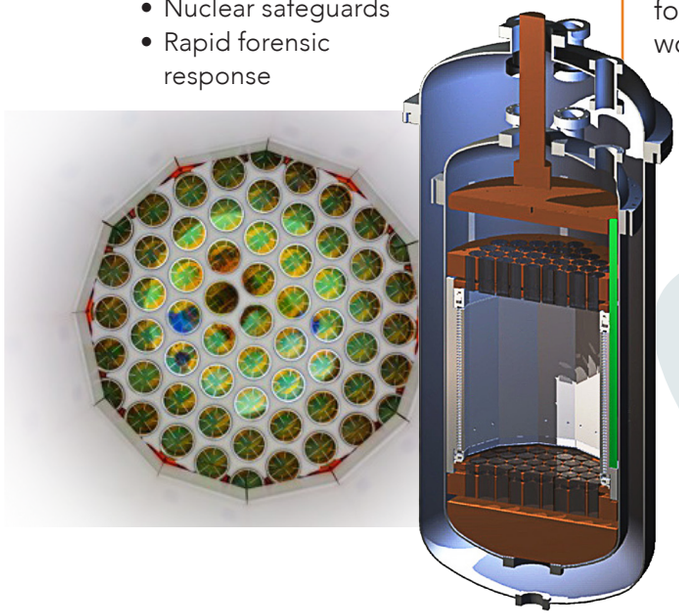
Nuclear & Chemical Sciences

On the Frontier of Nuclear Physics, Particle Physics, and Chemistry

Lawrence Livermore National Laboratory's (LLNL's) Nuclear and Chemical Sciences Division offers deep expertise in physics and chemistry. Combined with experience conducting programmatic work in nuclear and chemical science, this enables us to provide innovative solutions to a range of national security problems. Every day we focus on fundamental science, such as developing cutting-edge tools to uncover new chemical signatures or studying plasma effects on nuclear reactions. Our world-class capabilities in radiation detection, chemical and nuclear forensic science, isotope geochemistry, and environmental radiochemistry also contribute to scientific advancements that help make the world safer. The Laboratory's scientists are exploring the chemistry of heavy elements and discovering new ones, chasing elusive new particles, and answering important scientific questions about dark matter, neutrino physics, nuclear structure, nucleosynthesis, and the origins of the universe.

Our research supports Laboratory missions in:

- Stockpile stewardship
- Pre- and post-nuclear event forensic science
- Nuclear threat reduction
- Nuclear safeguards
- Rapid forensic response



NUCLEAR PHYSICS & DETECTION

Nuclear theory and experimentation provide a fundamental understanding of atomic nuclei, their role in the universe, and how they impact LLNL's security missions. We seek to answer questions about the structure of nuclei, the strong forces between nucleons, the limits of nuclear stability, and how nuclear reactions formed the elements in the cosmos. We conduct experimental work at national user facilities and LLNL's accelerator complex, and participate in international projects in neutrino physics, dark matter search, and high-energy physics. We are also preparing for experimental work at the Facility for Rare-Ion Beams, which will provide unprecedented access to new nuclei. Our nuclear detection research leverages the Nuclear Counting Facility and the Environmental Monitoring Radioanalytical Laboratory. We are designing field-portable, smart detectors for first responders, and unique noble-liquid systems for rare-event detection. Essential to our nuclear security work, high-performance computing enables theoretical descriptions of complex nuclei from first principles, quantum chromodynamics calculations, and Big Data analysis.

Inside the large underground xenon detector, elusive dark-matter particles can be detected when they interact with xenon atoms to create photons and electrons. Photo courtesy of SURF.

