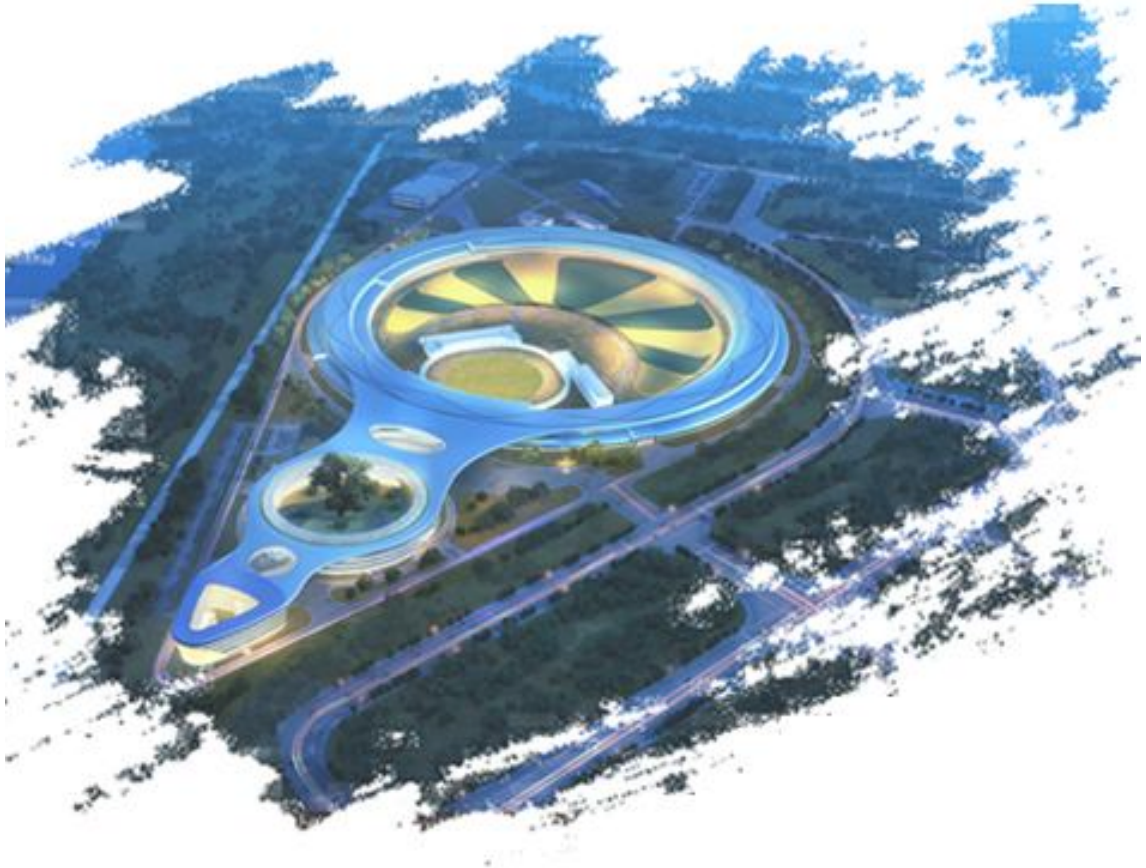
Status of HEPS

Yi JIAO

August. 6, 2025



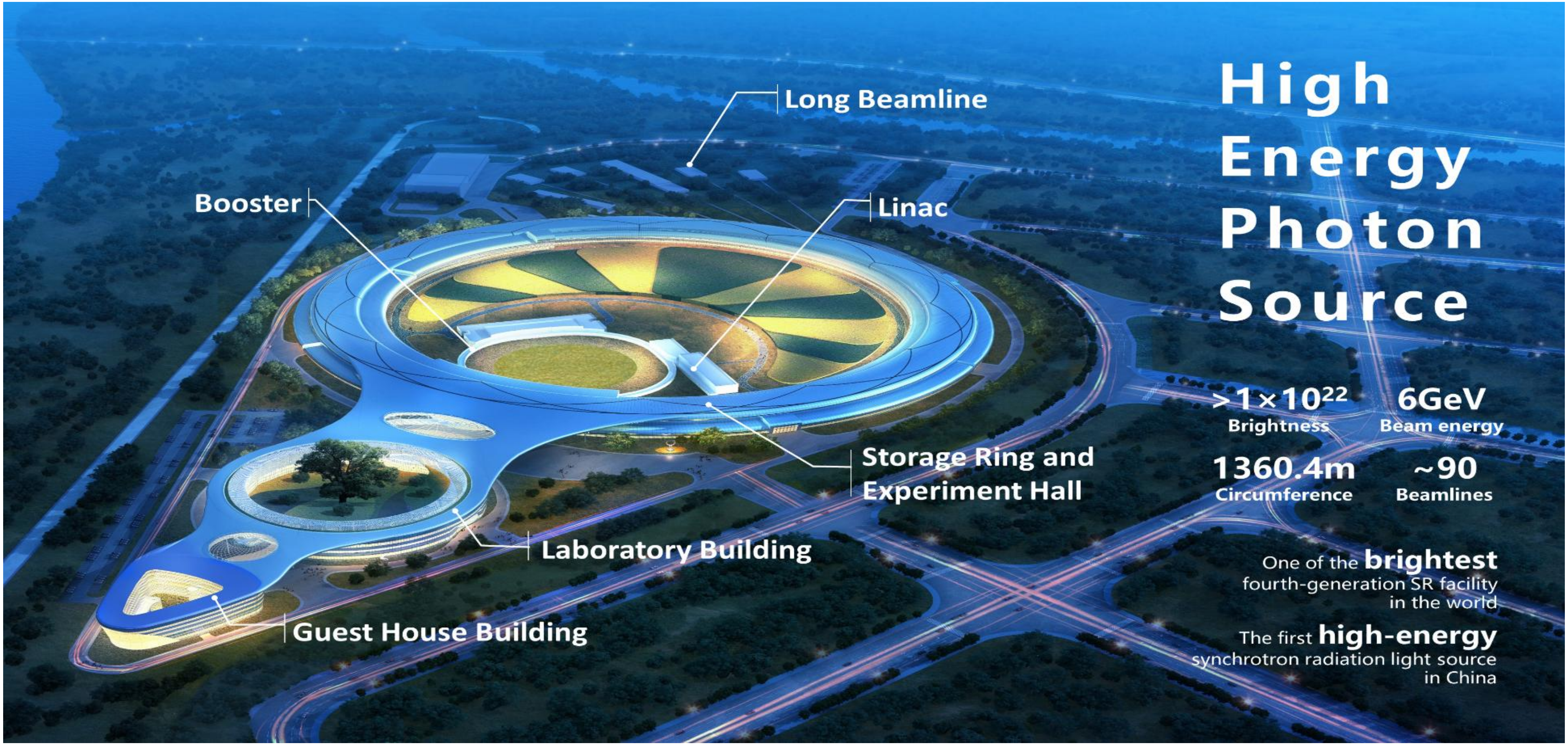
12th OCPA Accelerator School (OCPA-2025)

Outline

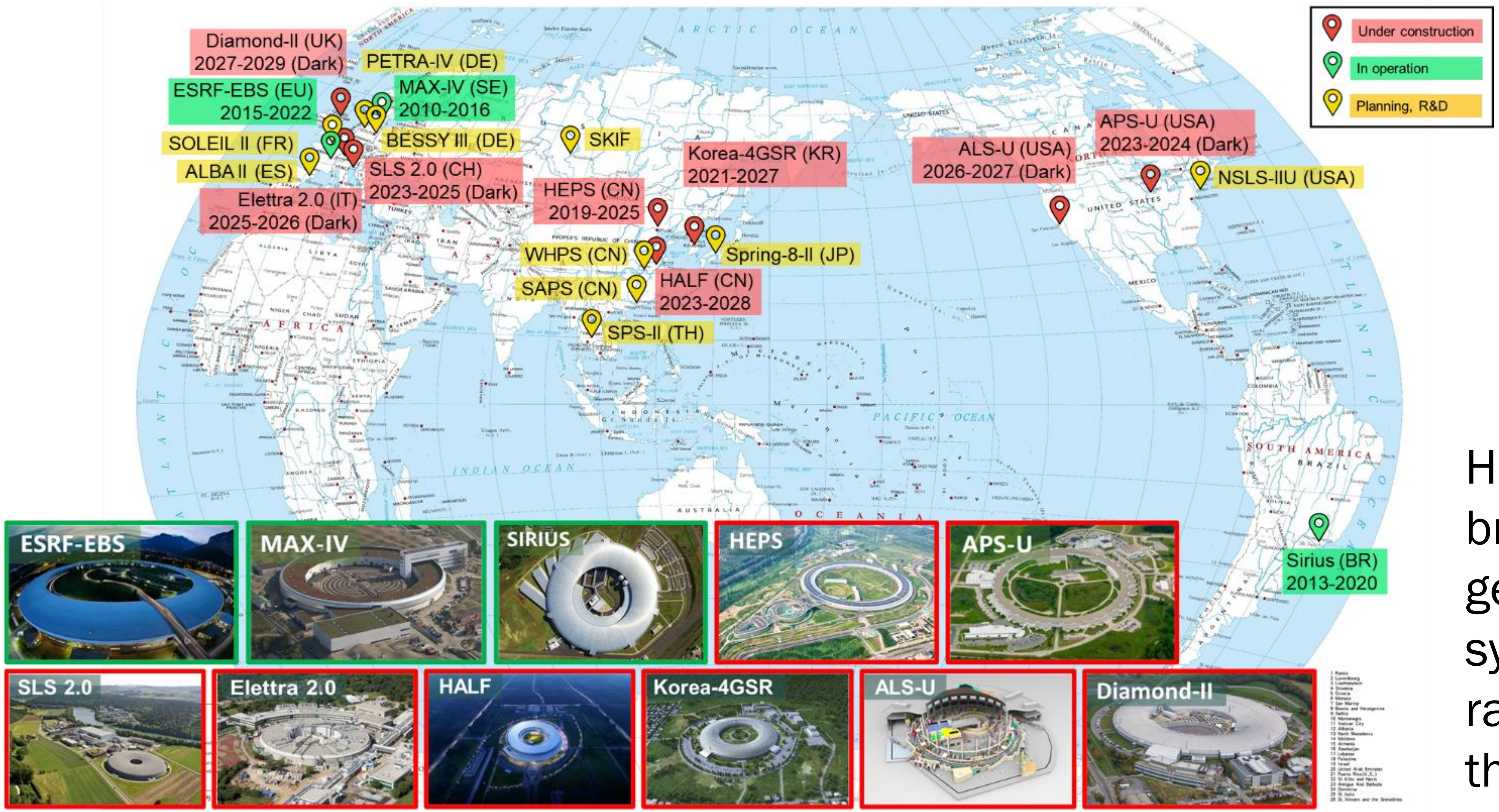
- HEPS overview
- HEPS accelerator
- HEPS status
- Summary

HEPS 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)

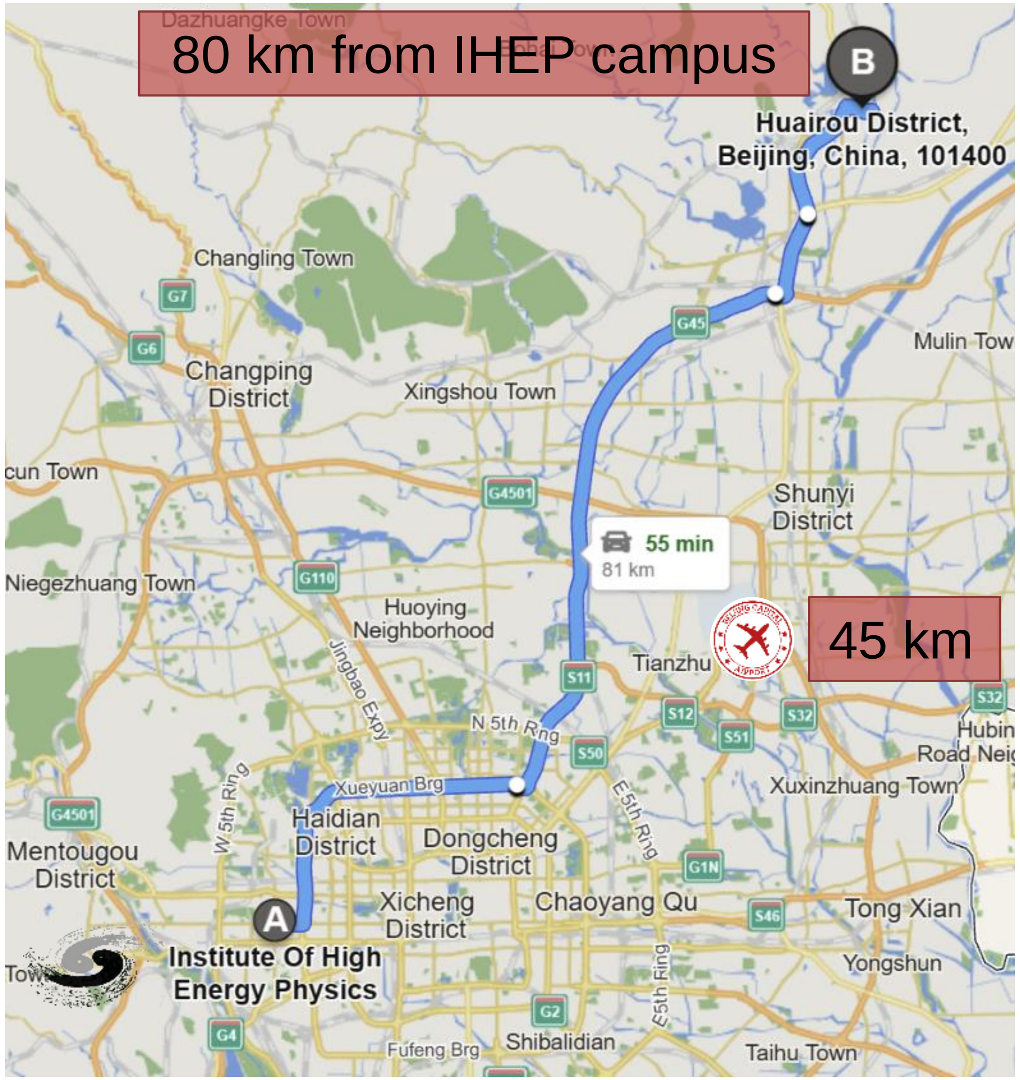
High Energy Photon Source

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）



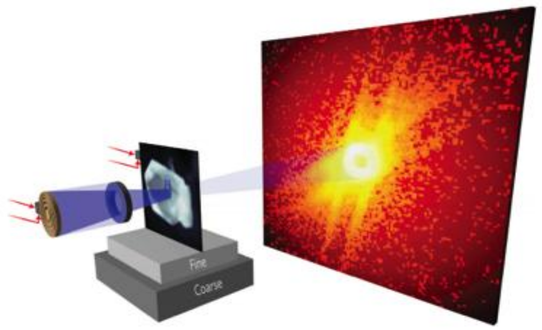
NDRC: National Development and Reform Commission

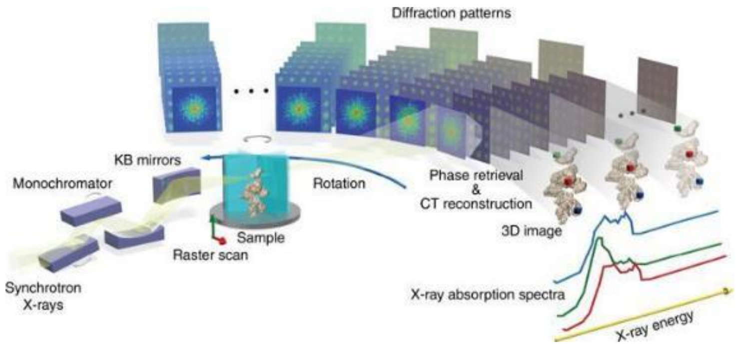
Powerful light sources

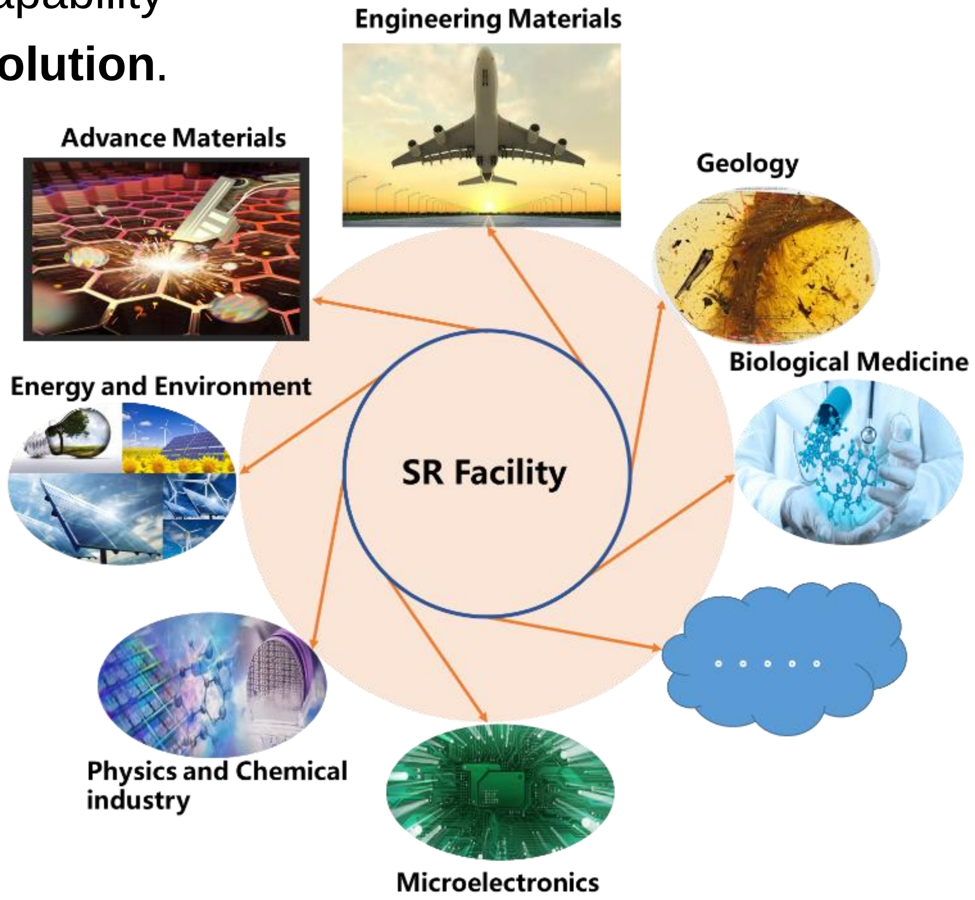
required with widely tunable frequency range from Infrared to X-rays !

