Toward the Development of a Next Generation Fast Neutron Portal Monitor

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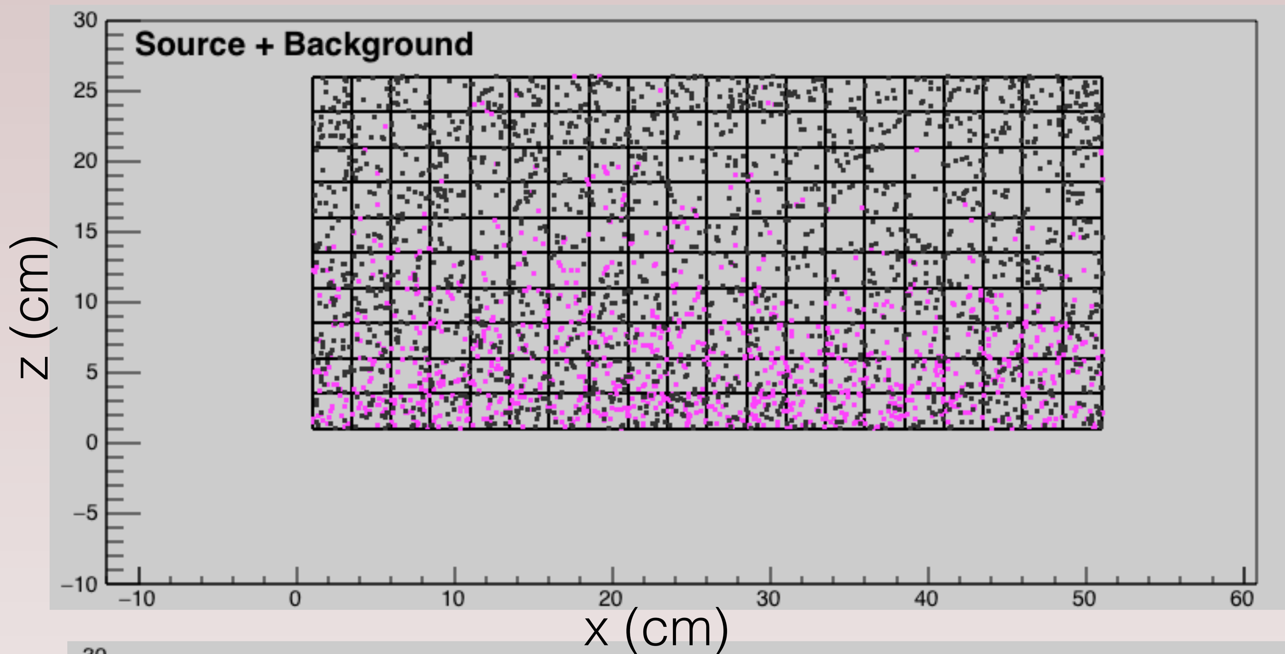
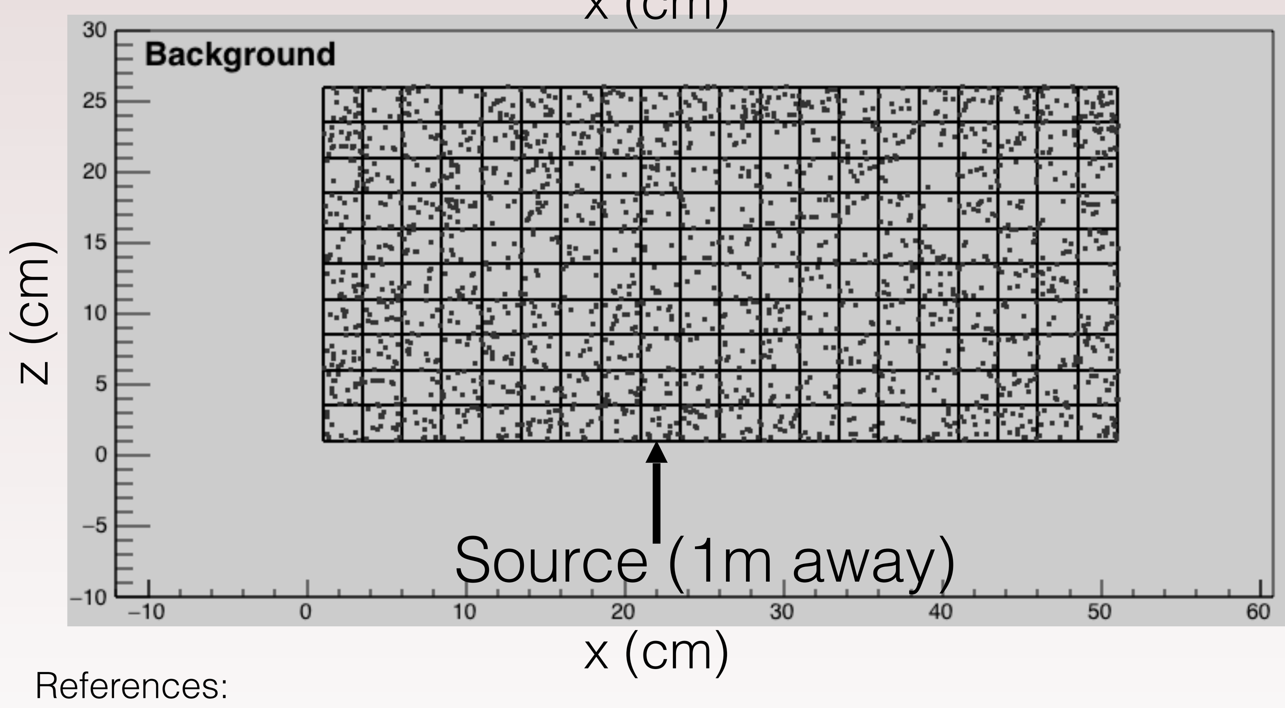
Background:

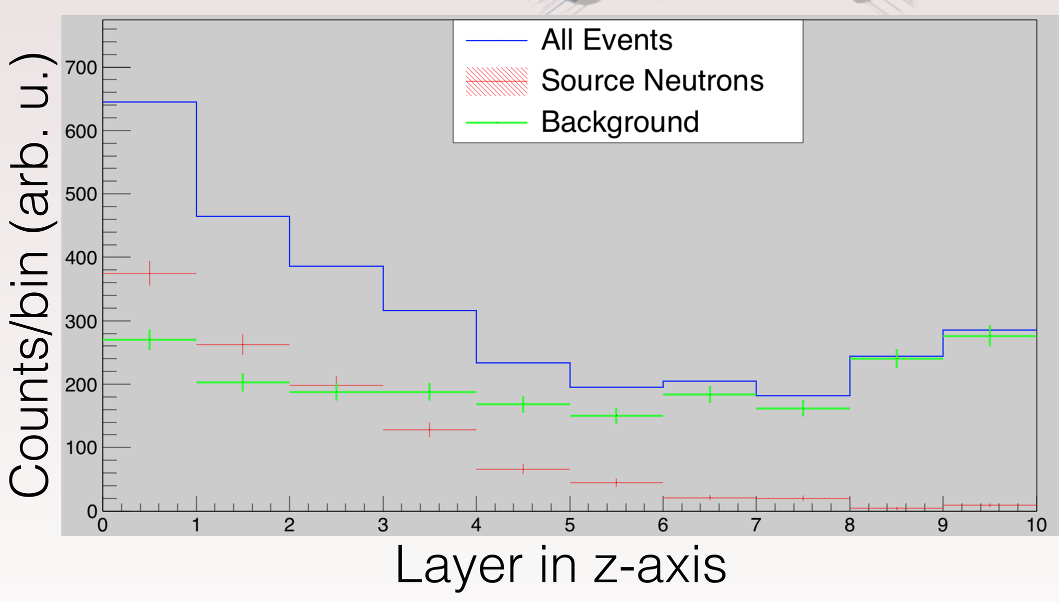
- Current methods for portal monitoring primarily rely on thermalization and counting techniques which can require expensive materials such as ^{3}He.
- Techniques have been developed to challenge the limitations of these detectors in the past [1], but still require complex detection systems.
- By designing a multi-crystal 3D position sensitive apparatus we can distinguish ambient background neutrons and source neutrons as well as localize the source, similar to the concept of the Gamma-Ray Burst Monitor[2].

