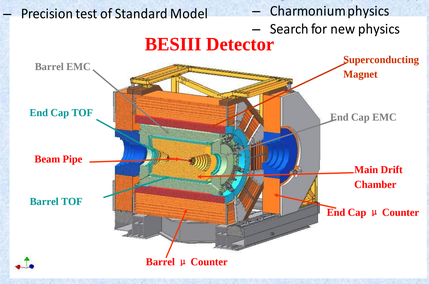
The Alignment of the BESIII Drift Chamber Using Cosmic-ray Data

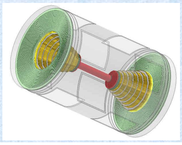
Wu Linghui
On behalf of BESIII Software Group

BESIII Experiment

- Physics goal:
  - Precision measurement of CKM matrix
  - Precision test of Standard Model
  - QCD and hadron production
  - Light hadron spectroscopy
  - Charmonium physics
  - Search for new physics

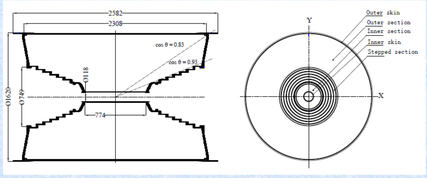


Drift Chamber



- 2.6m long cylindrical chamber
- It consists of inner section，stepped section and outer section
- The stepped section is assembled from a set of 6 aluminum rings
- With an inner radius of 59mm and an outer radius of 810mm
- Filled with He/C_3H_8(60/40)

Inner section



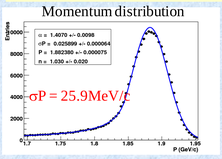
- Square cell
- 6796 sense wires and 21884 field wires.
- The average half-cell size is 6mm for the inner chamber and 8.1mm for the outer chamber
- Half cell staggering to resolve the left-right ambiguity

Misalignment

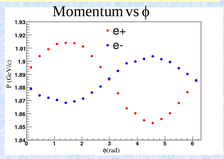
- Displacement of sub-endplates caused bad momentum resolution.
- Alignment with tracks is the only possible strategy to estimate positions and orientations of each component with sufficiently high precision.

Misalignment in reconstruction of Bhabha events

Momentum distribution

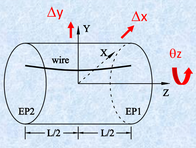


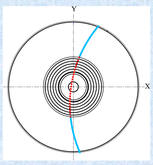
Momentum vs ϕ



Software Alignment

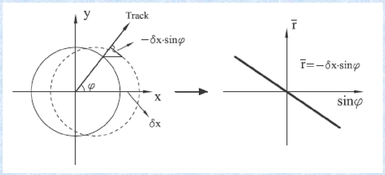
- Use cosmic-ray data to do preliminary alignment
- Alignment parameters
  - 16 independent sub-endplates
    - Inner section （×2)
    - Ring ×6 (×2)
    - Outer section(×2)
  - For each component , 3 alignment parameters are considered
    - Δx : Translation in x direction
    - Δy : Translation in y direction
    - θz : Rotation around z axis
- Alignment methods
  - Use hits in the outer section to do track fit
  - Align the inner and stepped sections
  - Many iterations are necessary

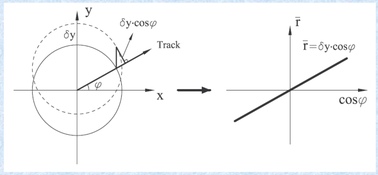


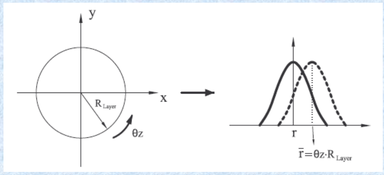


Impact of Misalignment on Residuals

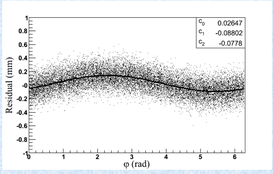
- Translation in x causes dependence of residual on sinφ
- Translation in y causes dependence of residual on cosφ
- Rotation in z causes shift of residuals which are independent of φ







Residual vs ϕ (simulation)



So $r_{mean} = c0 - c1 \cdot \sin\varphi + c2 \cdot \cos\varphi$

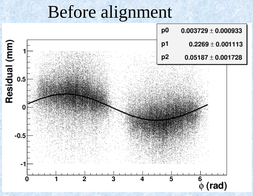
where

- r_{mean} is the mean value of residuals
- c1 and c2 are estimated values of δx and δy, respectively
- $\theta z = c0 / R_{layer}$

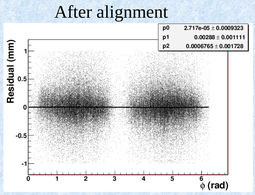
(R_{layer} is the radius of the layer)

Residual vs ϕ (cosmic-ray data)

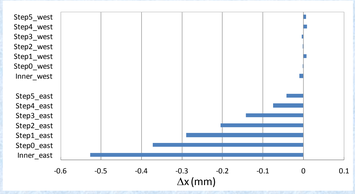
Before alignment

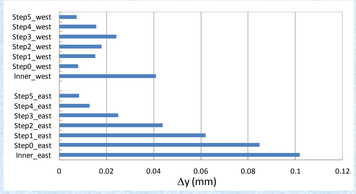


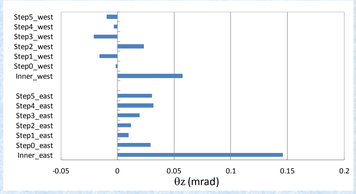
After alignment



Alignment Results



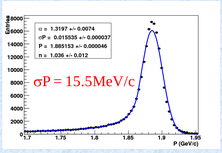




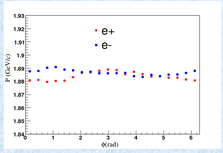
- The shift of the east sub-endplates in x direction is very large.

Reconstruction of Bhabha after alignment

Momentum distribution

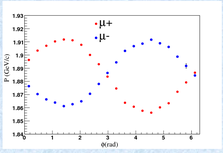


P vs azimuth angle

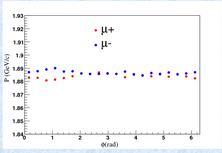


P as a function of ϕ of dimuon

Before alignment

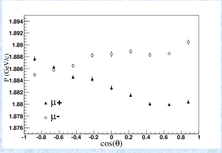


After alignment



P vs cosθ

After alignment



Conclusion and Outlook

- Use cosmic tracks to do preliminary alignment for the BESIII drift chamber. Estimate alignment parameters from the residual fits.
- Momentum resolution is improved significantly after alignment. But misalignment still exists.
- Begin to do alignment with high precision:
  - Use other alignment method: Millepede matrix method
  - Use other data samples: dimuon