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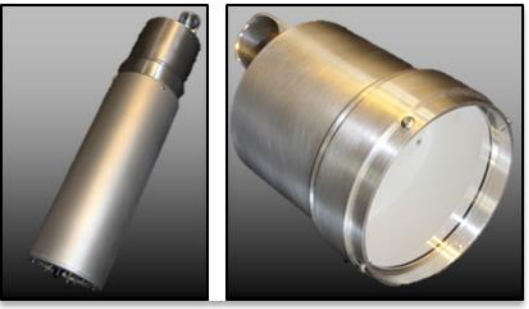

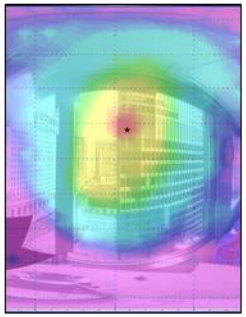

MINER – A Mobile Imager of Neutrons for Emergency Responders

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U.S. DEPARTMENT OF ENERGY

NNSA National Nuclear Security Administration

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Background

- PI: John Goldsmith
- Mobile Imager of Neutrons for Emergency Responders (MINER)
- Compact neutron scatter camera provides omni-directional (4π) imaging with only a ~twofold decrease in sensitivity compared to our much larger neutron scatter camera.
- Optimized for fission energy (1-10 MeV) neutrons localization and energy spectrum reconstruction.

The Neutron Scatter Camera

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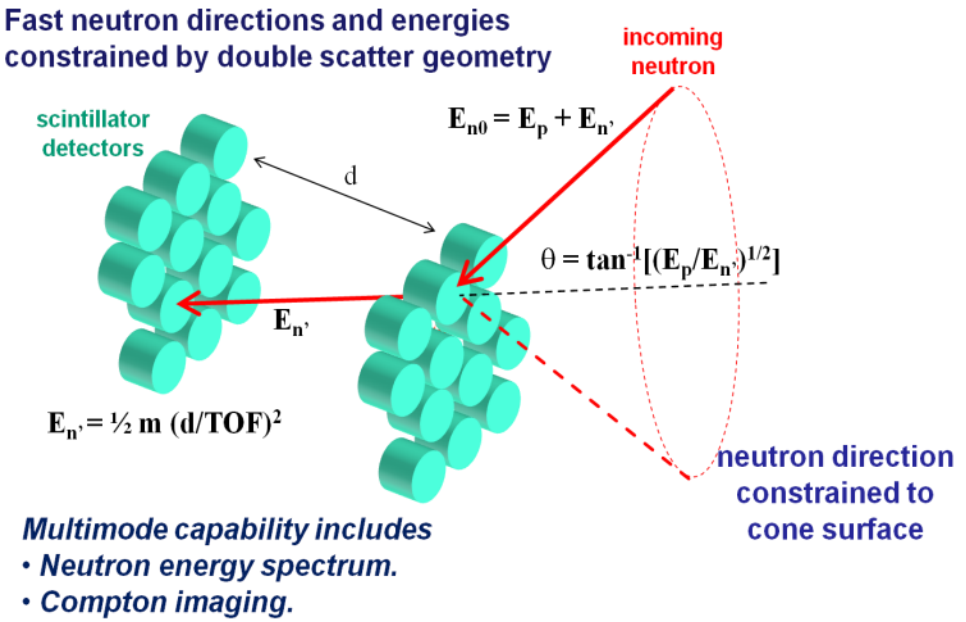
- Sandia has been developing the Neutron Scatter Camera concept for almost a decade.
- Technique relies on detecting neutron-proton recoil in two separate cells, as well as the time between the two events.
- System measures energy, pulse-shape, and timing of every event.
- Pulse shape allows discrimination between neutron and gamma events.

Approximate Scaling…

Neutron Imaging and Spectroscopy

- Energy deposited in the first interaction (E_p) and the time-of-flight (τ) between the first and second interaction allows the neutron origin to be tracked back to the surface of a cone, and its initial energy reconstructed.



