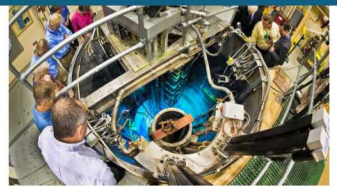
SAND2019-12040PE

Science and Engineering at Sandia National Laboratories

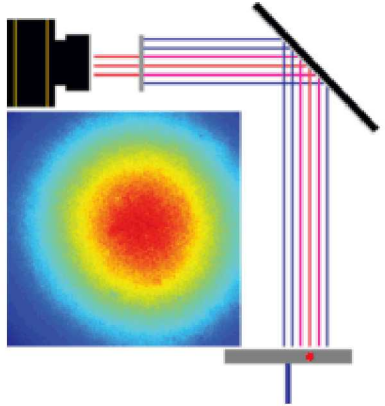


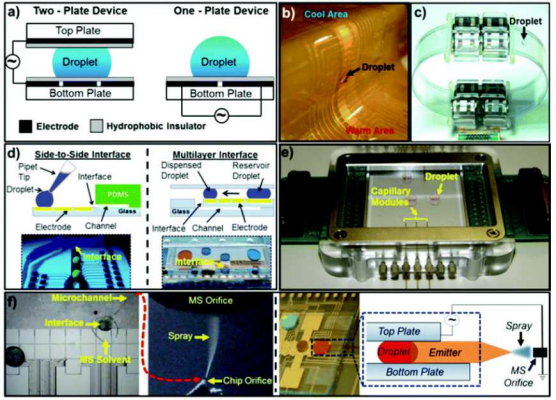
Brian Z. Bentz and Kamlesh D. Patel

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.

Introductions

- Brian Z. Bentz
  - Purdue alumni (undergraduate in 2011 and Ph.D. in 2017)
  - Sandia R&D staff member
  - Fog, radiation mapping, plasma diagnostics
  - bzbentz@sandia.gov
- Kamlesh D. Patel
  - Sandia manager living at Purdue
  - Microfluidics, DNA sequencing, lab-on-a-chip devices
  - kdpatel@sandia.gov





[1] B. Z. Bentz, D. Lin, and K. J. Webb, *Physical Review Applied* ***10***, 034021 (2018)
[2] M. J. Jebrail, M. S. Bartsch, and K. D. Patel, *Lab on a Chip* **12**, 2452 (2012)

