Neutron scattering at Oak Ridge National Lab will advance your scientific research

OAK RIDGE National Laboratory | HIGH FLUX ISOTOPE REACTOR | SPALLATION NEUTRON SOURCE

Add the power of neutron science to your research — at little to no cost

Oak Ridge National Laboratory (ORNL) is the US epicenter for a powerful technique for studying the nature of materials and energy—neutron scattering. Neutrons have no electrical charge, which allows them to easily and non-destructively pass through materials, revealing the material's structure and properties.

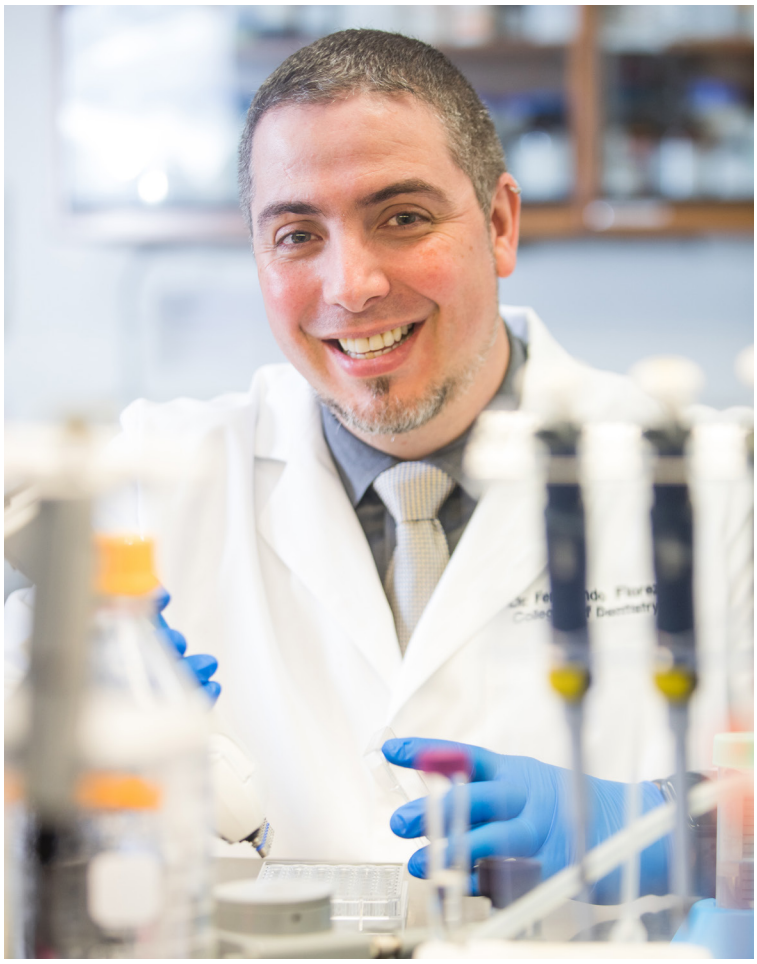
Both scientists and non-scientists can access ORNL's leading research facilities via the U.S. Dept. of Energy's **User Program**. ORNL's neutron research user facilities—the **High Flux Isotope Reactor (HFIR)** and the **Spallation Neutron Source (SNS)**—are open to researchers to facilitate their studies in science and technology. HFIR and SNS, two of the world's most advanced neutron scattering research facilities, offer thirty advanced instruments covering a wide range of materials science techniques.

Beam time is granted through the **User Program** and is completely free of charge with the condition researchers publish their results to make them available to the scientific community. A fee is charged only for proprietary research that will not be made public.

No neutron experience? No problem.

A Brazilian dentist, Fernando Luis Esteban Florez, while teaching at the University of Oklahoma College of Dentistry, began pursuing his idea for a new technology: the world's first long-acting antibacterial adhesive resin for dental restorations. His research proposal was approved and with the help of experts at ORNL's Center for Nanophase Materials Sciences and the High Flux Isotope Reactor, he created and characterized multifunctional nanoparticles with long-lasting antimicrobial properties.

"I'm grateful for the DOE's user program, which enabled me, a dentist without advanced scientific training, to access the world-leading expertise and resources at Oak Ridge National Laboratory," said Esteban Florez. "It saved me six to eight years of development time and we are now in talks to commercialize our product."



