Imaging Special Nuclear Material using a Hand-Held Dual Particle Imager

William Steinberger[1], Nathan Giha[1], Peter Marleau[2], Shaun Clarke[1], Sara Pozzi[1]
[1]University of Michigan, [2]Sandia National Laboratory
William Steinberger, wmst@umich.edu
Consortium for Verification Technology (CVT)

Introduction and Motivation

- Emergency responders, inspectors and warfighters require a low-power, compact, light-weight, inexpensive and durable imager to be able to successfully locate sources of radiation
- To do this, we propose a system composed of stilbene bars coupled to silicon photomultipliers (SiPMs) to produce a dual-particle imager

Mission Relevance

One of the missions of the NNSA is to reduce the threat to national security posed by nuclear weapons proliferation or the illicit trafficking of nuclear materials. This proposed detector system would give those charged with the defense of our country a compact imager that has been shown to be capable of detecting and imaging special nuclear material (SNM).

Prototype

Imaging Techniques:

- Simple Back-Projection (SBP)
- List-Mode Maximum Likelihood Expectation Maximization (LM-MLEM)

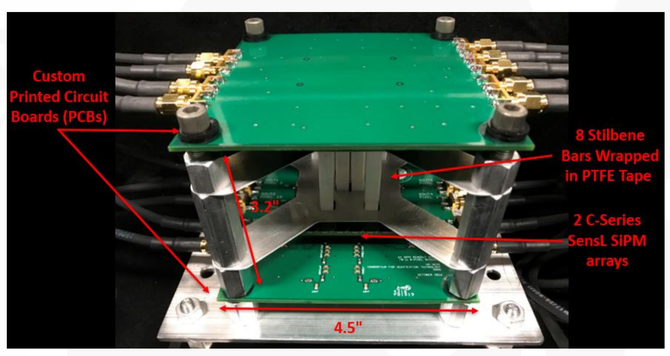
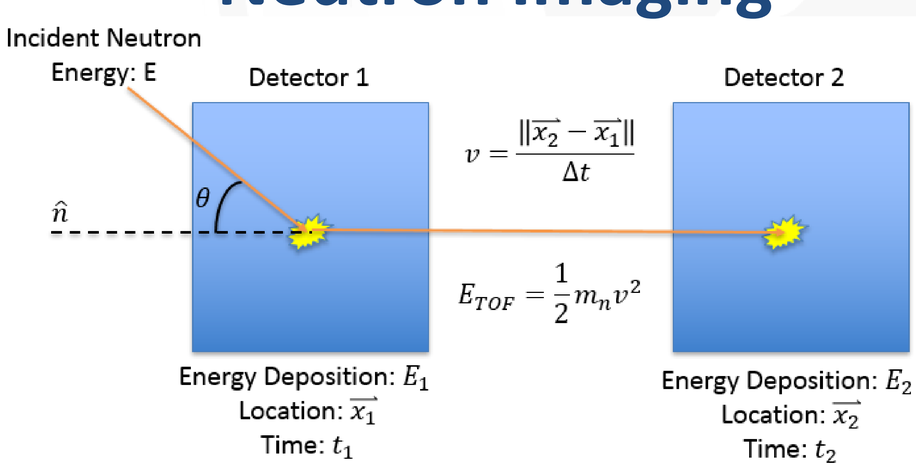


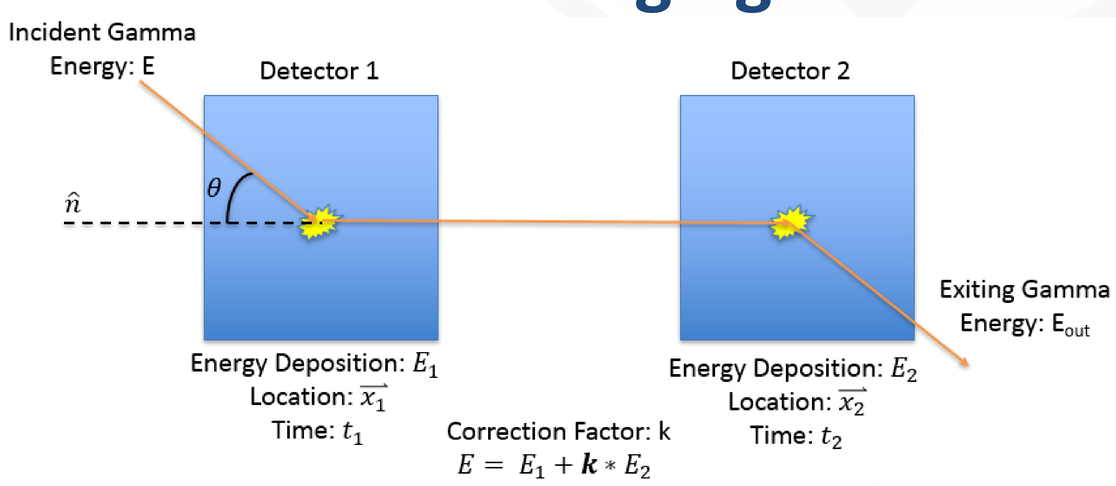
Figure 1: Photograph of the prototype hand-held dual particle imager (H2DPI)

