SUPERCONDUCTING UNDULATOR ACTIVITIES AT THE EUROPEAN XFEL

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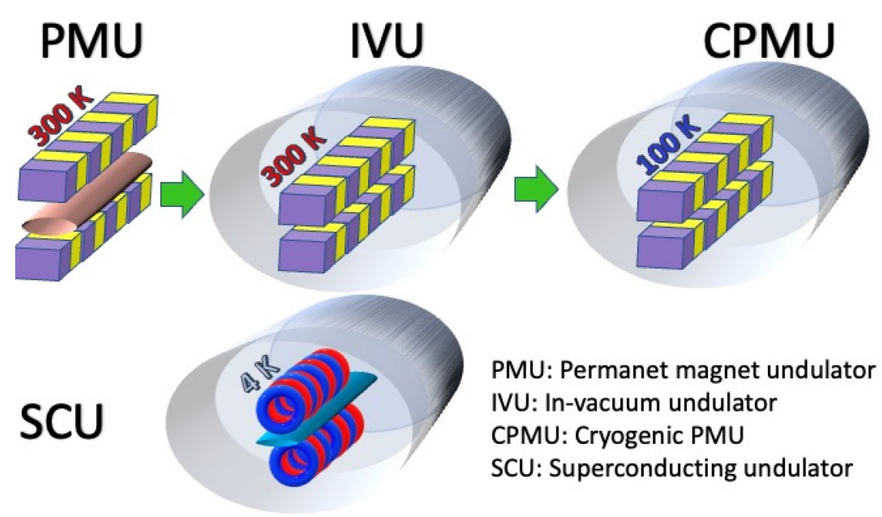
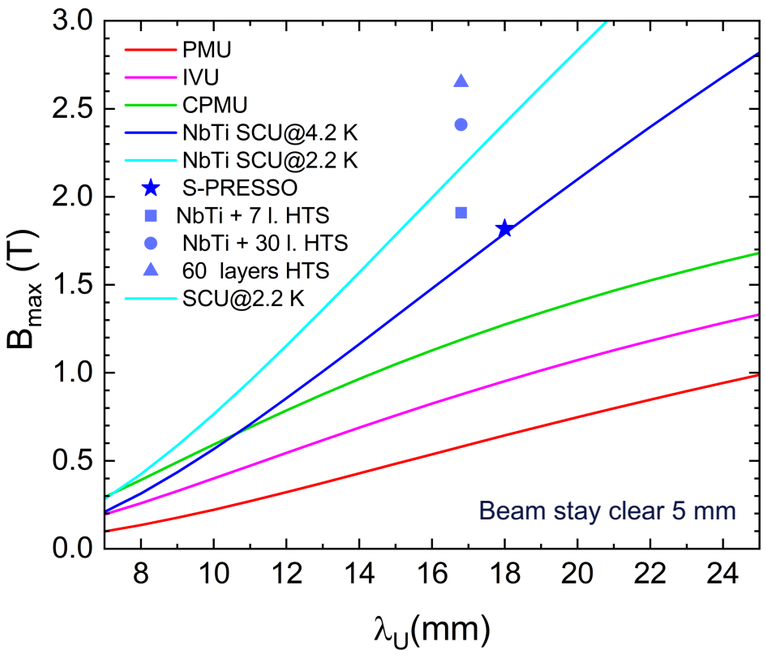
Abstract

For more than 5 years, superconducting undulators (SCUs) have been successfully delivering X-rays in storage rings. The European XFEL (EuXFEL) plans to demonstrate the operation of SCUs in XFELs. For the same geometry, SCUs can reach a higher peak field on the axis with respect to all other available technologies, offering a larger photon energy tunability range. The application of short-period SCUs in a high electron beam energy FEL > 11 GeV will enable lasing at very hard X-rays > 40 keV. The large tunability range of SCUs will allow covering the complete photon energy range of the soft X-ray experiments at the European XFEL without changing electron beam energy, as currently needed with the installed permanent magnet undulators. For a possible CW upgrade under discussion at the EuXFEL with a lower electron beam energy of approximately 7–8 GeV, SCUs can provide the same photon energy range as available at present with the permanent magnet undulators and electron energies. This paper will describe the potential of SCUs for XFELs. In particular, it will focus on the different activities ongoing at the EuXFEL and in collaboration with DESY to allow the implementation of SCUs in the EuXFEL in the upcoming years.

