CEPC-SppC Status and Perspectives

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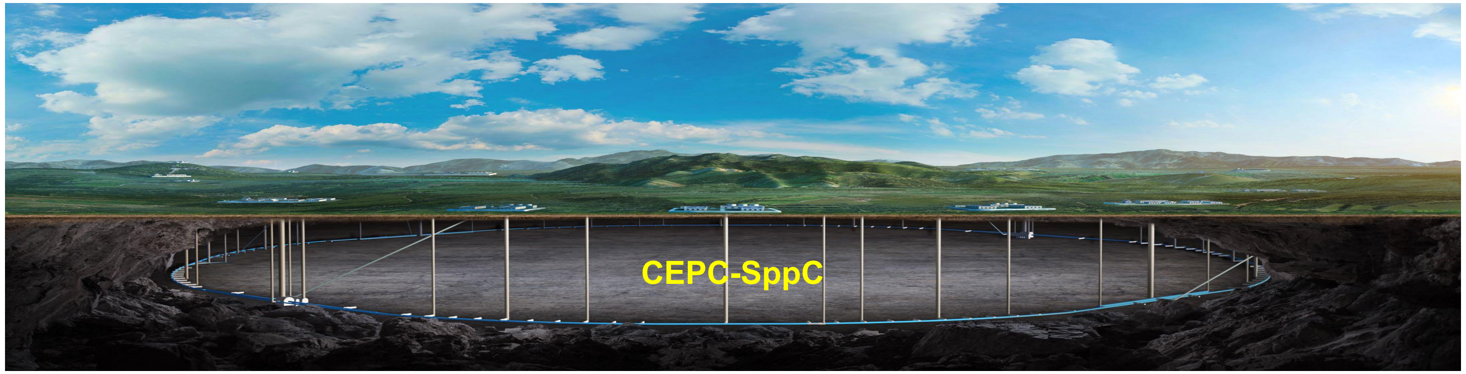
IHEP

On behalf of CEPC-SppC Group



Free Meson Seminars, Sept. 24， 2020

Department of Theoretical Physics (DTP) at TIFR， India

Outline

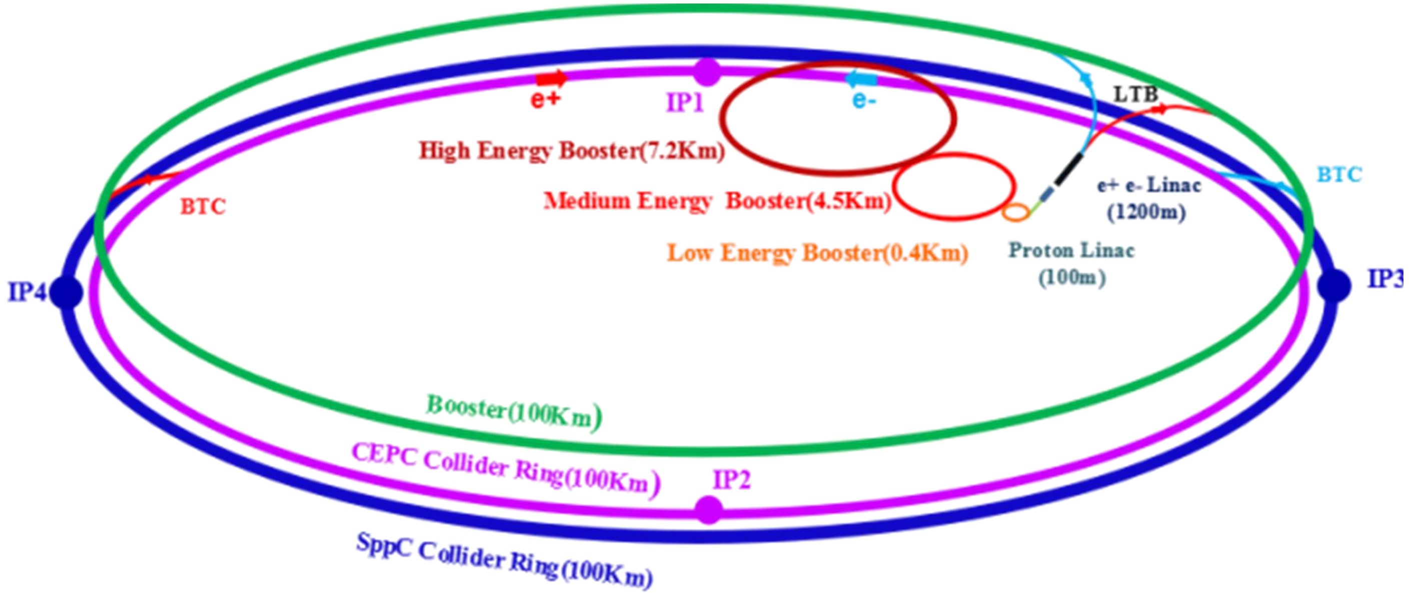
- CEPC sicentific goals and CDR
- CEPC from CDR towards TDR
- CEPC TDR R&D plan and status
- SppC status and key technology R&D
- CEPC-SppC siting and civil engineering
- CEPC-SppC collaborations
- Summary

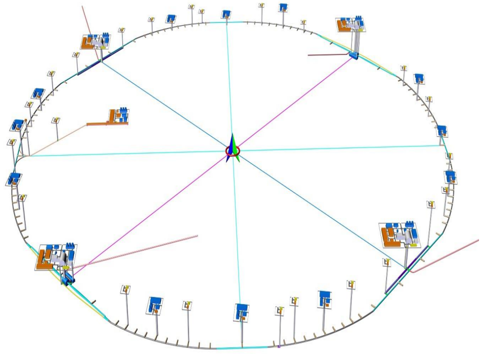
CEPC-SppC Physics Goals in CDR (remind)

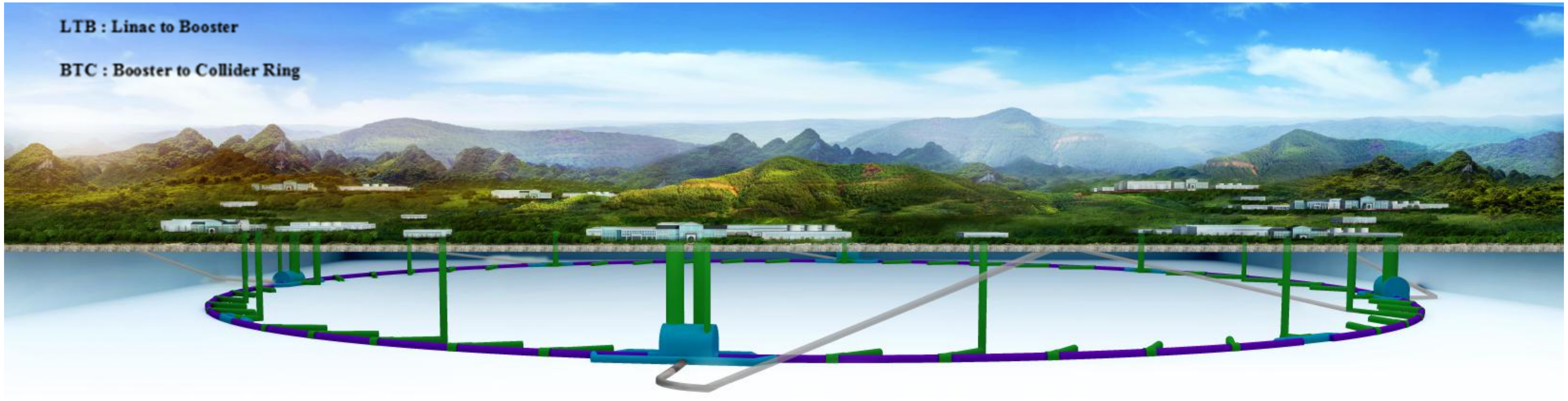
- **Electron-positron collider (91, 160， 240 GeV)**
  - Higgs Factory（10^6 Higgs）：
    - Precision study of Higgs(m_H, J^{PC}, couplings)， Similar & complementary to ILC
    - Looking for hints of new physics
  - Z & W factory（10^{10} Z^0）：
    - precision test of SM
    - Rare decays ?
  - Flavor factory: b, c, τ and QCD studies
- **Proton-proton collider(~100 TeV)**
  - Directly search for new physics beyond SM
  - Precision test of SM
    - e.g., h^3 & h^4 couplings

CEPC as a Higgs Factory (Z,W and followed by SppC)

Propsed by Chinese scientists in Sept. 2012 after Higgs Boson particle was found in July 2012







CEPC CDR Accelerator Chain and Systems

10 GeV

1) Injector

L=1.2km

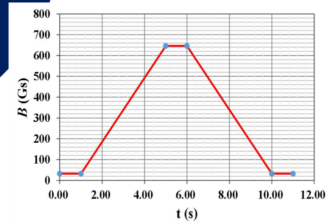
Electron

Positron

2) Booster

C=100km

Energy Ramp
10 ->45/120GeV



Booster Cycle (0.1 Hz)

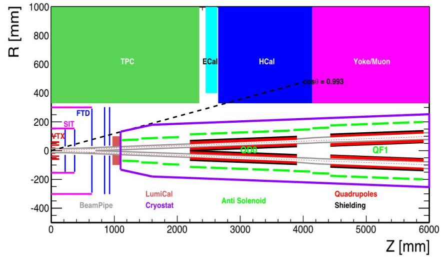
Three rings in the sane channel：

- **CEPC & booster**
- **SppC**

3) Main Ring

C=100km
2IP

45/120 GeV



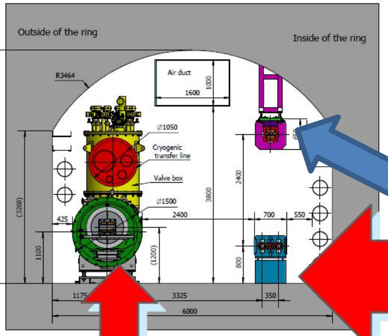
4) Detector Machine Interface (MDI)

The key systems of CEPC:

1) Linac Injector
2) Booster
3) Collider ring
4) MDI
5) Civil Eng.

5) Civil Eng.

TUNNEL CROSS SECTION OF THE ARC AREA



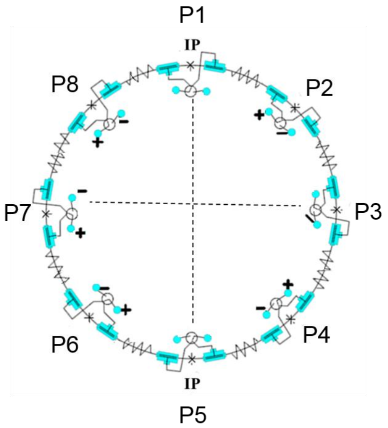
CEPC Booster

CEPC Collider

SppC

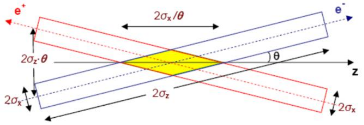
CEPC Four Options Evoluting towards CDR

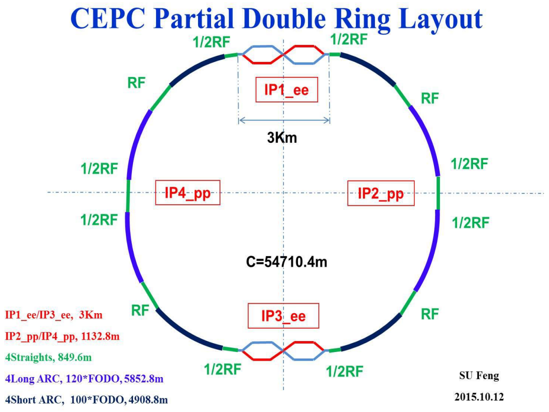
CEPC Pre-CDR Scheme (head -on collision)



Since Oct 2012

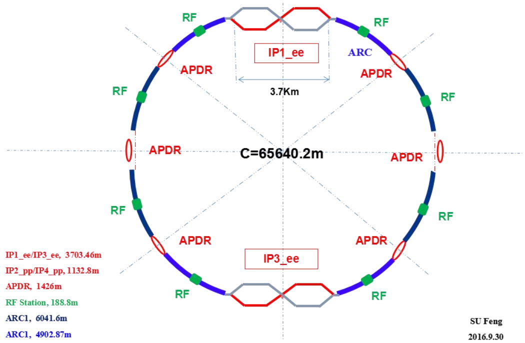
Crab-waist collision in CEPC CDR





Since May 2015

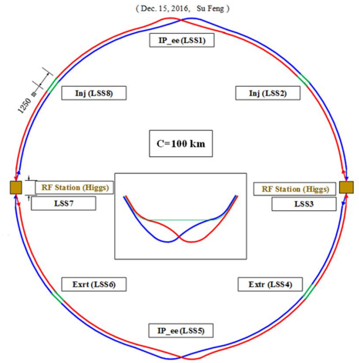
CEPC Advanced Partial Double Ring Option II



Since May 2016

CEPC Alternative Design

Lower cost and reaching the fundamental requirement for Higgs and Z luminosities, under the condition that sawtooth and beam loading effects be solved



Since Nov 2016

CEPC Baseline Design

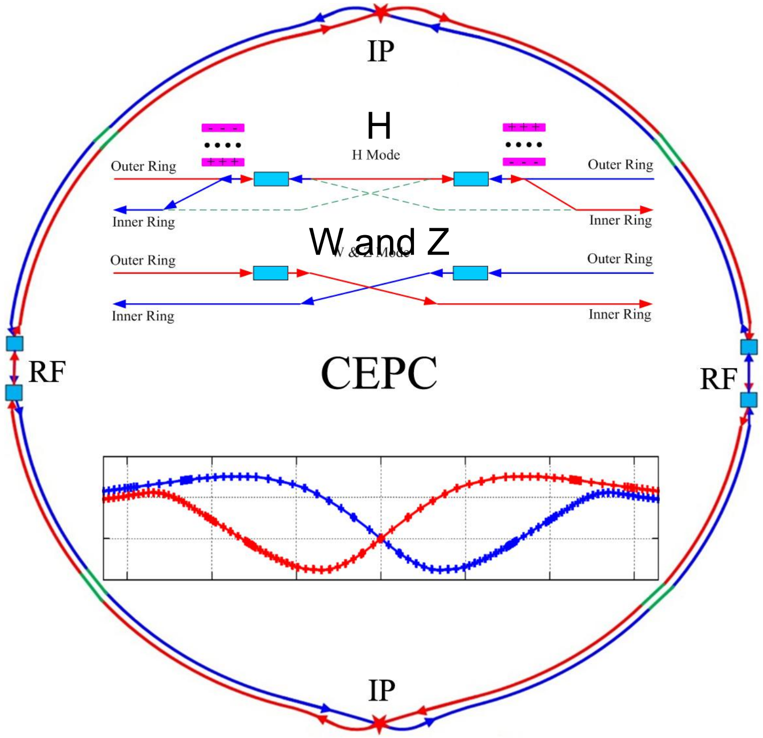
Better performance for Higgs and Z compared with alternative scheme, without bottle neck problems, but with higher cost

30MW synchrotron radiation power/beam

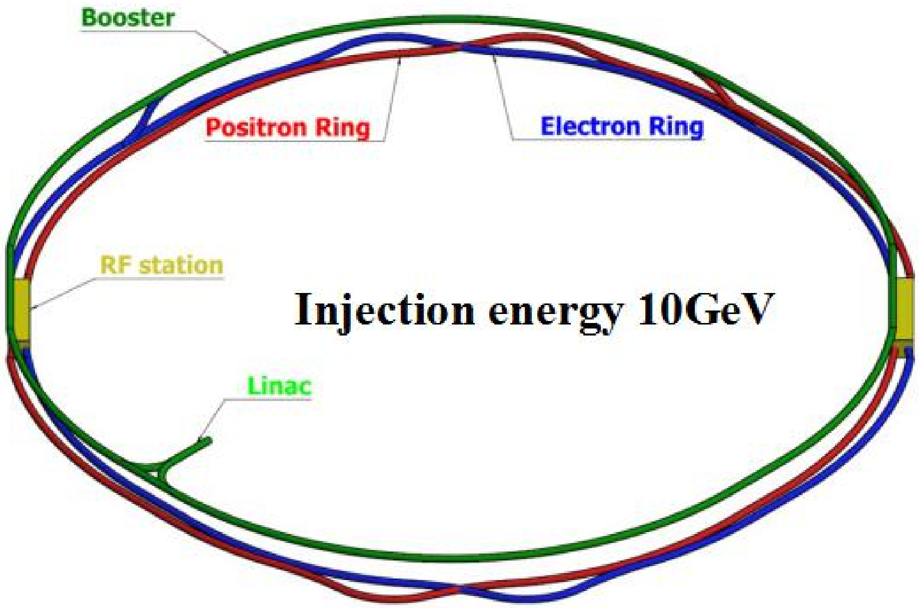
- ➢ CEPC 100km circumference was decided by CEPC SC based on the recommendation from IAC in Nov. 2016
- ➢ CEPC baseline and alternative options have been decided on Jan. 14, 2017

CEPC from CDR towards TDR

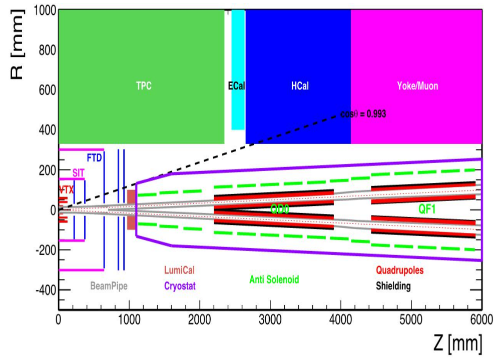
CEPC CDR Baseline Layout

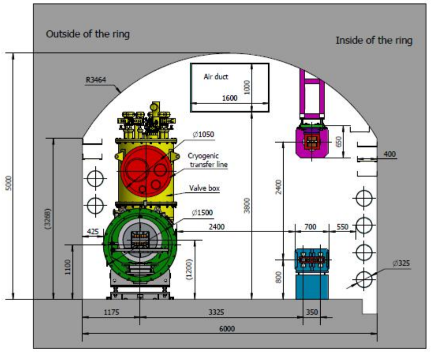


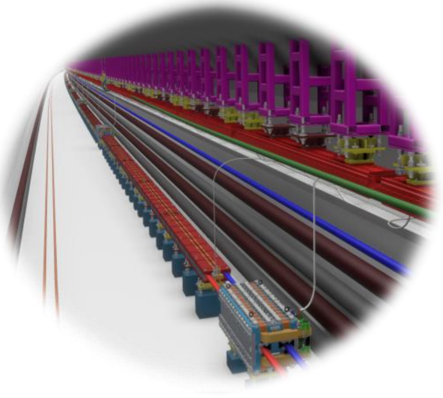
CEPC collider ring (100km)

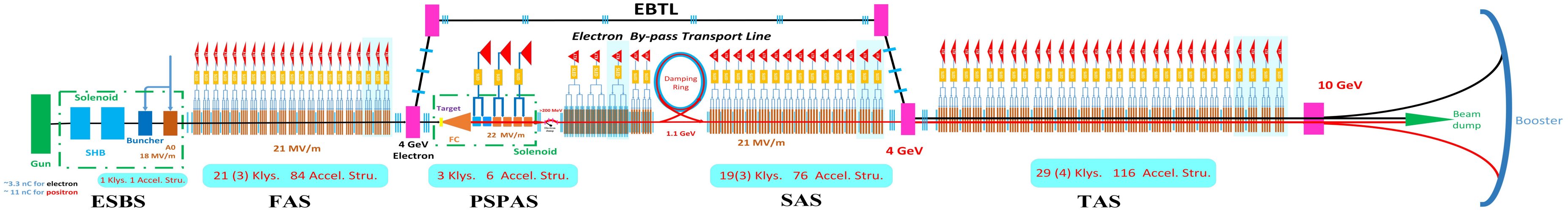


CEPC booster ring (100km)









CEPC Linac injector (1.2km, 10GeV)

CEPC CDR Parameters

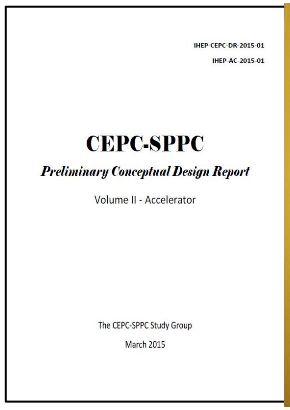
	Higgs	*W*	*Z* (3*T*)	*Z* (2*T*)
Number of IPs	2			
Beam energy (GeV)	**120**	**80**	**45.5**	
Circumference (km)	100			
Synchrotron radiation loss/turn (GeV)	1.73	0.34	0.036	
Crossing angle at IP (mrad)	16.5×2			
Piwinski angle	2.58	7.0	23.8	
Number of particles/bunch N_e (10^{10})	15.0	12.0	8.0	
Bunch number (bunch spacing)	**242 (0.68μs)**	**1524 (0.21μs)**	**12000 (25ns+10%gap)**	
Beam current (mA)	17.4	87.9	461.0	
Synchrotron radiation power /beam (MW)	**30**	**30**	**16.5**	
Bending radius (km)	10.7			
Momentum compact (10^{-5})	1.11			
β function at IP β_x^* / β_y^* (m)	**0.36/0.0015**	**0.36/0.0015**	**0.2/0.0015**	**0.2/0.001**
Emittance $\varepsilon_x/\varepsilon_y$ (nm)	1.21/0.0031	0.54/0.0016	0.18/0.004	0.18/0.0016
Beam size at IP σ_x/σ_y (μm)	20.9/0.068	13.9/0.049	6.0/0.078	6.0/0.04
Beam-beam parameters ξ_x/ξ_y	0.031/0.109	0.013/0.106	0.0041/0.056	0.0041/0.072
RF voltage V_{RF} (GV)	2.17	0.47	0.10	
RF frequency f_{RF} (MHz) (harmonic)	650 (216816)			
Natural bunch length σ_z (mm)	2.72	2.98	2.42	
Bunch length σ_z (mm)	3.26	5.9	8.5	
HOM power/cavity (2 cell) (kw)	0.54	0.75	**1.94**	
Natural energy spread (%)	0.1	0.066	0.038	
Energy acceptance requirement (%)	**1.35**	**0.4**	**0.23**	
Energy acceptance by RF (%)	2.06	1.47	1.7	
Photon number due to beamstrahlung	0.1	0.05	0.023	
Lifetime _simulation (min)	100			
Lifetime (hour)	**0.67**	**1.4**	**4.0**	**2.1**
F (hour glass)	0.89	0.94	0.99	
Luminosity/IP L (10^{34}cm^{-2}s^{-1})	**2.93**	**10.1**	**16.6**	**32.1**

CEPC Accelerator from Pre-CDR, CDR towards TDR

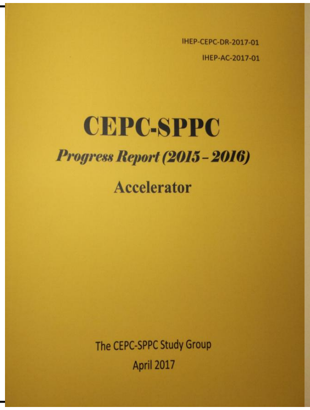
CEPC accelerator CDR completed in June 2018 (to be printed in July 2018)

- Executive Summary
1. Introduction
2. Machine Layout and Performance
3. Operation Scenarios
4. CEPC Collider
5. CEPC Booster
6. CEPC Linac
7. Systems Common to the CEPC Linac, Booster and Collider
8. Super Proton Proton Collider
9. Conventional Facilities
10. Environment, Health and Safety
11. R&D Program
12. Project Plan, Cost and Schedule

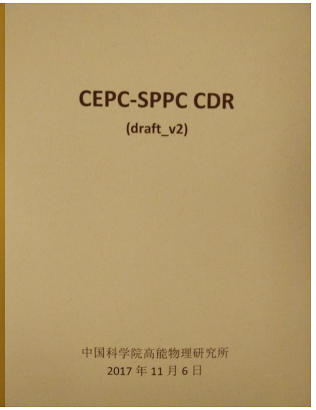
- Appendix 1: CEPC Parameter List
- Appendix 2: CEPC Technical Component List
- Appendix 3: CEPC Electric Power Requirement
- Appendix 4: Advanced Partial Double Ring
- Appendix 5: CEPC Injector Based on Plasma Wakefield Accelerator
- Appendix 6: Operation as a High Intensity γ-ray Source
- Appendix 7: Operation for e-p, e-A and Heavy Ion Collision
- Appendix 8: Opportunities for Polarization in the CEPC
- Appendix 9: International Review Report



March 2015

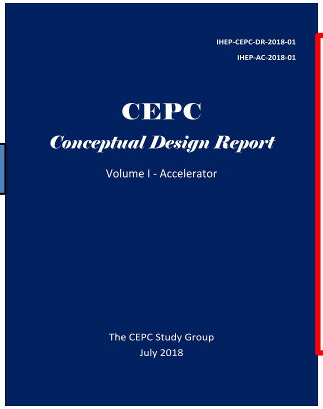


April 2017



Draft CDR for Mini International Review in Nov. 2017

CEPC CDR Vol. I and II was publically released in Nov. 2018



CEPC Accelerator Submitted to European Strategy in 2019

1) CEPC accelerator: ArXiv: 1901.03169
2) CEPC Physics/Detector: 1901.03170

CDR Version for International Review June 2018
Formally relased on Sept. 2, 2018:arXiv： 1809.00285
http://cepc.ihep.ac.cn/CDR_v6_201808.pdf

CEPC New Parameters for Higgs after CDR

	tt	*Higgs*	*W*	*Z（3T）*	*Z（2T）*
Number of IPs	2				
Beam energy (GeV)	**175**	**120**	**80**	**45.5**	
Circumference (km)	100				
Synchrotron radiation loss/turn (GeV)	7.61	1.68	0.33	0.035	
Crossing angle at IP (mrad)	16.5×2				
Piwinski angle	0.91	3.78	8.5	27.7	
Number of particles/bunch N_e (10^{10})	24.15	17.0	12.0	8.0	
Bunch number (bunch spacing)	**34 (4.9μs)**	**218 (0.76μs)**	**1568 (0.20μs)**	**12000 (25ns+10%gap)**	
Beam current (mA)	3.95	17.8	90.4	461.0	
Synchrotron radiation power /beam (MW)	**30**	**30**	**30**	**16.5**	
Bending radius (km)	10.7				
Momentum compact (10^{-5})	0.91				
β function at IP β_x^* / β_y^* (m)	1.2/0.0037	**0.33/0.001**	**0.33/0.001**	**0.2/0.001**	
Emittance $\varepsilon_x/\varepsilon_y$ (nm)	2.24/0.0068	0.89/0.0018	0.395/0.0012	0.13/0.003	0.13/0.00115
Beam size at IP σ_x/σ_y (μm)	51.8/0.16	17.1/0.042	11.4/0.035	5.1/0.054	5.1/0.034
Beam-beam parameters ξ_x/ξ_y	0.077/0.105	0.024/0.113	0.012/0.1	0.004/0.053	0.004/0.085
RF voltage V_{RF} (GV)	8.93	2.4	0.43	0.082	
RF frequency f_{RF} (MHz) (harmonic)	650 (216816)				
Natural bunch length σ_z (mm)	2.54	2.2	2.98	2.42	
Bunch length σ_z (mm)	2.87	3.93	5.9	8.5	
HOM power/cavity (kw)	0.53 (5cell)	0.58 (2 cell)	0.77 (2 cell)	**1.94** (2 cell)	
Energy spread (%)	0.14	0.19	0.098	0.080	
Energy acceptance requirement (%)	**1.57**	**1.7**	**0.90**	**0.49**	
Energy acceptance by RF (%)	2.67	3.0	1.27	1.55	
Photon number due to beamstrahlung	0.19	0.104	0.050	0.023	
Beamstruhlung lifetime /quantum lifetime* (min)	~ 60	30/50	>400		
Lifetime (hour)	**0.7**	**0.22**	**1.2**	**3.2**	**2.0**
F (hour glass)	0.89	0.85	0.92	0.98	
Luminosity/IP *L* (10^{34}cm^{-2}s^{-1})	**0.38**	**5.2**	**14.5**	**23.6**	**37.7**

*include beam-beam simulation and real lattice

CEPC High Luminosity after CDR: Z (2T)

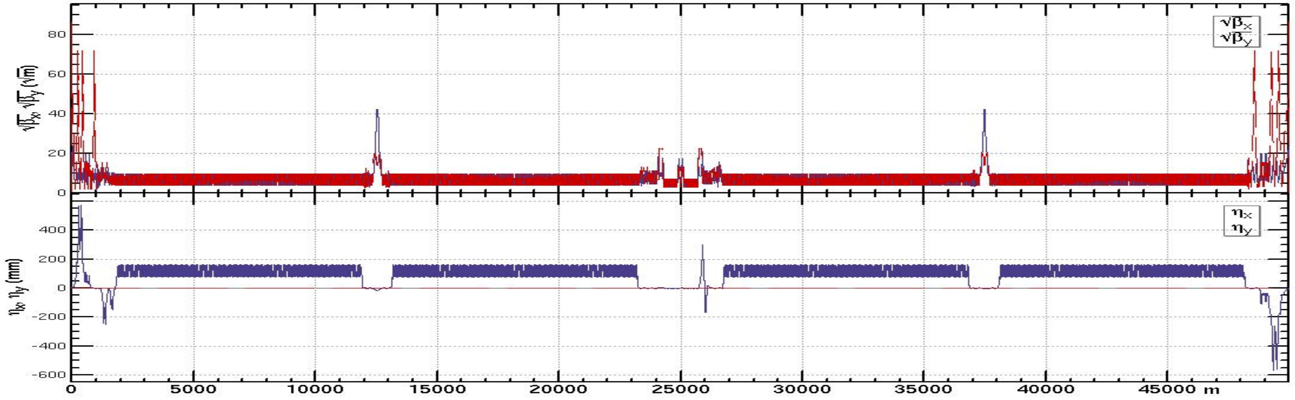
	CEPC-CDR	*CEPC-30MW*	*CEPC-38MW*	*FCC-ee*
Number of IPs	2	2	2	2
Energy (GeV)	45.5	**45.5**	**45.5**	45.6
Circumference (km)	100	100	100	100
SR loss/turn (GeV)	0.036	0.036	0.036	0.036
Half crossing angle (mrad)	16.5	16.5	16.5	15
Piwinski angle	23.8	27.9	33.0	28.5
N_e/bunch (10^{10})	8.0	12.0	15.0	17
Bunch number	12000	**14564 (20.6ns+10%gap)**	**15000**	16640
Beam current (mA)	461	839.9	1081.4	1390
SR power /beam (MW)	**16.5**	**30**	**38.6**	**50**
Bending radius (km)	10.7	10.7	10.7	10.76
Momentum compaction (10^{-5})	1.11	1.11	1.11	1.48
β_{IP} x/y (m)	0.2/0.001	**0.2/0.001**	**0.2/0.001**	0.15/0.0008
Emittance x/y (nm)	0.18/0.0016	0.18/0.0016	0.18/0.0016	0.27/0.001
Transverse σ_{IP} (um)	6.0/0.04	6.0/0.04	6.0/0.04	6.4/0.028
ξ_x/ξ_y/IP	0.004/0.079	0.004/0.093	0.004/0.098	0.004/0.133
V_{RF} (GV)	0.1	0.10	0.10	0.1
f_{RF} (MHz) (harmonic)	650	650	650	400
Nature bunch length σ_z (mm)	2.42	2.42	2.42	3.5
Bunch length σ_z (mm)	8.5	10.0	11.8	12.1
HOM power/cavity (kw)	1.94 (2cell)	**2.29 (1cell)**	**3.15 (1cell)**	?
Energy spread (%)	0.08	0.1	0.115	0.132
Energy acceptance (DA) (%)	1.5	**0.6**	**0.7**	1.3
Energy acceptance by RF (%)	1.7	1.7	1.7	1.9
Lifetime by rad. Bhabha scattering (hour)	2.9			1.13
Lifetime (hour)	2.5	**2.0**	1.8	1.0
L_{max}/IP ($10^{34}cm^{-2}s^{-1}$)	**32.1**	**74.5**	**101.6**	**230**

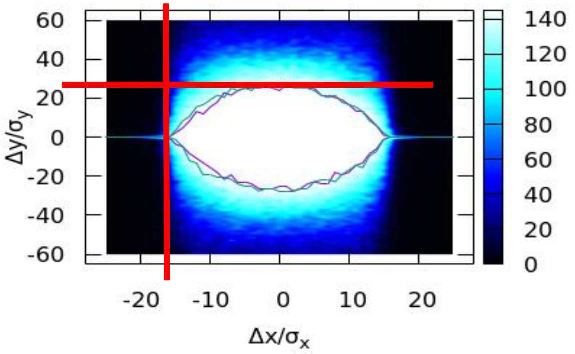
CEPC Lattice and Dynamic Aperture Status

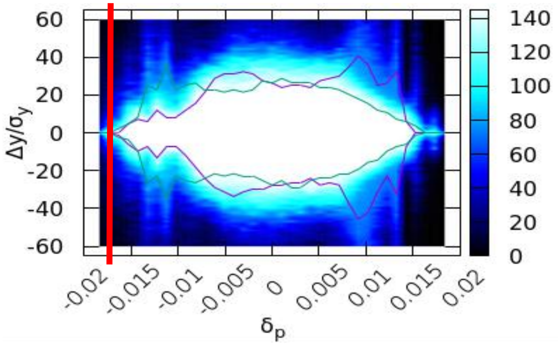
- Fit parameter list with luminosity of $5.2\times10^{34}/\mathrm{cm}^2/\mathrm{s}$
  - Stronger optimization and stricter hardware requirement should be made to get enough dynamic aperture
- Optimization of the quadrupole radiation effect
  - Interaction region: longer QD0/QF1 (2m/1.48m => 3m/2m)
  - ARC region: longer quadrupoles (2m => 3m)
- Reduction of dynamic aperture requirement from injection
  - Straight section region: larger βx at injection point (600m => 1800m)
- Maximization of bend filling factor to minimize the synchrotron radiation loss per turn
  - ARC region: sextupoles in two rings changed from staggered to parallel; The left drifts are used for longer bend.
  - RF region: shorter phase tuning sections

