中国科学院高能物理研究所
Institute of High Energy Physics
Chinese Academy of Sciences

CEPC Accelerator EDR Highlights and Collaborations

J. Gao

IHEP



On behalf of CEPC-SppC accelerator team

The 2026 International Workshop on the High-Energy Circular Electron-Positron Collider (CEPC2026)
October 22 to 26, 2026, Shanghai, China

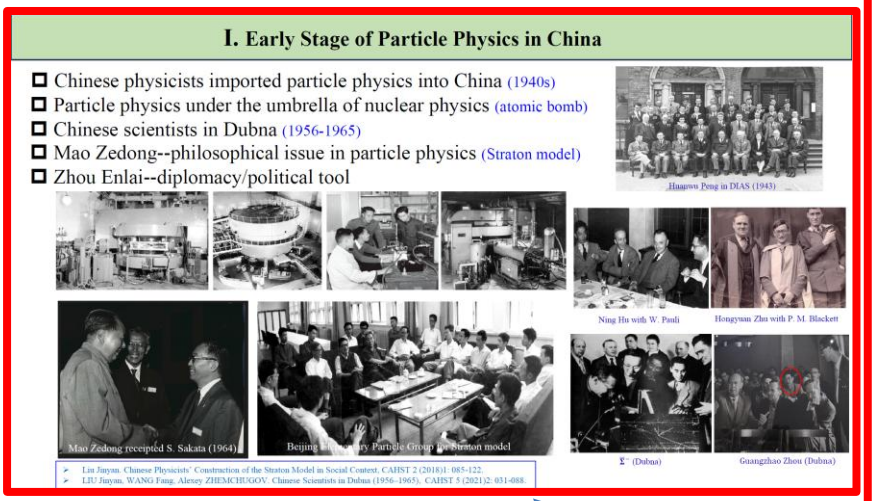
Contents

- Introduction
- CEPC accelerator EDR progress highlights
- CEPC-SppC and FCC synergy and collaboration issues
- Summary

A Brief Recall of Physics and Particle Physics Histories in China

The first Chinese Ph.D degree on physics is Dr. Fuji Li, from University of Bonn, Germany, in 1907

The first Chinese Ph.D student in China, Dr. Zhongqi Ma, in 1982 from IHEP



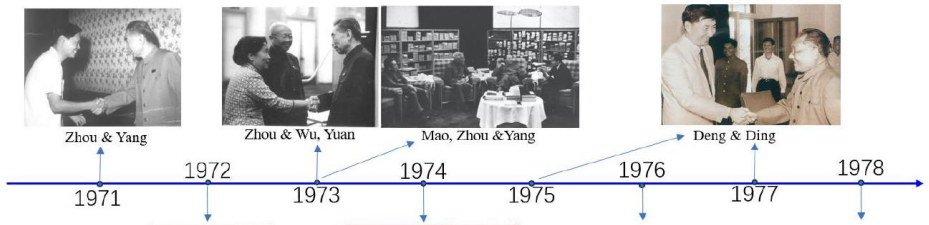
The Rise and Internationalization of Particle Physics in China

Liu Jinyan

Institute for the History of Natural Sciences, CAS
13 Nov. 2025 Geneva

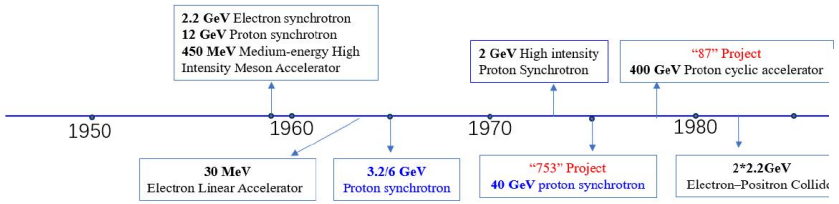
I. Early Stage of Particle Physics in China

- How to develop China's own particle physics
  - A-bomb success; withdrew from JINR; career transition; accelerator design discussions
- China-US relationship thawed: CY Yang, TD Lee, CS Wu and Samuel Ting came back to China
  - cultural revolution, bridge maker of the international cooperation
- Fulfill MAO Zedong and Zhou Enlai's last wish—Deng Xiaoping era





H. Kissinger visited China (July 1971)



BEPC

CEPC/SppC is a continuation of the history of particle physics in China as international projects

International collaboration on particle physics have always been a powerful engine to move forward

4th International Symposium on the History of Particle Physics
Nov. 10-13, 2025, CERN https://indico.cern.ch/event/1480892/timetable/

M. Davier, "Minghan Ye and China–France collaboration in high-energy Physics", Int. J. Mod. Phys. A 40 (2025) 2545005, https://doi.org/10.1142/S0217751X25450058

Time： 1974
Machine: Brookhaven AGS & SLAC SPEAR
Country: USA

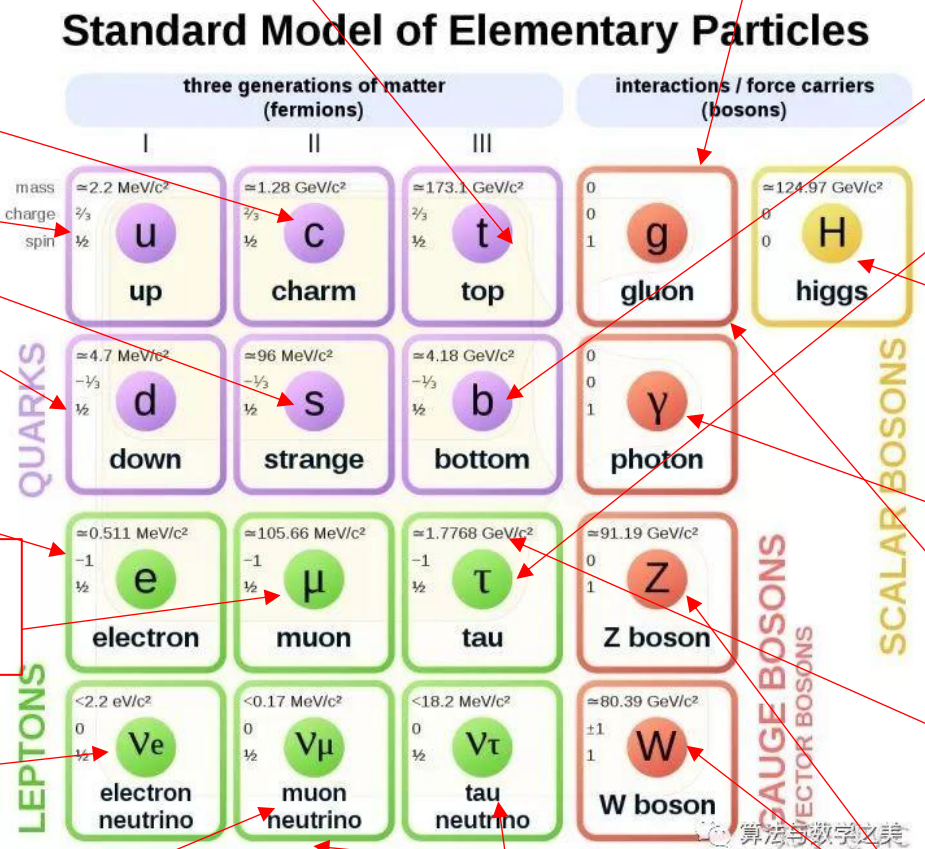
Time： 1995
Machine: Tevatron Collider (Fermilab)
Discovered by CDF & D0 collaborations
Country: USA

Time： 1979
Machine: PETRA Collider (DESY)
Discovered by TASSO
Country of Machine: Germany

Time： 1977
Machine: Fermilab Proton Accelerator
Country of machine: USA

Time： 1968
Machine: SLAC
Discovered by SLAC team
Country: USA

Time： 1975
Machine: SPEAR Collider
Country: USA



Time： 1897
Machine: Cathode ray tube
Country: UK

Time： 2012
Machine: Large Hadron Collider (LHC) at CERN
Discovered by ATLAS & CMS collaborations
Country: Switzerland

Time： 1936
Machine: Cloud Chamber (Cosmic Rays)
Country: USA

Time:1905 (theory) / 1922 (exp.)
Machine: SLAC
Country: Germany/USA

Time： 1992
Machine: BEPC
Tau mass and R value precise measured by BES collaboration
Time: 2012 Neutrino oscillation angle θ13
Experiment: Daya Bay
Time: 2026 glueball discovered, BEPCII
Country: China

Time： 1956
Machine: Savannah River Nuclear Reactor
Country: UK

Time： 1962
Machine: Alternating Gradient Synchrotron (AGS) with Spark Chamber
Country: USA

Time： 2000
Machine: DONUT experiment at Fermilab
Discovered by DONUT collaboration
Country: USA

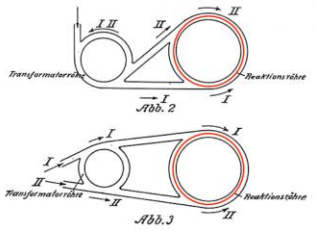
Time： 1983
Machine: Super Proton Synchrotron (SPS) converted to proton-antiproton collider (CERN)
Discovered by UA1 & UA2
Country: Switzerland

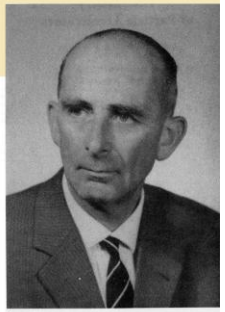
From the First e+e- Circular Collider Ada to CEPC/FCC



Rolf Wideröe 1902-1996

1943: secret patent of a 'nuclear mill' (published in 1953)





Rolf Wideröe

IL NUOVO CIMENTO Vol. XVIII, N. 6 16 Dicembre 1960

The Frascati Storage Ring.

C. Bernardini, G. F. Corazza, G. Ghigo
Laboratori Nazionali del CNEN - Frascati

B. Touschek
Istituto di Fisica dell'Università - Roma
Istituto Nazionale di Fisica Nucleare - Sezione di Roma

(ricevuto il 7 Novembre 1960)

The AdA collaboration in Orsay

C. Bernardini, G. Corazza,
G. Di Giugno, J. Haïssinski,
P. Marin, R. Querzoli, B. Touschek

Pierre Marin (1927-2002)



1966 photograph

The Orsay linear accelerator wave guide

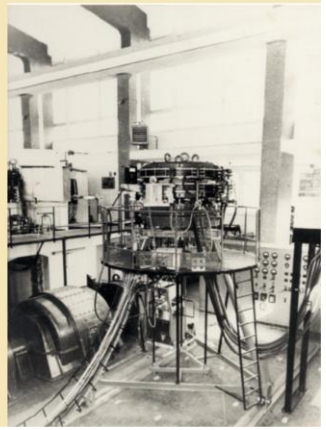


Bruno Touschek



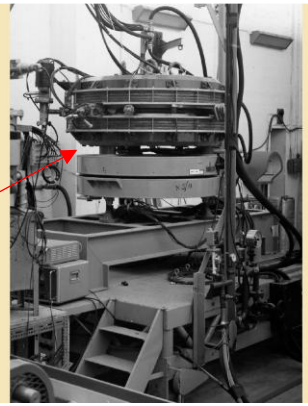
Bruno Touschek (1964)

AdA in the electron synchrotron hall in the Frascati Laboratory (1961-62)



1962

AdA at LAL



Spring 1964: first observation ever of e^+- e^- collisions in a storage ring

$e^+ + e^- \rightarrow e^+ + e^- + \gamma$ ray

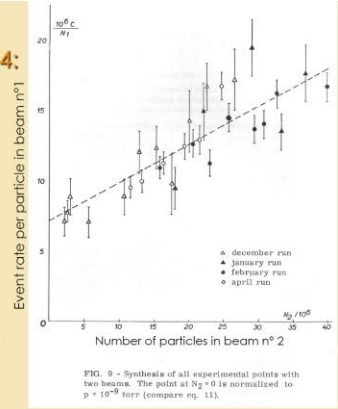
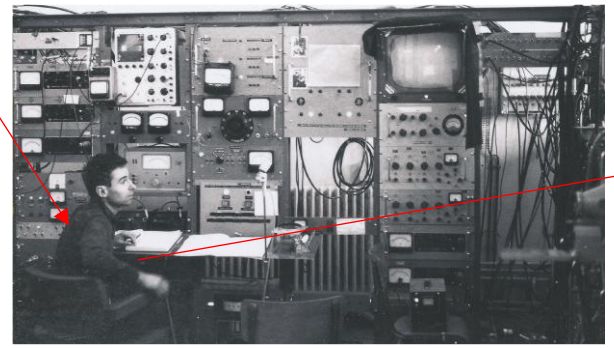
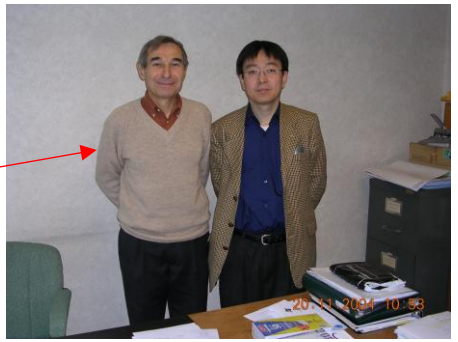


FIG. 9 - Synthesis of all experimental points with two beams. The point at $N_2 = 0$ is normalized to $p = 10^{-5}$ torr (compare eq. 11).





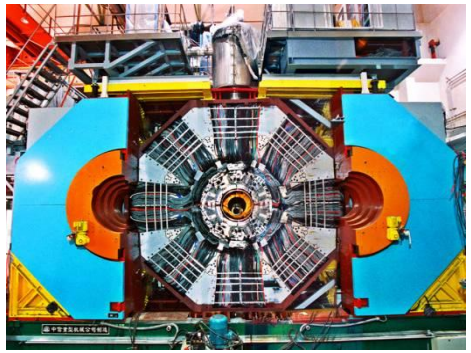
From BEPC, BEPCII, BEPCII-U to CEPC

BEPC, the first collider in China, was completed in 1988 with luminosity $1\times10^{31}cm^{-2}s^{-1}$ @1.89GeV
BEPC II was completed in 2009
On April 5, 2016, BEPCII luminosity reached: $10\times10^{32}cm^{-2}s^{-1}$ @1.89GeV (reached the design value)

On May 7, 2026, BEPCII-U luminosity reached: L= 1.112×10^33 cm^-2s^-1@2.35 GeV (reached the design value)

After BEPCII what is the next high energy collider?

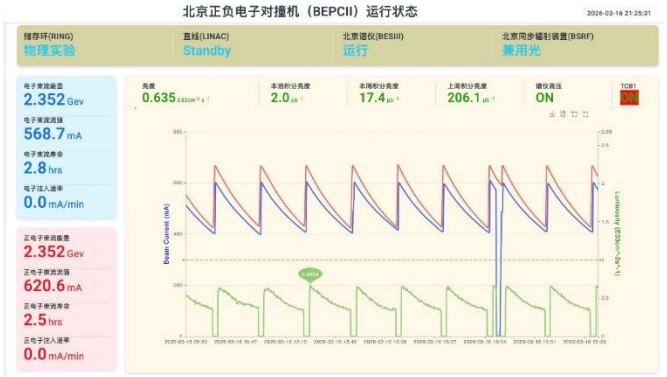
The discovery of Higgs at LHC@CERN in July 4, 2012, the answer is clear, CEPC!







BEPCII-U in operation





J. Gao, “BEPCII and CEPC”, Proceedings of eeFACT 2025, arXiv:2505.02401, https://doi.org/10.48550/arXiv.2505.02401

A Brief Historical Recall: High Energy Colliders and Factories

The era of Higgs boson started from 2012， and we entered the BEST EPOCH of High Energy Physics

In the last 60 years we have made a tremendous progress in particle physics, and we have to prepare for the next exciting and discovering years of human being

In 60's, Ada, VEP-I, VEPP-II, ACO…

Year

Next?

2018

2012

2010

2006

2002

1999

1994

1990

1988

1980

1972

SppC, FCC-hh
Muon collider
FCC-ee
(H,t, Z,W…Dark matter)
CEPC/ILC/CLIC: new e^+e^- collider
(B physics…)
SuperKEKB: $\sqrt{s} \simeq 10\ \mathrm{GeV}, \mathcal{L} \simeq 10^{35}$
LHC: $\sqrt{s} \simeq 14\mathrm{TeV}, \mathcal{L} \simeq 10^{33}$
(τ − charm,…)
BEPCII: $\sqrt{s} \simeq 2-5\ \mathrm{GeV}, \mathcal{L} \simeq 10^{33}$
(τ mass, charmonium,…)
VEPP-4: $\sqrt{s} \simeq 1.5-2.0\mathrm{GeV}, \mathcal{L} \simeq 10^{33}$; DAFNE: $\sqrt{s}$ ~1GeV , $\mathcal{L} \simeq 10^{32}$
(B-quark, CP violation, CKM…)
KEKB/PEP-II
SSC: $\sqrt{s} \simeq 40\mathrm{TeV}, \mathcal{L} \simeq 10^{33}$ 1993 stopped
(Z, W bosons,…)
LEP/CERN, SLC/SLAC
(τ −charm,…)
BEPC: $\sqrt{s} \simeq 2-5\ \mathrm{GeV}, \mathcal{L} \simeq 10^{31}$
CESR: $\sqrt{s} \simeq 10\ \mathrm{GeV}$
(J/ψ,c-quark, t …)
SPEAR&BNL: $\sqrt{s}$

Future Large Colliders:
- new paradigm/theory
- new colliders equipped with advanced detectors

Higgs,…

LHC/CERN:

Higgs boson 2012

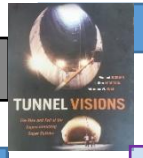
Crab-Waist in 2014 at DAFNE

CEPC-SppC was proposed by Chinese scientists in Sept. 2012 after Higgs Boson was discovered on July 4, 2012 at CERN

Top

Tevatron

Top quark 1995



HERA: ep

J. Gao, "Review of Different Colliders", **International Journal of Modern Physics A**, (2021) 2142002 (25 pages).

W, Z,…

SPS/CERN

W,Z bosons 1983

Bottom,…

PETRA: $\sqrt{s} \simeq 12\sim46.7$ GeV GeV

Gluon 1979

Fermilab: 400GeV p on Cu, Pt

Bottom quark 1977

4th International Symposium on the History of Particle Physics
Nov. 10-13, 2025, CERN https://indico.cern.ch/event/1480892/timetable/

The Classification of Electron Positron Circular Colliders

$$L_{\max}[\mathrm{cm}^{-2}\mathrm{s}^{-1}] = \frac{0.158\times10^{34}(1+r)}{\beta_y^*[\mathrm{mm}]} I_b[\mathrm{mA}] \sqrt{\frac{U_0[\mathrm{GeV}]}{N_{\mathrm{IP}}}} \cdot e^{\frac{\sqrt{\Phi p}}{3.22}} (1+0.000505*\Phi p^2)\, e^{-\frac{A}{\beta_y^2[\mathrm{mm}]}} \quad \text{Eq. 1}$$

$$L_{\max}[\mathrm{cm}^{-2}\mathrm{s}^{-1}] = \frac{0.158\times10^{34}(1+r)}{\beta_y^*[\mathrm{mm}]} I_b[\mathrm{mA}] \sqrt{\frac{U_0[\mathrm{GeV}]}{N_{\mathrm{IP}}}} \cdot e^{\frac{\sqrt{\Phi p}}{3.22}} (1+0.000505*\Phi p^2) \boldsymbol{F_{DA}} \quad \text{Eq. 2}$$

Φp is the Piwinski angle

$$\boldsymbol{F_{DA}} = e^{\left(-\frac{A}{\beta_{y*}(mm)^2}\right)} = e^{-C\left(\frac{Da_inj}{Accep_inj}\right)^2}$$

Eq. 1 and Eq. 2 could be found in following reference: J. Gao, "The Status of the CEPC Project in EDR", International Journal of Modern Physics A (2026) 2641001 (16 pages), https://www.worldscientific.com/doi/10.1142/S0217751X26410010

I: Classical circular collider ($\boldsymbol{F_{DA}}\sim1$, $\boldsymbol{F_{DA}} = e^{\left(-\frac{A}{\beta_{y*}(mm)^2}\right)}$)

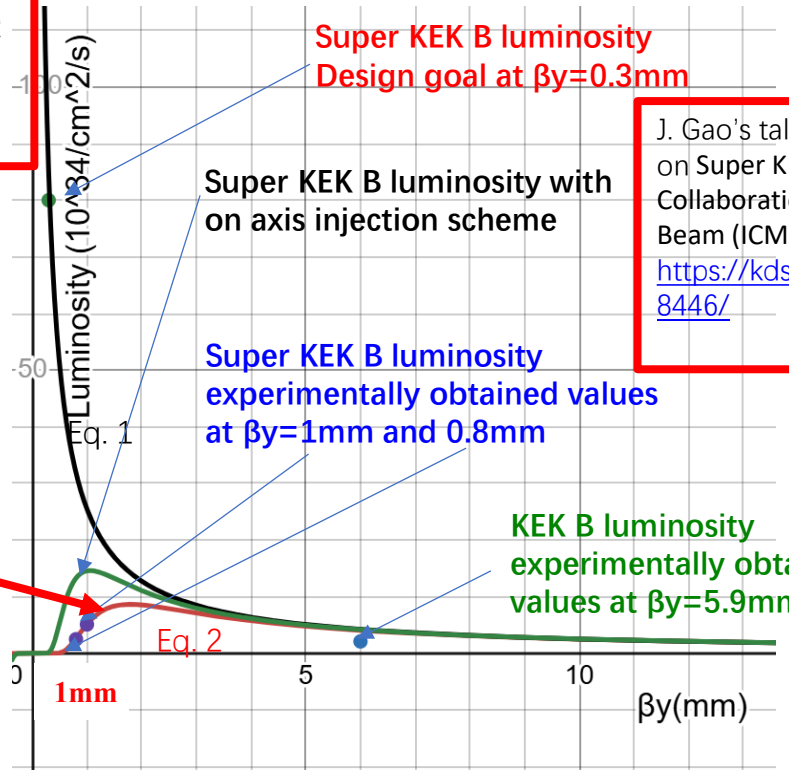
Ada, VEP-I, VEPP-II, ACO, ADONE, SPEAR, PETRA, CESR, BEPC BEPCII, LEP-I,II, KEKB, PEP-II, VEPP-4, DAFNE(CW)

II: Advanced circular collider ($\boldsymbol{F_{DA}} < 1$, $\boldsymbol{F_{DA}} = e^{\left(-\frac{A}{\beta_{y*}(mm)^2}\right)}$)

SuperKEKB, CEPC, FCCee, LEP3, BEPCII-UP (CW), STCF, SCTF...

For Super KEK B: A=1.6mm^2 (off axis injection)
For Super KEK B: A=0.56mm^2 (on axis injection)

SuperKEKB 24-Hour Operation Summary (live): https://www-linac.kek.jp/skekb/snapshot/dailysnap.html



J. Gao's talk on Super KEK International Collaboration on Beam-Beam (ICMbb) Meeting https://kds.kek.jp/event/58446/

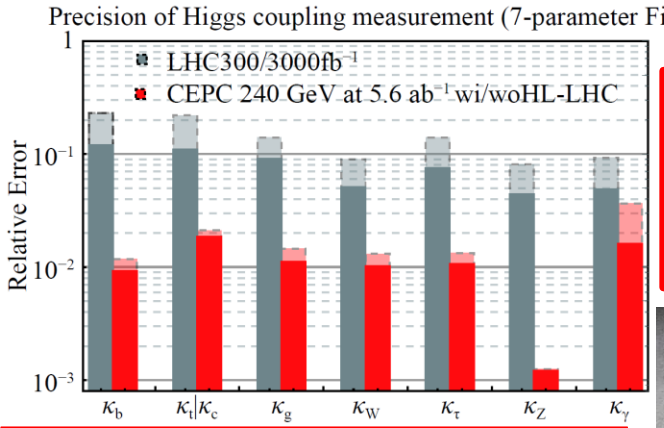
Figure 1: Super KEK B luminosities from the experiments and the analytical formulae Eq. 1 and Eq. 2

CEPC Physics Goals, Operation Plan and Goals in TDR/EDR

Operation mode		ZH	Z	W^+W^-	$t\bar{t}$
$\sqrt{s}$ [GeV]		~240	~91	~160	~360
Run Time [years]		10	2	1	5
30 MW	L / IP [$\times 10^{34}$ $cm^{-2}s^{-1}$]	**5.0**	**115**	**16**	**0.5**
	$\int L\,dt$ [ab^{-1}, 2 IPs]	13	60	4.2	0.65
	Event yields [2 IPs]	2.6×10^6	2.5×10^{12}	1.3×10^8	4×10^5
50 MW	L / IP [$\times 10^{34}$ $cm^{-2}s^{-1}$]	**8.3**	**192**	**26.7**	**0.8**
	$\int L\,dt$ [ab^{-1}, 2 IPs]	21.6	100	6.9	1
	Event yields [2 IPs]	4.3×10^6	4.1×10^{12}	2.1×10^8	6×10^5

* Higgs is the top priority for CEPC

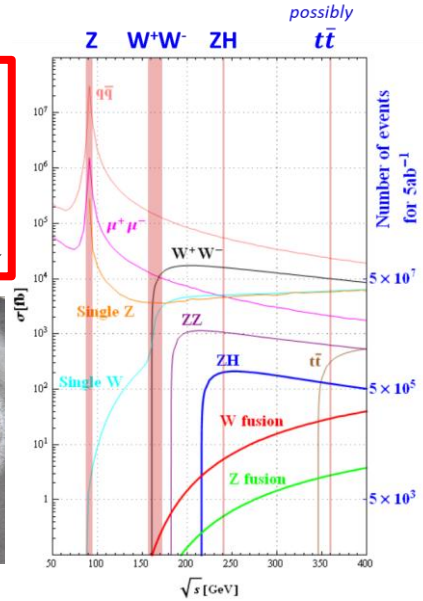
** Detector solenoid field is 3 Tesla for all other energies.



