Exceptional service in the national interest

Sandia National Laboratories

SAND2016-9452PE

Overview of Sandia National Laboratories, Technical Area V, and the 90's Medical Isotope Production Program

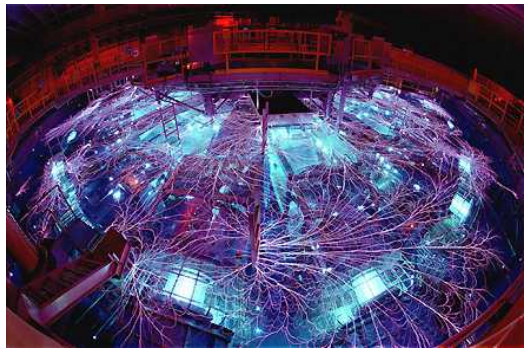
U.S. DEPARTMENT OF ENERGY

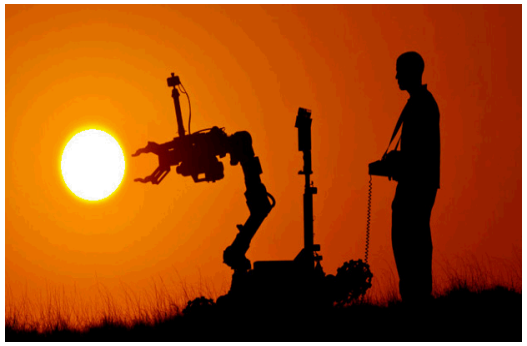
National Nuclear Security Administration

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. SAND NO. 2014-17395 PE

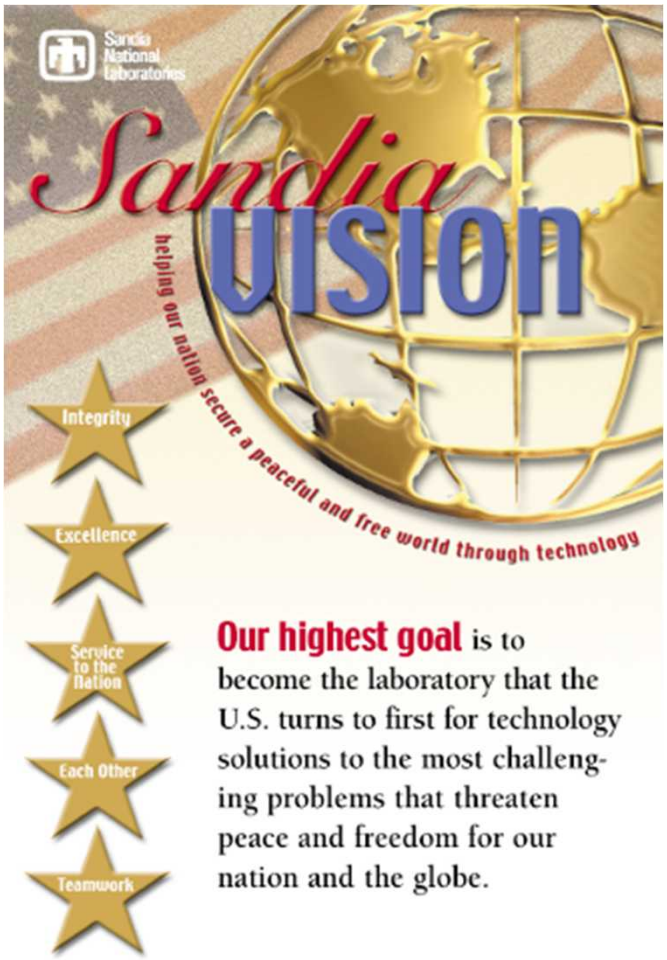
The laboratory the U.S. turns to first

Sandia National Laboratories





- 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



Sandia's Impact

Sandia National Laboratories

Cleanroom invented 1963

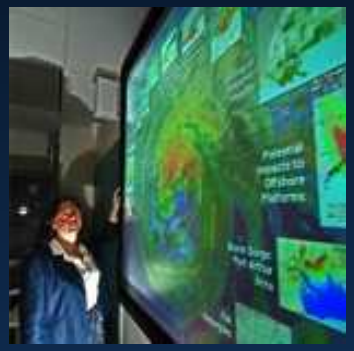
$50 billion worth of cleanrooms built worldwide It's used in hospitals, laboratories and manufacturing plants today.

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.

2008 Satellite Takedown

Red Storm computing helps shoot down rogue satellite.



Hurricane Katrina

Sandia is called to assess flooding and infrastructure failures.

Fukushima Quake

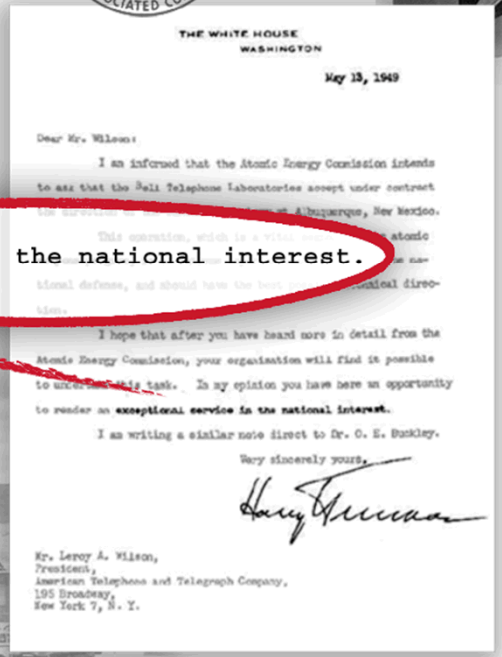
Sandia helps cleanup radioactive wastewater.

Gulf Oil Spill

Sandia works to help to develop an approach for securing the damaged well head, stopping the leak, and minimizing the severity of the oil spill.

Sandia's History

Sandia National Laboratories



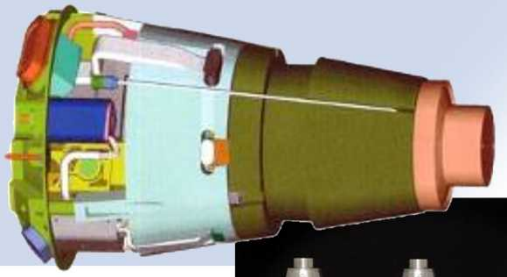
exceptional service in the national interest.

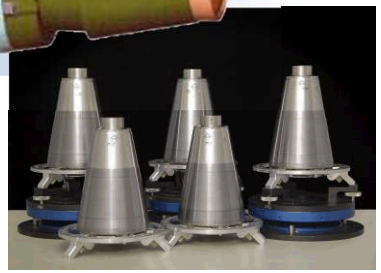
- Sandia's roots can be traced to the Manhattan Project. J. Robert Oppenheimer established "Z Division" at Sandia Base near Albuquerque immediately after World War II, to perform stockpile development activities.
- In 1949, at the urging of the Atomic Energy Commission, President Truman encouraged the American Telephone and Telegraph Company to accept management and operating responsibility for the Sandia operation. His letter to AT&T President Leroy Wilson contained a phrase that captures the ethos of Sandia to this day: "In my opinion, you have here an opportunity to render an exceptional service in the national interest." The AT&T Bell Laboratories operated Sandia from November 1949 through 1992.
- In 1993 Martin Marietta Corporation became the management and operating contractor for Sandia National Laboratories. (Martin Marietta later merged with Lockheed to form Lockheed Martin Corporation.)
- Sandia established a laboratory facility in Livermore, California, in 1956 to the support the nuclear weapon development activities of the University of California Radiation Laboratory—now Lawrence Livermore National Laboratory.

