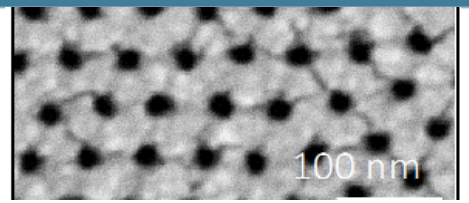
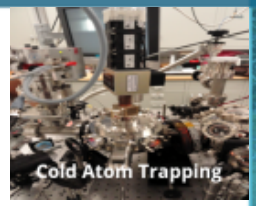
SAND2021-12365PE

Sandia National Laboratories

# Sandia/NSSC Consortium Meet-and-Greet


## SNL/CA and SNL/NM

October 5, 2021

U.S. DEPARTMENT OF ENERGY | NNSA

Sandia National Laboratories is a multimission laboratory managed and operated by National Technology & Engineering Solutions of Sandia, LLC, a wholly owned subsidiary of Honeywell International Inc., for the U.S. Department of Energy's National Nuclear Security Administration under contract DE-NA0003525.

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# Agenda

| PDT | MDT | |
|---|---|---|
| 8:30 | 9:30 | Introduction |
| 8:40 | 9:40 | Faculty presentations |
| 9:30 | 10:30 | Sandia PI presentations |
| 10:10 | 11:10 | Breakout room discussions |

- Nuclear physics and nuclear data
- Radiochemistry and nuclear chemistry
- Nuclear material science
- Nuclear chemical engineering & nuclear engineering
- Radiation detection
- Computing and optimization in nuclear applications
- Education in nuclear science, technology and policy

| | | |
|---|---|---|
| 10:30 | 11:30 | Official meeting ending (allowed to continue until 11:00/12:00 as needed) |

# SNL/NM Facilities: Gamma Irradiation Facility (GIF) and Low-Dose-Rate Irradiation (LDRIF) Facility

The GIF provides high-fidelity simulation of radiation environments for materials and component testing. The GIF can produce a wide range of gamma radiation environments (from $10^{-3}$ to over $10^{3}$ rad/second) using cobalt-60 sources, and can irradiate objects as small as electronic components and as large as an Abrams M1 tank. The GIF provides in-cell dry irradiations in three test cells and in-pool submerged irradiations.

LDRIF offers gamma (Cs-137) and neutron (AmBe) irradiation environments for long-term tests at low dose rates (from $10^{-6}$ to $10^{-1}$ rad/second for gammas and from $10^{-6}$ to $10^{-5}$ rad/second for neutrons).

- Configurable radiation sources that provide different geometries for the source array (e.g., point, planar, and circular)
- Shielded windows that enable experiment observation during irradiation
- Remote manipulators that can be installed to facilitate experiment or source handling
- Pass-throughs in the shielding walls so that experiment power and instrumentation cables can penetrate the shield walls
- A movable wall that measures 5.5-m (~18-ft.) wide in the large cell, providing access for large components (e.g., space vehicles or military vehicles)
- Removable cell-roof-shield plugs that provide access for large and/or massive experiments
- An overhead bridge crane that spans the facility's high bay and that can access the cells through the cell-roof-shield plugs
- Dry experiment canisters are available for in-pool irradiation experiments
- In-pool experiments can be heated and purged with air or other gas

# SNL/NM Facilities: Saturn and Hermes

Accelerators that create X-ray and gamma ray environments powerful enough to simulate certain conditions created by nuclear weapons, allowing researchers to conduct radiation-effects testing in a laboratory setting.

## Saturn

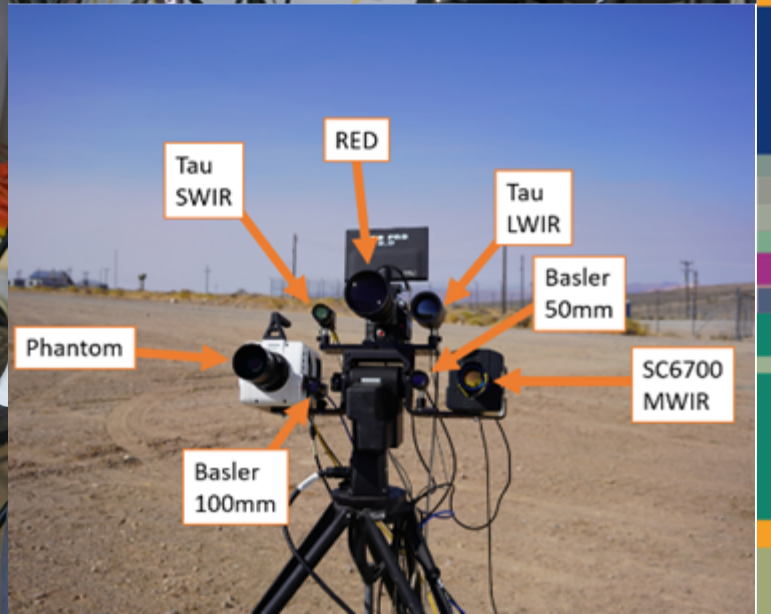
The Saturn accelerator is a modular, high-power, variable-spectrum, x-ray simulation source. Saturn can be operated with two different bremsstrahlung diodes or any one of several plasma radiation sources. The diodes and sources provide x-ray radiation environments with enhanced simulation fidelity based on fast rise time, short pulse duration, and tailored spectral content. Saturn's major function has been to produce x-rays to test the effectiveness of the countermeasures that are used to protect electronics and other materials against x-ray radiation from nuclear weapons.

## HERMES III

The High-Energy Radiation Megavolt Electron Source (HERMES) III accelerator is the world's most powerful gamma simulator, primarily used to demonstrate the effects of gamma-ray radiation. HERMES III has both indoor and outdoor test cells, and is used predominantly for simulating the effects of prompt radiation from a nuclear burst on electronics and complete military systems. This accelerator can produce eight shots per day, four days a week.

# SNL/NM Facilities: Mobile Remote Sensing

Multiple trailers with ability to field a variety of sensors and data collection computers. We have used one of these on an ETI consortium project (at UWisc).

# David Peters

## Proliferation Detection Remote Sensing, SNL/NM

- Manager of Proliferation Detection Remote Sensing department: Mostly low TRL work for NA-221, NA-222, LDRD, and OGAs
- SNL point of contact for Remote Sensing, Near Field, and Innovation portfolios
- SNL PoC for the NA-22 university consortia: feel free to contact me
- Technical background: EM modeling, subwavelength optics, metamaterials, FPAs

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# Matt Windsor + Mallory Stites

## Illinois Partnerships (+Human Factors/Applied Cognitive Science)

- Matt and Mallory are the Campus Partnership Managers for the Sandia Academic Alliance with the University of Illinois
  - Sandia has a special “Academic Alliance” relationship with 5 schools: Illinois, Purdue, UT Austin, GA Tech, and UNM
  - Our role is to help foster and facilitate research collaborations, pipeline efforts, and many other engagements between Sandia and U of IL
- We are Sandia technical staff but are located in Champaign, IL
- We both split our time between our Academic Alliance role and technical work in our “home” departments
  - We are both Cognitive Science PhDs
  - Mallory’s “home” department is Applied Cognitive Science
  - Matt’s “home” department is Human Factors
- We both have experience in safeguards related work
  - But our presence here is primarily from an Academic Partnerships perspective

