
Choose HEPS for your achievement

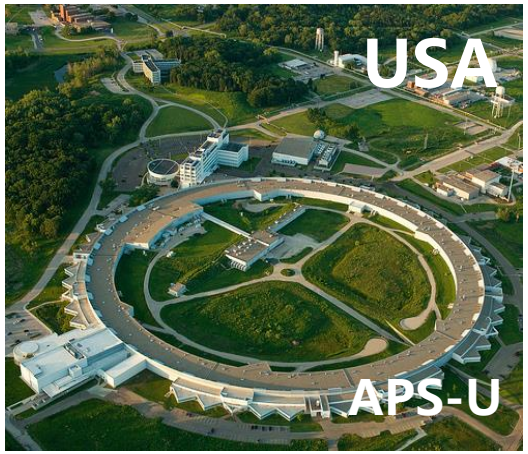
Why Choose HEPS?

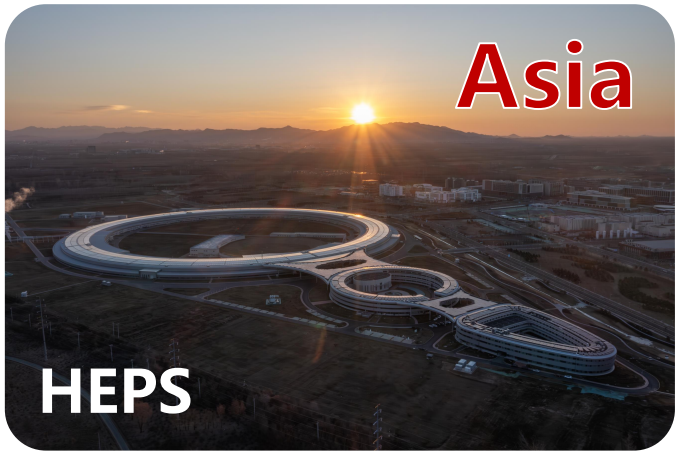
- ✓ **World-class Flagship light source**
- ✓ **More than 60 new beamlines capacity (Phase II beamlines coming), More opportunities**
- ✓ **Your ideas and pursuit supported by strong in-house R&D teams in Insertion device, X-ray optics, Opto-mechanics, Detectors, Software and AI for Sciences**
- ✓ **Access to junior collaborators and Support for Postdoc recruitment**
- ✓ **Surrounded by other large facilities in extreme condition, biomedical, Nanoscience, Energy etc.**
- ✓ **International working environment. HEPS belongs to Institute of High Energy Physics (IHEP). IHEP is a world-class, large scale and multidisciplinary institution**

World-class Flagship light source

World-class Flagship light source

High energy 4th generation Synchrotrons





Ring Energy	**6 GeV**	**6 GeV**	**6 GeV**
Designed emittance (achieved)	**130 pm•rad (130)**	**42 pm•rad (45)**	**35 pm•rad (93)**
MBA	**7BA**	**7BA**	**7BA**
Ring circumference	**0.84 km**	**1.10 km**	**1.36 km**
	upgrade	**upgrade**	**Green field**
Status	**in operation**	**in operation**	**under commissioning**

Progress Released

Joint-Commissioning Phase announced on Mar. 27, 2025

SR News: regularly

Nature News, May 2024

Science, Oct. 2024

Physicsworld Mar. 2025

SRN2019

News and Views

Groundbreaking Ceremony at Source in Beijing

On June 29, 2019, a sunny morning in Beijing, more than 300 participants, including officials as well as the engineers and beamline scientists, witnessed the groundbreaking at the High Energy Photon Source (HEPS), a greenfield high-energy (6 GeV) ultralow emittance synchrotron facility. The light source is being constructed by the Institute of High Energy Physics, Chinese Academy of Sciences. The kickoff of the HEPS represents China's formal start of construction of the first new-generation synchrotron light source in Asia.

The circumference of the HEPS storage ring is 1360.4 m. The lattice takes a modified hybrid seven-bend achromat (7BA) design, in which some bending magnets with reversed bending angles and longitudinal gradients will enable the electron beam to reach an ultralow natural horizontal emittance of smaller than 60 pm.rad [1]. Forty-eight six-meter-long straight sections, with alternating high and low beta ones, are designed for generating the brilliant X-ray with a brightness of more than 1×10^{22} photons/s/mm²/mrad²/0.1% BW.

In Phase I, 14 beamlines will be constructed with 13 from insertion devices and one from the bending magnet. Feature beamlines will take advantage of the ultralow emittance to focus X-rays into a probe spot smaller than 10 nm with more than two orders of magnitude higher flux, and generate unprecedented coherent flux for coherence X-ray experiments.

Artistic aerial representation of the HEPS. The design looks like a magnifier, representing the exploration of the atomic world by the HEPS.

Shoveling site

This high-energy mach a high-energy X-ray up trial applications. Amo lines, there are three lon out of the experimental length of 350 m. As the will start after the infras optimization of beamlin until 2021.

Prior to the HEPS p was launched in 2016 a nologues' preparation fo the R&D project includ rupoles, a small-apert with non-evaporable ge precision power suppli cryogenic permanent been set up with a prec and PrFeB as the magn of beamline technologi trace profiler—"FSP"— whose self-comparison surfaces is up to 30 nra accuracy with interfero RMS, and the elliptical bending accuracy up ent prototype monoch

SRN2022

News and Views

HEPS Is Standing Out

Figure 1: The HEPS building complex. The circumference of the larger 1500 m. The extension buildings from this ring will contain three long bea the HEPS, reflecting its magnifier design.

Figure 2: HEPS booster and storage ring magnets.

Nearly 3 years after the groundbreaking ceremony for the High Energy Photon Source (HEPS) in June 2019, the HEPS buildings are standing out in Huairou Science City in Beijing (Figure 1). The design of the HEPS building complex looks like a magnifier with the storage ring as its head and auxiliary buildings as its handle. This is symbolically fitting, as HEPS is designed to enable structural details of matter to be magnified and observed by high energy, high brilliant, and high coherent X-rays.

The goal for the e than 60 pm rad. In ord to house the accelera 4th-generation 6 GeV ated 4 m deep. It was to form a stable slab. measurement result of been positive, and the long beamlines in Pha

As a result of en volving the accelerat age ring lattice and in

SRN2023

Facility Update

Update on HEPS Progress

Ping He, Jianshe Cao, Guoping Lin, Ming Li,
Institute of High Energy Physics, Chinese Academy of Sciences,

The High Energy Photon Source (HEPS) is a greenfield 4th-generation light source. Its storage ring energy is 6 GeV and its ring circumference is 1,360 m. One year after the HEPS complex buildings were constructed (Figure 1), we report here considerable progress, despite the COVID pandemic's impact on supply chain and on-site personnel leading to unanticipated delays.

Another major milest pletion of a mock-u HEPS storage ring (nets in this cell are all of the vacuum c nected together and The mock-up assemb installation team to corrections, which ha production process [

As a necessary beam commissioning, a high-level application framework based on Python, named Python accelerator physics application set (Pyapas), was proposed and has been developed [3]. By December 2022, the high-level applications for the injector had been developed, while and others are still ongoing.

Accelerator status

The year of 2022 witnessed completion of several milestones in accelerator progress. Installation and high-power conditioning of the linac [1] were completed in the autumn (Figure 2). Almost 95% of the booster accelerator components (magnet, girder, and vacuum chamber) have been put into the booster tunnel.

corrector coils to the quadrupole field has been thoroughly studied. Over 50% fast corrector magnets have been tested and the bandwidth measured to be 4 kHz.

The manufacture of the more than 2,000 power supplies to power the main magnets and correctors has been completed and testing

Figure 1: Bird's eye view of HEPS complex buildings in the summer of 2022.

SRN2025

HEPS Update in 2024.pdf

HEPS Update in 2024

Ping He, Jianshe Cao, Ming Li, Yuhui Li, Yuhui Dong, We
Institute of High Energy Physics, Chinese Academy of Sciences, Beijing, China

Year 2024 witnessed two key milestones of the High Energy Photon Source (HEPS) project: the beam stored in a storage ring and the first X-ray light emitted from an insertion device, respectively. As a green field 4th generation 6 GeV lightsource (Figure 1), commissioning of the accelerator and Phase I beamlines will be completed in 2025 and HEPS will be gradually open to pilot users at the same time.

bandwidth, high impressive resul sponse and 20 pp

Approximate accelerator and seal treated with NE and providing d team successfull antechamber, wh was made possib of segmented strength in the er

Regarding th stalled and teste gen frequency achieves 1 μm p tors has been pos curacy of approx

Accelerator status

The HEPS storage ring incorporates 1,776 advanced magnets, comprising 26 different types, designed to precisely steer and focus the electron beam into a more concentrated form. These magnets were integrated into 288 modules, with each magnet's center aligned to an exceptional precision of 30 microns. The complete installation of all magnets into the storage ring tunnel was accomplished this year (Figure 2).

All magnet power supplies are situated within the Power Supply hall. The high-precision current-stable power supplies demonstrate exceptional performance metrics, including long-term stability of 10 ppm, accuracy of 50 ppm, and repeatability of 20 ppm. Testing of the wide-

nature

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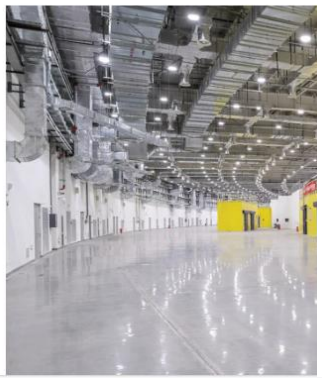
nature › news › article

NEWS | 13 May 2024

World's brightest in Asia to build n synchrotron

The US$665-million High Energy Photon among only a handful of countries that ha sources.

By Gemma Conroy



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PROJECTS AND FACILITIES | FEATURE

China's High Energy Photon Source prep world

25 Mar 2025 Robert P Crease

Robert P Crease visits the High Energy Photon Source ne it opens later this year – the most advanced fourth-generat

Leading light The High Energy Photon Source (HEPS), due to sta be the world's most advanced synchrotron light source of its type.

I'm standing next to Yang Fugui in front of the High Energy Beijing's Huairou District about 50 km north of the centre o HEPS isn't just another synchrotron light source. It will, wh the world's most advanced facility of its type. Construction 2019 and for Yang – a physicist who is in charge of designi we're at a critical point.

"This machine has many applications, but now is the time t science," says Yang, who is a research fellow at the Institut (IHEP) of the Chinese Academy of Sciences (CAS), which With the ring completed, optimizing the beamlines will be v new research areas.

READ MORE

China's next big thing: a new fourth-generation synchrotron facility in Beijing

From the air – Google will show you ph giant magnifying glass lying in a grass and from my perspective it resembles walled silver sports stadium, surrounde and fountains.

I was previously in Beijing in 2019 at th was broken when the site was literally told, the HEPS would take six-and-a-half years to build. We continues to run as planned, the facility will come online in

Lighting up the world

There are more than 50 synchrotron radiation sources arou intense, coherent beams of electromagnetic radiation used from condensed-matter physics to biology. Three significar one after the other, have created natural divisions among s them to be classed by their generation.

Science

BACK TO SCIENCEINSIDER

SCIENCEINSIDER | ASIA/PACIFIC

China poised to turn on one of world's most powerful sources of x-ray light

Beams from $657 million next-generation synchrotron will reveal atomic-scale structure of proteins and materials

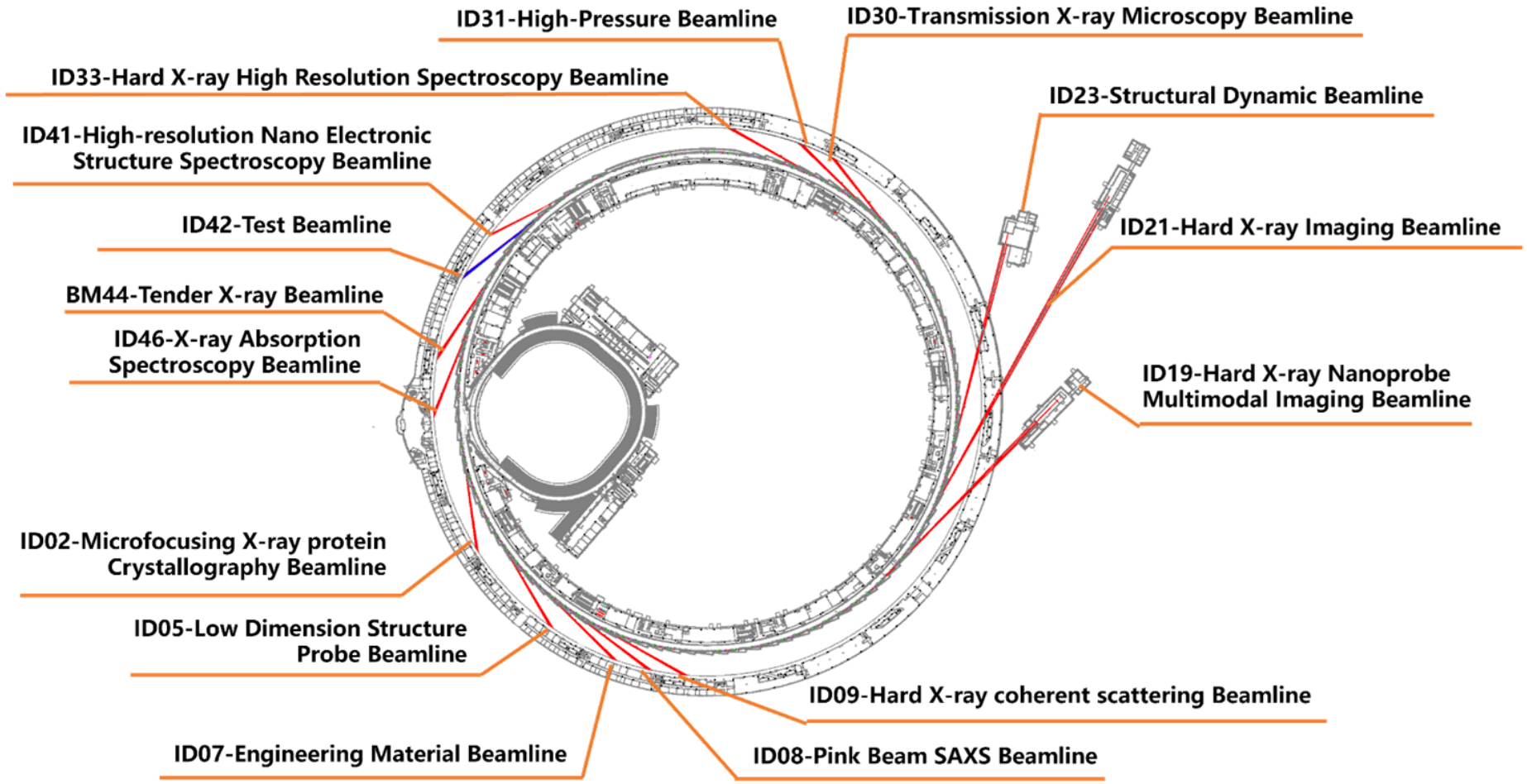
22 NOV 2024 · 5:30 PM ET · BY RICHARD STONE

