First Search for Neutrino Induced Nuclear Fission

2024 MTV Workshop

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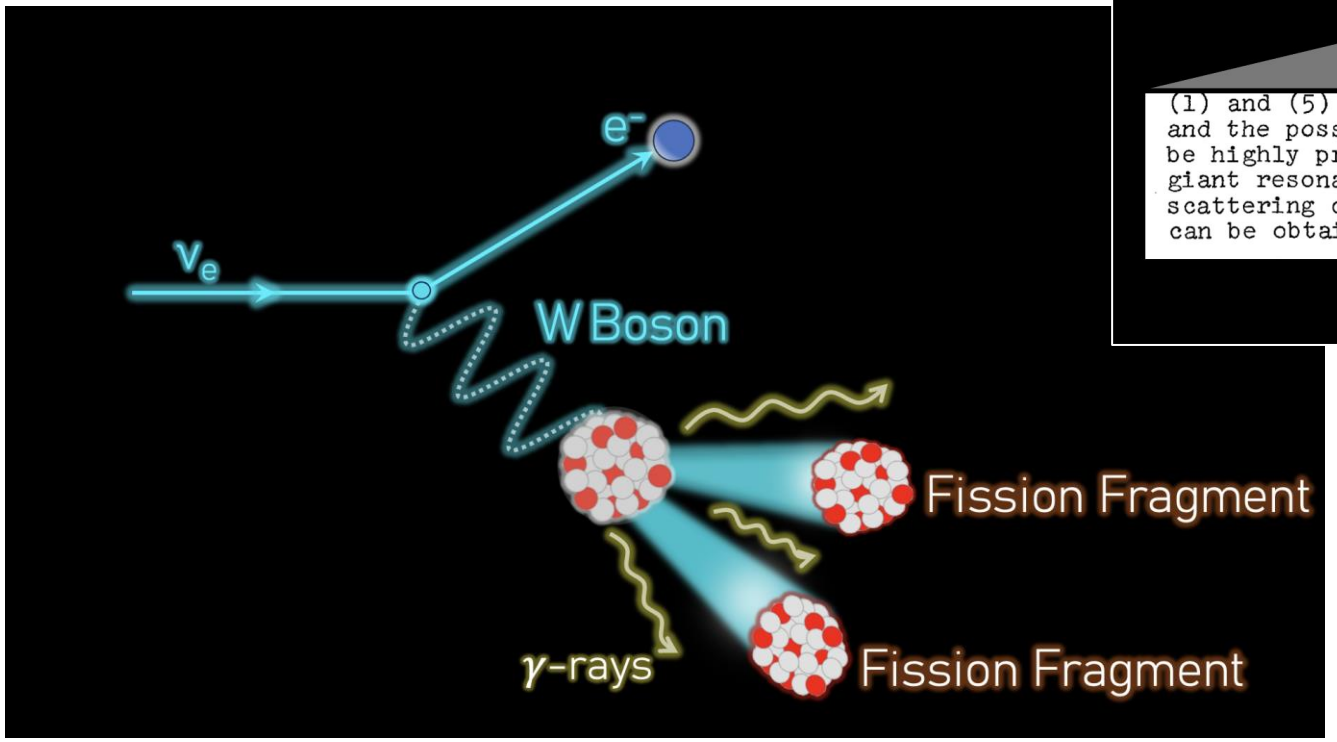
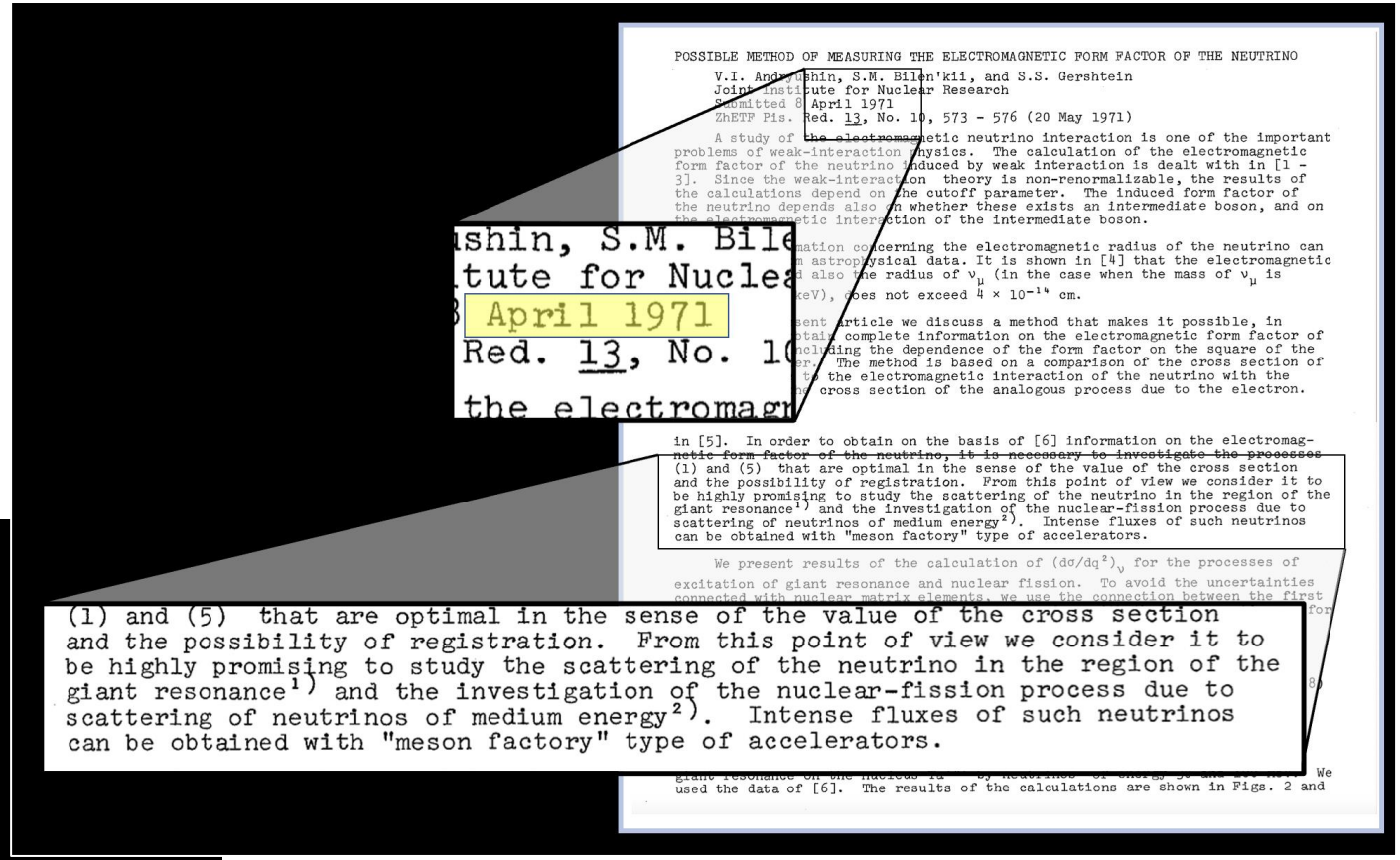
Introduction and Motivation