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**.

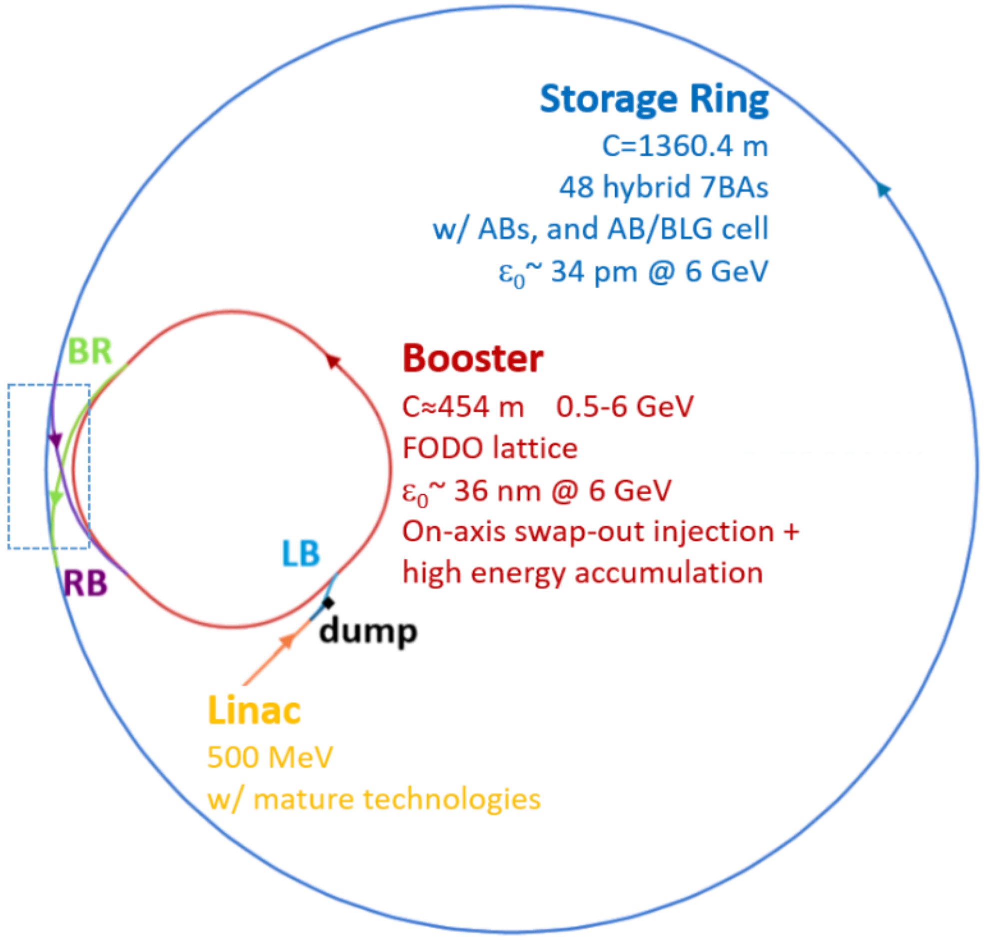
While providing conventional technical support for the general users, HEPS will operate as a platform to analyze the structures, as well as the evolution of structures of engineering materials in the whole process, by in-situ, multi-dimensional and real-time observation.







Main parameters: Accelerator



[1] Y. Jiao *et al.*, *J. Synchrotron Rad.* 25, 1611–1618 (2018).
[2] Y. Jiao, *RDTM* 4, 399 (2020).
[3] H. Xu *et al.*, *RDTM* 7, 279–287 (2023).

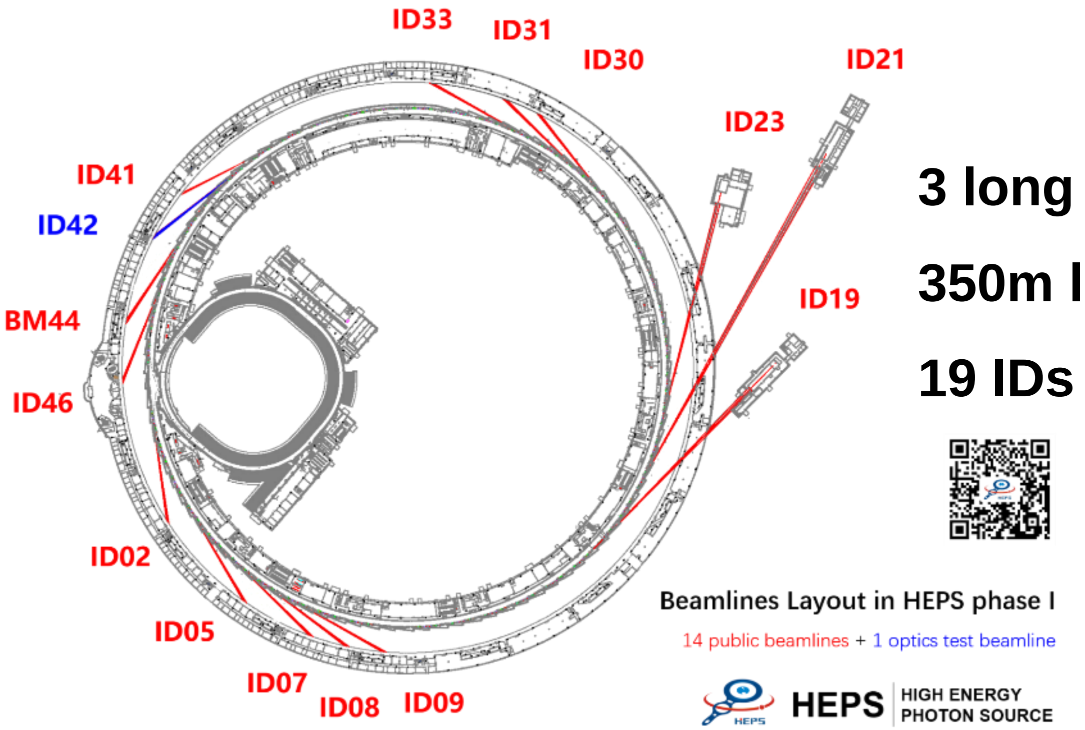
- **Accelerator complex**
  - Linac (500 MeV)
  - Booster (500 MeV to 6 GeV, 1 Hz)
  - Storage ring (6 GeV, top-up)

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

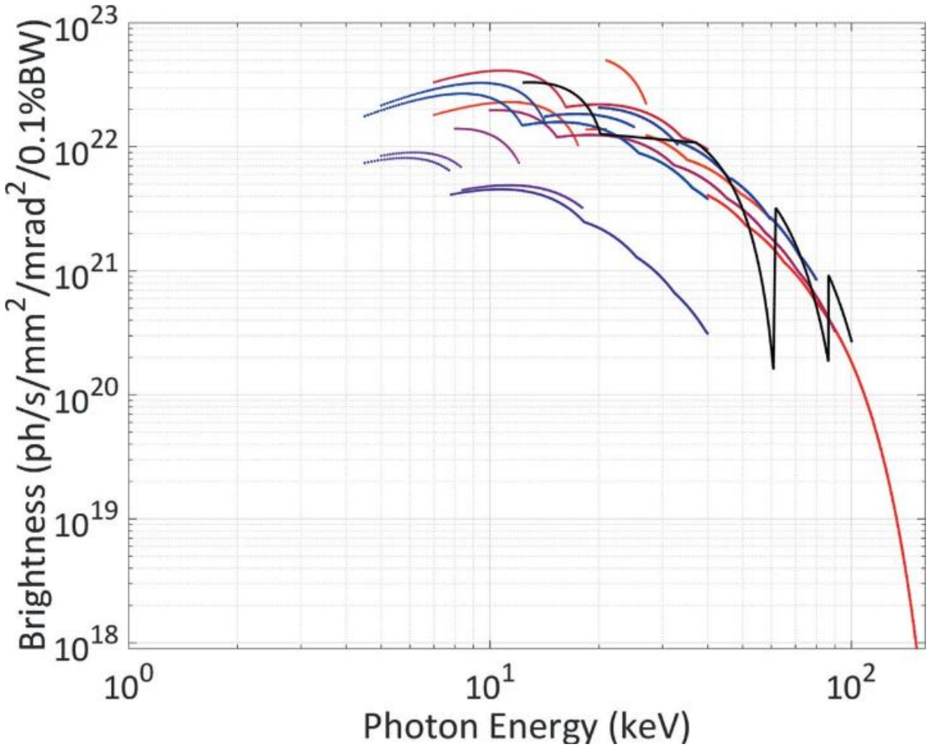
- Brightness of 5×10^{22} phs/s/mm^2/mrad^2/0.1%BW at the photon energy of 21 keV, can provide X-ray with energy up to 300 keV
- **14 user beamlines + 1 test BL** in Phase 1, HEPS can accommodate up to 90 BLs



3 long BLs

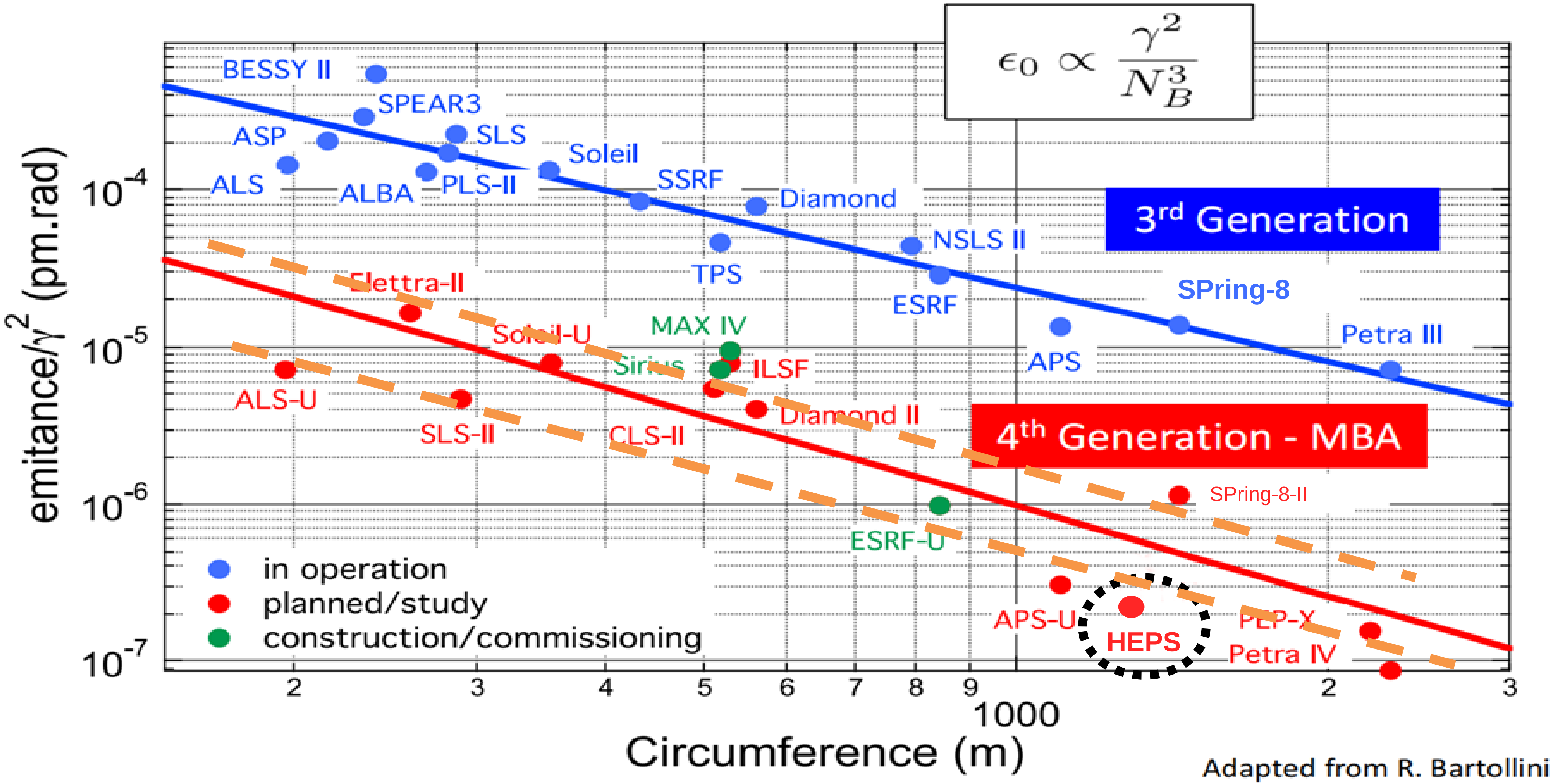
350m longest

19 IDs 6 types



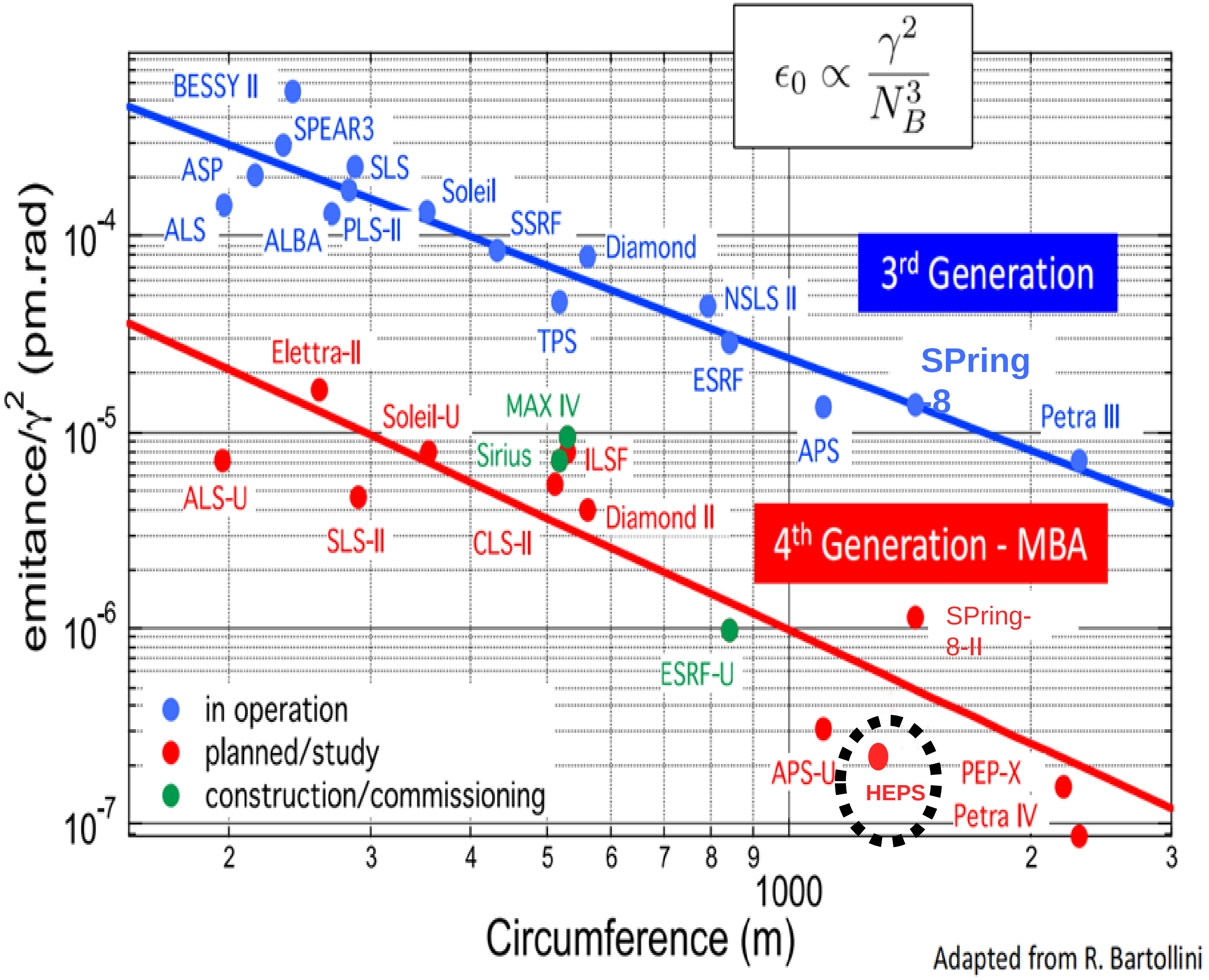
Y. Jiao *et al.*, *J. Synchrotron Rad.* 25, 1611–1618 (2018).

Emittance



L. Liu, H. Westfahl Jr., IPAC2017, TUXA1.

Emittance



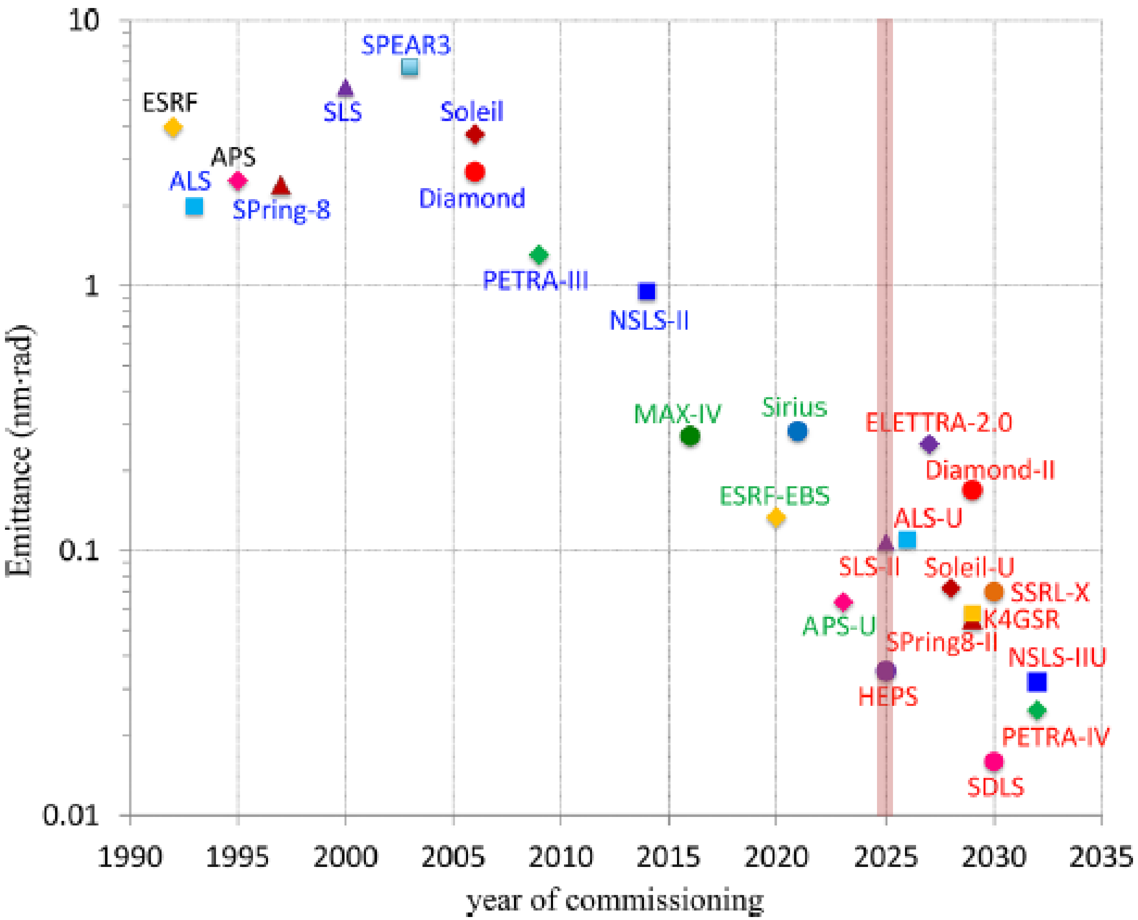


Figure 3
Evolution of the electron beam emittance in synchrotron light sources.

