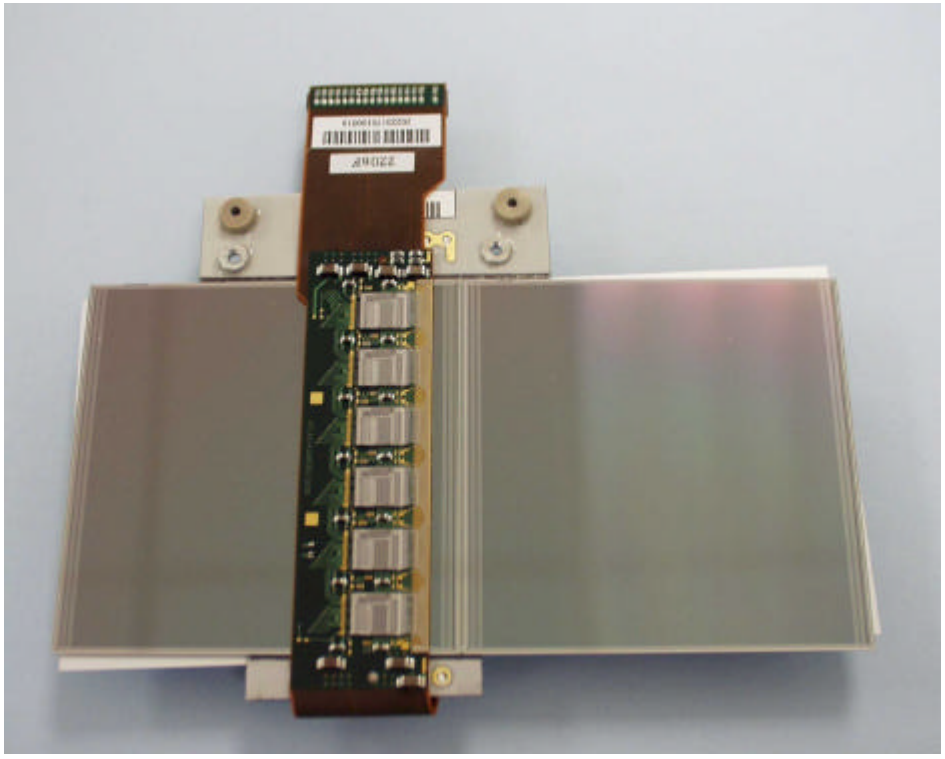
Alignment of the ATLAS Inner Detector Using Tracks