POSSIBLE METHOD OF MEASURING THE ELECTROMAGNETIC FORM FACTOR OF THE NEUTRINO

V.I. Andr[illegible]shin, S.M. Bilen'kii, and S.S. Gershtein
Joint Institute for Nuclear Research
Submitted 8 April 1971
ZhETF Pis. Red. 13, No. 10, 573 - 576 (20 May 1971)

A study of the electromagnetic neutrino interaction is one of the important problems of weak-interaction physics. The calculation of the electromagnetic form factor of the neutrino induced by weak interaction is dealt with in [1 - 3]. Since the weak-interaction theory is non-renormalizable, the results of the calculations depend on the cutoff parameter. The induced form factor of the neutrino depends also on whether these exists an intermediate boson, and on the electromagnetic interaction of the intermediate boson.

[illegible]shin, S.M. Bile
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April 1971
Red. 13, No. 1[illegible]
the electromagn

[illegible]nation concerning the electromagnetic radius of the neutrino can [illegible]m astrophysical data. It is shown in [4] that the electromagnetic [illegible]d also the radius of ν_μ (in the case when the mass of ν_μ is [illegible]keV), does not exceed 4×10^{-14} cm.

[illegible]sent article we discuss a method that makes it possible, in [illegible]btain complete information on the electromagnetic form factor of [illegible]cluding the dependence of the form factor on the square of the [illegible]er. The method is based on a comparison of the cross section of [illegible]to the electromagnetic interaction of the neutrino with the [illegible]e cross section of the analogous process due to the electron.

in [5]. In order to obtain on the basis of [6] information on the electromagnetic form factor of the neutrino, it is necessary to investigate the processes (1) and (5) that are optimal in the sense of the value of the cross section and the possibility of registration. From this point of view we consider it to be highly promising to study the scattering of the neutrino in the region of the giant resonance[1] and the investigation of the nuclear-fission process due to scattering of neutrinos of medium energy[2]. Intense fluxes of such neutrinos can be obtained with "meson factory" type of accelerators.

We present results of the calculation of $(d\sigma/dq^2)_\nu$ for the processes of excitation of giant resonance and nuclear fission. To avoid the uncertainties connected with nuclear matrix elements, we use the connection between the first [illegible]for

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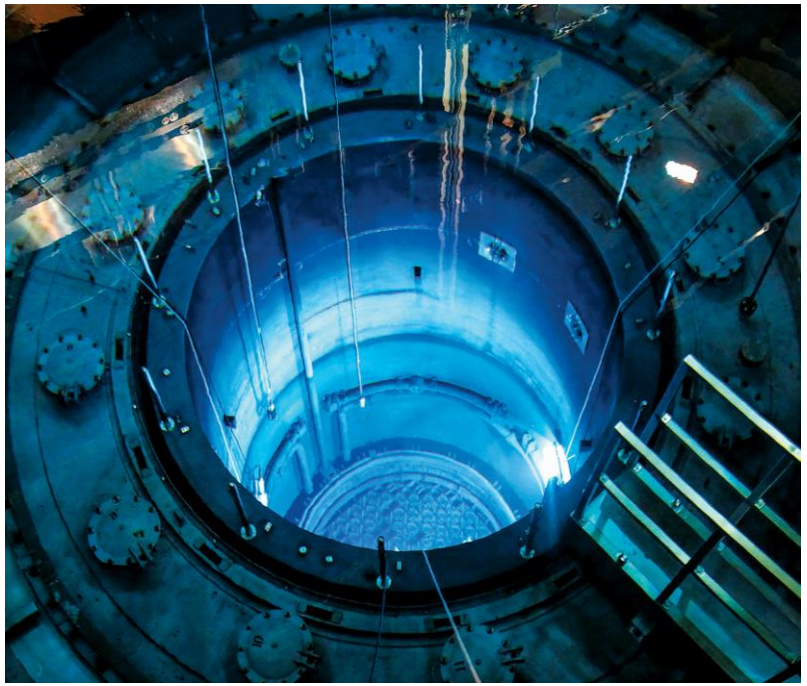
[illegible]giant resonance of the nucleus Ta[illegible] by neutrinos of energy 30 the [illegible]. We used the data of [6]. The results of the calculations are shown in Figs. 2 and

