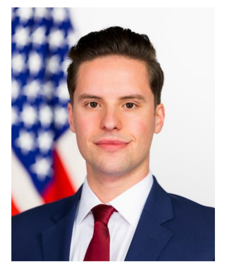
Epithermal Neutron Resonance Imaging for Nuclear Disarmament



PRESENTER:
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BACKGROUND

- Nuclear material identification and isotopic composition analysis are important capabilities for verifying nuclear arms control treaties.
- X-ray imaging and most passive detection techniques are not suitable for analysis of high-Z materials
- Epithermal neutron resonance imaging is a proven technique with high sensitivity to isotopes of interest for safeguards applications (e.g. U, Pu)
- Recent progress in the development of high intensity neutron sources could make this technique increasingly feasible to serve as a tool for nuclear inspectors.

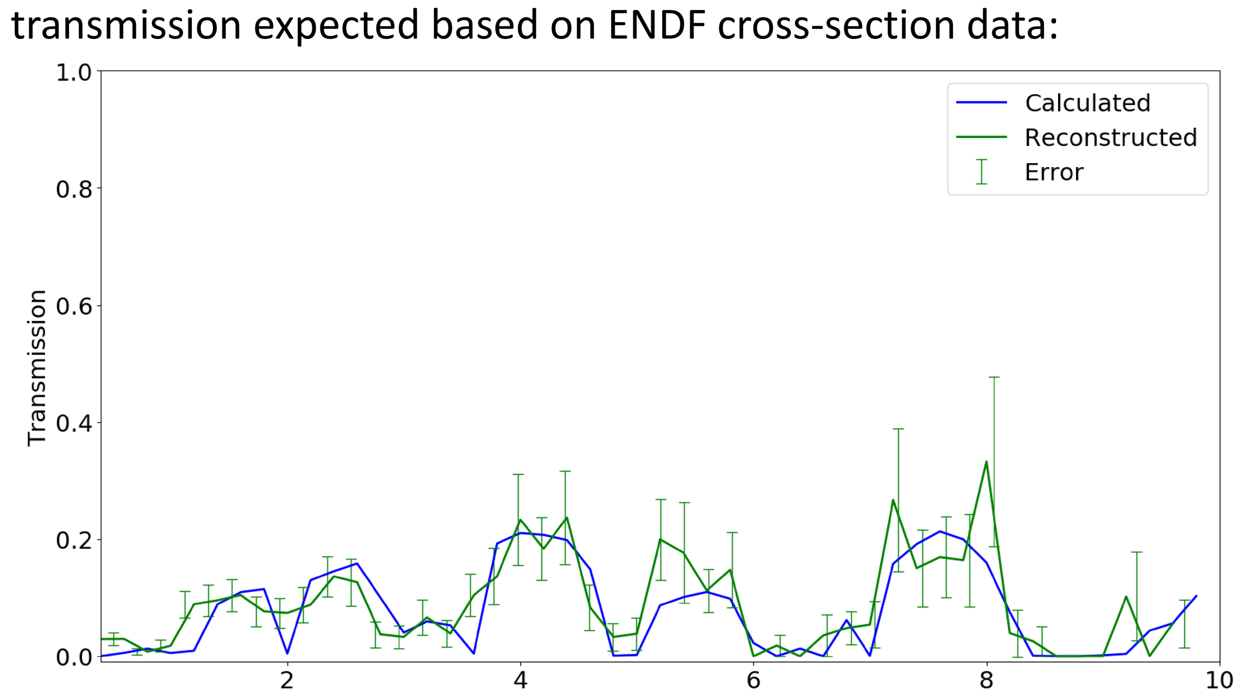
METHODS

- Conducted Monte Carlo simulations to optimize a portable apparatus using a D-T neutron generator
- Tested thin samples of mid-, high-Z materials (*e.g.* Ag, W) at a user facility to demonstrate isotopic- and hoax-resistance of technique
- Explored potential alternatives for mobile neutron generators (*e.g.* near-threshold $^{7}Li(p,n)^{7}Be$)

