MATTER

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Fueling the Fusion Revolution

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Savannah River National Laboratory®

Cover: Chris Dandeneau adjusts equipment in the SRNL fusion laboratory. (photo: LJ Gay, SRNS)

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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, protect the environment and ensure energy resilience.

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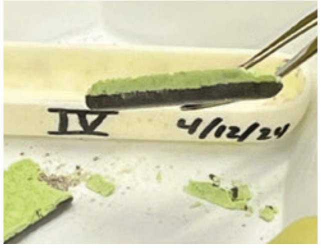

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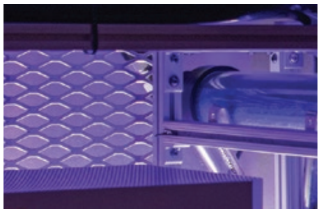

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Introducing Johney Green: A Visionary Leader Committed to Growth and Strategic Impact

by Fateish Graham

Exciting changes are on the horizon at Savannah River National Laboratory with new Laboratory Director, Johney Green. A lifelong learner, champion of innovation, and strategic leader, Johney is passionate about putting SRNL on the national map for its impactful work in supporting the nation. With deep roots in the Southeast, he brings decades of experience, a fresh vision, and a personal commitment to driving meaningful change.

Johney has spent nearly 30 years in laboratory leadership roles across the country. He dedicated 21 years to Oak Ridge National Laboratory (ORNL) in Tennessee before bringing his expertise to National Renewable Energy Laboratory (NREL) in Colorado where he led for eight years.

Johney's influence extends beyond laboratory leadership. He currently serves on the Department of Defense Science Board, the longest serving advisory board in the Office of the Secretary of Defense and the leading body in providing science and technology solutions to support Department of Defense missions and operations. Serving in this role gave him greater insight about SRNL's mission and important contributions in national security and environmental stewardship.

Johney's passion for learning and leadership is deeply personal. He credits his late mother — a dedicated educator — as his greatest inspiration. Though he only had her for 22 years before she succumbed to breast cancer, her influence instilled curiosity and a commitment to education in him at an early age. Her legacy continues to fuel his drive to uplift others, making him not just a leader, but a mentor who is passionate about expanding knowledge.

Though he is excited to lead SRNL into a new era, Johney's attraction to SRNL runs deeper than having a chance to be laboratory director. "My connection to this region and my belief in SRNL's potential to lead in areas critical to national security and energy resilience make this opportunity deeply meaningful," said Johney. He grew up in Memphis, Tennessee and Baton Rouge, Louisiana and he's a proud graduate of Georgia Tech, one of SRNL's university partners. His return to the Southeast is a homecoming for him and his wife, and he is eager to leverage his experience to drive innovation in a region he knows and loves.

Quoting famous words by Outkast while addressing SRNL staff at his first all-hands meeting, Johney proudly stated, "The South's got something to say," reinforcing his belief that this region is poised for national recognition in cutting-edge solutions. Johney's arrival at SRNL is timely with the development of the Advanced Manufacturing Collaborative which he calls a "strategic asset for SRNL" to provide a foundation to advance cutting-edge technologies to support economic development in the region.

Johney Green visited Washington, DC recently to meet with other National Laboratory directors. (photo: SRNL)

Johney's approach to leading SRNL into the next phase of growth and strategic impact begin with a focus on developing SRNL's people, partnerships and programs through six strategic directions:

1. Expanding our nuclear deterrence nuclear nonproliferation missions while accelerating our environmental clean-up mission
2. Fostering a culture of scientific innovation and empowerment, integrated with operational principles
3. Maximizing the impact of the Advanced Manufacturing Collaborative Facility
4. Driving innovation in energy technologies
5. Expanding our role in emerging technologies for defense mission priorities
6. Strengthening partnerships with national labs, academia, industry and community stakeholders

Johney's vision is clear: to elevate the laboratory's work to national prominence while staying true to its core mission. "I am optimistic and committed to SRNL's mission and the well-being of its workforce and look forward to working together to deliver innovative solutions for the nation," said Johney. His leadership combines strategic expertise with an authentic, people-first approach, ensuring that innovation and impact go hand in hand.

FC-FIRE: Fueling the Fusion Revolution

by Kent Cubbage

While the future is always said to be uncertain, one certainty is that the world's demand for energy will continue to grow. An increasing population, burgeoning transportation grid, large data centers and other factors are pressuring scientists to develop new energy technologies to meet the demand. As these new energy sources take shape, it's paramount that they be affordable and efficient.

At the top of the list of new sources of power is fusion energy. The same type of energy that powers the sun, fusion occurs when the nucleus of one atom fuses with the nucleus of another atom, and a tremendous amount of energy is released. Scientists' knowledge and understanding of fusion is not new. The concept has been used in nuclear weapons since the early days of the Cold War. However, harnessing fusion as an everyday source of power is another matter. Commercial use of fusion does not yet exist.

However, a collaborative of chemists, engineers and nuclear scientists led by Savannah River National Laboratory looks to change this. The U.S. Department of Energy Fusion Energy Sciences program has a goal of realizing viable commercial fusion energy as soon as possible, and recently announced the funding of six Fusion Innovation Research Engine (FIRE) collaboratives. Among the winners was FC-FIRE - SRNL's collaborative - which is tasked with developing the fusion fuel cycle. FC-FIRE consists of experts from five national laboratories, nine universities and one private company, as well as industry associations and international partnerships. It will be led by SRNL's Brenda-Garcia Diaz, director and lead principal investigator, and George Larsen, deputy director.

Commercial fusion energy is an incredibly complex endeavor that involves a multitude of phases, processes, technologies and facilities, all of which must integrate seamlessly. Like any form of energy, fusion needs fuel, and that fuel goes through a cycle from its origins to providing energy to becoming spent

Brenda Garcia-Diaz (right) and Paul Beaumont (left) in SRNL's fusion laboratory. (Photo: LJ Gay, SRNS)

waste. FC-FIRE is tasked with seeing that cycle through to completion.

Although fusion can occur via a handful of different fuels, the fuel of choice is tritium, an isotope of hydrogen. SRNL is the logical choice to take the lead in this area. It has more than 60 years of experience in tritium research and is the design authority for the processes at Savannah River Site's Tritium Facilities.

"SRNL's core competencies in hydrogen isotope processing, isotope separation, and purification technologies, gained from decades of experience in the U.S. defense program, are directly applicable to the [tritium] fuel cycle," said Garcia-Diaz.

Tritium has low radioactivity, and SRNL has facilities for handling, storing and characterizing radiological and tritium-exposed materials. SRNL is completing the Advanced Manufacturing Collaborative on the USC-Aiken campus, which will provide modern, dedicated project space. Moreover, SRNL is leading the design and fabrication of the Tokamak Exhaust Processing system for the International Tokamak Experimental Reactor (ITER), a massive fusion device currently under construction in France. The lab has successfully completed several other tritium-related projects in recent years.

The fusion fuel cycle is a multi-step process, and all of the steps will work in concert. The project partners were assembled based on their expertise with these different processes, which FC-FIRE organized into six different "thrusts." Leads for each thrust are principal investigators from across the collaborative that bring specific skills and experience to the project, and they will all serve on the FC-FIRE Executive Committee.

A sprawling team of diverse partners that is geographically scattered could create logistical and communication issues. SRNL is confident it can overcome these challenges. "Building a cohesive team culture across different locations requires deliberate effort," said Garcia-Diaz. "We plan to utilize state of the art technology and frequent virtual meetings to support meaningful and efficient remote collaboration."

FC-FIRE will ultimately reach several milestones and produce a myriad of tangible products. To begin with, it will produce an integrated, open-architecture process model for the fusion fuel cycle. This will include all aspects of tritium from start to finish and, as a whole, can be integrated into a wide variety of commercial fusion applications. Commercial fusion companies can use this fuel cycle when designing and optimizing fusion plant systems going forward.

"The fuel cycle can indeed be viewed

as a 'cycle in a box' that will be useable by the entire fusion community," said Dale Hitchcock, SRNL scientist.

FC-FIRE will also develop component-level models, tritium experimental data, and advanced, highly durable fusion materials. The economic viability of the technologies involved is critical, so techno-economic analyses will also be conducted for various processes in the fuel cycle.

