Michel Electron Analysis in ProtoDUNE

Aleena Rafique
For the DUNE collaboration
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Argonne NATIONAL LABORATORY

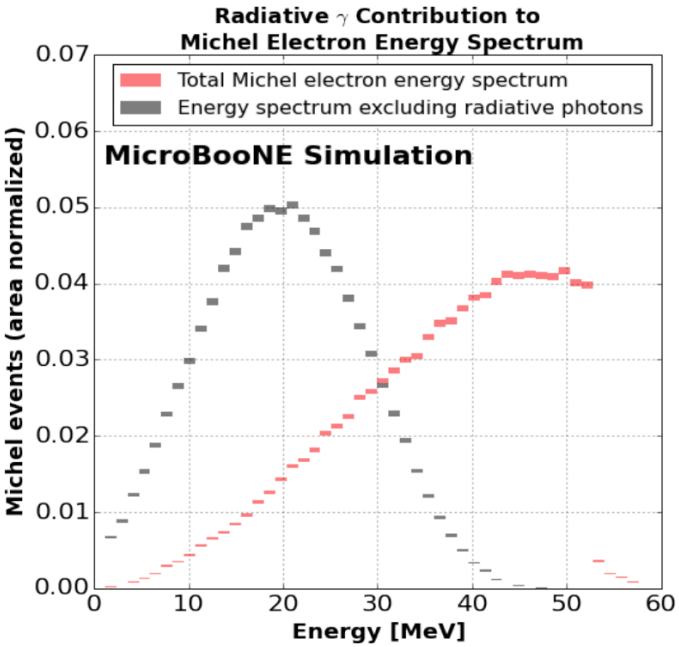
DUNE DEEP UNDERGROUND NEUTRINO EXPERIMENT

Introduction

- Michel electrons are electrons from the decay of muons
- Common channels (in ProtoDUNE):
  - $\mu^{+} \rightarrow e^{+} \bar{\nu}_{\mu} \nu_{e}$ (80%)
  - $\mu^{-} \rightarrow e^{-} \bar{\nu}_{\mu} \nu_{e} n\gamma$ (20%)
- Analysis makes use of low energy shower

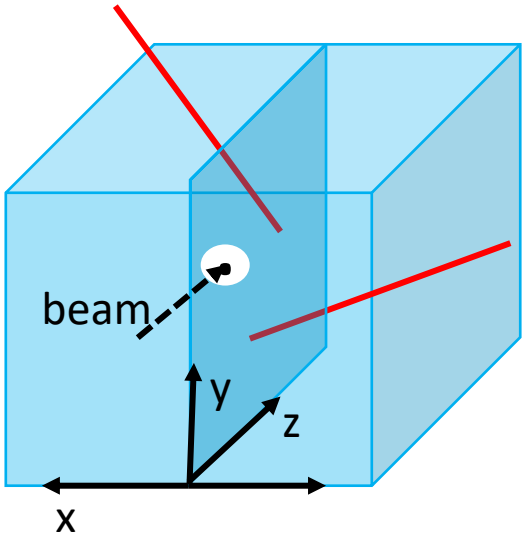
reconstruction– useful for many DUNE analyses

- Analysis goals:
  - Obtain michel electron energy spectrum
  - Correlate these events with the photon detector data



Michel event initial selection

1. T_0 tagged (cathode crossing) tracks



Michel event initial selection

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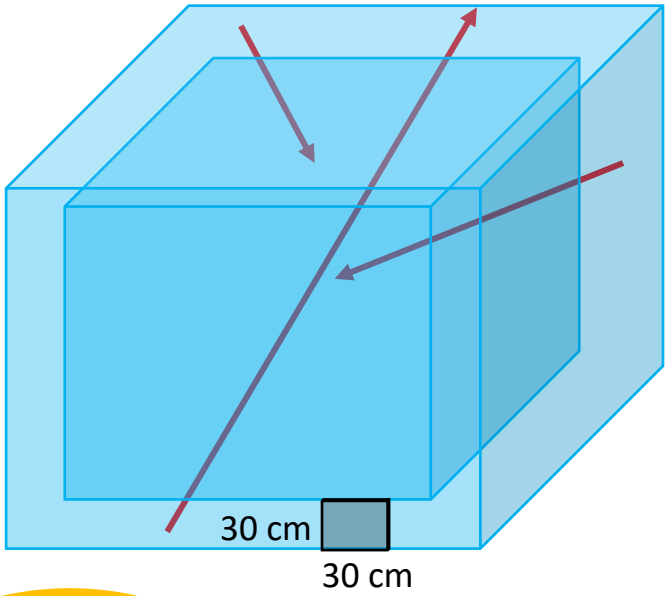


