Accomplishments

On June 8th, ATR NSUF announced award of five new research projects from the spring solicitation. Fourteen total proposals were received and reviewed for feasibility, programmatic relevance and technical merit. Award of these five projects brings the total to 25 awards made by ATR NSUF since its first call for proposals in 2008. ATR NSUF has two calls for proposals each year with awards made in January and June, along with a variety of faster turnaround experiments with awards made throughout the year. (See the ATR NSUF website http://atrnsuf.inl.gov/ for all calls for proposals and schedules.)

Of the five projects awarded, three are irradiation and post irradiation examination experiments, and two are for post irradiation examination only.

- Darryl Butt of Boise State University will work with collaborators from the University of Wisconsin on an irradiation experiment titled, "High Temperature In-Pile Irradiation Test of Single Phase U3Si2." The team will perform high-temperature nuclear fuel testing on uranium silicide (U3Si2) which has previously only been tested at temperatures below 200°F; the research will therefore fill a void in the existing fuel data.
- Yongho Sohn of University of Central Florida will work with a team from the Georgia Institute of Technology, INL, Argonne National Laboratory and Ohio State University on an irradiation experiment titled, "Low Fluence Behavior of Metallic Fuels." The team will analyze new metallic fuels under development and advance understanding and modeling of fuel performance.
- Sean McDeavitt of Texas A&M University will collaborate with several researchers from the Lightbridge Corporation on an irradiation experiment titled, "Irradiation Behavior and Performance of a Uranium-Zirconium Metal Alloy Fuel." McDeavitt aims to determine whether metallic fuels being developed for next-generation reactors could also be used in present-day Light Water Reactor (LWR) cores. The team will compare current oxide fuel to the next-generation fuel, with the aim of improving the latter's performance and reliability.
- Emmanuelle Marquis of the University of Michigan will collaborate with TechSource, Inc., and INL on a PIE-only experiment titled "Radiation-induced Segregation/Depletion at Grain Boundaries in Neutron Irradiated 304SS at Low Dose Rates." The experiment will utilize post-irradiation equipment to collect more complete data on stainless steels irradiated at low dose rates, develop new methods for grain boundary analysis and allow for materials degradation predictions. It will also analyze the microstructural changes in hex blocks irradiated in INL's EBR-II fast reactor.
- Mitra Taheri of Drexel University in Philadelphia will utilize the ATR Pre-Irradiated Sample Library for aPIE-only experiment titled, "Multi-scale Investigation of the Influence of Grain Boundary Character on RIS and Mechanical Behavior in LWR Steel." Taheri will perform a multi-scale analysis on how specific grain boundary character distributions can have a negative effect on mechanical behavior of steel alloys in Light Water Reactors.

ATR
National Scientific User Facility

Noteworthy News

ATR NSUF Users Week 2010

ATR NSUF 2010 Users Week participants

The rainy Seattle-like weather didn't keep the almost 150 participants away from Idaho National Laboratory's second annual Advanced Test Reactor National Scientific User Facility (ATR NSUF) Users Week, held June 7-11 at University Place in Idaho Falls.

The week-long INL-sponsored event brought together students, faculty and top industry and national laboratory researchers from seven different countries and 33 universities. Participants had the opportunity to network, share information about their research and learn about the latest techniques and capabilities in nuclear science and engineering.

The first day of the 2010 Users Week opened with a morning workshop covering the capabilities of INL's ATR NSUF and the irradiation and post-irradiation tools available to Users. U.S. Department of Energy (DOE) Assistant Secretary for Nuclear Energy Pete Miller greeted attendees Monday morning via a special video welcome. He credited the ATR NSUF as a "vital resource" that helps make irradiation and post-irradiation facilities accessible by granting Users, both university and industry, access to some of the "most modern analytical capabilities" in the world.