Goal (w/ error): $8\sigma_x \times 15\sigma_y \times 1.7\%$

Achieved (w/o error): $16\sigma_x \times 28\sigma_y \times 1.8\%$

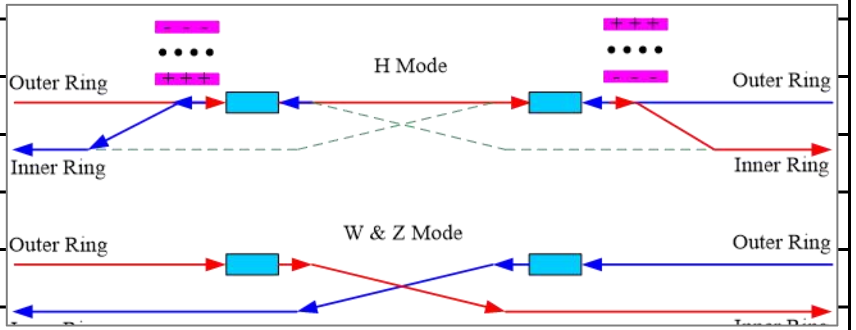






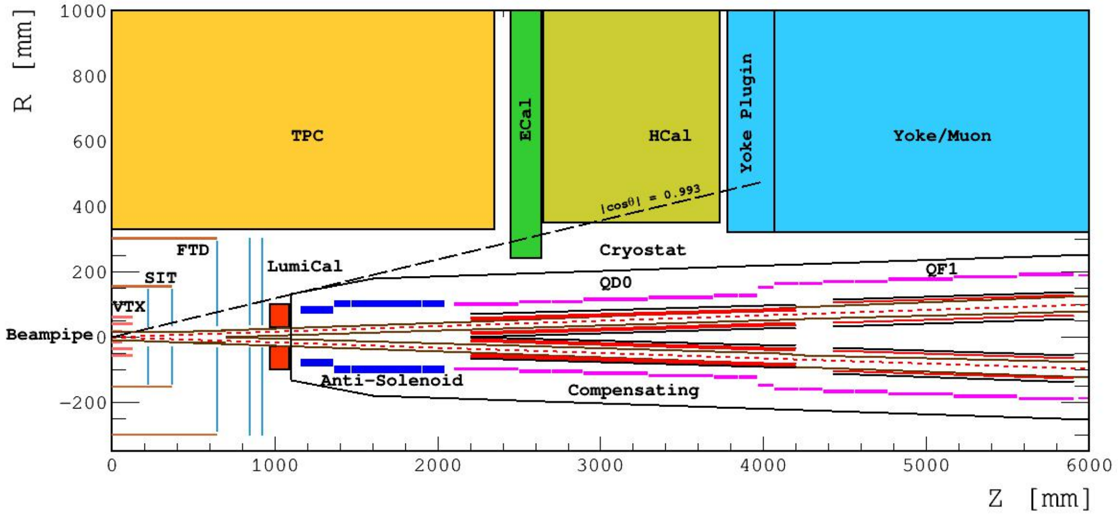
CEPC Collider Ring SRF Parameters

New machine parameters 20190226 SRF parameters 20190301	CDR (2-cell)			HL-Z (new2) (1-cell)				HL-Z (2-cell)	Performance Limits & Risks
	H	W	Z	H	W	Z (a)	Z (b)	Z	
Luminosity / IP [10^{34} $cm^{-2}s^{-1}$]	2.93	10.1	**32.1**	2.93	10.1	**74.5**	**74.5**	**74.5**	
SR power / beam [MW]	30	30	16.5	30	30	30	30	30	
RF voltage [GV]	2.17	0.47	0.1	2.17	0.47	0.1	0.1	0.1	
Beam current / beam [mA]	17.4	87.7	460	17.4	87.7	838	838	838	
Bunch charge [nC]	24	19.2	12.8	24	19.2	19.2	19.2	19.2	
Bunch number / beam	242	1524	12000	242	1524	14564	14564	14564	
Bunch length [mm]	3.26	5.9	8.5	3.26	5.9	10	10	10	
Cavity number (650 MHz)	**240**	2 x 108	**2 x 60**	**240**	2 x 120	**2 x 120**	**2 x 60**	**2 x 120**	Smart by-pass could be a better approach than 1-cell.
Cell number / cavity	**2**	2	**2**	**1**	1	**1**	1	**2**	Common 1-cell for Z & H/W necessary or different cavity?
Idle cavities on line / ring	0	12	60	0	0	0	**60**	0	Z 2x60 symmetry detune parked half cavities for FM CBI
Cavity gradient [MV/m]	**20**	9.5	3.6	**40**	17	3.6	7.2	1.8	Current status: ~ 10 MV/m in storage ring. Field emission
Q_0 for long term operation	**1.5E10**	1.5E10	1.5E10	**3E10**	3E10	3E10	3E10	1.5E10	~ 1E9 in storage ring. Field emission. Magnetic shield
Input power / cavity [kW]	250	278	**275**	250	250	**250**	**500**	250	~ 300 kW in storage ring. Window events and damages
Klystron max power [kW]	800	800	800	800	800	800	**1400**	800	Klystron max power limit: 1200 kW? KLY # & $
Number of cavities / klystron	2	2	2	2	2	2	**2**	2	Avoid RF power source reconfiguration
HOM power / cavity [kW]	0.57	0.75	**1.94**	0.29	0.37	**2.28**	2.28	**4.57**	HOM coupler capacity (not HOM power per cavity) : 1 kW
Optimal Q_L	1.5E6	3.2E5	4.7E4	3.1E6	5.8E5	2.6E4	5.2E4	1.3E4	Coupler variation range, coupler kick to beam
Optimal detuning [kHz]	0.2	1.0	**17.8**	0.1	0.5	**32.3**	**16.1**	**64.6**	Fundamental mode coupled bunch instability
Wall loss / cavity @ 2 K [W]	25.6	5.9	0.9	25.6	4.8	0.2	0.9	0.2	Field emission will drastically increase the cryogenic load.
Total cavity wall loss [kW]	6.1	1.3	0.1	6.1	1.2	0.05	0.05	0.05	(cryogenic wall loss in two rings)

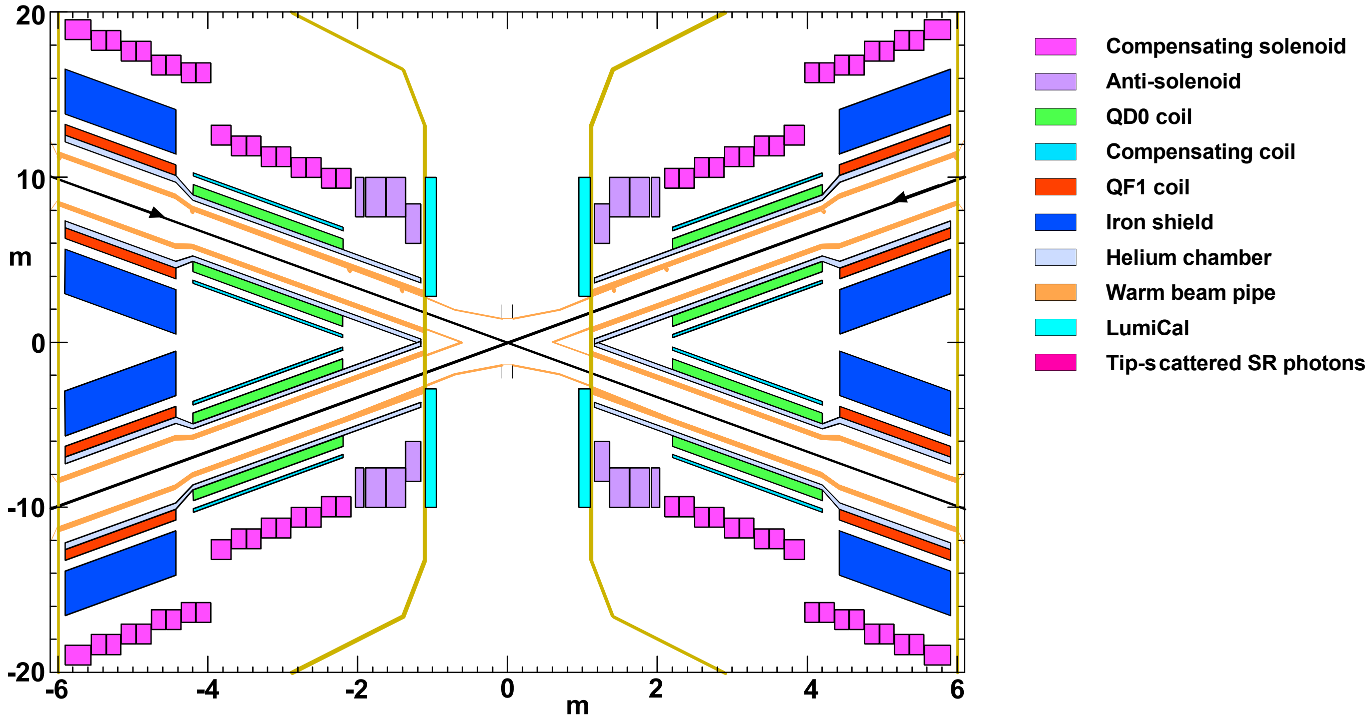


MDI Layout and IR Design

With Detector solenoid



Without Detector solenoid ~cryostat in detail



- The accelerator components inside the detector without shielding are within a conical space with an opening angle of cosθ=0.993.
- The e+e- beams collide at the IP with a horizontal angle of 33mrad and the final focusing length is 2.2m
- Lumical will be installed in longitudinal 0.95~1.11m, with inner radius 28.5mm and outer radius 100mm.

- The Machine Detector Interface (MDI) of CEPC double ring scheme is about ±7m long from the IP
- The CEPC detector superconducting solenoid with 3T magnetic field and the length of 7.6m.

Booster New Parameters after CDR

Injection		H	W	Z
Beam energy	GeV	10		
Bunch number		242	1524	6000
Threshold of single bunch current	μA	3.06		
Threshold of beam current (limited by coupled bunch instability)	mA	33.3		
Bunch charge	nC	0.78	0.63	0.45
Single bunch current	μA	2.3	1.8	1.3
Beam current	mA	0.57	2.86	7.51
Energy spread	%	0.0081		
Synchrotron radiation loss/turn	keV	79.5		
Momentum compaction factor	10^{-5}	1.064		
Emittance	nm	0.00895		
Natural chromaticity	H/V	-610/-228		
RF voltage	MV	78.7	38.2	
Betatron tune ν_x/ν_y		319.14/131.23		
Longitudinal tune		0.076	0.053	
RF energy acceptance	%	3.29	2.29	
Damping time	s	83.9		
Bunch length of linac beam	mm	1.0		
Energy spread of linac beam	%	0.16		
Emittance of linac beam	nm	40		

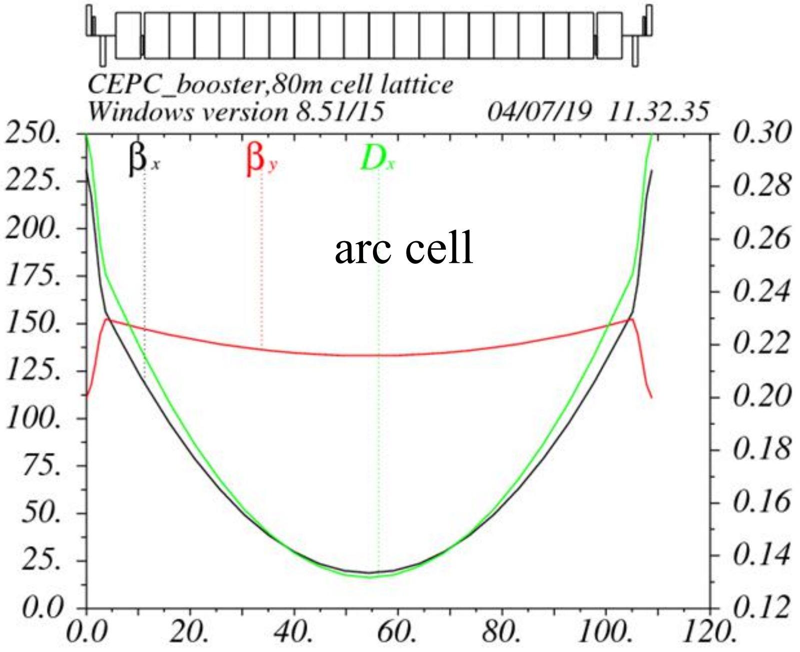
Extraction		H		W	Z(3T)	Z(2T)
		Off axis injection	On axis injection	Off axis injection	Off axis injection	
Beam energy	GeV	120		80	45.5	
Bunch number		242	235+7	1524	6000	
Maximum bunch charge	nC	0.72	24.0	0.58	0.41	
Maximum single bunch current	μA	2.1	70	1.7	1.2	
Threshold of single bunch current	μA	77.33				
Threshold of beam current (limited by RF power)	mA	1		4	10	
Beam current	mA	0.52	1.0	2.63	6.91	
Injection duration for top-up (Both beams)	s	26.6	35.8	51.9	275.8	
Injection interval for top-up	s	47.0		153.0	504.0	276.0
Current decay during injection interval		3%				
Energy spread	%	0.098		0.065	0.037	
Synchrotron radiation loss/turn	GeV	1.65		0.326	0.0326	
Momentum compaction factor	10^{-5}	1.064				
Emittance	nm	1.29		0.57	0.18	
Natural chromaticity	H/V	-610/-228				
Betatron tune ν_x/ν_y		319.14/131.23				
RF voltage	GV	1.97		0.45	0.177	
Longitudinal tune		0.076		0.053	0.053	
RF energy acceptance	%	1.0		1.0	1.96	
Damping time	ms	48.7		164	920.7	
Natural bunch length	mm	2.15		2.08	1.18	
Injection duration from empty ring	h	0.17		0.25	2.2	

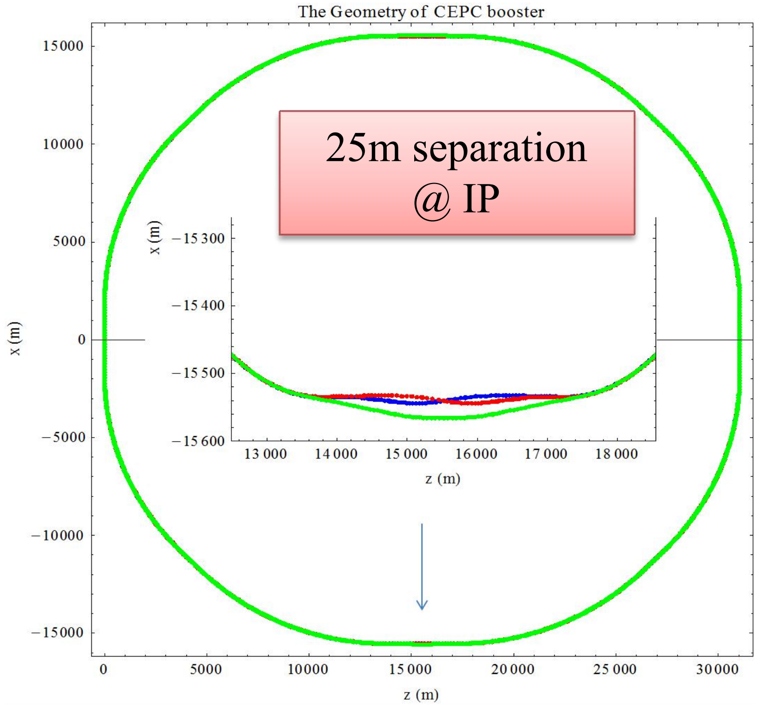
New Booster Design based on TME Lattice after CDR

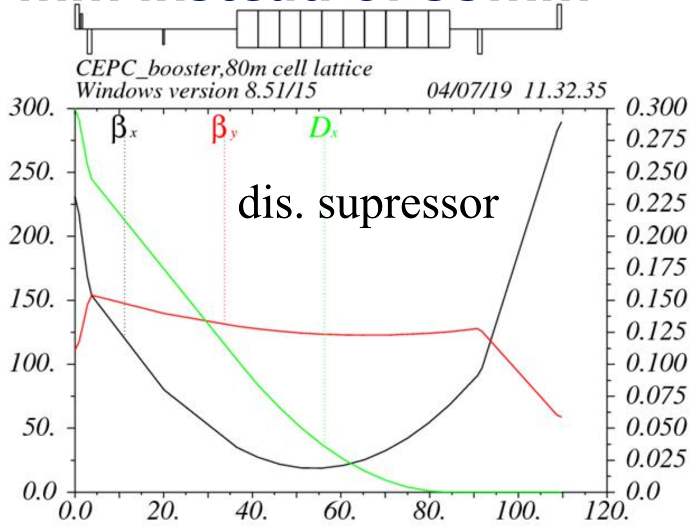
The emittance of booster is reduced from 3.6nm to 1.2nm

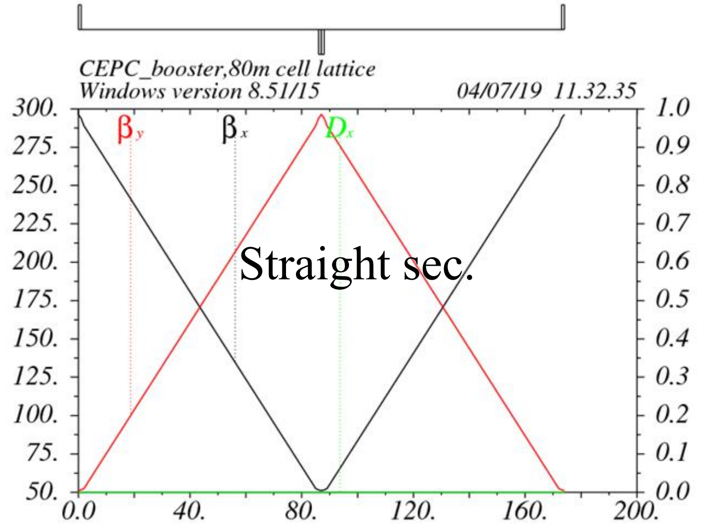
Inner aperture of the vacuum chamber is chosen to be 44 mm instead of 55mm

- emittance=**1.29nm** @120GeV
- TME lattice
- Cell length: 110m
- Interleave sextupole scheme









Helium Distribution to CEPC SC Cavities

-diagram for 2.2K, 1.2bar supply

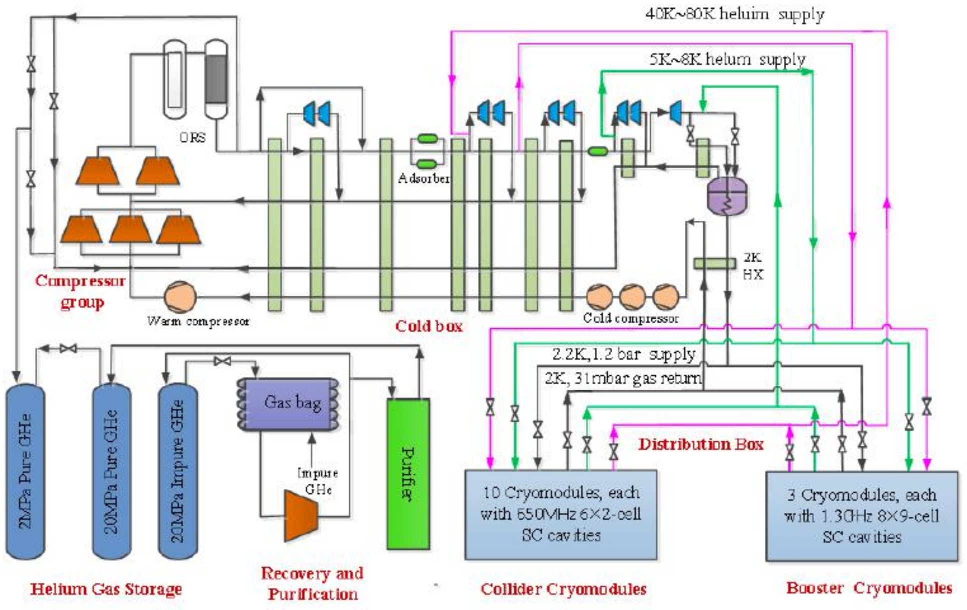
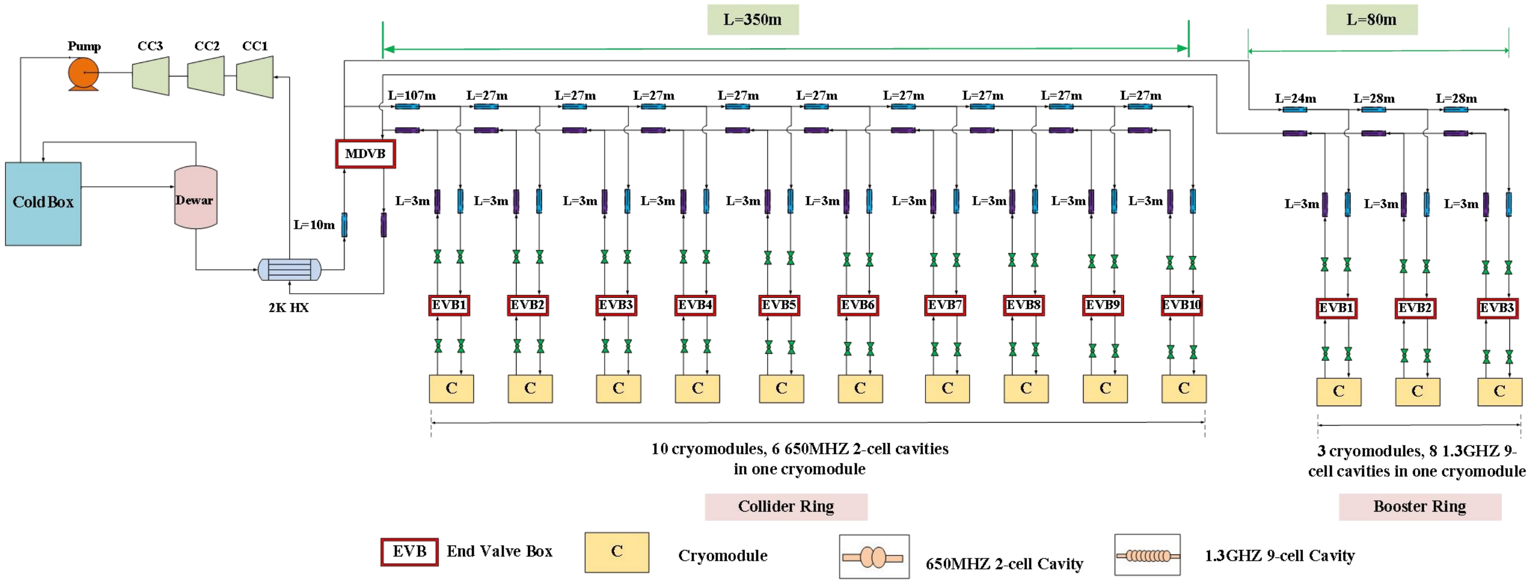


Figure 7.1.7: Cryogenic system schematic



- 1.3bar,4.5K liquid helium from DW to 2K HX, and the outlet condition of the 2K HX is 1.2bar,2.2K.
- There are 10 cryomodules in collider ring, and 3 cryomodules in booster ring.
- The distance of supply pipe in collider ring is 350m, and the distance of supply pipe in booster ring is 80m.
- the outlet condition of the cryomodule is 31mbar,2K.
- The return gas from cryomodules as cold fluid flows into the 2K HX, then the pressure is increased by three cold compressors and one warm pump, finally into the warm compressors.

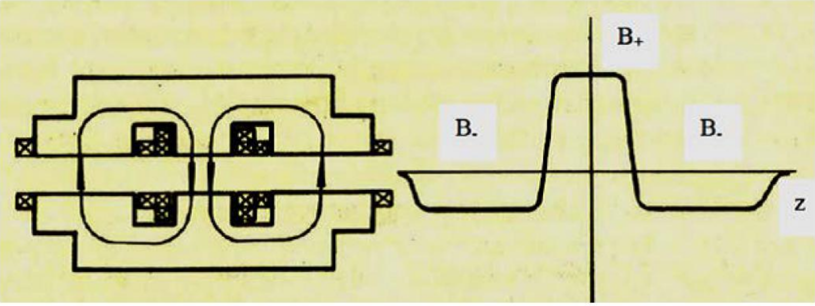
CEPC Self Polarization at Z-pole with Asymmetric Wigglers

- **Special wigglers to speed up self-polarization:**

N_w	B_+	L_+	B_-	L_-	$\frac{\tau_p}{\tau_p^w}$	u	$\frac{\Delta E_w}{\Delta E}$	$\frac{P_0^w}{P_0}$
10	0.6T	1m	0.15T	2m	13.4	0.34	3.2	0.99

In collaboration with Sergei Nikitin of BINP

u: Fraction of radiation energy loss enhancement. **:Factor of beam energy spread enhancement.**

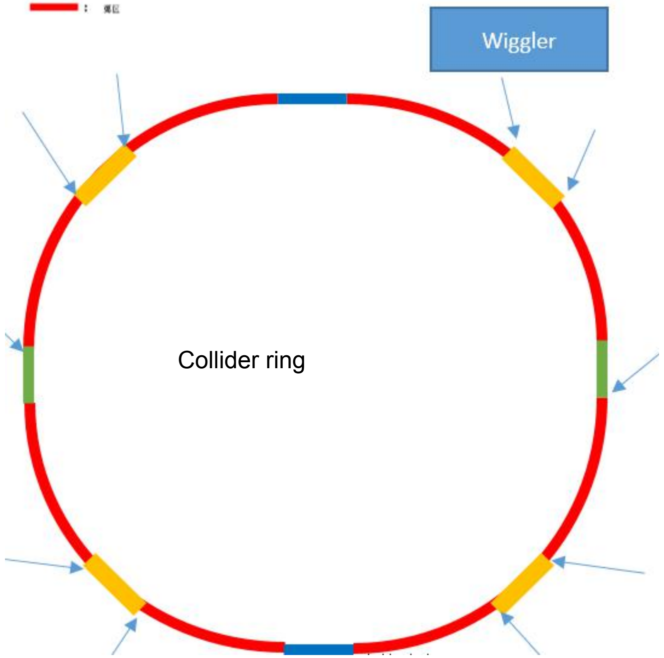


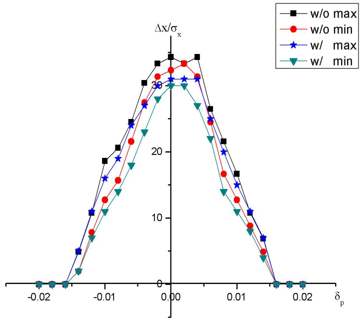
$$P(t) = P_0^w\left(1 - e^{\frac{-t}{\tau_p^w}}\right)$$

$$\tau_p^w = 19.6h,\ P(t) = 5\%,\ P_0^w = 0.913,$$

$$t = 1.10h$$

5% is enough for energy calibration.





DA

Longitudinal polarized beam collision and full plozrization injection scheme are under studies

Siberian Snake in the Booster Ring for the Ramping of the Vertically Polarized Beam to the Z-pole Energy

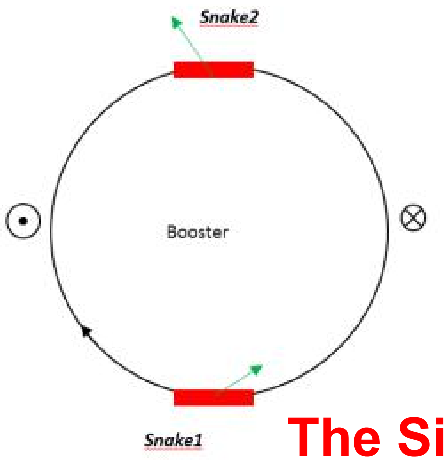
- **Snake configuration:**

  - $\eta_1 = \eta_4, \eta_2 = \eta_3$.
  - $r_{h1} = -r_{h4}, r_{h2} = -r_{h3}$.
  - $N_1 = N_4, N_2 = N_3$, where N_j is the number of periods in the jth helix.
  - The magnetic field at the entrance of each helix is vertical ($\alpha_i = 0$).

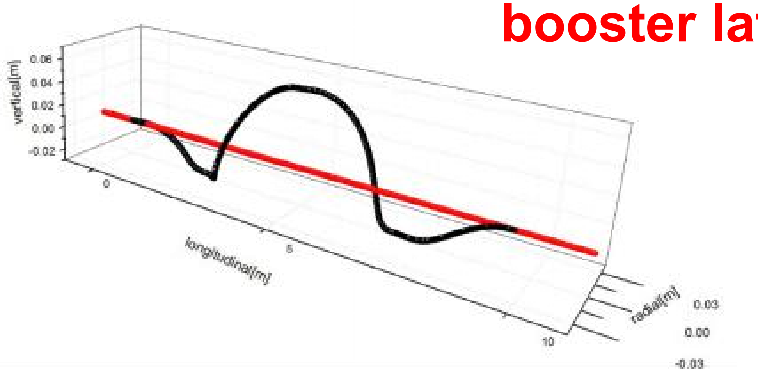
  Here we choose η1=η2=η3=η4=1, N1=N2=N3=N4=1.

