Resolution Studies and Pattern Recognition with Vertex Detector

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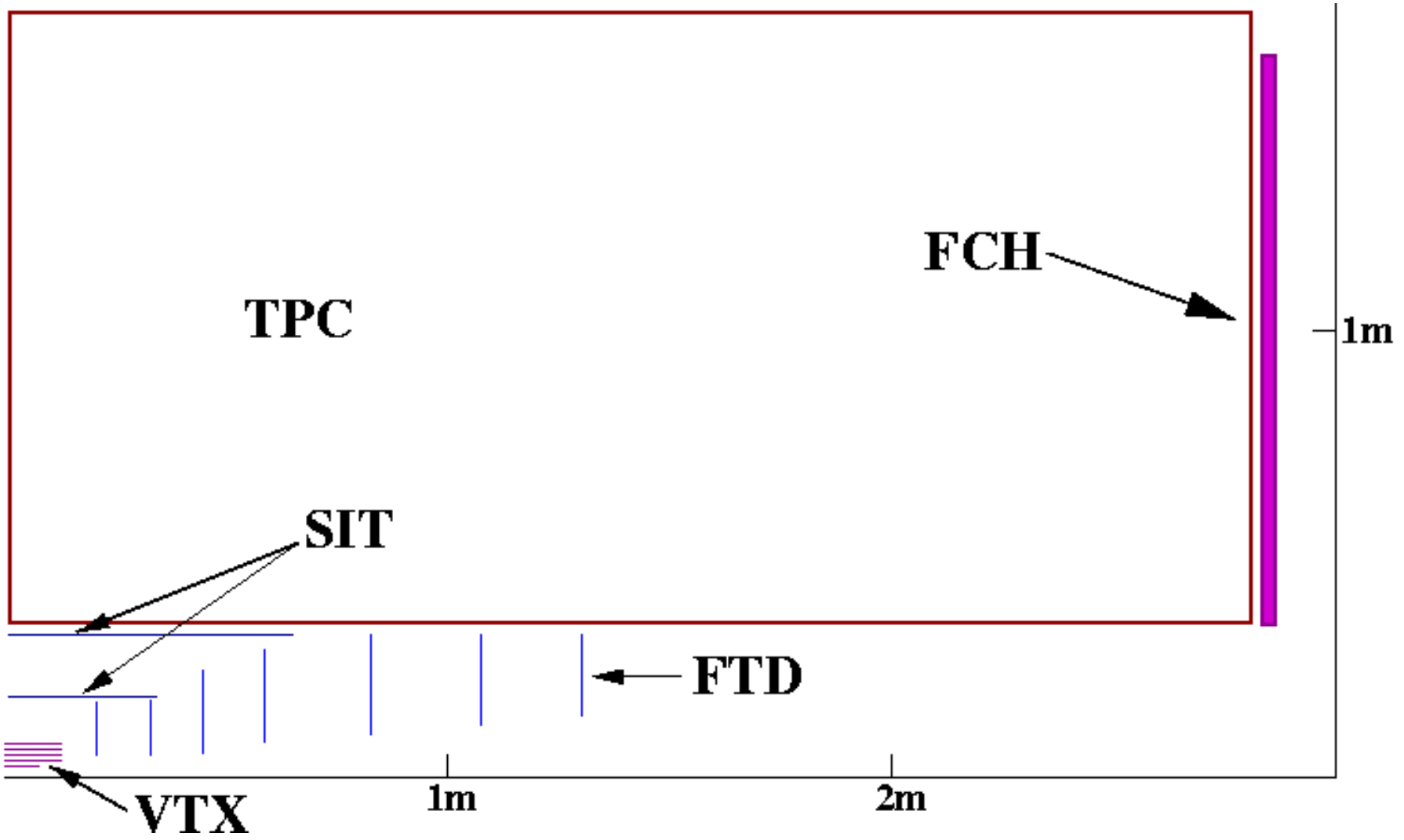
OUTLINE

- Tracking system in LDC detector
- Digitization of hits in VXD
- Track fitting
- Pattern recognition in VXD

Tracking System in LDC Detector



Overall detector needs further optimization

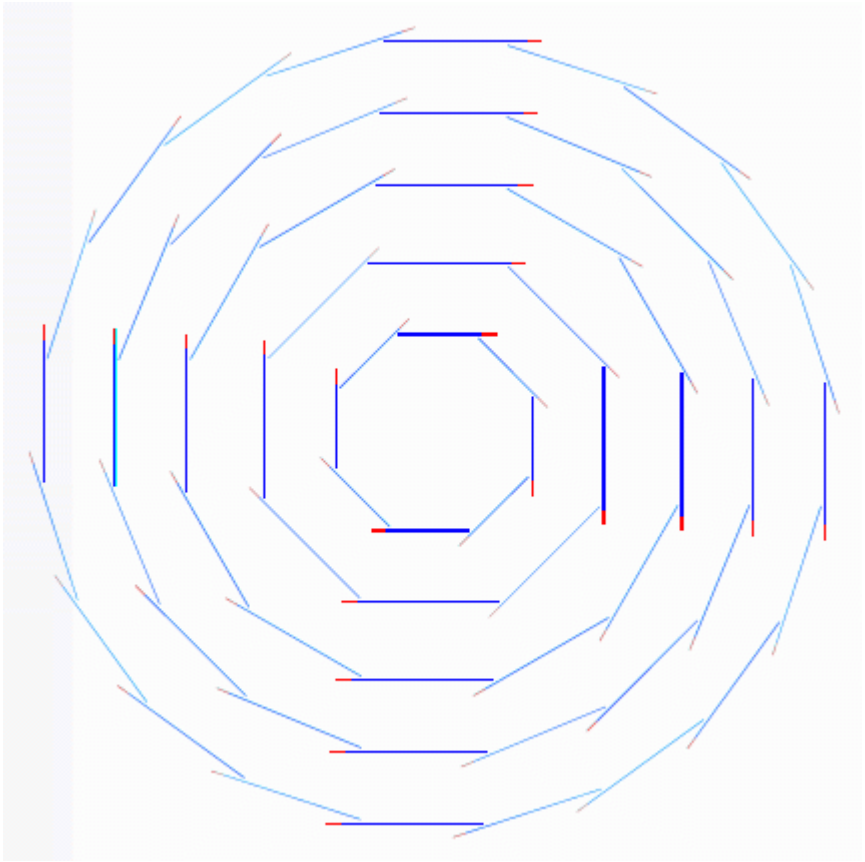
Tools Needed for Tracker Optimization

- It is planned to perform detector optimization with full simulation and realistic reconstruction
- Mokka – Geant4 based detector simulator
  - Almost complete description of the LDC detector : VXD + TPC + forward tracker + ECal + Hcal + forward calorimeters; the only missing ingridient : muon system
  - flexible definition of detector configuration via MySQL database: allows to change detector dimensions and material
- NB : Detector simulation is disentangled from digitization

Tools for Detector Optimization

- MARLIN (Modular Analysis and Reconstruction framework for LINear collider) : digitization, reconstruction and analysis framework
- Currently includes
  - Digitization of TPC hits, track finding and fitting in TPC
  - Digitization of calorimeter hits, pattern recognition in calorimeters
  - PFA implementation
  - Some high level tools (jet clustering, event shape variable calculation)
- Still missing
  - Realistic digitization of VXD, FTD and SIT hits
  - Pattern recognition in VXD, FTD and SIT

