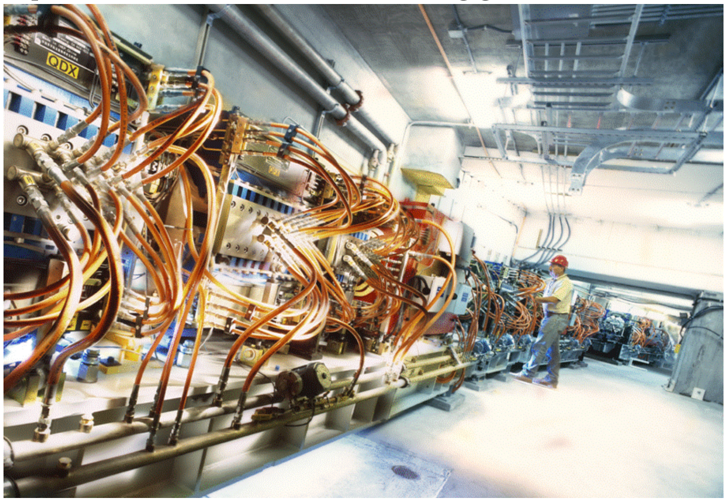
Stanford Synchrotron Radiation Lightsource

The Stanford Synchrotron Radiation Lightsource (SSRL) was founded in 1972 and has provided synchrotron radiation to the scientific community for over 30 years. SSRL is one of four lightsources, funded by the U.S. Department of Energy (DOE), for scientific research which benefits every sector of the American economy, including nanotechnology, energy production, environmental remediation, and medicine. Facilities such as SSRL also provide unique educational experiences and serve as a vital training ground for students in the sciences.



Third Generation Light Source – SPEAR3

SSRL, a part of the Stanford Linear Accelerator Center (SLAC), utilizes x-rays produced by the Stanford Positron Electron Asymmetric Ring (SPEAR). The SPEAR accelerator was upgraded in 2004 to an intermediate energy (3-GeV), 500-mA capable, high-brightness "third-generation" storage ring**.** This upgrade, jointly funded by the DOE and the National Institutes of Health (NIH), is an example of extraordinary teamwork and enables groundbreaking synchrotron science.

State-of-the-Art Experimental Facilities

In conjunction with the SPEAR3 upgrade, parallel upgrades of beam line optics and end station instrumentation has been underway since 2004. Currently there are 12 beam ports on SPEAR3; the 8 insertion device and 4 bending magnet beam lines serve 26 experimental stations. There are expansion opportunities for additional techniques at numerous locations around the SPEAR ring, including: soft x-ray microscopy, scattering, and advanced spectroscopy; high-throughput macromolecular crystallography; and hard x-ray transmission x-ray microscopy station.

Central Management Ensures Optimal Utilization of User Facilities

The experimental facilities at SSRL are all scheduled and managed centrally to ensure that the unique resources are most fully and efficiently utilized and supported by staff to ensure that all visiting scientists have a productive experience. With a strong focus on serving the general scientific user community, SSRL provides access to beam lines, instrumentation, ancillary equipment and dedicated staff scientists and technicians in numerous areas, such as:

- Correlated and Magnetic Materials – high T_C materials and oxides with nanoscale ordering phenomena, magnetic materials and magnetic nanostructures
- Molecular Environmental Science – chemical bonding, oxidation states, micro- and nano- structures and compositions
- Structural Biology/Chemistry – local atomic coordination and bonding, macromolecular crystal structure, nanoscale structure
- Surface and Interface Science – surface reactions, catalysis, liquid-solid interfaces

Public Dissemination of Scientific Advances

SPEAR3 is one of the world's leading sources for photon science research and serves the research needs of a growing number of national and international scientists across a range of science, engineering, environmental and biomedical disciplines. The results of experiments conducted at SSRL are shared publicly in numerous ways, including publications in peer-reviewed journals, presentations at scientific conferences, and recognition through international awards. Recent user research highlights include:

- **Understanding transcription** - How DNA is converted into RNA. Roger Kornberg, professor of Structural Biology at the Stanford University School of Medicine, received the ***2006 Nobel Prize in Chemistry*** for this work, a significant part of which was conducted at SSRL's macromolecular crystallography beam lines.
- **Chemical form of mercury in the fish we eat –** Understanding mercury toxicity resulting from early mining activities (*Eniviron. Sci. Technol., 2007*).
- **Steps toward understanding autism** – Scientists determined three-dimensional structural model of a complex with the only two extracellular synaptic proteins implicated in autism and mental retardation *(Structure, 2007).*
- **How stents take the strain –** Investigations into stress/strain characteristics of superelastic materials used for endovascular stents *(Adv. Mater., 2007).*

