The First Indication of Neutrino-Induced Nuclear Fission

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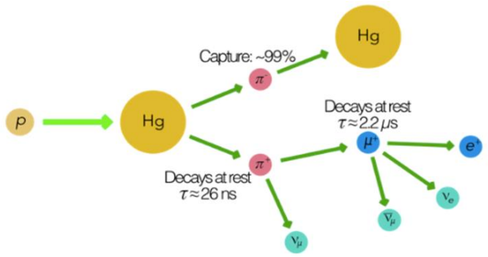
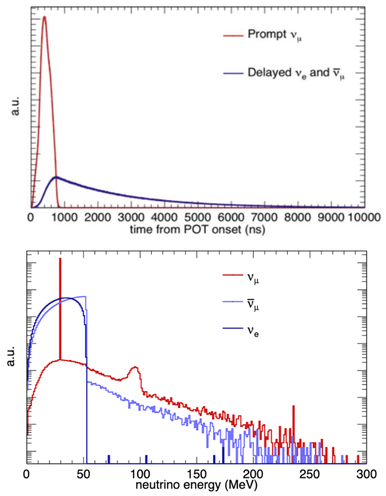
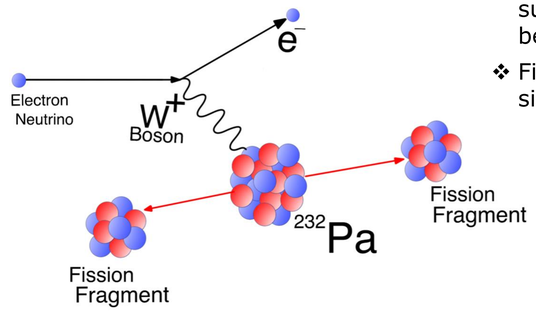
Neutrinos at the SNS

- The Spallation Neutron Source (SNS) is an intense, pulsed source of neutrinos.
- Electron neutrinos produced at the SNS target have an average energy of approximately 30 MeV, sufficient to induce charged-current interactions on a variety of nuclei.

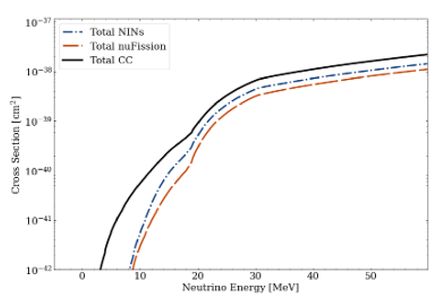


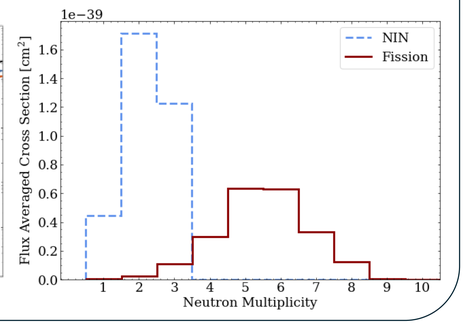


Neutrino-Induced Nuclear Fission (vFission)



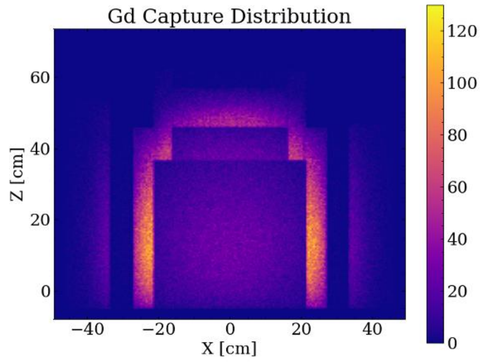
- Electron neutrinos can interact with nuclei and the excited nucleus subsequently de-excites through any available decay channel. For nuclei with sufficiently low fission barriers (typically 5–10 MeV), nuclear fission can become a dominant de-excitation mode.
- Fission produces multiple neutrons in coincidence, providing the experimental signature of neutrino-induced fission (vFission).

