The First Search Neutrino-Induced Nuclear Fission

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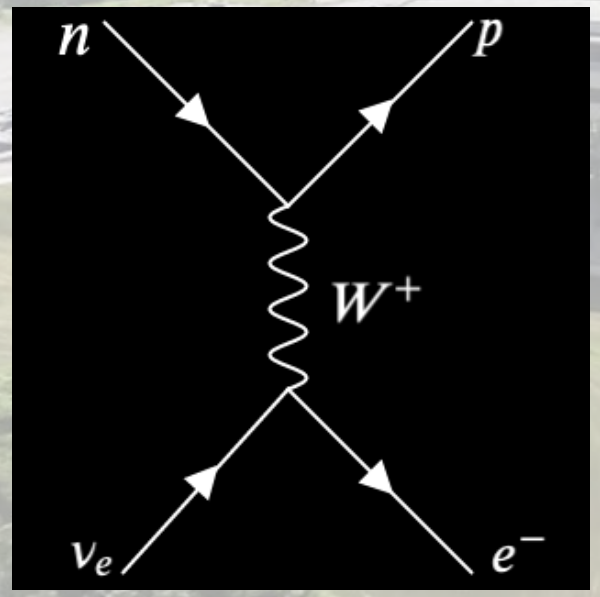
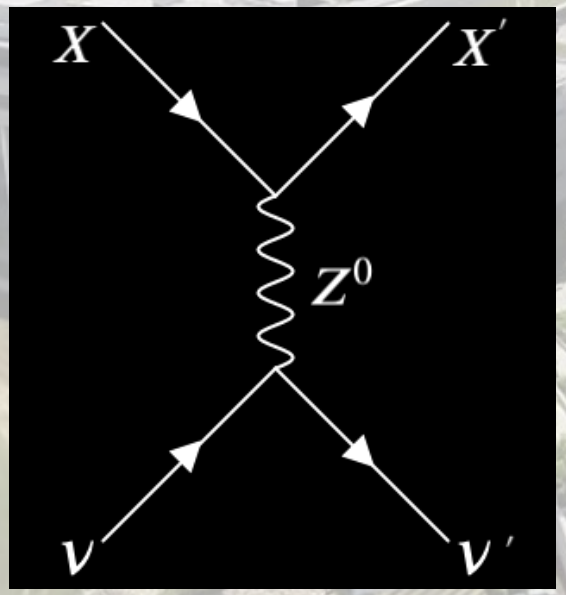
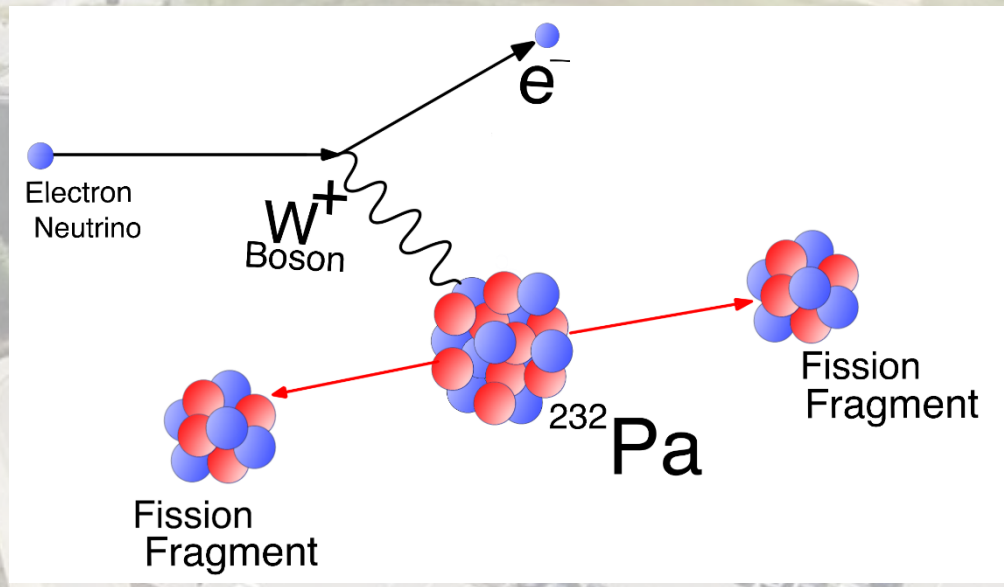
Introduction and Motivation

This experiment would be the first observation of Neutrino-Induced Nuclear Fission or NuFission at least 50 years after its first prediction

Neutrino-Induced Nuclear Fission may constitute a novel reactor monitoring approach with a dramatic 200 MeV signal of a nuclear fission