Neutron Imaging



From this information we can find: $E = E_{TOF} + E_1$ and $\alpha = cos^2(\theta) = \frac{E_{TOF}}{E}$

Gamma Imaging



From this information we can find: $\alpha = cos^2(\theta) = (1 - \frac{m_e c^2 E_1}{E(E-E_1)})^2$

Neutron Imaging Results

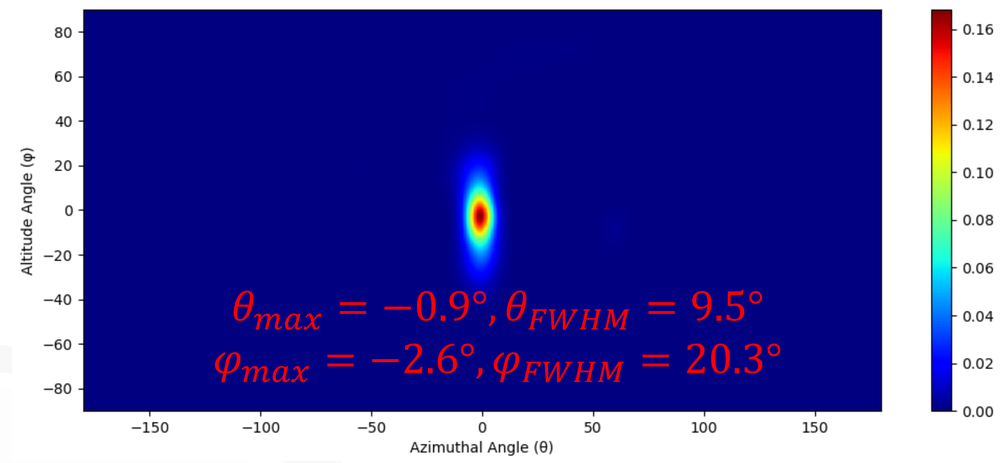


Figure 2: Neutron image of a 1E7 n/s Cf-252 source measured for 30 minutes at 58.4 cm with 25 iterations of LM-MLEM applied to the image

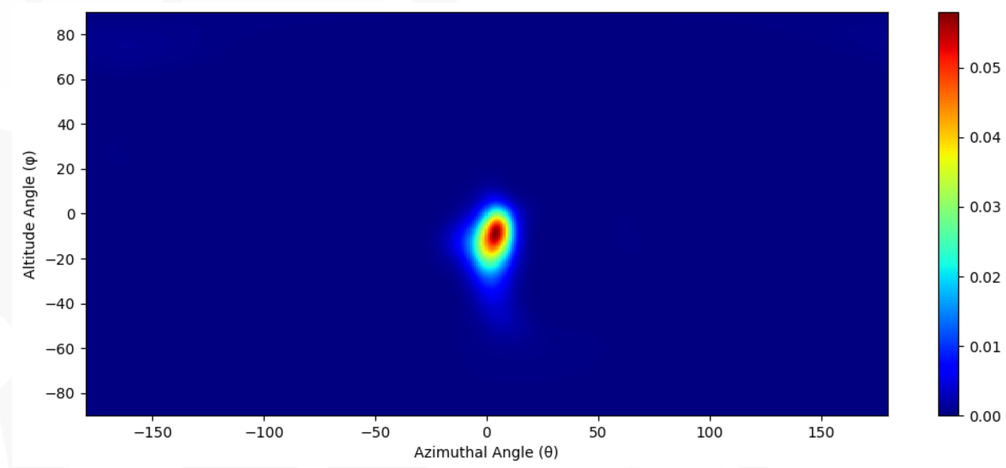


Figure 3: Neutron image of the BeRP Ball (4.5 kg of α-phase WGPu) measured for 30 minutes at 52 cm with 10 iterations of LM-MLEM applied to the image

