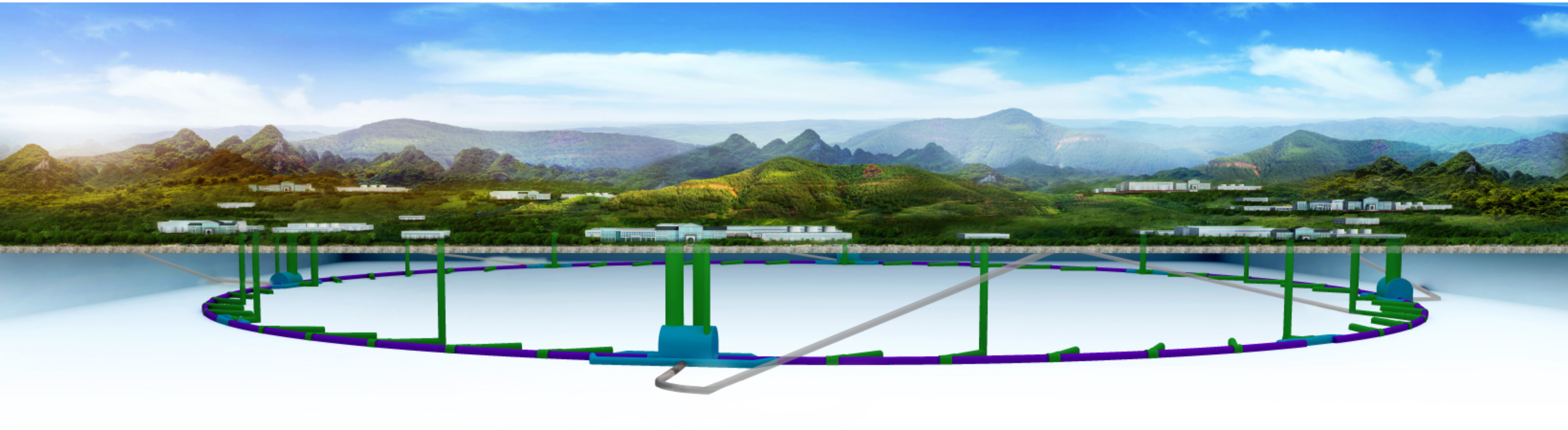
Circular Electron Positron Collider

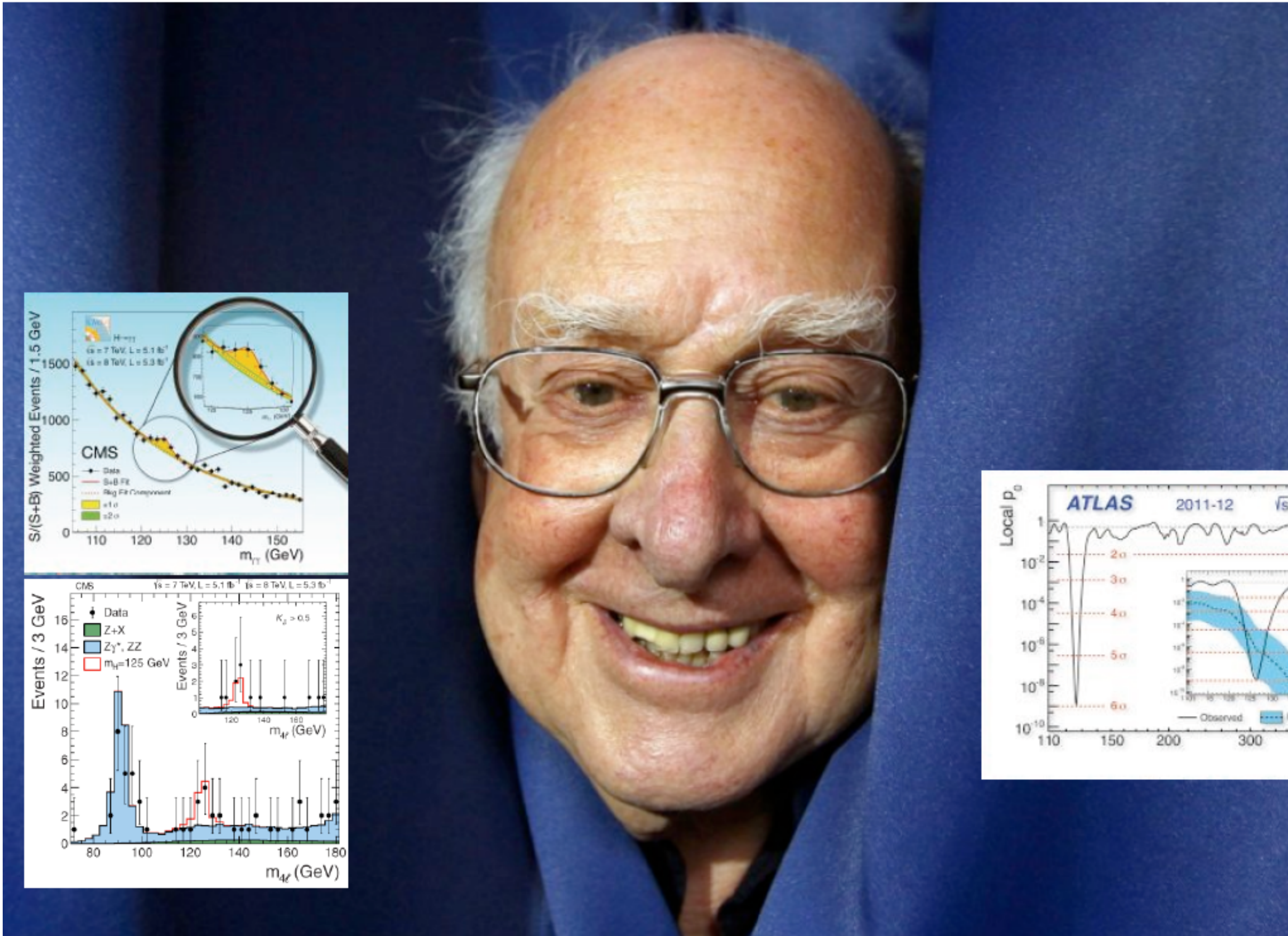
CEPC-SppC Project

Q. Qin for the CEPC team

IHEP

16th Nov., 2018

