Extracting Neutron Energy Spectra Using a Handheld Dual Particle Imager

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Handheld Dual Particle Imager

- 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
- We propose a system composed of stilbene and LYSO(Ce) pillars coupled to silicon photomultipliers (SiPMs) to produce a scatter-based handheld dual-particle imager (H2DPI)
- Reconstructing neutron double-scatter events yields the energy of the incident neutron, allowing for spectroscopic identification of neutron sources

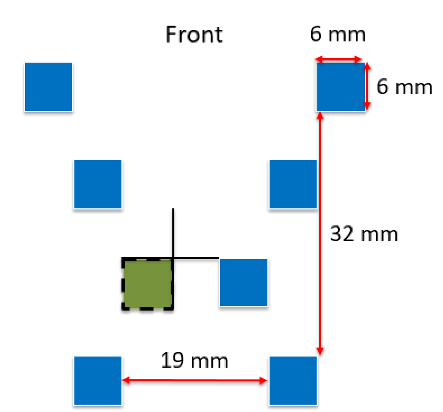

Figure 1. Layout of the H2DPI where blue represents stilbene pillars and the green represents a LYSO(Ce) pillar.

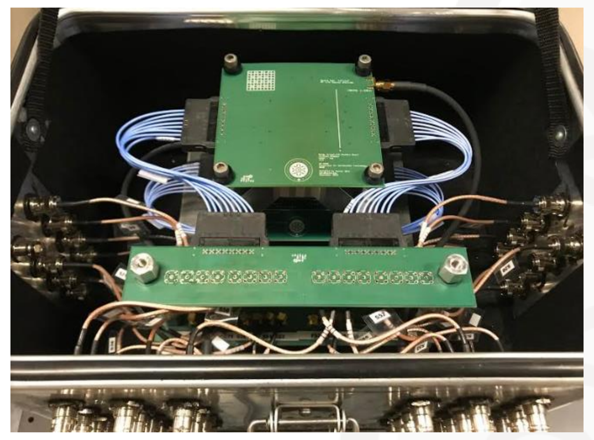

Figure 2. Photograph of the H2DPI.

