2D Michel Reconstruction

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Detector Physics

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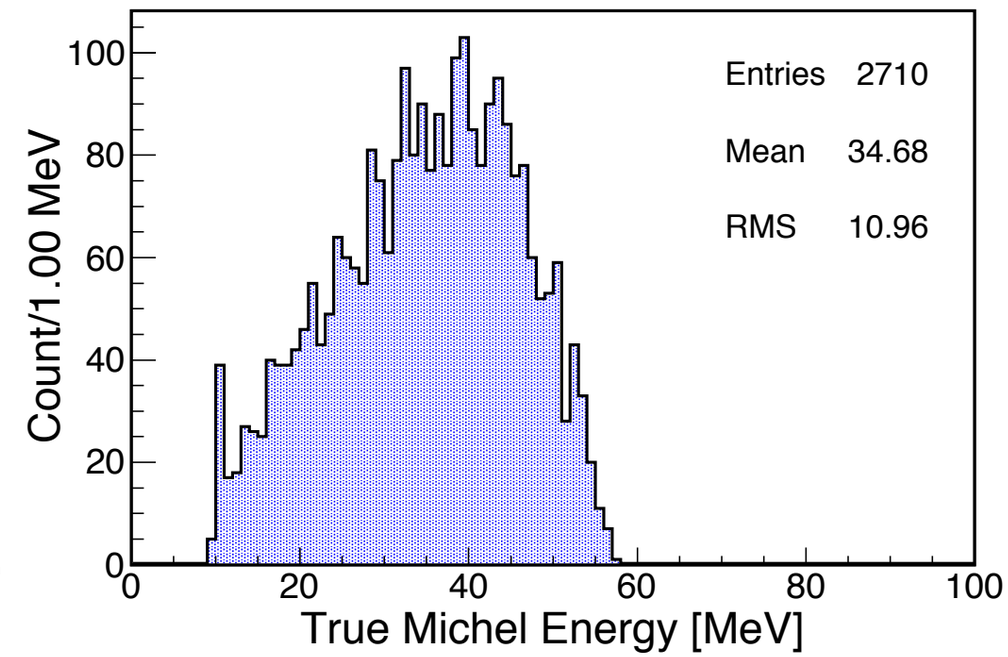
Why Michels?

Motivation

- Michel spectrum is important!
  - Benchmark for low energy scale calibration
  - Study low energy shower characteristics
  - PMT correlation(!)
- Demonstrates our understanding of the detector
  - Important commissioning goal!
- High statistics cosmic data during commissioning is a great source of stopping muons



Michels

Goals

- Initial approach: simple algorithm development
  - Use **only collection plane**
  - No matching, possibly no deconvolution needed
- With 2D reconstruction information…
  - tag stopping muons
  - cluster the Michel shower
- Apply lifetime correction to charge spectrum to get MeV scale
- Party!

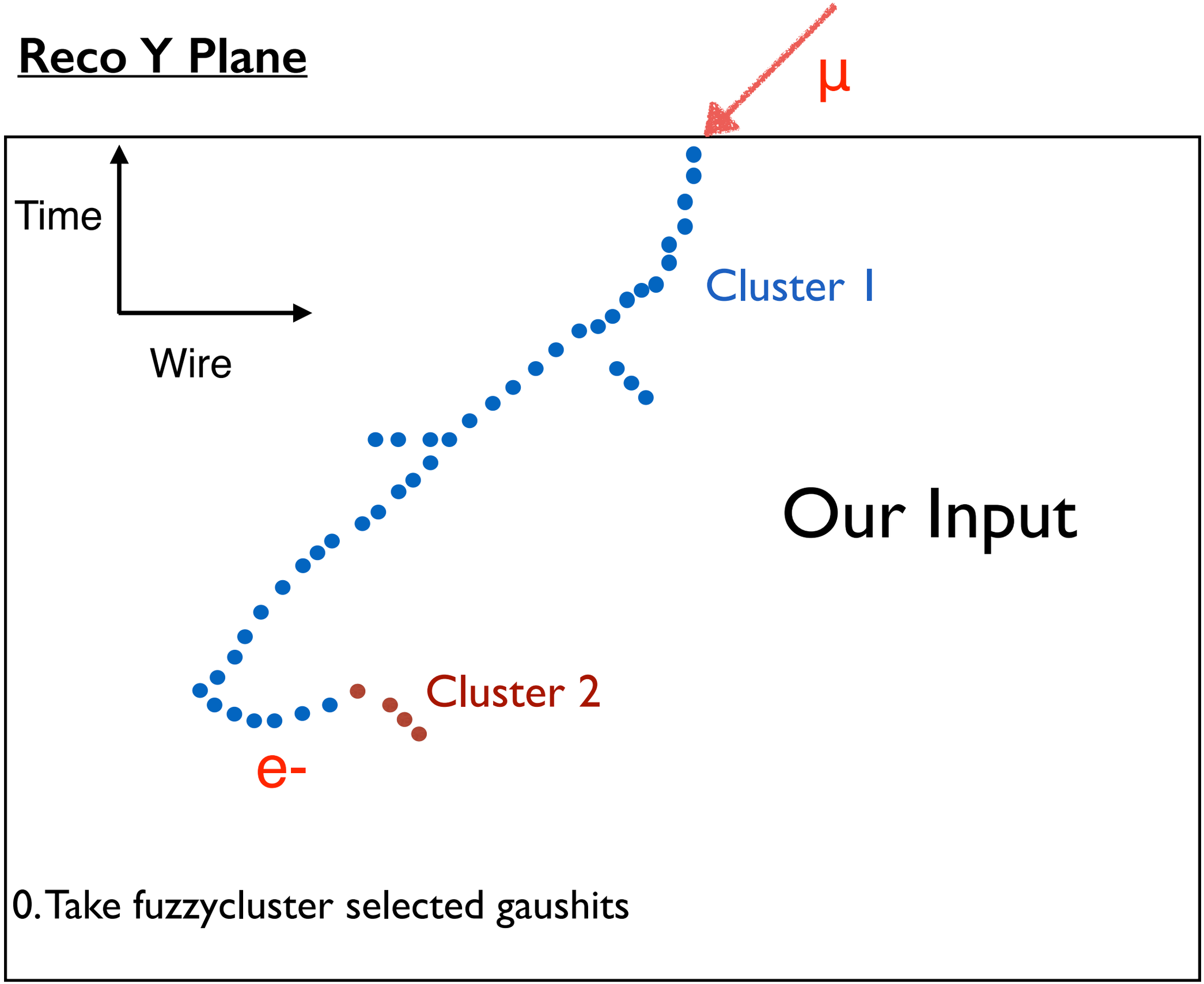
Clustering Michel Shower

Input

- Sample of isotropic muons
  - prod_muminus_0.1-2.0GeV_isotropic_uboone
- 100K sample muons → filter events with Michels (~5%)

