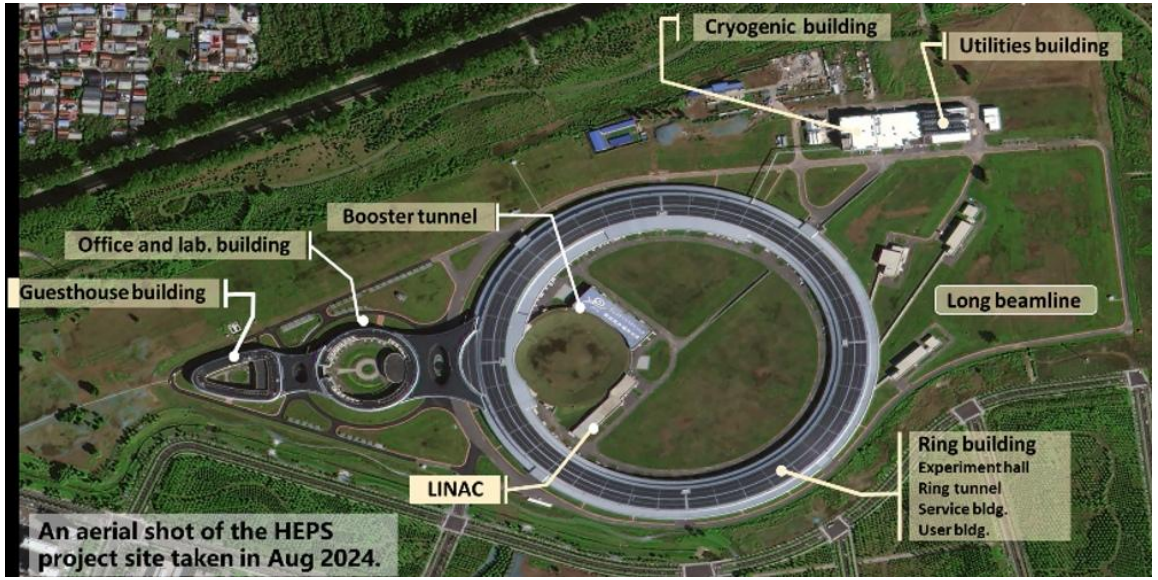
Operation experiences of BEPCII U and HEPS2026

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BEPCIIU



HEPS



Two facilities, two commissioning priorities

01 **BEPCIIU** 03–13

Introduction → milestones before 2026 → 2026 progress

02 **HEPS** 14–27

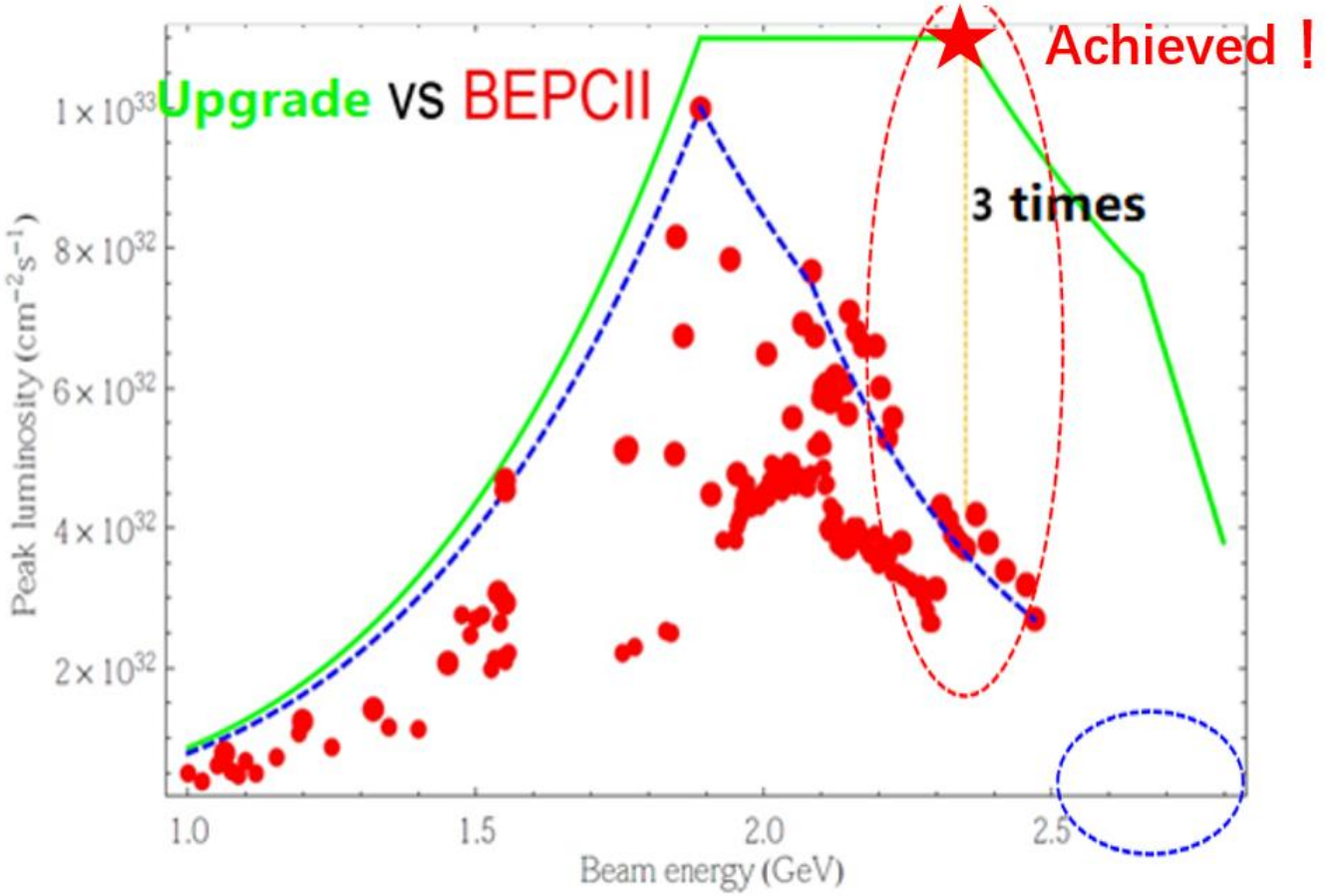
Introduction → milestones before 2026 → 2026 progress

Measured performance • commissioning methods • operating limitations

BEPCIIU

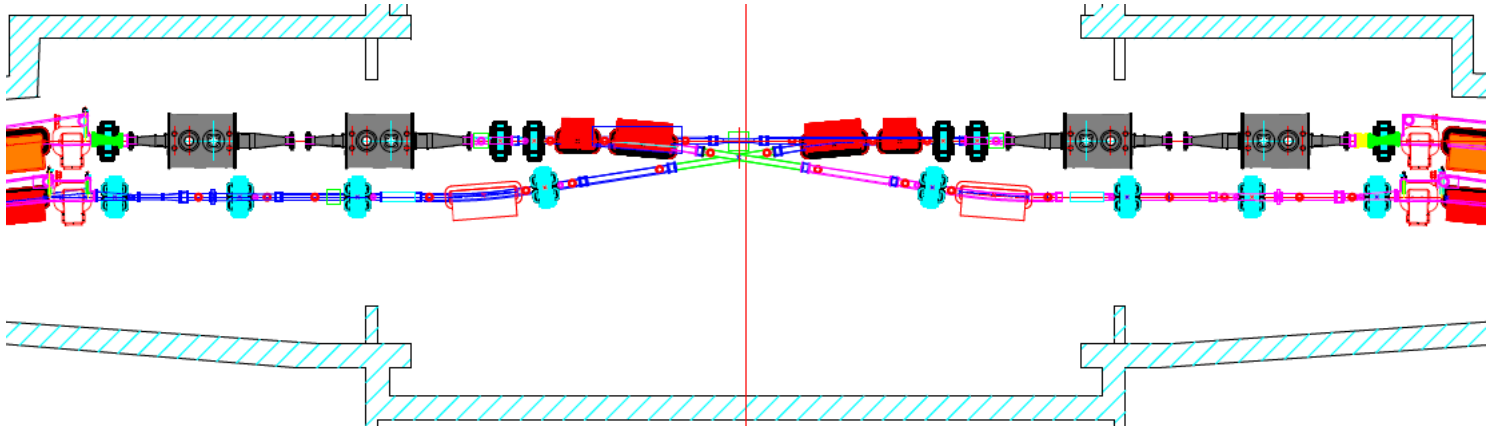
An upgraded electron–positron collider serving BESIII and BSRF