- **Preliminary parameters of Snake:**

Helical Magnets				
#	length	Field helicity	Field orientation at entrance/exit	Field strength
1	2.4m	right-handed	vertical	1.01T
2	2.4m	right-handed	vertical	-3.26T
3	2.4m	right-handed	vertical	3.26T
4	2.4m	right-handed	vertical	-1.01T
Max. orbit excursion(hor/ver) (at 10GeV)				76mm/240mm
Radiation energy loss per turn in snakes U0[MeV] (at 10GeV/45.5GeV)				7.08/146.62

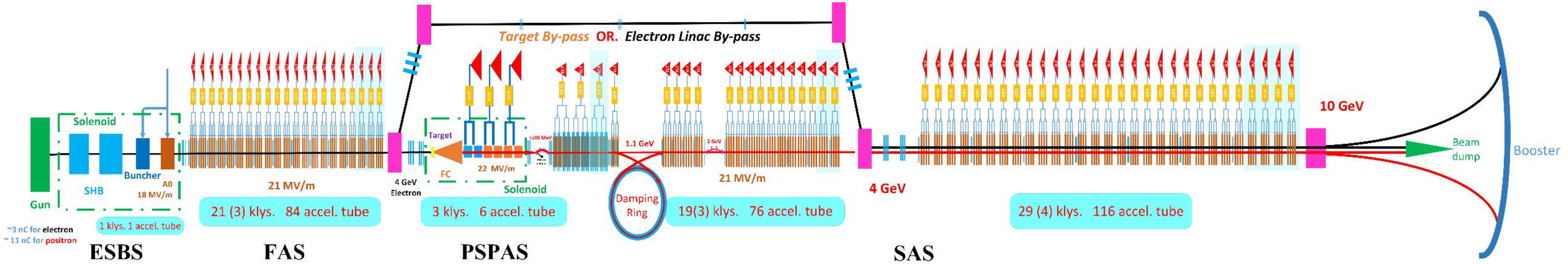


The Siberian Snake will be inserted into the booster lattice

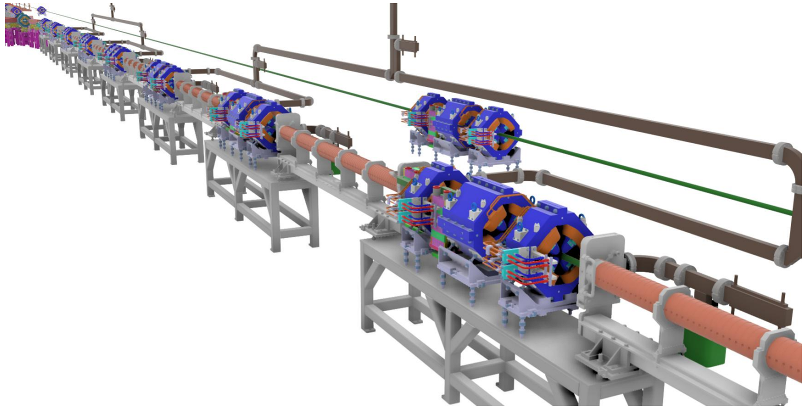


Orbital motion in Snake

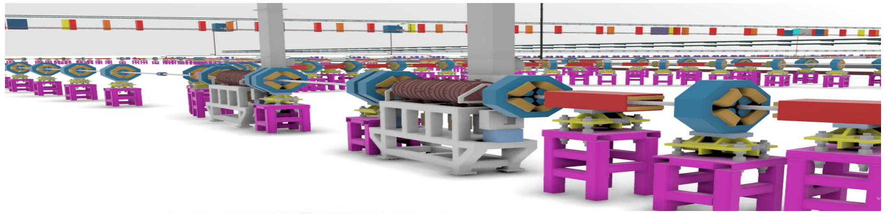
CEPC Linac Injector (CDR)

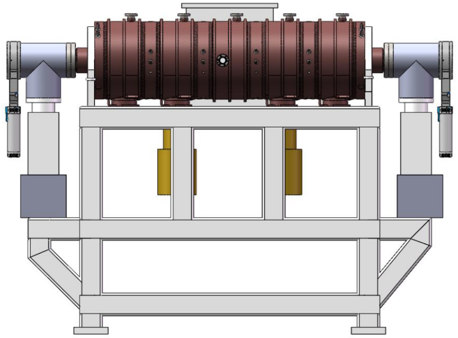


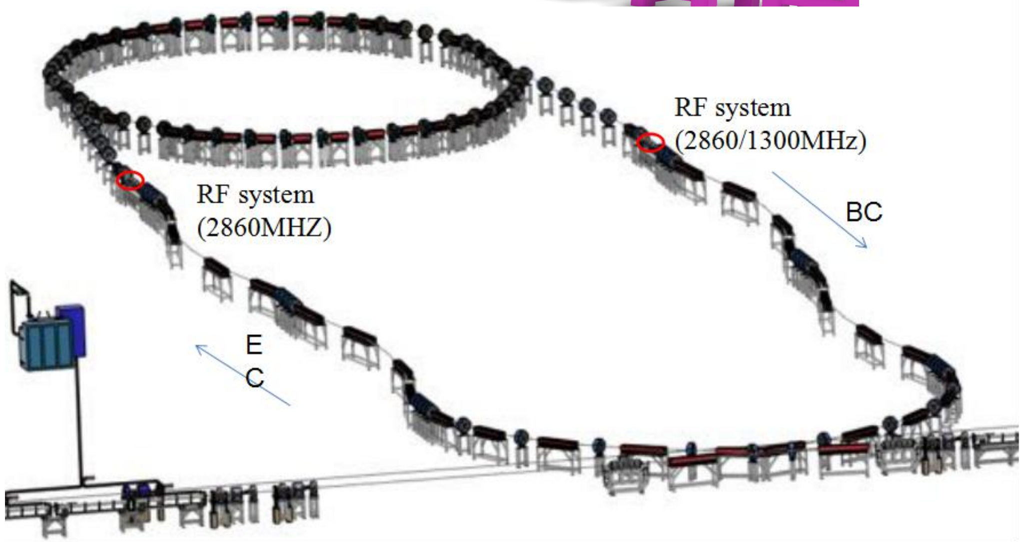
Parameter	Symbol	Unit	Baseline	Design reached
e^-/e^+ beam energy	E_{e-}/E_{e+}	GeV	**10**	**10**
Repetition rate	f_{rep}	Hz	**100**	**100**
e^-/e^+ bunch population	N_{e-}/N_{e+}		$> 9.4\times10^9$	**1.9×10^{10} / 1.9×10^{10}**
		nC	**> 1.5**	**3.0**
Energy spread (e^-/e^+)	σ_e		**$< 2\times10^{-3}$**	**1.5×10^{-3} / 1.6×10^{-3}**
Emittance (e^-/e^+)	ε_r	nm· rad	**< 120**	**5 / 40 ~120**
Bunch length (e^-/e^+)	σ_l	mm		**1 / 1**
e^- beam energy on Target		GeV	4	**4**
e^- bunch charge on Target		nC	10	**10**



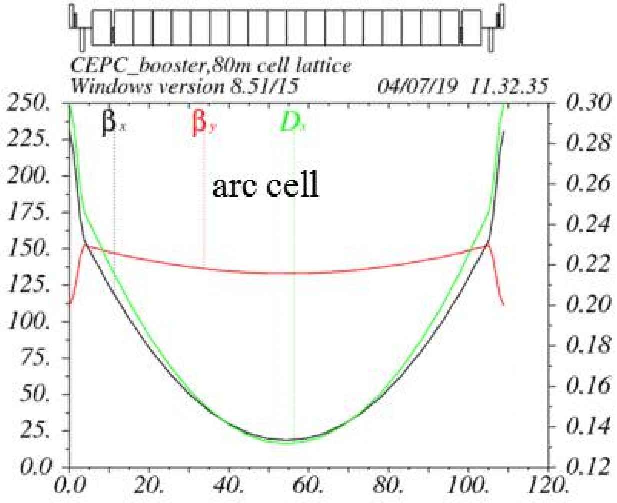
Design of Damping Ring System

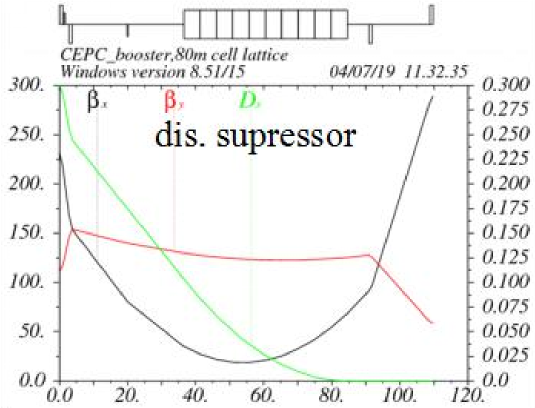


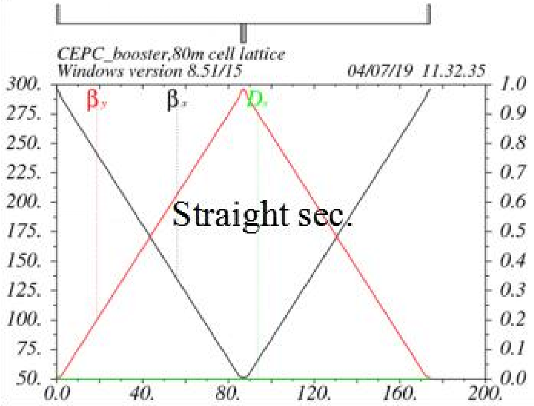




- emittance=**1.29nm** @120GeV
- TME lattice
- Cell length: 110m
- Interleave sextupole scheme

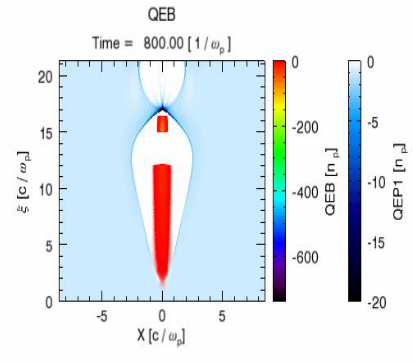


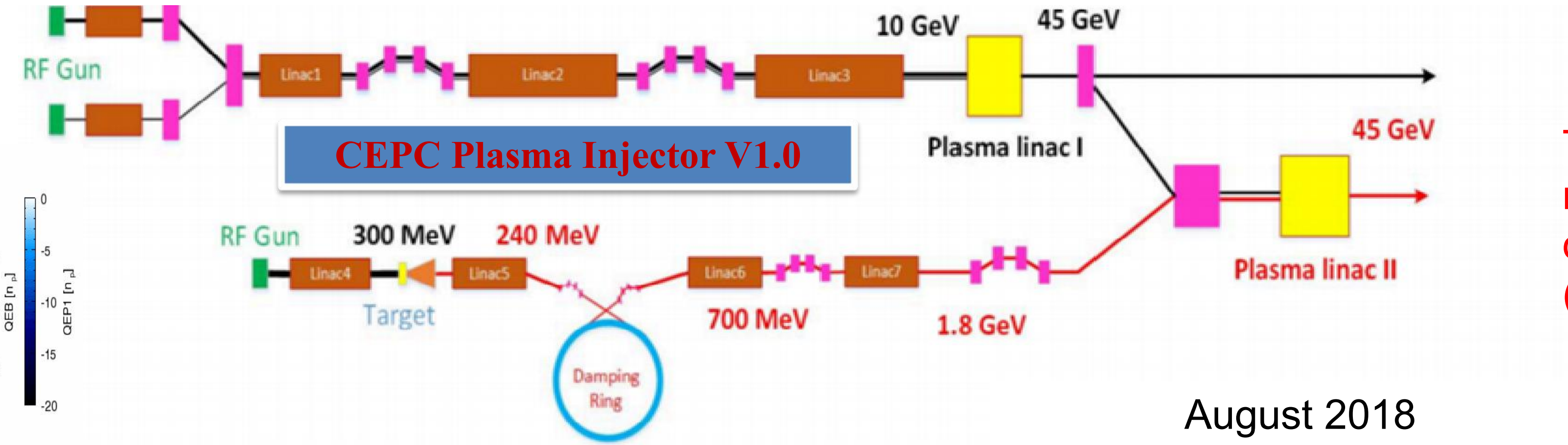




parameters	damping ring for SuperKEKB	damping ring for CEPC
Energy	1.1Gev	1.1Gev
circumference	135.5	75.4
Beta tune	8.24/7.265	3.84/4.81
Bunch lenght	11.12mm	5mm
Bunch number	4	2
synchtron tune	0.0153	0.062
Beam current	70 mA	10 mA

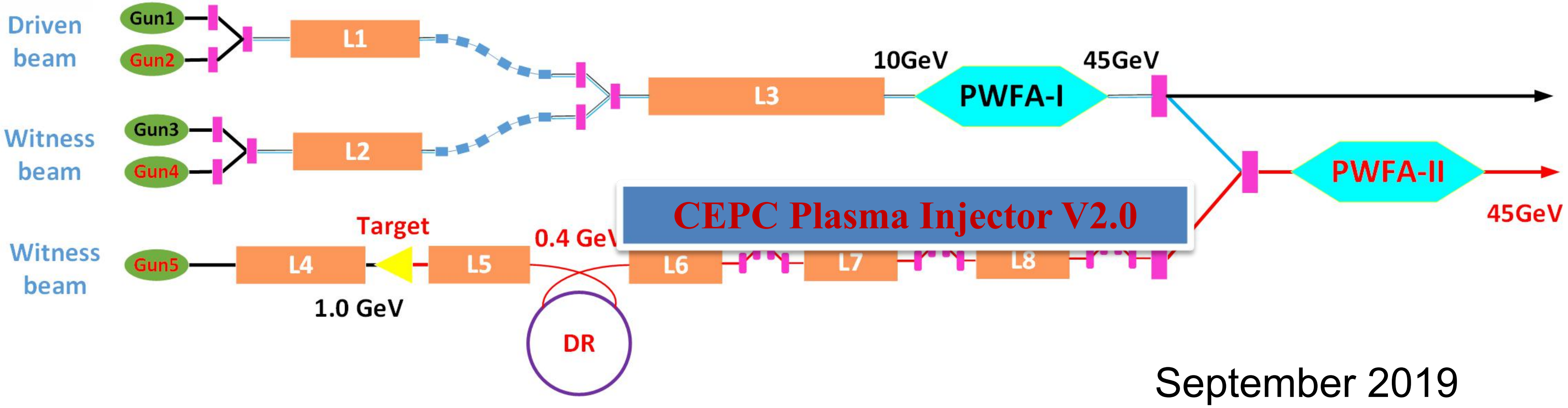
Conceptual Design for CEPC Plasma Injector: V1.0→V2.0 (Alternative injection scheme)





Technical design review has been done (August 22,2019)

August 2018



September 2019

- **Electron plasma acceleration will be tested in Shanghai's Soft XFEL Facility**
- **Positron plasma acceleration scheme might be tested at FACET-II at SLAC**

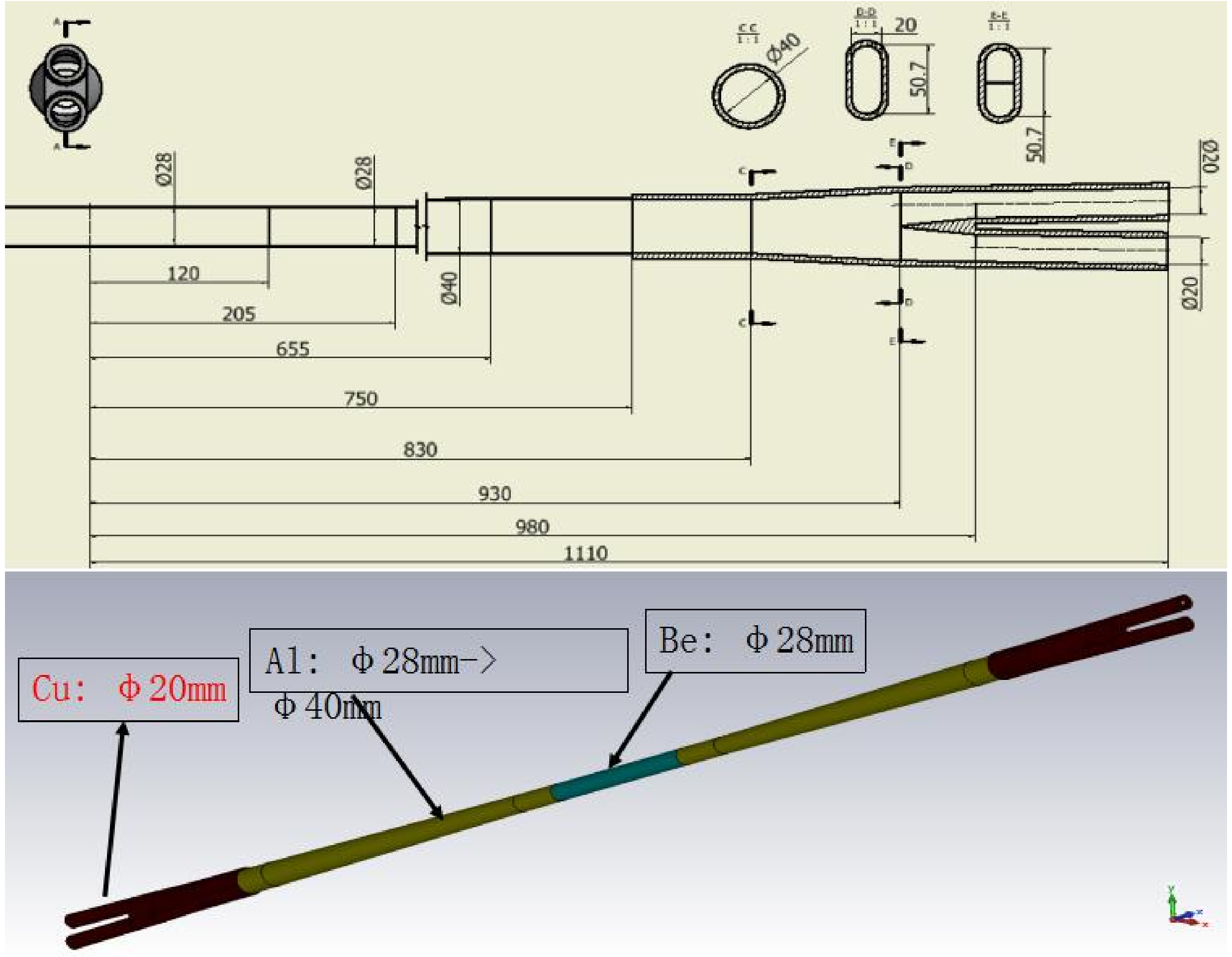
QDa/QDb, QF1 Design Parameters

β_y*=1mm, β_x*=0.33m

QDa/QDb	Horizontal BSC 2（$18\sigma_x$+3）	Vertical BSC 2（$22\sigma_y$+3）	e+e- beam center distance
Entrance	10.16/14.38 mm	15.13/19.06 mm	72.61/124.75 mm
Middle	11.78/17.52 mm	17.67/18.97 mm	97.03/149.17 mm
Exit	14.09/22.03 mm	19.00/17.46 mm	122.11/174.26 mm
Good field region	Horizontal 14.09/22.03 mm; Vertical 19.11/19.19 mm		
Effective length	1.5 m		
Distance from IP	2.2/3.78 m		
Gradient	77.5/77.5 T/m		

QF1	Horizontal BSC 2（$18\sigma_x$+3）	Vertical BSC 2（$22\sigma_y$+3）	e+e- beam center distance
Entrance	23.64 mm	16.79 mm	181.85 mm
Middle	29.04 mm	14.72 mm	214.52 mm
Exit	30.91 mm	14.01 mm	247.85 mm
Good field region	Horizontal 30.91 mm; Vertical 16.79 mm		
Effective length	2 m		
Distance from IP	5.51 m		
Gradient	63.4 T/m		

Power deposition in Be (Z &CDR parameters &σ_z@5mm&material@Lossy mental)



	CDR beam parameters
Total Power on Be(w)	234.8
Power density (w/cm²)	1.07
Temperature without coolant(℃)	428.3
Temperature with coolant(℃)	32.3

(1) Trap mode power (below f_cut_off):
2*104.56w

(2) Power propagating from MDI (above f_cut_off): 2* (191.9*250/1e9) ~ 0w

(3) HOM from other part of the ring:
2*12.84w

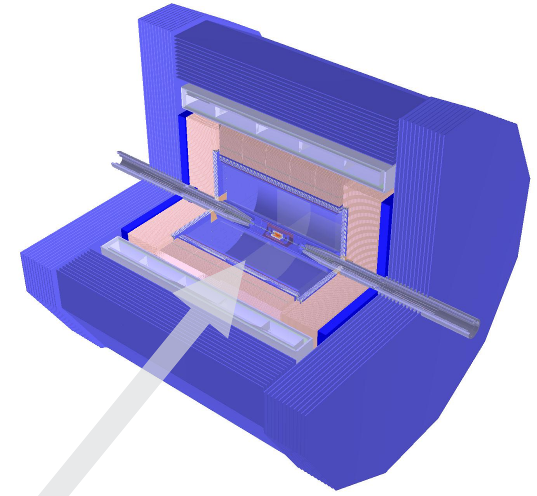
Total power on Be pipe: 234.8w Heat load can be accepted.

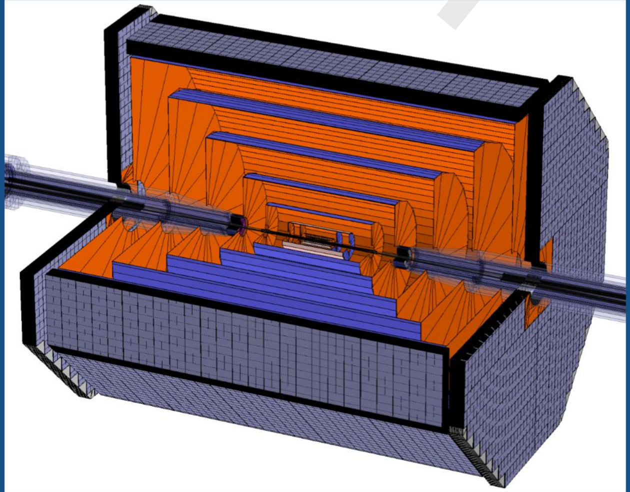
CEPC Detector Concepts included in CDR

CEPC plans for
2 interaction points

Particle Flow Approach

ILD-like
TPC-based dete
(3 Tesla)

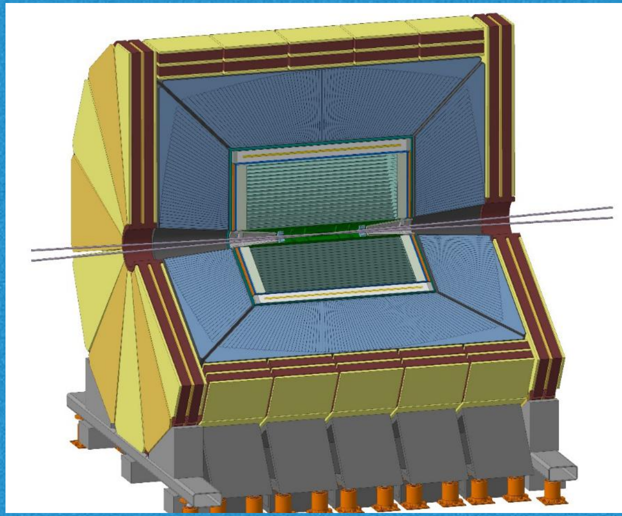




Full silicon
tracker
concept

IDEA Concept
also proposed for FCC-ee

Low
magnetic field
concept
(2 Tesla)



Joao Guimaraes da Costa

Final two detectors likely to be a mix and match of different options

CEPC TDR R&D Plan and Status

CEPC Accelerator R&D Priority

1) CEPC 650MHz 800kW high efficiency klystron (80%) (No commercial products)

2) High precision booster dipole magnet (critical for booster operation)

3) CEPC 650MHz SC accelerator system, including SC cavities and cryomules

4) Collider dual aperture dipole magnets and dual aperture qudrupoles

5) Vacuum chamber system

6) SC magnets including cryostate

7) MDI mechanic system

8) Collimator

9) Linac components

10) Civil engineering design

11) Plasma injector

12) 18KW@4.5K cryoplant (Company)

Main On-going CEPC Detector R&D Activities

Tracking

Time Projection Chamber
Silicon Vertex Detector

Drift Chamber
Muon detectors - RPC, μRwell

Solenoid design

Machine Detector Interface

Calorimetry

High Granularity Calorimeter:
ECAL with Silicon and Tungsten
ECAL with Scintillator+SiPM and Tungsten
SDHCAL with RPC and Stainless Steel
SDHCAL with ThGEM/GEM and Stainless Steel
HCAL with Scintillator+SiPM and Stainless Steel

Dual Readout Calorimeter
Crystal Calorimeter

LumiCal

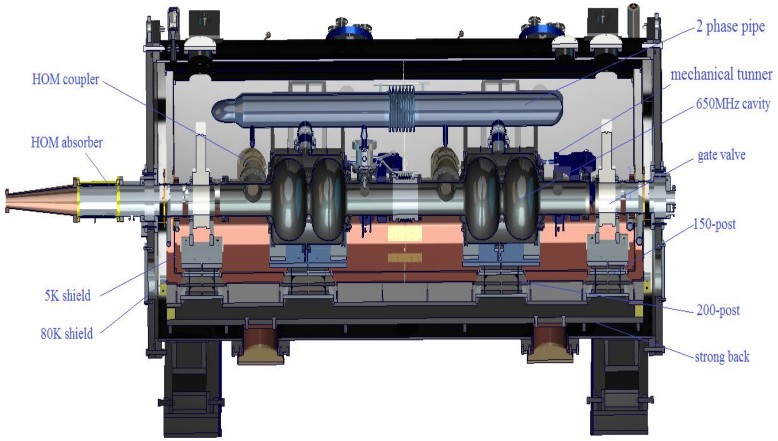
Funding from MOST, NSFC, CAS, INFN, and collaboration with international partners

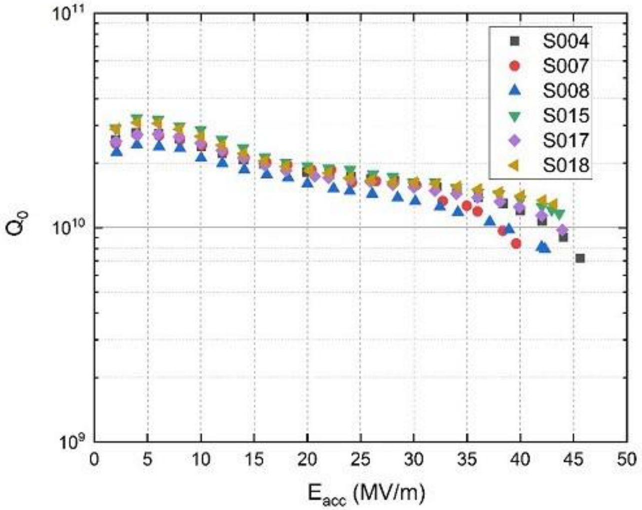
International Detector R&D Committee formed to evaluate research proposals
(First meeting November 2019)

CEPC SCRF R&D Progresses

CEPC 2*2cell 650MHz cryomodule with beam test later **(2019-11-11 at IHEP)**

SC cavity vertical test temperature monitor system established **(2019-11-01 at IHEP)**





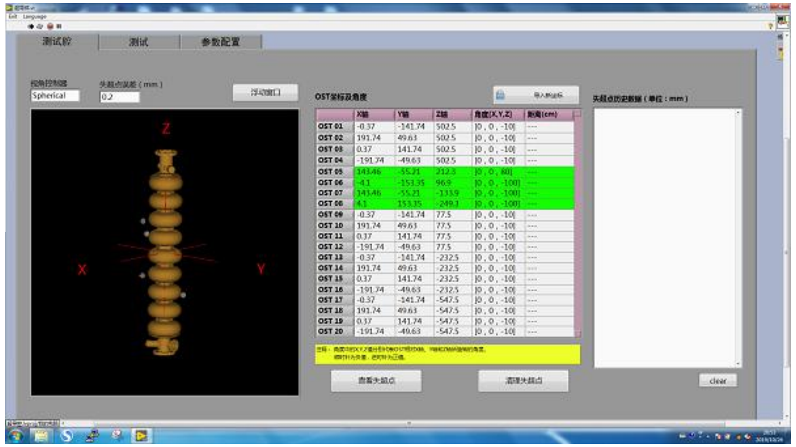
1.3GHz fine grain single cell:

1) 45.6MV/m

2) 43MV/m@Q01.3×10^{10}

(2020-12-25 at IHEP)

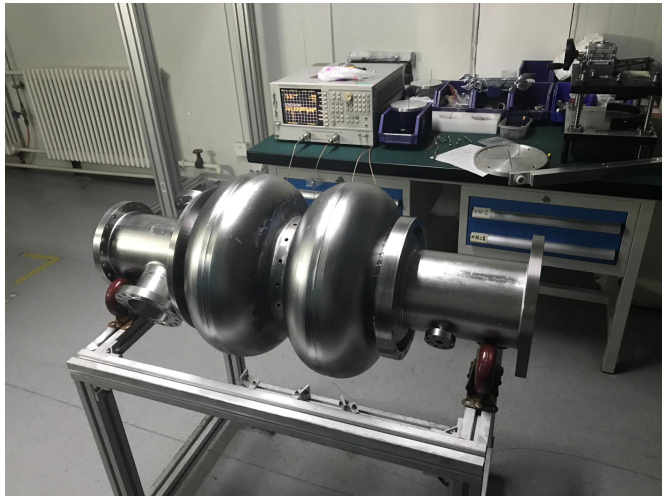
General superconducting cavity test cryomodule in IHEP New SC Lab **(2019-12-27 at IHEP)**

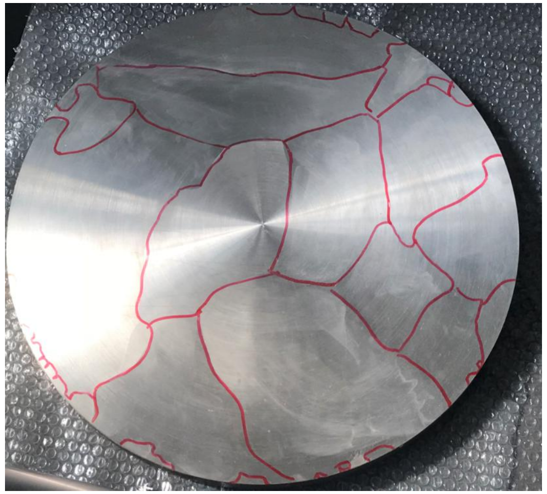


General superconducting cavity test cryomodule in IHEP New SC Lab

650 MHz High Gradient High Q Cavity

- Previous 650 MHz single cell and 2-cell cavities reached max 36 MV/m and high Q.
- EP and N-doing development now focusing on 1.3 GHz and then apply to 650 MHz.
- PAPS large SRF lab and enabling advanced facilities will soon boost CEPC cavity R&D.

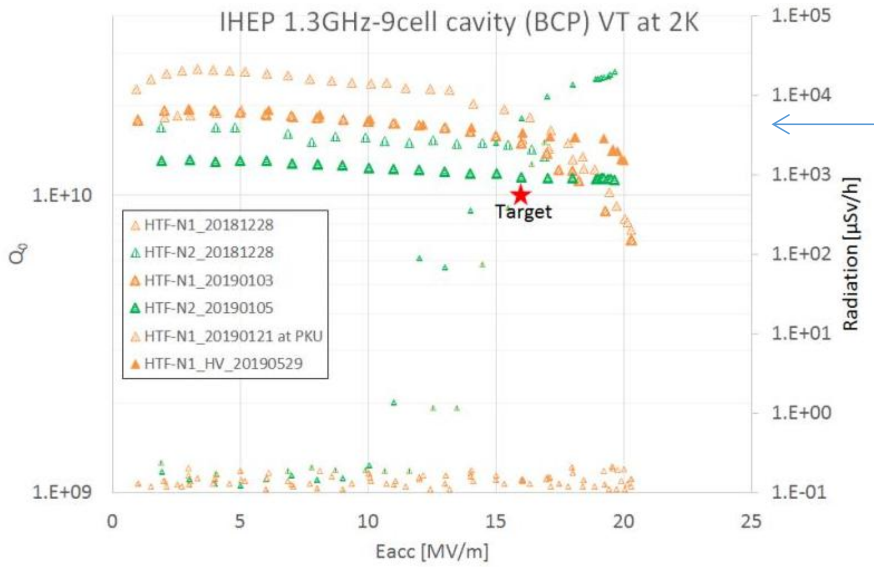




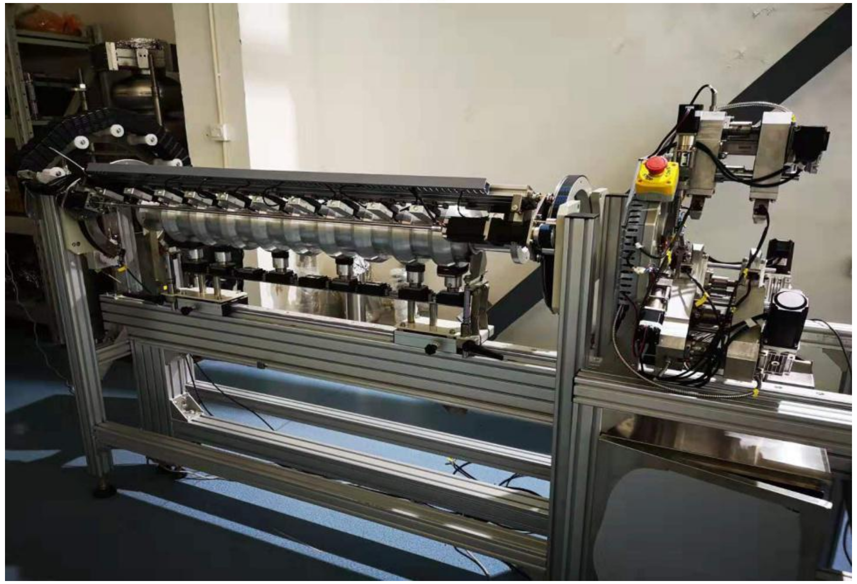
Three fine grain 650 MHz 2-cell cavities fabricated and processed (BCP). Soon to do vertical test, helium vessel weld and vertical test with HOM couplers. Two of them will install to the test cryomodule for horizontal test and beam test in 2020. Cavity helium vessel and tuner in fabrication.

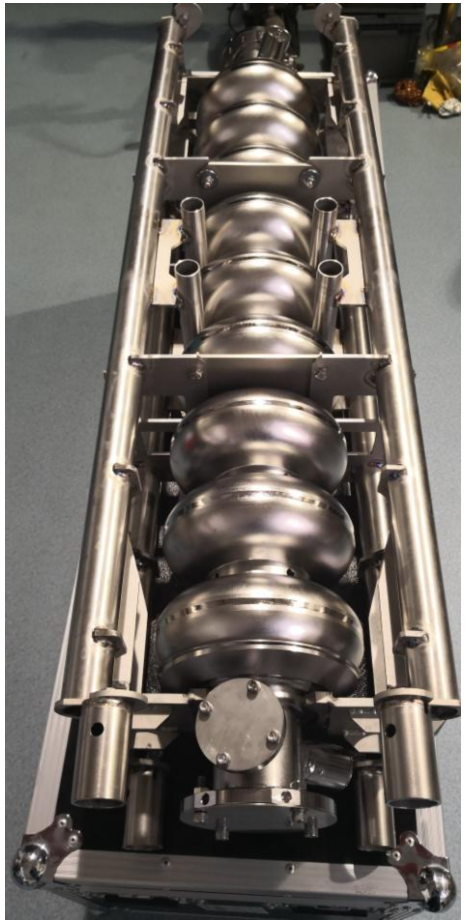
Four large grain 650 MHz cavities for high gradient high Q study. Processed with BCP. Vertical test soon. EP and possible CBP later.