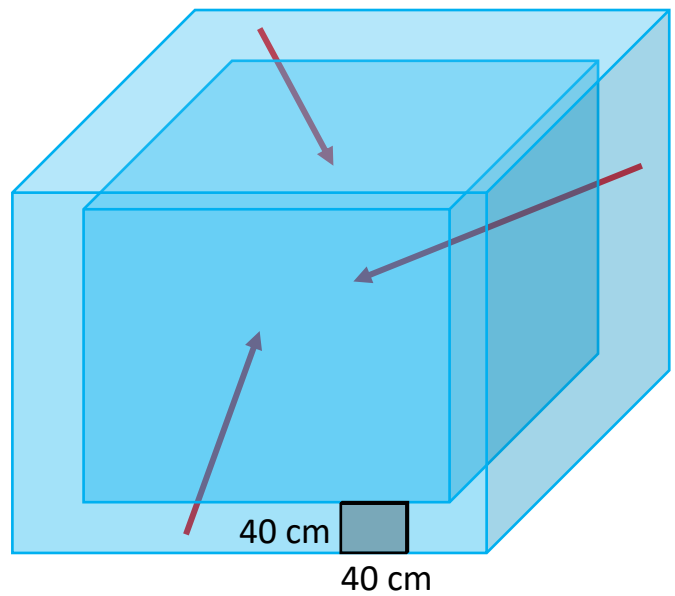
2. Tracks starting in detector edges

Michel event initial selection

1. T_0 tagged (cathode crossing) tracks

2. Tracks starting in detector edges

3. Tracks ending in FV



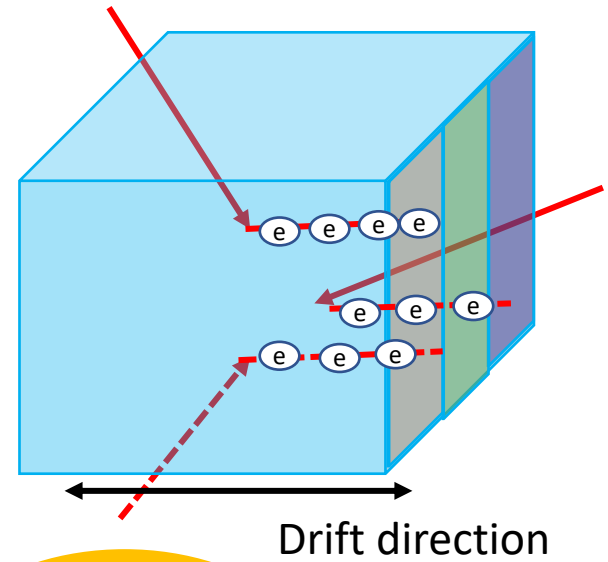
Michel event initial selection

1. T_0 tagged (cathode crossing) tracks

2. Tracks starting in detector edges

3. Tracks ending in FV

4. Tracks ending not around APA bounds

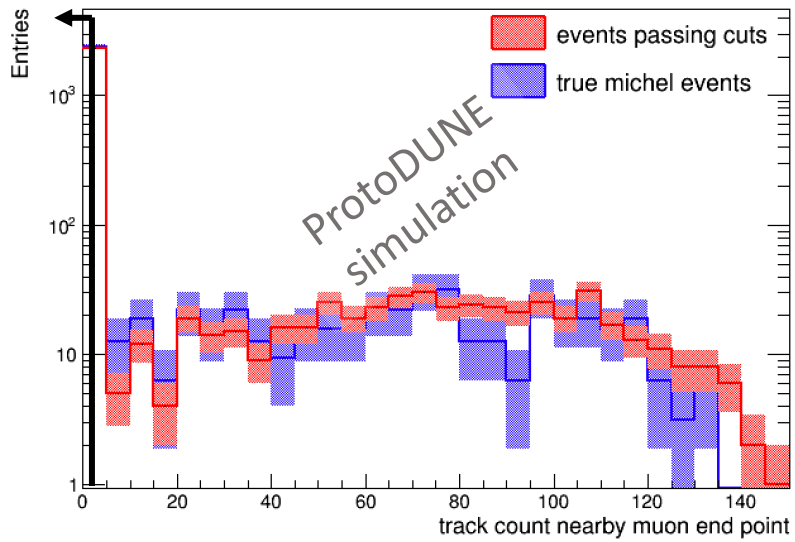


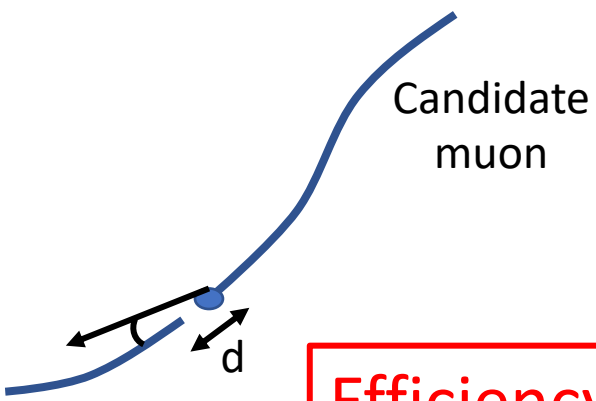
Analysis definitions of efficiency and purity

- <u>Efficiency</u>
  - Passing rate or selection rate as we move along with different cuts in the selection
  - *Efficiency* = $\frac{number\ of\ tracks\ passing\ the\ corresponding\ cut}{numebr\ of\ all\ T_0\ tagged\ tracks}$
- <u>True michel events</u>
  - Michel events inside FV having 3D distance b/w true electron start and muon reco stopping point < 15 cm
- <u>Purity</u>
  - *Purity* = $\frac{number\ of\ true\ michels}{number\ of\ tracks\ passing\ the\ corresponding\ cut}$
- <u>Data samples</u>:
  - MC: beam + cosmics MCC11 with SCE ON (1 GeV) (~2000 events)
  - Data: Beam + cosmics Run 5817 (1 GeV) (~7000 events)

