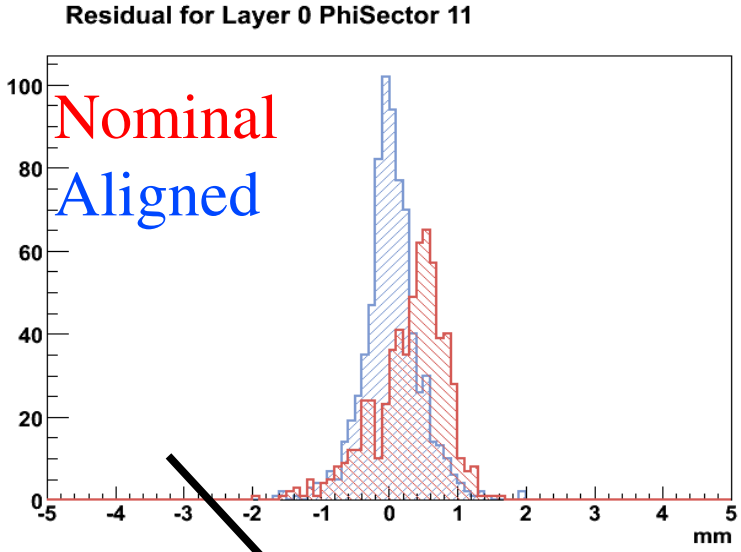
TRT Alignment

TR τau-Fest '08

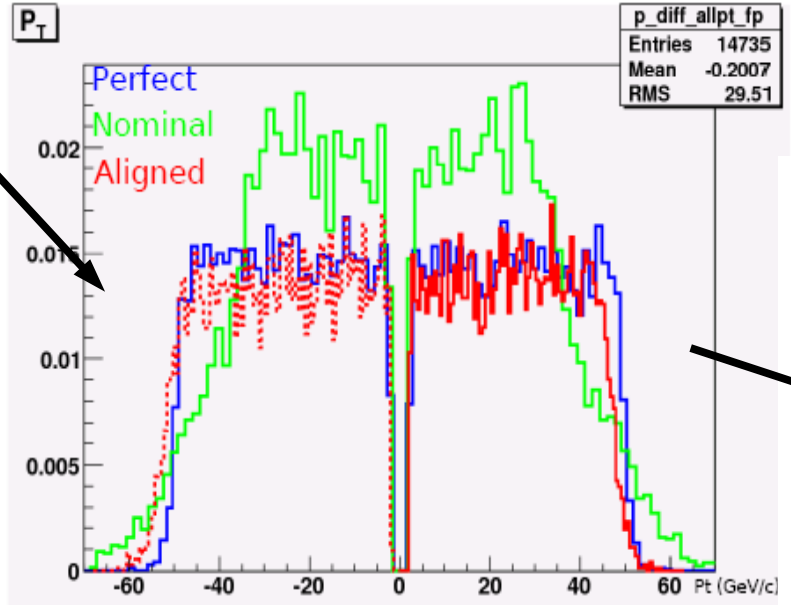
John Alison

Why is alignment a problem?

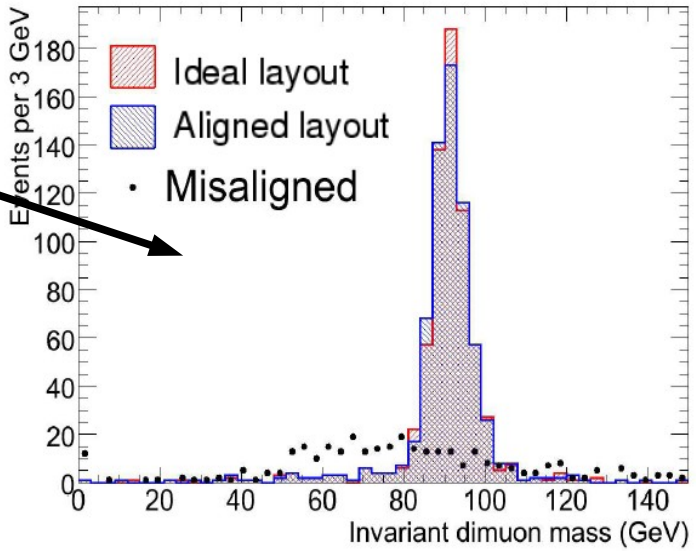


Assumptions about the relative positions of the detector are made by software used offline to process events. (Eg: reconstruct tracks)

Initially, these relative positions are not precisely know.



