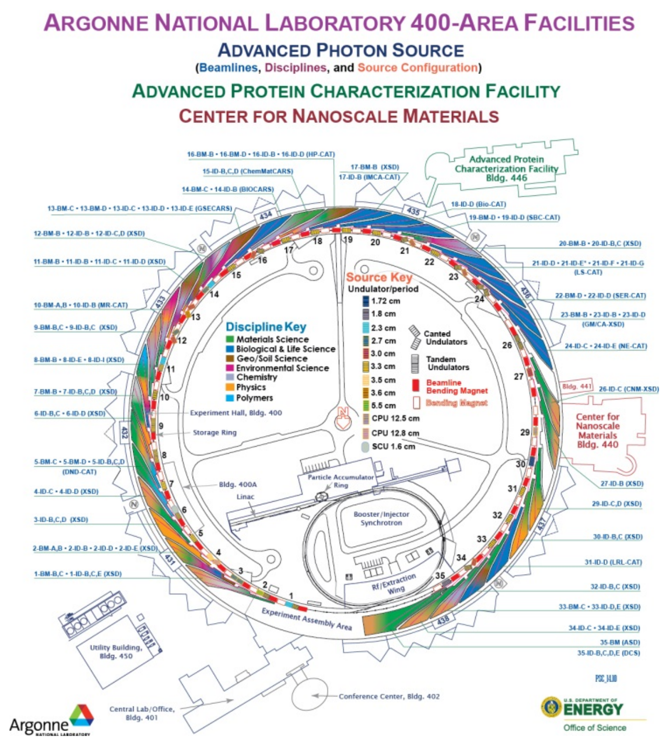
The Advanced Photon Source

General Information

The Advanced Photon Source (APS), which was completed in 1996, is supported by the U.S. Department of Energy Office of Science - Basic Energy Sciences (DOE-BES), and serves the largest scientific user community in the U.S. Located at the Argonne National Laboratory near Chicago, IL, the APS facility provides high-brightness, high-energy (or "hard") x-ray beams to users from all 50 states, the District of Columbia, Puerto Rico, and more than 30 nations who annually publish more than 1800 papers contributing to knowledge and innovation in energy, health, environment, and the physical and life sciences.

At the core of the APS is a high-energy, 7-GeV electron accelerator that feeds a 1.1-km-circumference storage ring where undulators and bending magnets deliver x-rays to 66 independently operating beamlines.

- User operations: started in 1997
- 7-GeV, 100-mA top-up operations
- 5000 user hrs of operation scheduled each year with ~98% user-beam delivery
- Operations budget: $120 M US in FY14
- Over 6200 unique users in FY14
- ~2000 new research proposals submitted each year
- ~ 60% acceptance rate for beam time requests
- World leader in solving protein structures - 1764 structure deposited in Protein Data Bank in 2013
- User affiliations (FY14):
  - 64 % from U.S. universities,
  - 14 % from federally-funded Labs
  - 4 % from industry
  - 13 % from foreign institutions
  - 6 % other



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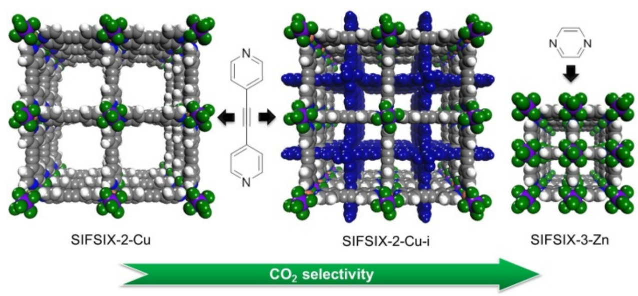
Current Activities

Today, the high-energy, high-brightness, highly-penetrating x-ray beams from the APS give researchers access to a powerful, versatile tool that is ideal for studies that can help to solve the challenges of our world, from developing new forms of energy, to sustaining our nation's technological and economic competitiveness, to pushing back against the ravages of disease.

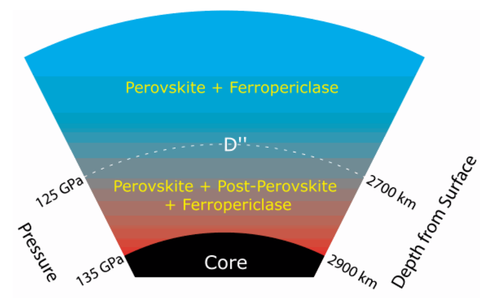
The APS has a very strong user base working in the field of **life sciences.** All three recipients of the 2009 Nobel Prize in Chemistry published papers on their award-winning work on **ribosomes** based on data collected at the APS (and other synchrotron radiation facilities). In 2012, the Nobel Prize in Chemistry was awarded for work **on G-protein-coupled receptors**, thanks in large part to research performed at the APS.

The structure of the G-protein-coupled receptor

Energy research, from better batteries to renewable energy sources, is another important area of research by APS users. For instance, fuel injector sprays have been studied to improve injector design. Researchers at the APS are also exploring **novel materials** design to develop the next generation of materials for electronic devices, new lightweight/high-strength materials, and other energy-related applications. In one study, researchers explored how to increase the efficiency of turbine engines by finding new ways to incorporate higher-performance materials into turbine blades.