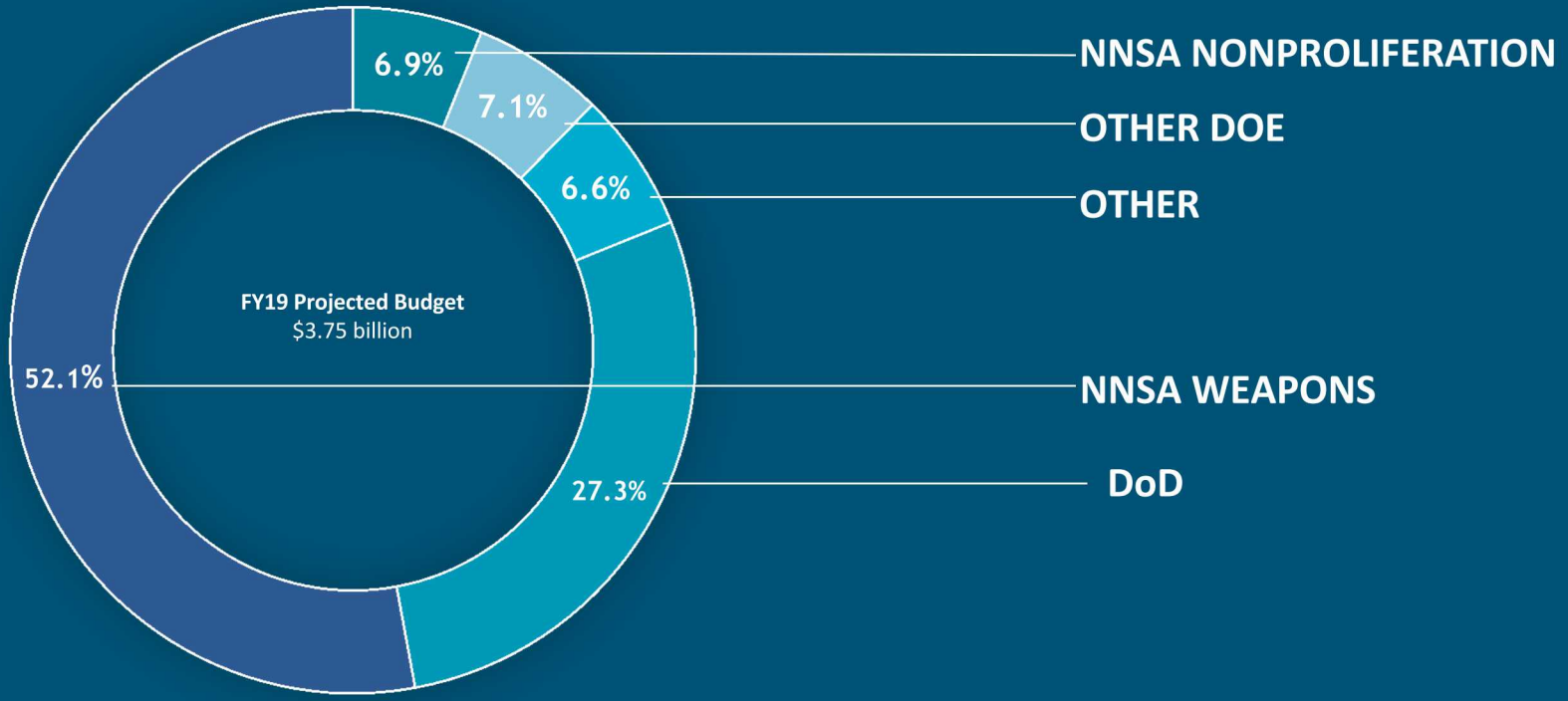
Outline

- About Sandia
- Fog
- Radiation Mapping

U.S. National Laboratories

Sandia Has Two Main Locations

Sandia's Funding ~ $3.75 Billion



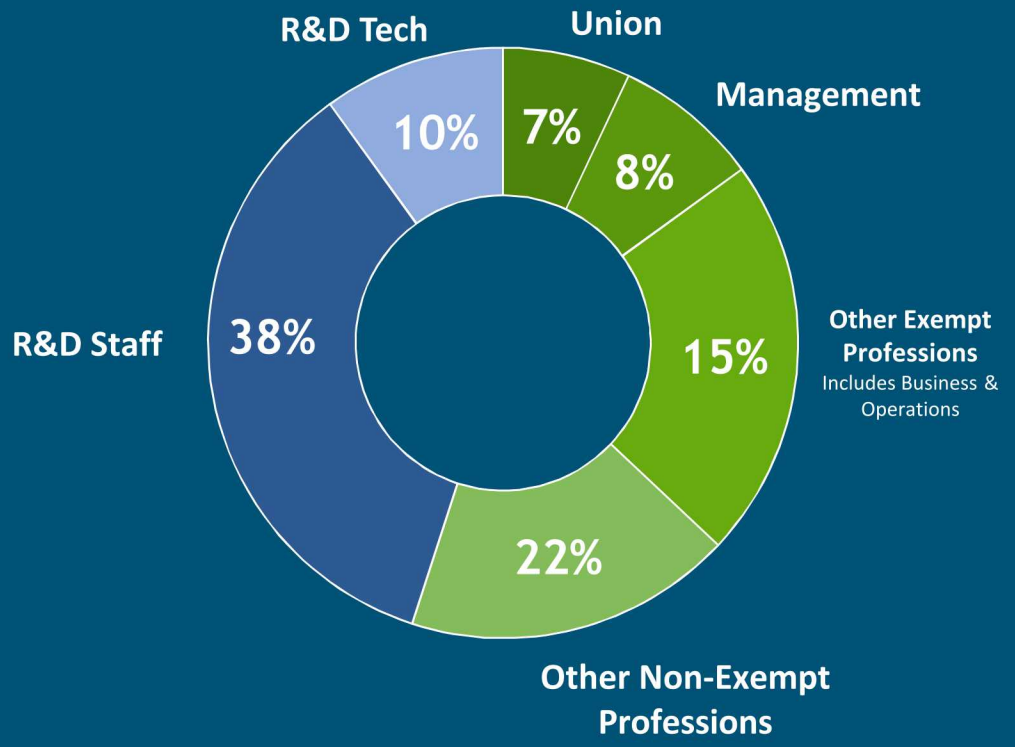
FY19 Projected Funding

Our Workforce ~14,100 employees

~12,300 Regular employees
~1,800 Temporary employees, students & postdoctoral appointees

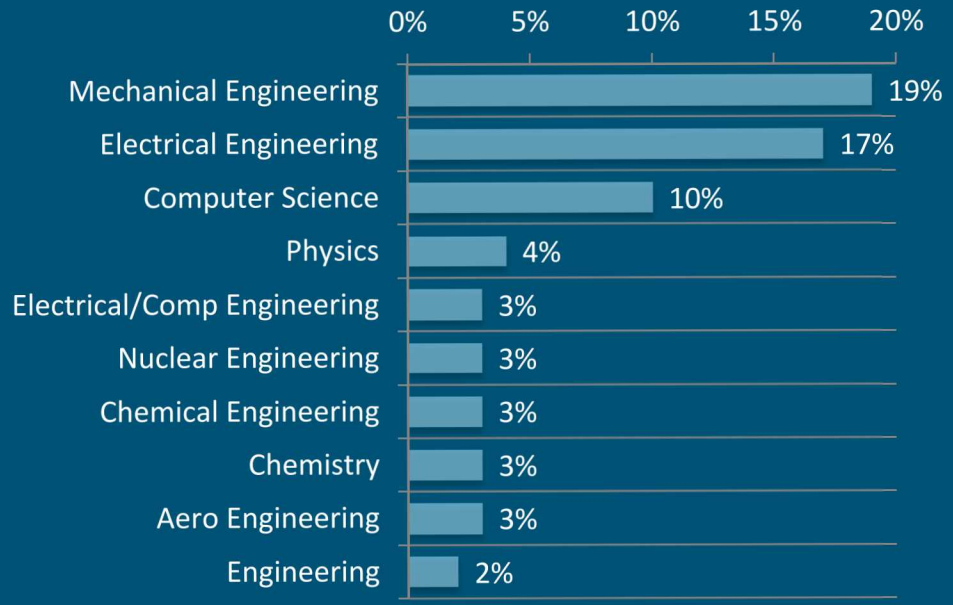
New Mexico Site: *(see breakout)*
Workforce: ~12,500
R&D employees: ~4,200
(R&D Staff & Technologists)

California Site: *(see breakout)*
Workforce : ~1,600
R&D employees: ~650
(R&D Staff & Technologists)

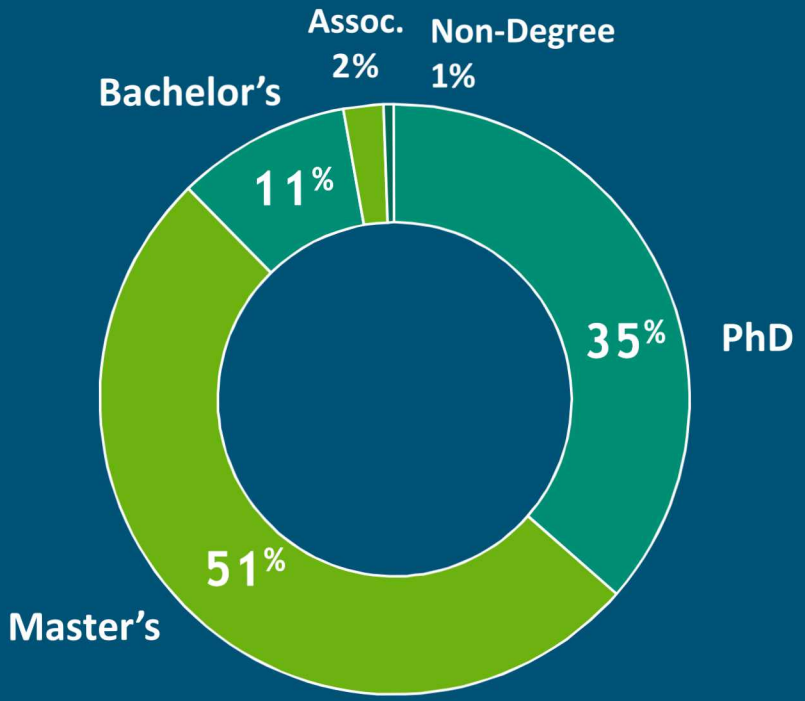


Data as of July 2019

R&D by Discipline & Degree

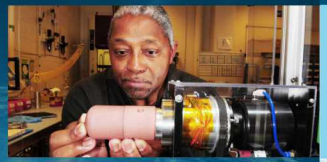


Top 10 job descriptions shown, Regular exempt non-management employees only



Data as of July 2019

Fulfilling Our National Security Mission



Nuclear Deterrence

Defense Nuclear Nonproliferation

National Security Programs

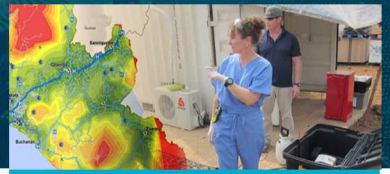
Energy & Homeland Security

Advanced Science & Technology

We [illegible] of life.

