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Identifying Special Nuclear Material in a Complex Environment

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Dual-Particle Imager (DPI)

Goals & Objectives

- Measure weapons-grade plutonium sample at the Device Assembly Facility (DAF) located at the Nevada National Security Site.
- Distinguish plutonium sample from a field containing three neutron emitting sources to emulate treaty verification applications.

Dual-Particle Imaging System

- The Dual-Particle Imager (DPI) is a combined Compton-scatter and neutron-scatter camera being designed for the detection of SNM.
- Use of maximum-likelihood expectation-maximization (MLEM) allows for simultaneous reconstruction of images and location-dependent energy spectra.

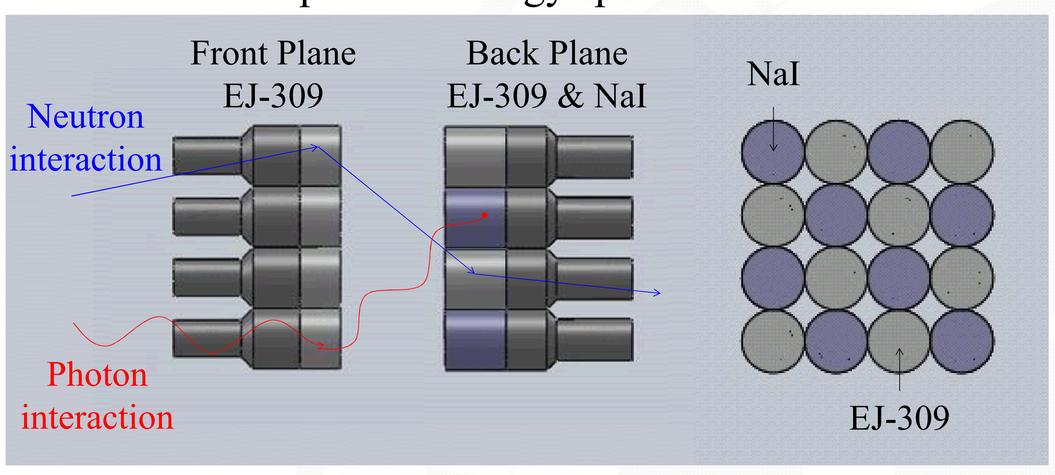

Fig. 1. Schematic of the DPI with common neutron and photon interaction paths. Cross-sectional view of the back plane detector pattern is shown on the right.

Experiment Setup

- 850-minute measurement of three sources:
  1) ~5.2×10^5 neutrons/second δ-phase plutonium sample (Thor Core) shielded by 1.3 cm of lead located at (90°, 85°)
  2) ~3×10^5 neutrons/second unshielded ^{252}Cf source located at (90°, 109°)
  3) ~1×10^6 neutrons/second AmBe source shielded by 10 cm of lead located at (141°, 85°)
- ~2-m standoff for all sources
- ~212,000 neutrons measured
- ~2,135,000 photons measured

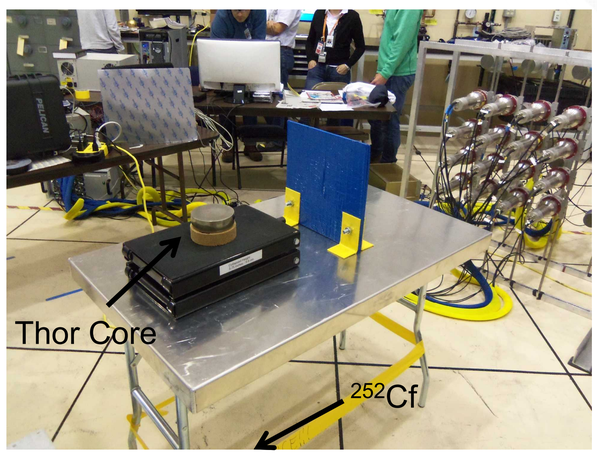

Fig. 2. Location of the two fission sources relative to the DPI. Thor Core is behind a 1.3-cm thick lead shield.

Fig. 3. Location of the lead-shielded AmBe source relative to the DPI.

