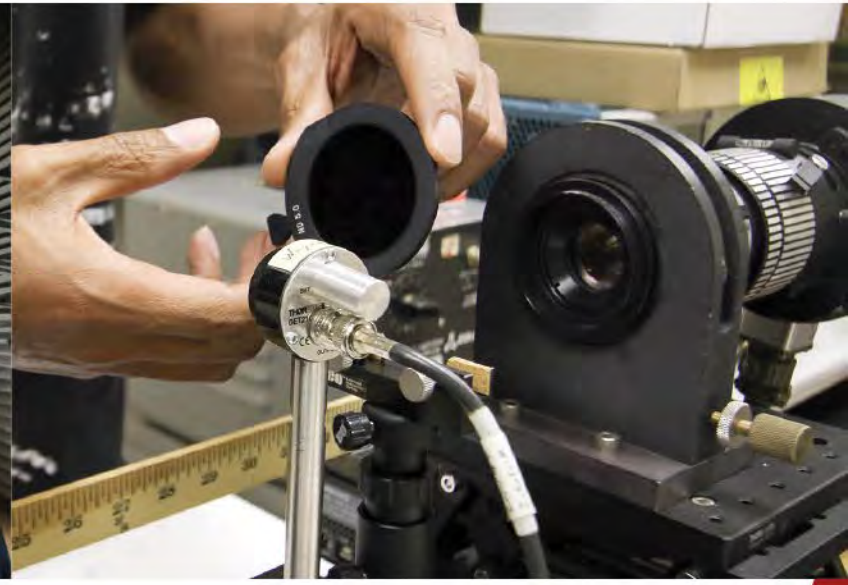
NEVADA NATIONAL NNSS SECURITY SITES

SDRD Program at the NNSS



Paul Guss, PhD

SDRD Program Manager

Export Controlled Information
Export Classification: EAR99
Reviewed for Classification
Paul P. Guss, MSTS, EV10
June 1, 2023

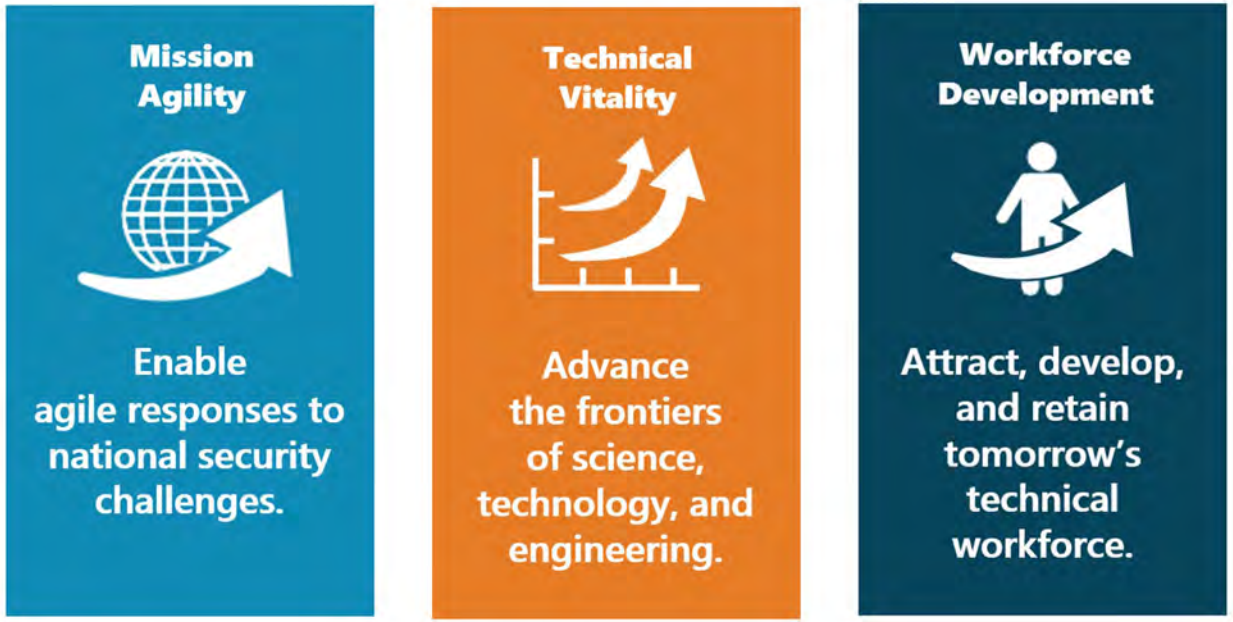
The Nevada National Security Site is managed and operated by MSTS under contract number DE-NA0003624.

This work was done by Mission Support and Test Services, LLC, under Contract No. DE-NA0003624 with the U.S. Department of Energy, the National Nuclear Security Administration's Office of Defense Programs, and supported by the Site-Directed Research and Development Program. DOE/NV/03624--1735

June 14, 2023

What is SDRD?

- **S**ite-**D**irected **R**esearch and **D**evelopment
- Internally funded Research and Development program
- Project durations from 1 to 3 years
- 40–60 projects in a given year
- Competitive process, projects are scored by a review committee
- Opportunity to be creative, try new things, take risks
- For many, SDRD offers the best opportunity for publication, conference attendance, etc.
- SDRD enables the mission execution of Science, Technology, and Engineering



SDRD Realignment into Mission Focused Thrust Areas is a Focused, Long-Term Technical Investment

Objectives for the STTAs

- Strengthen technical capabilities in the near term
- Enhance readiness of our core competencies in the long term
- Make us more agile and adaptable to new global threats

Strengthen existing and develop new technical capabilities throughout the NNSS in support of future NNSA-10/20/80 missions, as well as SPP/SIPP

- Align SDRD investments to better support NNSA missions
- Focus programmatic R&D efforts with a goal of enhancing or enabling new capabilities
- Deepen our scientific and engineering benches within these focused areas

