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January 2023 NS&T Highlights

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Addison Marie Arave

Changing the World's Energy Future

Idaho National Laboratory

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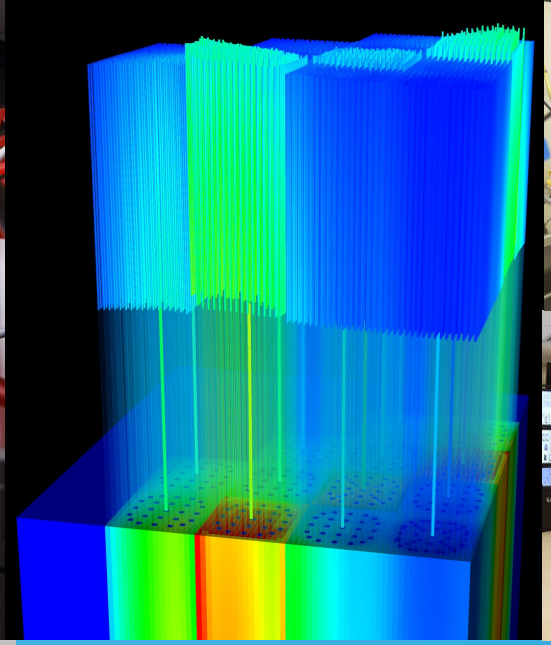
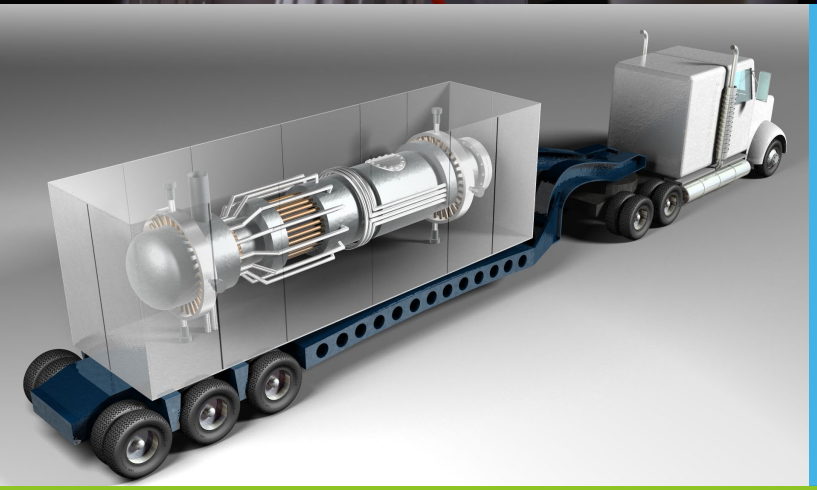


Nuclear Science & Technology

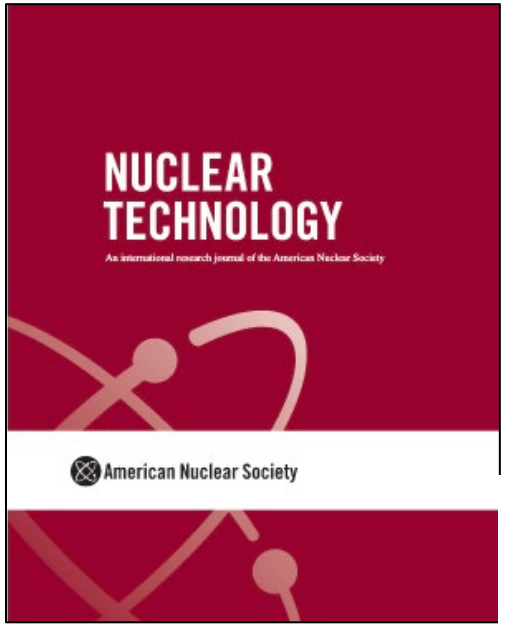
January 2023 Highlights

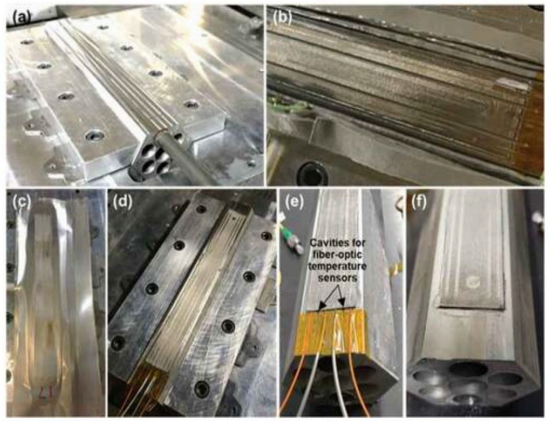
Idaho National Laboratory

DOE-NE Microreactor Program

Nuclear Technology Publishes a Special Issue on the U.S. Department of Energy Microreactor Program