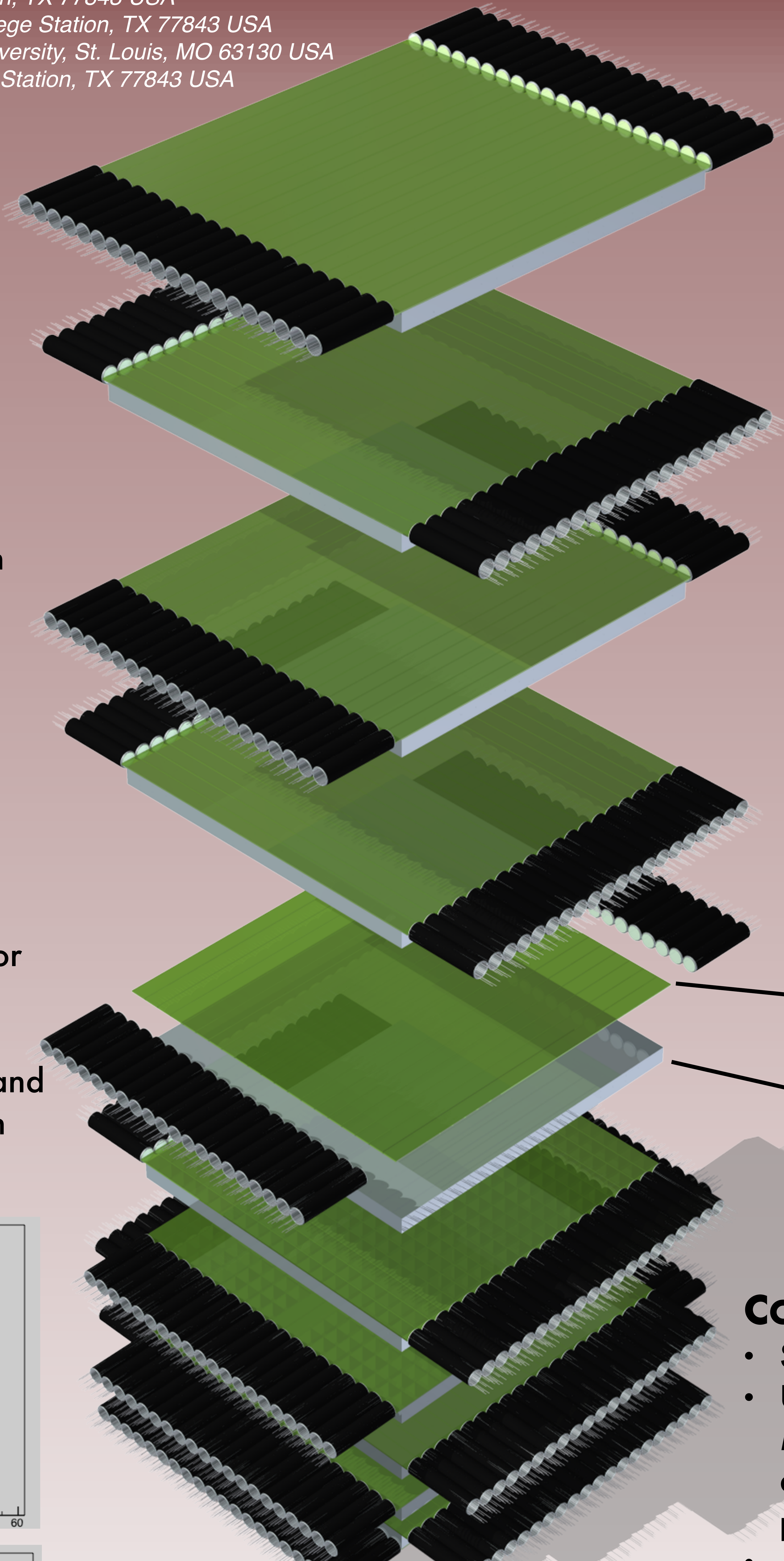
MCNP6 Simulations:

- Using MCNP6 [3] we can accurately model neutron scattering in our detector array.
- MCNP6 has been used to simulate a realistic ambient neutron background and a Watt fission spectrum for ^{235}U+n with varying source strengths.









Statistical Analysis:

- The Uniformly Most Powerful Bayesian Tests (UMPBT) method [4] was used to estimate the sensitivity limitations for our detector.
- With simulation data of the ambient neutron background we can use the UMPBT method to estimate a sensitivity threshold with respect to time and number of neutrons emitted from the source.