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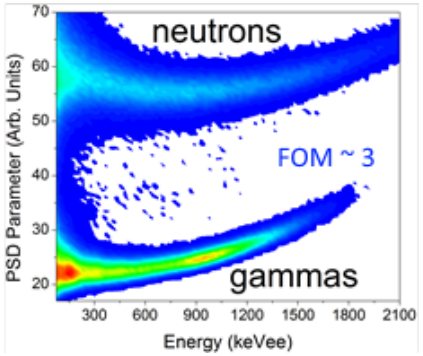
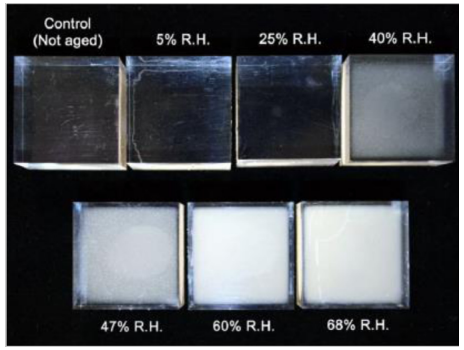
# Jonathan Zimmerman,

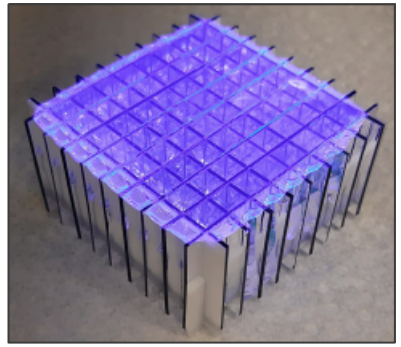
## Nuclear Deterrent Materials and Radiation Effects, SNL/CA

- Manager of Nuclear Deterrent Materials and Rad Effects department; acting Senior Manager of Radiation Signatures and Detection Sci & Tech group

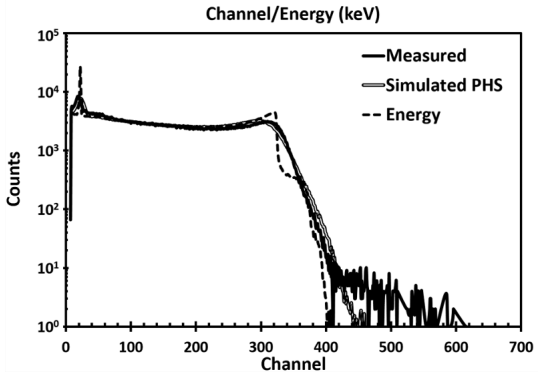

**Radiography & Computed Tomography**

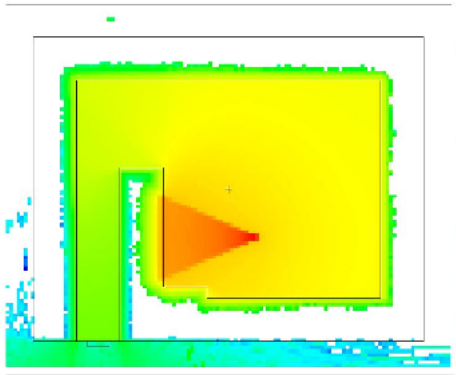


**Scintillator & Radiation-Sensitive Materials Development**



**Radiation Source & Transport Modeling**

- Detection of ionized particles & radiation signatures
- Radiation transport modeling & simulation
- Radiography & Imaging
- Optical sensing science & engineering
- Environmental effects on materials
- Spectral imaging

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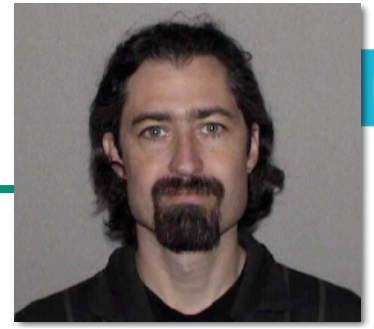
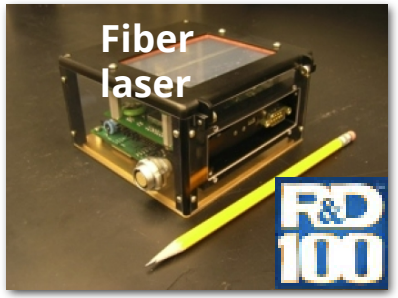
# David Reyna

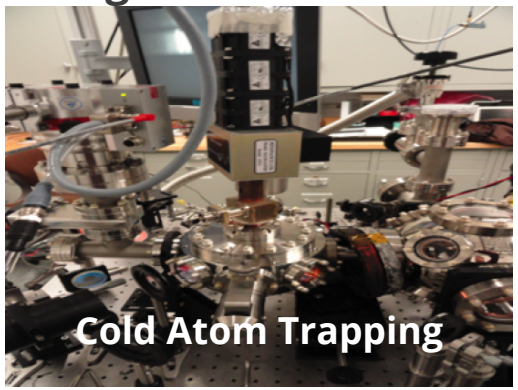
## Proliferation Signatures Discovery & Exploitation, SNL/CA

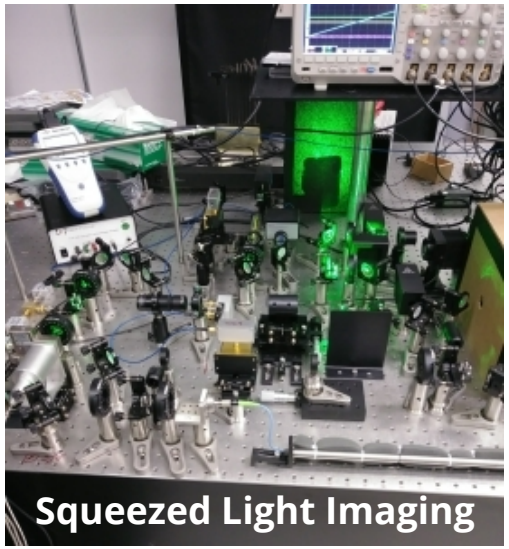


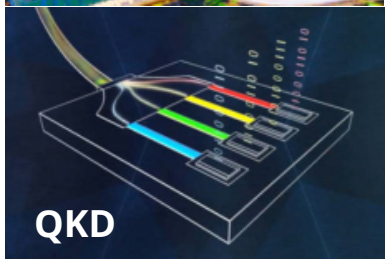
We have a department of 10 researchers with 2 primary focus areas:

### Advanced Optical Techniques and Quantum Sensing



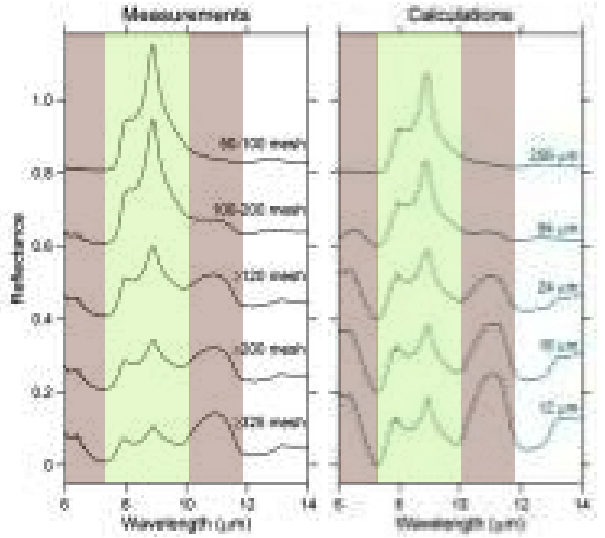



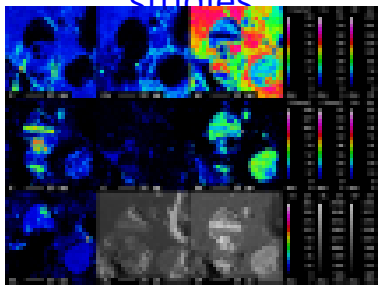



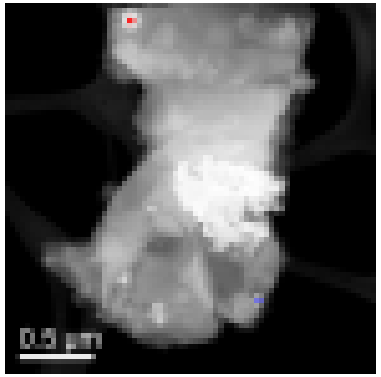

### Solids Detection Signatures for Proliferation Detection

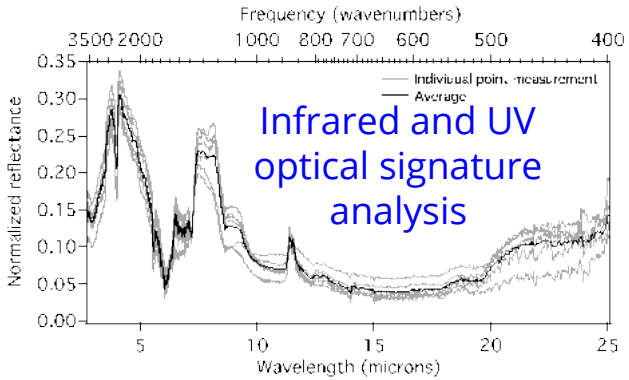
Modeling and simulation




Chemical and morphological studies





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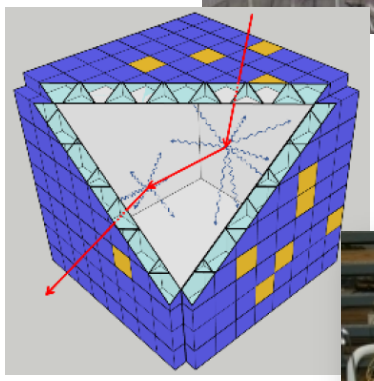
# Erik Brubaker

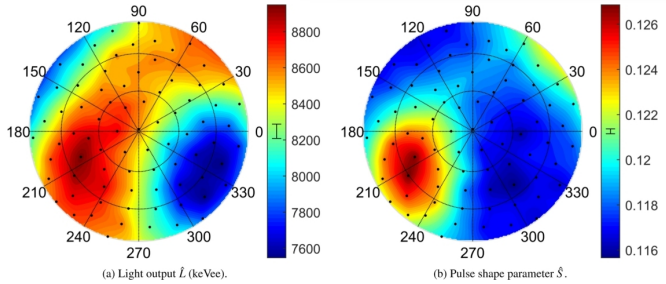
## Rad/Nuc Detection Systems, SNL/CA

13 years at SNL: Radiation detection physicist, various projects on neutron detection & imaging. Previously experimental particle physics.



Areas of interest for collaboration/mentoring:

- Neutron emission imaging: double scatter (SVSC), coded aperture (NCA), time-encoded (TEI)
- Organic scintillator: anisotropic response in crystals, self-guiding structures, other characterization
- Image reconstruction: MLEM, SOE, regularization, task-based imaging




(a) Light output $\hat{L}$ (keVee). (b) Pulse shape parameter $\hat{S}$.

Current collaborations with UC Berkeley & NCSU: single-volume neutron scatter camera development

Served on dissertation committees at UC Berkeley, NCSU, AFIT, U of Michigan, U of Arizona

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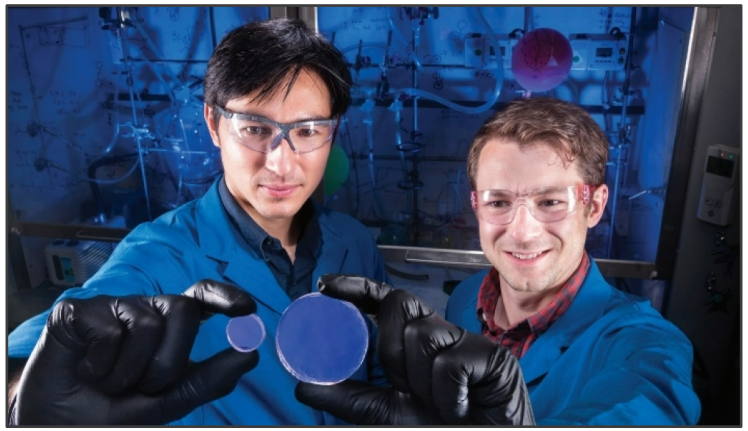
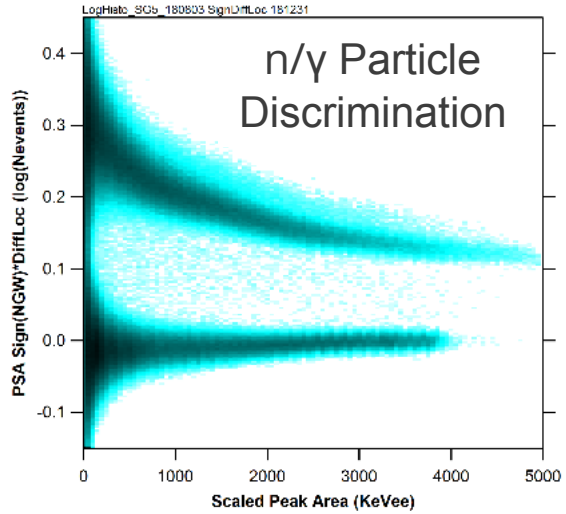
# Patrick Feng

## ND Materials and Radiation Effects, SNL/CA

## Research Description and Interests:

- Ionizing radiation detection materials development and characterization
  - New organic compound design and synthesis – small molecules, polymers, organometallics
  - Emphasis on photophysical and thermomechanical properties → processing into structured scintillator configurations
  - Bridging the gap between foundational R&D and commercial application






- Collaborations with:
  - Dr. Bethany Goldblum, UC-Berkeley/LBNL (NSSC) – 88-inch Cyclotron characterization
  - Prof. Alan Sellinger, Colorado School of Mines – Custom fluorophores for organic scintillators
  - Prof. Sara Pozzi, University of Michigan – Detector fabrication and characterization studies

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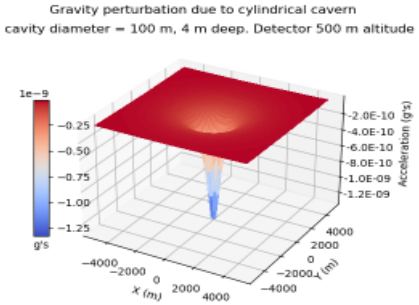
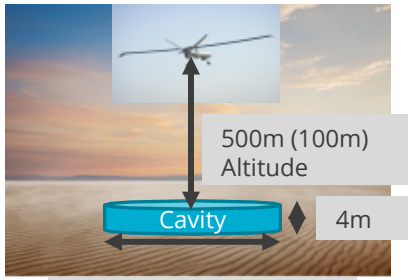
# David Farley

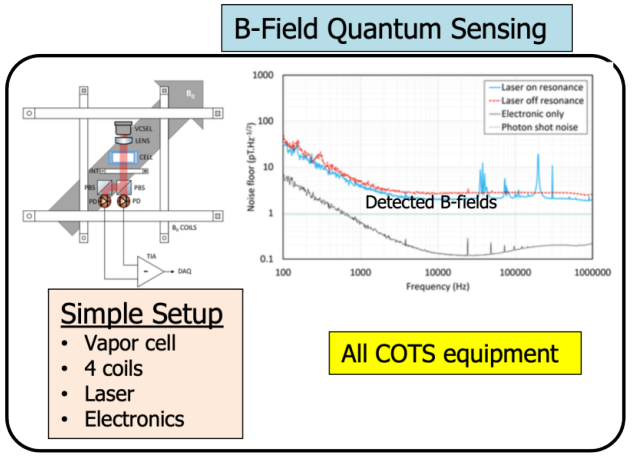
## Proliferation Signatures & Exploitation, SNL/CA