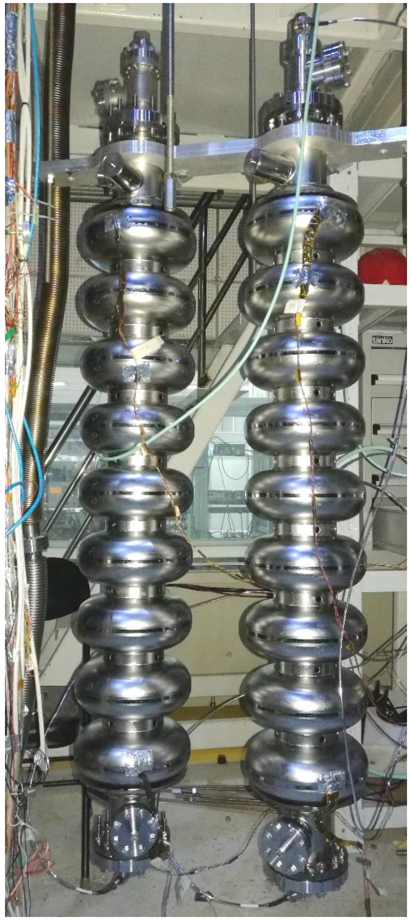
IHEP 1.3 GHz 9-cell Cavities (BCP)

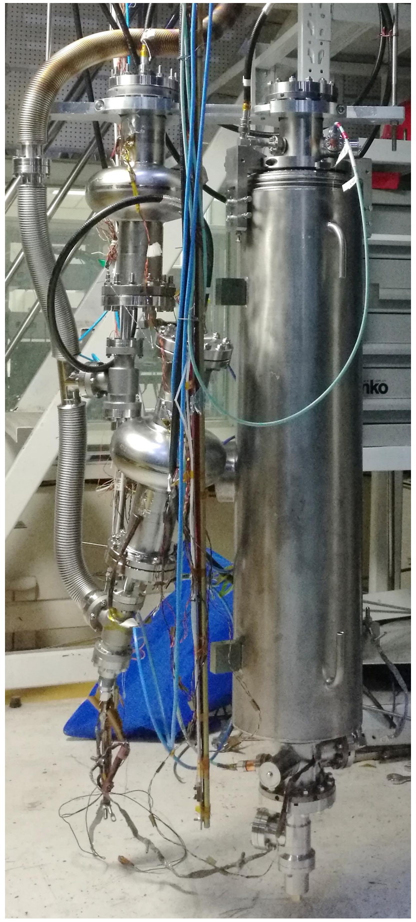


IHEP made 1.3GHz 9cell cavity reaches the goal of SHINE



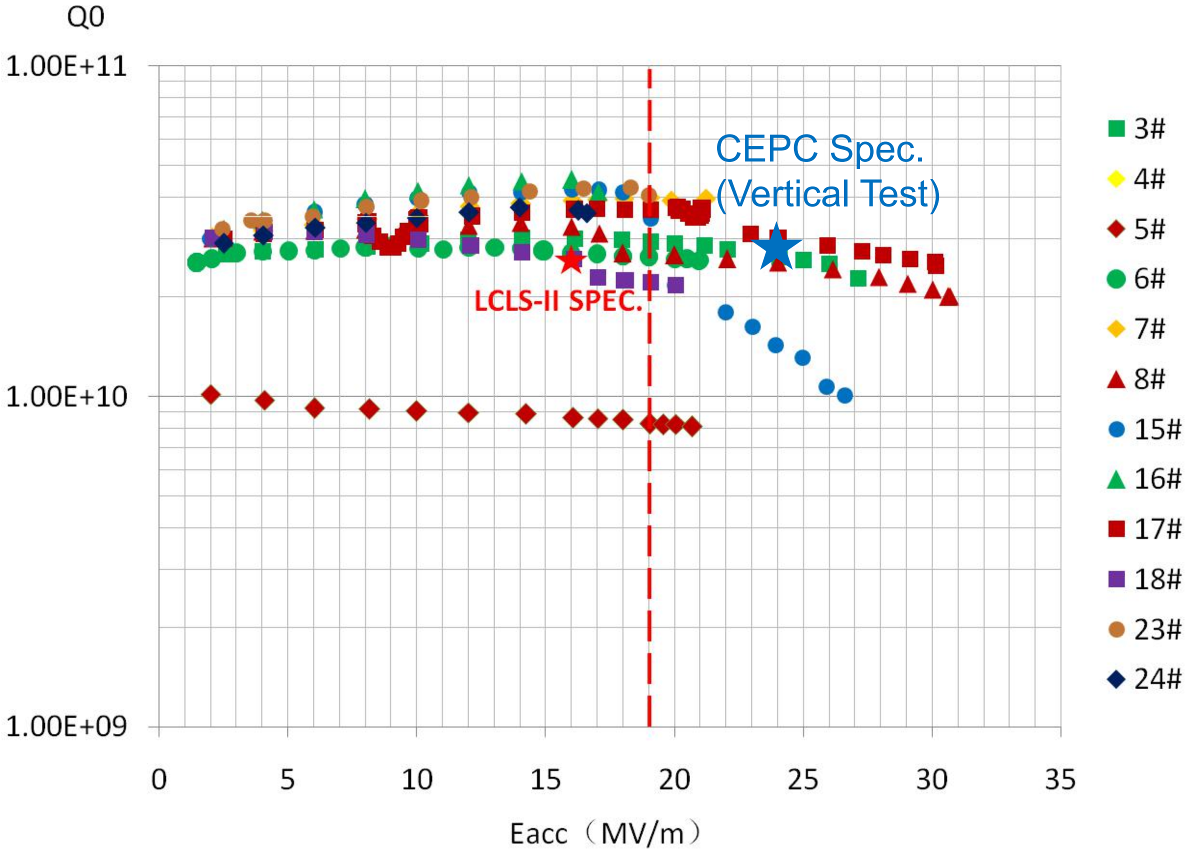




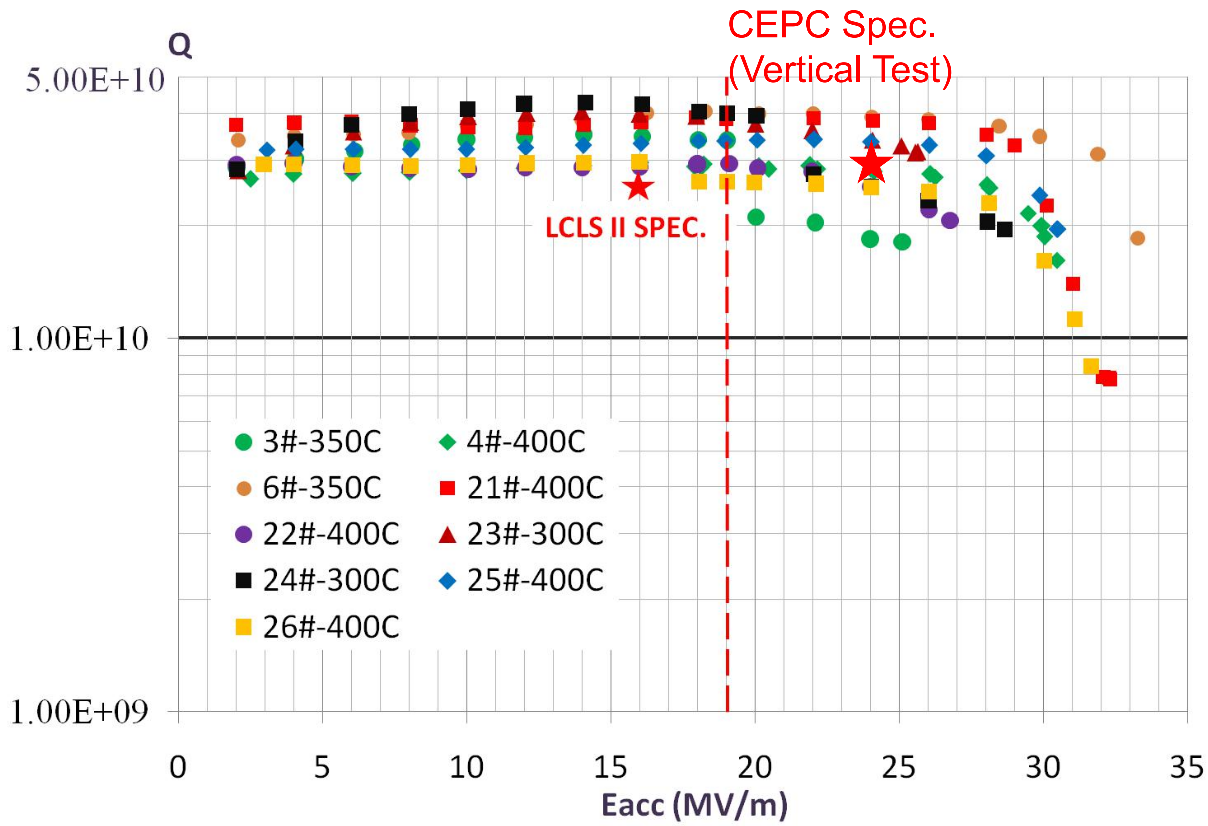


1.3GHz Cavity R&D

- N-doping of several 1.3GHz 1-cell cavities has succeeded，the best result reached **2.6E10@30MV/m。**
- Research of Mid-T annealing has been carried out firstly in China，the best result of 1.3 GHz 1-cell cavities reached **3.5E10@30MV/m。**
- Electro-polishing of 1.3GHz 9-cell cavity is underway, which will be followed by N-doping and Mid-T annealing。



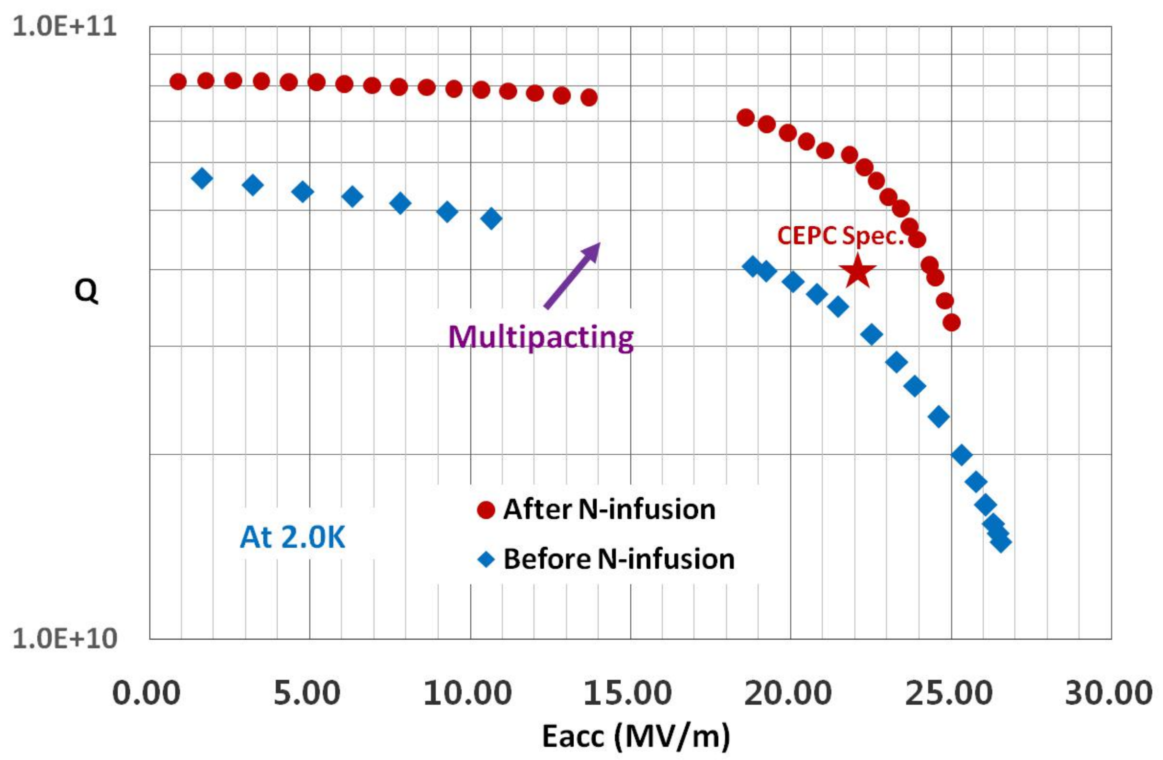
Vertical test results of 1.3GHz 1-cell cavities N-doped



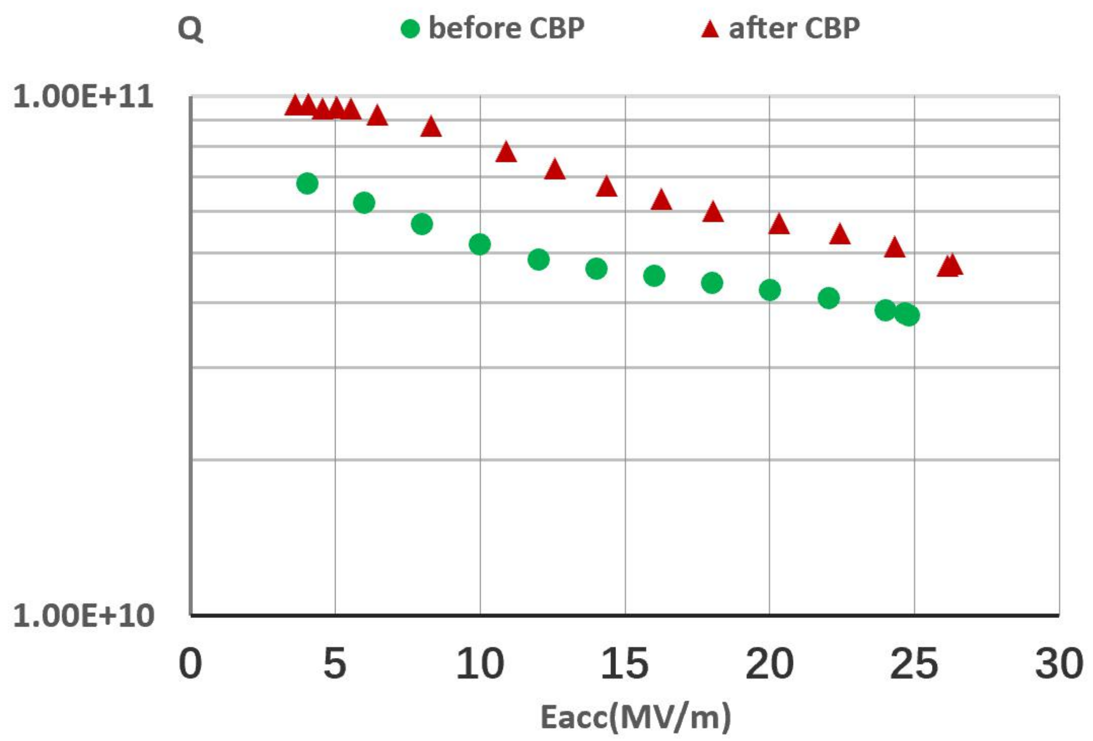
Vertical test results of 1.3GHz 1-cell cavities after Mid-T annealing

650MHz Cavity R&D

- 650 MHz 2-cell cavity reached 6E10@22MV/m after N-infusion, which has exceeded CEPC Spec （Q=4E10@Eacc=22MV/m）. Next, Electro-polishing will be applied to increase the gradient.
- 650 MHz 1-cell cavity (large grain) reached 4.8E10@26MV/m after centrifugal barrel polishing (CBP). Next, Electro-polishing , N-doping or N-infusion will be applied to increase Q and gradient.

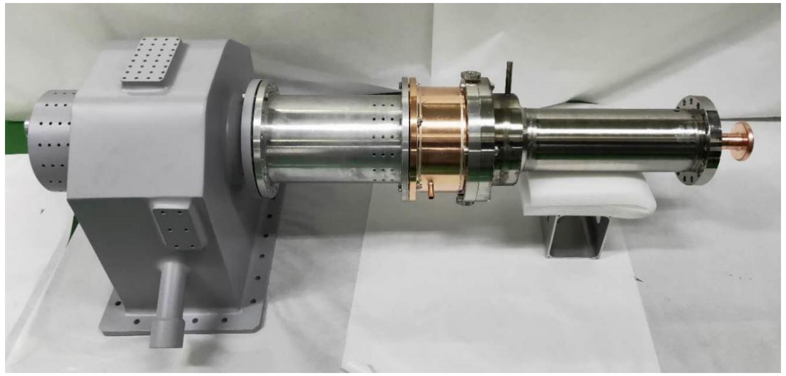


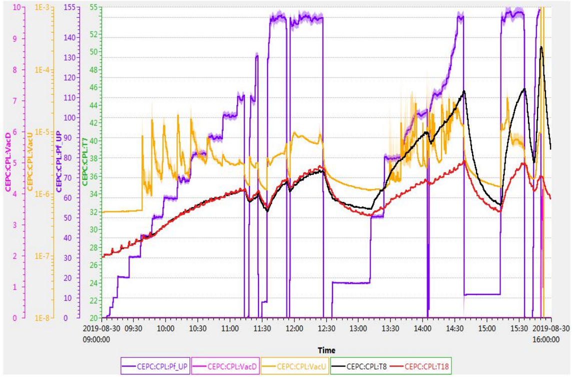
Vertical test result of 650 MHz 2-cell cavity（Collaboration with Peking University）

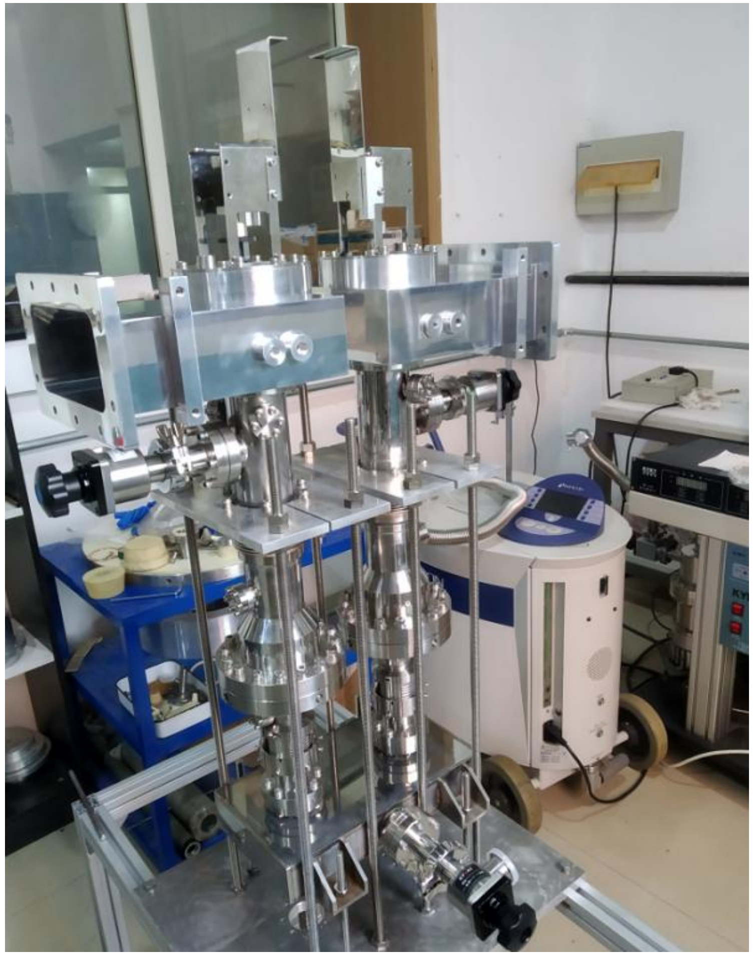


Vertical test result of 650 MHz 1-cell cavity (large grain)

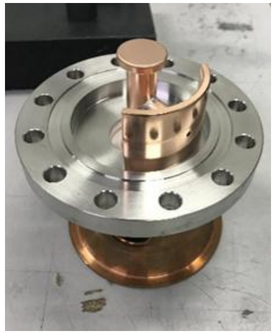
650 MHz and 1.3GHz High Power SRF Components



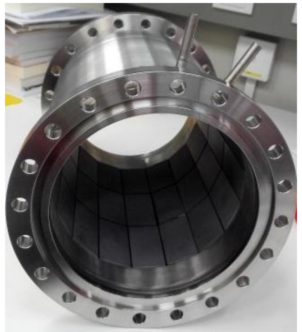




High power test of one 650 MHz fixed coupling input coupler reached 150 kW SW (corresponding to 400 kW TW at the window).



Four high power HOM couplers fabricated and low power tested.



Wideband high power HOM absorber with SiC+AlN material.

1.3GHz power coupler travelling wave 14kW, standing wave7kW. 2019-12-27 at IHEP

IHEP New SC Lab under Construction (Status in Nov. 2019)

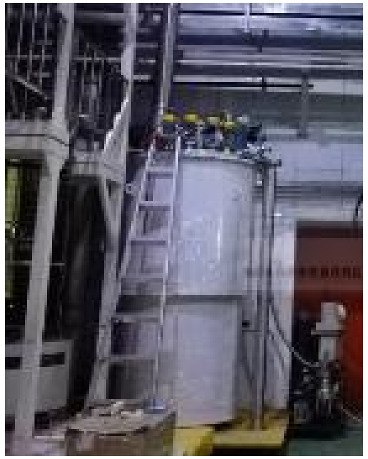
New SC Lab Design (4500m^2)

Bird view in Nov. 15, 2019

Crygenic system hall in Jan. 16, 2020

Hellium recirculating tanks

2.5KW@4.5Kcold box



2K JT heat exchanger

CEPC 650MHz High Efficiency Klystron Development

Programs:
1) Ajdisk
2) KlyC
3) CST

Collaborators:
Aaron Jensen (SLAC)

JinChi Cai (CERN)

S. Fukuda (KEK)

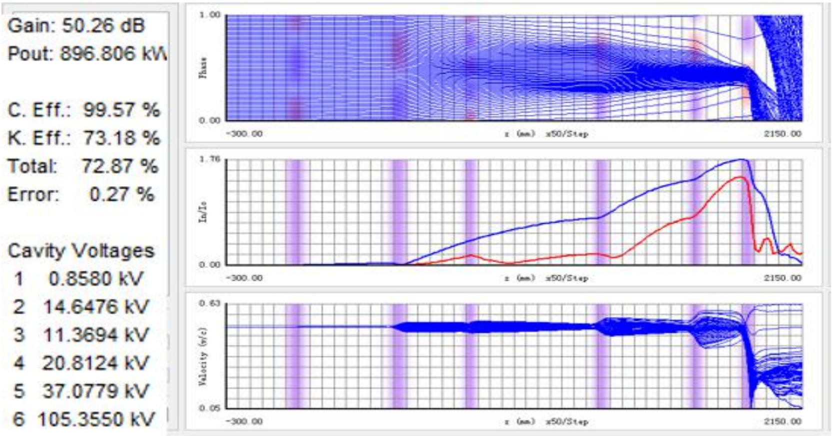
Abid Aleem

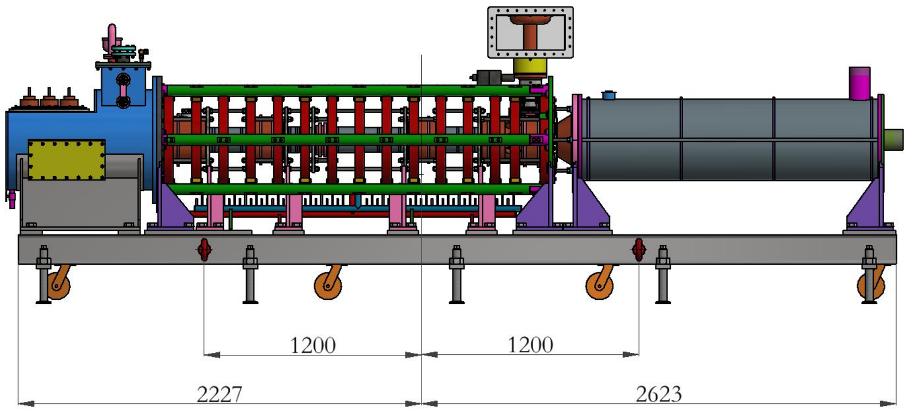
Munawar Iqbal (Bakistain)

Established "High efficiency klystron collaboration consortium", including IHEP & IE(Institute of Electronic) of CAS, and Kunshan Guoli Science and Tech.

- 2016 – 2018: Design conventional & high efficiency klystron
- 2017 – 2018: Fabricate conventional klystron & test
- 2018 - 2019 : Fabricate 1st high efficiency klystron & test
- 2019 - 2020 : Fabricate 2nd high efficiency klystron & test
- 2020 - 2021 : Fabricate 3rd high efficiency klystron & test

Parameters	Conventional efficiency	**High efficiency**
Centre frequency (MHz)	650+/-0.5	**650+/-0.5**
Output power (kW)	800	**800**
Beam voltage (kV)	80	**-**
Beam current (A)	16	**-**
Efficiency (%)	~ 65	**> 80**

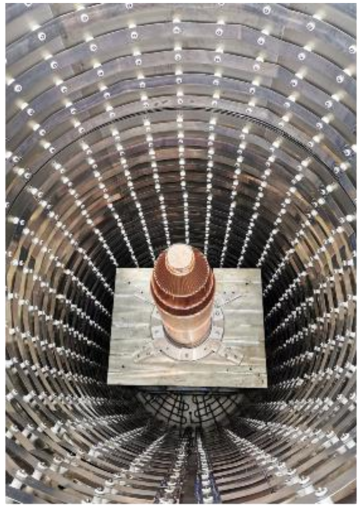




Mechanical design of conventional klystron

⇨ 73%/68%/65% efficiencies for 1D/2D/3D

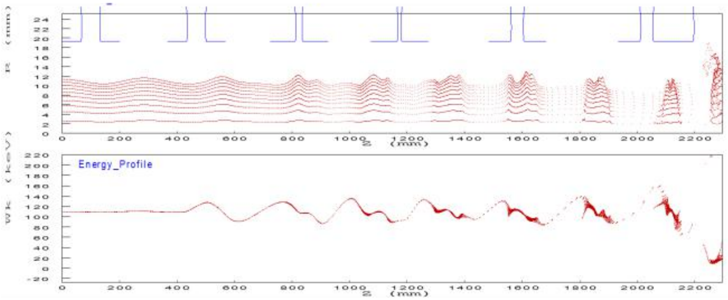
CEPC 650MHz High Efficiency Klystron Development-2



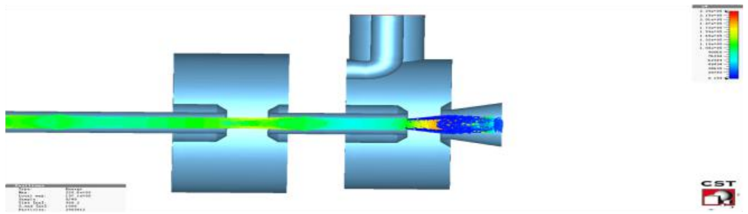
On March 10， 2020， the first CEPC650Mhz klystron output power has reached pulsed power of 800kW (400kW CW due to test load limitation), efficiency 62% and band width>+-0.5Mhz.

①High voltage klystron

EMSYS2.5D efficiency:78.6%

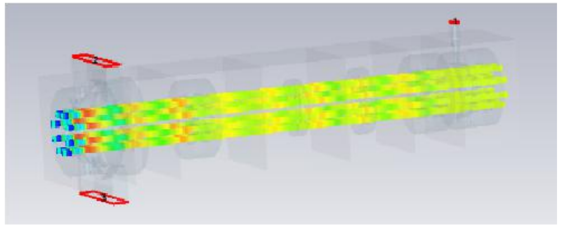


CST3D efficiency:76.5%

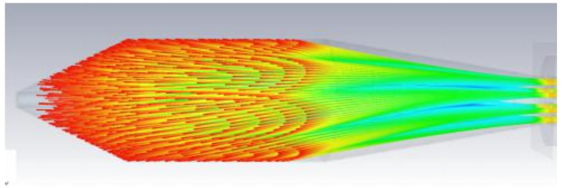


②Multi-beam klystron

CST3D efficiency80.7%



Beam dynamic simulation



Collector design

To increase the klystron efficiency, two types of high efficiency klystrons are under way, 1) single beam high volatge klystron, and the design efficiency is 76.5%; 2) multibeam klystron， and the designed efficiency is 80.7%.

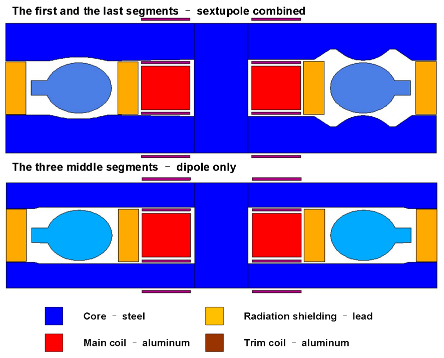
CEPC Collider and Booster Ring Conventional Magnets

China Astronotics Department 508 Institute participates CEPC magnets mechanical designs

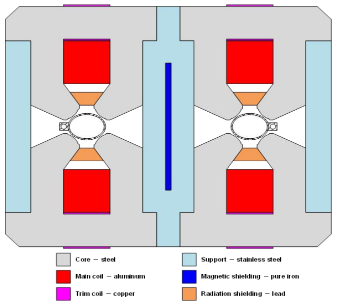
CEPC collider ring magnets

	Dipole	Quad.	Sext.	Corrector	Total
Dual aperture	2384	2392	-	-	13742
Single aperture	80*2+2	480*2+172	932*2	2904*2	
Total length [km]	71.5	5.9	1.0	2.5	80.8
Power [MW]	7.0	20.2	4.6	2.2	34

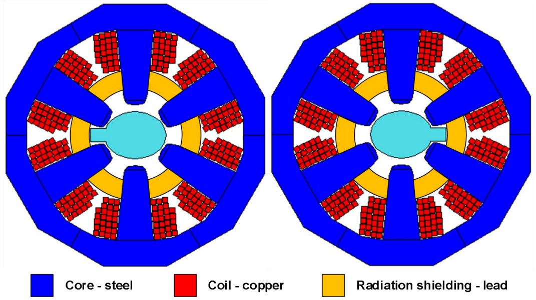
First short model magnets will be fnished in Nov, 2019



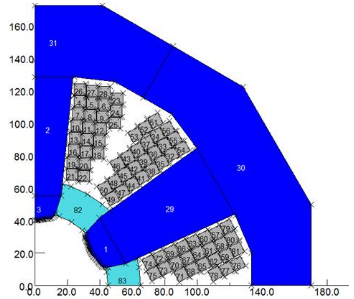
Dipole



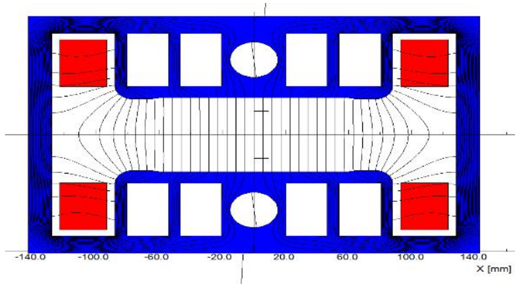
Quadrupole



Sextupole

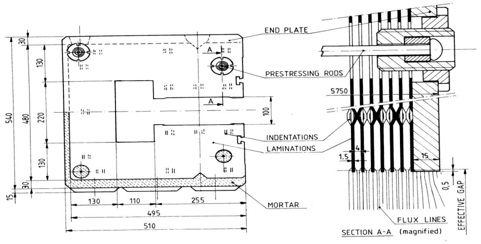


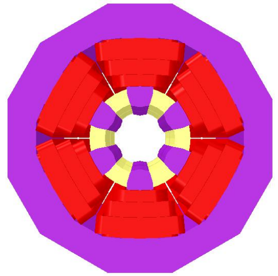
Dipole



Booster ring low field magnets

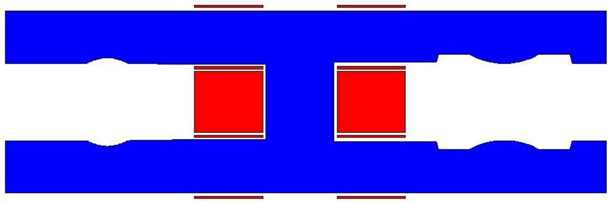
Quantity	16320
Magnetic length(m)	4.711
Max. strength(Gs)	338
Min. strength(Gs)	28
Gap height(mm)	63
GFR(mm)	55
Field uniformity	5E-4



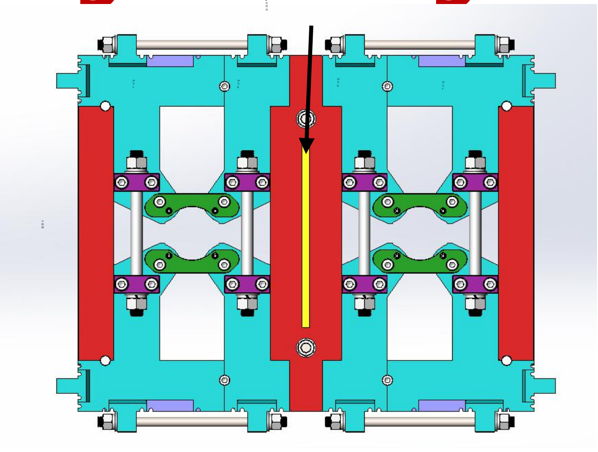


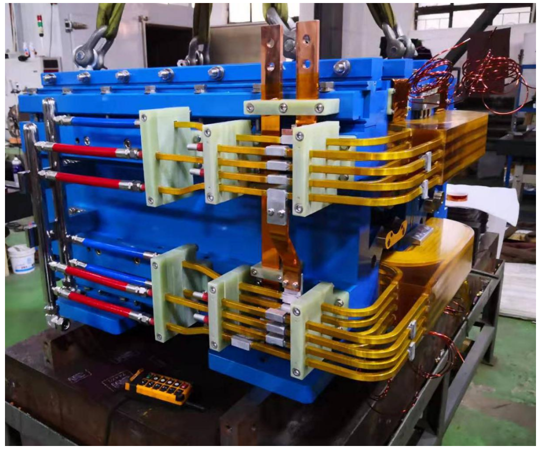
Sextupole

CEPC Collider Ring dual Aperture Dipole, Quadrupole and Sextupole Magnet Design Progress

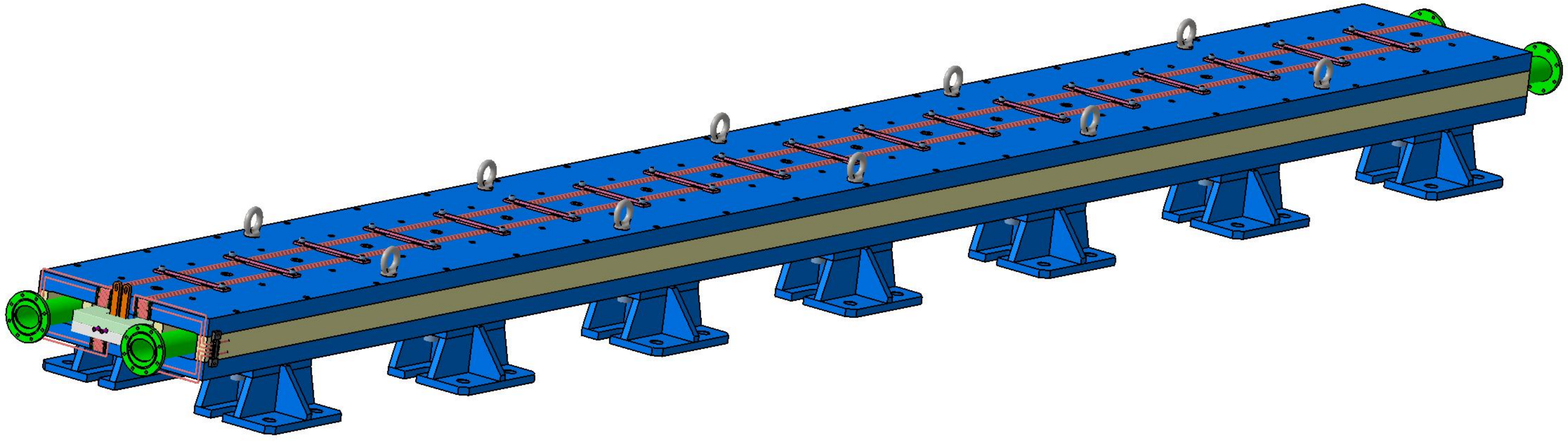


First dual aperture dipole test magnet of 1m long has been fnished in Nov, 2019





First dual aperture quadrupole magnet has been fnished in Nov, 2019



The mechanical design of a full size CEPC collider ring dual aperture dipole of 5.7m long has been designed and be fabricated at the end of 2020.