Sandia's Global Impact

Sandia is often called upon to respond to high-profile events, including 9/11 and the Ebola outbreak.



Ebola Outbreak

Sandia contributes to global response of Ebola outbreak by developing a sample delivery system cutting the wait time and potentially fatal exposure.

Cleanroom invented 1963

$50 billion worth of cleanrooms built worldwide. They're used in hospitals, laboratories and manufacturing plants today.

9/11

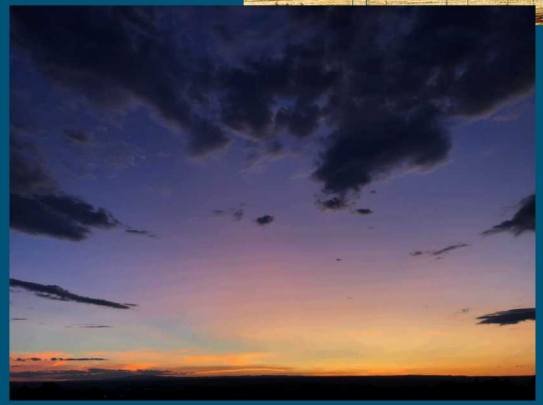
Sandia sets contingency plans for release of materials and aircraft attacks on critical facilities immediately after 9/11. Search dogs are equipped with cameras for search and rescue K-9 handlers. The capability allowed search efforts to be carried out in spaces inaccessible to humans.

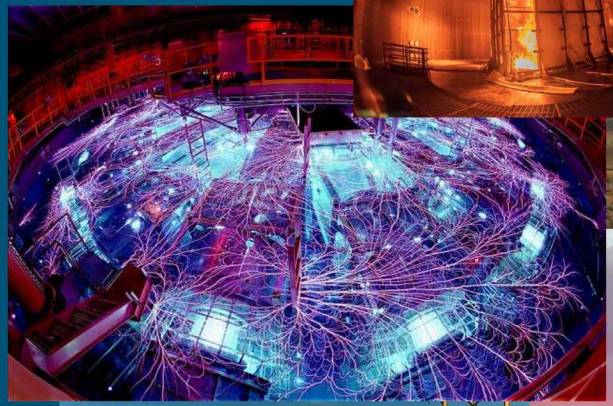
Detecting IEDs

Combat personnel now have a new tool for uncovering improvised explosive devices: Sandia's highly modified miniature synthetic aperture radar system, which is being transferred to the U.S. Army.

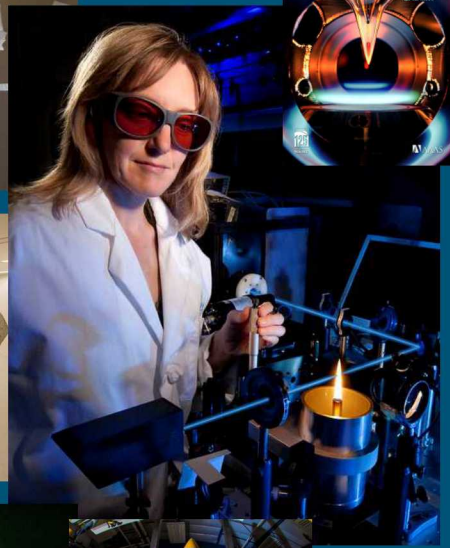
My Path to Sandia

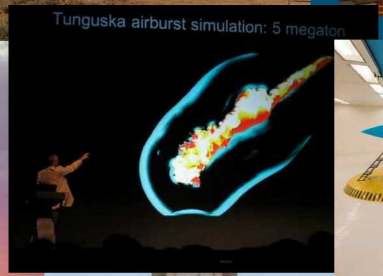
- Sought opportunity for high-impact, fun work
- Mentorship by successful research scientists and engineers
- International engagement with students, academia, and other national labs
- Access to state-of-the-art world renowned facilities

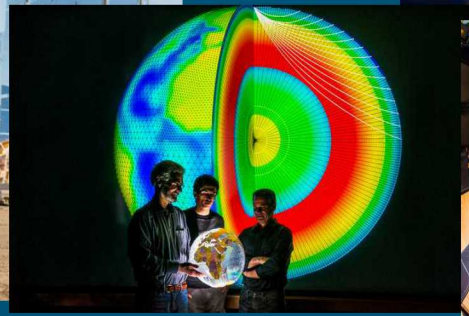





Science




Tunguska airburst simulation: 5 megaton

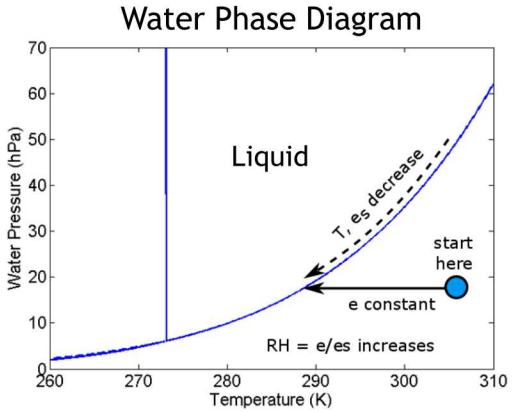


Outline

- About Sandia
- Fog
- Radiation Mapping

What is Fog?

