



# Cosmogenic Fast Neutron Backgrounds in the PROSPECT Reactor Antineutrino Detector

Christian Nave | Drexel University, on behalf of the PROSPECT Collaboration APS April Meeting: April 19, 2020



- PROSPECT: Precision Reactor Oscillation and Spectrum Experiment
- PROSPECT is a reactor antineutrino experiment
  - Measures energy spectrum of antineutrinos
  - Searches for short baseline neutrino oscillations
  - Short baseline (7-9 meters from High Flux Isotope Reactor--HFIR)
  - Segmented detector (11x14 segments)
    - Active, fiducial segments acting as individual detectors
    - Allows use to utilize topological cuts to reject backgrounds
  - $\circ$   $\quad$  Born out of desire to solve the Reactor Antineutrino Anomaly

arXiv: 1808.00097





### **Inverse Beta Decay (IBD)**

- IBD:  $\overline{v_e} + p \rightarrow e^+ + n$
- Reactor antineutrino  $\rightarrow$  IBD  $\rightarrow e^-e^+$  annihilation/neutron capture  $\rightarrow$  detection (prompt signal) (delayed signal)





### What is PSD?

• PSD - Pulse Shape Discrimination

• PSD =  $Q_{tail}/Q_{full}$ 





#### **Reactor Antineutrino Energy Spectrum**



#### Muon Veto and its Impact on nH Peak



- Cyan: RxOff accidentals
- Blue: RxOff truly correlated
- Magenta: RxOn accidentals
- Red: RxOn RxOff

Muons associated with multi-neutron capture events (such as nH background peak)

#### **Muon-Induced Neutron Recoils**



Neutron Recoil	Yield	

- Closed circles: RxOff; Open dots: RxOn
  - No expectation of difference between RxOff and RxOn
- 0<sup>th</sup> bin shows "muon rates" for each run
  - Minor differences between runs, time dependence deeper than seasonal variations
- All one-hour runs normalized by runtime
- Cosmogenic background simulations have been run and will be analyzed to quantitatively compare to data

# **PSD/Energy Relations**



Above: PSD vs. Neutron Energy for single multiplicity neutron recoil events, May 1 compared to September 28

- Difference of PSD vs. Energy distribution between May and September can be explained by:
  - Low energy, high PSD events detected from increase in fiducial volume (scintillator in PMT housings)
  - High energy, low PSD events are events being classified as neutron recoils due to broadening of PSD band

# "Neutron Mobility"

Neutron Mobility Relative to Prompt Signal





arXiv: 1808.00097

- Searching for location of neutron capture relative to positron-electron annihilation in IBD events
- Excess in Regions 2 & 3 compared to Regions 4 & 5 due to initial antineutrino momentum
- Could give insights into neutrino directionality

# Summary

- PROSPECT is measuring the prompt energy spectrum of reactor antineutrinos and searching for short baseline neutrino oscillations
- PROSPECT is well-equipped to reject backgrounds, particularly cosmogenic backgrounds
- Detector design provides observables such as PSD and topology to understand background event characteristics
- Neutron Mobility and Muon-Induced Neutron Recoils are great lenses with which to study our background signals

#### **Thank You!**



#### **Questions?**