

Two Track Resolution

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Goal

- Determine the efficiency of distinguishing two tracks as a function of the separation distance in X (drift direction)
- Look for systematic effects in reconstructing closely separated hits
 - E.g. X position, hit amplitude

Method

- Generate two 5 GeV muon tracks with a 30 mrad opening angle



- All tracks in all events start at the same origin
 - True track separation vs distance varies from event to event due to MCS
- Select 70 events with little δ -ray activity
- Observe transition from single hit reconstruction to double hit reconstruction
- Only consider collection plane for this study

MC Parameters

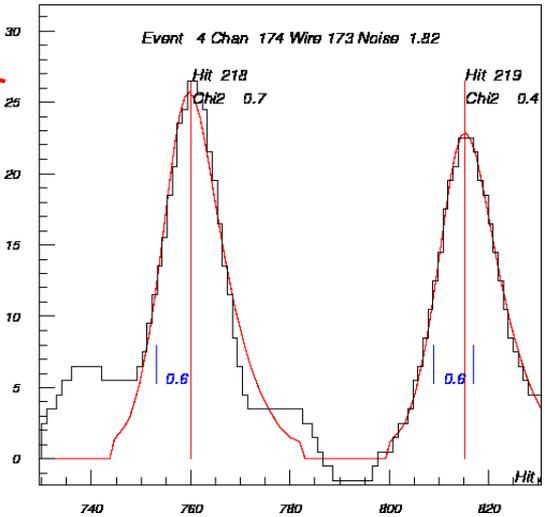
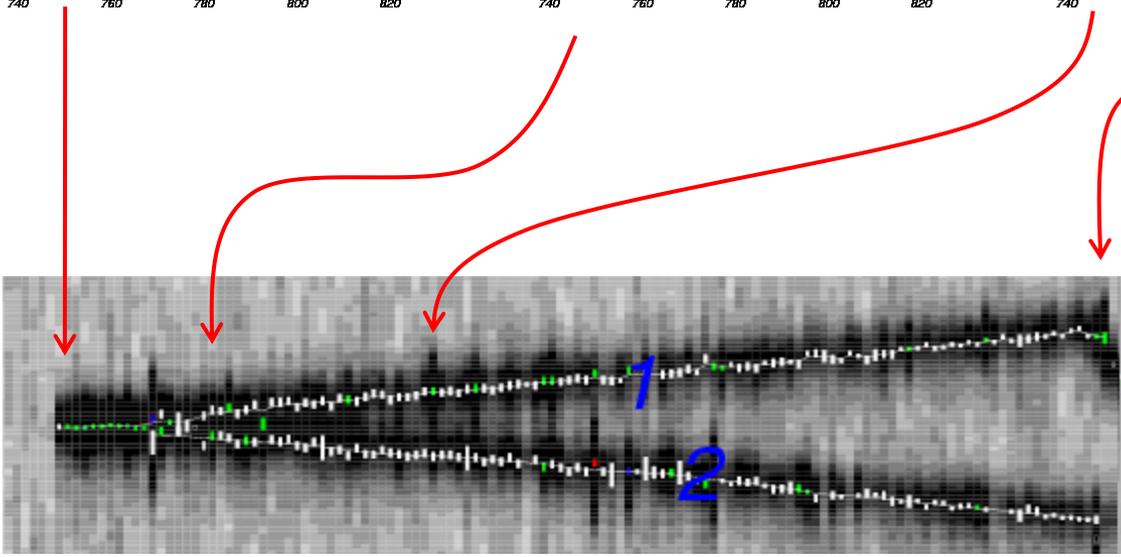
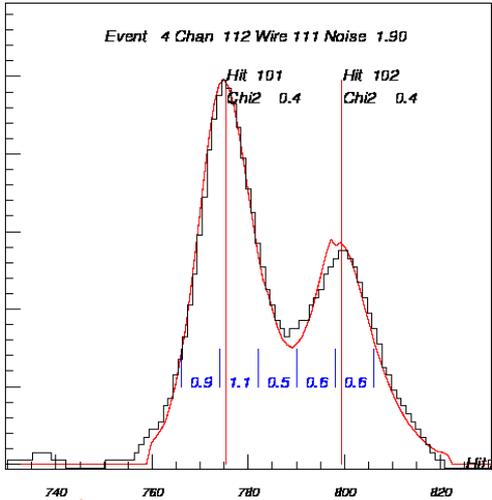
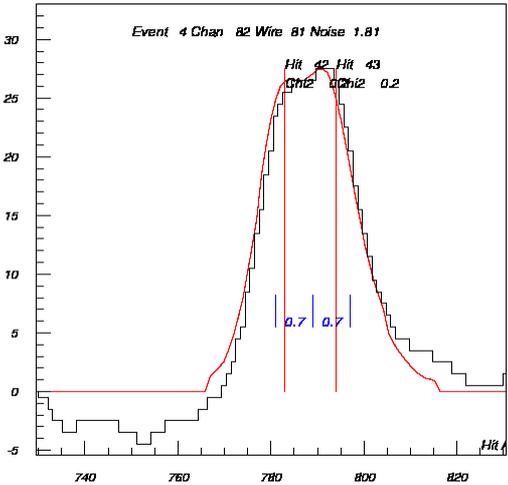
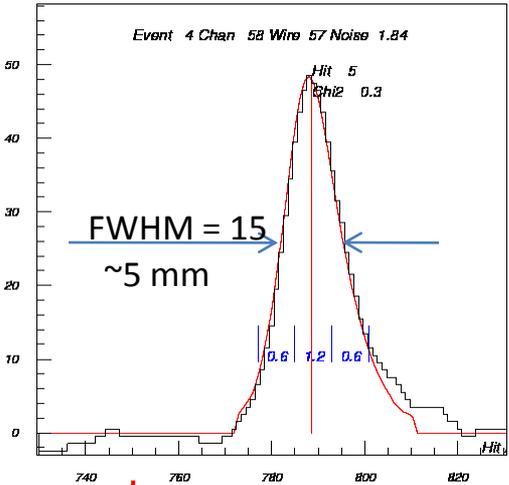
- ArgoNeut detector (4 mm wsp x 4 mm gap)
- Electronics shaper
 - $\tau_1 = 1.5 \mu\text{s}$, $\tau_2 = 0.45 \mu\text{s}$
- ArgoNeut electronics gain
 - 12 ADC count/fC
- Frequency dependent noise matched to ArgoNeut data
 - Noise $\sigma \sim 1.5$ ADC count

