Analysis and Simulation of Michel Electrons in ProtoDUNE VD

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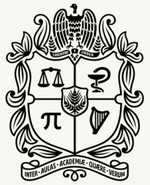
Internship Final Presentation

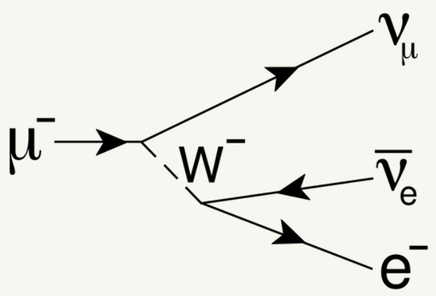
July 13, 2023

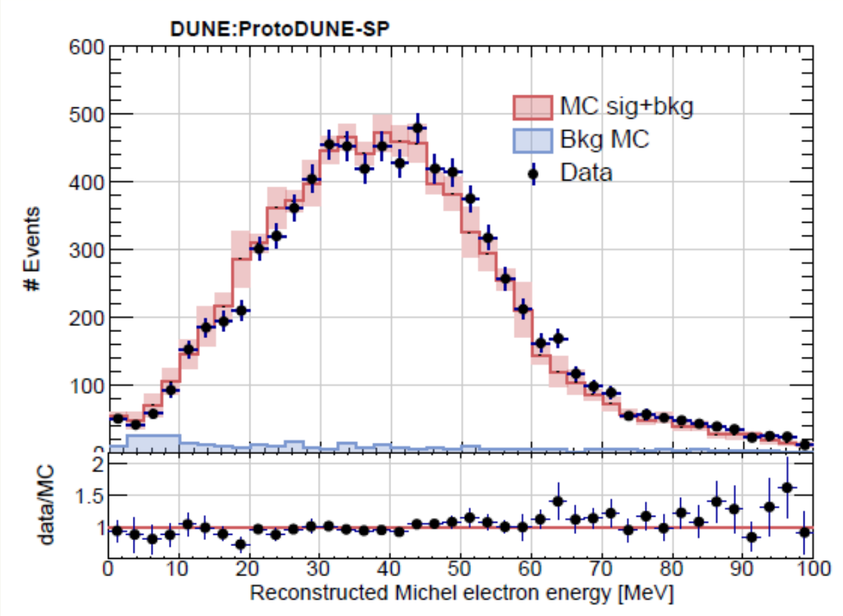


UNIVERSIDAD
NACIONAL
DE COLOMBIA

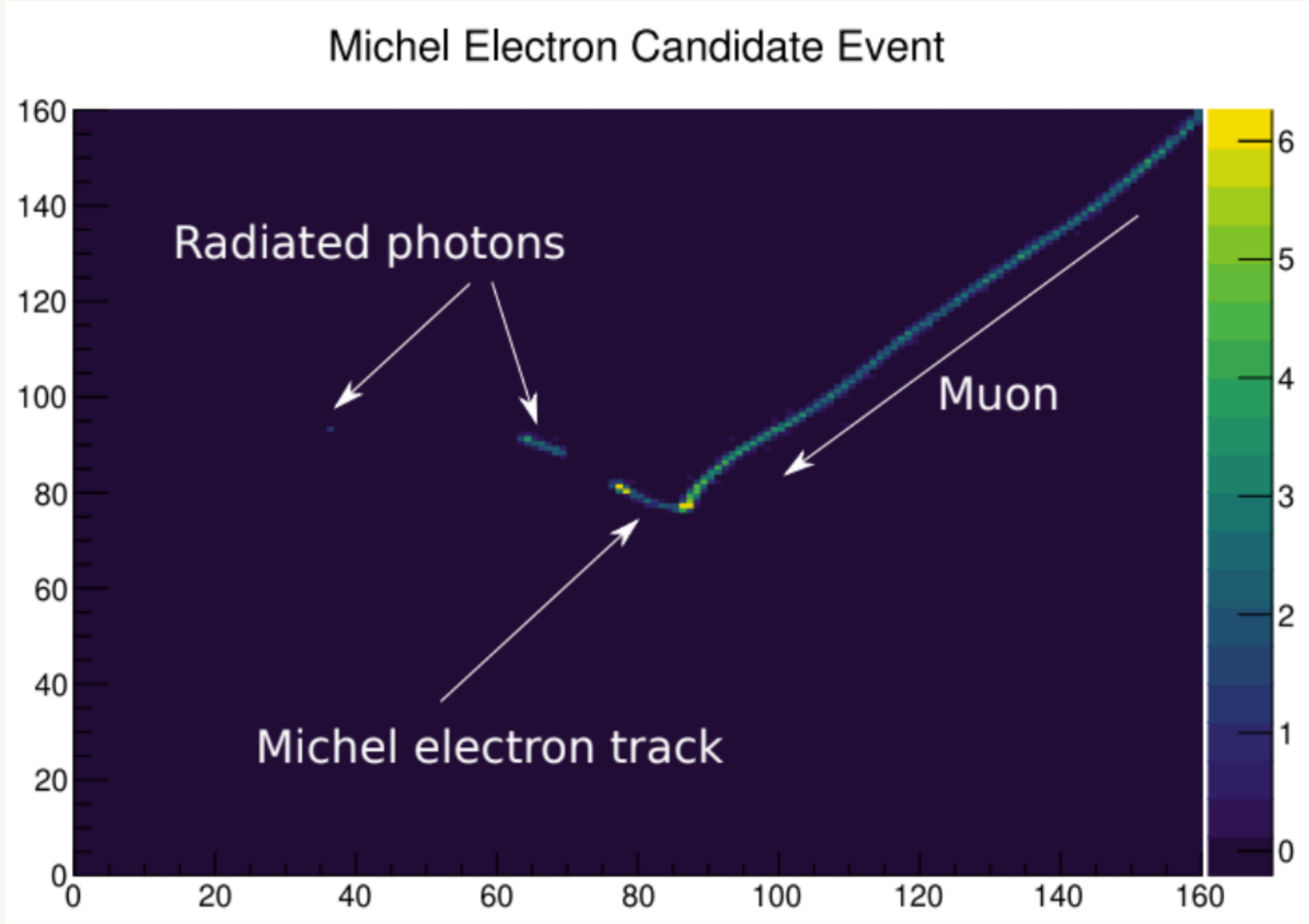
Supervisors: Thibaut Houdy
Yoann Kermaïdic

Michel Electrons





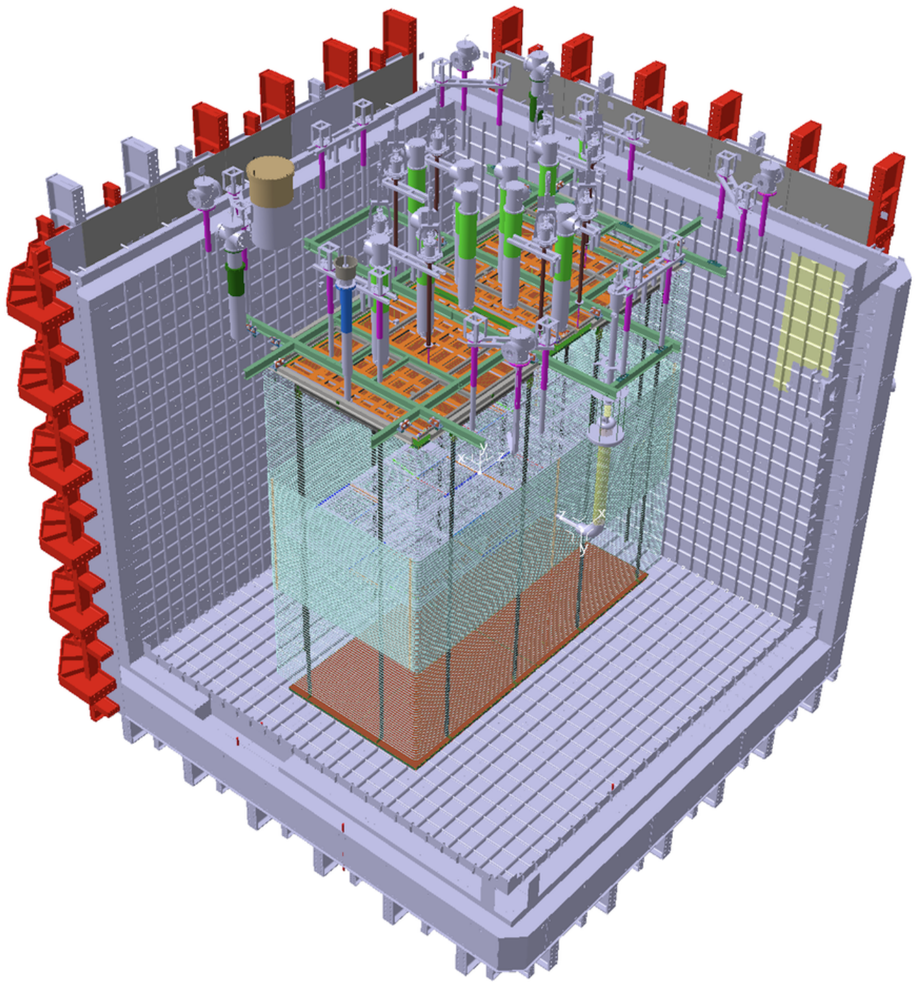
A. Abed Abud et al. arXiv :2211.01166 (2023)



A. Reynolds. Michel electron reconstruction (2020)

Simulation Workflow

ProtoDUNE Vertical Drift



Event generator
- Single Generator
- Supernova (marley)
- Cosmics
- GENIE (beam, atm…)
- …

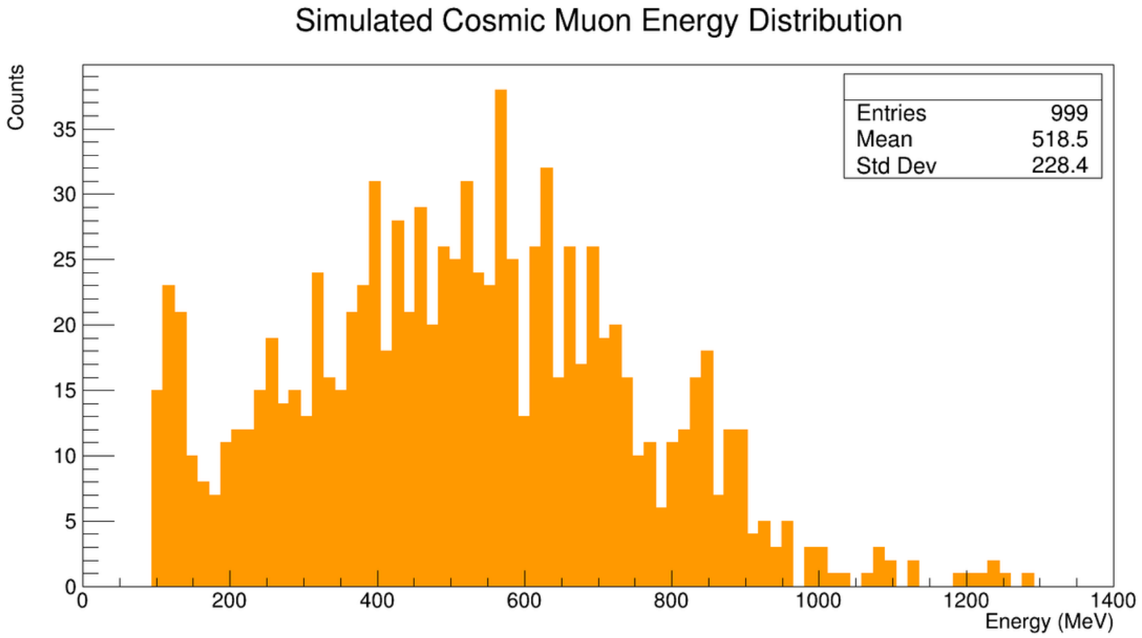
G4
- Larg4Main (handles interface with G4)
- Energy deposition (ion + scint.)
- Drift of electrons