The sustained success of commercial fusion is not only dependent on technological development, but the hands and minds to implement and improve that technology. If commercial fusion is to revolutionize the energy industry, it will need a new generation of trained workers. Thus, FC-FIRE will prioritize fusion workforce development, both at SRNL and across all partner organizations.

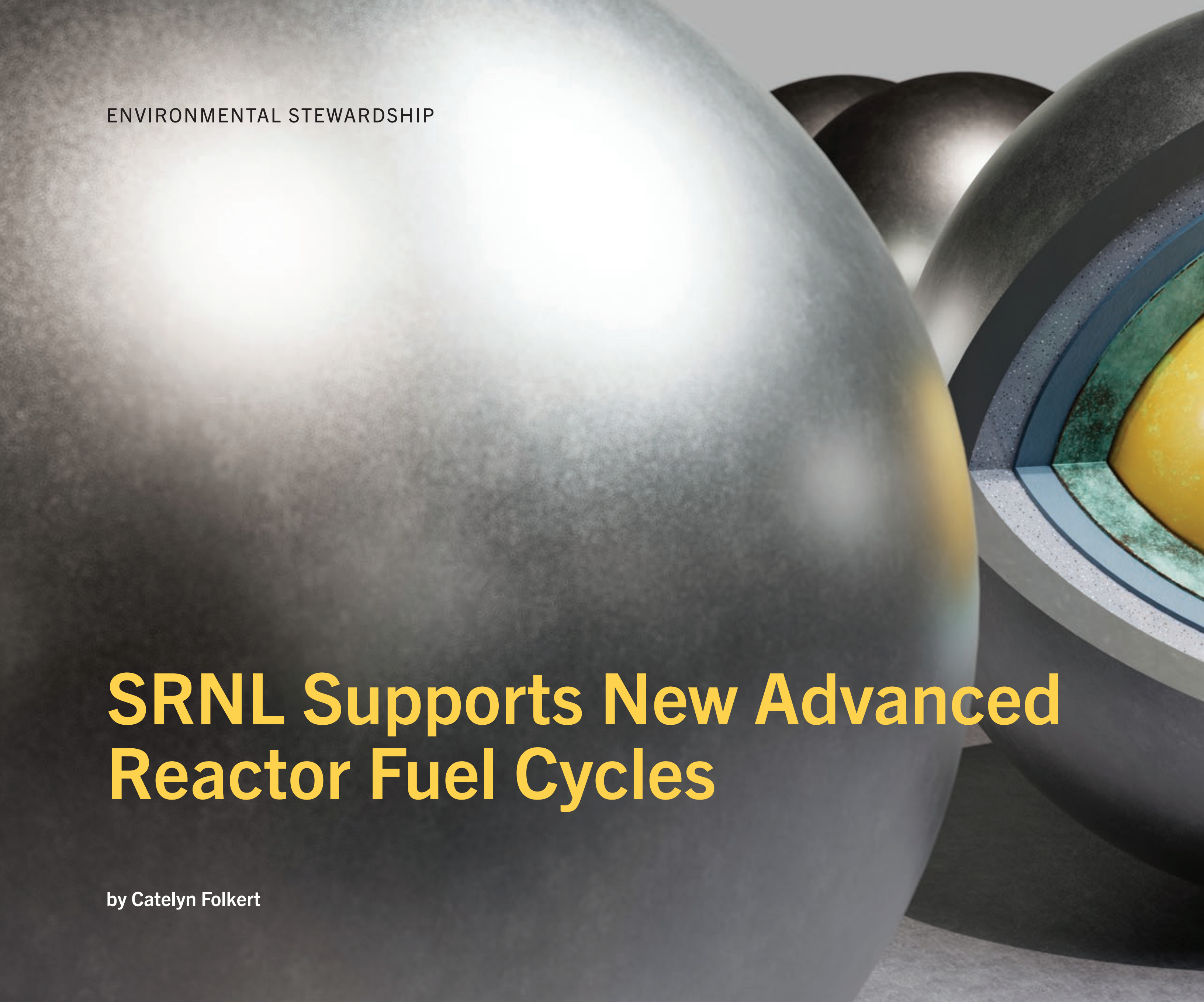
"A quantitative measure of success will be the number of individuals trained and engaged in the fusion fuel cycle R&D, as well as their retention within the fusion ecosystem," Garcia-Diaz emphasized.

A prime example is SRNL's Holly Flynn. She is a recent recipient of DOE's Early Career Scientist Award. Flynn has done innovative work on modeling of tritium accounting in the fusion fuel cycle. Retention of talent like Flynn in the fusion community will be paramount. To this end, FC-FIRE will develop an Early Career Network of young workers as the project progresses.

Early career scientists will learn and mentor from experts in the field in the national labs, universities and industry. From this wealth of knowledge and talent, groundbreaking achievements in fusion will hopefully spring. The FC-FIRE team is certainly big, but so is the payoff for world's energy demand.

Brenda Garcia-Diaz (second from right) and colleagues in SRNL's fusion laboratory. (Photo: LJ Gay, SRNS)

Hear Holly Flynn describe her fusion research on the SRNL podcast, Science at Work: https://www.srnl.gov/newsroom/the-digest/podcasts/.
(Photo: SRNS)



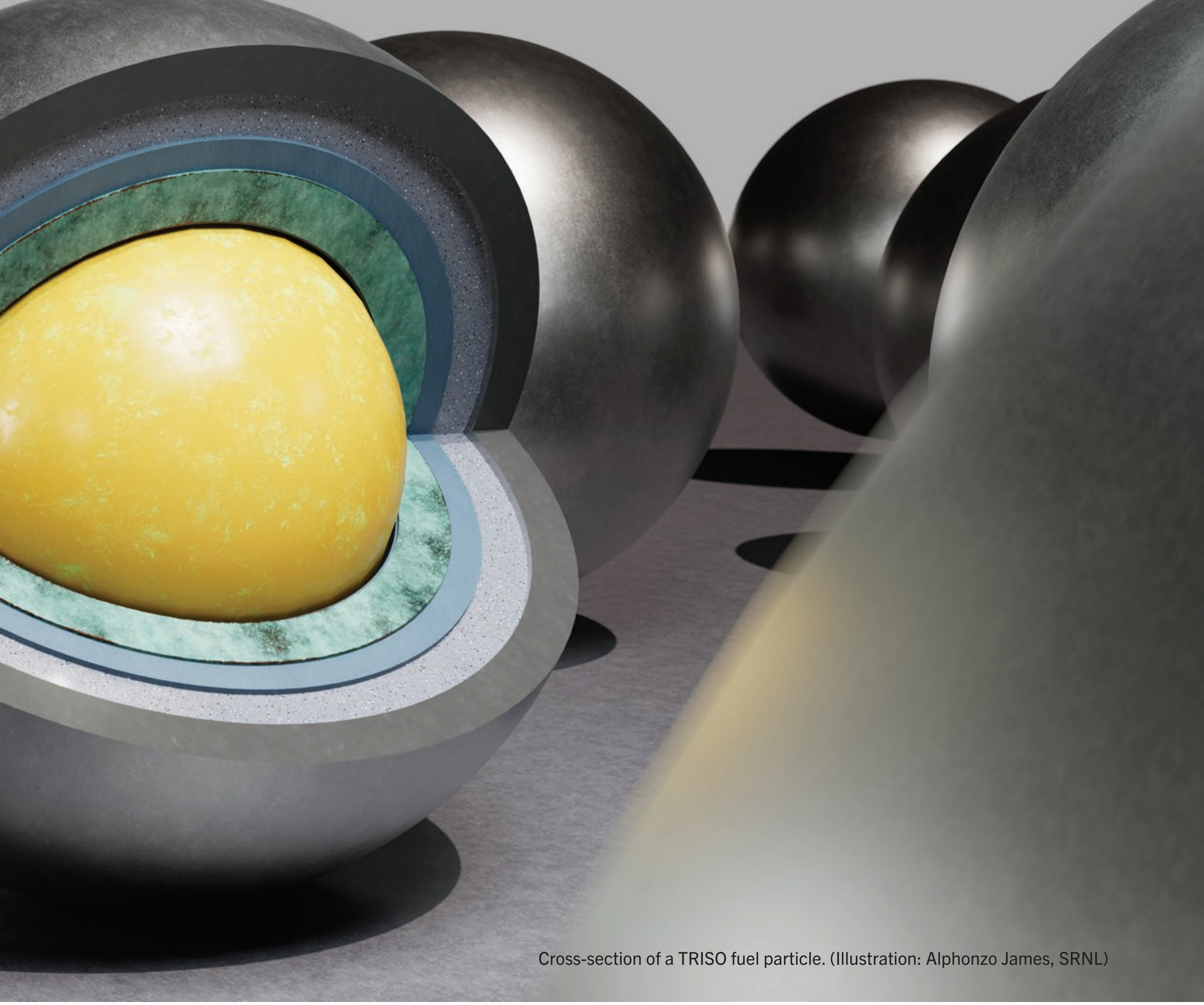
SRNL Supports New Advanced Reactor Fuel Cycles

by Catelyn Folkert

Our nation's energy needs continue to increase and advances in nuclear power technologies are central to ensuring energy resiliency. Savannah River National Laboratory is leveraging decades of expertise in four key areas that address the emerging needs associated with advanced small modular reactor fuel cycles.