Neutron Imaging

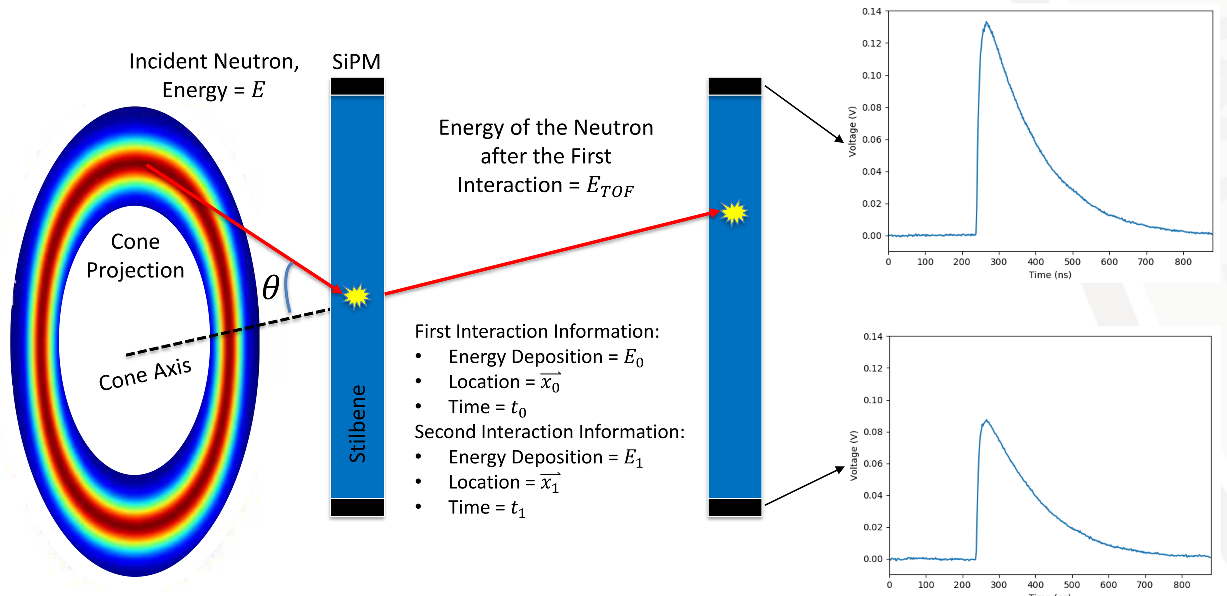

Figure 3. Depiction of a neutron double-scatter event within the H2DPI.

- Summing the energy deposition of the incident neutron in the first interaction, E_1, with the time-of-flight energy, E_{TOF}, yields the energy of the incident neutron

$$E_{TOF} = \frac{1}{2} m_n \frac{\|\vec{x_1} - \vec{x_0}\|}{t_1 - t_0} \quad (1)$$

$$E = E_1 + E_{TOF} \quad (2)$$

$$\cos\theta = \sqrt{\frac{E_{TOF}}{E}} \quad (3)$$

Technical Approach

- An experiment was designed using a ^{252}Cf and PuBe source to determine if the sources can be separated and differentiated by neutron imaging
- The sources were separated by 55.6°

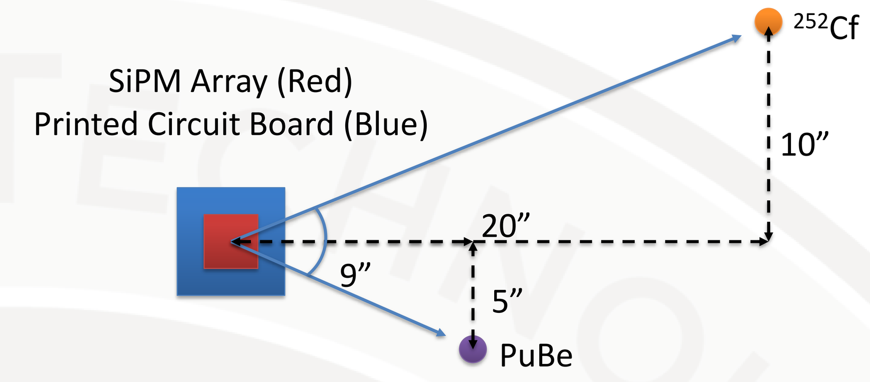

Figure 4. Experimental setup for the H2DPI measuring a ^{252}Cf and PuBe source in the same field of view.