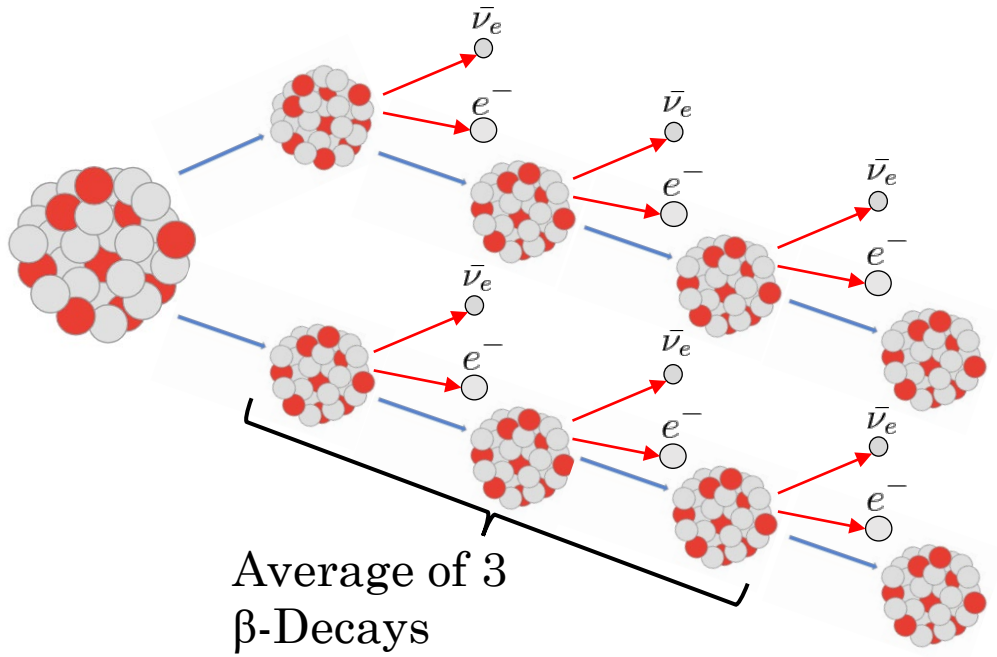


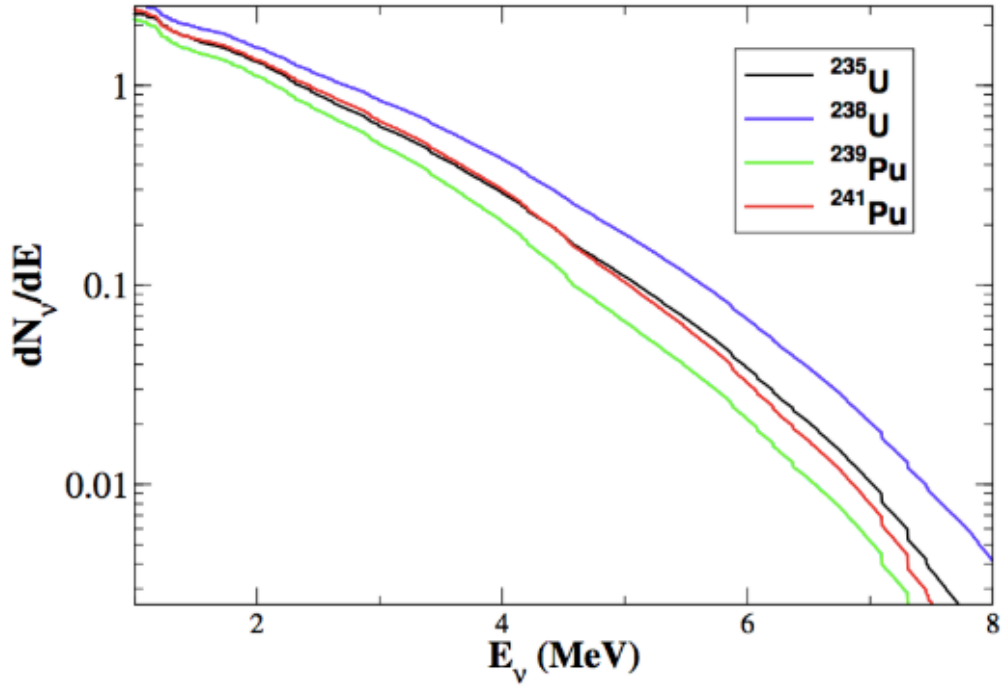




Mission Relevance

- A NuFission-based neutrino detector would be a simple, compact apparatus that chiefly relies on neutron counting rather than a complex event topology
- Fission outputs ~200 MeV so the event is dramatic and unambiguous