Can effect all track parameters

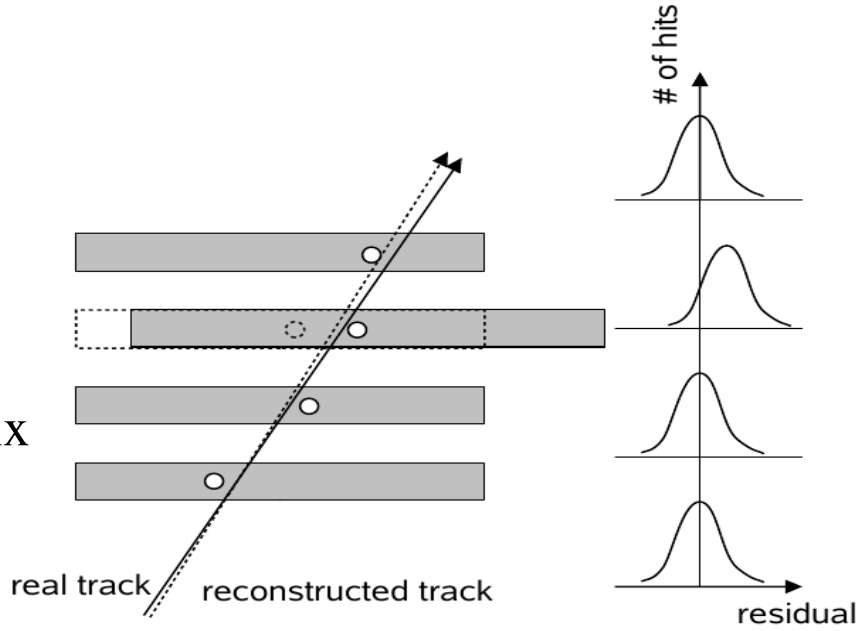


How we can address the problem.

- Survey Measurements
- **F**requency **S**canning **I**nterferometry
- Track Based Alignment

$$\chi^2 = \sum_{\text{tracks j}} \left(r^T V^{-1} r \right)_j$$

r- residual vector
V – correlation matrix



"Warm up" track fit

$$0 \equiv \frac{d\chi^2}{dx} = -2H^T V^{-1} r$$ minimization Condition

$$x^{(1)} = x^{(0)} - \left(\frac{d^2\chi^{2\,(0)}}{dx^2} \right)^{-1} \frac{d\chi^{2\,(0)}}{dx}$$ solution by linearizing

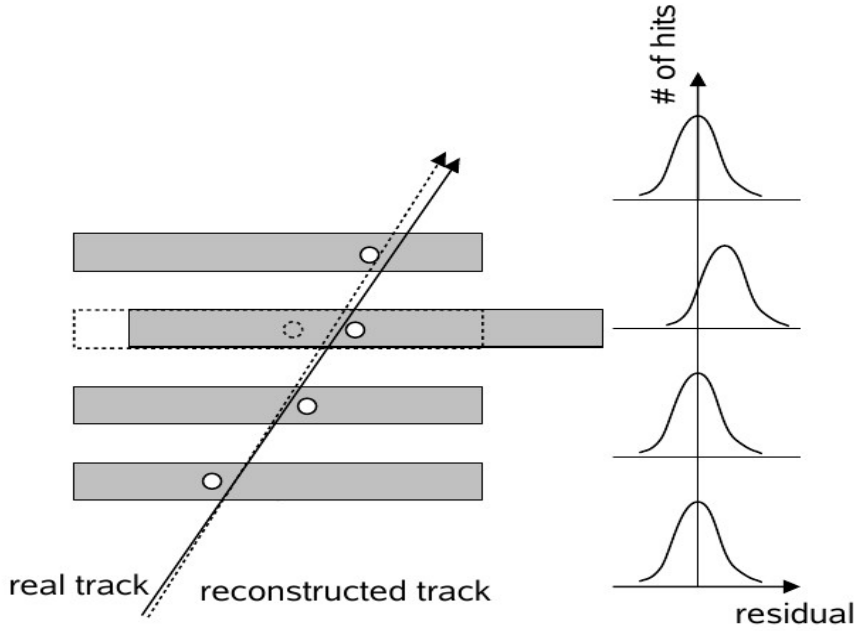
NxN matrix

moral equivalent to
$f(x) = f(x0)+f'(x0)(x-x0)$

How we can address the problem.