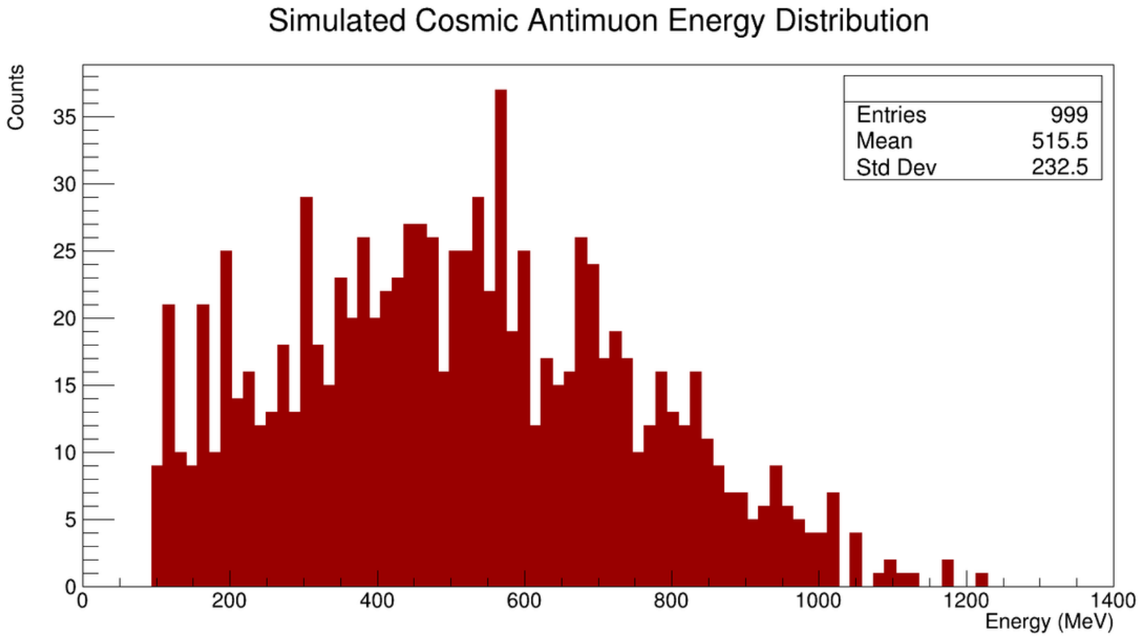
DETSIM
- Signal simulation at the strip level (rawdigits)
- Noise model

RECO
- Coherent Noise Removal
- Signal filtering, deconvolution
- Hit Finder
- High level reco (showers, tracks…) & event classifier (CVN)

Simulation

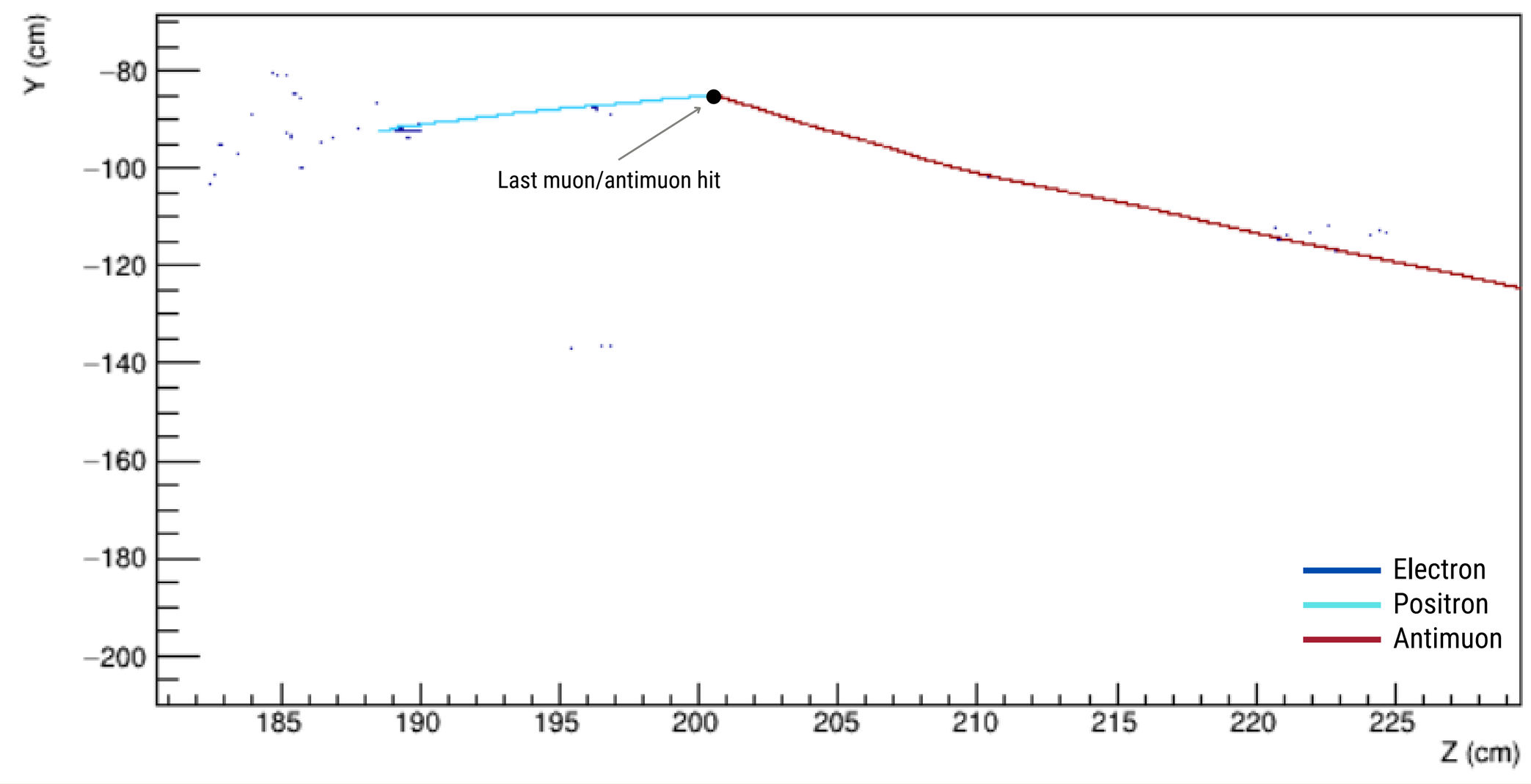
- Generated muons/antimuons near to one of ProtoDUNE VD walls
- MIP ~ **2.12 MeV/cm** in LAr





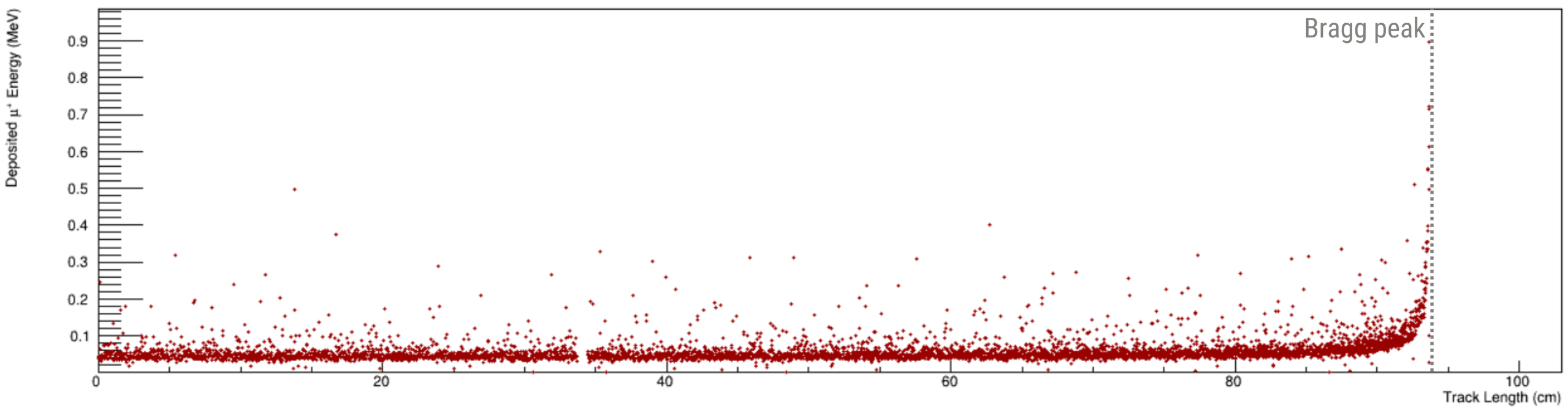
Simulation

>>> Access to particle energy deposition in LAr



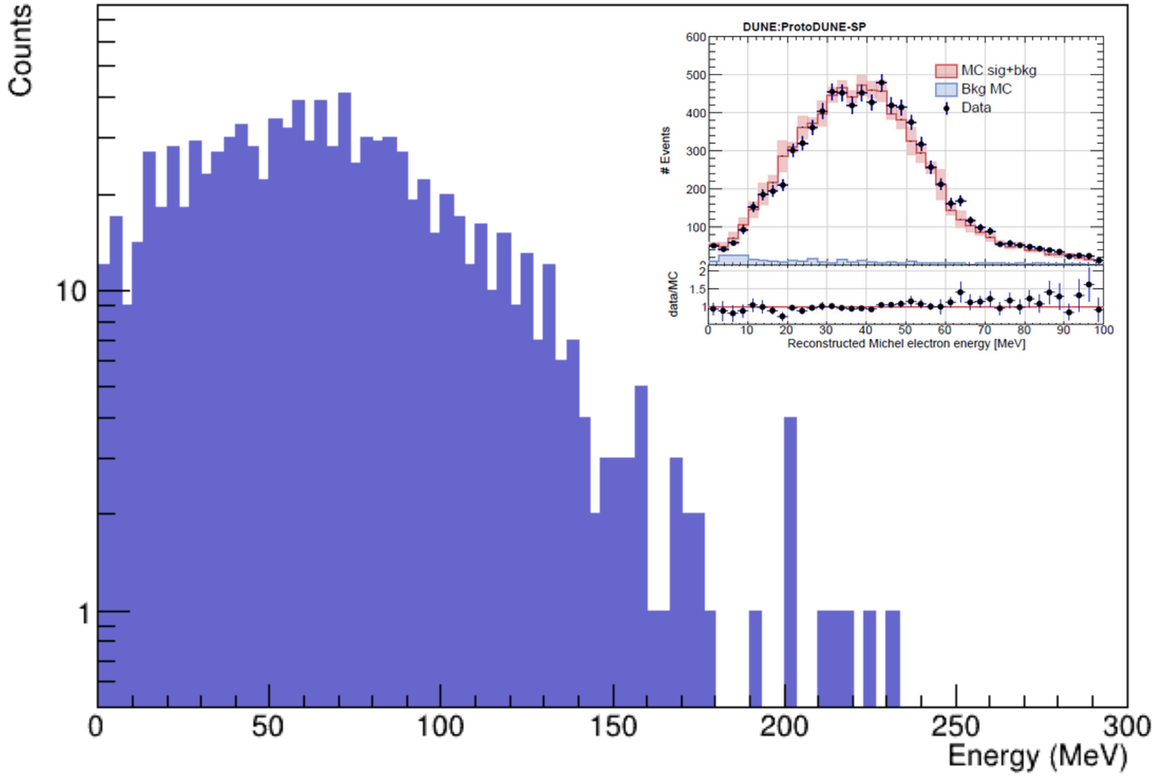
Cosmic Muons Information

>>> **dQ/dX** in order to know the vertex decay (~ reconstruction stage)