Baseline VXD configuration

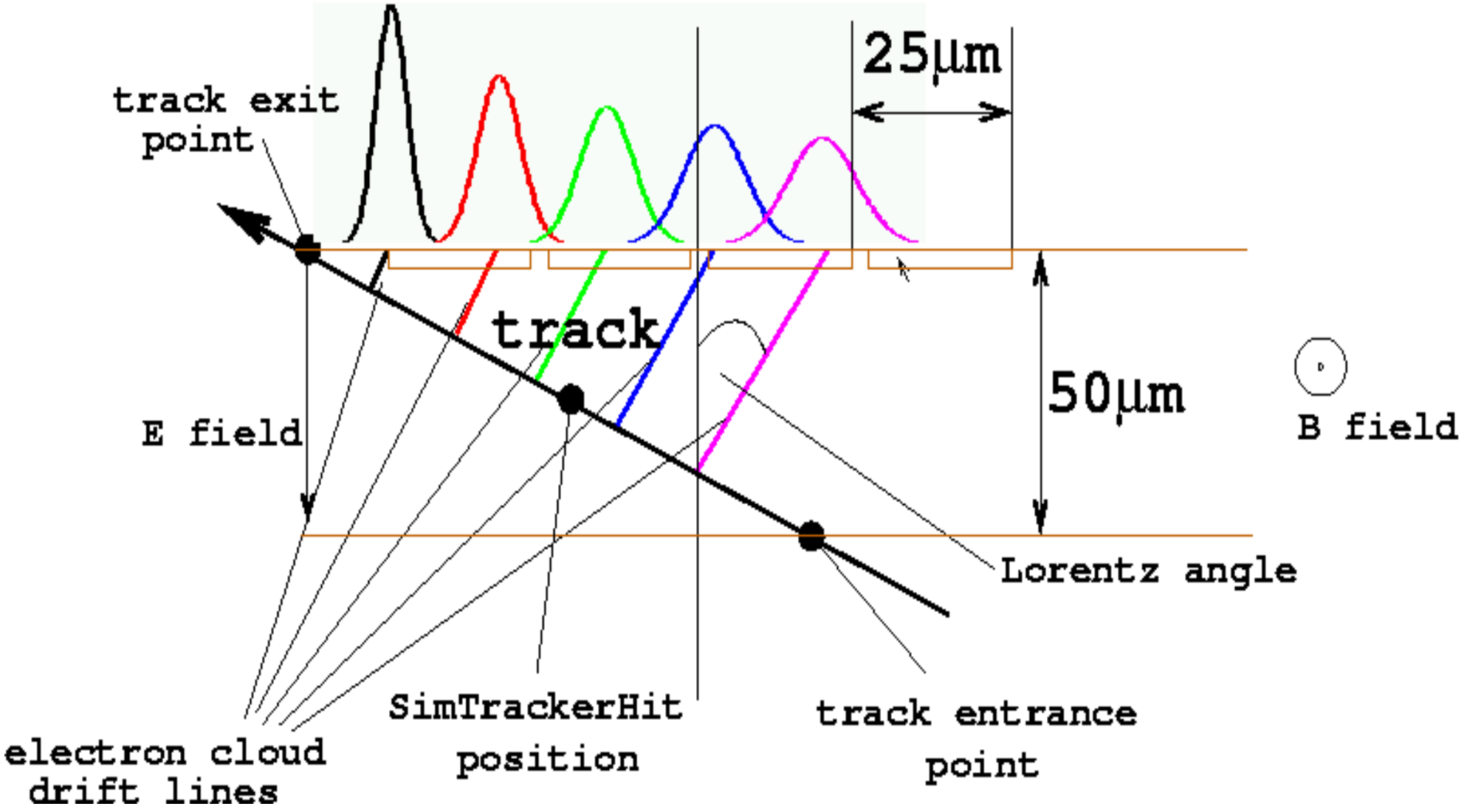


Si layer thickness = 50 μm
Support (carbon fibers) = 50 μm
Pixel size = 25x25 μm

	Radius (cm)	Ladders	Length (cm)
1	1.5	8	10.0
2	2.6	8	2×12.5
3	3.8	12	2×12.5
4	4.9	16	2×12.5
5	6.0	20	2×12.5

Material up to first layer : beam pipe (500 μm beryllium)

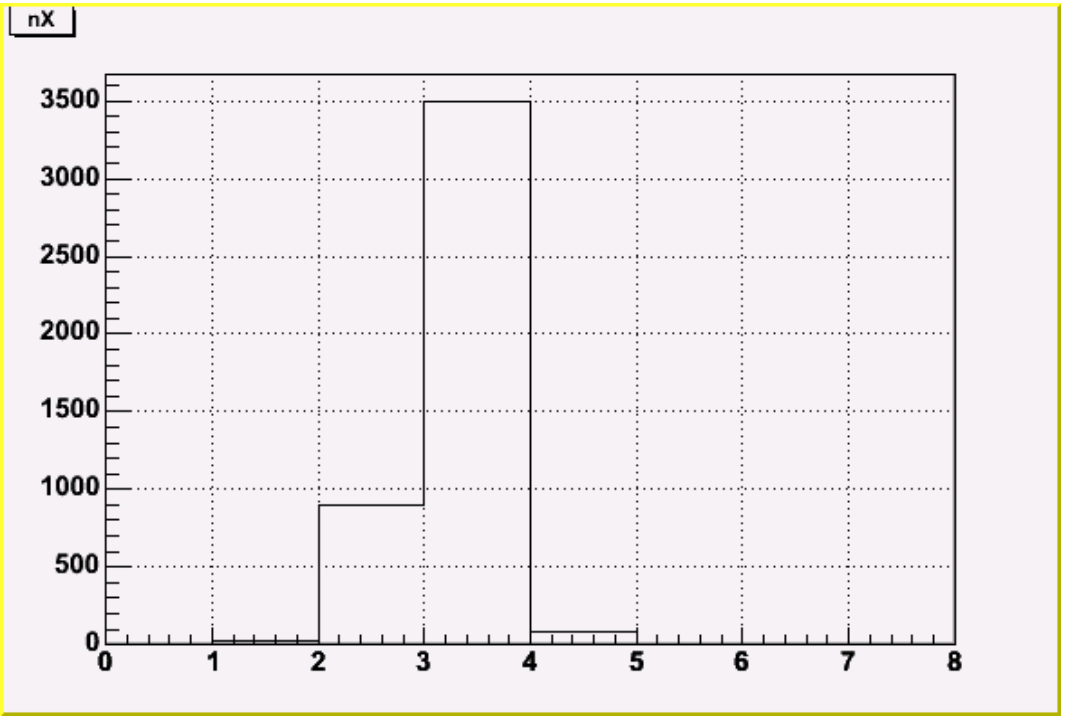
Digitization Procedure



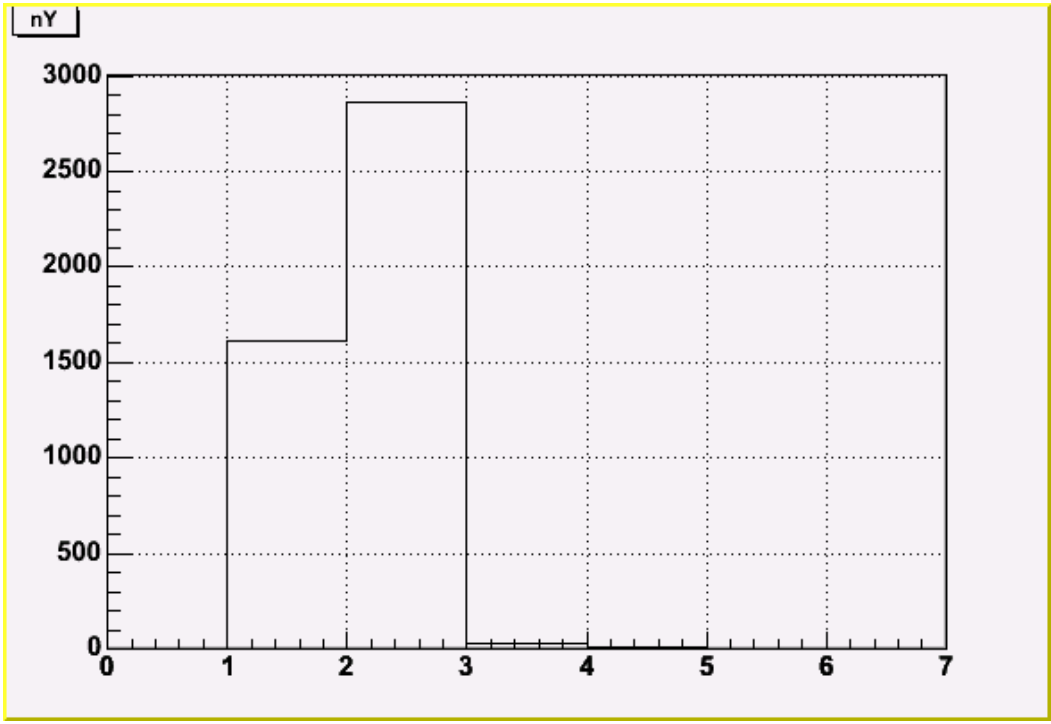
Parameters for Digitization

- Number of segments : 20
- Calculated diffusion normalised to layer thickness : 2.4 μm.
- Tan Lorentz angle : 33° at 4 T field (V. Bartsch etal LC-Note LC-Det-2001) (compared to calculated value of 42°)
- No electronic noise is implemented yet
- Coefficient converting deposited energy into e-h pairs : 270.3 e / keV
- Hit amplitude threshold : 10 electrons