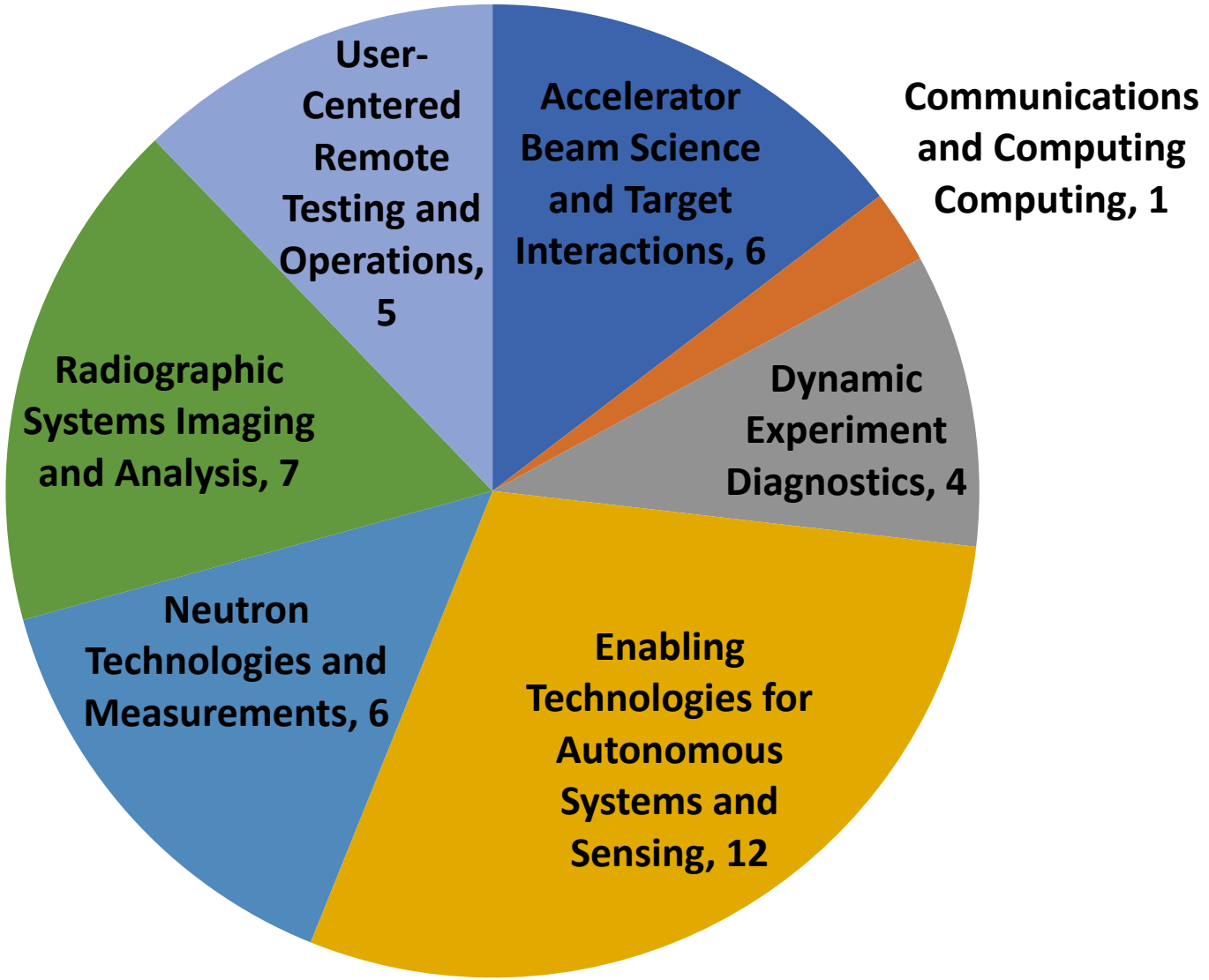
SDRD Alignment to the STTAs

- Focus areas
- Strategic areas (STTAs)
- Exploratory Projects
- Research associates

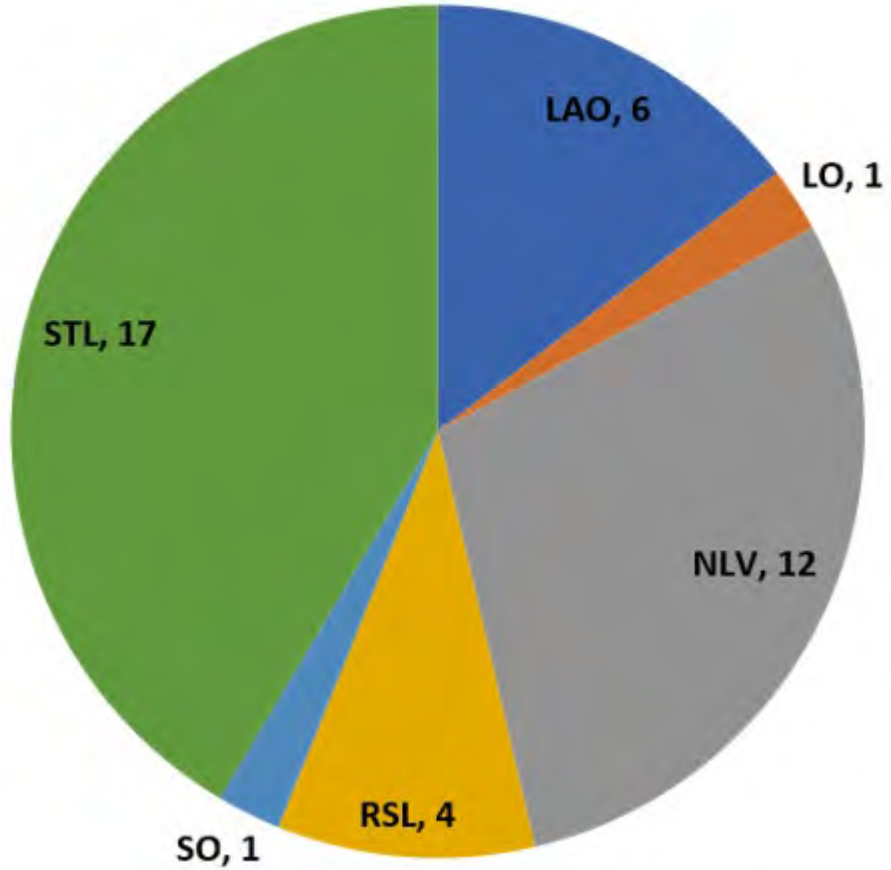
Strategic Response Toward NNSS Future Technology Preparedness

FY23 SDRD Projects

By STTA



By Site



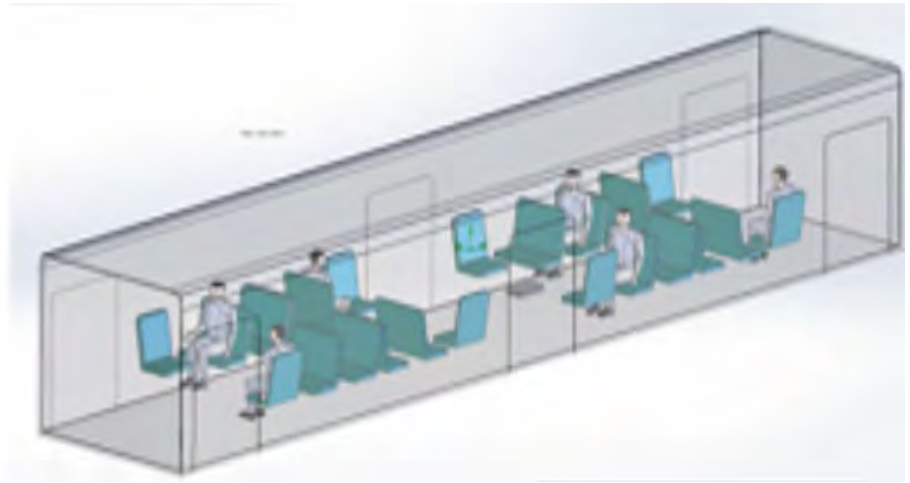
DHS Relevant Projects for FY23

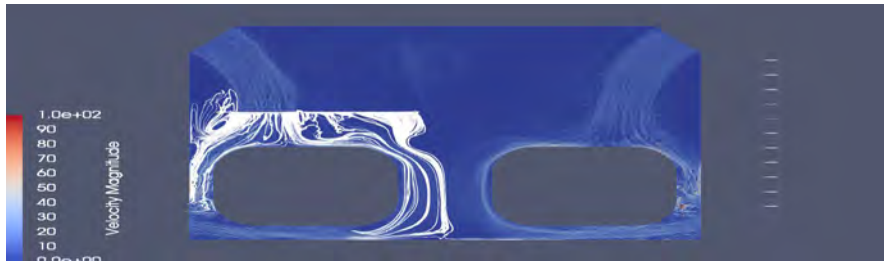
PID	Title	PI	STTA
23-016	Computational Fluid Dynamic Simulations for Critical Infrastructure (CFD-SCI)	Breckling, Sean	Communications and Computing
23-002	Mass-Selective Photoionization Detector	Manard, Manuel	Enabling Technologies for Autonomous Systems and Sensing
23-009	Low SNR, High Clutter UAS Detection and Tracking	McKenna, Ian	Enabling Technologies for Autonomous Systems and Sensing
23-010	Multi-Modal Remote Vibrometer for Infrastructure Interrogation	Koppenjan, Steven	Enabling Technologies for Autonomous Systems and Sensing
23-024	Measurements for combined gamma-ray and video modalities	Mendoza, Paul	Enabling Technologies for Autonomous Systems and Sensing
23-034	Surface Gas Sampling Payload for Autonomous Underwater Vehicles	Priest, Cameron	Enabling Technologies for Autonomous Systems and Sensing
23-041	Development of a compact, high-specificity, single-use sensor/sampler	Baldwin, David	Enabling Technologies for Autonomous Systems and Sensing
23-075	Microwave Detection Through Thin Films	Tarvin, Hilary	Enabling Technologies for Autonomous Systems and Sensing
23-081	AR/VR CBRN Solution for Emergency Responders	Richardson, Brian	Enabling Technologies for Autonomous Systems and Sensing
23-085	Improved Active and Passive Fluorescence Sensing	Baldwin, David	Enabling Technologies for Autonomous Systems and Sensing
23-087	Agnostic Modular Payloads for Multi-INT Collection	Davies, Andrew	Enabling Technologies for Autonomous Systems and Sensing
23-114	Spatially Aware Multi-modal Directional Radiation Detection Swarms	Essex, James	Enabling Technologies for Autonomous Systems and Sensing
23-017	Dual use high-Z, high cross section materials for neutron imaging and in-vivo X-Ray initiated cancer drugs.	DiBenedetto, John	Neutron Technologies and Measurements
23-019	Additive manufacturing of structural and pixelated/discriminating scintillators	Staska, Matthew	Neutron Technologies and Measurements
23-053	Increased Fidelity vis Quantum Correlated X-Rays: IF via QCX	Martin, Ryan	Radiographic Systems Imaging and Analysis
23-007	Fundamental Experiments for Detonation Signature Modeling	Kimblin, Clare	User-Centered Remote Testing and Operations
23-095	Spatial Spectral Observations from Near and Far	Howard, Michael	User-Centered Remote Testing and Operations