- The Department of Energy Office of Nuclear Energy (DOE-NE) Microreactor Program (MRP) was created to facilitate and accelerate commercial demonstration and deployment of microreactors: small, factory-fabricated, transportable, self-regulating nuclear fission reactors.
- This Nuclear Technology special issue highlights the current research and development (R&D) being conducted through the MRP and shows how the Department of Energy (DOE) complex is empowering this exciting and rapidly developing technology.
- It focuses on the cross-cutting R&D and technology information generated by a variety of organizations under the DOE-NE MRP.
- This special issue is open access. To view the publication, click here.





Pictures of a stainless-steel mini hex block during sensor embedding.

Sketch of eBlock37 subcritical core mounted on gCart37 handling unit.

REACTOR SYSTEMS DESIGN & ANALYSIS
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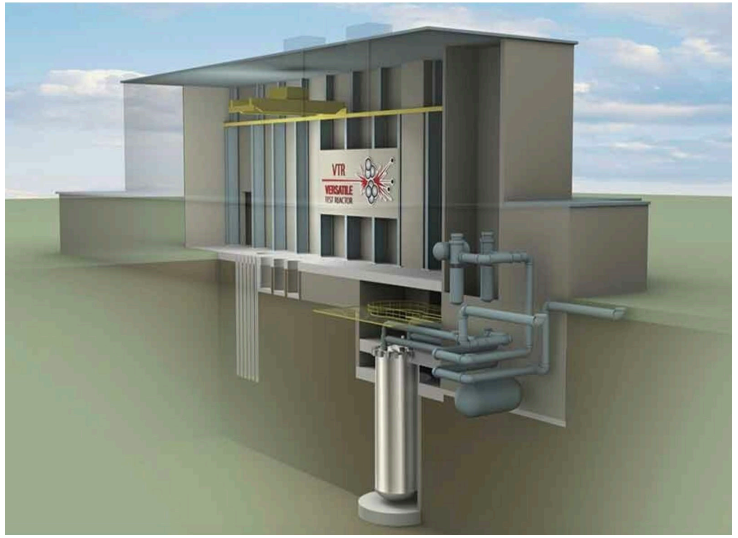
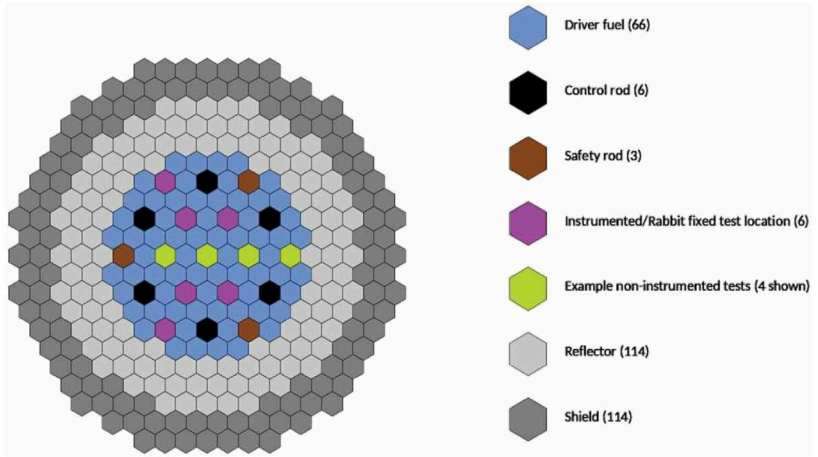
DOE-NE Versatile Test Reactor Program

Nuclear Technology Publishes Special Issue on the U.S. Department of Energy Versatile Test Reactor Program