- ATLAS Inner Detector
- Alignment
- Track alignment
- Results

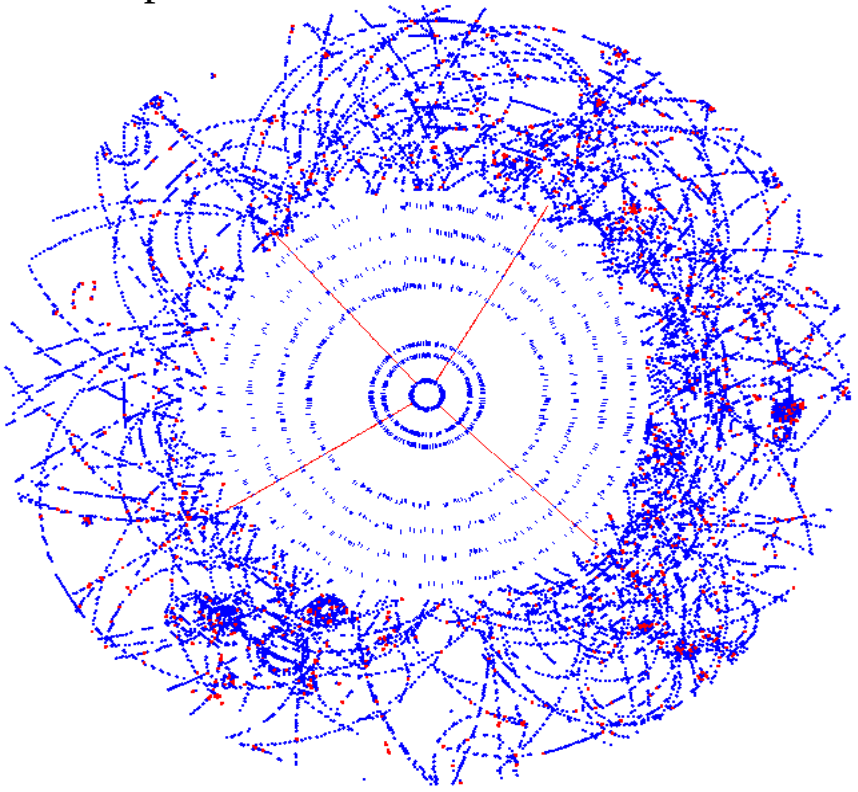
Inner Detector - Silicon



4088 modules

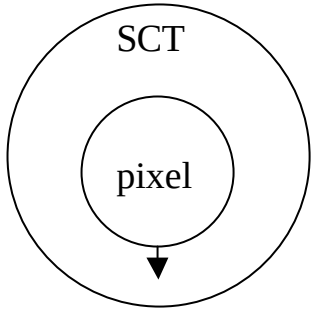
2112 barrel modules

~200 UK produced modules received in Oxford



Focus on aligning the 7 barrels of silicon detectors

Alignment

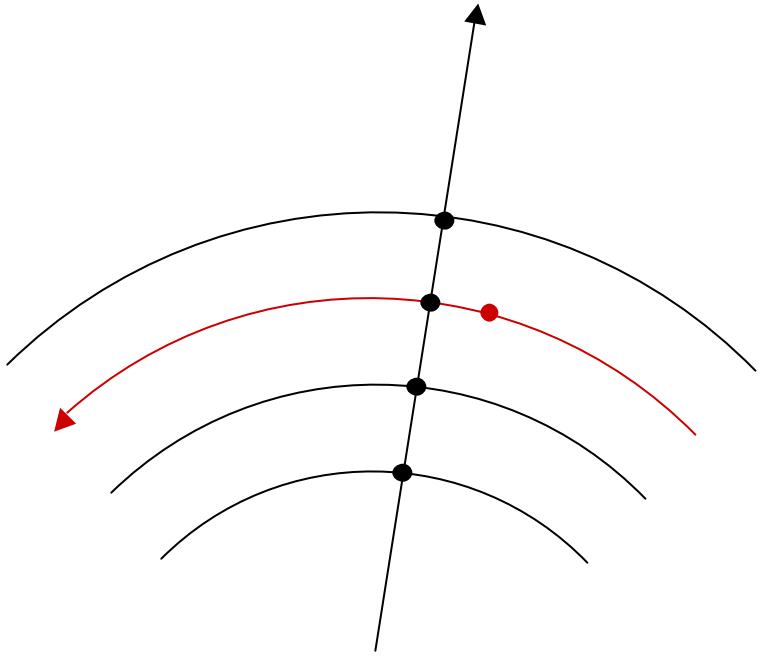


Barrels not concentric

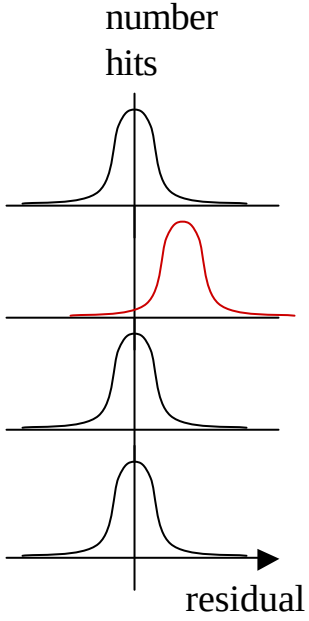
~2 mm

- Sources of misalignment
  - Installation =>
  - Magnetic field turn on
    - ID mounted on the cryostat containing the solenoid/EM cal
- Effect
  - Resolution of track parameters degraded
    - Impact parameter – B Physics
  - Systematic errors introduced
- Targets
  - RPhi alignment to ~10 microns
  - Measure W Mass => Higgs mass prediction (1 micron)

Alignment using Tracks



Use high p_T muons



23 μm for SCT

$$s_{mean} = \frac{s}{\sqrt{n}}$$

Two residuals for each hit (rphi,z)