CEPC Low Field Booster Dipole Magntes' Specifications and Challenges

	BST-63B
Quantity	16320
Minimum field (Gs)	28
Maximum field (Gs)	338
Gap (mm)	63
Magnetic Length (mm)	4700
Good field region (mm)	55
Field uniformity	0.1%
Field reproducibility	0.05%

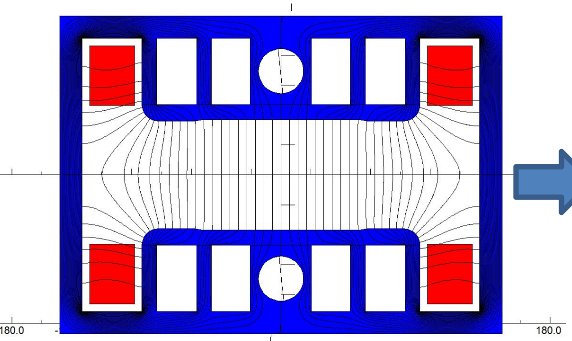
10GeV injection enegy fromlinac to 100Km booster

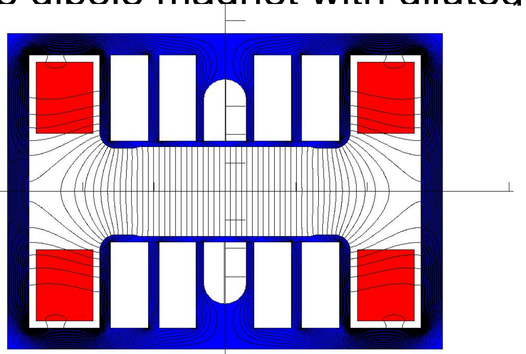
Challenges

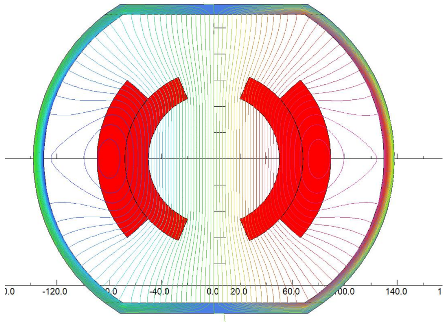
- **Total length of the dipoles ~75km** **how to reduce cost**
- **Field error <29Gs*0.1%=0.029Gs** **how to design**
- **Field reproducibility<29Gs*0.05%=0.015Gs** **how to measure**
- **Magnet length ~4700mm** **how to fabricate**

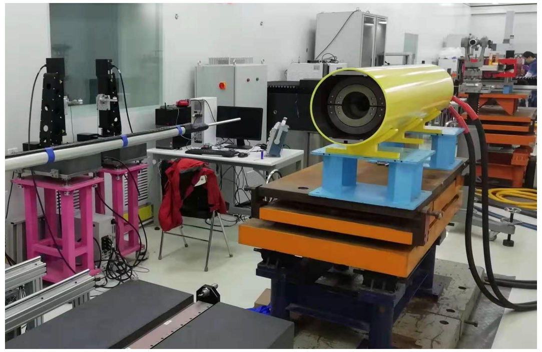
Booster High Precision Low Field Dipole Magnets

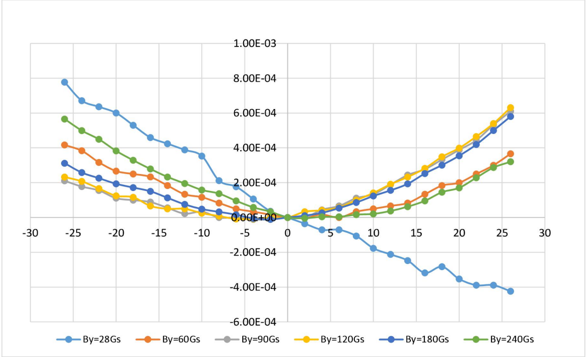
Two kinds of the dipole magnet with diluted iron cores and without iron core (CT) are proposed and designed



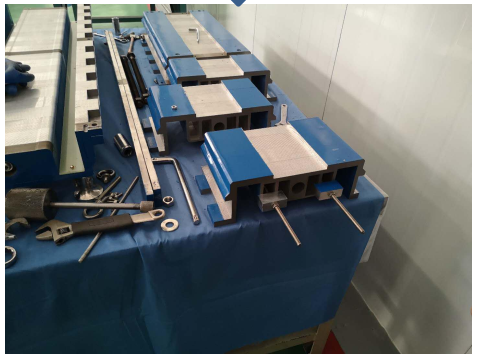




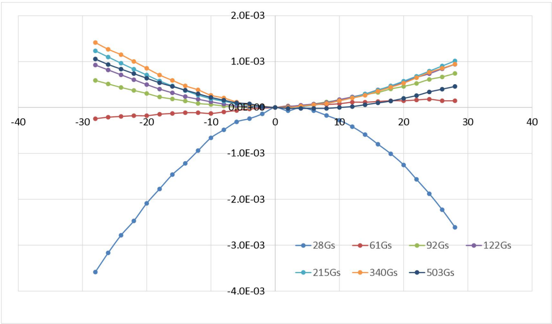




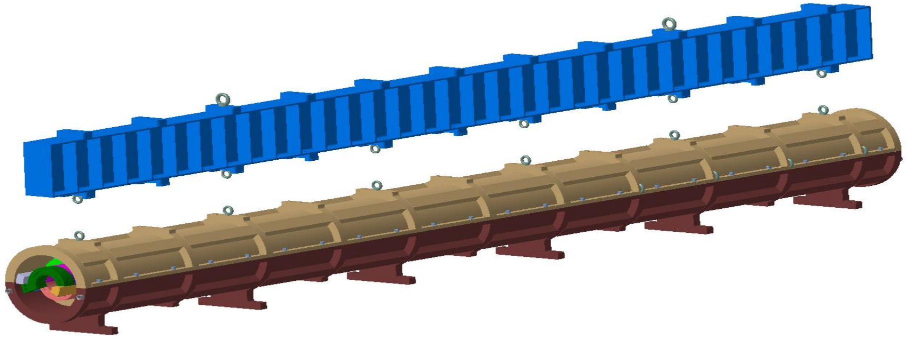
1m long CT test booster dipole magnet without iron core completed in Oct. 2019, and the test result shows that CT design reached the design goal.



The improved model is under test



The first 1m long test booster dipole magnet with iron core, completed in Nov. 2019, and not yet reached design goal, improvement is under way



A full scale CT dipole magnet of 5.1m long is under design, and fabrication will be completed at te end of 2020

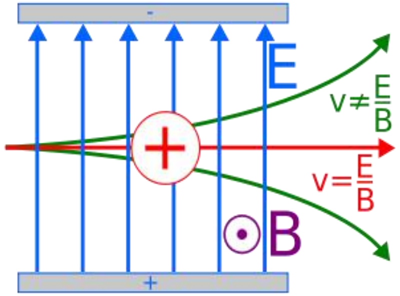
CEPC Collider Ring Electro-Magnet Separator

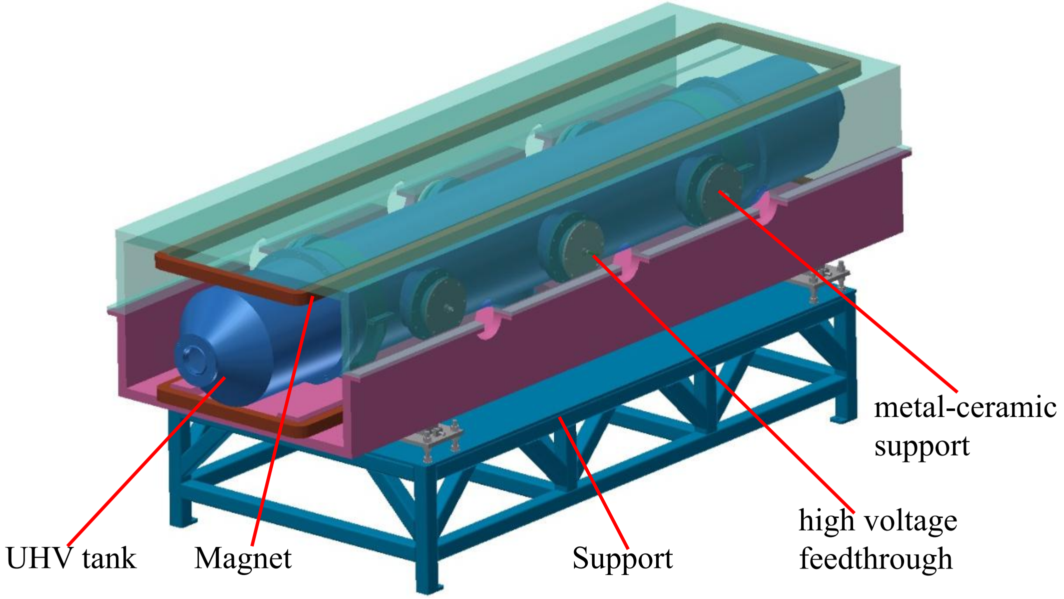
The **Electrostatic-Magnetic Deflector** is a device consisting of perpendicular **electric** and **magnetic** fields, just like **Wien filter**.

Challenges: To maintain E/B ration in fringe field region

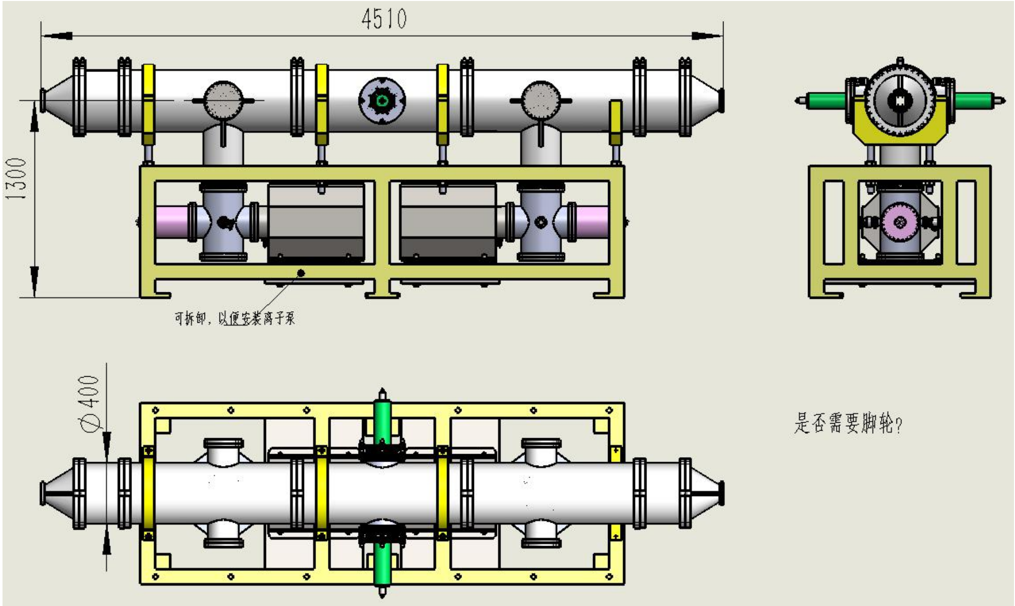
Reduce the impedance and loss factor of the separator

	Filed	Effective Length	Gap	Good field region	Stability
Electrostatic separator	2.0MV/m	4m	110mm	70mm x 30mm	5 x 10^{-4}
Dipole	66.7Gauss	4m	600mm	70mm x 30mm	5 x 10^{-4}





structure drawing of Electrostatic-Magnetic Deflector

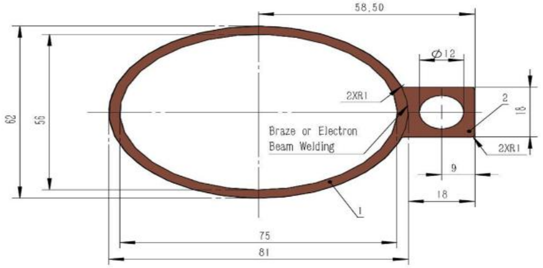


CEPC Vacuum System R&D

NEG coating suppresses electron multipacting and beam-induced pressure rises, as well as provides extra linear pumping. Direct Current Magnetron Sputtering systems for NEG coating was chosen.

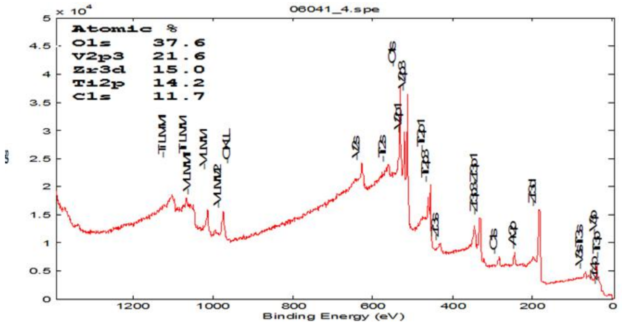
- The vacuum pressure is better than 2 x 10-10 Torr
- Total leakage rate is less than 2 x 10-10 torr.l /s.

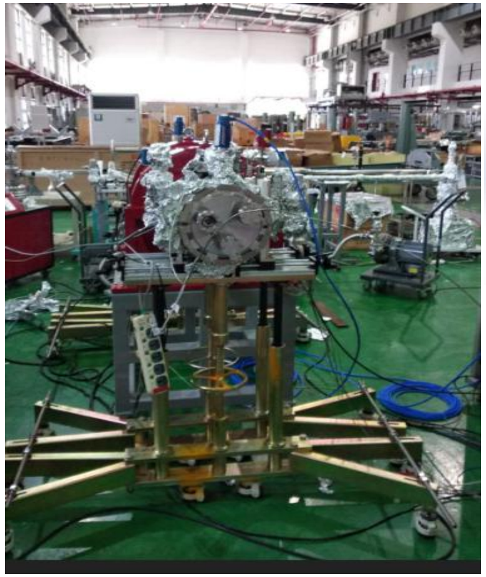
Positron ring

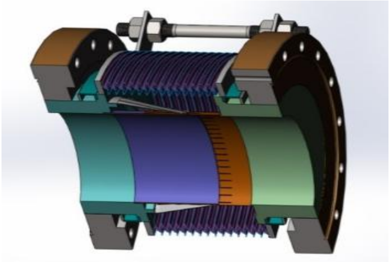


Copper vacuum chamber (Drawing) elliptic 75×56, thickness 3, length 6000)

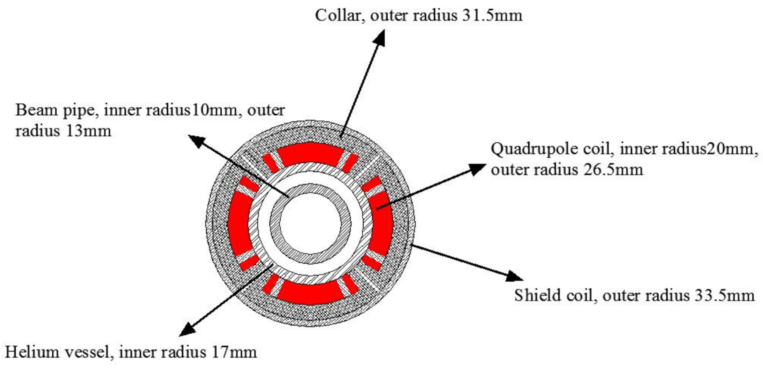
Two 6m long vacuum chambers both for copper and aluminum







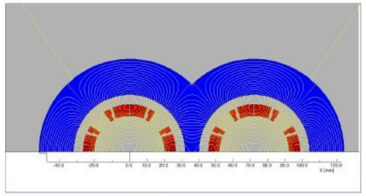
CEPC IR Superconducting Magnets



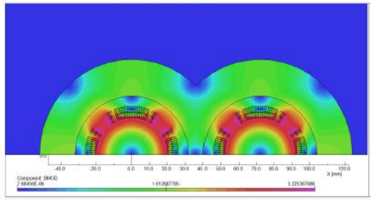
Room-temperature vacuum chamber with a clearance gap of 4 mm

Superconducting QD coils

- 2D field cross talk of QD0 two apertures near the IP side.

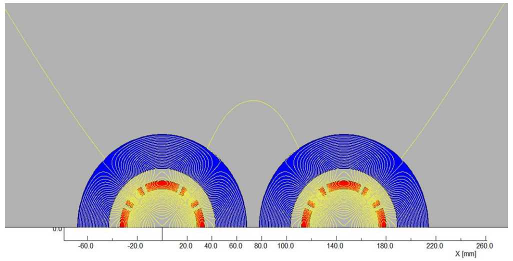


2D Flux lines



Bmod distribution

Superconducting QF coils



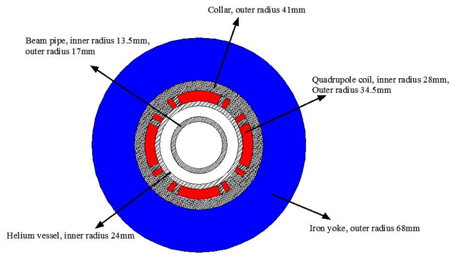
There is iron yoke around the quadrupole coil for QF1. Since the distance between the two apertures is larger enough and there is iron yoke, the field cross talk between two apertures of QF1 can be eliminated.

Technical design review has been done (July 19, 2019)

Mag net	Central field gradient (T/m)	Magnetic length (m)	Width of Beam stay clear (mm)	Min. distance between beams centre (mm)
QD0	136	2.0	19.51	72.61

QF1 Integral field harmonics with shield coils（$\times 10^{-4}$）

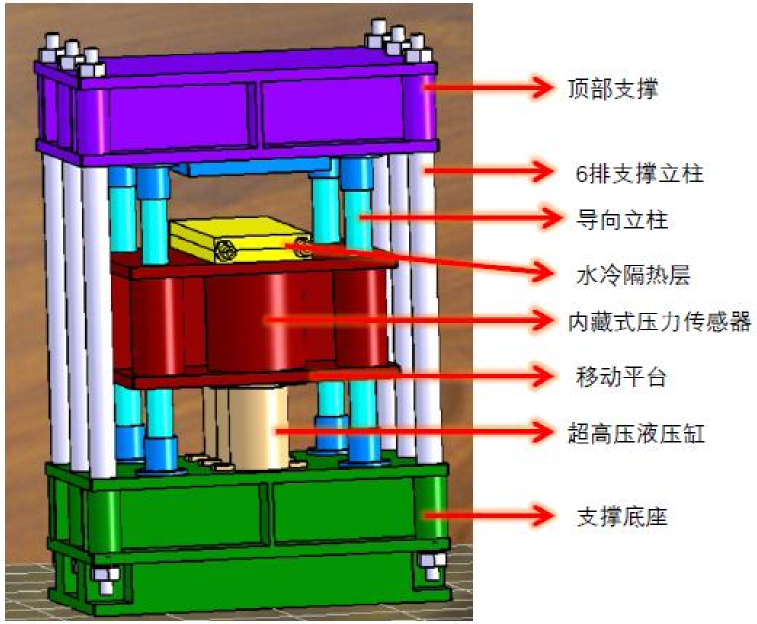
n	B_n/B_2@R=13.5mm
2	10000
6	1.08
10	-0.34
14	0.002



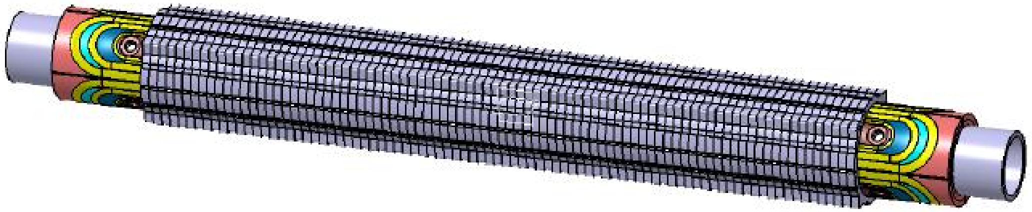
One of QF1 aperture (Peak field 3.8T)

Mag net	Central field gradient (T/m)	Magnet ic length (m)	Width of Beam stay clear (mm)	Min. distance between beams centre (mm)
QF1	110	1.48	27.0	146.20

CEPC MDI SC Quadrupole R&D

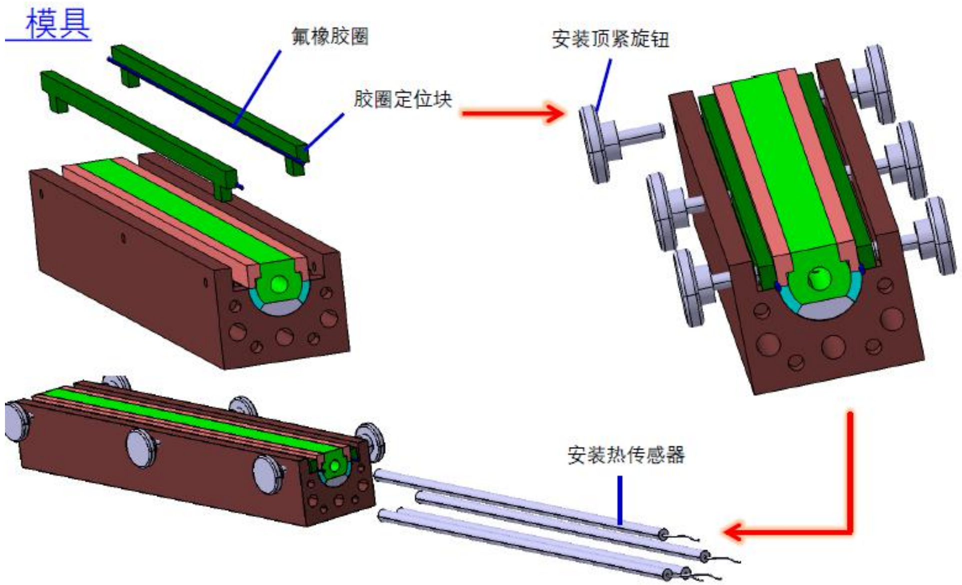


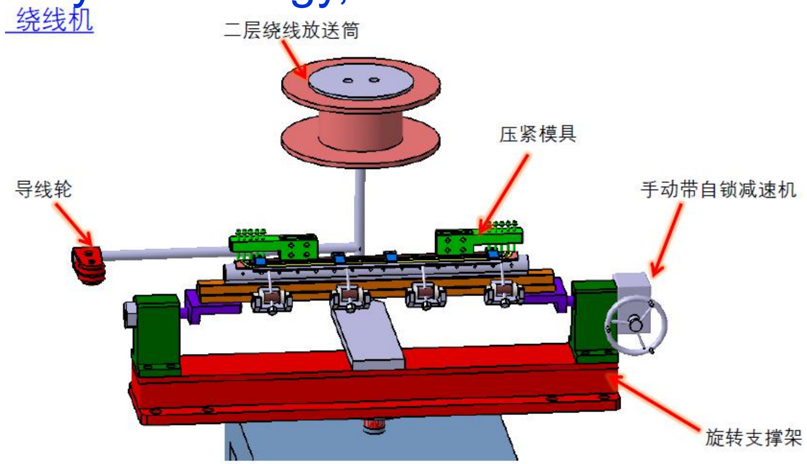
Superconducting quadrupole coil heating and curing system.



Field gradient 102T/m, coil bore diameter 38mm; The minimum distance between the center of the two apertures is 62.7mm

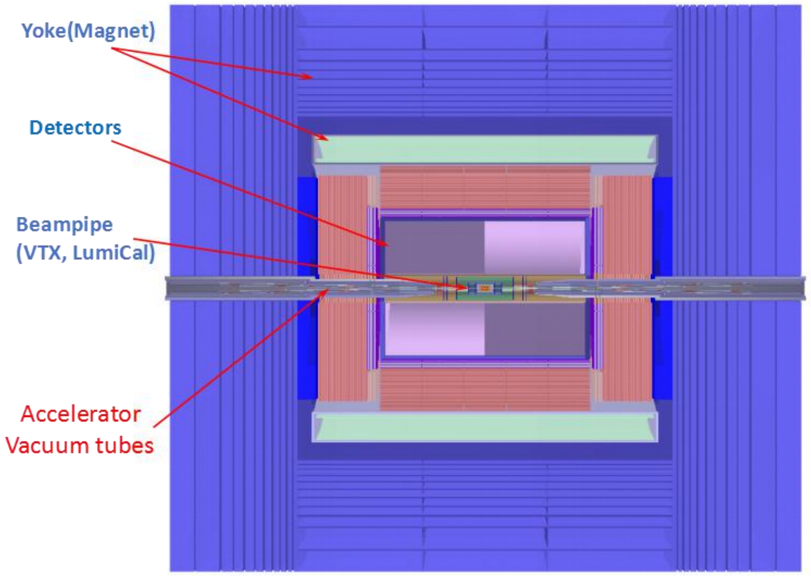
SC quadrupole mechanical design, coil winding technology, fabrication procedure study of quadrupole coil with small diameter, stress applying and monitoring, quadrupole magnet assembly technology, etc.





CEPC MDI Issues

CEPC MDI talks in IAS Mini workshop on MDI for Colliders
http://iasprogram.ust.hk/hep/2020/workshop_accelerator.php?from=singlemessage



From outside to inside:

Yoke(Magnet) --- in design

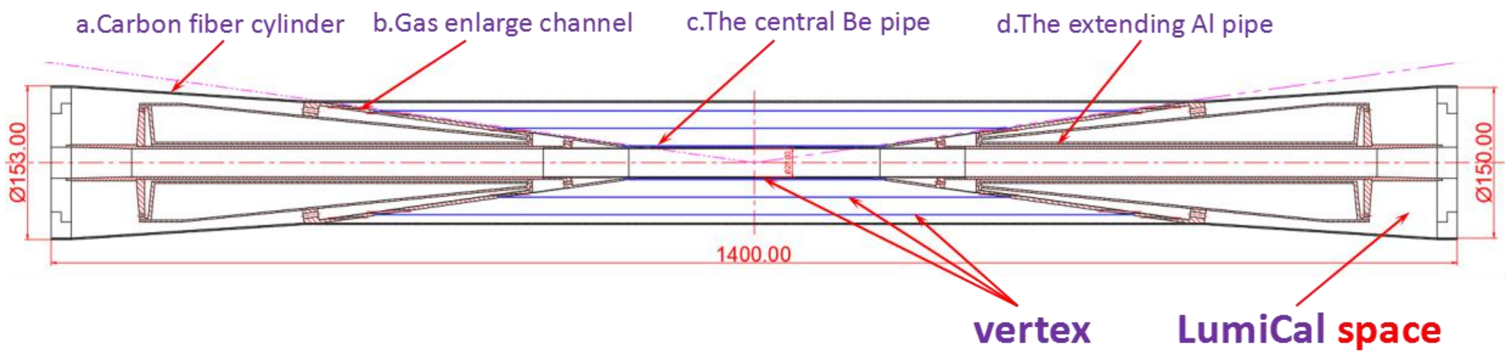
Detectors

- Muon detector
- Hadronic calorimeter
- Electromagnetic calorimeter
- Silicon external tracker
- Time Projection Chamber
- Silicon Inner Tracker

Beampipe(VTX,LuniCal) --- in design

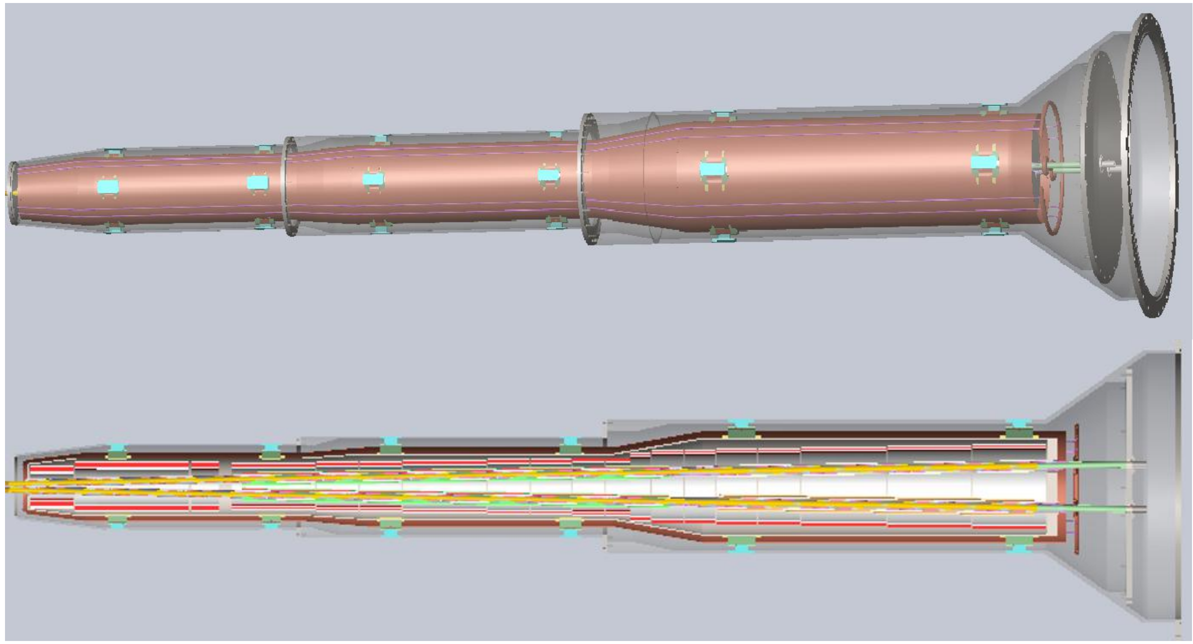
General requirement:
On the premise of meeting the physical requirements of the experiment, the sealed connection between the accelerator vacuum tube and the beam pipe is realized

The connection part between spectrometer and accelerator is accelerator vacuum tube

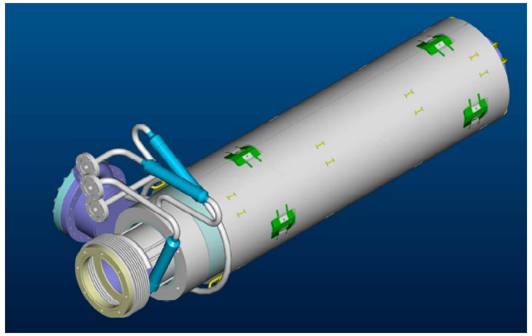


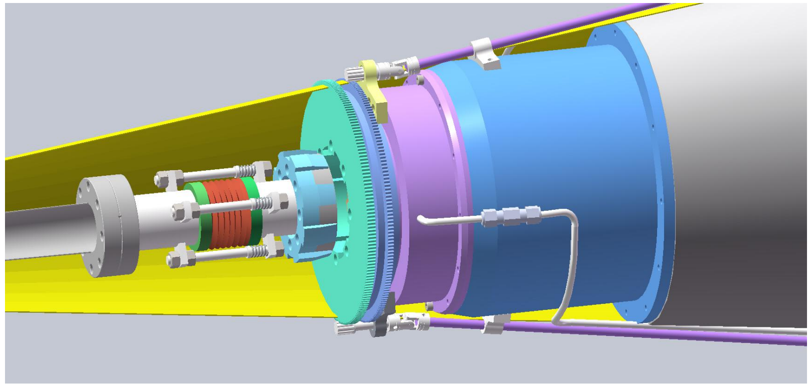
Note:
1.The beam tube consists of four components: a, b, c and d
2.On the beampipe, two detectors are installed --- Vertex and Lumical