- Higher luminosity near 2.35 GeV
- Design luminosity achieved in April 2026
- Performance recovery and reliable delivery remain coupled challenges



Upgrade targets: 3× luminosity and 2.8 GeV

BEPCIIU: upgrade the high-energy luminosity reach



×3

luminosity goal near 2.35 GeV

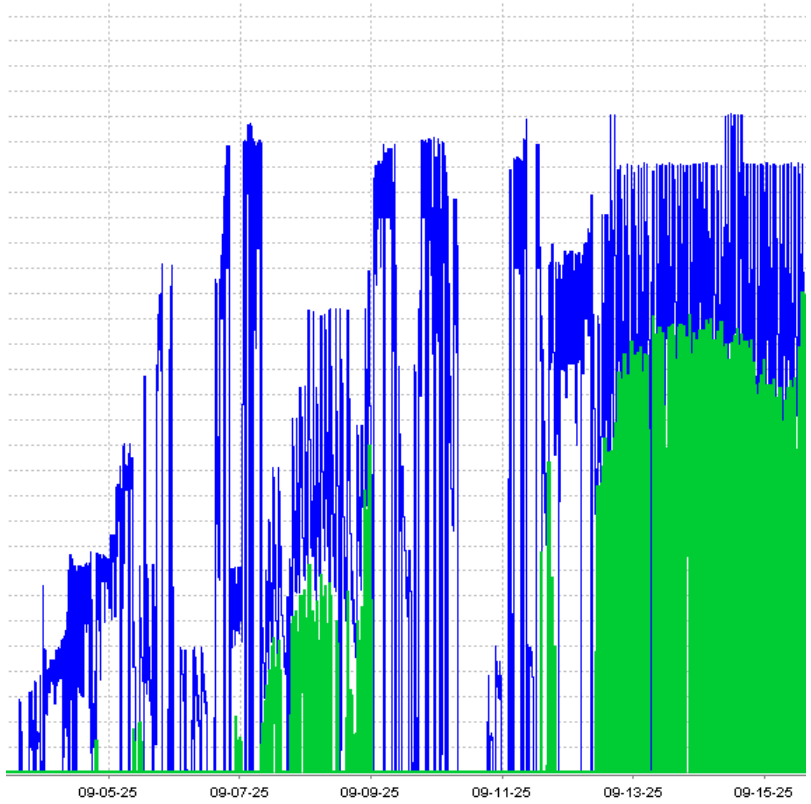
2.8 GeV

future maximum beam-energy goal

- Two rings: electron and positron beams collide for BESIII; eight BSRF beamlines operate parasitically.
- Add one 500 MHz cavity per ring; increase RF voltage, shorten the bunch and reduce β*y.
- Upgrade RF power, cryogenics and photon absorbers; redesign local optics in the RF regions.

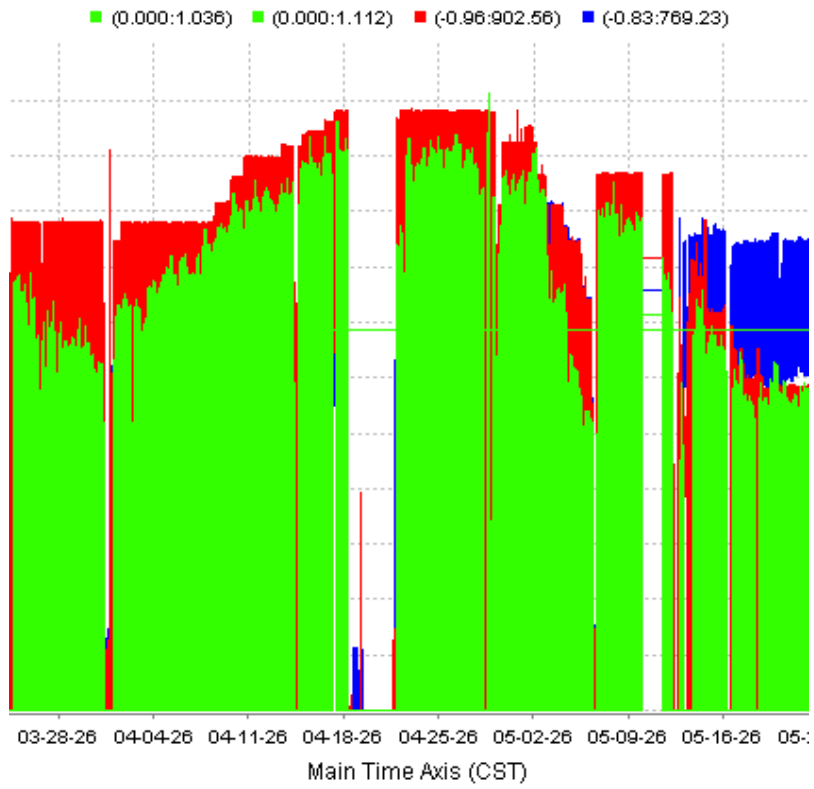
Before 2026: restart, condition and resume data taking

Jul–Dec 2024	**Hardware installation** RF-region upgrade and associated installation.
Mar–Apr 2025	**Injection without RF** Multi-turn beam signals obtained in both rings.
May 2025	**Cryogenic readiness** RF-enabled commissioning and current accumulation.
Aug–Sep 2025	**Physics operation resumes** 720 mA per beam and 3.8 × 10^{32} cm^{-2} s^{-1} peak luminosity.



2026: reach design luminosity within two months

26 Feb	**Energy change** Start BESIII data taking in the 2.34 GeV run.
3 Mar	**Two cavities per ring** Enter regular dual-cavity operation in both rings.
Mar–Apr	**Collision optimization** Orbit / energy correction, beam–beam tuning and luminosity optimization.
28 Apr	**Design target reached** Peak luminosity 11.12 × 10^{32} cm^{-2} s^{-1}.
13 Jul	**Summer shutdown** Complete the 2025/2026 operating cycle.