The clouds cleared Tuesday, and a beautiful sunny day greeted participants attending the first full day of courses. The curriculum for the week included several lectures and presentations, plus new instrumentation and experimenter hands-on courses and a research forum showcasing presentations by current Users. Throughout the week, Users had the opportunity to attend sessions covering a variety of topics, including:

- Advanced Test Reactor and Post-Irradiation Capabilities
- Current and Advanced Techniques for Length Detection
- Basics of Corrosion and Radiation Damage
- Light Water Reactor Materials
- Reactor Materials Modeling
- Fast Spectrum Reactors Fuels and Materials
- Advanced Gas-Cooled Reactor Fuels and Materials
- Non-destructive Examination
- Experimental Design, Tools for Neutronic Analysis, and Thermal Analysis

In addition to the course curriculum, participants also had the opportunity to tour the INL site facilities to see first-hand what the ATR NSUF has to offer. The tour visited the ATR, Materials and Fuels Complex (MFC), Hot Fuel Examination Facility (HFEF) hot cell, Analytical Laboratory (AL) and Electron Microscopy Laboratory (EML).

The Users Dinner, held Wednesday, June 9, in the Center for Advanced Energy Studies (CAES) building gallery, gave participants a chance to interact with each other in a more relaxed and unstructured environment.

Dinner speaker Dennis Miotla, Office of Nuclear Energy Deputy Assistant Secretary for Nuclear Power Deployment, welcomed participants to INL and explained why making a long-term investment in the nuclear industry is important to DOE. “We want to encourage people to become nuclear engineers and scientists and get back to the high numbers of graduates we had in the 1970s," he said. "Without [a new generation of nuclear scientists], there will be no nuclear renaissance in the United States.”

Tim Abram presenting LWR fuel performance and research challenges

The advantages for students attending Users Week and working with researchers and scientists on experiments through the ATR NSUF are numerous. Dr. Jeff King, the lead for a faculty-student research team from the Colorado School of Mines and the Missouri University of Science and Technology, said two of the research students who worked with him on experiments in the ATR NSUF received job offers at INL immediately thereafter. King remarked that through the ATR NSUF, the students “were able to practice [advanced techniques on state-of-the-art equipment] to gain the experience they needed when they were given real specimens…The big outcome for [the students] was the contacts [they] made working at the ATR NSUF. After working [as researchers] at the User Facility, they came back and were hired.”

During the research forum session, current and recent Users shared their positive experiences working with the INL ATR NSUF and encouraged participants to take part in the program.

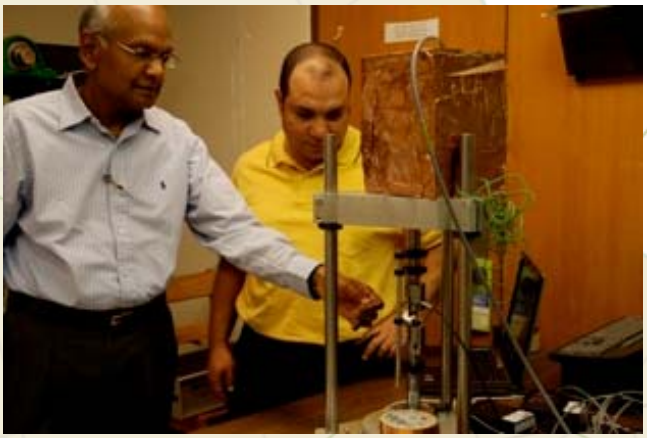
Meimei Li of Argonne National Laboratory explained how she used ATR Pre-irradiated Sample Library archive specimens to complete her research project on Irradiated Ferritic Steel in a very short amount of time. She credited the Sample Library as a great tool available to Users to expedite the research process. Li submitted her research proposal in October 2009, it was approved in November 2009, and the team started research in December 2009.

"It was no miracle [we could complete the research so quickly]. It only happened because we got great support from a lot of people at the ATR NSUF, Argonne National Laboratory and Los Alamos National Laboratory. This helped us to [accomplish a lot] in a very short amount of time," said Li.

Rick Provencher, Manager of the DOE Idaho Operations Office, commented on the growth of Users Week. "Look at attendance this year versus last year – we have more attending and more curriculums for participants to choose from. Attendees from last year spread the word about Users Week to colleagues and peers. Help make next year's Users Week an even bigger success by continuing to share what Users Week has to offer."

