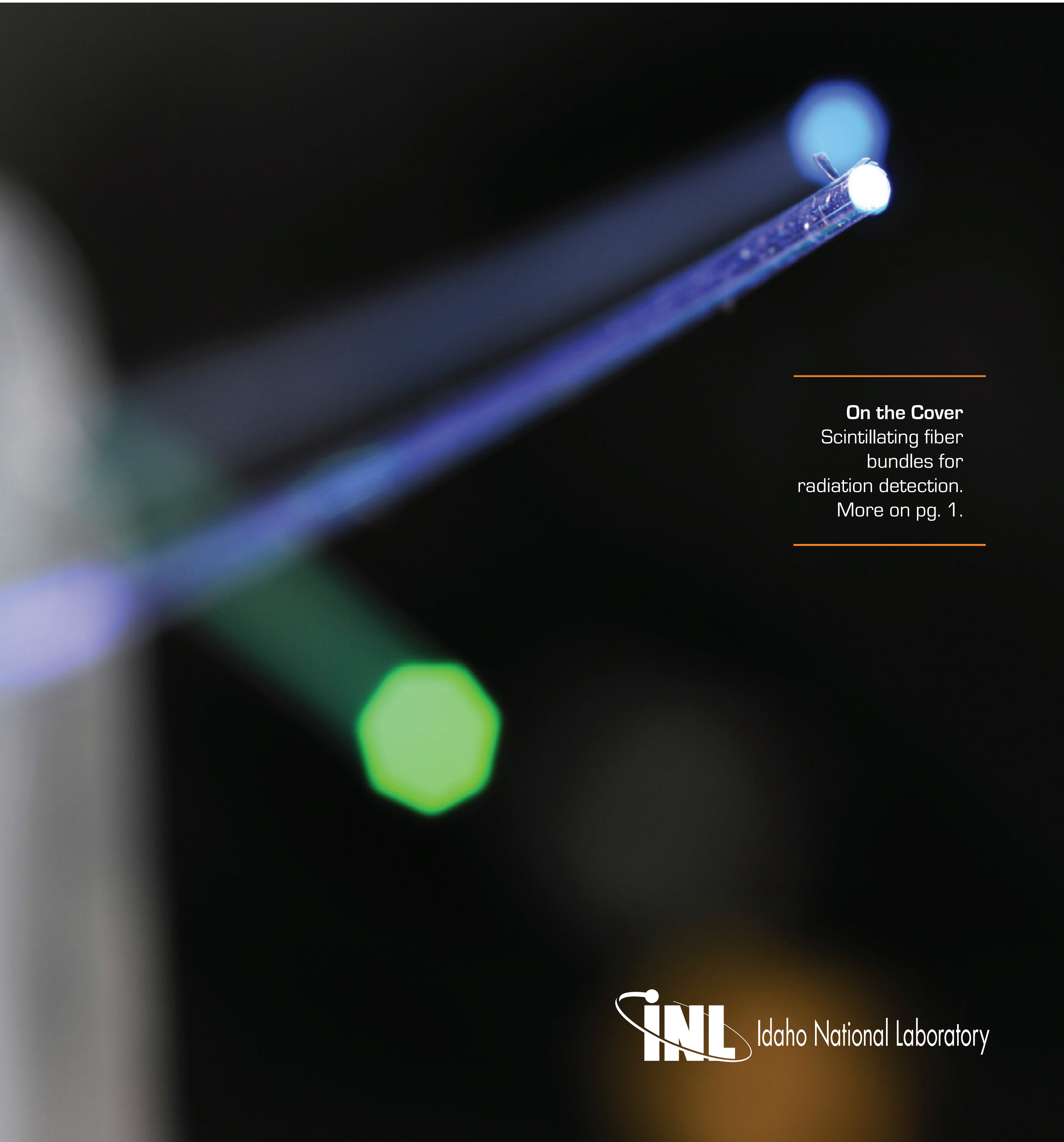
Idaho National Laboratory **ANNUAL REPORT FY 2013**

LDRD SNAPSHOT



On the Cover
Scintillating fiber bundles for radiation detection.
More on pg. 1.

INL Idaho National Laboratory

FROM THE DIRECTOR

John Grossenbacher
Director, Idaho National Laboratory

March 2014

It is my pleasure to present the Idaho National Laboratory (INL) fiscal year 2013 Laboratory-Directed Research and Development (LDRD) Annual Report. This report demonstrates the types of cutting-edge research INL is undertaking to mature our technical capabilities and help ensure the nation's energy security. This is the second year we've produced the LDRD Snapshot to highlight the program's research diversity, university collaborations, metrics and successes.

INL's LDRD Program is operated in compliance with the Department of Energy (DOE) order 413.2B. This work aligns with INL's strategic plan and benefits the DOE. The program's diverse research and development emphasizes the DOE Office of Nuclear Energy (DOE-NE) mission, which encompasses both advanced nuclear science and technology, and underlying technologies. INL's LDRD program also advances that mission by helping develop technical capabilities necessary to support future DOE-NE research and development needs. Research areas during FY 2013 included advanced reactor modeling, nuclear fuel fabrication improvements, advances for studying irradiated fuel, fuel modeling, fuel recycling and advanced radiation detection.

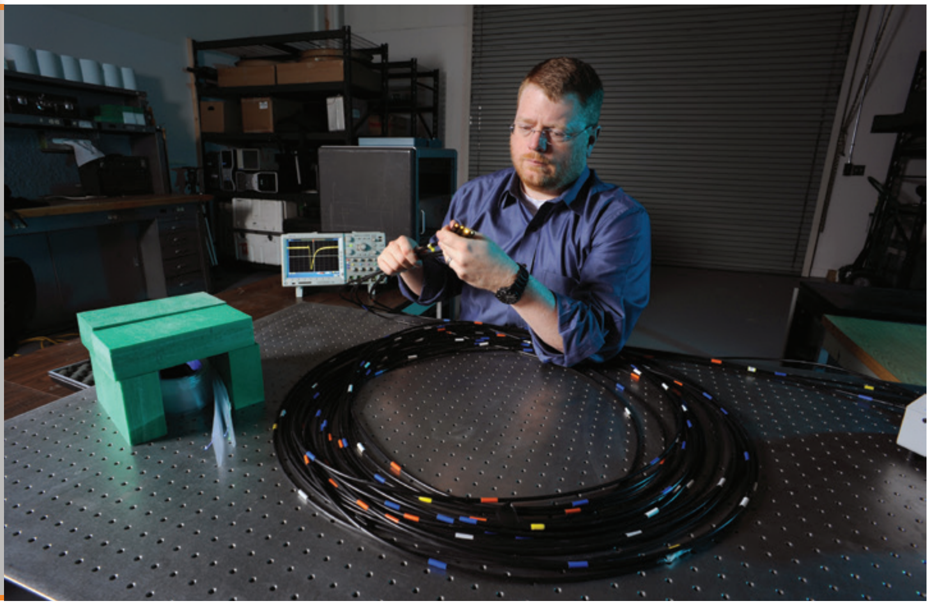
As a multiprogram national laboratory, INL also serves the nation through technology research that enhances homeland security. These research areas include wireless technologies, cybersecurity, electric grid reliability, nuclear nonproliferation and explosives protection. INL's isolated site and test bed infrastructure are ideal for experimentation and demonstrations that help protect the nation's resources and advance energy security.

INL's science base is further strengthened by research to advance alternative energy systems that reduce greenhouse gas emissions and bolster energy security. INL's applied science and real-world assessments of improved energy systems and natural resource development help secure the country's future and protect the environment.

This year's LDRD projects offer a snapshot of the diverse creativity and expertise residing at INL. They offer innovative approaches to scientific questions and technical problems. In short, these projects help the lab maintain scientific and technical vitality, while fostering creativity and stimulating exploration at the forefront of science and technology.

I am proud of the accomplishments and opportunities that INL's LDRD projects provide to the nation. I encourage you to take the time to review these project narratives and reflect on their contributions.

On the cover
Study of long-length scintillating fiber bundles for radiation detection is part of a larger LDRD effort exploring innovative methods that transcend traditional reliance on neutron and gamma rays or seek to adapt existing measurement tools for new applications (project 11-059, led by David Chichester).



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INTRODUCTION

INTRODUCTION

The FY 2013 LDRD Annual Report Snapshot provides a glimpse of the diverse research performed to develop and ensure that INL's technical capabilities support current and future DOE and National Nuclear Security Administration (NNSA) missions and national research priorities.

