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Short Pulse Active Interrogation System for Finding Fissile Materials

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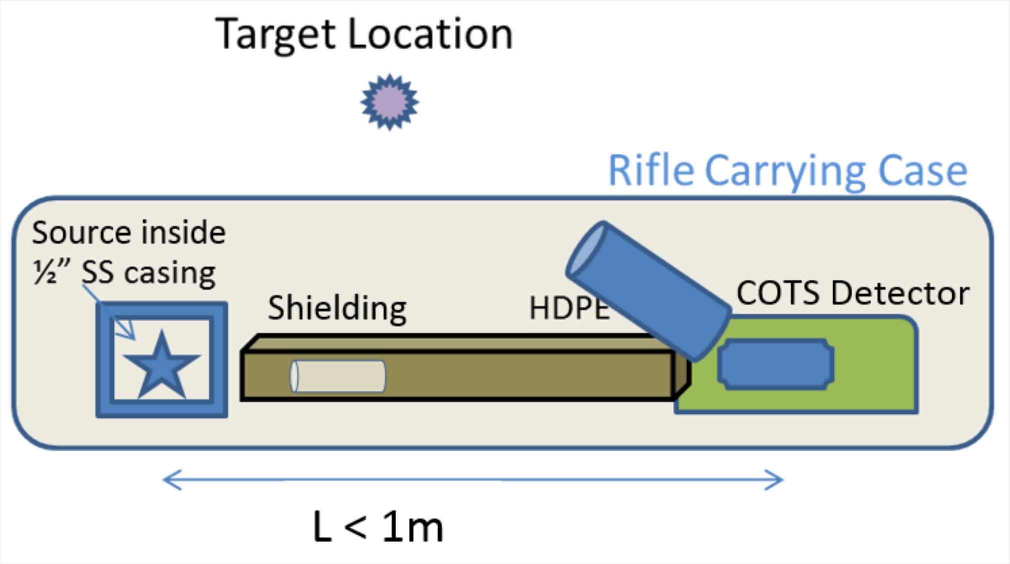
INTRODUCTION

- Passive gamma and neutron systems can detect unshielded fissile and fissionable (SNM) materials that have a strong gamma or neutron signal, but many SNMs do not emit a strong signal.
- Active interrogation methods have been used to overcome weaknesses of passive systems, but traditional active systems pose other problems (e.g., use of neutron generators that are too large, powerful, and expensive to be practical for rapid, portable detection capability and/or that expose operating personnel to too much radiation).
- Weaknesses of active systems can be overcome by use of a neutron source that emits short, intense neutron pulses.
- Our work involves developing a safe, portable system that measures prompt emissions and works at short distances. The system can detect shielded and unshielded uranium and plutonium materials.
- Short pulses result in orders of magnitude less radiation than most other active interrogation systems. The prompt gamma radiation induced by our pulsed neutron source makes the system unique and safe to use at minimal stand-off distance.
- We present the status of a joint research and development project between Sandia National Laboratories, Los Alamos National Laboratory, and AQUILA using a short pulse active interrogation system for SNM, and some results obtained to date.

EXPERIMENTAL SETUP

- Our neutron source is housed in a stainless steel (SS) enclosure and emits an intense, short duration (<< 1s) neutron interrogation pulse.
- All mechanical components are contained in a standard hard-sided plastic rifle case.
- A high density polyethylene (HPDE) shield between the source and the detector protects the detector from direct neutron bombardment.
- Typically, a single trace from a commercial off-the-shelf (COTS) $LaBr_3$ scintillator is analyzed to determine gamma spectra while the source is on and again after the source is powered down.
- Traces from multiple consecutive shots can also be summed for better statistics, if needed.



SUMMARY OF ANALYSIS PROCESS

- Neutrons in the interrogation pulse interact with the target; emission of gamma radiation characteristic of material in the target produces a detection pulse.
- Timing and energy of prompt gammas in the detection pulse differ from timing and energy of background gammas.
- The prompt gamma portion of the detection pulse contains identifying features primarily observed while the neutron source is on or shortly after the interrogation pulse ends.
- Current data has been collected with a $LaBr_3$ detector connected to a photomultiplier and fast-digital oscilloscope. Other detectors and signal processing electronics are possible if they can handle the fast data rate.
- An algorithm rapidly converts the data stream from the gamma detector into gamma spectra. The algorithm bins time and magnitude of responses to create the spectra.

