

# World's most powerful X-ray laser

The Linac Coherent Light Source (LCLS), the world's most powerful X-ray laser located at the SLAC National Accelerator Laboratory in the US, will undergo a major upgrade that will increase the machine's X-ray energy 3,000-fold.

Once the upgrade is complete, the machine's X-ray energy will allow scientists to explore processes at the atomic level to answer many questions in the fields of biology, materials science, and quantum physics.



LCLS is the first machine to produce high-energy X-rays (hard X-rays) using a free-electron laser, built with funding from the US Department of Energy (DOE).

The facility began operations in 2009. In 2023, LCLS was upgraded to include a superconducting accelerator and a magnetic structure called a pulsar that can produce both soft and hard X-ray beams. The most recent upgrade, called LCLS-II, will enable the facility to produce one million X-ray pulses per second. To accelerate electrons to high energies with minimal energy loss, the superconducting accelerator in the LCLS-II upgrade includes 37 cryogenic modules that can be cooled to -271 degrees Celsius.

The next upgrade, called LCLS-II HE (high energy), was recently approved by DOE, to double the energy of the electron beam coming from the superconducting accelerator, thereby doubling the X-ray energy.

With the new HE upgrade, LCLS will feature 23 new cryogenic modules, each containing eight superconducting radio frequency cavities to provide optimal performance. All modules are scheduled to be installed in the accelerator tunnel by 2026.

LCLS-II-HE is expected to produce its first X-rays sometime in late 2027–2030. The first run will determine how well the new laser will perform. The facility has two accelerators, and only the superconducting accelerator

is being upgraded, so the accelerator will typically continue to serve as a science experiment during the upgrade.

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