



Exceptional service in the national interest

# Sandia National Laboratories

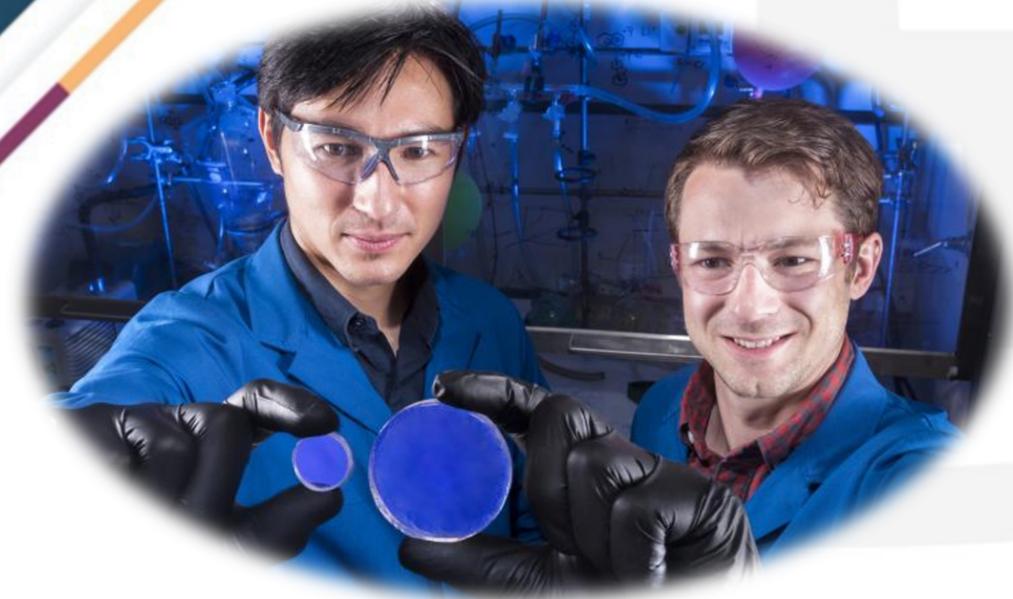
Overview and Mission Work for NA-22

Jon Zimmerman, ND Materials and Radiation Effects

David Peters, Proliferation Detection Remote Sensing

NSSC Fall Workshop and Advisory Board Meeting

October 17-18, 2023

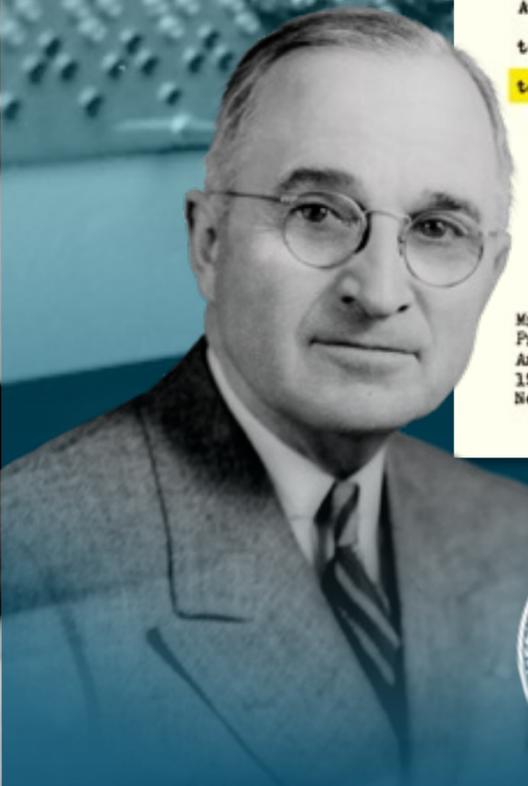


SAND2023-10933PE

Sandia National Laboratories is a multimission laboratory managed and operated by National Technology and 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.



# OUR HISTORY IS TRACED TO THE MANHATTAN PROJECT



THE WHITE HOUSE  
WASHINGTON  
May 13, 1949

Dear Mr. Wilson:

I am informed that the Atomic Energy Commission intends to ask that the Bell Telephone Laboratories accept under contract the direction of the Sandia Laboratory at Albuquerque, New Mexico.