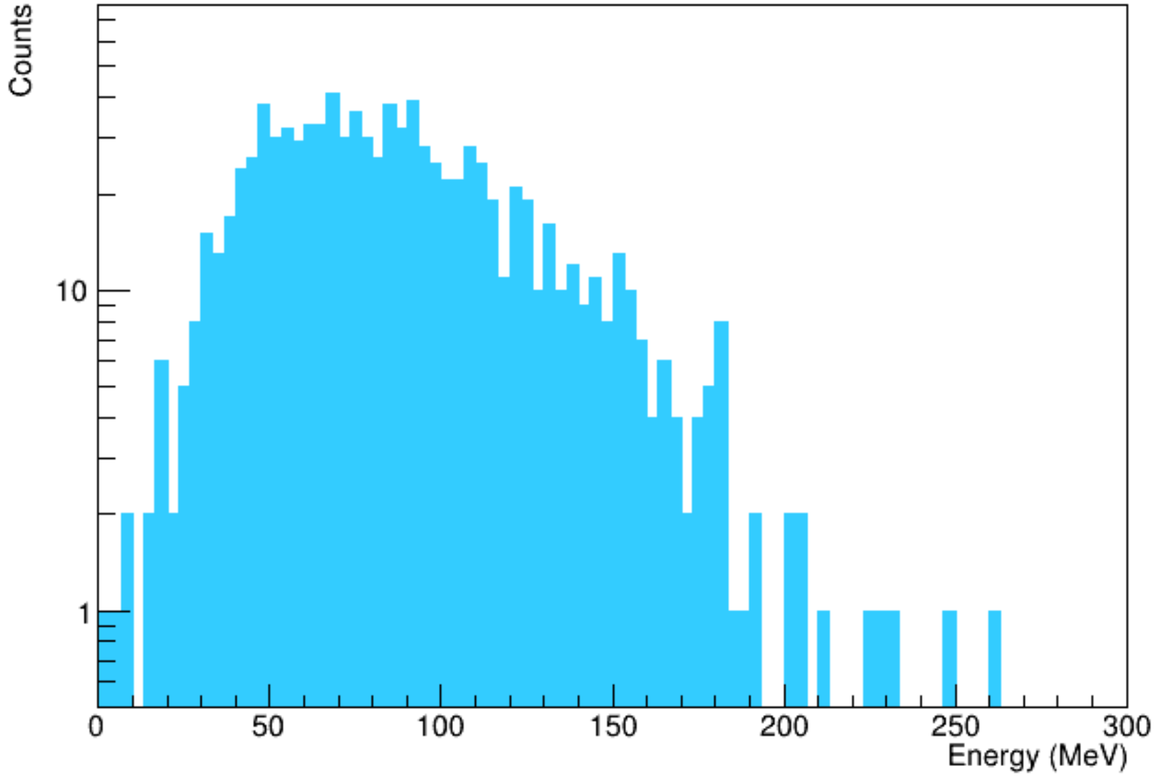


Electron Information

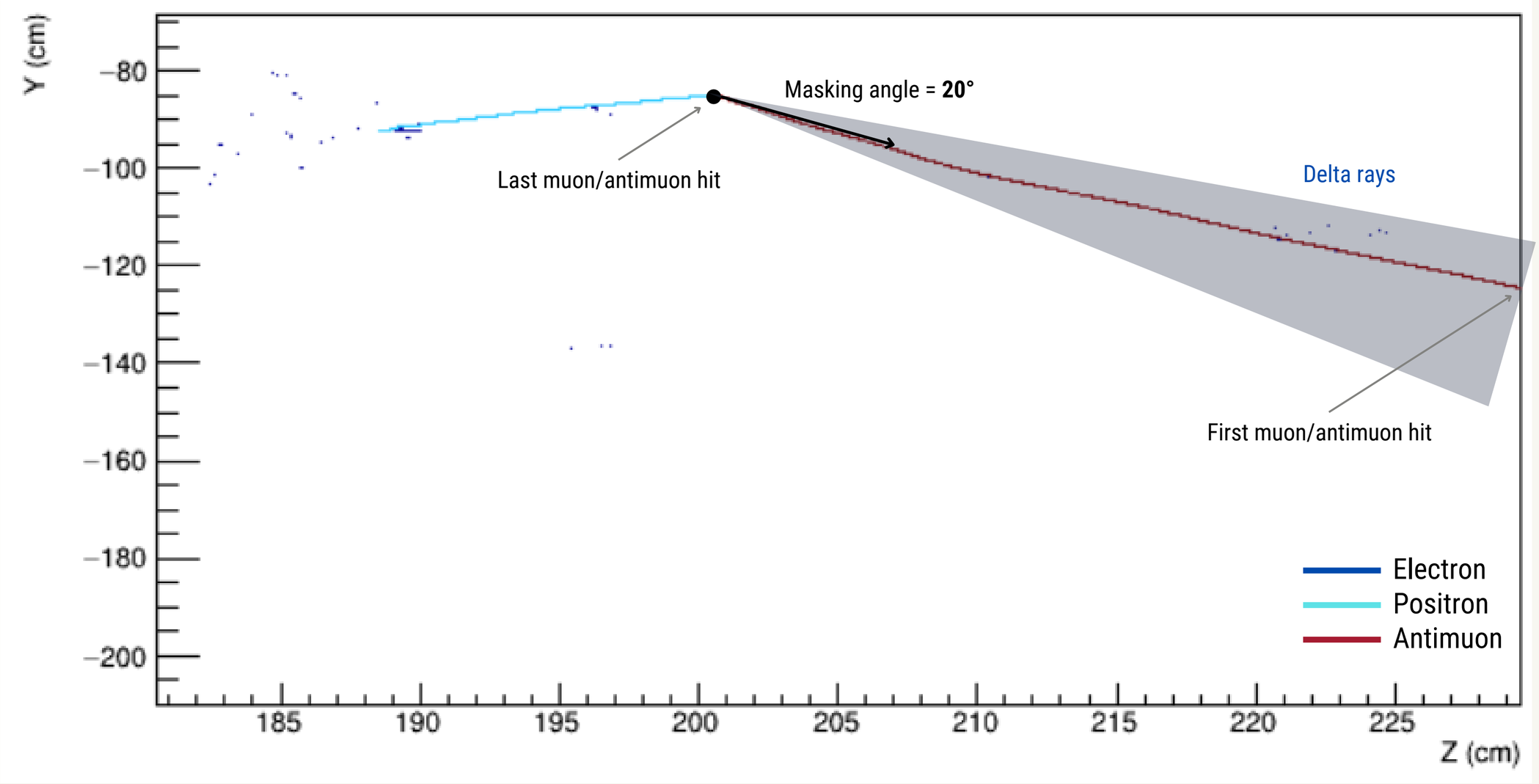
>>> e^- and e^+ from **956** muons



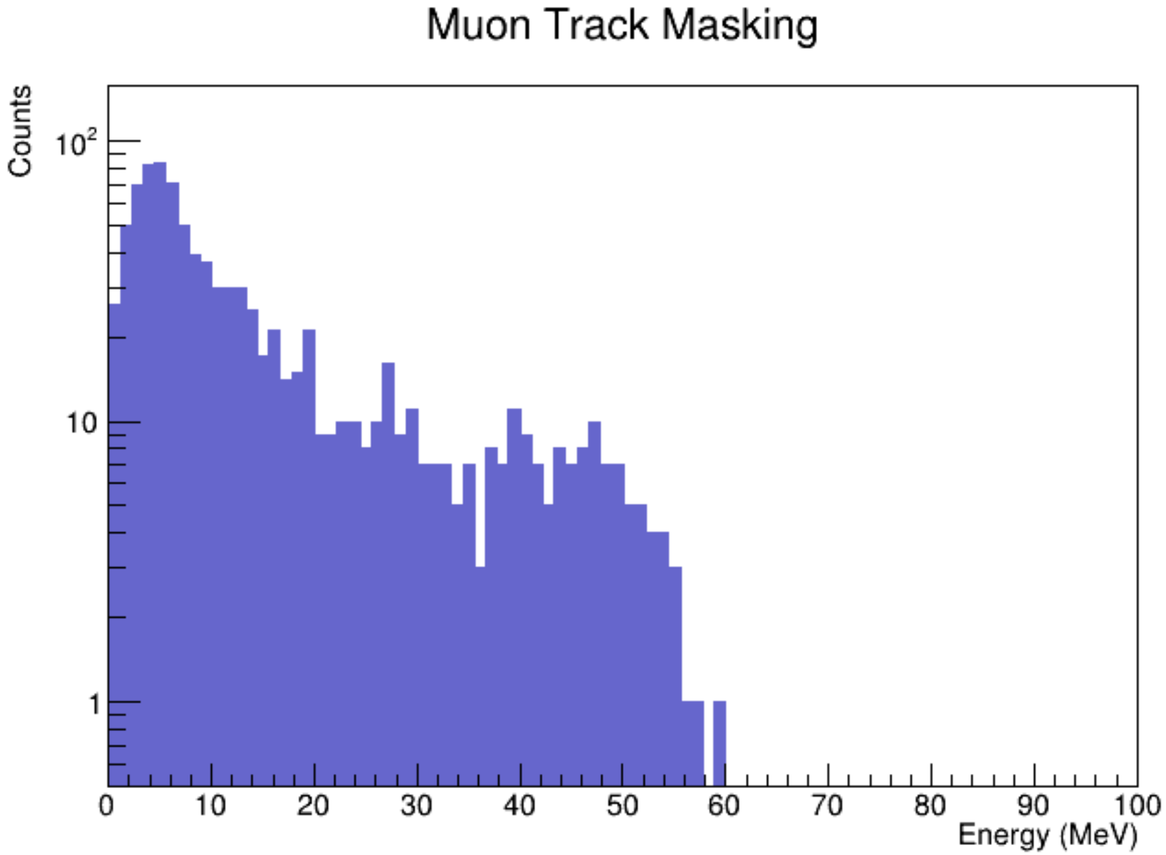
>>> e^- and e^+ from **960** antimuons

