The High Energy Photon Source

Address book

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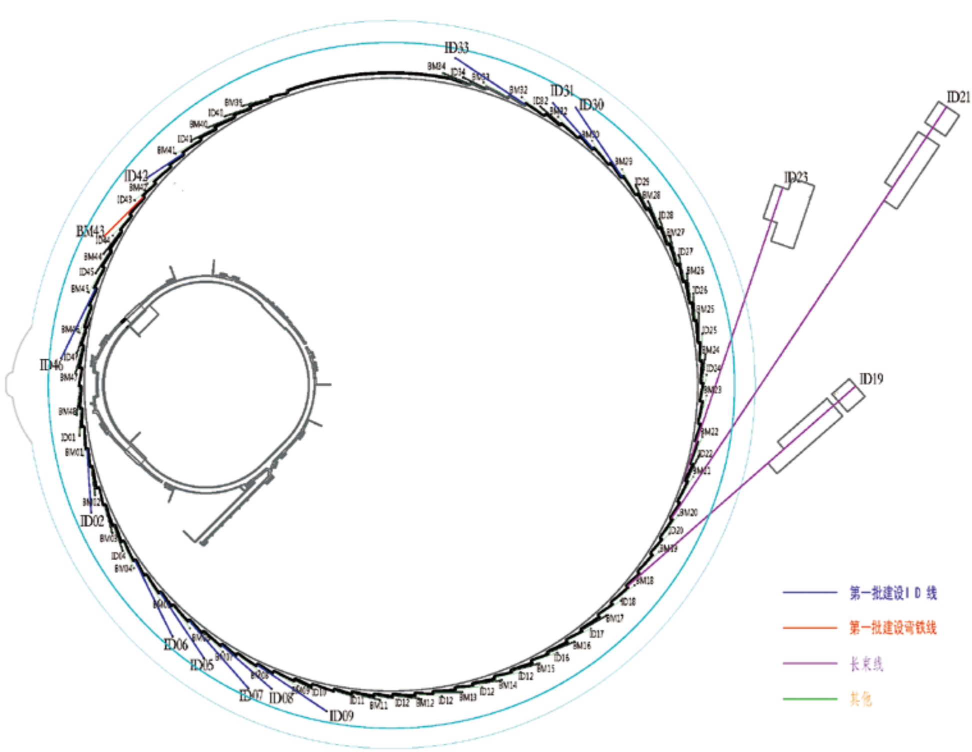
Overview

The high energy photon source (HEPS), as one of large scientific facilities, was started its construction in June 2019, in the northern core area of HUAIROU Sciences City. HEPS will be not only the first high-energy light source in China but also the brightest fourth-generation synchrotron radiation facility in the world when it goes into commission.

The overall building looks like a magnifying glass, which means HEPS is a powerful tool for characterizing microstructure. And as one of the key projects listed in the 13th Five-year Plan for national major scientifi c and technological infrastructure construction, HEPS is an important platform to support original and innovative research in the fi elds of basic science and engineering science. HEPS project is constructed by Institute of High Energy Physics, Chinese Academy of Sciences. The construction contents comprise accelerators, beamlines and auxiliary facilities. The estimated construction period is six and a half years.