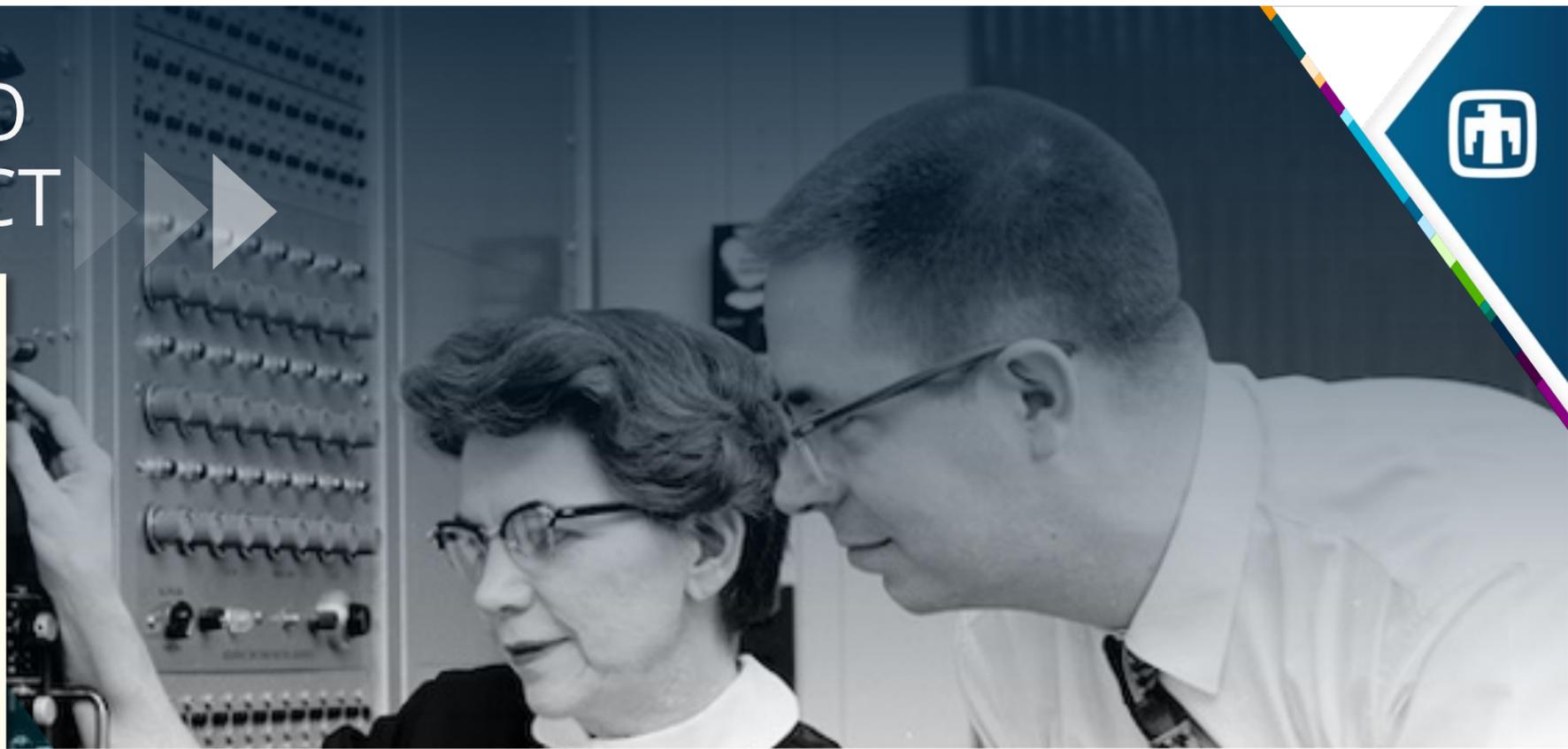
This operation, which is a vital segment of the atomic weapons program, is of extreme importance and urgency in the national defense, and should have the best possible technical direction.

I hope that after you have heard more in detail from the Atomic Energy Commission, your organization will find it possible to undertake this task. **In my opinion you have here an opportunity to render an exceptional service in the national interest.**

I am writing a similar note direct to Dr. G. E. Buckley.

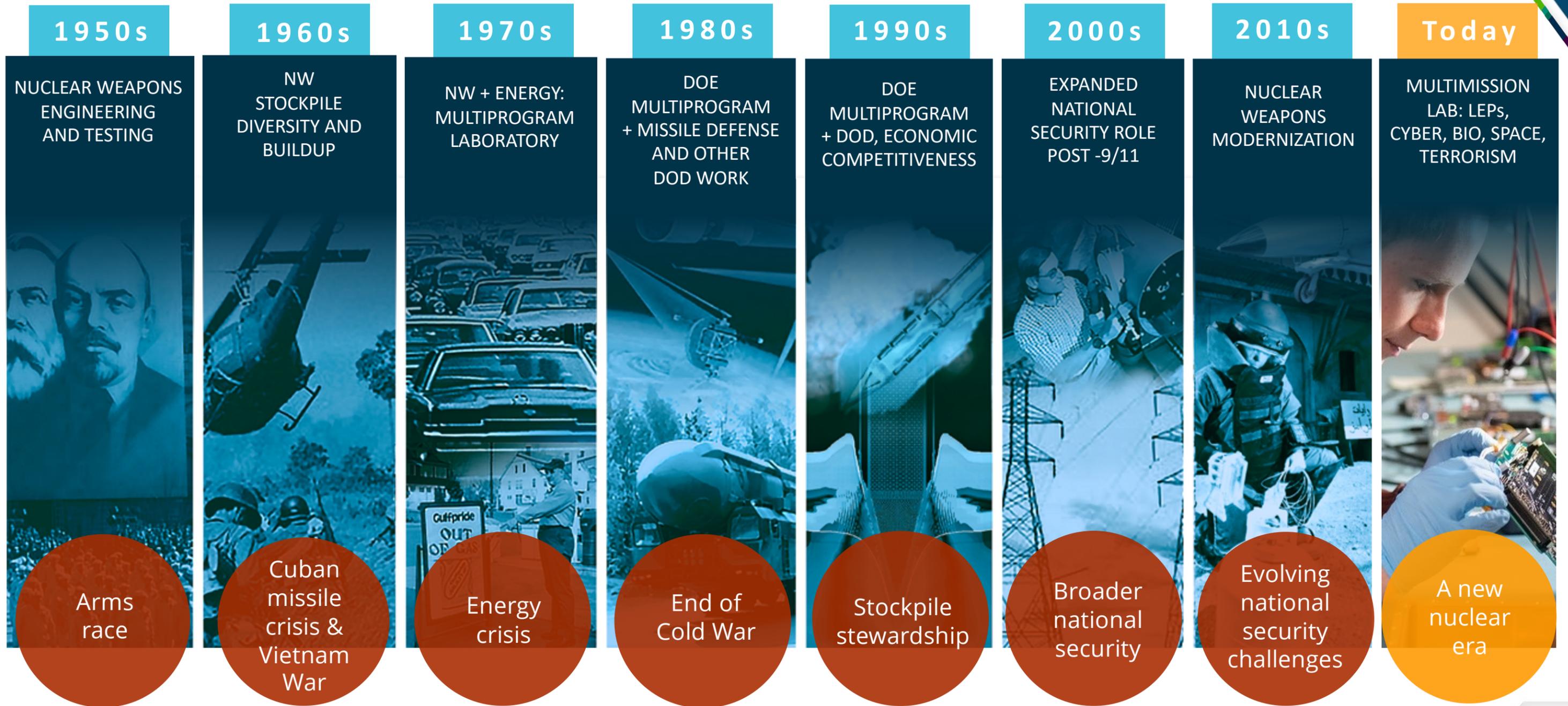
Very sincerely yours,  
*Harry Truman*

Mr. Leroy A. Wilson,  
President,  
American Telephone and Telegraph Company,  
195 Broadway,  
New York 7, N. Y.



