Tracking Reconstruction

Simon Taylor / JLAB

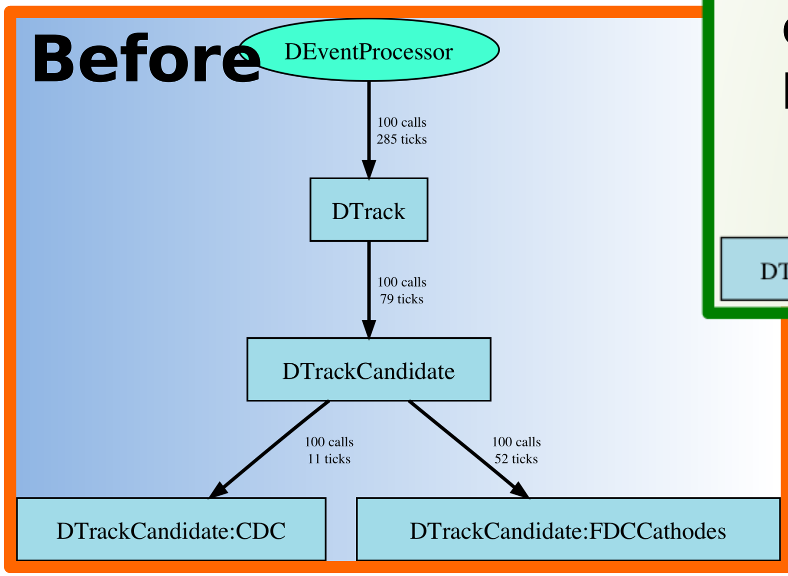
Tracking Reorganization

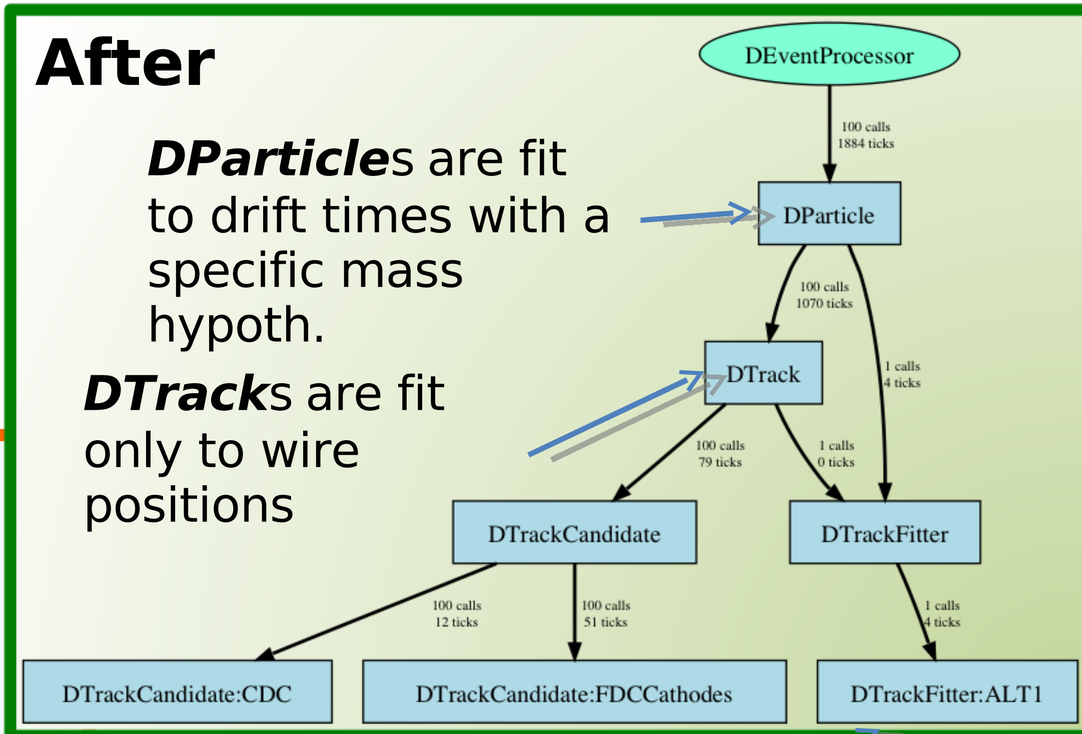
Mark's alternate fitter

Simon's Kalman filter

Reorganizing the data flow in tracking

Previous organization integrated *time*-based and *wire*-based tracking forcing TOF association inside track fitter code





***DParticle**s are fit to drift times with a specific mass hypoth.*

***DTrack**s are fit only to wire positions*

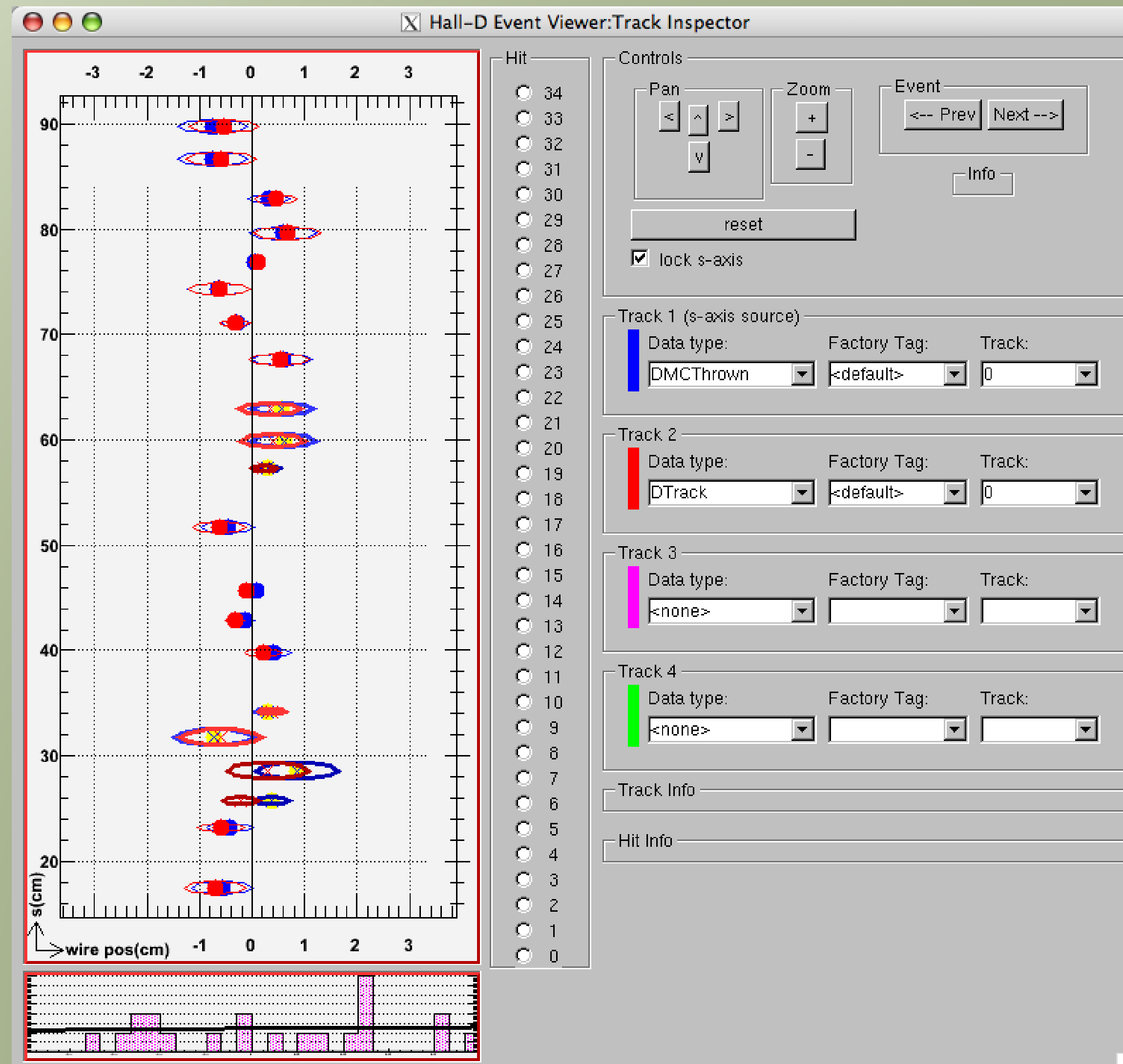
Algorithm shared by *wire*-based and *time*-based fits is in a separate class so it can be easily swapped out

Change committed 9/4/2008 with rev. 4143
this change is not included in the latest stable release

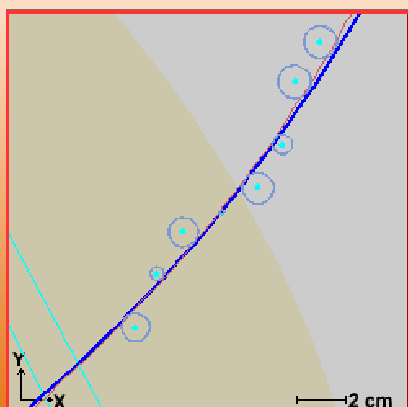
Event viewer now has Track Inspector

This allows all wires (CDC axial and stereo as well as FDC wires) to be viewed in the same way