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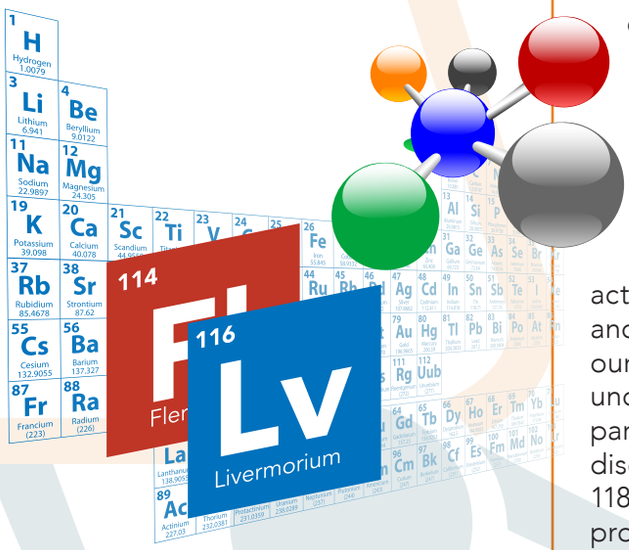


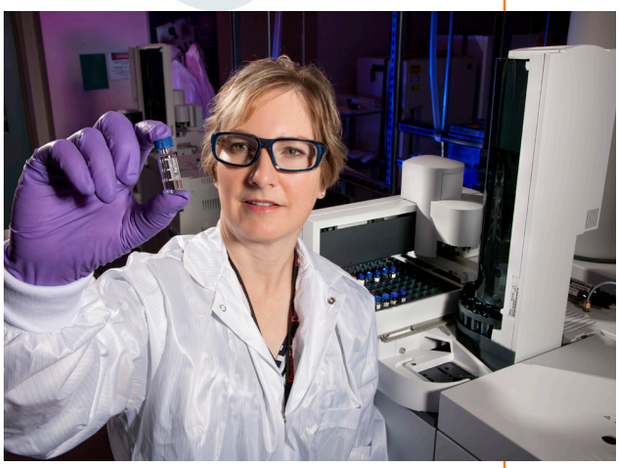
Among the elements discovered by LLNL scientists, elements 114 and 116 bear commemorative names. Flerovium honors our collaboration with the Flerov Laboratory of Nuclear Reactions, and livermorium recognizes LLNL and its hometown of Livermore, California.

RADIOCHEMISTRY

LLNL's deep expertise in radiochemistry combines nuclear testing experience with world-leading contributions to the field of heavy-element chemistry. Our focus includes the development of nuclear diagnostics and platforms for the National Ignition Facility to answer fundamental questions about the effects of plasmas on nuclear reactions, the understanding of fractionation, and the exploration of the properties of short-lived isotopes. We also produce sources, target materials, and synthetic debris for nuclear experiments and forensic exercises. Applied research addresses long- and short-term actinide transport at contaminated field sites around the world and uses isotopic tracers and miniaturized detectors to expand our understanding of watersheds and subsurface water storage under the conditions of a changing climate. LLNL researchers, in partnership with the Joint Institute for Nuclear Research in Russia, discovered the heaviest transactinides—elements 114 through 118. Separation methods are now being developed to explore properties of these new elements.

ANALYTICAL & FORENSIC SCIENCES

LLNL's rapid forensic science capabilities in CBRNE—chemical, biological, radiological, nuclear, and explosive—defense contribute to the nation's responsiveness to the use of weapons of mass destruction. Our laboratories analyze interdicted samples, provide 24/7 radiological assistance, prepare for potential nuclear device detonation, and deliver key assessments and technologies to the intelligence community. Our synthetic and analytical chemists support the Forensics Science Center, which is accredited by the Organisation for the Prohibition of Chemical Weapons. Among recent forensic developments is a protein identification technique that paves the way for new methods of crime scene investigation. We are world leaders in inorganic mass spectrometry, which we utilize in our pre- and post-detonation nuclear forensics missions, and to advance our understanding of cosmochemistry, water resources, and environmental microbial communities relevant to biofuels, the terrestrial carbon cycle, and environmental remediation.



Analytical chemists work in an environmental reference laboratory at the Forensic Science Center to develop and validate sensitive methods for analyzing chemical warfare agents.

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