Access rphi/z misalignments directly

Other degrees of freedom more complex

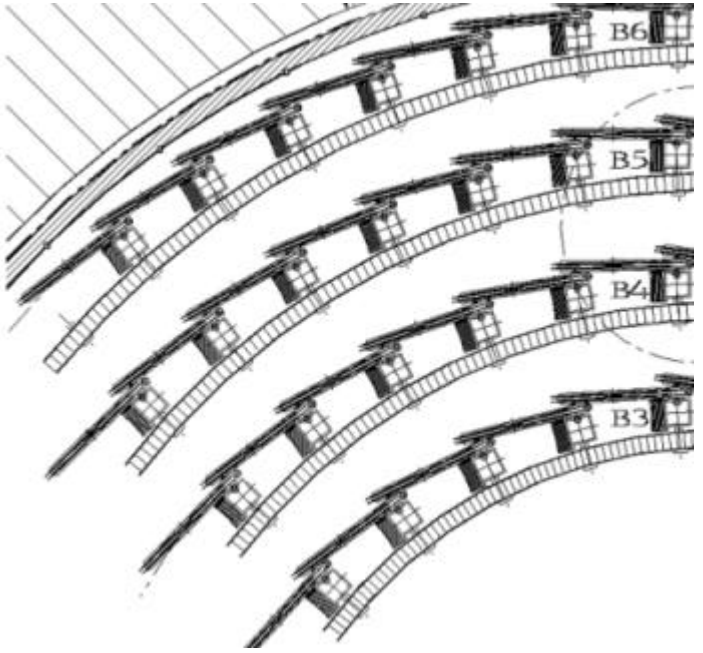
Not doing chisquared fit

Alignment strategy

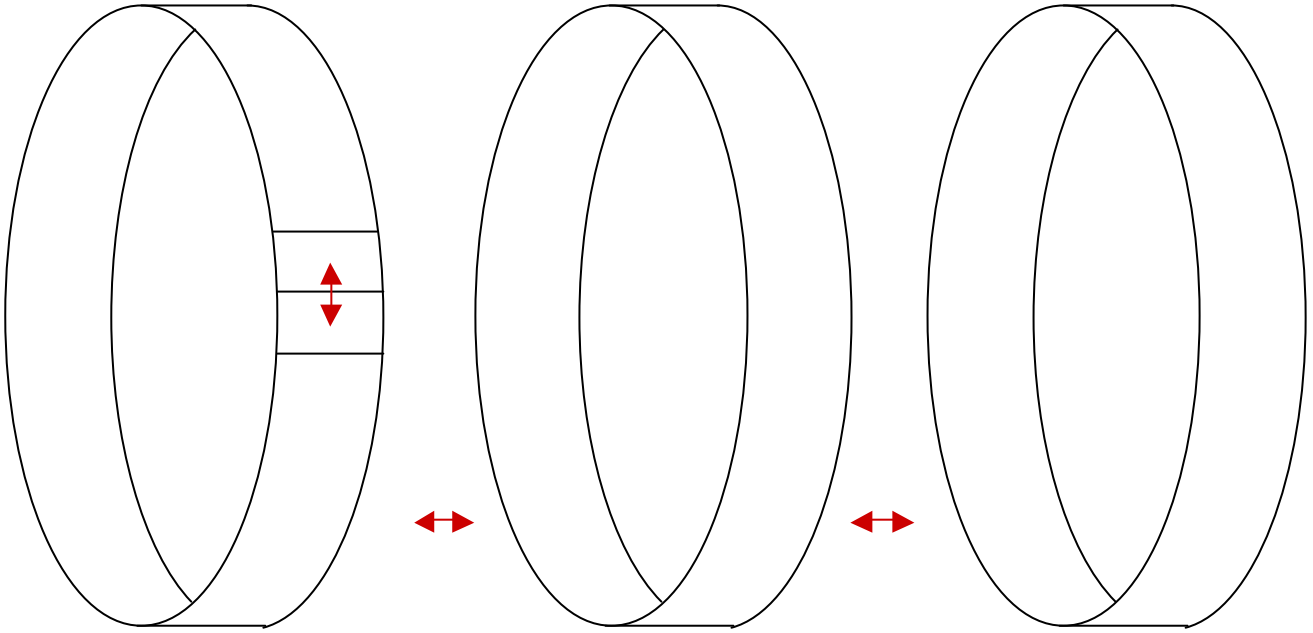
In stages

– Align barrels internally (rphi/z)
  - exploit module overlaps
  - relative positions
  - ~independent of full barrel movements

– Align complete barrels
  - all 6 degrees of freedom
  - some sources of misalignment affect complete barrels