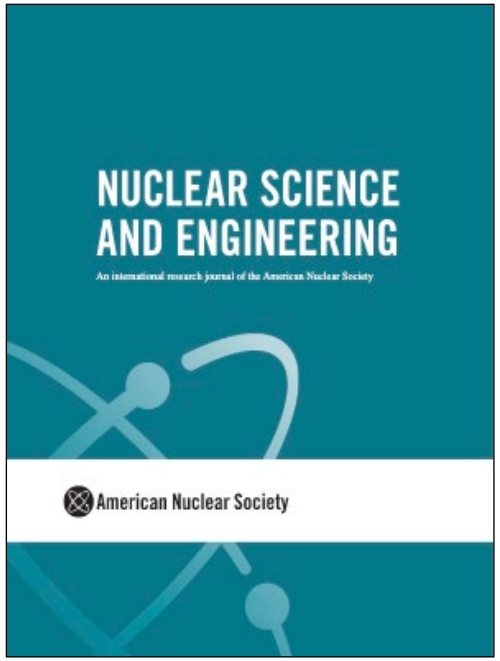
- In 2018, the Department of Energy Office of Nuclear Energy (DOE-NE) initiated the Versatile Test Reactor (VTR) program to develop a fast-spectrum neutron irradiation facility to fill a gap in the domestic research and development infrastructure.
- The VTR design is a state-of-the-art 300-$MW_{thermal}$ pool-type sodium-cooled test reactor with a core optimized to produce fast-spectrum neutrons at very high fluxes over large volumes.
- A special issue of Nuclear Science and Engineering (NSE) presents a snapshot of the VTR design at the end of its conceptual design phase. It describes some of the VTR planned facilities and capabilities with their technical status.
- To view the publication, click here.



VTR
SOLVING ENERGY CHALLENGES THROUGH SCIENCE



VTR conceptual design core map.



REACTOR SYSTEMS DESIGN & ANALYSIS
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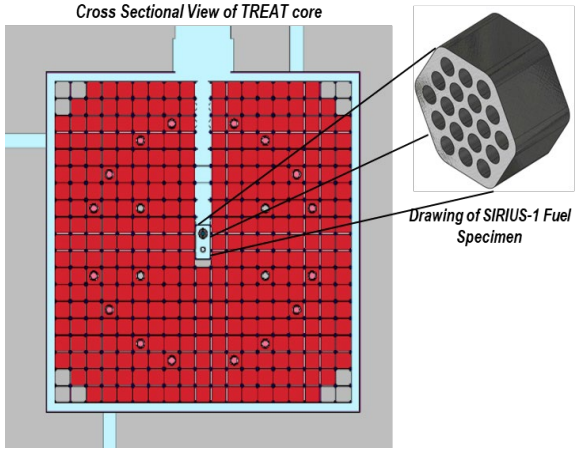
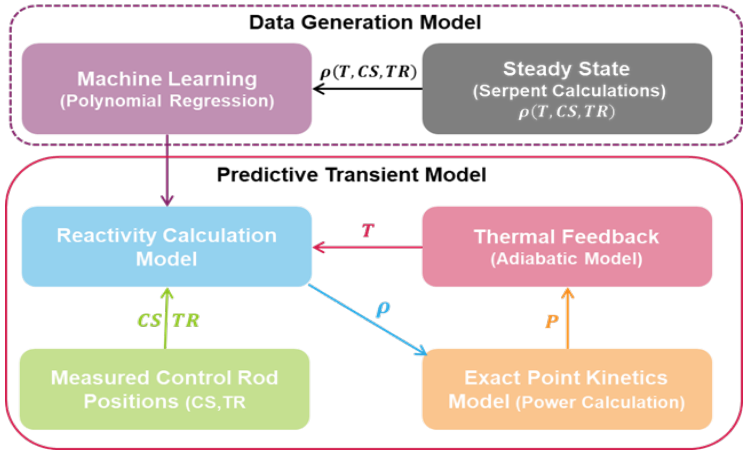
Space Nuclear Propulsion Project

Researchers Develop Predictive Transient Model of NASA-Sponsored Experiments

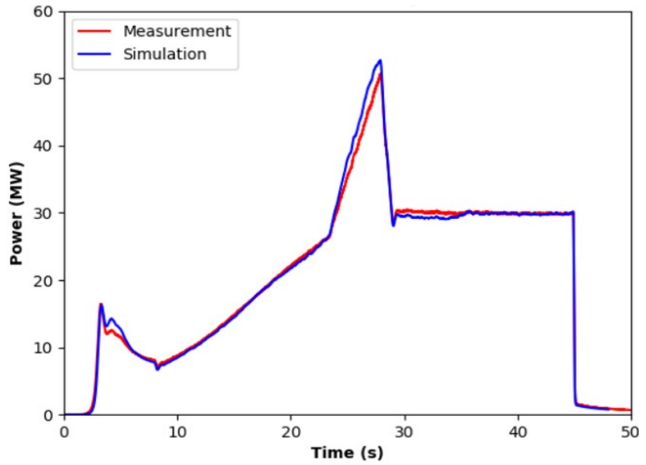
- To support experiment transient analysis for the National Aeronautics and Space Administration (NASA) sponsored SIRIUS experiments in the Transient Reactor Test Facility (TREAT), a predictive transient model was developed, leveraging:
  - Monte Carlo Calculations: for steady state analysis using Serpent code to generate reactivity data as a function of control rod positions and fuel temperature.
  - Adiabatic Thermal Feedback Model: to obtain average fuel temperature at each time point.
  - Machine Learning: to functionalize Serpent-generated data and predict the total reactivity of the core during the transient as function control rod positions and fuel temperature.
  - Exact Point Kinetics (EPK) Model: to calculate the total reactor power with given reactivity and kinetics parameters during the transient.



