



Alignment Validation

Example: L3 Barrel and Endcaps

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How do we validate a new Alignment?

“Everything should get better.

Nothing should get worse.”

Attempt here to put some meat behind this answer.

- **Five standards which need to be met.**
- **Example with the L3 Validation.**

Things to keep in mind ...

Should ask: Why are we doing the alignment in the first place?

(Can lead to trivial methods for validating the alignment)

*Often not a question of whether these are the ultimate constants,
but rather are they better than the current ones.*



The Gold Standard

1. Convergence

'Does the alignment algorithm think these are the best constants?'

2. Hippocratic Oath

New alignment should not harm the tracking performance in any way.

(eg: nTracks, nHits on track, hit eff. ect)

3. Effects we attribute to misalignment should be resolved.

(eg: L2.5 structure should be removed with L3 alignment)

4. Magnitude of physical movements acceptable.

Are the movements with physical tolerances?

5. Physics Impact.

The Ultimate Test.

(eg: Zmass, pT resolution, position resolution)



The Gold Standard

1. Convergence

'Does the alignment algorithm think these are the best constants?'

(in house, before alignment released)

2. Hippocratic Oath

New alignment should not harm the tracking performance in any way.

(eg: nTracks, nHits on track, hit eff. ect)

(in house / Alignment Monitoring (AM))

3. Effects we attribute to misalignment should be resolved.

(eg: L2.5 structure should be removed with L3 alignment)

(in house, migrate to AM)

4. Magnitude of physical movements acceptable.

Are the movements with physical tolerances?

(in house)

5. Physics Impact.

The Ultimate Test.

(eg: Zmass, pT resolution, position resolution) **(AM, dedicated studies)**

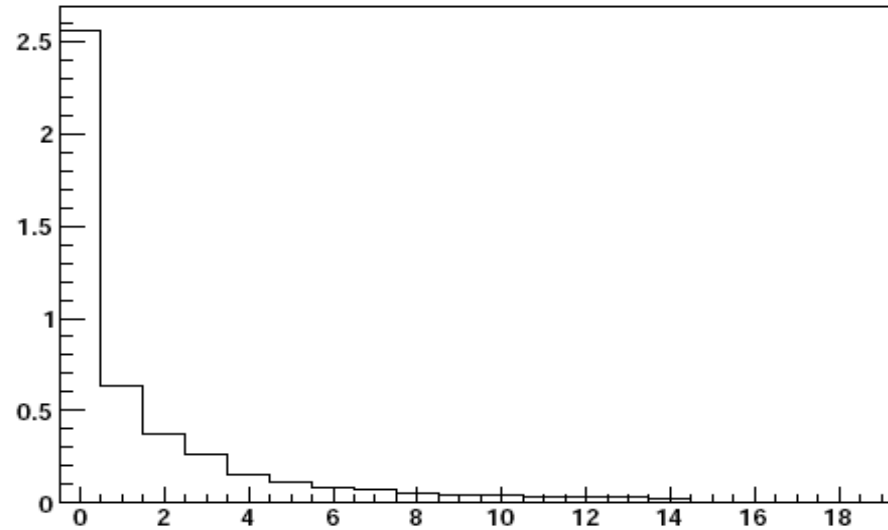


L3 Barrel Alignment



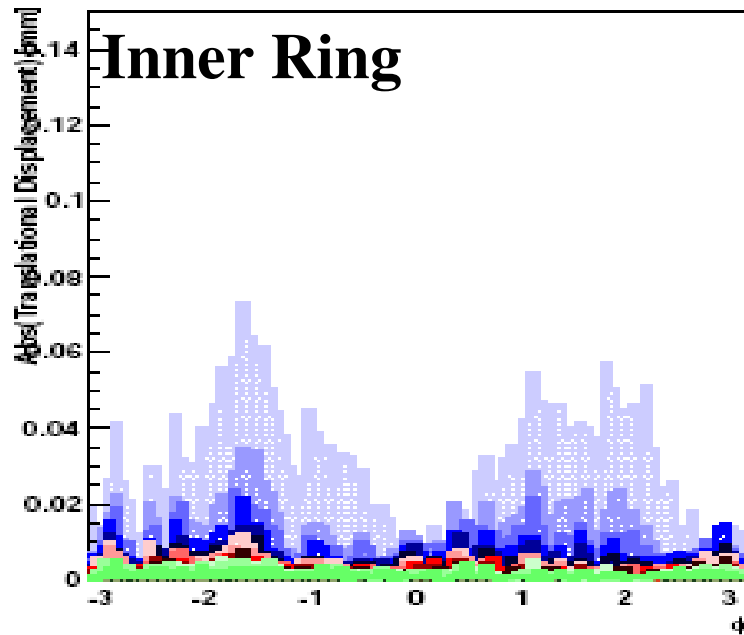
Convergence

$\Delta\chi^2 / \text{nDoF}$, Both Endcaps

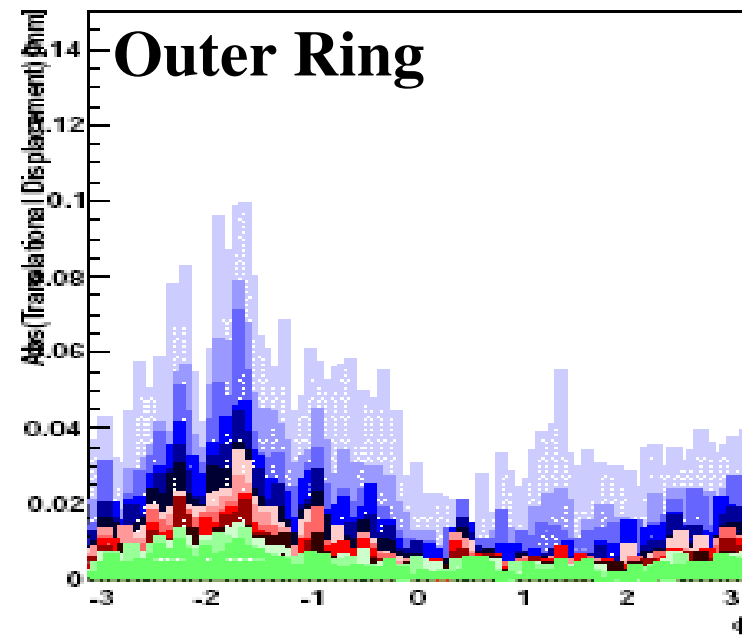


Alignment Iteration

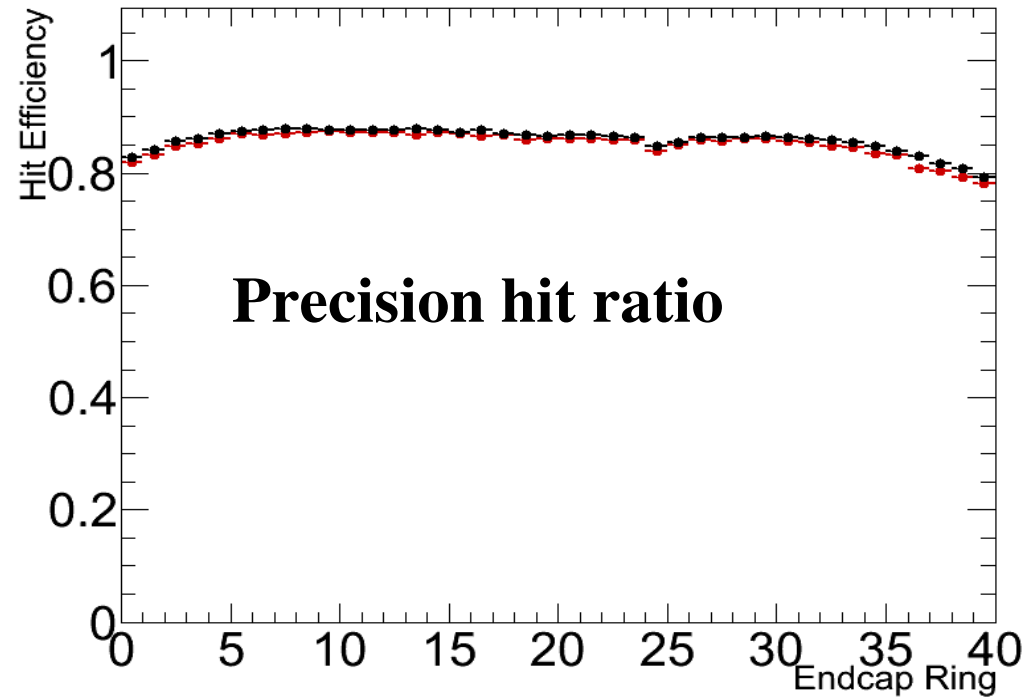
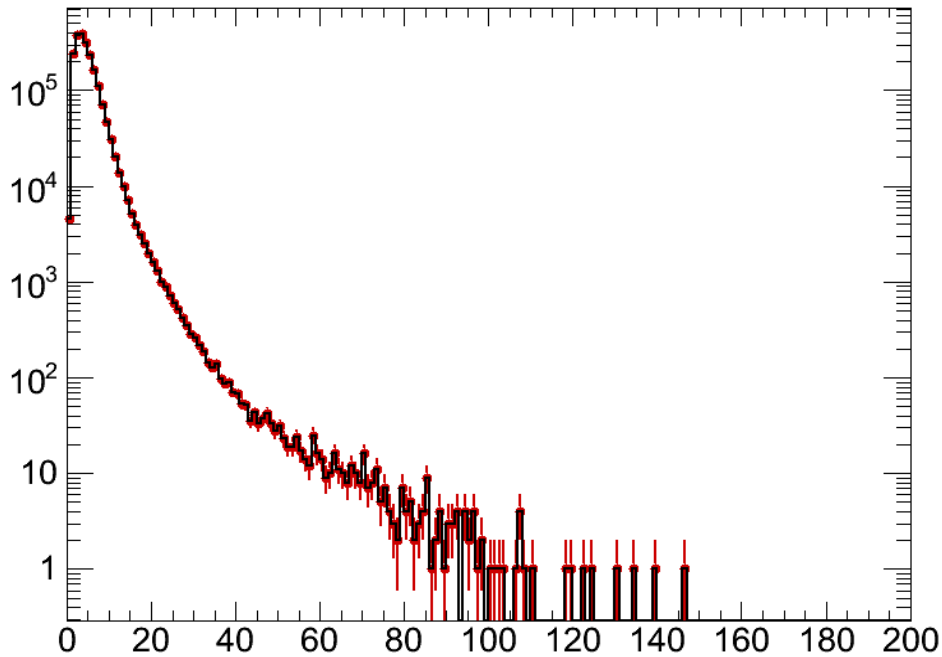
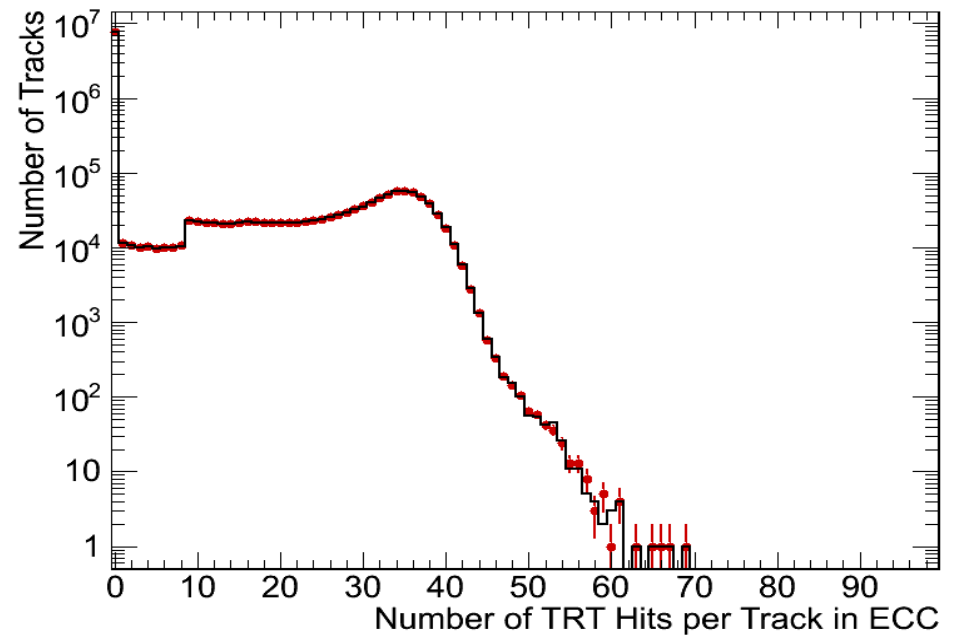
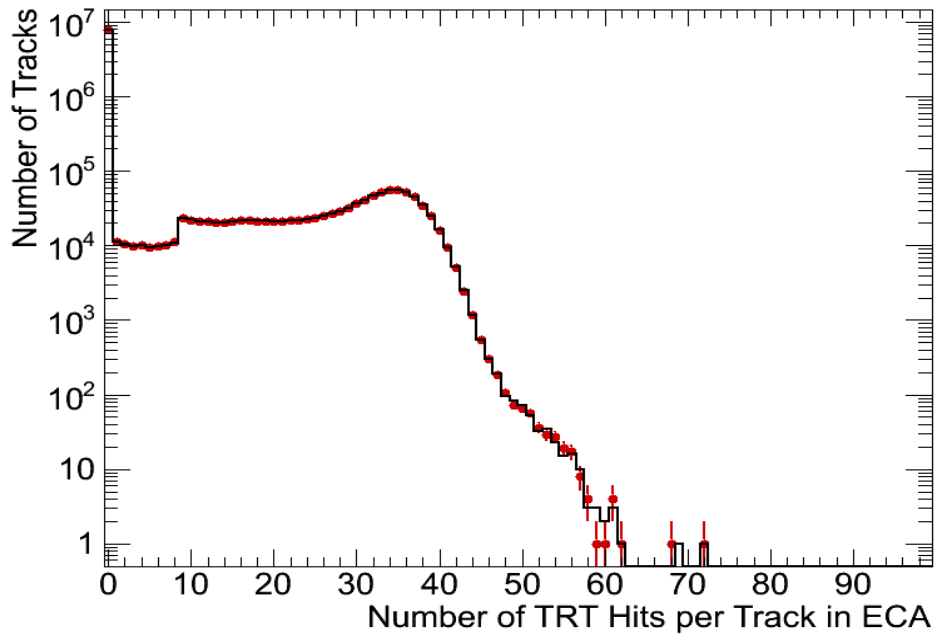
C_wheel09_plane04_InnerAbs



