Global Reconstruction Update

Peter Lane
Illinois Institute of Technology
MICE Collaboration Meeting 38

Outline

- Track Fitting Algorithm
- Current State of Affairs
- Beam Definition
- Detector Resolutions
- Selected Reconstruction Examples
  - Show that fitting algorithm is valid
  - Tracker reconstruction issues
- Summary

Track Fitting Algorithm

1. Solve linear least squares equation for each target location in MICE
    - Each estimator maps 6D primary particle coordinates (points) to coordinates at a target location (measurement)
    - Generate estimators using MC simulation
2. Use Minuit to find common primary for actual measurements by searching for min. total χ^2
    - Only partial measurements!

Current State of Afairs

- Naive, single-particle, single-track version of algorithm is implemented
- TOF reconstruction works
    - Validated with Monte Carlo instead of space points
    - Space points reconstructed within detector resolution
- Tracker reconstruction has issues

Beam Definition

- Fire 100 muons upstream of TOF0
  - No decays. Mean energy loss only.
- Longitudinal Parameters:
  - Gaussian distribution in Pz
  - Mean Pz: 200. MeV/c (Mean E: ~226. MeV)
  - σ_{pz}: 0.01 MeV/c (approx. monochromatic)
- Transverse Parameters:
  - $\sigma_{x,y}$: 50 mm
  - $\sigma_{Px,Py}$: .01 MeV/c (approx. axial)

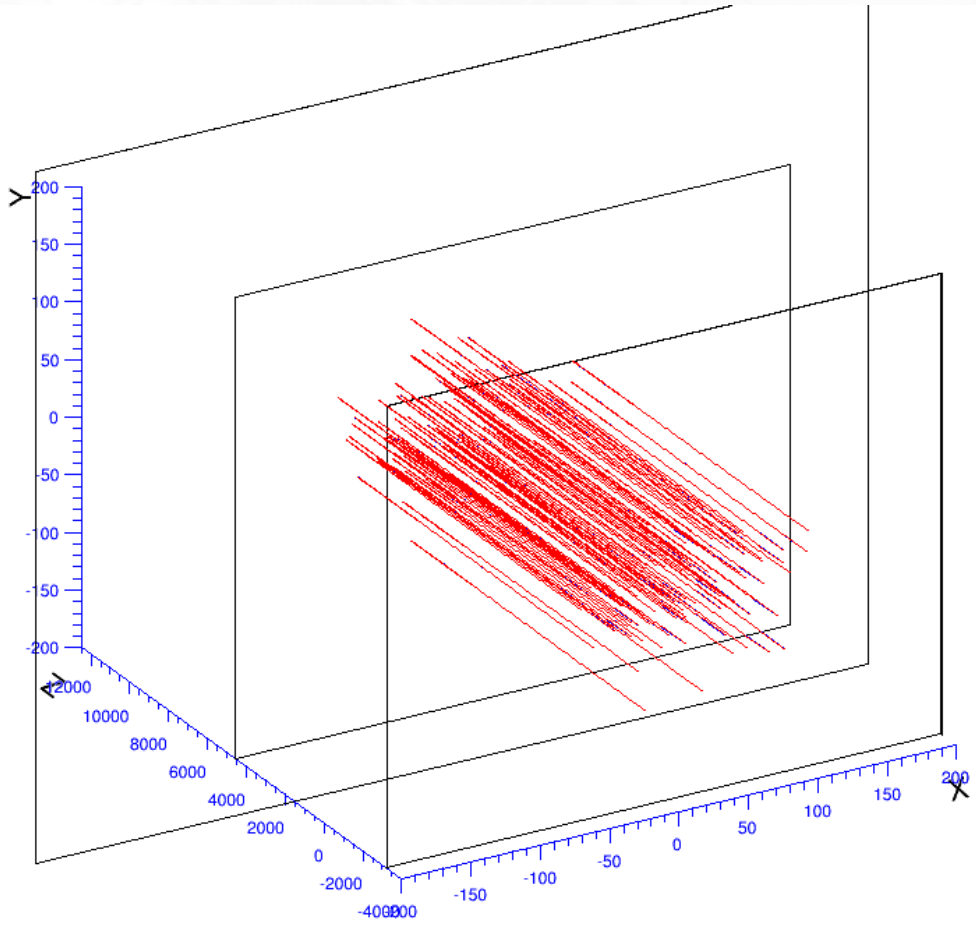
Detector Resolutions

- TOF0
  - $\delta t \simeq 70ps$, $\delta x = \delta y = 12mm$
- TOF1
  - $\delta t \simeq 70ps$, $\delta x = \delta y = 17mm$
- Tracker (Pz=200MeV/c)
  - $\delta x \simeq .1mm$
  - $\delta Pt = 1.4MeV/c$, $\delta Pz = 2.6MeV/c$
  - $\delta E = 2.3MeV$ (propagated)

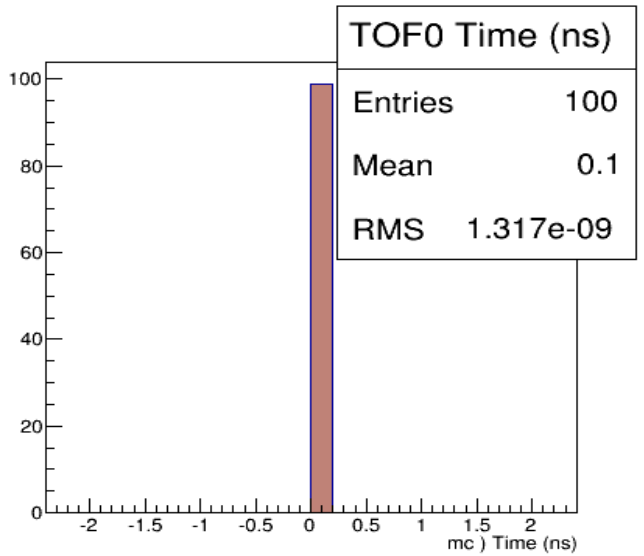
TOF Geometry MC Reconstruction

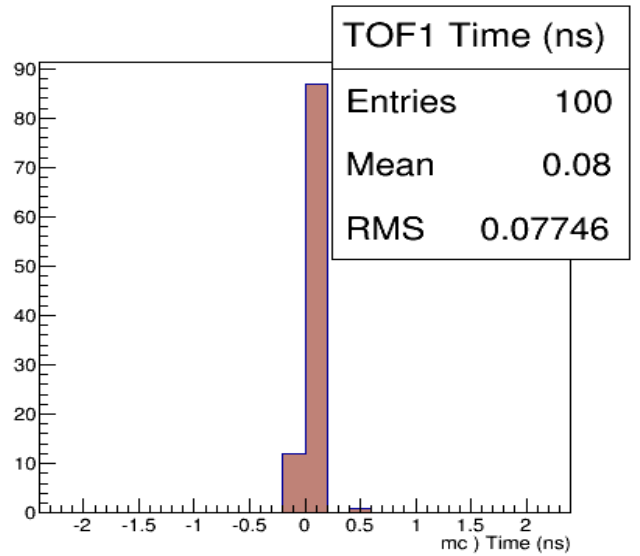
- Geometry: TOF0, TOF1, TOF2 (no B field)
- Using Monte Carlo instead of space points
- Validate fitting algorithm