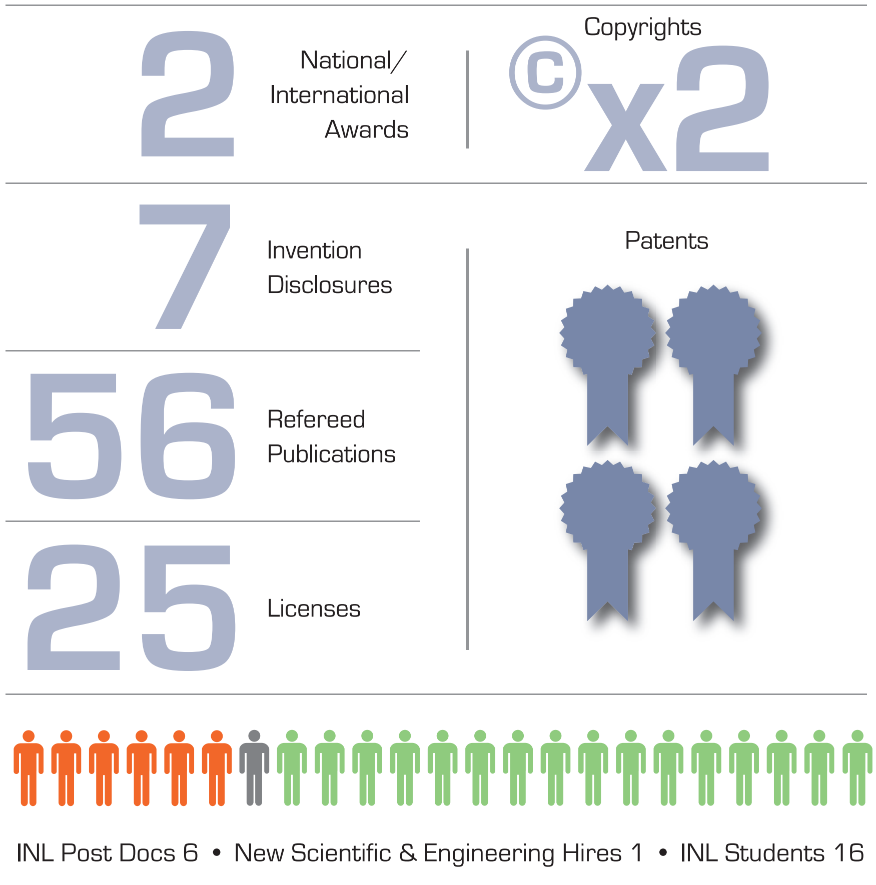
LDRD is essential; providing a means to maintain scientific and technical vitality by funding highly innovative, high-risk, potentially high-value research and development (R&D). INL's diverse LDRD portfolio explores scientific and engineering concepts to develop the needs of DOE's Office of Nuclear Energy (DOE-NE) — including advanced reactor modeling, nuclear fuel advances, fuel recycling and nuclear nonproliferation. INL's LDRD research stimulates exploration at the forefront of cybersecurity , electric grid reliability and wireless technology. The forward-looking nature of the laboratory's R&D strengthens the DOE mission by advancing hybrid energy systems and evolving energy security needs.

The LDRD program proves its benefit each year through new programs, intellectual property, patents, copyrights, national and international awards, and publications. It also provides a means to feed the pipeline with scientists and engineers through undergraduate and graduate internships, postdoctoral assignments and internal Ph.D. candidates.

BENEFITS OF LDRD

INL consistently realizes significant benefits from the LDRD program. The FY 2013 metrics are shown below.

FY 2013 LDRD METRICS



INL's LDRD portfolio explores scientific and engineering concepts to stimulate exploration at the forefront of nuclear energy, national and homeland security, and energy security.

FY 2013 LDRD PROGRAM STATISTICS

22,052 (dollars, K)
TOTAL LDRD PROGRAM COST

90 (projects)
TOTAL LDRD PROJECTS

910 (dollars, K)
LARGEST PROJECT ALLOCATION

40 (dollars, K)
SMALLEST PROJECT ALLOCATION

130
STAFF MEMBERS SUPPORTED BY LDRD FUNDING

43%
LDRD FUNDING GOING TO NEW STAFF

REPORT ORGANIZATION

This report consists of the FY 2013 Annual Report Snapshot (Part I) and individual LDRD project highlights (Part II, via CD and online at www.inl.gov/LDRD). The Snapshot begins with research highlights that exemplify the diversity of scientific and engineering research performed at INL in FY 2013, followed by sections summarizing FY 2013 awards and recognition resulting from LDRD funding as well as university collaborations utilizing LDRD funding. Part II (CD) includes individual project summaries with a general description of the project, a summary of the scientific or technical progress achieved during the life of the project, a brief statement describing how the project benefited the DOE/NNSA missions, and relevant peer-reviewed publications and presentations. The CD also includes appendices (acronym list, author index and project relevance to DOE program offices) that may be useful to readers.

THE LDRD PROCESS AT INL

INL solicits ideas for LDRD projects through an annual call for proposals. The call takes into consideration the need to support key technical capability development, collaboration with university and industry partners, and crucial research that includes enabling or crosscutting science. These solicitations encourage innovative approaches proposed by individual researchers or small multidisciplinary teams.

The call for proposals includes a requirement for a pre-proposal followed by a full written proposal, a technical peer review and a management review prior to project selection. The intent of the pre-proposal process is to provide principal investigators the opportunity to briefly articulate an idea prior to investing time and effort to write a full proposal. The principal investigators on selected projects then submit a full detailed proposal, which is subject to technical peer review and management review. A data sheet for selected projects is provided to DOE's Idaho Operations Office (DOE-ID) for concurrence. The continuing and proposed new LDRD projects are authorized to start work at the onset of the new fiscal year following receipt of DOE-ID's concurrence, and approval by DOE-NE of the annual LDRD Program Plan.

Success Story

LDRD initially funded the Human System Simulation capability, which supports studies of human responses to normal and emergency situations in control rooms and other environments where operators interact with complex technology. The reconfigurable capability, the first of its kind in the U.S., fosters advanced research, testing and validation using both generic and plant-specific models from industry partners (project 11-062).

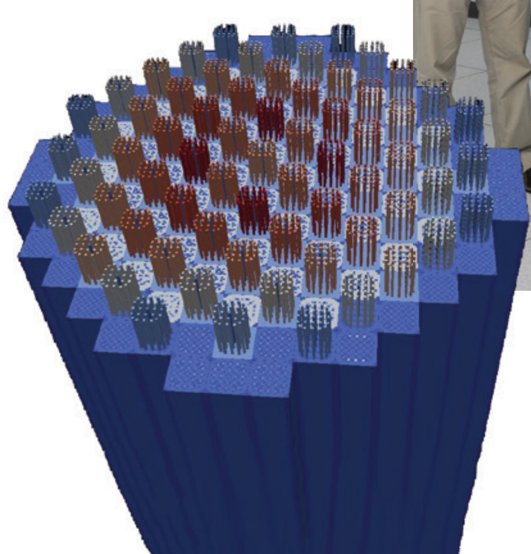
Nuclear plant safety analysis

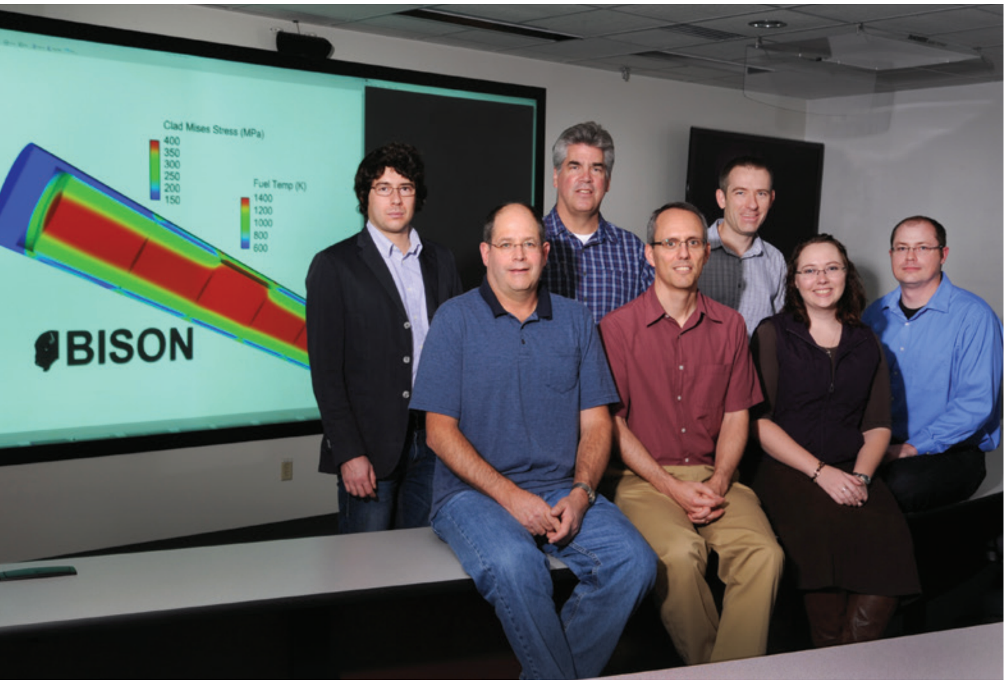
Nuclear energy plants are engineered with layer upon layer of safety systems. Risk analysts study such systems to assess the probabilities of different accident scenarios and ensure ample safety margins. As sophisticated simulations began aiding these efforts, the volume of data has soared. This LDRD project helps analysts extract useful information about the most relevant trends and the likely timing and progression of events. Specifically, the research team created new methodologies and algorithms for safety analysis codes along with new visual analysis techniques to help analysts more fully explore the uncertainties in a simulation. Such information could help designers, regulators and operators better understand how a system will behave during accident conditions (project 11-076).

