MATTER

A publication of Savannah River National Laboratory
Winter 2024

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Savannah River National Laboratory®

The morning sun breaks on the 39-acre SRNL campus, located on the Savannah River Site, Aiken, South Carolina. SRNL photo by Laura Russo, SRNS.

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Produced by the SRNL Office of Communications

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Savannah River National Laboratory is a United States Department of Energy multi-program research and development center that's managed and operated by Battelle Savannah River Alliance, LLC (BSRA) for the Department of Energy's Office of Environmental Management. SRNL puts science to work to protect the nation by providing practical, cost-effective solutions to the nation's environmental, nuclear security, nuclear materials management, and energy manufacturing challenges.

cover: Nick Spivey dons robotic gloves, photo by Mike Ettlemyer

From the Director

"We put science to work" is more than just a tagline at Savannah River National Laboratory (SRNL). It's what we are known for throughout the nation and around the world.

SRNL is an applied research national lab. We put science to work to solve our nation's toughest problems, and to make our world safer and more secure.

We bring efficient scaled solutions necessary to complete the safe cleanup of waste from decades of nuclear weapons development and government-sponsored nuclear energy research. We also develop solutions to ensure our nation maintains a safe, secure and reliable nuclear stockpile, while preventing nuclear weapon proliferation. Finally, we house scientific and engineering expertise that is critical to the development of reliable clean energy.

In this issue of MATTER we examine SRNL's research to more accurately and rapidly account for tritium – a radioactive isotope of hydrogen that is a component of nuclear weapons and vital to fusion energy. Our research using magnetic fields to measure tritium in just milliseconds has the potential to save time, effort and expense associated with tritium accountability in the field.

Another article describes how additive manufacturing is helping sustain legacy equipment still in use today for which parts haven't been made since the 1970s. Wearable robotics is the subject of another story that highlights how our research is contributing to the development of devices designed to reduce injuries to those who do physically demanding work in environmental management.

I believe that after reading MATTER, you'll have new insight into what SRNL does and how our work benefits our nation, the Savannah River Site and the world. I'm pleased to share this issue of MATTER with you as we approach the 20th anniversary of our designation as a national laboratory and continue to put science to work.

Vahid Majidi
Director, Savannah River National Laboratory

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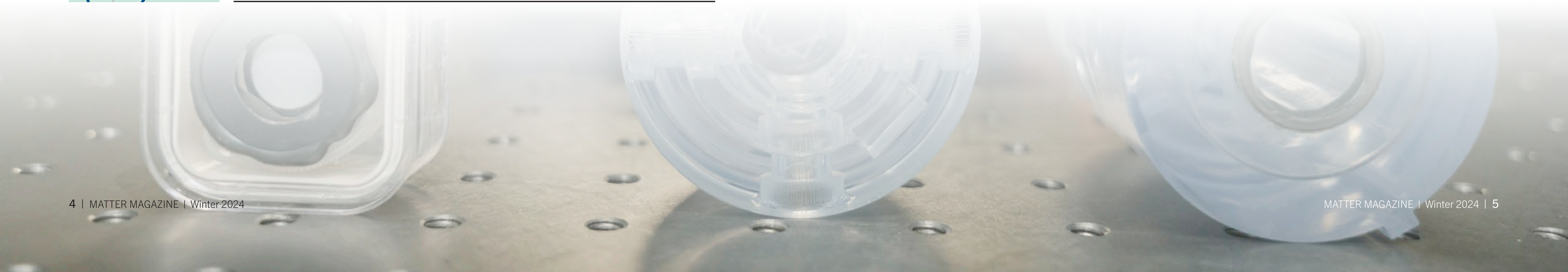


Hydrogen Process Imaging Project Wins 2023 MVP Award

Collaboration with university partners helps develop SRNL expertise in magnetic characterization.

by Mike Ettlemyer

Savannah River National Laboratory (SRNL) strives to continually improve process efficiencies, generate innovation and increase impact. The Laboratory Directed Research and Development (LDRD) program helps meet these objectives by providing early investment in research concepts, discovery science and programs that further strategic goals and future missions.

Each year, the LDRD program recognizes a Most Valuable Project (MVP) that generated the highest return on investment during the previous five-year period. For 2023, the MVP award went to George Larsen and his Hydrogen Isotope Science team for their work on hydrogen process imaging using magnetic fields.

"I was trying to think of a way that we could use an external system to probe the interior of a process vessel to provide information of what type of hydrogen content might be in there," says Larsen.

George Larsen (right) leads the Hydrogen Isotope Science team at SRNL.
SRNL photo by LJ Gay, SRNS.

"We found that the interaction with hydrogen, metals and magnetic fields is actually a very useful way to create a hydrogen sensor."

- George Larsen

Hydrogen, the smallest element, can get absorbed into solid materials. The project presented new concepts for magnetic measurement of metal hydrides and successfully demonstrated that this technology can detect hydrogen in metals enclosed inside a metal vessel.

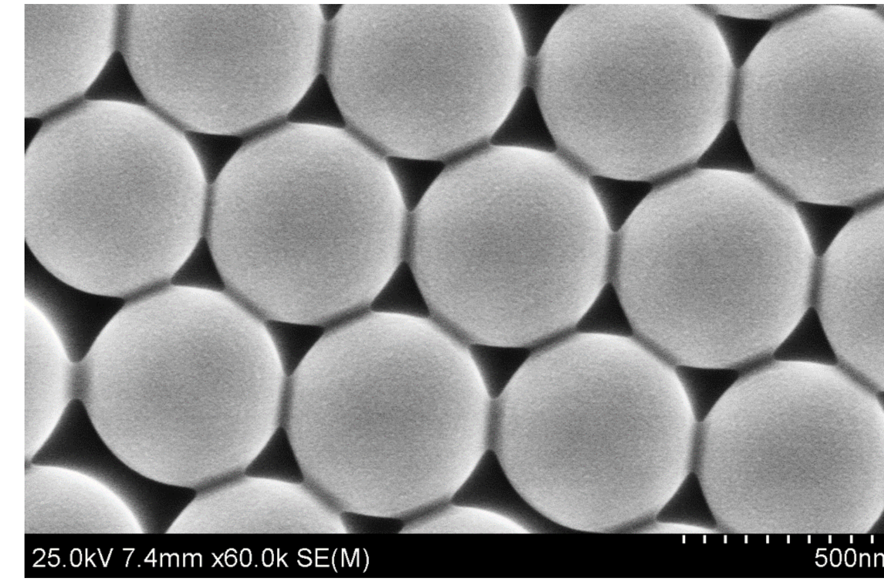
"We demonstrated that we could measure the hydrogen content of the metals through solid vessels and that we could create an image of that," says Larsen. "We found that the interaction with hydrogen, metals and magnetic fields is actually a very useful way to create a hydrogen sensor."

Much of the Hydrogen Isotope Science group's work is focused on tritium, an isotope of hydrogen, and supporting the Savannah River Site's (SRS) Tritium Enterprise.

These measurements of hydrogen content are important. Tritium is a radioactive material and component of nuclear weapons. The Department of Energy (DOE) has strict rules on radiological accountancy, such as keeping track of all the tritium in a facility like those at SRS, or when it's transferred to another site. While the current measurement process used is very accurate, it is slow – requiring more time, effort and expense than is desired.

The novel idea of using magnetic fields and sound execution of supporting research resulted in the development of advanced, ultrafast hydrogen sensors with a record response time of 90 milliseconds. The idea was to deploy these sensors in the field.

The MVP award is based on objective measures of the return on investment of the research, including follow-on-funding, publications, presentations, intellectual property, new hires, partnerships and awards. Larsen and his team, in collaboration with the



A top-view scanning electron microscope image of palladium-cobalt nano-patchy, the material that comprises the hydrogen sensor Larsen's team developed.
photo: Savannah River National Laboratory

University of Georgia (UGA) and four other academic institutions, helped develop SRNL's expertise in magnetic characterization.

The research's contributions to the scientific community as well as its relevance to tritium, clean energy and legacy waste missions, will continue to help maintain SRNL's strength in science and technology. It has accumulated an impressive return on investment, including: an additional $2 million in follow-on projects from three separate funding opportunities; seven publications in top peer-reviewed journals, including *Nano Energy, Nature Communications* and *Applied Nano Materials*; and one patent for the team's sensor concept.

"We spent a lot of time getting measurements right, performing additional experiments, and diving deep into the fundamental mechanisms of our materials," says Larsen. "This was 'below-the-surface' work that allowed us to take these sensors to the next level and inspired follow-on projects."

Larsen credits his close collaboration with Professor Tho Nguyen and his UGA students, Hoang Luong and Minh Pham, as a primary reason for the project's success. He's also proud to contribute meaningful research to SRNL.

"[George] is a remarkable figure in SRNL and I am confident he will continue harvesting more successes from his efforts," says Jose Cortes-Concepcion, manager of the SRNL Hydrogen Isotope Science Group. "The group is very happy to have him as a teammate and mentor."