C_wheel09_plane04_OuterAbs



Hippocratic Oath

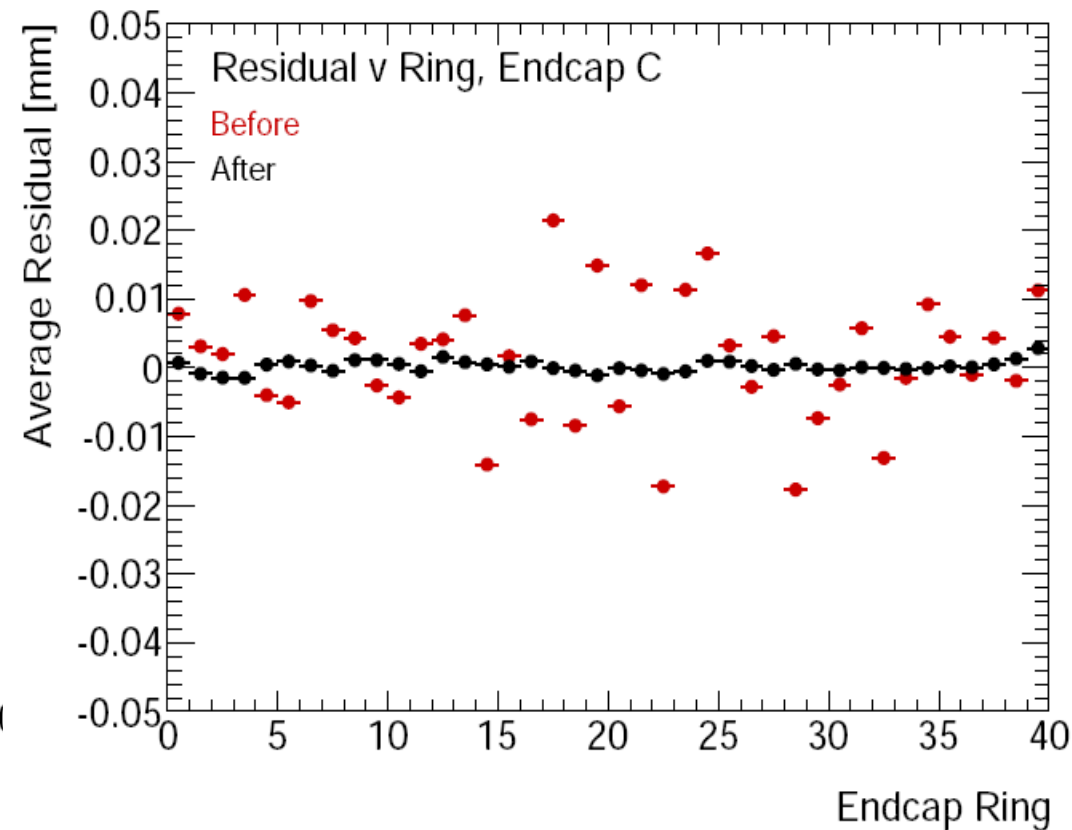
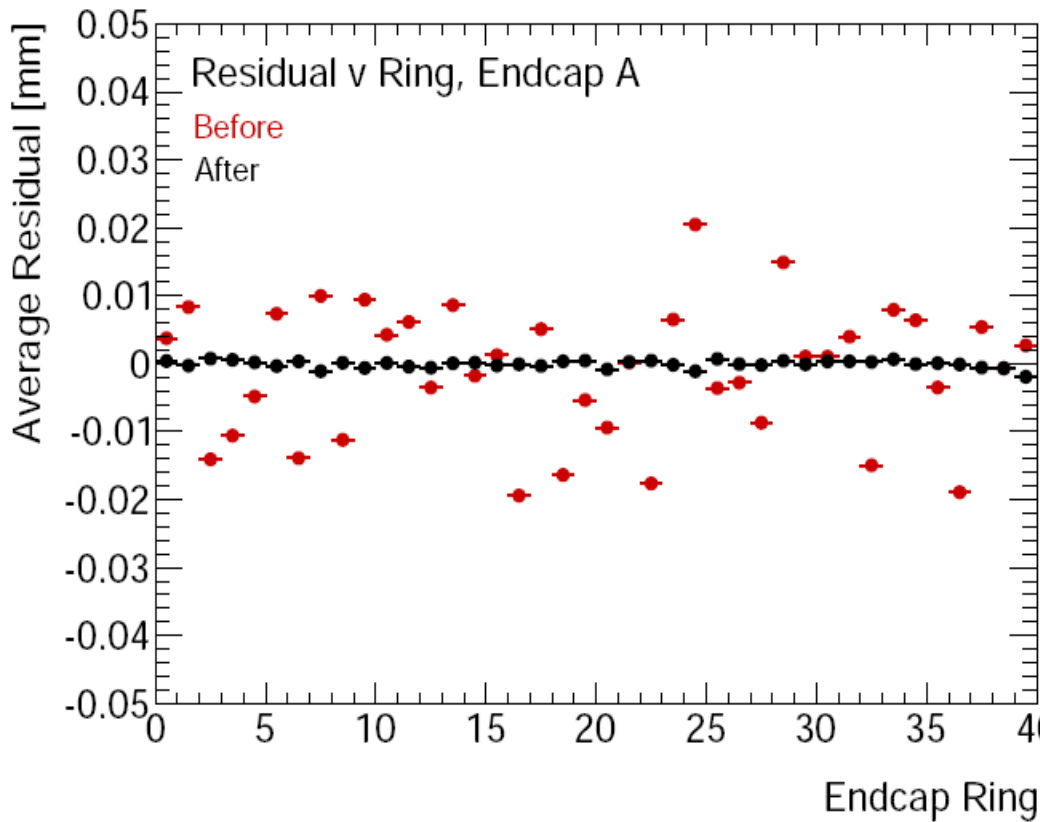




