

## LCLS-II

# Boosting the Power of SLAC's Premier X-Ray Laser

SLAC's renowned Linac Coherent Light Source is getting a major upgrade that will significantly boost its power and capacity, allowing it to deliver X-ray laser beams that are 10,000 times brighter with pulses that arrive up to a million times per second. LCLS-II will further sharpen our view of how nature works at the atomic scale and help advance transformative technologies of the future, including novel electronics, life-saving drugs and innovative energy solutions.

### A Superior X-Ray Microscope

Hundreds of scientists use LCLS each year to catch a glimpse of nature's fundamental processes. The unique X-ray microscope uses the brightest X-ray pulses ever made to provide unprecedented details of the atomic world.

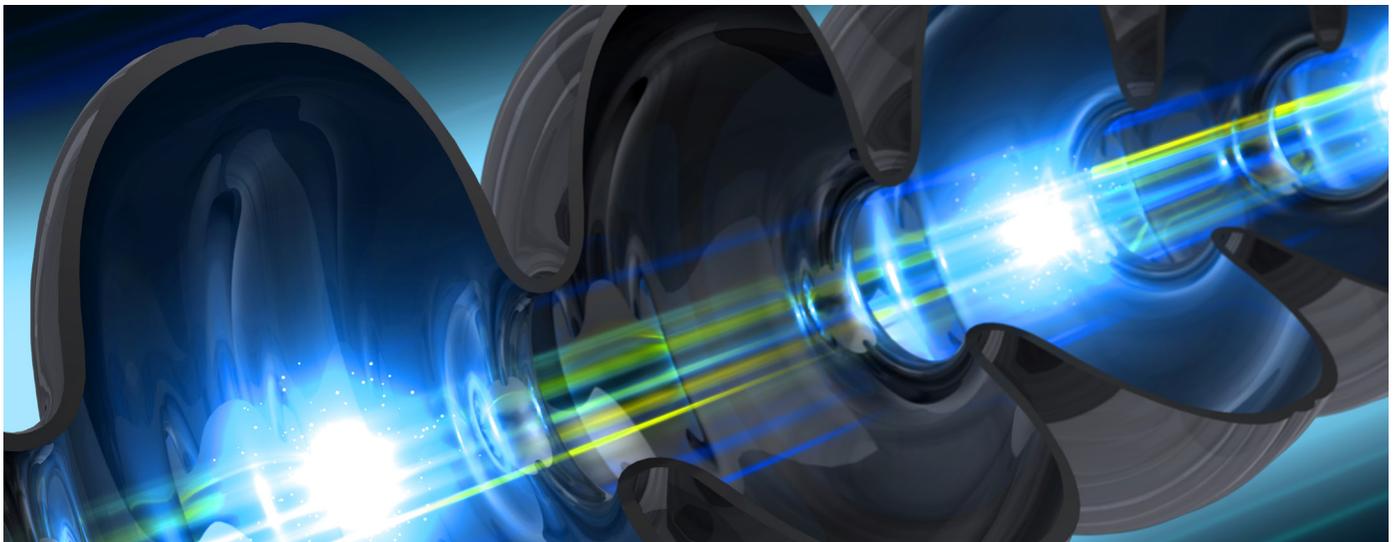
LCLS's ultrafast pulses allow scientists to create:

- Molecular movies that reveal how chemical bonds form and break, which can lead to novel energy production and storage technologies;
- Snapshots that capture the rapid rearrangement of electric charges in materials, which can inform the designs of advanced electronics and materials with revolutionary new properties; and
- Sharp 3-D images of disease-related proteins with atomic-level details that could hold the key for discovering cures.

LCLS-II will allow researchers to make observations over a wider energy range using the existing accelerator, capture detailed snapshots of rapid processes, probe delicate samples and gather more data in less time, thus greatly increasing the number of experiments that can be performed at this pioneering facility. Construction began in 2016, and the new facility is scheduled to begin operations in the early 2020s.