- Energy (E_n) = $E_p + E_{n1}$
- E_{n1} = Time-of-Flight energy
- Scattering Angle, $\tan^2(\theta) = E_p/E_{n1}$

MINER Advantages

- Spectroscopy:
  - Requiring two interactions allows a measurement of initial neutron energy, which can be important for discriminating between more benign industrial sources (AmBe) and Special Nuclear Material.
- Imaging:
  - In situations where more portable neutron counters are unable to get close enough, a neutron imager may locate sources faster.
- Portability:
  - While still weighing in at ~90 lbs, this detector brings the same advantages as the much larger scatter camera, while sacrificing only ~2x sensitivity and brings with it lower power electronics.
- Real Time Imaging:
  - LabVIEW and C++ DAQ systems produce real time images and spectra.

Portability

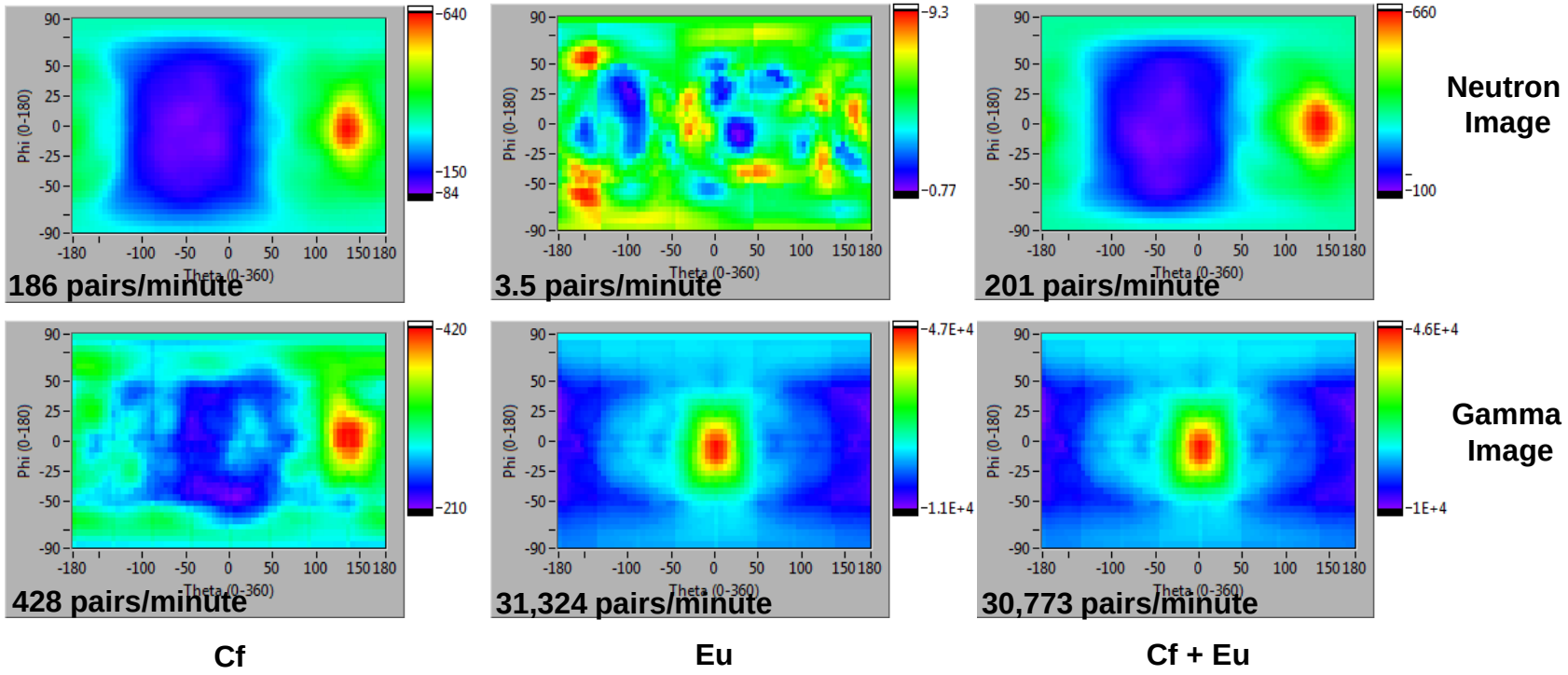
- MINER can be packed into a Pelican case in under ten minutes, and ships in this form factor with all the necessary equipment to operate.
- Battery operation can be accomplished for several hours using a car battery through the power distribution box (not shown, but also fits in this case).

