ProtoDUNE-SP Argon-39 Update

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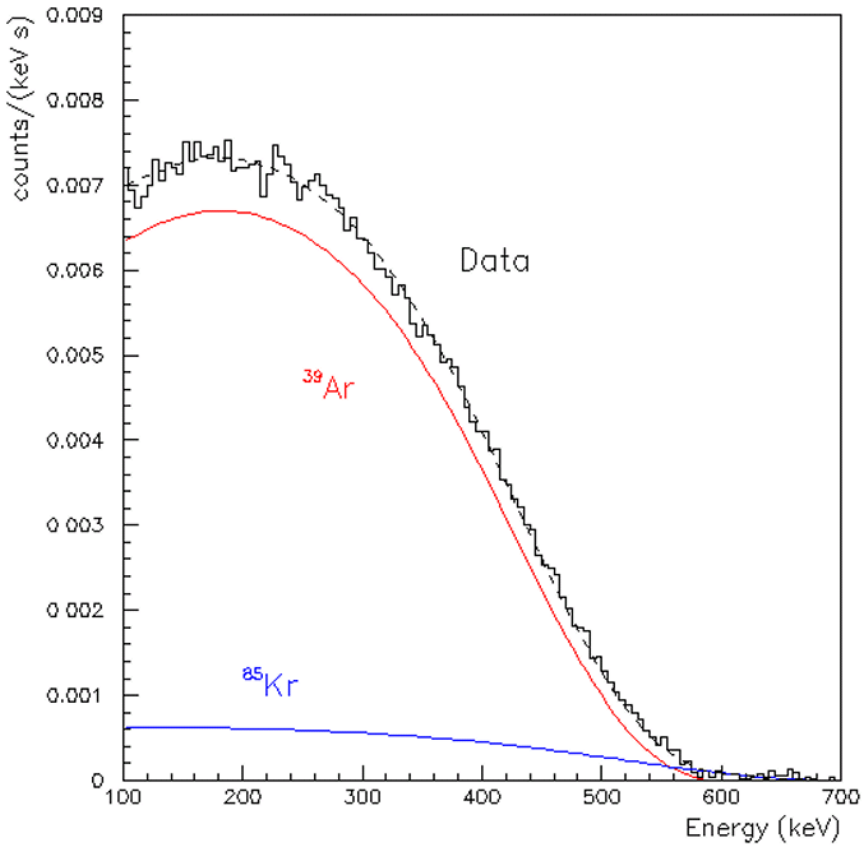
Michael Mooney

DUNE Calibration WG

July 24, 2020

Summary of ^{39}Ar Beta Decay Studies:

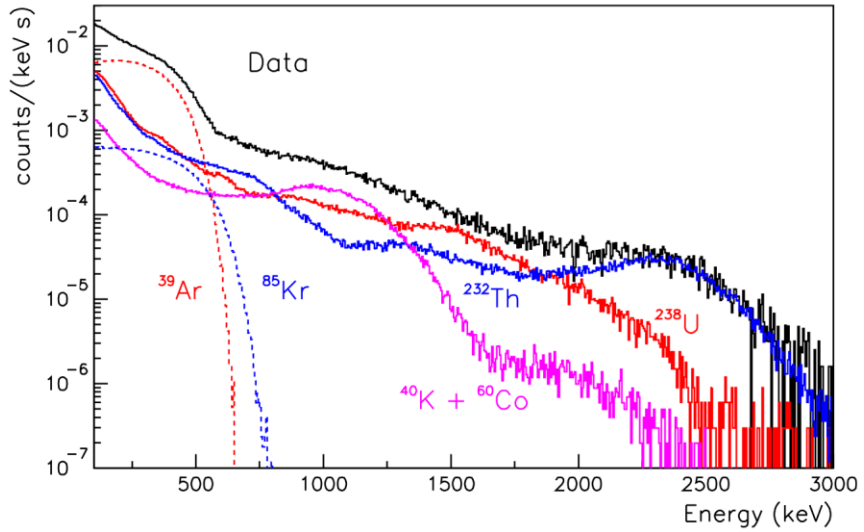


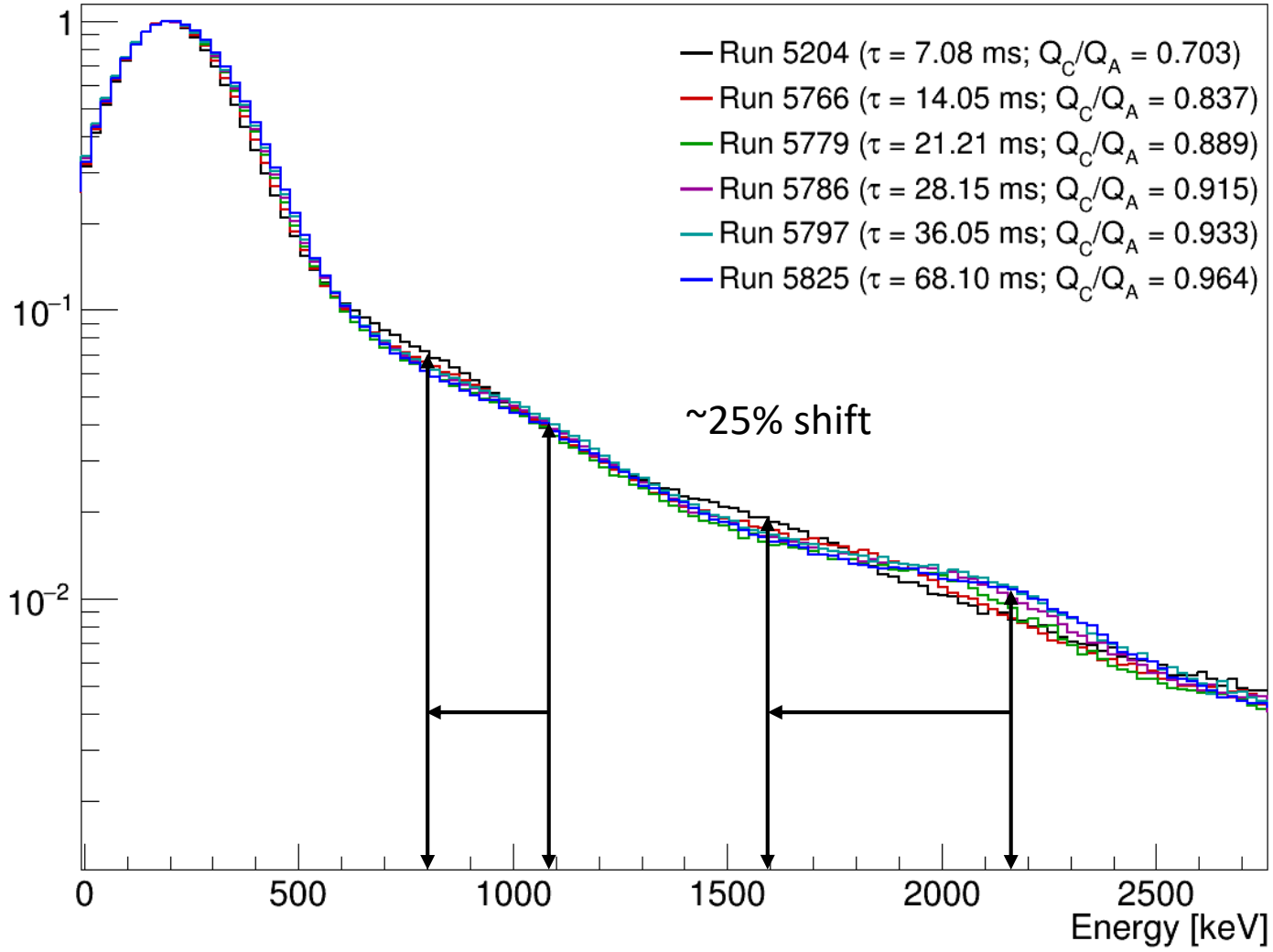
- ^{39}Ar beta decays could help supplement the low cosmic rate in DUNE FD for calibrations
  - Expect 50000 decays on any DUNE FD readout
- ^{39}Ar beta decay cut-off at 565 keV (about half of the energy deposited by a MIP on a single wire at DUNE)
- Decay events should be uniform in x
  - Can make measurement without knowing t_0 of individual Ar-39 decay events

Credit: Benetti et al (2007). Measurement of the specific activity of Ar-39 in natural argon.