- July 1945: Los Alamos creates Z Division
  - Nonnuclear component engineering
  - Federally Funded Research and Development Center
- November 1, 1949: Sandia Laboratory established
- March 8, 1956: Sandia California officially opened
- AT&T: 1949-1993
  - Martin Marietta: 1993-1995
  - Lockheed Martin: 1995-2017
    - Honeywell: 2017-present

# OUR ROLE HAS EXPANDED OVER THE DECADES



# SANDIA HAS FIVE MAJOR PROGRAM PORTFOLIOS





# NUCLEAR DETERRENCE

Responsibilities form a critical mandate

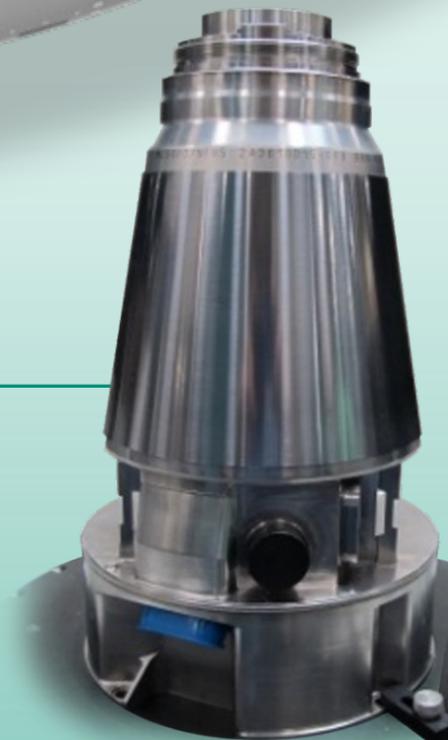
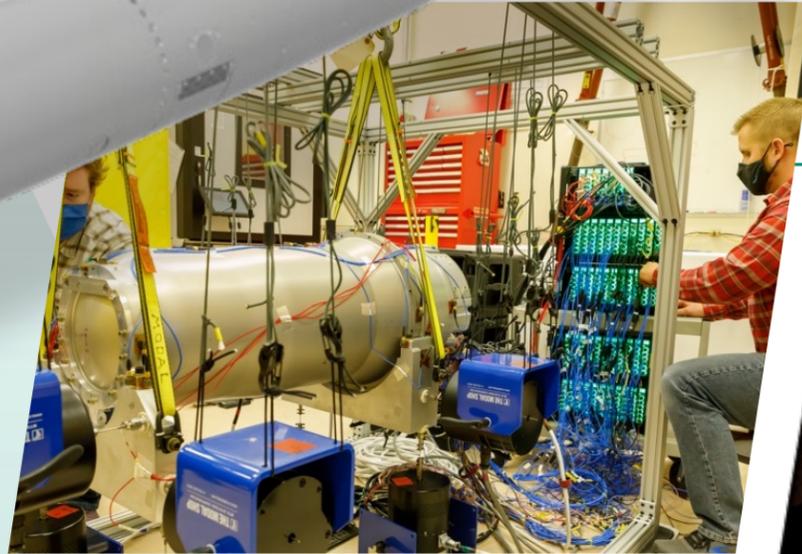
Warhead systems engineering & integration

Design agency for nonnuclear components

Specialized component production

Multidisciplinary capabilities

Required for design, qualification, production, surveillance



Sandia's Weapon Quality organization proactively drives component and system reliability to ensure weapon quality



# GLOBAL SECURITY

Protects the nation from threats at home and abroad



- Space- and ground-based sensor systems for monitoring emerging threats
- Technology and training to respond to a crisis associated with weapons of mass destruction
- Capabilities for protecting U.S. nuclear weapons and materials at fixed sites and in transit
- Systems that deter proliferation and verify compliance with international agreements using space-borne and ground-based sensing technology
- Global technical engagement to prevent the misuse of nuclear, chemical, biological and radiological materials