Experiment Results

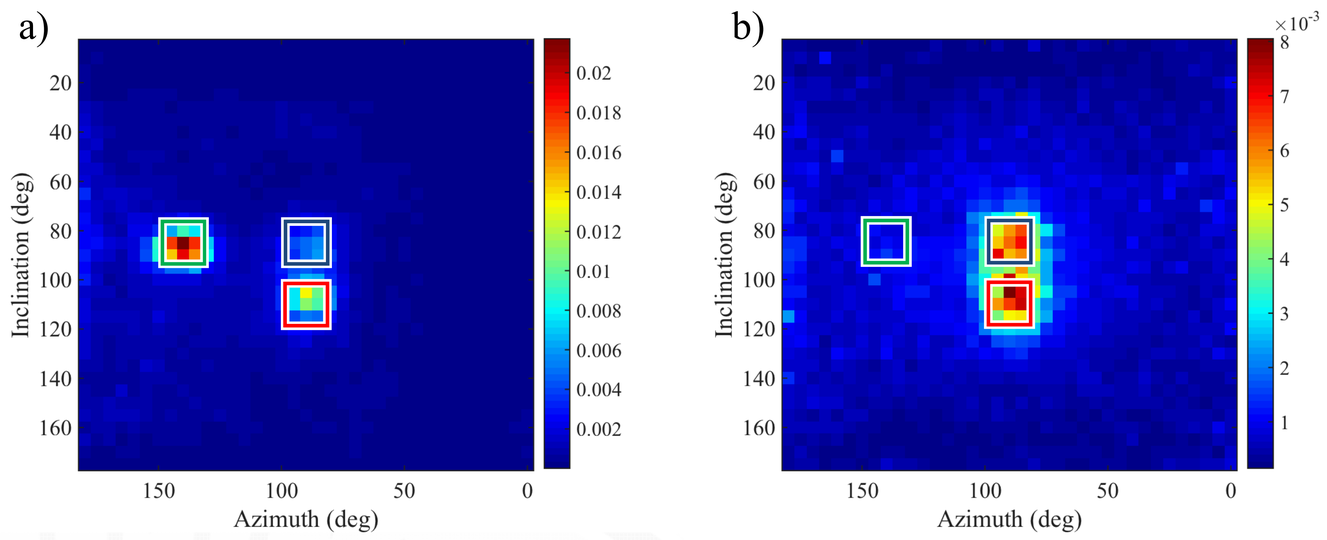

Fig. 4. Neutron image reconstructed between 1 and 10 MeV (a). Photon image reconstructed between 0.3 and 5 MeV (b). Boxes signify the 3×3-pixel regions used for energy spectrum analysis.

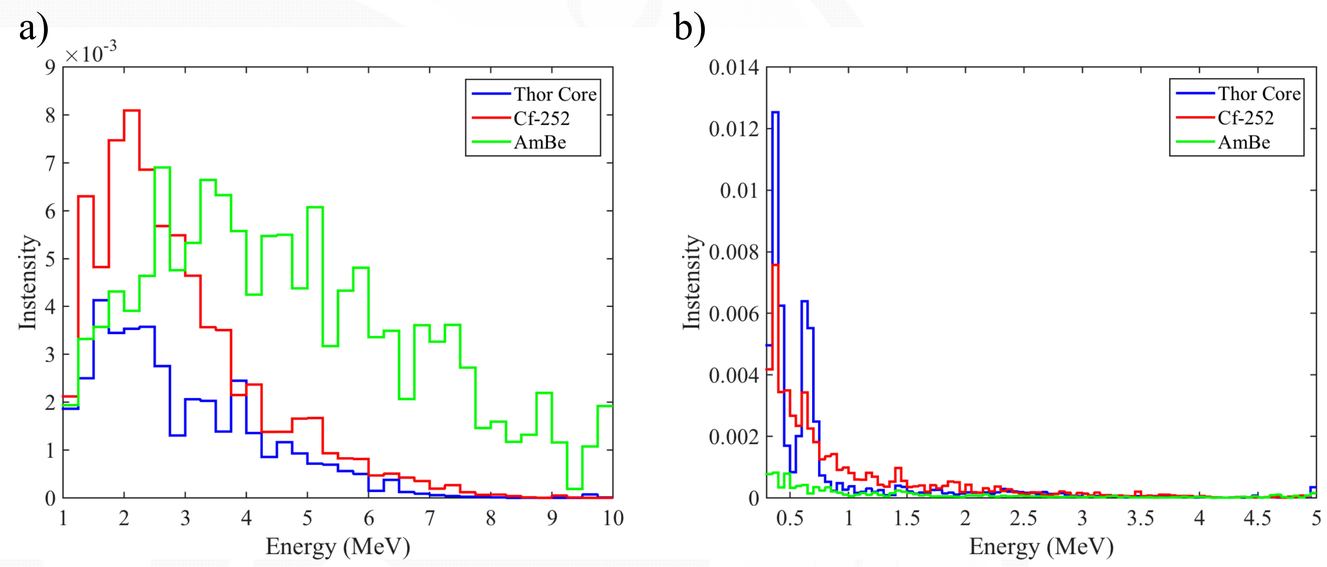

Fig. 5. Neutron energy spectra reconstructed between 1 and 10 MeV (a). Photon energy spectra reconstructed over between 0.3 and 5 MeV (b). Spectra come from 3×3-pixel regions shown in the reconstructed images.

Conclusions

- The DPI was able to locate all three sources present within the field-of-view.
- Neutron spectrum analysis shows the presence of two fission sources (Watt distribution) and one (α,n) source.
- Photon spectrum analysis shows that one fission source is accompanied by gamma lines associated with plutonium and its decay products.
- Lack of photon spectrum suggest that (α,n) source is shielded by a high-Z material.

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  - University of Michigan: David Goodman, Michael Streicher, Michael Hamel, Kyle Polack, Zhong He, Sara Pozzi
  - North Carolina State University: Jonathan Mueller, John Mattingly
  - Oak Ridge National Laboratory: Jason Newby

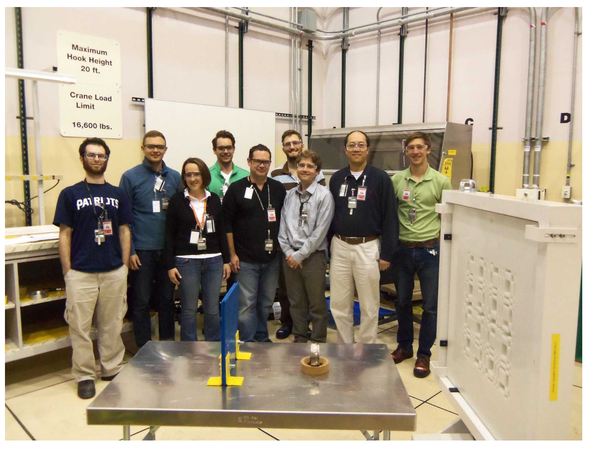

Fig. 6. Participating members of 2015 DAF Campaign.

National Nuclear Security Administration

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