Neutron Timing study of CubeRecon

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Introduction

- **We have a reconstruction ready by Clark. A more complete description: https://indico.fnal.gov/event/22617/contributions/197701/attachments/135065/167347/software-3dst-tpc-ecal-200924.pdf**

- **What do we have:**
  - reconstructed objects including tracks, clusters, vertices.
  - each object has a list of information such as dedx, track length, energy deposit, position, direction etc.
  - true information are available for each of the reconstructed objects.

- **Full simulation chain: GENIE → edep-sim → erep-sim (detector response) → cube reconstruction → higher level analyses**

- **An event display can be used to understand the reconstructed objects.**
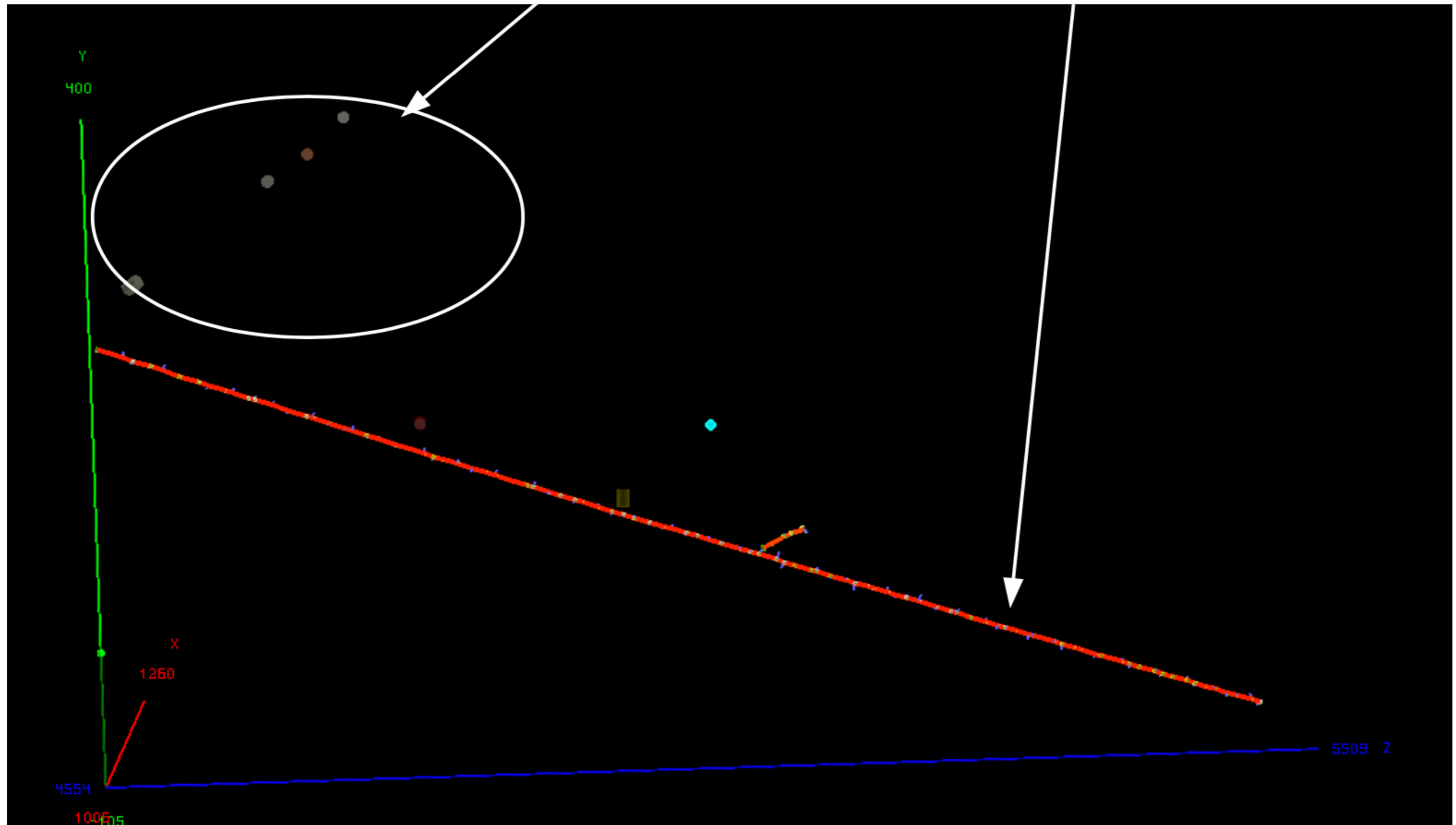
Introduction
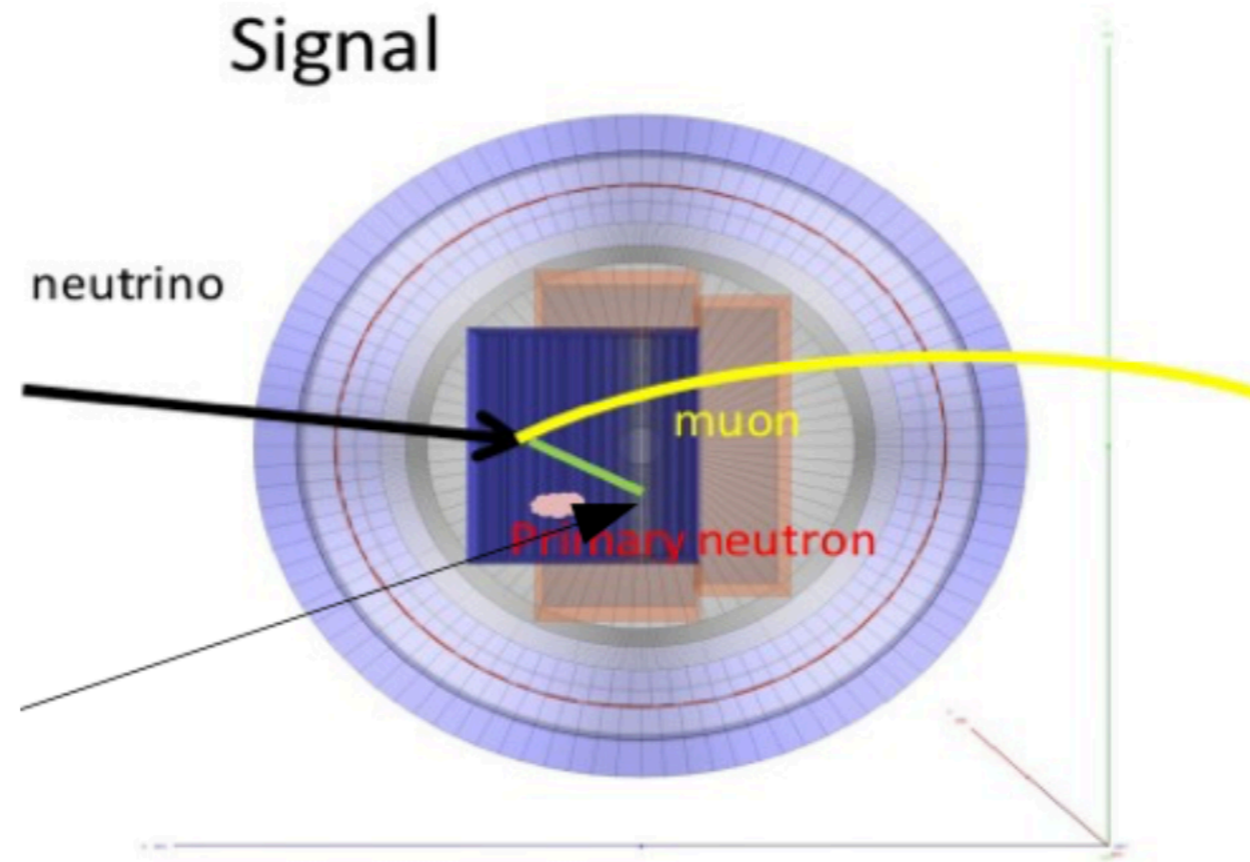
- **We used full reconstruction.**

