THE SOURCE

ALUMNI MAGAZINE • FALL 2019

Progress continues on the department's new home. Plus, the race to fusion, **page 2.**

TNUCLEAR ENGINEERING

A Scattered Approach to Materials • Darwinian Nuclear Reactors • Fusion Futures

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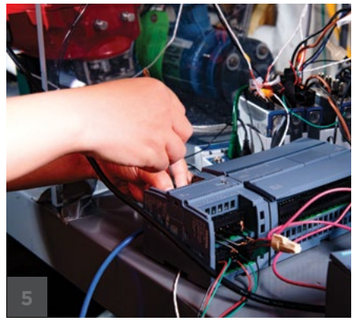

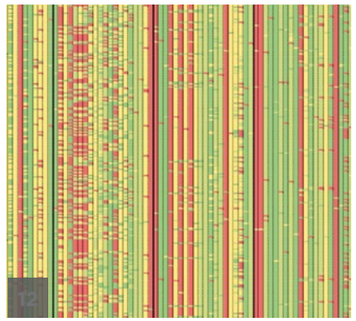

On the Cover: Construction on the new engineering complex that will house the department is under way and expected to be completed in the summer of 2021.

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From the Department Head

It's fall on Rocky Top, and we have a new class of freshmen on campus. With this class comes unbridled excitement, technical savvy, and fresh ideas. I am always amazed by the quality of these young minds. They have the highest entrance scores to date, and most come with considerable AP and college credit. Reloading top talent is necessary as we continue to graduate classes of highly qualified nuclear engineers.

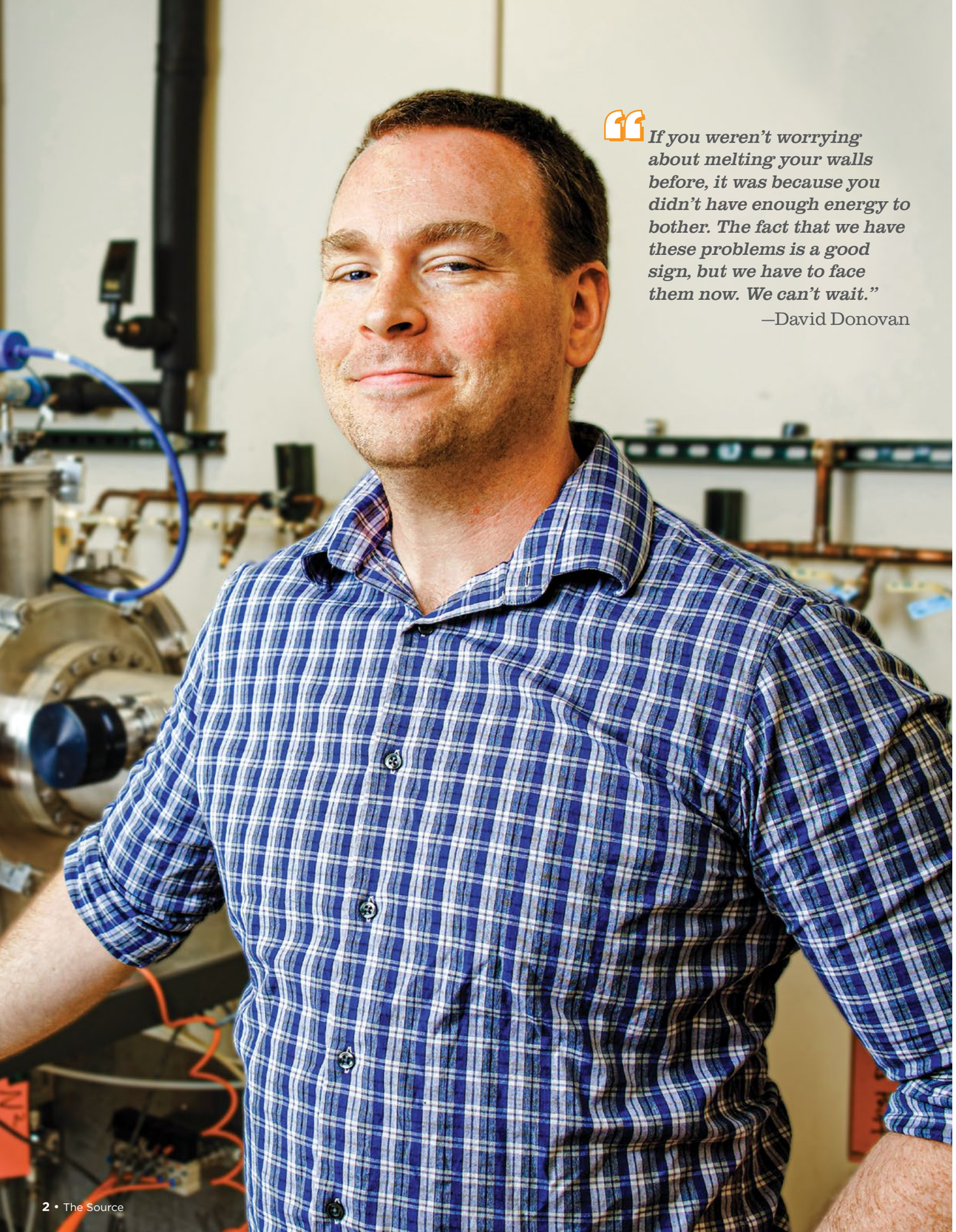
After such strong departmental growth over the last decade, we have taken the opportunity to pause, communicate with industrial partners, and have developed a focus on nuclear safety that we feel will give our graduates a competitive advantage in the job market. We are developing an undergraduate minor in Nuclear Safety and a concentration in Nuclear Safety at both the MS and PhD levels. Through a new partnership with Bechtel, we are offering a licensing class that will provide the foundation to this new focus. Our newest faculty member, Associate Professor Nicholas Brown, is teaching a new class focused on computational modeling to support safety and licensing. This addition, along with Associate Professor and Southern Company Faculty Fellow Jamie Coble's Process System Reliability and Safety, and Associate Professor Ronald Pevey's Criticality Safety classes, make a strong core curriculum in the nuclear safety area.

I hope you enjoy the articles featured in this seventh issue of our department magazine. The stories showcase the impact our students and faculty are making on our world, which is especially relevant during this 225th anniversary year of the university, which carries the theme of "Lighting the Way." Our departmental tag line, "Study Nuclear Engineering: Save the World," resonates throughout this issue. I hope it is refreshing to learn about all the successes we have had over the last year as we continue our journey to improve society.

I am pleased to also read the stories of our two most recent additions to our Nuclear Engineering Hall of Fame. The successes that Tony Buhl and Tom Kerlin have had on society are unparalleled—knowing that they are just two of our over 1,300 graduates humbles me.

Please feel free to reach out, visit us and stay involved with our talented students and faculty.

J. Wesley Hines
Charles P. Postelle Distinguished Professor
Chancellor's Professor
Department Head, Nuclear Engineering



> ***If you weren't worrying about melting your walls before, it was because you didn't have enough energy to bother. The fact that we have these problems is a good sign, but we have to face them now. We can't wait."***
>
> —David Donovan

A FUTURE IN FUSION

By Élan Young. Photography Shawn Poynter.

Donovan is holding a diagnostic that will be installed in the UT Plasma Exposure Stage to measure the ion temperature.

Fusion powers the sun and all the stars in the galaxy. It produces nearly all of the elements. It's the power inside a thermonuclear weapon. No wonder it has the capacity to captivate the collective imagination—both with hopes and fears—like no other field of science or engineering.

Research into fusion for the production of electricity has been a 60-year international pursuit, and harnessing it for the energy grid with a net energy gain is one of the 14 grand challenges for engineering in the 21st century.

"It's easy to make fusion happen if you're only interested in putting 1/10,000th of the power out that you are putting in to make it happen," said Assistant Professor David Donovan. "But a power plant only works if there is greater energy out than energy in."

Fusion research has received funding to build experimental devices that can not only produce a reaction, but also contain the reactions in a structure that won't melt from the intense heat created. Heat is a major focus of the fusion research happening at UT—in particular, the study of materials and technology that are essential to making fusion a truly viable energy source.

Unlike a fission reactor, there's no equivalency of meltdown in a fusion reactor; however, the containment walls of a fusion device must be able to withstand the hottest achieved temperatures on the planet, and that requires developing new materials.

"If you weren't worrying about melting your walls before, it was because you didn't have enough energy to bother," said Donovan. "The fact that we have these problems is a good sign, but we have to face them now. We can't wait."

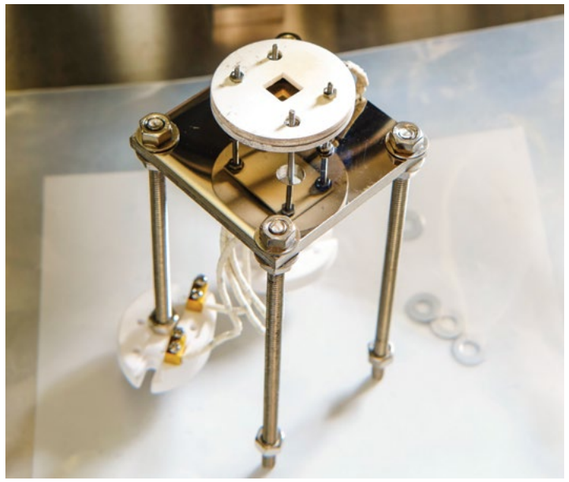
Both government and private enterprises have joined the race to achieve a reliable source of fusion energy for the power grid. The largest fusion experiment in the world, ITER, is a $20 billion international effort located in France with a construction completion date of 2025.

