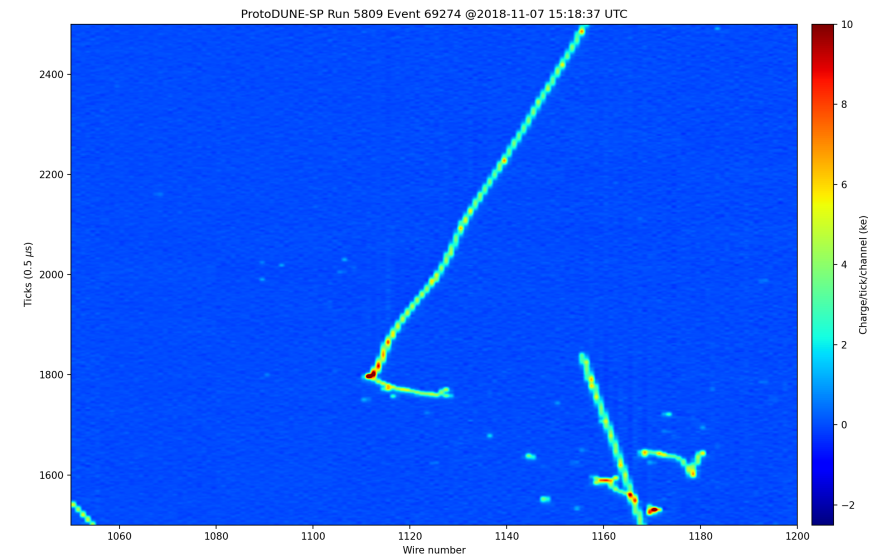


# Michel analysis current status

Aleena Rafique, Zelimir Djurcic  
ProtoDUNE sim/reco meeting  
08/19/2020

# Current status

- Developed a selection of events in which muons decay into candidate Michel electrons
- Obtained the Michel energy spectrum in MC and data
  - Both agree well within statistical error bars
- An analysis note is already posted on the DocDB ([DocDB # 17579](#))
  - Needs to be updated

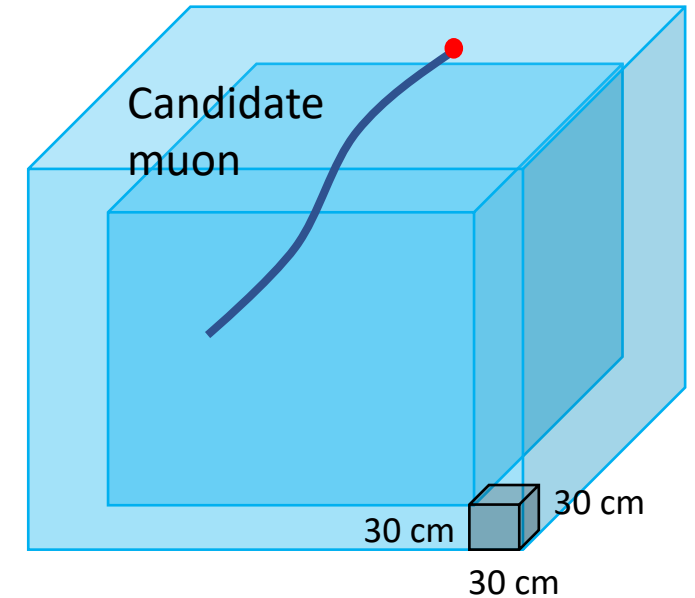


# Data and MC samples

- PDSP Prod 2
- Data:
  - protodune-sp\_runset\_5809\_reco\_v08\_27\_XX\_v0 (Full statistics ~150k events)
- MC:
  - PDSPProd2\_MC\_1GeV\_reco\_sce\_datadriven (Full statistics ~100k events)
- Events after selection:
  - Data: 3166
  - MC: 6283

# Muon event selection

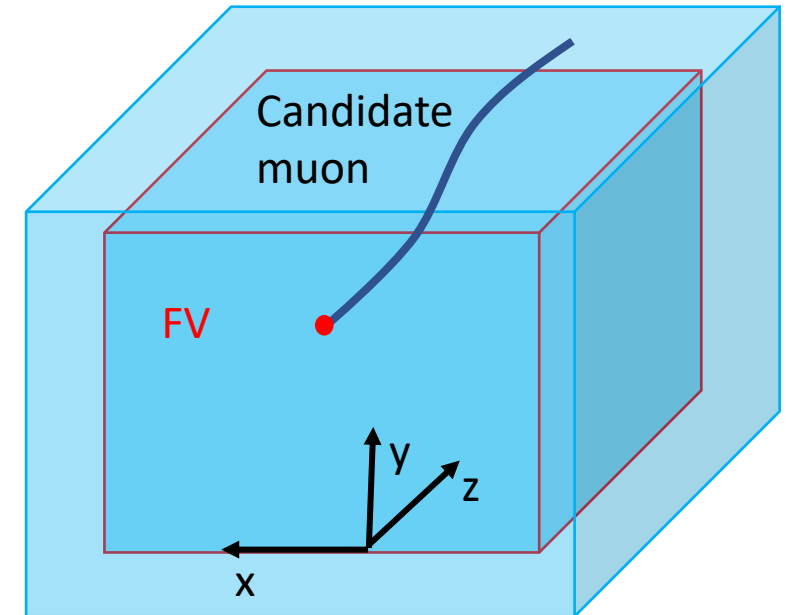
- Reconstructed track one end point is close to the detector edges
  - Helps to select mostly cosmic muons entering in detector from outside



Sample/quantities	MC	Data
Passing rate	62%	66%

# Muon event selection

- Reconstructed track other end point is within FV



Sample/quantities	MC	Data
Passing rate	8.3%	21%

FV:

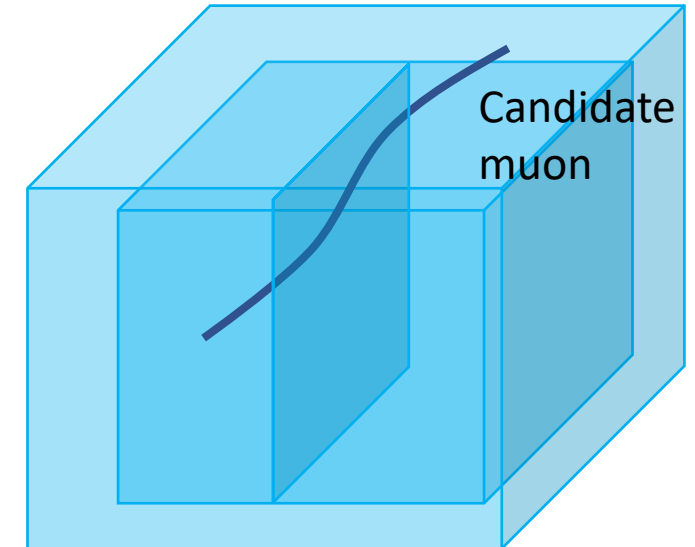
X = (-310, 310) cm

Y = (80, 557) cm

Z = (80, 610) cm

# Muon event selection

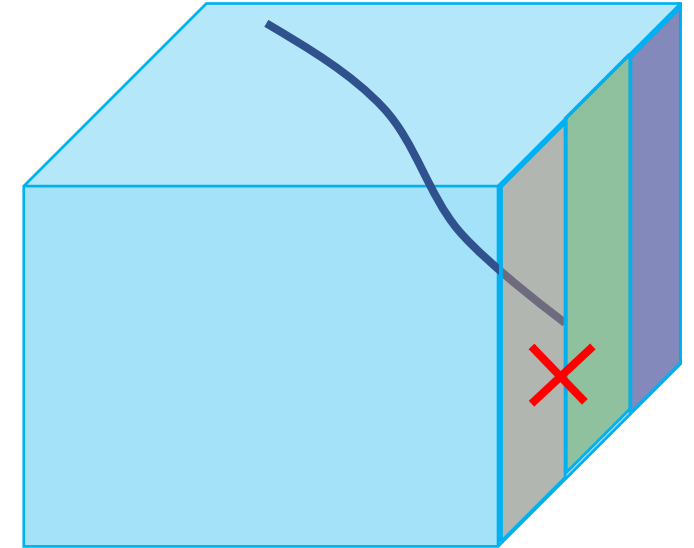
- Reconstructed track cross cathode
  - To select tracks having correct reco end positions



Sample/quantities	MC	Data
Passing rate	6.8%	21%
Purity	26%	----

# Muon event selection

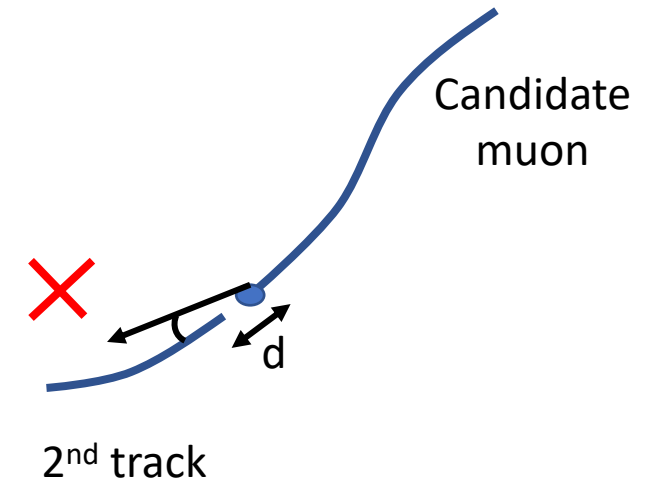
- Reject tracks where reconstructed track end point lie around APA boundaries



Sample/quantities	MC	Data
Passing rate	5.9%	15%
Purity	26%	----

# Muon event selection

- Reject broken tracks

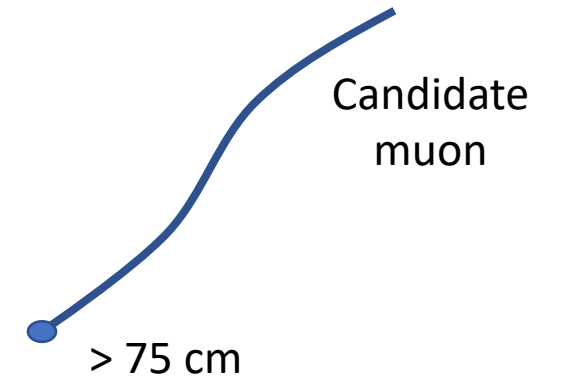


Sample/quantities	MC	Data
Passing rate	5.5%	14%
Purity	27%	----



# Muon event selection

- Candidate muon track length  $> 75$  cm

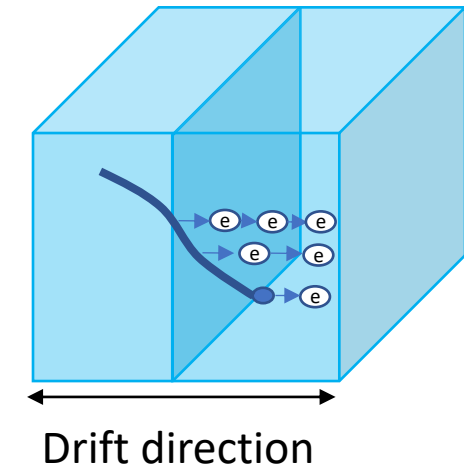


Sample/quantities	MC	Data
Passing rate	5.4%	14%
Purity	27%	----

# Muon event selection

- Candidate muon track minimum hit peak time  $> 200$  ticks

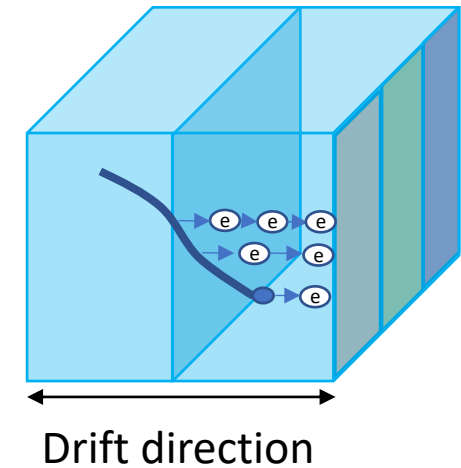
Sample/quantities	MC	Data
Passing rate	2.1%	5.8%
Purity	63%	----



