Heavy Neutral Particle Search in MINERvA
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Neutrino Events — Beam Ends — Quiet Period — Rare Event

Motivation

- Pure neutrino beam
  - Less interactions and less kinds of interactions than other particle detectors in beam and collision experiments
  - Simpler background makes it easier to search for potential unexpected events and particles
- Higher statistics than cosmic neutrino experiments
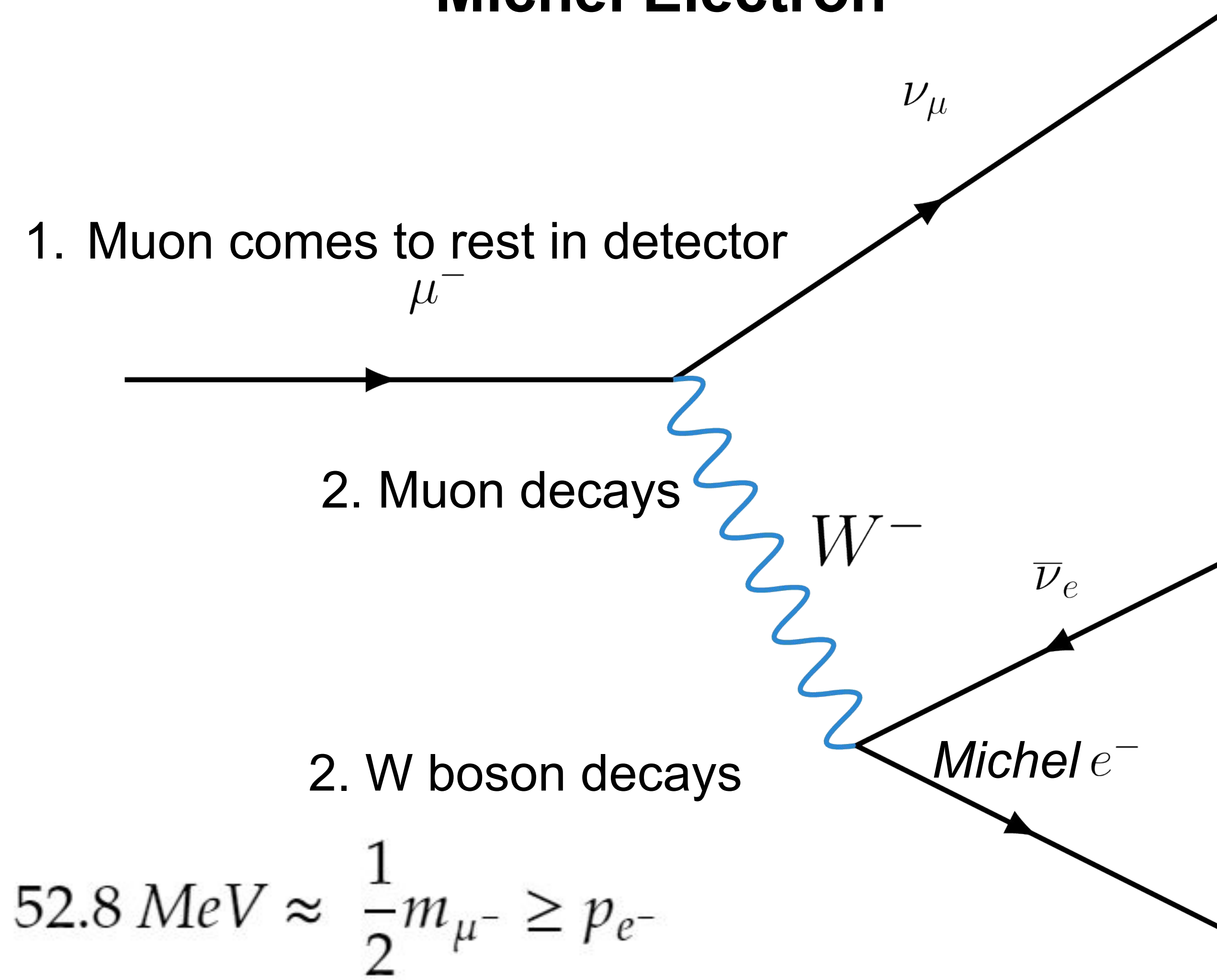 - Higher chance to see ultra-rare events.

