

# Oak Ridge National Laboratory: Research and Development Capabilities

Presented at  
**Mo-99 Topical Meeting**  
Montreal, Quebec

**Chris Bryan**  
Research Reactors Division  
Oak Ridge National Laboratory

September 12, 2017

ORNL is managed by UT-Battelle  
for the US Department of Energy

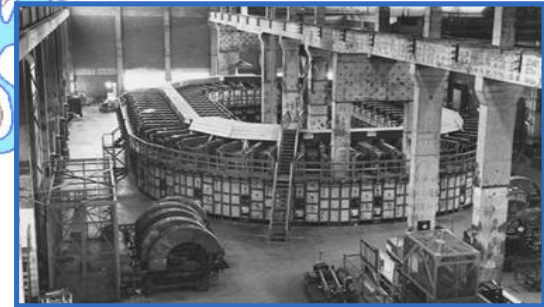
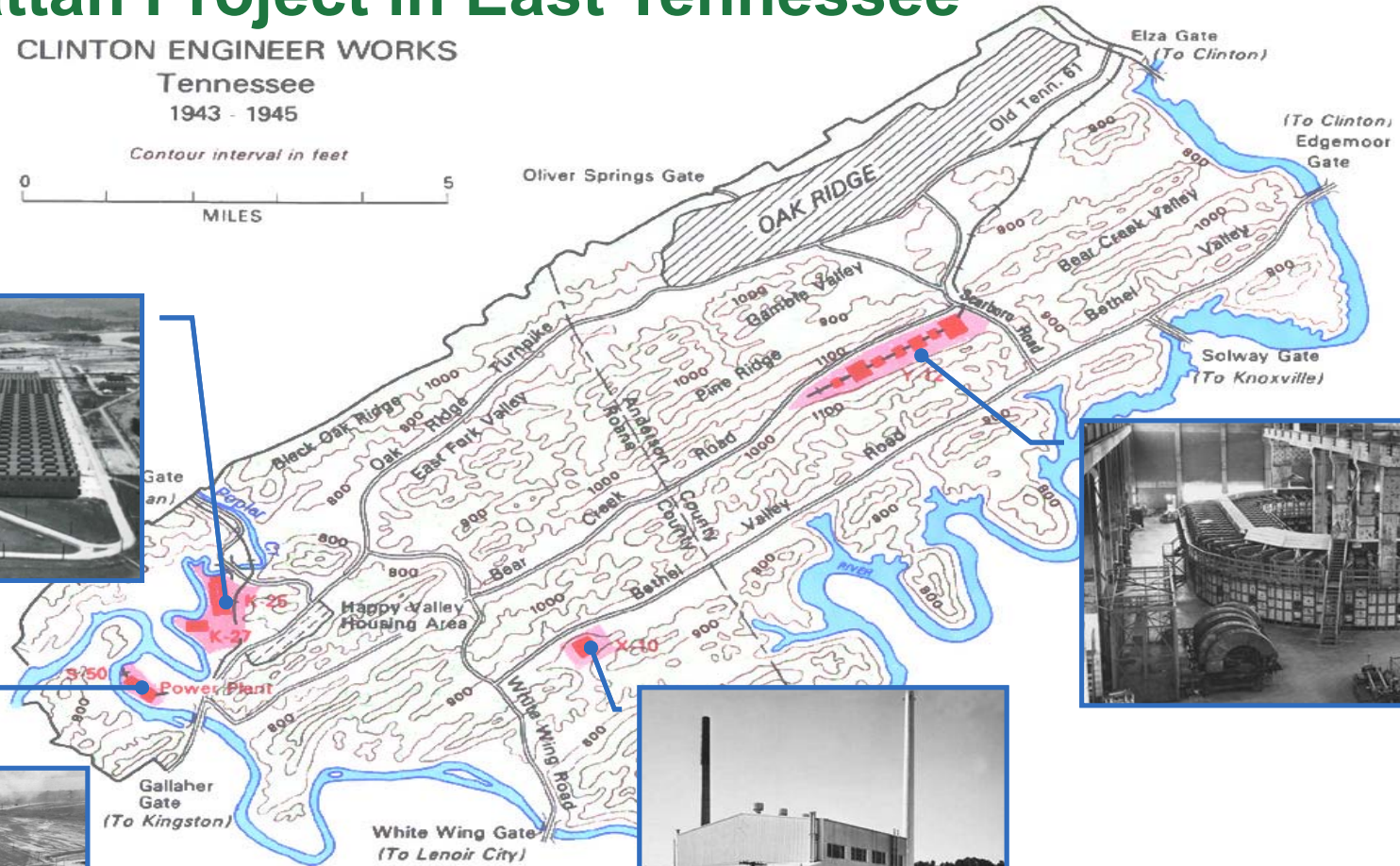