CEPC MDI SC Magnets and Mechanical Study

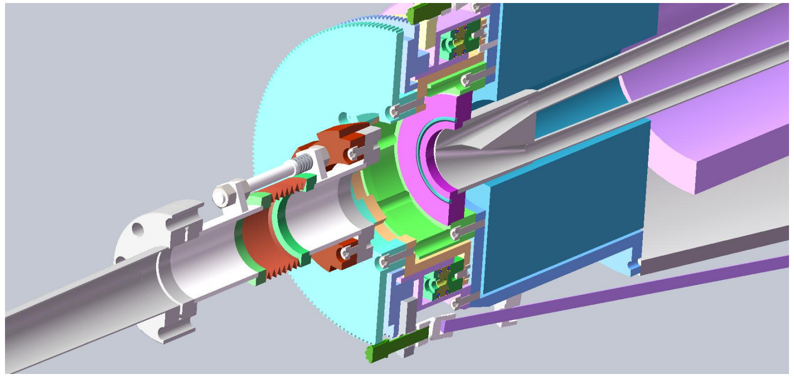


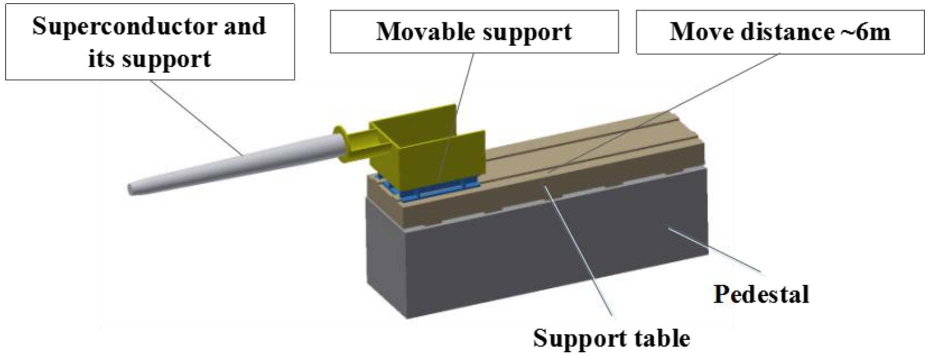
Design status of MDI SC magnet cryostat



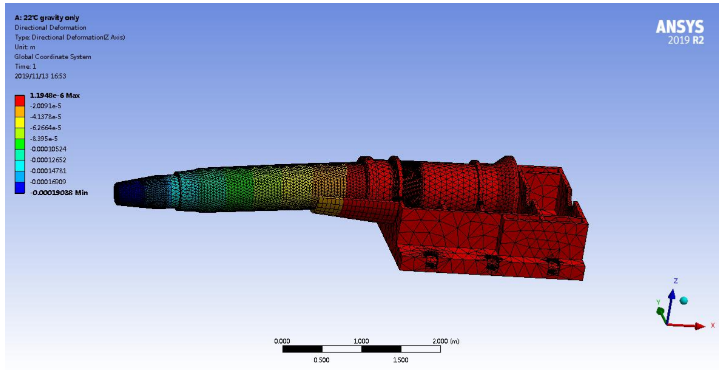


Technical design review has been done (July 23, 2019)

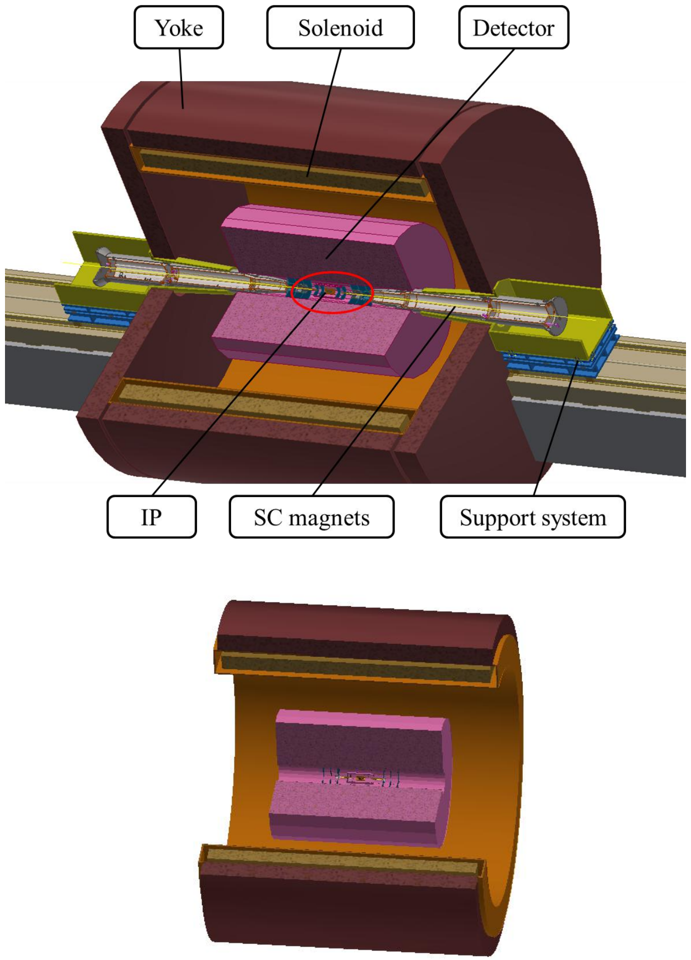


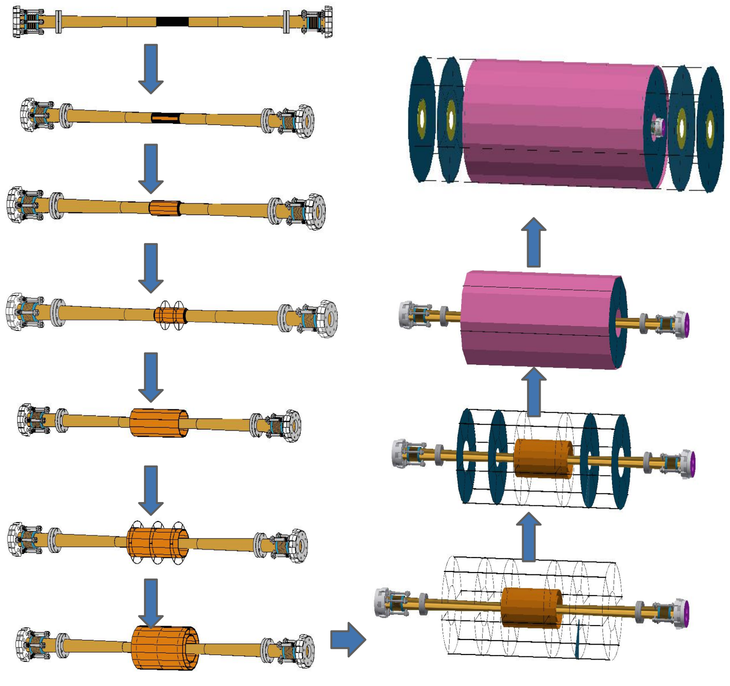


Schematic of support system of superconducting magnets

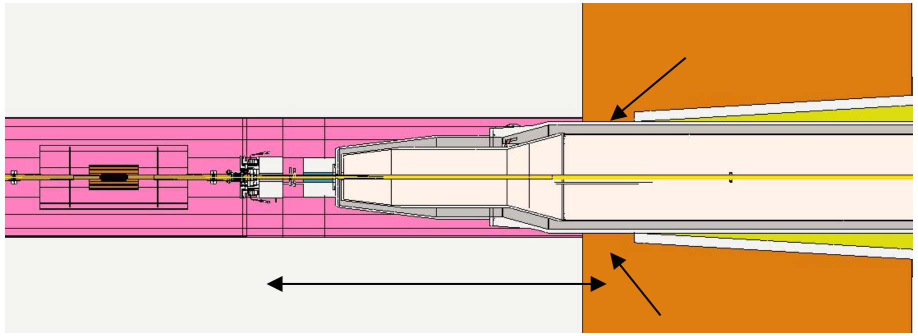


IR Mechanics Assembly





- Both sides of IP chamber are fixed to VTX transversally and are free longitudinally.
- The IP chamber, VTX, SIT and FTD can be considered as one assembly.
- The assembly above can be supported by TPC and be aligned transversally.
- Remote vacuum connector can be used.
- The high precision part of Lumical is with the detector and the main body is with the accelerator.



Little transversally space & long longitudinally distance. It is impossible to connect flanges by hands.

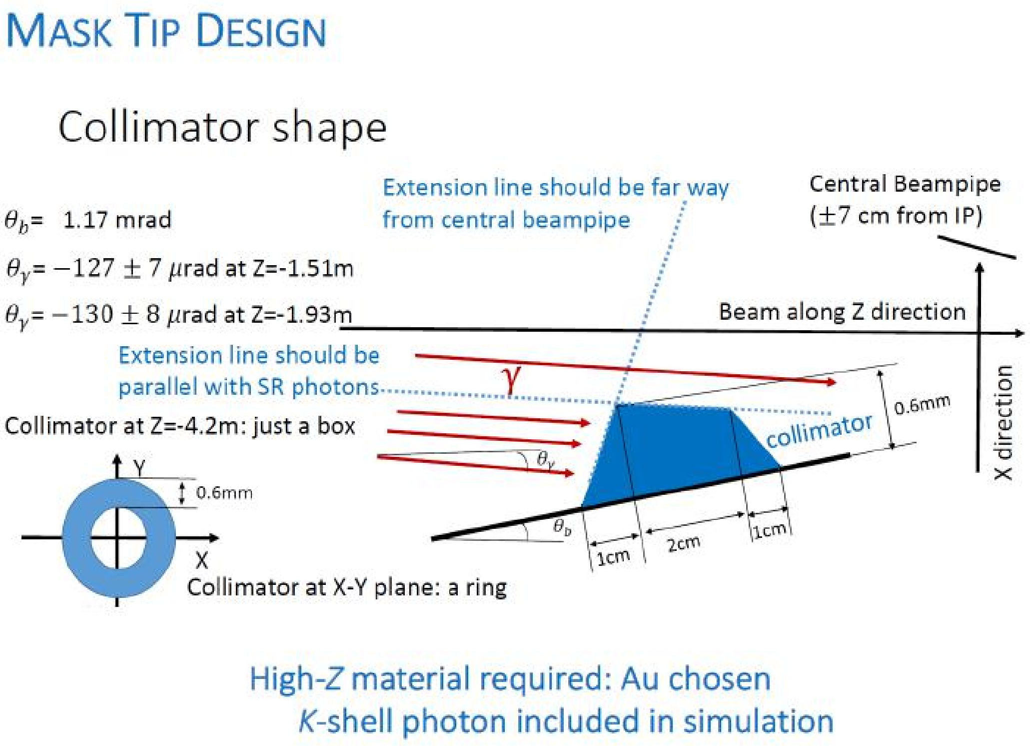
Technical design review has been done (July 23, 2019)

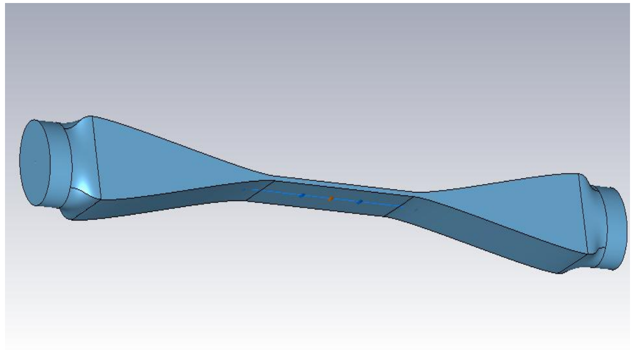
CEPC Movable Collimators

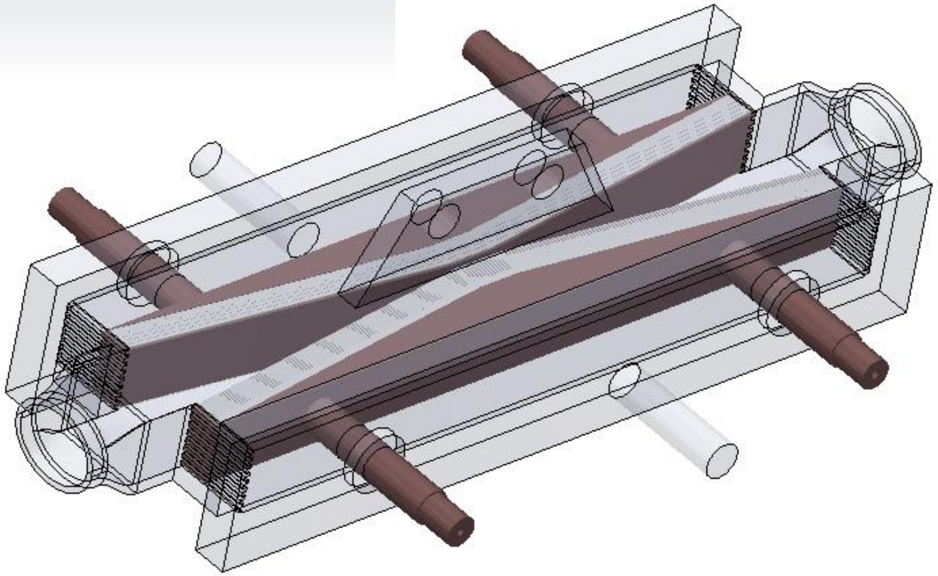
- Located in straight section between two dipoles, the length is 800 mm.
- Primary impedance estimation has been done.
- The synchrotron radiation is the main thermal load, the cooling method is under consideration.

We proposed a design using laminated material with metal and membrane of high thermal conductivity, the photon absorber is also considered.

Y: Highest temperature;
X: Thickness of membrane of high thermal conductivity



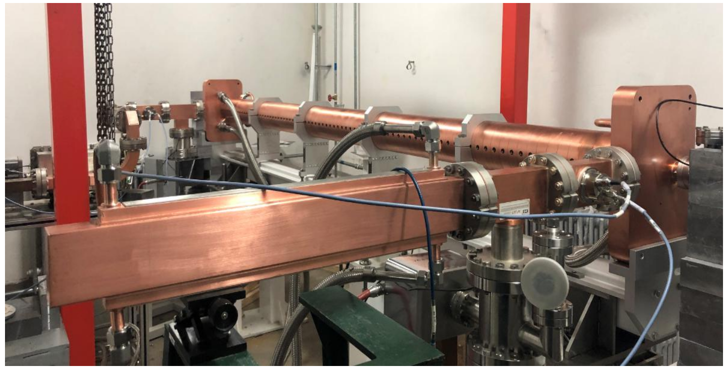




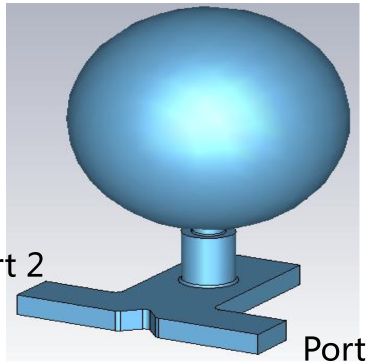
CEPC Linac and damping ring key technology R&D

Accelerating structure

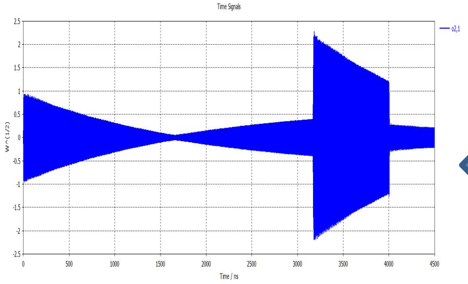
- The structure is 3 meters long with constant gradient design which work mode is 2π/3
- The high power test has finished and the gradiet is up to 33 MV/m



The acclelerating strucutre on high power test bench



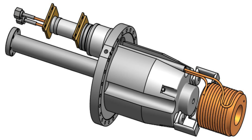
Simulation model



Simulated waveform

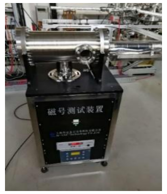
Pulse compressor:
Spherical cavity pulse compressor has devoloped
The TE_{113} mode is selected and the RF design is finished.
The Q value is about 140000
The Maximum Energy Multiplication Factor M=1.84.

Positron source R&D

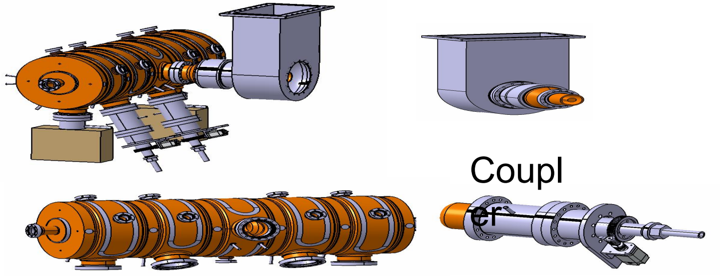


The mechanical design of FLUX concentrator

The finished FLUX concentrator



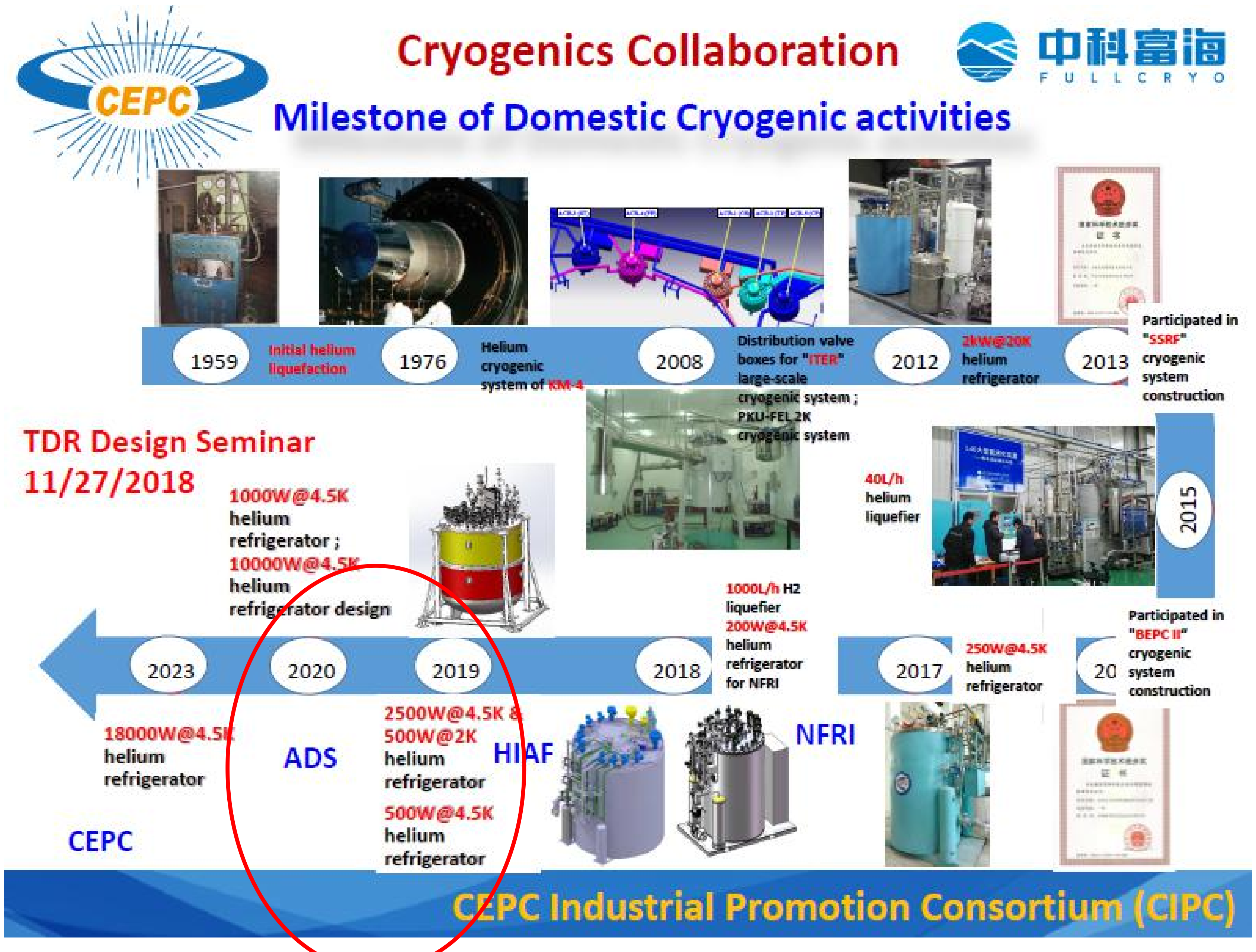
The test bench of the FLUX concentrator



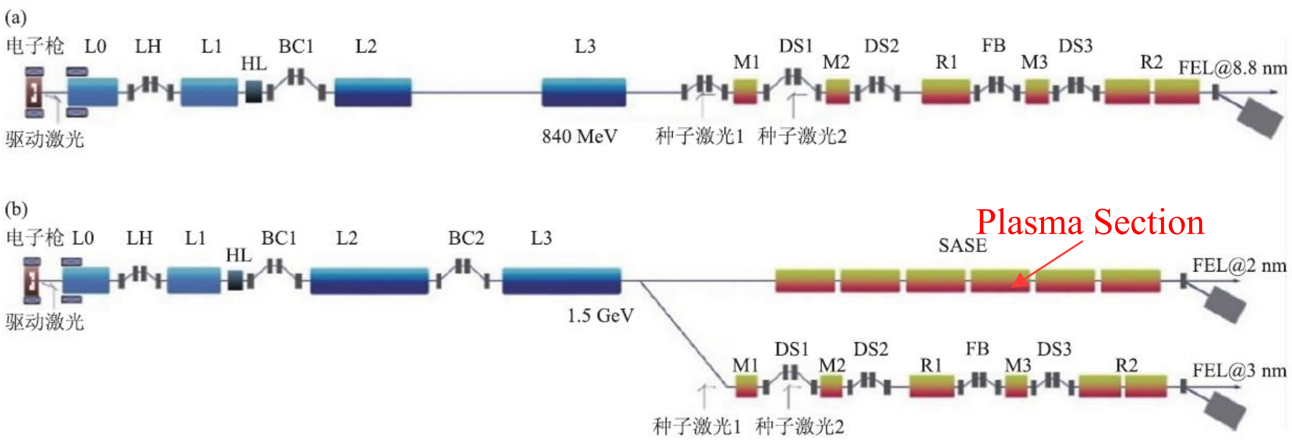
Damping ring 5cell Cavity   Tunner

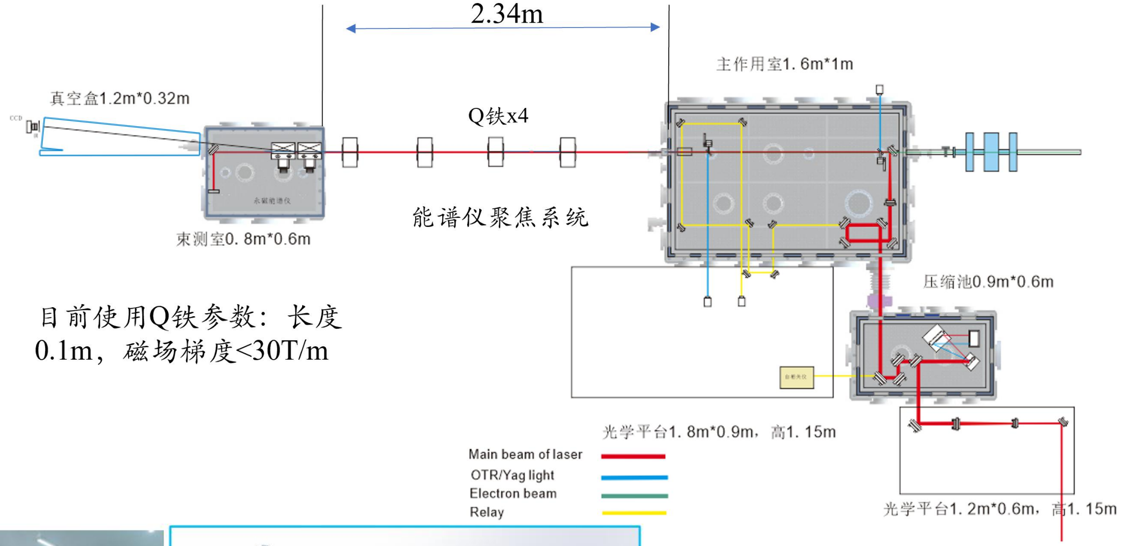
Damping Ring 5 cell cavity: The The 1.1 GeV damping ring need the RF system provide 2 MV.Two 5 cell constant temperature cavities have recommended and the frequency is 650 MHz. According to the simulation, each cavity can provide 1.2 MV cavity voltage when the cavity consumption is 54 kw

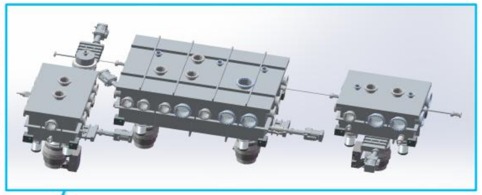
CEPC 18kW@4.5K Cryogenic Plant R&D

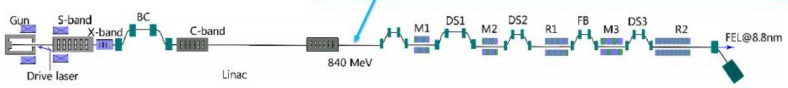


Plasma Dechirper & HTR Experiment Preparation@ SXFEL









Parameter	Value
Energy	0.8GeV
Charge	50pC
Emittance	0.8μm
Beam size	10μm
Peak current	2.4kA
Energy Chirp	~8MeV

Dechirper experiment schedule

- **First step:** Obtaining a stable positively-chirped beam with few percent energy spread
- **Second step:** Post-processing the beam using a passive dechirper

SppC status and key technology R&D

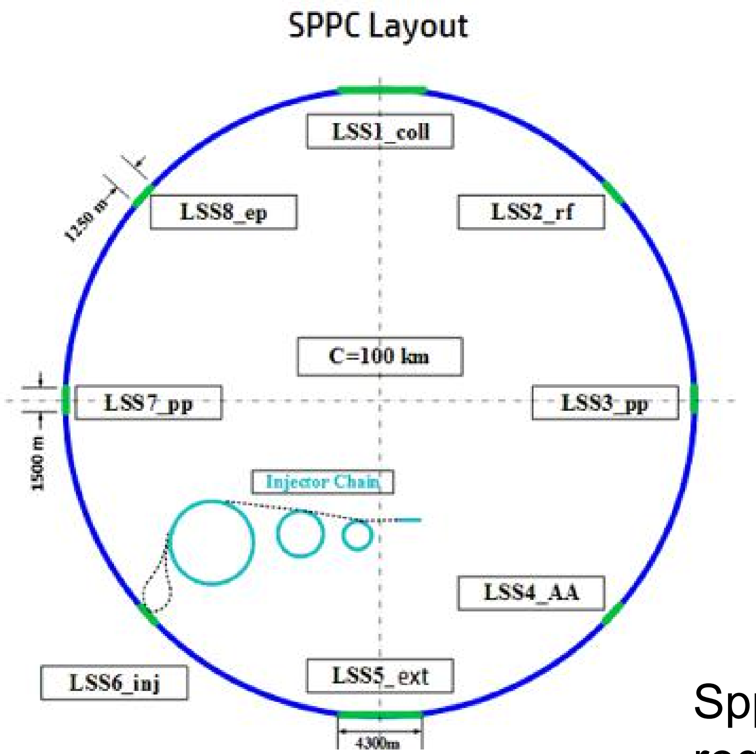
SPPC Parameter Choice and Comparation

CDR F. Su

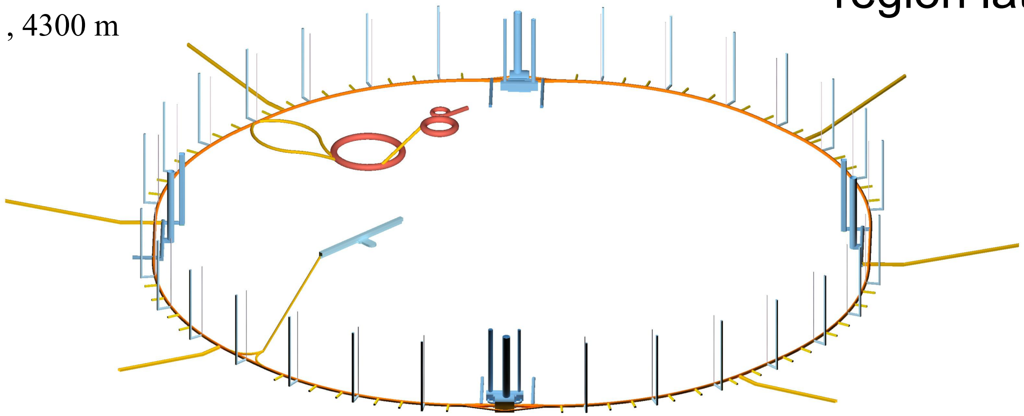
Table 2: SPPC Parameter list(2017.1)[4,6]

	SPPC (Pre-CDR)	SPPC 61Km	SPPC 100Km	SPPC 100Km	SPPC 82Km	SPPC phase 1	SPPC phase 2
Main parameters and geometrical aspects							
c.m. Energy[E_0]/TeV	71.2	70	100.0	128.0	100.0	75.0	125.0-150.0
Circumference[C_0]/km	54.7	61.0	100.0	100.0	82.0	100.0	100.0
Dipole field[B]/T	20	19.88	16.02	19.98	19.74	12.00	20-24
Dipole curvature radius[ρ]/m	5928	5889.64	10676.1	10676.1	8441.6	10415.4	-
Bunch filling factor[f_2]	0.8	0.8	0.8	0.8	0.8	0.8	-
Arc filling factor[f_1]	0.79	0.78	0.78	0.78	0.78	0.78	-
Total dipole length [L_{Dipole}]/m	37246	37006	67080	67080	53040	65442	-
Arc length[L_{ARC}]/m	47146	47443	86000	86000	68000	83900	-
Straight section length[L_{ss}]/m	7554	13557	14000	14000	14000	16100	-
Physics performance and beam parameters							
Peak luminosity per IP[L]/ $cm^{-2}s^{-1}$	1.1×10^{35}	1.20×10^{35}	1.52×10^{35}	1.02×10^{36}	1.52×10^{35}	1.01×10^{35}	-
Beta function at collision[β^*]/m	0.75	0.85	0.99	0.22	1.06	0.71	-
Max beam-beam tune shift per IP[ξ_y]	0.006	0.0065	0.0068	0.0079	0.0073	0.0058	-
Number of IPs contribut to ΔQ	2	2	2	2	2	2	2
Max total beam-beam tune shift	0.012	0.0130	0.0136	0.0158	0.0146	0.0116	-
Circulating beam current[I_b]/A	1.0	1.024	1.024	1.024	1.024	0.768	-
Bunch separation[Δt]/ns	25	25	25	25	25	25	-
Number of bunches[n_b]	5835	6506	10667	10667	8747	10667	-
Bunch population[N_p] (10^{11})	2.0	2.0	2.0	2.0	2.0	1.5	-
Normalized RMS transverse emittance[ε]/μm	4.10	3.72	3.59	3.11	3.35	3.16	-
RMS IP spot size[σ^*]/μm	9.0	8.85	7.86	3.04	7.86	7.22	-
Beta at the 1st parasitic encounter[$\beta 1$]/m	19.5	18.67	16.26	69.35	15.31	22.03	-
RMS spot size at the 1st parasitic encounter[σ_1]/μm	45.9	43.13	33.10	56.19	31.03	41.76	-
RMS bunch length[σ_z]/mm	75.5	56.69	66.13	14.62	70.89	47.39	-
Full crossing angle[θ_c]/μrad	146	138.03	105.93	179.82	99.29	133.65	-
Reduction factor due to cross angle[F_{ca}]	0.8514	0.9257	0.9247	0.9283	0.9241	0.9265	-
Reduction factor due to hour glass effect[F_h]	0.9975	0.9989	0.9989	0.9989	0.9989	0.9989	-
Energy loss per turn[U_0]/MeV	2.10	1.98	4.55	12.23	5.76	1.48	-
Critical photon energy[E_c]/keV	2.73	2.61	4.20	8.81	5.32	1.82	-
SR power per ring[P_0]/MW	2.1	2.03	4.66	12.52	5.90	1.13	-
Transverse damping time [τ_x]/h	1.71	1.994	2.032	0.969	1.32	4.70	-
Longitudinal damping time [τ_ε]/h	0.85	0.997	1.016	0.4845	0.66	2.35	-

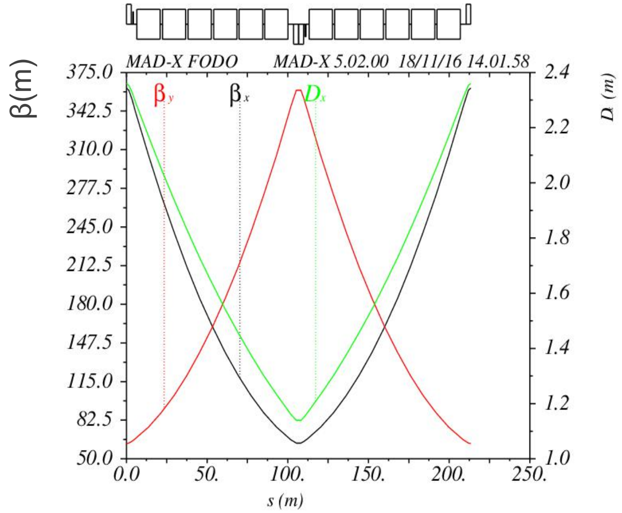
General Layout of SPPC



- Length of each section at present:
- 8 arcs, total length 83400 m
- 2 IPs for pp, 1500 m each
- 2 IRs for injection or RF, 1250 m each
- 2 IRs for ep or AA, 1250 m each
- 2 IRs for collimation(ee for CEPC ）, 4300 m each
- C = 100 km