- Micron sized water droplets suspended in air
  - < 1 km visibility
- Radiation fog – humid air cooled by emitted radiation causes supersaturation
- Advection fog –humid air cooled while passing over colder wet surface



[1] J. B. Wright, J. D. Van der Laan, A. Sanchez, S. A. Kemme, and D. A. Scrymgeour, *Proc. SPIE* **10197**, 2017

Sandia Fog Chamber

- NaCl is dissolved in water and sprayed through 64 nozzles into temperature controlled chamber
- Particle diameter controlled by amount of NaCl
- Dimensions: $3 \times 3 \times 55$ m
- Particle size distribution measured by Malvern diffraction system

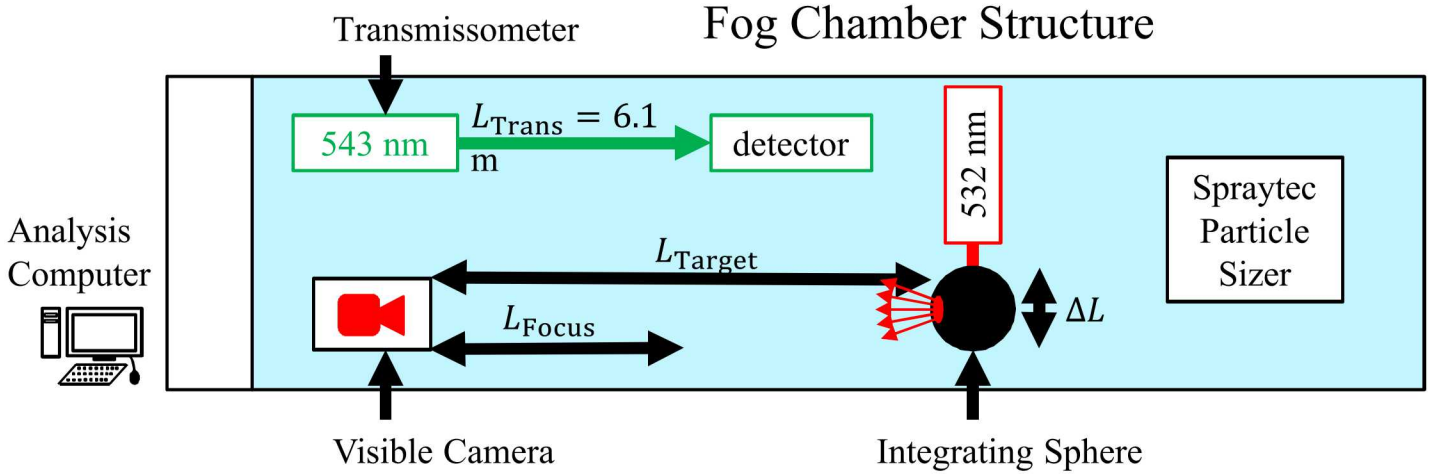
SNL fog chamber under nominal conditions [1].

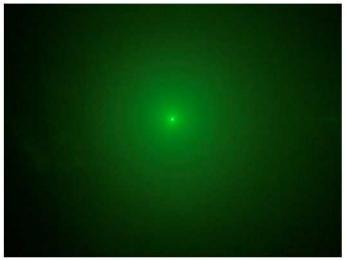
SNL fog chamber with simulated fog [1].

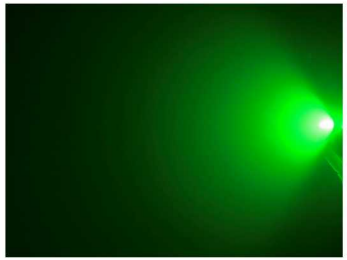
Malvern-Spraytek (0.1 – 900 μm)

[1] G. C. Birch, B. L. Woo, A. L. Sanchez, and H. Knapp, *Optical Engineering* **56**(8), 2017
[2] J. D. Van der Laan, J. B. Wright, S. A. Kemme, and D. A. Scrymgeour, *Applied Optics* **57**(19), 2018

Experimental Setup





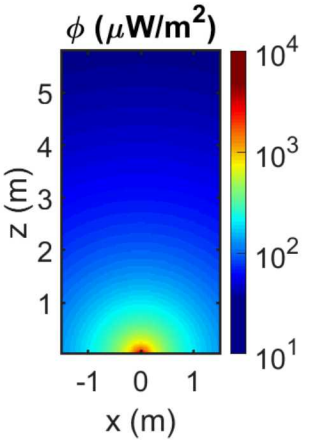


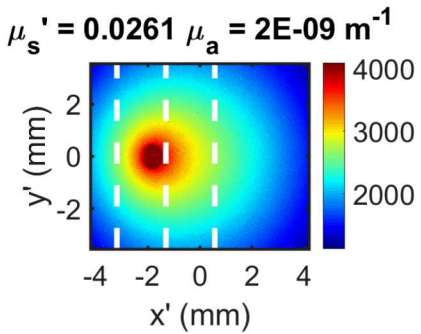
Model Validation

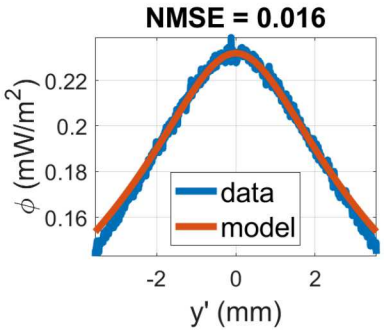
- A diffusion model can describe light propagation

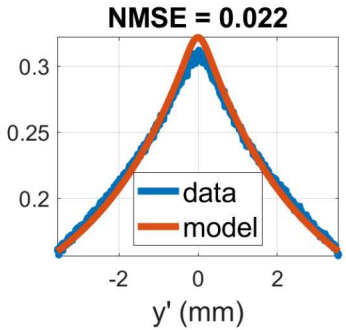
$$\nabla \cdot D(\boldsymbol{r})\nabla\Phi(\boldsymbol{r},\omega) - \left[\mu_a(\boldsymbol{r}) + \frac{\mathrm{j}\omega}{c}\right]\Phi(\boldsymbol{r},\omega) = -S_o\delta(\boldsymbol{r}-\boldsymbol{r_s})$$

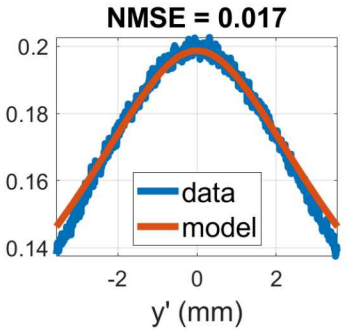
- Comparison of model predictions to experiment