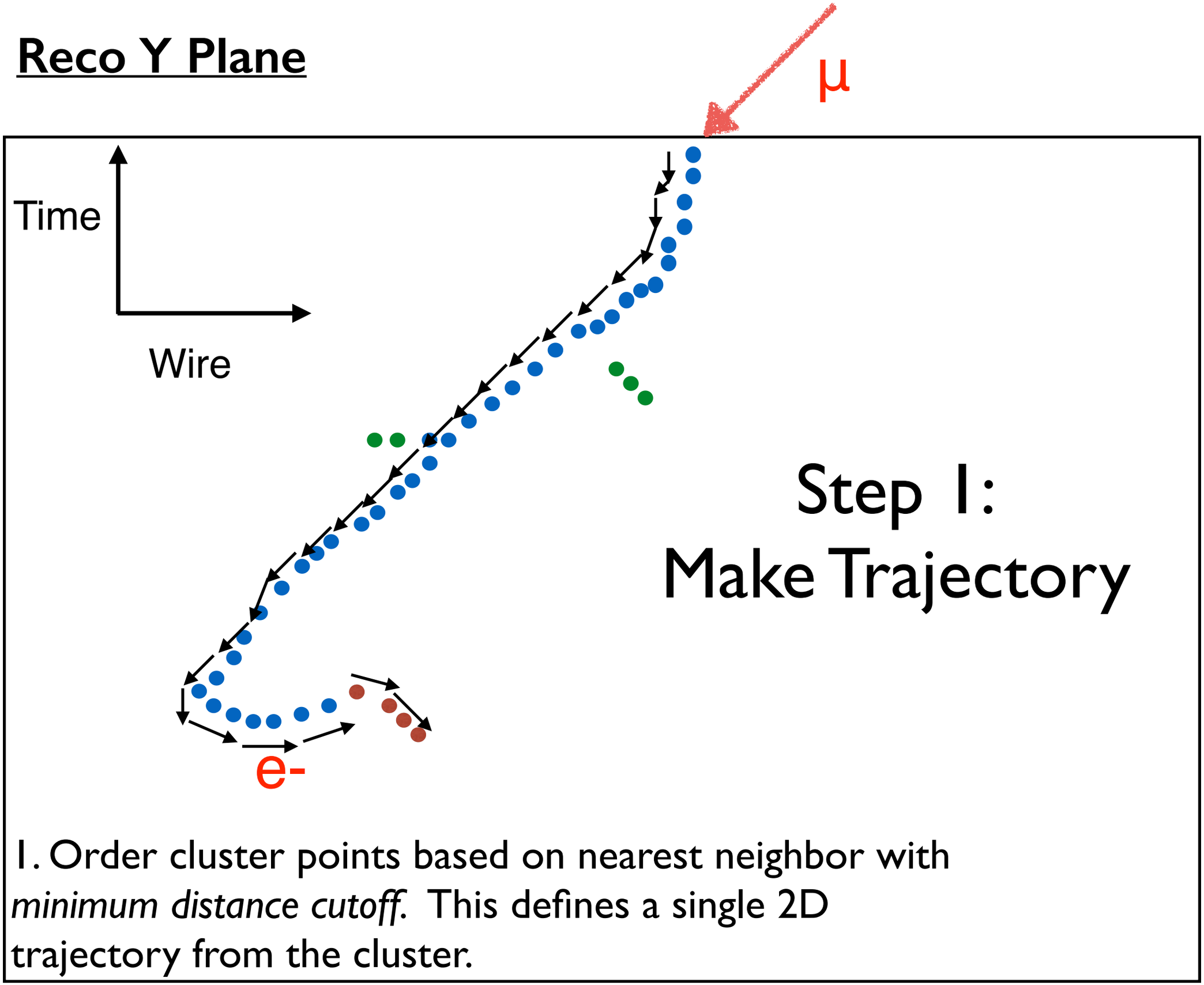
Cluster Michel and Muon

Reco Y Plane



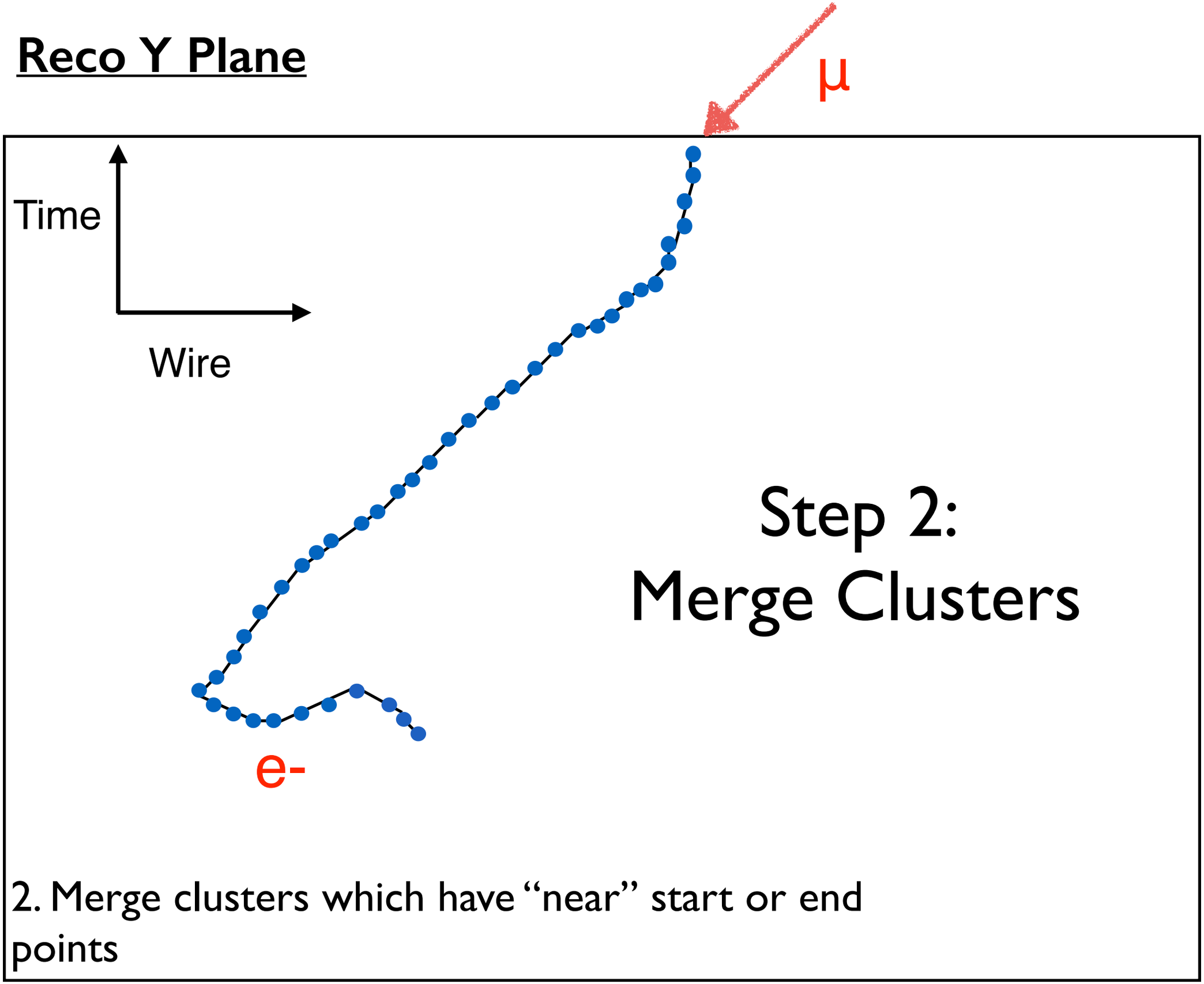
TPC active

Reco Y Plane



TPC active

Reco Y Plane

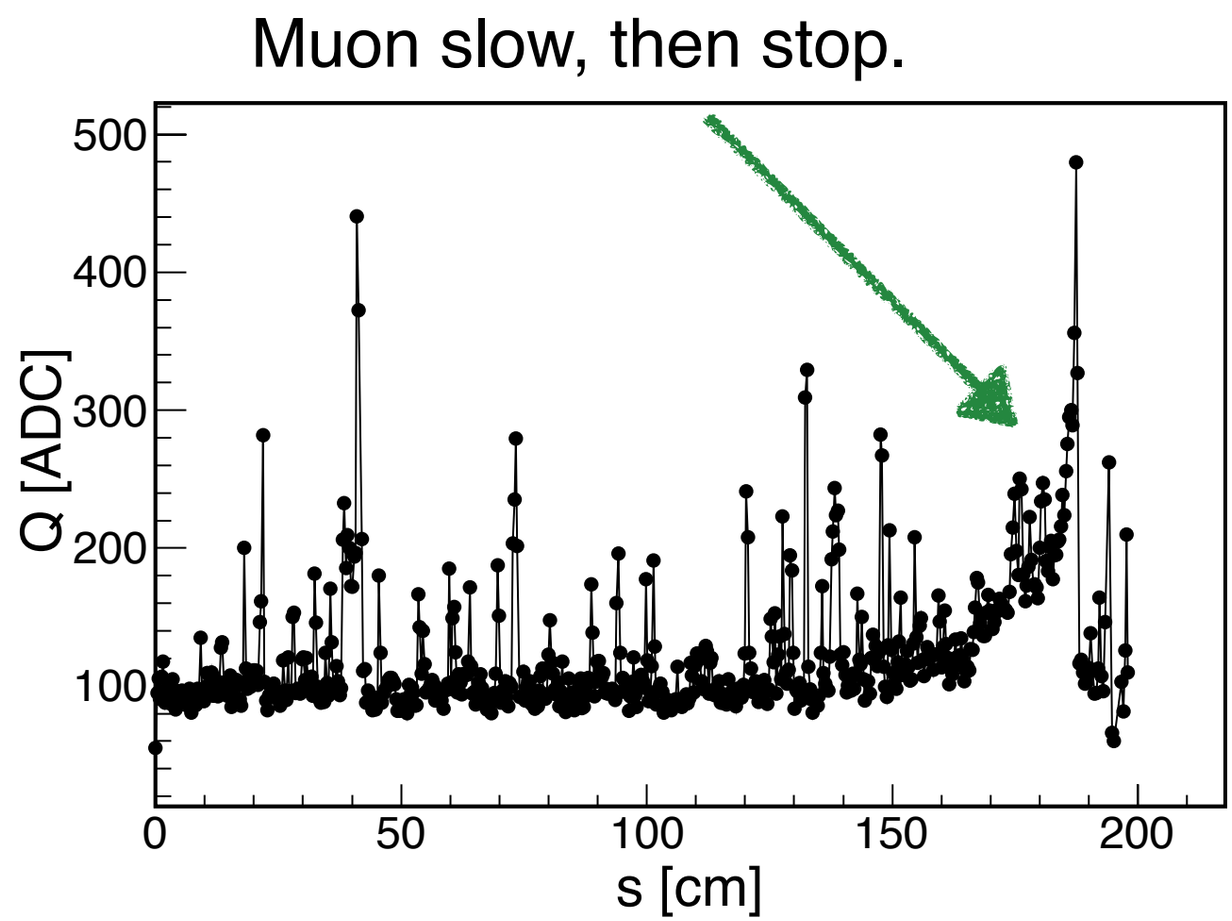


TPC active

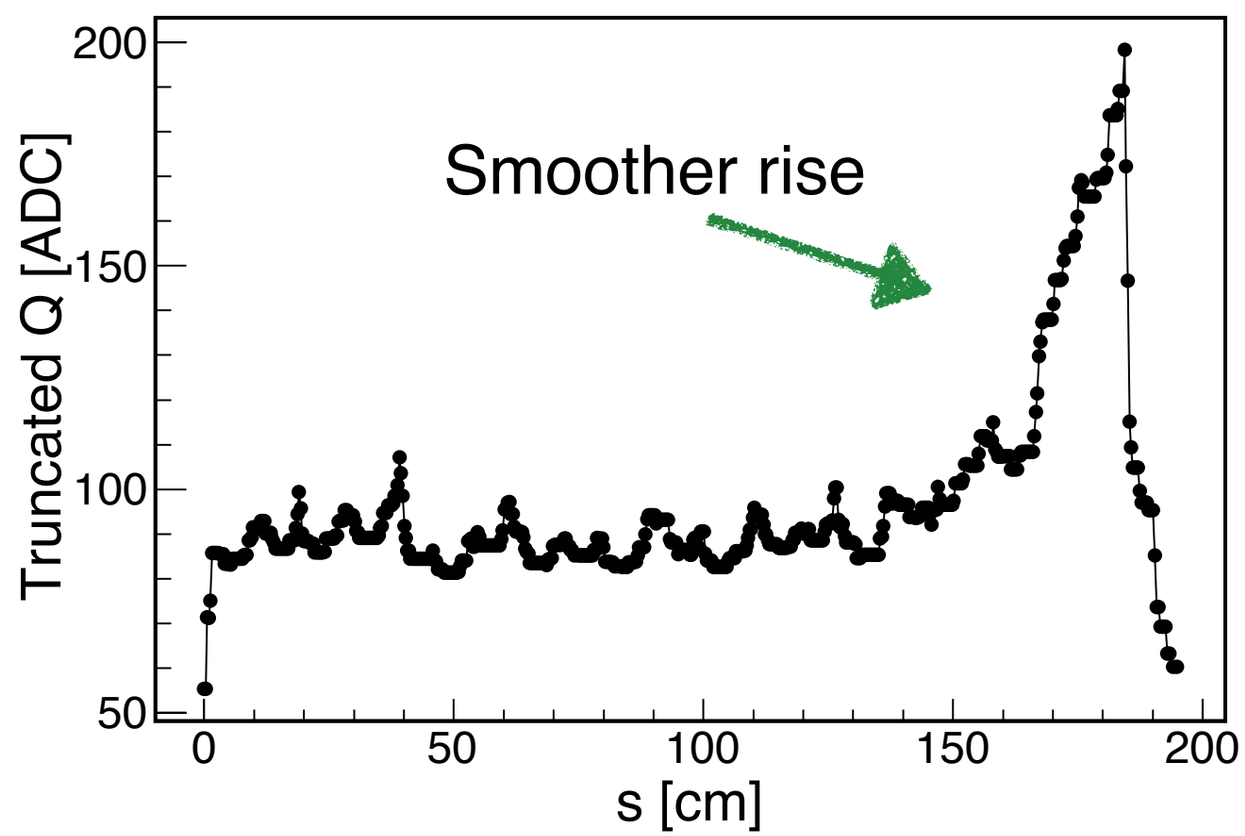