When finished, ITER, which means "The Way" in Latin, will produce fusion power experiments that will inform the design of next-generation fusion reactors that will eventually power the planet. Its donut-shaped Tokamak reactor design is 40 feet tall.

Donovan says it's very alluring to say researchers can create this next-generation nuclear reactor simply through computer modeling, but at the end of the day, they still don't know what they don't know, and at some point, a reactor just has to be built.

"It's a financial risk, but we have to build fusion devices to experiment," he said. "We want to do as much homework as we can ahead of time, but at some point, we have to acknowledge that it's never going to be perfect. Fission power wasn't perfect when it began."

Challenges are understandable, considering fusion devices can have the hottest and coldest temperatures in the universe within a few meters of each other—all of them manmade. However, with a vision that extends far into the future and a population expected to grow by a billion people in the next decade, the value of pursuing fusion energy cannot be underestimated.



Sample exposure stage capable of mounting fusion relevant materials, like tungsten, and heating them up to 1000 degrees C while exposed to a beam of high energy ions to study how the walls of a fusion device will experience damage.

Nuclear Cybersecurity Research Gains **International Attention**

By Élan Young. Photography by Shawn Poynter.

Aging nuclear infrastructure has prompted utilities across the world to look toward implementing digital instrumentation and control (I&C) systems, which offer improvements over current analog technology in ease of maintenance, convenience, and economic viability.

As with many aspects of digital technology, I&C systems also need cybersecurity measures to protect from malicious threats. Doctoral student Fan Zhang is researching a new approach to do just this, and her findings have found a home with one of the most respected bodies in the nuclear field—the International Atomic Energy Agency (IAEA).

"With the number of threats and methods of cyberattacks increasing every day, it's important to focus on detecting a breach in security as early as possible so that nuclear power plants have enough time to respond before a severe consequence," she said.

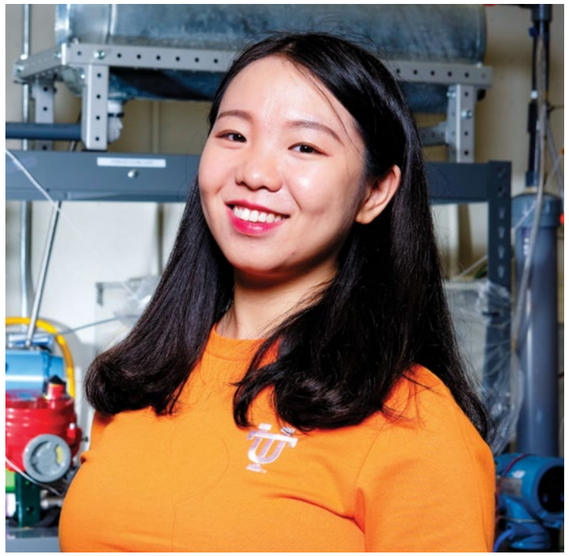
The cybersecurity of nuclear power plants requires dedicated efforts to re-envision the way operational technology and information technology teams work. Zhang's solution creates a novel architecture that promotes cross-collaboration by combining both teams. Her proposed cyber-attack detection system consists of three modules based on four types of data, including classification models, unsupervised models, and network and host system data.

Zhang first built a real-time cybersecurity test bed consisting of a simulated two-loop power system; a supervisory control and data acquisition (SCADA) system to receive data and pass control commands to the system; and a local area network to simulate cyberattacks.

Most current cybersecurity efforts use firewalls and network analysis to prevent attacks, but Zhang pointed out that threats originating from within, such as those coming from removable media and insiders, still pose a risk despite such precautions. Additionally, data tampering attacks may not leave any trace in the actual networks themselves.

By using "process data" (data coming directly from the plant sensors) in combination with machine learning to detect when a cyberattack is ongoing or has occurred, on-site personnel would gain precious time to prevent severe damage, economic consequences, or potential loss of life.

Zhang tested five types of attacks, including man in the middle (MITM), denial of service (DoS), data exfiltration, data tampering, and false data injection to simulate the consequences of a cyberattack and generate data for building data-driven detection models. The results show the proposed model is able to effectively detect these attacks carried out on the testbed with almost no false alarms.

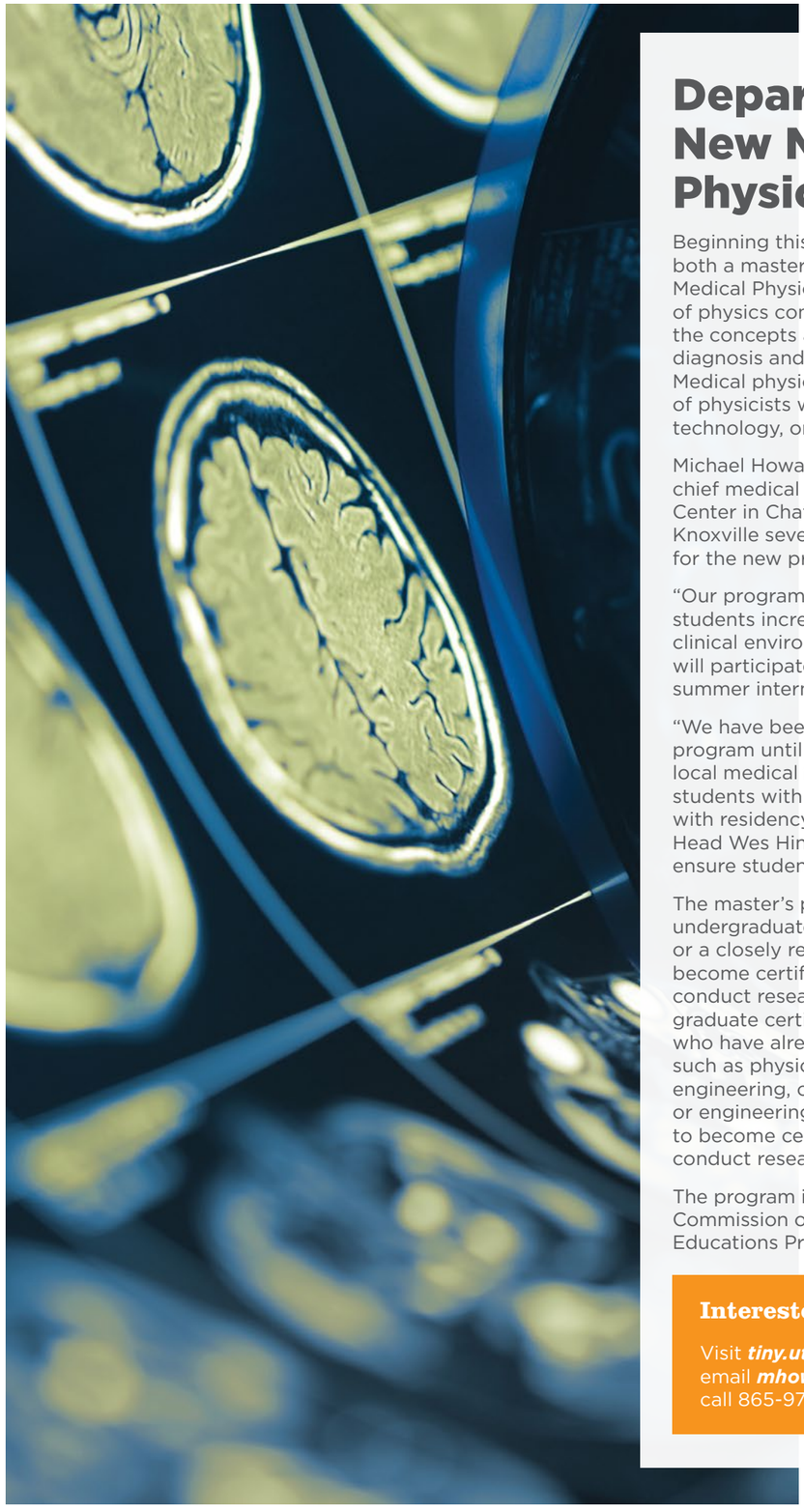


A conversation with Michael T. Rowland, former IAEA cybersecurity director, led to Zhang being invited to participate in an IAEA Coordinated Research Project (CRP). Entitled "Enhancing Computer Security Incident Response at Nuclear Facilities", the CRP explores best practices in cyberdefense; technology and analytical solutions for intrusion detection; and recommended procedures for response, including forensic activities for computer security incidents at nuclear facilities.

The CRP has led to Zhang sharing her research findings with partners from 17 institutes across 13 countries and at CRP meetings in Canada, Austria, China, and South Korea as well as international conferences hosted by ANS and the International Society for Automation.

