LHCb RICH Alignment

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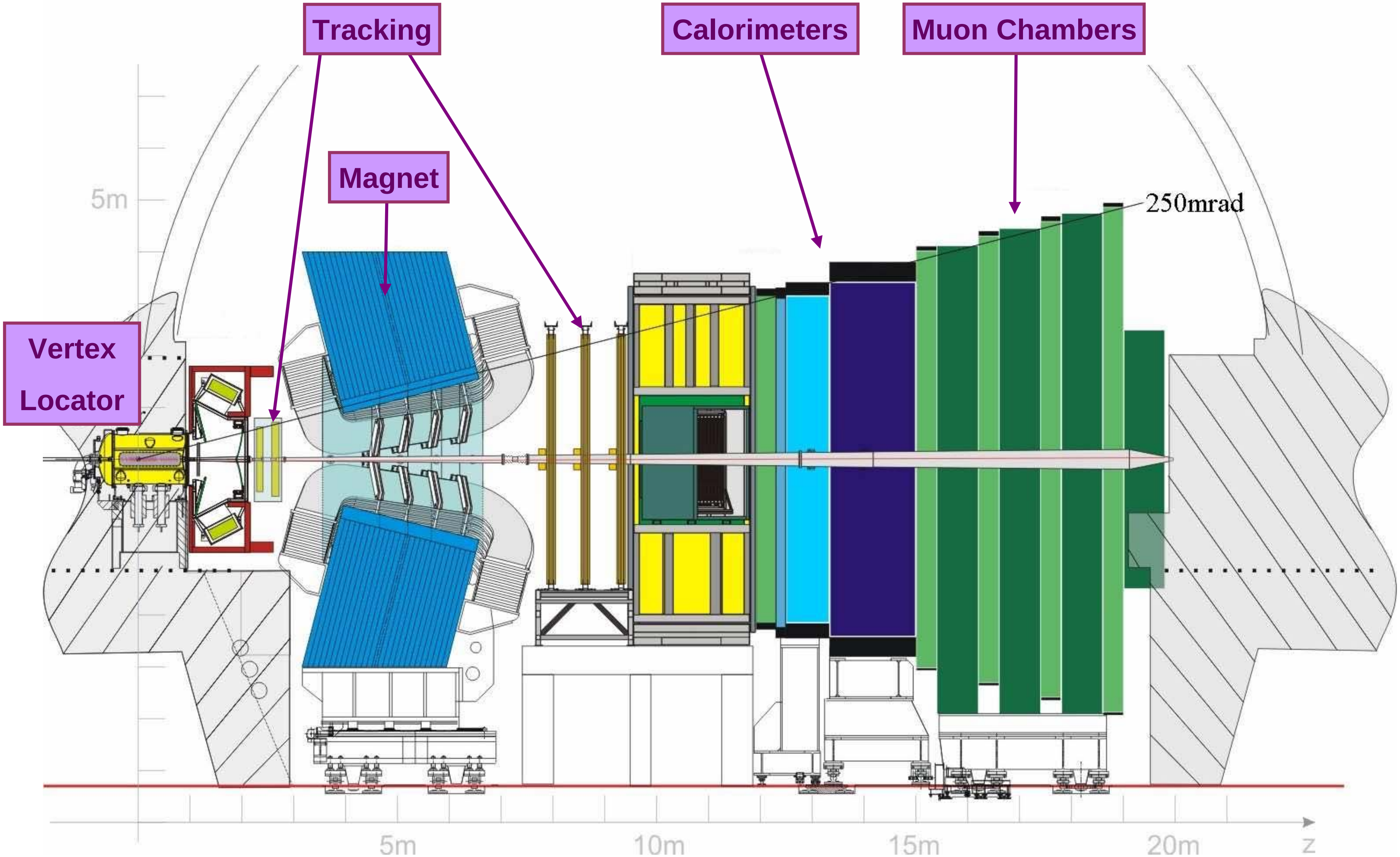
Overview