X=0 is wire position, y is distance along track



Inspired by CDC axial wire view



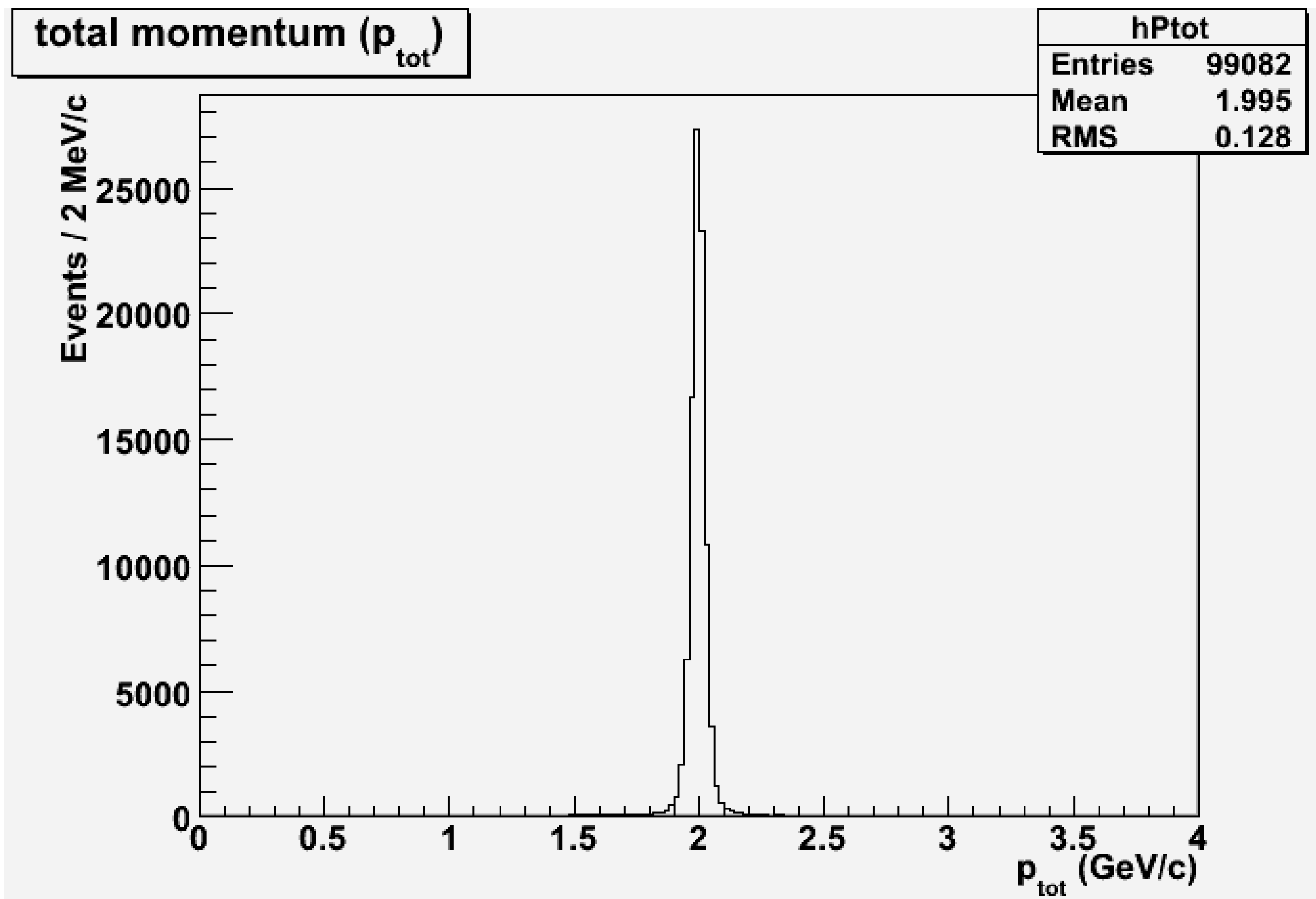
Mark's Least-Squares Track Fitter

- Uses Levenberg-Marquardt algorithm from GNU Scientific Library (in turn, taken from MINPACK)
- Works with FDC hits, CDC hits, or any combination
- Current status: Unweighted fit (assume equal measurement errors)
- Track parameters:
  - Total inverse momentum: $1/p$
  - Polar angle: θ
  - Azimuthal angle: ϕ
  - Transverse distance of point of closest approach to beamline: x'_0
  - Z of point of closest approach to beamline: z_0

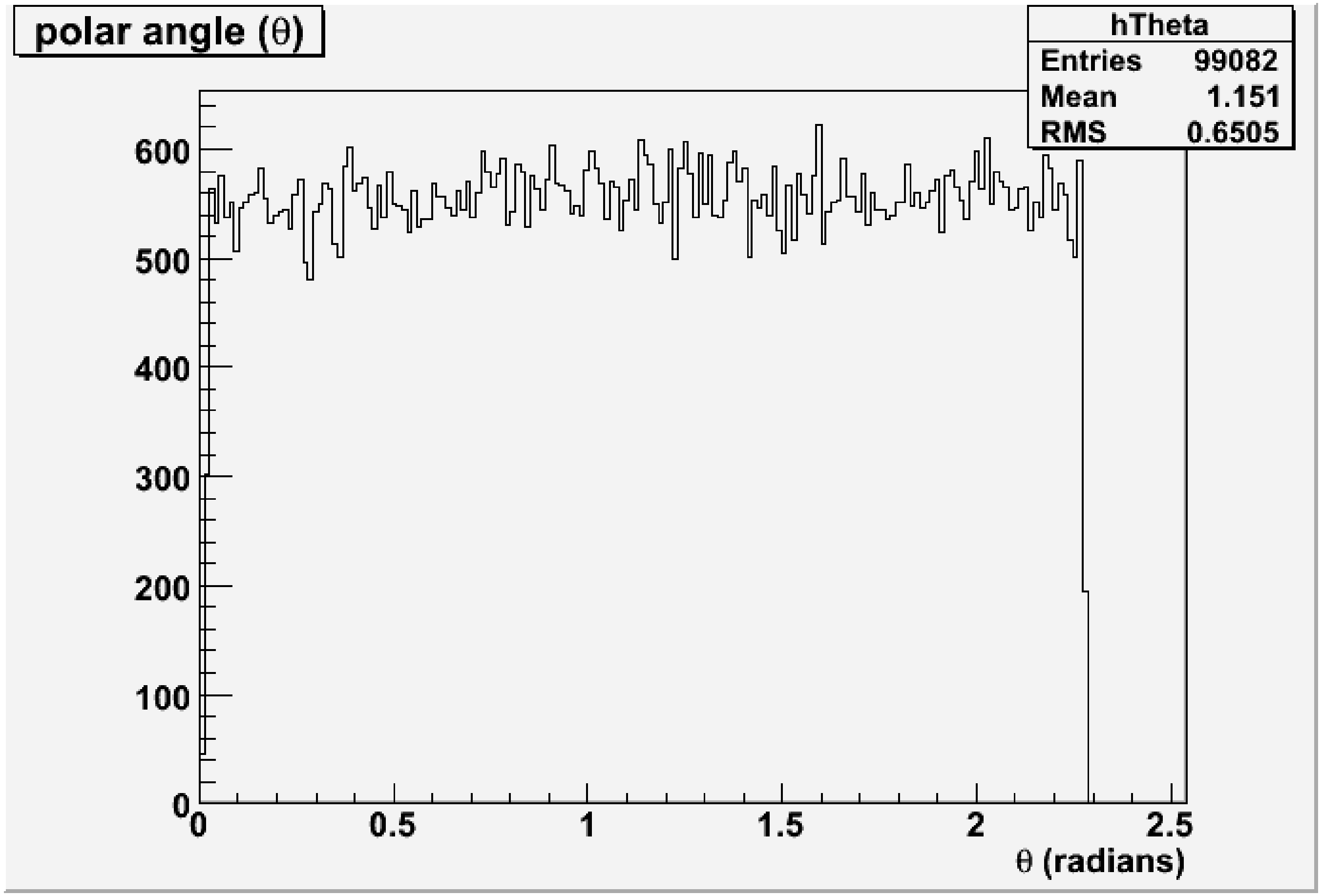
Monte Carlo Data Sample

- Thank you Simon
- Positive pions
- P = 2.0 GeV/c
- Uniform in theta and phi
- Fixed starting point:
  - $X'_0 = 0$
  - $z_0 = 65$ cm
- 100,000 events generated