L. Liu, H. Westfahl Jr., IPAC2017, TUXA1.

V. Smaluk, JSR, 32, 595-604, 2025.

Brightness

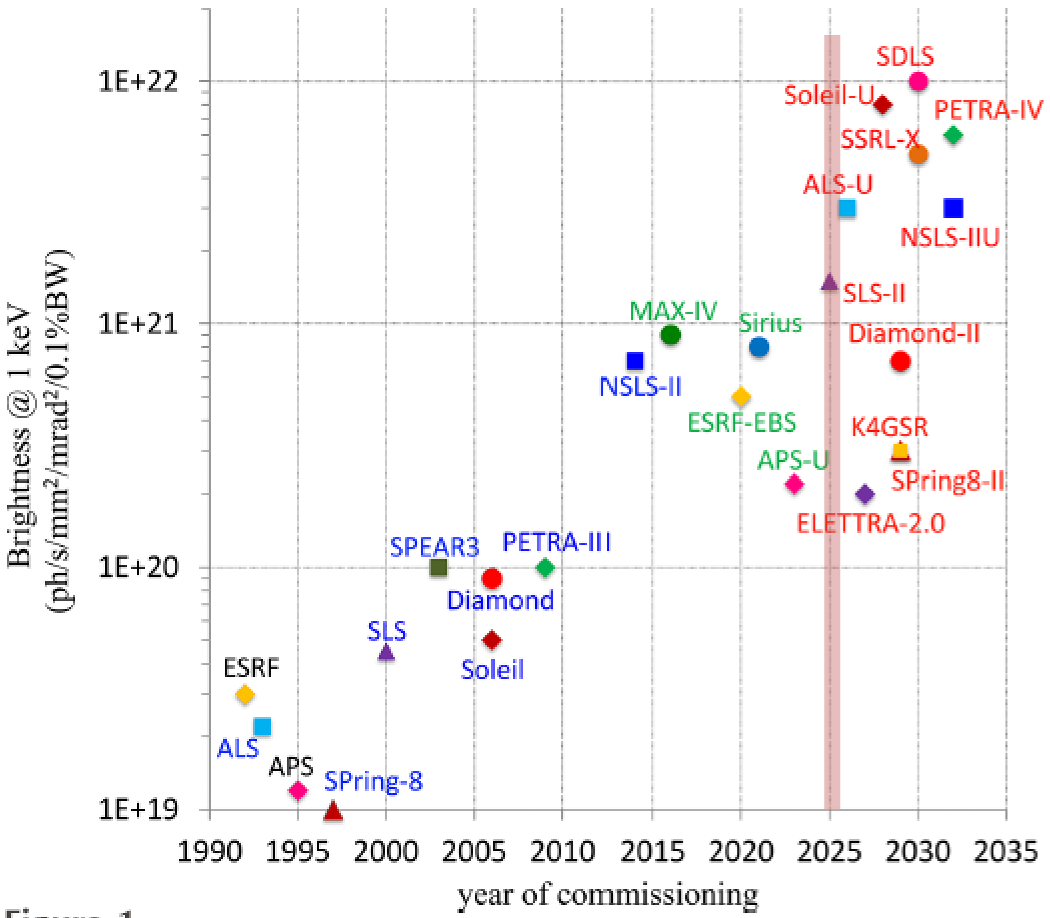


Figure 1
Evolution of brightness at 1 keV photon energy.

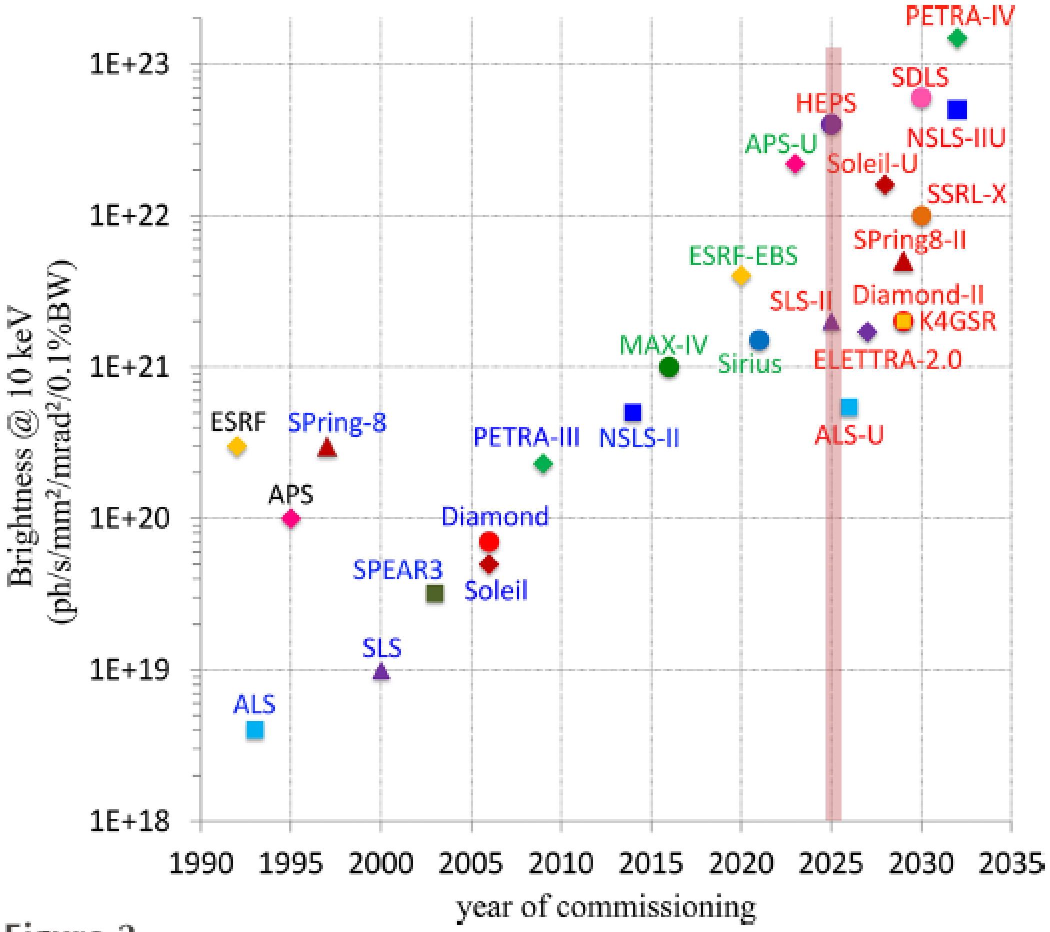
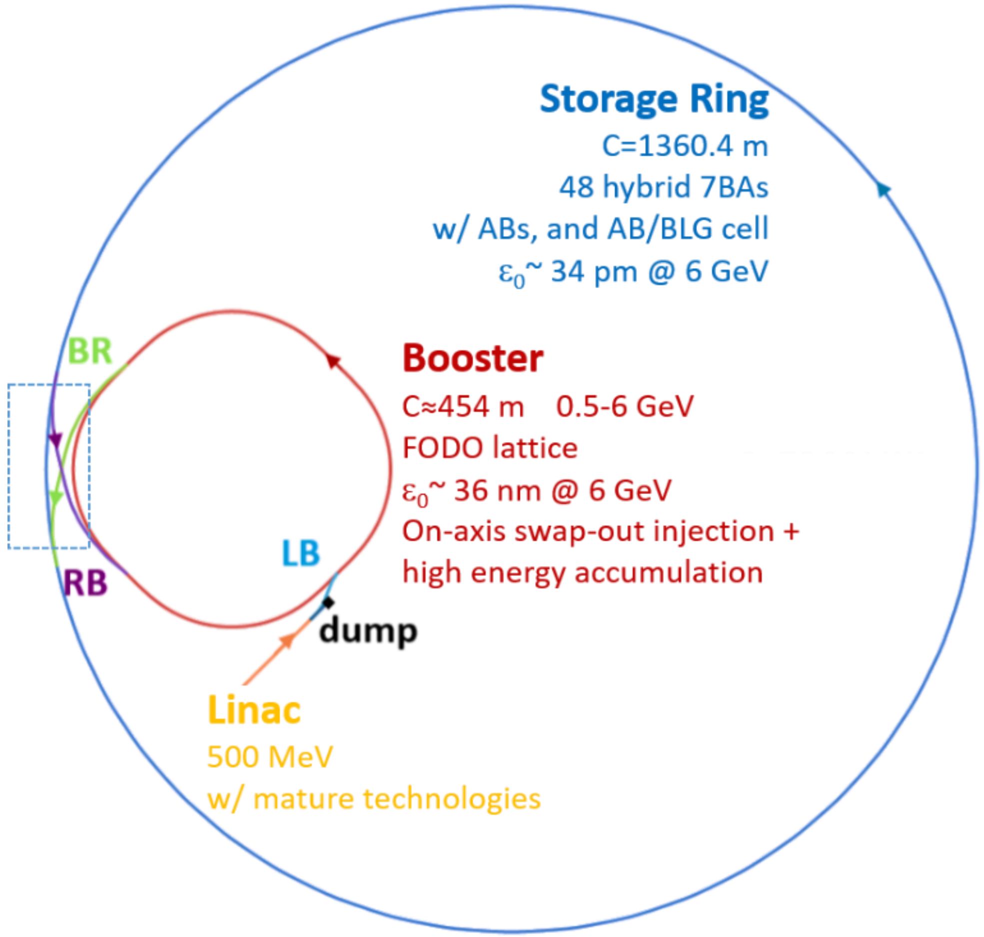


Figure 2
Evolution of brightness at 10 keV photon energy.

V. Smaluk, JSR, 32, 595-604, 2025.

HEPS Accelerator

HEPS Accelerator



- **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

[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).

Injector

Linac (high bunch charge 7 nC)

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.

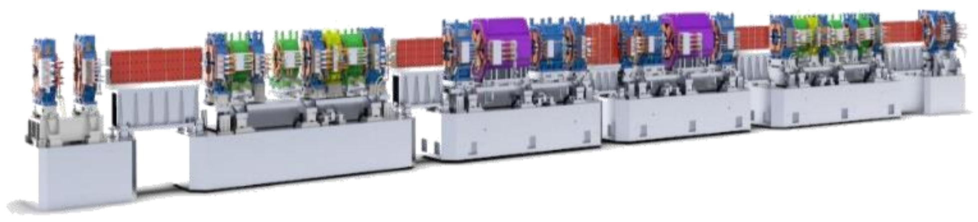
Booster (high bunch charge 5 nC)

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.

Storage Ring

the main component of the HEPS accelerator complex



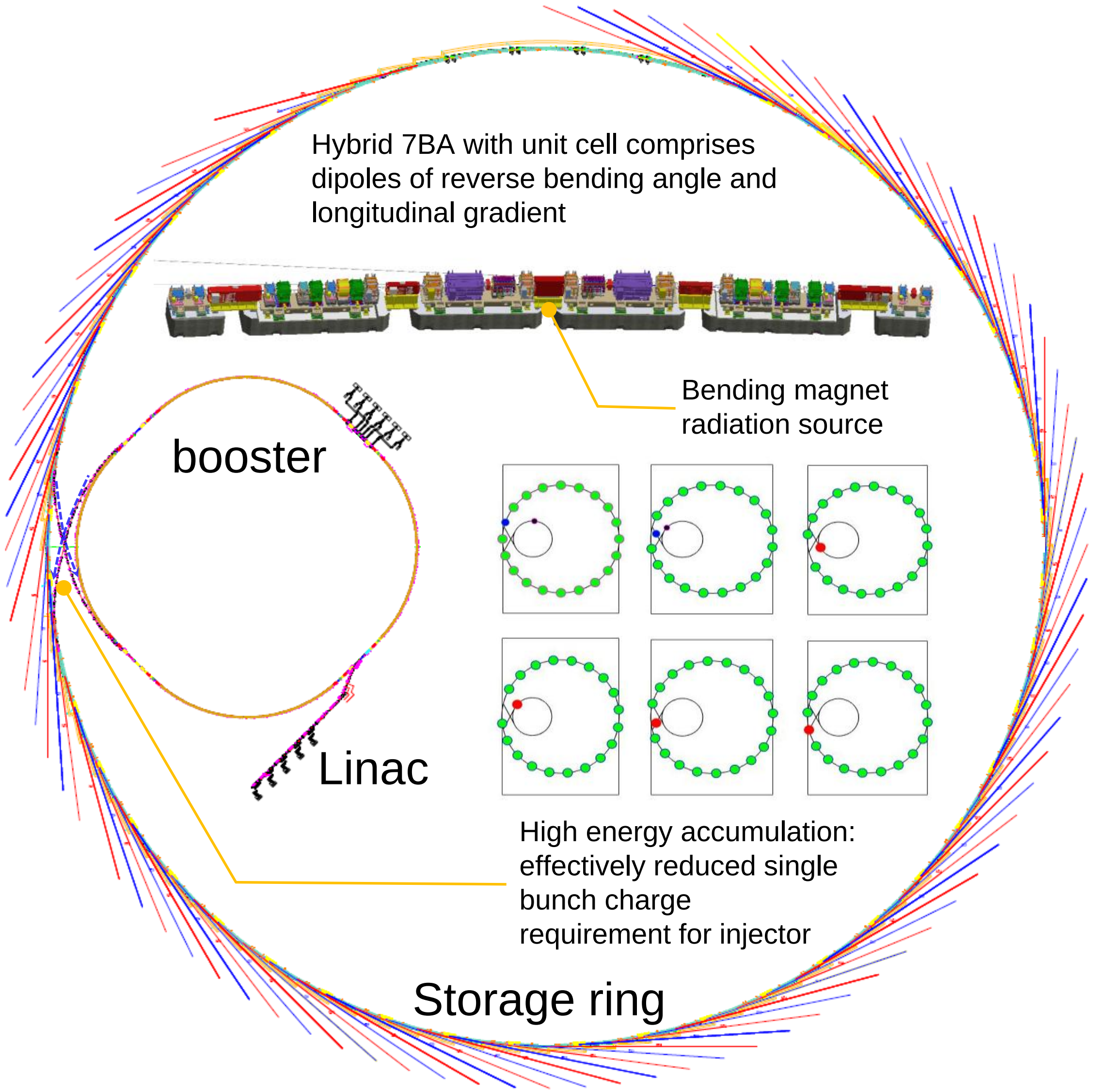
1700+ Magnets **19 IDs**

~1300 vacuum chambers

500+ BPMs **288 Girders**

a circumference of **1360.4 meters**

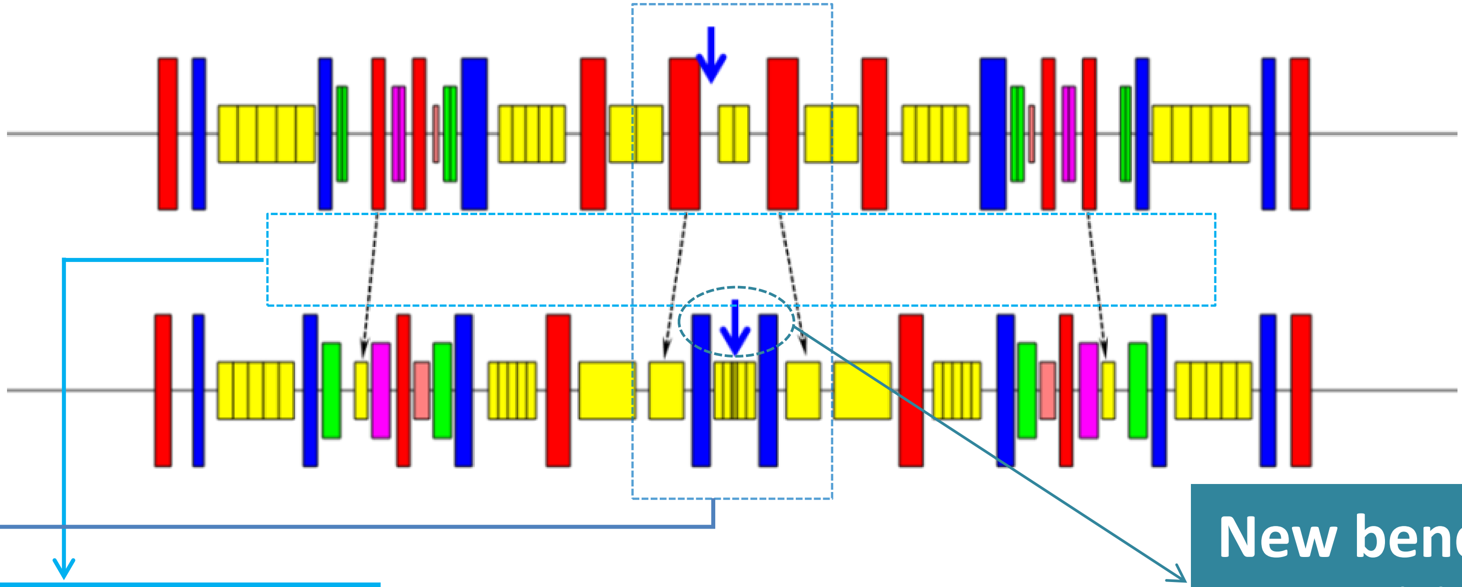
48 seven-bend achromats, meticulously designed to achieve a horizontal natural emittance of **~35 pm•rad** at a beam energy of **6 GeV**.



