

# Oak Ridge National Laboratory: Science for the Energy Challenge

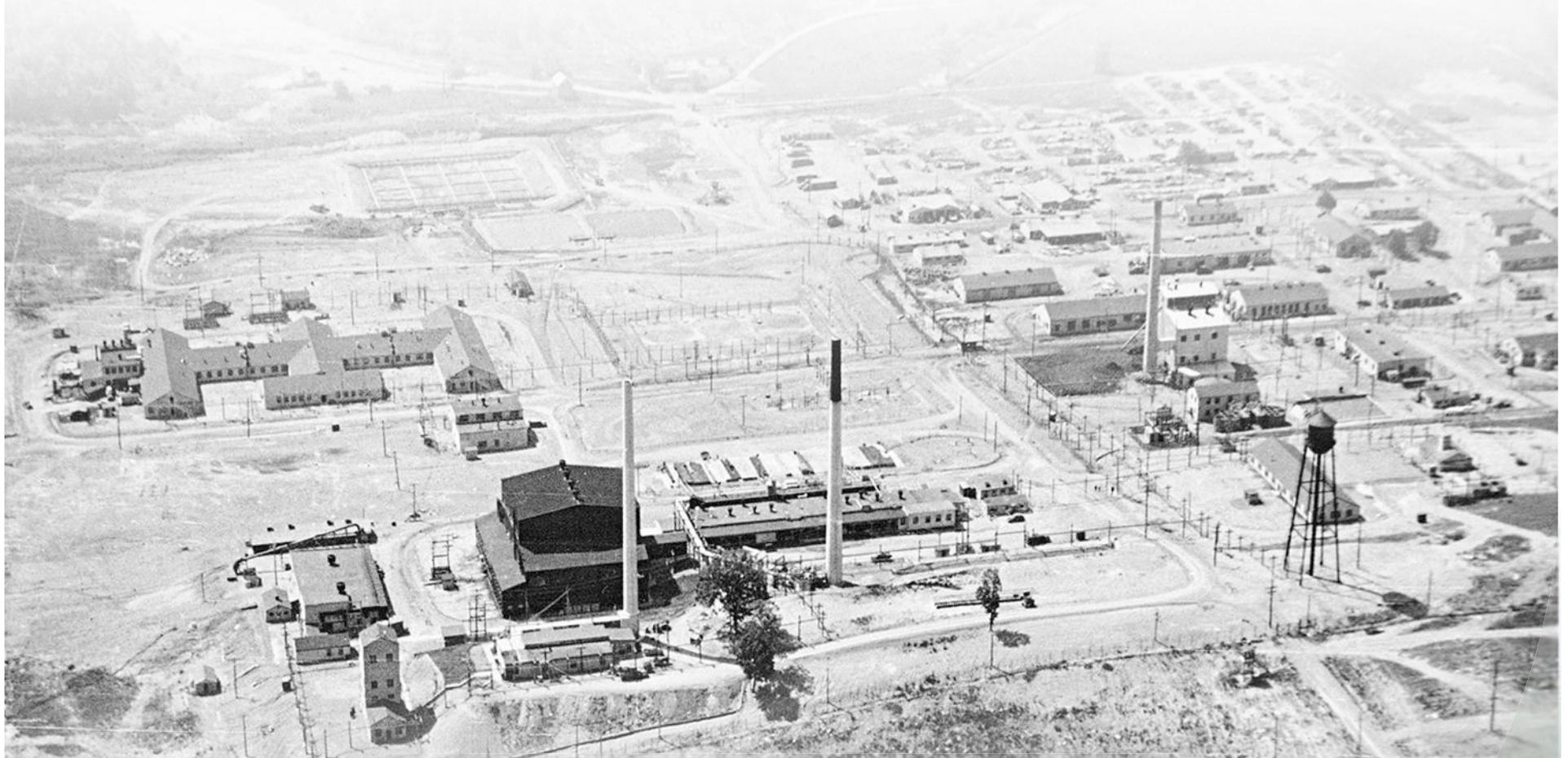


**Presented to**  
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Review and Workshop

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Science and Technology**

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# Oak Ridge National Laboratory evolved from the Manhattan Project



