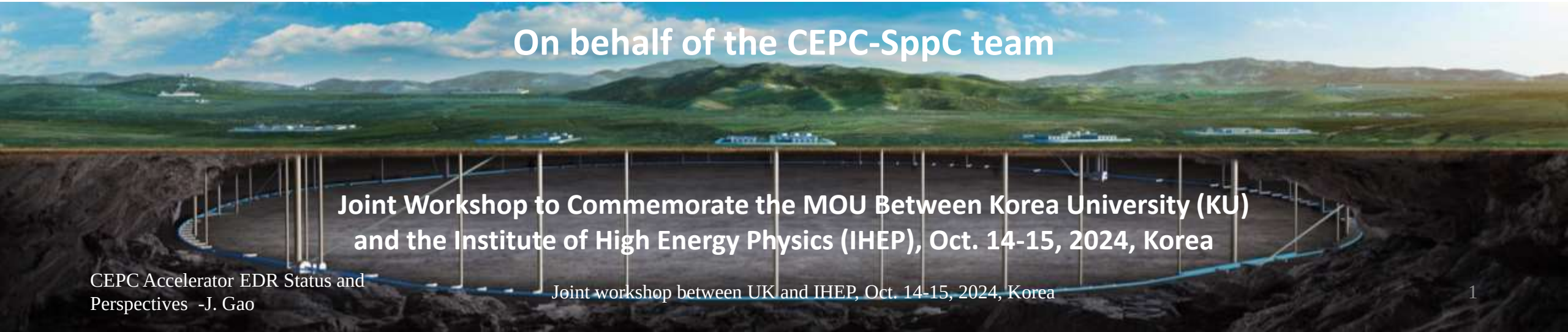
中国科学院高能物理研究所
Institute of High Energy Physics
Chinese Academy of Sciences

CEPC Accelerator EDR Status and Perspectives

Jie Gao

IHEP



On behalf of the CEPC-SppC team

Joint Workshop to Commemorate the MOU Between Korea University (KU) and the Institute of High Energy Physics (IHEP), Oct. 14-15, 2024, Korea

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- Introduction
- CEPC Accelerator Design and Key Hardware R&D in TDR as Start of EDR
- CEPC EDR Goals, Scope, Plan, Progress status
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- Summary

A Brief Historical Recall: High Energy Colliders and Factories

Year

Next?

2018

2012

2006

2002

1999

1994

1990

1988

1980

1972

The era of Higgs boson started from 2012

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…

SppC, FCC-hh
Muon collider
FCC-ee
(H,t, Z,W…Dark matter)
CEPC/ILC/CLIC: new e^+e^- collider

(B physics…)
SuperKEKB: $\sqrt{s} \simeq 10$ GeV, $\mathcal{L} \simeq 10^{35}$

(τ − charm,…)
BEPCII: $\sqrt{s} \simeq 2-5$ GeV, $\mathcal{L} \simeq 10^{33}$

(τ mass, charmonium,…)
VEPP-4: $\sqrt{s} \simeq 1.5-2.0$GeV, $\mathcal{L} \simeq 10^{33}$

(B-quark, CP violation, CKM…)
KEKB/PEP-II

(Z, W bosons,…)
LEP/CERN, SLC/SLAC

(τ −charm,…)
BEPC: $\sqrt{s} \simeq 2-5$ GeV, $\mathcal{L} \simeq 10^{31}$

CESR: $\sqrt{s} \simeq 10$ GeV

(J/ψ,c-quark, t …)
SPEAR&BNL: $\sqrt{s}$

$(e^+e^-$ colliders)

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

Higgs,…

LHC/CERN:

Higgs boson 2012

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

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

W, Z,…

SPS/CERN

W,Z bosons 1983

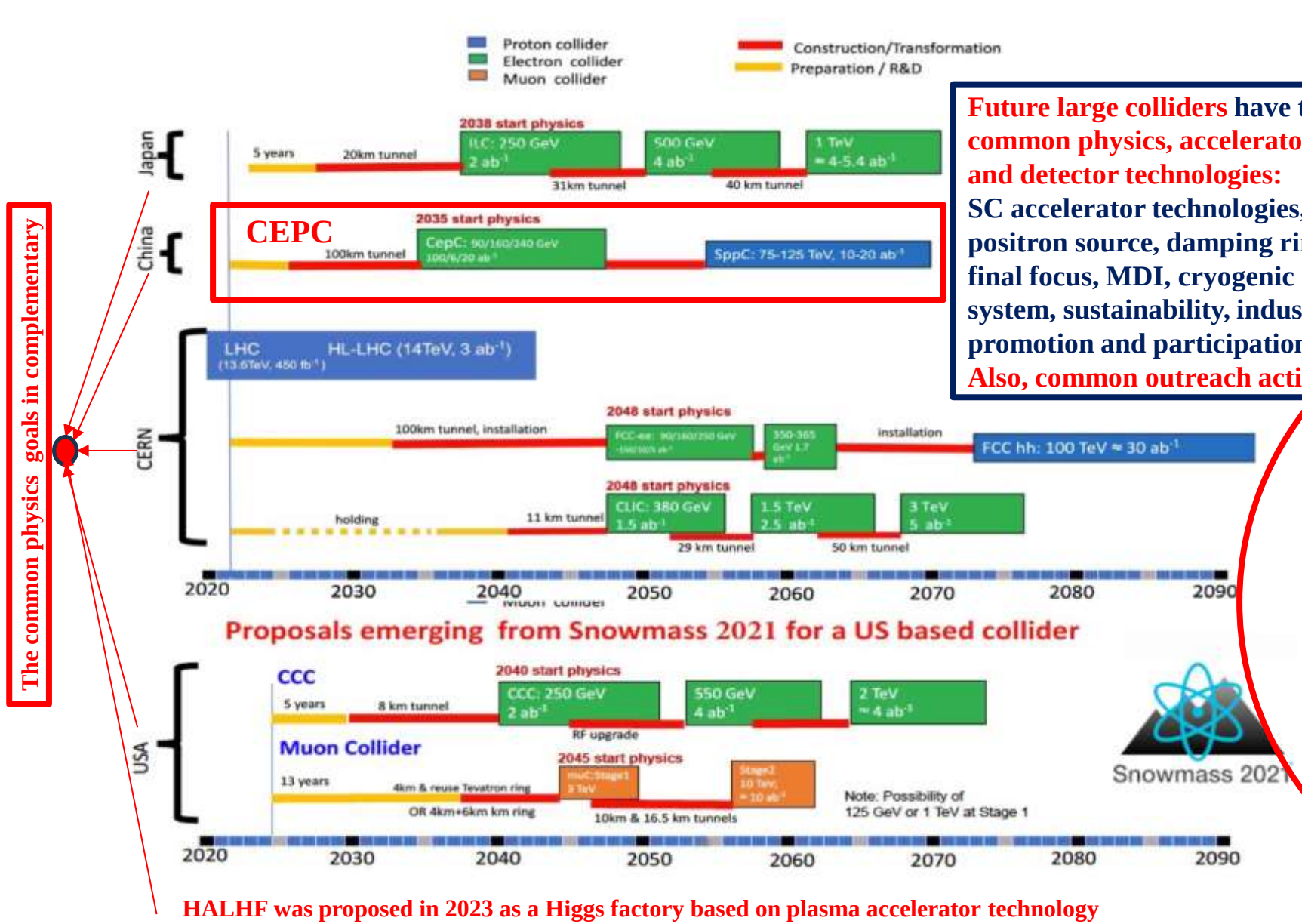
Bottom,…

Fermilab: 400GeV p on Cu, Pt

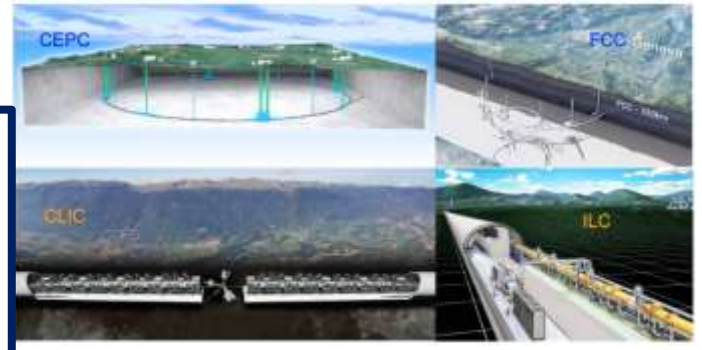
Bottom quark 1977

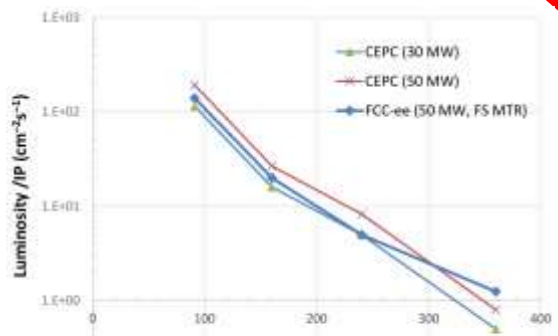
(proton accelerators and colliders)

Worldwide High Energy Physics Goal Timelines and Common Efforts



Future large colliders have the common physics, accelerator and detector technologies:
SC accelerator technologies, positron source, damping ring, final focus, MDI, cryogenic system, sustainability, industrial promotion and participation.
Also, common outreach activities



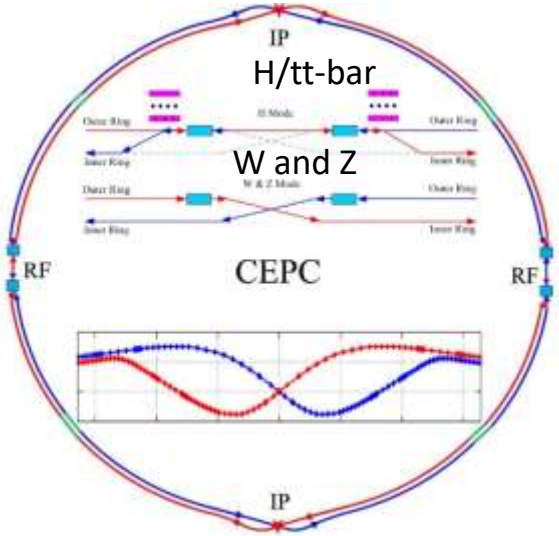


	Operation mode			
	H	Z	W	$t\bar{t}$
CEPC (TDR, 30 MW)	5	115	16	0.5
CEPC (TDR, 50 MW)	8.3	192	26.7	0.8
FCC-ee (FS MTR, 50 MW)	≥ 5.0	140	20	1.25

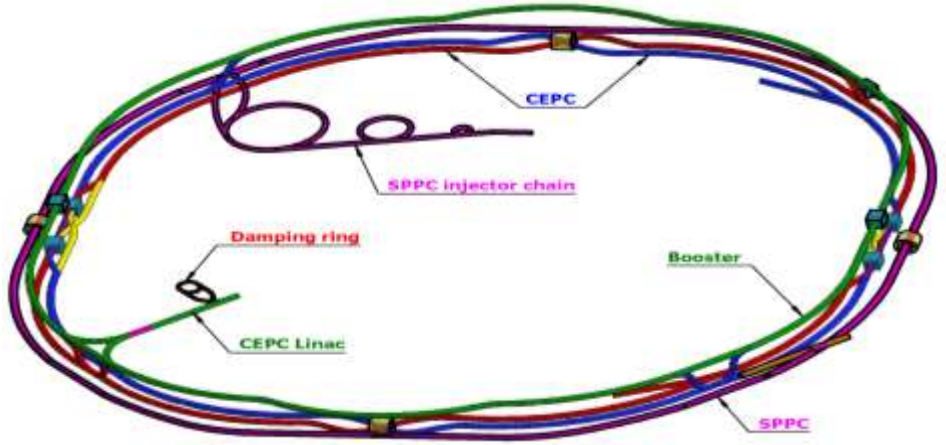
HALHF was proposed in 2023 as a Higgs factory based on plasma accelerator technology

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

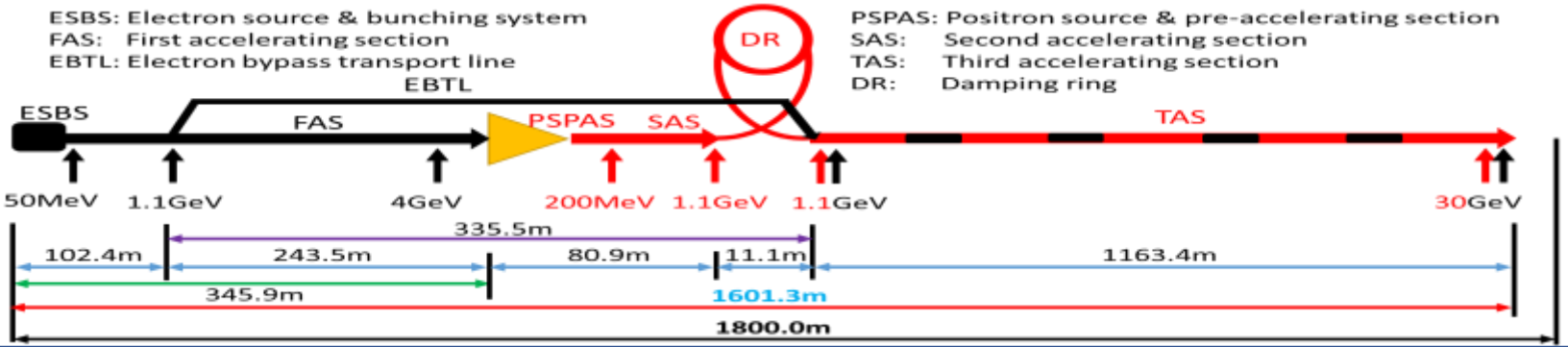


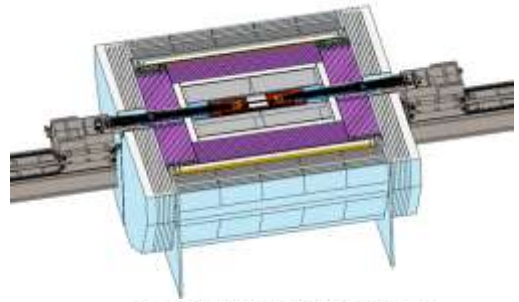
CEPC collider ring (100km)



