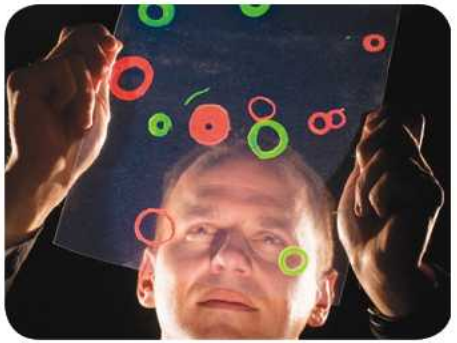
SAND2014-15225PE

Exceptional service in the national interest

Sandia National Laboratories



Sandia's Nuclear Facilities & Technologies

Presented to Nuclear Safety and Security Consortium

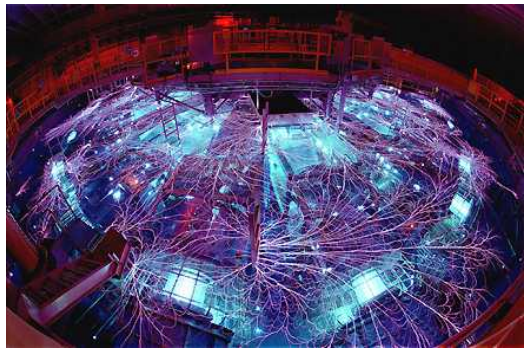
David Wheeler and Michael Greutman

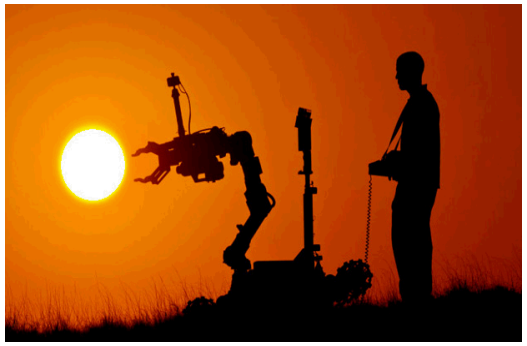
U.S. DEPARTMENT OF ENERGY

National Nuclear Security Administration

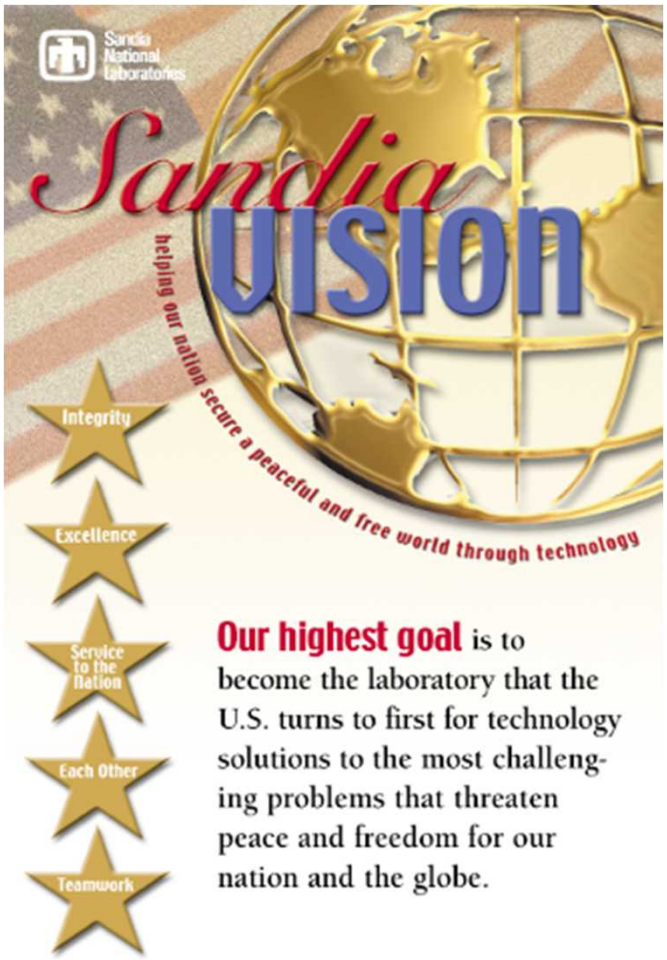
Sandia National Laboratories is a multi-program laboratory managed and operated by Sandia Corporation, a wholly owned subsidiary of Lockheed Martin Corporation, for the U.S. Department of Energy's National Nuclear Security Administration under contract DE-AC04-94AL85000. SAND2011-0439P

The laboratory the U.S. turns to first





- National Security Laboratory
- Broad mission in developing science and technology applications to meet our rapidly changing, complex national security challenges
- Safety, security and reliability of our nation's nuclear weapon stockpile



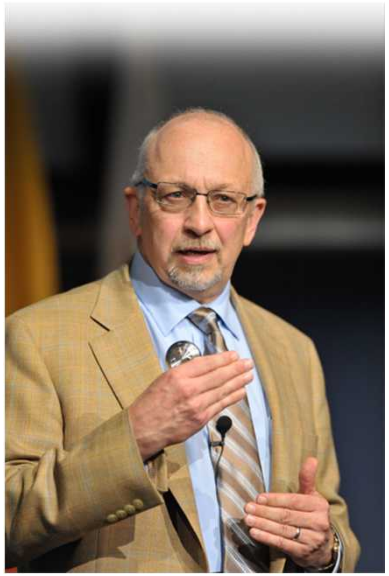
Partnerships & Collaboration Accelerate Innovation