- The predictive model was tested with SIRIUS-1 experiments, which were performed at three different power levels.
- Test results show a good agreement with the measured values for the three different power levels and the results were within uncertainty level of the reported power (5~10%).
- This predictive model will help researchers understand the modeling requirements and details for full dynamic analysis; it also will help in predicting the transient behavior of other experiments.
- Currently the predictive model is being tested for SIRIUS-3 experiments and preliminary results show similar agreement.



Predictive Transient Model: Calculation Workflow.



Power Evolution During SIRIUS-1 Full Power Experiment.

REACTOR SYSTEMS DESIGN & ANALYSIS | REACTOR PHYSICS METHODS & ANALYSIS
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DOE-NE Light Water Reactor Sustainability Program

R&D 100 Award-Winning Technology Presented to Secretary Granholm and U.S. Senators

- During the 2023 Consumer Electronics Show, Ahmad Al Rashdan presented Machine Intelligence Review Analysis Condition Logs Entries (MIRACLE), a key technology developed by the Light Water Reactor Sustainability (LWRS) Program, to Secretary of Energy Jennifer Granholm, Senator Jacky Rosen of Nevada, Senator Mark Warner of Virginia, and Senator Ben Ray Lujan of New Mexico.
- MIRACLE uses machine learning and natural language processing to automate the corrective action screening process while saving millions of dollars and improving safety.
- During an interview with the Associated Press, Secretary Granholm mentioned MIRACLE as an example of how the Department of Energy is helping improve the efficiency of the nuclear power industry.

Al Rashdan explaining the R&D 100 award winning technology, MIRACLE, and its potential in the nuclear power industry to Senator Warner, Dr. Chan (DOE Chief Commercialization Officer), Secretary Granholm, Senator Rosen, and Senator Lujan (from left to right).

NUCLEAR SAFETY AND REGULATORY RESEARCH | INSTRUMENTATION, CONTROLS, AND DATA SCIENCE
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LWRS LIGHT WATER REACTOR SUSTAINABILITY

IDAHO NATIONAL LABORATORY

Catherine Riddle Receives Laboratory Director Award for Inventor of the Year

- Catherine Riddle has been awarded the INL Director's Award for Inventor of the Year in honor of her dedication to bringing technology from benchtop to market for the past 23 years.
- Riddle is a senior research scientist with expertise in radiochemistry and radiochemical separations. She also volunteers her time working with INL's K-12 Education Enrichment Programs.
- Riddle has 14 patents and patents pending for her work in Nuclear Science & Technology and Energy and Environment Science & Technology. Her Colorimetric Detection of Actinides (CoDeAc) technology received an R&D 100 Award and has been commercialized as the new company CoDeAc Solutions.

Award winner Catherine Riddle.

Division Director Curtis Smith Receives Laboratory Director Leadership Award

- Dr. Curtis Smith, Director of the Nuclear Safety and Regulatory Research Division, was awarded the 2022 INL Laboratory Director Leadership award.
- This award recognizes individuals who have made substantial contributions to Idaho National Laboratory and demonstrated outstanding leadership and commitment.
- Dr. Smith has dedicated 33 years of service to INL in a variety of positions, including his current position as the Director of Nuclear Safety and Regulatory Research.

Award winner Dr. Curtis Smith.

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Ahmad Al Rashdan Receives Laboratory Director Award for Exceptional Engineering Achievement

- Ahmad Al Rashdan, a senior research and development (R&D) scientist in the Nuclear Safety and Regulatory Research division, was awarded the 2022 Exceptional Engineering Achievement Award.
- This award is to recognize scientific R&D staff who have made major contributions to the advancement of an engineering field of study over a sustained period.
- Al Rashdan has more than 17 years of industrial and research experience and has been with INL for eight years.

Award winner Ahmad Al Rashdan.