Total momentum

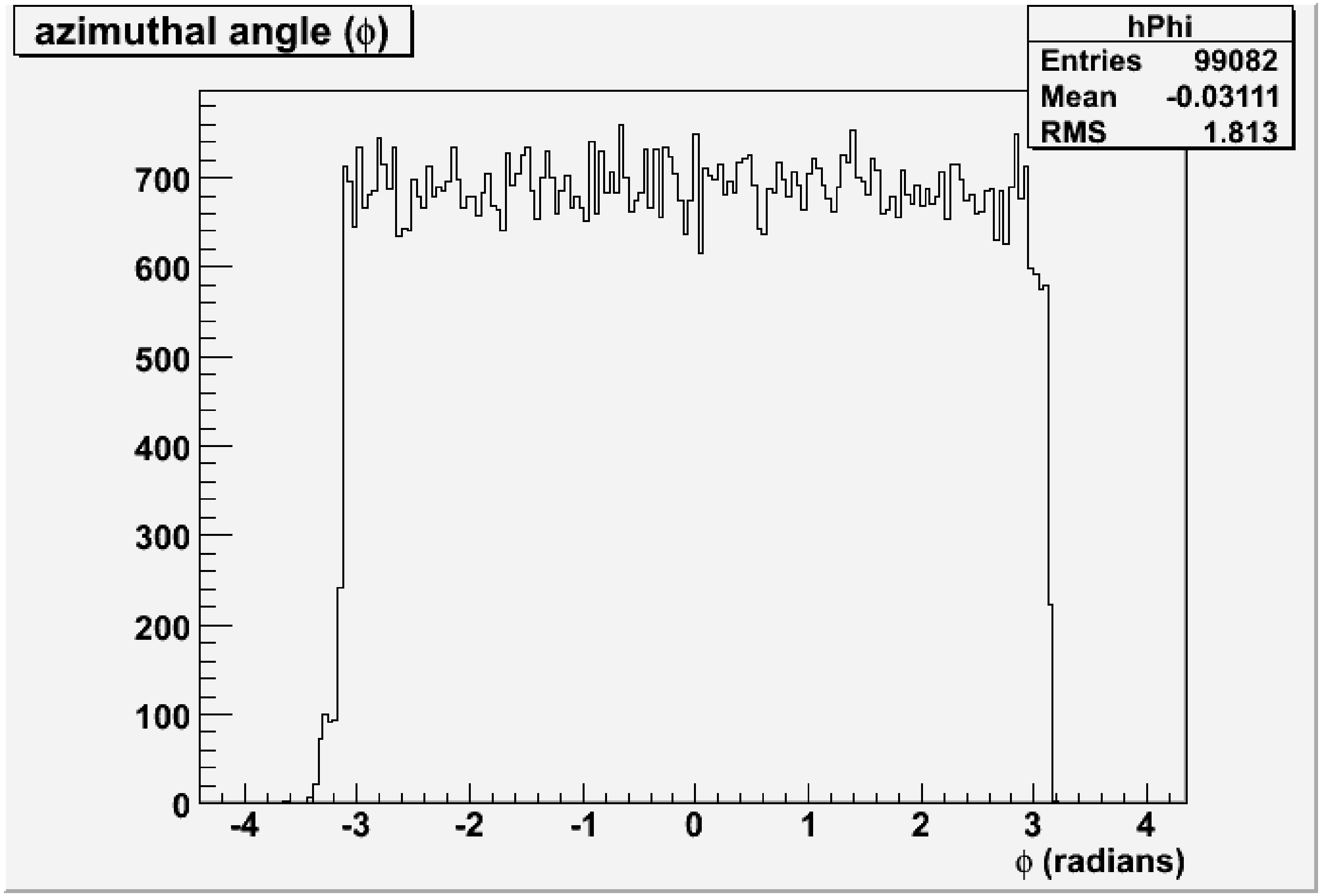


Polar angle

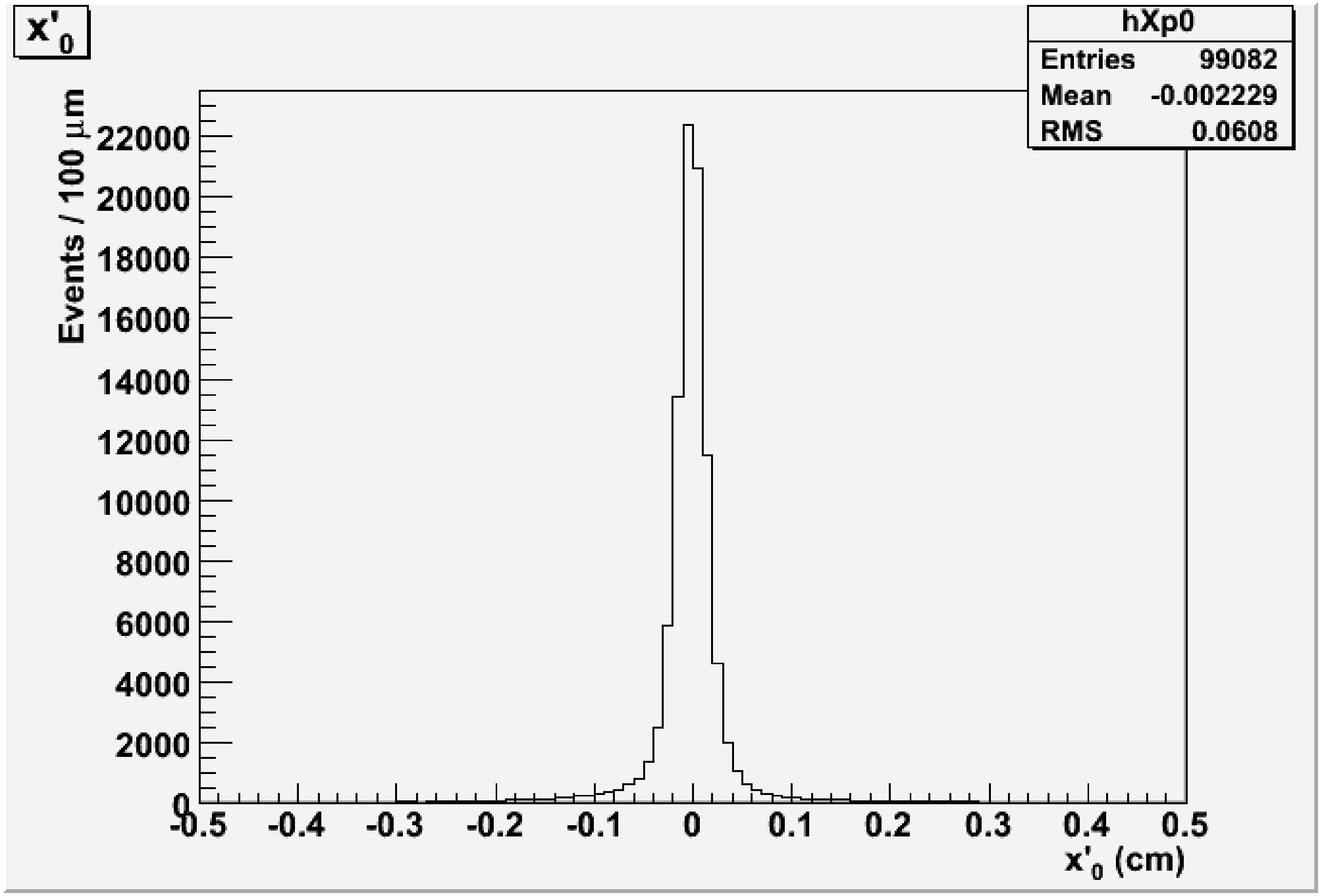


polar angle (θ)
hTheta
Entries 99082
Mean 1.151
RMS 0.6505
600
500
400
300
200
100
0
0
0.5
1
1.5
2
2.5
θ (radians)

