Status of BEPCII and its upgrade

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- Overview of BEPCII
- Status of 5 years operation
- Upgrade project for BEPCII
- Summary

Overview of BEPCII

Collider

Synchrotron radiation facility



Status of 2018/2023 operation

For example 2022/2023 operation year 7296 hours



Distribution of failures time



Machine statistic

Dedicated 60 days + parasitic experiments. User experiments 662+473/year.

- Topup operation & High machine efficiency
- Add more and more beam lines for **BSRF parasitic experiments** during HEP operation

Right now 9 beam lines (9/14) with 3 wigglers without significantly reducing machine performance.



June 27 ~ July 26, 2023 BSRF operation

Availability 99.21 %, MTBF 687.0 hours, MDT 0.1 hours



Integral luminosity of BEPCII every operation year

- Improve the peak luminosity to 1.1×10³³cm⁻²s⁻¹ (Jan. 6, 2023) step by step •
- Extend beam energy from 2.3GeV to 2.47GeV after Feb. 6, 2021 ٠





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1, Improve the peak luminosity to 1.1×10³³cm⁻²s⁻¹ (Jan. 6, 2023) step by step





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Remove the bottleneck of beam current

RF Trip $\begin{bmatrix} \text{(Sep. 2020)} \\ \text{Loading angle jump} \rightarrow \text{Improve the mechanical structure of the tuner} \\ & \text{(Dec. 2022)} \\ & \text{(Dec. 2022)} \\ & \text{Multipacting effect inside coupler} \rightarrow \text{Optimize the DC bias voltage of the coupler} \\ & \text{(Dec. 2022)} \\ & \text{(Dec. 202)} \\ & \text{(Dec. 202)} \\ & \text{(Dec. 202)} \\ & \text{(Dec. 202)} \\ &$

Helium pressure of the east cavity \rightarrow

Change the switching valve to be regulating valve for quench protection (Sep. 2022)





1, Improve the peak luminosity to 1.1×10³³cm⁻²s⁻¹ (Jan. 6, 2023) step by step

Redesigned and installed more powerful feedback kickers





Online longitudinal feedback, drift chamber type, 2.25GHz, Large impedance



New longitudinal feedback, 360MHz, Low impedance



Online 125MHz transverse feedback, Length of 620mm, kick on 3 bunches



New 250MHz transverse feedback, Length of 305mm, kick on single bunch Longitudinal feedback BPR: New BER: Old

> Transverse feedback

BPR: 10ld+1new 2 sets electronics BER: 10ld+1new 1 set electronics

1, Improve the peak luminosity to 1.1×10³³cm⁻²s⁻¹ (Jan. 6, 2023) step by step

Upgrade of control logic of transverse feedback system



2, Extend beam energy from 2.3GeV to 2.47GeV after Feb. 6, 2021

Key technologies: The power supply & the air-cooling system of bending magnet





2, Extend the max. beam energy from 2.3GeV to 2.47GeV after Feb. 6, 2021



Peak luminosity 4.2×10^{32} cm⁻²s⁻¹ @ 2.370GeV, 360mA, beam-beam parameter 0.032 Peak luminosity 2.7×10^{32} cm⁻²s⁻¹ @ 2.472GeV, 330mA, beam-beam parameter 0.023