Nuclear Weapons

Sandia National Laboratories

Integrated, engineered warhead systems

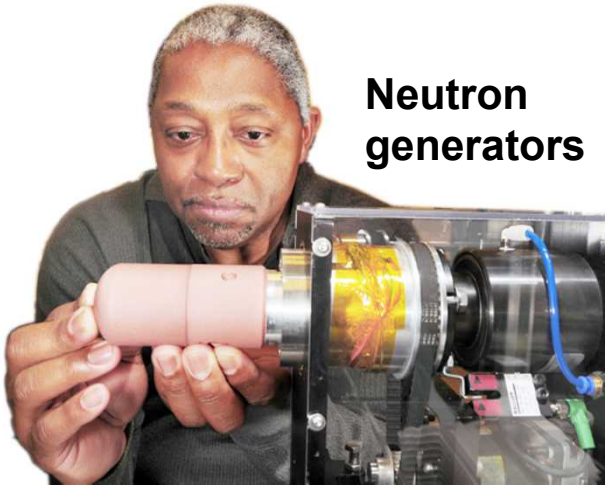




Arming, fuzing, and firing systems

Safety systems

Gas transfer systems



Neutron generators

Emerging National Security Thrusts

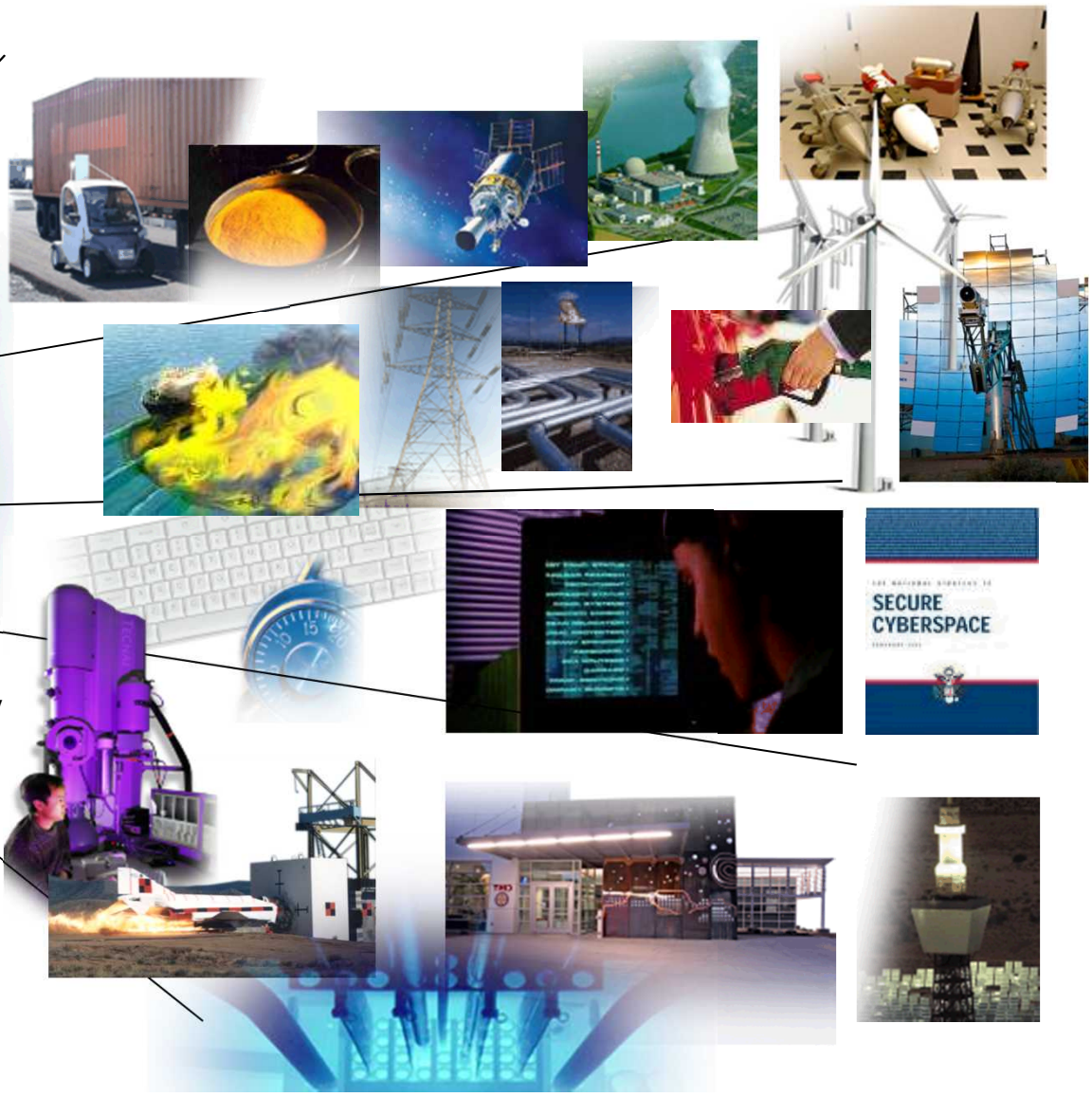
Sandia National Laboratories

Nuclear

Energy

Cyber

Science & Technology



Sandia is a National Laboratory

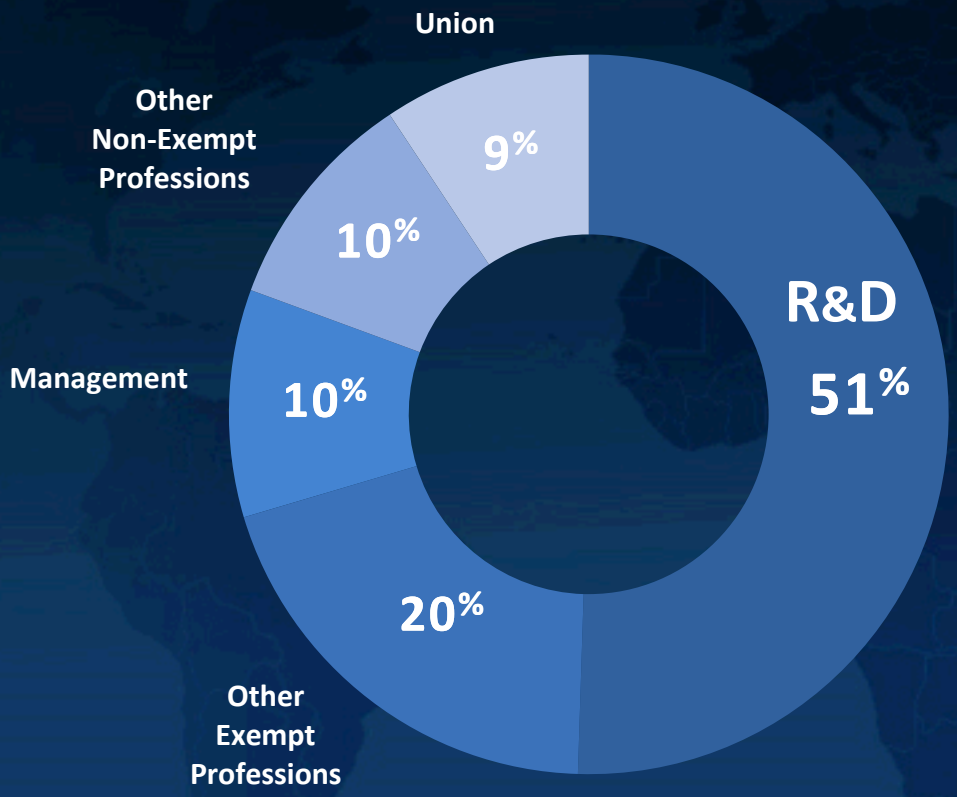
Our Workforce

Regular Employees	Highest Degree
1,728	PhD
3,580	Masters
1,721	Bachelors
8	Doctor of Medicine
31	Doctor of Law

