Resolution of Matching CRT Hits to Reconstructed Tracks

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Overview

- Two algorithms currently match Cosmic Ray Tagger (CRT) hits to reconstructed tracks caused by the same muon.
  - One matches pairs of CRT hits to reconstructed track (muon hits CRT on way in AND out)
  - Other matches each CRT hit to a single reconstructed track (one hit per track)
- Took interest (for now) in the first, since we can easily study resolution.
  - Draw straight line from one CRT hit to the other, giving “CRT predicted track”
  - Can see how close reconstructed track is to CRT prediction
  - Can’t do this with single-hit method

Arbin Timilsina goes in-depth here (Method 1: combinatorial tracks): https://indico.fnal.gov/getFile.py/access?contribId=47&sessionId=7&resId=0&materialId=slides&confId=12345

Goals

- Looking at the resolution under different metrics can let us:
  - Test for recurring biases in reconstruction algorithms
  - Try to understand where these biases might come from
  - Find out where inefficiencies/impurities in matching come from
- Some advantages over efficiency/purity tests:
  - Gives more information:
    - How far off incorrect tracks are, and in which ways
    - How close correct tracks are (recurring discrepancies could be studied)
  - Arbitrary cutoffs can be set at any point given full histograms

Comparison Metrics

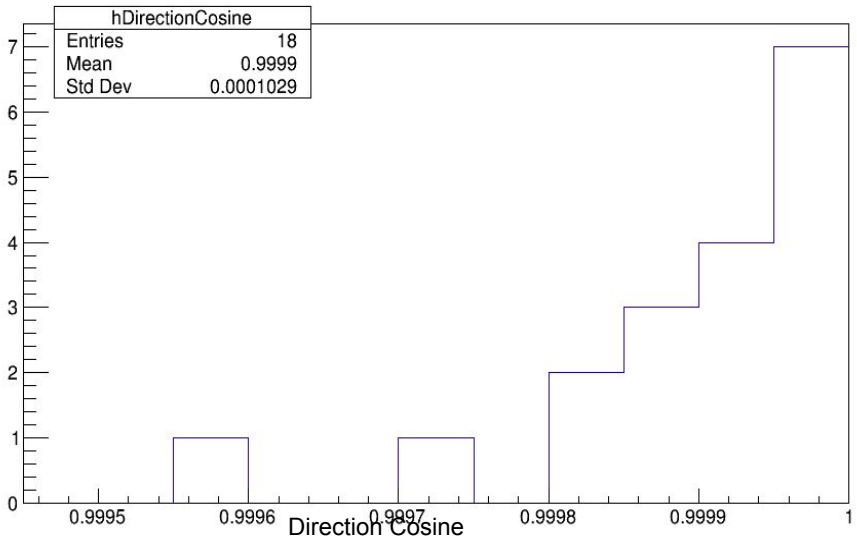
- For these metrics, treat both the reconstructed tracks and CRT predicted tracks like straight lines (for now).
- Compare those lines via:
  - Cosine of the angle between them (direction cosine)
  - Distance of closest approach in YZ plane
- Want to compare distance of closest approach in XZ plane as well, but...
  - X is drift direction, so reconstructed X position depends on timing (when particle enters TPC)
  - Currently set to spill time for all particles, so cosmics then end up with a pseudo-random X position
  - Fixable using time signature from each CRT hit; not yet implemented in this method
- Would also like a single, overall metric: still TBD.

Difficulties:

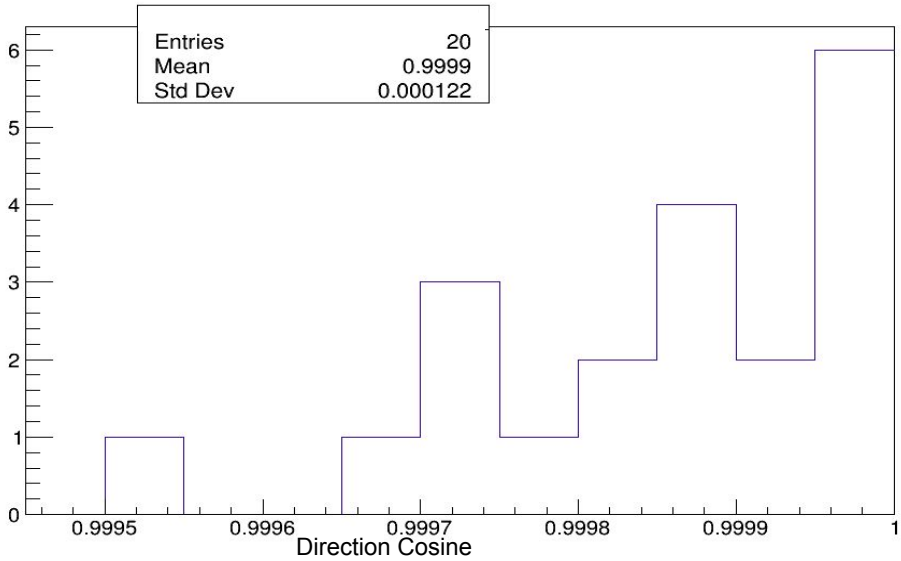
- Space Charge Effect (SCE):
  - SCE is distortion of the electric field in the TPC due to buildup of slow positive ions
  - Protodune SCE distortions estimated to be as large as 20cm (Timilsina)
  - MCC9 contains simulations both with and without SCE
  - We compare CRT predicted tracks to reconstructed ones both with and without SCE
- Low Efficiency:
  - Even when simulating ~700 muons, only tens of muons will actually have two CRT hits (<10%).
  - Without SCE, ~80% of those get matched to a reconstructed track, while with SCE, ~50%.
  - Currently haven't run enough simulations to get cleanest possible data since yield is so low.
  - But we do have some!