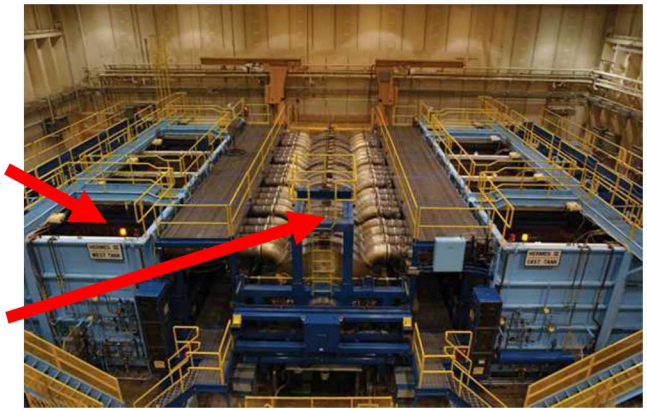


Outline

- About Sandia
- Fog
- Radiation Mapping

High-Energy Radiation Megavolt Electron Source (HERMES III)

- 80 pulses added in magnetically insulated transmission line (MITL)
  - Creates 22 MV, 730 kA, 40 ns pulse
- This pulse drives an electron beam to generate bremsstrahlung radiation at the converter
- Provides an above-ground source for gamma-ray radiation effects experiments



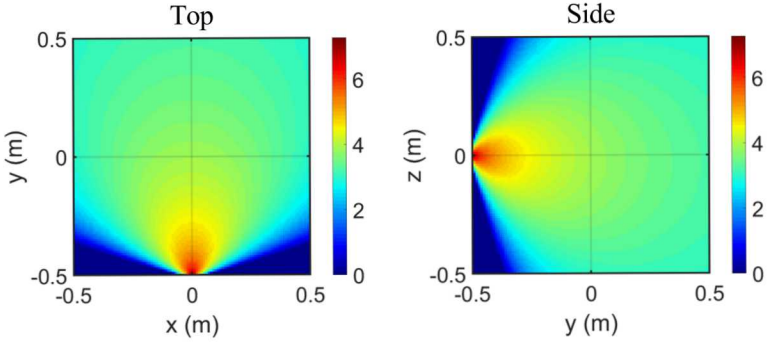
[1] J. J. Ramirez *et al.*, IEEE *7th Pulsed Power Conference*, 1989
[2] E. J. Parma, *SAND2017-13566*, 2017

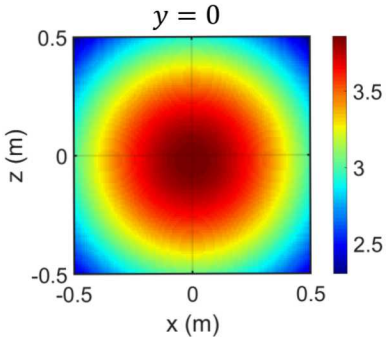
Dose Profile

- Average values fit to empirical equation

$$D = D_o \left\{ \frac{\exp\left(-\frac{R}{\lambda_o}\right) \exp\left[\lambda_1 \left(1 - \frac{R'}{y}\right)\right]}{R^2} \right\}$$

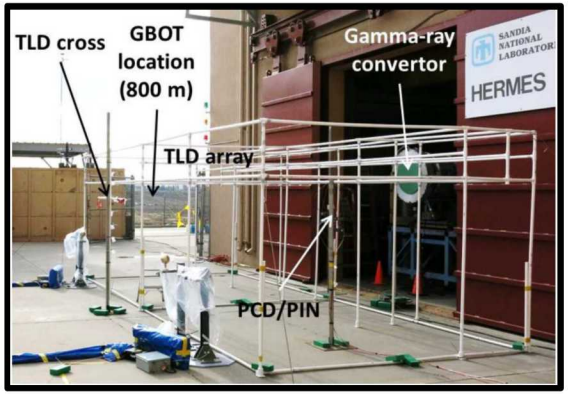
- Where
  - R is radial distance from $(x_o, y_o, z_o) = (0, -3, 2.02)$ (m)
  - y is distance downstream along the beam (m)
  - $R' = \sqrt{(x - x_o)^2 + (y - y_o - z \tan\theta)^2 + (z - z_o)^2}$
  - $\theta = -3.5^o$ is the beam tilt
  - $\lambda_o = 150$ m
  - $D_o = 1888$ rad
  - $\lambda_1 = 3.37$





Optical Radiation Dose Mapping

- Characterizing dose profile important for radiation effects testing
- Currently measured via thermoluminescent dosimeters (TLDs)
  - Expensive
  - Spatial and temporal resolution is limited
- Imaging UV emission of radiation-excited nitrogen allows mapping of radiation
  - Inexpensive
  - Higher spatial and temporal resolution



Outdoor Field Testing

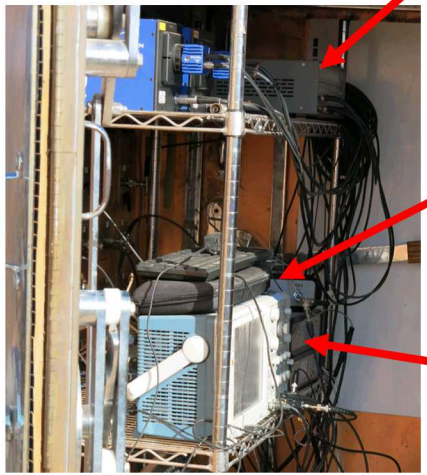
Communications and Triggering

- Ethernet and USB over fiber for user control
- Isolated co-axial cables between copper enclosures trigger CCD and Intensifier
- 50 μs pre-trigger for CCD and scopes
- Q-switch triggers intensifiers for lower jitter

