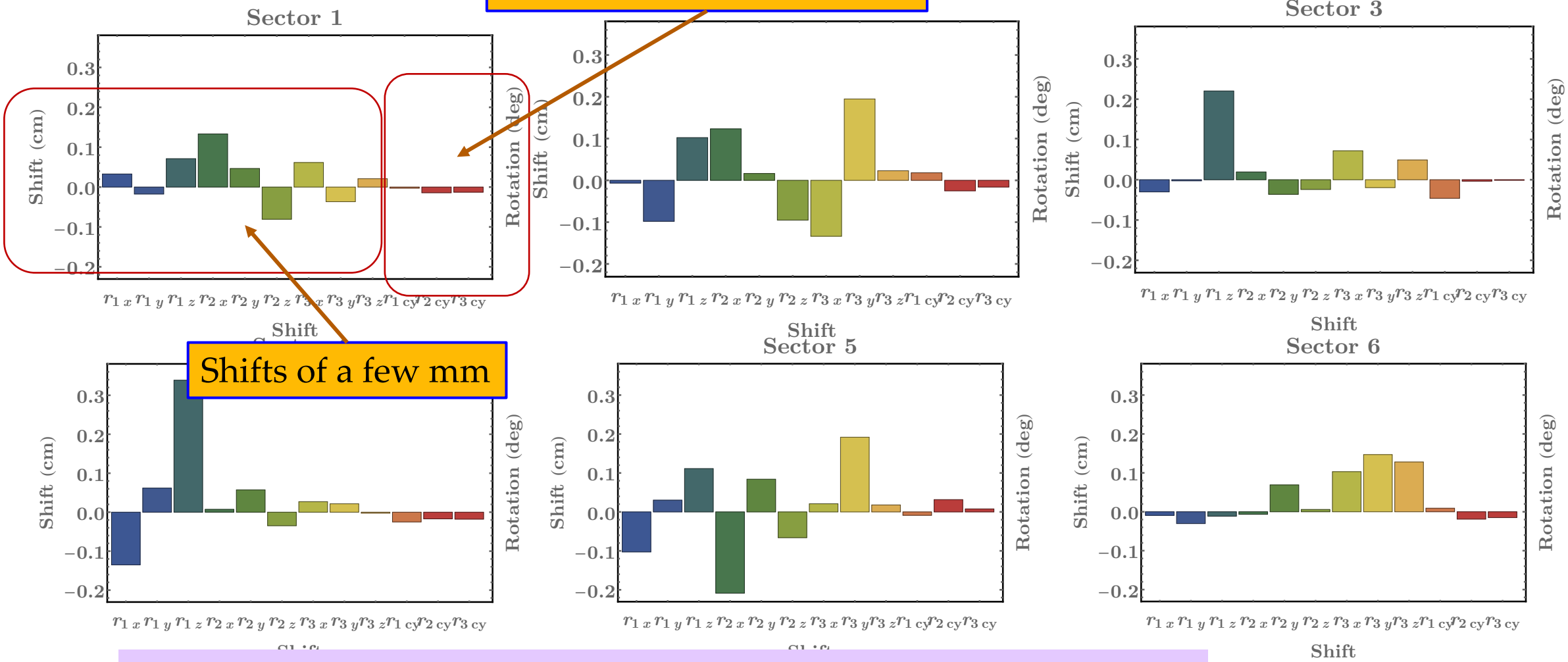
Track z vertex positions at global x = 0.

* Timothy Hayward's slides from Spring '19 Collaboration Meeting

Fall Alignment Numbers*

Rotations less than 1 mrad

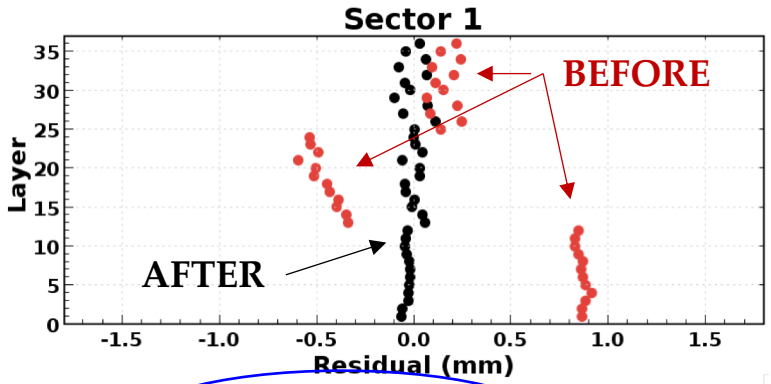
Shifts of a few mm



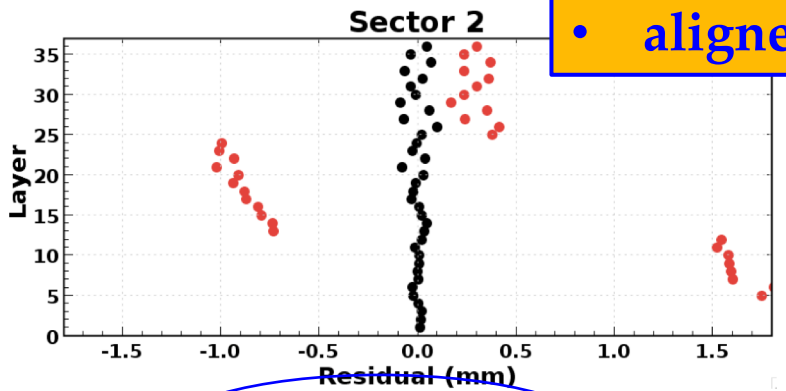
* Timothy Hayward's slides from Spring '19 Collaboration Meeting