SRNL's applied science solutions for Tri-Structural Isotropic (TRISO) fuel processing, High-Assay Low-Enriched Uranium (HALEU) feedstock, spent nuclear fuel (SNF) reprocessing, and packaging and transportation, are poised to accelerate broad adoption of advanced small modular reactors by addressing the fuel cycle needs. Advanced small modular reactors (SMR) are key to the future of reliable and secure energy, with many planned to come online during the next decade. While these reactors offer many benefits, a viable solution is needed to handle the resulting spent nuclear fuel.

The Department of Energy has identified three new reactor designs that will require TRISO fuel before coming online by 2030. TRISO fuel particles are encased in graphite moderator and TRISO fuel is more structurally sound and resilient than traditional reactor fuel. However, a TRISO-based reactor typically discharges the largest volume of SNF in the industry — compared to more traditional light water reactors — per unit of energy produced. This situation creates both short and



Cross-section of a TRISO fuel particle. (Illustration: Alphonzo James, SRNL)

long-term storage challenges. SRNL began addressing this issue in2013 when the laboratory partnered with the German national research institution at Jülich, to advance an alternative technology.

"A major drawback of the TRISO-based High Temperature Gas-Cooled Reactors (HTGRs) is that they typically discharge the largest volume of used fuel per megawatt (MW)/hour of energy produced, approximately 10-16 times more SNF volume compared to light water reactors," said SRNL scientist Bob Pierce. "Apart from the impact of the SNF volume on geological disposal, the SNF presents a sizable interim storage liability that diminishes the appeal of the HTGR technology. The SRNL vapor digestion process can overcome that barrier, and it is the technology best positioned to solve this issue in time for the generation of these spent fuels in the early- to mid-2030-time frame, said Pierce.

TRISO Fuel Particles

SRNL's patented process reduces TRISO SNF volume by a factor of 20 by removing the graphite binder in which the small particles of fuel are dispersed. The goal is to have a complete, mature process demonstration at an engineering scale. Project collaborators and funding partners include the

Department of Energy (DOE) Office of Technology Transfer, the University of South Carolina, the Advanced Research Projects Agency-Energy and Westinghouse.

High-Assay Low-Enriched Uranium (HALEU) Feedstock

An additional challenge in the deployment of advanced SMRs is the need for HALEU fuel. Many of the new reactors will require HALEU fuel, which contains a higher relative percentage of Uranium-235 than what is used in existing commercial reactors. Unfortunately, the current US industry projected demand for HALEU far exceeds the available supply.

Through our work with a reactor fuel vendor, we know the available high enriched uranium fuel at the Savannah River Site meets the purity needs of select reactor fuels, according to SRNL scientist Tom Shehee. Dependent on a blend scenario, SRNL and the Savannah River Site can provide the fuel stock needed to completely fuel one of the first advanced reactors to come online in the US, noted Shehee.

SRNL is performing two key roles to provide the needed supply of HALEU fuel:

1. **Analysis of Solutions**
   SRNL analyzed batches of High Enriched Uranium solutions in storage at the Savannah River Site and determined production of low-enriched uranium can be readily transitioned to produce HALEU solutions to meet the extensive fuel specifications of the reactors.

2. **Licensing of a Transportation Shipping Package**
   SRNL is collaborating with a partner certified in container compliance to perform analysis and develop a Safety Analysis Report for Packaging. This effort will use a typical LEU transportation package to transport HALEU to a fuel fabrication facility that will produce new fuel for the advanced small modular reactors.

Fuel Reprocessing

While SNF can be reprocessed, numerous separation steps are required to convert this material into a usable product. Scientists at SRNL are testing a new technology for processing SNF for use in molten salt reactors, which are gaining attention for their increased efficiency and reduced waste volumes when compared to conventional reactors.

"SRNL is focused not only on advancing technologies related to MSR fuel fabrication, but also on how to remediate the spent nuclear fuel that comes from existing commercial reactors," said SRNL scientist Bryan Foley.

In theory, SNF from any existing reactor could be converted into fuel for molten salt reactors by using a molten, salt-based, chlorination technique patented by collaborator Metatomic, Inc. SRNL is working with Metatomic, Inc. to perform proof-of-concept experiments to assess the viability of this technique.

Packaging and Transportation

The safe storage and transportation of nuclear materials is critical to sustain safety in the nuclear power industry. SRNL's packaging and transportation group is leveraging more than 200 years of combined experience and technical expertise in the radioactive material packaging field to address the safe transportation of advanced small modular reactor fuels and spent fuels.

SRNL is involved in developing two packages to meet the specific needs of both TRISO and HALEU fuel transportation. Package 9979 type AF is capable of safely transporting TRISO fuel and process materials. SRNL was recently contracted to develop a similar package for a company developing micro-modular reactors that would utilize TRISO particles within the reactor. Work is currently underway to re-develop a package commonly referred to as the Liqui-Rad Transport Unit, to make it capable of transporting HALEU liquid material.

As the energy landscape continues to develop and the need to support a variety of reactors increases, SRNL is providing solutions. Advances in technology for the "back end" fuel cycle efforts are necessary to advance emerging nuclear power technologies to meet the nation's growing energy needs. The scientists and engineers at SRNL are dedicated to producing practical and effective solutions to ensure our nation's energy resilience.

SRNL program manager Kurt Eberl notes, "We are one of three regulatory review teams for radioactive material packaging shipments under the DOE Packaging Certification Program. Not only is it unique that we're involved in it, but the unique part is that we do everything. We have a pretty diverse crew, mostly mechanical, but also chemists and other engineers that work together to do analysis, design, testing, and write and review SARPs."

Loaded crucibles in a process tube prior to insertion into the tube furnace. (Photo: Bryan Foley, SRNL)

Opposite page

Top: Material transport test drum (Photo: Kurt Eberl, SRNL)

Middle: Uranium oxide that has been hydrochlorinated and tested at a high temperature that resulted in a green color, indicating a successful reaction of the uranium with the hydrogen chloride (Photo: Bryan Foley, SRNL)

Bottom: Current LR-230 Transportation Shipping Package. (Photo: Tom Shehee, SRNL)