Computer Control, Lead Protection

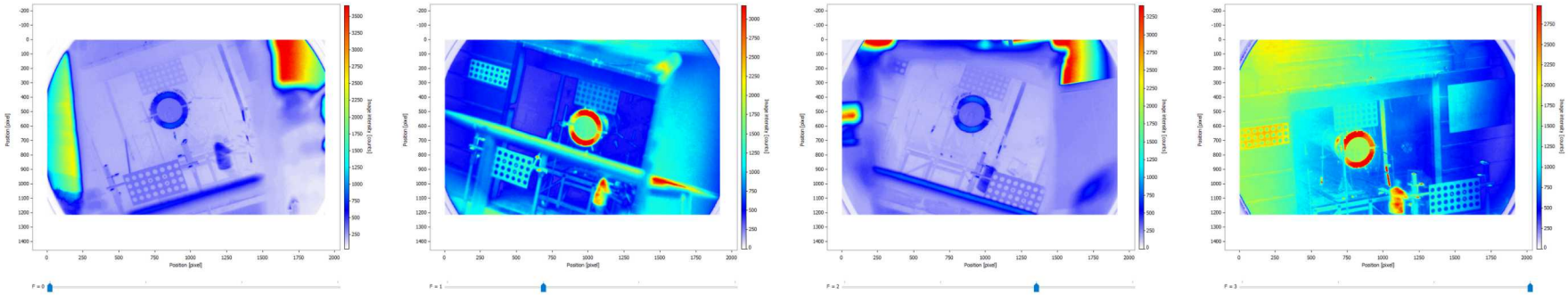
Communications

Co-Axial Isolators

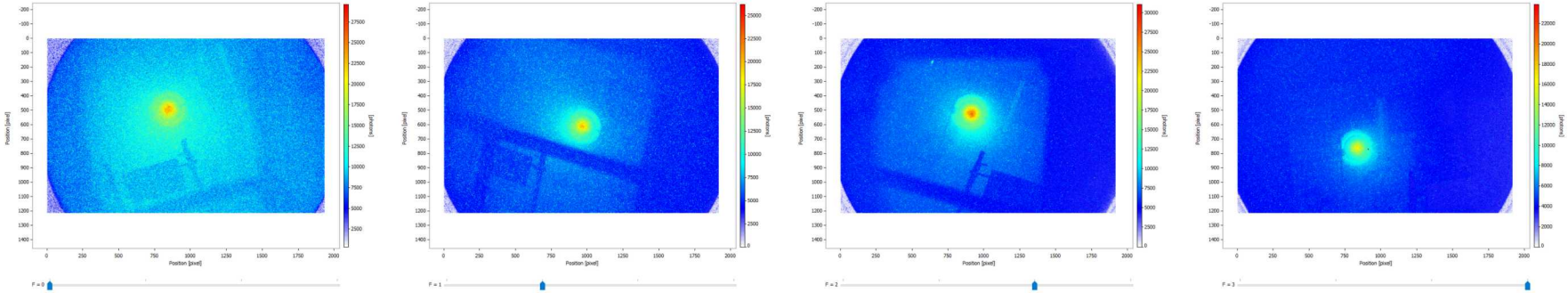


HERMES Shot 11149

Calibration Images



UV Images



We're Hiring and Seeking Collaborators

- Current postings at https://www.sandia.gov/careers/
  - R&D staff, fellowships, postdoctoral, internships, professor sabbaticals
- Academic alliance
  - Purdue is 1/5 schools
  - Sandia manager on campus can assist in networking
- **Contact: Ken Patel (kdpatel@sandia.gov)**


Thank You!

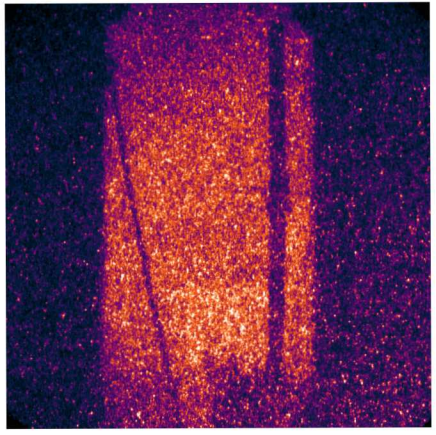
Backup Slides

Optical Radiation Dose Mapping

- ICCD camera with UV optics and ns gates
- Tomographic reconstruction could reveal asymmetries and interaction with objects

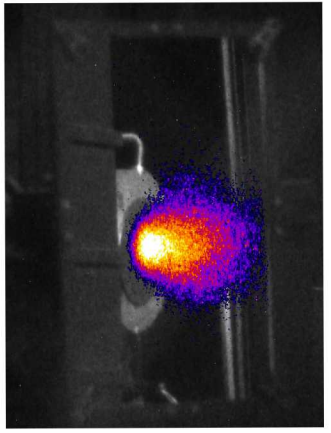
Daylight Image

Rad. Signal Image



Daylight Image

Rad. Signal Image



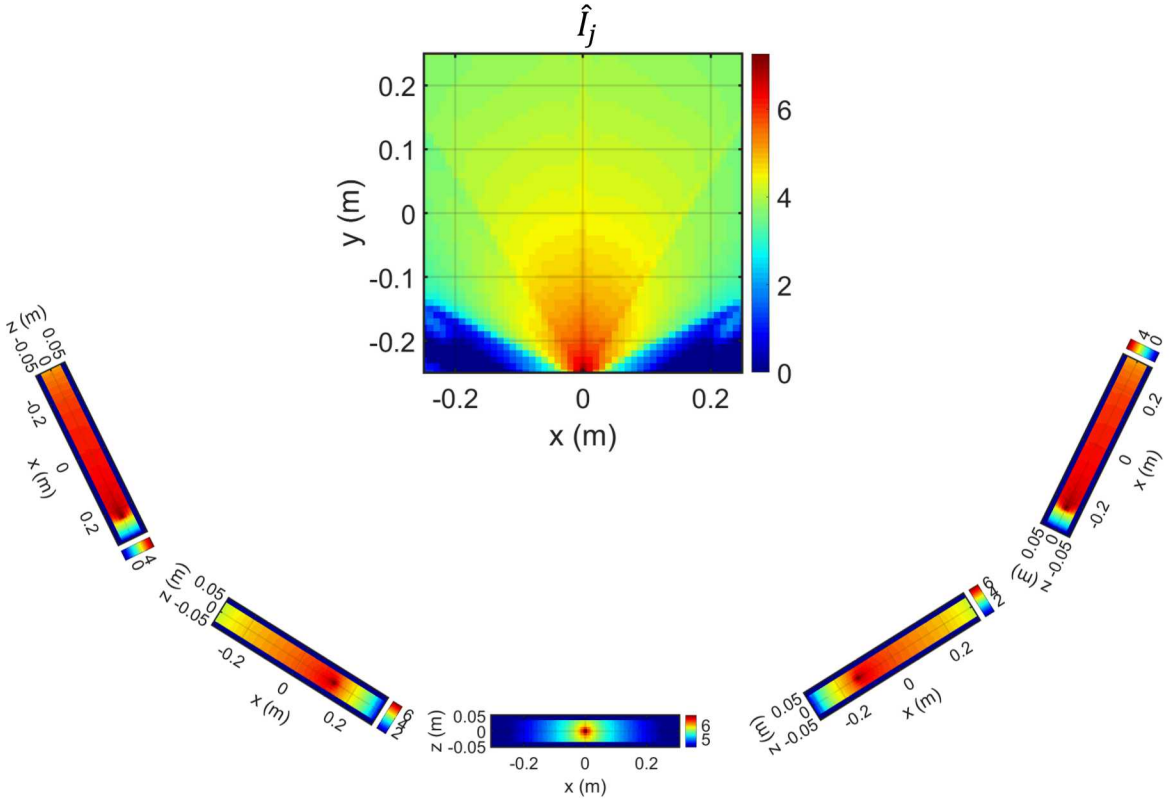
Multiplicative Algebraic Reconstruction Technique (MART) [1]