**ORNL in 1943**  
**The Clinton Pile was the world's first**  
**continuously operated nuclear reactor**

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



- **\$1.3B budget**
- **4,275 employees**
- **3,900 research guests annually**
- **\$350 million invested in modernization**
- **World-leading systems for open scientific computing**
- **Nation's largest concentration of open source materials research**
- **Nation's most diverse energy portfolio**
- **Operating the world's most intense pulsed neutron source**
- **Managing the billion-dollar U.S. ITER project**

# Energy is the defining challenge of our time

- **The major driver for:**
  - Climate change
  - National security
  - Economic competitiveness
  - Quality of life
- **Incremental changes to existing technologies cannot meet this challenge**
  - Transformational advances in energy technologies are needed

# ORNL's role in tackling the energy challenge

We have an extraordinary set of assets

- **Outstanding tools for materials R&D**
- **World-leading systems for open scientific computing**
- **Bioenergy Science Center**
- **Growing strength in climate change impact R&D**
- **The nation's broadest portfolio of energy programs**
- **Unique resources for nuclear technology**
- **Robust national security programs**

**Our challenge:  
Use these assets  
to deliver results  
that are significant  
on both the  
national and the  
international scale**



# Studying materials with the world's best resources for neutron scattering

**Spallation Neutron Source:  
World's most powerful  
accelerator-based  
neutron source**

**High Flux Isotope Reactor:  
Complementary  
capabilities  
and a new cold  
neutron source**

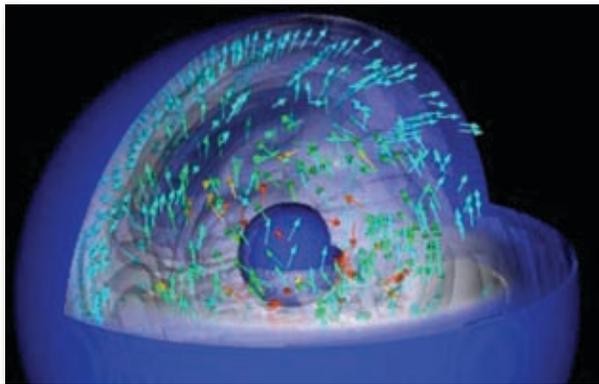
**UT-ORNL  
Joint Institute for  
Neutron Sciences:  
User gateway  
for SNS and HFIR**

**Ready  
to welcome  
thousands  
of researchers  
each year**

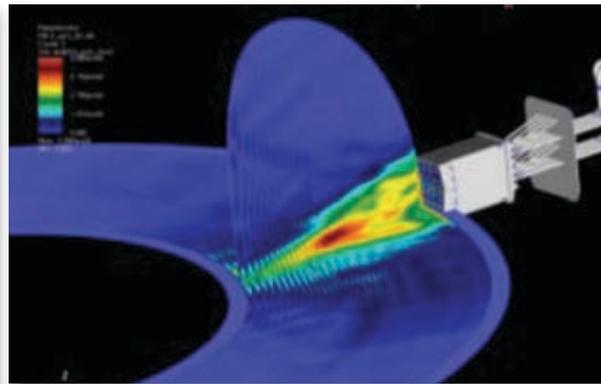


# Leading the development of ultrascale scientific computing

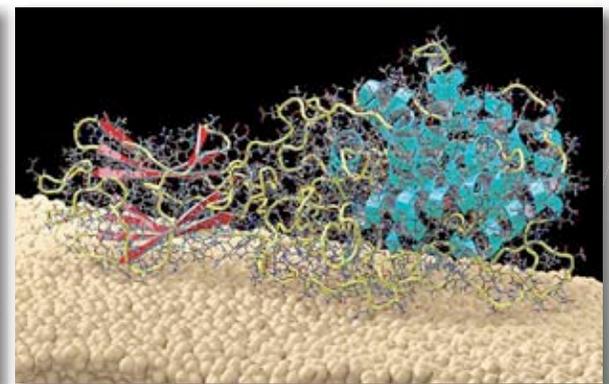
- One of the world's most powerful open scientific computing facilities
- Currently operating at 263 teraflops (1000 TF late this year)
- Focus on computationally intensive projects of large scale and high scientific impact
- Partnered with UT in developing an NSF-funded petascale computing center through the UT/ORNL Joint Institute for Computational Sciences



