Introduction

- Neutron scatter cameras use the kinematics of elastic neutron-proton scattering to estimate the incoming direction of neutrons to locate SNM or other neutron-emitting sources.
- Neutrons must scatter twice in the detector to reconstruct incident neutron direction.
- Single volume design enables an order-of-magnitude efficiency increase compared to a dual plane neutron scatter camera developed at Sandia National Laboratories.

Methods (cont.)

- Scintillation response, transit time spread, and photodetector impulse responses obtained from manufacturer data.
- Nominal response functions tabulated by simulating 10^7 scintillation photons in 0.5 cm increments in Geant4.
- Channel response functions estimate temporal spread of photons as they propagate through the pillar.
- We fit the observed responses to nominal responses (Figure 2) using Broyden-Fletcher-Goldfarb-Shanno minimization (MLEM) method and a negative log Poisson likelihood objective function.

Results (cont.)

- Scintillation timing uncertainty estimated using constant fraction discrimination (CFD) and MLEM (Figure 4).
- MLEM and EJ-230 outperformed the other scintillators and methods where MLEM and EJ-230 resulted in a ~25% better timing uncertainty compared to CFD.

Conclusions

- Scintillator of choice for an optically segmented neutron scatter camera is EJ-230 due to having fast and bright scintillation (~0.55 cm).
- Overall, MLEM yields the lowest scintillation position uncertainty.
- The fast rise time of an SiPM results in the best scintillation time estimates.
- Excluding events in neighboring pillars increases source localization precision.

Figure 1: Instrument conceptual design using pillars of scintillator and angular definition.

Figure 2: Nominal responses created using Equation 1. a) Responses using stilbene/SiPM combination. b) Responses using EJ-204/MCP-PM combination.

Figure 3: Comparison of scintillation position uncertainty at 2 MeV using MLEM, the timing of the two opposing waveforms (LE), and the overall light intensity for three scintillators.

Figure 4: Timing uncertainty comparison of constant fraction discrimination and MLEM for three scintillators.

Figure 5: Azimuth angle uncertainty after 15 MLEM iterations to a Cf-252 point source. Excluded events due to interaction in neighboring pillars counted towards the number of back-projected cones.