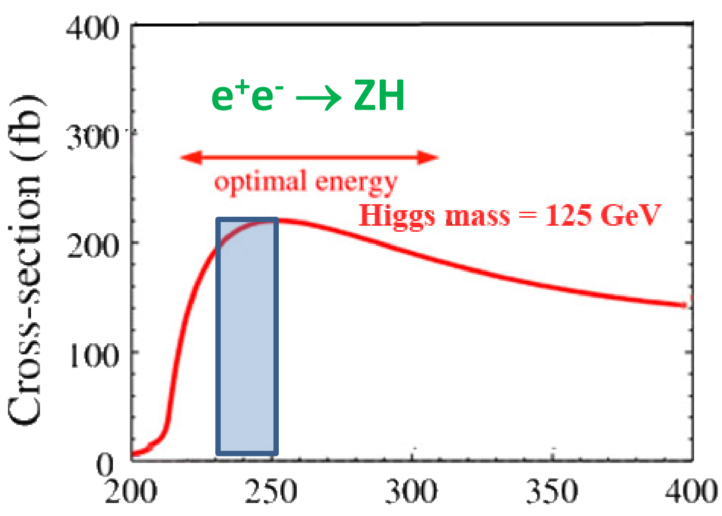




S/(S+B) Weighted Events / 1.5 GeV
CMS
Data
S+B Fit
±1σ
±2σ
m_γγ (GeV)
Events / 3 GeV
Data
Z+X
Zγ*, ZZ
m_H=125 GeV
m_4ℓ (GeV)
Local p_0
ATLAS
2011-12
Observed