Sandia National Laboratories

Government Laboratories

Universities

Industry



Emerging National Security Thrusts

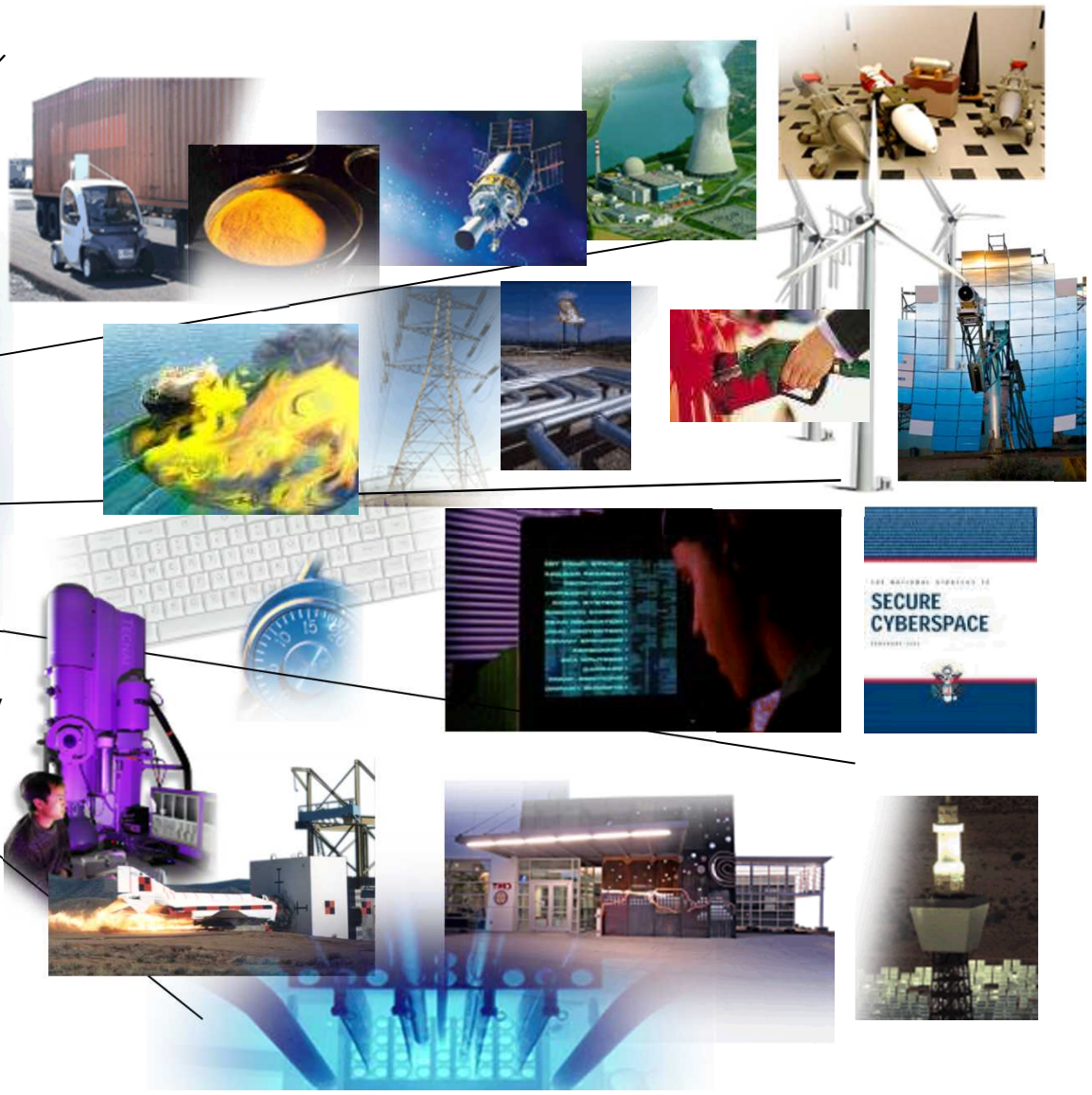
Sandia National Laboratories

Nuclear

Energy

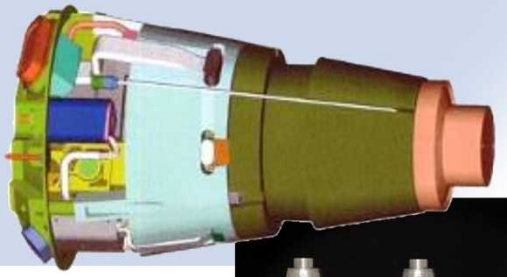
Cyber

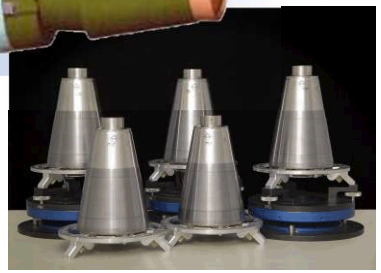
Science & Technology



Nuclear Weapons

Integrated, engineered warhead systems

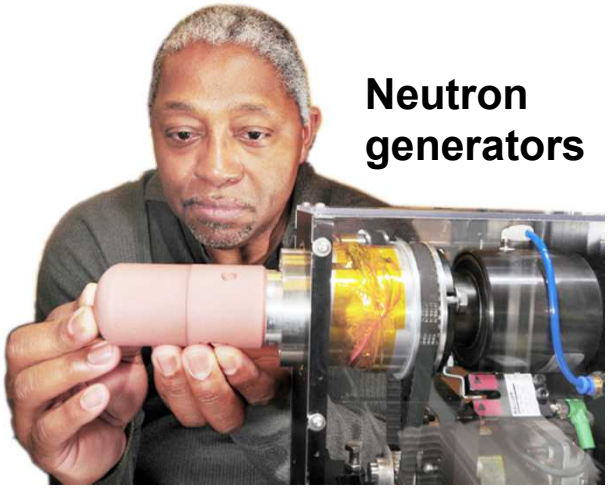




Arming, fuzing, and firing systems

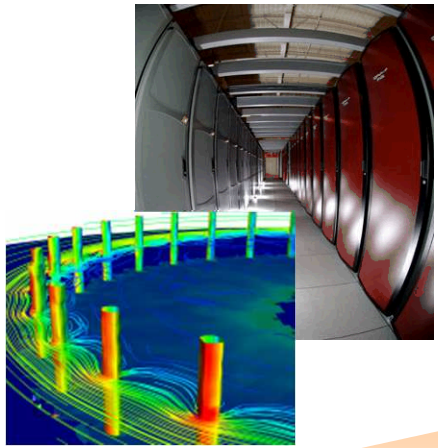
Safety systems

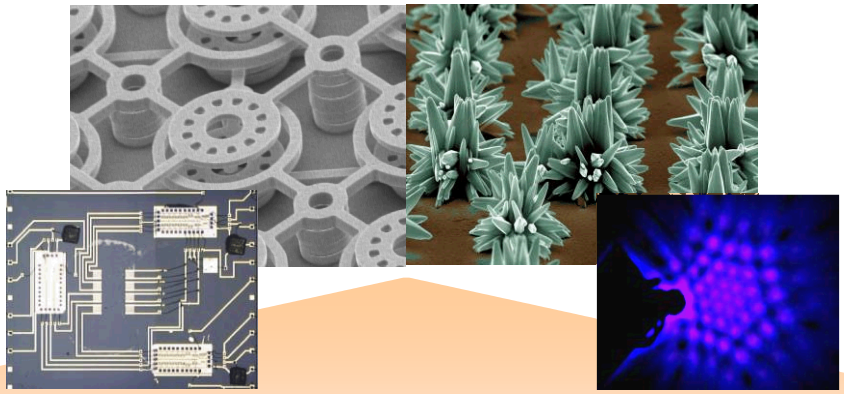
Gas transfer systems

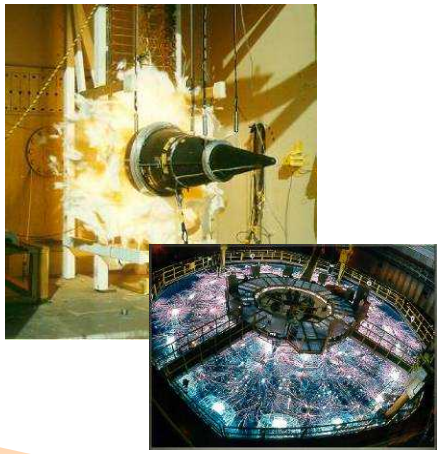


Neutron generators

Research Disciplines Drive Capabilities





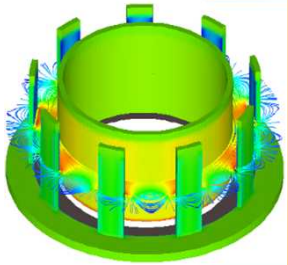


High Performance Computing

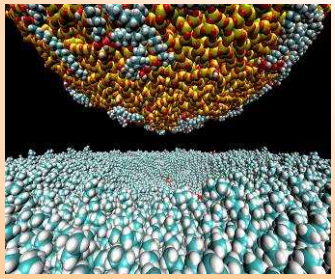
Nanotechnologies & Microsystems

Extreme Environments

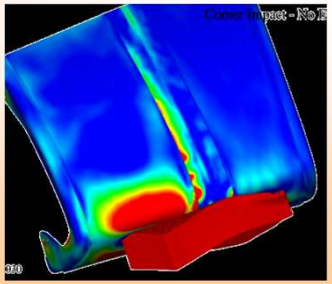
Computer Science



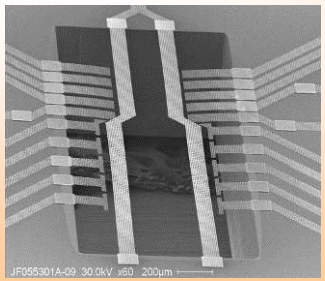
Materials



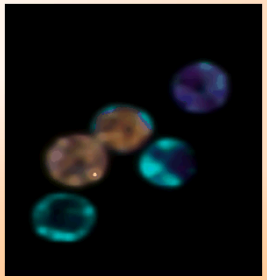
Engineering Sciences



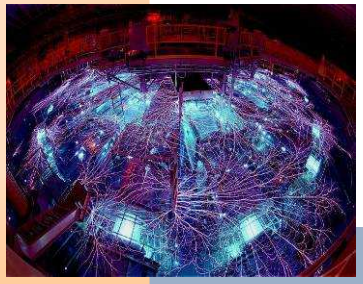
Micro Electronics



Bioscience

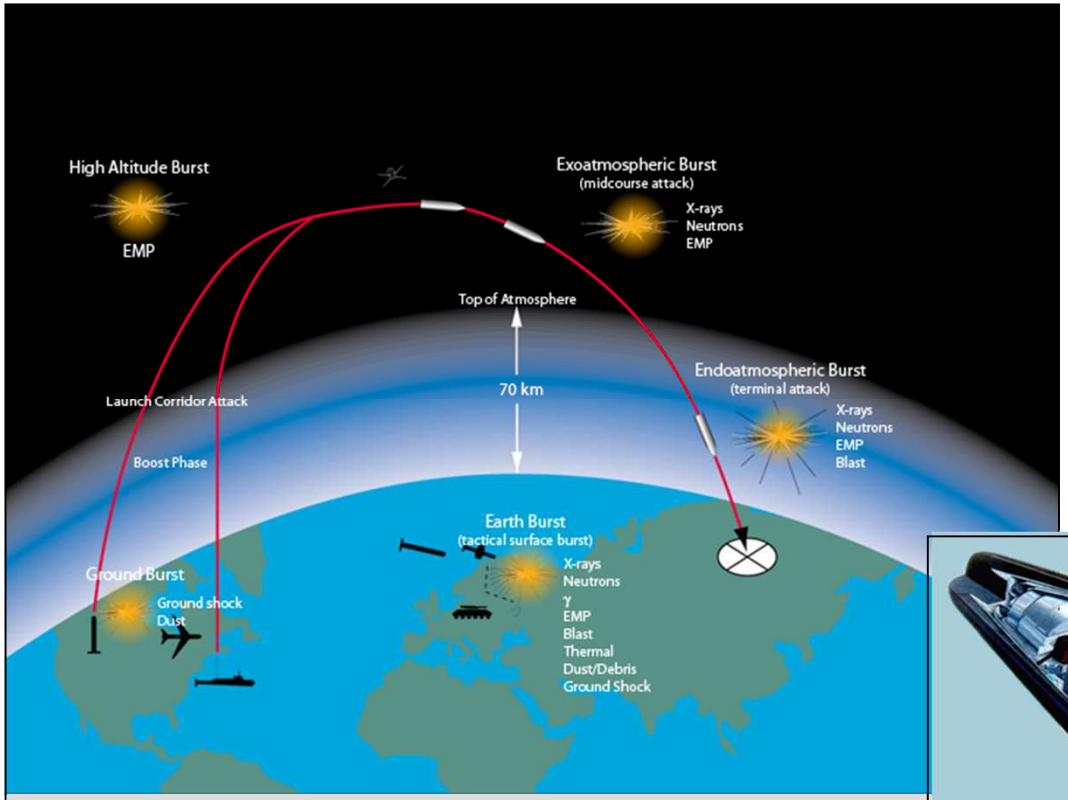


Pulsed Power

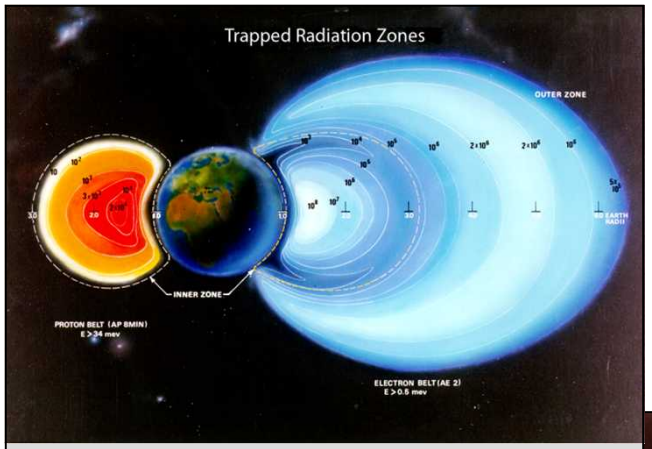


Research Disciplines

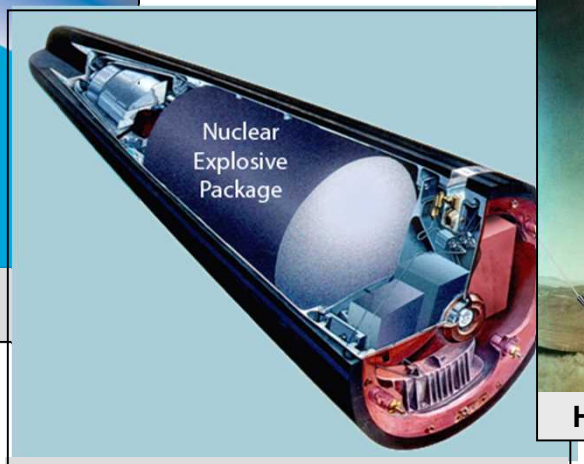
Radiation Requirements



Hardness against nuclear countermeasures



Hardness against space radiation