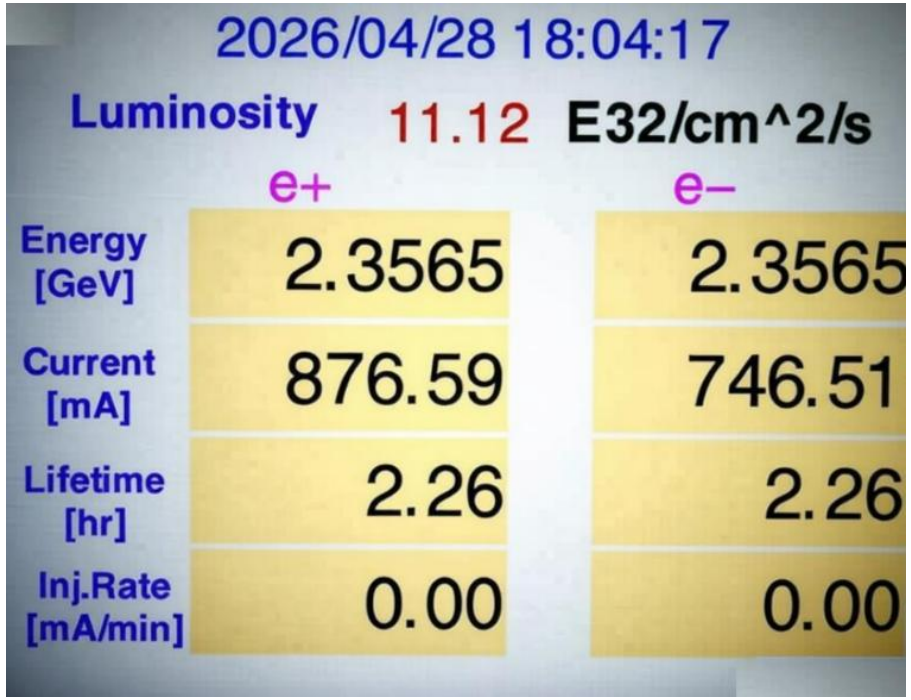
Design luminosity reached; new operating records

1.112×10^{33}

$cm^2\ s^{-1}$ peak luminosity

$54.0\ pb^{-1}$

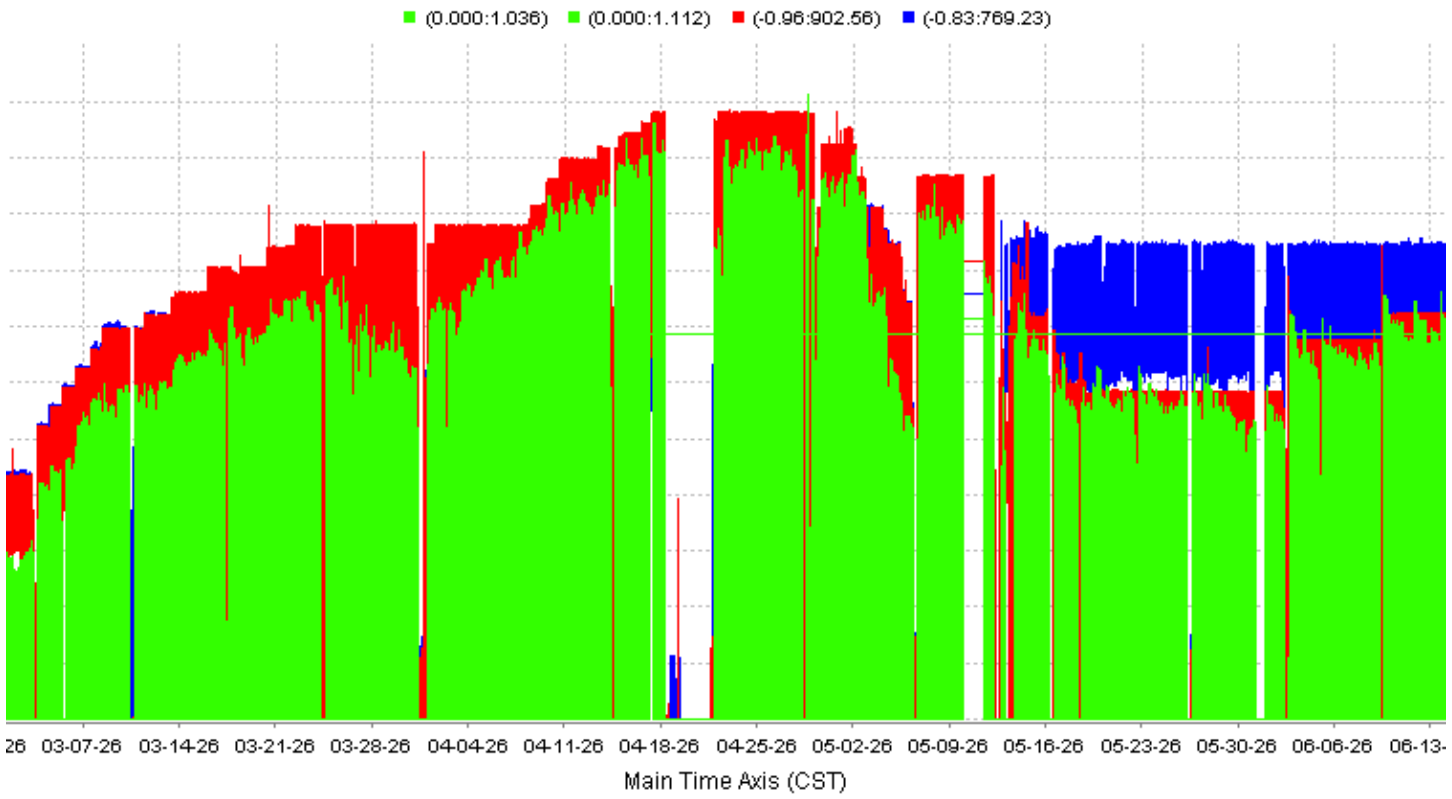
maximum daily integrated luminosity



- Both peak and daily integrated luminosity exceed three times the pre-upgrade level near this energy.
- 115 bunches; maximum collision currents e^-/e^+ = 760/900 mA.

- Detector dark current <7 μA, below the reported <9 μA requirement.

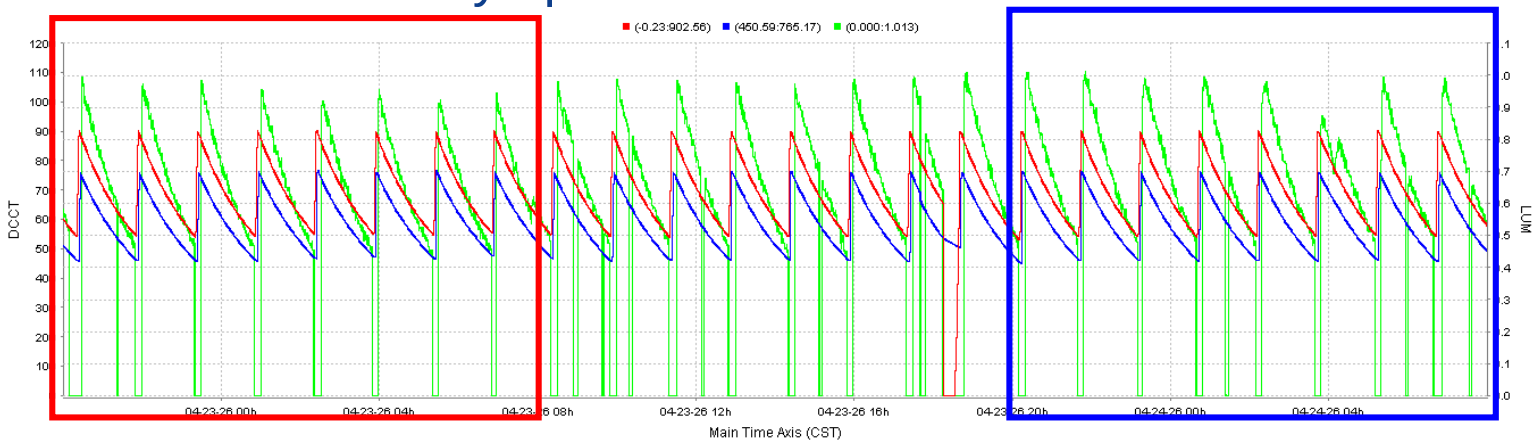
Collision tuning recovered the luminosity margin



- Horizontal orbit / energy correction was an effective tuning step in the higher-energy run.
- The correction increased BER energy by 0.5 MeV and reduced BPR energy by 0.5 MeV.
- The achieved beam–beam parameter was 0.036, versus the design value of 0.033.
- This additional beam–beam performance compensated for the reduced electron current.