# NATIONAL SECURITY PROGRAMS



Provide trusted, threat-informed pathfinder technology for national security

Information Operations



Proliferation Assessments



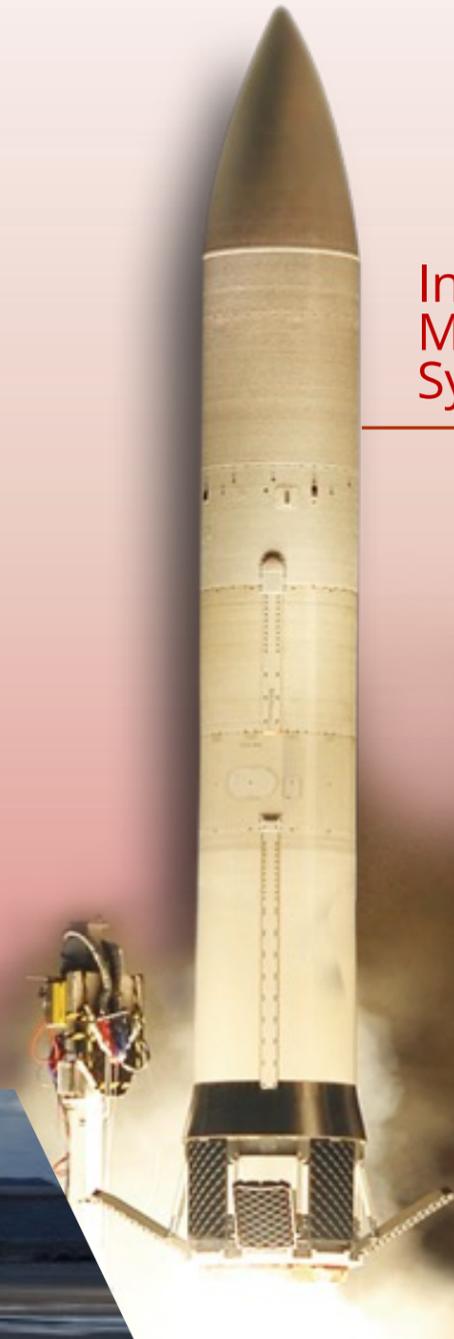
Science & Technology Products



Surveillance & Reconnaissance



Integrated Military Systems



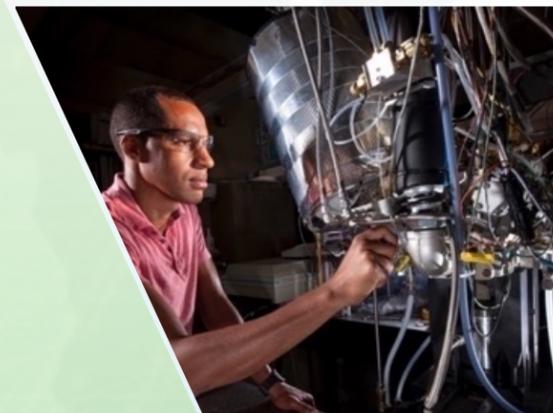


# ENERGY & HOMELAND SECURITY

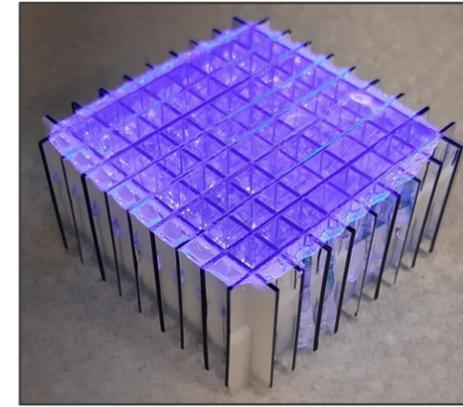
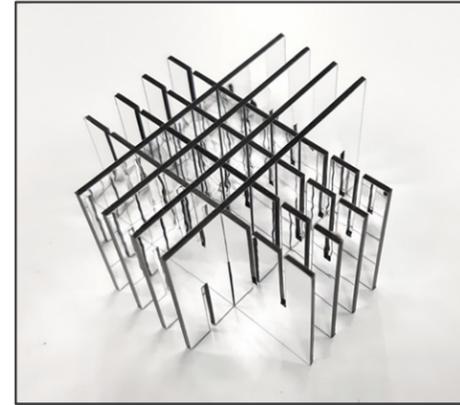
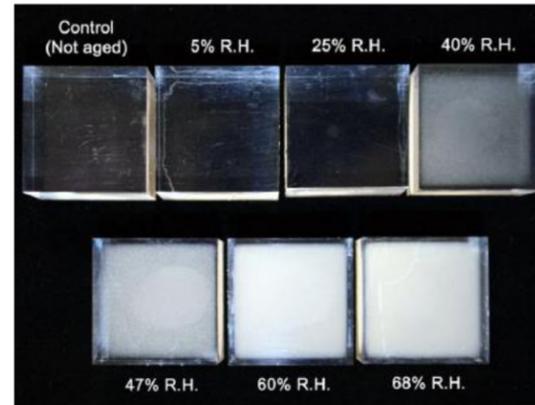
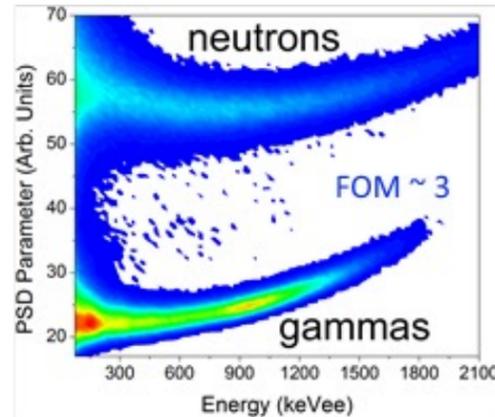


Secures the nation's critical infrastructures and environment against attacks, threats and climate change by performing world-class research and development

- Reduce the nation's vulnerability to chemical, biological, radiological and nuclear threats
- Enable the full potential of renewable energy and subsurface resources
- Ensure the safety, security and resilience of nuclear power and the electric grid, and the safe management and disposal of radioactive wastes
- Advance efficient and sustainable energy use for a changing world
- Increase our nation's digital and physical critical infrastructure security and resilience to natural and human-made threats



# SCINTILLATOR & RAD-SENSITIVE MATERIALS DEVELOPMENT



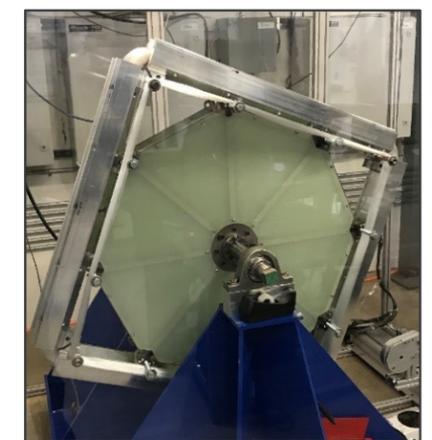
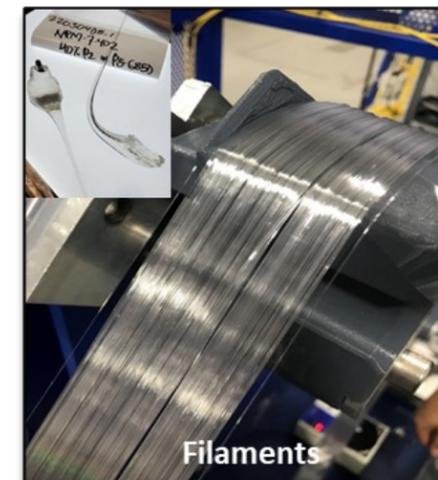
Mission Requirements for nuclear non-proliferation, defense, and nuclear energy have spawned the need for spatially-resolved fast neutron detectors:

- Neutron double-scatter imaging
- Associated particle imaging
- Neutron radiography