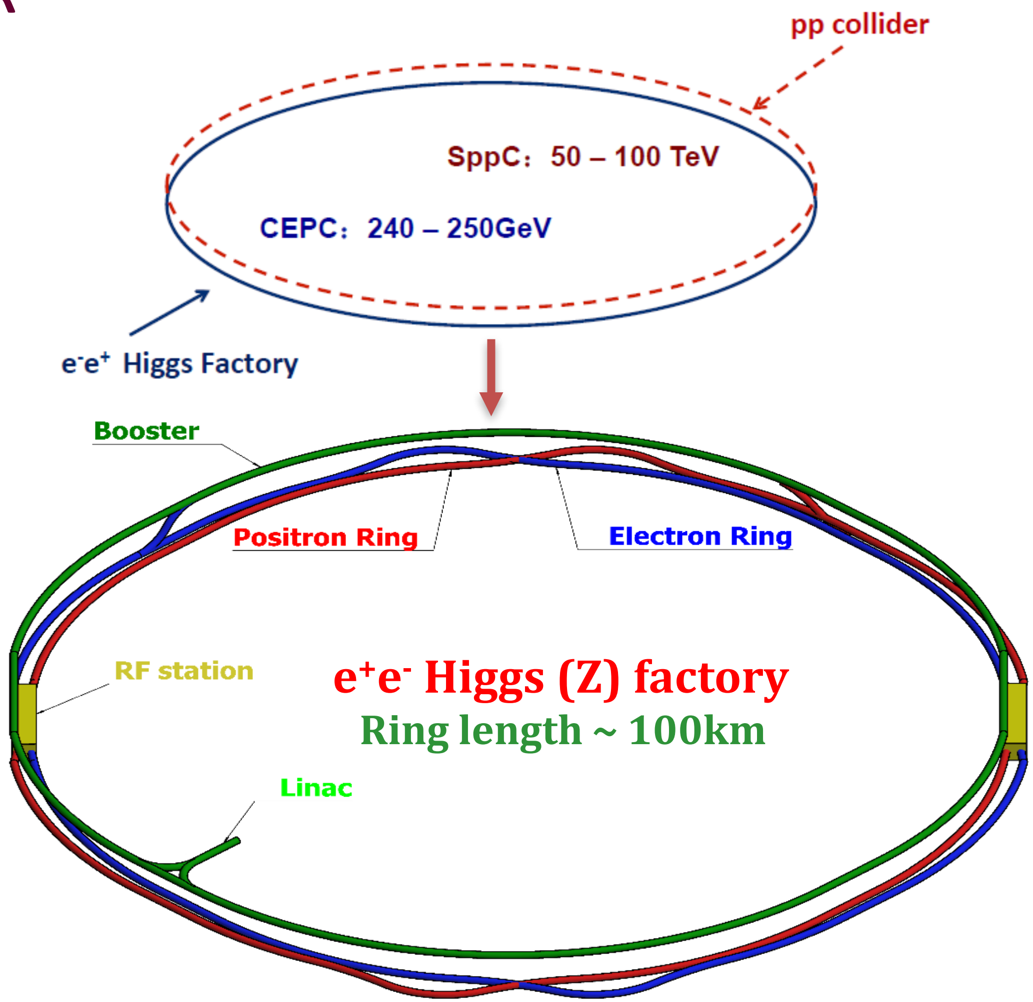
CEPC-SppC outline

- E_b=120GeV for CEPC
  - Limited by beamstrahlung & SR (~125GeV)



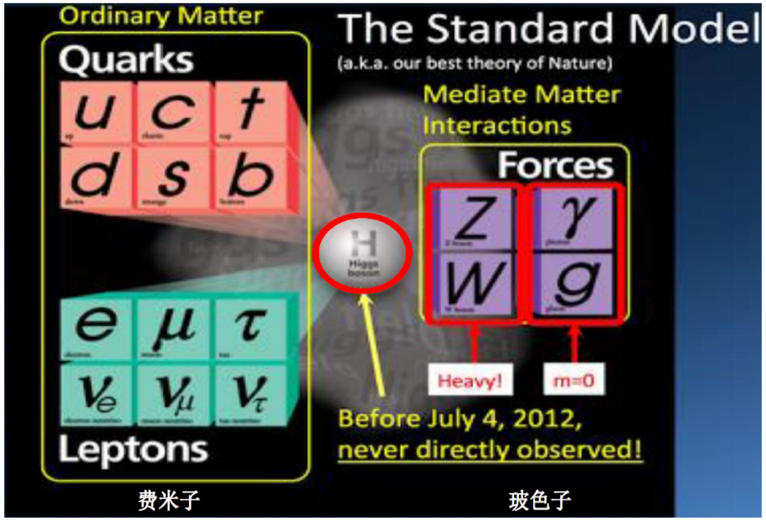
- $E_{b,max}$=100TeV for SppC
  - Limited by dipole field & C