Automatic tuning improved delivered luminosity

Automatic luminosity optimization

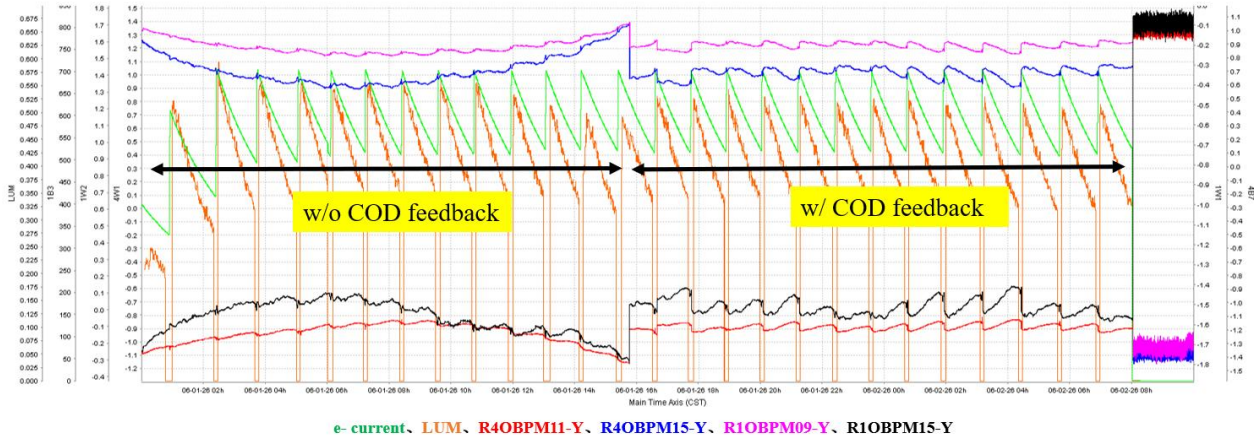


+4.3% peak luminosity

+5.0% integrated luminosity

Night-shift comparison:
22 Apr OFF: 25.63 pb^{-1}
23 Apr ON: 26.91 pb^{-1}

Vertical closed-orbit feedback: OFF / ON



Vertical orbit corrected at the start of each run

- Suppresses orbit-driven coupling changes.
- Helps sustain high luminosity.
- Improves orbit stability for BSRF users.

Collision top-up: tested, with a clear next target

10 Mar 2026

collision top-up experiment

≈350 mA

beam current in the test

- Positron injection at 25 Hz: detector dark current ≈8 μA; injection rate ≈50 mA/min.
- Electron injection at 5 Hz: detector dark current ≈4 μA; injection rate ≈50 mA/min.
- The study projects collision top-up at 700 mA using lower positron repetition rates (10/5 Hz) and 5 Hz electron injection.

After the record: hardware limited sustained current

Limitation	2026 evidence	Operational implication
Electron RF cavity E1	Voltage fell from 0.95 to 0.91 MV (Mar–May); summer treatment did not restore performance.	RF margin constrained electron current.
Positron feedback	LFB amplifier failure in May; repeated TFB amplifier failures persisted into run end.	Positron current later limited to about 600 mA.
Photon-absorber cooling	Seven over-temperature faults, 26 May–13 Jul; low flow / blockage identified.	Thermal margin became critical after the power increase.
Magnet / services	ISPB water leaks caused interruptions; the earlier SSM outage ended on 20 Dec 2025.	Diagnostics, spares and maintenance govern delivered beamtime.

2025/2026 delivery: complete the physics task

5.09 fb⁻¹
BESIII integrated luminosity

7,222 h
storage-ring operation

≈600
BSRF user experiments

Scope	Result	Context
1.843 GeV	1.13 fb⁻¹	Calibration and physics data
2.34 GeV	3.96 fb⁻¹	High-luminosity operation
Hardware failures	≈10%	Storage-ring fault fraction

BEPCIIU: what 2026 established

Design reached

$1.112 \times 10^{33}\ \mathrm{cm^{-2}\ s^{-1}}$ near 2.35 GeV

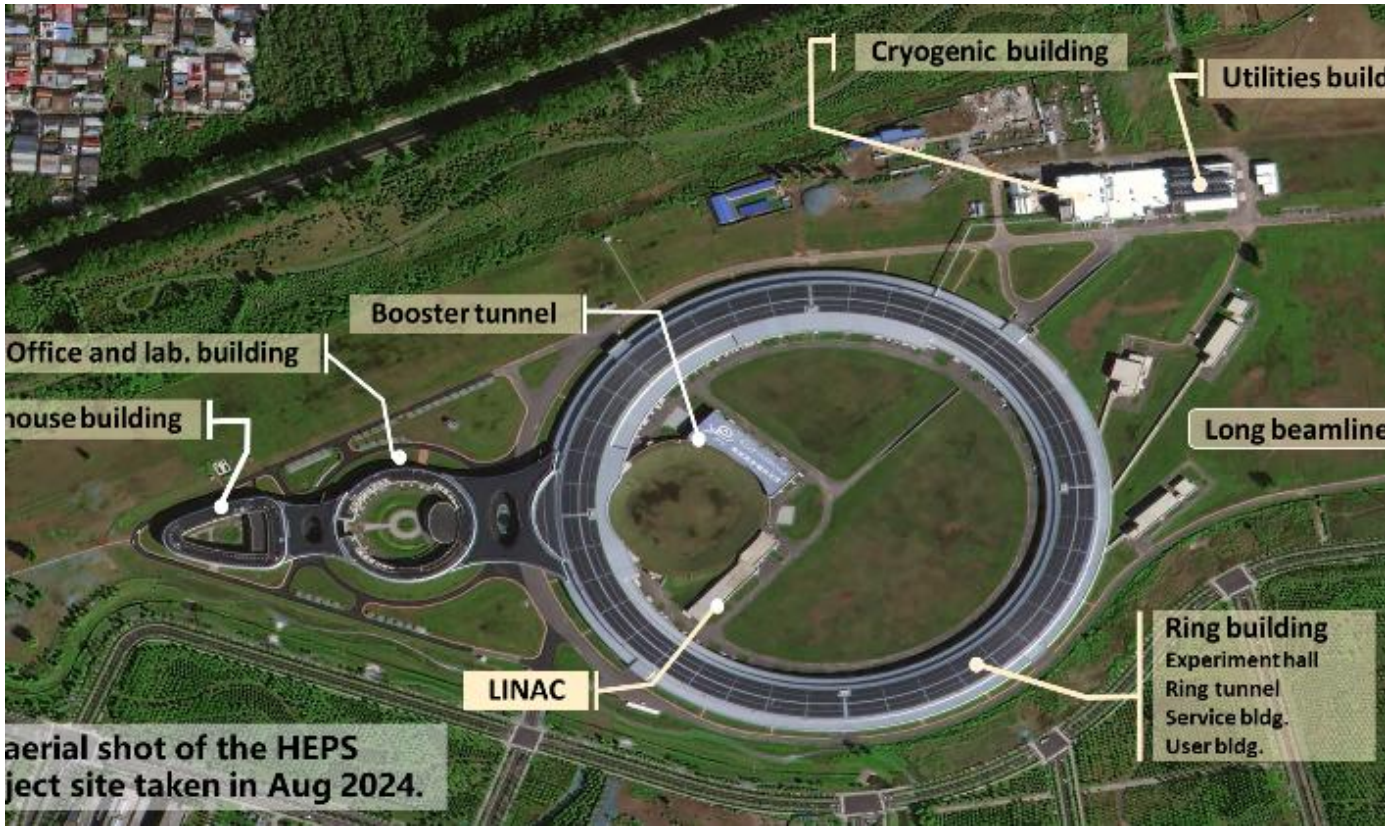
- The luminosity upgrade works: peak and best daily integrated luminosity exceed three times the pre-upgrade level at this energy.
- Orbit / energy correction, beam–beam tuning and automatic optimization support efficient data taking.