Post-irradiation Begins for Two University Experiments

The fun part has just begun for Walid Mohamed. The North Carolina State University doctoral student and his supervisor, NCSU nuclear engineering professor K.L. Murty, spent nearly two years preparing an experiment for insertion into Idaho National Laboratory's Advanced Test Reactor. In March, the pair's first samples came out of the ATR, and now Mohamed is getting to see how those samples held up under the reactor's intense neutron irradiation.



NCSU's K.L. Murty (left) and Walid Mohamed in the lab, working with a machine that gauges materials' tensile properties

The NCSU team's experiment was one of the first four chosen by INL's ATR National Scientific User Facility back in 2008.

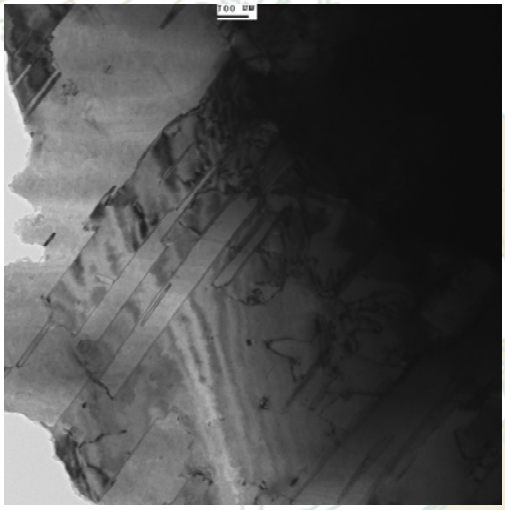
An experiment led by the University of Florida also started performing post-irradiation examination (PIE) recently, and several other projects will soon do the same. The PIE work represents another important milestone for the ATR NSUF, which was established by the U.S. Department of Energy in 2007.

"We've now proven we can get most of the way through an experiment," says INL's Todd Allen, director of the ATR NSUF. "We can get through the design and execution phases based on a university's input."

Searching for stronger nuclear materials Murty and Mohamed are working with INL researcher Doug Porter to determine how radiation affects nanocrystalline materials, which are very finely structured on the atomic scale. Nanocrystals are composed of many minuscule grains, far more per unit area than are found in traditional nuclear materials.

Theoretically, smaller, more densely packed grains should help protect turbine blades, fuel cladding and other reactor components against radiation damage, because the boundaries between grains tend to absorb and mitigate radiation-induced defects. But few researchers have performed in-depth work with nanocrystals, so the NCSU team is putting that theory to the test.

At INL's Materials and Fuels Complex (MFC), Mohamed is examining irradiated nanocrystalline copper, nickel and steel. He's looking for defects in the materials using several methods, including transmission electron microscopy (TEM) and X-ray diffraction. And he's testing the materials' mechanical properties too, to see if irradiation makes them softer or more brittle.



A transmission electron microscope image of irradiated nanocrystalline material.

Though a lot of work remains to be done, the NCSU team already has some interesting results. "At least for copper, we're seeing grain growth," Mohamed says. "This is significant. One big advantage of nanocrystalline materials is having really fine grains. So if you get grain growth under irradiation, that advantage may be negated."

Over the next few months, Mohamed will see if nanocrystalline nickel and steel show similar post-irradiation properties. He hopes to be done with this work, and his Ph.D., by the end of the year.

INL's Pavel Medvedev (left) with University of Florida graduate student Donald Moore

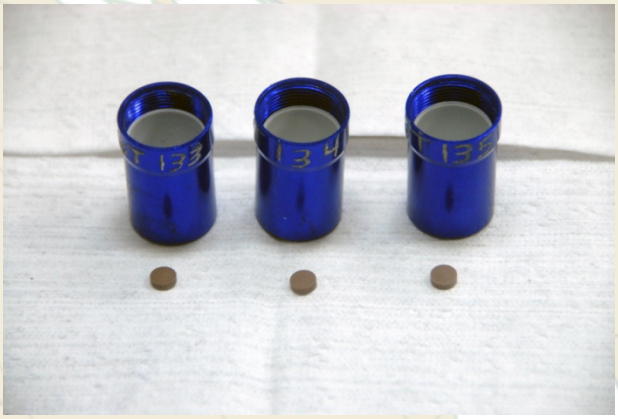
The University of Florida project is also testing out new types of materials. But the UF team, led by materials science and engineering professor Juan Nino, is interested in improving nuclear fuels rather than finding better structural materials.