Computational Fluid Dynamic Simulations for Critical Infrastructure

Project Scope

- Develop in-house capability to numerically simulate fluid flow physics in incompressible regimes common to HVAC systems
- Construct a proof of concept HVAC/internal flow model surrogate using Continuous Data Assimilation (CDA) + Reduced Order Models (ROM)
- Validate new capabilities against previous and future physical experiments
- Develop techniques to assimilate physical measurement data (e.g., chemical species concentration, temperature, pressure) into numerical simulations.





Agnostic Modular Payloads for Multi-modal Collection

Project Scope

- Investigate self-contained collection systems that attach to aerial platforms, but do not rely on specific resources or interfaces to any particular platform
- Rather than directly developing new platforms or autonomous vehicle capabilities, resources can focus on payload integration and demonstrations of capability
- Sponsor multiple Capstone teams to investigate payloads and use cases
- Develop means to combine multiple modalities and location-awareness
- Demonstrate with flight tests

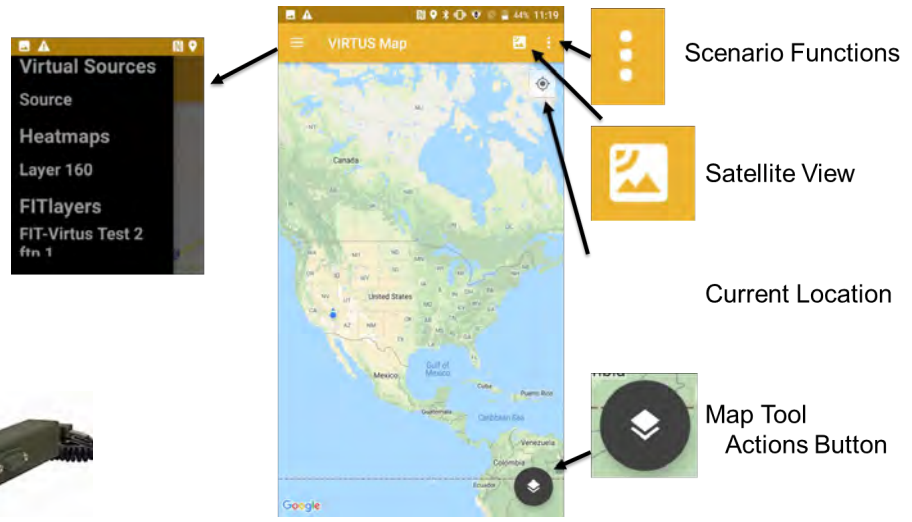
Year 2 BYU payload attached to quadcopter.

Payload will be flown by H6 drone to demonstrate multi-modal processing.

AR/VR CBRN Solution for Emergency Responders

Project Scope

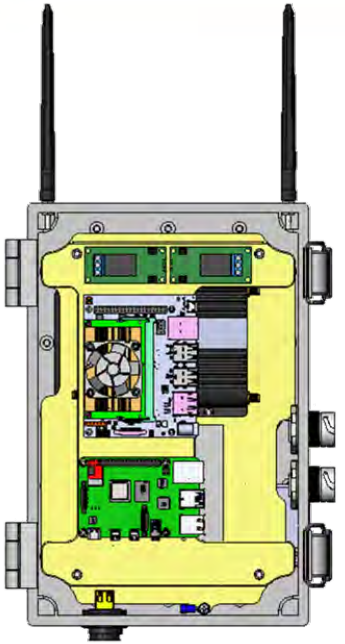
- Use Android smart device sensors and systems to create low-cost, external probes used by First Responders to more accurately and completely simulate chemical, biological, radiological, nuclear, and high explosive detection in virtual and augmented reality training programs



Measurements for Combined Gamma-Ray and Video Modalities

Project Scope

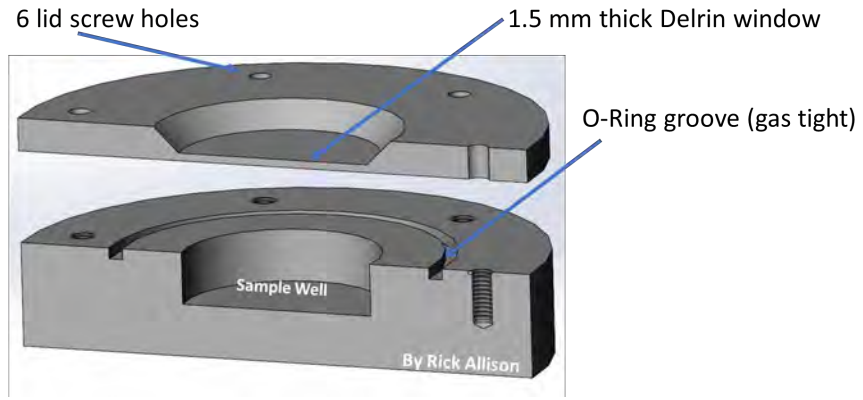
- Combine contextual video classification and weather information data with Nevada National Security Site (NNSS) in-house gamma identification algorithms to aid in convolution neural network source identification
- Provide rich stationary and mobile datasets for gamma identification algorithm training
- Extend applicability space of NNSS's Northern Virginia Radiation Sensor Array (NoVArray) from dataset generation to information generation
- Refurbish old nodes with current comms and edge compute hardware
- Contextual video classification and weather information to aid in convolutional neural network (CNN) source ID

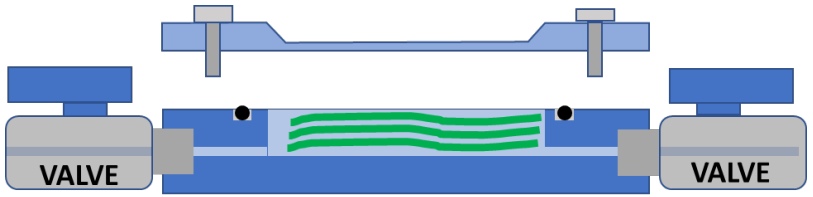


Dual Use High-Z, High Cross Section Materials for Neutron Imaging and In-Vivo X-Ray Initiated Cancer Drugs

Project Scope

- Develop chemical formulations of nanoparticles and cluster complexes which are viable options for optical up conversion under high energy excitation
- Develop optical methods for detecting time-resolved scintillation (alpha for neutrons and beta for gammas, respectively)
- Leverage the emerging use of novel materials development to create new detection materials for x-ray, gamma, and neutron detection
- Demonstrate scintillation-driven up conversion of high LET (dE/dx) events that can better discriminate neutrons from gammas by color.
- Develop scintillation-activated anti-tumor agents based on nitric oxide production.