 **OAK RIDGE**  
National Laboratory

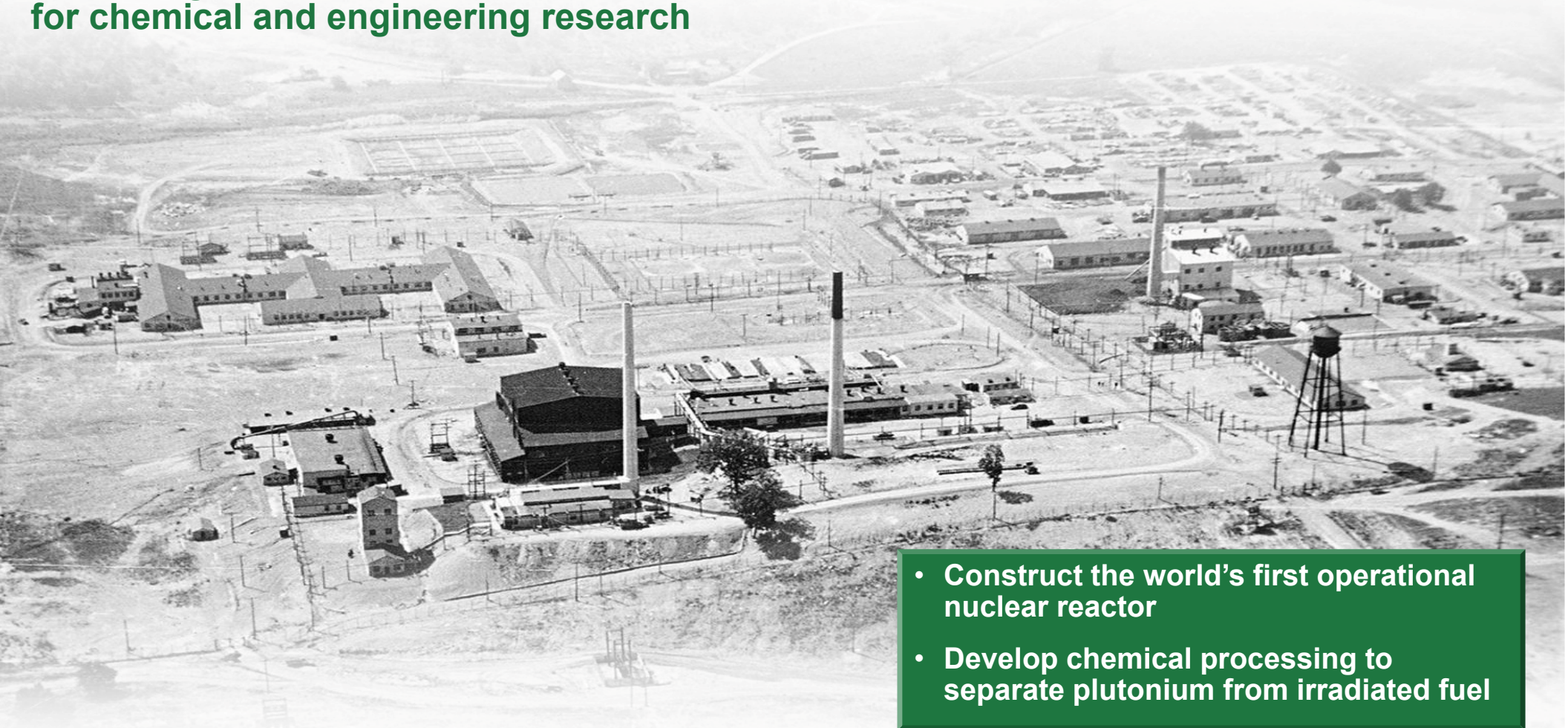
# The Manhattan Project in East Tennessee