$$\frac{e^{-t/\tau_1}}{1 + e^{-t/\tau_2}}$$

Hit Shape Fitting

- Hit shape templates created for 0°, 40° and 60° dip angle tracks
 - Create larger angle templates when χ^2/dof of fit to small angle templates ~ 2
 - Assign a template flag = (dip angle)/10
- Fit ADC shape to one template at 0°, 40°, 60°
 - Two parameter fit (amplitude, time)
 - If $\chi^2 < 2$ and no shape distortions
 - Then use single hit fit
 - Else do double hit fit: $3 \times 3 = 9$ (4 parameter) fits
 - If χ^2 (double hit) $< \chi^2$ (single hit) and $\chi^2 < 2$ use double hit fit
 - Else do triple hit fit: $3 \times 3 \times 3 = 27$ (6 parameter) fits
 - If χ^2 (triple hit) $< \chi^2$ (double hit) use triple hit fit
 - Else use ADC bump peak positions as the hit position

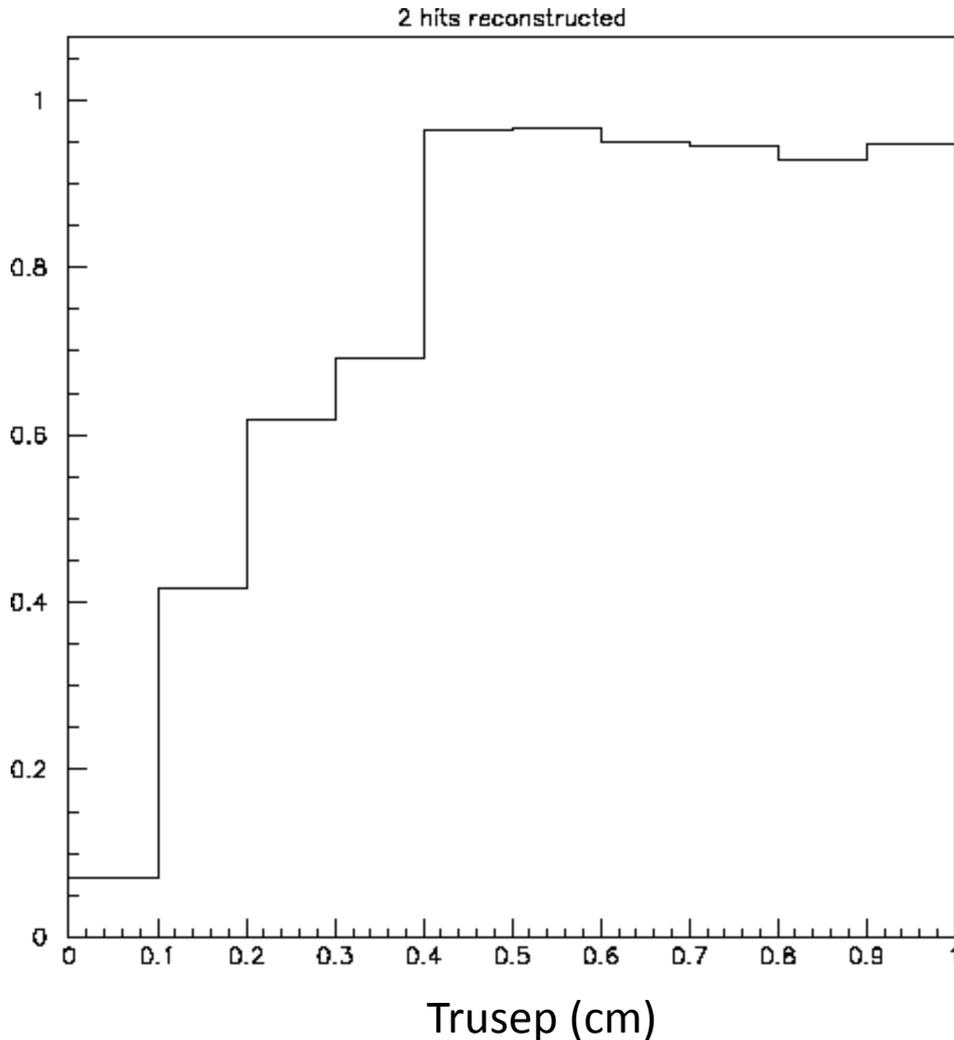
Hit Fits



Track Separation

- MC track trajectories are sampled at a momentum-dependent distance
 - A 5 GeV muon is sampled every 5 wire spaces
 - Use linear approximation between samples to determine truth track X separation (trusep in histogram titles)
- Determine reconstructed hit separation (recsep) from fitted hit positions

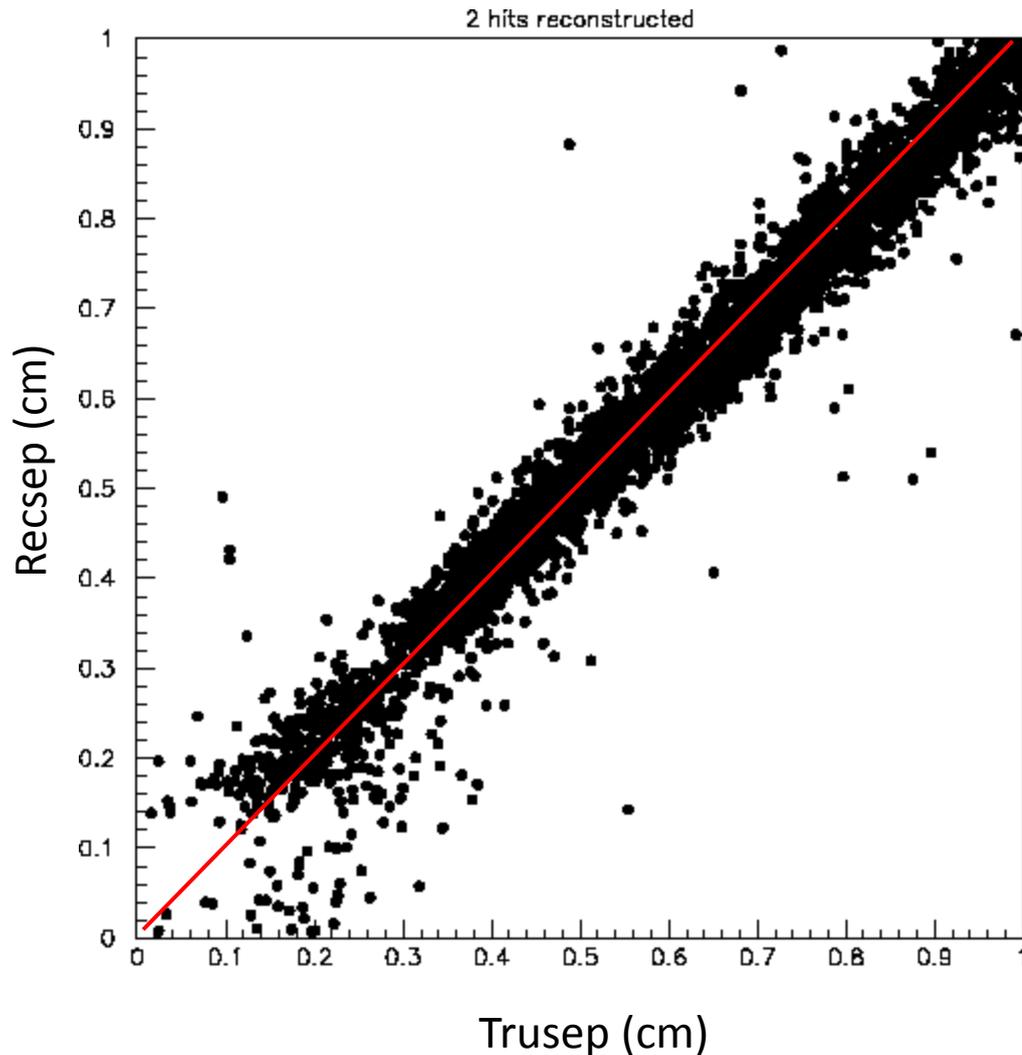
Probability of Reconstructing Two Hits vs True Separation



