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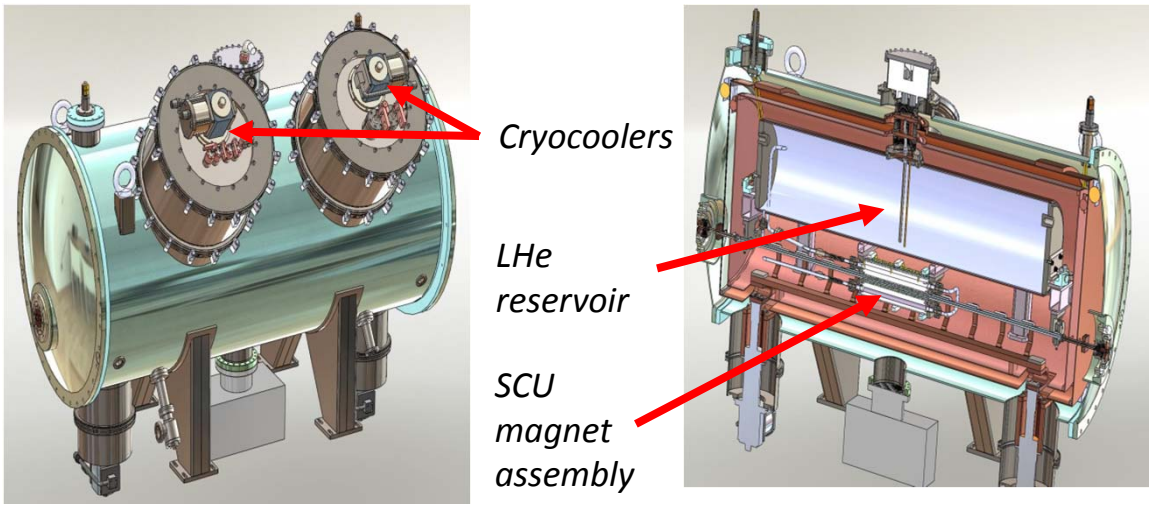
Improved Utilization of Cryocooling Power for the ANL-APS Superconducting Undulator

Argonne NATIONAL LABORATORY

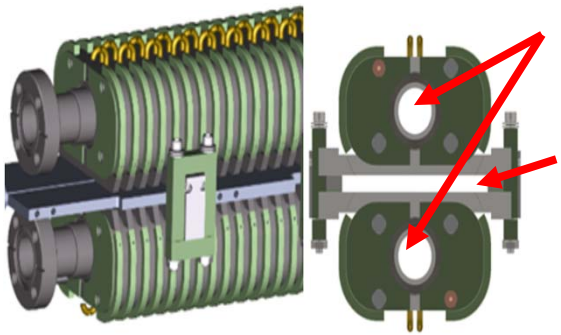
The Superconducting Undulator (SCU) in the ANL-APS

The **Advanced Photon Source** (APS) at **Argonne National Laboratory** (ANL) uses superconducting magnets to induce undulations in the APS electron beam, increasing emission intensity.

The SCU magnet windings must be maintained at 4.2K, and are cooled using liquid helium (LHe), cooled in turn by cryocoolers.



SCU cryostat solid model (left) and section view (right)



SCU magnet core assembly

Ivanyushenkov, Y. "Development of superconducting undulators at the Advanced Photon Source." FNAL Accelerator Physics and Technology Seminar, Sept.22, 2011

"Advanced Photon Source Upgrade Project, Preliminary Design Report", Ch. 5, APSU-2.01-RPT-002. Argonne National Laboratory, Sept. 2017