# Muon event selection

- Candidate muon track maximum hit peak time < 5800 ticks

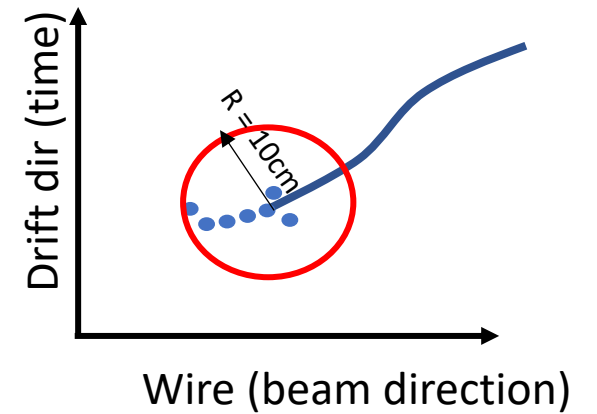
Sample/quantities	MC	Data
Passing rate	1.9%	5.3%
Purity	63%	----



# Muon event selection

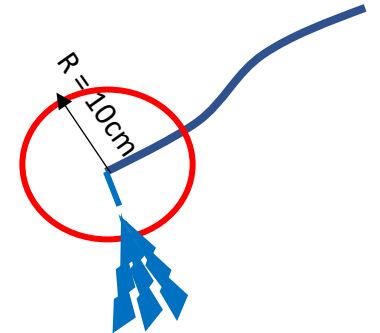
- Nearby hit count  $> 5$  &  $< 40$

Sample/quantities	MC	Data
Passing rate	0.9%	2.7%
Purity	86%	----



# Muon event selection

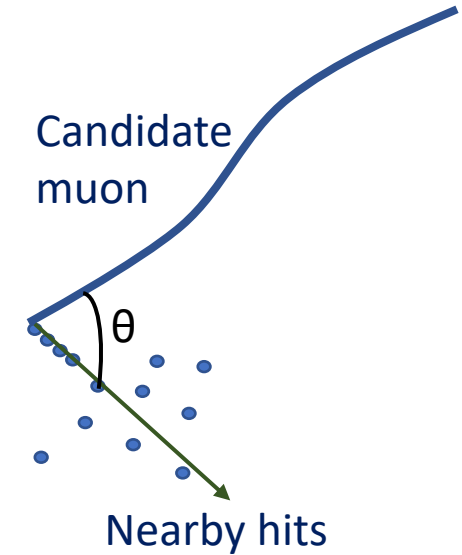
- Closest reco shower distance  $< 10$  cm



Sample/quantities	MC	Data
Passing rate	0.8%	2.1%
Purity	89%	----

# Muon event selection

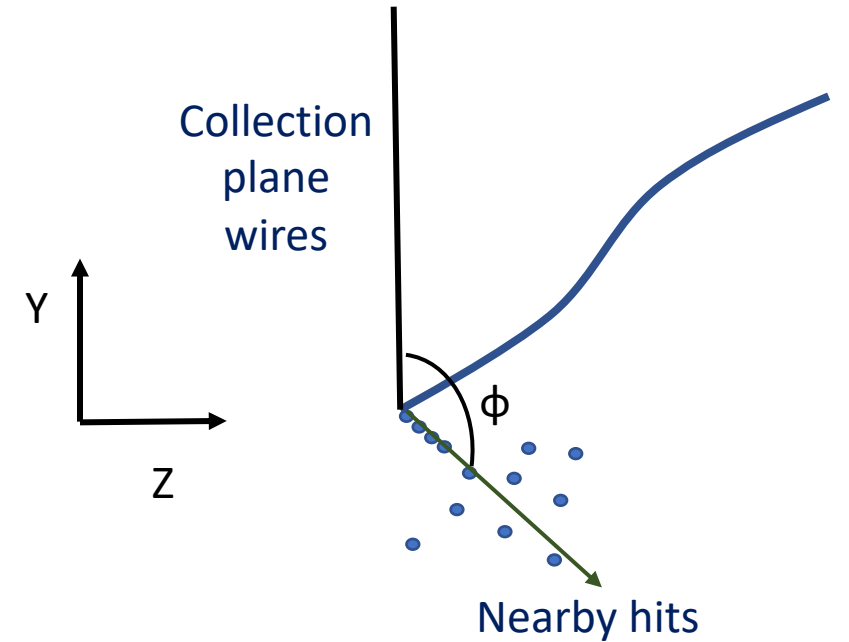
- Angle between candidate muon and Michel  $< 130^\circ$



Sample/quantities	MC	Data
Passing rate	0.5%	1.1%
Purity	94%	----

# Muon event selection

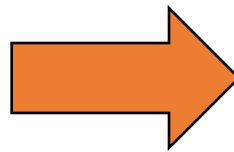
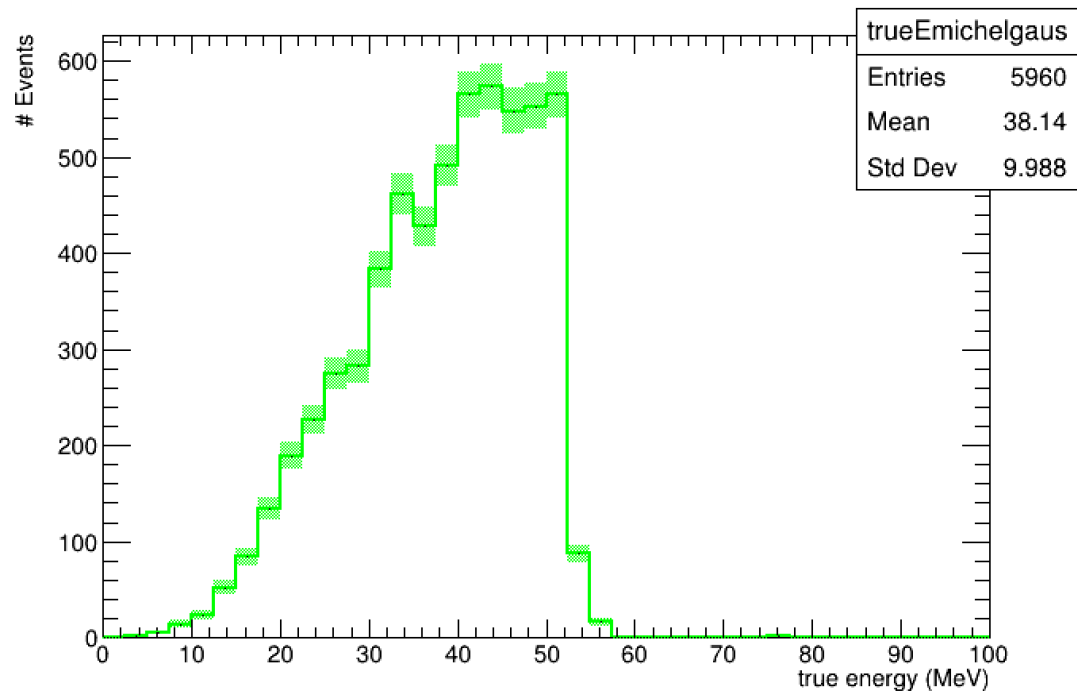
- Angle between collection plane wires and Michel  $< 150^\circ$