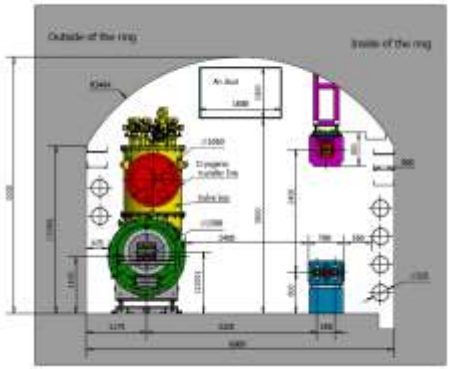
CEPC booster ring (100km)

CEPC TDR S+C-band 30GeV linac injector

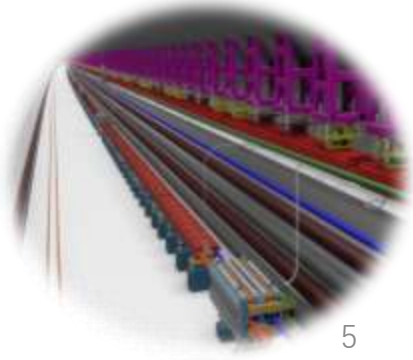




TUNNEL CROSS SECTION OF THE ARC AREA



CEPC/SppC in the same tunnel



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

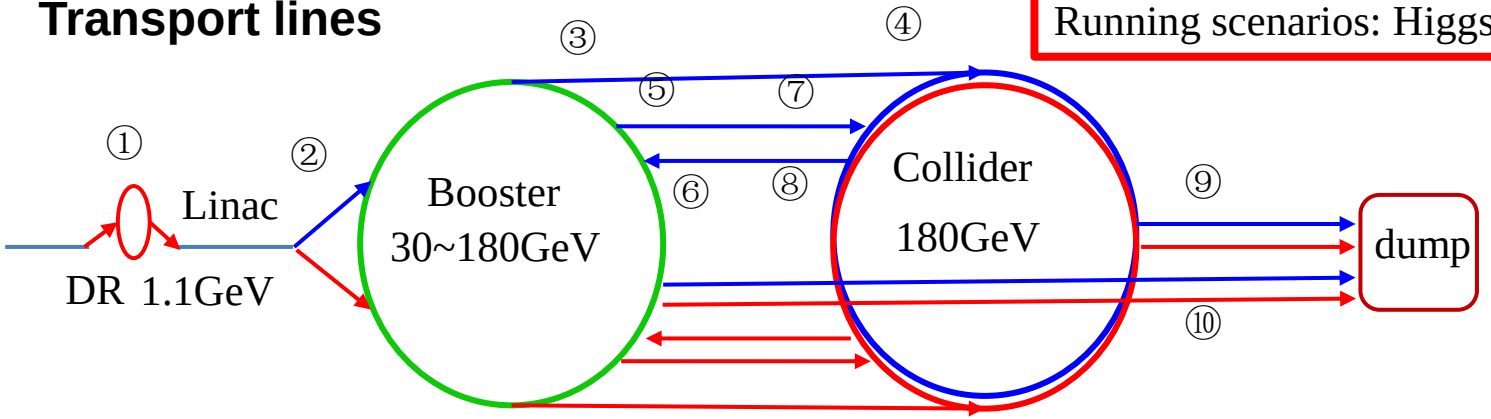
Booster

		tt	*H*		*W*	*Z*	
		Off axis injection	Off axis injection	On axis injection	Off axis injection	Off axis injection	
Circumfer.	km	100					
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)	**100.0**			
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**

Transport lines



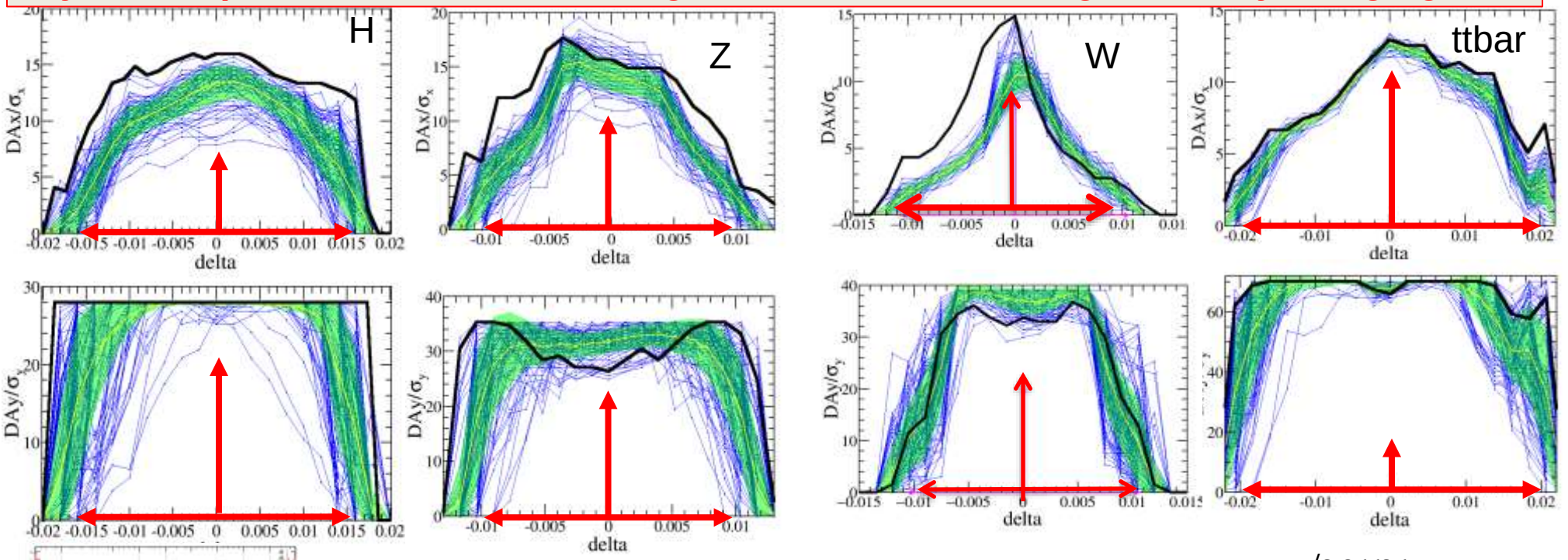
Running scenarios: Higgs 10 years, Z 3 years, W 1 year, ttbar 5 years

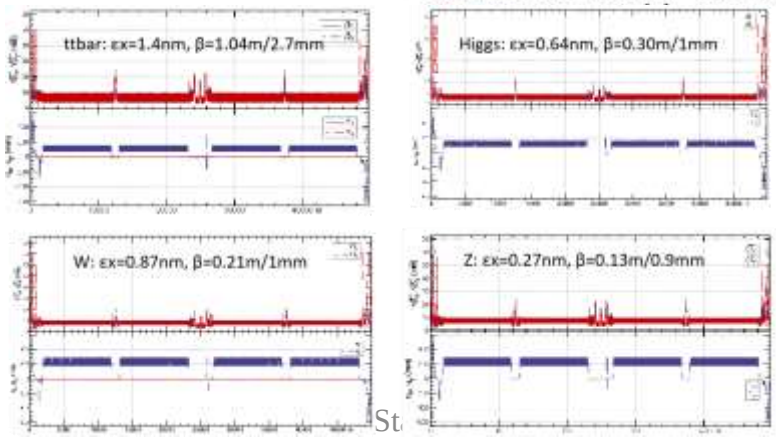
CEPC Technical Design Report (TDR) includes:
1) CEPC Accelerator TDR
2) CEPC Detector TDRrd (rd=reference design)
will be completed by June 2025

CEPC Collider Ring Daynamic Apertures

Dynamic apertures with errors at Higss, W/Z and ttbar energies satisfy design goals

Effects included in tracking
Synchrotron motion
Radiation loss in all magnets
Tapering
Crab waist sextupole
Maxwellian fringes
Kinematic terms
Finite length of sextupole