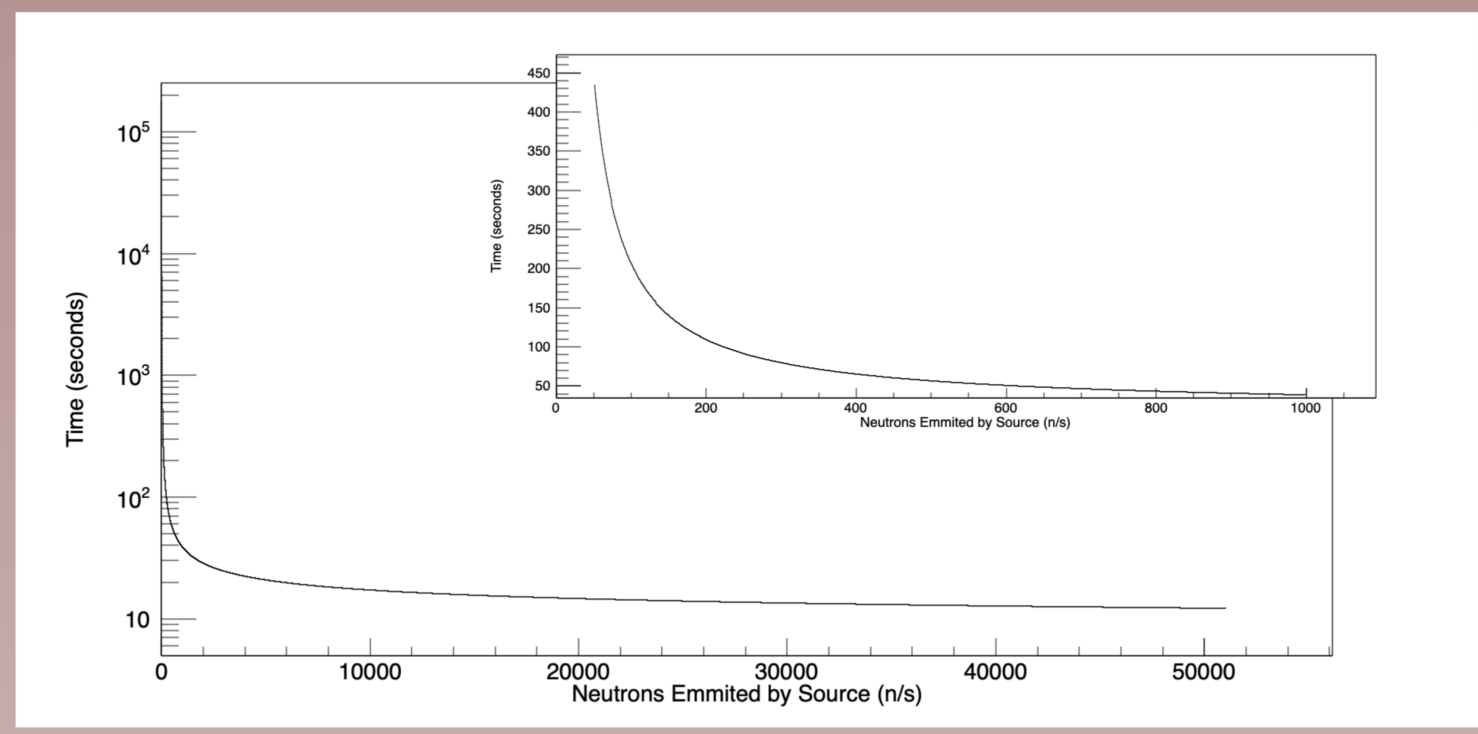
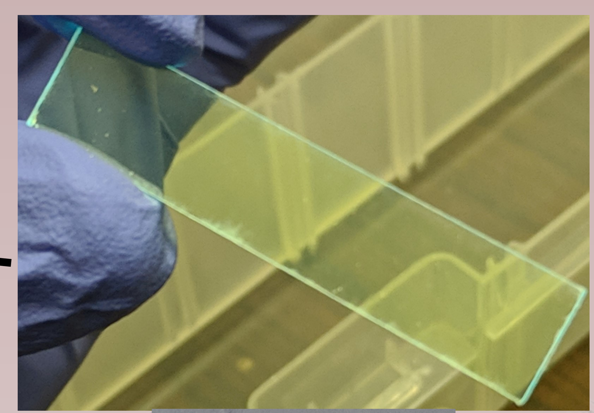
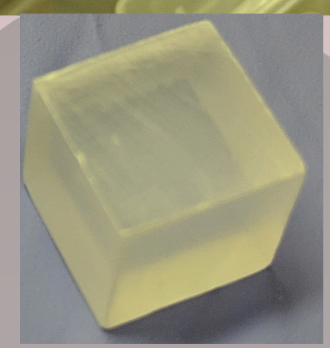


Figure: Time vs. Neutrons Emitted from Source plot that uses the UMPBT method to approximate the sensitivity threshold of our detector apparatus, assuming ideal conditions.



Wavelength Shifters (EJ-282)



-2.5cmx2.5cmx2.5cm Para-Terphenyl (C18H14) scintillators

-Total detector size: 50cmx50cmx25cm

Conclusion:

- Simulations and physical testing are still ongoing.
- Using similar techniques to the Gamma-Ray Burst Monitor, we are developing a novel fast neutron detector which overcomes the limitations of current portal monitoring neutron detectors.
- MCNP6 simulations have shown our ability to separate ambient background neutrons and neutrons from fissile sources being smuggled.
- The UMPBT method paired with MCNP6 simulations have estimated the sensitivity limitation for our detector in an ideal case.

References:
[1] P.B. Rose *et al*., Scientific Reports 6, 24388 (2016)
[2] C. Meegan, et al., The Astrophysical Journal, 702, 791 (2009)
[3] T. Goorley, et al., "Initial MCNP6 Release Overview", Nuclear Technology, 180, pp 298-315 (Dec 2012).
[4] V.E. Johnson, "UNIFORMLY MOST POWERFUL BAYESIAN TESTS", *Ann Stat.* (2013)

Nuclear Solutions Institute
SCIENCE TEXAS A&M UNIVERSITY
NSNA Grant Number: DE-NA0003841
DOE Grant Number: DE-FG03-93ER40773
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