James Miller, Rian Bahran, and Jesson Hutchinson

Nuclear Engineering and Nonproliferation Division

Los Alamos National Laboratory

Consortia for Verification Technologies Workshop

Ann Arbor, MI

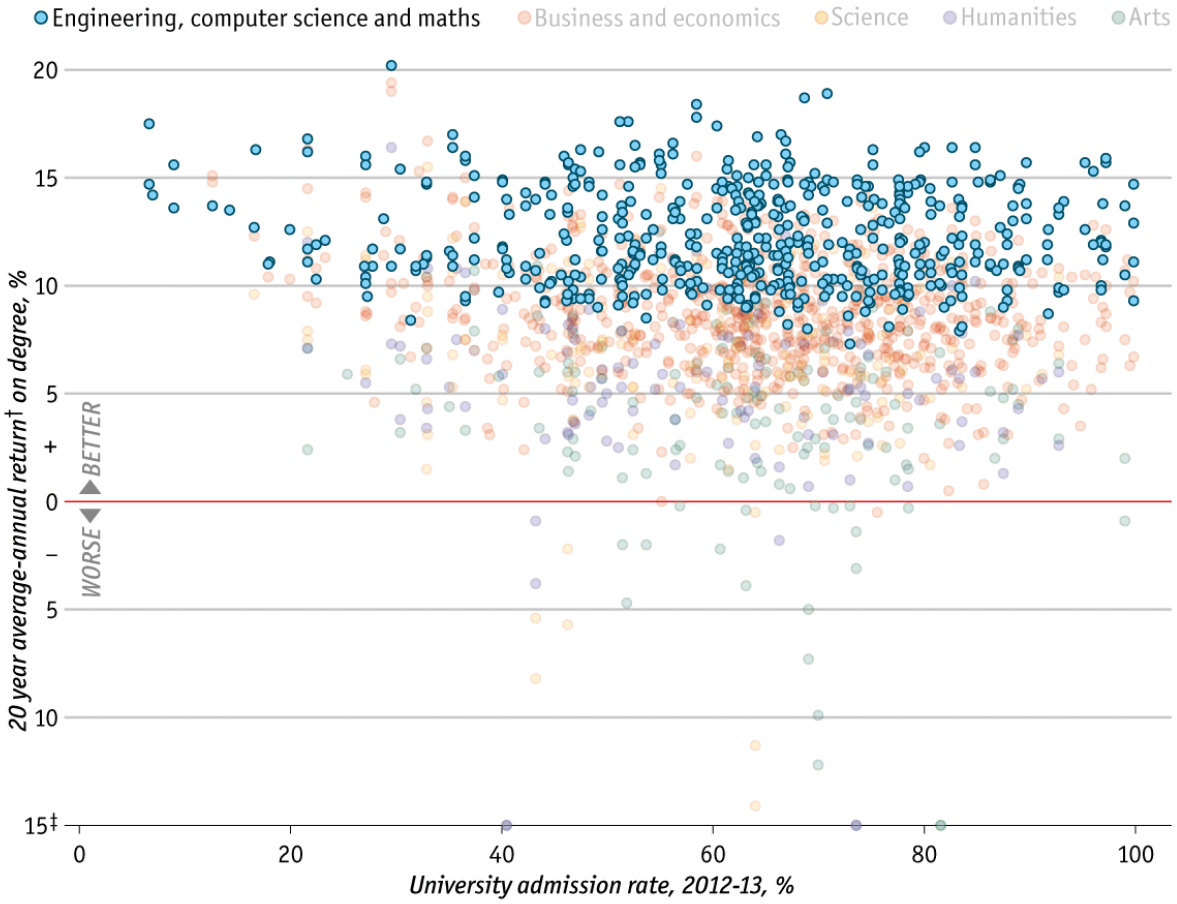
20 October 2016

STEM Students - Great Return on Investment

The Economist (Daily Chart Mar 6th 2015)

20-year annualized return on educational investment of 12% (the S&P 500 managed just 7.8%).

Engineers were also least dependent on institutional prestige: graduates from less-selective schools experienced only a slight decrease in average returns."



We are in northern New Mexico, 35 miles from Santa Fe

2013

10 Best Small Towns

Best Small Towns

13 30

6 Los Alamos, NM

« PREV NEXT »

With one of the highest concentrations of Ph.D. holders in the nation, Los Alamos, NM, stands out as the "smartest" small town. Innovative education, health and recreational programs have earned the city and surrounding county national recognition, including such titles as "healthiest" and "wealthiest" places in America.

The city's location atop the Pajarito Plateau, near the Jemez Mountains, not only provides breathtaking views but gives residents easy access to high-altitude sports such as mountain biking, skiing, rock climbing and hiking. An urban trail system connects to forest paths. Golf courses, parks, a skating rink and aquatic center provide even more recreational options. Cultural landmarks like the Bradbury Science Museum, Fuller Lodge Art Center, and the Los Alamos Little Theatre frequently hold special events and educational programs for children and adults.

The Los Alamos National Laboratory employs more than 7,000 people and the area's science-based businesses attract top talent from across the globe, making the city the most culturally diverse in New Mexico. Scientific endeavors such as the Manhattan Project, the development of super computing, the Human Genome Projects and the creation of the world's fastest movie camera, reflect the community's innovative spirit. Research and development continues to be the driving economic force. Local companies support initiatives that get children interested in science, technology and art.