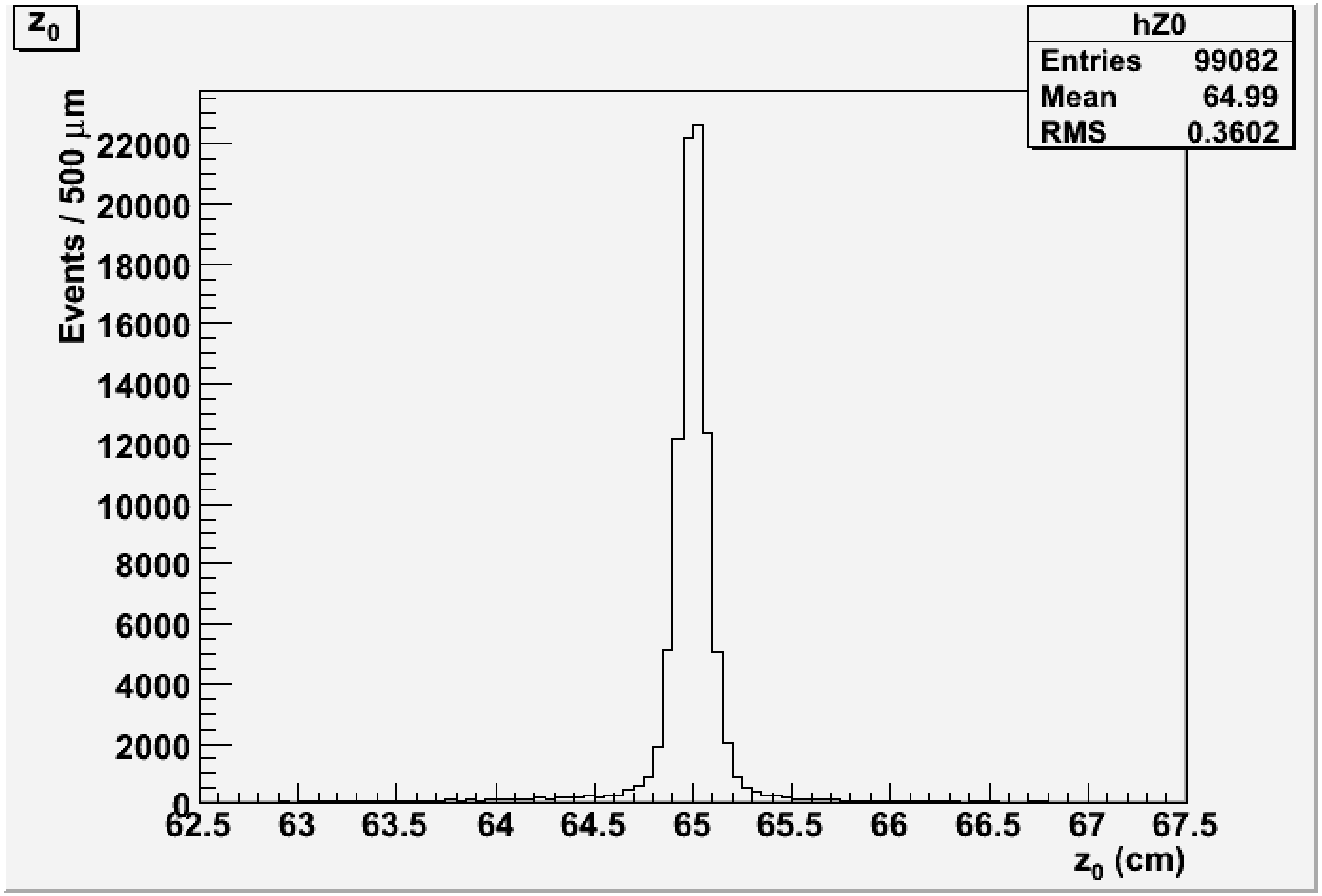
Azimuthal angle



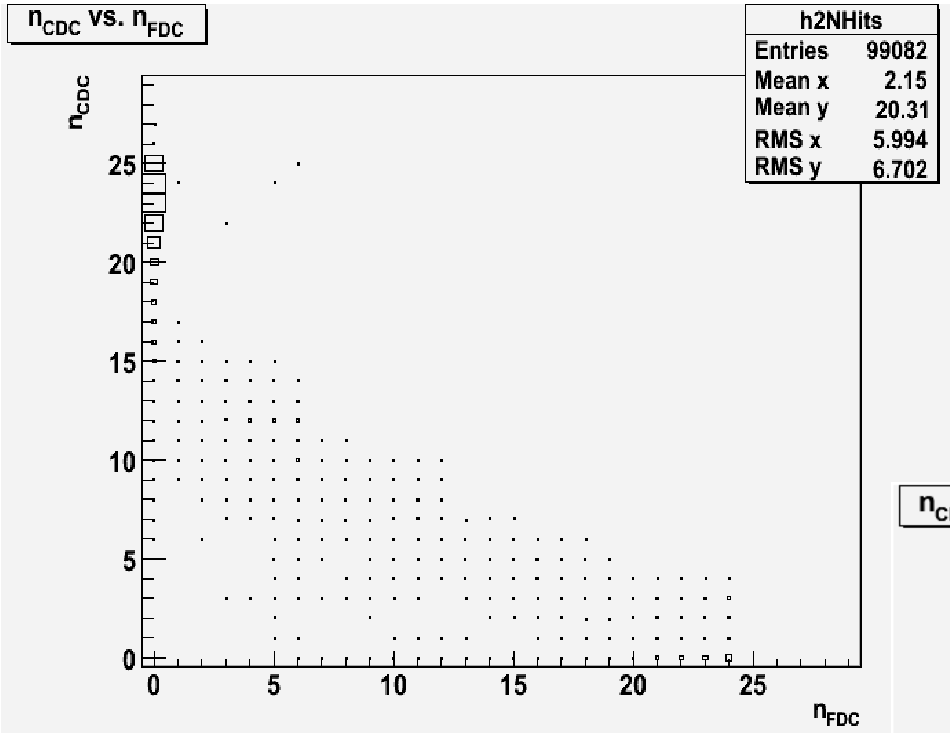
Transverse distance near beamline



Z-position near beamline

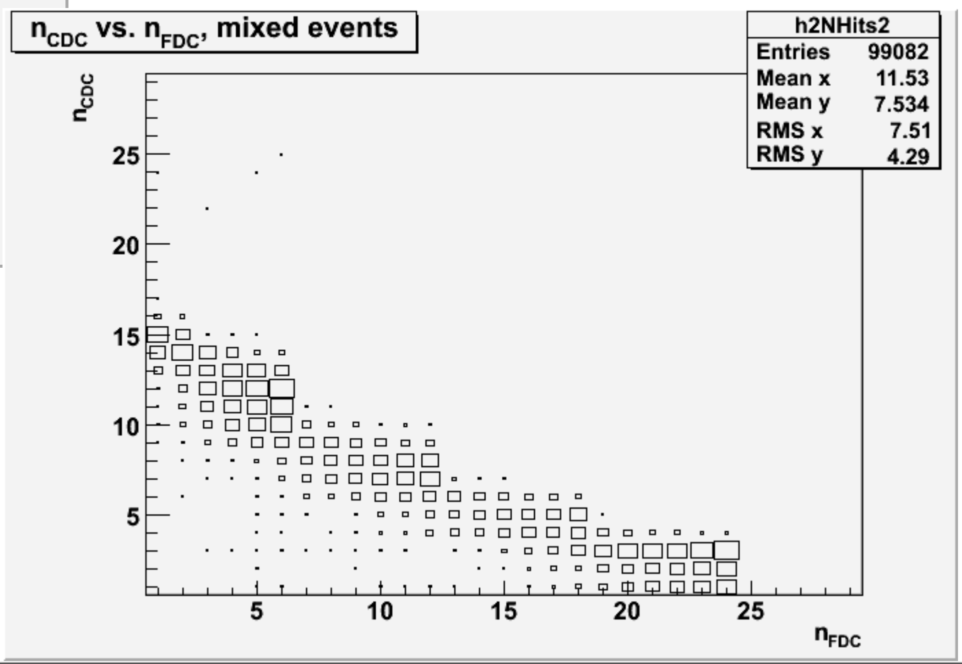


FDC/CDC Hit Distributions



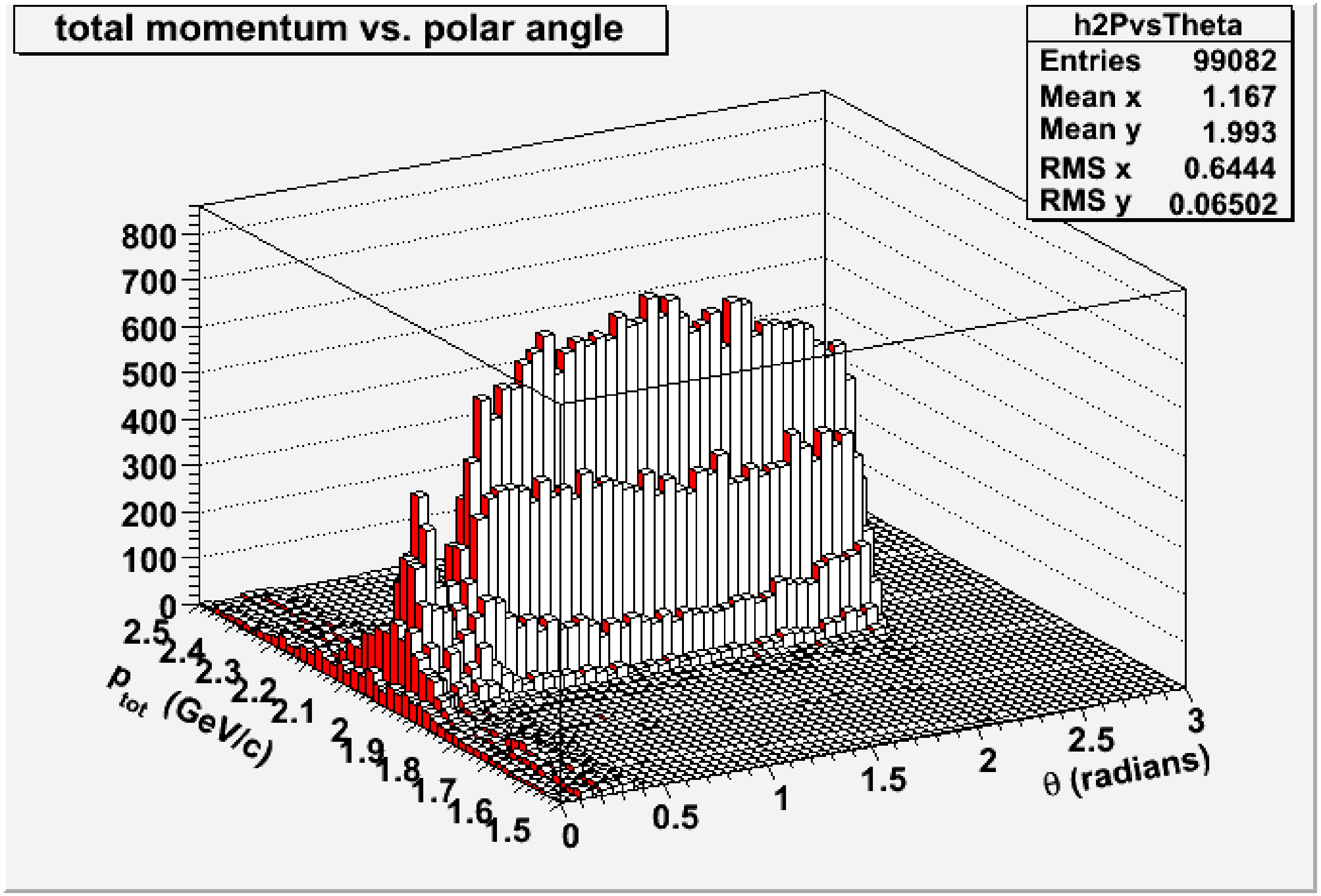
n_CDC vs. n_FDC

- All events



- Supress events where n_FDC = 0 or n_CDC = 0

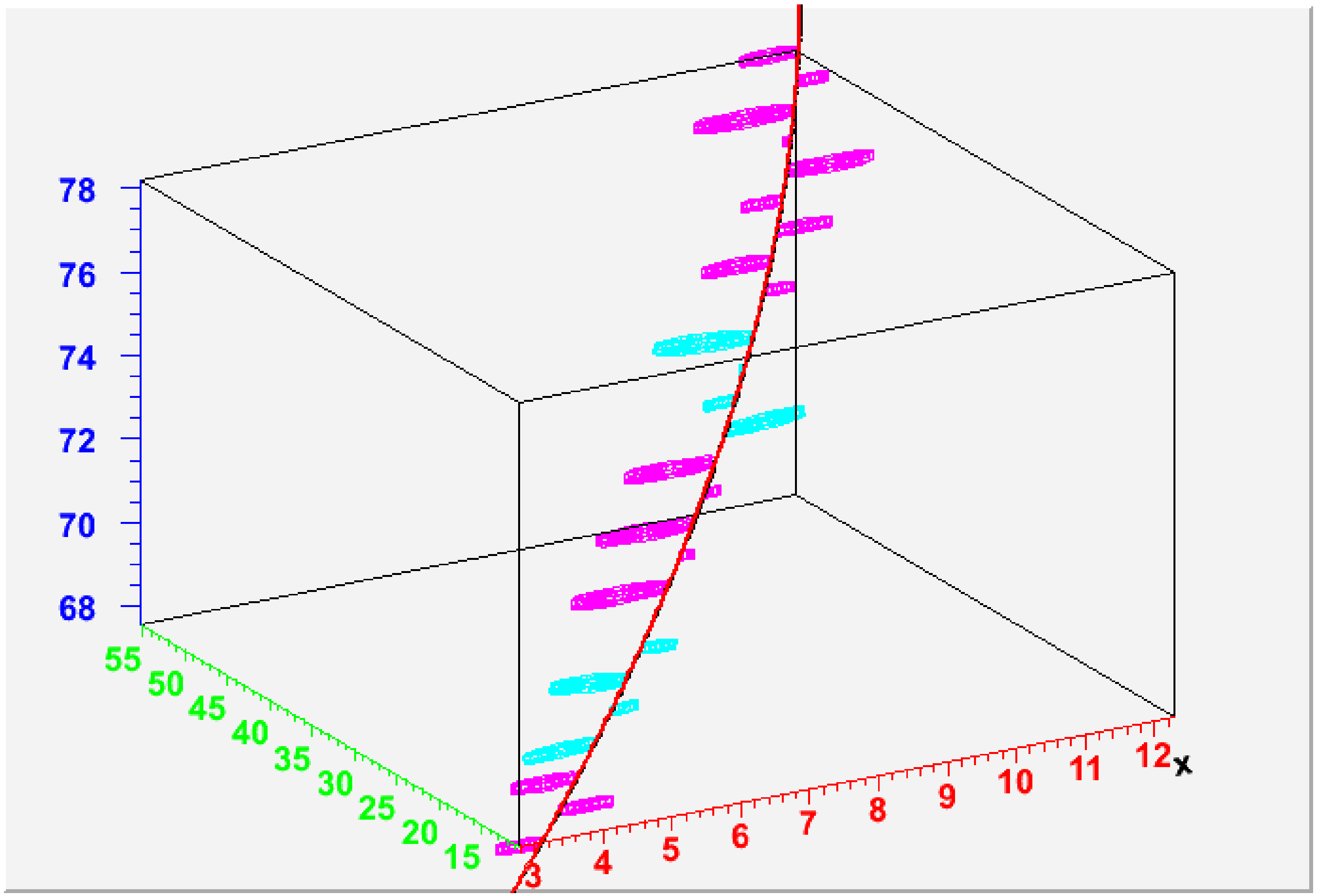
Momentum vs. polar angle



