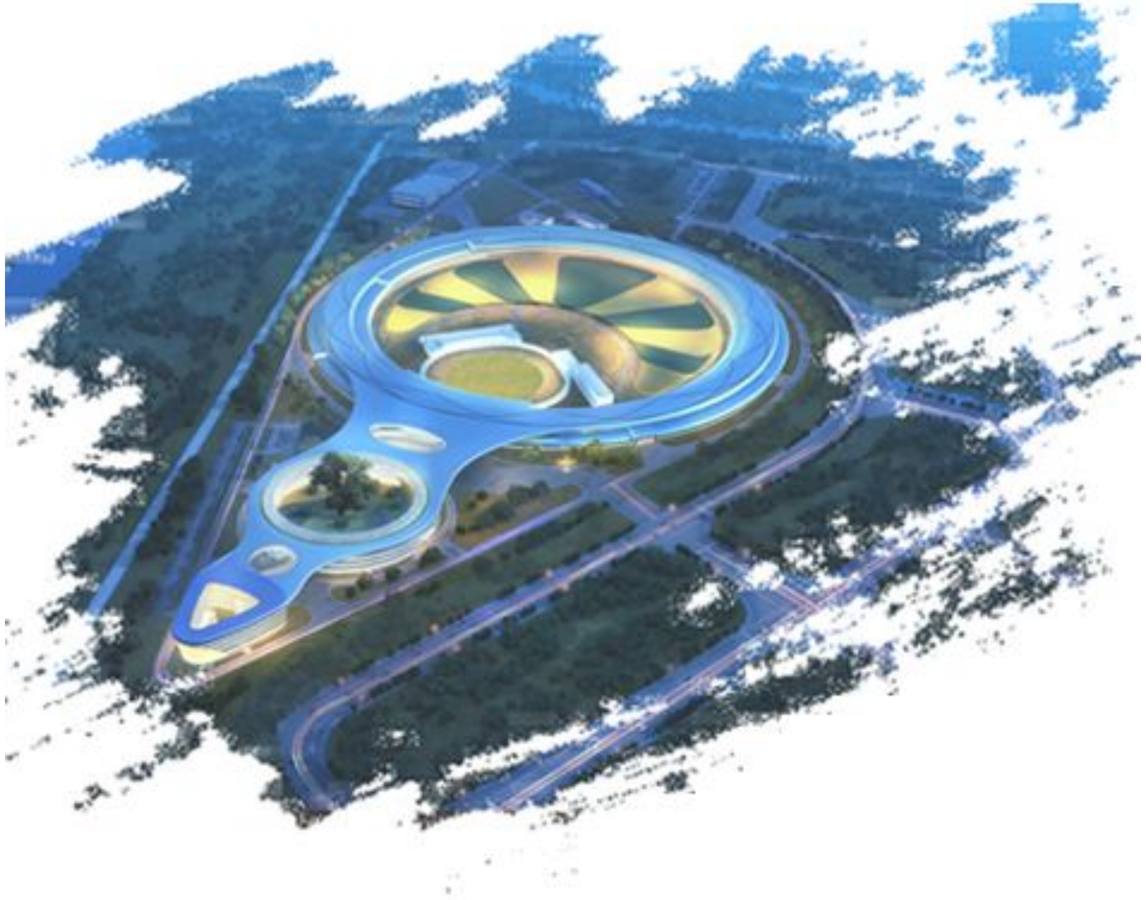
Status of HEPS

Ping HE

On the behalf of HEPS management

June. 25, 2025

1st workshop for future science in next generation synchrotron • Korea

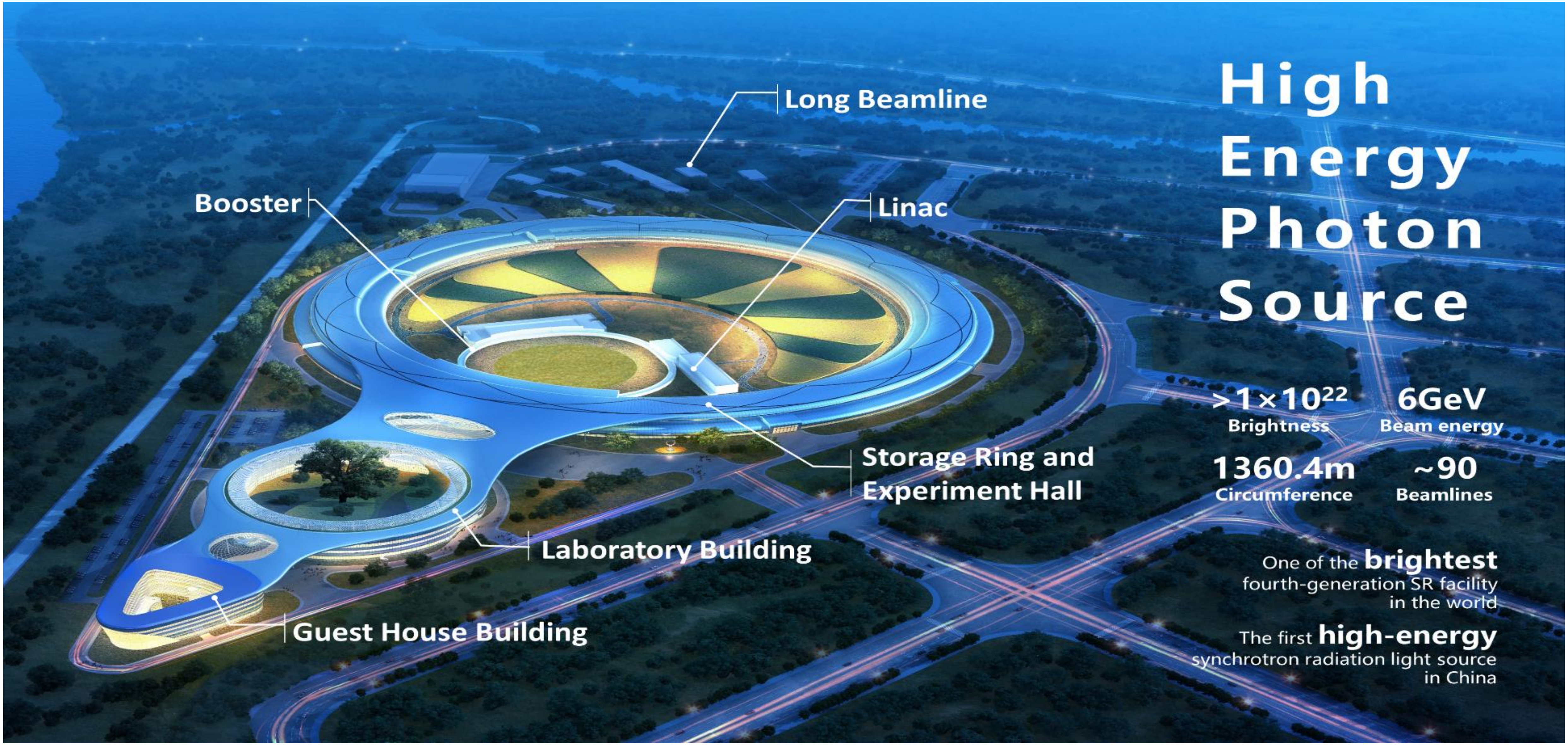


Outline

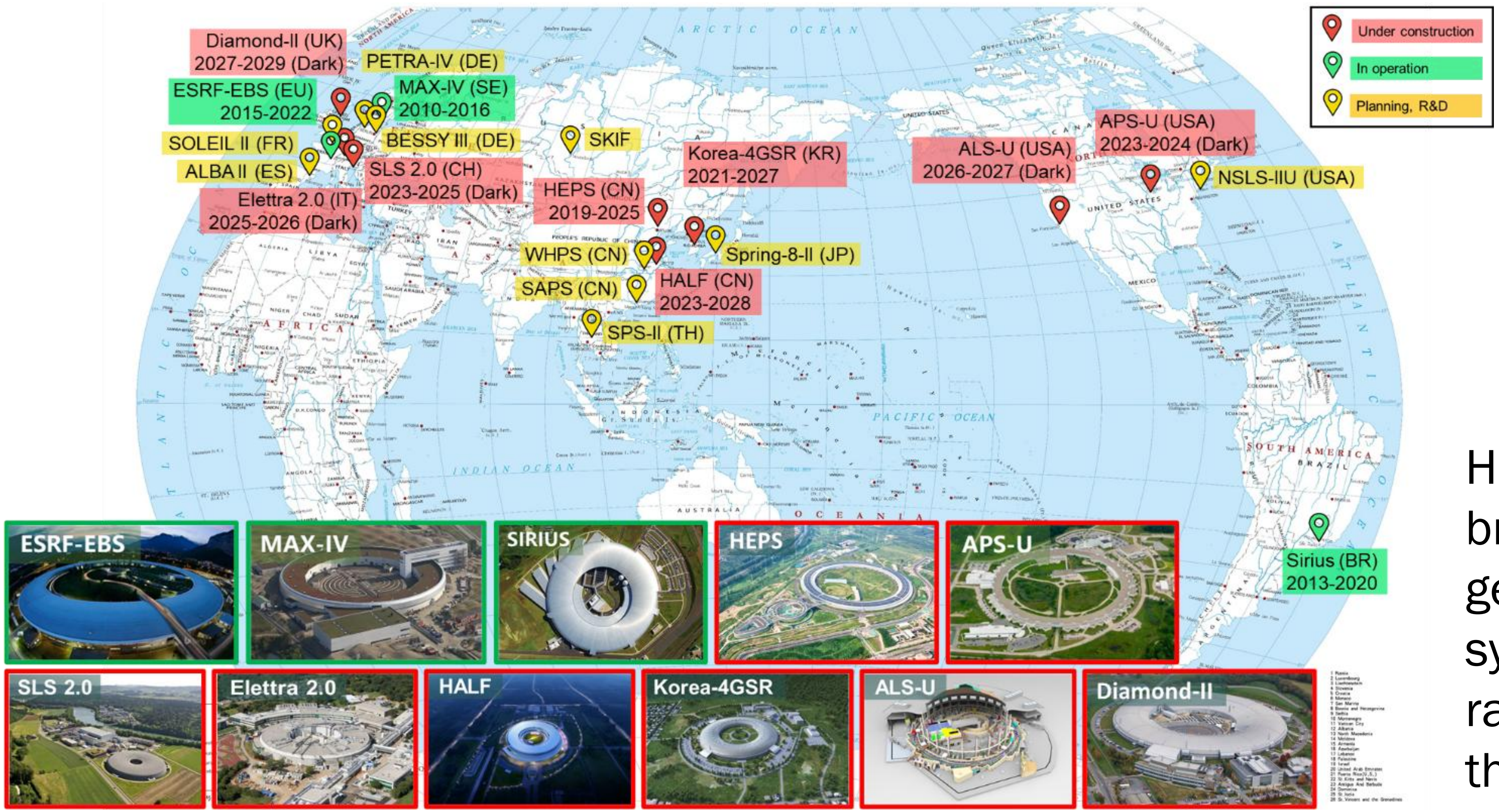
- Project overview
- HEPS Progress Update
- Future Plan
- Collaborations
- Summary

Project overview

Overview of HEPS



HEPS: a 4th-gen high-energy SR Source



HEPS: One of the brightest fourth-generation synchrotron radiation facilities in the world

HEPS: 1st High-energy SR source in China

Beijing Synchrotron Radiation Facility (1st-gen)

Hefei Light Source (2nd-gen)

Shanghai Synchrotron Radiation Facility (3rd-gen)

- In operation: 5 light sources (3 SRs + 2 Linacs)
- Under constr.: 3 light sources (2 SRs + 1 Linac)
- Planning, R&D: 4 light sources (3 SRs + 1 Linac)

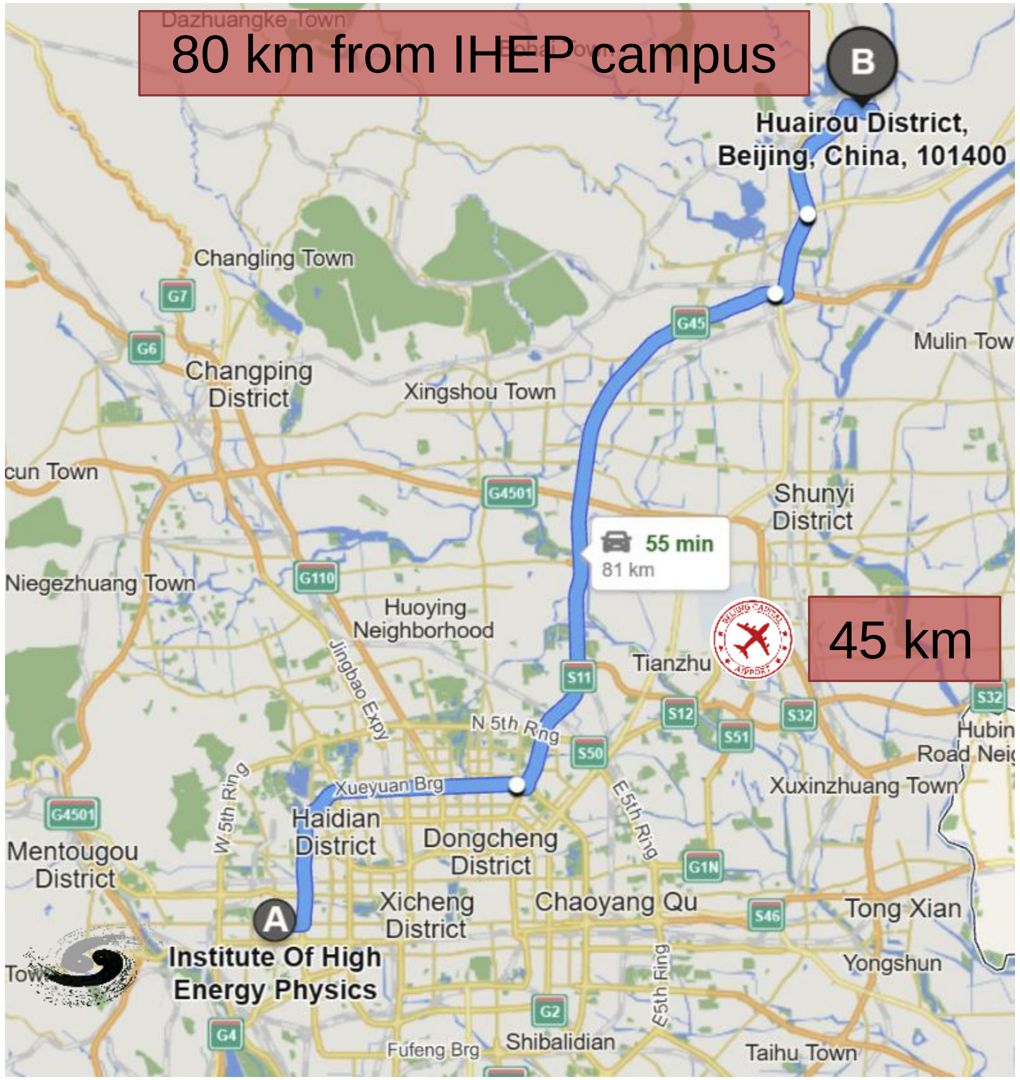
High Energy Photon Source

Hefei Advanced Light Facility

Southern Adv. Photon Source

High Energy Photon Source

- **Project outline**
  - A diffraction-limited SR light source (4th-gen)
  - The 1st high-energy SR light source in China
  - **Location**: Huairou Science City, Beijing
  - **Construction time**: 06.2019 – 12.2025
  - Land: 650,667 m^2, Building: 125,000 m^2
  - **Budget**: 4.76B CNY (~$652M) (incl. materials, civil constr. & commissioning, excl. labor costs) + 0.1M RMB/person/year (CAS)
  - **Support**: Central government （NDRC，80%） + Local government （Beijing，20%） + Chinese Academy of Sciences （labor costs）



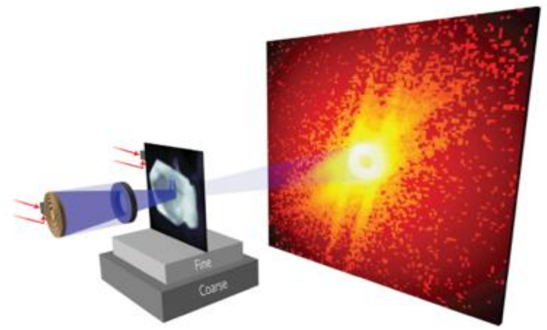
NDRC: National Development and Reform Commission

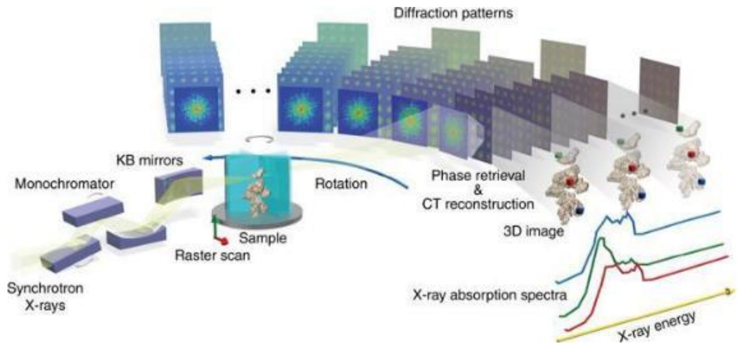
Powerful light sources

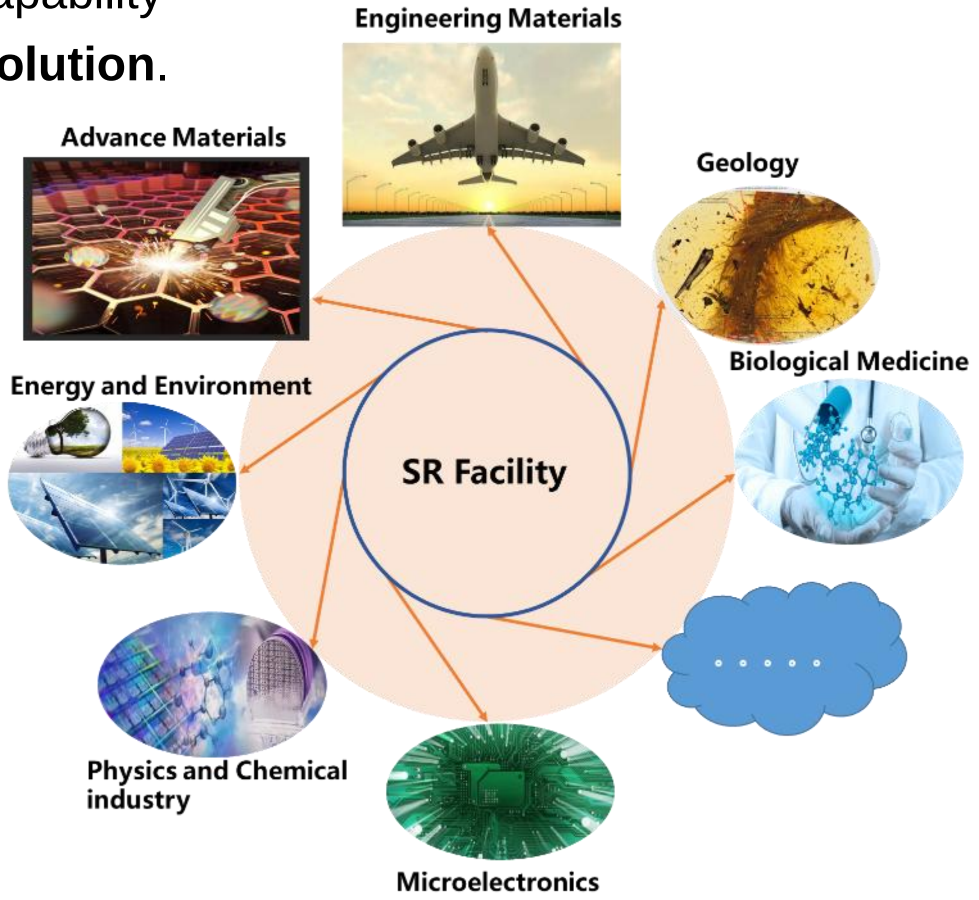
required with widely tunable frequency range from Infrared to X-rays !

HEPS will provide **high-energy, high-brilliance, high-coherence** synchrotron **light with energies up to 300 keV and more**, with the capability for **nm spatial resolution, ps time resolution, and meV energy resolution**.

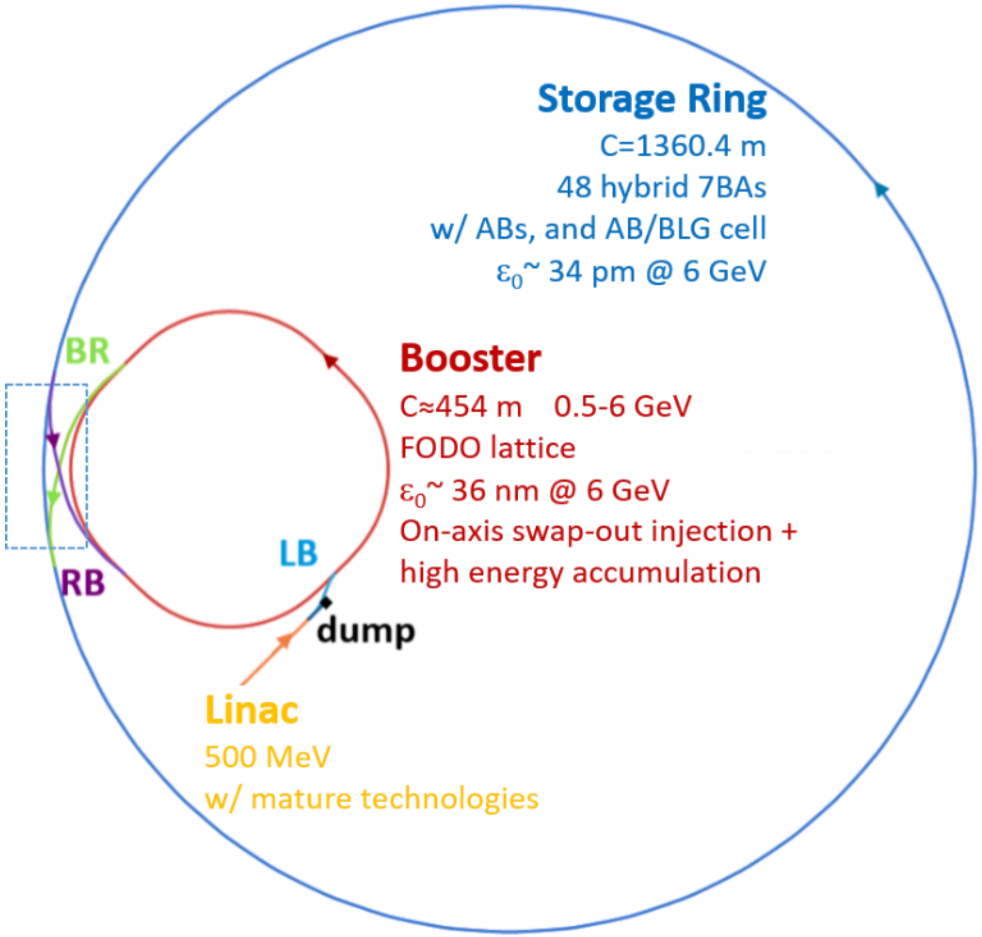
While providing conventional technical support for the general users, HEPS will operate as a platform to analyze the structures, as well as the evolution of structures of engineering materials in the whole process, by in-situ, multi-dimensional and real-time observation.







