Modular Next Generation Fast Neutron Detector for Portal Monitoring

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BACKGROUND:

- Special nuclear materials (SNMs) such as HEU and WGPu have non-spontaneous fissioning primary components, ^{235}U and ^{239}Pu respectively.
- Current neutron portal monitoring methods rely on neutron thermalization for detection.

Figure 1: Example of a portal monitor via polimaster.

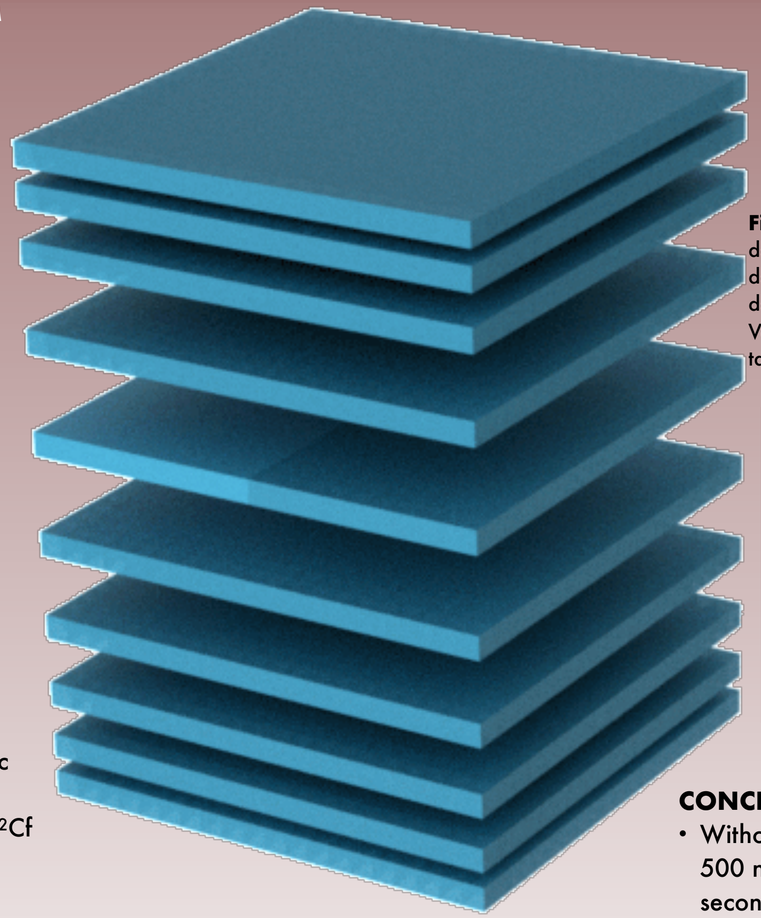
MCNP6 SIMULATIONS:

- MCNP6 [1] simulations replicate ambient neutron background and realistic sources.
- Simulations have been done with ^{235}U+n for the proposed detector and ^{252}Cf for a ^{3}He detector as well as the proposed detector.

STATISTICAL ANALYSIS:

- Uniformly most powerful Bayes tests (UMPBTs) [2] were used to define tests for positive identification.
- MCNP6 simulations of ambient neutron background power UMPBTs to determine the sensitivity limitations of our detector.

Total detector size: 50cmx50cmx25cm



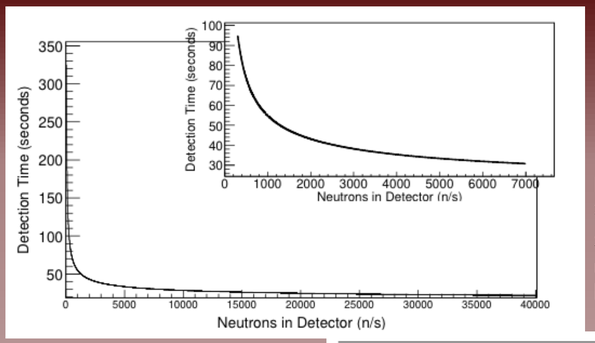


Figure 2: Time vs. Mass of ^{235}U. The overlaid plot is a zoomed in portion of the main plot to highlight the low mass region.

Figure 3: Comparison of neutron detection efficiency of the proposed detector and commercially-available detectors studied in Kouzes *et al.* [3]. Values marked with a dagger were taken from Kouzes *et al.*

Detector Type	Efficiency (cps/ng)
Proposed Detector - Without UMPBT	26.8
^{3}He proportional detector (1 Tube)	3.0(2)†
BF_3 proportional detector (3 tubes)	3.7(2)†
Boron-lined proportional detector	3.0(2)†
Lithium-loaded glass fibers	1.7(6)†
Coated non-scintillating plastic fibers	2.0(1)†

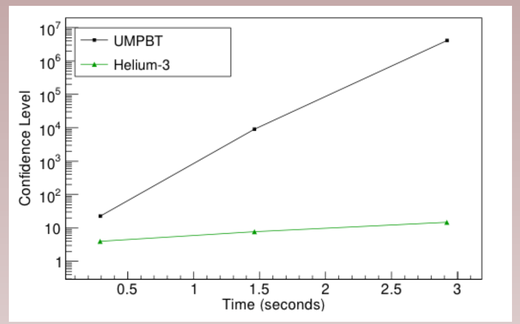


Figure 4: Confidence levels in the form 1 in gamma, i.e. gamma=10^6 corresponds to a confidence level of 1 in 10^6, which were calculated for a ^{3}He detector (green) and the proposed detector using the UMPBT model (black). The confidence levels were derived from sets of 50 MCNP simulations with and without a source present. Comparison of the confidence levels shows a sensitivity comparison of the proposed detector to a standard ^{3}He detector.

CONCLUSION:

- Without moderation, the proposed detector can identify a source emitting approx. 500 n/s (8.1 mg) in 25 minutes, similarly approx. 5000 n/s (80.7 mg) in 192 seconds.
- The National Committee on Radiation Instrumentation set an efficiency requirement of 2.5 cps/ng. A helium-3 detector [3] has an efficiency of 3.0(2) cps/ng.
- The proposed detector has an estimated efficiency of 26.8, after size corrections.
- With UMPBTs, the proposed detector achieves significantly greater positive detection confidence levels than a helium-3 detector [3].

References:
[1] T. Goorley, *et al.*, "Initial MCNP6 Release Overview", Nuclear Technology 180, pp 298-315 (Dec 2012).
[2] V.E. Johnson, "UNIFORMLY MOST POWERFUL BAYESIAN TESTS", Annals of Statistics (2013)
[3] R. T. Kouzes *et al.*, Passive neutron detection for interdiction of nuclear material at borders, NIM A (2008)

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