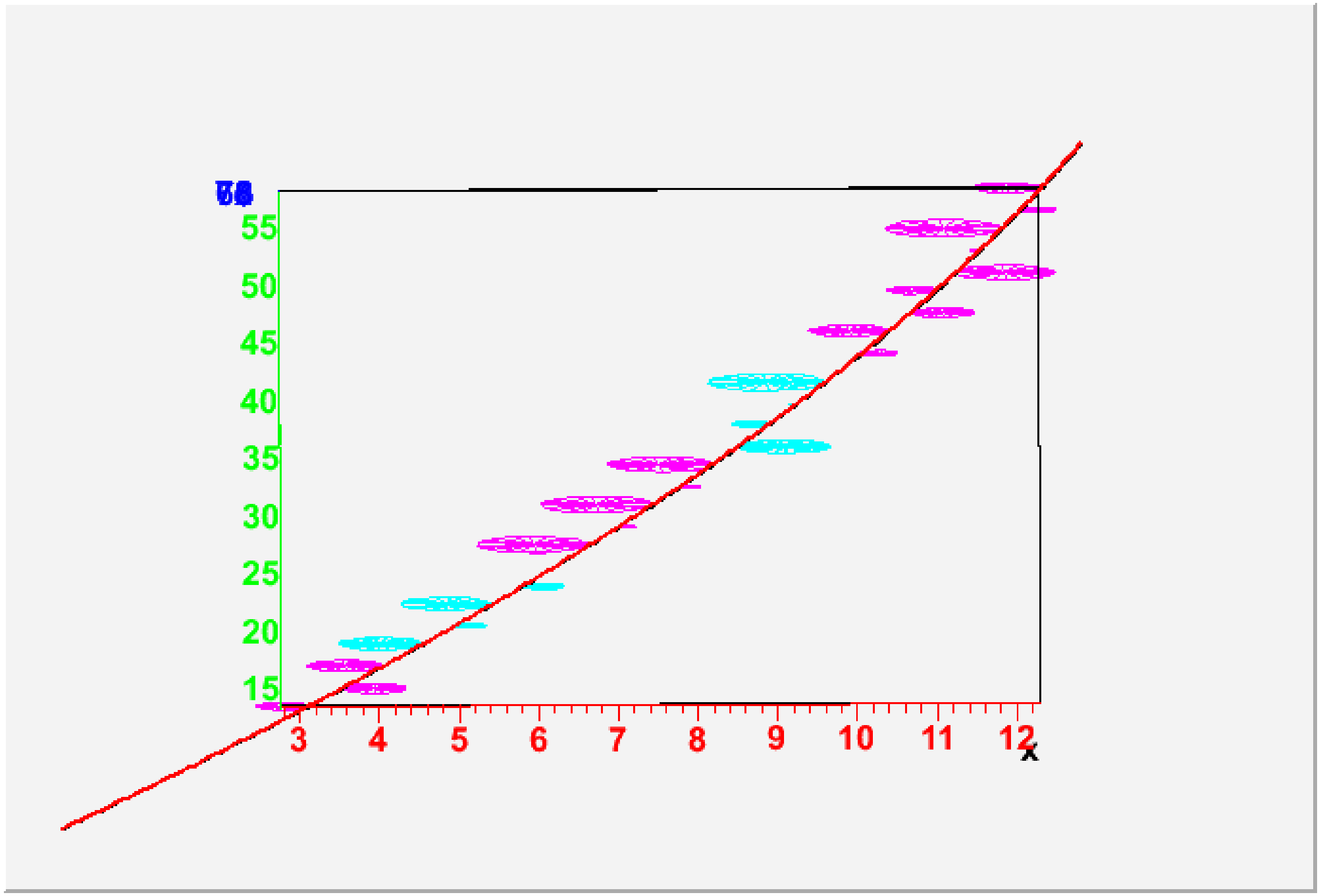
- Camel humps!

Event 1, 3-D fitter's view

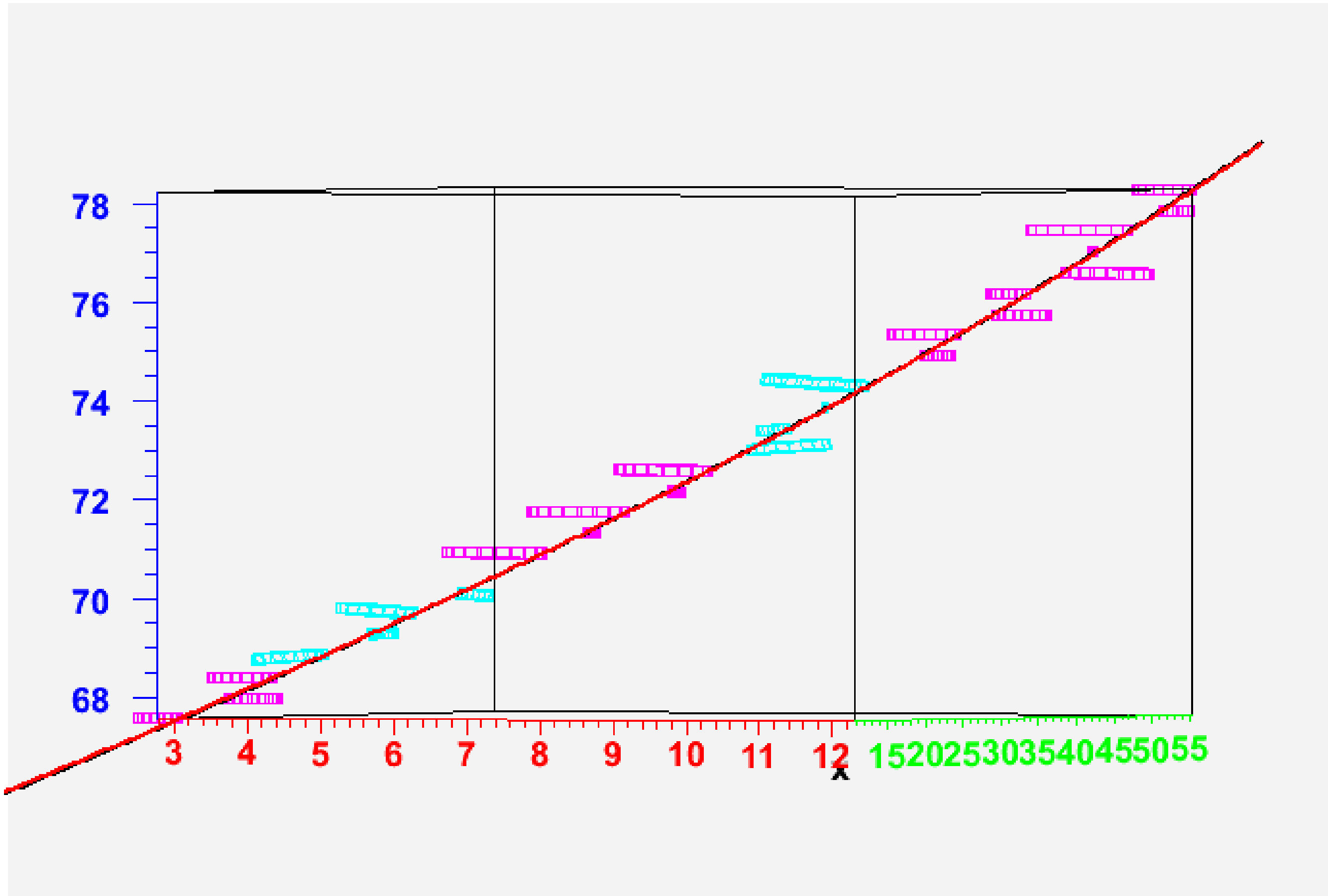
- Downstream is vertical (sorry)
- Axes: x=red, y=green, z=blue
- CDC-only event
- Axial straws in magenta, stereo in cyan
- Radius of cylinders = measured drift distance
- Fitted trajectory in red, starting trajectory in black
- Straws drawn only where near trajectory