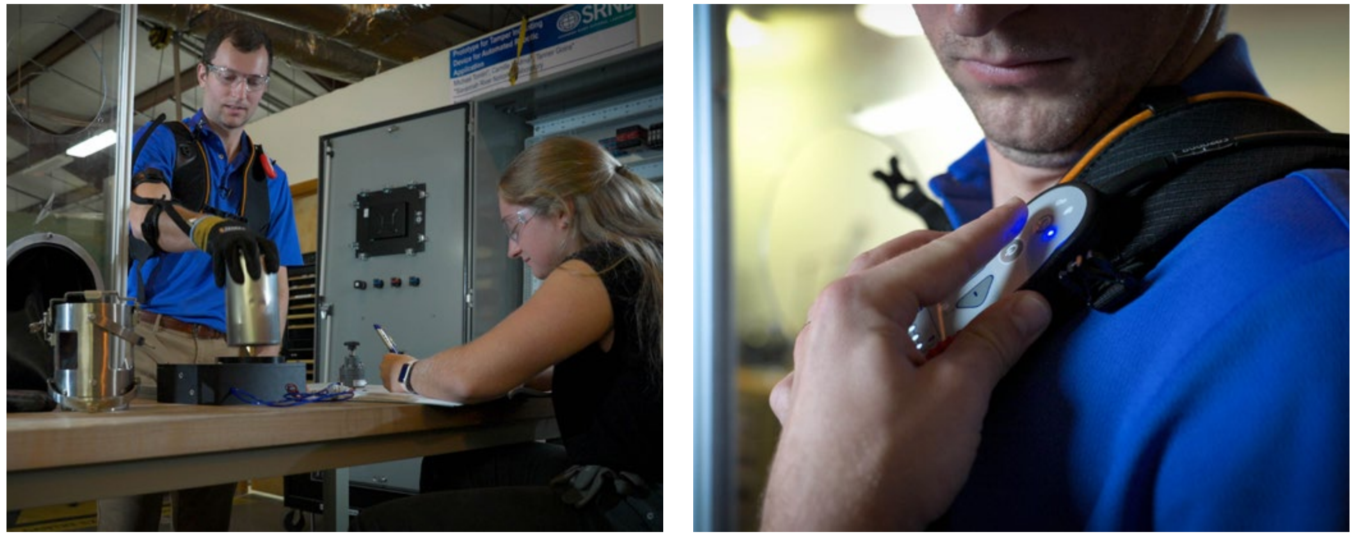
SRNL's LDRD program fosters early exploration and application of creative and potentially transformational ideas that contribute to the global scientific community and enhance the lab's ability to execute current and future mission priorities.

Larsen's scientific leadership and risk-taking innovation are an excellent representation of LDRD and SRNL's overall mission.

Wearable Robotics Team Finds Innovative Ways to Prevent Injuries

by Kent Cubbage
photos by Justin Crawford, SRNS

SRNL wearable robotics team members Cami Kudrna (left) Nick Spivey (center) and Tanner Goins (right) evaluate robotic devices in routine tasks.



(left) Nick Spivey demonstrates the Iron Hand device. (right) Iron Hand grip strength adjustment control.

The nation's nuclear weapons program helped win the Cold War and continues to provide a deterrent vital to national security, but it also left a significant environmental legacy. While environmental cleanup has been completed at most Department of Energy (DOE) sites associated with the nuclear defense program, fifteen sites still have decades of waste processing, storage, remediation and decommissioning work ahead of them.

Automation and teleoperation have sped up legacy cleanup and increased worker safety, but the complex nature of many tasks still necessitates manual, physically challenging work. Personal protective equipment (PPE) can be ungainly, jobs can be both highly diverse and repetitive, and strain can be placed on the musculoskeletal system. Fatigue is also common while performing these tasks. These conditions greatly increase the risk of injury.

DOE's Office of Environmental Management (EM) recognized this issue, and sponsored Sandia National Laboratories ("Sandia") as the testbed to develop wearable robotics technologies to increase worker safety at EM sites. In turn, Sandia assembled a team of partners for the project from academia, industry and other national laboratories including Savannah River National Laboratory (SRNL).

Jason Wheeler, EM wearable robotics program lead at Sandia, said the team was built as an "organic collaboration," as interdisciplinary partners came into focus by having unique expertise and experience. "SRNL has deep institutional knowledge of DOE and DOE-EM," Wheeler said. "They know how to deploy devices compatible with [DOE] PPE, security, and safety culture."

In late 2021 Sandia reached out to the Instrumentation, Robotics, and Imaging Systems group in SRNL's Advanced Engineering department. Knowing the tremendous potential for wearable robotics across the EM landscape, the SRNL team jumped at the chance to participate. The group consists of Rick Minichan, Tanner Goins, Cami Kudrna, and Nick Spivey, with Spivey serving as lead.

The team's expansive facility boasts large robotic machines worthy of an automotive production line, but the wearable devices are personal and sleek, even referred to as "exoskeletons." This term conjures up images of full-body superhero suits like Iron Man's, but the team emphasizes that the devices are for strain, injury and fatigue prevention, not performance enhancement. "These devices don't help you lift more – that's a slippery slope – someone will get hurt trying to do too much," said Spivey. "But what it does do is prevent overuse and strain injuries, so if you are lifting heavy things from the ground, these [devices] help reduce the chances of that happening by offloading the weight to somewhere else on your body that's less likely to be injured."

> "There are devices for basically every joint, every muscle you can use, to help in some way or another."
>
> - Nick Spivey

Some of the devices are truly robotic, containing active sensors and motors, but many of them are passive. They contain a band or a spring that stores and releases energy to make tasks less physically demanding. Some of the devices have rigid structures, while others are constructed of only soft materials. The group has custom fabrication capability, but 80-90% of the devices are existing, commercial technologies. It's the team's charge to identify potential applications for EM. SRNL supports a myriad of different activities across the Savannah River Site (SRS) and the DOE complex, greatly increasing the chances of a match between task and device.

The shoulderX device reduces shoulder strain and fatigue associated with overhead lifting.

One of these applications is shielded cell work, a labor-intensive task in heavy use at SRS. Shielded cell workers must be on their feet for long periods of time, which causes stress and fatigue on the lower extremities. The Noonee "Chairless Chair" device attaches discreetly to the thigh and shoe, with articulated pieces running up the back of the legs. A worker can stand and walk while wearing the device but when transitioning to the sitting position, the device instantly reconfigures into a chair, taking the standing weight off the legs.

Another common task at SRS is lifting 45 lb. lead shielding blankets at H Tank Farm. Individual workers must lift and reposition these blankets onto process pipelines up to 50 times per day. The HeroWear "Apex" device offloads weight from the lower back to the thighs, greatly reducing the chances of back injury. Moreover, glovebox tasks are common across SRS. The Bioservo "Iron Hand," a true robotic device, actively enhances each finger's grip strength, reducing strain on the hands.

The SRNL wearable robotics team hopes to identify more applications at SRS, but also markets the technology to other EM sites. Recently the team traveled to Oak Ridge National Laboratory to demonstrate some of the devices. SRNL is geographically positioned to be the project liaison to other EM sites in the eastern U.S. "There's such a wide range of use cases for these devices," said Spivey. "There are devices for basically every joint, every muscle you can use, to help in some way or another."

In doing so, the team reflects SRNL's ability to partner across the DOE complex and beyond, as well as support projects headquartered at other locations, including wearable robotics at Sandia.

The team might not be developing technology for superheroes, but in reducing the chance of injury and allowing workers greater peace of mind while on the job, they are everyday heroes in their own right.

ENVIRONMENTAL &
LEGACY MANAGEMENT

SRNL Expands Biological Research, Biotechnology Programs

by Chris O'Neil, APR

Courtney Burckhalter, a research associate in Savannah River National Laboratory's biological and analytical sciences group, prepares samples taken from one of the 24 Savannah River Site cooling towers. Burckhalter's group, which is part of SRNL's division of earth biological and quantitative system science, helps keep Savannah River Site workers safe from Legionnaires' disease. SRNL photo by Chris O'Neil, APR.

Savannah River National Laboratory is well known for its body of work in tritium, development of technologies for the disposition of nuclear wastes, and advancements in environmental remediation. Not as widely known is SRNL's work in biological research. For nearly 25 years, SRNL also conducted applied research related to microbiological processes focused on bioenergy and environmental processes. Today, Savannah River National Laboratory is expanding its work in biological research and biotechnology.

Biomanufacturing at SRNL is poised to take on renewed interest as the Advanced Manufacturing Collaborative opens in 2025. SRNL's Director, Vahid Majidi, sees biomanufacturing as a means to, "apply non-fossil fuel-based hydrocarbons that still allow the use of modern processes familiar to industry to produce materials we all use every day."

Corey Radtke, biomanufacturing lead in SRNL's Earth Biological and Quantitative System Science Division, said SRNL is expanding its biological competence and expertise so that the Lab can help assist commercial successes stemming from fundamental microbiological and molecular processing that drives environmental, advanced biomanufacturing, and national security processes. "SRNL leverages a strong history regarding analysis and understanding of complex microbial and chemical processes in aquatic and subsurface environments to allow interrogation of coordinated biological processes at process levels, considering nucleic acid, protein and metabolite levels, letting the bottom line drive decisions, not necessarily the metrics along the way." Radtke said.