CLINTON ENGINEER WORKS  
Tennessee  
1943 - 1945

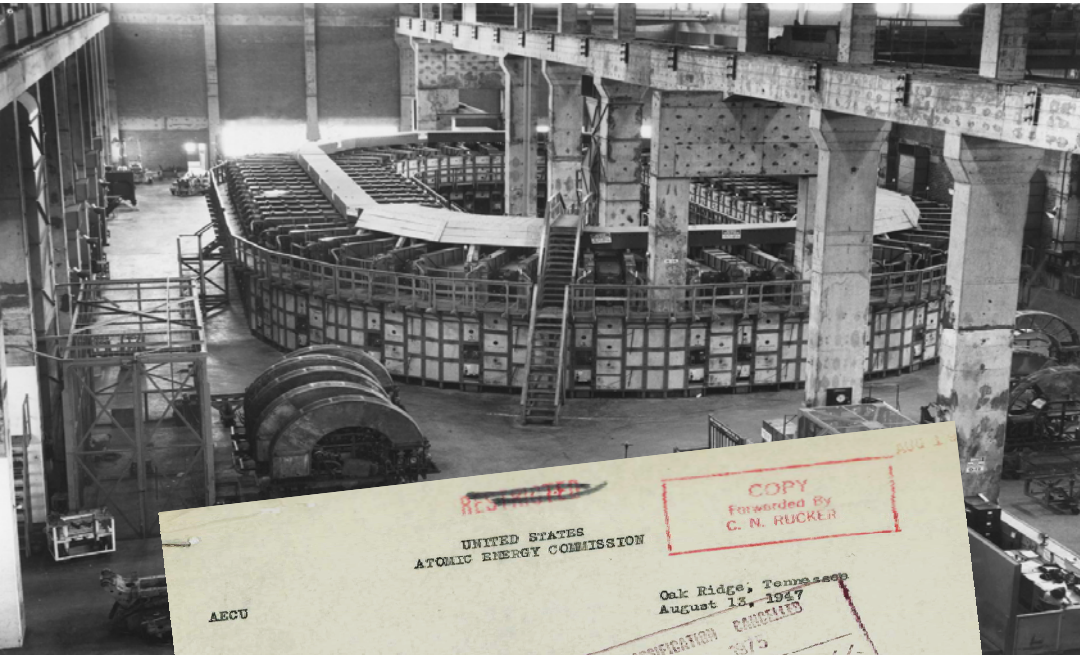
Contour interval in feet



## **Mission of Clinton Laboratories, 1943:** **Produce gram quantities of plutonium** **for chemical and engineering research**



- **Construct the world's first operational nuclear reactor**
- **Develop chemical processing to separate plutonium from irradiated fuel**



## Isotope production, enrichment and distribution began at Oak Ridge just after WWII

~~RESTRICTED~~

UNITED STATES  
ATOMIC ENERGY COMMISSION

COPY  
Forwarded By  
C. N. RUCKER

AECU

Oak Ridge, Tennessee  
August 13, 1947

Carbide and Carbon Chemicals Corporation  
Post Office Box P  
Oak Ridge, Tennessee  
Attention: Mr. C. E. Center