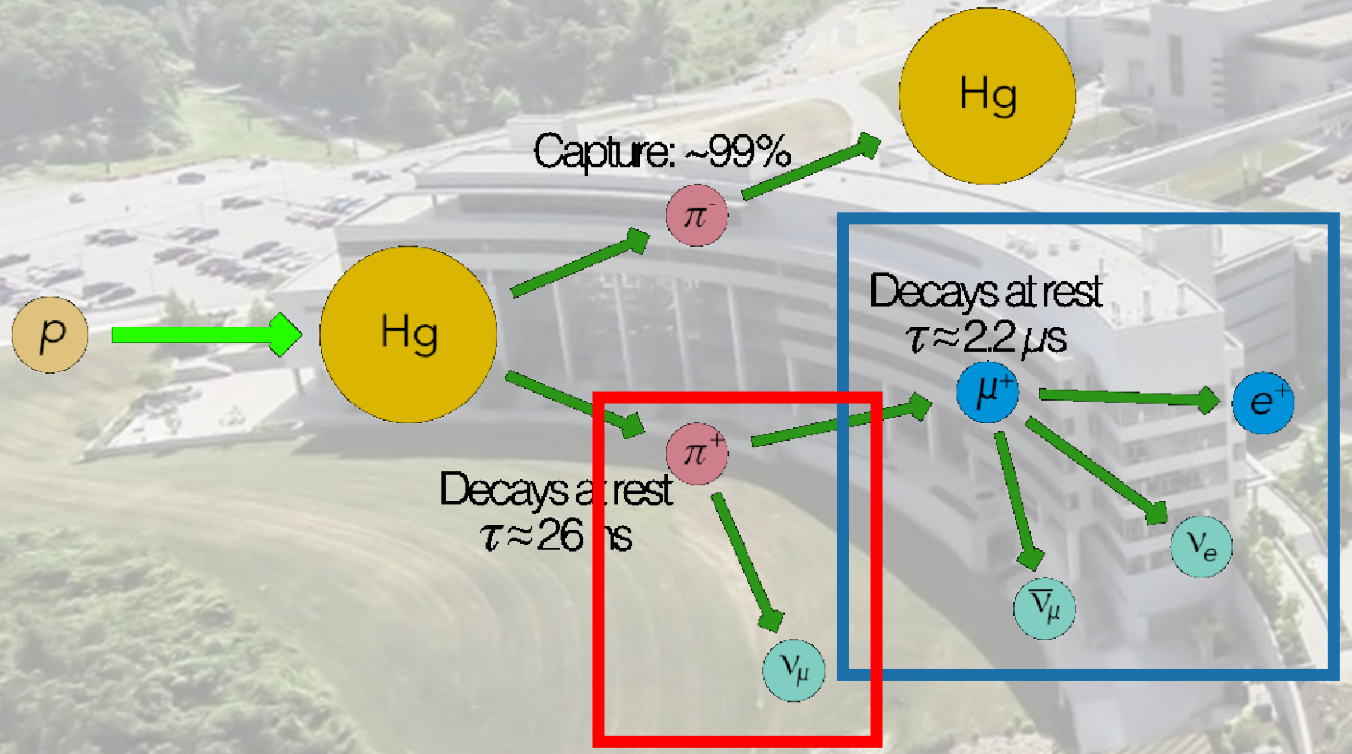


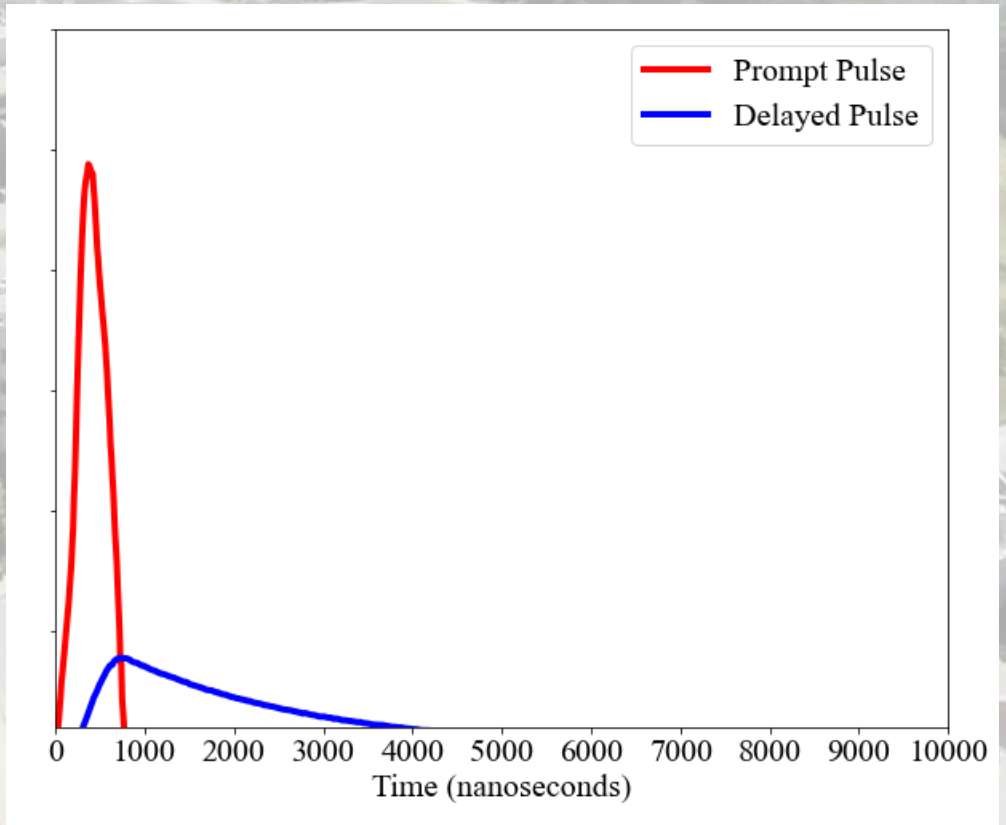
Source: A. Hayes, P. Vogel, *Reactor Neutrino Spectra*