USA.COM

Los Alamos Public Schools (1.8 miles)
751 Trinity Dr
Los Alamos, NM 87544
phone: 505-663-2222
Regular Local School District **Grade:** Prekindergarten to Grade 12
7 Schools **Students:** 3,455 **Teachers:** 247.08 **Student-Teacher Ratio:** 13.98
High School: ★★★★★ Elementary/Middle School: ★★★★★

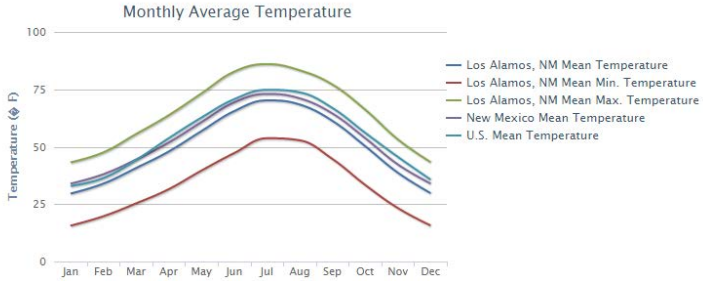
Family Income

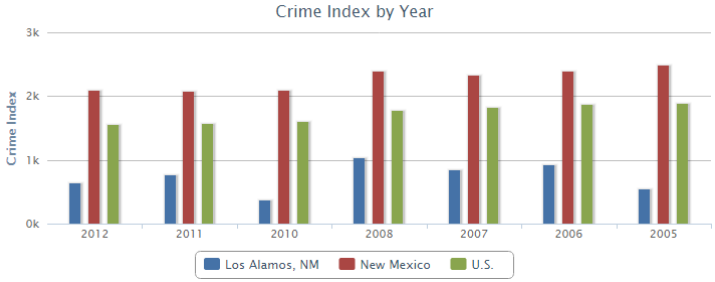
Median Family Income, see rank

Los Alamos, NM	124,284 USD
New Mexico	54,221 USD
U.S.	64,585 USD

Mean Family Income, see rank

Los Alamos, NM	135,943 USD
New Mexico	70,760 USD
U.S.	85,065 USD





http://livability.com/best-places/top-10/best-small-towns/10-best-small-towns/2014/los-alamos

LANL is a National Nuclear Security Administration (NNSA) Laboratory within the U.S. Department of Energy (DOE)

Office of Science Laboratories

1. **Ames Laboratory**
   Ames, Iowa
2. **Argonne National Laboratory**
   Argonne, Illinois
3. **Brookhaven National Laboratory**
   Upton, New York
4. **Fermi National Accelerator Laboratory**
   Batavia, Illinois
5. **Lawrence Berkeley National Laboratory**
   Berkeley, California
6. **Oak Ridge National Laboratory**
   Oak Ridge, Tennessee
7. **Pacific Northwest National Laboratory**
   Richland, Washington
8. **Princeton Plasma Physics Laboratory**
   Princeton, New Jersey
9. **SLAC National Accelerator Laboratory**
   Menlo Park, California
10. **Thomas Jefferson National Accelerator Facility**
    Newport News, Virginia

Other DOE Laboratories

1. **Idaho National Laboratory**
   Idaho Falls, Idaho
2. **National Energy Technology Laboratory**
   Morgantown, West Virginia
   Pittsburgh, Pennsylvania
   Albany, Oregon
3. **National Renewable Energy Laboratory**
   Golden, Colorado
4. **Savannah River National Laboratory**
   Aiken, South Carolina

NNSA Laboratories

1. **Lawrence Livermore National Laboratory**
   Livermore, California
2. **Los Alamos National Laboratory**
   Los Alamos, New Mexico
3. **Sandia National Laboratory**
   Albuquerque, New Mexico
   Livermore, California

Nuclear Security Enterprise

1. **Kansas City Plant**

2. **Lawrence Livermore National Laboratory**

3. **Los Alamos National Laboratory**

4. **Nevada National Security Site**

5. **Pantex Plant**

6. **Sandia National Laboratories**

7. **Savannah River Site**

8. **Y-12 National Security Complex**

Los Alamos NATIONAL LABORATORY

LANL's Strategic Plan is aligned with the Department of Energy (DOE), the National Nuclear Security Administration (NNSA)

The **NNSA** plays a critical role in ensuring the security of our Nation by:

- maintaining the safety, security, and effectiveness of the U.S. nuclear weapons stockpile without nuclear testing

  (NA-10, FY 17 Budget Request ~9.2 bn)

- reducing the global danger from the proliferation of nuclear weapons and materials

  (NA-20, FY 17 Budget Request ~1.8 bn)

- providing the U.S. Navy with safe and effective nuclear propulsion

  (NA-30, FY 17 Budget Req ~1.4 bn)

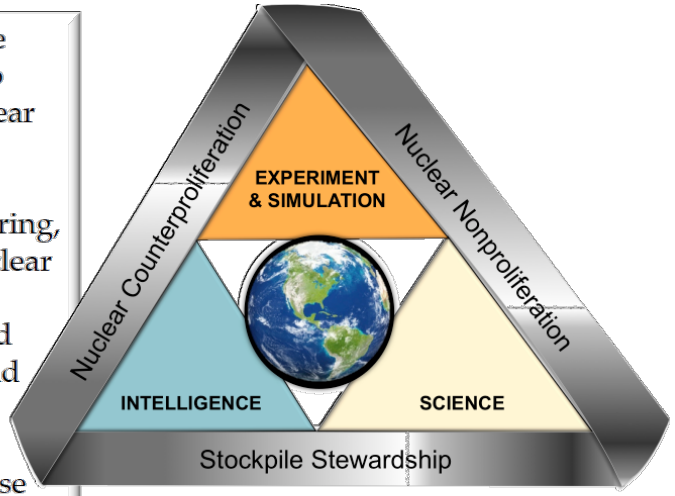
- providing domestic and international capabilities in counterterrorism and counter-proliferation, and nuclear incident response

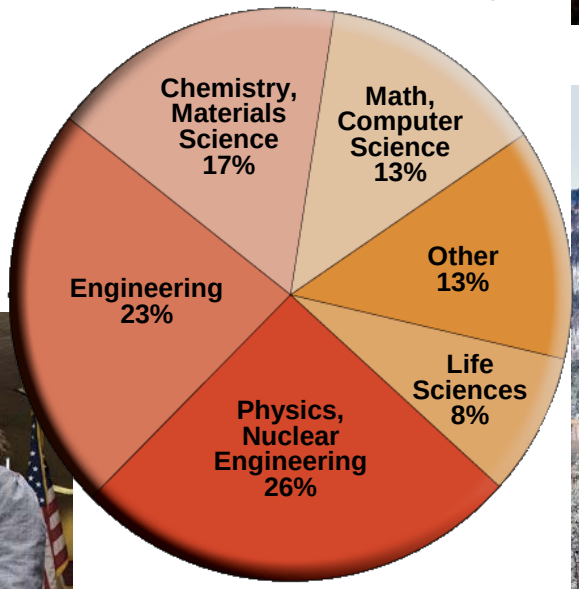
  (NA-40/80)

