Validation of Neutron Simulation Framework for Scintillator-based Imaging Systems

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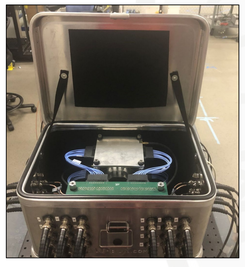
Introduction and Motivation

- Comparing a simulated (MCNP) model of the H2DPI system against experimental results
- Verify and validate the simulation

Mission Relevance

- Supports the NNSA in the mission of nonproliferation – Global Material Security
- Accurate, validated simulations are used to
  - Generate training data for AI programs
  - Better the understanding of scatter-based imaging systems

H2DPI (Dual Particle Imager)



- 12 - 6 x 6 x 50 mm^3 organic glass scintillators
- 8 - 6 mm (diameter) x 6 mm (length) $CeBr_3$ inorganic scintillators
- Compactly measures the spectrum of and images incoming neutrons and gamma rays

^{252}Cf was measured and simulated at both -20 and +20 azimuth (Figure 1)

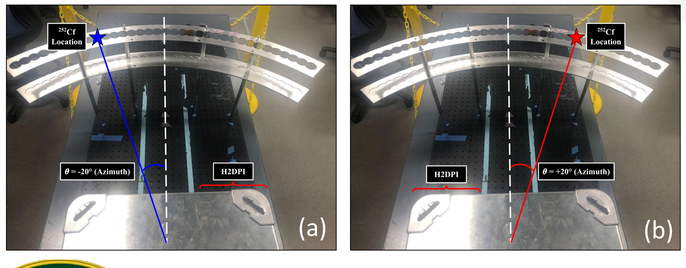


Figure 1: Measurement position for -20 (a) and +20 (b)

Results

- **Time broadening was implemented in the simulation post processing**
  - Smoothed out the E_{TOF} uncertainty Curve (Figure 2)
  - Reduced the ratio of values between the simulation and experiment from 3.06 to 2.87
- **Z position broadening was implemented in the simulation post processing**
  - Further reduced the ratio down to 2.72
- Simulation reconstructed neutron response spectra comparison magnitude improved (Figure 3)

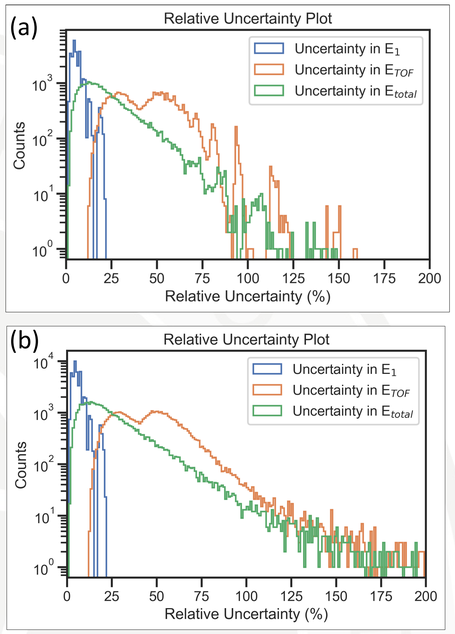


Figure 2: E_{TOF} uncertainty before (a) and after (b) time broadening

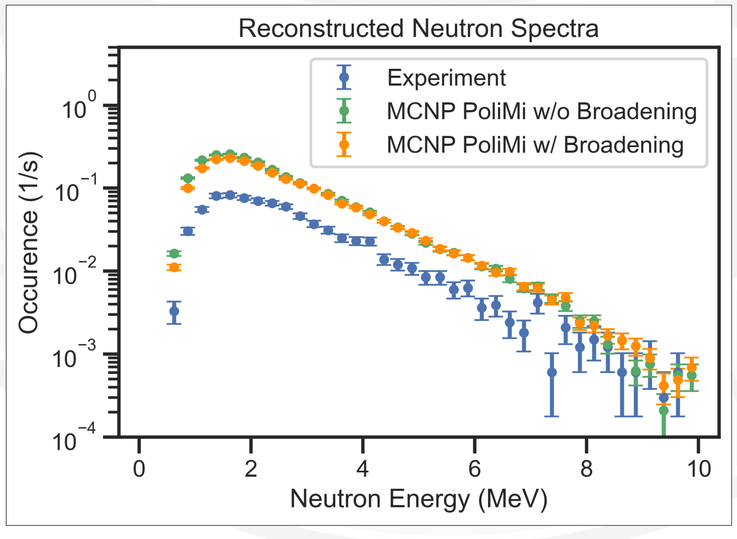


Figure 3: Comparison of the reconstructed neutron spectra for experimental and simulated data without and with time and Z position broadening.

- **Simulation post processing methods were matched to the experimental post processing methods**
- Experimental outlier at 7.357 MeV was removed for the ratio calculations
- Log scale causes minor improvements to be harder to see visually
- Future steps are expected to have a larger visible impact on spectra similarity

Expected Impact

- Efficient data generation for future radiation imager design improvements
- Validated experiment allows for confident generation of training data for AI models
- Ability to further evaluate performance of the system for a range of applications

MTV Impact

- The MTV fellowship enabled me to do this research
- This work supports the NNSA Global Material Security Branch in the verification of nuclear material

Conclusion

- Time and Z position broadening were implemented to further improve the accuracy of the simulation
- This work supports the NNSA Global Material Security Branch in the verification of nuclear material using scatter-based imaging

Next Steps

- Introduce equivalent PSD sampling response in the simulation data
- Implement broadening for the simulation light outputs to better match light output observed in experiment

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