Expected Improvements

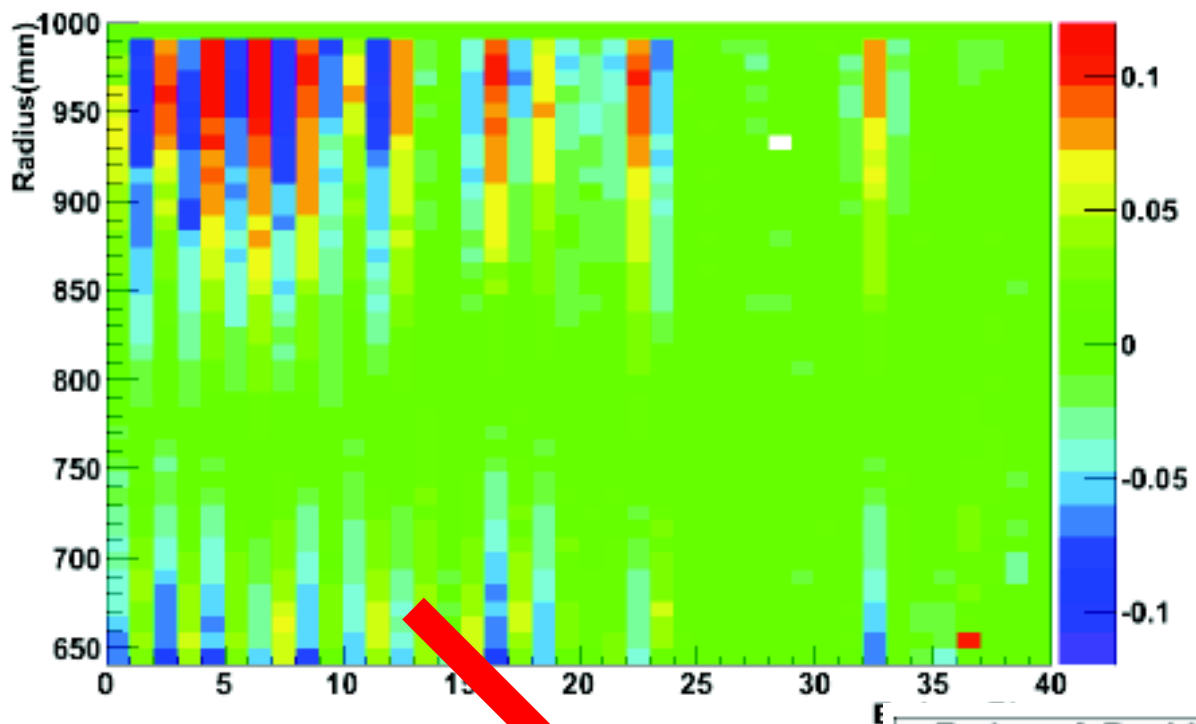
Before TRT L3 Endcap

After TRT L3 Endcap



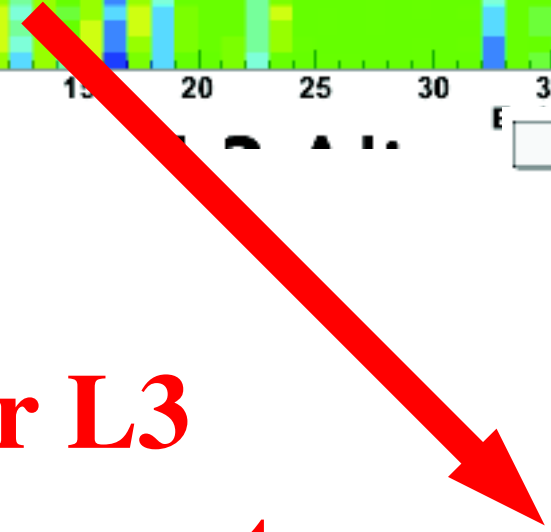


Endcap A Residuals - Gaussian Core Fit - μ

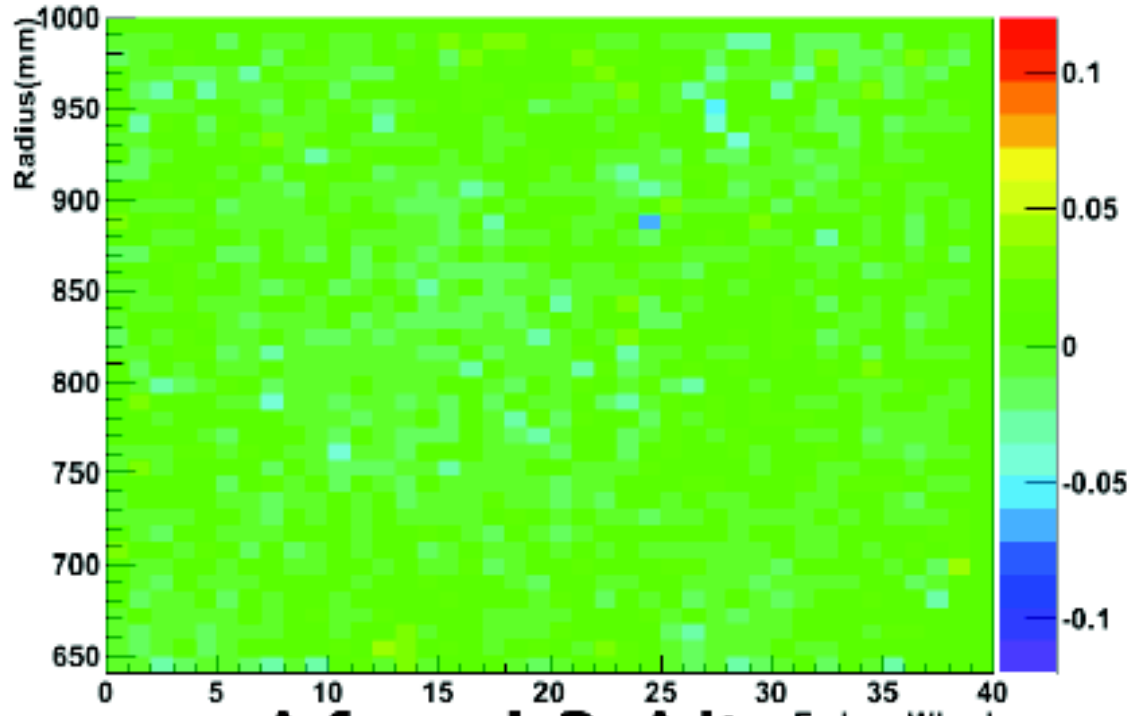


Endcap A

After L3
Alignment



Endcap A Residuals - Gaussian Core Fit - μ



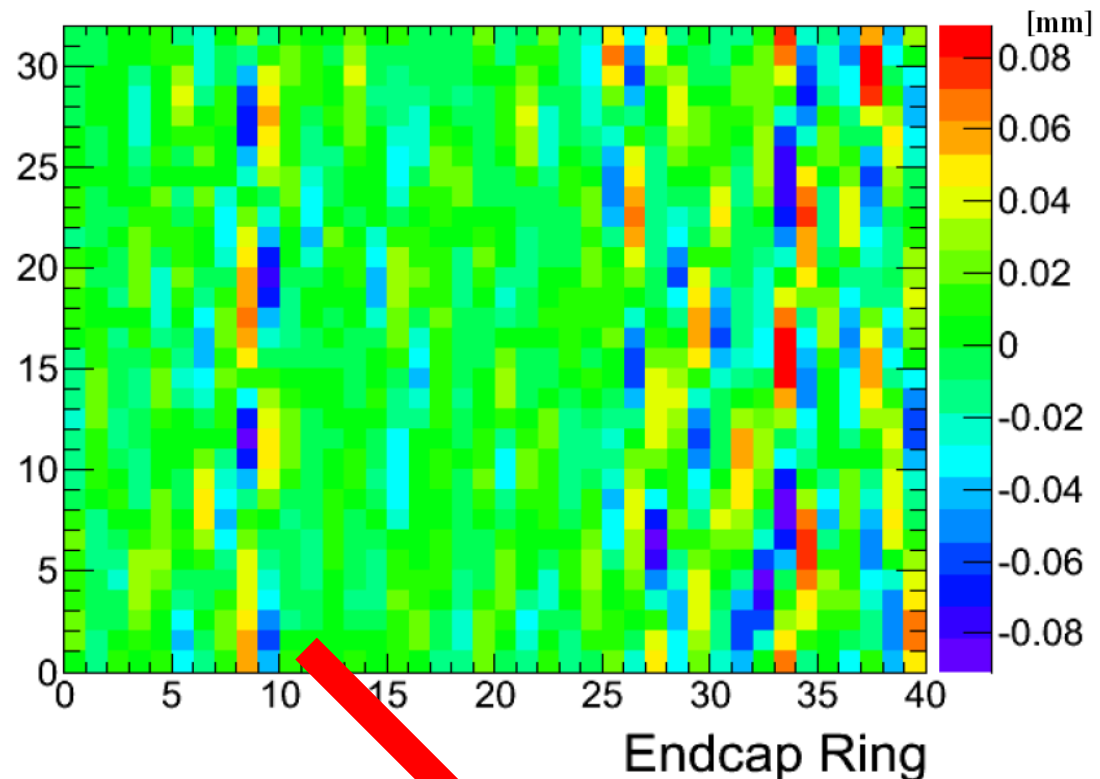
After L3 Alignment Endcap Wheel



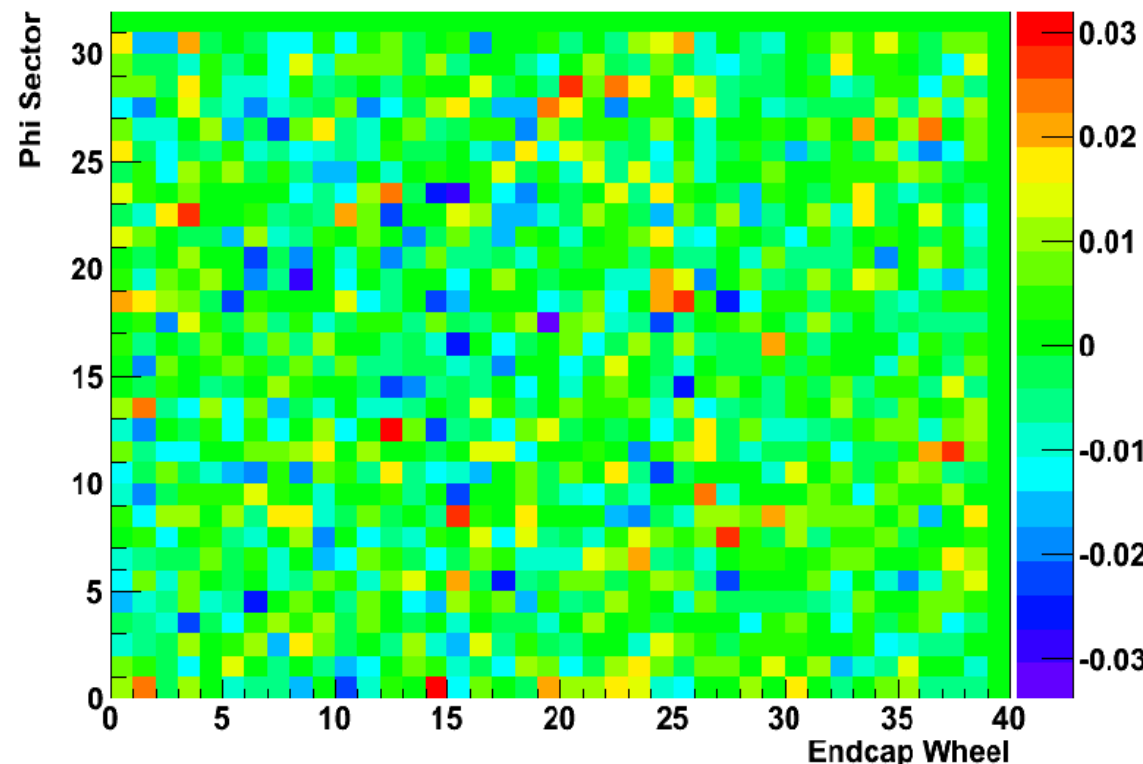
Endcap A

Endcap A

Phi Sector

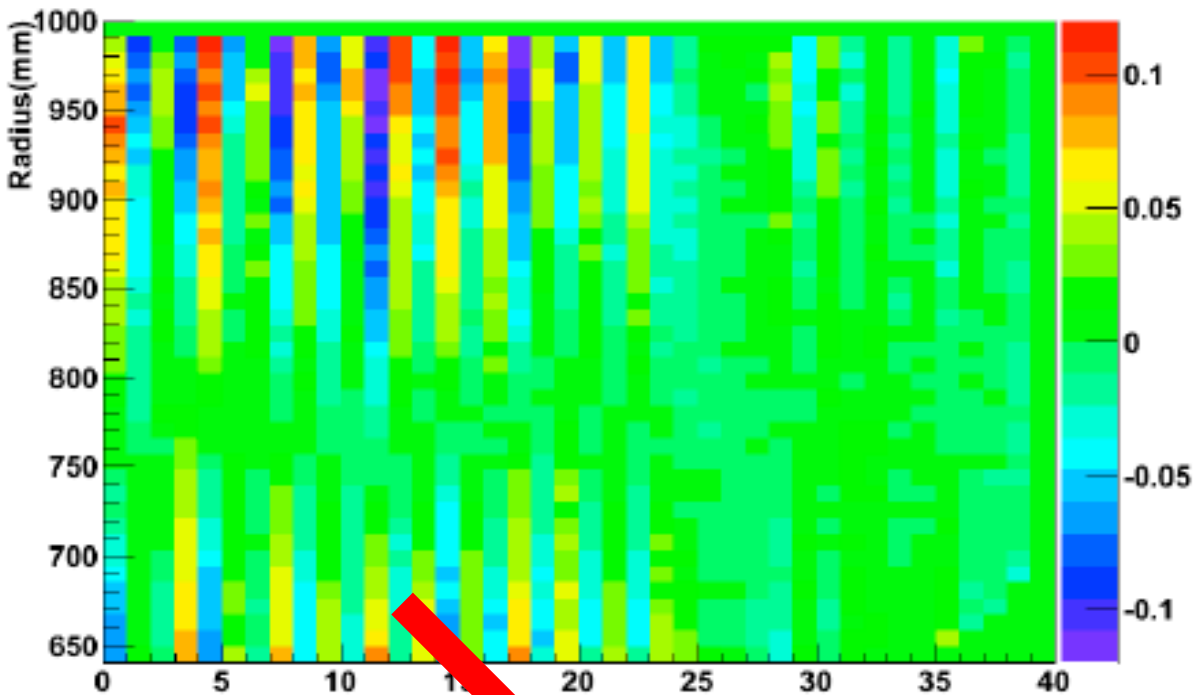


After L3
Alignment



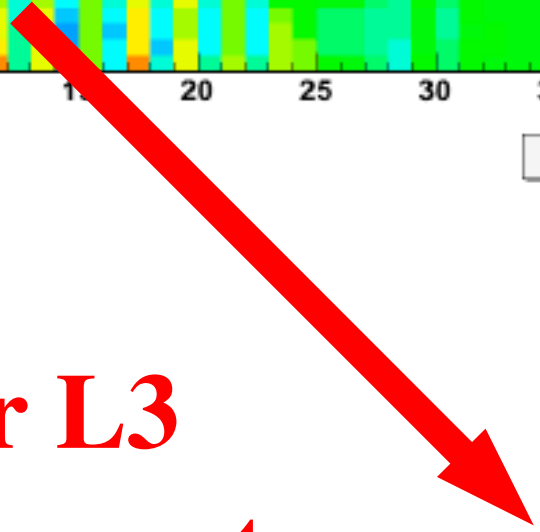


Endcap C Residuals - Gaussian Core Fit - μ

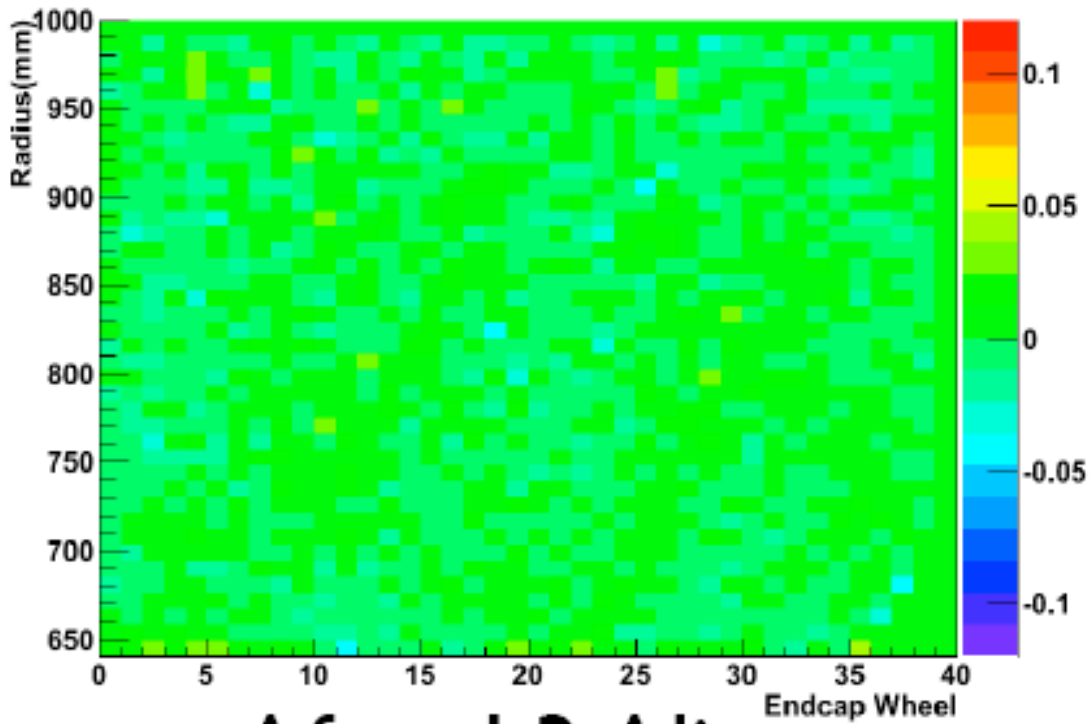


Endcap C

**After L3
Alignment**

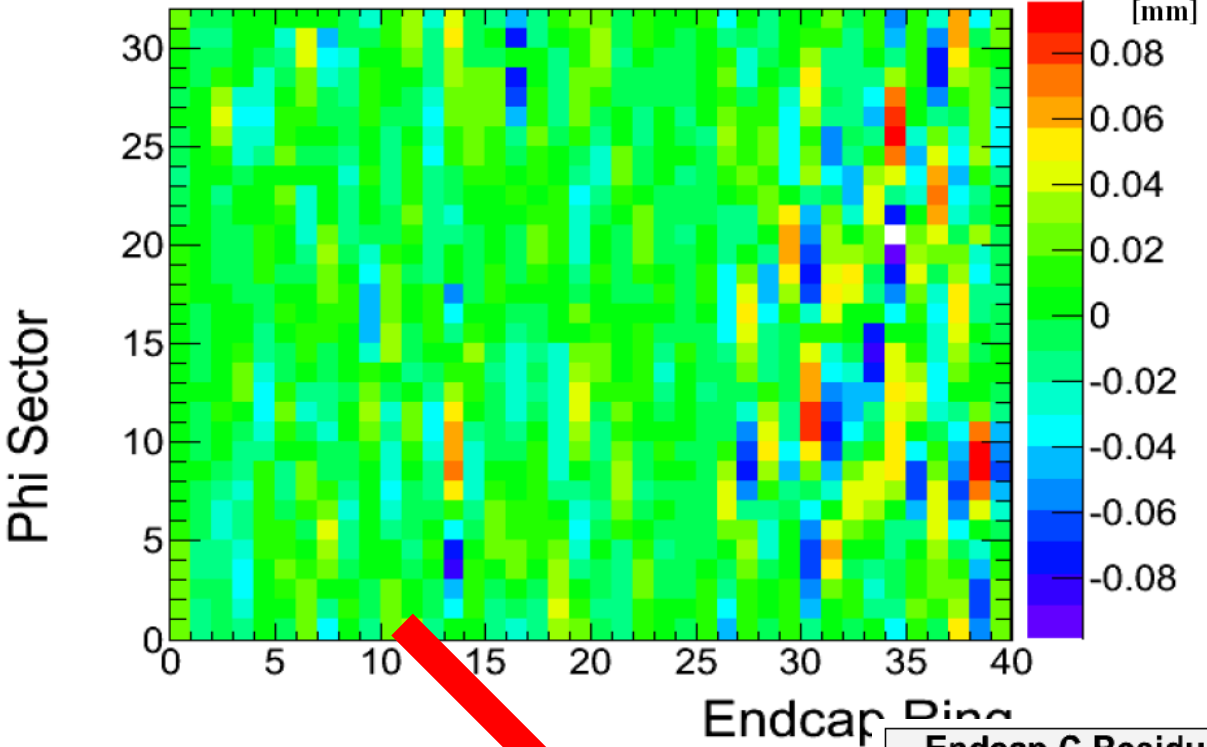