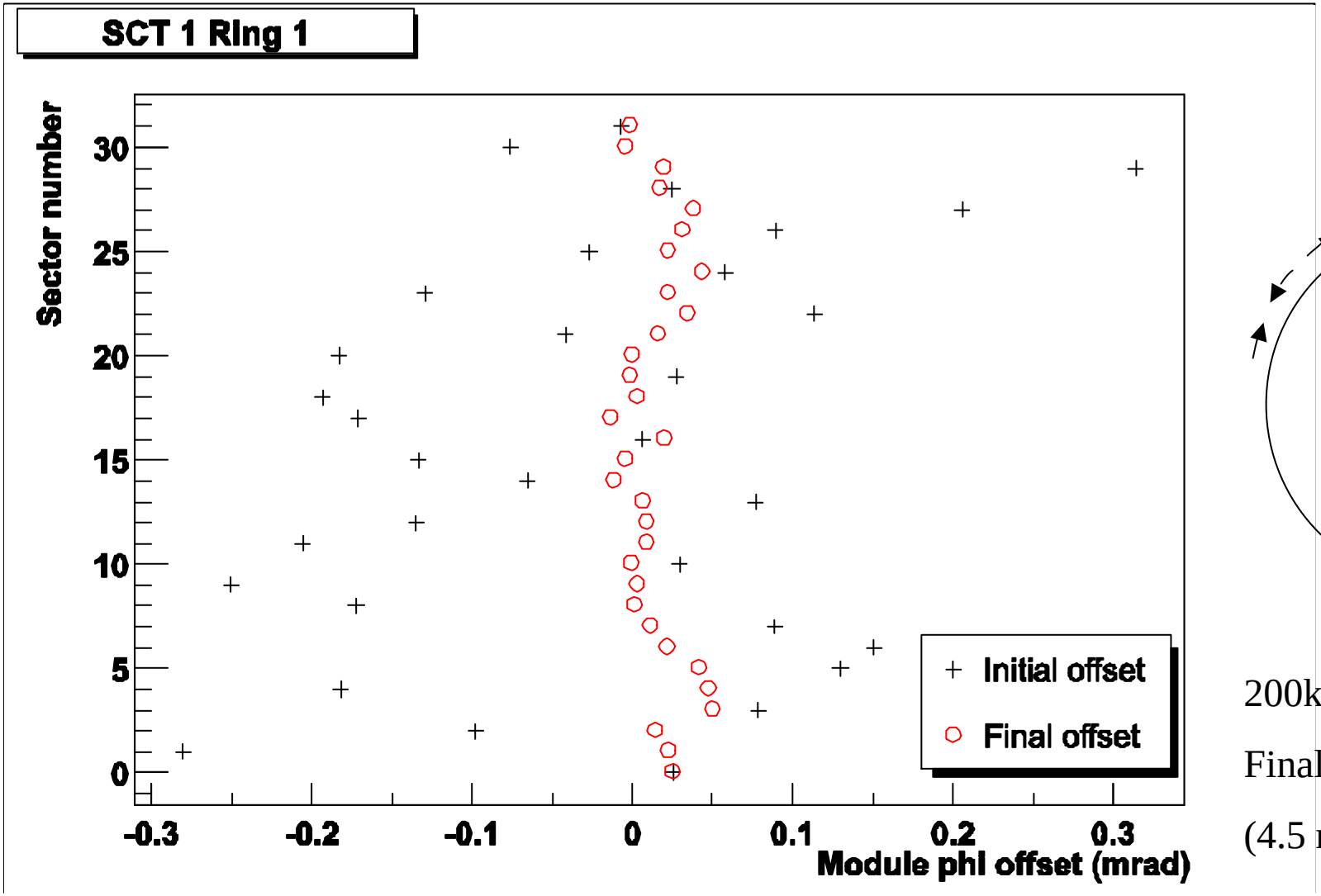


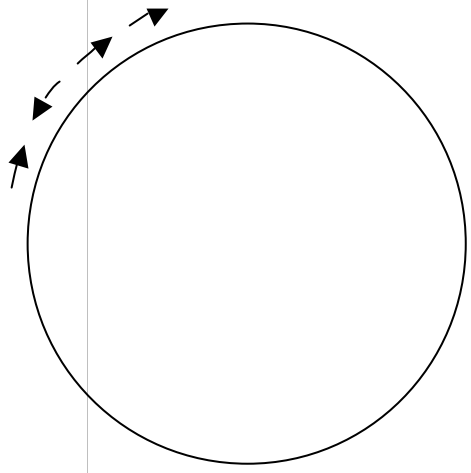
Internal barrel alignment



1) Align rings internally – relative positions should add to zero
2) Align entire rings relative to each other