Find Michel Start

Charge Deposition Along the Path

- Scan *charge* vs. *distance* along the ordered hits in cluster

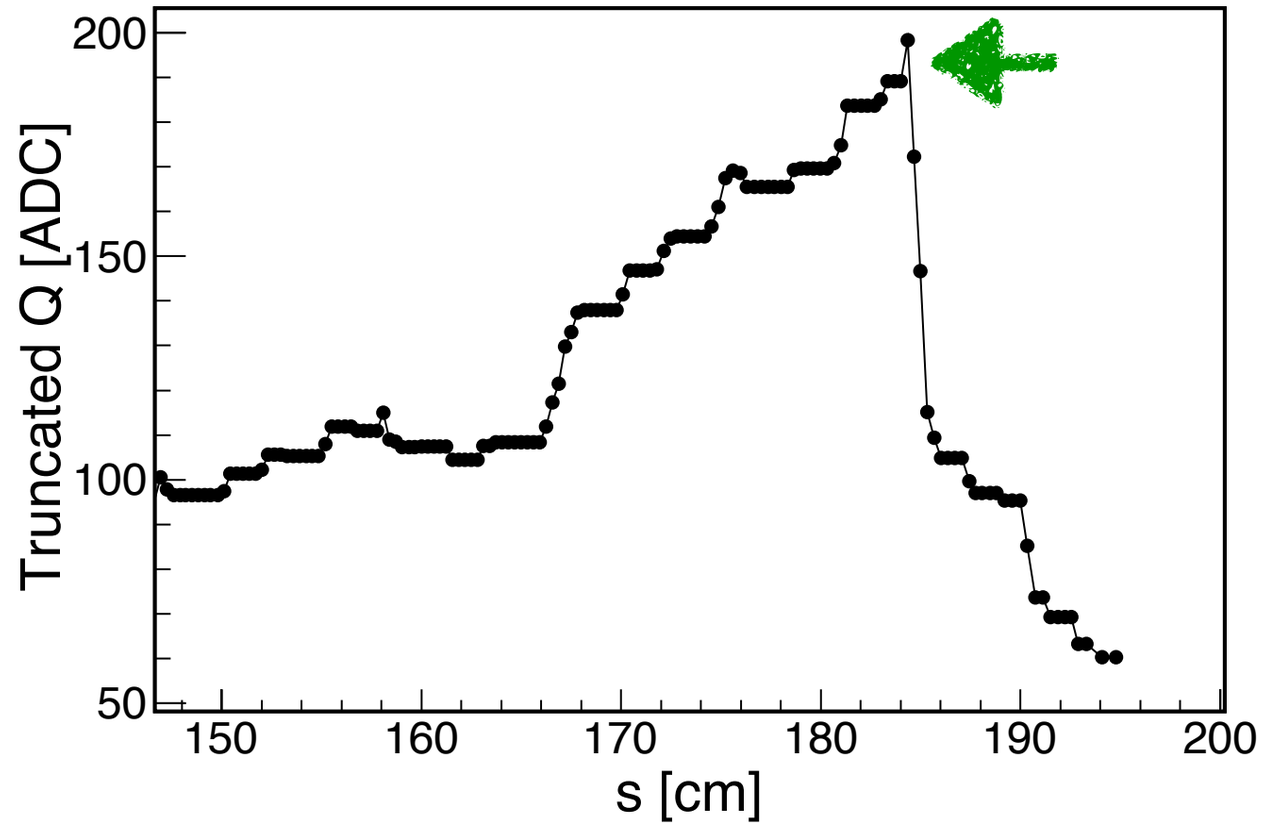


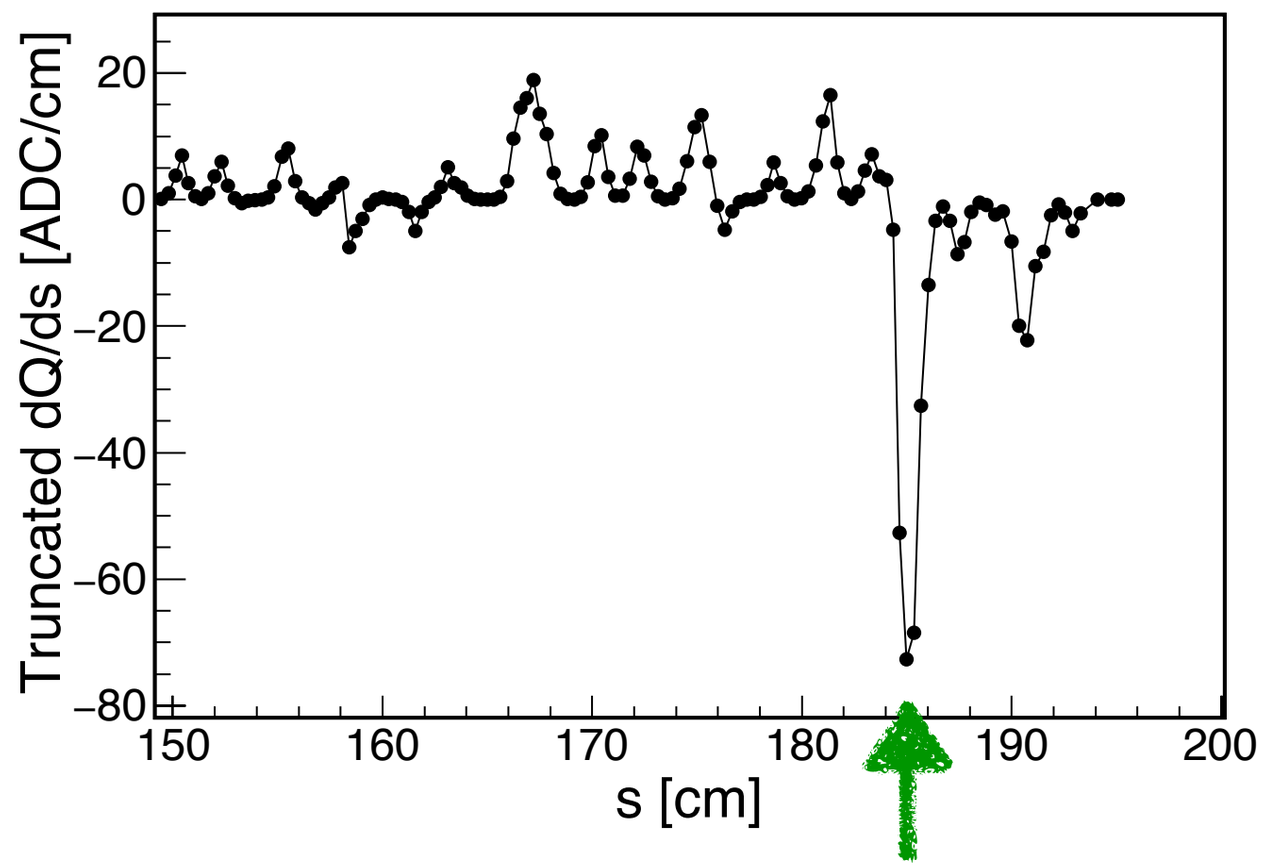
- Apply truncated mean to smooth out, trimming hits above the local mean