Main parameters: Accelerator



[1] Y. Jiao *et al.*, *J. Synchrotron Rad.* 25, 1611–1618 (2018).
[2] H. Xu *et al.*, *RDTM* 7, 279–287 (2023).
[3] C. Meng *et al.*, *RDTM* 4, 497–506 (2020).

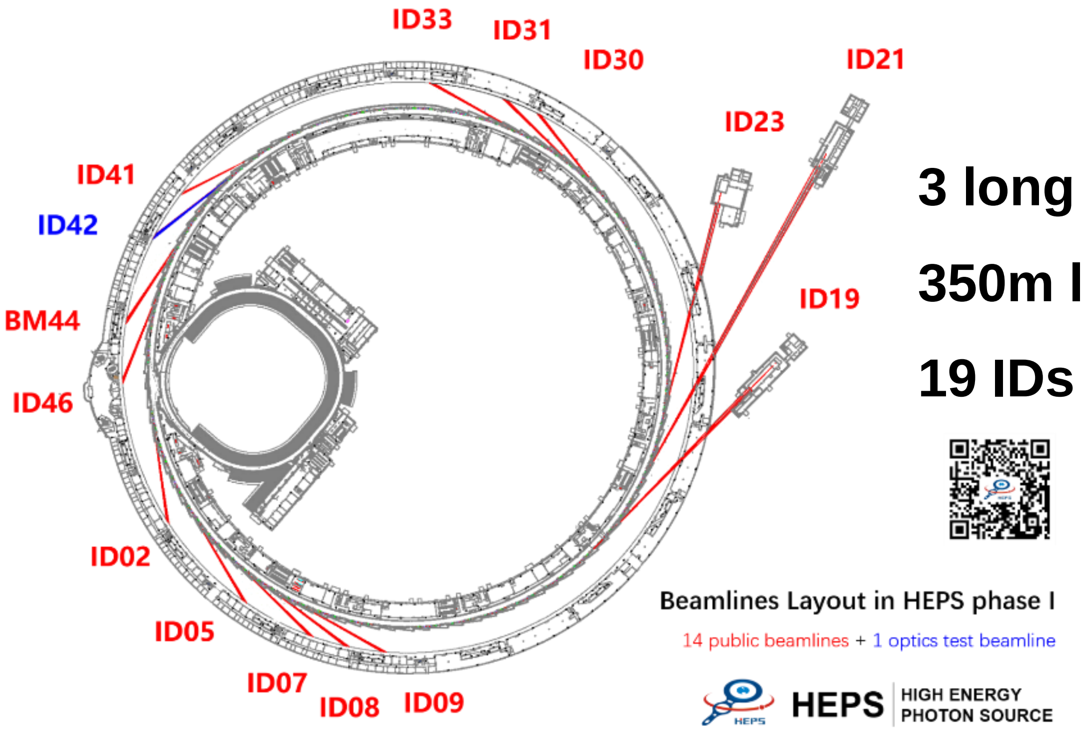
- **Accelerator complex**
  - Linac (500 MeV)
  - Booster (500 MeV to 6 GeV, 1 Hz)
  - Storage ring (6 GeV, top-up)

Parameter	Value	Unit
Beam energy	6	GeV
Circumference	1360.4	m
Lattice type	Hybrid 7BA	
Hori. Natural emittance	<60	pm·rad
Brightness	$>1\times10^{22}$	*
Beam current	200	mA
Injection mode	Top-up	-

*: phs/s/mm^2/mrad^2/0.1%BW

Main parameters: Beamlines

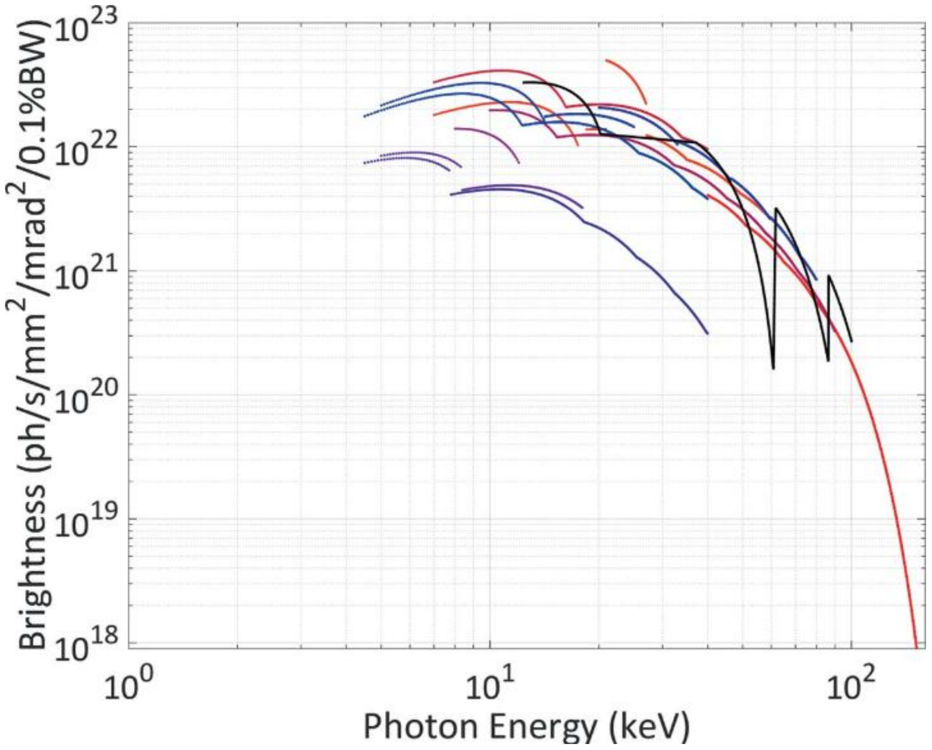
- Brightness of 5×10²² phs/s/mm²/mrad²/0.1%BW at the photon energy of 21 keV, can provide X-ray with energy up to 300 keV
- **14 user beamlines + 1 test BL** in Phase 1, HEPS can accommodate up to 90 BLs



3 long BLs

350m longest

19 IDs 6 types



Y. Jiao *et al.*, *J. Synchrotron Rad.* 25, 1611–1618 (2018).

HEPS Phase I Beamlines list

	Beamlines	Features
High Energy	**Engineering Materials**	50-170keV, XRD, 3DXRD, SAXS, PDF
	Hard X-Ray Imaging	10-300keV, Phase and Diffraction contrast imaging, 200mm large spot, 350m long, **Mango Wiggler**
High Brightness	**NAMI-NanoProbe**	Small probe, <10nm; *In-situ* nanoprobe, <50nm; 220m long
	Structural Dynamics	15-60keV, single-shot diffraction and imaging; < 50nm projection imaging
	High Pressure	110nm focusing, diffraction and imaging
	Nano-ARPES	100-2000eV, 100nm focusing, 5meV@200eV, APPLE-KNOT U
High Coherence	Hard X-ray Coherent Scattering	CDI(<5nm resolution), sub-μs XPCS
	Low-Dimension Probe	Surface and interface scattering, surface XPCS
General beamlines	NRS&Raman	Nuclear Resonant Scattering and X-ray Raman spectroscopy
	XAFS	Routine XAFS, plus 350nm spot and quick XAFS
	Tender spectroscopy	Bending magnet, 2-10keV spectroscopy
	μ-Macromolecule	1μm spot, standard and serial crystallography
	Pink SAXS	Pink beam, lest optics
	Transmission X-ray Microscope	Full field nano imaging and spectroscopy
Test BL	Optics Test	With undulator and wiggler source for optics measurement and R&D

HEPS-TF and HEPS: two phases

	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
HEPS-TF	Preparation			Execution									
HEPS				Preparation			Construction (6.5 yrs.)						

NOW

SRF installation underway

HEPS-TF (R&D project before HEPS)

- Schedule： 04.2016 - 10.2018, Budget: 321.6 M CNY (~48 M USD)

HEPS Phase I: the construction will be completed this year

- 28.09.2016, Project settled in Huairou (Beijing)
- 15.12.2017, **Project proposal** approved by NDRC (CD0 equivalent)
- 28.12.2018, **Feasibility study** approved by NDRC (CD1 equivalent)
- 22.05.2019, **Preliminary design and budget** approved by NDRC (CD2 equivalent)
- 29.06.2019, Construction started in Huairou (CD3 equivalent)

NDRC: National Development and Reform Commission

Platform of Advanced Photon Source Technology R&D (PAPS)

Trials started in June 2021 to support the HEPS construction and develop SR-related technologies

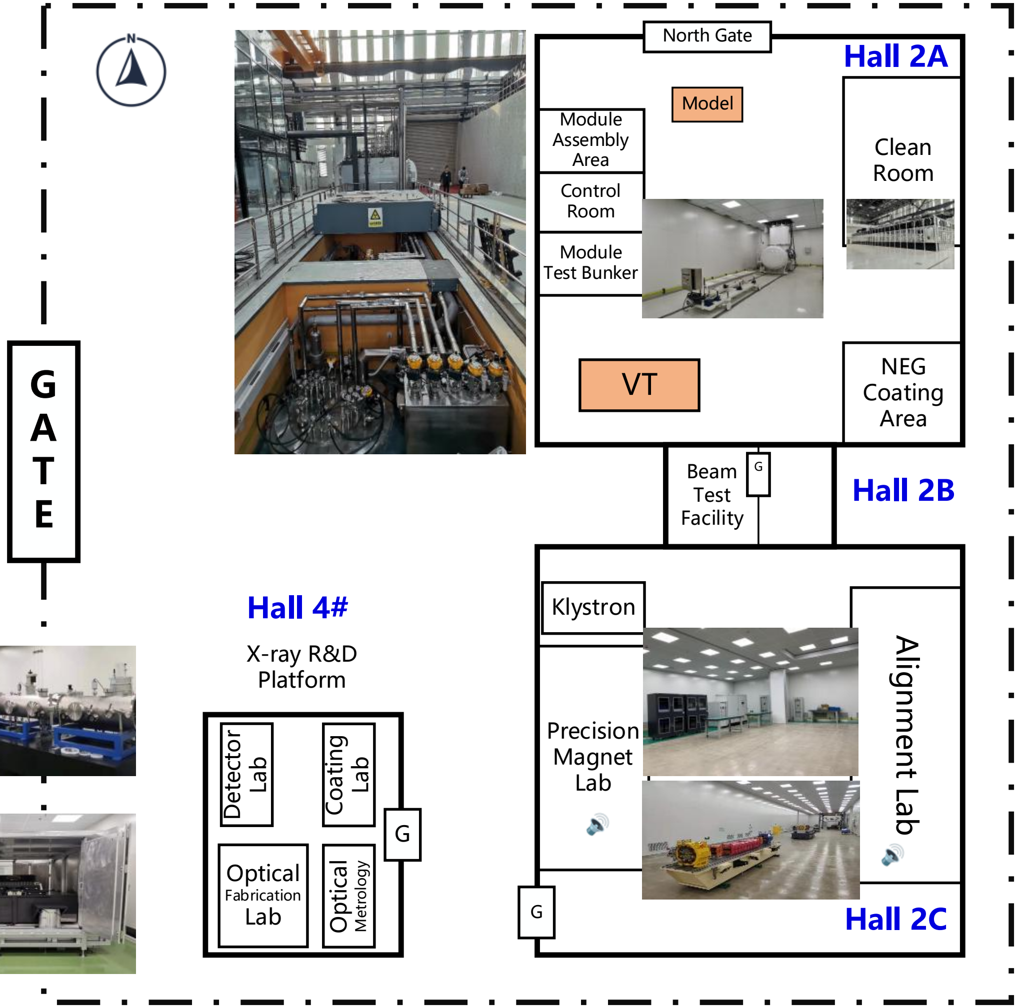
Accelerator Technology Innovation Research Sub-platform

X-ray Technology Innovation Research Sub-platform

200-400 sets/year SRF cavities / couplers test
2000 magnets tested
400 Girders pre-aligned **1300** chamber coated
Crystal fabricated and measured | detector developed

0.5B CNY **21,295** m^2 building area

Supported by Beijing Government



Technologies Developed

166 MHz SRF cavity module

the world's first quarter-wave SRF structure to accelerate relativistic particles (beta=1) as a main accelerating cavity heavy damping of higher order modes achieved

Mango Wiggler

a special Delta type PPM wiggler **to meet the requirement of large vertical field range for X-ray phase contrast imaging**

High Gradient Quadrupole

Magnetic field gradient 80 T/m

High order harmonics $<4\times10^{-4}$

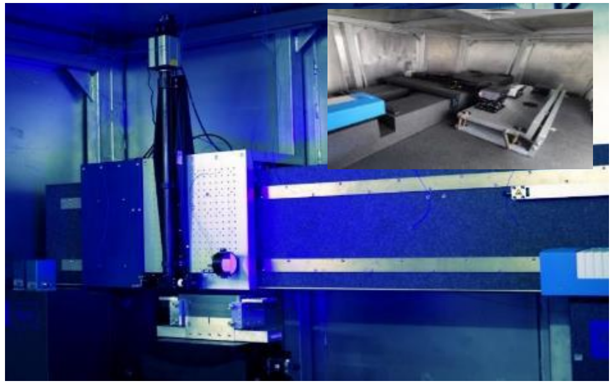
NEG film coating

Non-evaporable getter (NEG) film coatings have been developed at IHEP to provide linear pumping for vacuum chambers of limited conductance and low SEY.

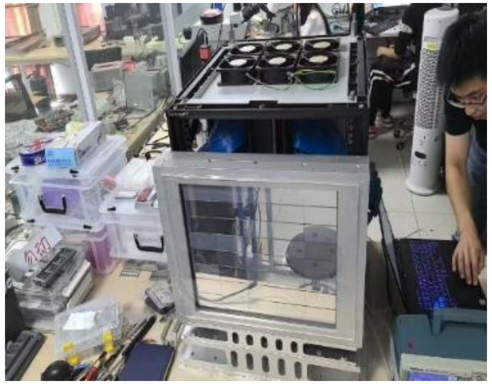
Beamline key technologies

- Optical Theory
- Optical metrology
- Optics Fabrication
- Optical Modulation
- X-ray detector

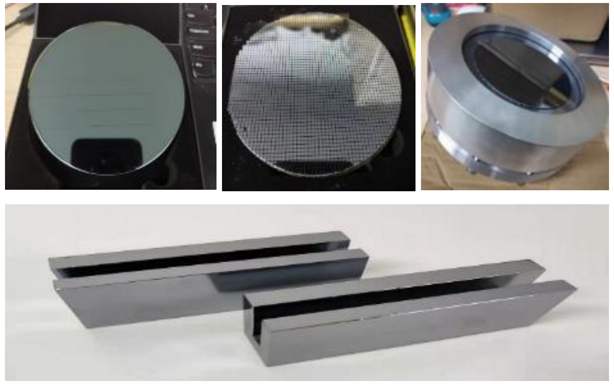
Supported by both HEPS and Platform for Advanced Photon Source Technology R&D (PAPS)



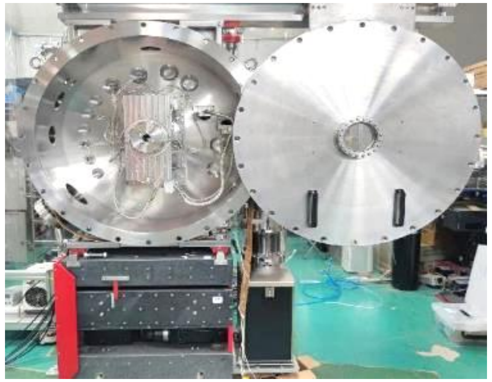
Flag-type Surface Profiler (FSP)
Bending shape accuracy RMS 50pm



In-house Detector development

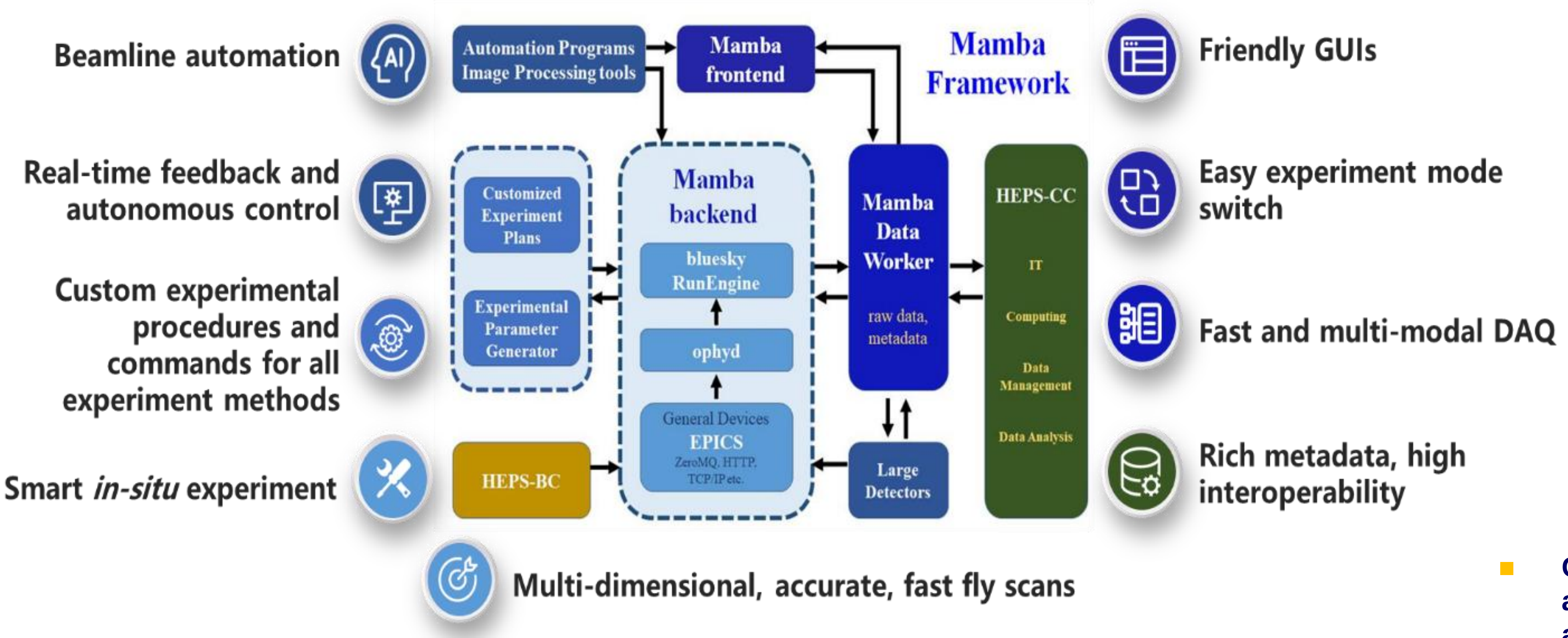


Mirror Fabrication



Monochromator
18 sets 8 types

Scientific software and computing



HEPS has taken the lead at China for the construction of the software system covering the whole life cycle of synchrotron experiments

- Control, data acquisition and analysis
- Data management
- Computing
- AI for Science

Mamba: A new generation synchrotron experiment operating software system

Unified framework for all HEPS beamlines

Unified data format and standards

DOMAS: Data Organization and Management Software

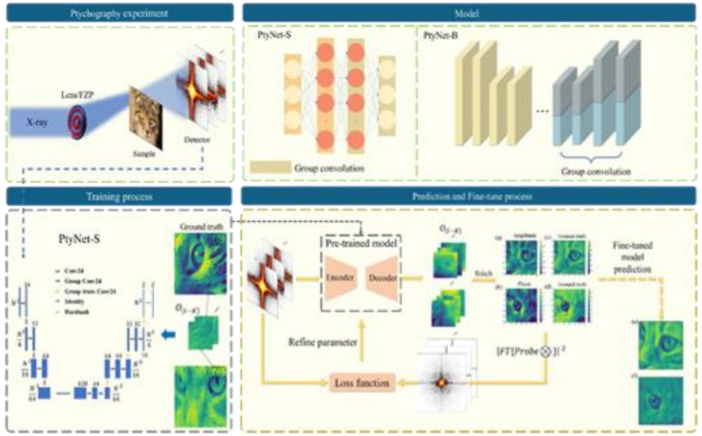
- Metadata catalogue, Metadata acquisition, Data transfer, Data service (User GUI)
- Data policy & Data format(HDF5)

Daisy: Data Analysis Integrated Software sYstem

- Basic, common, scalable framework
- Data engine, Workflow engine, Computing engine, GUI
- Released *https://daisy.ihep.ac.cn/*

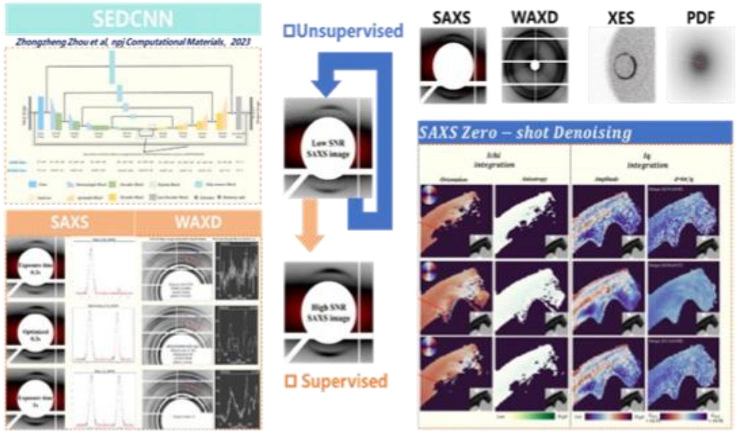
AI for Science

☐ Large AI model solves ptychographic phase retrieval problem



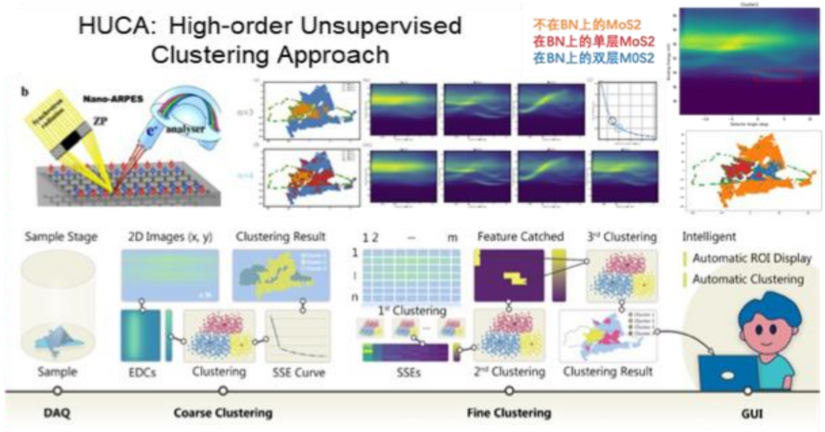
X.Y. Pan et al. *iScience*, 2023
X.Y. Pan et al. *Acta Physica Sinica*, 2023

☐ Physics-informed denoising solution



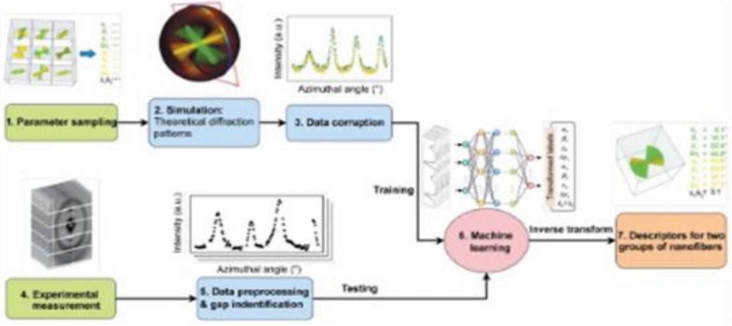
Z.Z. Zhou et al. ***npj Comp. Mater.***, 2023
Z.Z. Zhou et al. ***Journal of Appl. Crystallogr.***, accepted