China's High Energy Photon Source is days away from funneling bright x-rays into experimental beamlines. INSTITUTE OF HIGH ENERGY PHYSICS/CHINESE ACADEMY OF SCIENCES

15 beamlines in Phase I

14 user beamlines (3 long beamlines)+ 1 test beamline

All of the beamlines under commissioning



HEPS | HIGH ENERGY PHOTON SOURCE

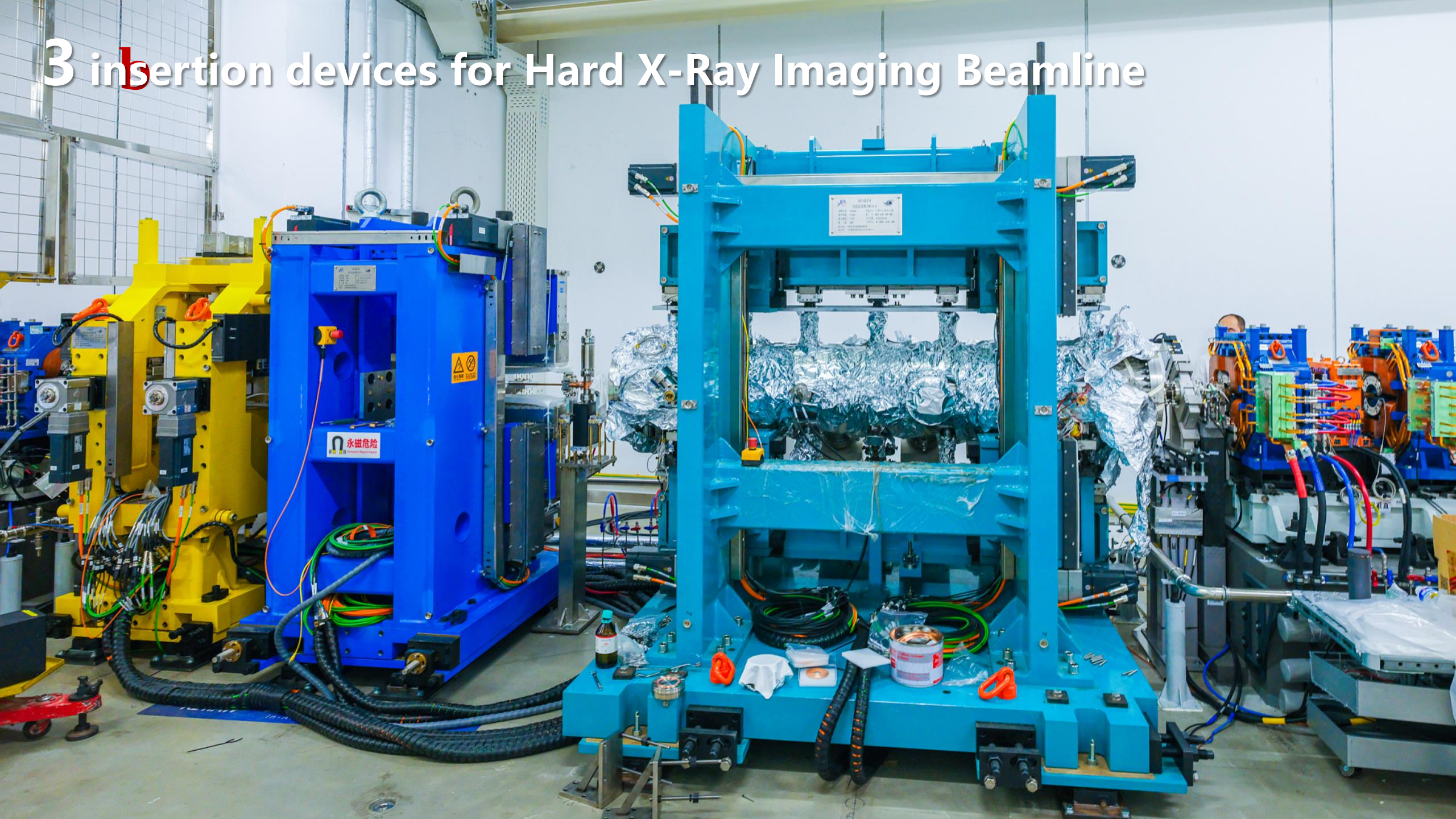
Two Groups, depending on its complexity and insertion device (ID) type

All Most featured beamlines in Group 2, such as nano and coherent beamlines, to have more time for design and preparation

	Beamlines	Features
Group1	Tender spectroscopy	Bending magnet，2-10keV spectroscopy
	XAFS	routine and quick XAFS，plus 350nm microprobe
	Hard X-Ray Imaging (350m long)	1 undulator/2 wigglers, 10-300keV, Phase/Diffraction contrast imaging
	Transmission X-ray Microscope	full field 20nm resolution imaging and spectro-imaging
	Macromolecular Crystallography	1μm spot, standard and serial protein crystallography
	SAXS	pink beam, lest optics
	Optics Test	1 undulator and 1wiggler, Optics online metrology and R&D
Group2	NanoProbe (180m long)	Nano mode, <10nm; In-Situ mode, <50nm; ptycho, BCDI; SEM
	Coherent Scattering	8-25keV, CDI and XPCS; XPSA 4M detector and EIGER2 XE 4M detector
	Engineering Materials	50-170keV, XRD, SAXS, PDF; Eiger16M CdTe detector;
	Structural Dynamics (200m long)	15-70keV, ultrafast diffraction and imaging; nanoholography;
	High Pressure	150nm focusing, diffraction and imaging, Eiger16M CdTe detector
	Low-Dimension Probe	surface and interface scattering, surface XPCS
	High Energy resolution spectroscopy	Nuclear Resonant Scattering and X-ray Raman spectroscopy
	Nano ARPES	100-2000eV, 100nm, 5meV@200eV, APPLE-KNOT undulator

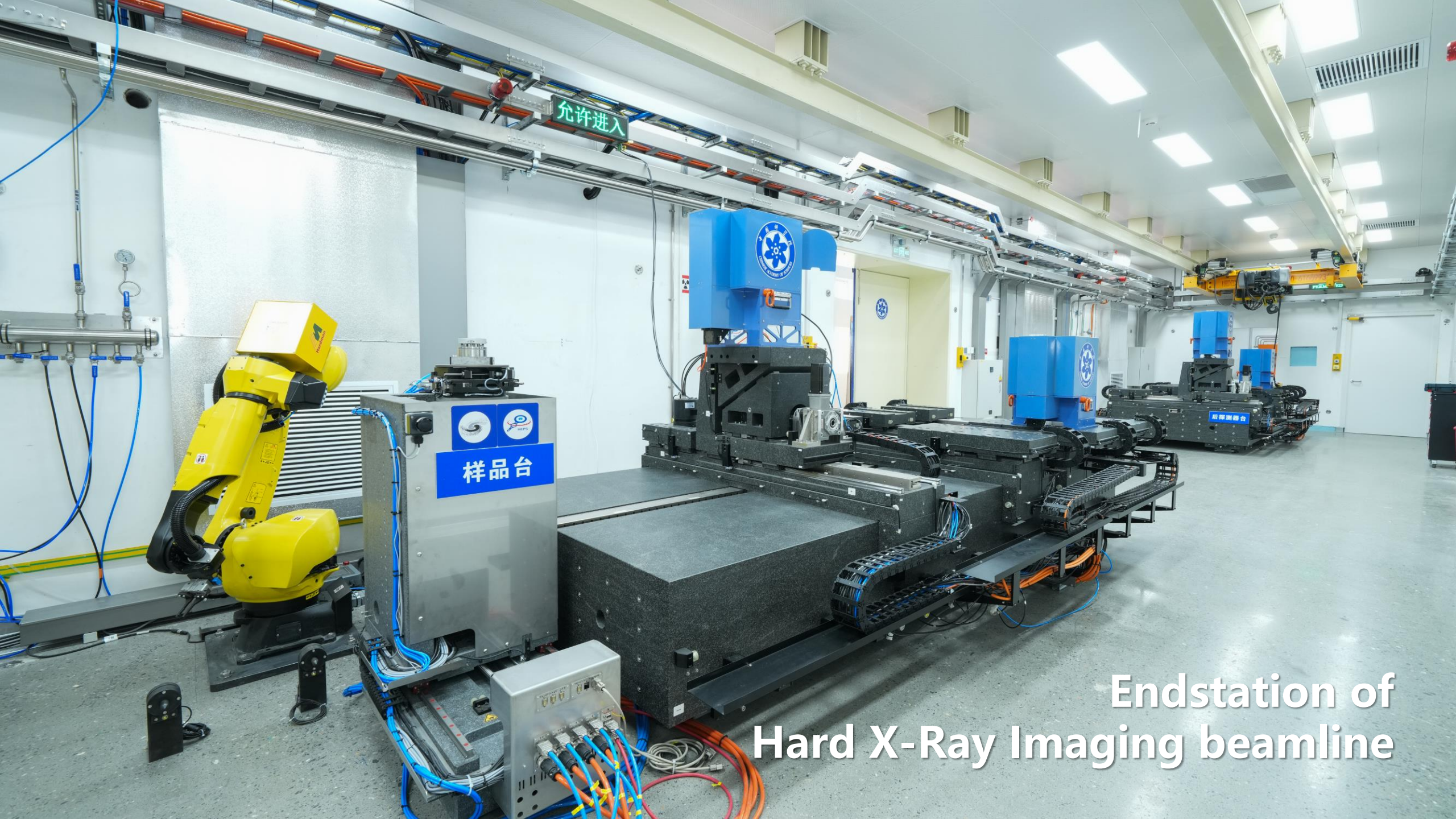
3 long Beamlines in Phase I

3 insertion devices for Hard X-Ray Imaging Beamline




Storage Ring Tunnel
Front End

Beamline organized in 4 colors



Endstation of Hard X-Ray Imaging beamline

Strong R&D capability

In-house development of X-ray technologies: Insertion device, X-ray optics, Opto-mechanics, Detectors, Software and AI for Sciences

International Assessment of IHEP (Sept. 2023)

- The R&D for the key technologies for the HEPS beamlines covers various topics in optics, X-ray detectors, and software. The technological advances in X-ray optics manufacturing and metrology have been truly impressive over the last five years, at the level of the best centers in the world. The efforts for X-ray detector development cover some of the most advanced

PAPS

Cross the street, a supporting facility-Platerform for Advanced Photon Source, dedicated to HEPS in-house R&D development