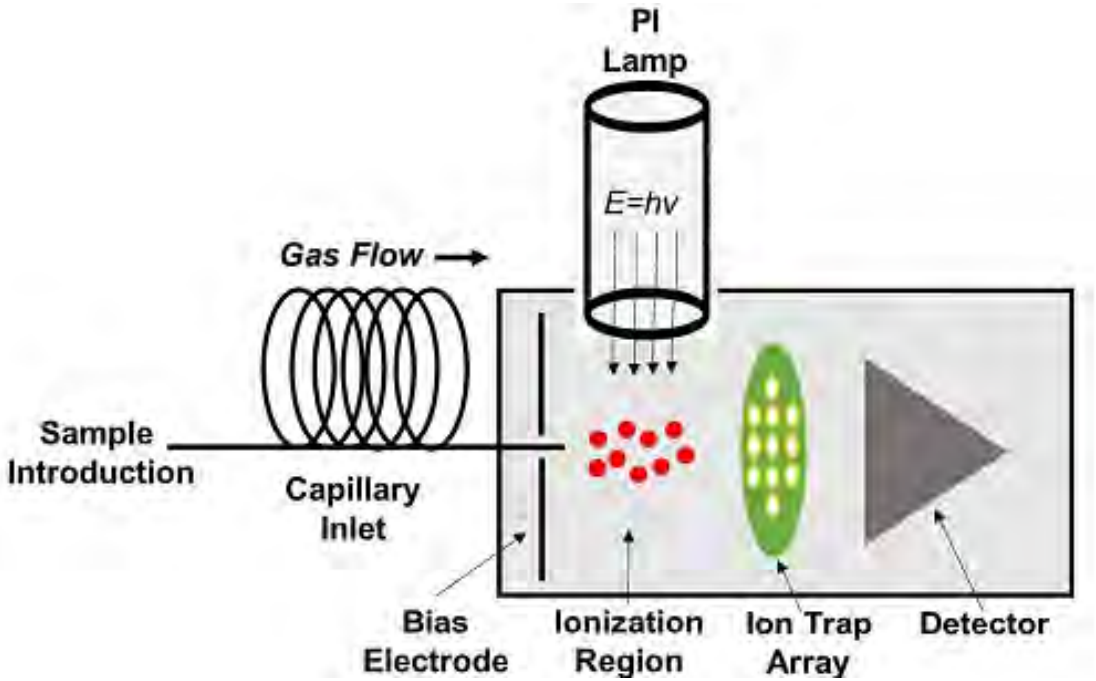


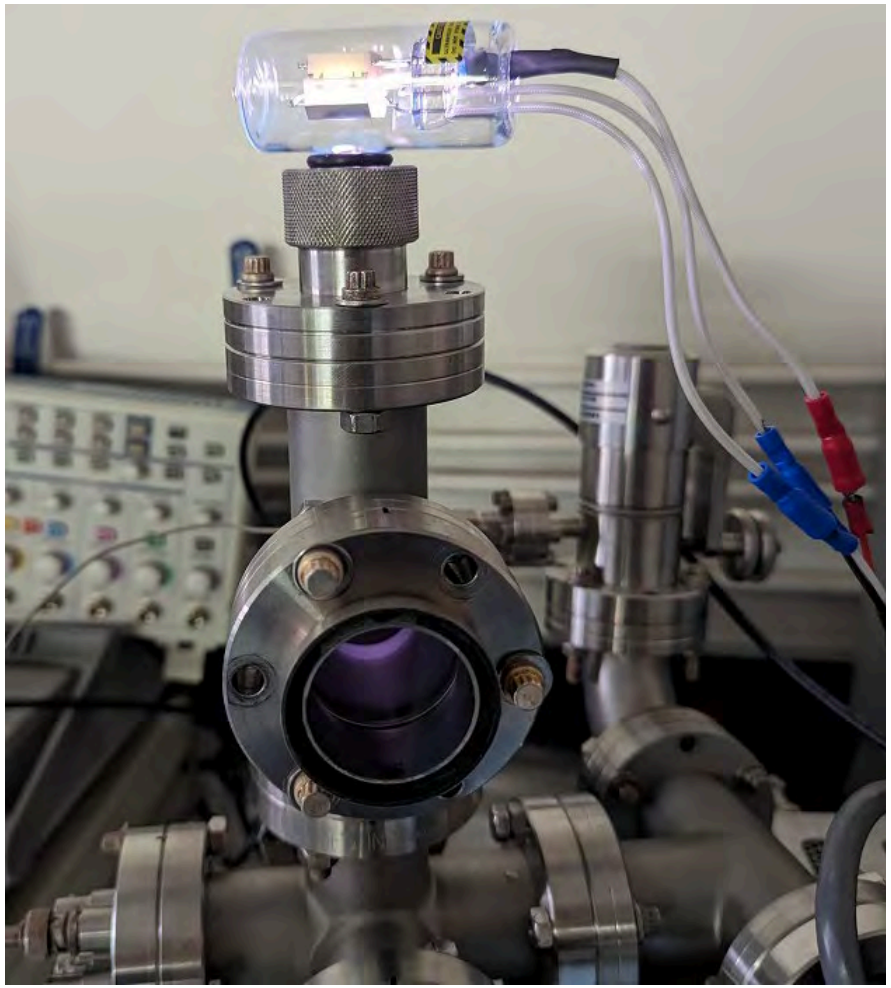


Mass-Selective Photoionization Detector

Project Scope

- Design, build, and test a proof-of-concept instrument that couples a photoionization (PI) lamp with an array of ion traps to provide mass spectra of chemical species in real time