Internal barrel alignment - rings



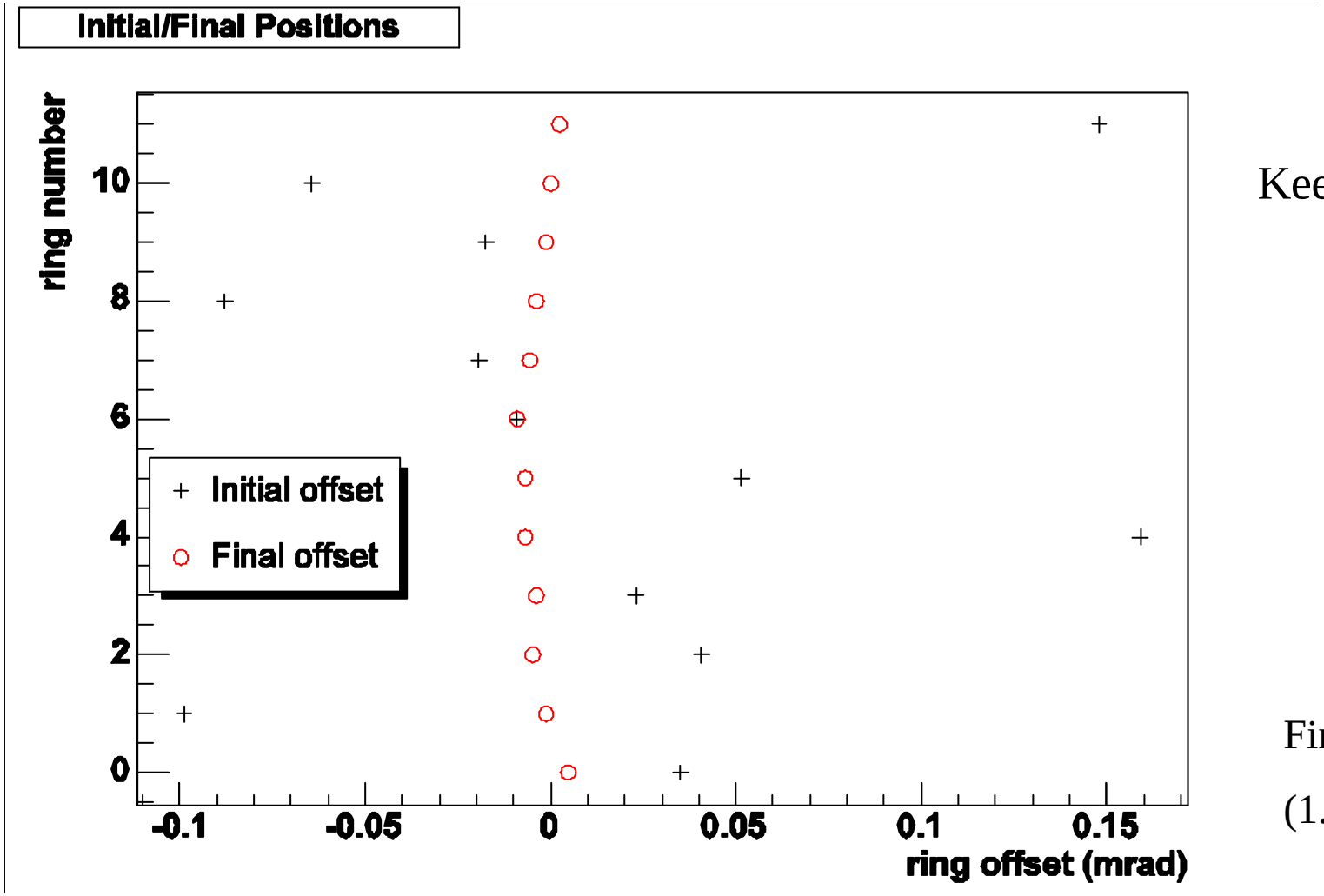


200k 6 GeV muons

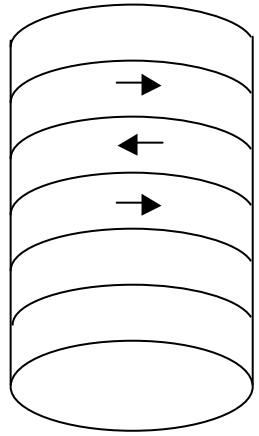
Final RMS=0.015 mrad

(4.5 microns)

Internal barrel alignment – ring to ring



Keep middle ring fixed



Final RMS=0.004 mrad

(1.5 microns)

Internal Barrel Alignment Results

	RPhi RMS (microns)		Z RMS (microns)	
Barrel	**before**	**after**	**before**	**after**
Pixel B	8.5	1.35	100.5	22.7
1	22.9	3.93	98.5	35.9
2	19.0	4.05	100.4	32.1
SCT 1	34.5	7.71	0	0
2	45.1	8.24	0	0
3	57.0	8.94	0	0
4	61.9	13.31	0	0

5 million 6 GeV muon tracks

(50 Hz => 28 hours)

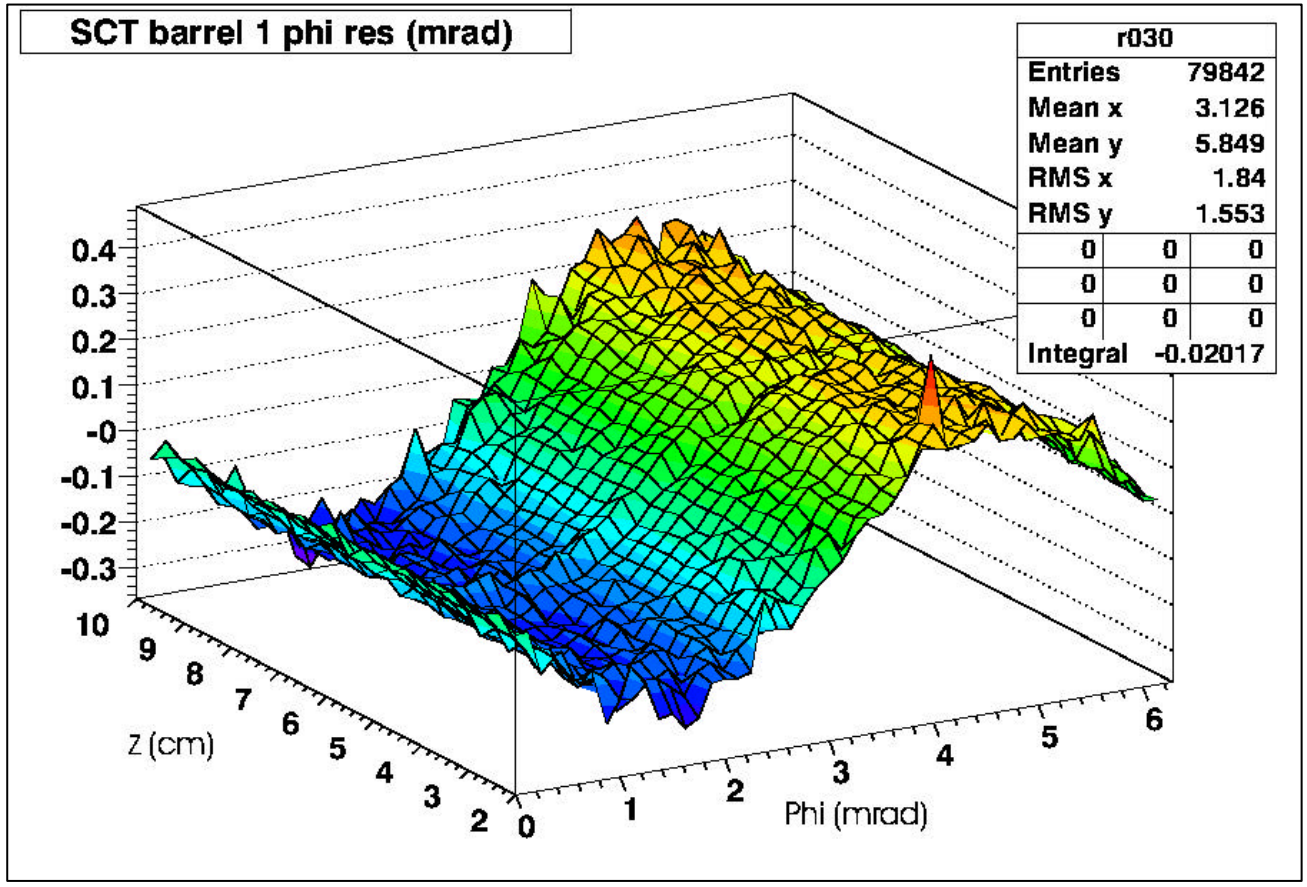
Not enough tracks for SCT z misalignments