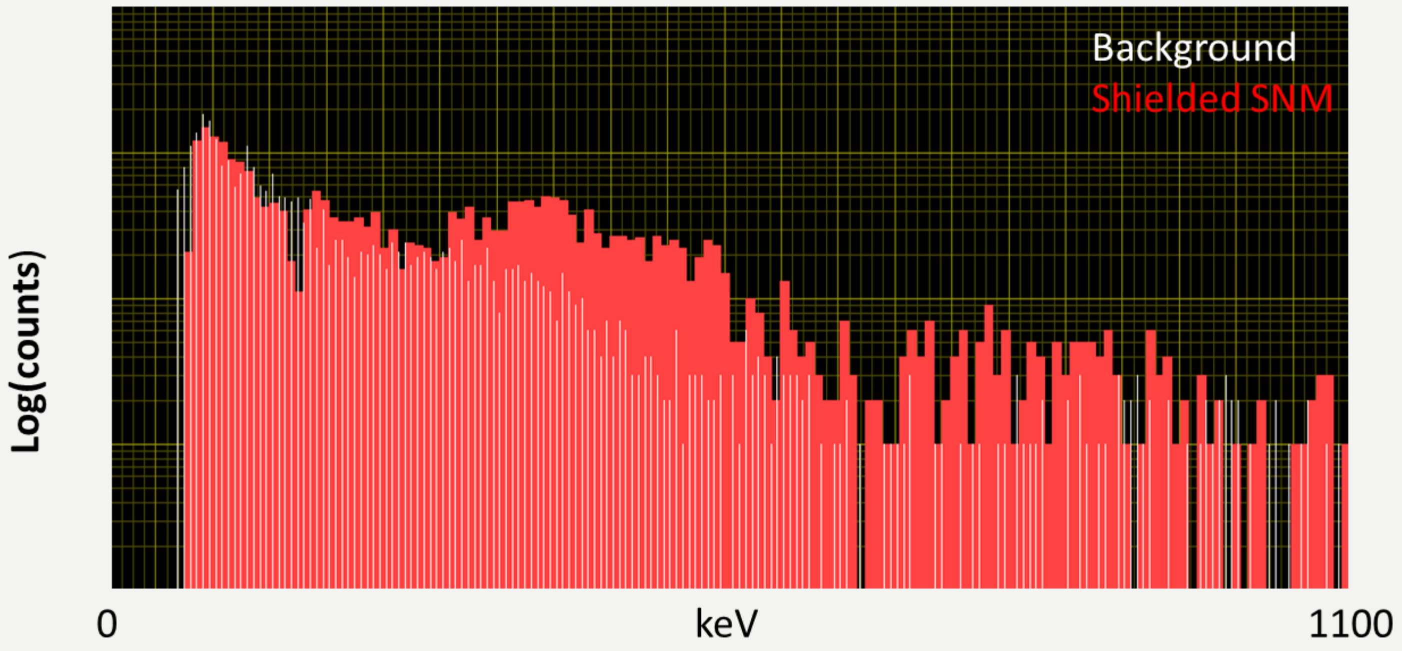
COMPARISON TO OTHER ACTIVE INTERROGATION METHODS

Method	Group	Estimated Normalized Neutron Source Dose†	Estimated Interrogation Time/Target	Effectiveness
Combined Neutron and Gamma (Long Pulse)	Eberhardt	5000	180 seconds (at 1 meter/minute scan rate for a 3-meter target)	Imaging 2D Z map
Delayed Neutrons Differential Die Away (14 MeV)	Runkle	100	500 seconds	Presence of SNM
Associated Particle (Prompt and Delayed)	Mihalczo	400	600 seconds	Presence of SNM
Short Prompt Intense Neutron (SPIN) Sensing	Our work	1	< 1 second	Presence of SNM, quantity of SNM

† Estimated Normalized Neutron Source Dose = (Group Src/SPIN Src)*(SPIN Solid Angle/Group Solid Angle)*(SPIN Estimated Detector Efficiency/Group Estimated Detector Efficiency)

MEASUREMENT RESULTS

- We conducted a series of experiments with various shielding materials combined with distinct SNM target materials (relevant to this audience).
- Analysis results show we have a high degree of confidence discriminating between target types and nulls (solid targets without actinides).



The red histogram (more events) shows results from a polymer-shielded small amount of SNM as a target. The white histogram shows a no target background. The difference between the two sets of results is clearest in the gamma energy range of approximately 300 keV to 500 keV.

SUMMARY

- With these results, the SNL/LANL/Aquila collaboration has demonstrated the fundamental characteristics of a near-field, portable, and nearly instantaneous method for searching for SNM.
- There are statistically significant differences between actinide-bearing targets and a series of non-actinide targets and backgrounds.
- The use scenario(s) can allow a user to operate the system routinely and still receive below the occupational dose limit.
- Additional work must be done to develop probabilities for false positive and false negative rates under the array of conditions expected during practical scenarios for SNM/WMD detection.