

Rich Mirror Alignment

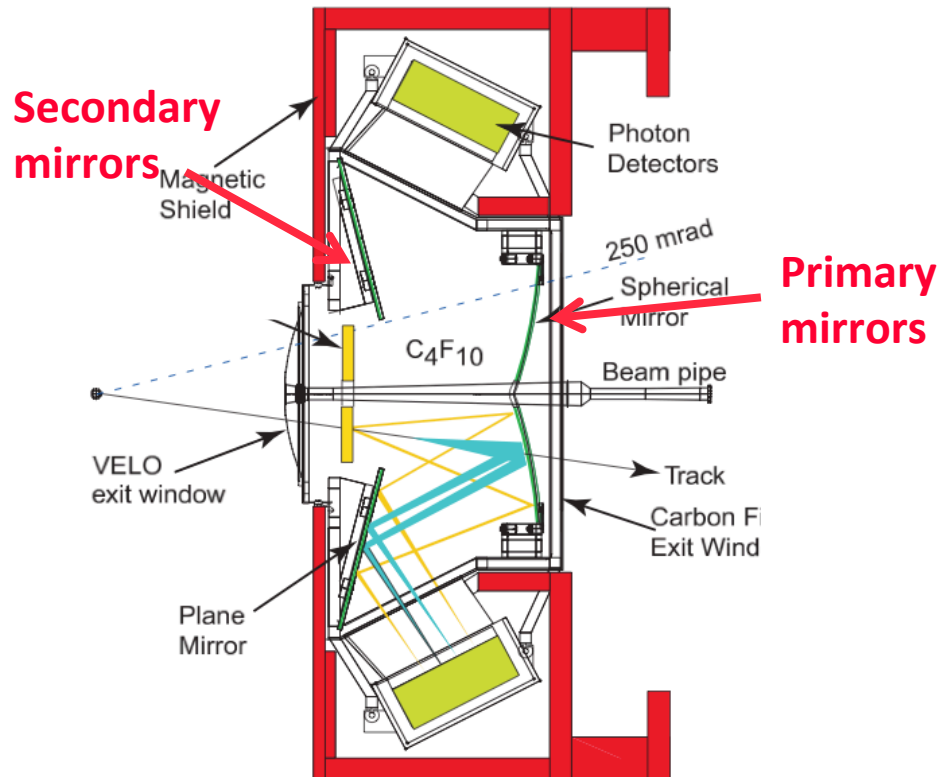
13/07/2015

Claire Prouve

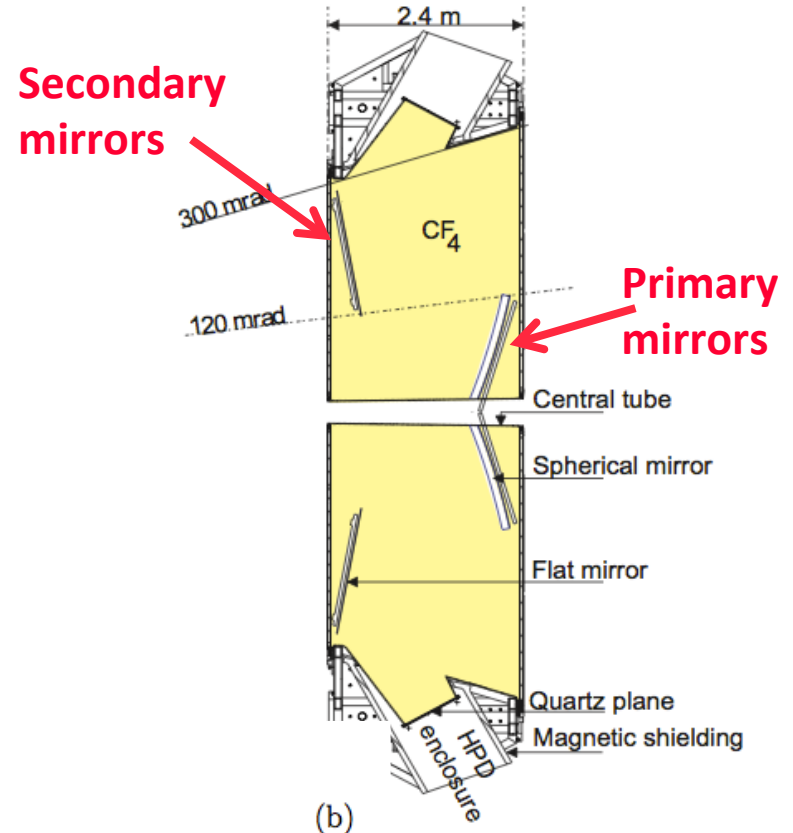
- How does it even work?
- Implementation in the online framework
- Current status