Summary of ^{39}Ar Beta Decay Studies:

- Portions of spectra could show effects from other radiological sources
- Other radiological sources show effects of electron lifetime differences





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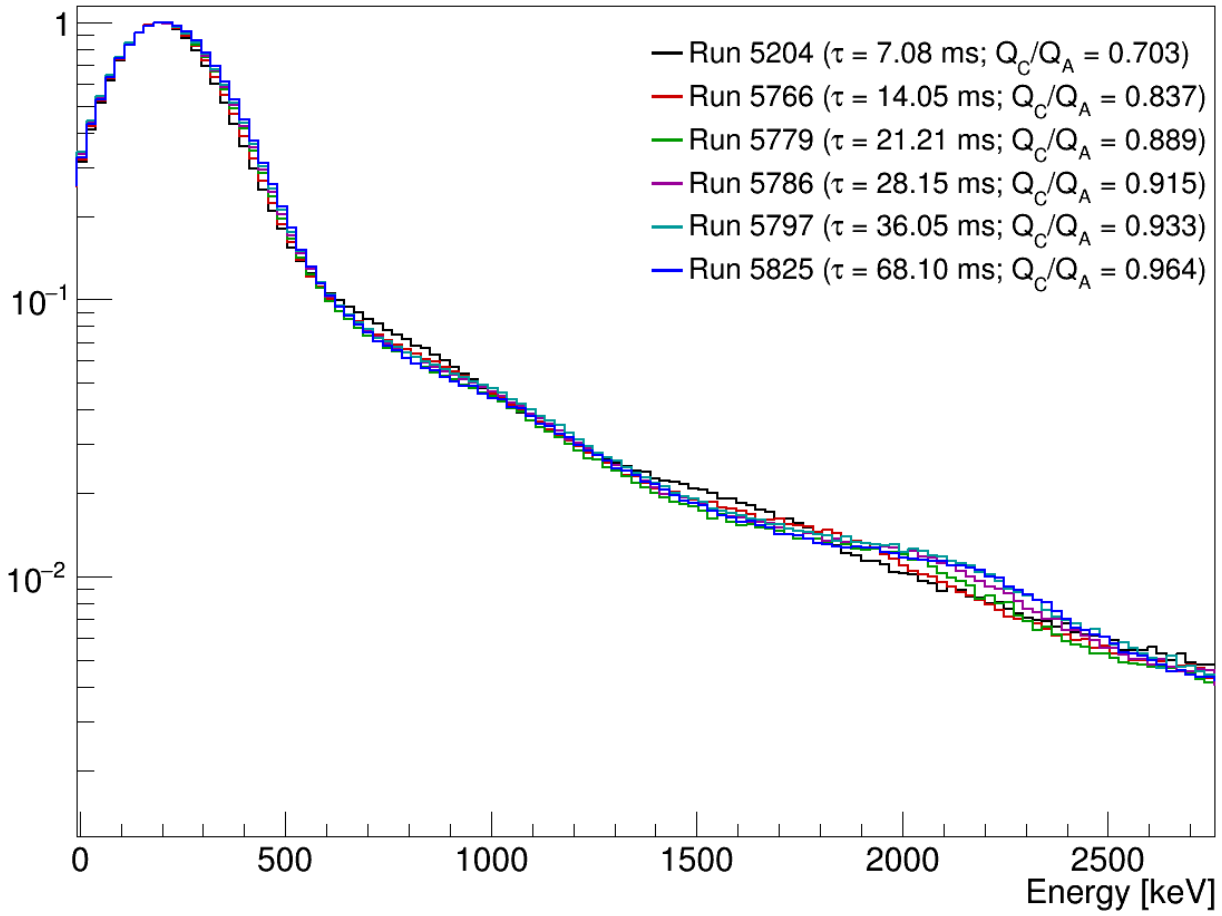
Summary of ^{39}Ar Beta Decay Studies:

- This result was presented at the July 8 DUNE Sim/Reco Meeting
- Next goal was reimplement track veto in ProtoDUNE-SP like at MicroBooNE



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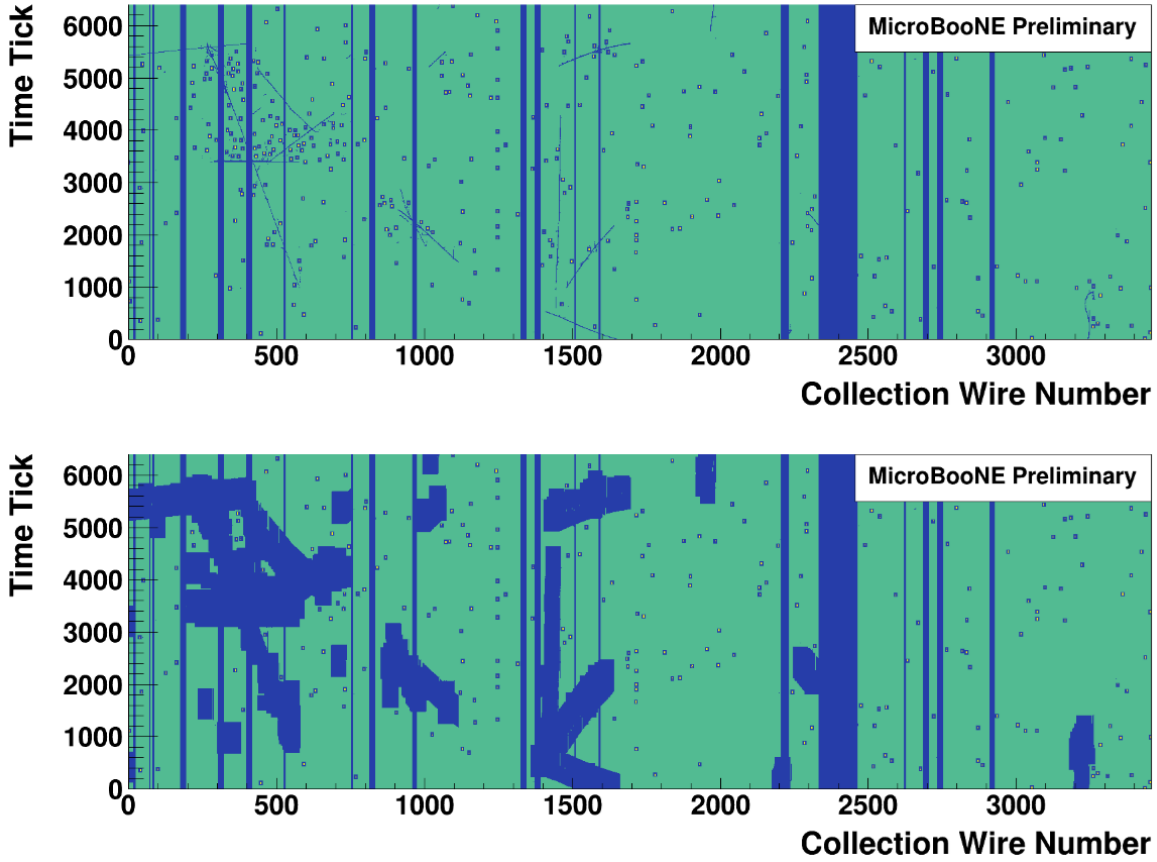
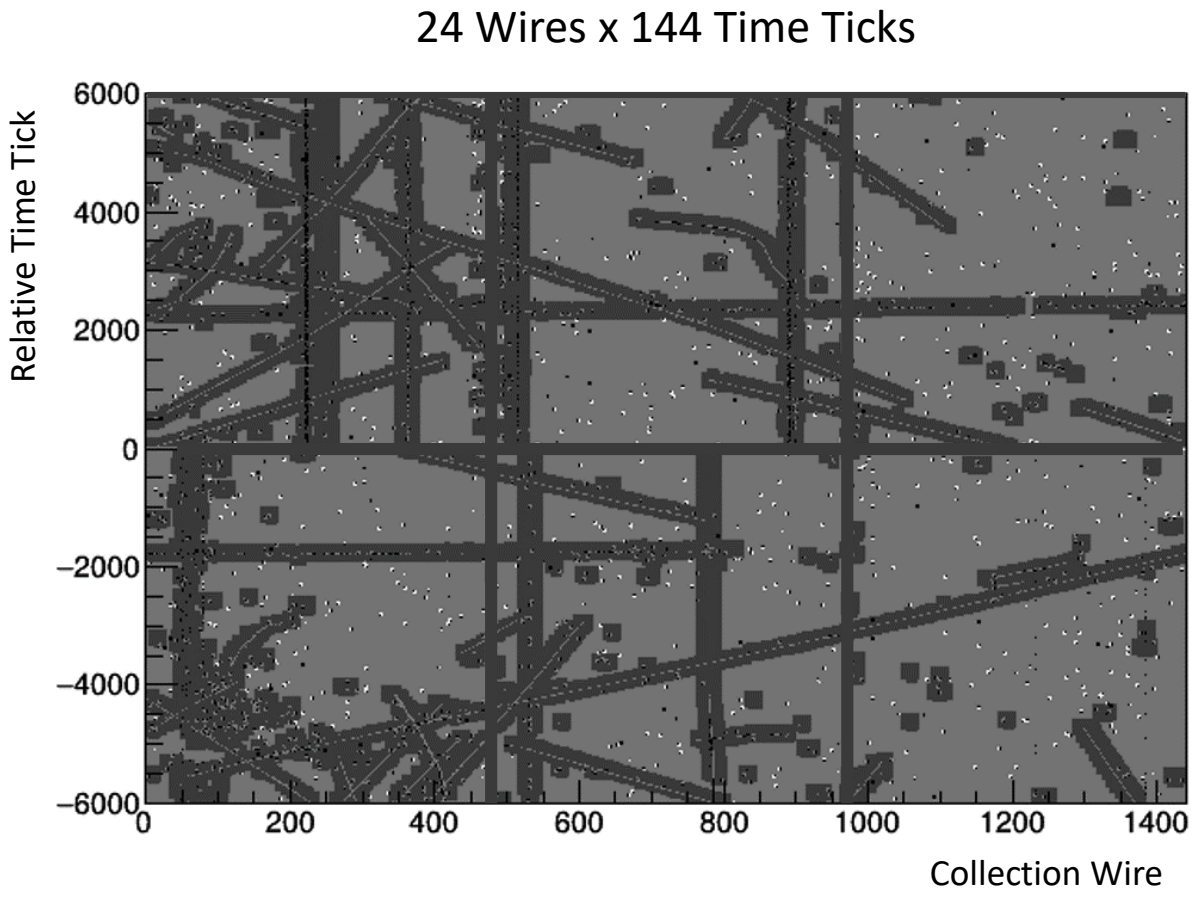