Number of Fired Rows for Normally Incident Particle



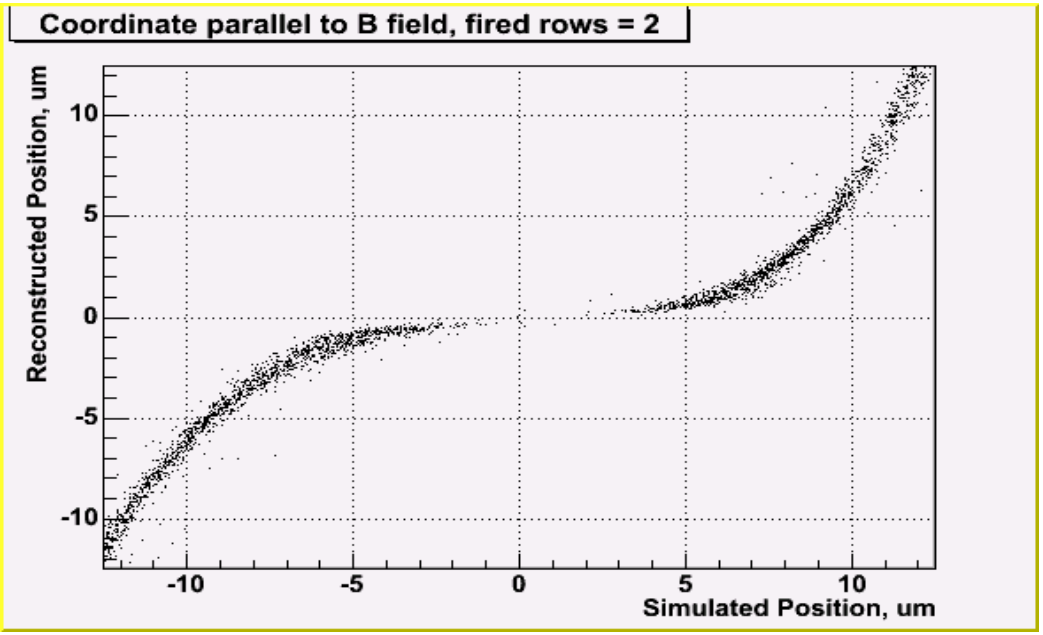
Coordinate perpendicular to B field

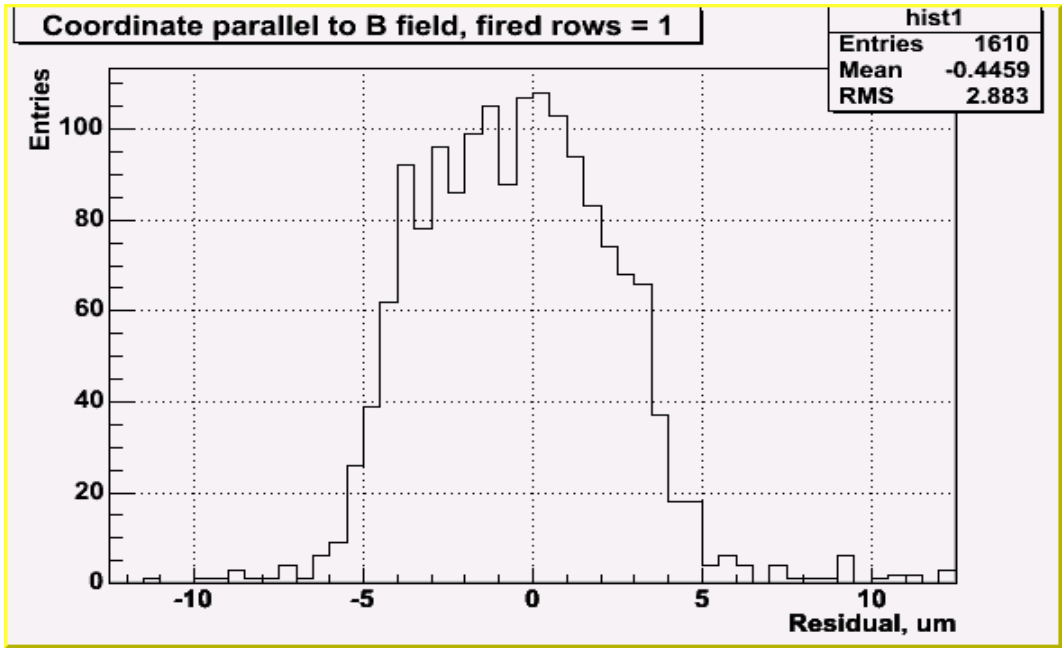


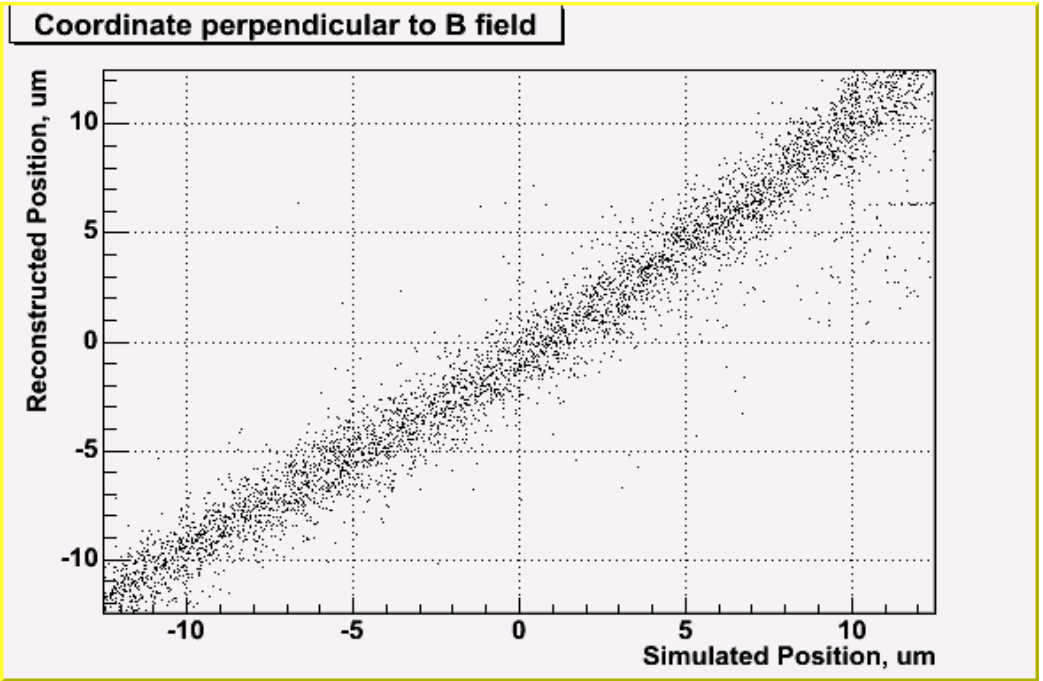
Coordinate parallel to B field

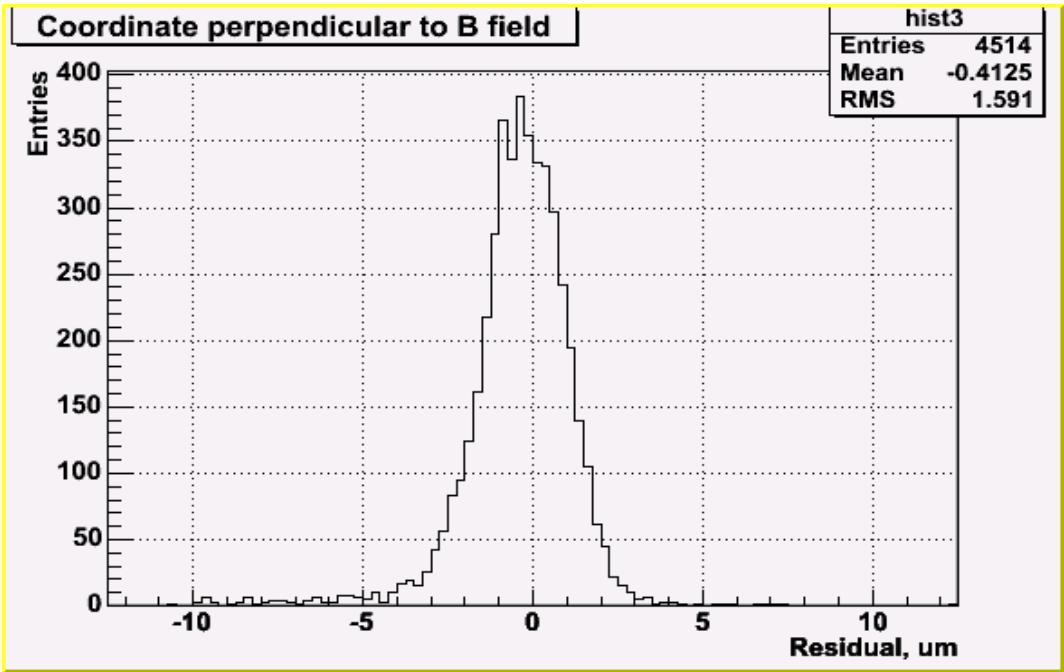
Polar angle of track is 90° (25 μm uniform smearing of z coordinate)

