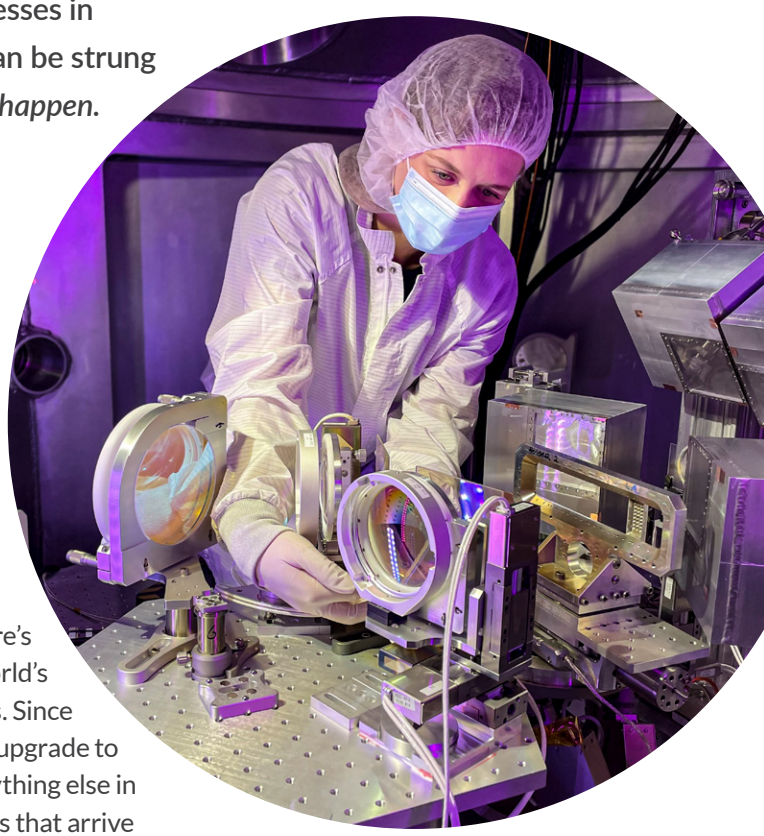
Linac Coherent Light Source (LCLS)

LCLS produces the world's brightest X-ray pulses. Like a high-speed camera with an incredibly bright flash, it takes X-ray snapshots of atoms and molecules at work, revealing fundamental processes in materials, technology and living things. These snapshots can be strung together into movies that show chemical reactions *as they happen*.



Quick facts

- Over 400 staff run the facility
- Over 4,000 scientists have conducted experiments at LCLS
- Users from 37 U.S. states and across the globe
- Approximately 30% first-time users each year
- Over 2,700 peer-reviewed publications
- 10 experimental instruments
- Free access for non-proprietary research
- Huge demand, with over 3-to-1 oversubscription rate from users

Pioneering a unique tool for science

Hundreds of scientists use LCLS each year to catch a glimpse of nature's fundamental processes. When LCLS turned on in 2009, it was the world's first free-electron laser producing "hard," or very high-energy, X-rays. Since then, similar light sources have sprung up around the world. A major upgrade to LCLS, completed in 2023, significantly boosted its power beyond anything else in the world, delivering beams that are 10,000 times brighter and pulses that arrive up to a million times per second. This continuous stream of X-ray laser pulses is transforming our view of how nature works at the atomic and molecular scale and helps advance technologies of the future, including novel electronics, life-saving drugs and innovative energy solutions.