- **Signal is neutron which is isolated objects apart from the main vertex activity**

- **There is no background.**

- **There is no threshold.**
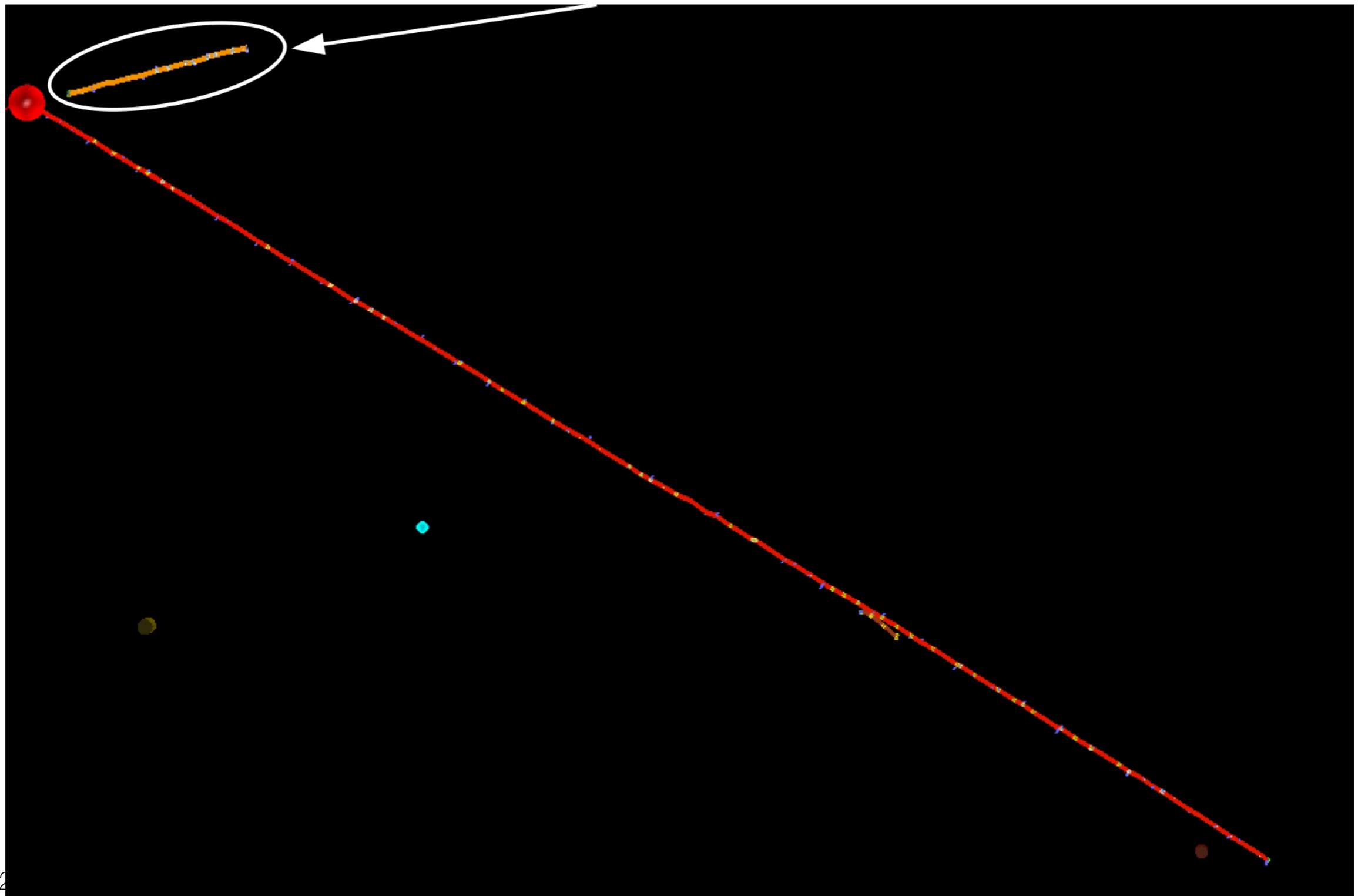
Neutron-induced signature