CLASSIFICATION **DECLASSIFIED**  
DATE **MAY 1 1975**  
*H. J. Muller*

DECLASSIFICATION OFFICER  
Mr. Edward Tamm  
AGREEMENT NO. 700-71

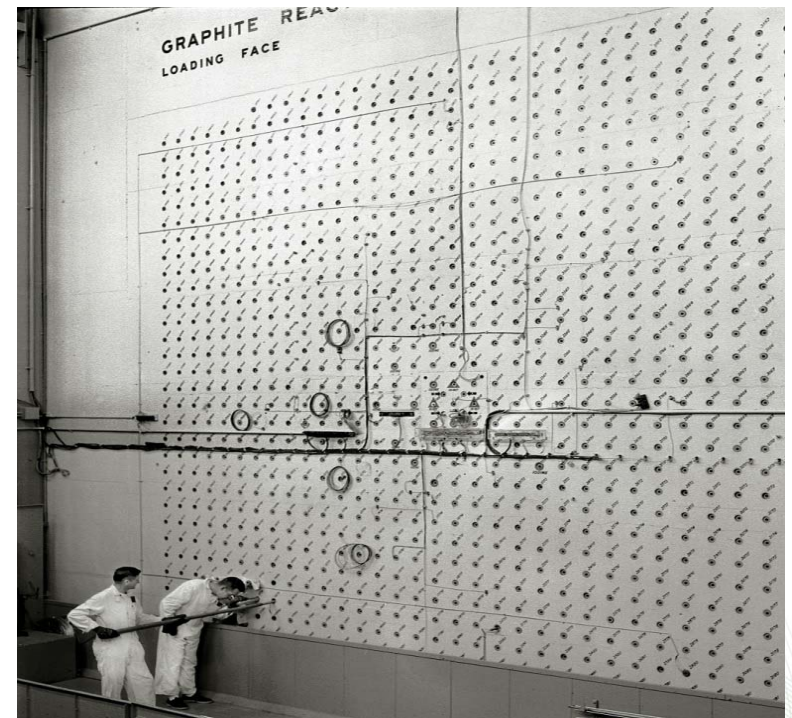
Gentlemen:

Subject: STABLE ISOTOPES FOR "OFF-PROJECT CUSTOMERS"

The Atomic Energy Commission is undertaking the formulation of a policy and program to make available and to distribute stable isotopes to qualified establishments beyond the limits of AEC projects and installations. The program will also include a survey of the potential market for stable isotopes.

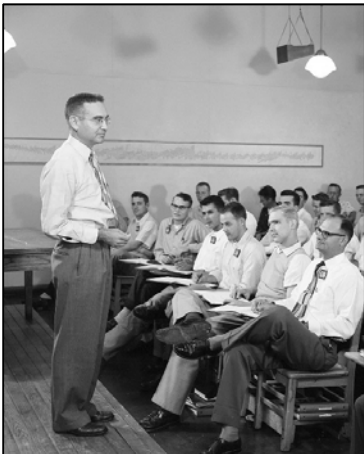
As discussed with Mr. Rucker in a recent conference on this matter, an arrangement similar to that effected with Monsanto Chemical Company for the distribution of radio isotopes would be considered very desirable and effective. Accordingly, the following outlined plan is offered for your consideration and comments:

- a. All requests for stable isotopes will be addressed to the Isotopes Branch, AEC. This branch will screen these requests and make determinations of approval or allocations between requesting agencies. Questions of availability, specifications, etc. will be coordinated between AEC and Carbide.
- b. Approved requests will be transmitted by the Isotopes Branch through the Contracting Officer to Carbide, Y-12.
- c. Upon receipt of an approved request, the properly authorized person in Carbide would then contact the requesting agency to consummate details to effect the shipment.



# ORNL grew into a leading nuclear science laboratory

Trained nuclear engineers at the Oak Ridge School of Reactor Technology



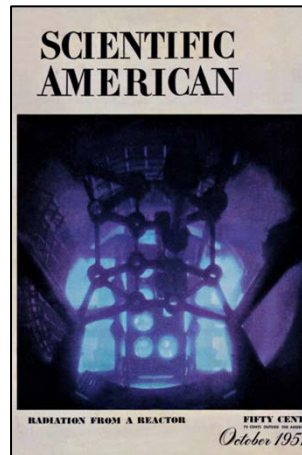
ORSORT established by Alvin Weinberg and Hyman Rickover, 1950

Contributed to the design of naval nuclear propulsion systems



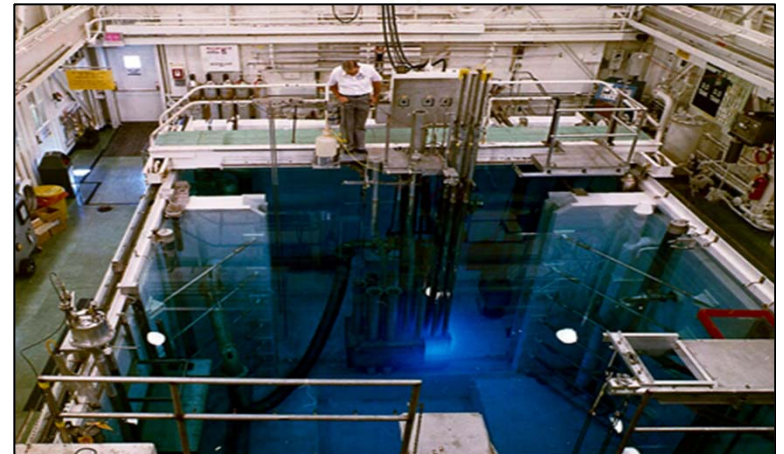
ORNL's Geneva reactor exhibited at UN conference on the Peaceful Uses of Atomic Energy, 1955

