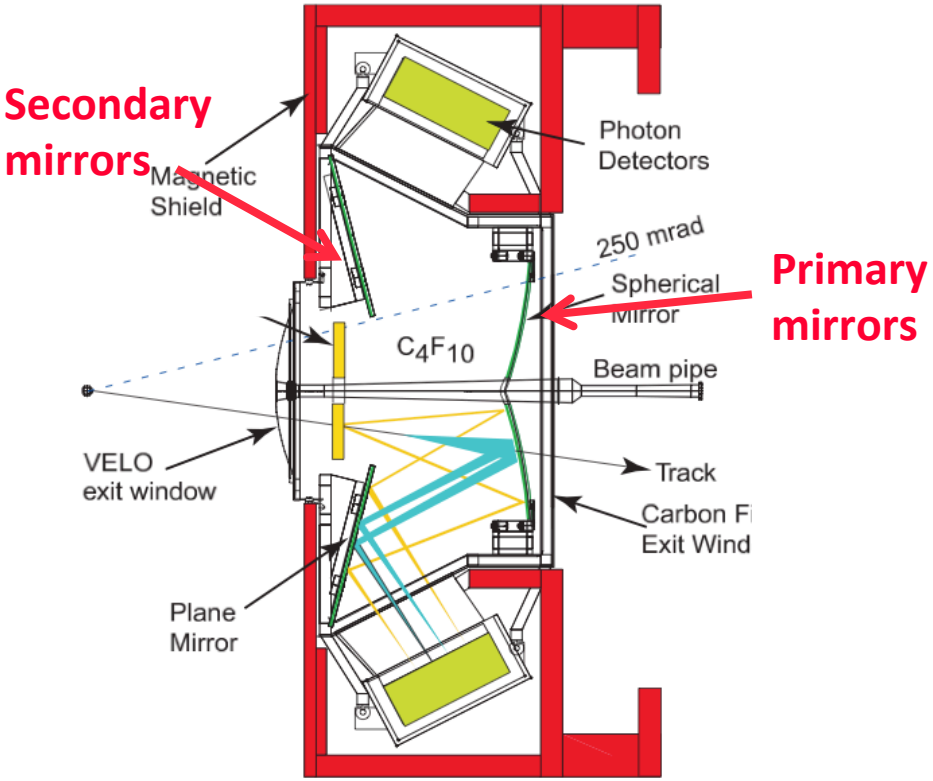
Rich Mirror Alignment

13/07/2015 Claire Prouve

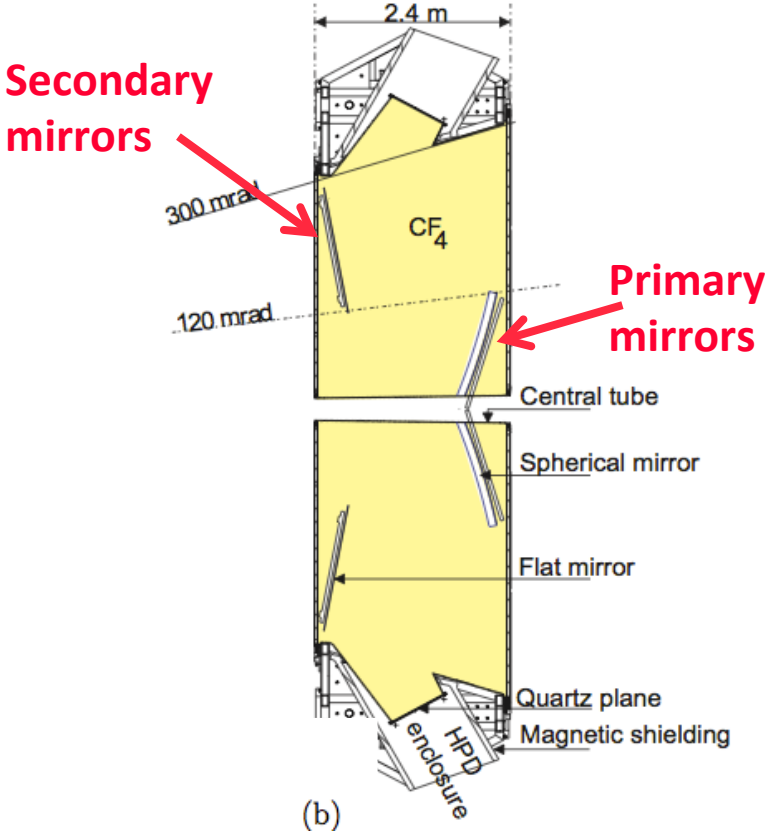
- How does it even work?
- Implementation in the online framework
- Current status

