The Advanced Photon Source

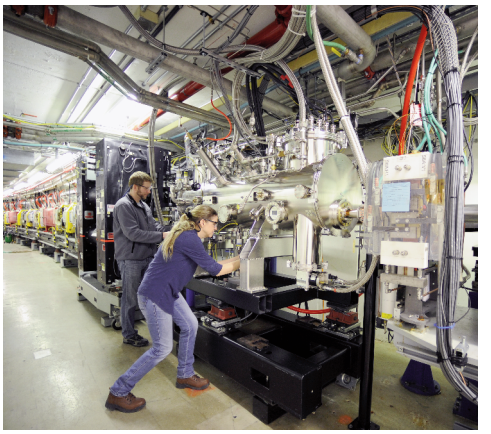
The Superconducting Helical Undulator is Operational at the APS

A first-of-its-kind insertion device (ID) is now in operation at the Advanced Photon Source (APS). The new device utilizes a unique superconducting technology that speeds electrons on a path much like that of a corkscrew.

The ID, called a Helical Superconducting Undulator (HSCU), was designed at the APS, a U.S. Department of Energy (DOE) Office of Science user facility at Argonne National Laboratory. The device has three primary advantages over other types of IDs: (1) it generates a stronger magnetic field; (2) it allows researchers to select a single energy from the x-ray beam without using any x-ray optics; and (3) it produces an x-ray beam with circular polarization. Taken together, these advantages allow researchers to collect data faster and more cleanly than with other, similar technology, as the HSCU does not require an extra optical device to perform experiments.

An HSCU is a very challenging device to integrate into an operating light source such as the APS, because it introduces strong limitations on the handling of the beam in the storage ring. It might cause disruptions in ring operations and, hence, in delivery of x-rays to waiting researchers. But the mechanical and magnetic design of the HSCU coil geometry developed by APS engineers and physicists makes it non-disruptive to the steady operation of the APS storage ring. Researchers only know the HSCU is there because of the x-ray beams it delivers.

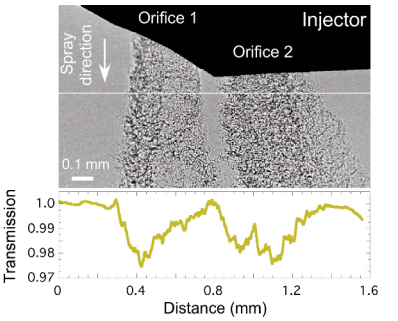
As electrons corkscrew through the device's magnetic field, they generate circularly polarized radiation. In order to force the spiral motion of electrons, a special magnet was built with a strong spiraling magnetic field. That goal was accomplished by wrapping superconducting wires around a corkscrew-shaped section of iron. The end result is a 1.1-m-long superconducting electromagnet with many spiral-shaped alternating north-south magnetic poles that cause the electrons to travel on a spiral path.



Matthew Kasa and Susan Bettenhausen of the APS Accelerator Systems Division Magnetic Devices Group put the finishing touches on installation of the HSCU in Sector 7 of the APS storage ring.

The HSCU provides researchers with a more intense x-ray beam that allows for faster data acquisition than conventional undulators, at time scales of a billionth of a second. While conventional undulators require monochromators to select the preferred energy of x-ray beam, the HSCU immediately delivers monochromatic x-ray beam directly from undulator to sample without a monochromator. This provides a more intense, coherent beam since any optic will have small imperfections that can introduce unwanted distortions in the x-ray beam.

The new undulator began operating at the X-ray Sciences Division 7-ID beamline on January 19, 2018.



Above: Ultrafast x-ray microimaging of automotive engine fuel sprays that could travel at a speed of up to 750 m/s. Top: Image was taken with a single x-ray pulse with an exposure time of 100 trillionth of a second from the HSCU at Sector 7 of the APS. Bottom: X-ray transmission along the thin solid line. The intense and quasi-monochromatic x-rays from the undulator allow qualitative analysis of instantaneous fuel distribution during the 1 thousandth of a second injection time. This experiment provides quantitative data for validating combustion simulations and for designing better injectors to improve engine efficiency and reduce engine emission.

This research used resources of the Advanced Photon Source, a U.S. Department of Energy (DOE) Office of Science User Facility operated for the U.S. DOE Office of Science by Argonne National Laboratory under Contract No. DE-AC02-06CH11357.

Call for APS General-User Proposals

The Advanced Photon Source is open to experimenters who can benefit from the facility's high-brightness hard x-ray beams.

General-user proposals for beam time during Run 2019-1 are due by Friday, October 26, 2018.

Information on access to beam time at the APS is at http://www.aps.anl.gov/Users/apply_for_beamtime.html or contact Dr. Dennis Mills, DMM@aps.anl.gov, 630/252-5680.

Argonne National Laboratory is a U.S. Department of Energy (DOE) laboratory managed by UChicago Argonne, LLC
The Advanced Photon Source is a U.S. DOE Office of Science User Facility operated for the DOE Office of Science by Argonne National Laboratory under Contract No. DE-AC02-06CH11357

Follow us: @advancedphoton Like us: Advanced Photon Source flickr: advancedphotonsource12

Advanced Photon Source
Bldg. 401/Rm A4113
Argonne National Laboratory
9700 S. Cass Ave.
Argonne, IL 60439 USA
aps.anl.gov
apsinfo@aps.anl.gov

U.S. DEPARTMENT OF ENERGY
Office of Science
science.energy.gov/

Argonne NATIONAL LABORATORY
anl.gov