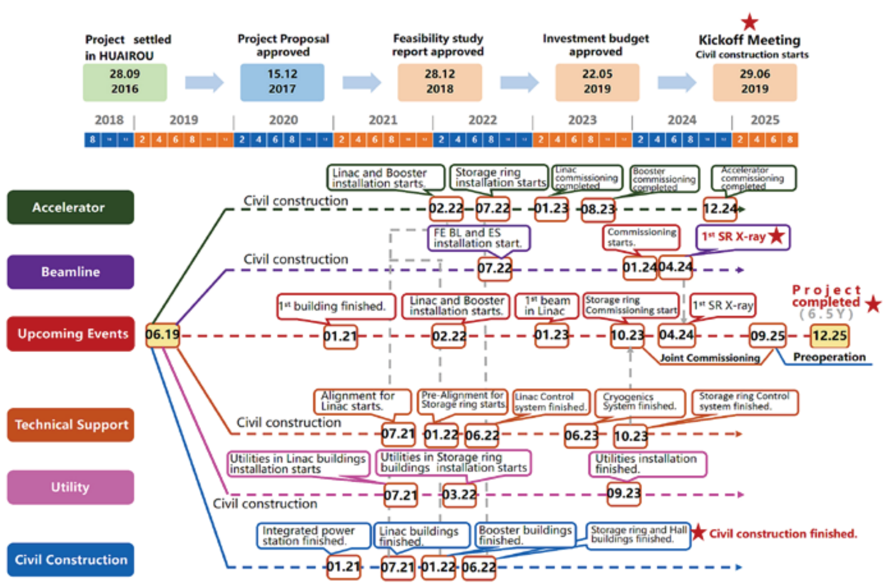
The storage ring of HEPS is 1360.4m in circumference, in which the electron energy is 6GeV and the brightness is more than 1×10^{22} phs/s/mm^2/mrad^2/0.1%BW. By using the 7-Bending Achromatic (7BA) lattice, the horizontal emittance of the electron beam becomes better than 60pm•rad, which is the main feature of the fourth-generation diffraction limited light source.

More than 90 high-performance beamlines and stations can be constructed in the experimental hall of HEPS. In the fi rst phase, there are 14 public beamlines and stations for users in the research fi elds of engineering materials, energy and environment, medicine and food industry, petrochemistry and chemical industry, et al. HEPS can provide highly brilliant and highly coherent X-rays with a photon energy up to 300keV, and has capabilities of nm spatial resolution, ps time resolution, and meV energy resolving. While providing conven-tional technical support for the general users, HEPS will operate as a platform to analyze the structures, as well as the evolution of structures of engineering materials in the whole process, by in-situ, multi-dimensional and real-time observation, to provide the information for the design and regulation of functional materials, and to serve the researches relating to the national development strategies and urgent core-like needs of industry.

14 public beamlines built in the HEPS phase I

NO.	Beamline	ID Type	Energy Range [keV]	Beta F.	National Demands	Industry	Energy and Enviornment for sustainable development	Frontier Science Field	High Energy	Low Emittance	Used widely
1	Hard X-ray nanoprobe multi-modal beamline	CPMU	50~170	Low	√	√	√		√	√	√
2	Engineering materials beamline	IVU	4.8-40	Low			√	√	√	√	
3	Structural dynamics beamline	CPMU	20~60	Low	√	√		√	√	√	√
4	Hard X-ray coherent scattering beamline	IVU	7-40	Low				√	√	√	
5	Hard x-ray High resolution spectroscopy beamline	IVU	7~25	Low	√			√	√	√	
6	High pressure beamline	IVU	20-50	Low	√			√	√	√	√
7	Hard X-ray imaging beamline	CPMU	10-90	Low	√	√		√	√	√	√
		Wiggler	40-300					√	√		
8	X-ray absorption spectroscopy beamline	IAU	4.8-45	High			√	√			√
9	Low-dimensional structure probe beamline	IVU	4.8-40	Low	√		√	√			√
10	Microfocusing x-ray protein crystallography beamline	IAU	5~18	High	√		√	√			√
11	Pink beam SAXS beamline	IAU	8~12	High	√	√		√			√
12	High resolution nanoscale electronic structure beamline	APPLE-KNOT	0.1-2	High		√		√		√	√
13	Tender x-ray beamline	BM	2.1~7.8				√	√			√
14	Transmission X-ray microscopic beamline	IAU	5~15	High		√	√	√			√

Construction progress



In 2019, the opening year of HEPS construction period, the budget estimate approval process and other preparations were completed. After the kickoff meeting on June 29, HEPS construction comprehensive began.