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

—w/o error

—mean value

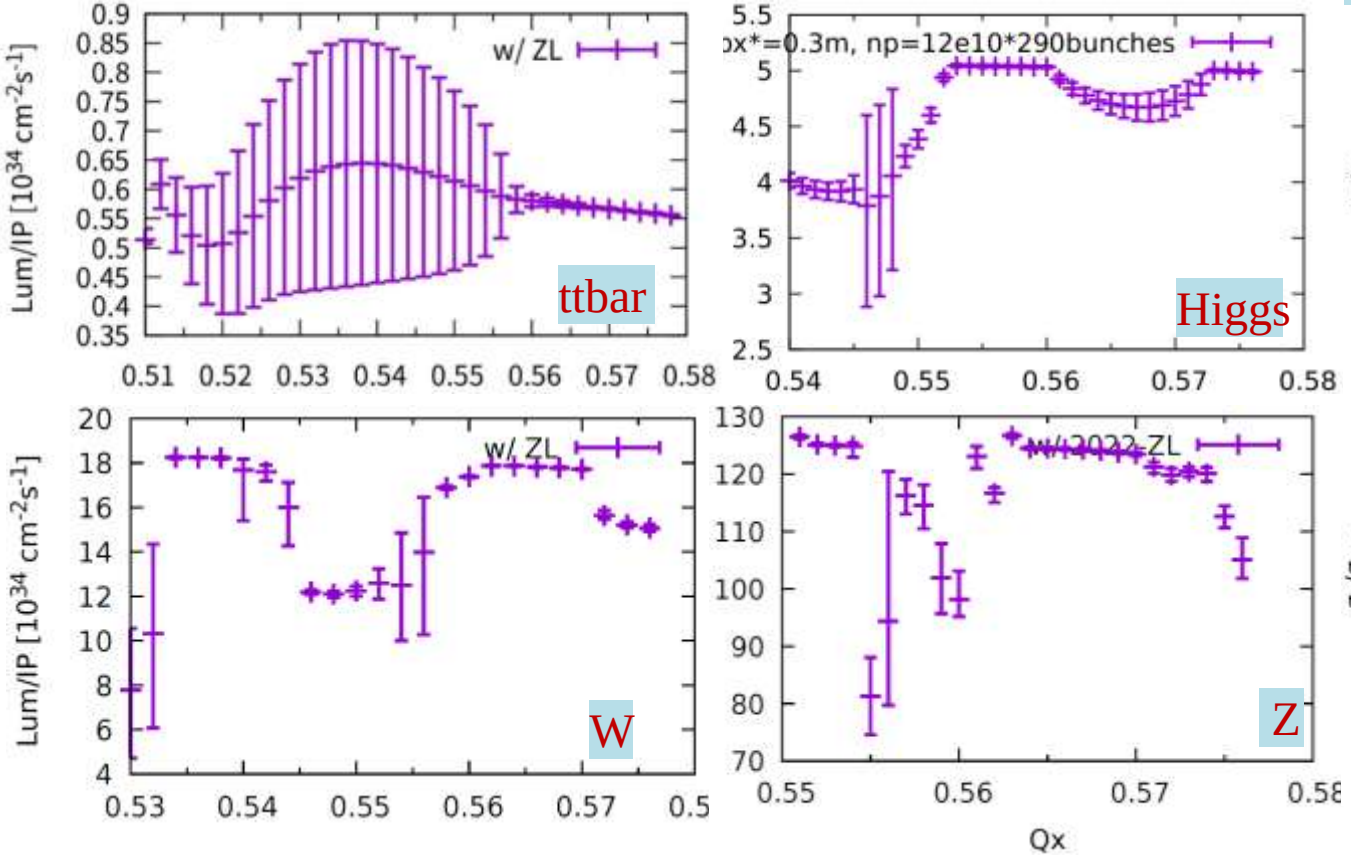
—statistic errors

—seeds

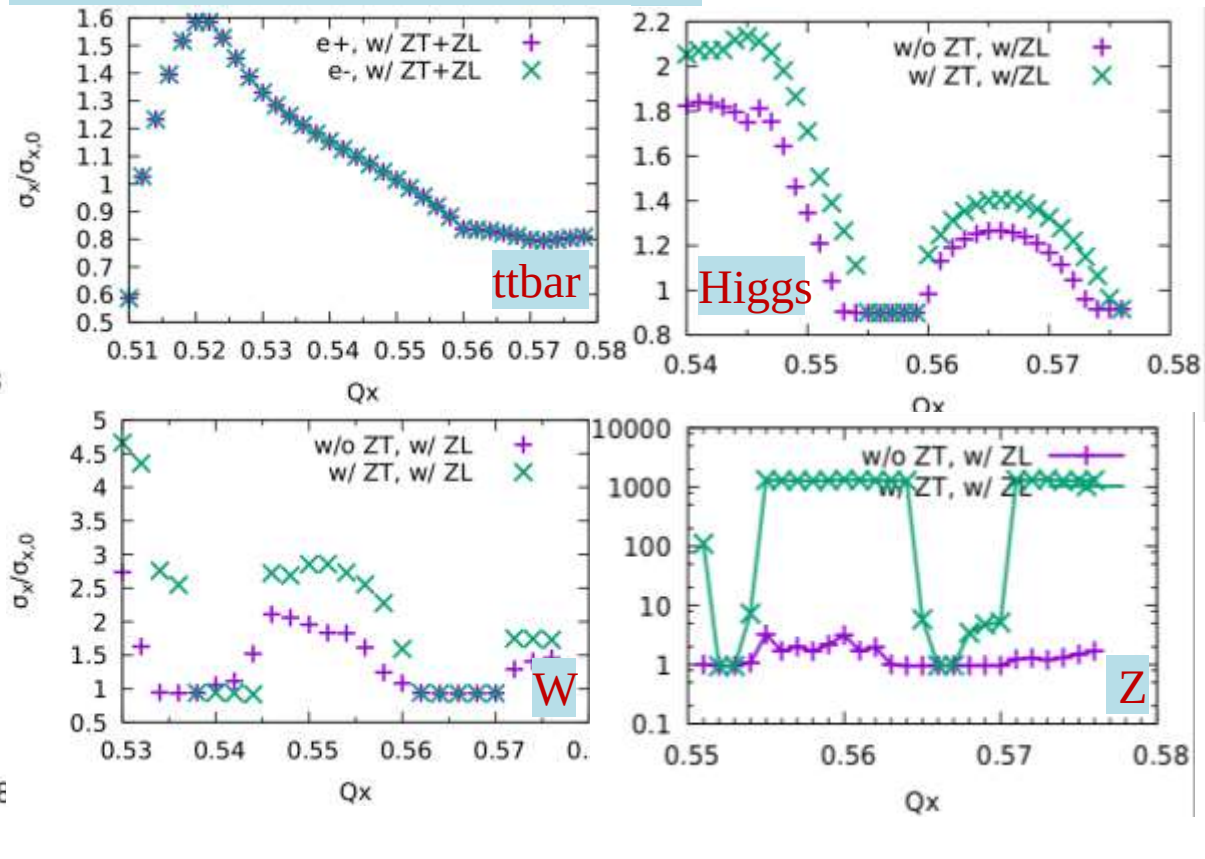
—requirement

Studies of Beam-Beam Effects in CEPC

- Luminosity simulations w/ZL



- Transverse size simulations

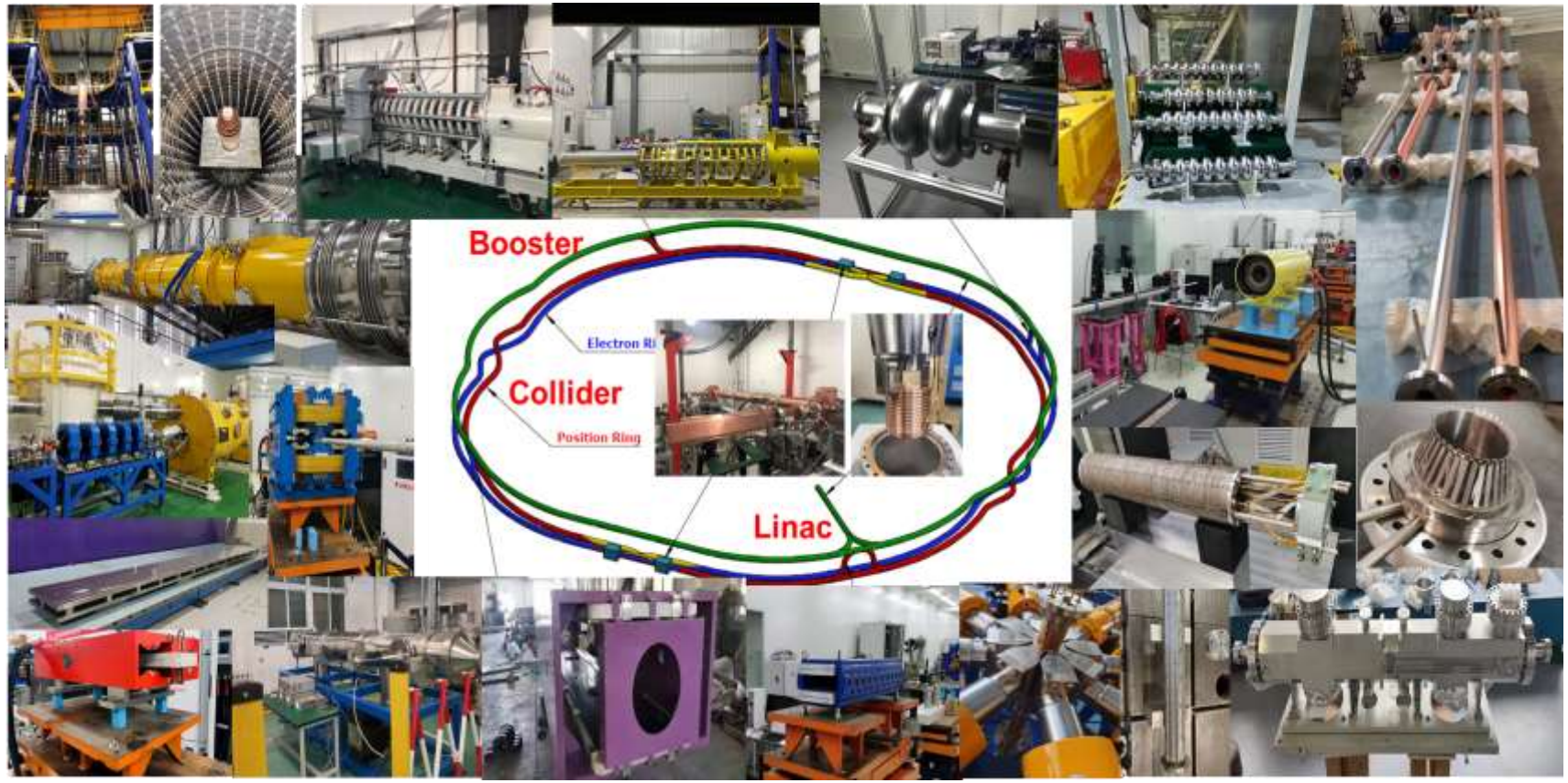


Beam-beam simulation results are consistent with the TDR parameter tables.

- **Luminosity & Lifetime is evaluated by strong-strong simulation**
- **X-Z instability is well suppressed even considering Potential Well Distortion**
- **Lifetime optimization with both beam-beam\lattice nonlinearity is done**

CEPC Key Technology R&D Status in TDR

Specification Met ✓ Prototype Manufactured ✓



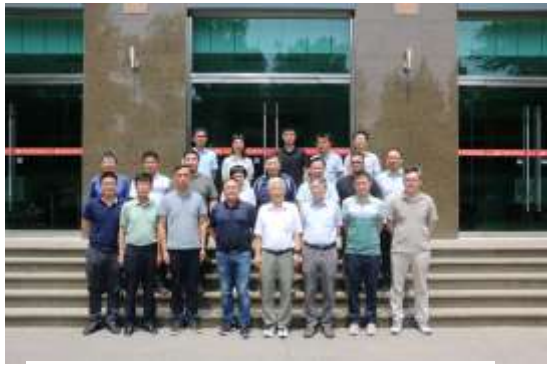
Accelerator	Fraction
✓ Magnets	27.3%
✓ Vacuum	18.3%
✓ RF power source	9.1%
✓ Mechanics	7.6%
✓ Magnet power supplies	7.0%
✓ SC RF	7.1%
✓ Cryogenics	6.5%
✓ Linac and sources	5.5%
✓ Instrumentation	5.3%
✓ Control	2.4%
✓ Survey and alignment	2.4%
✓ Radiation protection	1.0%
✓ SC magnets	0.4%
✓ Damping ring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

Key technology R&D in TDR spans all component lists in CEPC CDR

CEPC Accelerator International TDR Review and Cost Review June 12-16, and Sept. 11-15, 2023, in HKUST-IAS, Hong Kong

CEPC Accelerator TDR Review
June 12-16, 2023, Hong Kong

CEPC Accelerator TDR Cost Review
Sept. 11-15, 2023, Hong Kong

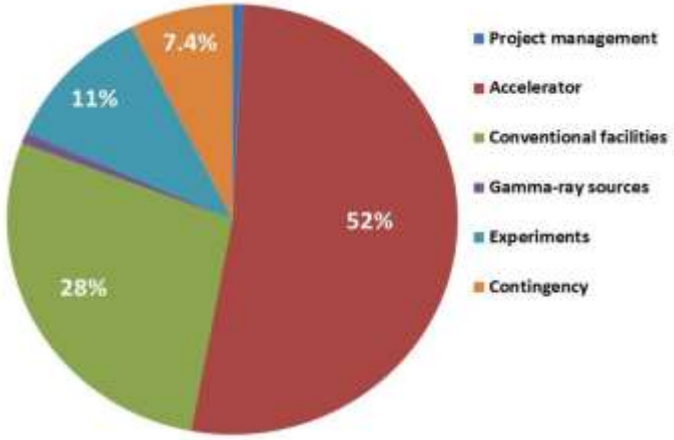


Domestic Civil Engineering
Cost Review, June 26, 2023, IHEP

9th CEPC IAC 2023 Meeting
Oct. 30-31, 2023, IHEP

Table 12.1.2: CEPC project cost breakdown, (Unit: 100,000,000 yuan)

Total	364	100%
Project management	3	0.8%
Accelerator	190	52%
Conventional facilities	101	28%
Gamma-ray beam lines	3	0.8%
Experiments	40	11%
Contingency (8%)	27	7.4%



Distribution of CEPC Project total TDR cost of **36.4B RMB (~5.2USD)**

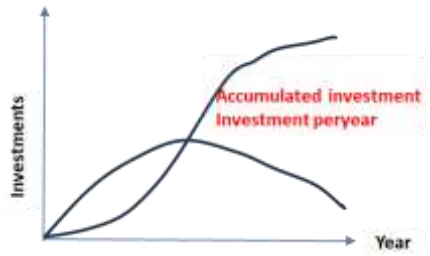
CEPC accelerator TDR has been completed and formally released on December 25, 2023:
http://english.ihep.cas.cn/nw/han/y23/202312/t20231229_654555.html
CEPC accelerator TDR has been published formally in Journal Radiation Detection Technology and Methods (RDTM) on June 3, 2024:
DOI: 10.1007/s41605-024-00463-y
https://doi.org/10.1007/s41605-024-00463-y

CEPC Milestones, Timeline and Human Resources

Year	2012	2013	2015	2017	2018	2023	2025	2027	2030	2035
Human resources (TFE)		~50			~100	~200	~300	~500	~2800	~2500

Year	Accelerator human resource	Accumulated accelerator spending Billion RMB
2015	50	-
2018	100	-
2023	200	0.2
2025	300	0.3
2027	500	0.4
2031	2800	9
2035	2500	20

CEPC kickoff meeting in Sept. 2013



CEPC detector reference design
Will be completed by June 2025

2025

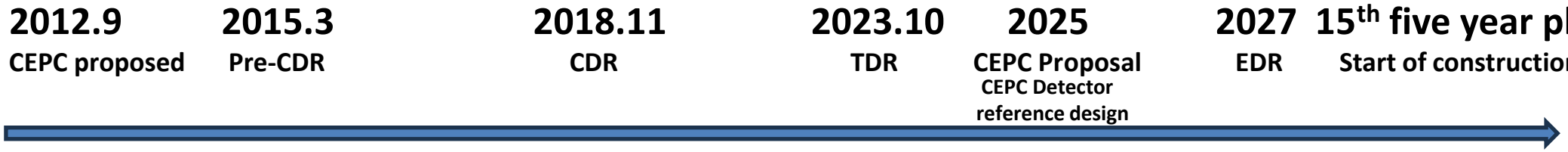
Proposal (2025) for CEPC entering 15th five year plan

36.4B RMB
Total construction

CEPC EDR site study and civil engineering design

2012.9	2013.9	2015.3	2017.4	2018.11	2023.12	2024 ~ 2027	~2035
CEPC proposed		Pre-CDR	Progress report	CDR	TDR	EDR start of construction	Completion

CEPC Engineering Design Report (EDR) Goal



CEPC EDR Phase General Goal: 2024-2027

After completion CEPC accelerator TDR in 2023, CEPC accelerator will enter into the Engineering Design Report (EDR) phase (2024-2027), which is also the preparation phase with the aim for CEPC proposal to be presented to and selected by Chinese government around 2025 for the construction start during the "15th five year plan (2026-2030)" (for example, around 2027) and completion around 2035 (the end of the 16th five year plan).

CEPC EDR includes accelerator and detector (TDRrd)
CEPC detector TDR reference design (rd) will be released by June 30, 2025

CEPC Accelerator EDR Phase goals, scope and the working plan (preliminary) of 35 WGs summarized in a documents of 33 pages to be reviewed by IARC in Spet. 18-20, 2024

CEPC Magnet Automatic Production Line in EDR

Mei Yang/Wen Kang

4 booster magnets fabricated per day

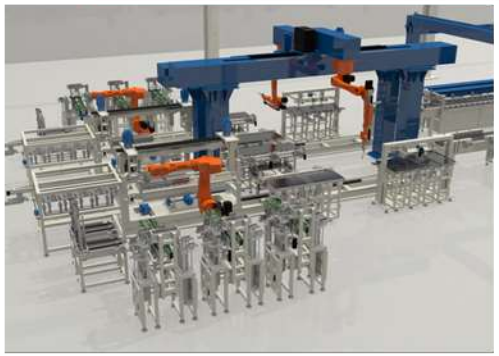
~15000 dipole magnets in the CEPC booster