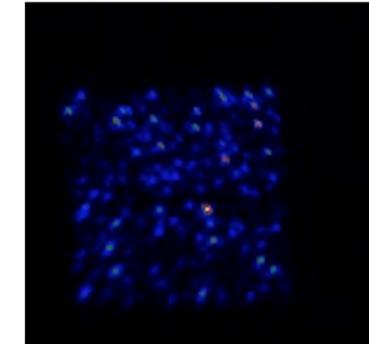
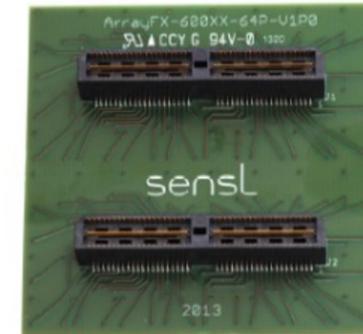
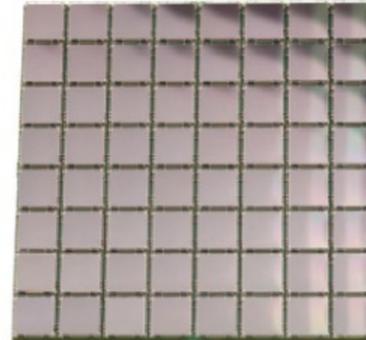


Goals:

- Provide improved neutron-gamma discrimination, increased light yield, and higher efficiencies
- Devise methods for scalable production to facilitate technology transfer to industry and ease of commercialization.



# SILICON PHOTOMULTIPLIER-BASED DETECTORS



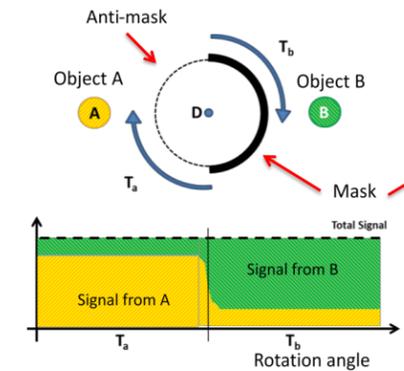
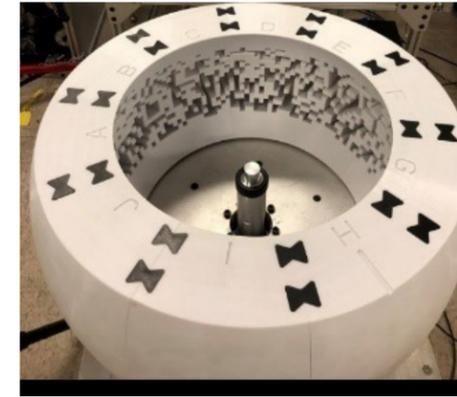
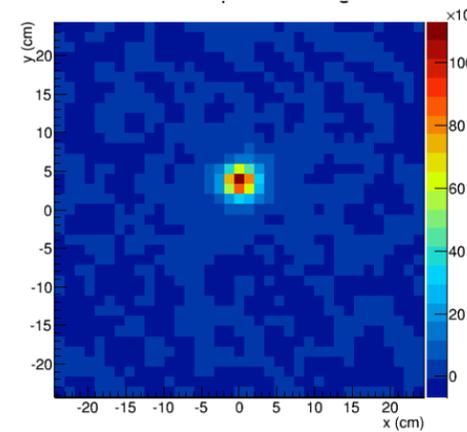
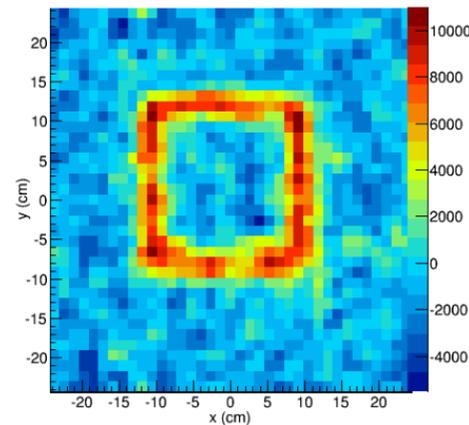
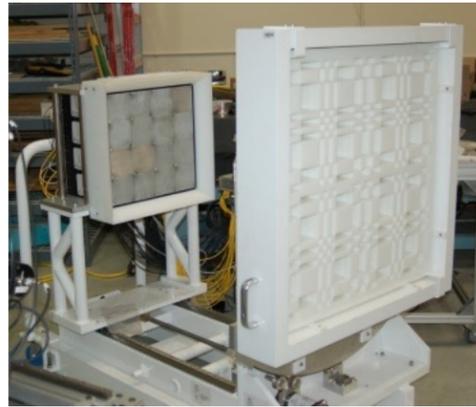
Silicon Photomultipliers (SiPMs) outperform traditional photomultiplier tubes (PMTs):

- Greatly improved size, weight and power (SWaP)
- Vacuum tube vs. solid state technology improves overall robustness
- Improved photo-detection parameters, e.g., efficiency, timing response, and gain resolution

Evaluating technology options for replacing PMTs with SiPMs, including

- devising pixelated readout solutions for 1000s of channels,
- understanding response to 70-80°C and compensate by...
  - designing temperature compensation circuits to account for gain changes
  - cutting out individual noisy avalanche photodiodes to reduce dark count rate

# NEUTRON AND GAMMA CODED APERTURES



Developing high-resolution passive emission neutron and gamma detection & imaging capabilities for warhead verification measurements and emergency response diagnostics.

- Neutron emission directionality can improve detection and enable localization of weak SNM sources.
- High-resolution imaging characterizes the spatial distribution of plutonium or other neutron emitters.
- Antisymmetric masks allow arms control verification measurements without revealing sensitive information.

Coded aperture systems have been tested and refined using measurements of arms control treaty-relevant objects through the Warhead Measurement Campaign and End-to-End projects, and has been devised for incorporation into a treaty CONOPS.