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Dean Burt Receives Laboratory Director's Award for Research and Development Technician of the Year

- Dean Burt has been awarded the INL Director's Award for Research and Development Technician of the Year, in recognition of his incredible expertise, motivation, and dedication.
- Dean is a senior technician who has been with INL for 13 years, possessing expertise in instrumentation and controls, system assembly, and light machining.
- Dean supports 30+ staff for a range of programs, facilities, and laboratory equipment. He always goes above and beyond in the projects he supports and is a stabilizing force keeping researchers and projects moving forward.

Award winner, Dean Burt

Fuel Cycle Science and Technology | Nuclear Science and Technology
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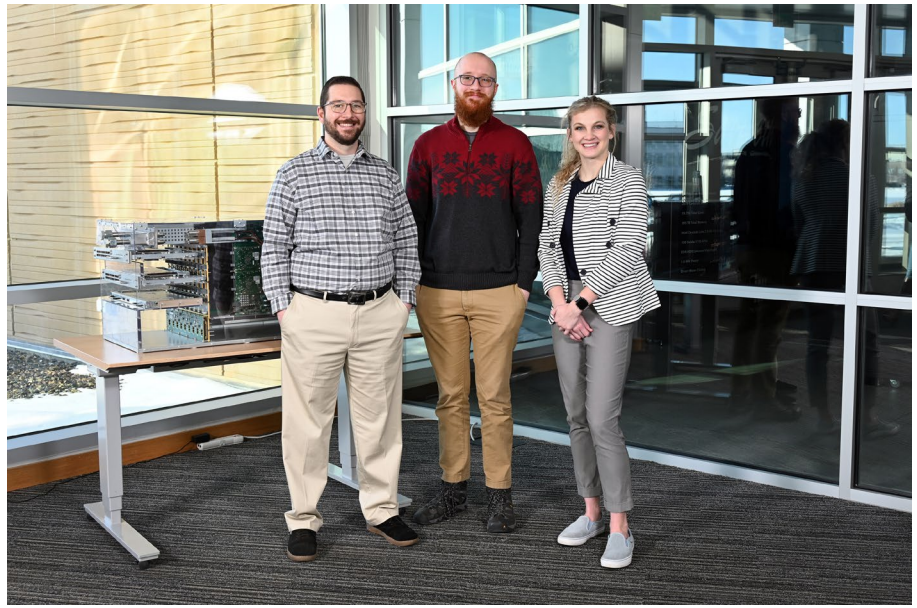
Open OnDemand HPC Team Receives Laboratory Director Award for Next-Level INL

- The Open OnDemand High Performance Computing (HPC) gateway deployed by Matthew Sgambati, Brandon Biggs and Bradlee Rothwell has radically changed how INL's HPC systems are used, enabling operation modalities not possible using conventional approaches.
- Open OnDemand was first deployed at INL in Fiscal Year 2019 in a limited way to better serve the large number of users without HPC experience. After a one-year trial period, it was made available to all users.
- In 2022 more than 84% of INL users accessed the lab's HPC capabilities through the OnDemand gateway.
- The design, implementation, and deployment of the Open OnDemand science gateway has transformed how INL HPC users execute research computing.



Award winners from left to right:
Matthew Sgambati, Brandon Biggs, Bradlee Rothwell

Nuclear Science and Technology | Advanced Scientific Computing
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Gregory Horne Receives Laboratory Director Award for Early Career Exceptional Achievement

- Greg Horne, an R&D scientist in the Nuclear Science and Technology department and Director for the INL Center for Radiation Chemistry Research, has been awarded the INL Director's Award for Early Career Exceptional Achievement in honor of his leadership and research excellence.
- This award recognizes outstanding scientific or engineering contributions by individuals near the beginning of their professional careers, this award is available to any individual member of the scientific and engineering research and development staff whose work has been accomplished before age 35 years or within seven years of their final degree.
- Greg's early careers contributions have established Idaho National Laboratory as an international leader in nuclear fuel cycle radiation chemistry, provided the laboratory with millions of dollars in support from multiple U.S. Department of Energy Offices through his proposal writing efforts, and increased diversity, equity, and inclusion in the laboratory's workforce.