Endcap C Residuals - Gaussian Core Fit - μ



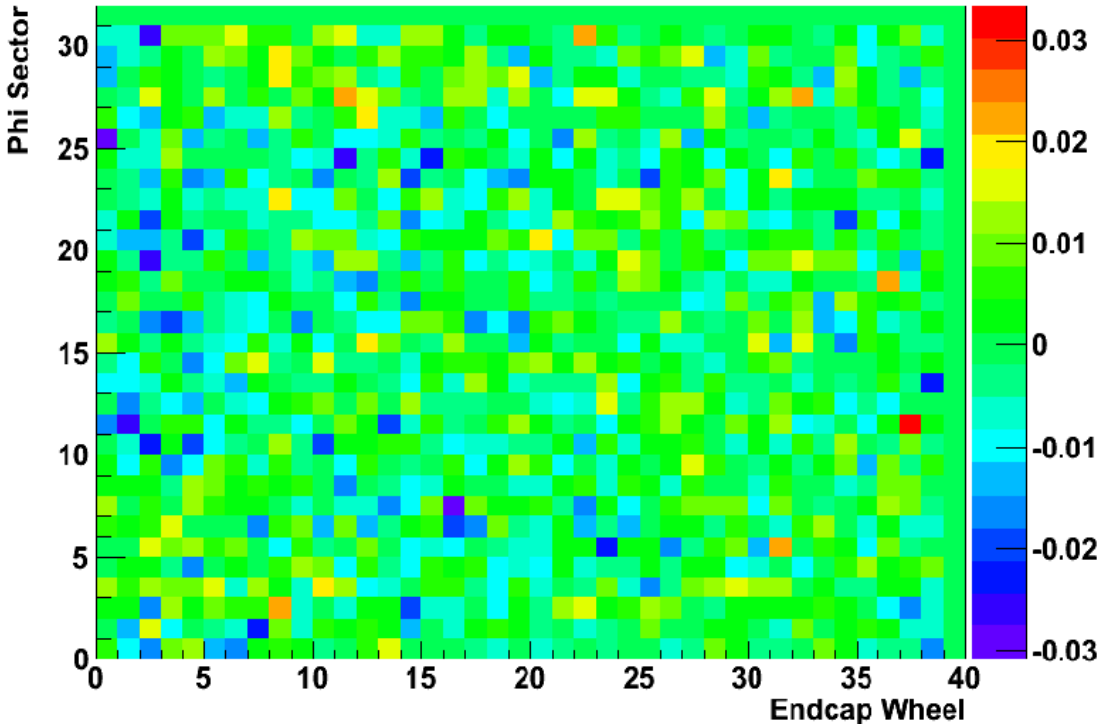
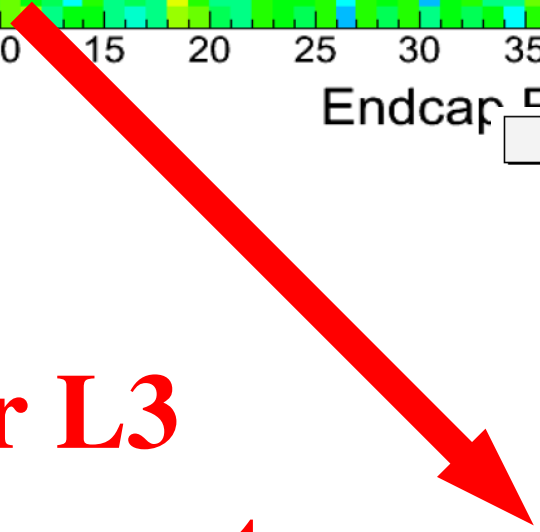


Endcap C



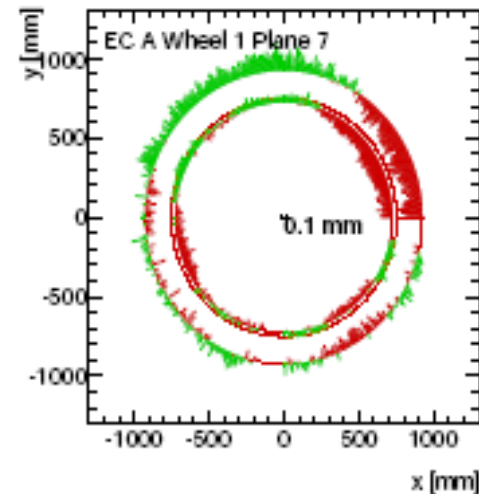
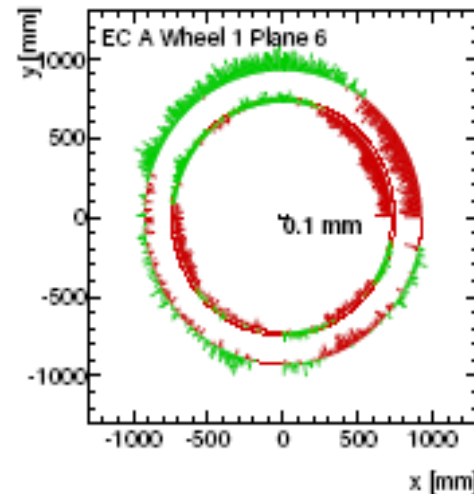
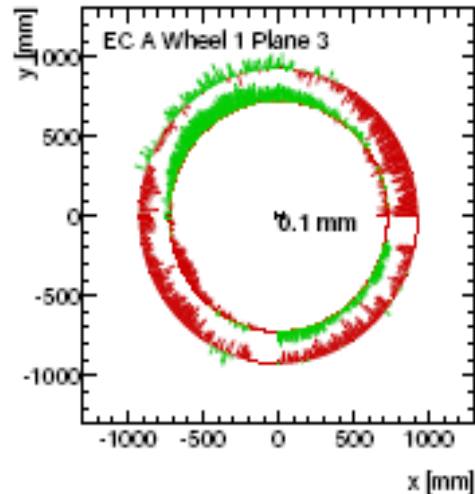
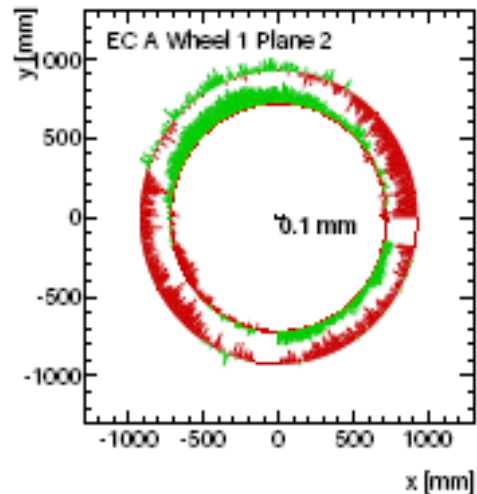
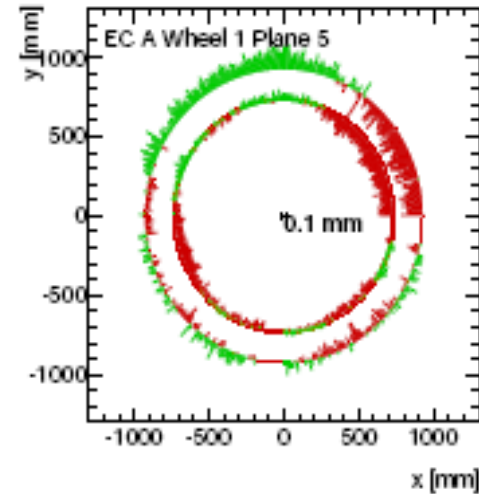
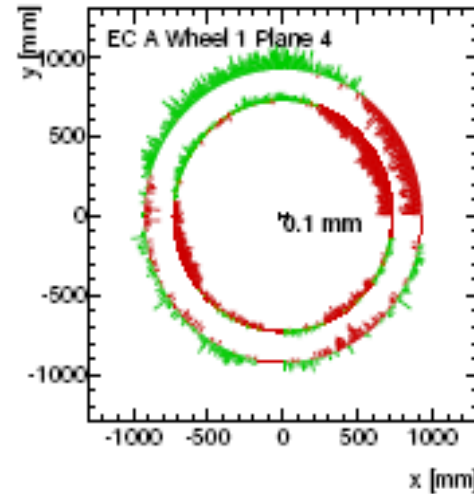
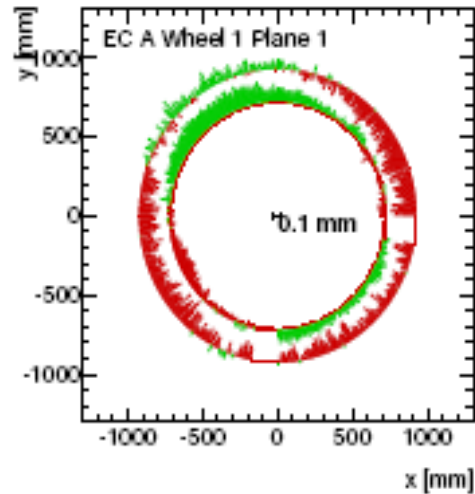
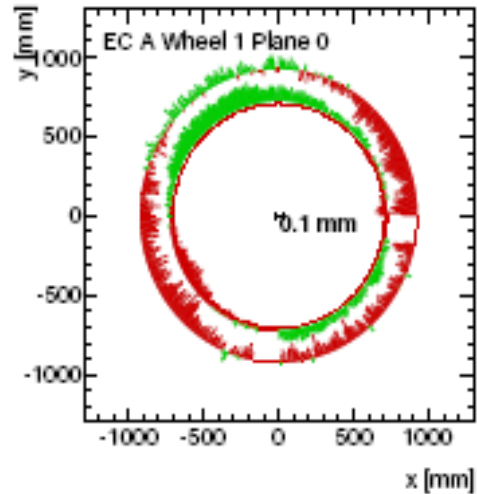
Endcap C Residuals - Gaussian Core Fit - μ

**After L3
Alignment**



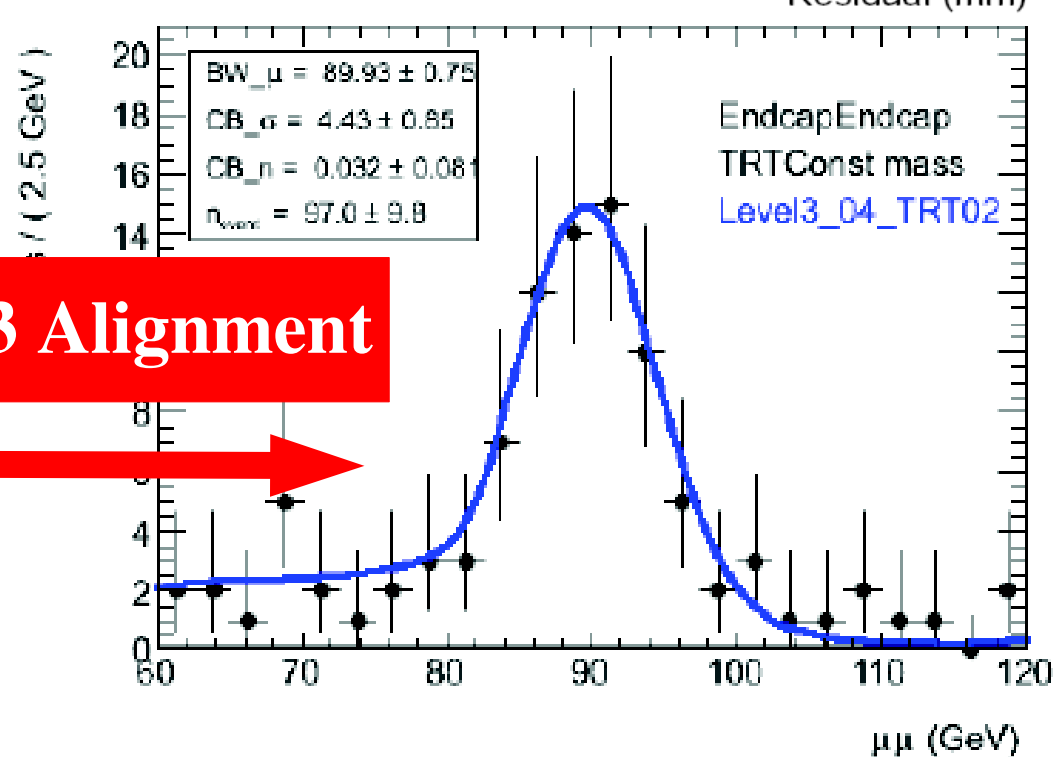
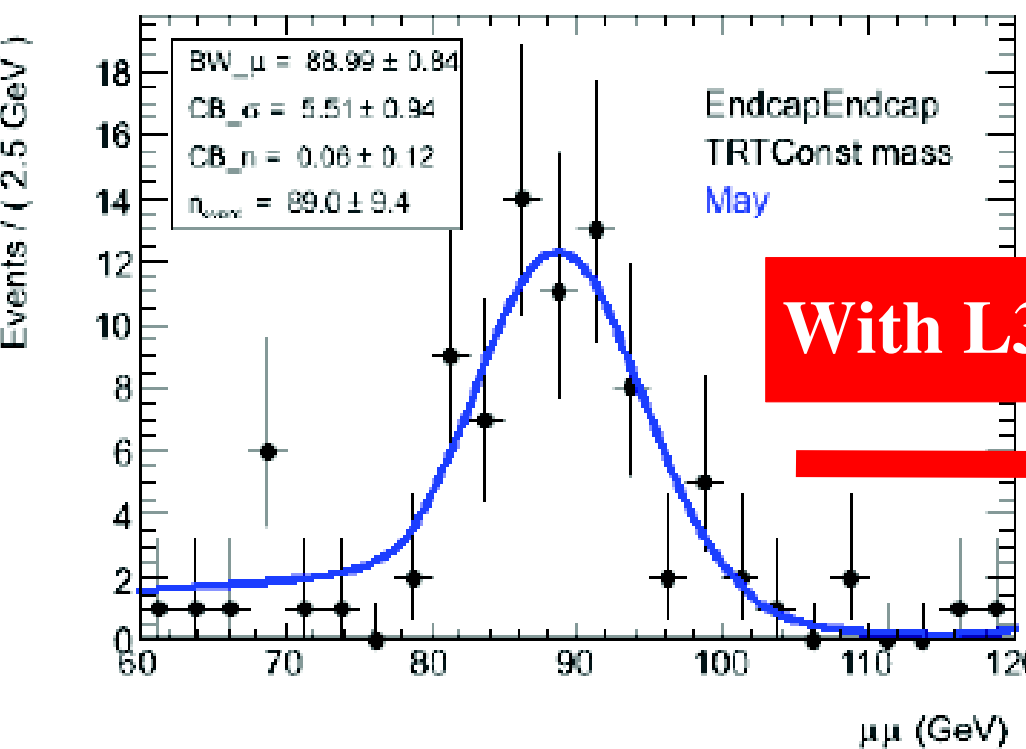
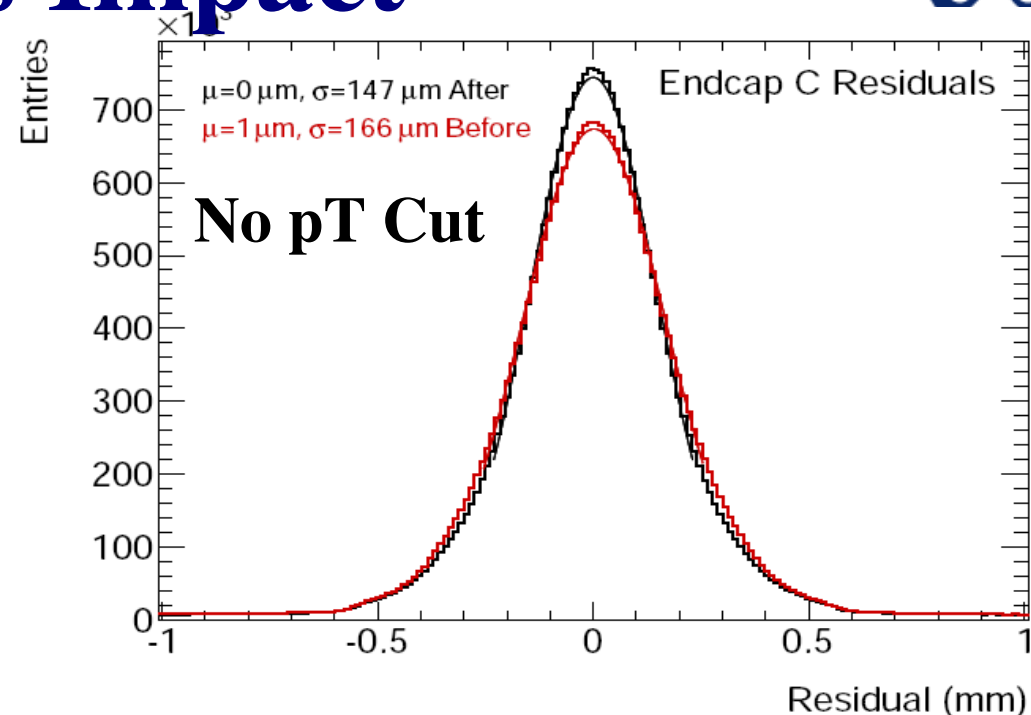
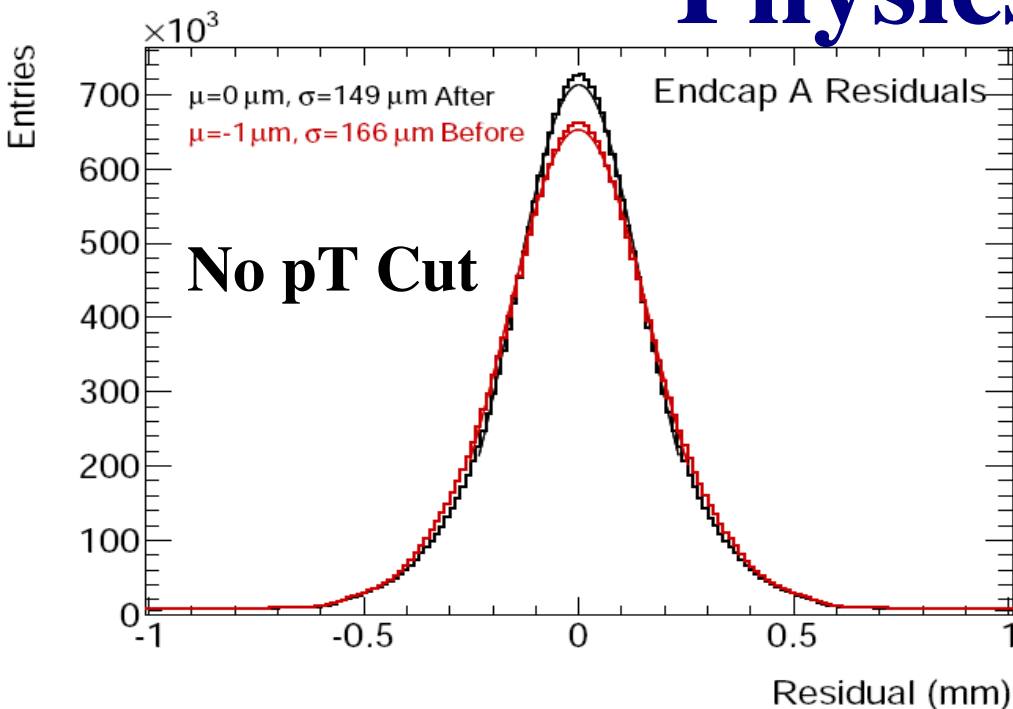