Over 53 years since first predicted

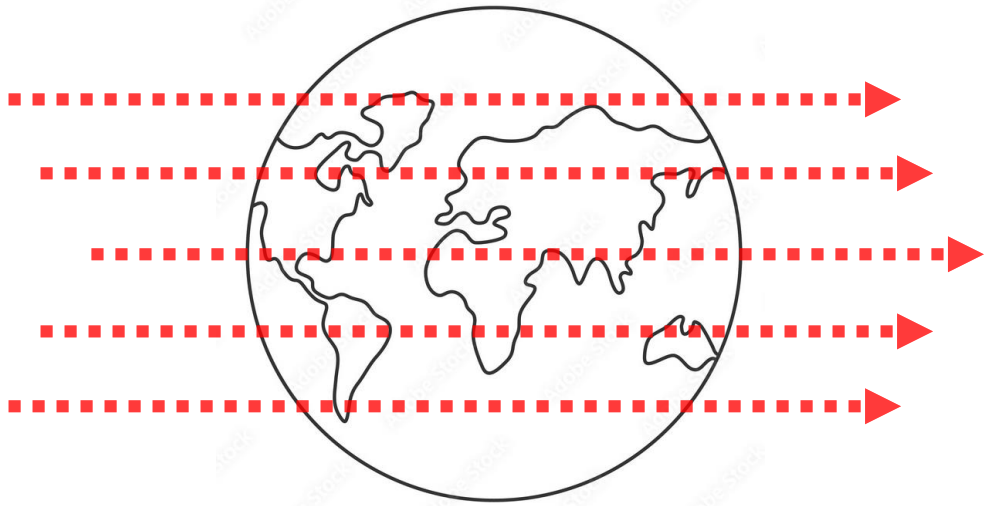
No Experimental Evidence yet

Mission Relevance

Reactor Core



Neutrinos are the unerasable fingerprint of nuclear activity. Produced in copious amounts from reactor cores



Neutrinos are impossible to shield with any volume of material on Earth

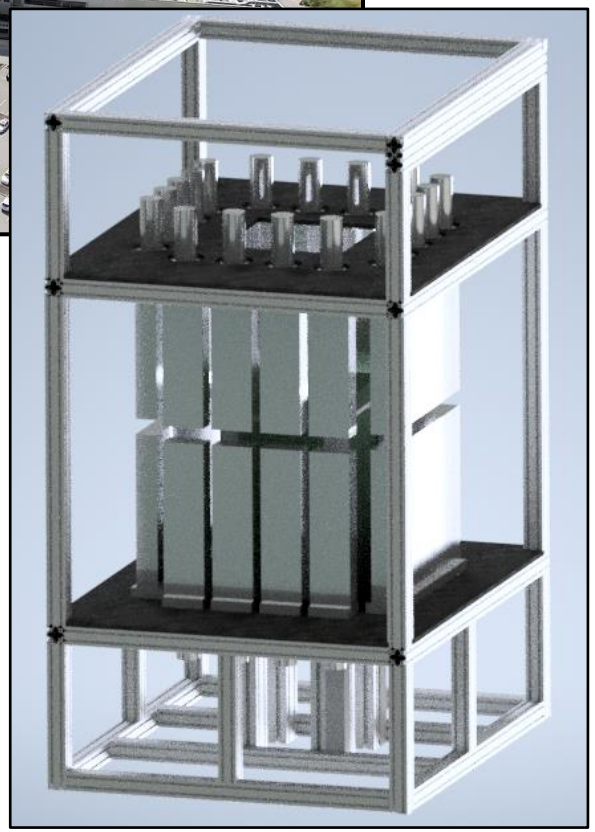
Via: DALL-E

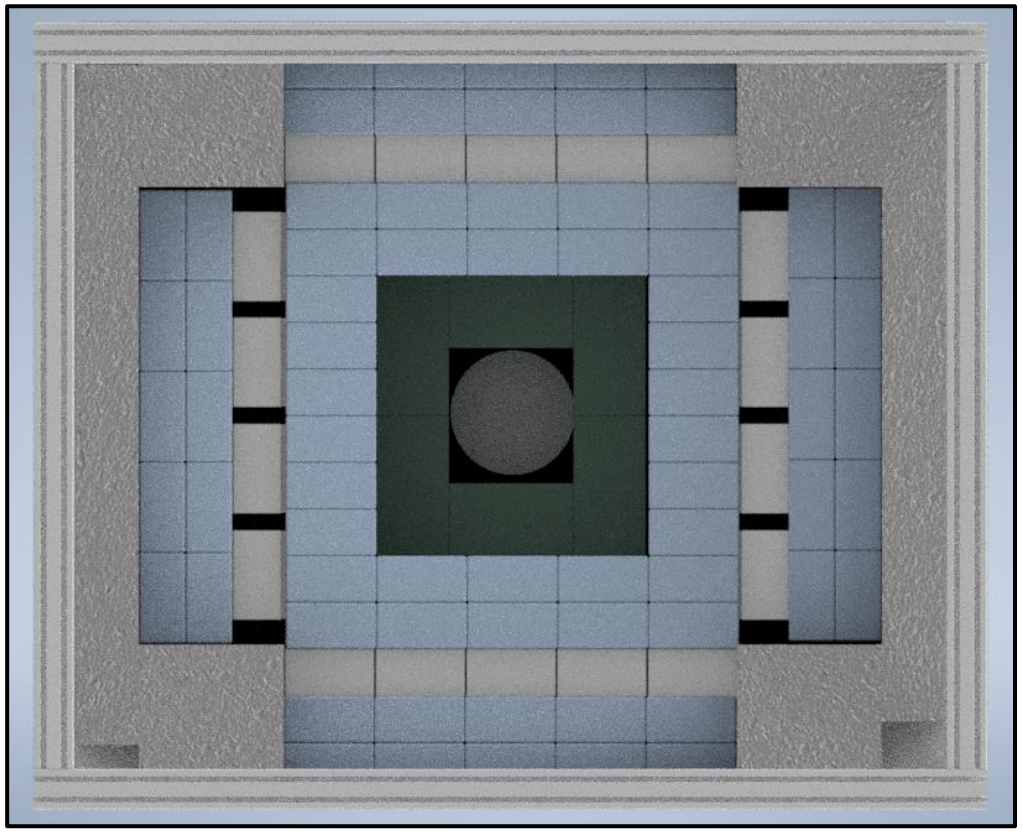
Neutrino-induced Nuclear Fission Would be the most energetically Visible reactor neutrino channel

