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Research Progress of a superconducting Undulator Prototype at the SSRF

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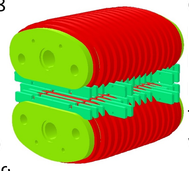
1. Introduction

A superconducting planar undulator is under development at the Shanghai Synchrotron Radiation Facility (SSRF). The design specifications are as follows.

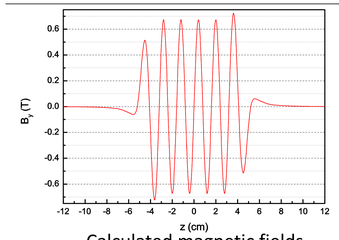
Electron Energy	3.5 GeV	
Current	200 mA	
Energy Range (keV, n=1)	3.9-7	
Magnetic Gap (mm)	9.5	
Peak Field (T)	0.67	
Period length (mm)	16	
Number of Periods	50	
RMS Phase Angle Error (°)	<4°	
Integrals and Multipoles	Normal	Skew
First Integral (Gcm)	50	30
Second Integral (Gcm^2)	25,000	25,000
Integrated Quadrupole (G)	50	30
Integrated Sextupole (G/cm)	60	60
Integrated Octupole (G/cm^2)	100	100

2. Magnetic field design

The main parameters of one SC coil pack	
Width of coil section (mm)	4.98
Height of coil section (mm)	5.8
Number of layers	11
Number of turns per layer	7/8
Total number of turns	83
Nominal current (A)	400
Current density (A/mm^2)	1149

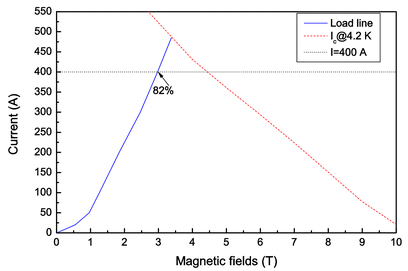


Calculated magnetic field	
Peak field at gap center (T)	0.67
3rd harmonic (Gs)	8.7
5th harmonic (Gs)	13.5
7th harmonic (Gs)	9.7
Peak field in the coil (T)	2.9
1st field integral (Gs cm)	0
2nd field integral (Gs cm^2)	79
Roll-off within x=±20 mm	0.2%



Calculated magnetic fields

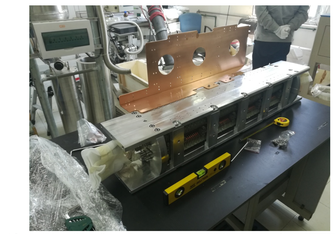
Specifications of the NbTi wires	
Cu/SC ratio	0.93
R.R.R.	>80
Filament diameter (μm)	95
Number of filaments	55
Twist pitch (mm)	30
Wire diameter (mm)	0.55 (bare)
	0.60 (insulated)
Critical current at 4.2K	347A@5T
	285A@6T
	217A@7T

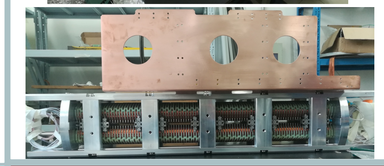


Design load line of the SCU magnet

3. The SCU magnet

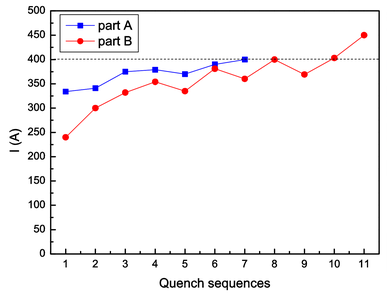
Fabrication of the SCU magnet is completed.





Cooling and excitation test of the SCU magnet was performed.

The upper and bottom part of the magnet was tested separately due to the limitation of the test cryostat.

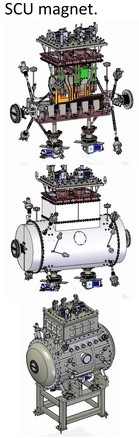


Training curve of the SCU magnet

4. Test of the cryostat

The cryostat was tested first with a dummy load due to fabrication delay of the SCU magnet.

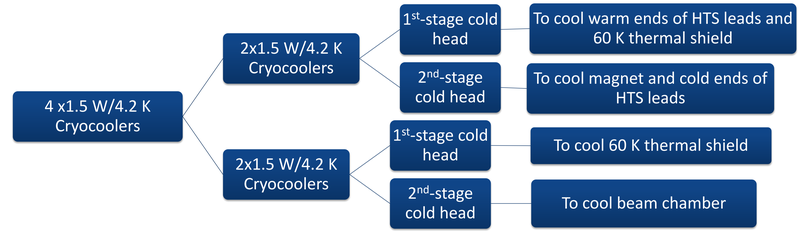
Specification of the cryostat	
Length along beam line (m)	1.8
Temperature on beam chamber (K)	10~20
Temperature on thermal shields (K)	40~60
Heat load on thermal shields (W)	100
Temperature on magnet (K)	4.5
Heat load on magnet (W)	1.8
Cooling capacity @4.5 K (W)	3

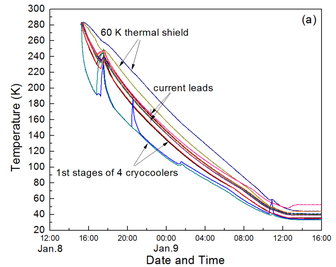


Cold test results

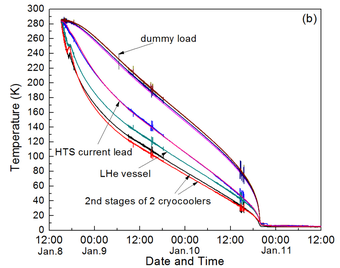
- Cooldown time: ~58 hrs for ~160 kg 4 K cold mass only by cryocoolers
- He liquefaction: ~89 hrs to accumulating 30 liters LHe in helium vessel

Cryocooler Type	KDE415
	CSIC PRIDE (NANJING) CRYOGENIC TECHNOLOGY CO.,LTD
Number	4
Cooling capacity (W)	35 @50 K
	1.5 @4.2 K





(a) Cool down curve: 1st-stage cold head, thermal shield and HTS HT-end



(b) Cool down curve: 2nd-stage cold head, He vessel, HTS CT-end and dummy load

5. Summary and outlook

- A 50-period SCU prototype is being developed at the SSRF
- Fabrication of The SCU magnet and the cryostat was completed.
- The upper and bottom parts of the SCU magnet were tested separately. The rated current of 400 A is reached.
- The cool-down of the cryostat was successfully performed with a dummy load simulating the magnet without beam vacuum chamber.

- Installation of the SCU magnet into the cryostat is planned in Oct. 2017.
- The stand-alone test of the SCU is planned in Feb. 2018.
- Installation of the SCU into the storage ring is planned in July 2018.

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