RICH Mirror Alignment

RICH 1: 4 primary mirrors
16 secondary mirrors



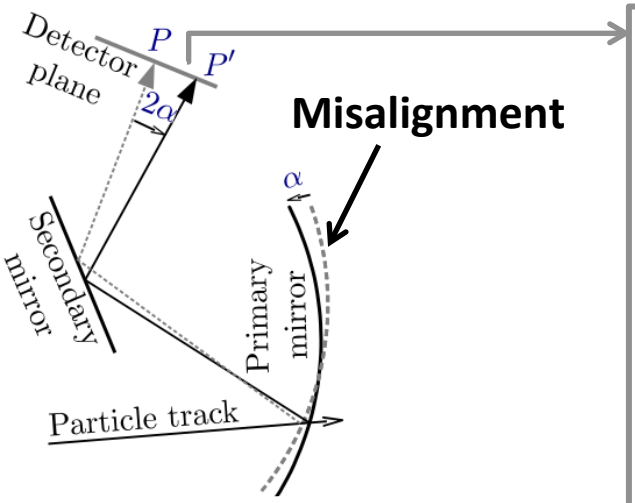
RICH 2: 54 primary mirrors
40 secondary mirrors

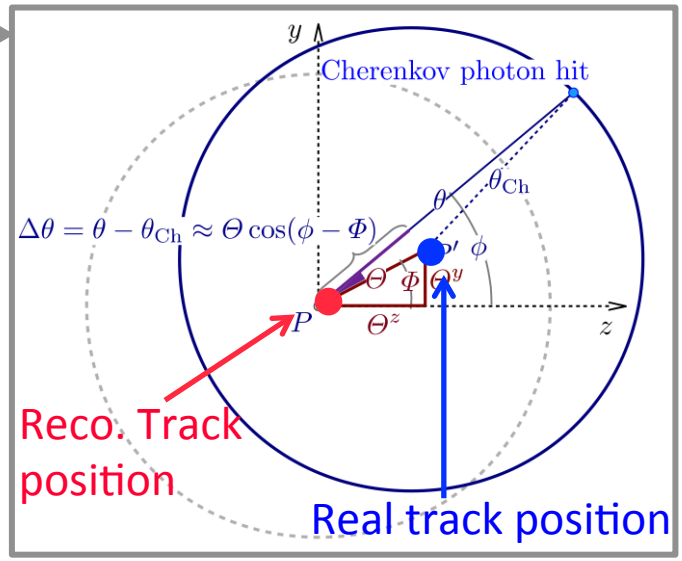


Misaligned mirrors will affect the PID due to incorrectly predicted Cherenkov angle!

Best possible resolution ~1.5mrad for RICH1, ~0.7mrad for RICH2.