Technical Approach

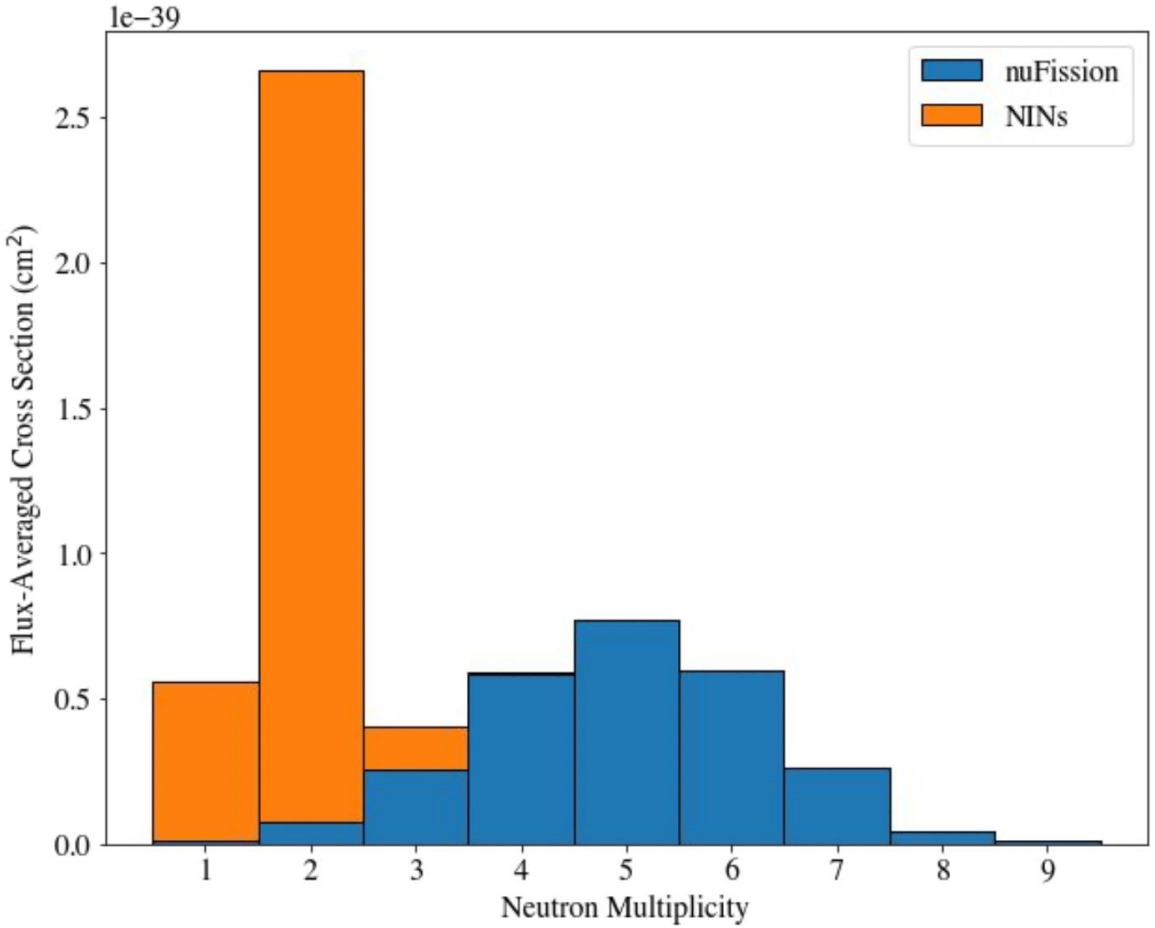
Leveraging Oak Ridge National Lab's Spallation Neutron Source