Neutron-induced signature
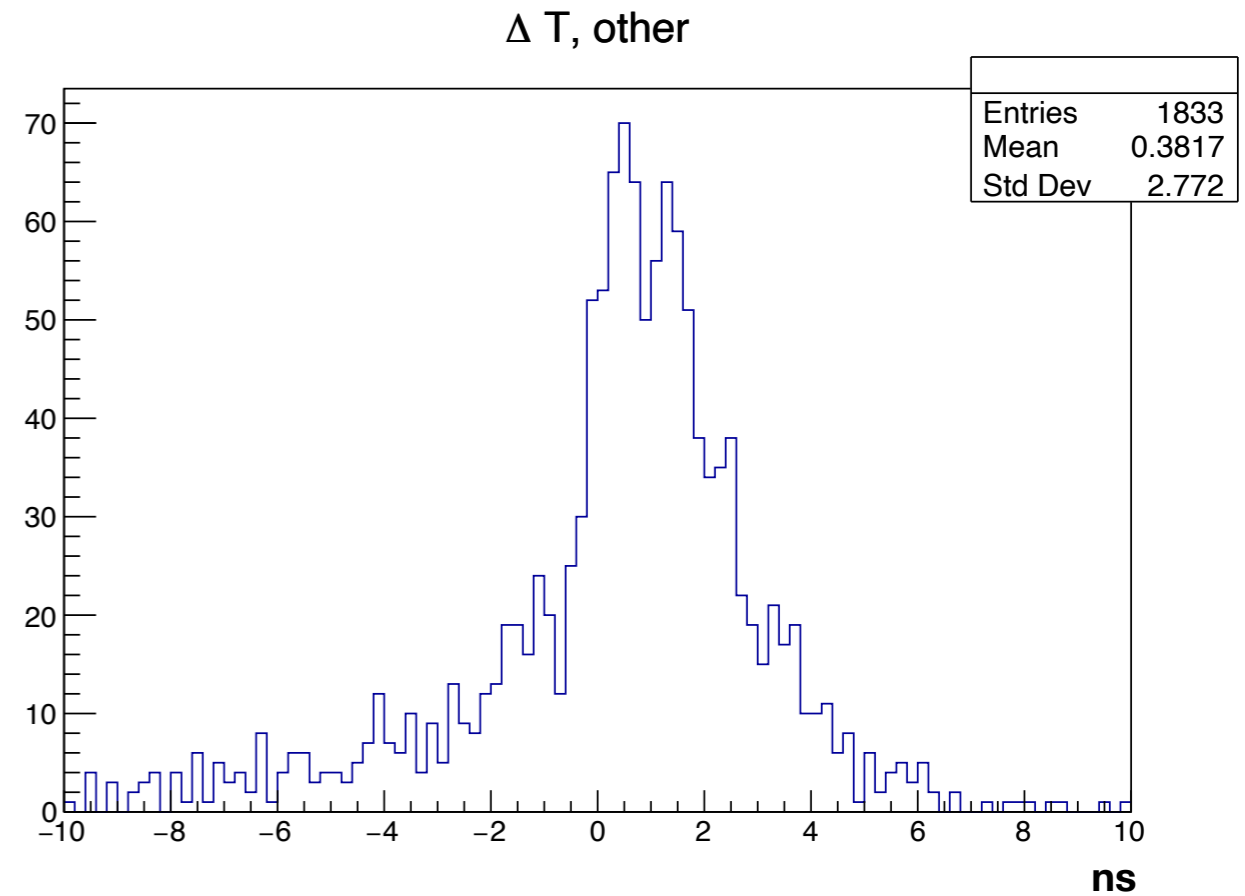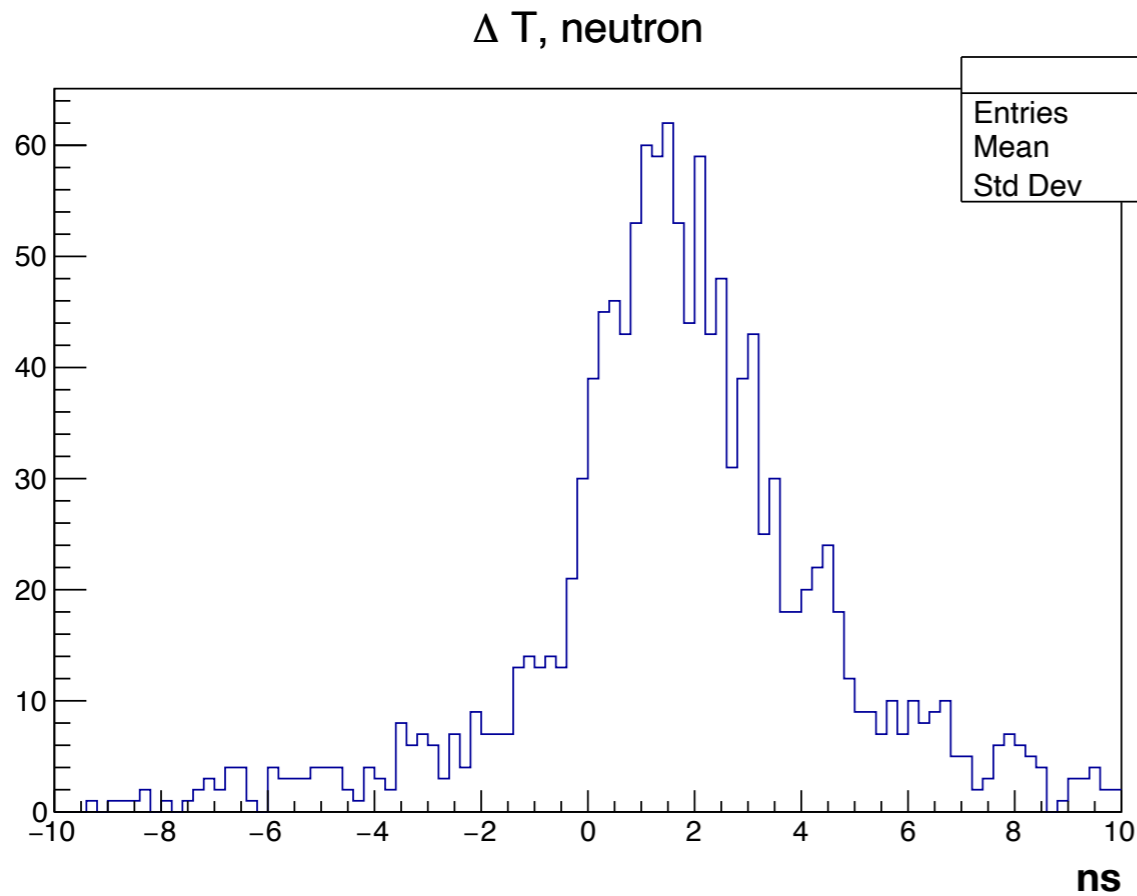
Numubar CC

neutron-induced

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Negative TOF

- **We are looking at CC0pi signal event based on true information.**

- **We found there are some event which has negative time of flight.**

- **The plots show ΔT (first object time - muon time).**

- **There is only two particles in final state:**
  1) neutron → ΔT neutron
  2) muon → ΔT other

Why negative TOF?