Her research will now be published and used in guidance and training of nuclear security methods for the IAEA. Additionally, this research will receive substantial funding by the DoE's Nuclear Energy University Program for a proposal entitled, "A Cyber-Attack Detection Platform for Cyber Security of Digital Instrumentation and Control Systems." As one of the proposal's co-authors, along with the PI, Associate Professor and Southern Company Fellow Jamie Coble, Zhang has had a strong influence on the direction and implementation of the project, which will receive an award of close to $800K in October.

In addition, this research was partially funded through Lloyd's Register Foundation and the International Joint Research Center for the Safety of Nuclear Energy. Lloyd's Register Foundation helps to protect life and property by supporting engineering-related education, public engagement, and the application of research.



Department Unveils New Medical Physics Program

Beginning this fall, the department now offers both a master's and a Graduate Certificate in Medical Physics. The field is an applied branch of physics concerned with the application of the concepts and methods of physics to the diagnosis and treatment of human disease. Medical physicists are a specialized category of physicists who work in radiotherapy, nuclear technology, or medical imaging.

Michael Howard, administrative director and chief medical physicist at Parkridge Medical Center in Chattanooga, Tennessee, travels to Knoxville several times a week to teach a course for the new program and serve as its director.

"Our program is unique in that we offer students increased hands-on time within the clinical environment. Medical physics students will participate in a variety of labs as well as a summer internship," said Howard.

"We have been holding off starting this new program until we developed relationships with local medical facilities that will provide our students with internships and our graduates with residency opportunities," said Department Head Wes Hines. "Now, we have partnerships to ensure student success."

The master's program is designed for undergraduate students in engineering, physics, or a closely related field who would like to become certified medical physicists and/or conduct research in medical physics. The graduate certificate is designed for students who have already earned a PhD in a related field such as physics, nuclear engineering, biomedical engineering, or other closely related science or engineering discipline and who would like to become certified medical physicists and/or conduct research in the field.

The program is accredited through the Commission on Accreditation of Medical Physics Educations Programs, Inc.

Interested in learning more?

Visit ***tiny.utk.edu/medphys***, email ***mhowar14@vols.utk.edu***, or call 865-974-2525.

▲ *Micah Folsom, second from right, with a group of researchers at the Naraha Center.*

Students Visit Site of Fukushima Nuclear Disaster

By Élan Young.

Doctoral student Micah Folsom was one of two UT engineering students to visit the newly reopened Fukushima Daiichi plant in Japan that experienced meltdowns in three of its reactors after a devastating tsunami in 2011. During the trip, they learned about the technologies used to decommission the reactors, including the use of remotely controlled robots, radiation sensors, and radiation-hardened electronics.

Folsom and Logan McNeil, a doctoral student from UT's Department of Mechanical, Aerospace, and Biomedical Engineering (MABE), attended with MABE Professor Bill Hamel, an invited speaker, thanks to financial support from the Japan Atomic Energy Agency (JAEA).

"We heard detailed presentations about the site recovery and the expanse of remaining technical challenges Japan faces in returning the environment as close as possible to its original condition," said Hamel. "The key technical challenge at this point is reactor fuel debris removal from the reactors that experienced meltdown conditions."

The conference was hosted through the University of Tokyo's Nuclear Education, Skills, and Technology program and included talks by experts on developing technologies as well as a tour of the plant site. They saw the town of Ōkuma, the reactor buildings, and the impressive infrastructure built for the clean-up effort, including massive arrays of water tanks holding contaminated water.

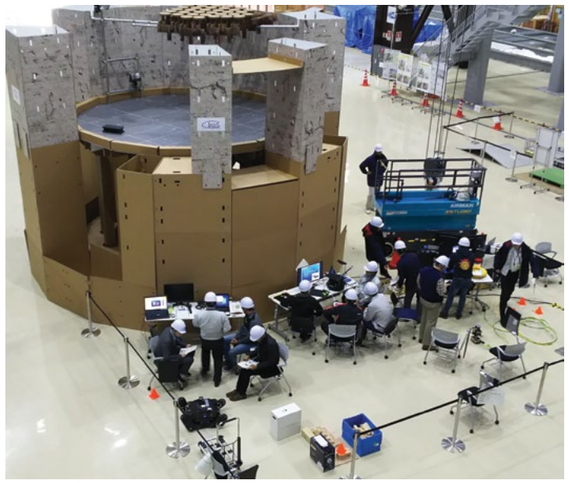
Following the conference, the students did hands-on exercises with robots to learn how to combine robots, cameras, algorithms, and radiation sensors to build 3D models and radiation maps of the inside of the reactor buildings.

"We created a 3D model of a cardboard mock-up of a reactor pedestal. Then, using simulated radiation data and radiation imaging algorithms, we created an image of a radiation source and overlaid it on the 3D pedestal scene. We were able to utilize the JAEA facilities, which housed the to-scale cardboard mock-up and worked with some of their scientists on the exercise," said Folsom.

They also spent time at the University of Tokyo campus working with their NE students on using software to perform the 3D scene reconstruction and radiation transport simulations.

Folsom's experience at Fukushima was enlightening and inspiring, reminding him of the work that remains to be done in his field.

"The decommissioning effort there will continue for decades, and I hope I have a chance to contribute in the future," said Folsom. "It was also a very stark reminder of the uphill battle nuclear technology faces in terms of public relations both in Japan and in the US, providing a strong motivator to continue my nuclear advocacy work."



▲ *One of the areas for hands-on exercises with robots at the Naraha Center*

Alumnus Develops Materials for Next-Generation Reactors

By Élan Young. Photography by Randall Brown.

While still largely conceptual, researchers around the world are working to replace current light water reactors with a new generation of advanced reactors that represent the cutting edge in nuclear technology. Advanced reactors take completely different approaches than light water reactors, operating at higher temperatures and exposing materials to much higher doses of radiation.

One current problem is that there aren't yet materials that can withstand the extreme environments associated with them. Caleb Massey (PhD/NE, '19), who studied under UT-ORNL Governor's Chair for Nuclear Materials Steven Zinkle, is now working at ORNL to help solve the problem. He recently received the Mark Mills Award from the American Nuclear Society for his research.

Massey is leveraging ORNL's manufacturing and advanced characterization facilities to develop innovative new materials to increase the readiness level of advanced reactor concepts.

His research is on Oxide Dispersion Strengthened (ODS) Steel, which he compares to the dispersion of chocolate chips in cookie dough, where the chocolate chips represent the oxides that both strengthen the steel alloy and protect it against damage caused by radiation. When the particle dispersion is maximized, the high number of interfaces attract and annihilate irradiation-induced defects, thus healing the material after irradiation damage.

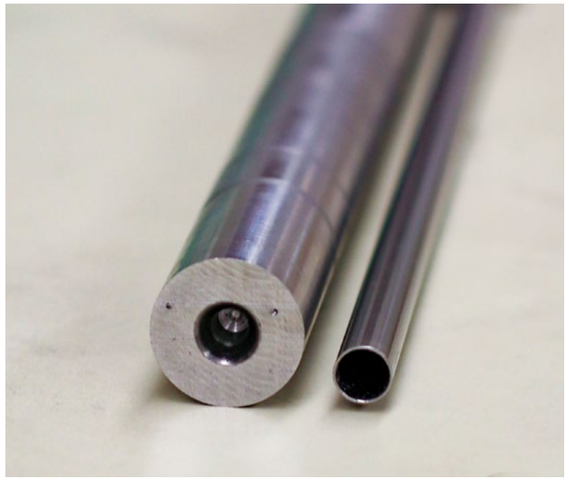
In comparison, regular steel would swell by more than 50 percent if exposed to high irradiation doses in the 450–550°C temperature range of an advanced sodium-cooled fast reactor, while the ODS alloy would show negligible volume change in the same environment.

"During nuclear reactions, the resultant energetic neutrons collide with surrounding material atoms in a manner similar to a billiard ball collision cascade. And then when everything finishes you have vacancies everywhere as well as atoms where they are not supposed to be, which can accumulate to form larger defects in the cladding," said Massey.

The concept of ODS steel is not a new phenomenon. The first alloys were originally developed and commercialized in the 1970s and '80s for fossil, space, and furnace applications, which required components that had a high temperature resistance to steam. As a UT student, Massey worked with a team of scientists at ORNL to develop new ODS alloys specifically designed for nuclear environments.

"Using 21st-century characterization tools, Caleb was able to tailor the alloy composition and processing conditions to achieve unprecedented strength, ductility, corrosion resistance, and predicted radiation resistance," said Zinkle. "In short, Caleb provided remarkable clarity to explain previously contradictory results by multiple worldwide research groups and single-handedly advanced the technology readiness level of this new class of alloys."

For light water reactors, ODS steel holds promise by retaining high mechanical integrity at high temperatures as well as good corrosion resistance and may be in use as early as 2020. Furthermore, advanced reactors may be deployed shortly thereafter if advanced materials such as ODS steel pass muster. Massey hopes his research will aid in creating the next generation nuclear reactors.



Students test their balloon cars and collect data in order to use Python to calculate the average speed and plot the results to find out who had the fastest car.

