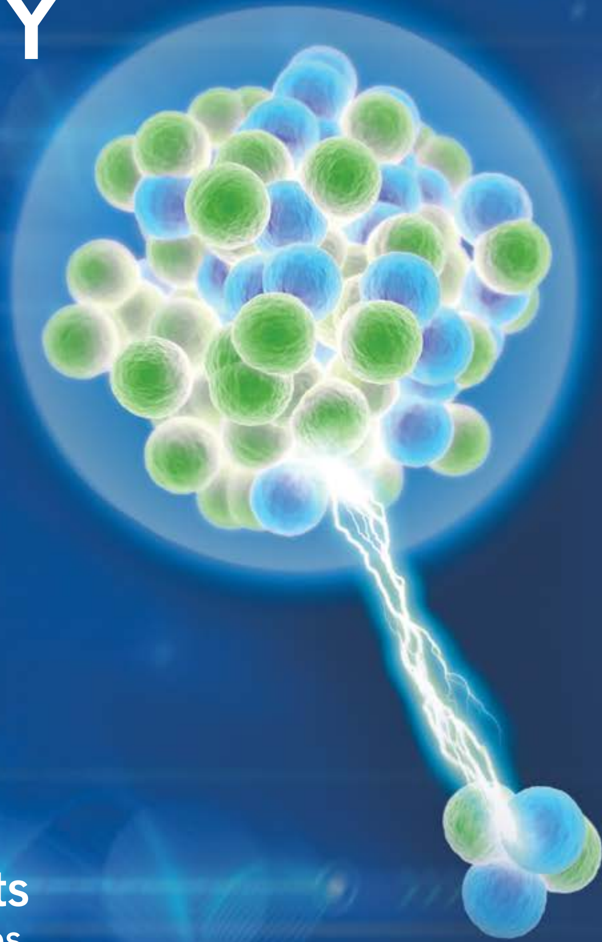
Powering New Discoveries in the RADIOCHEMISTRY COMPLEX



50 Radiological Labs
specially designed for studying radioactive isotopes

Nuclear Counting Instruments
that enable high-sensitivity radiation measurements

Mass Spectrometry Instruments
used to measure and analyze isotopes

World-Class Diagnostic and Experimental Platforms

Radiochemistry research at Lawrence Livermore National Laboratory (LLNL) addresses a broad range of challenges, including nuclear threat reduction, nuclear forensics, stockpile stewardship, cosmochemistry questions, and environmental concerns. At LLNL's radiochemistry complex, our nuclear chemists and radiochemists leverage an expanding array of world-class resources to explore solutions to high-priority national security challenges and other key science questions.

With a unique suite of tools, our researchers study nuclear reactions, the limits of nuclear stability, element transformation, and the properties of the heaviest elements. They benefit from access to rare radioisotopes collected from underground nuclear tests, which ended in 1992, as well as samples available through irradiation experiments.

Lawrence Livermore National Laboratory

Mass Spectrometry Instruments

The mass spectrometry instruments housed in LLNL's radiochemistry complex offer experimental and diagnostic techniques that make it possible to count atoms, study lunar rocks, isolate isotopes, and characterize unknown material. These sophisticated tools enable our nuclear chemists, cosmochemists, and radiochemists to tackle complex science challenges.

Secondary Ion Mass Spectrometry (SIMS)

Analyzing isotope ratios in sub-micron samples

When LLNL scientists need a versatile tool that can analyze isotopic information from solid samples, they turn to our three SIMS instruments. With SIMS, they study metal, mineral, glass, aerosol, soil, and biological samples.

These imaging tools use focused ion beams to sputter the sample and generate secondary ions, which are analyzed by mass-to-charge ratios. With our NanoSIMS instrument, our scientists can analyze the isotope composition of sub-micron samples.

These robust analytical capabilities support research in bioforensics, biofuels, geoscience, materials science, optics, and nuclear forensics.