From MicroBooNE Public Note 1050

Track Veto Upgrades:

- New Track Veto is much faster to run allowing larger window (even in a larger detector)

- 24 Wires x 144 Time Ticks is equivalent to the veto size used for MicroBooNE



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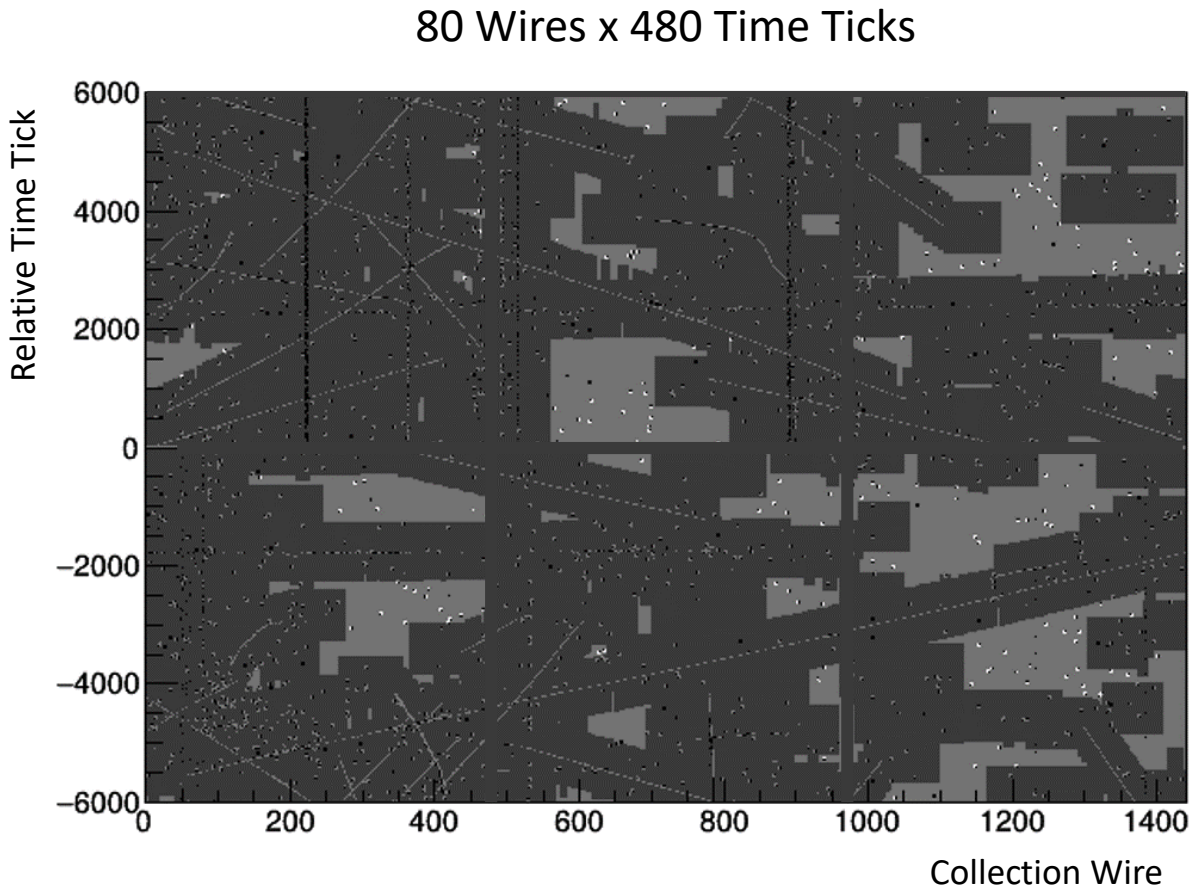
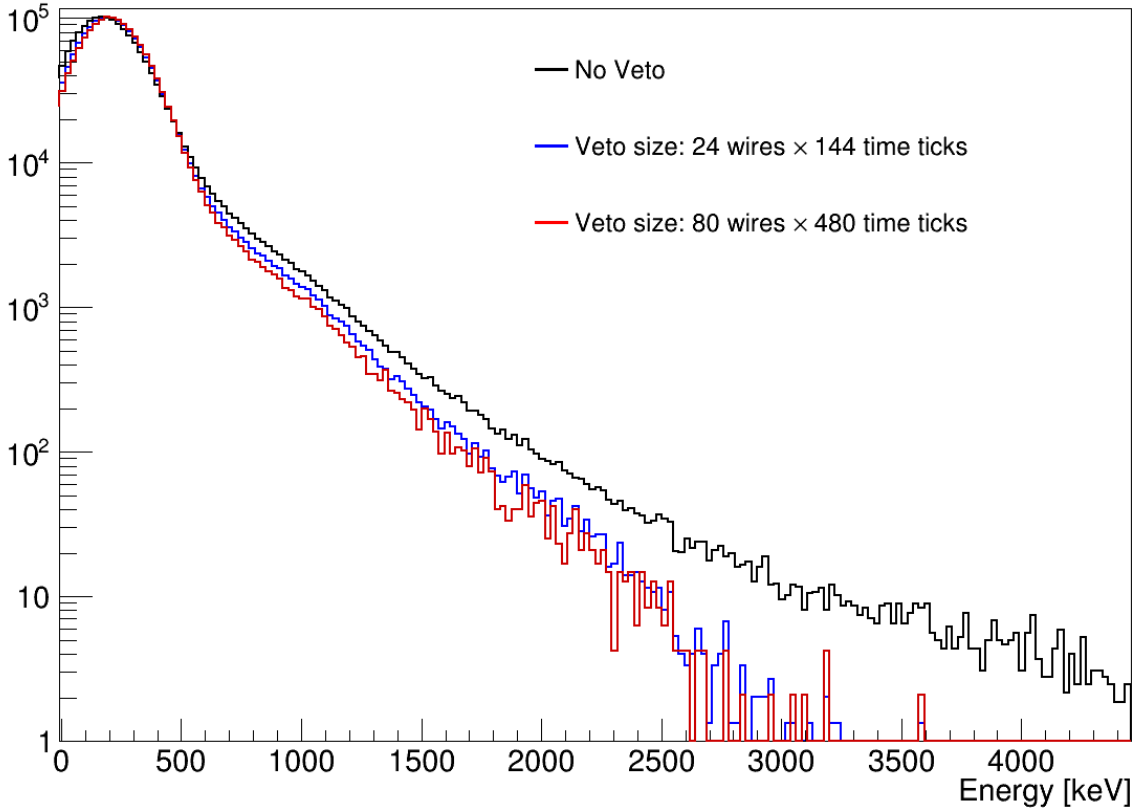


Track Veto Upgrades:

- Both configurations cut down significantly on cosmic contribution at high energy
- 24 Wire x 144 Time Tick still seems the most efficient
- High energy tail due to radiologicals still visible with track veto