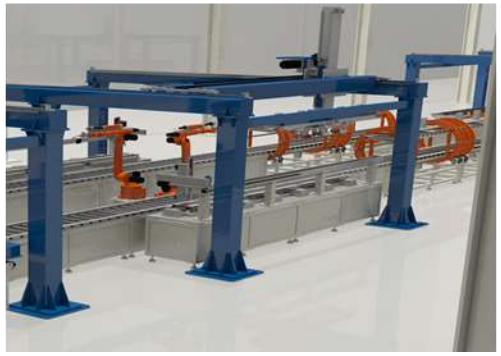
Stacking of 1/3 length core

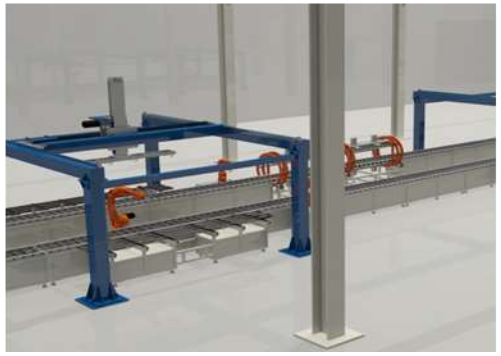
Production of full length cores

Assembly of the magnet

Field measurement of the magnet



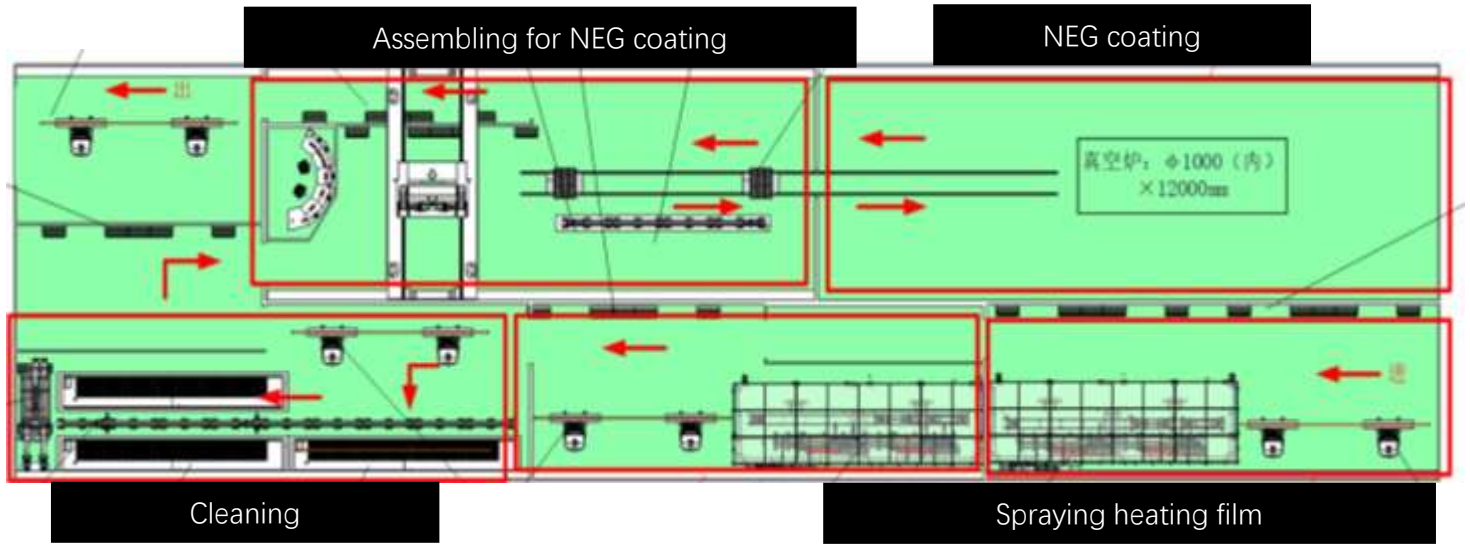




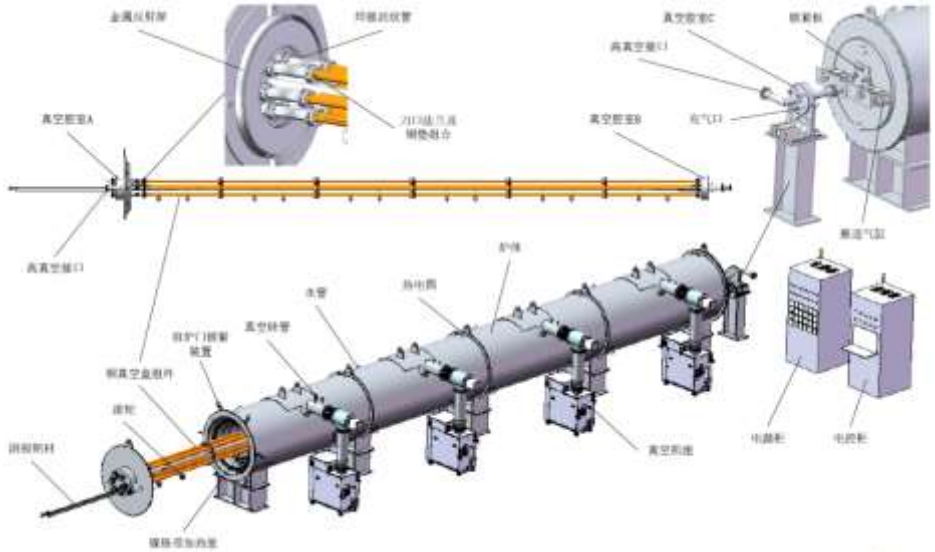
Plan：Middle of 2024 design completed，To be completed in 2025

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

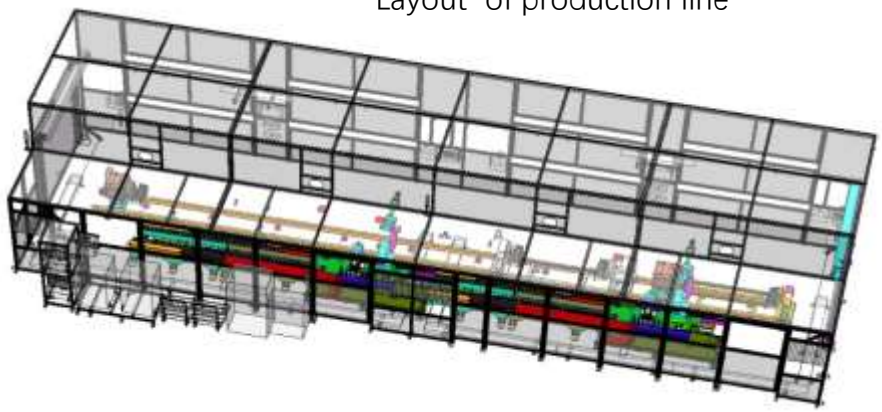
Yongsheng Ma



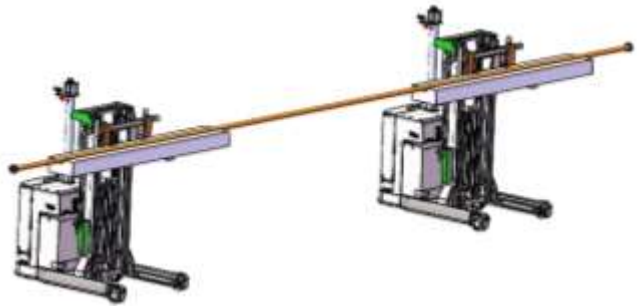
Layout of production line



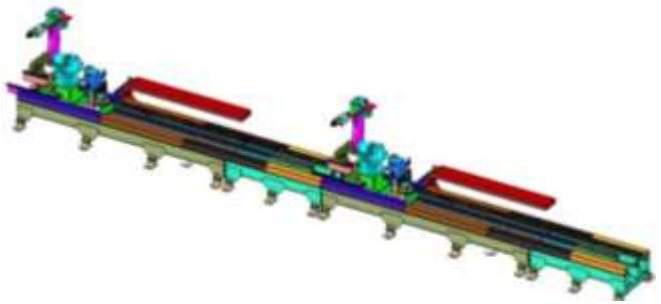
NEG coating facility by horizontal method



Production line of NEG coating, spraying



AGV(Automatic Guided Vehicle) transport

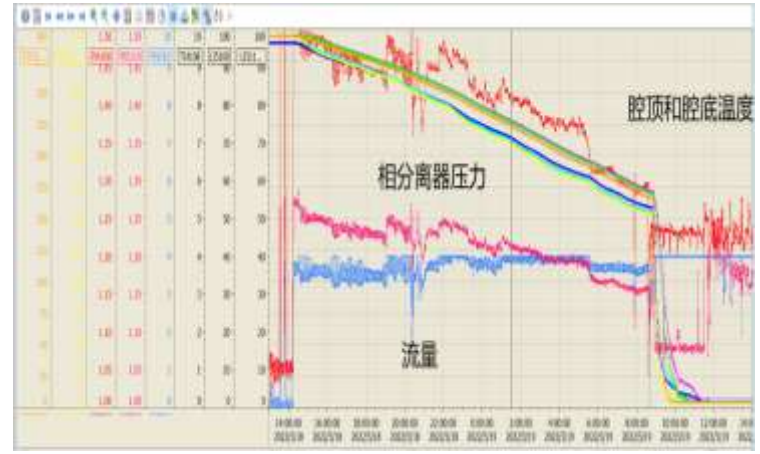


7-axis robot for assembling

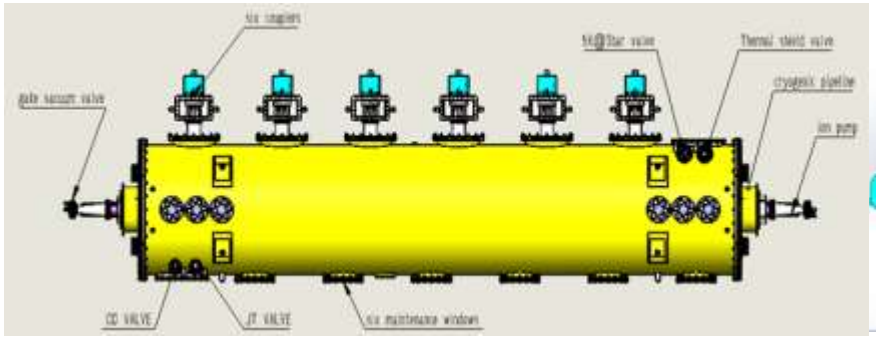
Plan：Middle of 2024 design completed. Technical design review will be done soon.
To be completed in 2025

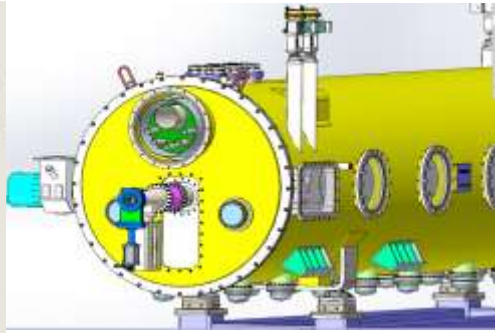
CEPC Accelerator SRF Development in EDR

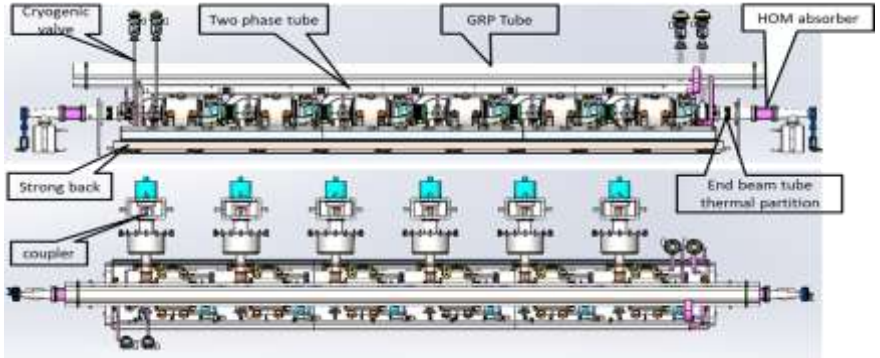
Jiyuan Zhai/Peng Sha



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

Plan：To be completed in 2025

CEPC Accelerator Main EDR Development: Klystrons

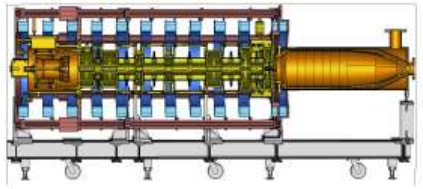
Zusheng Zhou

Klystron R&D

Klystron No. 1
Efficiency 65%
(2020)

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

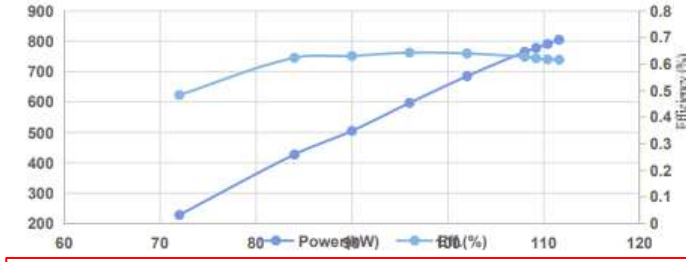
Klystron No. 2
Efficiency 77%
(2021)

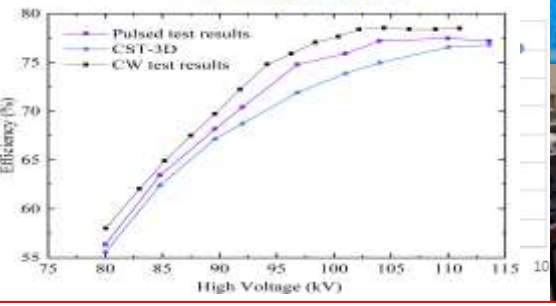


78.5%@803kW CW in 2024

Klystron No. 3 （MBI
Efficiency 80.5%
To be completed in 2024

High Voltage vs. Power&Efficency

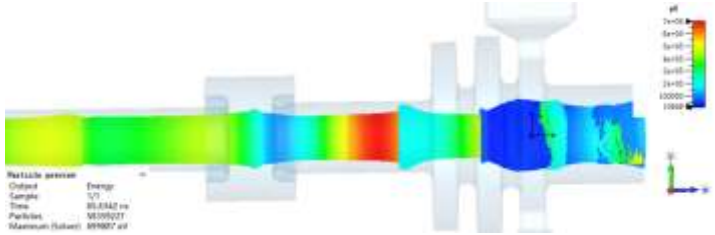


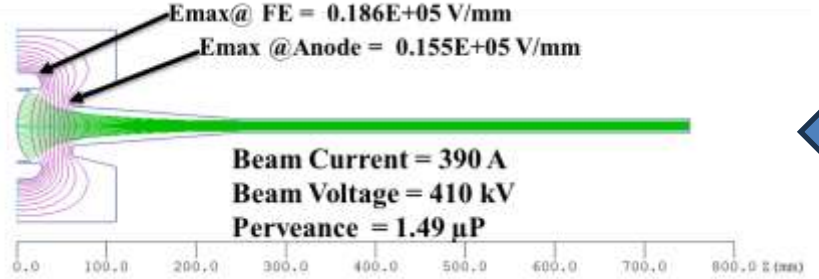


CEPC collider ring 650MHz klystron development in TDR phase

Parameters	Value
Frequency	5720 MHz
Output Power	80MW
Pulsed width	2.5us
Repetition rate	100Hz
Gain	54 dB
Efficiency	47%
$3dB$ bandwith	±5MHz
Beam voltage	420 kV
Beam current	403 A
Focusing field	0.28 T

C band 5720MHz 80MW Klystron

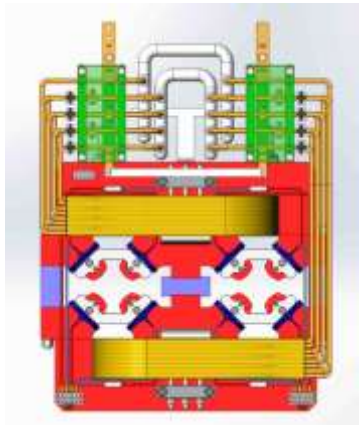


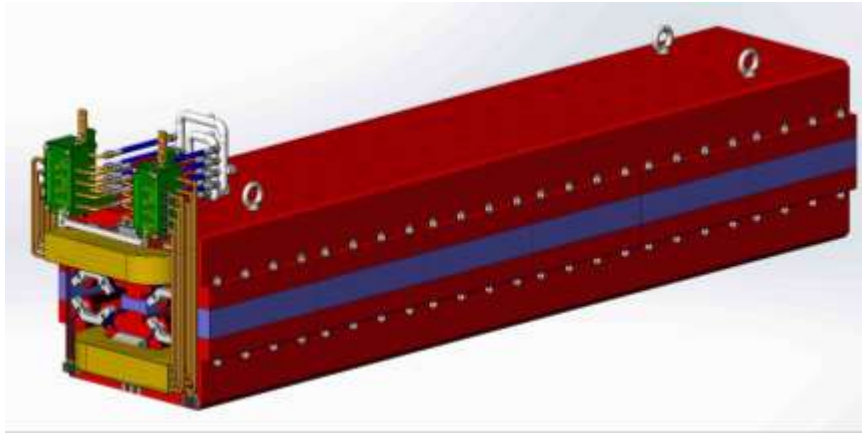


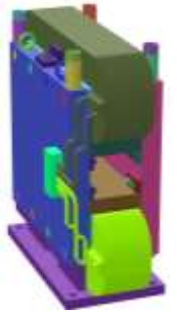
C band 5720MHz 80MW Klystron design completed