Real problem alignment

$$\chi^2 = \sum_{\text{tracks j}} \left(r^T V^{-1} r \right)_j$$



Added Complication

$$\frac{\mathrm{d}}{\mathrm{d}\alpha} = \frac{\partial}{\partial\alpha} + \frac{\partial x}{\partial\alpha}\frac{\partial}{\partial x}$$

Already done trackfit.

$$0 = \frac{\mathrm{d}}{\mathrm{d}\alpha}\frac{\partial\chi^2}{\partial x} = \frac{\partial^2\chi^2}{\partial\alpha\partial x} + \frac{\mathrm{d}x}{\mathrm{d}\alpha}\frac{\partial^2\chi^2}{\partial x\partial x} \longrightarrow \frac{\mathrm{d}x}{\mathrm{d}\alpha} = -\frac{\partial^2\chi^2}{\partial\alpha\partial x}\left(\frac{\partial^2\chi^2}{\partial x\partial x}\right)^{-1}$$

Solution to linear model

$$\alpha = \alpha_0 - \left(\frac{d^2\chi^2}{d\alpha^2}\right)^{-1}\frac{d\chi^2}{d\alpha}\Big|_{\alpha_0}$$

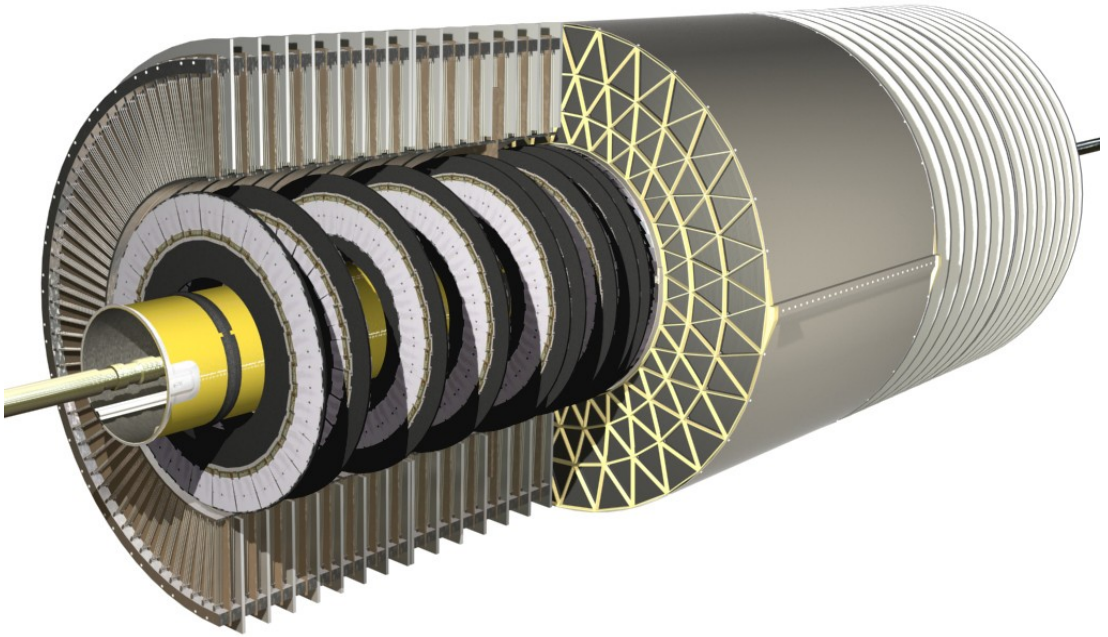
NxN matrix

Alignment at Atlas, and in the TRT.

Many Track Based Alignment Algorithms implemented in Athena

- Local Chi2
- Global Chi2
- Robust Alignment
- TRT Alignment

→ Si



Inner Detector composed of ~ 6000 alignable modules
TRT has ~ 150 alignable modules

- **Most work on Barrel**
- **TRT Global and Local**
- **L1 / L2**
- **Only algorithm can align entire ID @ L1**