Differential Charge Deposition Along the Path

- Apply "Lanczos differentiator" to calculate dQ/ds with suppressed noise

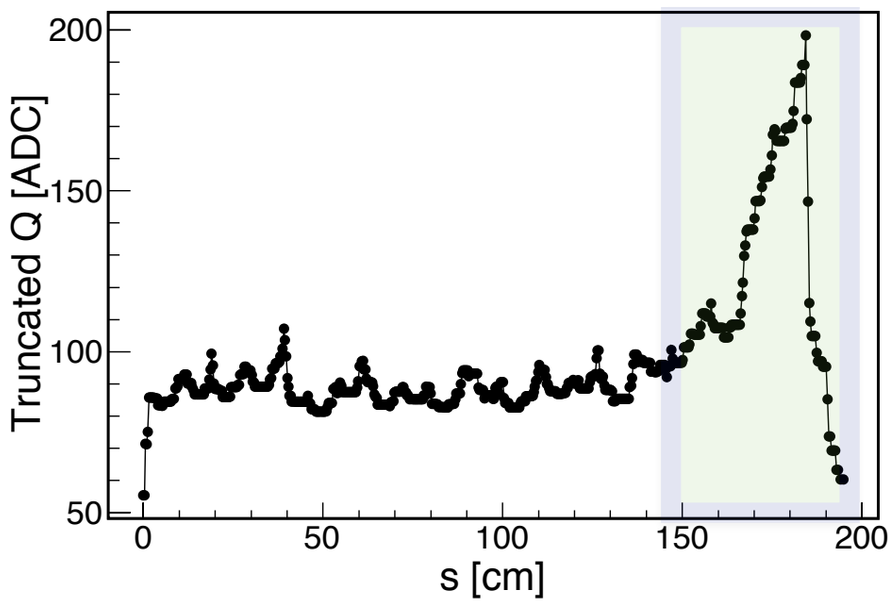


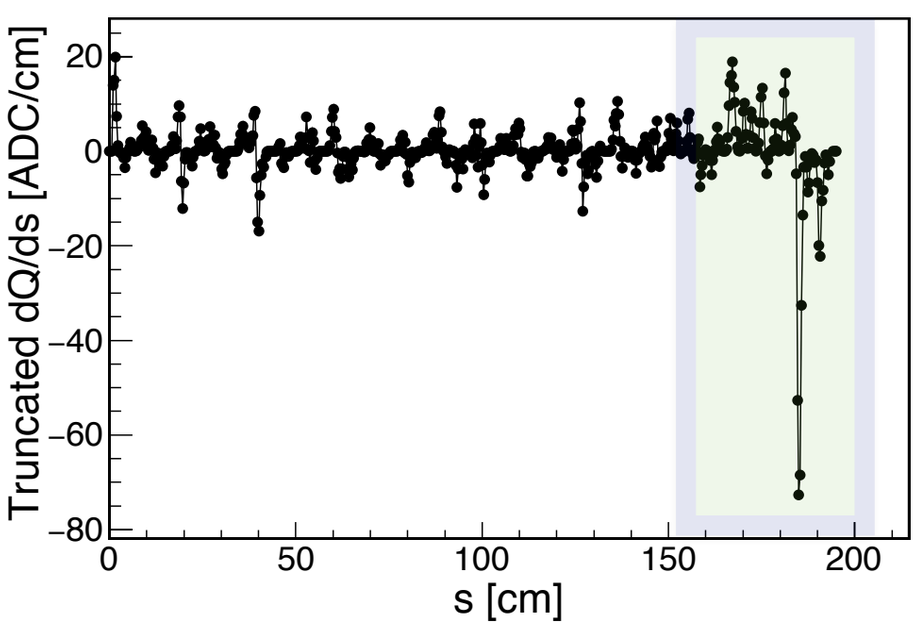


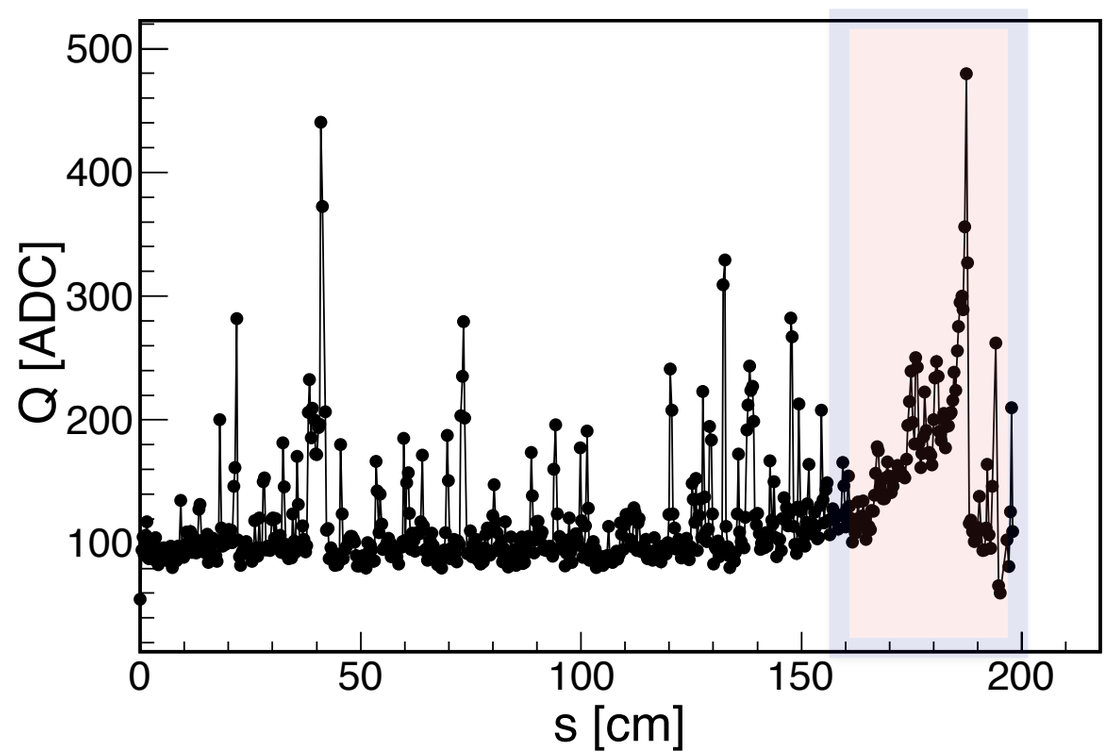
Sharp peak @ last muon hit

Reconstruction

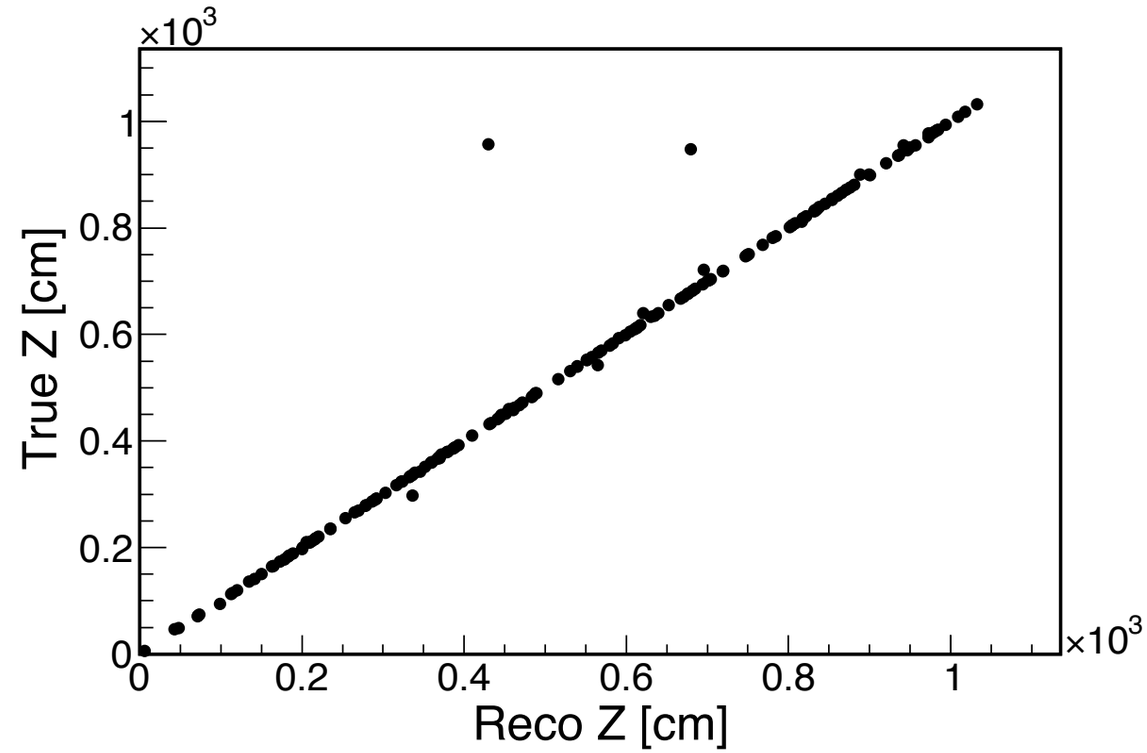
- Use *largest* peak in truncated mean and *largest* dip in dQ/ds to identify region of interest in true Q
- Use to find Michel start point based on local peak in charge