Nino, UF master's student Donald Moore and INL scientist Pavel Medvedev are looking for materials that would make good inert matrix fuels (IMFs). When today's commercial power reactors "burn" uranium, they generate plutonium and other radioactive elements. IMFs incorporate these so-called "transuranics" as fuel, allowing reactors to burn up or transmute them — and therefore produce less radioactive waste.

Nino and his colleagues synthesized several potential IMF ceramics — without the transuranics — back in Gainesville. They irradiated the materials in the ATR, and now Moore is starting to investigate the effects at MFC. He's looking for radiation defects and swelling in the materials using TEM and scanning electron microscopy. He'll also see how irradiation has changed the ceramics' heat-conducting properties, if at all.

This work should occupy Moore for the next year or so. But if he identifies any promising materials, Nino's group will follow those leads far into the future. "The next step would be mixing the ceramic with fuel and testing how the IMF performs under irradiation," Moore says.

The NCSU and UF experiments are just two of 25 the ATR NSUF has chosen during its brief lifetime. And more will continue to come aboard; the facility picks new projects twice a year, following the closure of rolling application periods in April and October.



Samples of some ceramics the UF-led project has been irradiating in the ATR.

"There's tremendous interest," Allen says. "We're getting four times more applications than we can possibly accommodate."

As the first few university-led projects have progressed and matured, so has the ATR NSUF itself. Allen says he has learned a lot in the last two years, and he anticipates making some tweaks to the program in the future. Allen foresees, for example, teaming more with other facilities, such as Argonne National Laboratory's Advanced Photon Source, or the research reactor at the National Institute of Standards and Technology — whatever's needed to answer the questions researchers have posed.

"I think you'll see us transitioning more and more to a nuclear energy user facility, not just the ATR user facility," he says. But the essence of the ATR NSUF, and its mission, won't waver. "We take capabilities that don't exist in many other places, and we pair them with the best ideas out there," Allen says. "That's what we do, and that's not going to change."