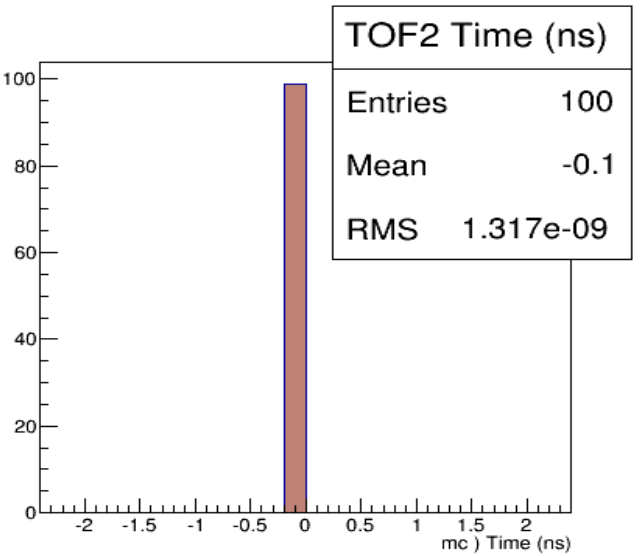
TOF Geometry MC Tracks

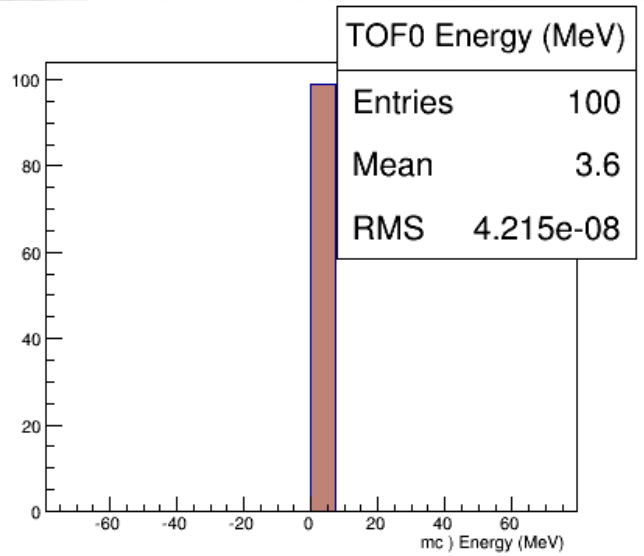


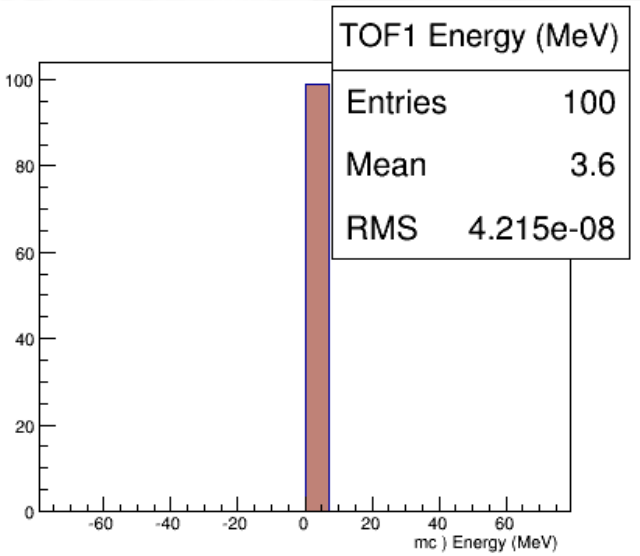
TOF Geometry MC t & E Residuals

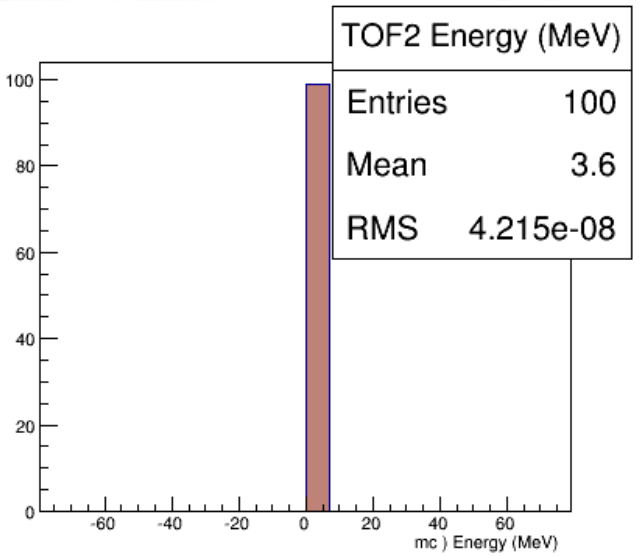




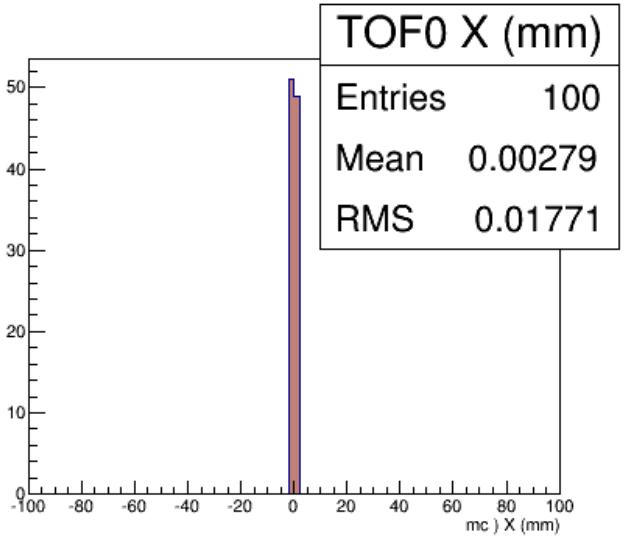


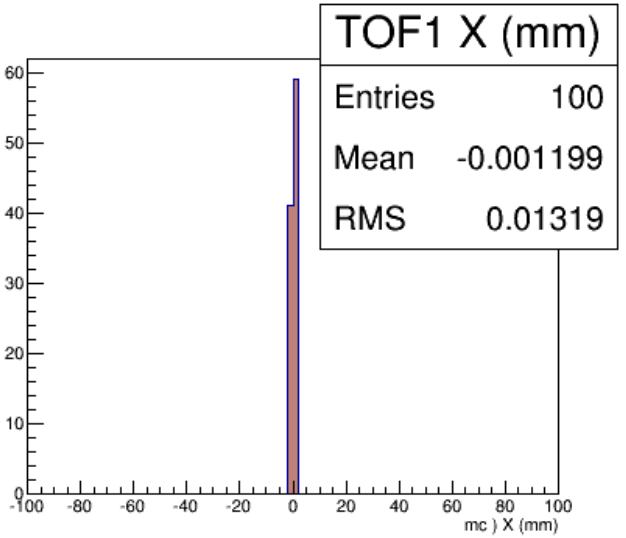


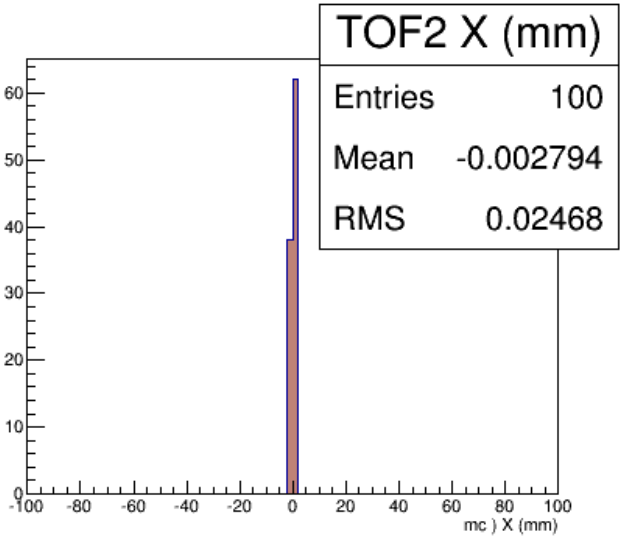


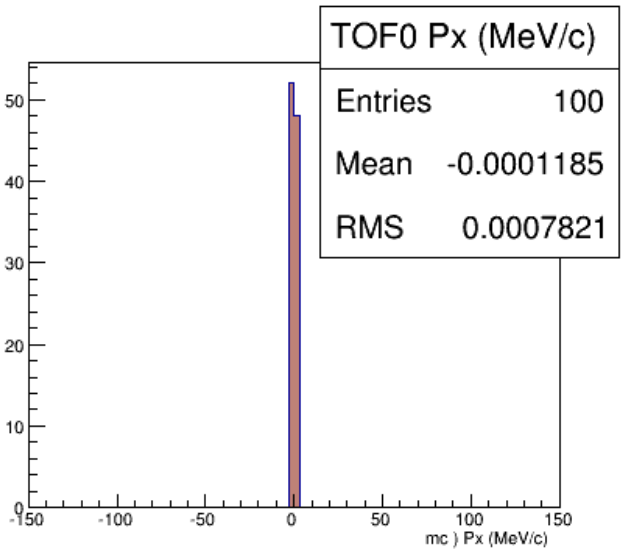


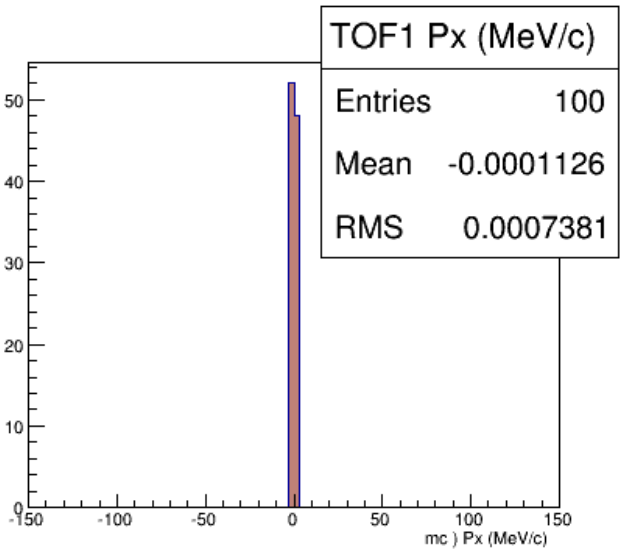
TOF Geometry MC x & Px Residuals

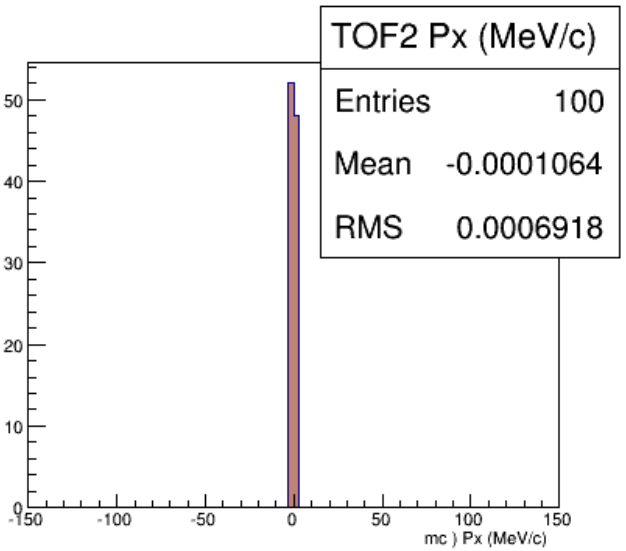












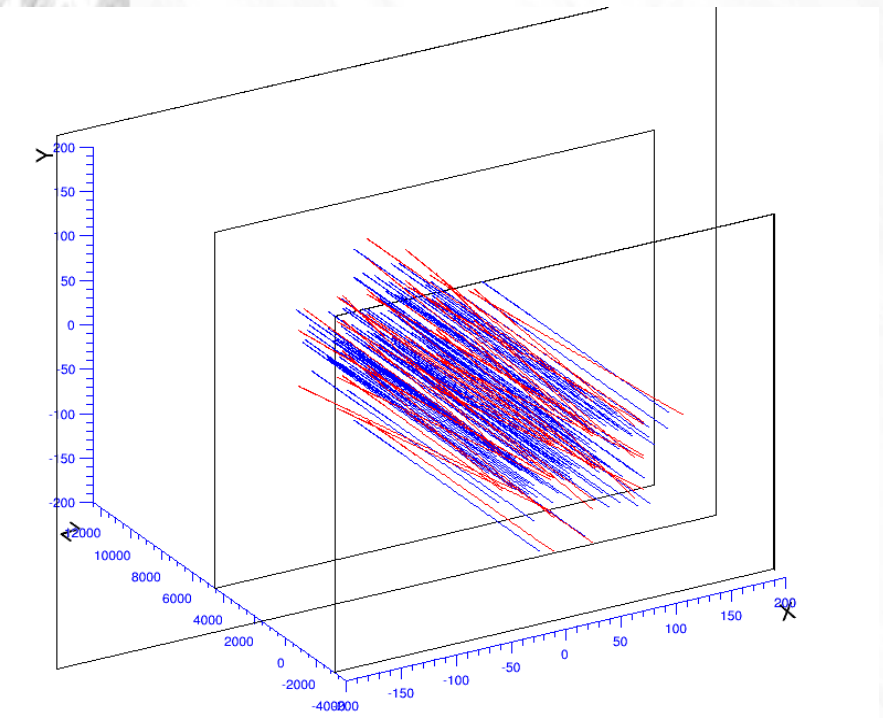
TOF Geometry Reconstruction

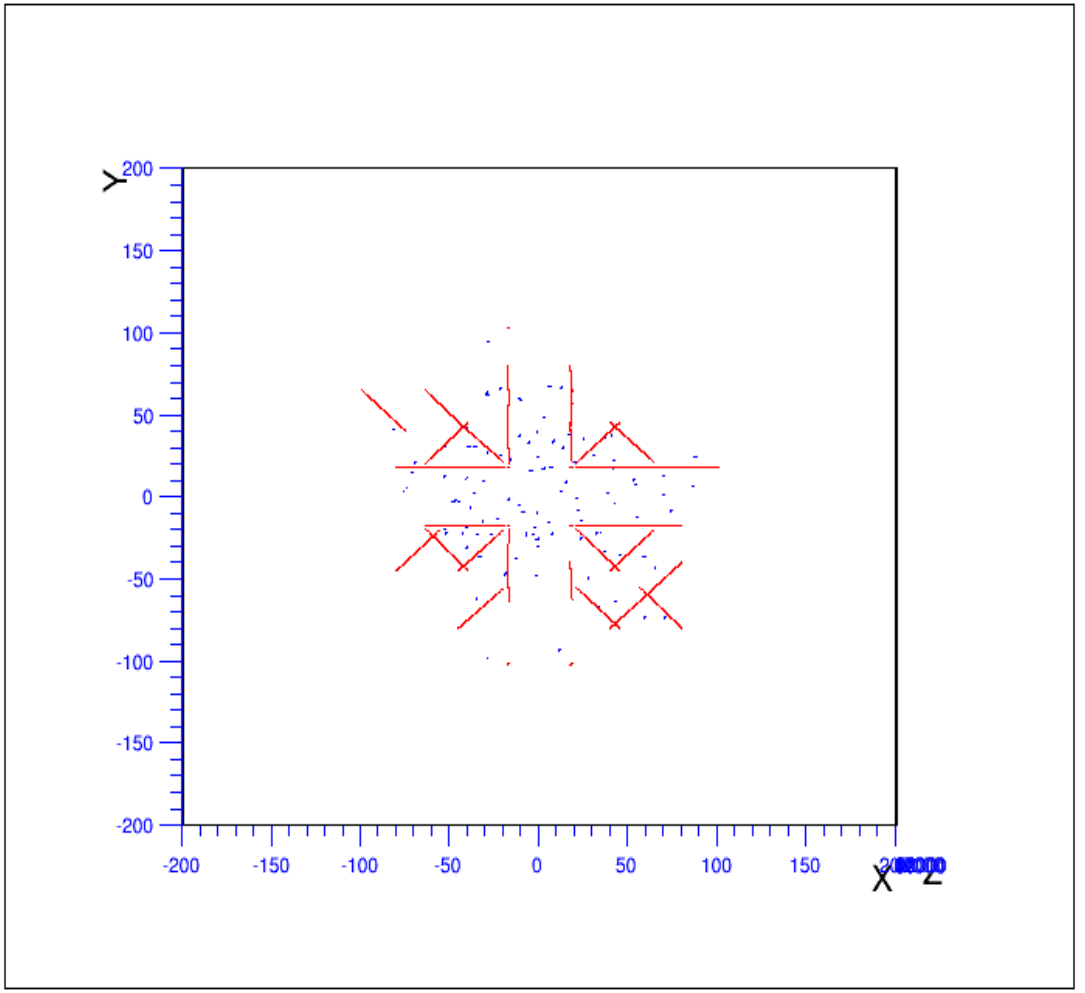
- Geometry: TOF0, TOF1, TOF2 (no B field)
- Time reconstructed better than space points
- Coarse x, y measurements lead to lower reconstructed energy (longer path)
- Transverse position reconstruction good
- Note: TOF0 slab centers at 20, 60, 100mm