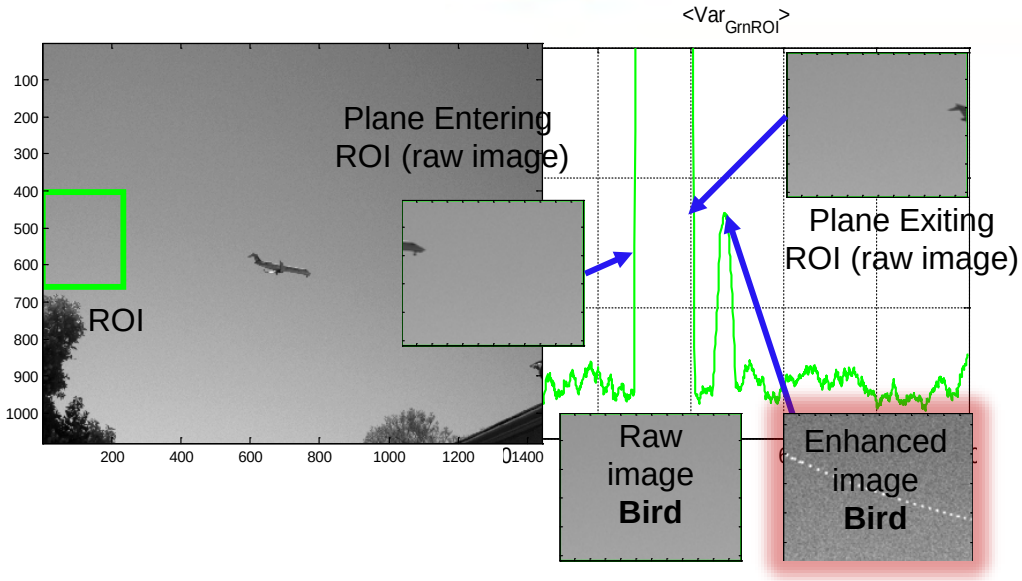


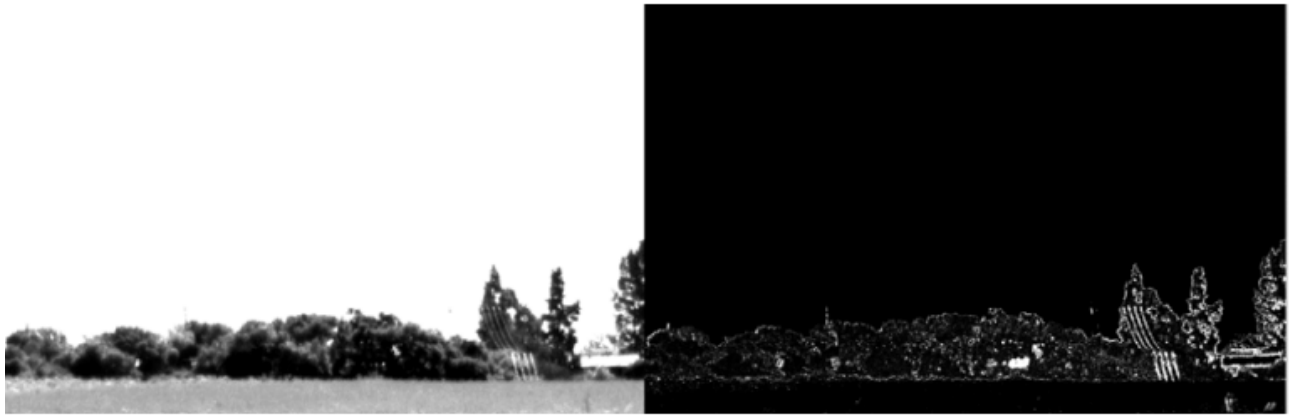


Low SNR, High Clutter UAS Detection and Tracking

Project Scope

- Develop methods to detect and track small unmanned aircraft systems (UASs) in complex environments
  - Leverage turbulence enhancement algorithms
  - Develop sensor model to assist in understanding scaling
- This work directly addresses the need to detect and characterize small UASs
- Sensor agnostic algorithms may allow implementation with existing hardware
- Expands our knowledge and understanding of UAS detection

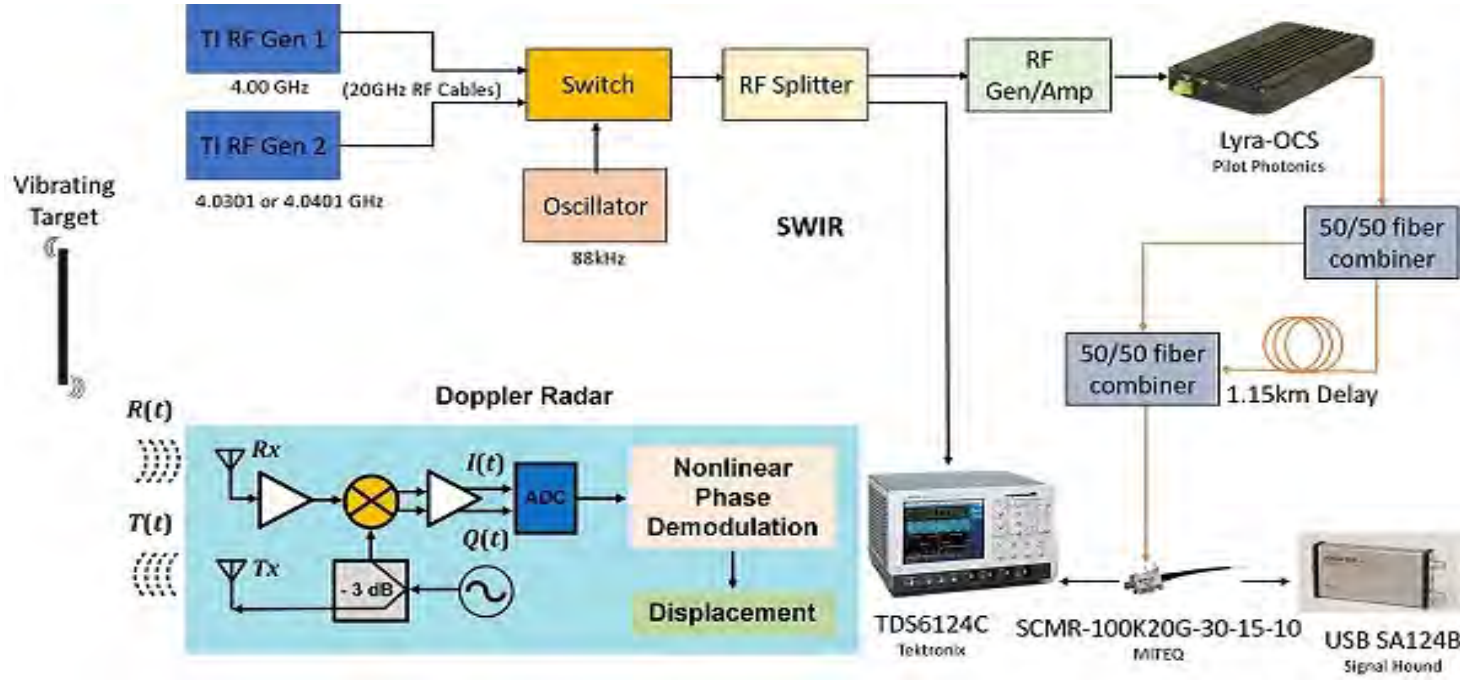




Multi-Modal Remote Vibrometer for Infrastructure Interrogation

Project Scope

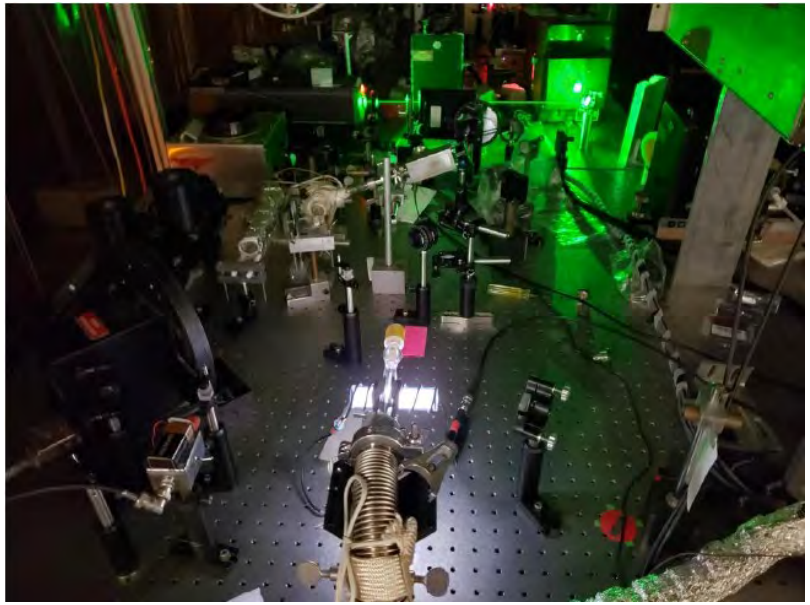
- Develop a next generation detection system to improve methods of remotely characterizing facilities of interest and increase standoff from hundreds of meters to multi-kilometer ranges
- Plan to extract unique signatures versus machinery operation levels; correlate to Patterns-of-Life.
- Combine temporal data analysis for more effective characterization of weak signals
- The Multi-Modal Remote Vibrometer for Infrastructure Interrogation combines active dual comb laser techniques, turbulence mitigation and micro-doppler radar
- This effort will move lab bench scale Dual Comb Spectroscopy techniques to the field and is directly related to the NNSA mission and treaty verification