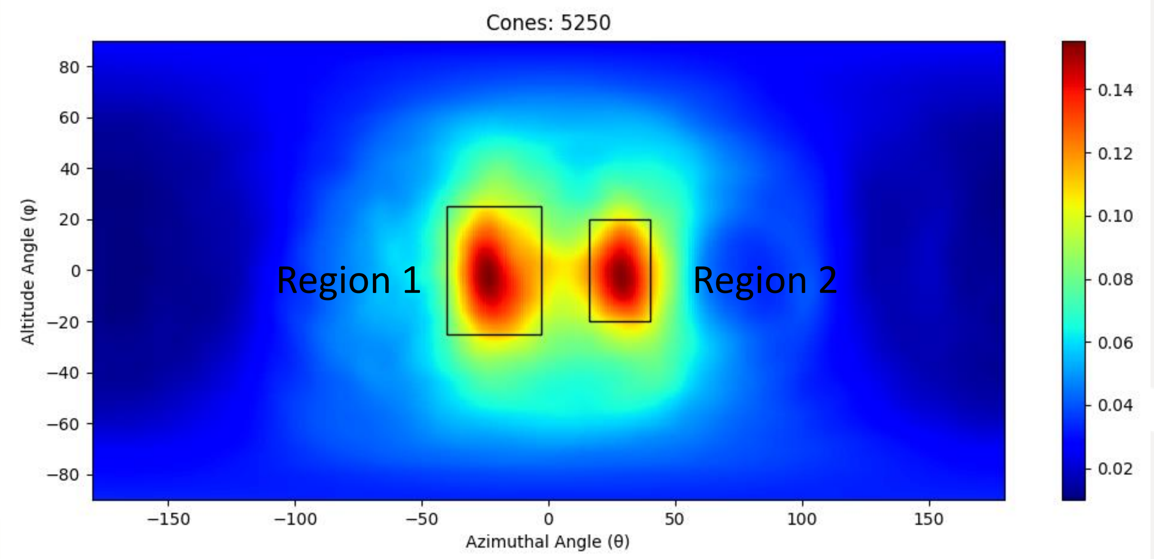

Figure 5. Reconstructed simple backprojection (SBP) image of the measurement shown in Figure 4.

The following analysis was performed to extract the energy spectra from the SBP image shown in Figure 5:

1. Regions were arbitrarily identified for each source
2. If a cone projection intersects one of the defined regions, then the incident neutron energy is counted towards that region
3. If a cone projection intersects both regions or neither region, then the projection is not counted

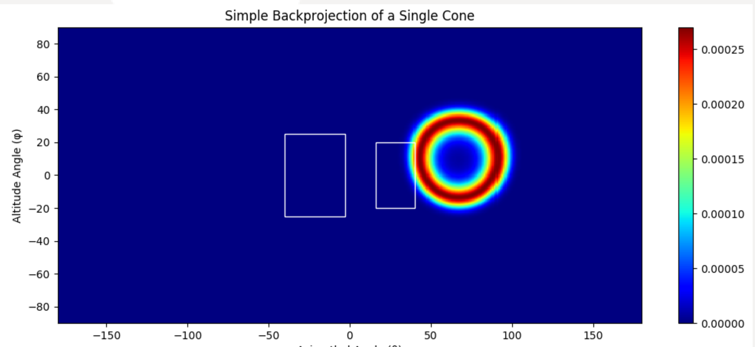

Figure 6. Example of a cone projection that would count for Region 2.

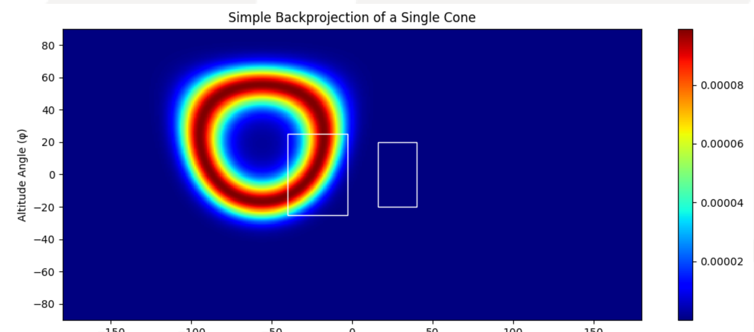

Figure 7. Example of a cone projection that would count for Region 1.

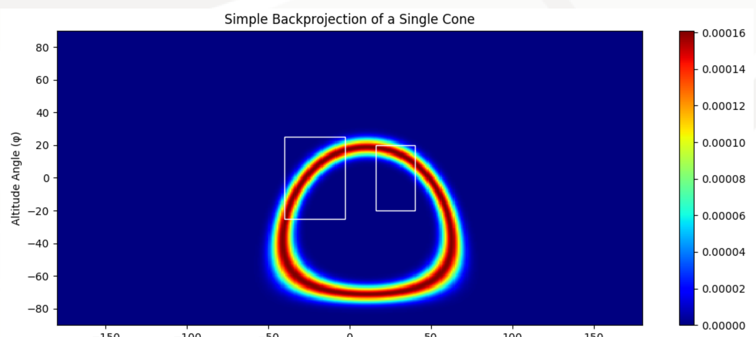

Figure 8. Example of a cone projection that would not be counted.