Regular Employees	Years of Service
3,098	Less than 5 years
1,554	5–9 years
2,541	10–19 years
1,652	20–29 years
766	30–39 years
25	40+ years

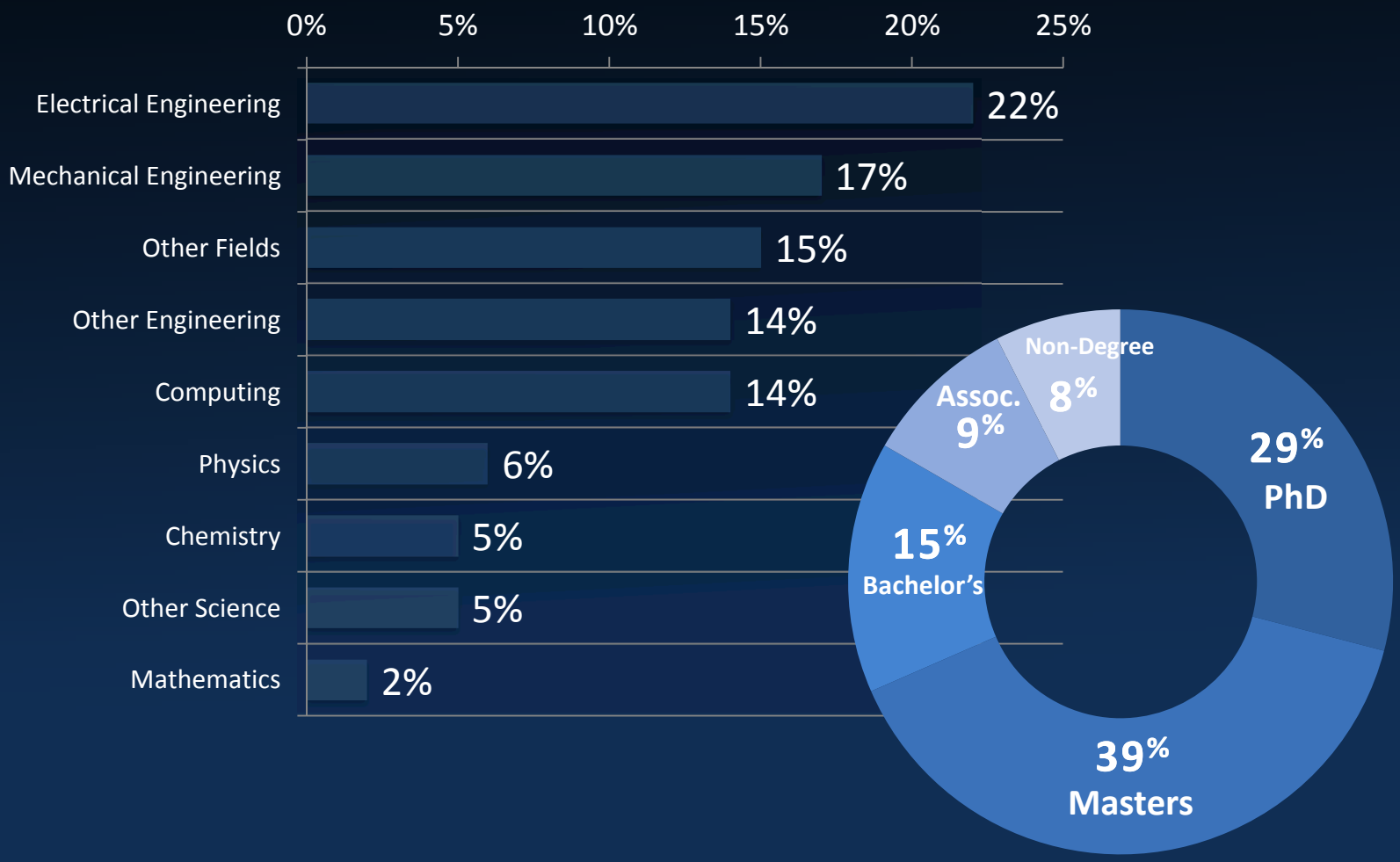
9,633 Regular employees

1,743 Temporary employees and contractor associates



Data as of July 15, 2013

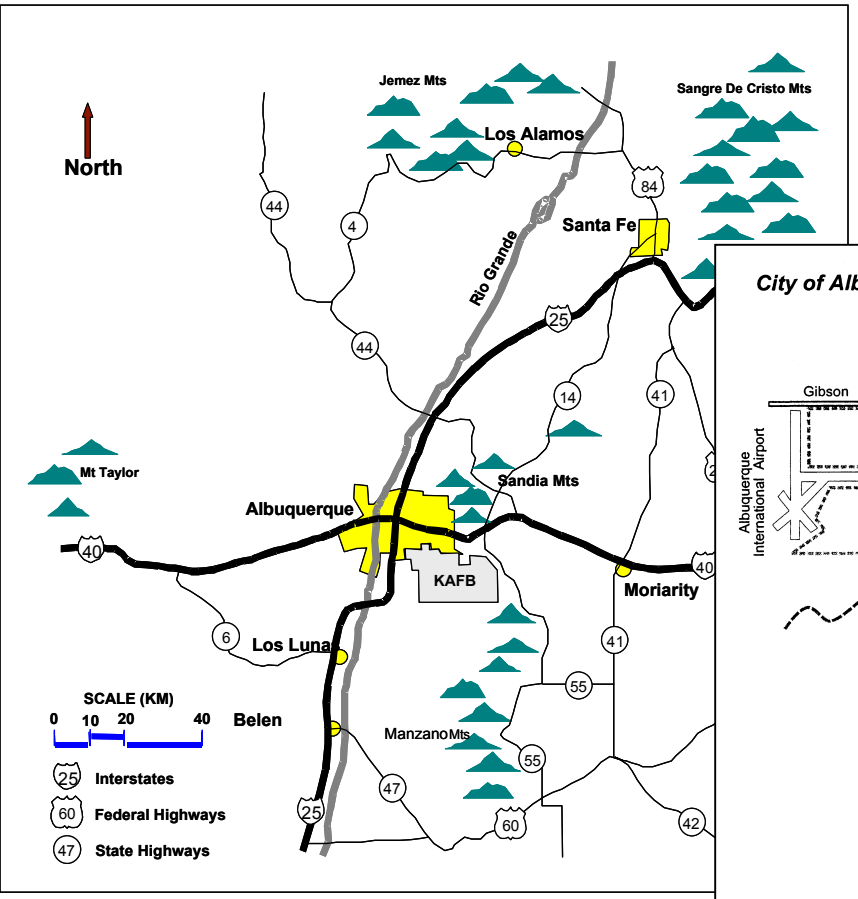
R&D by Discipline & Degree