Technical assessment has been done on August 12, 2024, start construction Soon, to be completed on 2025

CEPC Collider Ring Magnets in EDR

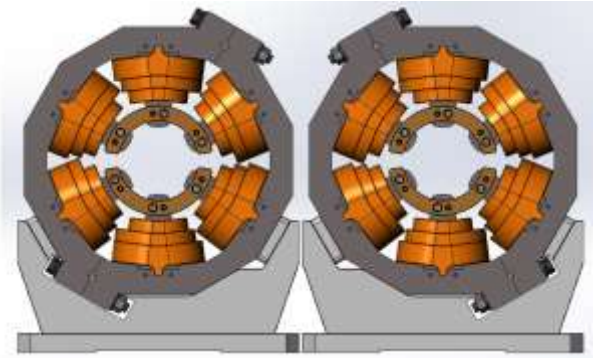


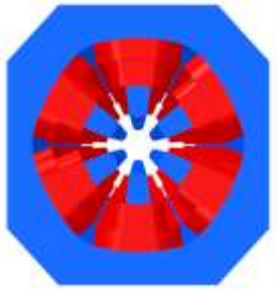


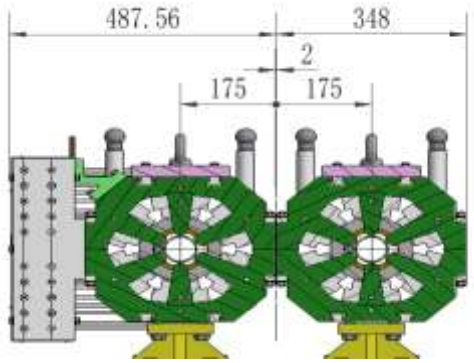


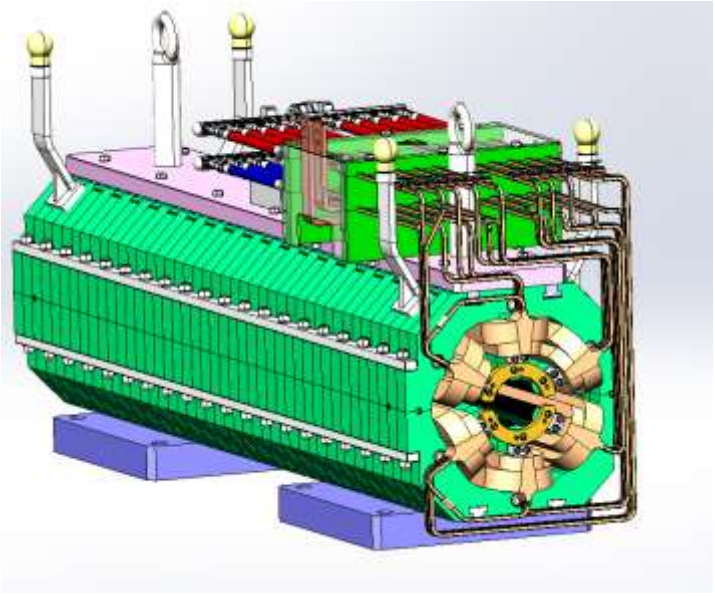
Correctors: mechanical design completed

Dual aperture quadrupole: block iron core and new cooling and power line design in EDR







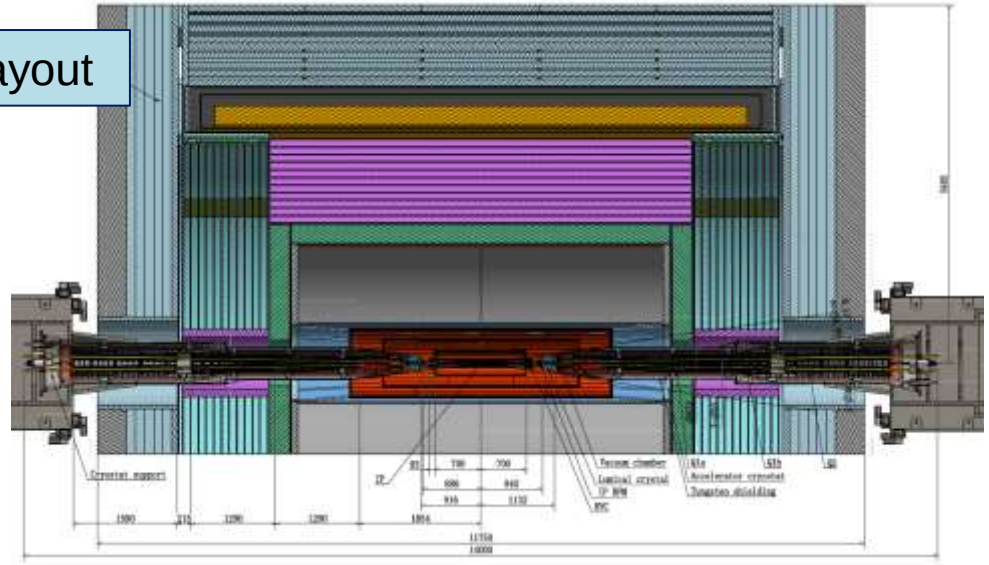


Sextupole magnets under design

CEPC MDI in EDR

Sha Bai

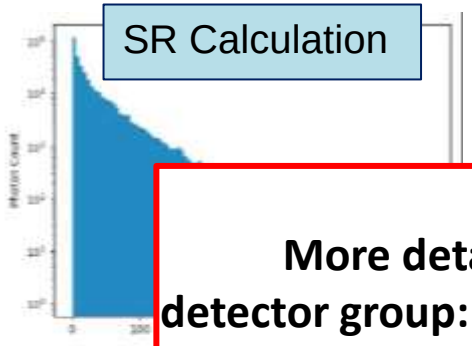
MDI Layout



General Parameters

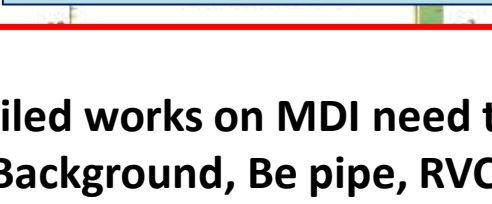
					length	Beam stay clear region	Min. distance between apertures	Beam pipe inner diamete r	Beam pipe outer diameter	Critical energy (Hor.)	Critical energy (Vert.)	SR power (Hor.)	SR power (Vert.)
L*	0~1.9m				1.9m								
Crossing angle	33mrad												
MDI length	±7m												
Acc. components in opening angle	8.11°												
QDa/QDb		3.5/2.8T	142/85T/m		1.21m	14.9/18.2mm	62.71/105.28mm	20/23mm	26/29mm	724.7/663.1keV	396.3/263.6eV	212.2/239.23W	99.9/42.8W
QF1		3.3T	96.7T/m		1.5m	24.48mm	155.11mm	32mm	38mm	675.2keV	499.4keV	472.9W	135.1W
Lumical	0.65~1.11m				0.16m								
Anti-solenoid before QD0		8.6T			1.1m								
Anti-solenoid QD0		3T			2.5m								
Anti-solenoid QF1		3T			1.5m								
Beryllium pipe					±85mm			20mm					
Last B upstream	64.97~153.5m			0.77mrad	88.5m					33.3keV			
First B downstream	44.4~102m			1.17mrad	57.6m					77.9keV			
Beampipe within QDa/QDb					1.21m							1.19/1.31W	
Beampipe within QF1													

SR Calculation



Radiation background

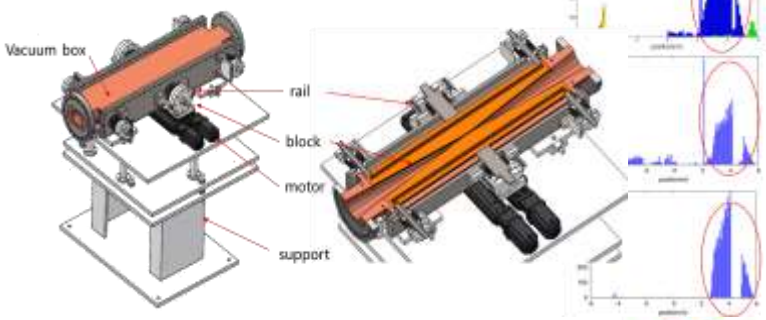
Radiative barbar, Beam-Gas, beam thermal photon scattering



Injection background

Radiation Mitigation

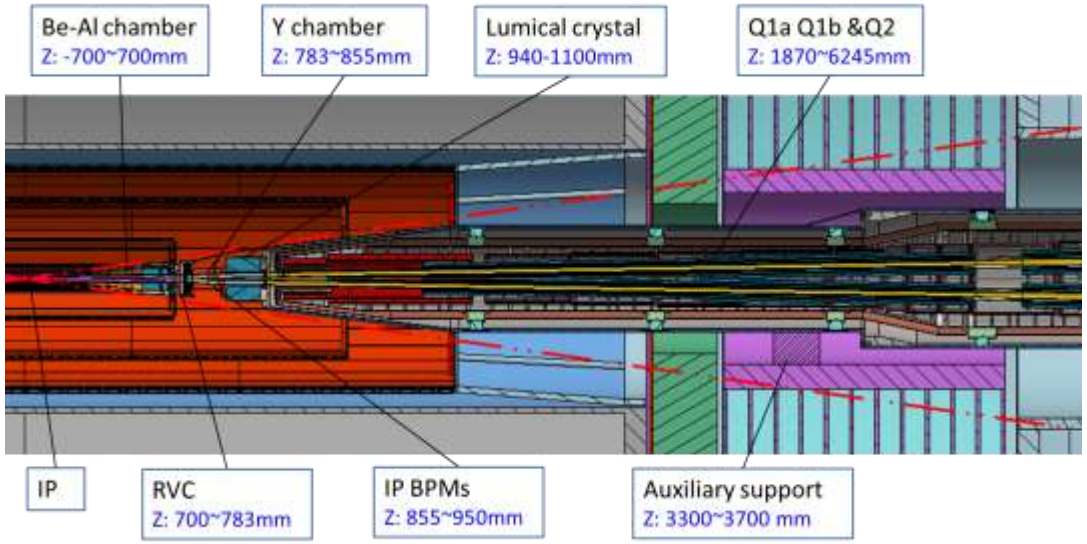
Masks, collimators, shielding



More detailed works on MDI need to be done in EDR together with detector group: Background, Be pipe, RVC, integration, alignment, mechanics,…

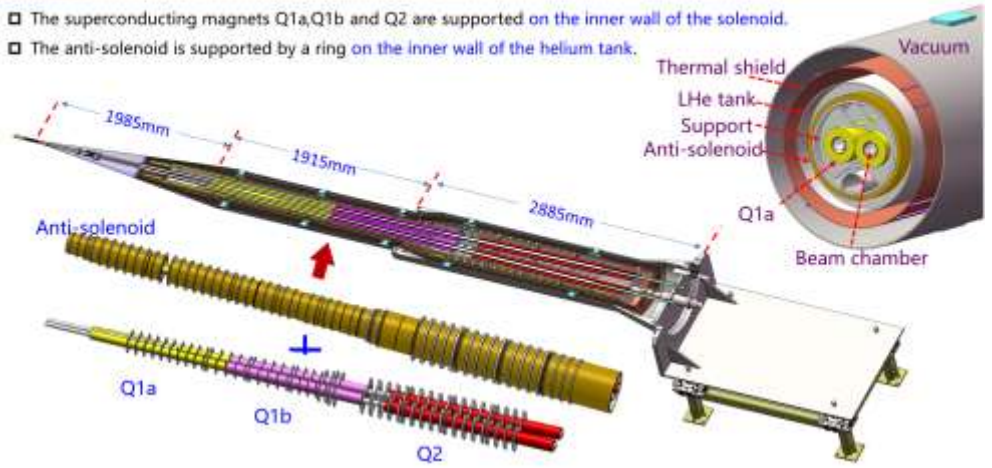
CEPC MDI Development in EDR

Haijing Wang, Yinshun Zhu
Rui Ge/Mei Li

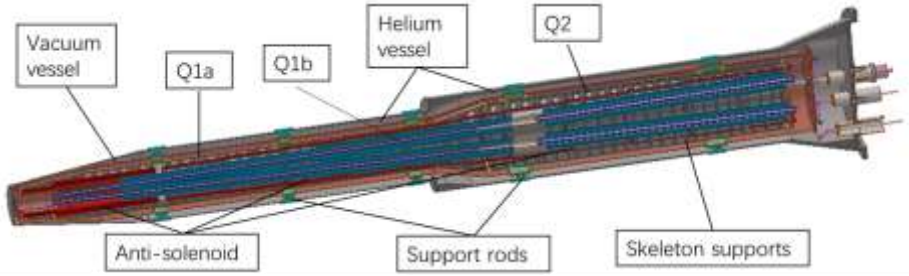


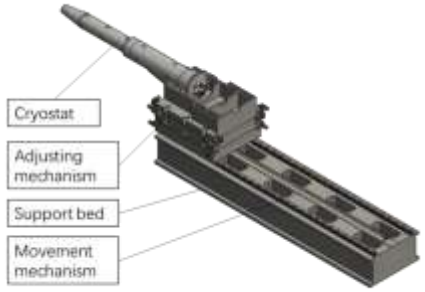
Structural Design of the SC Quadupole Cryostat and Support

- The superconducting magnets Q1a,Q1b and Q2 are supported on the inner wall of the solenoid.
- The anti-solenoid is supported by a ring on the inner wall of the helium tank.