Results

Average neutron energy spectra for each region:

$$\langle E_{R_1} \rangle = 2.90\ MeV$$

$$\langle E_{R_2} \rangle = 3.91\ MeV$$

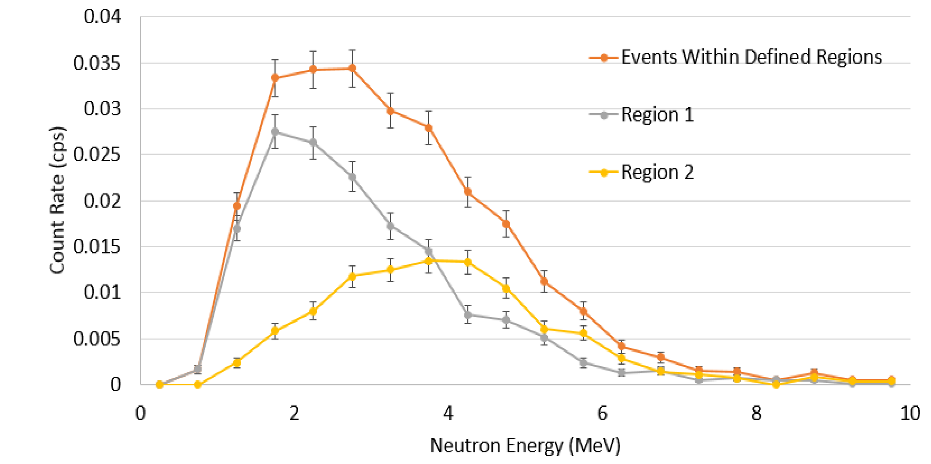

Figure 9. Measured neutron energy spectra for the SBP image shown in Figure 5.

The experiment shown in Figure 4 was repeated with each source individually to validate the extraction analysis

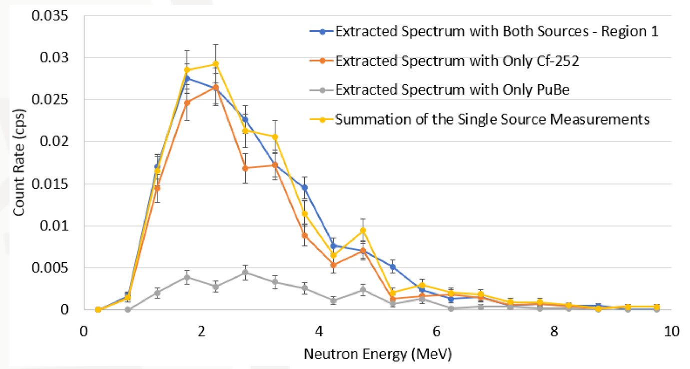

Figure 10. Measured neutron energy spectra for Region 1 in the SBP image shown in Figure 5.

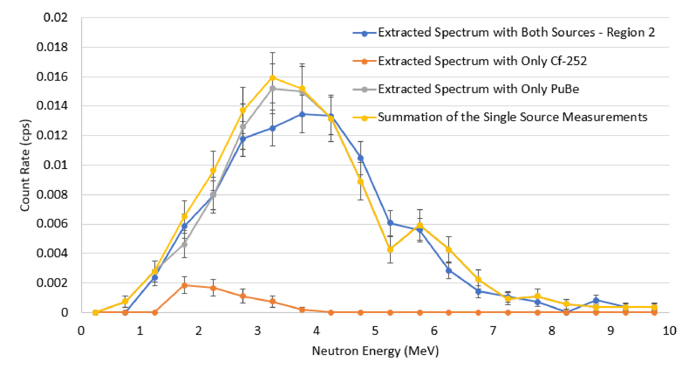

Figure 11. Measured neutron energy spectra for Region 2 in the SBP image shown in Figure 5.

MTV Impact

- MTV has given us the opportunity to measure significant quantities of special nuclear material through measurement campaigns. We hope to apply this methodology in future campaigns.

Conclusion

- We demonstrated neutron spectra extraction and identification of a ^{252}Cf source and a PuBe source in the same field of view
- This work demonstrates that neutron scatter cameras can be used by the NNSA for neutron-spectroscopic source identification

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