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Detecting Neutrons in MicroBooNE

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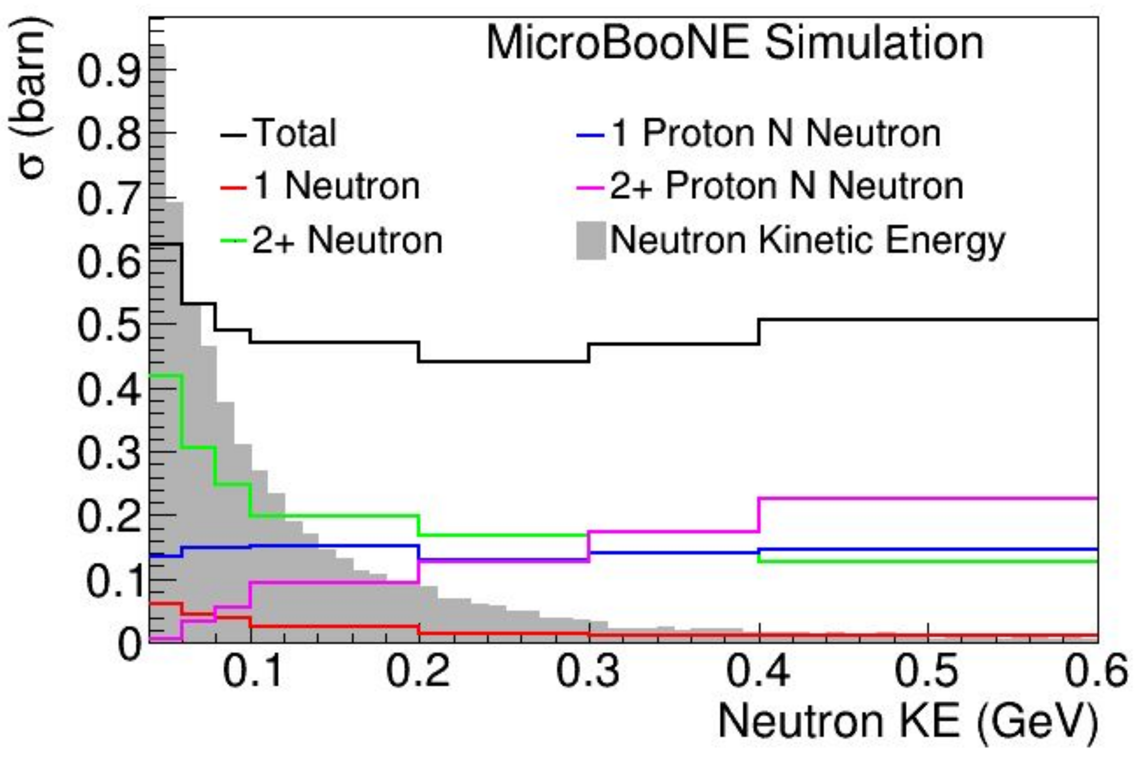
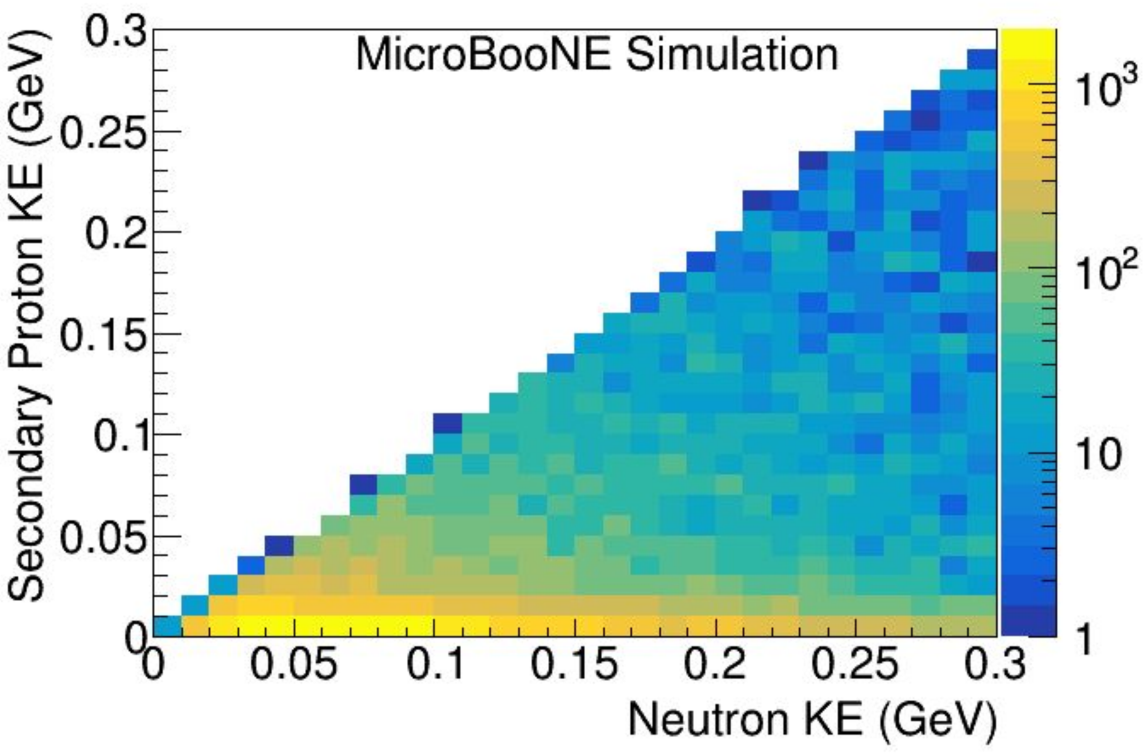
Motivation