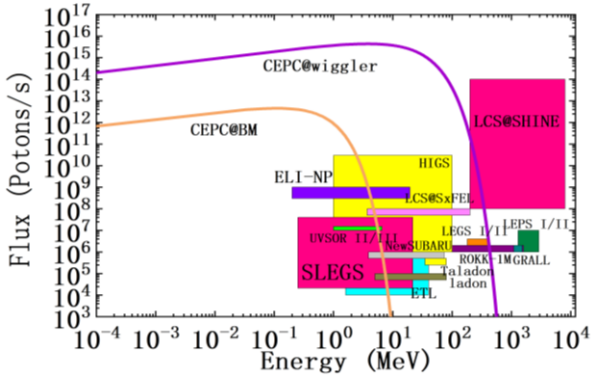
CEPC operation scenarios:
Higgs 10 years, Z-pole 2 years,
W 1 year, ttbar 5 years as upgrade

Higgs potential and the spontaneous symmetry breaking (618?~1878) in the Ghost city of Fengdu County of Chongqing, China

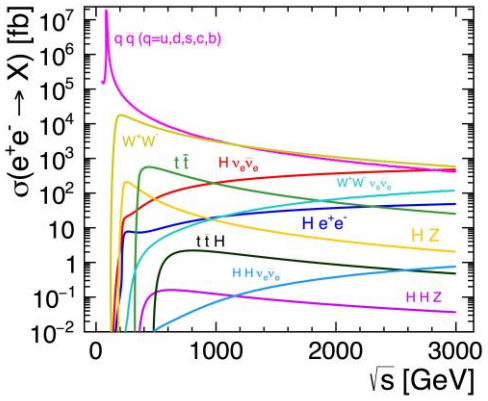




Circular Higgs factories



CEPC as high energy SR light source



Linear colliders

CEPC physics white papers:

1: Higgs physics, Chinese Physics C Vol. 43, No. 4 (2019) 043002
https://arxiv.org/pdf/1810.09037

2: Flavor physics, https://arxiv.org/pdf/2412.19743 (2024)

3: Electroweak physics, to be published

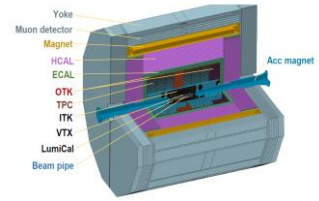
4: New Physics Search at the CEPC: a General Perspective
https://doi.org/10.48550/arXiv.2505.24810 （2025）

5: QCD, to be published

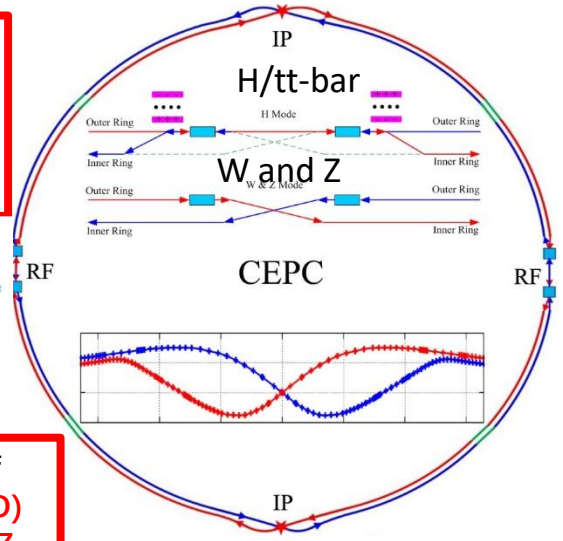
CEPC Higgs Factory and SppC Layout in TDR/EDR

CEPC as a Higgs Factory: H, W, Z, upgradable to ttbar, followed by a SppC (a Hadron collider) ~125TeV
30MW SR power per beam (upgradable to 50MW) , high energy gamma ray 100Kev~100MeV

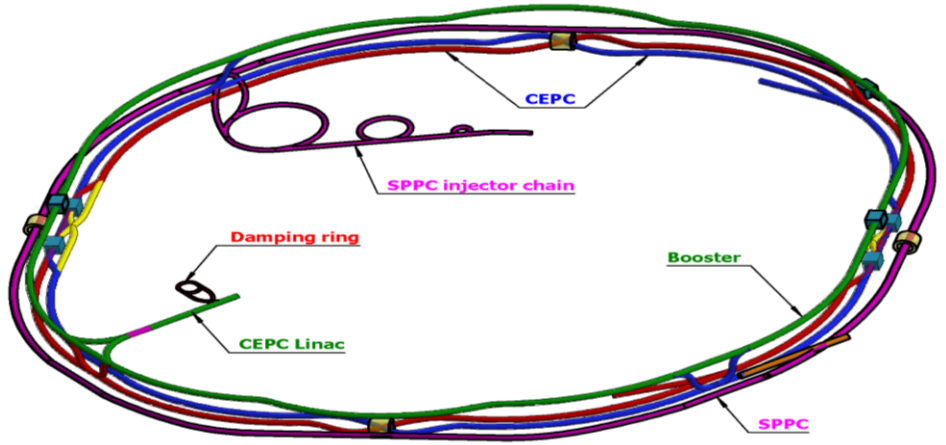
CEPC design has two detectors @H,W,Z and ttbar



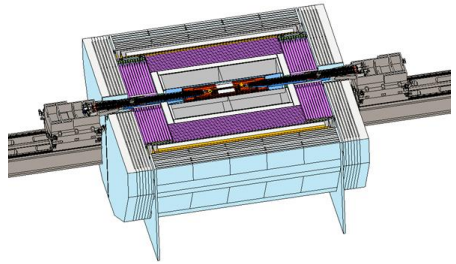
CEPC EDR cost of 38B RMB (~5B USD) @SR 30MW, H,W,Z
This cost EDR contains only one detector

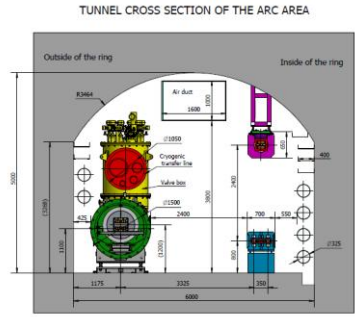


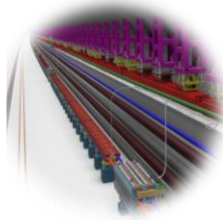
CEPC collider ring (100km)



CEPC booster ring (100km)



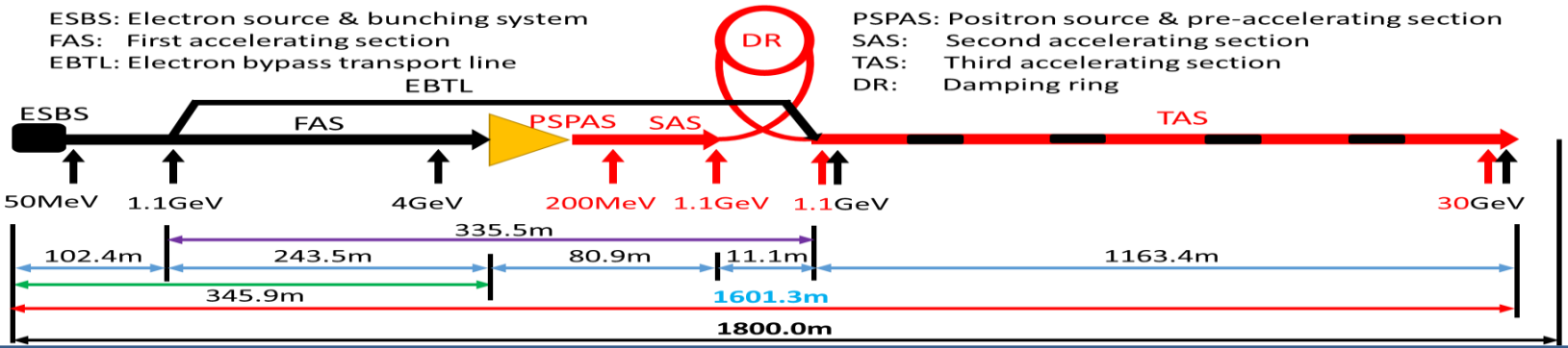


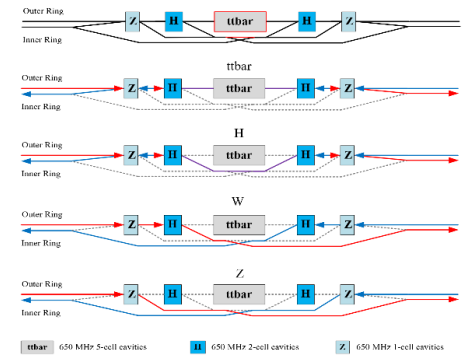


CEPC/SppC in the same tunnel

CEPC TDR S+C-band 30GeV linac injector

ESBS: Electron source & bunching system
FAS: First accelerating section
EBTL: Electron bypass transport line
PSPAS: Positron source & pre-accelerating section
SAS: Second accelerating section
TAS: Third accelerating section
DR: Damping ring





Z,W, Higgs and ttbar energies

J. Gao, D. Wang and Y.F. Wang*, Vision for high-energy frontier particle colliders in China, **Annual Review of Nuclear and Particle Science, Volume 75**, 2025, https://doi.org/10.1146/annurev-nucl-121423-101120

CEPC Accelerator System Parameters in TDR/EDR

Linac

Parameter	Symbol	Unit	Baseline
Energy	E_e/E_{e+}	GeV	30
Repetition rate	f_{rep}	Hz	100
Bunch number per pulse			1 or 2
Bunch charge		nC	1.5 (3)
Energy spread	σ_E		1.5×10^{-3}
Emittance	ε_r	nm	6.5

Booster

		tt	*H*		*W*	*Z*	
		Off axis injection	Off axis injection	On axis injection	Off axis injection	Off axis injection	
Circumfer.	km	99.955					
Injection energy	GeV	30					
Extraction energy	GeV	180	120		80	45.5	
Bunch number		35	268	261+7	1297	3978	5967
Maximum bunch charge	nC	0.99	0.7	20.3	0.73	0.8	0.81
Beam current	mA	0.11	0.94	0.98	2.85	9.5	14.4
SR power	MW	0.93	0.94	1.66	0.94	0.323	0.49
Emittance	nm	2.83	1.26		0.56	0.19	
RF frequency	GHz	1.3					
RF voltage	GV	9.7	2.17		0.87	0.46	
Full injection from empty	h	0.1	0.14	0.16	0.27	1.8	0.8

Collider

	Higgs	Z	W	$t\bar{t}$
Number of IPs	2			
Circumference (km)	99.955			
SR power per beam (MW)	30			
Energy (GeV)	**120**	**45.5**	**80**	**180**
Bunch number	268	11934	1297	35
Emittance $\varepsilon_x/\varepsilon_y$ (nm/pm)	0.64/1.3	0.27/1.4	0.87/1.7	1.4/4.7
Beam size at IP σ_x/σ_y (um/nm)	14/36	6/35	13/42	39/113
Bunch length (natural/total) (mm)	2.3/4.1	2.5/8.7	2.5/4.9	2.2/2.9
Beam-beam parameters ξ_x/ξ_y	0.015/0.11	0.004/0.127	0.012/0.113	0.071/0.1
RF frequency (MHz)	650			
Luminosity per IP (10^{34} cm^{-2} s^{-1})	**5.0**	**115**	**16**	**0.5**
Luminosity per IP (10^{34} cm^{-2} s^{-1}) From J. Gao's formula below	**5**	**115**	**12**	**0.59**

Running scenarios: Higgs 10 years, Z 2 years, W 1 year, ttbar 5 years

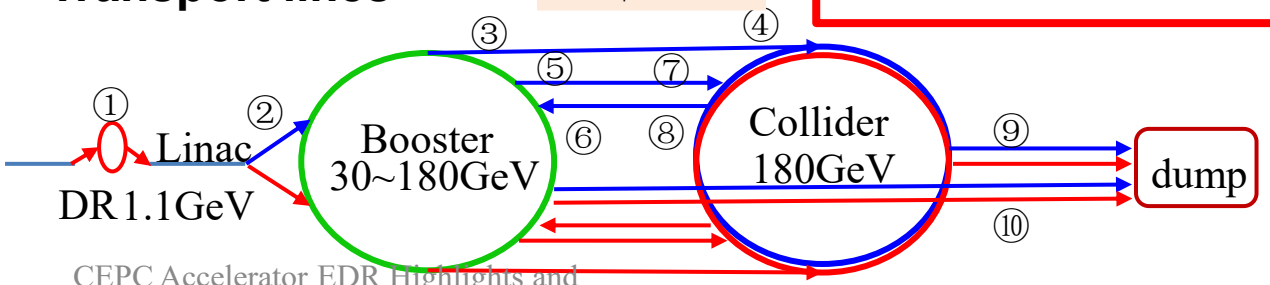
Factory of
4 Million Higgs
4 Trillion Z bosons
200 Million W^+W^- pairs
600K $t\bar{t}$ pairs

$$L_{max}[cm^{-2}\,s^{-1}] = 0.158\times10^{34}\,\frac{(1+r)}{\beta_y[mm]}\sqrt{\frac{R[m]}{C_\gamma[mGeV^3]N_{IP}}}\,(P_b[MW]/E[GeV]^2)\,e^{\frac{\sqrt{\Phi_p}}{3.22}}\,(1+0.000505*\Phi_p^2)$$

(J. Gao's formula)

for isomagnetic machine with crab-waist collision

Transport lines



CEPC Technical Design Report (TDR) includes:
1) CEPC Accelerator TDR released on Dec. 25, 2023
2) CEPC Detector ref-TDR (reference design) has been completed and reviewed by IDRC and released in 2025. Submitted to RDTM in 2026

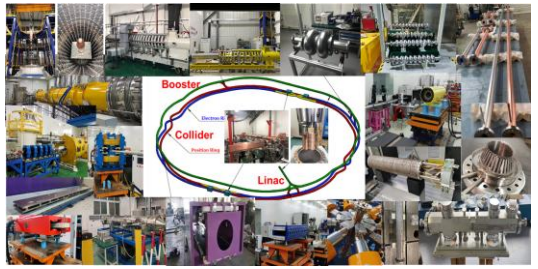
CEPC Milestones and Timeline

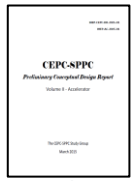
Year 2012 2013 2015 2017 2018 2023 2025 2026 2030 ~2030's construction

Higgs discovered on July 4, 2012



CEPC kickoff meeting in Sept. 2013



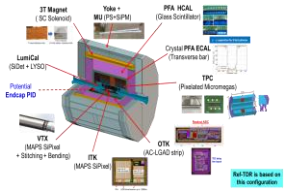


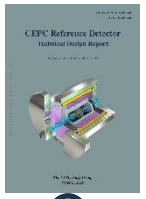






CEPC detector reference design released in Oct. 2025



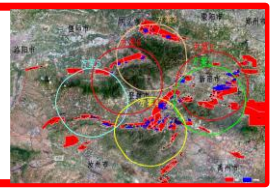


Proposal (2030) for CEPC entering 16th five-year-plan

38B RMB
Total construction



CEPC EDR site study and civil engineering design



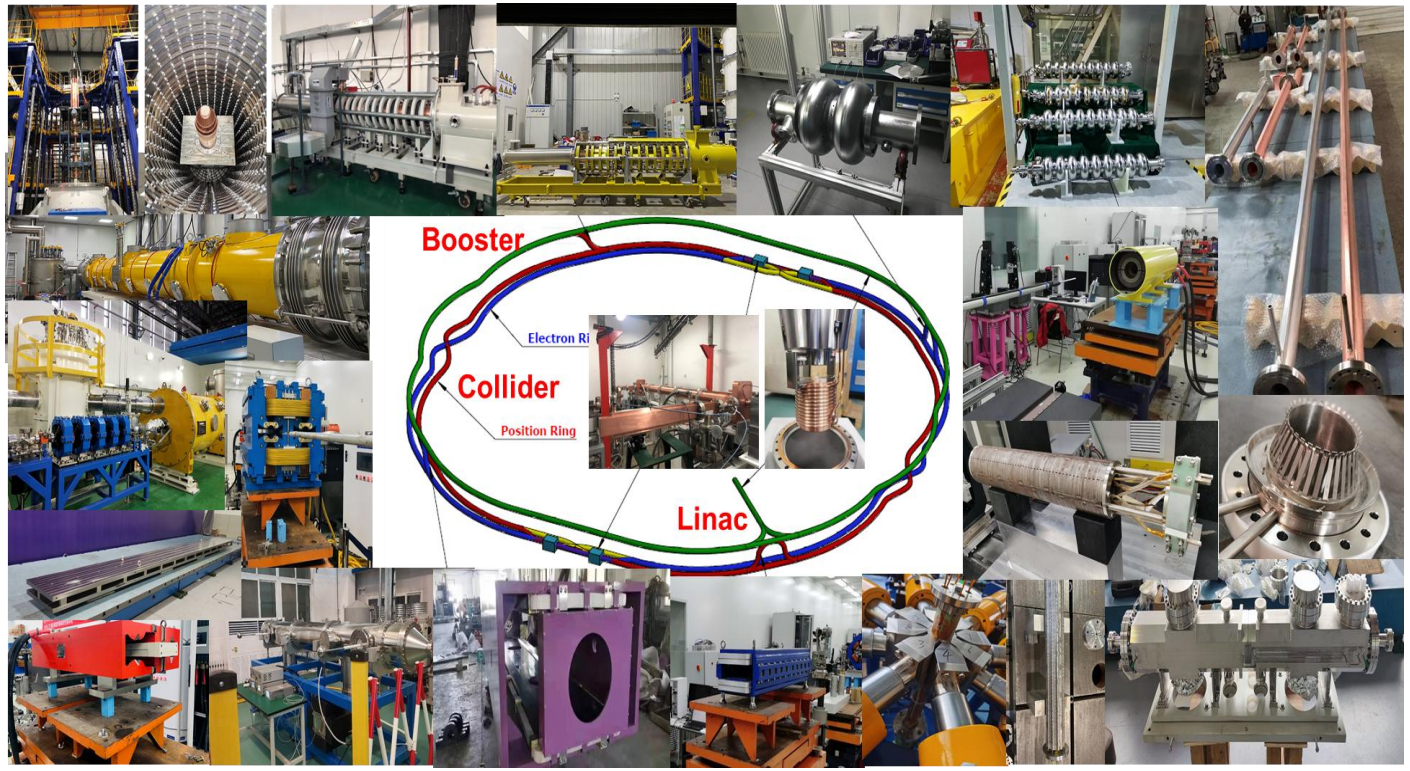
2012.9 CEPC proposed
2013.9 Pre-CDR
2015.3 Progress report
2017.4 CDR
2018.11 TDR
2023.12 2024 ~ 2027 EDR
~2030's construction

FCCee decision in 2028 and construction ~2033

J. Gao, "The status of the CEPC project in EDR", IJMPA, (2026) 2641001 (16 pages) 2026, https://doi.org/10.1142/S0217751X26410010

The European Strategy for Particle Physics: 2026 Update Recommendations by the European Strategy Group(CERN-ESU-2025-002, Dec.2025)
https://cds.cern.ch/record/2950671

CEPC Accelerator TDR Completed in 2023











IHEP HEPS (4th generation light source at IHEP) 6 GeV, 36 nm·rad, has been completed in Oct. 2025

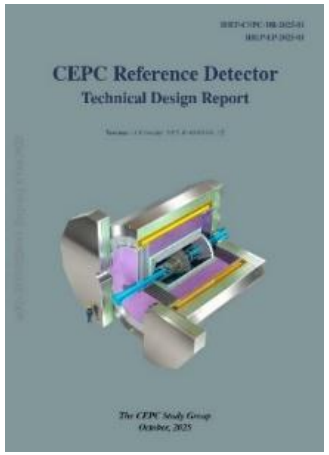
CEPC Accelerator TDR was published in Radiation Detection Technology and Methods (RDTM) on June 3, 2024:
DOI: 10.1007/s41605-024-00463-y https://doi.org/10.1007/s41605-024-00463-y

✓ **Specification Met**

✓ **Prototype Manufactured**

Accelerator	Fraction
✓ Magnets	27.3%
✓ Vacuum	18.3%
√ RF power source	9.1%
✓ Mechanics	7.6%
✓ Magnet power supplies	7.0%
✓ SC RF	7.1%
✓ Cryogenics	6.5%
✓ Linac and sources	5.5%
✓ Instrumentation	5.3%
✓ Control	2.4%
✓ Survey and alignment	2.4%
✓ Radiation protection	1.0%
✓ SC magnets	0.4%
✓ Damping ring	0.2%

CEPC EDR Milestones and Check Points



Year: 2024 — 2025 — 2026 — 2027 — 2028 — 2030

Start EDR site geological studies by civil engineering company; EDR items started to be executed in an industrial way, such as magnet and vacuum NEG coating automatic lines, 650MHz full size cryomodule, C-band 80 MW klystron, C-band accelerator test band, CEPC 60m mockup tunnel, MDI SC CCT type quadrupole magnet, MDI design with SC quadrupole cryomodule, booster and collider ring magnets, civil engineering design, etc.

Complete Detector TDR ref Design report CEPC Detector Reference Design Report submitted to arXiv on Oct. 7, 2025 https://arxiv.org/abs/2510.05260

EDR site geological study completed with good understanding of EDR site for starting site dependent civil engineering design; Complete following key EDR items: magnet and vacuum NEG coating automatic lines, 650MHz full size cryomodule, C-band 80 MW klystron, CEPC 60m mockup tunnel, etc. ; Continue C-band accelerator test band, MDI SC CCT type quadrupole magnet, MDI design with SC quadrupole cryomodule, booster and collider ring magnets, civil engineering design, etc. Obtaining government approval.

EDR site dependent civil engineering design completed; Complete EDR report with following key EDR items completed: magnet and vacuum NEG coating automatic lines in operation, 650MHz full size cryomodule, C-band 80 MW klystron, CEPC 60m mockup tunnel, C-band accelerator test band, MDI SC CCT type quadrupole magnet, MDI design with SC quadrupole cryomodule, booster and collider ring magnets, etc., ready for construction with government approval.

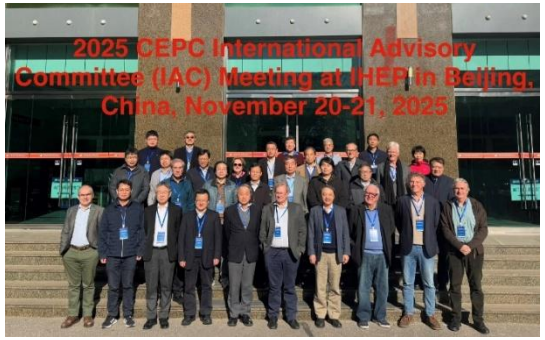
Application for 16th five year plan

CEPC IARC, IDRC and IAC Meetings since EDR





CEPC IARC meeting was held from Sept. 18-20, 2024
https://indico.ihep.ac.cn/event/22311/



CEPC IARC meeting was held from Sept. 16-19, 2025
https://indico.ihep.ac.cn/event/26917/



The International Detector Review Committee (IDRC) held its inaugural meeting at IHEP, Oct 21-23, 2024, to review the status and plan of Ref-TDR.

https://indico.ihep.ac.cn/event/23265/



CEPC IAC meeting in 2024 was held from Oct. 29-30, 2024
https://indico.ihep.ac.cn/event/23450/timetable/

CEPC IAC meeting was held from Nov. 19-21, 2025
https://indico.ihep.ac.cn/event/27018/overview

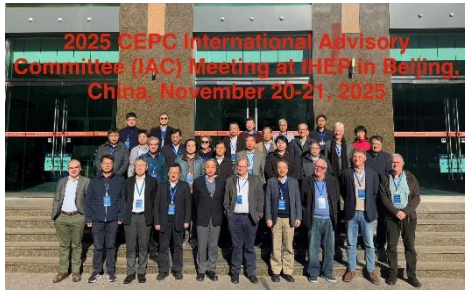


CEPC IARC meeting Sept. 22-24, 2026
https://indico.ihep.ac.cn/event/30002/timetable/

CEPC IAC meeting Nov. 16-17, 2026



CEPC IDRC meeting was held from April 14-16, 2025
https://indico.ihep.ac.cn/event/25539



CEPC IAC 2025 meeting is held from Nov. 20-21, 2025
https://indico.ihep.ac.cn/event/27018/timetable/

CEPC IDRC meeting was held on Sept. 10, 17 and 24, 2025
https://indico.ihep.ac.cn/event/27191/

CEPC Accelerator Lattice Optimization Design

Error Correction to the Higgs lattice with solenoid and anti-solenoid

Closed-orbit distortion (COD) correction was performed with sextupoles off, then the sextupoles were turned on and the COD correction repeated.

- The dispersion correction (DISP) and beta-beating correction are also used for optics correction.
- The coupling and vertical dispersion correction are used to decrease the vertical emittance.
- The above correction scheme is iterated until the emittance and tracking dynamic aperture satisfy the design requirements.

The correction targets: 50 mm for COD correction, 2mm for DISP correction and 3% for beta beating correction. Taking the Higgs mode correction as an example.

Software: SAD and Matlab-based accelerator toolbox (AT)

Other issues such as IP tunning and the ground motion, etc. are under detailed studies

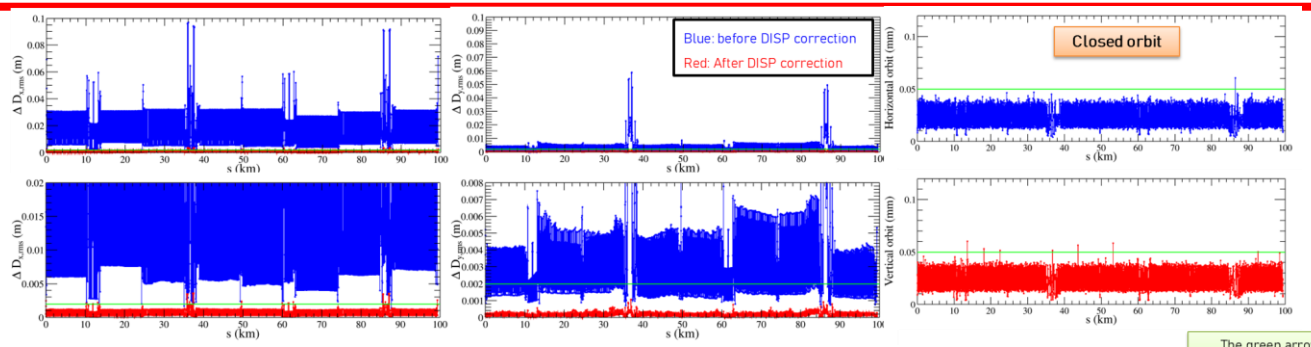
Component	Δx (mm)	Δy (mm)	$\Delta\theta_z$ (mrad)	Field error
Dipole	0.10	0.10	0.10	0.01%
Quadrupole	0.10	0.10	0.10	0.02%
Sextupole	0.10	0.10	0.10	0.02%

Misalignment and field error requirements.