For Radtke, SRNL's tag line of we put science to work means accepting tradeoffs and pivoting to economical solutions, embracing costs and energy requirements of feedstocks, capital equipment sensitivities, material throughput capacity, including costs such as labor and product purification, against the market values and volumes of the produced materials. To him it means embracing the reality of biomanufacturing's technoeconomic analysis, looking at it, and asking, what will work and what can we do to make this work. "What pathways emerge when we take this sober-minded reality, including the full lifecycle analysis, the full carbon footprint, what are the types of things that jump out at us," said Radtke. "There are relationships and synergies that jump out at you that are very much doable, but for some reason people aren't doing it quite yet, and that is tremendously exciting. There are commercial interfaces to go after that make a lot of sense," he said.

Brady Lee, director of SRNL's Earth Biological and Quantitative System Science Division, said he envisions the division working in the development of sensors and biosensors for environmental, bioenergy and nonproliferation monitoring. Lee said coupling those sensors with machine learning and artificial intelligence, as is being done in the ALTEMIS project, could provide real time and actionable information. "We're starting to bring in new areas of research both from environmental management, bioenergy and defense related organizations," said Lee.

Another area of biological research at SRNL involves understanding what genetic markers make microbes resistant to radiation.

"We were trying to sequence microbial samples from the L-basin on the Savannah River Site to see how the microbes were tolerating the radiation there," said Nate Losey, a postdoctoral research associate in the biological and analytical sciences group, under Lee's Earth Biological and Quantitative System Science Division. "We were collaborating with New Mexico Tech and they were studying some organisms that were very radiation resistant and we thought if we could figure out what made those organisms radiation resistant, could that property be transferred to other organisms?"

"If we know what these radiation resistant biomarkers are, and if we could come up with the ability to transfer those to non-radio-resistant microbes, we could possibly find additional remediation processes," said Lee. "If you had a microbe that broke down the organic portion, and then were able to give it the ability to survive in those high radioactive environments, they you're basically taking out one component of the mixed waste. That decreases cost."

Biofilms and their relationship with corrosion is another area of research for Losey. Instead of looking at radio resistant microbes for remediation, Losey and other researchers are looking at microbes' effect on metals, including those metals used in radiological storage and processing.

"Biofilms are layers that microbes produce on surfaces when they grow and they secrete a lot of gooey organics," said Losey. "It helps them stick, it's part of their life strategy, and sometimes the microbes seem to enhance the rate at which corrosion occurs. Metal will develop pitting and start to corrode at an accelerated rate where biofilms are present," he said. Courtney Burckhalter, a research associate in SRNL's Biological and Analytical Sciences Group, works in the L-Basin Corrosion Monitoring Program, where biofilms and corrosion are studied. Burckhalter

The tools of the Legionella program researchers await their use in the biological and analytical sciences laboratory at Savannah River National Laboratory. The chemistry of water samples taken from 24 Savannah River Site cooling towers is part of understanding if conditions are favorable or unfavorable for the development of Legionella pneumophila. SRNL photo by Chris O'Neil, APR.

samples the water surrounding spent fuel rods stored in the basin to see what bacteria in the water is contributing to corrosion and the results of the analysis are provided to L-Basin.

Losey is also working to DNA sequence microbes in a metal contaminant wetland. Tims Branch, on the Savannah River Site, has a lot of uranium – mostly depleted uranium – in it. "That's not so much a radiological concern but uranium also isn't necessarily healthy so we want to see how the uranium is being trapped in the wetland and how microbes are contributing to that process," he said.

A challenge in studying the wetland is attempting to determine if the uranium is sticking to organic material or if it's sticking to iron, but in either case, Losey says, the microbes are likely involved in that process.

Losey said he'll soon start work on his recently funded Laboratory Directed Research and Development project that proposes to use microbes to enhance methane production in a landfill environment, using an electrolysis cell to assist the microbes. "I like the idea of using microbes and electrolysis cells, it's sort of a way of combining two different types of technologies," he said. "The Three Rivers Landfill [on the Savannah River Site] collects waste from the surrounding counties, and like many landfills, once you load trash into it, the landfill starts to produce methane as the result of anaerobic decomposition. Microbes help break down that trash some more, producing more methane. Three Rivers installed a collection system for that and sells it as a primary constituent of natural gas," said Losey.

For all of the focus on new applications, there is a part of SRNL's biological research that has been protecting the health of Savannah River Site employees for decades.

There are 24 cooling towers across the Savannah River Site used to reject heat from buildings and processes on the 310 square mile site. Water is circulated through the towers, passing through a condenser where the water becomes heated, and that heat exchange is an ideal environment for Legionella pneumophila – the bacteria that cases the potentially deadly Legionnaires' disease. SRNL's Legionella program ensures water used at the towers is regularly sampled and examined for the presence of Legionella pneumophila or the conditions – conductivity, pH, bromine and chlorine concentrations – that promote or inhibit the bacteria's growth. Burckhalter, along with Anna Sophia Knox, Ph.D., analyze the water chemistry of the samples, filter the samples and prep the filtered material for microscopic examination using an epifluorescence microscope.

As a member of the Battelle family of laboratories, SRNL follows the eight safe conduct of research principles, which includes the principle that a healthy respect is maintained for what can go wrong. Despite the handling of samples containing Legionella pneumophila, and other microorganisms, no one has fallen ill or been infected. Lee aims to maintain that record, even as the Lab broadens its work in biological research and biotechnology. One step toward that goal was the Lab's attainment of Biosafety Level 2 (BSL2).

"We thought there are enough BSL3 facilities around the country and we could even go to one of our Battelle Savannah River Alliance partners to do that level of work," said Lee. "But if SRNL were to attain the BSL2 capability, we'd be able to work with some of the various organisms that could be important to our work. When we do environmental sample work, we often do isolation enrichment, and once we run a molecular analysis, we find out that some or our isolates are pathogens. Having the capability to work with them and properly handle and dispose of them is helping build our capability in cell biology," Lee said. SRNL attained BSL2 in September 2022, which allows the Lab to handle biological material including bacteria, human and animal cells, viruses, and organisms associated with human diseases. The microorganisms SRNL researchers will work with are those that either pose no risk of infection to humans or those that could potentially pose a risk of infection to humans, but are readily treatable (e.g. e-coli, legionella, etc.) In BSL2 workers wear lab coats and gloves and any work that could cause infection from aerosols or splashes is done within a biological safety cabinet, and an autoclave is used for decontamination for proper disposal of materials.

The National Academies of Sciences, Engineering, and Medicine' publication "Successes and Challenges in Biomanufacturing" (proceedings of a workshop, 2023) quotes Paula Hammond (MIT and President's Council of Advisors on Science and Technology [PCAST]) as saying estimates for the future value of the global bioeconomy range from $4 to $30 trillion by the end of the decade. She also said that currently, the United States lacks the biomanufacturing infrastructure and workforce required to scale biology-based prototypes to products and remain globally competitive. Savannah River National Laboratory's Biological Research and Biotechnology plans to put science to work to help the United States be a leader in the field and to deliver the benefits of biotechnology to the nation.

Courtney Burckhalter is using an epifluorescence microscope to search for signs of Legionella pneumophila. Samples are regularly taken and analyzed for signs of Legionella pneumophila or the conditions conducive to the bacteria's growth.
SRNL photo by Chris O'Neil, APR.

NONPROLIFERATION

Double Impact

How COVID and a new tool increased the Laser Spectroscopy Team's nonproliferation research

by Jason Dehart
photos by LJ Gay, SRNS

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The team has attained a multitude of scientific achievements in the field of spectroscopy in the last three years. These successes can be tied directly to two events: the development of the Double-Walled Cell and the COVID-19 pandemic.