Multiscale nuclear reactor simulation

Modeling and simulation has the potential to greatly accelerate nuclear materials and reactor research. Traditional approaches to building a useful simulation capability required software developers to work for years with scientists to describe a given phenomenon. INL's MOOSE

The MOOSE development team includes, from left, David Andrs, Cody Permann, Andrew Slaughter, Richard Martineau, Derek Gaston, John Peterson and Jason Miller.





The BISON development team includes, from left, Giovanni Pastore, Richard Williamson, Richard Martineau, Jason Hales, Benjamin Spencer, Danielle Perez and Stephen Novascone.

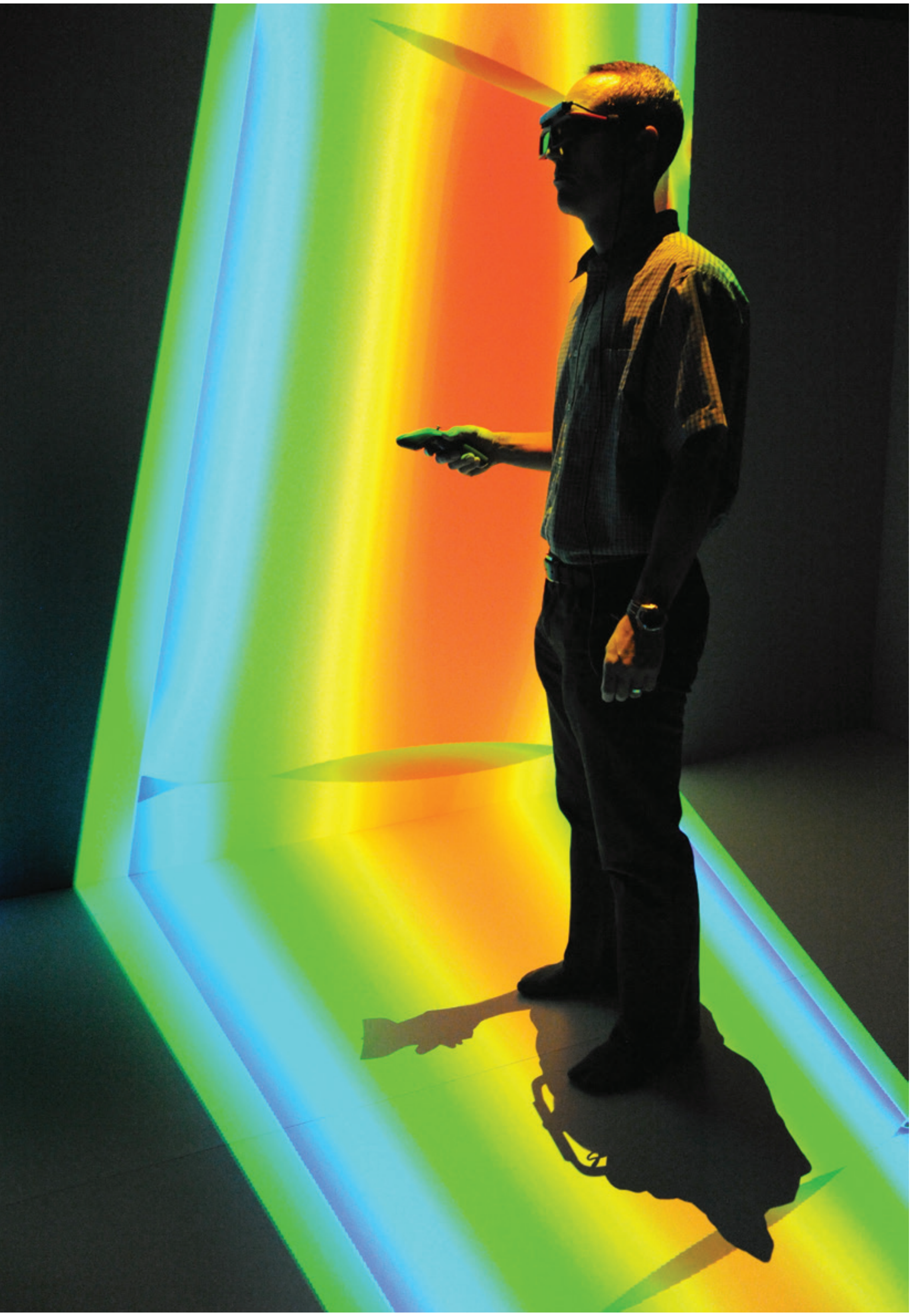
(Multiphysics Object Oriented Simulation Environment) enables simulation tools to be developed with a fraction of the resources previously required. With support from LDRD funding, MOOSE has now demonstrated the foundation for state-of-the-art full-core reactor simulation.

This project adds capability enabling MOOSE to simultaneously model multiple coupled physical systems. For example, reactor fluid flow, temperature changes, fission physics and fuels performance all impact each other. Simultaneous modeling makes it possible to simulate a full-core reactor over multiple operating cycles. The work lays the foundation for research that could enhance design and operation of nuclear fuels and reactors (project 13-097).

Another LDRD project aims to refine the simplifying approximations of fission physics used for the initial full-core simulations. The team is working to create a highly accurate neutronics model that combines modeling rigor with lower order approximations that provide accuracy without overwhelming computing resources. The goal: develop a 3-D coupled-physics model for INL's one-of-a-kind Advanced Test Reactor. The achievement would lead to smarter ATR experiment design and fuel usage, help improve safety margins, and demonstrate the ability to create accurate multiphysics models of both commercial and next-generation reactors (project 13-115).

Success Story

The MOOSE simulation capability has LDRD funding at the core of its inception and advancements. MOOSE's achievements have impacted funding decisions from national programs such as DOE's Nuclear Energy Advanced Modeling and Simulation (NEAMS) program and its Consortium for Advanced Simulation of Light Water Reactors (CASL). MOOSE also has inspired partnerships with Westinghouse and GE.



Nuclear fuel modeling

Fracturing in ceramic nuclear fuel influences its thermal and mechanical behavior under both normal and abnormal conditions. Empirical models that approximate the expansion of the fractured fuel are typically used in fuel performance simulations, but these models have a limited range of applicability. Two fracture modeling techniques — the extended finite element method (XFEM) and the discrete element method (DEM) — can model arbitrary fracture and fragmentation. This LDRD project applies those techniques to nuclear fuel performance modeling via the MOOSE-based BISON code. By accounting for fracture using physically-based models, this work will strengthen the ability to predict fuel behavior, particularly in abnormal conditions (project 13-071).

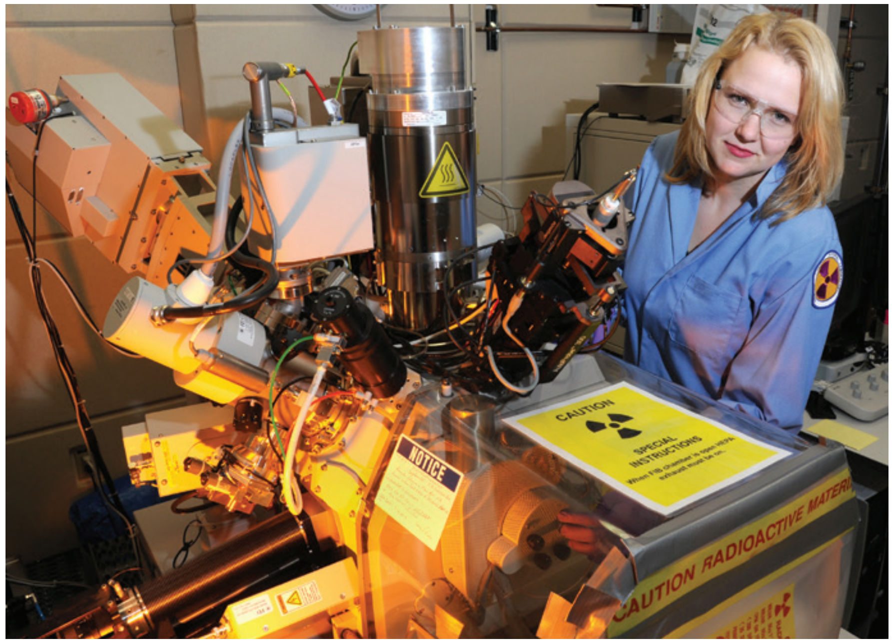
Another project explores how radiation damage leads to swelling, embrittlement and changes in material properties such as elasticity. Researchers are developing a multiscale fuel performance model that bridges atomic and macroscales. To extend an existing multiscale framework (developed under a previous LDRD) to the atomic scale, it implements the phase field crystal (PFC) model into INL's MOOSE-based

Simulation data from the BISON fuel performance code can be visualized in a Computer-Assisted Virtual Environment (CAVE).