- The next gains depend on restoring RF and feedback margin, improving cooling reliability and extending stable high-current running.
- Higher-current collision top-up and the future 2.8 GeV energy upgrade remain development objectives.

HEPS

A 6 GeV diffraction-limited synchrotron radiation source in Beijing

- From 2025 performance acceptance to 2026 pilot operation
- Higher current, lower losses and stable photon delivery
- Aperture recovery and coordinated feedback are central operational lessons



HEPS: low emittance with high stored current



6 GeV

storage-ring energy

200 mA

design stored current

- 1,360.4 m circumference; 48 hybrid seven-bend achromats.
- Bare-lattice design natural emittance: 34.8 pm·rad; project overview specification: <60 pm·rad.
- 500 MeV linac → 6 GeV booster → storage ring; swap-out injection with high-energy accumulation.
- Active dual RF: five 166.6 MHz cavities and two 499.8 MHz harmonic cavities.

Before 2026: from first turn to accepted performance

Jul–Oct 2024

Establish stored beam and first light

First turn: 23 Jul; first storage: 6 Aug; first beamline light in Oct.

2 Jan 2025

Demonstrate swap-out injection

High-energy accumulation in the booster successfully verified.

May–Aug 2025

Complete the nominal RF installation

Install the 166.6 MHz system and remaining harmonic-cavity hardware.

Sep–Oct 2025

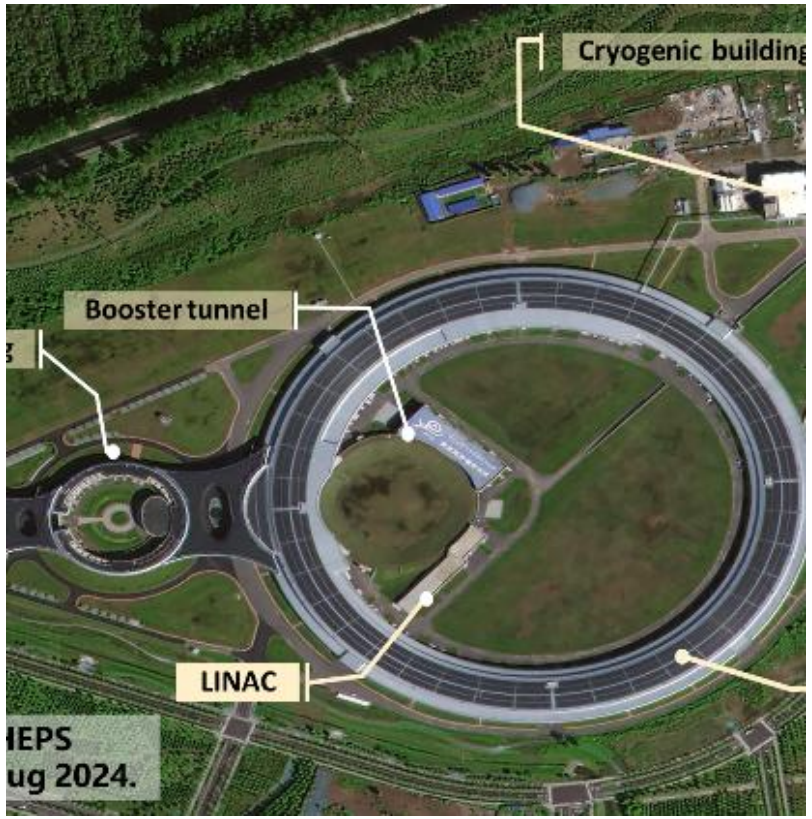
Achieve acceptance-level performance

First 100 mA: 12 Sep; accelerator tests: 26–29 Sep; acceptance review: 29 Oct.

Dec 2025

Start pilot operation

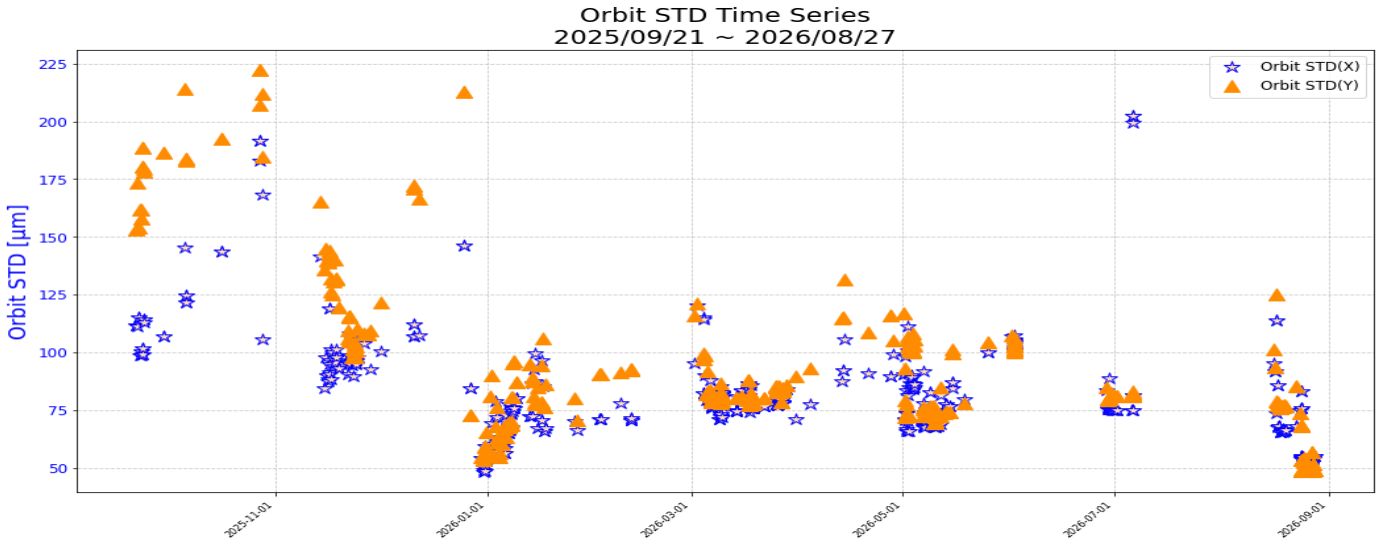
User commissioning and fast orbit feedback enter operation.