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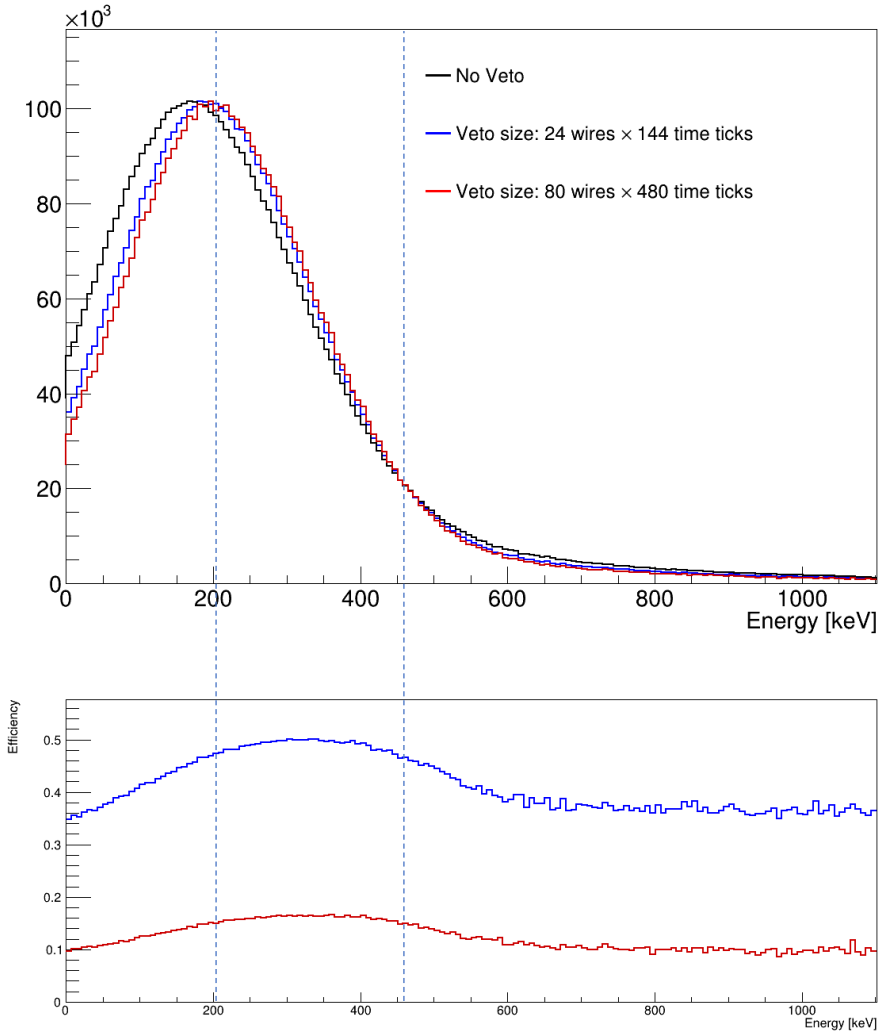
- The highest efficiency region is exactly where we will make the Electron lifetime measurement



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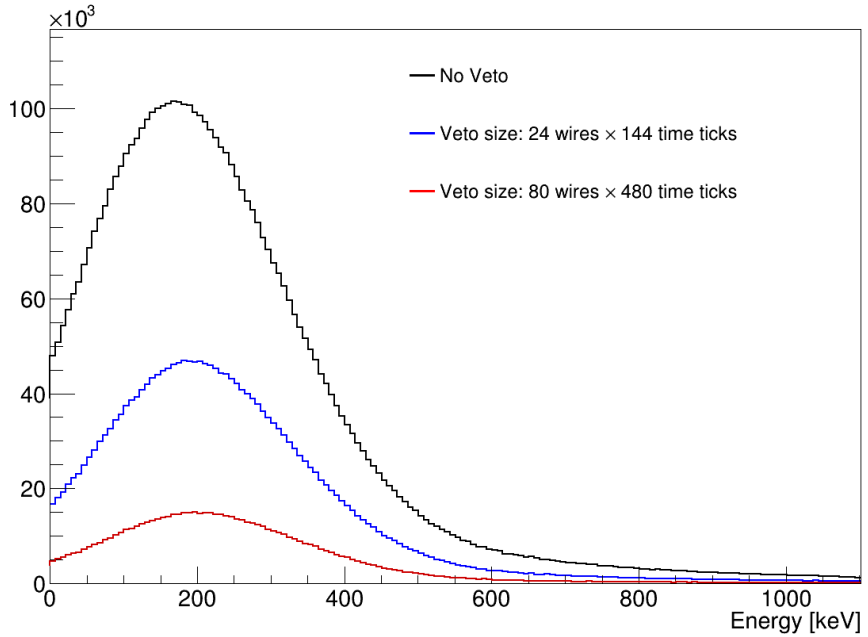
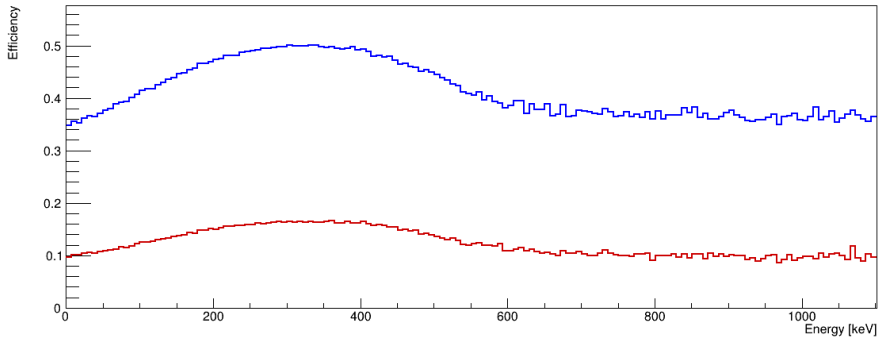
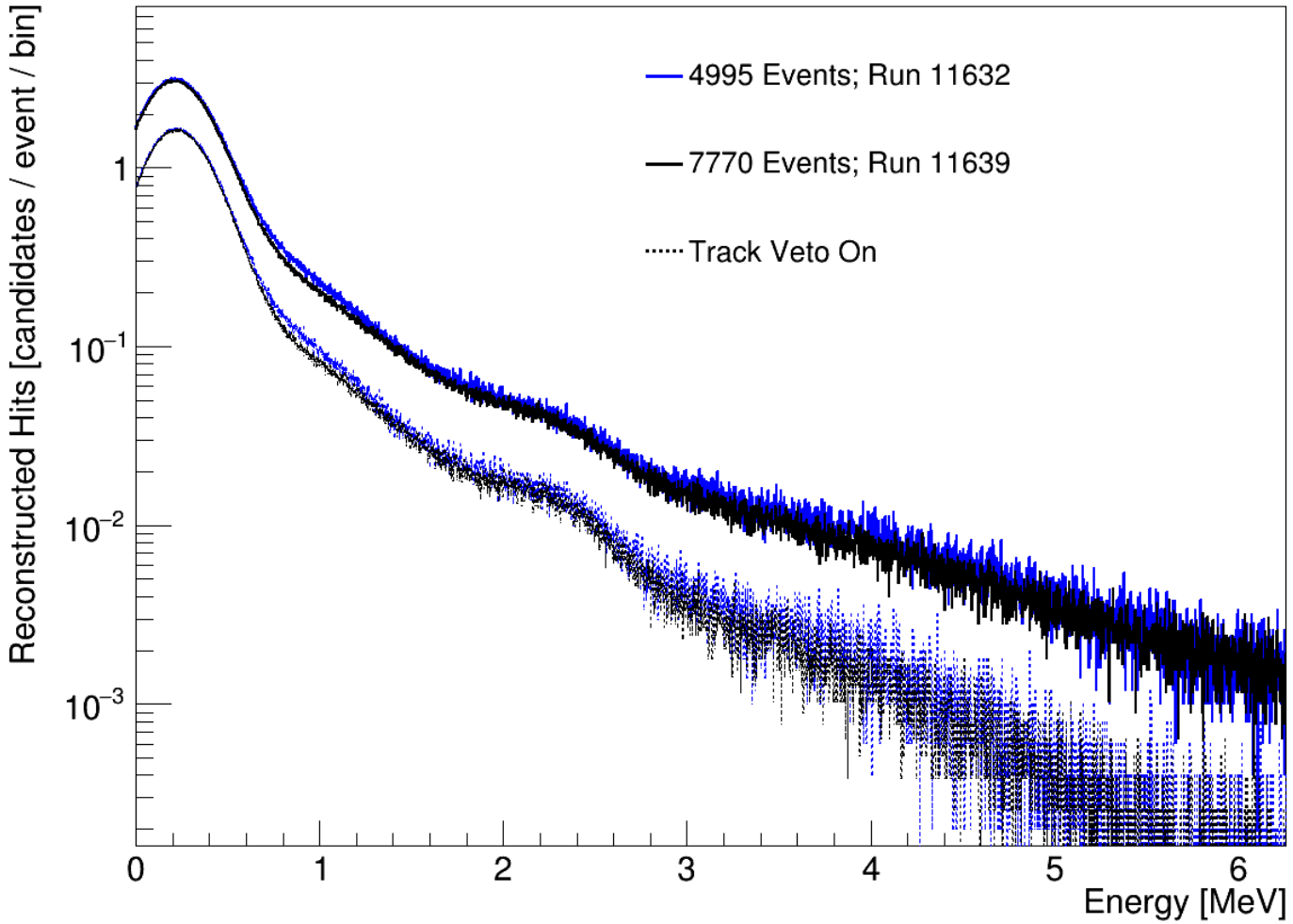