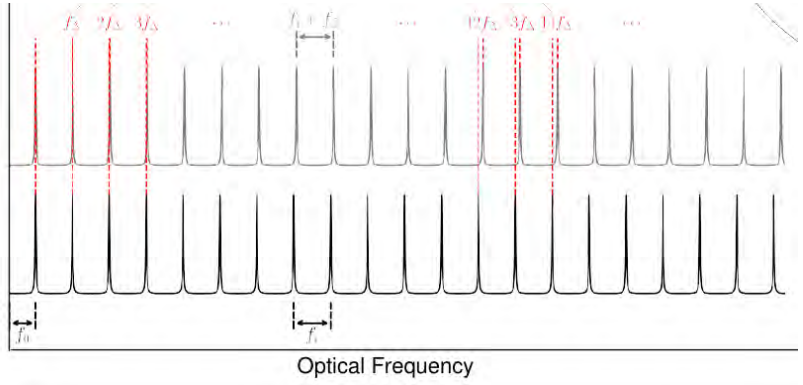


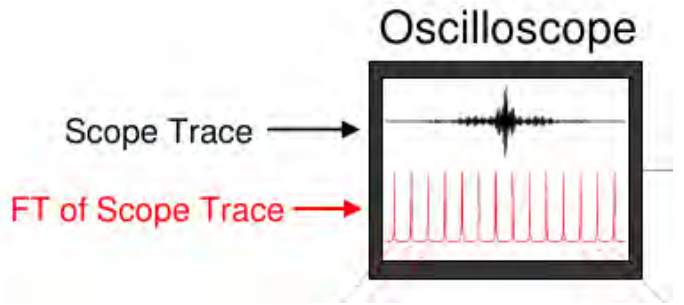
Optical Comb Techniques for Hyperfine Spectroscopy

Project Scope

- Measurement of atmospheric noble gases for radioactive isotopes, (radio-Xenon in particular) is an important tool in the detection of nuclear proliferation activities
- Measure isotopic abundances of Xenon samples by means of optical hyperfine spectroscopy
- The apparatus utilizes a Ti:sapphire laser that is large, complex, and expensive
- Comb techniques offer simplification of laser scanning, with an eye on portability for field deployment (in a van or aircraft).



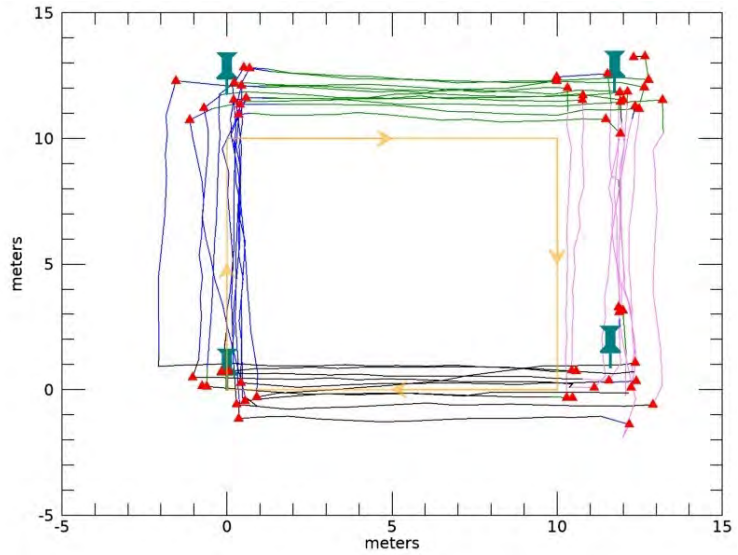


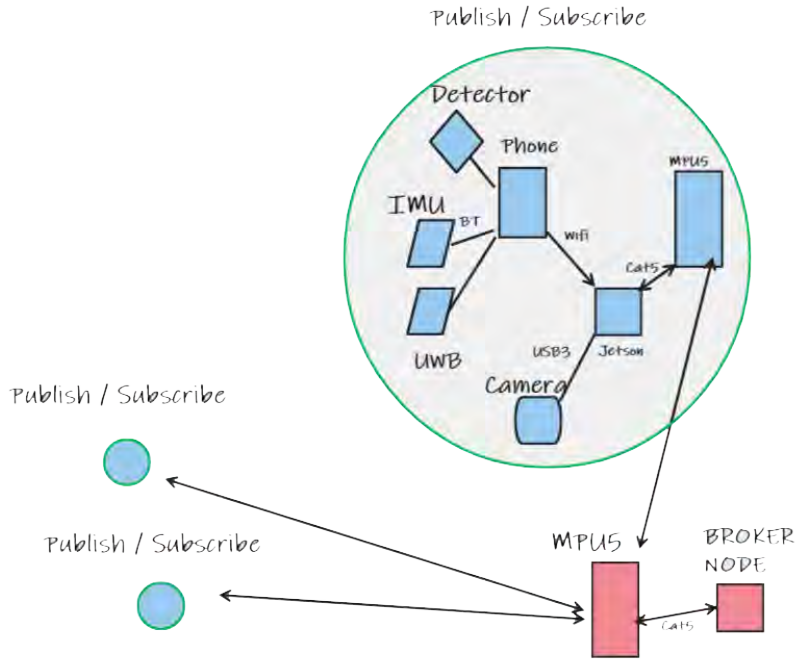


Spatially Aware Multi-Modal Directional Radiation Detection

Project Scope

- Explore spatially aware platforms that combine multiple inputs to estimate detector measurement locations and protocols for data exchange between sensors to develop methods to optimize detection and localization of radiation sources
- Improve anomaly detection and 2D radiation-source localization for both gamma and neutron radiation sources
- GPS-denied environments are most relevant, but tracking solutions that are adequately sophisticated will redefine the state of the art.





Dynamic Sub-Micron Particulate Behavior in Turbulent Media

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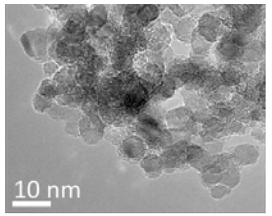
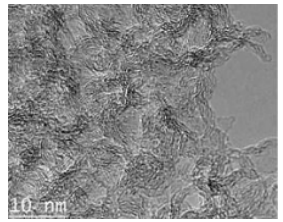
Project Scope

- Design, build, and execute particulate shock-tube and small scale high explosive experiments for improved understanding of characteristics and signals associated with carbonaceous detonation soot
- This effort will benefit modelers and diagnostic developers