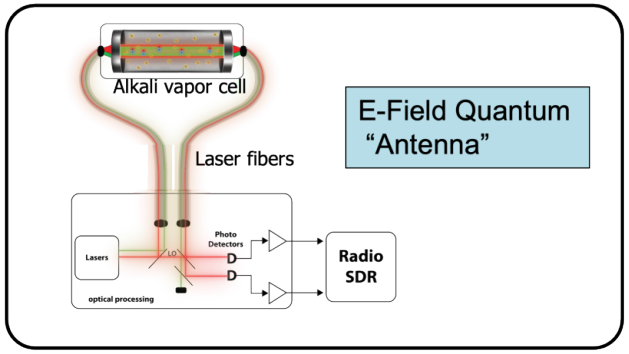
- My work involves nuclear fuel cycle, energy, safeguards, and nonproliferation; quantum technologies (quantum sensing & quantum encryption); cryptography; and machine learning
- Funded Berkeley PhD student on cryptography for safeguards applications



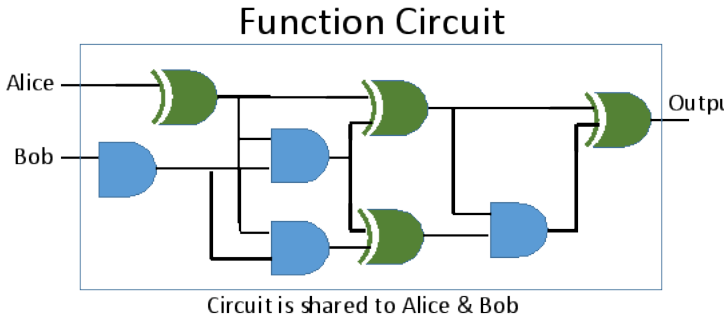

Quantum Gravimetry to detect underground facilities




Privacy-Preserving Garbled Circuits (never expose raw data)

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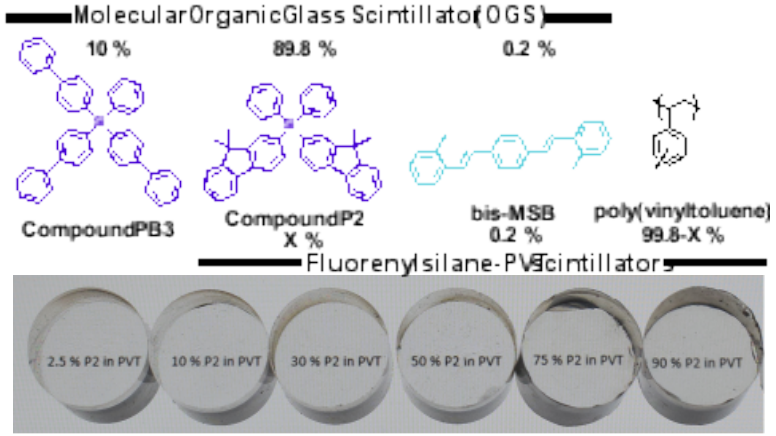
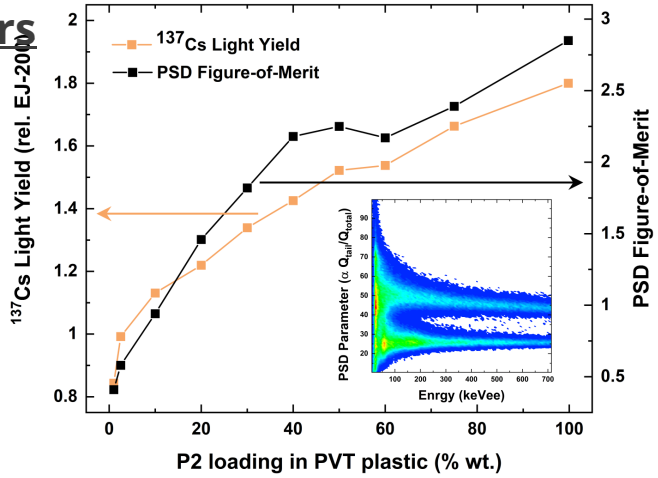
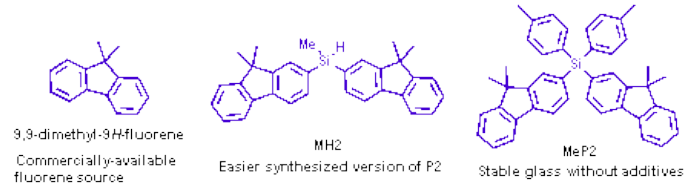
# Nick Myllenbeck

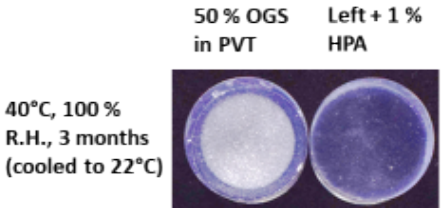
## Synthetic/materials chemist, SNL/CA

## High light yield, PSD plastic scintillators

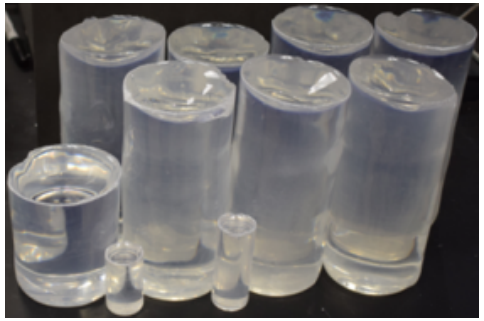


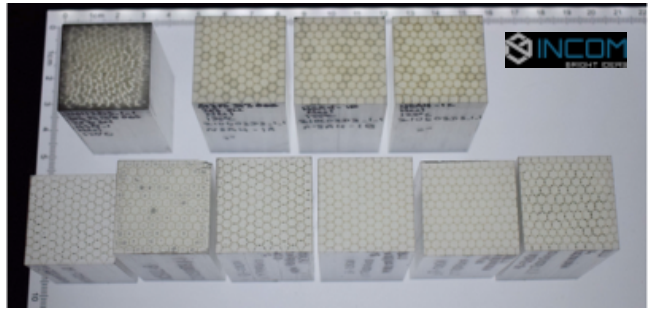




## Scintillating Nanoguide for High Resolution Neutron Imaging



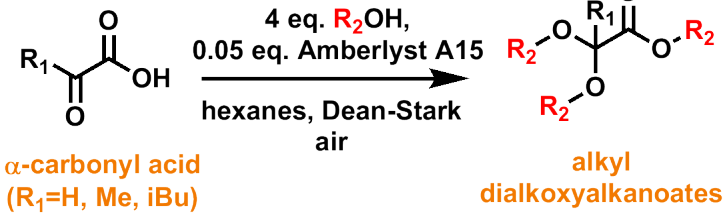
4.5 kg of 2.5” diameter cylinders, 30 % P2 in PS

Co-draw with PMMA using heat lamps




Fused Nanoguide hex. elements with individual fiber size ~500 nm

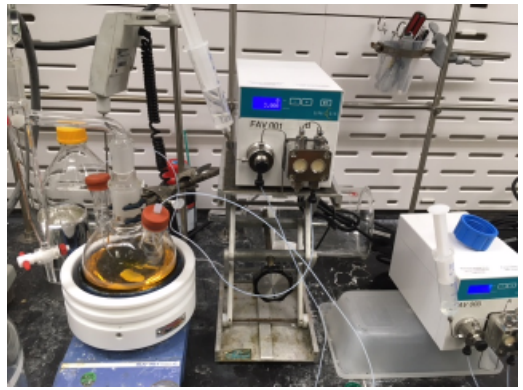
## Synthesis of sustainable biofuels (Co-Optima)