  TOF1 slab centers at 0, 60, 120mm

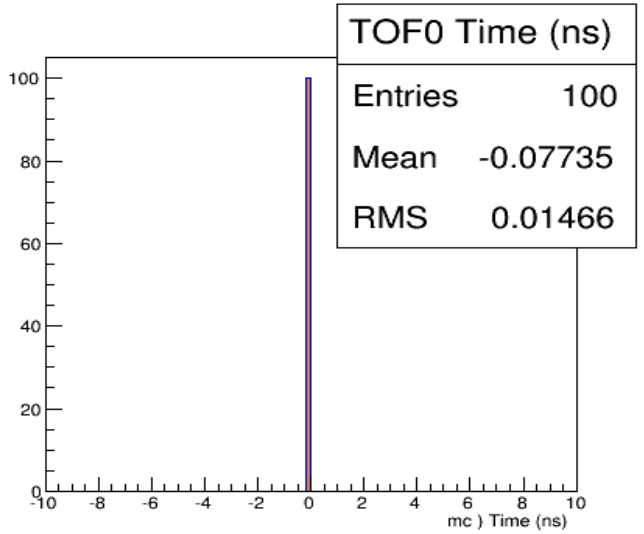
  TOF2 slab centers at 30, 90, 150mm

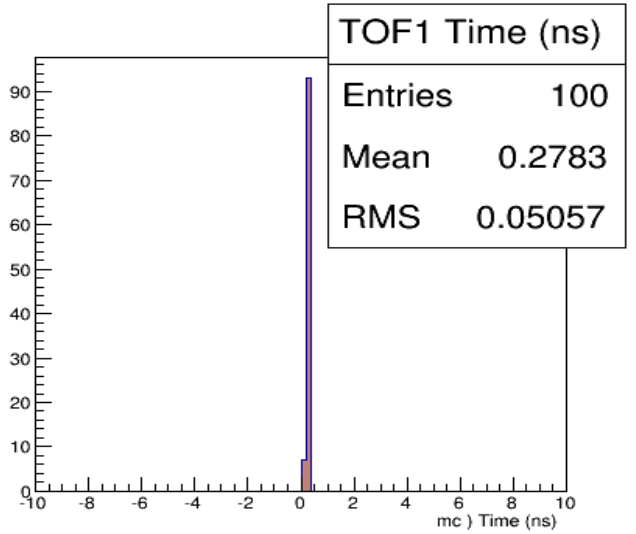
TOF Geometry Tracks

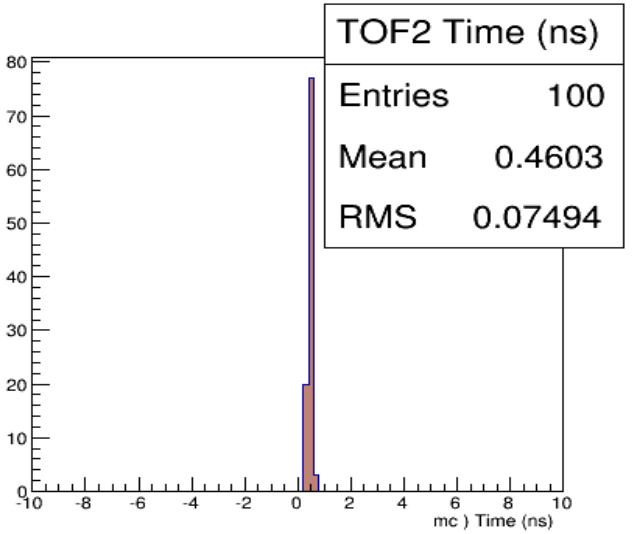


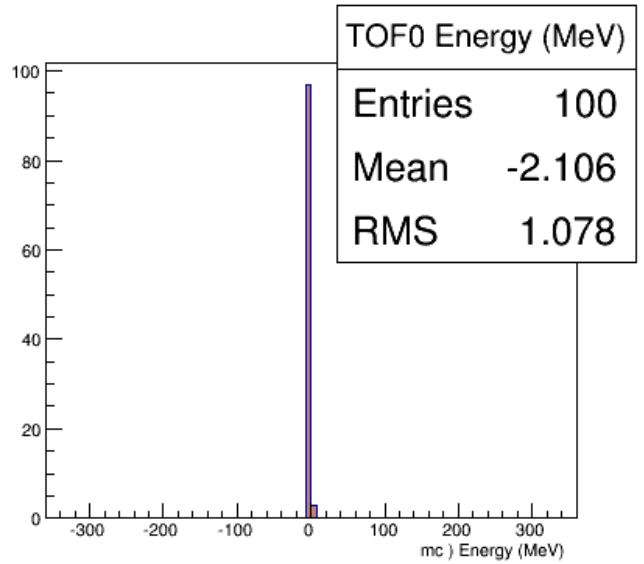


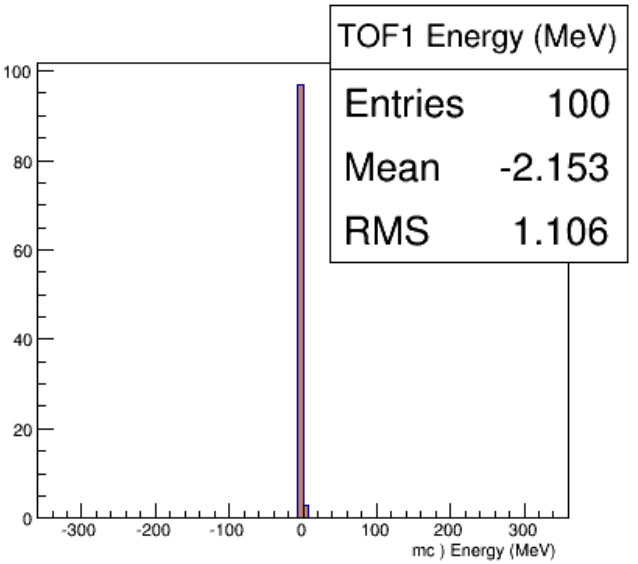
TOF Geometry t & E Residuals

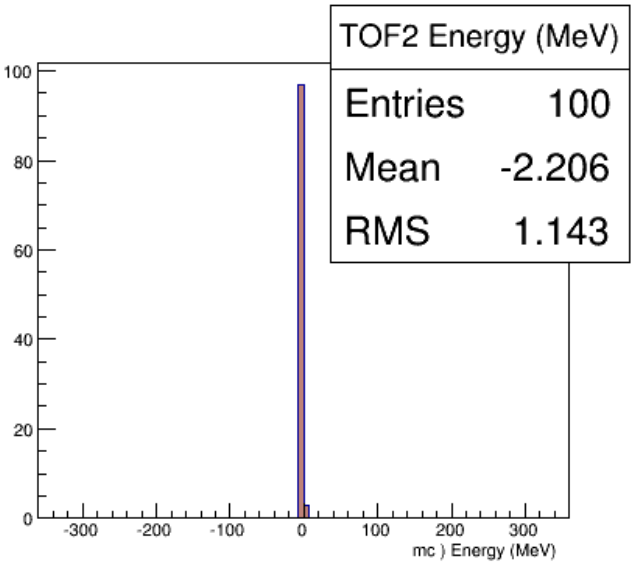




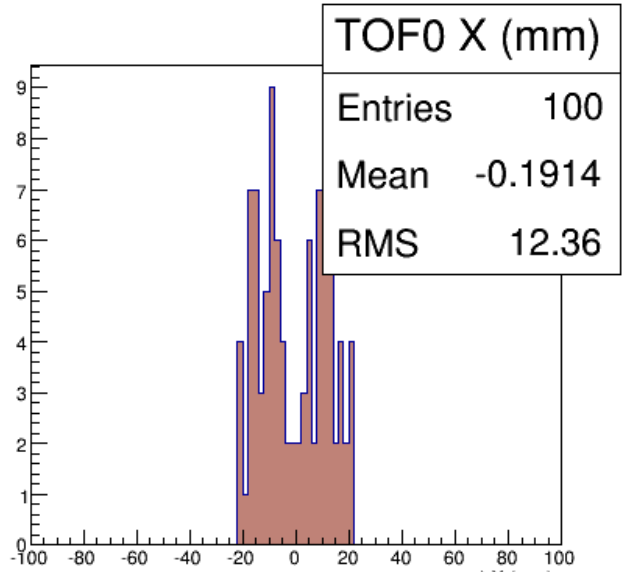


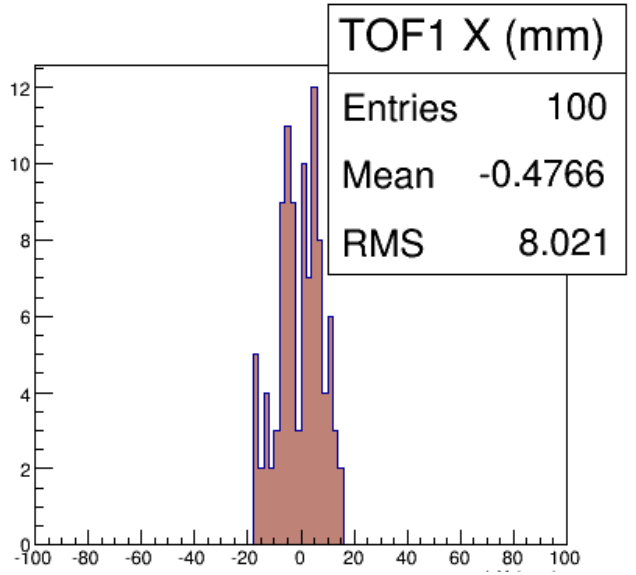


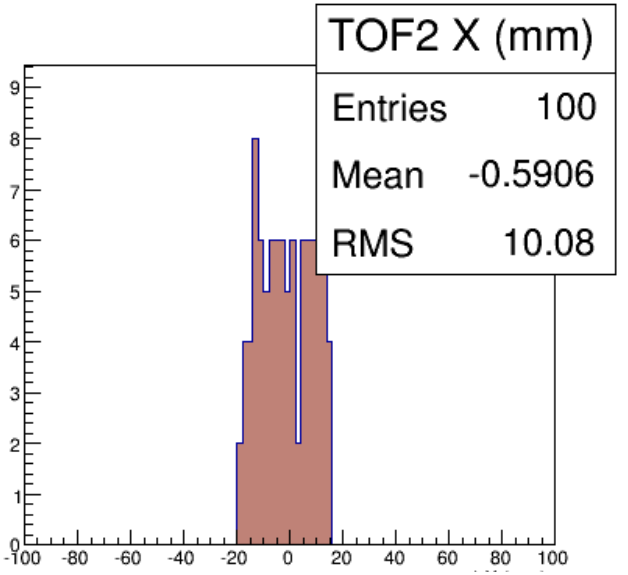


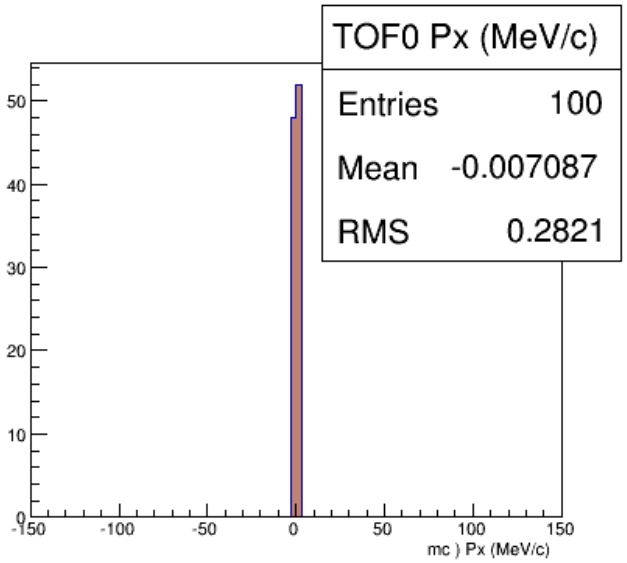