☐ Clustering of Nano-ARPES experimental spectra



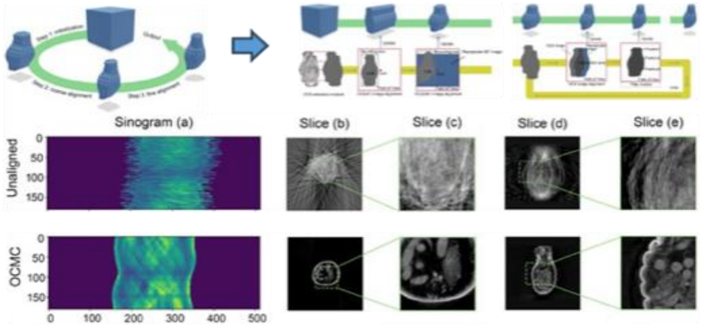
L.Z. Bian et al. ***Commun. Phys.***, under review

☐ Physical information retrieval from massive diffraction data using machine learning methods



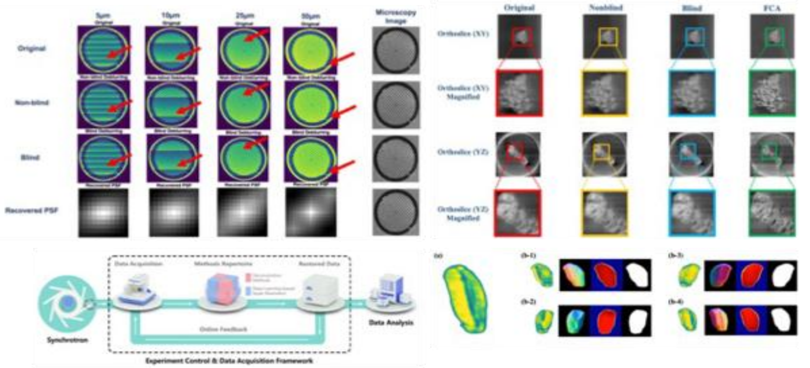
M. Sun et al. ***IUCrJ***, 2023
X. Zhao et al. ***IUCrJ***, 2024

☐ End-to-end image misalignment correction method for tomography



Z. Zhang et al. ***iScience***, 2023

☐ Deconvolution and super-resolution pipeline

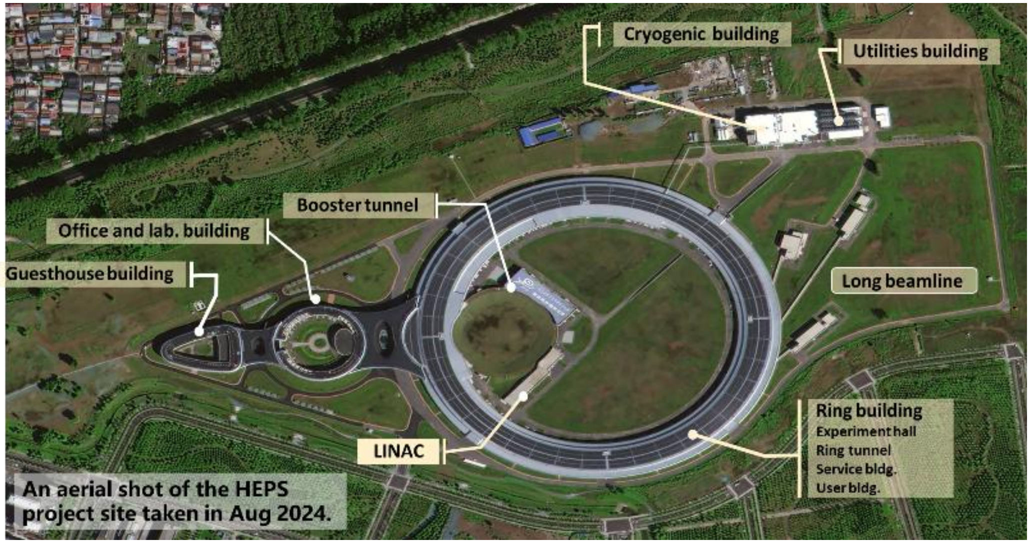


C. Li et al. ***Nucl. Sci. Tech.***, accepted

Design → Fabrication → Installation → Commissioning → Operation

HEPS Progress (June 2019-June 2025)

4^{th} round Joint-Commissioning completed on May 20, 2025



An aerial shot of the HEPS project site taken in Aug 2024.

Civil Construction and Utility: Completed

LINAC: in operation

Booster: in operation

Storage Ring: Installation of SRF cavities and IDs underway

Beamlines: Installation of BL Group 2 underway

Progress Released

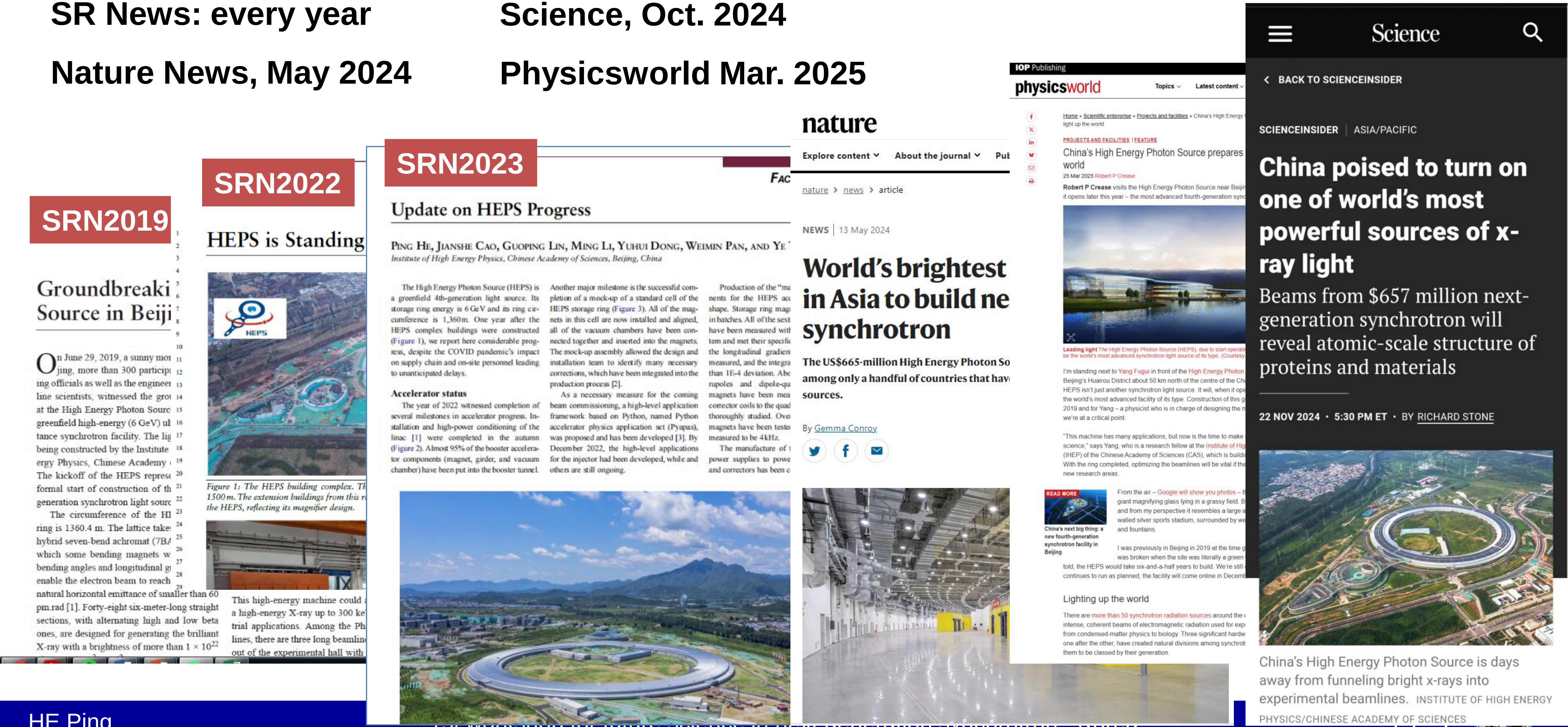
Joint-Commissioning Phase announced on Mar. 27, 2025

SR News: every year

Science, Oct. 2024

Nature News, May 2024

Physicsworld Mar. 2025



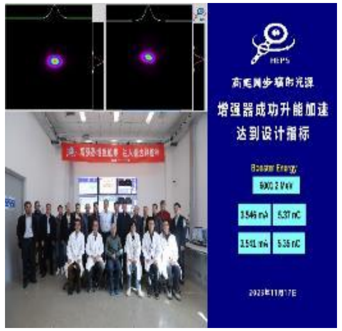
Milestones

May 12, 2022
The Linac Vacuum-sealing in the tunnel completed

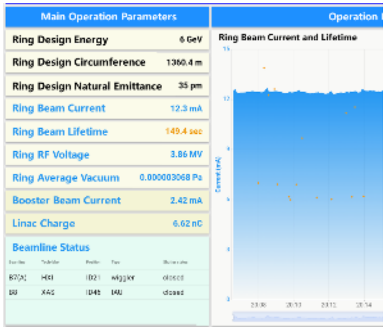
Jan. 13, 2023
The Booster Vacuum-sealing in the tunnel completed

Feb. 1,2023
The first girder was installed in the storage ring tunnel

Mar. 14, 2023
The first electron beam



Nov. 17, 2023
Electron Beam Ramped Up to 6 GeV

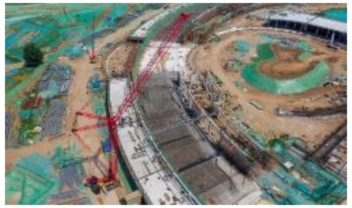


Aug. 18, 2024
Electron beams with currents higher than 10mA were successfully stored.

Oct. 12, 2024
the SR X-ray emitted from the R21 wiggler was successfully transmitted to the end station.

June 29, 2019
Groundbreaking ceremony

July 1, 2020
The first steel beam was installed



Apr. 13, 2021
Utility installation in NO.2 Hall commenced

June 27, 2021
Roof-sealing work for the main ring building completed

June 28, 2021
HEPS Installs First Piece of Accelerator Equipment in Linac Tunnel.

Nov. 3, 2023
Civil Construction for ancillary buildings completed

Civil Construction

650,000m² site area 150,000m² building area

Guest House building, Laboratory Building, Facility buildings

- In 2020, the foundation and the steel structure construction proceeded.
- April 2021, Utility building completed.
- Jun., 2021 The construction of HEPS Linac tunnel completed.
- Dec., 2021, Booster tunnel building completed.
- Dec. 2022, SR and Experimental Hall building completed.
- Dec. 2023, Outdoor project construction proceeded.
- Jan. 2024, Guest house and Lab buildings completed.
- Nov. 2024, Civil construction completed.

LINAC

higher bunch charge (5->7 nC) and optimized layout

HEPS Linac

a total length of about **49 m, 500MeV**

an s-band normal conducting electron linear accelerator

high bunch charge and large bunch charge range

an electron gun, a bunching system, and S-band accelerating structure system.

June 2019: Design completed.

June 2021: Electron gun, the first piece of accelerator equipment, was installed in the Linac tunnel.

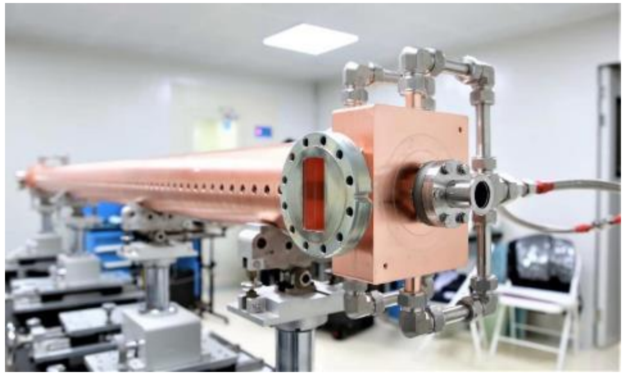
Mar. 2022: Installation in the Linac tunnel begun

May 2022: Linac vacuum-sealing in the tunnel completed

Sep. 2022: Linac online RF conditioning completed

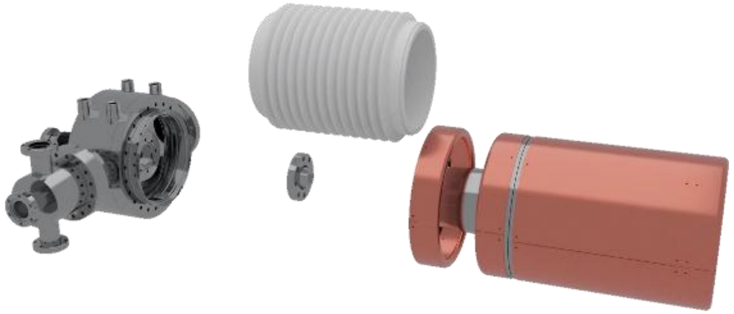
Mar. 2023: Linac commissioning began

LINAC



The accelerating gradient of the **S-band accelerating structures** with a symmetrical coupler and internal water-cooling system was measured at **33 MV/m**.

The pulse-to-pulse stability of **the solid-state modulator** based on insulated gate bipolar transistors was measured at better than 0.02%, improved by about an order of magnitude than the pulse-forming network (PFN) type modulator.



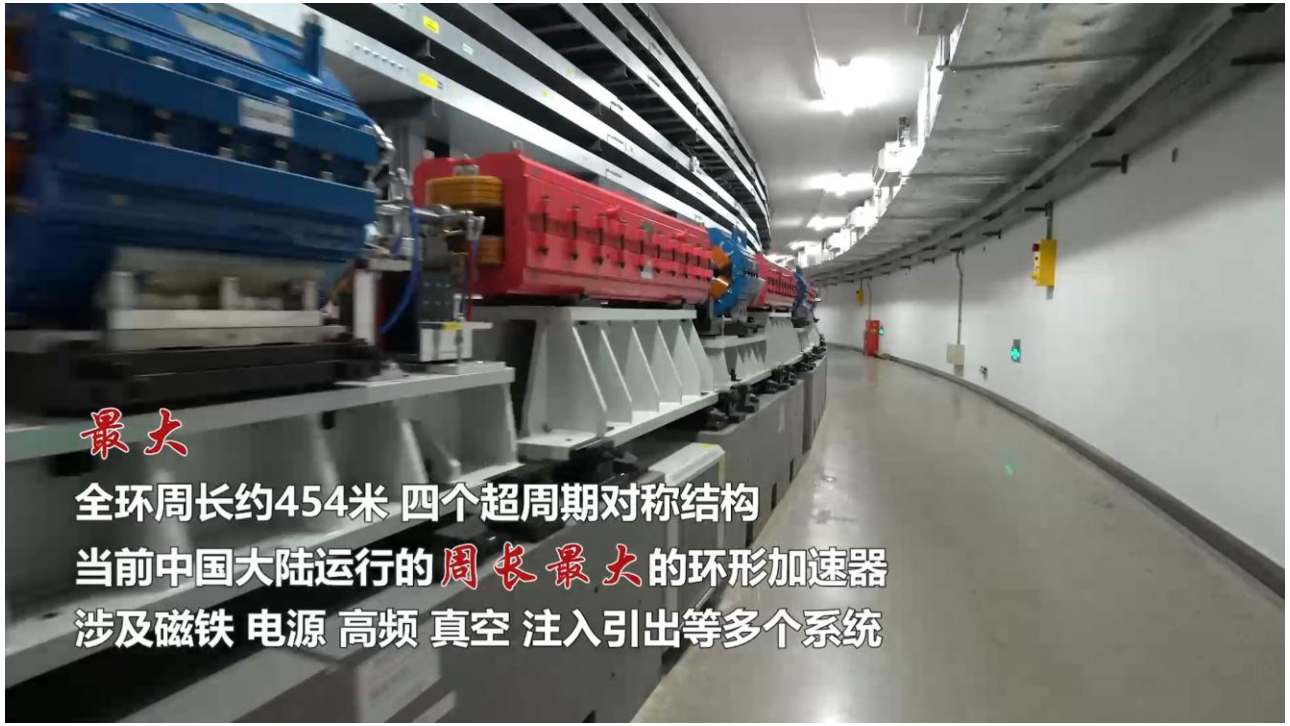
The electron gun, with its cathode grid assembly developed in-house, can provide a **14.7-nC** beam current for 1 ns at 50 Hz and is the first piece of accelerator equipment installed in the accelerator tunnels.

Booster

higher bunch charge (2->5 nC), and emittance reduced by more than 50% (35->16 nm)

454 meters in circumference **500MeV -> 6GeV**

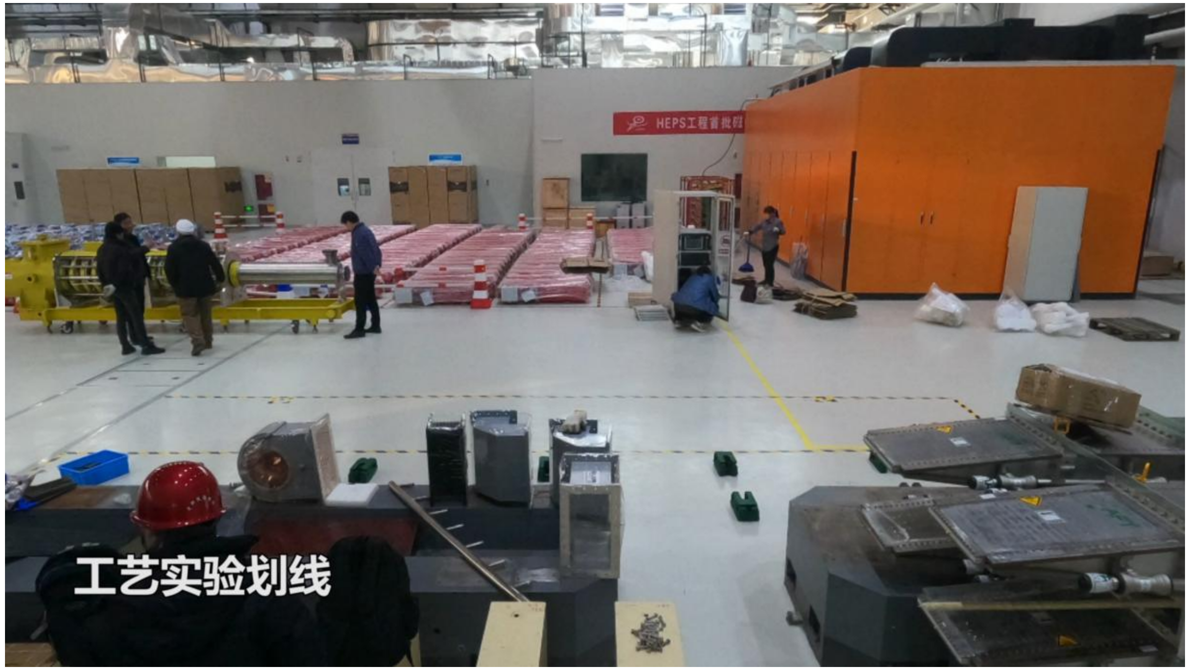
a four-fold symmetrical FODO structure, with each super-period consisting of 14 standard FODO cells, two matching sections, and an 8.8-meter-long dispersion-free straight section.



Booster

Mar. 2021, First 15 magnets transported to PAPS building in HUAIROU.

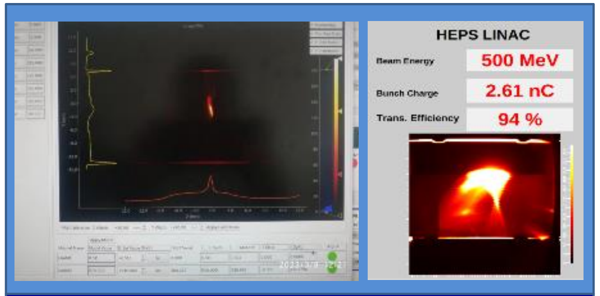
Dec. 2021---Jan. 2022
Process Experiment for Booster Installation



Aug. 8, 2022 Booster installation began

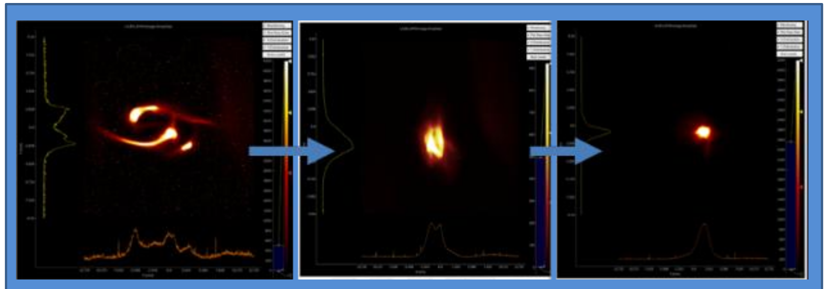
Jan. 13, 2023 Vacuum-sealing in the tunnel completed

Injector commissioning



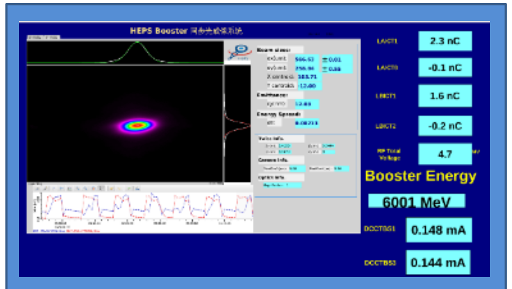
500 MeV, ~2.5 nC

1st electron beam



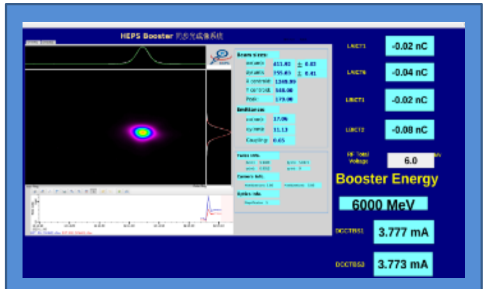
500 MeV, max bunch charge > 7 nC

LINAC passed SAT



Ramped to 6 GeV

1st electron beam in Booster



>5 nC of single bunch charge

Booster passed SAT

3.9 LINAC CX started — 3.14 — 6.5 — 7.25 Booster CX started — 8.9 — 11.17

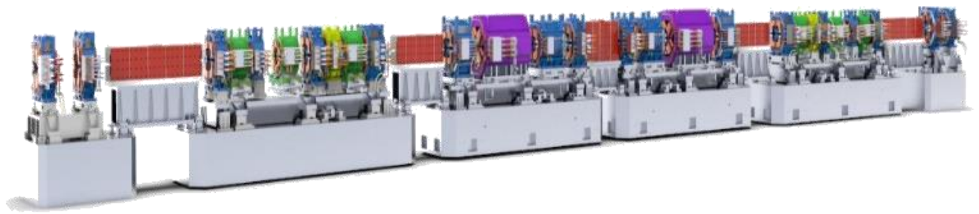
2023

On-site testing of LINAC in May, 2023, the macro-pulse charge reached 7.29 nC, and beam energy stability was 0.014%.

The electron beam achieved more than 5 nC of bunch charge at 6 GeV via the booster on Nov. 17, 2023.

Storage Ring

the main component of the HEPS accelerator complex



1700⁺ Magnets **19 IDs**

~1300 vacuum chambers

500⁺ BPMs **288 Girders**

enlarged drift space in arc (1.1 m more space/7BA), slightly larger magnet aperture (25->26 mm), emittance preserved (34.2->34.8 pm) with however smaller dynamic acceptance

a circumference of **1360.4 meters**

48 seven-bend achromats, meticulously designed to achieve a horizontal natural emittance of **~35 pm•rad** at a beam energy of **6 GeV**.