run 5297, Fall Alignment Residuals*

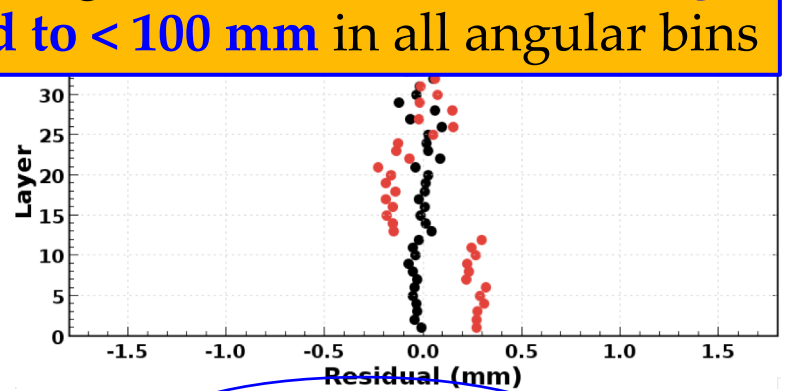
Chambers aligned to **< 50 mm on average**
- **aligned to < 100 mm** in all angular bins



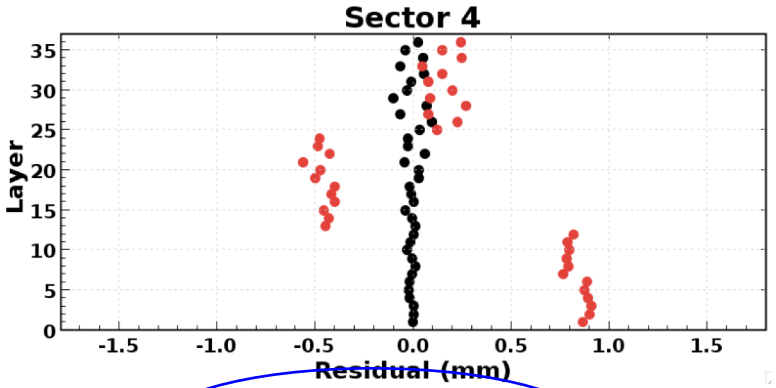
Mean RMS: 47 μm



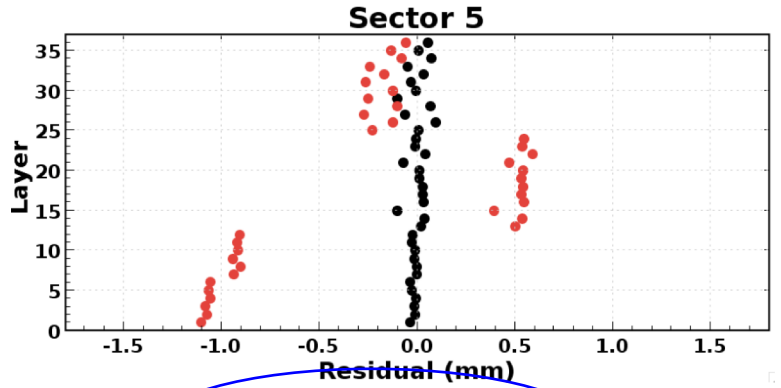
Mean RMS: 41 μm



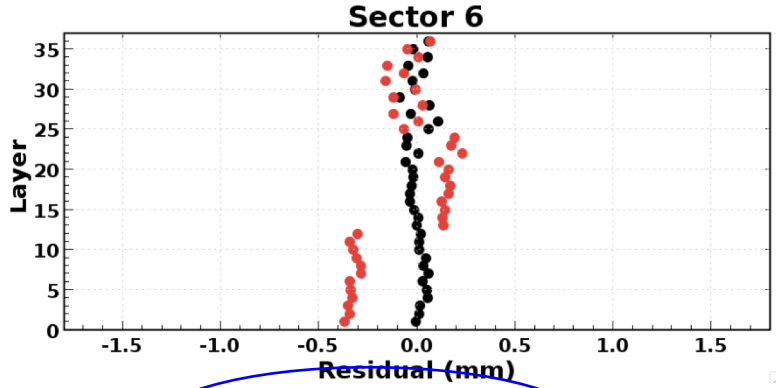