PNS Studies:

- ^{39}Ar analysis took a small excursion into studying Neutron generator data
  - Finding out if Track Veto would help this effort
- 11632 is PNS on; 11639 is a nearby reference run with the PNS off
  - Only looking at the 4 APAs online in both runs
- Utilizes the same point-like reconstruction for ^{39}Ar, optimized for higher energy hits
  - Uses 5 wire x 61 time tick window instead of 3 wire x 41 ticks (for ^{39}Ar)



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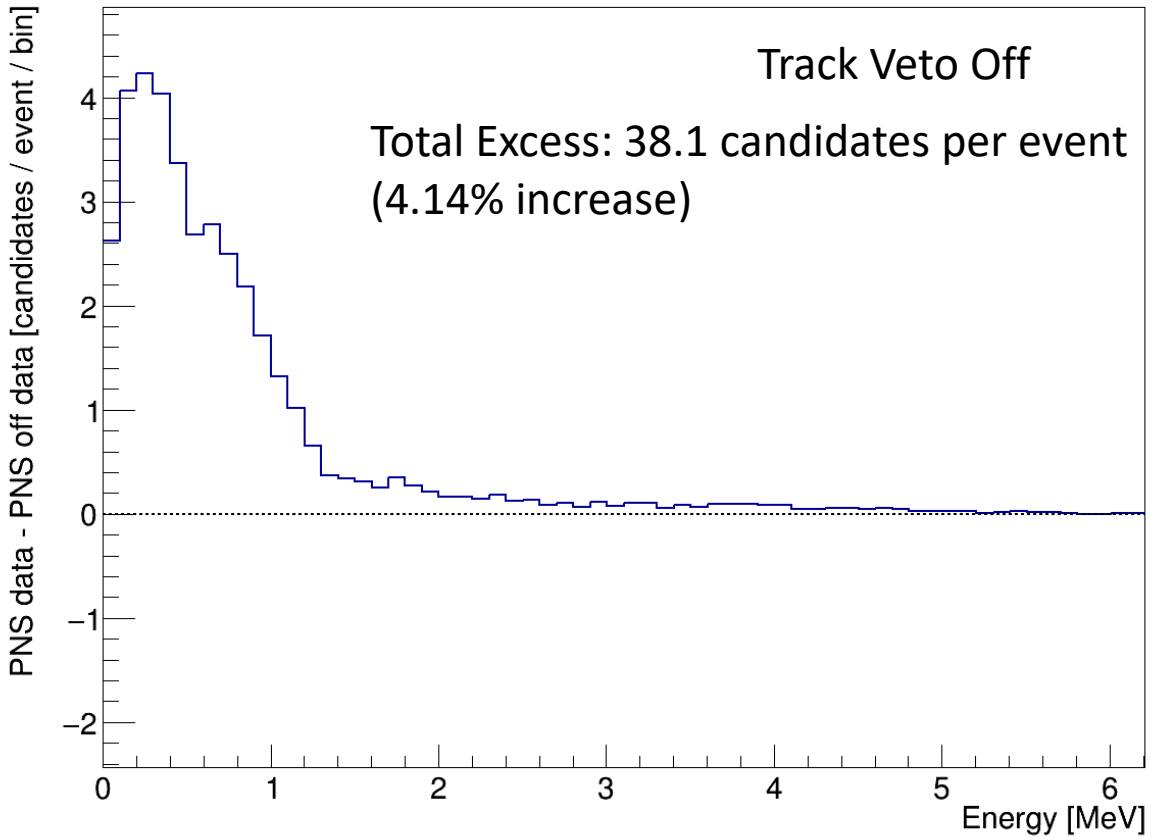

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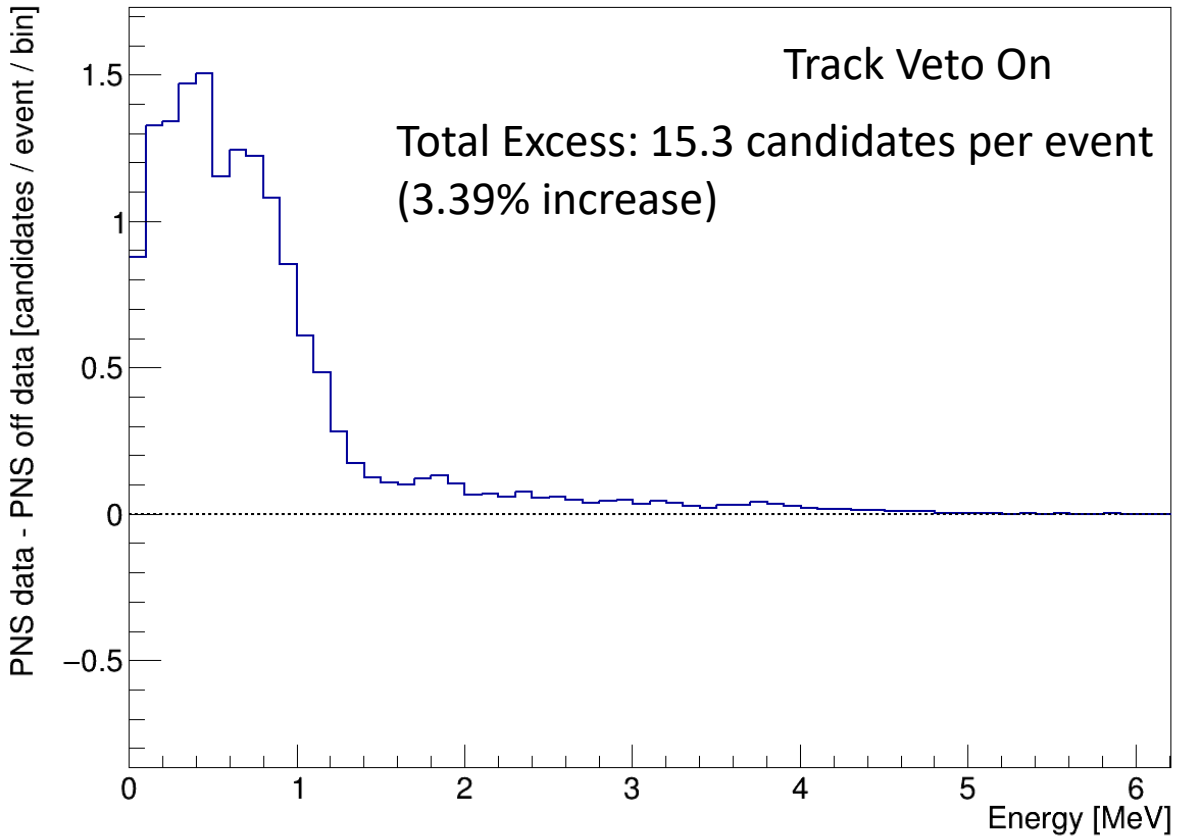