At the Intersection of Entrepreneurship *and* Rural STEM Outreach

By Élan Young.

These days, more people on the planet use a mobile phone than a toothbrush, according to the Smithsonian Science Education Center, yet millions of STEM jobs go unfilled in a growing industry because there simply aren't enough workers to meet the demand.

Senior Matthew Herald, who hails from the small town of London, Kentucky, gained exposure to nuclear engineering through high school. When choosing a college to attend, he picked UT for its highly ranked NE program and proximity to ORNL.

Through minoring in engineering entrepreneurship, he heard about an internship program with the Knoxville Entrepreneur Center (KEC). As a self-starter who enjoys writing his own computer code, he decided to apply and was accepted.

Herald ultimately created a 10-week summer camp focused on computer science and coding. KEC provided funding as well as program management and an additional intern.

"What initially sparked my interest was the opportunity to teach a subject which I was very passionate about to an audience of middle school students with similar backgrounds as I had," said Herald.

Each week, they traveled to a new group of students organized through community and education connections. The first two days covered the basics of programming in Python and Arduino. Mid-week, students coded and worked on individual creative projects. On Friday, they would finalize projects and showcase their work to parents at a closing ceremony.

"Most of the schools we reached out to were rural, small, and didn't have a large tech exposure," said Herald. "This was similar to how I grew up in Kentucky; there were no coding classes or many opportunities to learn about tech. Providing this opportunity to these students was important for me to encourage their curiosity and willingness to follow their interests in a creative way."

Herald believes the program had successful outcomes, with many participants expressing gratitude to be able to explore their interests. Herald continues to encourage other engineering students to explore the path to engineering entrepreneurship as a way to learn what's possible with advanced STEM skills

Armed with Experience

By Élan Young.

In 2007, Jason Matheny read an article about plans for the National Ignition Facility. The article discussed the approach of inertial confinement fusion using 192 powerful laser beams to compress and fuse deuterium and tritium in an effort to develop a method to produce clean fusion energy. Matheny, who was serving in the Army at the time, was intrigued and sought a way to learn more about nuclear science.

> **"I thought it was fascinating how a bunch of scientists and engineers worked together to build this really large facility to have lasers hit a target the size of a pencil eraser in an attempt to gain energy from fusion."**
>
> **—Jason Matheny**

For eight of his ten years of service, which included deployments to Iraq and Afghanistan, Matheny worked as an explosive ordnance disposal tech—the military's version of a bomb squad—earning two Bronze Stars along the way.

He worked with robotic platforms to mitigate explosive hazards and gained knowledge of the chemistry behind common homemade explosives as well as the circuits used in improvised explosive devices. He learned first-hand that the skills to render explosive hazards safe—both conventional and improvised—requires a great deal of problem-solving.

This rigorous study paid off for him, and Matheny went to work at the Combined Explosives Exploitation Cell in Iraq where all explosives-related evidence was processed for biometric and electronic information.

His military experience gave him special insight into homeland security issues while he gained national security experience through secret service support for both Presidents Bush and Obama, Vice President Biden, and presidential candidates in 2008.

"From a homeland defense perspective, I wanted to learn more about how I can help limit the threat of radiological and nuclear attacks and support nuclear emergency response operations. I am interested in how to best detect, identify, and confirm potential threats," said Matheny.

Drawn to UT's top-ranked nuclear program, he applied and was accepted. His past experiences helped him stand out as an undergraduate student, even taking two graduate level courses in nuclear security.

"Jason is an outstanding student, very alert and well prepared," said Professor Ivan Maldonado. "He consistently scored near or at the top of my reactor physics class, and on occasion, he even identified errors in some of the equations on my slides."

Matheny completed two summer internships at Los Alamos National Laboratory (LANL) where he studied nuclear security and nonproliferation issues as well as gamma spectroscopy and neutron noise techniques associated with neutron multiplicity counting.

"These internships have helped give me an idea of what I could focus on in graduate school and what I could potentially do to help with emergency nuclear response operations in the future," Matheny said.

While he applies for graduate school, Matheny has already lined up another internship at LANL on his continued path toward a career in nuclear security.

A SCATTERED APPROACH

By Élan Young. Photography by Shawn Poynter.

> ***"When we looked with neutrons instead of X-rays and applied the total scattering approach, we found a high degree of atomic order at a local level in materials that appear to be completely disordered and random."***
> —Maik Lang

Although Associate Professor and Pietro F. Pasqua Fellow Maik Lang is a faculty member in the nuclear engineering department, he's not technically an engineer; instead, he's a physicist concerned with the fundamental behavior of materials when placed under extreme conditions, especially materials with a wide range of applications.

Lang uses structural characterization involving microscopy, spectroscopy, and scattering techniques to identify why materials exhibit certain properties and behaviors. Understanding how a material functions in harsh environments through atomic-scale techniques—that can view placements of individual atoms and chemical bonds—can have great implication when scaled up to the macro level and real-world applications.

One material class Lang is concerned with is pyrochlore—complex oxides with many technological applications. These ceramics have been frequently studied over the past 30 years, particularly in regard to what happens to their structural properties when exposed to ion irradiation or high temperatures that can render them defective. They have been less studied by neutron characterization, and, prior to Lang's work, no one had yet used this technique for ion-irradiated materials.

In the atomic world, neutrons' neutral charge and interaction, which is based on strong force—one of the four fundamental forces in nature—allows them to be focused at a material's atomic nuclei without bouncing off electrons the way X-ray probes do. This behavior also enables them to provide information on the position of light elements in a material, such as oxygen, which would be mostly invisible to X-rays due to their small number of electrons.

Lang's proximity to the Spallation Neutron Source (SNS) at ORNL, the most intense pulsed neutron source in the world, allowed him to conduct experiments to see if neutron scattering in particular could provide new insight into defective and disordered pyrochlores.

"Neutron characterization is very demanding because it requires a lot of material, and for irradiated material, it's very challenging to get enough material to make such measurements," said Lang.

To produce sufficient irradiated material for the SNS, Lang used one of the largest ion accelerator facilities in the world, the GSI ion-beam laboratory in Darmstadt, Germany, where he spent time during his doctoral research.

The particles accelerated inside the very large accelerators of GSI are so energetic that they move at about 15 percent of the speed of light and can penetrate deep into a material—enough for about 0.1 gram of damaged material to be obtained, which is just about enough to generate valid data from Lang's experiments at the SNS.

Previously, researchers thought disordered materials had very random placements of atoms, but through working with GSI and SNS, Lang and his students found something different.

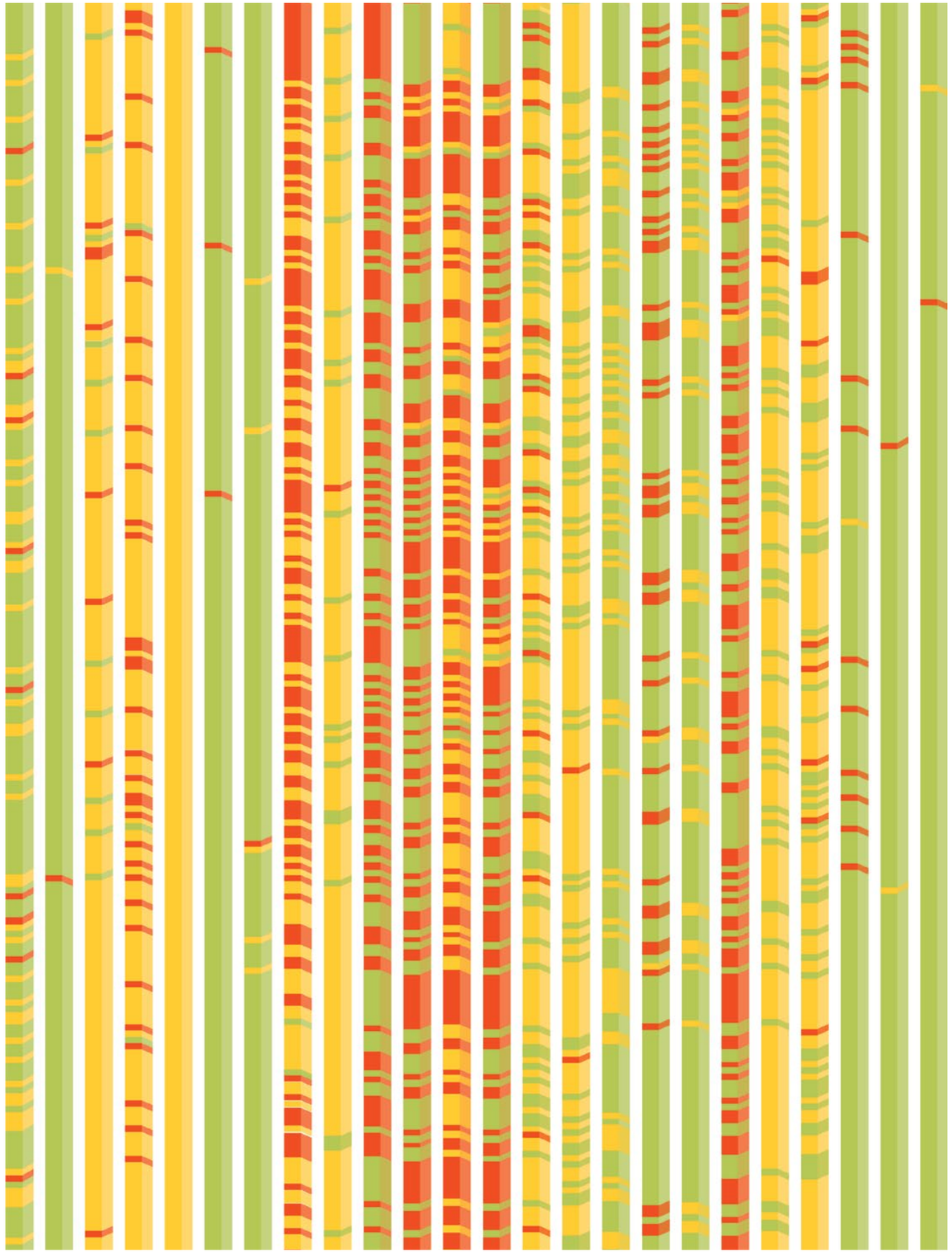
"When we looked with neutrons instead of X-rays and applied the total scattering approach, we found a high degree of atomic order at a local level in materials that appear to be completely disordered and random," Lang said.