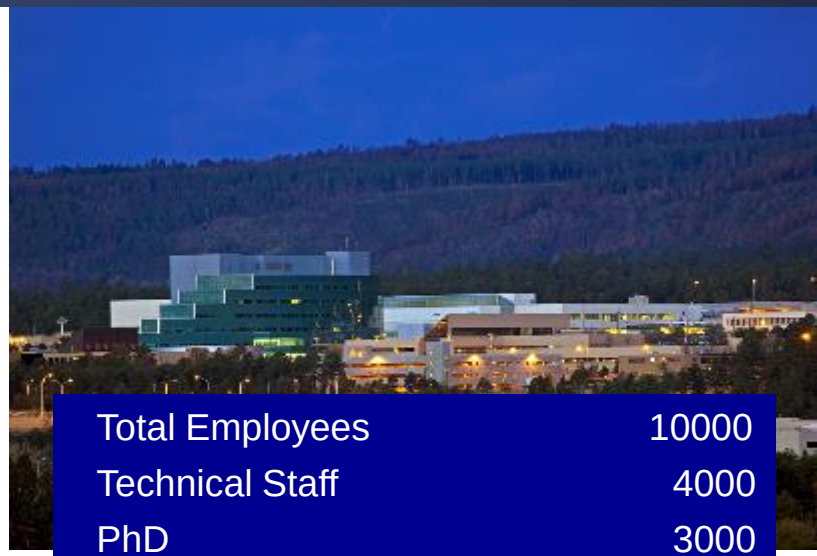
LANL's mission is to develop and apply science and technology to ensure the safety, security, and reliability of the U.S. nuclear deterrent; reduce global threats; and solve other emerging national security and energy challenges

…In order to uphold the Department's mission to ensure an effective nuclear deterrent through the application of science, technology and engineering, we must ensure our nuclear capabilities meet the challenges of known and potential geopolitical and technological trends. Therefore we must look ahead, using the expertise of our laboratories, to the capabilities that may be employed by other nations…

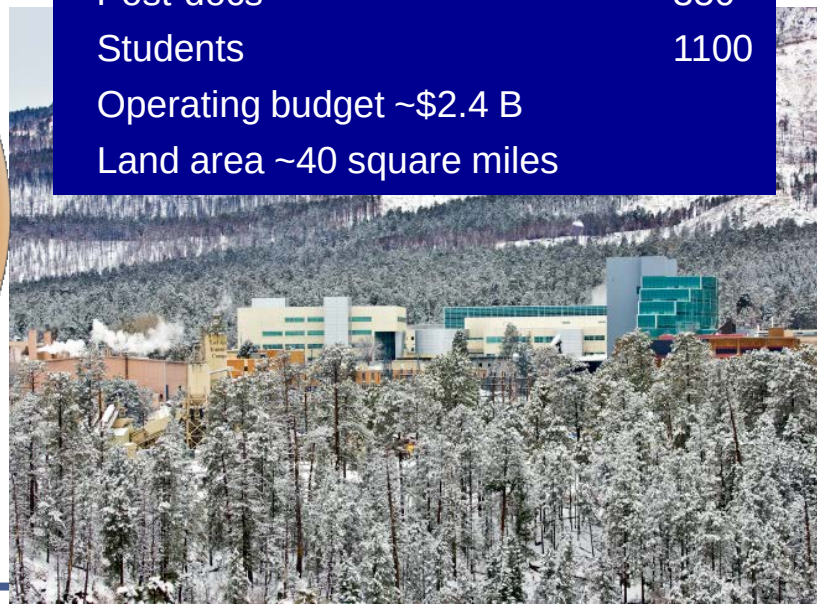
Secretary Moniz, 2014







Total Employees	10000
Technical Staff	4000
PhD	3000
Post-docs	350
Students	1100
Operating budget ~$2.4 B	
Land area ~40 square miles	



We are managed by Los Alamos National Security, LLC

Managed and operated by the University of California

1943 to 2006

Now managed by Los Alamos National Security (LANS), LLC

2006 to present

Work at LANL is organized under five lines of business

Director's Office

Charlie McMillan
Director

Rick Kacich
Deputy Director

Dave Lyons
Executive
Director

Principal Associate Directors

Alan Bishop

Science, Technology, and Engineering

Bob Webster

Weapons Programs

Terry Wallace

Global Security

Craig Leasure

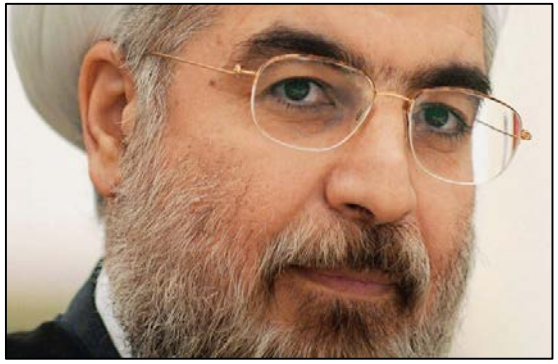
Operations and Business

Larry Simmons (interim)

Capital Projects

Nuclear Nonproliferation and Security (NNS)

Prevent nuclear proliferation and improve nuclear security, with focus on diplomacy, cooperation, and international partnerships



The NNS Program focuses on preventing nuclear proliferation and enhancing nuclear security

Strengthen global nuclear safeguards and security

Support treaty monitoring mission of nuclear detonation detection

Detect foreign SNM production or weaponization

Secure vulnerable rad/nuc materials & reduce global HEU and Pu inventories

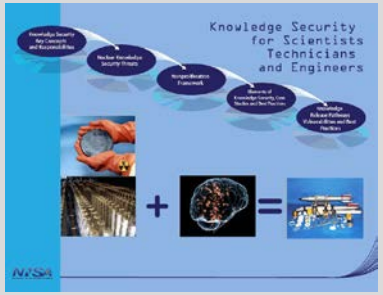
Deter and detect illicit movement of material

Strengthen global nuclear safeguards and security

50 years of direct support to IAEA

- Ongoing tech-development projects
- Development of nearly every neutron non-destructive assay instrument used by IAEA
- Training every IAEA inspector at Los Alamos
- Staff on assignment in Vienna
- NWAL analytical lab