RICH Mirror Alignment

RICH 1: 4 primary mirrors
16 secondary mirrors



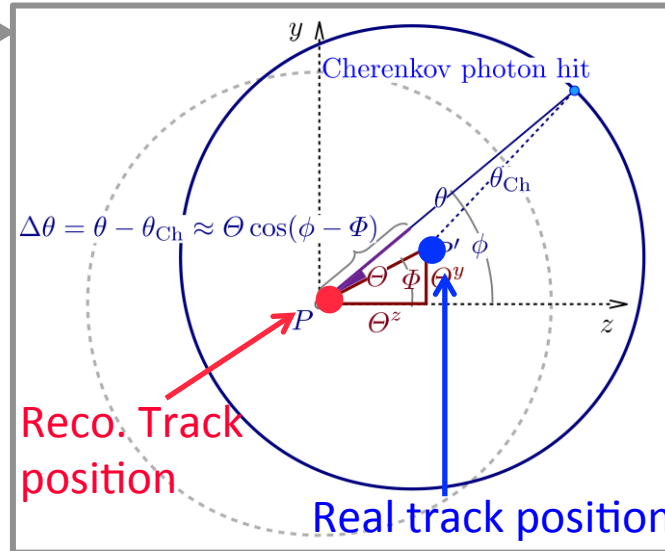
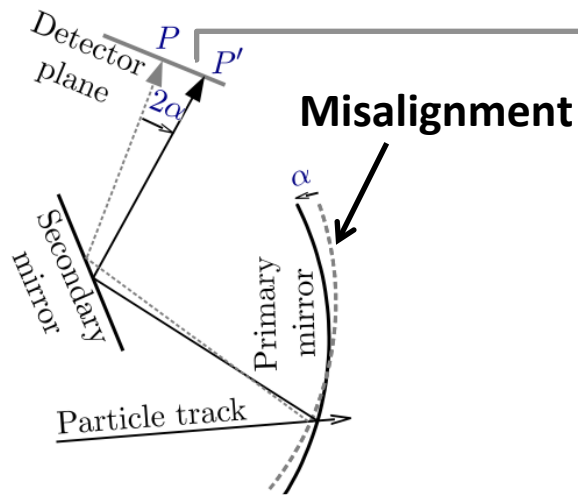
RICH 2: 54 primary mirrors
40 secondary mirrors



Misaligned mirrors will affect the PID due to incorrectly predicted Cherenkov angle!

Best possible resolution $\sim 1.5\text{mrad}$ for RICH1, $\sim 0.7\text{mrad}$ for RICH2.

Misalignment

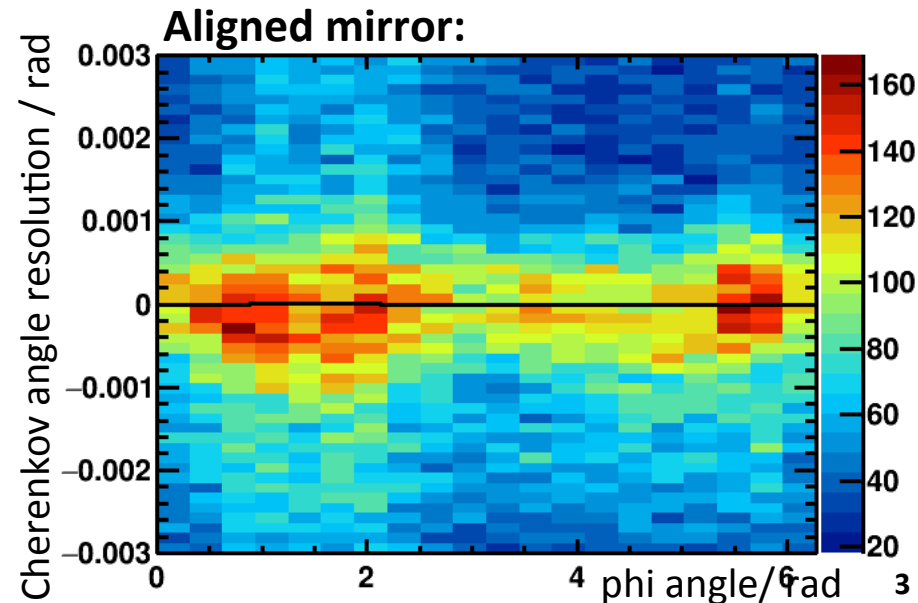
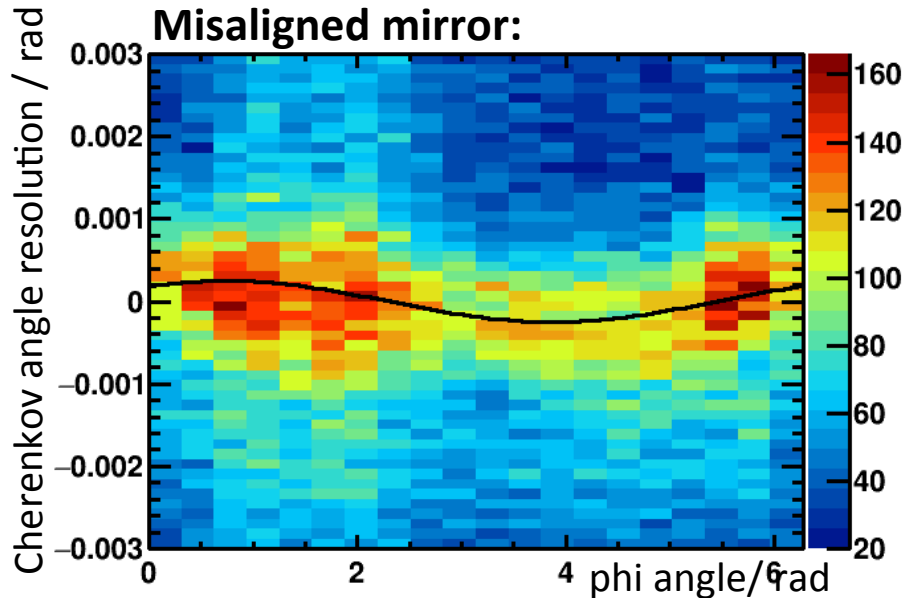