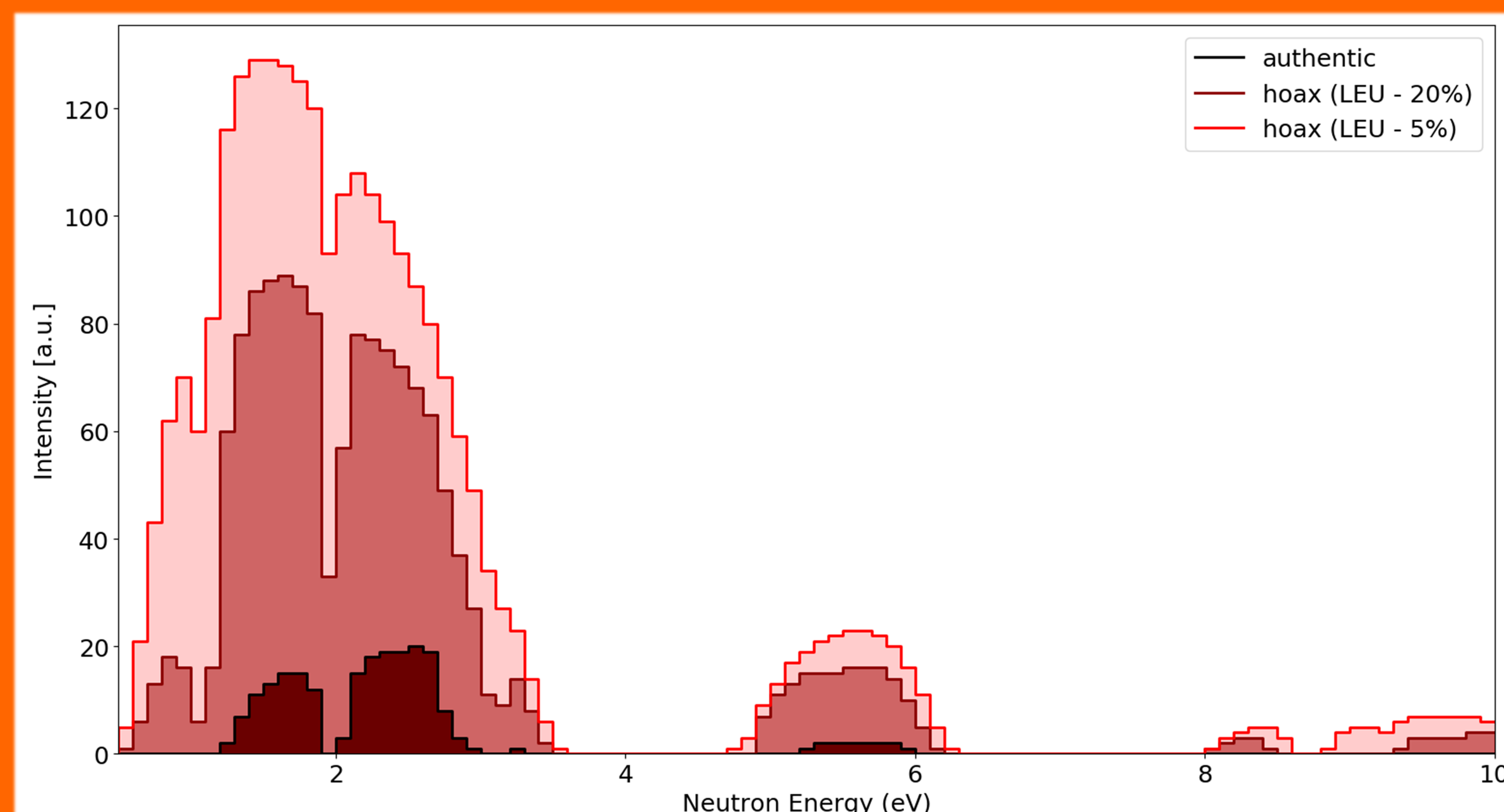
RESULTS

- GEANT4 simulations demonstrate feasibility of D-T based apparatus for hour-long interrogation of targets of ~cm thickness
- Shielded special nuclear material can be reliably distinguished from high-Z shielding material
- Simulations demonstrate potential for verifying pit + tamper and differentiating hoax objects with lower enrichment (see figure on right)

GEANT4 simulation of a 3-cm thick shielded HEU target, compared to transmission expected based on ENDF cross-section data:

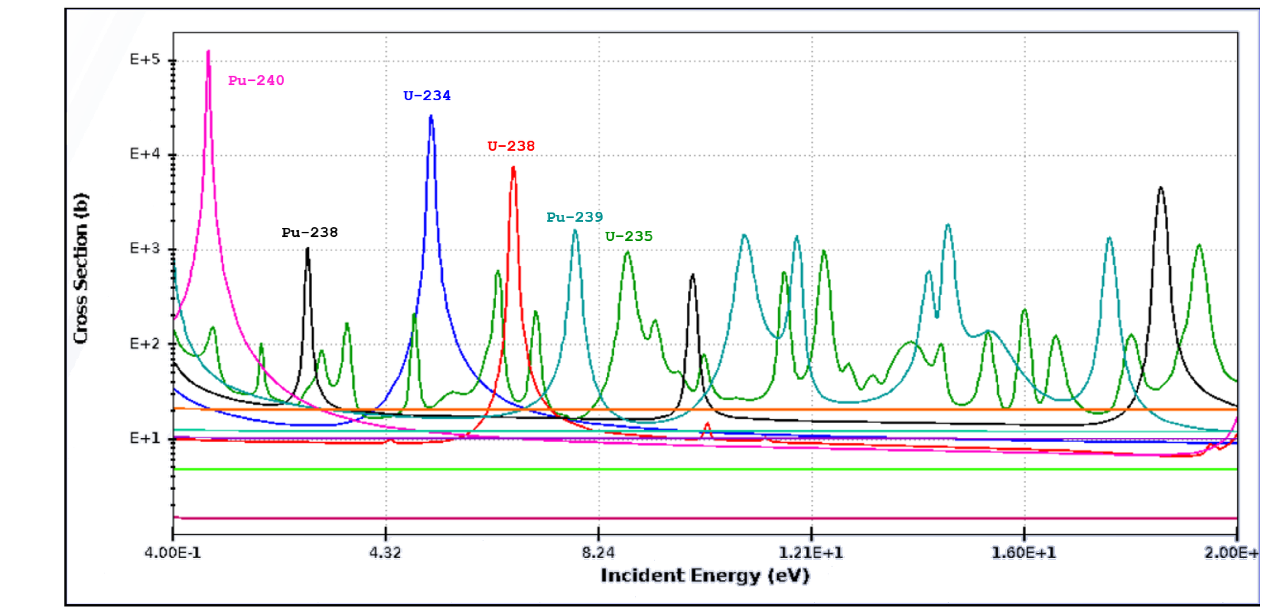


Epithermal neutron resonance imaging can be a **mobile, isotope-sensitive** tool to **identify shielded nuclear material** and **verify warhead authenticity.**