α-carbonyl acid ($R_1$=H, Me, iBu)

alkyl dialkoxyalkanoates

- ✓ 10+ examples, 63-95 % isolated yield
- ✓ Recyclable catalyst, solvent, reagents
- ✓ Scalable synthesis > 1 kg using flow chemistry
- ✓ Widely available, bio-derived substrates
- ✓ Cetane number 40-63
- ✓ Cloud point <-60°C



Lab-scale continuous stirred tank reactor w/ *in-situ* water removal

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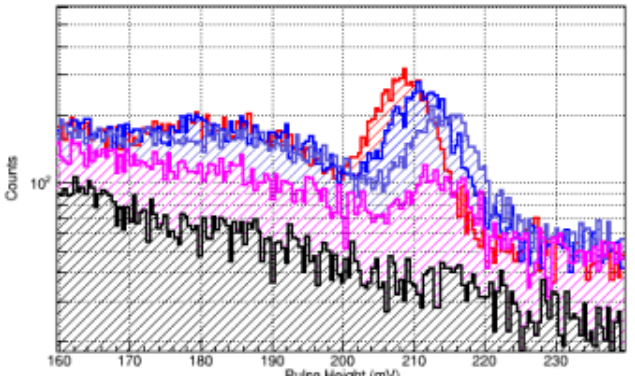
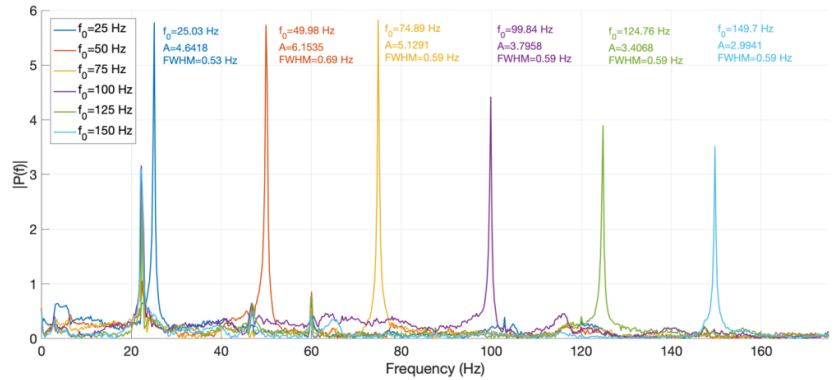
# Kyle Polack

## Rad/Nuc Detection Systems, SNL/CA

- Interested in collaborations related to novel methods (both hardware and algorithm development) for detection of concealed nuclear materials and explosives
- Ongoing work includes techniques that leverage traditional and alternative signatures:
  - Investigation of low-field nuclear magnetic resonance (NMR) and magnetic induction tomography (MIT) for detection and characterization of objects through conductive materials
  - Development and validation of a methodology for using gammas generated by neutron capture as surrogate neutrons in multiplicity analysis
  - Development and optimization of minimally intrusive measurement techniques and analysis algorithms based on gamma counting for application to arms control treaty verification
- Alumni of the Consortium for Verification Technologies
  - Developed image reconstruction and spectral deconvolution techniques for a combined neutron/gamma imager
  - Thesis advisor: Sara Pozzi




*2.2-MeV region for measurements of BeRP ball shielded by 1", 2", 3", 3.5" and 4" of HDPE.*




*Low-frequency NMR signatures detected through 4 mm of Copper*

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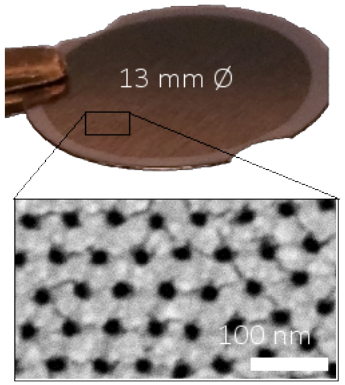
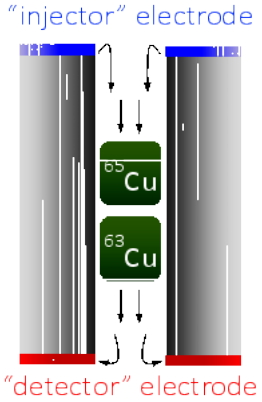
# Michael P. Siegal

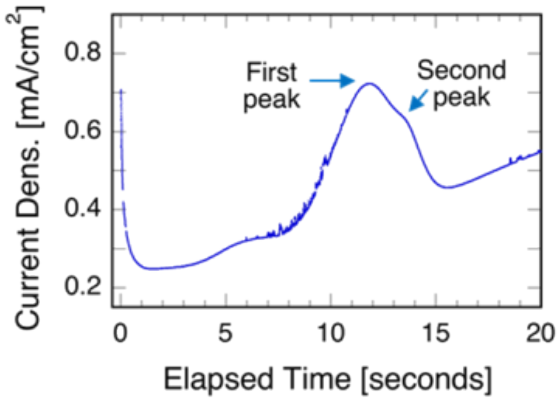
Nanoscale Sciences, SNL/NM

- Wide ranging materials-oriented research includes synthesis and characterization of thin films and nanomaterials, ranging from studies of materials with unusual transport properties, thermal cooling, and electrochemical energy storage, to novel chemical sensor materials and devices for trace detections of various gas and ionic species.
- Present (non-NNSA) university collaborations include Rice University, Georgia Tech, and Maryland.
- **New NNSA-funded project** developing/studying a nanopore array sensor for isotopic ratio analysis by simultaneously using billions/cm$^2$ of individual electrophoresis separation tubes together with electrochemical time-of-flight detection. ***Interested in collaborations*** to model ion transport behavior in high-aspect ratio nanopores, provide novel characterizations, apply concepts to other applications….




**Microsensor with billions/cm$^2$ of parallel capillary electrophoresis separation nanopores.**




**Preliminary evidence of Cu isotope separation and detection.**

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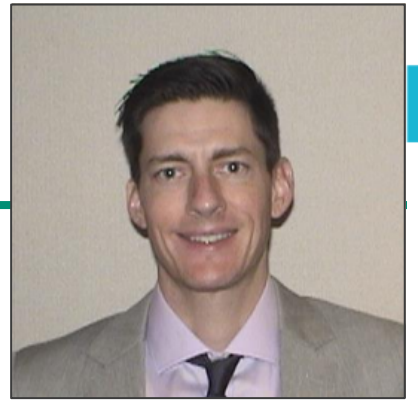
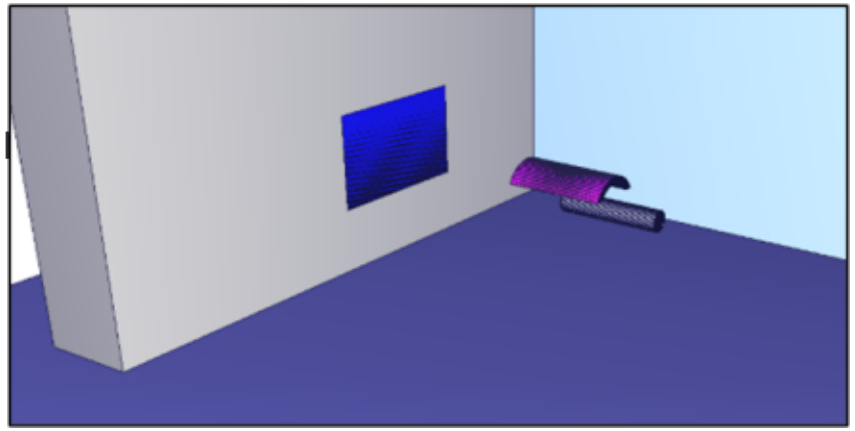
# Jeremy Osborn