- ✓ **Accelerator Technology**
- ✓ **X-ray Technology**

21,295 m^2 building area

Supported by Beijing Government

HEPS | HIGH ENERGY PHOTON SOURCE

Accelerator Technologies

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

High Gradient Quadrupole

Magnetic field gradient 80 T/m

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

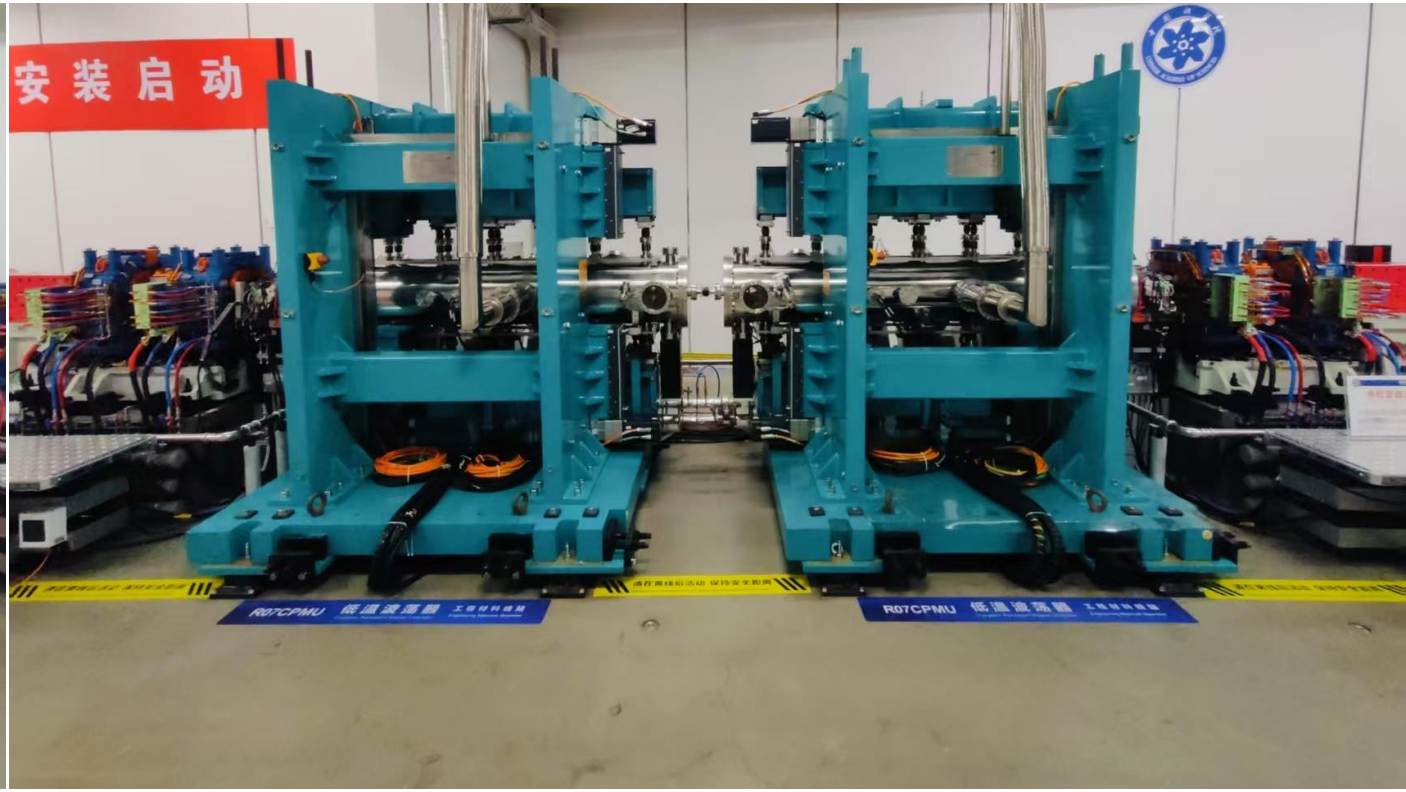
NEG film coating

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

Insertion devices

IVU 4m In Vacuum Undulator with NdFeB or SmCo magnet, min gap 5.2mm

CPMU 2m Cryogenic Permanent Magnet Undulator with PrFeB magnet, min gap 5.2mm



Insertion devices

IAU 5m In-Air Undulator, min gap 11mm

AK Apple-Knot Undulator

a special 5m elliptical undulator to emit soft X-ray in high energy machine with downstream heatload mitigated

Insertion devices

Mango Wiggler

Yellow one

a special Delta type PPM wiggler for large vertical field of view for X-ray phase contrast imaging

IAW

Blue one

In-air Wiggler

X-ray Technologies

Beamline **WHOLE-CHAIN** R&D capability from source to the endstation

Optical Metrology

Optics Fabrication

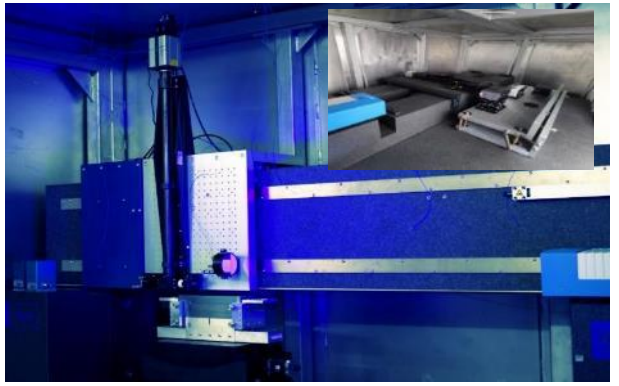
Multi-physical Field Control

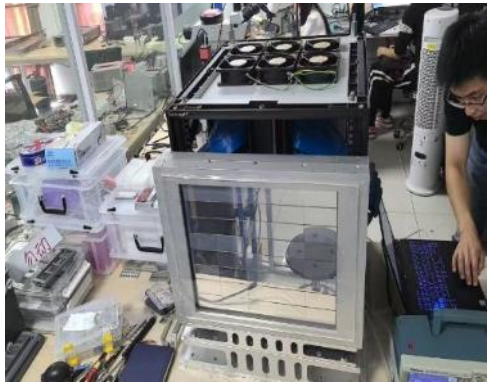
Opto-Mechanics design and assembly

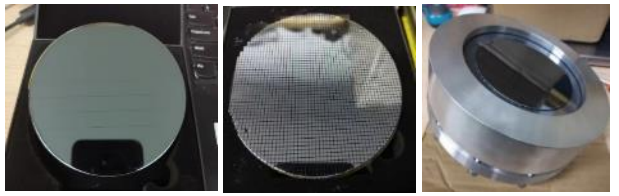
for Mirror system, Transfocator and Monochromator and endstation Instrument, Beamline Defining and Diagnostic instrument

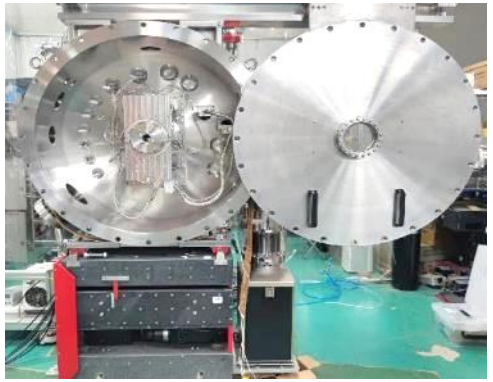
Detectors

Control Software and AI for Sciences

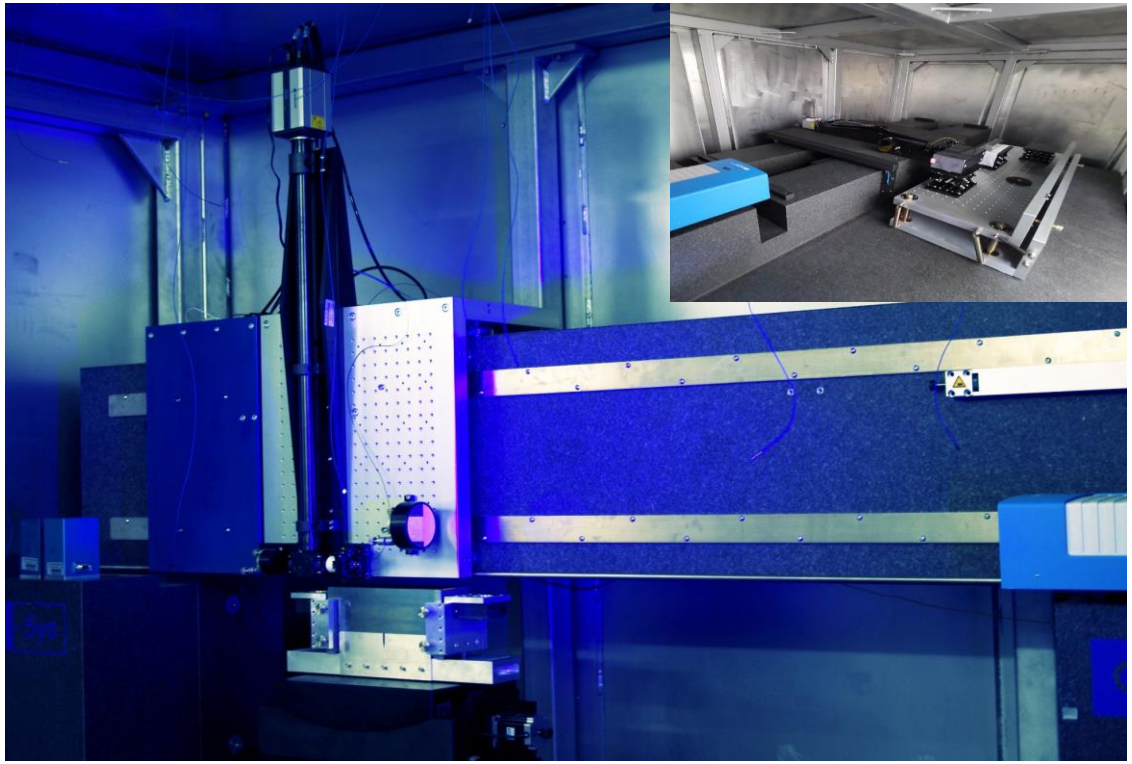


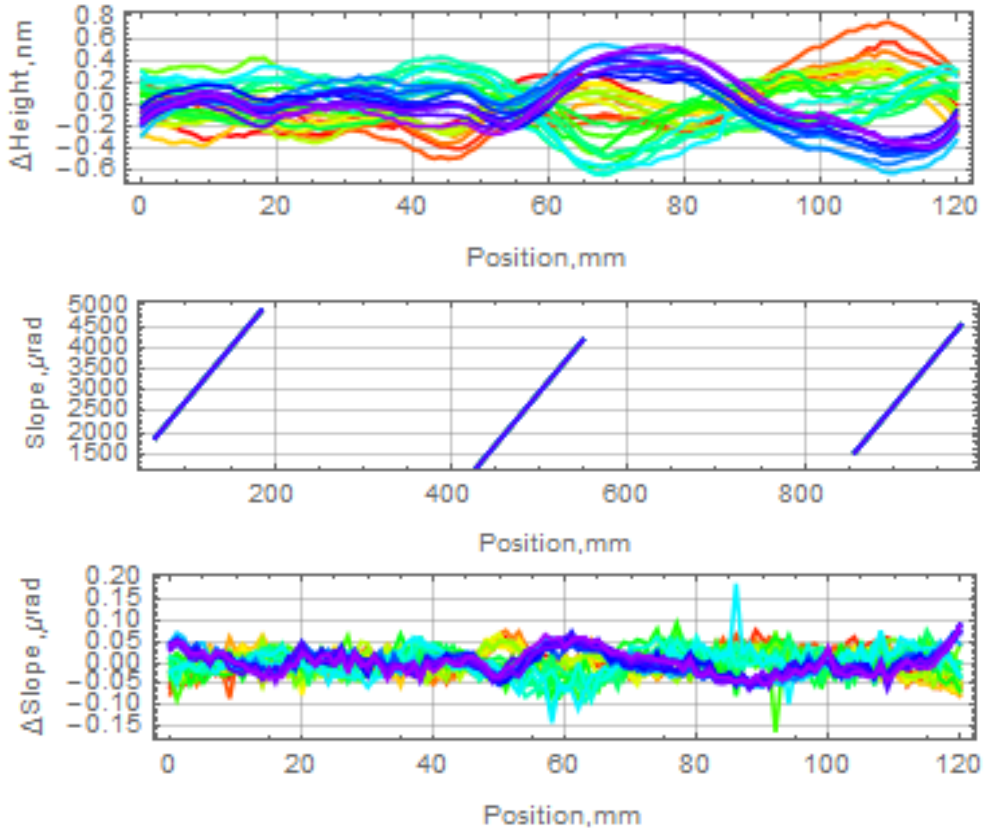






Optical metrology





Flag-type Surface Profiler, **FSP**

Ming Li et al., Chinese Invention Patent (ZL 2014 1 0253989.7)

Measurement accuracy of curved mirror

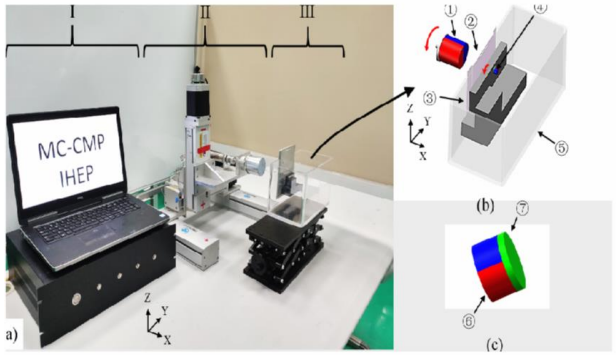
RMS 29.0nrad / RMS 0.23nm

@ once scanning

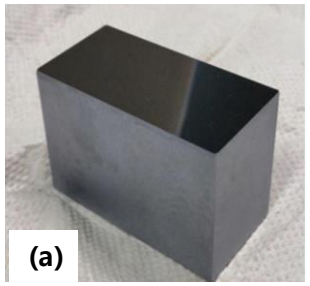
Optics Fabrication- Silicon crystal for Monochromator

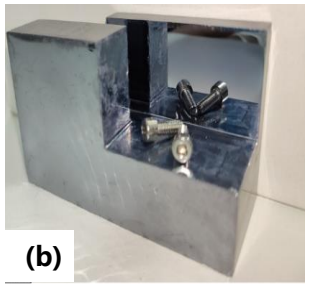
- With chemical-mechanical polishing methods, the ultra-high wavefront preservation within the full beam of nearly **10mm** has been achieved.
- The fabricated flat and Channel-cut silicon crystals also qualified sub-nanometer surface roughness, X-ray topography with uniform contrast

J Synchrotron Radiation 30 (2023) 3084-89.