Neutron scattering research advances almost every area of science

Here are just a few of the many types of neutron research conducted at ORNL's two world-leading neutron sources:

Physics
Transport processes, Weyl semimetals, pressure-induced phenomena, topological systems

Biology & Structural Biology
Domain dynamics, lipid systems, protonation states and proton structure in proteins

Quantum
Quantum entanglement

Materials
Imaging, interface fluctuations, functional materials, strengthened alloys, lattice vibrations

Climate & Clean Energy
Solar cells, metal-organic frameworks, catalytic processes, greenhouse gas sequestration

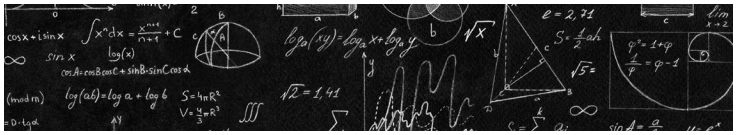
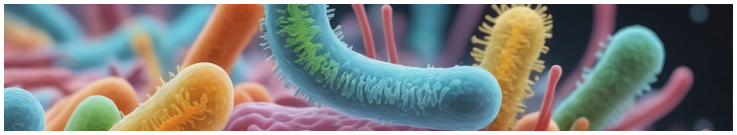
Medicine & Health
Drug design, drug delivery

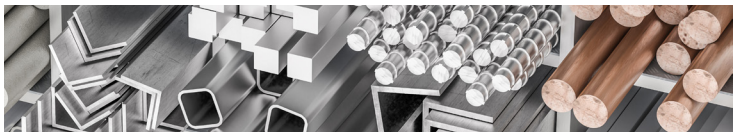
Plants & Water
Membrane cell activities, nutrient uptake

Energy Materials
Thermoelectrics, phase transitions

Magnetism
Magnetic excitations

Manufacturing
Residual stress mapping, 3D-printing model validation






Neutrons are one of the most versatile, effective ways to study and develop a wide range of materials

ORNL neutrons have helped scores of researchers save time and money by identifying ways to improve their materials and make their processes more efficient. Our experts work closely with you to choose the right experiments and conduct them successfully. No technical or scientific experience is necessary. The following are just a few of the thousands of successful research projects that used ORNL neutrons:

The 'holy grail' of catalysis

Neutrons helped develop a method of converting methane, a greenhouse gas, into useful liquid methanol. **Univ. of Manchester (UK)**

Real-time evaluation of 3-D printed parts

Neutrons mapped residual stresses in 3-D printed parts during heat treating to improve manufacturing methods. **Univ. of California Berkeley**

Solid electrolyte for solid-state batteries

Neutrons analyzed a promising solid electrolyte that allows solid-state lithium-ion batteries to run longer at higher capacities. **Univ. of Pittsburgh**

Perfecting imperfections in quantum materials

Neutrons showed inducing imperfections in quantum materials creates electronic properties for use in quantum technologies. **Univ. of Minnesota**

Safer, faster-charging batteries

Neutron imaging helped track lithium movement in battery electrodes to improve next-generation batteries. **Univ. of California San Diego**

Next-generation solar cells

Neutrons found a way to slow phonons, which could improve how solar cells convert light to energy. **Univ. of Tennessee Knoxville**

Stopping cancer from hijacking a metabolic highway

Neutrons helped draw a map of the atoms, bonds and charges in a key enzyme of a metabolic pathway that cancer cells use to reproduce, paving the way for new cancer drugs. **Tennessee Wesleyan University**

The copper key to more efficient biomass breakdown

Neutrons revealed how oxygen binds to copper to break down biomass and how an amino acid drives the process, which can make producing cellulosic ethanol more efficient. **Oklahoma State University**

Developing MOF traps that mitigate toxic gases

Neutron studies are helping develop materials that can detect and capture acid gases in the air. **Univ. of Manchester (UK)**

Revealing the properties of an antioxidant polymer

Researchers used neutron data to combine a synthetic antioxidant with a natural one to improve drug delivery methods and other biomedical applications. **Univ. of Alabama at Birmingham**

Heat transport in thermoelectric materials

Neutron scattering was used to measure structural changes and phonon spectra, revealing a transition where the atomic spacings expand in one direction but contract in others. **Duke University**

Neutrons offer advantages over X-rays when studying the atomic structures and behaviors of materials

Neutrons scatter from the nuclei of atoms in materials

They scatter at different angles and energies that are recorded by detectors. This data is used to calculate the material's atomic structure and other complex properties.