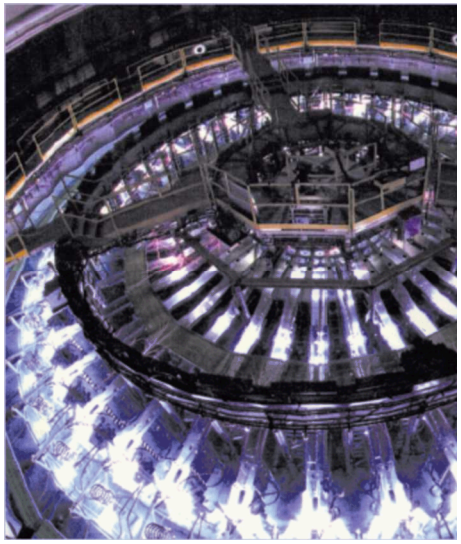


Hardness against in situ radiation

Hardness against fratricide

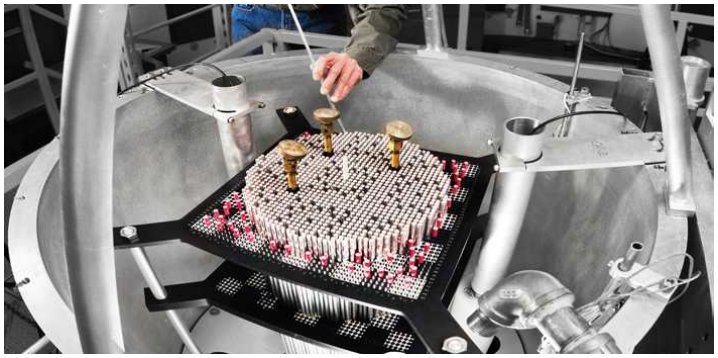
Applied Radiation Sciences

Sandia National Laboratories

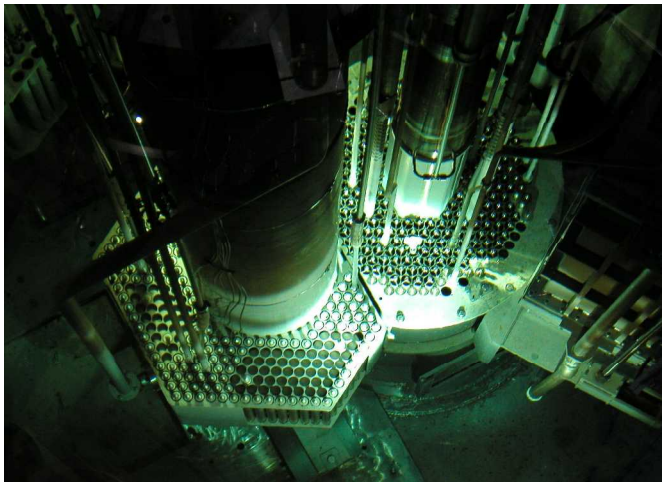


Simulating Radiation Environments

Nuclear Reactor Safety and Accident Testing



Designing and Testing Nuclear Fuel



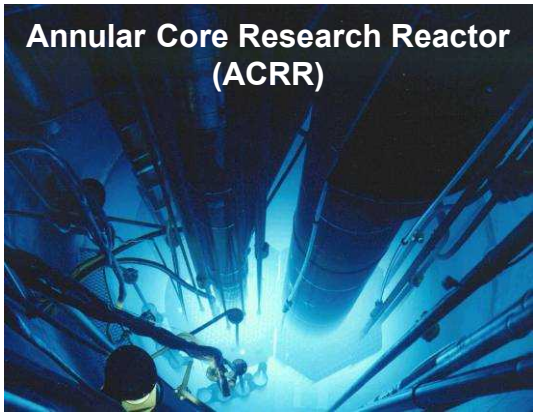
Designing and Modifying Nuclear Reactors

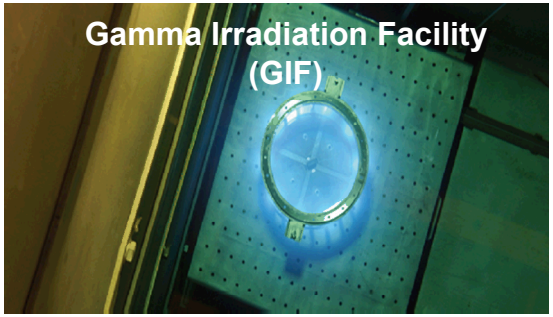
Nuclear Facilities Operations

- **Mission** Advance nuclear technology through applied radiation sciences and unique nuclear environments.
- **Vision** Leading nuclear technologies vital to the nation.
- **Primary Competency**: Provide neutron and gamma radiation environments for design qualification and certification for the entire stockpile to target lifecycle and analysis for Sandia Labs in the area of nuclear weapons systems safety, surety and survivability.
  - Management: 1 Senior Mgr., 7 Dept. Mgrs.
  - 70 Technical Staff in R&D, Eng., and Operations
  - 30 Support Staff in Quality, Training, IT, and Administration
  - Education: 16% PhD, 36% Masters, 30% Bachelors, 30% Other
  - 77% Male, 23% Female

TA-V Nuclear Facilities
Unique Capabilities

A Complete Range of Nuclear and Radiation Facilities for Research, Testing and Production