**Astrophysics**



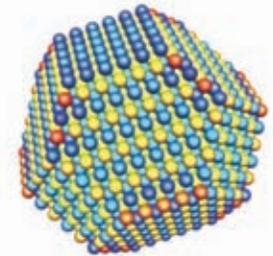
**Fusion**



**Biology**

# World-class tools for nanoscale R&D

- DOE's first Nanoscale Science Research Center
- Leverages neutron scattering and leadership computing capabilities at ORNL
- Unique facilities for:
  - Nanofabrication
  - Nanoscale characterization
  - Materials synthesis and chemistry at the nanoscale
- Understanding materials and chemistry at the length scale where properties are determined

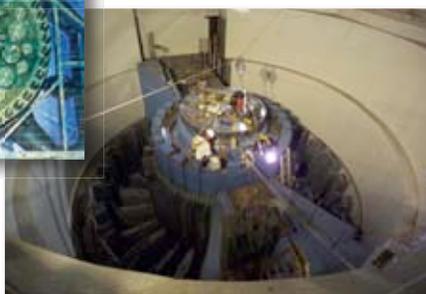


# Materials science and chemistry

Materials and chemistry research	SNS and HFIR offer transforming capabilities	World-class capabilities for nanoscale science	Leadership-class computing	Outstanding characterization capabilities
Special strengths in advanced alloys and ceramics, correlated electron materials, macromolecular systems, carbon-based materials, interfacial chemistry, separations	Structure and dynamics, large-scale structures, spins, molecular systems	Synthesis, nanoscale characterization, spin-sensitive and other probe spectroscopies, catalysis	Predictive simulation of materials and molecular interactions	Electron microscopy, mass spectrometry, local electron probes, physical and chemical properties measurement



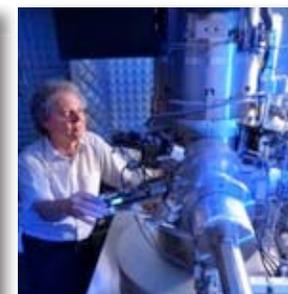
State-of-the-art nanoscience center



World's foremost capabilities for neutron science



Leadership-class computing



Powerful characterization tools

# Nuclear physics

## Understanding the origin of elements

- **World's only facility for both neutron and proton-rich beams**
- **Nuclear astrophysics and limits of nuclear structure**
- **New and expanded capabilities**
  - 120 radioactive ion beams (RIBs) and 79 stable beams at HRIBF
  - World record accelerator mass spectrometry ( $10^{-16}$  sensitivity for  $^{36}\text{Cl}$  in seawater)
  - New technique for ultrapure Sn and Ge RIBs
  - First operation of south mirror spectrometer at PHENIX/RHIC
- **New science**
  - Structure of exotic nuclei near  $^{132}\text{Sn}$
  - Precision measurements of nuclear reactions that power novae



PHENIX muon detector at RHIC

Holifield Radioactive Ion Beam Facility:  
World's largest variety  
of radioactive beams

