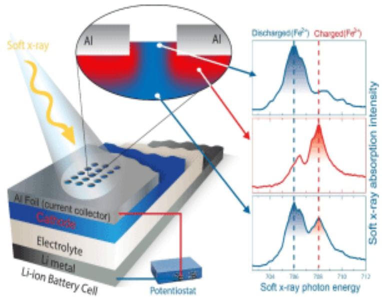
Advanced Light Source

General Information

The Advanced Light Source (ALS) is located in Berkeley, California. The original building, situated in the East Bay hills overlooking San Francisco Bay, was completed in 1942. Designed by Arthur Brown, Jr. (designer of the Coit Tower in San Francisco), the domed structure was built to house Berkeley Lab's namesake E. O. Lawrence's 184-inch cyclotron, an advanced version of his first cyclotron for which he received the Nobel Prize in Physics in 1939. Today, the expanded building houses the ALS, a third-generation synchrotron and national user facility that attracts scientists from around the world.

Scientific leadership

- world-class infrared to x-ray science
- world-leading soft x-ray science
- spectroscopy, scattering, and imaging techniques



Outstanding annual metrics

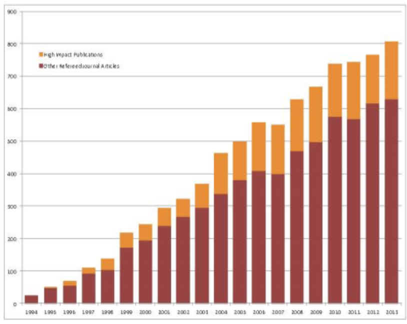
- 2400 users
- 800 scientific publications
- 5000 operating hours

ABOUT THE ACCELERATOR

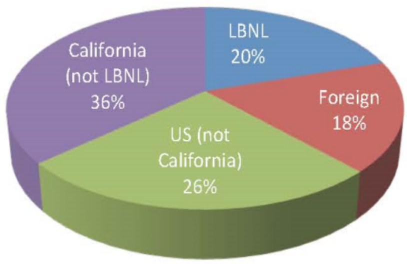
- Number of electrons in each bunch .... 7 billion
- Time between electron bunches .... $2x10^{-9}$ sec
- Size of the electron beam .... ~0.20mm x 0.01mm (the width of a human hair)
- Distance electrons travel in the booster ring (in 0.45 sec) .... 135,000 km
- Electron revolutions around the storage ring per second .... 1.5 million
- Energy of electrons in the storage ring .... 1.9 GeV
- Speed electrons travel at their highest velocity .... 299,792,447 meters/sec (that's 99.999996% the speed of light!)
- Aluminum foil used per year .... 20,928 sq ft

20 years of growth

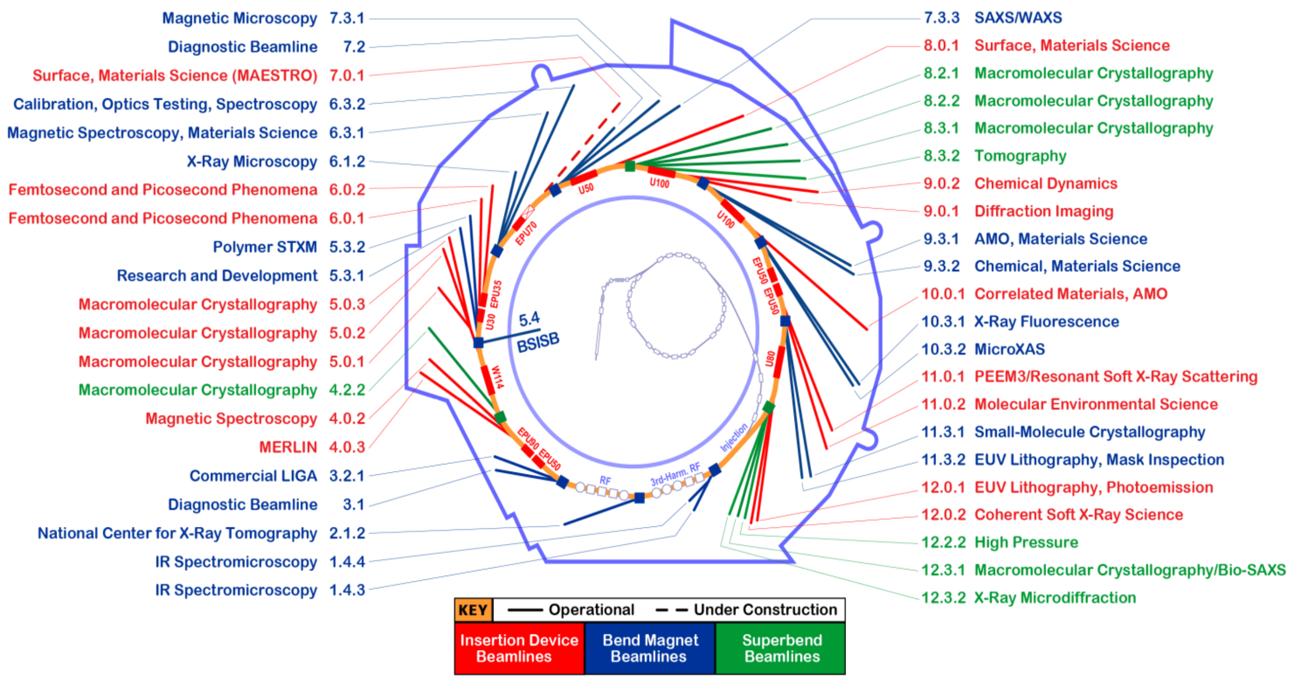
- 40 instrument beamlines
- continual upgrade of machine brightness
- continual upgrades of science capabilities