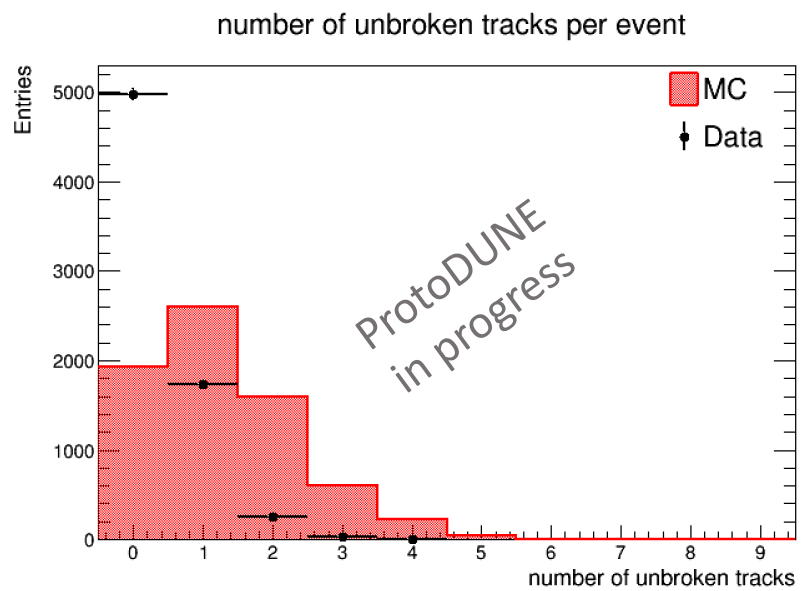
Michel event selection

5. Remove broken tracks



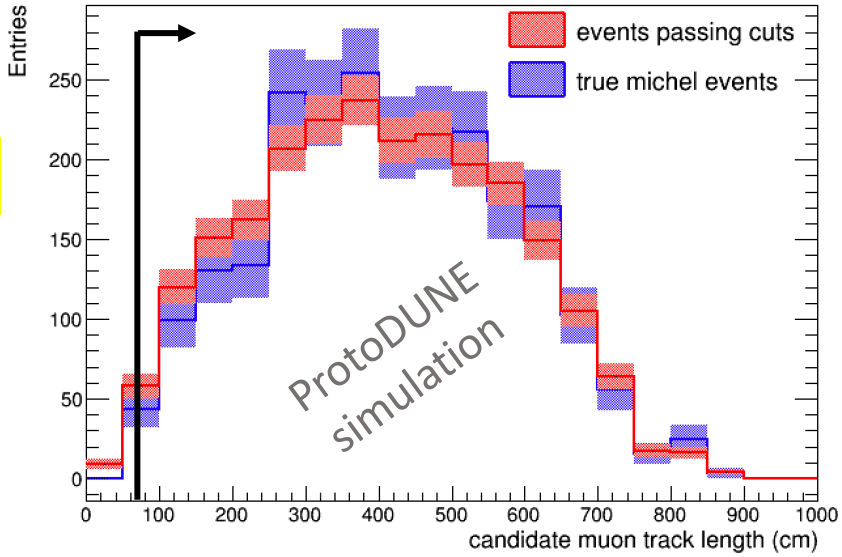


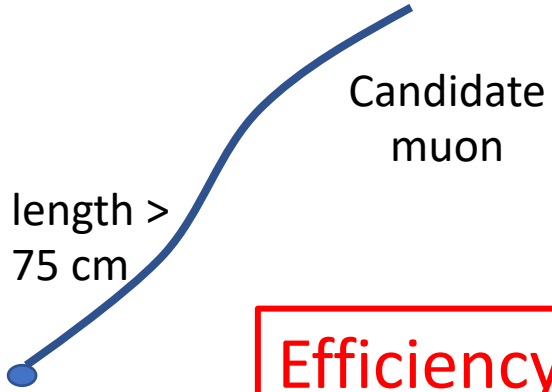
Efficiency: 18%
Purity = 32%



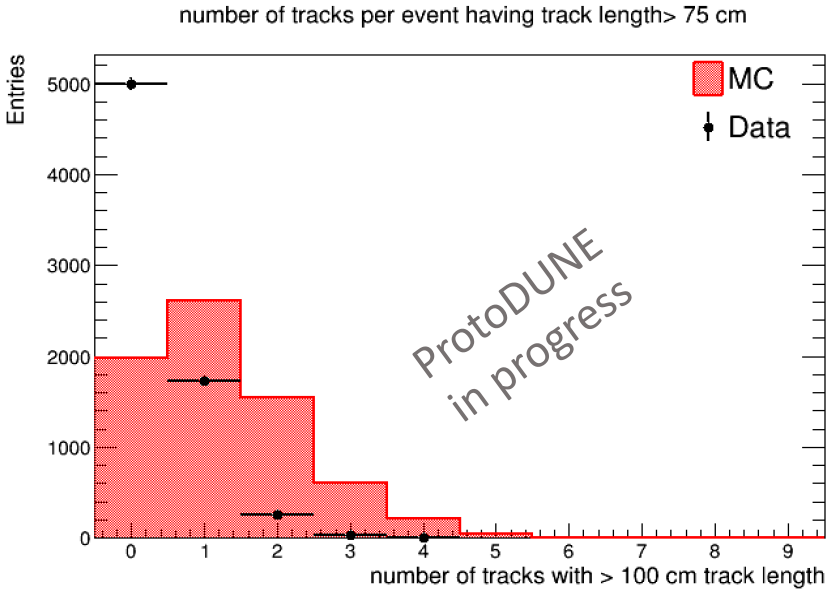
Michel event selection

5. Remove broken tracks