International nuclear security engagement and cooperation

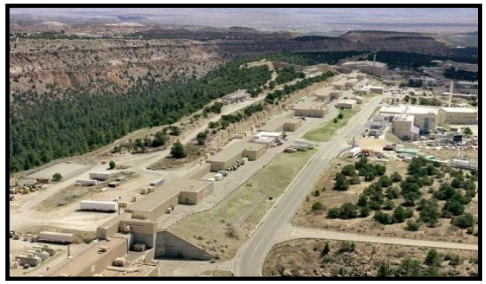


Technology and expertise to support arms control treaties and multilateral agreements

LANL's unique infrastructure supports both our Nuclear Weapons Program and our Global Security Mission

Metropolis Center for Modeling & Simulation

High Explosive Laboratories



Los Alamos Neutron Science Center

Plutonium Processing Facility (TA-55)

SIGMA Building

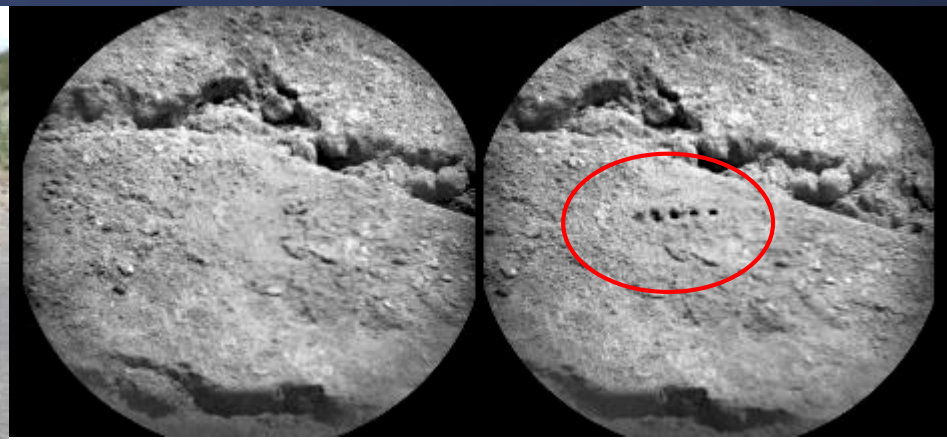
Dual Axis Radiographic Hydrotest Facility

- **40 square miles**
- **47 technical areas**
- **1,000 buildings**
- **13 nuclear facilities**

Chemistry and Metallurgy Research (CMR) Building

Radiological Laboratory Utility Office Building (RLUOB)

Los Alamos laser for detecting nuclear material on Earth goes to Mars to determine habitability



- **Laser-Induced Breakdown Spectroscopy (LIBS) was a Laboratory-Directed Research and Development (LDRD) project to look for material within gloveboxes at LANL's plutonium facility**
- **A backpack LIBS unit has been developed for consideration by the IAEA**
- **LIBS is the basis for the ChemCam laser unit on the current Mars Curiosity rover; the next-generation SuperCam instrument has been selected for the Mars 2020 mission, which endeavors to pave the way for human visitation to the Red Planet**

Monte Carlo Reactor Simulations

LANL POC: Holly Trellue – trellue@lanl.gov

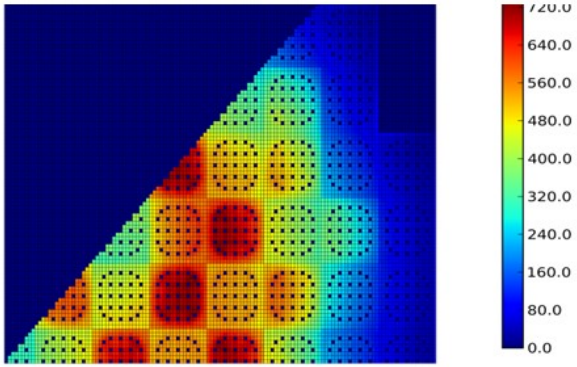
Background

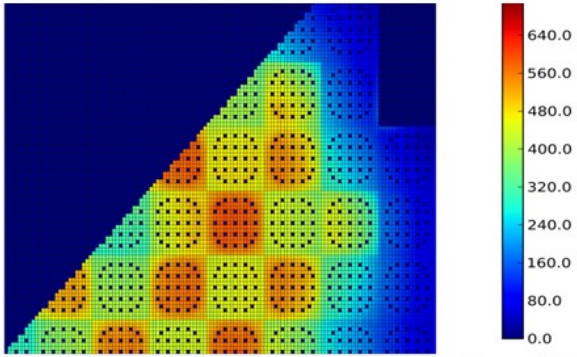
- Monte Carlo transport codes like MCNP use continuous-energy cross sections (interpolated from ENDF data) to provide accurate probabilities of interactions at all energies and fluxes.
- Link to depletion code ORIGEN-S or CINDER90 through Monteburns provides 3-D reactor simulation. Link to thermo-mechanical code BISON for additional feedback (temperature and swelling) is being developed.

Applications

- Boiling Water Reactor (with discrete axial zones).
- Heavy Water Reactor (i.e. CANDU).
- Gas-Cooled Reactor with actual operating conditions.
- Design of space and special purpose reactors.
- Creation of spent fuel libraries representing neutron and gamma emissions for simulation of Nondestructive Assay instrument performance.
- Generation of database with irradiated fuel compositions for various reactor types.