Storage Ring Installation

Process Experiment for Storage Ring Installation

April 2022

Aim to verify the feasibility of the magnet, vacuum chamber, BPM, etc. installation procedure

- The operation space and interfaces have been checked, and pre-alignment scheme, transport scheme and other critical problems have been thoroughly tested

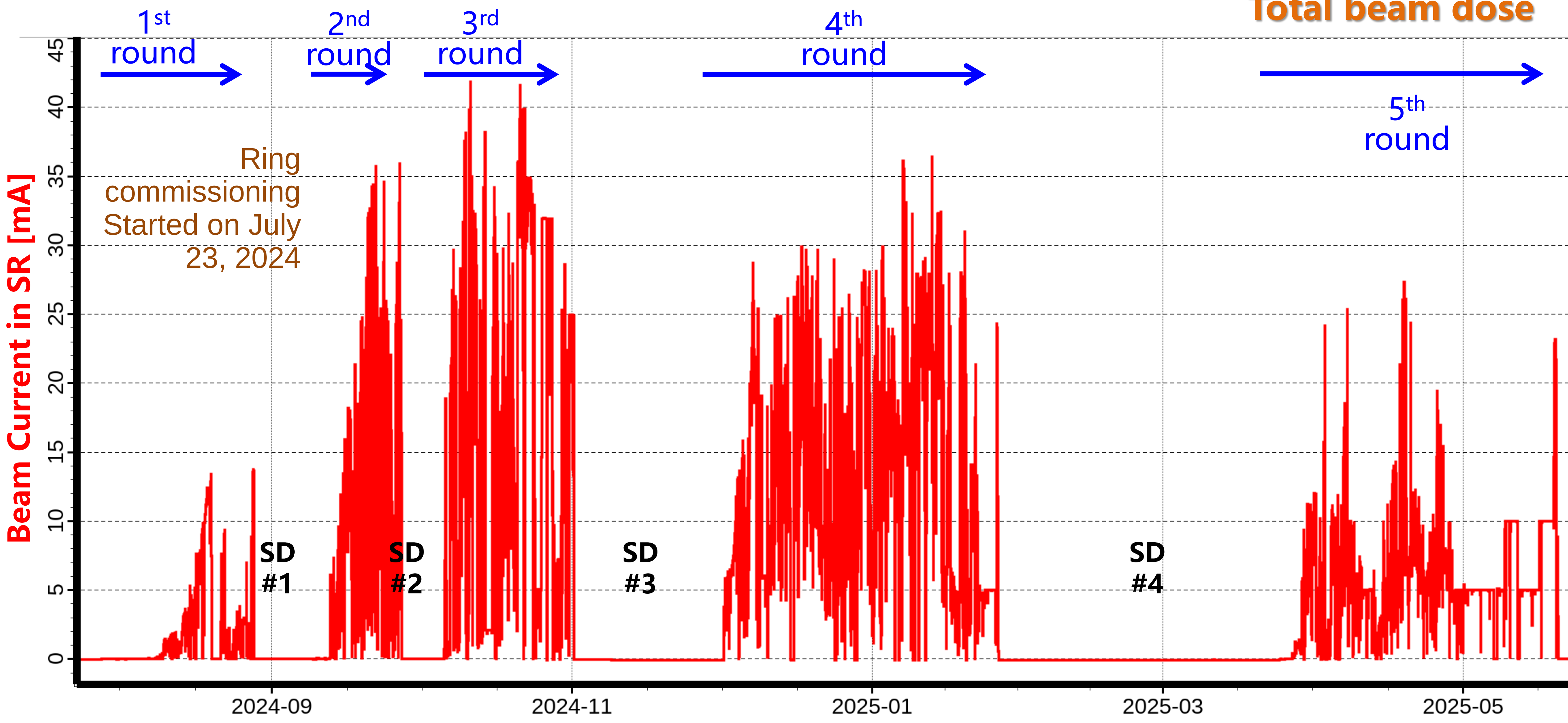
July 2022
The pre-alignment began.
30μm for pre-aligned girders

Feb. 2023
The installation began
50μm **for alignment in tunnel**

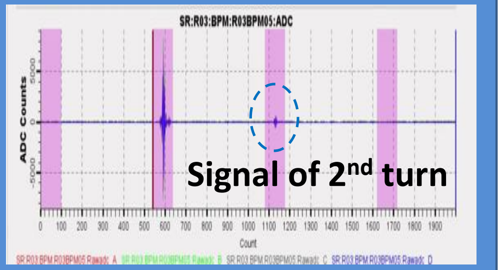
July 1, 2024
Vacuum sealing completed.

5 round commissioning completed

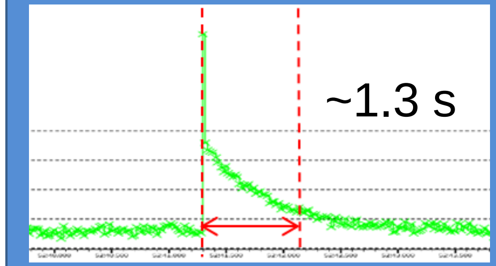
41.037A·h
Total beam dose



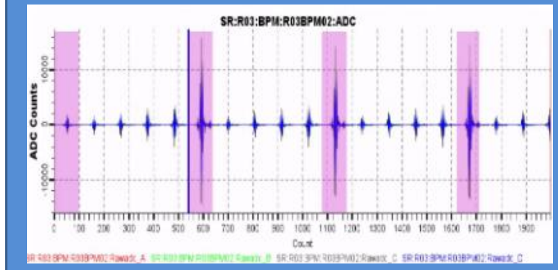
Storage ring commissioning



First turn

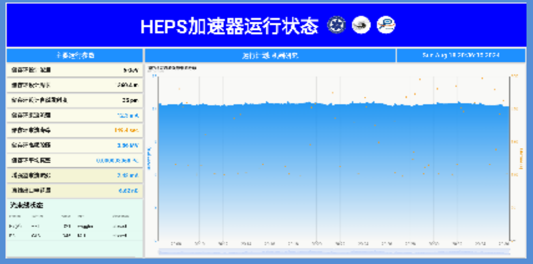


One bunch stored



Current: ~0.4 mA, Life time: ~1 min

Multi-bunch stored



Current: ~12 mA, Life time: ~2 min

12 mA stored

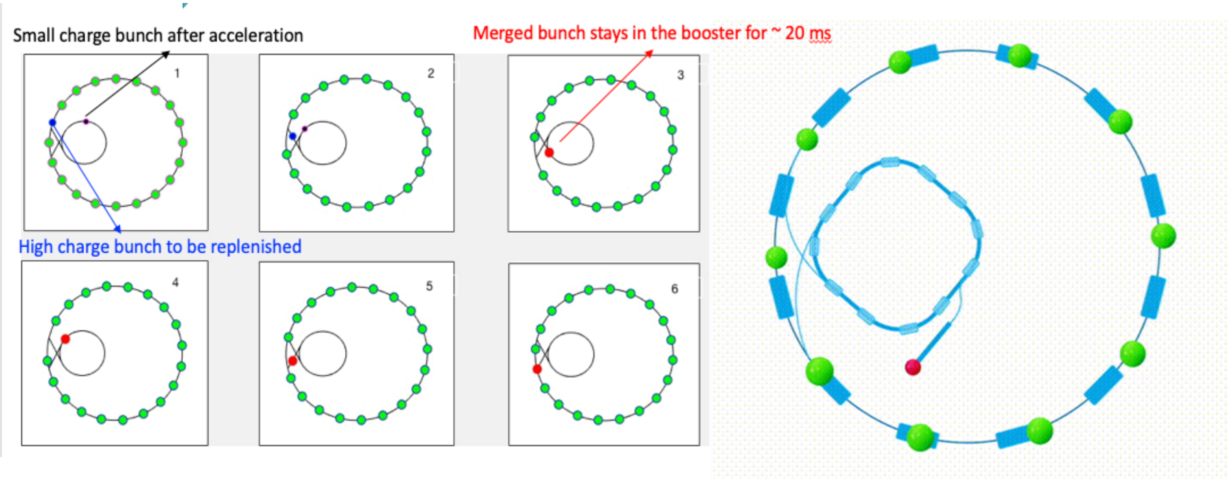
SR CX Started

- 7.23 — First turn
- 7.29 — 10 turns
- 8.4 — 1000 turns
- 8.6 — One bunch stored
- 8.8 — Multi-bunch stored
- 8.15 — 7 mA, 2 min
- 8.18 — 12 mA stored

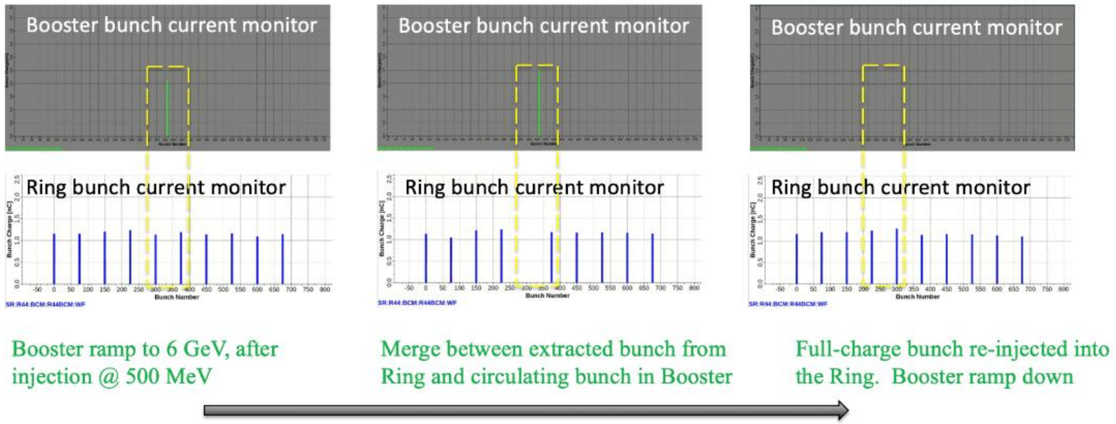
First light in Oct. 2024

Swap-out injection: commissioning and operation

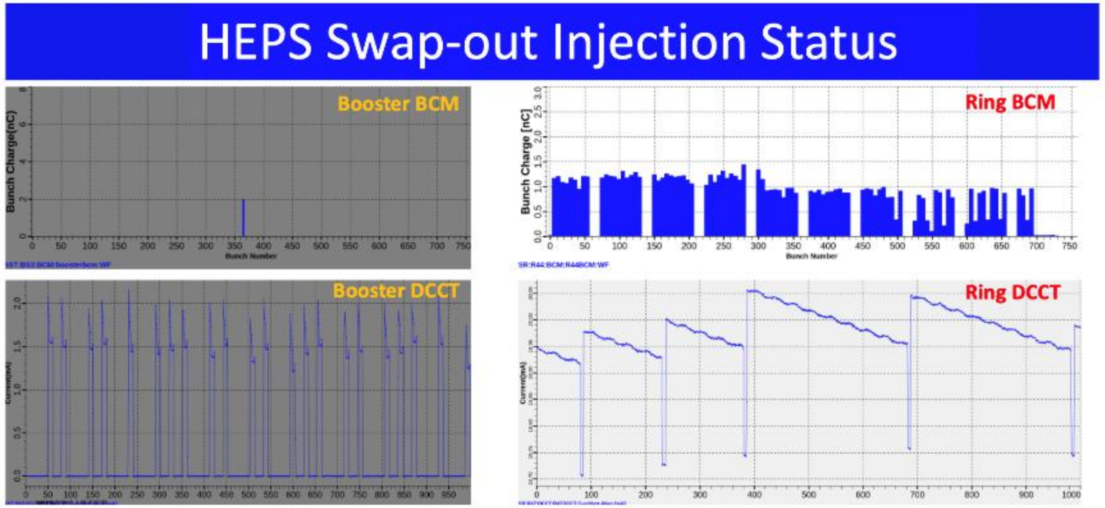
Design scheme



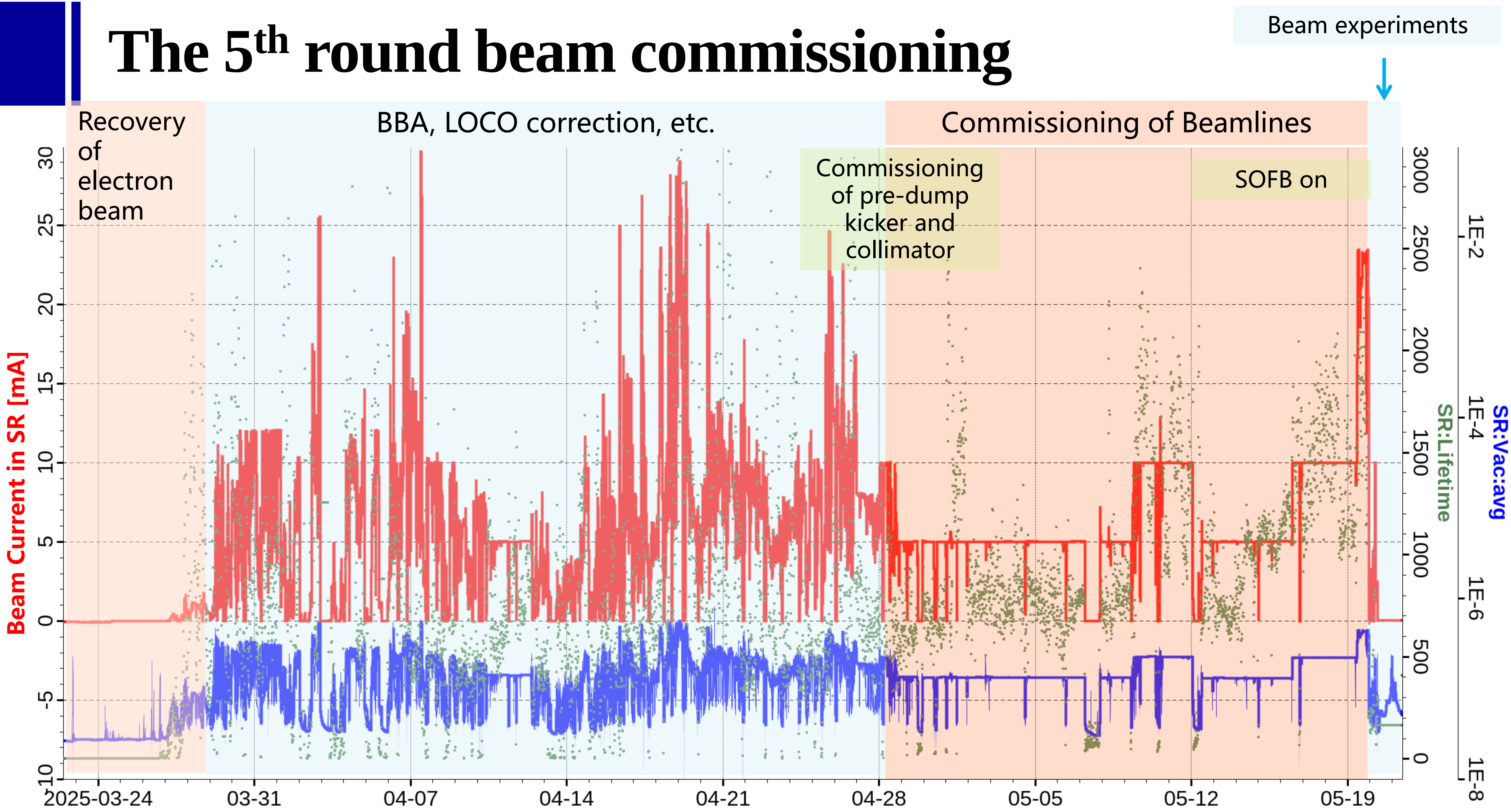
Experimental demonstration



- The swap-out injection with high energy accumulation in the booster, has been successfully demonstrated.
- Now used in routine operation since Jan. 2, 2025