Examined the safety, environmental, and waste disposal challenges of nuclear energy



ORNL's Low Intensity Test Reactor—First visible Cerenkov glow, 1950

Designed, built, and operated 13 experimental reactors



ORNL's Bulk Shielding Reactor, 1950–1991

Developed techniques for nuclear fuel reprocessing

# Today, ORNL is DOE's largest science and energy laboratory

\$1.5B budget

4,700 employees

\$750M modernization investment

Nation's largest materials research portfolio

3,200 research guests annually

Nation's most diverse energy portfolio

Forefront scientific computing facilities

World's most intense neutron source

World-class research reactor

1,853 journal articles published in CY15

Managing major DOE projects US ITER, exascale computing

198 invention disclosures in FY15

66 patents issued in FY15

# ORNL's mission

Deliver scientific discoveries and technical breakthroughs that will accelerate the development and deployment of solutions in clean energy and global security, and in doing so create economic opportunity for the nation



## Signature strengths

Computational science and engineering

Materials science and engineering

Neutron science and technology

Nuclear science and technology

# ORNL's unique facilities attract thousands of researchers each year

Spallation  
Neutron Source

Center for  
Nanophase  
Materials Sciences



Manufacturing  
Demonstration Facility



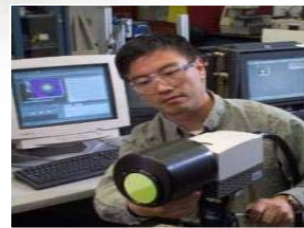
Building Technologies  
Research and  
Integration Center



Oak Ridge Leadership  
Computing  
Facility



High Flux  
Isotope  
Reactor



High  
Temperature  
Materials Laboratory



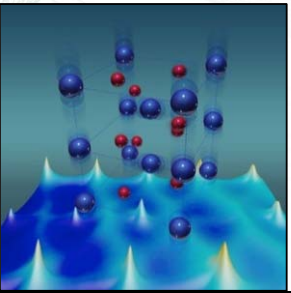
National Transportation  
Research  
Center



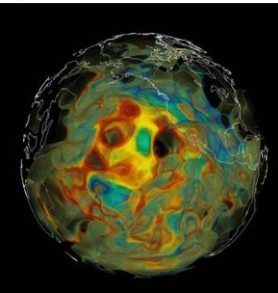
BioEnergy  
Science  
Center



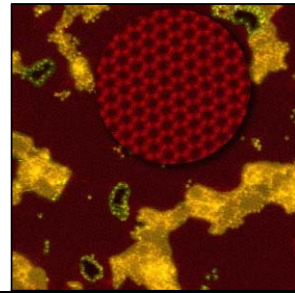
# We focus our resources on compelling science and technology challenges



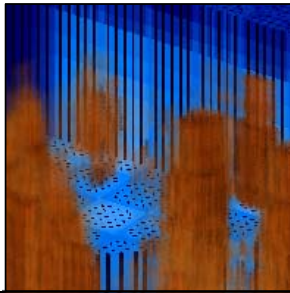
Advance the science and impact of neutrons



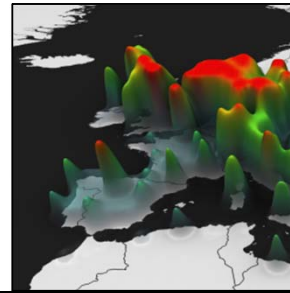
Scale computing and data analytics to exascale and beyond for science and energy



Accelerate the discovery and design of new materials for energy



Advance the scientific basis for nuclear technologies and systems: Fission, fusion, and isotopes



Advance understanding of complexity in biological and environmental systems



Discover and develop sustainable and secure integrated energy systems



Deliver science and technology to address complex security challenges

## Deliver transformative impacts regionally, nationally and internationally

- Accelerate deployment of DOE intellectual property
- Expand strategic engagement with industry and universities