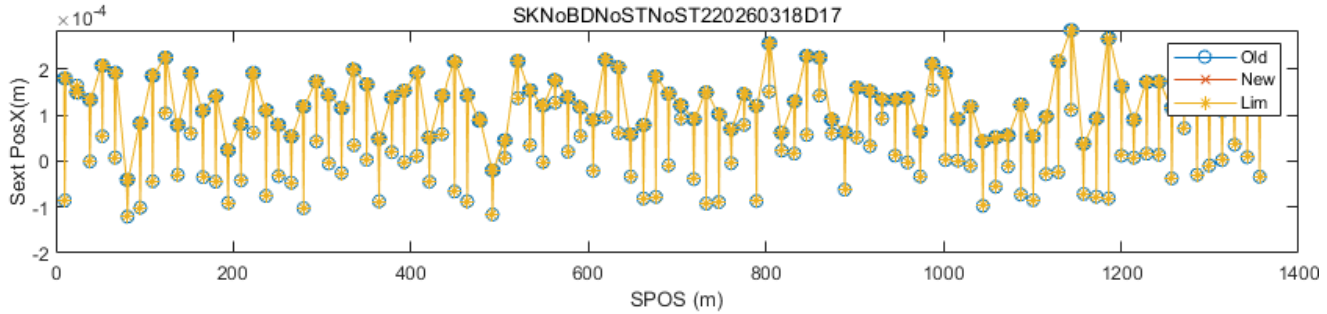


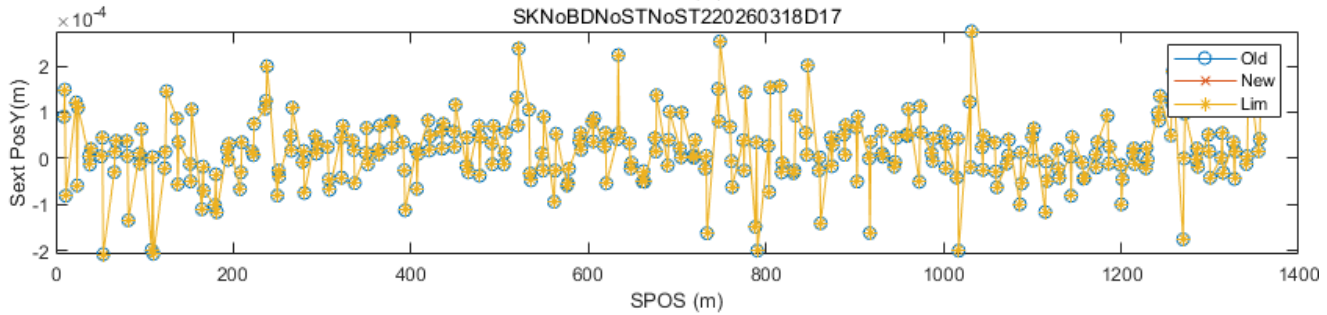
2026: distinguish peak, stable and user currents

7 Mar	**150 mA**	First achievement of this stored current.
5 Jul	**1.04×10^{22}**	Photon brightness reaches the design target.
23 Aug	**180 mA**	Peak stored current, sustained for 20 min.
29 Aug	**150 mA**	Continuous fault-free operation for 6.5 h.
8 Oct	**120 mA**	Photon delivery during trial operation.

Optics correction: iterate model, orbit and measurements







50~60um

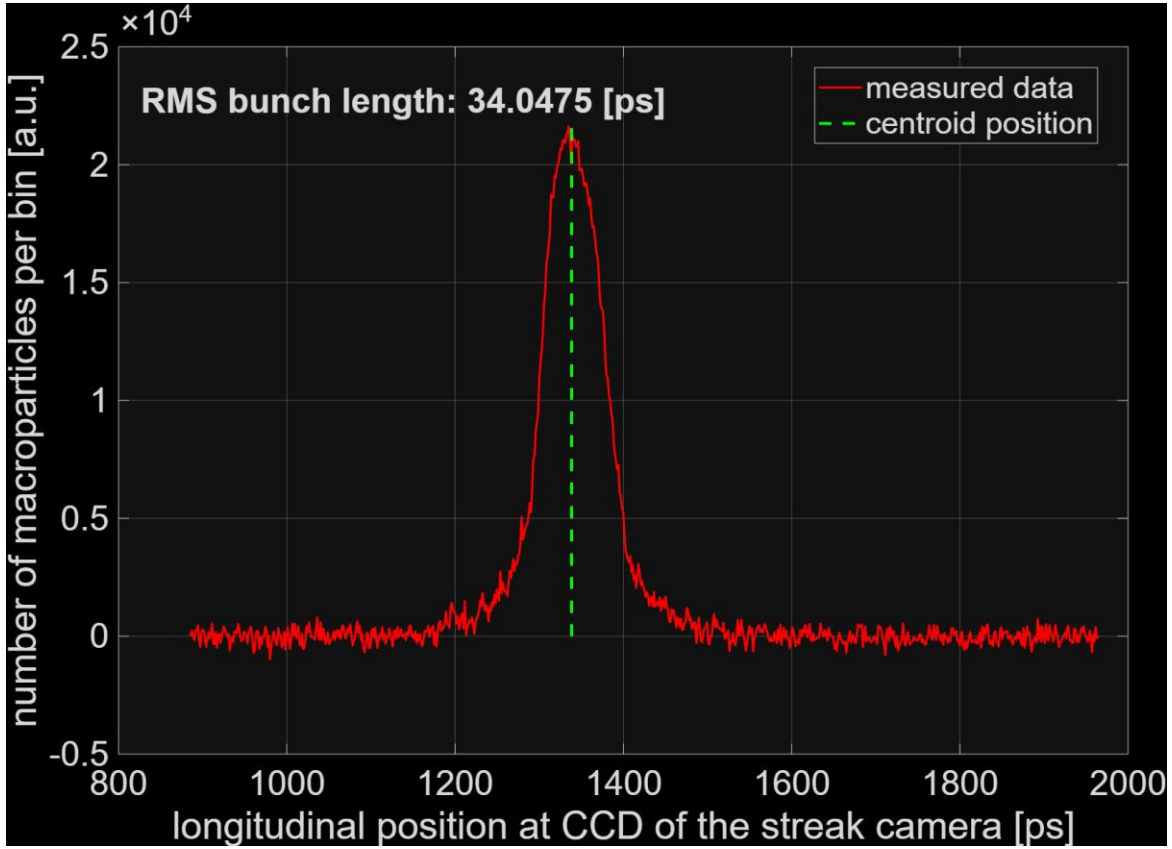
rms Orbit, horizontal / vertical

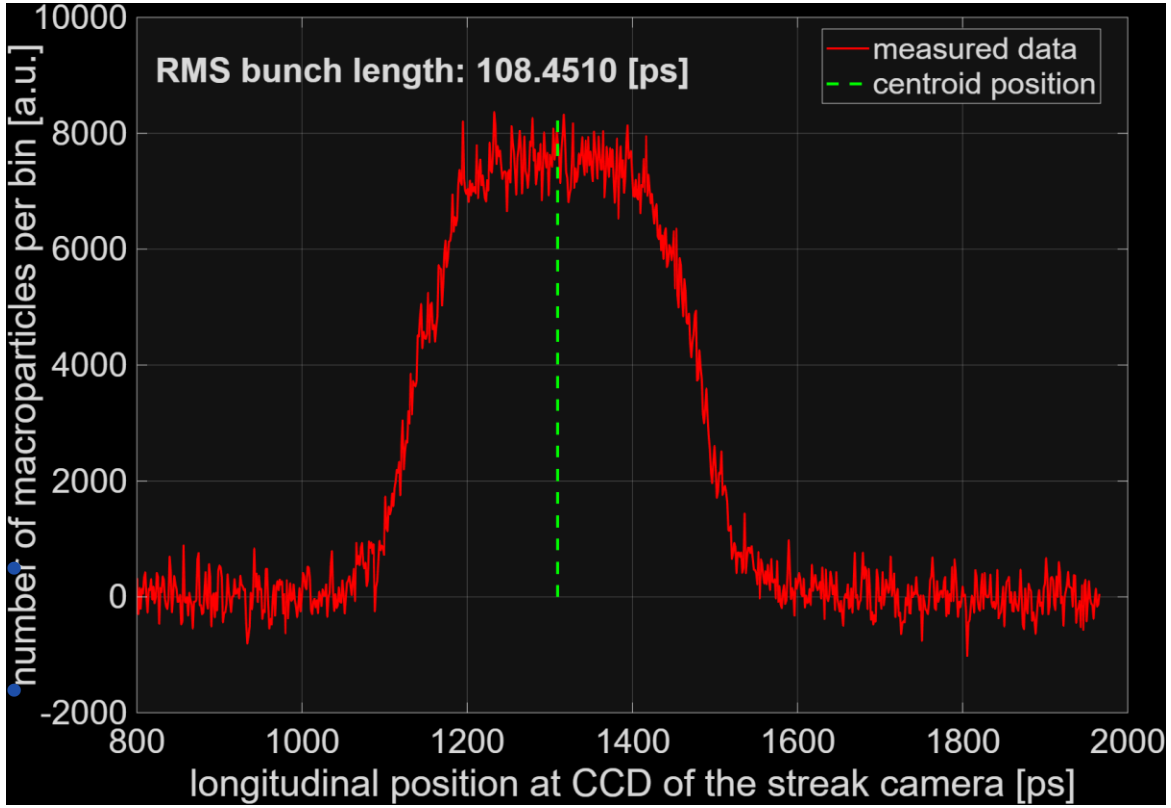
1.28% / 1.41%

rms beta beating, horizontal / vertical

- 18 Mar: dispersion deviations 1.29 / 1.25 mm (H/V).
- Iterate LOCO with BBA, cross-talk modelling and sextupole movers.
- Repeat correction cycles in May, June and August.
- Include beam loss, radiation dose and lifetime in optimization.