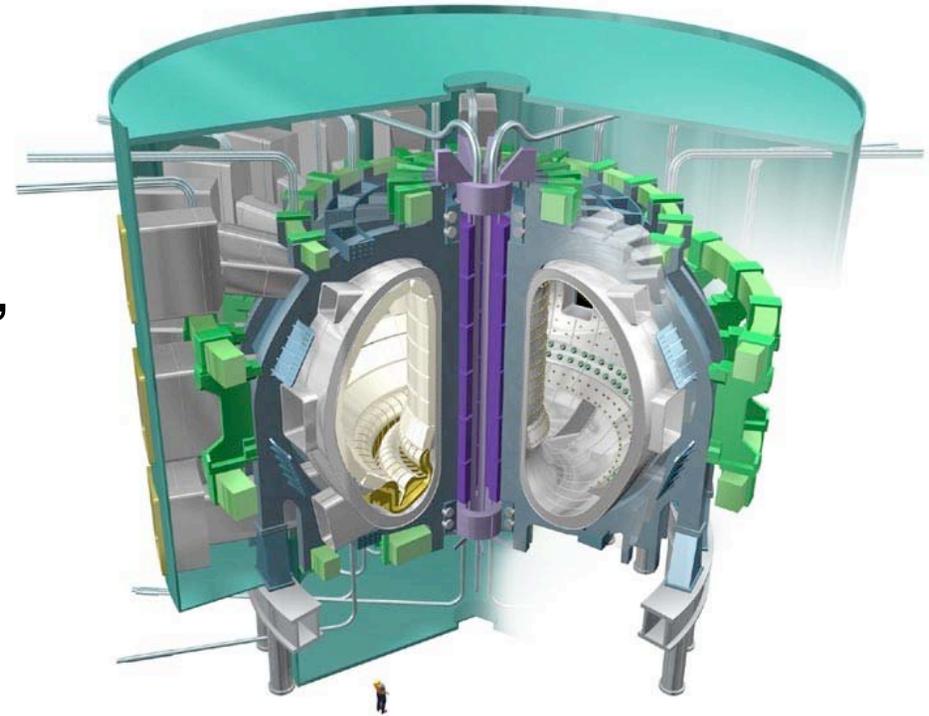
# Transforming the new biology into bioenergy

- **Developing bio-based solutions for energy, the environment, and carbon sequestration**
- **Managing the \$135M DOE BioEnergy Science Center to advance cellulosic ethanol research**
- **Part of the \$73M Tennessee Biofuels Initiative**
  - Brings ORNL, UT, and industry together
  - Includes bioenergy research, a 5M gal/year pilot plant, and agricultural incentives for switchgrass



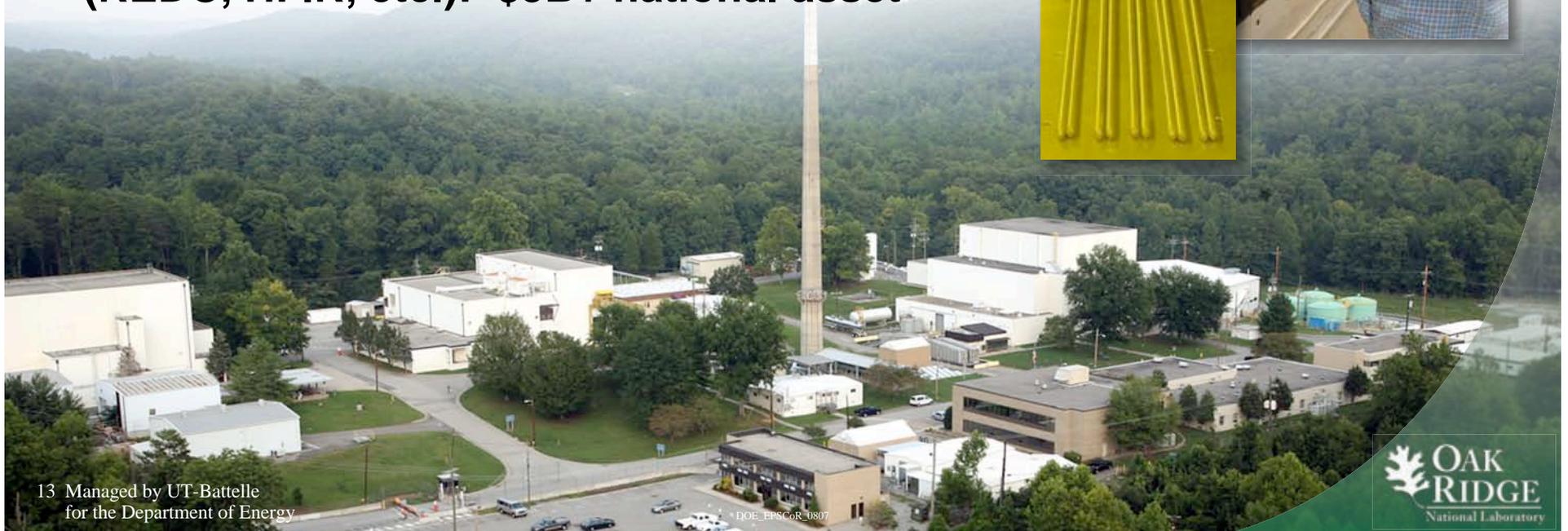
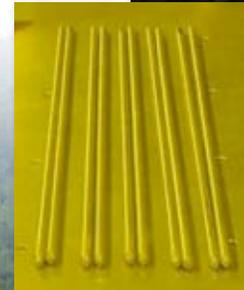
# ITER is the next step toward fusion power