Identify misalignment:

$$\Delta\theta_C = \theta_x \cos(\phi) + \theta_y \sin(\phi)$$

Misalignments
on detector plane

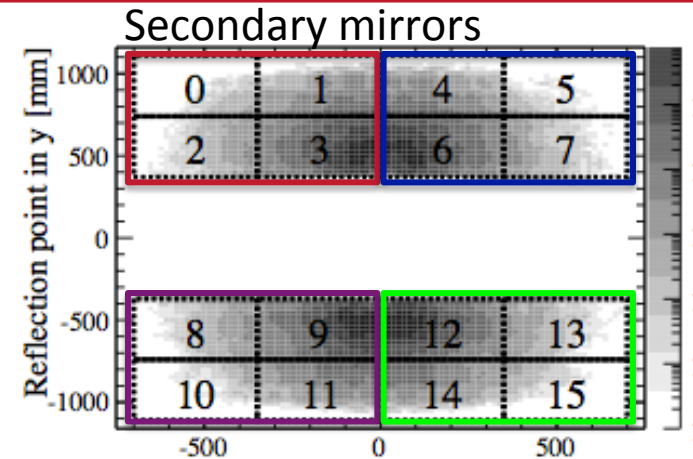
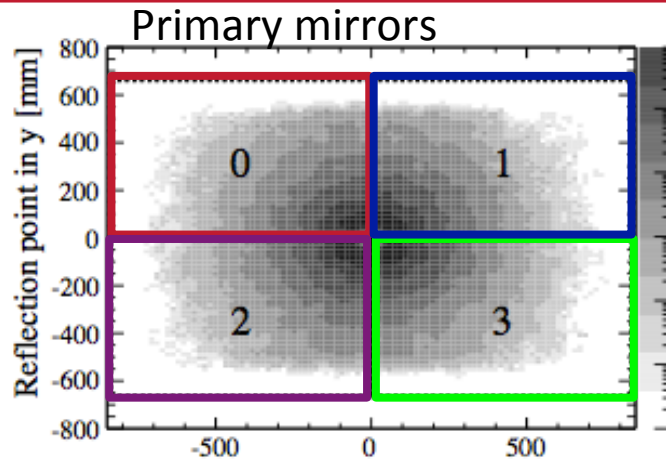
$$\Delta\theta_C = \theta_{\text{meas.}} - \theta_{\text{exp.}}$$



Aligning mirrors to each other

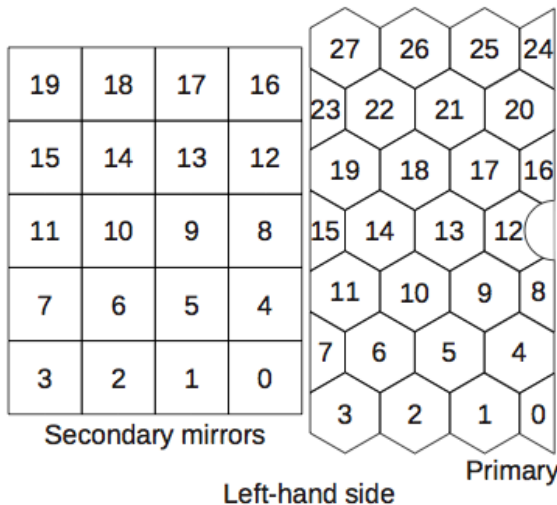
RICH1: easy!

