SNM Detection Using Time-Encoded Imaging

MTV Kickoff Meeting

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Introduction and Motivation

Disarmament Verification

- Count warheads as opposed to delivery vehicles (upgrading New START)
- Verify SNM is separated from high explosives

Google Maps. (2018). 32.1502366, -110.821673

Treaty Verification

- Verify ICBMs are not carrying MIRVs
- START II style treaty

https://en.wikipedia.org/wiki/Multiple_independently_targetable_reentry_vehicle

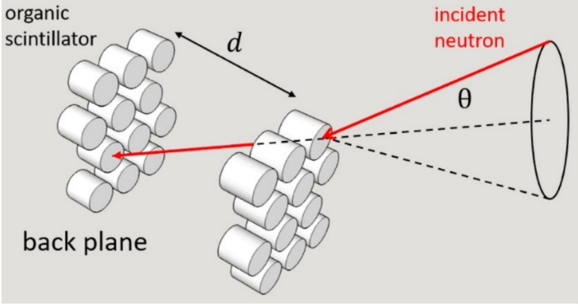
Nuclear Safeguards

- Continuous surveillance and accounting of sources within a storage vault or vessel
- Search for undeclared sources in an access restricted setting

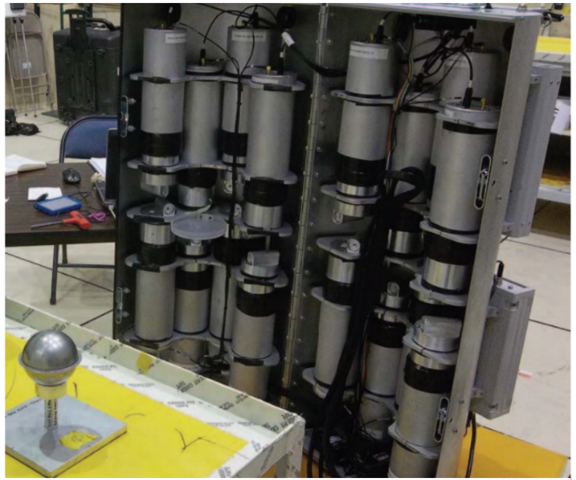
Monzano Alarm and Nuclear Material Consolidation Project

