Completion of CEPC Accelerator CDR and R&D towards TDR

J. Gao

On behalf of CEPC Accelerator Team

Institute of High Energy Physics
CAS, Beijing

Workshop on the Circuar Electron Positron Collider-EU edition
May 24-26, 2018, Università degli Studi Roma Tre, Rome, Italy

Contents

- CEPC CDR physics and accelerator design goals
- CEPC CDR baseline status
- CEPC site selection and civil engineering plementation
- CEPC alternatives and new ideas
- CEPC CDR accelerator hardwares and R&D progresses towards TDR
- CEPC industrial consortium and international collaboration
- China's new scietific policies
- Conclusions

CEPC-SppC Physics Goals in CDR (remind)

- **Electron-positron collider (90, 160，250 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 Design –Higgs Parameters

Parameter	Design Goal
Particles	e+, e-
Center of mass energy	2*120 GeV
Luminosity (peak)	>2*10^34/cm^2s
No. of IPs	2

CEPC Design – Z-pole Parameters

Parameter	Design Goal
Particles	e+, e-
Center of mass energy	2*45.5 GeV
Integrated luminosity (peak)	>10^34/cm^2s
No. of IPs	2
Polarization	to be considered in the second round of design

***Be noted that here the luminosities are the lowest reuiqrement to accomodate different collider schemes**

CEPC-SPPC Timeline (preliminary and ideal)

CEPC

2015 · 2020 · 2025 · 2030 · 2035

- Pre-studies (2013-2015)
- R&D Engineering Design (2016-2022)
- Construction (2022-2028)
- Data taking (2028-2038)

1st Milestone: Pre-CDR (by the end of 2014) ;2nd Milestone: R&D funding from MOST (in Mid 2016); 3rd Milestone: CEPC CDR Status Report (by the end of 2016); 4th Milestone: CEPC CDR Report (by the end of 2017);5th Milestone: CEPC TDR Report and Proto R&D (by the end of 2020);6th Milestone: CEPC construction start (2022);

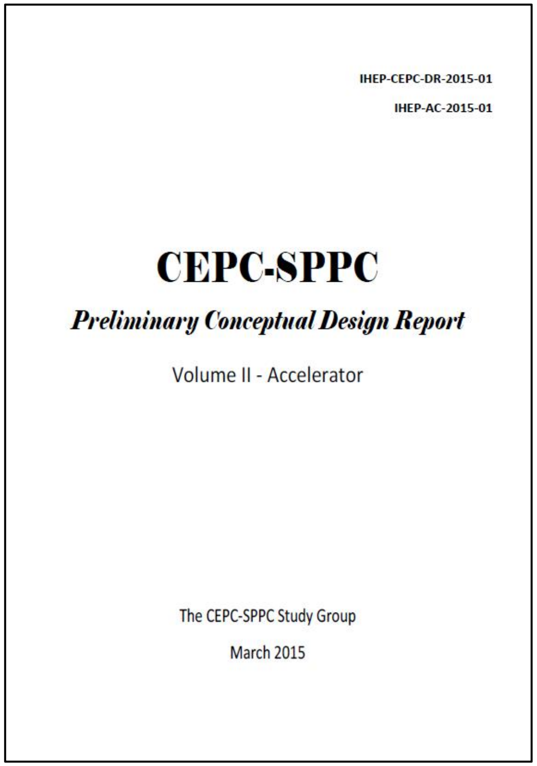
SPPC

2020 · 2030 · 2040

- R&D and CDR (2014-2030)
- Engineering Design (2030-2035)
- Construction (2038-2045)
- Data taking (2045-2060)

CEPC-SppC from Pre-CDR towards CDR

http://cepc.ihep.ac.cn


IHEP-CEPC-DR-2015-01
IHEP-AC-2015-01

CEPC-SPPC

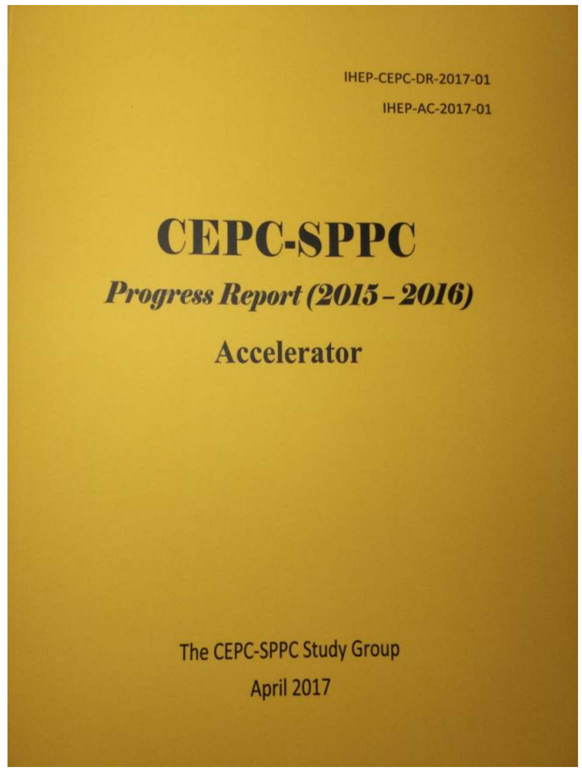
Preliminary Conceptual Design Report

Volume II - Accelerator

The CEPC-SPPC Study Group

March 2015

March 2015


IHEP-CEPC-DR-2017-01
IHEP-AC-2017-01

CEPC-SPPC

Progress Report (2015 – 2016)

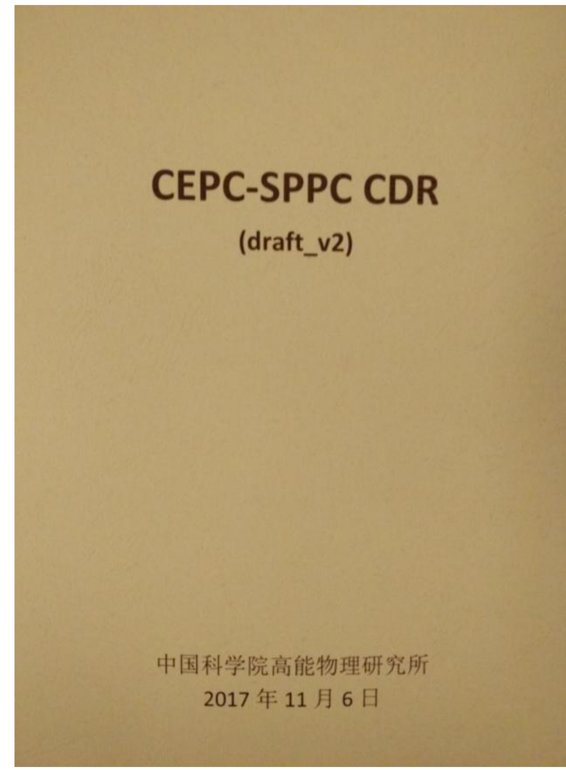
Accelerator

The CEPC-SPPC Study Group

April 2017

April 2017

CEPCSppC baseline and alternative decision processe recorded


CEPC-SPPC CDR

(draft_v2)

中国科学院高能物理研究所

2017 年 11 月 6 日

Nov 2017

CEPC-SppC CDR Preliminary Draft during CEPC-SppC Mini review

CEPC-SppC CDR will be available by July 2018 after international review in Jun2 2018

CEPC-SppC CDR Table of Contents

CEPC-SPPC CDR Table of Contents (v2, 10/19/2017)

CEPC-SPPC CDR Timeline

November 4-5, 2017	CDR mini-review
November 6-8, 2017	CEPC workshop
November 9-10, 2017	CEPC IAC meeting
December 2017	Complete draft of each chapter
January – February 2018	Editing, final draft, limited no. of printing
March 2018	CDR international review
March-April 2018	Final version, online, also mass printing
April 2018 CEPC workshop	Mass distribution of printed copies

CEPC CDR Accelerator Chain and Systems

10 GeV

1) Injector

L=1.2km

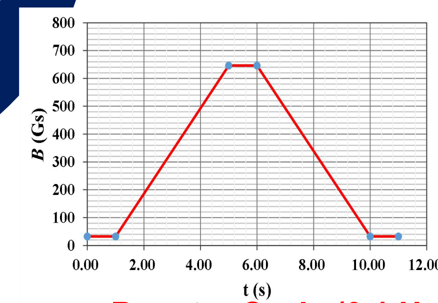
Electron

Positron

2) Booster

C=100km

Energy Ramp
10 ->45/120GeV



Booster Cycle (0.1 Hz)

Three rings in the sane channel:
- CEPC & booster
- SppC

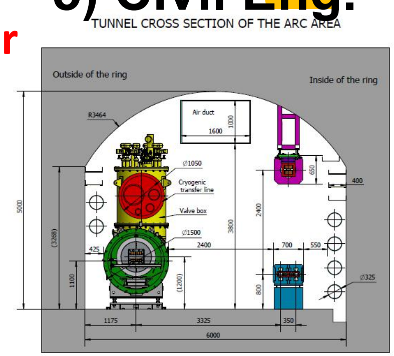
3) Main Ring

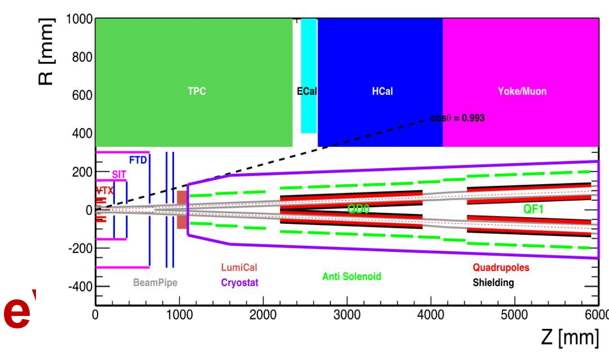
C=100km

45/120 Ge

The key systems of CEPC:
1) Linac Injector
2) Booster
3) Collider ring
4) MDI
5) Civil Eng.

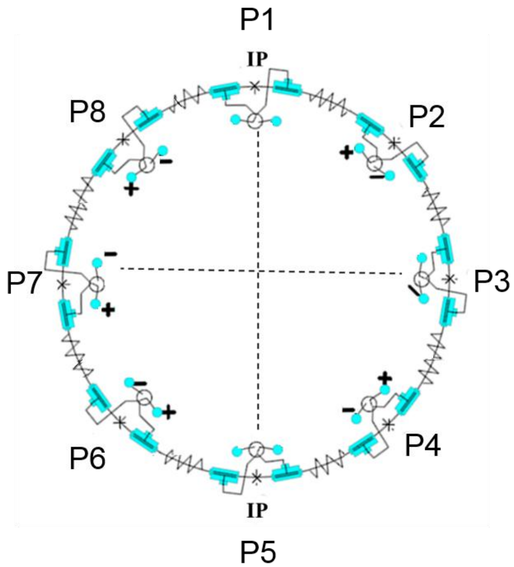
5) Civil Eng.



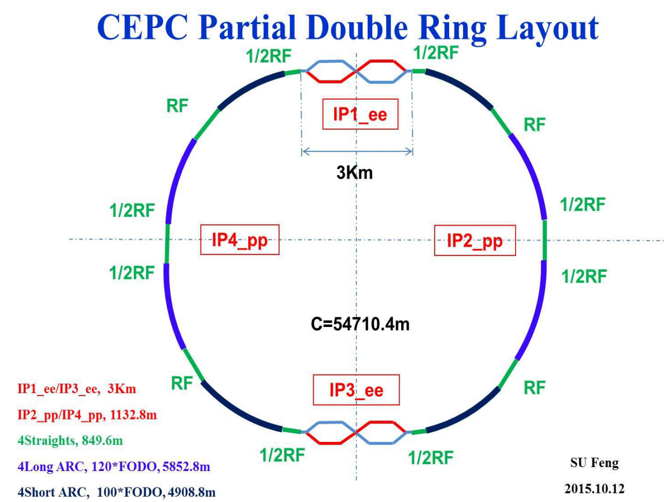


4) Detector Machine Interface (MDI)

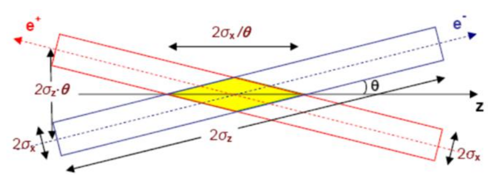
CEPC four options towards CDR

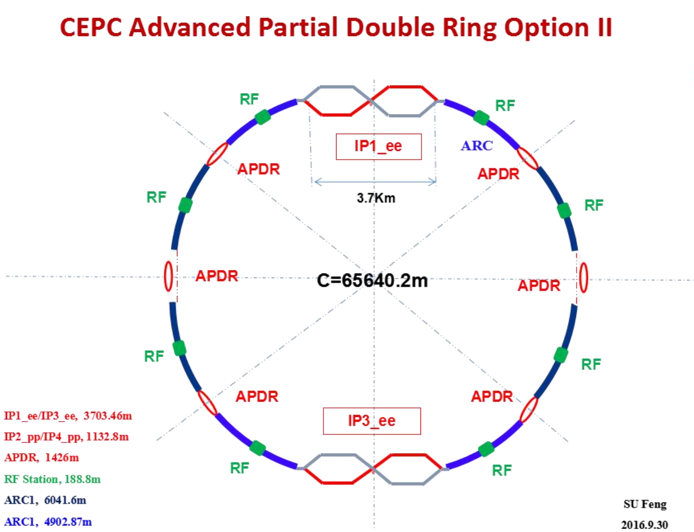


Since Oct 2012

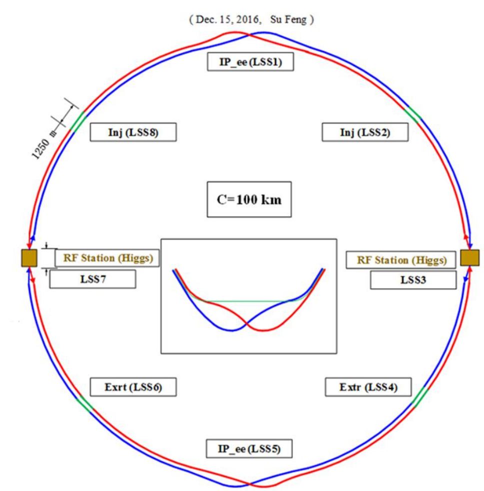


Since May 2015



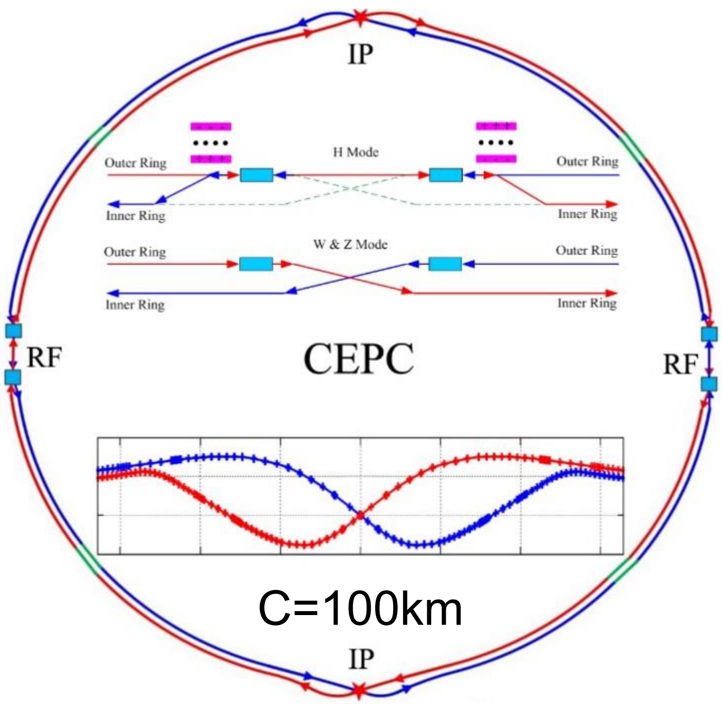


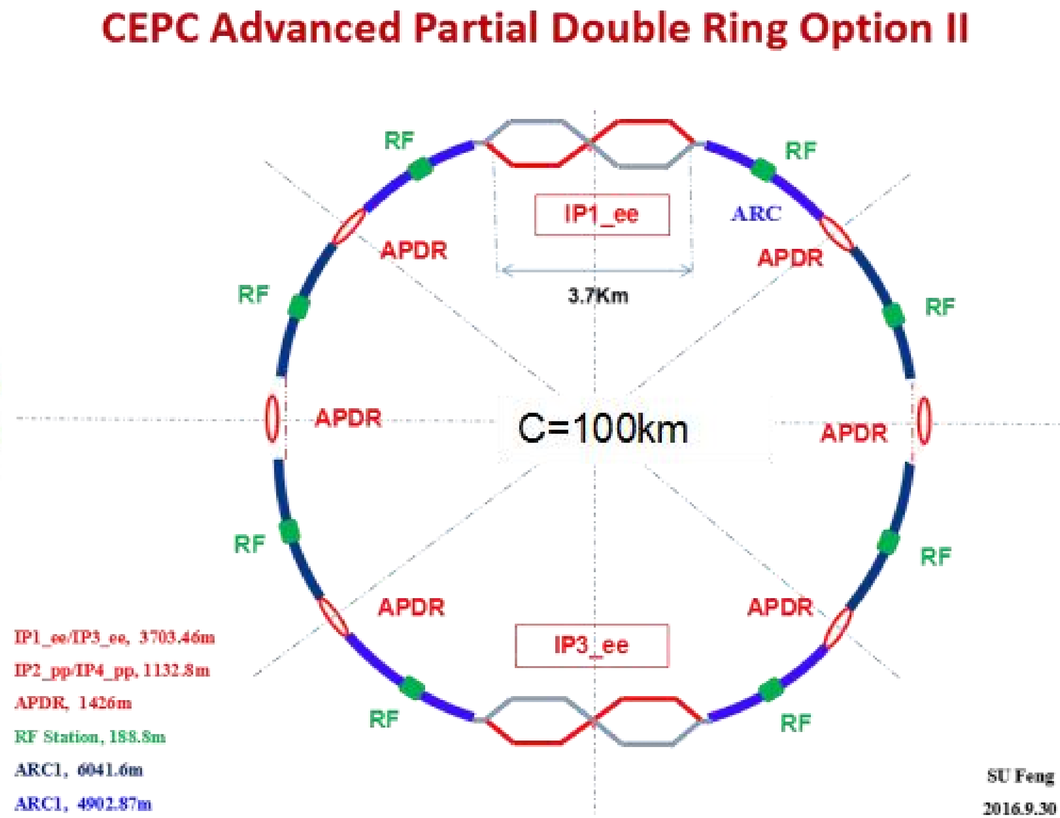
Since May 2016



Since Nov 2016

CEPC CDR Baseline and Alternative Design





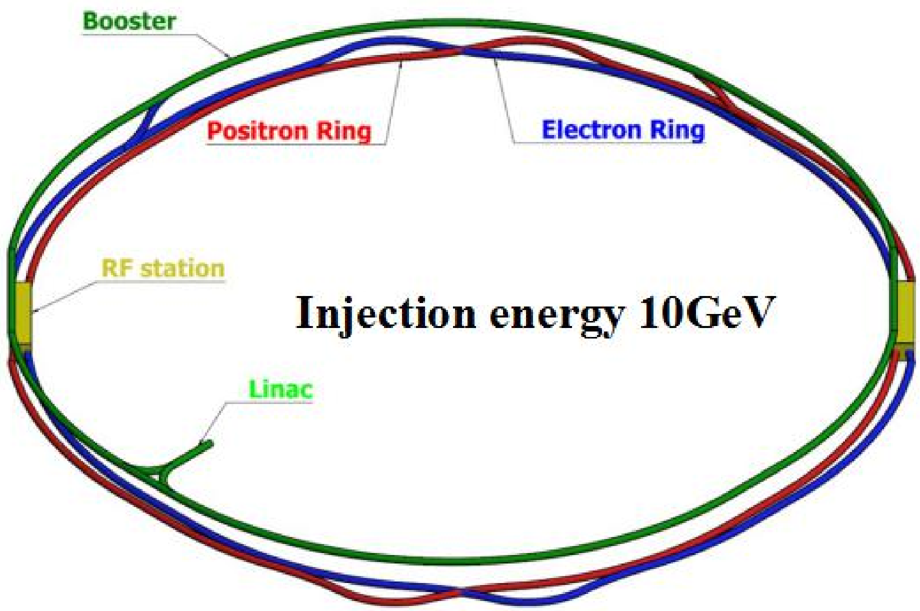
CEPC Baseline Design

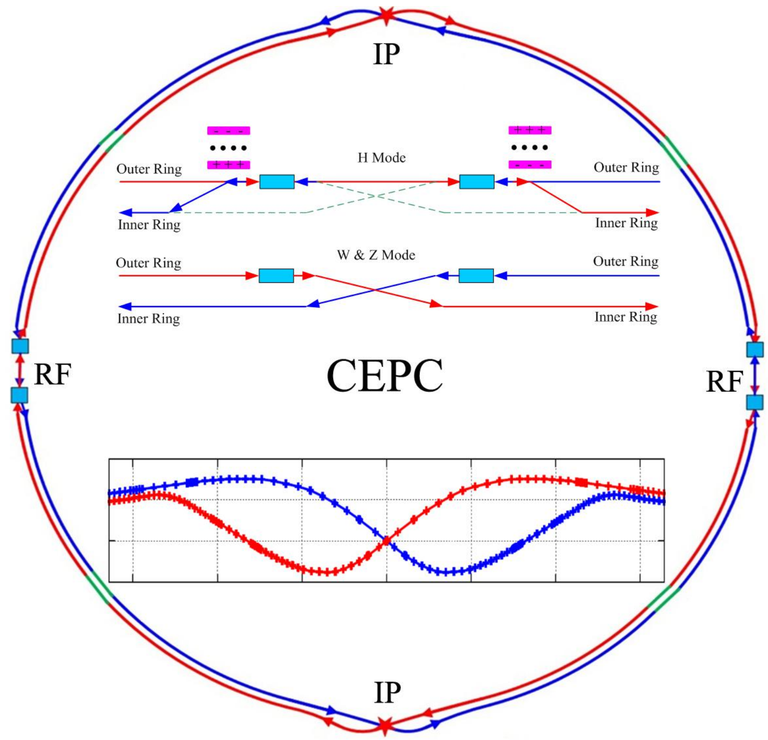
Better performance for Higgs and Z compared with alternative scheme, without bottle neck problems, but with higher cost

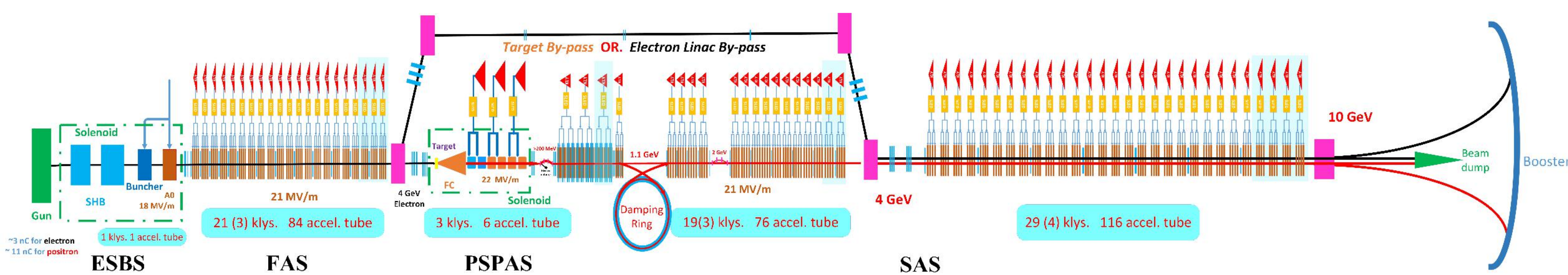
CEPC Alternative Design

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

CEPC CDR Layout







CEPC CDR Parameters

D. Wang

	Higgs	W	Z（3T）	Z（2T）
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	
Betatron tune ν_x/ν_y	363.10 / 365.22			
Synchrotron tune ν_s	0.065	0.0395	0.028	
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	0.29	0.35	0.55	
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 CDR Design Status

CEPC Collider Ring

Parameter	Symbol	Unit	Goal	Status
Beam Energy	E	GeV	120	**120**
Circumference	C	km	100	**100.006**
Emittance	$\varepsilon_x/\varepsilon_y$	nm·rad	1.21 / 0.0036	**1.208 / -**
Beta functions at IP	β_x/β_y	m	0.36 / 0.002	**0.36 / 0.002**
Energy acceptance	$\Delta P/P$	%	1.35	**1.8**
DA requirement	DA_x/DA_y	σ	13 / 12	**20 / 20 (w/o errors)**

* Z and W satisfies CDR requirement as well

CDR goal reached

CEPC Booster Design Status

Parameters	Design goals	Design results
Beam current (mA)	<0.8	0.54
Emittance in x (nm rad)	<3.6	3.1
Dynamic aperture for 0.5% off-momentum particles	>3σ	8.5σ
Energy acceptance	>1%	2.5%
Timing	Meet the top-up injection requirements	√