-> fix primary mirrors
only align secondary mirrors

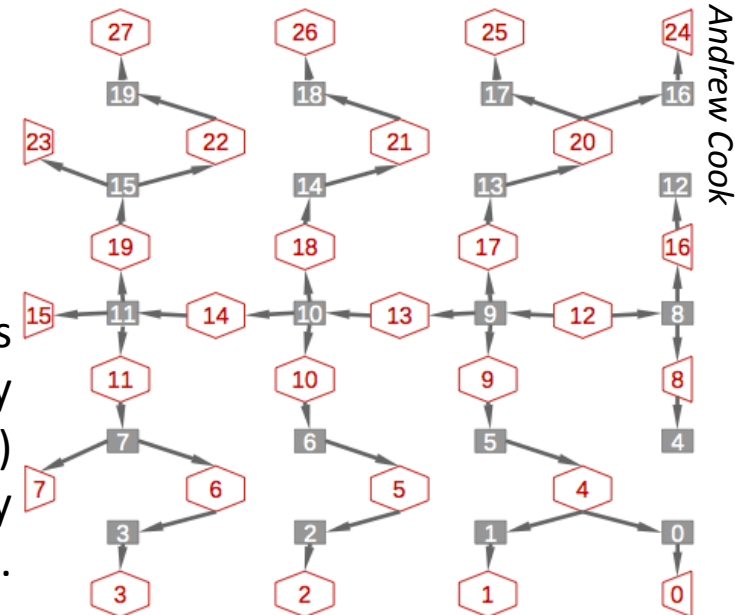


RICH2: more complicated

For a given secondary mirror several primary mirrors possible -> solve a set of simultaneous equations per half of RICH2

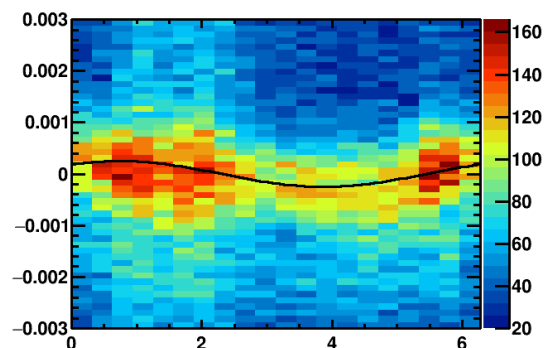
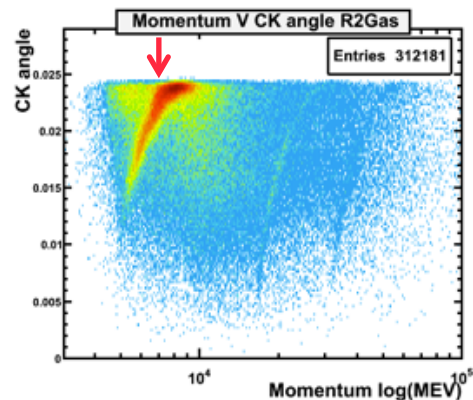
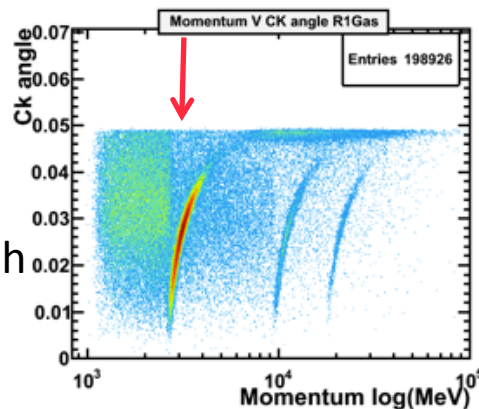


System of equations linking all primary mirrors (grey) and secondary mirrors (red).