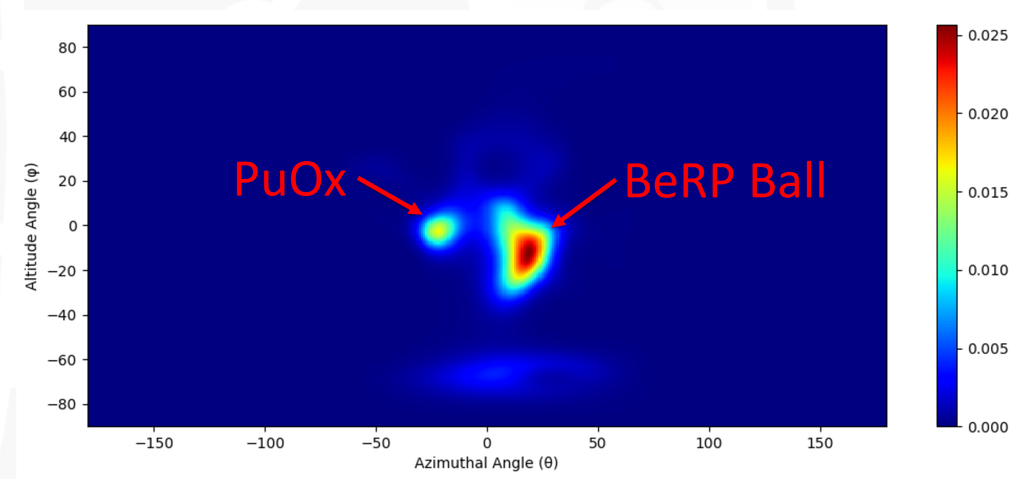


Figure 4: Neutron image of the BeRP Ball and a PuOx canister (3.3 kg of WGPu) measured for 30 minutes at 56 cm with the objects separated by 50 cm with 10 iterations of LM-MLEM applied to the image

Gamma Imaging Results

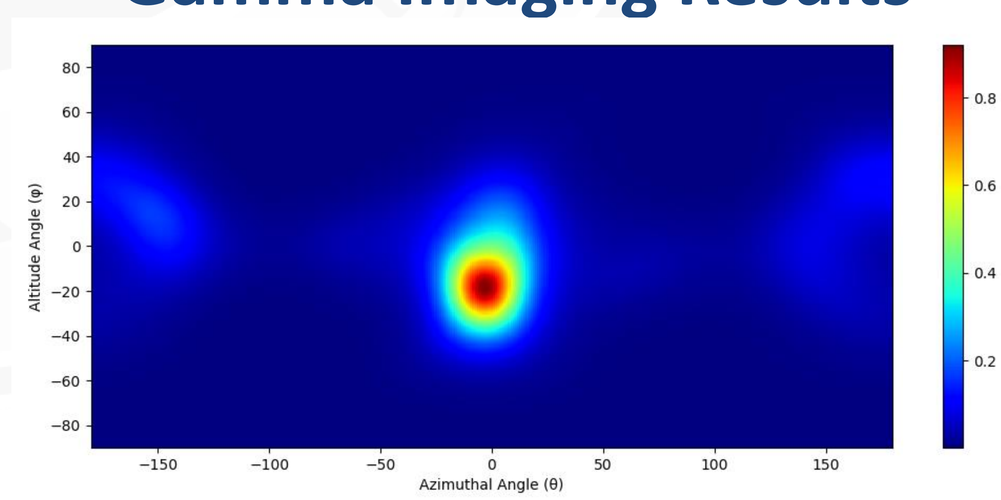


Figure 5: Gamma image of the Neptunium Sphere (6 kg of metal Np-237) with a ½" Fe reflector measured for 45 minutes at 46 cm with 75 iterations of LM-MLEM applied to the image

Conclusion

This work demonstrates the functionality of the H2DPI as well as the necessity to be able to image both gamma-rays and neutrons for locating and identifying special nuclear material.

This work was funded in-part by the Consortium for Verification Technology under Department of Energy National Nuclear Security Administration award number DE-NA0002534 and the Department of Defense, Defense Threat Reduction Agency under contract number HDTRA117C0046.

National Nuclear Security Administration