Flexibility

- While primarily a neutron scatter camera, MINER's liquid scintillator volume can also be used for gross singles counting.
- Opened up, MINER also has the ability to perform fast neutron multiplicity measurements.
- Full digital list mode data output allows extensive post processing options, including full waveforms if necessary.

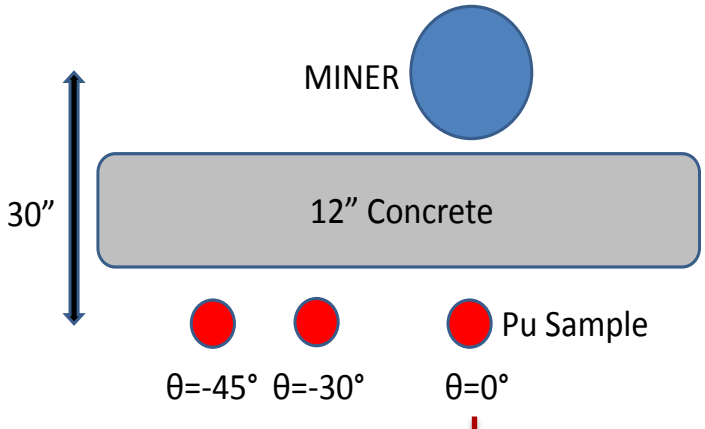
Gamma Rejection + Imaging

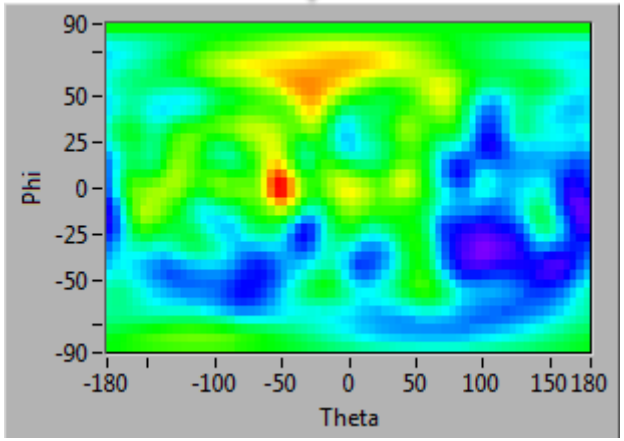
- ^{252}Cf source 2 m from MINER at a relative angle of 135
- ^{152}Eu source 1 m from MINER at a relative angle of 0
- (Background neutron rate: ~1.5 pairs/minute.)