100% efficiency in 2 track separation when separation > 4 mm

50% efficiency in 2 track separation when separation = 2 mm

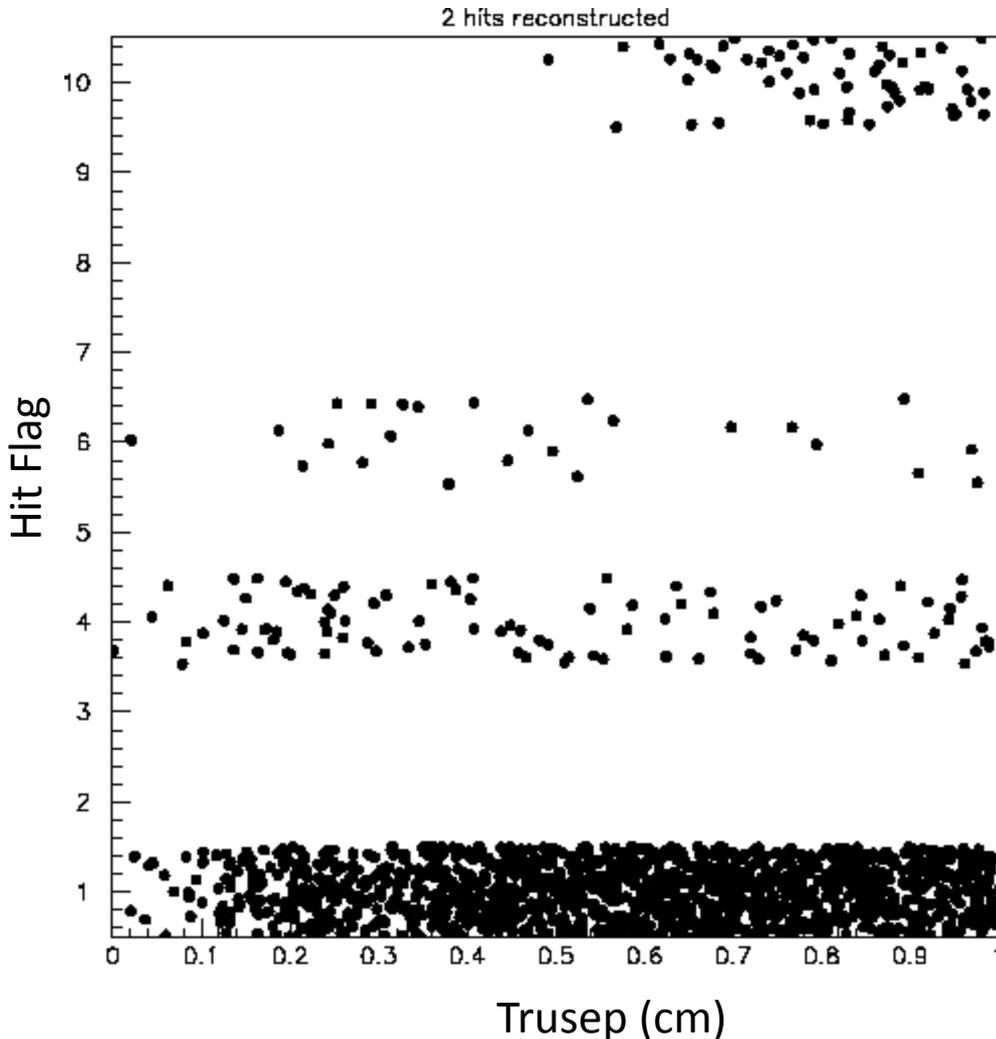
Reconstructed Hit Separation vs True Track Separation