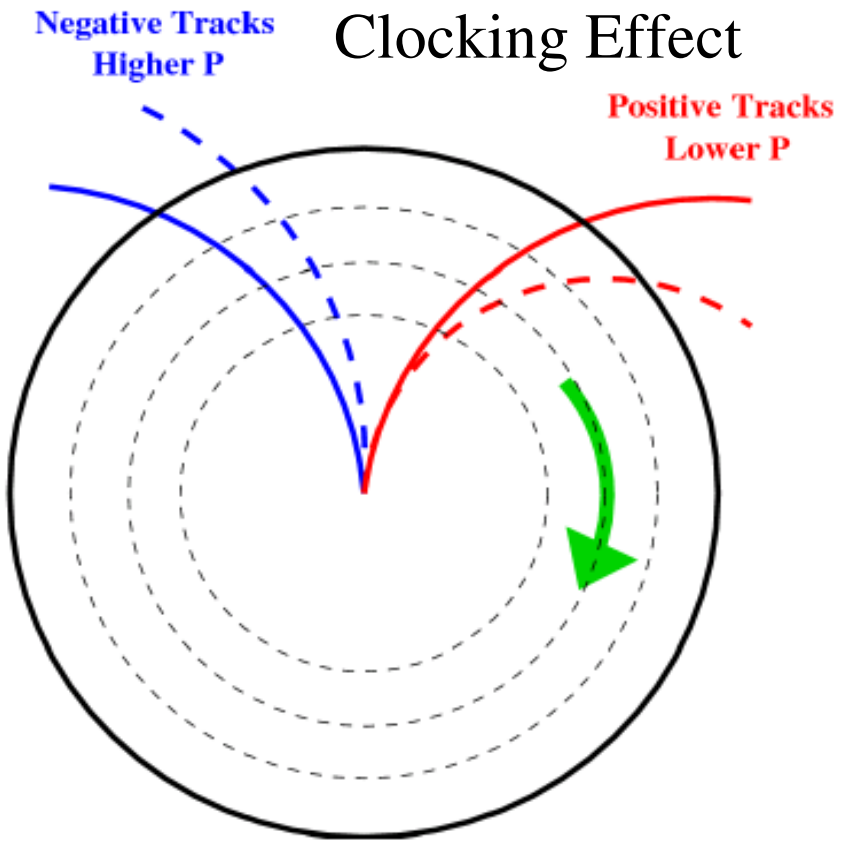
Weak Modes, the real problem.

Chi2 statistic only depends position residual.

By biasing track parameters Chi2 remains insensitive to classes of real misalignments. Small eigenvalues in SVD.

- Alignment can be insensitive to these misalignments
- Alignment can introduce these misalignments

Eg. TRT Barrel Clocking Effect



<u>Possible Solutions</u>

track topologies – cosmics/decays

expanding meaning of residuals

Systematically biasing Pt in Pt dependent way

How do we know when were done?

"If you don't know what you're doing, how do you know when your done?"

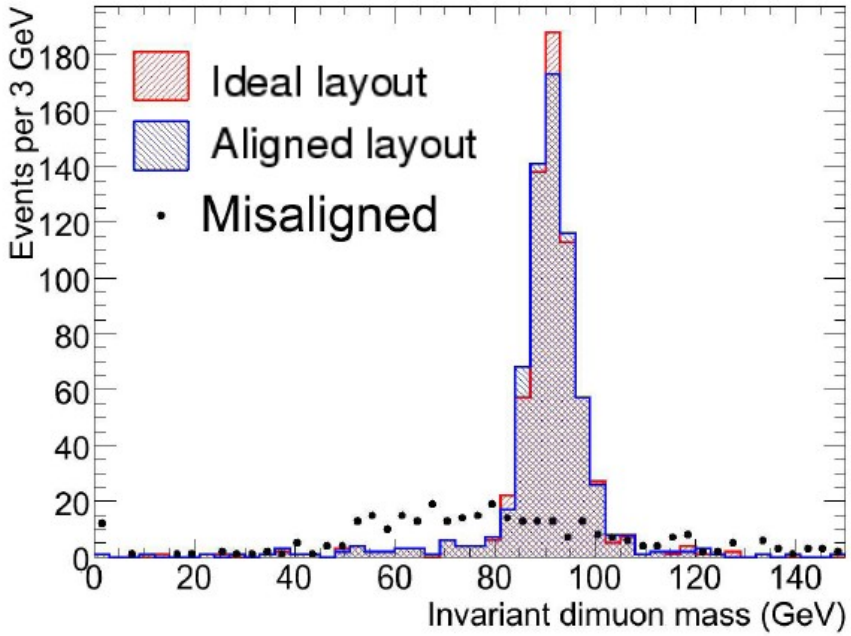
- Walter Brown
(FNAL Computing Division)

IDAlignment Monitoring

monitor physical observables sensitive to misalignments
assess quality of alignment
sign off on alignment constants
assess need for re-alignment