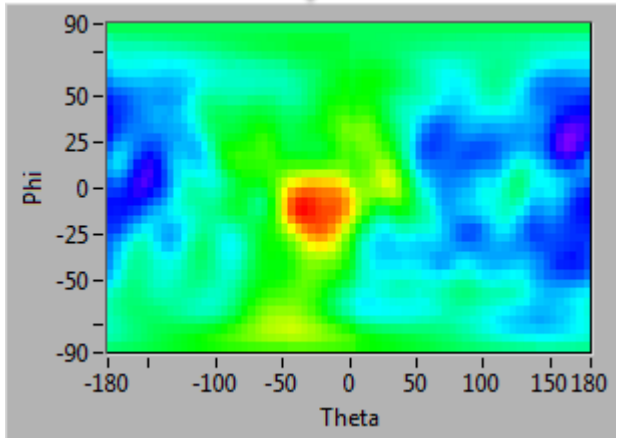


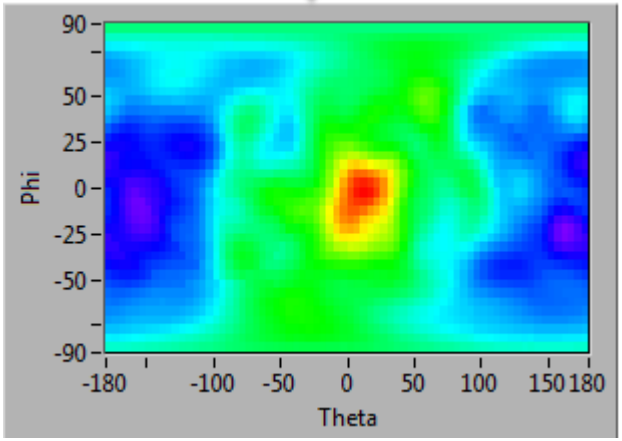
Monitoring SNM

- Small Pu source, study movement detection
- Images produced in 450 minutes
- No shielding, imaging in 2 hours
  - Weak source: imaging took time even without shielding