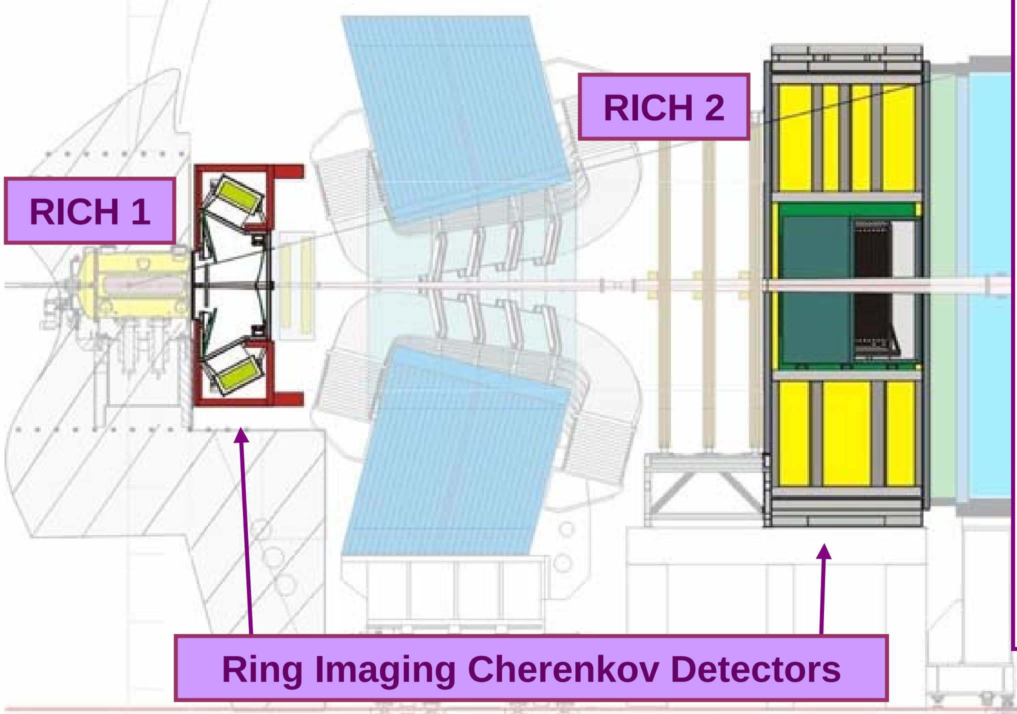
- Introduction to LHCb and the RICH detectors
- Effects of detector misalignment on data
- Determining and compensating for misalignments
- Validating techniques using 2006 Testbeam data
- RICH Alignment Strategy and preliminary results