CDR goal reached

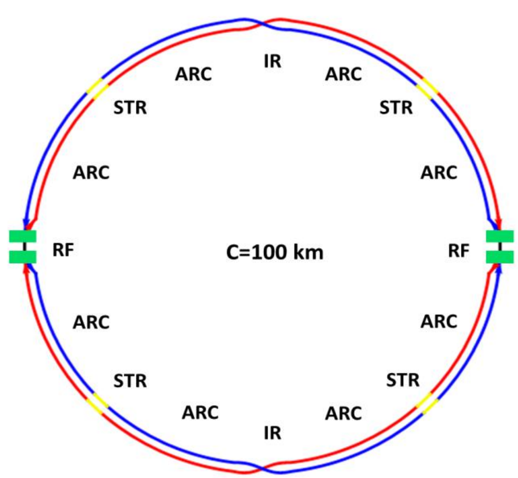
CEPC Linac Injector CDR Status

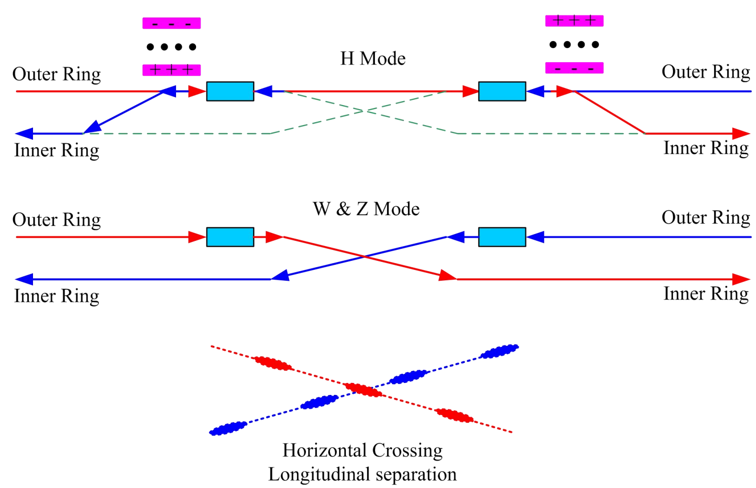
Parameter	Symbol	Unit	Goal	Status
e^- /e^+ beam energy	E_{e-}/E_{e+}	GeV	10	10/10
Repetition rate	f_{rep}	Hz	100	100
e^- /e^+ bunch population	$Ne-/Ne+$		$>6.25\times10^9$	$\sim1.875\times10^{10}$ $\sim1.875\times10^{10}$
	$Ne-/Ne+$	nC	>1.0	1.0/3.0*
Energy spread (e^- /e^+)	σ_E		$<2\times10^{-3}$	1.5×10^{-3} 1.4×10^{-3}
Emittance (e^- /e^+)		mm· mrad	<0.3	0.005/0.12**
e^- beam energy on Target		GeV	4	4
e^- bunch charge on Target		nC	10	10

CEPC Collider Ring

Y.W. Wang

- The circumference of CEPC collider ring is **100 km**.
- In the RF region, the **RF cavities are shared by two ring for H mode**.
- **Twin-aperture of dipoles and quadrupoles is adopt in the arc region** to reduce the their power. The distance between two beams is 0.35m.
- Compatible optics for H, W and Z modes
  - For the **W and Z mode**, the optics except RF region is got by **scaling down the magnet strength with energy**.
  - For H mode, all the cavities will be used and bunches will be filled in half ring.
  - **For W & Z modes, half number of cavities will be used** and bunches can be filled in full ring

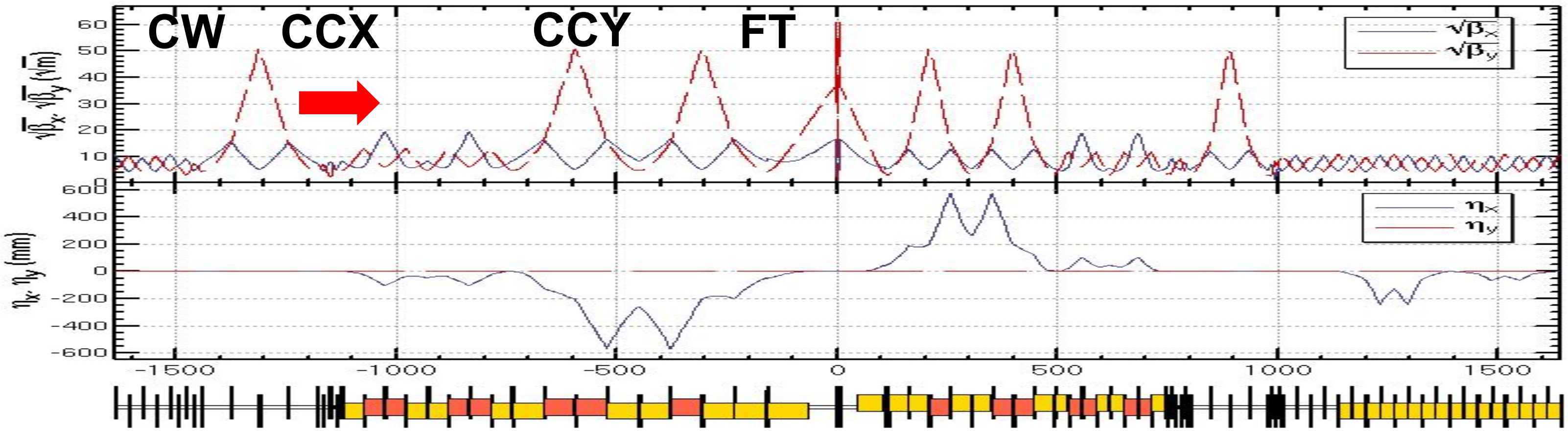




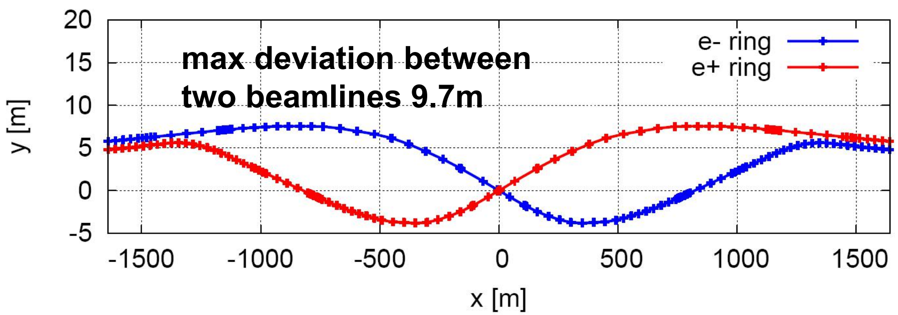
Linear optics of Interaction region

Y.W. Wang

- Provide local chromaticity correction of both plane
- **L*=2.2m, θc=33mrad, GQD0=136T/m, GQF1=111T/m**
- IP upstream of IR: **Ec < 120 keV within 400m, last bend Ec = 45 keV**
- IP downstream of IR: Ec < 300 keV within 250m, last bend Ec = 97 keV
- The vertical emittance growth due to solenoid coupling is less than 4%.
- Relaxed optics for injection can be re-matched easily as the **modular design**.



L*= 2.2m
βx*= 0.36mm
βy*= 1.5mm
GQD0≅-136T/m
GQF1≅111T/m
LQD0=2.0m
LQF1=1.48m

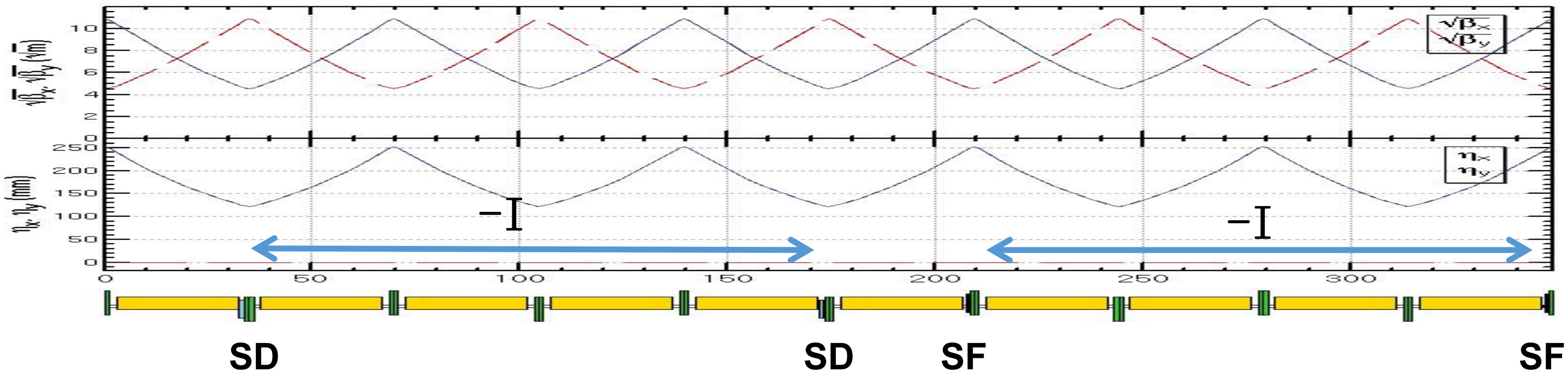


Yiwei Wang

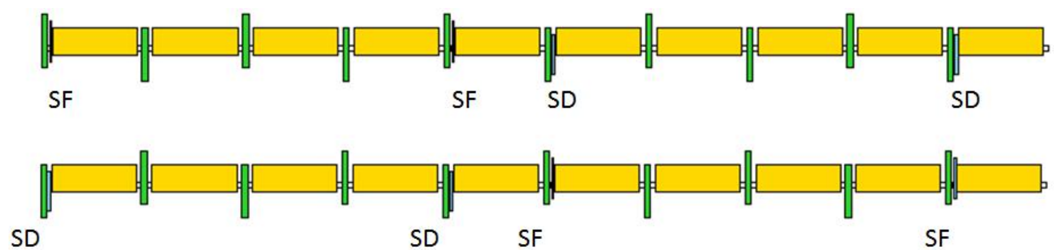
Linear optics design of ARC region

Y.W. Wang

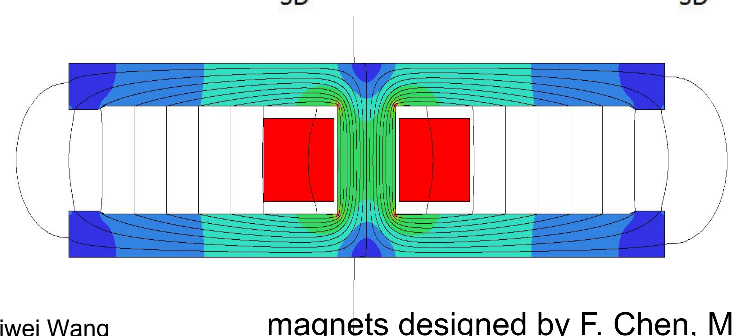
- **FODO cell, 90°/90°, non-interleaved sextupole scheme, period =5cells**

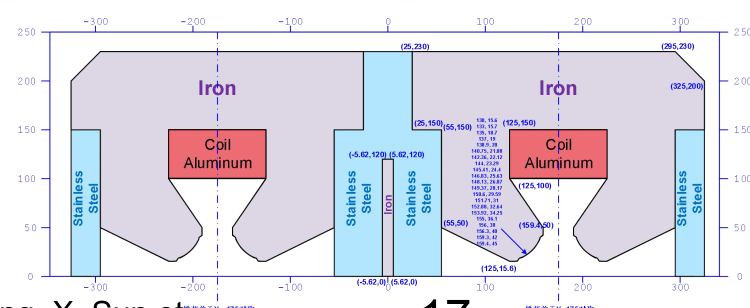


- **Twin-aperture of dipoles and quadrupoles* is adopt in the arc region** to reduce the their power. The distance between two beams is 0.35m.



*Ref: A. Milanese, PRAB 19, 112401 (2016)



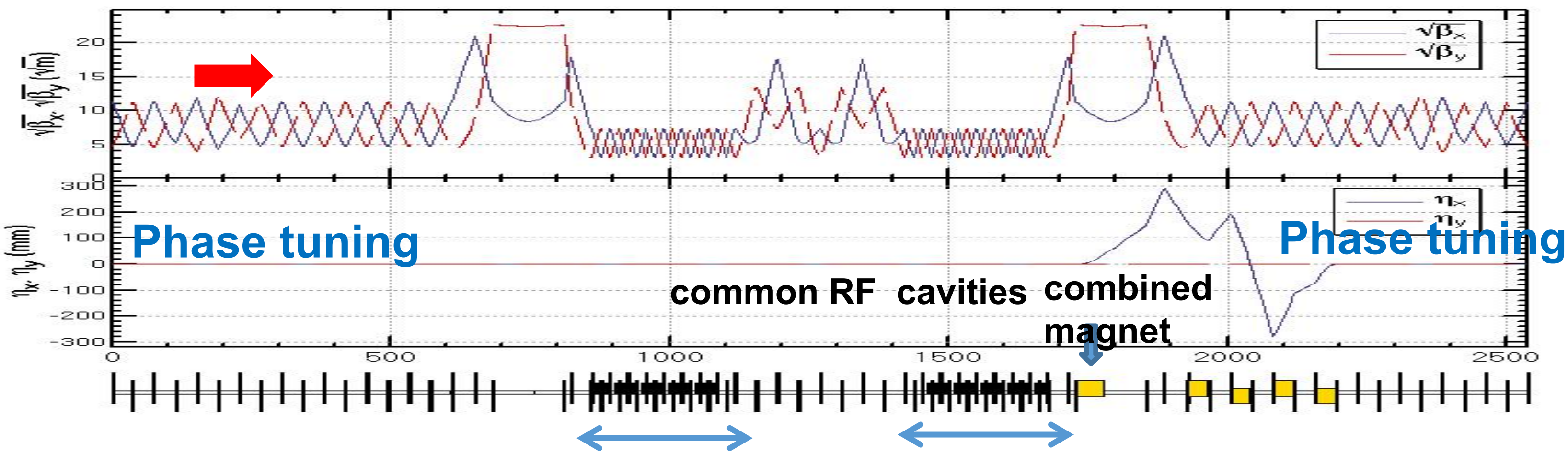


magnets designed by F. Chen, M. Yang, X. Sun et al.

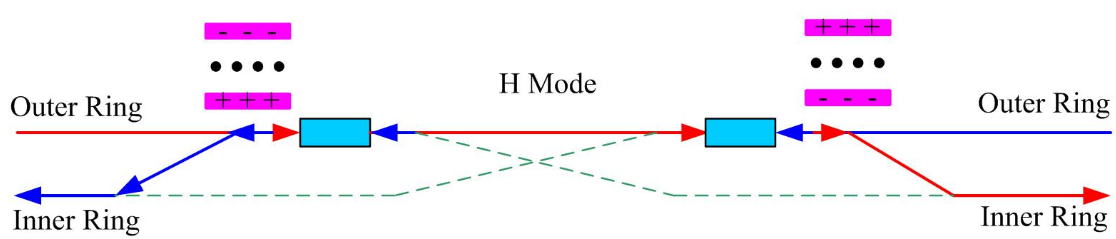
Optics design of RF region

Y.W. Wang

- **Common RF cavities** for e- and e+ ring (Higgs)
- An electrostatic separator combined with a dipole magnet to avoid bending of incoming beam(ref: K. Oide, ICHEP16)
- **RF region divided into two sections for bypassing half numbers of cavities in Z mode**



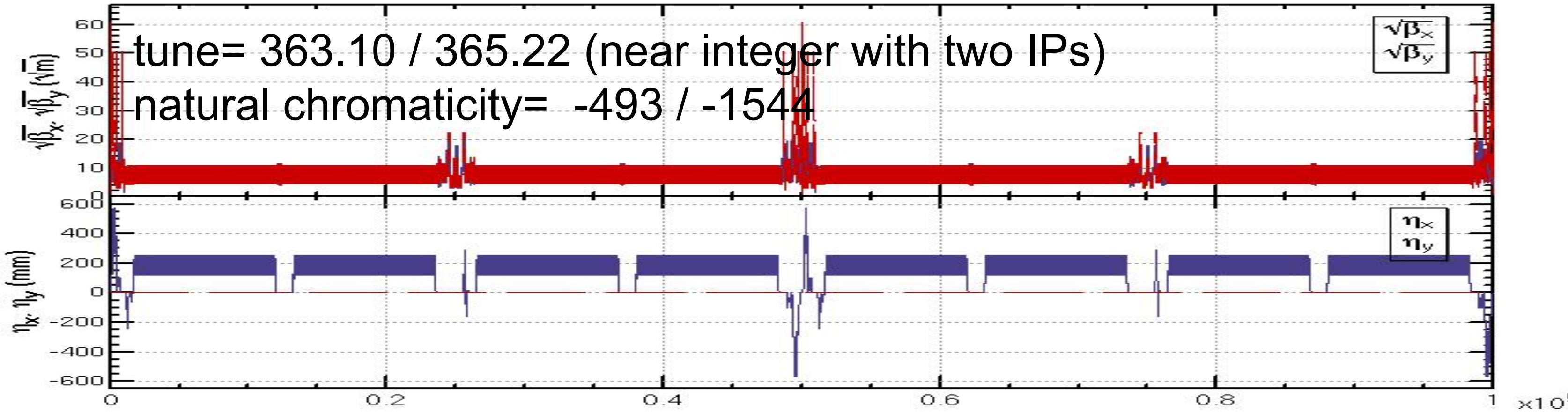
Esep=1.8 MV/m
Lsep=50m
Ldrift=75m
Δx=10cm at entrance of quad

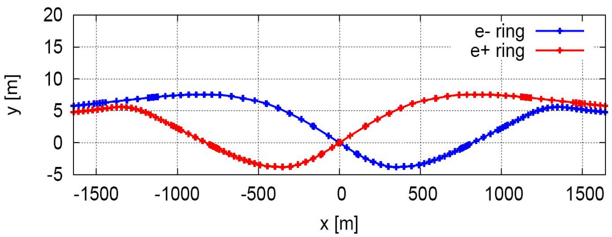


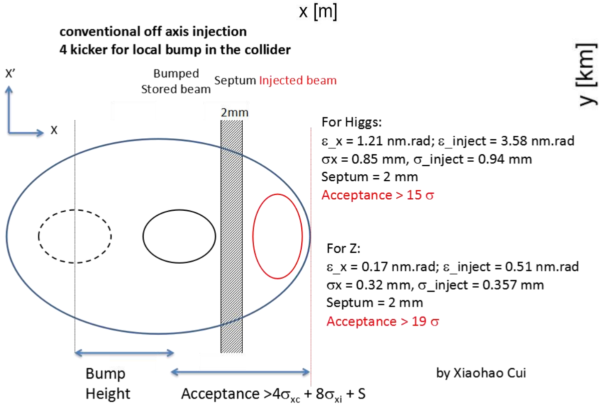
Linear optics of the collider ring

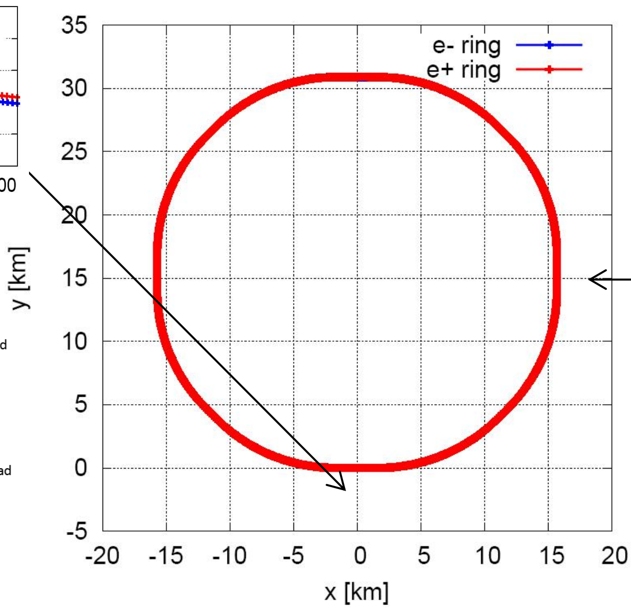
Y.W. Wang

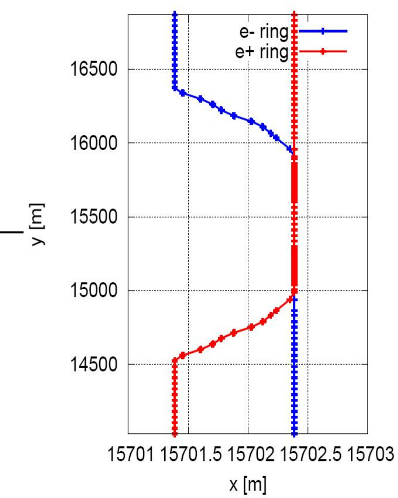
- An optics fulfilling requirements of the parameters list, geometry, photon background and key hardware.







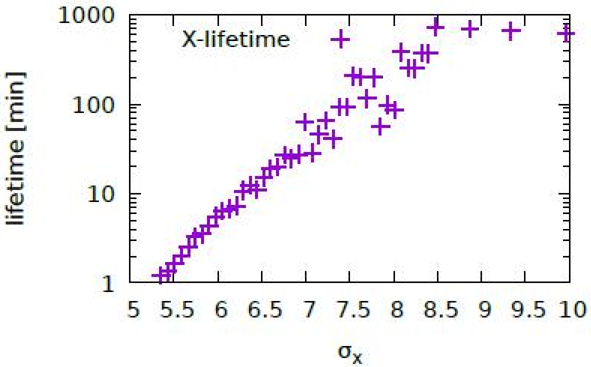


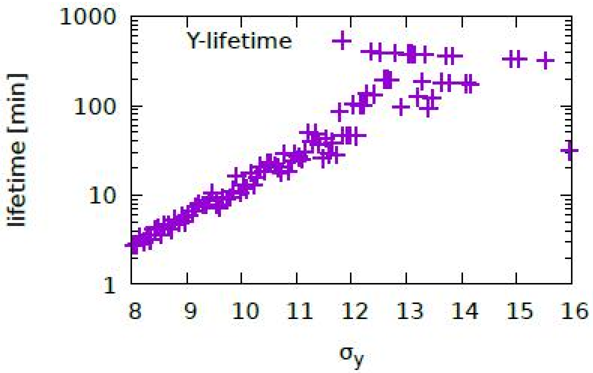


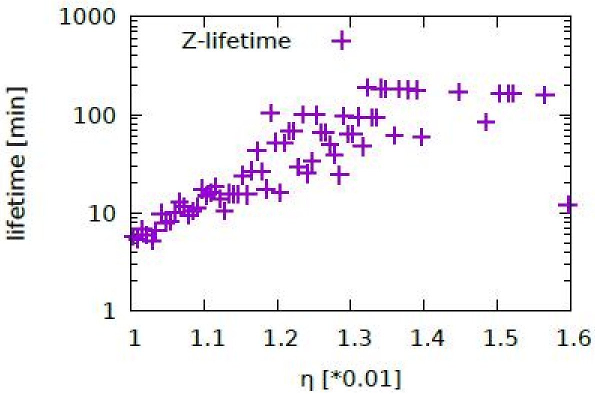
Lifetime with real lattice and beam-beam interaction at Higgs

Y. Zhang

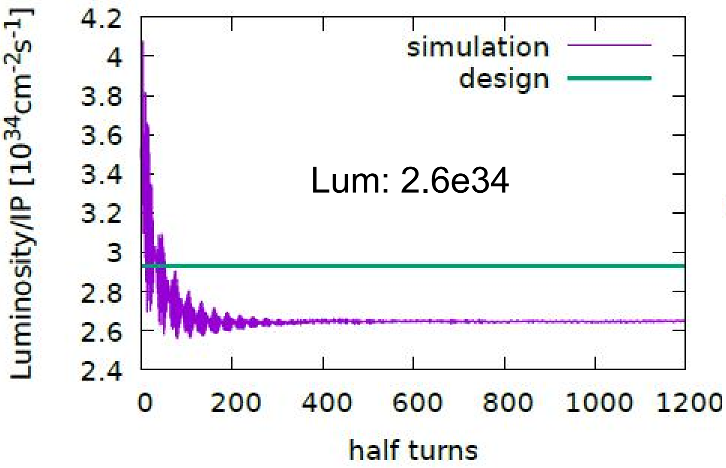
- To ensure 100min limited by x/y/z direction respectively, the dynamic aperture should be larger than $8\sigma_x \times 12\sigma_y \times 0.0135$