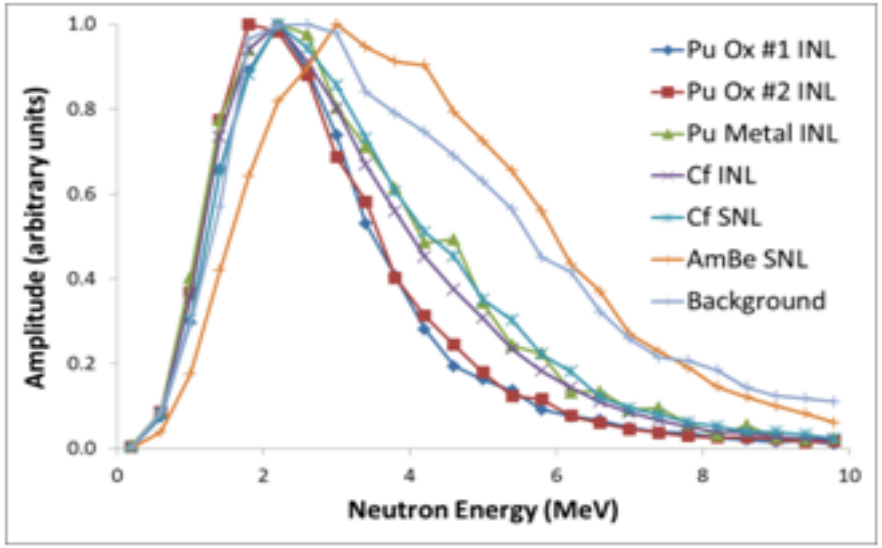


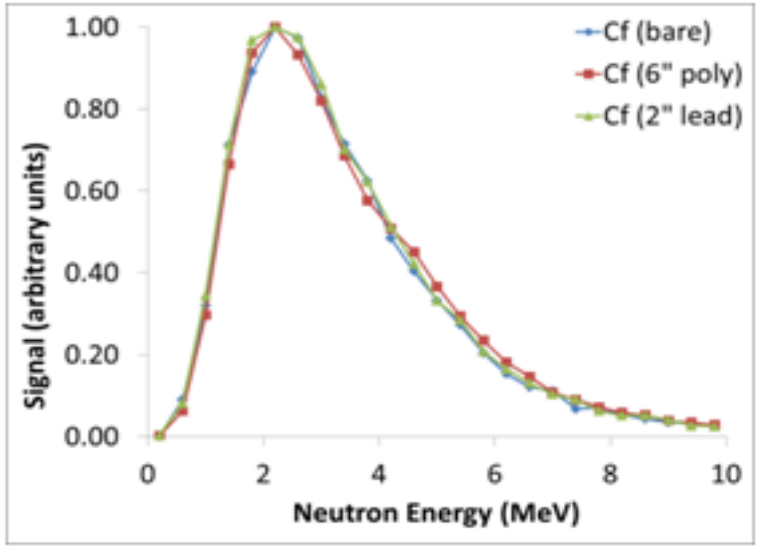




INL/Sandia, Spectroscopy

- Energy measurements made at the Idaho National Laboratory Zero Power Physics Reactor facility of Plutonium Oxide, Plutonium Metal, compared to Cf-252 and AmBe sources.

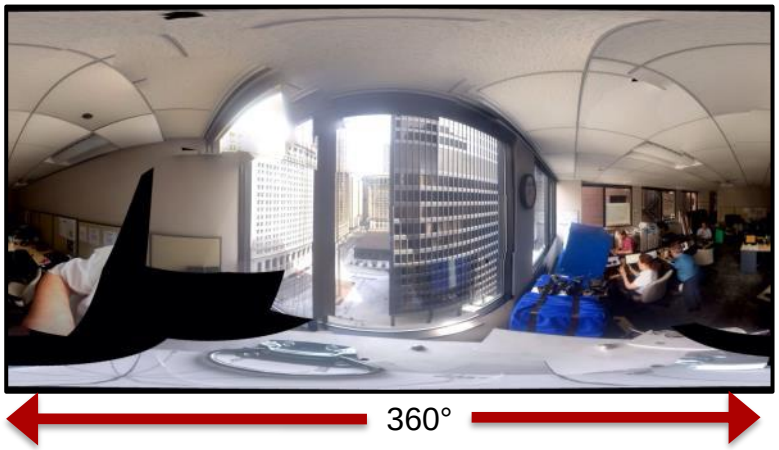




- AmBe and Cf-252 can be easily discriminated, with smaller differences between Plutonium Oxide and Plutonium Metal/Cf-252 noticeable.

High-rise, Search

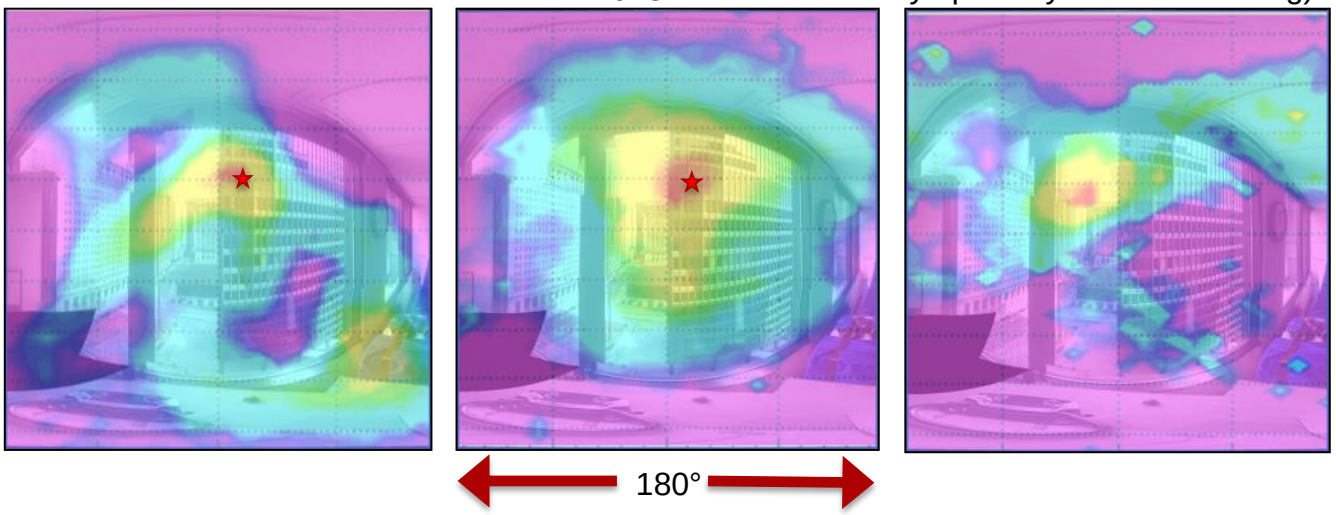
- High-rise to high-rise search demonstration 28 meters apart.
- Background measurement highlights non-uniformity caused by buildings.