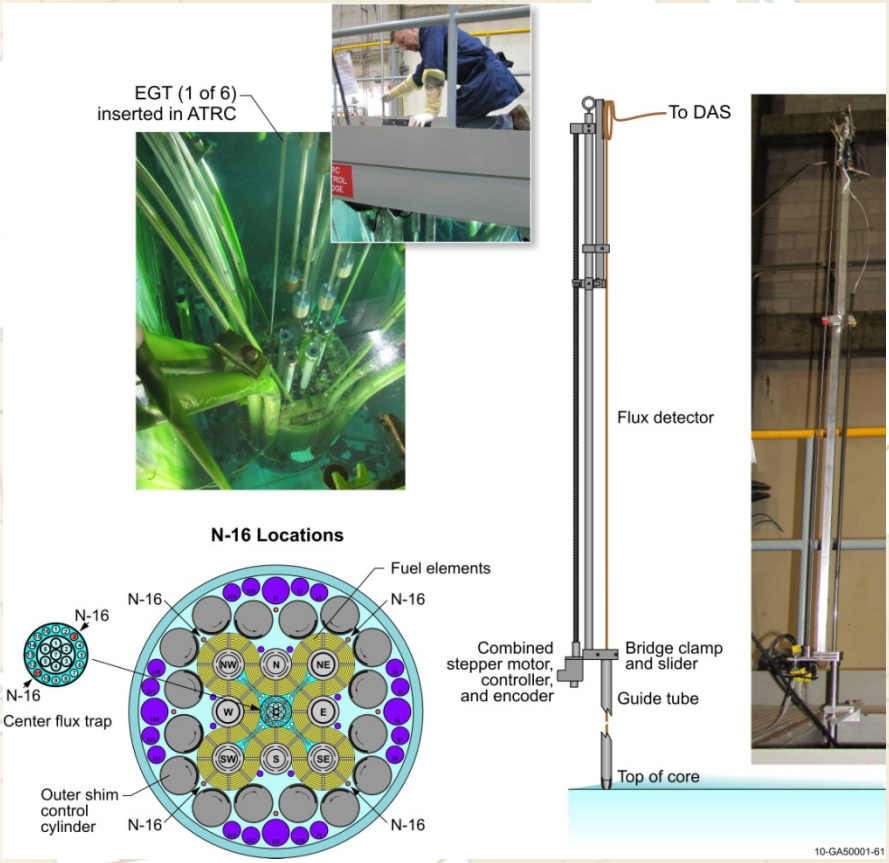
FIT Test Completed at ATR-Critical

On July 7, 2010, a fit test of the Experimental Guide Tube (EGT) instrument positioning hardware, and associated software was successfully completed at the Advanced Test Reactor Critical (ATRC) facility. This fit test represents a major milestone for several programs relying on this new ATRC capability - the Idaho State University/Idaho National Laboratory ATR NSUF project to evaluate new real-time state-of-the-art in-pile flux detection sensors, and the ATR Modeling, Simulation and V&V Upgrade initiative. These EGTs will also assist INL efforts to replace nuclear instrumentation under the ATR Life Extension Project (LEP) and support other ATR NSUF activities. EGTs are used to experimentally evaluate the accuracy, response-time and long duration performance of a variety of neutron detectors. Detectors to be evaluated in the first year of this program include the French Atomic Energy Commission (CEA)-developed miniature fission chambers; specialized self-powered neutron detectors (SPNDs) developed by the Argentinean National Energy Commission (CNEA); specially developed commercial SPNDs; and, back-to-back fission (BTB) chambers developed by Argonne National Laboratory.

Troy Unruh, ATR Project Engineer, included a test fit into the program plan to identify any modifications that might be required prior to fabricating the location-specific EGTs and verify software performance prior to flux detector evaluations that are planned to start in August 2010. EGT mockup was placed on six N-16 positions to check fitment for which 6 EGTs will be developed for flux measurement evaluations. The unique EGT design, which was developed by *Neal Boyce*, allows positioning of the detector into the desired N-16 core position and includes a

motor that axially positions the detectors using a LabView-based software program developed by *Eric Larsen*. Initial SPND and BTB fission chamber evaluations will be accomplished using the expertise of *Paul Hart*, who first evaluated such detectors in the Transient Reactor Test Facility (TREAT). In October 2010, CEA researchers will travel to ATRC to assist with miniature fission chambers evaluations.

Principal Investigators of the ATR NSUF program, *George Imel* and *Joy Rempe* and Principal Investigator of the ATR V&V Upgrade Initiative program, *David Nigg*, are collaborating on efforts to develop and deploy fixtures for evaluating sensors in the ATRC because of the cost-savings and increased potential for success. In addition to *Neal Boyce, Troy Unruh, Paul Hart, and Eric Larsen*, INL and ISU principal investigators wish to acknowledge the efforts and expertise from the following individuals: *Bill Bauer, Aaron Balsmeier, Andy Beasley, Brian Bergeson, Eric Bonebrake, Shellie Campbell, Ben Chase, Shannon Corrigan, Keith Condie, Chuck Forshee, Jason Harris, Lawrnel Harrison, Richard Hatch, Fred Hayner, Chris Jensen, Darrell Knudson, Jerod Lambson, Tony LaPorta, Jim Lee, Jim Lowden, Pete Matonis, Gene Matranga, Joe Nielsen, Dan Ogden, Mark Ogden, Bubba Ricker, Dave Rowsell, Fred Stewart, Kirk Stueve, Kevin Steuhm, Tony Walters, Byron White, Chris White, Curt Wilkins.*



Recently completed ATRC test fit allowed EGT mockup to be placed on the six N-16 positions shown to check fitment. Efforts are underway to complete fabrication of the six N-16 location-specific EGTs flux evaluations in August.