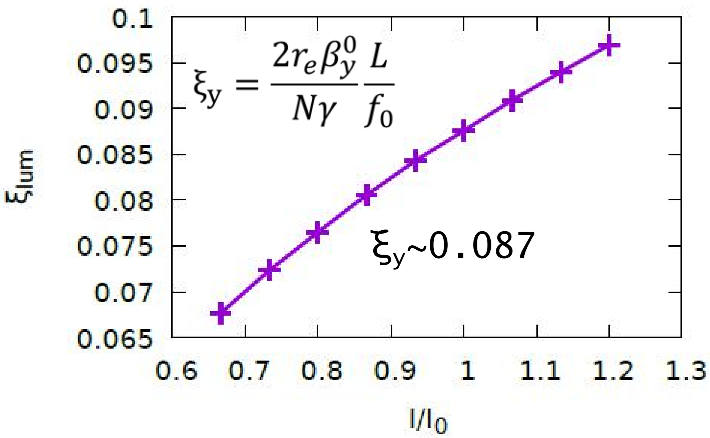


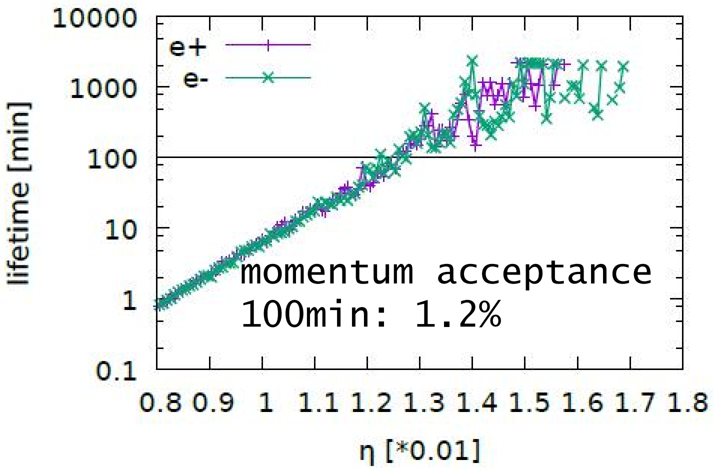


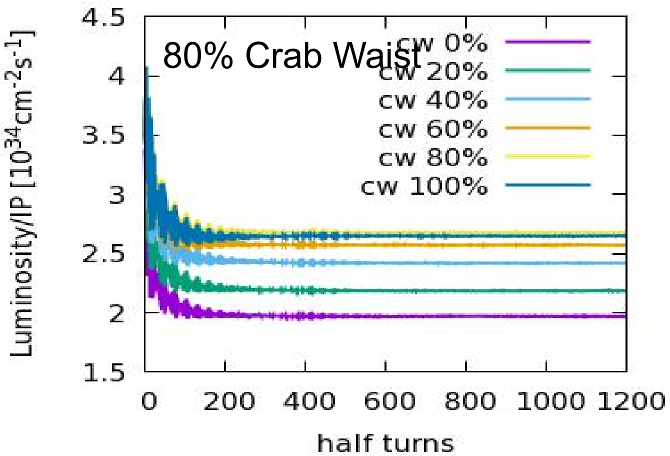


CEPC Beam-Beam Simulation at Higgs





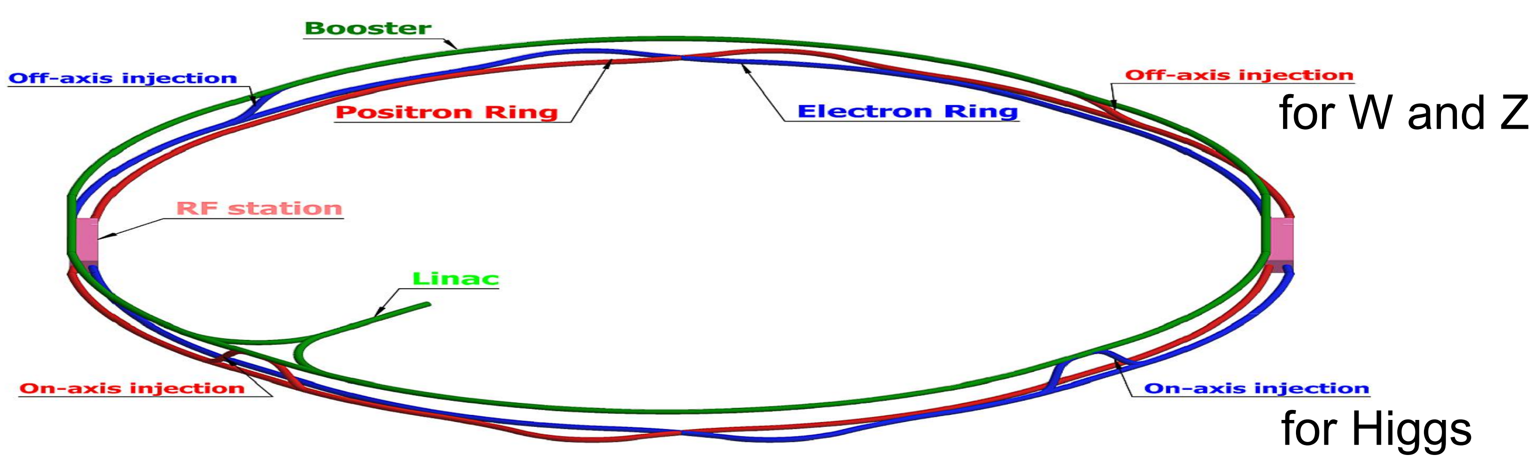




CEPC Collider Ring requirements on Dynamic Aperture

The requirements of dynamic aperture from injection and beam-beam effect to get efficient injection and adequate beam life time:

	Higgs	W	Z
with on-axis injection	$8\sigma_x \times 12\sigma_y \times 1.35\%$	-	-
with off-axis injection	$13\sigma x \times 12\sigma y \times 1.35\%$	$15\sigma_x \times 9\sigma_y \times 0.4\%$	$17\sigma_x \times 9\sigma_y \times 0.23\%$

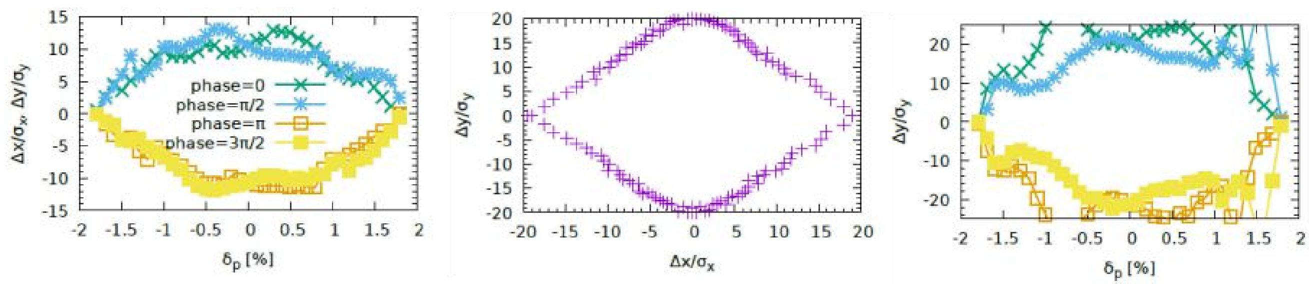


CEPC DA@Higgs,W and Z-pole

Y. Zhang

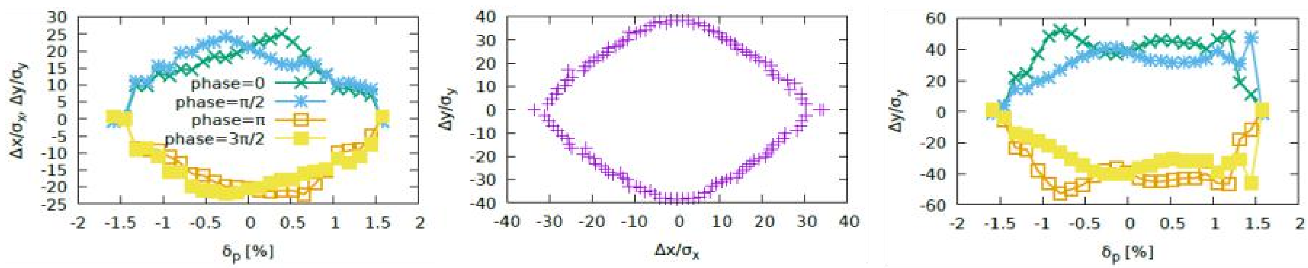
- Synchrotron radiation fluctuation is considered
- 100 samples are tracked
- 90% survival boundary is shown

H



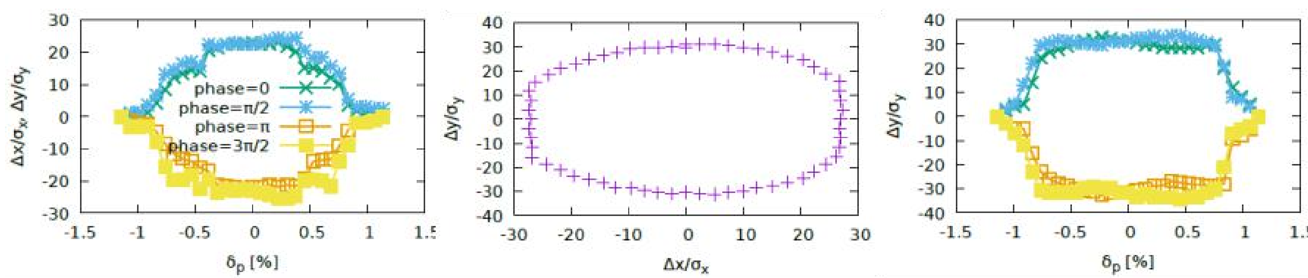
$20\sigma_x \times 20\sigma_y \times 0.018$

W



$30\sigma_x \times 38\sigma_y \times 0.015$

Z



$28\sigma_x \times 30\sigma_y \times 0.012$

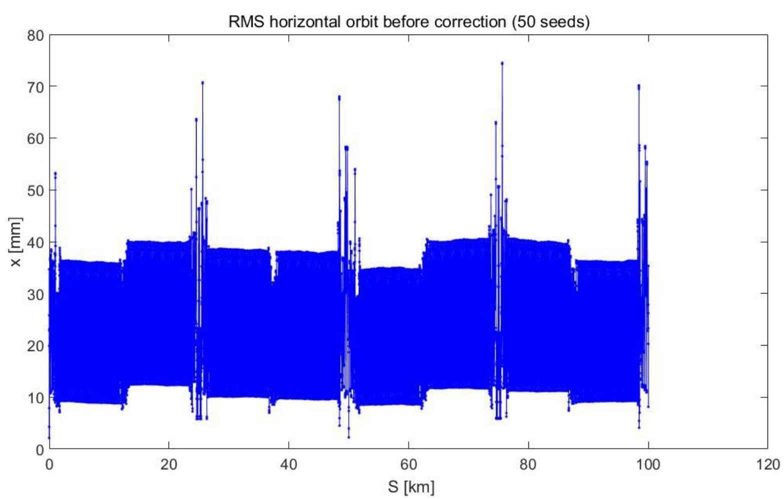
Alignments, field errors and orbit corrections

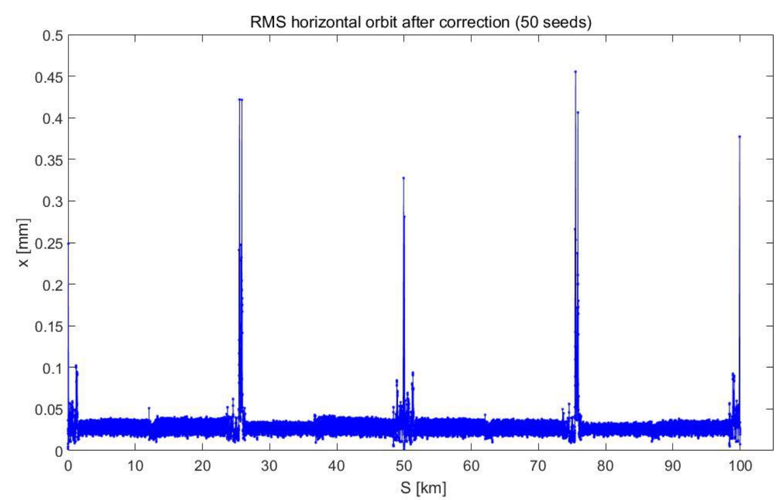
Component	Δx (mm)	Δy (mm)	$\Delta \theta_z$ (mrad)
Dipole	0.05	0.05	0.1
Quadrupole w/o FF	0.03	0.03	0.2
Sextupole	0.03	0.03	0.2

Component	Field error
Dipole	0.03%
Quadrupole (w/o FF)	0.02%

About **1500BPMs,1500 horizontal correctors and 1500 vertical correctors** are placed in the storage ring (4 per betatron wave) .

Y.Y. Wei

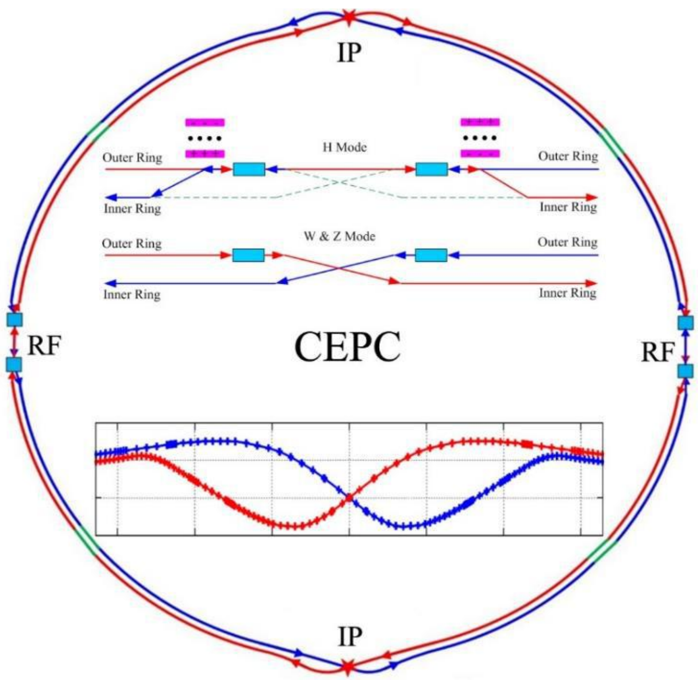




In the ARC, residue $\sigma_{COD} \approx$ 40/75 um (x/y) after orbit correction (50 seeds)

CEPC SRF Design Requirements

J. Y. Zhai



- Higgs long operation first:
  one-time full installation of all the same cavities for H, W, Z. Use part of the Higgs cavities for W and Z. Park the idle cavities (not off beamline).
- Cavity and cryogenics cost reduction:
  common H cavities, separate W/Z cavities.
- Upgradable to 50 MW SR per beam:
  longer tunnel, add cavities, variable coupler, RF configuration and cavity suitable for higher power.

CEPC Collider Ring SRF Parameters

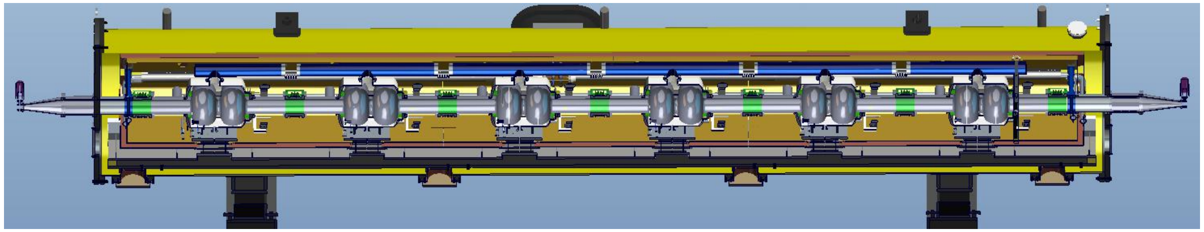
J. Y. Zhai

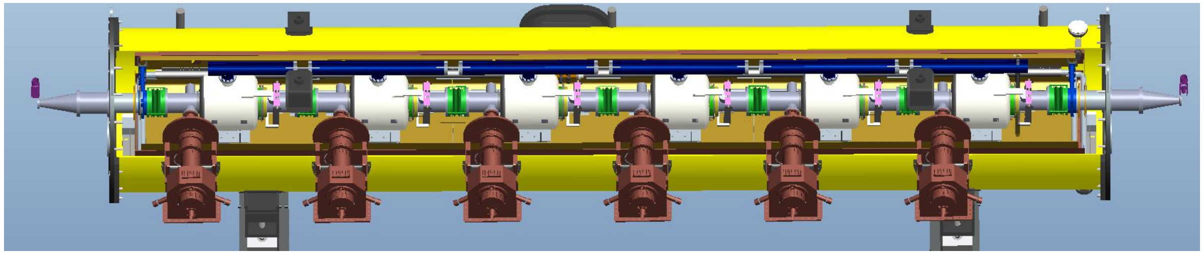
Collider parameters: 20180222	H	W	Z
SR power / beam [MW]	30	30	16.5
RF voltage [GV]	2.17	0.47	0.1
Beam current / beam [mA]	17.4	87.9	461
Bunch charge [nC]	24	24	12.8
Bunch number / beam	242	1220	12000
Bunch length [mm]	3.26	6.53	8.5
Cavity number (650 MHz 2-cell)	240	2 x 108	2 x 60
Cavity gradient [MV/m]	19.7	9.5	3.6
Input power / cavity [kW]	250	278	276
Klystron power [kW] (2 cavities / klystron)	800	800	800
HOM power / cavity [kW]	0.54	0.86	1.94
Optimal Q_L	1.5E6	3.2E5	4.7E4
Optimal detuning [kHz]	0.17	1.0	18.3
Total cavity wall loss @ 2 K [kW]	6.6	1.9	0.2

CEPC 650 MHz Cavity Cryomodule

J.Y. Zhai

- Structure based on ADS cryomodule. High Q requirement drives new design features (fast cool down and magnetic hygiene).
- Fast cool down rate is supposed to be 10 K/min during 45 K to 4.5 K.
- Ambient magnetic field at cavity surface should be less than 5 mG. Magnetic shielding and demagnetization of parts and the whole module should be implemented for the magnetic hygiene control.





Overall length (flange to flange, m)	8.0
Diameter of vacuum vessel (m)	1.3
Beamline height from floor (m)	1.2
Cryo-system working temperature (K)	2
Number of cavities and tuners	6
Number of couplers	6
Number of RT HOM absorbers	2
Number of 200-POSTs	6
Static heat loads at 2 K (W)	5
Alignment x/y (cavities) (mm)	0.5
Alignment z (mm)	2

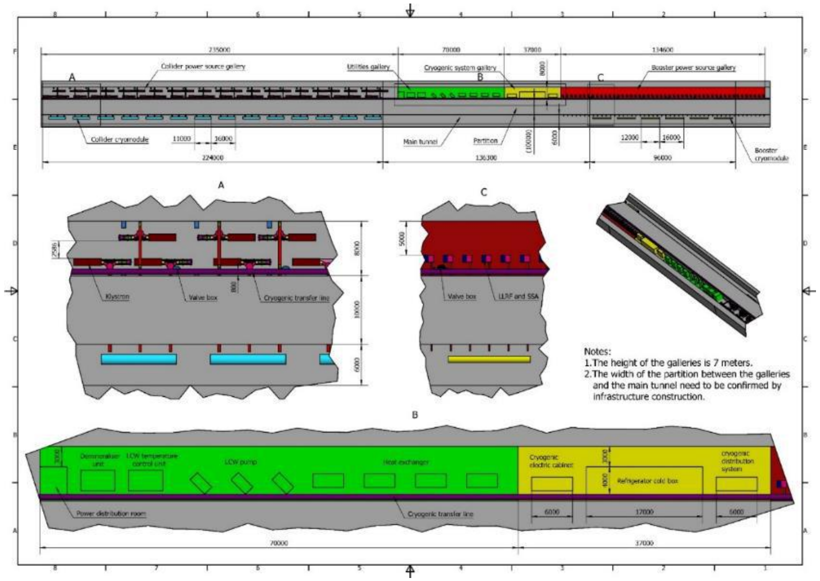
CEPC RF Layout

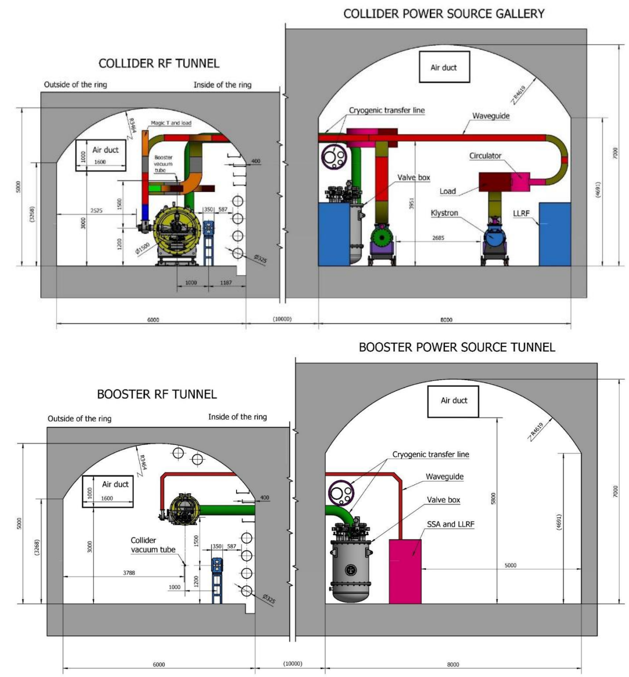
For 30 MW Higgs:

Collider: 240 650 MHz 2-cell cavities in 40 cryomodules (6 cav./ module).

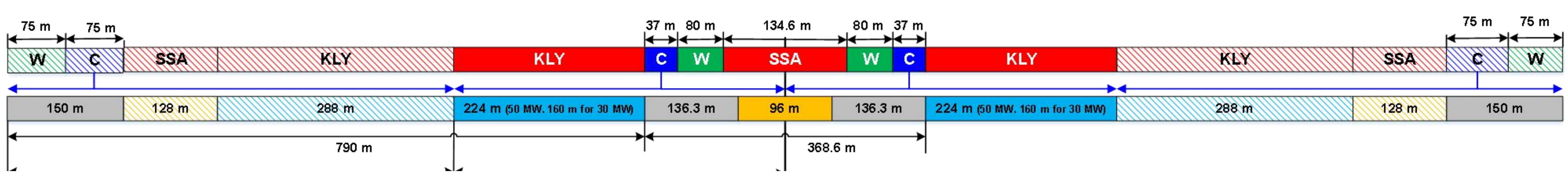
Booster: 96 1.3 GHz 9-cell cavities in 12 cryomodules (8 cav. / module).

For 50 MW Higgs: add 16 Collider modules.





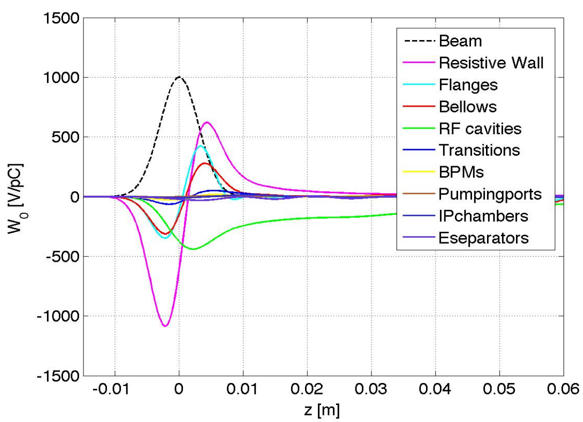
RF Section A @ IP2 / LLS2 (length 1948.6 m)



CEPC Collider Ring Impedance Budget

N. Wang

Components	Number	$Z_{\|\|}/n$, mΩ	k_{loss}, V/pC	ky, kV/pC/m
Resistive wall	-	6.2	363.7	11.3
RF cavities	336	-1.4	315.3	0.41
Flanges	20000	2.8	19.8	2.8
BPMs	1450	0.12	13.1	0.3
Bellows	12000	2.2	65.8	2.9
Pumping ports	5000	0.02	0.4	0.6
IP chambers	2	0.02	6.7	1.3
Electro-separators	22	0.2	41.2	0.2
Taper transitions	164	0.8	50.9	0.5
Total		**10.5**	**876.8**	**20.4**



Longitudinal wake at the nominal σ_z = 3mm

Broadband impedance threshold:

Threshold	ttbar	Higgs	W	Z
$\|Z_L/n\|_{eff}$, mΩ	13.6	9.0	8.0	2.1
κ_y, kV/pC/m	81.2	61.6	69.0	38.7

CEPC Cillider Ring Impedance Requirement

N. Wang

- For different operation scenarios, the design of Z shows the most critical restriction for both broadband and narrowband impedances.

Parameter	Symbol, unit	Higgs	W	Z
Beam energy	E, GeV	120	80	45.5
Beam current	I_0, mA	17.4	88.0	183.1
Bunch number	n_b	242	3390	9524
Bunch current	I_b, mA	0.072	0.026	0.019
Bunch Population	N_e, $\times 10^{10}$	15.0	5.4	4.0
Threshold of broadband ZL	$\lvert Z_L/n \rvert_{eff}$, mΩ	9.0	8.0	2.1
Threshold of broadband ZY	κ_y, kV/pC/m	61.6	69.0	38.7
Threshold of narrowband ZL	$\frac{f}{\mathrm{GHz}} \frac{\mathrm{Re}\, Z_L}{\mathrm{G\Omega}} e^{-(2\pi f \sigma_l)^2}$	3.5	0.08	3.0E-3
Threshold of narrowband ZY	$\frac{\mathrm{Re}\, Z_\perp}{\mathrm{G\Omega/m}} e^{-(2\pi f \sigma_l)^2}$	2.4	0.09	4.5E-3

CEPC Collider Ring Collective Instabilities

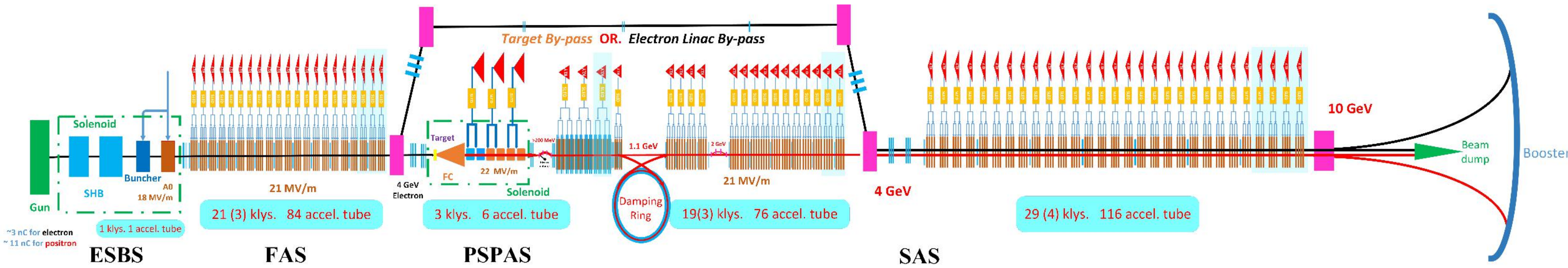
N. Wang

- The design single bunch intensity are all below the instability threshold.
- Transverse and longitudinal feedbacks are needed to damp the coupled bunch instabilities.