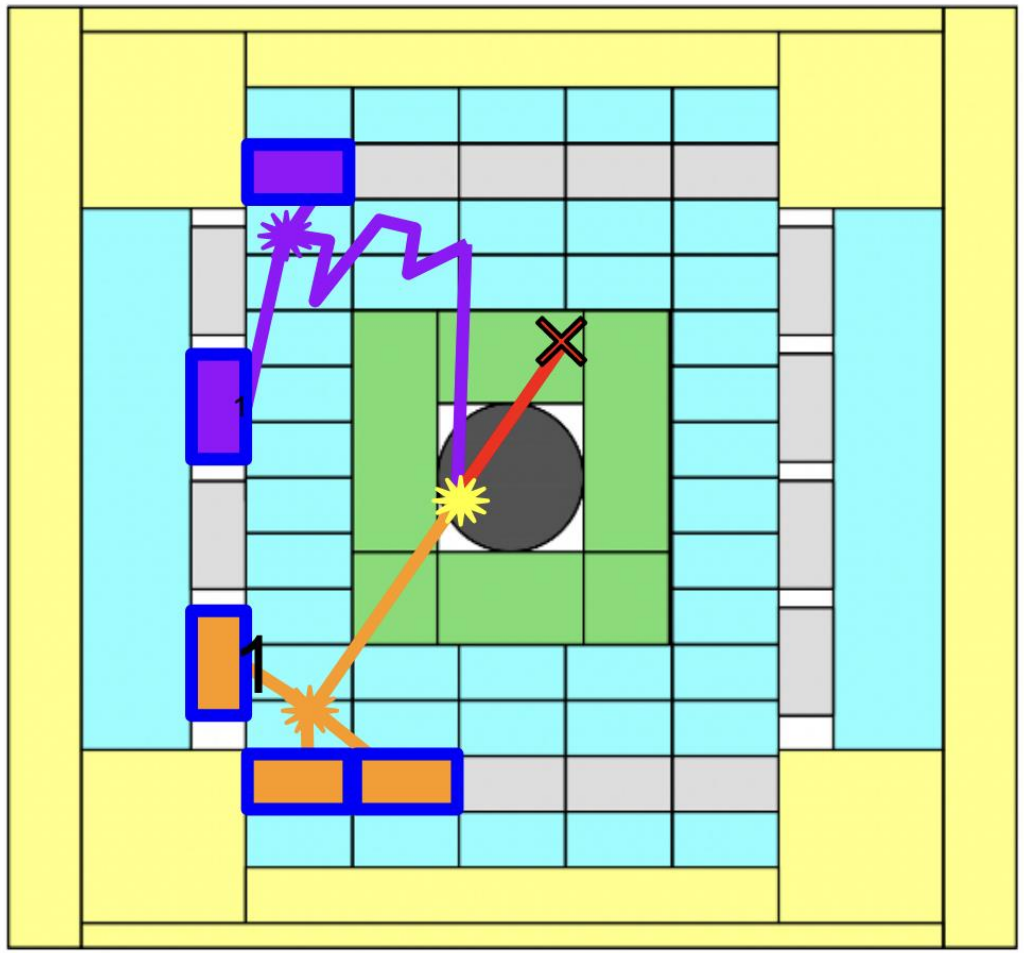
The NuThor Detector





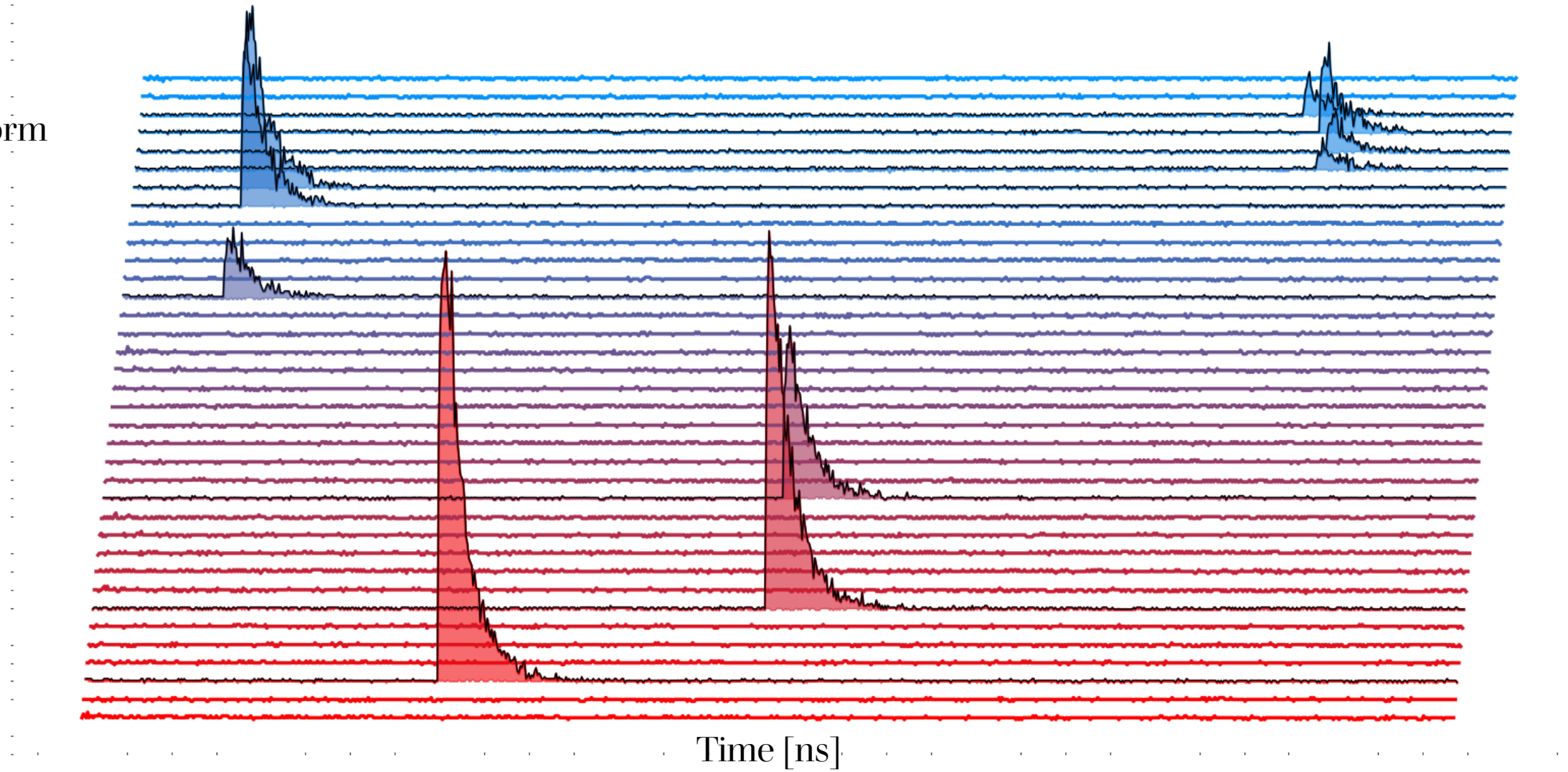