Approach: Radiation Imaging

Scatter Camera

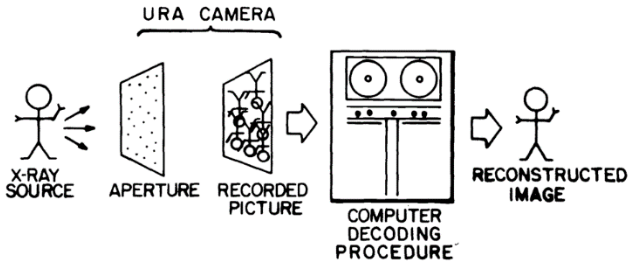


K. Weinfurther, "Model-based design evaluation of a compact, high-efficiency neutron scatter camera", NIMA, 2018.

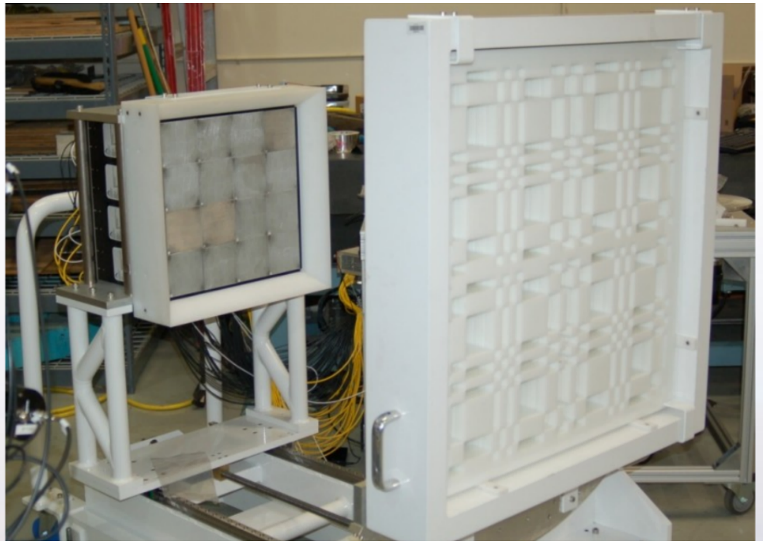


J. Goldsmith, "Additional capabilities of a compact neutron scatter camera", NSS/MIC 2015.

Spatial Coded Aperture

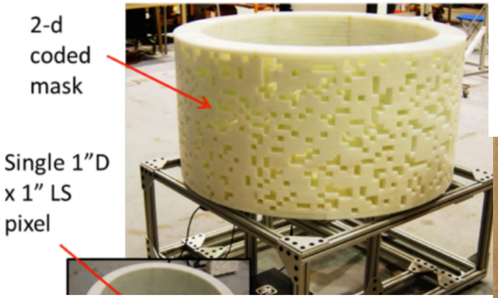


T. Cannon, "Coded aperture imaging: many holes make light work", Optical Engineering, 1980.



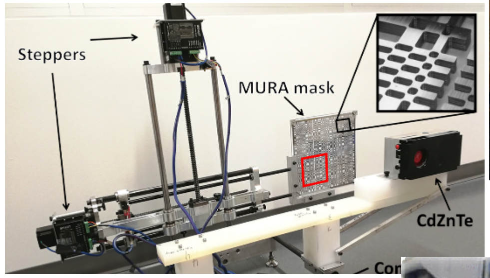
P. Marleau, Fast Neutron Detection and Imaging, NSSC Summer School, 2011, SAND2011-6904P.

Time-Encoded Imaging



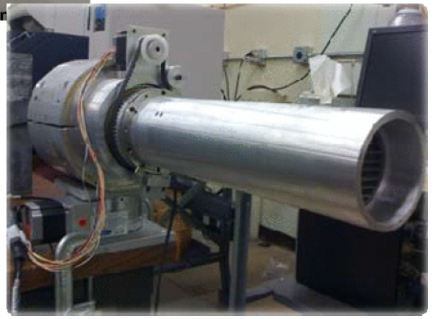
P. Marleau, "Time encoded fast neutron/gamma imager for large standoff SNM detection," IEEE NSS 2011.