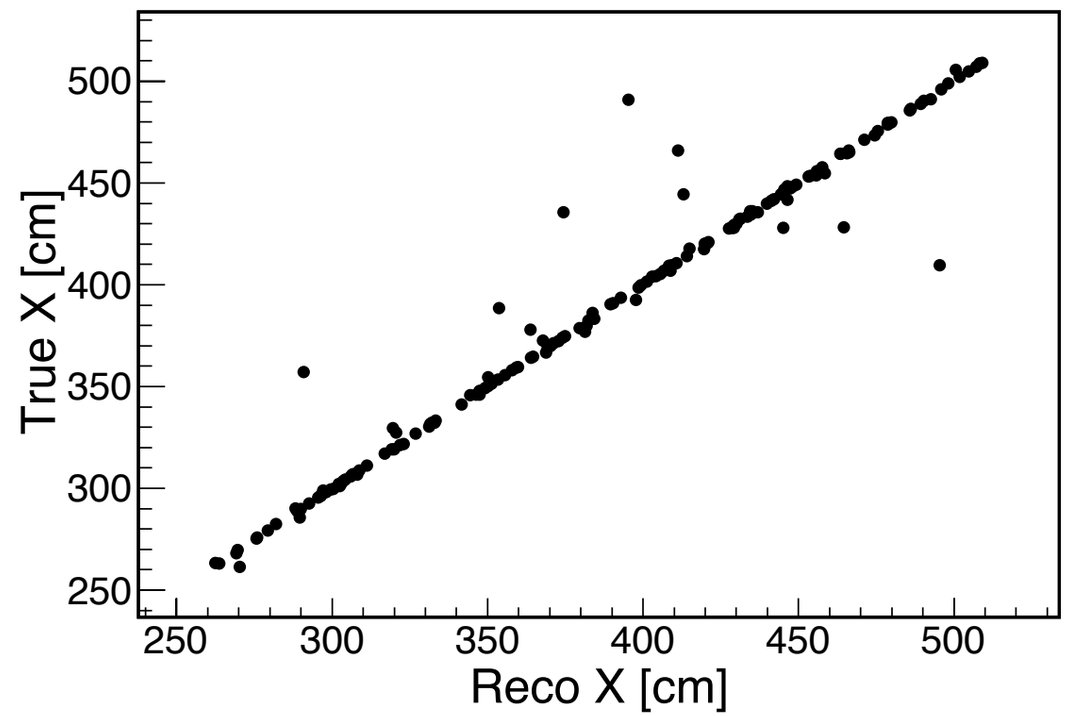


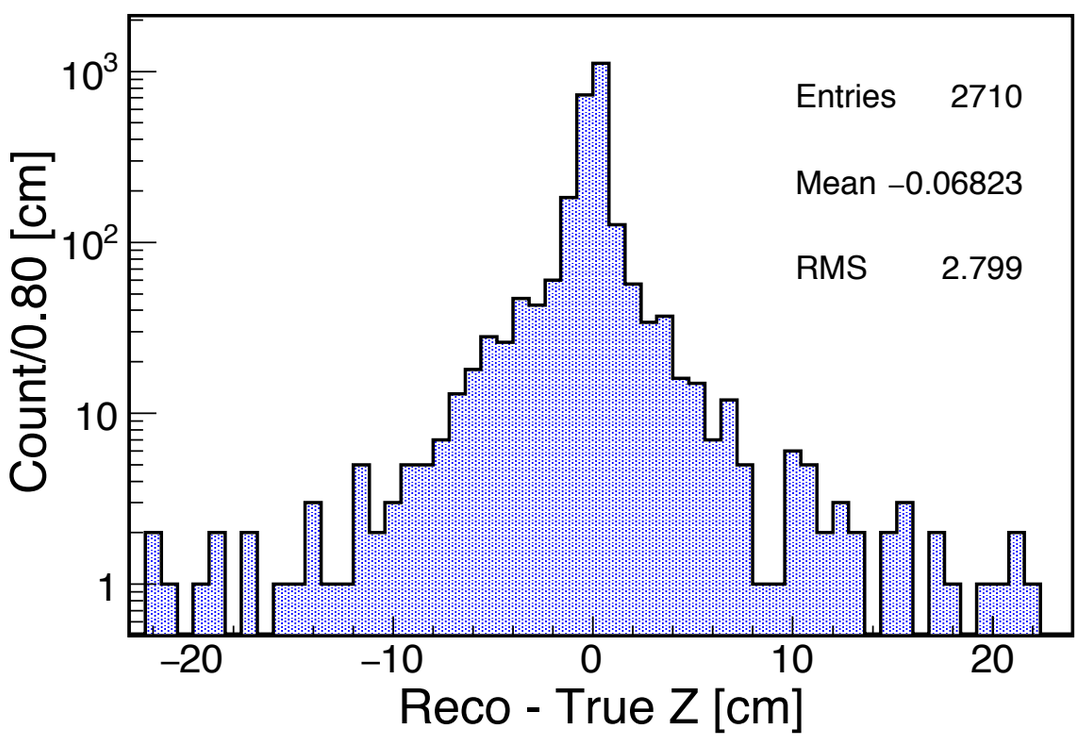


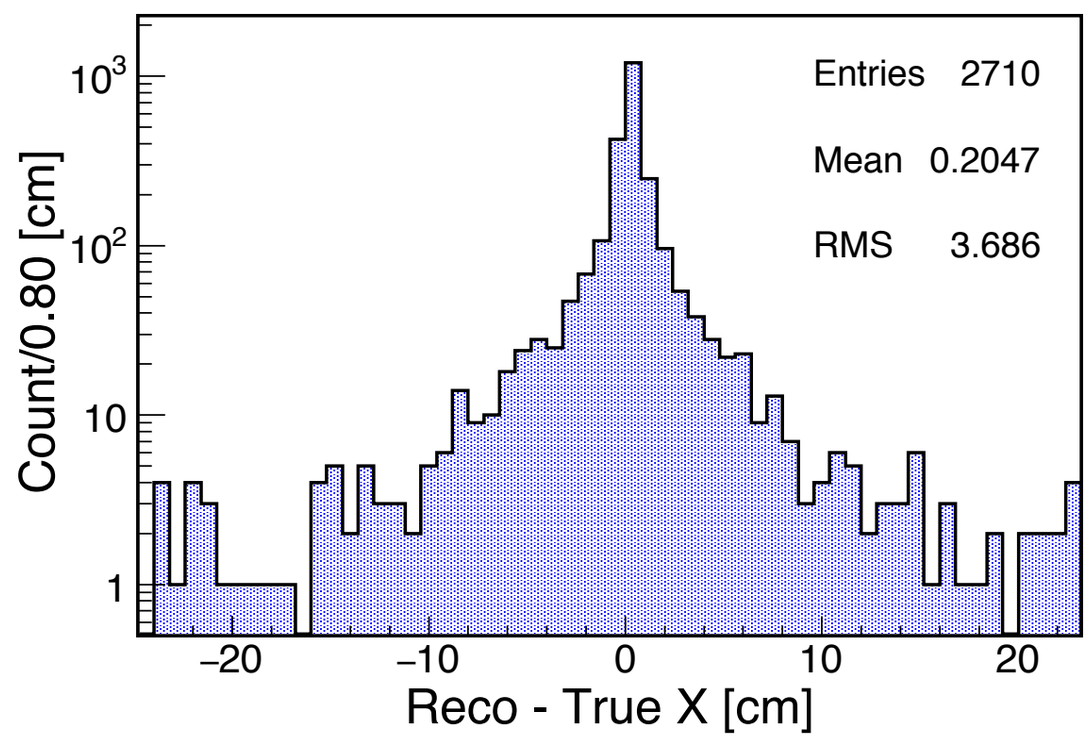


All Events…


×10^3
True Z [cm]
Reco Z [cm]
×10^3


True X [cm]
Reco X [cm]

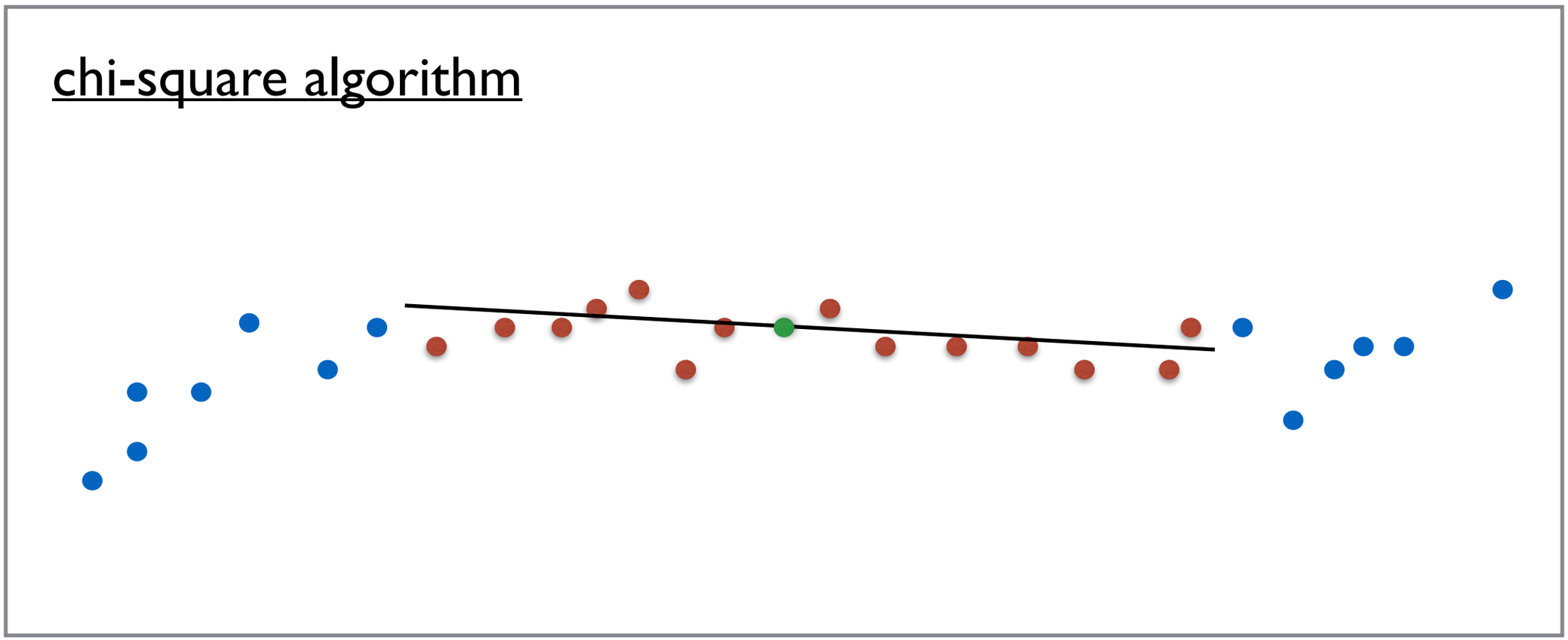

Entries 2710
Mean −0.06823
RMS 2.799
Count/0.80 [cm]
Reco - True Z [cm]