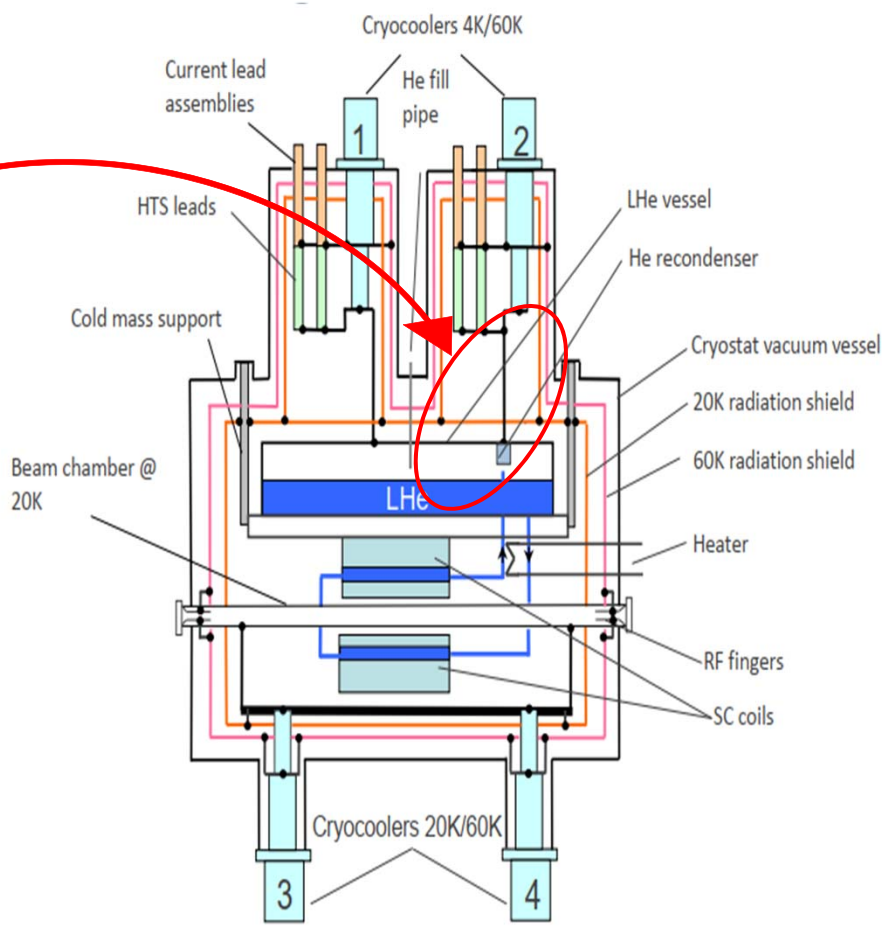
Helium Re-condensation in the SCU: Current Solution

The LHe reservoir and ullage vapor are cooled by heat conduction through copper straps connecting the He recondensers to the cryocooler cold finger's 2nd stage.

The Problem:

The thermal resistance of this configuration requires the cryocoolers to operate at lower-than-intended temperatures.

A redesign of the thermal interface between the He ullage and the cryocoolers is necessary to improve cooling system efficiency.



Ivanyushenkov, Y. "Development of superconducting undulators at the Advanced Photon Source." FNAL Accelerator Physics and Technology Seminar, Sept.22, 2011

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Helium Re-condensation in the SCU: Redesign Process

Stage 1:

- Analysis and modeling of the current cooling system to identify major thermal resistances
- Development of mitigating strategies
- Emphasis on ease of implementation into existing SCU cryostat design

Stage 2:

- Evaluation of alternative cryocooler-based cooling and He re-condensation solutions
  - Directed GHe flow through re-condenser chambers directly attached to the cryocooler flange [1,2]
  - Direct conduction cooling of the undulator magnets by the cryocoolers [3]

Stage 3:

- Evaluation of solutions utilizing pulsating heat pipes (PHP's) as thermal bridge to cryocoolers
  - PHP-driven cooling of re-condenser surfaces in a LHe-cooled undulator
  - Direct cooling of the undulator by PHP's in a cryogen-free undulator

[1] M.A. Green, "The Potential Role of Cryogenics in Insertion Magnets," 2017 IOP Conf. Ser.: Mater. Sci. Eng. 278 012177
[2] M.A. Green and H. Pan, "The Connection of Refrigeration to a Superconducting Magnet with a Minimum Amount of Cryogen," 2017 IOP Conf. Ser.: Mater. Sci. Eng. 278 012180
[3] S. Casalbuoni et al., "Characterization and Long-term Operation of a Novel Superconducting Undulator with 15 mm period Length in a Synchrotron Light Source," Physical Review Accelerator and Beams 19, 110702 (2016)