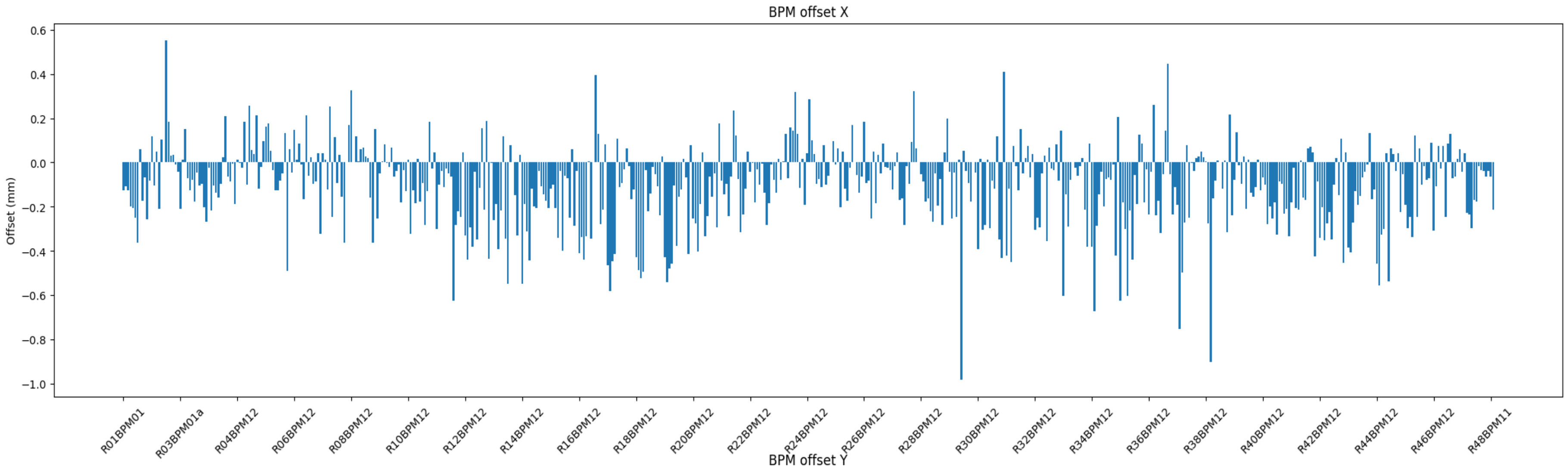


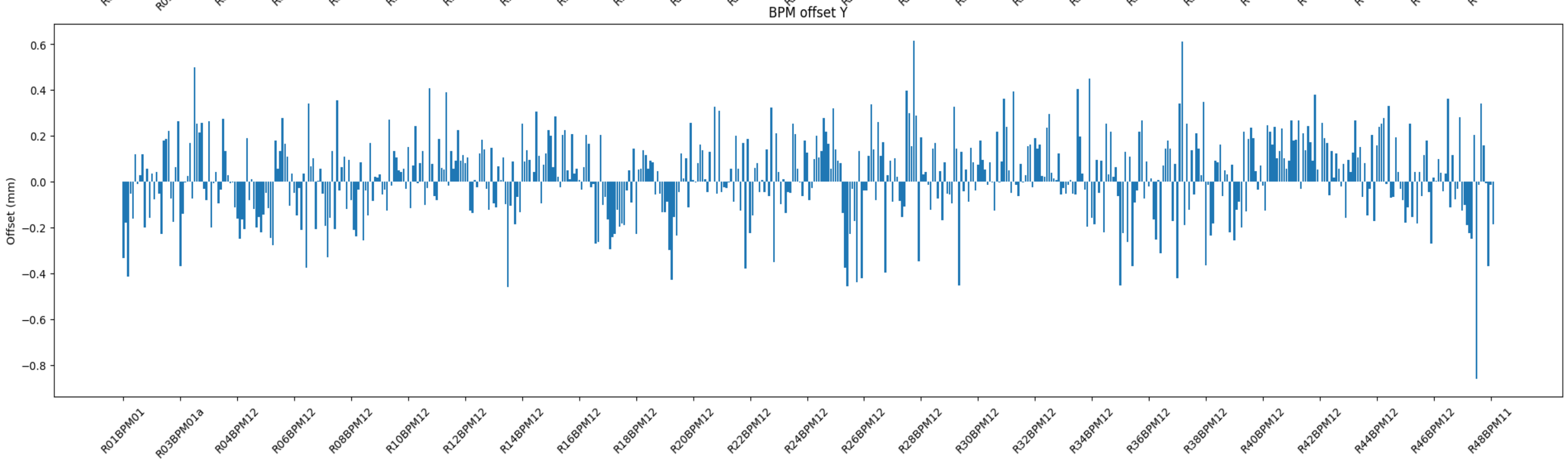
The 5th round beam commissioning



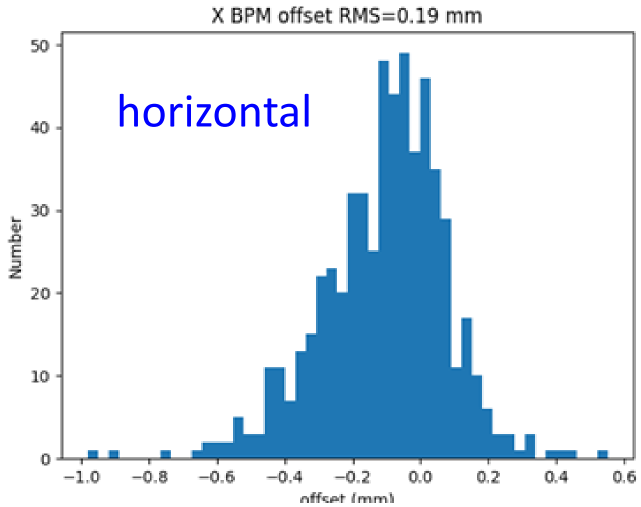
BBA --- total 3 round measurements

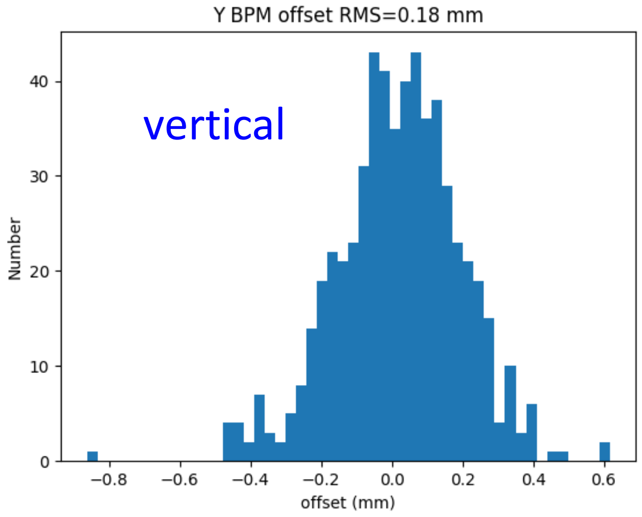
Results of BBA #2 of all BPMs





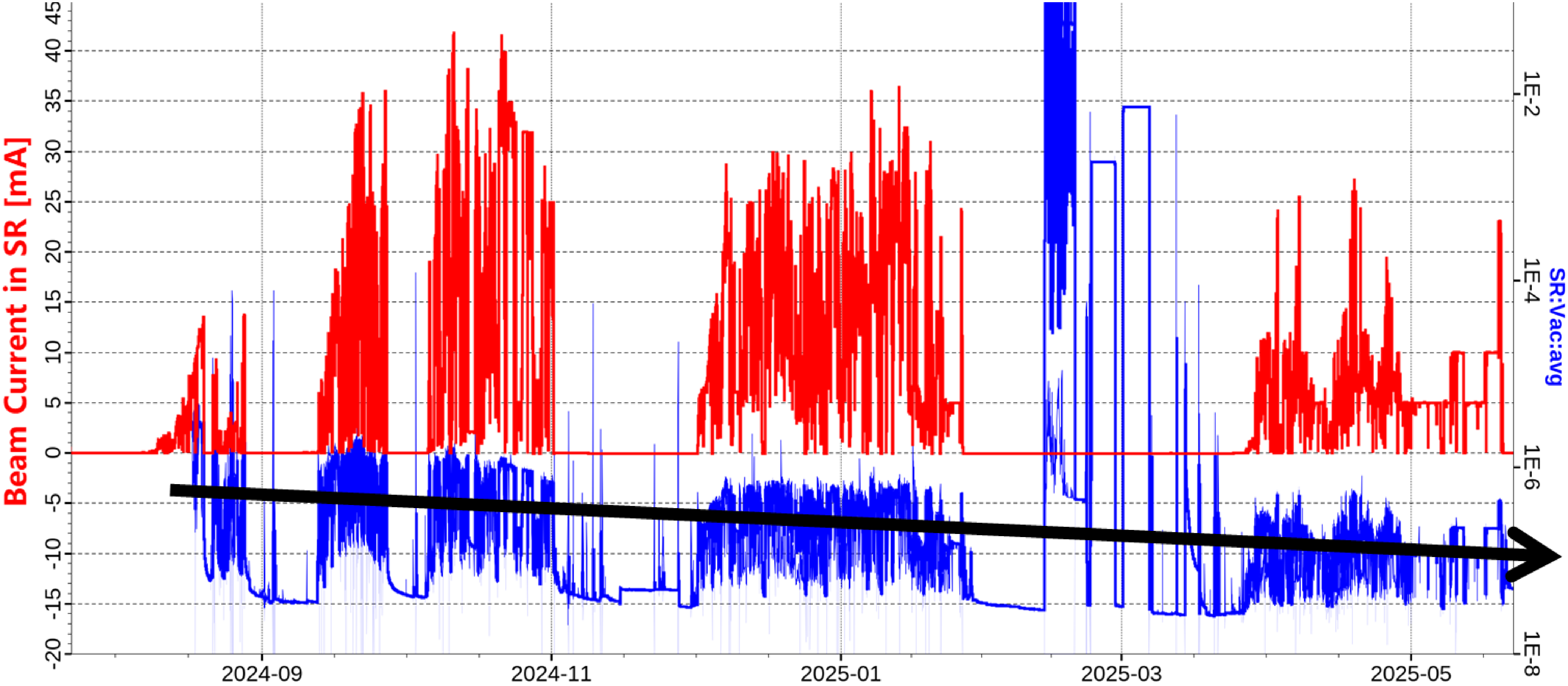
Histogram of all BPM offset of BBA #2





Current and Vacuum history in the HEPS storage ring

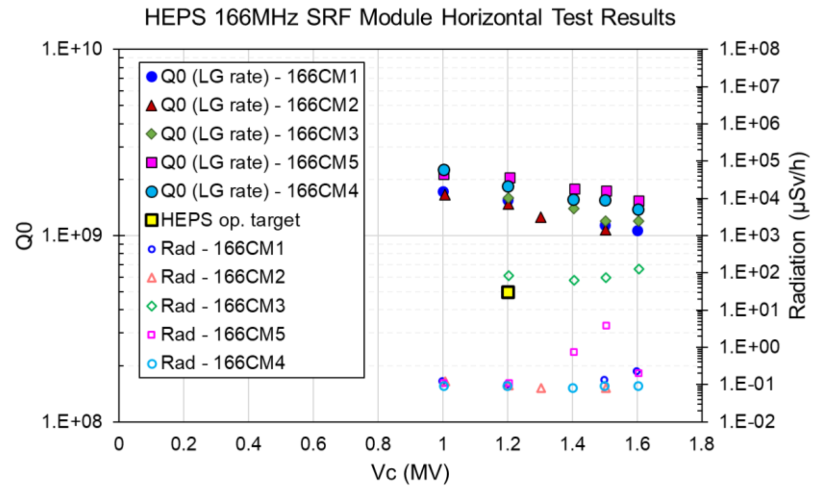
Vacuum conditioning on going: average pressure going down slowly



166.6MHz SRF cavities for storage ring

- All five 166.6MHz SRF cavities assembled and passed horizontal tests in Jun 2025
- Excellent performance in vertical tests nicely preserved in horizontal tests of the module
- HOM impedance measurement in line with design (heavy damping)
- Total heat load per module: 39~43W (dynamic: 5~7W)

Max Vc: >1.6MV (administration limit), Q0@1.2MV: 1.5e9~2.1e9, Rad. < 0.1mSv/h



SRF gearing up for 100mA

6th round Storage Ring Commissioning will begin in the last week of August or the beginning of Sep., 2025.

- Five 166.6MHz SRF cavities and two 499.8MHz SRF cavities installed in storage ring, cabling and transmission line installation underway
- One more 499.8MHz NCRF cavity added in booster ring (5 cavities in total)
- The final 166.6MHz-260kW SSA and 499.8MHz-100kW SSA being installed
- **All 7 SRF cavities expected to cooldown in Aug 2025**

All of the beamlines under commissioning

- **Group 1 beamline, BM/IAU/IAW**

  IDs installed in storage ring

  Installation and commissioning completed / ongoing

  Control and data acquisition software ready

  Photon beam Commissioning began in Oct. 2024

- **Group 2 beamline, IVU/CPMU/Apple Knot/MANGO**

  Installation finished in the end of 2024

  Photon beam Commissioning in Apr. 2025

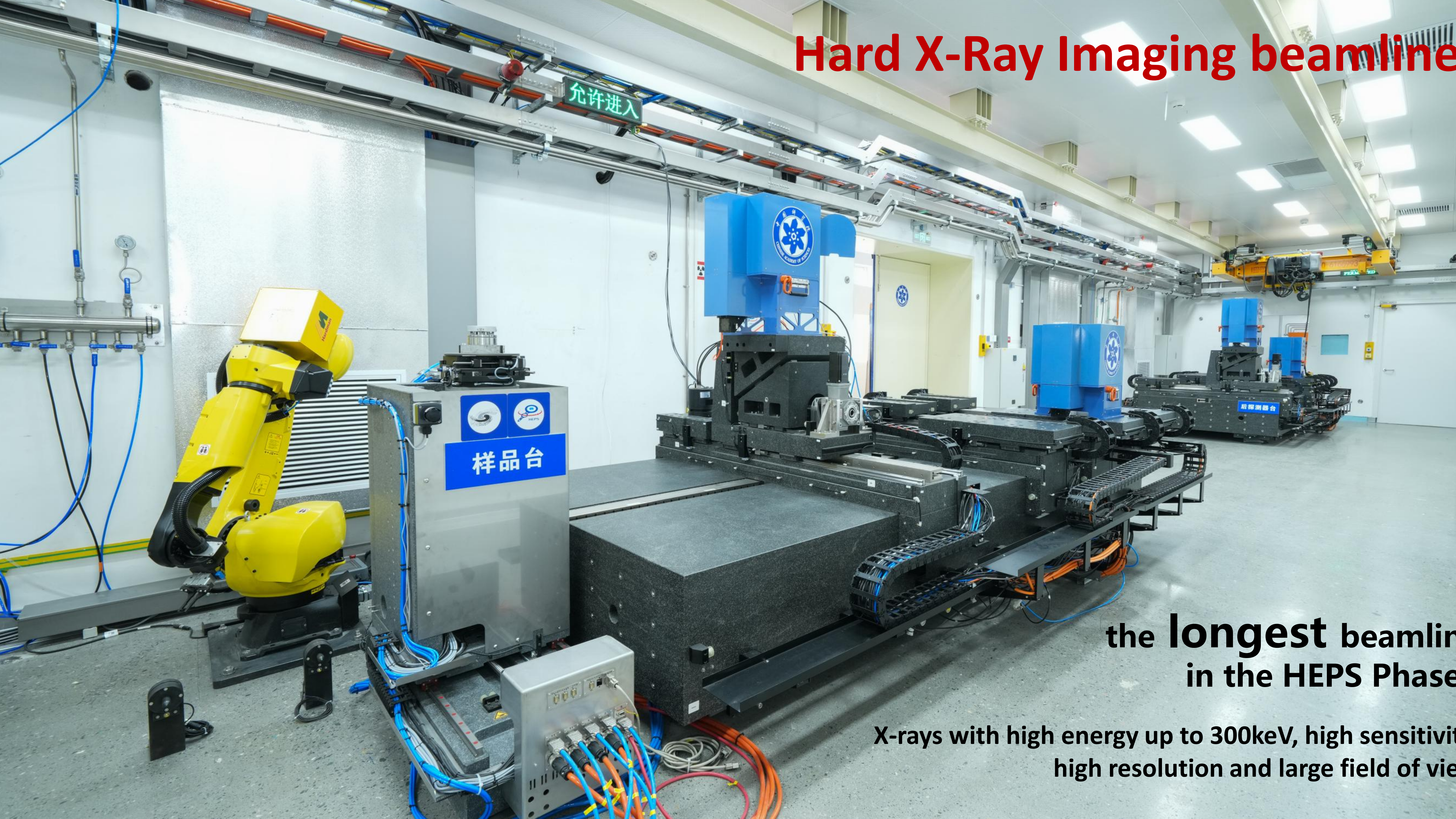
Group 1	Hard X-Ray Imaging	IAW/Mango/IVU(G2)
	TXM	IAU
	XAFS	IAU
	Tender spectroscopy	BM
	Pink SAXS	IAU
	μ-Macromolecule	IAU
	Optics Test	IAW/CPMU(G2)
Group 2	Engineering Materials	CPMU
	Nano-probe	CPMU
	Structural Dynamics	CPMU
	High Pressure	IVU
	Nano-ARPES	Apple knot
	Hard X-ray Coherent Scattering	IVU
	Low-Dimension Probe	IVU
	NRS&Raman	IVU



Front end: bridge between storage ring and beamline

All of Beamline Shielding and Utilities installed

Hard X-Ray Imaging beamline



the longest beamlin
in the HEPS Phase

X-rays with high energy up to 300keV, high sensitivit
high resolution and large field of vie

Installation of All IDs to be completed by the beginning of July 2025

Apple-Knot and MANGO wiggler be developed for ARPES and HXI Beamline

TYPE		Number	In Tunnel	With Beam
In Air	IAU	4	4	4
	IAW	2	2	2
In Vacuum	CPMU	6	6	5
	IVU	5	5	5
Special	AK	1	1	1
	Mango	1	1	0
Total		19	19	17

19 IDs total

for 14 BLs

All In-house R&D

17 IDs

conditioning

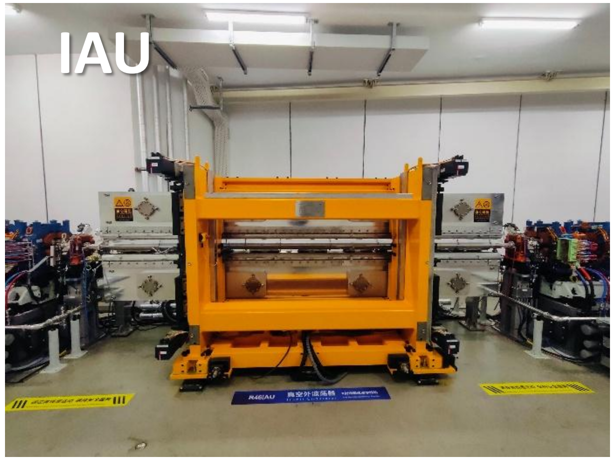
with beam

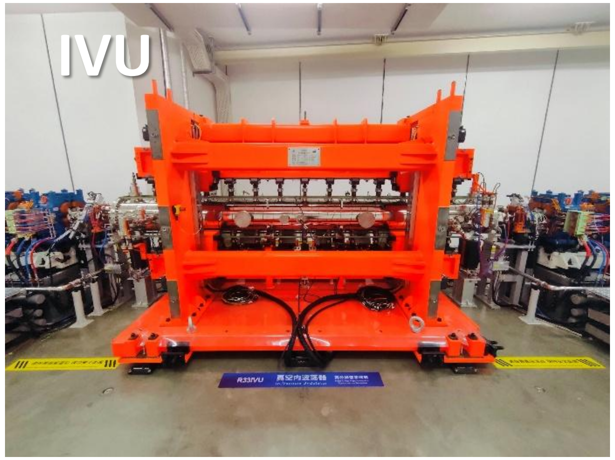
2 IDs AK+Mango

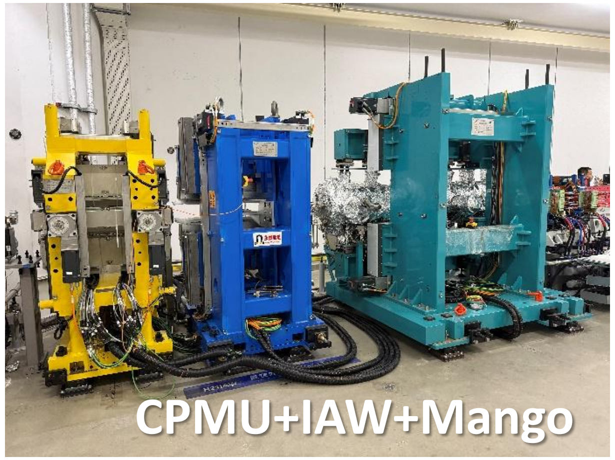
being installed

4th round SR beam commissioning with 17 IDs

- Preliminary user experiments have been conducted on beamlines sourced from IAU/IVU/CPMU.
- IDs are running smoothly and reliably, including **gap motion, taper mode, coil compensation function, cryogenic and beam vacuum performance, etc.**







3 insertion devices in ID21 beamline

Mango + IAW + CPMU

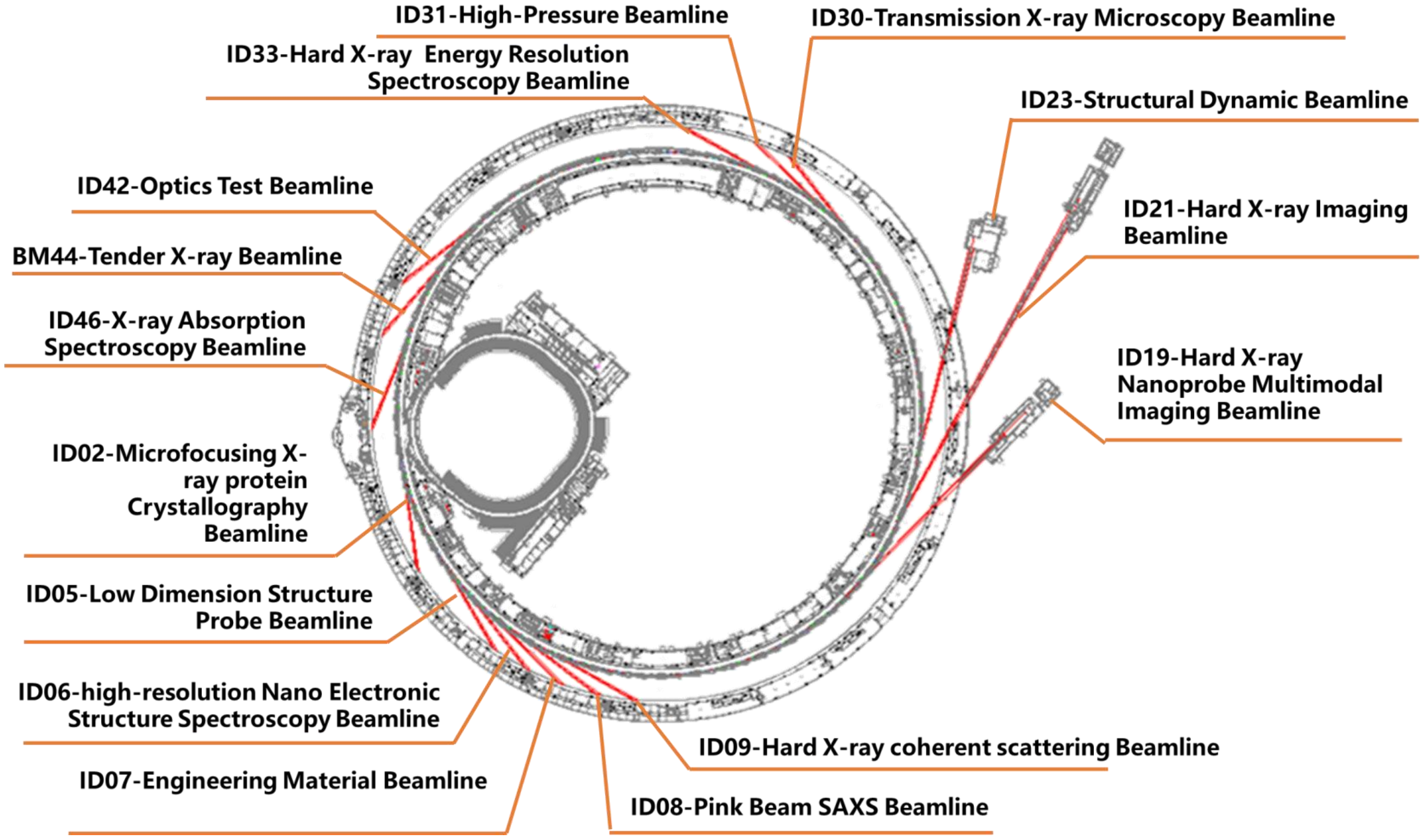
Nano-instrumentation in Coherent scattering beamline

IXS beamline, X-ray Raman spectrometer --- Qiankun

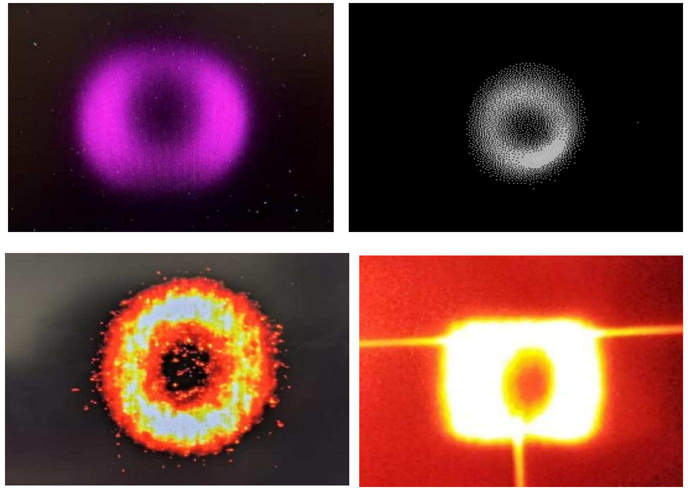
4 round SR beam commissioning

All 15 BLs under commissioning

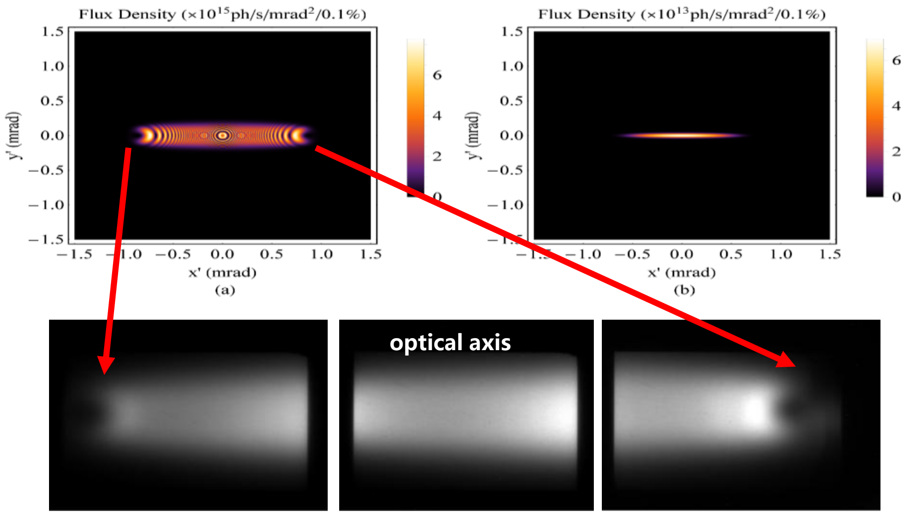
- **1st round: 2024.10.10.-2024.10.31.** 22Days， **4 BLs,** BL21I-HXI, BL44B-Tender, BL46U-XAFS, BL42I-Test beamline
- **2nd round: 2025.01.22.-2025.01.25.** 4Days, **+3BLs**, BL09U-Coherence, BL08U-Pink SAXS, BL30U-Imageing
- **3rd round: 2025.04.10.-2025.04.11.** 2Days, **+5BLs,** BL07U-Engineering M, BL19U-Nano, BL33U-Raman, BL31U-HP, BL02U-Protein
- **4th round: 2025.04.28.-2025.05.20.** 22Days, **+3BLs,** BL23U-Dynamic, BL05-LODISP, BL46U-ARPES



Locate the optical axis based on beam distribution characteristics



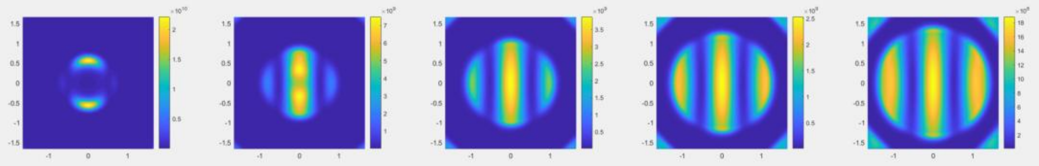
For all undulator beamlines, the optical axes are located by using redshift ring through monochromators or crystal diagnostic instruments.



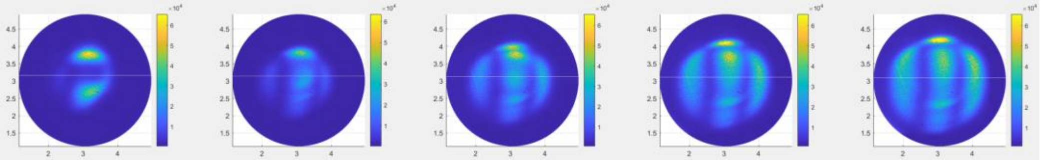
For wiggler beamlines, the optical axes are located by using a special low-energy distribution on fluorescent screen.

Light source characterization and diagnosis

Simulated

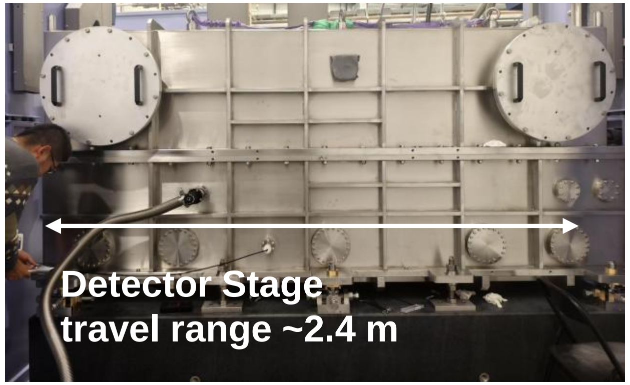


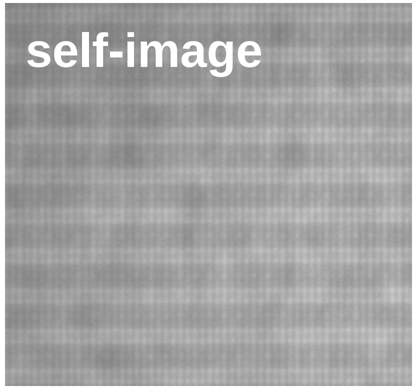
measured

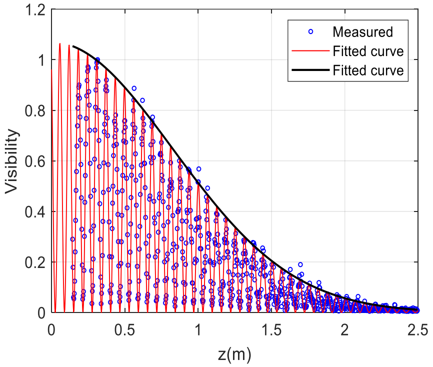


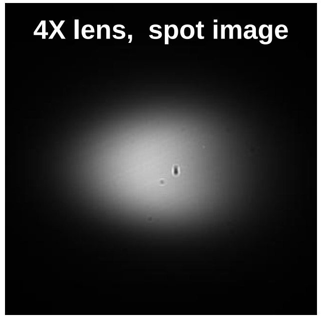
The crystal diagnostic instrument is used for the characterization of undulator radiation, such as the locating of optical axis, the measurement of phase error, and calibration of tapering and the optical alignment.