- Neutrons carry away missing energy from (anti)neutrino interactions
- SBN and DUNE will rely on generators to predict and correct for missing energy from neutrons
- Neutron tagging in liquid argon TPC can be used to:
  - Measure neutron production rates
  - Identify events with missing energy
  - Statistically separate neutrino and antineutrino interactions
- We use MicroBooNE [1] to demonstrate the feasibility of identifying neutrons in a LArTPC

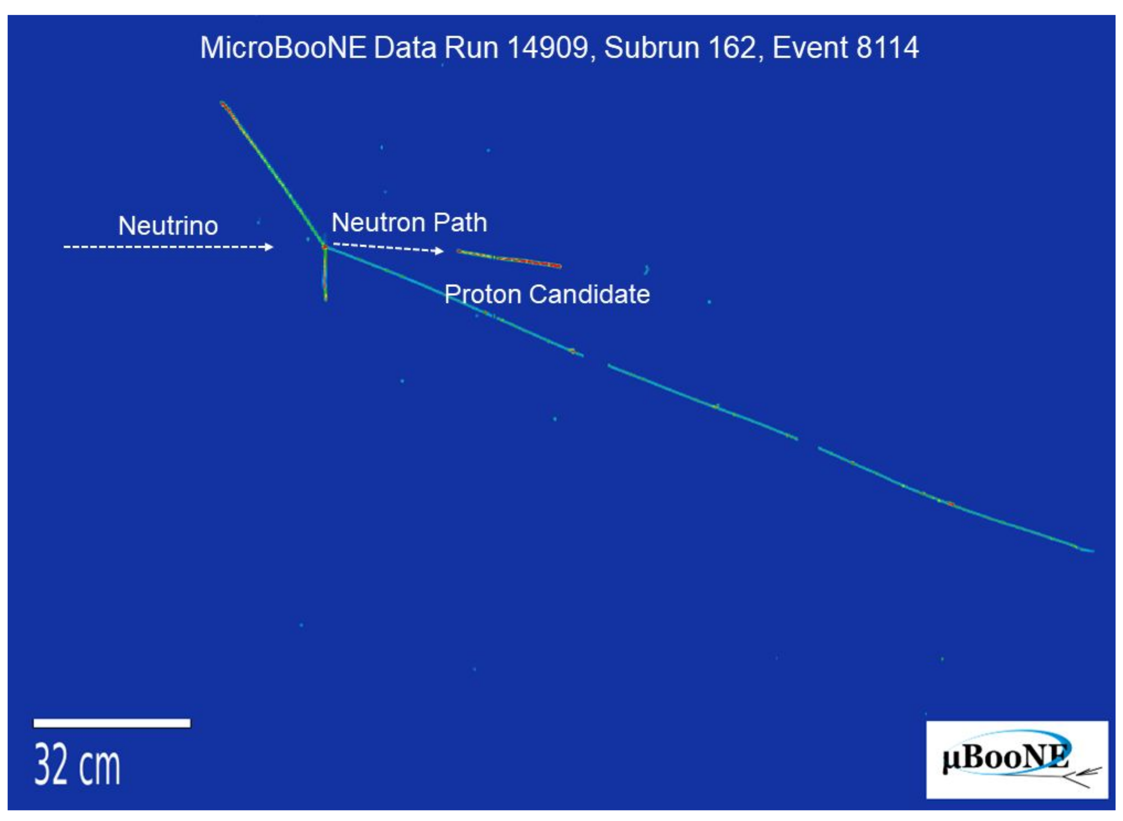
Neutron Detection

- Above 100 MeV the neutron-argon inelastic cross section doesn't depend strongly on energy
- Interaction length is approximately 70 cm
- Significant fraction of neutron-argon interactions produce secondary protons
- Secondary proton spectrum peaks at low energies