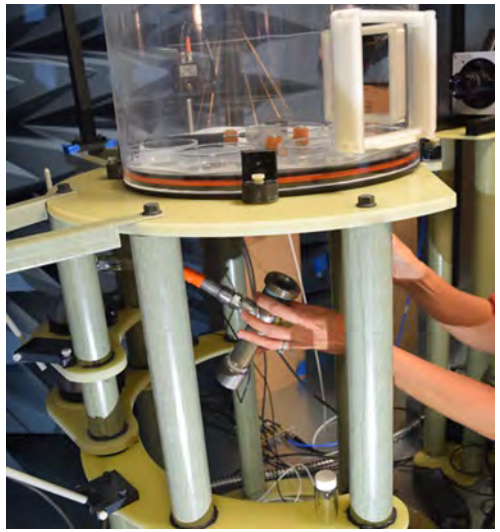
Comp B, *diamond



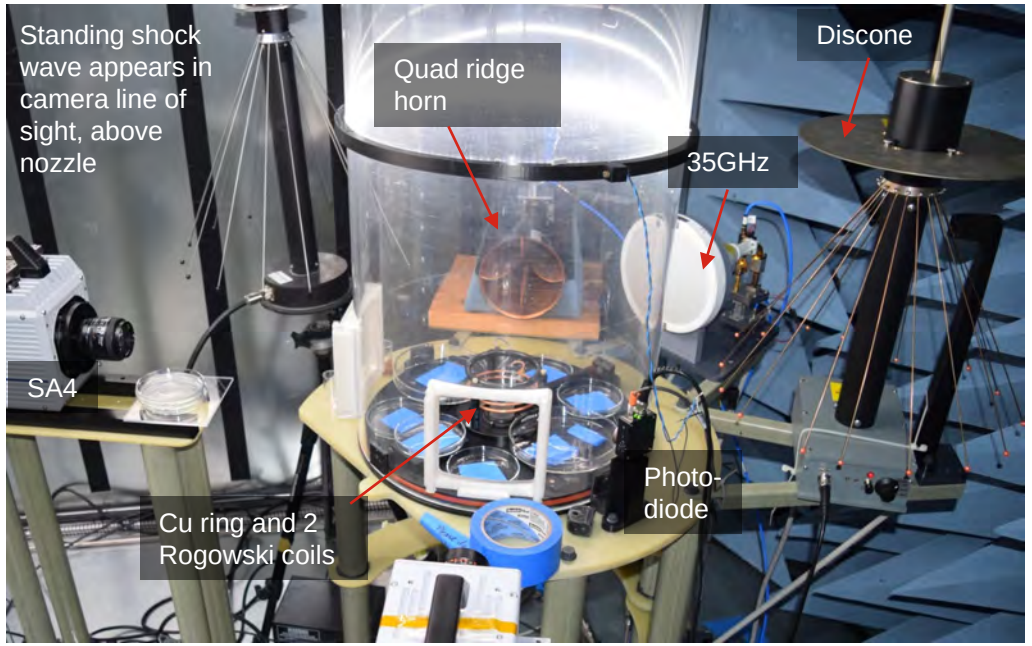
TNT, *graphite



Differing HE soot compositions



Sample loaded into base of Al shock tube, or into nozzle



Diagnostics include antennas (10 kHz – 35 GHz) and high-speed cameras

**Samplers shown were used for post-shot analysis of particulates in programmatic experiments.*

Increased Fidelity via Quantum Correlated X-Rays: IF via QCX

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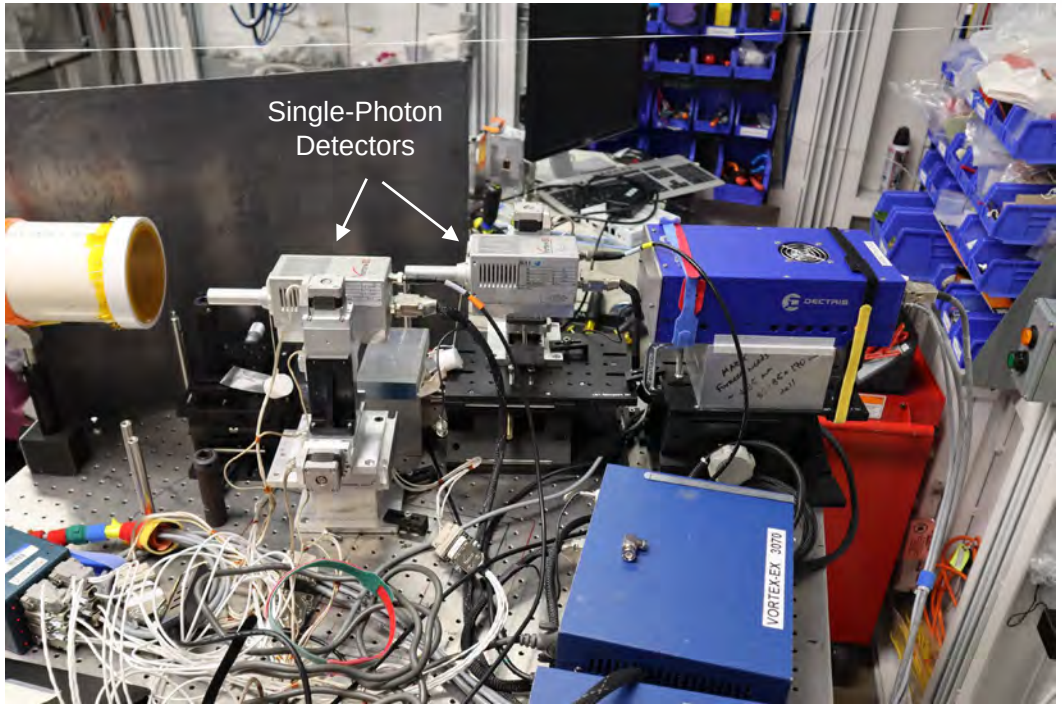
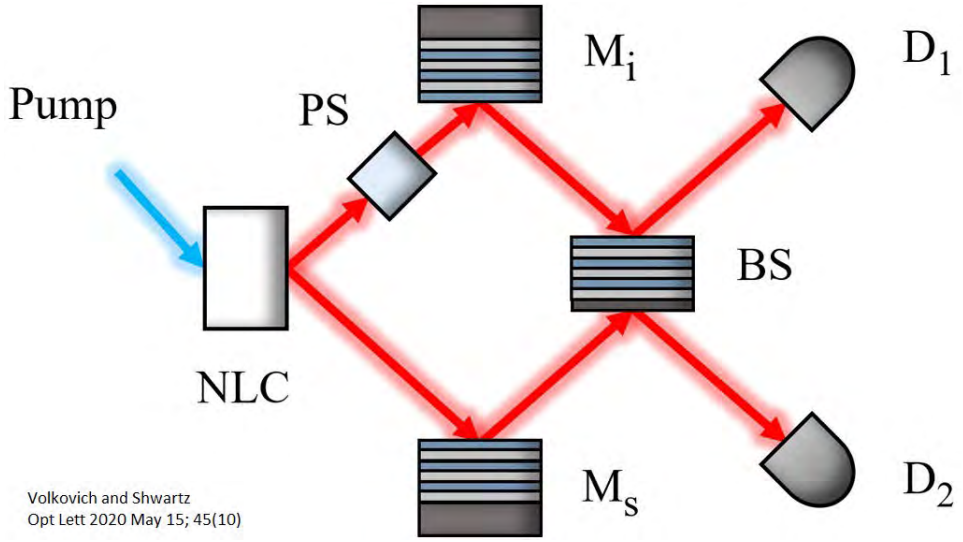
Project Scope

- There is a long-standing need within the response community to be able to determine the internal characteristics of an enclosed target
- This project is investigating the use of quantum-correlated x-rays for enhanced interrogation of enclosed targets



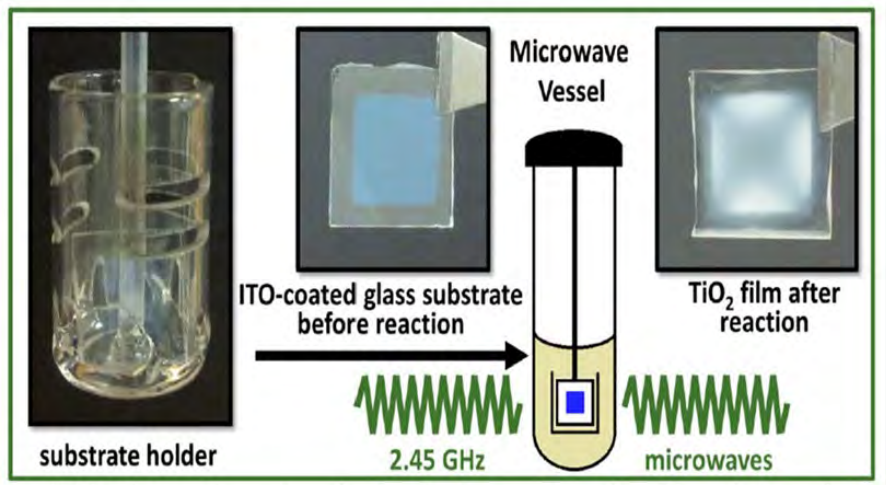


Volkovich and Shwartz
Opt Lett 2020 May 15; 45(10)

