LDRD

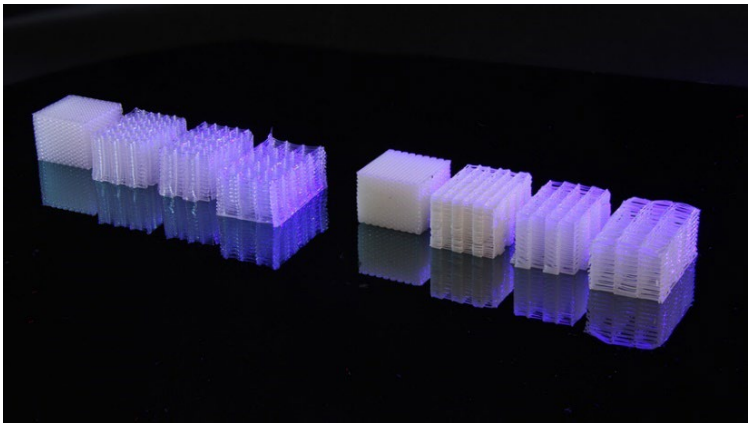
Quarterly Highlights

Mission Agility | Technical Vitality | Workforce Development

FY25 Q4

FEATURED HIGHLIGHTS FOR Q4

Lawrence Livermore National Laboratory



Scientists at Lawrence Livermore National Laboratory (LLNL) and their collaborators have created a new class of programmable soft materials that can absorb impacts like never before, while also changing shape when heated. (Photo: Julie Mancini)

LLNL team develops new material that bends, bounces and absorbs energy on demand

Scientists at Lawrence Livermore National Laboratory (LLNL) and their collaborators have created a new class of programmable soft materials that can absorb impacts like never before, while also changing shape when heated. The research — which includes collaborators from Harvard University, the California Institute of Technology (Caltech), Sandia National Laboratories and Oregon State University — opens the door to smarter, lighter and more resilient materials that respond to the world around them. Read more...

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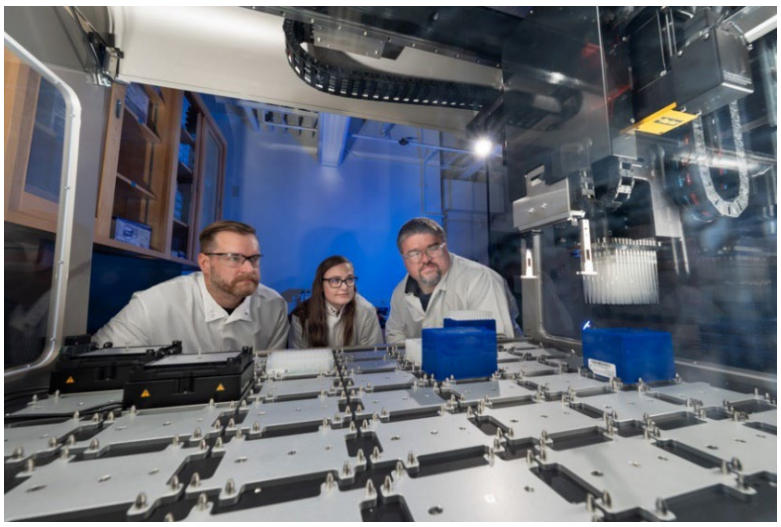

From left: chemists Brian Mayer and Katelyn Mason and biologist Todd Corzett observe the operation of the robot that independently executes the acetylcholinersterase assays the team uses to assess Novichok inhibition and to discover new oxime antidotes for Novichok poisoning. (Photo: Blaise Douros/LLNL).

LLNL and Purdue University accelerate discovery of medical countermeasures for emerging chemical threats

In a major advance for chemical defense and public safety, scientists at Lawrence Livermore National Laboratory's (LLNL) Forensic Science Center (FSC) and Purdue University have developed and demonstrated a high-throughput, automated mass spectrometry platform. Their platform dramatically accelerates the discovery of medical countermeasure candidates against A-series chemical warfare agents, also known as "Novichoks." The collaborative research, published today in the *Proceedings of the National Academy of Sciences (PNAS)*, provides the first quantitative data on the potency of these agents and identifies promising new directions for antidote development. A-series nerve agents have gained notoriety in recent years due to their use in high-profile poisonings. Despite the attention they have received, little experimental data exists about their biological effects or how best to treat exposures. Read more...