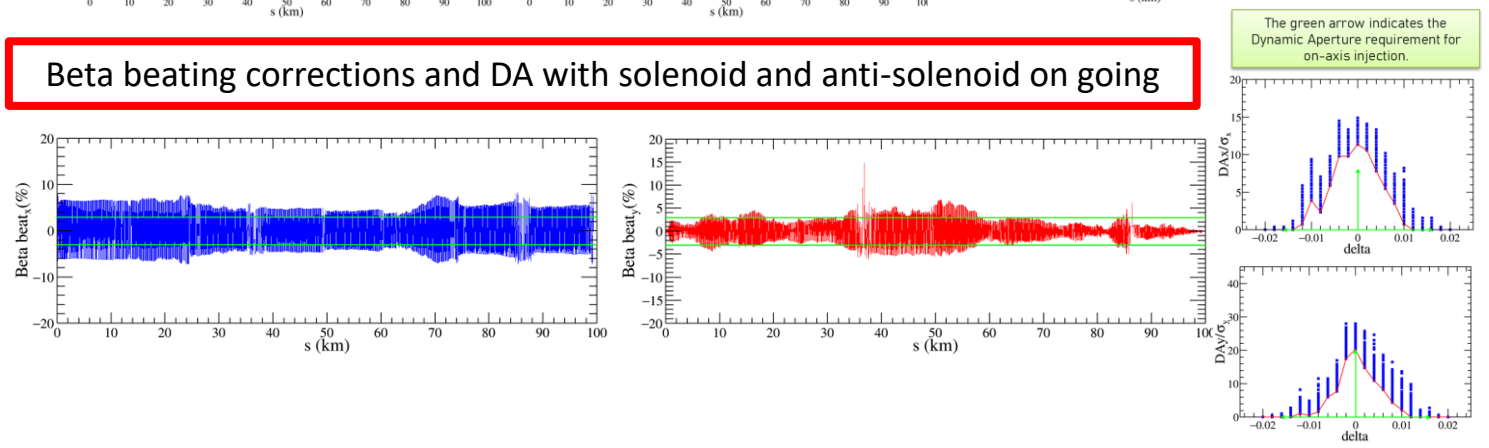
RMS	Higgs	Z	W	$t\bar{t}$
Orbit (μm)	< 50	< 50	< 50	< 50
Dispersion (mm)	1.8/0.9	2.8/1.4	2.7/1.8	0.6/0.3
Beta-beating (%)	1.0/2.8	2.0/3.0	0.5/2.5	1.1/1.2

The starting lattice quality status without solenoid and anti-solenoid.

Dispersion corrections and the closed orbit corrections with solenoid and anti-solenoid @Higgs mode



Beta beating corrections and DA with solenoid and anti-solenoid on going



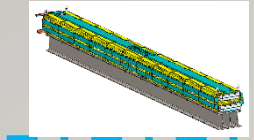
CEPC Booster Magnet Automatic Production Line in EDR

4 booster magnets fabricated per day

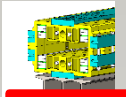














~15000 dipole magnets in the CEPC booster

The 1/3 magnet assembly line arrived @IHEP on Oct. 10, 2026



Stacking of 1/3

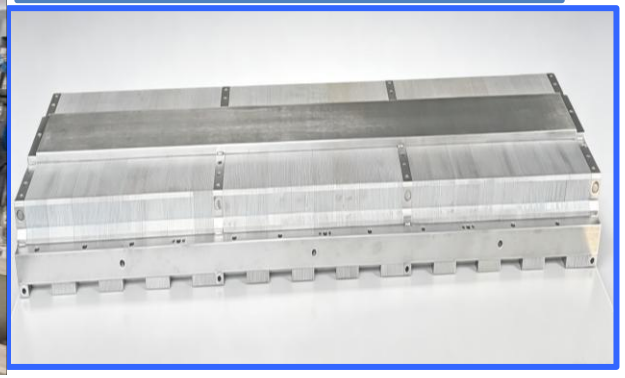
Production of

Assembly of the



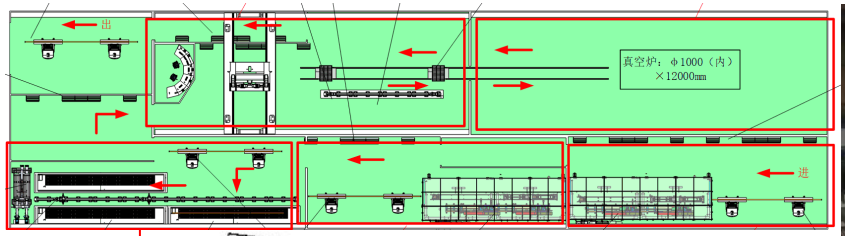


First Magnet Core from Production Line



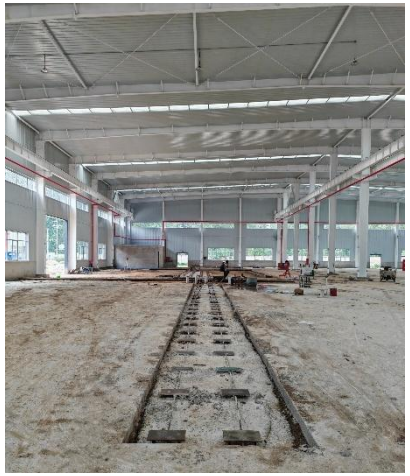
Status： 1/3 completed, fully completed by November 2027

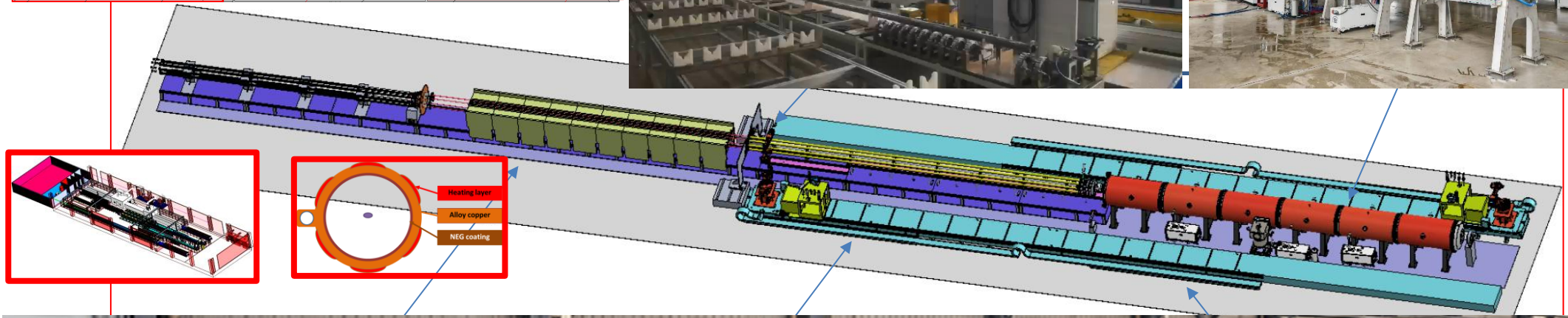
CEPC NEG Coated Vacuum Chamber (200km)
Automatic Production Line in EDR













- **The main components of vacuum oven for NEG coating have been manufactured and under are now being assembled.**

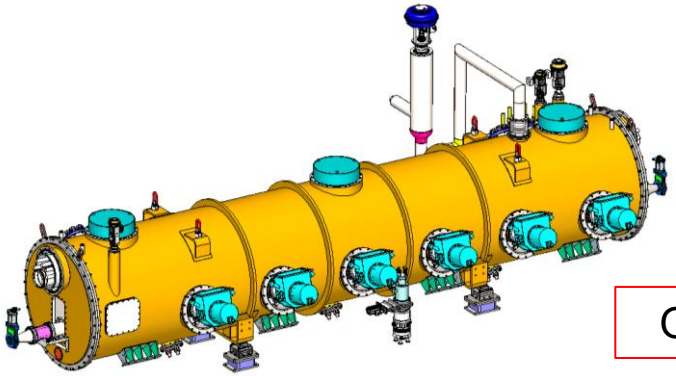
Status：under construction, to be completed and tested in 2026

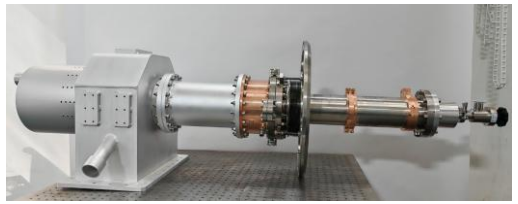
CEPC 650MHz SRF Development in EDR



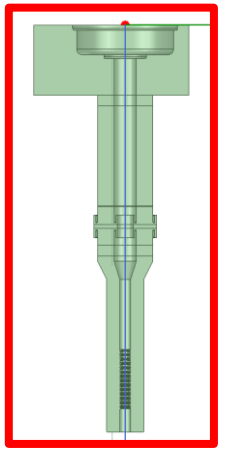


CEPC collider ring 650MHz 2*cell short test module has been completed in TDR phase

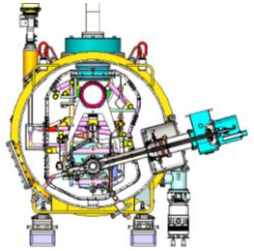


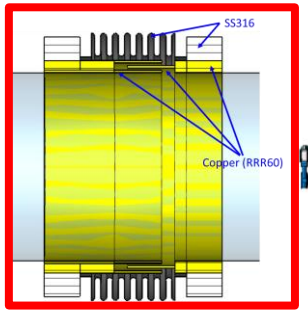


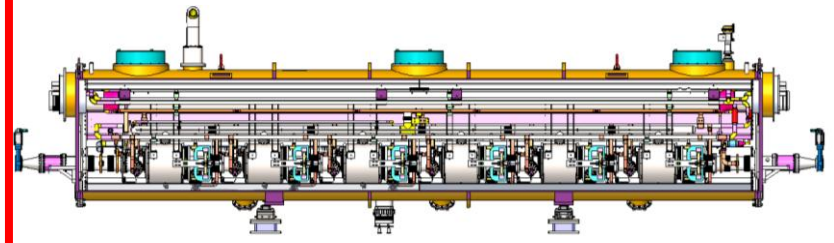
Old lower CW power coupler

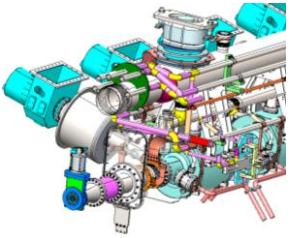


New 300kW CW high power coupler design in the 650 cryomodule

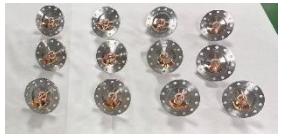








High power below design in the 650 cryomodule









The collider Higgs mode for 30 MW SR power per beam will use 32 units of 11 m-long collider cryomodules will contain six 650 MHz 2-cell cavities, and therefore, a full size 650 MHz cryomodule is under development in EDR

Status： to be completed in 2027

CEPC High Efficiency and High Power Klystrons

Klystron R&D

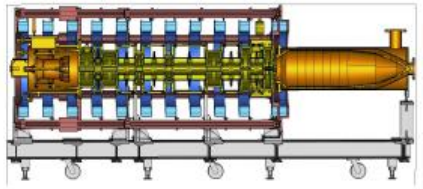


Klystron No. 1
Efficiency 65%
(2020)

Pulsed RF Mode (30% duty factor, 60ms/5Hz



Klystron No. 2
Efficiency 77%
(2021)

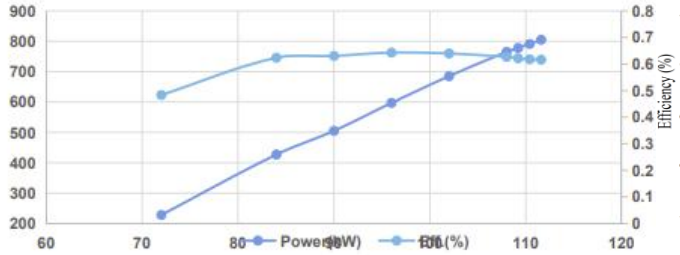


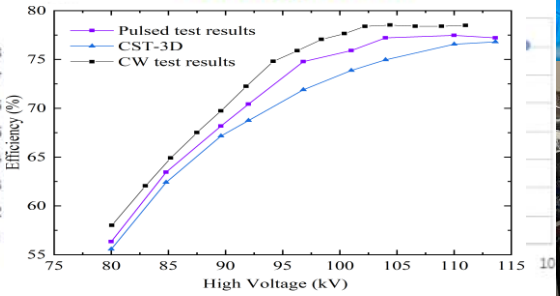
78.5%@803kW CW in 2024

Klystron No. 3 （MBI
Efficiency 80.5%
To be completed in 2026



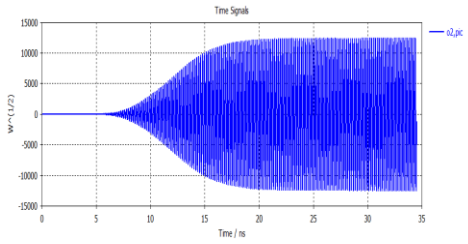
High Voltage vs. Power&Efficency

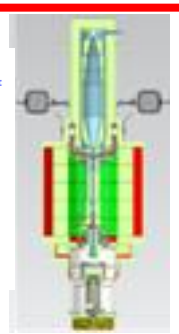




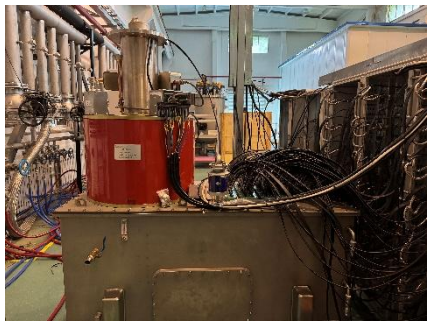
CEPC collider ring 650MHz klystron development in TDR/EDR phase

Parameters	Value
Frequency	5712 MHz
Output Power	80MW
Drive power	350W
Gain	54 dB
Efficiency	47%
$3dB$ bandwith	±10MHz
Beam voltage	420 kV
Beam current	403 A
Focusing field	~0.27 T maximum

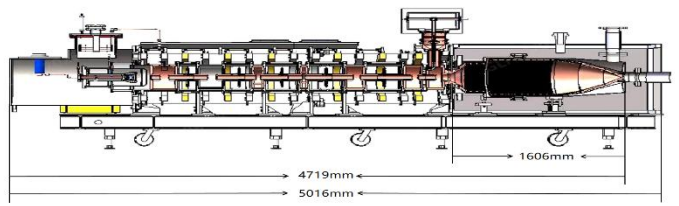


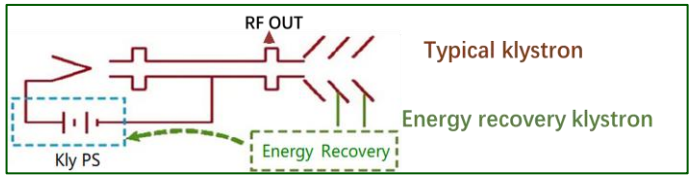




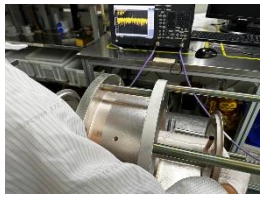


CEPC 650Mhz Energy Recovery Klystron





Parameter	Value
Operating frequency	650 MHz
Beam Voltage	113 kV
Efficiency	77.5%
Output power	800 kW
Beam perveance	0.25 μP
Beam current	9.5A
Efficiency (one-stage depressed collector)	85%



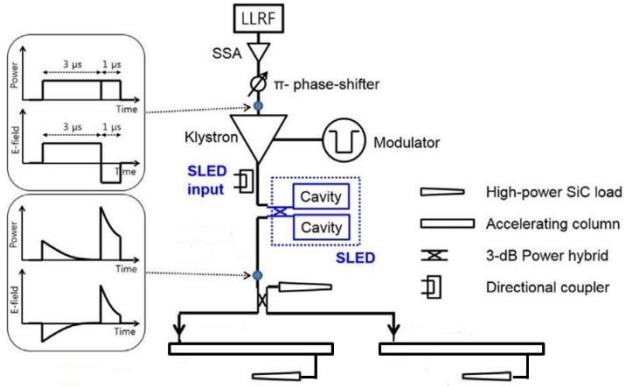


CEPC 650Mhz Energy Recovery Klystron to be completed by end of 2026

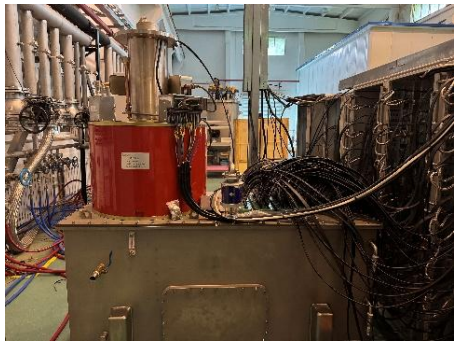
CEPC Linac C band 5720MHz 80MW Klystron fabrication completed and under test in September in 2026

CEPC C-Band Linac Test Bench in EDR

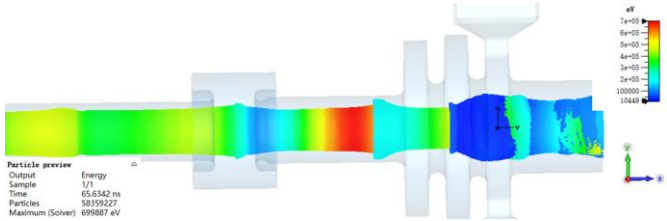
- CEPC EDR will establish the **C-band test bench** and test the components. With pulsed compressor, waveguides, directional couplers, loads, bend and straight waveguides, etc. **as a basic unit of CEPC C-band linac**
- The C-band test band is equipped with a CEPC 5720MHz 80MW power source
- The CEPC C-band test band will be completed in 2026





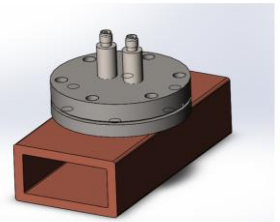


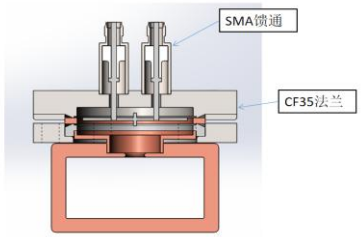
CEPC 80MW C-band linac test band completed in 2026

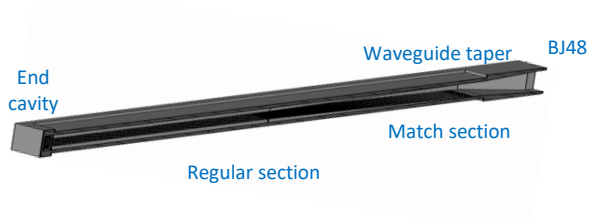


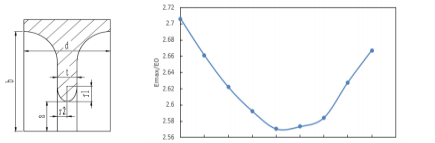
C band 5720MHz 80MW Klystron design completed, and fabrication will be completed in 2025



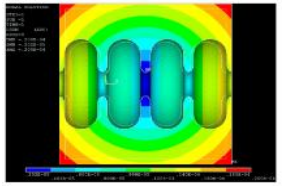




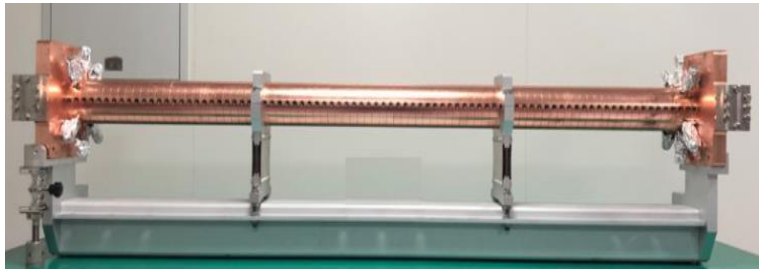


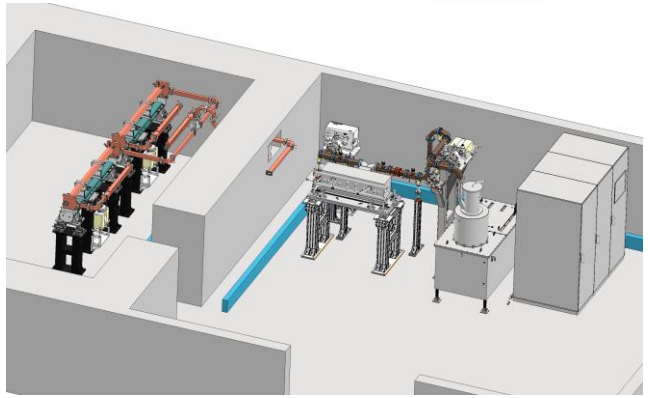


Cavity shape



The deformation caused by temperature variation





CEPC C-band linac test band will be completed in 2026

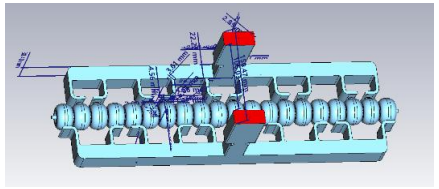
CEPC Cool Copper C-Band Linac Technology R&D

- CEPC is exploring the Cool Copper **C-band linac** technology (5712MHz is the test facility frequency)
- Two types of structures have been studied, type I and type II

Type I has reached 128.5MV/m, Q0=31387 with input power of 32.45MW on Nov. 24, 2025 (Iris diameter 5.25mm).

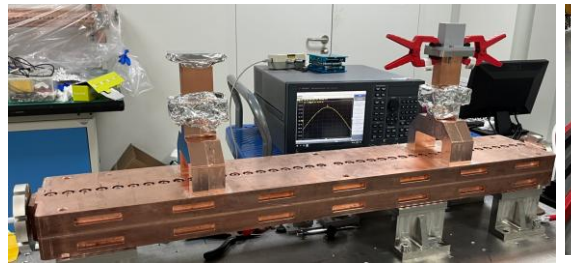
Type II will reach 144MV/m with 80MW input (Iris diameter 10.49mm)

Parameters	Value
Fre (MHz)@77K	5712
Mode	Pi
Cavity numbers	20
Shunt impedance per meter(MΩ/m)@77K	303
E_s/E_0	2.42
Q_0@77K	31905





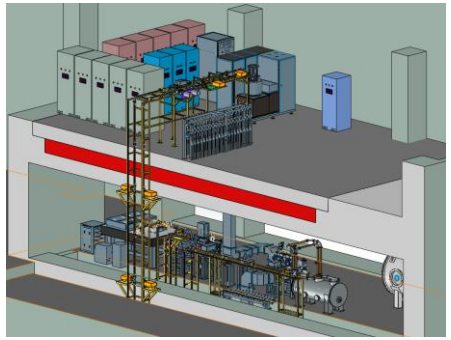
Type I: Aperture diameter 5mm, Length 0.5m



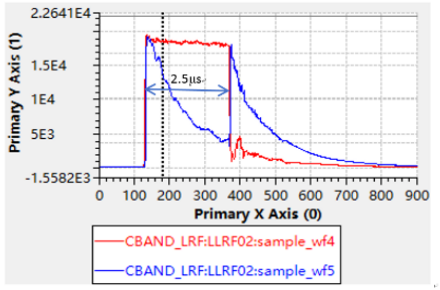
Type II: Aperture diameter 10mm, Length 1m under measurement and power test in Nov. 2026

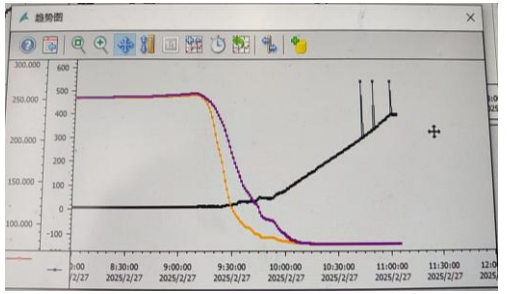
This cool coper C-band type-II structure has the potential to be applied to CEPC injector when necessary (also for FEL)



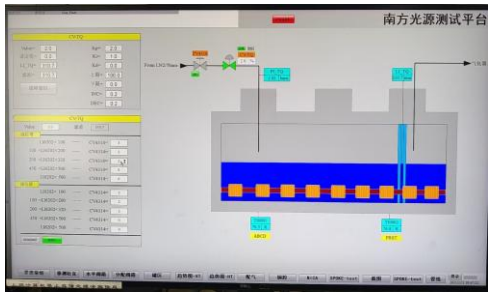












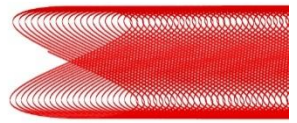
Crucial Parameters	Symbol	Values	Units
Temperature	T	77	K
Resonant Frequency	f_o	5.712	GHz
Working Mode	-	π	-
No. of Cavities	n	40	-
Total Length	L	1.17	m
Gradient @ 64MW	G	128.6	MV/m
Gradient vs Power ratio @64MW	$G/\sqrt{P_{in}}$	16.1	MV/m/$\sqrt{MW}$
Aperture	2a	10.487	mm
Diameter	2b	39.24	mm
Nose Distance	d	18.7	mm
Cell Length	p	26.24	mm
Copper Conductivity	σ_{77K}	45.47 x 10^7	S/m
Q factor(with Coupler)	Q_O	31536	-
Shunt Impedance	R_s	259	MΩ/m
E_s/E_0	E_s/E_0	1.96	-
Frequency Sensitivity	f_s	300	kHz/μm
Coupling Strength	β	1.007	-
Modified Poynting Vector @ 128MV/m	S_c	4.5	W/μm^2
Pulse Heating @128MV/m	ΔT	48.6	K
$H_{Coupler}/H_{Cavity}$	-	1.15	-

Design parameters of SC quadrupoles with CCT coil

• Design parameters of Q1a, Q1b, Q2 magnet with iron-free CCT coil @ Higgs

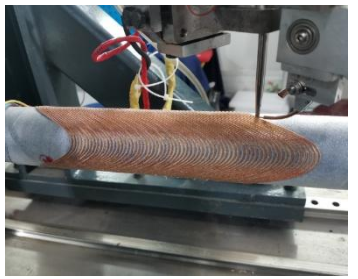
	Q1a	Q1b	Q2
Field gradient (T/m)	142.3	85.4	96.7
Magnetic length (m)	1.21	1.21	1.5
Excitation current (A)	780 (Traditional) 730 (Direct winding)	640	760
Conductor diameter (HTS or LTS, mm)	0.7	0.8	0.8
Current density (A/mm^2)	2030 / 1900	1270	1510
Maximum dipole field in aperture (Gs)	226	124	127
Stored energy (KJ)	16.7	15.2	36.1
Peak field in coil (T)	4.3	3.8	4.2
Integrated field harmonics		$<2\times10^{-4}$	
(Single aperture) Coil inner radius (mm)	20	26	31
(Single aperture) Coil outer radius (mm)	30.5	39	44
Magnet mechanical length (m)	1.23	1.23	1.53
Net weight (kg)	25	32	43
Total weight of Q1a, Q1b, Q2 (kg)		100	
For comparison, old net weight with iron option (kg)		Q1a: 93, Q1b:124, Q2: 235 Total weight of Q1a, Q1b, Q2: 452	