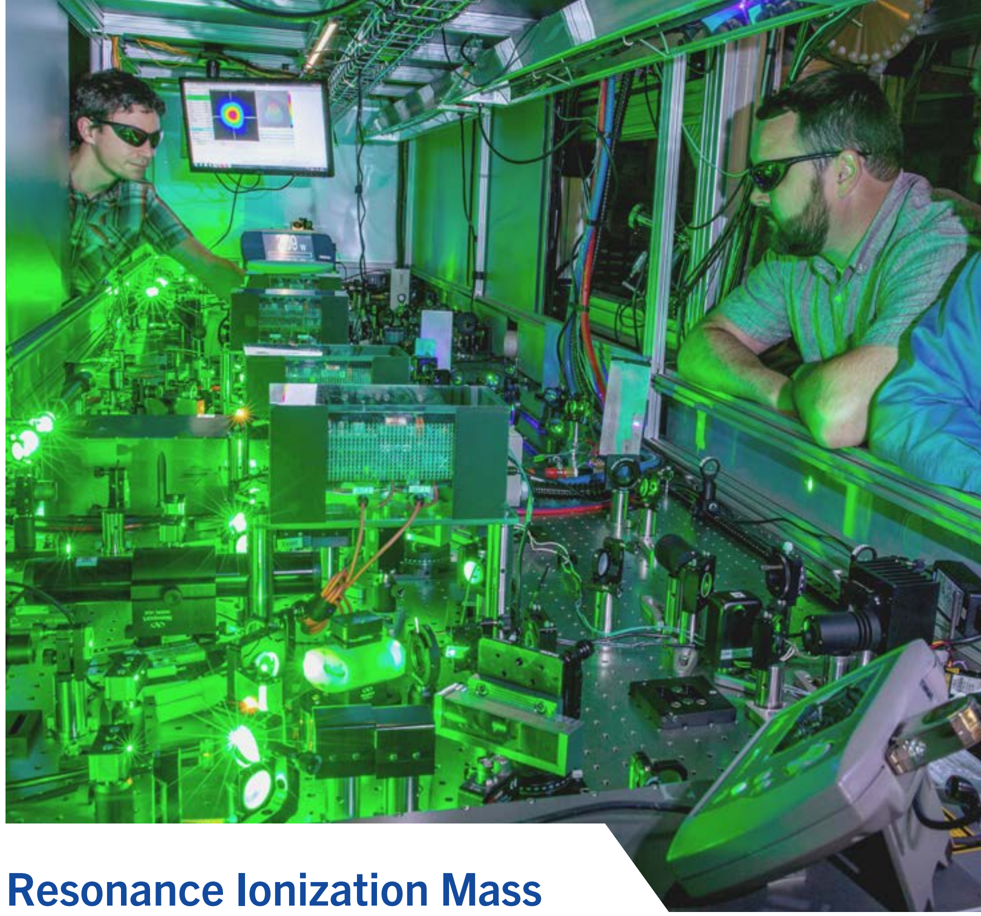
Our SIMS instruments generate secondary ions that our scientists analyze to obtain isotopic information regarding solid samples.

Inductively Coupled Plasma Mass Spectrometry (ICP-MS)

Our ICP-MS instruments offer fast, precise ionization, allowing scientists to quantify trace levels of impurities in a range of elements and measure isotopic compositions of environmental, nuclear, and extra-terrestrial samples.

Our facility houses single-collector ICP-MS instruments, as well as three multi-collector ICP-MS instruments, which can measure multiple isotopes simultaneously. These instruments are a mainstay of LLNL's nuclear science capabilities and support our research in radiochronometry, nuclear safeguards, and forensic analysis of nuclear material.

LLNL's custom-designed RIMS instrument uses lasers to measure isotope ratios in tiny samples.



Noble Gas Mass Spectrometry

LLNL offers a state-of-the-art facility for noble gas isotope ratio and abundance measurements, including:

- A membrane-inlet mass spectrometer, developed at LLNL, which allows scientists to measure dissolved noble gases in water samples as part of our groundwater tracer experiments to study water quality.
- Our multi-collector noble gas mass spectrometer, which provides the versatility needed to concurrently analyze high- and low-abundance isotopes, such as helium, neon, argon, krypton, and xenon.