We need much higher beam energy and luminosity \rightarrow **BEPCII-U**

All the scheduled data blow 2.0 GeV will

samples for the	he remainder of the ph	iysics program. Th	ne most right colur	nn shows the		ha	totally collected next July
number of rec	quired data taking days	s in current $(T_{\rm C})$ o	or upgraded $(T_{\rm U})$ n	nachine. The		vei	olally collected hext July.
machine upgrades include top-up implementation and beam current increase.							
Energy	Physics motivations	Current data	Expected final data	$\mathcal{T}_{\rm C}$ / $T_{ m U}$	-		Increase luminosity by a factor of
1.8 - 2.0 GeV	R values	N/A	0.1 fb ⁻¹	60/50 days	-		increase fullinosity by a factor of
	Nucleon cross-sections		(fine scan)				Increase been energy to 28CoV
2.0 - 3.1 GeV	R values	Fine scan	Complete scan	250/180 days	-	•	Increase beam energy to 2.0Gev
	Cross-sections	(20 energy points)	(additional points)				
$J/\psi ~{ m peak}$	Light hadron & Glueball	$3.2 { m fb}^{-1}$	$3.2 { m ~fb^{-1}}$	N/A			$e^+e^- \rightarrow \pi^+\pi^-\psi(2S)$
	J/ψ decays	(10 billion)	(10 billion)				
$\psi(3686)$ peak	Light hadron & Glueball	$0.67 { m ~fb^{-1}}$	$4.5 { m ~fb^{-1}}$	150/90 days	qd)	100	points measured
	Charmonium decays	(0.45 billion)	(3.0 billion)		UOI		
$\psi(3770)$ peak	D^0/D^{\pm} decays	2.9 fb^{-1}	20.0 fb^{-1}	610/360 days	sect	80	- points collected
3.8 - 4.6 GeV	R values	Fine scan	No requirement	N/A	ss	00	
	XYZ/Open charm	(105 energy points)			So S		BELLE points
$4.180 { m GeV}$	D_s decay	3.2 fb^{-1}	6 fb^{-1}	140/50 days		60	
	XYZ/Open charm						
	XYZ/Open charm	- 1				10	
$4.0 - 4.6 \mathrm{GeV}$	Higher charmonia	16.0 fb^{-1}	30 fb^{-1}	<u>770/310 days</u>		40	
	cross-sections	at different \sqrt{s}	at different \sqrt{s}				
$4.6 - 4.9 \mathrm{GeV}$	Charmed baryon/ XYZ	0.56 fb^{-1}	15 fb^{-1}	1490/600 days		20	
	cross-sections	at 4.6 GeV	at different \sqrt{s}				
4.74 GeV	$\Sigma_c^+ \Lambda_c^-$ cross-section	N/A	1.0 fb ⁻¹	100/40 days			
4.91 GeV	$\Sigma_c \Sigma_c$ cross-section	N/A	1.0 fb^{-1}	120/50 days		0	4 4.1 4.2 4.3 4.4 4.5 4.6 4.7 4.8
4.95 GeV	Ξ_c decays	N/A	1.0 fb^{-1}	130/50 days	:		Center-of-Mass Energy (GeV)

Table 7.1: List of data samples collected by BESIII/BEPCII up to 2019, and the proposed samples for the remainder of the physics program. The most right column shows the

→5.6

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Key Technologies: Double beam power & Optics upgrade & Higher gradient of magnets

	BEPCII @ 2.35GeV	BEPCII-U @ 2.35GeV	BEPCII-U @ 2.8GeV	
L $[10^{32} \text{cm}^{-2} \text{s}^{-1}]$	3.5	11	3.7	1×10 ³³ Upgrade
β_y^* [cm]	1.5	1.35	3.0	
Beam current [mA]	400	900	450	¹ _S 8×10 ³²
SR Power [kW]	110	250	250	5) A 6 × 10 ³²
$\xi_{y,\mathrm{lum}}$	0.029	0.033	0.043	lisouic
Emittance [nmrad]	147	152	200	4×10 ³²
Couping [%]	0.53	0.35	0.5	Pec
Bucket Height	0.0069	0.011	0.009	2×10 ³²
$\sigma_{z,0}$ [cm]	1.54	1.07	1.4	- An
σ_{z} [cm]	1.69	1.22	1.6	1.0
RF Voltage [MV]	1.6	3.3	3.3	



- Give up the dedicated SRF. Keeping parasitic experiments during HEP op.
- 2 RF cavities for each ring.



Institute of High Energy Physics Chinese Academy of

- 2019 Apr. IHEP strategy meeting
- 2019 Sep. Initial communication with CAS
- 2020 May Internal discussion on accelerator
- 2020 July IHEP strategy meeting
- 2020 Sep. Project proposal
- 2021 Apr. Internal discussion of IHEP
- 2021 Jun. Feasibility study report
- 2021 July Project Approved

ç	2020	Jun. 2021	Q Apr. 2022	o Jul. 2024
	White Paper of BESIII	Feasibility Study Report	Design Finished	Shutdown for Installation
			BEPCII keep running	•
	Internal Review o	f Accelerator Project Appro	Fabrication Finished	Commissioning
	O May. 2020	🂿 Jul. 2021	Jun. 2024	Jan. 2025



IP insertion magnet, composed of Quad+AS, is ready now



- Bz = 2.85T (stable Max. test 3.4T)
- Field gradient 25.2T/m (\u00f6190mm, stable Max. test 29.5T/m)
- Field harmonics < 3.2×10⁻⁴
- Continuous test for > 2 weeks, stable enough for online
 - Meet the requirements of BEPCII-U @ 2.8GeV
 - A backup of BEPCII insertion magnet
 - -• A R&D progress of CEPC

Summary

- Through continuous efforts and improvements over the past 5 years, the beam performance of BEPCII is quite good right now.
- Both BSRF and BESIII achieved many exciting research results based on the high efficiency accelerator.
- Much higher beam energy and luminosity are needed for HEP research so that the collider upgrade project was submitted and finally approved.
- For BEPCII-U project, the procurement & manufacture is in progress and on schedule. The commissioning will start on Jan. 1, 2025.