^{252}Cf unshielded, 30 min

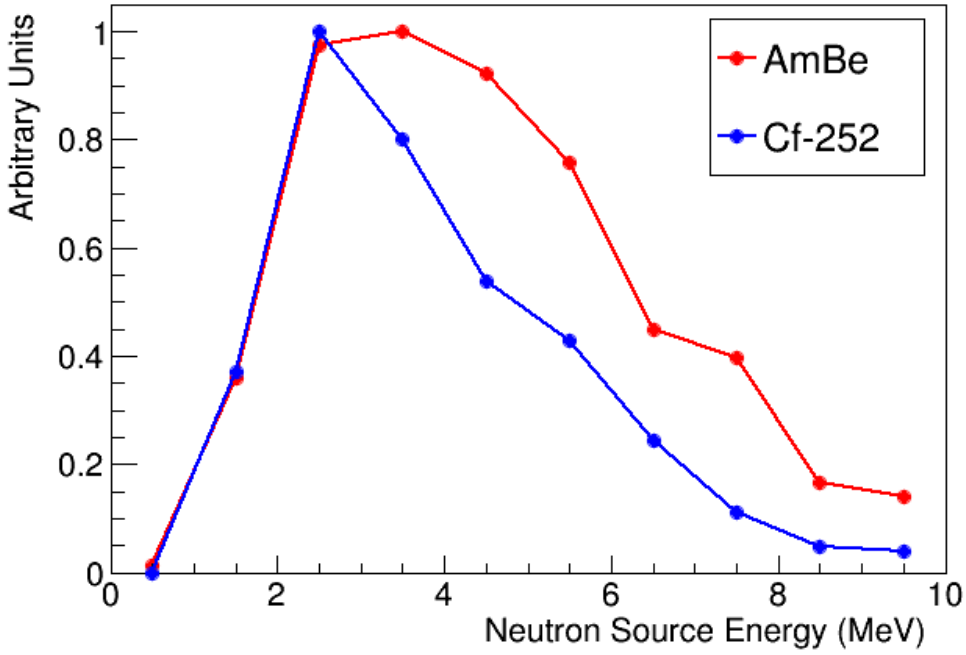
^{252}Cf through 4" poly, 618 min

10-hour background (dominated by open sky to left of building)



Identification at Distance

- Spectroscopy at 28 meter distance, in several hours.
  - Identification of industrial AmBe sources.
- Cf-252 energy spectrum is very similar to potential threat sources, such as Plutonium.



Conclusions

- MINER has participated in several demonstrations, and has shown many of its capabilities and versatility.
  - Imaging, spectroscopy, portability, real-time analysis.
- Further investigations warranted for multiplication measurements, more quantitative detection significance.

Thank You!

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- Special acknowledgement to the many people at NNSS, as well as INL and the ZPPR facility, and all others who helped make these measurements possible!

- Thank you for your attention!

Abstract – For Reference

- Our research group has been developing a mobile fast neutron imaging platform to enhance the capabilities of emergency responders in the localization and characterization of special nuclear material. This mobile imager of neutrons for emergency responders (MINER) is a compact neutron scatter camera optimized to provide omni-directional (4-Pi) imaging with only a ~twofold decrease in sensitivity compared to our much larger neutron scatter cameras. The system performance is tuned for fission energy neutron imaging and spectroscopy, and it also can function as a Compton camera for gamma imaging. Results will be presented relating to detector response as well as several measurement campaigns at external facilities.