Users by Geography



ALS Operates 40 Instrument Beamlines for Users



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Current Activities

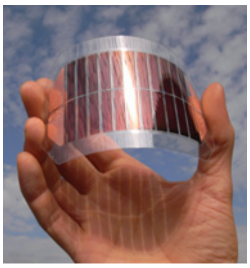
Materials by Design

- Longer-lasting lithium-ion batteries for electric vehicles and mobile electronics
- Nanoscale magnetic imaging for compact data storage
- Plastic solar cells that are flexible and easy to produce

Lithium-ion batteries can power a wide variety of mobile devices, from cell phones to electric cars. X-ray studies can reveal what electrode materials perform best, providing a rational basis for the design of longer-lasting batteries.

Magnetic imaging reveals how magnetic materials behave at the nanoscale. With such information, researchers can discover new ways to encode and manipulate data for faster, smaller, and more reliable digital applications.

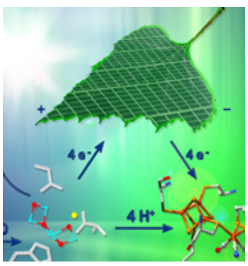
Plastic solar cells are light, flexible, and inexpensive. At the ALS, it is possible to determine the amount of molecular mixing in the active materials, a key to improving the cells' efficiency at converting sunlight into electricity.

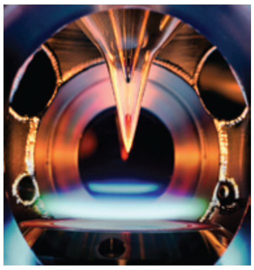


Chemistry of Energy

- Harnessing "artificial photosynthesis" for clean, renewable energy
- Fine-tuning combustion for cleaner-burning fuels
- More effective chemical reactions for fuel cells, pollution control, or fuel refinement

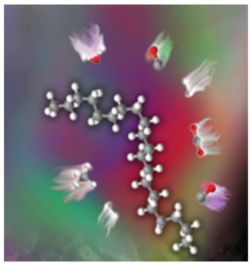
Artificial photosynthesis could be a promising way to convert sunlight into clean, renewable fuel. X-ray experiments can help researchers to understand and re-create the chemical processes that occur naturally in all plants.





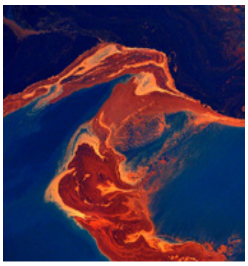
Understanding combustion at a detailed level can help control pollution and improve efficiency. ALS flame chemistry studies have yielded surprising insights that have caused researchers to rethink their models for combustion processes.

More effective chemical reactions are the ultimate goal of ALS studies of how catalysts perform under realistic reaction conditions, such as feeding hydrogen fuel cells, sweeping toxins from emissions, or driving fuel-refinement techniques.



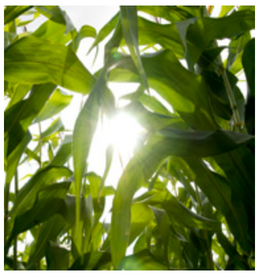
Environment & Health

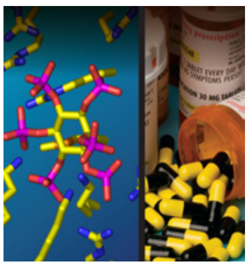
- Using microbes to clean up toxins in the environment
- Cheaper biofuels from abundant, renewable plants
- Solving protein structures for rational drug design



Bioremediation is a neat solution to a difficult problem: toxins, such as oil, are broken down into less-harmful form by microbes. At the ALS, we can study this process by correlating the form and location of the toxin with that of the microbe.