My Search

- Something spatially compact
- Rarely Interacting
- High energy
  - Could look like the neutrino events
- Late in time
  - After the Beam shuts off
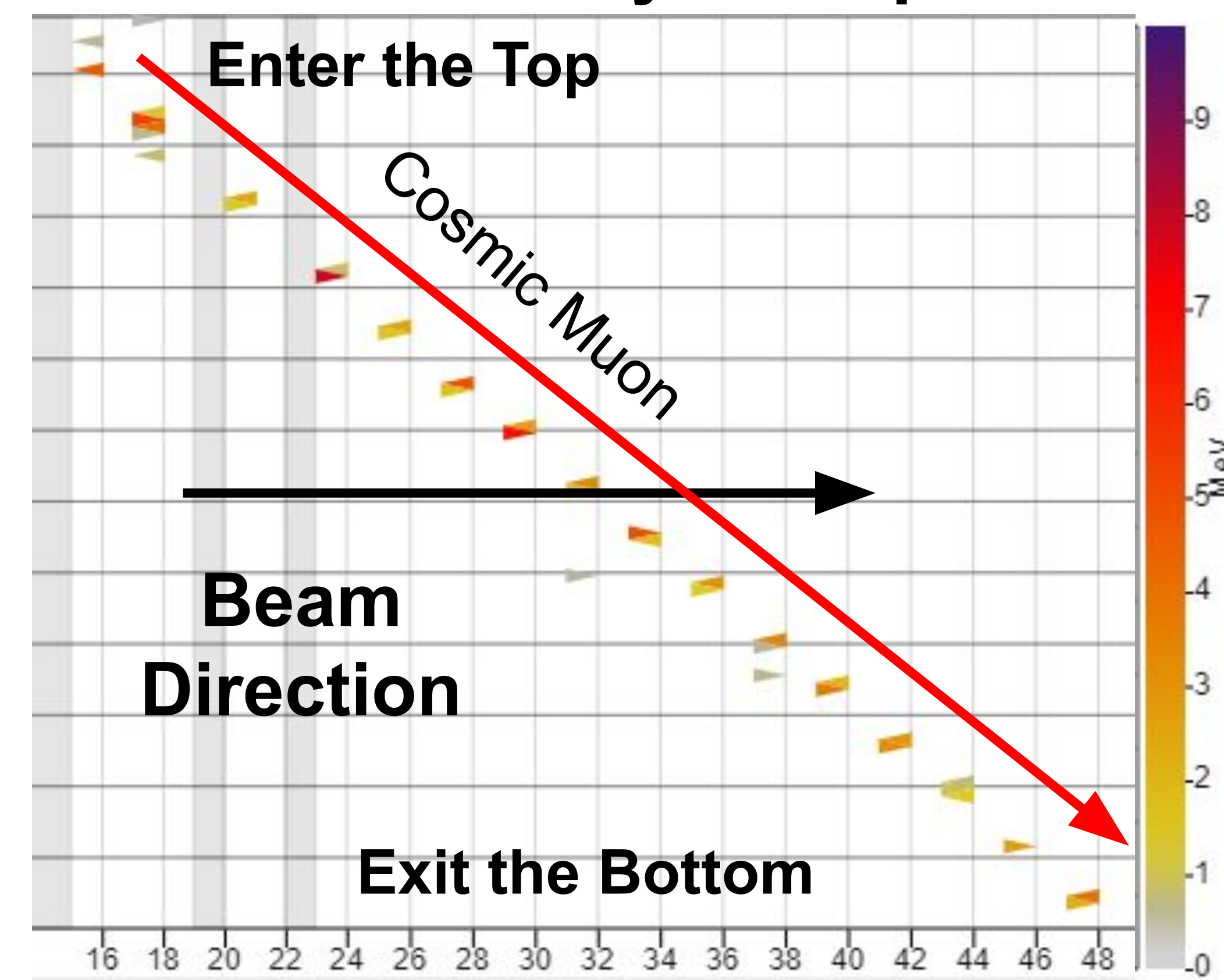 - Tortoise Particle (Slow Massive)
  - Compared to Neutrino (Hare)