Barrel to Barrel Alignment

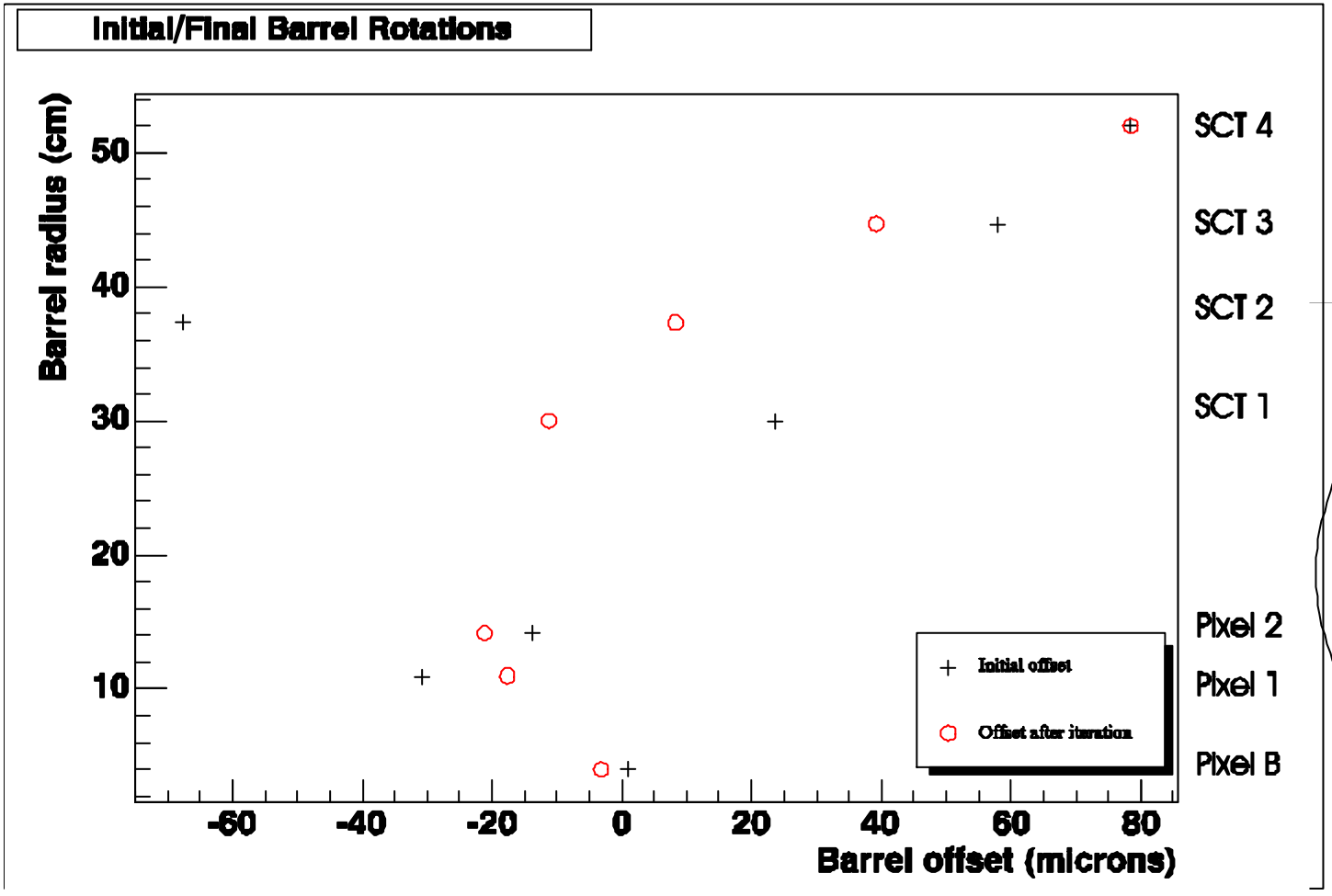
- Plot phi residual and z residual surfaces