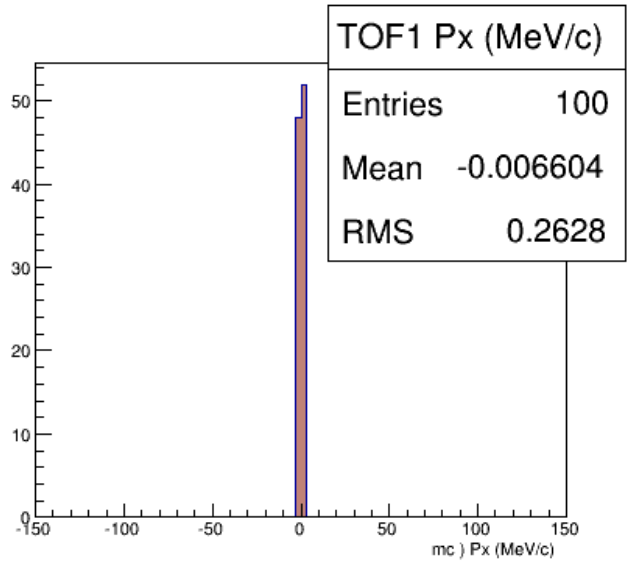
TOF Geometry x & Px Residuals

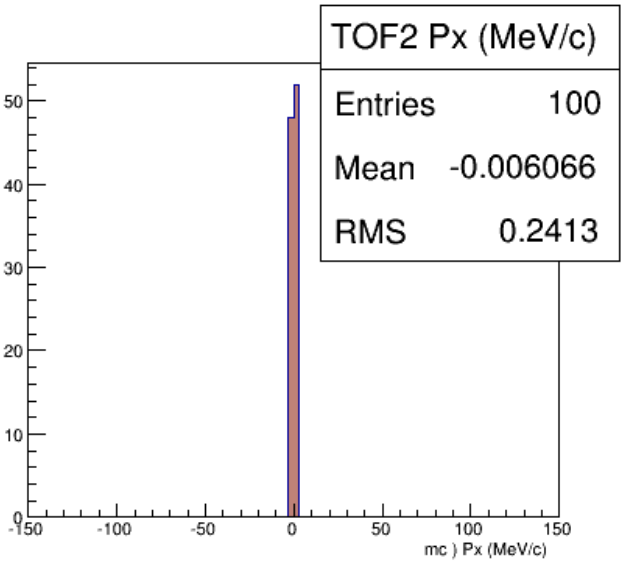








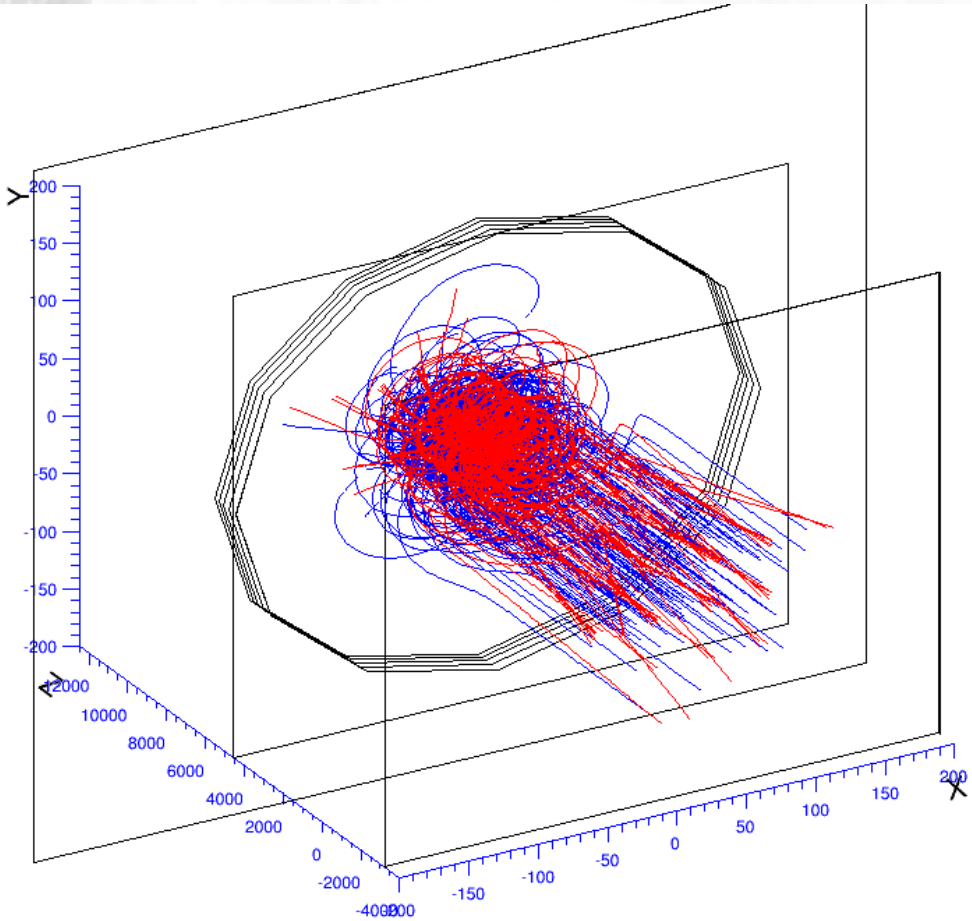


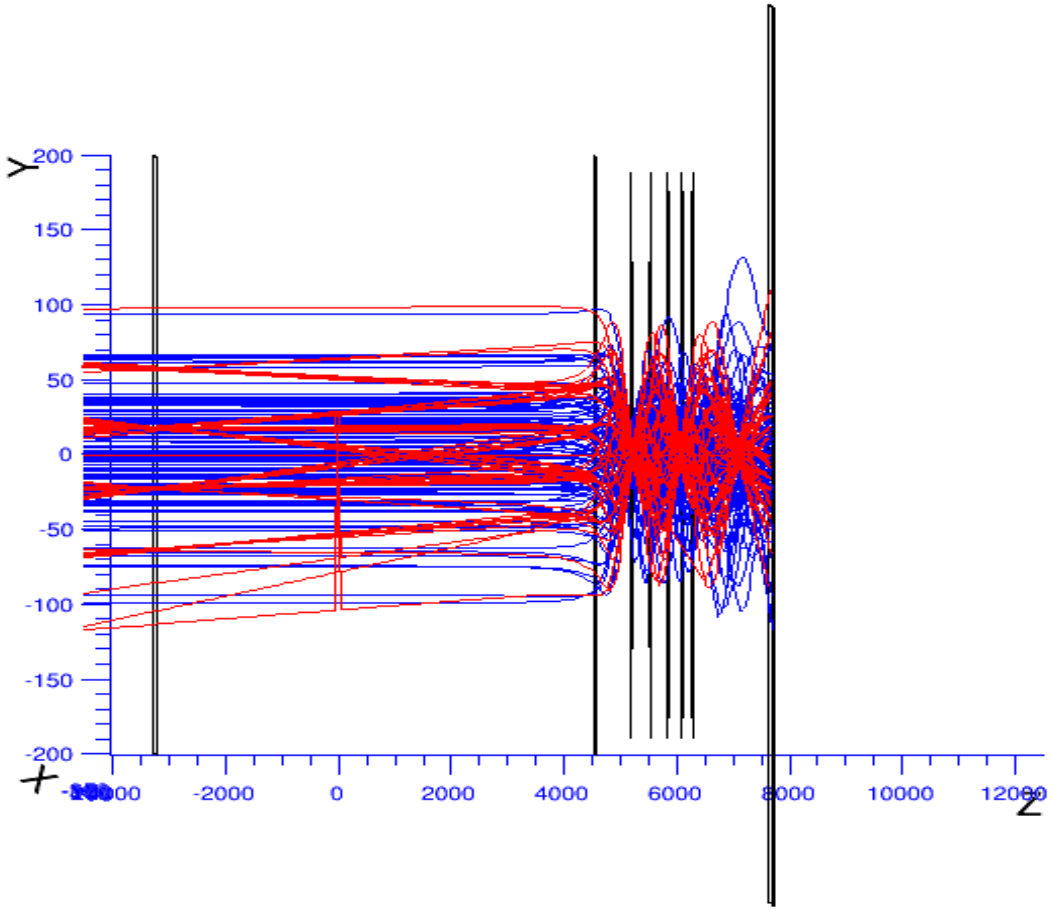


TOF-only Reconstruction

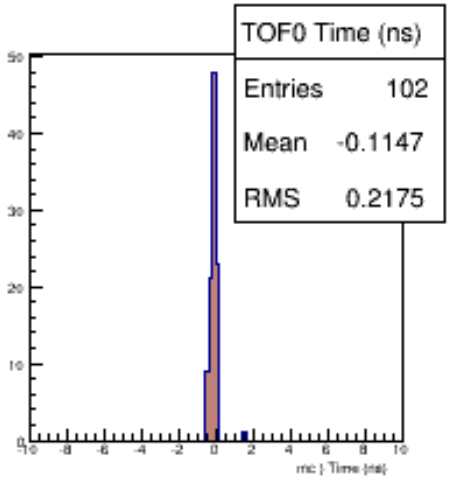
- Geometry: TOF0, TOF1, TOF2, Tracker0
- Reconstruct using only TOF measurements
- Time residuals a little too big
- Energy and momentum residuals poor, but we're only fitting t, x, and y at this point
- Position residuals are good in TOF0 and TOF1, but they're a bit too large in TOF1

