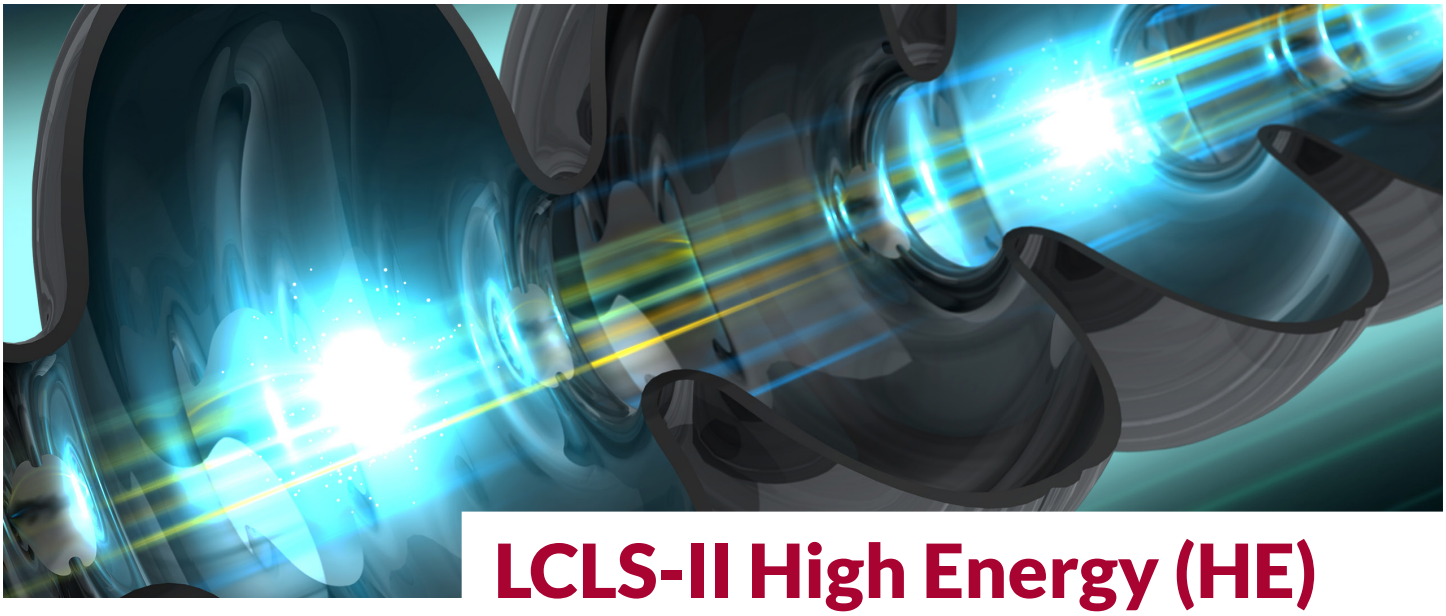

LCLS-II High Energy (HE)

LCLS Linac Coherent Light Source

slac.stanford.edu
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The Linac Coherent Light Source-II High Energy (LCLS-II-HE) project is a major upgrade that will double the energy of the accelerator that drives the world's most powerful X-ray free-electron laser (XFEL). The project will significantly extend the maximum X-ray energy of the facility to provide atomic resolution at high repetition rate, unlocking unprecedented opportunities for scientific discovery across multiple disciplines, including energy technologies, human health and quantum information.

The upgrade will keep the U.S. at the forefront of X-ray science and technology into the next decade, attracting the best and brightest scientific talent.

These "superconducting" niobium cavities, constructed at Fermi National Accelerator Laboratory, allow radio frequency fields to boost electron energies practically without electrical resistance. (R. Hahn/Fermilab) Top: An electron beam travels through a niobium cavity. (Greg Stewart/SLAC National Accelerator Laboratory)

Brighter than ever

LCLS-II-HE builds on the success of LCLS-II, completed in 2023, which incorporated a superconducting accelerator capable of producing up to a million X-ray pulses per second – 8,000 times more than its predecessor.

LCLS-II-HE will double the energy of the electron beam, extending the X-ray energy range from 5 keV to 13 keV. **It will deliver a 3,000-fold increase in the brightness** of these high-energy ("hard") X-rays. With the ability to deliver the world's shortest X-ray pulses, highest repetition rate and brightest beams, the facility's **enhanced resolution and sensitivity** will allow researchers to capture atomic-scale motion with unmatched clarity and precision.

Together, these advancements will empower researchers to study complex processes at ultrafast timescales, providing tools for solving humanity's most pressing challenges.