Experiment Site – Oak Ridge National Lab

Spallation Neutron Source

- Pulsed at 60 Hz for excellent background suppression





Fission Material Selection

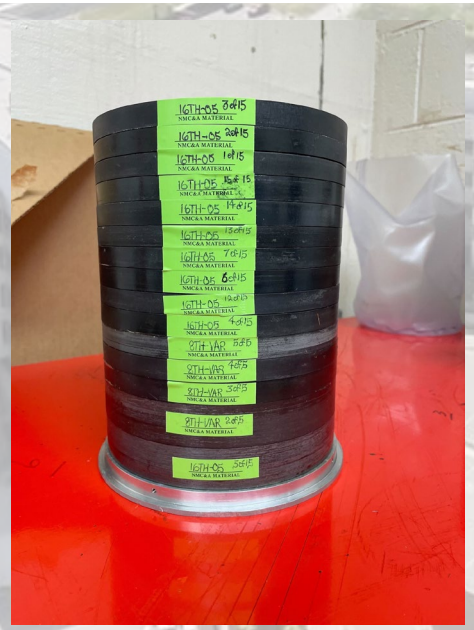
There are several fissionable nuclei to choose from, but few are available in large quantities

89	90	91	92	93	94	95	96	97	98	99	100	101	102	103
Ac	Th	Pa	U	Np	Pu	Am	Cm	Bk	Cf	Es	Fm	Md	No	Lr
Actinium (227)	Thorium 232.0377	Protactinium 231.03588	Uranium 238.02891	Neptunium (237)	Plutonium (244)	Americium (243)	Curium (247)	Berkelium (247)	Californium (251)	Einsteinium (252)	Fermium (257)	Mendelevium (258)	Nobelium (259)	Lawrencium (266)

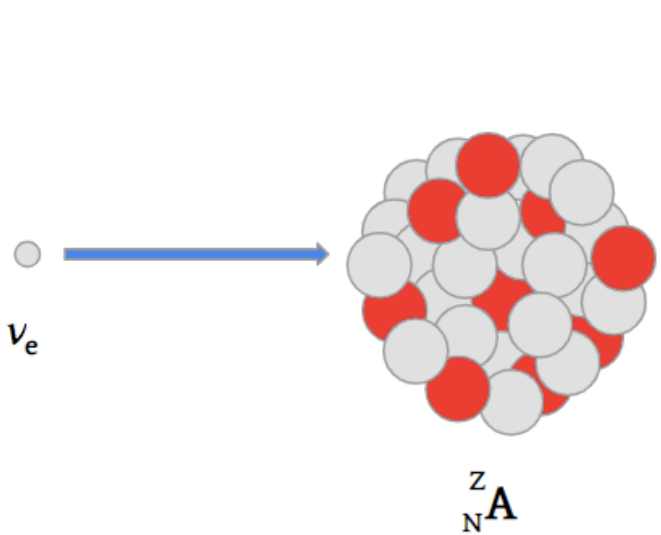
Thorium & Uranium are the most practical candidates