Alignment procedure

1. Select high momentum-tracks with **pion hypothesis** ($p > 20\text{GeV}$ for RICH1, $p > 40\text{GeV}$ for RICH2)
2. Reconstruct **unambiguous photons** for each *necessary* mirror pair
3. Fit $\Delta\theta(\Phi)$ distributions
4. Calculate *magnification coefficients* by reconstructing same events for **8 different mirror tilts**
5. Translate misalignments on detector plane into **mirror-tilts** using *magnification coefficients*
6. If changes for each mirror tilt smaller than threshold (0.1mrad) **consider mirrors as aligned**, otherwise **restart at 1.** with newly made alignment constants
7. Alignment usually converges after ~ 5 iterations



Unambiguous photons will be reflected by the same mirror-pair no matter where along the track they were emitted.

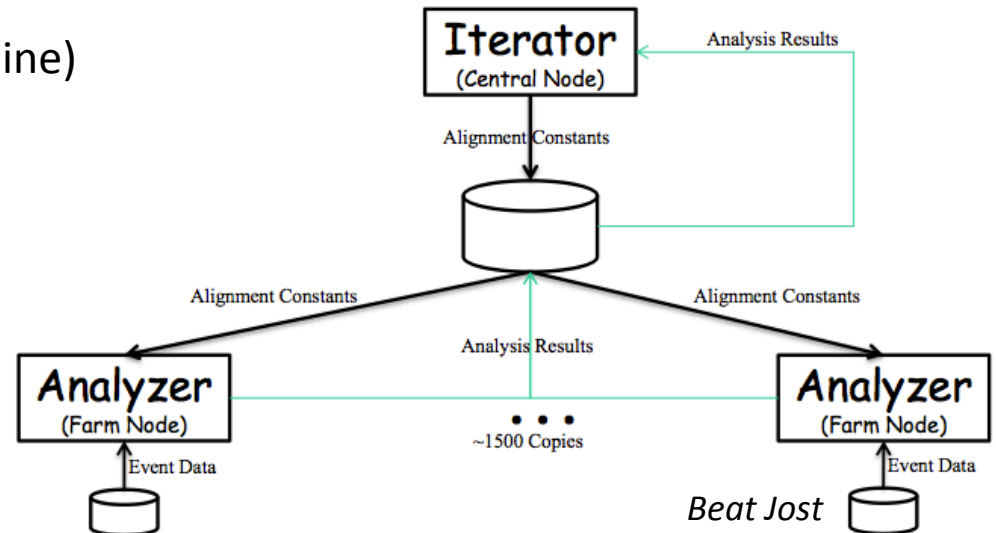
Use of online framework

Previously alignment done offline:

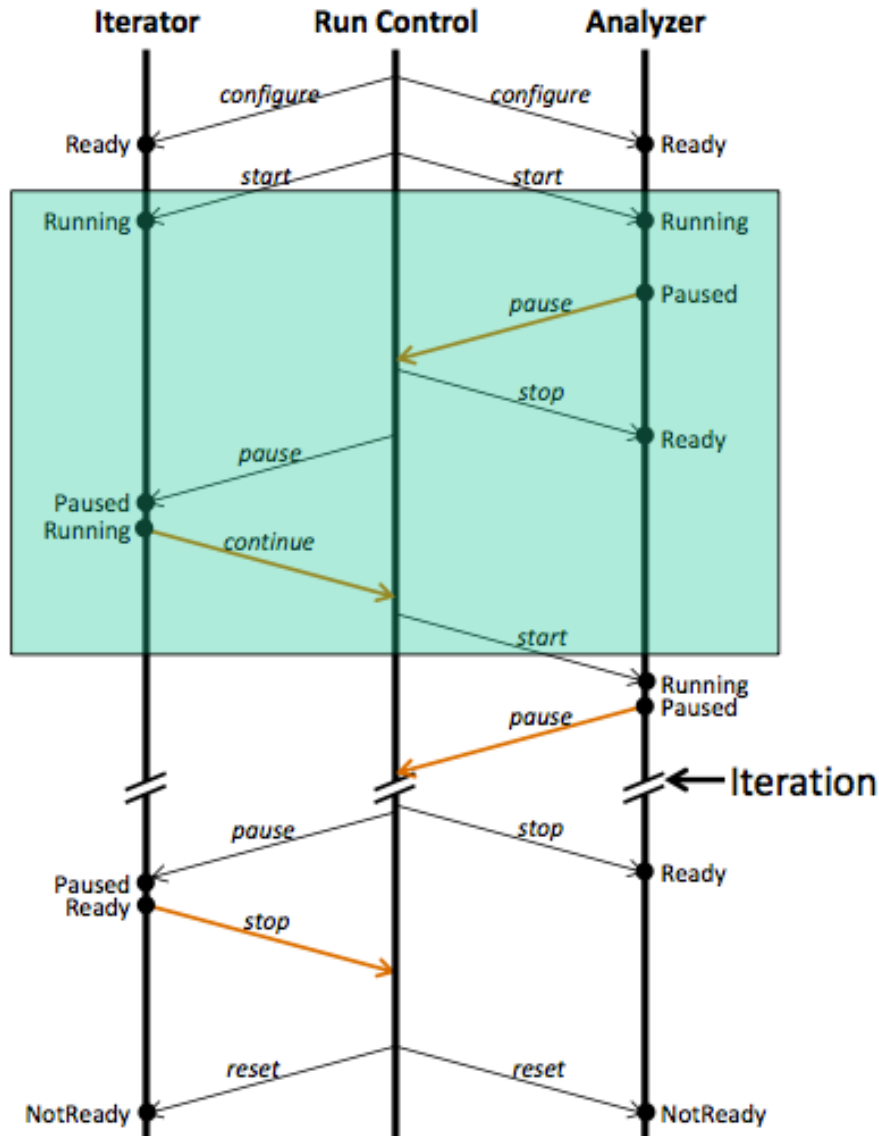
- python driver script executed in ganga
- ganga starts Brunel jobs + waits for them to finish