6. Select candidate muon tracks with > 75 cm length





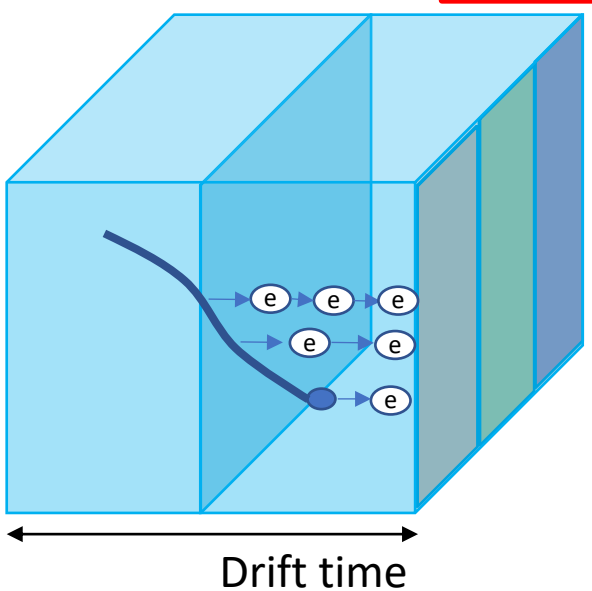
Efficiency: 18%
Purity = 32%

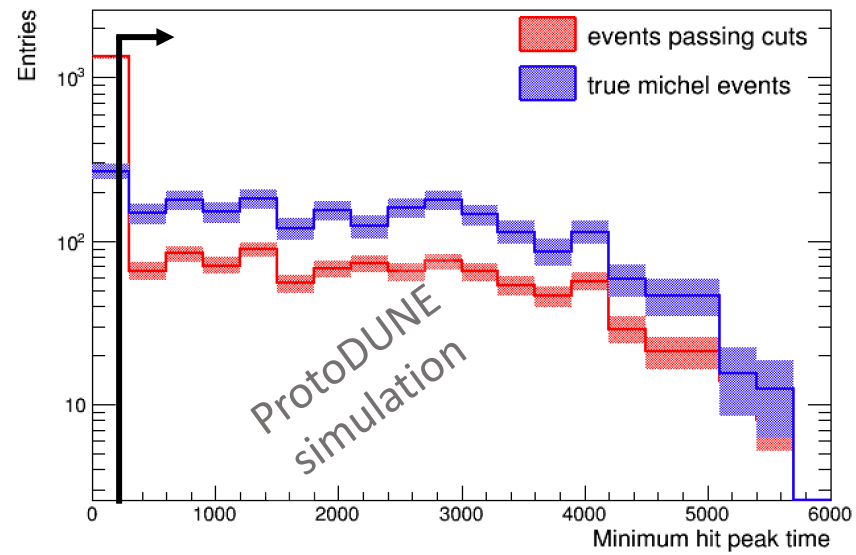


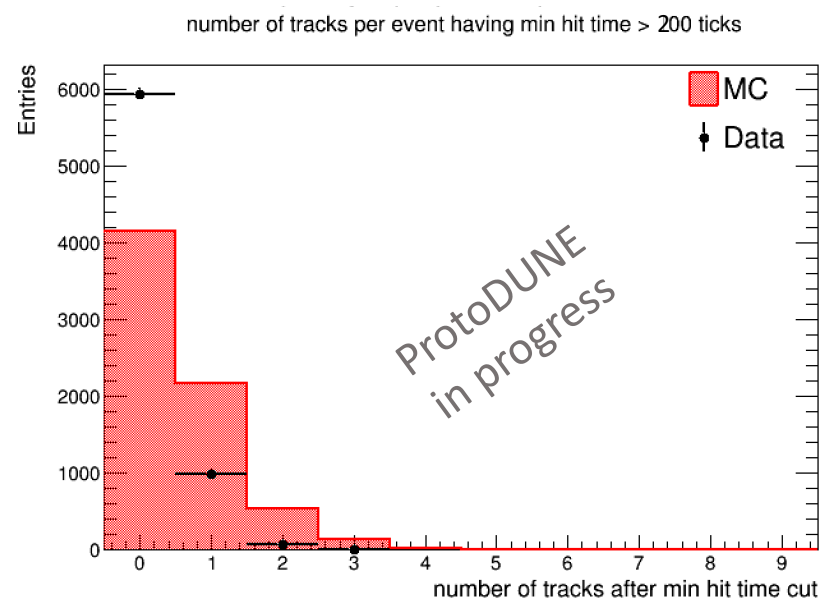
Michel event selection

5. Remove broken tracks
6. Select candidate muon tracks with > 75 cm length
7. Minimum hit time > 200 ticks