"Lower" Level observables
general track parameters
residuals
efficiencies

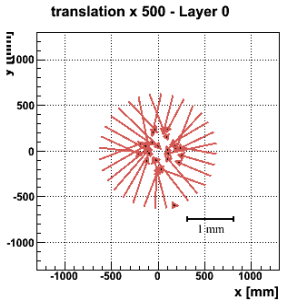
"Higher" Level observables
electrons
Z->mumu Z-> ee
W->e nu

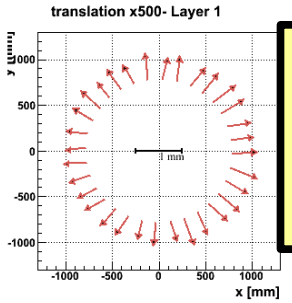


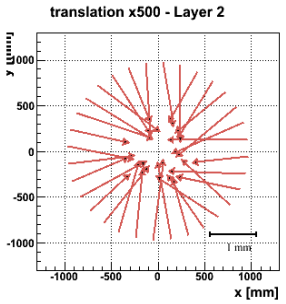
Great way to understand the detector and offline reconstruction

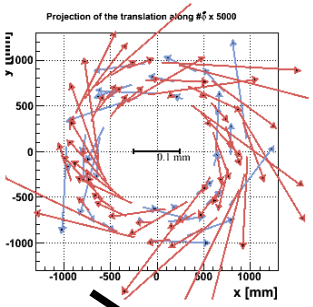
CSC / FDR "data"

- Explaination - initial misalignments, multi-muons
- Results - 1st order success
- Concerns - remnant clocking effect