Beam instability	ttbar	Higgs	W	Z
Bunch lengthening, σ_l/σ_{l0}	13%	20%	22%	73%
Beam energy spread increase, σ_e/σ_{e0}	~0	~0	2%	15%
CSR threshold $N_{bth,}$ nC	1565	622	201	38
Transverse impedance tune shift $\Delta v_{x,y}$	-0.02	-0.01	-0.006	-0.008
Transverse Mode Coupling N_{bth}, nC	207	93	37	16
Transverse resistive wall instability, ms	1986	298	39	11
Longitudinal RF HOMs CBI, ms	4.3E4	3.8E3	446	87
Transverse RF HOMs CBI, ms	1.2E4	1.7E3	352	85
Fast beam ion instability, ms	900	76	18	7

CEPC Linac Injector

C. Meng



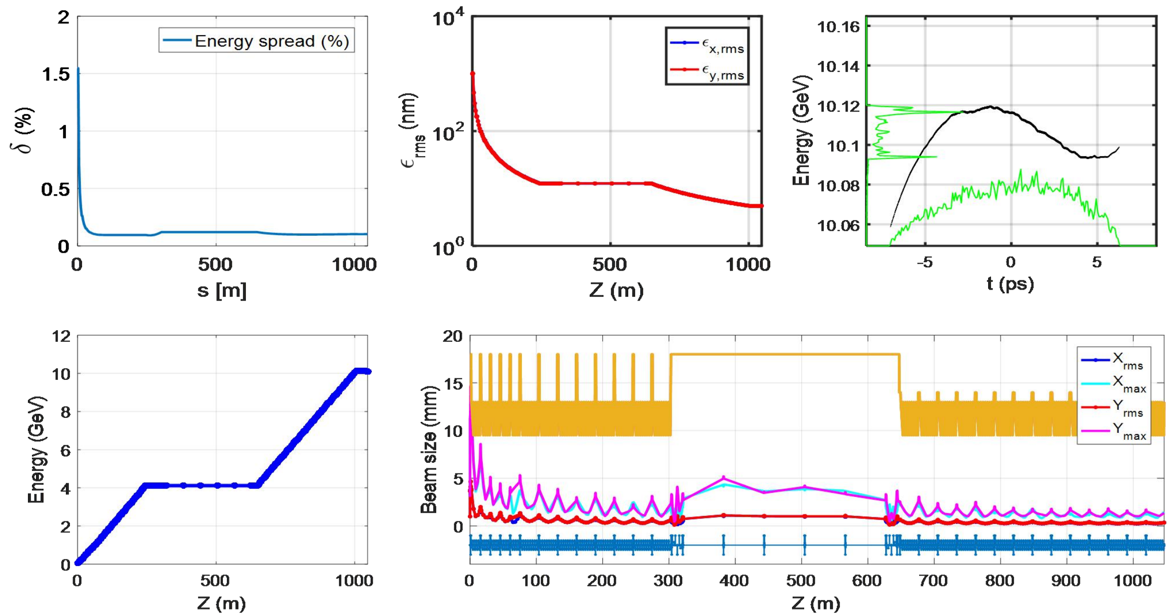
Parameter	Symbol	Unit	Baseline	Design reached
e^- /e^+ beam energy	E_{e-}/E_{e+}	GeV	**10**	**10**
Repetition rate	f_{rep}	Hz	**100**	**100**
e^- /e^+ bunch population	N_{e-}/N_{e+}		> 9.4×10^9	**1.9×10^{10} / 1.9×10^{10}**
		nC	**> 1.5**	**3.0**
Energy spread (e^- /e^+)	σ_e		**< 2×10^{-3}**	**1.5×10^{-3} / 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**

CEPC Linac Injector

Electron linac

Low charge mode

- 3 nC @ 10 GeV
- Energy spread (rms): 0.15%
- Emittance (rms): 5 nm



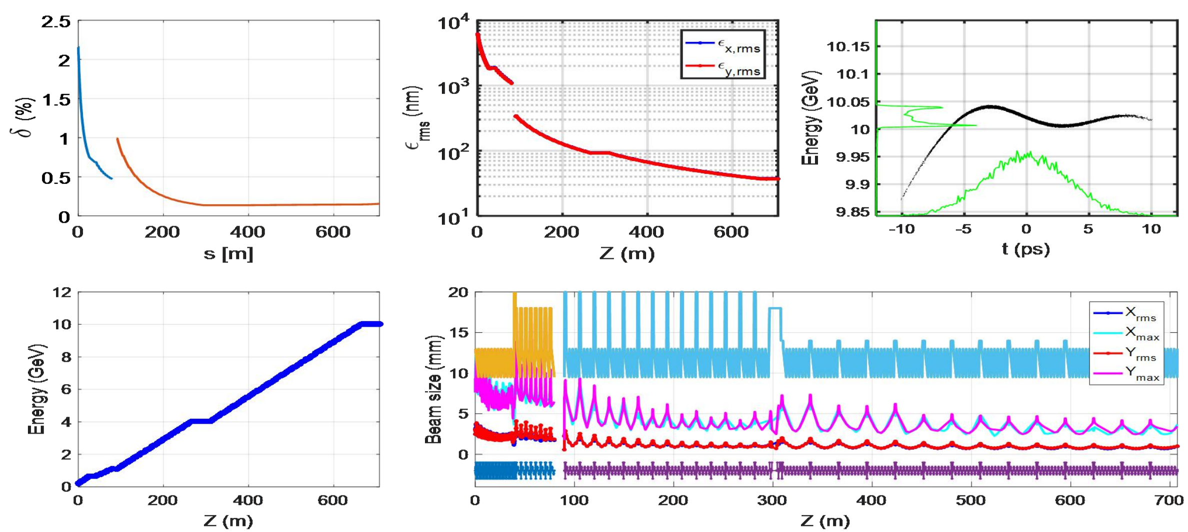
Positron linac

3 nC && 10 GeV

Energy spread (rms): 0.16%

Emittance with DR (rms): 40/24nm

Emittance without DR (rms): 120/120nm

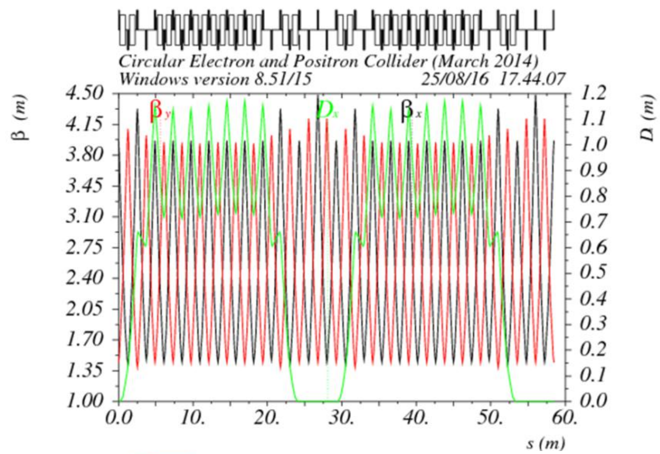


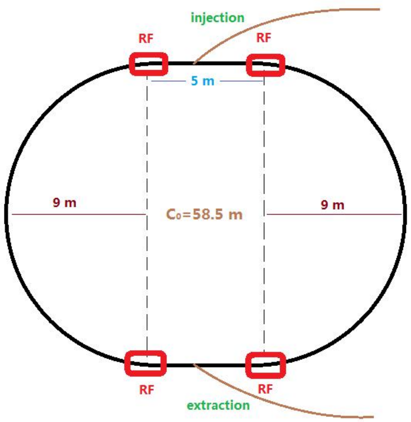
CEPC Linac Injector Damping Ring

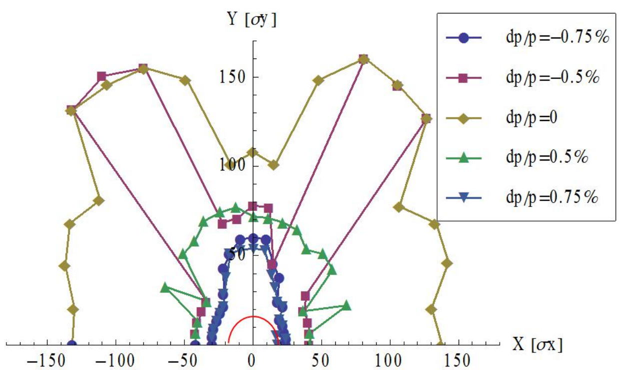
D. Wang

and layout

DR V1.0	Unit	Value
Energy	GeV	1.1
Circumference	M	58.5
Repetition frequency	Hz	100
Bending radius	M	3.6
Dipole strength B_0	T	1.01
U_0	keV	35.8
Damping time x/y/z	Ms	12/12/6
δ_0	%	0.049
ε_0	mm.mrad	302
Nature σ_z	mm	7 (23ps)
Extract σ_z	mm	7 (23ps)
ε_{inj}	mm.mrad	2500
$\varepsilon_{ext\ x/y}$	mm.mrad	716/471
$\delta_{inj}/\delta_{ext}$	%	0.6/0.07
Energy acceptance by RF	%	1.0
f_{RF}	MHz	650
V_{RF}	MV	1.8







CEPC Booster parameters @ injection (10GeV)

D. Wang

		H	*W*	*Z*
Beam energy	GeV	10		
Bunch number		242	1524	6000
Threshold of single bunch current	μA	25.7		
Threshold of beam current (limited by coupled bunch instability)	mA	127.5		
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	%	0.0078		
Synchrotron radiation loss/turn	keV	73.5		
Momentum compaction factor	10^{-5}	2.44		
Emittance	nm	0.025		
Natural chromaticity	H/V	-336/-333		
RF voltage	MV	62.7		
Betatron tune $\nu_x/\nu_y/\nu_s$		263.2/261.2/0.1		
RF energy acceptance	%	1.9		
Damping time	s	90.7		
Bunch length of linac beam	mm	1.0		
Energy spread of linac beam	%	0.16		
Emittance of linac beam	nm	40~120		

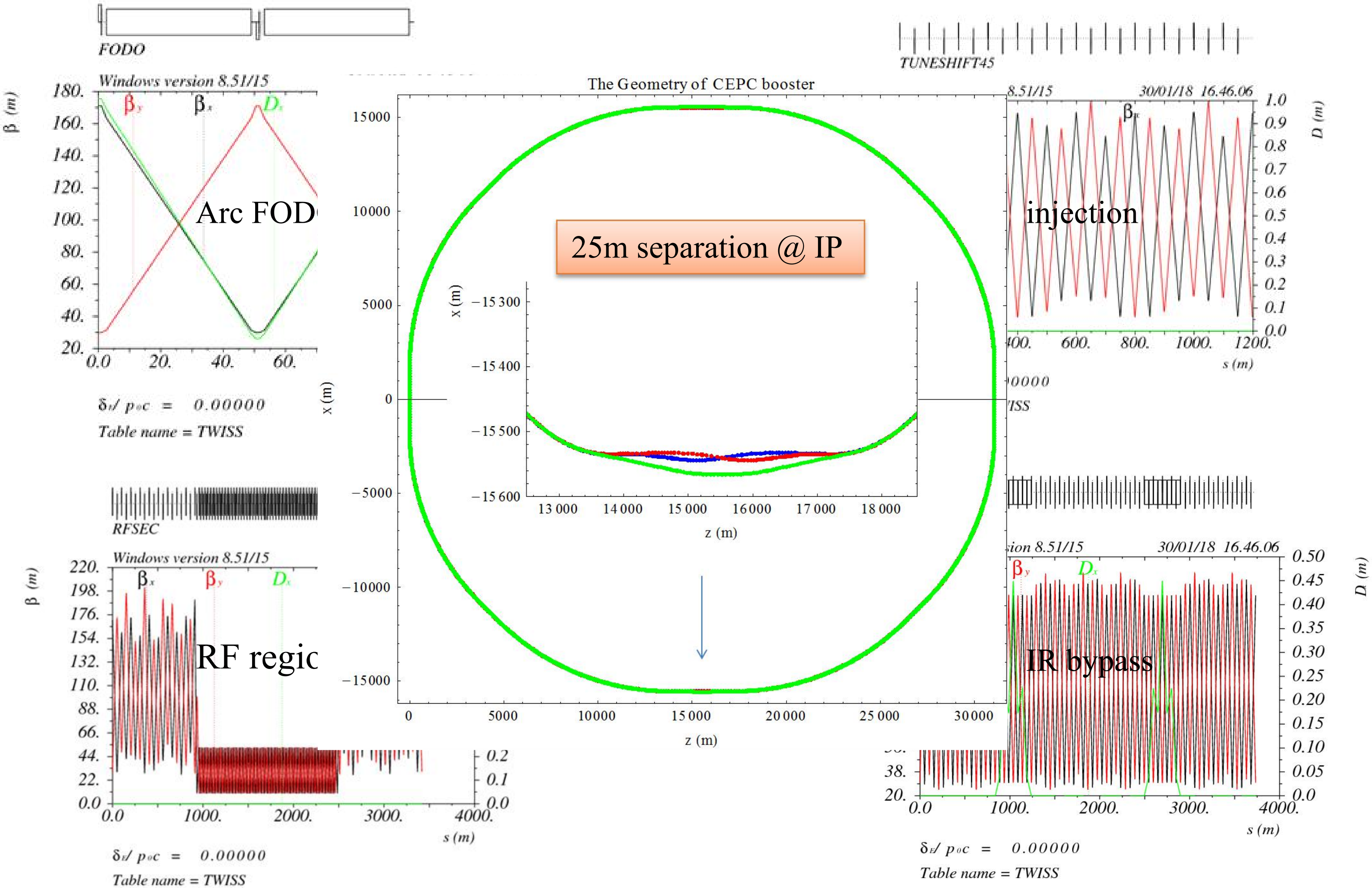
CEPC Booster parameters @ extraction

D. Wang
T.J. Bian

		H		*W*	*Z*
		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	300			
Threshold of beam current (limited by RF power)	mA	1.0		4.0	10.0
Beam current	mA	0.52	1.0	2.63	6.91
Injection duration for top-up (Both beams)	s	25.8	35.4	45.8	275.2
Injection interval for top-up	s	73.1		153.0	438.0
Current decay during injection interval		3%			
Energy spread	%	0.094		0.062	0.036
Synchrotron radiation loss/turn	GeV	1.52		0.3	0.032
Momentum compaction factor	10^{-5}	2.44			
Emittance	nm	3.57		1.59	0.51
Natural chromaticity	H/V	-336/-333			
Betatron tune ν_x/ν_y		263.2/261.2			
RF voltage	GV	1.97		0.585	0.287
Longitudinal tune		0.13		0.10	0.10
RF energy acceptance	%	1.0		1.2	1.8
Damping time	ms	52		177	963
Natural bunch length	mm	2.8		2.4	1.3
Injection duration from empty ring	h	0.17		0.25	2.2

CEPC Booster Optics & Geometry

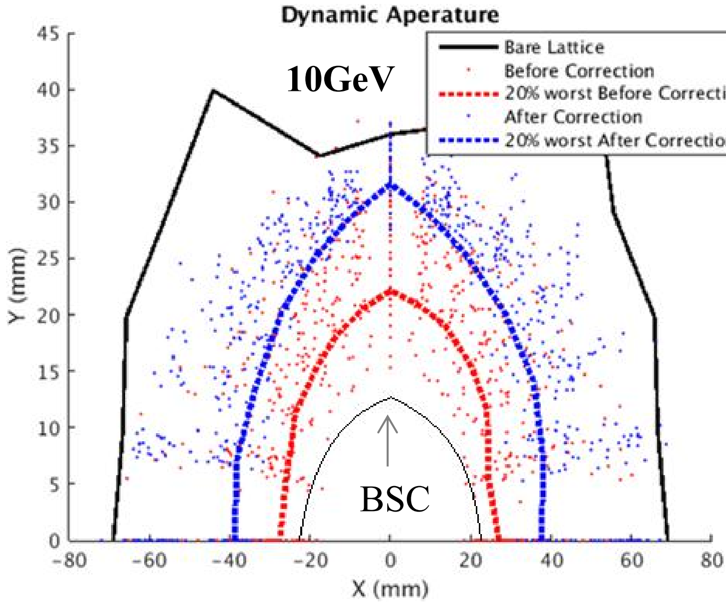
D. Wang
T.J. Bian

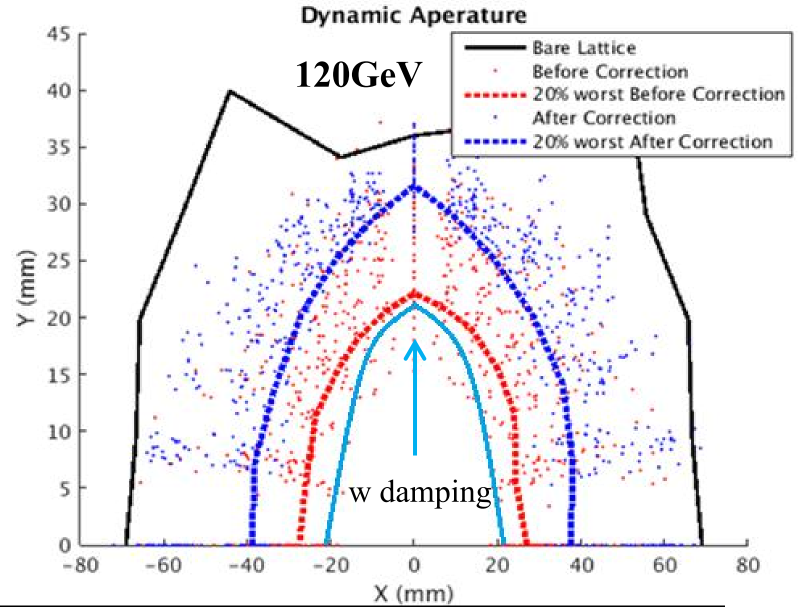


CEPC Booster DA

D. Wang

Parameters	Dipole	Quadrupole	Sextupole	Parameters	BPM (10Hz)
Transverse shift x/y (μm)	50	70	70	Accuracy (m)	1×10^{-7}
Longitudinal shift z (μm)	100	150	100	Tilt (mrad)	10
Tilt about x/y (mrad)	0.2	0.2	0.2	Gain	5%
Tilt about z (mrad)	0.1	0.2	0.2	Offset after BBA(mm)	30×10^{-3}
Nominal field	3×10^{-4}	2×10^{-4}	3×10^{-4}		

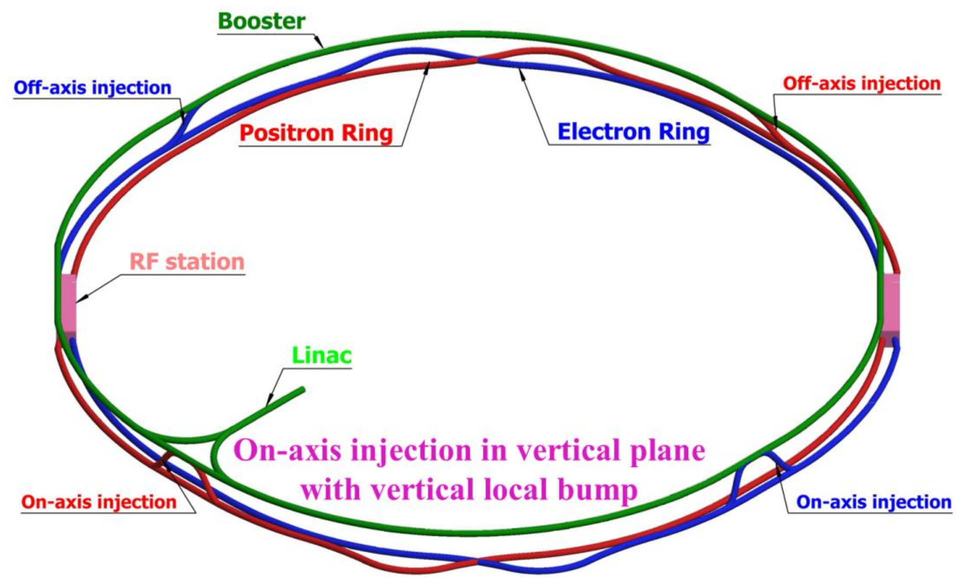




	DA requirement		DA results	
	H	V	H	V
10GeV ($\varepsilon_x = \varepsilon_y$ =120nm)	$4\sigma_x$ +5mm	$4\sigma_y$ +5mm	$7.7\sigma_x$ +5mm	$14.3\sigma_y$ +5mm
120GeV (ε_x=3.57nm, $\varepsilon_y = \varepsilon_x$*0.003)	$6\sigma_x$ +3mm	$16\sigma_y$ +3mm	$21.8\sigma_x$ +3mm	$1006\sigma_y$ +3mm

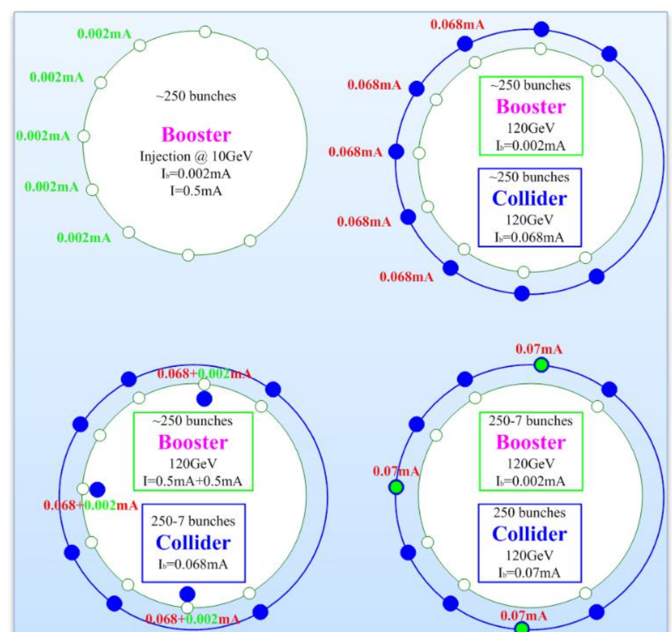
CEPC Collider Injection Schemes

- Higgs: off-axis & on-axis injection
- W: off-axis injection
- Z: off-axis injection



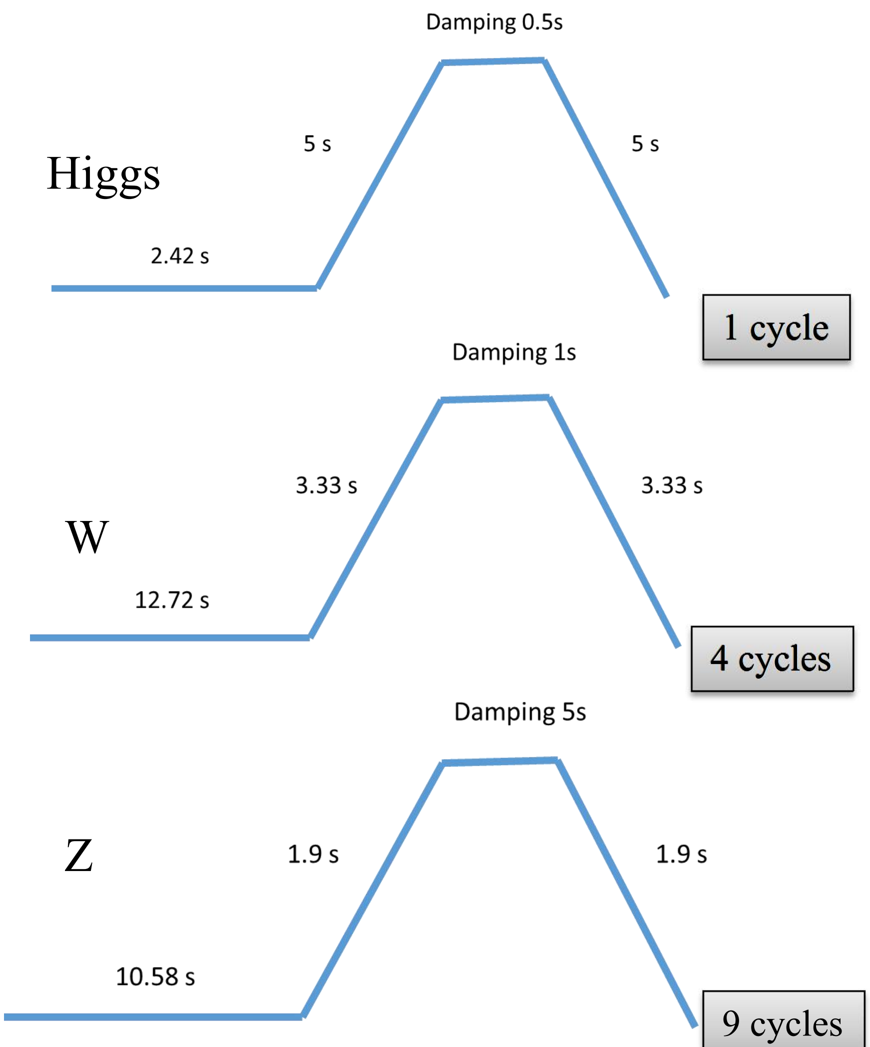
➢ On-axis injection @ Higgs

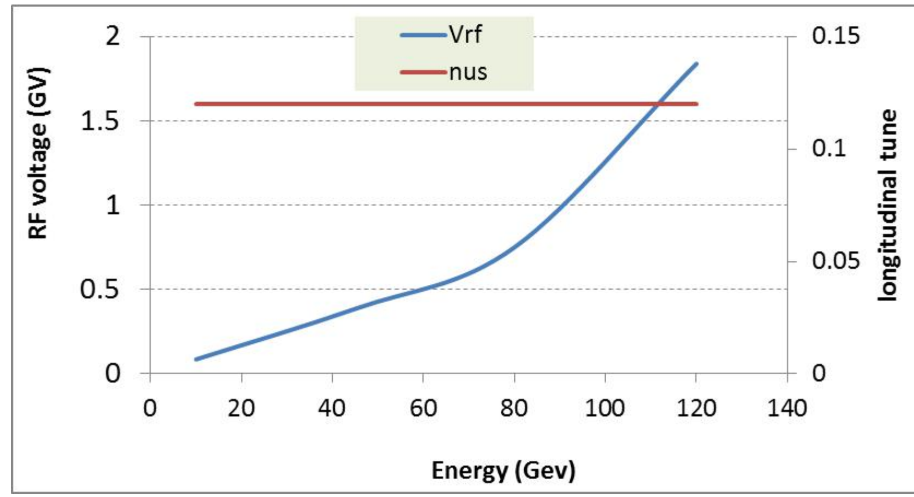
- Step 1: Linac→booster (250 small bunches)
- Step 2: Collider→booster (7 big bunches)
  off-axis injection
- Step 3: Mix in booster
  (243 small bunches + 7 big bunches)
- Step 4: Booster→collider (7 big bunches)
  on-axis injection
- → Step 2
- …