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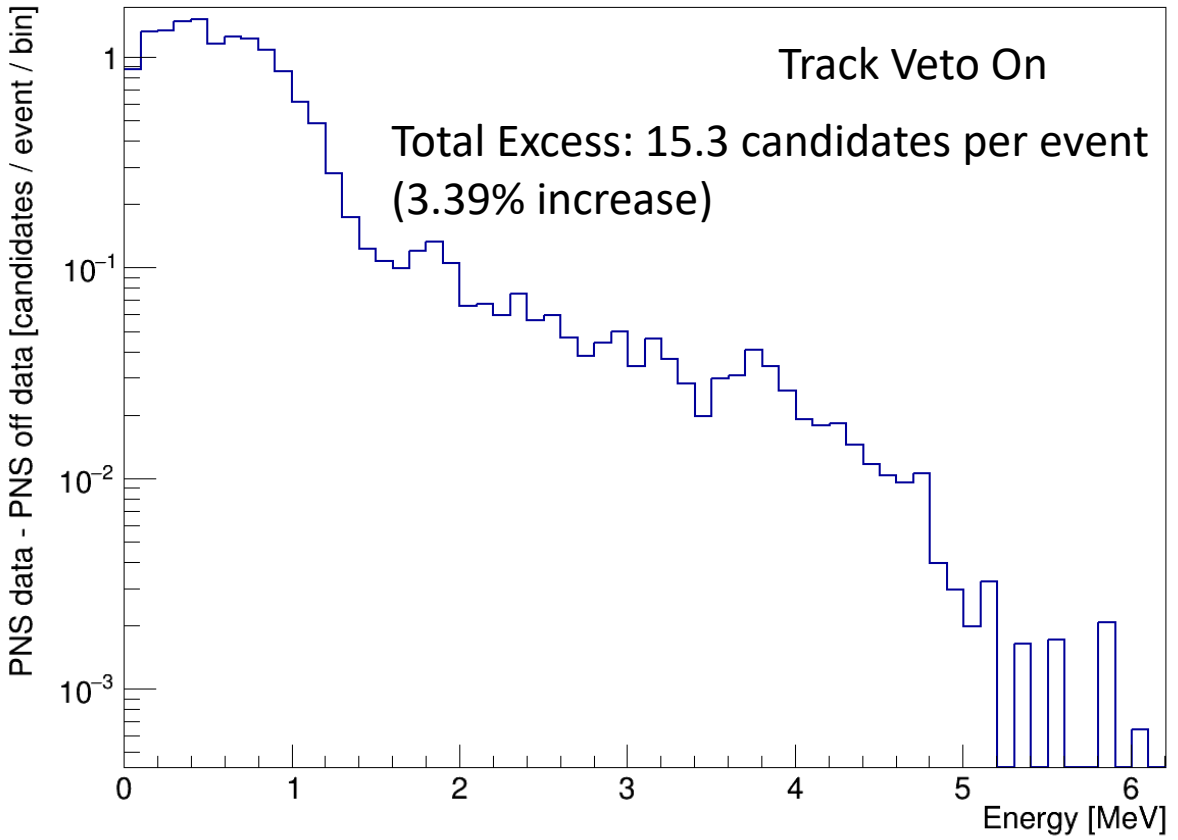