# ORNL's nuclear programs are anchored by multi-billion dollar investment in facilities and infrastructure



High Flux Isotope Reactor

Radiochemical Engineering Development Center

Irradiated Fuels Examination Laboratory

Irradiated Materials Examination and Testing Laboratory



Low Activation Materials Design and Analysis Laboratory

Radiochemistry Laboratory and Experimental Engineering Buildings

Proto-MPEX



Enriched Stable Isotope Production Facility

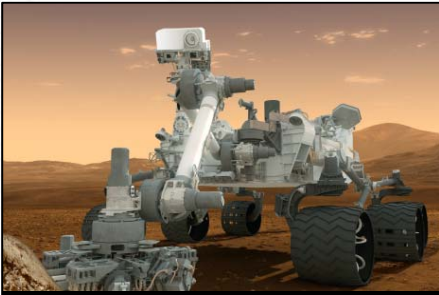


Ultra-trace Forensic Science Center

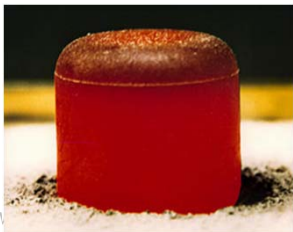


# Enabling strategic isotope production and R&D

## Plutonium-238



- Radioisotope power systems for 26 space missions
- Leading project to reestablish US production capability



## Californium-252



- Supplying ~67% of  $^{252}\text{Cf}$  worldwide
- Applications
  - Oil well logging
  - On-line coal quality analysis
  - Cancer treatment
  - Nuclear reactor start-up sources
  - Nuclear fuel rod examination
  - Homeland security

## Industrial and medical applications

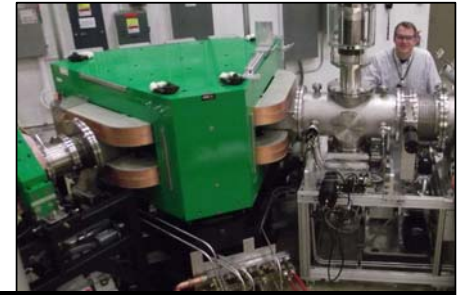


- Developing radioisotopes for diagnostics and therapy
  - C-14
  - Ni-63
  - Se-75
  - W-188
  - Pb-212
  - Ac-225
  - Ac-227
  - U-234



Ac-225

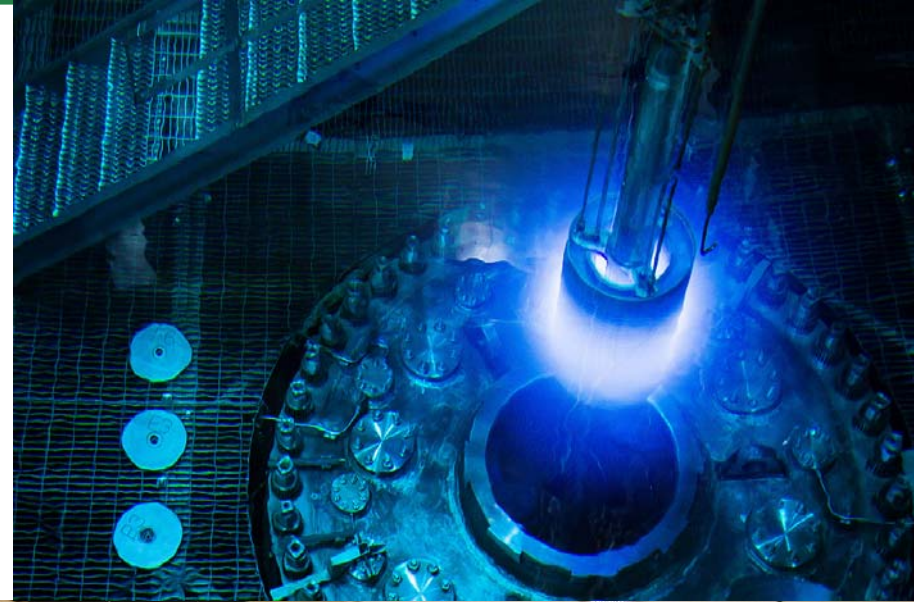
## Stable isotope production tools



- Compact electromagnetic isotope separation device
- Enriched stable isotope pilot project