Research at SLAC

X-ray & ultrafast science

Physics of the universe

Advanced accelerators

Science of life

New technologies

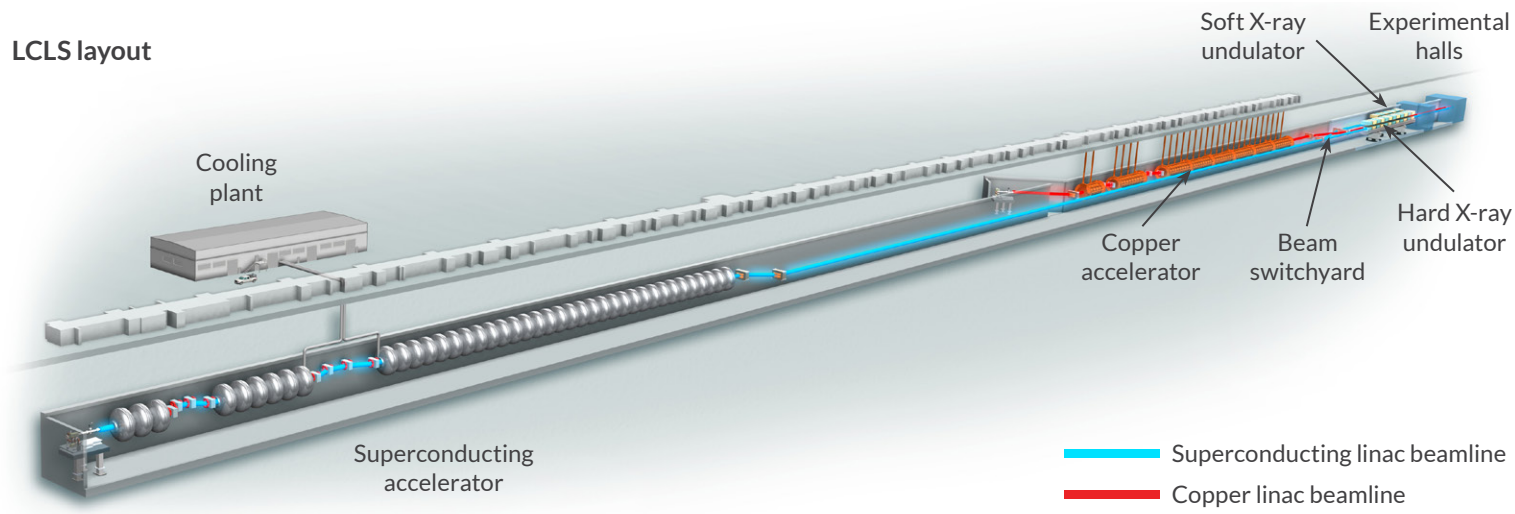
Energy sciences

SLAC NATIONAL ACCELERATOR LABORATORY

Stanford University

U.S. DEPARTMENT of ENERGY

LCLS.SLAC.STANFORD.EDU



Developing future electronics

Scientists use LCLS to study interactions in quantum materials on their natural timescales, which is key to understanding their unusual and often counterintuitive properties. These materials are being used to build energy-efficient devices and quantum computers and to enable ultrafast data processing and other future technologies.

Optimizing for energy innovation and sustainability

By capturing snapshots of chemical reactions on attosecond and femtosecond timescales – the scale at which electrons move and energy flows across molecules – LCLS provides unprecedented insights into chemical and biological reactions. These insights lead to advances in energy technologies, better batteries, more resilient catalysts and even artificial photosynthesis.

Designing 21st century materials

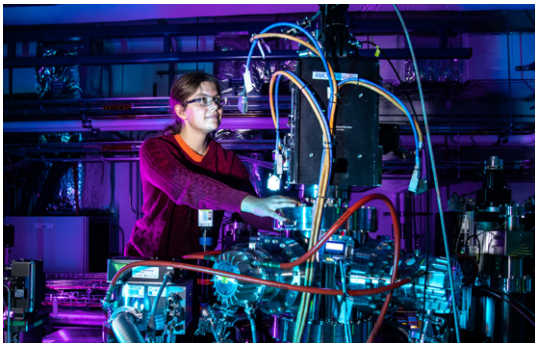
At the intersection of physics, chemistry and engineering, materials science benefits substantially from LCLS. The X-ray laser can observe the internal structure and properties of materials at atomic and molecular scales. These insights lead to breakthroughs in the design of new materials with unique properties, impacting a range of industries, from energy storage to manufacturing and aerospace engineering.

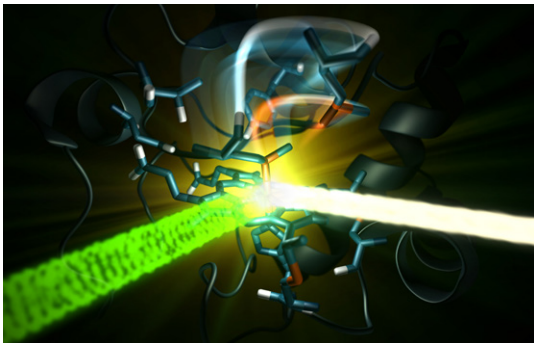
Studying matter in extreme conditions

LCLS allows us to study the behavior of extremely hot, dense matter that is typically only found at the centers of stars, giant planets and fusion reaction chambers. These experiments help researchers explore how fusion energy processes that power the sun could be harnessed here on Earth, how planets form and sustain life, and the impact of meteorite collisions.

Revealing life's secrets

Life's processes occur at scales and speeds that have often eluded detailed study. The ability of LCLS to create "molecular movies" can reveal these phenomena, revolutionizing our understanding of life at its most fundamental level. From the intricate dance of proteins and enzymes to the development of new types of pharmaceuticals and the machinery of photosynthesis, LCLS sheds light on biological systems in unprecedented detail.





Front left image: The LCLS tunnel. (Jim Gensheimer/SLAC National Accelerator Laboratory) Front right image: A SLAC scientist sets up an experiment at the Matter in Extreme Conditions instrument at LCLS. (All photos by Jacqueline Ramseyer Orrell/ SLAC National Accelerator Laboratory, unless otherwise noted)

Top image: LCLS uses the last third of SLAC's 2-mile-long linear accelerator – a hollow copper structure that operates at room temperature. As part of the LCLS upgrade completed in 2023, the first third of the copper accelerator was replaced with a superconducting one. The superconducting accelerator (gray/blue) is shown alongside the existing copper one (red). At the beam switchyard, electron beams from each linac are directed to one of two undulators to produce hard or soft X-ray laser pulses. The pulses then travel to experimental halls where scientists conduct research. (Greg Stewart/SLAC National Accelerator Laboratory) Inset left image: A scientist works at the Time-resolved Atomic, Molecular and Optical Science instrument. Inset right image: An optical laser (green) excites the iron-containing active site of the protein cytochrome c, and then an X-ray laser (white) probes the iron a few femtoseconds to picoseconds later. (Greg Stewart/SLAC National Accelerator Laboratory)

SLAC is operated by Stanford University for the U.S. Department of Energy Office of Science.

INC0534528-112026