No severe systematic shifts in the reconstructed separation vs true separation

Hit Flag vs True Separation

Two Hits Reconstructed



A small fraction of double hits failed the shape fit – assigned hit flag 10

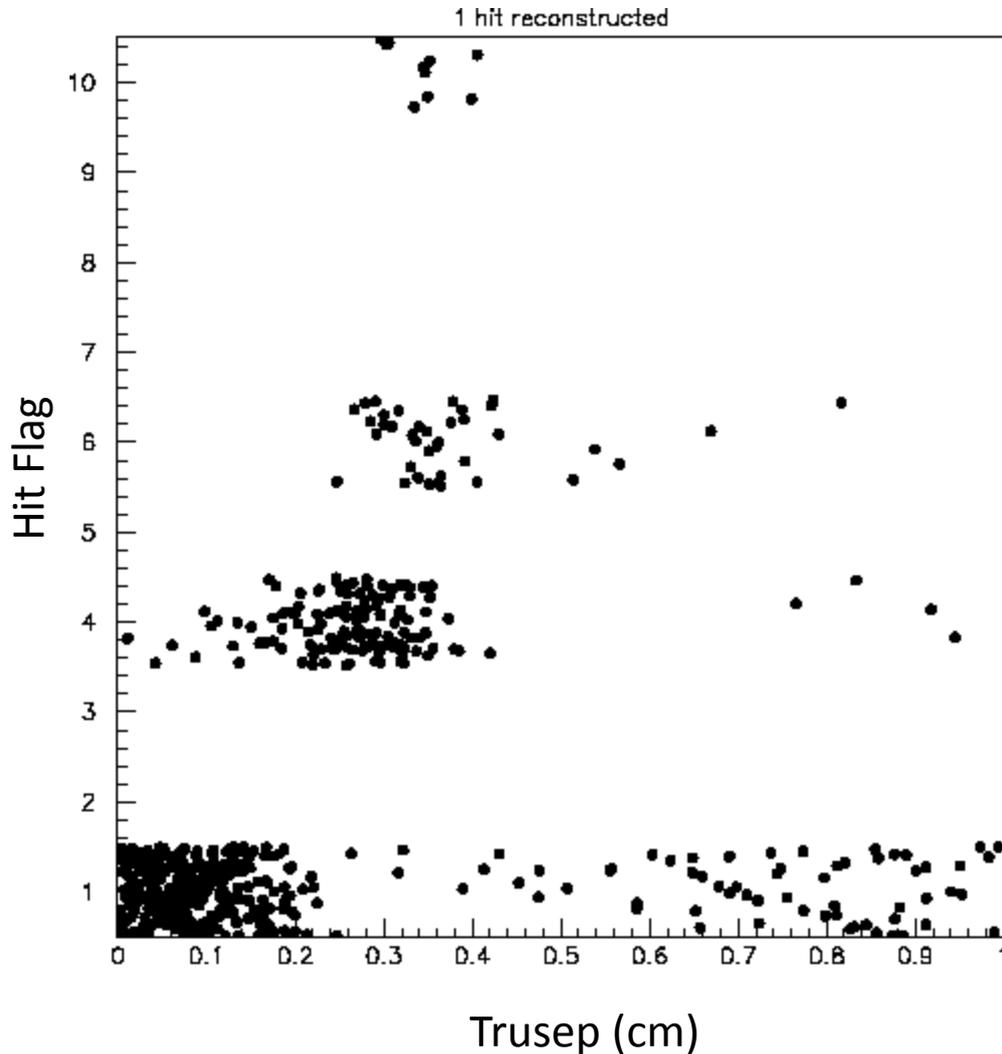
A very small fraction of double hits are incorrectly fitted to the 60° hit template