Award winner Greg Horne

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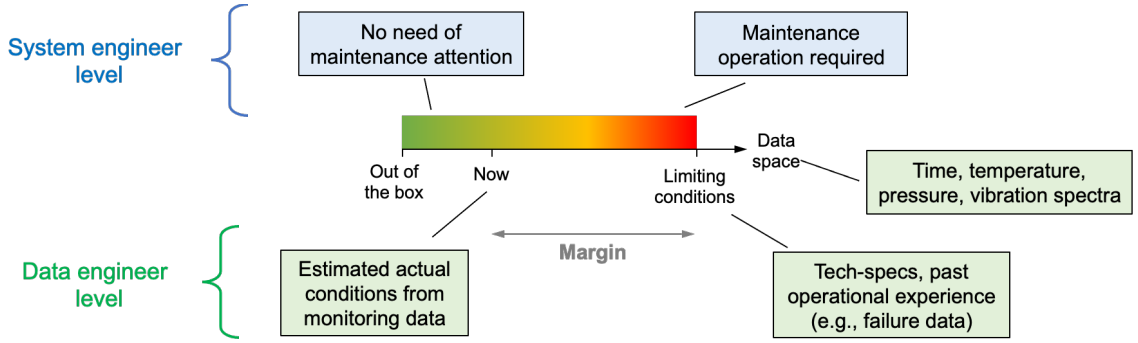
DOE-NE Light Water Reactor Sustainability Program

Reliability Modeling Provides a Bridge Between Monitoring Data and Asset Management Decisions

- Researchers have developed innovative reliability techniques designed to adequately serve in a predictive maintenance setting. These techniques move away from a failure probability mindset to a margin-based mindset. As a result of the developed methods, the health of systems and assets can be measured analytically.
- Health management is an essential task that ensures the successful operation of complex systems such as nuclear power plants operation. Continuous monitoring and processing of data, such as diagnostic and prognostic algorithms, identifies trends in asset degradation.
- The LWRS Program cross-pathway activity targeted the direct application of margin-based analysis to a large amount of historic monitoring data of a specific system in an existing nuclear power plant.
- Diverse data elements are merged into a unified model to assess system/asset health. This means margin-based reliability can inform data monitoring and asset management decision making.



A graphical representation of reliability margin as a bridge between data and system engineer decisions.

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LWRS LIGHT WATER REACTOR SUSTAINABILITY

Nuclear Science & Technology

Future of Nuclear Energy: Community Discussion in Boise

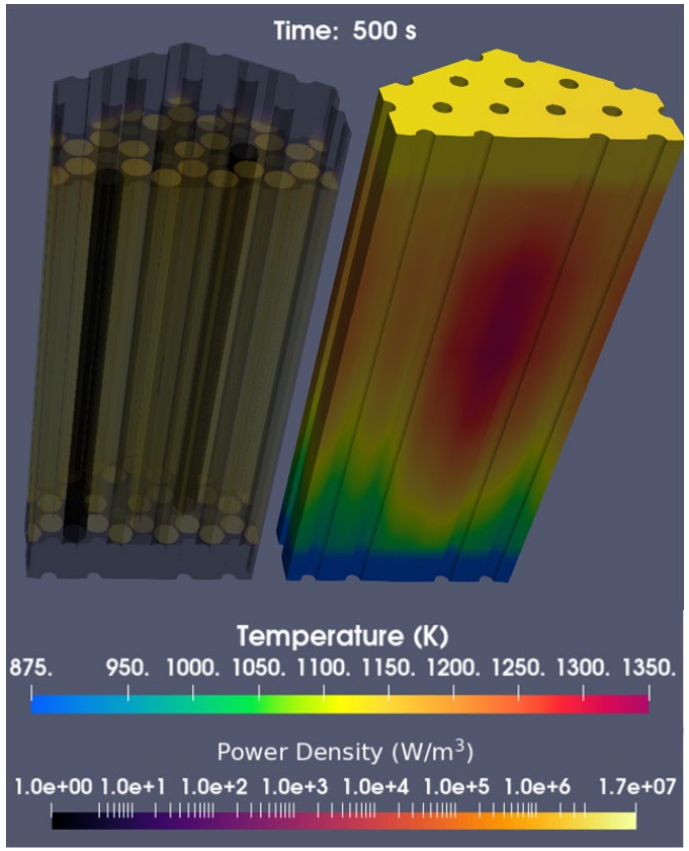
- Idaho National Laboratory (INL) hosted a panel discussion on January 25 at Boise State University with an attendance of approximately 50 people.
- The discussion focused on current INL projects, how INL works with industry and communities, and nuclear application possibilities other than electricity.
- Panelists included leadership of INL's Nuclear Science & Technology Directorate.
- The community discussion featured interactive polling about topics of interest and audience members had the opportunity to ask questions about advanced nuclear energy deployment, safety concerns, and supply chain issues.
- This community discussion followed a meeting of the Leadership in Nuclear Energy (LINE) Commission at the state Capitol.