Magnitude of Physics Movements





Physics Impact



With L3 Alignment



L3 Endcap Alignment



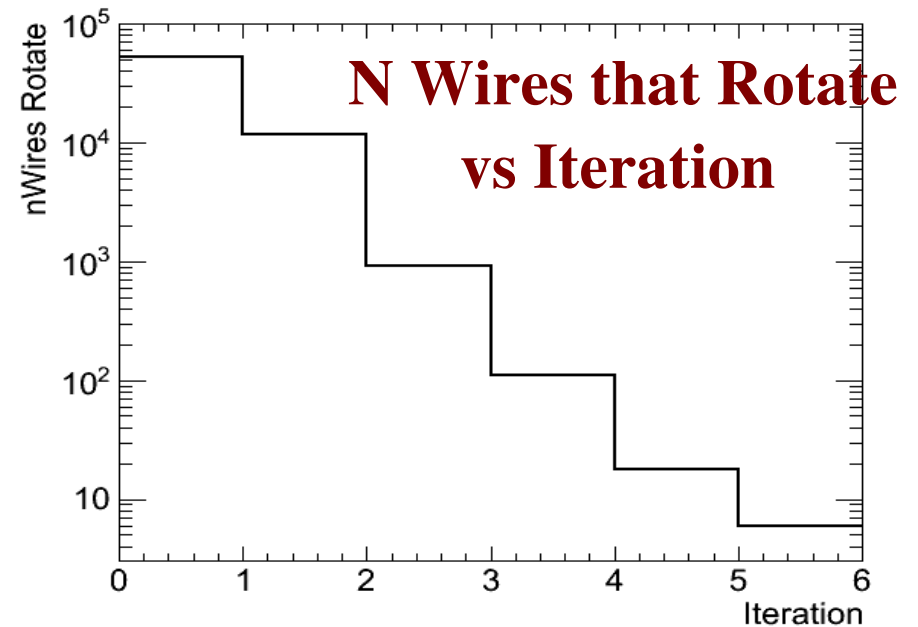
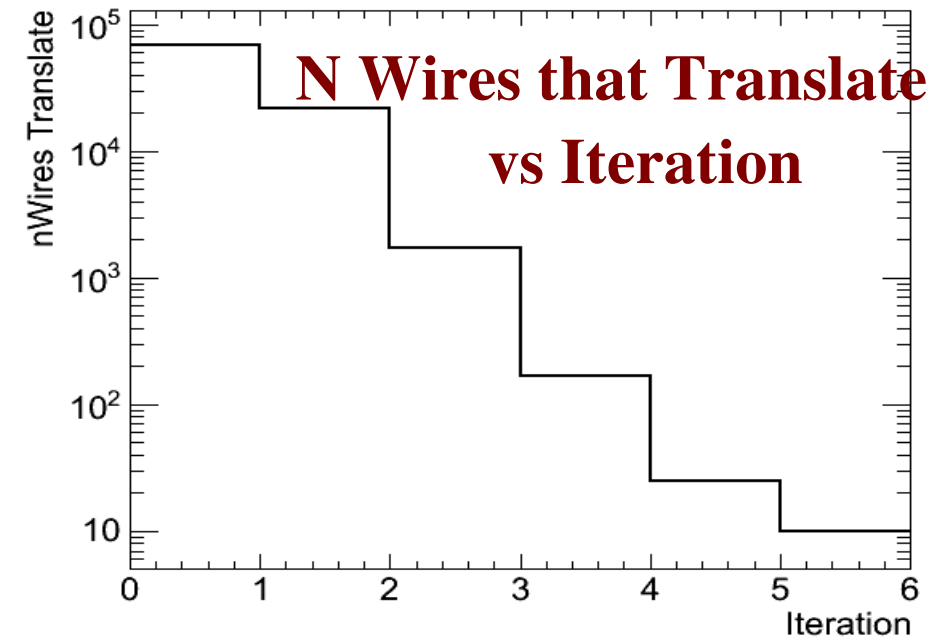
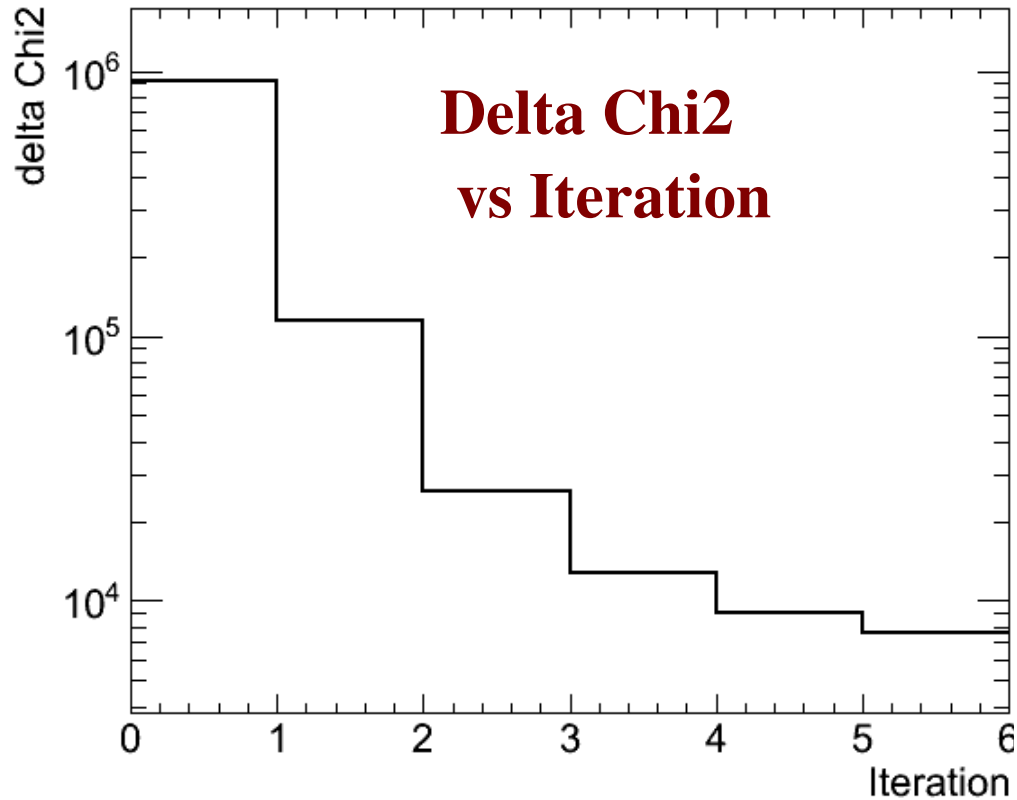
Convergence