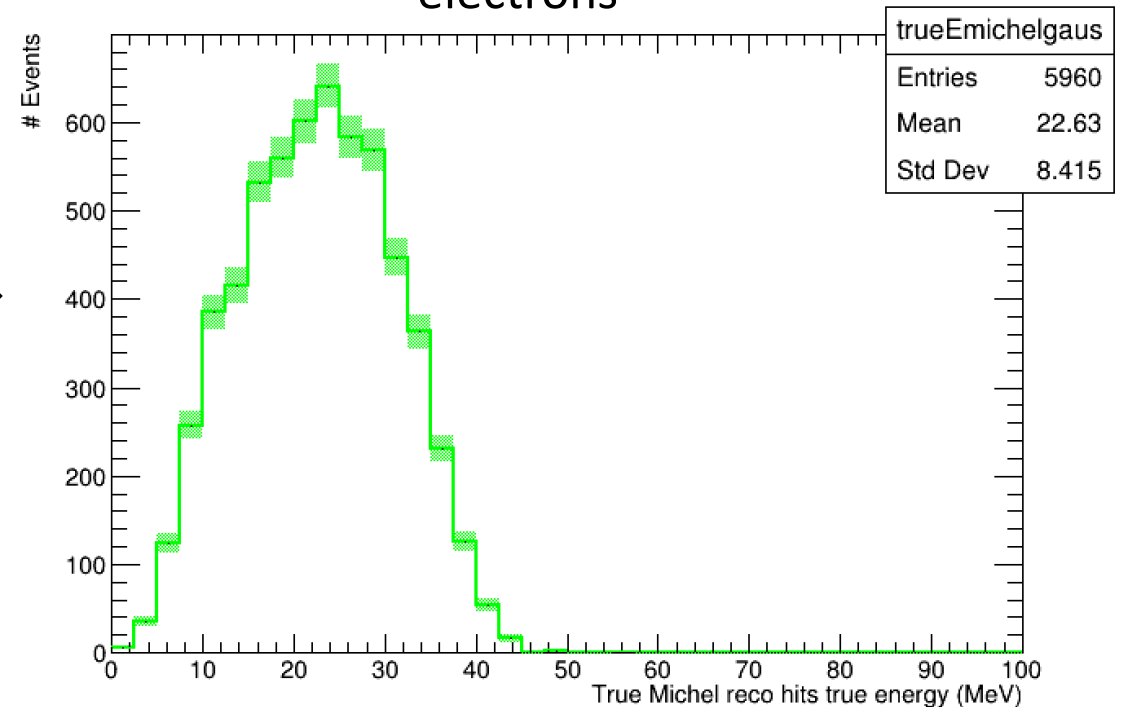
Sample/quantities	MC	Data
Passing rate	0.4%	0.9%
Purity	95%	----

# True Michel true energy distribution

By directly determining the true energy  
(simb::MCParticle::E) for a true Michel electron



By summing up the true energy  
(sim::TrackIDE::energy) deposited on those coll.  
plane reco hits for which the majority of energy  
depositions are coming from the true Michel  
electrons

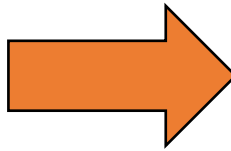
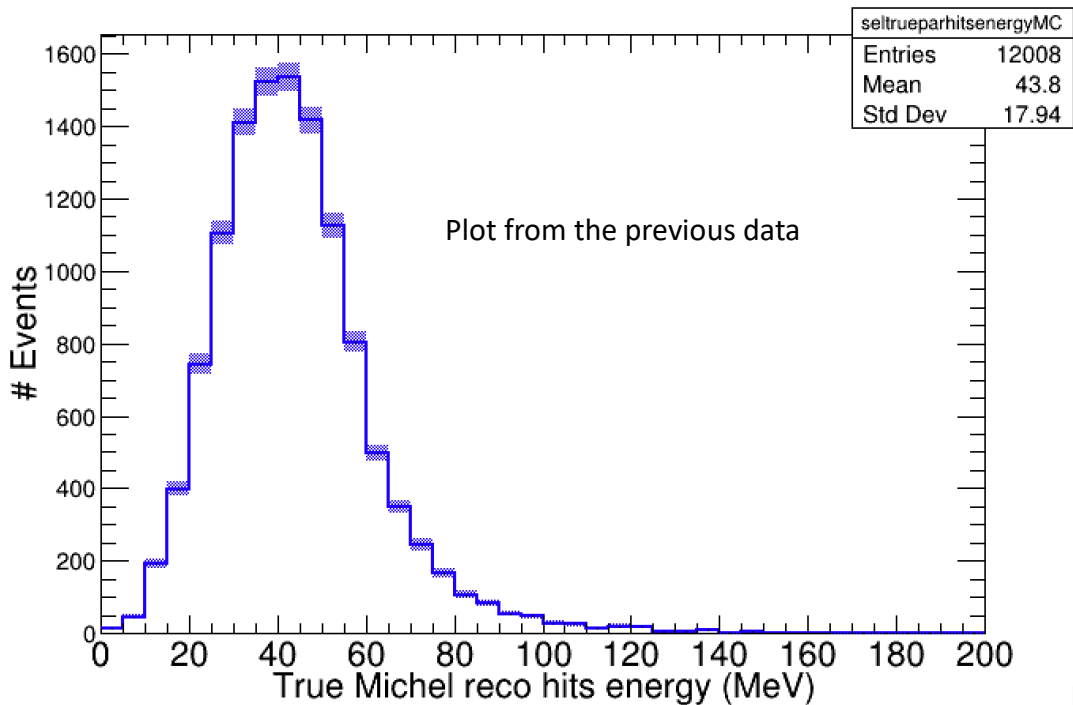