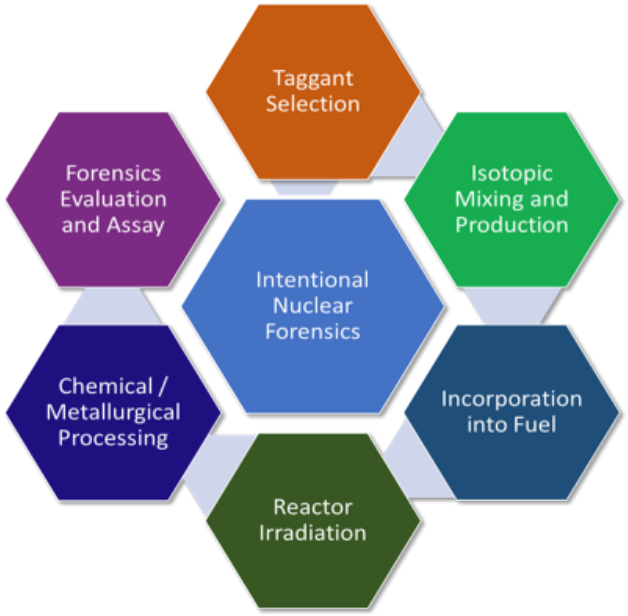
## Proliferation & Weaponization Detection, SNL/NM

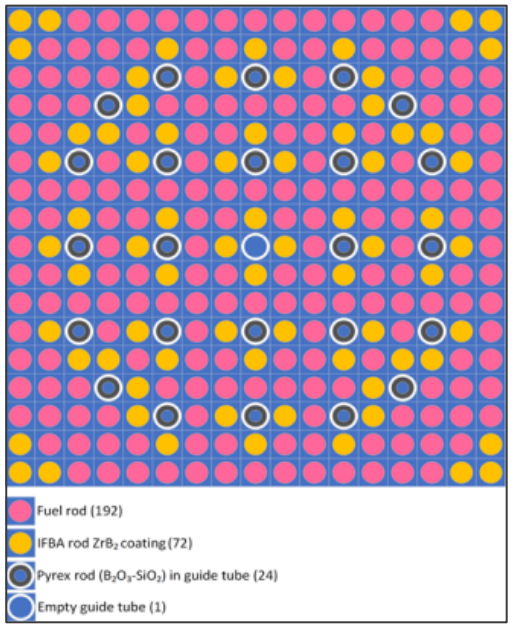


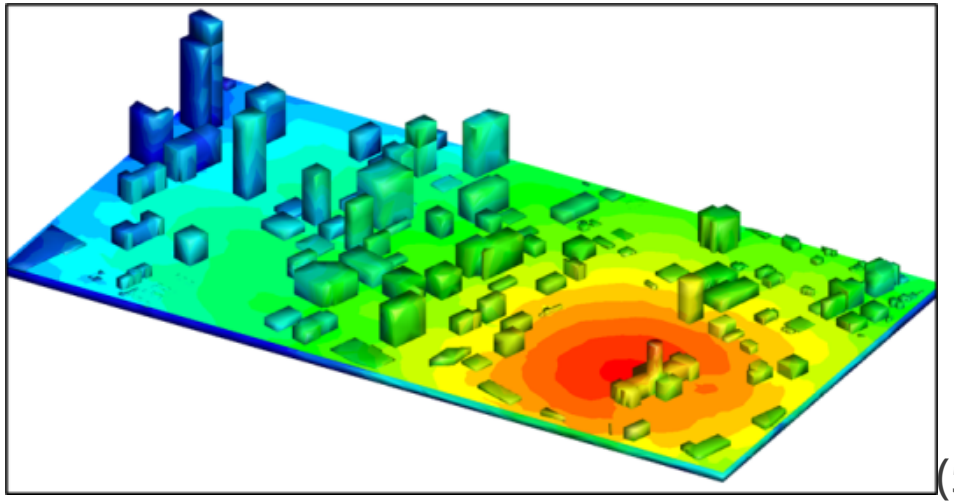
Research Interest Include:

- Radiation transport modeling,
- Novel radiation detection techniques
- Intentional forensics-by-design indicators of fuel provel
- Fuel cycle, and proliferation resistant fuel technology
- Collaborations with Oskar Searfus (UM)





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# Chris Saltonstall

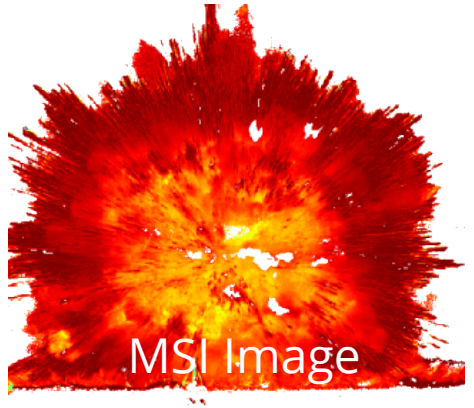
## Proliferation Detection Remote Sensing, SNL/NM

**Background:**

Graduated from the University of Virginia, Physics/Chemistry Undergrad, nano-scale energy transport Ph.D.

Intern, post-doc and now staff at Sandia of the last decade. Worked on developing laser based optical systems from probing nanoscale material properties. Currently, working on developing remote sensing capabilities for various applications.

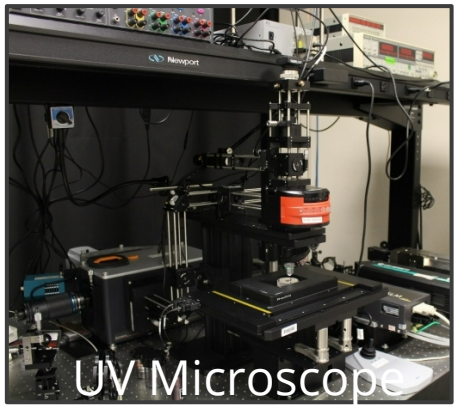
Recently built UV-Raman and PL mapping system. Also, being used to interrogate radiation hardness of microelectronics



MSI Image

**Research Interests:**

1. Nanoscale material science: radiation effects, defects, nano-structuring, thermal transport
2. Nuclear Mission: radiation hardness of microelectronics, remote sensing of radiation, remote characterization of explosions
3. Techniques: UV-Raman, Photoluminescence, laser SEU testing, mapping, multi-spectral imaging (MSI)



UV Microscope

**Informal Collaborations:**

Penn State (Sukwon Choi), University of Virginia (Patrick Hopkins), Purdue (Thomas Beechem)

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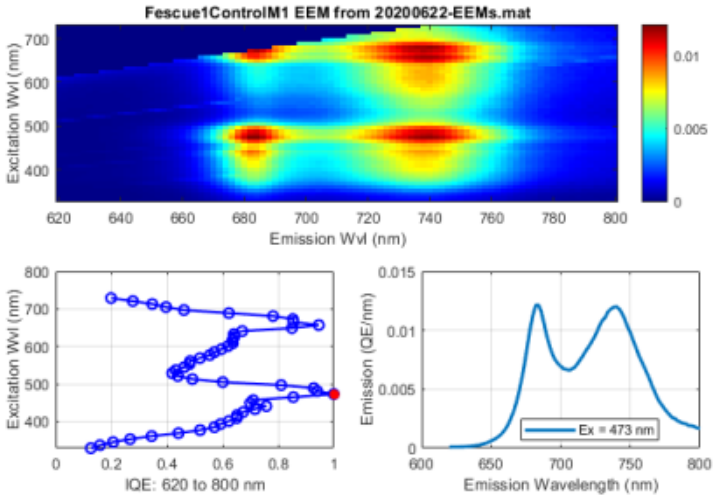
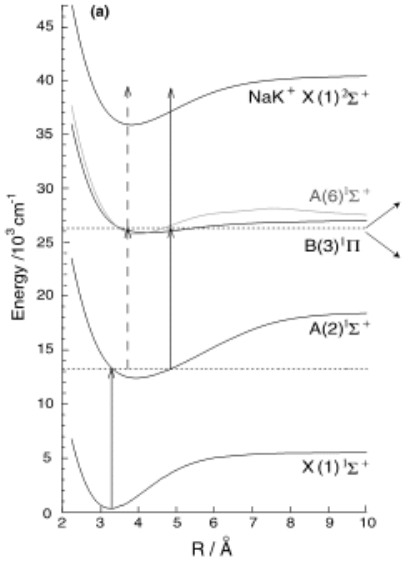
# Mark W. Smith