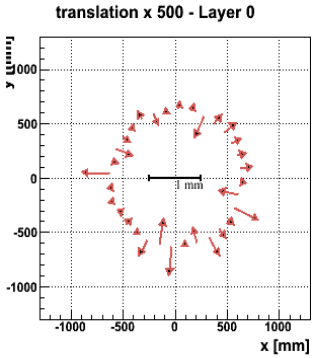


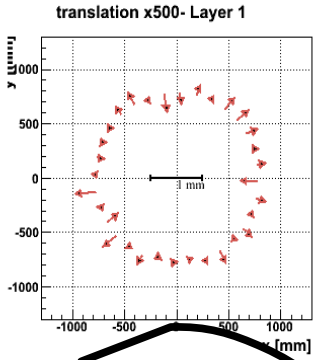


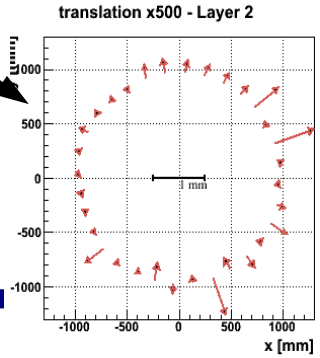


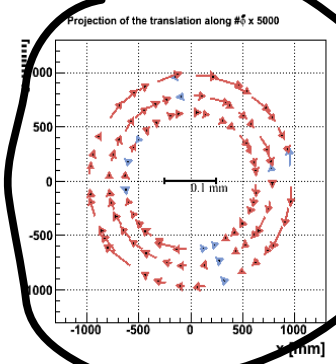


alignment

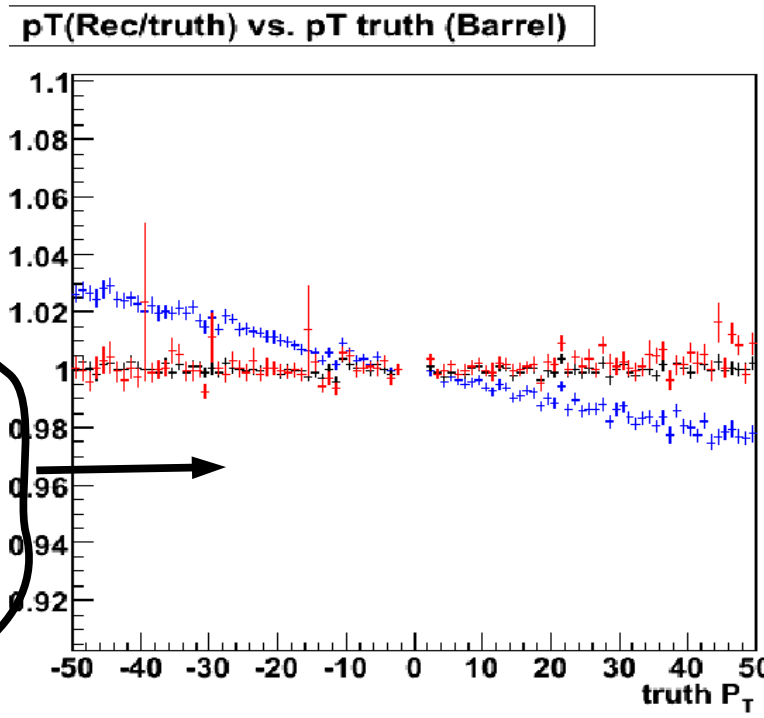




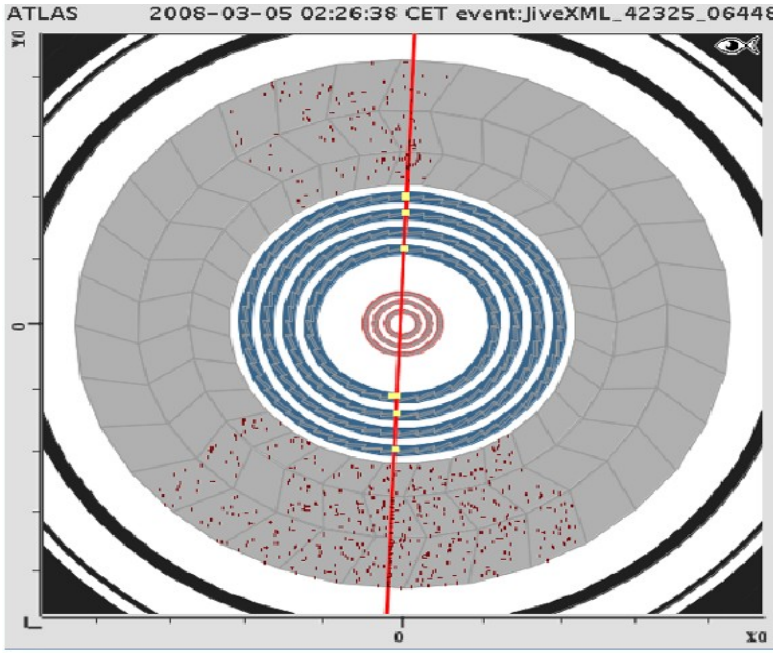




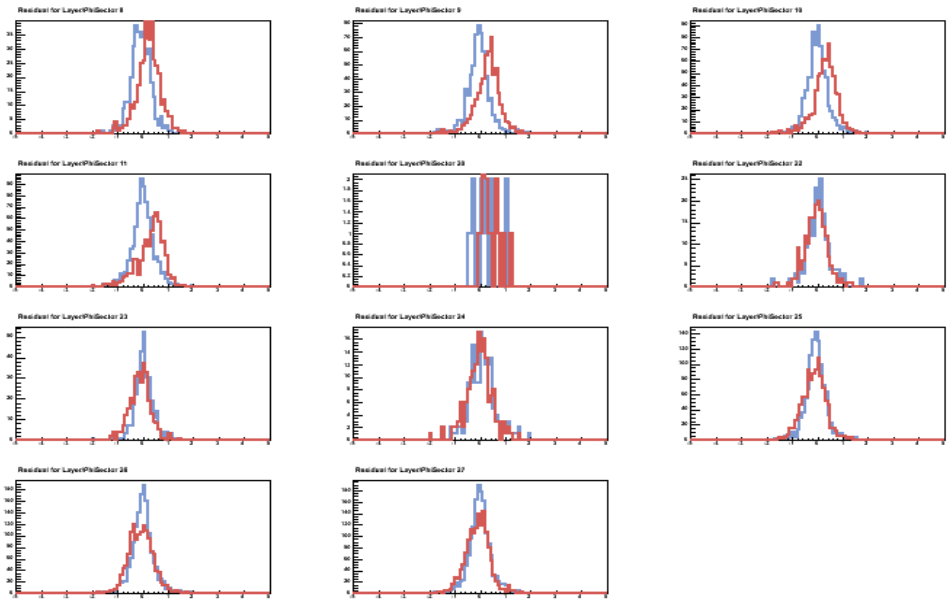
- test of commissioning procedure
- our ability to relay calibrations to the wider community



Cosmic data (no quotes)



- 1st combined running of Si + TRT after installation, ~ 1/3 of TRT barrel read out
- ~ 4000 tracks with TRT and Si information
- #s of Hits and Tracks increased with iterations
- test of IdAlignmon, => more info
- interplay of calibration / other subdetectors



Resolution improvement of over 200 mircons.

Future

Weak modes
EndCaps
Cosmics
Beam Halo (“EndCap cosmics”)
Collisions