Define a wire as

“rotating” or “translating” if

$$|\Delta X| > \sigma(\Delta X)$$

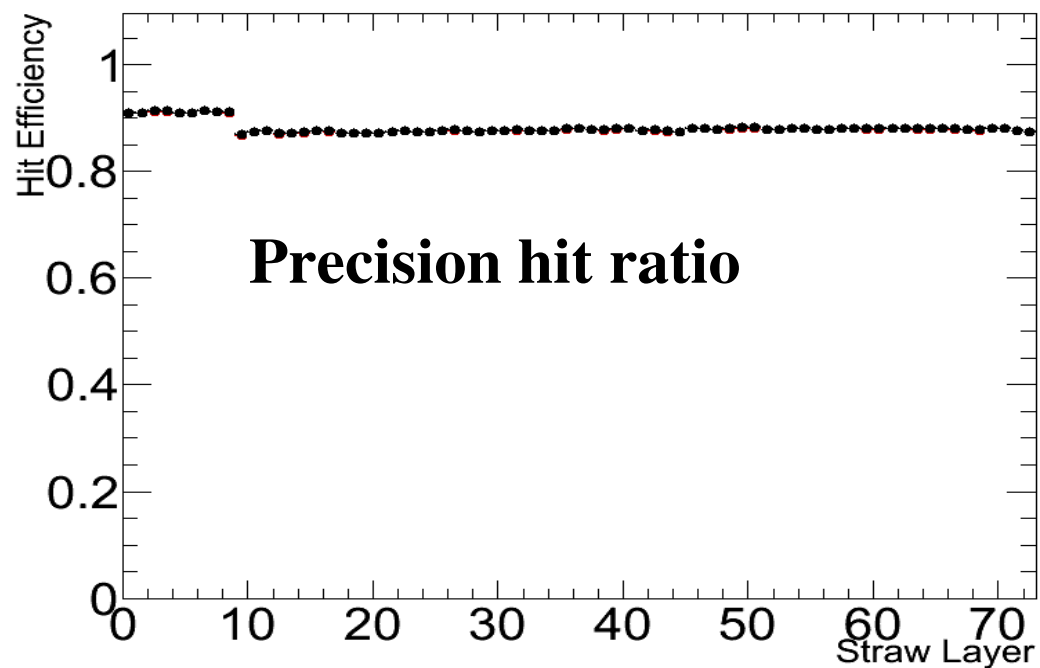
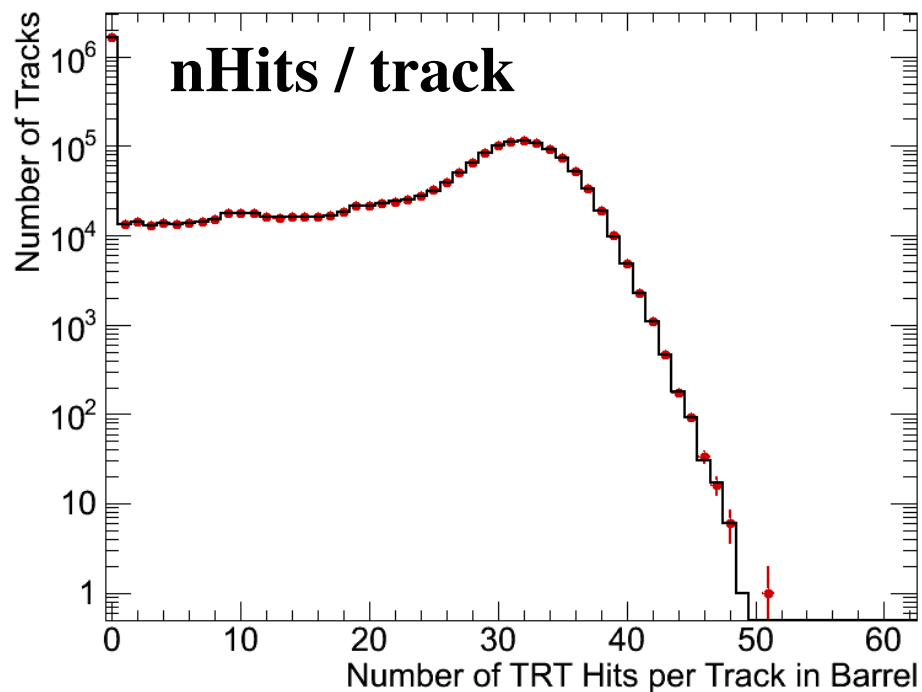
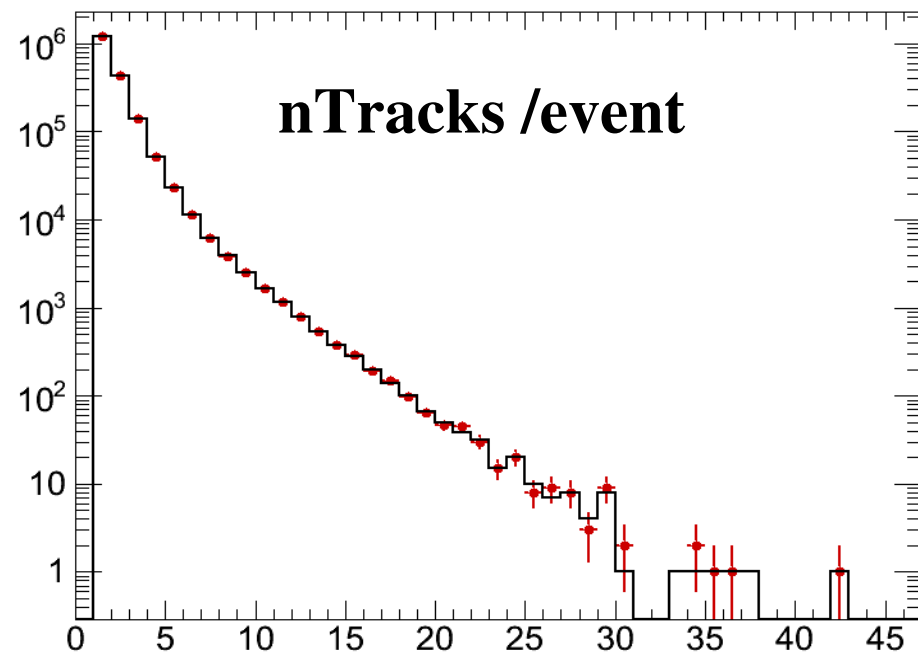
$$|\Delta \text{rotz}| > \sigma(\Delta \text{Rotz})$$





Hippocratic Oath

Before TRT L3 Barrel
After TRT L3 Barrel





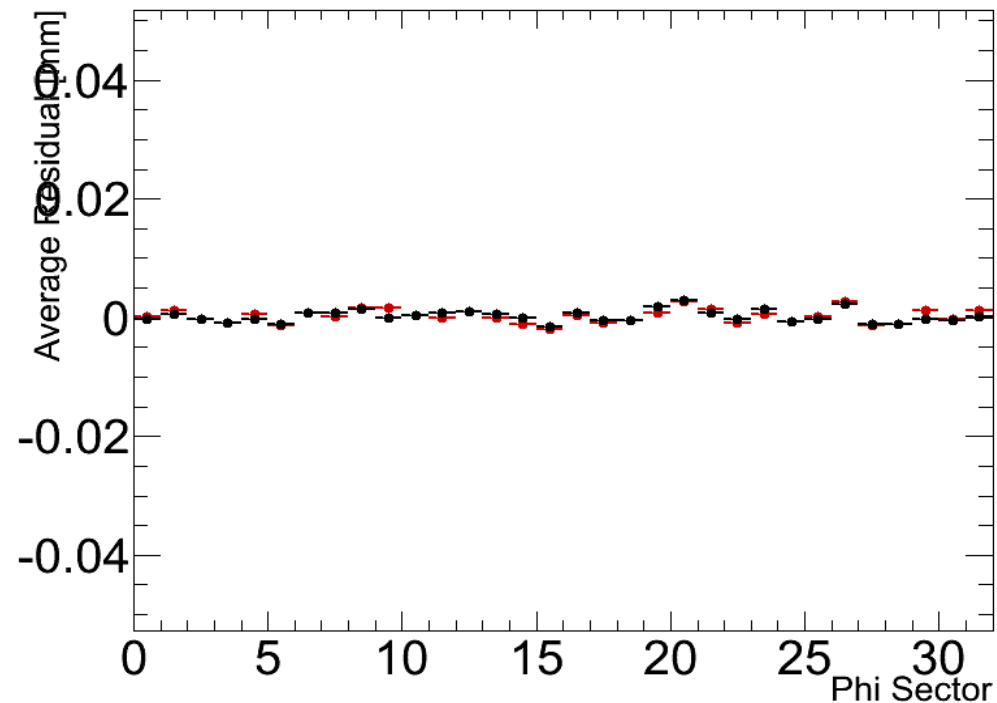
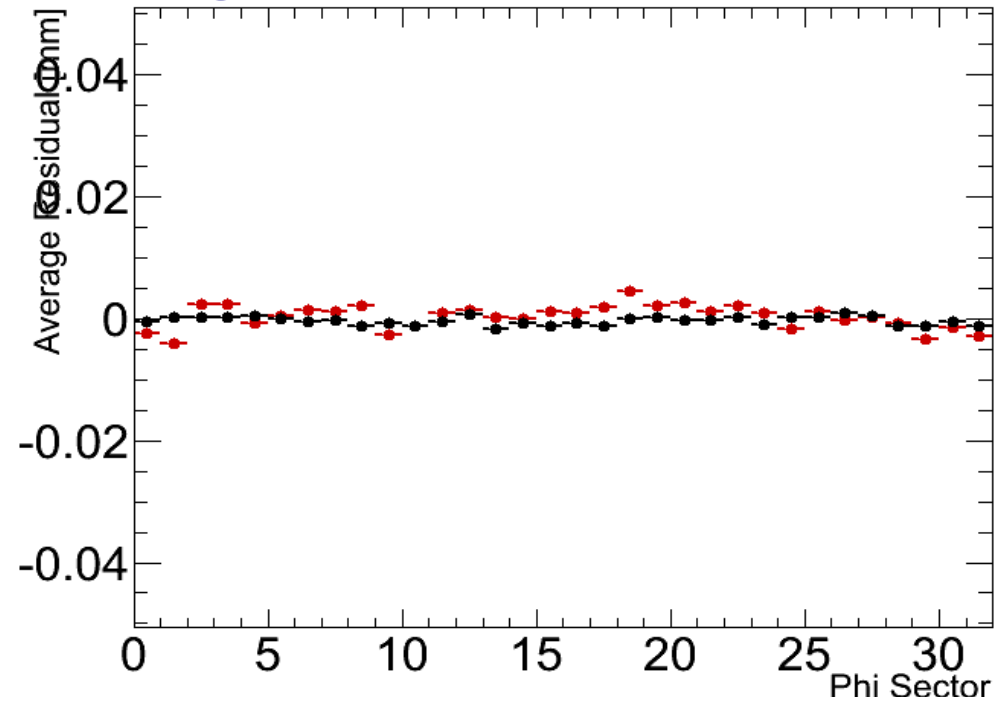
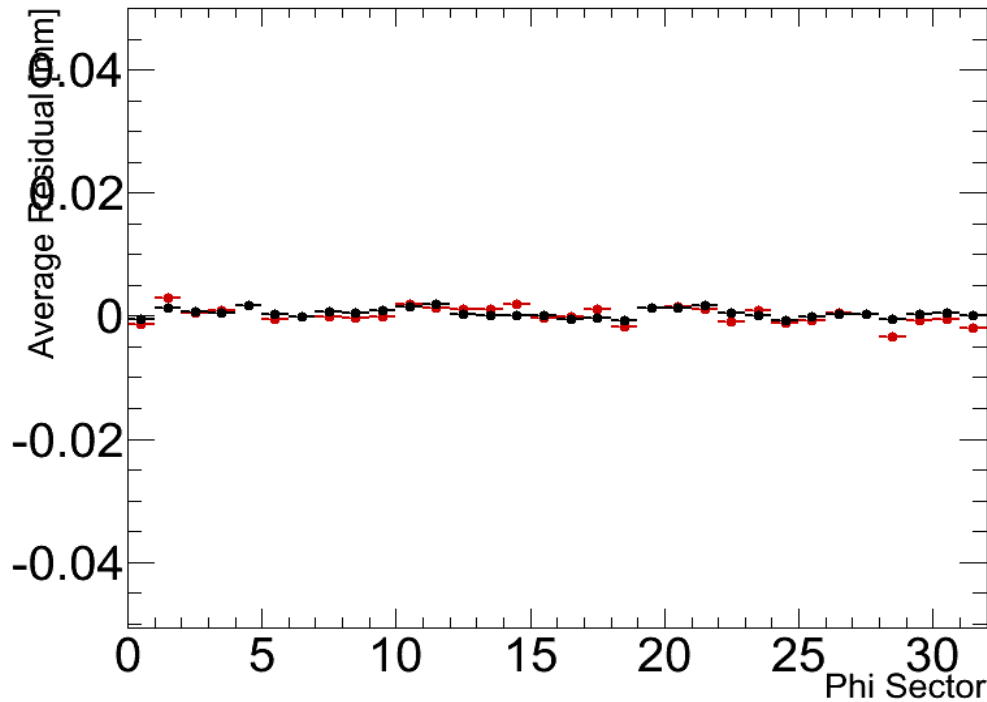
Hippocratic Oath

Average Residual Vs Phi Sector

Before / After Alignment

Indication of quality L2.