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Sandia National Laboratories

Thinking creatively about rotations, the Sandia LDRD team discovered new numerical methods for solving differential equations on rotation groups with increased precision. Here, Mike Walker (left), Daniel Foreman (center), and Michael Sparapany (right) spin toy tops. (Photo by Jennifer Sanderson)

Accelerating navigation algorithms

Navigation algorithms are essential in delivering new capabilities to warfighters more swiftly, which is why one Sandia LDRD team was determined to investigate and compare their performance. Their pursuit of algorithm comparison sparked a wave of innovation, leading to the development of new tools for code reuse that streamlined their workflow. They adopted cutting-edge digital engineering methods to quantify algorithm fidelity, enabling them to assess performance with newfound accuracy. These findings resulted in multiple publications. Read more…

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Scientist John Sandusky stands in the field of heliostats at Sandia's National Solar Thermal Test Facility. John conducted research at night showing the heliostats might be able to detect asteroids. (Photo by Craig Fritz)

Asteroid hunting using heliostats

Sandia scientist John Sandusky believes he has found a way to put heliostats, which typically turn solar energy into electricity, to work in the dark. He proposes that these large mirrors could help find asteroids at night. "The heliostat fields don't have a night job. They just sit there unused. The nation has an opportunity to give them a night job at a relatively low cost for finding near-Earth objects," Sandusky said. "If we knew ahead of time that an asteroid was coming and where it might hit, we'd have a better chance to prepare and reduce the potential damage." Read more…

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Los Alamos NATIONAL LABORATORY

In this representation of the adversarial threat detection framework, vibrant filaments carry incoming text and image icons into a central node, while a faceted topological shield composed of glowing simplices deflects a dark, glitchy mass on the right. The composition emphasizes the contrast between clean data flows and adversarial interference. Image courtesy: DALL-E by Manish Bhattarai, LANL

New approach detects adversarial attacks in multimodal AI systems

New vulnerabilities have emerged with the rapid advancement and adoption of multimodal foundational AI models, significantly expanding the potential for cybersecurity attacks. Researchers at Los Alamos National Laboratory have put forward a novel framework that identifies adversarial threats to foundation models — artificial intelligence approaches that seamlessly integrate and process text and image data. This work empowers system developers and security experts to better understand model vulnerabilities and reinforce resilience against ever more sophisticated attacks. Read more….

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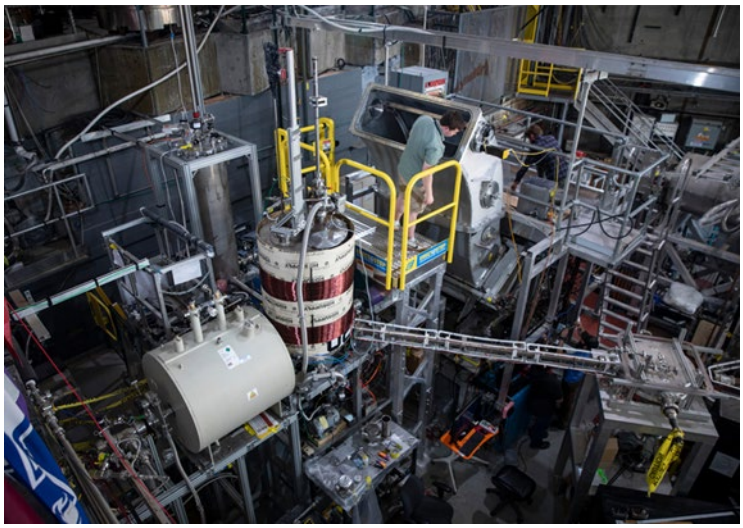

Student researchers Lucas Opiola from Valparaiso University and Nathan Washecheck from North Carolina State University check on the elevator movement. The UCNTau apparatus extends more than 20 feet above the ground at the Ultracold Neutron Facility.
Image courtesy: LANL

New measurement of free neutron lifetime achieves world-record precision

Incorporated into every aspect of everyday life, the neutron is a fundamental particle of nature. Now, a research collaboration led by Los Alamos National Laboratory has improved the precision of free neutron lifetime measurements. The team's results highlight the success of the UCNTau experiment's design and previews the effectiveness of new techniques and approaches that the team is incorporating into the next generation of the experiment.

