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INL and the Consortium for Verification Technology

INL Support in FY2016 and Capabilities and Resources for Future Support



October 2016

David Chichester, Directorate Fellow Nuclear Nonproliferation Division National & Homeland Security Science and Technology Directorate

Our Mission

Discover, demonstrate and secure innovative nuclear energy solutions, other clean energy options, and critical infrastructure.

ldaho National Laboratory

Our Vision INL will change the world's energy future and secure our critical infrastructure.



Idaho National Laboratory

- ~4000 employees
- 890 square miles
- 111 miles of electrical distribution lines
- 579 buildings
- 177 miles of paved roads
- 14 miles of railroad lines
- 4 reactors
- Mass transit system
- Protective security force
- Multiple irradiatedfuel storage pools
- Dry-cask fuel storage research testbed





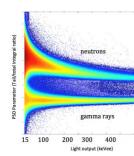
Idaho National Laboratory

CVT Summer Intern at INL

Charles Sosa

• U. Michigan

- Optimization of organic scintillator detectors to improve neutron/gamma-ray pulse shape discrimination (PSD)
- Evaluation of optimal waveform digitization parameters to maximize PSD performance of organic scintillators



PSD-focused optimization aimed at further separating neutron and gamma-ray msignals Candidate organic scintillator geometries

Right

circular

cylinder

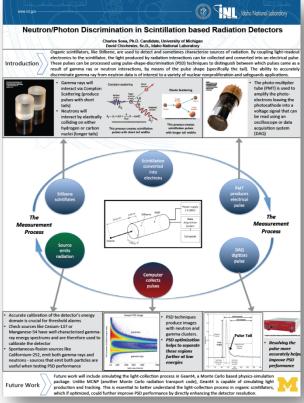
ultraviolet

illumination

under







Summer 2016 intern poster at INL



CVT Activities at INL – Fast-Neutron Multiplicity Analysis

We hosted Dr. Angela Di Fulvio and Tony Shin (U. Michigan) for a week-long experiment campaign at INL's ZPPR facility in August

- U Mass standards (6)
 0.5 4 kg
 93% ²³⁵U
- U enrichment standards (3) 0.230 kg each (0.690kg) 20%, 53%, 93%
- Clad UO₂ pins (32)
 0.080 kg each (2.5 kg)
 16.4% ²³⁵U



Detection for Nuclear Nonproliferation Group

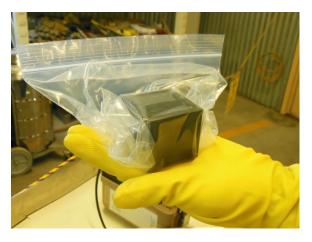


Packaging Depleted Uranium Cubes for Princeton

- Conversation with Rob Goldston at the UITI meeting requesting uranium
- INL identified nine depleted uranium cubes (2" × 2" ×2") and prepared them for shipment to Princeton Plasma Physics Laboratory to support CVT experimental activities at Princeton University (Alexander Glaser)
- Request initiated June 7
- Materials packaged and ready for shipment July 22



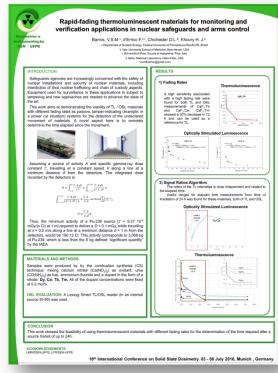




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Emerging Collaboration Related to Passive Smart Tags

- Working with Dr. Francesco D'Errico, Yale University
- Exploring ideas for using dosimeters in nontraditional ways to meet safeguards and arms control measurement challenges
 - Use of TL and OSL materials for passive, time-sensitive tags
 - Use of bubble detectors for passive area/portal monitors
- Planning experiments at INL



Presentation at the 18th Int. Conf. on Solid State Dosimetry Rapid-fading TL and OSL materials for monitoring and verification applications in nuclear safeguards and arms control

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1. Introduction

Subgrands agreeses are concerned with the subrey of nuclear initial interactivity discuss materials. Material protection, control and accountary are the first rays towards maintaining continuity of innovidage of these materials and proventing iller thatficking or diversity of the start field in the property transfer and malicious acts involving modern materials are key aspects of Nuclear source of the start field of the start start in the start of the start start property of the start control of the start start in the start of the start start of the start of the start of the start start of the s

Therefore, there is a growing creeginition of the need for comprehensive security systems on issues and a simplexing technical measures to deter illicit movement and tufficiang in nuclear and other andicastic materials, developing relevant instruments and methods, and polytica nuclear forestication to prevent, and rependito, nuclear security subscription and the security of the security subscription measures. Interprepared foreviews and materials capable of timing degreed since the movement are needed to advance the start of the art.