Mean RMS: 48 μm



Mean RMS: 39 μm



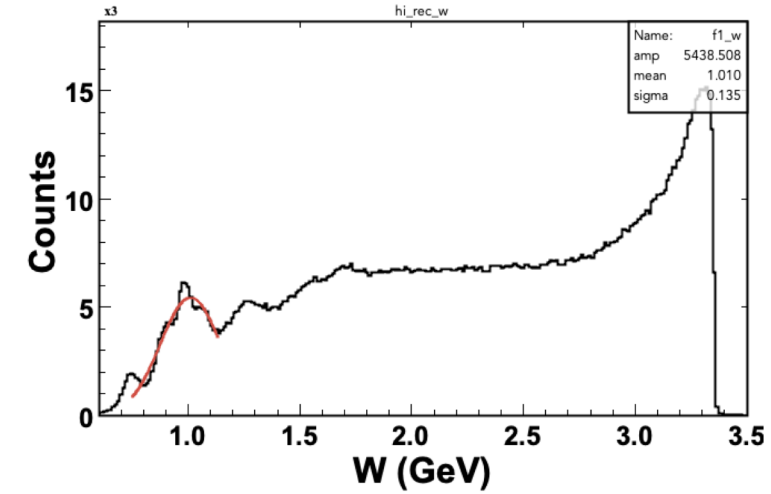
Mean RMS: 44 μm

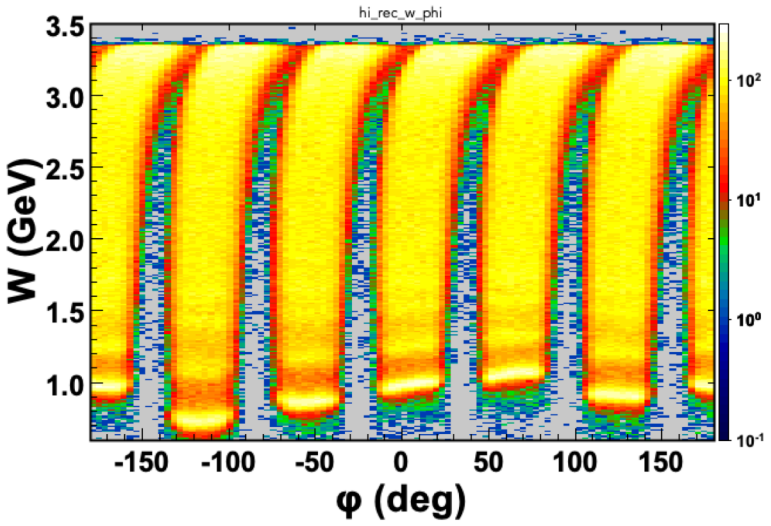


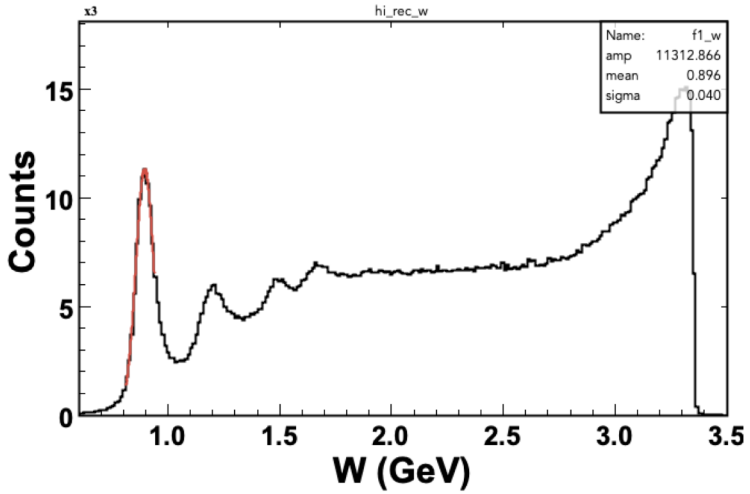
Mean RMS: 44 μm

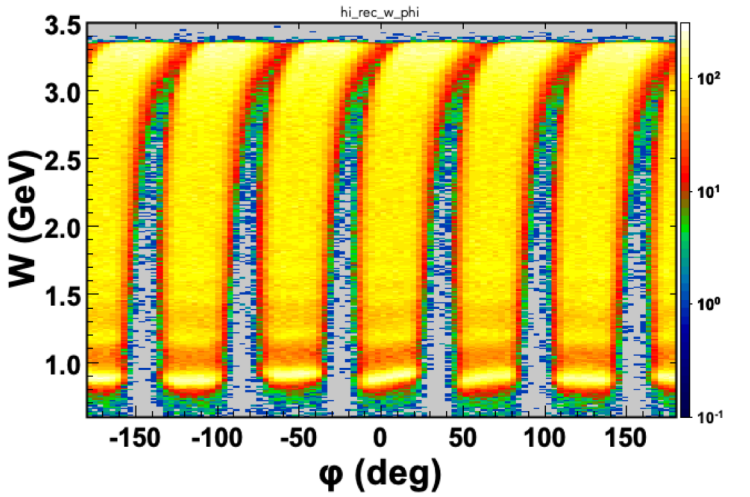
* Timothy Hayward's slides from Spring '19 Collaboration Meeting