Efficiency: 8%
Purity = 69%



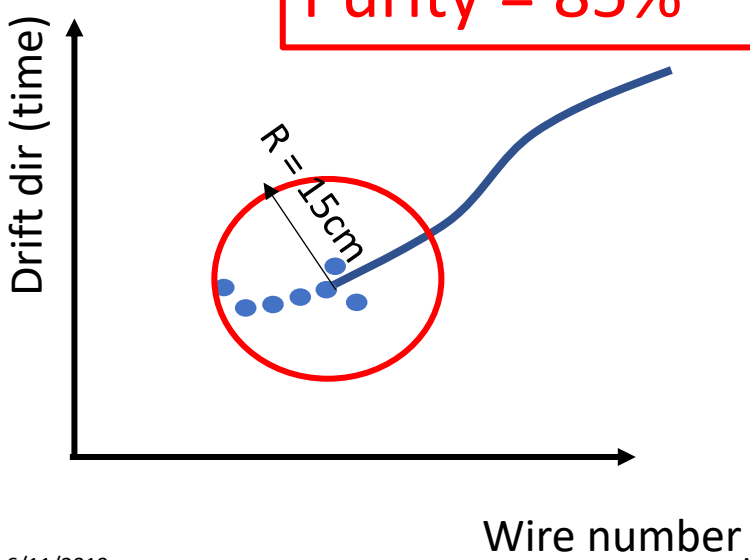


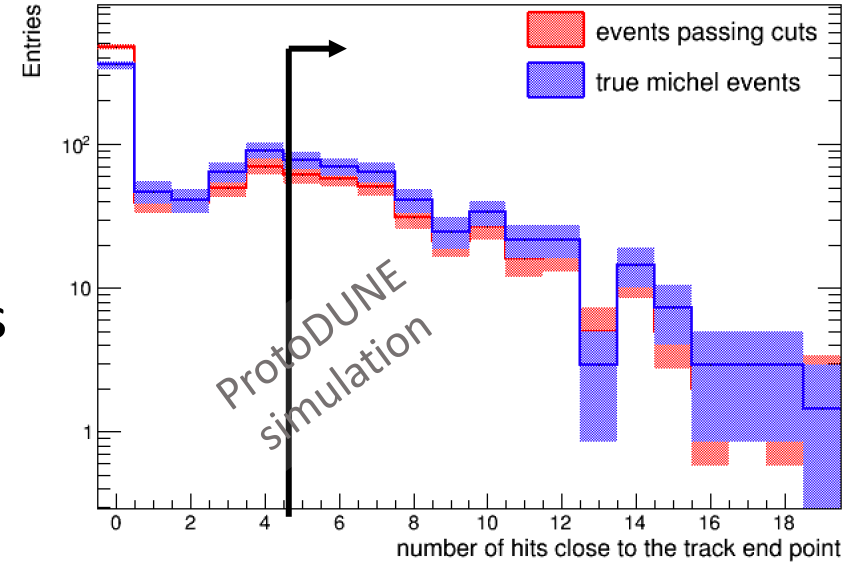


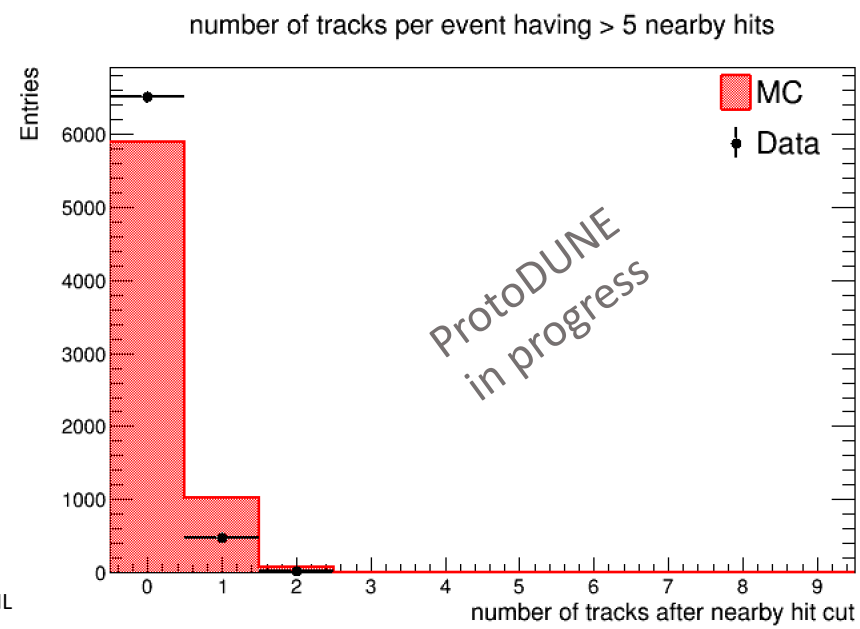
Michel event selection

5. Remove broken tracks
6. Select candidate muon tracks with > 75 cm length
7. Minimum hit peak time > 100 ticks
8. Nearby hit count > 5

