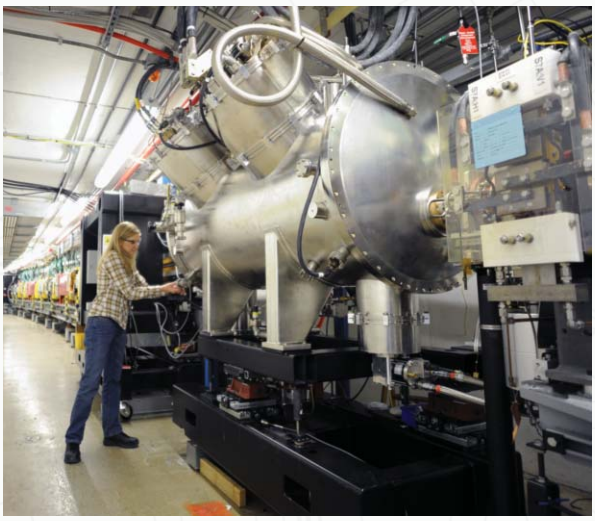
The Advanced Photon Source

First X-rays from the APS Superconducting Undulator

A decade-long R&D program for an APS superconducting undulator (SCU) culminated in January 2013 with the installation and testing at the APS of the first prototype, SCU0. On January 21, the SCU0 produced the first photon beam for the users at APS Sector 6. During the 2012-13 winter shutdown of the APS accelerator, the SCU0 was installed in the downstream part of straight section 6 of the storage ring. The undulator was cooled down, filled with liquid helium, and commissioned in a two-week period.

Many synchrotron radiation (SR) facilities have adopted an in-vacuum undulator (IVU) technology that permits extension of the high-energy spectrum of SR radiation. But IVU technology is approaching its physical limits. A significant leap in the development of a new generation of undulators belongs to superconducting technology.



The SCU prototype installed in the APS storage ring at Sector 6. An APS Undulator A can be seen just upstream of the SCU.

For many years, scientists and engineers at different SR facilities have been attempting to employ SC undulators as a radiation source. All of these attempts, for various reasons, have not resulted in long-term utilization of these devices. Superconducting wigglers, on the other hand, have found much wider acceptance at SR facilities including third-generation SR sources.

The APS is the first third-generation x-ray facility to make significant investments in the development of novel undulators based on superconducting technology in order to achieve unsurpassed performance from short-period, high-magnetic-field undulators. Even with well-established SC materials, SC undulator performance will exceed the brightness of the high-energy x-rays delivered by the APS Undulator A. But in the future, novel SC materials, such as Nb_3Sn and high-temperature superconductors, will lead to a performance that will exceed the best possible IVU devices.

The detailed design of the SCU0 was done at the APS in collaboration with the Budker Institute of Nuclear Physics (BINP, Russia). The cryostat of the first APS superconducting device was designed and built following the BINP concept for superconducting wigglers, while the superconducting magnetic structure and the cooling system were developed at the APS during the R&D program. A special cryostat was built to test cooling of the SC coils with liquid helium via a thermosyphon concept. The cooling design was improved by thermally insulating the undulator beam chamber from the superconducting coils and cooling it with two cryocoolers. Two more cryocoolers in the undulator cryomodule cooled the liquid-helium circuit.

The SCU0 magnet, wound with NbTi SC wire, has a 42-pole structure with a period length of 16 mm, twice as small as APS Undulator A. The SCU0 undulator peak field is 0.4-0.64 T, which corresponds to the photon energy at the fundamental of 20-25 keV.

Although the SCU0 magnet is only 330-mm long, it is comparable in photon brightness at 50-100 keV with the 2.4-m-long Undulator A. The first experience of operating the superconducting undulator in the APS storage ring indicates stable cryogenic behavior and minimal effects on stored beam. More studies are on the way, but it is clear that SC undulator technology can deliver on its promises to the synchrotron radiation community.

Next will be design and fabrication of an SCU with 72 periods (the same number as APS Undulator A) and the replacement of the prototype with this longer SC magnet. The existing cryostat, with all auxiliary systems, will accommodate this 1.2-m long, 72-period SCU. The new, long device will increase by almost an order of magnitude the brightness at 60 keV. Both the prototype and future devices will, for the first time provide users with orders-of-magnitude "cleaner" (much better signal-to-noise ratio) high-energy radiation than any existing SR source in the world.

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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 2013-3 are due by Friday, July 12, 2013.

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.

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