CEPC SC Quadrupole Magnet Design with CCT Coil





Design parameters of Q1a, Q1b, Q2 magnet with CCT coil @ Higgs mode

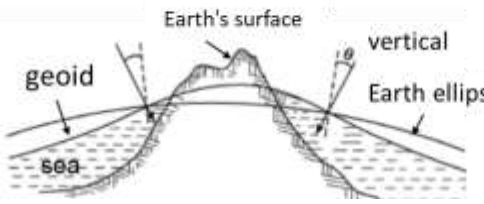
Magnet name	Q1a	Q1b	Q2
Field gradient (T/m)	142.3	85.4	96.7
Magnetic length (mm)	1.21	1.21	1.5
Excitation current (A)	780	650	770
Conductor (HTS or LTS)	0.8 or 0.7mm in diameter		
Maximum dipole field in aperture (Gs)	226	124	127
Stored energy (KJ)	16.7	15.2	22.9
Peak field in coil (T)	4.3	3.4	4.5
Integrated field harmonics	$<2\times10^{-4}$		
(Single aperture) Coil inner radius (mm)	20	26	31
(Single aperture) Coil outer diameter (mm)	30.5	39	44
Magnet mechanical length (m)	1.22	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		

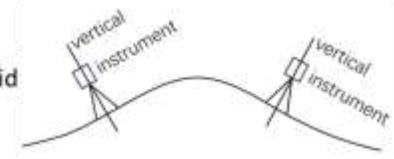
CEPC Alignment and Installation Plan in EDR

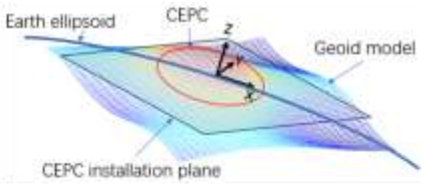
- Alignment accuracy requirement

Component	Δx (mm)	Δy (mm)	$\Delta\theta_z$ (mrad)
Dipole	0.10	0.10	0.10
Arc Quadrupole	0.10	0.10	0.10
IR Quadrupole	0.10	0.10	0.10
Sextupole	0.10*	0.10*	0.10

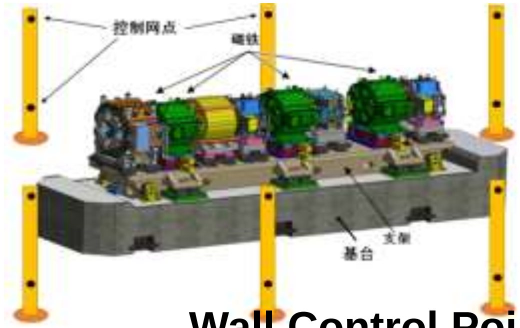
*implement beam-based alignment





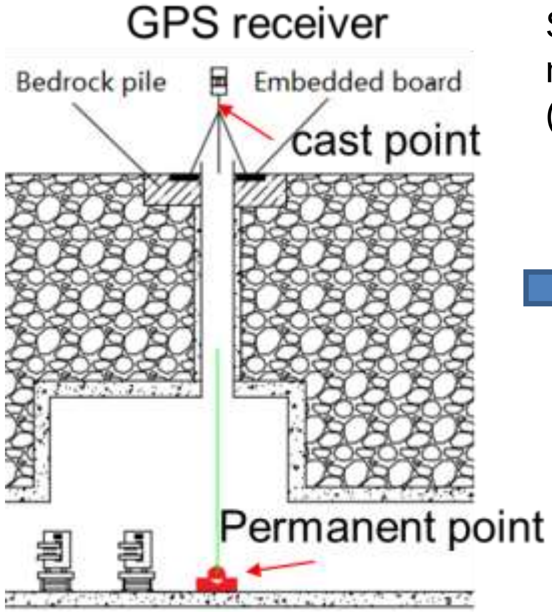


Component Pre-alignment

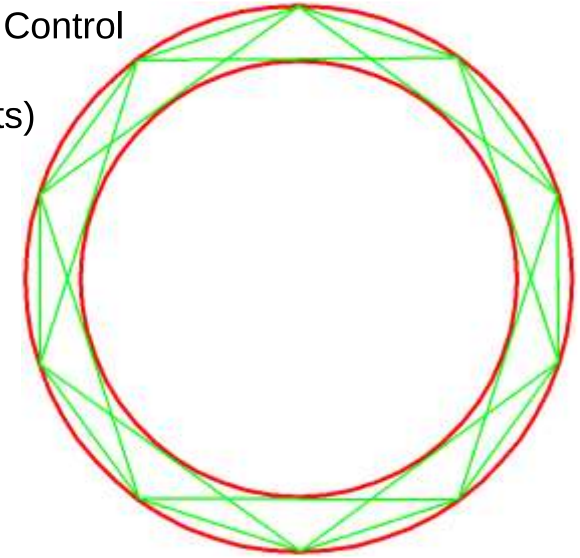


Wall Control Point

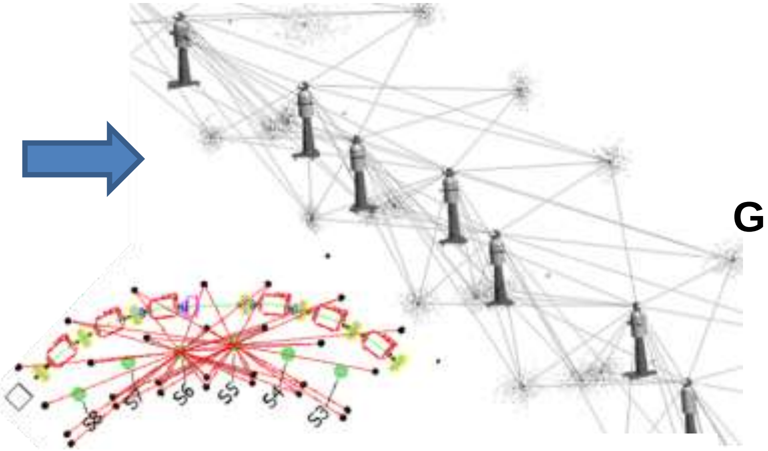
Ground Control Point



Surface Control network (14Points)

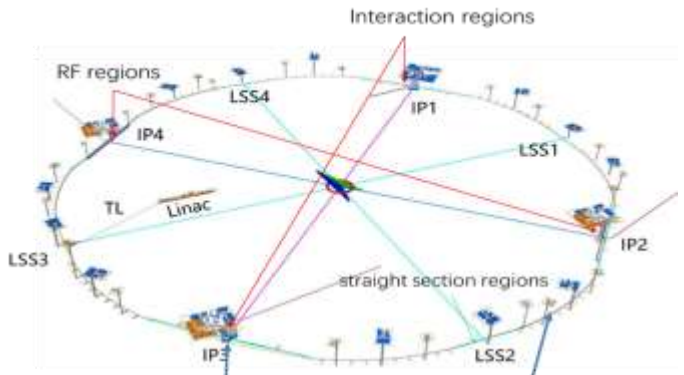


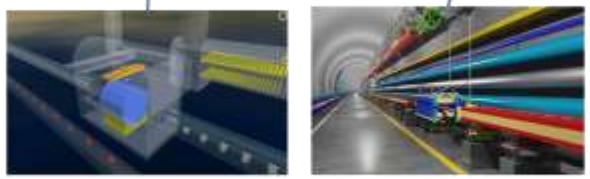
Backbone Control network
(short line:300m, long line 600m)



Tunnel Control network
(interval of 6 meters)

CEPC Installation Strategy Study in EDR

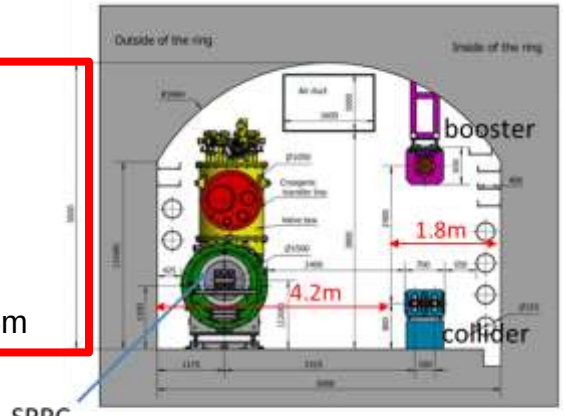




Detector

Ring

Linac: 1.6km
TL:1.5km
Circumference of ring tunnel:100km
Collider：100km
Booster：100km
Tunnel cross section：6X5m



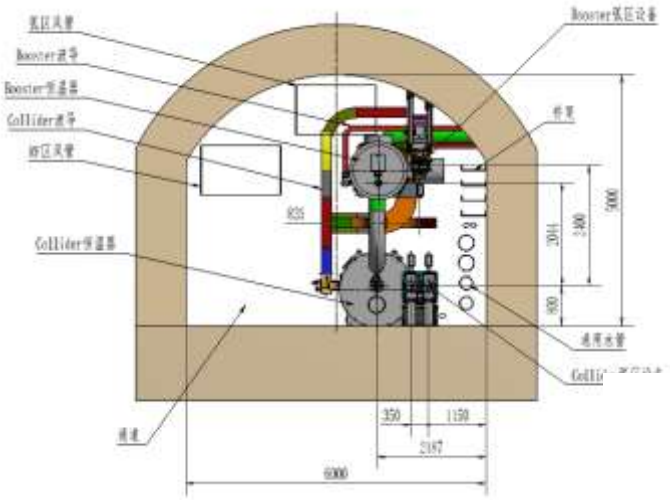
Tunnel cross section

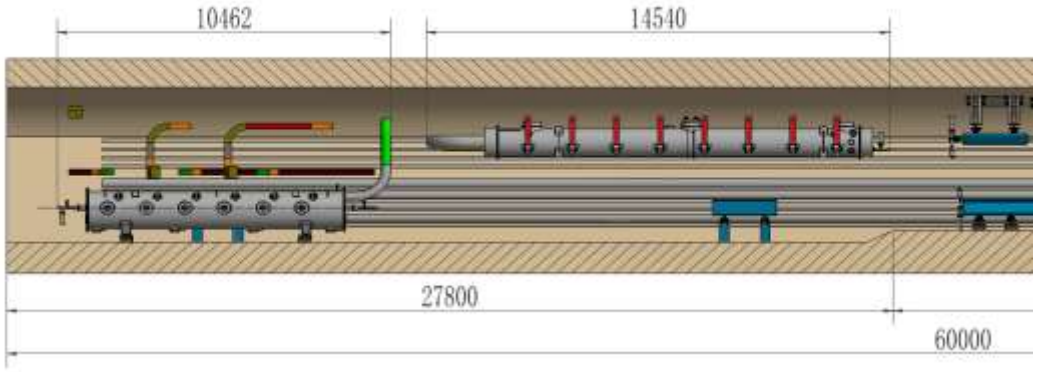
CEPC component list and quantities

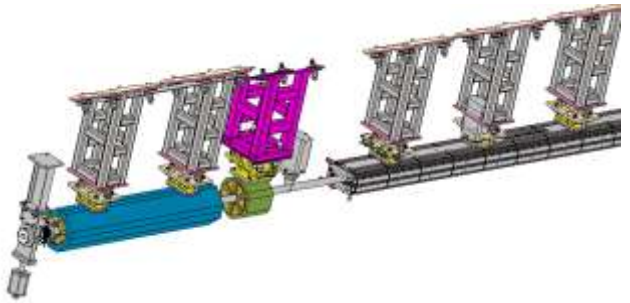
Component	Collider Ring	Booster	Linac, DR, TL	Total
Dipole	16258	14866	135	31259
Quadrupole	4148	3458	714	8320
Sextupole	3176	100	72	3348
Corrector	7088	2436	275	9799
BPM 、 PR 、 DCCT 、 kicker	3544	2408	180	6132
Septum Magnet	68	32	2	102
Kicker	8	8	2	18
Cryomodule	32	12		44
Electrostatic separator	32			32
Collimator dump	36		8	44
Superconducting Magnets	4			4
Solenoid			37	37
Accelerating structure			577	577
Cavity			4	4
Electron Source			1	1
Positron Source			1	1
Detector	2			2
Total	34396	23320	2008	59724

CEPC Tunnel Mockup for Installation in EDR

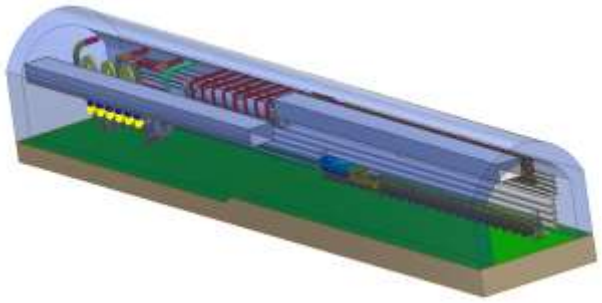
Haijing Wang

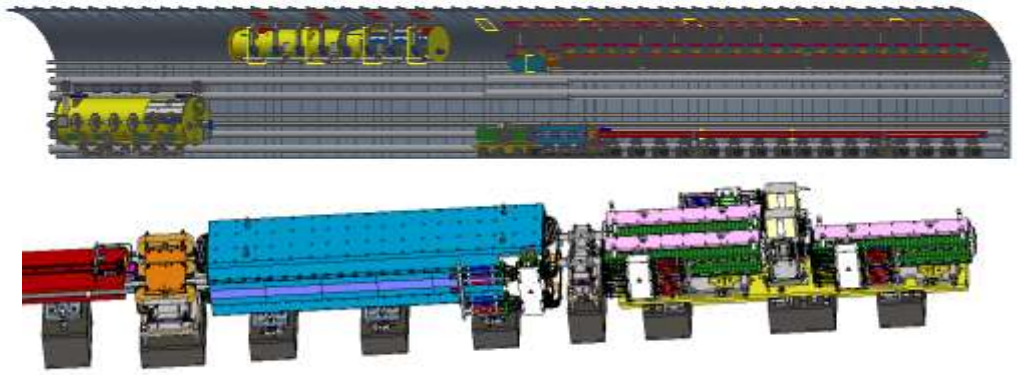


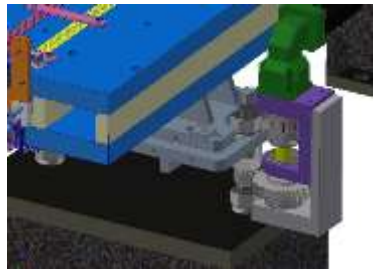


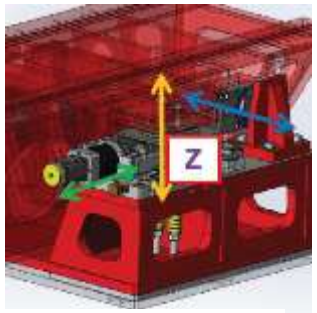


Booster magnets installation









Collider ring magnets supports

A 60 m long tunnel mockup, including parts of arc section and part of RF section

To demonstrate the inside tunnel alignment and installation, especially for booster installation on the roof of the tunnel