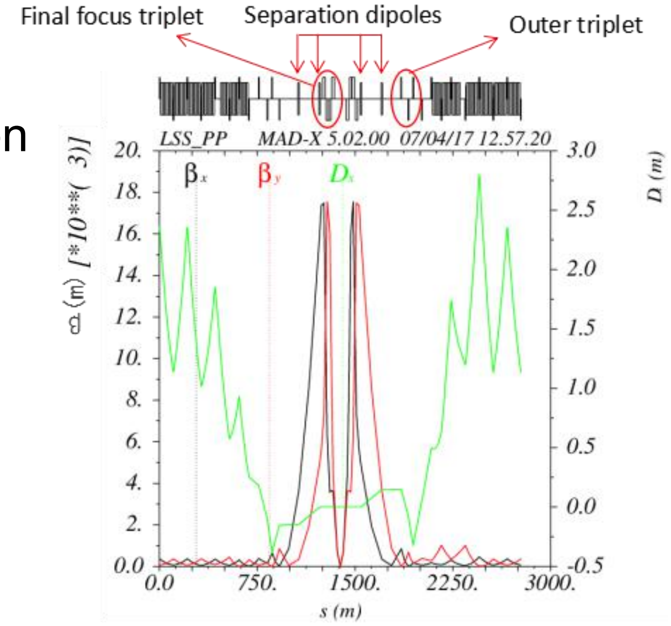


SppC ARC lattice



ARC FODO cell structure

SppC interaction region lattice



LSS_PP(beta*=0.75 m)

Geometry compatibility of CEPC collider, CEPC booster and SPPC

- CEPC booster will locate upside of CEPC collider (d=2.4m) except the IP1 and IP3
- CEPC booster will also bypass the CEPC detector at IP1 and IP3
  - The present design is to share the part of SPPC tunnel at IP1 and IP3.
  - However, SPPC collimation section is nasty and the power is as high as MW. Putting the booster into the same tunnel will be challenging

Tunnel in the ARC

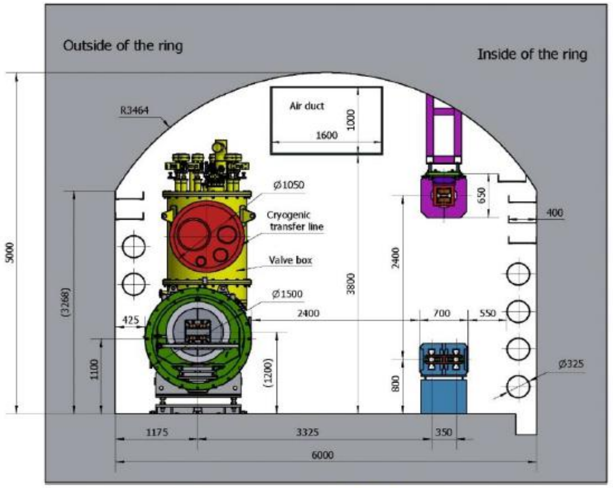
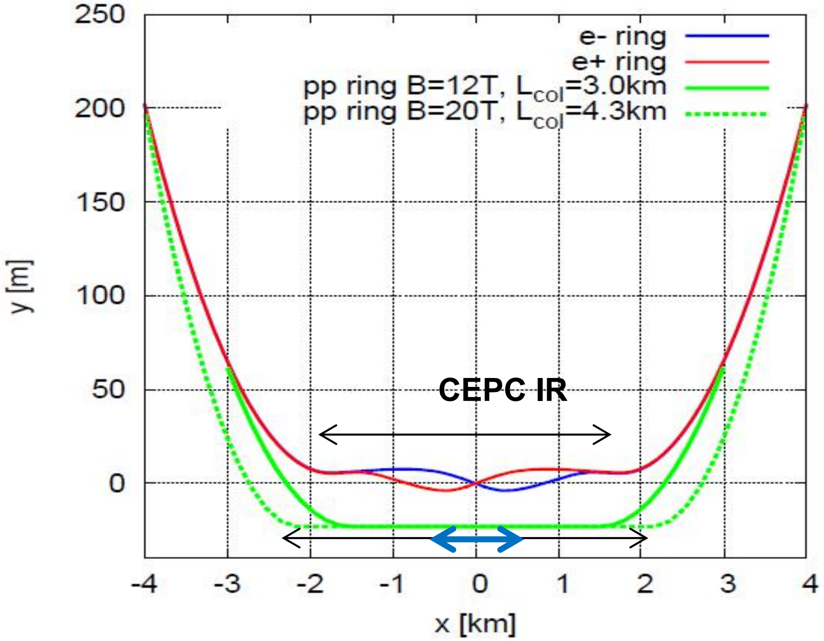


Figure 2.1: Tunnel cross section in the arc region

solutions of two schemes

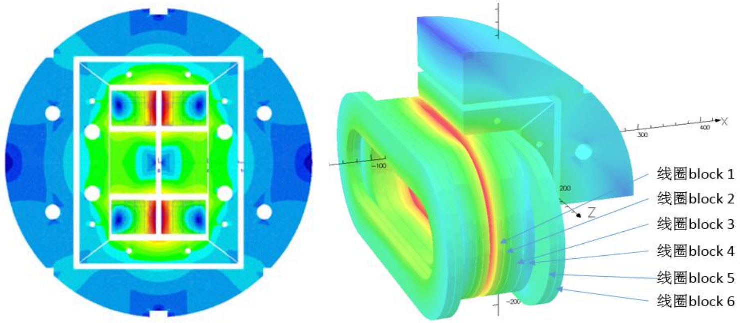


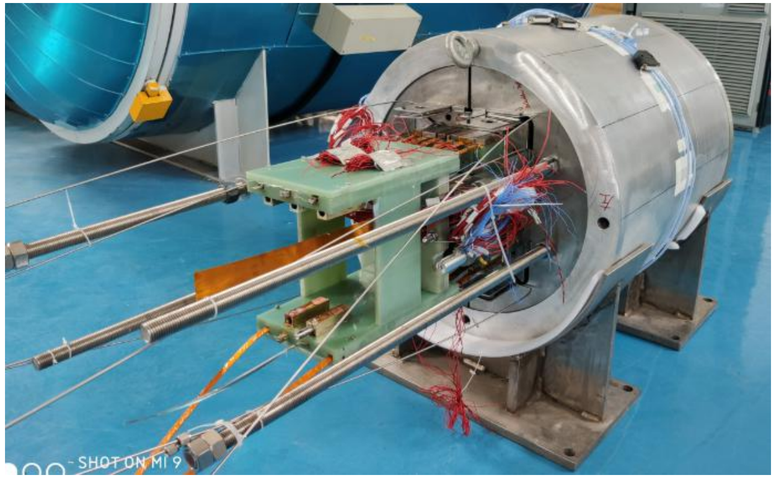
CEPC booster

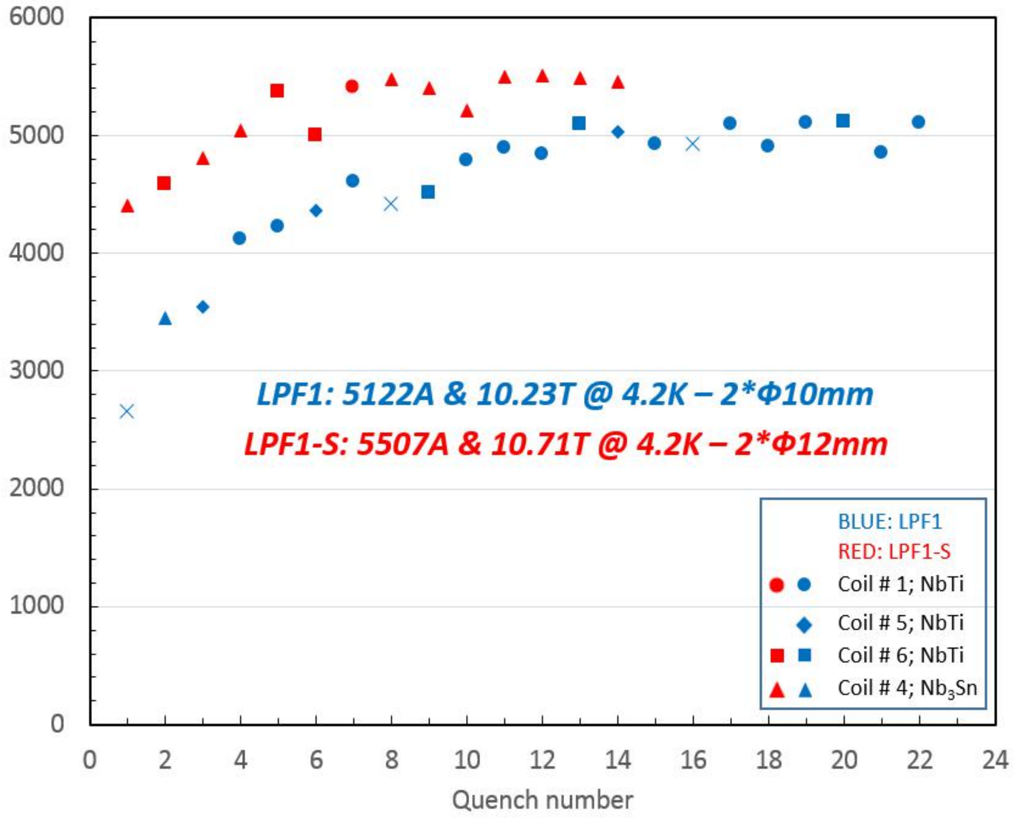
SPPC collimation

Status of the High Field Dipole Magnet R&D-1

10.7 T@4.2K NbTi+Nb_3Sn Twin-aperture Model Dipole (2*φ12mm)







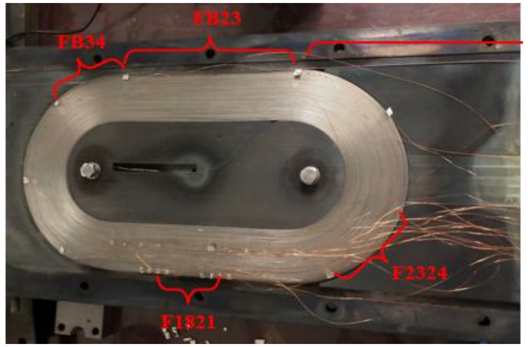
Status of the High Field Dipole Magnet R&D-2

Test of the 1st IBS solenoid coil at 24 T and the 1st IBS racetrack coil at 10 T

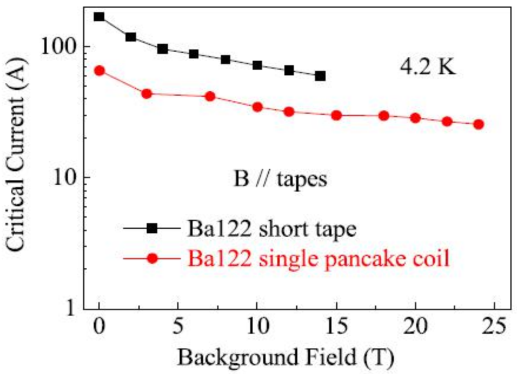
Table 2. Specification of single pancake coil

Parameter	Unit	Value
Inner diameter	mm	30
Outer diameter	mm	34.8
Height	mm	4.62
Thickness of stainless steel tape	mm	0.1
Turns		4.5
Total length of IBS wire	mm	450

Very good performance!

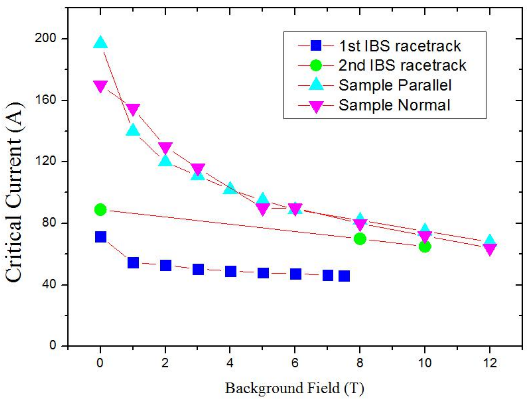


25T-HM, RT bore Φ38 mm



Demonstrating that IBS are very promising for high-field magnet applications

Critical Current w.r.t Background Field of IBS Racetracks



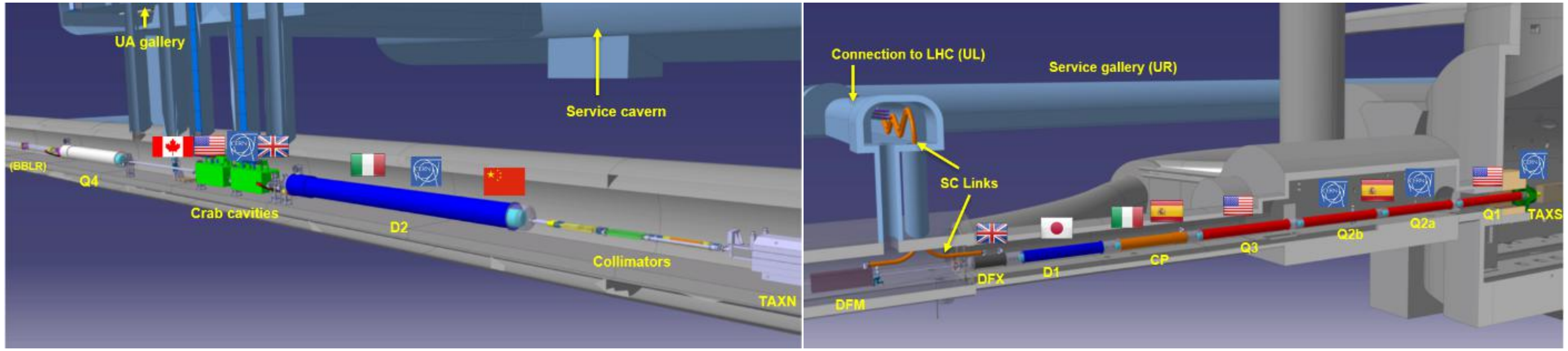
Supercond. Sci. Technol. 32 (2019) 04LT01

Supercond. Sci. Technol. 2020, in press

China-CERN HL-LHC CCT Project

China provides 12+1 units CCT superconducting magnets for the HL-LHC project

Agreement For HL-LHC CCT Magnets Signed in Sep 2018

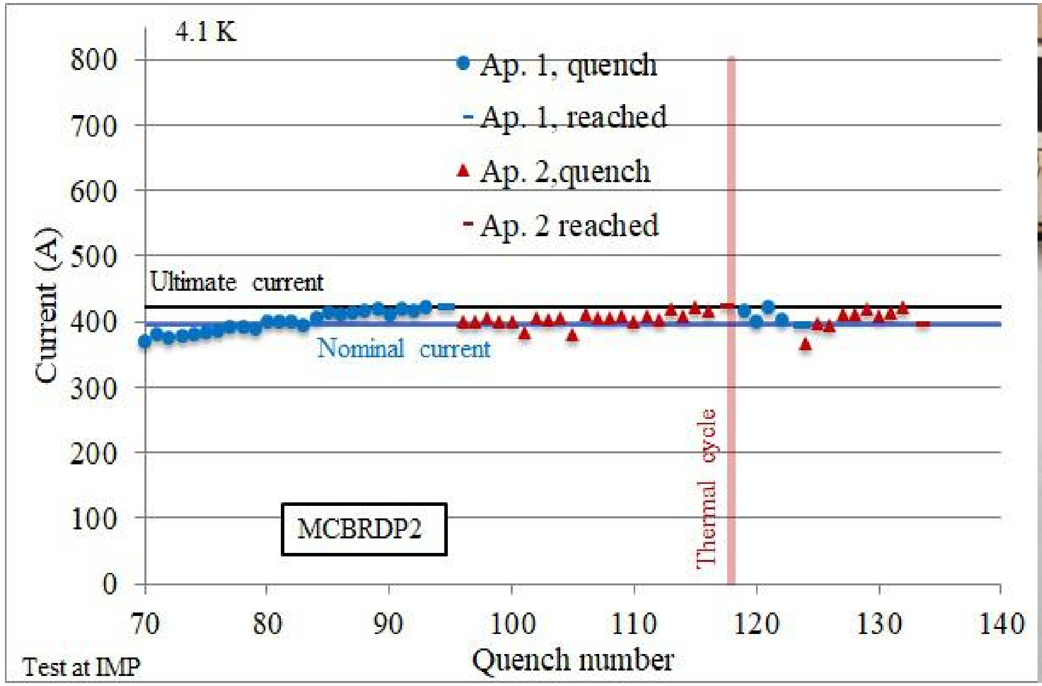


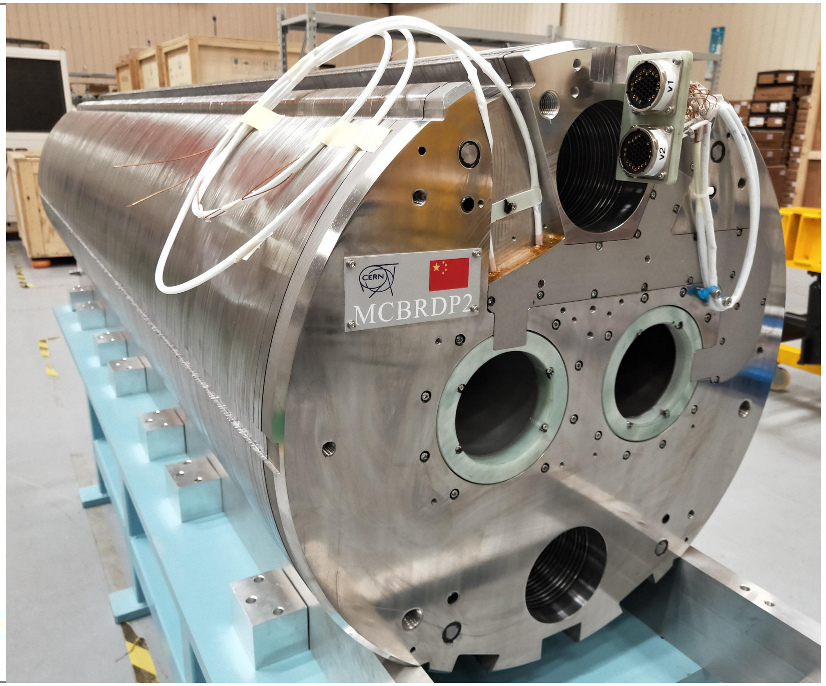
Layout of the HL-LHC Magnets and Contributors

China-CERN HL-LHC CCT Project

Performance of the 1st full-length prototype magnet from China

After more than 1 month test and training at 4.2K, both apertures reached the design current and ultimate current, and the field quality is within the limit.

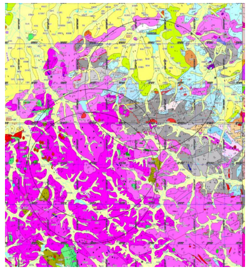


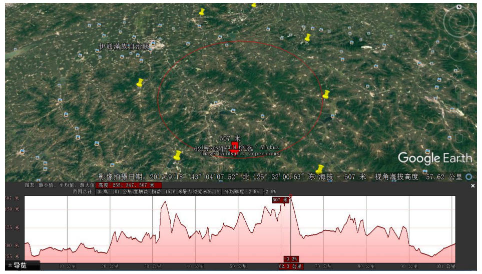


<u>The 1st prototype CCT magnet is on the way to CERN. A good start for the series production.</u>

CEPC Site Selection
and Civil Engineering

CEPC Site Selections





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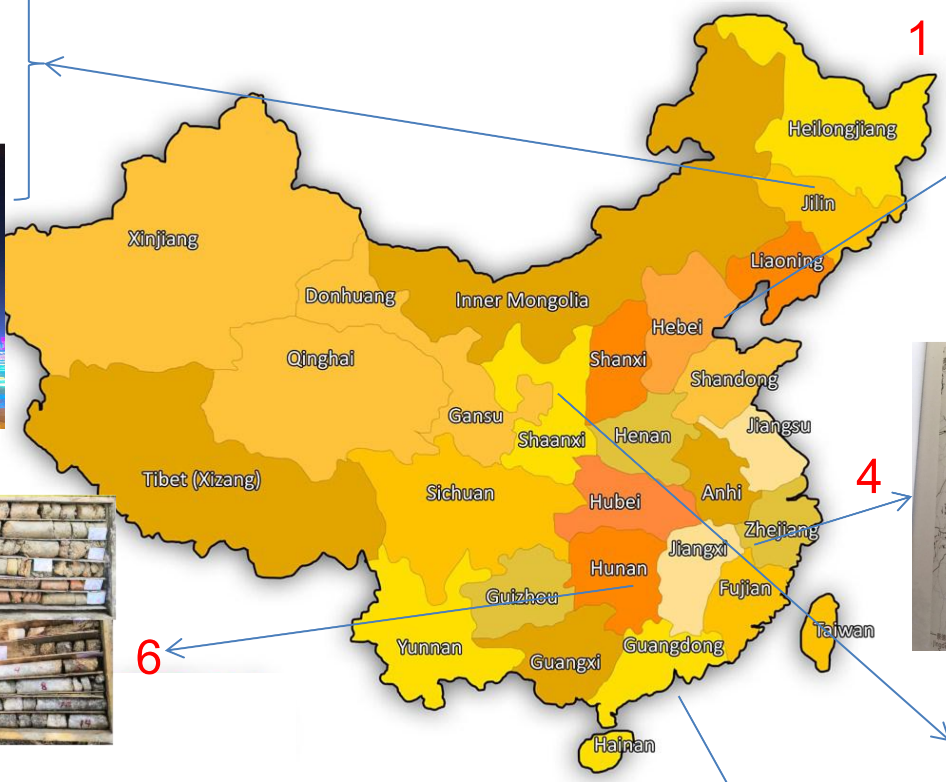

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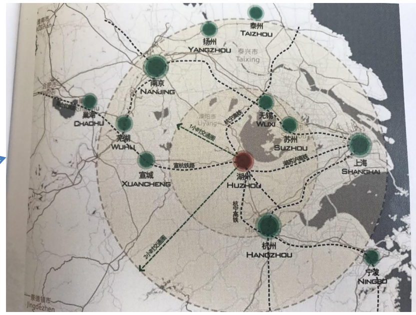

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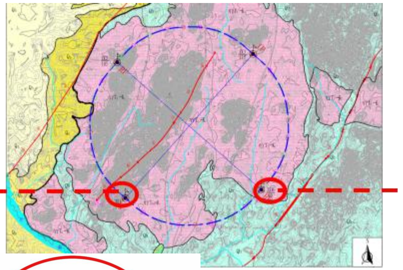

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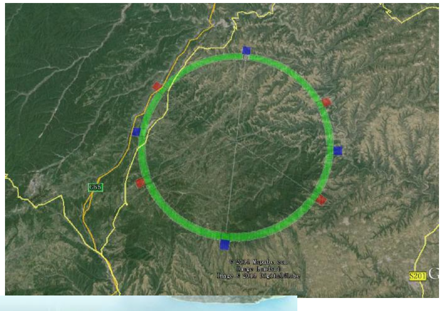

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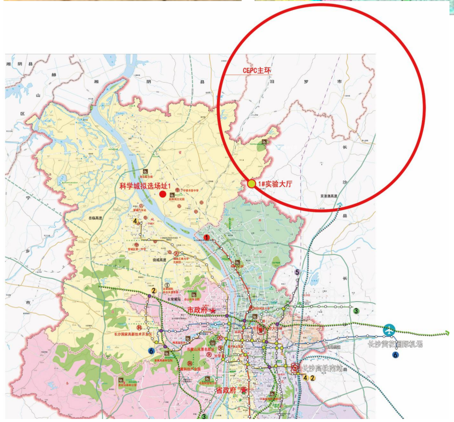
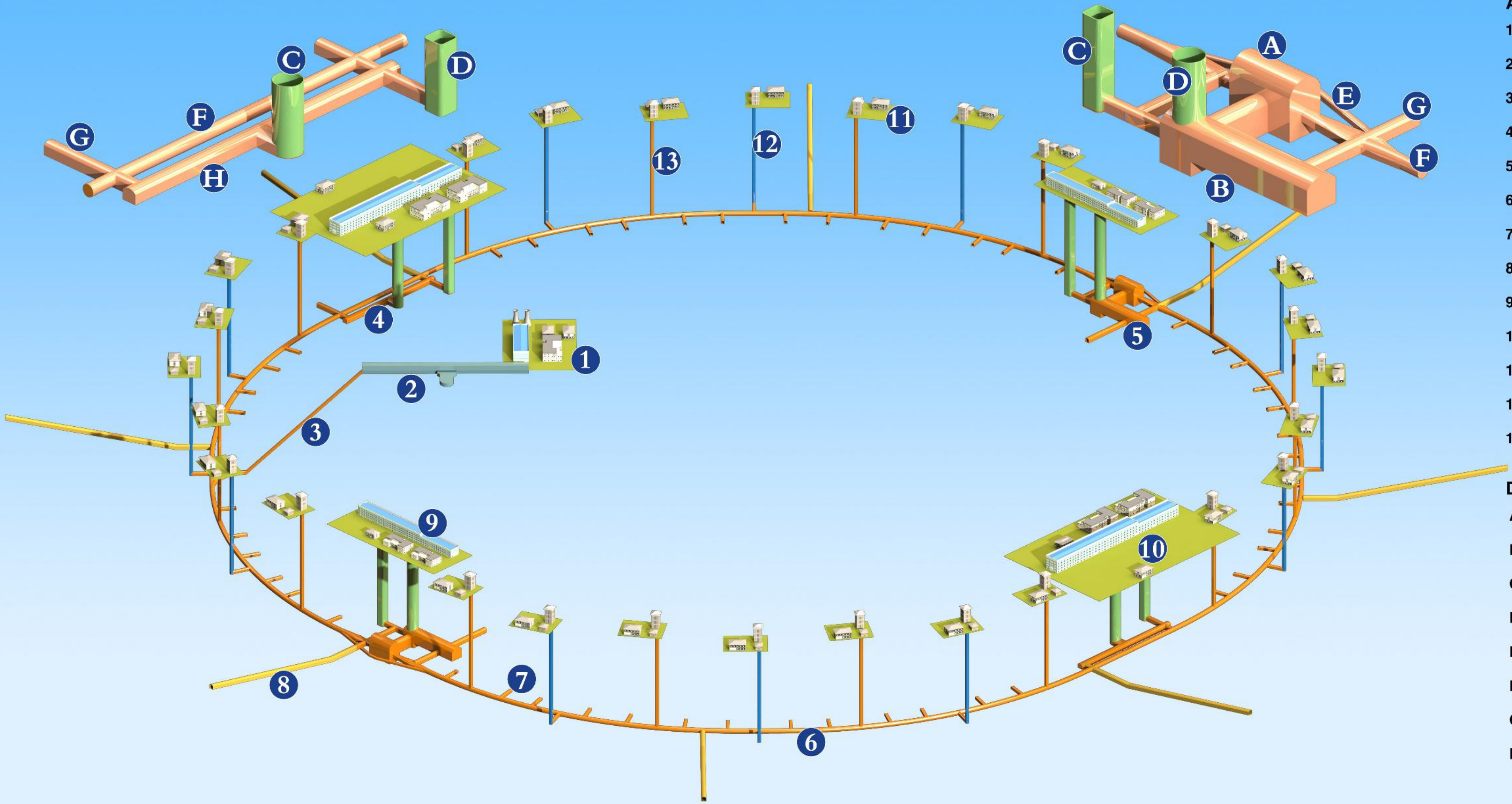


1) Qinhuangdao, Hebei Province（Completed in 2014）
2) Huangling, Shanxi Province（Completed in 2017）
3) Shenshan, Guangdong Province(Completed in 2016)
4) Huzhou, Zhejiang Province (Started in March 2018)
5) Chuangchun, Jilin Province (Started in May 2018)
6) Changsha, Hunan Province (Started in Dec. 2018)

CEPC



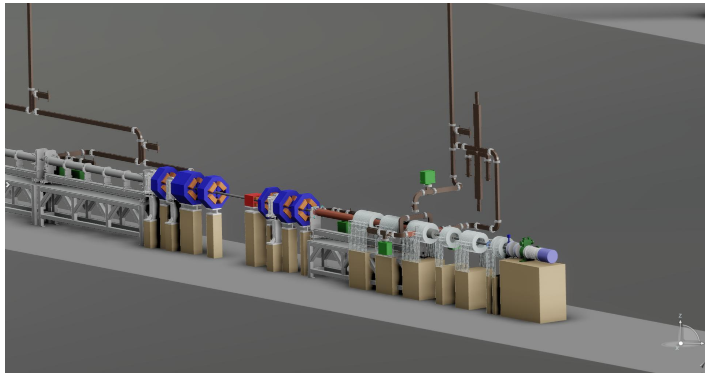
Accelerator Region Caverns:

1. Surface Buildings of Linac Segment
2. Linac Segment
3. Transfer Line
4. Tunnel Complex of RF Region
5. Detector Region Caverns
6. Main Ring Tunnel
7. Auxiliary Tunnel
8. Access Tunnel
9. Surface Buildings of Experiment Hall
10. Surface Buildings of RF Region
11. Surface Buildings of Shaft for Access and Cable
12. Shaft for Access and Cable
13、Shaft for Access, Cable and Measure

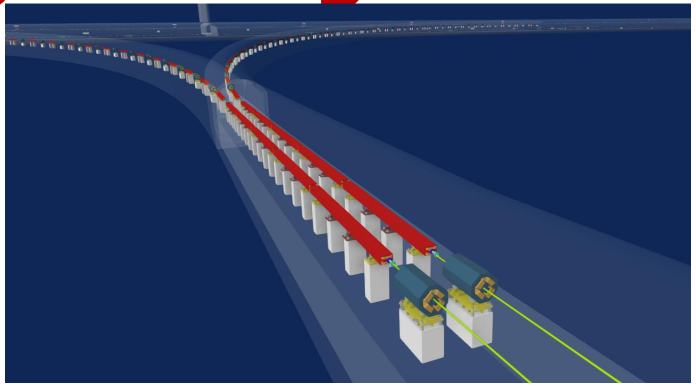
Detector Region Caverns:

A. Experiment Hall
B. Service Cavern
C. Transport Shaft
D. Shaft for Access, Cable and HVAC
E. Booster Bypass Tunnel
F. Main Ring Tunnel
G. Traffic Tunnel
H. Auxiliary Tunnel of RF Region