MARMOT code. That code models intermediate-scale (mesoscale) defect evolution and the resulting change in material properties. Coupling the resulting model to BISON will create a first-of-its-kind multiscale capability that bridges the atomic to the macroscale. By providing a better fundamental understanding of mechanisms occurring during the early stages of irradiation, this project could inform design of nuclear fuels and materials with enhanced accident tolerance (project 13-050).

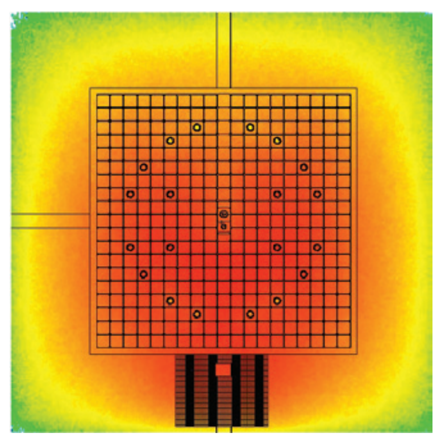
Advanced reactor fuel

Nations could reduce the inventory of nuclear waste by making electricity from some of the most long-lived elements in used or "spent" nuclear fuel. But first, scientists would like to better understand the physical properties of ultra-high burn-up mixed oxide nuclear fuel. This LDRD project combined the MOOSE/BISON/MARMOT fuel performance modeling codes with INL's one-of-a-kind capabilities for microscopic examination of irradiated materials. Specifically, the researchers used atom probe tomography to analyze mixed oxide fuel containing simulated fission products — the first ever such analysis on plutonium-bearing material. Combining the data with INL's fuel performance modeling codes will enhance fundamental understanding and modeling of nuclear fuel performance (project 13-023).



Studying fuel during irradiation

Traditional radiation experiments place a material sample inside a nuclear reactor, irradiate the sample for a set period of time, then take it out and examine it. Samples irradiated for longer or shorter periods should show a corresponding amount of changes. With enough data, a rough picture emerges of how such changes evolve. That data can inform computer models and simulations that approximate the progression. This LDRD project is investigating the possibility of monitoring the process in real time, while samples are inside a reactor. The researchers found that it should be possible to get sufficient irradiation and scanning electron microscope data for samples residing in an unused space adjacent to the Transient Reactor Test (TREAT) Facility reactor vessel. This would provide real-time data about the dynamics of nuclear fuels during the first several hours of irradiation (project 13-121).



INL has one-of-a-kind capabilities for microscopic examination of irradiated materials (top) and could soon add the ability to collect microscopic data during irradiation at the Transient Reactor Test (TREAT) facility at INL (core schematic above).

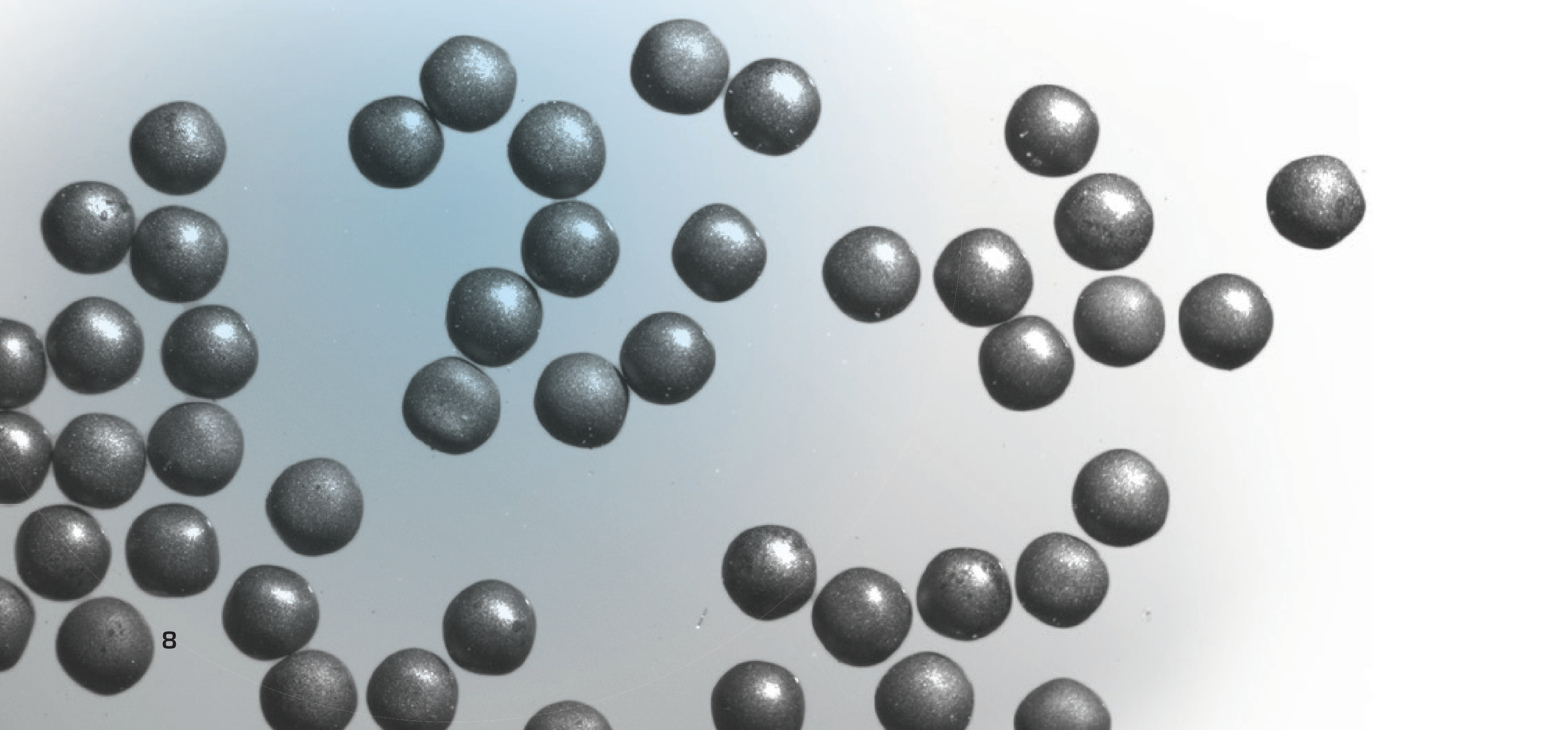
INL scientist Bruce Mincher is principal investigator on a project studying treatment of TRISO fuel particles, below.

Improved fuel fabrication

Many reactors worldwide generate electricity using ceramic-based fuels, and uranium oxide (UO_2)-based fuel pellets are among the most common. INL research previously focused on metal-based fuels showing them to be passively safe in fast reactors and less complicated to fabricate compared to oxide and other ceramic fuels. An LDRD team has developed a processing technique which resulted in improved physical and chemical properties of the granules comprising UO_2-based fuel pellets. This led to more efficient methods of packing granules into pellets, and homogeneously pressing and densifying the pellets. The scientists have begun applying what they learned about the properties of the ceramic pellets to develop fuel that is more accident tolerant (project 11-051).

Recycling from advanced fuel

One promising type of advanced nuclear fuel consumes uranium more efficiently than current technology and has built-in safety features. Layers of carbon and silicon carbide coat the poppy-seed-sized tristructural isotropic (TRISO) particles and act as the "primary containment" for fission products. Methods for treating used TRISO fuels have not been developed, and this LDRD project studied the feasibility of using supercritical carbon dioxide (Sc-CO_2) technology. Because Sc-CO_2 possesses both gas- and liquid-like properties, it can penetrate porous materials and dissolve constituents in a solid matrix. This enables Sc-CO_2 to remove specific elements directly from solid and densely packed materials, such as crushed TRISO fuel. This creates the possibility for recycling fissionable materials without the need to dissolve fuel in acid (project 11-006).



Radiation detection

Sophisticated radiation detection technologies can help officials enforce nuclear nonproliferation treaties, identify suspect materials or investigate terrorist activity. Several LDRD projects are helping enhance detection capabilities. One project is using a moderate-energy photon beam to induce emission signatures that can reveal an inspected item's contents. This extended imaging capability would enable inspectors to quickly identify the location and isotopic composition of suspect items (project 12-054).

Inspectors and investigators need to be able to detect specific fission products at very low levels. A second LDRD project developed and qualified fission product standards that can be used to calibrate sensitive detection devices. By synthesizing precise mixtures of specific short-lived isotopes, the project fills a need for calibration standards in the treaty monitoring and nuclear forensics communities (project 13-092).

A third LDRD project could spur development of new detectors and detection systems. The work bolsters confidence in a modeling tool for the nonproliferation community. The newcomer — the GEANT4 simulation toolkit — counts among its assets extreme flexibility and a strong history in the high-energy physics discipline. This project demonstrated robust agreement between GEANT4 and the trusted Monte Carlo N-Particle (MCNP) family of codes. Such understanding can improve validation and benchmarking during development of new detection technologies (project 12-073).