Point Resolution for Normally Incident Track

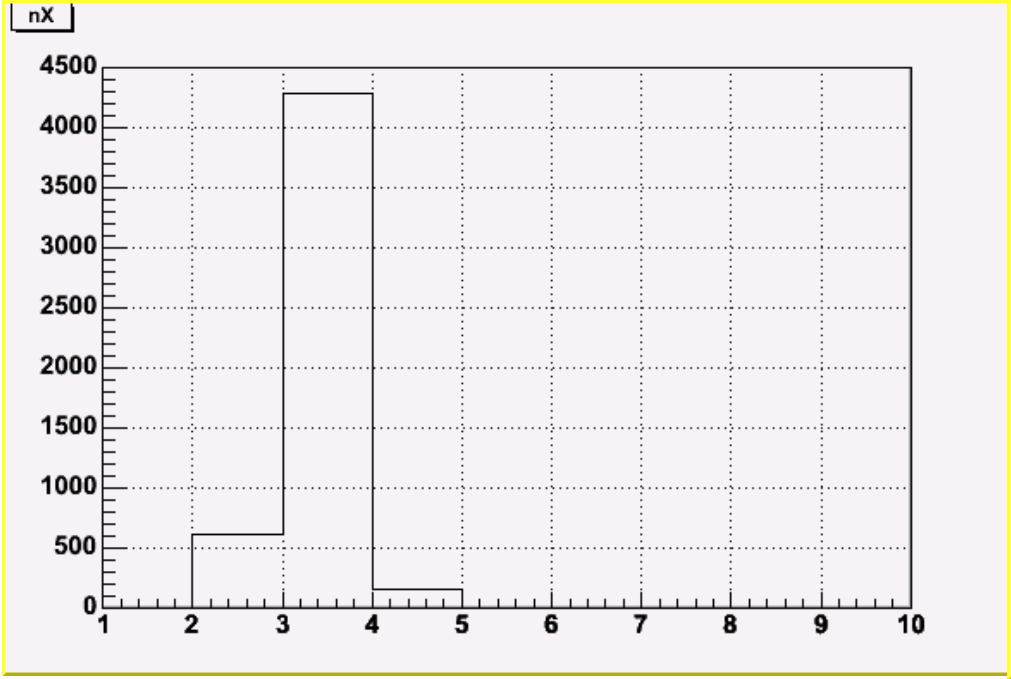




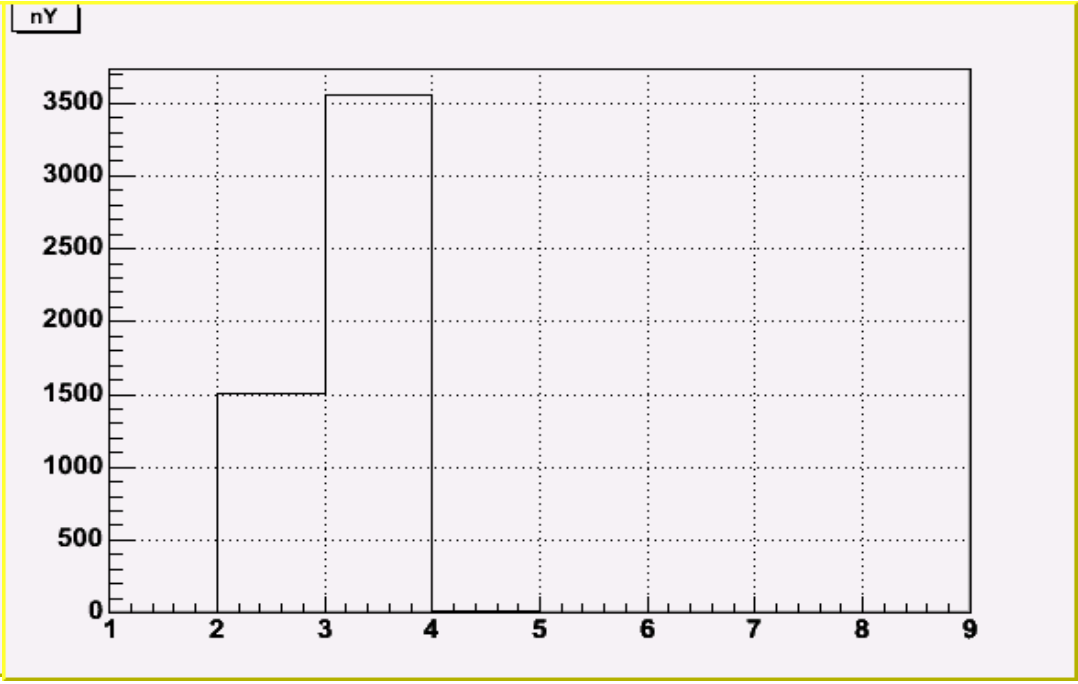




Number of fired rows for Track Incident at 45°



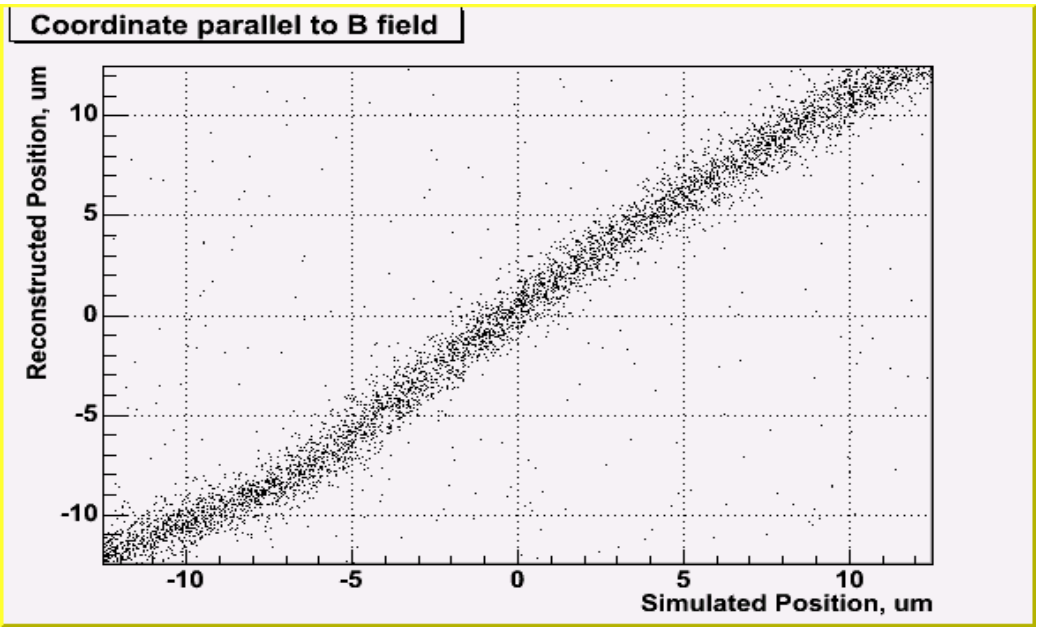
Coordinate perpendicular to B field

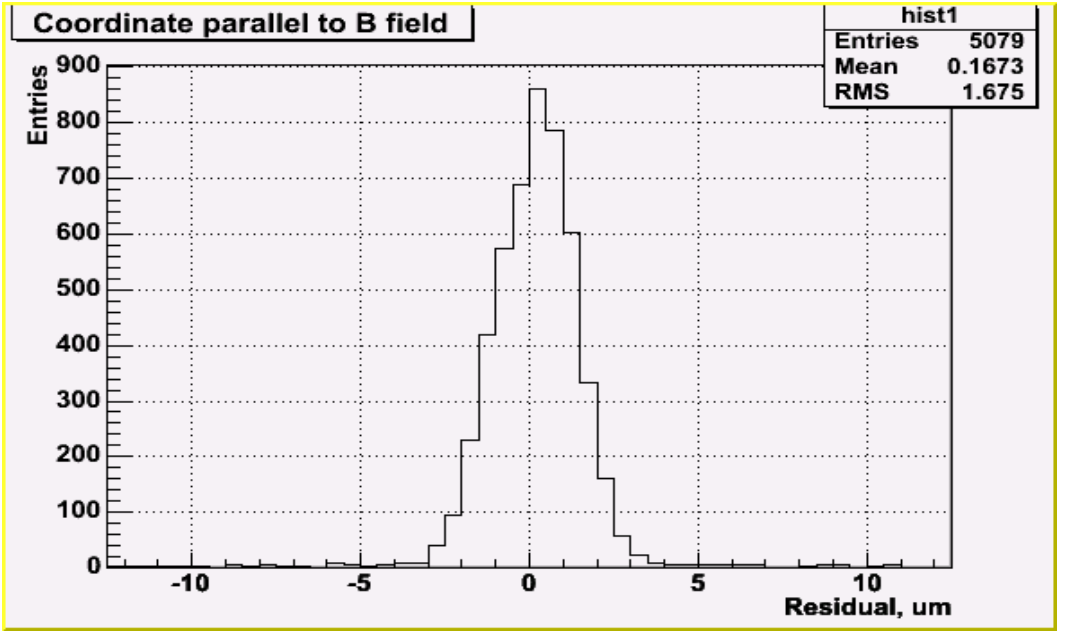


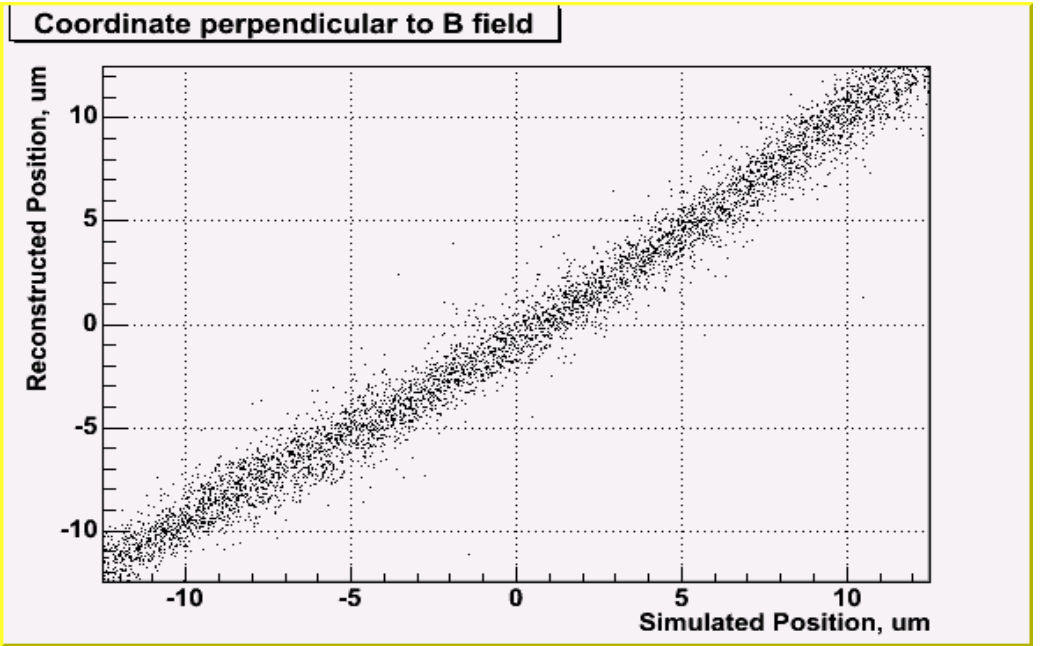
Coordinate parallel to B field

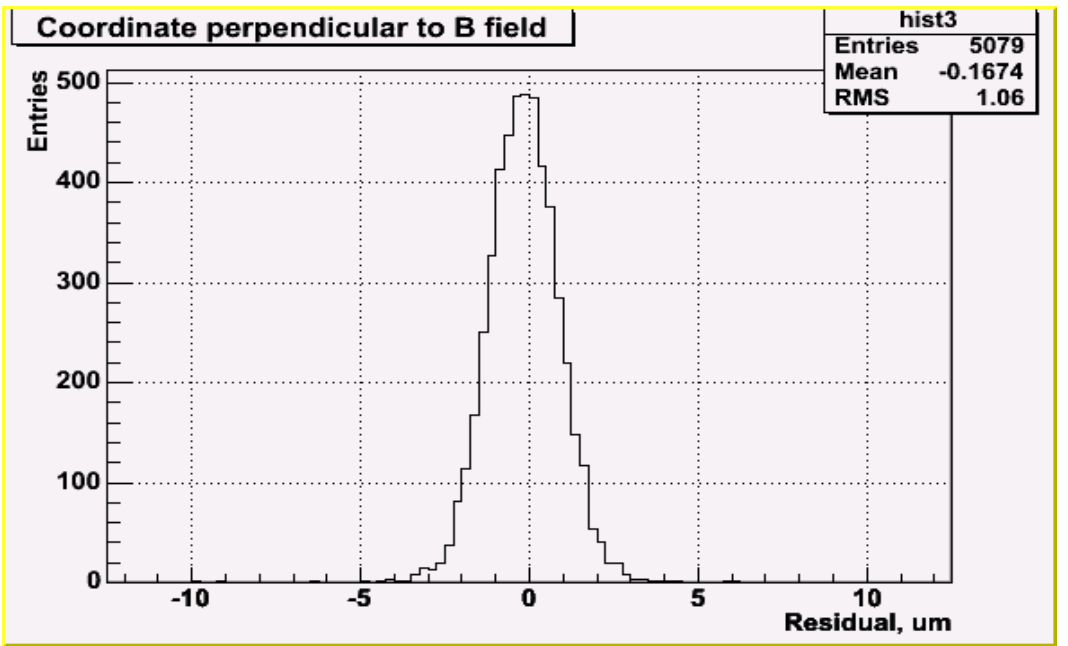
Polar angle of track is 45° (25 μm uniform smearing of z coordinate)