Neutron Counting





Technical Approach

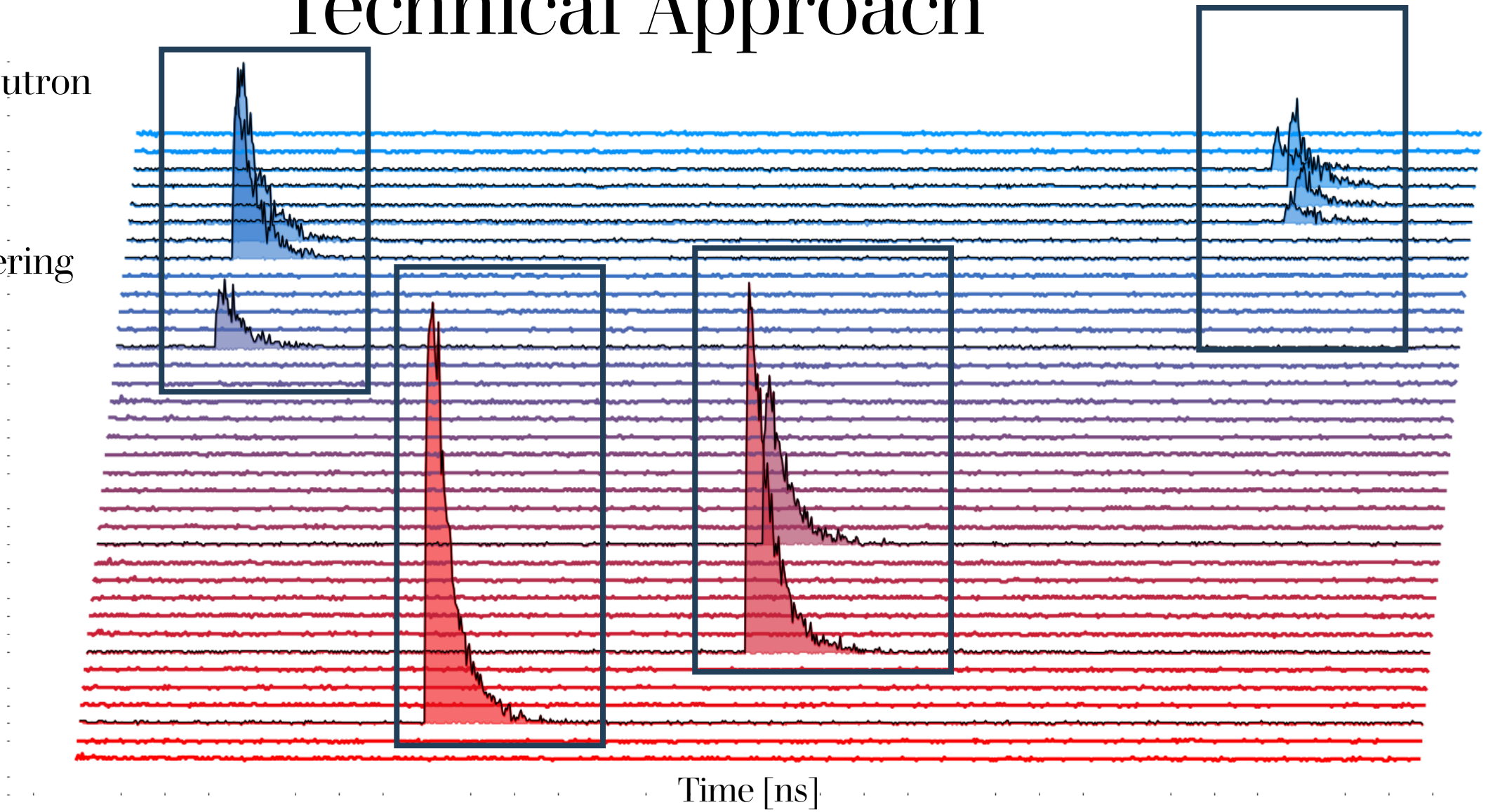
All NuThor NaI[Tl] waveform event display