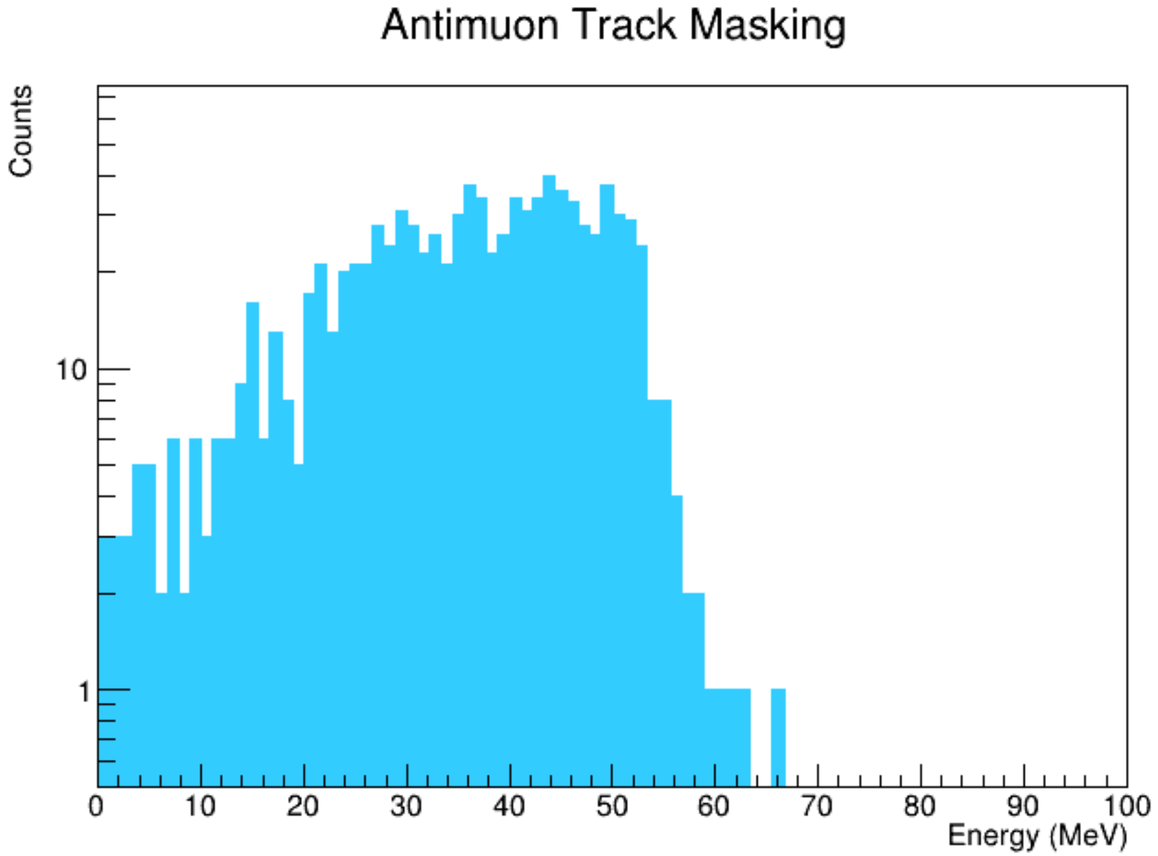


Analysis: track masking



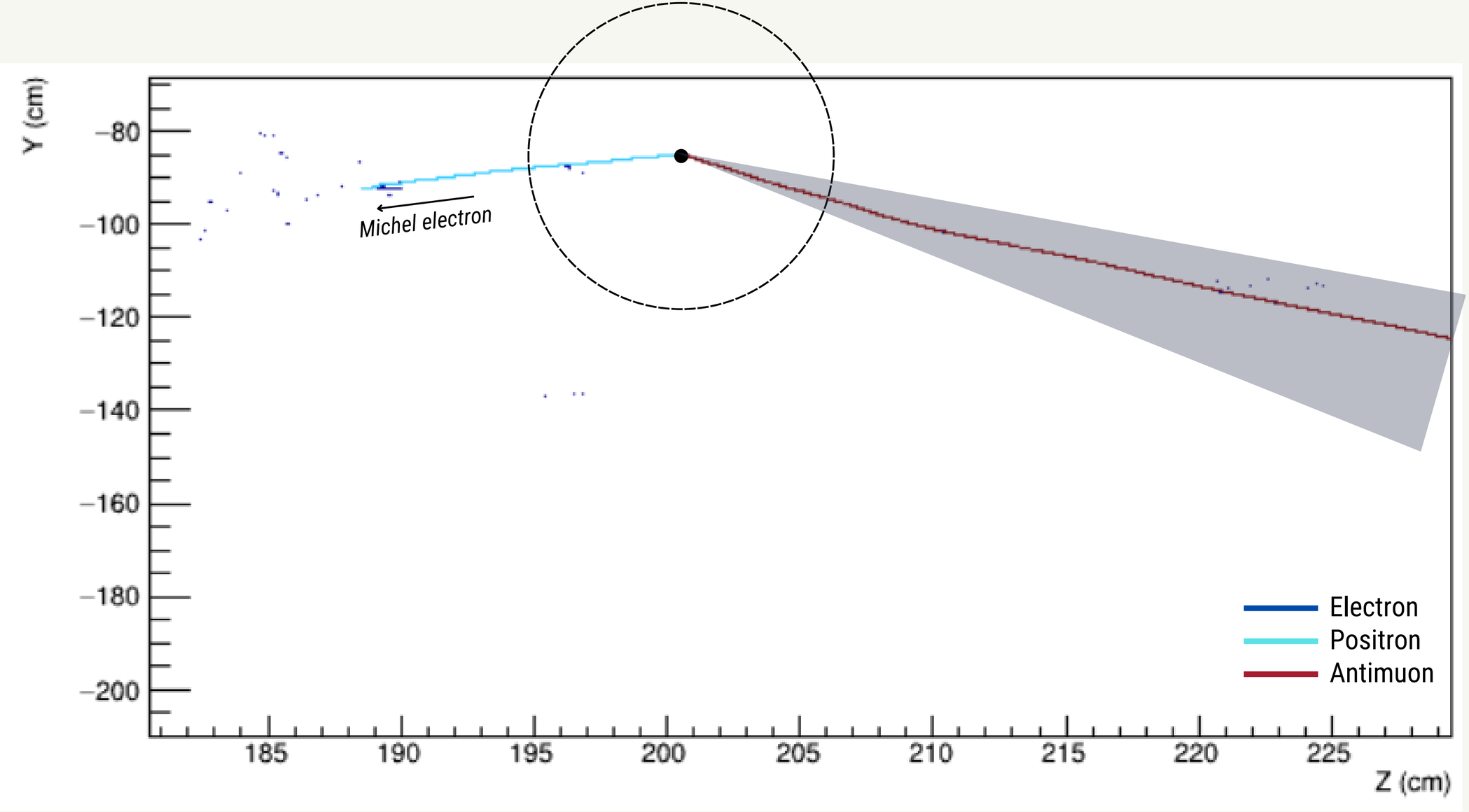
Analysis: track masking





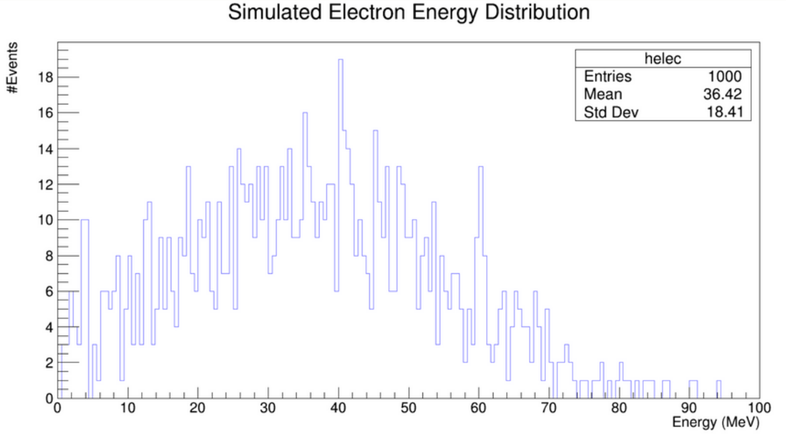
Let's go further!