BUT

Thorium has a spontaneous fission rate 5 orders of magnitude less than uranium

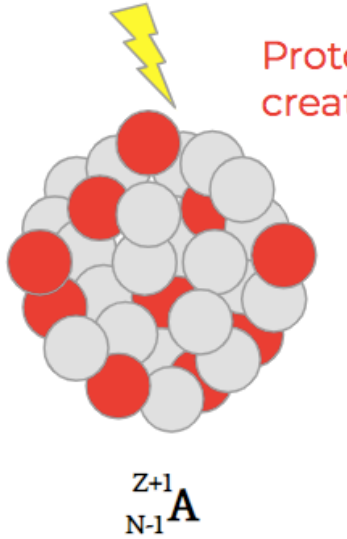


Statistical Decay



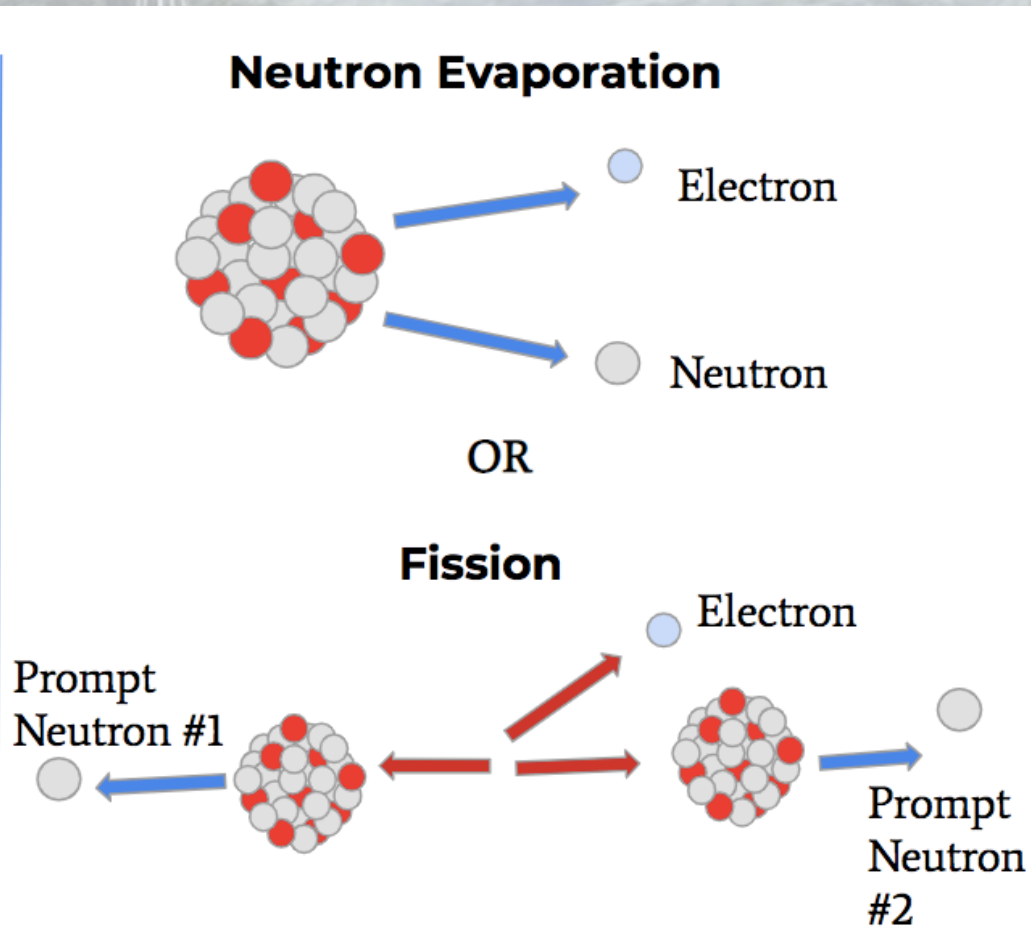
Thorium-232

Giant Gamow-Teller Resonance and Isobaric Analog State enhance charged current capture cross section