Dual RF: control bunch length at operating current





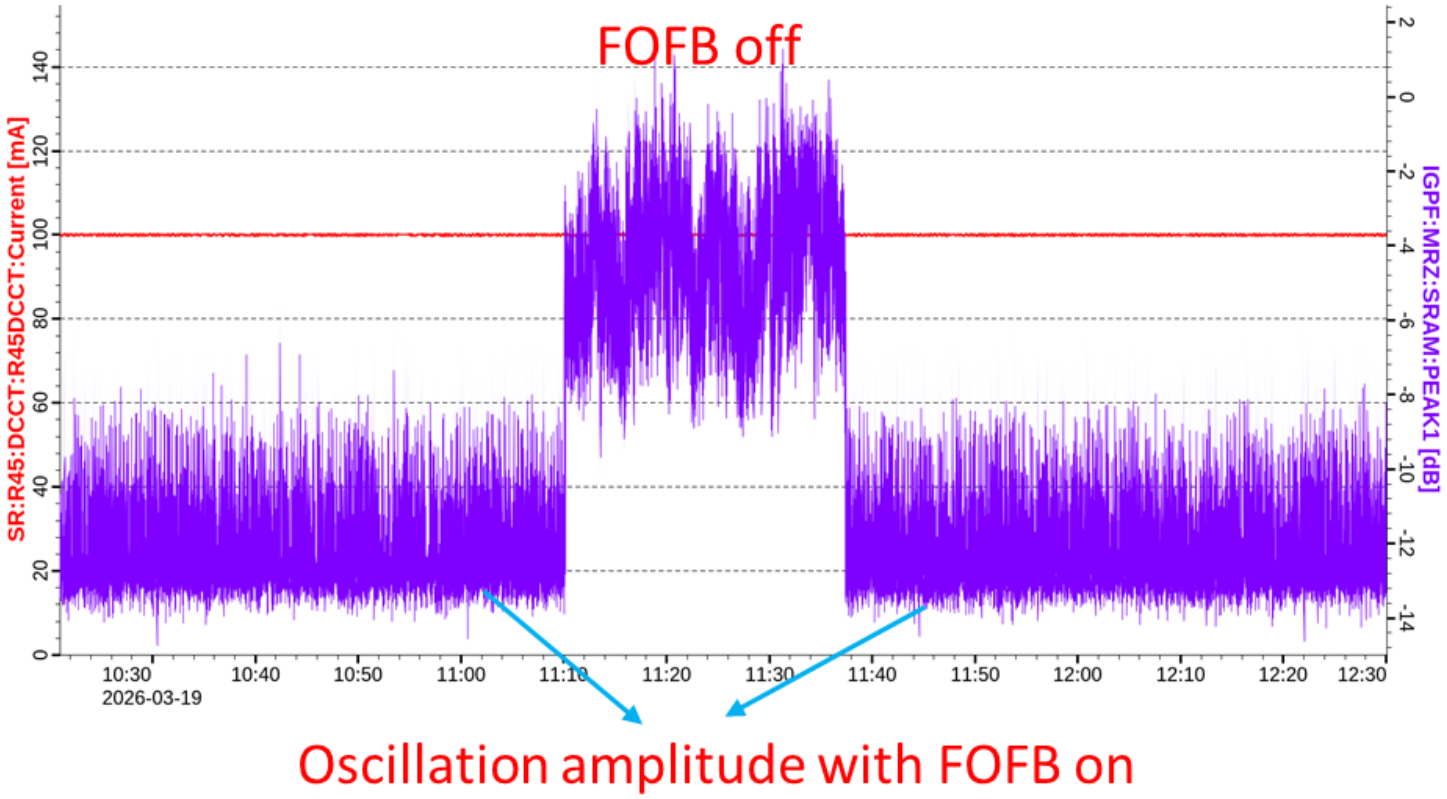
10.21 → 32.51 mm

166.6 / 499.8 MHz有源系统可在宽流强范围内利用谐波腔拉长束团。

近似平顶的束团分布降低峰值电荷密度，支撑高流强积累。

高频频率与谐波相位反馈抑制慢漂移，稳定束团拉长状态。

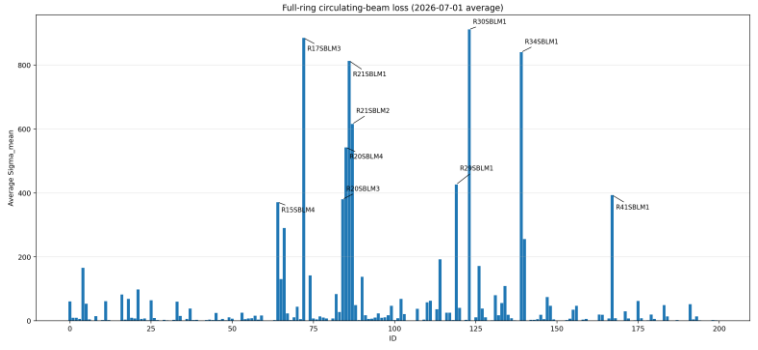
Collective effects require coordinated feedback

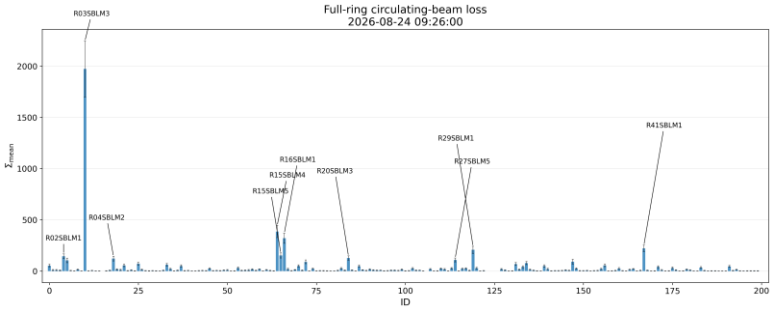


- Low momentum compaction and slow longitudinal motion increase sensitivity to collective effects.
- Longitudinal zero-mode oscillations were investigated using orbit, RF and bunch-by-bunch diagnostics.
- Fast orbit feedback, low-level RF and bunch-by-bunch feedback need coordinated settings.
- Impedance measurements broadly agree with the component-based model and support further high-current studies.

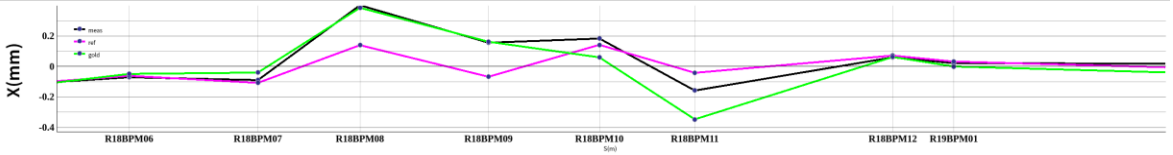
R18 obstruction: diagnose, bypass, then remove







March: local-bump diagnosis



TBT sum, beam-loss monitors and dosimeters localized abnormal loss near R18BPM08.