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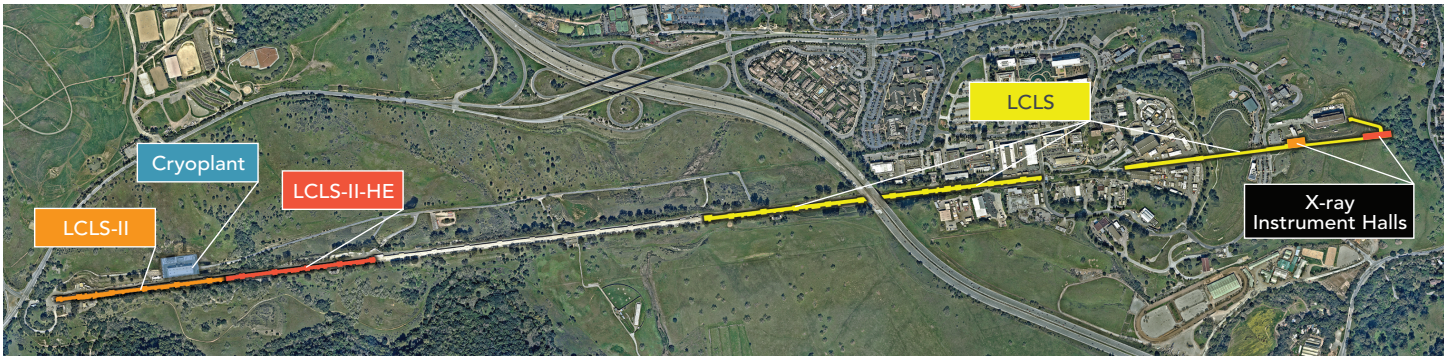
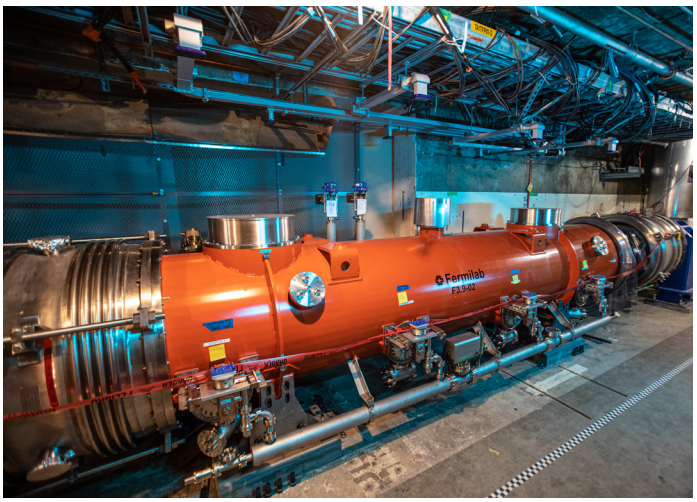


The LCLS-II-HE accelerator will occupy the first kilometer of the SLAC accelerator tunnel and make use of the cryogenics infrastructure installed for the LCLS-II project.

Driving innovation

As part of the upgrade, teams will install 23 new cryomodules in the SLAC accelerator tunnel. Each cryomodule contains eight superconducting radio frequency cavities that implement the latest technology for enhanced performance. The high-energy upgrade will use the existing hard X-ray undulator, and teams will modify the soft X-ray undulator so that both can be used simultaneously with the new beam.



Cryomodules, constructed at Fermi National Accelerator Laboratory and Thomas Jefferson National Accelerator Facility, installed in the SLAC accelerator tunnel. (Jacqueline Ramseyer Orrell/SLAC National Accelerator Laboratory)

When complete, LCLS-II-HE will provide deep insights into the atomic-level dynamics governing the natural and technological world. This will drive innovations in:

- **Energy storage:** Revealing the fundamental processes that drive chemical reactions to store or release energy
- **Sustainability:** Providing a deep understanding of the fundamental processes in catalysis – essential for directed design of efficient new systems for sustainable manufacturing, energy storage and solar energy conversion
- **Biomedical science:** Imaging biological function and dynamics in physiologically relevant conditions to drive the design of a new generation of targeted pharmaceuticals
- **Materials:** Capturing the behavior of real-world materials to understand the complexity and dynamics that enable the performance of functional materials and novel devices for energy efficient applications
- **Quantum materials:** Understanding the exotic properties of emergent behavior that can underpin a new generation of ultrafast computers and communications
- **Extreme states:** Accessing and characterizing extreme states of matter to provide important new insights into planetary physics, geoscience and aerospace applications
- **Data science and AI:** Generating over 1 petabyte of high-quality data daily to fuel machine learning, predictive modeling and autonomous experimentation.

About LCLS

When LCLS opened in 2009 as a Department of Energy Office of Science user facility, it was the world's first light source of its kind, a free-electron laser producing "hard" X-rays. Since then, more than 4,000 scientists from 37 U.S. states and 50 countries around the world have conducted experiments at LCLS, and over 30% of experimenters each year are first-time users. Access is provided free to user proposals assessed for the greatest scientific impact in a highly competitive selection process.

Strong partnerships in X-ray science

SLAC is proud to partner with four other national labs – Argonne National Laboratory, Lawrence Berkeley National Laboratory, Fermi National Accelerator Laboratory and Thomas Jefferson National Accelerator Facility – and the Facility for Rare Isotope Beams at Michigan State University on planning, design and construction for LCLS-II-HE with input from experts around the world. The DOE's Office of Science program for Basic Energy Sciences continues to invest in this groundbreaking light source, maintaining U.S. leadership in the field.

The Linac Coherent Light Source at SLAC National Accelerator Laboratory is an Office of Science user facility operated for the Department of Energy by Stanford University.

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