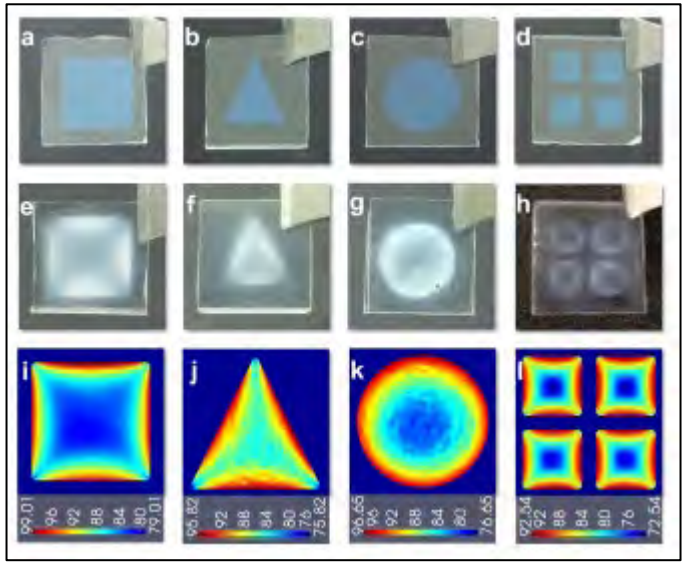
Microwave Detection through Thin Films

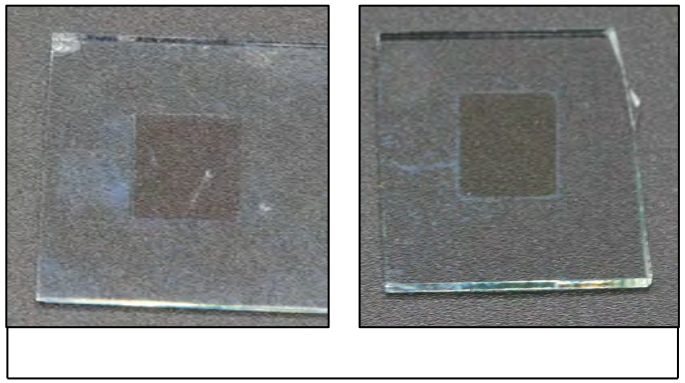
Project Scope

- Exposure to microwaves in certain power/frequency regimes can cause harmful health effects
- Electronic microwave detectors require calibration and are cost prohibitive for issuance to a large workforce or in device limited areas
- We hope to leverage a microwave catalyzed reaction that results in thin film deposition with an associated physical color change to create a TLD-like badge for microwave exposures



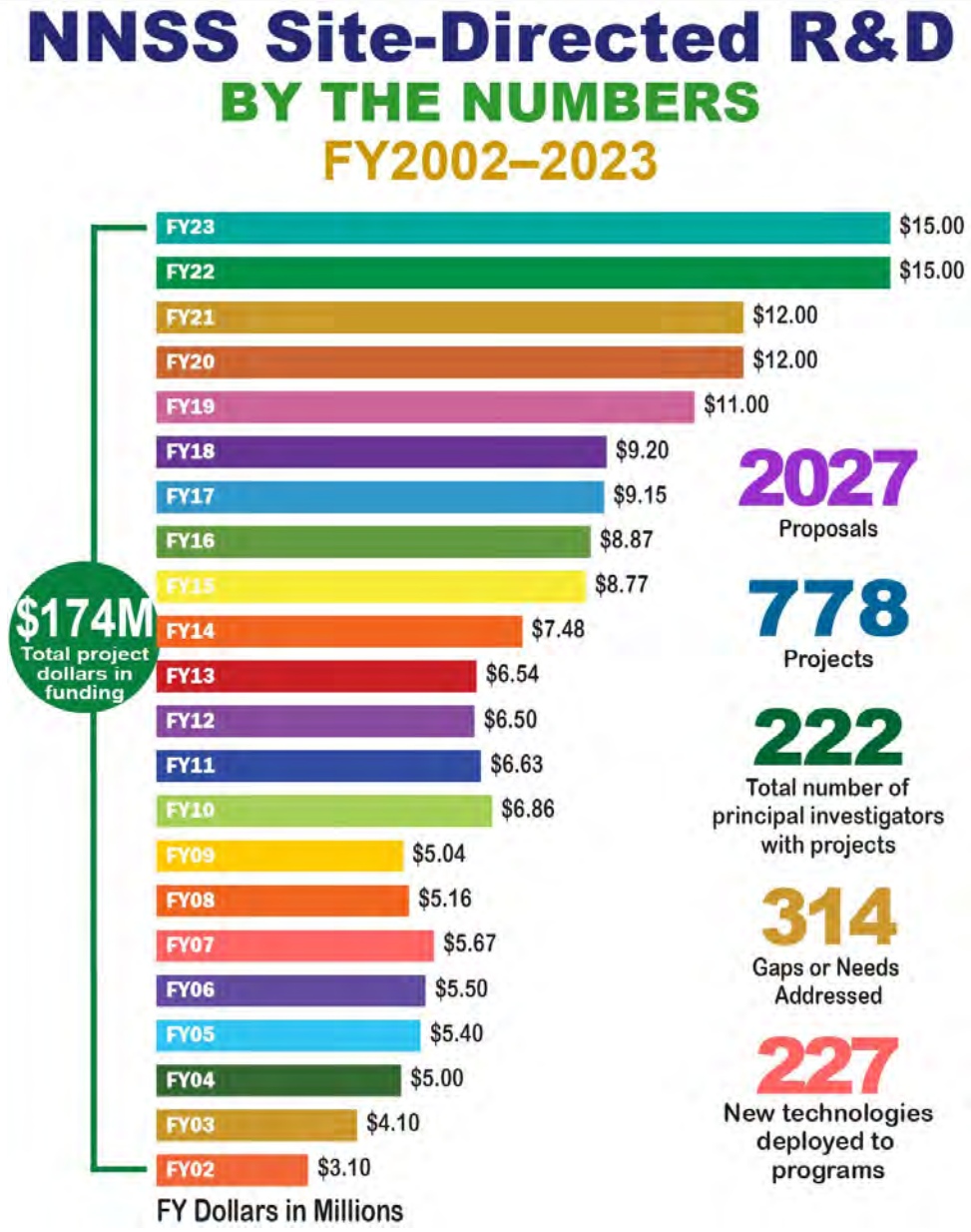
UT-Austin experimental results showing the transformation of the substrate after microwave reaction





Successive improvement of etching procedure

SDRD Trends


NNSS Site-Directed R&D
BY THE NUMBERS
FY2002–2023
FY23 $15.00
FY22 $15.00
FY21 $12.00
FY20 $12.00
FY19 $11.00
FY18 $9.20
FY17 $9.15
FY16 $8.87
FY15 $8.77
FY14 $7.48
FY13 $6.54
FY12 $6.50
FY11 $6.63
FY10 $6.86
FY09 $5.04
FY08 $5.16
FY07 $5.67
FY06 $5.50
FY05 $5.40
FY04 $5.00
FY03 $4.10
FY02 $3.10
FY Dollars in Millions
$174M
Total project dollars in funding
2027
Proposals
778
Projects
222
Total number of principal investigators with projects
314
Gaps or Needs Addressed
227
New technologies deployed to programs

SDRD also Impacts Innovation & Tech Transfer

SDRD Program Performance Metrics: FY 2014 to FY 2023										Year-to-Date
Metric	**FY14**	**FY15**	**FY16**	**FY17**	**FY18**	**FY19**	**FY20**	**FY21**	**FY22**	**FY23**
Number of projects	25	28	27	30	28	28	29	39	**54**	**46**
Invention disclosures	7	6	5	4	2	4	4	3	**0**	**2**
	28%	21%	19%	13%	7%	14%	14%	8%	**0%**	**2%**
Patents	--	--	3	4	2	--	--	1	**2**	**1**
Technology adopted by programs	10	11	10	8	9	11	9	13	**9**	**11**
	40%	39%	37%	27%	32%	39%	31%	33%	**16%**	**26%**
Gap or need addressed	11	10	10	13	11	14	12	18	**27**	**29**
	44%	36%	37%	43%	39%	50%	41%	46%	**50%**	**70%**
Emerging Area and Special Opportunity	5	5	3	5	6	3	6	18	**11**	**9**
	20%	18%	11%	17%	21%	39%	21%	46%	**20%**	**22%**
Postdocs	--	1**	2	1	2	2	2	12	**4**	**5**
Journal publications	8	7	7	8	8	10	24	21	**16**	**1**

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Questions?