Efficiency: 2.4%
Purity = 85%

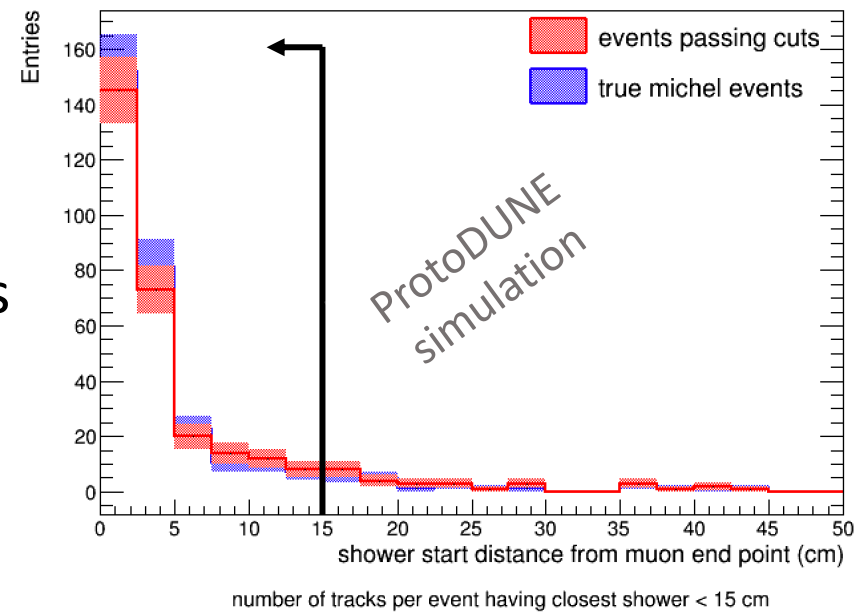


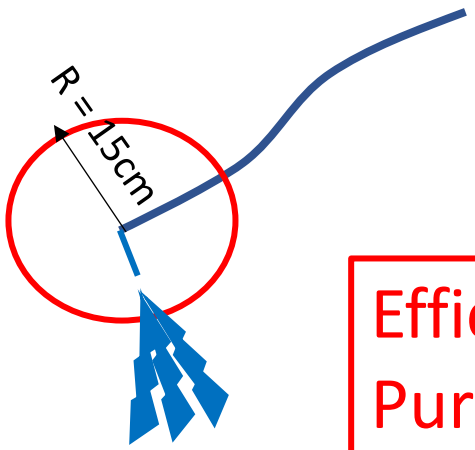




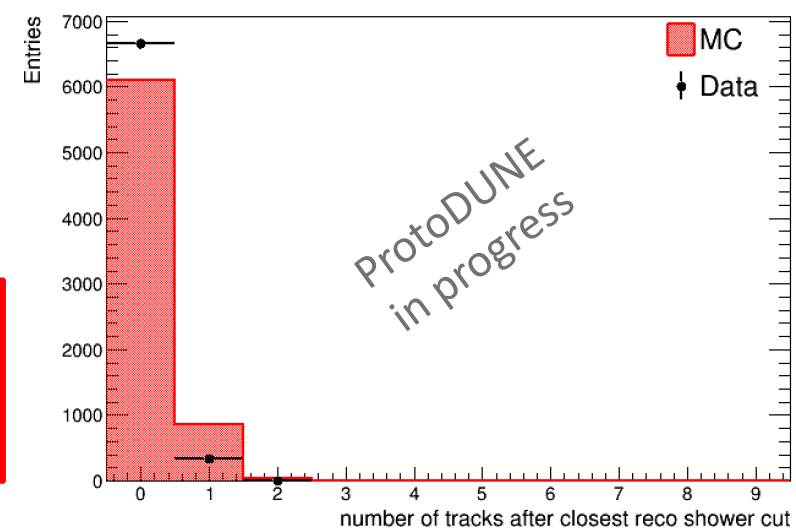
Michel event selection

5. Remove broken tracks
6. Select candidate muon tracks with 75 cm length
7. Minimum hit peak time > 100 ticks
8. Nearby hit count > 5
9. Closest reco shower distance < 15 cm