Joe Campbell, communications liaison for the Advanced Test Reactor, moderates a panel discussion at Boise State University featuring panelists Jess Gehin, associate director of NS&T, Lori Braase, business development executive, Stephanie Weir, siting and regulatory manager for National Reactor Innovation Center, and Marianne Walck, deputy lab director for NS&T and chief research officer.

Nuclear Energy Advanced Modeling and Simulation Program

Nuclear Computational Resource Center Simplifies Software Distribution

- The Nuclear Computational Resource Center (NCRC) distributes controlled software developed at INL (BISON, Griffin, etc.) to external collaborators, including industry.
- Controlled code was previously distributed within an internal network, which required additional steps for access for external users.
- Distribution is now done securely through a public enterprise-grade service located at github.inl.gov that has greatly simplified access for these external users.
- Licensable export-controlled applications can now be distributed with Okta, the company standard multi-factor authentication application, where applicable.



Gas cooled microreactor result, produced by external collaborators at Argonne National Laboratory, using NCRC distributed codes.

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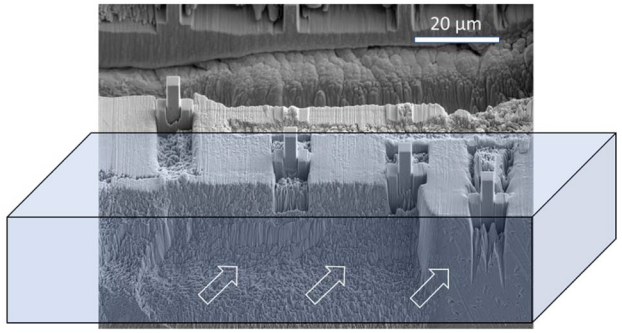
Research Highlight

DOE-NE Nuclear Science User Facilities

A Comparison Study Guides Stainless Steels Toward Better Irradiation Tolerance and Longer Lifetimes

- Additive manufacturing (AM) offers lower cost and higher flexibility in fabricating components of complicated geometry; however, the material's performance is influenced by the initial directional microstructure introduced from AM processes.
- In this project, the ion-beam radiation response and changes in mechanical properties of additively manufactured 316L stainless steels were studied using an *in situ* scanning electron microscopy.
- The effect of AM print direction on mechanical properties, and on material microstructure, was examined by studying the compression of micropillars taken parallel and perpendicular to the proton irradiated surface of the samples.
- Taking micropillars in the direction of the ion beam leads to considerable uncertainty in the estimated dose experienced by the pillar, potentially resulting in different deformation mechanisms along the length of the pillar. Micropillars taken perpendicular to the direction of irradiation show a dependence with better precision.
- The ion beam irradiation in this project was supported through a Nuclear Science User Facilities Rapid Turnaround Experiment award.



Microscopic image of pillars that were prepared on the irradiated sample. The box indicates the region irradiated by the proton ions. The arrows refer to the proton beam direction.

Title: Micropillar Compression of Additively Manufactured 316L Stainless Steels after 2 MeV Proton Irradiation: A Comparison Study between Planar and Cross-Sectional Micropillars
Authors: Ching-Heng Shiau, (Texas A&M University, Boise State University, Center for Advanced Energy Studies), Miguel Pena, Yongchang Li, Sisi Xiang, Lin Shao (Texas A&M University), Cheng Sun, Michael D. McMurtrey (INL).
Journal: Metals
Link: doi.org/10.3390/met12111843

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NSUF Nuclear Science User Facilities

IDAHO NATIONAL LABORATORY

DOE-NE Nuclear Science User Facilities

Brenden Heidrich Selected to Lead the Nuclear Science User Facilities

- Nuclear Science & Technology (NS&T) staff member, Brenden Heidrich, has started a new role as the director for the Nuclear Science User Facilities (NSUF).
- In previous positions, Brenden has served as a senior nuclear engineer focusing on neutron irradiation experiment management at the Advanced Test Reactor and the Transient Reactor Test Facility. Most recently, he managed the Irradiation Testing department for NS&T's Nuclear Fuels and Materials Division and has served as the irradiation chief scientist for the NSUF since 2014.
- Brenden replaces Rory Kennedy, who has served as the director for the NSUF for the past nine years. He will be leaving this position focus on his role as the director for INL's Glenn T. Seaborg Institute.

Brenden Heidrich, the new director for the Nuclear Science User Facilities.