Beginning of Cycle Power Distribution



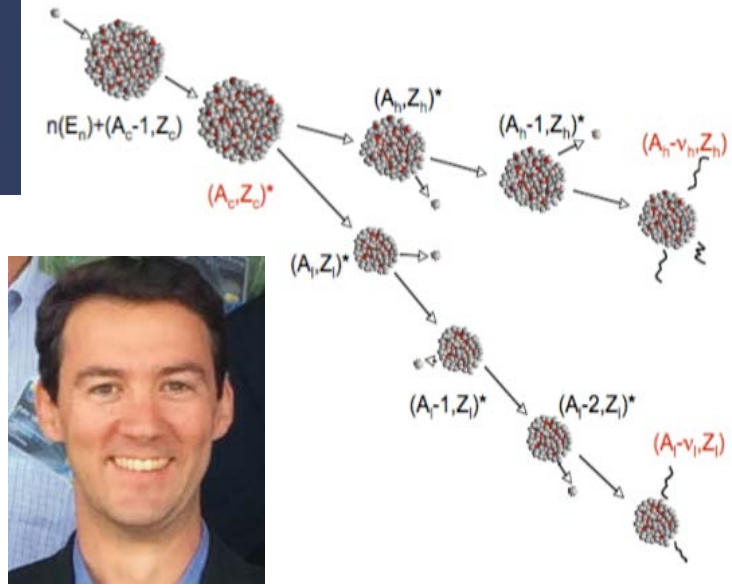


End of Cycle Power Distribution (W/cc)

1/8 core PWR (~6000 pins)

Correlated Fission Events

LANL POC: Patrick Talou – talou@lanl.gov



Event-by-Event Simulation of Fission Fragment Evaporation

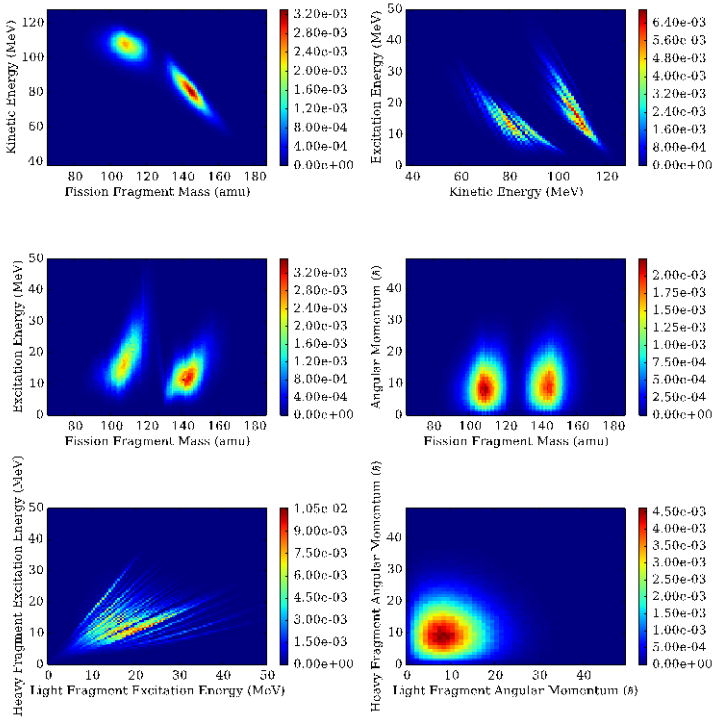
- Access to prompt fission neutrons and γ rays
- Multiplicity-dependent spectra
- Distributions $P(\nu)$, $P(N_\gamma)$
- Correlations in energy, angle and multiplicity

Fission event generators (CGMF, FREYA) implemented in MCNP6.2

- MCNPTools to analyze PTRAC list-mode output
- Advanced simulation of detector response (DRiFT)
- Close collaboration with experimentalists (LANL, UM)

Plans to expand calculations to

- More isotopes
- Photo-fission reactions
- Perform sensitivity calculations & UQ
- Independent and Cumulative Fission Yields



Advanced Materials for Detectors

LANL POC: Sven Vogel – sven@lanl.gov

Working to establish discovery-to-commercialization pathways for:

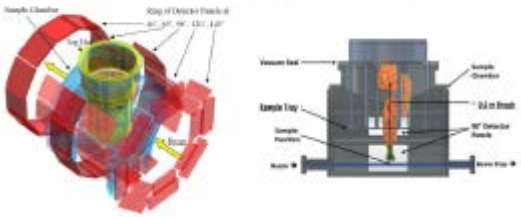
- High-performance scintillator and semiconductor materials
- Scintillator detector materials suitable for large low-cost detectors

Uses energy resolved neutron imaging and neutron diffraction

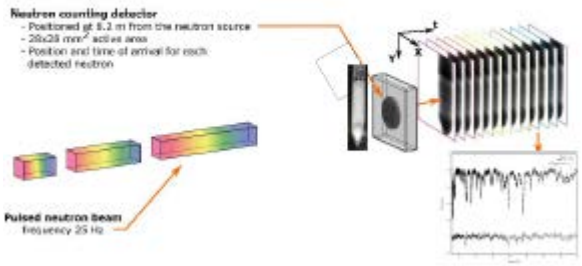
Next steps include:

- Measuring lattice strains as a function of dopant concentration from powders
- Model stresses during cooling to identify methods to avoid cracking
- Improving analysis techniques for dopant concentration

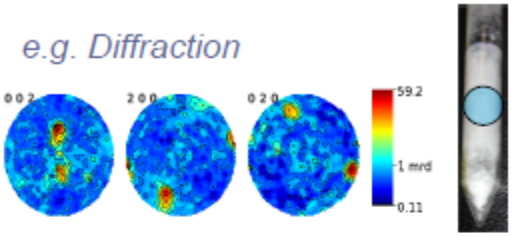
Neutron Diffraction (HIPPO)



Neutron Tomography (FP5)



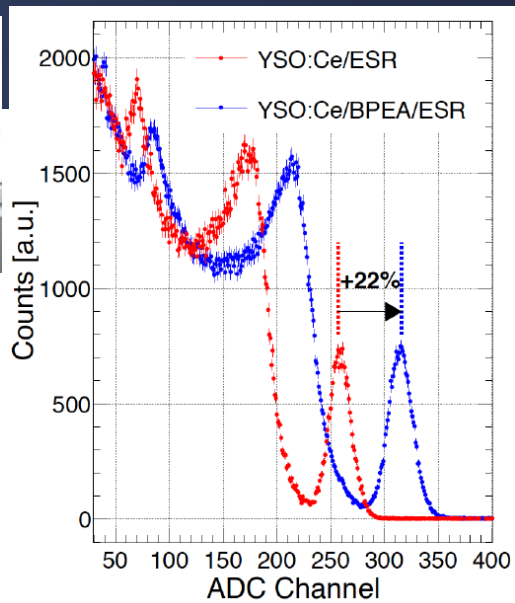
e.g. Diffraction



- The probed volume is shaded in blue in the photograph (Right).
- Pole figures with the long sample axis in the center on logarithmic probability scale (Left)
- All three pole figures show two maxima, indicating that two crystal orientations, with a and b axes approximately radially to the sample axis, dominate the probed volume.
- The maximum (of ~60 mrd) is consistent with single crystal textures and is correlated with growth directions along temperature gradients.