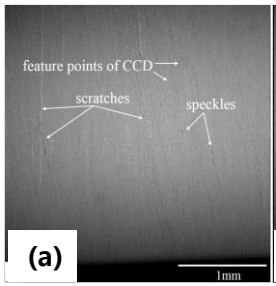


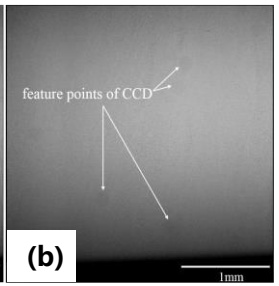
Magnet controlled-chemical mechanical polishing system for Channel-cut fabrication





(a) Flat silicon crystal
(b) Channel-cut silicon crystal

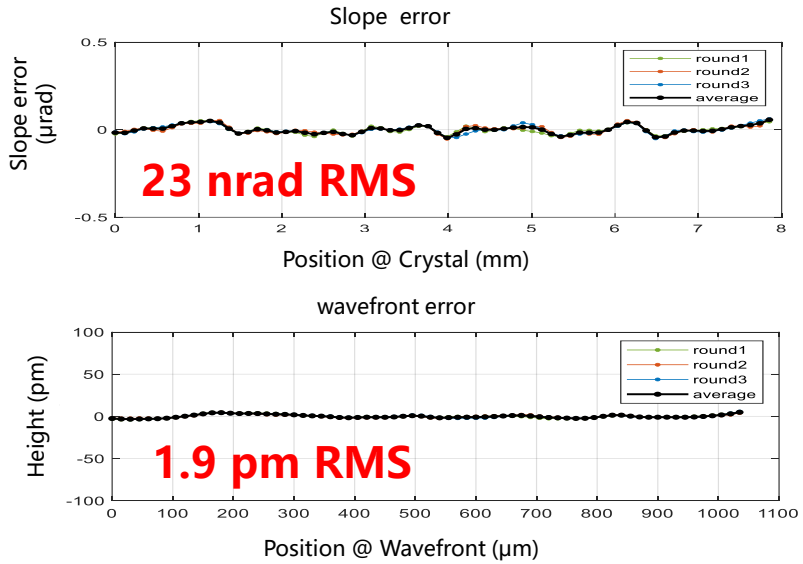




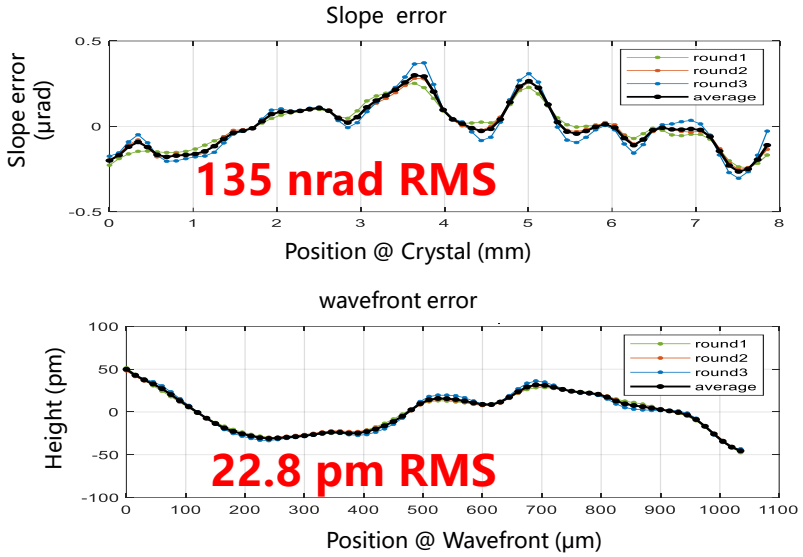
(a) Topography of the etching CC
(b) Topography of the polishing CC

Optics Fabrication- Silicon crystal for Monochromator

Measured by novel Double-edge Method @ SSRF



Wavefront error of flat crystal

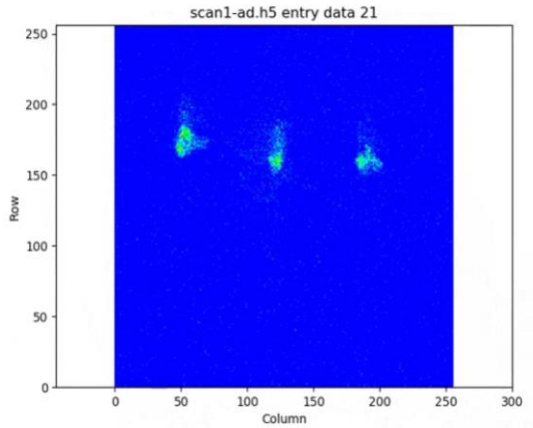


Wavefront error of CC crystal (2 reflections)

Optics Fabrication - Bent-crystal Analyzer

Spherically bent for XRS

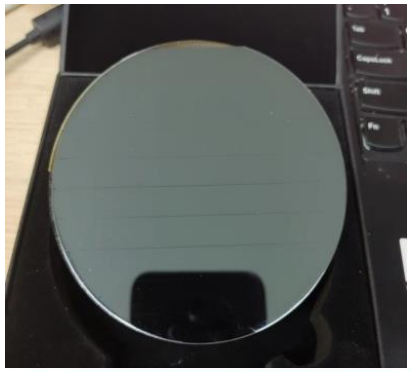
Si(660) ~1eV @ 9.7keV

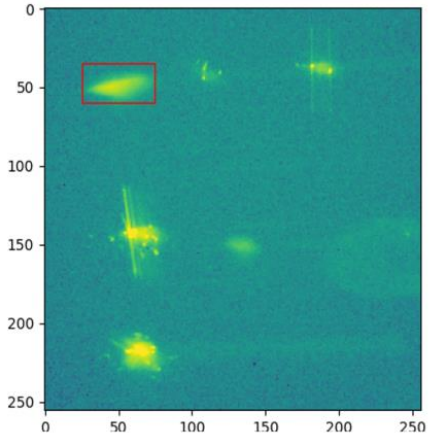


excellent focusing & energy resolution

Bent striped for XRS

Si(660) ~0.53 eV@ 9.7keV

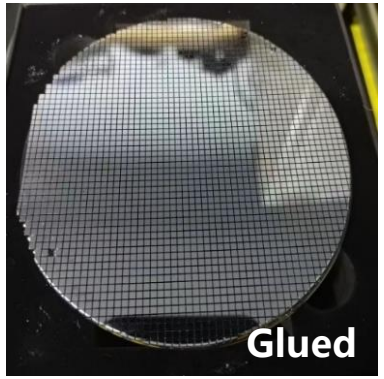


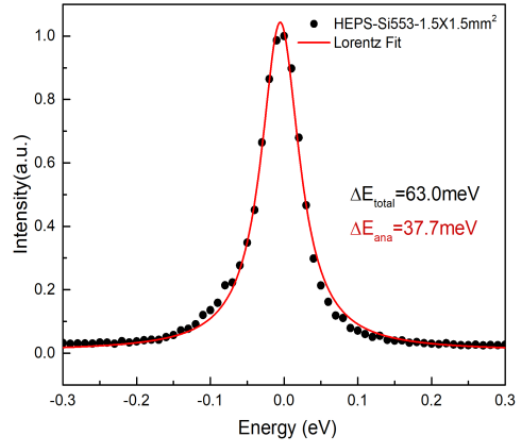


energy resolution improved

Mosaic-diced for RIXS

Si(553) ~0.037 eV@ 8.9keV

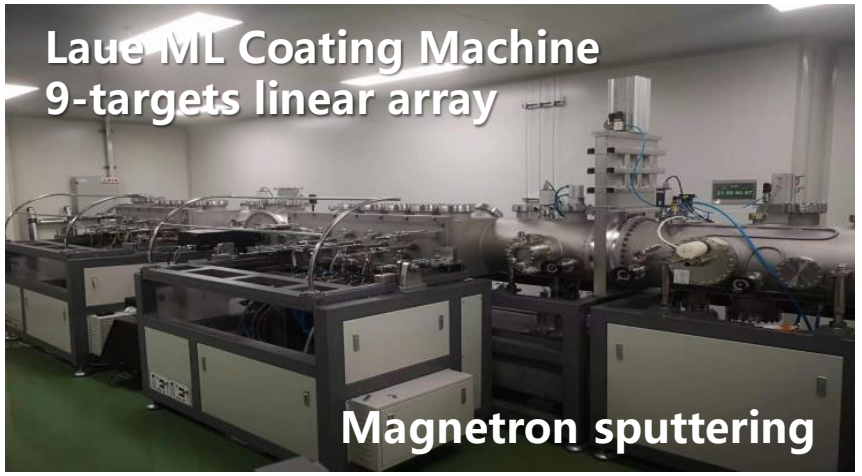


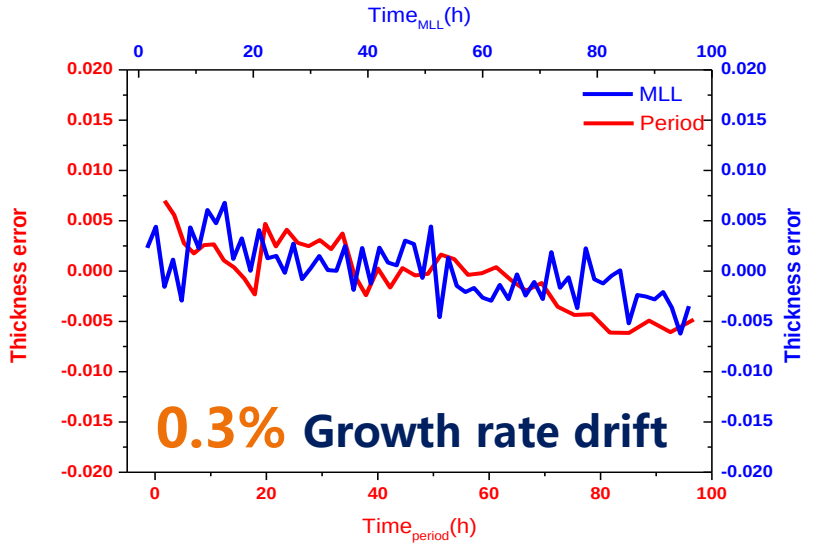


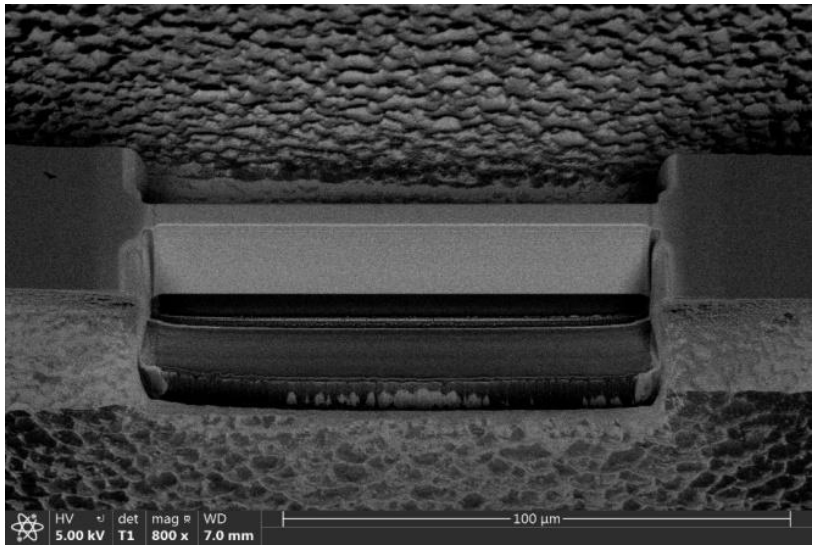
highly improved energy resolution

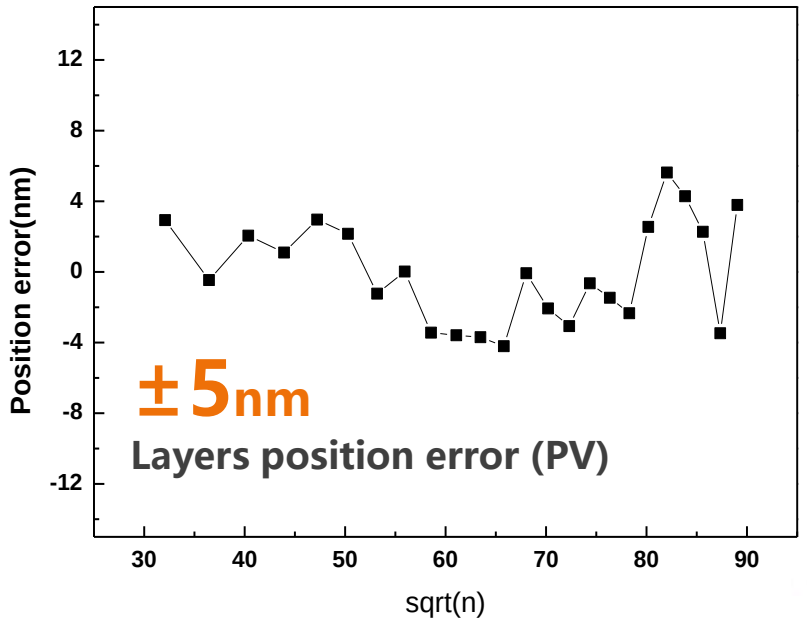
Optics Fabrication - Multilayer Laue Lens (MLL)

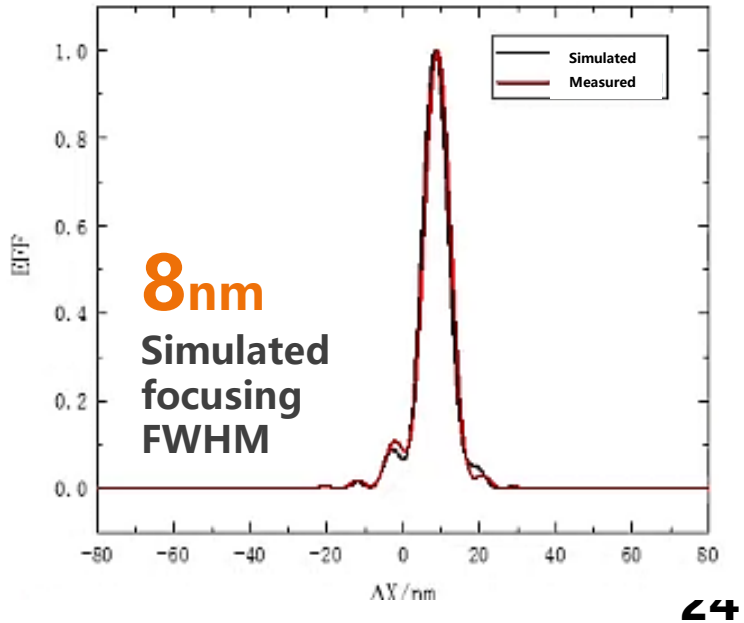
Para.	Req.
Material	WSi_2/Si
N. Layer	13030/8030
Thickness	64μm/44μm
Focus	$8\times8nm^2$