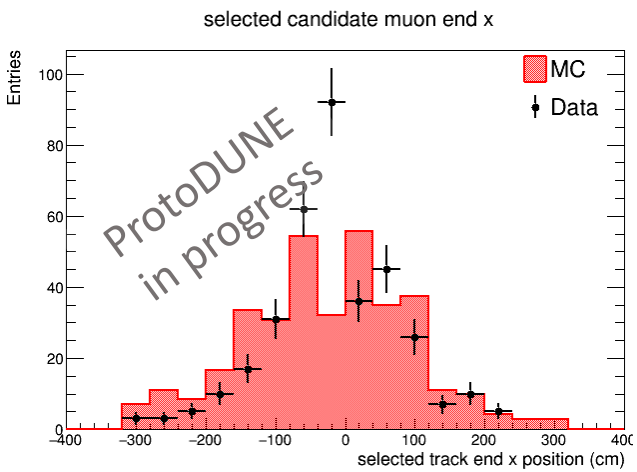


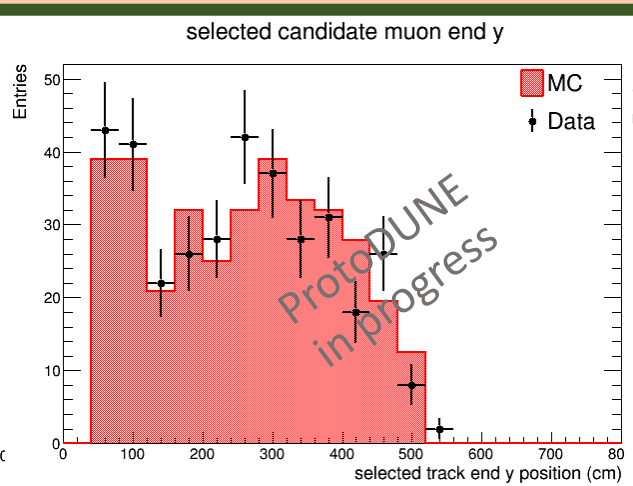


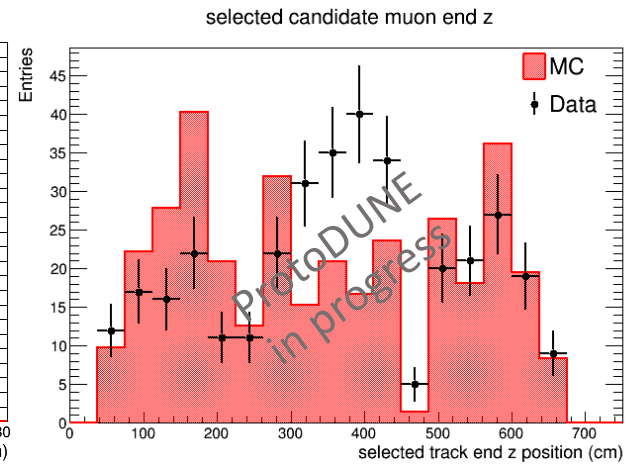
Efficiency: 2%
Purity = 89%

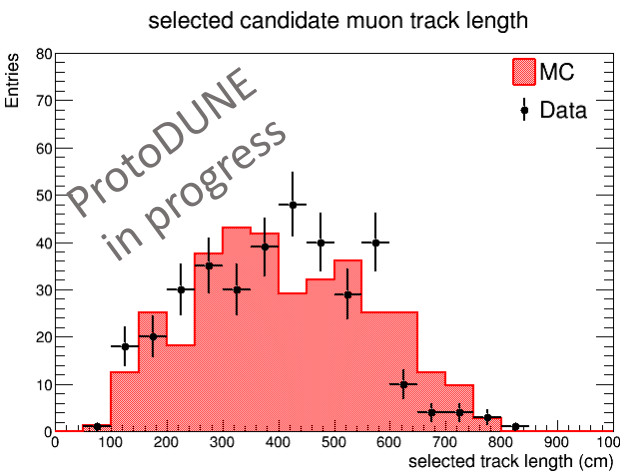


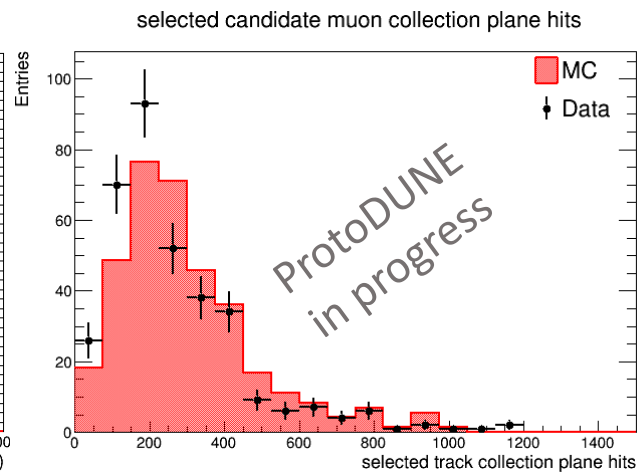
Candidate muon kinematics

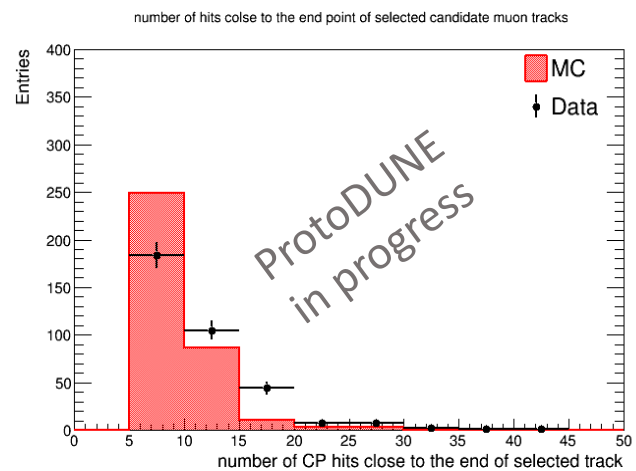




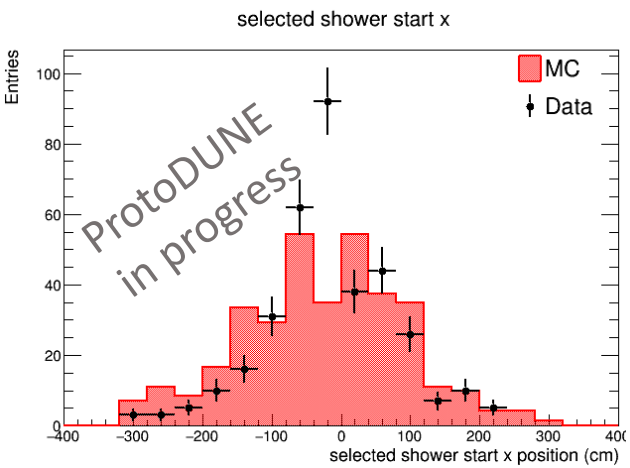