- **Joint international R&D project aimed at demonstrating the scientific and technical feasibility of fusion power**
- **To be built in Cadarache, France, with operation set to begin at the end of the next decade**
- **Total cost: About \$12 billion**
  - **ORNL is managing the U.S. contributions to ITER**



# ORNL is uniquely positioned to support advanced nuclear fuel cycle research

- **Coupled End-to-End (CETE) demonstration delivers advanced nuclear fuel cycle S&T**
- **Fuel examination and reprocessing**
- **Materials irradiation at HFIR**
- **Reactor design and engineering**
- **Nuclear research facility infrastructure (REDC, HFIR, etc.): \$3B+ national asset**



# ORNL has a large and growing energy efficiency, renewable energy, and electricity delivery portfolio

- **Over \$100M in FY 2007: Largest national lab effort in transportation and industrial technologies and in superconductivity**
- **Significant growth in fuel cells, biomass, and grid visualization/modeling**
- **Major national facilities including High Temperature Materials Laboratory, National Transportation Research Center, and Buildings Technology Center**



**Lightweight carbon fiber materials from lignin**



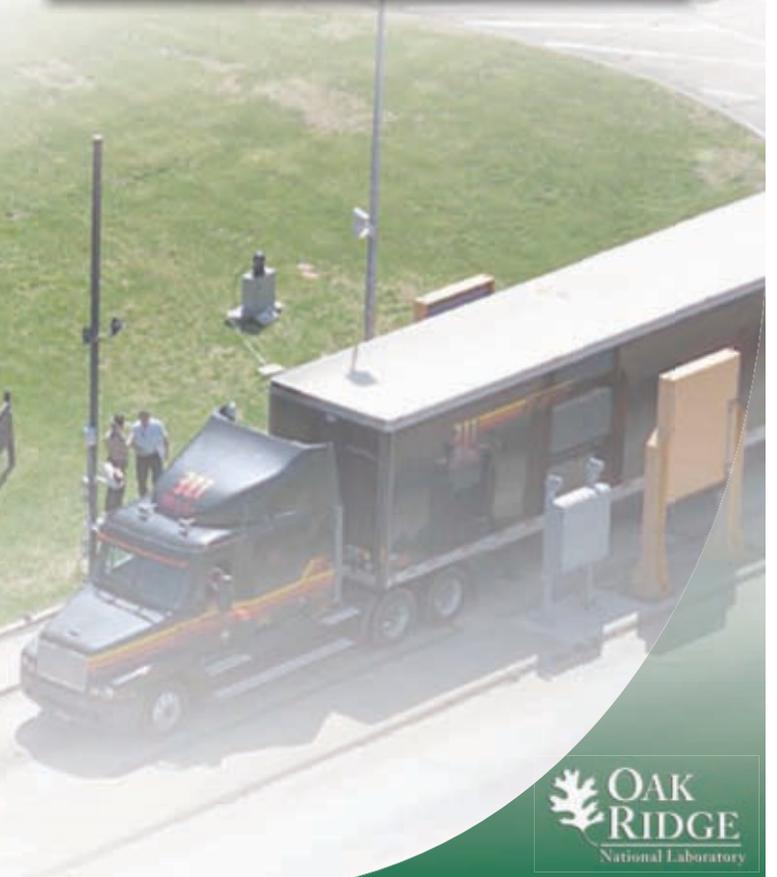
**“Zero-energy” homes**



**Triaxial superconducting cable installed at AEP Bixby**

# National security S&T has become a major business line at ORNL

- **We are DOE's leading lab for nuclear nonproliferation**
- **We have a growing role with the Department of Homeland Security**
- **National security S&T builds upon and complements our DOE missions**



# Strong university partnerships are critical to ORNL's success

## Major projects

- Bioenergy Science Center
- NSF Track 2 computer led by UT
- 4 SNS instruments led by university consortia



## Collaborative research

- More than 200 universities



## Joint hiring

- 61 joint faculty with 8 universities



## Joint institutes

- Heavy ion research
- Neutron sciences
- Biological sciences
- Computational sciences
- Materials sciences



## User facilities

- Thousands of university users

# National labs have much to offer university faculty and students

- **Access to unique experimental facilities**
  - Designated user facilities
- **Collaborations that can expand faculty opportunities**
- **Mentoring and training of students**
  - Various programs for undergrads and for graduate students