# RAD2K: NEW APPROACHES FOR REMOTE OPTICAL RADIATION DETECTION

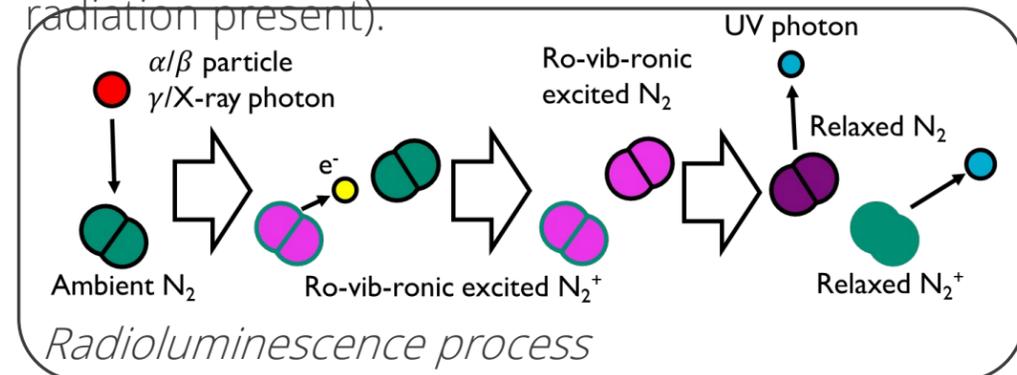


PI: Garrett Marshall, *Sandia National Laboratories*

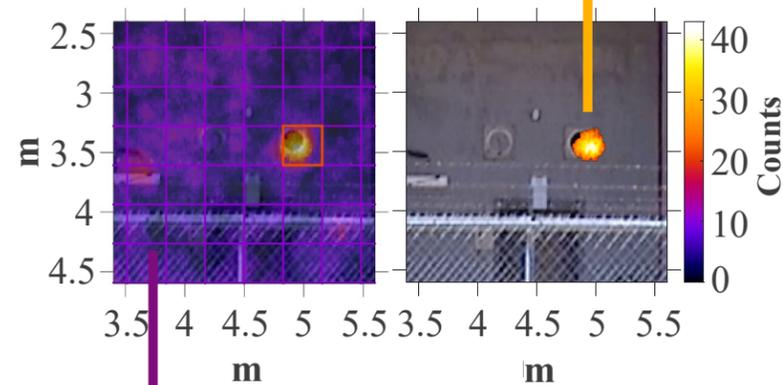
Collaboration: Vassilia Zorba, *Lawrence Berkeley National Laboratory*

## Foundational Past Effort

Group successfully demonstrated passive, *UltraViolet (UV) optical radiation detection from kilometer stand-offs* (only natural background radiation present).



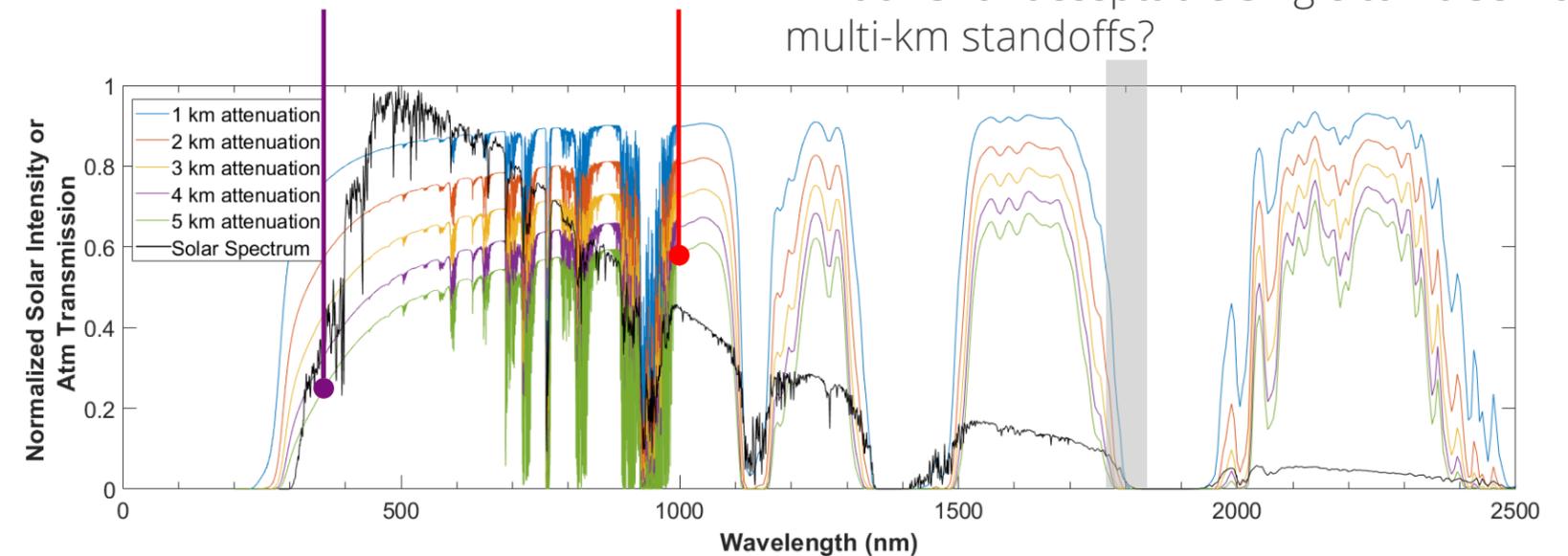
Air column fluorescence from  $^{60}\text{Co}$  irradiation



Context image overlaid by full UV image

## RAD2K Advancements

UV attenuation > IR attenuation



Radioluminescence bands near transmission windows for acceptable single to noise from multi-km standoffs?

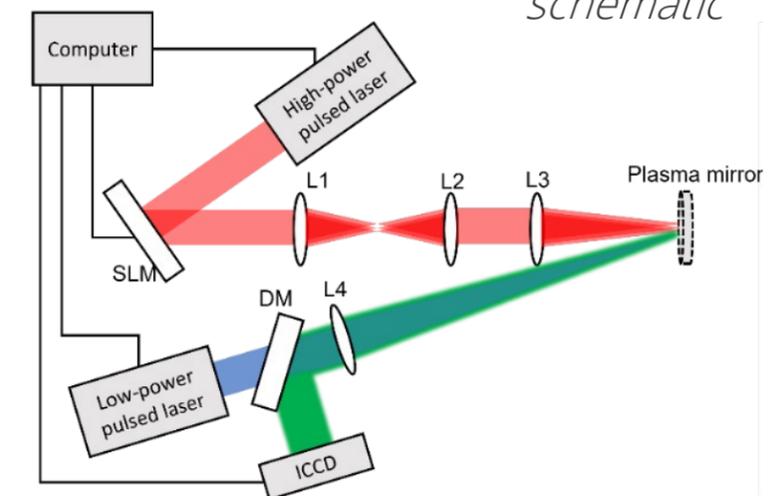
## Thrusts

**Discovery:** evaluation of long attenuation length **infrared (IR) signals** for the potential remote detection of irradiated air with **passive or laser-probing** techniques.