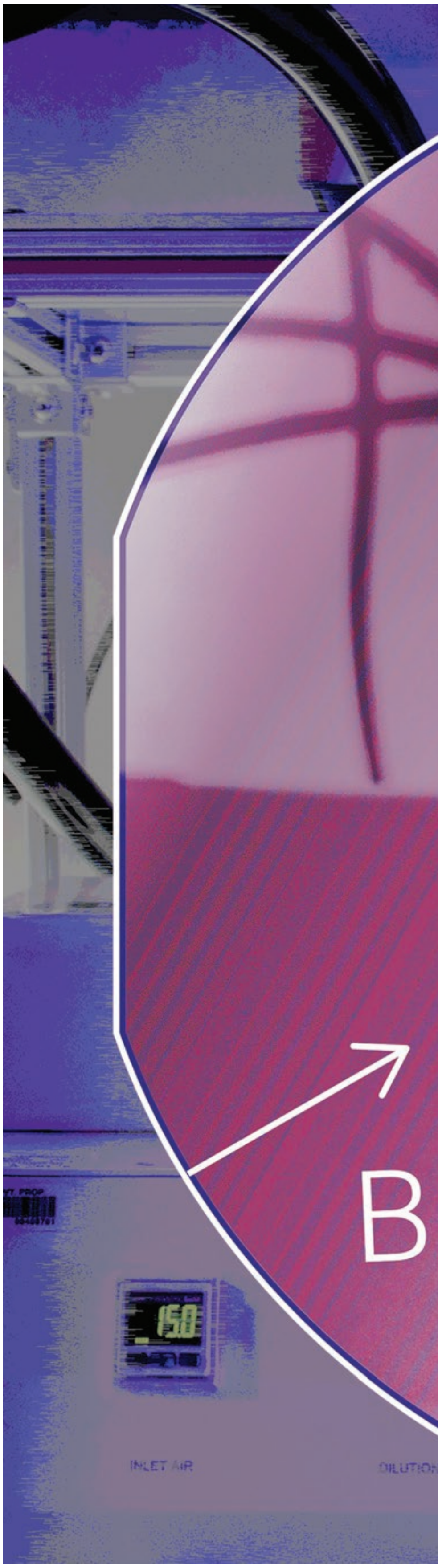
Watch the video

SRNL's Environmental and Legacy Management Directorate Supports New Advanced Reactor Fuel Cycles

Tiny Particles, Big Impact

SRNL's Particle Reference Materials Support Nonproliferation Efforts

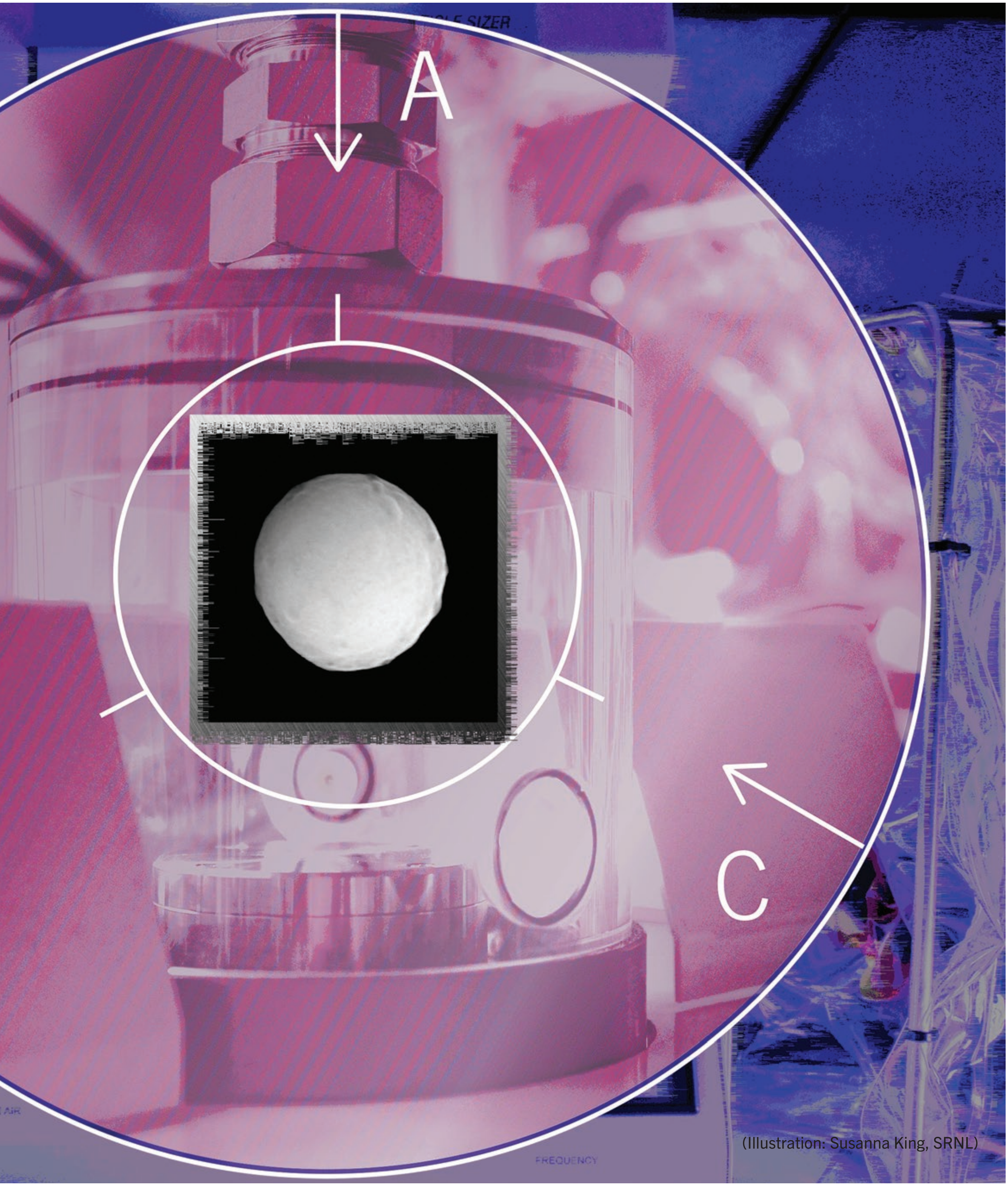
by Federica Staton



Ensuring the safe and effective management of nuclear materials and preventing the spread of nuclear weapons is a matter of national security. The Savannah River National Laboratory is contributing to nuclear nonproliferation by providing high-quality particle reference materials using their THermally Evaporated Spray for Engineered Uniform particulateS (THESEUS) platform.

The prioritization of particle reference materials by the International Atomic Energy Agency (IAEA) Department of Safeguards has enabled the accurate analysis of particles found in environmental samples from nuclear facilities around the world and allows the IAEA to verify compliance with treaty obligations on the peaceful use of nuclear materials and technologies. Particle reference materials are an important tool for laboratories performing particle analysis on environmental samples. They are used for quality assurance, method development, method calibration, and establishing the metrological traceability of measurement results by the IAEA and other US government agencies.

To philosophy enthusiasts the Ship of Theseus thought experiment challenges our perception of an object's changing substance. SRNL's THESEUS platform lives up to its name by having most of the platform's components replaced for each use. This ensures lingering material from previous work doesn't change the intended properties of the current material.



(Illustration: Susanna King, SRNL)

THESUS Instrumentation (Photo: Laura Russo, SRNS)

SRNL's particle reference materials are micrometer-sized particles of custom elemental and isotopic composition that are uniform in size and homogeneous in isotopic and elemental composition. A particle batch delivered to the IAEA may contain up to 10 billion particles, and they must be compositionally identical with fewer than 1:1000 having unintended compositions. Particles produced by THESEUS are collected using electrical charges (electrostatic precipitation) on planchets or through gravity-settling onto substrates. The collected particles are characterized using a suite of analytical techniques both at SRNL and Los Alamos National Laboratory. These particle standards were initially developed as part of the Safeguards Technology Development Program (NA-241) in the National Nuclear Security Administration's Office of International Nuclear Safeguards and were ultimately transferred to support the IAEA's nonproliferation efforts.

The Culmination of Years of Work

The SRNL particle reference material program was seeded in 2013 as part of the SRNL Laboratory Directed Research and Development (LDRD) program. At that time SRNL was analyzing the aging dynamics of uranium particles in the environment. As a part of that project, a particle generator system was developed to make uranium particles and the project team also received approval to attempt to create plutonium particles.