Booster Injection Time Structure

D. Wang





30Gauss @ 10GeV

Eddy current effect

- Transverse quantum lifetime@10GeV: **1.65×10^8s (ε_{inj}=120nm)**
- Beam loss due to lifetime << **1%**

CEPC Booster Kickers and Septums

X. H. Cui

Booster Injection

Component	Length (m)	Waveform	Deflection angle (mrad)	Field (T)	Beam-Stay-clear	
					H(mm)	V(mm)
Septum	2	DC	9.1	0.152	63	63
Kicker	0.5	Half_sin	0.5	0.034	63	63

Booster Extraction

Component	Length (m)	Waveform	Deflection angle (mrad)	Field (T)	Beam-Stay-clear	
					H(mm)	V(mm)
Septum	10	DC	10.4	0.41	20	20
Kicker	2	Half_sin	0.2	0.04	20	20

CEPC Booster SRF Parameters

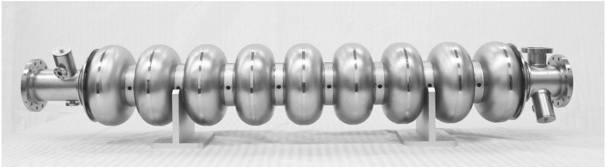
J. Y. Zhai

10 GeV injection	**H**	**W**	**Z**
Extraction beam energy [GeV]	120	80	45.5
Bunch number	242	1524	6000
Bunch charge [nC]	0.72	0.576	0.384
Beam current [mA]	0.52	**2.63**	**6.91**
Extraction RF voltage [GV]	1.97	0.585	0.287
Extraction bunch length [mm]	2.7	2.4	1.3
Cavity number in use (1.3 GHz TESLA 9-cell)	96	64	32
Gradient [MV/m]	19.8	8.8	8.6
Q_L	1E7	6.5E6	1E7
Cavity bandwidth [Hz]	130	200	130
Beam peak power / cavity [kW]	8.3	12.3	6.9
Input peak power per cavity [kW] (with detuning)	18.2	12.4	7.1
Input average power per cavity [kW] (with detuning)	0.7	0.3	0.5
SSA peak power [kW] (one cavity per SSA)	25	**25**	**25**
HOM average power per cavity [W]	0.2	0.7	**4.1**
Q_0 @ 2 K at operating gradient (long term)	1E10	1E10	1E10
Total average cavity wall loss @ 2 K eq. [kW]	0.2	0.01	0.02

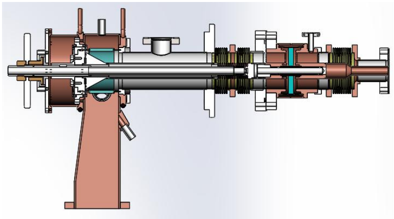
1.3 GHz SRF Technology for CEPC Booster

J.Y. Zhai

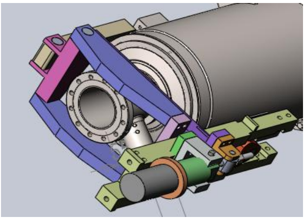
XFEL and LCLS-II type cryomodule, without SCQ. Technology R&D in synergy with Shanghai XFEL (SCLF). No big challenge.



TESLA cavity. Nitrogen-doped bulk niobium and operates at 2 K. $Q_0 > 3 \times 10^{10}$ at 24 MV/m for the vertical acceptance test. $Q_0 > 1 \times 10^{10}$ up to 20 MV/m for long term operation.



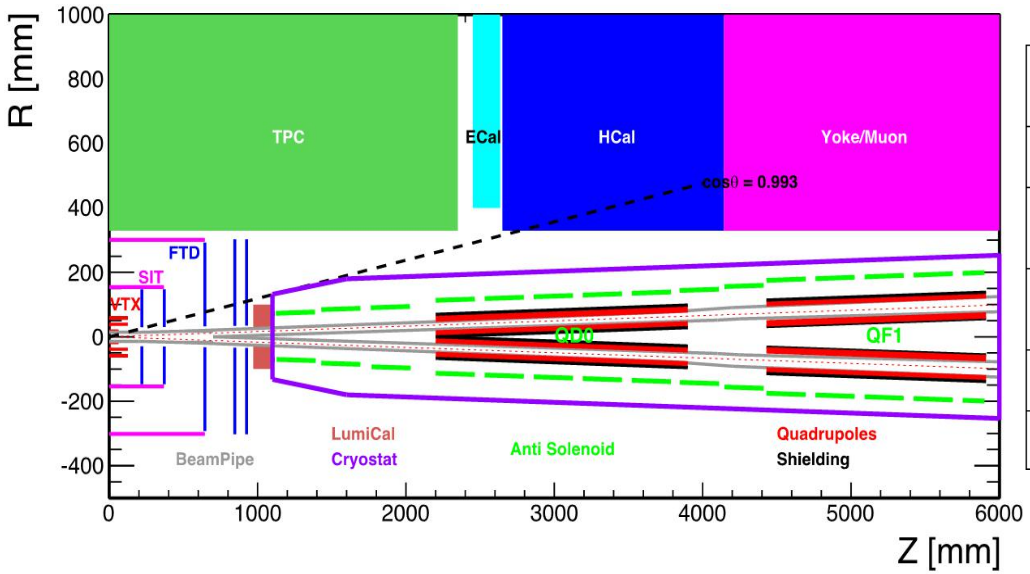
XFEL/ILC/LCLS-II or other type **variable power coupler**. Peak power 30 kW, average 4 kW, Q_{ext} 1E7-5E7, two windows.



XFEL/LCLS-II type **end lever tuner**. Reliability. Large stiffness. Piezos abundance, radiation, overheating. Access ports for easy maintenance.

CEPC MDI Layout

S. Bai
H.B. Zhu



MDI parameters	Values
*L** (m)	2.2
Crossing angle (mrad)	33
Strength of QD0 (T/m)	150
Strength of detector solenoid (T)	3.0
Strength of anti-solenoid (T)	7.0

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

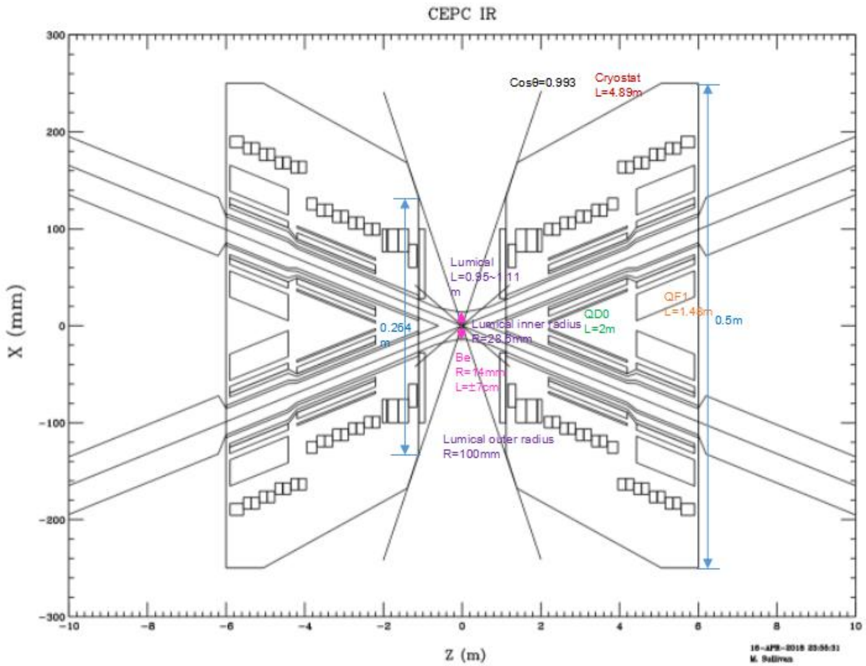
CEPC MDI Parameters

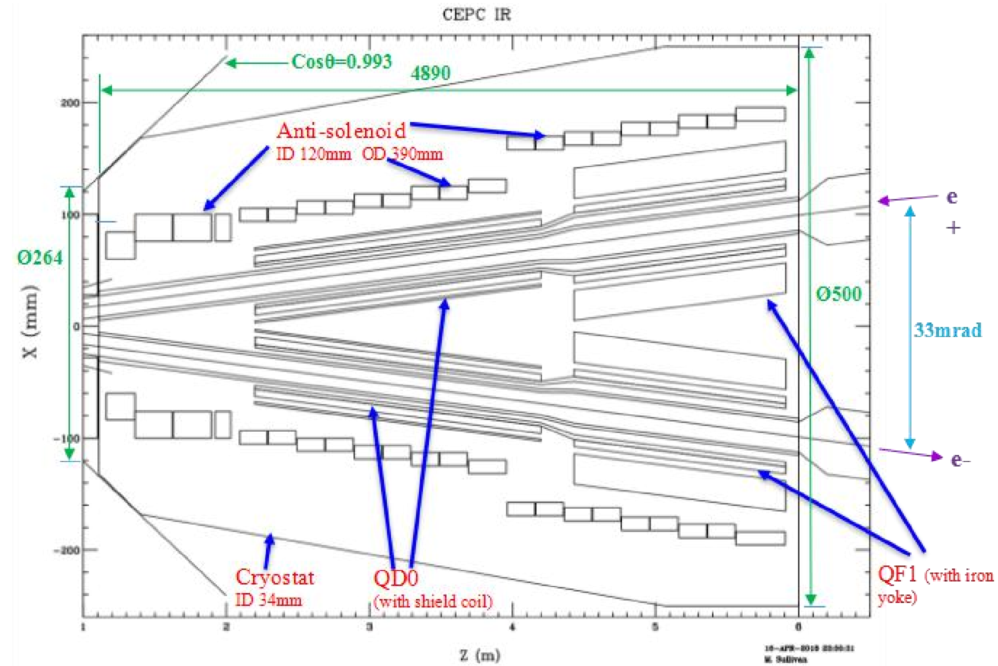
S. Bai,H.B. Zhu

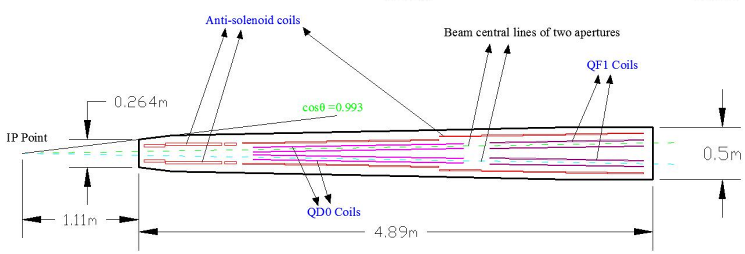
	range	Peak filed in coil	Central filed gradient	Bending angle	length	Beam stay clear region	Minimal distance between two aperture	Inner diameter	Outer diameter	Critical energy (Horizontal)	Critical energy (Vertical)	SR power (Horizontal)	SR power (Vertical)
L*	0~2.2m				2.2m								
Crossing angle	33mrad												
MDI length	±7m												
Detector requirement of opening angle	13.6˚												
QD0		3.2T	136T/m		2m	19.51mm	72.61mm	40mm	53mm	1.3MeV	527keV	639W	292W
QF1		3.8T	110T/m		1.48m	26.85mm	146.2mm	56mm	69mm	1.6MeV	299keV	1568W	74W
Lumical	0.95~1.11m				0.16m			57mm	200mm				
Anti-solenoid before QD0		7.26T			1.1m			120mm	390mm				
Anti-solenoid QD0		2.8T			2m			120mm	390mm				
Anti-solenoid QF1		1.8T			1.48m			120mm	390mm				
Beryllium pipe					±7cm			28mm					
Last B upstream	67.66~161.04m			1.1mrad	93.38m					45keV			
First B downstream	46.06~107.04m			1.54mrad	60.98m					97keV			
Beampipe within QD0					2m							2.9W	
Beampipe within QF1					1.48m							3.1W	
Beampipe between QD0/QF1					0.23m							36.2W	

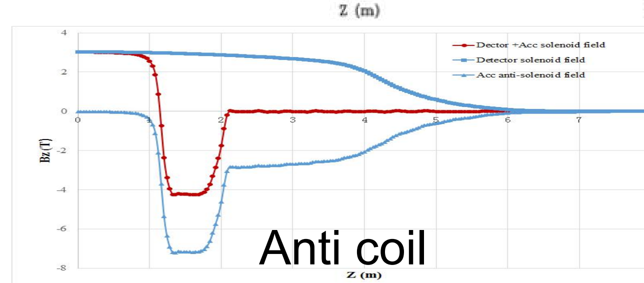
The superconducting magnet parameters are same in tt and higgs.

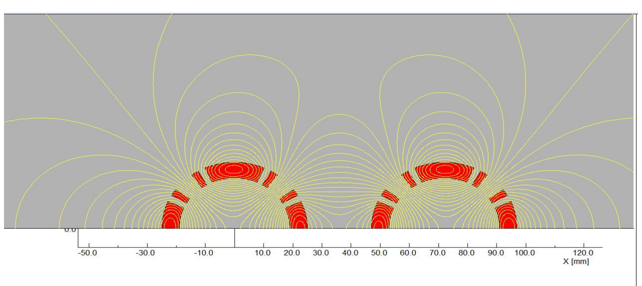
CEPC Final Focus Magnets & Cryostat



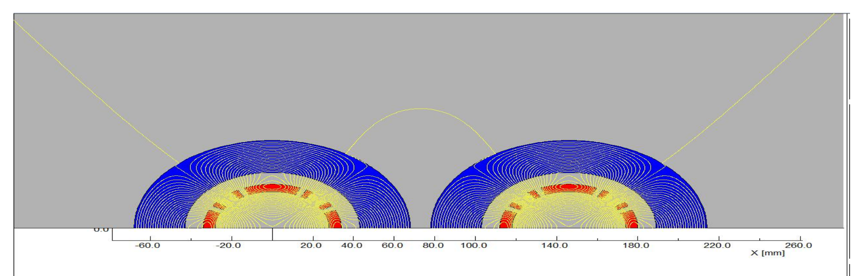






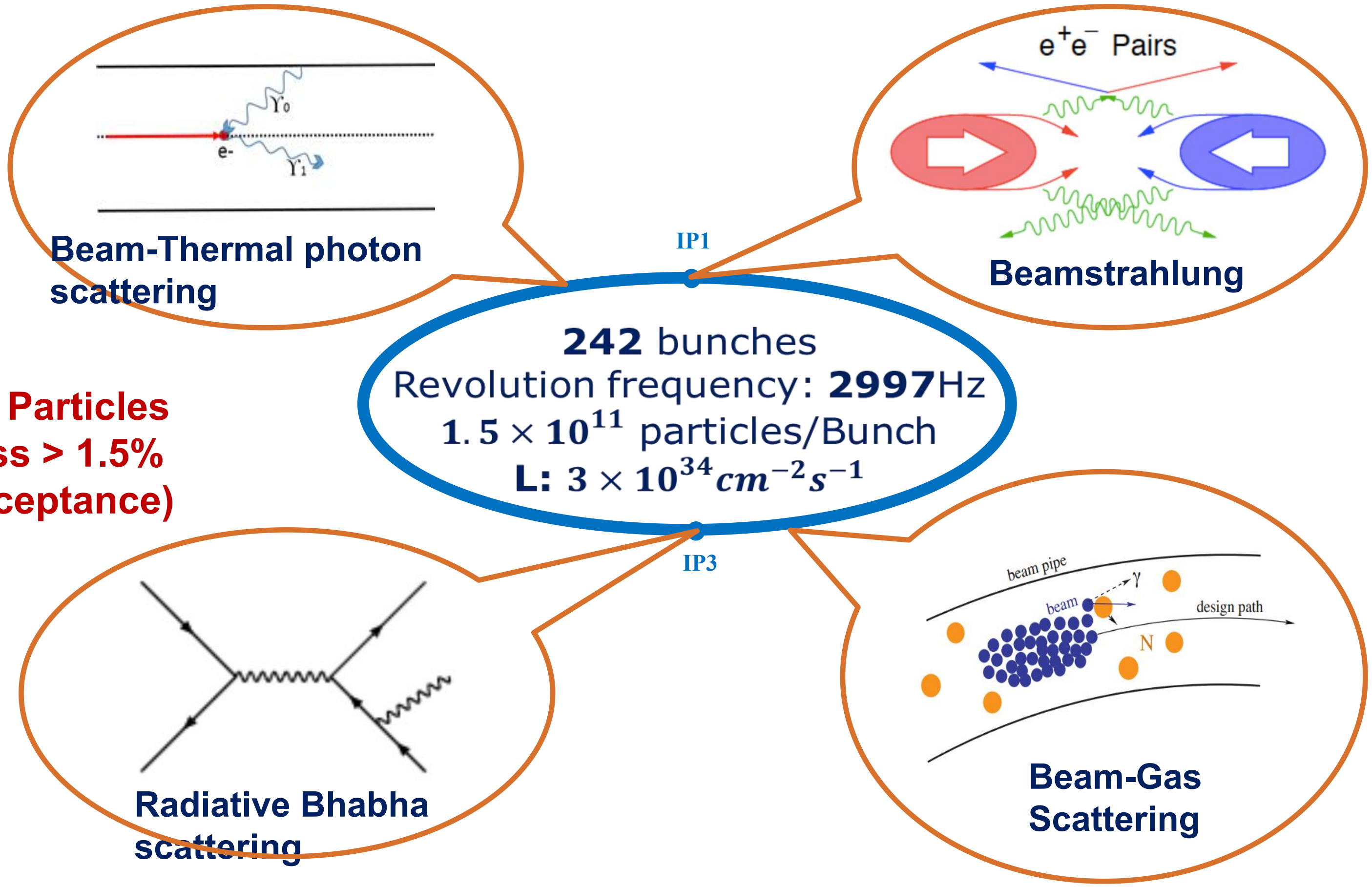


QD0



QF1

CEPC Beam Loss Backgrounds at IP



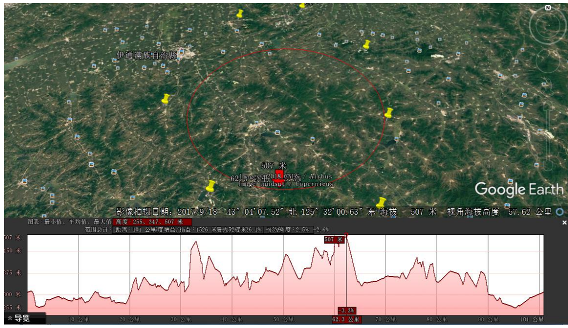
Beam Lost Particles
Energy Loss > 1.5%
(energy acceptance)

CEPC beam life time

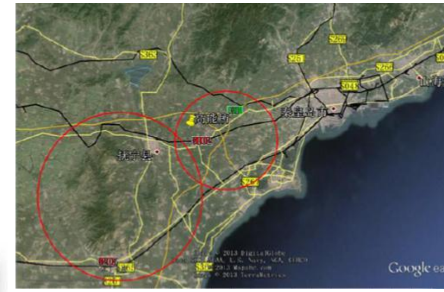
S. Bai, H.B. Zhu

	Beam lifetime	others
Quantum effect	>1000 h	
Touscheck effect	>1000 h	
Beam-Gas（Coulomb scattering）	>400 h	Residual gas CO，10^{-7}Pa
Beam-Gas（bremsstralung）	63.8 h	
Beam-Thermal photon scattering	50.7 h	
Radiative Bhabha scattering	100 min	
Beamstrahlung	60 min	

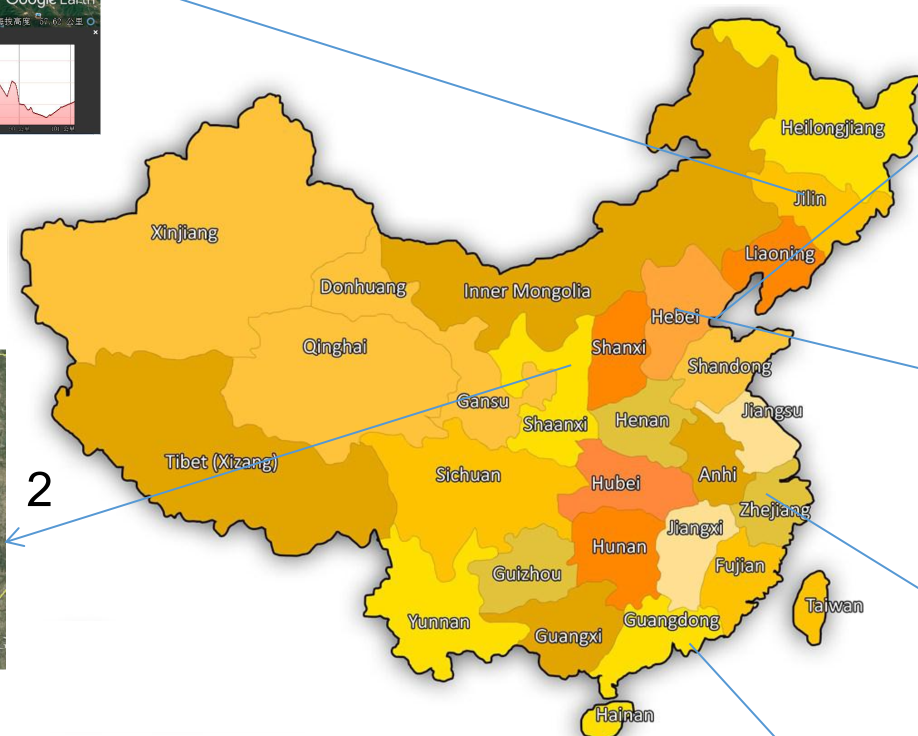
CEPC Site Selections

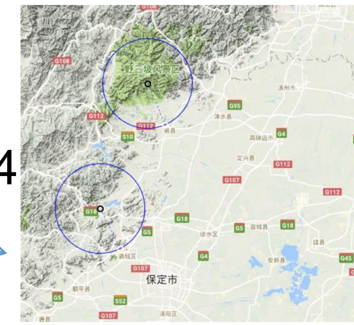


6

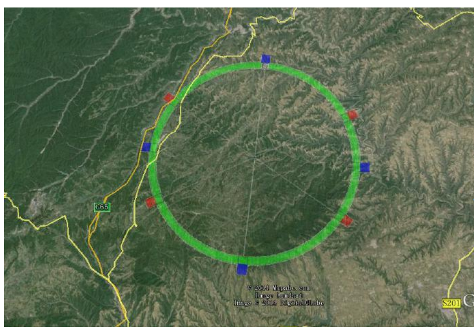


1

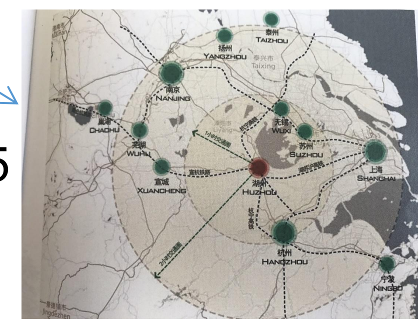




4



2



5

3

1) Qinhuangdao, Hebei Province（Completed in 2014）

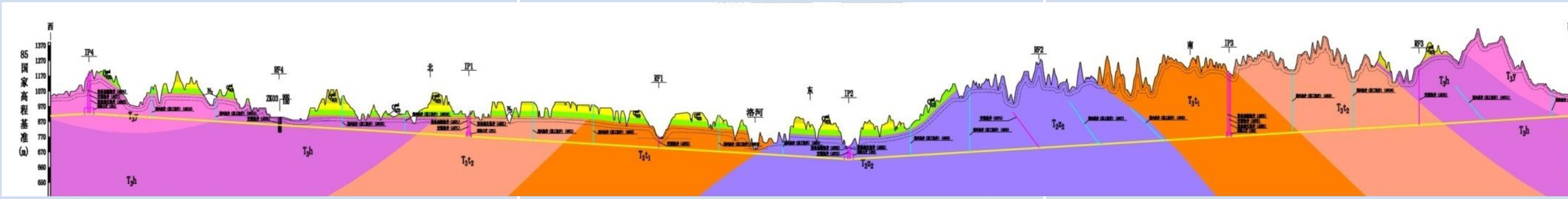
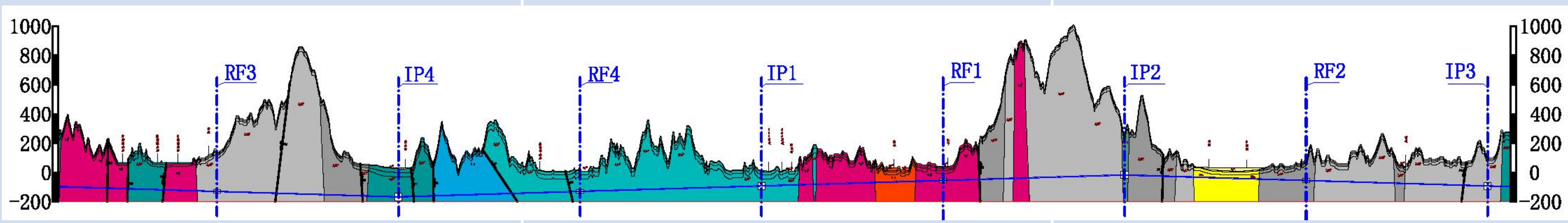
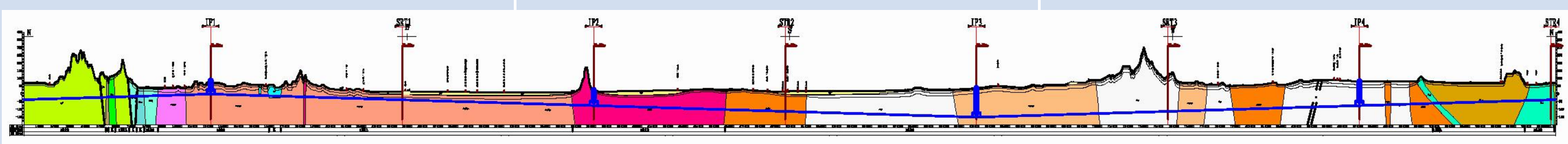
2) Huangling, Shanxi Province（Completed in 2017)