Direct winding CCT coil is preferred for CEPC









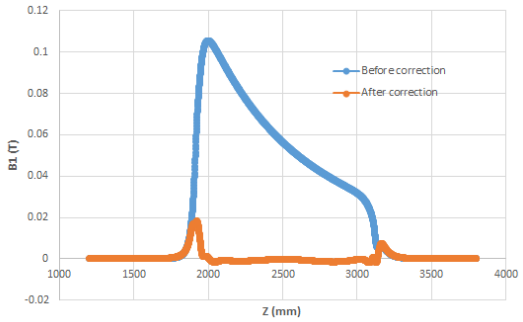




IHEP fabricated CEPC CCT coil prototype with direct winding, inner diameter 40mm, 600mm long, **vertical tested in August 2026,**

Experimental results analysis is on going

Q1a Direct winding CCT coil
Preliminary design
Round 0.7mm conductor, canted angle: 24 deg
8 layers CCT quadrupole coil. The inner radius of the coil is 20mm
Excitation current: 730A @4.2K (2K is also under study)
3D calculation in OPERA-3D
Radius of single aperture <31mm

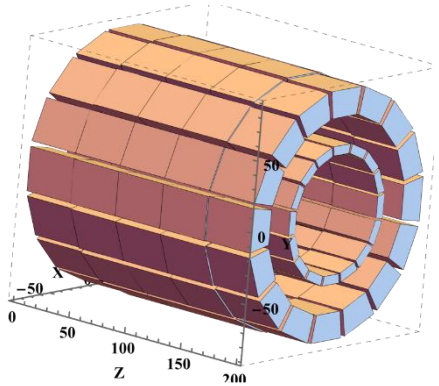


Q1b Q2 Direct winding CCT coil
Round 0.8mm conductor, canted angle: 24 deg
8 layers CCT quadrupole coil.
After correction, local dipole field decreases to less than 150Gs (Higgs)
Calculated integrated field harmonics are smaller than 2×10^{-4}

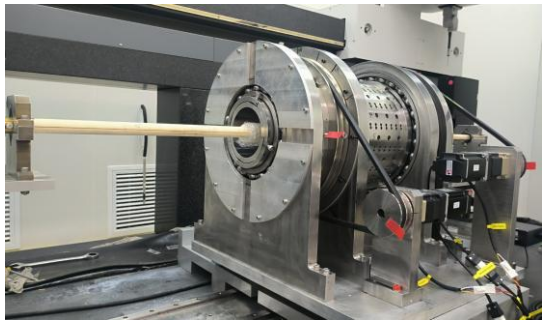
CEPC Collider Ring Adjustable Permanent Quadrupole Magnets Development

To save the electric power from quadrupoles of collider ring

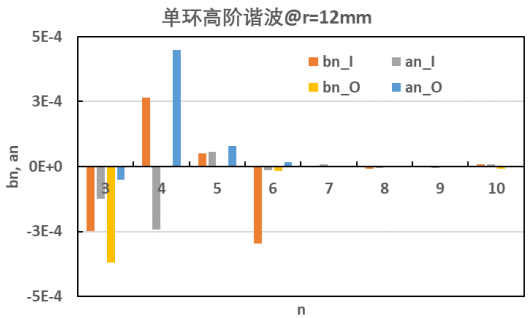
Quadrupole magnet aperture	Φ	mm	≥66
Effective magnet length	L_{eff}	mm	≥200
Max. gradient	G_{max}	T/m	≥10.6
Gradient adjustable range		T/m	1.8 ~ 10.6
Gradient adjust precision	ΔG	T/m	≤0.002
Rings' rotation precison	Δθ	mrad	≤0.08
Good field radius	GFR	mm	12
High order magnet component量 @G_{max}	B_n/B_2	10^{-4}	＜5

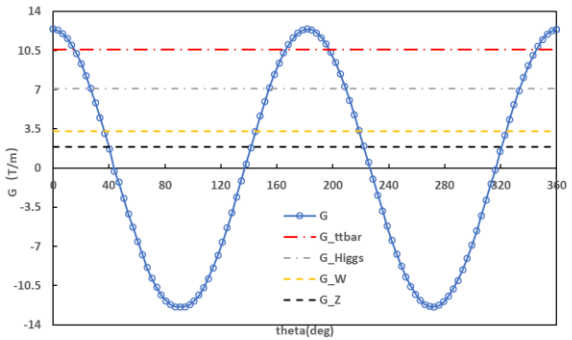


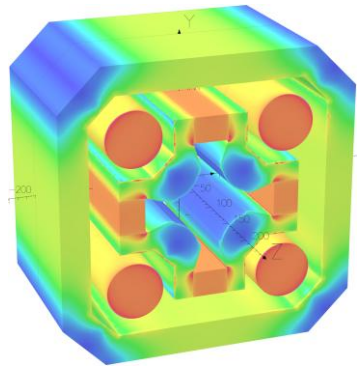
Type 1: Halbach double-ring all-permanent magnet



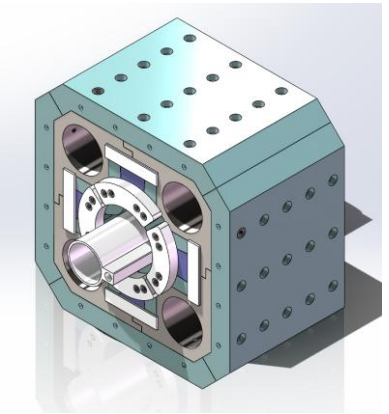
Type 1: Halbach double-ring all-permanent magnet experimental results:
Two ring high order magnetic components less than 0.05%, and adjustable range reached the 4 energy modes

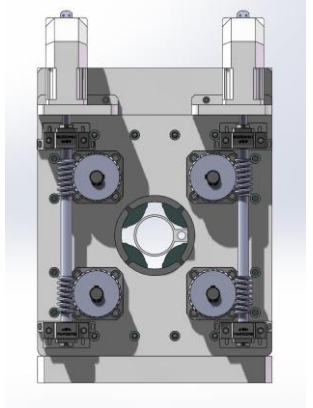




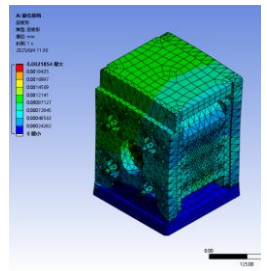


Type 2: Hybrid

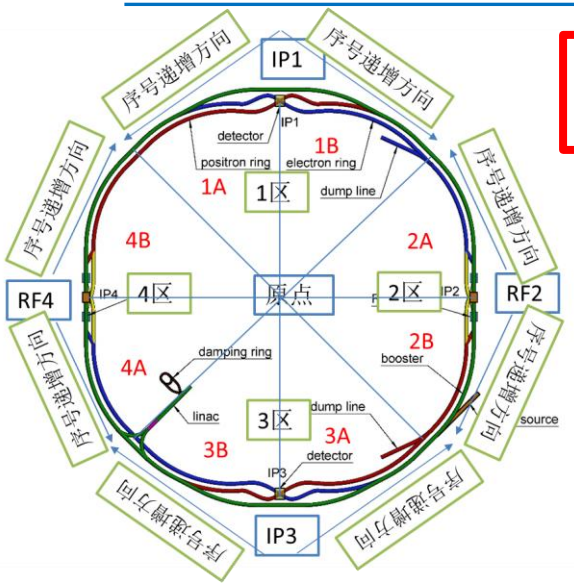




Type 2: Hybrid adjustable quadrupole is under design



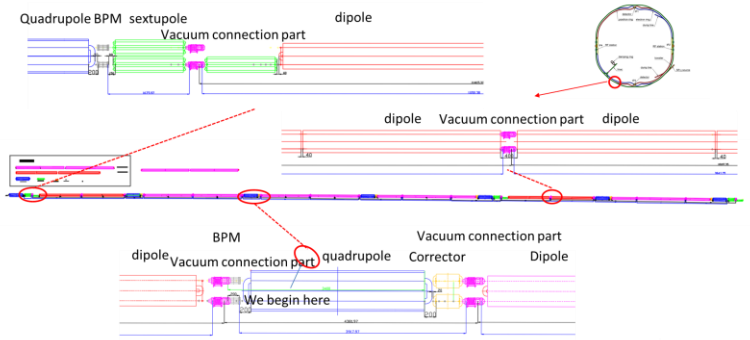
CEPC Accelerator EDR: Survey and Mechanical 2D/3D Design

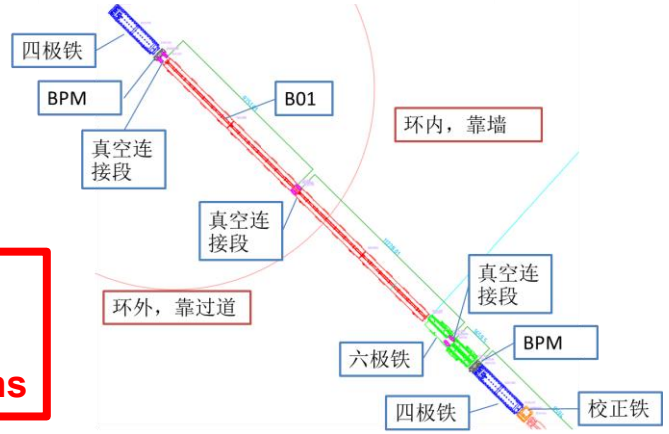


CEPC Facility components' naming system established

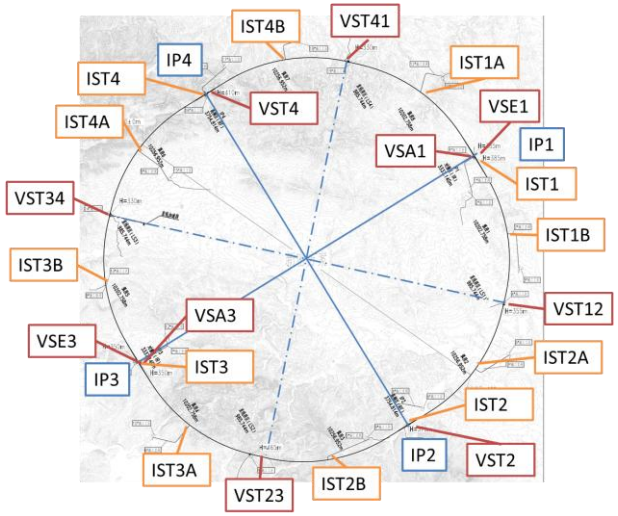
2D/3D linkage design for CEPC accelerator survey:

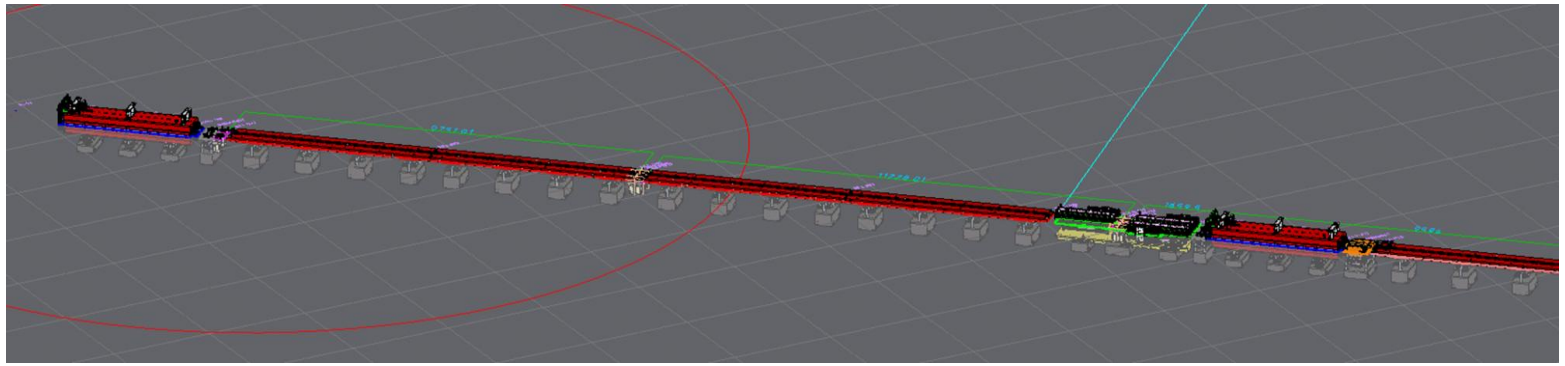
- If the 3D model is changed or replaced, the 2D model will be updated.
- If the 2D model is replaced or its location is changed, the 3D model will be updated.





CEPC accelerator survey and mechanical design has been ~90% completed with components right positions and right dimensions



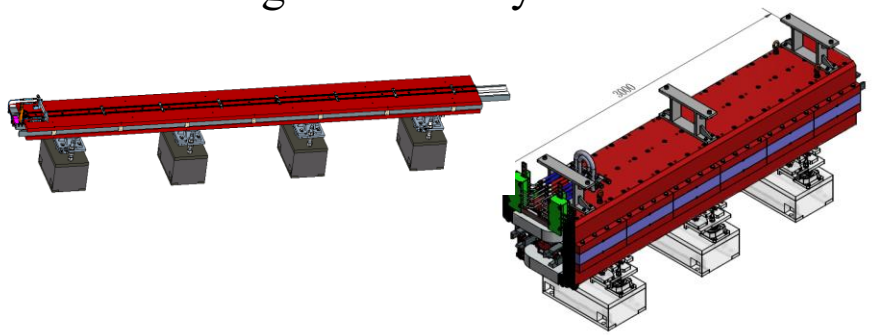


CEPC 10 vertical shafts and 12 horizontal access tunnel distribution

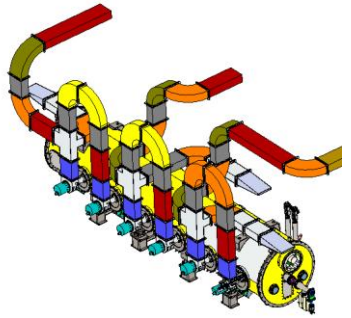
CEPC Accelerator Components Types in Survey

The complete components designs in the CEPC accelerator survey with dimensions, positions and name tags

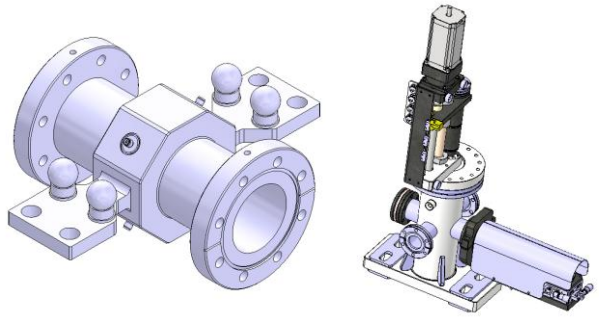
Magnet assembly in collider



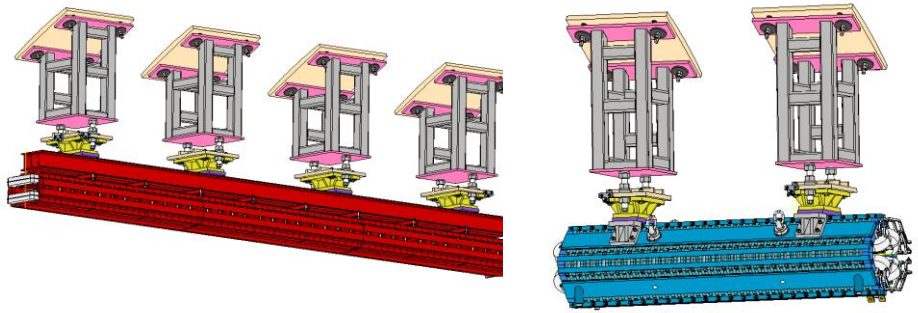
RF module in Collider



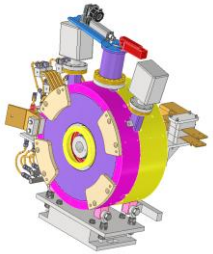
Some instruments



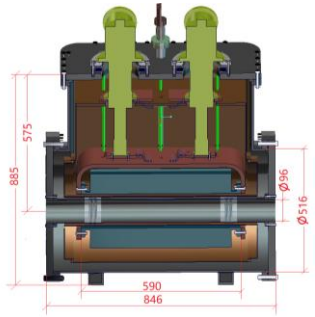
Magnet assembly in Booster



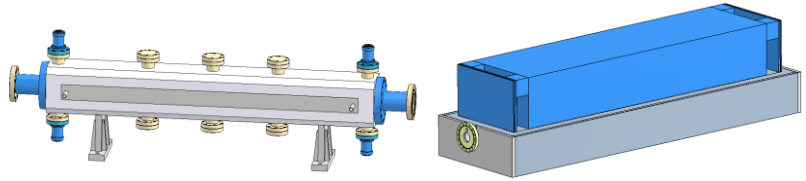
PT & AMD for Linac



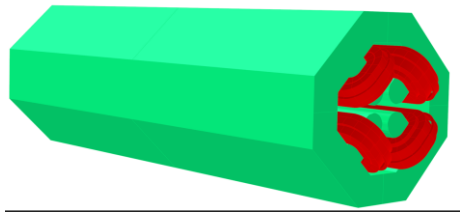
IR region SC sextupole cryomodule



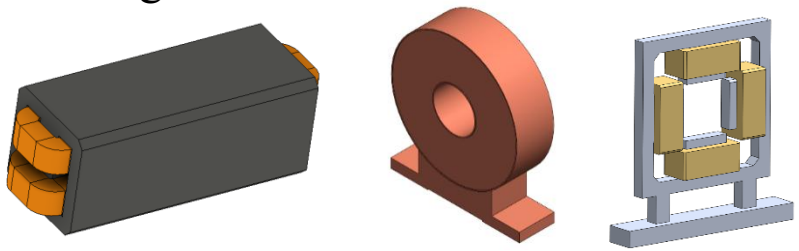
INJ & EXT magnets



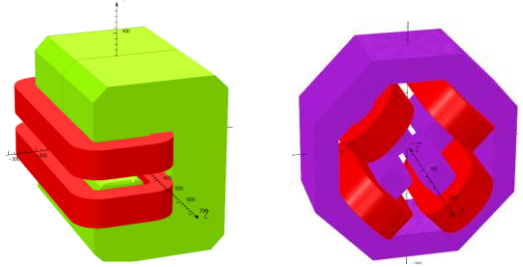
QRFB in collider



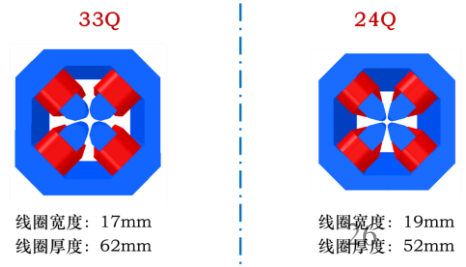
Magnets for Linac



Magnets for damping ring

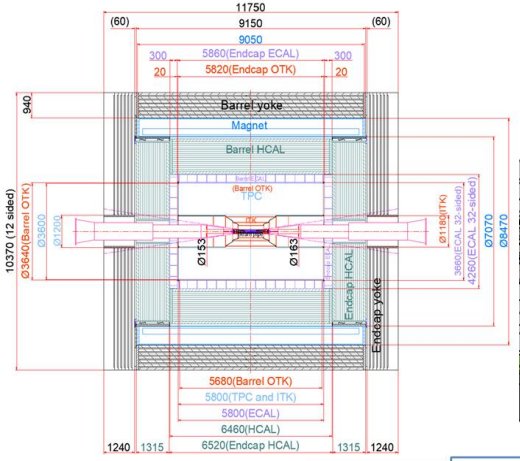


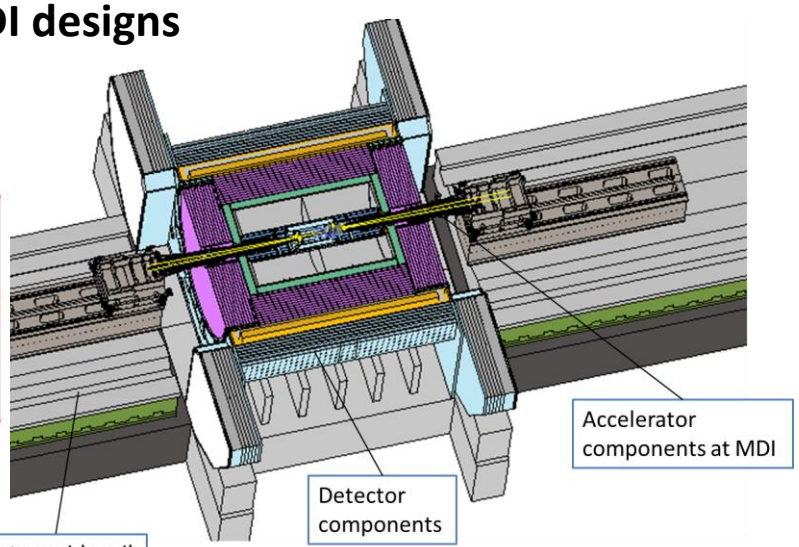
Quadrupoles in TL

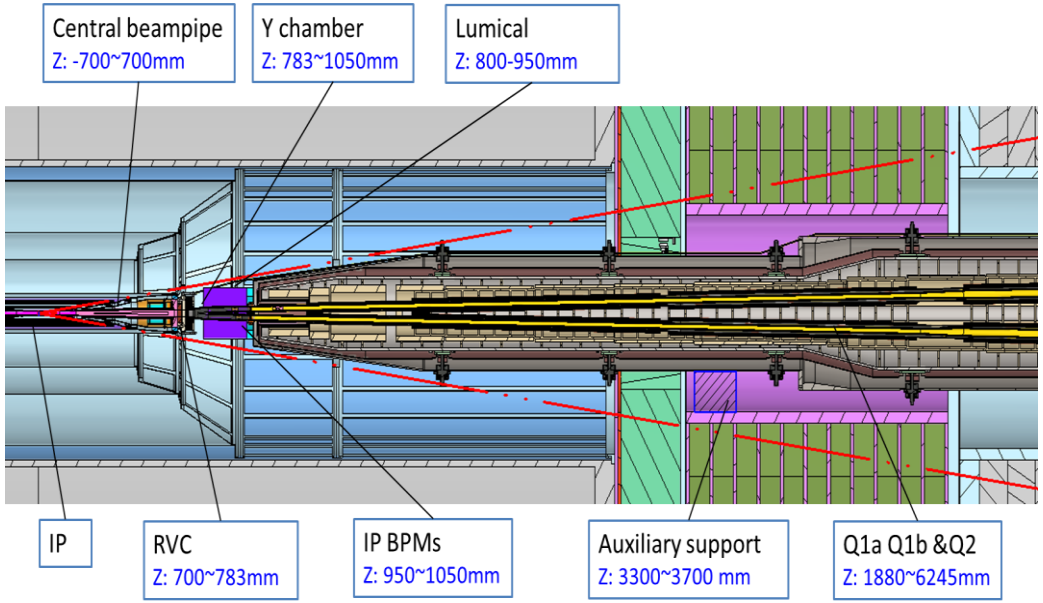


CEPC MDI EDR Activities

CEPC MDI designs

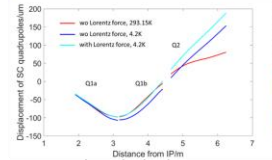




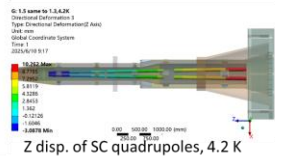


CEPC MDI mechanics progress-mechanical analyses

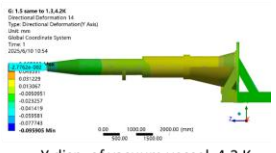
- Simulation results, with Lorentz force and gravity



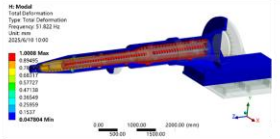
SC quadrupole displacement



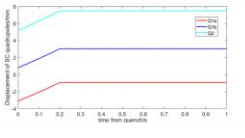
Z disp. of SC quadrupoles, 4.2 K



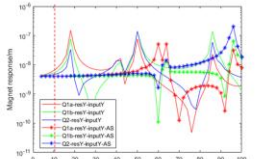
Y disp. of vacuum vessel, 4.2 K



1st order of mode, 4.2 K



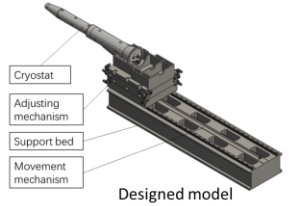
Displacement of SC quadrupoles when quenching



Harmonic response, 1-100Hz

CEPC MDI Mechanical Analyses

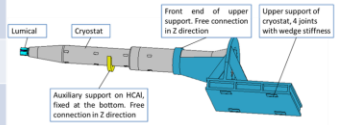
- Mechanics and vibration analyses
  - **Static structure**: max. deformation and displacement change with/wo Lorentz force
  - **Vibration analyses**: natural frequency & harmonic response
  - **Structure optimization**



Designed model

	Related requirements	Response now*
Position accuracy (X/Y) of SC quadrupoles ≤100μm	Adjusting resolution≤5μm Adjusting accuracy≤30μm	≤5μm ≤30μm from HEPS experience
	Max. def. and disp. change, < 50μm	FEA, <40μm
Small vibration, 1-100Hz RMS ≤4nm	High natural frequency	FEA, ~50Hz and 1 (same level to HEPS, and arc section of CEPC)
	Low amplification factor	

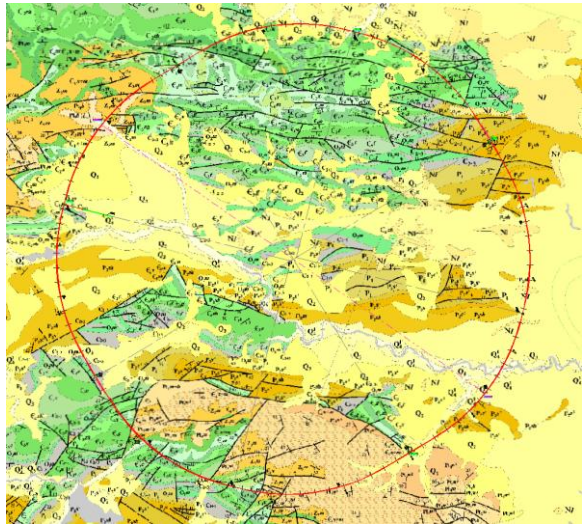
* The response now only considers the mechanics aspect.