- **Negative tof is because of 'early hits' which is proposed by Clark.**

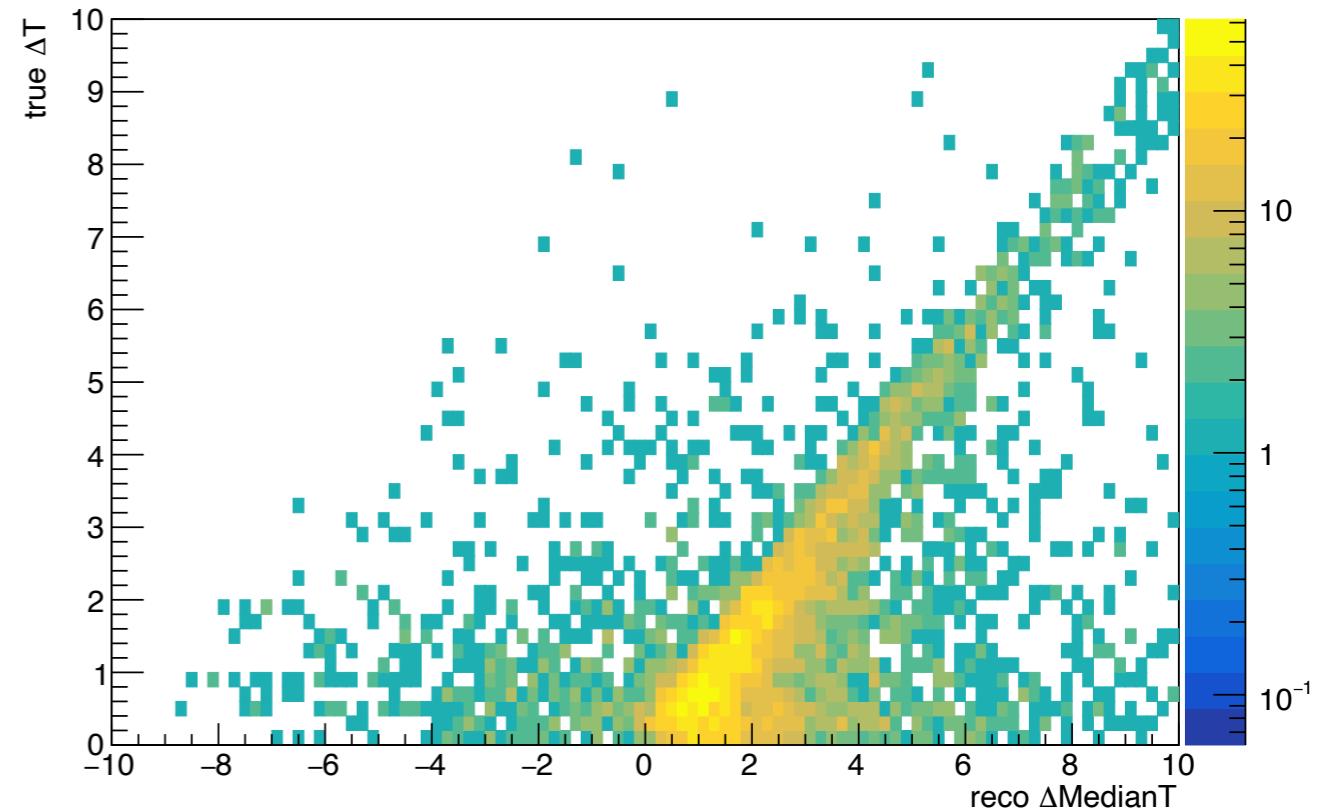- **The early hit is caused by energy deposit close to an MPPC.**
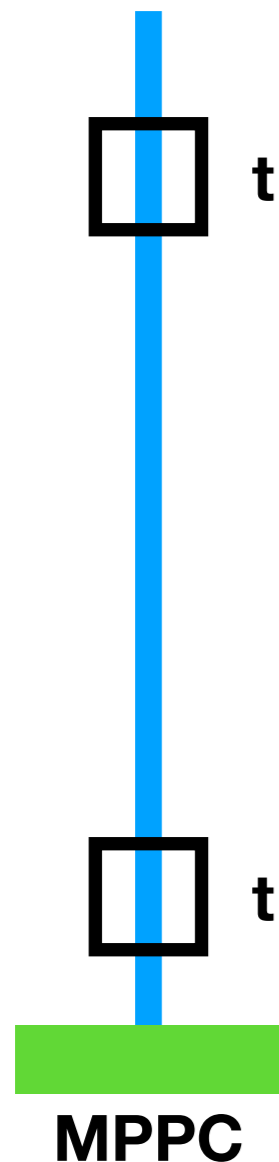
  - **The distance corrected times for all three fibers are earlier than the time when energy was deposited in the cube.**
    → Early hit