New alignment on the HLT farm:

- Uses the online FSM (Finite State Machine)
- Driver script: python Iterator
- Brunel jobs: python Analyzer
- Analyzers run on each node of the HLT farm (~1500)



Use of online framework



1. Run control gives command to *configure*
2. When all analyzers and the iterator are configured run control gives command to *start*
3. Analyzers execute Brunel jobs
4. When all analyzers are finished they go to *ready* and write the rootfiles
5. The iterators goes to *paused* and sets everything up for the next iteration
6. The Iterator goes to *running* which makes the Analyzers *run* again (this time with a different mirror-xml file as input)
7. After 9 of these iteration the iterator calculates the magnification coefficients, fits the mirror tilts, calculates the new mirror constants and determines if the alignment has converged
8. If no: set up next iteration with new xml file and start at 3.

New HLT Lines

- Triggers on tracks that will populate the hardest-to-populate mirror-pairs
- ➔ usually the very outer mirrors
- Other tracks in the events will populate the rest

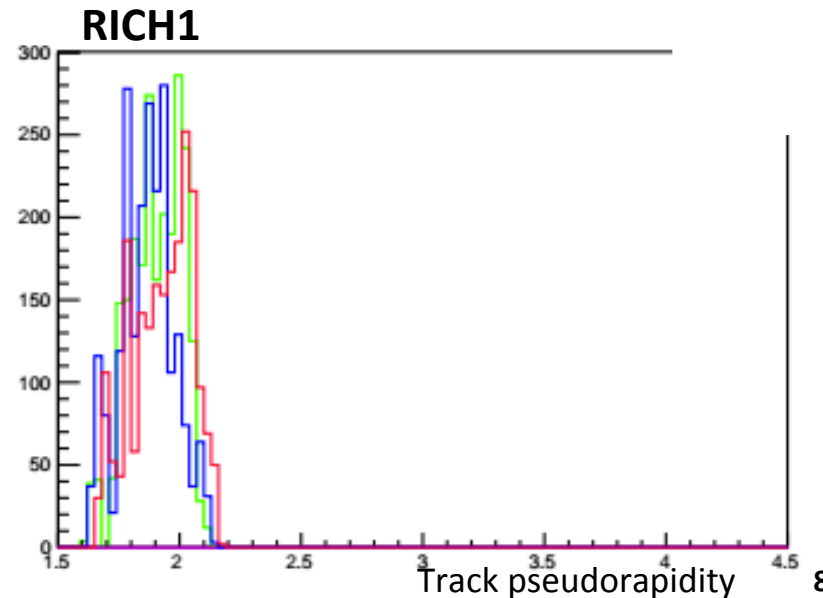
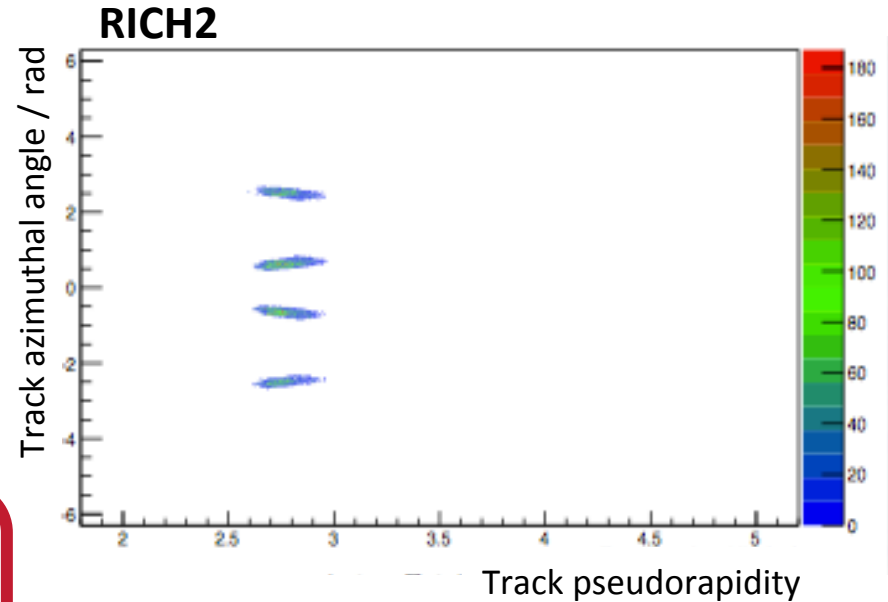
RICH2 line:

$p > 40 \text{ GeV}$ && $\chi^2 < 2$ && $2.59 < \eta < 2.97$
 $(-2.69 < \Phi < -2.29)$ || $(-0.85 < \Phi < -0.45)$ ||
 $(0.45 < \Phi < 0.85)$ || $(2.29 < \Phi < 2.69)$

RICH1 line:

$p > 10 \text{ GeV}$ && $\chi^2 < 2$ && $1.6 < \eta < 2.04$
 $(-2.65 < \Phi < -2.3)$ || $(-0.8 < \Phi < -0.5)$ ||
 $(0.5 < \Phi < 0.8)$ || $(2.3 < \Phi < 2.65)$

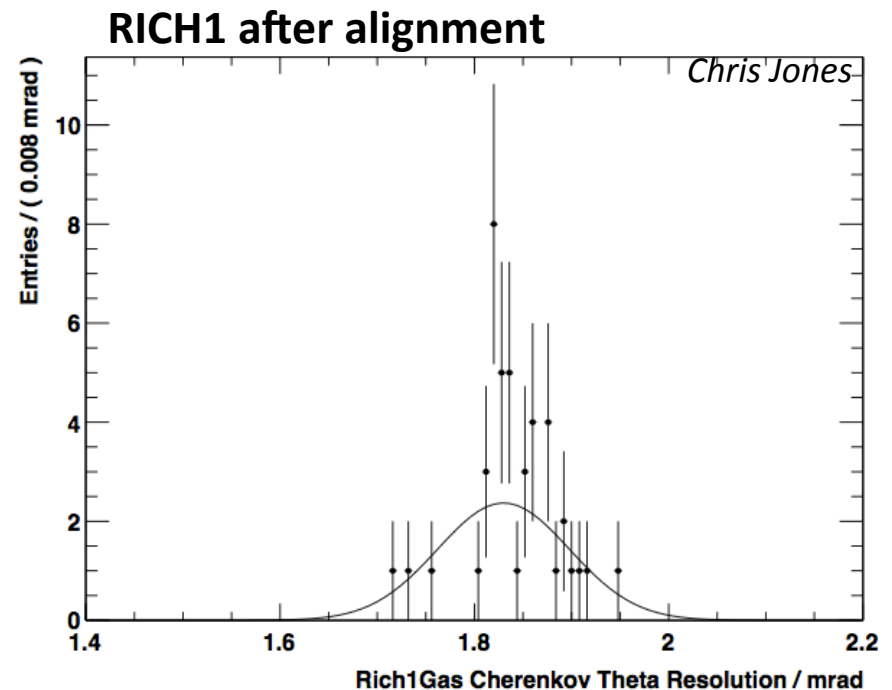
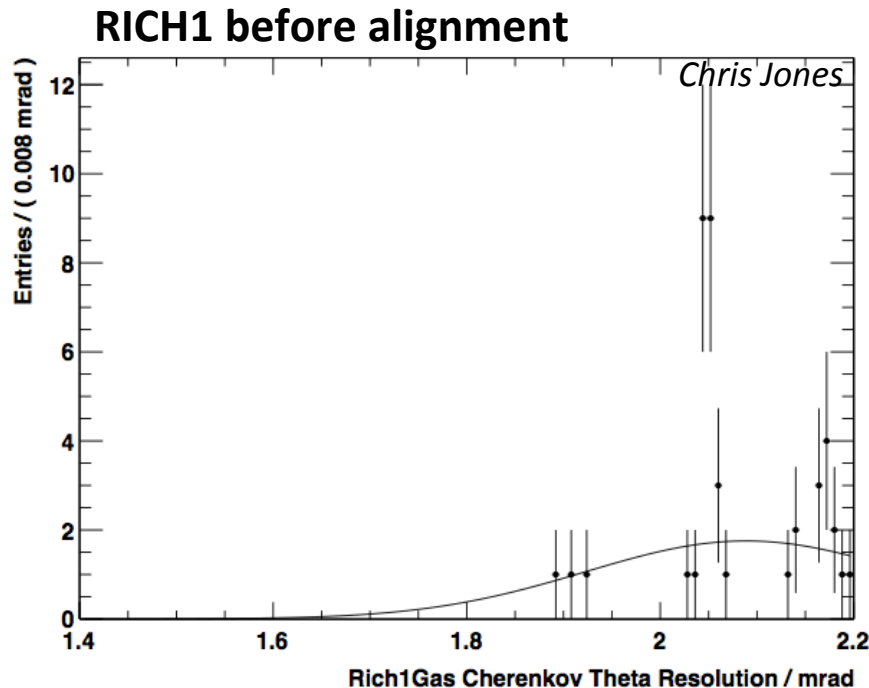
Need to reconstruct ~10 times less events!