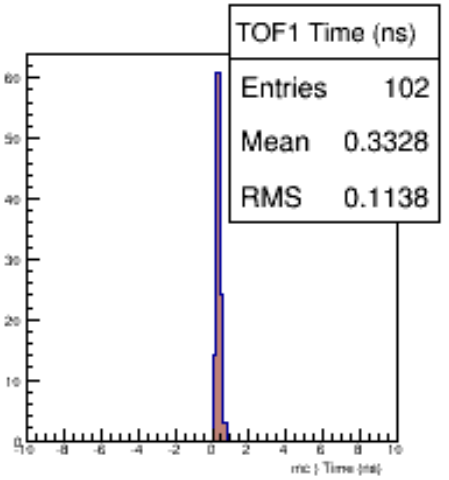
TOF-only Tracks

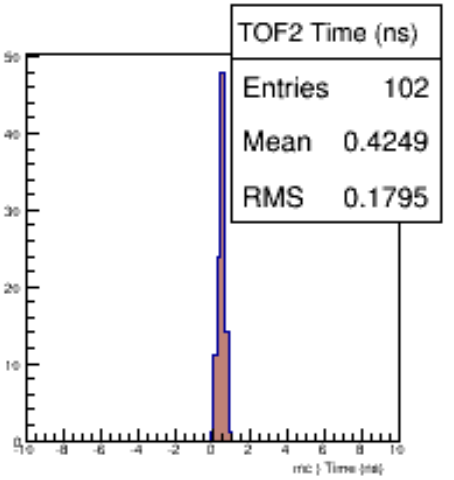


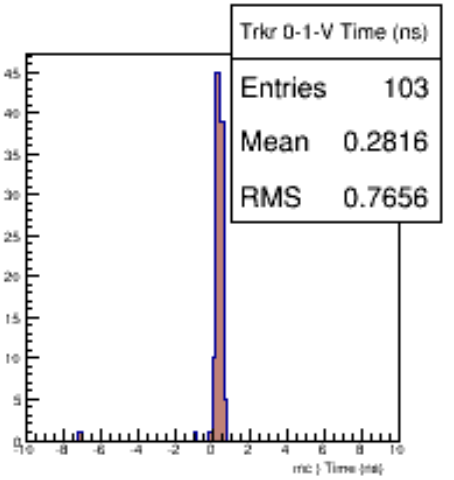


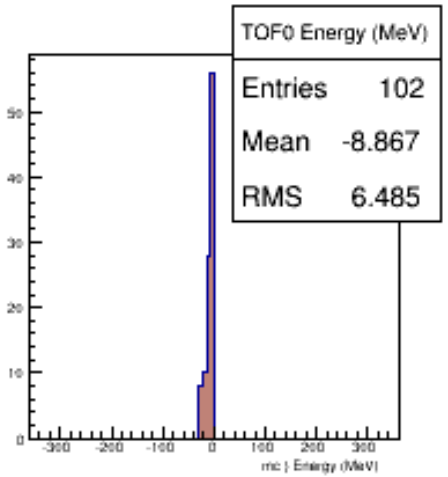
TOF-only t and E Residuals

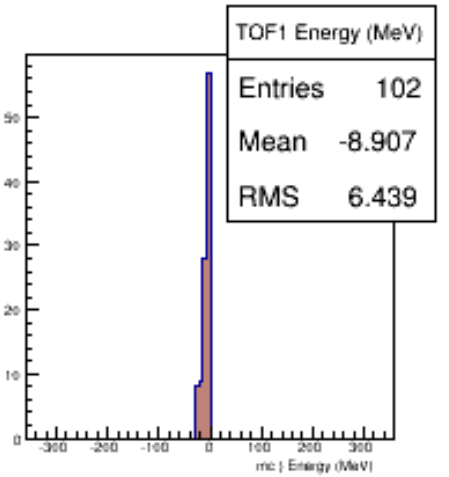


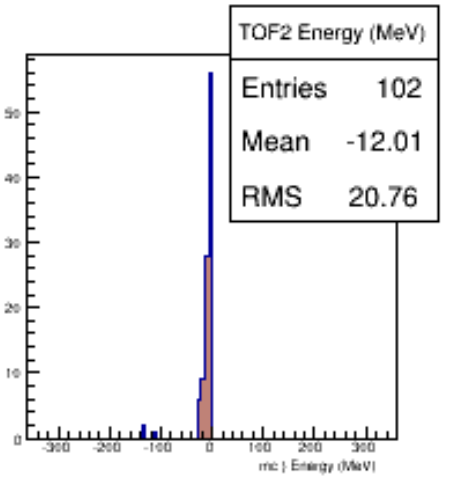


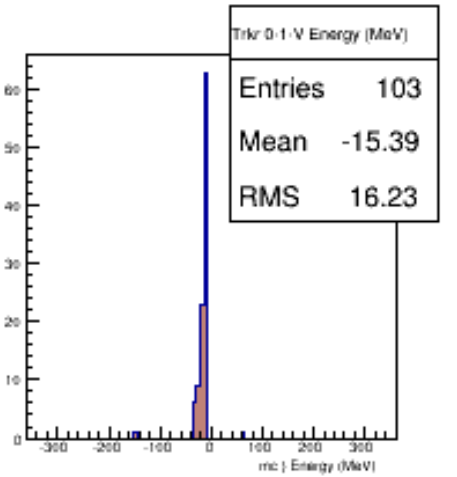




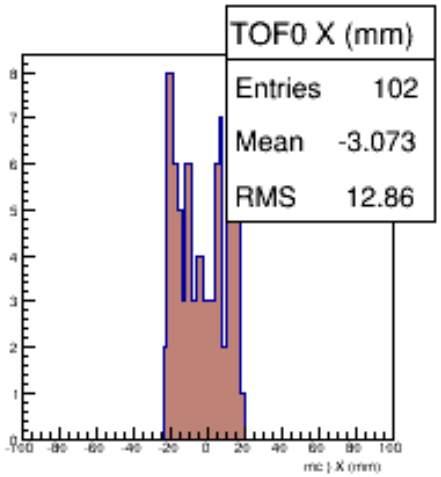


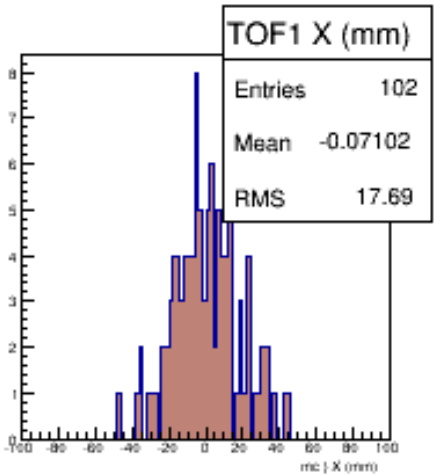


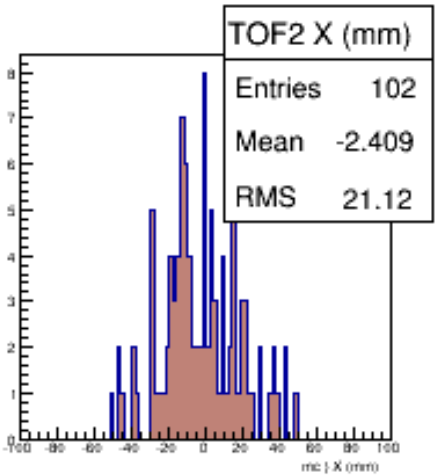


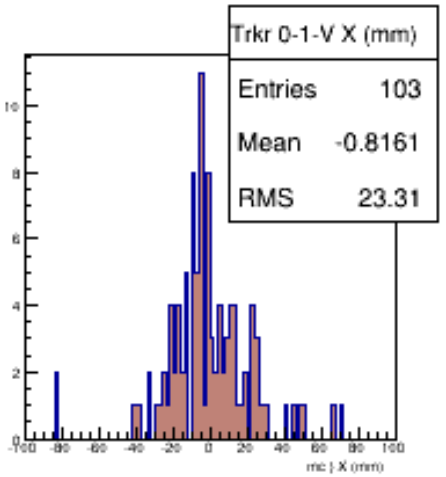