Lattice——Modified hybrid MBA

Hybrid 7BA

HEPS design



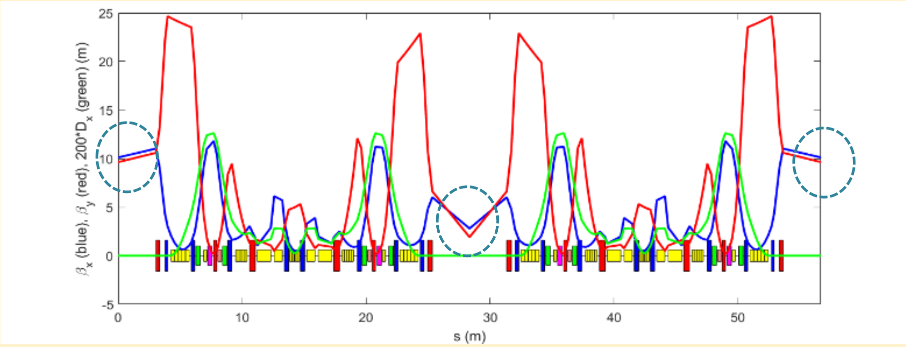
Reverse bending magnet

Unit cell w/ long. Grad. & reverse bending magnet

Emittance reduced~40%

New bending magnet source

Not need dedicated BM light source, avoid related physics and technical issues



Alternating high- and low-beta straight sections→ **Brightness increased ~30%** at half of sections

Y. Jiao, et al. JSR, 2018, 25, 1611-1618

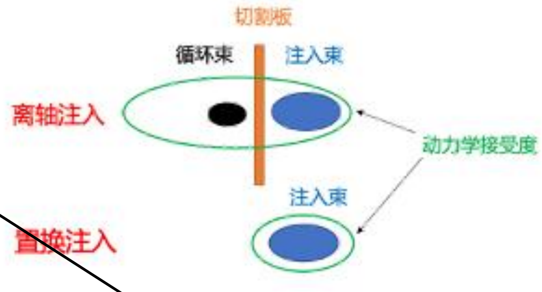
Y. Jiao, et al. RDTM, 4, 2020, 415–424

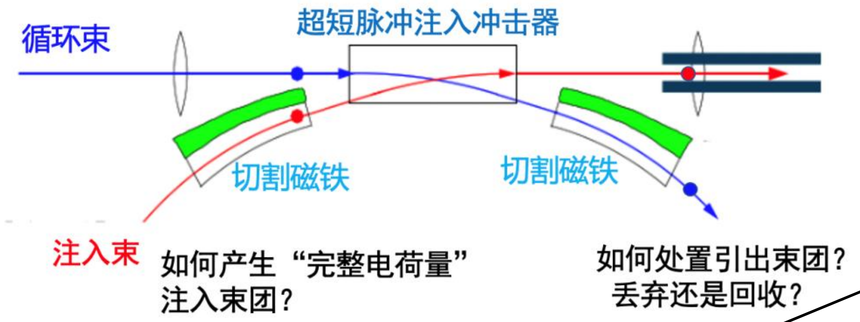
Swap-out injection w/ booster high-energy accumulation

Small dynamic acceptance

⇕

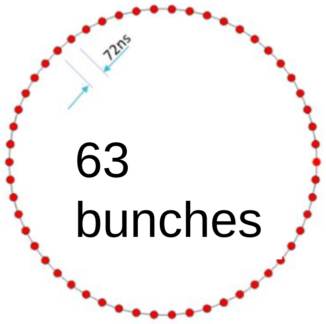
swap-out injection

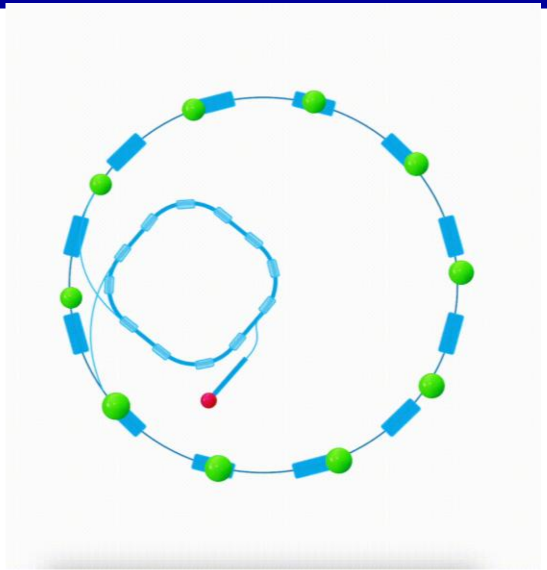




Key: How to realize high-charge bunch

Timing mode requires high-charge bunch： spacing~72 ns, bunch charge ~15nC



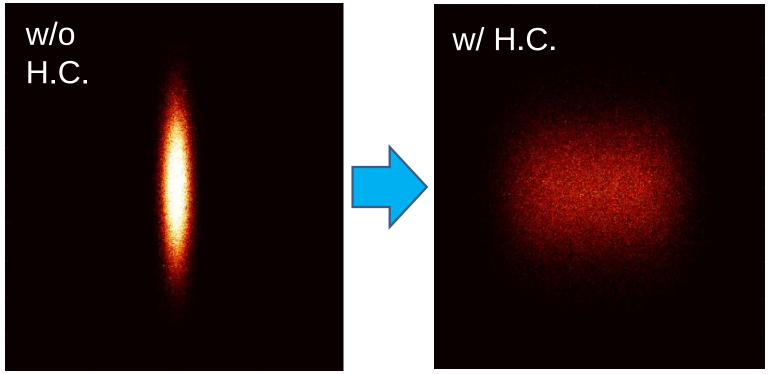


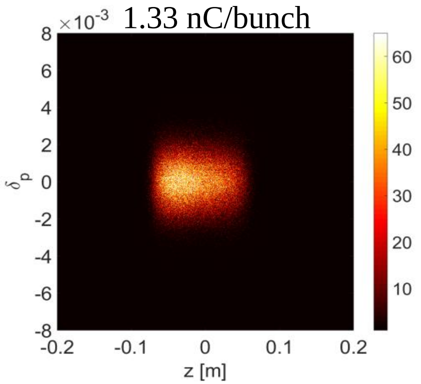
HEPS: **use booster at high energy as an accumulator**

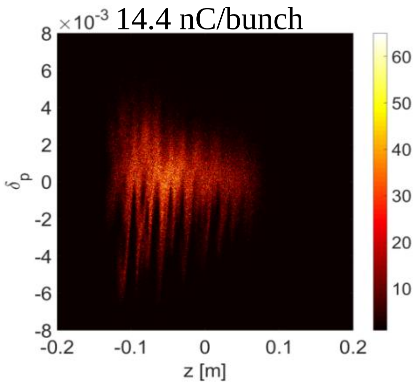
- Reduced cost compared to dedicated accumulator
- Reduced requirement on bunch charge compared to w/o high-energy accumulation

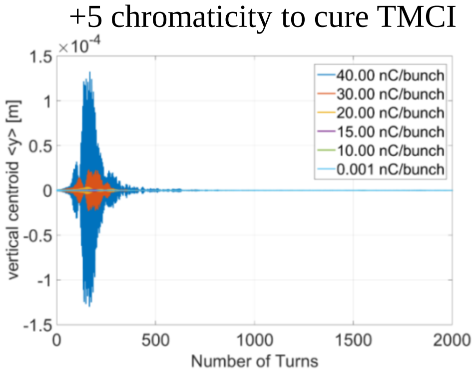
Measures to ensure 200 mA operation

- Detailed impedance modeling
  - Impedance contributions were evaluated and optimized based on iteration with hardware designs[1-2]
- Numerical simulation on single and multi-bunch instabilities
  - Harmonic cavities (500 MHz) and fundamental cavities (166.6 MHz) are used to lengthen the bunches, so as to increase beam lifetime [3] and especially to mitigate IBS effect and collective beam instabilities [4]
  - With the aid of feedback system and positive chromaticity, it is feasible to control the multi-bunch instabilities (coupled bunch instability [2], and ion instability [5,6,7]) for 200 mA operation
  - No beam loss at the max. target single bunch charge (14.4 nC/bunch, 63 bunches & 200 mA), however, brightness reduction (10~20%) is unavoidable [2]; also, injection transient instability should be careful [8,9]





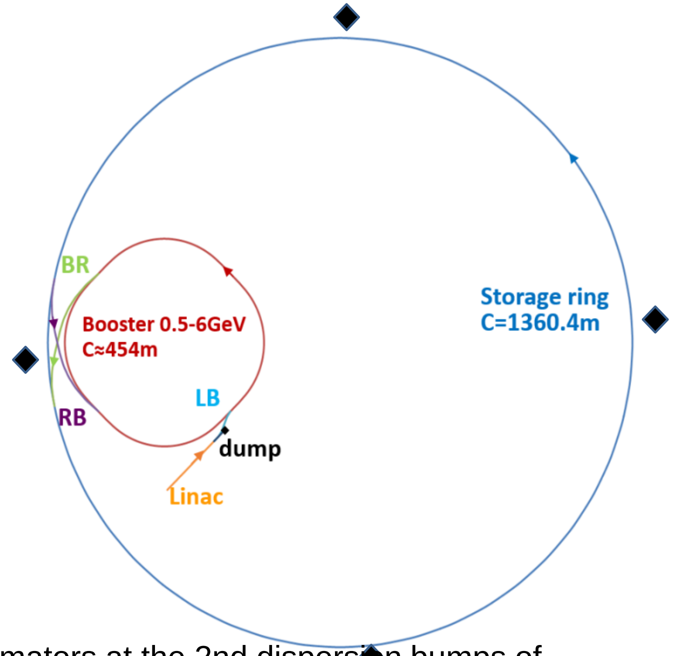




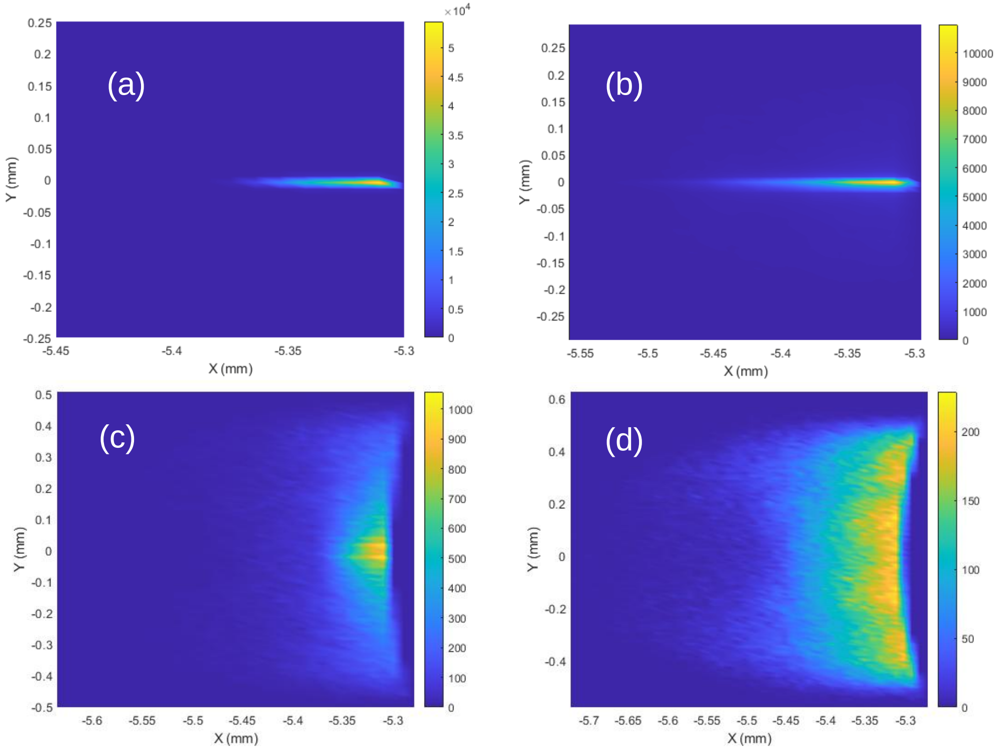
[1] N. Wang, *et al.*, IPAC17, WEPIK078. [2] N. Wang, *et al.*, Atom Energ Sci Technol 2019, 53(9): 1601-1606. [3] S.K. Tian, *et al.*, IPAC2017, TUPAB067.
[4] H. Xu, N. Wang, FLS2018, WEP2PT024. [5] N. Wang, *et al.*, IPAC2018, THPAK014. [6] S.K. Tian, *et al.*, IPAC2018 THPMF055.
[7] C. Li, *et al.*, Phys. Rev. Accel. Beams 23, 074401 (2020). [8] Z. Duan, *et al.*, IPAC19, TUPGW053. [9] H. Xu, *et al.*, Nucl. Instr. Meth.. A 986 (2021)

Beam loss control in the ring

- Use collimators to localize the beam loss (due to Touschek effect and active beam dump) in the ring
- Found the beam deposition would be destructive on collimators in the cases of active beam dump, and other components (e.g., Lambertson septum in the case of extraction failure)
- Plan to use pre-kickers [1, 2] (before active beam dump or beam extraction) to increase the beam size and decrease the en ponents



4 collimators at the 2nd dispersion bumps of the 1st, 13th, 25th, and 41th 7BA.



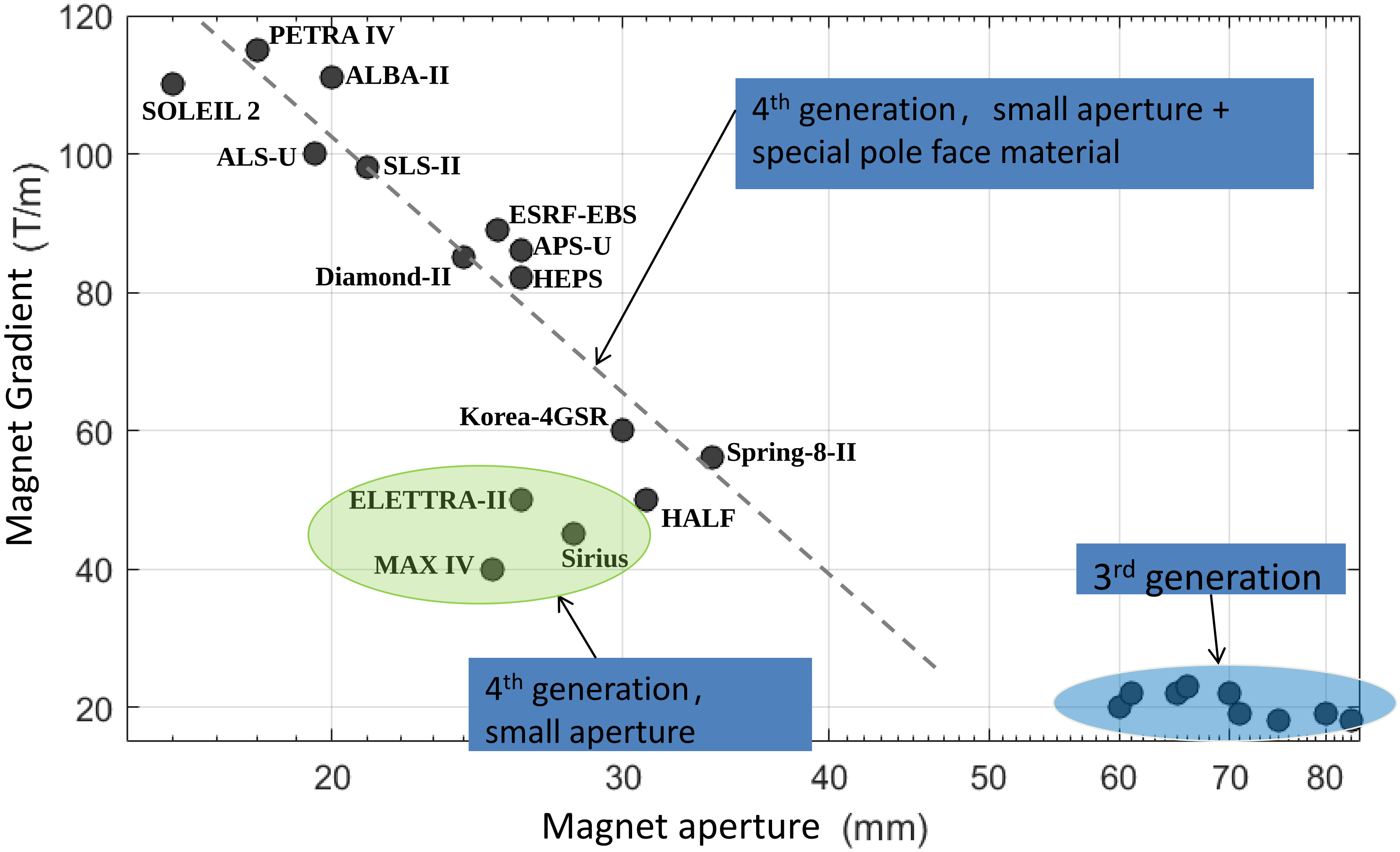
Electron beam distribution at the collimator after active beam dump

(a) w/o pre-kicker
(b) w/ horizontal pre-kicker
(c) w/ vertical pre-kicker
(d) w/ horizontal and vertical pre-kickers

The max. beam intensity at collimators reduced by about 200 times with pre-kickers

[1] Y.L. Zhao, *et al*., HEPS-AC-AP-TN-2020-024-V0.
[2] Z. Duan, *et al*., HEPS-AC-AP-TN-2020-031-V0.

Key technology: small-aperture magnet and vacuum chamber



JIAO Yi, BAI Zheng-He, LI Xiao. PHYSICS, 2024, 53(2): 71-79. DOI: 10.7693/wl20240201

Magnet

Magnet type	Abbr.	Qty
Longitudinal grad. dipole	BLG	245
Dip./quad. comb. magnet	BD/ABF	294
Quadrupole	QF/QD	686
Sextupole	SF/SD	294
Octupole	OCT	98
Fast corrector	FC	196
Magnet field measurement system		
Rotating coil system	RCS	3
Hall probe system	HPS	3
Planar moving coil system	MCS	1
Stretched wire system	SWS	1
Trans. field meas. system	TFS	1

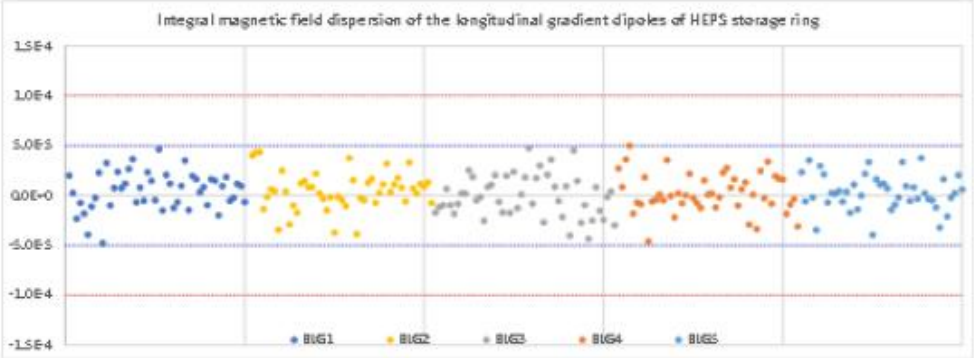
All magnets and measurement systems developed in-house by the Magnet group.