A small fraction of double hits are incorrectly fitted to the 40° hit template

Most double hits are correctly fitted to the 0° hit template

Hit Flag vs True Separation

One Hit Reconstructed

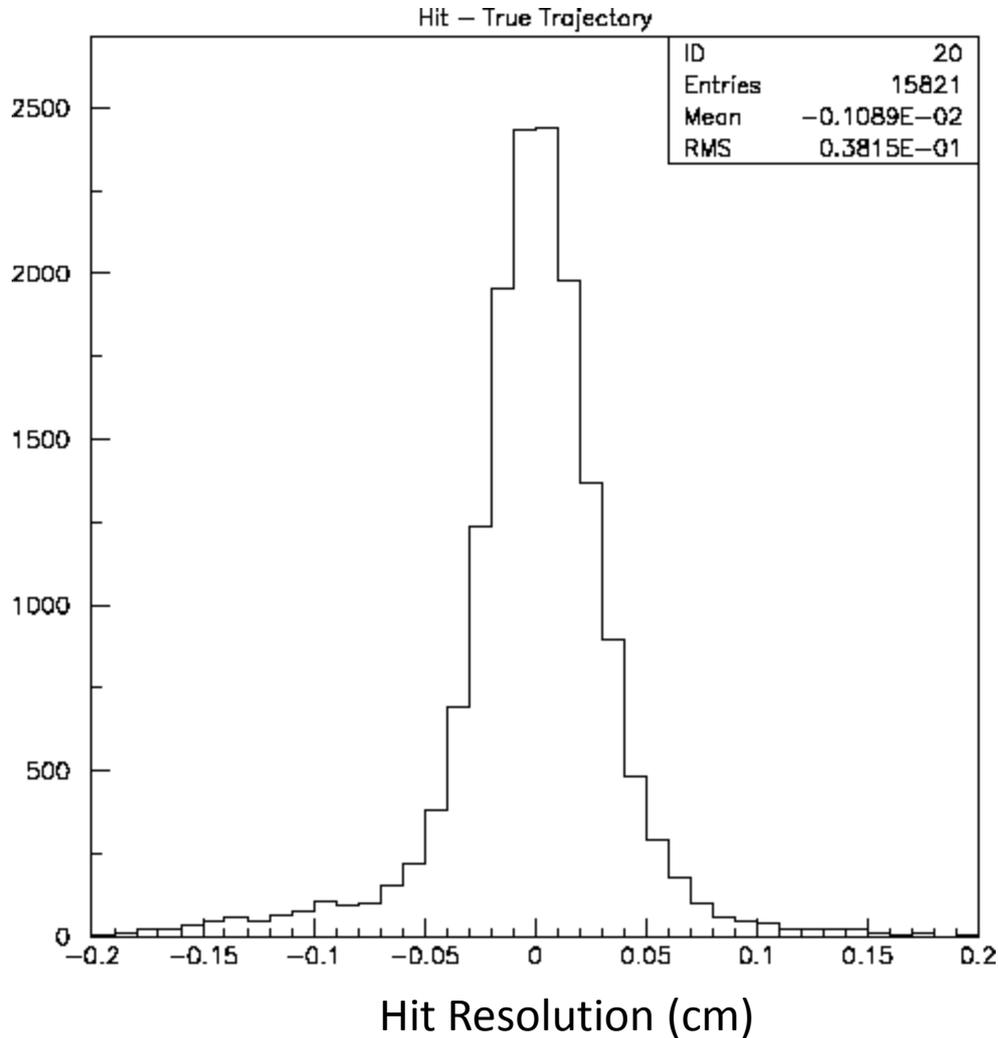


60° single hit $\chi^2 < \text{double hit } \chi^2$

Close single hits that cannot be resolved reconstruct as 40° template hits

Most single hits are correctly fitted to the 0° template at very small separation