Technical review has been done on August 16, 2024, and construction will start soon

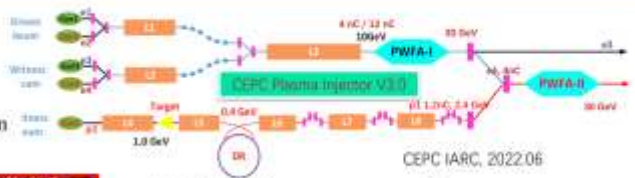
Plan：to be completed in mid of 2025

Advanced Technologies Development in Progress

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

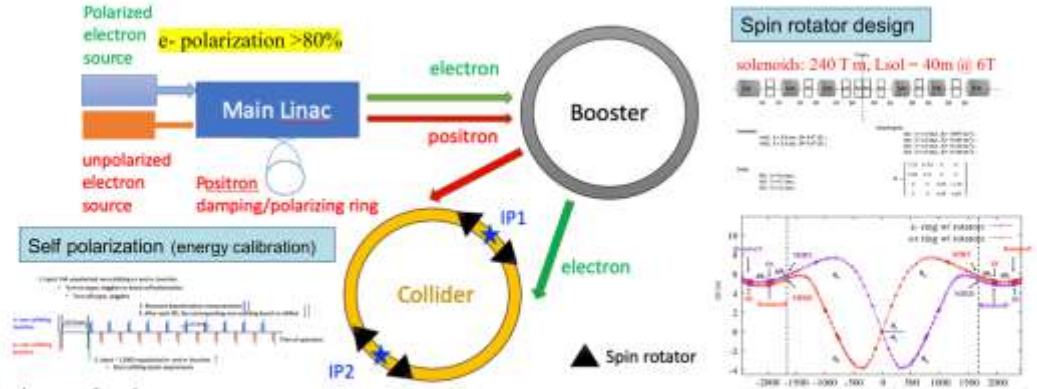


Phase I (YearD-Year2)
1. Re-design and install transport beamline, optimise the e- / e+ beam quality
2. Clean room and high power installation200TW
3. Beam instrumentation
4. RF Gun platform
5. Commissioning systems

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

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

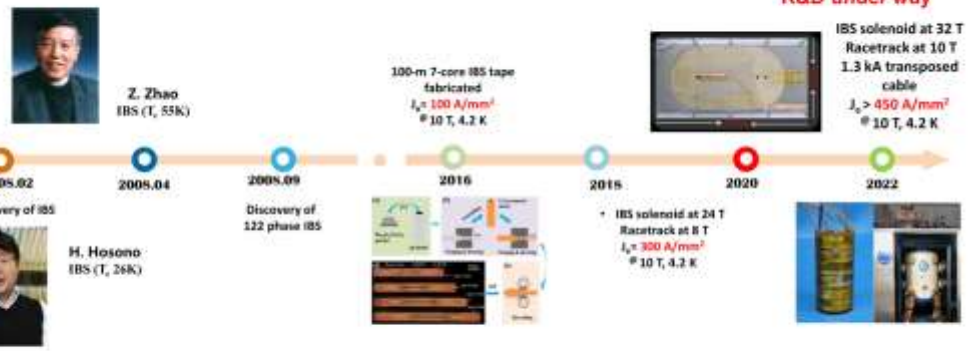
CEPC Polarized Beam Studies(alternative option)



Key issues of study:
- Energy calibration in collider ring with transverse polarization (self polarization & inj. polarization)
- Longitudinal polarization for collision
- Polarization beam injection, positron polarization and ramping in booster

Key technology development for polarized electron beam generation, measurement and manipulation have been started

IBS Technology for High Field Magnets

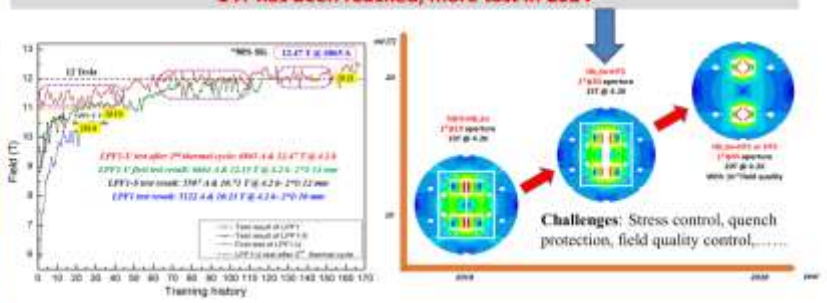


J_e of IBS expected to be similar as ReBCO in 2020s with better mechanical properties and lower cost, ready for mass applications in ultra high field magnets

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

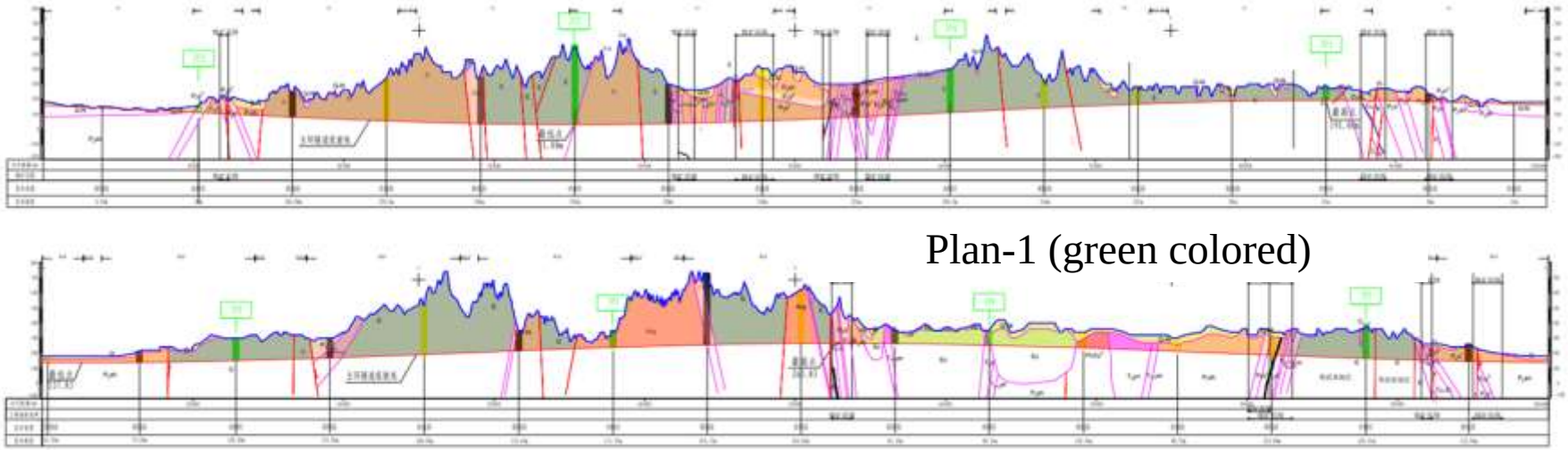
Picture of LPF1-U



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

CEPC EDR Selection and Civil Engineering Design Progresses

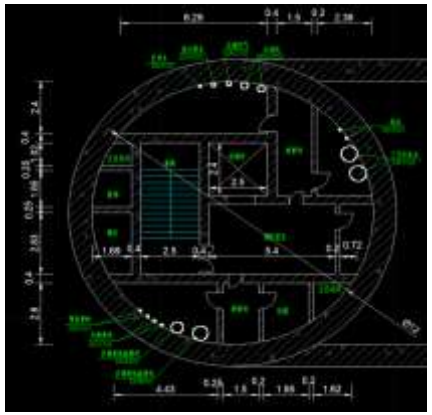
Preliminary EDR site selection report (completed)
And detailed site geological study will start soon in 2024



Plan-1 (green colored)

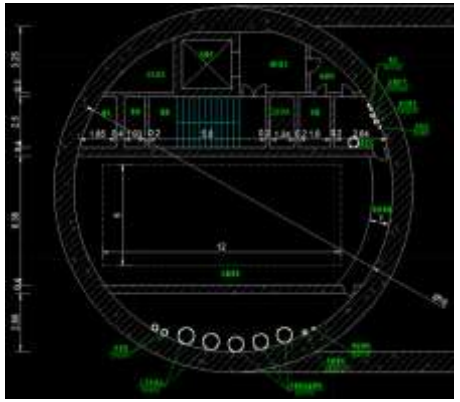
Plan-4 (bleu colored)

The number of shafts is under optimization



Experimental region shaft cross section design

Arc region shaft cross section design

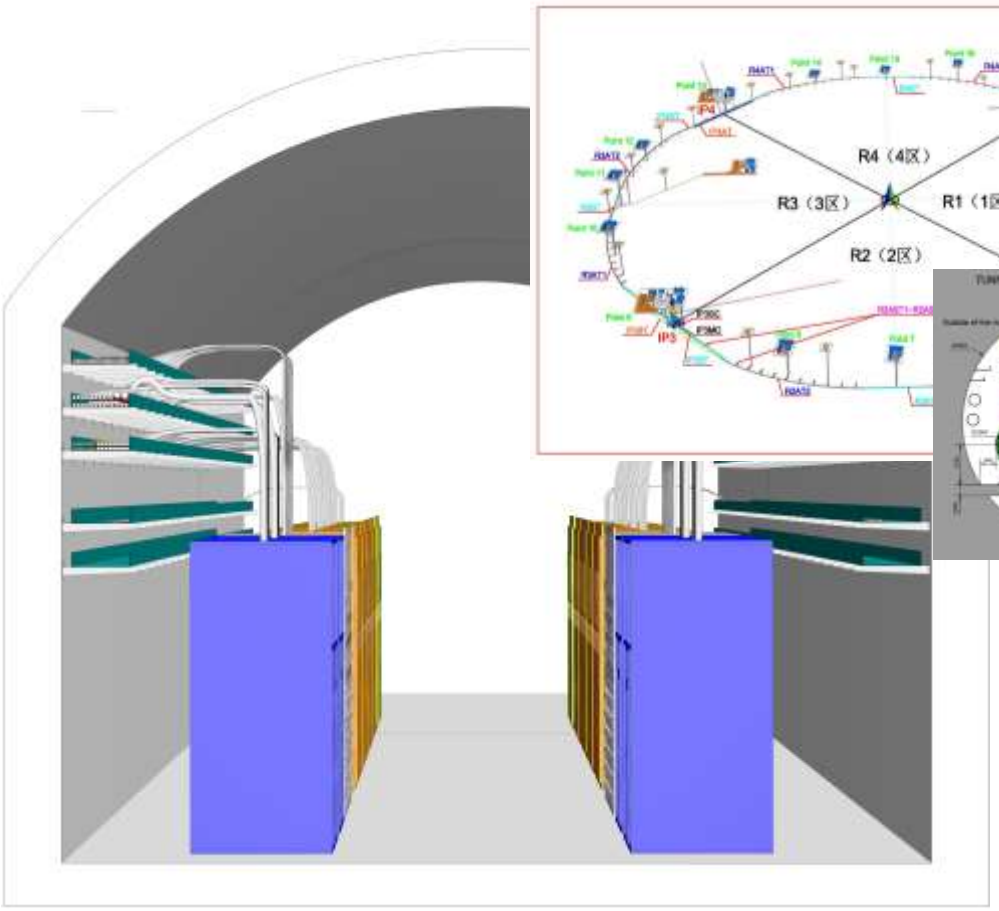


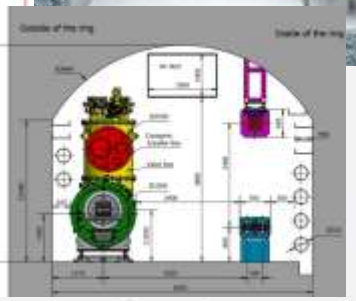
SRF region shaft cross section design

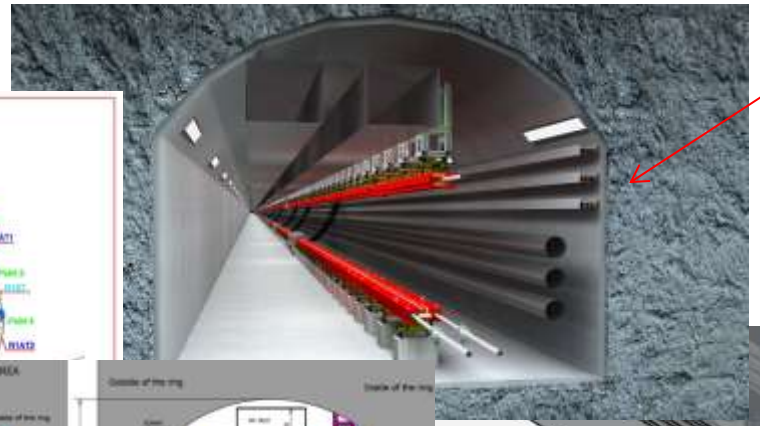
On site geological investigation

CEPC Conventional Facility and Civil Engineering in EDR

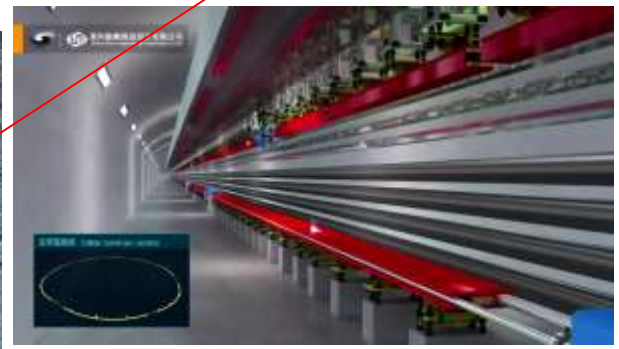
Electrical Equipment General Layout in Auxiliary Tunnel/500m along 100km







Cables installed!