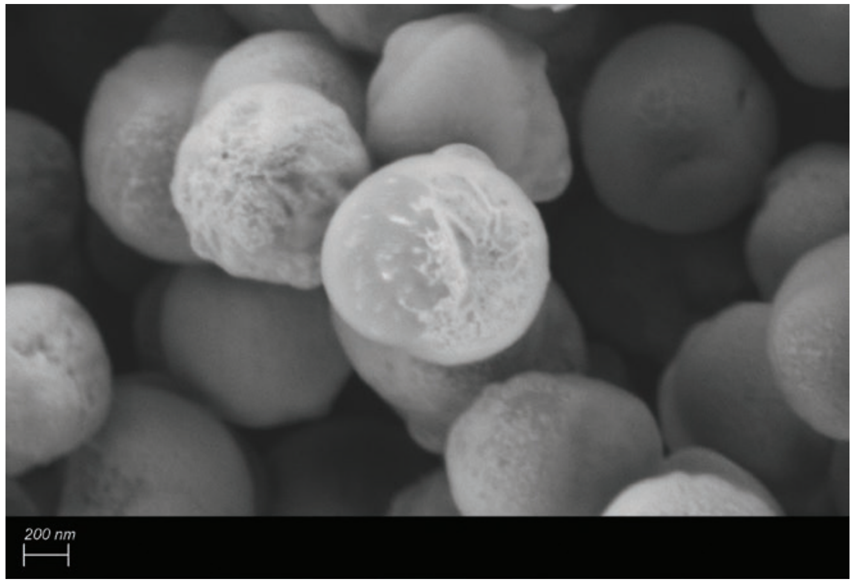
"Seeing the particles that originated from those very simple systems at the time was exciting," said, Matt Wellons, SRNL Advisory Program Manager. "The team liked what we saw and thought they would be really good test materials."

While the team didn't have a background in nuclear safeguards, they had successfully navigated the engineering and safety approval process to handle and manipulate particularly hazardous radioactive materials. This later helped them communicate to sponsors about their ability to handle enriched uranium and plutonium and perform research and development to generate test materials. A few years later, a second LDRD award helped mature SRNL's particle generation techniques and ultimately allowed the team to answer a request from NNSA's Office of Nonproliferation and Arms Control to produce reference particles which led to the conceptualization and development of THESEUS.

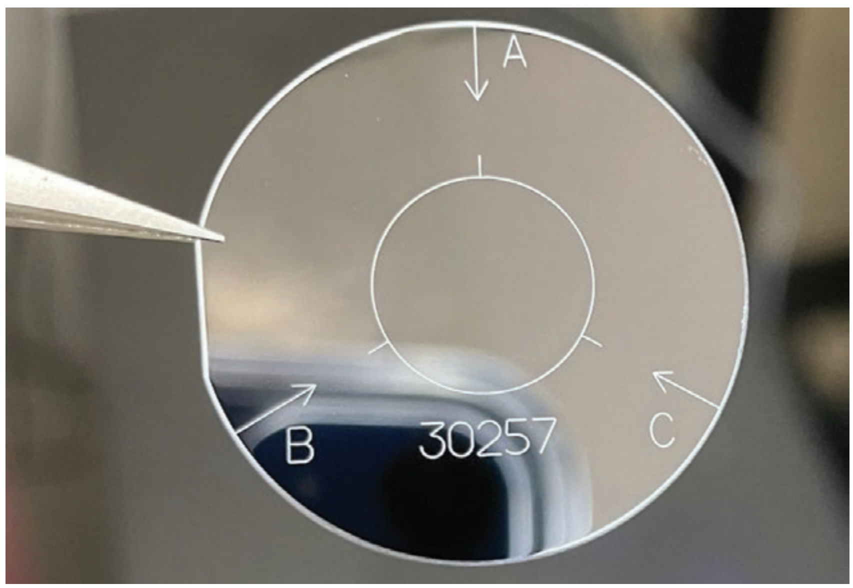
The THESESUS Process

Once SRNL receives a request to create materials, researchers use a combination of commercially purchased and in-house feedstock materials to generate custom elemental and isotopic feedstock solutions. The liquid feedstock solution is then injected into the THESESUS platform. THESEUS aerosolizes the solution into microscopic droplets that fly through conductive silicone tubing to a drier tube and tube furnace where the aerosolized feedstock droplets are dried and solidified in-flight prior to deposition (either gravimetric or electrostatic) and collection.

"It was very exciting. We leveraged a lot of information from our experience and training in aerosol science to coordinate with the vendors that sell that instrumentation," said Wellons. "It seemed like a golden opportunity. SRNL is a smaller lab, but we were in a position, based on prior work, competencies and skill sets to do something unique and valuable for the international nuclear safeguards community."



Uranium reference particles (photo: SRNL Trace Nuclear Measurement Technology)

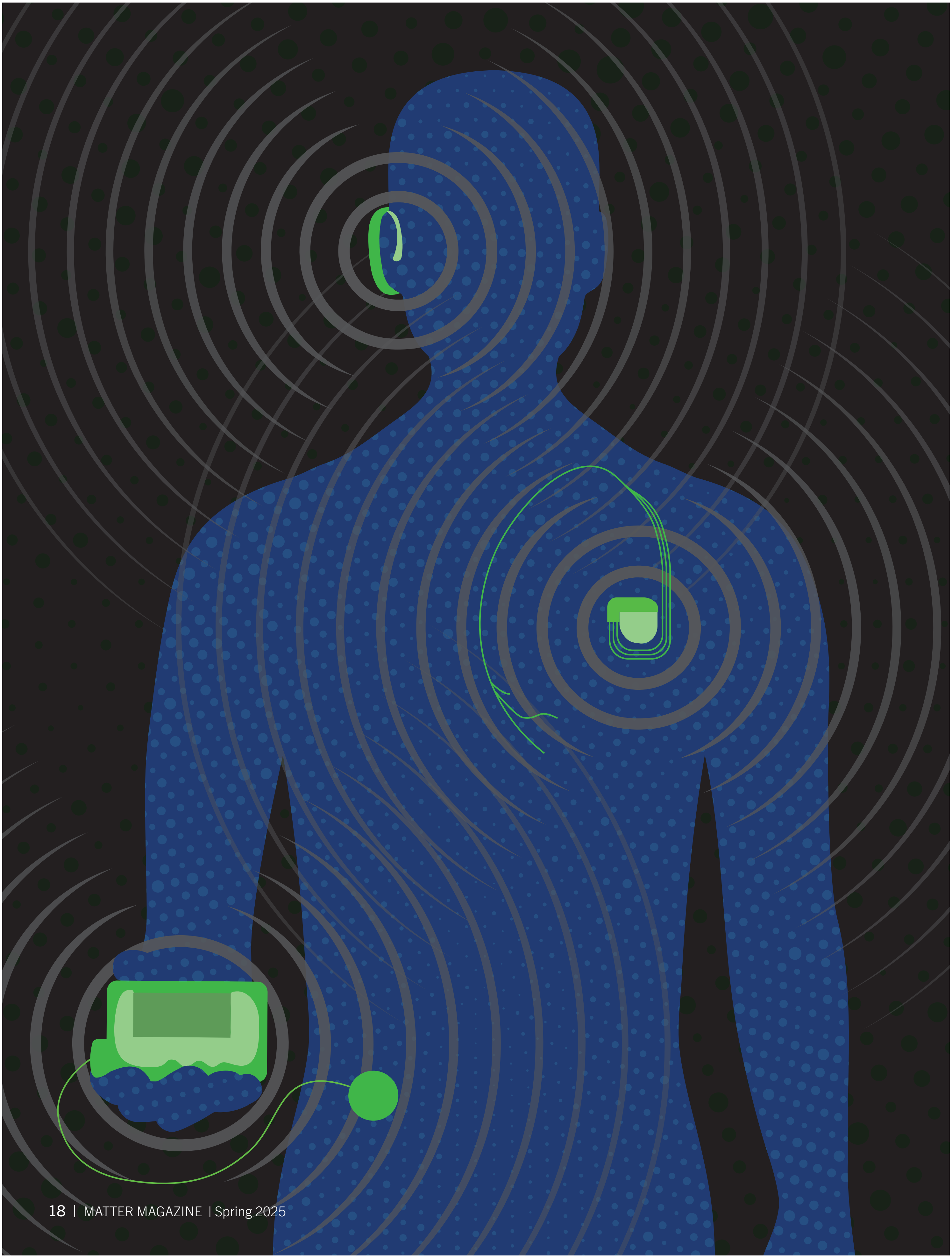


Mixed U/Pu particle planchet (photo: SRNL)

During the last decade, SRNL has worked with Los Alamos and Pacific Northwest National Laboratories, the National Institute of Standards and Technology and the IAEA, to refine the production and characterization technology to produce particle reference materials. SRNL is one of three labs in the world which are qualified to provide particle reference material production support to the IAEA.