In recent years, novel applications for thermolourinsevence have been explored where the "ideal disinter" is not necessarily well united. For example, posientialized dostineters with multiple traps have been used for temperature measurements [3]. In this application the deepopulation of each timp is used as a agrituation of the time-temperature profile when the sensors are embedded in extreme environments such as fires and exploration.

In therms (T.1) act optically timulated luminescence dometry (OS.1), faing is unally considered an underinkthe material elametricritic. A tima rad temperature dependent loss of signal will occur after irradiation and before the readout. This is inherently related to the release of trapped charged (leattons or holes) at ambient temperaturely when the trap depth.² is too small. In the simplest model, with a single trap, the rate of charge of the population is distrated by an Arbenian segression:



where n is the trap population density, s is a frequency factor, E is the trap depth, k is the <u>boltzmann</u> constant and T is temperature.

Paper submitted to Radiation Measurements



INL Capability Alignment with the CVT Thrust Areas

Thrust Areas	Sub Areas	INL Staff	INL Resources
1: Characterizing Gaps & Emerging Challenges	FMCT Verification Challenges	✓	✓
	Future Disarmament Treaties	✓	✓
2: Fundamental Physical Data, Data Acquisition & Analysis Techniques	Physics of Fission	✓	*
	Data Analytics	\checkmark	×
	Data Acquisition for High-Throughput Radiation Detector Systems	\checkmark	\checkmark
3: Advanced Safeguards Tools for Accessible Facilities	Neutron Multiplicity Counting	✓	✓
	Handheld/Portable Room Temp. Semiconductor γ-Ray Imagers	\checkmark	\checkmark
	Stand-off Meas. using LIBS for Limited Access Areas	\checkmark	\checkmark
	Chain-of-Custody Detectors	\checkmark	✓
4: Detection of Undeclared Activities and Inaccessible Facilities	Seismic Signatures	×	\checkmark
	Infrasound Signatures	?	\checkmark
	Atmospheric Radionuclide Sensing	\checkmark	\checkmark
	Signatures from Undeclared Fuel-Cycle Facilities	\checkmark	\checkmark
5: Disarmament Verification	Rad. Detection Systems for Arms Control & Treaty Verification	\checkmark	✓
	Warhead Dismantlement Facility & Managed-Access Simulator	\checkmark	✓
	Zero-Knowledge Neutron-based Verification System	\checkmark	\checkmark
	Limited Knowledge Transmission NRF	\checkmark	\checkmark
6: Education & Outreach	Multiple	\checkmark	\checkmark



INL Research Staff Interests Aligned with the CVT

 Automated, information-barrier software for assessing gamma-ray spectra for CTBT on-site inspections

PI: Gus Caffrey TA: 1, 5, & 6

- Study of nontraditional signatures and observables associated with reprocessing LWR fuel; evaluation of forensic signatures from LWR fuel
 PI: Kevin Carney TA: 1, 4, & 6
- Development of passive and active interrogation methods for characterizing assemblies of SNM for safeguards, arms control, and treaty verification
 PI: David Chichester TA: 1, 2, 3, 5, & 6
- Methods and instruments for ultra-trace mass and radiochemical analyses and the production of reference materials
 - PI: Matt Watrous TA: 1, 4, & 6



Screen shot of the OSIRIS user interface, showing results of allowed gamma-ray results



Disassembly of an LWR fuel pin at INL for followon radiochemical analyses



Source-assisted multiplicity counting to determine multiplication, M, of an assembly of HEU

Potential INL Resource Support for the CVT

Working with Bulk SNM (Thrust_Areas: 1, 2, 3, 5, & 6)



Active interrogation & multiplicity counting for SNM detection and characterization U & Pu Processing Facilities (Thrust Areas: 1, 3, 4, & 6)



Hot-cell facilities processing irradiated fuel; U and Pu radiochemistry

> PUREX Pilot Plant (Thrust Areas: 1, 2, 4, & 6)



Engineeringscale solvent extraction pilot plant for nonproliferation R&D Large explosives test range supporting outdoor RDD detonation events

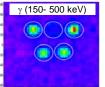
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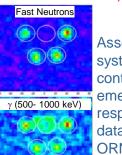
Explosives Test Range

(Thrust Areas: 4)

Radiation Imager Trials (Thrust Areas: 3 & 5)







Assessing imaging systems for arms control and emergency response (example data from an ORNL system)