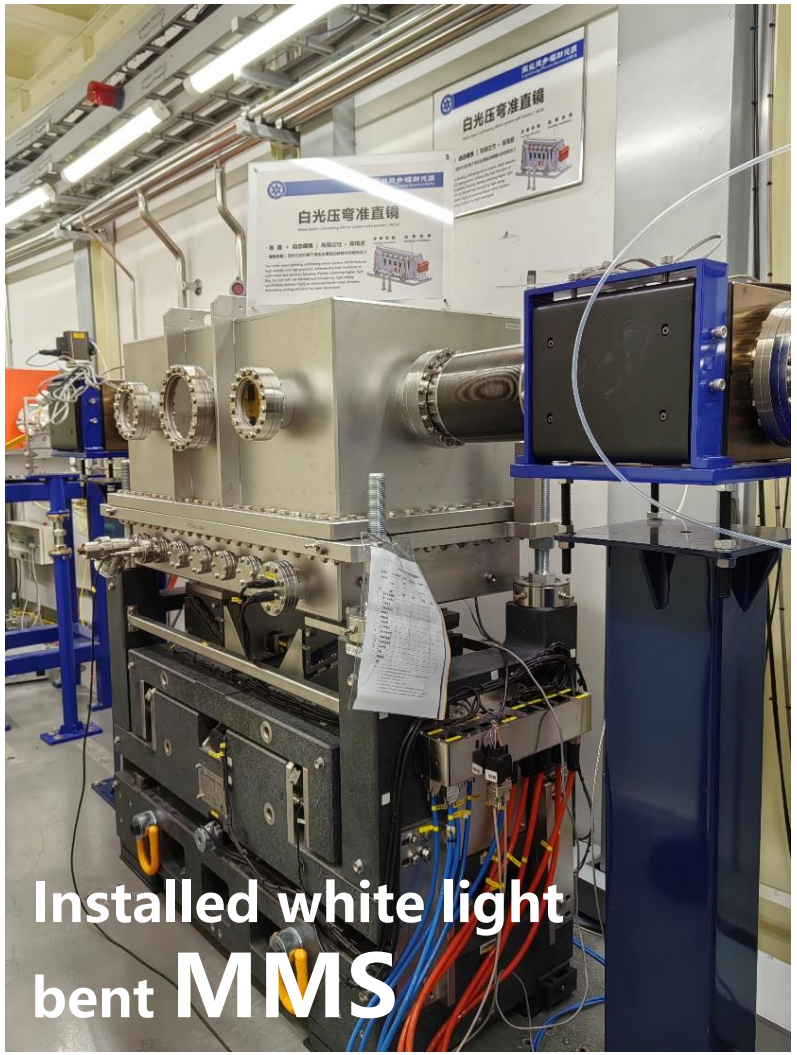


HEPS HIGH ENERGY PHOTON SOURCE

Opto-Mechanics

MMS Mirror mechanical system

- **Generic MMS:**
  - State-of-the art performance
  - Used for 4th gen advanced light soure
- **Nano KB (included Bender):**
  - Focusing spot up to **≤100nm**
  - Stability of the vibration **≤20nm RMS @1-120Hz**
- **25+ sets commissioning**

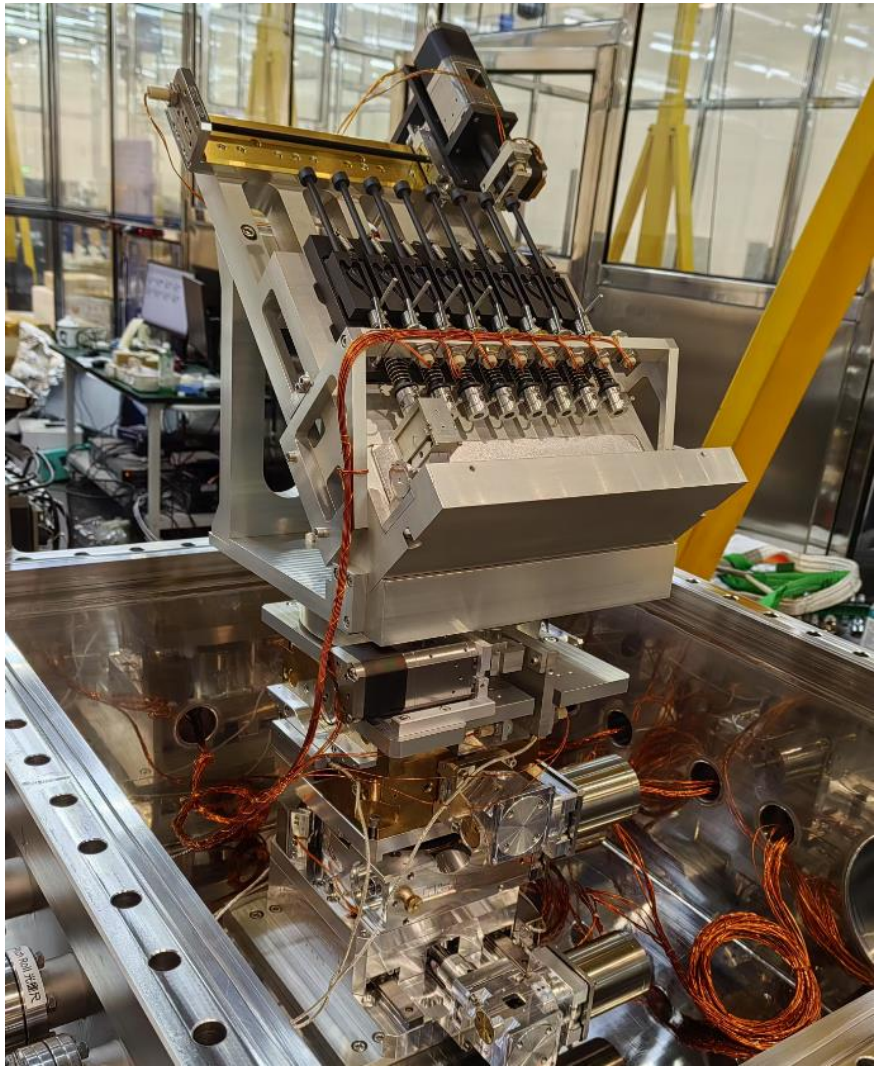


Installed white light bent MMS

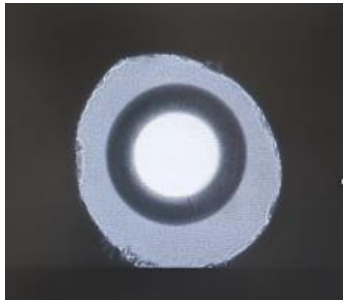
Opto-Mechanics

TRANSFOCATOR

- Novel device based parallel mechanism
- Compact & larger work distance
- **2 patents** authorized (US and China)
- **25+sets** installed at HEPS



Transfocator Prototype and X-ray spot observed behind Transfocator



Opto-Mechanics

MONOCHROMATORS

- **18** sets, **8** types total

  covers almost all kinds of monochromators that could be used in a Synchrotron beamline

  Completely new designs to meet the most demanding requirements of the HEPS

- **Cooling**: 13 LN2 cooled, 3 water cooled, 2 without cooling
- Started developing monochromators since **1990s** for BSRF, including bending crystal monochromator

66% HEPS in-house developed monochromators

Vertical diffracting Double Crystal Monochromator

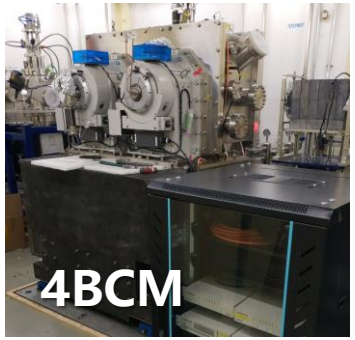
Horizontal diffracting Double / Channel-cut Crystal Monochromator

Quick EXAFS Channel-cut Crystal Monochromator

Horizontal diffracting Double Multilayer Monochromator

High energy Resolution Monochromator

Medium energy Resolution Monochromator



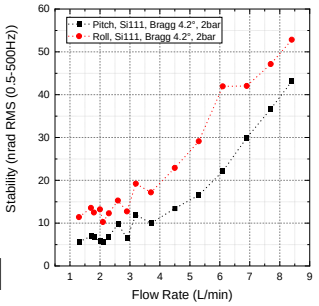
Four Bounce Crystal Monochromator

Double Laue Crystal Monochromator

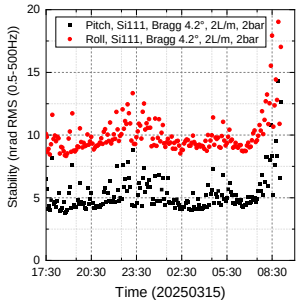
Opto-Mechanics

MONOCHROMATORS

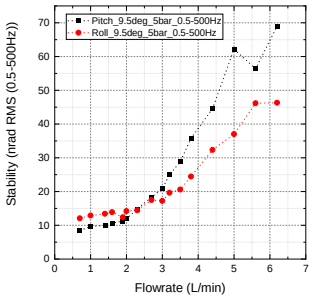
- Novel Design, **High Performance**
  - **High stability**: 4nrad RMS for VDCM, 8nrad for HDCM, 6nrad for HDMM, 3.5nrad for HRM
  - **High scanning speed**: 0.5°@100 spectra/s
  - **High precision**: HRM resolution 10nrad/step
- **Supporting labs** provide full support from validation to testing
  - FEA and optical analysis team, crystal fabrication and testing lab, optical metrology lab, cryogenic lab and systems



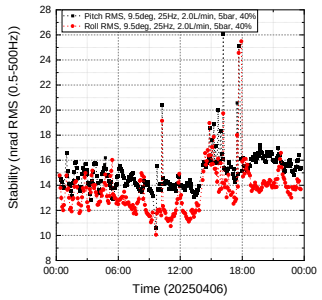
VDCM stability vs LN2 flow rate



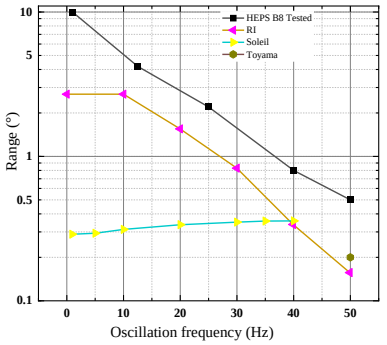
VDCM long term stability: best **4**nrad



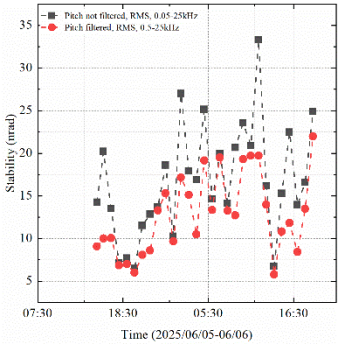
HDCM stability vs LN2 flow rate: Best **8**nrad RMS