Measuring neutron flux

Engineers test new nuclear fuels and materials by subjecting them to the high-radiation environment inside research reactors such as INL's Advanced Test Reactor. Researchers can estimate how much neutron radiation a sample receives, but different test areas inside ATR experience differing levels of fast and slow neutrons. Developing a way to monitor real-time neutron flux for individual experiments is the goal of this LDRD project. The research team is evaluating the performance of thin-film diamond semiconductor radiation detectors that may be suited for use in high-neutron environments. Compared to existing technology, it may be smaller, more cost-effective and able to provide simultaneous information about slow and fast neutrons (project 12-062).

Success Story

LDRD funded work underlying a project that earned recognition from the U.S. Department of Energy's Innovations in Fuel Cycle Research award program. First prize in the Advanced Fuels competition was awarded to the paper describing a method for measuring fuel thermal conductivity during irradiation (project 09-007).

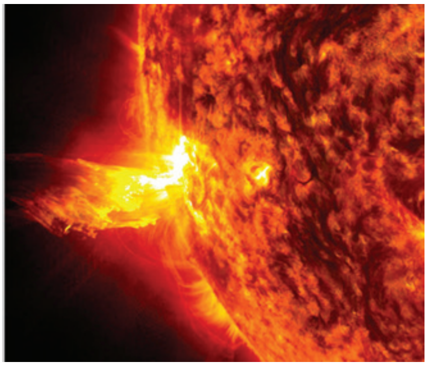
The Nuclear & Radiological Activity Center (NRAC) at INL offers an ideal location for testing or training with new radiation detection technologies.

Success Story

An LDRD project to develop novel armor materials (right) has resulted in several invention disclosures. The project developed a cost-effective process to fabricate armor-grade ceramic and a new process method to manufacture high-hardness armor steel. The research successes are a result of collaborations across INL, including the Center for Advanced Energy Studies, and the LDRD-developed capabilities on the explosives test range (project 11-060).

Energetic material ignition

Energetic materials such as fireworks or materials used for welding or cutting metal require ignition triggers that need to produce a lot of heat quickly. Such materials require careful handling so they aren't set off unexpectedly by environmental factors such as static electricity. This LDRD project resulted in an additive that can make both energetic materials and ignition triggers less prone to accidental ignition due to static electricity, yet still be effective for its intended purpose. The project has resulted in two patent applications and collaboration with Texas Tech University that helped enhance safety procedures (project 12-066).



Studying geomagnetic disturbances

When solar storms (above) create Ground Induced Currents, they have the potential to damage power grid transformers and threaten reliable energy distribution. Previously, utility companies had to rely on models and theories to mitigate possible effects. Now, INL's 138 kV transmission grid lets researchers track the impacts of such geomagnetic disturbances.

By correlating solar storm activity with data from the INL power grid, scientists can monitor any problematic effects of ground induced currents. This ability to understand and predict potential problems will benefit national utility companies and help ensure consistent energy supplies to U.S. military installations — foreign and domestic (project 13-118).

Grid security and resilience

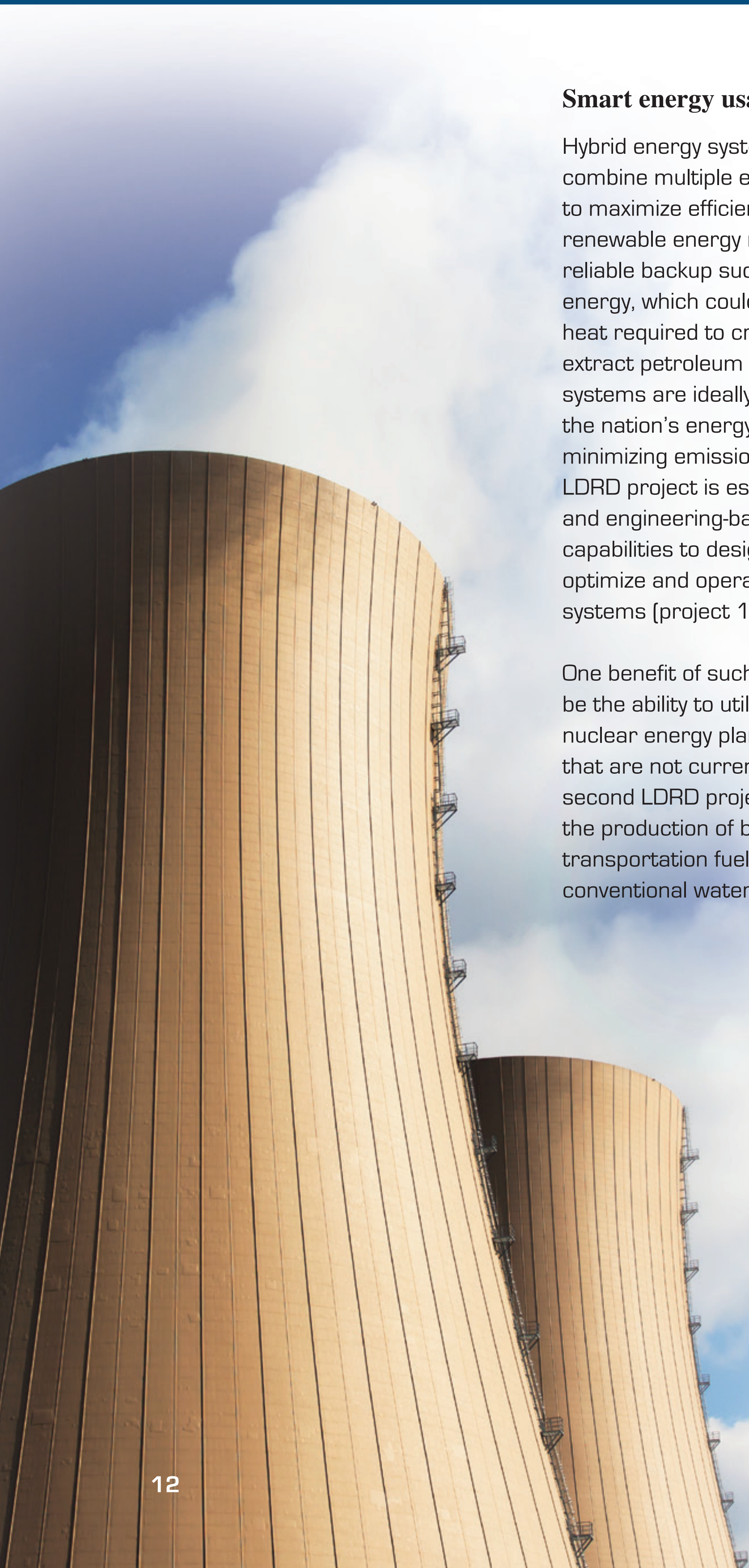
Security risks associated with networked control systems, such as a Smart Grid, can be significantly impacted by human interaction. One LDRD project explored how establishing clear goals for the interaction between human operators and control systems can allow operators to respond more calmly and efficiently to natural or malicious events. The team developed metrics and models to test and improve levels of state awareness among the operators, with the result being more effective decision-making in the face of various potential situations (project 12-121).

Another way to improve operating procedures may be to remove the human element altogether. A second LDRD project looked at increasing the autonomy of Microgrids, which are small, local electric grids like those used by universities and military bases. It is not cost-effective to staff such small grids, but current Microgrid designs lack self-governing capabilities. The team developed a control system called a hierarchical, multiagent dynamic system that is semi-autonomous and adaptive to rapidly changing conditions. Though this project focused on Microgrids, the framework can be applied to provide increased independence to various critical infrastructure control systems (project 12-089).

Success Story

New metrics for technically-based cyberthreat analysis — originally developed under LDRD investments — were developed and then integrated into INL's Mission Support Center vulnerability analysis methods to better predict, detect and respond to cyberthreats to our nation's critical infrastructure. The result is an innovative Technical Analysis Doctrine that is attracting new programs and influencing national cybersecurity policy.

The Real-Time Data Simulator at INL supports studies of how new technologies affect power grid dynamics and how ground induced currents from solar storms could affect or damage power grids.



Smart energy usage

Hybrid energy systems could combine multiple energy sources to maximize efficiency. For example, renewable energy requires a reliable backup such as nuclear energy, which could provide the heat required to create biofuels or extract petroleum products. Such systems are ideally suited to enhance the nation's energy security while minimizing emission concerns. One LDRD project is establishing scientific and engineering-based computational capabilities to design, analyze, optimize and operate hybrid energy systems (project 13-065).

One benefit of such systems would be the ability to utilize the heat from nuclear energy plants for applications that are not currently possible. A second LDRD project is exploring the production of biomass-based transportation fuels using heat from conventional water-cooled reactors. Because the biofuel production process requires higher temperatures than those produced by conventional light-water reactors, the research team analyzed favorable biomass sources and chemical heat pumps (ChHPs) that would be optimal for the task. Next, the researchers will collect data from a lab-scale prototype followed by a design and economic study (project 13-107).