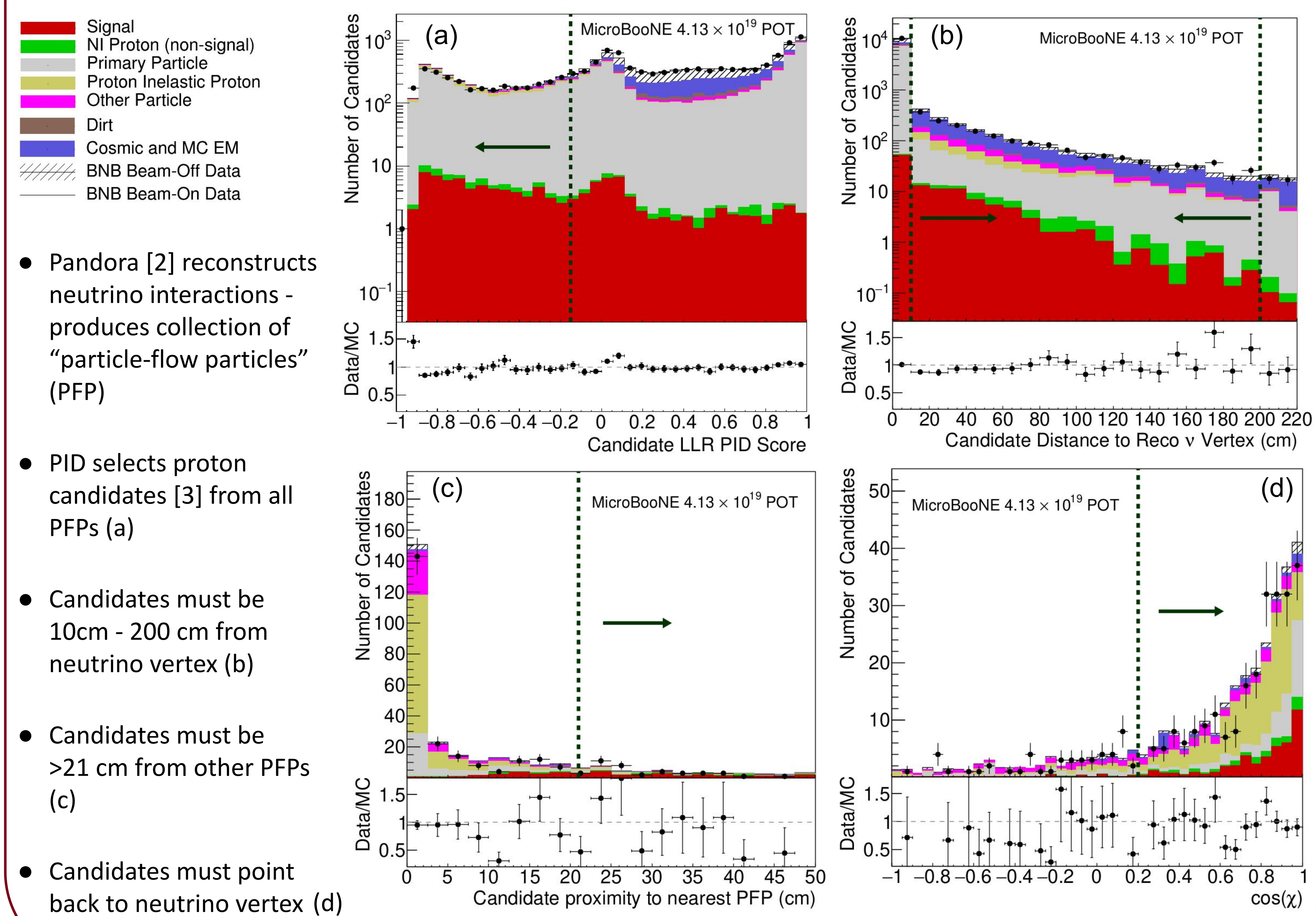




- Event selection targets isolated protons from secondary scatters
- Successfully selected neutrons in data using neutrino-induced protons:

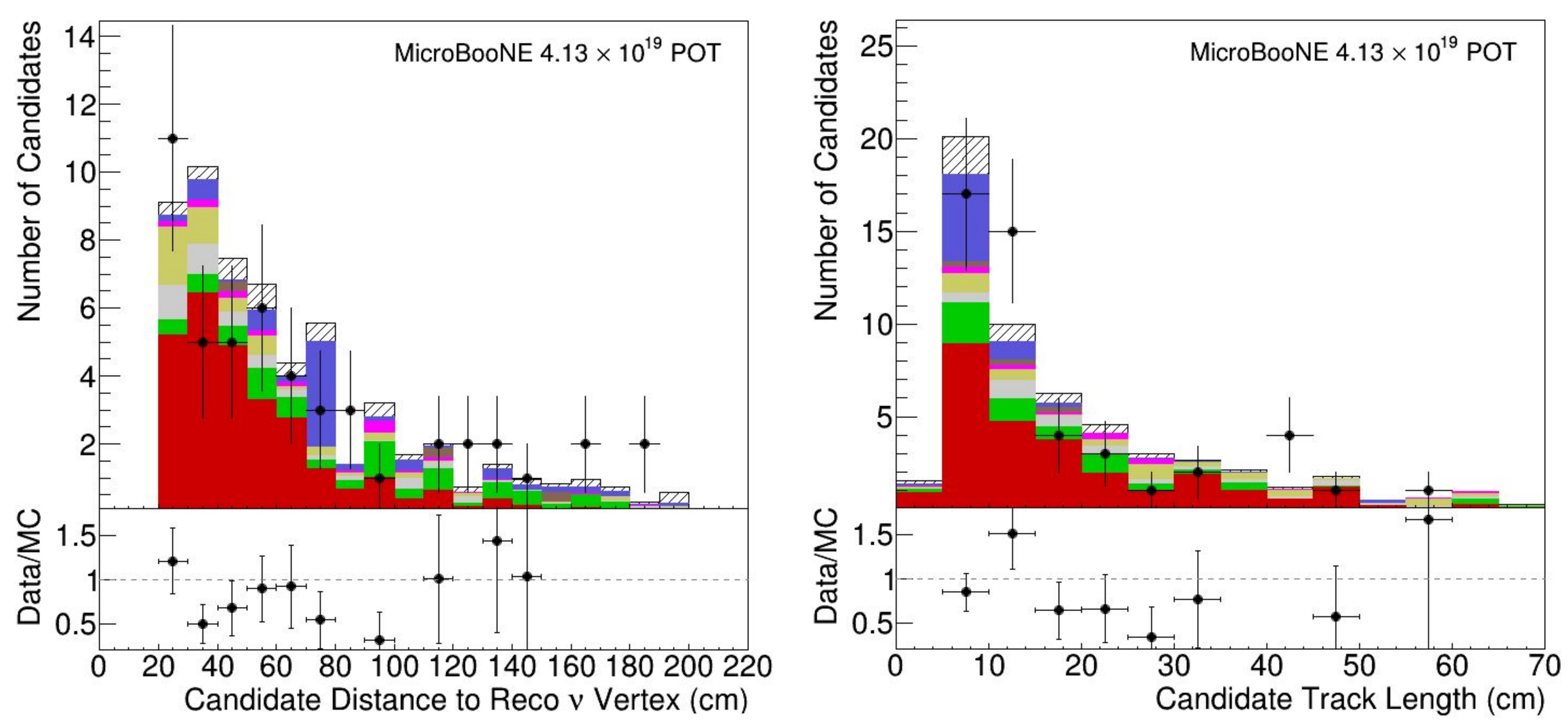


Event Selection

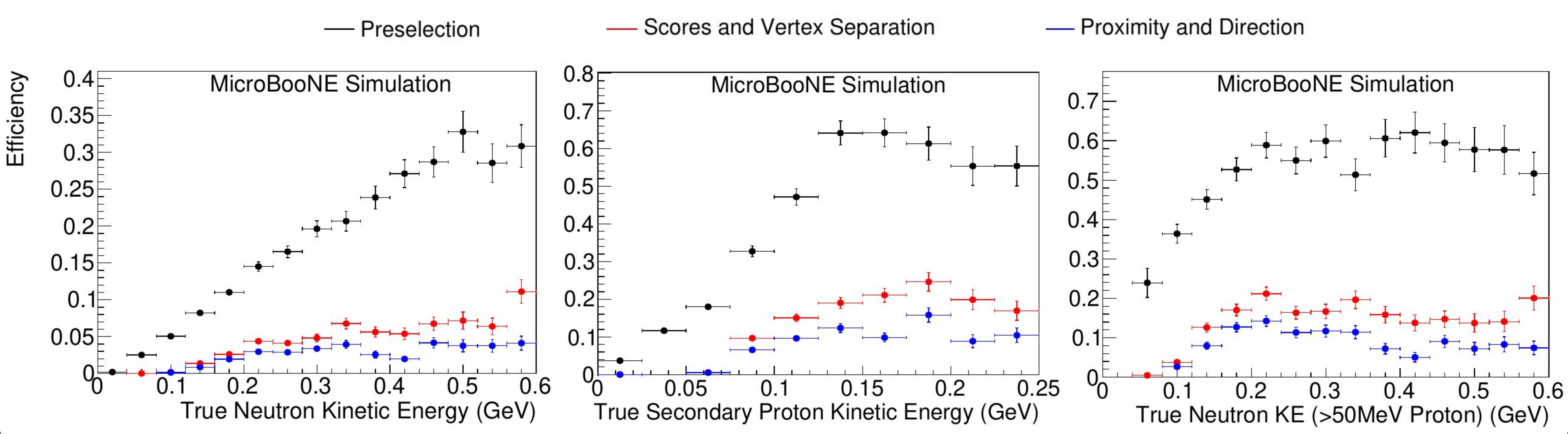


- Pandora [2] reconstructs neutrino interactions - produces collection of "particle-flow particles" (PFP)
- PID selects proton candidates [3] from all PFPs (a)
- Candidates must be 10cm - 200 cm from neutrino vertex (b)
- Candidates must be >21 cm from other PFPs (c)
- Candidates must point back to neutrino vertex (d)

Event Selection Performance



- **60%** of candidates are neutron-induced neutrons from the beam
- 48% of candidates originate from primary neutrons
  - 12% are secondary neutrons
- Zero efficiency below 100 MeV
  - Due to proton ID efficiency below 50 MeV
- *If* neutron produces a 50 MeV proton, average efficiency is 8.3%



References

[1] JINST 12, P02017 (2017)   [2] Eur. Phys. J. C78, 1, 82 (2018)   [3] JHEP 2021, 153, (2021)

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