This discovery provides a new understanding of the order-to-disorder transformations in pyrochlore that are used for plutonium immobilization (host materials for nuclear waste containment), fast ion conduction (solid oxide fuel cells), and thermal barrier coatings (gas turbine jet engines).

The team's findings also confirmed that traditional characterization techniques for pyrochlore do not paint a complete picture of their properties and behavior.

"Even if a pyrochlore is exposed to intense ion irradiation for a long time, which destroy the crystalline lattice, there will be always some level of order that remains. More important than showing that such an ordered pattern of atoms exist in disordered pyrochlore is to understand why nature in fact does this."

Lang's team has also demonstrated the same behavior in other ceramics such as spinel, which he said points to a more general phenomenon. His team recently received $600k in research funding from the DoE to continue deepening this new understanding of the nature of disorder in pyrochlore.



◀ *Graphic illustration of computer model helping to show one possible organization of the FNS design.*

Genetic Algorithms

Where Evolutionary Biology Meets Nuclear Engineering

By Élan Young. Photography by Randall Brown.

What does Charles Darwin have to do with building an advanced nuclear reactor? Potentially quite a lot. In the groundbreaking 1859 book *On the Origin of Species*, Darwin introduced the scientific theory of biological evolution through natural selection: the strongest live on, breed, and create the next generation.

Department Head Wes Hines has found that the same genetic algorithm (GA) can be adapted for mechanical systems, including nuclear reactor designs, in which designs can "mate" and create new designs.

Hines was brought to UT by Bob Uhrig in 1995, a Distinguished Professor of Engineering and Distinguished Scientist in the Advanced Science and Technology Division at ORNL under the Science Alliance program.

Once at UT, Hines began to write a supplement to Uhrig's book on the specific applications of artificial intelligence (AI) to nuclear engineering.

"It was about fuzzy logic, neural networks, and expert systems," Hines said. "After I got here, we started looking at other types of AI and began using GA as an optimization method."

Now, with the Fast Neutron Source (FNS), a subcritical nuclear facility design underway for the new Engineering Complex, Hines revisited GA as an optimization method specifically for design—a first for the department in at least 25 years.

"The goal of this research is to explore how AI can be used to aid in the design of a complex nuclear system," said John Pevey, a doctoral student on Hines's team. "Twenty years ago, it would have required an unreasonable amount of computer resources, but today we have that kind of computer power at our fingertips."

At first, the team optimized the FNS design manually, which only resulted in a marginal improvement. Pevey proposed removing some of the constraints on the system to let the computer have a go. In a matter of hours, it had used GA to evaluate thousands of potential designs, narrowing down to designs that improved performance metrics by a factor of three.

"We still have the opportunity to check the GA's designs manually for safety, but its ability to evaluate thousands of designs allows us to create blueprints for the FNS that we could not have come up with ourselves," said Sarah Davis, a master's student on the team.

This new way of thinking about GA opened up the possibility for the team to contribute to ORNL's Transformational Challenge Reactor program, which aims to combine the latest innovations in materials, manufacturing, and machine learning to design the next generation of reactors.

"There are solution algorithm methods that have been applied to optimization problems in general, so we need to study and experiment with how they apply to reactor design," said Vladimir Sobes, a research and development staff member at ORNL. "The genetic algorithm is just one of the optimization methods."

Hines added that GA has potential when there are single or multiple goals, and many possible solutions.

"Sometimes when you do optimization, you can apply mathematical techniques to find an optimal solution," he said. "In the case of nuclear reactor designs, it's not a problem you can solve with equations."

While the team is using GA for the FNS, it's just the tip of the iceberg of how increased computer capability can allow for safer and more efficient reactor designs.

"This opened up our eyes that old gray-haired men think they know the best way to solve a problem—the best way to design a core—and in reality, we are constrained in our thinking, and the constraints penalize us," Hines said. "What we need to do is look outside the box and do things that we didn't think we were allowed to do. When you remove the biases that people have and let the computer figure things out, we get results we've never thought of."

Those results could help fuel the next generation of nuclear engineering.

▲ *From left, John Pevey, Sarah Davis, and Professor Wes Hines stand in front of the cluster that runs the codes for the Genetic Algorithm.*

Faculty Receive $2.4M in Funding

Three faculty members recently received funding from the DoE Nuclear Engineering University Program (NEUP), which seeks to maintain US leadership in nuclear research across the country.

Professor Richard Wood and Associate Professors Jamie Coble and Maik Lang each received grants of approximately $800,000 to pursue their research.

Wood's research project, entitled "Prevention of Common-Fault-Trigger Combinations for Qualification of Digital Instrumentation and Control (I&C) Technology," aims to effectively design an evaluation approach based on the prevention of concurrent triggering conditions to eliminate common-cause failures and enable qualification of digital I&C technology for application in nuclear plant modernization.

Coble is researching cybersecurity, with a project entitled, "A Cyber-Attack Detection Platform for Cyber Security of Digital Instrumentation and Control Systems." She aims to develop a robust cyber-attack detection system for monitoring digital I&C systems. She is also a co-PI for a project entitled, "Economic Risk-Informed Maintenance Planning and Asset Management."

Lang was funded for his project, entitled "Radiation-Induced Swelling in Advanced Nuclear Fuel." He aims to clarify the microstructural evolution of advanced fuel (uranium carbide and uranium nitride) under fission-fragment type radiation.

Since 2009, NEUP has funded $334 million in outstanding, cutting-edge university research and collaborations between universities, national laboratories, and industry to address near-term significant needs for US nuclear research. This year, the NEUP awarded more than $28.5 million to support 40 university-led nuclear energy research projects.

FACULTY NOTES

Associate Professor and Southern Company Faculty Fellow **Jamie Coble** was promoted from assistant professor and granted tenure.

Assistant Professor **David Donovan** received the Tickle College of Engineering Research Fellow Award at the college's 2019 Faculty and Staff Awards Banquet.

Professor and UCOR Faculty Fellow **Jason Hayward** was promoted from associate professor. He was also the recipient of the DoE 2018 Early Career Award.

Associate Professor **Lawrence Heilbronn** joined a council of experts with his election to the National Council on Radiation Protection and Measurements. Experts on this council provide analysis and recommendations for the nation regarding all aspects of radiation protection. Other members include physicists, biologists, epidemiologists, medical physicists, health physicists, and others.

In January, Department Head **Wes Hines** shared news of the department's transformation and growth in a cover story of Nuclear News, published by ANS. He also spoke about the department's growth at the Conference on Nuclear Training and Education, where he was appointed as general chair of the organization's next conference in 2021. Hines also spoke on a panel hosted by the DoE Office of Nuclear Energy in Washington, DC, which focused on bi-partisan Hill engagement. Lastly, he received the Arthur Holly Compton Award in Education from ANS, which recognizes outstanding contributions to education in the field of nuclear science and/or engineering.

At the 2019 Chancellor's Awards Banquet, Associate Professor and Pietro F. Pasqua Fellow **Maik Lang** was honored with the Research and Creative Achievement—Professional Promise Award.

Research Professor and SMRC Director **Chuck Melcher** received the Tickle College of Engineering Translational Research Award at the college's Faculty and Staff Awards Banquet.

Professor Emeritus **Belle Upadhyaya** won the ANS Human Factors Instrumentation and Controls Division Don Miller Award, considered a lifetime achievement award.

UT-ORNL Governor's Chair for Nuclear Materials **Steven Zinkle** received the International Gold Medal from ASM International, the country's largest materials professional society.

Brown Joins NE Faculty

The department welcomed Nicholas Brown to the faculty as an associate professor this January. Brown joins UT after two years at Penn State and has degrees from the University of New Mexico and Purdue.