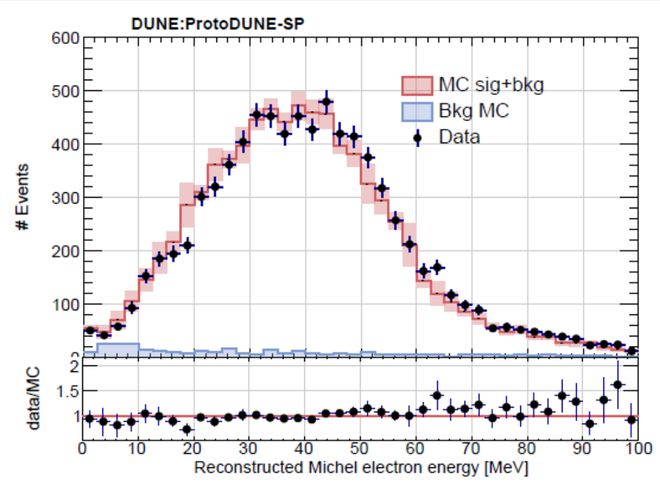
Analysis: containment sphere



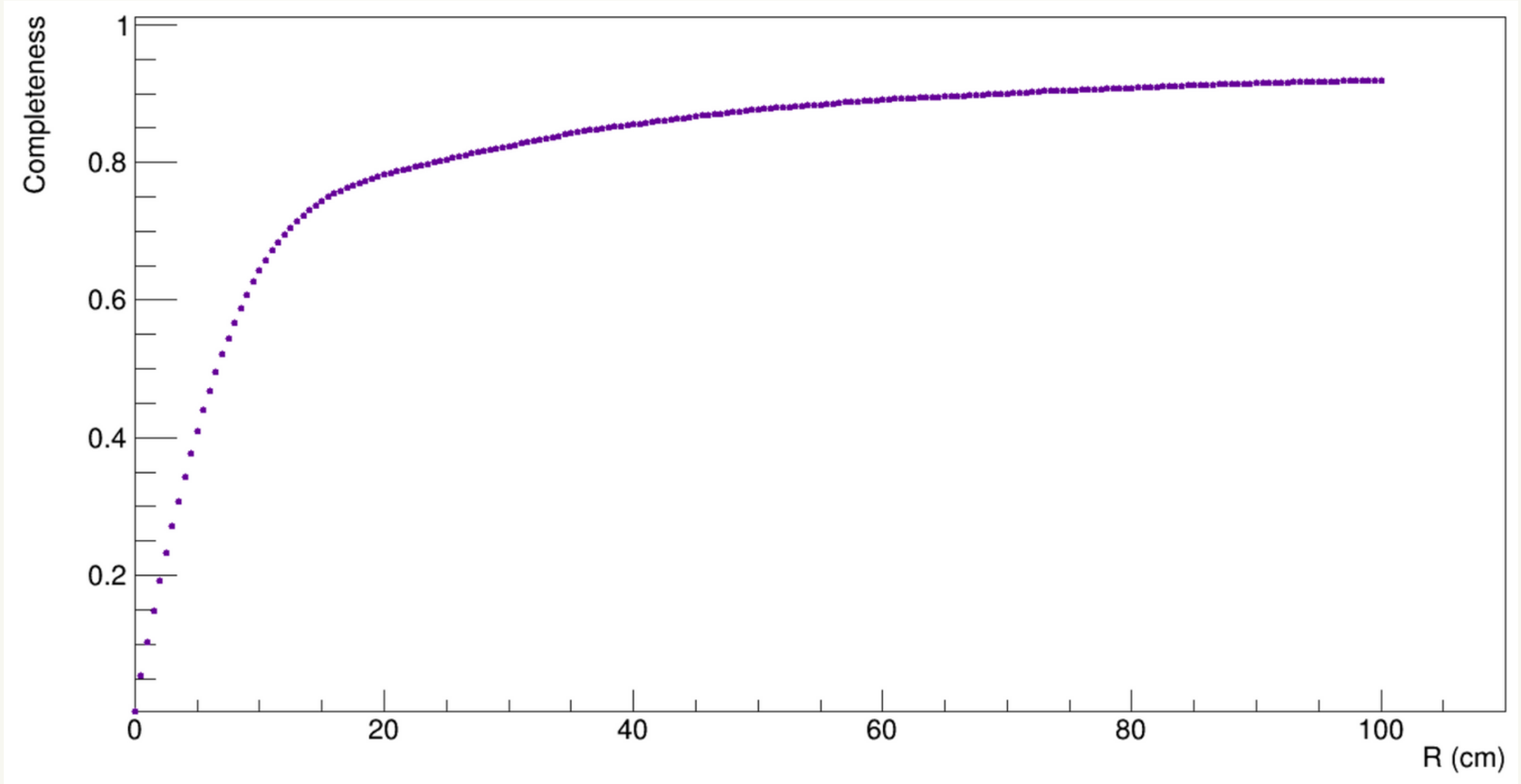
Analysis: MeV Electrons in LArTPC

>>> **1000** generated electrons





A. Abed Abud et al. arXiv :2211.01166 (2023)



Analysis: MeV Electrons

Hit completeness: fraction of electron hits inside the containment sphere over the total electron hits.

- This analysis:
  R = 25 cm
  Completeness = 0.8041

- DUNE Collaboration:
  R = 20 cm
  Completeness = 0.7819

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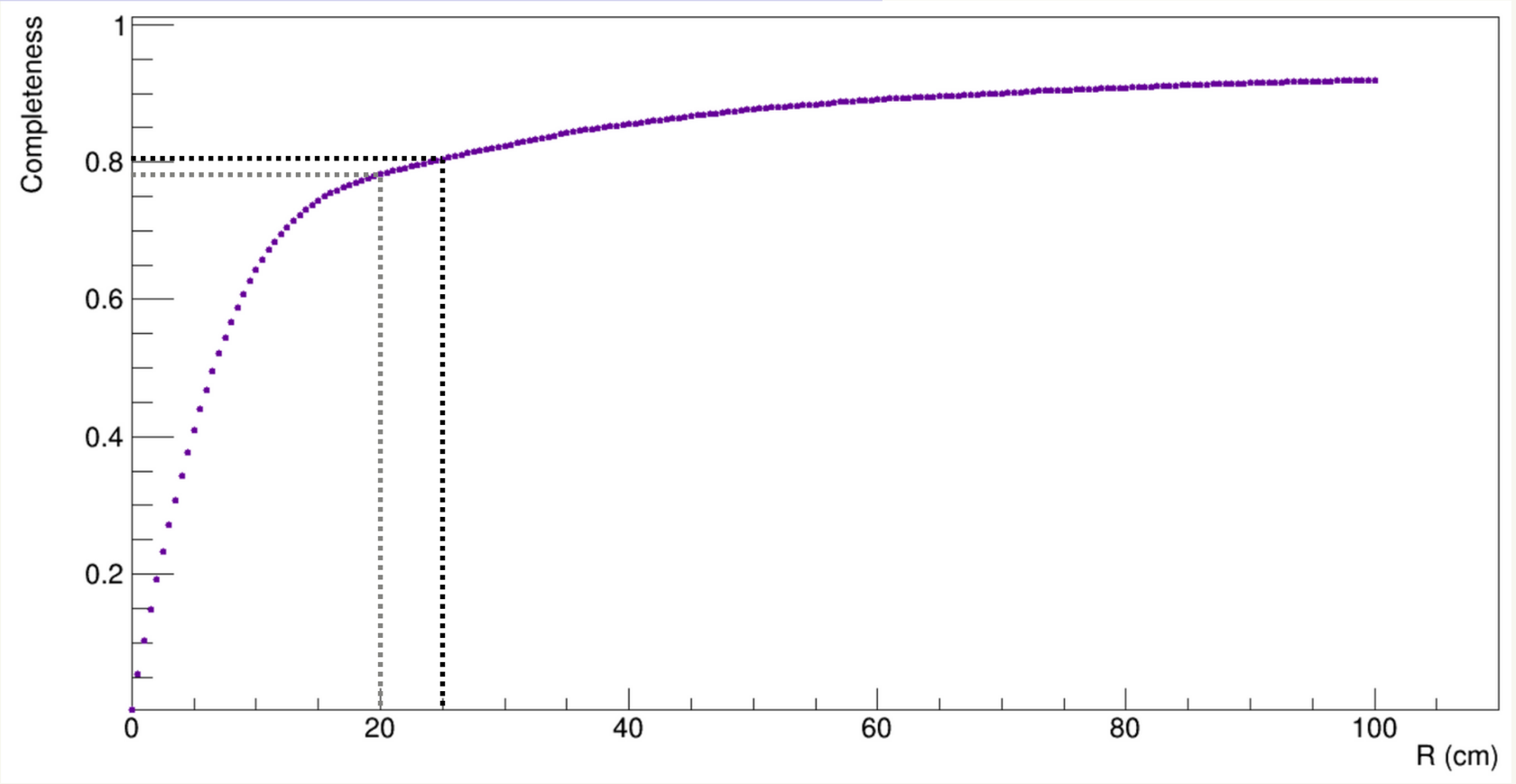
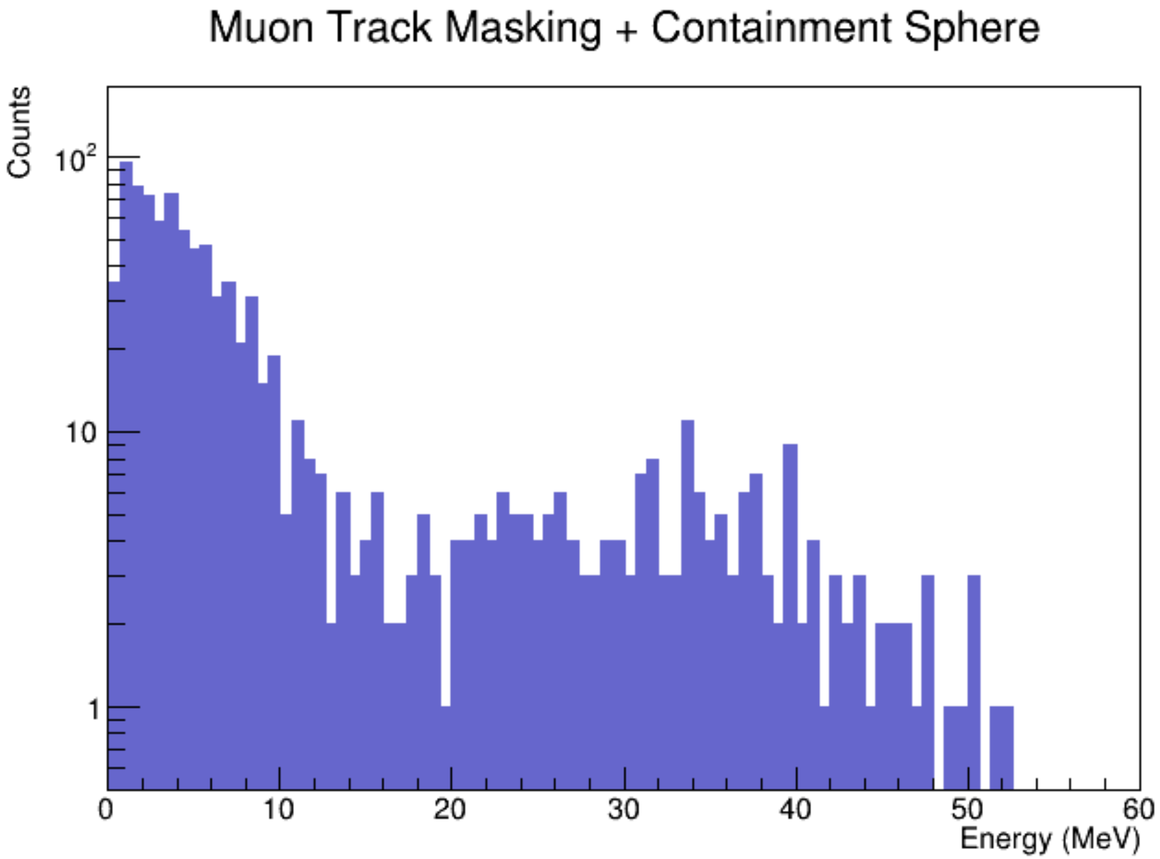
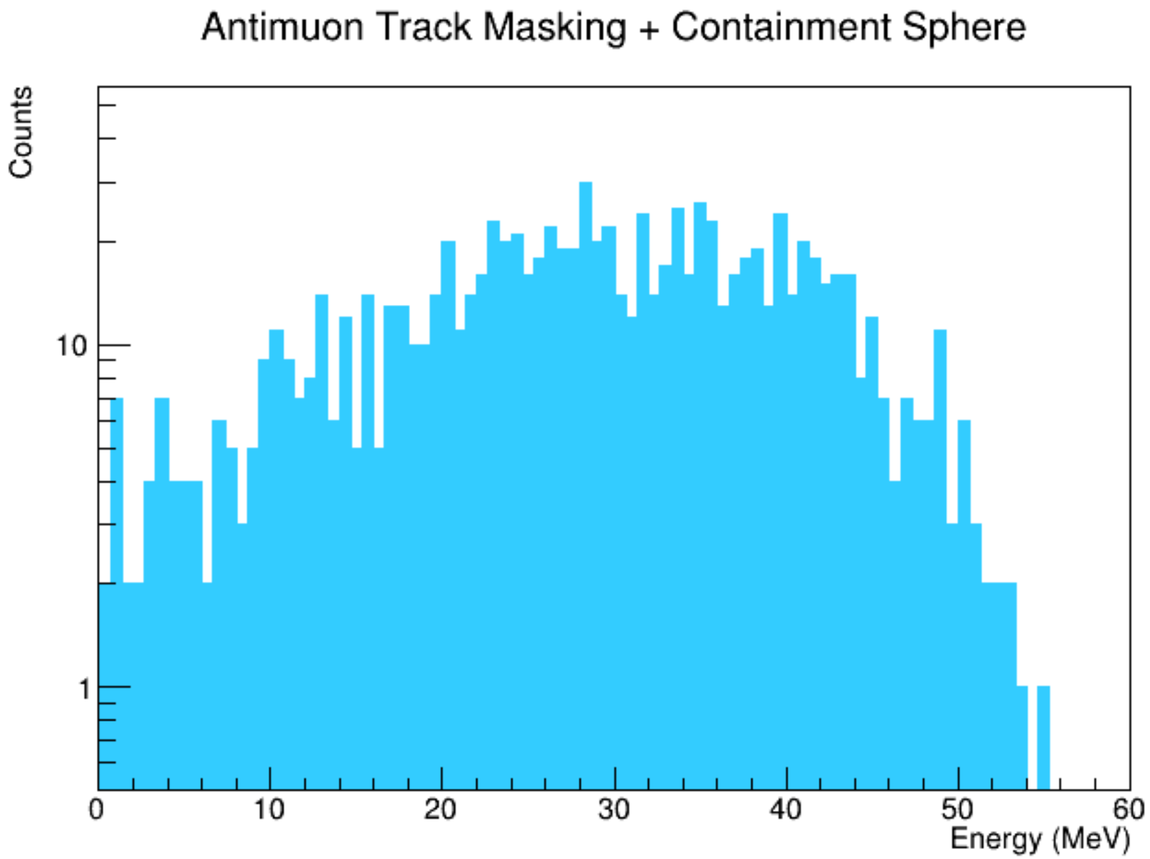