**Refinement:** ultrafine spectroscopic methods to resolve individual **ro-vibrational characteristic spectral features** for **improved detection** capability.

**Pursuit:** development of **laser-generated plasma mirror** to create free-space retroreflector for **monostatic laser-based probing applications**.

Table-top plasma mirror schematic

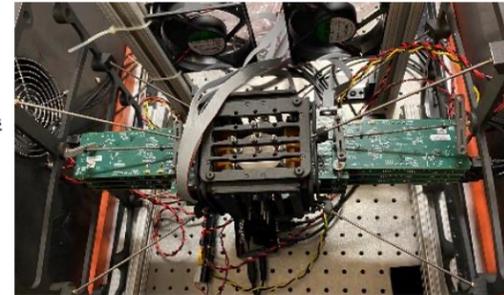
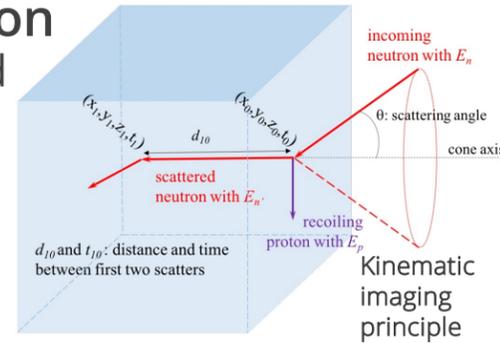


# JON BALAJTHY (FORMER NSSC POSTDOC, CURRENT STAFF AT SNL/CA)



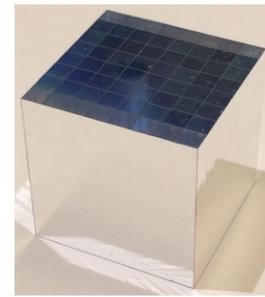
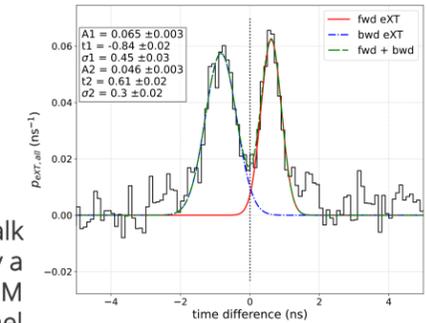
## Single Volume Scatter Camera Collaboration

- Commissioned and characterized SiPM-Based monolithic prototype
- Developed likelihood model for event reconstruction
- Made in-situ measurement of SiPM external crosstalk

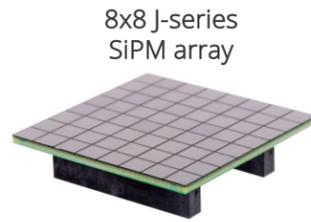


Monolithic imager with 2-sided instrumentation

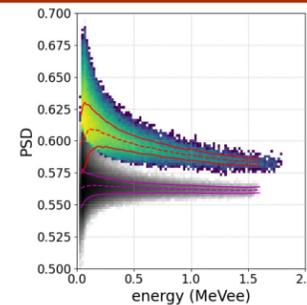
External crosstalk generated by a single SiPM channel



Pixelated PSD-capable scintillator

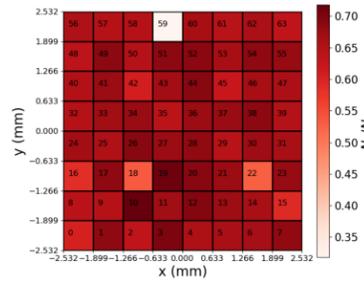


8x8 J-series SiPM array



Selected neutrons in single pixel

Measured efficiency in all pixels



## Pixelated Neutron Detector

- Performed neutron detection efficiency measurements for a new pixelated neutron scintillation detector with individual pixel readout

## Warhead Attributes from Radiation Imaging (WARI)

- Developed attribute confirmation analysis algorithm using reconstructed images from neutron-coded aperture

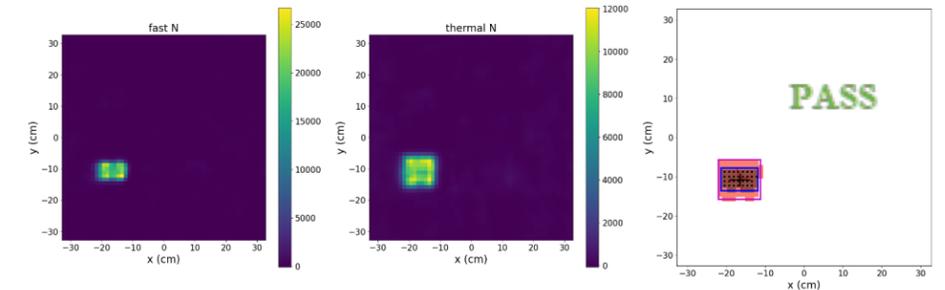


Neutron coded aperture imaging detector

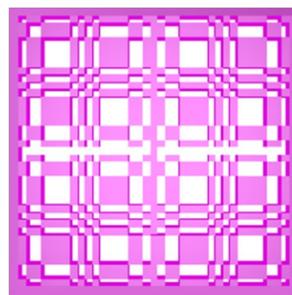
(Left) Simulated fast neutron image of rectangular source