J. Brennan, "Demonstration of two-dimensional time-encoded imaging of fast neutrons", NIMA, 2015.

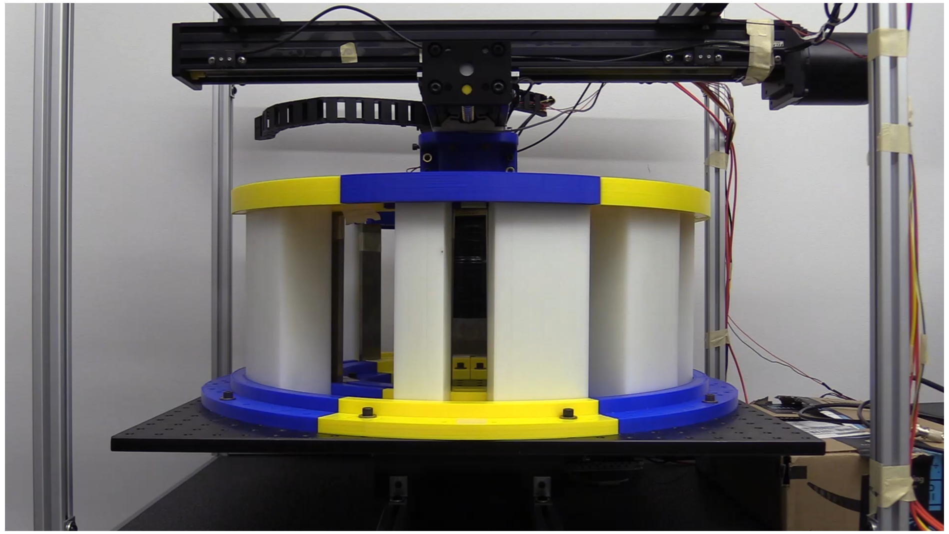


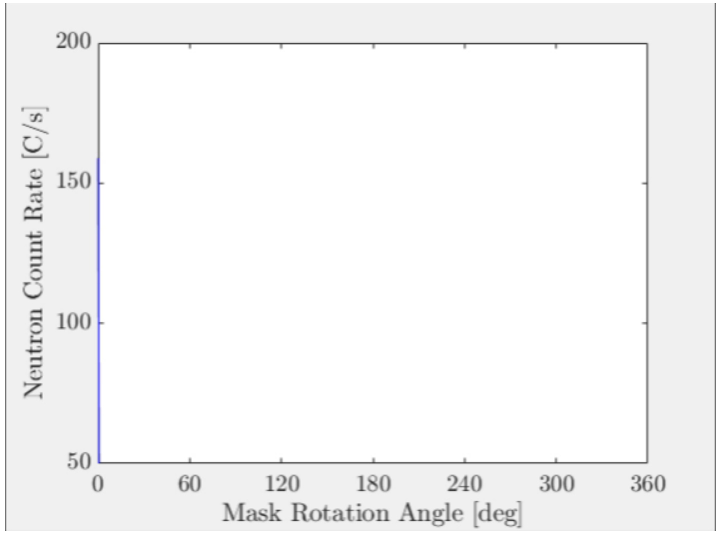
S. Brown, "Time-encoded thermal neutron imaging using large-volume pixelated CdZnTe detectors", UM Thesis 2017.

D. Willcox, "Adaptive imaging using a rotating modulation collimator (RMC)", IEEE NSS 2010.



Time Encoded Imaging





Advantages

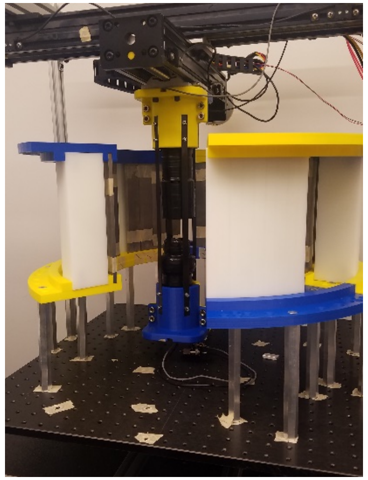
- Works for any detector
  - High resolution gamma, fast/thermal neutron
- Simplicity => few detectors, robust, and fieldable
- Easily inspectable

Attributes	Scatter Camera	Coded Aperture	Time-Encoded
Directionality	Double scatter physics	Spatial encoding	Temporal encoding
Detector Requirements	**Position & energy resolution**	**Position resolution**	**Minimal**
Channel Count	**High**	**High**	**Minimal**
Mask	N/A	Planar	Moving
Resolution	Coupled with detector	Only geometry	Only geometry
Sensitivity	Low	High	Moderate
Field of View	4π	Limited	$>2\pi$

Technical Work Plan

Adaptive Imaging

- Given we've collected some data, how should we modify the imaging system to collect new data?
- Searching for a weak source in the presence of a strong source