- Pixel intensity P_i

$$P_i = \int_{s_i} I(x,y,z)ds_i$$

- Image reconstruction

$$I_j^{k+1} = I_j^k \left(\frac{P_i}{\sum n_y \left(\sum_{vw} \boldsymbol{W} I_j \right)} \right)^{\mu \boldsymbol{W}}$$



[1] C. Atkinson and J. Soria, *Exp. Fluids* **47**, 2009

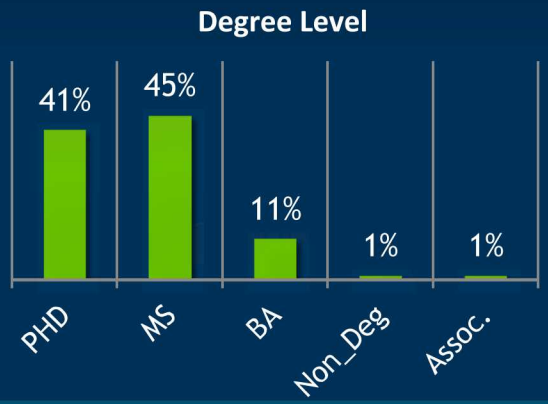
Sandia California - *Livermore*

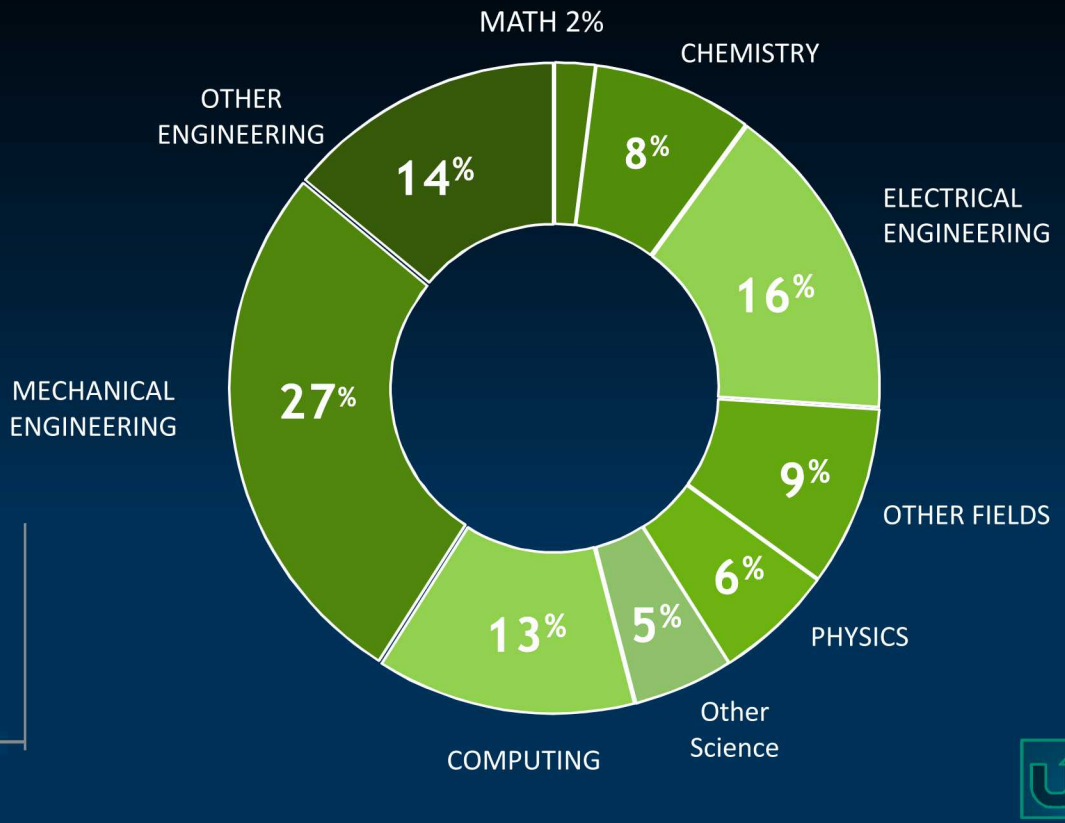
On-site workforce: ~1,600

R&D staff& technologists: ~650

Distinguishing research capabilities:

- Applied Biosciences
- Combustion Research
- Information Systems
- Micro & Nano Technologies and *more*