Superconducting undulators: motivation



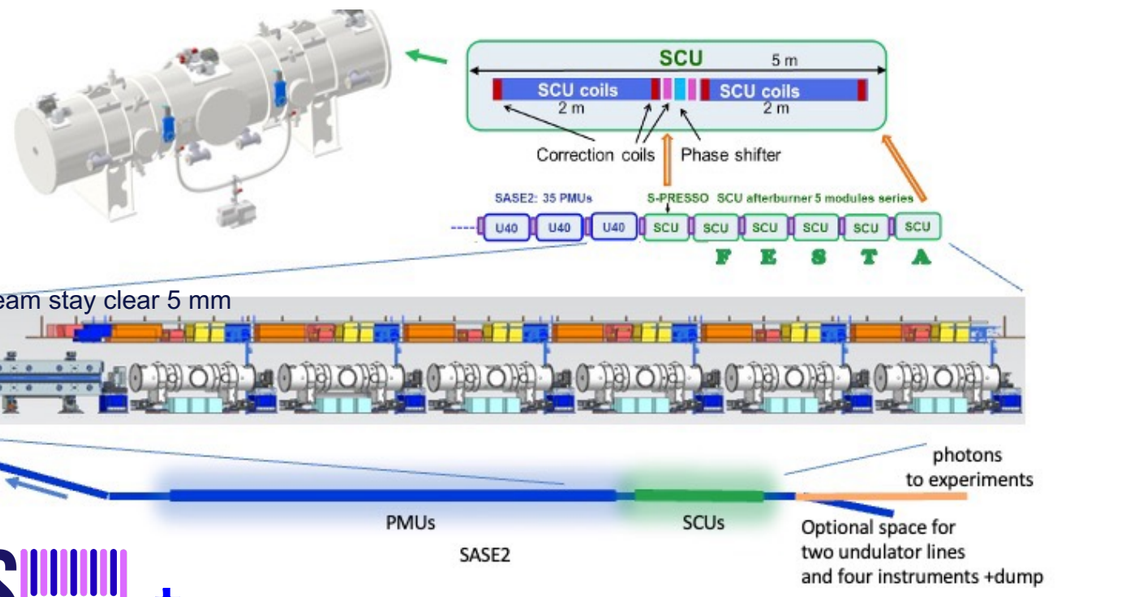
- Technology development to increase B_{max} and therefore tunability
- Further advantage is radiation hardness widely demonstrated for NbTi magnets (i.e. HERA, Tevatron, LHC)



SCU plans at European XFEL

- The development and implementation of superconducting undulators (SCUs) is part of the EuXFEL facility development program. Several advantages:
  - CW mode under discussion for EuXFEL upgrade limits electron beam energy to 7-8 GeV. SCUs cover approx. the same photon energy as present PMUs with 17 GeV
  - State of the art SCUs with a period length ~ 70 mm, allow to cover the complete photon energy range offered by the present soft X-ray experiments at EuXFEL with the same electron beam energy, not possible with the installed PMUs
  - Enabling lasing at photon energies up to approx. 60 keV, fully exploiting the capability of the FEL linac with the highest electron beam energy worldwide

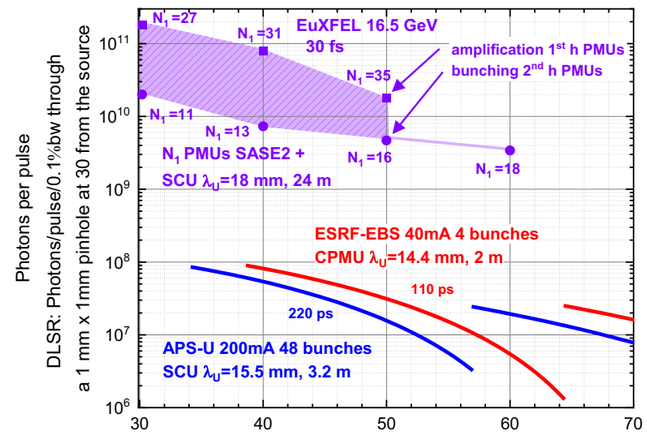
SCU afterburner



S-PRESSO + FESTA

FREE ELECTRON LASER SUPERCONDUCTING AFTERBURNER

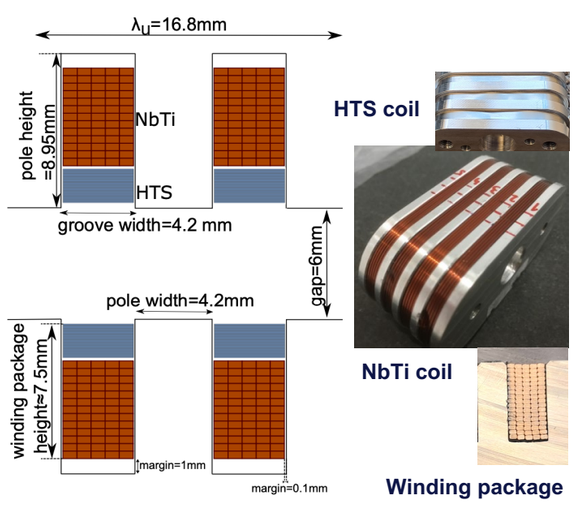
Period length (mm)	18
Vacuum gap (mm)	5
K max.	3.06
Beam heat load (W)	10
Normalized emittance	0.4 mm mrad
Initial energy spread	3 MeV
Current	5 kA