**Hit selection effects change the distribution. No detector, calibration, or reconstruction effects are associated**

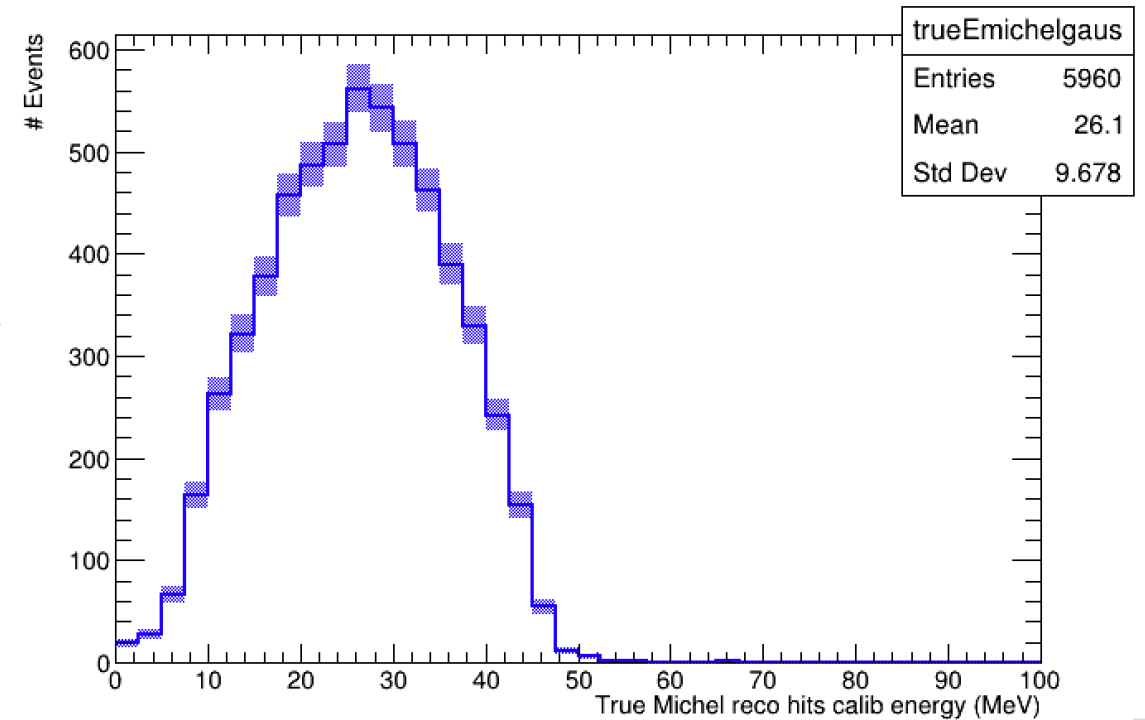


# True Michel reco energy distribution

By summing up all coll. plane reco hits reconstructed energy of the true Michel

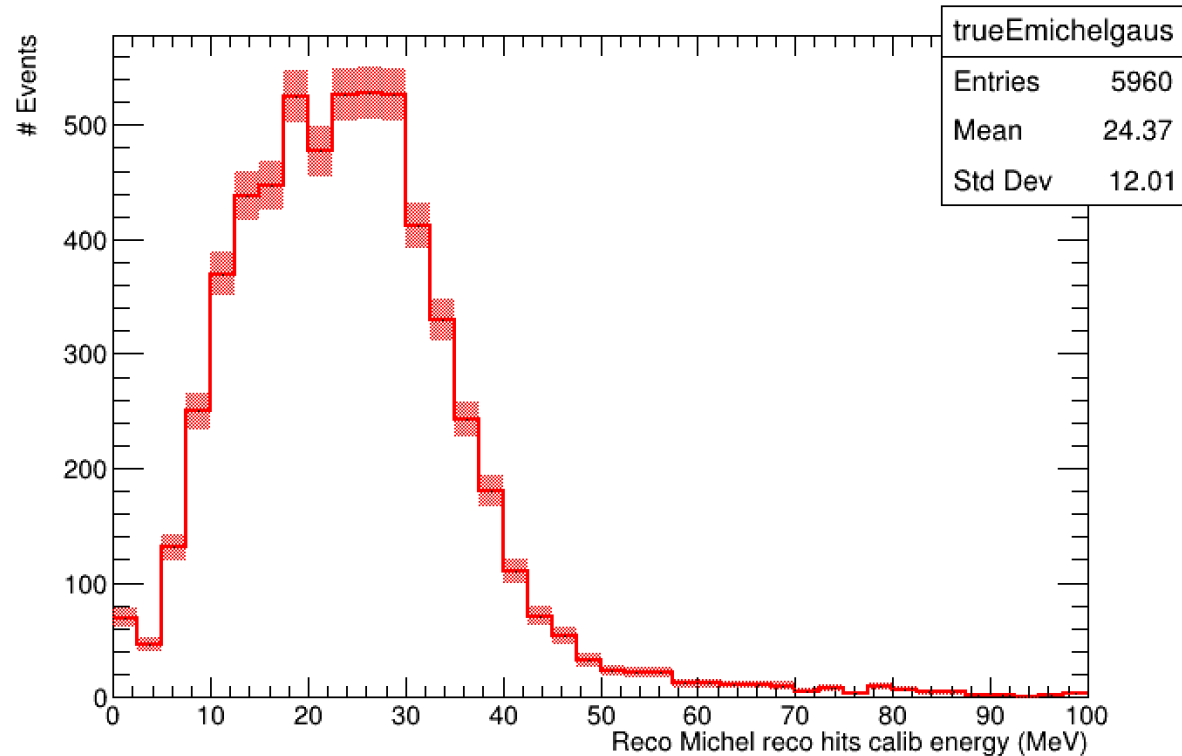


By summing up the reconstructed energy on only those coll. plane reco hits of the true Michel where energy deposition is majorly coming from true Michel electrons