From nominal geometry to aligned





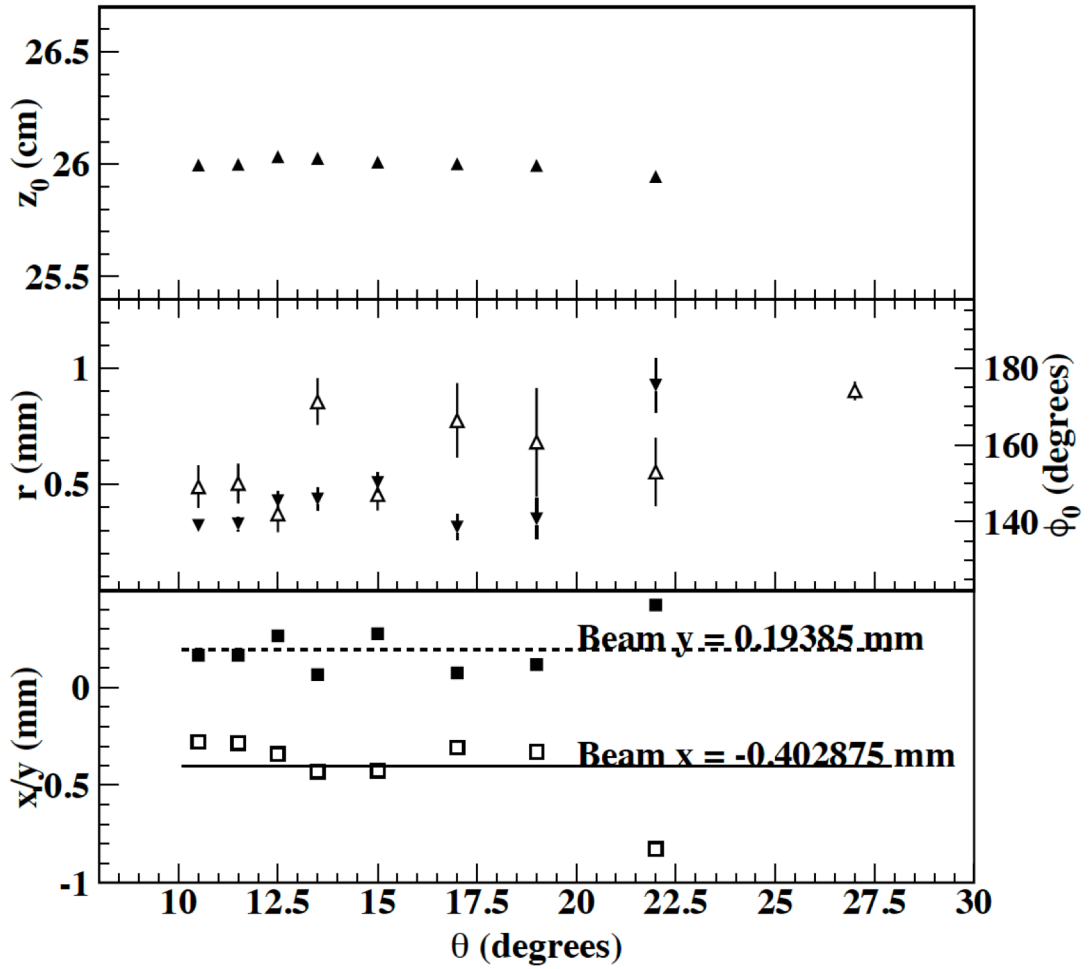




Vertex analysis after alignment

From Stepan's presentation at CalCom on 3/29:

- After alignment, theta dependence of downstream foil position is reduced
- Phi dependence consistent with sinusoidal wave due to x/y beam offset



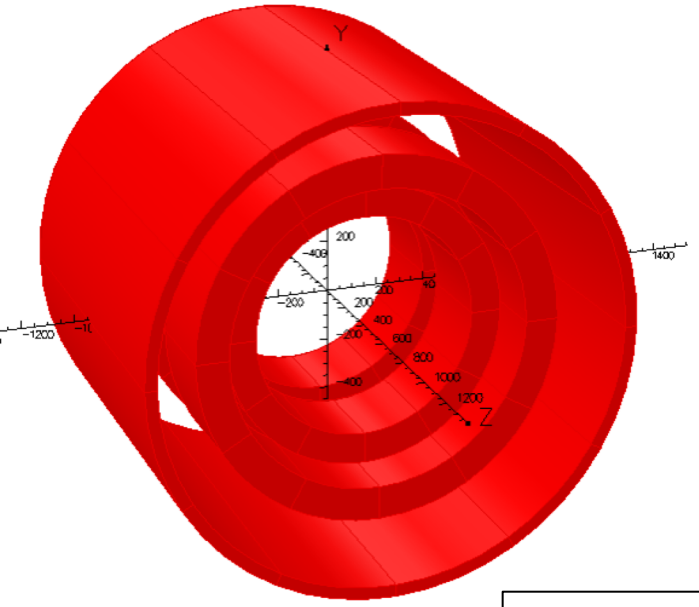
Forward Track Resolution: Status

Project	Method	Project Status / Results	Who*
Measure torus B-field → improve **model** (original disagreements of ~ 2)	**Fit (model vs. measurement) differences** to a **weighted sum** of pre-calculated differences caused by **"unit displacements"** of coils	**Done** • modify coil shape • apply 6 independent coil shifts • coil shifts of ~ 1-2 mm → **B-field model vs. measurement agrees within ~ 0.4%**	JN, Engineers
Align Drift Chambers → improve **tracking** (original misplacements of ~2mm)	**Fit residual mean offset patterns from "straight-track" data** to a **weighted sum** of pre-calculated offset patterns caused by **"unit displacements"** of chambers	**Done** • produce "unit distortion" tables of residual mean offsets vs. layer • fit weighted sum to data • chamber displacements of ~ 1-2 mm → **chambers aligned to 100 μm**	TH