# High Flux Isotope Reactor (HFIR)

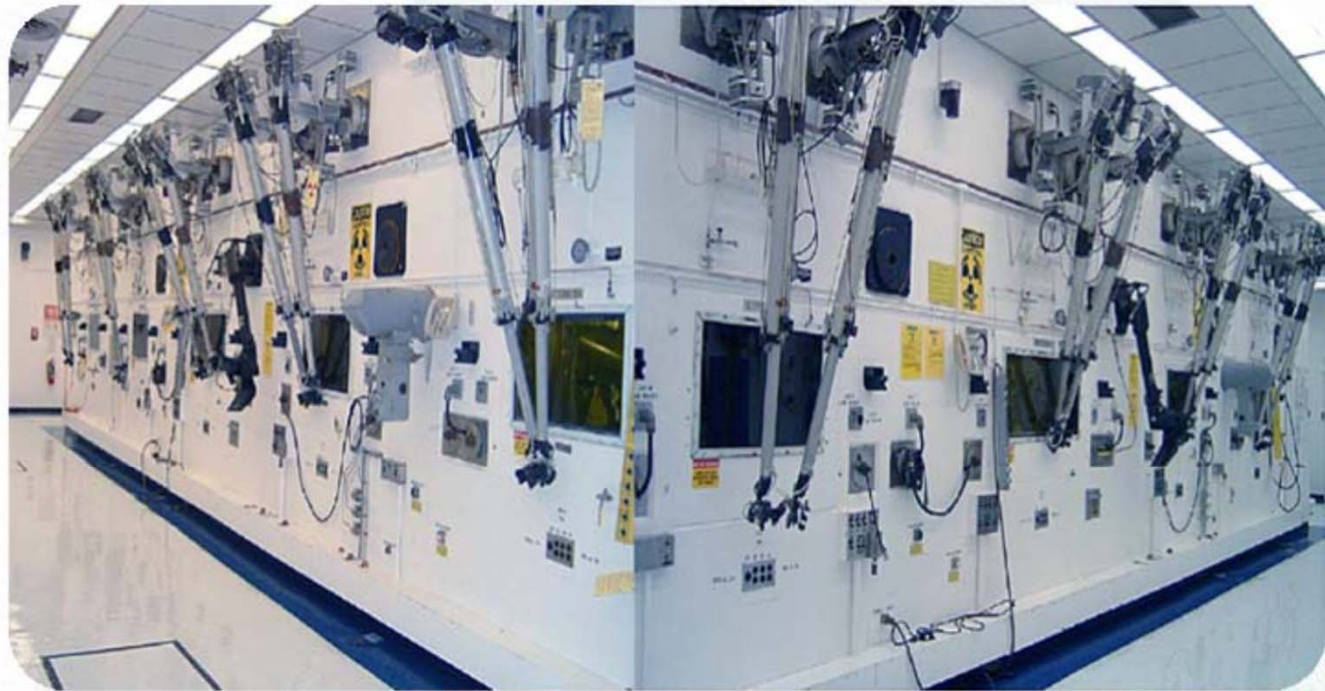
- Primary mission of neutron scattering (funded by DOE- Office of Science, Basic Energy Sciences)
- Isotope production
- Accelerated neutron damage testing of materials
- Nuclear forensics



# Irradiation Fuels Examination Laboratory (IFEL)

## Description

The Irradiated Fuels Examination Laboratory (IFEL), located in Building 3525, was initially designed and constructed in 1963 to permit the safe handling of increasing levels of radiation in the chemical, physical, and metallurgical examination of nuclear reactor fuel elements and reactor parts. The IFEL is classified as a Category 2 nuclear facility.



# Irradiated Materials Examination Testing Facility (IMET)

- Various materials testing equipment (mechanical/thermal)
- In-cell Scanning electron microscope
- Capsule opening and sorting equipment
- Small samples can be sent to Low Activation laboratory for further processing in a low-activation environment.