"The results represent the most precise measurement of the neutron lifetime to date," said Steven Clayton, physicist at Los Alamos. "Our goals have been to better understand and quantify systematic uncertainties in the experiment and to improve the lifetime statistical precision. With this level of precision, we've taken the current design as far as it can go." Read more…

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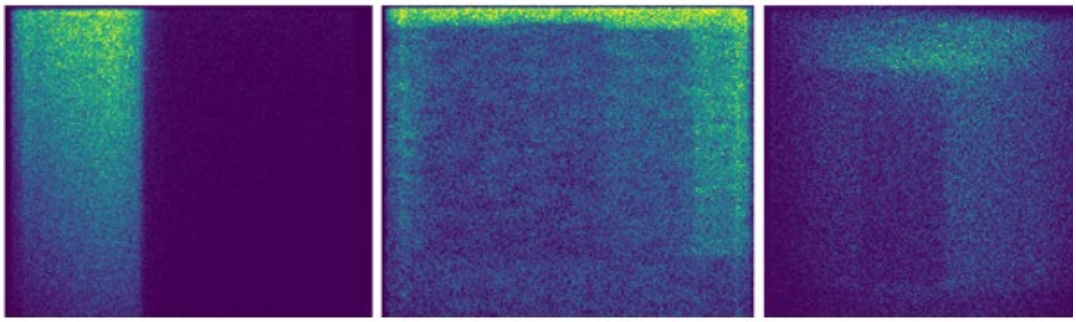

Constructed images with gammas (A and B) and DT neutrons (C).

Stuart Miller Constructs First Images from a Two-Camera System with Gammas and Fast Neutrons

Neutron imaging plays several important roles across global security, industrial, and medical spaces. But despite its wide range of uses and potential for national security applications, imaging neutrons is a challenge because of their high penetrative power. Traditional neutron imaging methods typically result in low quality, poor spatial resolution images. Principal investigator Stuart Miller set out to develop a new imaging detector and analysis methodology that would significantly improve the sensitivity and spatial resolution of neutron imaging of test objects in his fiscal year 2025 Site-Directed Research and Development project "Novel Photon-Counting Detector Concept for High-Resolution Radiographic Imaging." This quarter, he and his team achieved a major milestone by demonstrating the first images acquired with this technique with both gammas and deuterium-tritium (DT) neutrons. Read more…

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LDRD/SDRD Working Group members at the Sedan Crater

NNSS Hosts LDRD/SDRD Biannual Working Group

Twice a year, members of Laboratory-Directed Research and Development (LDRD) programs at the national labs and the NNSS' Site-Directed Research and Development (SDRD) team meet in person to discuss national security research innovation and standards as part of their regular working group. These meetings promote collaboration and alignment with National Nuclear Security Administration (NNSA) research and development (R&D) efforts between the NNSS' SDRD program and the LDRD programs at Los Alamos National Laboratory (LANL), Lawrence Livermore National Laboratory (LLNL), and Sandia National Laboratories (SNL). On April 2 and 3, the NNSS had the opportunity to host this working group in-person at both the Site and in North Las Vegas. Read more…