No need for realignment at L2



Expected Improvements

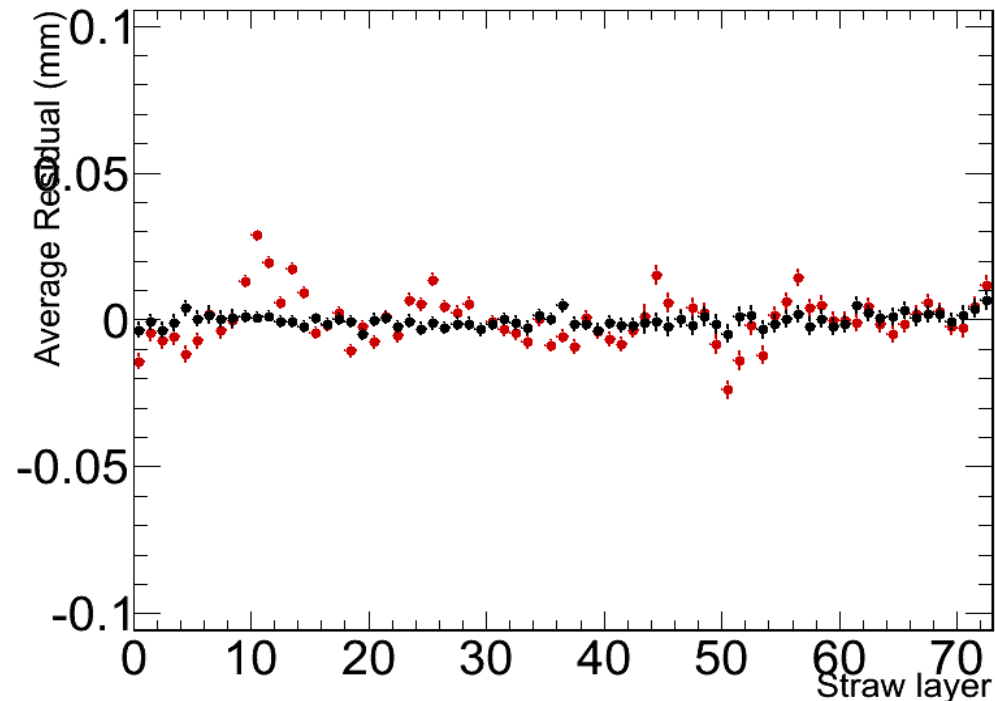
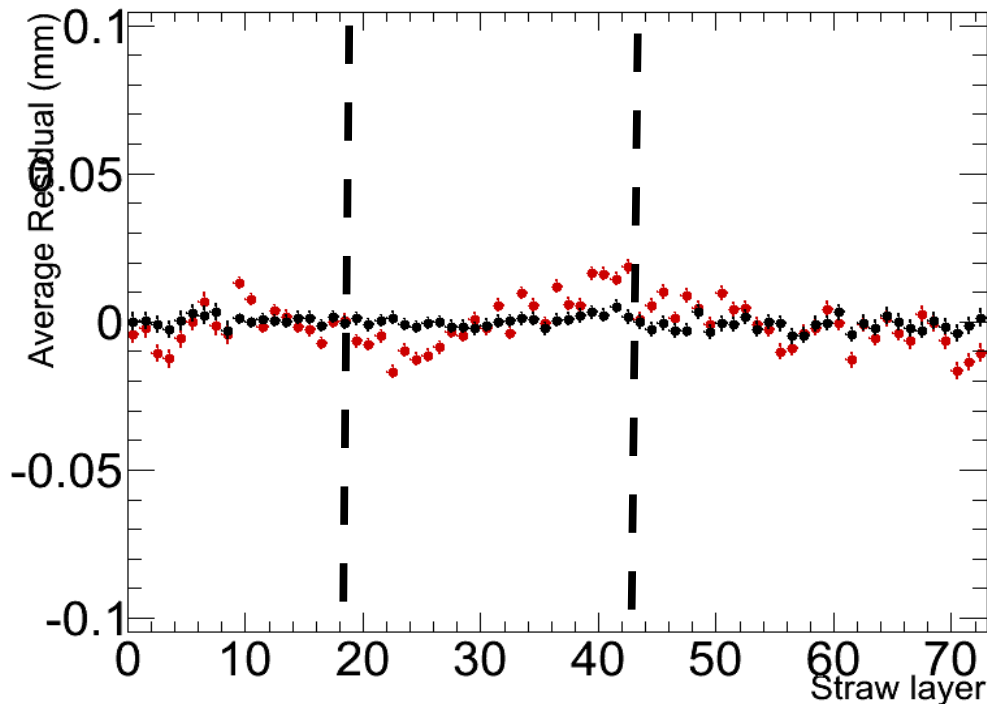
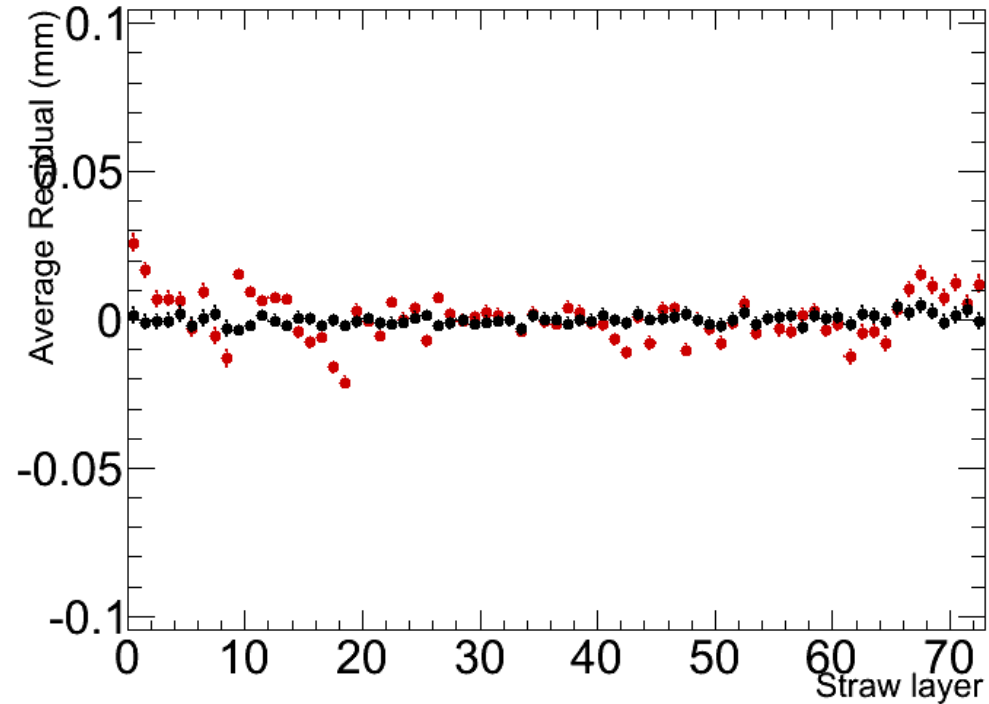


Average Residual Vs R

Before / After Alignment

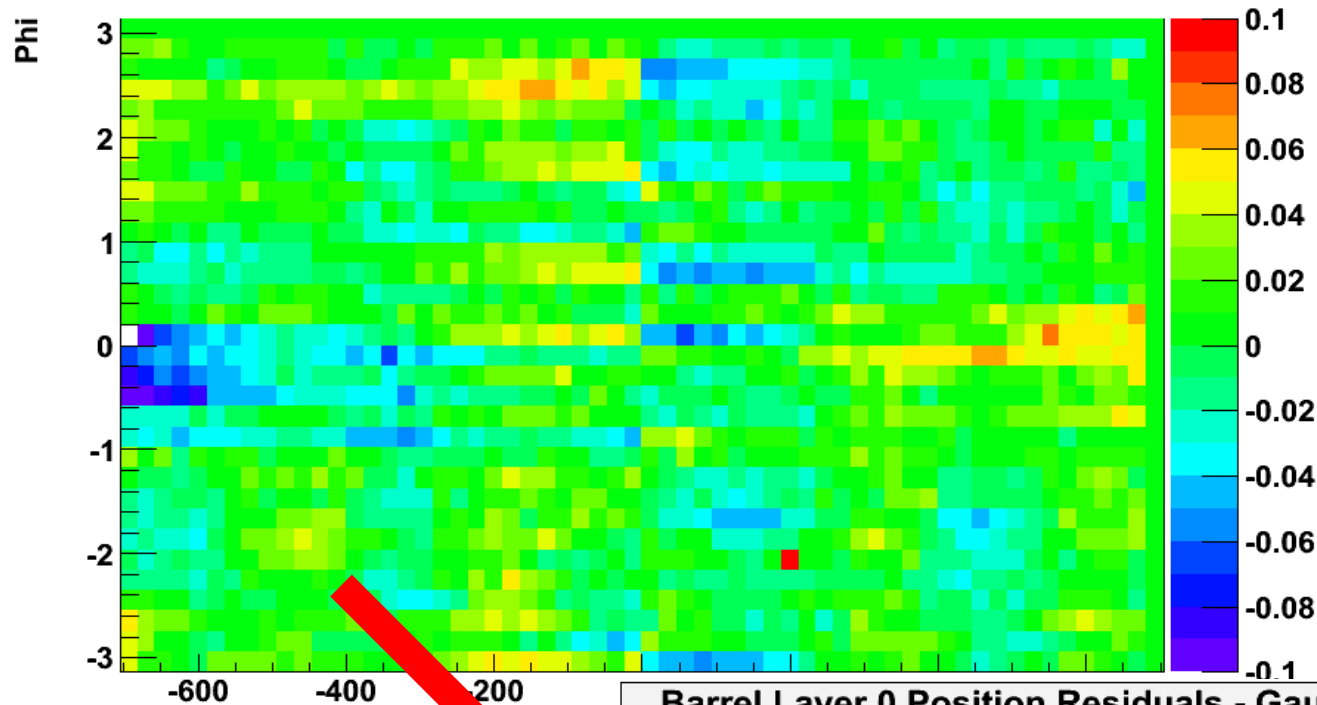
Shown for 3 different phi sectors

Residual Structure with in the
module level removed at L3



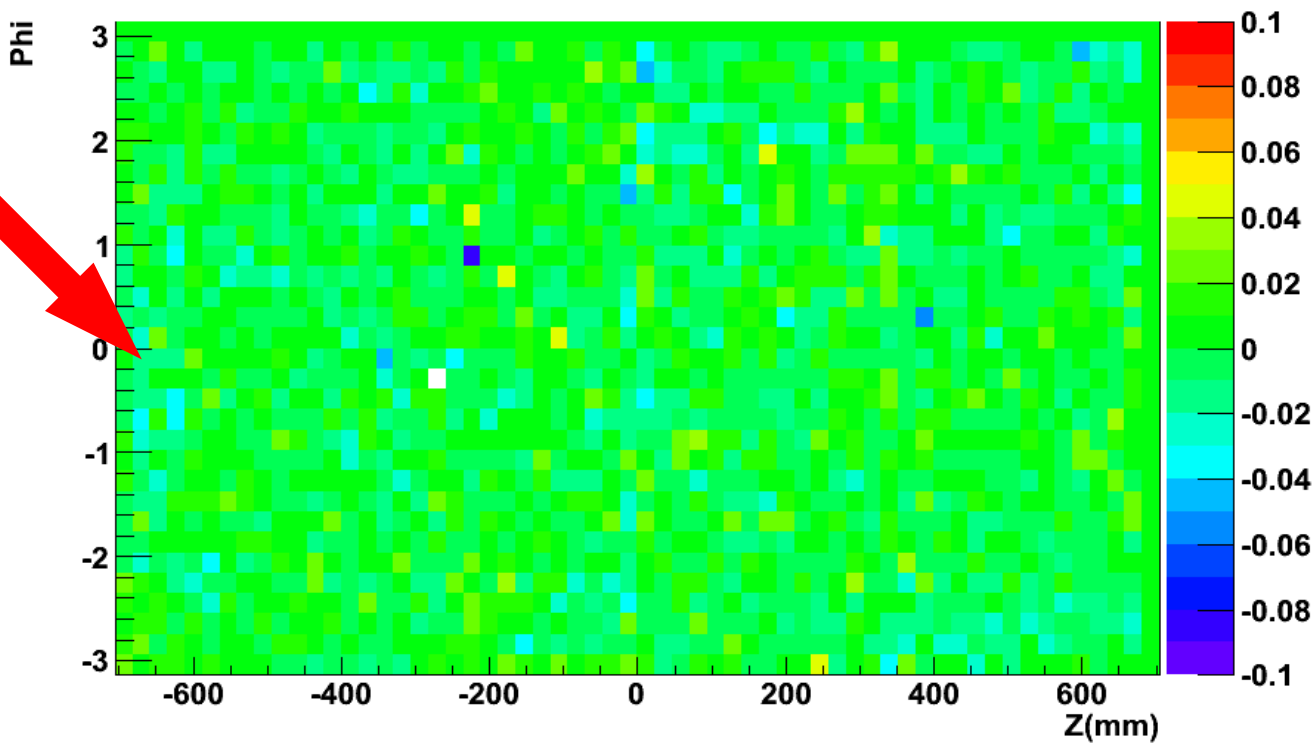


Barrel Layer 0 Position Residuals - Gaussian Core Fit - μ



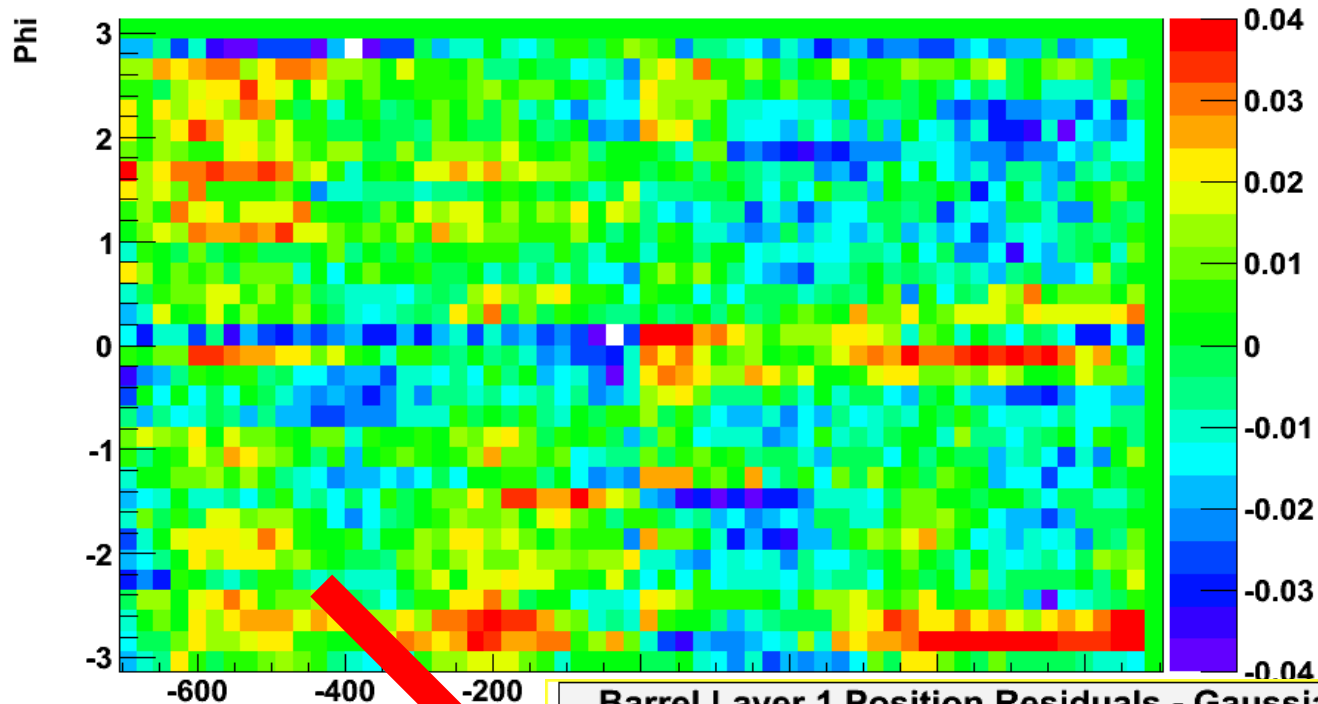
Barrel Layer 0 Position Residuals - Gaussian Core Fit - μ