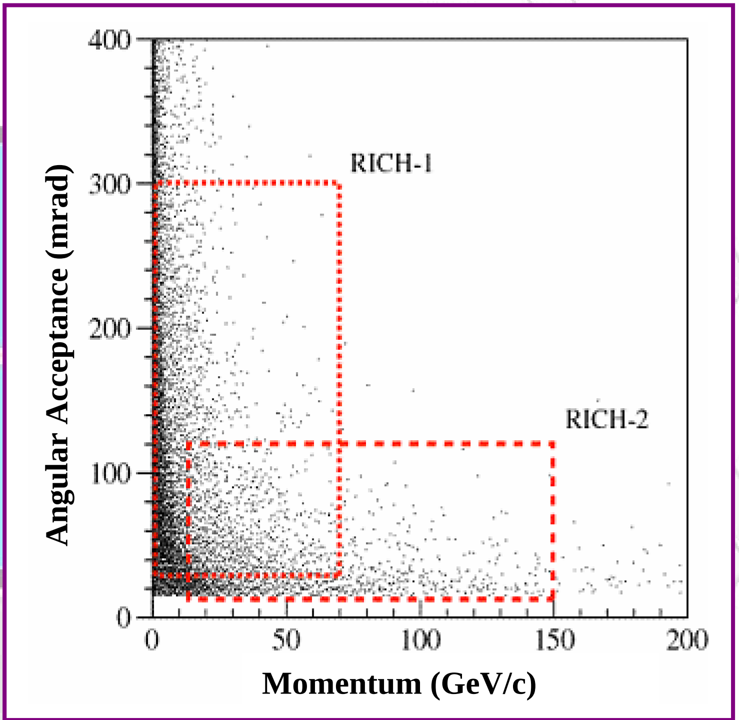
LHCb Experiment



LHCb RICH

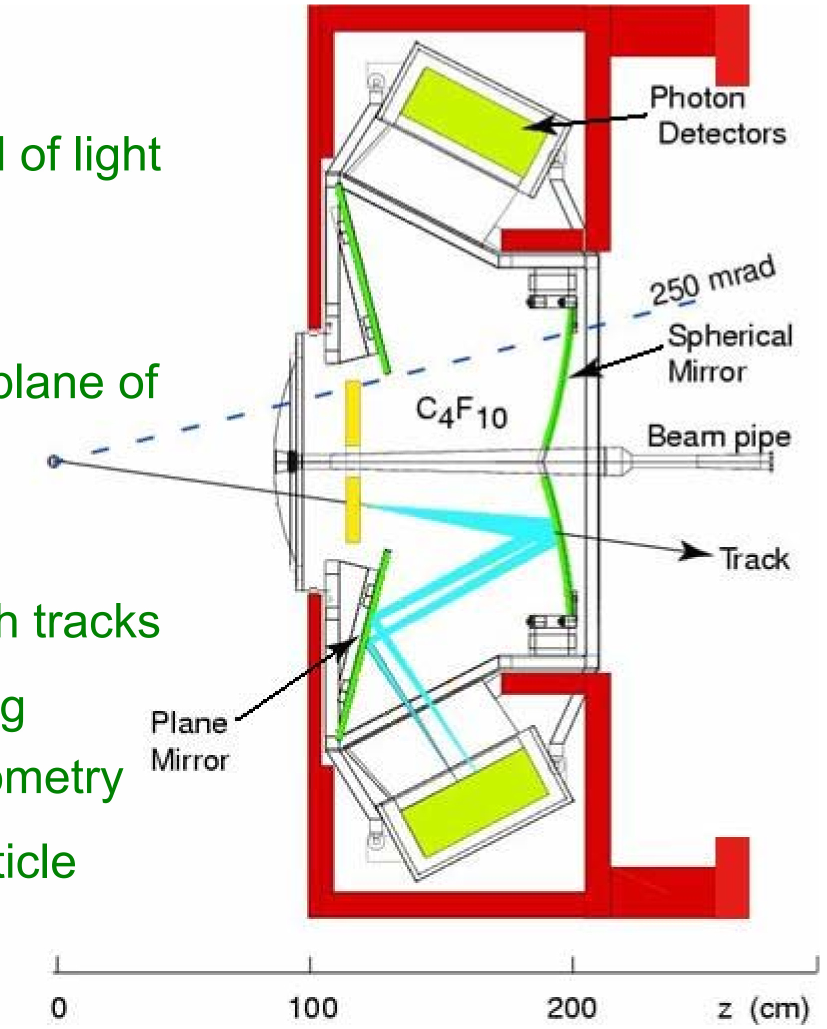
- Responsible for Particle Identification – specifically K/π separation
- Cover complementary momentum and acceptance ranges





LHCb RICH

- RICH Detector:
  - → Particles travelling faster than the speed of light in a given radiator gas emit Cherenkov Radiation at angle Θ_c
  - → Cone of light focused into a ring on the plane of Photon Detectors by mirror system
- LHCb Reconstruction:
  - → Hits on Photon detectors associated with tracks
  - → Θ_c Determined for each hit using tracking information and knowledge of RICH geometry
  - → Θ_c and momentum used to Identify Particle