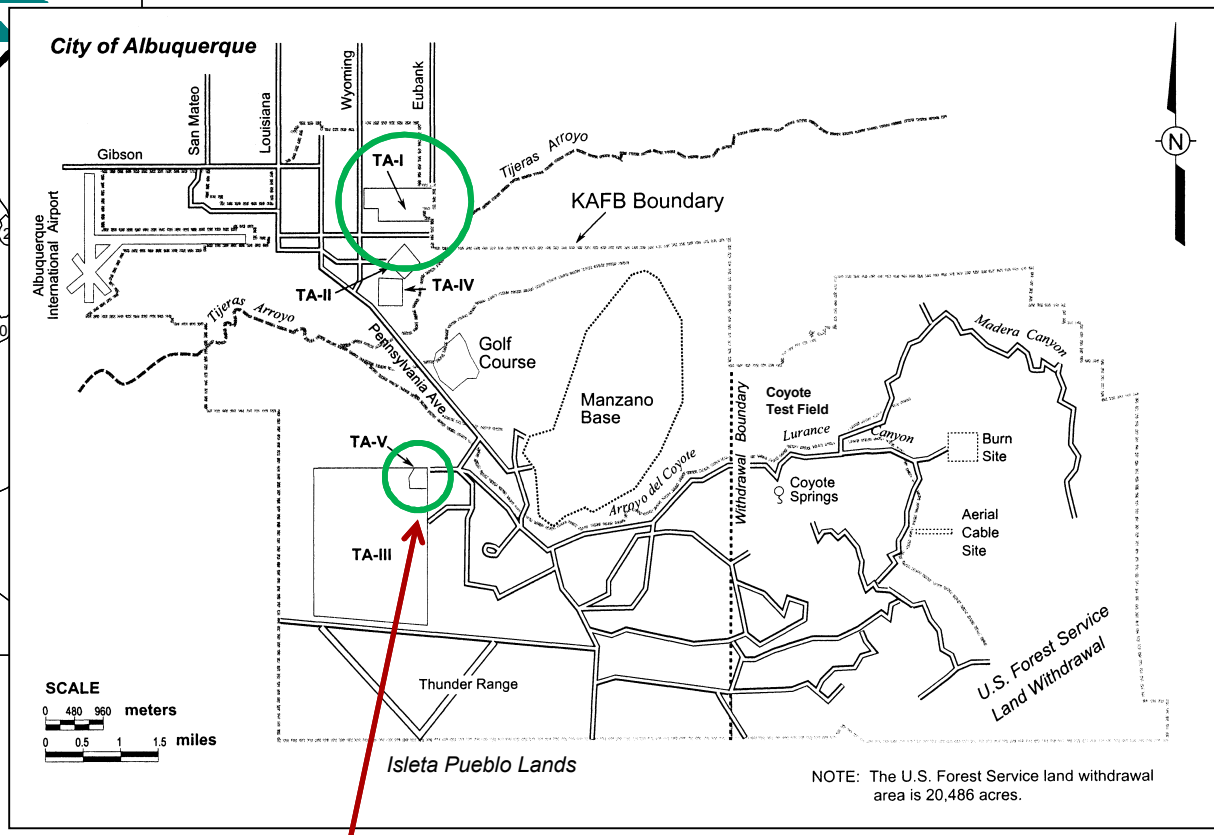


Sandia National Laboratories - ABQ

Sandia National Laboratories

Sandia National Laboratories (SNL) is located on Kirtland AFB in Albuquerque, NM.

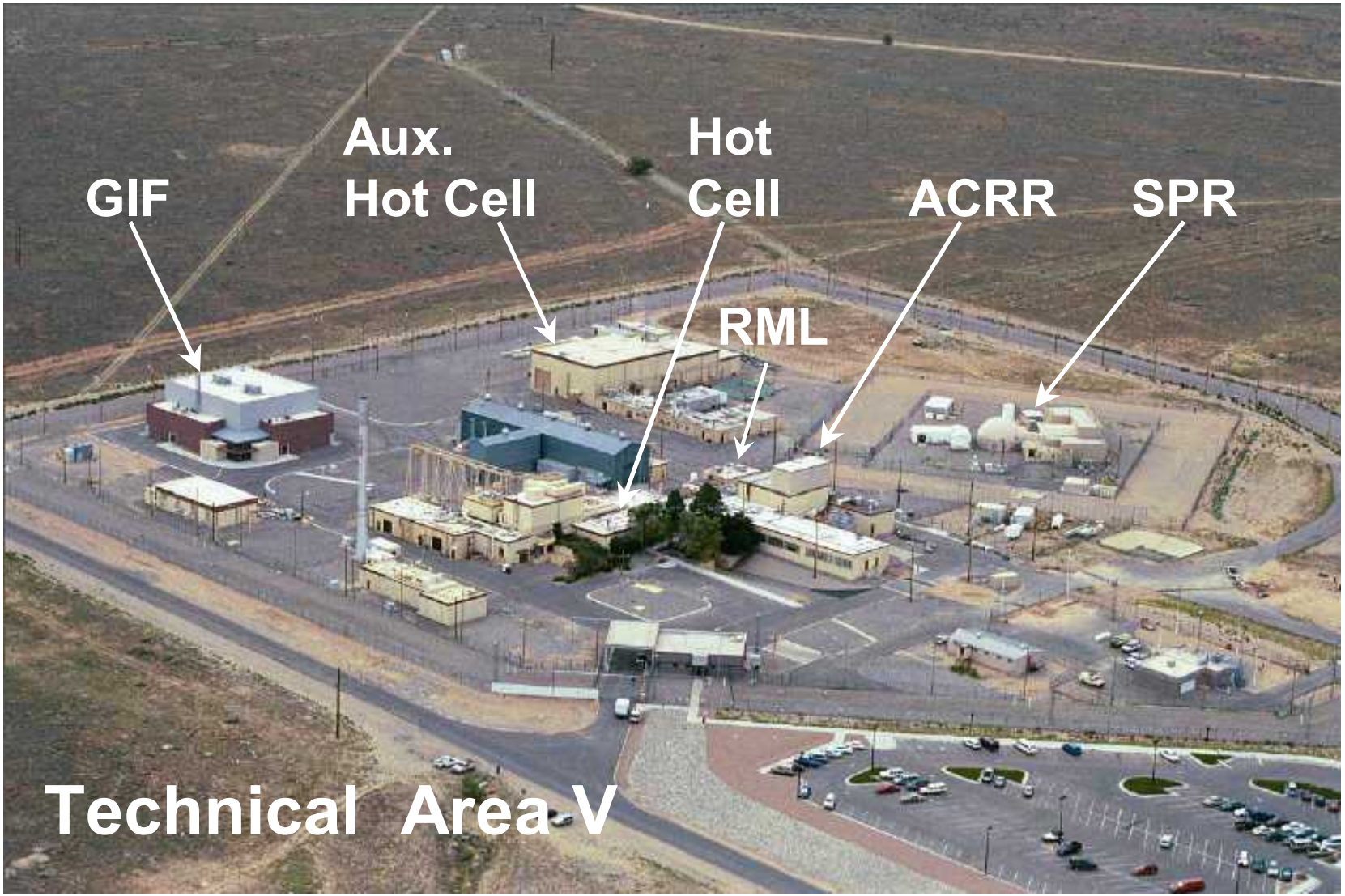




Sandia's nuclear reactor facilities are in Technical Area V - a few miles south of the main research campus.