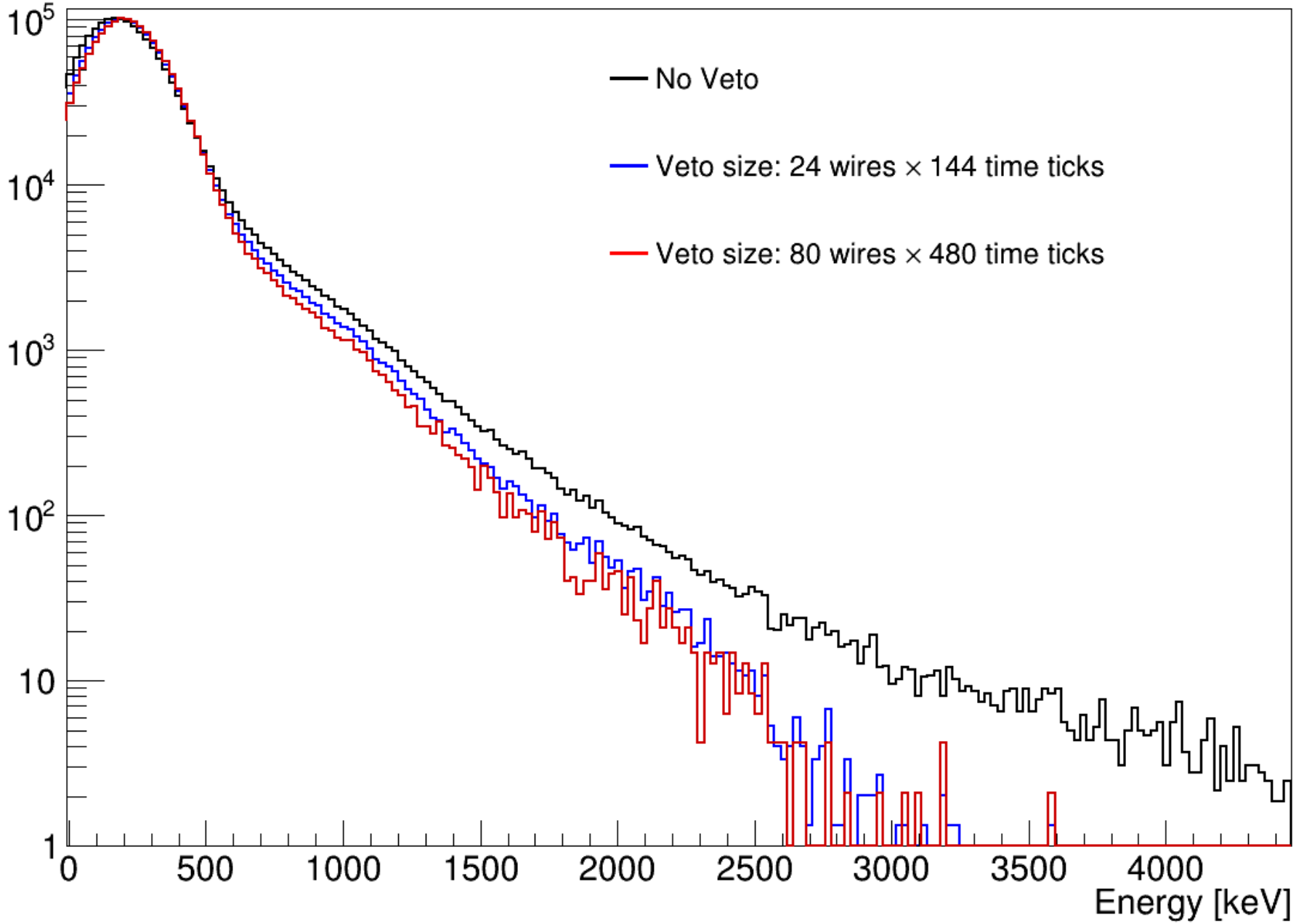
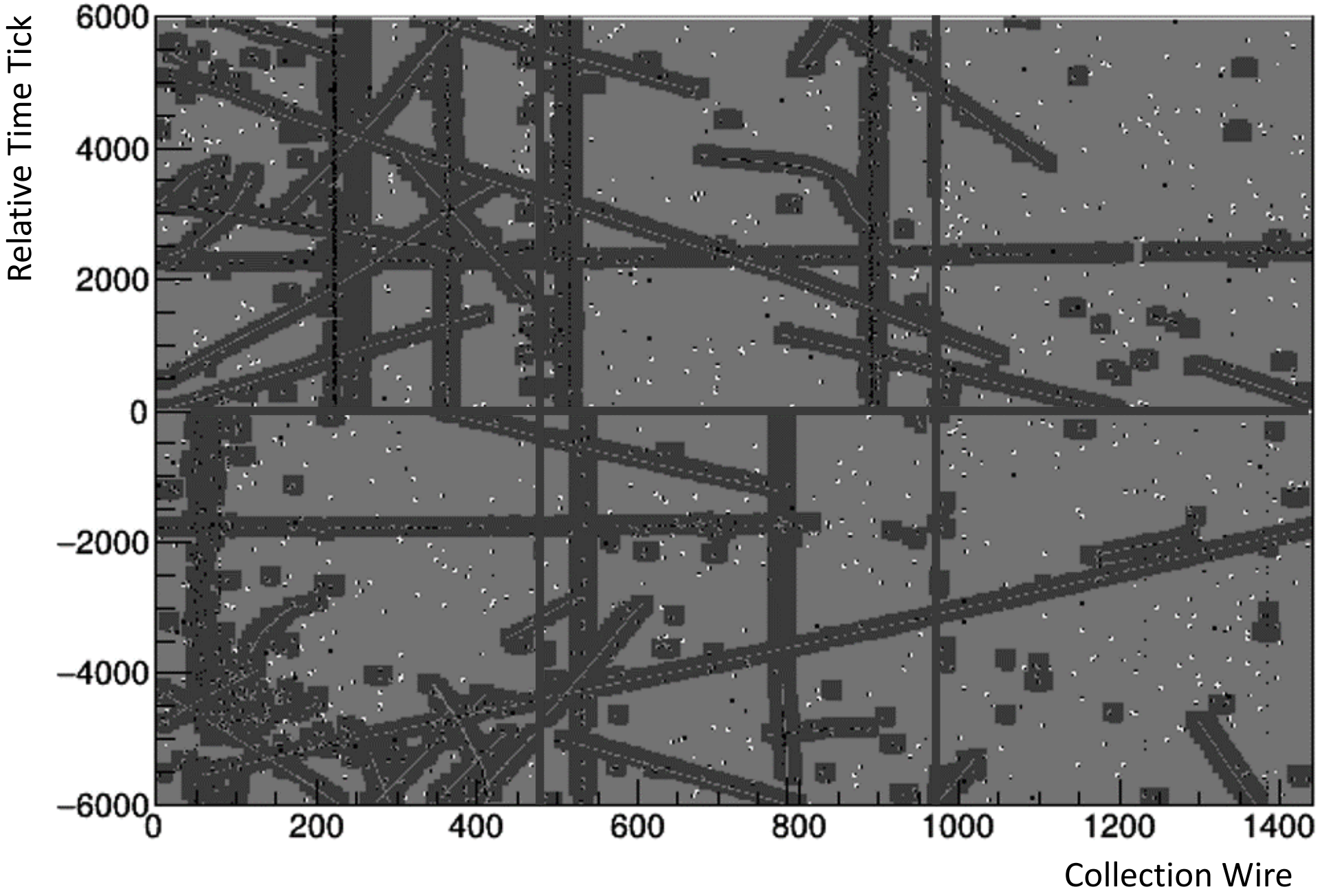
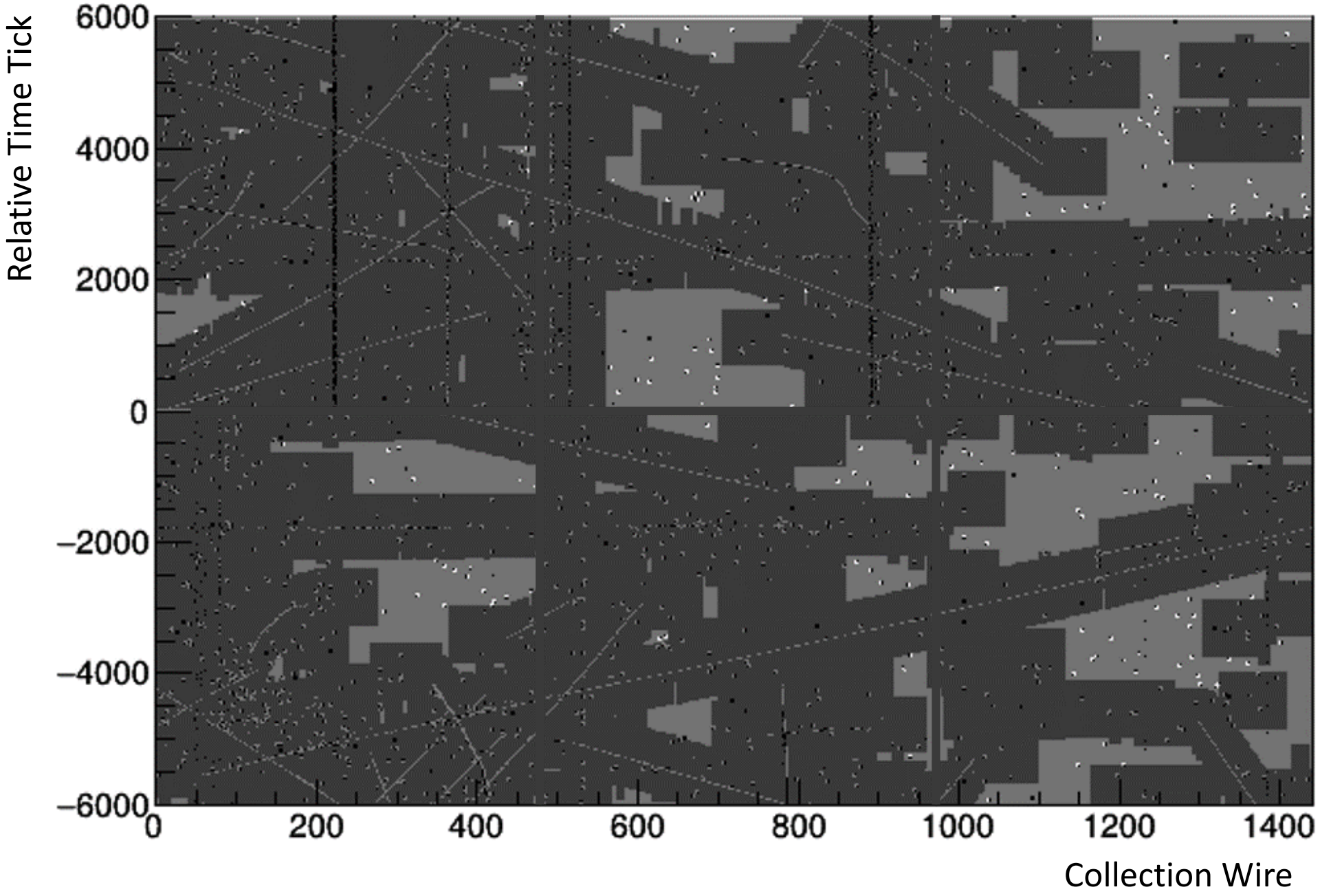