State of the Art Dosimetry

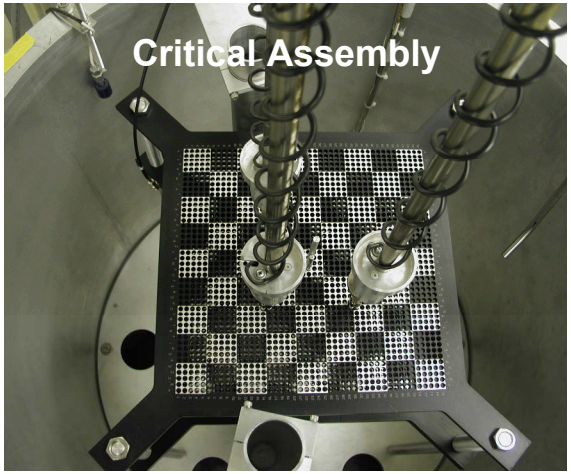
Criticality Benchmarks

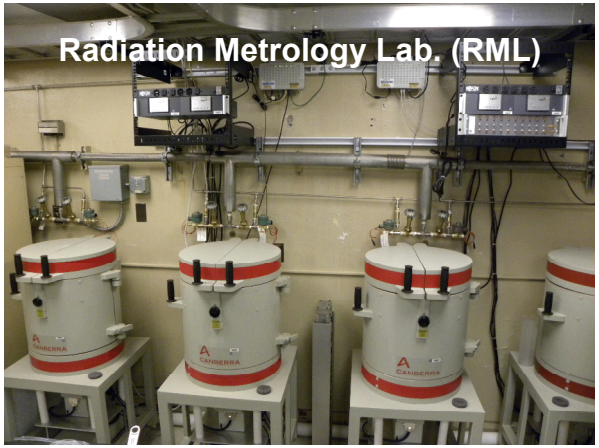
Radiation Effects Testing

Reactor Safety Experiments

Fuel Cycle Research

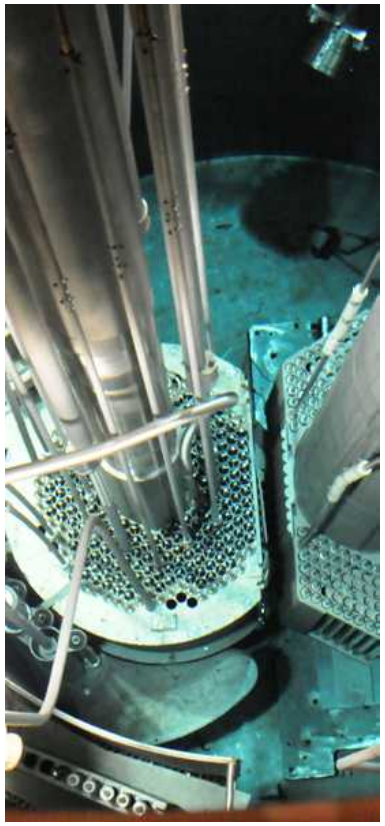
Space Nuclear Power



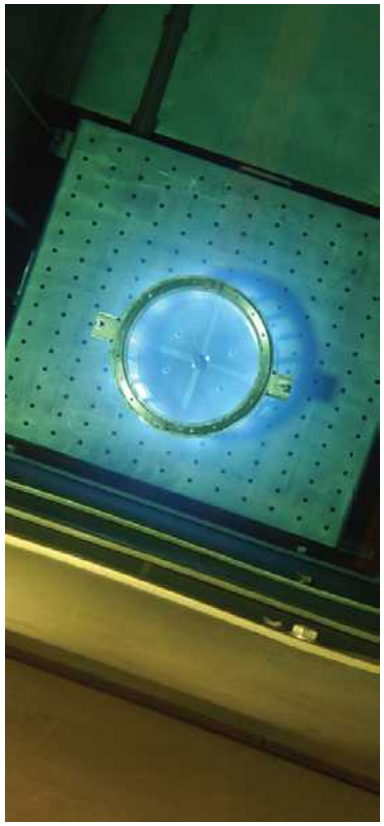


Unique Nuclear Environments

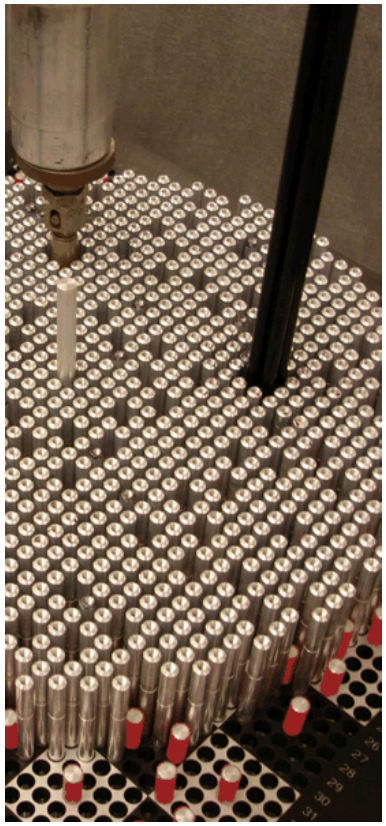
Sandia National Laboratories



Annular Core Research Reactor (ACRR)



Gamma Irradiation Facility (GIF)



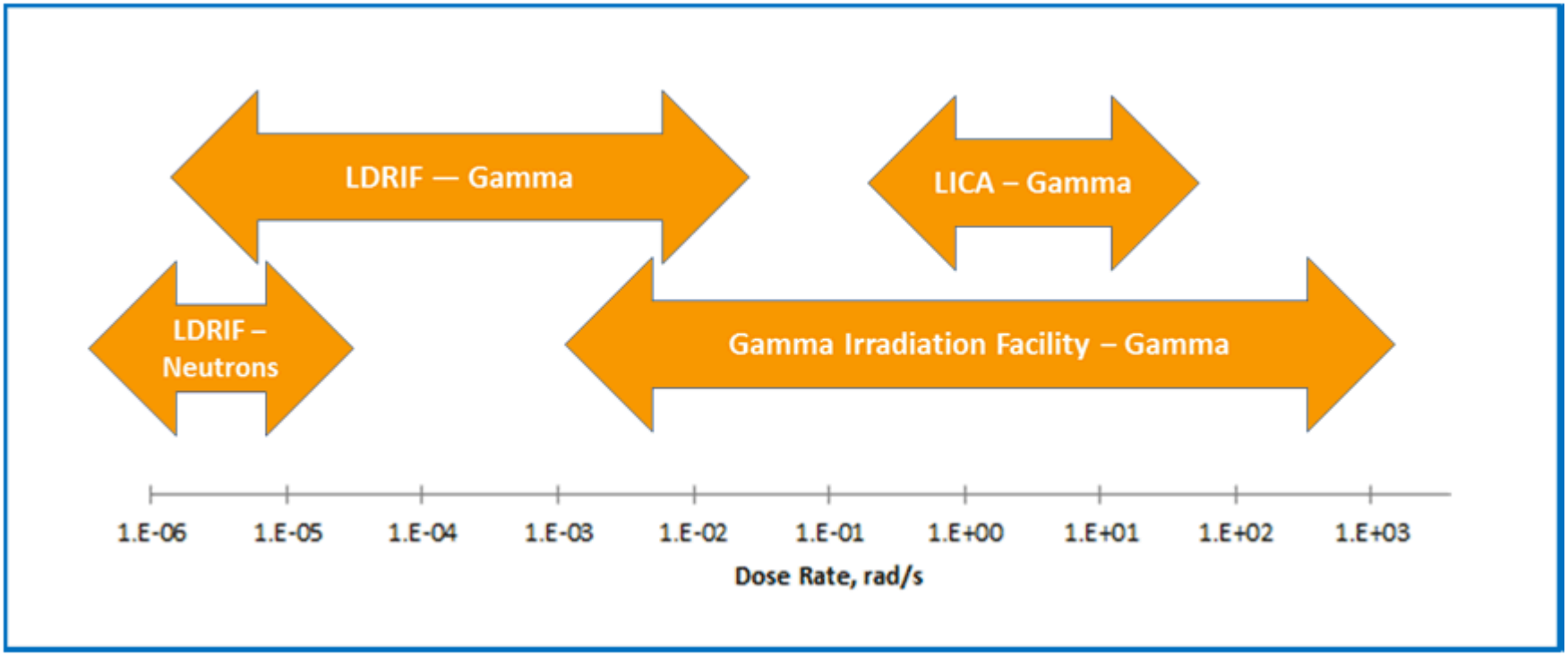
Sandia Pulsed Reactor Critical Experiments (SPR/CX)

Radiation Metrology Lab (RML)

Gamma Irradiation Facility

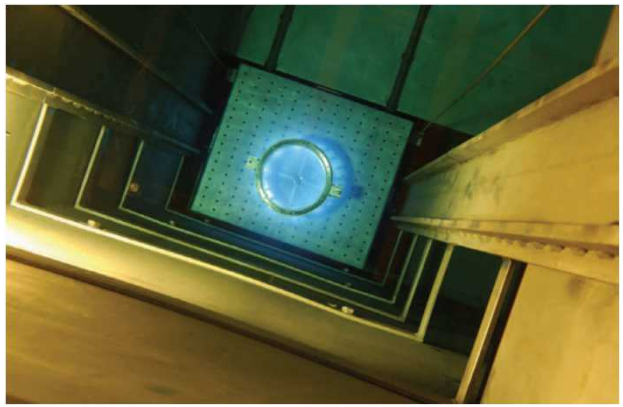
TA-V
LEADING NUCLEAR TECHNOLOGIES

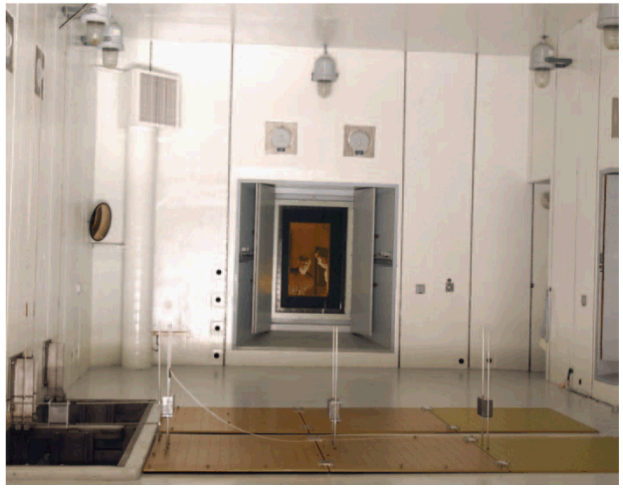
Irradiation Facilities Dose Rate Capabilities



Gamma Irradiation Facility

- Gamma Irradiation Facility (GIF) is available for in-cell dry and in-pool submerged irradiations.
- The GIF is used mainly for radiation certification of satellite and weapon systems electronic components, dosimetry calibration, and studies on radiation damage to materials.
- A movable wall creates access for large components.