SNL Tech Area V

Sandia National Laboratories

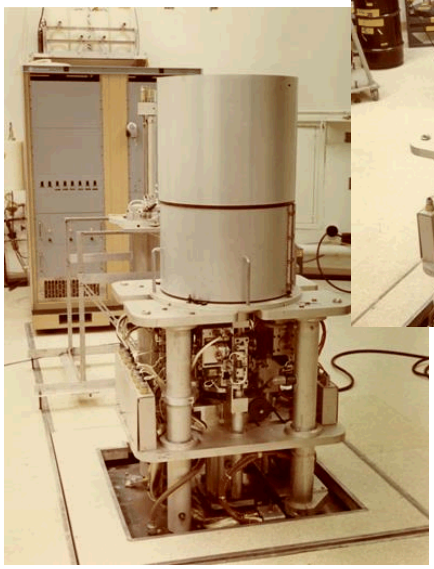


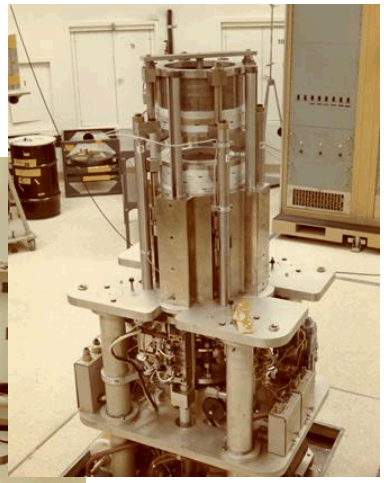
TA-V History

- TAV was constructed in 1959 as part of the Nuclear Airplane Project
  - Sandia Pulse Reactor (SPR-I) – 1961
  - Sandia Pulse Reactor (SPR-II) - 1967
  - Sandia Nuclear Assembly Reactor (SNARE) – 1962
  - Sandia Engineering Reactor (SER) – 1963
  - Annular Core Pulse Reactor (ACPR) 1967

TA-V Recent History

- TAV continued to build on its nuclear reactor success through the ‘70s and ‘80s
  - Sandia Pulse Reactor (SPR-III) - 1976
  - Annular Core Research Reactor (ACRR) – 1978
  - Critical Experiment-Space Nuclear Thermal Power (SNTP-CX) 1989)
  - ACRR-Fueled Ringed External Cavity (FREC-II) – 1988

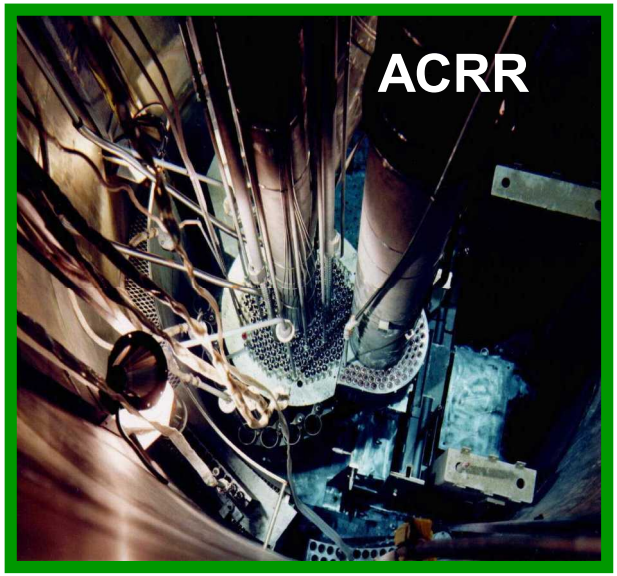




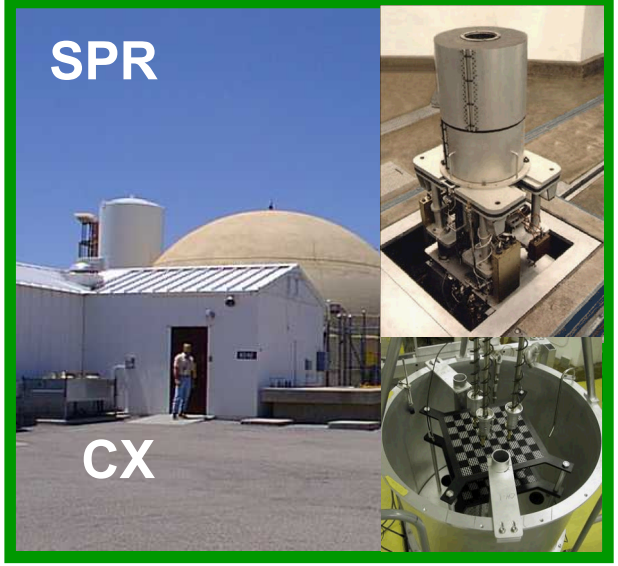
TA-V Facilities Currently Operating

Sandia National Laboratories

Annular Core Research Reactor



Sandia Pulse Reactor and Critical Experiments

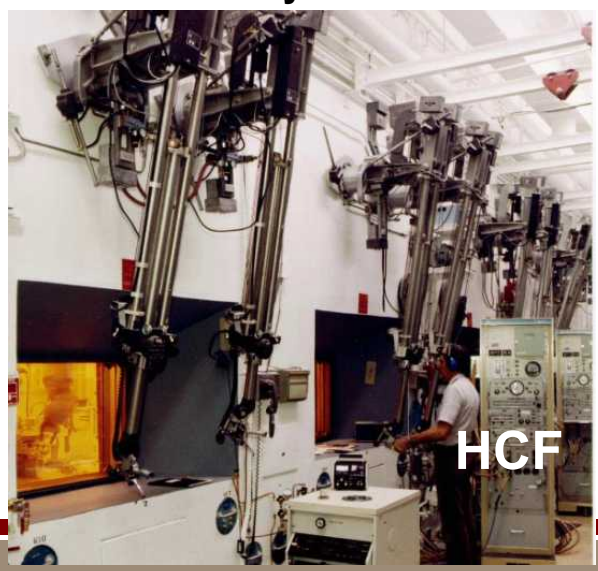


Radiation Metrology Laboratory

Gamma Irradiation Facility

Auxiliary Hot Cell Facility

Hot Cell Facility



Past Experiment Programs at TAV

Sandia National Laboratories

- TAV has been involved in many nuclear experiment programs over the years
  - Weapon Component Testing – Our original and continuing mission
  - Radiation Effects Sciences – New methods base on science discovery
  - Fast Reactor Safety – CRBR, Advanced fuel/cladding testing, equation of state
  - Light Water Reactor Safety – TMI, Severe fuel damage and fission product release from debris beds
  - Nuclear Pumped Laser (FALCON) – Part of Reagan's Star Wars Defense
  - Space Thermal Nuclear Power (SNTP) – Critical experiments, particle fuel testing, element testing using hydrogen
  - Medical Isotope Production (Mo-99, I-125) – Domestic production initiative
  - Space Power (JIMO) – Advance reactors for space power
  - Nuclear Hydrogen Production – Hydrogen as transportation fuel

Current Experiment Programs at TAV

Sandia National Laboratories

- TAV is still relevant – last research reactor standing
  - Weapon Component Testing – Our original and continuing mission
  - Radiation Effects Sciences – New methods base on science discovery
  - Burnup Credit – Critical experiments fission product reactivity effects
  - Criticality Safety – Critical experiments training for the complex
  - Advanced Reactor Concepts – Right Size Reactor Concept (RSR)
  - Advanced Power Generation Cycles – Supercritical CO2 cycle

Mo-99 Supply History

Sandia National Laboratories

1980s – Canada (AECL/MDS Nordion) and a domestic source (Cintichem, Inc. – Tuxedo, NY) supplying Mo-99 to US.

