Simplified Neutron Scatter Camera for Nuclear Safeguards Applications

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Introduction and Motivation

- Neutron imaging systems can provide valuable spatial information in about neutron sources
- Many successful systems have been made, but most are large, expensive, or have complicated readout, making widespread adoption in the safeguards repertoire difficult
- This project seeks to build a simplified, less expensive prototype neutron scatter camera that can perform satisfactory source localization

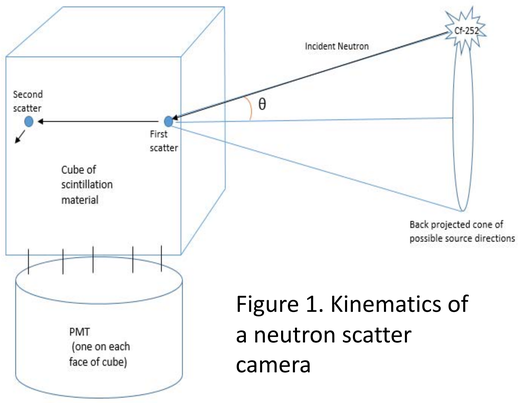


Figure 1. Kinematics of a neutron scatter camera

Mission Relevance

- An affordable, mobile neutron imaging system could be of use in managing nuclear materials, treaty verification, accident response, external reactor core monitoring, and security in smuggling or diversion scenarios.

Technical Approach and Results

- Prototype simulation performed using MCNP-PoliMi
- Cube-shaped fast plastic scintillator EJ-230 chosen for good timing and relatively high light yield
- PMTs coupled to each of the 6 faces of the cube
- Positions of neutron scattering events within scintillator volume determined by analyzing the ratios of light arriving at photodetectors
- Simulations show ability to localize point and distributed neutron sources

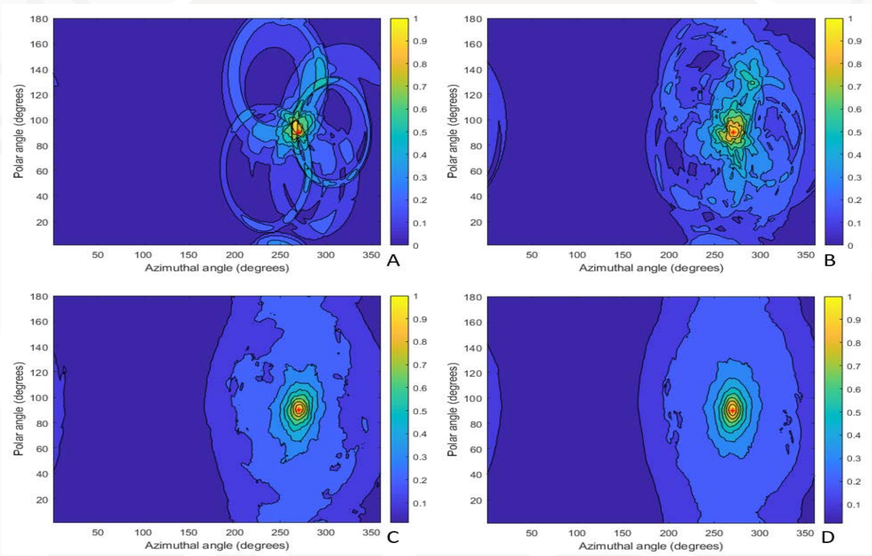
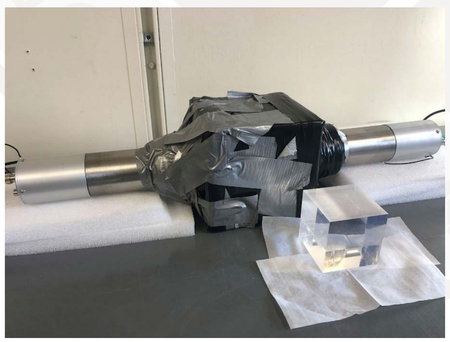
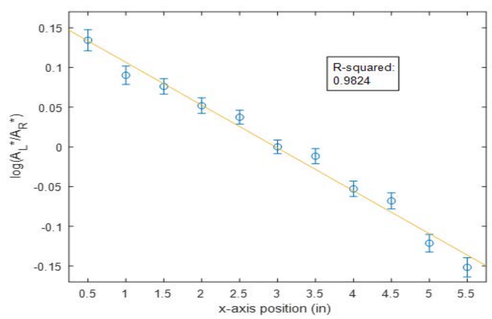


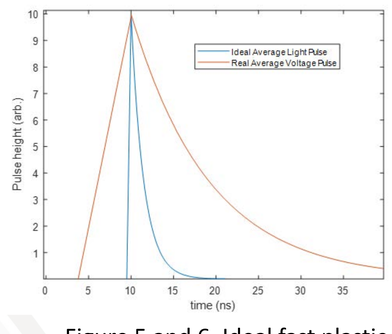
Figure 2. Simulated localization of neutron source at (270,90) with A) 10 B) 30 C) 300 and D) 1000 back projected cones with 1 MeV energy deposition cutoff.

- Based on simulation results, a 1D prototype has been constructed and properly calibrated





Figures 3 and 4. 6-in side length 1D scatter camera prototype and neutron scatter position calibration curve



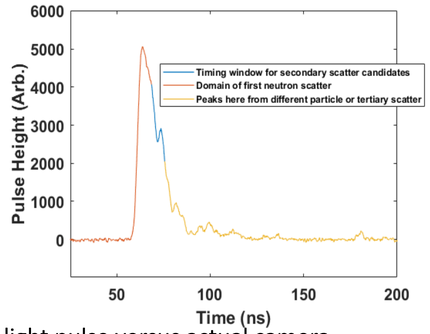


Figure 5 and 6. Ideal fast plastic light pulse versus actual camera readout and candidate neutron double scatter event

MTV Impact

- MTV, and previously CVT, were instrumental in my two National Lab internships at Brookhaven in 2019 and Los Alamos in 2017
- During my time with MTV and CVT, I have presented at the 2019 Workshop and the 2019 INMM Annual meeting
- Three journal articles on work supported by MTV in progress

Conclusion

- Simulations and preliminary prototype results show promise in the production of a simplified neutron scatter camera that does not require expensive fast photodetectors
- While this prototype is not as efficient or accurate in localizing sources as other designs, the hope is that the lower price tag and compact size will make it viable in some safeguards scenarios

Next Steps

- Creation of light response curve for neutrons in fast plastic
- Development of script to automatically identify neutron double-scatter candidates
- Add more photodetectors to prototype to increase imaging dimensionality
- Test efficiency and resolution of camera and demonstrate capabilities in test cases based on safeguards scenarios

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