Analysis: containment sphere

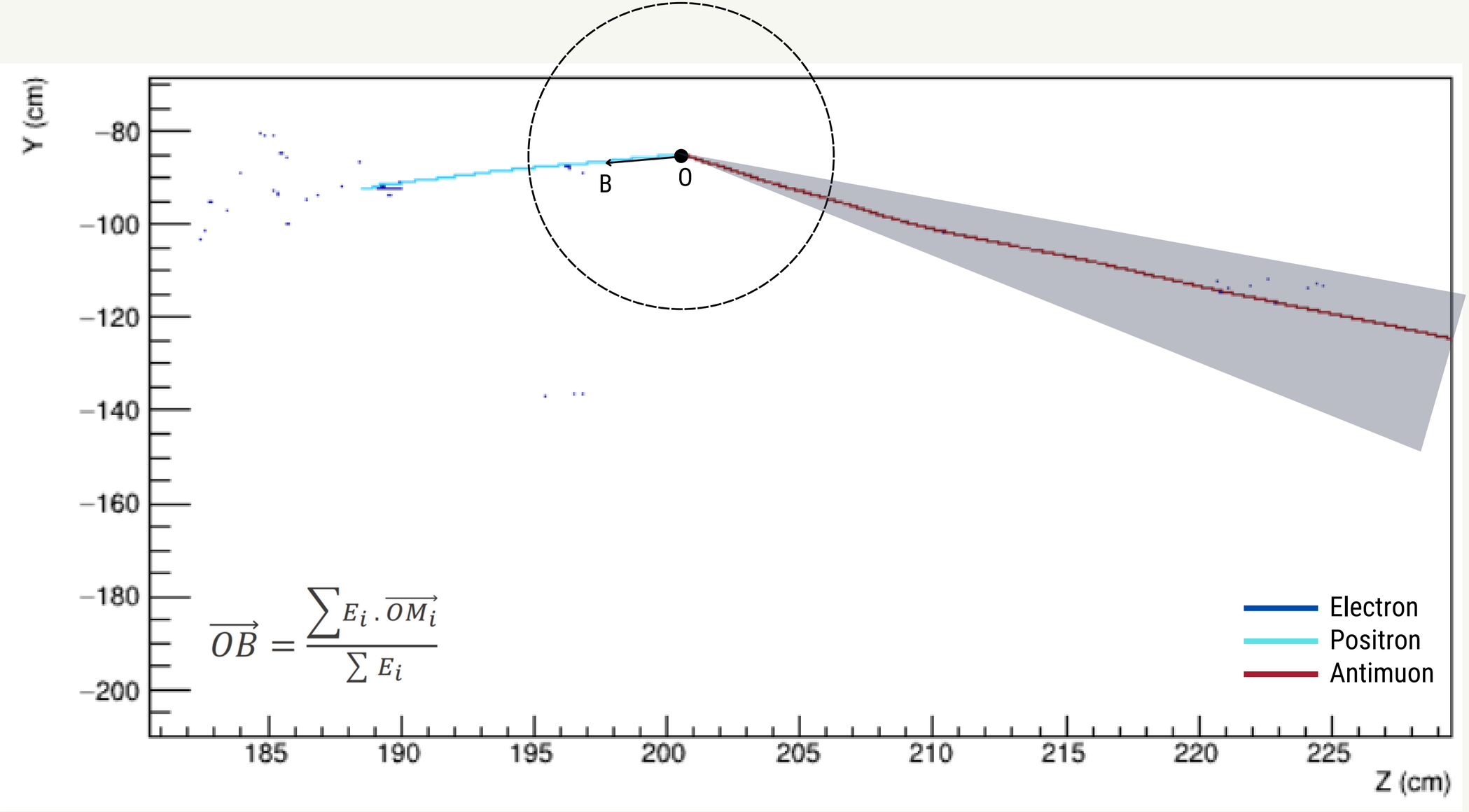
>>> **R = 25 cm**



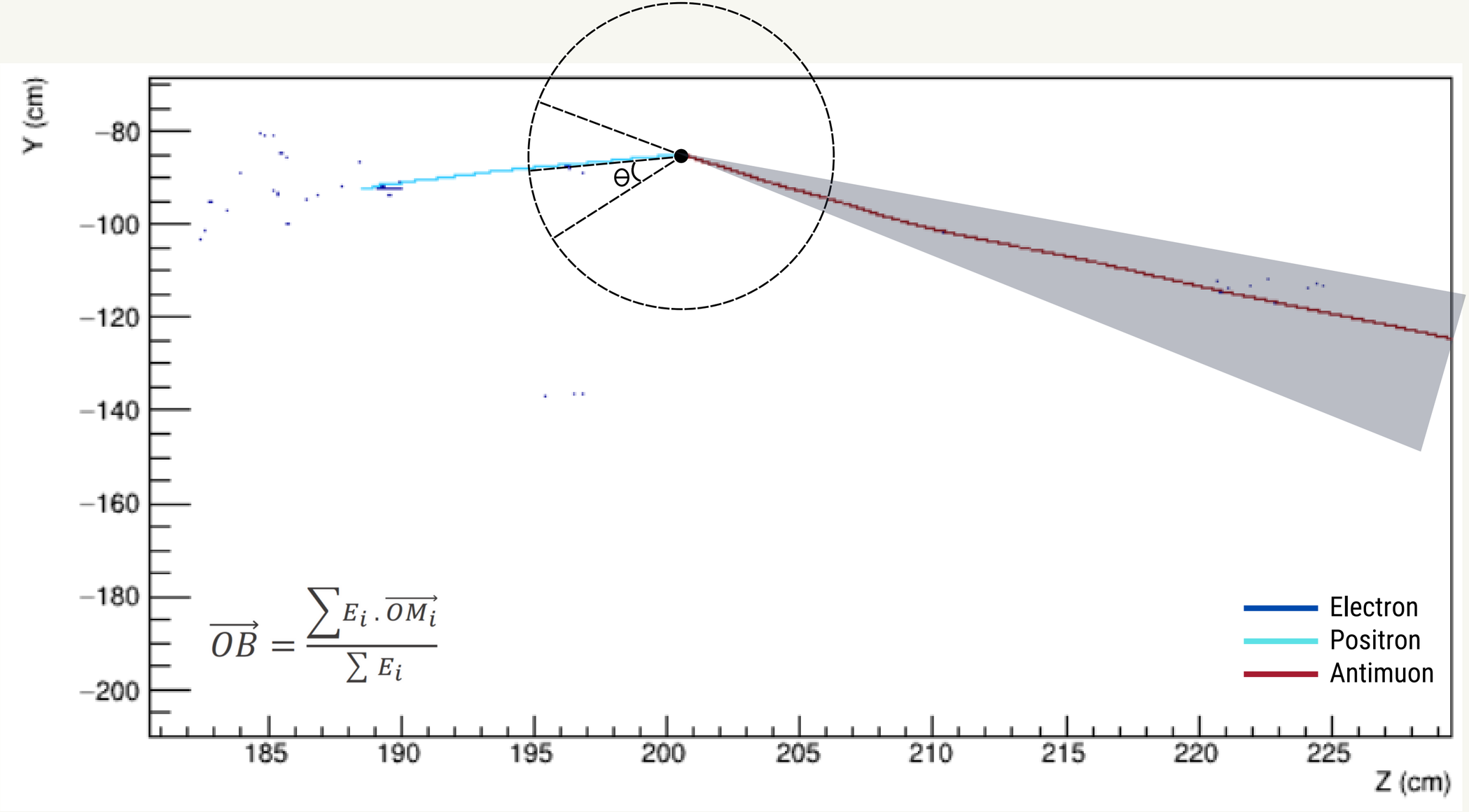


Let's go even further!