  - **If a reconstructed object contains the early hit, it can be earlier than muon time (interaction time).**
    → negative time of flight

  - **The early hits are a feature of the 3DST design and validated by Clark.**

  - **There can be two solution:**
    1) removing the negative,
    2) using median time.

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solution?

true ΔT vs reco ΔT
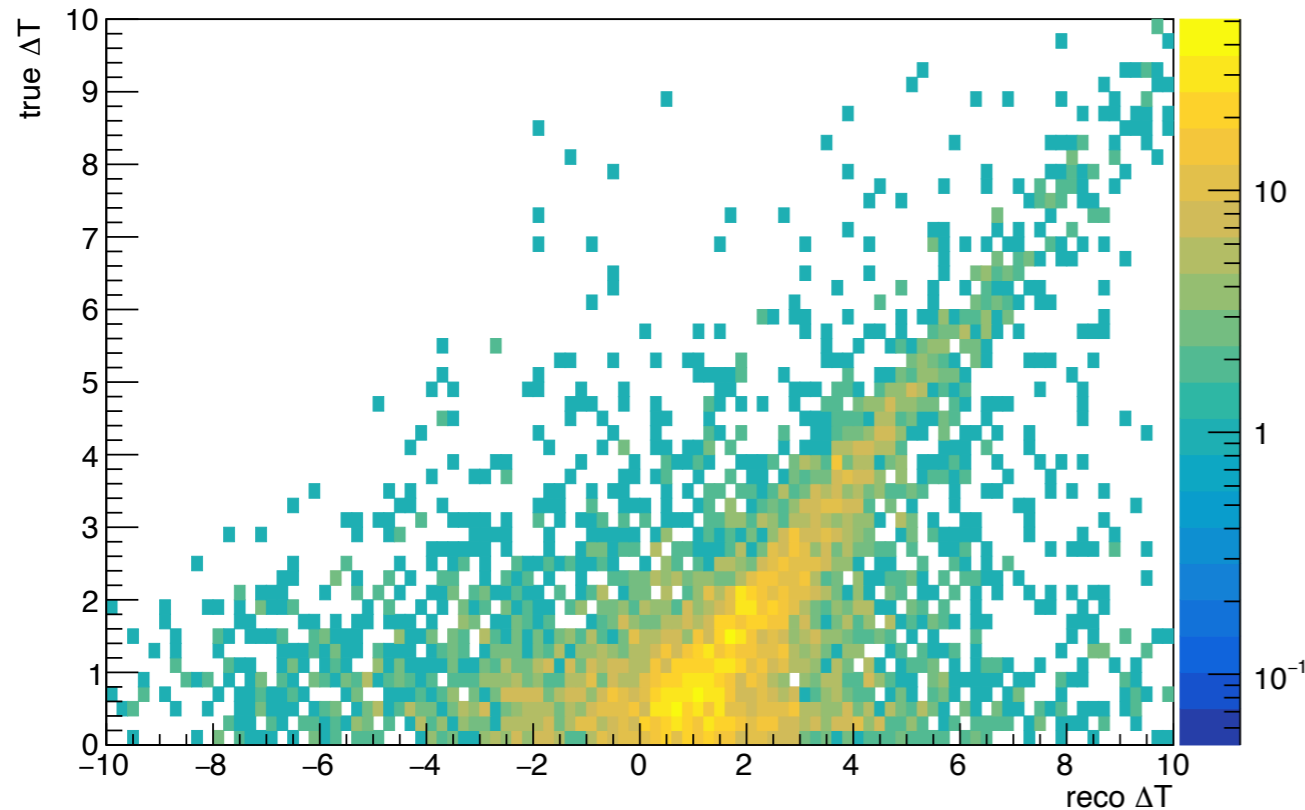
true ΔT vs reco ΔMedianT