Since the conclusion of both LDRD projects, the SRNL particle program has received continual funding from NA-241, as well as the Department of State through the International Safeguards Project Office, for the provision of reference materials to the IAEA. SRNL continues to provide high-quality, well-characterized, microparticle reference materials to the IAEA and other government agencies.

In 2023, SRNL made history by becoming the first national lab to produce mixed U/Pu microparticle reference materials for the international community – a material unlike any others produced in the last 40 years. This accomplishment is the result of extensive investment, innovation, and advocacy by SRNL, NNSA and their partner institutions. Historically, the international nuclear safeguards community, under the IAEA, has not had access to microparticle reference materials with certified uranium and plutonium compositions. SRNL's successful production of these reference materials fills this gap, enhancing microanalytical measurement traceability. Distributing these materials globally will strengthen the international nuclear safeguards system and support the development of next-generation analytical methods and technologies. The production of reference particle materials highlights SRNL's advanced production technology of creating precisely controlled and complex microparticles and paves the way for the development of new and unexplored material formulations in the future.



Ensuring the Cybersecurity of Medical Devices

by Kent Cubbage

Wireless technology has become ubiquitous. In our kitchens, our workplaces and our pockets, we are increasingly surrounded by and dependent upon wireless communication. This electronic ecosystem has even been given a name – the Internet of Things (IoT). These devices have greatly enhanced our lives and increased our productivity, and in the process made the world dramatically more connected.

While this connectivity is generally a net positive, it has made us more vulnerable to nefarious motives. Not a week goes by that we don't read about a cybersecurity breach, and unfortunately many of us have personally been the victim of such a crime. Having our information or money stolen as part of a computer hack is a constant concern these days, but electronic privacy and safety concerns have extended to the medical field. Wireless devices vital to our health and wellness have become commonplace in doctors' offices, hospitals, the military and even on and in our bodies. As such, these devices are potentially vulnerable to cyber attack.

A group of researchers at Savannah River National Laboratory is attempting to change that. It is led by David Baldwin of SRNL's Unconventional Cybersecurity Group and his project, Reverse Engineering of Medical Devices for Innovation and Advancement in Healthcare. The team is working in conjunction with joint appointee Jeffrey Morris and Michael Nowatkowski from nearby Augusta University.

Baldwin has had an interest in the medical IoT since his college days. "I had the opportunity to go to Black Hat, which is a very large cybersecurity conference hosted in Las Vegas," said Baldwin. "My favorite talk while I was there was a group that talked about hacking insulin pumps, pacemakers and other medical technology. I saw the vulnerabilities these devices have, and that the device developers downplayed them."

Baldwin determined that it was imperative and vital that research into medical device hacking be undertaken, and that it be conducted by third party scientists who did not have a financial interest in the devices' success. When Baldwin came to SRNL he discovered a nascent effort in this space was underway at the lab, and he inherited the effort when the principal investigator moved on.

Baldwin explained that there are a multitude of cyber hazards associated with IoT medical devices. So-called "White Hat" hackers, those who discover vulnerabilities for patching before malicious actors can exploit them, determined that heart attacks can be induced in those with pacemakers. In addition, hackers can cause insulin pumps to discharge all of their insulin at once, with potentially fatal consequences.

Medical device cyberattacks can be leveraged to collect data and information as well. "Hacking of hearing aids can be spying-related," said Baldwin. "All of the audio data can be intercepted, so they can essentially just listen in on our conversation, and they can even grab geolocation data . . . so there's a huge variety of exploits associated with IoT devices."

Baldwin's research is focused primarily on existing medical devices. Common weaknesses in these devices are in a broad spectrum that applies to similar devices in general, but each specific instrument has its own individual vulnerabilities. The goal is to analyze the vulnerabilities in a handful of devices to understand the methodology that can be utilized to leverage general weaknesses associated with IoT devices, which will also help with the design life cycle of new ones.

Medical devices are increasingly dependent on usage with handheld devices such as cell phones or tablets. This allows the medical device to be simpler, easier to use and cheaper to design and manufacture. The interaction a cell phone has with the medical device via Bluetooth and Wi-Fi represents the most common vulnerability, explained Baldwin.

The group has been working with Augusta University on the electronic security of IoT portable ultrasound devices. These devices can be dependent on Wi-Fi networks that can be pinpointed when turned on, potentially giving away their location. The group is also analyzing a Bluetooth hearing aid that is available without a prescription. This scenario could lead to supply chain vulnerabilities, as well as security issues with the signal encryption and both the hardware and software.

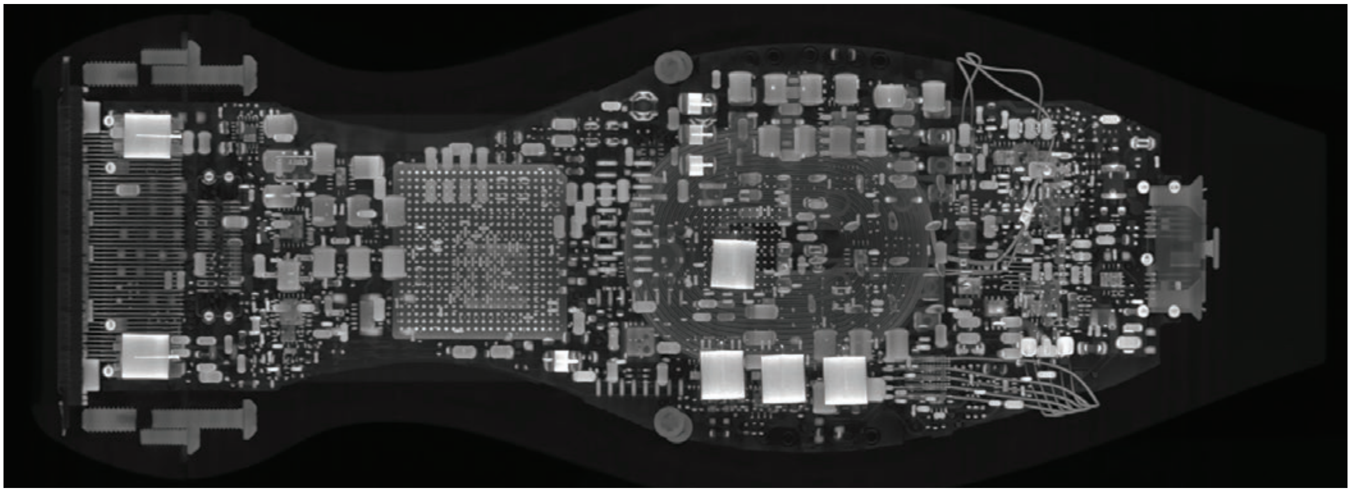
Baldwin indicated that Bluetooth devices can be susceptible to a "man in the middle" attack, whereby the hardware address of the device and cell phone are stolen. Then the hacker can break the connection between device and cell phone, essentially posing as one or the other. They can intercept all of the data coming from one of the devices, with both devices unaware of the breach.

The process of reverse engineering the device for the purposes of determining electronic vulnerabilities starts relatively low-tech. "Typically when you get a new device you look at the user manual and any other technical documents for the device," said Baldwin. "To comply with the FCC, they have to tell you all of the different ways the device communicates . . . and the encryption levels."

The next step is to determine if similar devices have had vulnerabilities. Databases can provide information about these, known as common vulnerability exposures (CVE) and common weakness exposures (CWE). Existing methods of attack can then be tested on the device. The software can be broken down into C and assembly code, which can be analyzed for potential electronic security issues. Moreover, the team has CT scanning capability with the SRNL CT laboratory, which helps determine hardware security issues.

Solutions to cybersecurity issues with medical devices can vary. For example, something as straightforward as

A CT scan of a medical device (Photo: Vincent Dinova)



multi-factor authentication can be used. The device hardware can be designed to be more resilient against certain exploits, and the direct communication signal via the cell phone can be hidden. However, proper encryption specific to the device is usually the best option.

The size of the medical device market and its electronic security present challenges and opportunities for research in the field. "It is a massive market projected to soon be close to a trillion-dollar market cap," indicated Baldwin. "Thus, our work is primarily for proof of concept. That's how we are going to have the biggest impact on this ecosystem."