Cheaper biofuels from plant matter may be possible if we can learn how to break down the cellulose in plant cell walls more efficiently. Promising new solvents and their effects can be studied using various ALS capabilities.





Rational drug design requires knowledge of the molecular structures of the proteins in our bodies so that we can understand how drug molecules interact with them. At the ALS, researchers have the tools they need to study protein form and function.

To learn more, go to www-als.lbl.gov

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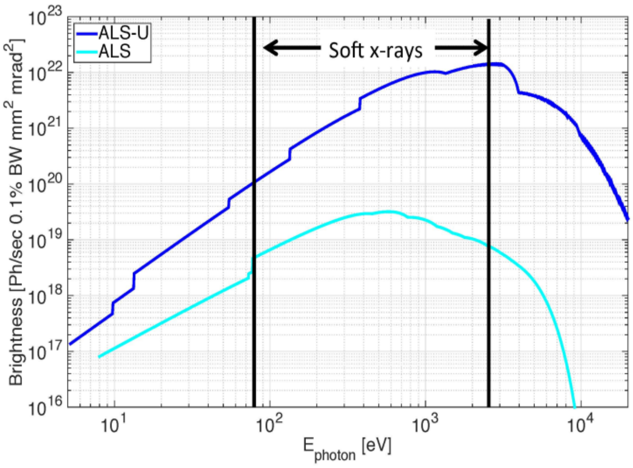
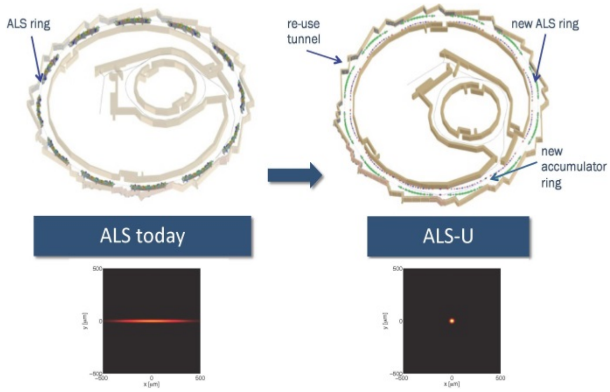
Future Perspective

An Upgrade of ALS to ALS-U Would Be Revolutionary





New ring based on multi-bend achromats
2 GeV, 500 mA, 50 x 50 pm rad

Upgrades Recently Completed or Near Completion

- Brightness upgrade. A recently completed upgrade project improved the brightness of the ALS by reducing the horizontal emittance from 6.3 to 2.2 nm. This resulted in a brightness increase of a factor of 3 for bend-magnet beamlines and at least a factor of 2 for insertion-device beamlines. a factor of 3 for bend-magnet beamlines and at least a factor of 2 for insertion-device beamlines generation light sources.
- Controls/instrumentation upgrade. The controls and instrumentation upgrade is a four-year project that is scheduled to be completed in FY15. Its goal is to replace all outdated control system hardware and software, as well as much of the beam diagnostics hardware. This will enable the ALS accelerator staff to maintain and improve the reliability of accelerator operations, reduce the effort necessary to support the control system in the future, and provide improvements in performance, particularly in orbit stability. With the 20x improved bandwidth of the new BPMs and existing corrector, we expect a 2x improvement in the fast orbit feedback system.
- Storage ring rf upgrade. The existing high-power rf system was nearing the end of its useful life and spares were becoming increasingly unavailable. Therefore an upgrade project is nearing completion with the goals of long-term maintainability, higher reliability, lower electricity consumption, and sufficient power reserves for all planned additions of new undulators, better immunity to AC line transients, and better fast phase stability. The main risk factor of the system, the old klystron, was replaced in FY12 and the project is planned to complete in FY15.
- Major storage ring power supply replacement. The original large power supplies used for the four major magnet chains in the ALS lattice had become unreliable. In addition, newer designs can be more power efficient and provide better stability, thereby improving orbit stability. The last of the major power supplies was replaced in FY13.

After the previously listed major upgrades are completed, many failure risks due to aging equipment will be retired. The largest remaining component is the injector rf system. In addition to the injector rf there will be need in the future to upgrade the 20-year-old single magnet power supplies for the 48 QF and QD magnets.