Improved Detector Energy Resolution via Wavelength-Shifted Scintillator Emission

LANL POC: Shawn Tornga – tornga@lanl.gov



Working to reduce the size, weight, and power consumption while increasing performance

Utilizing a stepwise process to employ a series of dye-containing thin films, wavelengths of scintillation photons are shifted (low to high) to allow more efficient transfer and detection

The impact of this project will enhance scintillator performance by:

- Decreasing time of detection
- Decreasing false alarm rates
- Increasing spectral identification capabilities

Next Steps include:

Design and development of non-hygroscopic crystals

- Single layer coatings with YSO
- Multilayer coatings with LiCAF:Ce

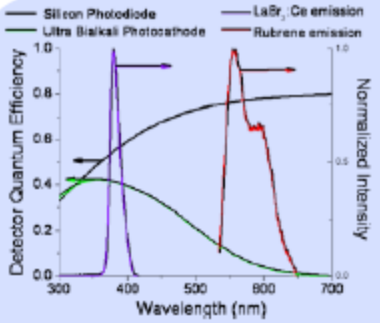


Figure 1. Comparison of the QE of commercial detectors; green = PMT black = PD. The fully shifted emission (dye is Rubrene) overlaps with the high efficiency region of the PD.

- Using a wavelength shifting dye as an intermediary step, the match between a scintillator and a photodetector can be significantly improved.
- **Increasing the match between the scintillator and photodetector will provide an improvement in energy resolution up to 40%.**

Los Alamos NATIONAL LABORATORY

Muon Imaging of Dry Storage Casks

LANL POC: Matt Durham – durham@lanl.gov

With increases stores of spent reactor fuel, more and more is being transitioned to dry storage

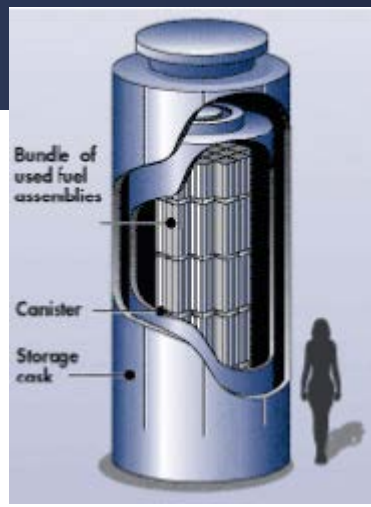
- Typically under IAEA safeguards
- Seals affirm continuity of knowledge of contents

Cosmic ray muons can penetrate cask shielding without intrusion.

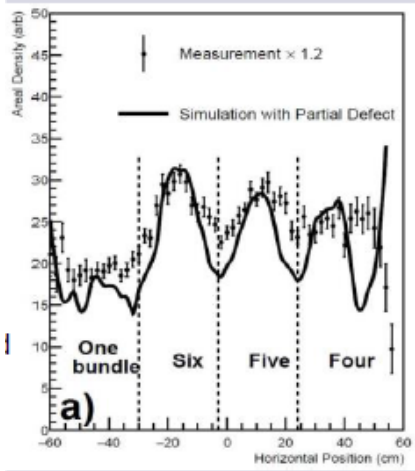
- To recover from a loss of continuity of knowledge is hazardous, costly, and invasive

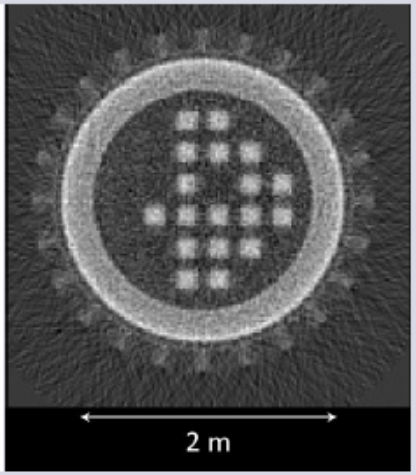
Next steps include:

- Data analysis from recent cask data taken at Idaho National Laboratory
- Development and testing of a fieldable instrument in an operational environment.



- Missing fuel assemblies can be identified from outside the cask, without opening, moving, or disturbing the cask.





Left: Measurement shows that rows in a cask basket with different numbers of fuel assemblies can be identified with a single viewing position. Right: A reconstructed image of the misloaded cask, using simulation of multiple viewing angles.

Fieldable Atomic Beam Laser Spectrometer for Isotopic Analysis

LANL POC: Alonso Castro – acx@lanl.gov

Working to provide immediate, in-field isotopic analysis of uranium samples

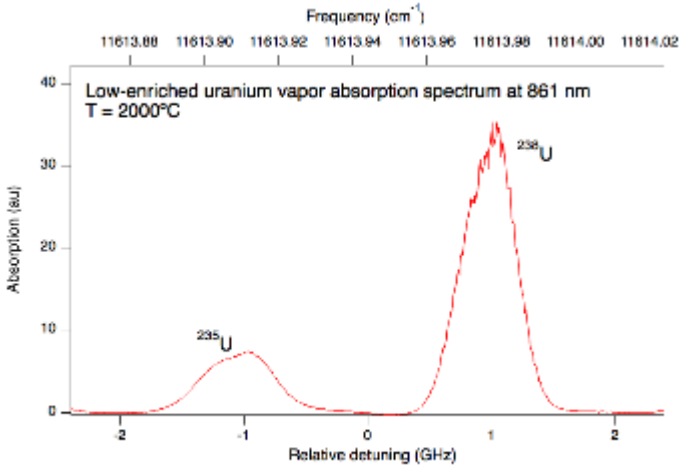
- Allows for reassessment during the course of an inspection
- Direct solid sample analysis (no preparation and no waste)

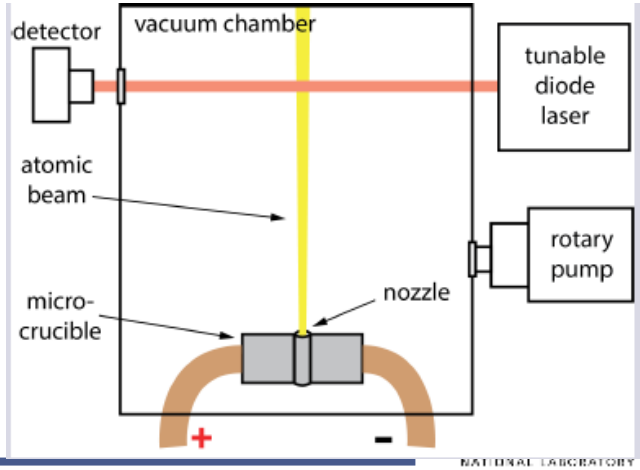
How it works:

- Development of a low-power microwave oven (2500°C)
- Collimated atomic beams using mg's of sample in vacuum
- Laser absorption spectroscopy using a diode laser
- Ultra-narrow laser line width to resolve isotopic ratios.