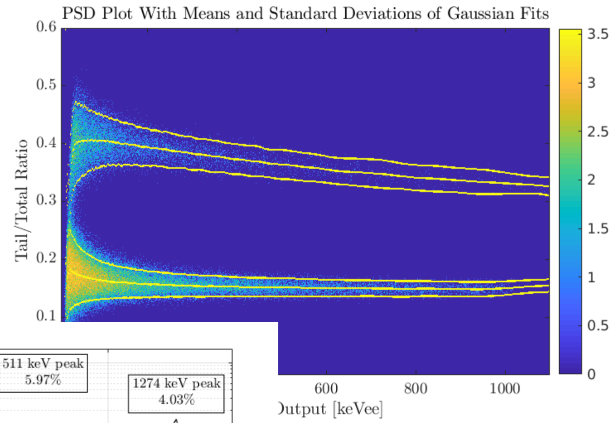


MATADOR System

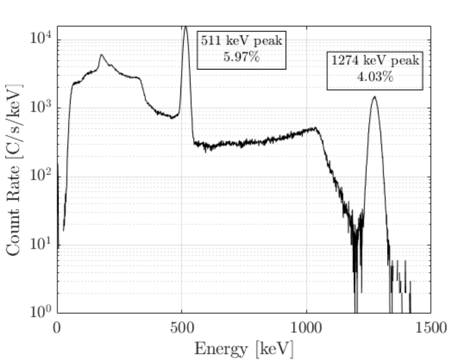
Multiple Particle Imaging

- Leverage gamma and neutron signatures to search for SNM
- Low- and high-Z shielded SNM

Stilbene



CLLBC



Portable TEI System

- Bring in the mask close to the detector
  - Sacrifice resolution?
  - Make the system handheld/portable
- Fast neutron imaging

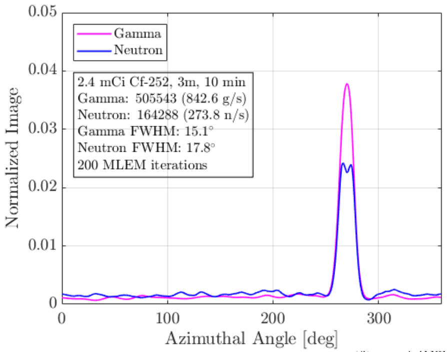
Collaboration with National Labs

- Expanding connection with Sandia on multiple projects
  - CONFIDANTE
  - Adaptive imaging
  - Portable TEI

Expected Technical Impact

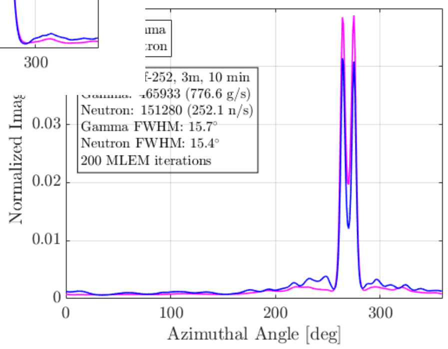
Adaptive Imaging

- Higher resolution images given the same size constraint
- Combining more unique information to reduce uncertainty



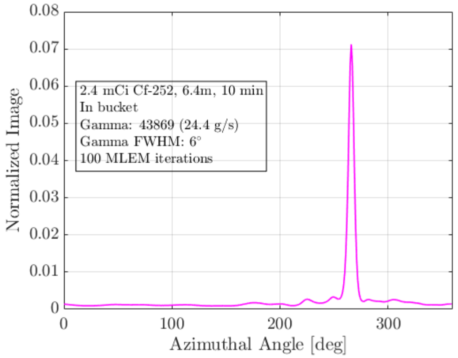
Conventional

Adaptive



Multiple Particle Imaging

- Improve detection efficiencies by combining data from multiple particles
  - Reduced measurement time or higher confidence
- Improve search capabilities for shielded sources



Portable TEI System

- Provide a portable, fast neutron imaging system that inspectors can use in facilities
- Combine radiation data with 3D mapping to assist in localization

Testing and Evaluation

- Measurement campaign at INL
  - Test system with SNM
  - Multiple and extended SNM sources
  - Portable TEI

MTV Impact

- Fostering strong collaborations across radiation imaging researchers
- Expertise and access of the national labs in shaping and guiding our research
  - Working with SNL on all projects
  - Testing and evaluation at INL
- Access to SNM in significant quantitates as opposed to surrogate sources
- Training of students through internships and conferences

Acknowledgements

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