New materials for capturing CO_2 from combustion gases



Schematic of the Earth's core-mantle boundary showing the location of the mixture perovskite, post-perovskite, and ferropericlase phases

Research at the APS is expanding our **environmental and geological** knowledge about everything from the center of the Earth to carbon sequestration. With a better understanding of the world around us, we are better prepared to protect and sustain our planet's precious natural resources.

Industrial scientists come to the APS to carry out investigations that increase our fundamental knowledge of processes and materials of technological and economic importance including advances in manufacturing, information technology, nanotechnology, pharmaceuticals, bio-medicine, oil and gas, transportation, agriculture, environment, and many other areas that are critical to our technologies, economy, and physical well-being.

The APS played a role in the development of Dow's POWERHOUSE™ solar shingles

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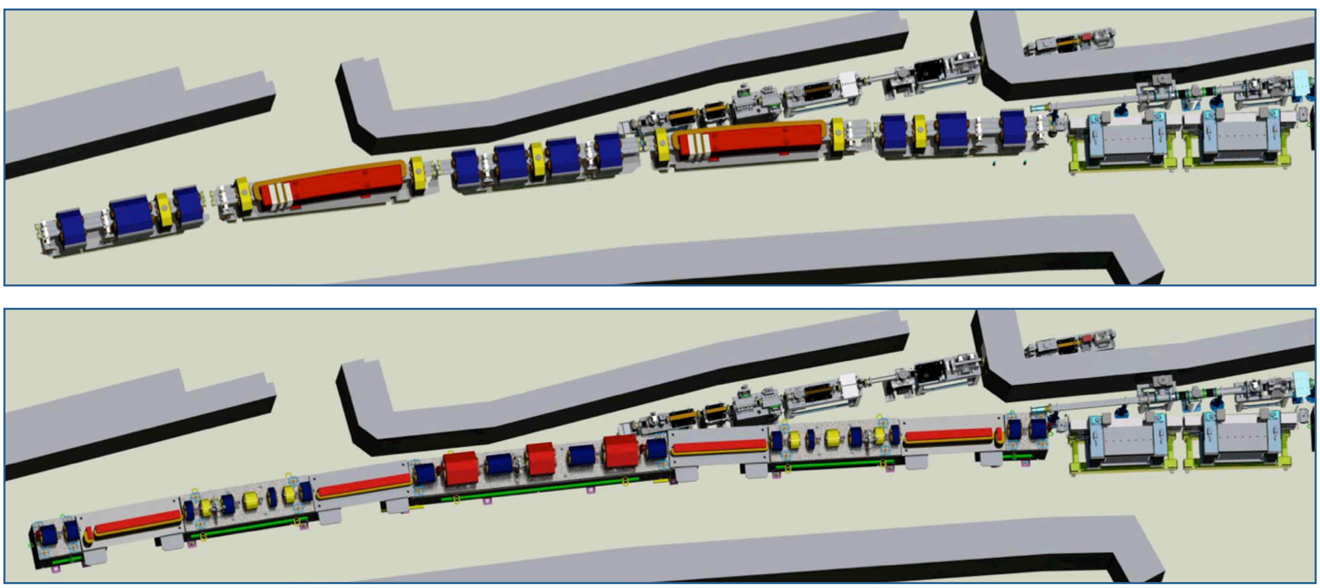
Future Perspective

In a report to DOE-BES dated July 2013, a subcommittee of the BES Advisory Committee on Future Light Sources reported that "*At best the present plans for upgrades of U.S. storage rings will leave the U.S. behind the international community in this area of x-ray science. The Office of Basic Energy Sciences should ensure that U.S. storage ring x-ray sources reclaim their world leadership position. This will require a careful evaluation of present upgrade plans to determine paths forward that will guarantee that U.S. facilities remain at the cutting edge of x-ray storage ring science*." With this recommendation in hand, BES managers began discussions with APS management on the possibility of installing a multi-bend achromat (MBA) storage ring lattice in the existing APS tunnel.

The APS Upgrade goal is to build a world-leading, high-brightness, hard x-ray storage ring with:

- An MBA lattice and high stability to provide the first U.S. fourth-generation storage ring x-ray source
- Next-generation undulators to produce the highest x-ray brightness
- Advanced beamlines that fully exploit the high-brightness source

The MBA lattice will deliver a generational leap in storage ring performance: 100x to 1000x increase in brightness enables revolutionary capabilities, such as coherent diffractive imaging and ptychography, delivers >10^4 enhancement for correlation spectroscopy techniques, and provides the ability to efficiently focus x-rays to nanometer-size spots.



The APS storage ring lattice today (top; red objects are the bending magnets) and in the future with a 7-bend achromat lattice (bottom; red objects are the bending magnets).

	APS Present	APS-U/High Brightness	APS-U/48-Bunch Mode
Energy/Current	7 GeV / 100 mA	6 GeV / 200 mA	6 GeV / 200 mA
Horizontal Emittance	3113 pm	67 pm	48 pm
Brightness* @ 20 keV	1	336	144
Flux Density*# @ 20 keV	1	10	9

*Relative to present APS performance
#Flux density through a 0.5-mm x 0.5-mm aperture @ 30 m