Early Results: Direction Cosine Histograms

Without SCE:



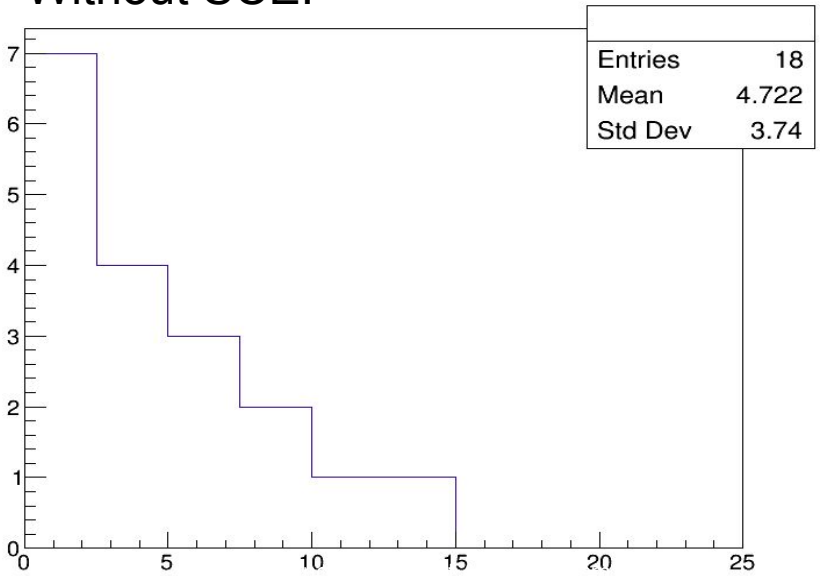
With SCE:



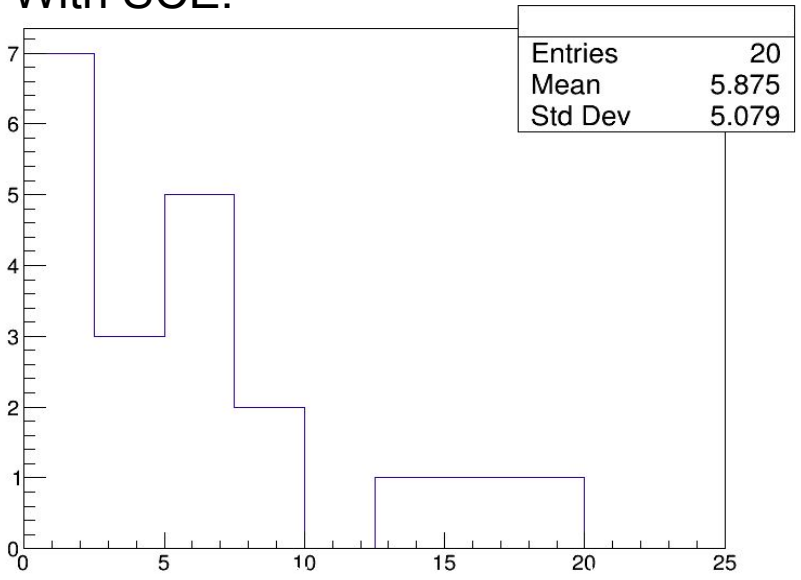
Since most preferences in the algorithm are related to angle/slope, the angles are very small; all within 2º in this case.

Early Results: Distances of Closest Approach (YZ)

Without SCE:



With SCE:



- CRT Resolution: 2.5cm (same as bin size on above histograms)
- Conclusions here more difficult to draw; more data needed

Questions?

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