- **Thanks** to the engineering group and magnet measuring group for design and fabrication of devices
- **Thanks** to volunteer shift takers for taking the field-map data
- **Credit** to Joseph Newton and Timothy Hayward for a great job of analyzing the data

Model Optimization Parameters

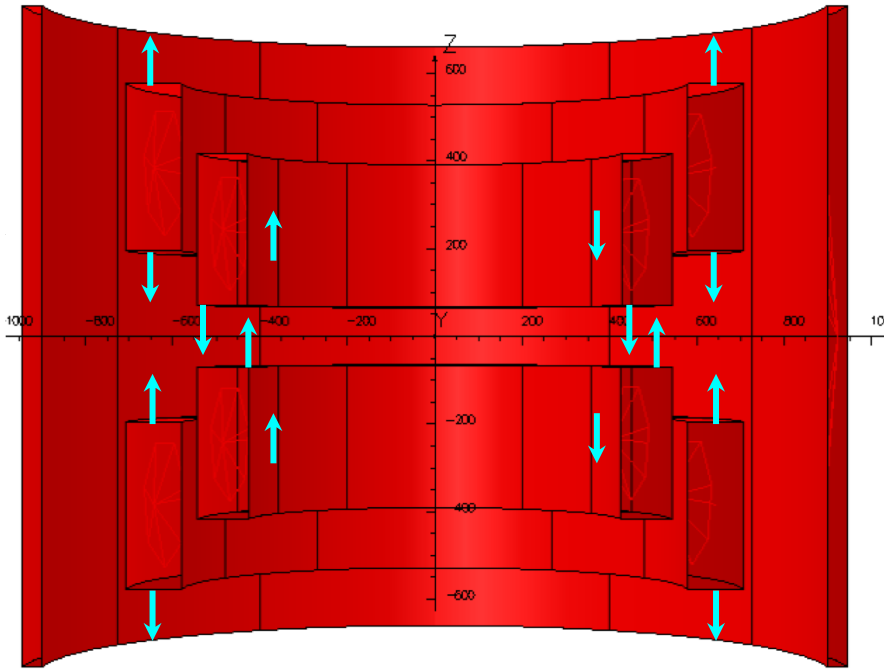
V. Lagerquist



The four inner coils of the solenoid were individually adjusted axially and radially, and stretched to attempt to optimize agreement with measured data. These parameters were chosen both on the strength of their effect on the field and the comparative ease of modeling them. The complete space of these parameters was searched to locate a global minimum of difference from data, then the values were refined in millimeter steps. Although the result increases agreement, the adjustments necessary represent unrealistic physical dimensions.

Middle Coils: Stretched axially 20 mm
Innermost Coils: Radius decreased 25 mm
Axially translated 7 and 5 mm

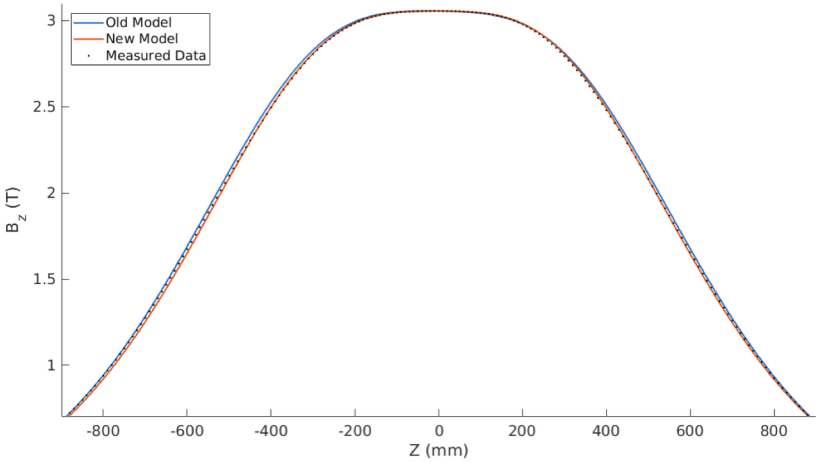
Coil	Inner Radius New | Old	Outer Radius New | Old	Z_1 New | Old	Z_2 New | Old
1	402.36 | 427.36	519.68 | 544.68	63.81 | 70.81	410.65 | 417.65
2	402.36 | 426.63	519.68 | 544.50	-65.81 | -70.81	-412.65 | -417.65
3	707.71 | 707.71	580.06 | 580.06	194.89 | 194.89	596.37 | 576.37
4	707.71 | 707.66	580.06 | 578.74	-194.89 | -194.89	-596.37 | -576.37
5	-754.287 | -754.287	754.287 | 754.287	900.17 | 900.17	946.23 | 946.23