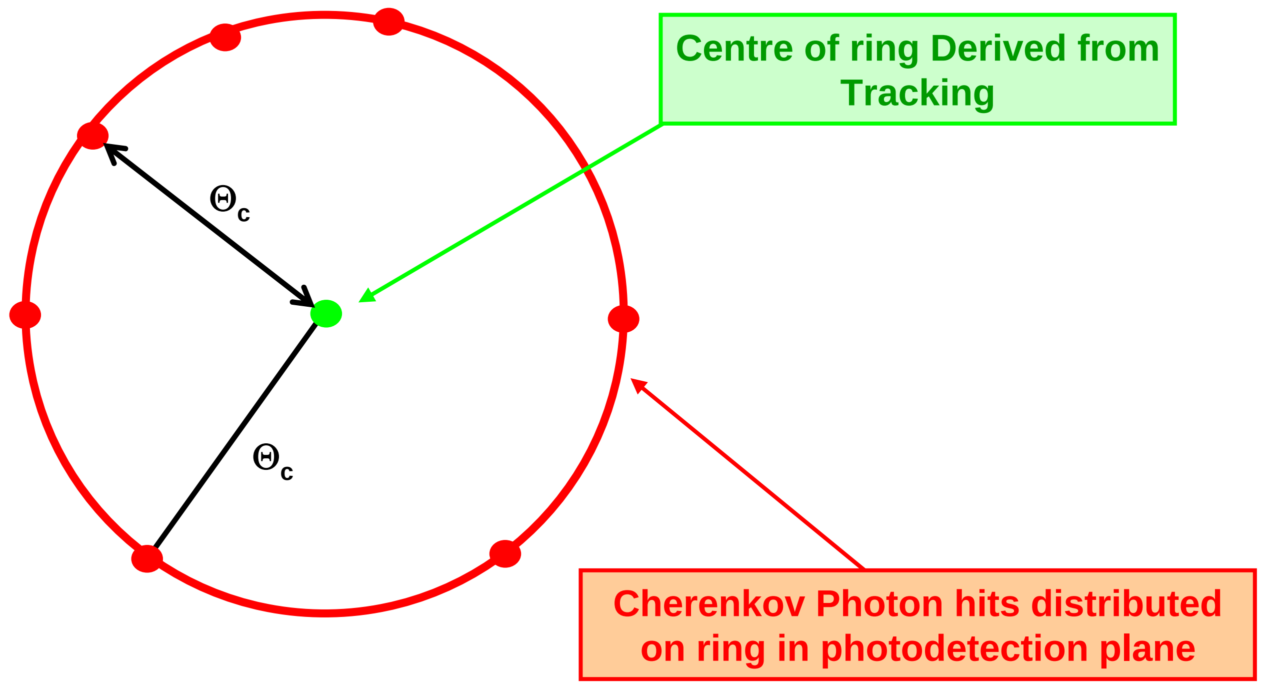


Misalignment Effects

- Software geometry does not accurately reflect physical hardware
- What effect does this have on reconstructed RICH data?
- Misalignments between the optical system and the LHCb tracking information:

Aligned System :

Projection of Cherenkov Angle Θ_c Identical for all points on ring



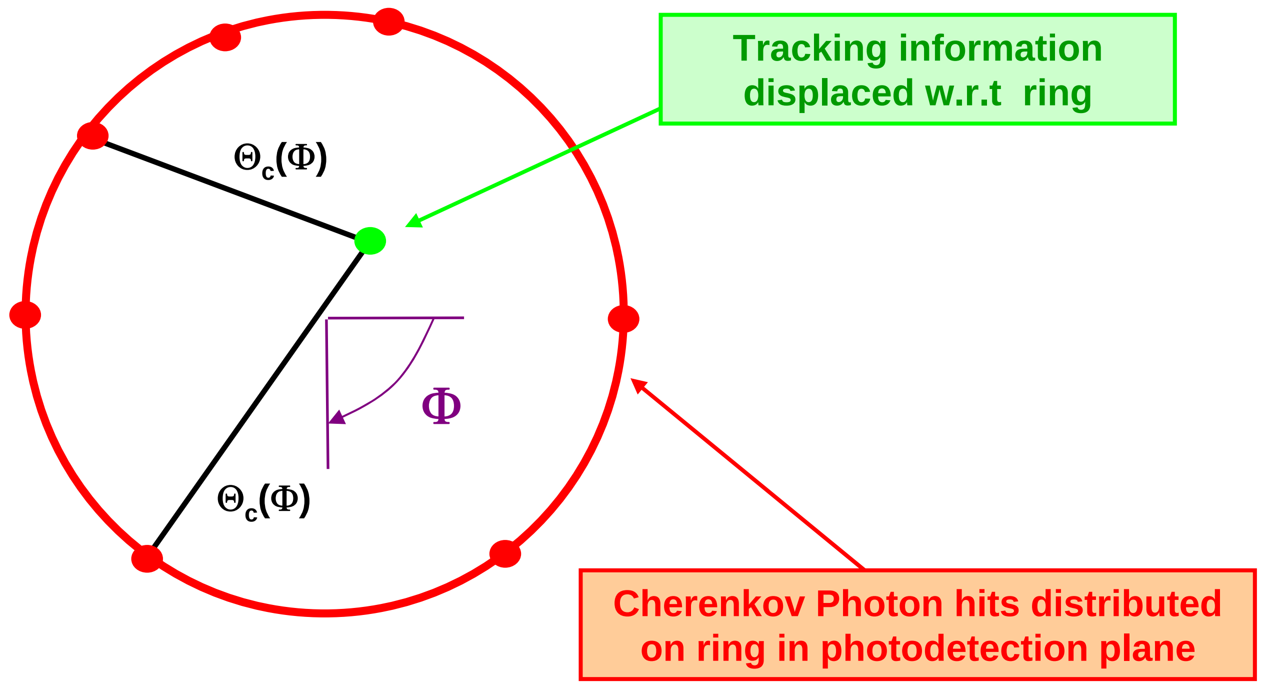
Misalignment Effects

- If the geometry used in the reconstruction no longer accurately reflects the physical hardware – System contains misalignments
- What effect does this have on reconstructed RICH data?
- Misalignments in the optical system are with respect to the tracking information:

Misaligned System :

Projection of Cherenkov Angle Θ_c varies around ring as a function of Φ

As a result, the Cherenkov angle resolution of the detector decreases

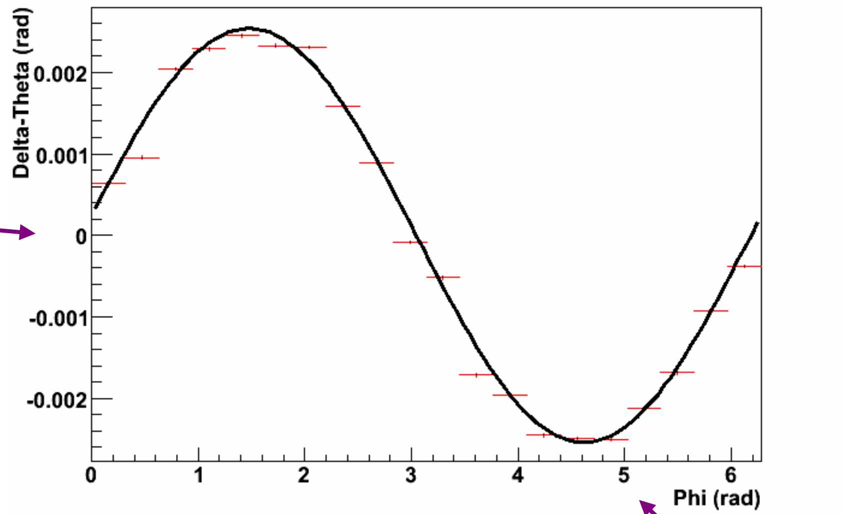


Determining Misalignment

- Can misalignments be determined from data?
- Change in Cherenkov Angle around ring can be plotted and fitted to determine misalignment parameters
- Detector Geometry in Reconstruction can be modified to compensate for misalignment & restore Cherenkov Angle Resolution