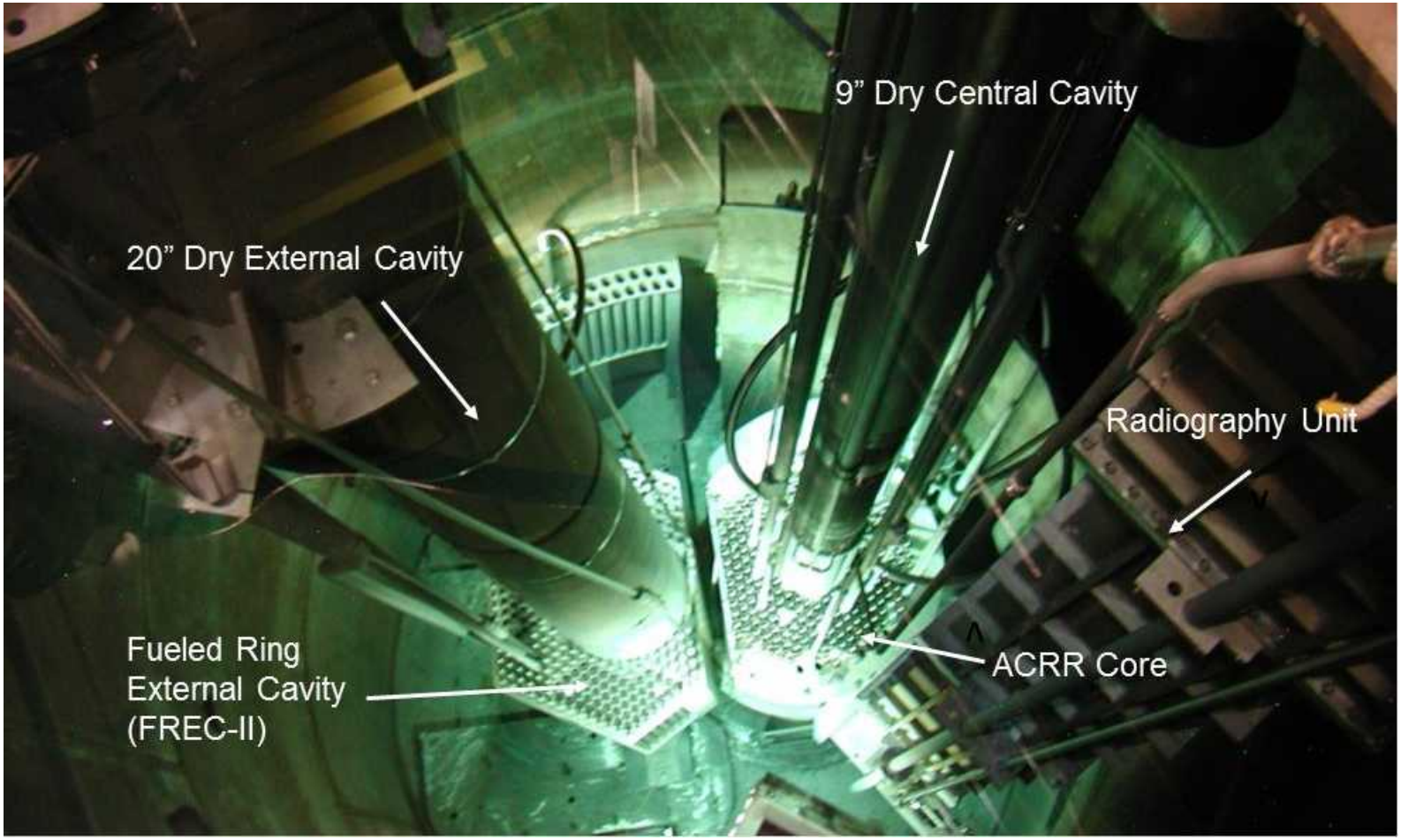




Gamma Irradiation Cells

Sandia National Laboratories

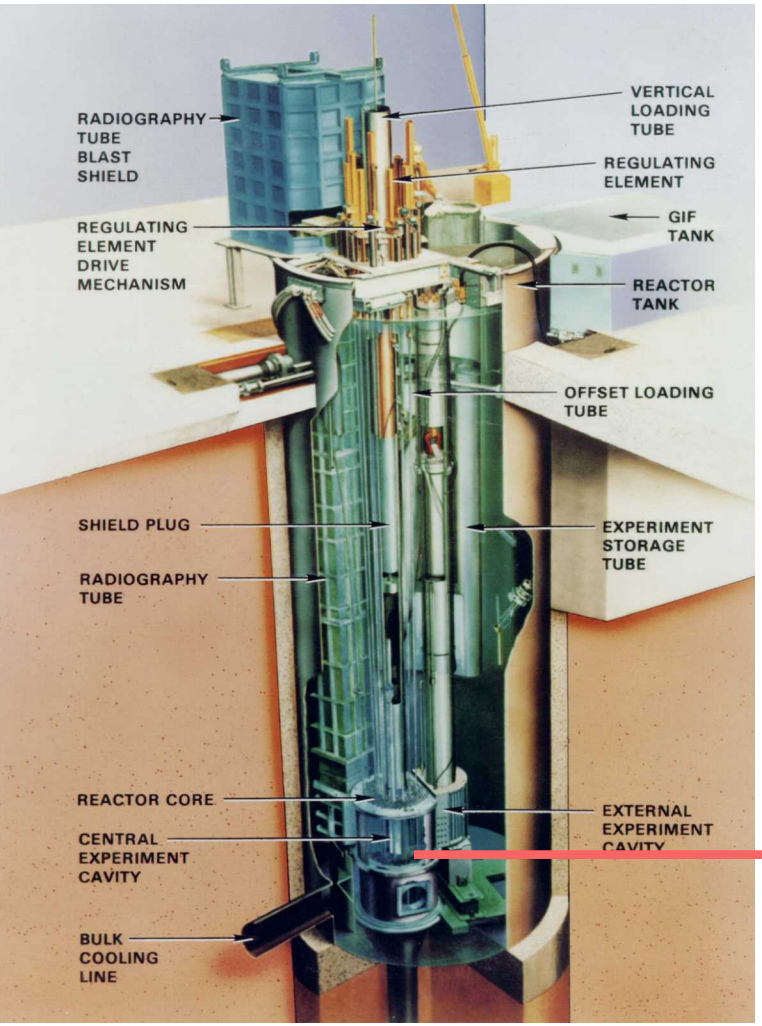
Annular Core Research Reactor



Annular Core Research Reactor

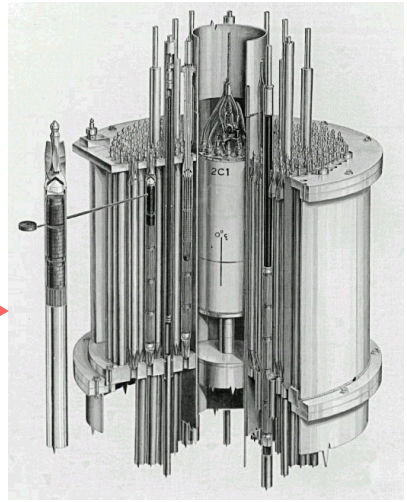
- UO2-BeO fuel consists of uranium enriched to 35 percent uranium-235, with 21.5-weight percent UO2 and 78.5-weight percent BeO.
- Fuel designed to allow steady state and pulsed operation at fuel temperatures up to 1400 C.
- Reactor controlled by two fuel-followed safety rods, three void-followed transient rods, and six fuel-followed control rods.
- The fuel-followed rods make up part of the 236 fuel elements in the normal core configuration.

Annular Core Research Reactor



- POWER CAPABILITY
  - 2-4 MW(th) Steady-State
  - 35,000 MW(th) Maximum Pulse

Reactor Core



Typical ACRR Experiments and Tests

Sandia National Laboratories

- Electronic circuit boards and components
- Passive and Active neutron and/or gamma dosimetry devices
- Arming, fusing, and firing systems and components
- Explosive components (including neutron generators)
- Radioactive materials
- Experiment holding/positioning fixtures
- Neutron spectrum modifying fixtures
- Nuclear fuel materials

Neutron Radiography Experimental Facilities Capabilities

- The ACRR has a neutron radiography experimental facility which can be used for neutron radiography and for the activation of components either at the imaging plane, experiment chamber, or suspended throughout the tube at various heights. Experiments can be irradiated with and without the collimator in place.