Conclusion:

- Recreated and explored the Track Veto for ^{39}Ar beta decay studies in ProtoDUNE
- Studied an application of the Track Veto to Neutron Generator studies
- Next:
  - We want to extract electron lifetime throughout the ProtoDUNE-SP detector
  - We are preparing a publication on ^{39}Ar beta decays at ProtoDUNE


No Veto
Veto size: 24 wires × 144 time ticks
Veto size: 80 wires × 480 time ticks
10^5
10^4
10^3
10^2
10
1
0
500
1000
1500
2000
2500
3000
3500
4000
Energy [keV]


Relative Time Tick
6000
4000
2000
0
−2000
−4000
−6000
0
200
400
600
800
1000
1200
1400
Collection Wire


Relative Time Tick
6000
4000
2000
0
−2000
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0
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1400
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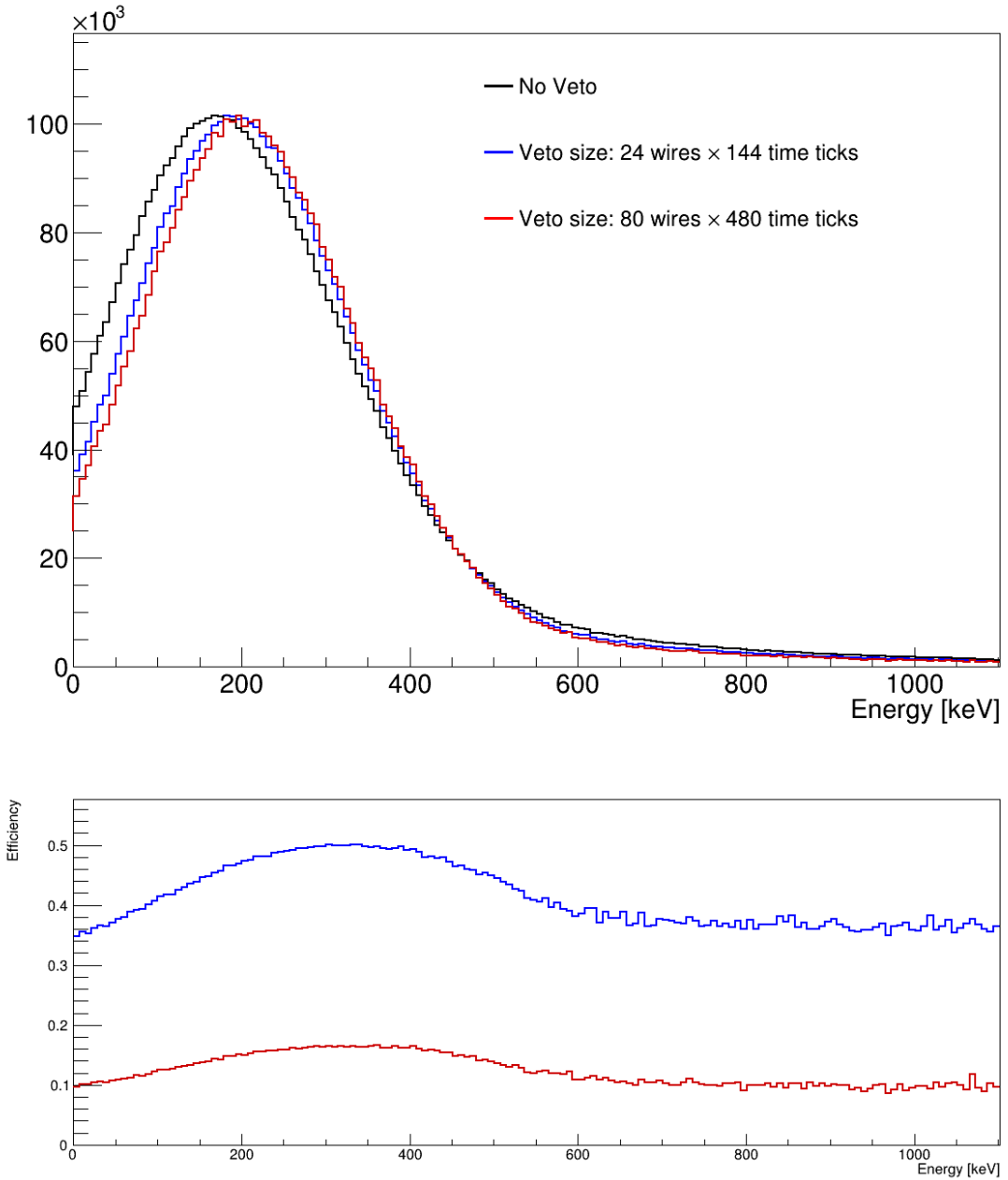
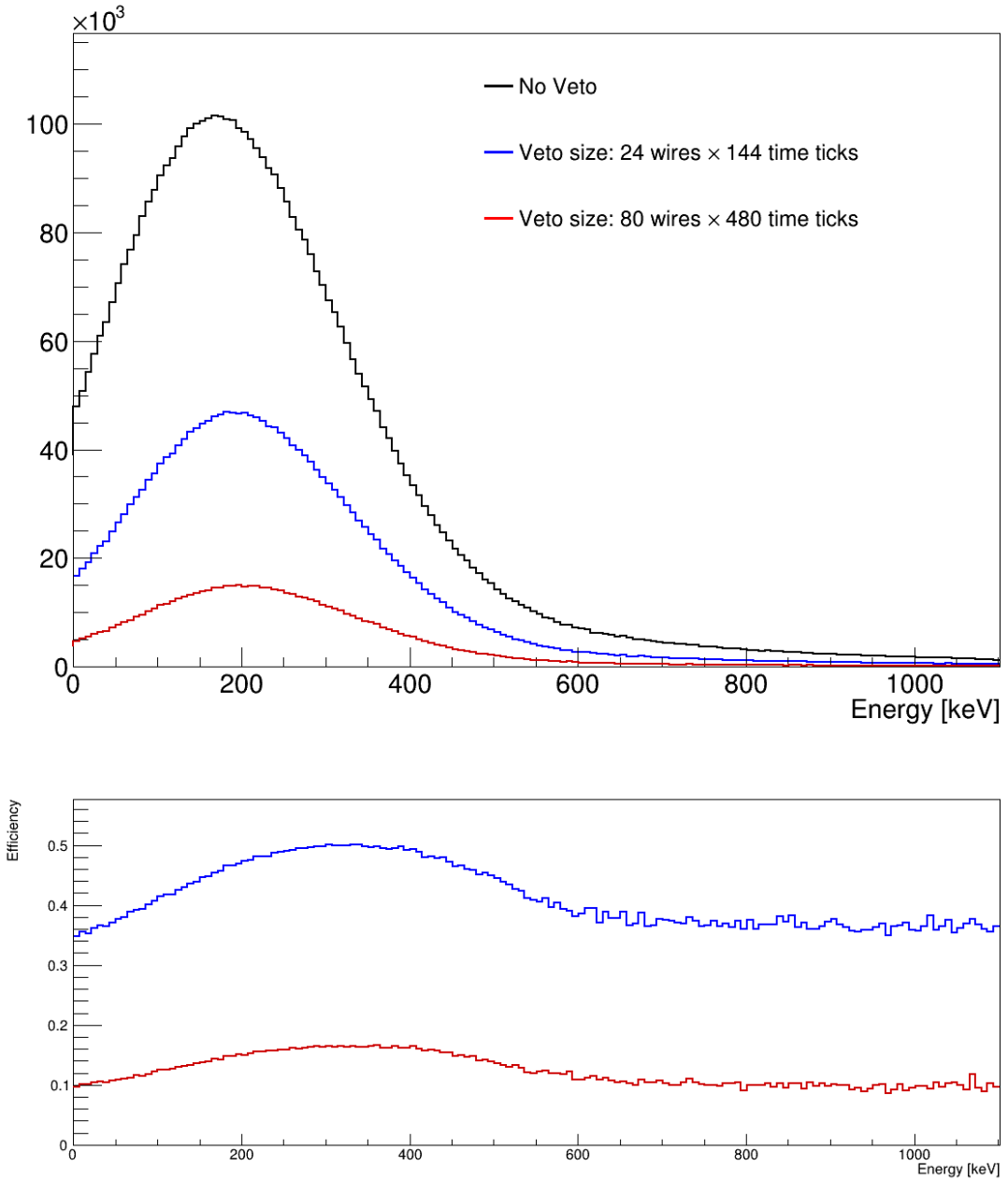
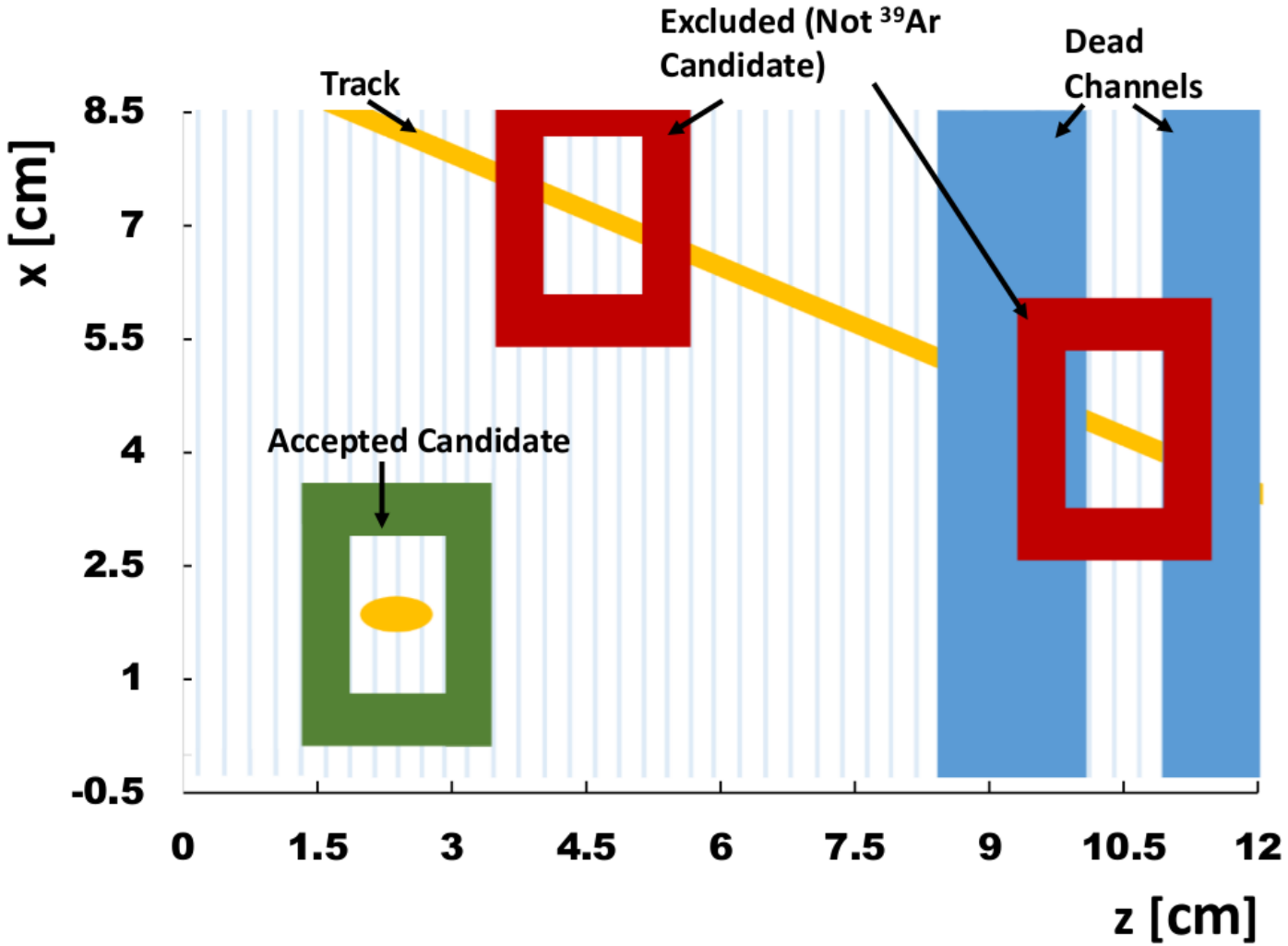

×10^3
100
80
60
40
20
0
0
200
400
600
800
1000
Energy [keV]
No Veto
Veto size: 24 wires × 144 time ticks
Veto size: 80 wires × 480 time ticks
Efficiency
0.5
0.4
0.3
0.2
0.1
0
0
200
400
600
800
1000
Energy [keV]


×10^3
No Veto
Veto size: 24 wires × 144 time ticks
Veto size: 80 wires × 480 time ticks
Energy [keV]
Efficiency
Energy [keV]



See MicroBooNE Public Note 1050