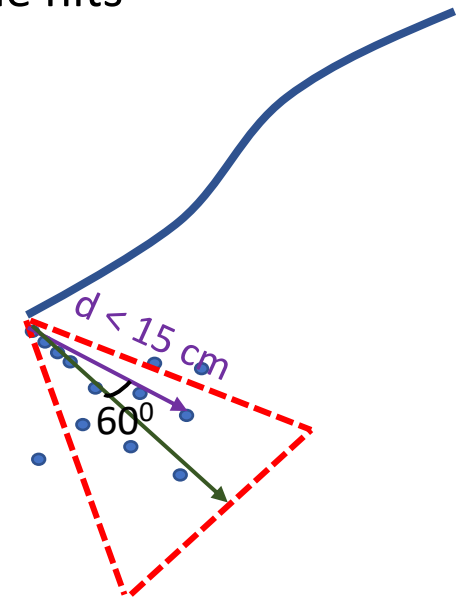


**Hit selection effects change the distribution. Detector and calibration effects are also associated with this distribution**

# Reco Michel reco energy distribution

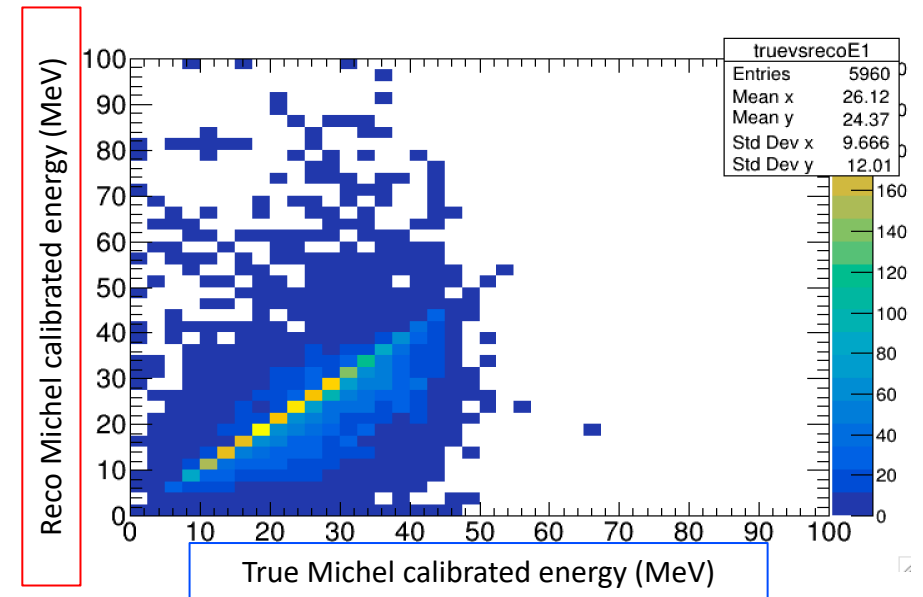
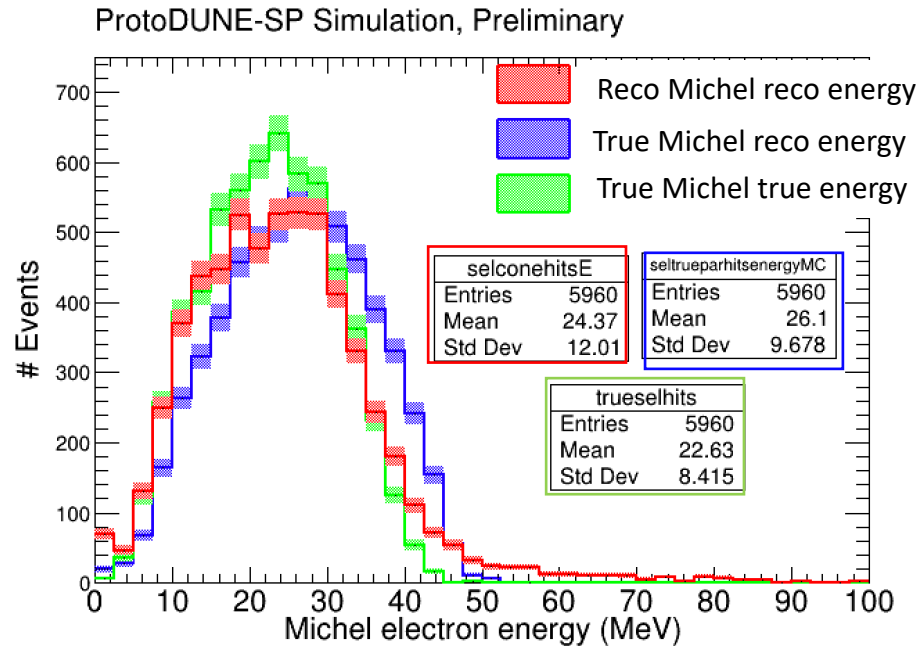