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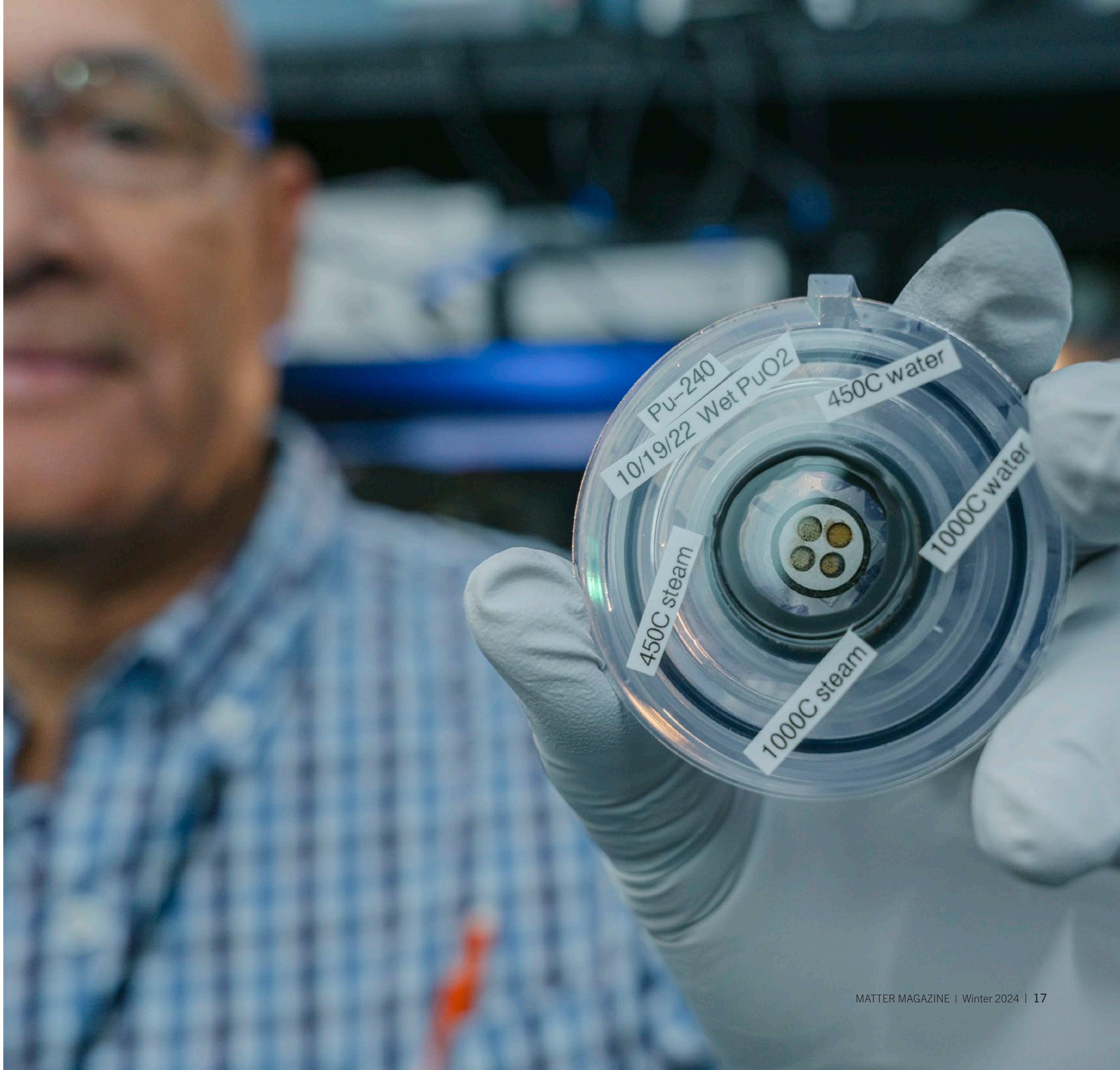
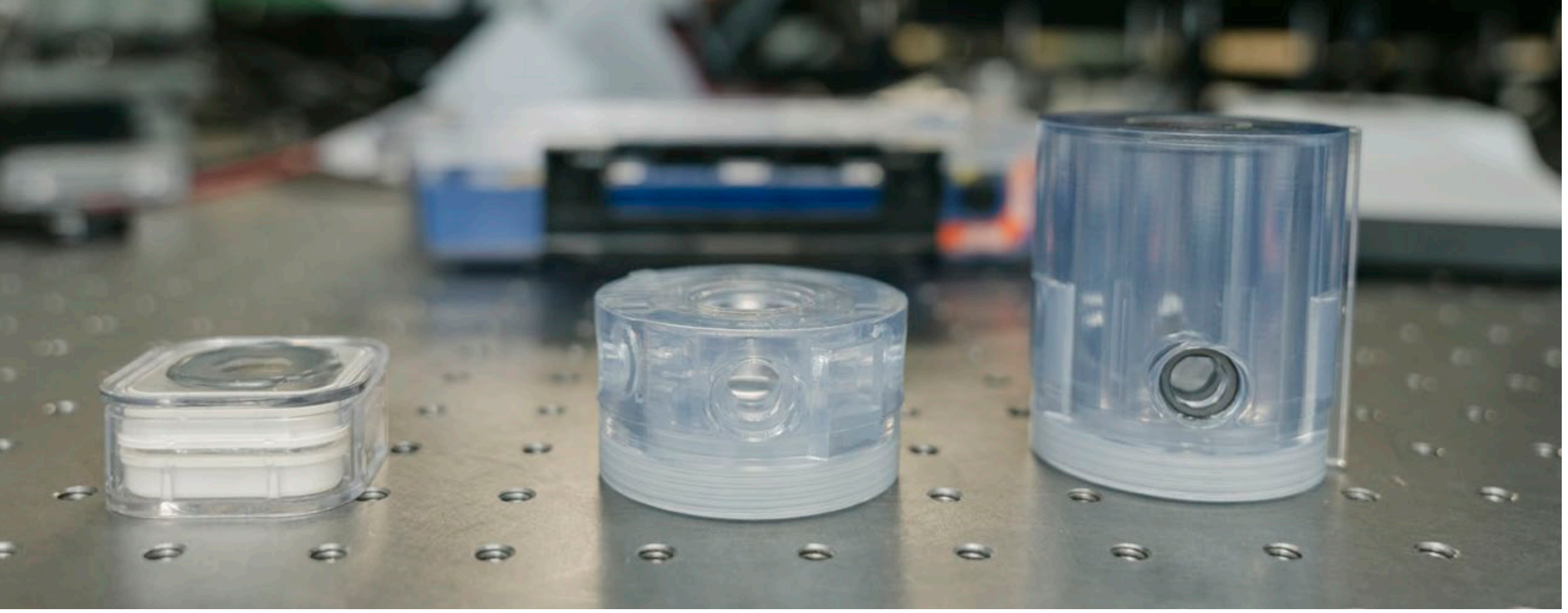




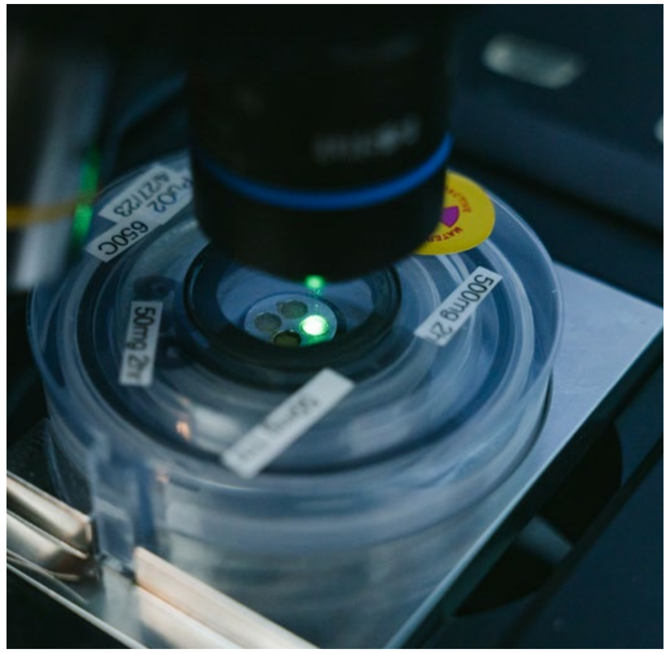
Left: Double-Walled Cell prototype used for Raman and diffuse reflectance spectroscopy.
Middle & Right: New versions of the Double-Walled Cell.

Spectroscopy is a scientific process used to identify the characteristics of nuclear material when light interacts with the sample. The Laser Spectroscopy Team within Savannah River National Laboratory's (SRNL) Global Security Directorate (GSD) support vital nonproliferation efforts by analyzing a sample to reveal critical information such as the production conditions inside a reactor, material purification processes, and enrichment quantification, which can answer the "when, how, and where" of radioactive material creation. These signatures help identify the methods of material generation. The team has attained a multitude of scientific achievements in this field in the last three years. These successes can be tied directly to two events: the development of the Double-Walled Cell and the COVID-19 pandemic.

Most spectroscopy researchers use a container to hold the nuclear materials and employ equipment in a contained radiological lab for analysis. A Double-Walled Cell uses this concept but changes the container to fit different equipment and the testing environment by meeting certain safety requirements. Chief among these conditions is to contain the nuclear material during analysis, not impede the measurement, transport the material outside of radiological buffer areas, and complete the analysis outside a fixed and tight container called a glovebox.

Eliel Villa-Aleman and his team perform their experiments inside a clean laboratory in the 735-A Building at SRNL. The team of three takes microscopic nuclear materials housed inside a Double-Walled Cell and places them in various instruments that conduct Raman, fluorescence, infrared, and other types of spectroscopy tests. Villa-Aleman says the goal is simple, "To detect one or more signature(s) to understand any nuclear material."

Villa-Aleman and his team felt the move to the Double-Walled Cell was necessary to grow its research capabilities and move from a glovebox environment to a clean laboratory. The extra space inside a clean lab allows the team



Double-Walled cell in use during a Raman spectroscopy experiment which contains a sample of $^{239}PuO_2$.

to add new equipment and "develop signatures of the material that wasn't possible," stated Villa-Aleman. Don Dick, a Scientist 2 on the team, described the difference between the two settings saying, "It would be much more difficult to align everything together in a glovebox environment than it is here [clean laboratory]."