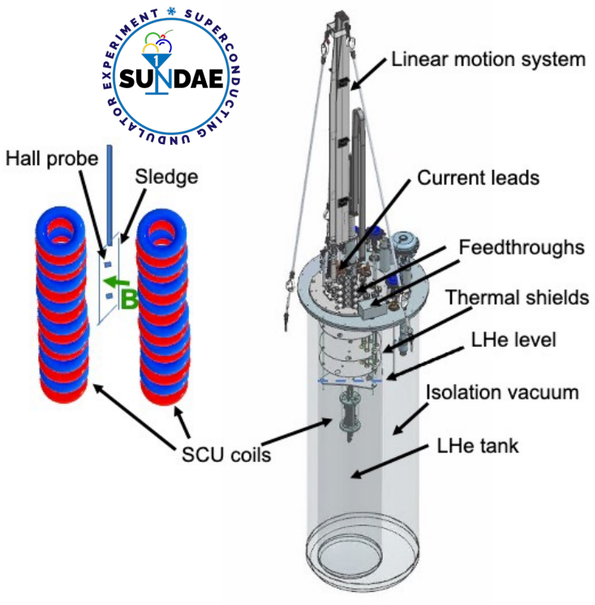


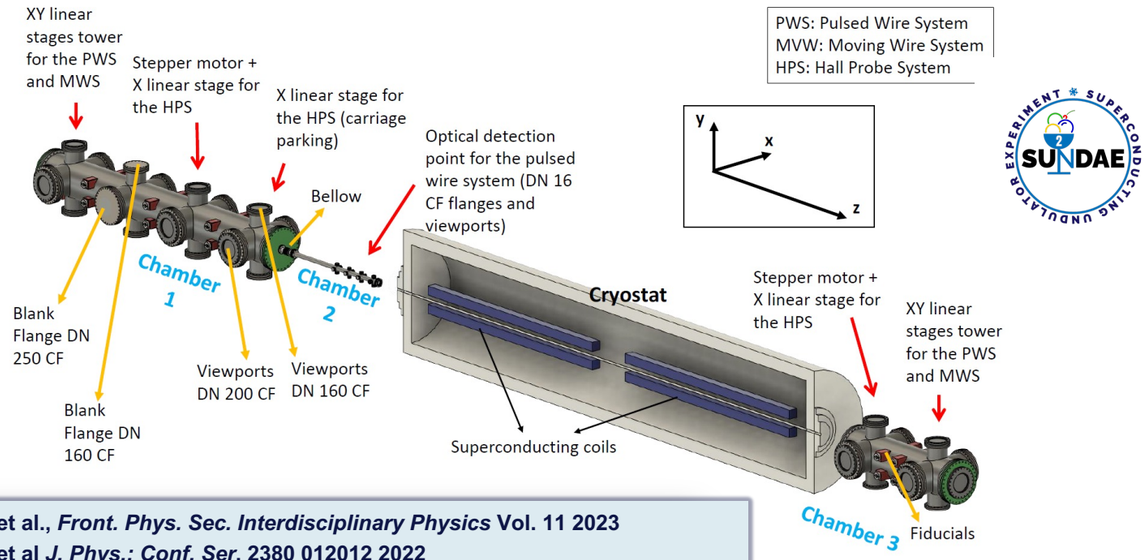
Steps to reach the SCU afterburner:

- two test stands are being developed: SUNDAE1 (Superconducting UNDulAtor Experiment) and SUNDAE2
  - SUNDAE1: vertical test stand for SCU coils up to 2 m length can be trained and characterized
  - SUNDAE2: a horizontal test stand to characterize the magnetic field of the coils in their final cryostat
- a Superconducting undulator PRE-SerieS mOdule (S-PRESSO), which has been specified. The contract has been assigned to the company Bilfinger Noell GmbH. S-PRESSO will be installed and tested in SASE2, one of the hard X-ray undulators of the European XFEL
- An R&D activity on advanced SCU coils has started to build up know-how inside the facility

Hybrid NbTi/HTS tape







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