R18 H/V bump: +400 / −400 μm; retained in routine orbit correction.

At 20 mA / 63 bunches: lifetime ~700 → ~3000 s; max. injection efficiency ~70% → ~90%.

Summer: obstruction removed

A smaller corrected orbit had reduced injection efficiency and lifetime. The local bump bypassed the restricted aperture.

A NEG-coating ceramic support was found between R18QD5 and R18BLG3 and removed.

After removal: 60 → 140 min lifetime at 100 mA / 252 bunches; cleaner BBA and ~0.05 mm rms orbit.

Injection: establish high-charge operating modes

101 mA

63-bunch mode on 16 Mar

7.3 nC

average charge per bunch

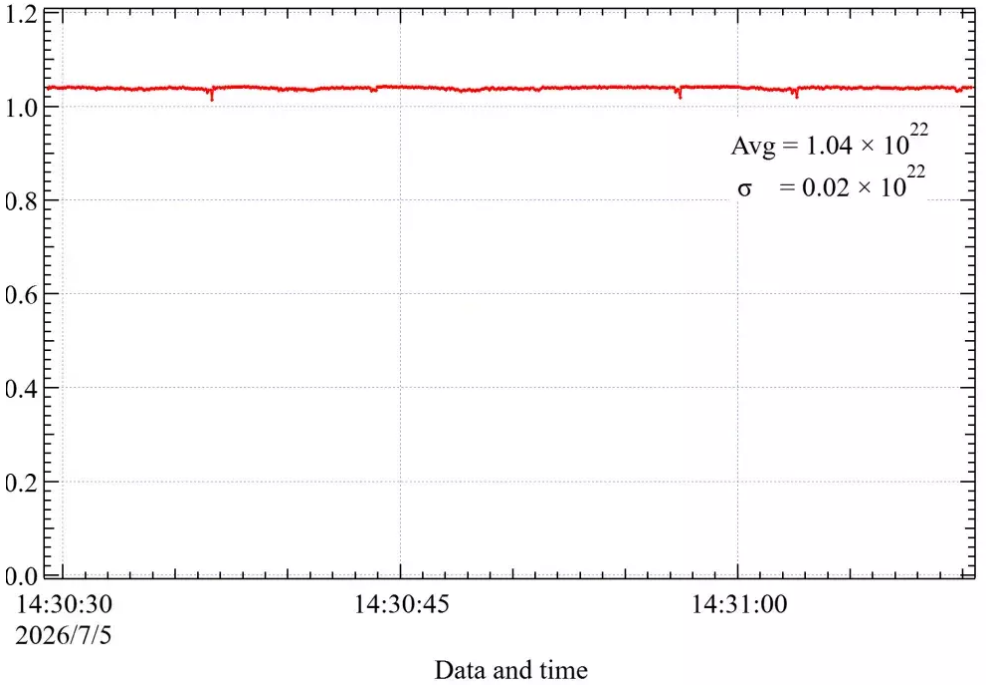
- The 63-bunch timing mode progressed from 58–65 mA to 101 mA after injection-acceptance optimization.
- Stable single-bunch operation above 10 nC was demonstrated.
- For the 28-bunch fill, transmission efficiency was 98.8–99.8%, supporting the booster accumulation scheme.
- R18 bump studies separated storage-ring acceptance losses from the reliability of high-energy accumulation.

5 July: HEPS reaches its design brightness target

$(1.04 \pm 0.02) \times 10^{22}$

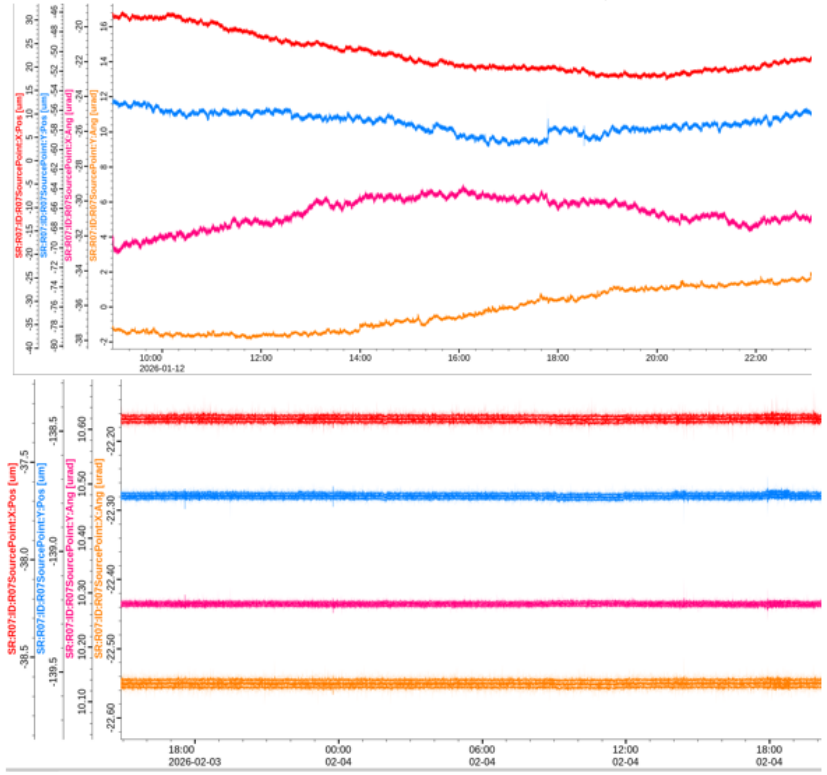
ph s^{-1} mm^{-2} $mrad^{-2}$ / 0.1% BW

- The measured brightness on 5 July 2026.
- This reaches the original >1 × 10^{22} design target.



Orbit feedback supports simultaneous beamline use

Long-term orbit stability: 100mA, >10 h SA data



Position jitter std: 1-10 μm
Angle jitter std: 0.5-2 μrad
(Jan 12, 2026, FOFB off)

Position jitter std < 10 nm
Angle jitter std < 3 nrad
(Feb 03, 2026)

SA data has a filtering effect on high-frequency components

<10%

short-term position motion / beam size at IDs

- FOFB + RF-frequency feedback suppress motion and drift.
- Over >10 h: <10 nm position and <3 nrad angle drift at IDs.
- The long-term result uses filtered slow-acquisition data.
- ID feed-forward reduces gap-change interference.

Pilot operation: reliability improves with experience

2026 user period	Scheduled	Availability	MTBF	MTTR
18 Jan–11 Feb	535.83 h	95.52%	23.26 h	1.09 h
4 Apr–1 May	569.11 h	96.54%	21.13 h	0.76 h
19 May–28 Jun	848.82 h	98.37%	39.76 h	0.66 h
Total	1,953.76 h	97.05%	27.48 h	0.83 h

69 faults

57.57 h total downtime

- Consolidated statistics: 97.05% availability through June.
- RF and power supplies dominate reported beam-loss causes.
- BPM / RF fault capture and ready spares speed up recovery.

Commissioning translated into early user delivery

412
pilot proposals conducted

11,535.5 h
reported beamline beamtime

1,785
visiting users

Scope	Result	Context
Coverage	14 beamlines	4 rounds of pilot proposals
Participation	133 institutions / industries	17 commercial proposals
General-proposal call, 2026	1,740 received	1,200+ approved

HEPS: 2026 progress and the next operating step

180 mA peak

150 mA stable for 6.5 h; 120 mA trial photon delivery

- Design brightness achieved in July; higher-current operation demonstrated in August.

- R18 aperture recovery, iterative optics correction and coordinated dual-RF feedback removed key commissioning obstacles.
- Pilot-user availability reached 97.05% across the consolidated 2026 periods through June.

- Next: reach 200 mA design current while maintaining low emittance, beam quality, controlled losses and reliable user delivery.