A glovebox worker takes the clean cell, with sticky tape inside it, and places one or more microscopic nuclear sample(s) in it. One glovebox materials handler holds the cell with one hand while another places the second outside cell on top and screws it in place. The completed cell now safely holding the radioactive materials, it's checked for nuclear material on the outside of the cell and then, if clean, brought to the clean lab.

The rapid rise of spectroscopic capabilities began at SRNL in 2015 when Villa-Aleman designed the original Double-Walled Cell. Between 2015 and 2020, the team used the original version to conduct several new experiments. But the team wanted to run more and different tests, which mean new and different Double-Walled Cells.

Then COVID-19 happened, and the spectroscopy group's operational tempo slowed.

The change of pace afforded Villa-Aleman, Don Dick, and engineer Mike Maxwell more time to think of ways to improve the original Double-Walled Cell design. Villa-Aleman recognized the need, "We knew there was a much better future than what we were doing." Understanding the flaws of the original model, the team quickly developed new versions.

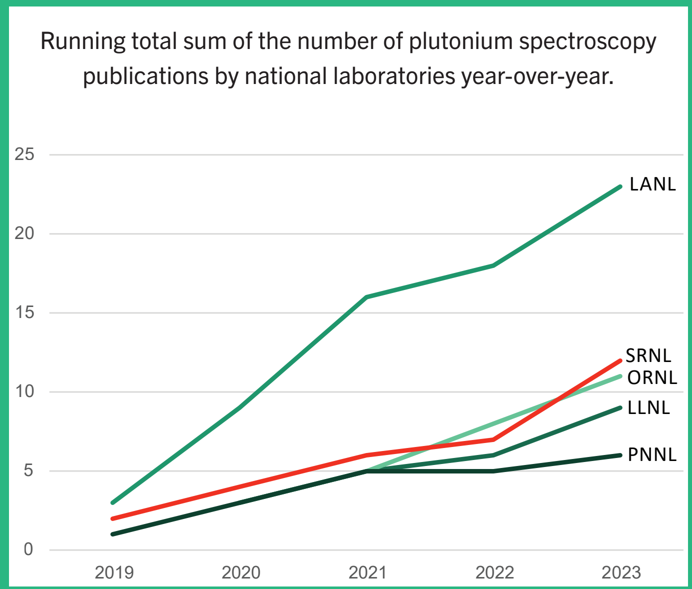
Villa-Aleman created a list of new, necessary features. Dick drew up the blueprints in a computer-aided design (CAD) program and passed the blueprints to Maxwell, who refined the blueprints and fabricated the prototypes using additive manufacturing. The team also collaborated with the radiological materials team to ensure the designs were usable within a glovebox environment and prevented the sample from exposure. Dick pointed out the need for teamwork saying, "It's not a very dexterous environment using a glovebox."

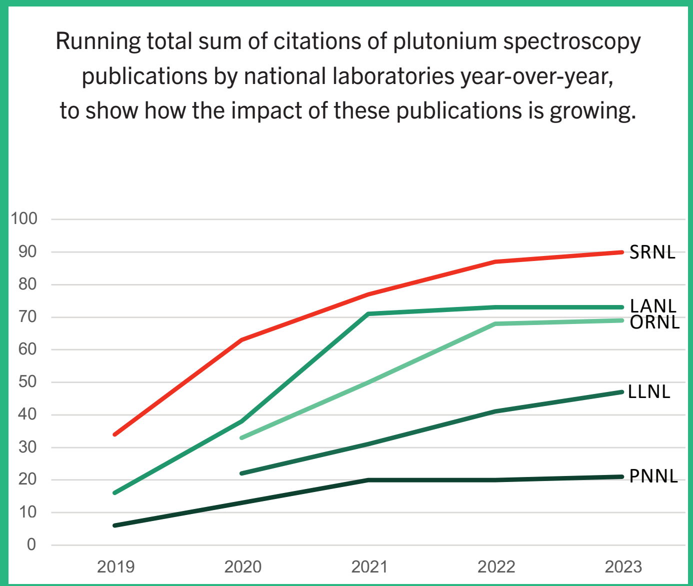
Two months of development between the spectroscopy group, Maxwell, and the radiological materials team resulted in the second iteration of the Double-Walled Cell.

The SRNL Spectroscopy group now uses seven different types of Double-Walled Cells to complete different types of spectroscopy tests. They are set to obtain a patent for their Double-Walled Cell design in early 2024.

Equipment and space availability is not the only benefit of using the Double-Walled Cell. Two of its most vital qualities are time and safety.

The pace of SRNL's plutonium spectroscopy publications as well as the number of citations those articles receive have increased noticeably in the last few years thanks to the Double-Walled Cell innovation.





Source: SciVal
Compiled by: Natalie Logue, SRNL

Dick described the difference between the old and current testing processes as, "Spectroscopy testing in a glovebox can easily take us more than a week to complete versus what we do in a clean laboratory in a day." He added, "It [the Double-Walled Cell] makes the job possible in the first place."

The group published nine papers and were cited 61 times in the last four years thanks to the Double-Walled Cell. The team's publication rate is higher than any other national laboratory in the plutonium spectroscopy research area. Villa-Aleman says he's spending more time authoring reports and analyzing test results than performing the examinations.

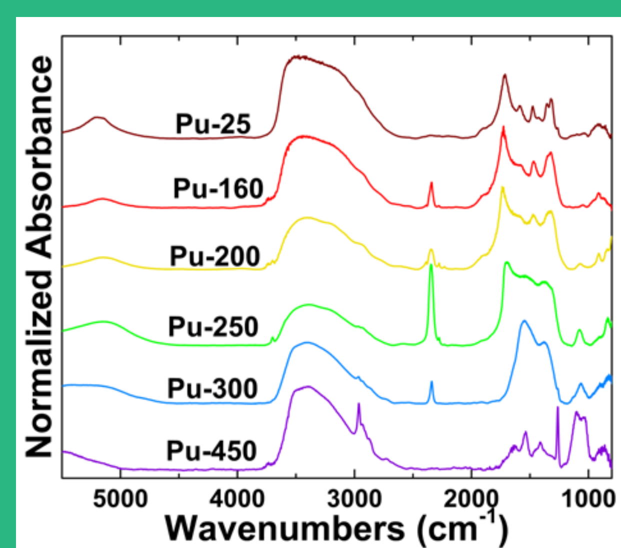
On the safety side, the Spectroscopy Group maintains SRNL's guidelines by miniaturizing glovebox requirements into a handheld object. The quartz or Barium fluoride (BaF2) window and hard plastic cells allows the team to store a limited number of materials in the clean lab, where they can recall the materials and perform additional tests to evaluate how the material(s) change over time.

Other national laboratories have noticed the effectiveness and application of SRNL's Double-Walled Cell. Oak Ridge National Laboratory contacted the SRNL team to assist its development of a Double-Walled Cell.

Villa-Aleman says he won't stop expanding the testing potential. His next step is to test materials in cryogenic conditions.

Each advancement in Double-Walled Cell technology builds a better tool for nonproliferation efforts with the goal of taking a sample of radioactive material(s) and accurately figuring out its origin and intended purpose, thus stopping bad actors from obtaining dangerous weapons.

Don Dick positioning the Double-Walled Cell for use in a Raman experiment.



IR spectra of Pu2(C2O4)3•9(H2O) (Pu-25) and its thermal degradation products. This data, obtained using a Double-Walled Cell containing plutonium (III) oxalate, was published in the October 2023 issue of *Journal of Nuclear Materials*.

Developing the Advanced Technology Proving Ground to Support National Security Missions

by Scott Shaw

Grounds for Development

What has the same area as the circumference of the Washington, D.C. beltway and offers unique topography, a subtropical climate, existing infrastructure, and fortified facilities, all within a secured boundary? If one is familiar with the history of the Central Savannah River Area in Georgia and South Carolina and the Cold War, the Department of Energy Savannah River Site (SRS) comes to mind.