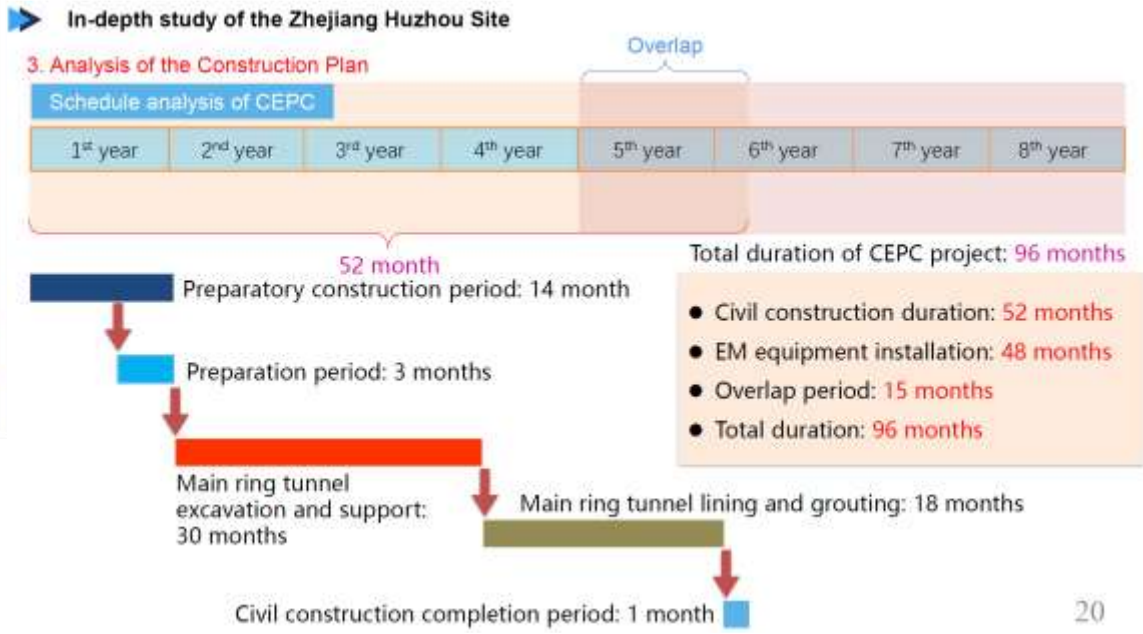


CEPC Site Implementation and Construction Plans

CEPC site implementation plan in EDR

The EDR site selection and the site dependent civil engineering design works has been started.

CEPC construction plan



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)

Potential international collaborating suppliers worldwide

CEPC Industrial Preparation

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.

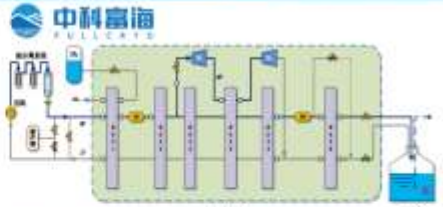
-The super large horizontal cold box with a length of 28m and a diameter of 4.2m achieves ultra-high vacuum and extremely low leakage.

-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.

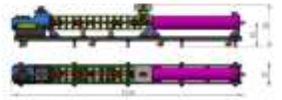
-Expected Goals: Achieving 3 operational mode adjustments: the cooling capacity ≥ 18kW@4.5K; the cooling capacity in the superfluid helium temperature range ≥4kW@2K.



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

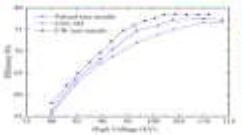
CEPC 650MHz 800kW CW High Efficiency Klystrons

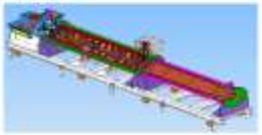
国力研究院 CUOLI INSTITUTE (CIPC member)



Preliminary mechanical design for UHFKP8001

78.5%@803kW CW in August 18, 2024

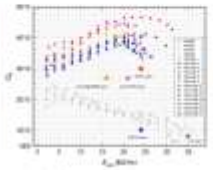




Kunshan National Research Institute has successively developed **650MHz/800KW klystron sample tubes, 650MHz/800KW high-efficiency klystron sample tubes, 648MHz pulse klystron tubes, 650MHz/800KW multi-injection klystron beam tubes**, and the latest 324MHz pulse klystron tubes Electro vacuum products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

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

高能祝新 (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
2014 Fermilab - LCLS II
RRR300 Nb: 5 tons, 50% of the project
2017 INFN and STFC - ESS
RRR300 Nb: 12.5 tons, 100% of the project
2019 IBS - RISP, CERN - HL-LHC, Fermilab - PIP-II, Shanghai - SHINE
RRR300 niobium material procurement in progress
We had built the business relationship with many great customers such as DESY, MSU, Fermilab, JLAB, INFN, STFC, CERN, TRIUMF, RI, ZANON, IHEP, IBS, RRCAT etc.

High RRR Nb sheet

High RRR Nb ingod

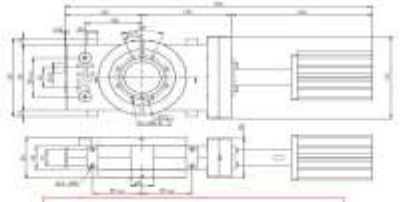
High RRR large grain Nb

CEPC booster and colliders: 2GeV 1.3GHz and 650MHz SRF accelerators (Higgs); 10GeV 1.3GHz and 650MHz SRF accelerators (ttar)

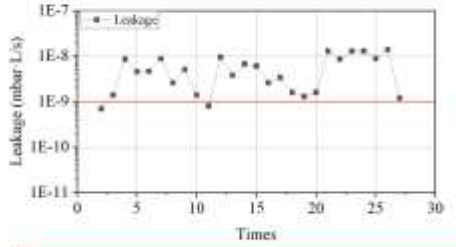
RF Shielding all Metal Gate Vacuum Valve

日揚科技

- 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 in Synergy with other Accelerator Projects in China

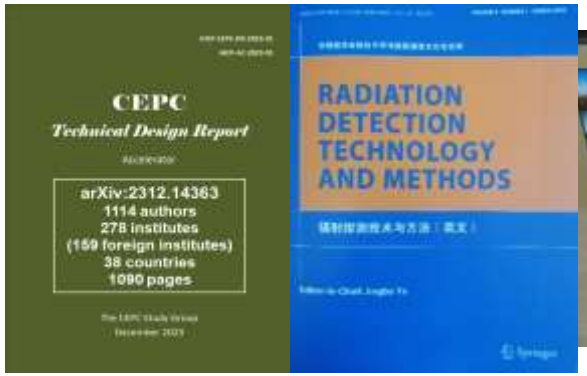
Project name	Machine type	Location	Cost (B RMB）	Completion time
CEPC	Higgs factory Upto ttar energy	Led by IHEP, China	**36.4 (where accelerator 19)**	Around 2035 (starting time around 2027)
BEPCII-U	e+e-collider 2.8GeV/beam	IHEP (Beijing)	**0.15**	2025
HEPS	4th generation light source of 6GeV	IHEP (Huanrou)	**5**	2025
SAPS	4th generation light source of 3.5GeV	IHEP (Dongguan)	**3**	2031 (in R&D, to be approved)
HALF	4th generation light source of 2.2GeV	USTC (Hefei)	**2.8**	2028
SHINE	Hard XFEL of 8GeV	Shanghai-Tech Univ., SARI and SIOM of CAS (Shanghai)	**10**	2027
S3XFEL	S3XFEL of 2.5GeV	Shenzhen IASF	**11.4**	2031
DALS	FEL of 1GeV	Dalian DICP	**-**	(in R&D, to be approved,)
HIAF	High Intensity heavy ion Accelerator Facility	IMP, Huizhou	**2.8**	2025
CIADS	Nuclear waste transmutation	IMP, Huizhou	**4**	2027
CSNS-II	Spallation Neutron source proton injector of 300MeV	IHEP, Dongguan	**2.9**	2029

The total cost of the accelerator projects under construction:39B RMB more than CEPC cost of 36.4B RMB

CEPC International Collaboration-1

CEPC attracts significant International participation and collaborations

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



- More than 20 MoUs have been signed with international institutions and universities
- CEPC International Workshop since 2014
- EU-US versions of CEPC WS since 2018
- Annual working month at HKUST-IAS (mini workshops and HEP conference) since 2015

CEPC International Collaboration-2

HKIAS23 HEP Conference, Feb. 14-16, 2023
https://indico.cern.ch/event/1215937/

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 HEP conference: Jan. 13-17, 2025.

CEPC Workshop EU Edition (Barcelona, Spain), May 5-8, 2024

The 2023 International Workshop on Circular Electron Positron Collider, EUEdition,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) will be held from Oct. 23-27, 2024, Hangzhou, China
https://indico.ihep.ac.cn/event/22089/

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

Professor Peter Higgs passed away on **April 8, 2024**. We miss him.

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

CEPC Accelerator IARC Review in EDR Phase (2024)

(Sept. 18-20, 2024, at IHEP)

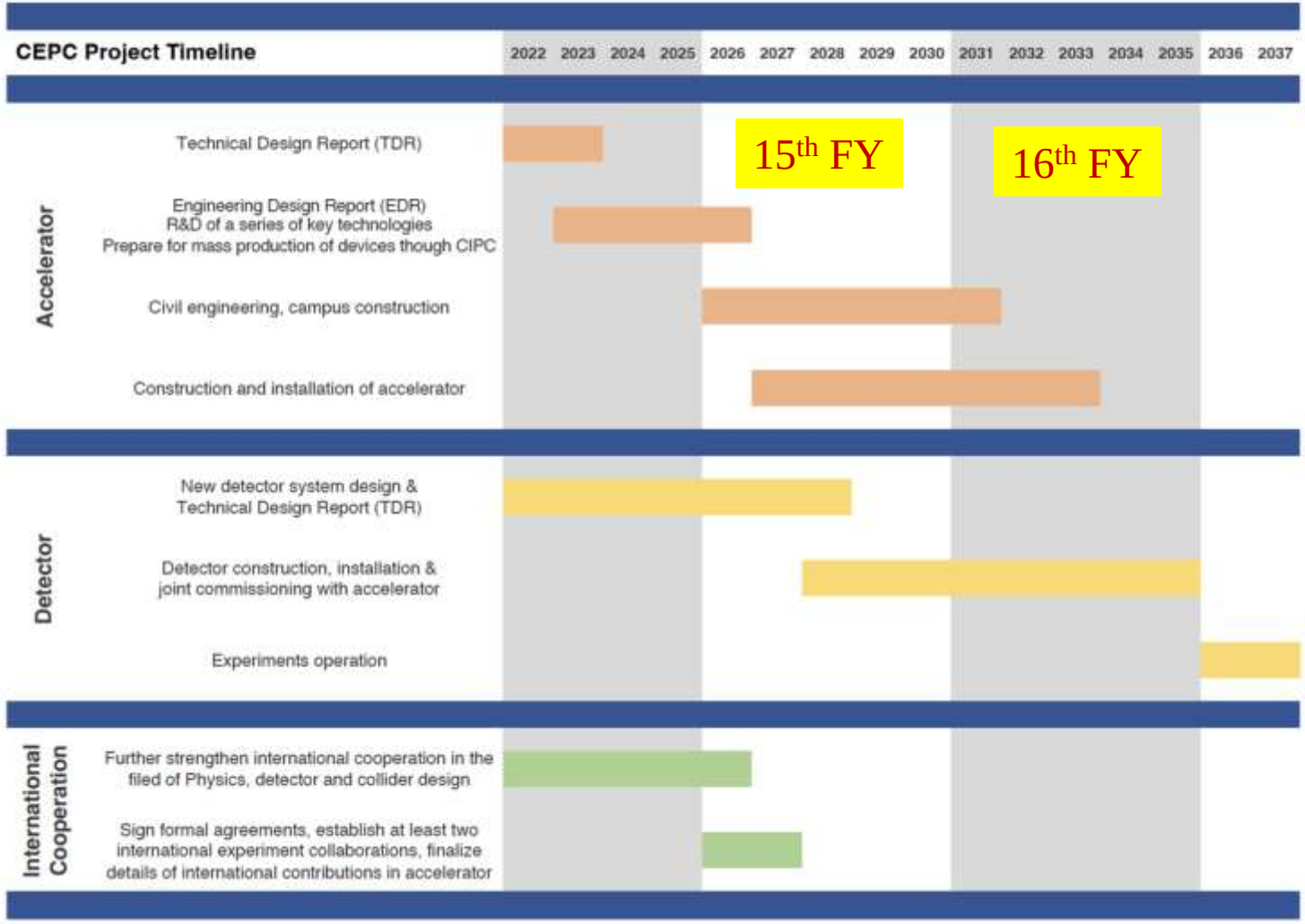
CEPC International Accelerator Review Committee (IARC) Meeting was held from Sept. 18-20, 2024 at IHEP

The CEPC International Accelerator Review Committee (IARC) members visited IHEP 4th Generation 6GeV HEPS light source in Huairou campus of IHEP on Sept. 20, 2024 at IHEP

The CEPC International Accelerator Review Committee (IARC) members in the control room Of HEPS, and 30mA stored beam current have been reached during storage ring commissioning in Sept. 2024

CEPC Planning, Schedule and Teams

TDR (2023), EDR(2027), start of construction (~2027)



CEPC team (domestic)

CEPC accelerator and detector/experiments/theory group is an highly experienced team with strong international collaboration experiences. It has demonstrated its expertise and achievements is the following related projects, both domestic and international ones, such as:

BEPC-BEPCII (BES-BESIII), BFELP, CSNS, ADS, HEPS, LEP, LHC, LHCb, ILC, EXFEL, HL-LHC, BELLE, BELLE-II, CLEO, Daya Bay, JUNO, etc.

CEPC international partners and collaborators

Summary

- The CEPC TDR optimizations designs with high luminosity (**30MW and 50MW**) operations for all four energies (**Higgs, W/Z and ttbar**) satisfy the CEPC scientific goals.
- CEPC accelerator **TDR international review and cost review** were held from **June 12-16, 2023 and Sept. 11-15, 2023**, respectively, and endorsed by **IAC meeting** held from **Oct. 30-31, 2023**. **CEPC Accelerator TDR has be released formally on December 25, 2023 and published in Journal 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
- EDR site selection and site dependent engineering design have already been started
- Detailed preparation of **CEPC EDR** phase (**2024-2027**) before construction working plan and beyond have been established with the aim for **CEPC proposal** to be presented to and selected by Chinese government around **2025** for the construction start during the ”**15th five year plan (2026-2030)”** (for example, around **2027**) and completion around **2035**.
- **CEPC Accelerator EDR have progressed well with corresponding EDR budgets and EDR human resources, and will be reviewed by IARC in Sept. 18-20, 2024 at IHEP.**
- A beam driven PWFA experimental program has been initialized and started at IHEP to address the cascade and e+ accelerations aiming on future plasma injector for CEPC and future linear colliders.
- **International collaboration and participation are warmly welcome.**

Thanks for your attention