1989 – Cintichem reactor and processing facility shut down due to operational issues. Facilities decommissioned.

Early 1990s – Canada only supplier; some labor relations issues. Congressional action mandates DOE to develop a domestic backup supply.

1991 – DOE purchases the right to the Cintichem process, equipment, and the Drug Master File (DMF) for the production of Mo-99, I-131, Xe-133, and activation isotope I-125.

1991 – DOE identifies Omega West Reactor (OWR) and the CMR at LANL as proposed backup supply facility.

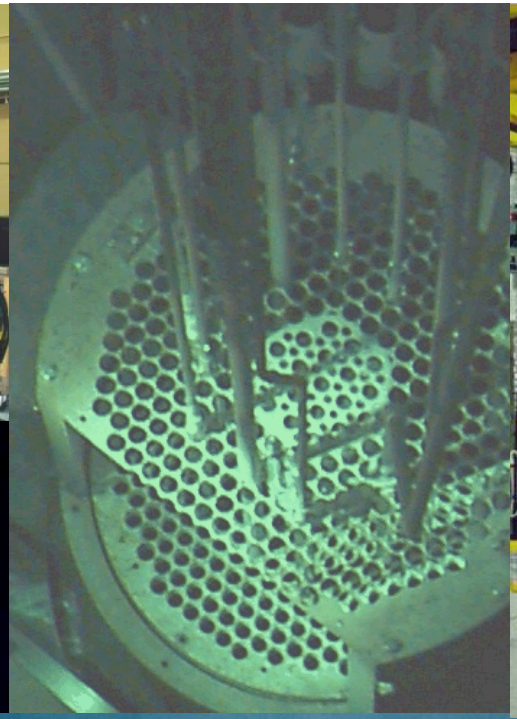
1992 – Leak discovered in OWR primary coolant pipe. Ultimately leads to OWR shutdown.

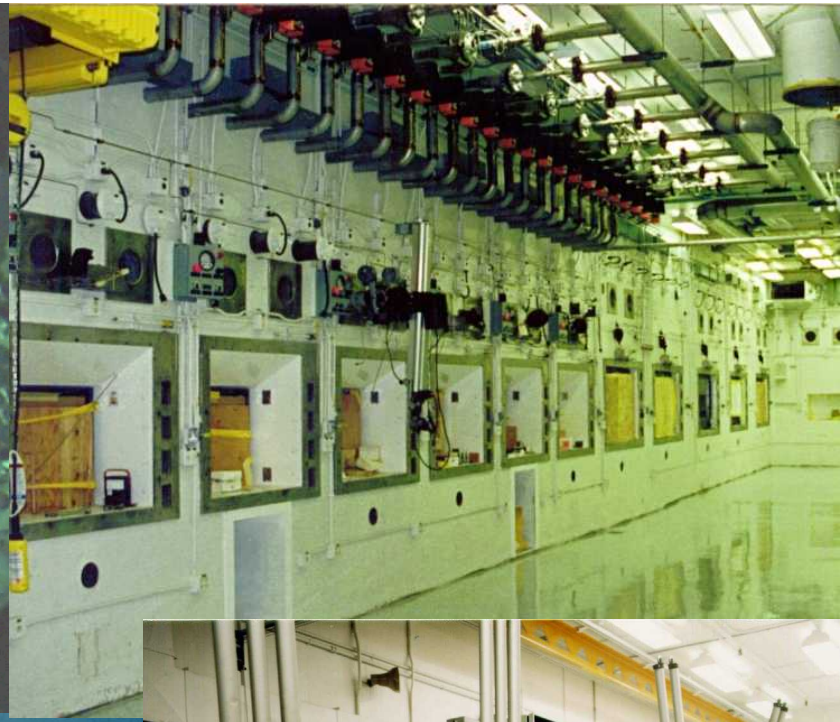
1996 – DOE selects Annular Core Research Reactor (ACRR) and the HCF at SNL to become backup facility. LANL to fabricate targets. EIS prepared and ROD signed.

1998 – Canada (AECL/MDS Nordion) petitions Clinton administration to discontinue development of a US backup supply. Canada is building two new 10 MW reactors (MAPLE 1 & 2) that will adequately supply the world.

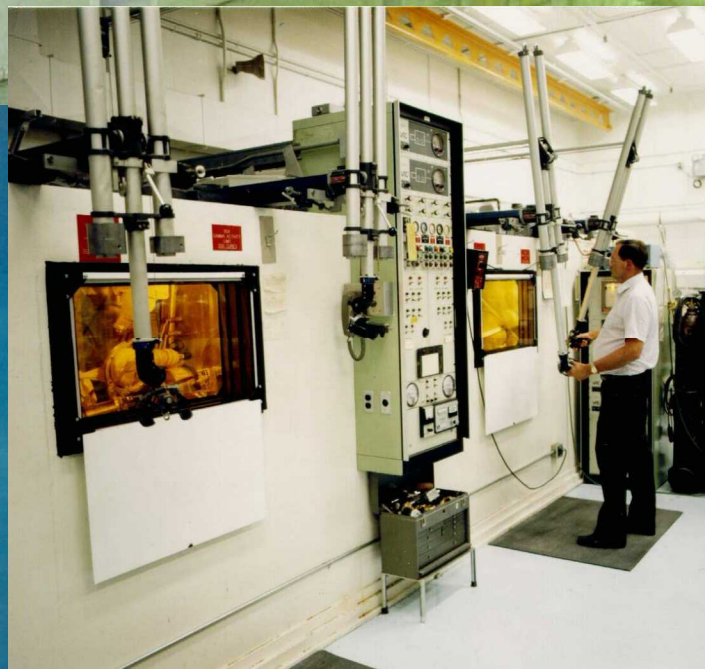
SNL Backup Supply?

Sandia National Laboratories





Sandia and Los Alamos were supposed to provide a backup supply for Mo-99 – *Never Completed*



Mo-99 Supply History (the rest of the story)

Sandia National Laboratories

1998 – SNL/LANL modification efforts cease with ~80% completion of HCF.

Late 1990s – Mallinckrodt invests in european consortium to produce significant quantities of Mo-99.

Early and Mid 2000s – Canada (NRU reactor) and european consortium providing virtually the world's supply. No major interruptions occur.

2008 – AECL cancels the MAPLE reactors after a investing ~$500M over a 12 year period. Major problem is a positive reactivity feedback coefficient at power.

2009 – NRU develops problems including a leak in its heavy water tank. HFR also develops a leak in its primary coolant piping.

2009 – US congress proposes The Medical Isotope Production Act to establish a domestic supply of Mo-99 using LEU.

Current – Several companies are promoting various concepts for Mo-99 production. All of them will fail because they are technically flawed and/or are not economically viable.

The US finds itself in the same situation it was in during the 1990s.

We are relying on foreign sources for a critical medical radioisotope without enough backup suppliers.