Protactinium-232*

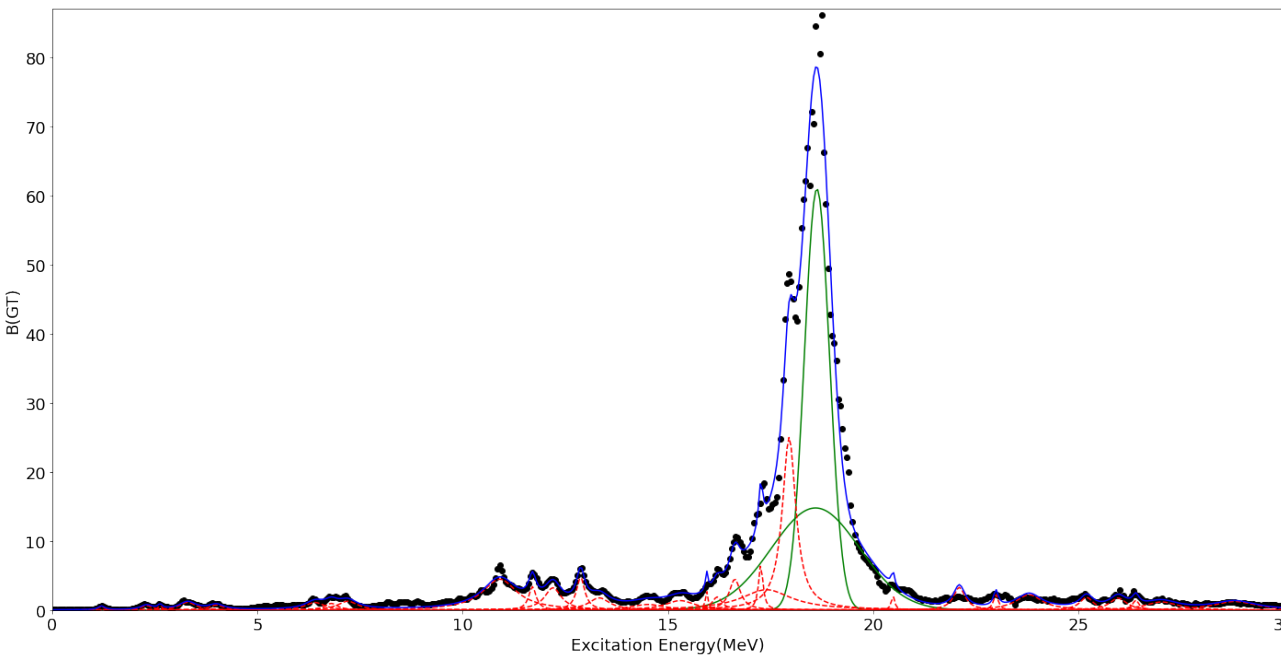
Pa-232 is highly excited



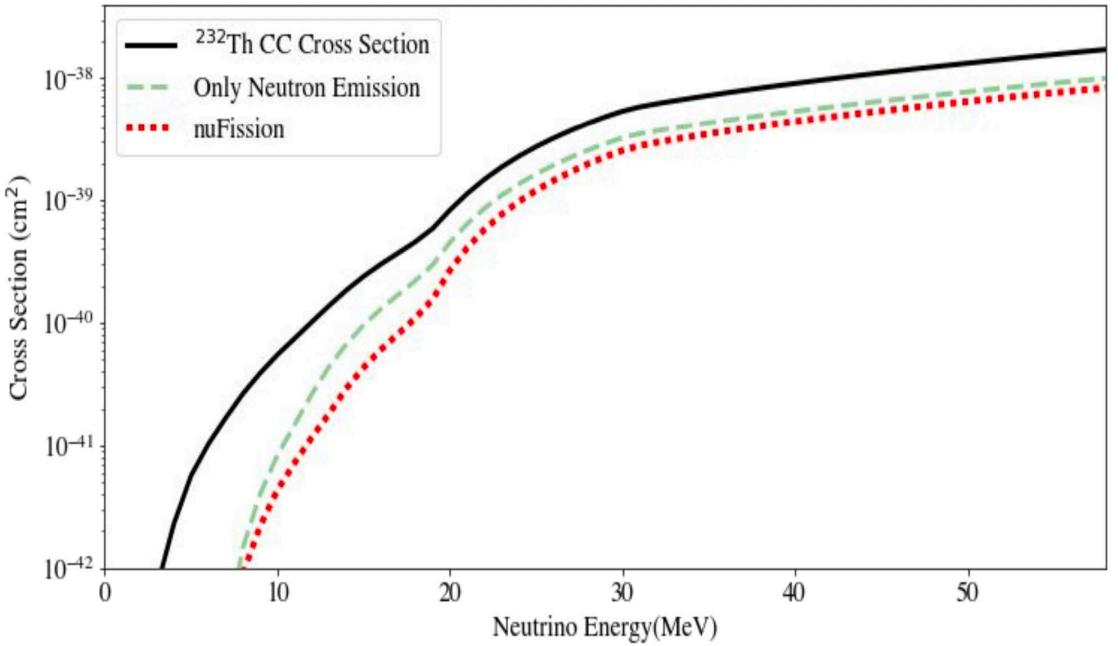
Thorium NuFission Signal

First needed the charged-current neutrino cross section for Thorium

Beta-Strength Function for Allowed Transitions