Next steps include:

- Application to and analysis of oxides
- Accuracy and precision determination
- Developing a fieldable prototype

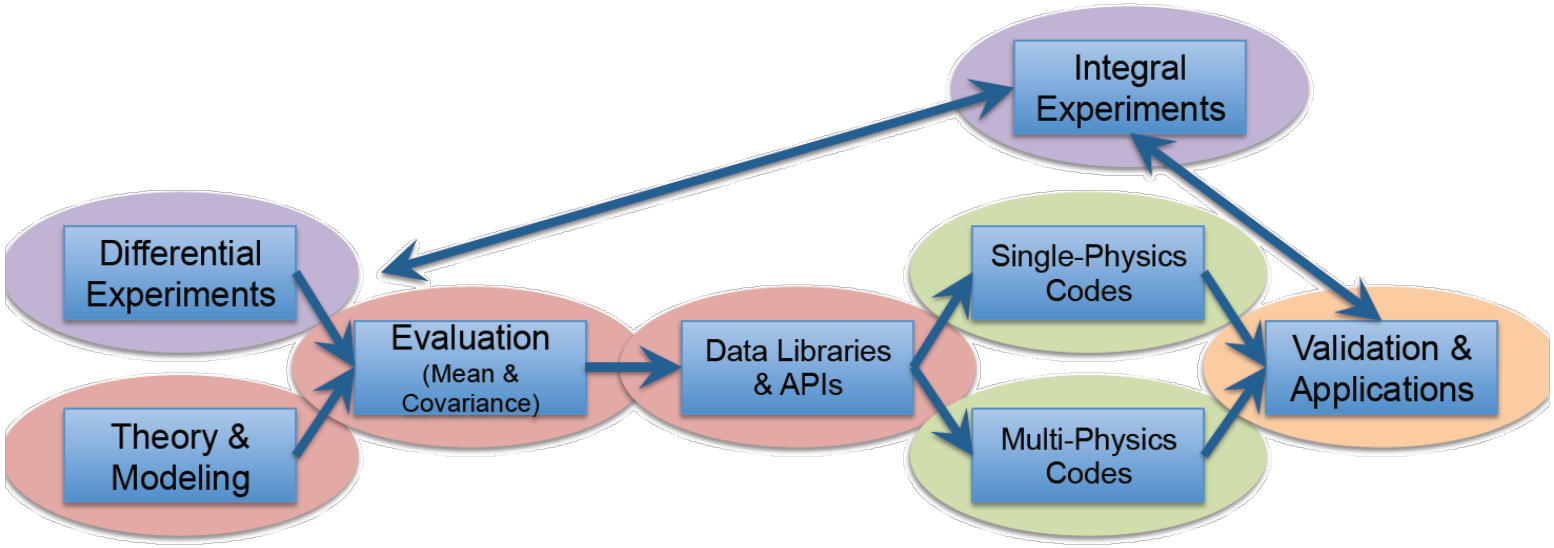




Differential and Integral Experiments for Nuclear Data and Modeling Validation

Predictive Radiation Transport Simulation Pipeline: Comprehensive, Complex, and (reasonably) Coordinated

Figure adopted from Morgan White (LANL)



Cross-section and emission measurements

Heuristic and advanced theory development

Expert judgment and evaluation tools

ENDF/B libraries
-neutron
-gamma (photons)
-charged particles
-decays

Nuclear data processing

Nuclear data libraries
-neutron/photon
-charged particles
-thermonuclear rx
-radchem

Standardized interfaces

Integral data

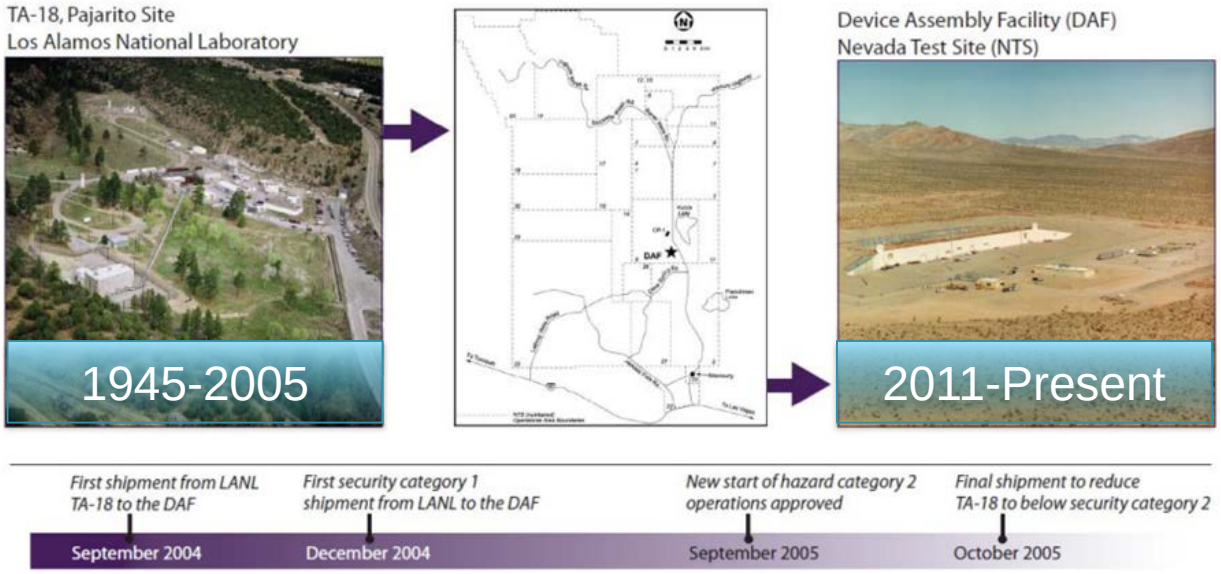
Single-physics
- critical assemblies
- pulsed spheres

Multi-physics
- NTS data

National Criticality Experiments Research Center

- The mission of the National Criticality Experiments Research Center (NCERC) at the Device Assembly Facility (DAF) is to conduct experiments on critical assemblies with fissile material at or near criticality in order to explore reactivity phenomena, and to operate the assemblies in the regions from subcritical through delayed critical.