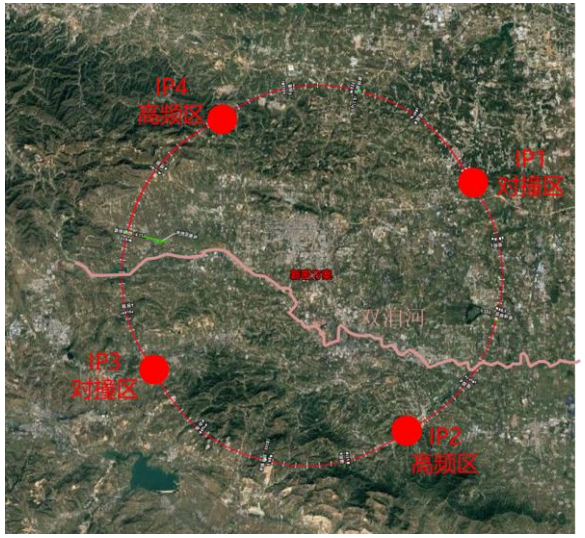


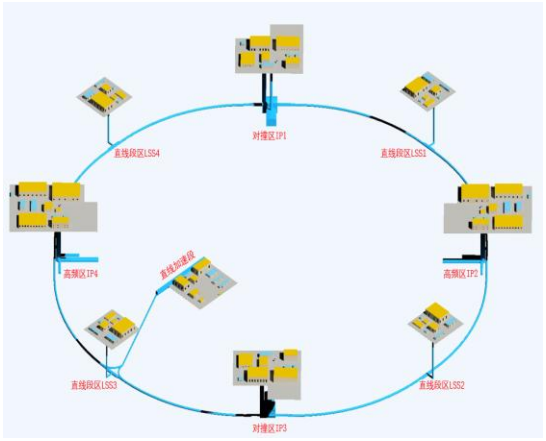
Analyses model

	Ground motion requirements, RMS, 1-100 Hz displacement integral
MDI	≤4 nm
Arc and straight section, and RF section in Collider	≤24 nm
Linac	≤50 nm

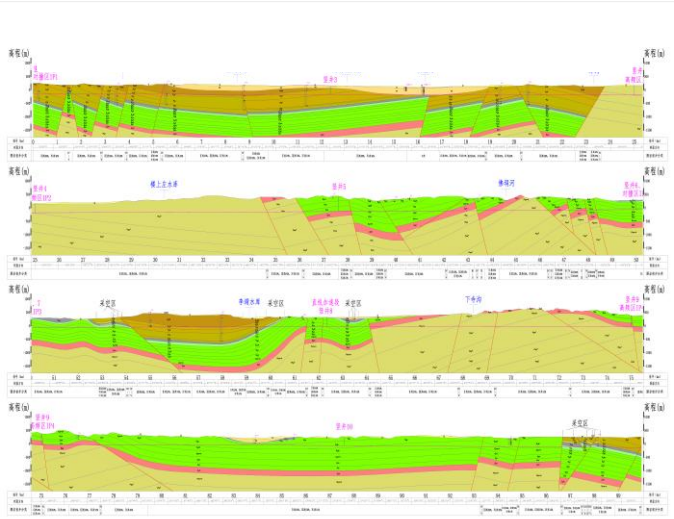
CEPC EDR Site Geological Study Status

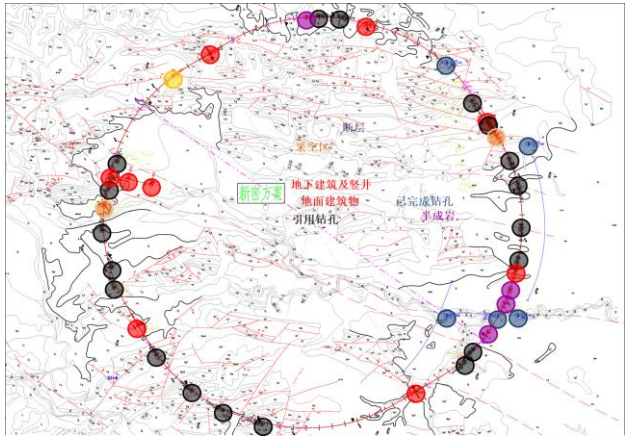






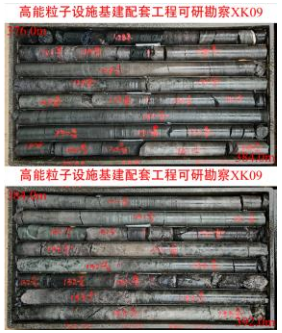
9 surface location building total surface：150k m^2；Total land surface occupied：475k m^2





After careful geological studies and comparisons, CEPC EDR site was proposed in June 2025 by a review, and the geological study results require that CEPC be built about 300m underground





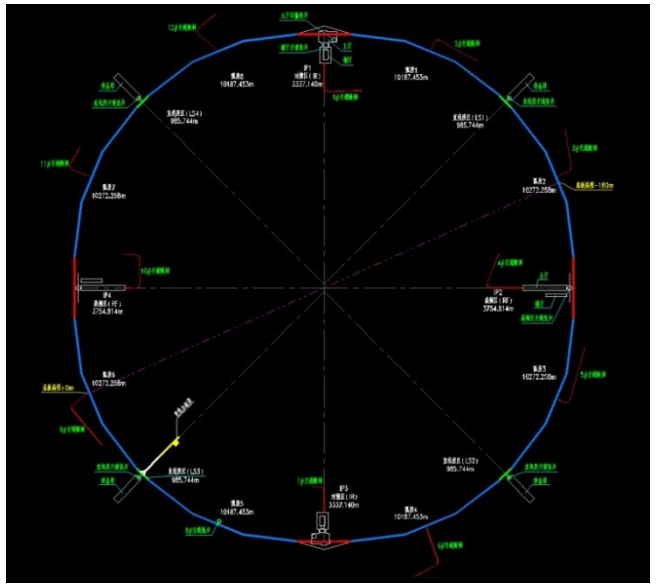




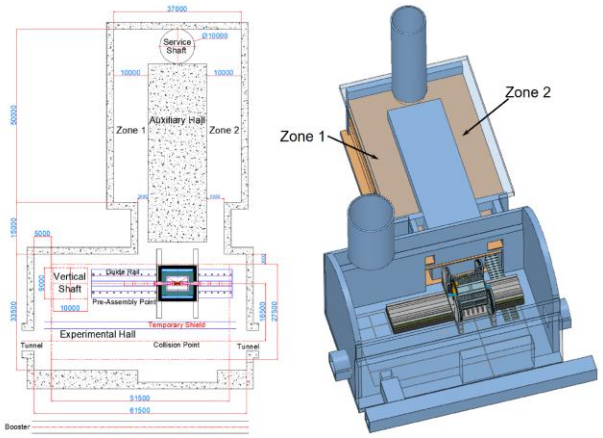


The geological investigation studies on CEPC EDR site has been completed and reviewed on June 4-5, 2026

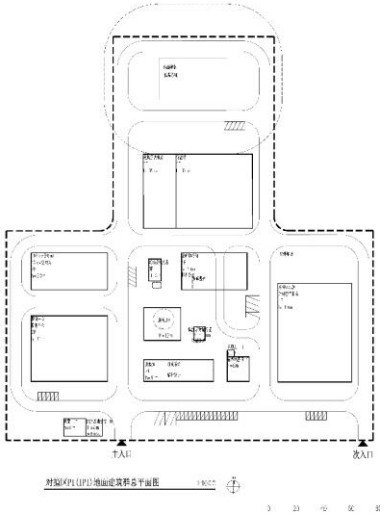
CEPC Civil Engineering and Conventional Facilities in EDR-2



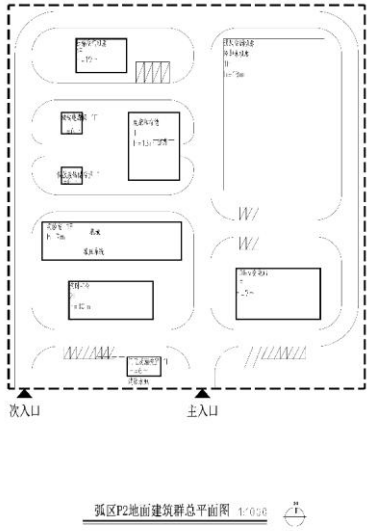
CEPC general layout 100km



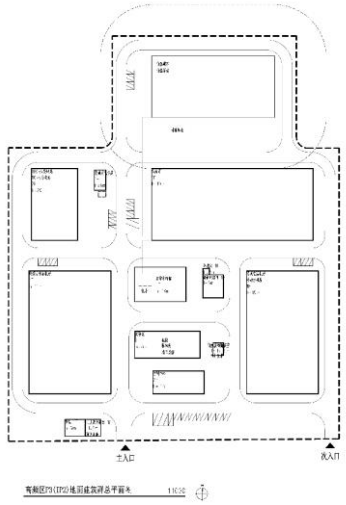
CEPC detector hall design



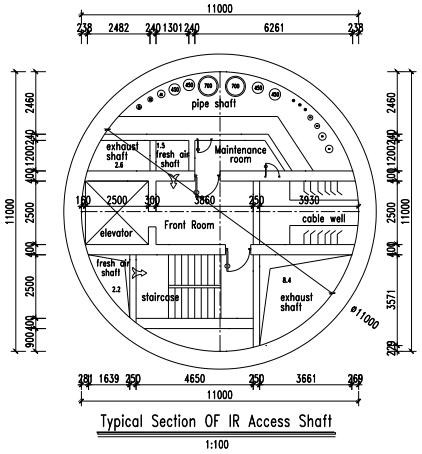
IP-1 surface building



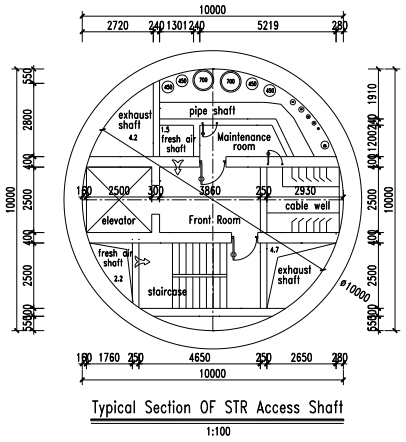
Arc shaft surface building



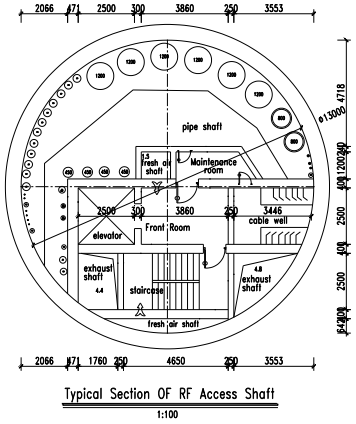
SRF shaft surface building



IP-1 auxiliary hall shaft



Arc shaft hall shaft



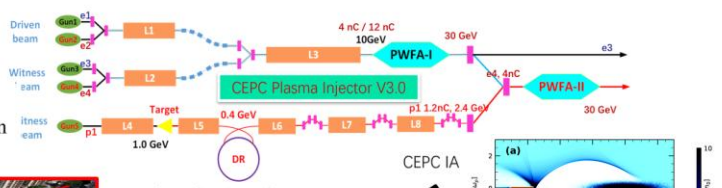
SRF shaft

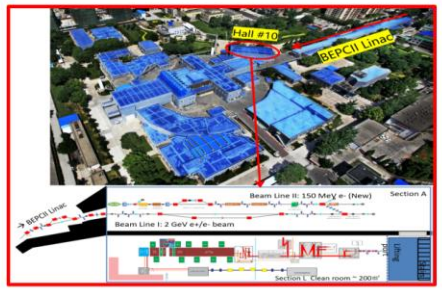
BEPCII-based PWFA Test Facility Development Status

CEPC Plasma Injector (alternative option) and TF Plan

CEPC plasma injector scheme:
From 10 GeV → 30 GeV → **TR ≥ 2**

Simulation results show that it works on paper with reasonable error tolerances for both electron and positron beams injected to the booster



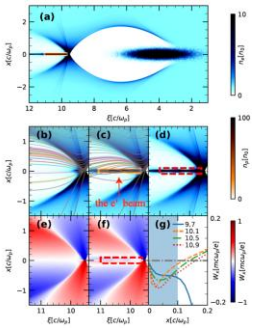


CEPC IA

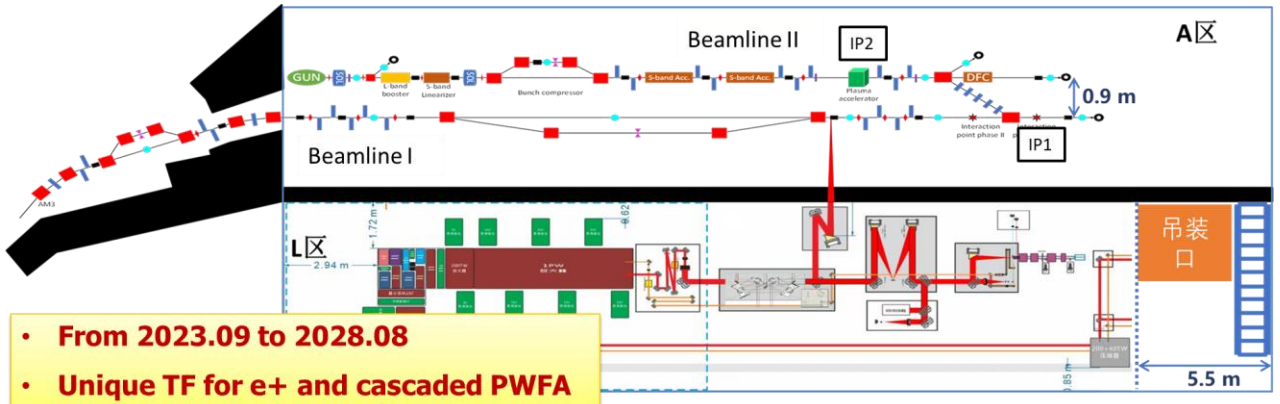
Phase I（Year0-Year2）
1. Re-design and install transport beamli optimize the e- / e+ beam quality
2. Clean room and high power installation200TW
3. Beam instrumentati
4. RF Gun platfor
5. Commissi

Phase II（Ye
- Positron and electron acceleration
- Cascading acceleration
- Future linear collider technologies
- High energy beam for detector R&D
- (possible application)

dumping ring the bunch compress
improve the e+ quality
ed FEL studies



PWFA/LWFA TF based on BEPC-II Linac and HPL has been founded by CAS 90M RMB in Sept. 2023
Under development in the experimental hall #10 of BEPC-II



- **From 2023.09 to 2028.08**
- **Unique TF for e+ and cascaded PWFA**

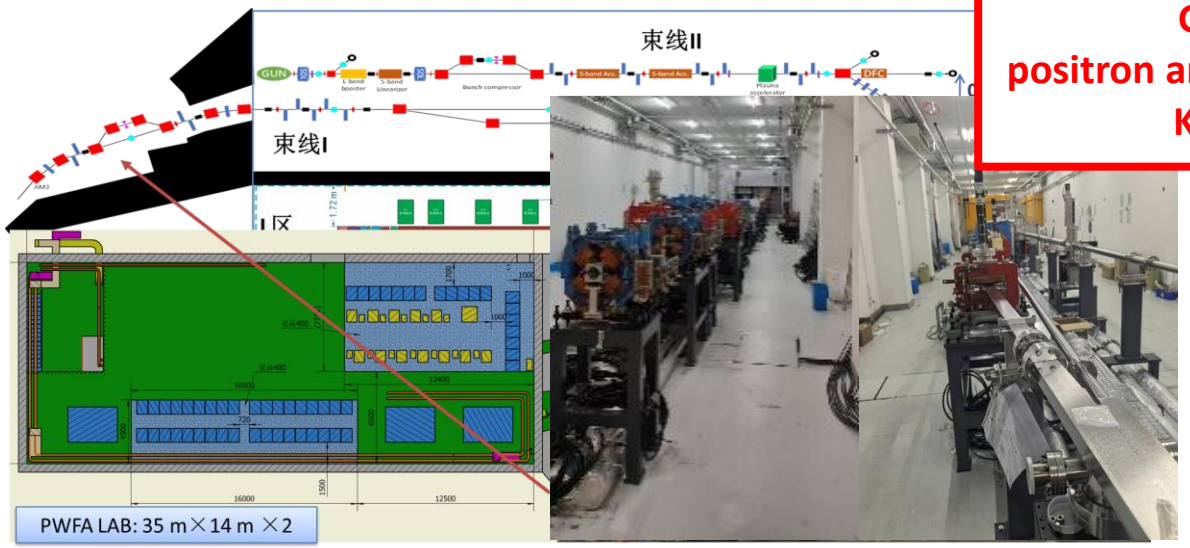
Beam quality

Beamline I

Parameters	Unit	BL-I e- (AM3)	BL-I e- (IP1)	BL-I e+ (AM3)	BL-I e+ (IP1)	BL-I e- (IP1, block)	BL-I e+ (IP1, block)
Energy	GeV	2	2	2	2	2	2
Charge	pC	2000	2000	100	100	9.4	0.2
bunch length	ps	10	1	10	1	~1	~1
Geo. emittance	mm·mrad	0.1/0.1	0.1/0.1	0.4/0.4	0.4/0.4	0.011/0.005	0.04/0.02
RMS beam size	μm	-	150/150	-	300/300	30/40	54/76

33

Goals: demonstration of acceleration of positron and electron beams with staging in next few years
Key technology for future linear colliders

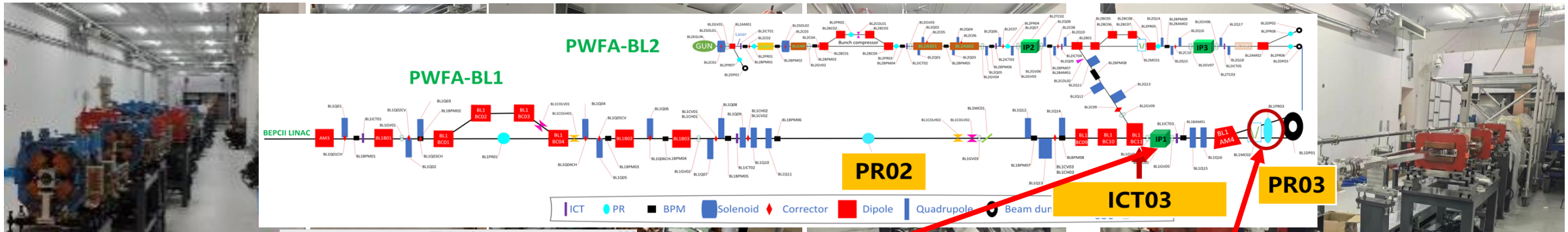


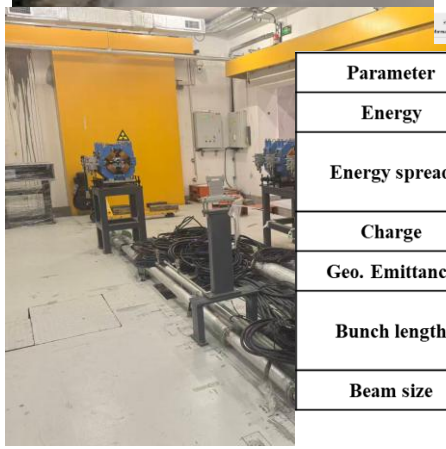


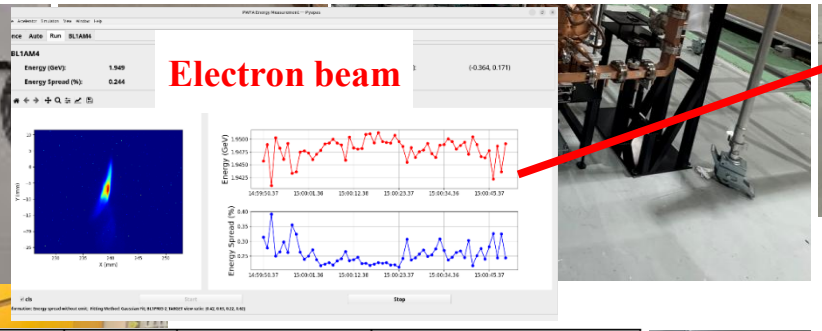


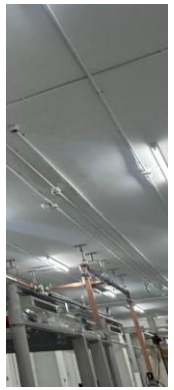
Dazhang Li, Wei Lu and Jie Gao, Research highlights on plasma-based acceleration at IHEP, AAPPS Bulletin (2025) 35:3, https://doi.org/10.1007/s43673-025-00143-z

BEPCII-based PWFA Test Facility – PWFA-BL1,2 in Commissioning



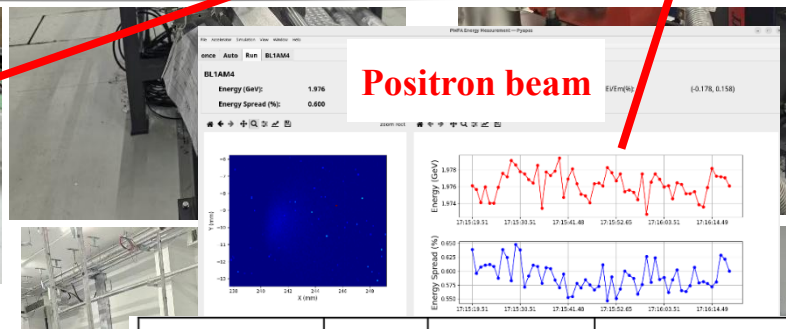




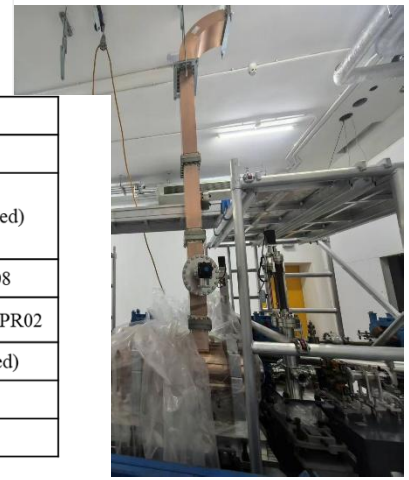


Parameter	Unit	Design	measure
Energy	GeV	2	~ 2.0
Energy spread	%	0.2 (slice)	0.16 (minimum)
		0.86 (chirped)	
Charge	nC	2.0	2.1 @ ICT03
Geo. Emittance	μm	0.1	0.22 / 0.07 (x/y) @ PR02
Bunch length	ps	4(chicane off)	-
		1(chicane on)	3.2 (not optimized)
Beam size	μm	129 / 129	580 / 600 @IP1 (not optimized)

Beamline 1 electron parameters







Parameter	Unit	Design	measure
Energy	GeV	2	~ 2.0
Energy spread	%	0.2 (slice)	0.42 (not optimized)
		0.86 (chirped)	
Charge	pC	50	60 pC @ BPM08
Geo. Emittance	μm	0.4	0.24 / 0.20 (x/y) @ PR02
Bunch length	ps	4(chicane off)	6.7 (not optimized)
		1(chicane on)	-
Beam size	μm	255 / 255	-

Beamline 1 positron parameters

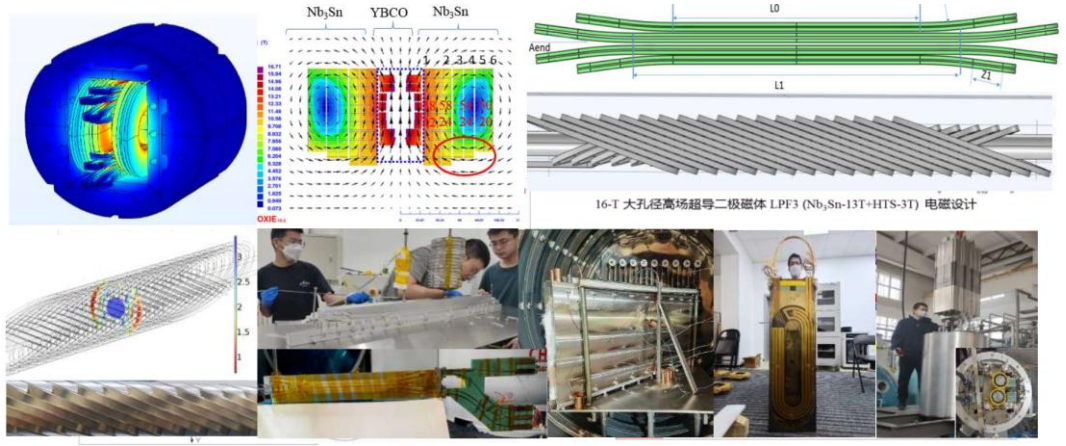
PWFA-BL 1 from BEPCII

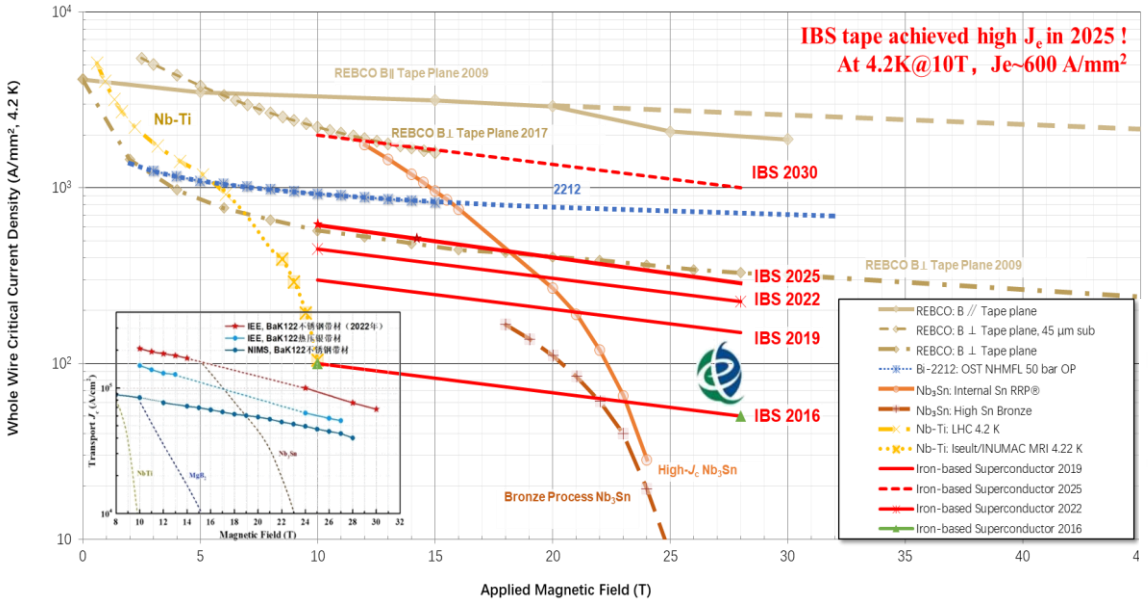
PWFA-BL 2 from L-Band RF gun

PWFA-BL 1 from BEPCII had the first beam in **April 2026, and the first plasma experiment will start in Sept. 2026**