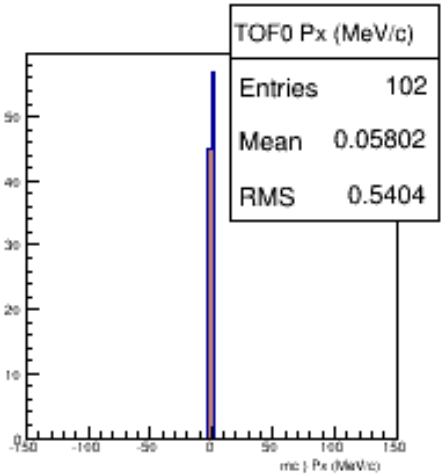
TOF-only X and Px Residuals

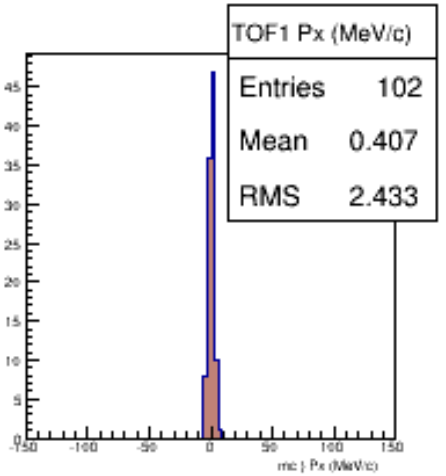


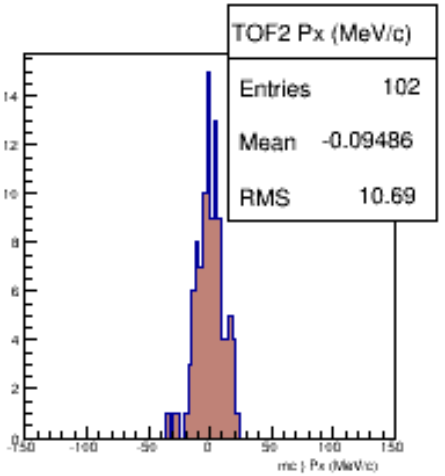


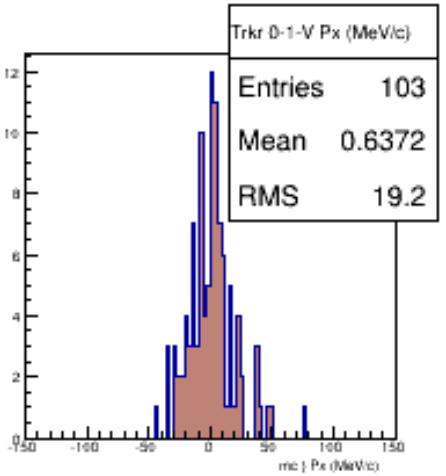








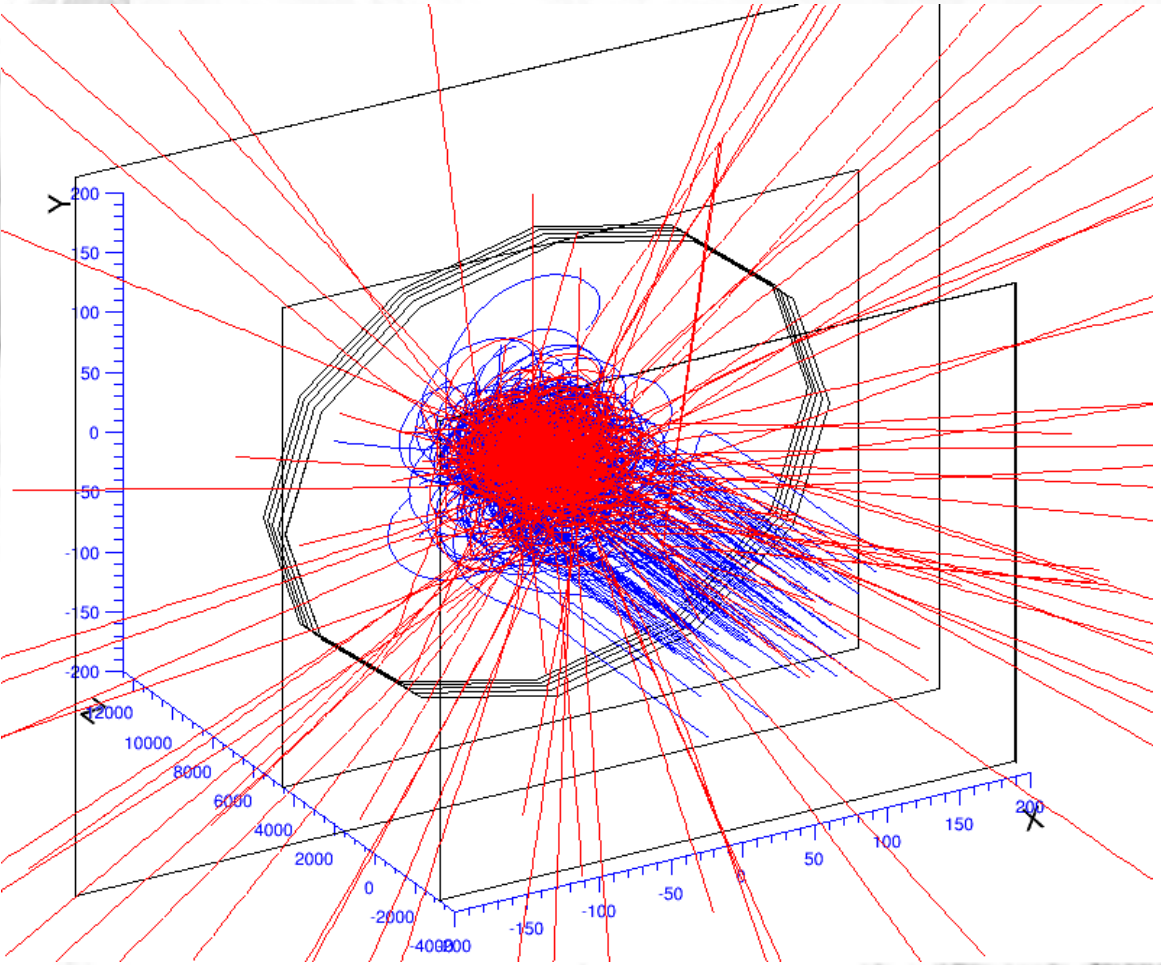


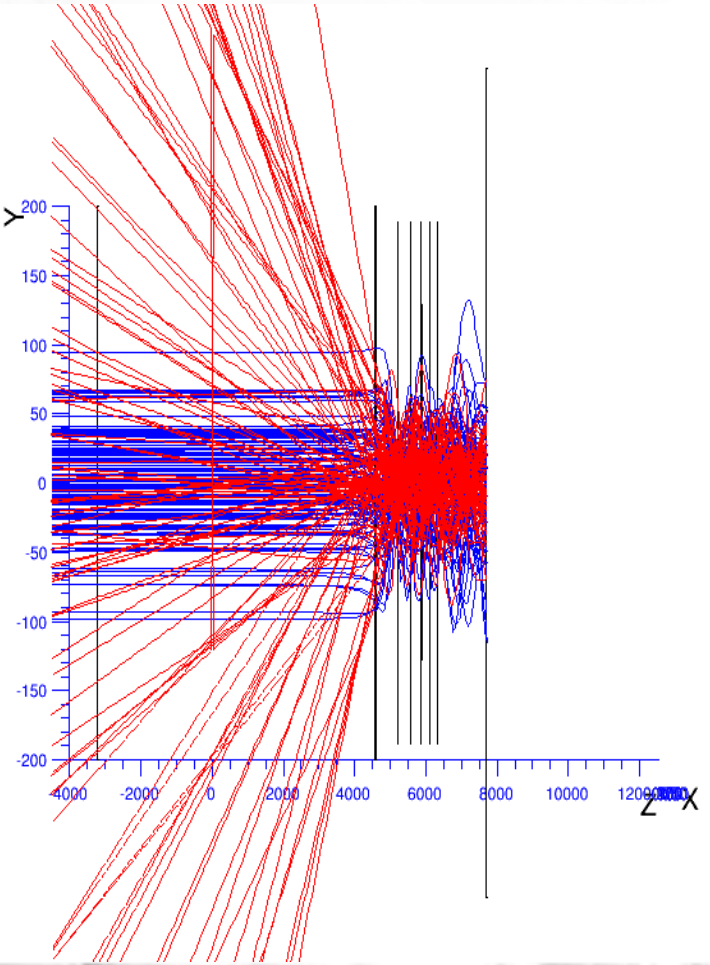


Tracker0-only Reconstruction

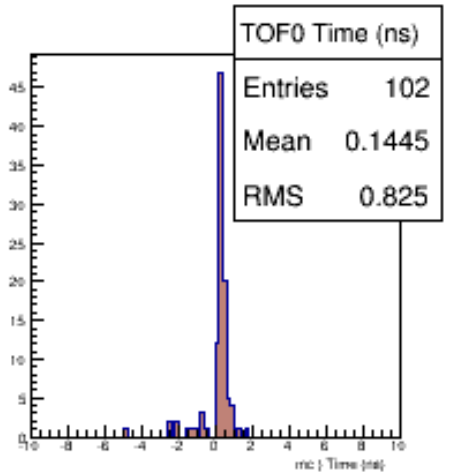
- Geometry: TOF0, TOF1, TOF2, Tracker0
- Reconstruct using only Tracker0 measurements
- Beam start positions are nonsensical
- Tracker residuals are way off