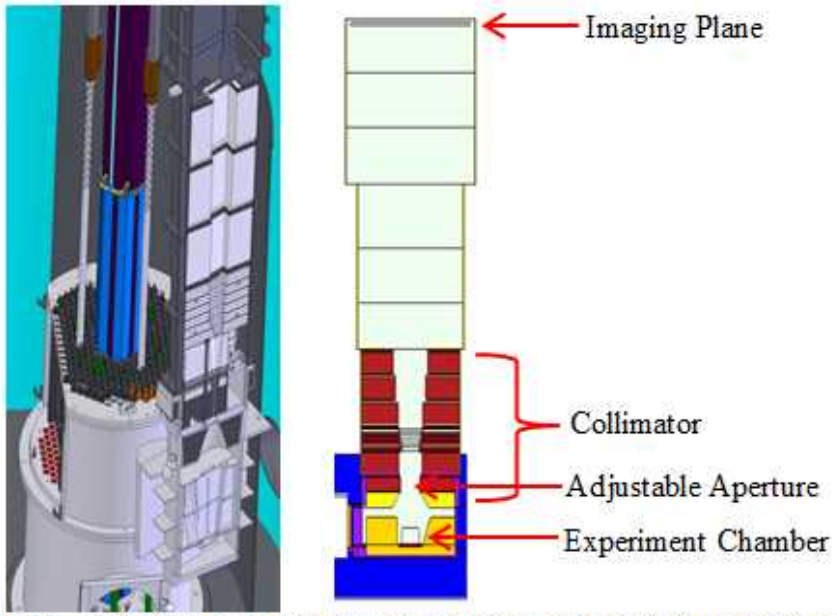


Figure 1 - Solid Works and MCNP Models of the ACRR Neutron Radiography System

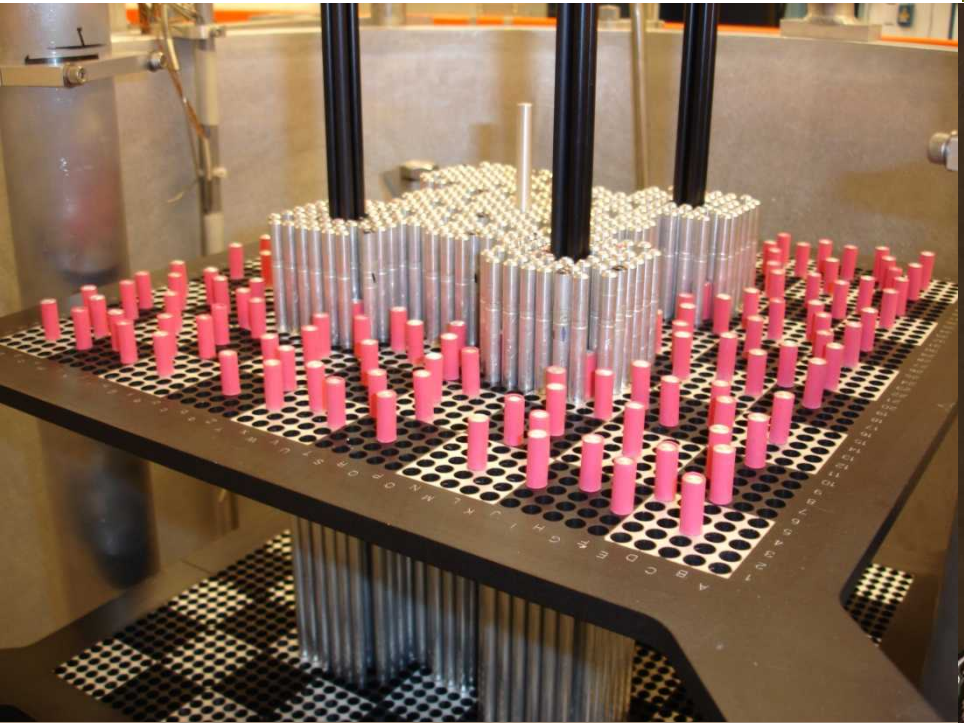
ACRR Pulse

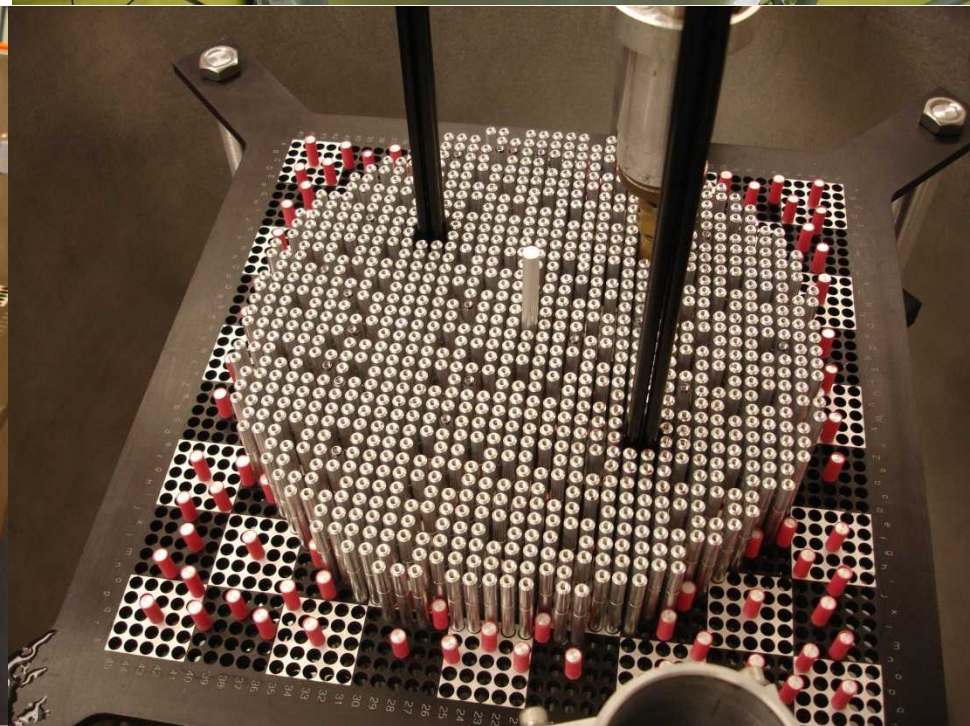
Sandia Critical Experiments



Critical Experiment (CX) – 7uP

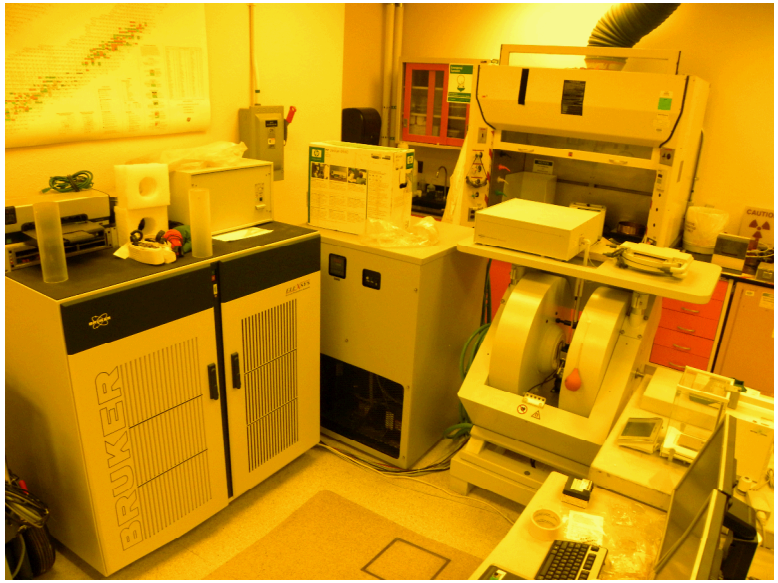
7% Enrichment





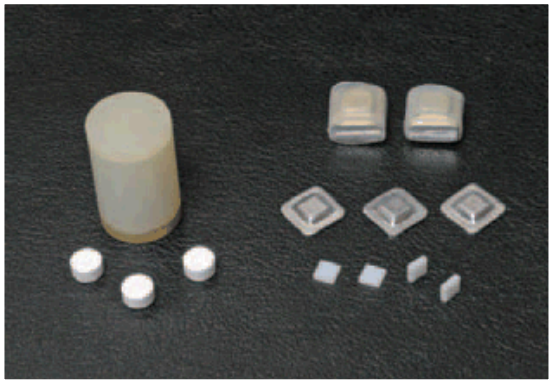
RADIATION METROLOGY LABORATORY (RML)

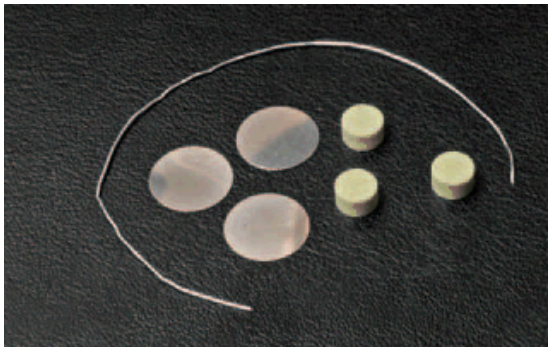
- PHOTON DOSIMETRY
  - Thermoluminescence Dosimetry (TLD)
  - Electron Spin Resonance – Alanine
  - Ionization Chambers
- NEUTRON DOSIMETRY
  - Activation Analysis
  - Sulfur



RML Testing Capabilities

- Gamma spectroscopy
  - Activation foils
  - Fission foils/wires
- General dosimetry
  - TLD
  - EPR
  - Ionization chamber
- Proportional counting
  - Sulfur activation pellets





Participation in Professional Societies

Sandia National Laboratories

American Nuclear Society

IEEE
Advancing Technology for Humanity
Instrumentation & Measurement Society

AGA

ASTM INTERNATIONAL
Standards Worldwide

HPS Health Physics Society
Specialists in Radiation Safety • Founded 1956 • http://hps.org