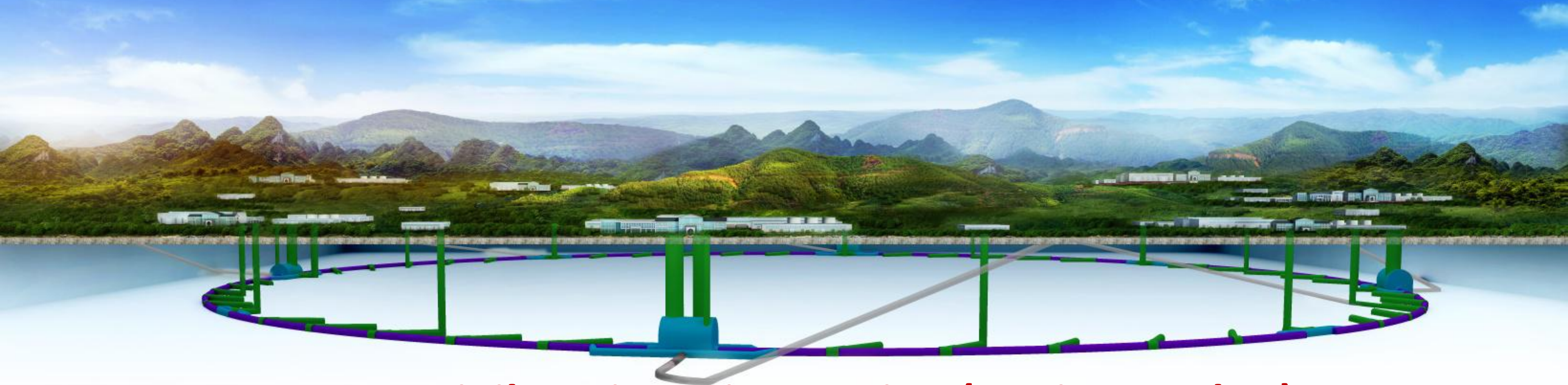
3) Shenshan, Guangdong Province(Completed in 2016)

4) Baoding (Xiong an), Hebei Province (Started in August 2017)

5) Huzhou, Zhejiang Province (Started in March 2018)

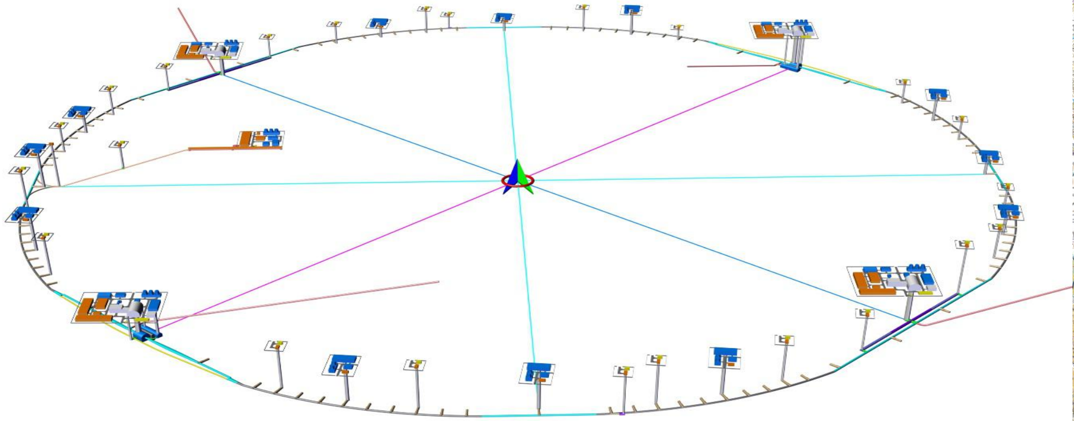
6) Chuangchun, Jilin Province (Started in May 2018)

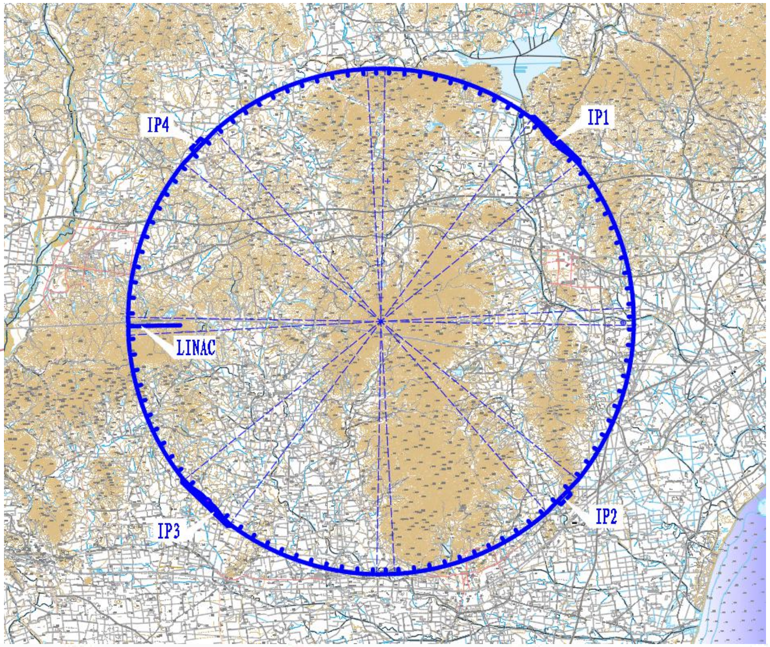
<table>
<tr><th>Item</th><th>Huangling</th><th>Shen-Shan</th><th>Funing</th></tr>
<tr><td rowspan="6">Project layout</td><td colspan="3">Huangling（100km）</td></tr>
<tr><td colspan="3"></td></tr>
<tr><td colspan="3">Shen-Shan（100km）</td></tr>
<tr><td colspan="3">
</td></tr>
<tr><td colspan="3">Funing（100km）</td></tr>
<tr><td colspan="3"></td></tr>
<tr><td>Construction difficulty</td><td>Moderate</td><td>Relatively difficult</td><td>Relatively easy</td></tr>
</table>

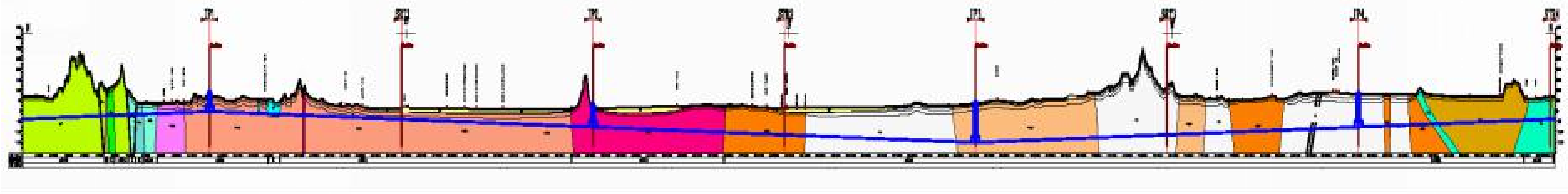


CEPC Civil Enginnering Design (Funing 100km)

Y. Xiao



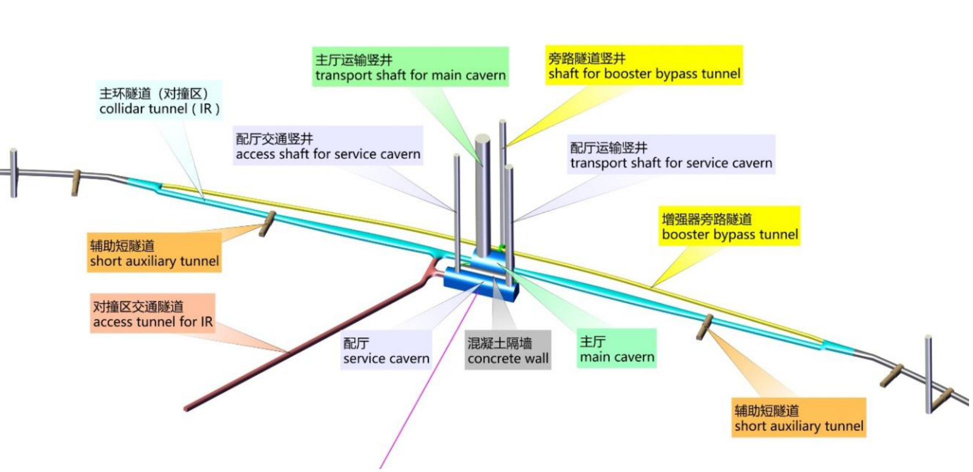




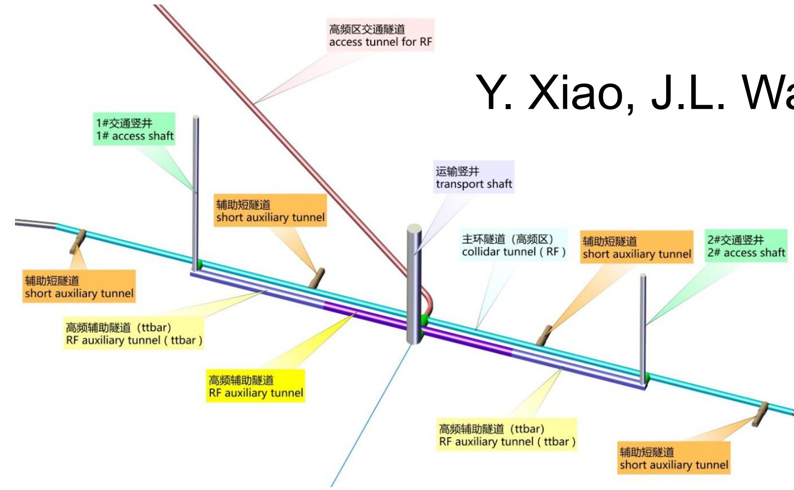
CEPC Tunnel Cross Sections, Detector and SCRF Regions

Y. Xiao, J.L. Wang

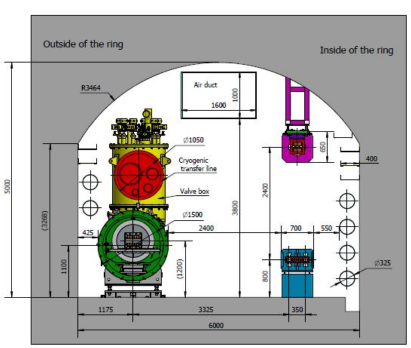
IP1 / IP3

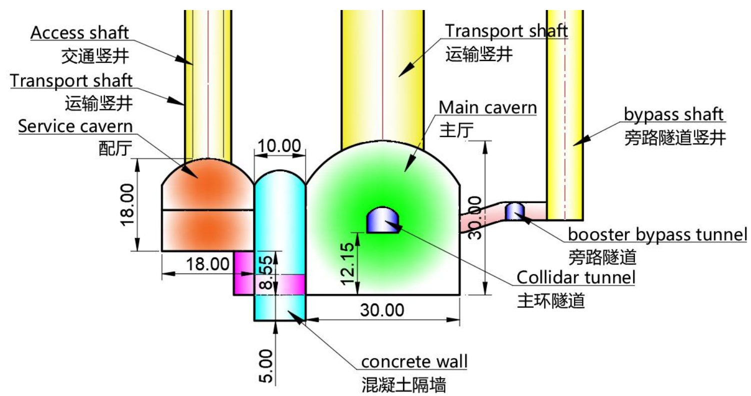


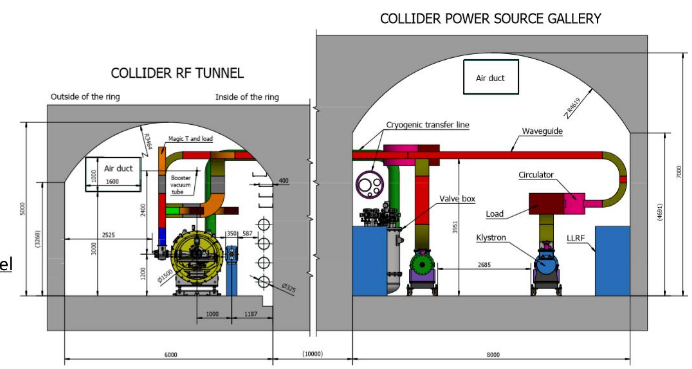
IP2 / IP4--SCRF region



TUNNEL CROSS SECTION OF THE ARC AREA



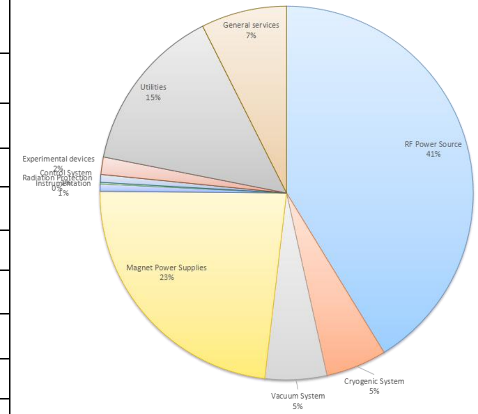




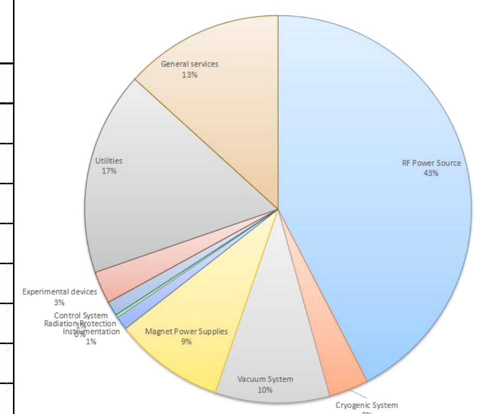
CEPC Power for Higgs and Z

S. Jin

	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

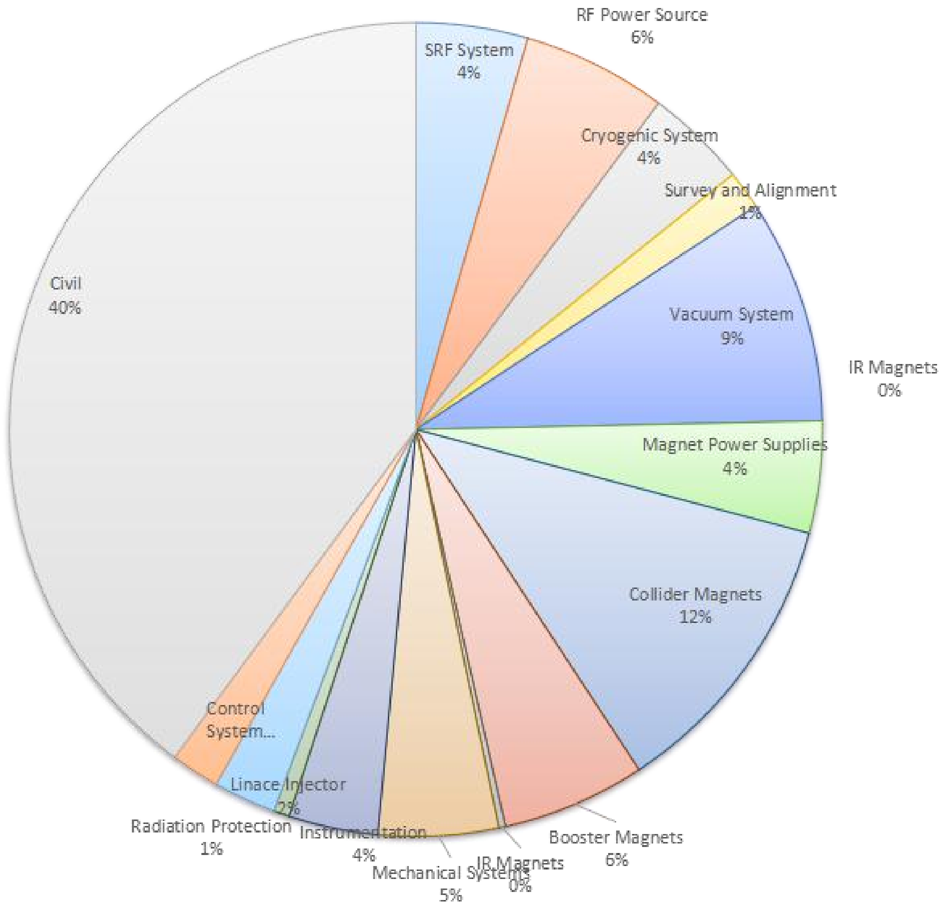


	System for Z	Location and electrical demand(MW)						Total (MW)
		Ring	Booster	LINAC	BTL	IR	Surface building	
1	RF Power Source	57.1	0.15	5.8				63.05
2	Cryogenic System	2.91	0.31			1.72		4.94
3	Vacuum System	9.784	3.792	0.646				14.222
4	Magnet Power Supplies	9.52	2.14	1.75	0.19	0.05		13.65
5	Instrumentation	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

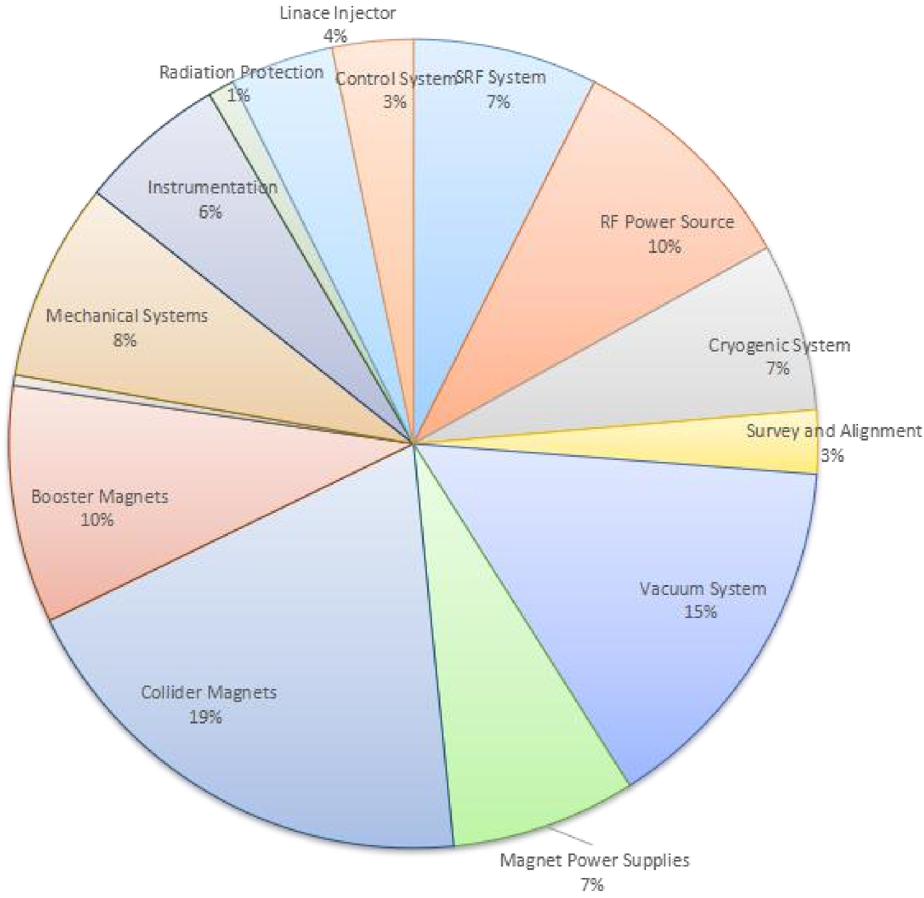


CEPC Cost Breakdown (no detectors)

S. Jin



Including civil cost



Without including civil cost

CEPC Alternatives and New Ideas in CDR Appendixes

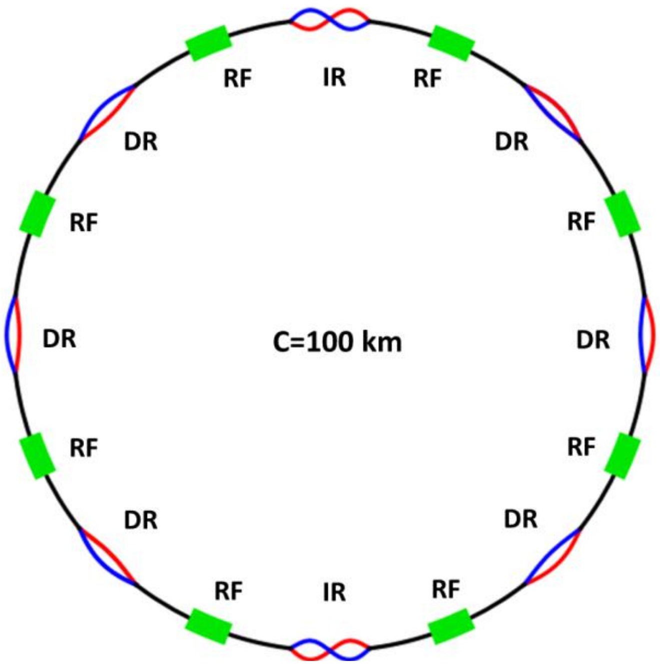
CEPC Alternative APDR Main parameters

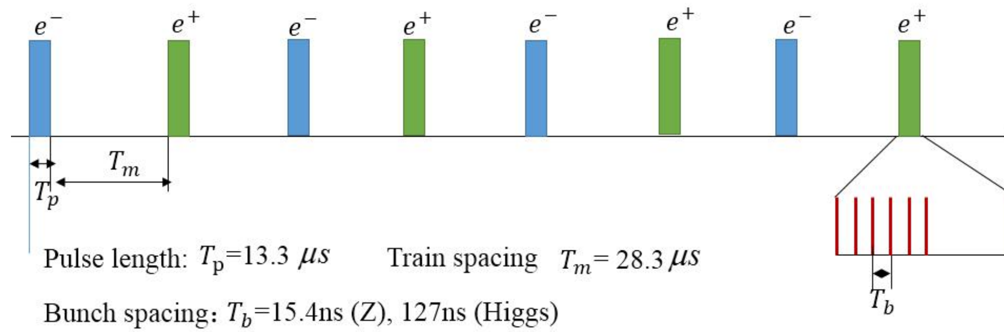
D. Wang

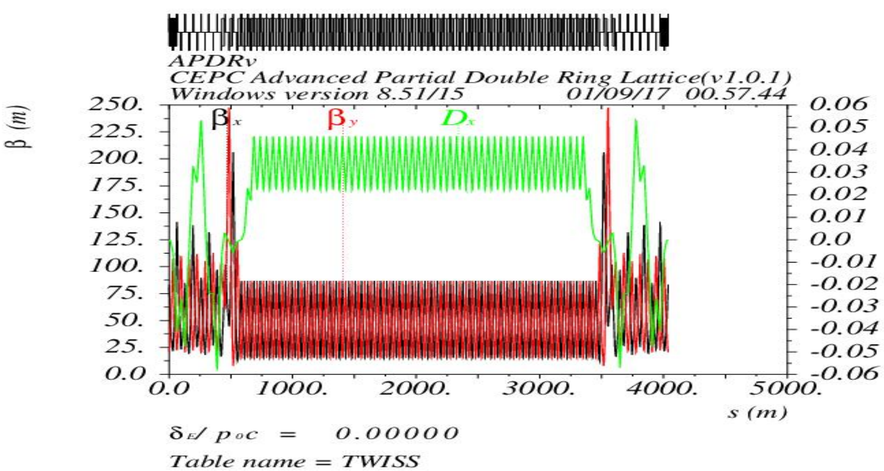
	Higgs	*W*	*Z*
Number of IPs	2	2	2
Energy (GeV)	120	80	45.5
Circumference (km)	100	100	100
SR loss/turn (GeV)	1.61	0.32	0.033
Half crossing angle (mrad)	16.5	16.5	16.5
Piwinski angle	2.28	4.4	8.83
N_e/bunch (10^{10})	9.68	6.0	2.6
Bunch number	420	900	3400
Beam current (mA)	19.5	26.0	42.5
SR power /beam (MW)	**31.4**	**8.3**	**1.41**
Bending radius (km)	11.4	11.4	11.4
Momentum compaction (10^{-5})	1.15	1.15	1.15
β_{IP} x/y (m)	0.36/0.002	0.36/0.002	0.36/0.002
Emittance x/y (nm)	1.18/0.0036	0.52/0.0016	0.17/0.0029
Transverse σ_{IP} (um)	20.6/0.085	13.7/0.056	7.85/0.076
ξ_x/ξ_y/IP	0.025/0.085	0.016/0.098	0.0097/0.049
RF Phase (degree)	128	135	151
V_{RF} (GV)	**2.03**	**0.45**	**0.069**
f_{RF} (MHz) (harmonic)	650	650	650
Nature σ_z (mm)	**2.75**	**2.96**	**2.92**
Total σ_z (mm)	2.85	3.68	4.2
HOM power/cavity (kw)	0.42 (2cell)	0.16 (2cell)	0.1(2cell)
Energy spread (%)	0.096	0.064	0.036
Energy acceptance (%)	1.1		
Energy acceptance by RF (%)	1.98	1.48	1.2
n_γ	0.19	0.18	0.13
Life time due to beamstrahlung_cal (minute)	63		
F (hour glass)	0.93	0.963	0.987
L_{max}/IP (10^{34}cm^{-2}s^{-1})	2.0	2.12	1.02