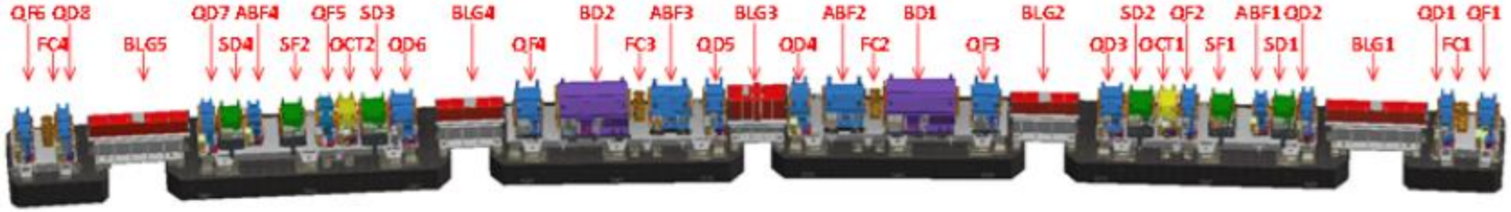
- **Features of key magnets & system**

- BLG: permanent magnet, field tuning to 50 ppm, temperature compensation to 50 ppm/°C
- QF/QD: 80 T/m, $B_n/B_2 < 4\times10^{-4}$, harmonics compensated by “Magic finger”©
- RCS: based on coordinate measuring machine (CMM), automatic alignment with 10 μm precision
- MCS: automatic alignment with 20 μm precision

Measuring BD magnet with CMM based Rotating coil system

Measuring BLG magnet with Arm based planar moving coil system

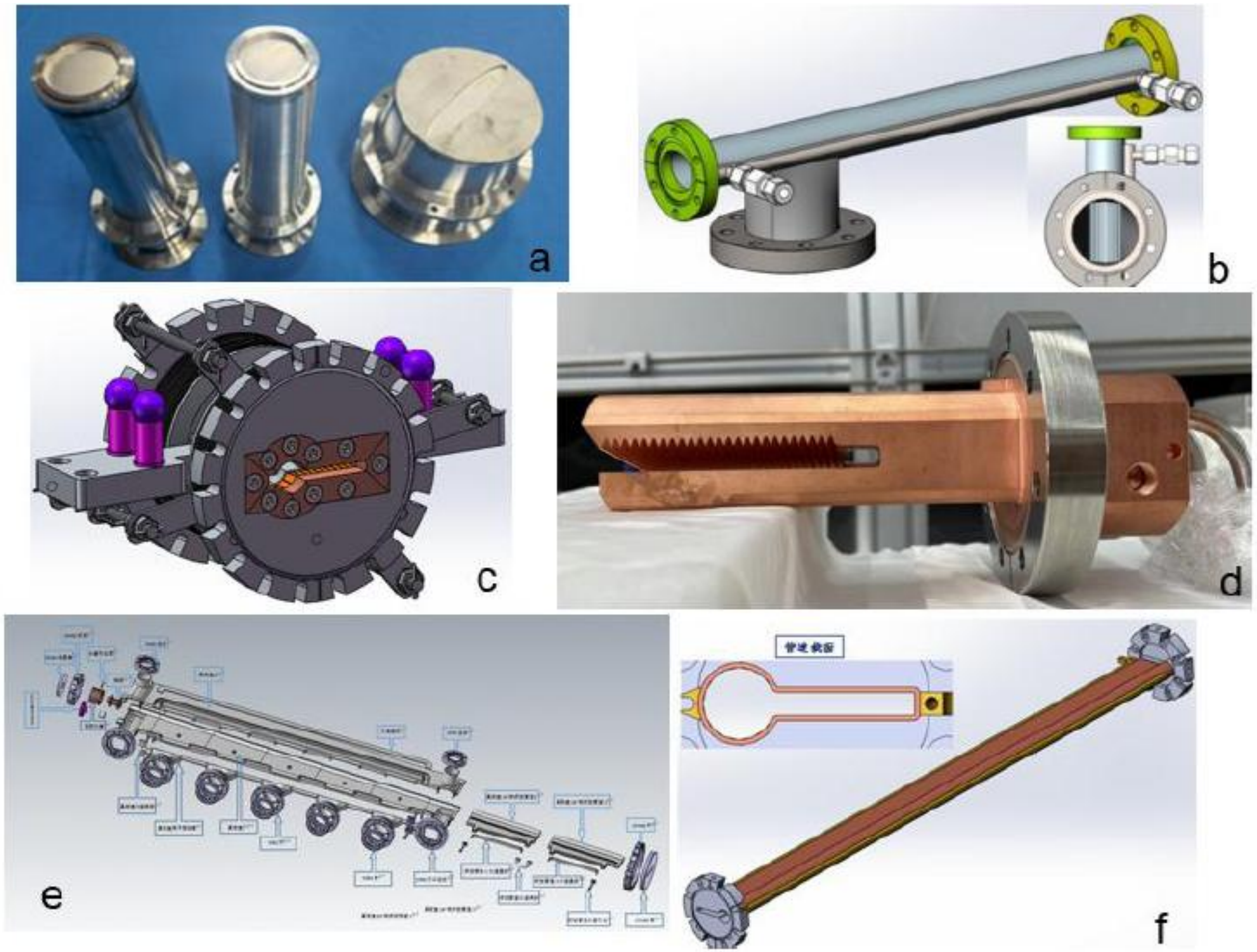




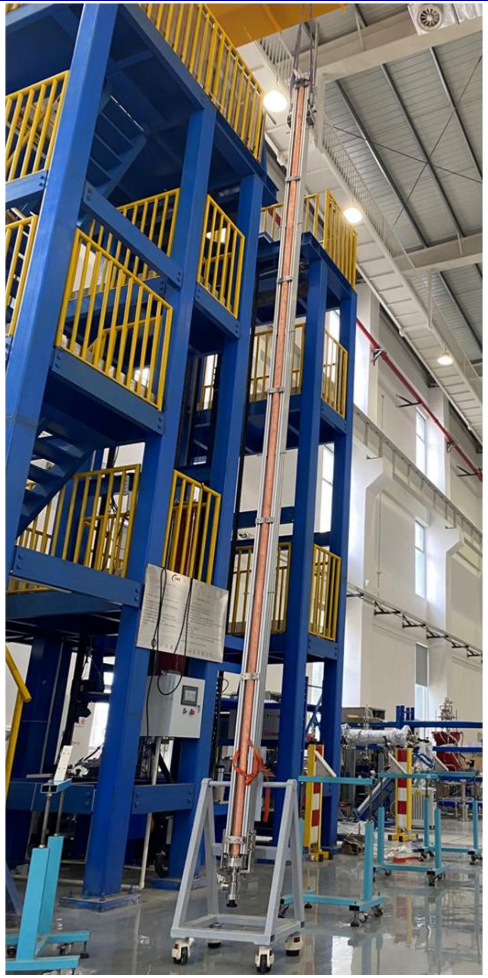
Vacuum system

SR requirement:
1.3e-7 Pa (dynamic)

Parameter	Value	Type/Qty
Thickness of electron beam window (a)	0.1 mm	3/4
Dimension of the booster vacuum chamber (b)	36*30*0.7 mm	87/423
Contact force of RF shielding bellows (c)	125±25 g	42/1125
Material of photon absorber (d)	C10100 C15715 C18150	11/288
Magnetic permeability of Stainless Steel vacuum chamber in storage ring (e)	1.02	7/532
Inner dimension of the CrZrCu vacuum chamber (f)	Di22mm Di22mm w/ antechamber, Di8 mm, etc.	27/1019



Vacuum system



- 3 sets of NEG coating equipment have been built;
- One is used to coat small aperture circle vacuum chambers, and 6*3.5m vacuum chambers can be coated simultaneously;
- Another is for antechambers paralleled with 4 groups in a length of 1.5m, and the NEG coating have been verified in a slit height of 6mm with a length of 1.2m;
- A 6m long vacuum chamber can be coated in the third setup by moving solenoid vertically.

Magnet Power Supply

Power Supplies	Qty.	Type
Linac	51	DC
Trans.	123	DC
BS Bend.	4	DC+AC
BS Quad.	8	DC+AC
BS Sext.	6	DC+AC
BS Corrector	84	DC+AC
SR Quad.	960	DC
SR Sext.	12	DC
SR Oct.	4	DC
SR FC	384	DC+AC
SR Corr.	864	DC
IDs related	105	DC
All power supplies, DCCTs and digital controllers developed in-house by PS group		

- **Features of the magnet power supply system**
  - **High precision** current-stable power supplies: long-term stability 10 ppm, accuracy 50 ppm, repeatability 20 ppm
  - **High bandwidth** high precision fast corrector power supplies: small-signal step response time 75us, current ripple 20ppm
  - **High power dynamic** power supplies: tracking error 0.1% vs. operating value, from injection to extraction point
  - **In-house developed digital power supply controller and DCCT**: all power supplies are fully digital-controlled with digital controllers and installed DCCTs as the current feedback component

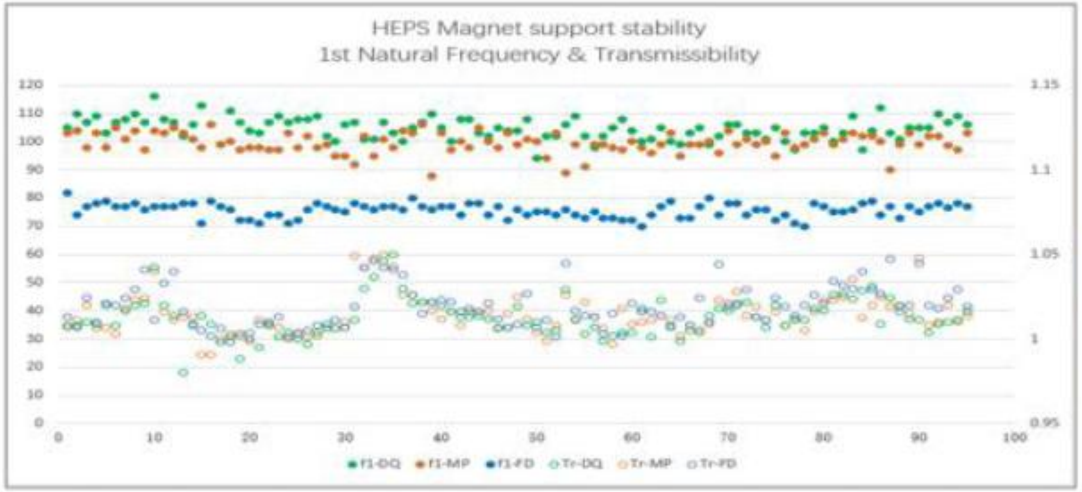
Storage ring PS hall | Booster PS hall | DCCT | Digital controller

Magnet support

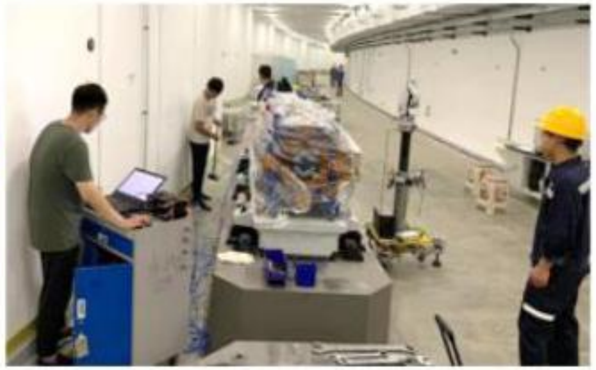
SR magnet support system

- Ultra-high stability & micron-level motion resolution
  →contradictory requirements
- Improve system stiffness : Self-developed wedge mechanism, high-stiffness concrete plinth & grouting installation process
- 288 support modules installed and met the requirements.
  - Eigen frequency: ≥70 Hz
  - Transmissibility: ≤1.05
  - Motion resolution : 1 μm

Parameters		Requirement
Resolution	X/Y	≤5μm
	Z	≤15μm
Adjusting range	X/Z	±10mm
	Y	±7mm
Natural frequency		≥54Hz



Wedge leveler



RF system

Parameter	Value	Unit
Beam energy	6	GeV
U_0 (w/ IDs)	4.14	MeV
Beam current	200	mA
Fundamental RF		
RF frequency	166.6	MHz
RF voltage	5.14	MV
No. of cavities	5	-
RF power per cav.	170	kW
Q0 at 1.5MV	>1e9	-
Harmonic RF		
RF frequency	499.8	MHz
RF voltage	0.91	MV
RF power abs from beam	105	kW
Q0 at 1.75MV	>1e9	-

- **Features of the storage ring RF system**
  - **Cavity (in-house)**: 166.6 MHz β=1 SC QWR (1.1e9 @ 1.6MV) + 499.8 MHz 1-cell SCC (2.6e9 @ 1.75MV), heavy HOM damping, individual cryostat per cavity
  - World's 1st main acc. cavity of β=1 SC quarter-wave type
  - **HPRF**: 260 kW SSA (joint dev.), 300 kW circulator (joint dev.)
  - **LLRF** (**in-house**): digital LLRF (±0.05%, ±0.1°, 1.2MV)
  - **Setup**: each cavity with individual SSA, occupying 4.5 straights

166.6 MHz cryomodule

499.8 MHz cryomodule

SSA

[1] P. Zhang et al., *Rev. Sci. Instrum.* 90, 084705 (2019). [2] L. Guo et al., *Rev. Sci. Instrum.* 95, 074702 (2024).

Insertion devices

Type		No.	L [m]	Min. Gap [mm]	Max. peak field [T]	Min. phase error RMS [Degree]
In Air	IAU	4	5	11	0.88	4
	IAW	2	1	11	1.64	-
In Vacuum	CPMU	6	2	5.2	1.35	3
	IVU	5	4	5.2	1.1	3
Special	AK	1	5	11	-	5
	Mango	1	1	11	1	-
Total		19				

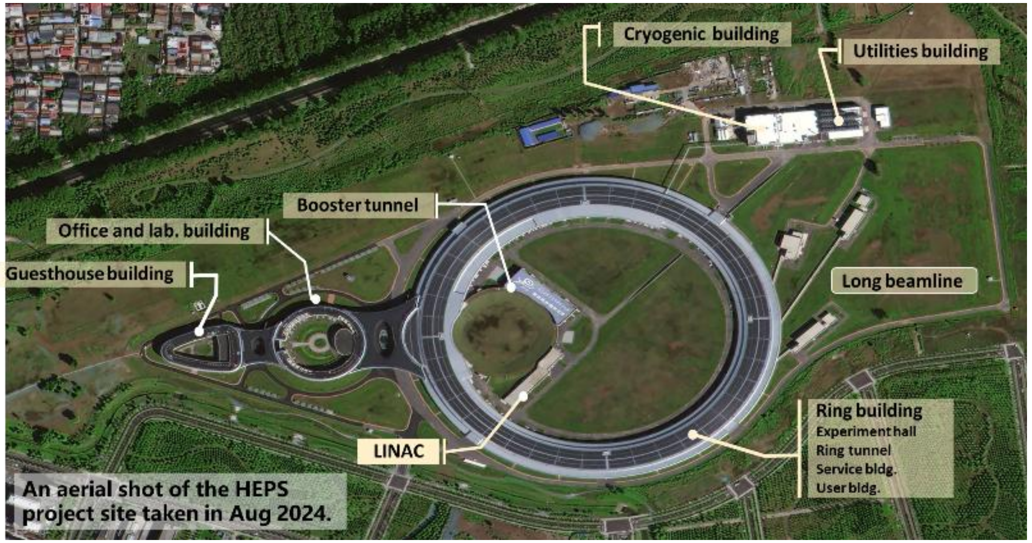
- **Highlight**
  - **CPMU12**: min. period length in the world, phase error and multiple error in the world's leading level
  - **Mango wiggler**: completely new idea, offer a big radiation spot size for Large-field X-ray diagnosis and flaw detection
  - **AK undulator**: realized by 4 arrays, both circular polarization and low on-axis heat load achieved

[1] X.Y. Li, et al., STATUS OF HEPS INSERTION DEVICES DESIGN, *IPAC 2021*, MOPAB090, P339-341.