ASME
SETTING THE STANDARD

ASQ

AIChE American Institute of Chemical Engineers

FCOG

Institute of Nuclear Materials Management
INMM

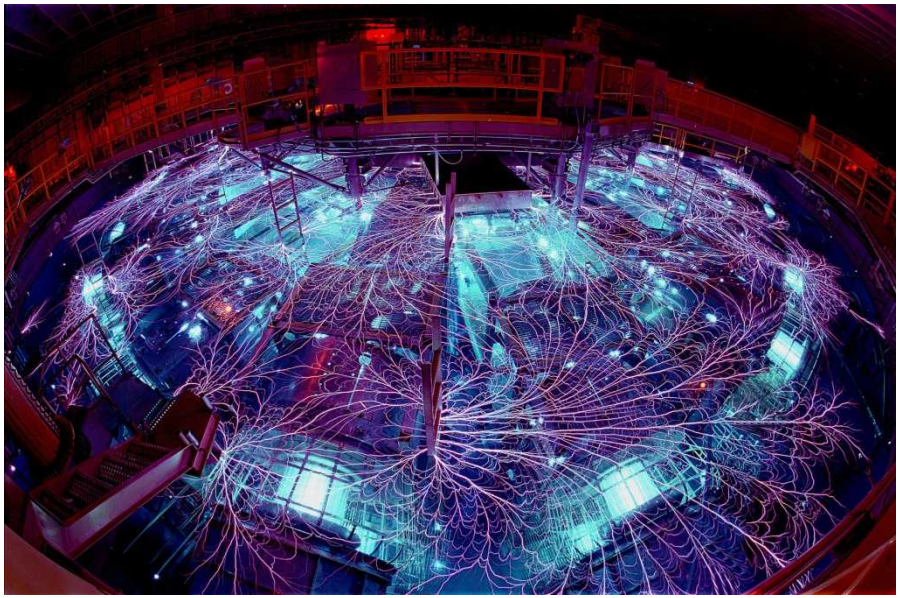
PMI Project Management Institute

TA-V Student Engagements

- Hired and mentored 19 student interns 2008 - Present
- Students at undergraduate and graduate level
- Participation in American Nuclear Society student conference: Technical presentations and professional development
- Student academic studies: Nuclear Engineering, Nuclear Physics, Mechanical Engineering, Computer Science, Information Systems, Health Physics
- 9 students > 2 years with organization
- 9 student interns currently on roll
- 6 students accepted to post-graduate education while student intern
- 4 direct hires from previous student internship

Dimitrios

Texas A&M University



Z Machine

- Neutron multiplication models in n,2n reactions related to Z-Machine experiments
- Angular flux detection models related to the ACRR

Taylor

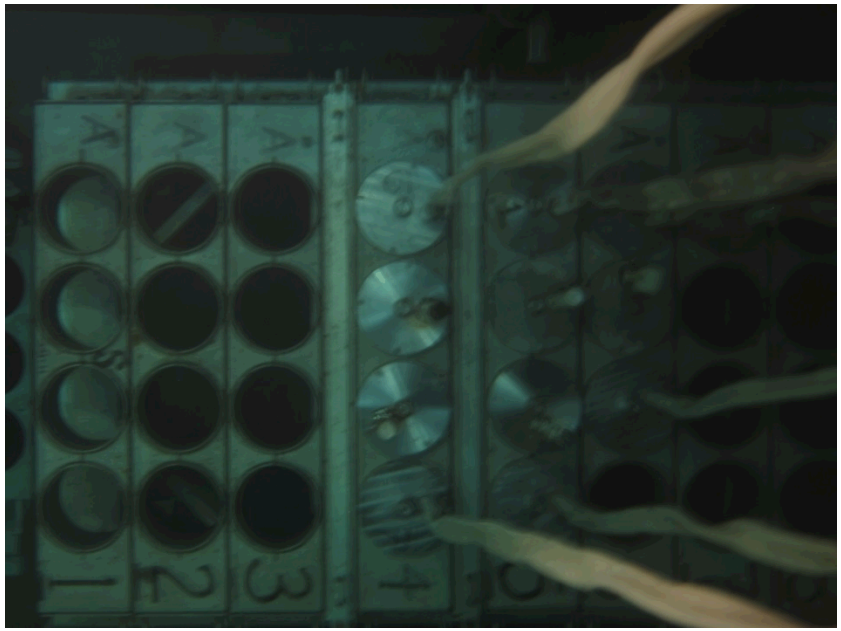
Texas A&M University

Annular Core Research Reactor (ACRR)

- Task: Develop a time and energy dependent gamma and neutron flux for the drywell of the ACRR.
- Benefit: More accurately design and/or control irradiation experiments.

Nathan

University of New Mexico



Low Intensity Cobalt Array (LICA)

Summer 2014 Project: MCNP Modeling of the LICA (Low Intensity Cobalt Array)

- LICA is used for underwater irradiations of materials in controlled conditions
- Model dose distribution of LICA for long-term irradiations
- Model effects of varying source loading, blocking can positioning, and materials in cans
- Use model to predict effects on materials in LICA not directly linked to experiments

Brandon

Georgia Institute of Technology

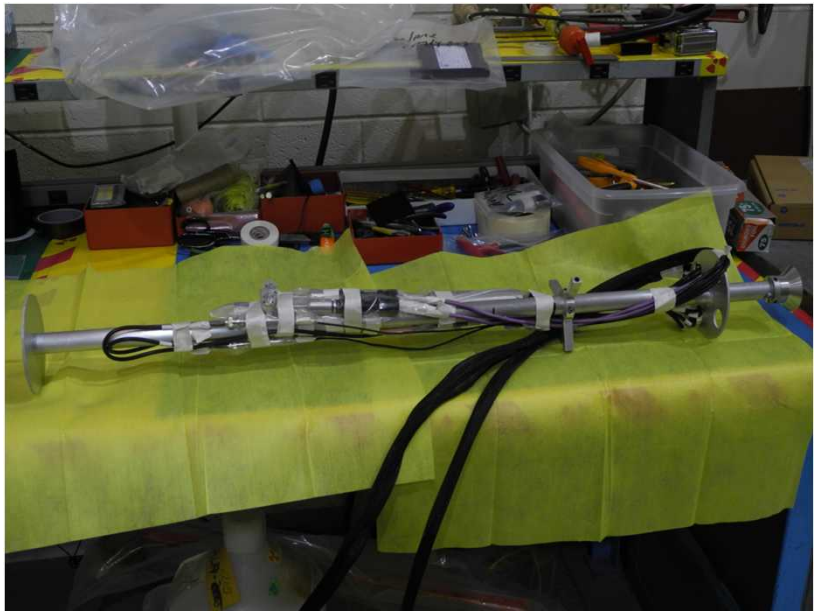
ACRR bridge

- Generate 3D CAD model of ACRR transient rod system.
- Simulate pneumatic actuation of transient rod pulse operation.
- Analyze system response and performance and compare to known behavior.

Jonathan

Sandia National Laboratories

North Carolina State University



Experimental fission chamber

- Setup and calibration of a fission chamber to use in the ACRR central cavity.
- Comparison of the detector response with previously used techniques such as passive dosimetry.

Richard

Sandia National Laboratories

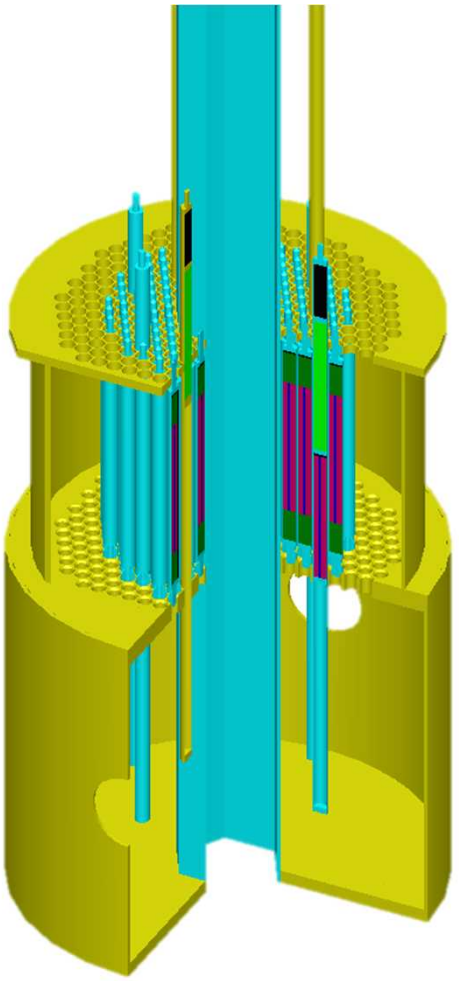
Texas A&M University

Serpent/SCALE Comparison

Nuclide	Atom Density on January 1, 2014 (atoms/barn cm)		Serpent/SCALE
	Serpent	SCALE	
Am241	6.12384E-12	6.33300E-12	0.967
Am242m	2.32810E-16	2.16500E-16	1.075
Am243	4.99171E-18	5.39900E-18	0.925
Cm242	6.07810E-19	5.64100E-19	1.077
Cm245	5.02218E-25	5.64600E-25	0.890
Cs137	4.42608E-08	4.45400E-08	0.994
Eu154	2.88483E-13	2.68700E-13	1.074
H3	4.43488E-17	1.86500E-11	0.000
Ho166m	7.63451E-17	7.10300E-18	10.748
Kr85	3.39044E-10	4.85500E-10	0.698
Np237	6.00419E-10	5.84500E-10	1.027
Pa233	2.06812E-17	2.01300E-17	1.027
Pu238	6.79241E-13	6.55700E-13	1.036
Pu239	2.87265E-07	2.87900E-07	0.998
Pu240	1.30397E-09	1.33100E-09	0.980
Pu241	1.15145E-12	1.19100E-12	0.967
Pu242	9.65333E-15	1.01100E-14	0.955
Sm151	5.47240E-09	5.50200E-09	0.995
Sr90	3.95464E-08	3.97900E-08	0.994
Th230	1.17664E-14	1.13600E-14	1.036
U234	1.05533E-10	1.02000E-10	1.035
U236	3.84302E-07	3.85800E-07	0.996
U235	3.73602E-04	3.73600E-04	1.000
U238	1.48402E-03	1.48400E-03	1.000
Y90	1.00312E-11	1.00900E-11	0.994