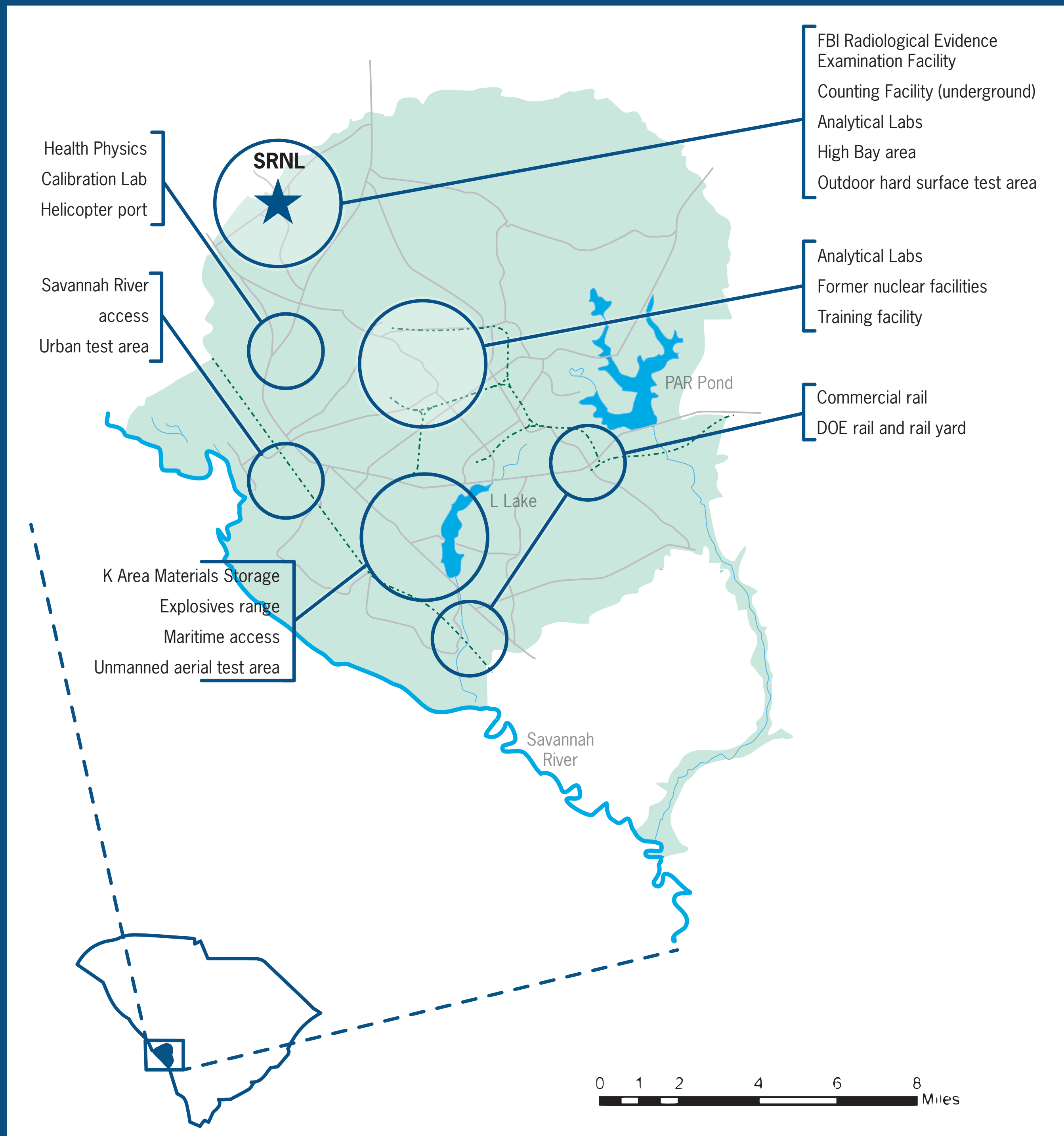
Created in 1950 for plutonium and tritium production in support of nuclear weapons during the Cold War, SRS consists of approximately 310 square miles in a relatively remote location along the Savannah River in South Carolina. The massive infrastructure needed for such a huge undertaking required a large area to provide the required security footprint and allow for public safety requirements. Today, SRS provides a unique opportunity to conduct a wide variety of testing and evaluation for national security missions in a protected boundary having high humidity and a dense foliage environment for open-air experiments. In addition, the massive Cold War legacy facilities provide an unrivaled indoor test capability for "zero-observable" requirements.

Department of Energy laboratories, sites and facilities throughout the United States play a significant role in technology advancement, testing and evaluation, as well as training of personnel from other government agencies. Over the past two decades, the preference for technology development and training exercises were with sites having predominantly desert or high-desert geography. Political and social circumstances have significantly changed, and the current need focuses on threat representative geography and topology found in the Southeast United States.

Proof in Certainty and Concept

As the research and development (R&D) and test/evaluation (T/E) organization on the SRS, Savannah River National Laboratory (SRNL) is developing the Advanced Technology Proving Ground (ATPG)* to support technology development and training for a wide variety of national security missions using existing infrastructure, facilities and areas of SRS. The site's unique location provides access to the Savannah River, is home to two large lakes, and features 610 miles of roadways that cut across both open terrain and heavily forested areas. Additionally, decommissioned nuclear facilities, special nuclear material storage areas, rail yards, 17-miles of isolated transmission lines and more allow endless testing and training environments for any situation.

"We are leveraging the legacy facilities and locations at Savannah River



graphic: Alphonzo James, SRNL

The 310-sq. mile Savannah River Site is uniquely suited to the development of a next-generation national security training facility.

*SRNL is considering a name change to the Advanced Technology Proving Ground, as future development plans include it being more than a proving ground for SRNL technologies.

SRNL is focused on two test ranges at SRS: an open-air test range in the P Area of the site, and an indoor test range involving the decommissioned C Reactor. These multi-domain, multi-user training, exercise, and test and evaluation ranges incorporate current and potential future capabilities, including:

Cybersecurity

Radio Frequency Spectrum Test Facility

Industrial Control Systems (ICS)/ Supervisory Control and Data Acquisition (SCADA) Modeling Lab

Electric Grid Vulnerability Lab

Electronic Warfare (Future)

Cyber Wireless Testing and Evaluation (Future)

Positioning, Navigation and Timing (PNT) Architecture

Chemical, Biological, Radiological, Nuclear and Energetic (CBRNE)/Countering Weapons of Mass Destruction (CWMD) Materials and Detector Benchmarking

Radiological Material Handling and Packaging Training

Field Exercises for U.S. Government Entities/Agencies

UAS/C-UAS

FCC Experimental Station License

Rural Operations and Separation from Controlled Airspace

2,500' x 50' Paved Runway (partially complete - 1000' x 50' paved)

FAA Special Use Airspace: National Security Area (can be restricted under 14CFR 99.7)

Near Sea Level Density Altitude

Beyond Visual Line of Sight Flight Operations

Training and Exercises

Live-sky Conventional Threat (CT) and Emergency Threat

(ET) test environments for fixed and mobile platforms

Resilient Navigation and Timing Solutions Not Solely Dependent on GPS

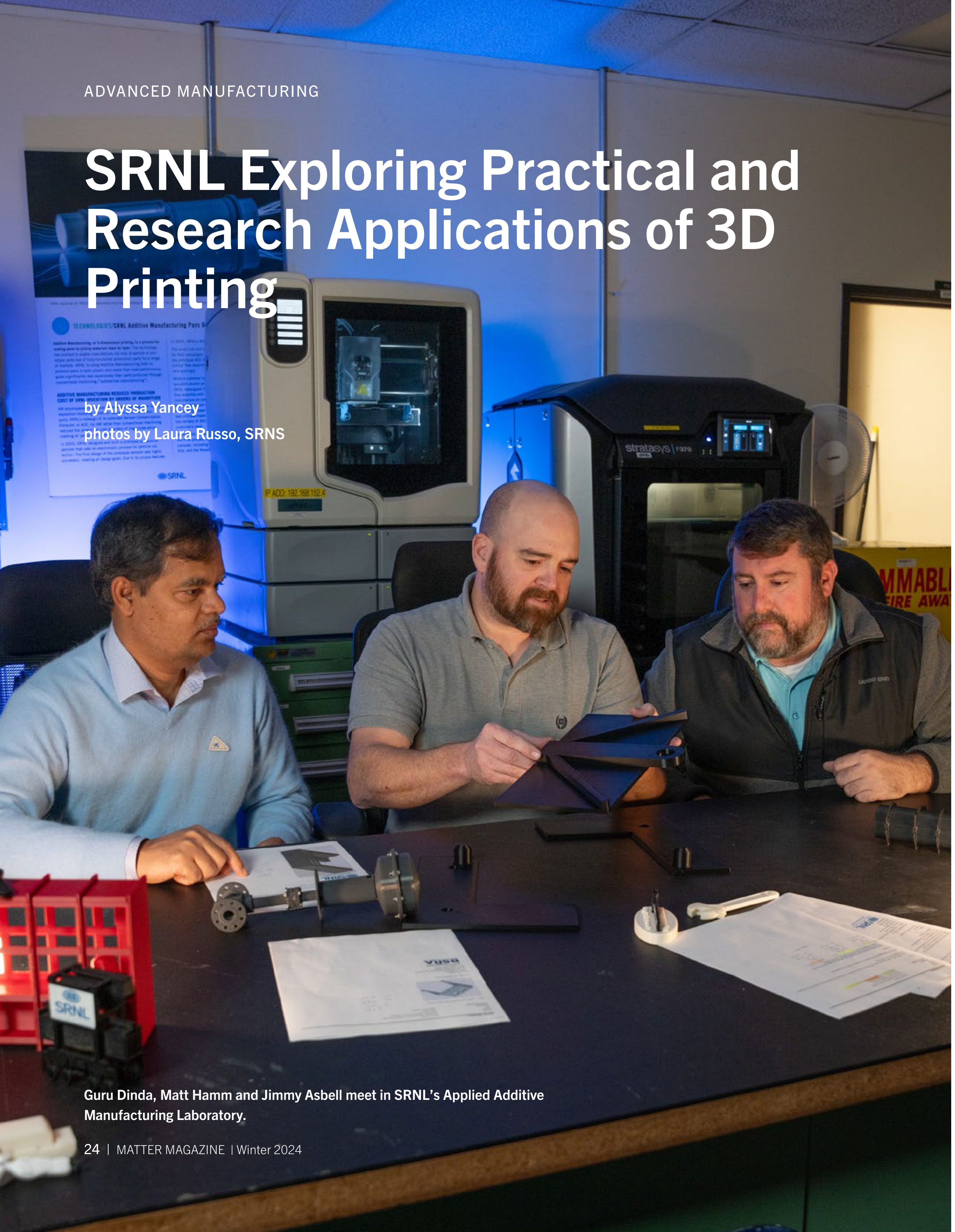
Site that's been a critical component of the nation's national security posture for 75 years," said Marc Taylor, SRNL Department of Defense portfolio manager. We're looking to continue this position for another 75 years to complete critical missions for the good of the nation."