Technical Approach

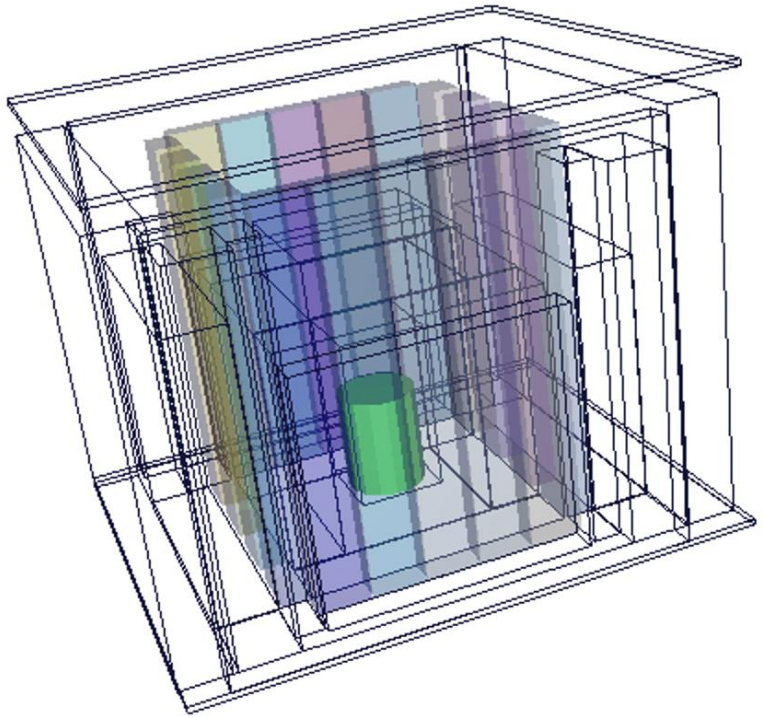
What a 4-neutron event looks

100 ns clustering

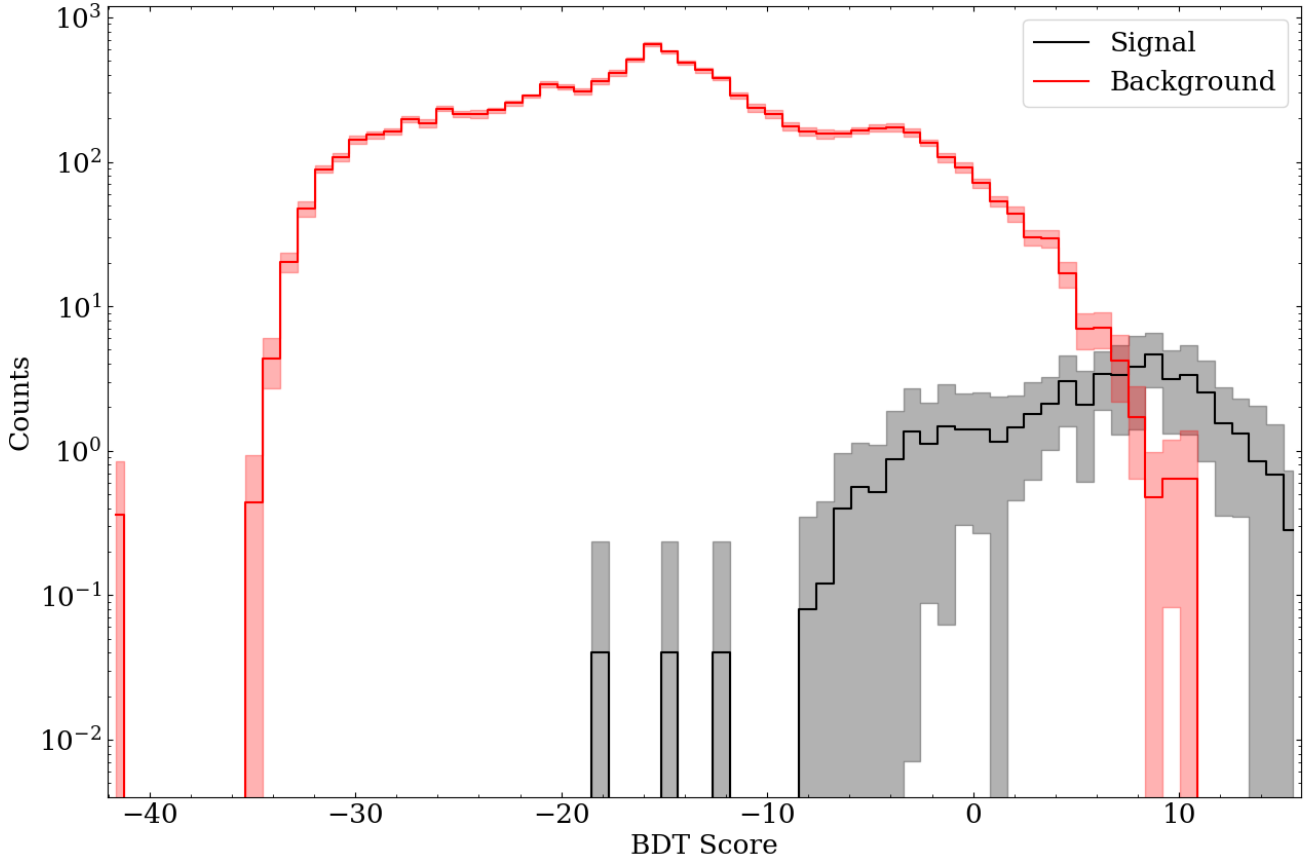


Boosted Decision Tree

Signal Expectation generated with MCNP Simulation
Background from Anti-Coincident Beam Data