Point Resolution for Track Incident at 45°







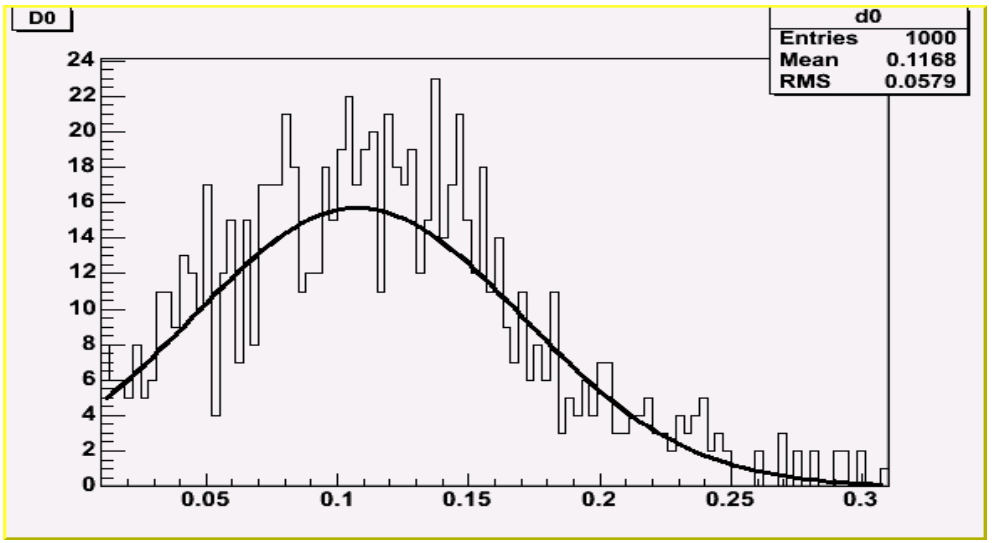


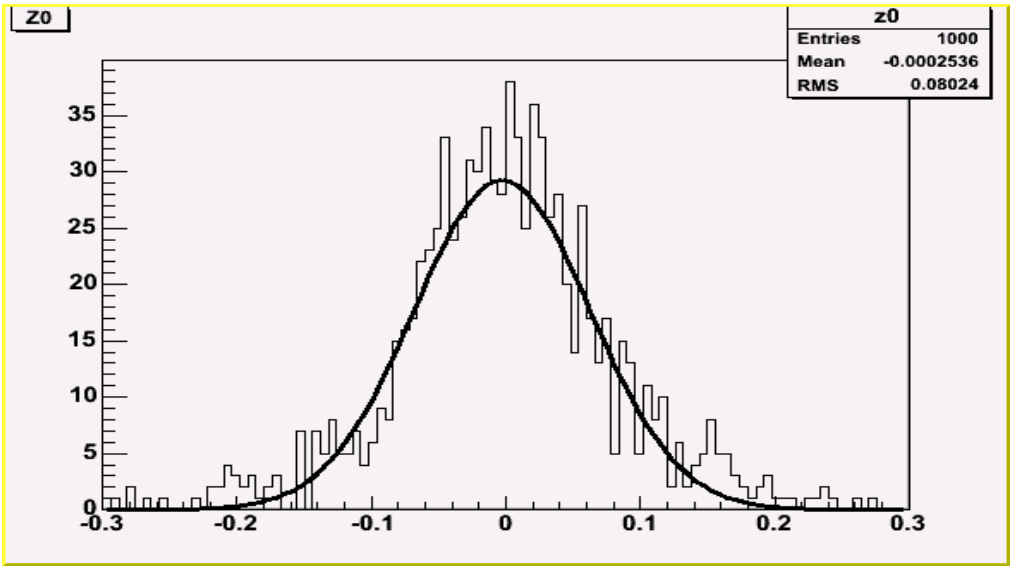
Track Fitting

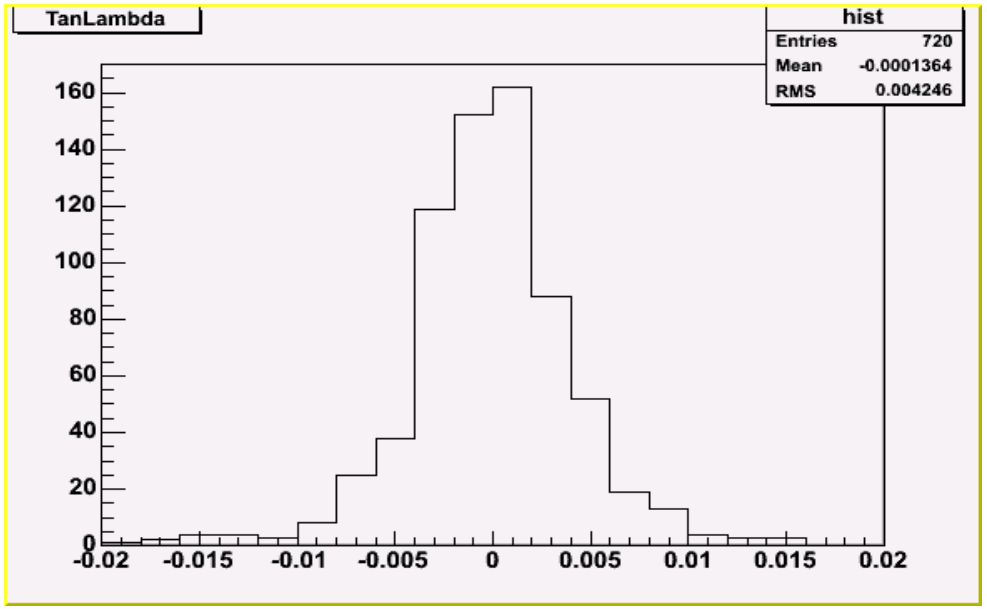
- Simple helix model (no energy loss and multiple scattering are taken into account)
  - D0 – signed impact parameter in R-Phi plane
  - Z0 – z offset w.r.t to PCA in R-Phi Plane
  - $\tan\lambda$ – tan of dip angle
  - Ω signed curvature
  - Φ atan2(P_y,P_x) at PCA