Design → Fabrication → Installation → Commissioning → Operation

HEPS Progress (June 2019-June 2025)

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



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

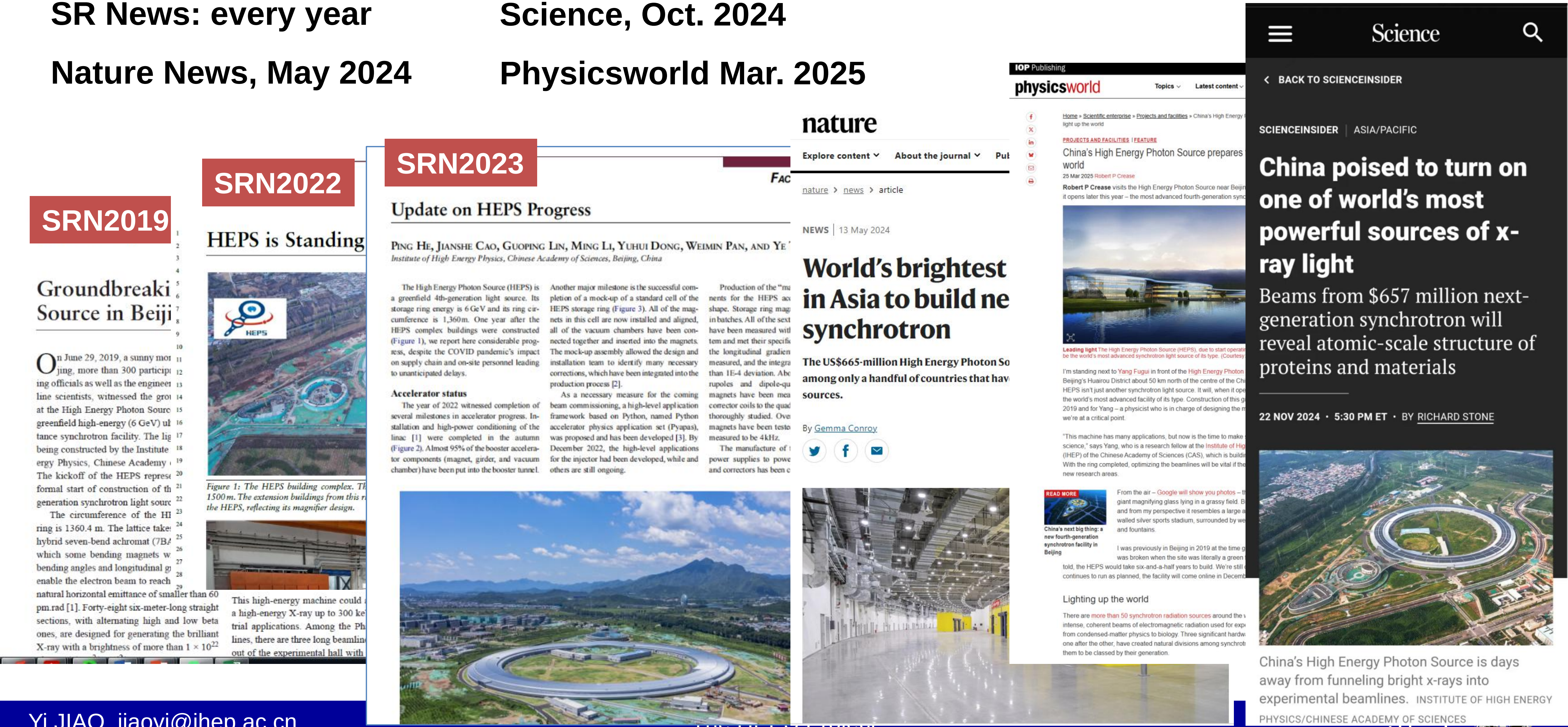
Joint-Commissioning Phase announced on Mar. 27, 2025

SR News: every year

Science, Oct. 2024

Nature News, May 2024

Physicsworld Mar. 2025



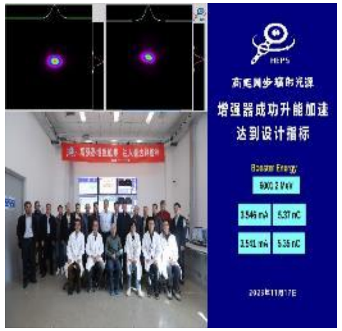
Milestones

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

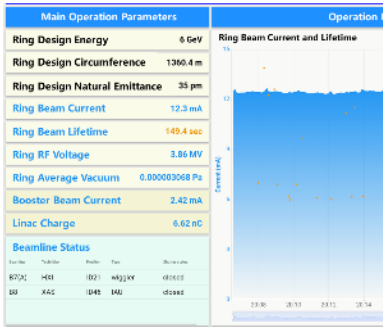
Jan. 13, 2023
The Booster Vacuum-sealing in the tunnel completed

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

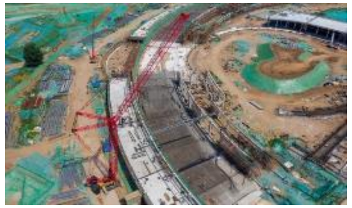


Aug. 18, 2024
Electron beams with currents higher than 10mA were successfully stored.

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



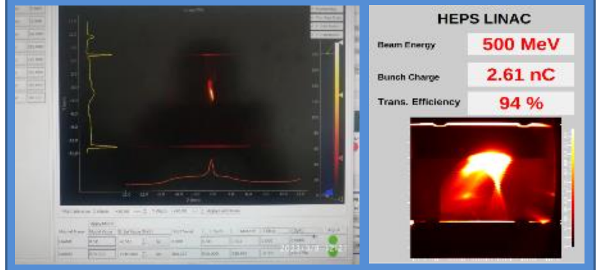
Apr. 13, 2021
Utility installation in NO.2 Hall commenced

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.

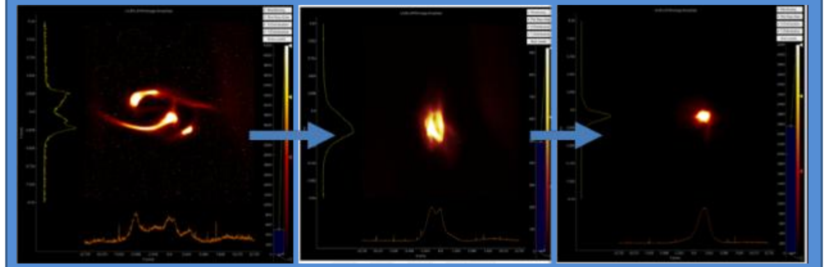
Nov. 3, 2023
Civil Construction for ancillary buildings completed

Injector commissioning



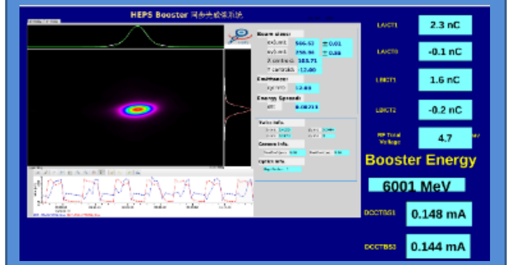
500 MeV, ~2.5 nC

1st electron beam



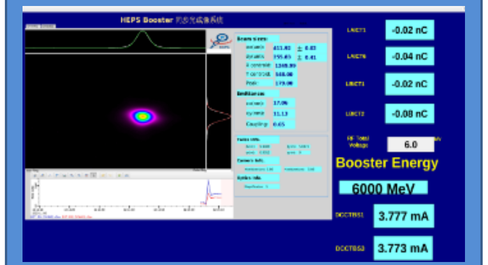
500 MeV, max bunch charge > 7 nC

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 Installation

Process Experiment for Storage Ring Installation

April 2022

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

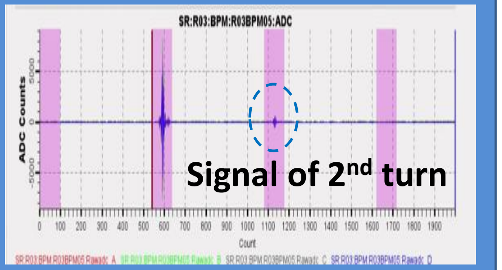
- The operation space and interfaces have been checked, and pre-alignment scheme, transport scheme and other critical problems have been thoroughly tested

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

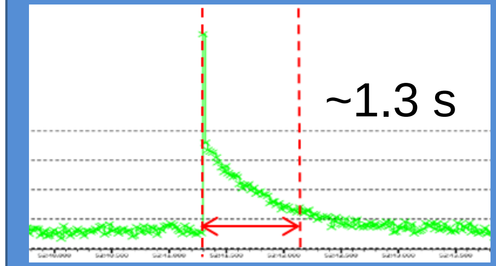
Feb. 2023
The installation began
50μm **for alignment in tunnel**

July 1, 2024
Vacuum sealing completed.

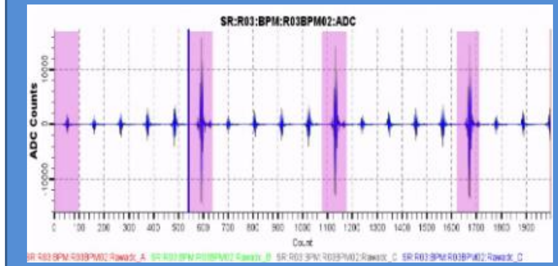
Storage ring commissioning



First turn

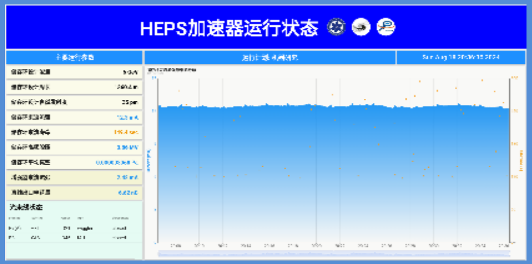


One bunch stored



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

Multi-bunch stored



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

12 mA stored

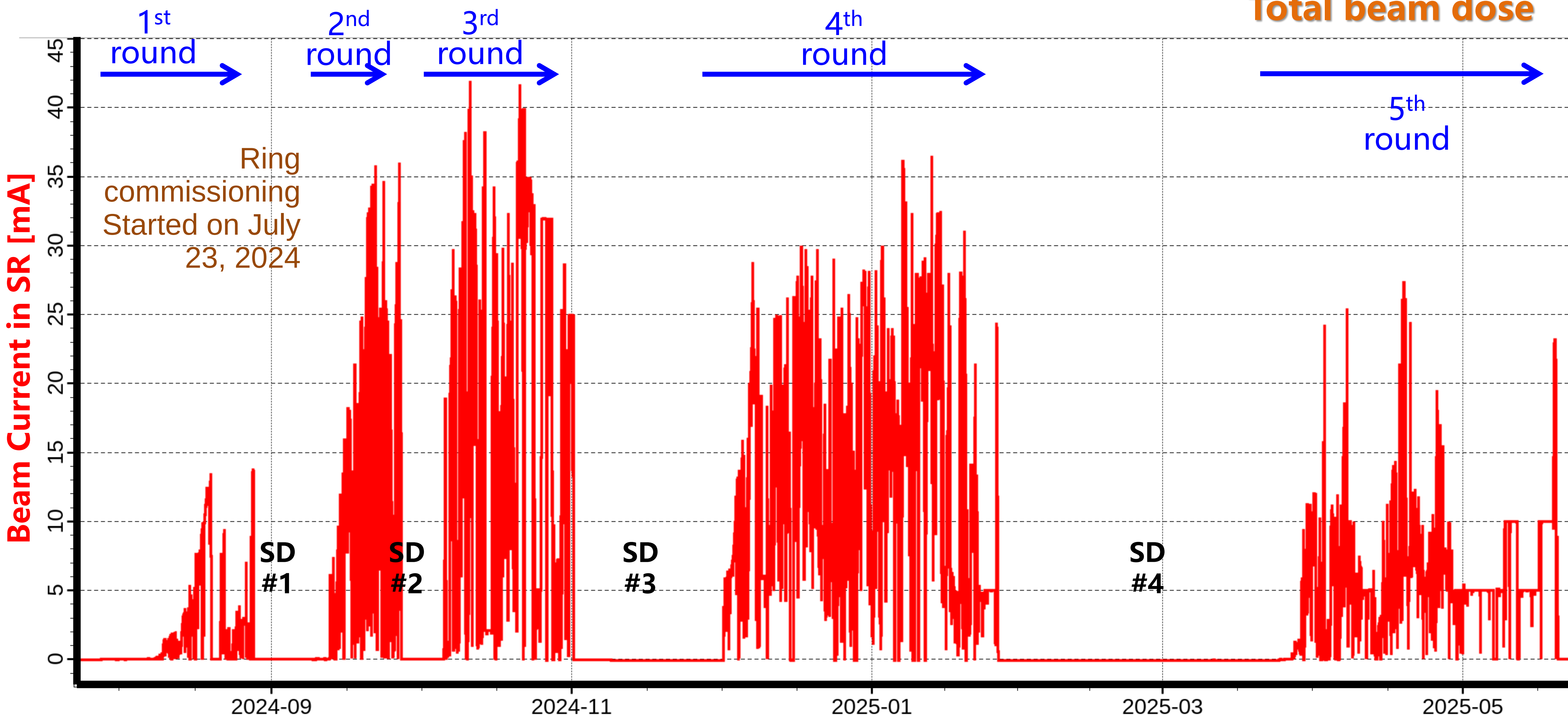
Comm. Started

- 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

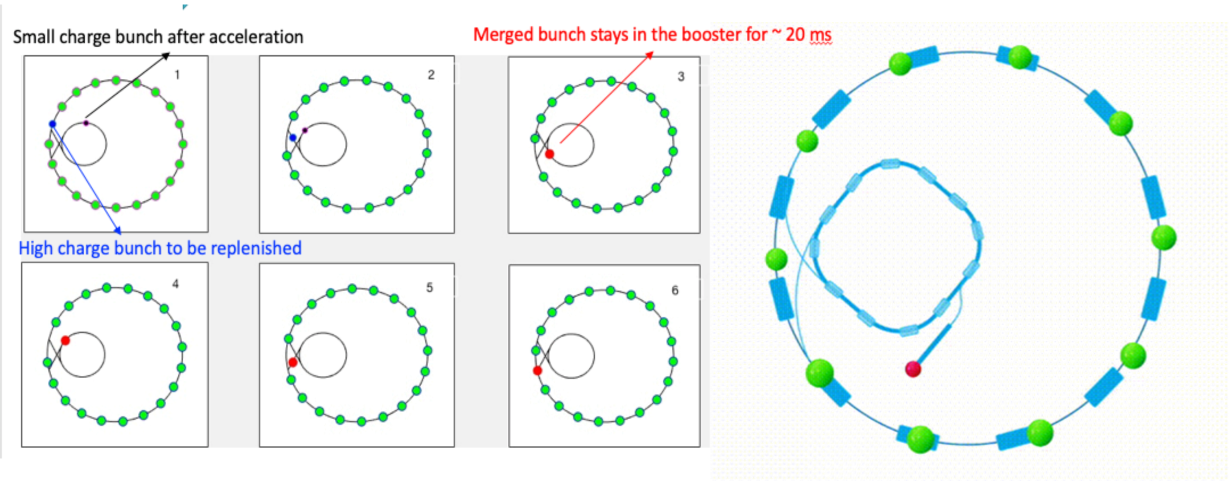
5 round commissioning completed

41.037 A·h
Total beam dose

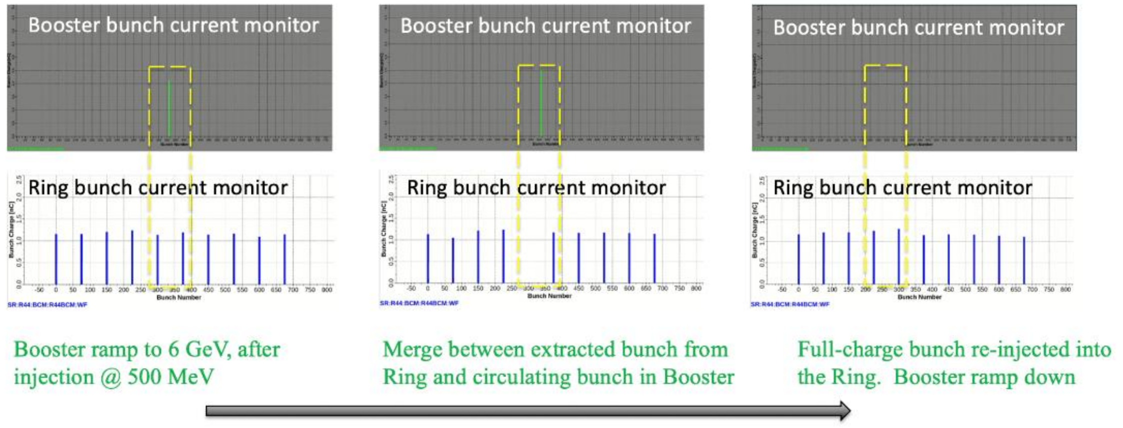


Swap-out injection: verified and in operation

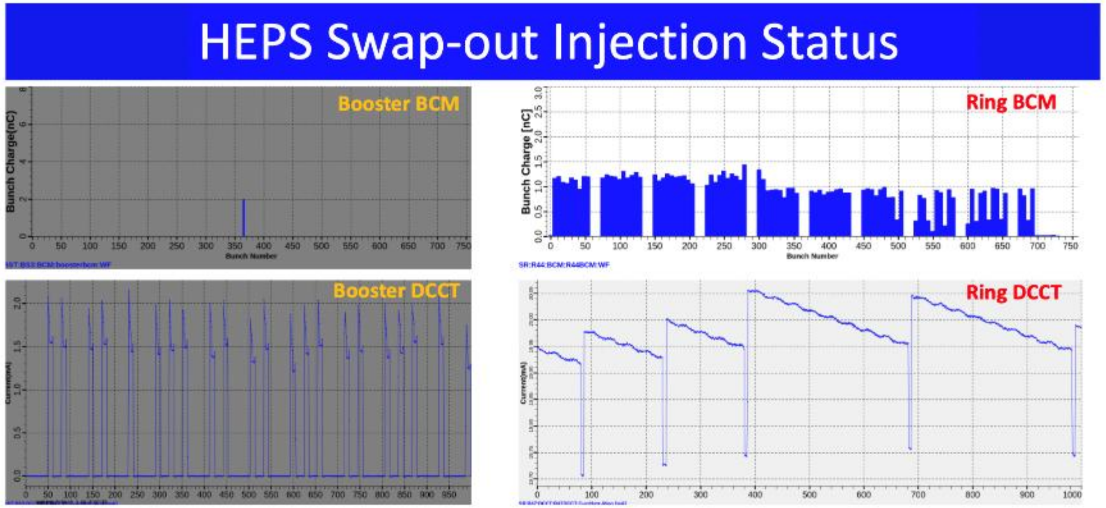
Design scheme



Experimental demonstration

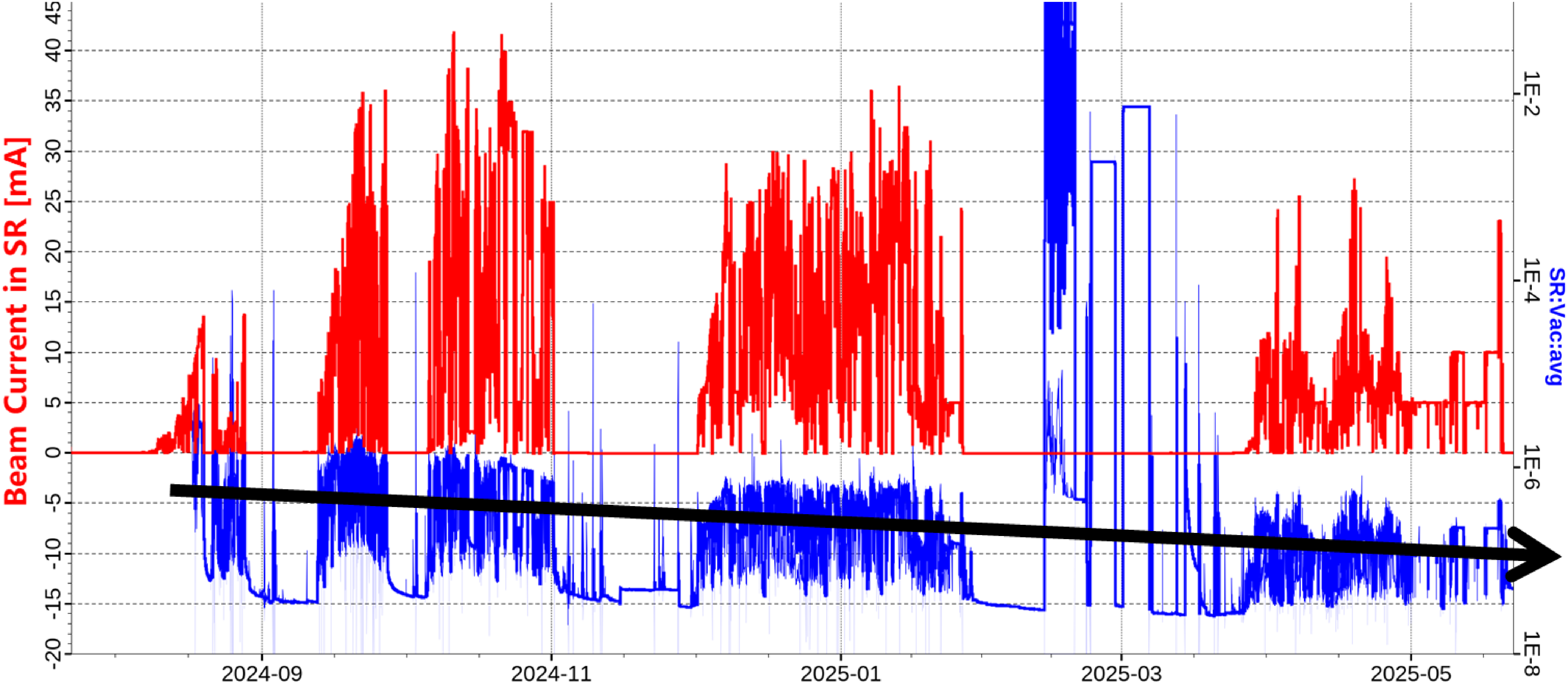


- The swap-out injection with high energy accumulation in the booster, has been successfully demonstrated.
- Now used in routine operation since Jan. 2, 2025