Event 1, x-y view

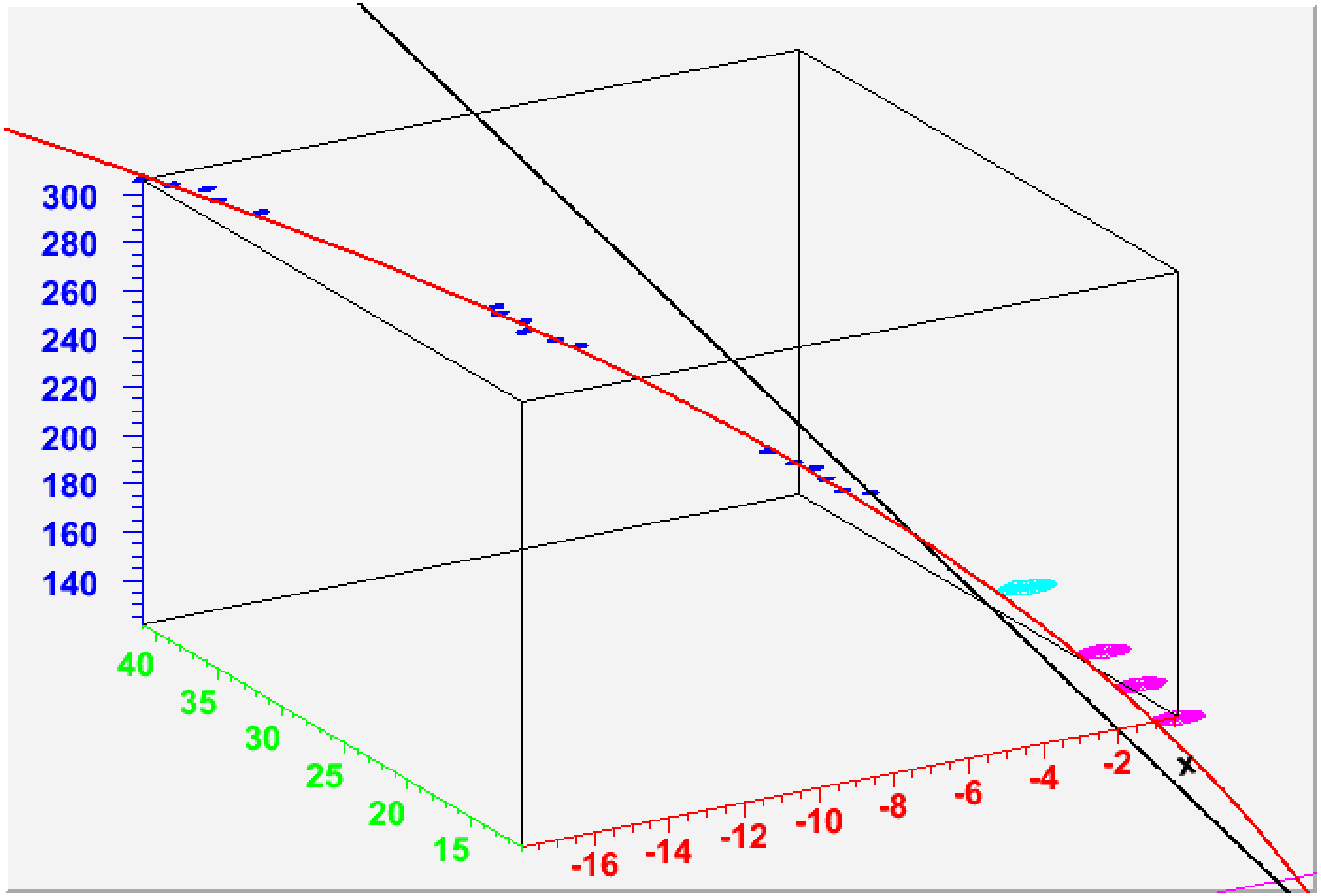


Event 1, z vs. x-y-mix



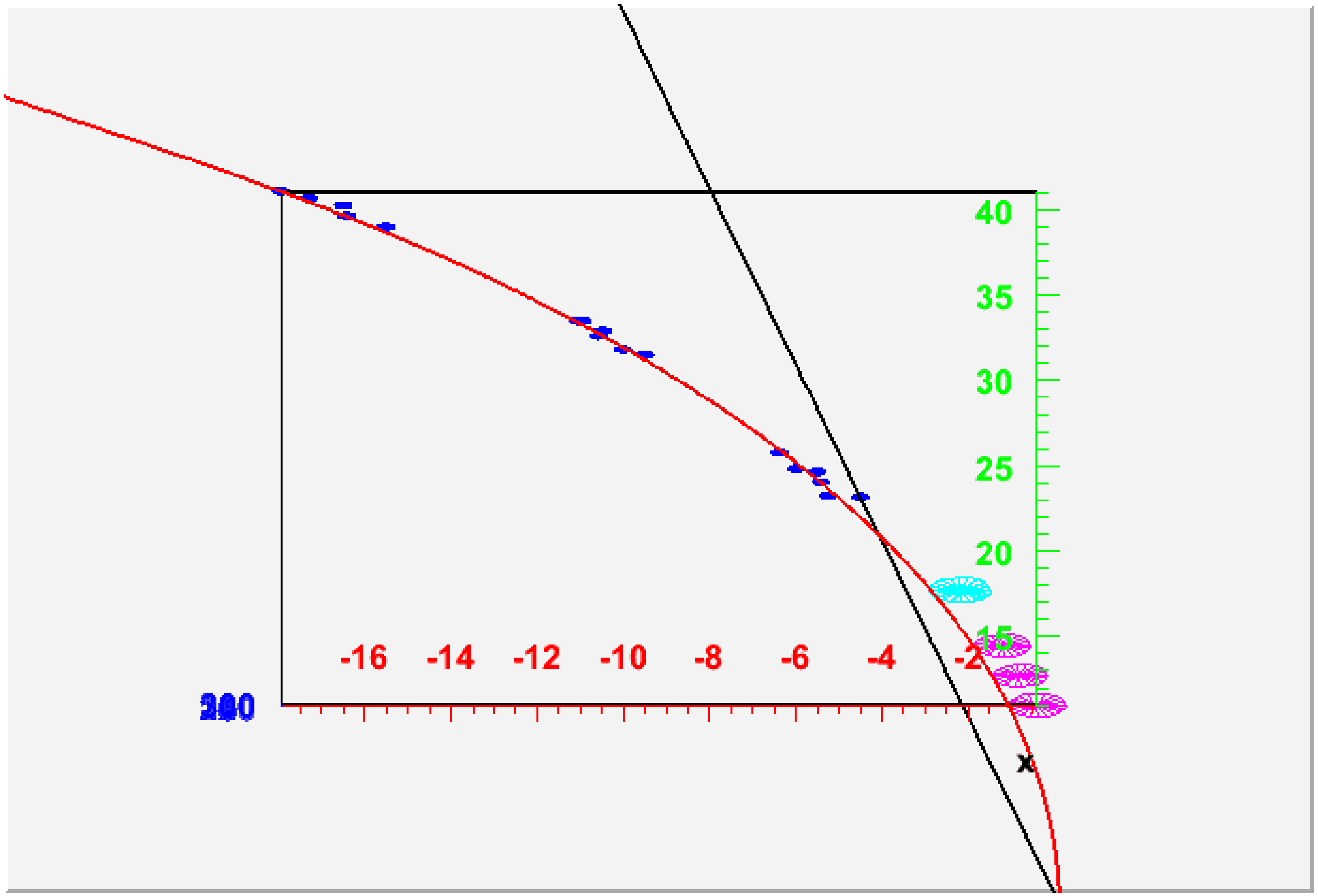
- Length of drawn portion of straws = 2 mm (arbitrary)
- Note tilt of stereo straws

Event 2, CDC + FDC

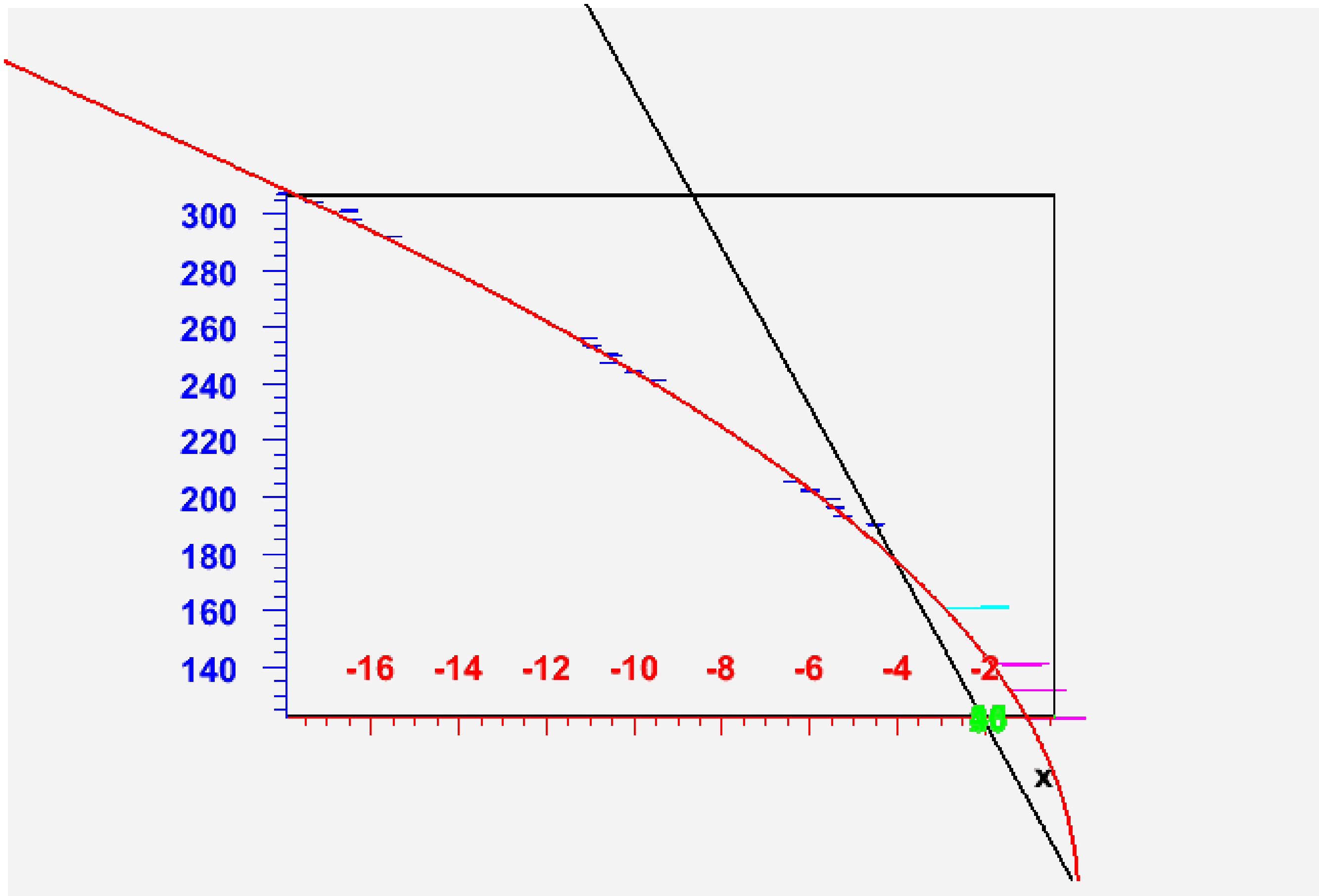


- FDC hits shown as blue spheres (arbitrary radius)
- No Lorentz correction in display (coming soon)