NUCLEAR FUELS & MATERIALS
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NSUF Nuclear Science User Facilities

Advanced Fuels Campaign

Joint Project Between United States and Japan Advances Global Fast Reactor Fuel Safety Research

- Idaho National Laboratory (INL) develops Temperature Heatsink Overpower Response (THOR) device to test advanced reactor fuel experiments in the Transient Reactor Test (TREAT) Facility.
  - The capsule brings new testing capabilities to TREAT that will help advance fuel performance research for sodium-cooled fast reactors.
  - The device houses fuel experiments in TREAT where it can mimic conditions of fast reactors during postulated accident conditions and hosts state-of-the-art instrumentation required to monitor the fuel's real-time response to these conditions.
- THOR is part of a joint project between the United States and Japan used to perform the world's first transient tests on fast reactor fuels in more than two decades.

Researcher working on THOR-C-2 assembly at INL..
Click the image to learn more.

NUCLEAR FUELS AND MATERIALS
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Advanced Fuels Campaign

INL Hosts Meeting with International Collaborators from Japan, Atomic Energy Agency, and Mitsubishi Heavy Industries

- Individuals from the Japan Atomic Energy Agency and Mitsubishi Heavy Industries visited staff from the Advanced Fuels Campaign at Idaho National Laboratory to discuss joint activities on irradiation testing and post-irradiation examination of accident tolerant fuels (ATF).
- Visiting individuals included project leads for developing and testing of ATF in Japan.
- They observed activities involving irradiation testing in the center flux trap of the Advanced Test Reactor and examinations of the test articles at the Materials and Fuels Complex.
- Hosting this group facilitates Department of Energy and INL international leadership in these essential technical areas.

JAEA

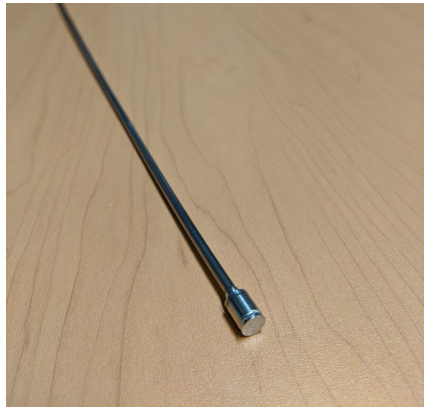
MITSUBISHI HEAVY INDUSTRIES

AFC Advanced Fuels Campaign

DOE-NE Advanced Sensors and Instrumentation, nternational Nuclear Energy Research Initiative

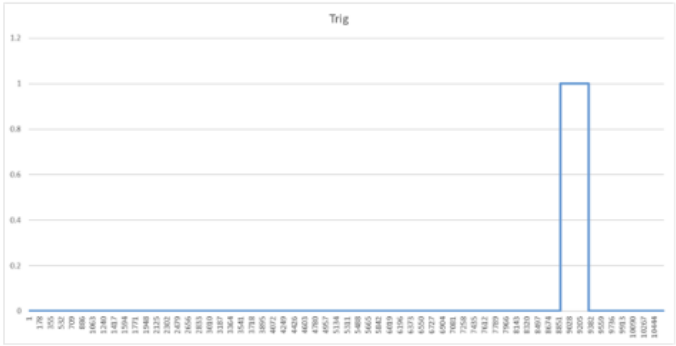
International Advanced Instrumentation Project Completes Development of Radiation-Hardened Instruments

- A collaborative team from INL and the Korea Atomic Energy Research Institute (KAERI) developed a radiation-hardened neutron sensor system to allow for greater understanding of what happens inside nuclear reactors.
- The project, “Radiation Hardened Readout System for Micro-Pocket Fission Detectors,” was successfully conducted at the:
  - Transient Reactor Test (TREAT) facility – For verifying overall system operation using INL-developed Micro-Pocket Fission Detectors (MPFD).
  - KAERI gamma ray facility – For assessing total ionizing dose effects of the KAERI-developed radiation-hardened electronics.



INL-developed MPFD.

KAERI-developed radiation-hardened electronics.



MPFD signals captured during TREAT transient testing.

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Publications

- Ching-Heng Shiau, (Texas A&M University, Boise State University, Center for Advanced Energy Studies), Miguel Pena, Yongchang Li, Sisi Xiang, Lin Shao (Texas A&M University), Cheng Sun 5ORCID, Michael D. McMurtrey (INL). “Micropillar Compression of Additively Manufactured 316L Stainless Steels after 2 MeV Proton Irradiation: A Comparison Study between Planar and Cross-Sectional Micropillars,” Metals, Vol. 1843. doi.org/10.3390/met12111843.
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Publications, cont.

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