Entries 2710
Mean 0.2047
RMS 3.686
Count/0.80 [cm]
Reco - True X [cm]

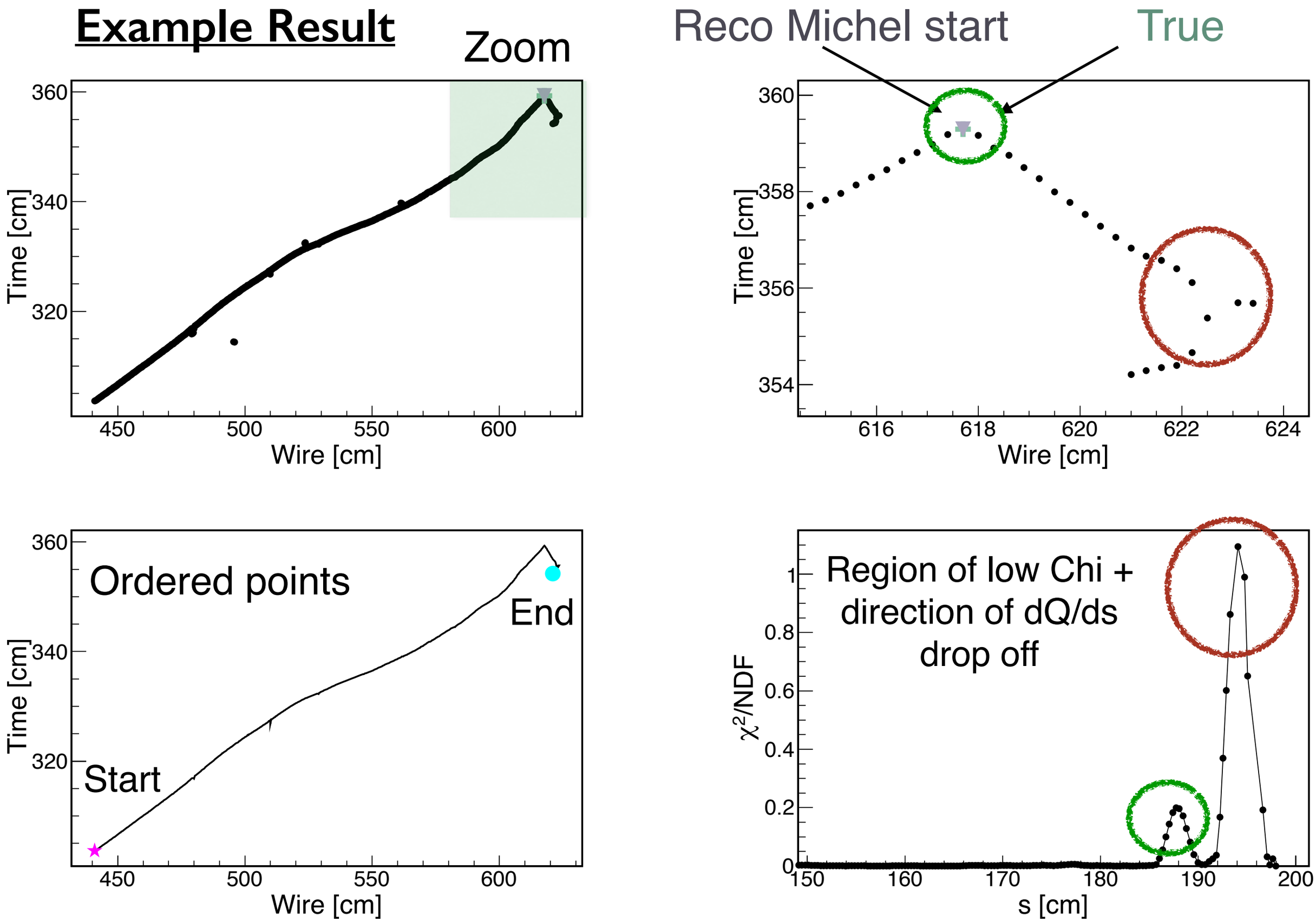
Identify Michel and Muon

We know the boundary point….

- Determine which segment is the Michel
- Use **local linear fit chi-square** and Reco track/charge info