Simulated misalignment: mirror tilt

Change in Cherenkov Angle Theta



Phi – angle around Cherenkov ring

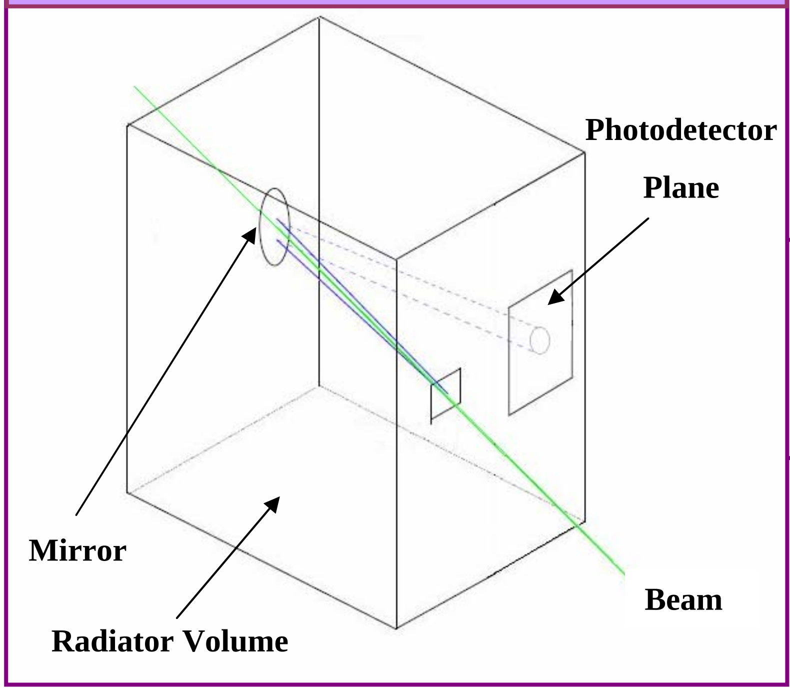
2006 RICH Testbeam

→ Simplified RICH system

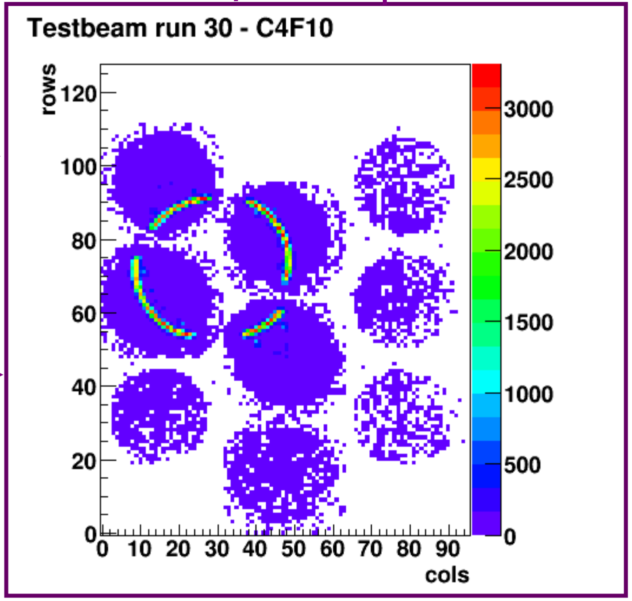
- Small plane of RICH photodetectors
- One Mirror, movable to focus rings on different areas of the active photon detector region

→ 80 GeV/c Pion beam from CERN-SPS

Testbeam Setup



Triggering + Data readout



Reconstruction: Photon Detector Hits + Tracking + Geometry

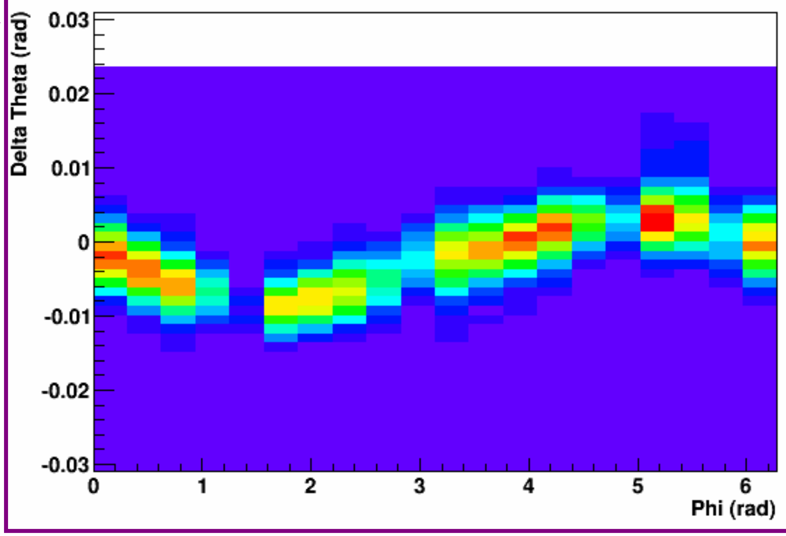
Cherenkov Angle

Testbeam Alignment

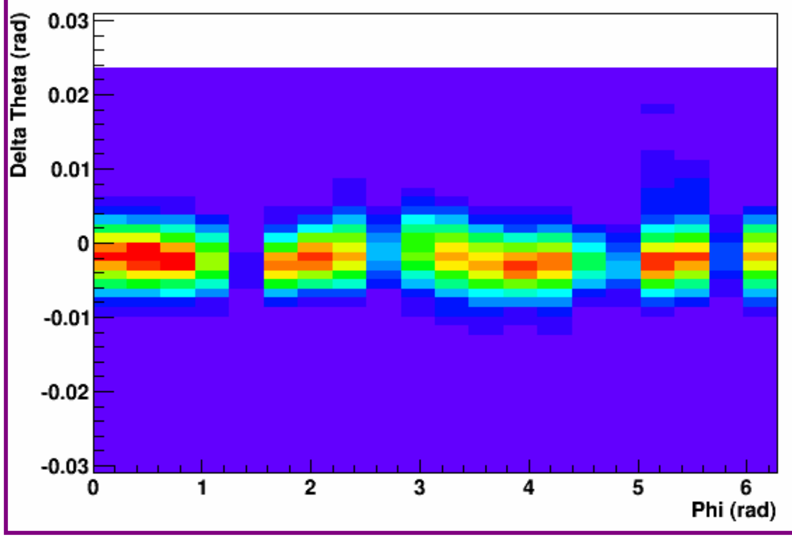
- Testbeam data taken over several runs with different mirror positions
- For each run, precise mirror position must be determined from data