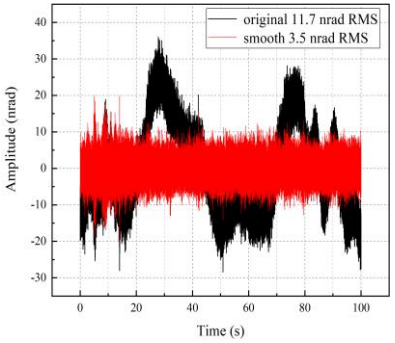
HDCM long term stability



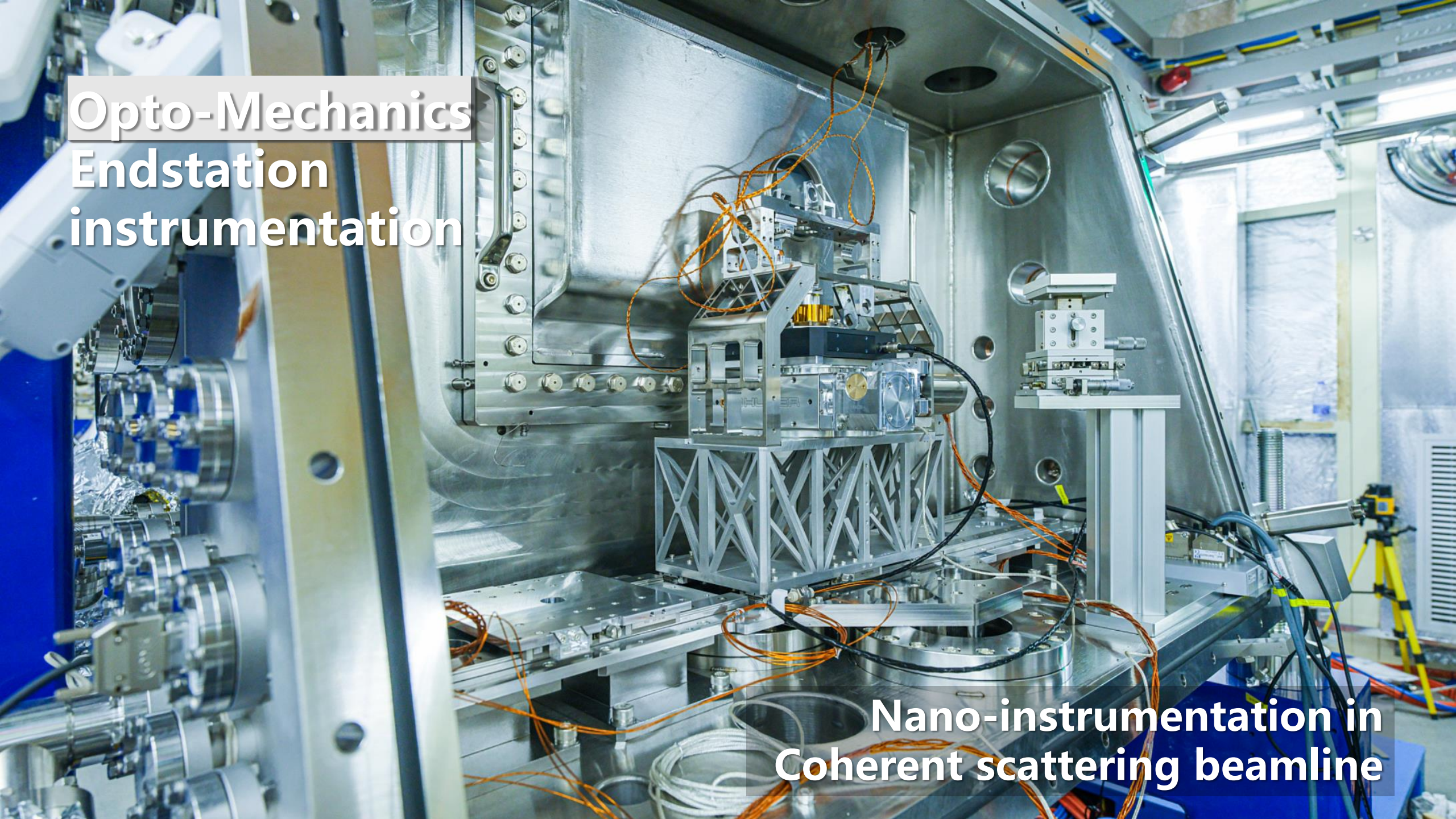
QCCM scan speed **0.5°@100** spectra/s



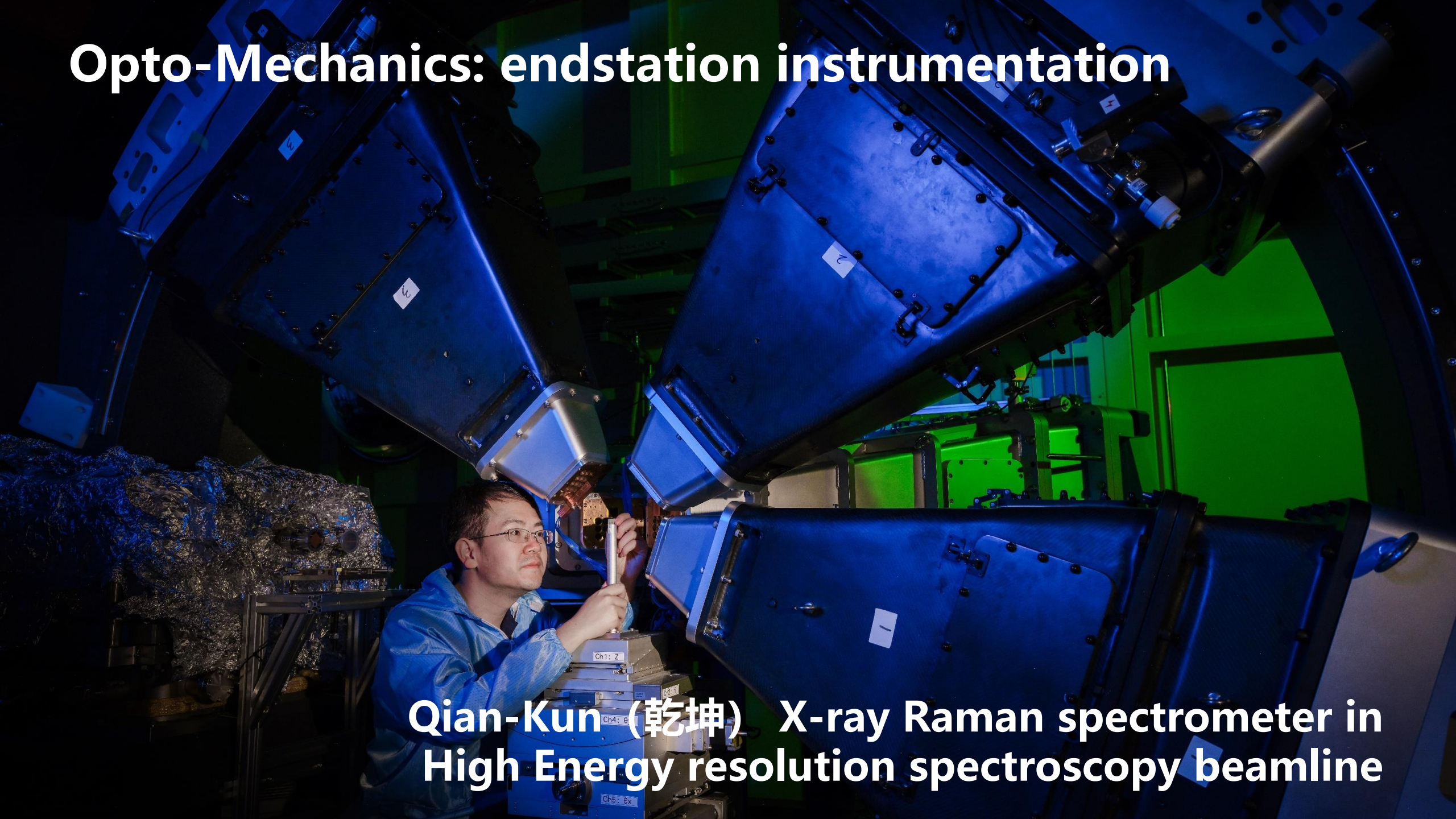
HDMM stability best **6**nrad RMS



HRM stability **3.5**nrad RMS


Opto-Mechanics
Endstation
instrumentation
Nano-instrumentation in
Coherent scattering beamline

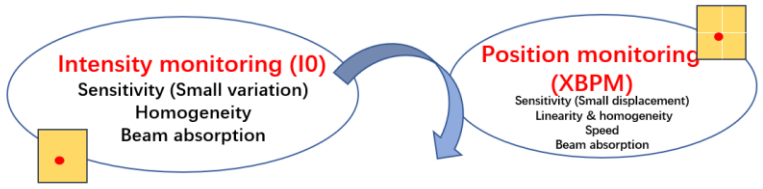
Opto-Mechanics: endstation instrumentation



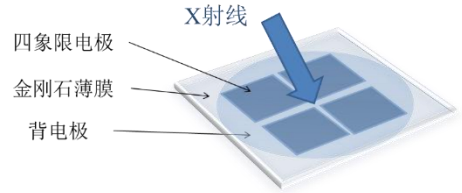
Qian-Kun（乾坤） X-ray Raman spectrometer in
High Energy resolution spectroscopy beamline

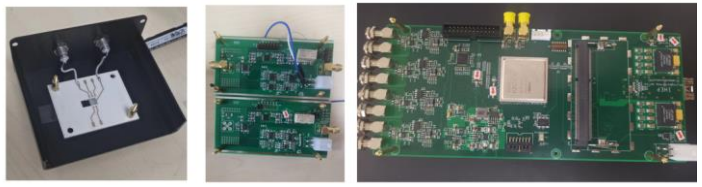
Detector development

Diamond XBPM



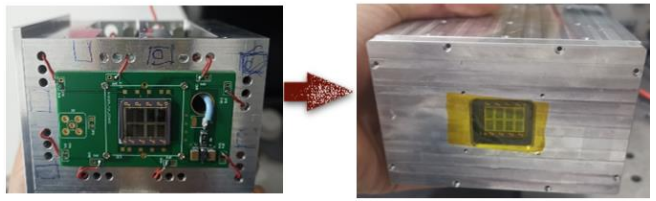
Vacuum compatibility & radiation hardness





Diamond XBPM & electronics performance comparable to the commercial

ns APD array

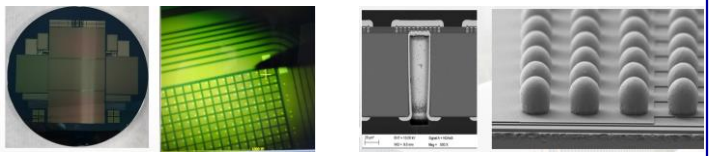


APD sensor Pre-amplifier

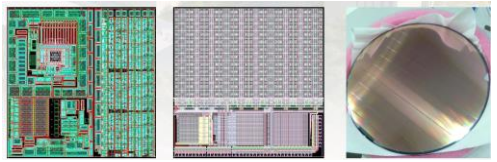
Readout electronics DAQ

- **Time resolution better than 100ps**

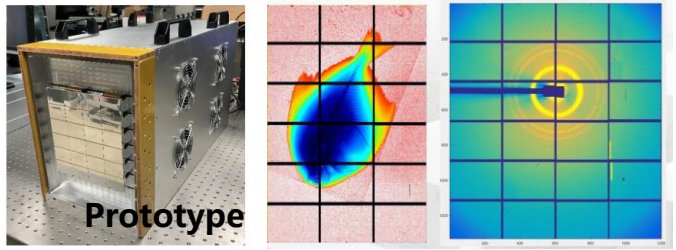
X-ray Pixel Array Detector



sensor flip-chip bonding

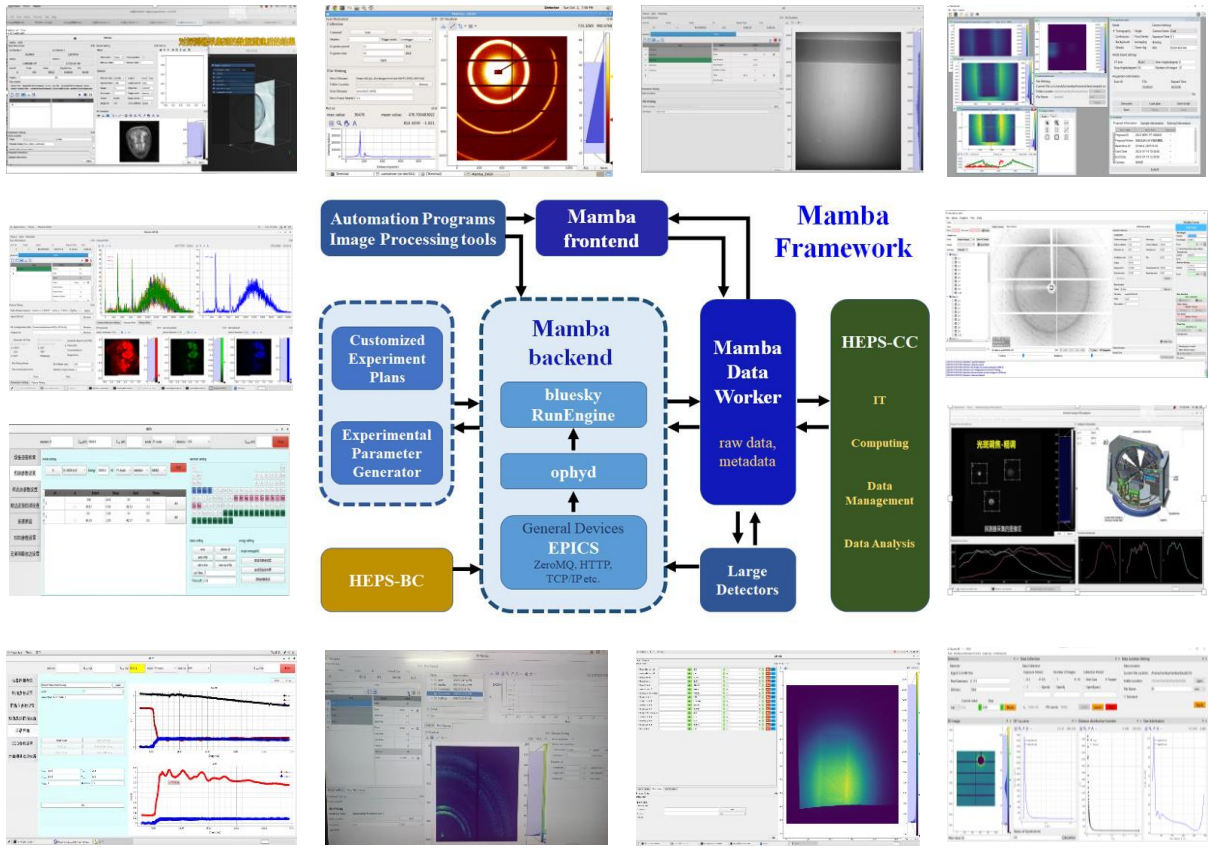


ASIC



- **6M 140μm pixel detector commissioning in PX beamline**

Mamba-A new generation experiment operating software system



One Framework

Support 15 beamlines in Phase I project

and future beamlines

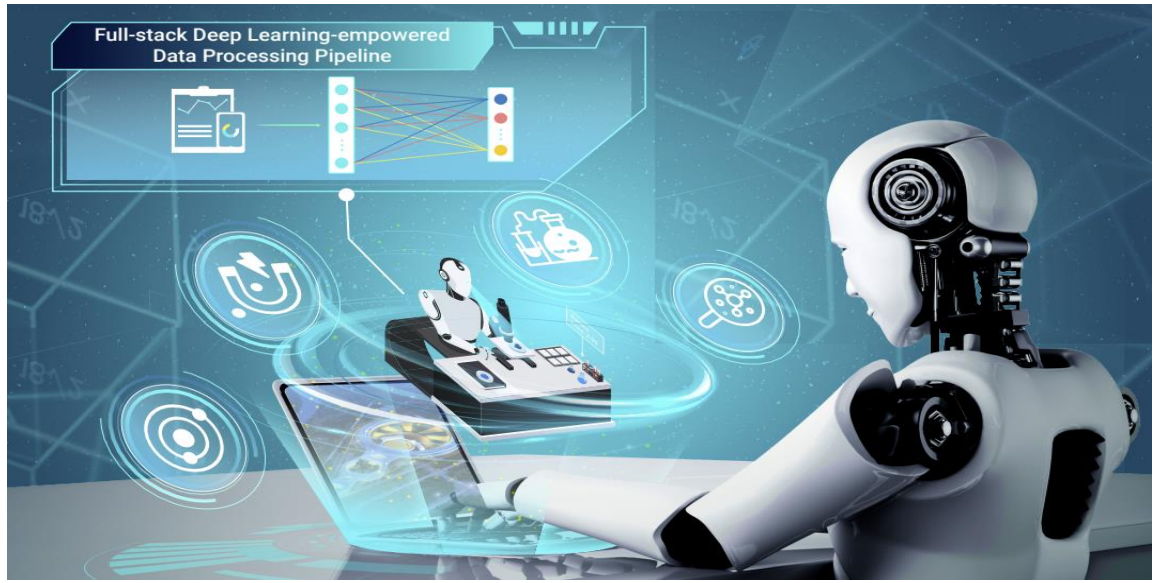
One Ecosystem

cover full synchrotron methods and experiment modes

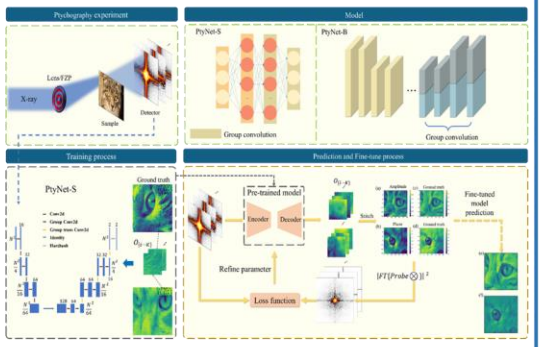
A High-Throughput Big Data Orchestration and Processing System for HEPS, ***Journal of Synchrotron Radiation***, (2023).