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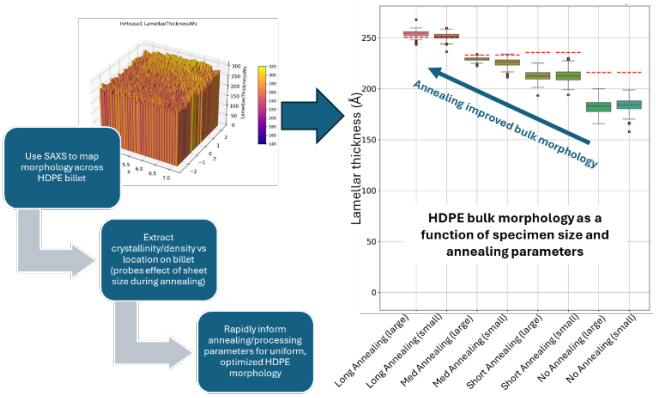
Plant Directed R&D PDRD



Improved Understanding of HDPE Through Polymer AM Consortium

HDPE is an engineering thermoplastic that is used in a number of nuclear weapon applications. Due to its crystallization kinetics, HDPE can be difficult to process without introducing internal stresses, primarily caused by manufacturing processes like extrusion combined with rapid cooling. Moreover, machining of HDPE exposes the material to thermal gradients that further impact the crystal structure and ultimately the dimensional stability of the parts especially as part thickness increases. Crystallinity of HDPE is proportional to its density, which is a critical property and governs its use in several end applications. Unfortunately, there aren't many characterization tools that can assess the density/crystallinity particularly as thickness increases. One such tool is Small Angle X-ray Scattering (SAXS), which is a non-destructive analytical tool that can be used for a myriad of semi-crystalline materials. In FY25, KCNSC worked with University of Texas El Paso (UTEP) to establish a suitable capability to nondestructively monitor HDPE density/crystallinity as a function of processing parameters.

Notably, SAXS was used to monitor morphological characteristics of HDPE such as density (voids), crystallinity, and crystal size. This work has been leveraged to predict optimal thermal annealing (i.e., heat treating) that eliminated costly iteration. As HDPE part thickness increases, the time to control properties (viz. crystallinity) through thermal annealing, including heating and cooling steps, leads to exceedingly long cycle times. Through this collaboration with UTEP, recommendations were provided to product teams to inform HDPE process development. The data show that bulk morphology (viz. lamellar thickness) is improved with increased annealing time and is summarized in the graphic below. Further development of SAXS capabilities is critical to fully map the impact and optimization of processing conditions on the ultimate performance of semicrystalline materials such as HDPE. KCNSC, Samantha Talley, Ph.D.

AMAZING LDRD HIGHLIGHTS

MODULATING THE TRANSMISSION OF NEAR-INFRARED LIGHT AT LLNL: **Carbon nanotube 'smart windows' offer energy savings** > Mission Agility, Technical Vitality

NOVEL3D PRINTING TECHNIQUE USING LIGHT AT LLNL: LLNL team tackles support structure bottlenecks with dual-wavelength 3D printing > Mission Agility,Technical Vitality

LLNL BUILDS PLATFORM FOR 3D PRINTING, GRINDING, POLISHING AND CHARACTERIZING ALLOY SAMPLES: Self-driving lab to automate the discovery of novel alloys > Mission Agility, Technical Vitality

HIGH-CONSEQUENCE SYSTEMS: Improving assurance through formal methods and automated reasoning > Mission Agility, Technical Vitality

PREDICTING TURBULENCE: Advancing models for hypersonic flows using machine learning > Mission Agility, Technical Vitality

STOPPING DESTRUCTIVE FIRES BEFORE THEY BEGIN: LANL researchers use AI to detect electrical faults > Mission Agility, Technical Vitality, Workforce Development

CONTROLLING CHEMICAL BONDING: LANL scientists tune oxidation states to make stronger chemical bonds > Mission Agility, Technical Vitality

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This newsletter, published quarterly, features LDRD, SDRD, and PDRD work done by Lawrence Livermore, Los Alamos, Nevada National Security Site, Sandia, and Y-12 National Security Complex. To see a PDF with all articles referenced in this newsletter or review past issues, visit https://organizations.lanl.gov/nnsa-directed-r-and-d/ and click on the Quarterly Highlights tab. (LLNL-TR-2011271)

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National Nuclear Security Administration