A third LDRD project also focuses on using the heat from nuclear reactors for other applications. The oil shale deposits in Colorado, Utah and Wyoming are among the largest potential sources of oil on Earth. But recovering these resources requires vast amounts of heat that would make the process unsustainable using conventional heat sources such as natural gas. A hybrid energy system anchored by nuclear energy could provide electricity to the grid during peak usage or when renewable sources are unavailable. When not needed, the nuclear plant's electricity and heat could be diverted to convert oil shale to oil and hydrocarbon gases. Such a system would enable the grid to accommodate more renewables without the associated challenges of requiring backup power (project 13-110).

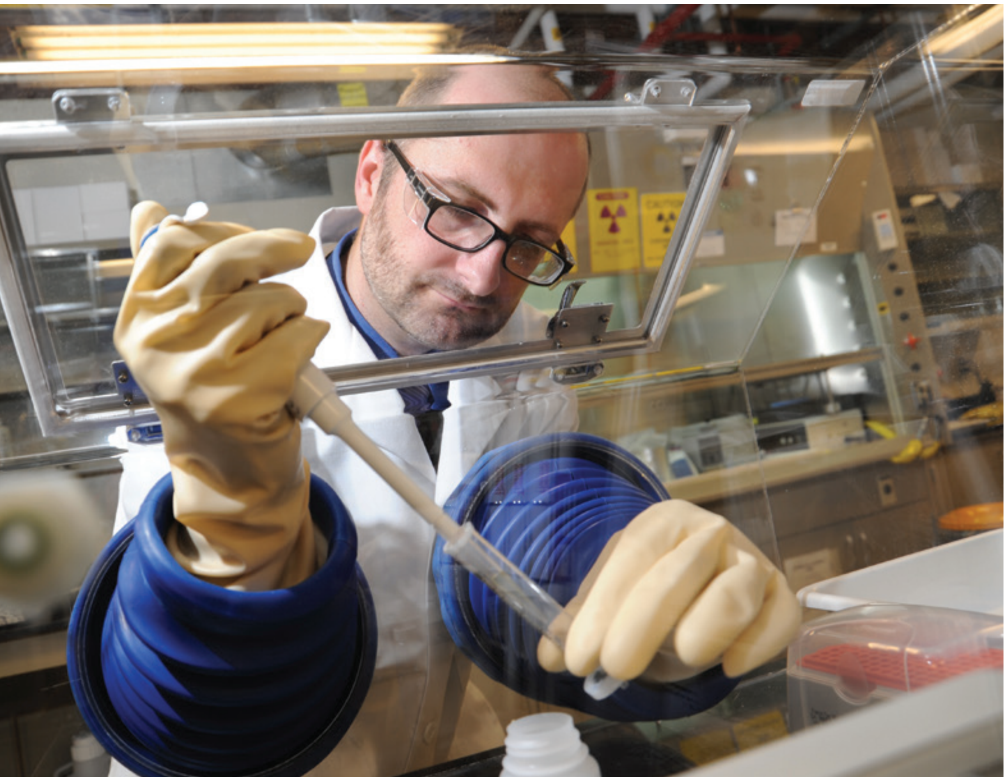
Sustainability via nanotechnology

LEDs and other solid-state lighting applications currently rely on Rare Earth phosphors, but supply issues associated with such materials are a growing concern. INL researchers are hoping to change that. LDRD researchers at INL have shown that highly luminescent semiconductor nanomaterials with tunable light emission properties could provide more sustainable lighting alternatives. An LDRD team led proof-of-principle tests demonstrating that a number of light-emitting phosphors using synthesized nanoparticles could advance "green" technologies and have practical uses for commercial industries (project 12-093).

With consumer electronics waste on the rise, INL scientists are also turning to nanotechnology as a means of removing and reusing Rare Earth elements and other critical energy materials. This LDRD project is testing composite agglomerates of carbon nanotubes that could be used in the recovery of precious metals from high-acid liquid waste streams. When these solutions were applied to products, such as computer and cell phone circuit boards, the scientists were able to remove particles of gold. Though this research focused mainly on gold, the general technology provides an opportunity to remove undesirable products from water and recover valuable materials at the same time (project 12-056).

Success Story

LDRD funding has been part of a deliberate effort to build INL capabilities related to the separation and recovery of critical energy materials. Those investments paid off when INL was named as a partner in the DOE's new Critical Materials Innovation Hub, which is being led by DOE's Ames Laboratory.



INL research scientist Peter Zalupski is principal investigator on a project studying precious metal recovery from waste streams such as consumer electronics.

Success Story

LDRD initiated the proof-of-principle project to explore a new, efficient, cost-effective way to convert greasy wastewater, such as from water treatment plants, to biofuel. The Supercritical/Solid Catalyst technology won numerous technology awards in 2010 including an R&D 100 Award. The technology has been licensed and has an active Cooperative Research and Development Agreement to further explore applications.

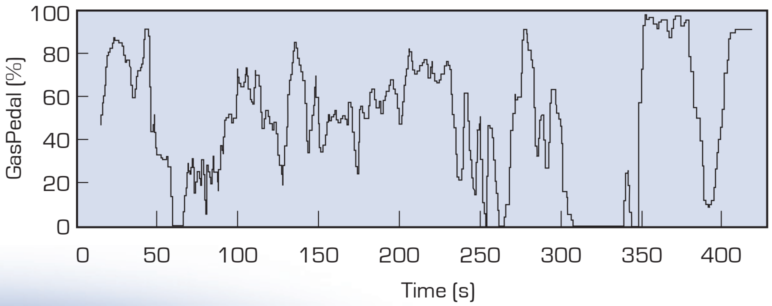
Improving lithium batteries

Improvements in both the safety and voltage capacity of lithium-ion batteries will be necessary to power transportation fleets with electricity. Current lines of research aim to improve Li-ion battery technology, but one group of LDRD researchers is exploring a novel approach using inorganic materials. In the past year, the researchers have developed alternative electrolyte solvents that significantly decrease battery flammability and volatility, dramatically improving safety and performance. Also, they are developing alternative cathode materials to improve battery voltage and overall performance while further enhancing safety. This use of inorganic materials is already improving the safety and lifetime of lithium-ion batteries (project 12-118)

Another LDRD team is taking a different approach to improving conductivity and lifetime performance of lithium-ion batteries. The team used first-principles simulations and thermodynamic models to guide the synthesis of nanostructured high-energy electrodes and to better understand the behavior of these nanomaterials. The ultimate goal is to develop an integrated nanostructure basis for cell design, which will use nanomaterials as the primary means of improving cell performance, stability and lifetime. This work will help accelerate INL intellectual property onto the lithium-ion battery market in a more competitive time frame (project 12-120).

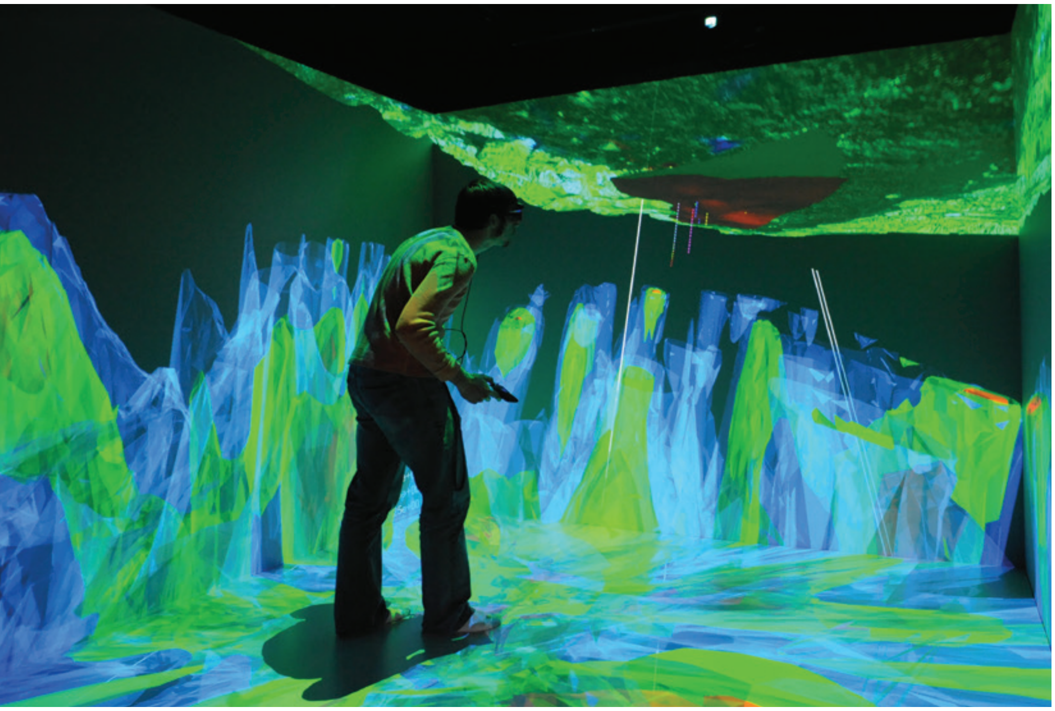
Driving for fuel efficiency

Heavy- and medium-sized trucks represent 4 percent of all vehicles yet they use more than 20 percent of all fuel (over 22 billion gallons per year). Most research focuses on improving fuel and engine design, but simple changes in driving practices can affect fuel efficiency by up to 30 percent. To help enact behavioral changes, LDRD researchers created a software program that tracks engine data and uses GPS to provide drivers with real-time performance analysis and optimal-driving cues in advance of upcoming terrain. They tested the software with the drivers of INL's fleet of large vehicles, and have caught the attention of many government and industry organizations (project 11-065).