Reconstructed Hit X – True Trajectory X

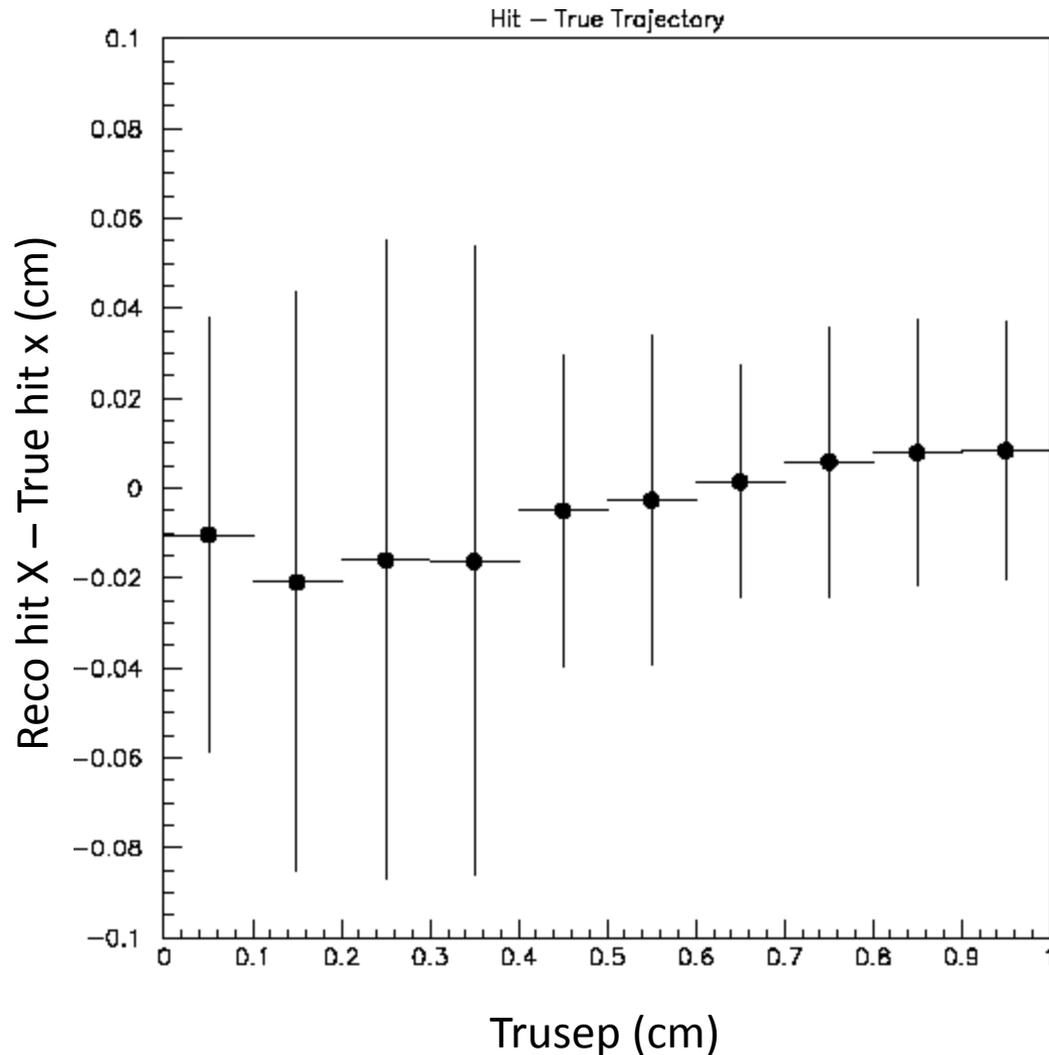


Hits at all separation distances
included

$$\sigma = 380 \mu\text{m}$$

Single muon hit resolution = 190 μm

Reconstructed Hit X – True Hit X vs True Separation



Includes single and double hits

Hit resolution

- $\sim 500 \mu\text{m}$ at small separation
- $\sim 300 \mu\text{m}$ at large separation

Why not $185 \mu\text{m}$?

Systematic bias in hit position vs separation \ll resolution

Summary

- Two track resolution is 4 mm (100% separation) for ArgoNeut detector with 5 MHz sampling using shape fitting algorithm
 - Scaling? Two track resolution $\sim <$ ADC pulse FWHM
- No significant systematic bias in reconstructed hit position vs two track separation