Current Status

Currently used alignment:

- Made offline on data taken on 12 – 14/06 (second weekend of data taking)
- Data from 'old' HLT1 line (suboptimal for RICH1)
- RICH1: 2.1mrad to 1.85mrad
- RICH2: 0.73mrad to 0.72mrad



Current Status

Online alignment functioning (with some hand-holding)

~ 8 times faster than offline alignment

New alignment for RICH1

- On the 50ns data
- With new HLT lines in place
- More than enough entries in all histograms!!!

Here plots are missing will be put in soon

Summary

- Online alignment running
- Decent alignment being used already (res. of 1.85/0.72 mrad for RICH1/RICH2)
- Better alignments on the way
- Without Roel we would all be lost

To do:

- Implement monitoring
- Stabilize the fitting of the histograms
- Run online alignment fully automatically
- Magnet polarity test

Backup

Cherenkov angle resolution

Limiting factors to Cherenkov angle resolution:

	σ [mrad]		
	RICH1		RICH2
	Aerogel	C ₄ F ₁₀	CF ₄
Emission point	0.4	0.8	0.2
Chromatic dispersion	2.1	0.9	0.5
Pixel size	0.5	0.6	0.2
Tracking	0.4	0.4	0.4
Total	2.6	1.5	0.7

Magnification coefficients

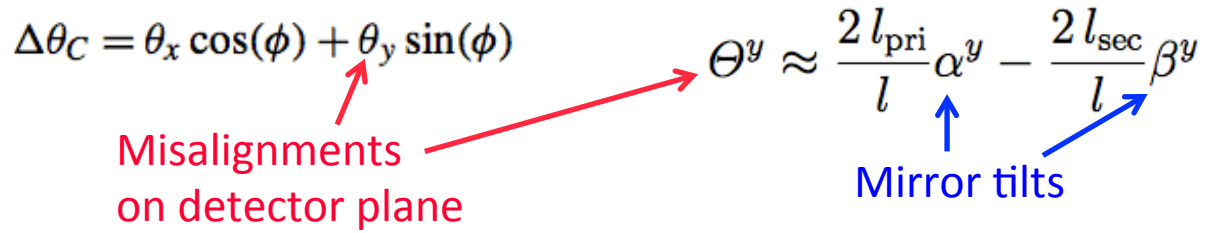
Magnification coefficients: Translate the tilt on the detector plane into actual mirror tilts

$$\Delta\theta_C = \theta_x \cos(\phi) + \theta_y \sin(\phi)$$

Misalignments
on detector plane

$$\Theta^y \approx \frac{2l_{\text{pri}}}{l} \alpha^y - \frac{2l_{\text{sec}}}{l} \beta^y$$

Mirror tilts



Magnification coefficients are calculated new for each iteration:

- Introduce 8 rotations: primary and secondary mirrors rotated around $\pm y$ and $\pm z$ axis respectively
- Rotate about 0.3 mrad (half the resolution of RICH2)
- Reconstruct events for each rotation and evaluate the tilts on the detector plane

Need to reconstruct all events 9 times!

$$\Theta^y \approx 2.0 \alpha^y - 0.9 \beta^y \quad \text{and} \quad \Theta^z \approx 1.8 \alpha^z + 0.6 \beta^z.$$