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

AI for synchrotron science

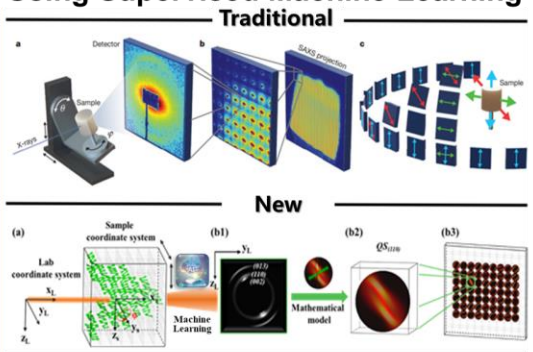


Efficient Ptychography Reconstruction Strategy Using Large Pre-trained Deep Learning Model



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

Fast Extraction of Nanofiber Orientation from WAXD Patterns Using Supervised Machine Learning



M. H. S et al, ***IUCrJ***, 2023
X. Y. Zh et al, ***IUCrJ***, Second Revision

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Comment | Published: 18 May 2022

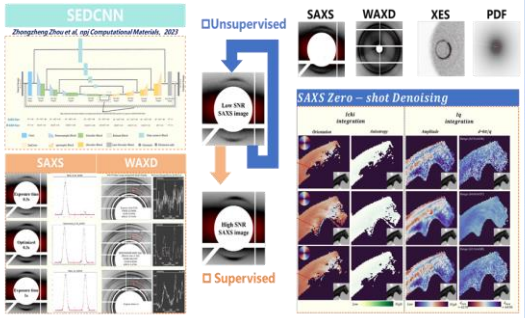
Exascale image processing for next-generation beamlines in advanced light sources

Yuhui Dong ✉, Chun Li, Yi Zhang, Pengcheng Li & Fazhi Qi

Nature Reviews Physics (2022) | Cite this article

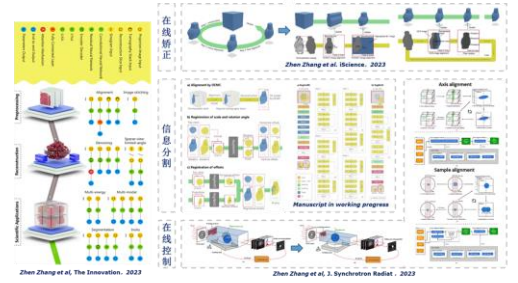
Large-scale scientific software framework + AI for Science

Physical Information-Embedded Unsupervised Denoising Using AI



Zhou et al, ***npj Computational Materials***, 2023
Zhou et al, ***Journal of applied crystallography***, under review

Full-stack Synchrotron Tomography Data Processing Pipeline (STDPP)



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

HEPS | HIGH ENERGY PHOTON SOURCE

Institute of High Energy Physics (IHEP)

HEPS belongs to IHEP. IHEP Running and Constructing several large science facilities and projects in high energy physics, astrophysics, neutron source and synchrotron radiation source.

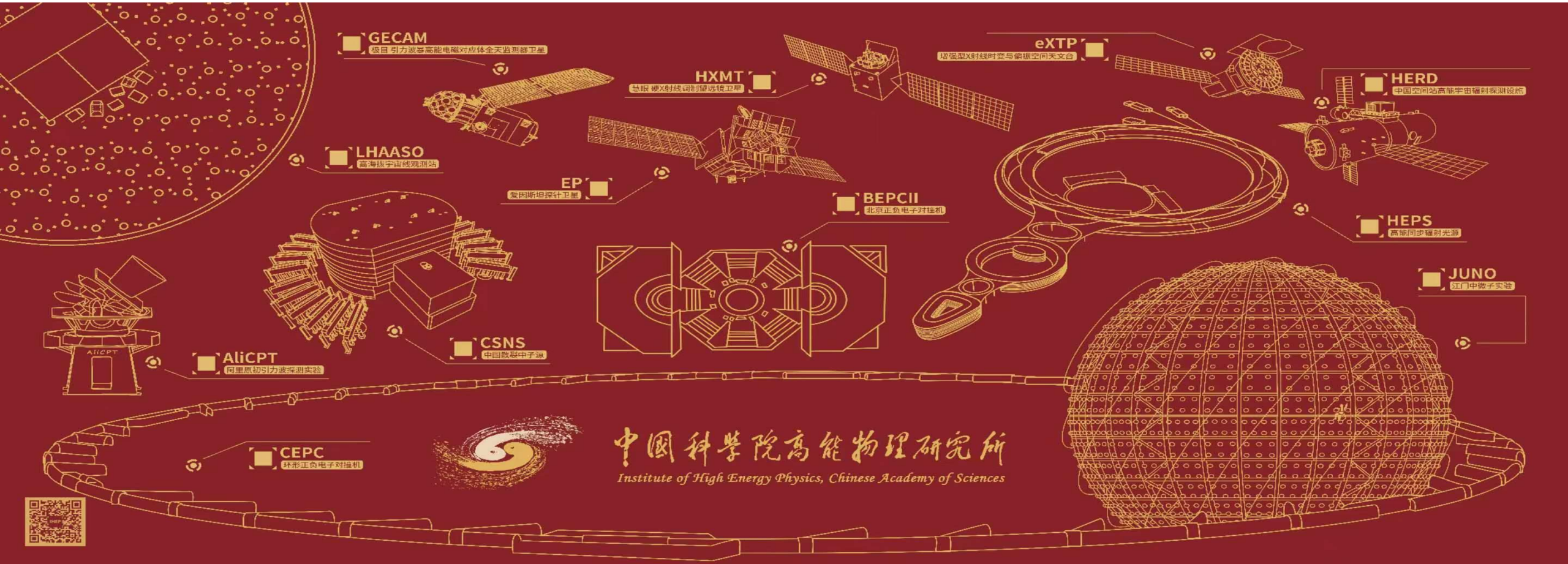
2023 international assessment on IHEP

Mission, Vision and International Standing:

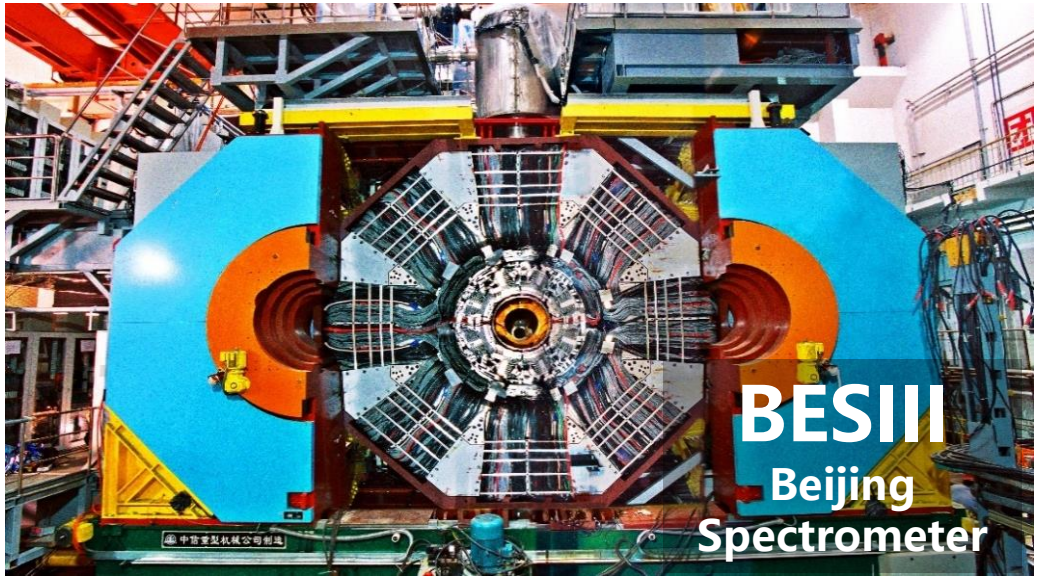
Over the last decade IHEP has become one of the world's major particle physics laboratories, as well as a world-class, large-scale, multidisciplinary research platform. IHEP has particle physics at the center of its activities, but its mission includes a much more diverse program in related fields, enabled by expertise in accelerator facilities, neutron and photon science. Another part of the program, in the fields of particle astrophysics and space, is enabled by other scientific and technical capabilities of IHEP originally developed for particle physics.

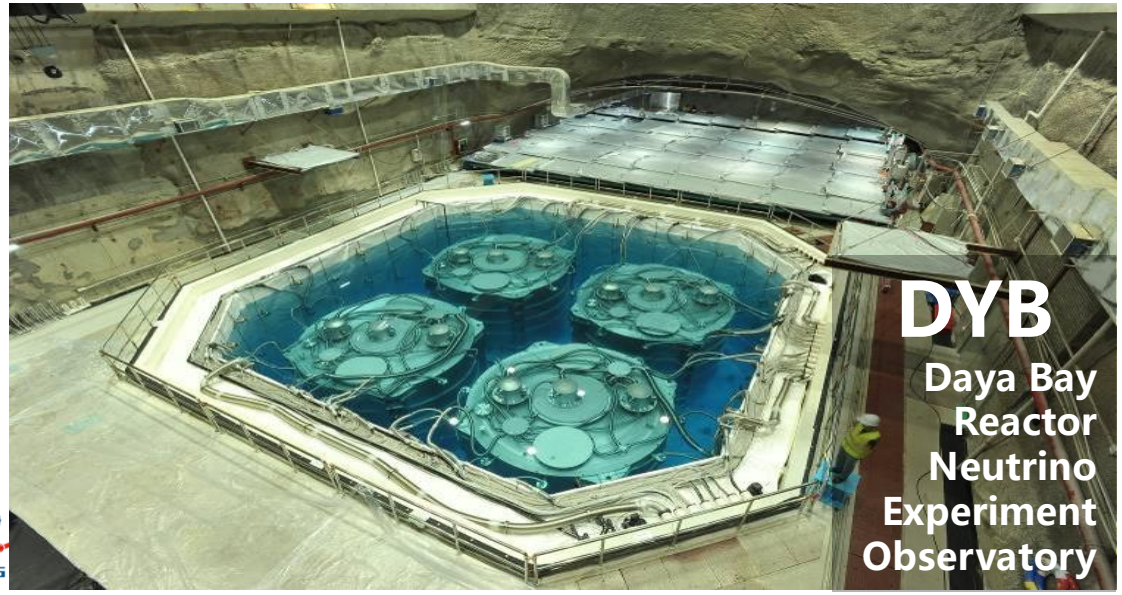
Large science facilities @ IHEP

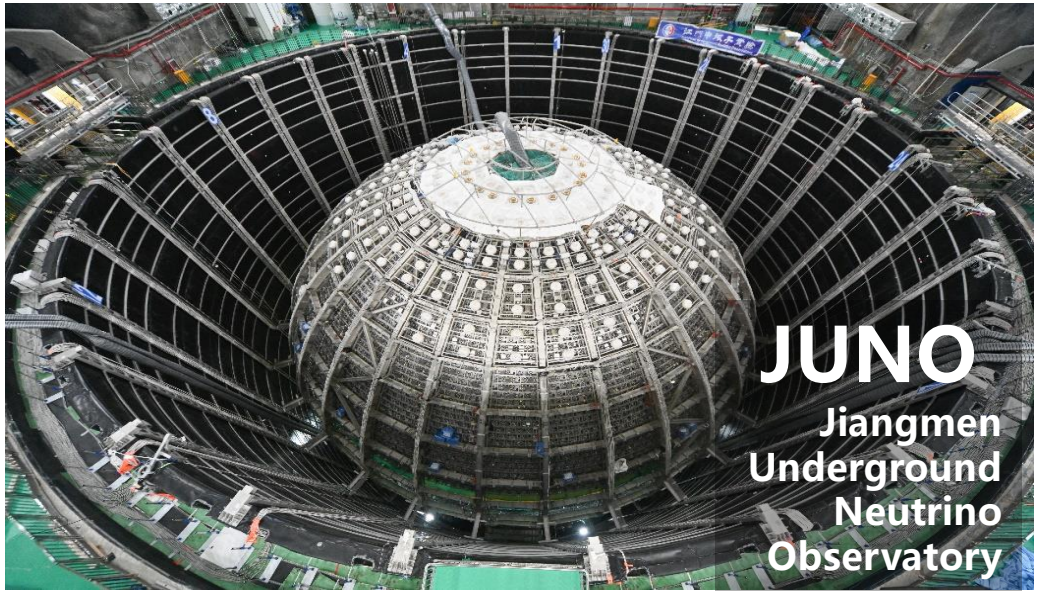
From JUNO neutrino underground lab to HXMT X-ray satellites in space, from Chinese Spallation Neutron Source (CSNS) to HEPS, from Large High Altitude Air Shower Observatory (LHAASO) to Cosmic Microwave Background Polarization Telescope (Ali-CPT), from Beijing Positron and Electron Collider (BEPC) to proposed Circular Positron and Electron Collider (CEPC)