A device is tested in an environment with no external communication interference (Photo: Mitchell Jordan)

Baldwin examines the computer code from a medical device (Photo: LJ Gay, SRNL)

Nuclear CSI: The Radiological Evidence Examination Facility at SRNL

by Kent Cubbage

Fewer things have been as popular on television over the last few decades as shows about crime scene investigation. Viewers have eagerly tuned in to watch stories that revolve around analysis of evidence. Often the case is cracked not by investigators and detectives in the field, but by those back in the crime laboratory using the latest in specialized techniques and technology to analyze evidence that was seemingly insignificant.

Television typically sensationalizes these scenarios and the laboratories that accompany them, but they are not all rooted in fiction. This is particularly the case at Savannah River National Laboratory (SRNL), which hosts the Radiological Evidence Examination Facility, known simply as REEF.

REEF represents a collaboration between SRNL and the FBI. The facility provides a physical location and technical expertise to the FBI in support of safe forensic examination of evidence contaminated or suspected to be contaminated with radiological material. The material can be from domestic or international criminal activity or terrorism.

The facility is staffed by Program Manager Kim Roberts and Operations Manager Kirby Scott, with support from Staff Scientist Josh King. It is overseen by Line Manager Chuck Schick.

"No radiological work happens at the FBI Laboratory in Quantico, so if radiological contamination is suspected, we are the FBI's go-to facility," said Roberts. "And we can also provide consultation and advice if they are in the field."

The FBI/SRNL partnership began in 1999, but was greatly expanded in the wake of September 11 and the anthrax (Amerithrax) incidents in 2001. The FBI provided a sizeable investment in the facility as a result. Five years later the initial REEF concept took shape, and began the process for ISO 17025 accreditation, which certifies analytical methods for measurements from items of interest collected during a forensic examination.

The facility's physical configuration was completed in 2010. Lab space was expanded to handle everything from small environmental to highly radiological samples. REEF contains approximately 6000 square feet of space in two wings. It contains "High Bay, Hot Cells" that can accommodate highly radioactive evidence and handle it safely and remotely. This was made possible by FBI funding in 2012, when two cells used during the Cold War were refurbished for REEF's use.

Currently, REEF is the only dedicated forensic examination facility in the U.S. for handling radiological evidence or traditional evidence contaminated with radiological materials. REEF works with the FBI's Hazardous Evidence Analysis Team (HEAT), which is capable of analyzing trace evidence for such things as explosives and latent prints. In addition, REEF can analyze evidence for DNA. Numerous SRNL and Savannah River Site personnel can serve as subject matter experts and expert witnesses in various aspects of radiological cases.

REEF is in regular communication with the FBI and stands at the ready 24/7 should it get the call. The facility prides itself on its flexibility and can adapt itself to the nature of the evidence it receives. It can construct custom containment spaces, and even large outdoor huts, as the evidence requires.

Another REEF asset is the Mobile Digital Radiography and Isotope Identification System, or MoDRIIS, also funded by the FBI. This self-contained trailer weighs a staggering 63,250 lbs. It can perform powerful X-rays on evidence and has a high-power detector to identify isotopes present in radiological

A custom containment and examination hut (Photo: FBI Laboratory)

REEF investigators examine evidence (Photo: FBI Laboratory)

material.

SRNL's reach and expertise is wide ranging. It has trained more than 80 forensic examiners and scientists, as well as more than 800 FBI special agents. REEF has several international partnerships, including collaborations with the U.K., Australia, Canada and Sweden.

The facility, its members and partners are kept sharp and at the ready through periodic exercises. Case scenarios with mock evidence provide opportunities to challenge capabilities, put equipment through its paces, and ensure the overall performance and readiness of the facility. These training opportunities allow for radioactive source detection and response, simulated radioactive contaminated evidence and tactical training. Though kept secret, the exercise code names are based on aquatic themes in keeping with the REEF motif.

SRNL works closely with the FBI in planning and executing these exercises, and strives to support the FBI in every way it can. "An FBI Laboratory Director visited REEF during my tenure as Program Director and praised our customer service," said Roberts. "We are always looking to foster and grow our relationship with the FBI."

Through its partnership with and support from the FBI, this one of a kind, adaptable and responsive facility will continue to serve as a center of excellence. REEF may not be as glamorous as crime scene television, but it's nonetheless a critical asset to the nation.

Partnering with SRNL's Advanced Manufacturing Collaborative

by Charnita Mack

Scientists and engineers from the Savannah River National Laboratory will continue tackling applied and technical challenges when the doors of the more than 60,000-square foot Advanced Manufacturing Collaborative open in 2025. The Advanced Manufacturing Collaborative provides a platform for public-private partnerships – connecting industry, academia and government – to improve advanced manufacturing in areas such as additive manufacturing, AI-driven automation, and novel materials for fusion energy, energy resilience and nuclear applications. Leveraging SRNL's historical expertise in separations science and materials science, and by integrating AI-driven process optimization tools, SRNL can accelerate the next generation of manufacturing technologies for energy, defense, and cleanup applications.

Regardless of the endeavor, Daren Timmons, AMC director and director of technology partnerships at SRNL, says partnerships that can be executed through Cooperative Research and Development Agreements, or a Strategic Partnership Project agreement are a key focus.

CRADAs and SPPs are just two of several ways to partner with any DOE national laboratory. Non-federal entities that are looking for a mutually beneficial collaborative research opportunity and can contribute in-kind resources, e.g. personnel, equipment, facilities, etc. may opt to enter into a CRDA agreement; while industry, nonprofit institutions, and other non-federal organizations that desire to utilize the AMC's highly specialized facilities, equipment, or SRNL scientists and engineers by fully outsourcing a specific task or scope of work to the lab may choose an SPP. In either case, funding must be secured by the partner or in conjunction with the lab,

The AMC under construction (Photo: SRNL)

One of the AMC's state-of-the-art laboratories (Photo: SRNL)

which is critical to the start of any project. Entering into either agreement type presents an opportunity to exhibit what the AMC has to offer.

"My role is to help connect the potential partners with the right people at the laboratory," Timmons said. "We're trying to lower the barrier to partner with SRNL. For those who have never worked with a national lab, it is not always obvious where to begin, or even what we do and how we can be useful."

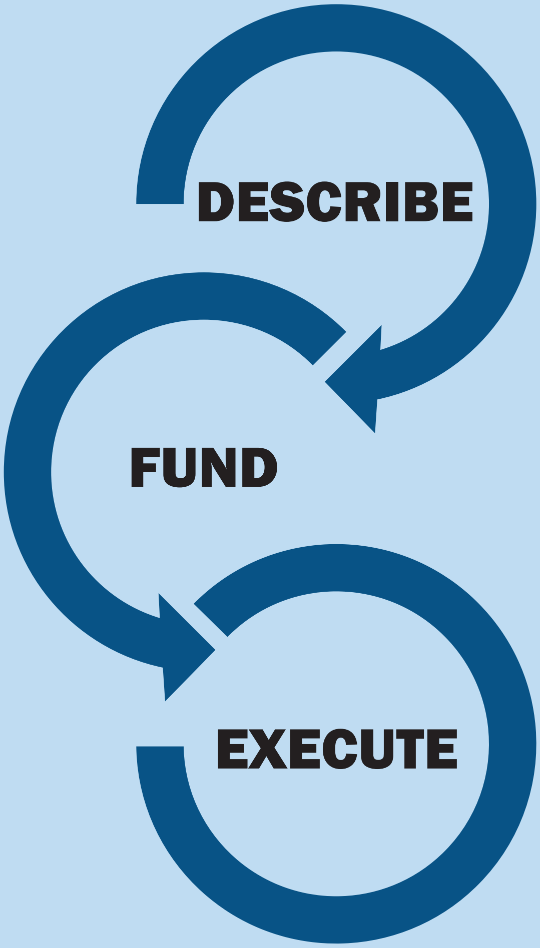
In addition, Timmons hopes that the licensing of SRNL intellectual property becomes a more visible asset of the lab through AMC partnerships.

"An established company might benefit from SRNL patented intellectual property, and we would gladly explore licensing options. Additionally, an entrepreneur could license SRNL technology and build a business around it," he explained. "Of course, SRNL expertise and intellectual property is much broader than the work to be conducted at the AMC, but I like to think of the AMC as the front porch to the lab."