## Proliferation Detection Remote Sensing SNL/NM

- Research Interests: optical remote sensing, applied spectroscopy, development of novel optical sensors and applied spectroscopy techniques
- Application Domain: Nuclear non-proliferation and proliferation detection
- Current university collaborations: Collaborating with Universities of Wisconsin and Massachusetts on passive detection of fluorescence from bioindicators
- Seeking collaborations on: Computational chemistry applied to optimal dynamic control of isotopologues (Quantum Enhanced Sensing of Isotopes = QESI)




Fluorescence data for tall fescue grass collected in 2020. (Collaborating with University of Wisconsin, Madison and University of Massachusetts, Amherst)




Potential energy curves for NaK published by A. Lindinger et al., Chem. Phys. Lett. 397 (2004) 123-127

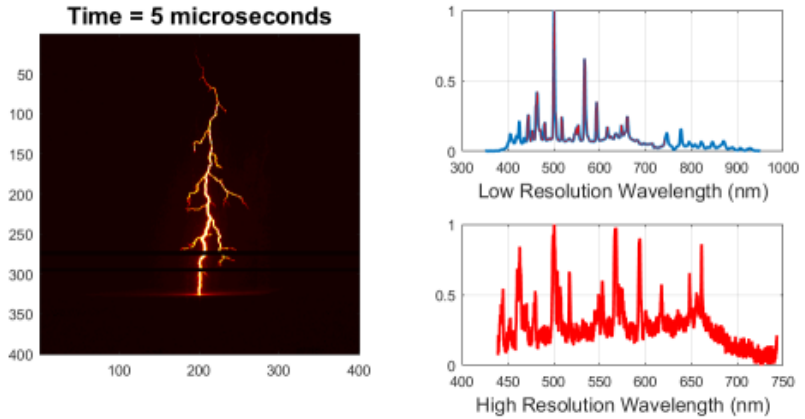



Image and spectra of lightning collected in 2016 (Collaborated with New Mexico Tech)

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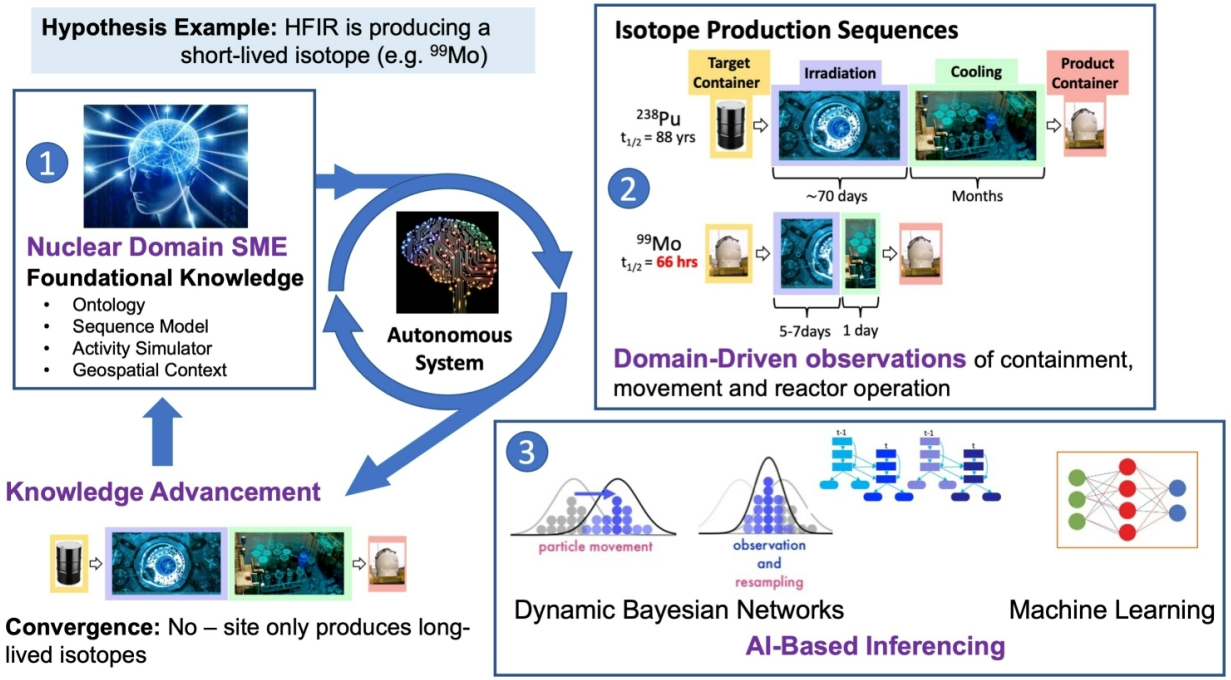
# Thomas J. Kulp

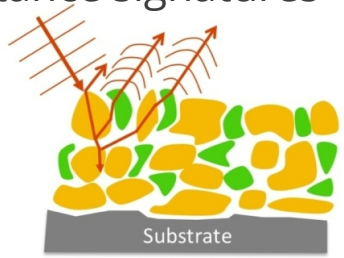
## Senior Scientist CBRN Defense and Energy Technology (SNL/CA)

- I am a physical chemist with a focus in spectroscopy, the linkage between chemical/material structure and optical spectra, and the linkage between nuclear activities and measurable signatures
- My areas of interest are:
  - Optical remote sensing (laser-induced fluorescence, hyperspectral imaging)
  - The advancement of experimental and computational methods methods to improve the prediction and interpretation of material signatures for detection by optical methods
  - Multimodal remote sensing (coordinated observations by many sensor types using  data analytics) and its use for observing industrial processes

Persistent DyNAMICS
Multimodal Remote Sensing




Physical and chemical basis of reflectance signatures

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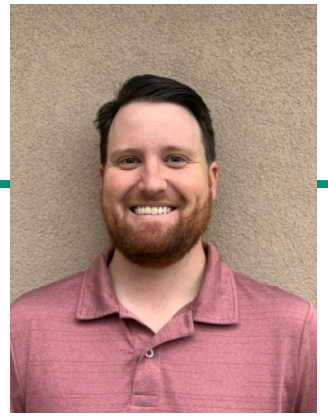
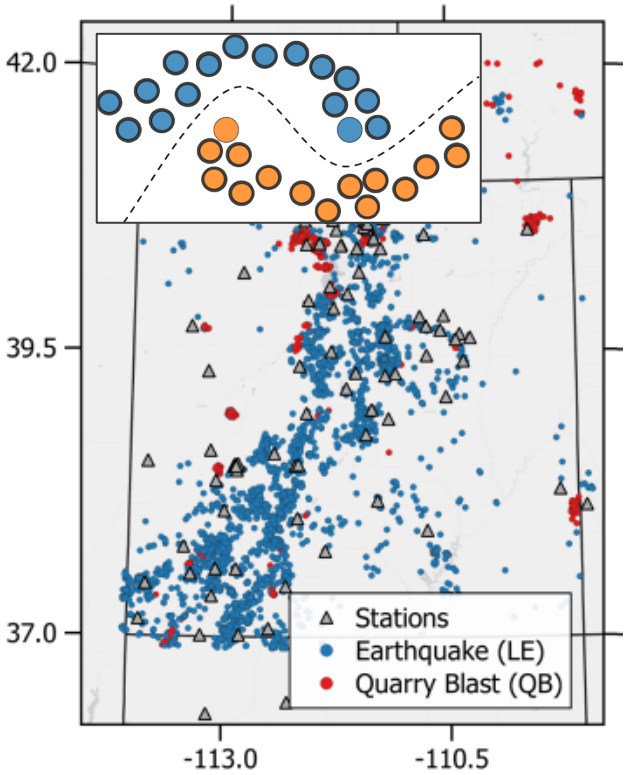
# Dylan Anderson