Event 2, x-y view



Event 2, x-z view



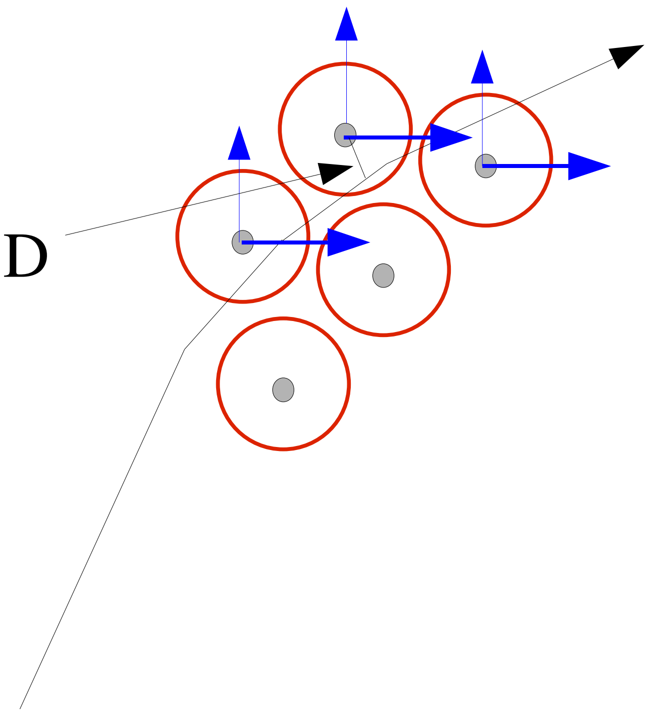
Summary of Mark's Work

- Robust convergence seen
- Local, non-global minima observed
- Wider event sample study needed
- Errors need to be studied (covariance matrix is produced by default)
- Software must be packaged for general users
- Ready to turn back on detector: design studies

Kalman Filter

- Algorithm originally developed for tracks with hits in FDC
  - State vector $\{x, y, t_x=dp_x/dp_z, t_y=dp_y/dp_z, q/p\}$
    - "Fitted" state vector considered as small perturbation relative to a seed
    - Seed determined from list of track candidates using helical model
    - Start with covariance matrix based on scaling track candidate resolutions
      - $\sigma(\Delta p/p) = 20\%$, $\sigma_x=1$ cm, $\sigma_y = 1$ cm, $\sigma(dx/dz)=10$ mrad, $\sigma(dy/dz)=10$ mrad
  - Measurements added one by one, starting with most downstream
    - Multiple scattering and energy loss can be taken into account when stepping from measurement to measurement
      - Currently use air for most material, but include CDC endplate
  - Iterate 5 times, choose result for state vector S with smallest χ^2
- CDC hits are now also included...

Using CDC hits

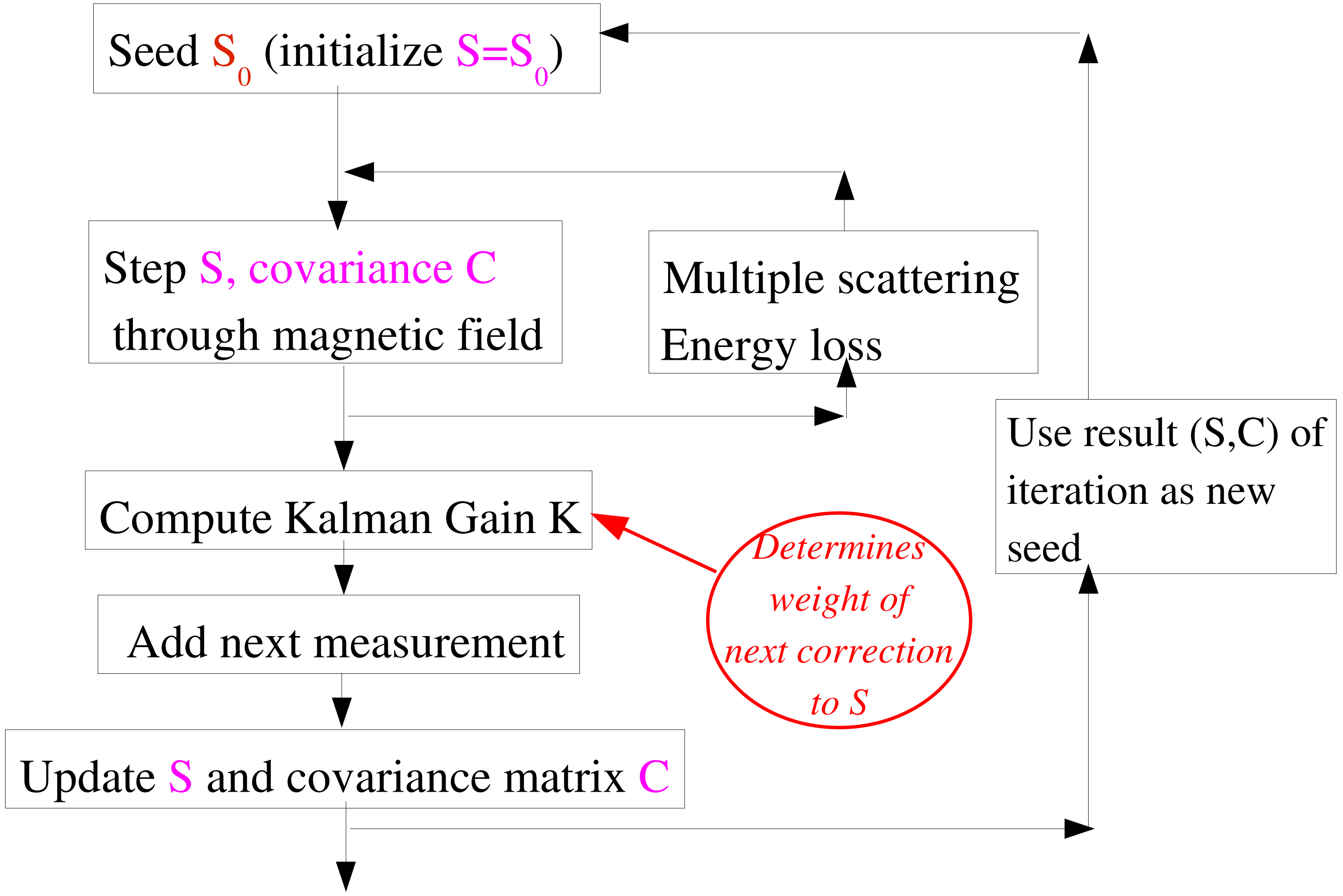


- Transform from forward parameters, **{q/p, x, y, dx/dz, dy/dz}** to central parameters, **{q/p_T, ϕ, tan λ , D, z}**
  - D is distance of closest approach to the wire
  - Origin of coordinate system for D moves from wire position to wire position as hits are added
    - Approach introduces steps in D!
    - Need additional rotations of covariance matrix
- Initial guess for covariance matrix (off-diagonal elements=0)

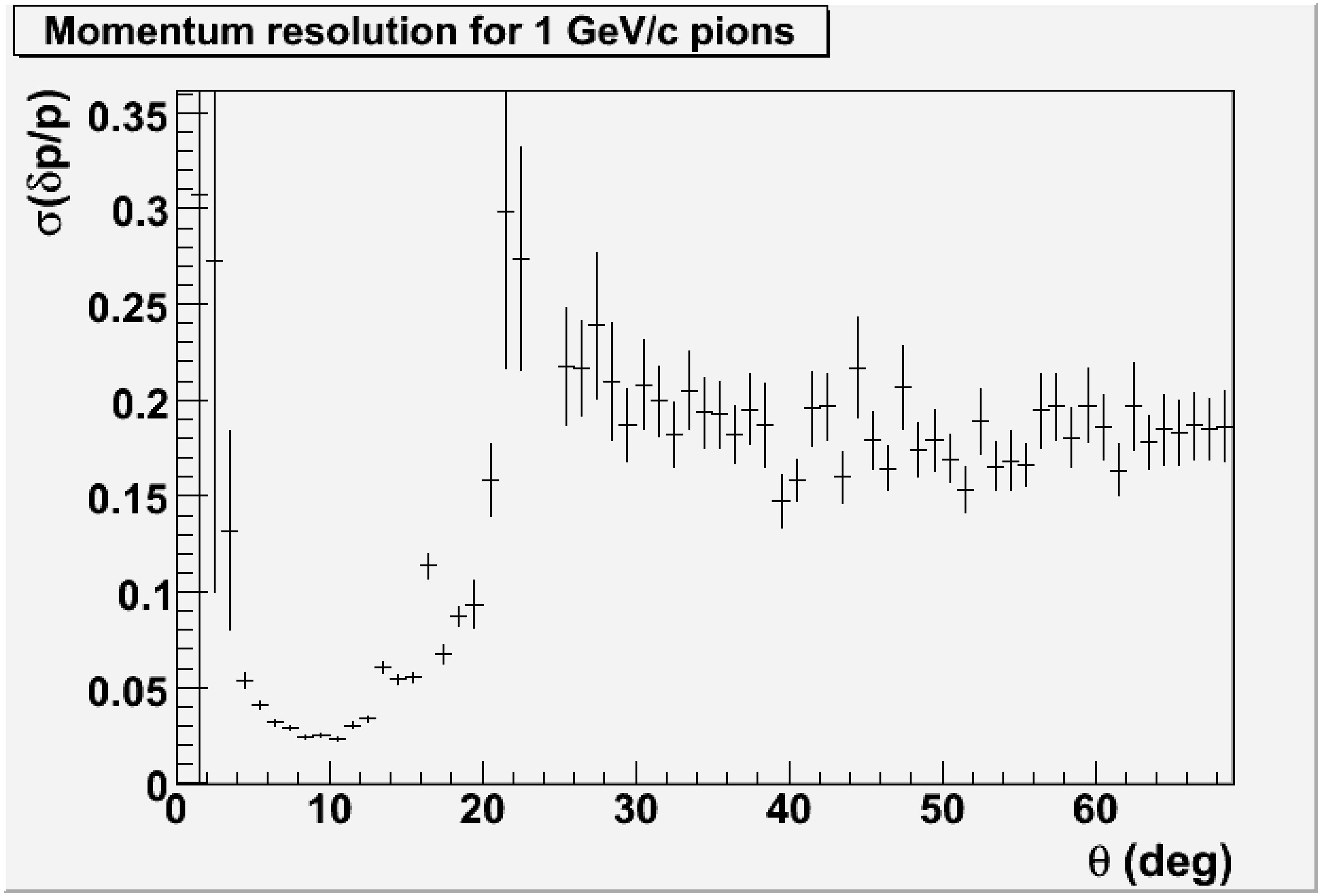
$\sigma(\Delta p_T/p_T) = 20\%$, σ_D=1 mm, σ_z = 1 mm, σ_ϕ=15 mrad, $\sigma_\lambda = 2.1 - 0.34\,\theta + 0.035\,\theta^2$ mrad