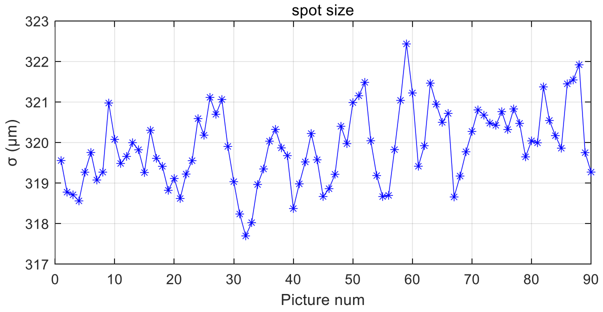
The grating interferometer is used for the measurement of source size and instability











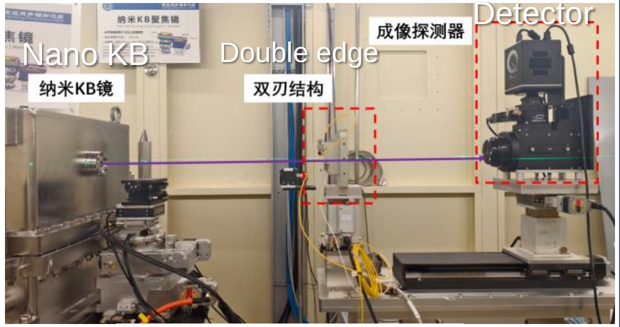
	Measurement1	Measurement6	Measurement7
σ_x (μm)	20.9	20.4	20.3

$\boldsymbol{\sigma_x \sim 20.63\ \mu m}$ **(diffraction effect included)**

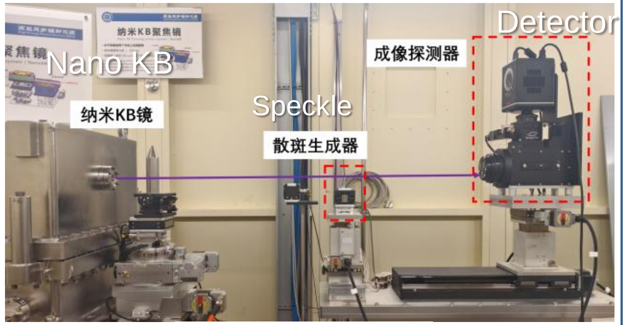
$\boldsymbol{emittance\text{:}\ \ 97.74\ \mathrm{pm\cdot rad}}$

Double checked by KB mirror imaging-based measurements

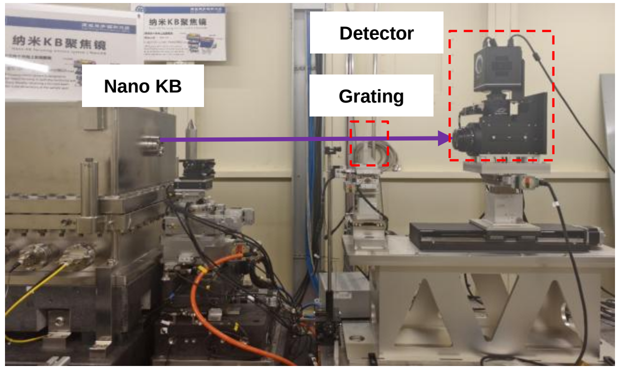
Wavefront for the adjustment of nano-focusing



Double-edge Method

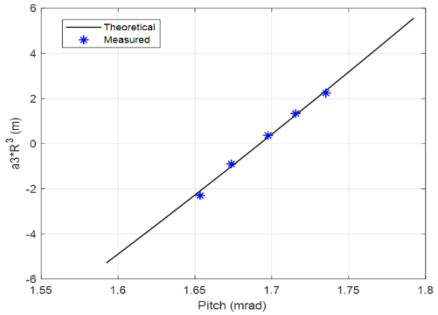


Speckle Method

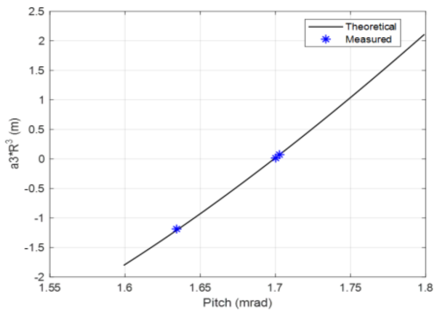


Grating Method

Coma aberration of wavefront

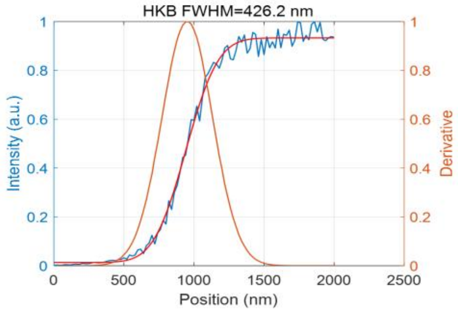


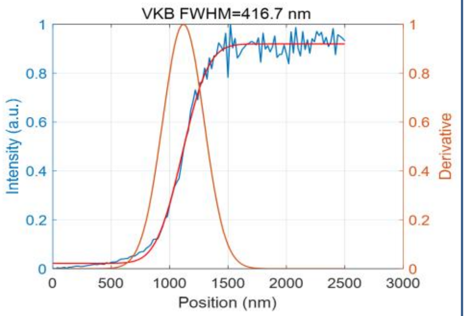
B8-VKB



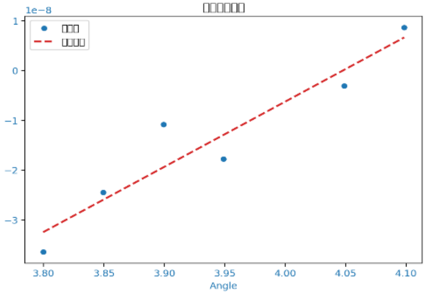
B8-HKB

B8-KB focusing



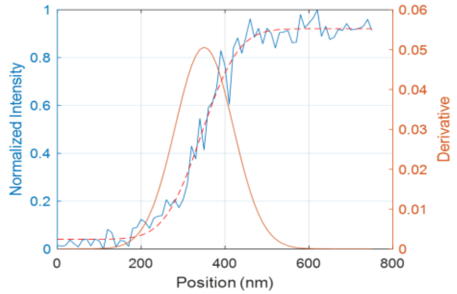


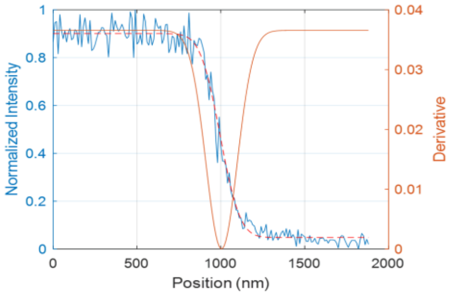
Spherical aberration of wavefront



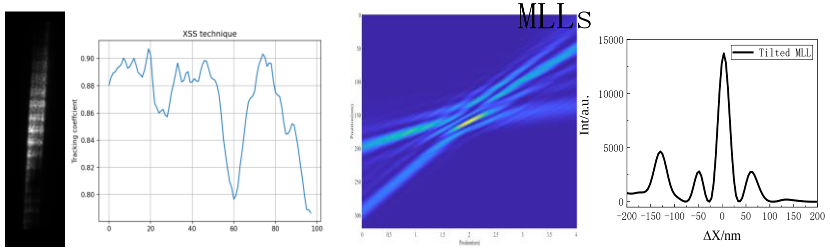
B6-VAKB

B6-KB focusing

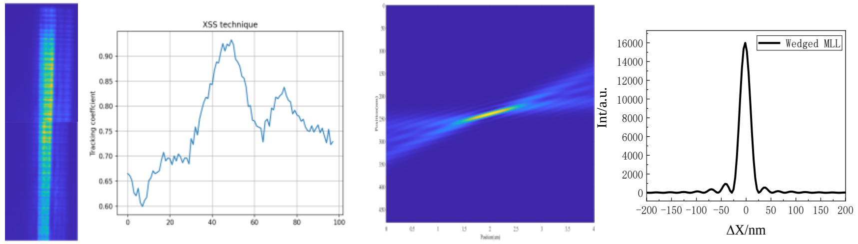




Wavefront metrology and inversion for MLLs



Tilted MLL FWHM=26 nm

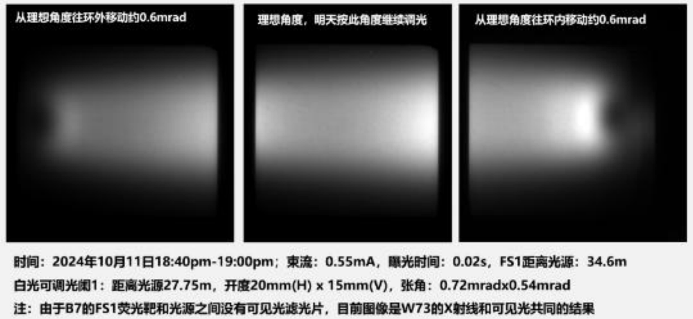


Wedged MLL FWHM=21 nm

Photon Beam Commissioning BL21I

Hard X-ray imaging beamline is the longest beamline in the HEPS Phase I, with the distance from the sample to light source being approximately 330m.

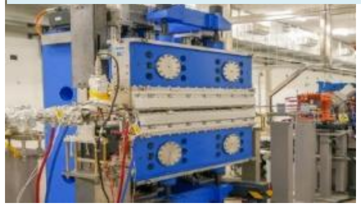
- high-quality X-rays with high energy up to 300keV
- SRX in-line phase contrast imaging and diffraction contrast imaging methods
- engineering materials and components, biomedical science, geology and archaeology



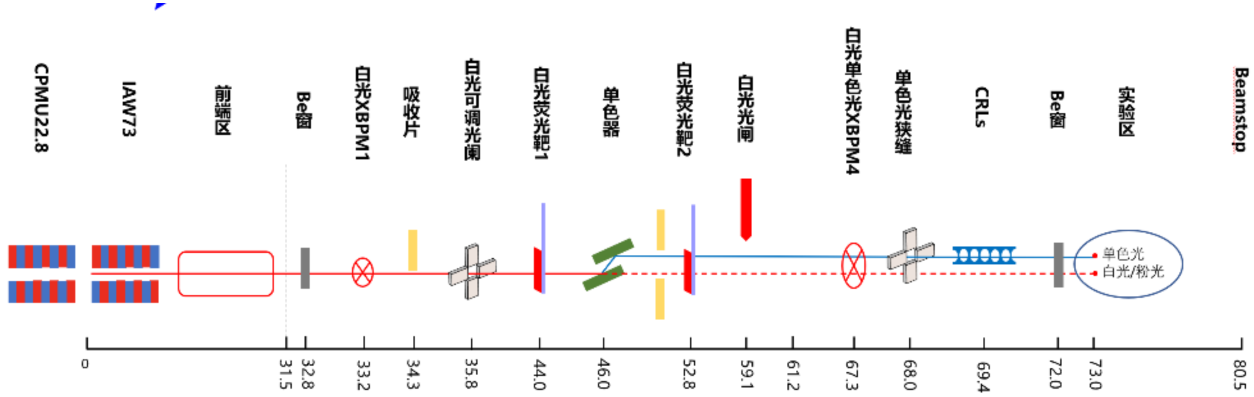
On October 12, 2024, the SR X-ray emitted from the R21 wiggler was successfully transmitted to the end station of the hard X-ray imaging beamline, 330 meters away form the light source.

Imaging Experiments on sample of high-temperature alloys conducted.

Wiggler Source	Front end	Optical hutch	BL tunnel	end station

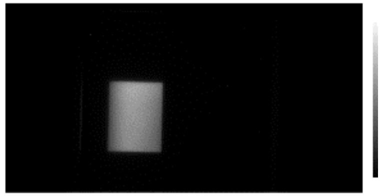


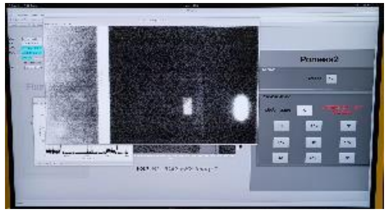
Photon Beam Commissioning G1 BLs

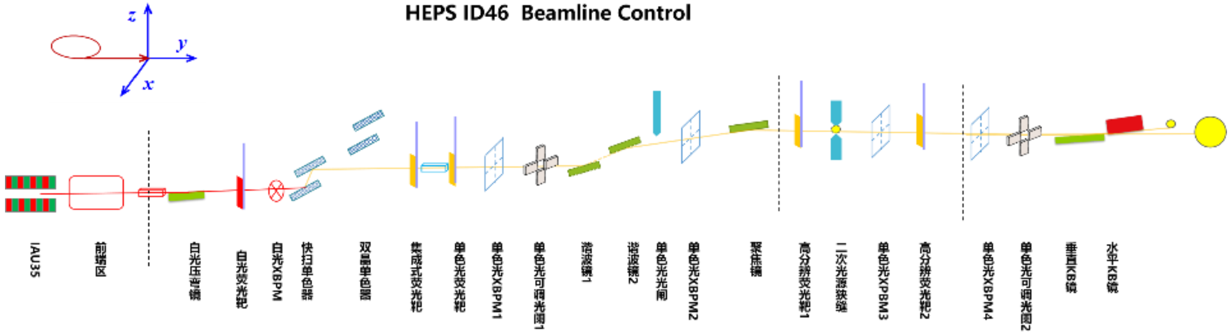


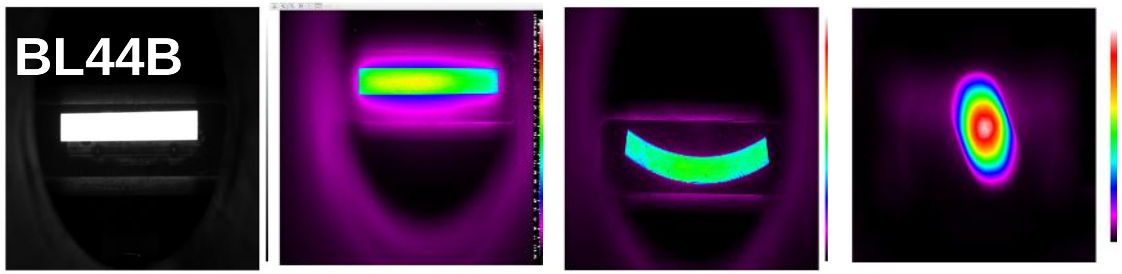
BL42I Test Beamline

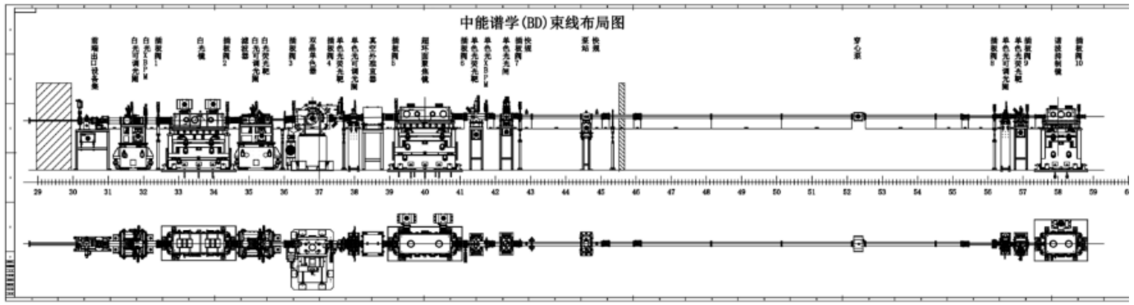
Oct. 31, 1st Mono X-ray beam



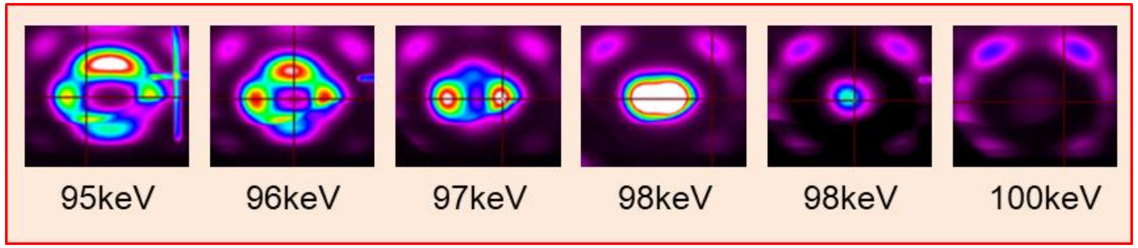




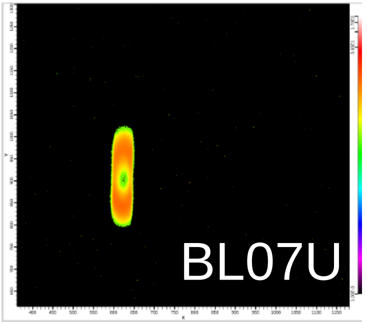


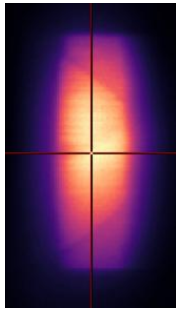


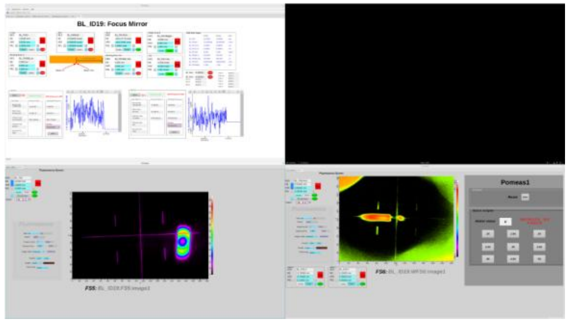
4^{th} round: ALL BLs entered SR beam commissioning phase