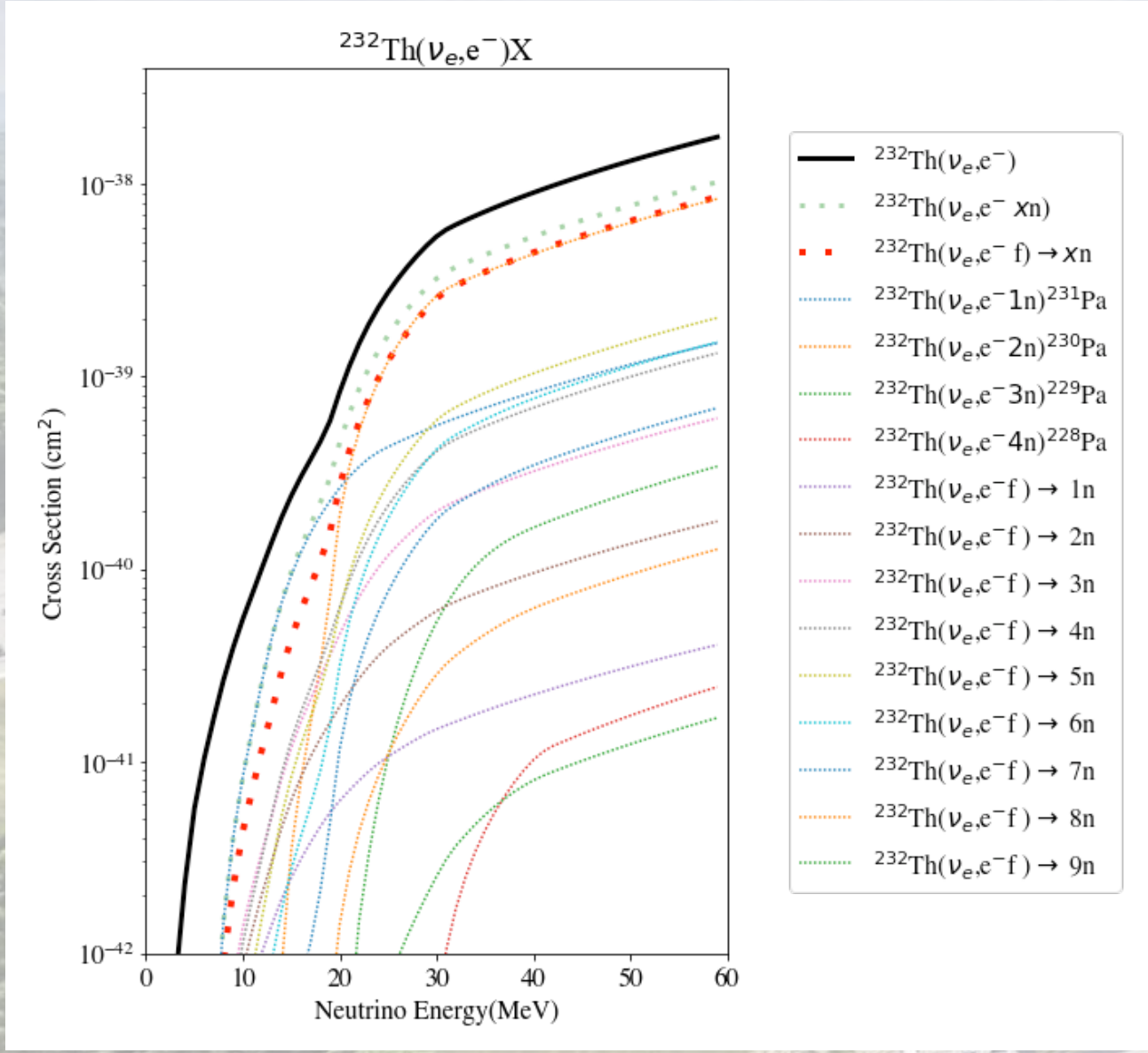


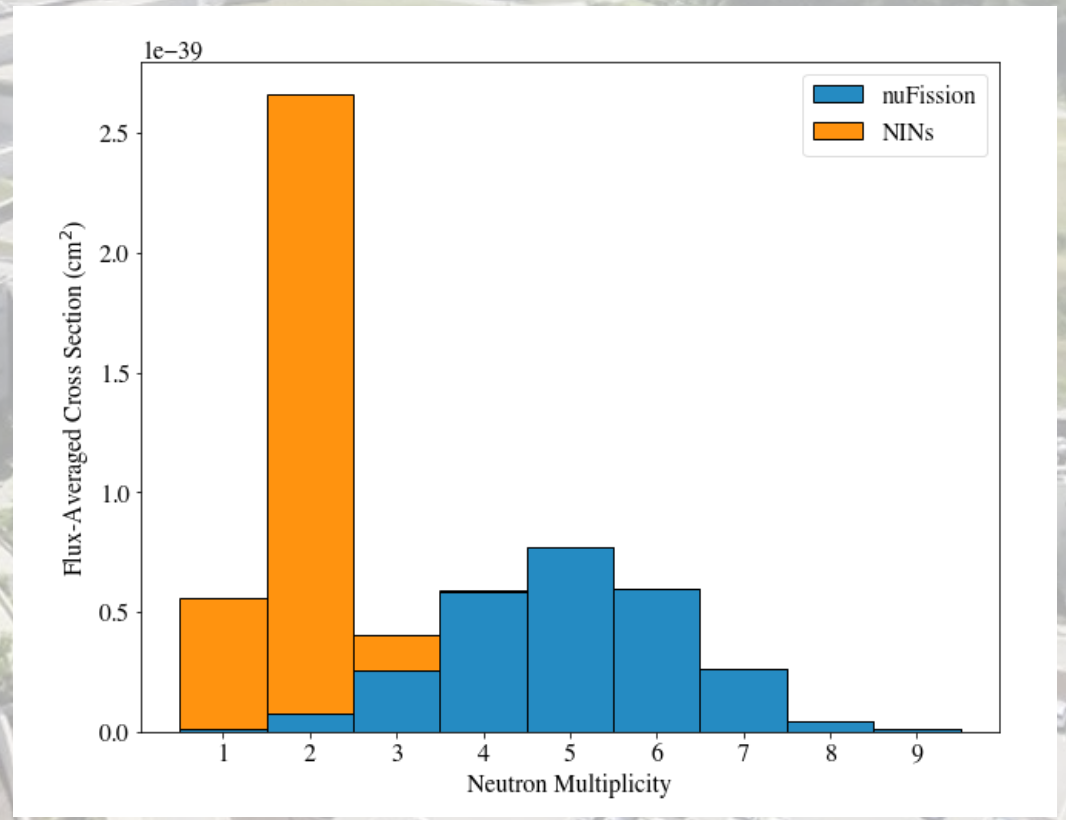
Charged-Current Cross Section on Thorium



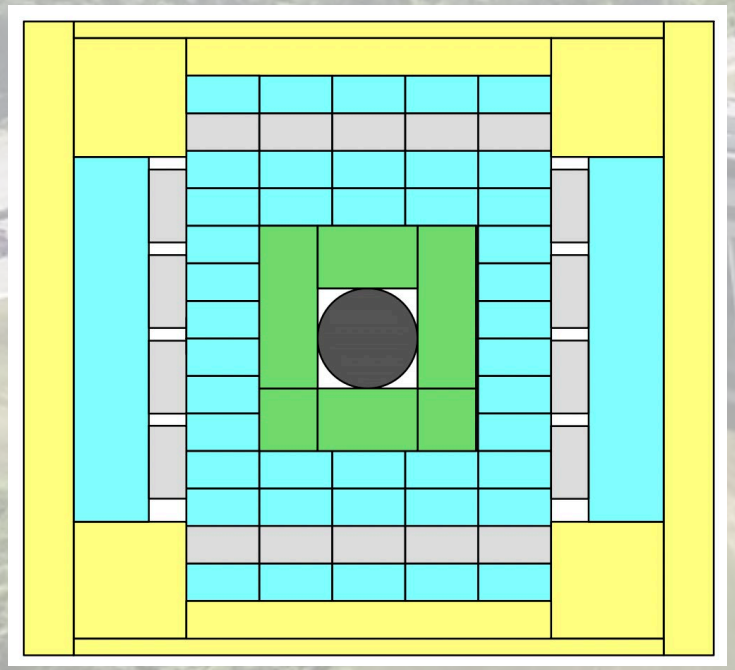
CC Event Estimate: **~2 CC Events per** kgs Th-232 per SNS year - nuFission Estimate: **~1 nu**Fission per kgs Th-232 per SNS year