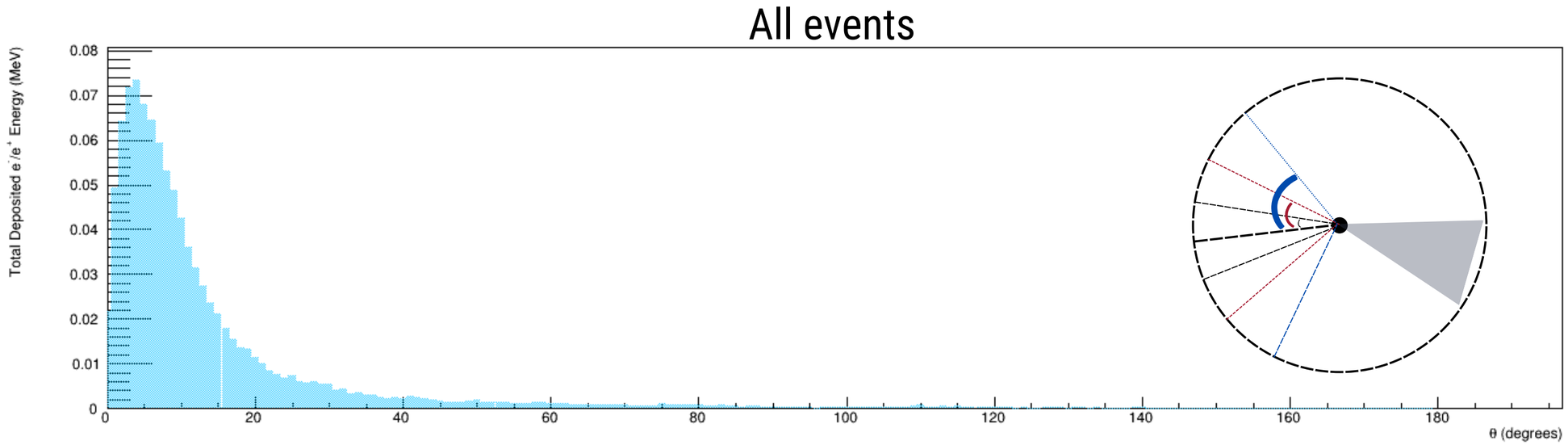
Analysis: selection cone

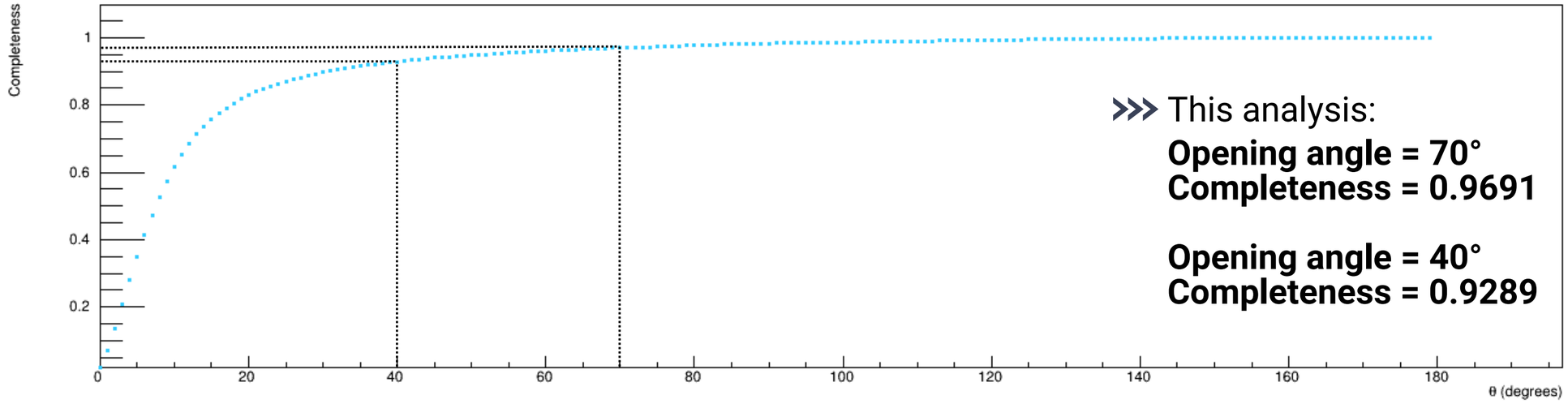


Analysis: selection cone



Analysis: selection cone - from antimuons





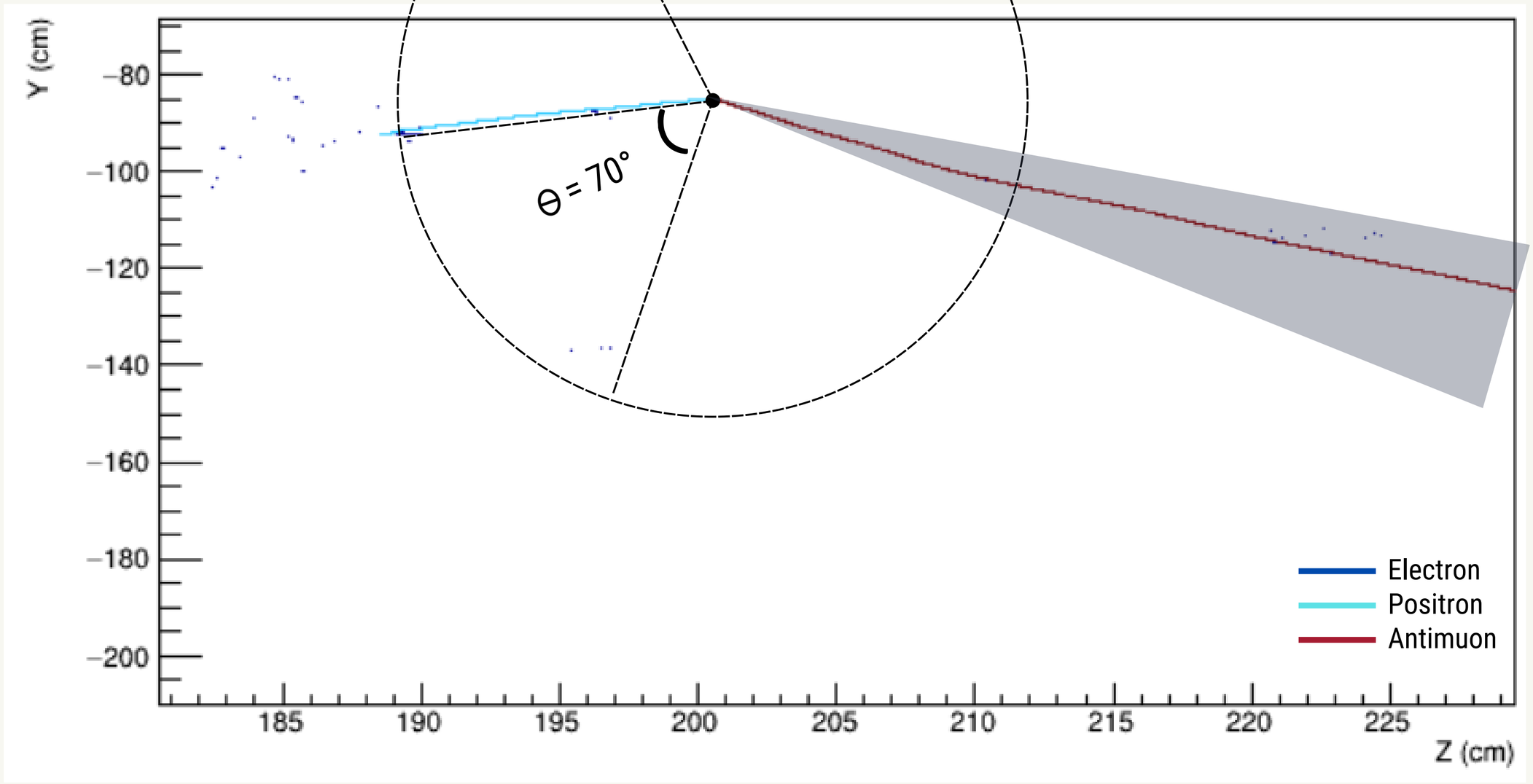
This analysis:

Opening angle = 70°
Completeness = 0.9691

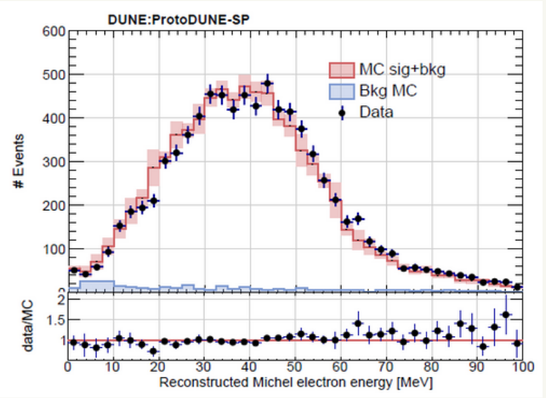
Opening angle = 40°
Completeness = 0.9289