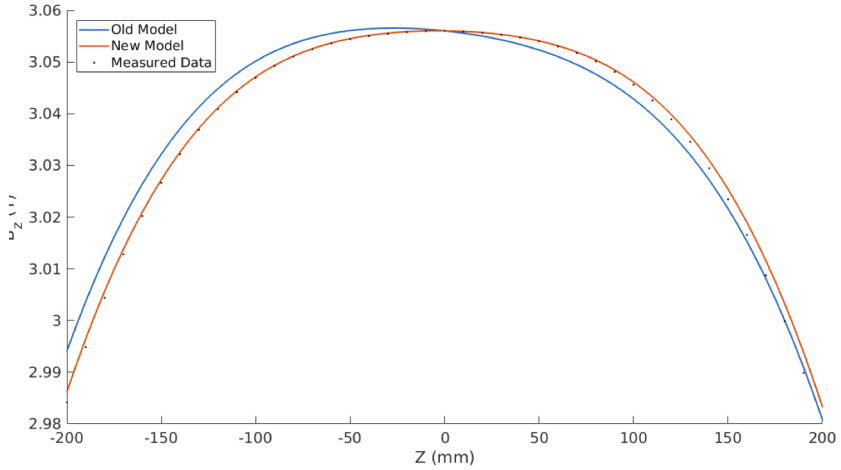


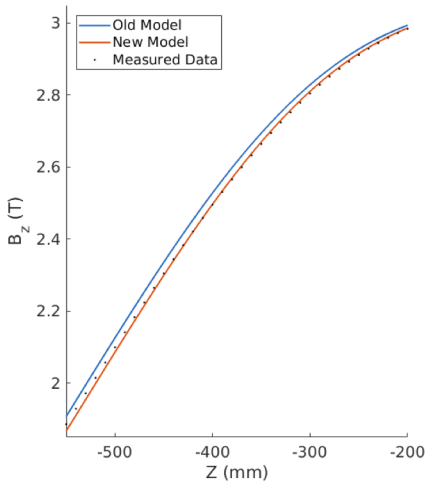
Model Comparison

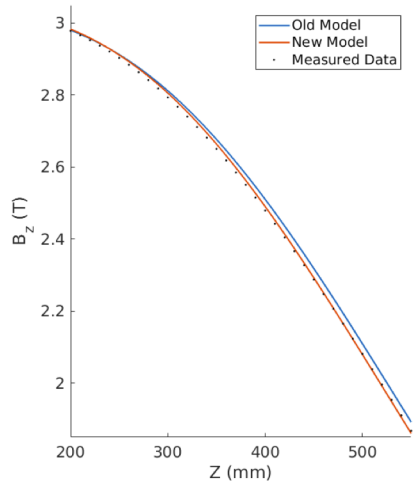
V. Lagerquist

On Axis:

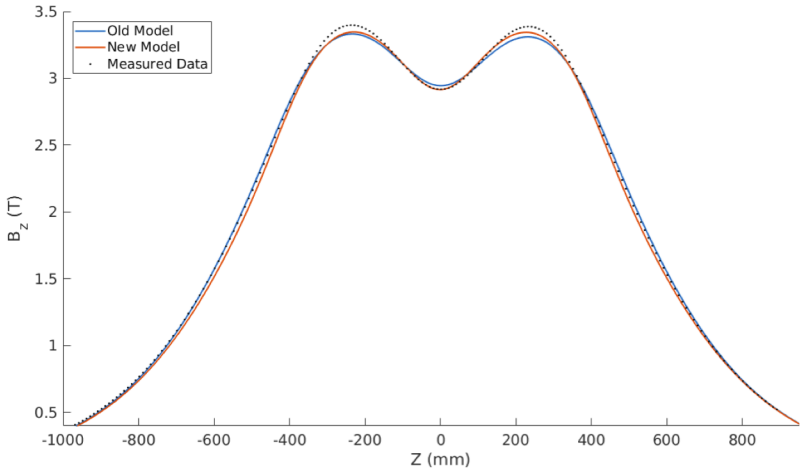


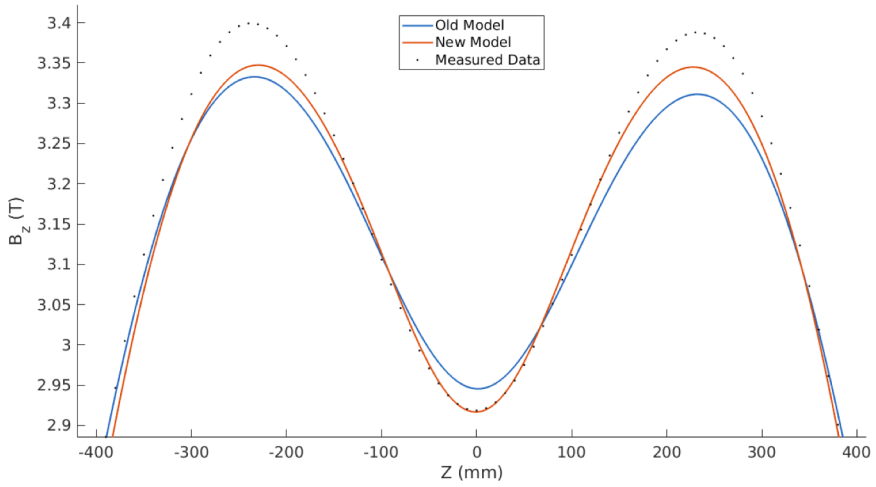


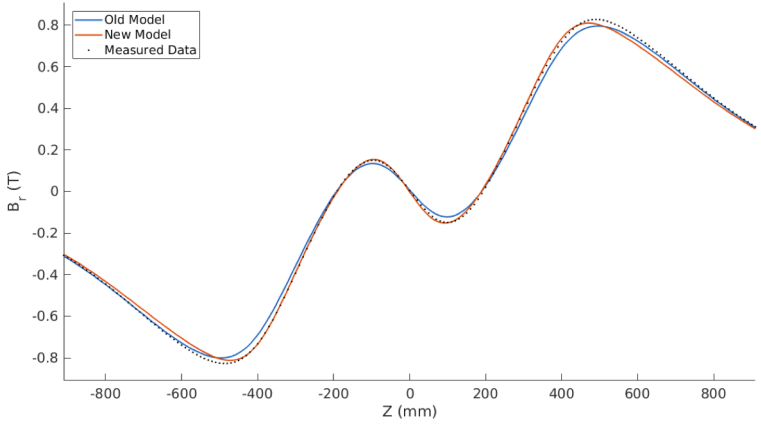




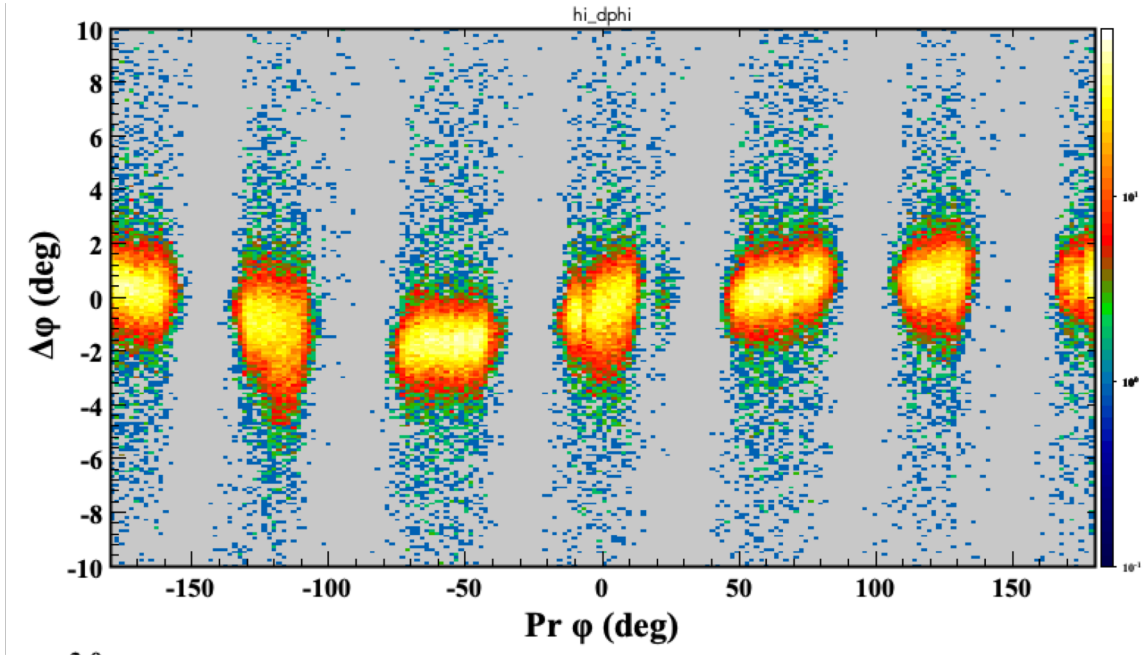
Off Axis (r=30 mm):