The AMC will be open to the public with some restricted access areas, much like the academic buildings on the University of South Carolina Aiken's campus, where the AMC is located. The public spaces will feature USC Aiken engineering classrooms, open collaboration spaces, and a conference room. Access to the AMC's laboratories and office spaces is controlled and will require visitors to be checked in and escorted by the lab employee they are visiting. No radiologic work will be conducted at the AMC but some research at the AMC may have uses in the nuclear industry.

"We are eager to be a part of the growing areas of innovation in the community and be more easily accessible to our partners across the country," Timmons added.

To get started on the journey of a partnership with SRNL's AMC, visit the Partner With Us page on srnl.gov.



Daren Timmons, AMC director and director of technology partnerships, is trying to lower the barrier to partner with SRNL. The process begins with describing the potential project or need, then solidifying funding, and finally, executing a contract to start work with SRNL's scientists and engineers.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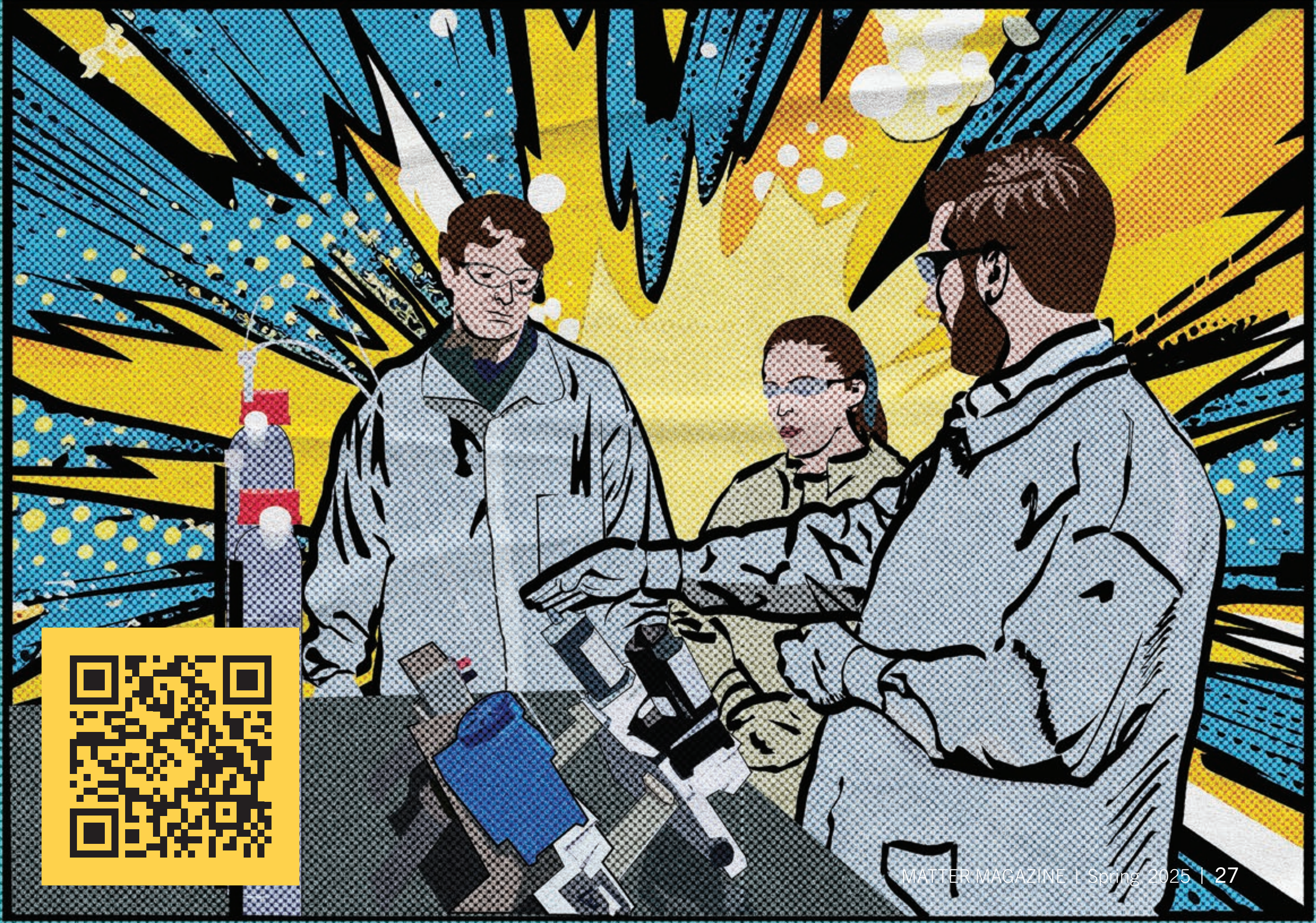

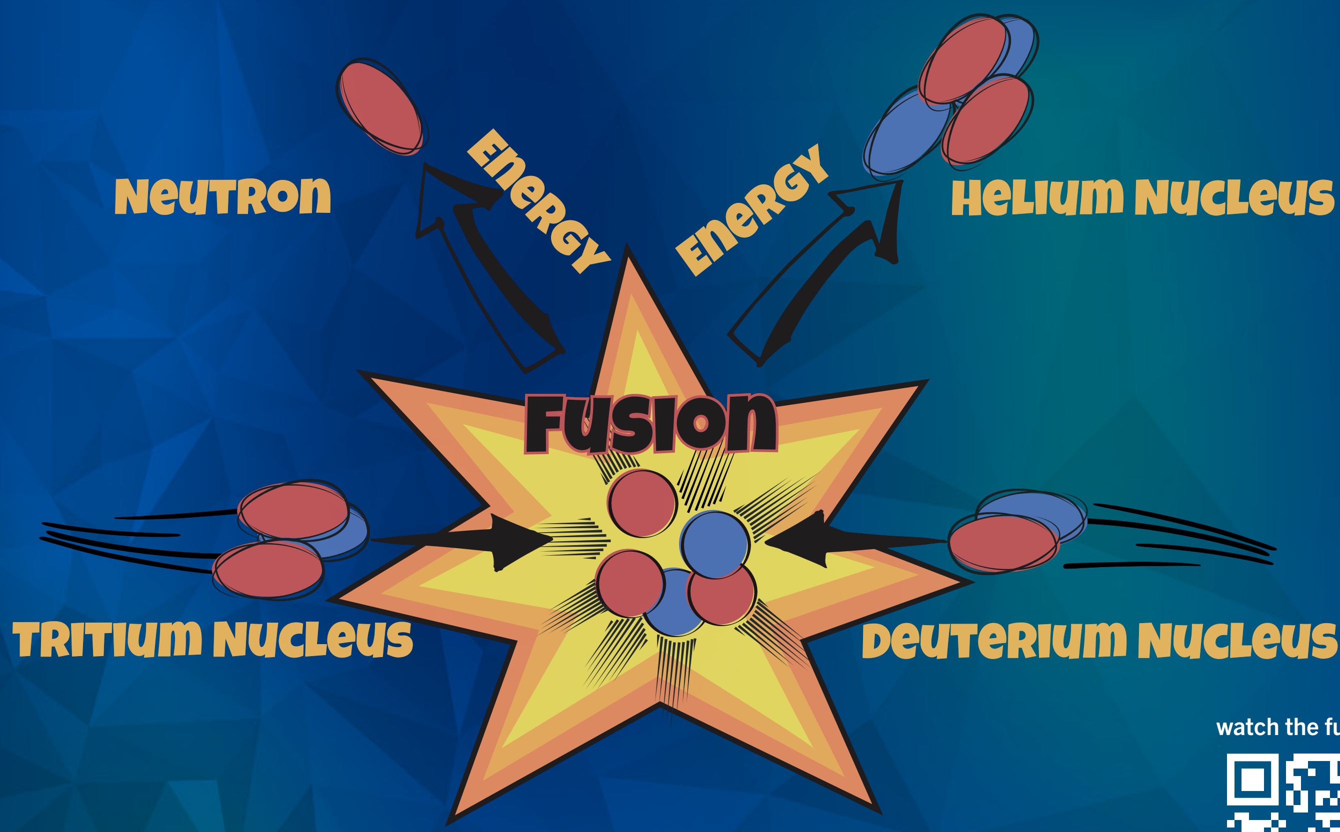

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