Neutrons penetrate even dense materials such as metals

They can penetrate deeply into dense, complex materials and devices to help accurately probe beneath a sample's surface. This helps in studying the structures and behaviors of samples while they are under extreme temperatures, pressures and magnetic fields.

Neutrons are nondestructive

They do not damage or alter the samples being studied. This enables observing material behaviors in real time and in real-world environments, such as inside a running engine or within delicate, living biological systems.

Neutrons detect atomic-scale magnetism

They have magnetic moments that can find and measure weak and elusive magnetic phenomena associated with new states of matter, exotic quantum behaviors and valuable new materials.

Neutrons detect lighter elements

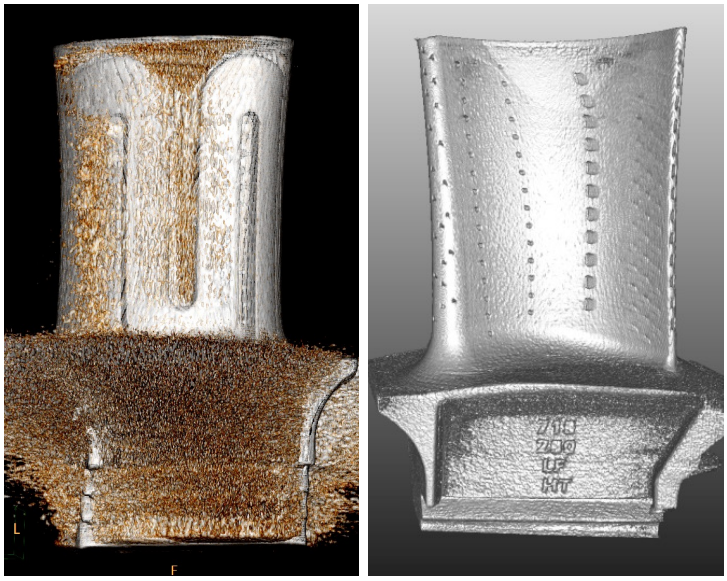
They can help identify where lighter atoms are located, such as the hydrogen atoms in water molecules and lithium atoms in energy storage devices.

Neutrons offer you information that other research techniques can't

The range of time scales and length scales that can be investigated simultaneously are unmatched by any other scientific method.

Neutrons can differentiate between isotopes of various elements, which permits doping techniques to be employed.

ORNL also offers high-speed data capture and expert data analysis to assist researchers in accomplishing their research objectives.



X-ray and neutron CT of an Inconel turbine blade

Many neutron science tools and techniques are available to help make your research successful

The neutron scattering facilities at HFIR and SNS provide users with laboratories to prepare and analyze samples before and after neutron scattering experiments. The labs provide convenient locations where users can work efficiently with instruments and equipment that support analysis techniques that complement neutron scattering.

The **Spallation Neutron Source** delivers short pulses of protons - 60 times a second - to a target where neutrons are produced by a "spallation" process and sent down beamlines.

The **High Flux Isotope Reactor** uses uranium-235 as the fuel to generate the highest rate of flowing neutrons, or neutron "flux," available for research in the United States.