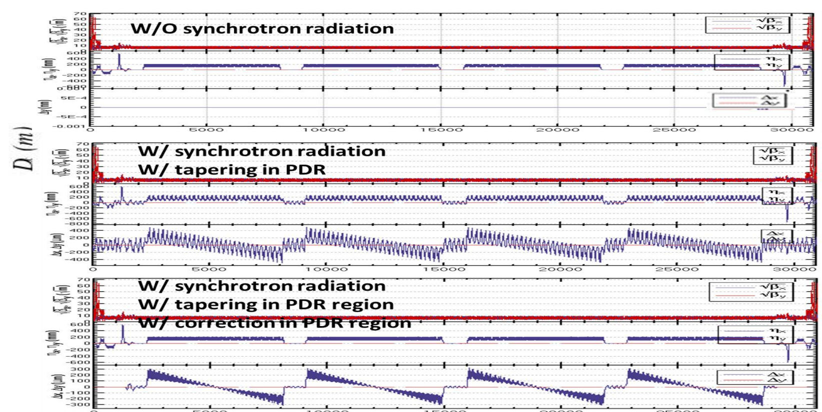
CEPC Alternative: APDR Lattice Design

Y.W. Wang









Sawtooth effects

CEPC APDR RF Parameters

D.J. Gong

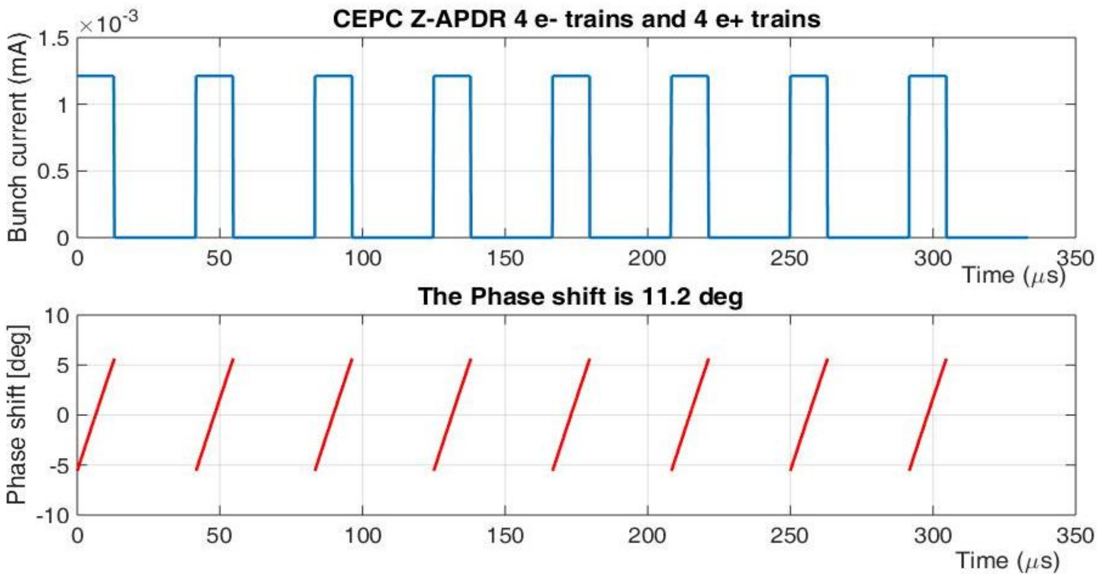
- 8 RF stations are uniformly spaced along the collider ring
- totally 336 SRF cavities with working frequency 650MHz and 5 cells

Parameter	Unit	Higgs	W	Z
Beam Energy	*GeV*	120	80	45.5
Circumference	*km*	100	100	100
SR loss/ turn	*GeV*	1.61	0.32	0.033
Luminosity (10^{34})	$cm^{-2}s^{-1}$	2.0	2.1	1.03
Momentum compaction (10^{-5})		1.15	1.15	1.15
Beam current	*mA*	19.5	25.9	42.4
SR power/beam	MW	31.4	8.3	1.4
Bunch number		420	900	3400
Bunch number/ train		105	225	850
Bunch charge	*nC*	15.5	9.6	4.2
RF frequency	*MHz*	650	650	650
RF voltage	GeV	2.03	0.45	0.069
Cavity number in use		336	64	12
Synchrotron phase	*deg*	37.5	44.7	61.4
Cavity voltage	*MV*	6.04	7.34	5.75
Input power/ cavity	*kW*	275	175	233
Loaded Q (10^5)		9.5	9.5	6.9
Optimal detuning	*kHz*	0.26	0.33	0.87
Cavity bandwidth	*kHz*	0.7	0.7	0.9
Cavity stored energy	*J*	43	64	39
Max voltage decrease		7.6%	8.4%	17.5%
Max phase shift	*deg*	6.7	6.8	11.2

CEPC APDR Beam Loading Analysis

D.J. Gong

- Electron beam and position beam share the same RF system.
- Both the beam gaps and the pulse currents are large.
- CEPC APDR Z-pole suffers from serious beam loading effect.
- The phase shift are calculated by K. Bane's formula and simulated by beam transfer function.

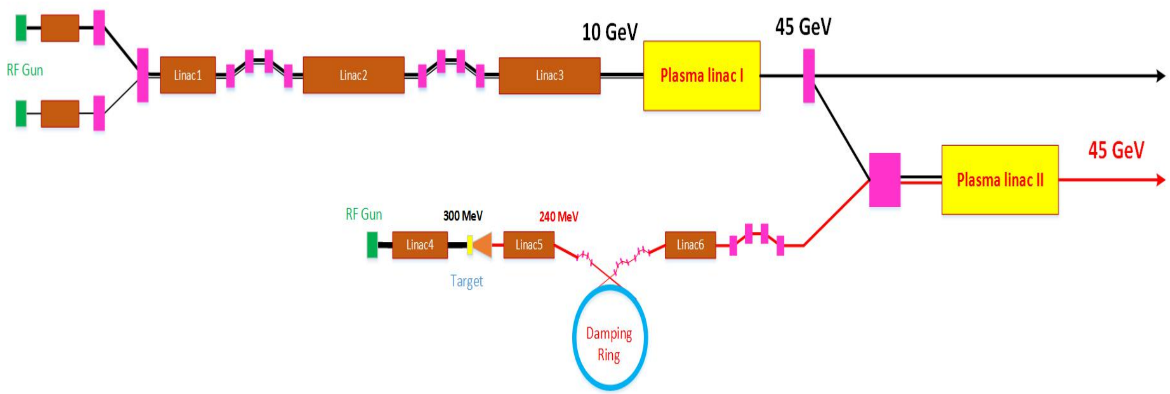


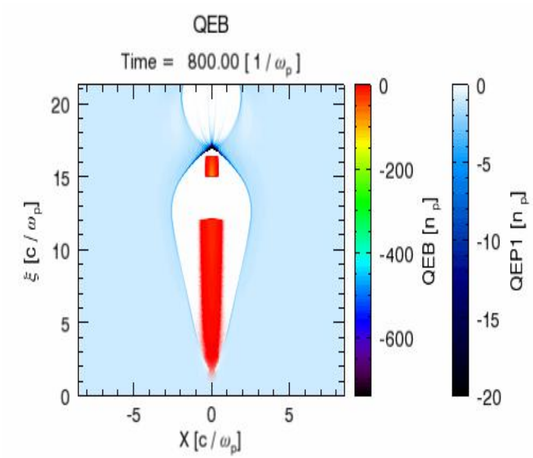
For CEPC APDR Z-pole, the phase shift is 11.2 deg, it will cause 12% bunch length spread, 12% Sync. Freq. spread and 0.15% RF acceptance drop. All these parameters are in the limit of the system, **the RF system of CEPC APDR can work theoretically in consideration of the beam loading effects**.

A High Energy CEPC Injector Based on Plasma Wakefield Accelerator

W. Lu

- Driver/trailer beam generation through Photo-injector
- HTR PWFA with good stability (single stage TR=3-4, Cascaded stage 6-12, high efficiency)
- Positron generation and acceleration in an electron beam driven PWFA using hollow plasma channel (TR=1)





Plasma density $n_0(cm^{-3})$	5.15×10^{16}
Driver charge $Q_d(nC)$	6.47
Driver energy $E_d(GeV)$	10
Driver length $L_d(\mu m)$	285
Driver RMS size $\sigma_d(\mu m)$	10
Driver normalized emittance $\epsilon_{nd}(mm\,mrad)$	10
Trailor charge $Q_t(nC)$	1.25
Trailor energy $E_t(GeV)$	10
Trailor length $L_t(\mu m)$	35
Trailor RMS size $\sigma_t(\mu m)$	5
Trailor normalized emittance $\epsilon_{nt}(mm\,mrad)$	100

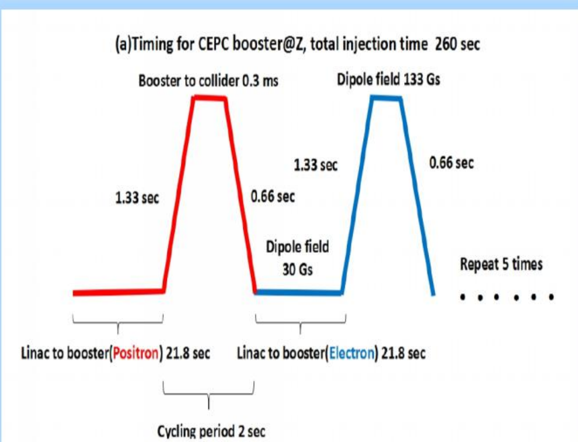
Trailor energy $E_t(GeV)$	45.5
Trailor normalized emittance $_{nt}(mm\,mrad)$	98.9
TR	3.55
Energy spread $\delta_E(\%)$	0.7
Efficiency (driver -> trailor)	68.6%

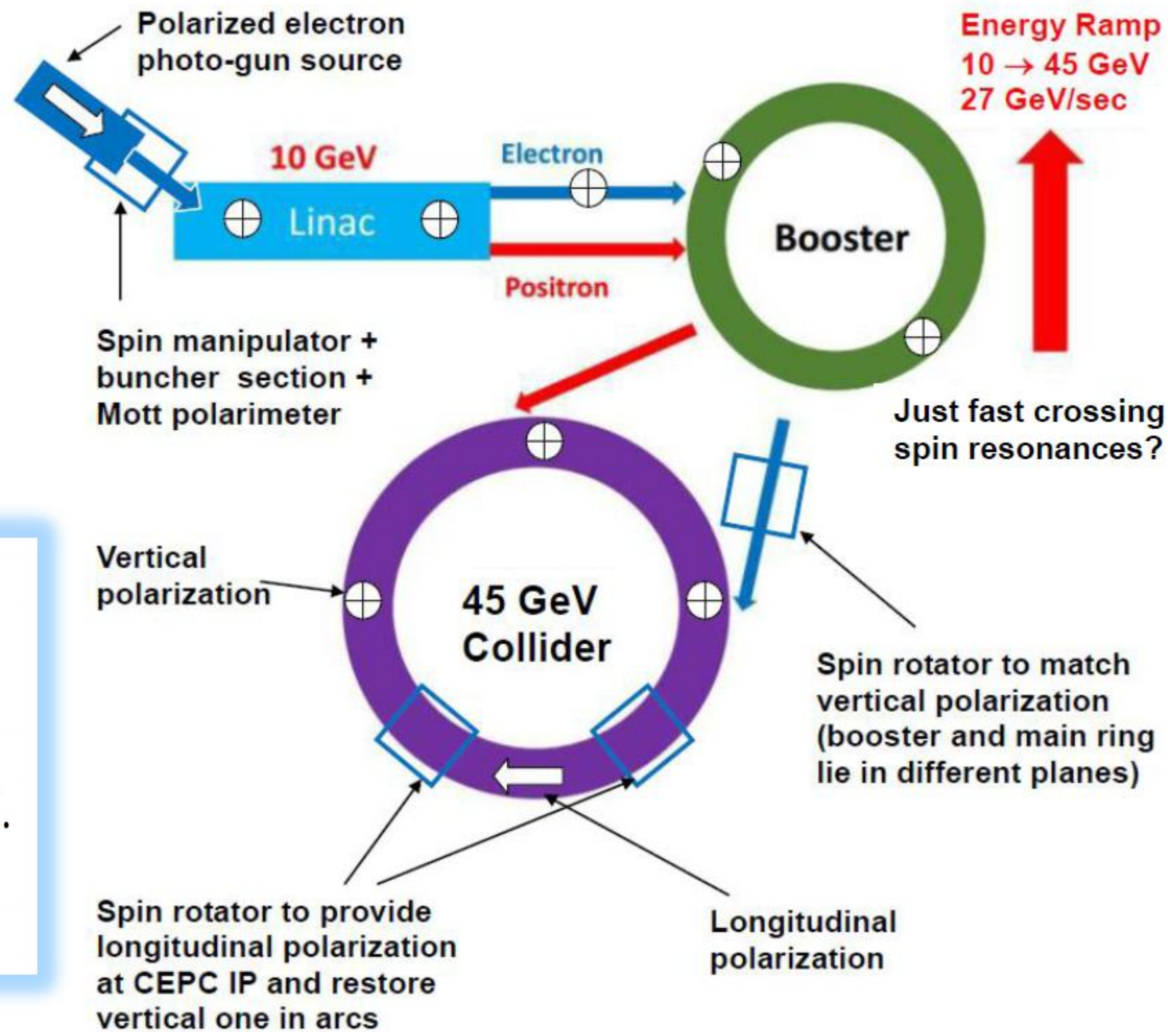
CEPC Longitudinal polarization of electrons (minimalist option)

S. Nikitin

CEPC Chinese MOST Fund application contents in 2018

Electrons from gun source are longitudinally polarized. Spins are rotated to vertical plane in special transport section downstream of gun.Variants (CEBAF, NIKHEF):
a) Wien's Filter
b) Z-manipulator includes two bends by E-field and solenoids between them.





CEPC e-p and e-A Options

Y.H. Zhang

CEPC-SPPC *e-p* and *e-A* Design Parameters

Particle		Proton	Electron	Lead ($^{208}Pb^{82+}$)	Electron
Beam energy	TeV	37.5	0.12	14.8	0.12
CM energy	TeV	4.2		2.7	
Beam current	mA	730	34.8	730	34.8
Particles per bunch	10^{10}	15	0.72	0.18	0.72
Number of bunch		10080		10080	
Bunch filling factor		0.756		0.756	
Bunch spacing	ns	25	25	25	25
Bunch repetition rate	MHz	40	40	40	40
Norm. emittance, (x/y)	μm rad	2.35	282	0.22	282
Bunch length, RMS	Cm	7	0.5	7	0.5
Beta-star (x/y)	Cm	75	3.7	75	0.88
Beam spot size at IP (c/y)	Mm	6.6	6.6	3.25	3.25
Beam-beam per IP(x/y)		0.0004	0.12	0.0016	0.12
Crossing angle	mrad	~0.95		~0.95	
Hour-glass (HG) reduction		0.77		0.34	
Luminosity/nuclei per IP, with HG reduction	$10^{33}/cm^2/s$			1.0	
Luminosity/nucleon per IP, with HG reduction	$10^{33}/cm^2/s$	4.5		23.6	

CEPC R&D towards TDR

CEPC SRF R&D Plan

J.Y. Zhai

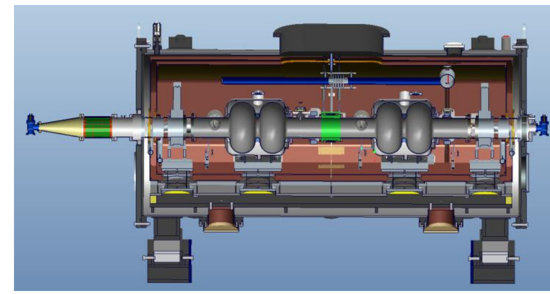
- **SRF Key Technology R&D (2016-2020, IHEP, MOST & PAPS)**
  - High Q & high gradient cavity with **N-doped Nb** & **Fe-based** superconductor
  - Very high power variable input coupler with low heat load
  - High power coaxial HOM coupler and wideband HOM absorber
- **Cryomodule Prototyping (2019-2022, PAPS, etc.)**
  - **Collider cryomodules**: 650 MHz 2 x 2-cell and full scale 6 x 2-cell (11 m)
  - **Booster cryomodules**: 1.3 GHz 2 x 9-cell and full scale 8 x 9-cell (12 m)
  - High Q operation (clean assembly, magnetic hygiene and flux expulsion)
  - Beam test with DC-photocathode gun
- **Prepare for Mass-Production (2021-2023)**
  - In the frame of CEPC Industrial Promotion Consortium (CIPC)
  - In synergy with other SRF accelerator projects (LCLS-II, SCLF, ILC, etc.)
  - Supported by PAPS large SRF infrastructure (start operation in early 2020)

CEPC SRF Hardware R&D

J.Y. Zhai

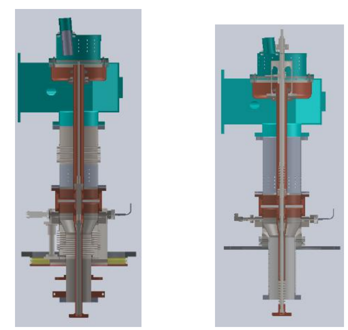
CEPC 650 MHz 2-cell cavity by OTIC

CEPC 650 MHz 2-cell cavity by HERT



CEPC 650 MHz 5-cell cavity with waveguide HOM coupler by HERT (poster 2AMSP17)

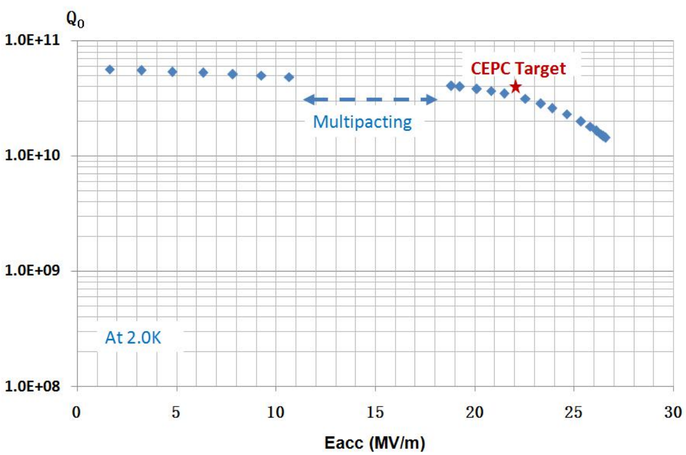
CEPC Collider HOM coupler (SS and Nb)



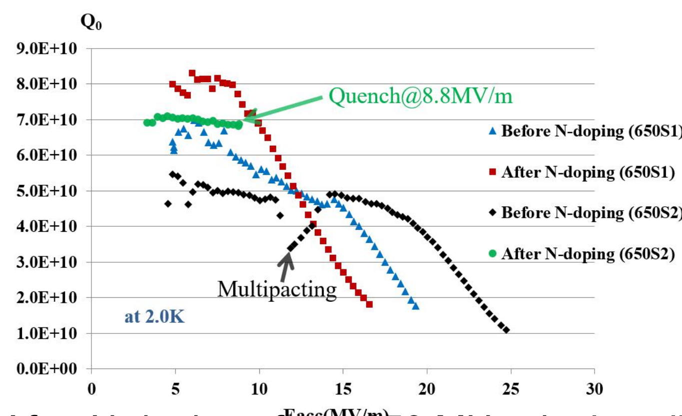
CEPC 650 MHz 300 kW variable input coupler (in fabrication)

Vertical Test of a CEPC Two Cell Cavity (11 May, 2018) and a Single Cell with Nitrogen-doping

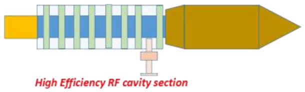
P. Sha



Vertical test result: Q_0=4.0E10@19.2MV/m， which is close to the CEPC target (Q_0=4.0E10@22.0MV/m).



After N-doping of two 650 MHz single cell cavities (BCP treated), Q_0 increased obviously at low field for both cavities. The goal is > 4E10 @ 20 MV/m.