Backup

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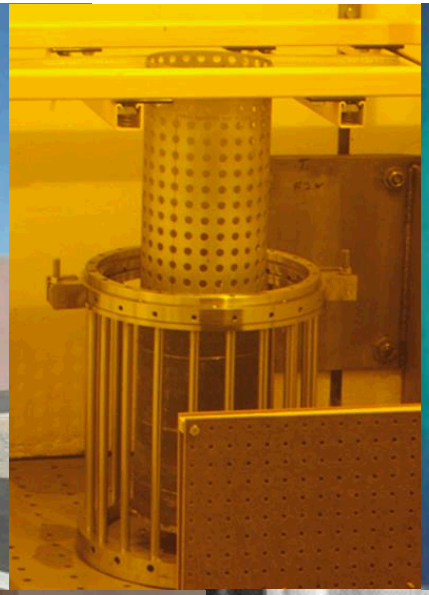
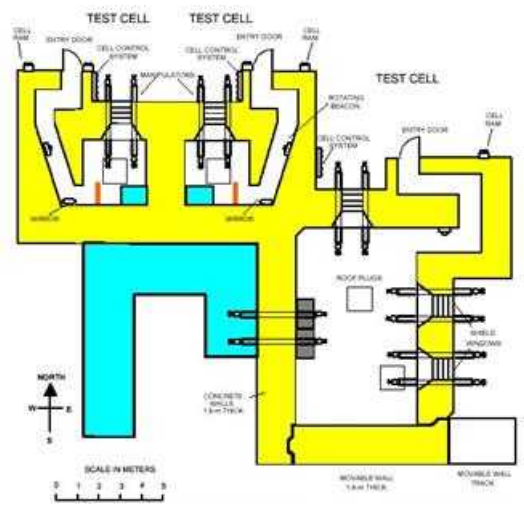
Sandia Critical Experiments