Summer 2013:

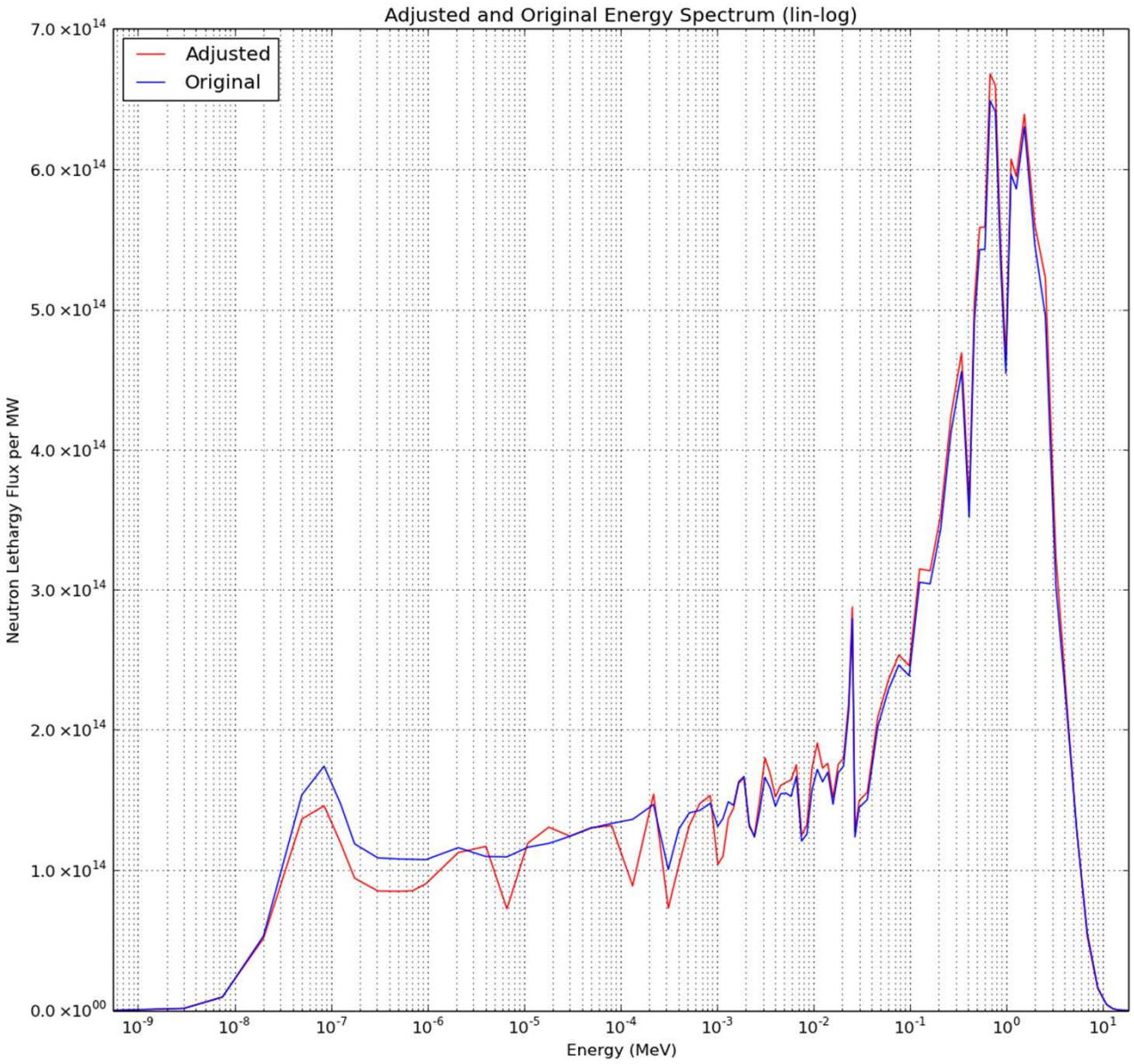
- Burnup calculations to estimate the present day isotopics of fuel from the Annular Core Pulse Reactor (ACPR: 1967-1977).
- Comparison of Serpent 2 Beta's burnup routine to ORIGEN (part of the SCALE package).



ACPR Modeled in SCALE

Summer 2014:

- Characterization of the free-field ACRR cavity using a logarithmic least squares spectrum adjustment.
- Development of a genetic algorithm for spectrum adjustment.
- Use Serpent 2 to detect any change in the ACRR wide range detector response for various reactor conditions and experiment environments.



Gabrielle

Sandia National Laboratories

University of New Mexico

- Enter documentation generated by TA-V operations into configuration database (eB)
- Provide document assistance to TA-V staff and generate inventory spreadsheets for document retrievability
- Ensure nuclear quality requirements for documents and records are maintained

David

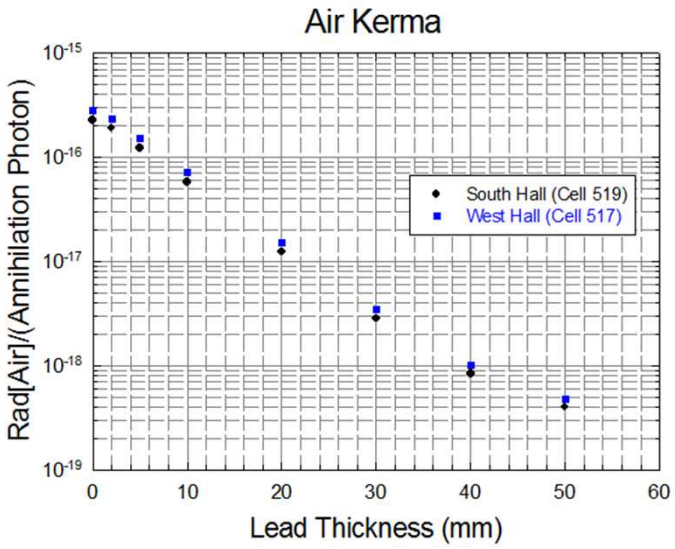
University of New Mexico

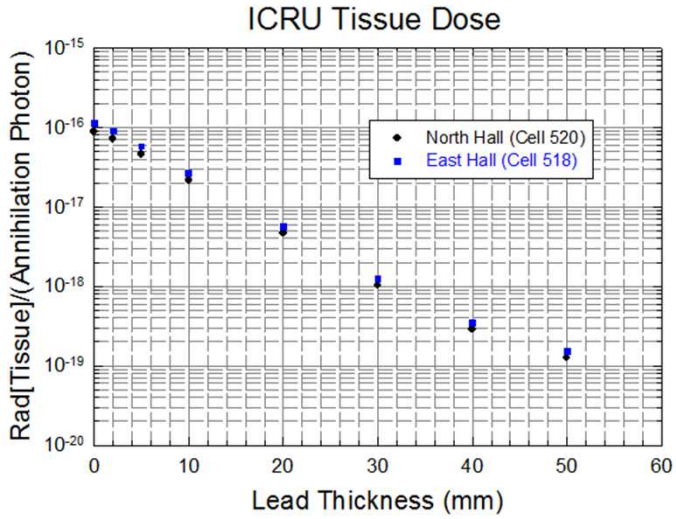
- Completed Projects
  - Radiation Transport
    - PET Shielding Benchmarks
    - Criticality Safety Standards for Sandia
  - Radiation Biology
  - Dosimetry/Radiation Environment Characterization
  - Molten Salt Reactor Core Study
    - Developing of Fluid Fuel Monte Carlo Simulation Tool

- Current & Future Work
  - Radiation Biology
    - Radiation exposure on cancer cells
  - Radiation Transport
    - Modeling of different ion chamber/fission chamber detectors in Annular Core Research Reactor (ACRR)

Radiation Transport

- PET Shielding Project
  - Approached by hospital to evaluate shielding changes needed for X-ray rooms to change to PET Suites
  - Monte Carlo simulations show expected results and give important dose data and buildup factors for the PET model





Extreme Radiation Environments

- Co-60 Radiation Sweeper Project
  - Needed reliable, quick way to generate 3-D radiation map of circular Co-60 array in high radiation area.
  - Created software, hardware, and data acquisition routine.
  - Experimental results meet theoretical expectations!