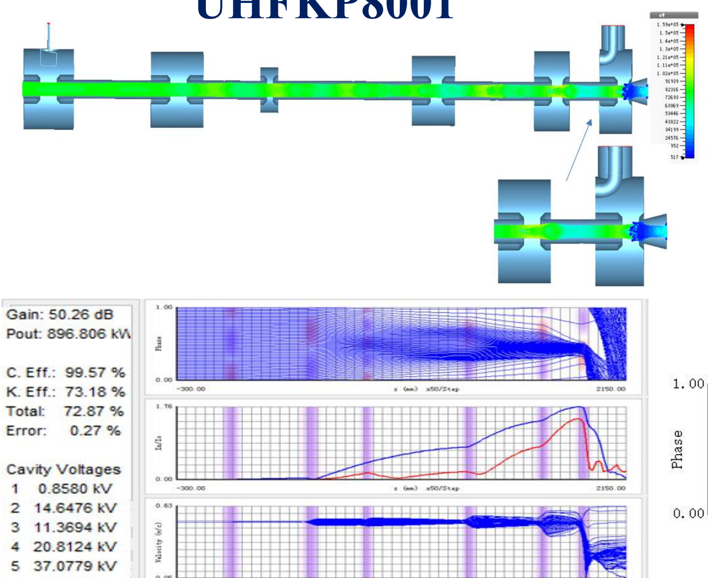


CEPC Klystron Parameters and Designs

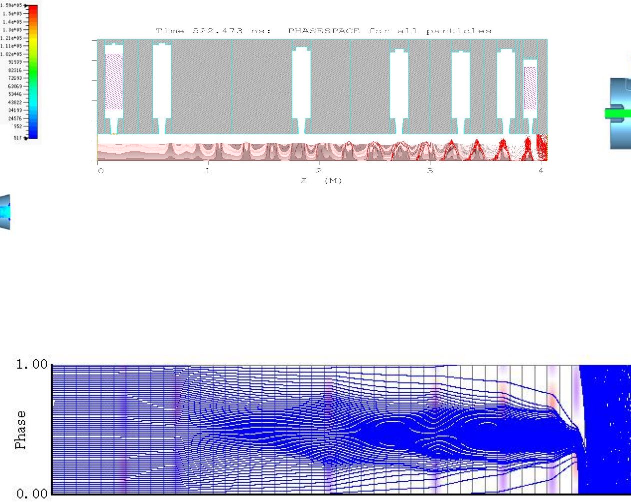
Parameters	UHFKP8001	UHFKP8002	UHFKP8003
Frequency(MHz)	650	650	650
Voltage (kV)	81.5	81.5	110
Current (A)	15.1	15.1	9.1
Perveance (μP)	0.65	0.65	0.25
Efficiency (%)	>60	>70	>80
Gain(dB)	>40	>40	>40
Power(kW)	800	>800	>800
1dB Bandwidth(MHz)	±0.5	±0.5	±0.5
Cavity QTY	6	7	7-9

S.L. Pei
Z.S. Zhou

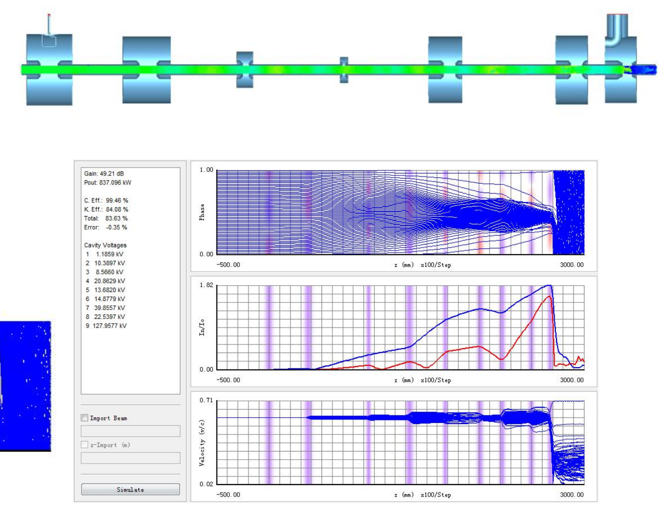
UHFKP8001



UHFKP8002



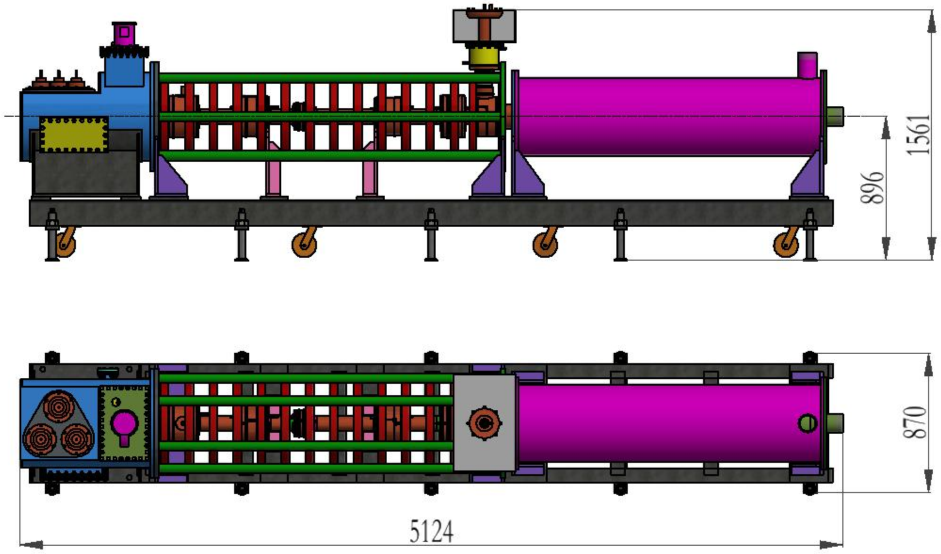
UHFKP8003

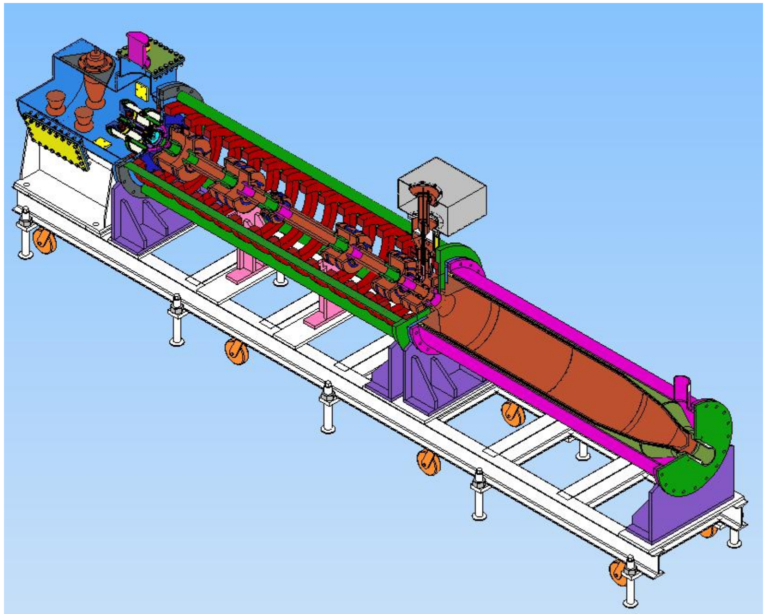


Mechanical design for UHFKP8001

S.L. Pei
Z.S. Zhou

- China consortium HERSC (High Efficiency RF Source R&D Collaboration) established in 2017 for 650MHz/800kW klystron R&D
- Preliminary mechanical design achieved (L×W×H: 5.12m×0.87m×1.56m)
- Manufacturing details communication inside HERSC being conducted





Preliminary mechanical design for UHFKP8001

R&D Plan of CEPC large scale cryoplant of 18kW@4.5K

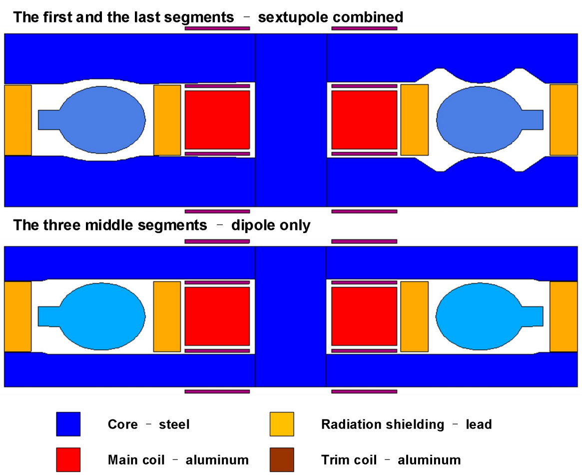
S.P.Li
L.Q. Liu

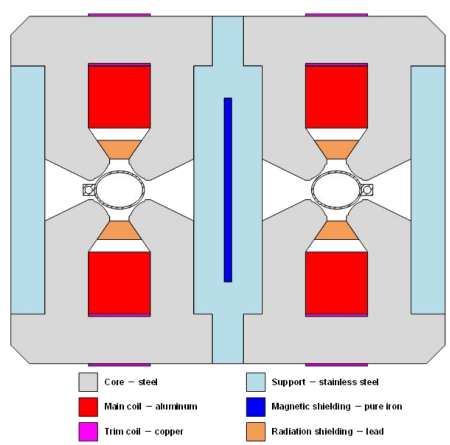
• Conceptual design	one year
• Engineering design	one year
• Purchase and Fabrications	two Years
• Assembly and commissioning	one Year
• Total	Five Years
• Total budget	248 Million RMB

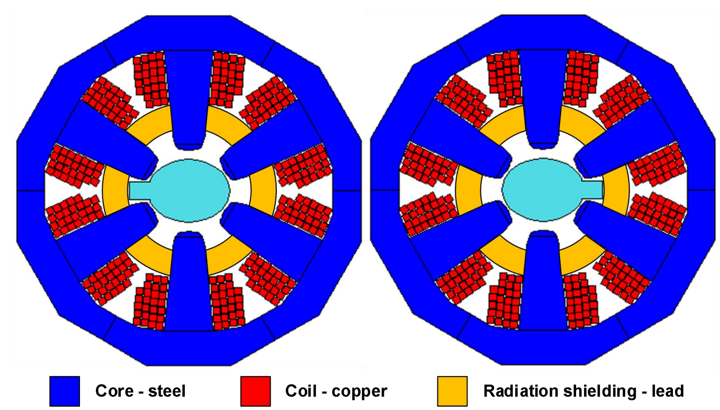
CEPC Collider Ring Conventional Magnets

F.S. Chen

	Dipole	Quad.	Sext.	Correct or	Total
• Dual aperture	2384	2392	-	-	13742
Single aperture	80*2+2	480*2+17 2	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



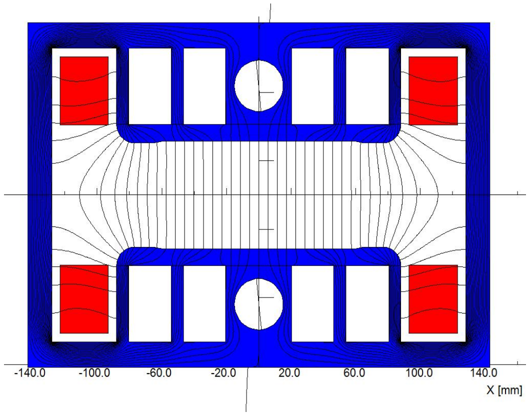


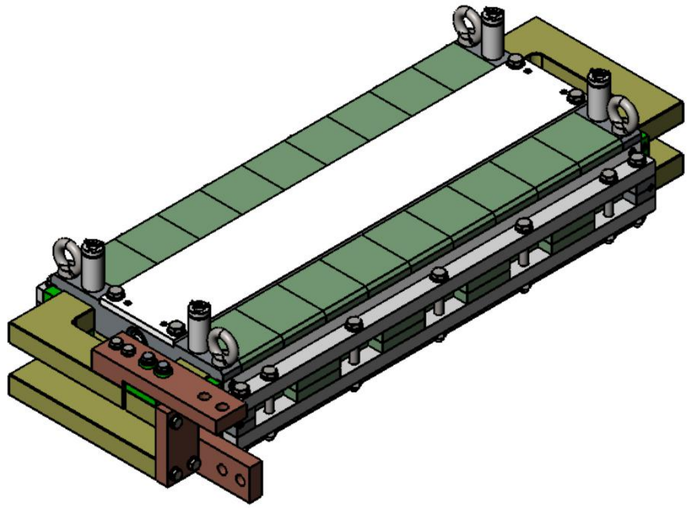


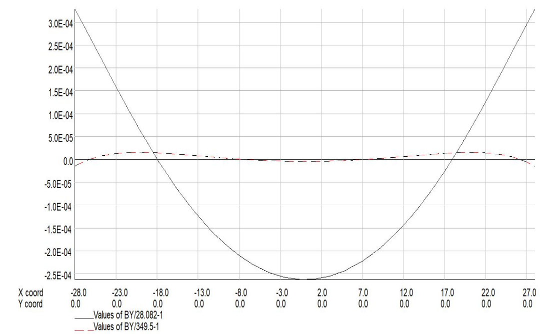
Design of CEPC Booster Low Field Dipole Magnet

(30 Guass)

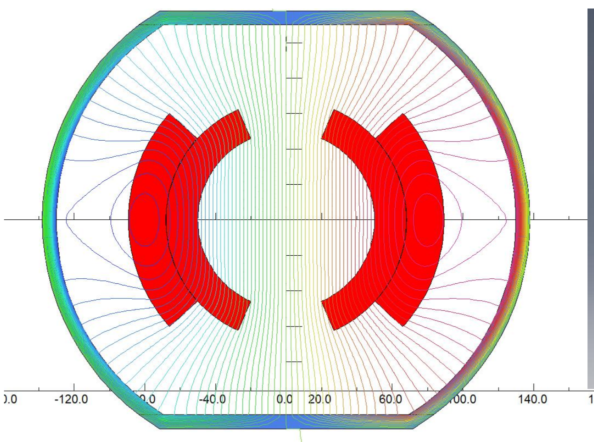
W. Kang

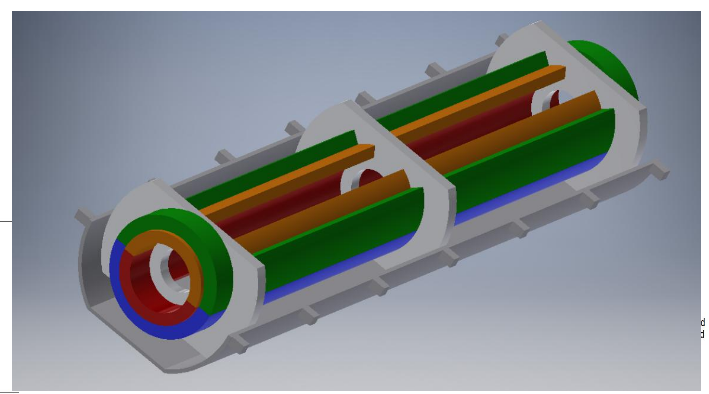


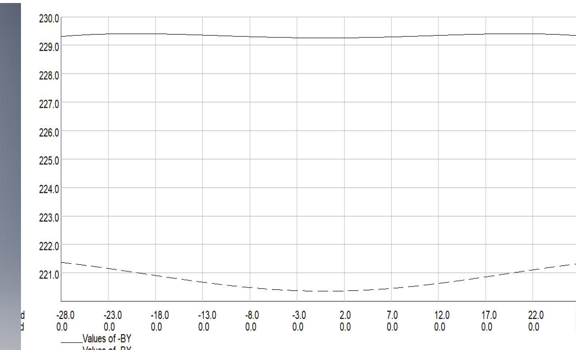




Solution No. 1



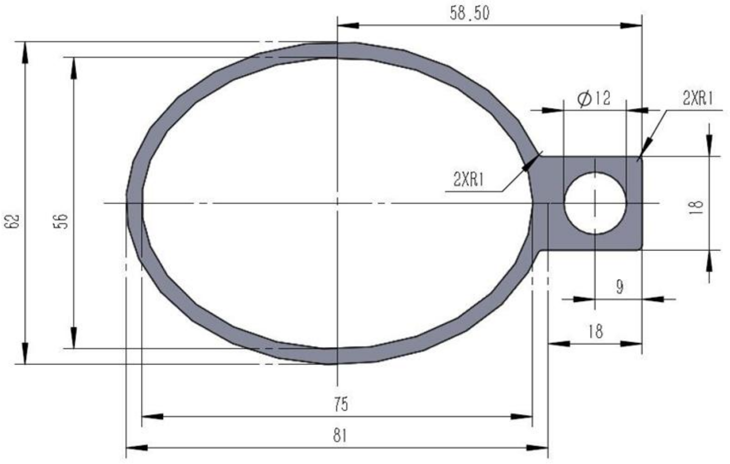




Solution No. 2

Dipole Vacuum Chamber of Electron Storage Ring

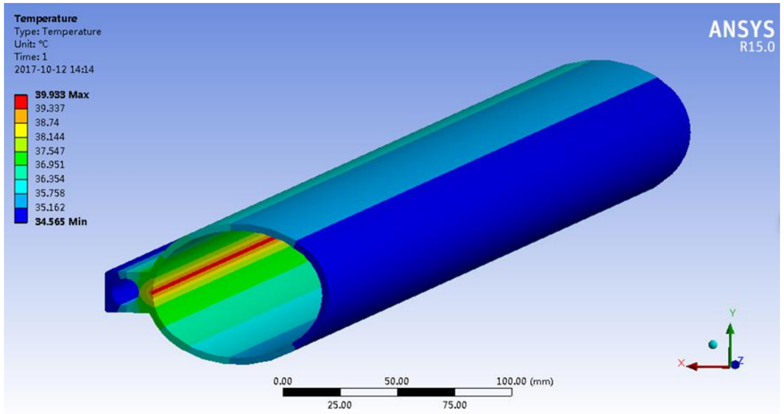
H.Y. Dong

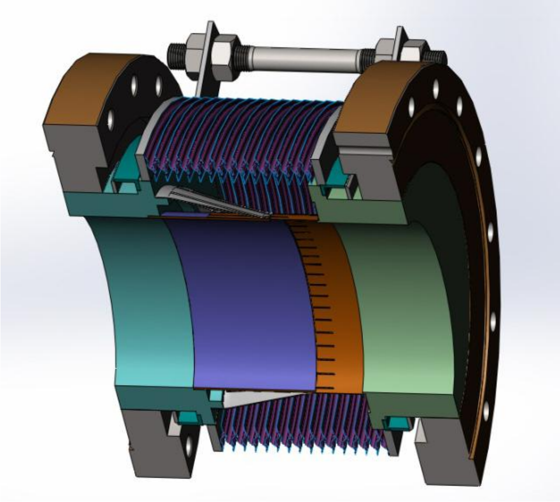


Aluminum vacuum chamber
(elliptic 75×56, thickness 3, length 6000)

The aluminum chamber manufacturing procedure is:

- Extrusion of the chambers,
- Machining of the components to be welded,
- Chemical cleaning,
- Welding of the water connections and flanges,
- Leak detections.





CEPC CIPC and International Collaborations

CEPC Industrial Promotion Consortium (CIPC)-1

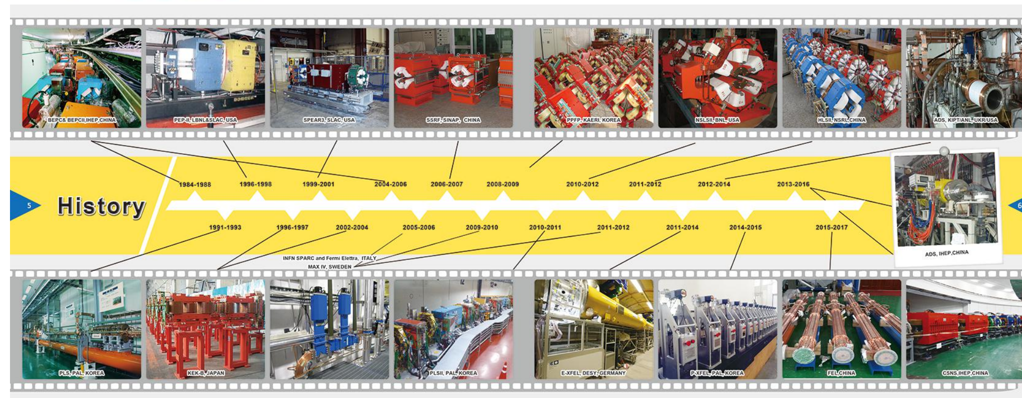
Established in Nov. 7 , 2017

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

More than 50 companies joined in first phase of CIPC,
and more will join later....

CEPC Industrial Promotion Consortium (CIPC)-2

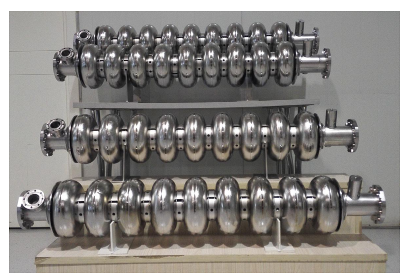
Beijing HE-Racing Technology Co., Ltd



Ningxia OSTEC: SC Materials and Cavity fabrication

High RRR Nb ingot

High RRR Nb sheet



CEPC International Collaboration Status-1

International collaboration experts in the CEPC study team:

- ✓ All accelerator subsystem working groups have established data base of potential international collaboration experts
- ✓ All accelerator subsystems have at least one international collaboration expert in the subsystem working groups

International collaboration with major international labs:

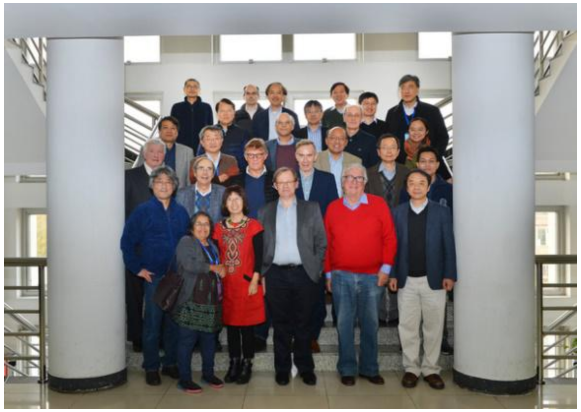
- ✓ IHEP-BINP (Russia) MoU (Jan 2016) (on CEPC collider lattice design, Z-pole polariztion)
- ✓ IHEP-KEK (Japan) MoU (Sept 2017) (on all systems of Super KEK B accelerators, good reference)
- ✓ IHEP-MEPhI (Russia) (Nov 2017) (CEPC SCRF)
- ✓ IHEP-IEF (University of Rostock, Rostock, Germany) (Jan 2018) (CEPC SCRF)
- ✓ IHEP-Jlab (USA) MoU update is considered (CEPC-SppC-ep)
- ✓ With CERN and Dubna high level collaboration will progress

More than 20 MoU in general

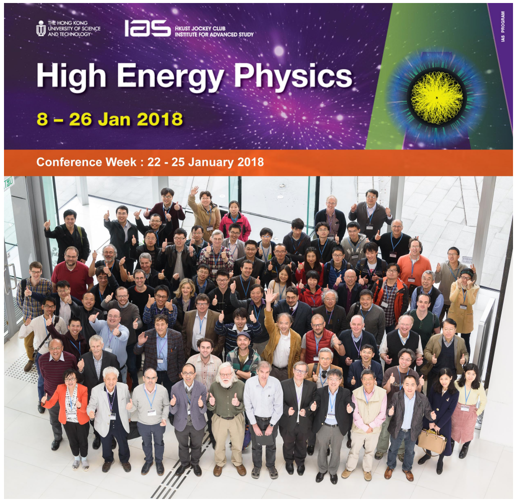
CEPC International Collaboration Status-2

The first CEPC-SppC international Collaboration Workshop
Nov 6-8, 2017, IHEP, Bejing

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)

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

IHEP ILC Collaboration

IHEP ILC R&D domain:

Since 2005 IHEP accelerator center has setup ILC collaboration group and since 2010 ILC group with administration nature has been established also, which guaranteed the smooth progress of China's participation of ILC international collaboration. The main R&D domais which IHEP participated are as following as shown in Fig. 3.

1) ILC250 GeV and ILC500 GeV parameter optimization design
3）ILC SC accelerator technologies
2) ILC ATF2 beam dynamics and hardwares
4）ILC damping ring design and technologies
5）ILC final focus optimization design and beam-beam effect study
6）ILC positron source target thermodynamics study and polarization source
7）ILC power source: Marx modulator

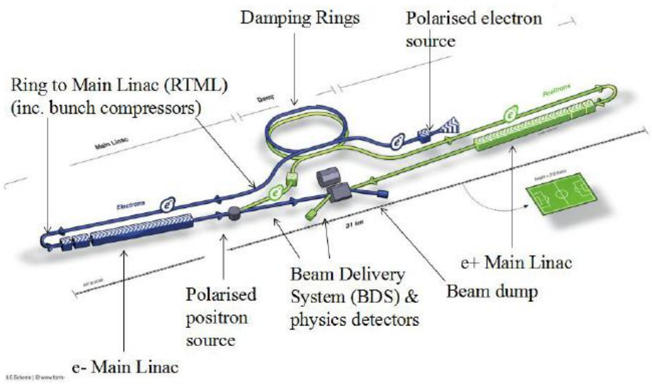


Fig. 3: IHEP ILC collaboration domains

Achievement of IHEP on ILC collaboration:

Since 2005 IHEP participated ILC ATF2 collaboration and fabricated all ATF2 beam line magnets, such as dipole and quadupoles, as shown in Fig. 4. In 2008, IHEP ILC group first demonstrated that on ATF2 the beam size has the potential to reach 20nm instead of 37nm, and due to this important result, ATF2 became a final focus facility not only for ILC but also for CLIC.

Fig. 4: ILC ATF2 beam line magnets

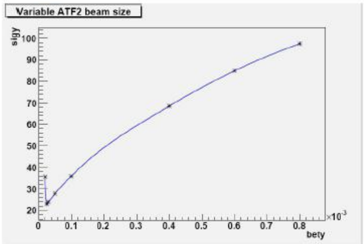


Fig. 5 AFT2 design and beam dynamics studies

Since 2005, IHEP ILC group started to make R&D on 1.3GHz superconducting cavities, from single cell to 9 cell, from fine grain to large grain niobium, from low loss shape, to TELSLA-like, and to TESLA cavities shapes, IHEP becomes the Institute which covers the whole range of the cavity types and materials, as shown in Fig. 5. In addition to cavity R&D, IHEP conducted ILC cryomodule study with both a 1.3GHz single 9cell cavity ILC Test Cryomoulde, including cacity, tunner, high power coupler, LLRF and cryostate, and 12m cryomodule cold mass industrialization for European X-XFEL project, as shown in Fig. 6 and 7. In the domain of 1.3GHz ILC rf power source R&D, IHEP ILC group made industrialization of high power L band Marx modulator and in collaborate with Institute of Electronics, CAS (IECAS), an ILC type 1.3GHz klystron of 10MW has been also constructed and tested by IECAS, as shown in Fig. 8. In the domain of ILC damping ring study, IHEP ILC group made a ILC damping design and made damping fast kicker, as shown in Fig. 9. As for ILC250GeV proposed in 2017, IHEP group made the optimization design for the accelerator parameters.

Fig. 5: ILC 1.3GHz 9-cell superconducting cavities

Fig: 6: IHEP ILC test cryomodule

Fig. 7: Euro-XFEL thermostat cryostate industrialization

Fig. 8: L band MarX Modulator and ILC 10MW klystron

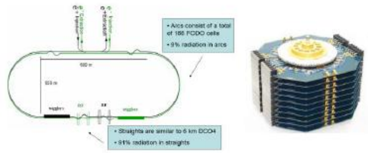


Fig. 9: ILC damping design and fast kiker

China New Scientific Policies

January 23, 2018 : The China Reform and Development Committee (led by President J.P. Xi) had the meeting on Jan 23, 2018, and passed the plan of "Chinese Initiated International Large Scientific Plan and Large Sicentific Project"

March 28, 2018 : Chinese Government (led by Premier Minister Keqiang Li) made public details of "Chinese Initiated International Large Scientific Plan and Large Sicentific Project" :

...till 2020 China will prepare 3~5 projects (hopefully, CEPC is inside)and finally select 1~2 projects to construct...(hopefully, CEPC will be selected)

...Actively participate the other country or multicountries's initiated Large Scientific Pojects (hopefully, ILC will have good news from Japan at the end of 2018)

...Actively participate important international scientific organizations' sicientific projects and activities...

(translated by J. Gao)

Conclusions

- CEPC Accelerator CDR has been completed with all systems reaching the CDR design goals with new ideas beyond CDR
- CEPC-SppC siting and engineering implementaion progress well
- Hardware design and key technologies' R&D progress well with financial funds prior to full TDR phase started in 2018
- International collabotaion and collaboration with indusries progress well
- Young generations played a key role during CEPC CDR and they are the key forces to realize the goals
- CEPC has entered a new phase towards TDR
- Government new scientific policies has been annouced just timley

Thanks go to

CEPC accelerator team and international collaborators

Thank you for your attention