(center) simulated thermal neutron image of overlapping rectangular source

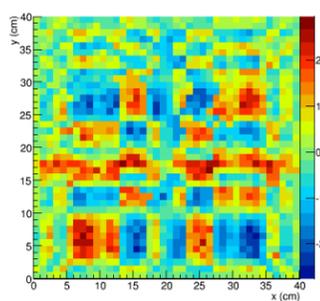
(right) algorithm output



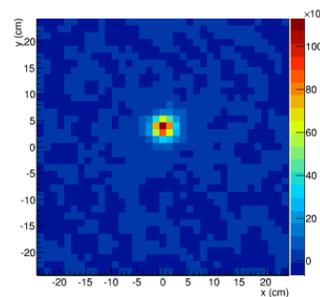
NCA mask pattern



Mask-modulated image



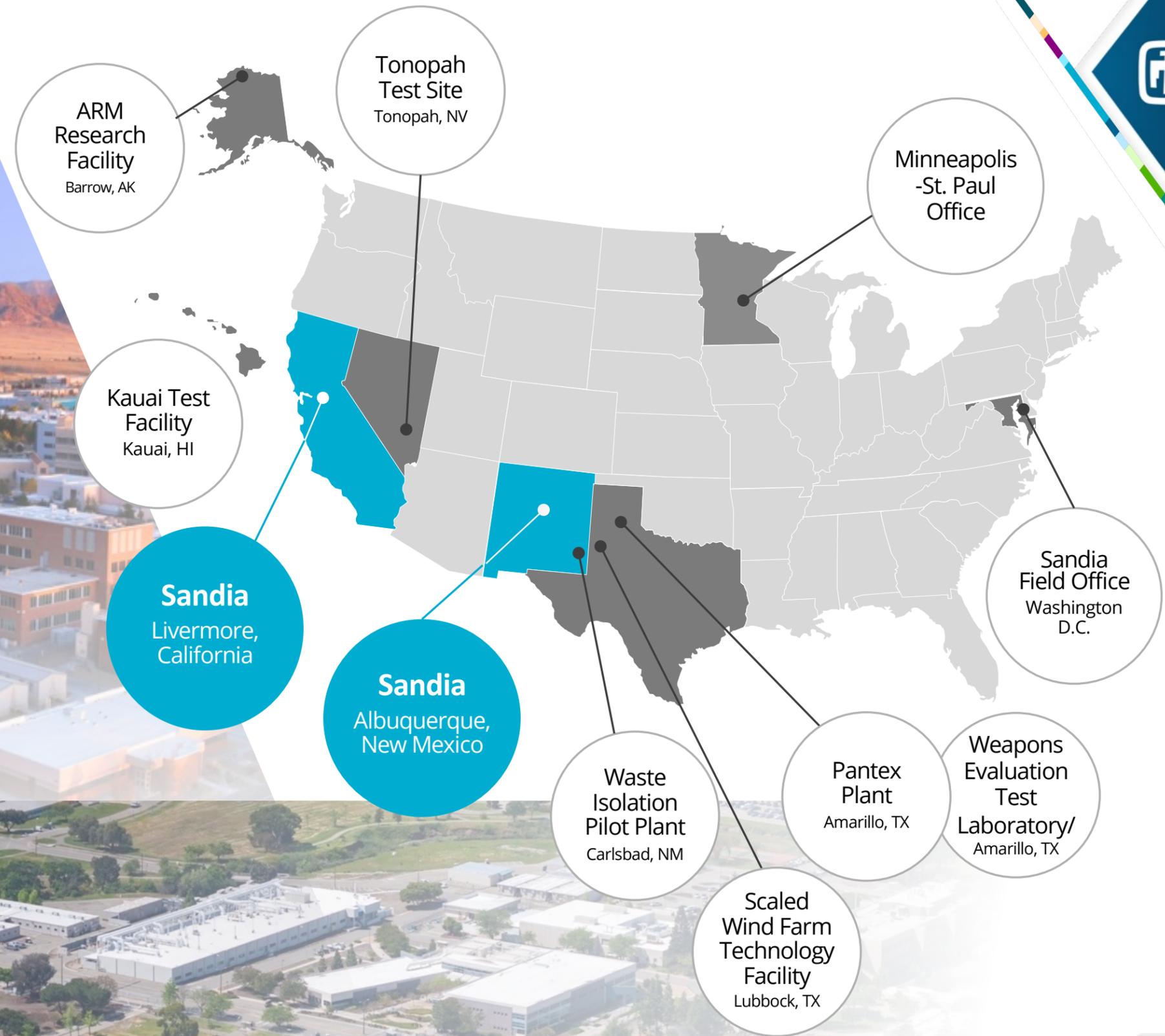
Reconstructed image



## PROACTIVE Venture: Neutron Coded Aperture (NCA) for Arms Control

- Adapting NCA technology for use in arms control
- Detector and electronic readout development for easy authentication and certification
- Development of arms control relevant analysis procedures using modelling and experiment

# WE HAVE FACILITIES ACROSS THE NATION



**Main Sites**  
Albuquerque, New Mexico  
Livermore, California



# ADVANCED SCIENCE & TECHNOLOGY

- ▶▶▶ Integrates multidisciplinary efforts to advance science for Sandia's missions
- ▶▶▶ Research Foundations play an integral role in mission delivery

Nanodevices & Microsystems



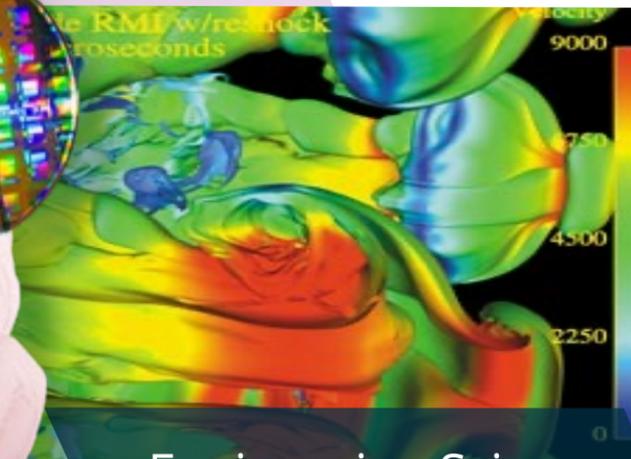
Radiation, Electrical and High Energy Density Science



Materials Science



Computing Information Science



Engineering Science



Earth Science



Bioscience