"Dr. Brown is a proven researcher with experience at multiple national laboratories and most recently at Penn State University," said Department Head Wes Hines. "He is clearly one of the most outstanding and sought-after young professors of his generation and we are fortunate that he chose to join our team"

Prior to his time at Penn State, Brown worked at ORNL and Brookhaven National Laboratory (BNL). His research focus includes reactor safety, nuclear fuel safety, and advanced reactor analysis and design. Specifically, he aims to address challenges resulting from aging nuclear infrastructure and expand the missions of nuclear energy. He is also committed to finding ways to reduce the burden of nuclear waste for future generations.

Brown, who has lived all over the country, says he enjoys Tennessee the most and is happy to be joining the faculty of a top-ranked program.

"UT has a strong nuclear engineering program with impactful researchers, and the future is even brighter," he said.

The proximity to ORNL is a big asset for Brown's research group, whose graduate students are almost all doing thesis or dissertation work in collaboration with national laboratories. In addition to ORNL, his group also has collaborations with Argonne National Laboratory, Idaho National Laboratory, and BNL.

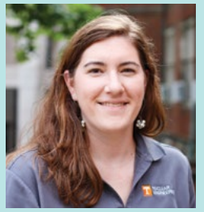
NE Staff Awarded for Outstanding Contributions to the Department

Staff members **Michelle McBee** and **Amanda Lovelace** were recently honored for their excellence at the department's annual awards banquet.

"Amanda and Michelle were both recognized for all the added value they bring to our department every day. These two individuals were highly praised by both faculty and students." said Department Head Wes Hines.

Michelle McBee

McBee, an accounting specialist, received the Outstanding Staff Award, which goes to a staff member who demonstrates professionalism and a positive attitude, initiative, and the willingness to go the extra mile in their job responsibilities. McBee brings order and organization to many functions of the department so it can operate at maximum capacity. She also serves as the face of the department's office, welcoming visitors and directing them to the appropriate resource.



Amanda Lovelace

Lovelace, a professional advisor, received the Service Award, which recognizes a staff member for their outstanding service to UT and the department. Lovelace guides students by helping them select the proper courses as well as attends conferences and field trips with them; she is with them every step of the way during their education at UT, and her involvement helps students succeed in school and beyond.

STUDENT NOTES

Amanda Bachman (BS/NE '19) won the Women in Nuclear Region II Leadership Award at the US Women in Nuclear Region II Conference, held in Oak Ridge in April.

Robert Corrigan's (Sr.) paper, "VCU Student Conference Empowers Tomorrow's Leaders," was published in *ANS Nuclear Café* and examines both the conference, held at Virginia Commonwealth University (VCU), and the impact it has on the industry's youngest members.

Will Cureton (PhD) and **Ty Austin** (PhD) received Nuclear Energy University Program fellowships. They will receive $50,000 per year for three years to help pay for their graduate studies and research, plus $5,000 toward a summer internship.

At the 2019 DoE Innovations in Nuclear Technology R&D Awards, **William Cureton** (PhD) received second place in the Open Competition in the category of Advanced Fuels with his paper, "Grain Size Effects on Irradiated CeO2, ThO2, and UO2." In the same category, **Peter Doyle** (PhD) also received second place for his paper, "Modeling the Impact of Radiation-enhanced Diffusion on Implanted Ion Profiles." **Travis Smith** (MS) won an Undergraduate Competition prize for his paper, "Temporal Fluctuations in Indoor Background Gamma Radiation Using NaI(Tl)," which he completed as an undergraduate in 2018 while attending the University of Michigan.

Sarah Davis (MS) and **Katelyn Bennett** (PhD) served as co-hosts for the Millennial Nuclear Caucus at Y-12's New Hope Center, hosted by the DoE. The event takes place in various cities around the country and encourages millennials to engage in nuclear engineering.

Kalie Knecht (BS/NE '19) and **Sydney Copp** (Jr.) both gave and received support in the Society of Women Engineers SWEeties program. Knecht served as the president of the 260-member UT chapter of SWE. Copp received support from the program as a freshman and now mentors other female students. Knecht also received the ISA Robert Hubby Scholarship from ANS.

Jonah Duran (PhD) received the Best Paper Award from ANS for his paper, "Multiple Analytical Approach to Isotopic Transport Analysis in Magnetic Fusion Devices," which explores impurity transport within nuclear plasma as it relates to harnessing fusion power.

Dan Floyd (PhD) received the ANS Human Factors Instrumentation and Control Division Uhrig Fellowship, named after Robert Uhrig, a former professor in the department.

Robby Kile (MS) wrote about Chernobyl on its 33rd anniversary for a recent issue of the *ANS Nuclear Cafe*. The article, entitled "Chernobyl Remembered," examines both the accident and its aftermath as well as how the Soviet Union's reactor design has since been improved so that no accident like Chernobyl ever happens again.

Ryan Tan (PhD) was one of 15 students selected to attend the PNNL Radiation Detector for Nuclear Security Summer School.

Fan Zhang (PhD) won the ISA Process Control and Measurement Division Scholarship from ANS.

At the 2019 Chancellor's Awards Banquet, **Jonathan Farmer** (Sr.) was recognized as a Chancellor's Top Collegiate Scholar, and graduate students **Kelsa Benensky**, **James Brechtl**, **Marie Kirkegaard**, **Angela Moore**, **Eric O'Quinn,** and **Caleb Massey** were each recognized with Extraordinary Professional Promise Awards.

First Step Awards Help Path to Scholarship

The Student First Step Awards recognize NE graduate students as they publish their first peer-reviewed journal articles. Publishing is an important step toward a scholarly career and should be celebrated. To qualify for this award, the student must be the first author on the article, signifying that the student led the research, analysis, and writing of the paper.

The Department of Nuclear Engineering is pleased to announce this year's Student First Step Award recognitions for the following students:

- C. Josh Beers
- James Brechtl
- Matthew Herald
- Nischal Kafle
- Congyi Li
- Matthew Lish
- Caleb Massey
- Caleb Redding
- Cody Walker
- Alex Wheeler
- Shawn Zamperini
- Fan Zhang

Hayward Sets Students Up for Publication Success

Professor and UCOR Fellow Jason Hayward is committed to student mentorship, which is one reason so many of his students are recipients of the department's First Step Award. His graduate students' success rates with publishing begins with having them read peer-reviewed journals in their first year and then encouraging them to follow related research by others in subsequent years.

"I let my mentored students and graduate students who take my NE 532 course know that publishing in peer-reviewed journals is a priority," he said. "Students in this class are required to write journal-quality review papers that describe the state-of-the-art in a particular research area, and often their own research area. I help them understand that graduate work is about making original contributions to move beyond the state-of-the-art."

Hayward asks students to identify remaining questions to be answered, and the inquiry process teaches them to think critically about work done by others. He also encourages them to reach out and contact authors with questions. By the end of their second year, Hayward recommends that students submit their first peer-reviewed publication as first author, with a goal of having it published within six months. He also challenges them to be first author on at least two published peer-reviewed journal articles by the time of their PhD defense.

Having peer-reviewed publications makes students significantly more attractive to employers who conduct research, with students who decide to pursue a career in research becoming incredibly productive at writing papers.

WIN Students Tour Watts Bar Nuclear Plant

From left to right: Amanda Lovelace, Michael Pagan, Kyle Anderson, Sidney Elertson, Amanda Bachmann, Xena McDonald, and Essa Atlalalah toured Watts Bar Nuclear Plant.

The UT Chapter of Women in Nuclear (WIN) recently got the chance to experience a nuclear power plant firsthand. Professional Advisor Amanda Lovelace joined the six students—Michael Pagan, Kyle Anderson, Amanda Bachmann, Sidney Elertson, Xena McDonald, and Essa Altalahlah—for a full day tour of the Watts Bar Nuclear Plant, which is owned and operated by TVA.

After a presentation about TVA and its mission, the crew learned about the plant's history and energy portfolio and were given a nuts-and-bolts overview of plant operations. They also saw firsthand the secondary side of the plant, including turbines, condensers, and a simulator room used for training operators.

The purpose of the trip was to give students a chance to experience the nuclear plant as a classroom and learn about possible careers working at one.

"It was a really cool experience to visit Watts Bar," said Amanda Bachmann, then-president of WIN. "My favorite part was seeing the safety culture of the plant; the PPE (personal protection equipment), the signs reminding everyone to hold the hand rails on the stairs, and learning how much training operators go through to be prepared in the unlikely event of an accident."

Students Visit Nation's Largest Fusion Experiment

By Élan Young.

▲ *Jonah Duran and Shawn Zamperini*

PhD candidates Jonah Duran and Shawn Zamperini, along with Assistant Professor David Donovan, recently visited DIII-D, the nation's largest magnetically confined fusion experiment, operated by General Atomics in San Diego, California.

"It is a great opportunity for our students to not only see how so many scientists come together to contribute to the research, but also to present their own ideas to the community and get a chance to plan their own experiments," Donovan said.