Eg X Translation gives sine wave on phi residual surface

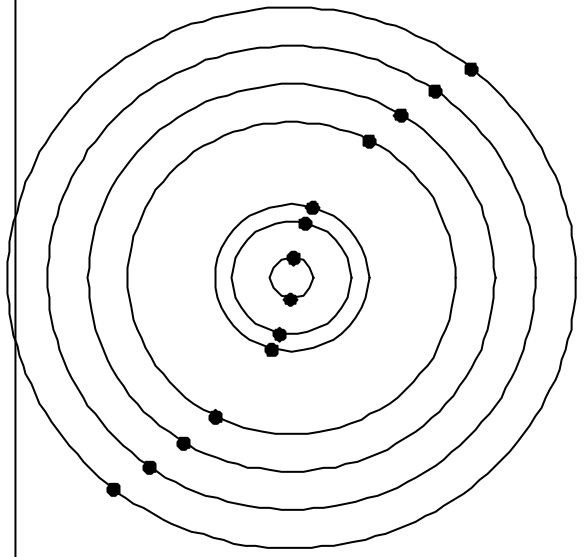
Fit 5 parameter function to phi surface for each barrel



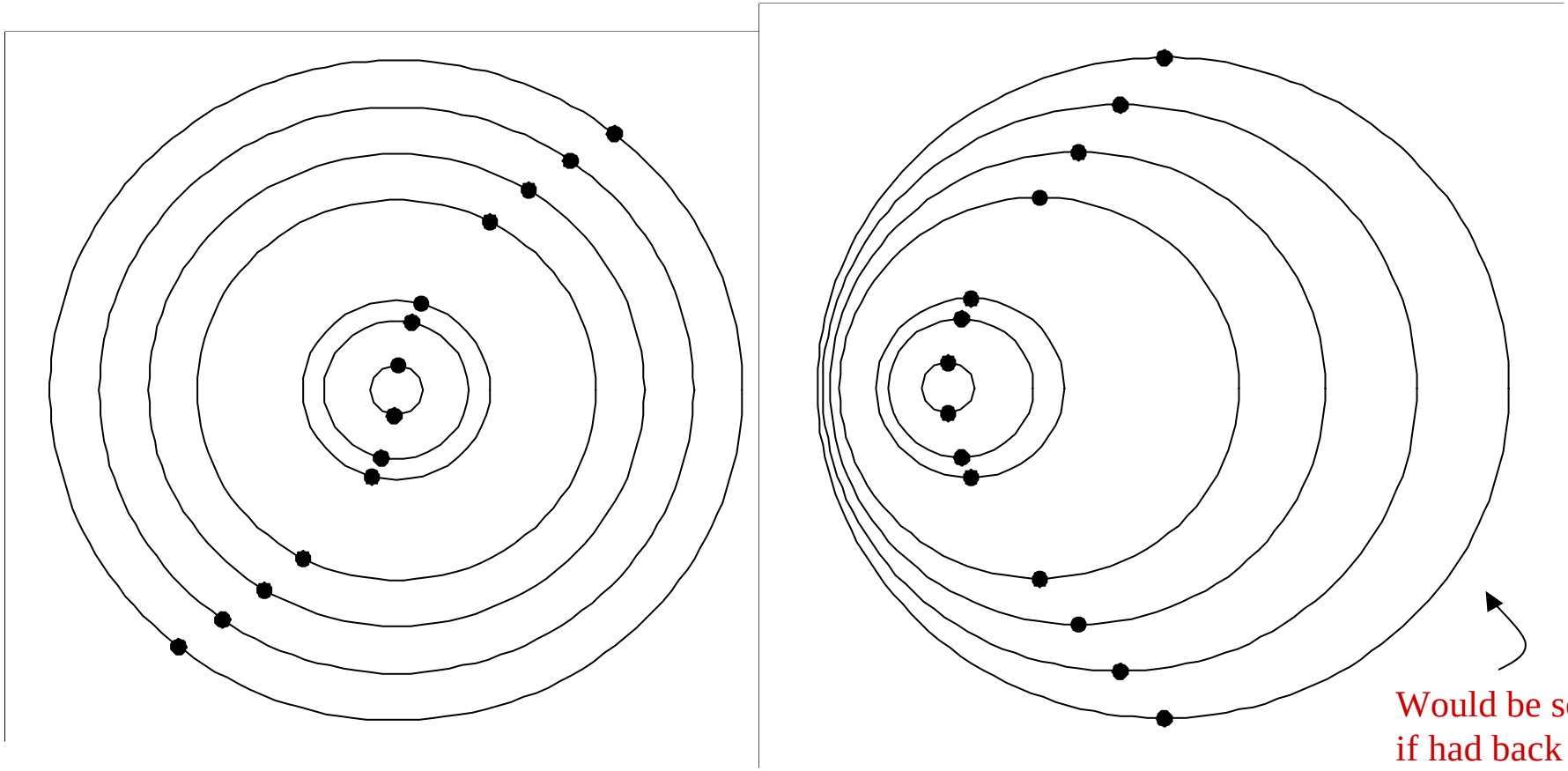
Alignment of complete barrels



Random initial rotations



Sagitta distortions



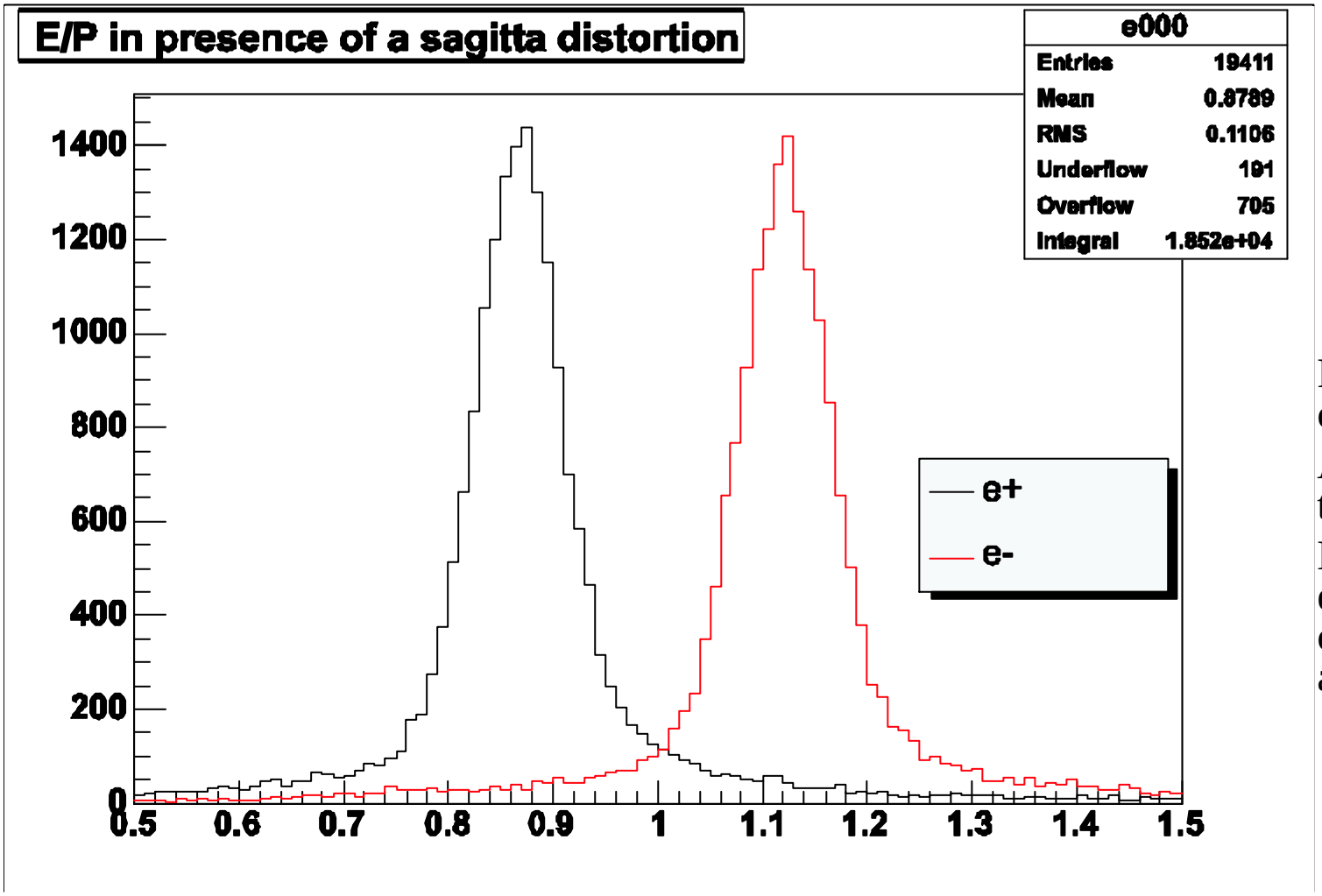
Would be seen if had back to back tracks

In high energy limit tracks are parabolic/straight lines in XY/XZ planes

This gives 15 degenerate modes

FSI?

Removing ‘sagitta’ distortions



Plot E/p (E from calorimeter) for e+/e-

Adjust detector until the two are the same

Natural ~100 MeV e+/e- asymmetry in calorimeter (due to accordian structure?)

Conclusions

- Demonstrated building blocks needed to construct track alignment system
  - most important degrees of freedom
- Further work
  - needs extending to the forward regions
  - degenerate modes