Backgrounds

- Michel Electrons
  - A muon from neutrino interactions decay into an electron if they are stopped in the detector
  - Decay constant of about 2.2μs
- Cosmic Rays
  - Mostly muons from cosmic neutrinos
  - Angled often close to perpendicular to the beam
  - Often the muon will enter and exit the detector
  - Example shown is about as aligned with beam as it gets

Michel Electron

1. Muon comes to rest in detector μ^-

2. Muon decays

W^-

ν_μ

$\overline{\nu}_e$

2. W boson decays — Michel e^-

$$52.8\ MeV \approx \frac{1}{2}m_{\mu^-} \ge p_{e^-}$$

Cosmic Ray Example

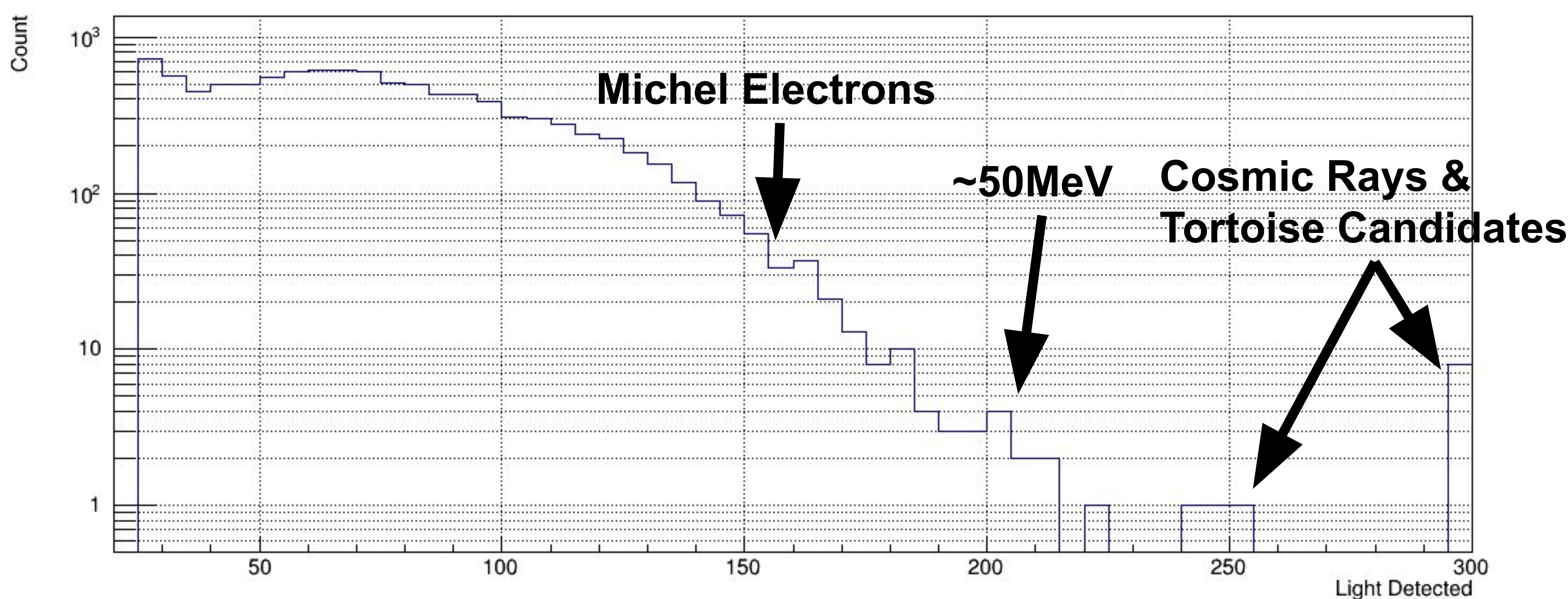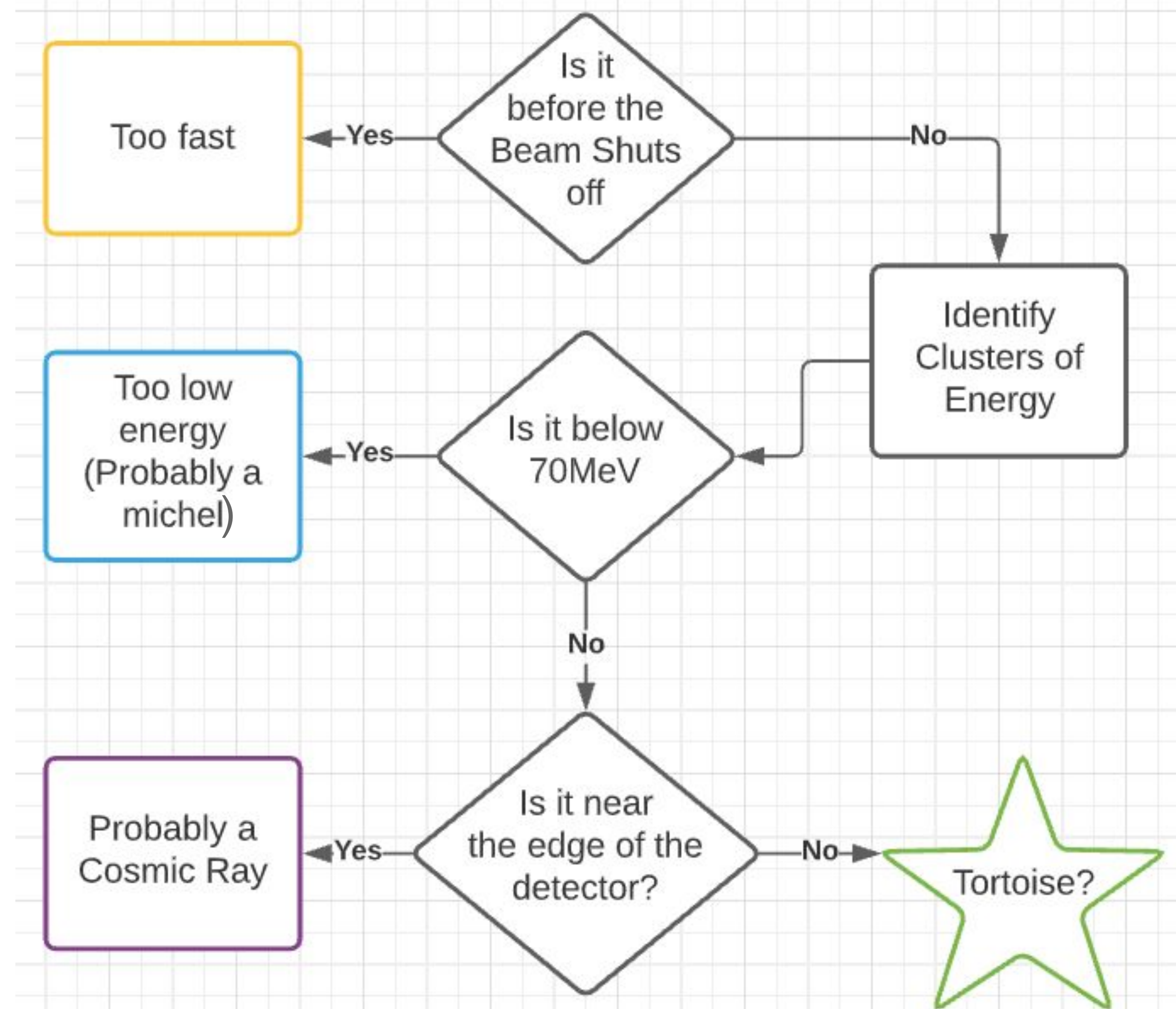Enter the Top — Cosmic Muon — Beam Direction — Exit the Bottom

My Algorithm

- Eliminate Beam Time hits
  - No neutrino events
- Eliminate clusters of hits below about 50-70 MeV
  - No Michel electrons
- Identify patterns of hits that seem to exit and enter the detector and remove those hits
  - No cosmic rays
- Analyze what is left.

Is it before the Beam Shuts off — Yes → Too fast — No → Identify Clusters of Energy

Is it below 70MeV — Yes → Too low energy (Probably a michel) — No

Is it near the edge of the detector? — Yes → Probably a Cosmic Ray — No → Tortoise?

Event Candidate Total Energy (hit_pe)

Michel Electrons — ~50MeV — Cosmic Rays & Tortoise Candidates

Light Detected

Next Steps

- Finalize cosmic ray cut
- Run over more data
- React to what comes out
  - Distinct pattern in time
    - Compare to models to determine energy and speed constraints of particle creation
  - Something else?

REFERENCES AND ACKNOWLEDGEMENTS

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