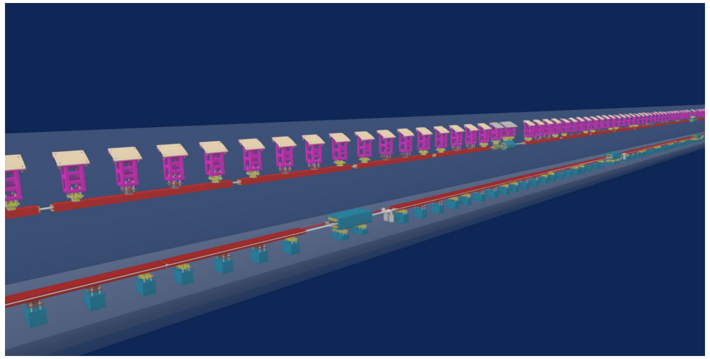
CEPC Civil Engineering



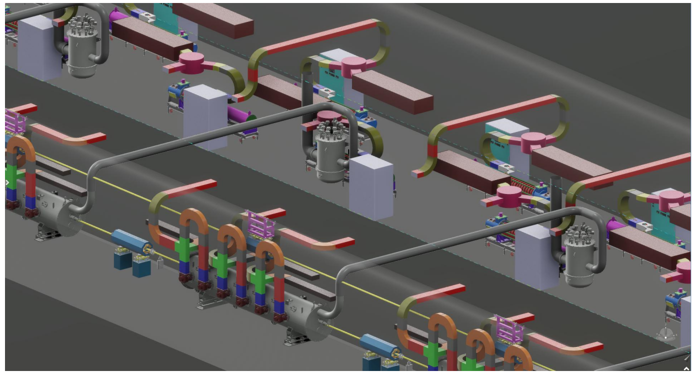
Electron source



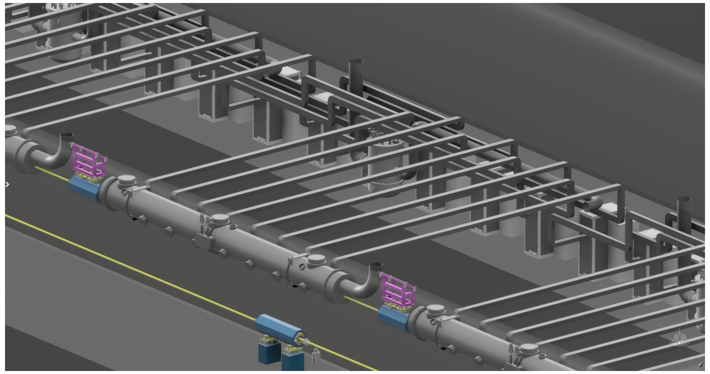
Linac to Booster



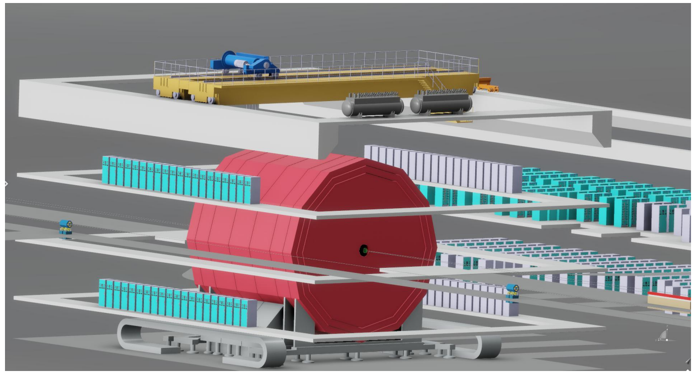
Booster and collider ring tunnel



Collider ring SCRF



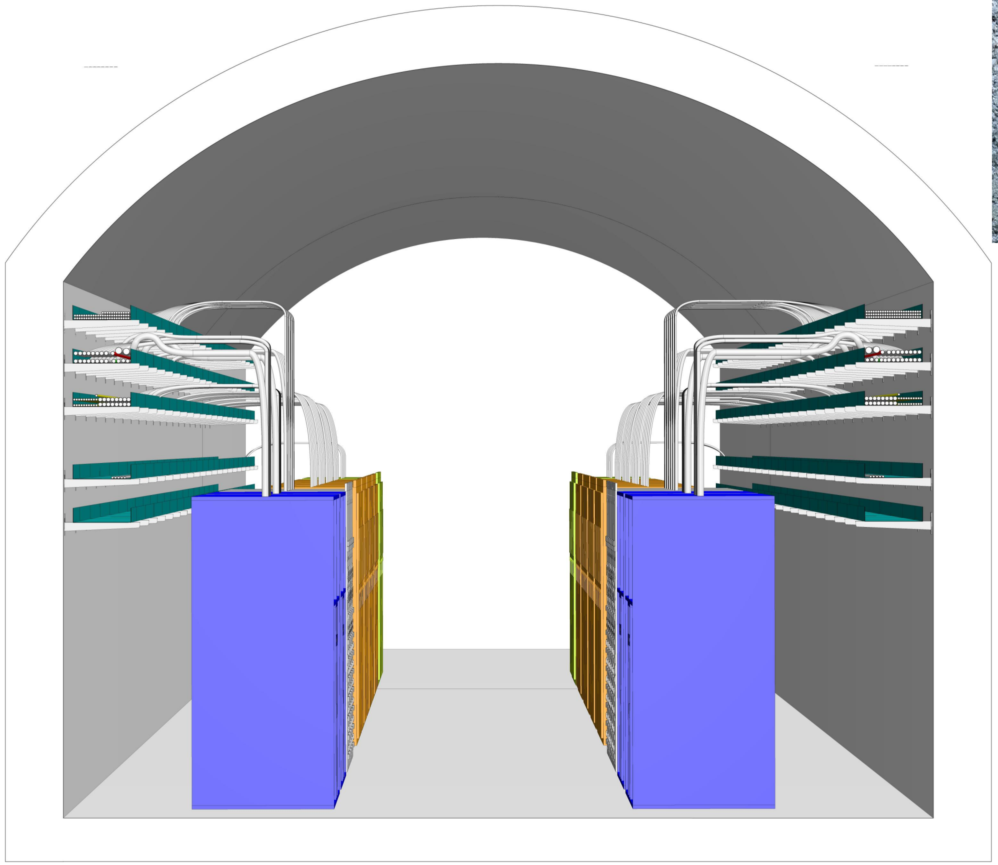
Booster SCRF

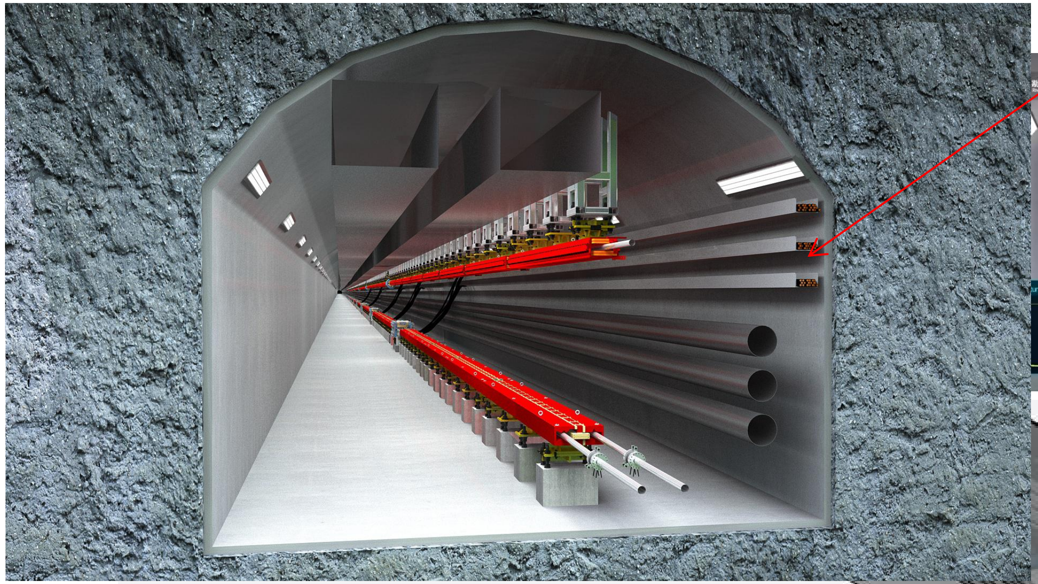


Detector hall

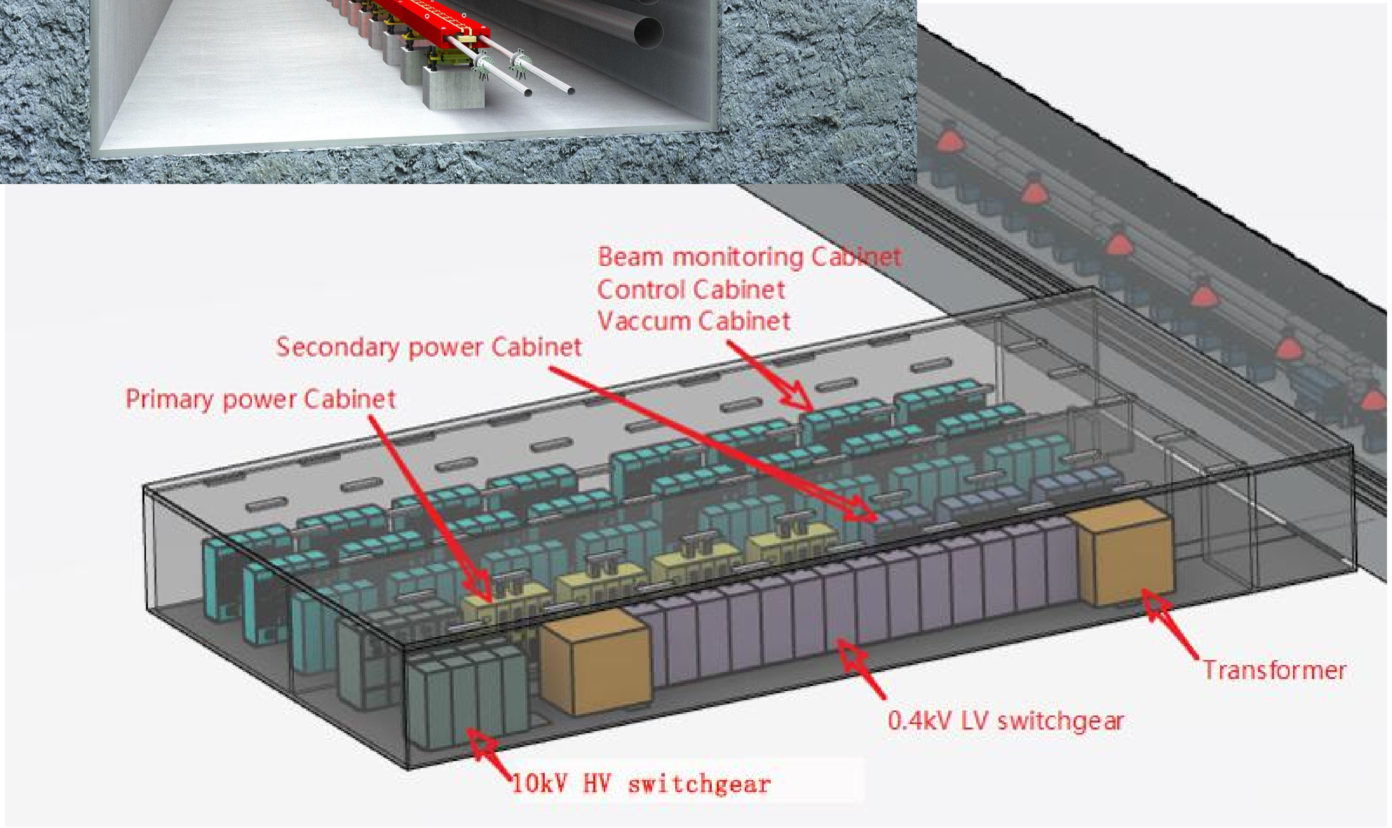
CEPC Conventional Facility and Civil Engineering

Electrical Equipment General Layout in Auxiliary

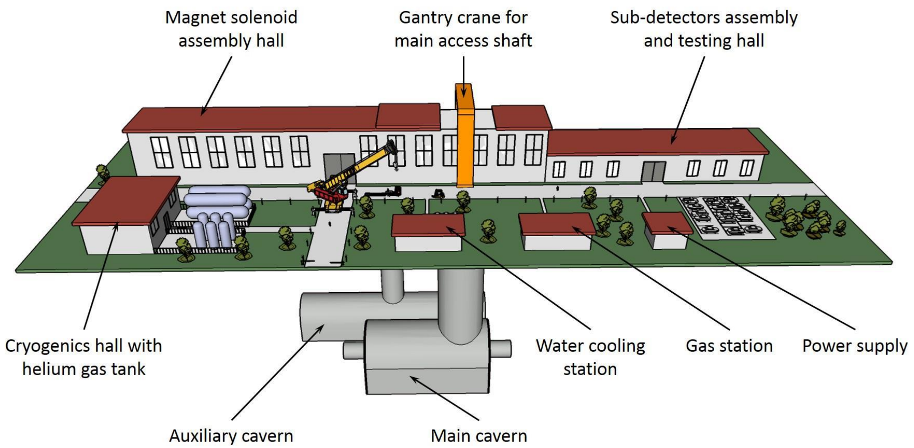


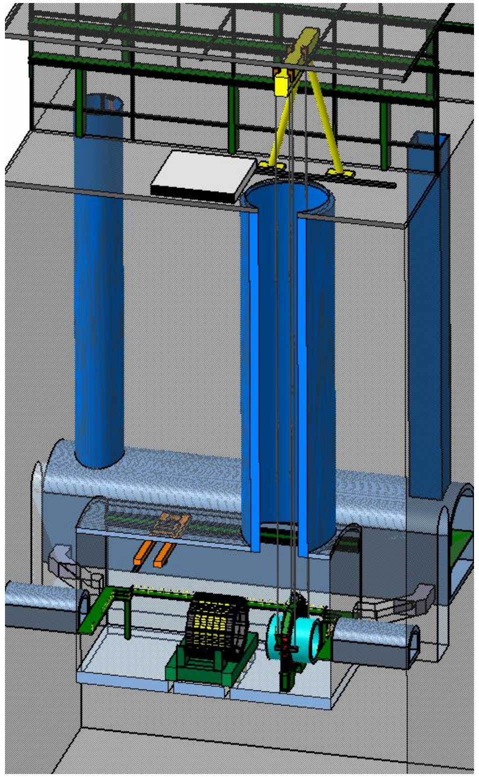


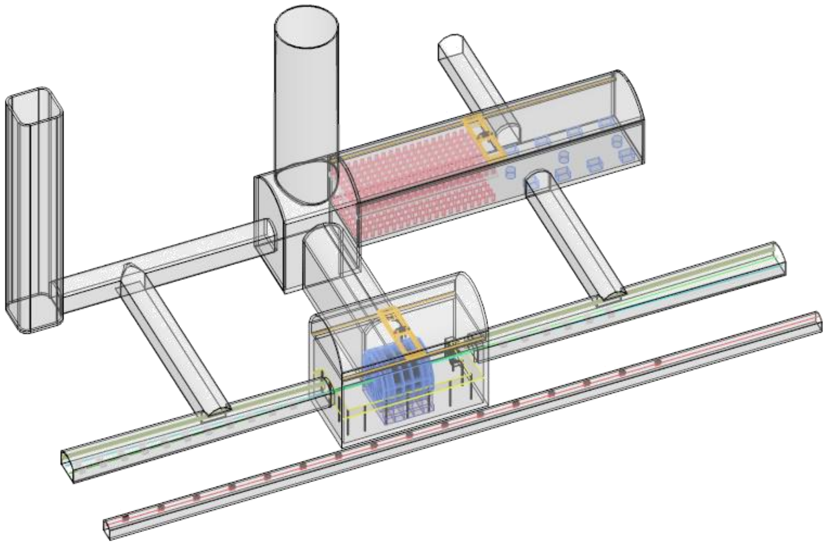
Cables installed!



CEPC IR







Experimental hall	39.4×20.4×31	×2
Axiliary hall	101.4×20×26.2	×2
Booster tunnel	1679×3.5×3.5	×4
Collider tunnel	1659.3x(6~11.4)x5	×4
Travel shaft	1200x7.5x7.5	×2
Connection, electric cable and ventilation shaft	70x10x10	×2

CEPC Power for Higgs and Z

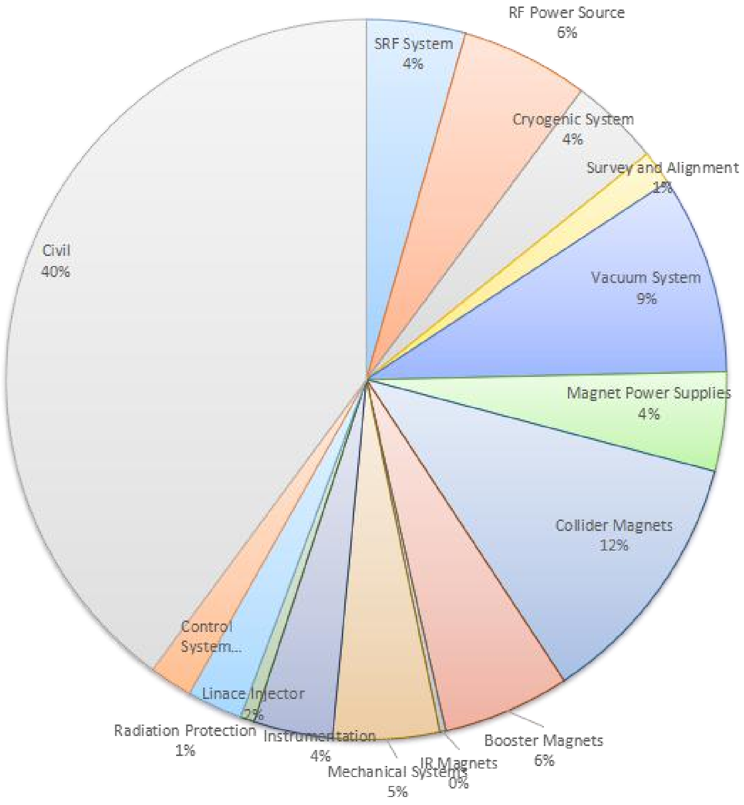
	System for Higgs (30MW)	Location and electrical demand(MW)						Total (MW)
		Ring	Booster	LINAC	BTL	IR	Surface building	
1	RF Power Source	103.8	0.15	5.8				109.75
2	Cryogenic System	11.62	0.68			1.72		14.02
3	Vacuum System	9.784	3.792	0.646				14.222
4	Magnet Power Supplies	47.21	11.62	1.75	1.06	0.26		61.9
5	Instrumentation	0.9	0.6	0.2				1.7
6	Radiation Protection	0.25		0.1				0.35
7	Control System	1	0.6	0.2	0.005	0.005		1.81
8	Experimental devices					4		4
9	Utilities	31.79	3.53	1.38	0.63	1.2		38.53
10	General services	7.2		0.2	0.15	0.2	12	19.75
	Total	213.554	20.972	10.276	1.845	7.385	12	266.032

266MW

	System for Z	Location and electrical demand(MW)						Total (MW)
		Ring	Booster	LINAC	BTL	IR	Surface building	
1	RF Power Source	57.1	0.15	5.8				63.05
2	Cryogenic System	2.91	0.31			1.72		4.94
3	Vacuum System	9.784	3.792	0.646				14.222
4	Magnet Power Supplies	9.52	2.14	1.75	0.19	0.05		13.65
5	Instrumentation	0.9	0.6	0.2				1.7
6	Radiation Protection	0.25		0.1				0.35
7	Control System	1	0.6	0.2	0.005	0.005		1.81
8	Experimental devices					4		4
9	Utilities	19.95	2.22	1.38	0.55	1.2		25.3
10	General services	7.2		0.2	0.15	0.2	12	19.75
	Total	108.614	9.812	10.276	0.895	7.175	12	148.772

149MW

CEPC Cost Breakdwon (no detector)



The total cost of CEPC~35Billion RMB~5Billion $ (Accelerator+2 Detectors+Civil+Contigence)

Civil Engineering

Schedule analysis of CEPC

2023 2024 2025 2026 2027 2028 2029 2030

51 months (including project preparation)

2023.1~2027.3 TBM excavation

63 months

2023.1~2028.3 Drilling & Blasting excavation

2027.1~2027.12 First-stage Control network construction and survey — 12months

2027.10~2028.9 Second-stage Control network construction and survey — 12months

2028.1~2029.6 Support installation and alignment — 18 months

2028.3~2029.8 Dipole magnets installation — 18 months

2029.9~2030.6 Installation of other equipment — 10 months

2030.7~2030.12 Overall alignment and commissioning — 6 months

Construction duration of civil engineering

63 months **2023.1~2028.3**

Critical path of the physical equipment installation

First-stage control network setting and survey (12 months) + physical equipment alignment and installation (30 months) + Overall alignment and commissioning (6 months) = Total duration (48 months)

2027.1~2030.12

Total duration of CEPC project

96 months **2023.1~2030.12**

CEPC Collaborations

CEPC Industrial Promotion Consortium (CIPC) Collaboration Status

Established in Nov. 7 , 2017
CIPC Annual Meeting, July 26 , 2018

1) Superconduting materials (for cavity and for magnets)
2) Superconducting cavities
3) Cryomodules
4) Cryogenics
5) Klystrons
6) Vacuum technologies
7) Electronics
8) SRF
9) Power sources
10) Civil engineering
11) Precise machinary.....

Please attend the CIPC parallel session to learn more details! **Recommend**

Now:

-Huanghe Company, Huadong Engineering Cooperation Company, on CEPC civil engineering design, site selection, implementation...

-Shenyang Huiyu Company on CEPC MDI mechanical connection design

-Zhongxin Heavy Industry on Elecletric-magnetic seperator design

-China Astronotics Department 508 Institute on CEPC MDI supporting design and CEPC magnets mechanical designs...

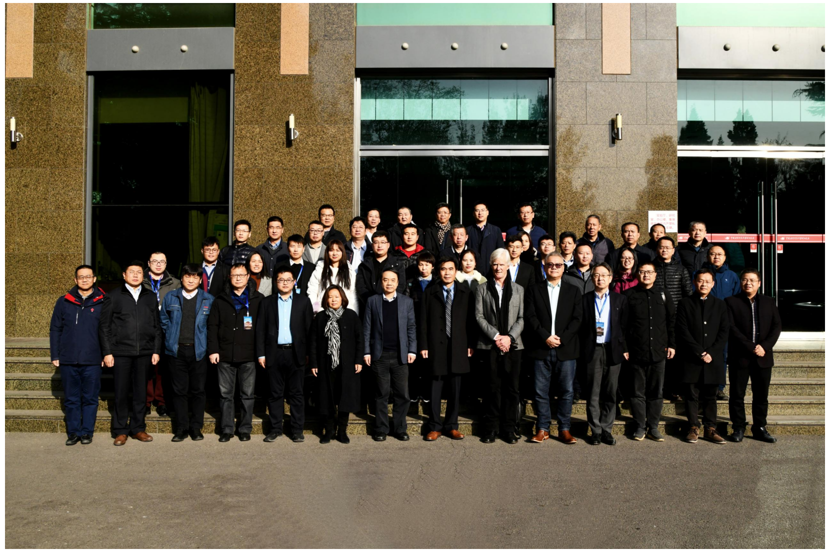
-Kuanshan Guoli on CEPC 650MHz high efficiency klystron

-Huadong Engineering Cooperation Company, on CEPC alignement and installation logistics...

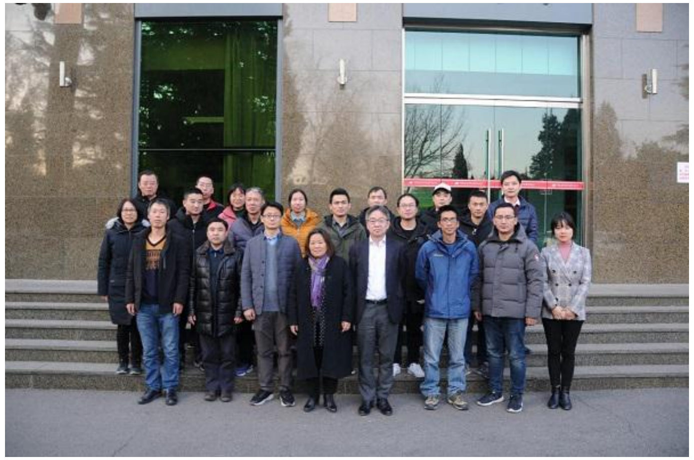
CEPC-CIPC Collaboration and CEPC Promption Fund (CPF)

CIPC established in Nov. 7 , 2017

CIPC Annual Meeting, July 26 , 2018

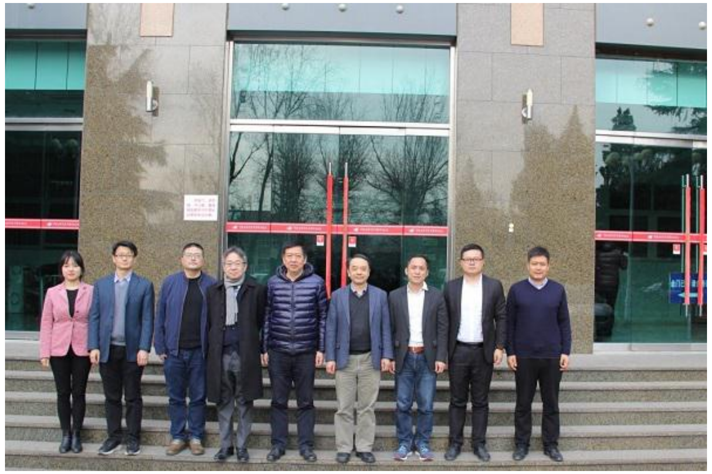


CEPC-CIPC Collavoration Meeting and CEPC Promotion Fund (CPF) First Meeting on Nov. 20, and 2019, IHEP



CEPC-Industry Collaboration Meeting Dec. 27 , 2019

CPF funding seed money of 500kUSD was from Yifang Wang on Nov. 17, 2019



The first Industry contributed to CPF Jan. 2 , 2020

CIPC Member Logo (part of CIPC members' logo)

LEIKE 雷科电子

KAITENG SIFANG

汉光科技

北广科技 BBEF

上创超导

统力电工 TOLY ELECTRIC

高能锐新 HE-RACING TECHNOLOGY

Superconductor Technology 苏州八匹马超导科技有限公司

上海普東科技 PUSU

VACREE

慧宇 HUI YU

湖州工业井巷建设集团有限公司 HUZHOU CHINA

上海超导 SHANGHAI SUPERCONDUCTOR

地矿建设 DIKUANG CONSTRUCTION

昆山国力电子科技股份有限公司 Kunshan GuoLi Electronic Technology Co., Ltd.

Western Superconducting Technologies Co.,Ltd.

中科富海 FULLCRYO

上海辰光医疗科技股份有限公司 Shanghai Chenguang Medical Technologies Co. Ltd

中船重工鹏力（南京）超低温技术有限公司 CSIC PRIDe (NANJING) CRYOGENIC TECHNOLOGY CO.,LTD.

爱科赛博 ACTIONPOWER

江苏克劳特低温 JiangSu Cryote Co., Ltd.

JJJ vac 三井真空

普达迪泰 PRODETEC

北京航天广通科技有限公司 Beijing Grantel Technology Co., Ltd.

中铁装备 CREG

正帆科技 GENTECH

VACUUM PRODUCTS

SEALTECH

SKY

北京鼎荣达

HUALUN

瑞隆 Rui Long

BRARC

HDKY浩德科仪 HoldKY Vacuum Technologies

RuiYuan

天合精机 TIAN HE JING JI

中国铁建

东方钼业 OTIC

NVT

冰轮环境 MOON-TECH

JST 金盘科技 JINPAN TECHNOLOGY

东方晨景 East Changing

EDWARDS

CBVAC

中国有色集团成员企业

黄河勘测规划设计研究院有限公司 Yellow River Engineering Consulting Co., Ltd.

中国电建 POWERCHINA 华东勘测设计研究院 HUADONG ENGINEERING CORPORATION

中国电建 POWERCHINA 中国电建集团昆明勘测设计研究院有限公司 KUNMING ENGINEERING CORPORATION LIMITED

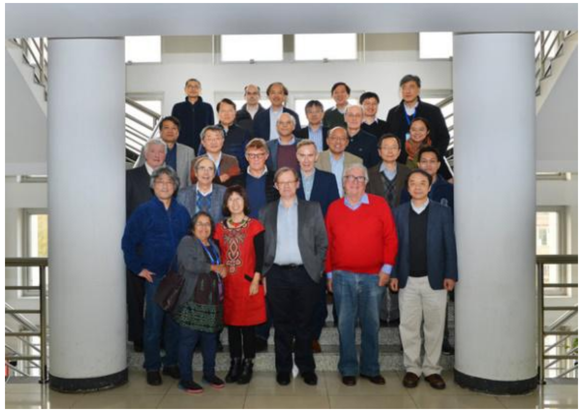
海南展创光电技术有限公司 HZC PHOTONICS

中国电建 POWERCHINA

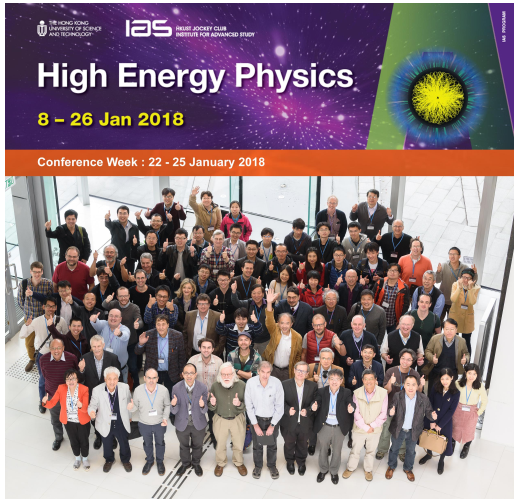
CEPC International Collaboration Meetings-1

The first CEPC-SppC international Collaboration Workshop
Nov 6-8, 2017, IHEP, Bejing (2018, 2019)

http://indico.ihep.ac.cn/event/6618



The the third CEPC-SppC International Advisory Committee Meeting, Nov 8-9, 2017, Beijing



IAS Higgh Energy Physics Workshop
(Since 2015 till now, every year

http://iasprogram.ust.hk/hep/2018

Workshop on the Circuar Electron Positron Collider-EU edition

May 24-26, 2018, Università degli Studi Roma Tre, Rome, Italy

https://agenda.infn.it/conferenceDisplay.py?ovw=True&confId=14816

2019 May Oxford,UK, Sept. Chicago,USA; 2020, Marseille, France

CEPC International Collaboration Meetings-2

CEPC workshop, EU edition
Apri 15-17, 2019 Oxford,UK,

https://www.physics.ox.ac.uk/confs/CEPC2019/index.asp

THE HONG KONG UNIVERSITY OF SCIENCE AND TECHNOLOGY | IAS HKUST JOCKEY CLUB INSTITUTE FOR ADVANCED STUDY

IAS PROGRAM

High Energy Physics

Mini-Workshop

Accelerator - Machine Detector Interface for Future Colliders (Jan 16-17, 2020)

Venue: IAS2042, 2/F, Lo Ka Chung Building, Lee Shau Kee Campus, HKUST

Jan 16, 2020 (Thu)

Time	Event
09:00 - 09:10	Opening Remarks Jie GAO (*Institute of High Energy Physics, Chinese Academy of Sciences*)
Session 1 Chair: Michael KORATZINOS	
09:10 - 09:40	Overview of Different Colliders Jie GAO (*Institute of High Energy Physics, Chinese Academy of Sciences*)
09:40 - 10:10	Background Status and Study at Belle II, SuperKEKB (Remote Talk) Carsten NIEBUHR (*Deutsches Elektronen-Synchrotron Hamburg*)
10:10 – 10:40	Status of the Superconducting Final Focus Magnets at SuperKEKB (Remote Talk) Norihito OHUCHI (*High Energy Accelerator Research Organization (KEK)*)
10:40 - 11:10	Coffee Break (Venue: Open Area, 2/F)
11:10 - 11:40	Stability of the Final Focus Magnets at SuperKEKB (Remote Talk) Hiroshi YAMAOKA (*High Energy Accelerator Research Organization (KEK)*)
11:40 – 12:10	Lessons Learned from LEP and Their Application to FCC/CEPC Helmut BURKHARDT (*CERN*)
12:10 - 12:40	CEPC MDI Accelerator Issues Sha BAI (*Institute of High Energy Physics, Chinese Academy of Sciences*)
12:40 - 14:10	Lunch (Self-arranged)
Session 2 Chair: Jie GAO	
14:10 - 14:40	CEPC MDI Physics Issues Hongbo ZHU (*Institute of High Energy Physics, Chinese Academy of Sciences*)
14:40 - 15:10	CEPC MDI SC Magnet System Yingshun ZHU (*Institute of High Energy Physics, Chinese Academy of Sciences*)
15:10 – 15:40	CEPC MDI Mechanics Issues Haijing WANG (*Institute of High Energy Physics, Chinese Academy of Sciences*)
15:40 - 16:10	Coffee Break (Venue: Open Area, 2/F)
16:10 - 16:40	CEPC MDI Detector Issues Quan JI (*Institute of High Energy Physics, Chinese Academy of Sciences*)
16:40 - 17:10	CEPC Detector Overall Facilities and Hall Issues Zian ZHU (*Institute of High Energy Physics, Chinese Academy of Sciences*)

Mini-Workshop: Accelerator - Machine Detector Interface for Future Colliders
Jan 16-17, 2020, IAS, Hongkang, China

http://iasprogram.ust.hk/hep/2020/workshop_accelerator.php

CEPC International Collaboration Meetings-3

CEPC Workshop, 22-23 April 2020, The Catholic University of America, Washitong DC, UAS

https://indico.cern.ch/event/863751/

3rd EU Edition of the International Workshop on the Circular Electron-Positron Collider

https://indico.in2p3.fr/e/cepc2020

International Scientific Committee

Philip Bambade (LAL, France)
Franco Bedeschi (INFN, Italy)
Marica Biagini (INFN, Italy)
Daniela Bortoletto (Oxford, UK)
Ivanka Božović-Jelisavčić (Vinča, Serbia)
Jean-Claude Brient (LLR, France)
Sarah Eno (Univ. of Maryland, USA)
Juan Fuster (IFIC, Spain)
Jie Gao (IHEP, China)
João Guimarães da Costa (IHEP, China)
Hongjian He (TDLI, China)
Eric Kajfasz (CPPM, France)
Imad Laktineh (IP2I, France)
Laurent Lellouch (CPT, France)
Eugene Levichev (BINP, Russia)
Jianbei Liu (USTC, China)
Emmanuel Monnier (CPPM, France)
Jianming Qian (Univ. of Michigan, USA)
Manqi Ruan (IHEP, China)
Aurore Savoy-Navarro (APC, France)
Anatoly Sidorin (JINR, Russia)
Makoto Tobiyama (KEK, Japan)
Liantao Wang (Univ. of Chicago, USA)

Local Organizing Committee

Jie Gao (IHEP, China)
João Guimarães da Costa (IHEP, China)
Eric Kajfasz (CPPM, France)
Brigitte Pantat (CPPM, France)
Angélique Pèpe (CPPM, France)
Manqi Ruan (IHEP, China)

CEPC Workshop, May 4-7, 2020, Marseille, France,

https://indico.in2p3.fr/event/20053/

CEPC Accelertor International Review Committee Established in August 2019

CEPC International Accelerator Review Committee (CEPC IARC) （10 members）:

k. Oide(CERN/KEK， **Chair**),

B. Forst (DESY/oxford)

E. Levichev(BINP, Russia),

Steinar Stapnes(CLIC, CERN)

KEK: Makoto Tobiyama (Super KEK B)

Italy：INFN (Italy) Marica Biagini(INFN)

Korea: I.S. Koo (PAL, Korea)

Dubna: Anatoly Sidorin (JINR)

France：Philip Bambade (LAL, France)

China: Zhentang Zhao (SINAP, Shanghai, China)

The first meeting will take place during CEPC Conference on Nov. 20，2019

CEPC International Detector R&D Committee

First meeting: November 19, 2019

Dave Newbold, UK, RAL (chair)
Valter Bonvicini, Italy, Trieste
Jim Brau, USA, Oregon
Ariella Cattai, CERN, CERN
Cristinel Diaconu, France, Marseille
Brian Foster, UK, Oxford
Liang Han, China, USTC
Harvey Newman, USA, Caltech

Andreas Schopper, CERN, CERN
Marcel Stanitzki, Germany, DESY
Steinar Stapnes, CERN, CERN
Hitoshi Yamamoto, Japan, Tohoku
Abe Seiden, USA, UCSC
Laurent Serin, France, LAL
Roberto Tenchini, Italy, INFN
Ivan Villa Alvarez, Spain, Santader

Summary

- After CEPC Accelerator CDR was released, CEPC optimization design efforts continue with higer luminosities for H,W, and Z
- CEPC R&D efforts towards TDR progress well with such as klystron, magntes, vacuum system, etc. with the aim to complet TDR before 2023
- CEPC-SppC compatibility study and SppC high field SC magnets were carried out
- CEPC site selection, civil engineering design have made new progresses
- CEPC international collaboration and collaboration with industries go well
- Scientists and engineers worldwide are welcome to join

Thanks go to CEPC-SppC team, CIPC and international partners and colleageus