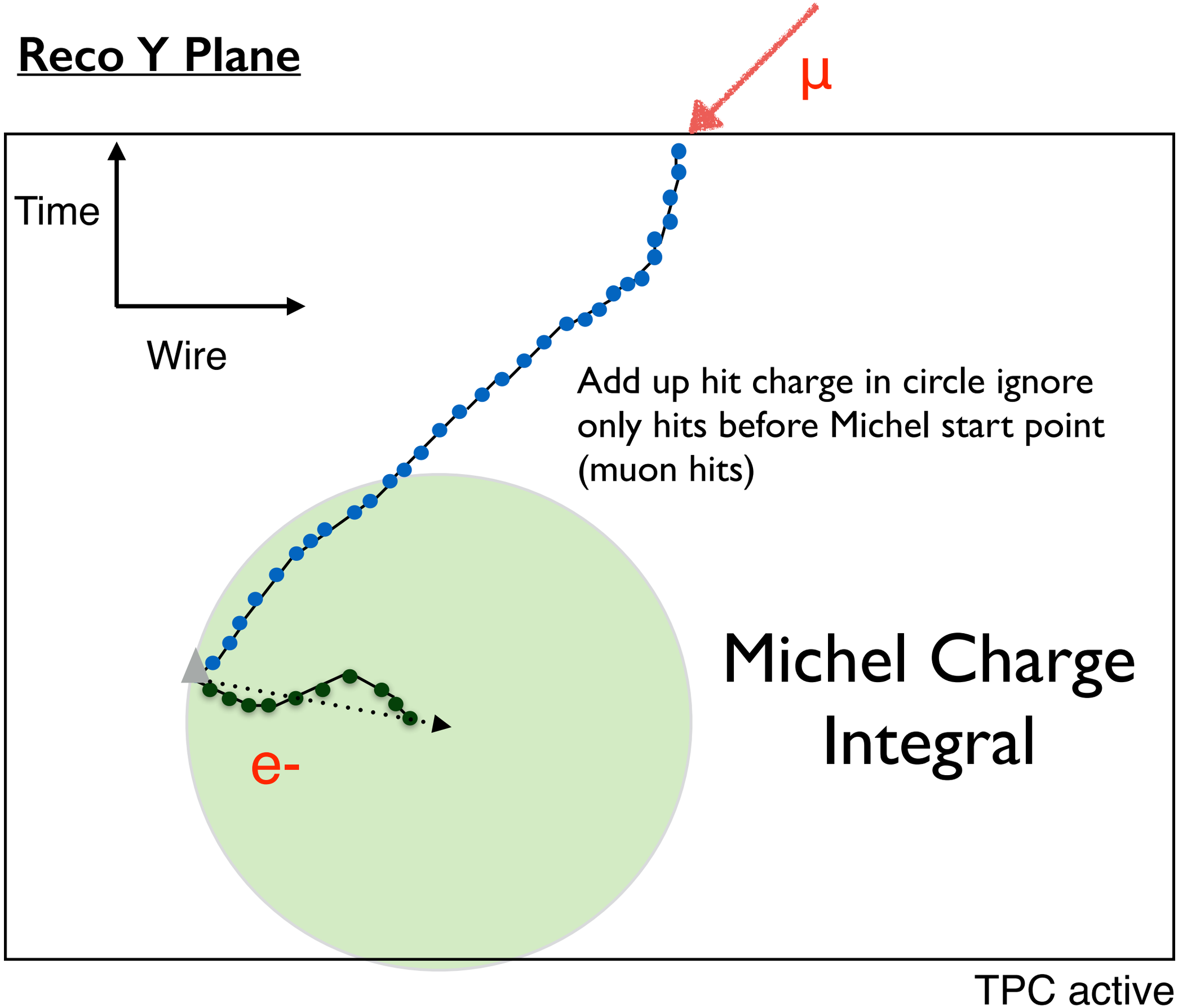


Example Result

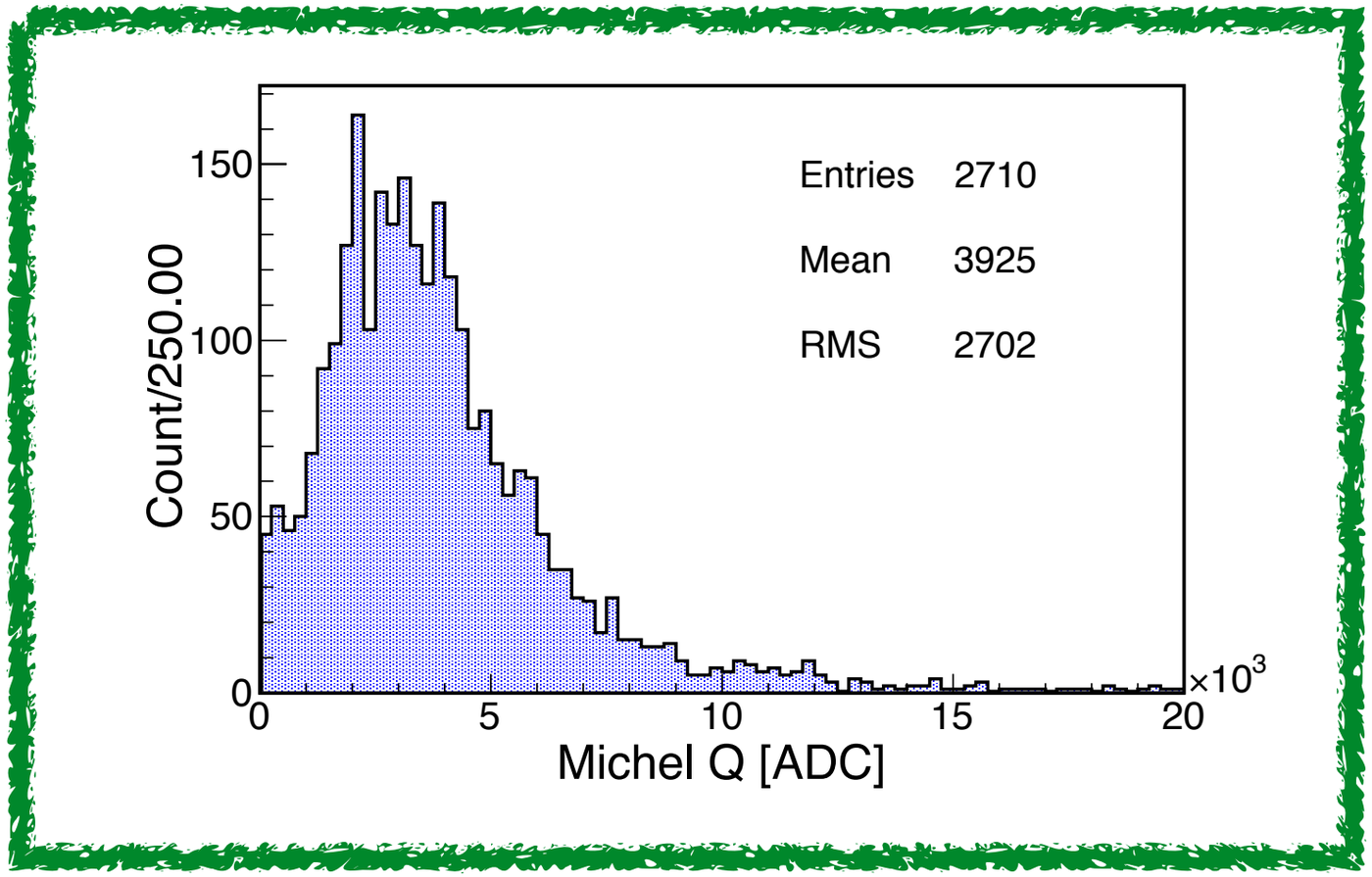


Michel Charge Spectrum

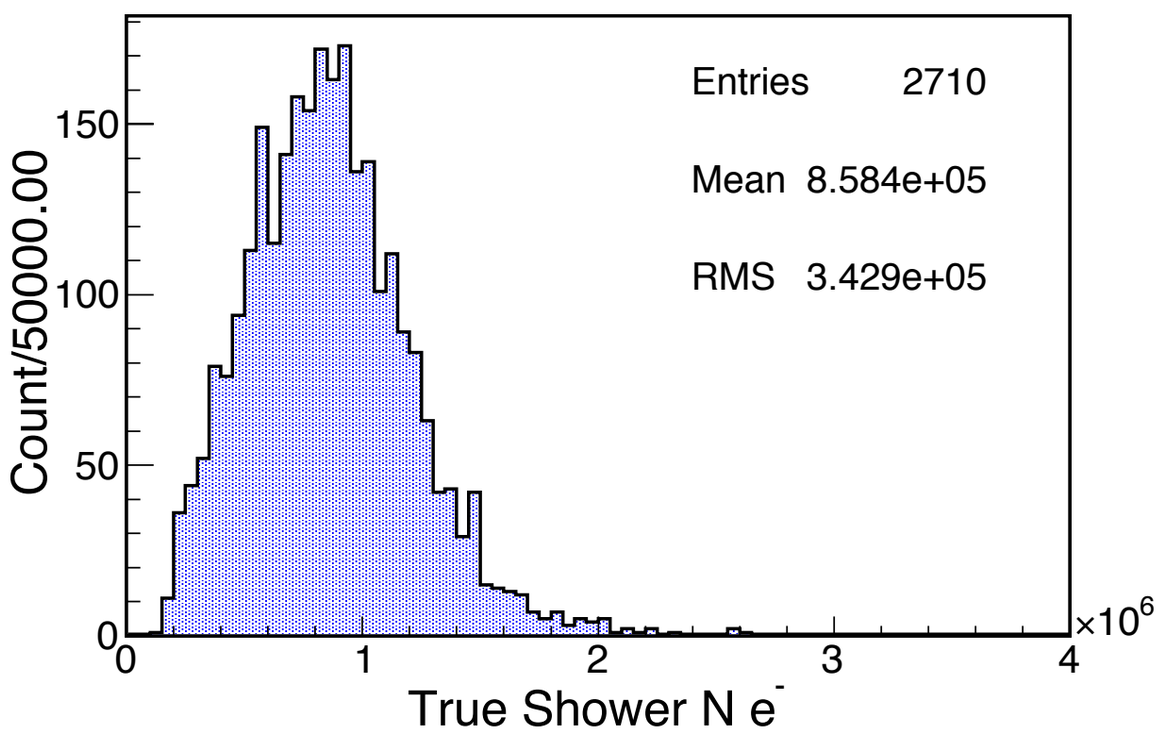
Reco Y Plane

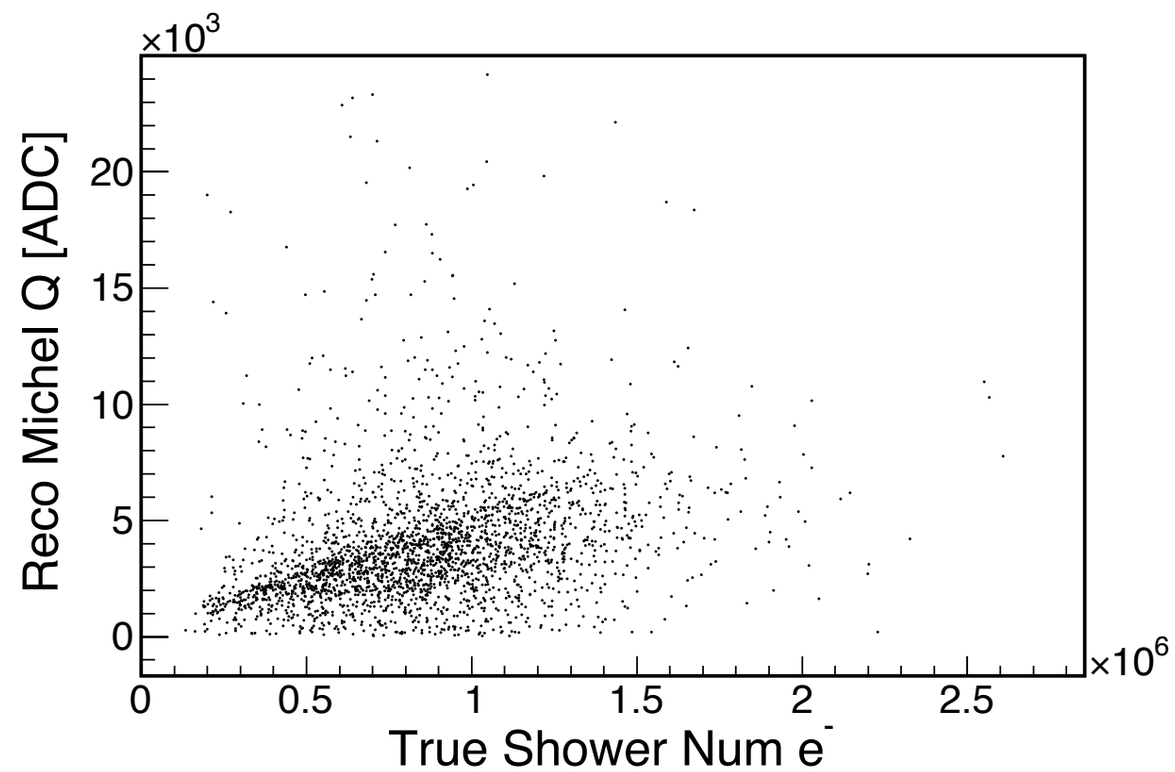

μ
Time
Wire
Add up hit charge in circle ignore only hits before Michel start point (muon hits)
e-
Michel Charge Integral
TPC active