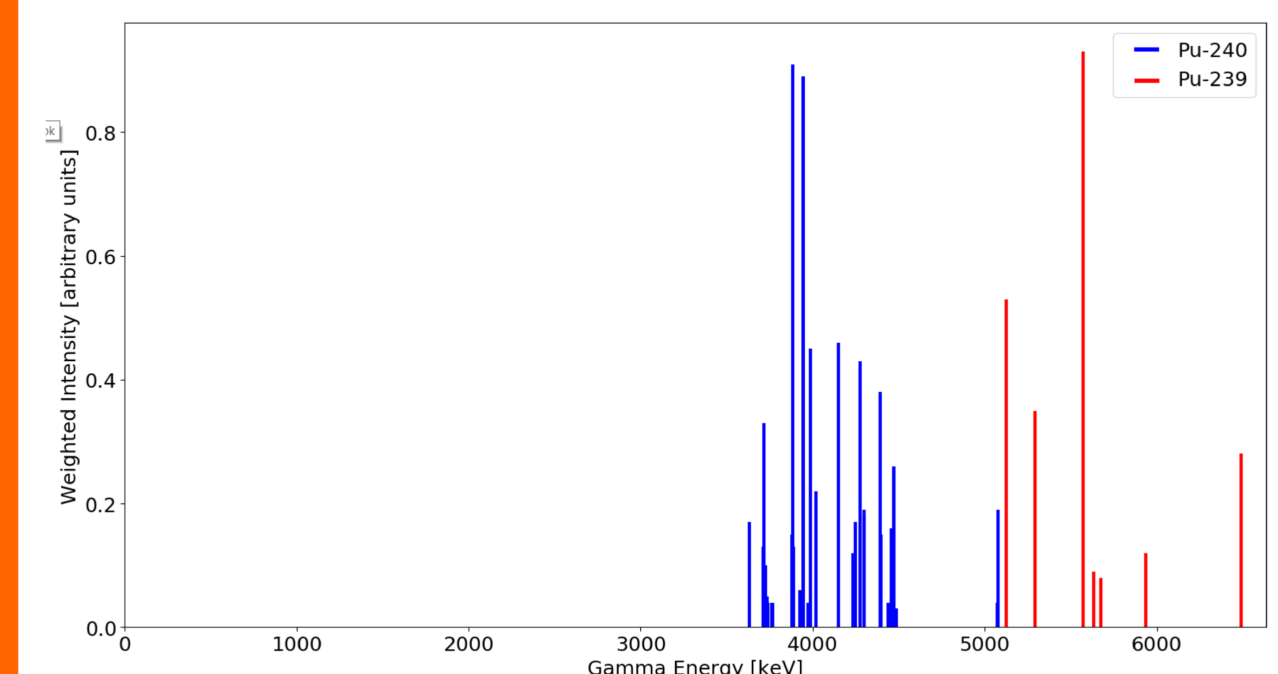


ADDITIONAL INFO

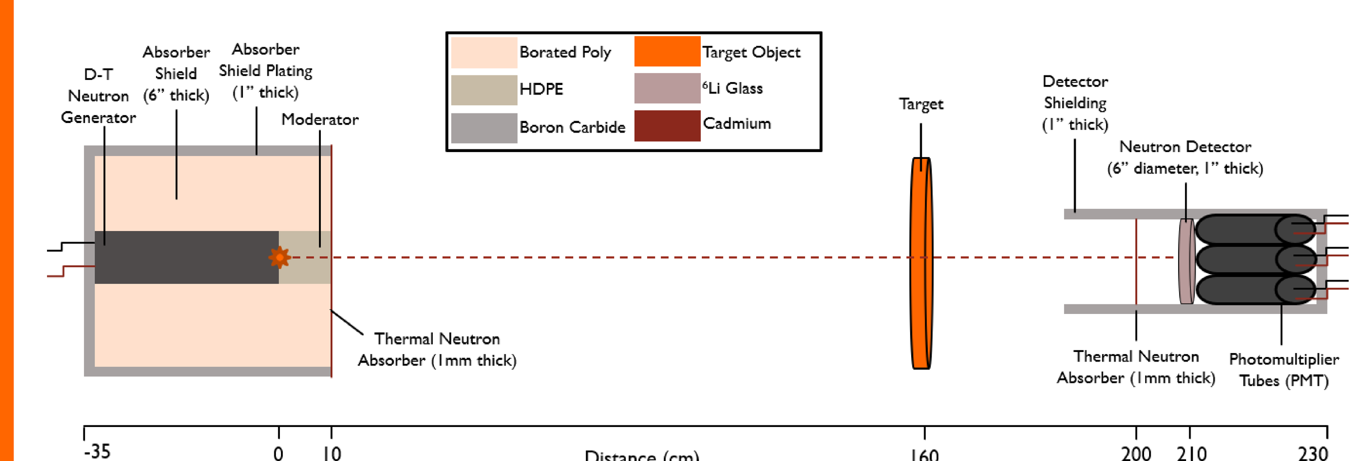
High-Z isotopes have unique neutron resonances in the 0.5-10 eV range, while common shielding materials (*e.g.* H, C, N, O, Al, Fe, Pb) do not have any energy-dependent neutron features:



Thermal neutron flux can be suppressed in the neutron detector, but used to produce high-energy neutrons through fission and ~3-6 MeV gammas through neutron capture in the presence of $^{239/240}Pu$ content:



Proposed experimental setup based on a portable D-T neutron generator, using HDPE moderator and ^{6}Li-enriched glass scintillator:



Fractional uncertainty in TOF-reconstructed energy is proportional to inverse of TOF distance, dominated by neutron generation pulse width:

$$\frac{\Delta E_n}{E_n} = \frac{2}{l_{TOF}} \sqrt{\frac{E}{\alpha^2} \Delta t_{TOF}{}^2 + \Delta l_{TOF}{}^2}$$

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