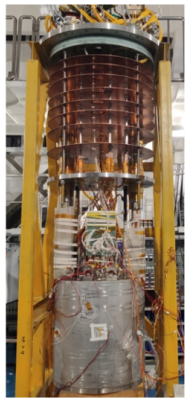
Advanced High Field SC Magnet (IBS) Development

Highest Quench Field Reached in 2024: over 14T @4.2K



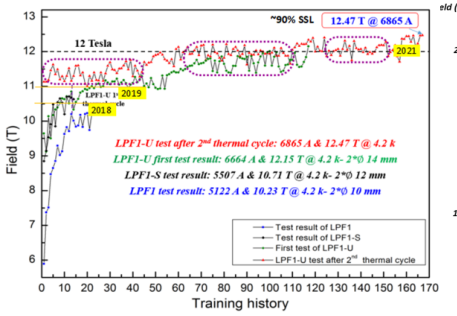


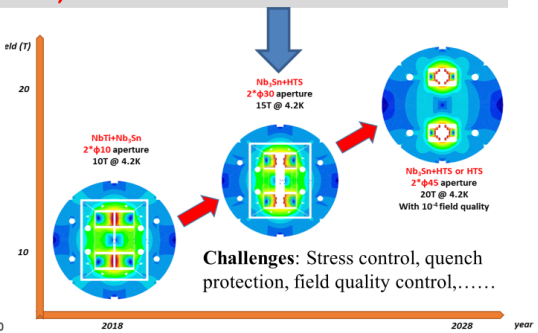
SppC HF Magnet Development



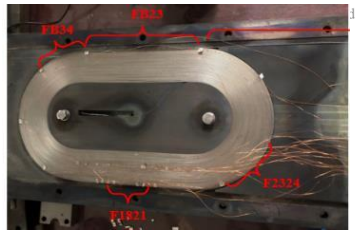
Picture of LPF1-U

SppC 16 T Model Dipole: Nb_3Sn 12~13 T + HTS 3~4 T;
14T has been reached, more test in 2024

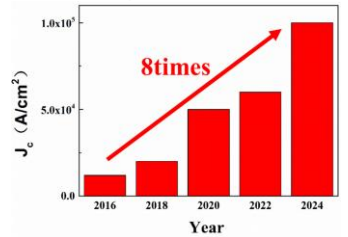


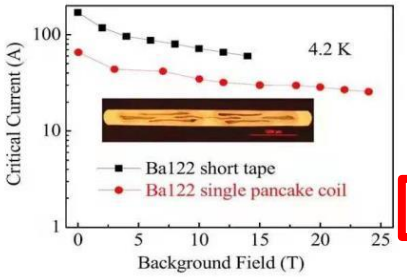


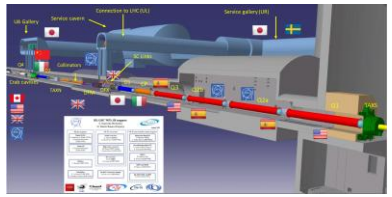
Dual aperture superconducting dipoles achieve 12T@4.2 K and 14T@4.2K entirely fabricated in China. The next step is reaching 16-20T



- First short coil with 40%Jc@24T
- First long coil with 80%Jc@10T







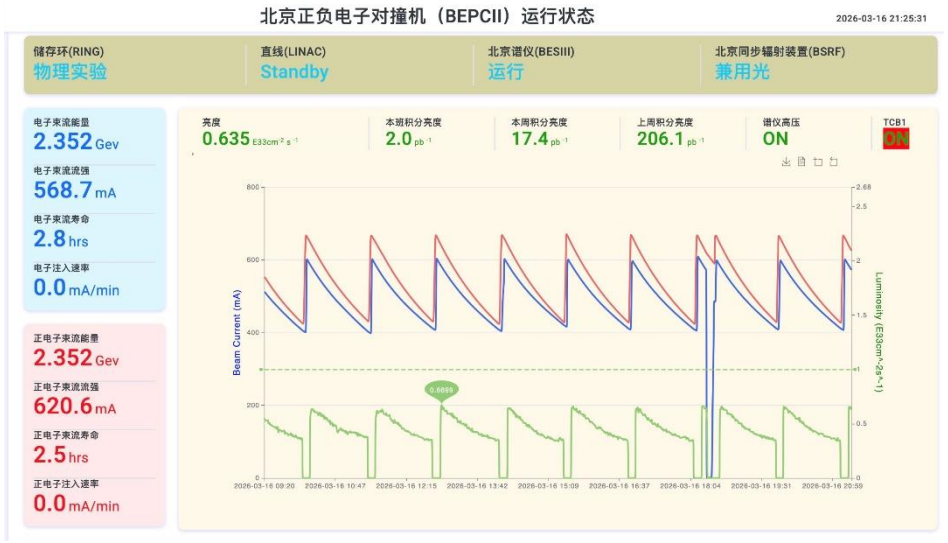


All HL-LHC CCT magnets have been delivered to CERN in early 2026

According to the progresses from 2016-2025, it is expected that the IBS could reach the technical requirements for SppC/FCChh around 2035

BEPCII-U Reached Design Goal and in Operation

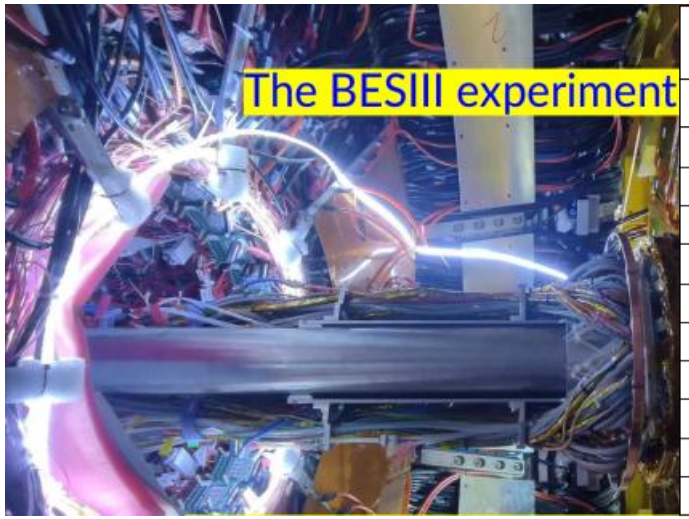




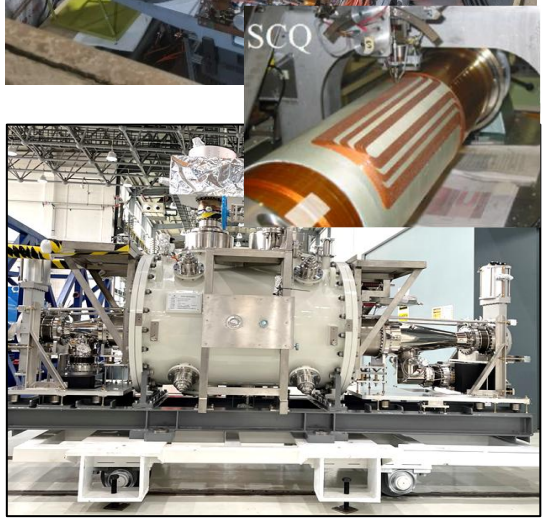


BEPCII-U L= 1.112×10^33 cm^-2s^-1@2.35 GeV





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

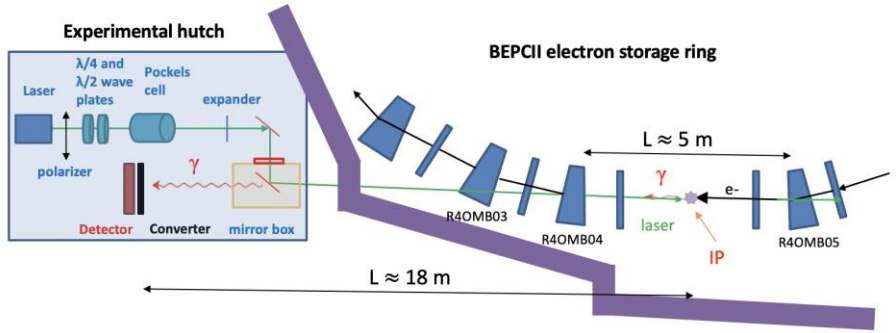


J. Gao, “BEPCII and CEPC”, Proceedings of eeFACT 2025, arXiv:2505.02401, https://doi.org/10.48550/arXiv.2505.02401

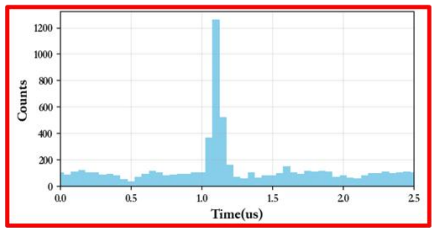
CEPC Polarization in Preparation Study

-Compton Polarimeter at BEPCII-U

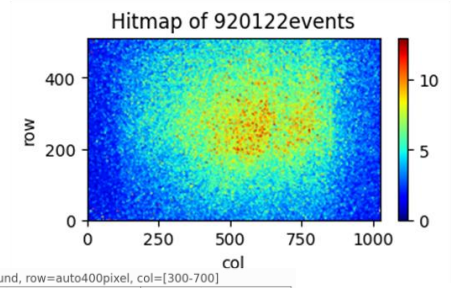
- A laser-Compton polarimeter has been implemented in BEPCII electron storage ring
- Laser-electron collision signal has been observed
- Measurement of electron beam polarization is under way

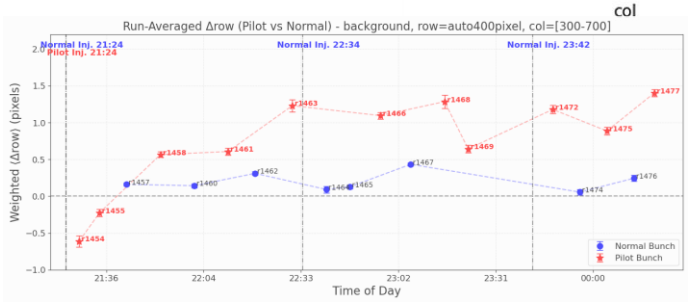


Laser-signal causality observed

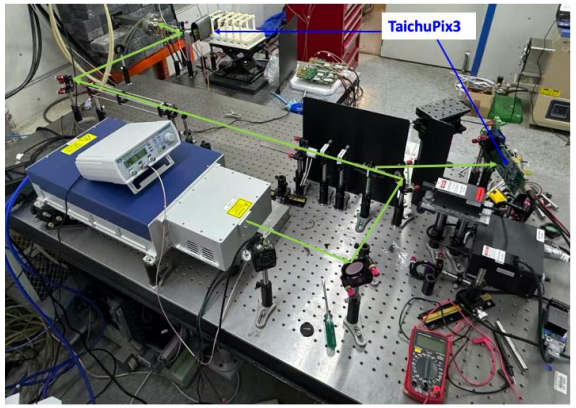


Signal on the Silicon pixel detector



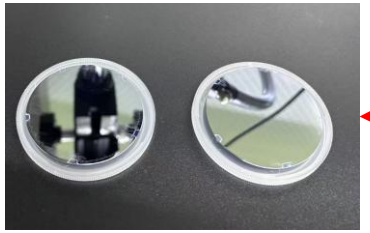


BEPCII-U electron polarization measurement is under way

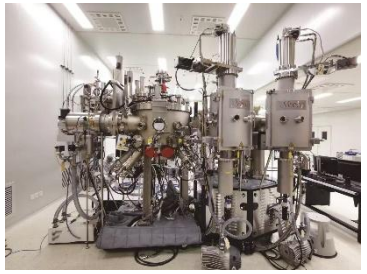


Key parameters

Location	beamline and experimental hall of 4W2 wiggler
Laser	532nm, 4.5 kHz, 2 mJ, 1 ns, flippable circular polarization
Observable	Vertical asymmetry of backscattered γ (up to 180 MeV)
Detector	lead preshower + silicon pixel detector
Signal	backscattered γ ~ 20kHz/mA/W
Background	bremsstruhlung γ ~ 1kHz/mA



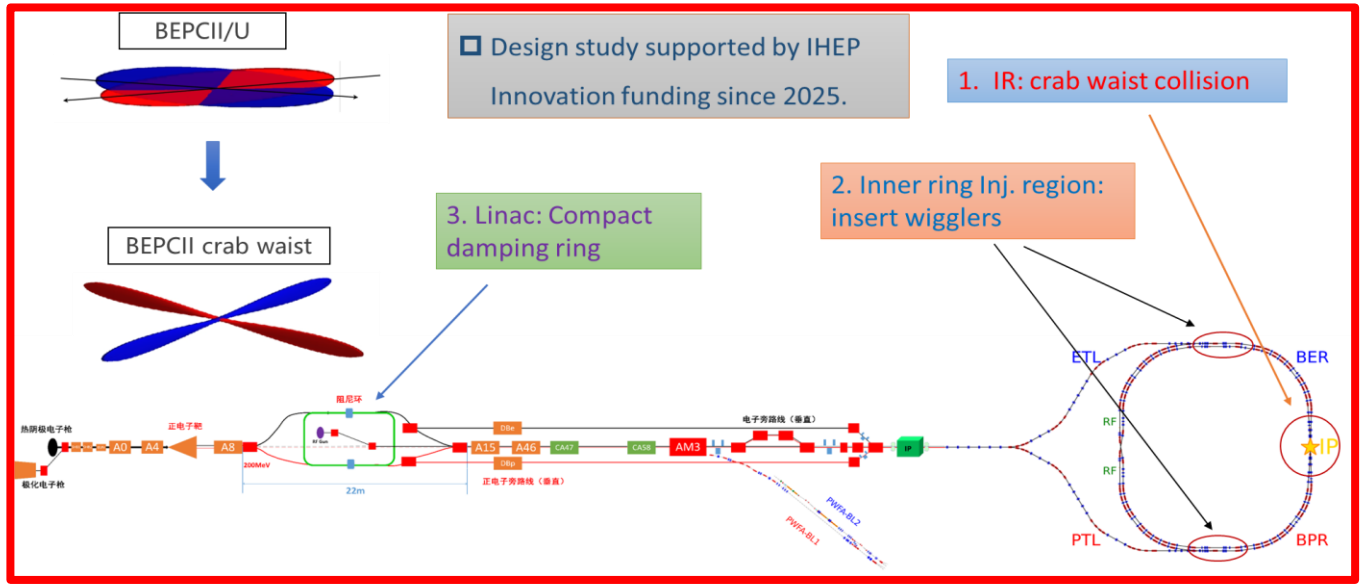
Parameter	Valery Tyukin @ JGU Mainz	Wei Liu @ Chongqing University
Beam polarization	80%~82%, slightly higher or comparable to SVT SL wafer	–
Activation method	Yo-Yo method, Cs + NF_3	Yo-Yo method, Cs + O_2
Quantum efficiency	0.1% @ 780 nm	0.7% @ 785 nm

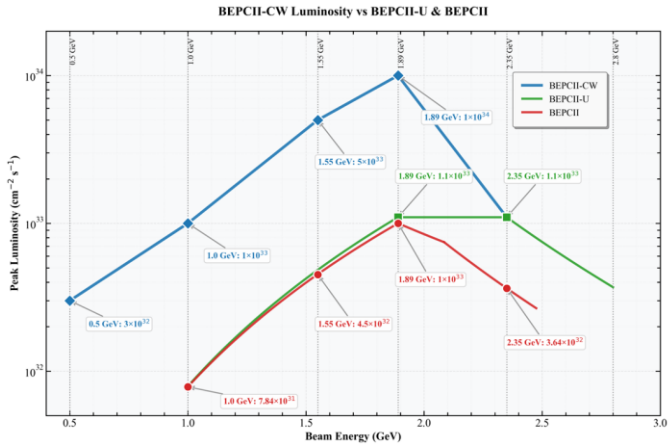


MBE system in Acken

Polarized electron cathode chip (diameter ~5cm) has been fabricated in **June 2025, and tested in 2026**
Polarization of 85%, for 1ns laser (780nm) pulse length, several nC polarized electron charge will be obtained with the expected cathode lifetime ~6 months.
The experimentally measured polarization is about 82%, And the quantum efficiency is around 0.7%(785nm)

BEPCII-UP (CW) Feasibility Study (New activities)





- The specifications at each energy are very preliminary.
- Parameters and lattice design need to be carefully optimized for each energy.
- Accelerator design is focusing on 1.89 GeV firstly.

- Luminosity may increase by ×10 below 1.89GeV,.
- Operation below 1GeV is enabled

	BEPCII (L_0=1E33cm^{-2}s^{-1})	BEPCII-CW ($10\times L_0$)
Circumference [m]	237	
Peak luminosity [$10^{33}cm^{-2}s^{-1}$]	1	10.9
β_x^*/β_y^* [m]	1/0.0135	0.15/0.005
Total current [mA]	910	1500
Bunch current [mA]	8.3	12.5
Bunch number	110	120
Beam-beam para. $\xi_x/\xi_{y,\mathrm{lum}}$	0.029/0.04	0.01/0.088
Emittance [nmrad]	120/0.6	55/0.193
Damping time [ms]	24.7/24.7/12.3	13.9/14.6/7.45
Coupling facter [%]	0.5	0.35
Longitudinal tune ν_s	0.032	0.040
Natural energy spread [%]	0.05	0.082
Natural bunch length $\sigma_{z,0}$ [mm]	11.5	13.3
Bunch length σ_z [mm]	13.5	16
Half crossing angle [mrad]	11	18.1
Piwinski angle	0.47	3.19
Working point	7.509/5.575	8.550/7.576

BEPCII UP will not only extend the physics reach of BESIII, but also serve as a prototype for CEPC with CW scheme with damping ring, SC wigglers, SC quadrupoles

	BEPCII-crab waist-3.6T (1.55GeV)	BEPCII-crab waist-3.6T (1.0GeV)	BEPCII-crab waist-3.6T (0.5GeV)
RF voltage [MV]	1.5	1.1	1.0
SR power/beam [kW]	107.4 (43.1 in arc)	19.5 (4.5 in arc)	1.4 (0.1 in arc)
Total current [mA]	795	464	160
Peak luminosity [10^{32}cm^{-2}s^{-1}]	50	11	3
β_x^*/β_y^* [m]	0.15/0.005	0.15/0.005	0.15/0.005
Bunch current [mA]	6.6	3.9	0.9
Bunch number	120	120	180
Beam-beam para.$\xi_x/\xi_{y,\mathrm{lum}}$	0.006/0.102	0.005/0.089	0.006/0.09
Emittance [nmrad]	27/0.095	12.5/0.1	3.3/0.052
Damping time [ms]	18/18/9	37.7/37.7/19	93/93/47
Coupling factor [%]	0.35	0.8	1.6
Longitudinal tune ν_s	0.032	0.044	0.059
Bucket Height [%]	0.35	0.8	1.6
Natural energy spread [%]	0.086	0.076	0.014
Natural bunch length $\sigma_{z,0}$ [cm]	1.77	1.8	1.1
Bunch length σ_z [cm]	1.86	1.9	1.2
Half crossing angle [mrad]	18.1	18.1	18.1
Piwinski angle	5.3	7.9	9.8

Participating and Potential Collaborating Companies in China (CIPC) and Worldwide

	System
1	Magnet
2	Power supplier
3	Vacuum
4	Mechanics
5	RF Power
6	SRF/ RF
7	Cryogenics
8	Instrumentation
9	Control
10	Survey and alignment
11	Radiation protection
12	e-e+Sources

CEPC Industrial Promotion Consortium (CIPC, established in Nov. 2017, totally 82 companies by 2025)

Potential international collaborating suppliers worldwide



CEPC Industrial Preparation (CIPC)

Large-scale Cryogenic Refrigeration & Liquefaction Equipment 中科富海 (CIPC member)

First 18kW@4.5K helium refrigerator fabricated in in China passes inspection

-It was developed by the Institute of TIPC,CAS, and integrated and manufactured by Fullcryo.

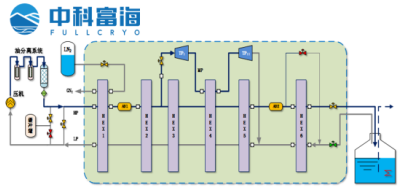
-The super large horizontal cold box with a length of 28m and a diameter of 4.2m achieves ultra-high vacuum and extremely low leakage.

-The horizontal cold box at megawatt-level is the largest of its kind in China and even in the world.

-The horizontal cold box system has exceeded the set targets.

-On-site testing: 1. The airtightness test of each internal channel revealed a pressure drop of 0, surpassing the target value of 0.02 bar. 2. The overall leakage rate is 9.1×10^{-10} Pa.m³/s, surpassing the target value of 1×10^{-7} Pa.m³/s.

-Expected Goals: Achieving 3 operational mode adjustments: the cooling capacity ≥ 18kW@4.5K; the cooling capacity in the superfluid helium temperature range ≥4kW@2K.





北京中科富海低温科技有限公司
Beijing Sinoscience Fullcryo Technology CO., Ltd. (CIPC member)

CEPC cryogenic system need four 14kW@4K cryogenic refrigerators
SppC needs 18kW@4.5K helium refrigerator as well

40

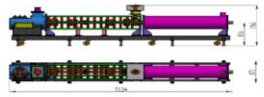
CEPC 650MHz 800kW CW High Efficiency Klystrons

国力研究院 GUOLI INSTITUTE (CIPC member)









2020年 650MHz/800kW速调管样管 | 2023年 650MHz/800kW多注速调管束流管 | 2023年 324MHz脉冲速调管

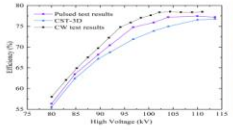
Preliminary mechanical design for UHFKP8001

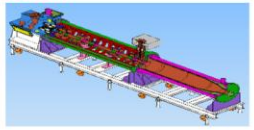
78.5%@803kW CW in August 18, 2024

2021年 650MHz/800kW高效率速调管样管 | 2022年 648MHz脉冲速调管









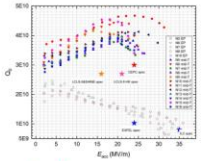
Kunshan National Research Institute has successively developed **650MHz/800KW klystron sample tubes, 650MHz/800KW high-efficiency klystron sample tubes, 648MHz pulse klystron tubes, 650MHz/800KW multi-injection klystron beam tubes**, and the latest 324MHz pulse klystron tubes Electro vacuum products for 50 years. Provide high power thyristor of GL1536A in batches for BEPCII in 2012.

43

HE-RACING Technology and OTIC on SRF Technologies (CIPC members)

高能锐新 (CIPC member)







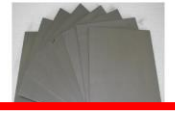


1.3GHz cryomodule assembly

东方钽业 OTIC (CIPC member)

2011 DESY - XFEL
RRR300 Nb: 8 tons, 30% of the project
2012 Michigan State University - FRIB
RRR250 Nb: 8.5 tons, 70% of the project







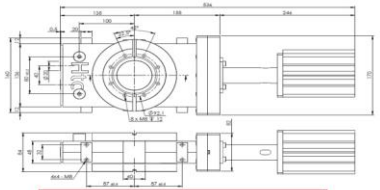


The key industries also available for ILC and LCF:
SC materials, 1.3GHz SC cavities, 1.3 Cryomodules
China's production potential >500 1.3GHz cavities/year and ~100 1.3 cryomodule cold masses/year

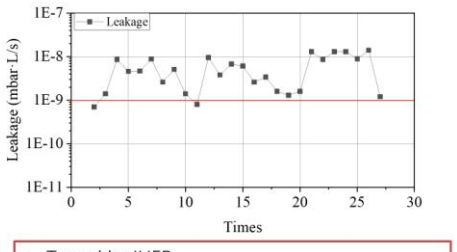
RF Shielding all Metal Gate Vacuum Valve

日揚科技 HIGHLIGHT TECH CORP.

- Two prototypes of RF shielding All metal gate valve have been developed, and the leakage of one of them have been tested.
- The delivery inspection leakage test results for two valves , conducted by the manufacturer, were found to be < 1×10^{9} mbar ·L/s (30 times open and closed).
- The difference of leakage by IHEP & manufacture will be checked and retested in next.



CEPC needs ~1700 all metal valves



- Tested by IHEP
- Expectation leakage < 1×10^{-9} mbar ·L/s



CEPC Development Consensus





Representatives from Chinese institutes and universities unanimously agree:

- will continue to pursue CEPC in China
- will enhance cooperation with CERN on future Higgs factory



Townhall meeting of Chinese institutional representatives at CEPC-2025 workshop, Guangzhou (November 8,2025)

CEPC development consensus and decisions from IHEP director board , CEPC IB, CEPC SC, CEPC IAC and the whole CEPC Team to continue CEPC efforts and prepare to apply for 16th five-year plan in 2030

The decision has been also feedbacked as Input to ESPP2026 on Dec. 1, 2025



CAST announced Top 10 Scientific Frontier Questions of 2025

On July 6, 2025, **China Association for Science and Technology (CAST)** delivered publicly the top ten frontier scientific questions, where "Higgs particle properties and the origine of masses" are among the top ten questions (the second) and CEPC is mentioned in association with replying this question

The Eleventh Meeting of the CEPC-SppC International Advisory Committee

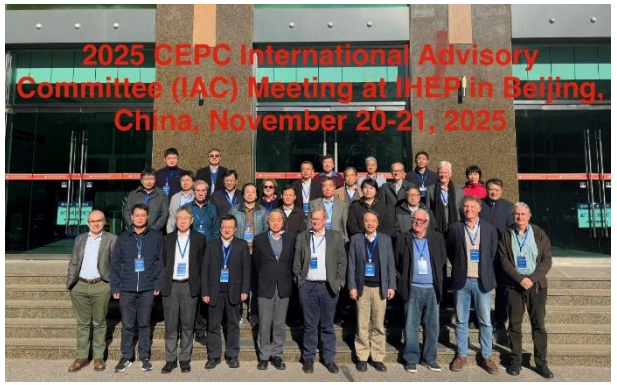
IAC Committee
M. E. Biagini, D. Bortoletto, A. Cohen, M. Davier, M. Demarteau, B. Foster (Chair), J. Fuster, D. Gross, A. Hoecker, L. Linssen, L. Maiani, M.L. Mangano, T. Nakada, S. Stapnes, G. N. Taylor, A. Yamamoto, H.W. Zhao.

November 20-21, 2025

1 Overview

The eleventh meeting of the CEPC-SppC International Advisory Committee took place in person and via Zoom on November 20–21, 2025, where the development in the accelerator design, progress in physics and detector work, as well as the recent development on the project approval process, were presented. The appendices to this report contain the charge for the meeting (Appendix A), the members of the IAC (Appendix B), and the agenda of the meeting (Appendix C).