Misalignment



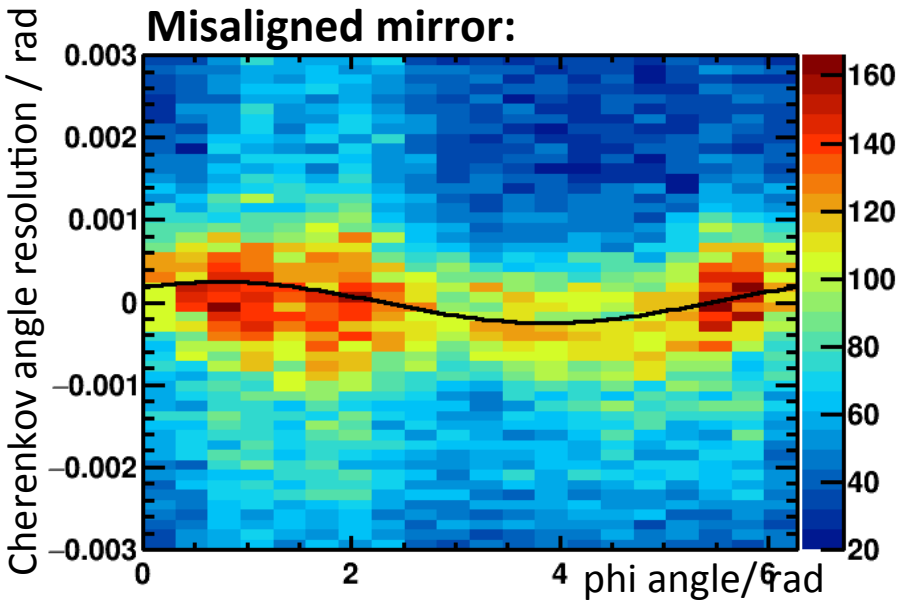


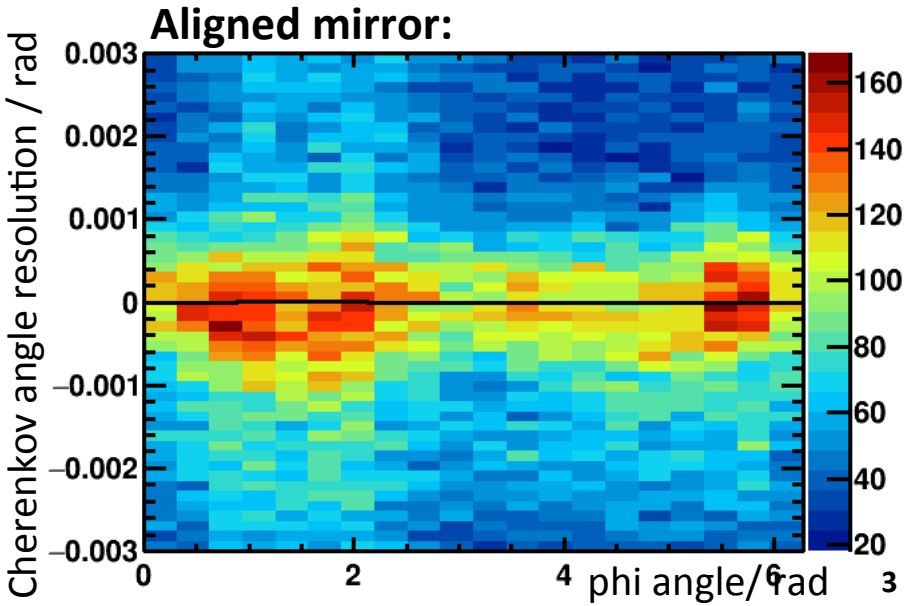
Identify misalignment:

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

Misalignments on detector plane

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

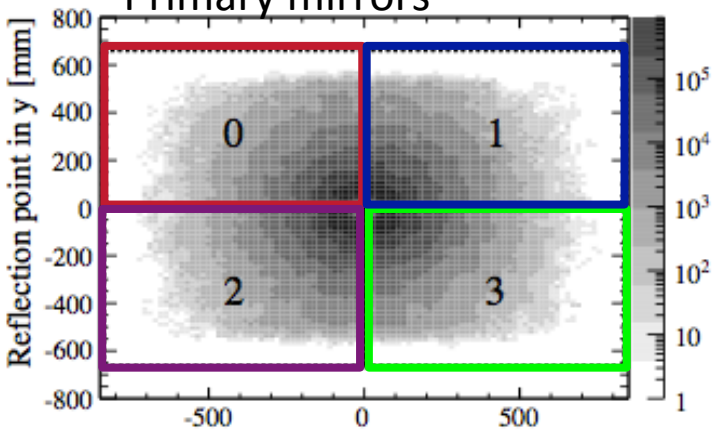




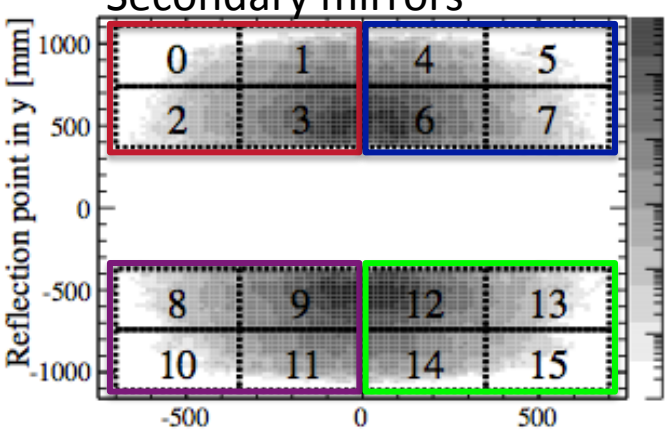
Aligning mirrors to each other

RICH1: easy!
-> fix primary mirrors only align secondary mirrors

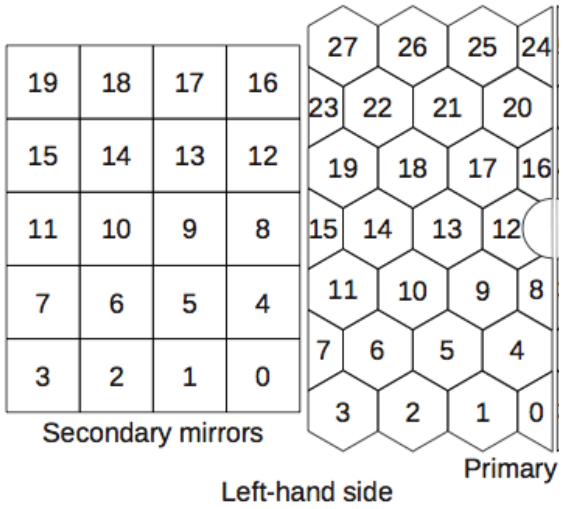
Primary mirrors



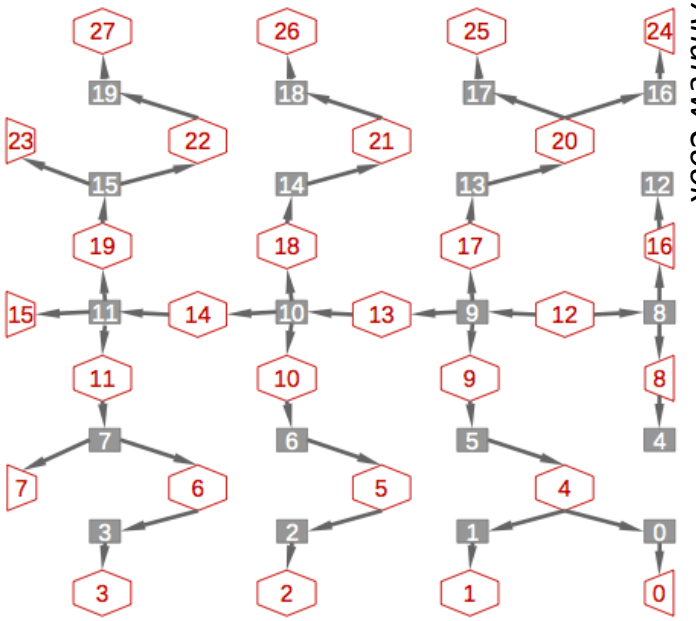
Secondary mirrors



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



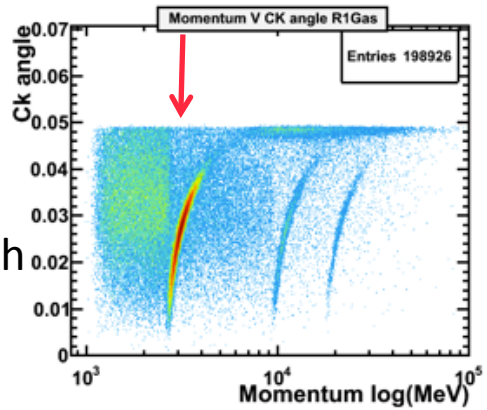
System of equations linking all primary mirrors (red) and secondary mirrors(grey).