Simple E Reco…



Our Reconstruction



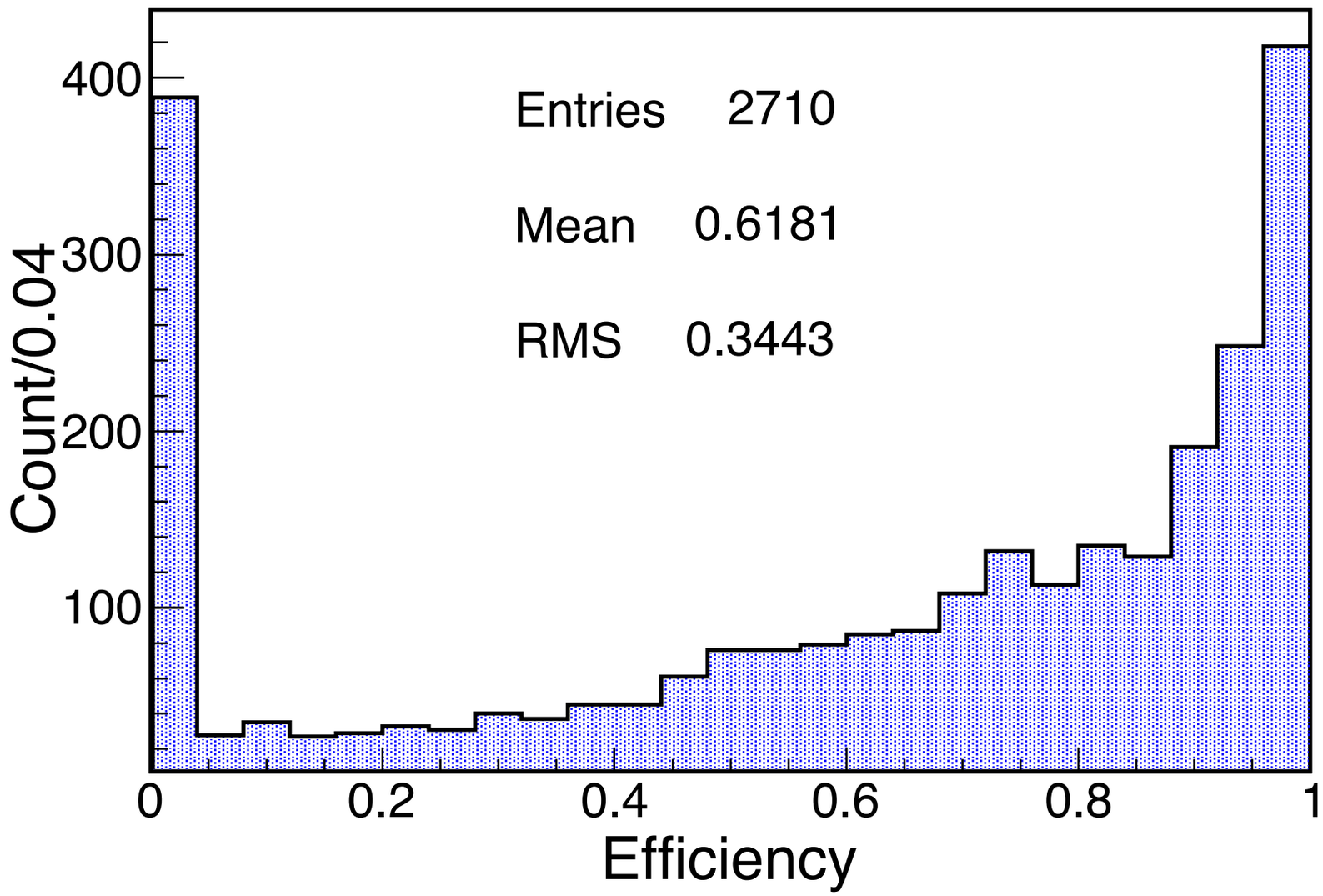


Summary

- **Progress:**
  - We have defined an algorithm that uses 2D Reco information to:
    - cluster a muon and Michel track
    - find the Michel start
    - cluster the Michel hits
    - Michel charge spectrum
- **Next Steps:**
  - Fine tune algorithm to reduce instances of over and under charge estimation
  - Apply algorithm to sample of muons that don't all stop
    - cosmic sample
  - Apply lifetime correction to charge spectrum

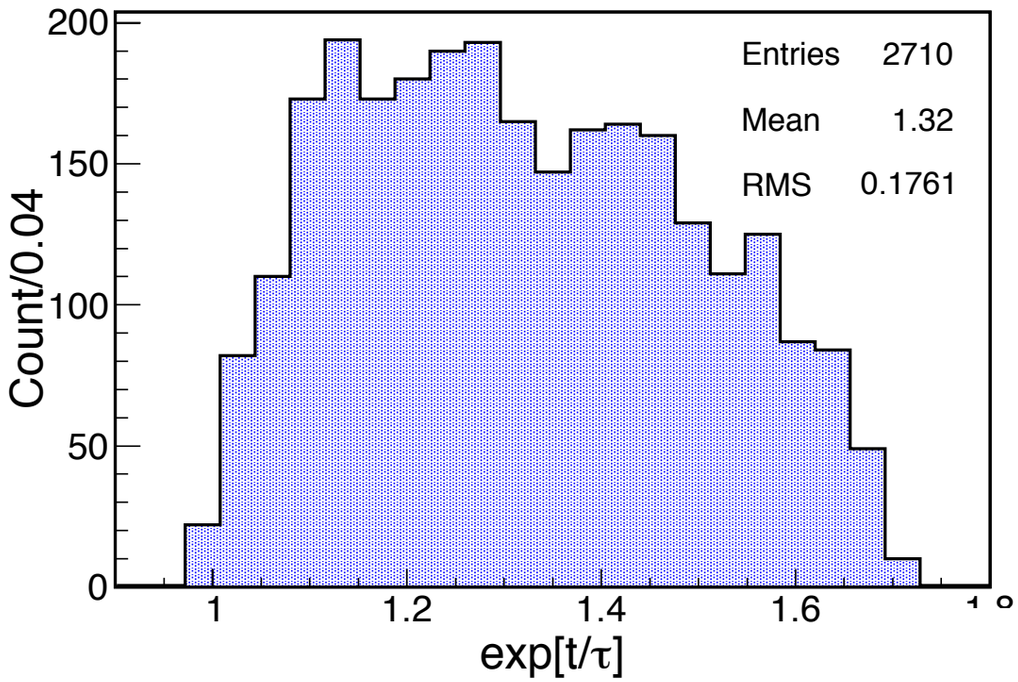
Backup

Efficiency



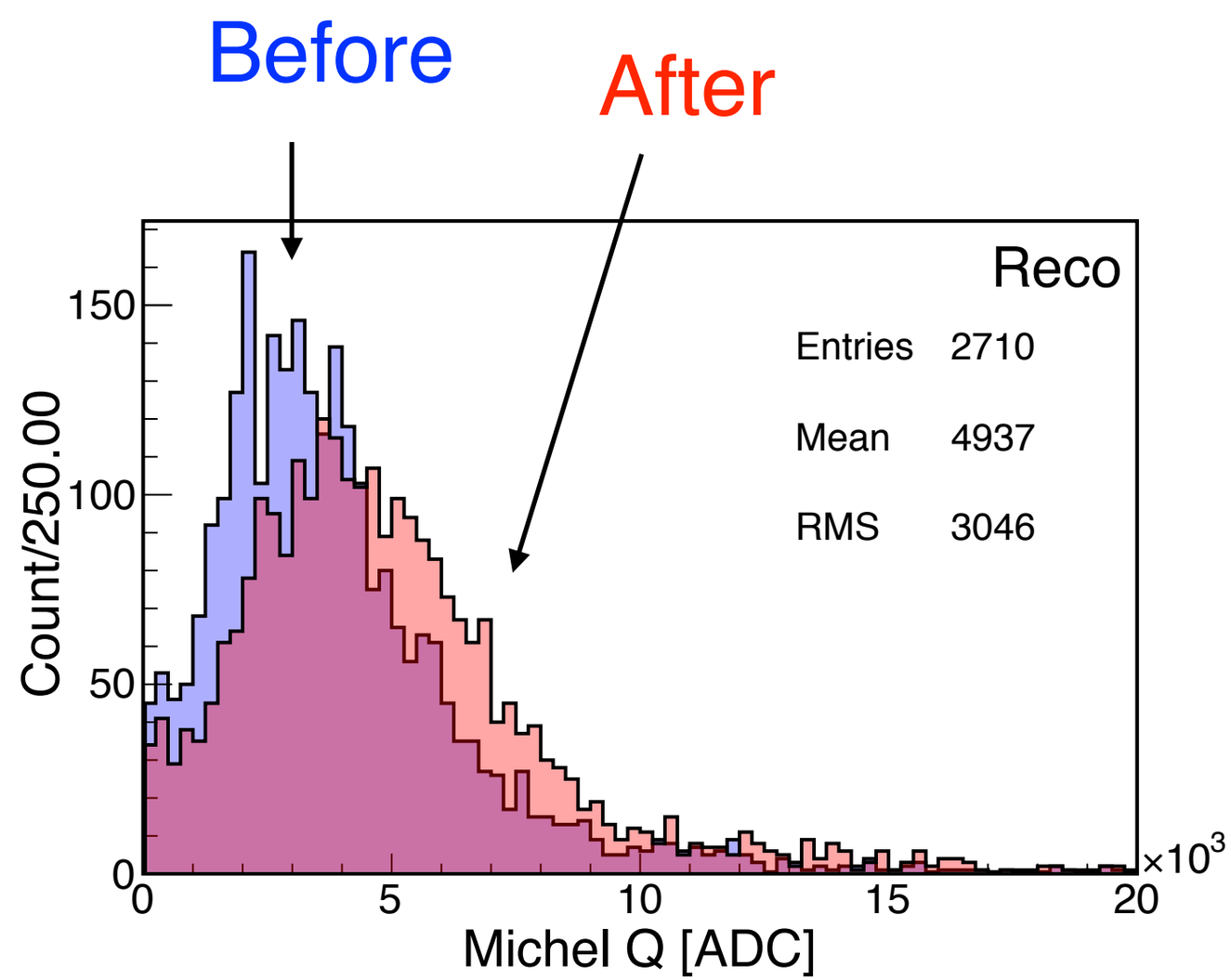
$$\text{Efficiency} = \frac{\#\ \text{chosen true Michel hits}}{\#\ \text{total true Michel hits}}$$

Lifetime correction



$$Q^{\text{corr}} = Q^{\text{raw}} e^{t/\tau}$$

$$\tau = 3\ ms$$

$$v = 160\ cm/ms$$

$$t_{\text{drift}} = X/v$$