Some of the most common neutron science techniques used at ORNL include:

DIFFRACTION

Identifies the location of atoms in materials and measures microscopic magnetism at the atomic level

REFLECTOMETRY

Probes the surface and interfacial structures in thin films

SPECTROSCOPY

Measures the motions of atoms and microscopic magnets in materials

IMAGING

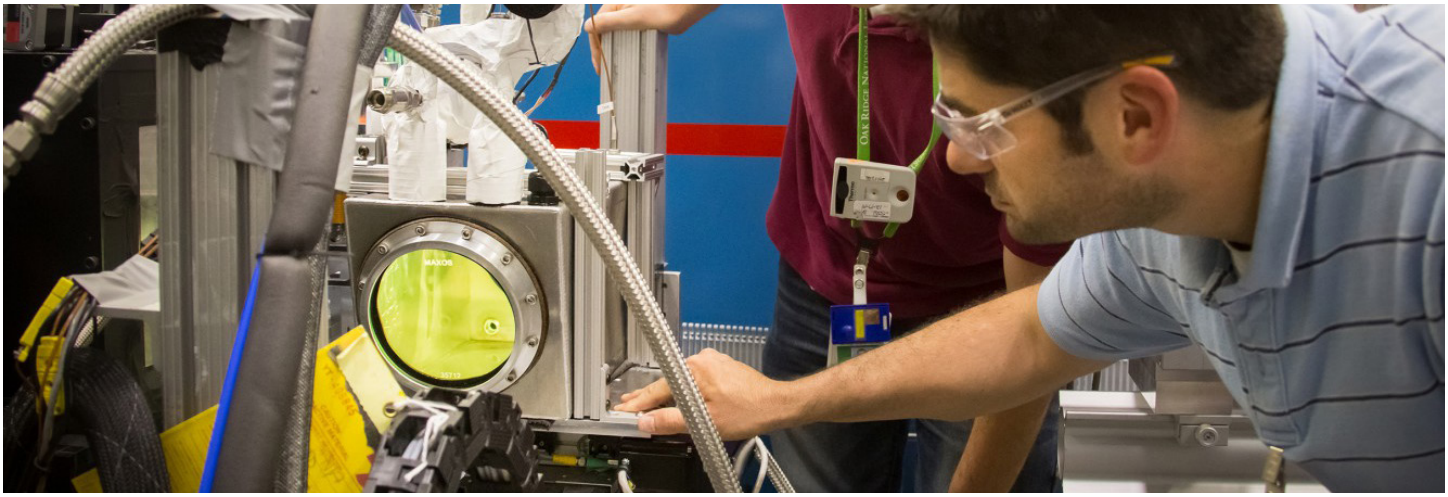
Identifies where an object or device experiences residual stress

SMALL ANGLE NEUTRON SCATTERING

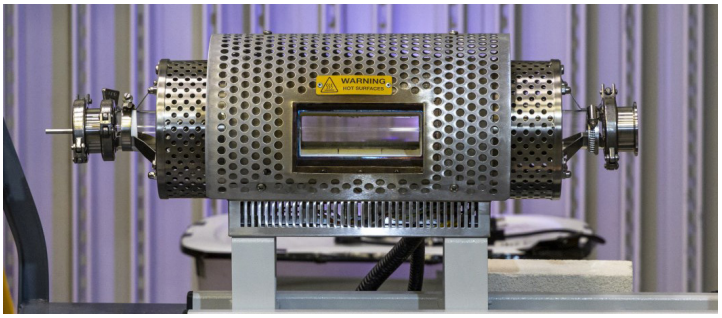
Measures the size and shape of things too small to be seen with microscopes

Choose from a wide array of sample environments

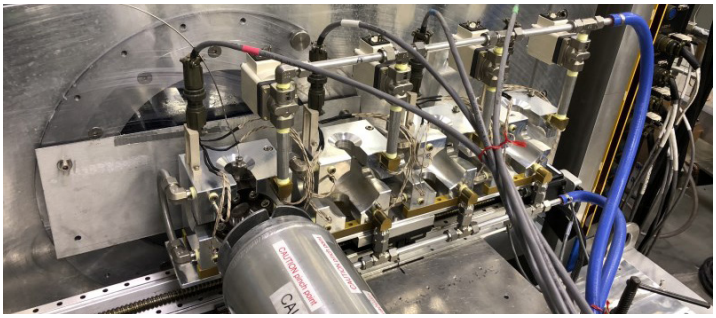
ORNL experts provide support for the development, deployment and operation of sample environments at both SNS and HFIR. They employ a wide variety of standard and highly unique environments in the areas of soft matter, magnetism, low and high temperatures, and extreme pressures.