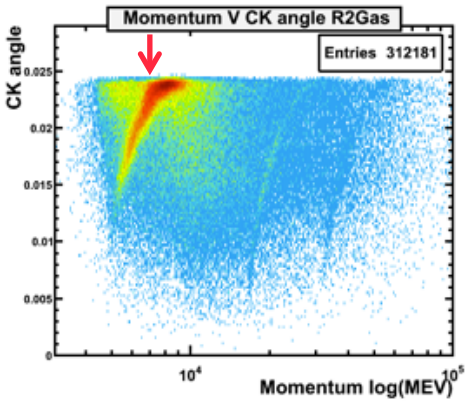


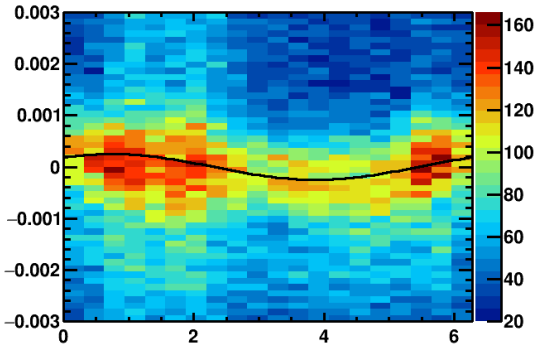
Andrew Cook

Alignment procedure

1. Select high momentum-tracks with **pion hypothesis** (p > 20GeV for RICH1, p > 40GeV for RICH2)
2. Reconstruct **unambiguous photons** for each *necessary* mirror pair
3. Fit **Δθ(Φ)** 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.

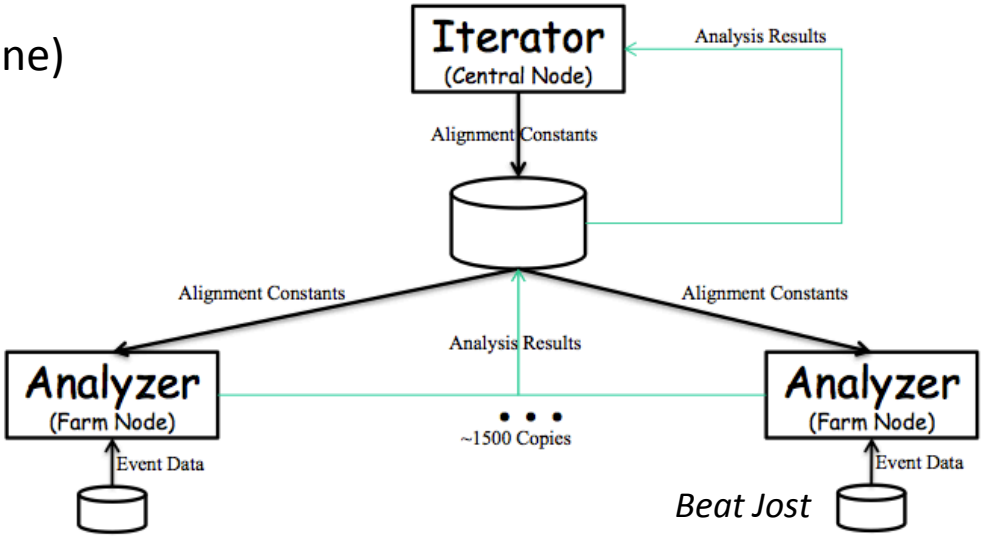
Use of online framework

Previously alignment done offline:

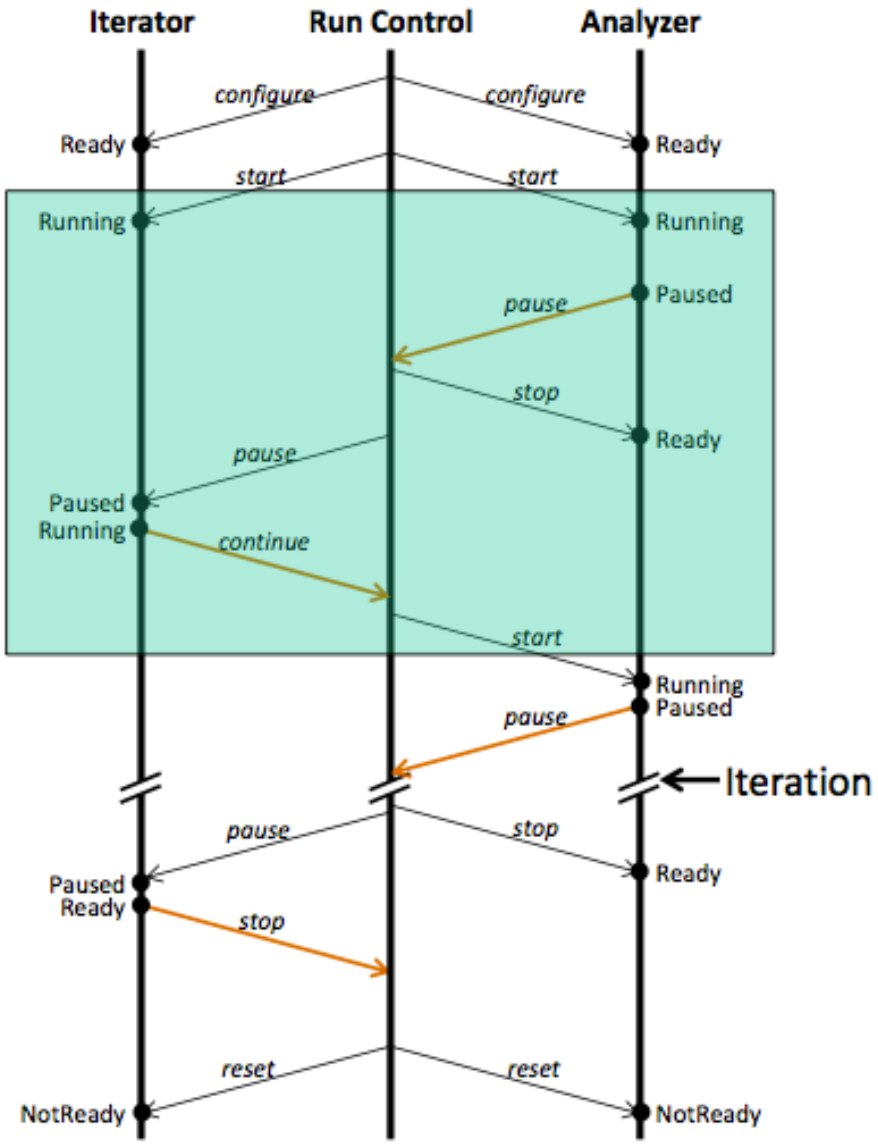
- python driver script executed in ganga
- ganga starts Brunel jobs + waits for them to finish