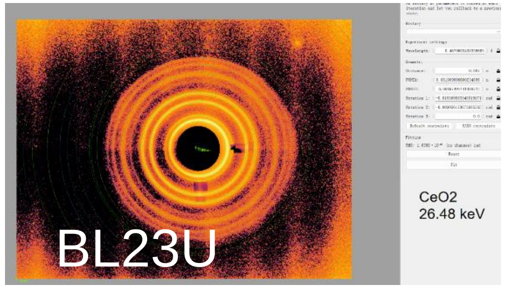


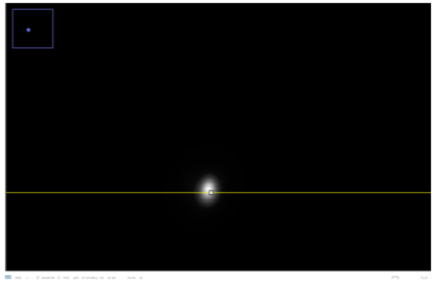
BL07U

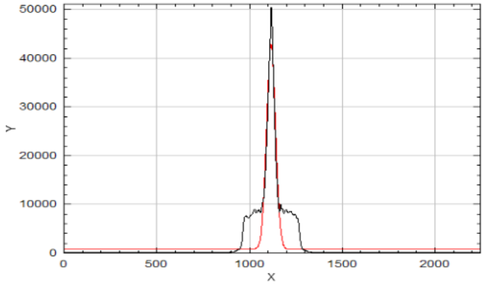


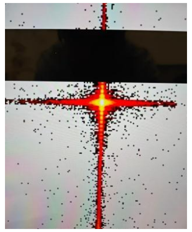


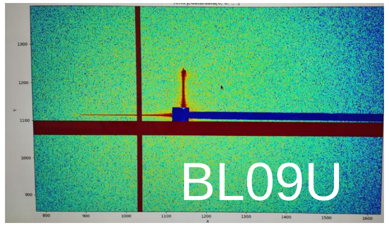


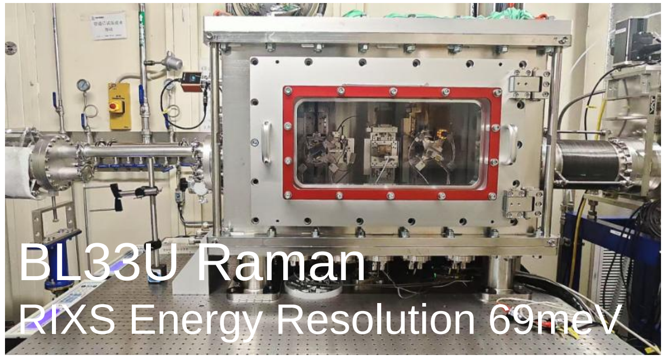


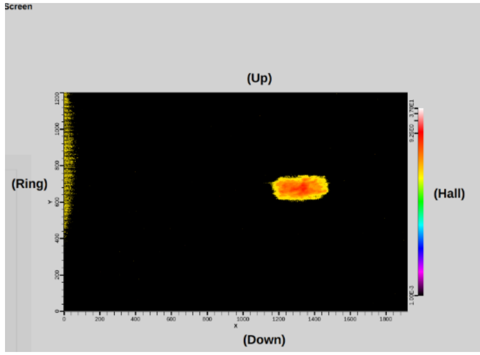


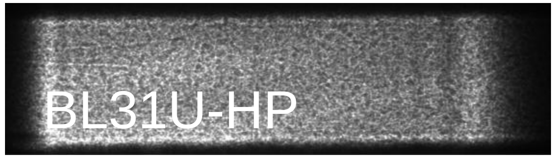




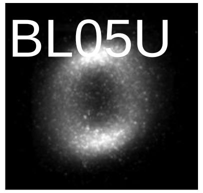




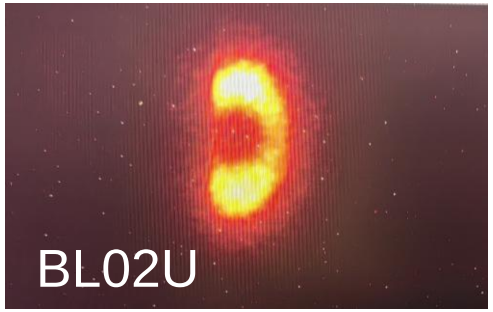




05.02



05.19

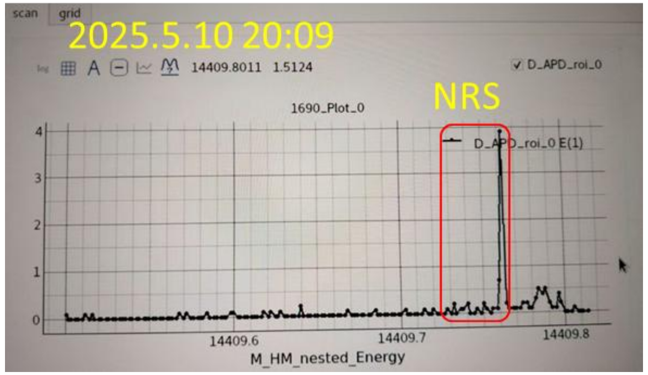


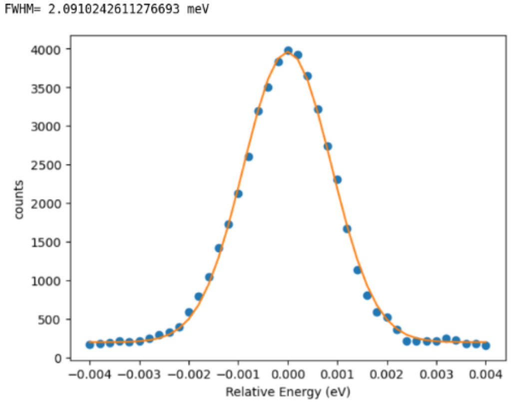
Preliminary commissioning results

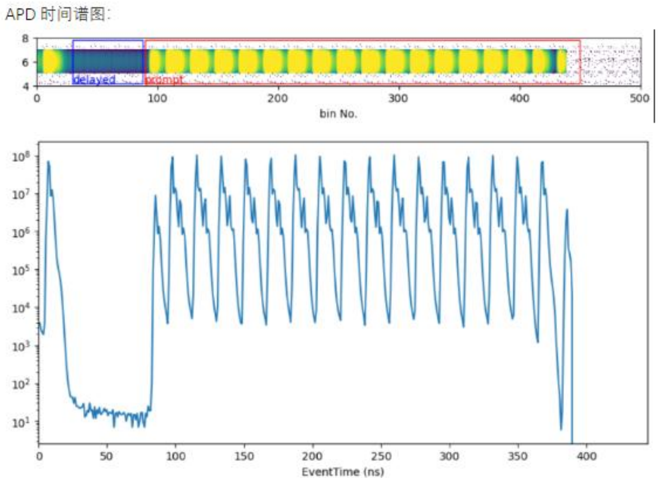
BL33U-Raman

APD detector, NRS

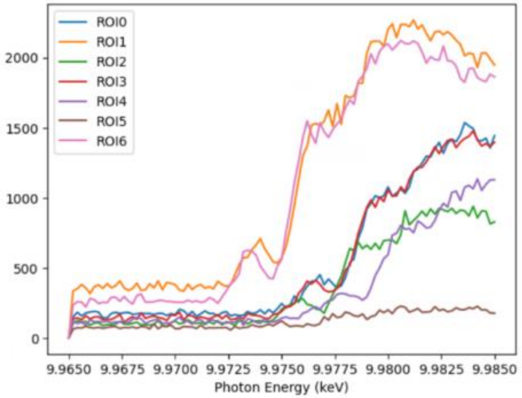
2meV resolution for NRS





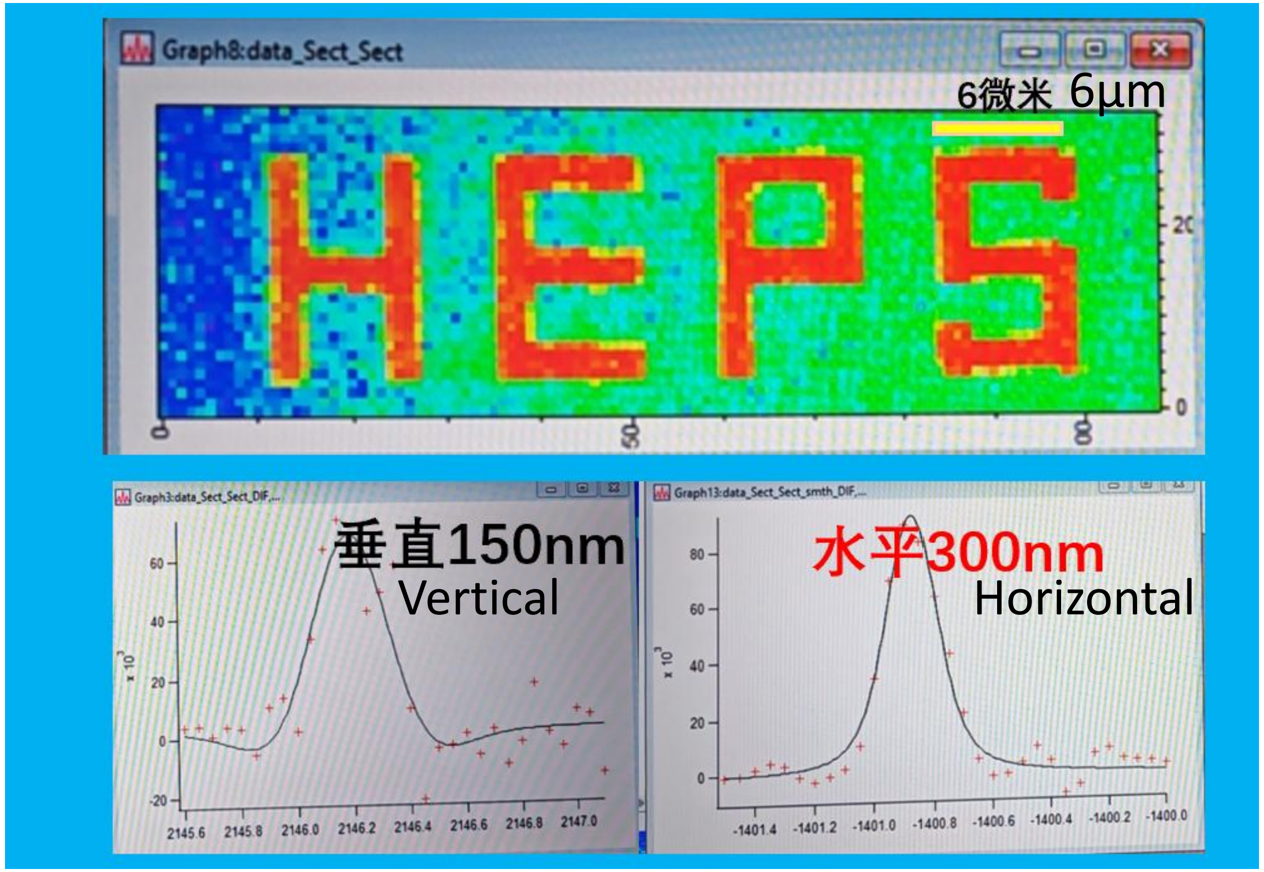


X-ray Raman spectroscopy



BL41U-ARPES Nano ARPES scanning imaging

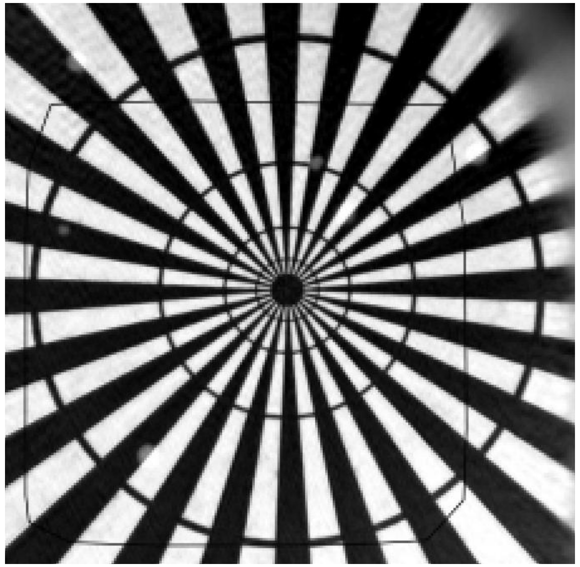
Photon Energy@900eV

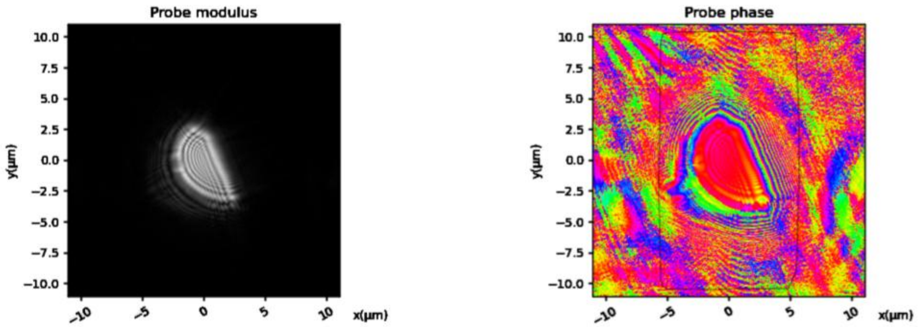


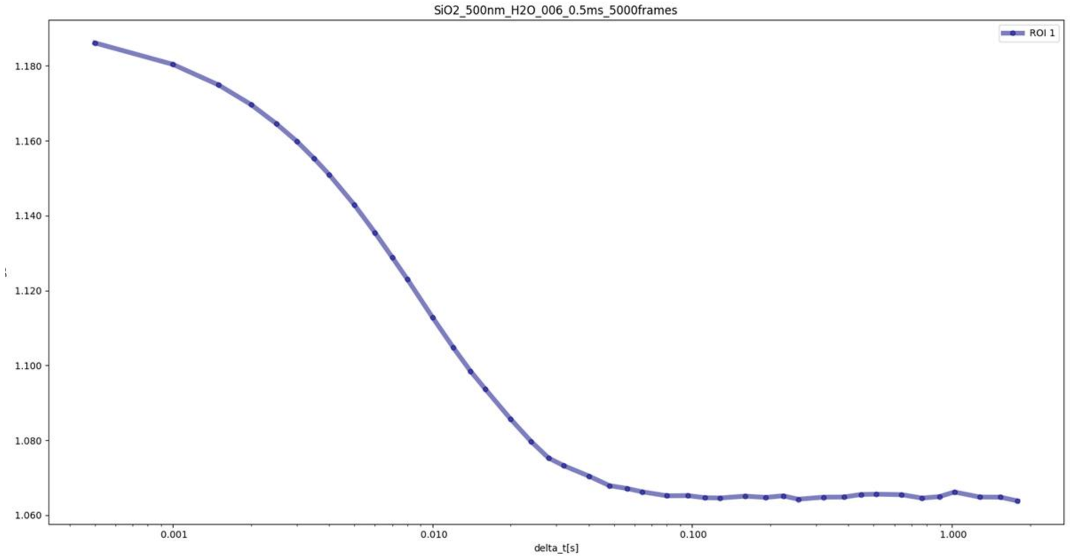
BL09U-Coherent Scattering BL

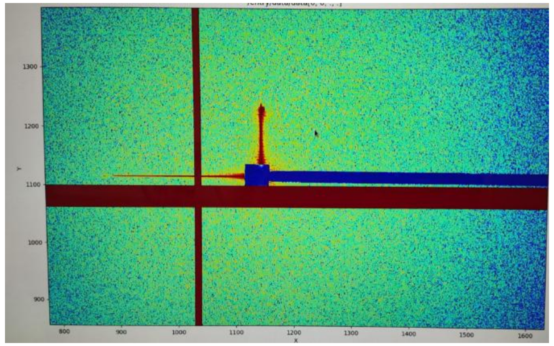
Pinhole-Ptychography, Resolution<50nm

XPCS dynamic sample experiment: 0.5 ms



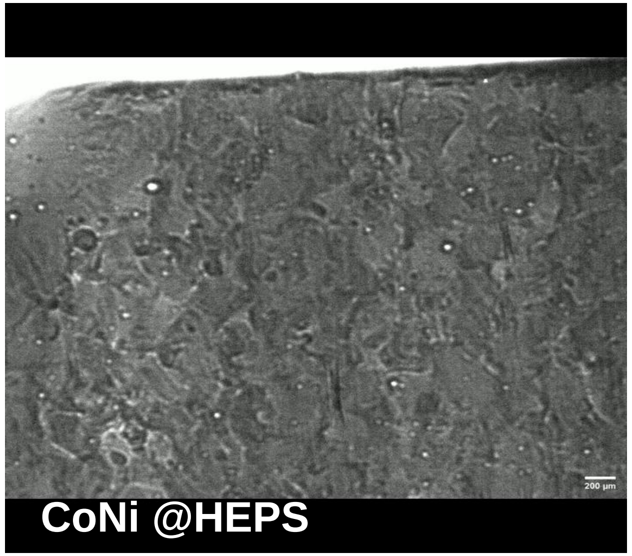


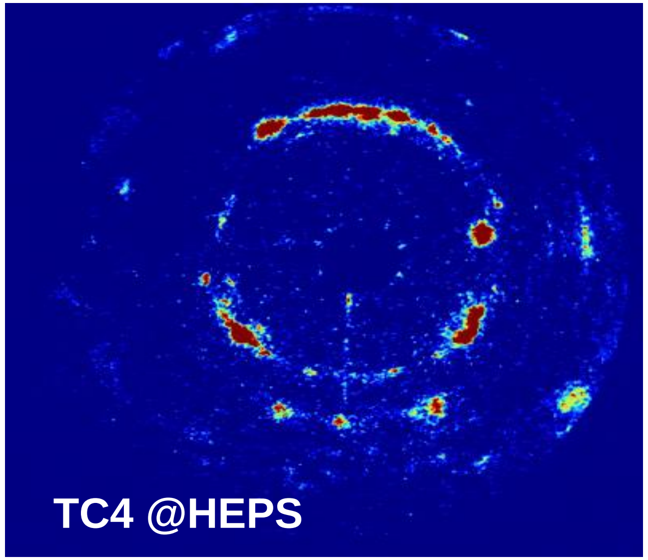


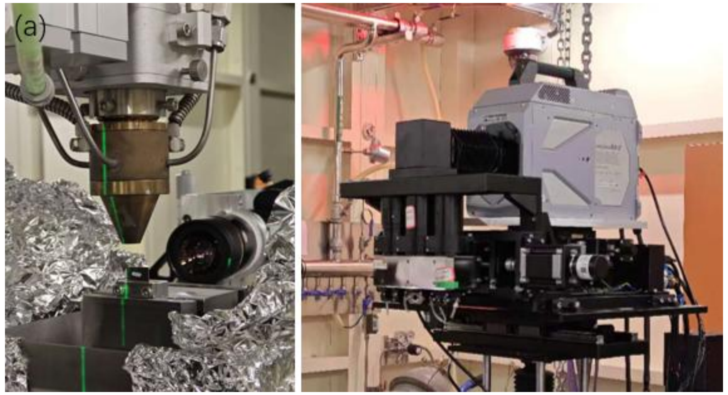


Preliminary commissioning results

Ultra-fast time-resolved imaging and diffraction at **BL23U-Dynamic beamline**

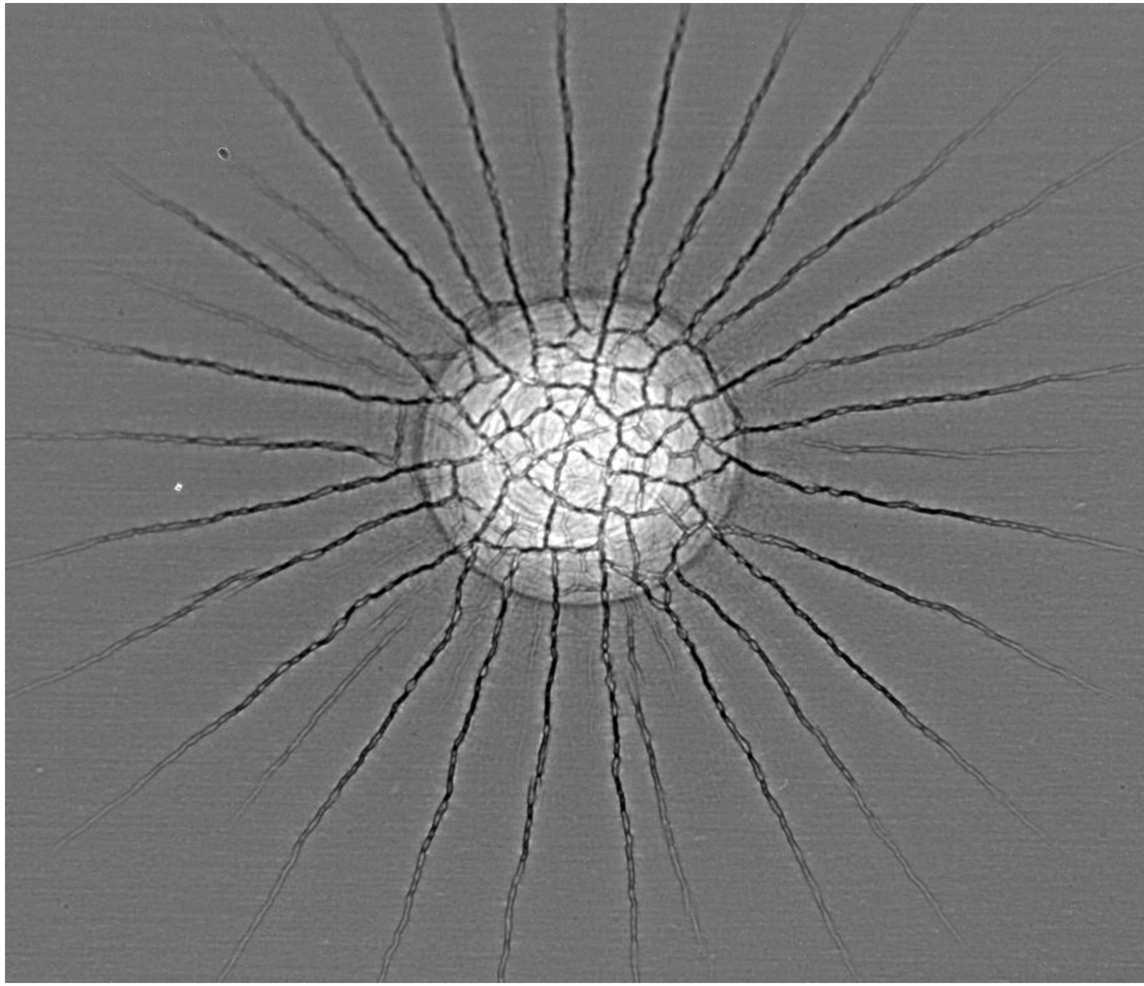




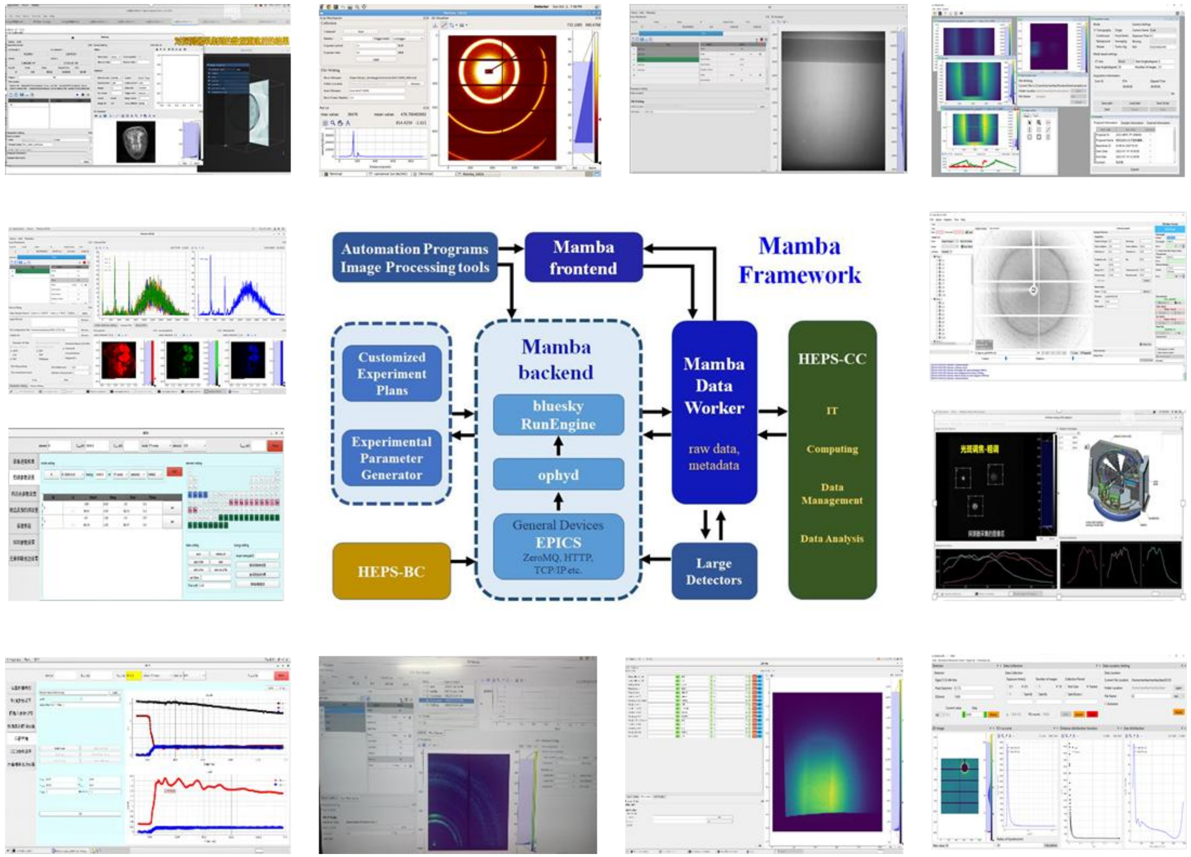


The in-situ process of additive manufacturing

Crack detection by high energy X-ray phase contrast imaging at **BL21I –HXI Beamline**



A new generation experiment operating software system (Mamba)



One Framework

Support 15 beamlines in Phase I project

and future beamlines

One Ecosystem

cover full synchrotron methods and experiment modes

Mamba: a systematic software solution for beamline experiments at HEPS. ***Journal of Synchrotron Radiation***, 2022

A High-Throughput Big Data Orchestration and Processing System for HEPS, ***Journal of Synchrotron Radiation***, (2023).

HEPS Phase II

HEPS phase II

- Preparing science cases and Project Proposal for the next 5-year plan
- Multiple reviews underway

✓ Criteria for HEPS beamline selection: Scientific and Industrial questions as well as cutting-edge experimental methods motivated in 4GSR.