By summing up the reconstructed energy of the reco cone hits

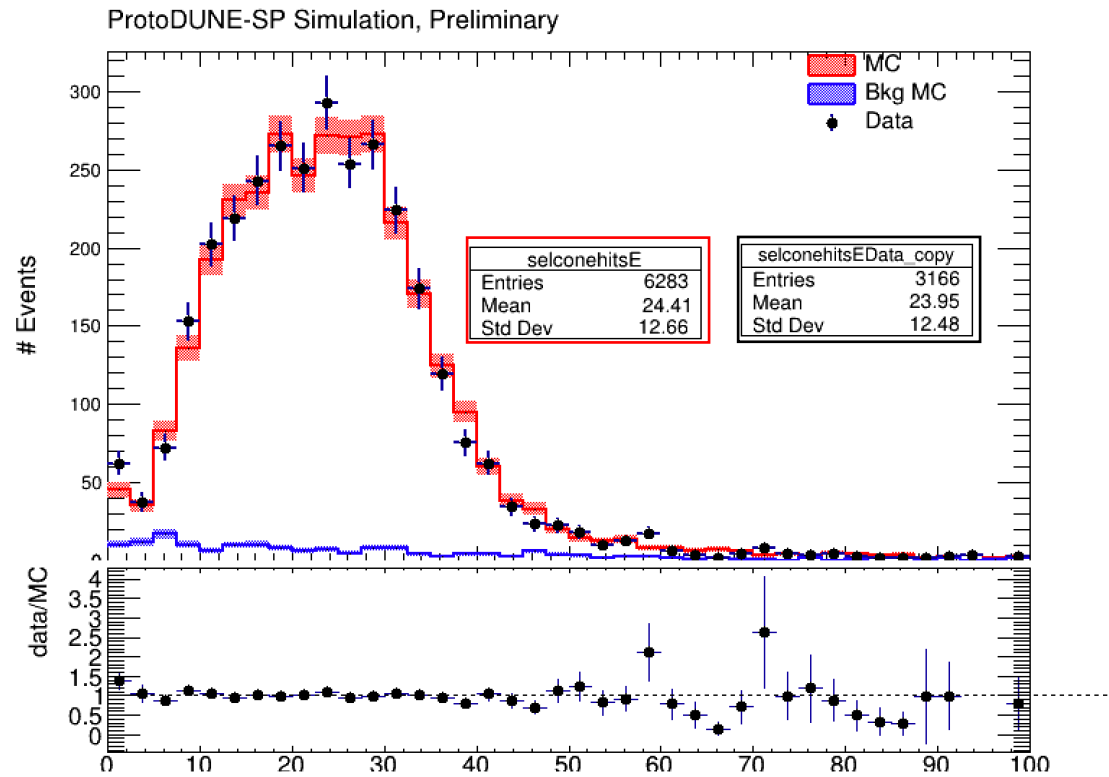


**All detector, calibration, and reconstruction effects are associated with this distribution.**

# Reconstructed Michel energy



# Michel energy data and MC



# Summary and next steps

- Developed a selection of events in which muons decay into candidate Michel electrons
- Obtained the Michel energy spectrum in MC and data
- Performed many other studies and presented results e.g.
  - looking for kink around muon end pos, recomb factor investigation, implemented new wire charge method, hit CNN scores, energy resolution studies via true calibration etc
- Need to perform systematic error study on Michel energy dist
- We will update the analysis note on DocDB with recent additions in analysis
- We ask to form a review committee/editorial board that can provide specific suggestions in order to take this analysis towards publication

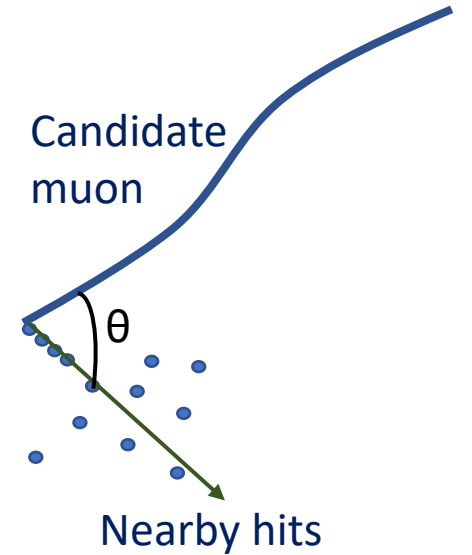
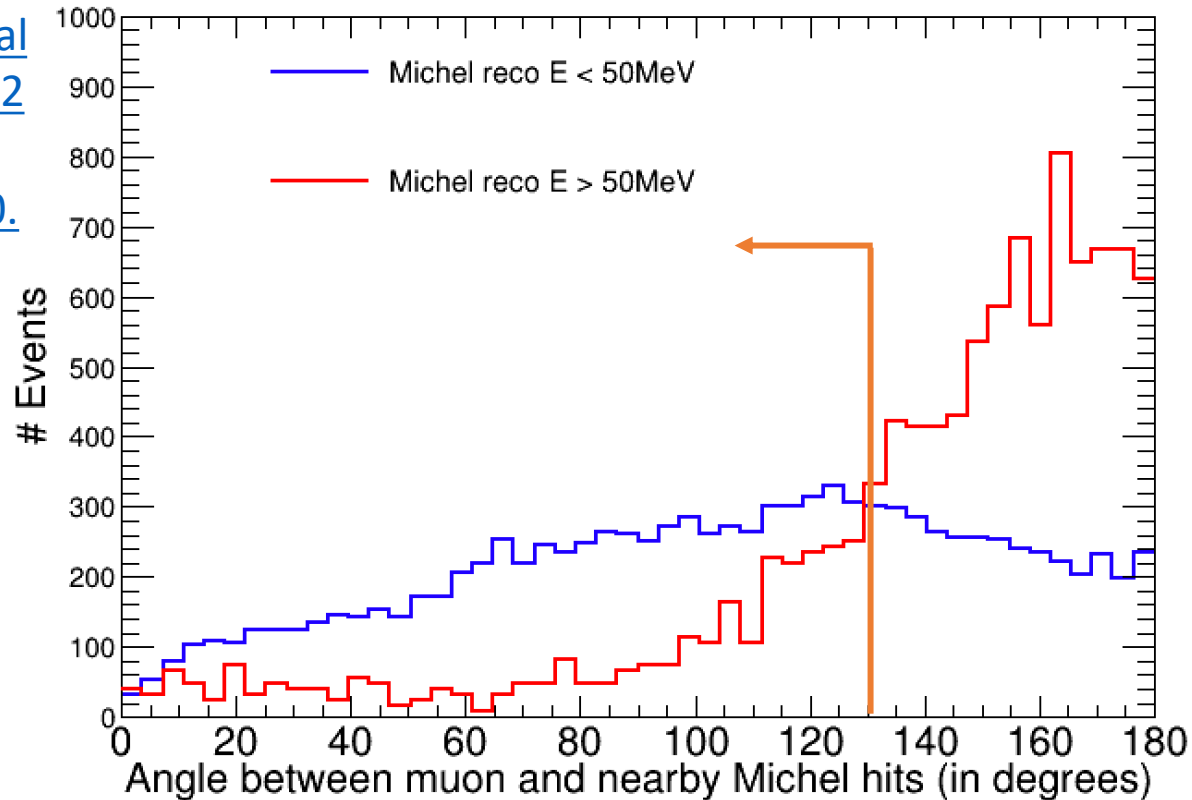
# Backup slides