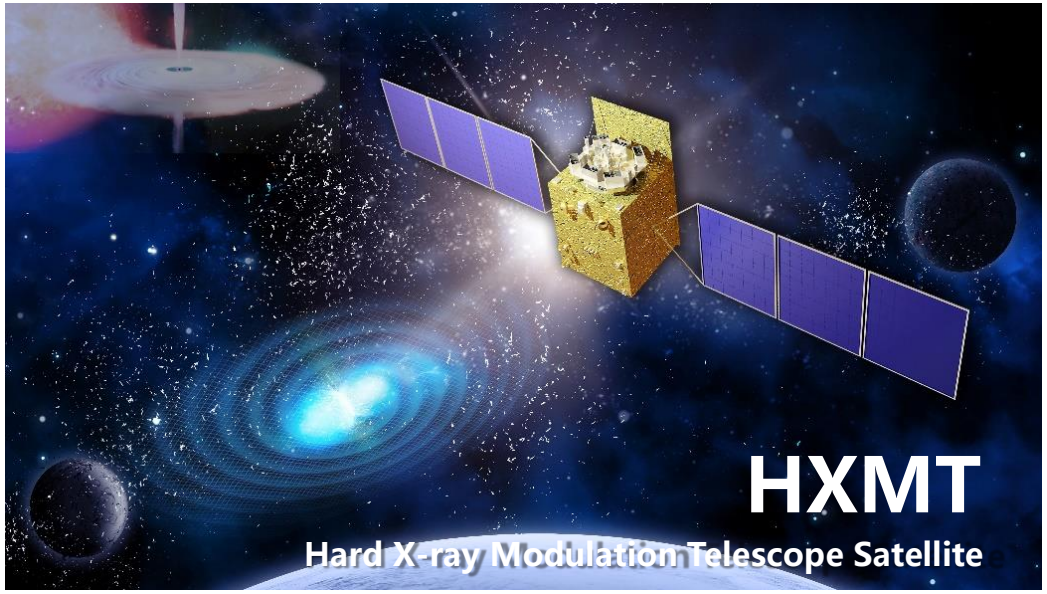
Large science facilities @ IHEP







Large science facilities @ IHEP



Life and Work environment

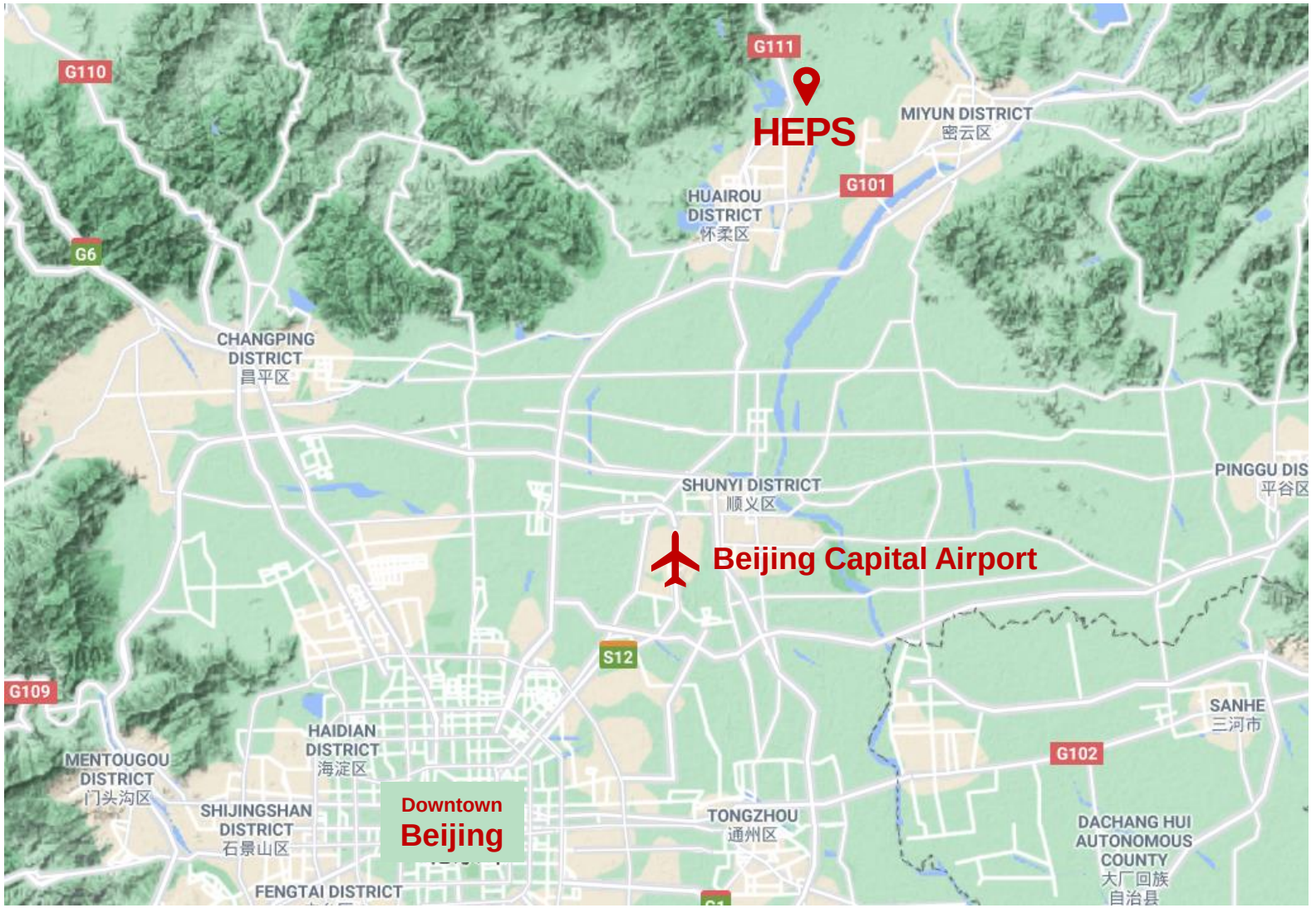
Where is HEPS?

HEPS

Huairou District, Beijing

80 km from IHEP campus

45 km from Beijing Capital Airport



HEPS | HIGH ENERGY PHOTON SOURCE

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

HEPS | HIGH ENERGY PHOTON SOURCE

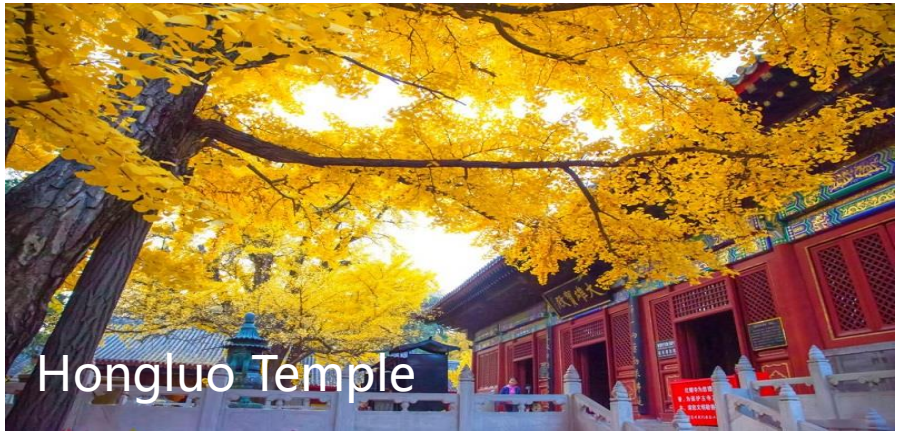
Huairou

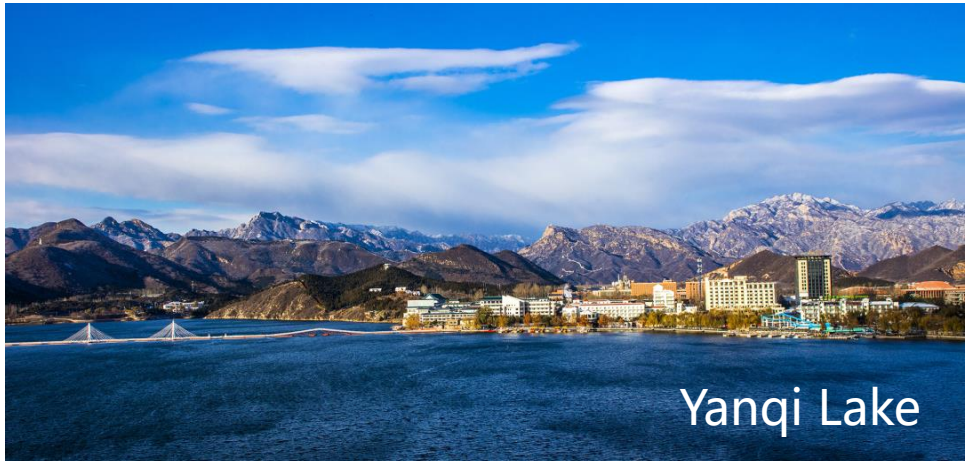
Huairou, the APEC meeting site, a pleasant place to live and work

Scenic hiking trails on Great Wall, around lakes and in mountains

Skiing – Huaibei ski resort within 10 km from HEPS


Mutianyu Great Wall

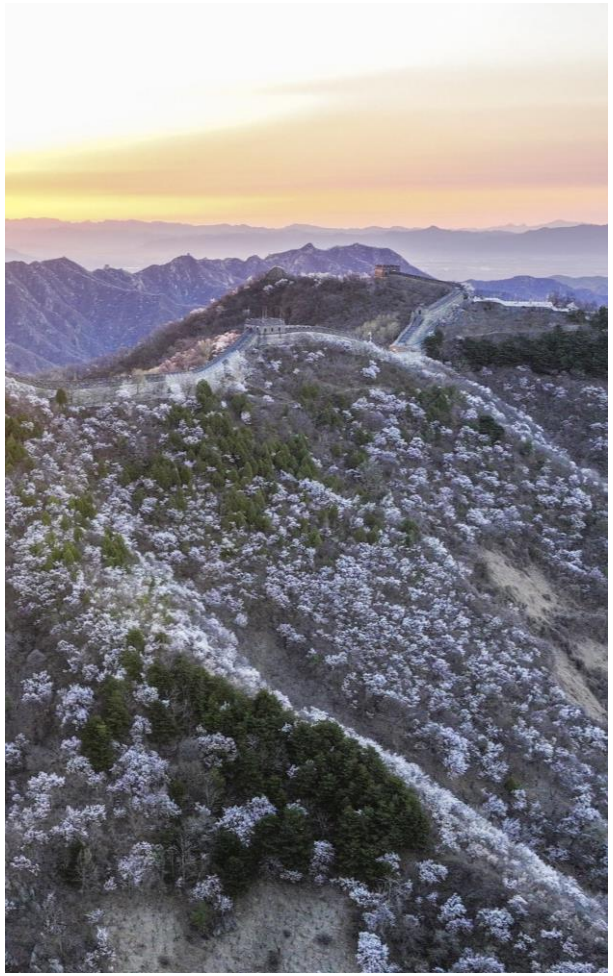

Hongluo Temple

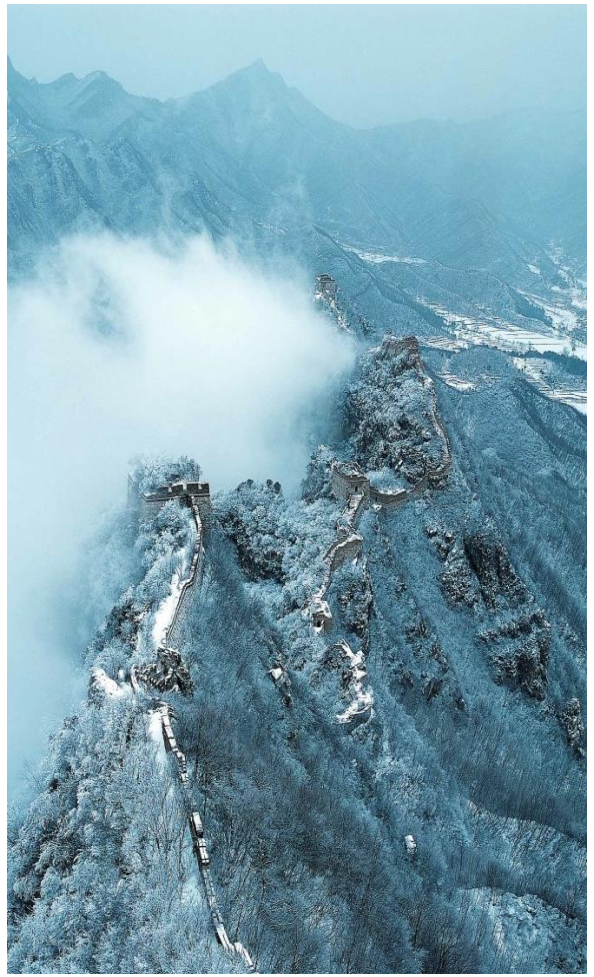

Yanqi Lake

Huaibei Ski Resort

MUTIANYU GREAT WALL ~20km to HEPS

AAAAA level Tourist Scenic Area






Work with us at HEPS!
Building international working environment
International life environment supported by local government
HEPS Bird´s eye view