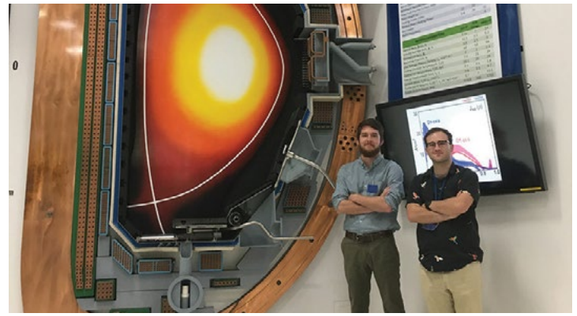
They presented potential research avenues that would benefit the fusion community and result in research for the students' PhD theses, gave presentations to the Advanced Materials Validation (AMV) group, and fostered collaboration with the facility for experimental time on the fusion device.

The proposed studies include impurity tracking experiments in which they aim to better understand the transport and negative effects of impurities in a plasma.

"Impurities can ruin the performance of the plasma, ultimately making it impossible to make a real fusion reactor," said Zamperini. "We need to know how they move around so as to keep them out of the plasma."

"Being at DIII-D was a highlight experience where we were able to network with some of the leading experts in the field of fusion energy science," said Duran. "On top of that, seeing one of the most significant fusion experiments in the world is another fond memory for which I am very grateful."

Zamperini said the chosen diagnostic method, called collector probes, are part of the DIII-D five-year plan, which will help keep UT in future campaigns by the facility.



▲ *Jonah Duran (left) and Shawn Zamperini visited DIII-D, the nation's largest fusion experiment.*

2019 Student Awards

Students from the department had a very successful and productive year, as reflected in their numerous activities and accolades. Recognition for their recent honors were bestowed at the recent Departmental Awards Banquet.

Student Ambassadors

This past year, the department implemented its own student ambassadors, with Robert Corrigan, Irfan Ibrahim, Bradley Balltrip, Amanda Bachmann, Kalie Knecht, Xena McDonald, Jillian Newmyer, and Andrew Volkovitskiy serving as the inaugural cohort.

Alpha Nu Sigma Inductees

Bradley Balltrip, Parker Forehand, Neal Gaffin, Nathan Huff, Irfan Ibrahim, Darrell Russell, Tyler Steiner, Hayden Sutton, and Molly Underwood.

Alpha Nu Sigma inductees (L–R) Parker Forehand, Bradley Balltrip, Neal Gaffin, Irfan Ibrahim, Darrell Russell, Tyler Steiner, Hayden Sutton, and Molly Underwood. (Nathan Huff not shown.)

PhD Graduate Research Excellence Award

Michael Moore and Eric O'Quinn

Master's Graduate Research Excellence Award

Travis Greene

Outstanding Graduate Teaching Award

Seungsup Lee

Outstanding Student Ambassador Award

Robert Corrigan, Irfan Ibrahim, and Bradley Balltrip.

Top Undergraduate Academic Performers

Top Freshmen
- Jonathan Barthle
- Kenneth Bott
- Casey Corbridge
- Brandon Hack
- Emma Houston
- Cale Overstreet
- Caitlyn Parsons
- Konnor Porter
- Ben Stoller

Top Sophomores
- Ashley Goluoglu

Honorable Mention:
- Miller McSwain
- Austin Williams
- Alex Zeringue

Top Juniors
- Sam Wehby

Honorable Mention:
- Irfan Ibrahim

Top Seniors
- Jonathan Farmer

Honorable mention:
- John Hirtz
- Kalie Knecht

Balancing **Musical** Notes **& Study** Notes

By Élan Young.

Junior Christopher Busch is not just at UT to pursue his passion for clean energy. He's also here to make (sound) waves as a member of Pride of the Southland Marching Band with his mellophone.

Originally from Spartanburg, South Carolina, once he landed on nuclear engineering as his major, UT jumped to the top of his list.

"After one visit and a football game I was hooked," he said. The chance to be in one of the most respected marching bands in the US sealed the deal.

Connecting with others in the band, including many other engineering students has given Bush a new home base.

"It is a pleasure to have Chris and other engineering students be a part of the Pride of the Southland Marching Band," said Don Ryder, director of bands. "Obviously, the discipline, time management, and hard work ethics of the band carry over into their professional lives!"

College has definitely expanded Busch's world. In high school, his marching band had one section with eight horns, and now he's one of 40. Being involved in band has also helped him develop strong personal discipline around study habits, especially during football season practice, games, and travel.

"During the season, I have to schedule myself. I try to stay a half to a whole week ahead just in case I get bogged down with excess practicing or if something unexpected comes up," he said.

Sometimes he has to resort to cramming, but with discipline, he's never less than two to three days ahead of his syllabus. He has also taken the advice of Professional Advisor Amanda Lovelace, who encourages band students to take the harder engineering courses in the spring.

"If you have a test that's going on while you're gone, it's best to take it before you leave, not after you get back," he said.

Busch's study tips are applicable to any student wishing to make the most of their time at UT. Being disciplined means he's better able to gauge his own productivity—he now knows he is more efficient in the middle of the day. His favorite place to study on campus is the library, but he always plans gaps during the day to do homework wherever he happens to be.

A team of NE and MSE students design a pneumatic transfer system for the planned Fast Neutron Source.

Senior Design **Showcase**

NE seniors recently completed their capstone Senior Design class (NE471/472), which involves tackling real-world scenarios and using advanced problem-solving skills to create solutions for a client. The ten teams participated in the college's inaugural Senior Design Showcase on April 25, which included 125 projects from all eight engineering departments at UT.

After the showcase, the teams participated in a poster presentation to the NE Board of Advisors, and the following six teams received awards based on criteria including innovation, quality of the executive summary, quality of the poster, knowledge of the presenters, and professionalism of the presenters.

Outstanding Team Award

High-Fidelity Small Modular Reactor Core Design in VERA

- Client: Oak Ridge National Laboratory
- Team: Madeleine Burrell, Logan Clowers, Michael Hines, Kalie Knecht, Andrew Naylor, Molly Underwood
- Mentors: Ivan Maldonado (UT) and Andrew Godfrey (ORNL)

Best Poster Award

Rapid Autonomous Pneumatic Transport System

- Client: EPRI
- Team (NE): Emily Hutchins, Xena McDonald, and John Taylor
- Team (MABE): Bobby Bohn, Elijah Davis, and Jacob Melton
- Mentors: Wes Hines (NE) and Larry Sharpe (MABE)

Best Professional Presentation Award

Radiation Field Mapping

- Client: Southern Company
- Team: Bryn Davies, Loraine Illia, Louise Langevin, William Lynch, Connor Myers, and Jeffrey Walsh
- Mentor: Matthew Cook

Best Innovation Award

Tertiary Safety System for Nuclear Spent Fuel Pools

- Client: Electric Power Research Institute (EPRI)
- Team: Taylor Adams, Eissa Altalalah, Amanda Bachmann, Jonathan Farmer, Trina Garrett, Jillian Newmyer, Drew Shayotovich
- Mentor: Martin Grossbeck

Best Knowledge Award

Axial Flux Mapping of a Sub-Critical Facility

- Client: EPRI
- Team (NE): John Terosky
- Team (MABE): Garrett Montgomery
- Mentors: Larry Miller (NE) and Larry Sharpe (MABE)

Best Summary Award

Fast Neutron Source Shutdown System

- Client: UT Department of Nuclear Engineering
- Team: Matthew Herald, Alex Solomon, and Robert Vradenburgh
- Mentor: Richard Wood

ALUMNI NOTES

The department was honored to induct two distinguished alumni into its Hall of Fame at the recent 2019 Departmental Awards Banquet. Tom Kerlin and Anthony Buhl both led enduring careers in the field of nuclear engineering that have positively affected the lives of countless others, exemplifying what it means to be a **Tennessee Volunteer**.

One Call That Changed It All

By Laura Tenpenny.

Anthony (Tony) Buhl devoted his career to the safe operation, decommissioning, and clean-up of nuclear facilities unheard of thanks to his work. He also played key roles in recovery from major incidents that you most certainly have heard of, like Chernobyl.

“Although the Russians spoke English, they used an interpreter. It took a few weeks before they spoke to our team directly,” Buhl remembered of the Chernobyl aftermath.

At the request of the US Senate’s Energy Committee, Buhl (BS/NE ’63, MS/NE ’64, PhD/Engr Sci ’67, Executive Development ‘83) supported recovery and investigation efforts following the plant’s explosion. Several years prior, Buhl also served during the recovery of the plant at Three Mile Island (TMI) following its partial meltdown.

“During emergency operation, there were only about ten of us in the control room,” Buhl recalled. “That accident influenced the world’s approach to the study of risk.”

As a result of TMI, international nuclear utilities established IDCOR, the Industry Degraded Core Rulemaking program, reporting to the Nuclear Regulatory Commission (NRC) on severe nuclear plant accidents. Buhl served as its director. He has held leadership positions in several government and nuclear industry regulatory entities, including the NRC.

Perhaps his most important role in industry was as vice president at Kaiser-Hill when he oversaw the clean-up of the Rocky Flats facility, dubbed by the Department of Energy as the most dangerous site in the US. Near Denver, CO, it produced some thirty-two thousand plutonium nuclear weapons during the Cold War.

“It took about ten years and $10 billion to clean up the contaminated site’s four hundred buildings, but we did it thirty-eight years ahead of schedule and $38 million under budget,” Buhl stated. “Today you’ll find about eleven square miles of grass there.”