In light of the decision by CAS not to put CEPC forward for inclusion in the 15th five year plan, the IAC devoted most of its deliberations to the future of CEPC. It wishes to place on record its conviction that the work done so far on CEPC has been of the highest quality and that the failure to get approval in no way reflects a lack of quality of the CEPC project or the promise of the physics that it would deliver. The IAC fully supports the determination of the CEPC team and IHEP to continue the efforts towards approval, and to treat the current situation as an opportunity for reconsideration leading to further work and optimisation of the project. This is also an opportunity for the project to reconceptualize their crucial role in the global effort to develop a high-luminosity Higgs and electroweak factory to explore the physics of electroweak symmetry breaking.



Strong supports from CEPC IAC, IARC, and IDRC

CEPC Collaborations in China

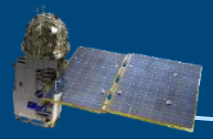
CEPC IB Members

上海交通大学 Shanghai Jiaotong University (SJTU)
中国科学技术大学 (USTC)
四川大学 Sichuan University
中国原子能科学研究院China institute of atomic energy
中国科学院近代物理研究所 Institute of Modern Physics
中国科学院高能物理研究所 IHEP
哈尔滨工业大学Harbin Institute of Technology
华北电力大学North China Electric Power University
中国科学院空天信息创新研究院The Aerospace Information Research Institute
中国科学院近代物理研究所
复旦大学Fudan University
中国科学院大学University of Chinese Academy of Sciences
浙江大学Zhejiang University
深圳技术大学Shenzhen Technology University
南开大学Nankai University
南华大学University of South China
山西大学Shanxi University
北京大学Peking University
西北有色金属研究院Northwest Institute for Non-ferrous Metal Research
国科大杭州高等研究院的英文名称是National University of Science and Technology Hangzhou Advanced Research Institute
东南大学Southeast University
山东大学Shandong University
武汉大学Wuhan University
清华大学Tsinghua University
南京大学 Nanjing University
广西大学Guangxi University
华东理工大学ECUST (East China University of Science and Technology)
香港科技大学The Hong Kong University of Science and Technology，HKUST
台湾中央研究院Academia Sinica
华中师范大学Central China Normal University; Huazhong Normal University; CCNU

CEPC Host Lab IHEP and its Large Science Facilities



HERD on Chinese Space Station



HXMT
Insight Hard X-ray Modulation Telescope

GECAM
Gravitational wave EM Counterpart All-sky Monitor



Huairou Campus
HEPS High Energy Photon Source

YBJ (retired)
International Cosmic Ray Observatory



IHEP, Beijing Campus
BEPC Beijing Electron-Positron Collider







Jinan Campus



HUNT, underwater in south China Sea

AliCPT
Ali CMB Polarization Telescope







LHAASO
Large High-Altitude Air Shower Observatory





Daya Bay (retired)
Daya Bay reactor Neutrino Experiment

JUNO
Jiangmen Underground Neutrino Observatory



Dongguan Campus
CSNS China Spallation Neutron Source

CEPC International Collaboration-1

CEPC attracts significant International participation and collaborations

CEPC Accelerator TDR report: 1114 authors from 278 institutes (including 159 International Institutes, 38 countries) Published in **Radiation Detection Technology and Methods (RDTM)** on June 3, 2024:

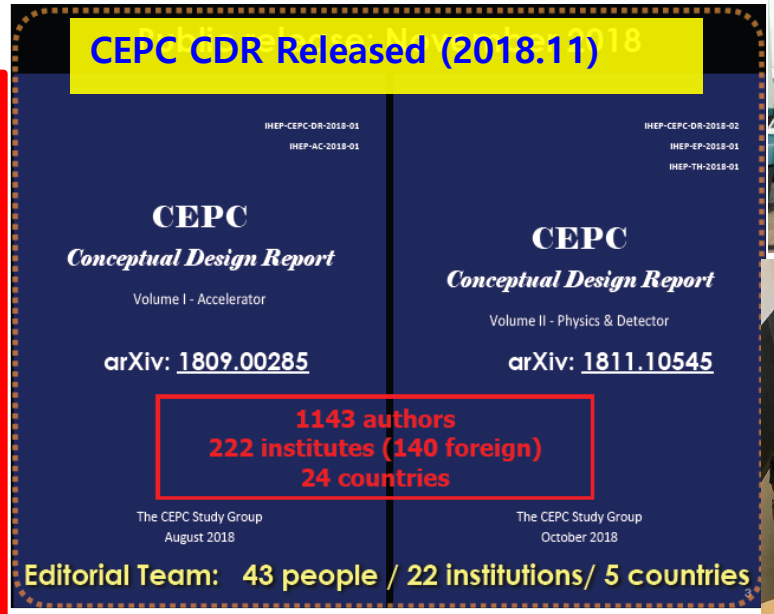
DOI: 10.1007/s41605-024-00463-y

https://doi.org/10.1007/s41605-024-00463-y



CEPC Detector Reference TDR report has been reviewed by IDRC in April 14-16, and Sept. 10, 17 and 24, 2025, and has been submitted to arXiv on Oct. 7, 2025, with >1500 authors, >30.5% international authors, 384 institutes, 63% international institutes, 47 countries. https://arxiv.org/abs/2510.05260

- 23 MoUs have been signed with international institutions and universities
- CEPC International Workshop since 2014-now
- EU and US versions of CEPC WS since 2018-now
- Annual working month at HKUST-IAS (mini workshops and HEP conference), Hong Kong, since 2015-now









CEPC International Collaboration-2

The 2024 HKUST IAS Mini workshop and conference were held from Jan. 18-19, and Jan. 22-25, 2024, respectively.
https://indico.cern.ch/event/1335278/timetable/?view=standard

The 2025 HKUST IAS fundamental physics conference: Jan. 14-17, 2025, Hong Kong
https://indico.cern.ch/event/1454867/overview

CEPC Workshop EU Edition (Barcelona, Spain) June 16-19, 2025
https://indico.ifae.es/event/2054/overview

The 2026 HKUST IAS fundamental physics conference: Jan. 12-16, 2026, Hong Kong
https://indico.global/event/15407/overview





CEPC Workshop EU, April 7-10, 2026, Lisbon, Portugal
https://indico.cern.ch/event/1598929/

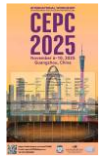
IAS Program on Fundamental Physics, January 18–22, 2027, IAS,HKUST

The 2023 International Workshop on Circular Electron Positron Collider, EU Edition, University of Edinburgh, July 3-6, 2023

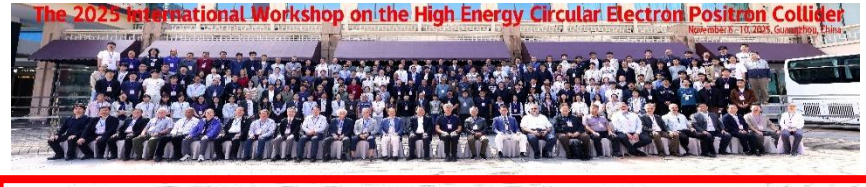


https://indico.ph.ed.ac.uk/event/259/overview

The 2024 international workshop on the high energy Circular Electron Positron Collider (CEPC) was held from Oct. 23-27, 2024, Hangzhou, China
https://indico.ihep.ac.cn/event/22089/



The 2025 international workshop on the high energy Circular Electron Positron Collider (CEPC) was held from Nov. 6-10, 2025, Guangzhou, China
https://indico.ihep.ac.cn/event/25300/



CEPC2026 workshop is held in Shanghai Oct.22-26, 2026
https://indico.ihep.ac.cn/event/cepc2026



https://indico.cern.ch/event/1720390/overview

The 2023 international workshop on the high energy Circular Electron Positron Collider (CEPC)
https://indico.ihep.ac.cn/event/19316/



The 2024 international workshop of CEPC EU-Edition were held in Marseille, France, April 8-11, 2024.
https://indico.in2p3.fr/event/20053/overview



FCPPNL, Bordeaux, France, June 10-14, 2024
https://indico.in2p3.fr/event/20434/overview

FCPPNL, Qingdao, China, July 21-25, 2025
https://indico.ihep.ac.cn/event/25400/

FCPPNL, Lyon, France, June 29-July 3, 2026
https://indico.in2p3.fr/event/38713/

CEPC-SppC and FCC Synergy and Collaboration Issues-1

After he European Strategy for Particle Physics: 2026 Update - Recommendations by the European Strategy Group (CERN-ESU-2025-002, Dec.2025) https://cds.cern.ch/record/2950671 ,
the CERN Council decided to update the European Strategy for Particle Physics
https://home.cern/the-cern-council-decided-to-update-the-european-strategy-for-particle-physics/ (May 22, 2026)

CEPC and FCCee timelines are becoming quite similar:
-CEPC plan to submit the proposal to Chinese government in 2029 for the 16th five-year plan (2030-2025) and
if approved to start the construction during 2030~2035
(in relation with FCCee decision)
-FCCee will be decided in 2028

Collaborations with Super KEK B is very important for CEPC
Understand SuperKEK B is the basis to under future advanced e+e- circular colliders (**Type-II in page 7**)

CEPC participated the FCC public debate on Sept. 18, 2026, and Prof. Y.F. Wang stated CEPC status and CEPC/FCC relation and collaboration issues



https://www.debatpublic.fr/projet-accelerateur-particules/lequipe-du-debat-interroge-les-porteurs-du-projet-chinois-de

It is important to have at least one Higgs factory as soon as possible for the HEP community worldwide , and Collaborations/Synergy/Contributions between CEPC-SppC/FCC, with common issues could be a subject of discussion

CEPC-SppC and FCC Synergy and Collaboration Status-2

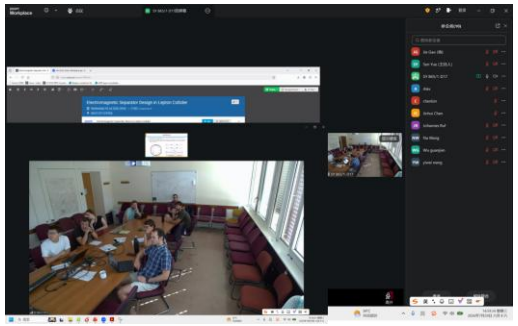
CEPC accelerator team participated FCC week 2026,
June 8-12, 2026 https://indico.cern.ch/event/1552126/timetable/
with 8 talks on CEPC key subjects: high efficiency klystrons, high field SC magnets, booster magnet and vacuum chamber fabrication lines, CEPC MDI, CEPC polarization R&D, BEPCII-UP designs

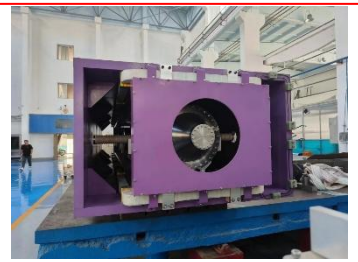
In terms of China-European collaboration in accelerator fields, IHEP is invited to join
GEAR-NG (Global Exchange Accelerator Research - Next Generation) program (2027-2030)
centered in the technologies of next generation Higgs Factories (CERN, DESY, IJCLab…)

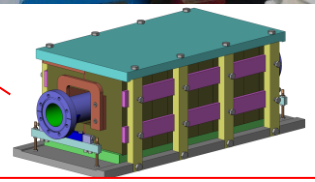
The workshop on electric-magnetic separators between FCC and CEPC on **29th of July, 2026** at 9:00, in room 865/1-D17
the Indico is here:
https://indico.cern.ch/event/1704501/

CEPC EM separator and an alternative kicker design to reduce the impedance

CEPC accelerator member visiting CERN in middle of **August, 2026**, exchanging the experiences on mechanics, mockup tunnel, ground motion, etc…







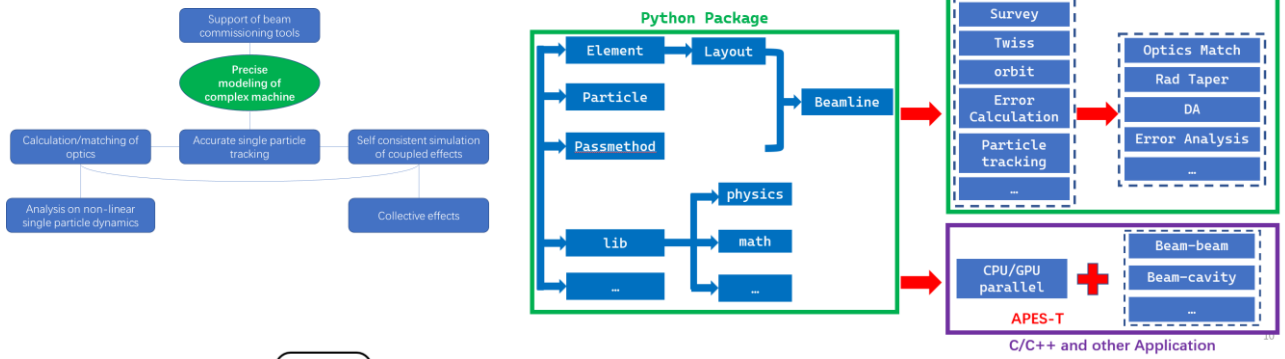


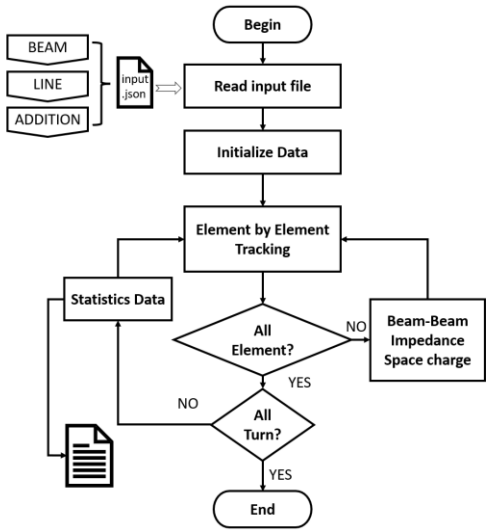


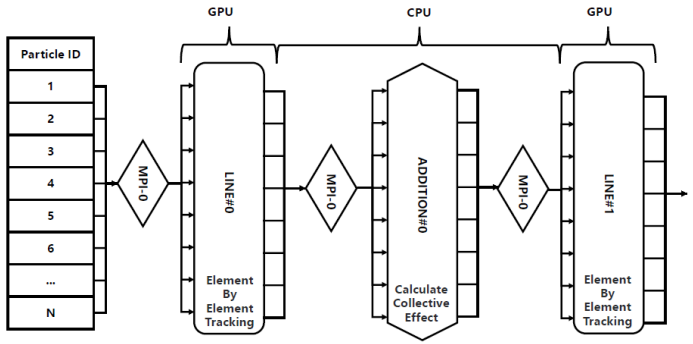
CEPC accelerator specialists have been invited to give presentation in FCC-ee Accelerator WG Meetings, for example,
-Jiyuan Li, “Strong–strong beam–beam simulations with lattices of circular e^+e^- colliders”, FCC-ee accelerator design meeting, Dec. 18, 2025,invited by Frank Zimmermann https://indico.cern.ch/event/1622390/ ,
-Yuanyuan Wei, CEPC IP tunning, FCCee optics tunning workgroup meeting, April 30, 2026, invited by Rogelio Tomas

CEPC and FCC Accelerator Codes and Designs

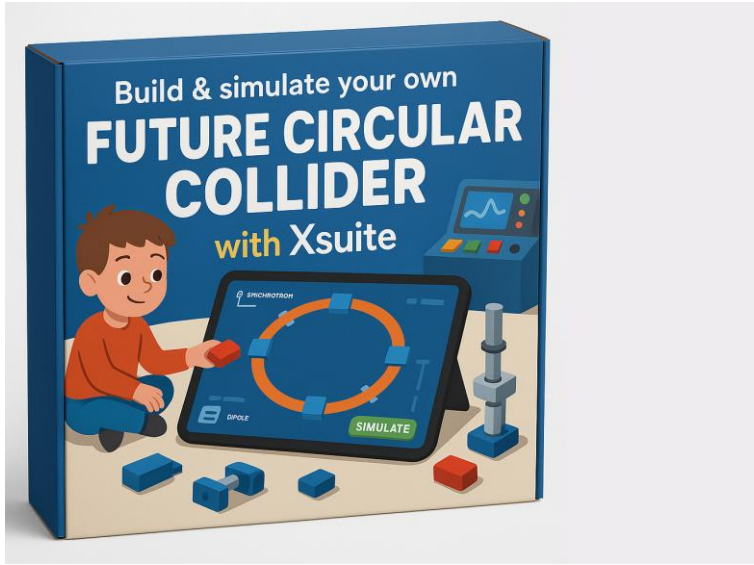
Accelerator Physics Emulation Studio （APES）







FCC design with Xsuite



G. Iadarola **tutorials in form of Jupyter notebooks**

CEPC and FCCee SRF Technology in Synergy(example)

IHEP PAPS SRF Infrastructure in Huairou, Beijing



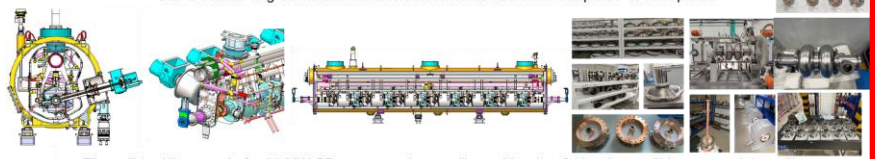
Accelerator key technology R&D and Testing platform:

- SRF cavity and module
- High precision magnet
- Vacuum assembly & coating
- High efficiency Klystron
- Mechanics and alignment
- Beam test facility

CEPC 650MHz SRF Development in EDR



CEPC collider ring 650MHz 2*cell short test module has been completed in TDR phase



The collider Higgs mode for 30 MW SR power per beam will use 32 units of 11 m-long collider cryomodules will contain six 650 MHz 2-cell cavities, and therefore, a full size 650 MHz cryomodule will be developed in EDR

Status: construction started, to be completed in 2027 Please see parallel talk by Peng Sha

Superconducting RF Systems at IHEP

Light Sources & FELs
BSRF, HEPS, CW FEL, ERL



166 MHz (HEPS)
World's first very low freq β=1 module



1.3 GHz (FEL, CEPC, ILC)
World's first mid-T high Q module

HEP Colliders
BEPCII&U, CEPC, ILC



500 MHz (BEPC-II&U, HEPS)
In-house-made, long-term operation in large scientific facility



650 MHz (CEPC, ADS, CSNS)
World's first 650 MHz cryomodule

High Intensity Proton Linacs
ADS, CSNS-II, *v* factory



325 MHz (ADS)
World's first spoke cavity linac



324 MHz (CSNS-II)
China's first double-spoke module

BEPCII-U and HEPS 500 MHz Cavity and Cryomodule

- One 500 MHz cavities for BEPCII-U and two 500 MHz third hormonic cavities for HEPS.
- Prevent cavity buckling by thicker Nb sheet (2.5 mm to 3.7 mm), deep drawing instead of spinning, adding stiffening rings.
- First CM assembly complete soon.



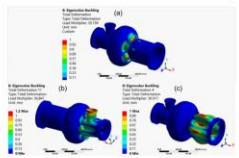
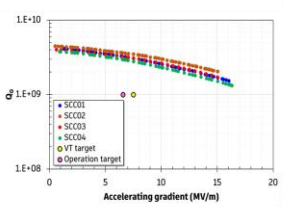


TABLE V
BUCKLING PERFORMANCE OF THE CAVITY UNDER TWO DIFFERENT BOUNDARIES

	Conditions	Φ (Bare)	Φ (Stiff.)	Φ_{cr}
Cell (LBP side)	BPs fixed	29.3	83.7	16.1
	LBP LF	10.5	30.2	
Cell (SBP side)	BPs fixed	29.4	85.1	16.1
	LBP LF	12.8	36.9	
LBP tube	BPs fixed	33.2	33.2	2.5
	LBP LF	17.2	31.0	

"BPs fixed" stands for both beam pipes are fixed. "LBP LF" stands for the cavity LBP side is free to move longitudinally while the SBP side is fixed. "Bare" stands for bare cavity without any stiffening rings, and "Stiff." stands for cavities with one pair of stiffening rings added on the cell.



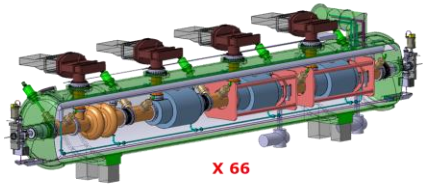


500 MHz KEKB-type single-cell SC cavity module

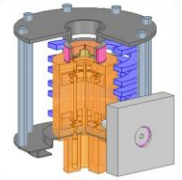
FCCee 400 MHz system – collider Z, W, ZH



X 264



X 66



X 264

Superconducting elliptical cavity
- 400 MHz, 2-cell
- 1.5 m. long
- Electropolished and seamless RF surface
- Niobium thin film with HiPIMS

Cryomodule
- Segmented design, 4 cavities
- Vertical FPC, HOM damping and extraction
- Frequency tuning system
- Thermal and magnetic shielding

Multibeam Tristron
- **400 MHz**
- 46 kV
- 500 kW, CW
- ~ 90% efficiency

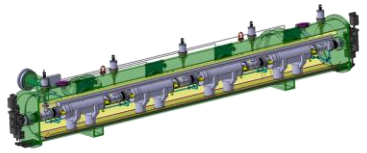
I. Syratchev

600MHz, 650MHz and 1.3GHz for FCCee?

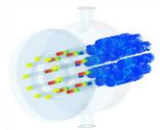
FCCee 800 MHz system – for tt̄ collider and booster



X (408 + 448)



X (102 + 112)



Multibeam Tristron X 408
- 800 MHz
- 250 kW, CW



Solid State Amplifier (SSA) X 448
- 800 MHz
- 10-15 kW pulsed

Superconducting elliptical cavity
- 800 MHz, 6-cell
- Nb_3Sn if R&D is successful

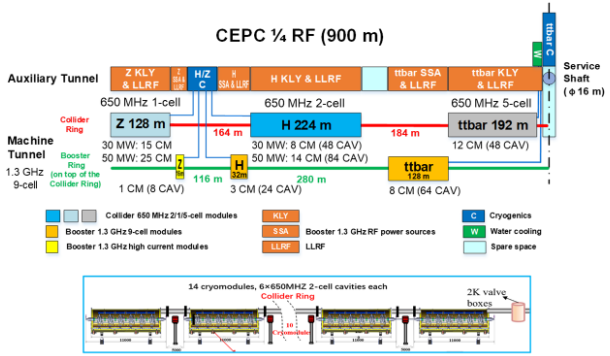
Cryomodule
- Segmented design, 4 cavities, 2 K
- Operation at 4.5 K if R&D successful

A. Butterworth

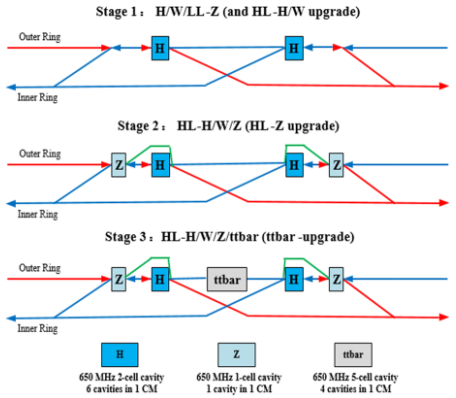
CEPC and FCCee SRF System in Synergy

FUTURE CIRCULAR COLLIDER

CEPC 650 MHz RF – 2, 1, & 5-cell cavities with bypasses



- 2x1.8 km RF section, 3 km RF module footprint, 2 km RF module length
- **628 650 MHz cavities, 384 1.3 GHz cavities, total 1012 cavities, 5188 cells**
- Collider and booster RF bypass for mode switch.



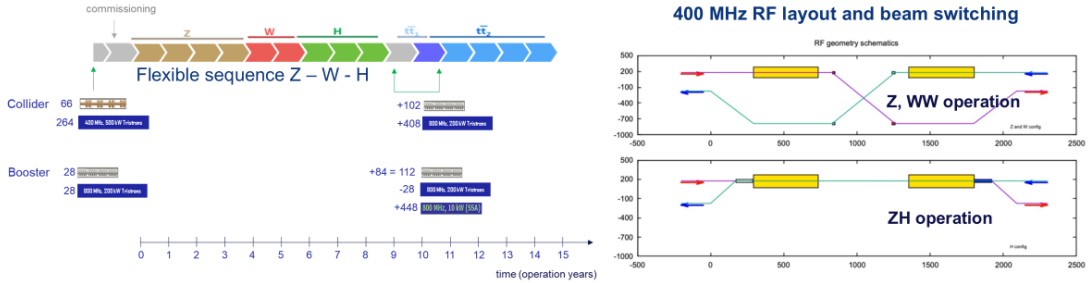
Collider RF Staging and Bypass Scheme

Z. Zhai

bypasses also proposed for FCC-ee ttbar running – impact on RF installation

FCC 7 April 2026

FCC-ee operation sequence and SRF concept



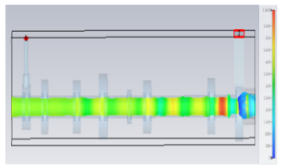
- **2-cell 400 MHz SRF system for Z, W and ZH**, entire system installed at operation start
  - flexibility for switching between Z, WW, ZH operation
  - reverse phase operation at Z allows constant cavity coupling
  - suppression of the single-cell 400 MHz system
  - reduced R&D, installation, commissioning, etc…
- **6-cell 800 MHz SRF system for collider ttbar operation and booster at all energies**

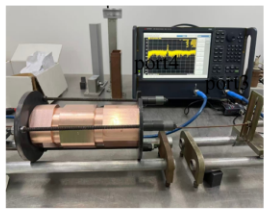
CEPC and FCCee Klystrons in Synergy

A Full Frequency Spectrum Klystron Development

16

CEPC Linac S band high efficiency klystron
（2860MHz/80MW/100Hz/4us/55%）
to be tested in 2026



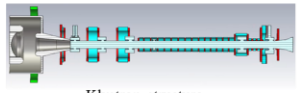


S band PPM klystron
（2856MHz/50MW/53%）
Fabrication starts in 2026

S-band 50MW PPM Klystron	Design Specifications
Beam Voltage	350kV
Beam Current	272A
Frequency	2856MHz
Tube Radius	13.8mm
Beam Radius	9mm
Output Power	50MW
Efficiency	53%



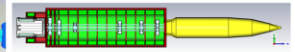
Beam dynamic

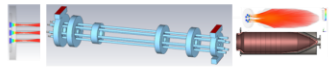


Klystron structure

L-Ban long pulsed klystron
（1.3GHz/10MW/1.5ms/10Hz
to be completed by the end of 2026

Parameters	Value
Freq.(GHz)	1.3
H.V.(kV)	115
Current(A)	21×6
Beam No.	6
Rep. Rate(Hz)	10
Pulse Width(ms)	1.5
Power(MW)	≥10
Eff.	≥65%

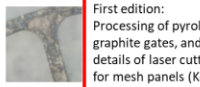




CEPC 650MHZ MB Tristron
R&D, to be completed in 2028

The maturation of pyrolytic graphite manufacturing technology, the refinement of gate cooling methods and advances in brazing techniques have made it possible to produce high-efficiency, high-power Tristrons.