**After L3
Alignment**

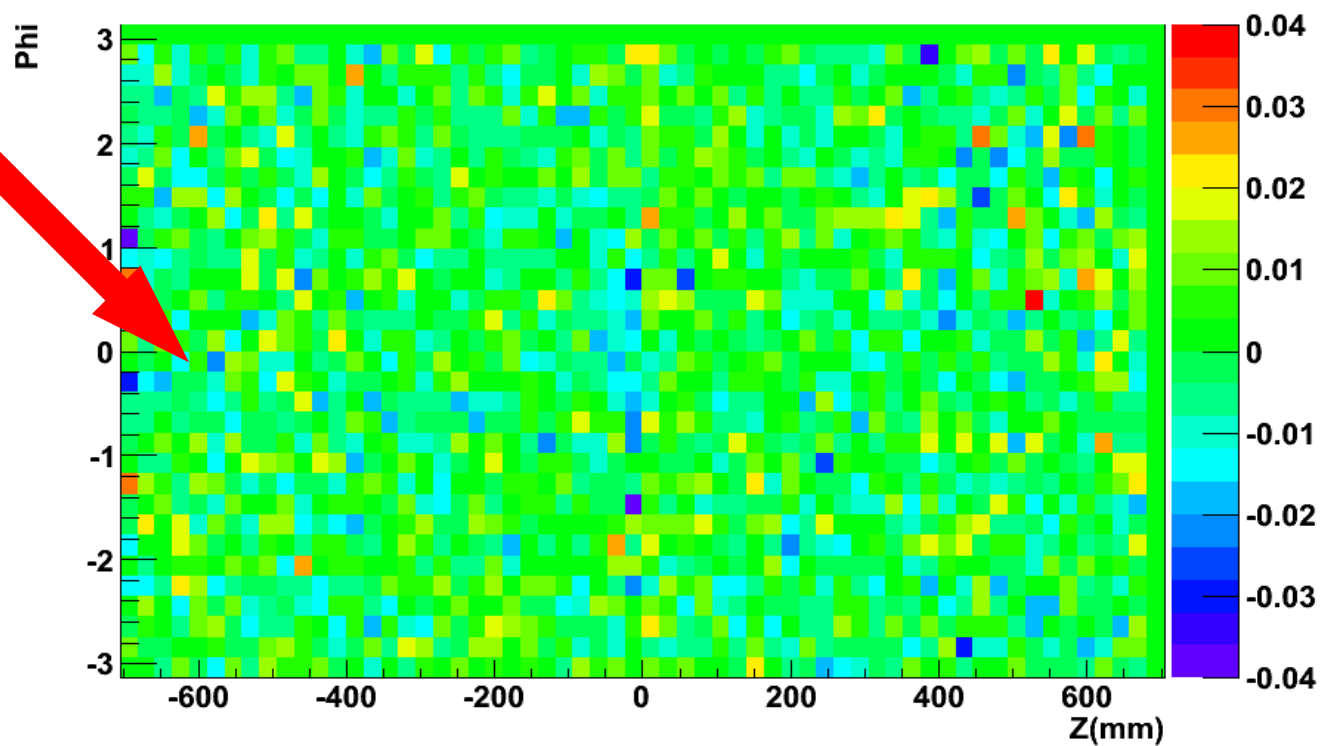




Barrel Layer 1 Position Residuals - Gaussian Core Fit - μ



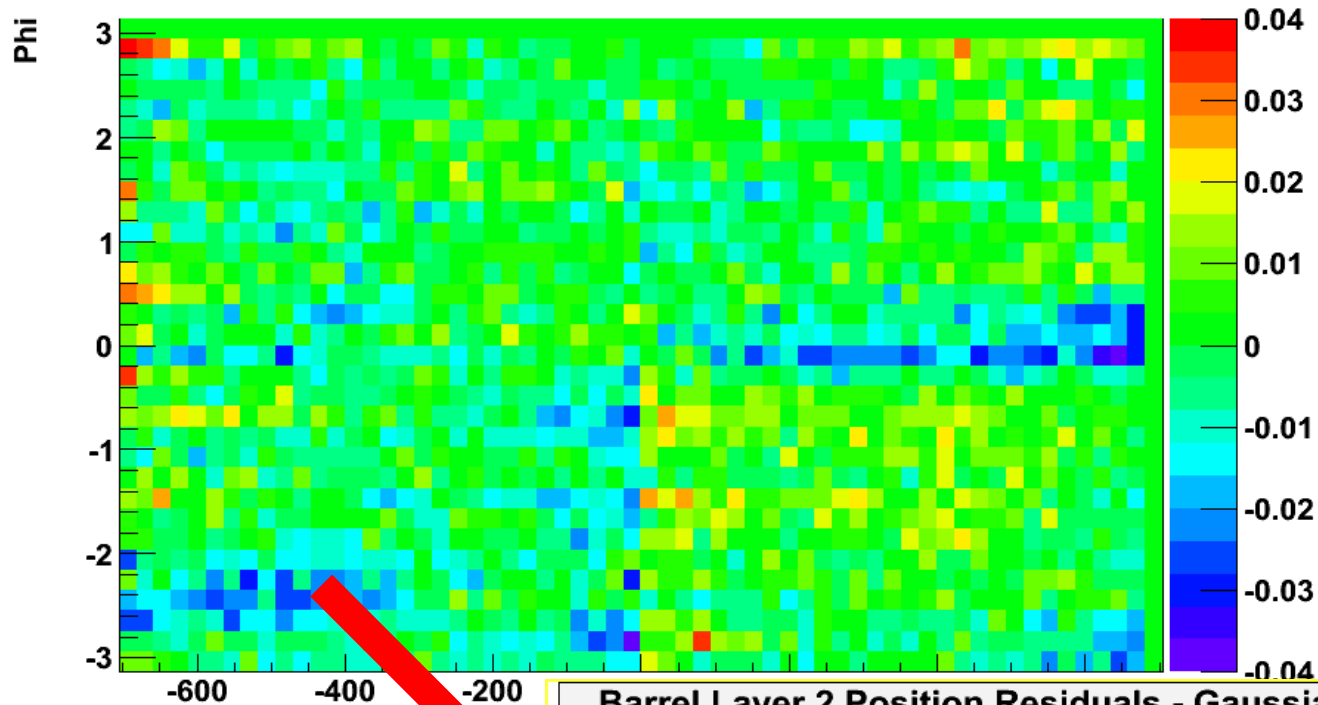
Barrel Layer 1 Position Residuals - Gaussian Core Fit - μ



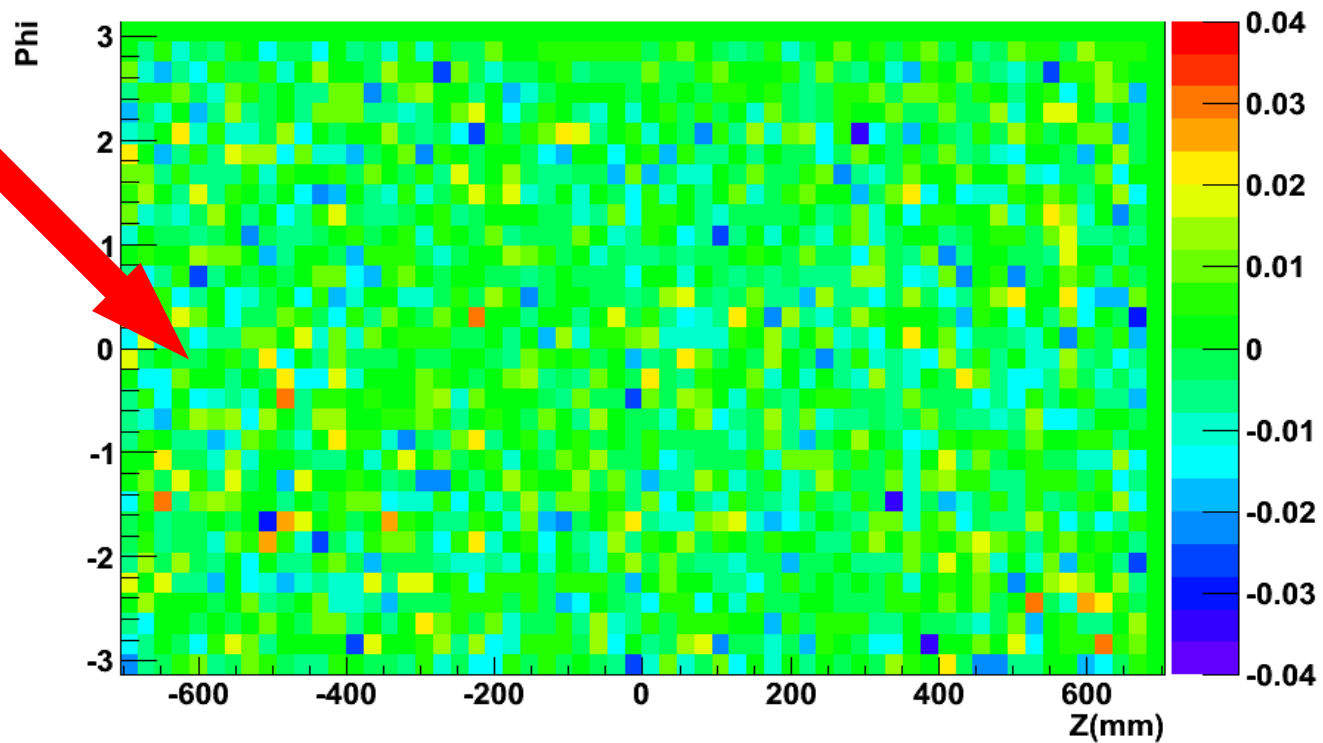
After L3
Alignment



Barrel Layer 2 Position Residuals - Gaussian Core Fit - μ



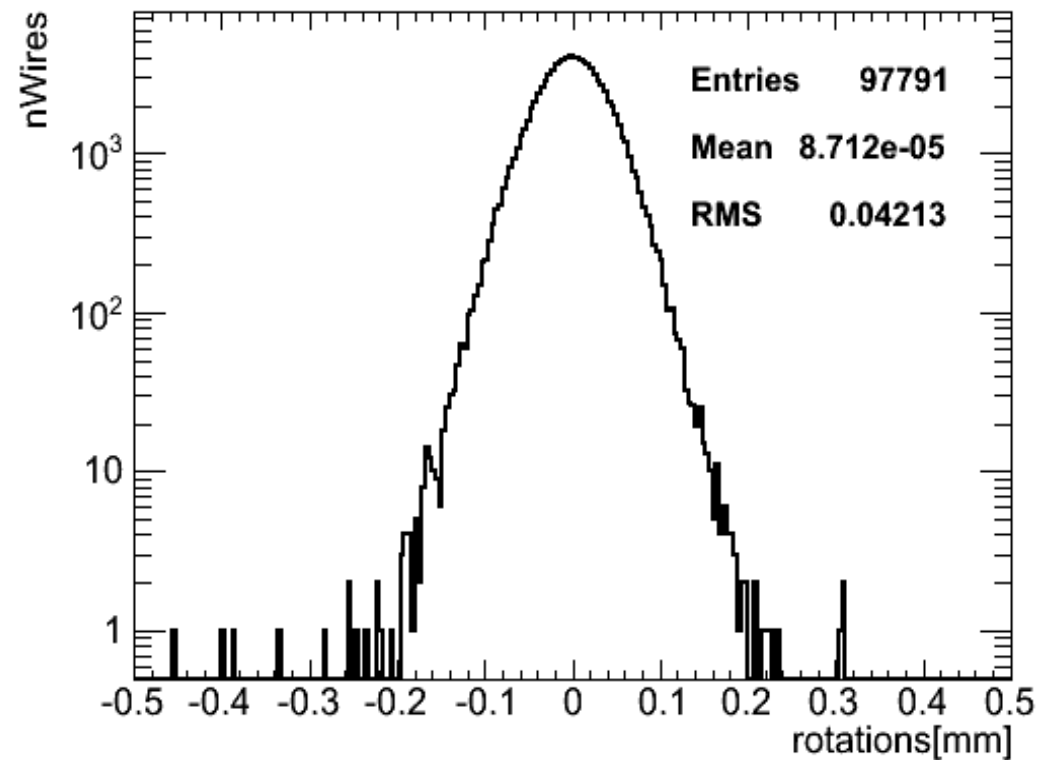
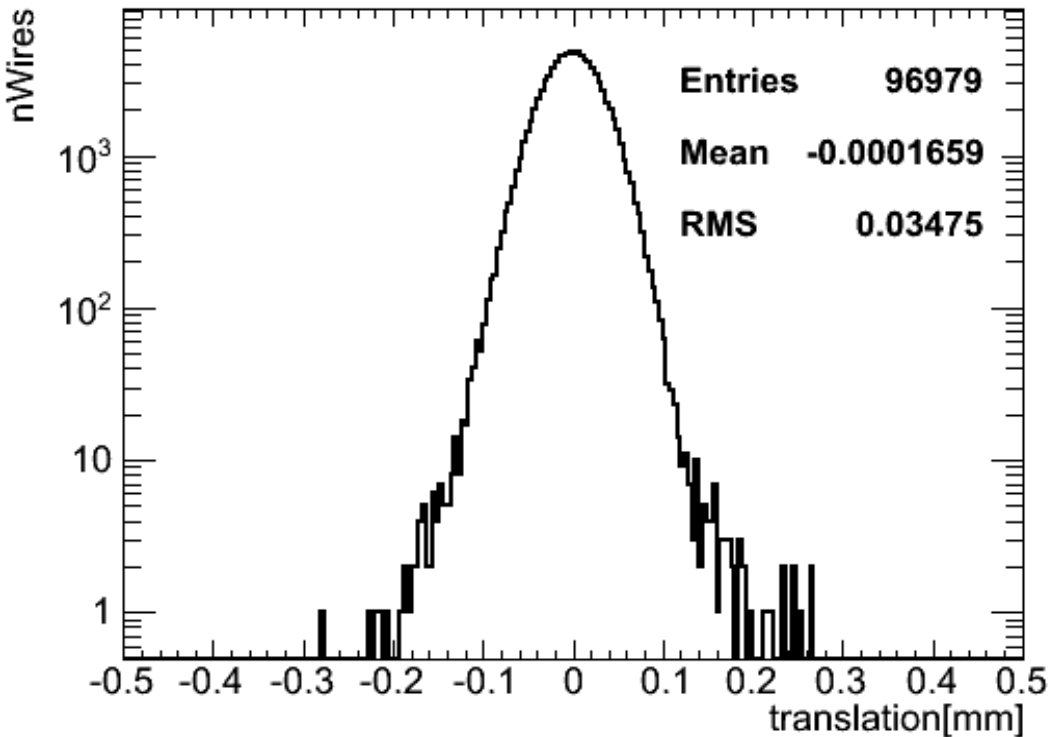
Barrel Layer 2 Position Residuals - Gaussian Core Fit - μ



**After L3
Alignment**



Magnitude of Physics Movements



Wire Placement Accuracy of Better than 50 Microns.



Physics Impact