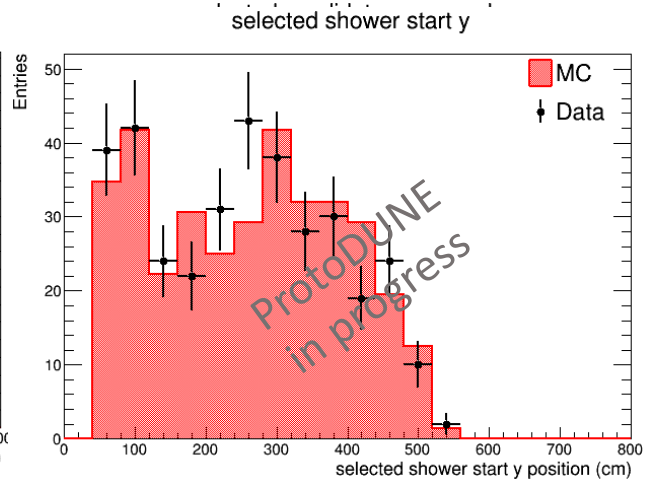


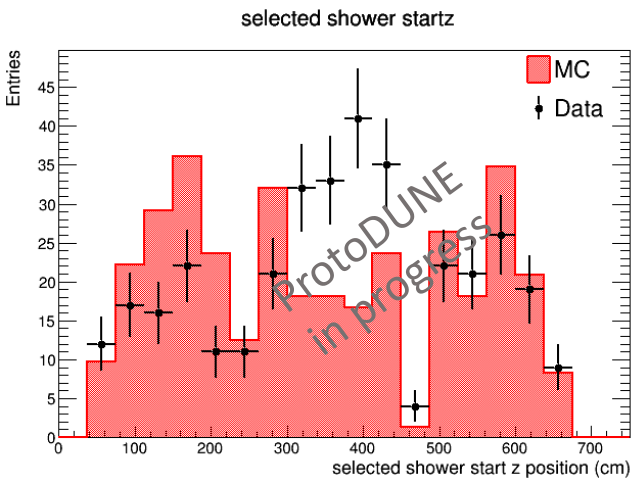


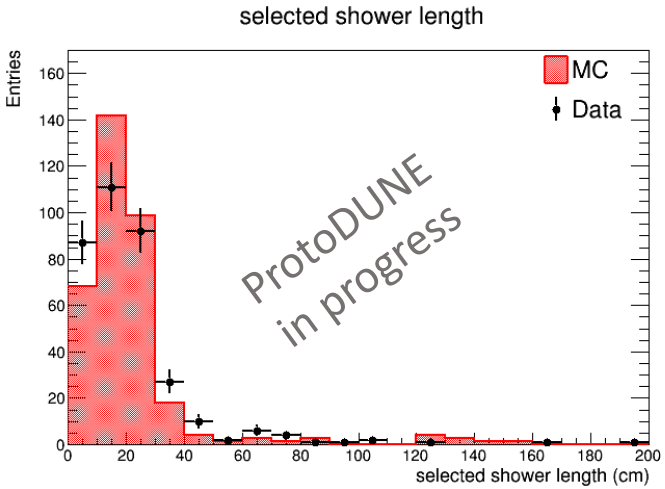


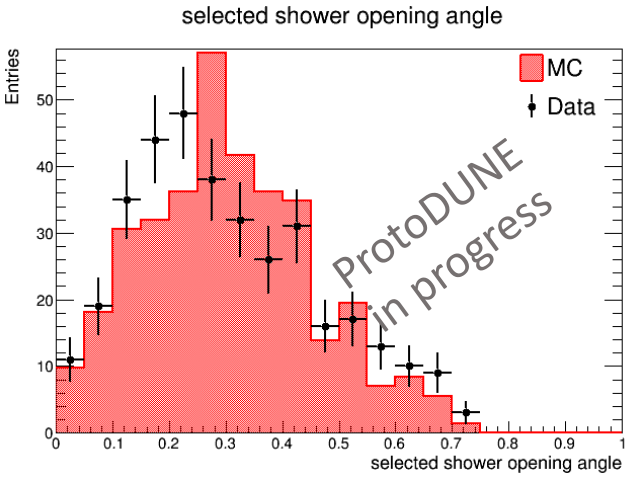
Candidate electron shower kinematics











Summary

- Michel event selection purity is high (~90%)
- Michel electron energy spectrum is underway
- Goal is to look for michels in photon detector