Unaligned data from Alignment Monitoring Algorithm in Reconstruction

Unaligned run



Aligned run



Data after Reconstruction repeated with updated mirror position

Final Detector Alignment

- Full RICH systems far more complicated than Testbeam:
  - → RICH 1: 20 mirror segments, 196 Photon Detectors
  - → RICH 2: 82 mirror segments, 288 Photon Detectors
- Design & installation precautions taken to reduce misalignments and identify serious alignment problems
  - → Mechanics designed with little possible freedom of movement
  - → Mirror panes aligned by laser system before installation
  - → Active monitoring of mirrors by Laser Alignment Monitoring System
- Software compensation planned for small misalignments of order
  - → < 3 mm translation , 0.5 mrad rotation of whole RICH subdetectors
  - → < 1 mrad rotation of mirror panels
  - → < 0.5 mm translation of photon detector sensors

Alignment Strategy

1. Simulate misalignments of individual components of RICH system to parameterise effects of movements in different single degrees of freedom
    - Underway for RICH 2
2. Simulate the misalignments in multiple degrees of freedom
    - Distinguish between rotations and translations by comparing different RICH photodetector planes
3. Misalign multiple components – disentangle by looking at specific mirror and photon detector combinations
    - Determine optimal order to approach misalignments.
4. Develop minimisation technique to recover main misalignments in one step

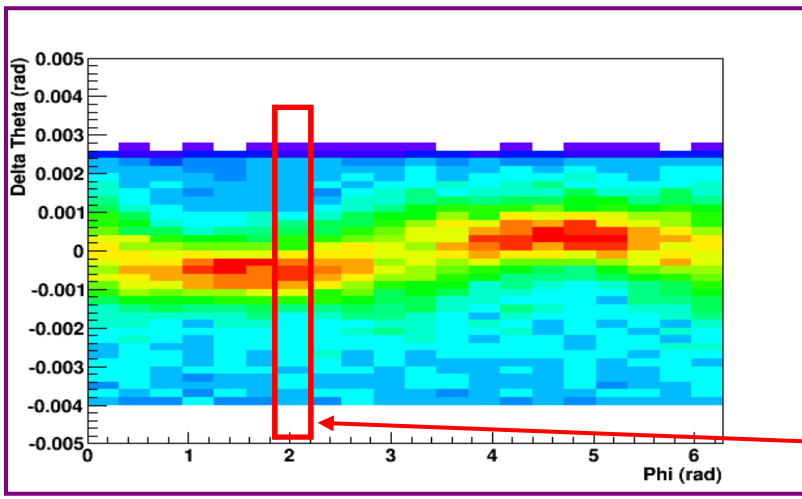
5. Blind Alignment challenge using Simulated data

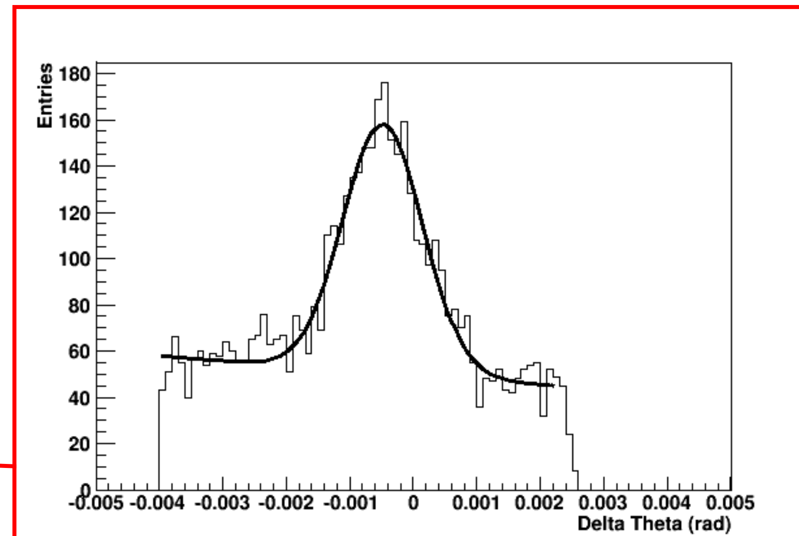
Preliminary Results

- Misalignments of the RICH 2 subdetector simulated
  - → Inclusive b events generated
  - → Events reconstructed with misaligned geometry
  - → Background reduction: fitted slices of Φ