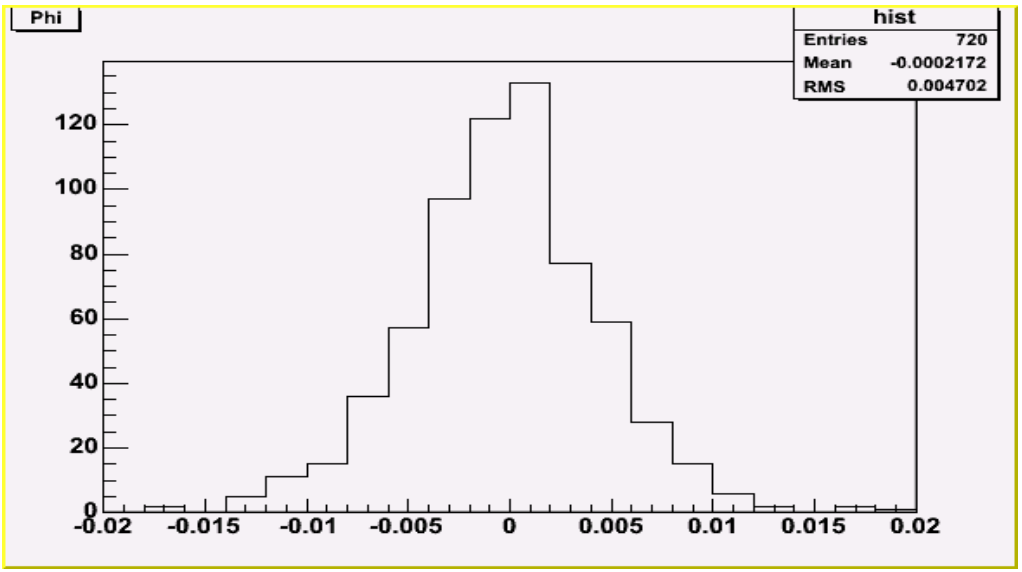
Fitted Track Parameters

Muon : P = 100 MeV, polar angle = 90°, D0 = 100 um, Z0 = 0



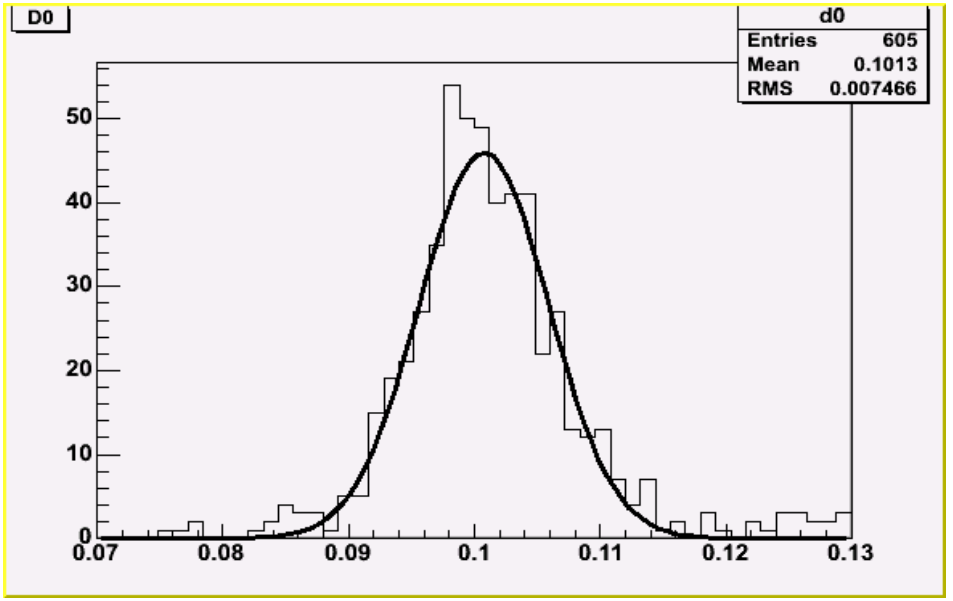


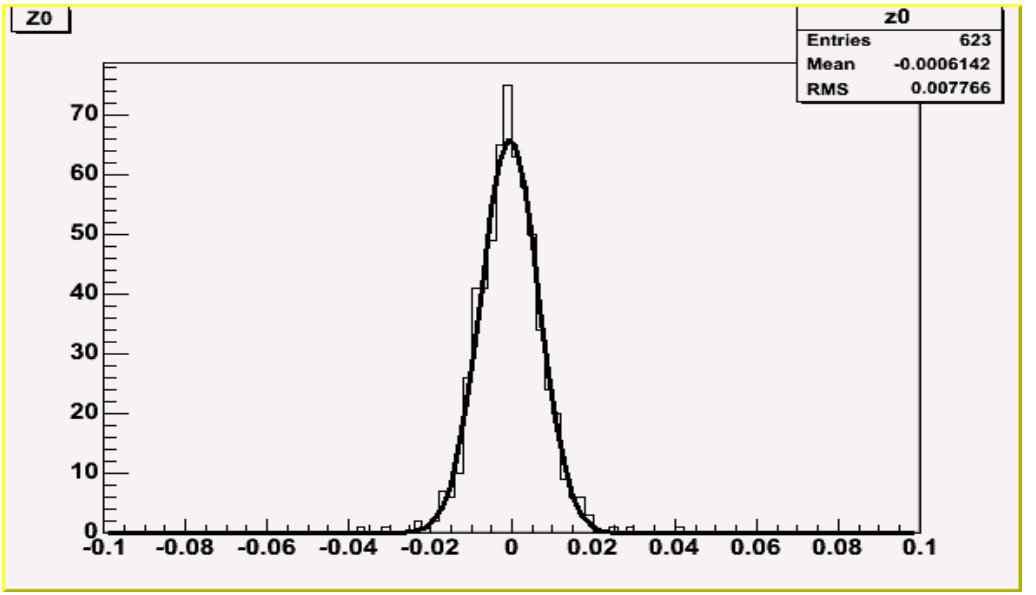


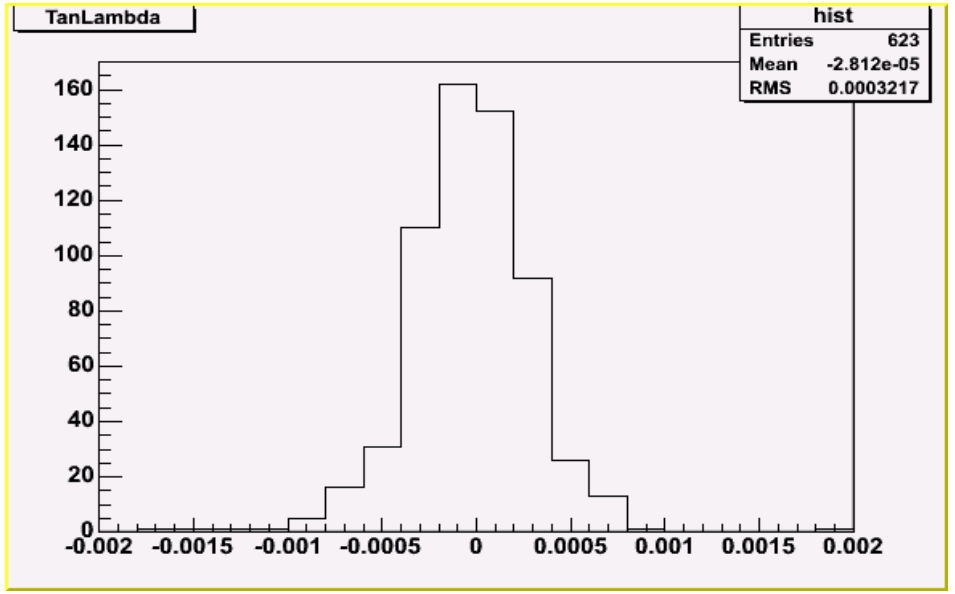


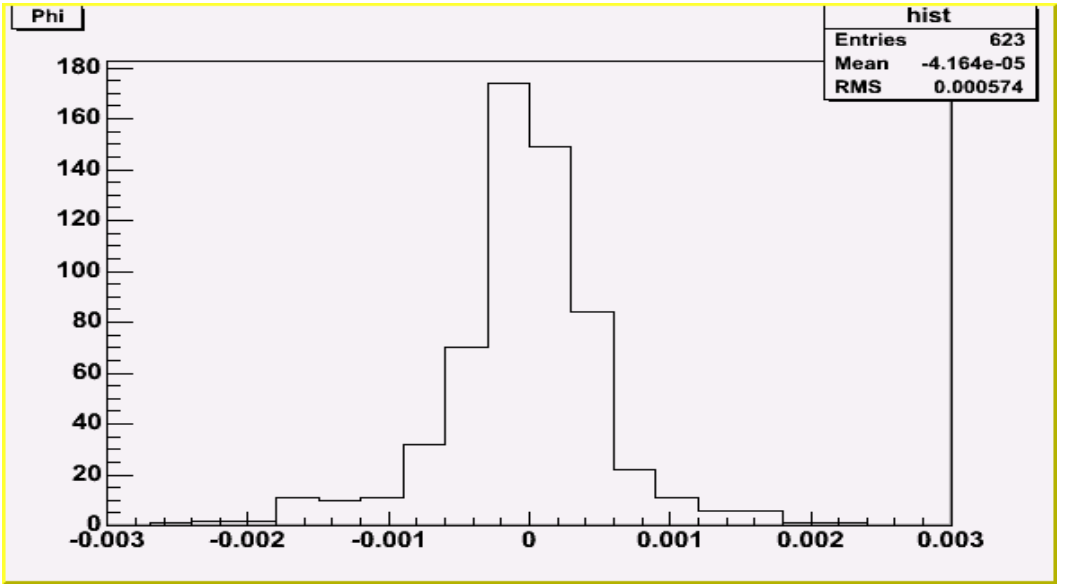
Fitted Track Parameters

Muon : P = 2 GeV, polar angle = 90º, D0 = 100 um, Z0 = 0

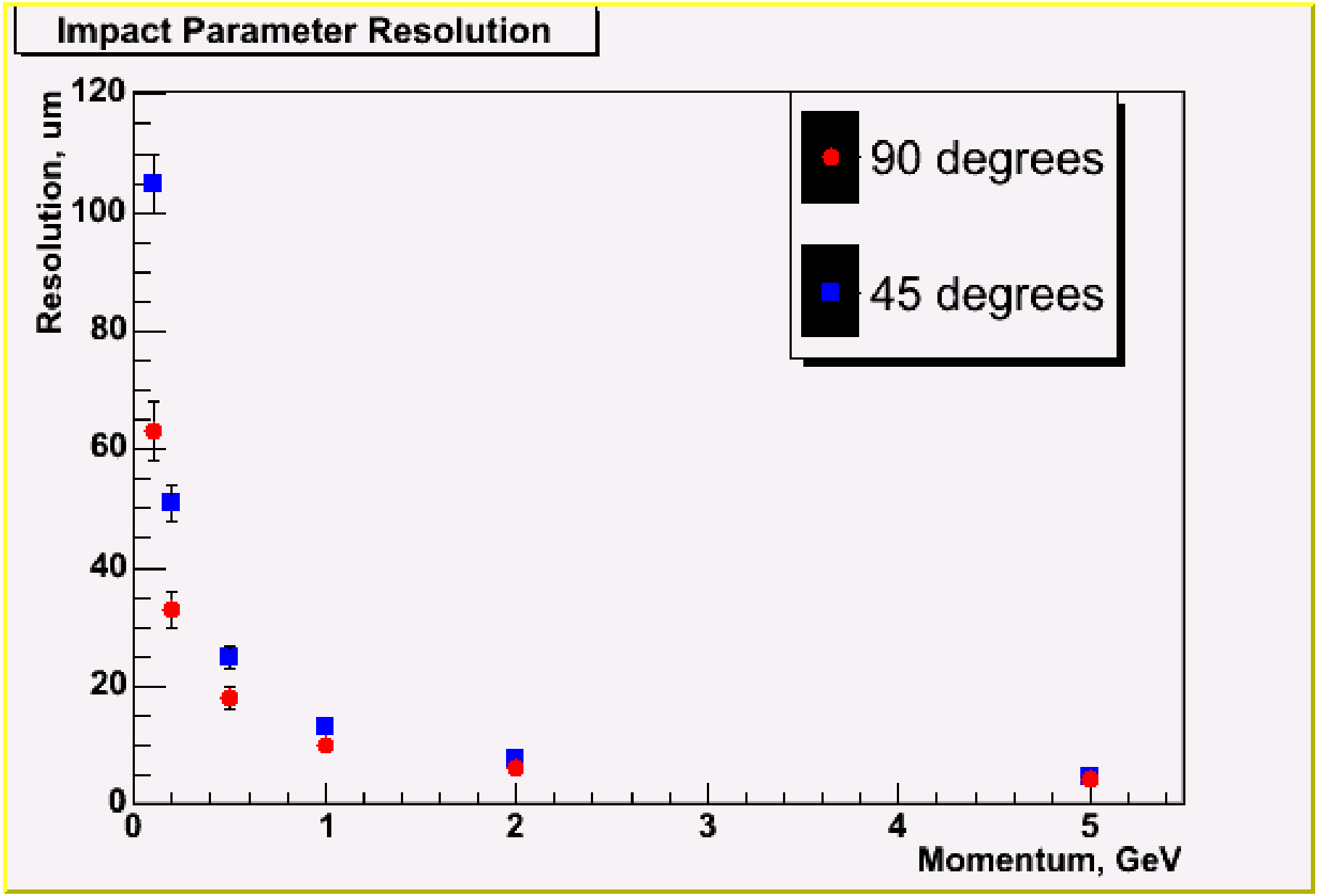




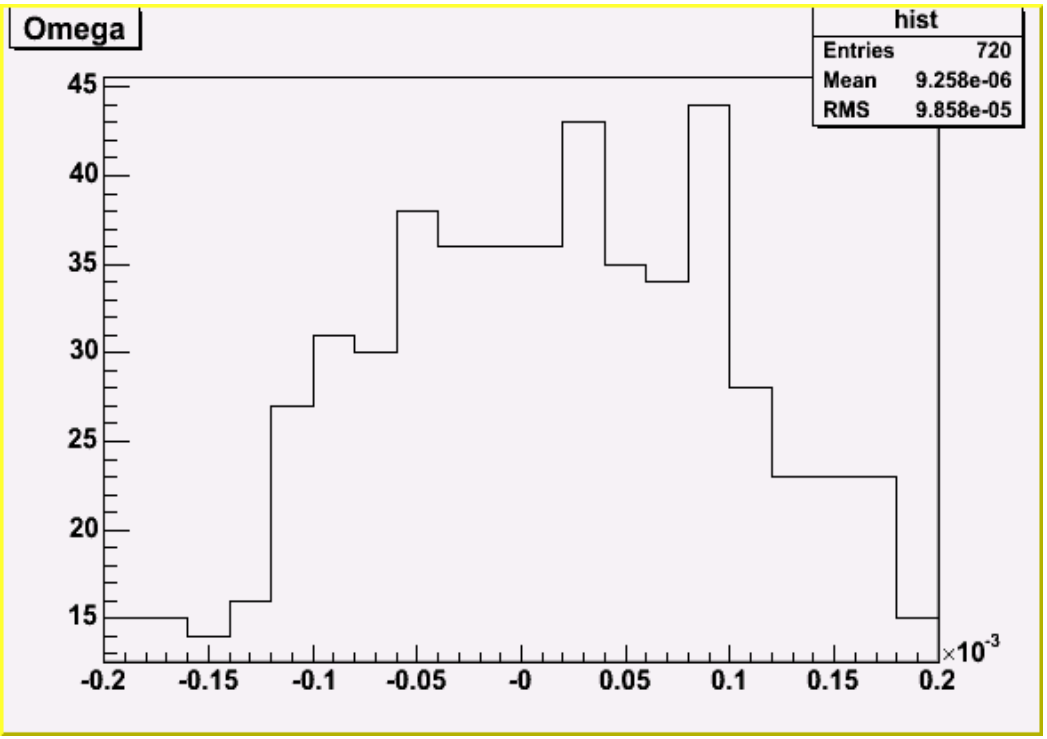




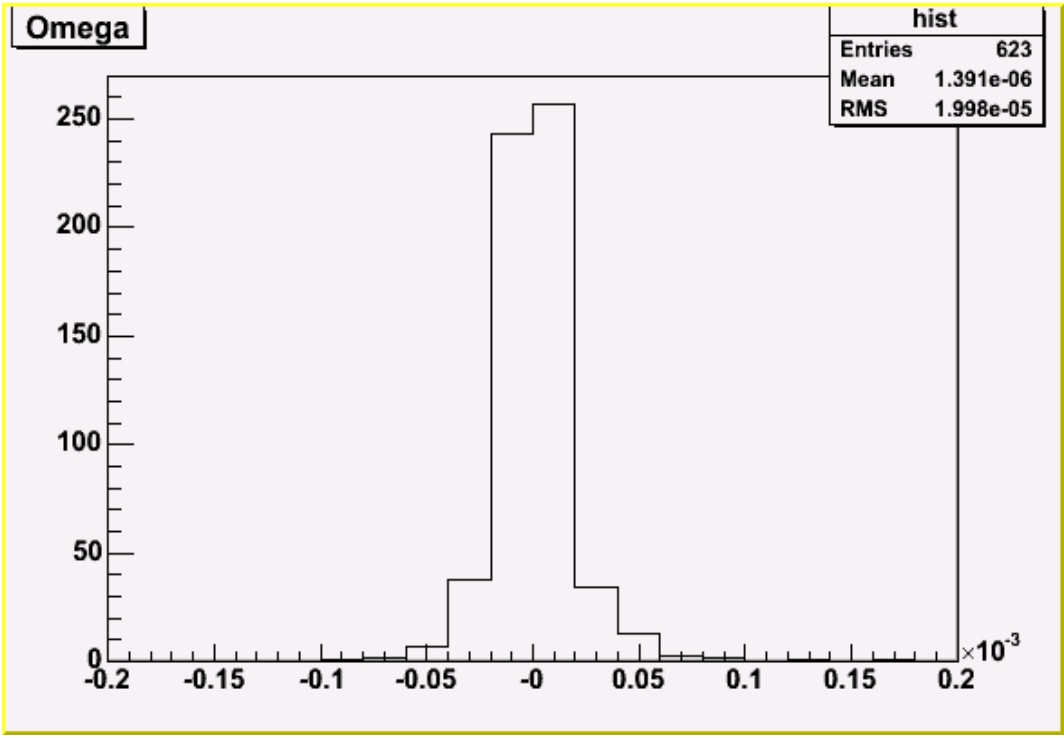
Impact Parameter Resolution



Curvature Reconstruction



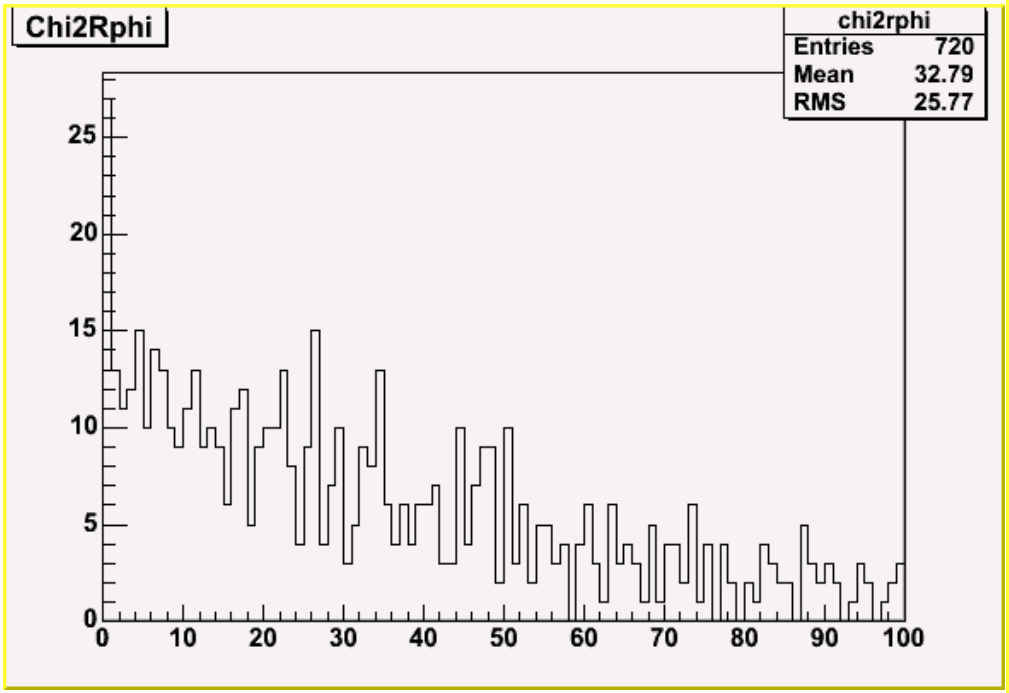
100 MeV muon



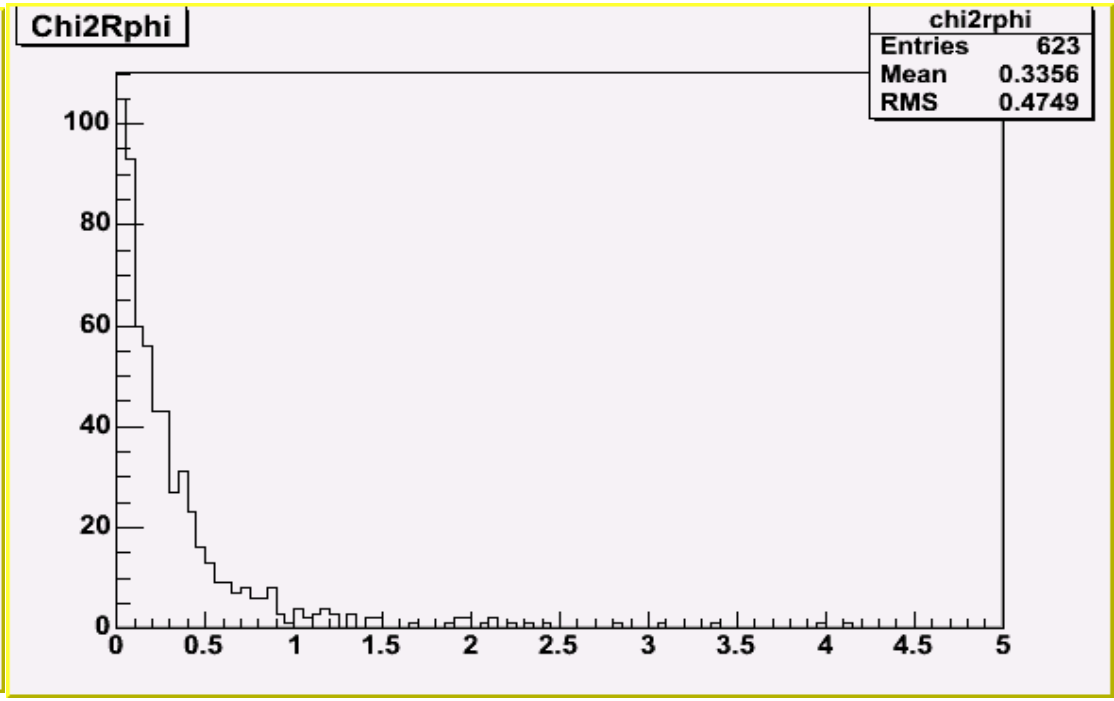
2 GeV muon

No precise momentum reconstruction is possible with VXD only!