Data as of July 2019

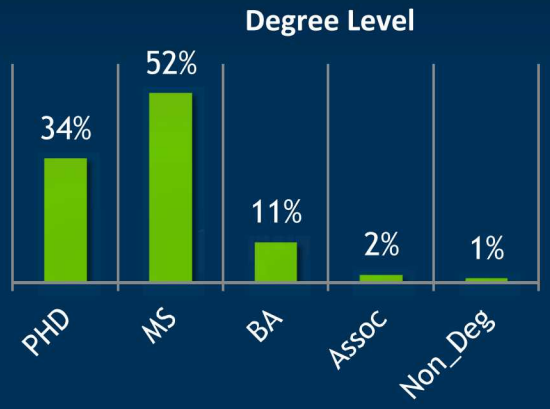
Sandia New Mexico - *Albuquerque*

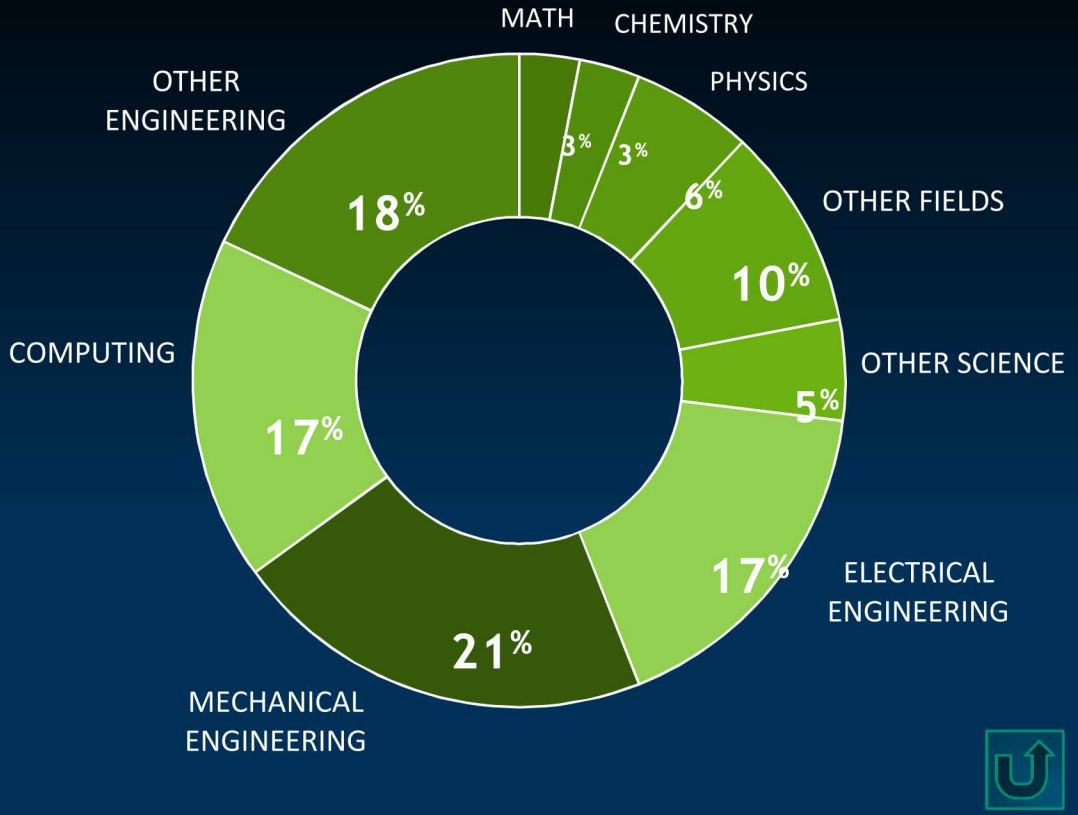
On-site workforce: ~12,500

R&D staff & technologists: ~4,200

Distinguishing research capabilities:

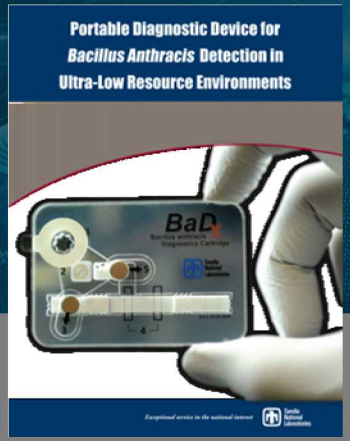
- Renewable Energy
- Micro-electronics/Semiconductors
- Cybersecurity
- Homeland Security *and more*





Data as of July 2019

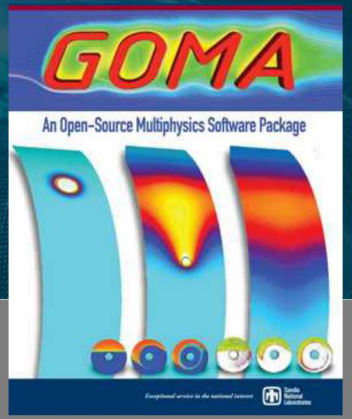
Work with real-world impact



Portable Diagnostic Device for Bacillus Anthracis Detection

Sandia developed a pocket-sized cartridge to sense concentrations of virulent B. anthracis, the bacteria that causes anthrax infection.

>> WATCH VIDEO



GOMA 6.0

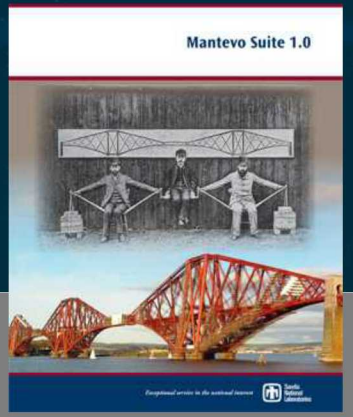
Sandia develops a software package for modeling and simulation, which solves problems in all branches of mechanics, including fluids, solids, and thermal analysis.

>> WATCH VIDEO

Triple Harvesting Plastic Scintillators

A new class of plastic scintillator enables efficient detection of illicit special nuclear materials that may be used to construct a nuclear weapon.

>> WATCH VIDEO



Montevo Suite 1.0

An integrated collection of small software programs (miniapps) models the performance of full-scale applications, yet requires a fraction of the code.

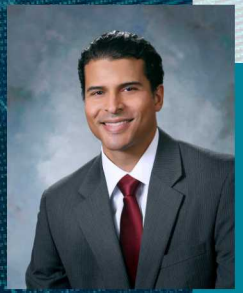
>> WATCH VIDEO

Work with top minds

Our unique work requires the collective minds of the nation's top scientists, engineers, and support staff.

Cliff Ho
Fellow of the American Society of Mechanical Engineers

Ireena Erteza
Asian American Engineer of the Year Award



Conrad James
Black Engineer of the Year Special Recognition Award

Salvatore Campione
Early Career Computer Modeling Award

Sandia's Brand Promise - *Sandia's Employee Value Proposition*

- ***National Security Mission:***
  Your work contributes to the security, peace and freedom of our nation and the world
- ***Uniquely Challenging and Important Work:***
  The work you do will be challenging, and amazing with real-world impact
- ***Work with Great People:***
  You will work with extraordinary people, the top minds in their field
- ***Research Facilities Like None Other:***
  You will have access to some of the best tools, equipment, and research facilities in the world
- ***Healthy Lifestyle, Work-Life Balance:***
  You will experience a balance between your work life and personal life through flexible schedules, competitive benefits, and convenient amenities
- ***Career Mobility:***
  You can have a full-life career at Sandia by working across multiple projects and areas of your interest

Available Videos

Videos require wifi in order to play

Sandia Mission Video (4:36)
Sandia Our Roots(3:05)

Location Videos
Sandia New Mexico Location (3:23)
Sandia California Location (3:41)

Diversity & Inclusion Videos
Black Leadership Outreach
Asian Leadership Outreach
American Indian Outreach
Hispanic Leadership Outreach

*For more Sandia Videos refer to Sandia's YouTube Channel