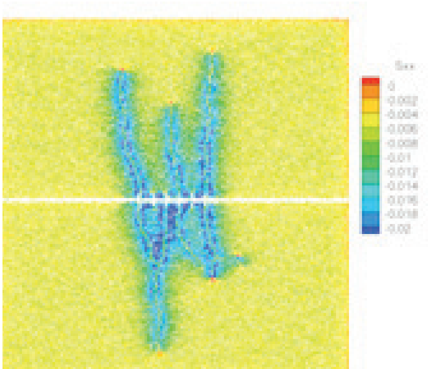


Modeling for geothermal energy

Geothermal energy is an important resource in the movement toward carbon-free energies. However, a better understanding of the lifetime of geothermal reservoirs is necessary. One LDRD project used a combination of established analytical and numerical modeling techniques to create a new modeling tool for these purposes. The tool can be used to predict the long-term thermal evolution and energy productivity for real and hypothetical geothermal reservoirs. The team also analyzed available data to look at productivity given typical geothermal operational constraints. This work will fill a critical gap in the industry's ability to understand and predict the effects of heat exchange in fractured geothermal reservoirs (project 13-068).



Researchers can view subsurface models using the Computer-Assisted Virtual Environment (CAVE) in the Center for Advanced Energy Studies (CAES) at INL.



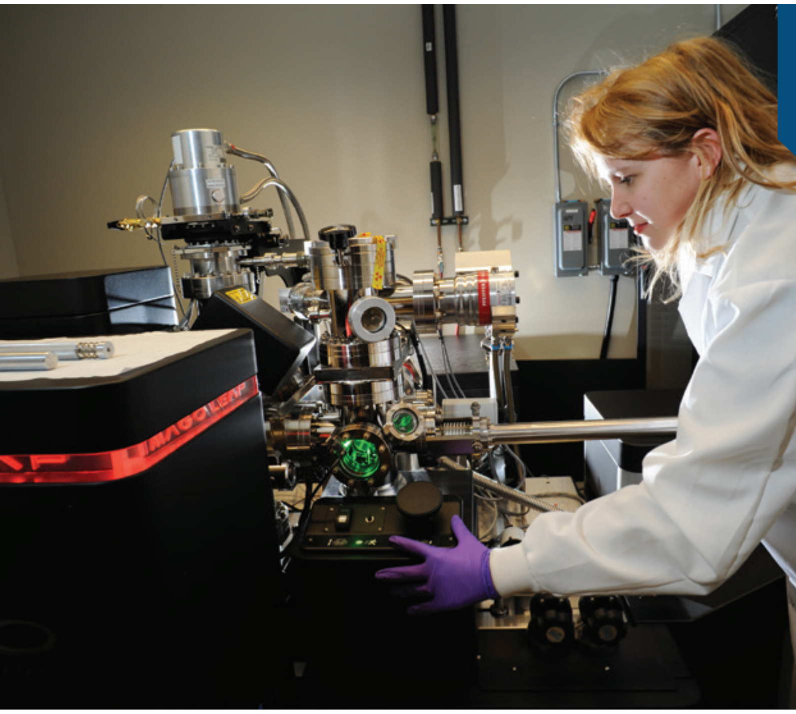
Safe natural gas recovery

As recovery and use of natural gas accelerate, scientists are studying ways to improve sustainable recovery. INL scientists are looking at the physics behind coupling fluid flow, deformation and fracturing in shale formations. The researchers created a computer model that combines two methods for analyzing particles in a fluid. Using this model, the researchers can now assess characteristics like the viscosity of the fluid to predict patterns of fracture. The results gathered over the next year will help fill gaps in current knowledge and fundamental understanding of the hydraulic fracturing processes (project 12-113).

Meanwhile, public concern about contamination of water due to hydraulic fracturing has led another LDRD team to evaluate improving water usage during the fracture process. A new fluid dynamic model allowed the team to run simulations suggesting that different locations along the fracture are important at different times during water and gas drainage. The scientists are now running simulated experiments to provide validation for the model. This advanced understanding of water usage during various stages of the fracture process could ultimately help minimize the amount of water necessary, which would benefit both the environment and the gas industry (project 13-114).

LDRD researchers are studying water saturation relevant to hydraulic fracturing using INL's geocentrifuge.

AWARDS AND RECOGNITION

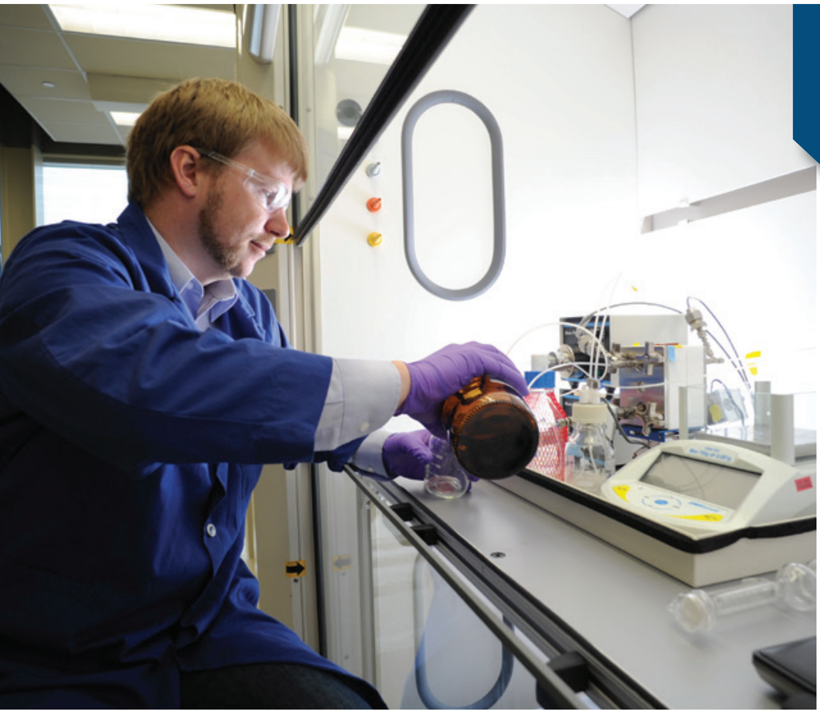


MELISSA TEAGUE

The fuel performance and design scientist was recognized with the Young Scientist Award at the European Materials Research Society (E-MRS) Spring Symposium in Strasbourg, France. The award was presented for her dissertation work, which included her LDRD research. She earned her doctorate from the Colorado School of Mines while working full time at INL. She was also one of a dozen women nationally honored at the Massachusetts Institute of Technology's Rising Stars in Nuclear Science and Engineering Symposium. Melissa is principal investigator on two LDRD projects related to microstructural characterization of nuclear fuel performance (projects 12-031 and 13-023).

"Melissa has an obvious passion for nuclear materials.... Her techniques will certainly become the standard for post-irradiation examination analysis of fuels using [these techniques]."

— Brian Gorman, Interdisciplinary Materials Science Program Director, Colorado School of Mines