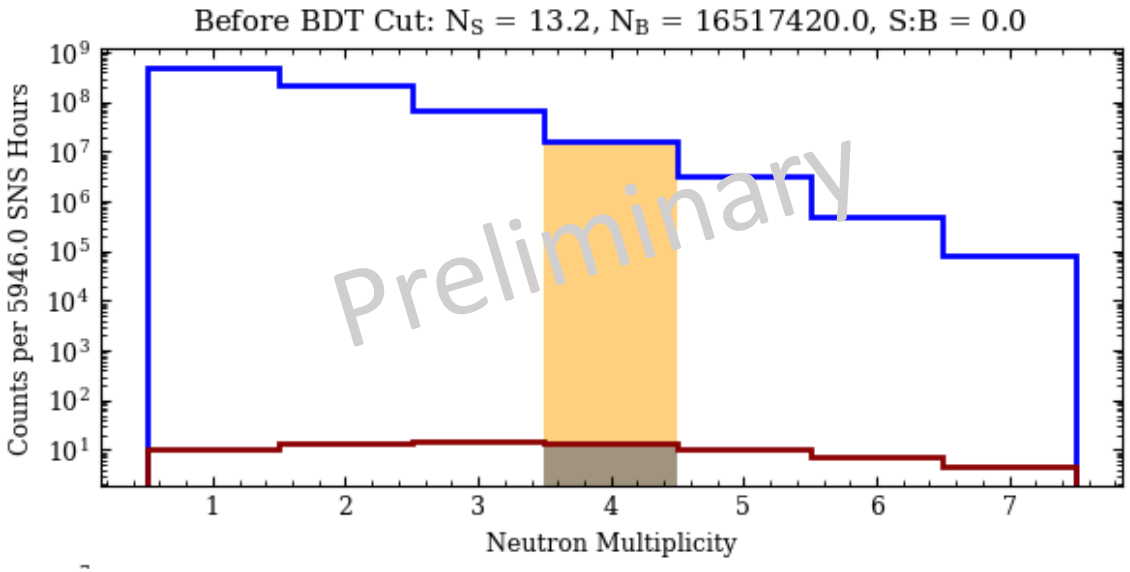


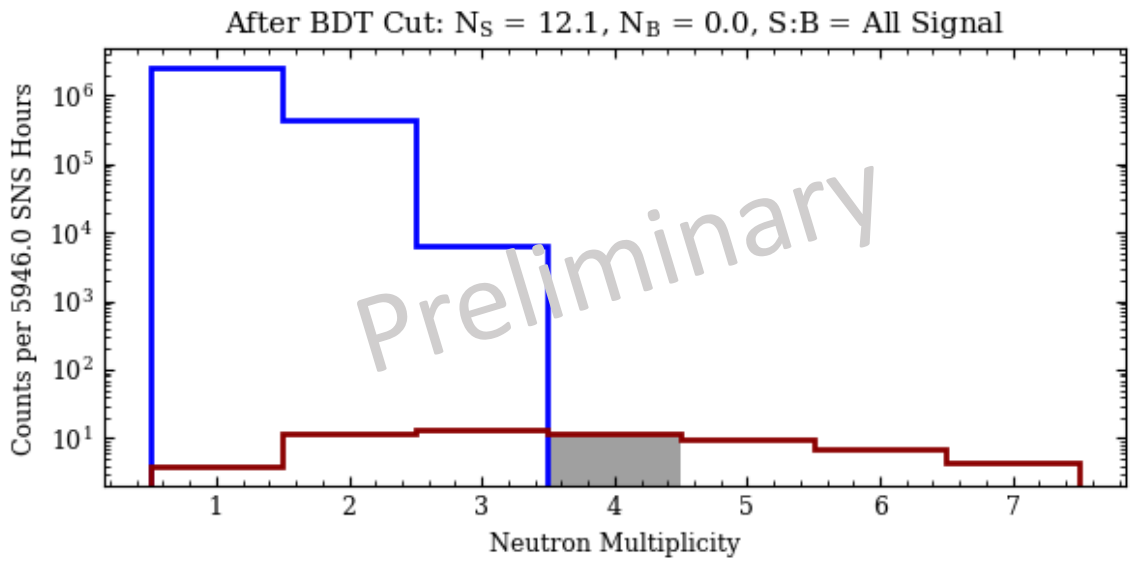
Deal with the radioactivity of the thorium



Results

Sensitivity Projection: After this next beam period





A very substantial decrease in radioactive backgrounds via the boosted decision tree model employed

Validation underway via cosmogenic induced neutrons in the detector data

Expected Impact

- This would constitute the first ever observation of neutrino-induced nuclear fission over 53 years after its prediction

- Implications for nuclear reactor neutrino monitoring, supernova neutrino detection and the universe's isotopic abundance through R-Process nucleosynthesis

MTV Impact

- Deepens the collaboration between MTV, ORNL, TUNL/Duke

- Building NuThor required a culmination of efforts/collaboration with the following:
  - Electronics/Hardware: the University of Washington at Seattle, North Carolina Central University, Duke
  - Thorium/Nuclear Material Handling: ORNL
  - Background Assessments: Sandia National Lab, ORNL

Conclusion

- The steady-state backgrounds from the thorium's radioactivity, cosmogenics, and beam-related gamma radiation are substantially tamped down via the boosted decision tree model

- Multivariate discrimination techniques like fisher linear discriminant are also being explored for a final maximum likelihood fit upon unblinding the data

Next Steps

- This summer brings in the Proton Power Upgrade to the SNS accelerator which means a dramatic increase in neutrino flux

- Will have ~6,000 hours of beam data by the end of this next summer 2024 beam period

Acknowledgements

The Consortium for Monitoring, Technology, and Verification would like to thank the DOE-NNSA for the continued support of these research activities.

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