- **The object consists of multiple hits.**

- **We can use median time of object.**

- **There still can be negative ΔT If the first cluster in time consists of only one early hit.**
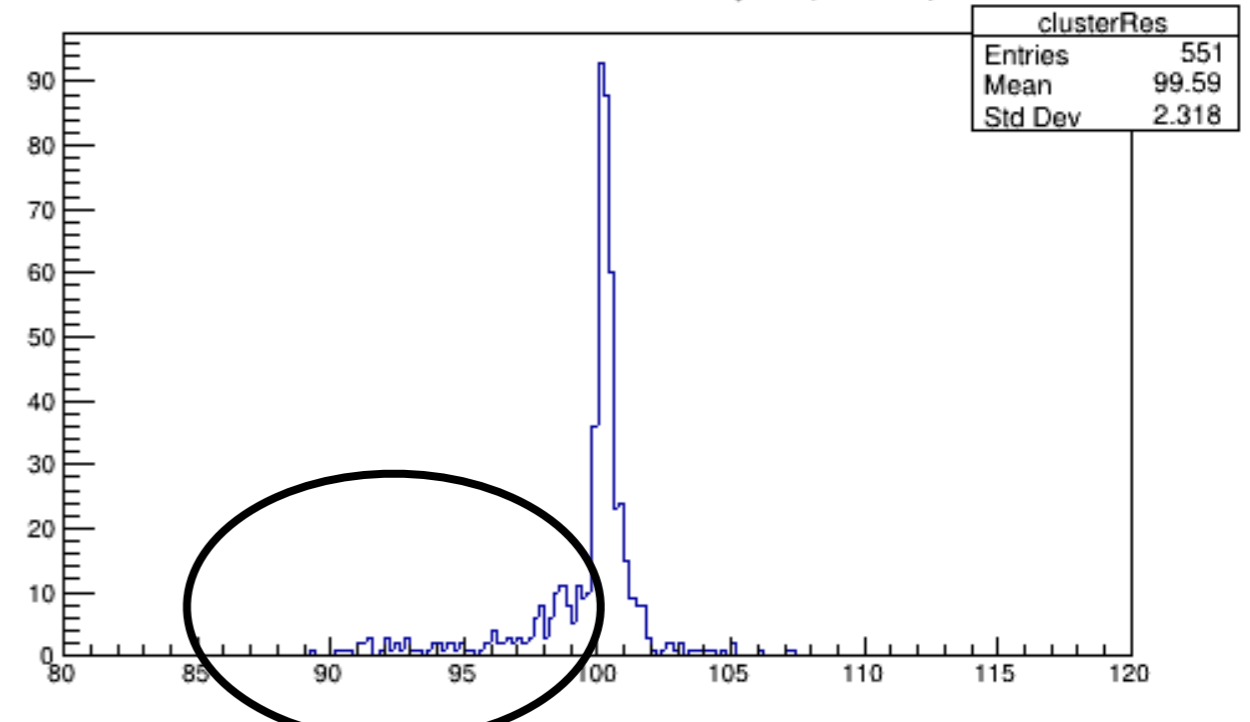   - **→ it's a small fraction, we might can apply some cut**

Summary

- **There is a timing issue : negative time of flight.**

- **We are looking for a good way to handle the issue.**

- **Next step: include background, selecting low nu sample.**
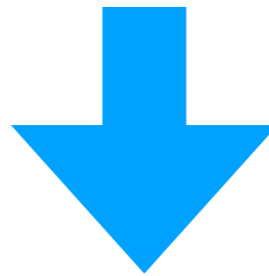
Time resolution of earliest object (track)