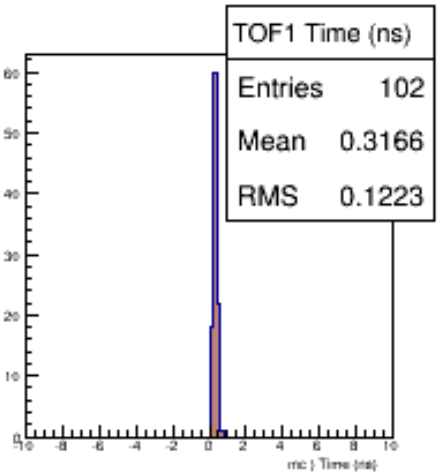
Tracker0-only Tracks

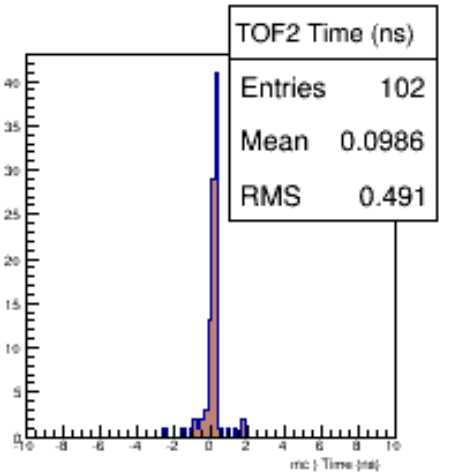


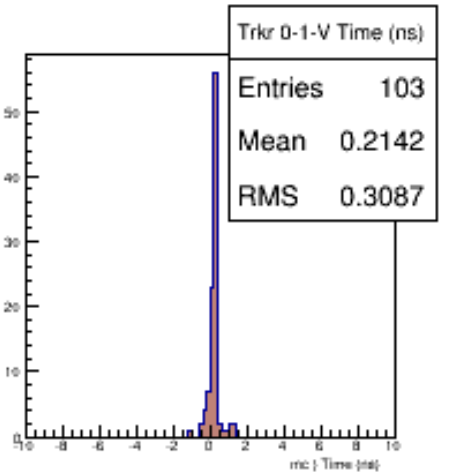


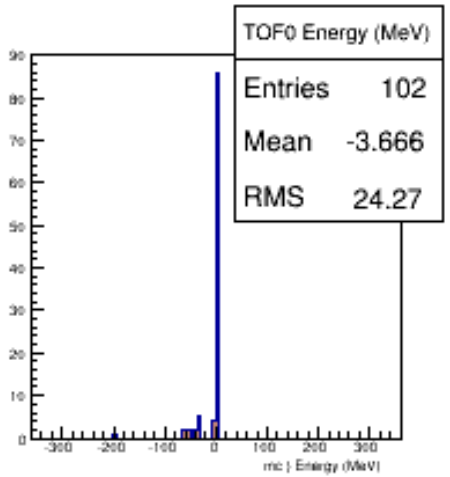
Tracker0-only t & E Residuals

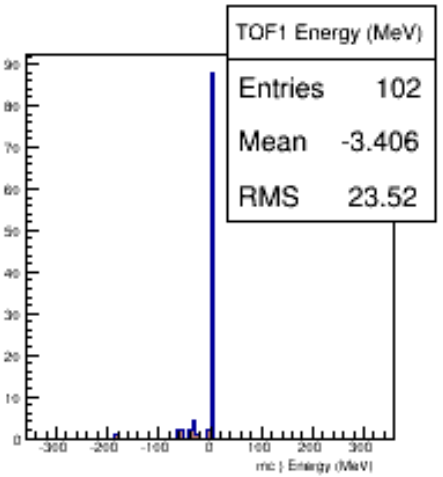


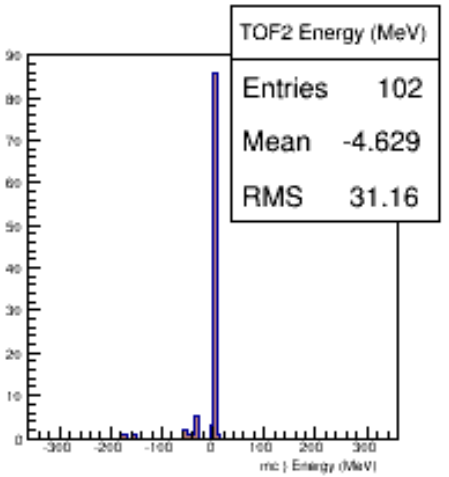


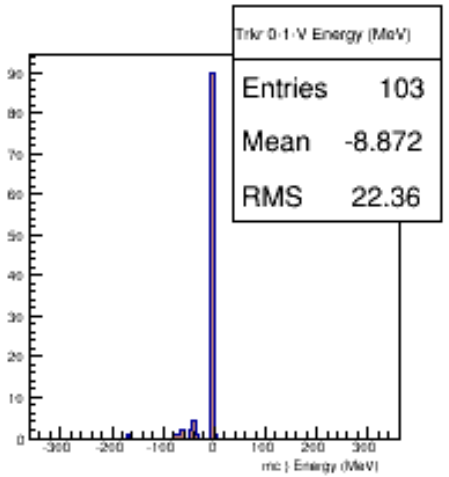




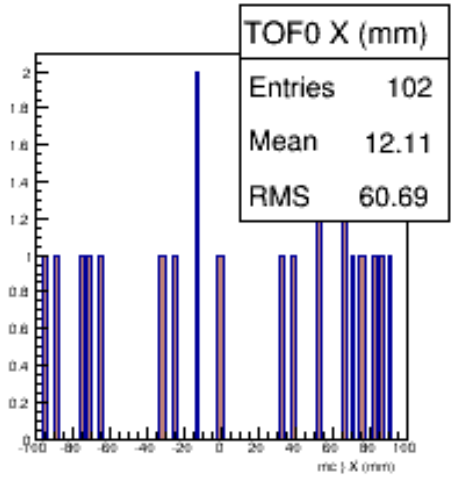


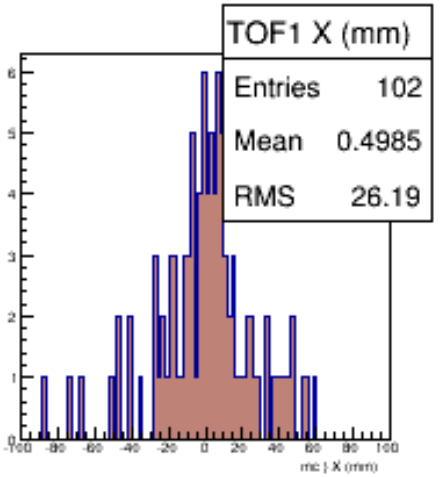


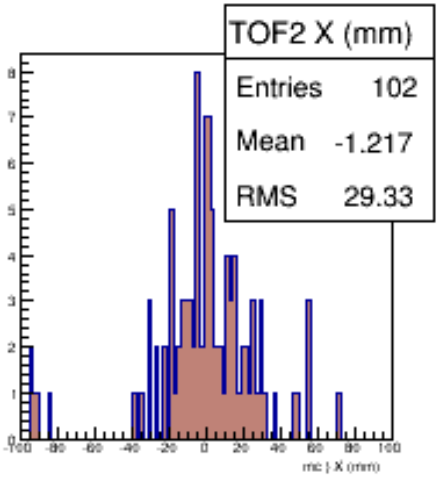


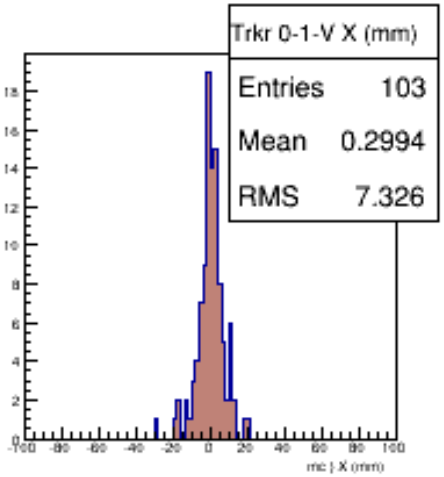


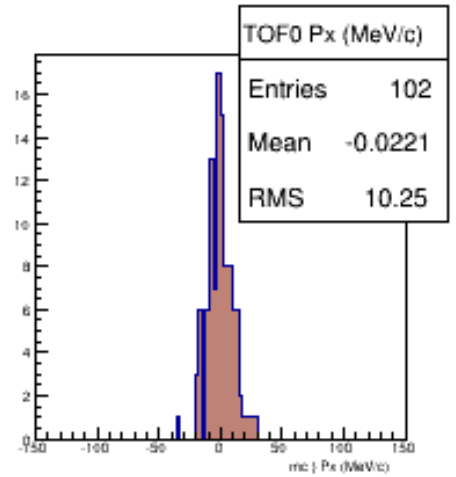
Tracker0-only x & Px Residuals

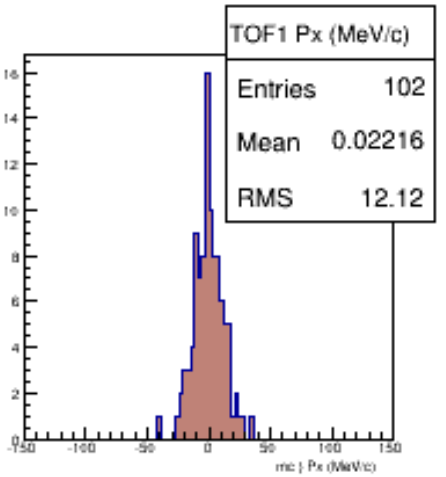


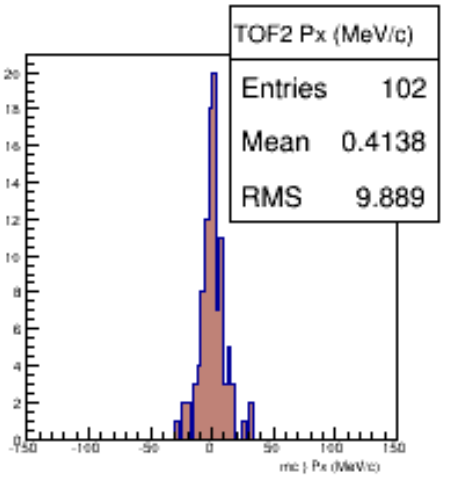


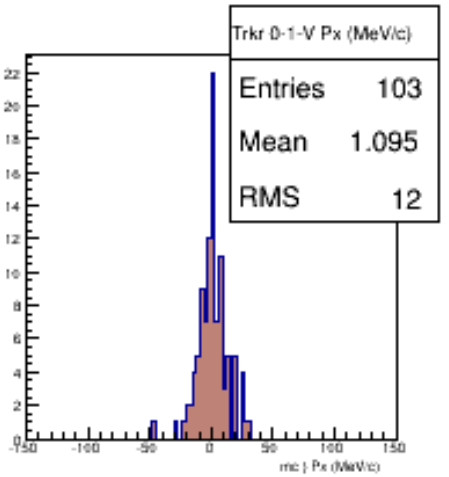












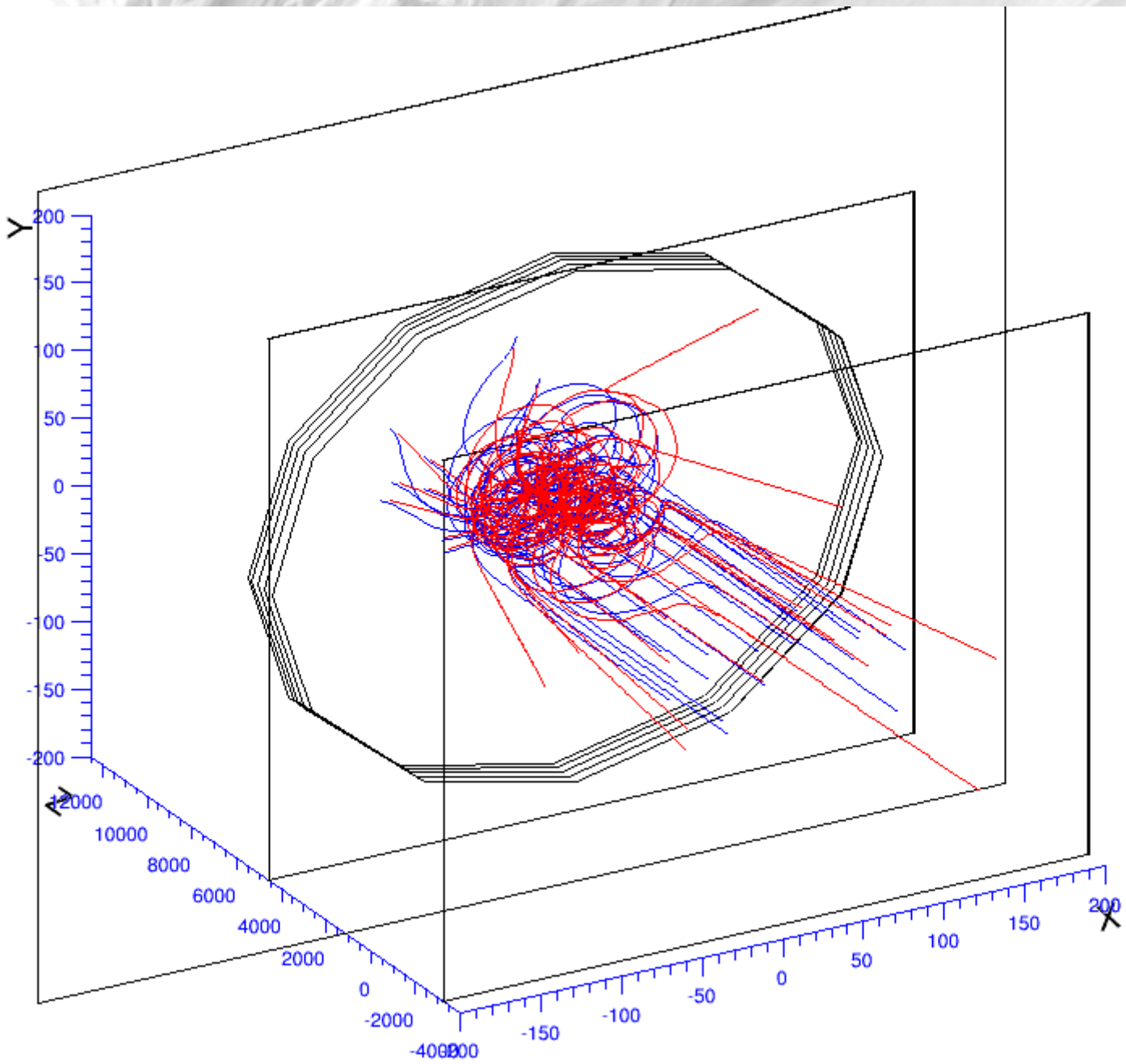
Summary

- TOF reconstruction is working for single track muons that don't decay
- Need to validate the tracker data I'm using
  - Use Monte Carlo for inputs like for the TOF geometry
- Will be meeting with people this week during the MAUS developer meeting
  - Hopefully this can be resolved soon!

Last Minute Slides

Tracker0-only MC Reconstruction

- Geometry: TOF0, TOF1, TOF2, Tracker0
- Reconstruct using Monte Carlo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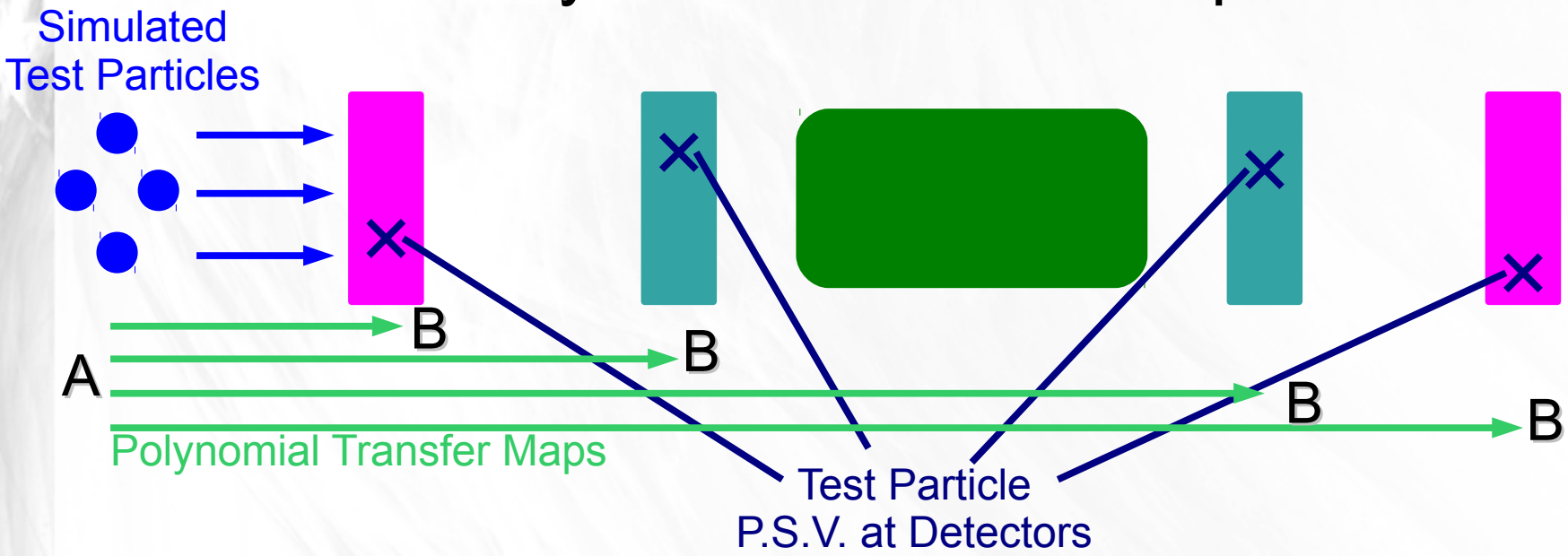