- **Discovering the many sides of cells –** Studies solved the structure of a protein that assists in the development of cellular polarization, which gives cells the ability to perform specific biologic functions *(Nature., 2006).*
- **Floppy hairs and sound waves** – Underlying molecular case for one form of deafness explored *(Phys. Rev. Lett., 2006).*
- **T-cell's guide to knowing who's who –** Stanford scientists develop better understanding of how immune cells distinguish between the body's own cells and foreign invaders *(Cell, 2007).*
- **Carbon joins the magnetic club** – Harnessing carbon's magnetic properties could benefit a range of fields from nanotechnology to electronics *(Phys. Rev. Lett., 2007).*
- **Closing in on dangerous infections –** Detailing the molecular structure of fiber-forming proteins will benefit the design of drugs that target these structures *(Molecular Cell, 2006).*
- **Using microorganisms to understand hydrogen complexes** – Research on synthetic biomimetic molecule that structurally models the active site of FeFe hydrogenases could lead to potential targets for hydrogen-based energy production and utilization technologies (*Chem. Commun., 2006*).
- **Using x-ray holography for simultaneous imaging** – SSRL scientists demonstrated a novel approach for improving efficiency of an x-ray microscopy technique that may prove beneficial for imaging radiation-sensitive objects such as biological samples *(App. Phys. Lett., 2006).*
- **Explaining the behavior of a high-temperature superconductor –** Stanford scientists made an important discovery about the coexistence of two distinct energy gaps in photoemission spectra of high temperature superconductors *(Science., 2006).*
- **Role of copper regulation in a *M. tuberculosis* repressor –** Scientists discovered gene for a protein that regulates the cellular response to copper in the bacterium tuberculosis *(Nature Chem. Bio., 2006).*
- **Learning how nature splits water -** High-resolution structure of photosynthetic catalyst holds promise for clean energy (*Science, 2006*).
- **Uranium-hungry bacteria lead to safer water supply** – Several common types of bacteria convert an unstable form of uranium into a stable form that greatly reduces the environmental and health threat of contamination *(Environ. Sci. Technol., 2006).*
- **Shedding light on cheaper communication –** Mechanism to deposit a special thin film with photoluminescent erbium onto silicon wafers could lead to the development of miniaturized optical amplifiers integrated with microchips for communications hardware *(J. Applied Physics, 2006).*
- **Ordered nanoporous germanium semiconductors -** Porous germanium, a semiconductor used in fiber optics and electrical components, could lead to use of nanoporous materials to develop new kinds of solar cells or highly sensitive electronic sensors *(Nature, 2006).*
- **Development of plastic semiconductors** - Researchers demonstrate that electrical performance of plastic semiconductors can be controlled and improved with surface treatments *(Nature Materials, 2006).*

Future Opportunities in Ultrashort and Ultrasmall

SPEAR3 offers high brightness x-ray radiation, which is emitted as ultrashort (about 30 ps) x-ray pulses. These capabilities allow the development of new instrumentation such as x-ray microscopy and scientific applications in new areas such as nanoscience. More generally, it will become increasingly important in the future to create micro- or nano-sized x-ray beams with high-intensity, well defined polarization and time structure. Such studies promise unique insight into the properties of numerous systems, including materials:

- under extreme conditions, such as pressure or high fields,
- which exhibit nanoscale dynamics, i.e. respond to excitations on the second to picosecond time scale,
- that are artificially nanostructured or intrinsically inhomogeneous on the micro- and nanoscale, and
- biological crystals which only exist on the microscale.

SSRL is one of the pioneering synchrotron facilities in the world, known for outstanding user support and important contributions to science and instrumentation. SSRL is well poised to continue make significant contributions to scientific discovery, development, and training the future workforce.

SSRL is primarily supported by the DOE Offices of Basic Energy Sciences and Biological and Environmental Research, with additional support from the NIH National Center for Research Resources, Biomedical Technology Program, and the National Institute of General Medical Sciences.

SSRL Mission

To enable and support outstanding scientific research by a broad user community in a safe environment.

Operations Overview

- Funded in 1973, began operation in 1974 **– first storage ring-based hard x-ray SR user facility in the world**
- SSRL scientists pioneered numerous techniques and applications:
  - Permanent magnet wigglers/undulators
  - MAD (multiple wavelength anomalous dispersion) phasing
  - X-ray Absorption Techniques: EXAFS, SEXAFS, NEXAFS
  - Soft x-ray science (200-3000 eV)
  - Synchrotron-based Photoemission Techniques (core level photoemission, photoelectron diffraction, ARPES)
  - Magnetic microscopy with X-rays
  - X-ray studies in Molecular Environmental Interface Science (MEIS)
  - Ultrashort pulse x-rays, XFEL radiation
- DOE-funded since 1983
- SPEAR dedicated for SSRL use in 1989
- SSRL operates ~9 months annually with **>98% uptime for users**
- User research has broad applications, including: energy efficiency and supply, toxic waste cleanup, bioterrorism and disease detection, electronics, telecommunications and manufacturing
- **User experiments resulted in ~8,600 user scientific publications since 1974**
- SSRL provides valuable **scientific training for the future workforce**: ~60% of users are undergraduate students, graduate students, or postdoctoral fellows.
- **~1,300 experiments are conducted annually on 28 experimental stations serving >2,000 scientists** from ~20 countries

www-ssrl.slac.stanford.edu