trackRes
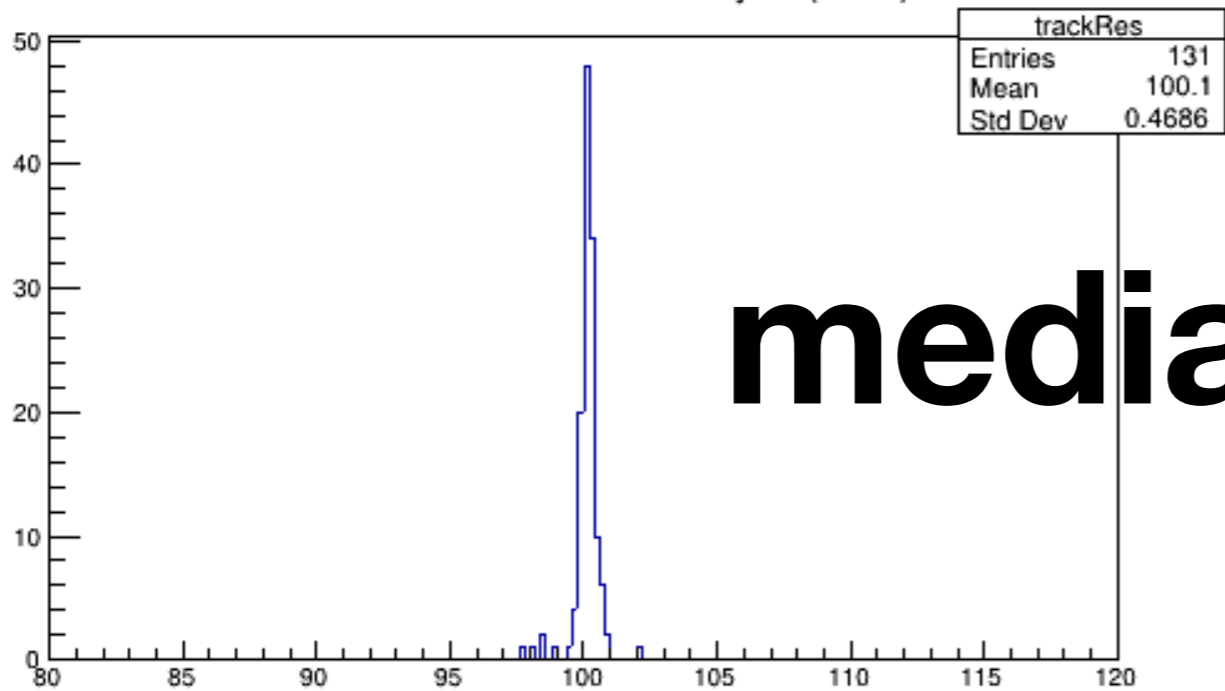Entries 344
Mean 98.06
Std Dev 2.766
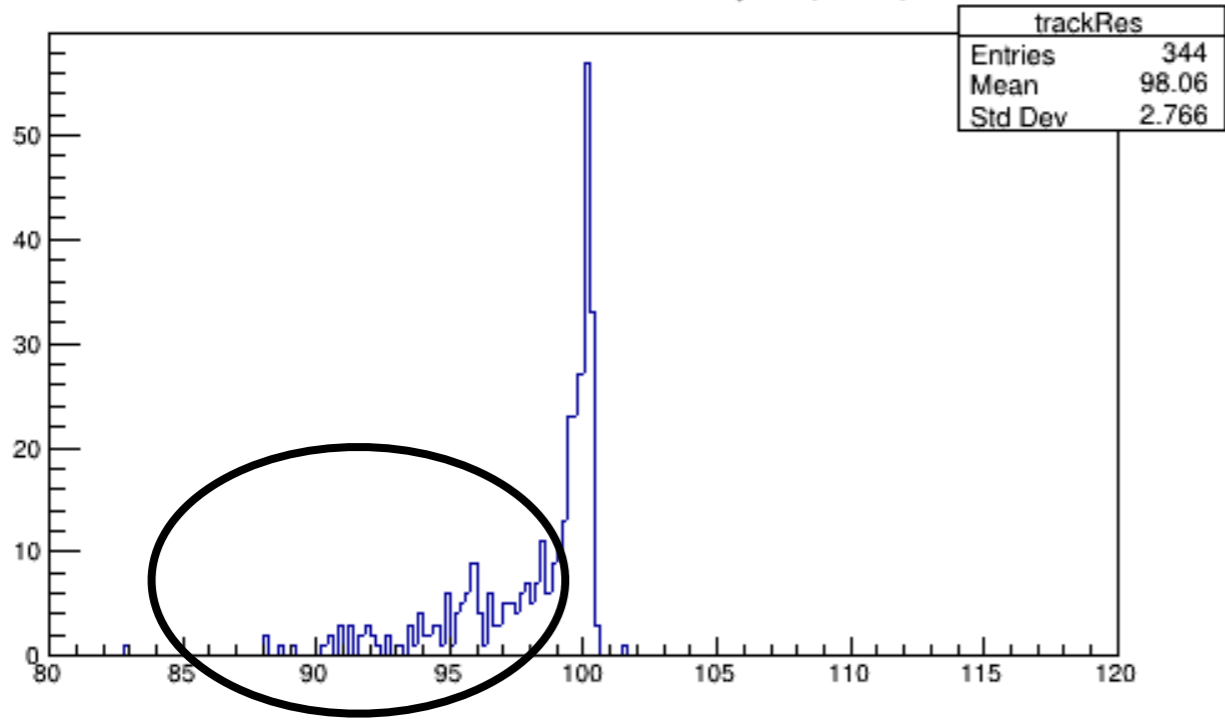
Early hits

Time resolution of earliest object (cluster)

clusterRes
Entries 551
Mean 99.59
Std Dev 2.318

Early hits

median time

Time resolution of earliest object (track)

trackRes
Entries 131
Mean 100.1
Std Dev 0.4686

Time resolution of earliest object (cluster)

clusterRes
Entries 597
Mean 99.87
Std Dev 2.301

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