Thermal Ionization Mass Spectrometry (TIMS)

Our scientists use TIMS to analyze elements with low ionization energy, providing precise isotope ratio measurements of chrome, lead, barium, and rare-earth elements. These capabilities are a key part of LLNL's research partnership with NASA, including studying lunar rocks collected during Apollo missions to expand our understanding of the moon's geologic history.

TIMS-based studies expand our understanding of our solar system and support nuclear forensics efforts to make our world a safer place.

Resonance Ionization Mass Spectrometry (RIMS)

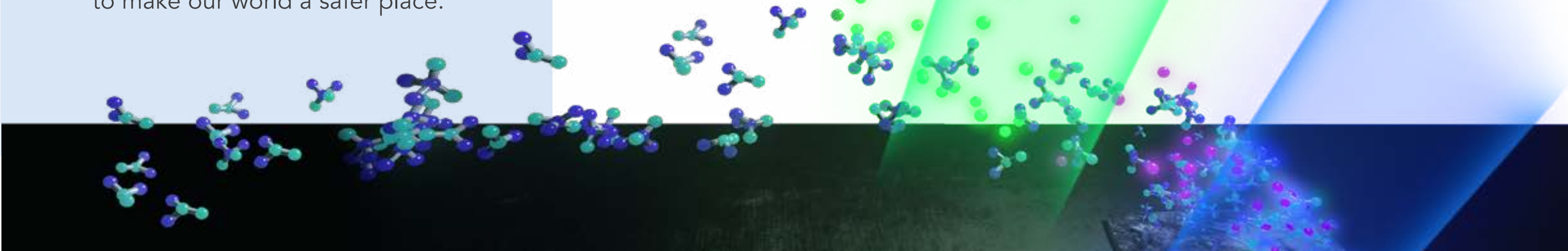
Measuring isotopes with lasers that ionize atoms

The RIMS instrument, custom designed at LLNL, measures isotope ratios *in situ*. Using lasers tuned to unique resonant frequencies that ionize only the atoms of a specific element, RIMS can measure samples with precision, consuming only a tiny portion of the material.

The highly sensitive process is fast because it leverages small sample quantities with minimal preparation, and analyzes multiple elements simultaneously.

RIMS can distinguish between isotopes of different elements that have the same atomic mass, a feature that is important for identifying stages in the nuclear-fuel processing cycle. The technique can also be used to measure uranium, plutonium, and cesium isotopic ratios in spent nuclear fuel.

Scientists use RIMS to analyze illicit nuclear material. Within very short timeframes, they can provide authorities with a read on whether an interdicted material was manufactured for use in a nuclear reactor or weapon—details that can provide the first clues to its origin and intended use.



Radiochemistry Labs

LLNL's radiochemistry research facility houses more than 50 labs designed specifically for experiments focused on studying radioactive isotopes and element transformation. From trace-level environmental analysis of tritium, to high-activity transuranic samples, our capabilities allow us to analyze solid, liquid, and gas samples.

A phased renovation of our dedicated radiochemistry facility is currently underway, creating a modern, flexible workspace for our radiochemists.

Our radiochemistry labs include fume hoods and gloveboxes, as well as Class-100 clean rooms for extremely sensitive chemistry and measurements.

Our high-vacuum fluorination system converts uranium oxides into O_2 gas for isotope ratio analysis, and facilitates synthesis of actinide compounds of interest to our nonproliferation mission. We also use a laser-heated fluorination capability, which reduces sample size requirements and increases throughput.

Nuclear Counting Facility

Located two floors below ground, with a layer of shielding materials between floors to minimize background radiation, LLNL's Nuclear Counting Facility provides high-sensitivity radiation measurements. Its assets include gamma spectrometers, solid-state detectors, alpha and beta counting systems employing ionization gas chambers, and liquid scintillation techniques.

The facility supports research in stockpile stewardship, nonproliferation, and counterterrorism, including:

- Analyzing samples and surrogate materials in support of nuclear forensics efforts.
- Studying samples collected during underground nuclear tests, which ended in 1992.
- Determining the number of radioactive atoms produced during experiments at LLNL's National Ignition Facility.

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