First edition: Processing of pyrolytic graphite gates, and the details of laser cutting for mesh panels (Key technology of Tristrons). The first Tristron to be completed in 2028

CEPC High Efficiency and High Power Klystrons



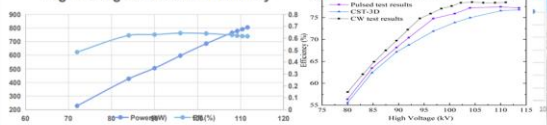
Klystron R&D



Klystron No. 1
Efficiency 65%
(2020)

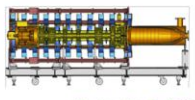
Pulsed RF Mode (30% duty factor, 60ms/5Hz

High Voltage vs. Power&Efficency





78.5%@803kW CW in 2024

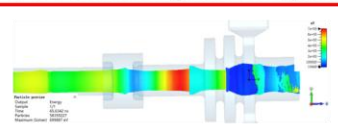


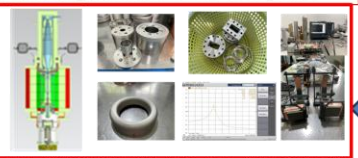
Klystron No. 2
Efficiency 77%
(2021)

Klystron No. 3 （MBI
Efficiency 80.5%
To be completed in 2026



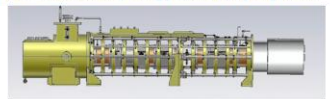
CEPC collider ring 650MHz klystron development in TDR/EDR phase

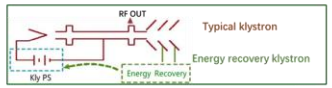




Linac C band 5720MHz 80MW
Klystron design completed
to be completed in 2026

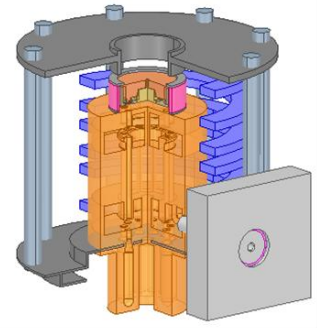
CEPC 650Mhz Energy Recovery Klystron





Parameter	Value
Operating frequency	650 MHz
Beam Voltage	113 kV
Efficiency	77.5%
Output power	800 kW
Beam perveance	0.25 μP
Beam current	9.5A
Efficiency (one-stage depressed collector)	85%

CEPC 650Mhz Energy Recovery Klystron to be tested in Sept. in 2026

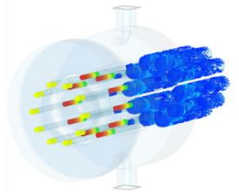


X 264

Multibeam Tristron

- **400 MHz**
- 46 kV
- 500 kW, CW
- ~ 90% efficiency

I. Syratchev



Multibeam Tristron **X 408**

- 800 MHz
- 250 kW, CW

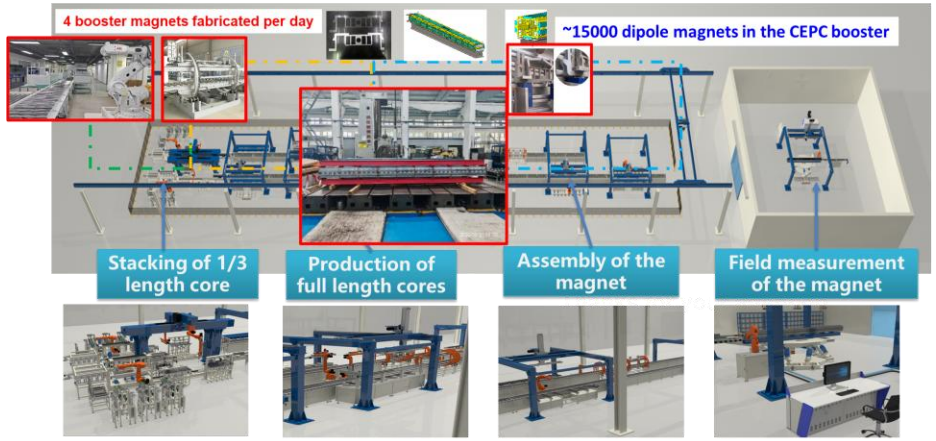
Solid State Amplifier (SSA) **X 448**

- 800 MHz
- 10-15 kW pulsed



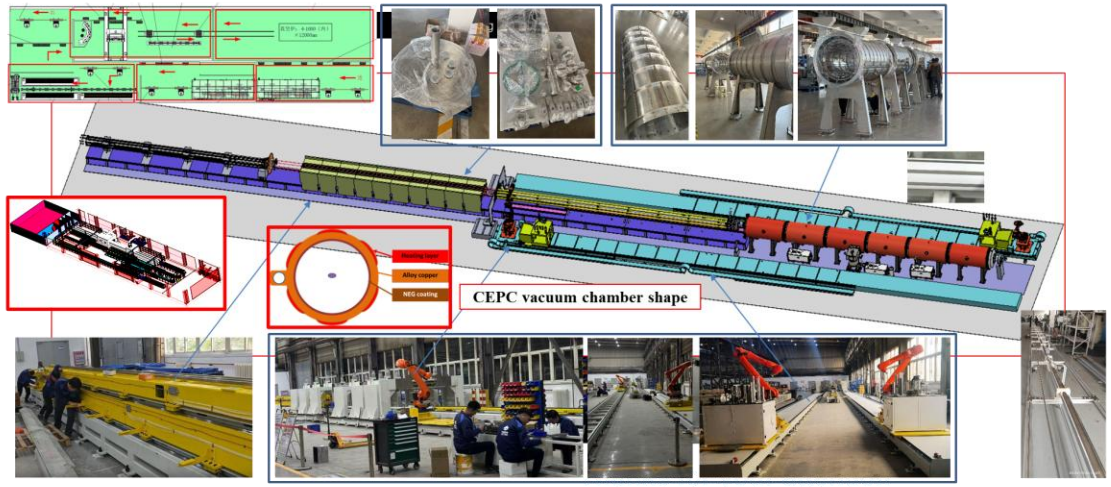
CEPC Booster dipole magnet and Vacuum NEG Automatic Production Line in synergy with FCCee Booster Magnets and Vacuum Chambers

CEPC Booster Magnet Automatic Production Line in EDR



Status： under construction, to be completed by May 2026

CEPC NEG Coated Vacuum Chamber (200km) Automatic Production Line in EDR



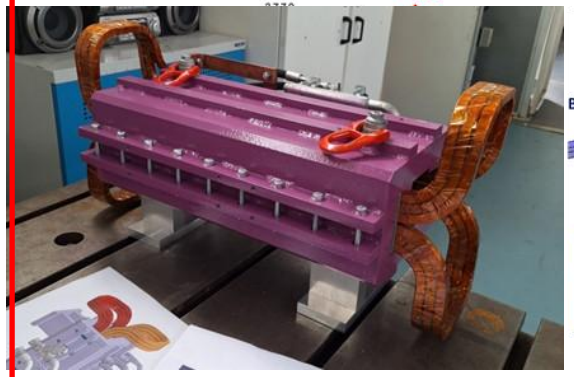
- The main components of vacuum oven for NEG coating have been manufactured and under are now being assembled.

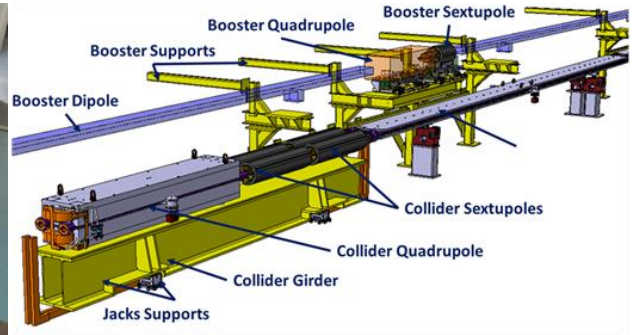
Status： under construction, to be completed by June 2026

FCC-ee booster

full energy booster, ramping from 20 GeV to 46 GeV – 182.5 GeV; injection ~several times per minute to keep collider beam currents constant; booster intensity ~1% of collider; full RF voltage as in collider

Booster

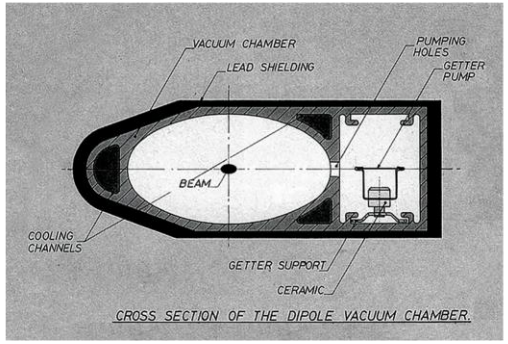




FCCee Booster dipole low-field cycling magnet

LEP3 rpund shape vacuum chamber

LEP2 vacuum chamber – extruded Aluminium



- Oval shape is bad for impedance
- Beam sizes were larger at LEP2
- Artist's impression of LEP3 beam pipe:

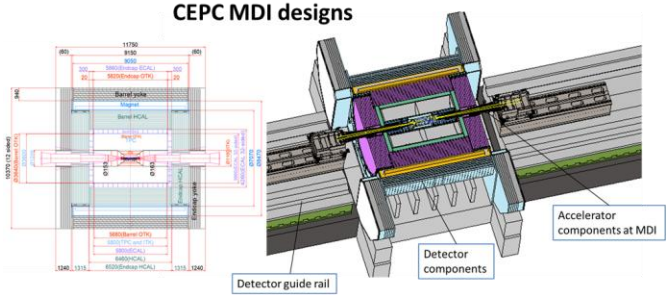


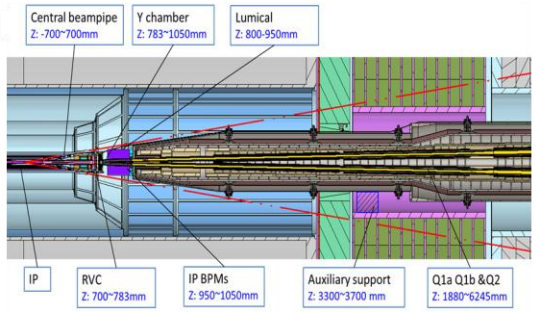
M. Koratzinos

CEPC FCCee MDI in Synergy

CEPC MDI EDR Activities

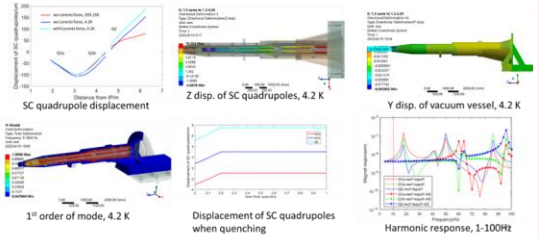
CEPC MDI designs





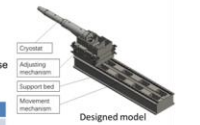
CEPC MDI mechanics progress-mechanical analyses

- Simulation results, with Lorentz force and gravity



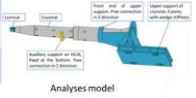
CEPC MDI Mechanical Analyses

- Mechanics and vibration analyses
  - **Static structure**: max. deformation and displacement change with/wo Lorentz force
  - **Vibration analyses**: natural frequency & harmonic response
  - **Structure optimization**



	Related requirements	Response now*
Position accuracy (X/Y) of SC quadrupoles ≤100μm	Adjusting resolution≤5μm Adjusting accuracy≤30μm	≤5μm ≤30μm from HEPS experience
	Max. def. and disp. change, < 50μm	FEA, <40μm
Small vibration, 1-100Hz RMS ≤4nm	High natural frequency	FEA, ~50Hz and 1 (same level to HEPS, and arc section of CEPC)
	Low amplification factor	

* The response now only considers the mechanics aspect.



FCCee Machine-Detector Interface

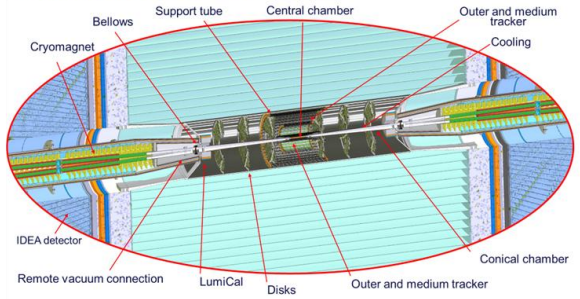
Key topics:

SC IR magnet system & cryostat design

3D integration

IR mock-up at INFN-LNF

Machine		FCCee	CEPC	ILC	SuperKEKB
Crossing-angle	mrad	30	33	14	83
L*	m	2.2	1.9	3.5	0.935
Vertical β_y* at IP	mm	0.7-1.6	0.9-2.7	0.4	0.3
Detector soln field	T	2/3	3	3.5/5	1.5
Detector stay clear	mrad	100	118/141	90	350/436
Two beam ΔX at L*	mm	66	62.7	49	77.6
He temperature	K	1.9	4.2	4.5	4.5

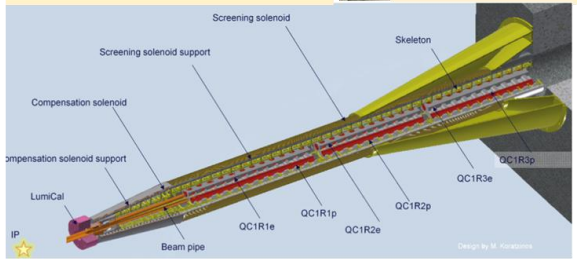


M. Boscolo, F. Palla, INFN

J. Seeman, A. Novokhatski, SLAC
B. Parker, Vikas Teotia, BNL
P. Tavares, CERN



M. Koratzinos, PSI



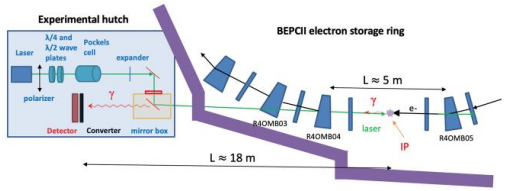
CEPC FCCee Synergies on Polarizations

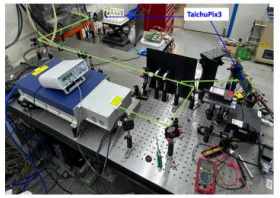
CEPC Polarization in Preparation Study

-Compton Polarimeter at BEPCII-U

24

- A laser-Compton polarimeter has been implemented in BEPCII electron storage ring
- Laser-electron collision signal has been observed
- Measurement of electron beam polarization is under way

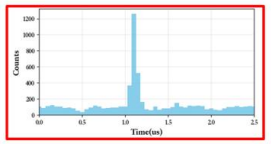




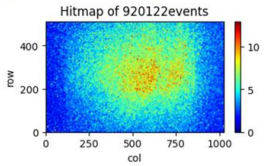
Key parameters

Location	beamline and experimental hall of 4W2 wiggler
Laser	532nm, 4.5 kHz, 2 mJ, 1 ns, flippable circular polarization
Observable	Vertical asymmetry of backscattered γ (up to 180 MeV)
Detector	lead preshower + silicon pixel detector
Signal	backscattered γ ~ 20kHz/mA/W
Background	bremsstruhlung γ ~ 1kHz/mA

Laser-signal causality observed



Signal on the Silicon pixel detector





MBE system in Acken

Polarized electron cathode chip (diameter ~5cm) has been fabricated in **June 2025**:
Polarization of 85%, for 1ns laser (780nm) pulse length, several nC polarized electron charge will be obtained with the expected cathode lifetime ~6 months.
The experimentally measured polarization is about 75%, And the quantum efficiency is around 0.7%

Please see parallel talks by Zhe Duan and Xiaoping Li

EPFL

FCC-ee Beam Polarization Studies —— Status and Challenges

Yi Wu, Jorg Wenninger, Léon Van Riesen-Haupt, Tatiana Pieloni, Mike Seidel

Acknowledgements to Zhe Duan, Desmond Barber, David Sagan, Alain Blondel, Frank Zimmermann and FCC-ee EPOL and optics tuning working groups

Work supported by the Swiss Accelerator Research and Technology (CHART)

CHART Swiss Accelerator Research and Technology

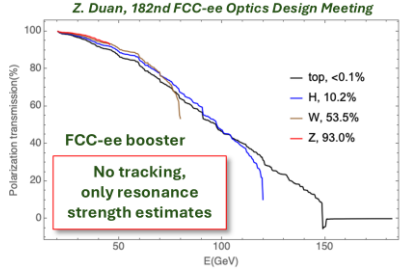
FUTURE CIRCULAR COLLIDER

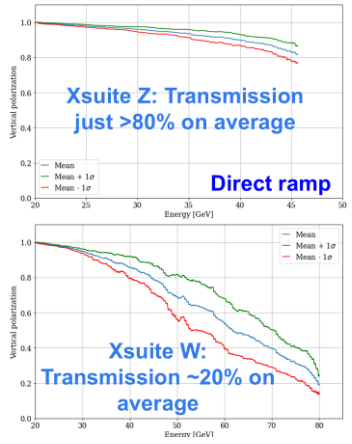
FCC 7 April 2026

polarisation

Simulation tools – consistency checks !
Polarimetry in collider and booster (!)

Z. Duan, 182nd FCC-ee Optics Design Meeting



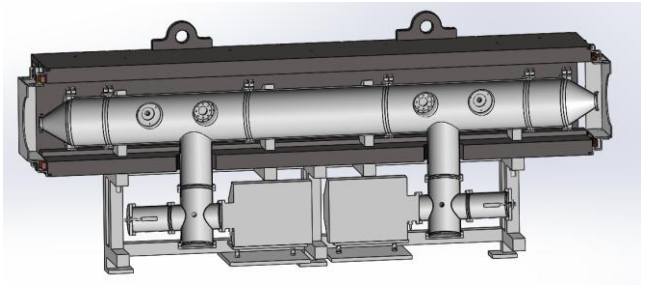


The booster machines are set up with **reduced error table**:

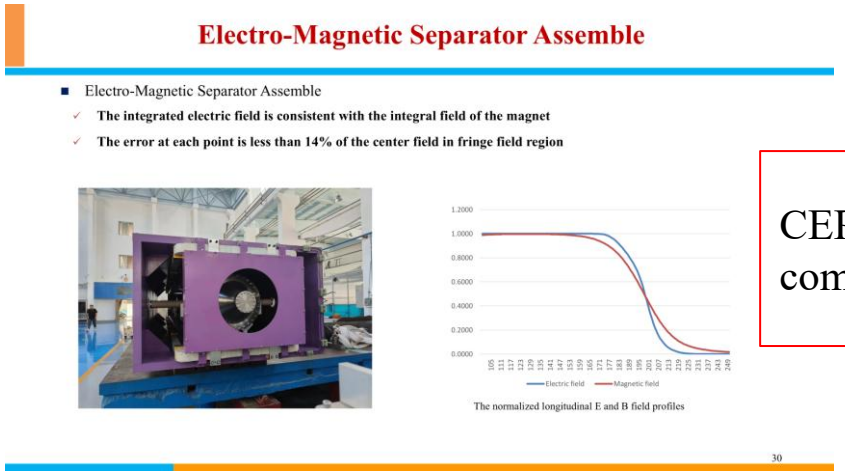
- **Girder misalignment** (Q, S, BPM): **100 μm rms** (nominal 200)
- Element misalignment on girder : 50 μm rms

J. Wenninger

CEPC and FCCee EM Separator in Synergy







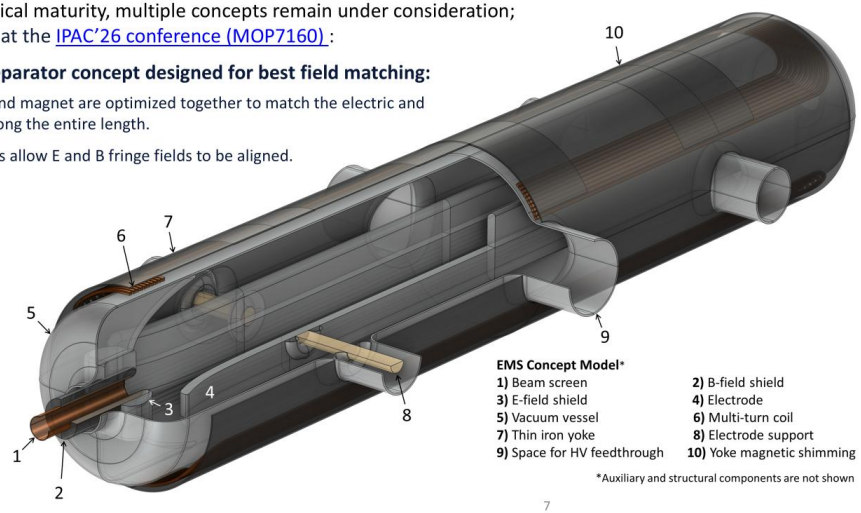
CEPC EM separator completed in TDR

Electro-Magnetic Separator Concept

At this low level of technical maturity, multiple concepts remain under consideration; one has been presented at the IPAC'26 conference (MOP7160) :

Electro-Magnetic Separator concept designed for best field matching:

- Electrode shape and magnet are optimized together to match the electric and magnetic fields along the entire length.
- Shielding elements allow E and B fringe fields to be aligned.



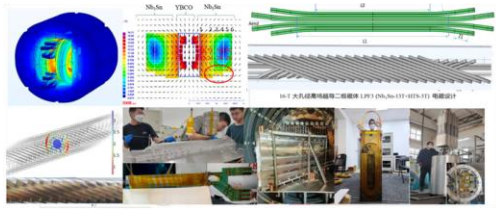
FCCee EM separator in the design

SppC and FCChh High Field SC Dipole Magnets in Synergy and Beyond

Advanced High Field SC Magnet (IBS) Development

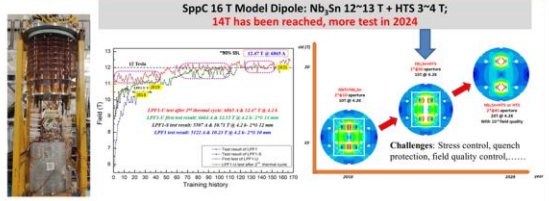
27

Highest Quench Field Reached in 2024: over 14T @4.2K



SppC HF Magnet Development

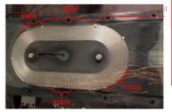
SppC 16 T Model Dipole: Nb_3Sn 12~13 T + HTS 3~4 T;
14T has been reached, more test in 2024

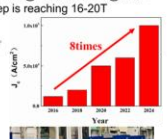


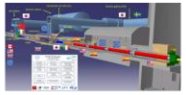
Picture of LPF1-U

Dual aperture superconducting dipoles achieve 12T@4.2 K and 14T@4.2K entirely fabricated in China. The next step is reaching 16-20T

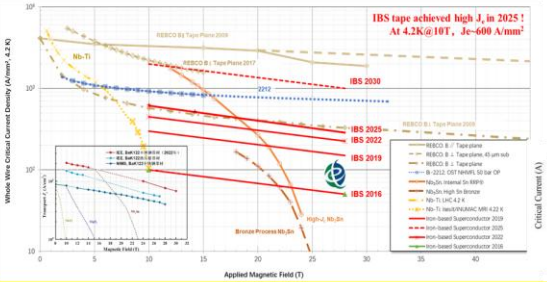
- First short coil with 40%Jc@24T
- First long coil with 80%Jc@10T

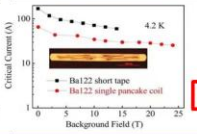












All HL-LHC CCT magnets have been delivered to CERN in early 2026

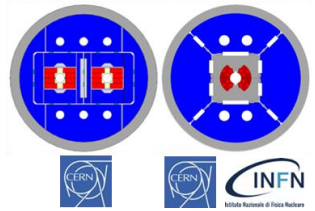
According to the progresses from 2016-2025, it is expected that the IBS could reach the technical requirements for SppC/FCChh around 2035

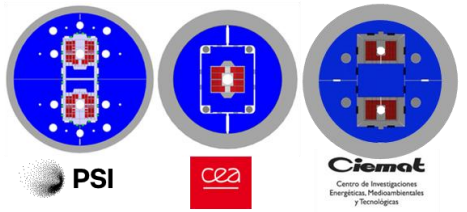
FCC-hh High-Field Magnet Nb_3Sn and HTS R&D

B. Auchmann, E. Todesco

Nb_3Sn:

- 12- and 14-T short demonstrators
- Different coil geometries
- tests scheduled for 2026



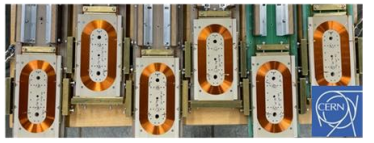


HTS R&D in various domains:

- REBCO and IBS Conductor R&D
- Racetrack coil developments



REBCO coated-conductor R&D line at KIT.



Insulated tape-stack coils for assembly in common-coil config at CERN.



Iron-based SC powder synthesis and R&D tape fabrication at CNR SPIN



Fabrication of racetrack from solder-impregnated tape-stack cable at PSI.



CEA process development for metal-insulated racetrack coils.

Down selection of technology by 2035-2040

Summary

- CEPC is continuing to complete EDR based on the completed TDRs according to the EDR plan and prepare for the application of 16th five-year plan in 2030
- Many EDR key technology developments will be completed in 2027, such as booster magnet and vacuum chamber NEG coating lines, various klystrons, SC quadrupole, etc.
- The geological study has been completed on CEPC EDR site in 2026, civil engineering and implementation have been carried out
- Plasma accelerator technology under developing at IHEP will serve also a longer term path to high energy range, and the PWFA test facility has been in commissioning since April 2026
- BEPCII-UP scheme (under studies) serves also as a prototype of CEPC (CW + damping ring) for training/collaboration platforms
- There are big potentials in the synergy and collaboration between CEPC and FCC
- China has a big potential to host a future Higgs factor, such as CEPC
- International efforts towards Higgs factories are common endeavors of human beings, and the final goals should be and could be reached with persistence, endurance, supports and collaborations.

Acknowledgements

Thanks go to CEPC-SppC team's hard works, international and CIPC collaborations

Special thanks to CEPC IB (universities and institutes), SC, IAC, IARC and IDRC committee's advices, suggestions and supports

Thanks for your attention