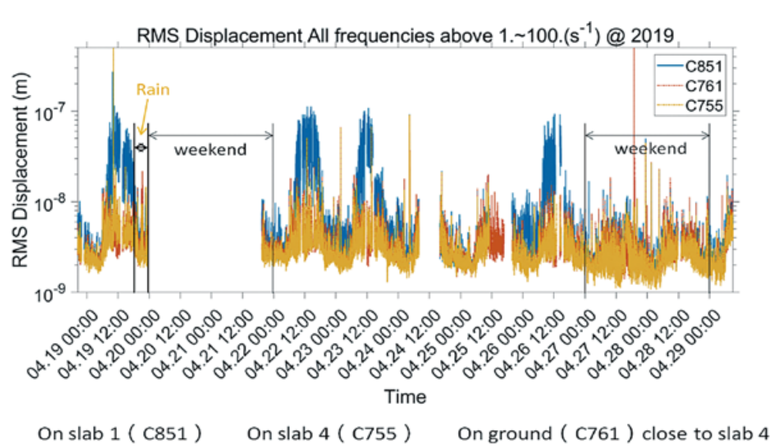
Civil construction and utility

In 2019, about 70 percent of the foundation replacement was accomplished and 11 percent of the total construction cost was completed. Due to the low emittance and the high stability, the RMS amplitude of the vertical vibration with vibration frequency of 1-100Hz was set to be less than 25nm in one second, and the foundation differential settlement was set to be less than 10μm/10m/year. Micro-vibration control system included foundation replacement, which was the most critical and whose design was cross-checked, and power equipment vibration isolation system. And two prototype slabs were pre-constructed to verify the construction scheme. On October 13, foundation replacement with C15 plain concrete was started in full swing, in the total volume of about 120,000 cubic meters.

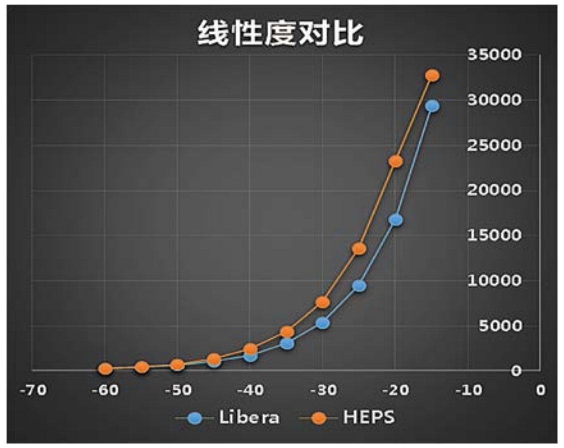
The design parameters of utility system for HEPS have been determined, and the detailed design drawings (version 1.0) have been completed. The high-voltage power supply scheme of HEPS was approval in Oct. 2019.

Accelerator

The storage ring lattice was optimized to the version 3.0 after iterations with accelerator hardware



The vertical ground motion measurement results on HEPS ground and the two prototype slabs: the red line shows the motion on ground, the blue line shows the vibration on prototype slab #1 with 1m graded sand gravel and 1m reinforced concrete, the yellow line shows the vibration on prototype slab #4 with extra 5m casting layer.



Linear measurement data of digital BPM electronics (home-made vs Libera)

design. The horizontal nature emittance of the booster is reduced to 16nm@6GeV by re-arrangement of the magnets.

The fast corrector power supply prototype, which based on the multi-level topology structure, has been making significant progress. The key parameters meet the specifications. Small-signal(-3dB bandwidth) 10KHz, current stability(AC RMS) 50 ppm, and output current ripple 20ppm.

BPM sensor configuration was optimized, with the linear measurement of the digital BPM electronics (built in house) consistent to the commercial LIBERA electronics.

The thickness of the Lambertson wall was reduced to optimize the injection performance. The in-vacuum design is adopted to the Lambertson magnet with a 2mm-thickness septum wall at the storage ring. A 3.5mm-thickness septum wall of the Lambertson magnet at the booster is designed as an in-air septum.