Experts work closely with users to ensure the safety and success of the experiments

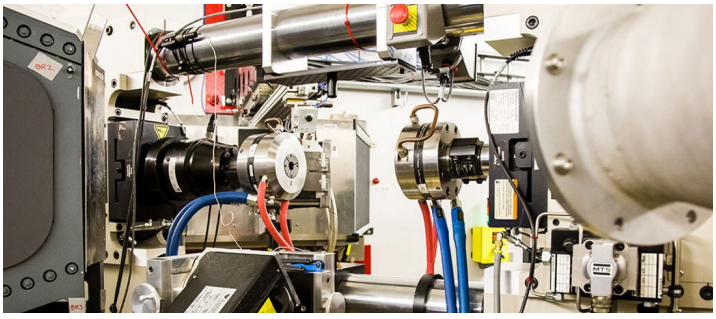


Tube furnace



High-pressure cells

High-power magnetic fields



Engineering studies using a load frame

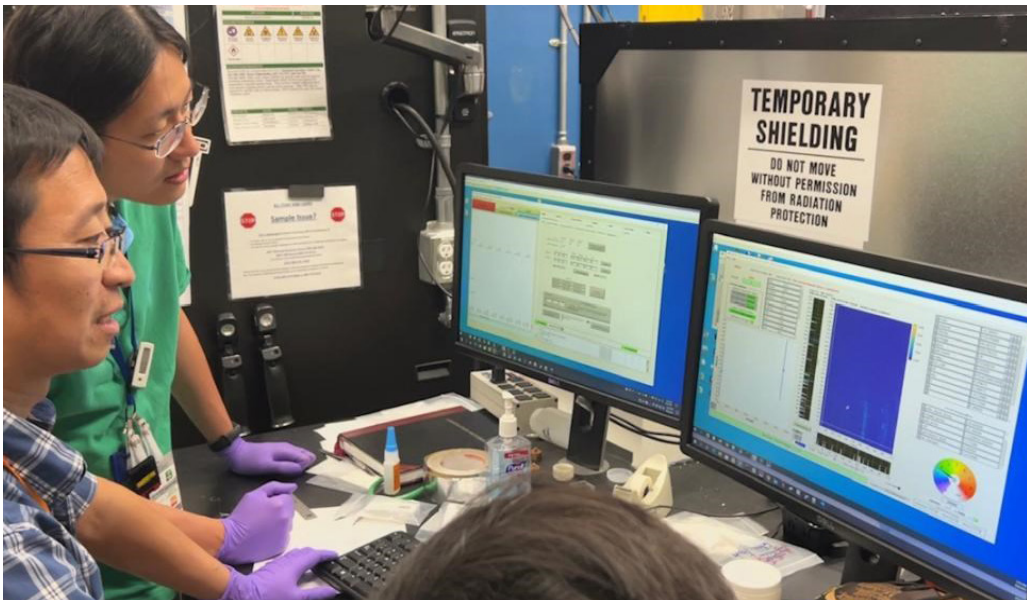
ORNL's Neutron Sciences User Program invites you to collaborate with us to achieve greater success

Each year the ORNL **User Office** issues two calls for research proposals, which correspond with upcoming operating cycles. Submissions are peer-reviewed by external panels, with recommendations based on scientific and technological impact. Experiments are also reviewed for feasibility and safety. Those with the highest potential for scientific impact are approved and scheduled for instrument access.

For individuals and institutions interested in learning more about conducting proprietary research or how neutrons can help them overcome a research hurdle they face, visit the **User Program** webpage at **https://neutrons.ornl.gov/users**. Or contact the **User Office** by email at neutronusers@ornl.gov or by telephone at (865) 574-4600.

ORNL has had research collaborations with many universities around the world, including:

- Columbia University
- Duke University
- Florida State University
- Georgia Tech
- Harvard University
- Johns Hopkins University
- Louisiana State University
- McMaster University (CA)
- North Carolina State University
- Seoul National University (KR)
- University of Alberta (CA)
- University of Edinburgh (UK)
- University of Florida
- University of Georgia
- University of Heidelberg (DE)
- University of Illinois
- University of Manchester (UK)
- University of Michigan
- University of Notre Dame
- University of Tennessee
- Vanderbilt University
- Virginia Tech



Use the QR code to get more details