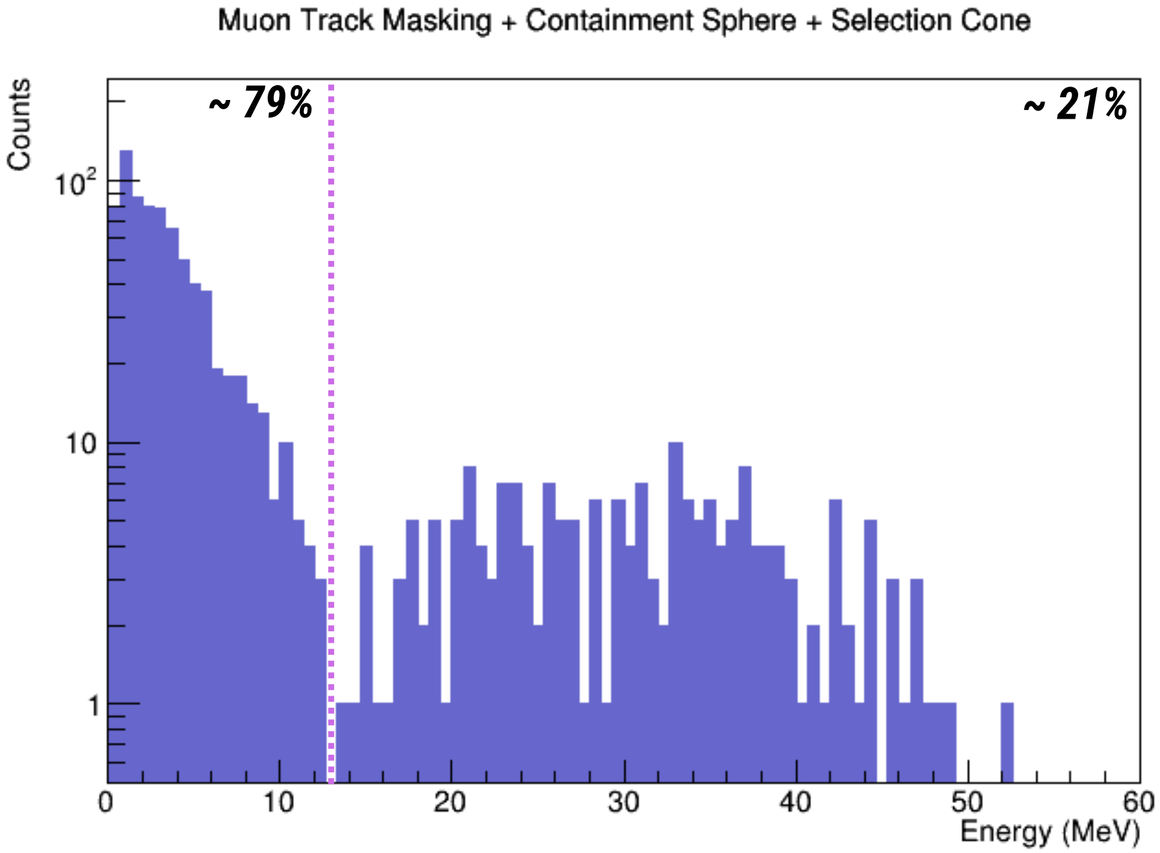
Analysis: selection cone

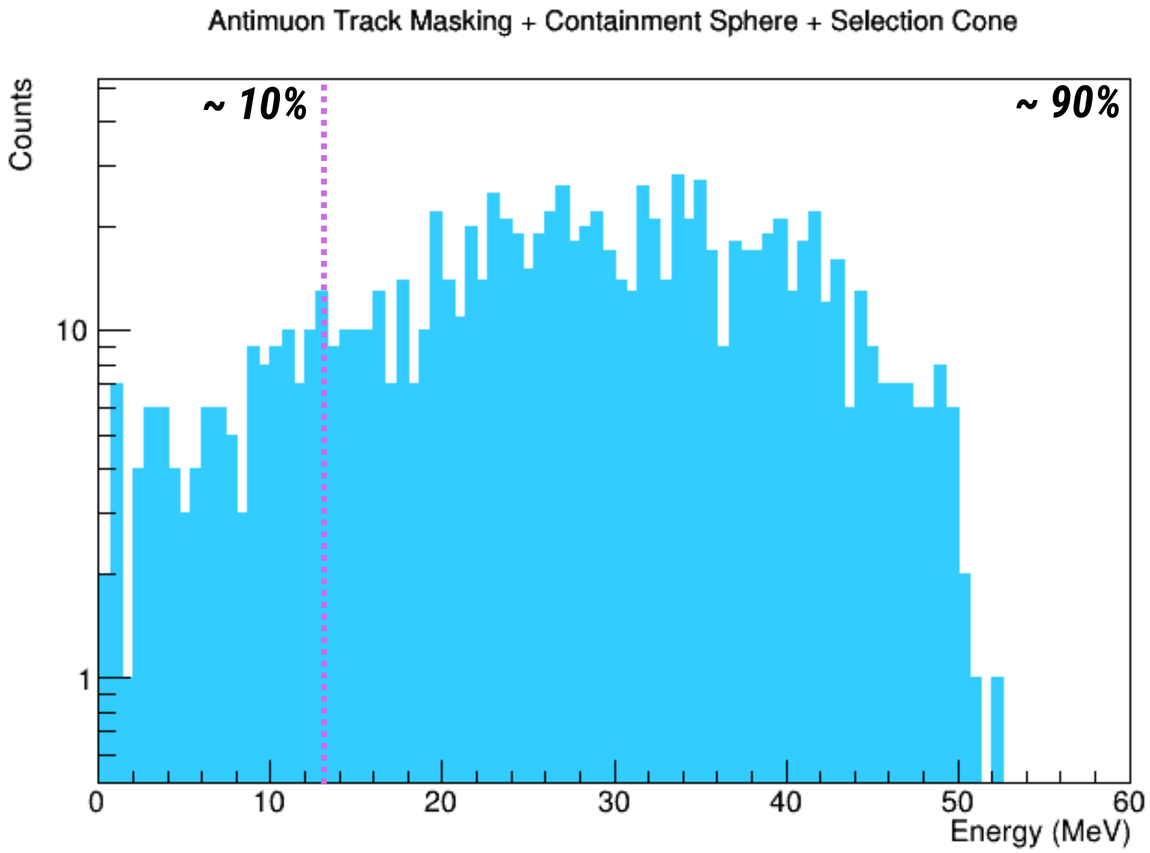
>>> About completeness



Analysis: selection cone







Conclusions

>>> **Selection Criteria from G4:**

- Cone **---> height = 25 cm** and **opening angle = 40°**
- Completeness ~ **74%**
- Decrease of the fiducial cone volume by 10% for same completeness (improvement of the signal/noise ratio)

A. Abed Abud et al. arXiv :2211.01166 (2023)

Future Prospects

- More inspection in muon track masking in order to avoid delta rays selection.
- Include noise simulation to compute **purity.**
- Test G4 selection criteria with LArSoft reconstruction tools.
- Prepare analysis pipeline for real data.
- Investigation of the CNN Michel electron score for ProtoDUNE VD.

Thank you!

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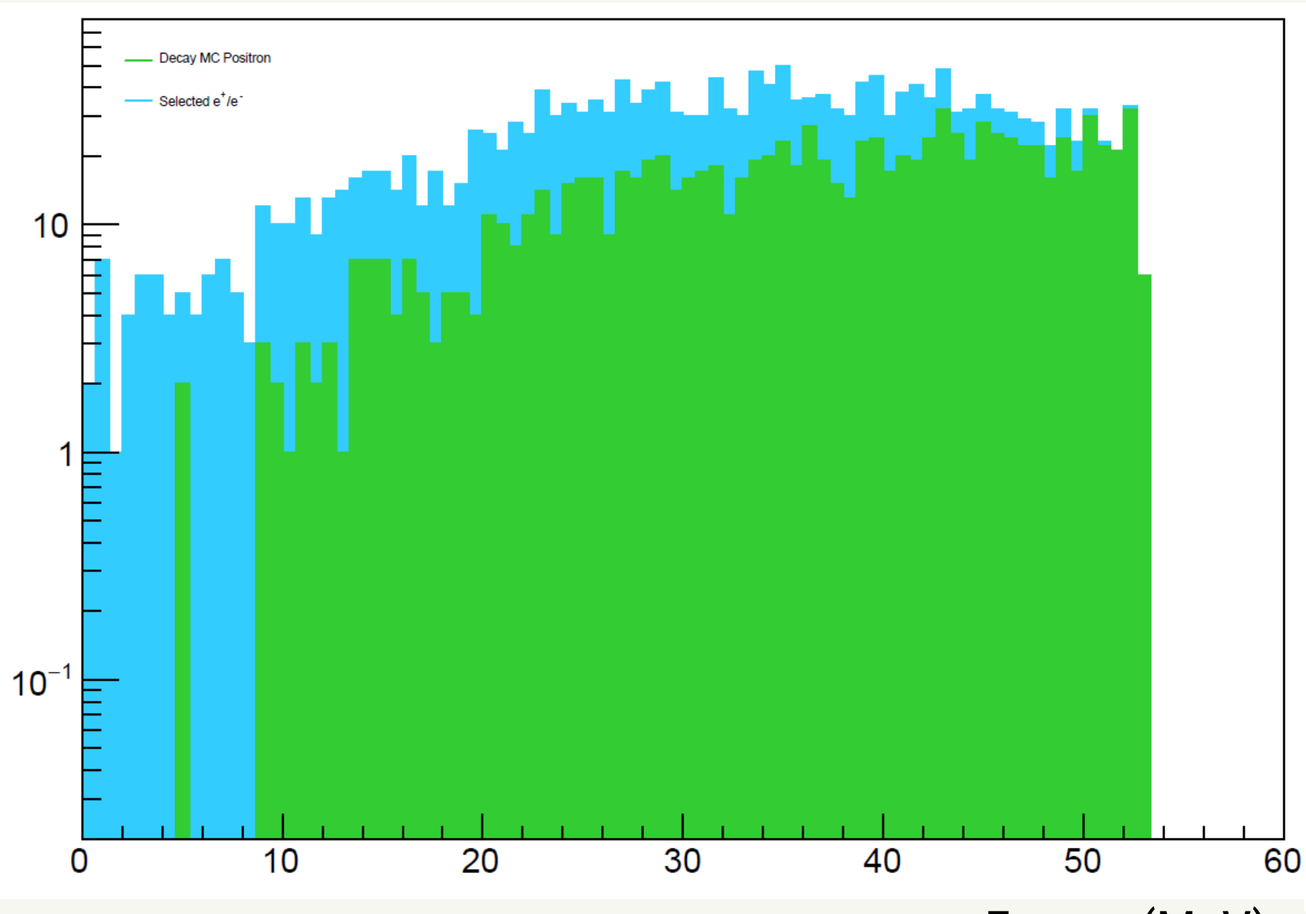
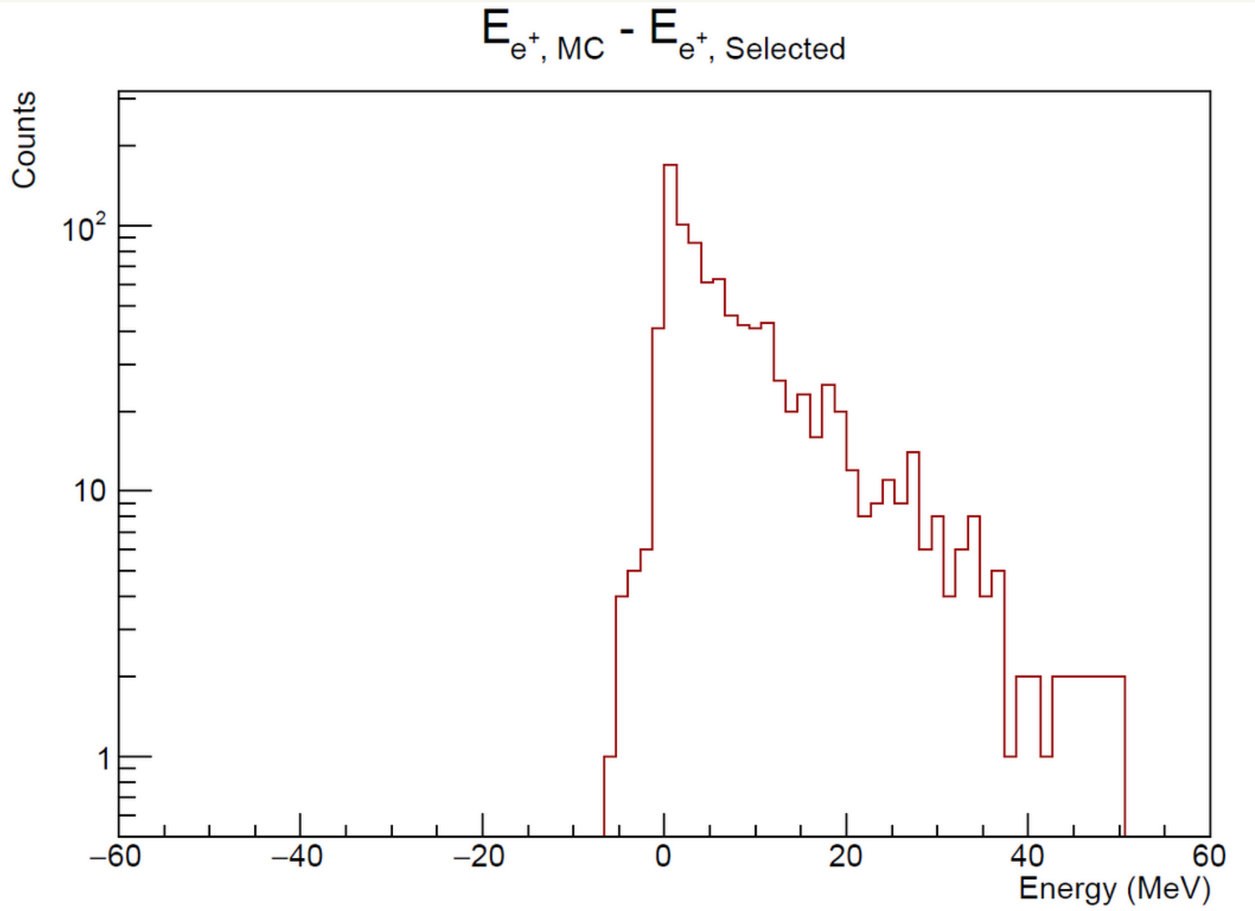
Extras

On MC positrons decaying from antimuons





Code information

- You can find everything here:
  - **/silver/DUNE/andres-cortes**
  - **https://github.com/camacortespar/MichelElectron_IJCLab.git**

- What would you find there?
  - **fcl** files to do the simulations
  - **scripts** running the fcl files on bash
  - **macros** that I used in the internship:
    - **SimMichelAnalysis.C** is the main one (muon information + Michel electron analysis)
    - **SimElectronAnalysis.C** related to how electrons behaves in LArTPC.