Fission Neutron Signal





Results: Detector Built & Deployed

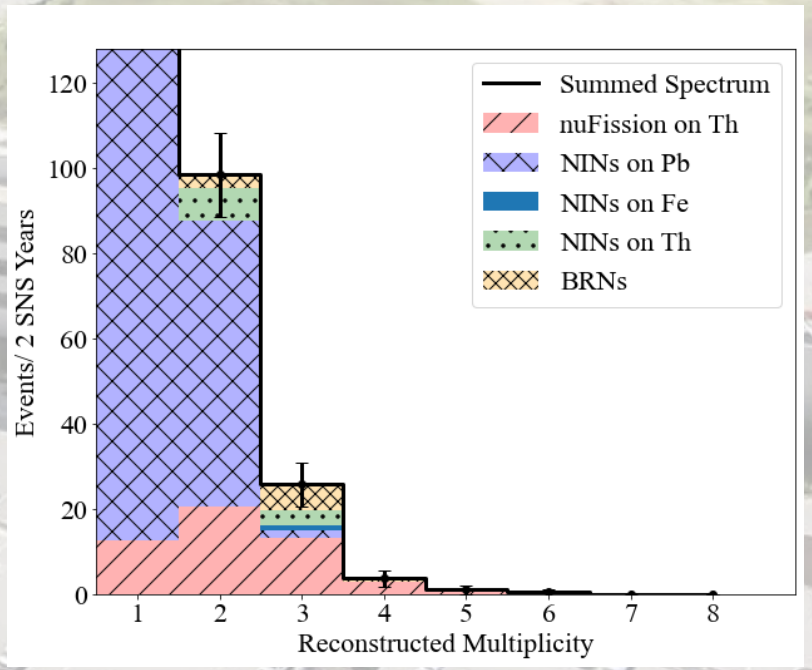


52.0 Kilograms of ^{232}Th Metal Core
Over 2,000 Beam Hours of data taken

Th-232 Metal	
Lead	
Gd-Water	
NaI[Tl]	
Bor. Poly.	

Expected Impact

- This would be the very first experimental confirmation of the new way to split the atom
- This would simultaneously be the first experimental confirmation of neutrino-induced neutron emission
- Could potentially be a novel method of detecting reactor neutrinos



MTV Impact

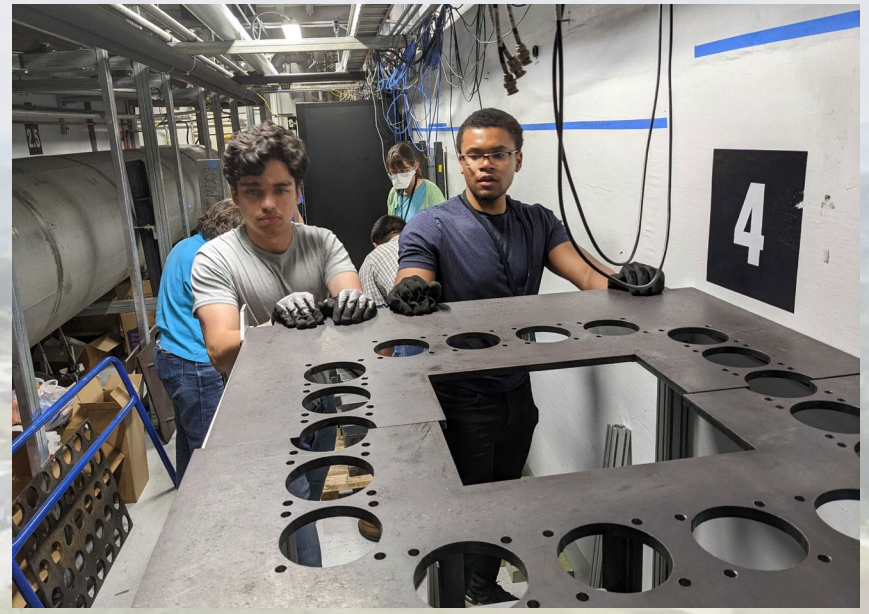
Theory & Simulation Collaboration
- COHERENT Collaboration
- Triangle Universities Nuclear Lab
- UNC Chapel Hill

Hardware Collaboration:
- University of Washington at Seattle
- North Carolina Central University
- Oak Ridge National Laboratory

Thorium Target & Deployment Site:
- Oak Ridge National Laboratory

Will help to deepen the relationships between Duke, MTV, Oak Ridge, and the maybe collaborating institutions

This work is only possible through the support provided by MTV



Conclusion

- We just finished the first SNS beam period with NuThor taking production data taking status with over 2,000-hours already accrued
- There are several upgrades planned for the intervening time before this summer's beam period to lower the threshold & mitigate backgrounds

Acknowledgements

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

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