Current and Vacuum in HEPS storage ring

Vacuum conditioning on going: average pressure going down slowly

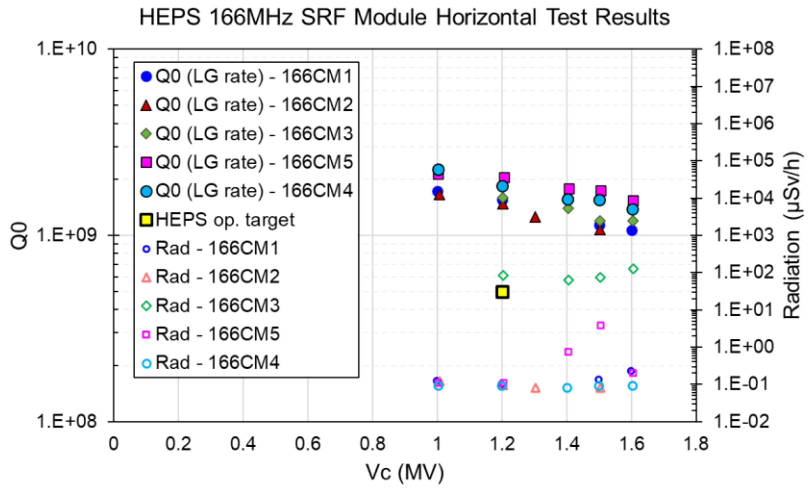


166.6 MHz SRF cavities for storage ring

- 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)

Photo taken on 27.05.2025 by G. Yuan.

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



SRF gearing up for 100mA

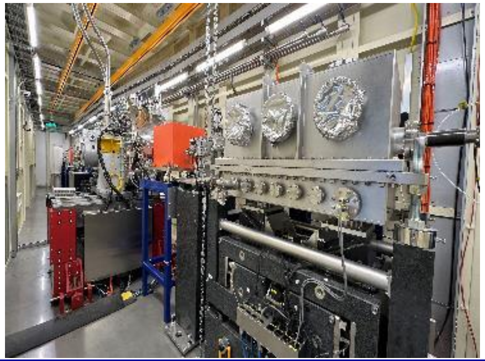
6th round Storage Ring Commissioning will begin in next week

- Five 166.6MHz SRF cavities and two 499.8MHz SRF cavities installed in storage ring, cabling and transmission line installation basically finished
- 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 cooldown and RF conditioning underway 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



Installation of All IDs completed by Aug 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

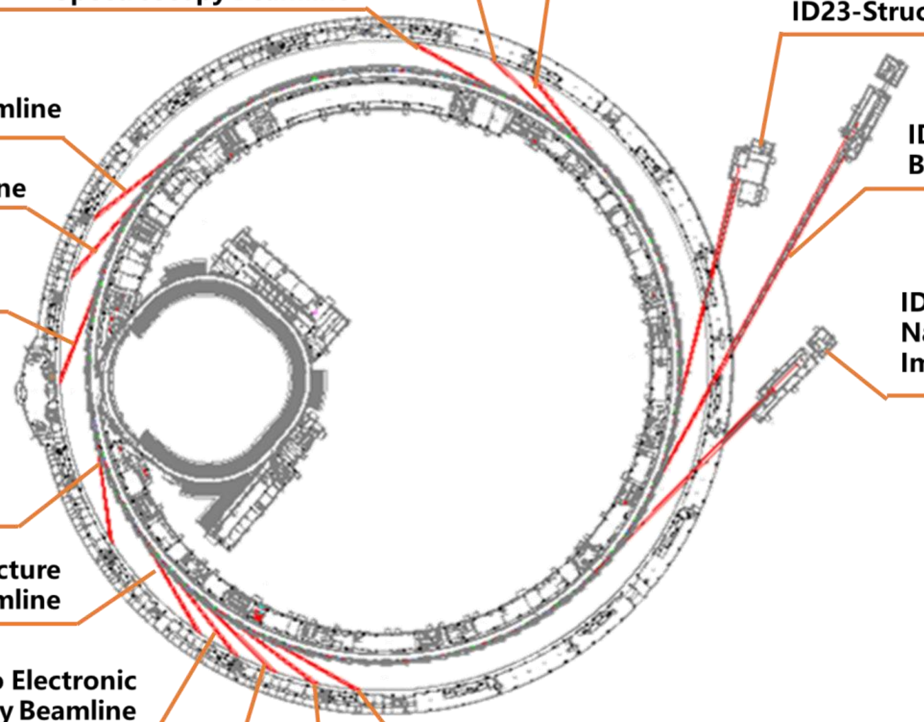
17 IDs conditioning with beam

2 IDs AK+Mango being installed

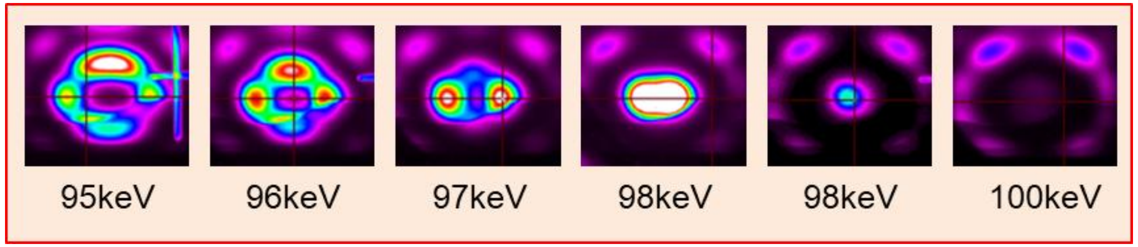
4 round SR beam commissioning

All 15 BLs under commissioning

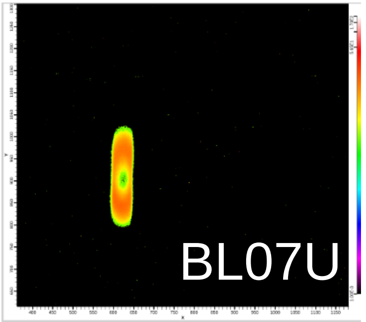
- **1st round: 2024.10.10.-2024.10.31.** 22Days， **4 BLs,** BL21I-HXI, BL44B-Tender, BL46U-XAFS, BL42I-Test beamline
- **2nd round: 2025.01.22.-2025.01.25.** 4Days, **+3BLs**, BL09U-Coherence, BL08U-Pink SAXS, BL30U-Imageing
- **3rd round: 2025.04.10.-2025.04.11.** 2Days, **+5BLs,** BL07U-Engineering 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

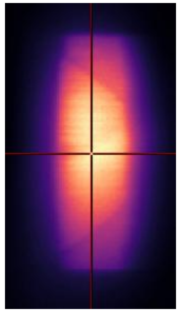


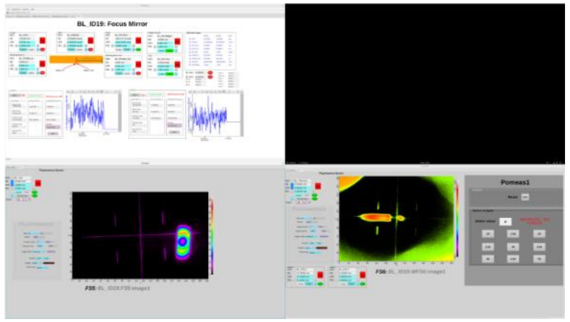
4^{th} round: ALL BLs entered SR beam commissioning phase