Chi2 of Fit



100 MeV muon



2 GeV muon

Pattern Recognition Algorithm

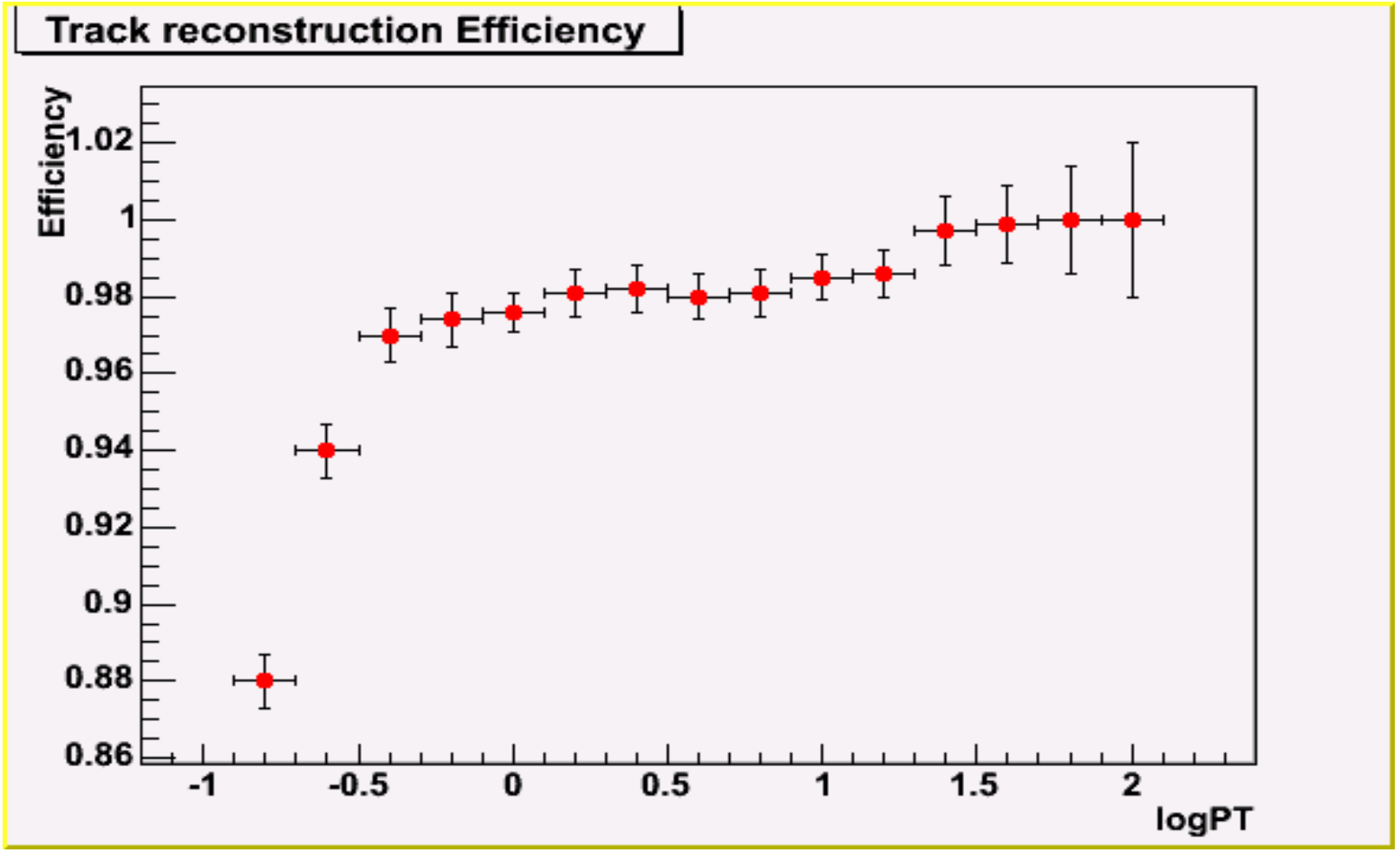
- Divide the whole (Φ,cosΘ) plane into (40,40) sectors
- Find triplets of hits compatible with the helix hypotheis in the 2x2 window of adjacent sectors
  - Hits must belong to different layers
  - Look sequentially for triplets in {5,4,3}, {5,4,2}, {5,3,2} and {4,3,2} layers
  - Accept triplet if $\chi^2 < 50$ (mild cut ; tighter cut may lead to rejection of low momentum tracks)
  - Discard triplet if hits are already assigned to one track
- Extrapolate track inward, pickup hits in the inner layers if they are close to extraplated helix (< 100 um), only one closest hit is allowed to be attached to track in one layer

Pattern Recognition Algorithm

- 3 categories of tracks (more than 4 hits, 4 hits, 3 hits)
- Sort tracks in each category in ascending order of fit χ^2
- Analyse sequentially each category
- First track candidate is accepted; hits belonging to track are marked as used
- Go to next candidate; candidate is discarded if it contains more than 1 already used hits
- Process continues until all track candidate in the sector window have been output or discarded
- Move to the next sector window

Pattern Recognition Performance

Performance is evaluated with tt -> 6jets events at 500 GeV



There are on average 0.75 fake tracks per event

Example of Reconstructed Event in VXD (tt -> 6jets @ 500 GeV)