Ethan Farquhar, director of the Advanced Technology and Analysis Division of the SRNL Global Security Directorate, says the goal of the ATPG is to repurpose what he refers to as "national treasures" for current and future national and energy security missions. He cites the 17 miles of isolated transmission lines and C-Reactor as examples of existing infrastructure/facilities that SRNL could develop to support research focusing on grid security and resiliency. "We have lots of infrastructure and components here that we could use to create and test the grid of the future," said Farquhar. "SRS has unique physical assets that could enable testing that's not necessarily available in one particular place around the country."

While building the grid of the future at SRS is currently only a concept, many opportunities and capabilities are certain and real. The open-air test range in P Area includes 1,500 acres centrally located within the secured SRS boundary. The open-air test range capabilities include radio frequency testing, UAS (rotary and fixed wing) exercises, a licensed FCC Experimental Station, a fully Instrumented Meteorological Tower, and land area for search/find missions for radiological and nuclear materials sources. This area, combined with already existing capabilities and labs within SRNL's main and ancillary locations, is only the beginning for the ATPG. "As our mission scope expands," said Taylor, "we hope to use and leverage other areas at Savannah River Site for the ATPG, as well."

SRNL Exploring Practical and Research Applications of 3D Printing

by Alyssa Yancey
photos by Laura Russo, SRNS



Guru Dinda, Matt Hamm and Jimmy Asbell meet in SRNL's Applied Additive Manufacturing Laboratory.

Anyone can buy a 3D printer for a few hundred dollars these days, but researchers at Savannah River National Laboratory (SRNL) are advancing the technology from the hobby shop to the science lab.

SRNL researchers are harnessing technology to improve safety, bolster supply chains, discover new materials and develop novel manufacturing methods. SRNL added 3D printing, also known as additive manufacturing, research facilities in 2017 and has continued to build upon capabilities in recent years. The laboratory has had 3D printing production capability since 2001. Today, SRNL has a robust program with the ability to print polymer, metal and ceramic-based objects.

Engineering Technical Support Specialist Matthew Hamm oversees SRNL's applied additive manufacturing laboratory, and says he enjoys helping clients with their varied needs.

"Every day we're working on something different and something that's supporting a different area of the lab," says Hamm.

Some of the projects Hamm and his fellow team members have worked on include mock-ups for job task previews and pre-job briefings, one-of-a-kind parts for deployment at Savannah River Site, training models and more. The lab's 3D printing capabilities increase employee safety by allowing better understanding of jobs and decreasing the amount of time individuals might be exposed to contamination. The technology also decreases the need to source parts from outside of SRS, which results in greater efficiency and speed.

SRNL engineer Thomas Lee says the additive manufacturing lab allows his team to be more responsive to customer requests.

"We currently use the advanced manufacturing lab to provide scale systems for ergonomic studies and training purposes. The lab and staff provide a quality product at a fraction of the cost and lead times while maintaining functionality," said Lee.

SRNL Polymer Additive Manufacturing Research and Development Lead Cam Chatham notes that the lab's additive manufacturing capabilities also are significant when it comes to maintaining legacy systems.

"Many of the DOE sites were constructed in the 1950s. It's not uncommon to come across parts that haven't been made since the 70s. There also are some items that are only being manufactured in sensitive countries that we can no longer source," said Chatham.

Cam Chatham loads a sample of a new material developed for additive manufacturing into the dynamic mechanical analyzer (DMA).

A 3D printed automated chilled water valve sits inside a printer in SRNL's Applied Additive Manufacturing Lab. The part was printed on the model 450 printer in high resolution ASA material.

"Additive manufacturing really helps to shore up our domestic supply chains, especially for the more unique, one-off parts."

Some of Chatham's work focuses on how 3D printing can be used to integrate multiple functionalities into one part. For instance, Chatham suggested additive manufacturing could allow structural components to double as energy or waste storage in alternative energy applications, such as hydrogen fuel cells.

"3D printing has different constraints compared to traditional manufacturing. It is great for creating flow optimized pathways," says Chatham. "You can get lots of surface area exposed that you could use to store energy or filter out byproducts."

SRNL's interest in 3D printing also goes beyond the practical applications. Chatham and his colleagues Guru Dinda and Drew Snelling are interested in the research and development side of additive manufacturing as well.

Not only is additive manufacturing a valuable tool for creating complicated objects, but it also can be used to discover new materials. SRNL Researcher Guru Dinda is doing just that. Dinda, an expert in metal additive manufacturing, is working to create new materials for extreme temperature applications, such as fusion reactors, gas turbines and rocket nozzles.

He hopes to develop a new alloy concept called a "refractory high entropy alloy." The material would harness the temperature resistance of refractory materials but reduce the brittleness and oxidation susceptibility typically associated with them. Dinda is developing the new material by combining different percentages of four different refractory elements.

"Initially we do thermodynamic simulations to find the composition space where we can get our desired material properties," says Dinda. "We plan to develop 200 to 500 discrete alloy combinations, and then analyze their properties to find out which composition range best achieves the desired material properties."

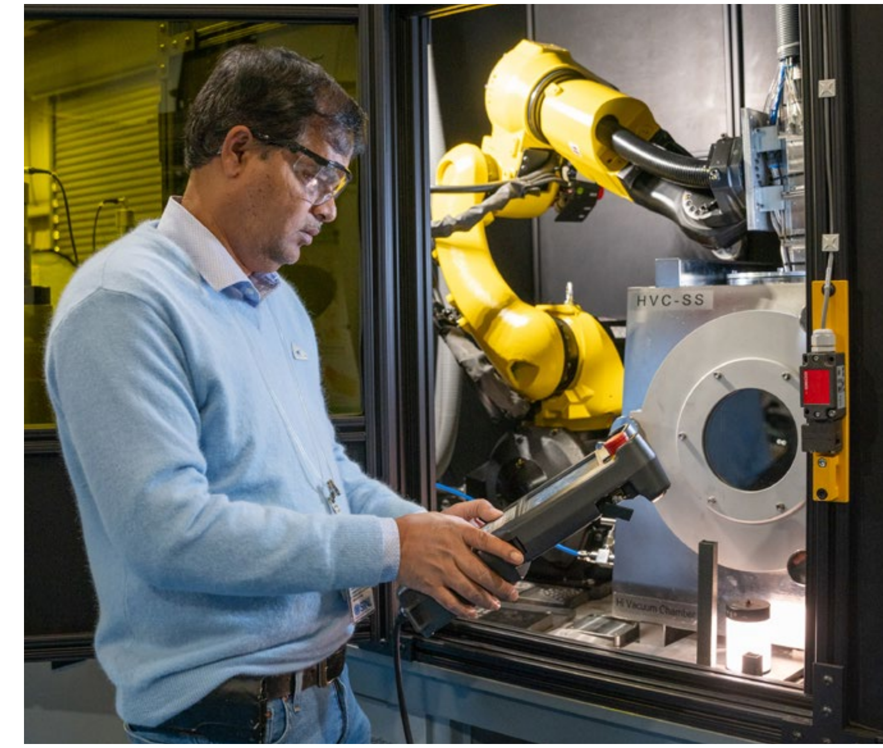
One application of Dinda's work is the development of an alternate material for plasma facing components, which are used to remove heat from fusion reactors. Currently, a component made of tungsten and copper is used, but their thermal expansion coefficient is quite different, so stress is generated at the interface between the two materials. 3D printing would allow for a gradual transition from tungsten to copper, which would significantly increase the strength of the component.