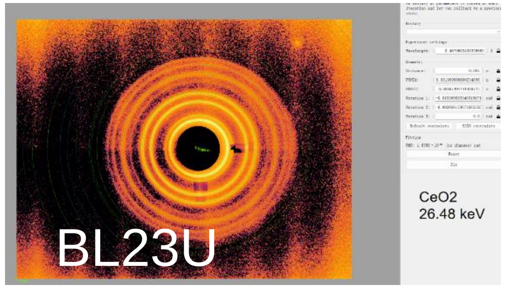


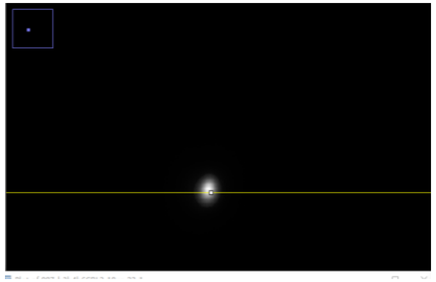
BL07U

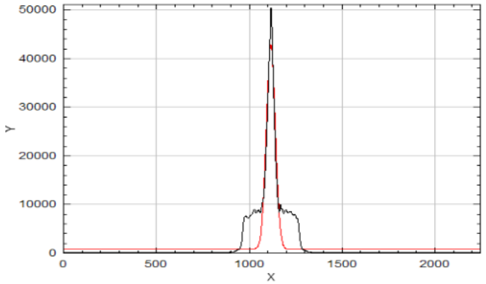


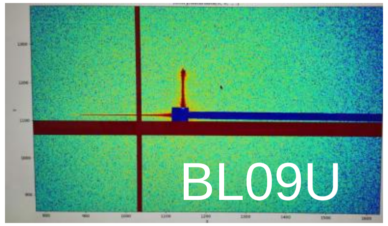


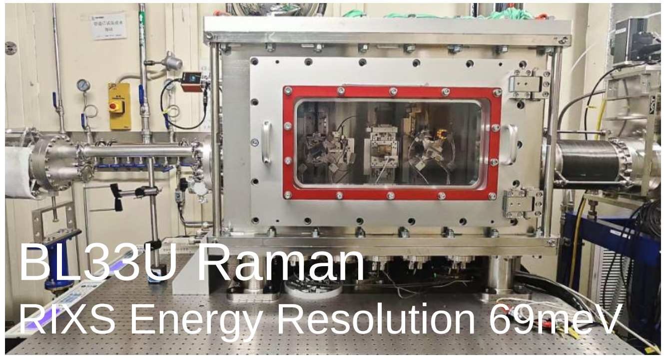


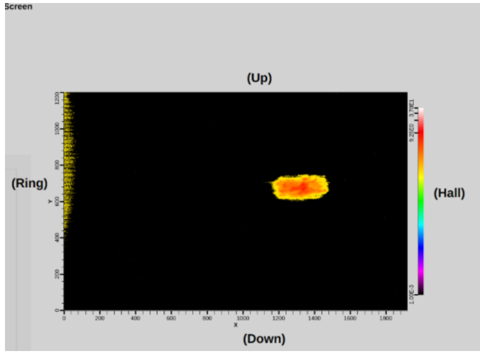


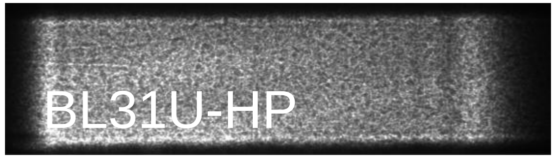




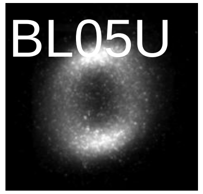








05.02



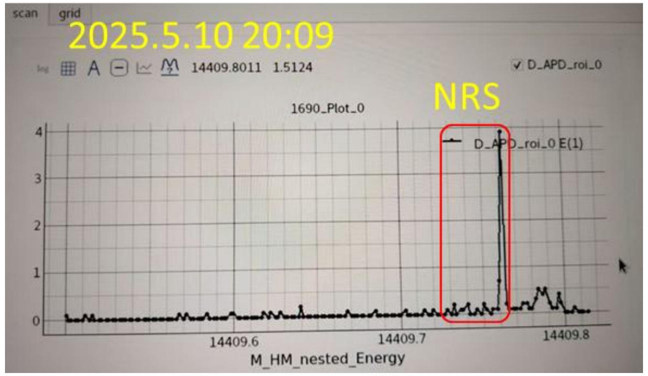
05.19

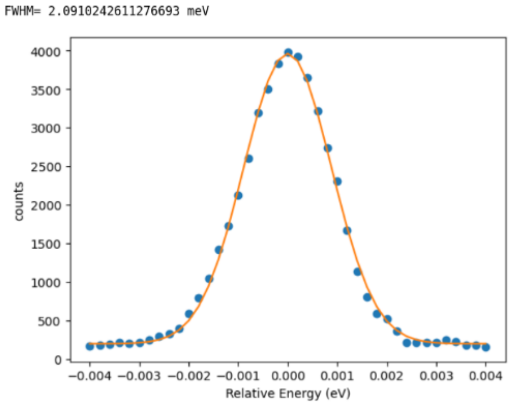
Preliminary commissioning results

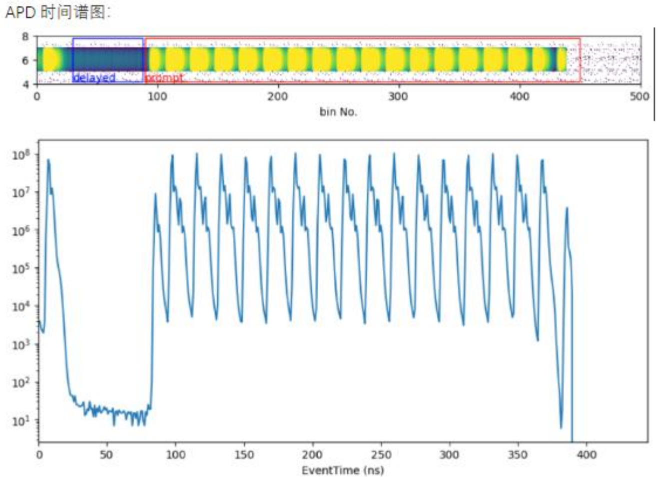
BL33U-Raman

APD detector, NRS

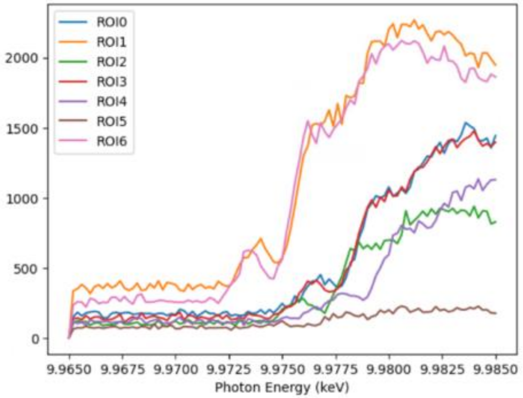
2meV resolution for NRS





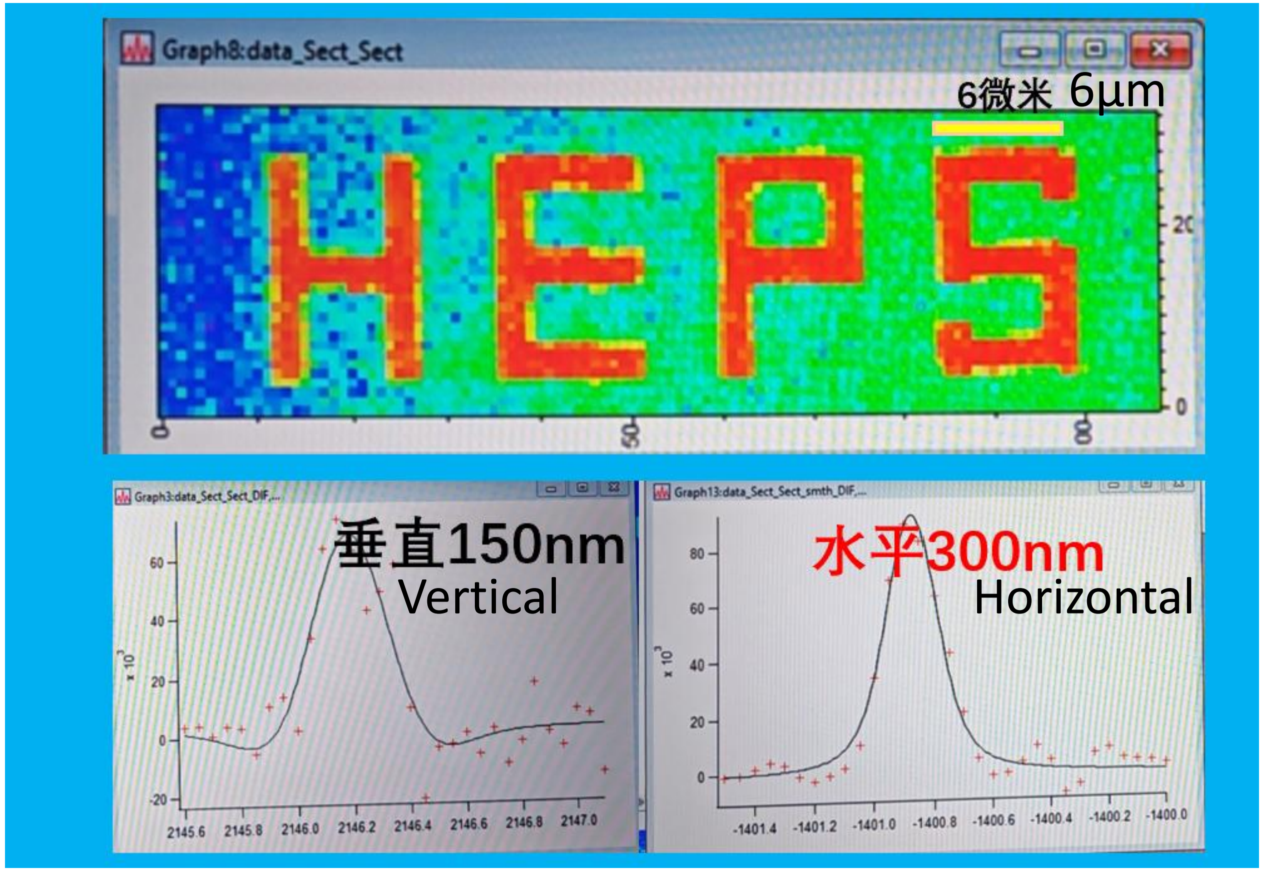


X-ray Raman spectroscopy



BL41U-ARPES Nano ARPES scanning imaging

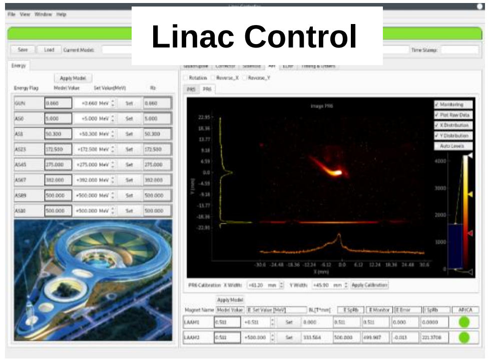
Photon Energy@900eV

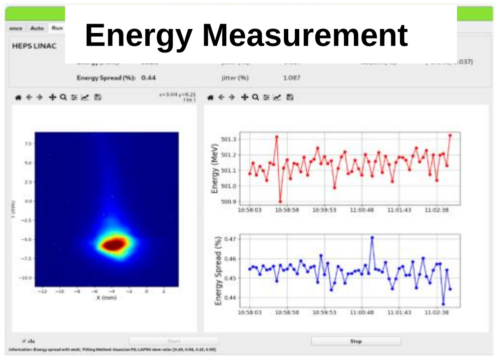


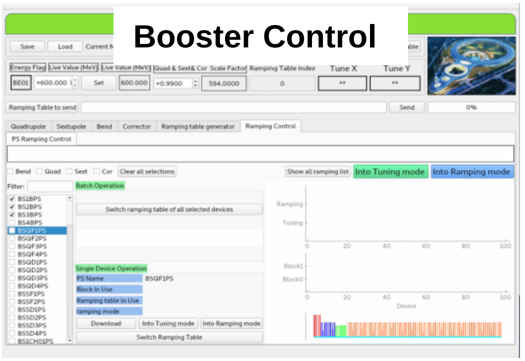
Accelerator HLA software

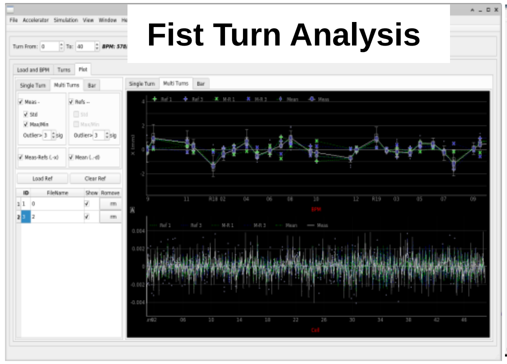
- ✓ Based on Physical Quantities
- ✓ Model-Based
- ✓ Modular Design

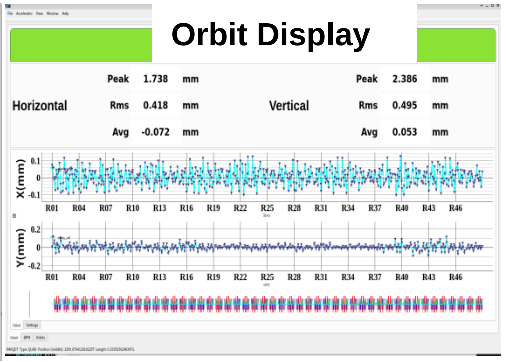
① Dual-layer physical module
② Friendly user interface module
③ Hardware communication module
④ Database connection module
⑤ Client-Server development module
⑥ Various phyiscal algorithm toolkits

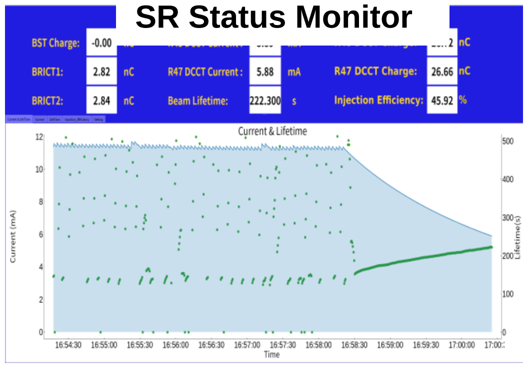




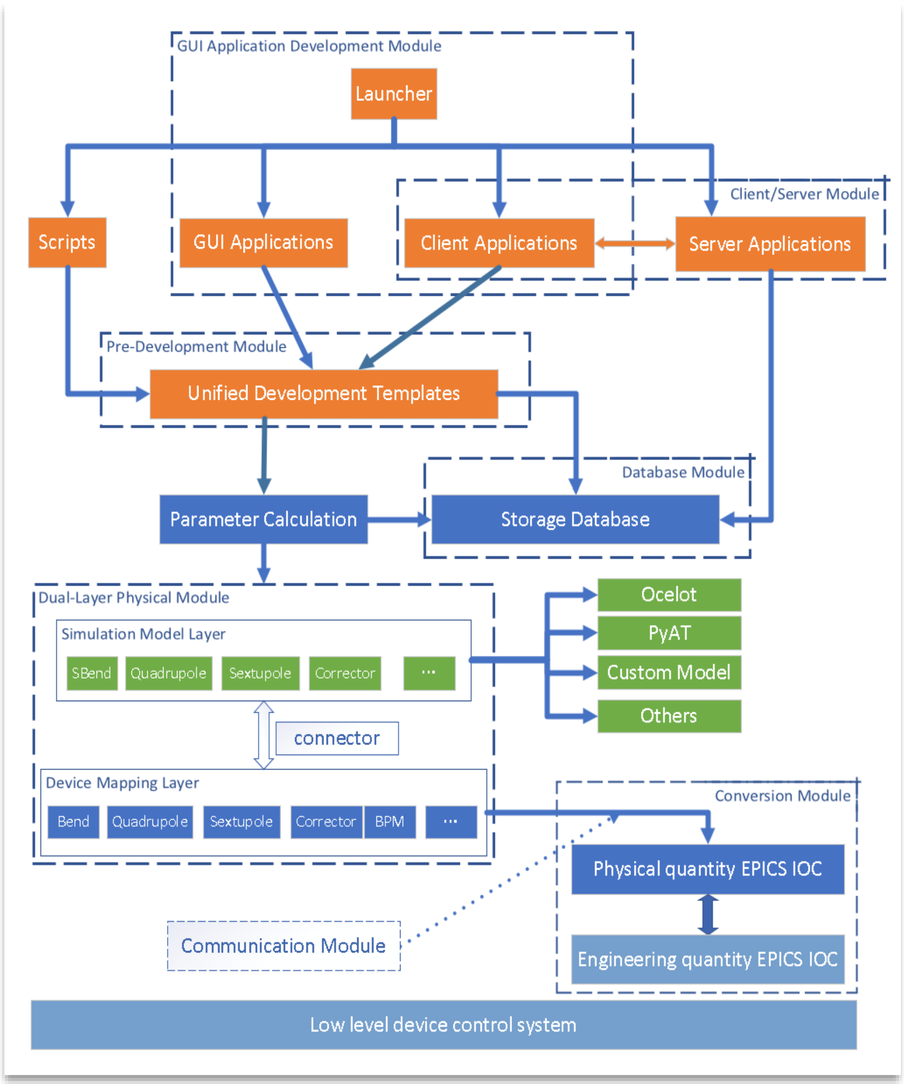






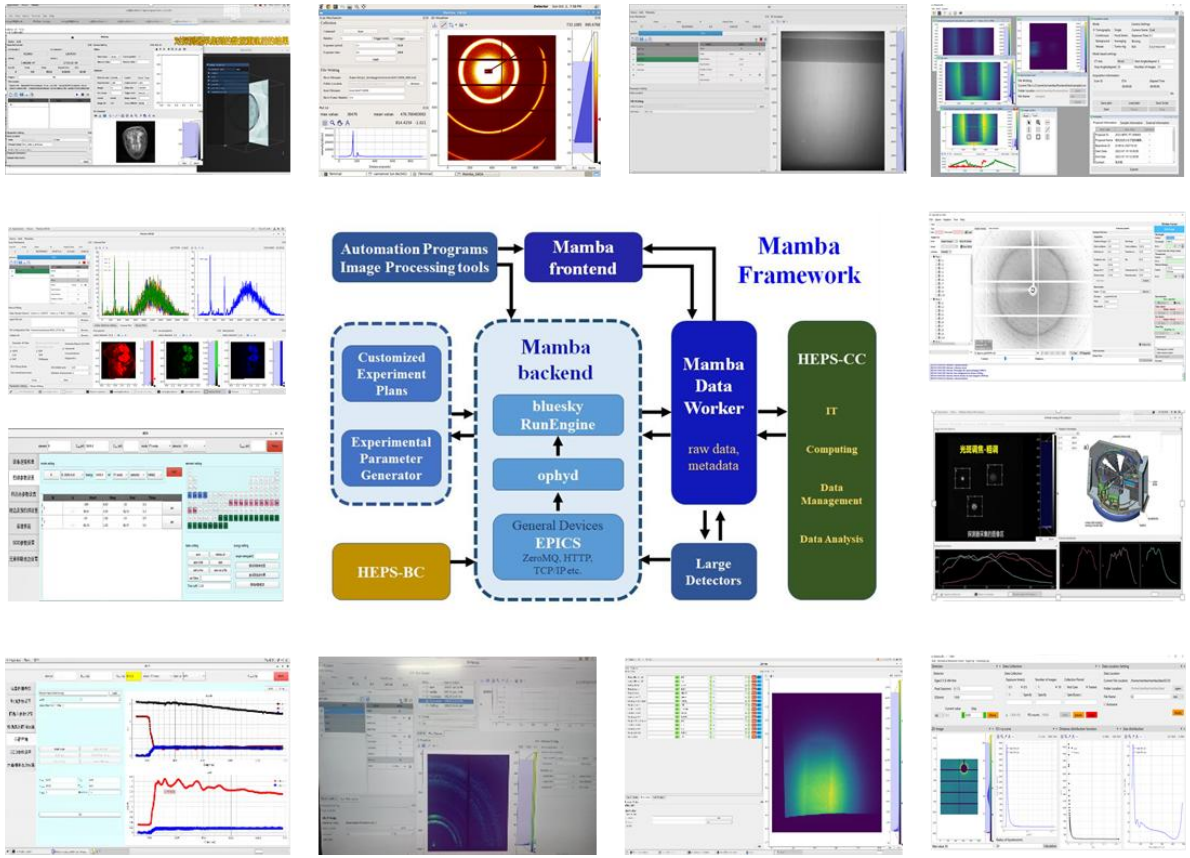


Pyapas framework



Beamline Software

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

Beamline Clusters

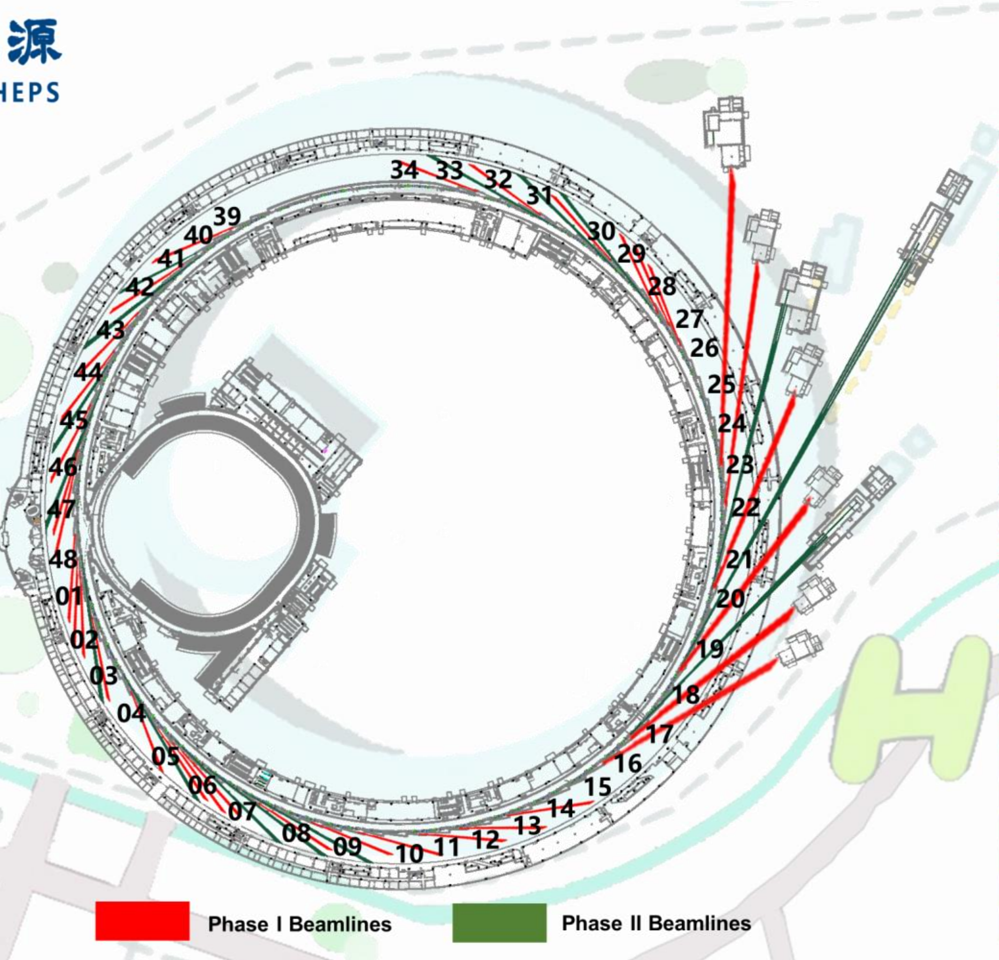
8 beamline clusters for **31 beamlines proposed**

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

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

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.

Summary

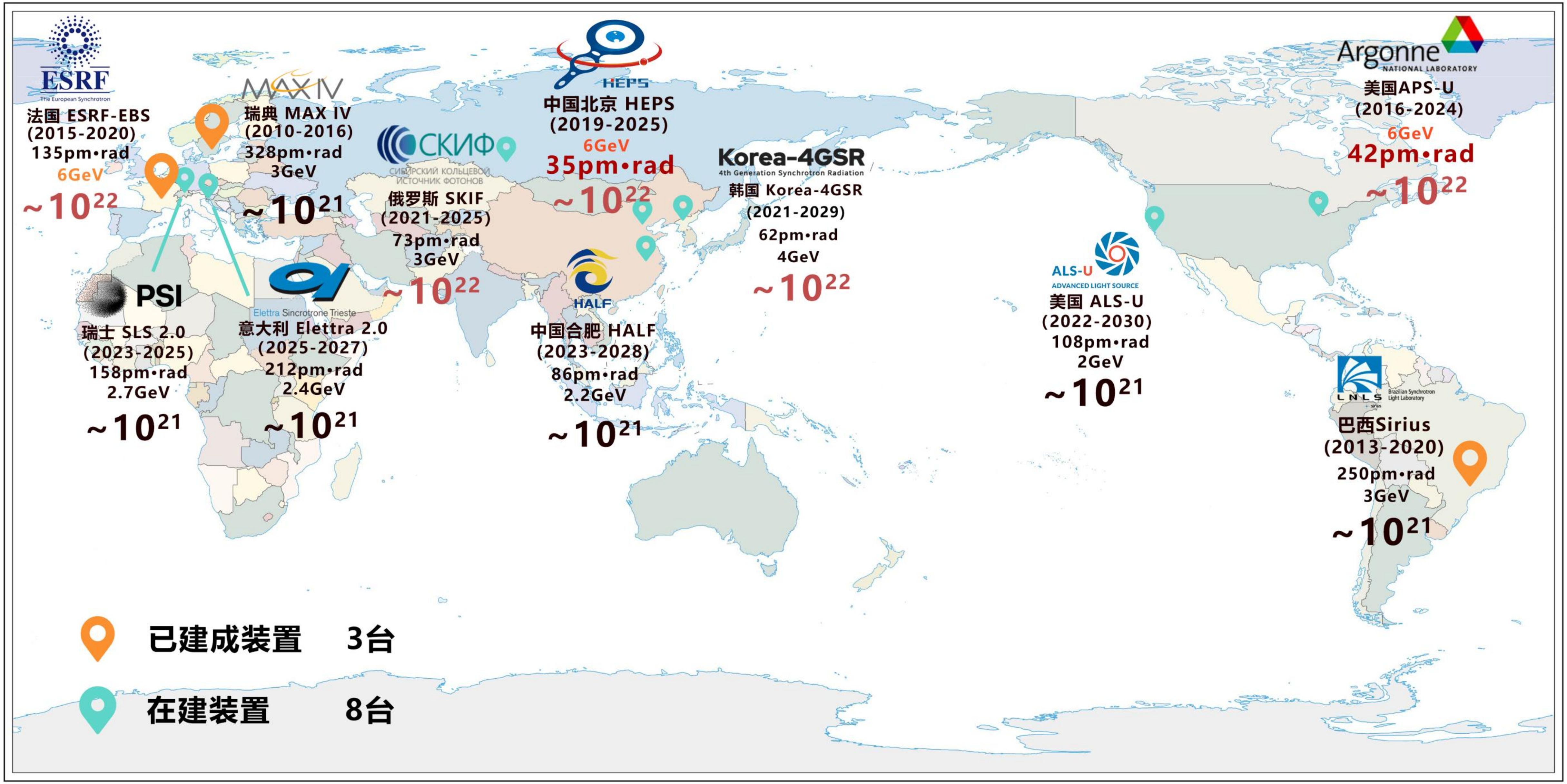
Summary

- HEPS is a greenfield, 4th generation, high energy, ultra-low emittance SR facility. It is the key facility of Huairou Science City.
- Construction started from 2019. Emittance 100pm·rad achieved. All of the beamlines under commissioning.
- HEPS is planned to be completed in 2025 (a great challenge and we will work hard in the next few months) and open to academic and industrial users globally in 2026.

Thanks for your attention！

Welcome to visit HEPS, Beijing!

世界地图



审图号：GS(2016)1663号

自然资源部 监制

5 round commissioning completed

41.037A·h
Total beam dose