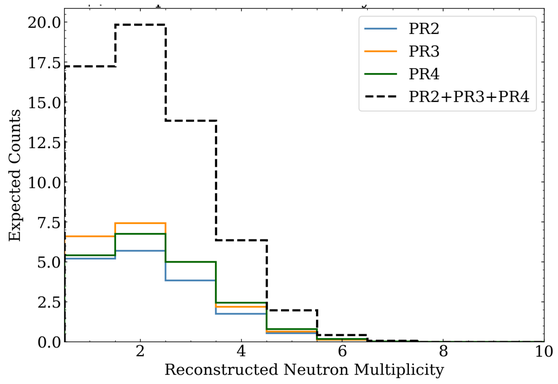


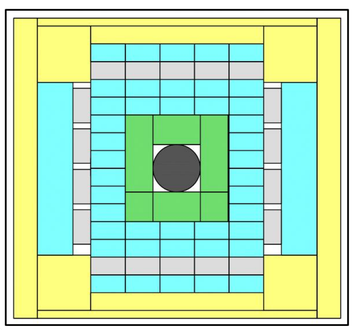


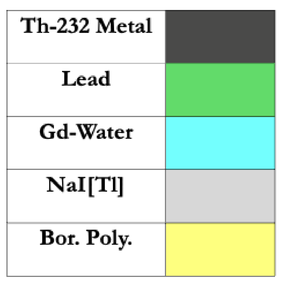
The NuThor Detector

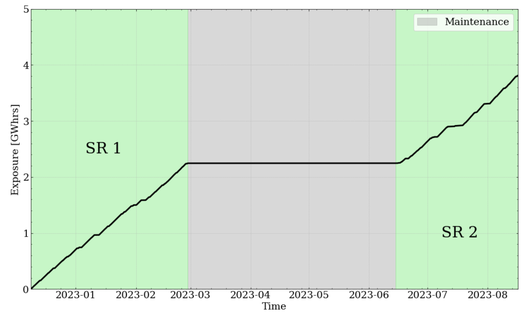
- The NuThor detector consists of a 52 kg thorium metal target surrounded by a custom neutron multiplicity detector composed of 36 NaI(Tl) scintillation crystals, water bricks doped with 2.5% gadolinium nitrate, and a thick borated polyethylene shield.
- Neutrons produced in a fission event are moderated in the gadolinium-doped water and subsequently captured on gadolinium nuclei release approximately 8 MeV in γ-rays, which are detected by the surrounding NaI(Tl) crystals. Because the neutrons thermalize and capture at different times, the resulting γ-ray signals are distributed over several microseconds, enabling the measurement of neutron multiplicity.





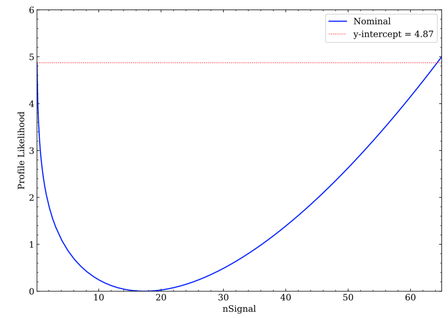


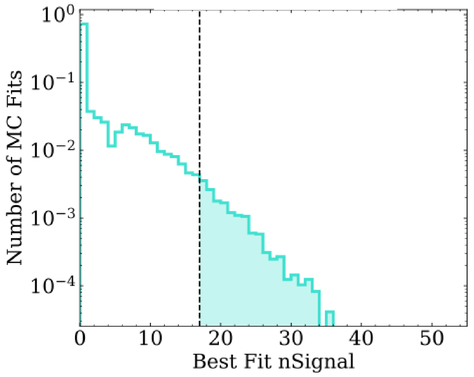




Results and Next Steps

- The analysis of Science Run 2 yielded a best fit of $17^{+12.3}_{-10}$ signal events
- This constitutes a 2.4 sigma rejection of the null hypothesis
- Since the initial analysis, the accumulated beam exposure has increased by a factor of 3.5.





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