RICH 2 rotated by 0.5 mrad about X axis

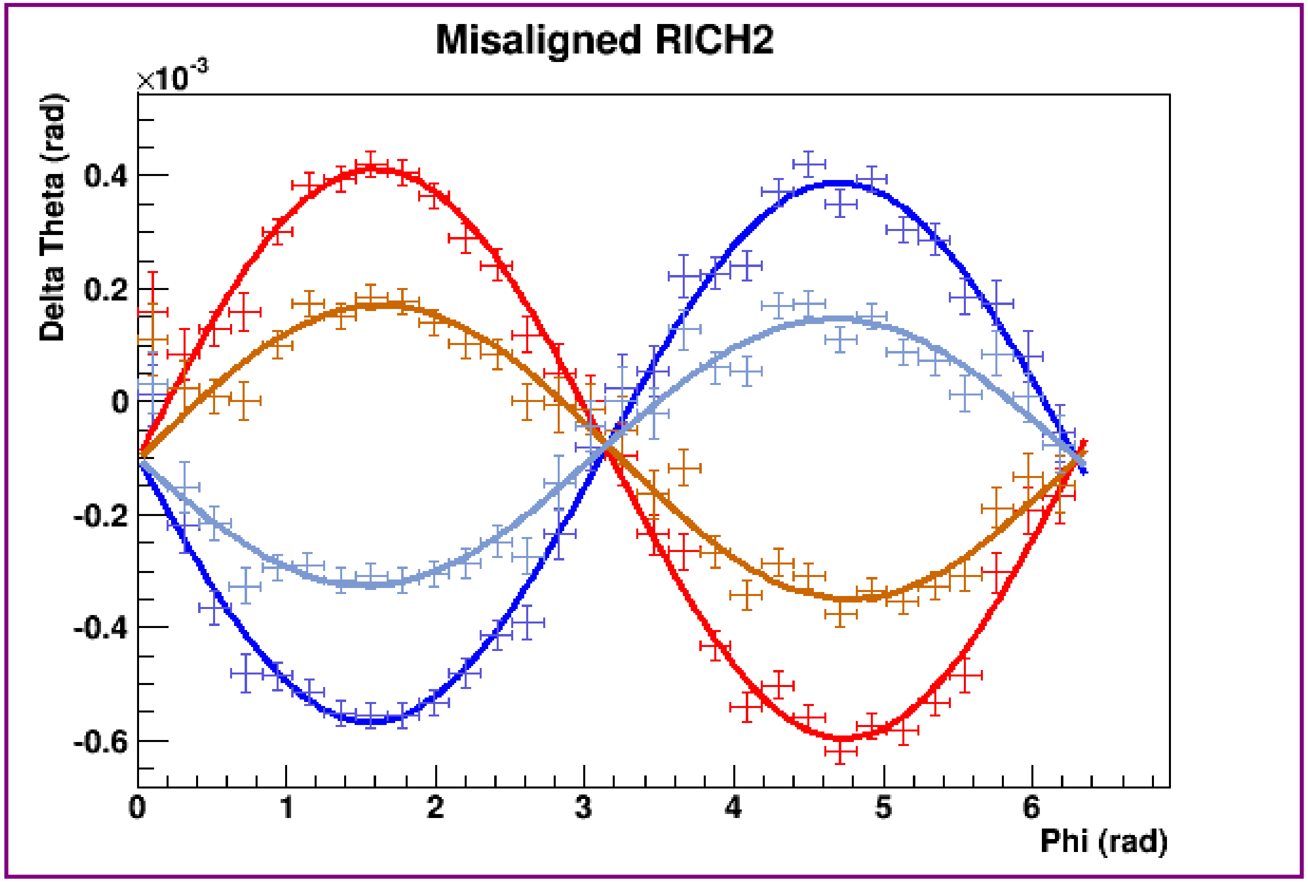
Peak of distribution found in bins of Φ by fitting Gaussian + Background





Preliminary Results

- RICH 2 misalignments can be identified and calculated from data – detector geometry can be corrected to account for correct positions of hardware



Simulated Misalignment

-0.5 mrad
-0.25 mrad
0.25 mrad
0.5 mrad

Conclusions

- Alignment considerations of great importance for all LHC experiments – LHCb RICH systems designed to minimise potential misalignments
- Small misalignments in RICH components can be detected and corrected for using first data
- Techniques developed and tested using simulation and Testbeam data
- Global RICH alignment strategy underway
- Blind 'Alignment Challenge' to begin soon