AARON WILSON

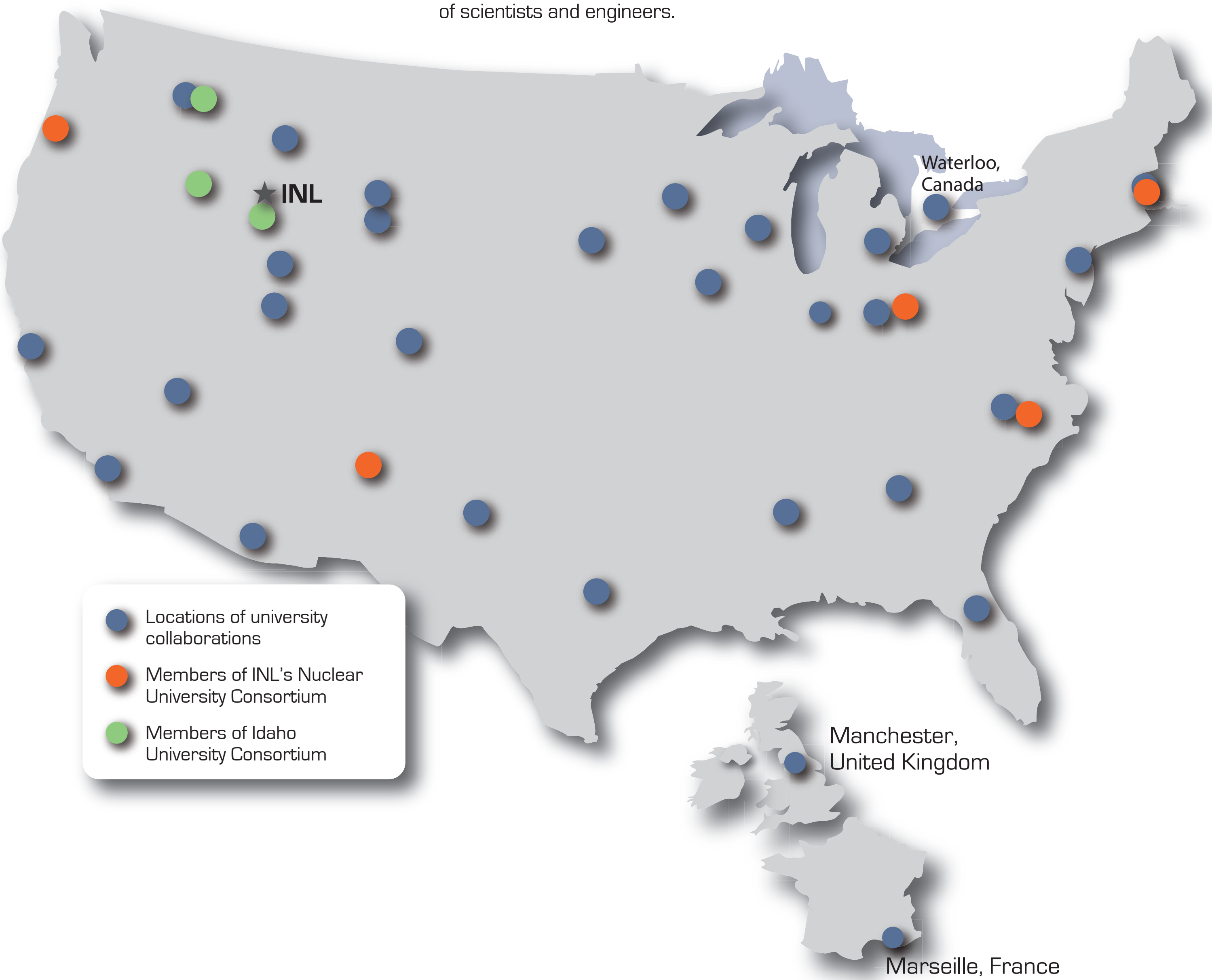
The INL researcher led a team that developed Switchable Polarity Solvent Forward Osmosis (SPS FO), which combined two known processes to create an innovative new water-filtration system for highly concentrated industrial wastewater. This technology can turn wastewater back into potable water more efficiently and less expensively than existing methods. The team won a 2013 R&D 100 Award and an Outstanding Technology Development Award from the Federal Laboratory Consortium Far West Region. LDRD provided funding for the work, and Aaron is principal investigator on another LDRD project (projects 10-092 and 12-096).

BEN LANGHORST

The materials scientist earned INL's Mentor of the Year Award for his work with Washington State University undergraduate student Andrew Robinson. During Andrew's 10-week internship at INL, Ben guided his work on an LDRD project to characterize the performance benefits of using polymers in advanced lightweight armor to protect vehicles used by military, law enforcement and emergency responders. Andrew said the work inspired him to explore graduate degree programs in the field (project 12-017).

UNIVERSITY COLLABORATIONS

Of 90 LDRD projects funded in FY 2013, more than half (55 projects) involve university collaborators. These projects supported 13 undergraduate students, 22 master's degree candidates and 55 doctoral candidates. Collaborations between university and national laboratory researchers foster creativity and opportunities for academic scientists to help find solutions to national challenges. Such collaborations also support DOE objectives for nurturing the next generation of scientists and engineers.



SUPPORTING INL DOCTORAL RESEARCH

Melissa Teague's doctoral research was supported by two LDRD projects: "2-D and 3-D EBSD Technique Development and Microstructure Reconstruction for Phase Field Microstructure Evolution Models" and "Characterization and Modeling of High Burn-up Mixed Oxide Fuel" described in the Advanced Reactor Fuel highlight on pg. 7 (projects 12-031 and 13-023).

Catherine Riddle's doctoral research is supported by the LDRD project "Speciation Behavior of Americium Oxidation States for the Separation of Americium from Curium in Nuclear Processing" (project 11-005).

The LDRD project "Epistemic Uncertainty Quantification in Dynamic Probabilistic Risk Assessment" is supporting **Joseph Nielsen's** doctoral research. The project is developing new tools for assessing nuclear plant safety risks so they can be effectively mitigated (project 13-040).

John Koudelka's doctoral research is supported by the LDRD project "Examination of the Impacts on Water Resources from Commercialization of Fossil Energy Development in an Arid Western Basin Using Integrated Hydrologic Modeling" (project 13-122).

The LDRD project "Improved Control System Resilience via Secure Machine Learning" is supporting **Todd Vollmer's** doctoral research (project 13-120).

Tim McJunkin's doctoral research is supported by the LDRD project "Known Secure Sensor Measurements for Detecting Unauthorized Process Manipulation and Falsification of State" (project 11-046).

INTERNS AND POST-DOCTORAL FELLOWS

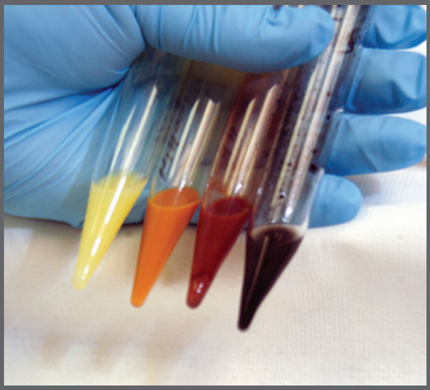
Post-doctoral fellows:

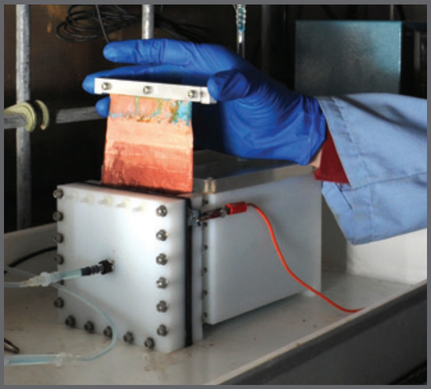
Pritam Chakraborty
Farhad Farzbod
Travis Grimes
Weifeng Rao
Prabhat Tripathy
Xiaoyu Zhang

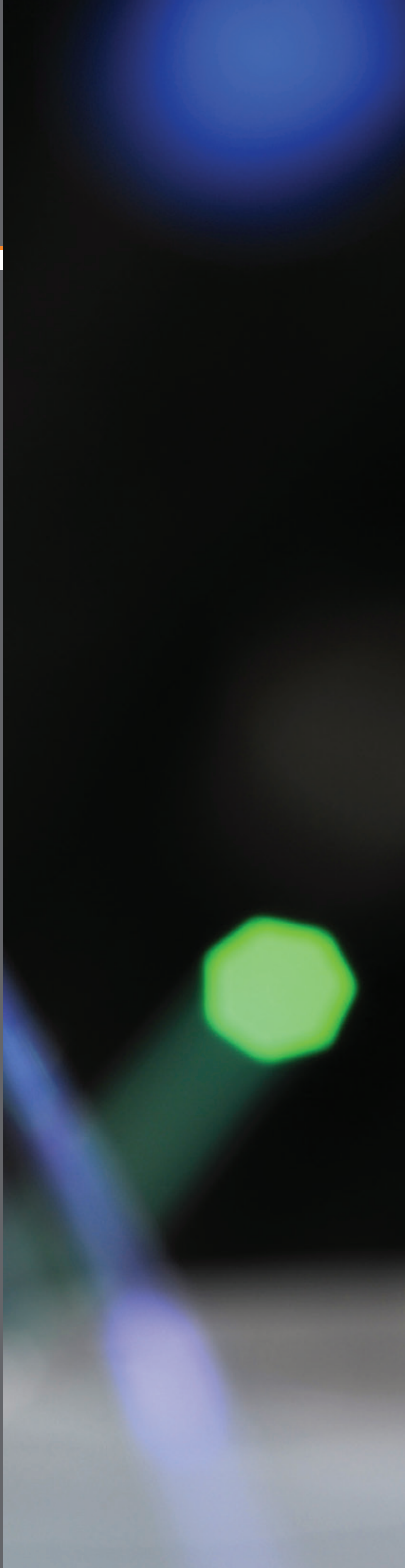
Interns:

Kevin Aiton
Tram Bui
Aaron Butterfield
Shane Carnohan
Guy Dutech
Matthew Ellis
Rita Hoggan
Kai Huang
Derek Lax
Mary Ellen Mincher
Jack Norbeck
Jacob Peterson
Megan Petti
Andrew Robinson
Sebastian Schunert
Michael West

The Laboratory Directed Research and Development (LDRD) program at Idaho National Laboratory advances cutting-edge research and helps develop strategic capabilities that span the lab's nuclear energy, national security and energy security mission areas.







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