# Angle between muon and Michels

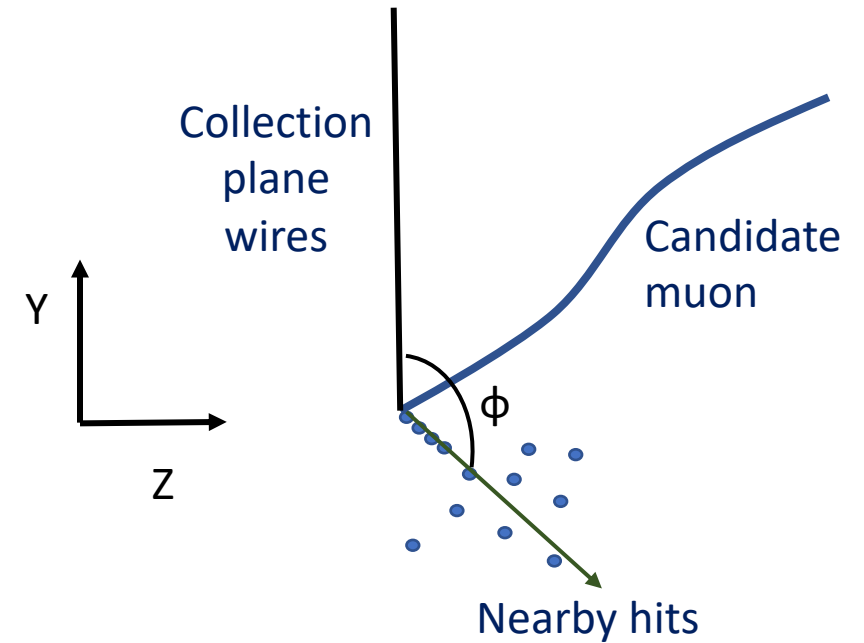
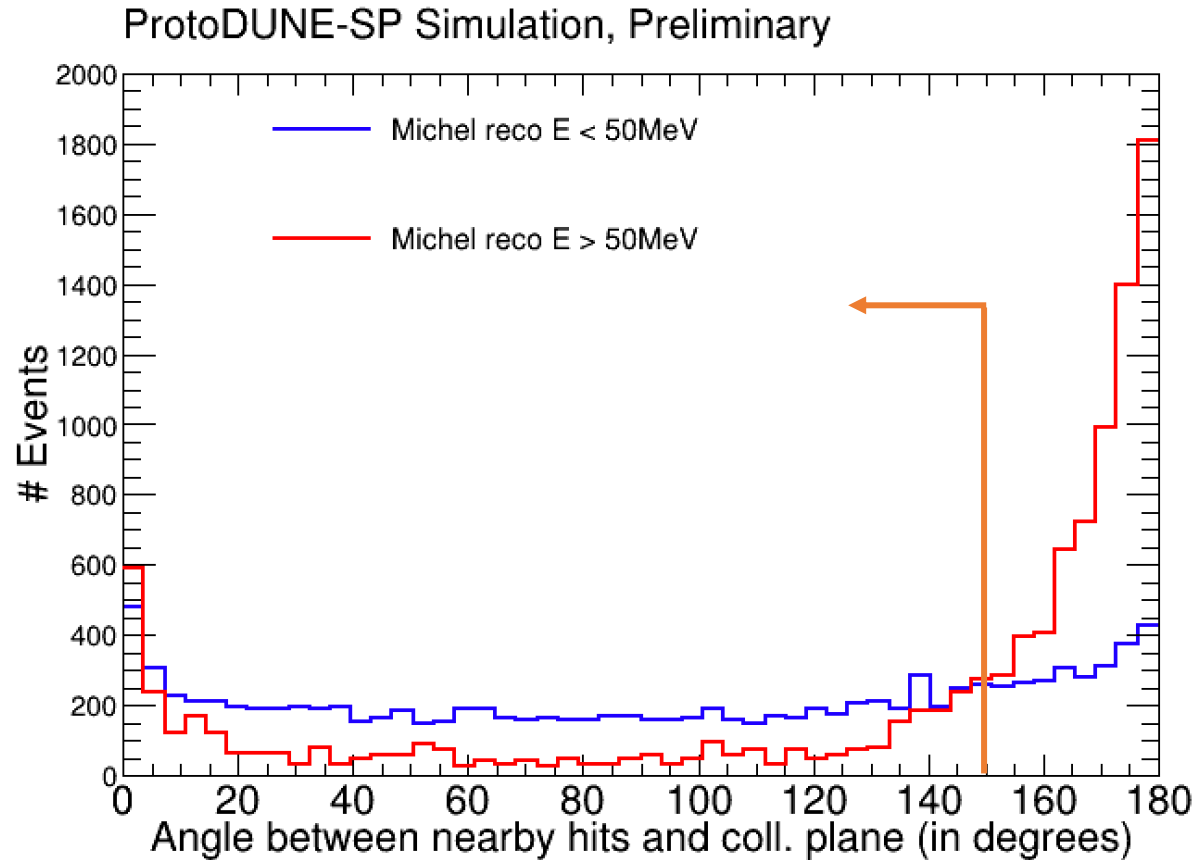
From the last time:

ProtoDUNE-SP Simulation, Preliminary

<https://indico.fnal.gov/event/24212/contribution/1/material/slides/0.pdf>



# Angle between collection plane wires and Michels



**Kept events only where ( $\theta < 130^\circ$  AND  $\phi < 150^\circ$ )**