Six hot cell faces in the IMET

# ORNL has supported multiple Mo-99 cooperative agreement projects

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GE Hitachi Nuclear Energy to develop neutron capture technology (GEH placed the project on-hold)

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NorthStar Medical Radioisotopes to develop accelerator target and production process

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SHINE Medical to develop accelerator technology with LEU fission



# ORNL Support for GE-Hitachi n-gamma Production Power Reactors



HITACHI

- Irradiation and shipping of mo-99 samples for chemical testing
- Impurities analysis of molybdenum target metal
- Oxidation/sublimation testing and mitigation using specialized coating techniques



Irradiation target



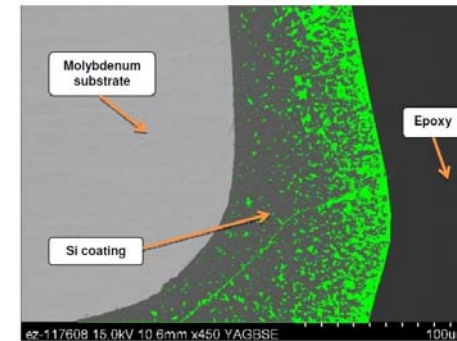
Shipping to Valecetos



No treatment (12.7 mm diameter ball)



Air, 800°C, 5 hrs

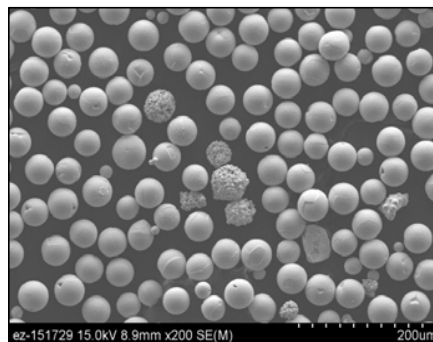
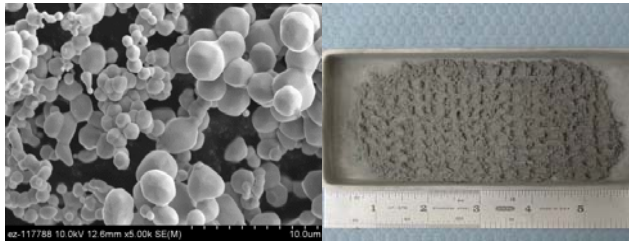


Porosity measurement of coating based on contrast. Porosity = 27%



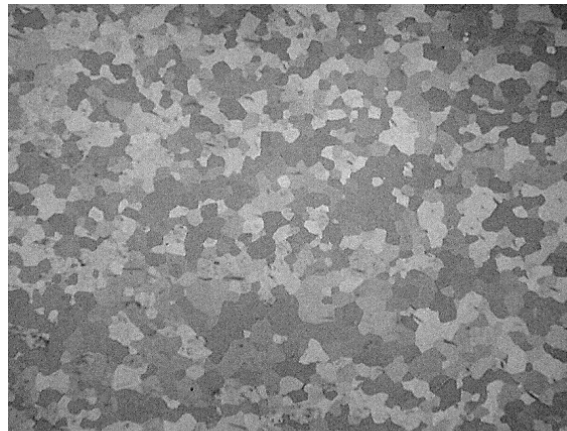
# ORNL supports NorthStar, investigating optimal accelerator disk production techniques including additive manufacturing

- Powder-based processes for pressing/sintering accelerator disk target production
- Powder production methods optimized for each target fabrication method
- Additive manufactured targets (3D printed) offers more customized designs for optimized production and target cooling

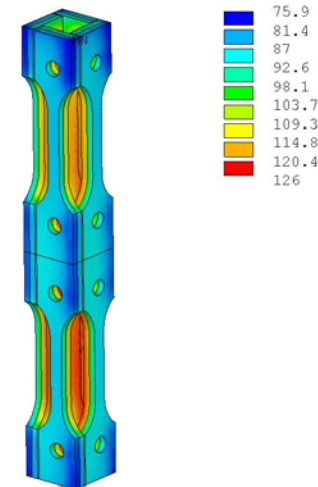


# ORNL supports SHINE with materials research for the target solution vessel and support pipes

- Zircaloy-based vessel material with low-temperature application (no data for zirc at low temperatures)
- Need to fully document irradiated/hydrided material characteristics pre- and post-irradiation to satisfy NRC
- Laboratory corrosion testing of candidate materials
- Irradiation testing of candidate materials



13-0575-08 Zircaloy - 4 As Received Side B - Pol Light 200X 20µm



# Questions?