Critical Experiment Capability



NA-22 Consortia Collaborations at NCERC-DAF

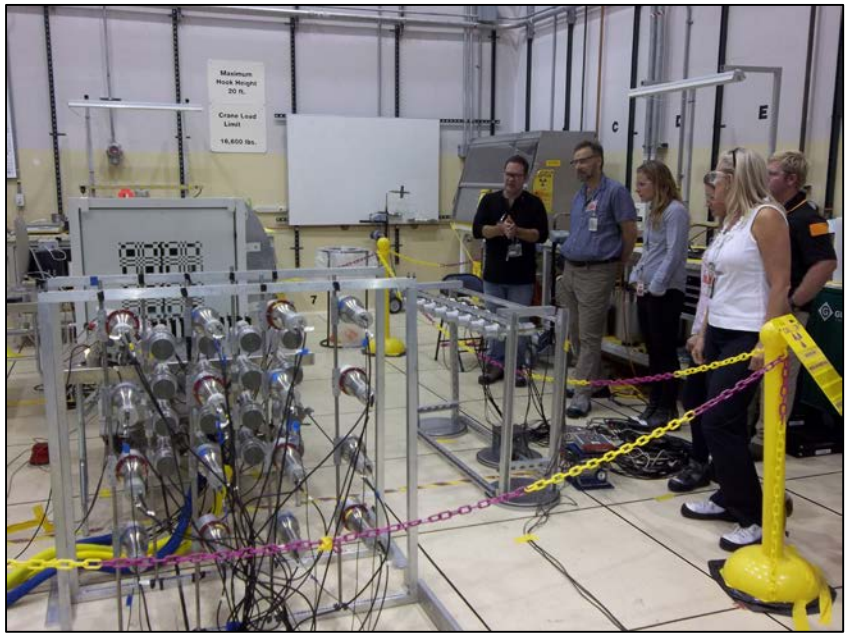
- **Unique facility/capabilities for all three consortia**
  - Facility (DAF-NCERC) = Category I Special Nuclear Material
  - Experimental Expertise = Experiment Design Guidance
    - In 2014, LANL performed 49 critical experiments and 46 Radiation Test Object operations which includes handling of large quantities of SNM including Pu, U and Np-237.
    - 2015: 62 critical experiments, 77 RTO builds
  - University Consortia
    - CVT/CNEC Focus - Passive and Active Measurements
    - NSSC Focus (discussions ongoing):

Critical experiments for validation originally proposed in Response to DE-FOA-0001300 for Nuclear Data + Modeling and Simulation thrust

….but expanding to forensics, passive/active detection measurements etc…

NSSC Technical Tour at the DAF

- **Observed partial CVT/CNEC measurements.**
- **Toured critical experiments facilities.**
- **Excursion to Sedan Crater.**
- **Discussed path forward on collaboration.**



LANL Nonproliferation Summer School

Dr. G. Robert Keepin
Nonproliferation Summer School
at Los Alamos National Laboratory

June/July 2017

Los Alamos NATIONAL LABORATORY EST. 1943

LA-UR-16-23586

Dr. G. Robert Keepin – An Early Architect of International Nuclear Safeguards R&D

Nonproliferation Summer School
at Los Alamos National Laboratory

Spend a summer learning about how game-changing science, engineering and technology are applied to reduce the dynamic threats of nuclear proliferation

Part I: Seminars, Tours, Hands-On Training (4 weeks in June - all participants)

Nuclear Nonproliferation Concepts & R&D Efforts (1 week)

Treaty Verification & Arms Control Intensive Course (1 week)

Hands-On Training & Technical Tours (2 weeks)

- Hands-on training at the LANL safeguards laboratory where all IAEA inspectors train.
- Hands-on training at the National Criticality Experiments Research Center at the Nevada National Security Site where critical/subcritical experiments are performed with significant quantities of special nuclear material for various national security missions.
- Tour of the Los Alamos Neutron Science Center (LANSCE) Accelerator.
- Tour of the Sedan Crater - located at the Nevada National Security Site - formed in 1962 as part of an excavation experiment using a 104-kiloton thermonuclear device.
- Tours of various Sandia National Laboratory Facilities.
- Tours of various Atomic and Nuclear Museums (Los Alamos, Albuquerque, Las Vegas).

Part II: Internship/Science Challenge (up to 6 weeks in July - select participants)*

Throughout the internship, students will spend most of their time working either individually or in small teams with a LANL staff member on a research project or science challenge that has a strong connection to nuclear nonproliferation.

**Applicants may also elect to apply to Part I (first 4 weeks) of the Summer School only.*

Eligibility: Participants must be U.S. citizens enrolled in accredited full-time upper-level undergraduate or graduate programs in science & engineering. Students enrolled in international affairs or policy programs may also apply. Limited slots are also available for faculty that are interested in the subject area.

Cost: Tuition is free for all accepted participants. A stipend may be provided for students that are also accepted into the research (internship) portion of the summer school & are in need of financial support.

Deadlines: Application material should be emailed (pdf only) to KEEPINschool@lanl.gov by Dec 31st, 2016. Applications for Part I of the Nonproliferation Summer School must include a Resume/CV with updated contact information (Email, Phone, Address). If you are also applying for Part II of the Summer School, you must also provide a one-page cover letter, an unofficial transcript, and a letter of university support. Applicants will be notified of decisions by March 1st.

Questions? Please email KEEPINschool@lanl.gov

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