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

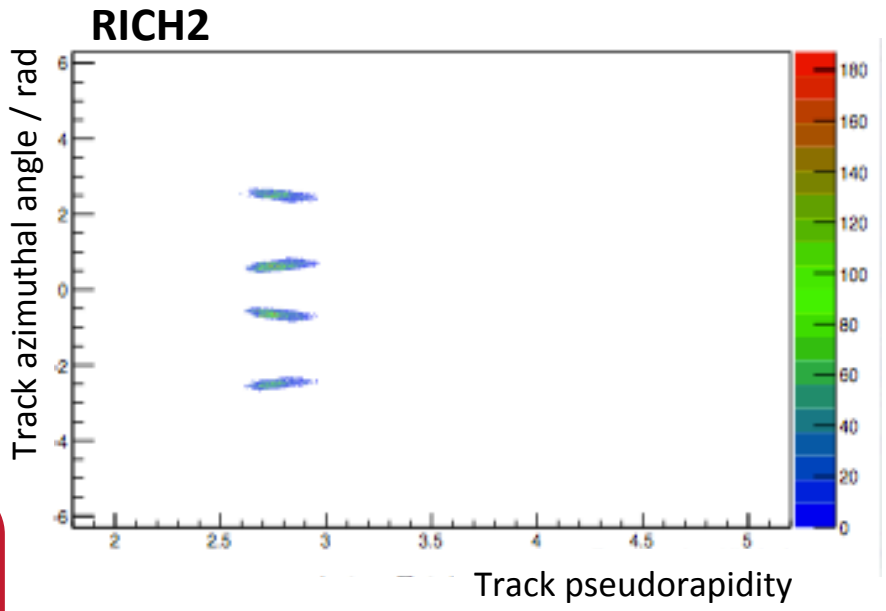
➔ usually the very outer mirrors

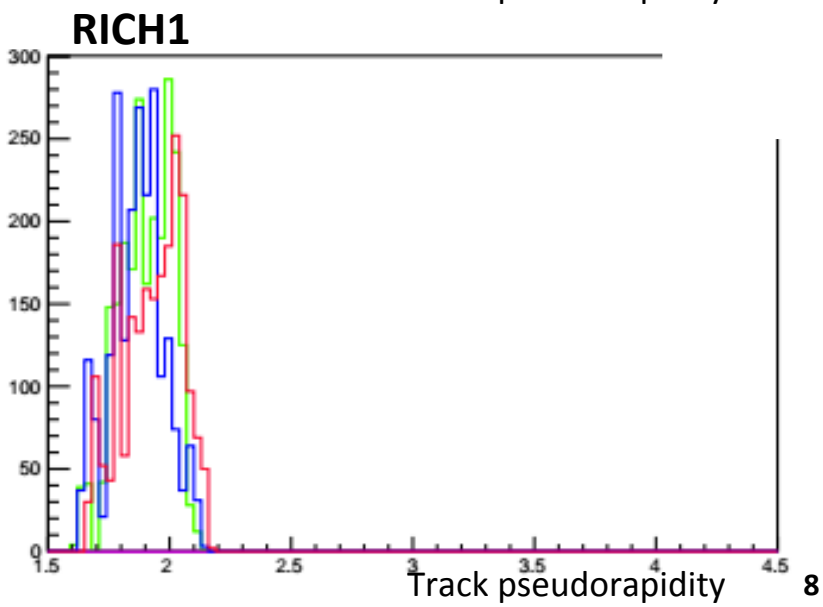
- Other tracks in the events will populate the rest

RICH2 line:
p > 40 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 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!



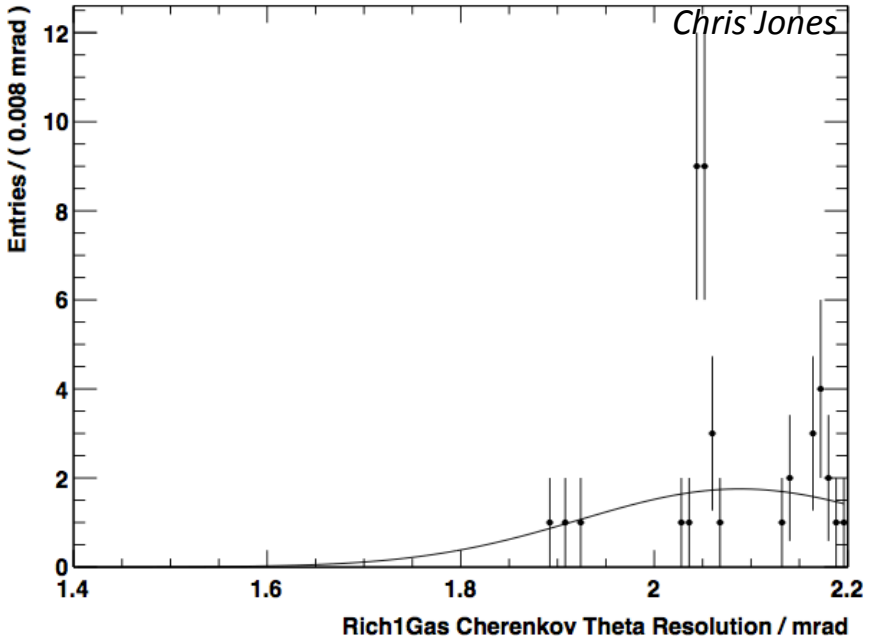


Current Status

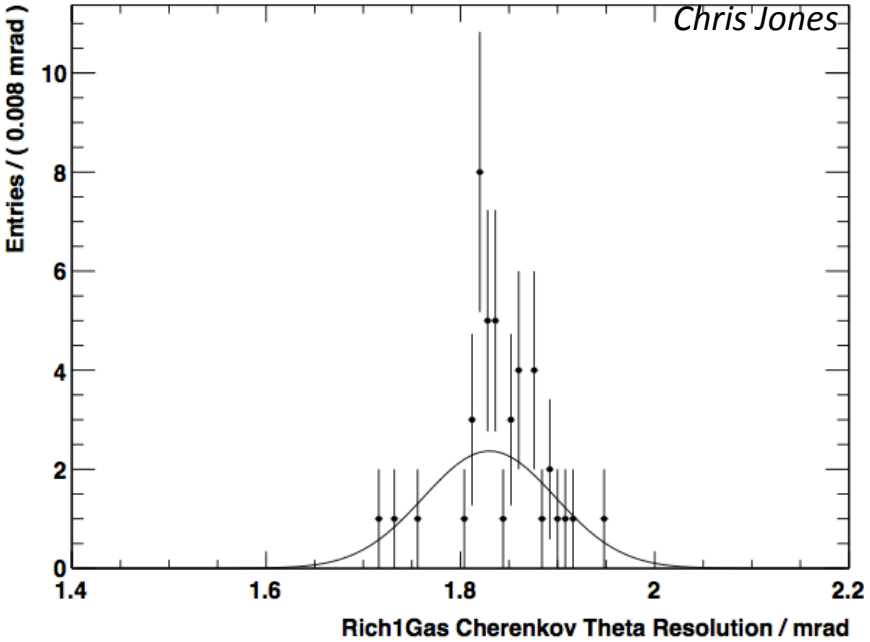
Currently used alignment:

- 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

RICH1 before alignment



RICH1 after alignment



Current Status

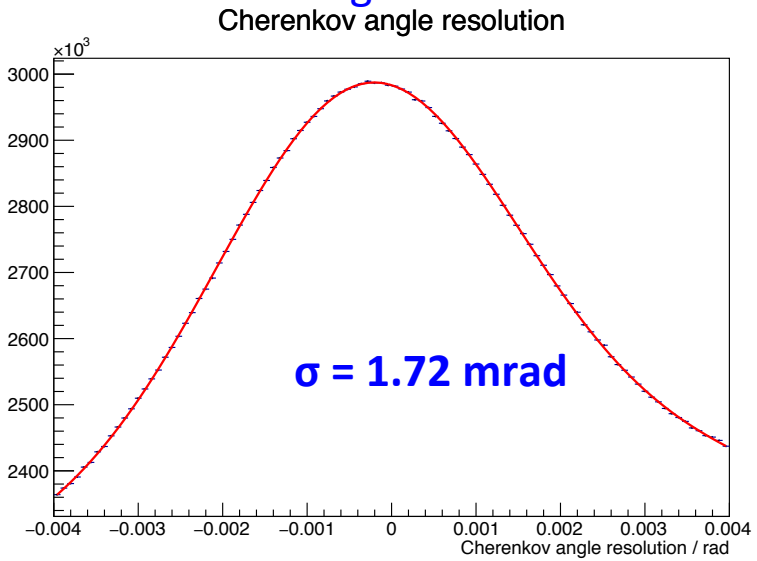
Online alignment functioning (with some hand-holding)

~ 8 times faster than offline alignment

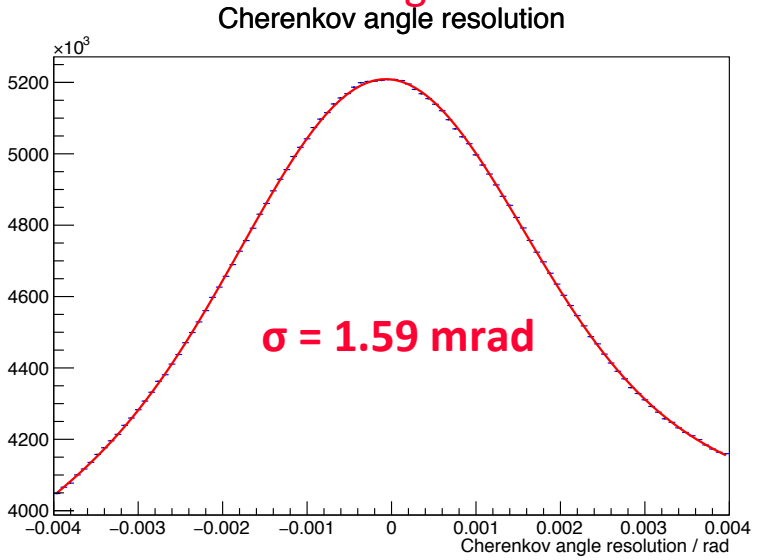
New alignment for RICH1

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

Before new online alignment:



After new online alignment:



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

<u>To do:</u>

- 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_4F_{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

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

Mirror tilts

Magnification coefficients are calculated new for each iteration:

- Introduce 8 rotations: primary and secondary mirrors rotated around ±y and ±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!

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