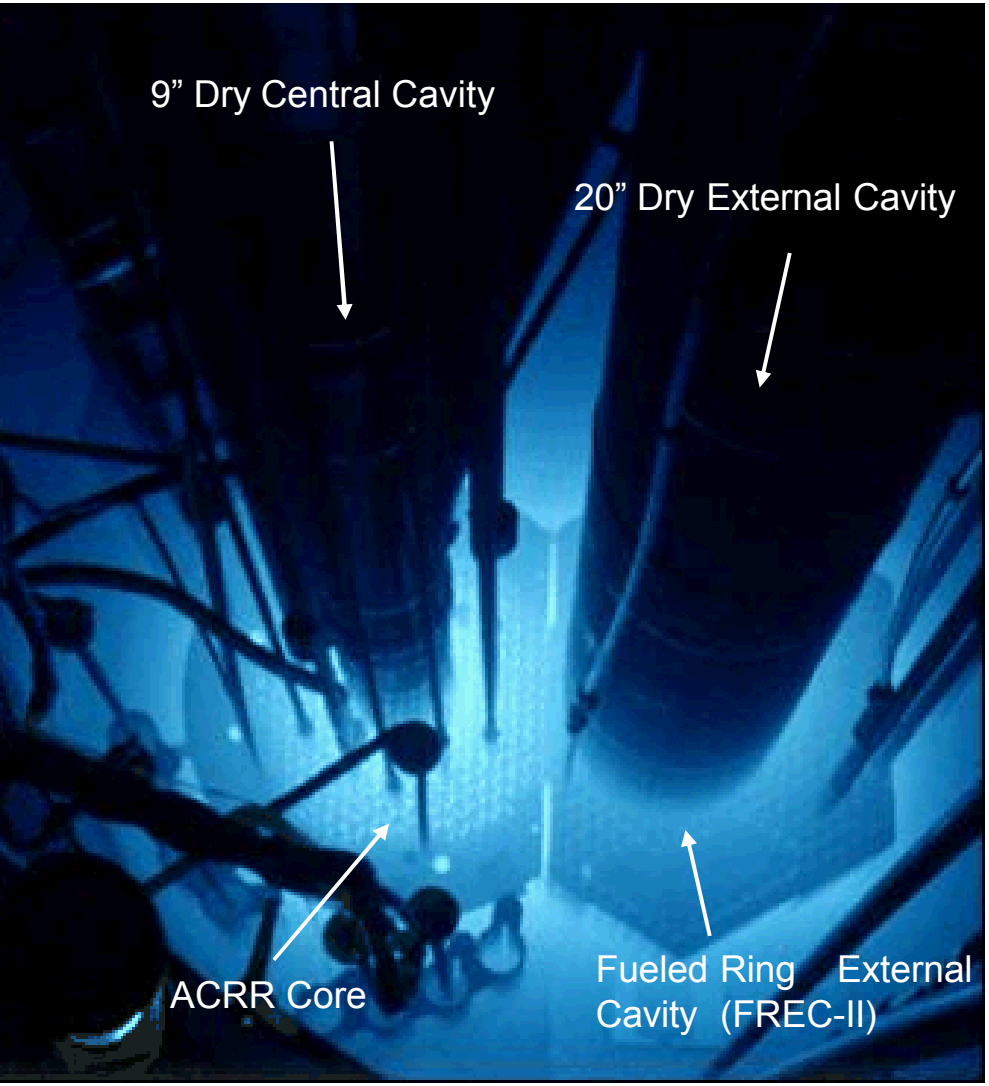
Sandia National Laboratories

GIF Description





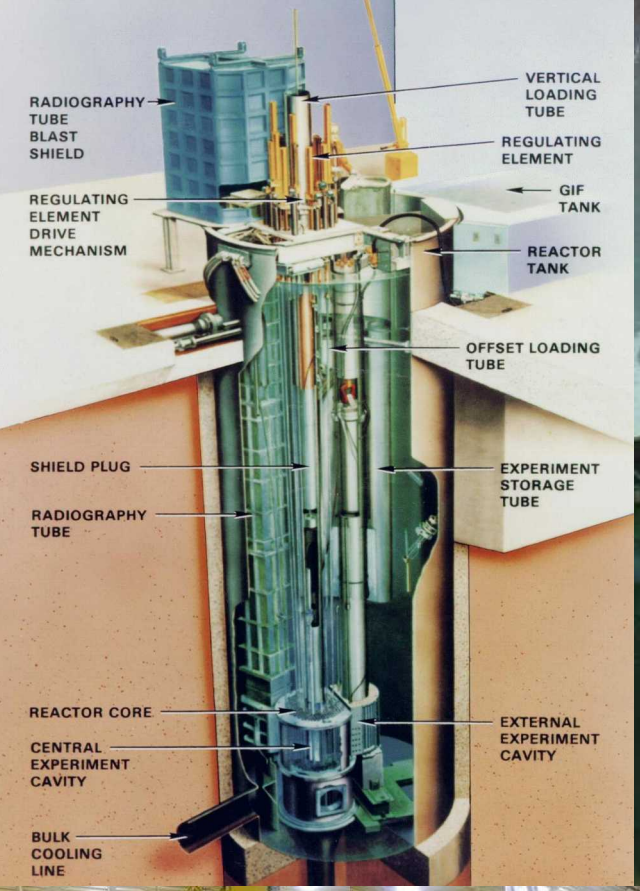
ACRR Description

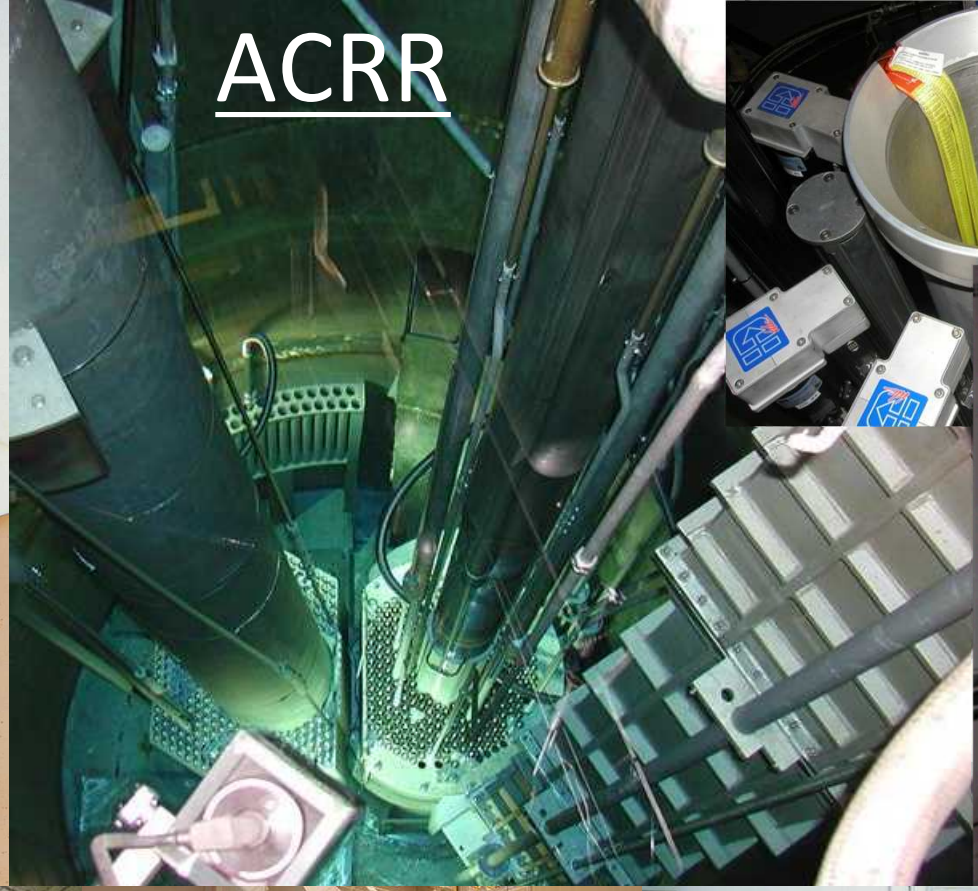


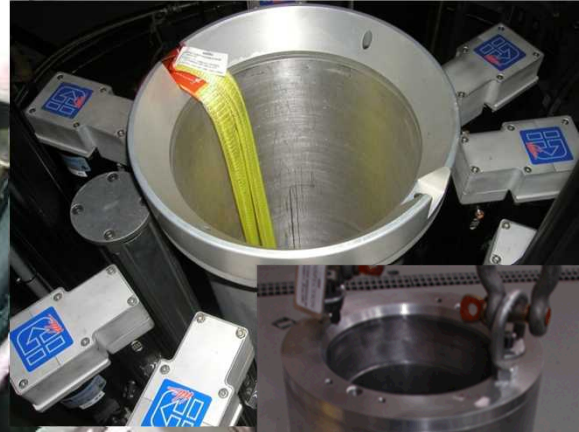
ACRR and FREC-II

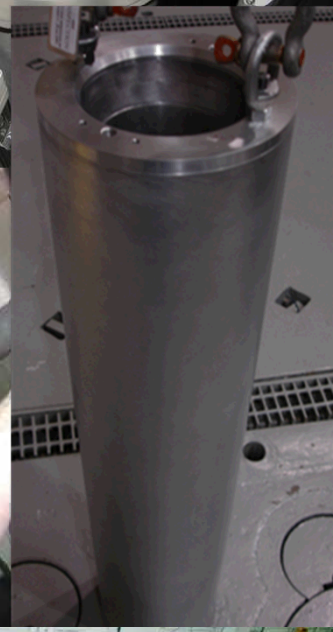
- 236 UO_2-BeO fueled elements
  - 1.5 in (3.8 cm) dia. x 20 in (51 cm)
  - 100 g U-235 per element – 35% enr.
- Operating Power level
  - MW_{th} Steady State Mode
  - 250 MJ Pulse Mode (6 ms FWHM)
  - 300 MJ Transient Mode (Programmable)
- Dry cavity 9 in (23 cm) diameter
  - Extends full length of pool through core
  - Neutron Flux 4E13 n/cm^2-s at 2 MW
  - 65% > 1 eV, 56% > 10 keV, 45% > 100 keV
- Epithermal Spectrum
  - Flux in cavity can be tailored for desired energy spectrum (Poly, B4C)
- Open-pool type reactor
  - Fuel elements cooled by natural convection
  - Pool cooled by HX and cooling tower
- FREC-II uses previous ACPR fuel
  - TRIGA type (UZrH) – 20 in (51 cm) dia. dry cavity
- Fuel burnup is minimal
- Reactor used for short duration power runs, pulses, and transients

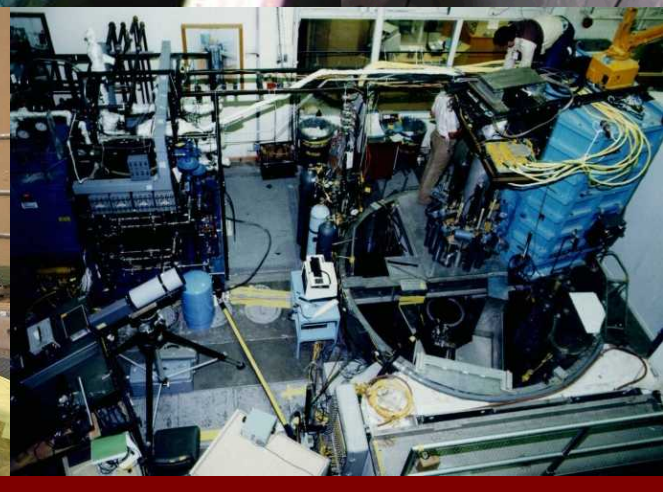
ACRR


RADIOGRAPHY TUBE BLAST SHIELD
VERTICAL LOADING TUBE
REGULATING ELEMENT
GIF TANK
REGULATING ELEMENT DRIVE MECHANISM
REACTOR TANK
OFFSET LOADING TUBE
SHIELD PLUG
EXPERIMENT STORAGE TUBE
RADIOGRAPHY TUBE
REACTOR CORE
EXTERNAL EXPERIMENT CAVITY
CENTRAL EXPERIMENT CAVITY
BULK COOLING LINE









Future Experiment Opportunities

- Future Generation Reactors
  - Advanced Fuel Performance Transient Testing
    - Phenomenology and Model Validation
    - Safety Margins
  - Advanced Power Cycles
  - Advanced Reactor Design Concepts
  - Hydrogen Production
- Critical Experiments
- Small Reactor Technology
  - NASA Missions
    - Nuclear Propulsion
    - Space Power
  - Commercial Space Propulsion
    - Space Tug
  - Medical Isotope Production
    - Target Reactor Concept