Algorithm

Start with seeds coming from CDC and FDC track finding code (helical fits)

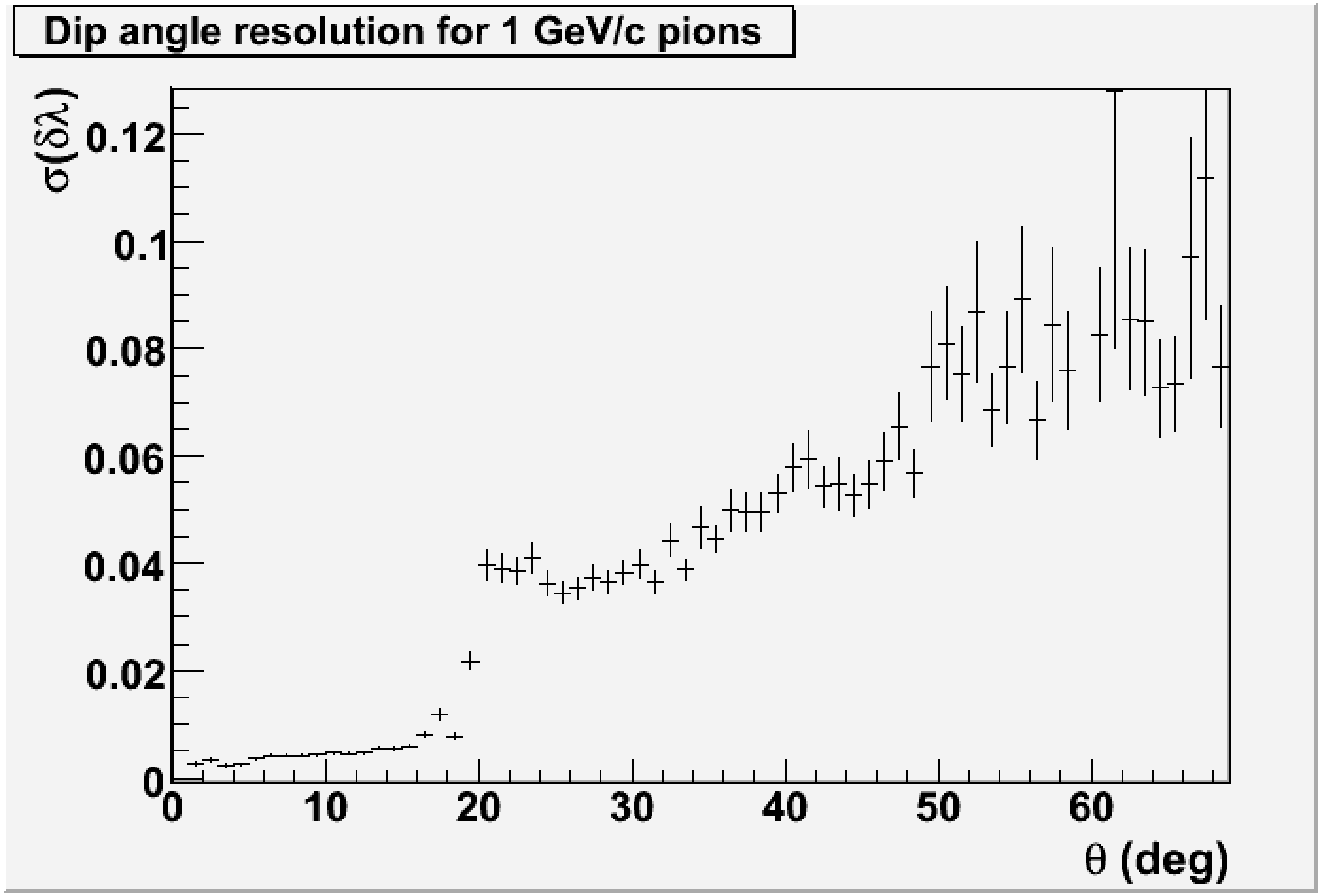


Momentum Resolution

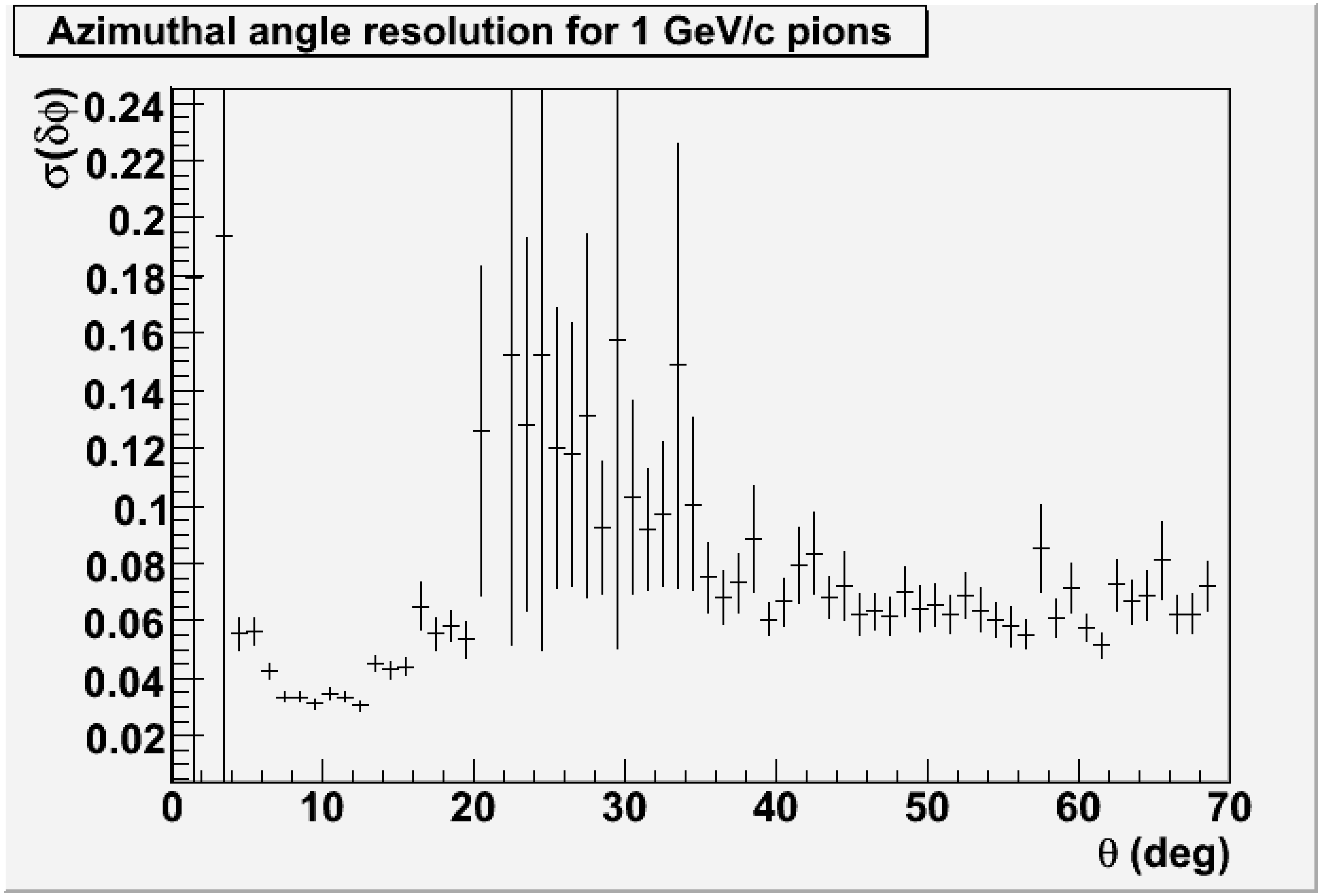


Relative difference between thrown and reconstructed values

Dip Angle Resolution



Azimuthal Angle Resolution



Conclusion on Kalman Filter Dev.

- Kalman filter working reasonably well for very forward going tracks
- Poor resolution for more central tracks
- Iteration for tracks in CDC alone does not work, tends to diverge
- Tricky part is getting the errors right – still working on this ...