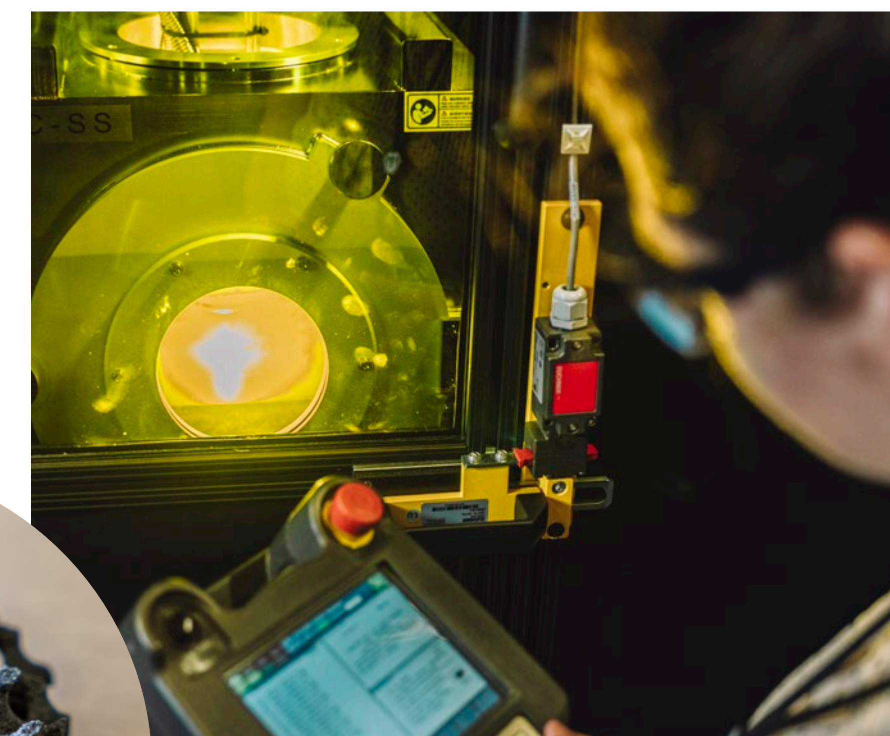
Another area of research focus is hybrid manufacturing technologies. Chatham recently completed a Laboratory Directed Research and Development (LDRD) funded project led by colleague Don Benza exploring the potential to pair filament extrusion 3D printing with 3D inkjet printing technologies. Chatham says the world of possibilities is endless when it comes to integrating additive manufacturing with more traditional methods.

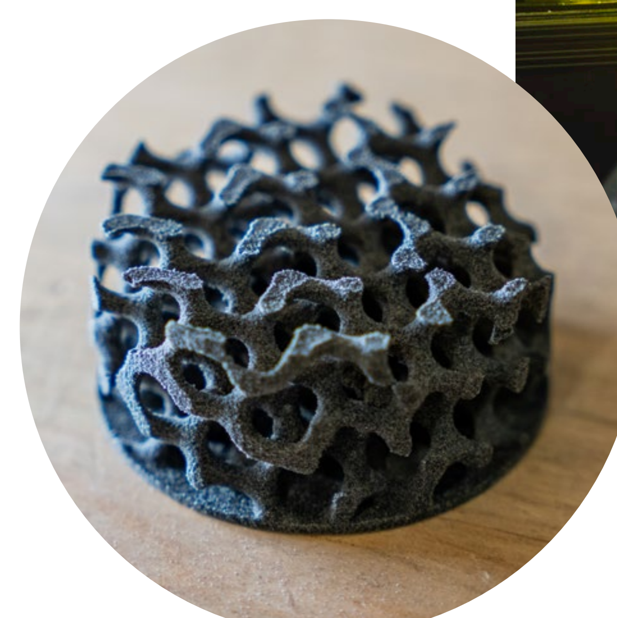
"I think from the research side we're going to see a lot more of the hybrid manufacturing technologies. For instance, a material extrusion system that also has an inkjet head or a hybrid additive plus subtractive machine," says Chatham. "We're going to see new processes combining technologies in a way that highlights what each process does best."

Drew Snelling, the newest member of SRNL's additive manufacturing team, echoes Chatham's sentiments and asserts that SRNL is perfectly positioned to forge a path in developing new manufacturing technologies.

"SRNL has the potential to advance additive manufacturing through new materials, processes and equipment research to support our missions. One of the ways this will be enabled is through the Advanced Manufacturing Collaborative (AMC), a new facility being constructed on the USC-Aiken Campus," says Snelling. "With investment in the AMC, significant opportunities exist to advance new technologies by fostering additional collaboration with academia, industry and other national labs."







Top: Guru Dinda inspects the DED system.
Bottom: Colleen Hilla monitors the laser directed energy deposition process.
Left: A gyroid lattice structure made from tungsten-filled polypropylene on a Sintratec Kit laser powder bed fusion machine.

Open Invitation to Partner with SRNL

by Scott Shaw

A Broadened View

Partnerships are important to any business or organization wanting to expand its market share or grow its technology base. They allow organizations to draw upon each other's strengths and achieve growth more quickly and efficiently. Ultimately, partnerships and or collaborations create a stronger and better community.

The Department of Energy (DOE) and its network of 17 national laboratories provide economic, security and environmental benefits for all Americans. Transfer of the DOE's research, development, demonstration and deployment portfolio through partnerships with private industry further advances the economic, energy and national security interests of the United States.

For many years, Savannah River National Laboratory (SRNL) focused its attention on the DOE cleanup mission for the nation. As DOE's newest independent national laboratory, SRNL is broadening its efforts. While still supporting the environmental cleanup efforts, SRNL's vision is to further develop and promote technology transfer with industry, organizations and agencies in additional areas that align with the Department of Energy's broad mission. To enable this vision, SRNL hired Daren Timmons, former provost and executive vice chancellor for academic affairs at the University of South Carolina Aiken (USC Aiken), as director, Industrial and Strategic Partnerships.

During his seven years at USC Aiken, Timmons helped strengthen the university in a variety of areas by providing critical support and impactful leadership to enhance the university's academic portfolio and industry connectivity. His role at SRNL is to work directly with SRNL staff, industrial partners and the Department of Energy (DOE) to identify SRNL innovations that advance the economic, energy and national security interests of the nation. He is working to identify potential partners, implement outreach activities and manage external engagements to accelerate the transition of SRNL innovations and technology into deployment by industry and eventually into the marketplace. Simply put, he's working to find others to partner with SRNL to do, in his own words, "cool things."

"We are eager to grow in the way we intersect and interact in the public sphere," said Timmons. "We still have a significant mission to support the Savannah River Site, but we want to continue to grow our impacts both for the benefit of the public, our economic engines here in the U.S., and, perhaps, more broadly in the areas of national security and energy security."

Partnering with SRNL

The National Laboratories Technology Transfer Work Group, a group of technology transfer professionals at each Department of Energy national lab, lists eight different partnering mechanisms; however, Timmons makes simpler the ways of partnering with SRNL by saying there are two primary ways of partnering with SRNL: licensing SRNL technology and working with SRNL to complete research.

"Large corporations that need an improvement in their processes could take advantage of licensing some of our technologies and build those into their existing infrastructure," said Timmons. "On the other end, there might be a startup company that wants to build their entire business model around some of our technologies, such as battery storage, nanoparticles or environmental monitoring."

He went on to explain the two ways SRNL can work with organizations to conduct research, by either conducting research jointly with an organization or SRNL solely conducting the research on behalf of the business or organization.

Initial Steps to Partner with SRNL

It's easy to start the process of setting up a partnership with SRNL. First, review the SRNL technologies available for licensing on the SRNL website at https://www.srnl.gov/partner-with-us/industry-partners/. Organizations can also reach out to SRNL directly by contacting Daren Timmons, director, Industrial and Strategic Partnerships, or Byron Sohovich, manager, Contracts Management, with details about the desire to license SRNL technology, or plans to develop a research project to help solve a problem. Timmons and Sohovich will then work with each organization to determine the best course and way of partnering with SRNL.

Daren Timmons, SRNL's director, Industrial and Strategic Partnerships

There are two main ways SRNL can work with organizations to conduct research, by either
1 conducting research jointly with an organization or
2 SRNL solely conducting the research on behalf of the business or organization.

Current Partnerships

Some examples of successful partnerships with SRNL

Texel Energy Storage

Developing new thermal battery technology that is up to 90% more cost-effective than lithium batteries for large-scale energy storage.

Kyoto Fusion Engineering

Advancing the technology of liquid lithium as a fusion coolant and tritium breeding material. The results could promote novel blanket designs that would potentially reshape the trajectory of fusion power plant development.

E4 Carolinas

E4 Carolinas is building a regional energy hardware community to support the Joules Accelerator in accelerating new ventures' innovative energy hardware technologies. SRNL is providing access to the network of national laboratories, connecting Accelerator ventures with new technologies, support, and workspace for Accelerator ventures and Cluster members.

Metatomics

Partnering to demonstrate newly-developed process to convert today's commercial spent nuclear fuel into fuel for molten salt fast reactors.

Silica X

Partnering to valorize waste streams from various municipal and industrial sources and develop products known as GeoEngineered Materials or GEMs™.

SHINE Technologies

Using SRNL's thermal cycling absorption process (TCAP) in its manufacturing facility. The use of TCAP provides the high-purity inputs needed for SHINE's patented technology, which enhances the production of medical isotopes, including molybdenum-99 (moly-99).

General Atomics

Combing General Atomic's experience in fusion energy research with SRNL's expertise in processing and storing tritium. Future fusion power plants will need safe, reliable systems for tritium handling and this partnership is significant on the road to fusion-generated electricity.

For more information about SRNL technology and partnerships, contact:

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Byron Sohovich
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Other Department of Energy websites for more information about technology transfer:

https://labpartnering.org/
https://www.energy.gov/technologytransitions/office-technology-transitions

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