Beamline

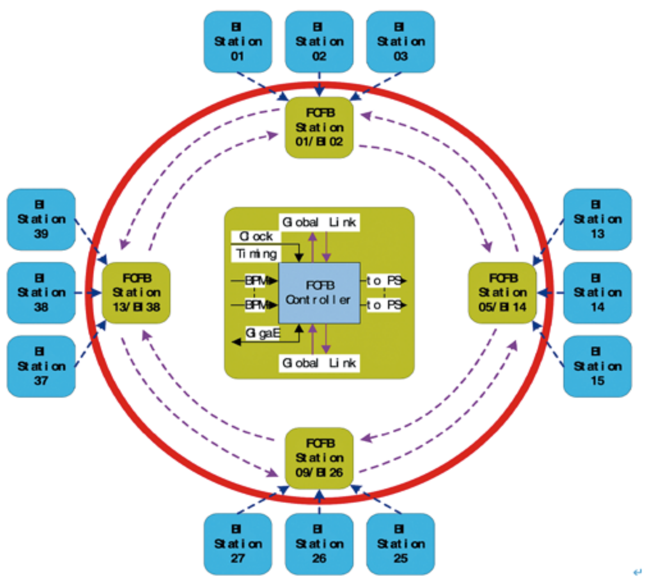
Optimization of 14 beamlines were implemented, including optics design, backup schemes, insertion device parameters. High stability is essential for HEPS beamlines. Efforts have been taken in new white-beam mirror cooling design, higher eigenfrequency design for mirror and monochromator, setup of vibration measurement system.

BSRF 3W1 beamline was updated in 2019 to provide a key high energy X-ray platform for HEPS project. The superconducting wiggler and high energy Laue monochromator developed in HEPS-TF project were installed and used. Capture of structural change in the process of dynamical loading and laser metal additive manufacture was realized using high energy white beam. Engineering materials was imaged using white and monochromatic high energy X-ray. Meanwhile, the white beam hutch with utilities construction provided the experiences and lessons for HEPS project.

Supportive Technologies

Technical support systems went on progress.

Function tests for the second edition in-house made circuit board has been completed, a test bench with the board for control system test has been built,



Block diagram of the FOFB system

and driver program has been developed. Development of microTCA version EVR board which collaborating with DESY is also making good progress.

FPGA of the main logic backboard of FOFB system has been determined, further design is going on to reduce the system latency. Prototype of the fast correctors has been manufactured, preliminary joint test between the fast response power supply and the fast corrector prototype has been done.

Cryogenic system design scheme has completed. The cryogenic pipeline trend and equipment layout has been determined. A platform of high-performance cryogenic transmission line and SRF cryostat of 166.6MHz also is designing.

The radiation protection and safety system completed the technological design scheme of the radiation dose monitoring system and the personal protection system. Using Monte Carlo methods and empirical formulas, optimized the shielding design of the storage ring labyrinth, ventilation duct, cable and pipe holes, collimator, etc., and optimized shielding design of first optical element hutch and experimental hutch of various types of beamlines, to achieve shielding design goals of dose rate, 2.5μSV / h testing at 30cm away from the shielding outer surface.

Cooperation and exchange

To grasp the latest developments trends of science and technology through exchange and discussion with peers at home and abroad, HEPS actively sent researchers to visit photon sources, such as MAX-IV, Diamond and PETRA-III. Meanwhile, international synchrotron radiation experts were invited supported by programs for foreign talent. They presented the latest design strategy, shared the building and operation experience of accelerator and beamlines.

IHEP signed MoU with DLS on April 17 to cooperate on synchrotron radiation facility construction.

On June 24, the 1st meeting of HEPS science and technology committee was held, which reviewed HEPS progress.

On Dec.16-18, the 2nd meeting of HEPS international advisory committee was held. Latest progress of HEPS project as well as risk analysis on key technologies and project management were presented. In-depth presentations and discussions were also held at system level, and instructions and solutions were proposed.

Besides, the international reviews were held on timing System and beamlines, including engineer material beamline and low-dimension structure probe beamline, etc., according to its progress.

Chronicle of events

Jan. 18	The preliminary design of HEPS was approved by Chinese Academy of Sciences.
Mar. 14	The HEPS Environmental Impact Report was approved by the Beijing Ecological Environment Bureau.
May. 19-24	HEPS was invited to the 2019 Beijing Science and Technology Week, and aroused wide public concern.
May. 22	The HEPS final budgetary was approval.
Jun. 24	The 1st meeting of HEPS science and technology committee was held.
Jun. 29	The HEPS kickoff meeting was held on June 29, 2019.
Aug. 19	The order of commencement was issued .
Oct. 13	Foundation replacement with C15 plain concrete was started in full swing
Dec. 16-18	The 2nd meeting of HEPS international advisory committee was held.