## Proliferation Signature and Data Exploitation, SNL/NM

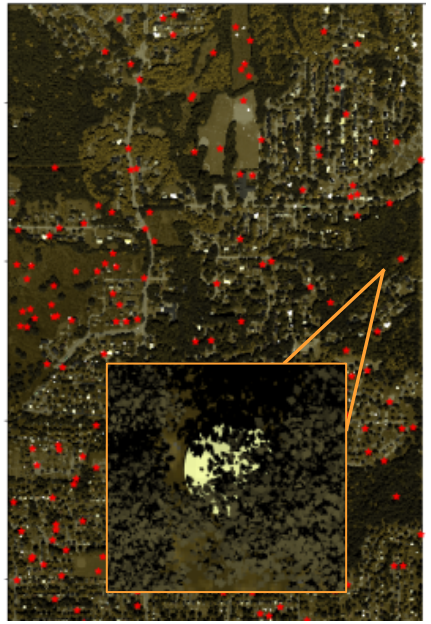


- Research Interests:
  - Deep learning, novel learning paradigms, heterogenous data fusion
  - Geophysical monitoring systems
  - Optical remote sensing data exploitation
  - Science Integration Lead for Advanced Data Analytics for Proliferation Detection (ADAPD)
- Some Recent Publications:
  - Paired Neural Networks for Hyperspectral Target Detection
  - Semisupervised Learning for Seismic Monitoring Applications
  - Shadow Semisupervised Library





*Scalable integration of all available data in the context of physics and process models will* **enhance US capabilities** for early detection.



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# William Hart

## Discrete Math & Optimization, SNL/NM

- Research Interests:
  - Advanced Data Analytics for Proliferation Detection (ADAPD)
  - Optimization applications: nonproliferation, remote sensing, optimal control
  - Data-driven operations research
  - Exascale computing
- Research Highlights
  - Strategies for Matching Process Models to Observational Data (MORS, 2021)
  - A survey of software implementations used by application codes in the Exascale Computing Project
  - Pyomo – Optimization Modeling in Python

**ADAPD Challenge Problem: Early detection of underground explosive tests**

Example: NNSA's Source Physics Project

- Conducted underground chemical high-explosive detonations to improve understanding of seismic activity

Various Types of Experimental Data

- Seismic, high-speed video and drone-mounted photography, gas-displacement recordings, ground-surface changes (SAR, LIDAR) and accelerometers

Key questions:

- Has preparation for a test begun? What stage of preparation has been executed? When will the explosive test occur?

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# Emily Moore

## Proliferation Detection Remote Sensing, SNL/NM

**SNL Engineer for over 15 years in Monitoring Systems Center**

**M.S. in Engineering Physics at Embry-Riddle Aeronautical Univ., Daytona**

**U.S. Army Reserve Captain FA-40 Space Operations Officer, Ft. Carson, CO**

- Automatic target recognition algorithm development for national security datasets/problems
- Custom automated algorithm validation and verification infrastructure via Gitlab CI/CD & Nexus
  - Hooks into any database (currently use Apache Solr - JSON)
  - Gitlab runner enabled – growth and HPC
  - Generate repeatable, documented tests with automated report HTML creation
  - Any language, any OS, any libraries, any data type (not just imagery), plug & play custom reports/scoring
  - Developing a learning harness for classifier creation
- Satellite system data exploitation, state-of-health and on-orbit commanding
- Collaborations in ML/CS with BYU and USU engineering students

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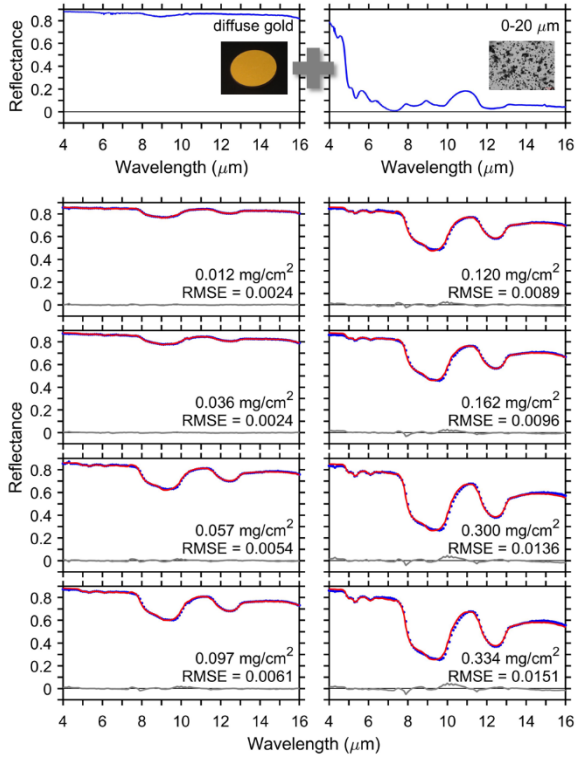
# Tom Reichardt

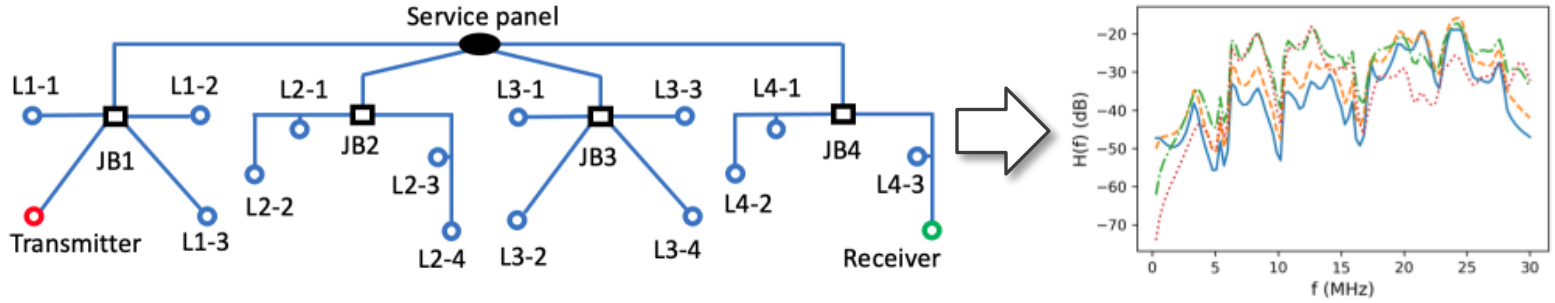
## Proliferation Signature Discovery & Exploitation, SNL/CA

- My research is focused on the interface between physics- and process-based predictive models and large spectral/temporal datasets
  - Hyperspectral data cubes
  - Persistently collected streams of multi-sensor electromagnetic, infrasound, and seismo-acoustic data.
- Model-driven efforts: Predicting signal source terms, the processes governing them, and their subsequent propagation to deployed sensors
  - Radiative transfer modeling of chemical reflectance signatures
  - Transmission line network modeling of conductive signal pathways
- Data-driven efforts: Both unsupervised and supervised approaches to extract interpretable signatures from multiple sensing modalities
  - Non-negative tensor factorization, partial least squares regression

Radiative transfer modeling of chemical deposits on different substrates




Transmission line network modeling of conductive signal throughput

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