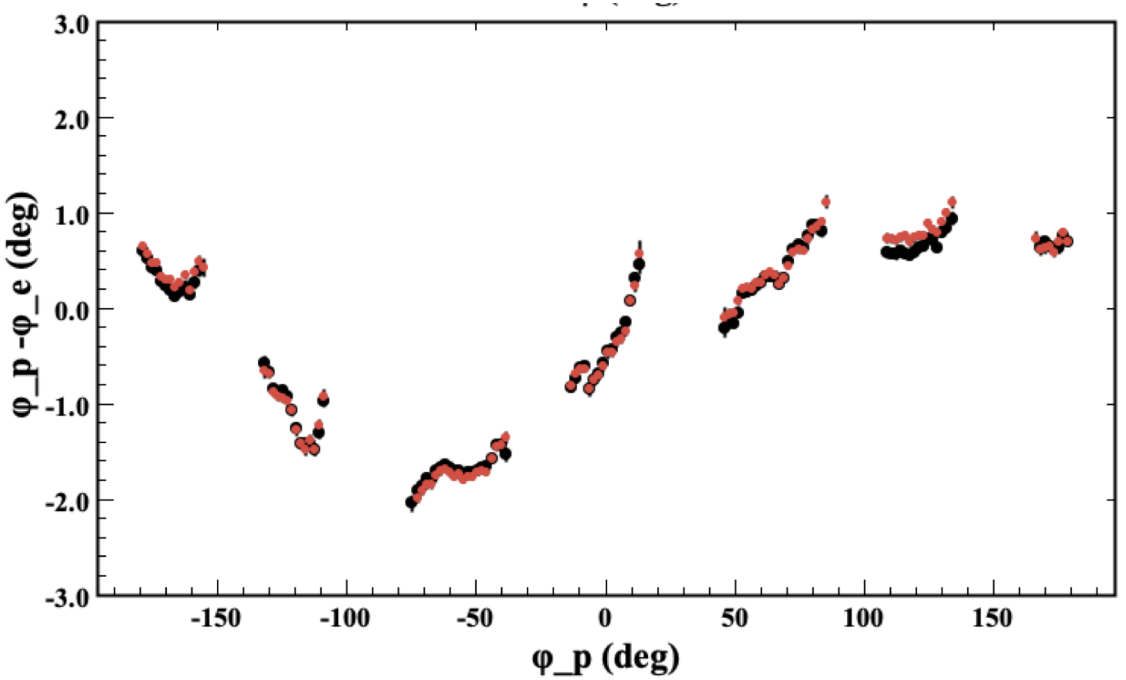






2018 solenoid map versus new from field mapping





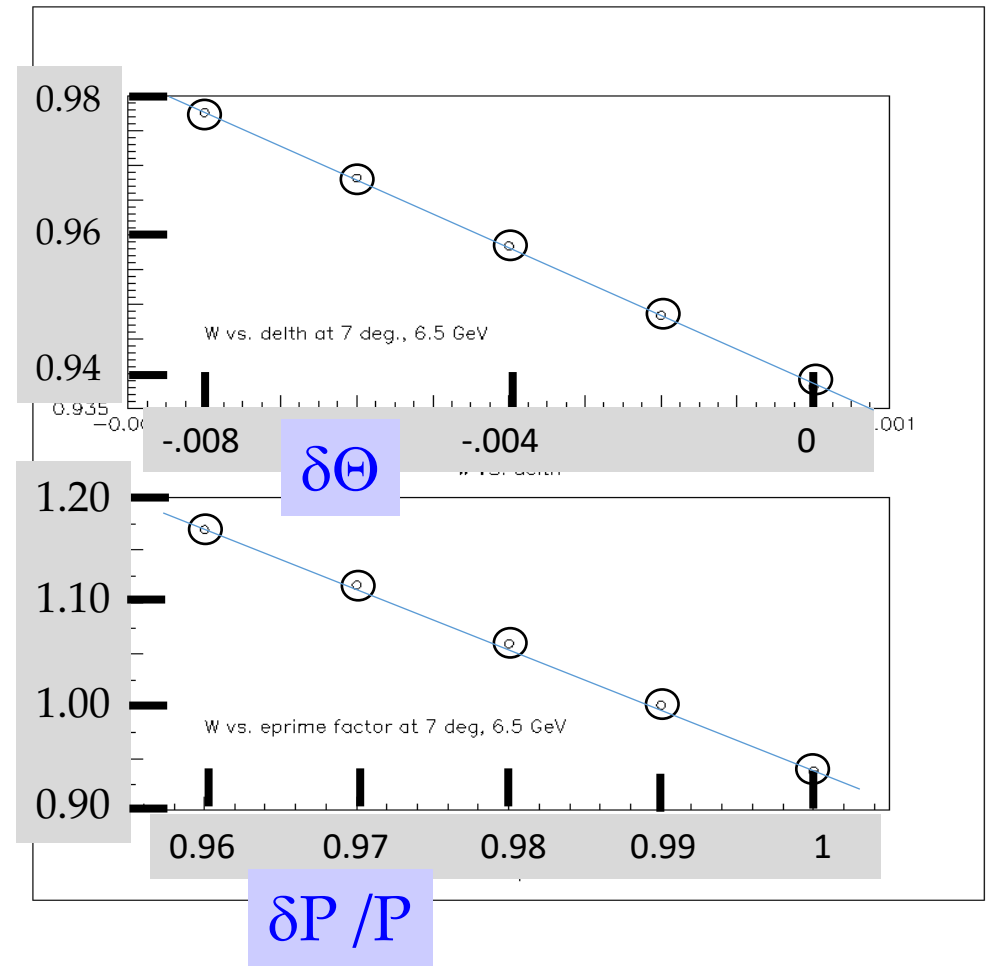
Summary

- DC alignment is crucial for forward tracker resolution. Current alignment gives dramatic improvements in removing sector dependencies. Fine tuning may still be possible.
- User of updated torus map based on coil survey is crucial for forward tracks reconstruction. Field mapping analysis confirms the new map gives better consistency with the data. Difference between new symmetric and asymmetric maps is small.
- Solenoid field map measurement indicate significant differences between the data and the original model. New map was generated and tested: effect on reconstructed tracks is small.

Backup

Elastic Peak Shift due to ΔΘ or δp/p

E = 6.5 GeV, Θ = 7^0



10 mRad shift in Θ
→ 50 MeV shift in W

1% shift in P
→ 50 MeV shift in W