✓ Upon schedule of insertion installation, without impeding the operation of existing BLs, 4-5 ID installed per year

✓ 30 BLs to be built in Phase II

✓ Organizing institutionalization research teams/projects based on HEPS

✓ Materials

✓ Chemistry (Dynamic properties of catalysis)

~**90** Total capacity

14 IDs**+ 3** BMs Phase I

~**15** IDs**+ 15** BMs Phase II

Strongly correlated systems

Science drives

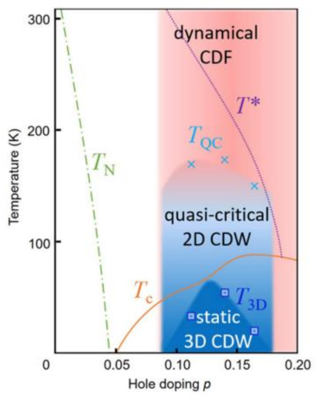
Technical difficulties

Microscope mechanism of unconventional superconductivity

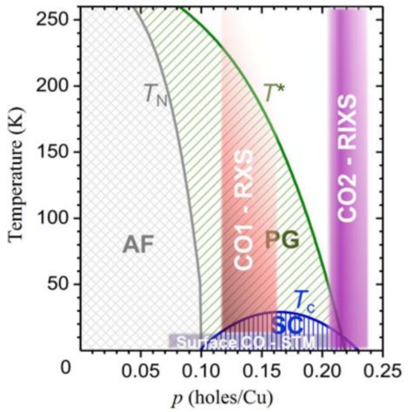
Phase diagram of unconventional superconductivity

Origin, chirality and dynamics of CDW/SDWs and nematicity

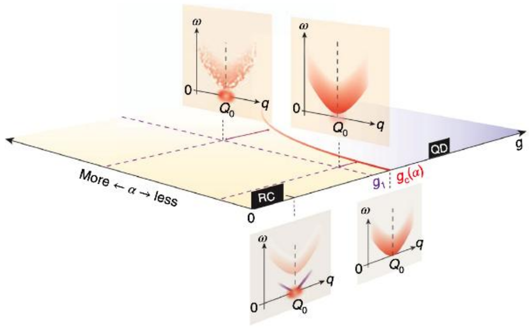
Quantum fluctuation and criticality



Science **365**, 906-910 (2019)



Nature Materials **17**, 697–702 (2018)

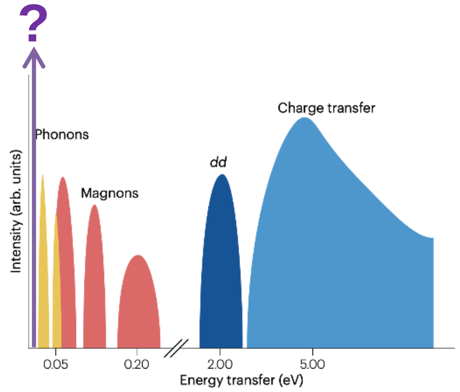


Nature Physics **17**, 53–57 (2021)

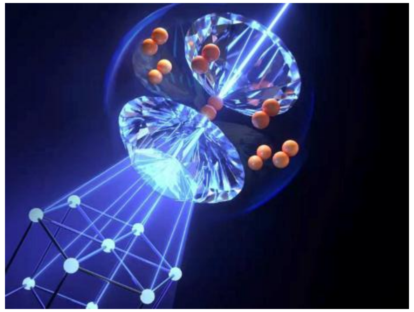
?

Ultra-high resolution

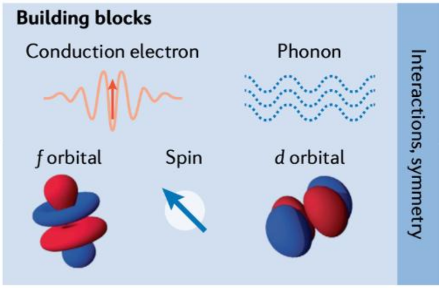
in energy, space or time scale



Any detection under extreme conditions



Sensitivity to degrees of freedom and their interactions



Beamline Clusters

8 beamline clusters for 31 beamlines proposed

Material Science	Condensed Matter	Chemistry	Environment	Energy	Biomedicine	Industrial	Tech frontier
• Operando, Insitu, Service span	• Phonon measurement, strongly correlated systems, high energy and momentum resolution	• Coordination, valence state in 3D and high spatial resolution	• Surface and interface in nanoscale, aging and decomposition mechanism	• Battery mechanism in nano and microscale, interaction and reaction mechanism and regulation	• New medicine, high throughput screeing, Connectomics and Brain imaging, Organ Atlas	• Additive manufacturing, semiconductor, Enginnering materials	• Exploration in frontier and cutting-edge techs

HEPS phase II： Accelerator part

Providing fundamental support for HEPS-II

- New insertion devices for the new beamlines

•New RF cavities to compensate more energy loss

•Updated cryogenic and diagnostics, timing control devices

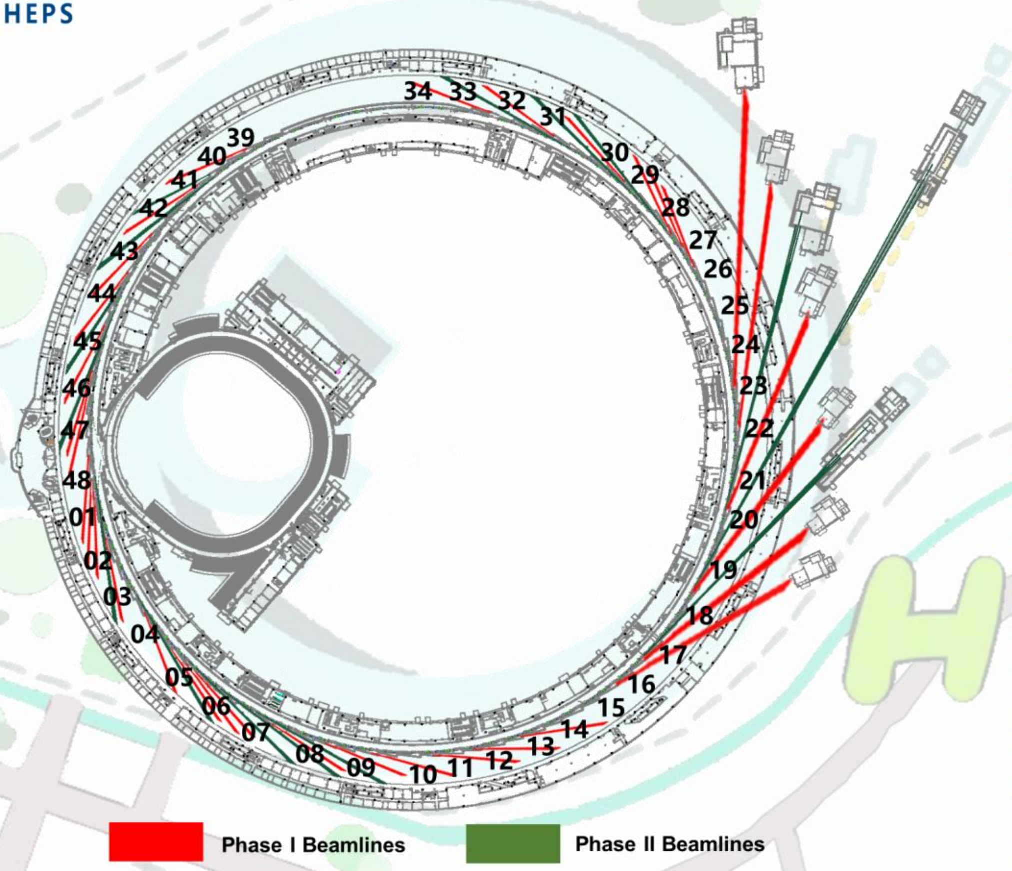
Upgrades for improved photon performance

- Beam parameter fluctuation compensation and longitudinal injection
- "Intelligent accelerator" upgrade and beam test platform for future new light source methods and mechanisms.

Layout of Beamline Clusters

高能同步辐射光源
High Energy Photon Source | HEPS

39I-X ray diagnostic	
40I-Soft RIXS	Condensed Matter
41I-Nano-ARPES	Condensed Matter
41B-General PES	Condensed Matter
42I-Optical Test	Tech frontier
43I-HE-NRS	Condensed Matter
44I-Magnetic Material	Condensed Matter
44B-Tender X-Ray	Chemistry
46I-XAFS	Chemistry
46B-High-throughput XAFS	Chemistry
47I-X-ray Chemical Imaging	Chemistry
48B-Time resolved XAFS	Chemistry
01I-Time-resolved Crystallography	Chemistry
01B-H-T Crystallography Fragment Screening	Biomedicine
02I-Microfocusing X-ray Protein Crystallography	Biomedicine
02B-Visible Light Diagnostic	
04B-EDXRD	Materials
05I-Low-Dimension Structure Probe	Materials
05B-Comprehensive Material Research	Materials
06I-High Energy Total Scattering	Materials
06B-High Resolution Powder Diffraction	Materials
07I-Engineering Materials	Materials
08I-Pink Beam SAXS	Chemistry
08B-High Energy SAXS	Chemistry
09I-Coherent Scattering	Materials



34I-High Energy Resolution IXS	Condensed Matter
33I-High energy resolution Spectroscopy	Condensed Matter
32B-Magnetic Coherent Imaging	Condensed Matter
31I-High Pressure	Condensed Matter
30B-HP Synergic Method	Condensed Matter
30I-Transsimission X-ray Microscopy	Energy
29I-Energy Materials and Devices Multimodal Spectroscopy	Energy
28B-Energy Materials and Devices Multimodal Imaging	Energy
28I-High Energy Compton Scattering and Imaging	Energy
25I-Large Volume Press	Materials
24I-Length Metrology	Industrial
23I-Structural Dynamics	Condensed Matter
22I-Multiscale Diffraction imaging	Materials
21I-Hard X-Ray Imaging	Materials
20I-Biomedical 3D Imaging	Biomedicine
19I-Hard X-ray Nanoprobe	Tech frontier
18I-Pink Beam Coherent Scattering	Tech frontier
17I-High Energy XPCS	Tech frontier
14B-High-throughput Industrial Application SAXS	Industrial
13B-Multispectral X-ray lithography	Industrial
12B-Flat Samples 3DNondestructive Imaging	Industrial
11I-Microscopy	Environment
10I-Nano Coherent Surface Scattering and Imaging	Environment

Collaborations

HEPS in Huairou Science City (Beijing)

- World-class original innovation area
- A new highland for strategic and forward-looking basic research
- A key area of Comprehensive National Science Center
- An eco-friendly and livable innovation demonstration zone

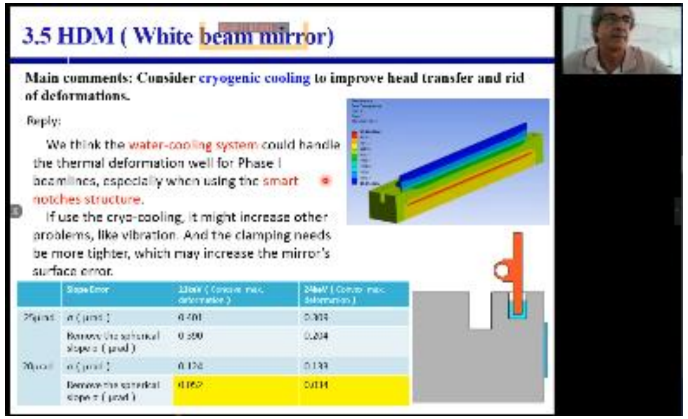
HEPS, SECUF (Synergized Extreme Condition User Facility), CMP Phase II (Chinese Meridian Project Phase II), EarthLab (the Earth System Numerical Simulation Facility), Multimodal Cross-Scale Biomedical Imaging Facility, HOPE (Human Organ Physiopathology Emulation System)

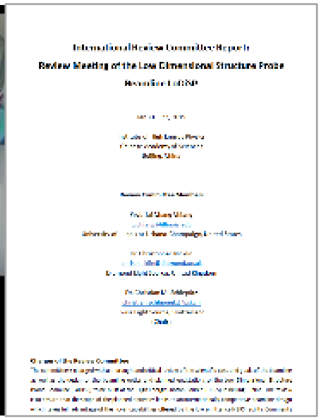
- **Series research platforms** in energy, environment, biology, materials, etc.

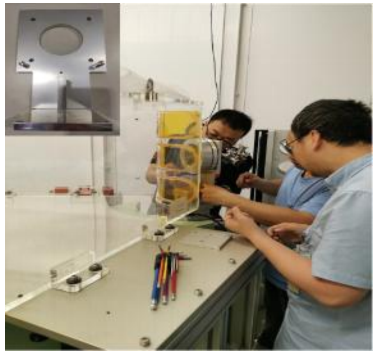
100.9 km^2 **6** large science facilities

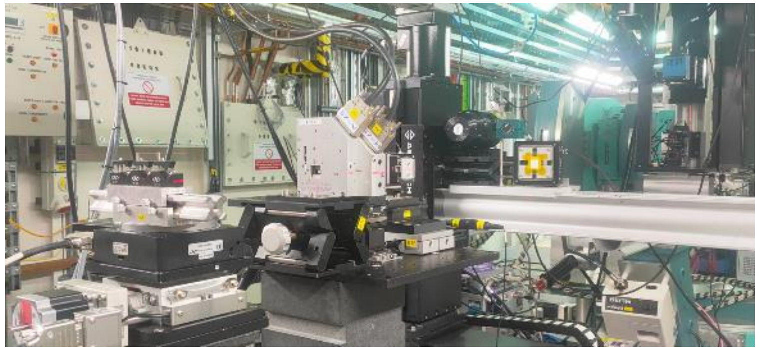
Beamline International Reviews

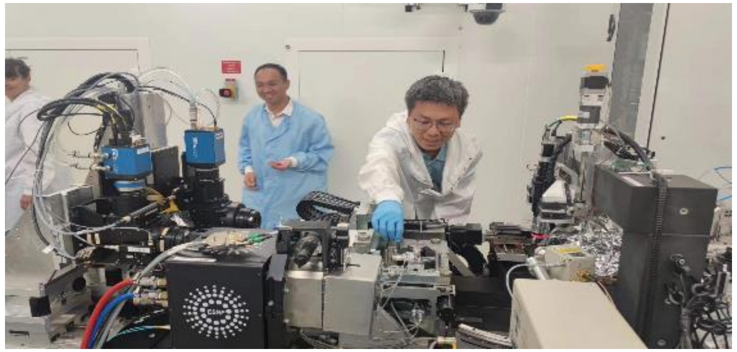
International reviews on optical design of beamline design, technology development











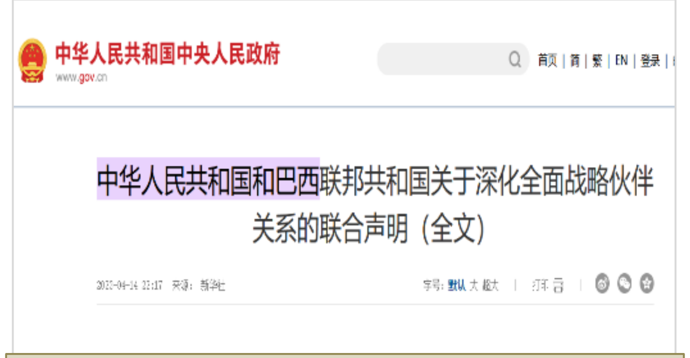
May 2023 SPring-8 HEPS Vacuum-Mounted Flat-Diced Analyzer RIXS

Sep. 2023 Diamond HEPS CRL tested online

June 2023 ESRF ID16B Ni-based alloy materials, holotomography, 6 shifts

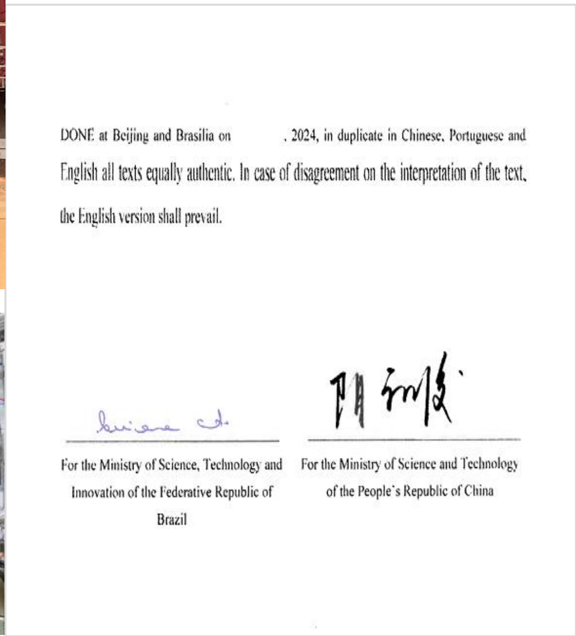
Collaborations

- MoU signed between HEPS and Sirius based on the joint statement on deepening comprehensive strategic partnership between China and Brazil in 2023.


中华人民共和国中央人民政府
www.gov.cn

中华人民共和国和巴西联邦共和国关于深化全面战略伙伴关系的联合声明（全文）

34. Recalling that Brazil is one of the few countries with fourth-generation synchrotron light technology and that China is also developing fourth-generation synchrotron light technology, the two parties will work together to develop the next generation of synchrotron technology. They welcomed the cooperation between the National Centre for Research in Energy and Materials (CNPEM) of the Ministry of Science, Technology and Innovation of Brazil (MCTI) and the Institute of High Energy Physics (IHEP) of the Chinese Academy of Sciences (CAS) for collaboration between Sirius and HEPS.


DONE at Beijing and Brasilia on , 2024, in duplicate in Chinese, Portuguese and English all texts equally authentic. In case of disagreement on the interpretation of the text, the English version shall prevail.

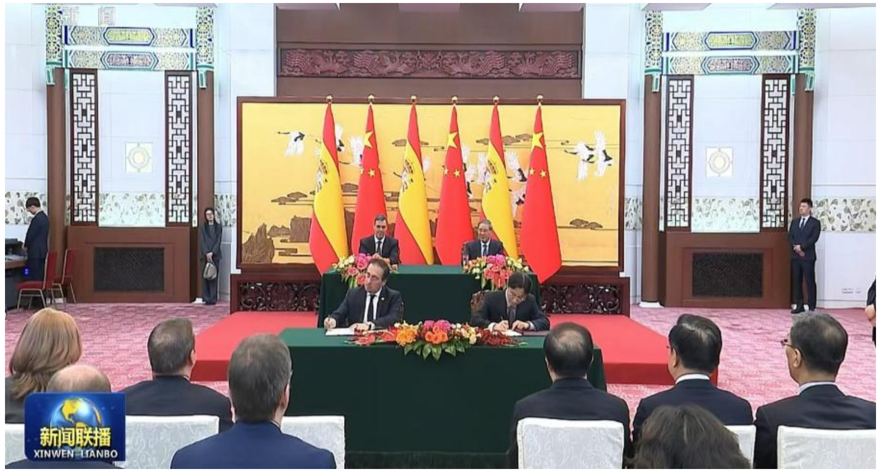
For the Ministry of Science, Technology and Innovation of the Federative Republic of Brazil

For the Ministry of Science and Technology of the People's Republic of China

- Agreement between two Ministries(MoST and MCTI) supporting the collaboration on 4th-Generatin light source

Collaborations

- **MoU between IHEP (HEPS) and Spanish CELLS (ALBA)** signed in 2025.04 witnessed by the two nations' prime ministers
- In Nov. 2024, **Spanish Secretary of State for Research, Innovation and Universities, Ministry of Science, Innovation and Universities(MICIU)** visited HEPS and stressed the collaboration.
- **HRH Princess Maha Chakri Sirindhorn** of Thailand Visits HEPS on April 13th, 2025, which was her fourth visit to IHEP.

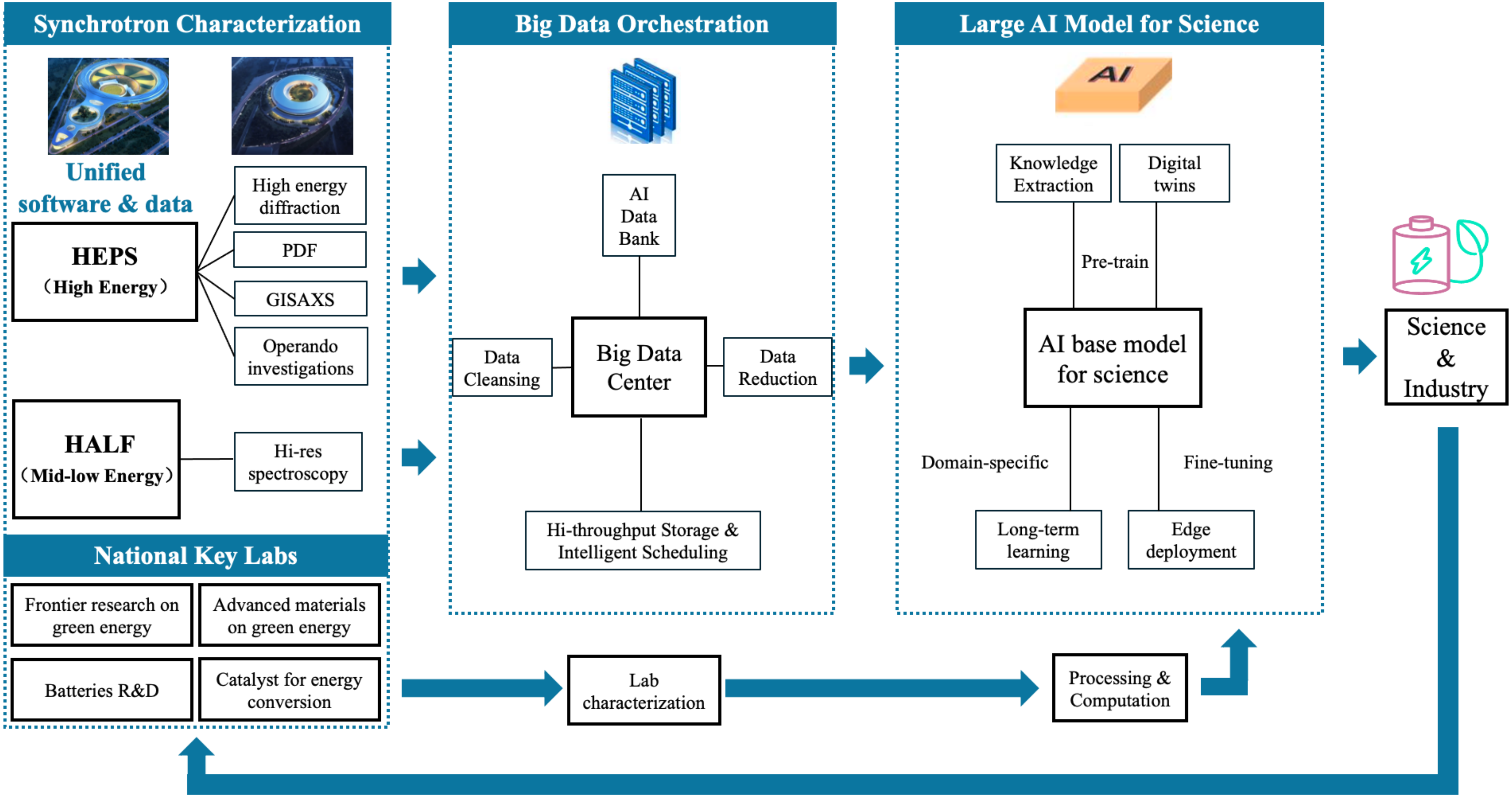


- IHEP signed MoU with DLS to cooperate on synchrotron radiation facility construction on April 17, 2019
- MoU between IHEP and NSRRC signed on Sep. 30, 2020.
- MoU between IHEP and RIKEN-SPring-8 was renewed in July, 2024.

International Advisory Committee

- Dec. 11-14, 2018, Beijing, 1st HEPS IAC Meeting (Chair: Pedro Fernandez Tavares, MAX-IV)
- Dec. 16-18, 2019, Beijing, 2nd HEPS IAC Meeting (Chair: Pedro Fernandez Tavares, MAX-IV)
- **Jan. 14-17, 2025, Beijing, 3rd HEPS IAC Meeting** (Chair: Harald Reichert, DESY)

AI for Science collaboration with other national Labs



International conferences and workshops

Nov. 6 to 10, 2023, Beijing

IBIC 2024--13th International Beam Instrumentation Conference

MEDSI2023--12th International Conference on Mechanical Engineering Design of Synchrotron Radiation Equipment and Instrumentation

LINAC 2018--29th Linear Accelerator Conference

Meeting Rooms, Hostel and Canteen in HEPS campus

Summary

- HEPS is a greenfield, 4th generation, high energy, ultra-low emittance SR facility. It is the key facility of Huairou Science City.
- A series of projects, HESP-TF, PAPS, Auxiliary building, are also carried on.
- Emittance 100pm·rad achieved. All of the beamlines under commissioning.
- Strong R&D capability on key technologies in both accelerator and beamline technology
- HEPS will be completed this year and Open to academic and industrial users globally in 2026
- HEPS open to the world to promote international collaborations.


A bright future of HEPS
Hope to see you at HEPS in 2026!

Thanks for your attention!