### Superconducting Technology

The new X-ray laser will work in parallel with the existing one. Both LCLS and LCLS-II will use electrons accelerated to nearly the speed of light to generate beams of extremely bright





X-ray laser light. The electrons fly through a series of magnets, called an undulator, which forces them to travel a zigzag path and give off energy in the form of X-rays. But the way those electrons are accelerated will be quite different and give LCLS-II much different capabilities. At present, electrons are accelerated down a copper pipe that operates at room temperature and allows the generation of 120 X-ray laser pulses per second.

LCLS-II will add a superconducting accelerator, occupying one-third of SLAC's original 2-mile-long linear accelerator tunnel, which will generate an almost continuous X-ray laser beam. In addition to the new accelerator, LCLS-II requires a number of other cutting-edge components, including a new electron source, a powerful cooling plant that produces refrigerant for the accelerator, and two new undulators to generate X-rays.

**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," or very high-energy X-rays. Since then, more than 500 experiments have been conducted at LCLS. In 2016 alone, scientists from 72 U.S. institutions, and others from around the world, performed research here.

**Strong Partnerships in X-Ray Science**

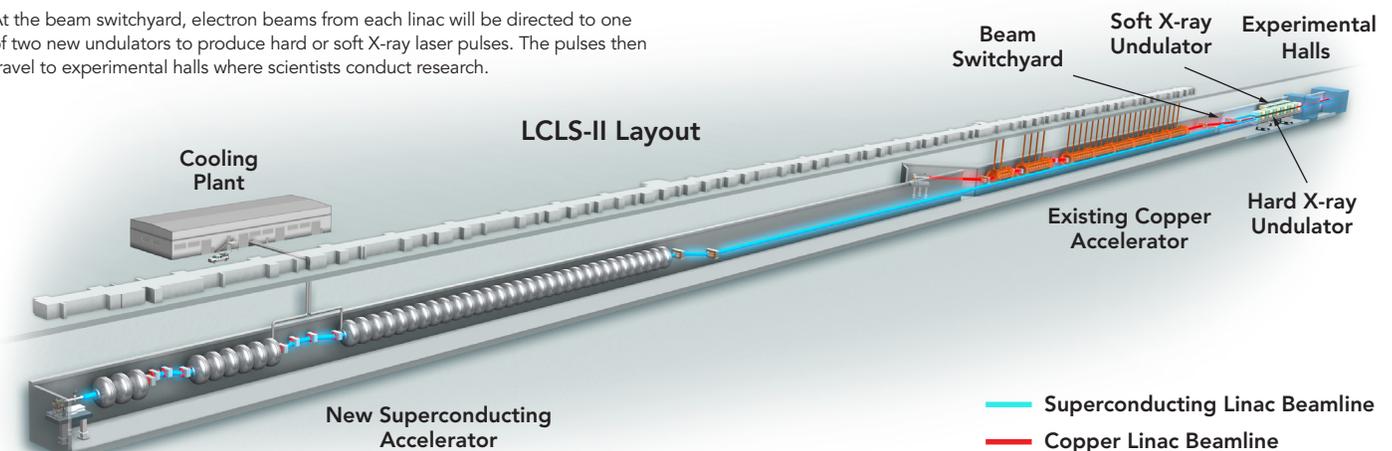
SLAC is proud to partner with experts at four other national labs – Argonne National Laboratory, Lawrence Berkeley National Laboratory, Fermilab National Accelerator Laboratory and Thomas Jefferson National Accelerator Facility– and Cornell University on planning, design and construction for LCLS-II. The DOE's Office of Science program for Basic Energy Sciences is investing in this groundbreaking light source.

The future LCLS-II X-ray laser (blue) is shown alongside the existing LCLS (red). LCLS uses the last third of SLAC's 2-mile-long linear accelerator – a hollow copper structure that operates at room temperature. For LCLS-II, the first third of the copper accelerator will be replaced with a superconducting one.

At the beam switchyard, electron beams from each linac will be directed to one of two new undulators to produce hard or soft X-ray laser pulses. The pulses then travel to experimental halls where scientists conduct research.



Cooled to minus 456 degrees Fahrenheit, these niobium cavities allow radiofrequency fields to boost electron energies without electrical resistance. Cryomodules—consisting of eight niobium cavities each—are a key component of LCLS-II's superconducting linear accelerator. (R. Hahn/Fermilab)



*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.*