Before retiring, he managed ORNL’s first Transuranic Waste Processing Center in conjunction with his own business, EnergX, which specialized in environmental management, safety assessment, and operational competency.

The youngest of eight siblings, growing up without electricity or running water at home, Buhl learned to recognize his opportunities. After returning from military service, he worked at ORNL. While reviewing reactor designs for a plant in Hanford, WA, he noticed a serious flaw. He relayed this to a contact at the Atomic Energy Commission (AEC).

“The AEC called me to Washington immediately to fully explain. I was correct. The design had to be changed,” Buhl said. “Then they offered me an amazing job. I was thirty-three, almost overnight a federal branch chief overseeing all non-military reactors.”

He shared this story during his acceptance speech at the 2019 NE Hall of Fame awards ceremony.

“Many opportunities flowed from having the courage to make that phone call,” Buhl imparted. “It was the confidence in what I had learned in this program that propelled me into a world-changing career.”

Buhl adds the Hall of Fame distinction to many other accolades, including the college’s Nathan Dougherty Award (2012) and UT’s Outstanding Engineering Alumnus Award (1977).

As well as time with family, he now enjoys working on his book, *Poverty, Sex, and the Nuclear Scientist*, a combination of autobiography and insight that is sure to be just as interesting as the life it recounts.

From First Graduate to Department Head

By Laura Tenpenny.

When he graduated with the first-ever Nuclear Engineering degree conferred by UT, Tom Kerlin (MS/NE ’59, PhD/Engr Sci ’65 with) did not expect to lead the department some 20 years later.

“Bob Paulson got his degree that day too, but I walked across the stage first. The alphabet was in my favor,” Kerlin remembered.

The much beloved Pietro Pasqua served as the department’s first head.

“I worked under Pasqua as a graduate student. He was generous and really cared about the students,” Kerlin said.

After graduating, Kerlin worked at ORNL before Pasqua hired him as a professor. A decade later as department head, he walked in Pasqua’s footsteps as a man of the students. He and his wife even shared their home briefly with a student in need.

Following the Three Mile Island and Chernobyl incidents, enrollment noticeably dropped, but Kerlin adapted. He took to the road, recruiting students with a traveling lab, visiting his native South Carolina quite often.

“At one time enrollment consisted of about 20 percent South Carolina residents,” Kerlin remembered.

“He’s an idea guy. He’s great at thinking strategically,” affirmed current Department Head Wes Hines.

During his leadership, Kerlin and Tom Shannon initiated one of his proudest legacies, the Reliability and Maintainability Center. The center contributes millions to the local economy and provides hands-on learning for students and cutting-edge solutions to business partners. Those partners have grown from 12 to over 75 today.

Yet another of his ideas resulted in a major economic boost to the area. He conceived and co-founded Analysis and Measurement Services Corporation (AMS) in 1977. Beginning with Northeast Energy, AMS provided technical testing of nuclear facilities’ safety and control systems. Kerlin sold his share of AMS in 1985, and it continues as a successful provider of technical service to the nuclear industry.

In addition to his accomplishments in industry, Kerlin made a successful scholar and educator. With an active research program, he and dozens of graduate students studied reactor dynamics, reactor control, dynamic testing, and instrumentation.

“I earned the second Glenn Murphy Award in its history from the American Society of Engineering Education, which honors a nuclear engineering professor every year for excellence in education,” Kerlin remembered.

His latest honor was his induction into the Nuclear Engineering Department’s Hall of Fame.

Kerlin, now retired, enjoys writing and spending time with his wife, Nancy, of 65 years. He has authored, co-authored, or contributed to eight books, including his latest, *Dynamics and Control of Nuclear Reactors*, with fellow Professor Emeritus Belle Upadhyaya.

AROUND THE **DEPARTMENT**

1. Rendering of the new Engineering Complex—the future home of the department. Visit *tiny.utk.edu/gateway* for the latest view of the progress being made.
2. Associate Professor Jamie Coble shared information about the NE department at the Secret City Festival in Oak Ridge in June. The festival is an annual celebration of Oak Ridge's history and showcased its many advancements in technology and science.
3. The department won first place in the college's 2018 Boo in the Courtyard Halloween contest with their Yabba Dabba Do themed costumes.
4. Gayle Williams (BA/Human Services '77) honored the memory of her husband of 42 years Mark Williams (PhD/NE '79) with a gift to the department. In her wish to continue helping others, she established a scholarship and will honor Mark with a room in his name in the new Engineering Complex. If you would like to add to the Williams endowment, or further naming opportunities in the Engineering Complex, contact **Natalia Hardin** at nhardin@utfi.org or 865-974-2385 for more information.

Join Madison.
Join the Journey.

"While on co-op with Southern Nuclear I experienced the nuclear power industry through corporate projects and field operations to refuel reactors, enhancing my education and professional growth immensely. I am grateful for the generous donors that continue to make these educational experiences possible for dedicated UT students."

—Madison Tippet,
Junior in Nuclear Engineering,
UT Track & Field Athlete

Invest in the journey to help other students enhance their educational experience. Call **865-974-8890** or visit **giving.utk.edu/nuclear**.

TICKLE
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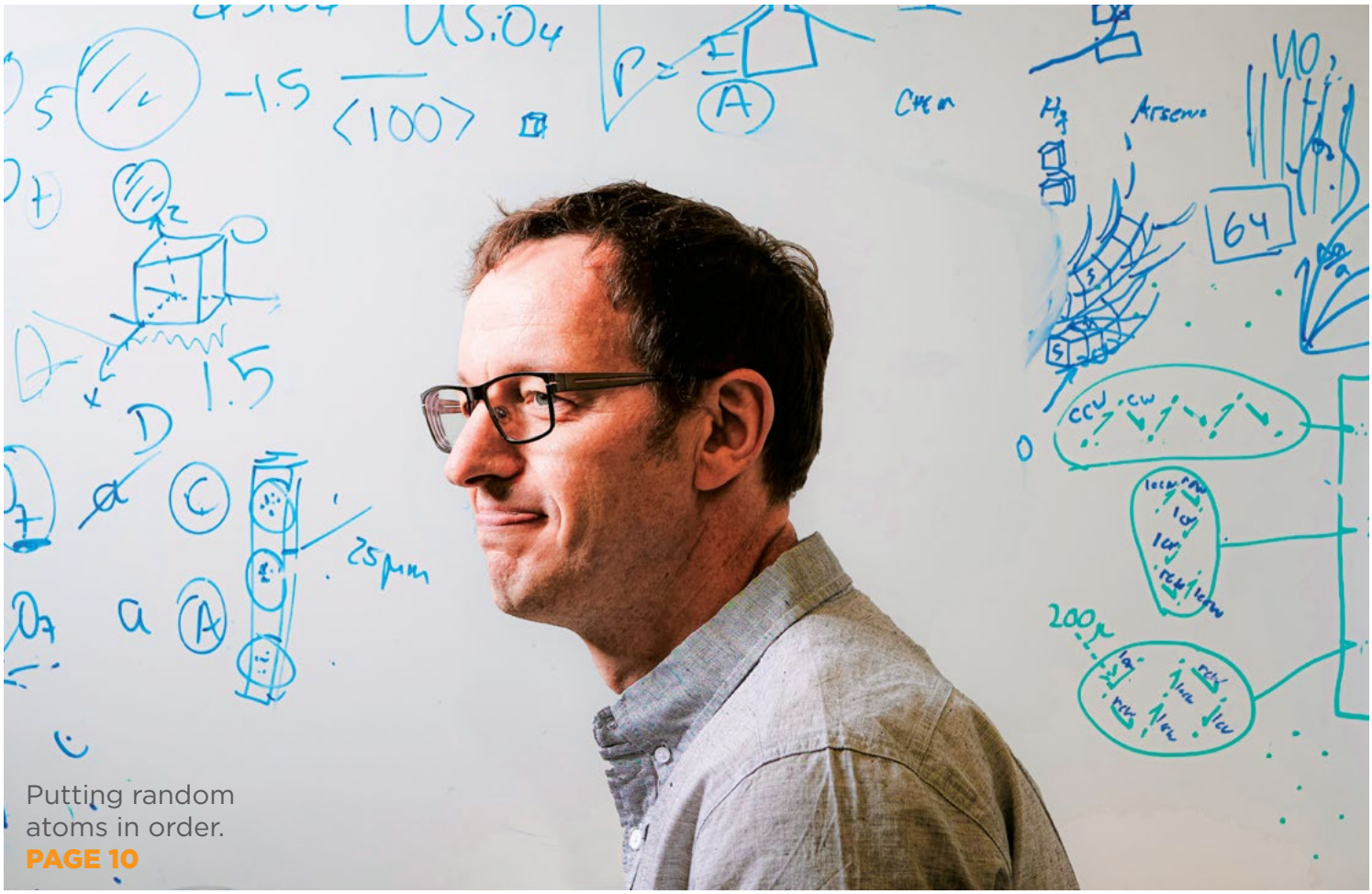

Putting random atoms in order.
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