- **Access to DOE programs**
  - Through partnerships with lab researchers
- **A research staff that is interested in working with academia**



# National user facilities at ORNL



- **Bioprocessing Research Facility**
- **Buildings Technology Center**
- **Californium User Facility for Neutron Science**
- **Center for Nanophase Materials Sciences**
- **Cooling, Heating, and Power Integration Laboratory**
- **Fuels, Engines, and Emissions Research Center**
- **High Flux Isotope Reactor**
- **High Temperature Materials Laboratory**
- **Holifield Radioactive Ion Beam Facility**
- **Metals Processing Laboratory Users Facility**
- **Mouse Genetics Research Facility**
- **National Center for Computational Sciences**
- **National Transportation Research Center**
- **Oak Ridge Electron Linear Accelerator**
- **Power Electronics and Electric Machinery Research Facility**
- **Safeguards Laboratory**
- **Shared Research Equipment Collaborative Research Center**
- **Spallation Neutron Source**

# Vehicles of cooperation with ORNL

Undergraduate	Graduate	Postdoctoral	Faculty
<ul style="list-style-type: none"> <li>• Co-op program</li> <li>• DHS HS-STEM Internship</li> <li>• HERE@ORNL</li> <li>• Laboratory Technology Program</li> <li>• Nuclear Engineering Science Laboratory Synthesis Internship</li> <li>• Research Alliance in Math and Science</li> <li>• Science Undergraduate Laboratory Internship</li> </ul>	<ul style="list-style-type: none"> <li>• Advanced Short-Term Research Opportunity</li> <li>• HERE@ORNL</li> <li>• Nuclear Engineering Science Laboratory Synthesis Internship</li> <li>• Research Alliance in Math and Science</li> <li>• Post-Master's Research Participation</li> </ul>	<ul style="list-style-type: none"> <li>• Advanced Short-Term Research Opportunity</li> <li>• Eugene Wigner Fellows</li> <li>• Clifford Shull Fellows: Neutron science</li> <li>• Alston Householder Fellows: Scientific computing</li> <li>• Instrument Development Fellows</li> <li>• Postdoctoral research associates</li> </ul>	<ul style="list-style-type: none"> <li>• DHS Summer Research Team</li> <li>• Faculty and Student Team</li> <li>• HERE@ORNL</li> <li>• NRC Faculty Research Participation</li> <li>• Sabbaticals and summer research</li> </ul> 

[jobs.ornl.gov](http://jobs.ornl.gov)

# Oak Ridge National Laboratory: Science and technology for the 21st century



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