End

Extra Slides

Background:
Polynomial Transfer Maps

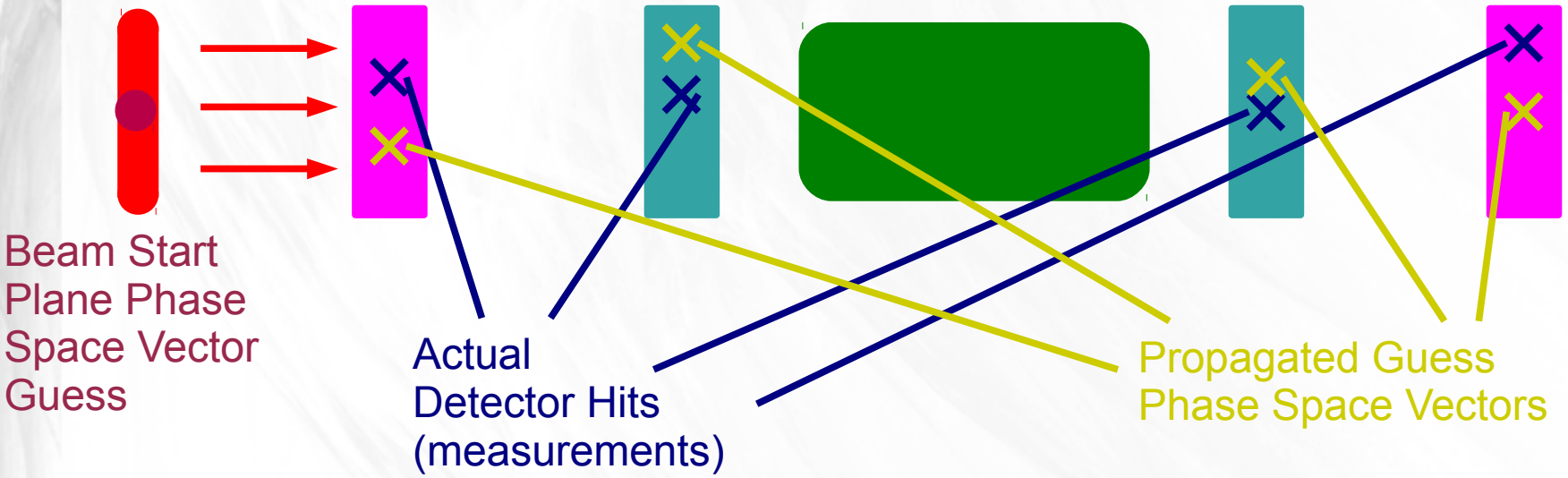


- Expand initial P.S.V. (t, E, x, Px, y, Py) of test particles into terms of a polynomial: A_i = (1, t, ..., t^2, tE, ..., py^2)$_i$
- B are the matrices formed from the P.S.V. at detector centers
- Solve the matrix equation $B = A\,C^T \rightarrow C^T = (A^T A)^{-1} A^T B$
  - For N linearly independent inputs, N = # polynomial terms
- C is a coefficient matrix for polynomials that describe the evolution of the phase space coordinates
  - Transport phase space vectors with b = C a

Transfer Map Generation

- Calculate C from matrix of polynomial vector inputs (A) and a matrix of p.s.v. outputs (B)
    - Solve the matrix equation $B = A\ C^T$
- The Moore-Penrose Pseudoinverse of A is the least squares solution
- The MPP takes the simple form $(A^T A)^{-1} A^T$ if there are N linearly independent inputs
    - N = number of polynomial terms

Background:
Track Fitting Algorithm



- Find initial phase space vector that minimizes total χ^2 -- the sum of the squares of the differences between the propagated guesses (estimates) and the detector hits (measurements).
    - weighted by the detectors' measurement uncertainties