- A CEPC (phase I) + SppC (phase II) was proposed in IHEP, Sept. 2012



CEPC – The Physics Case

The discovery of H(126) ⇒ golden opportunity

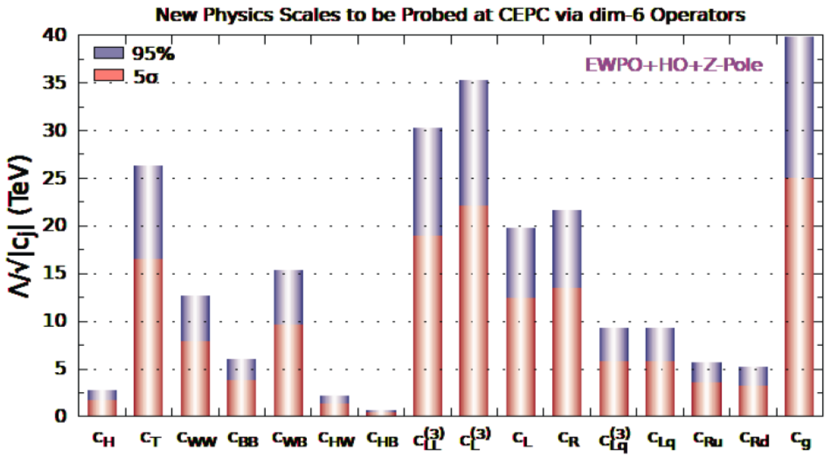


Higgs: it interacts with all fermions and W/Z

Is it connected to DM, DE?

Experiment with the H: portal to the new world?

BSM new physics searches



S. Ge, H. He, R. Xiao, 1603.03385

Pre-CDR

CEPC directly / indirectly: probes new physics ~10s TeV scale

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Physics goals of CEPC-SppC

e^+e^- Higgs & Z factory

$E_{cm} \approx$ 240GeV, luminosity $\approx 3\times10^{34}cm^{-2}s^{-1}$, 2 IPs, >1M Higgs in 10 years

$E_{cm} \approx$ 91GeV, luminosity > $1\times10^{34}cm^{-2}s^{-1}$, 2 IPs, 10^{10} Z /year

Precision measurement of the Higgs boson and the Z boson

Higgs precision 1% or better

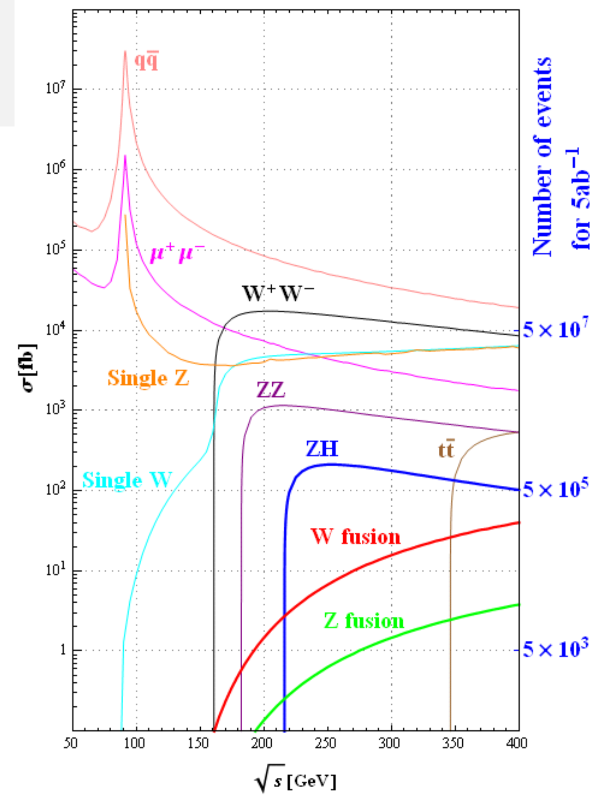
p-p collider

Upgradable to pp collision with $E_{cm} \approx$ 50-100 TeV (with ep, HI options) **in the tunnel of CEPC**

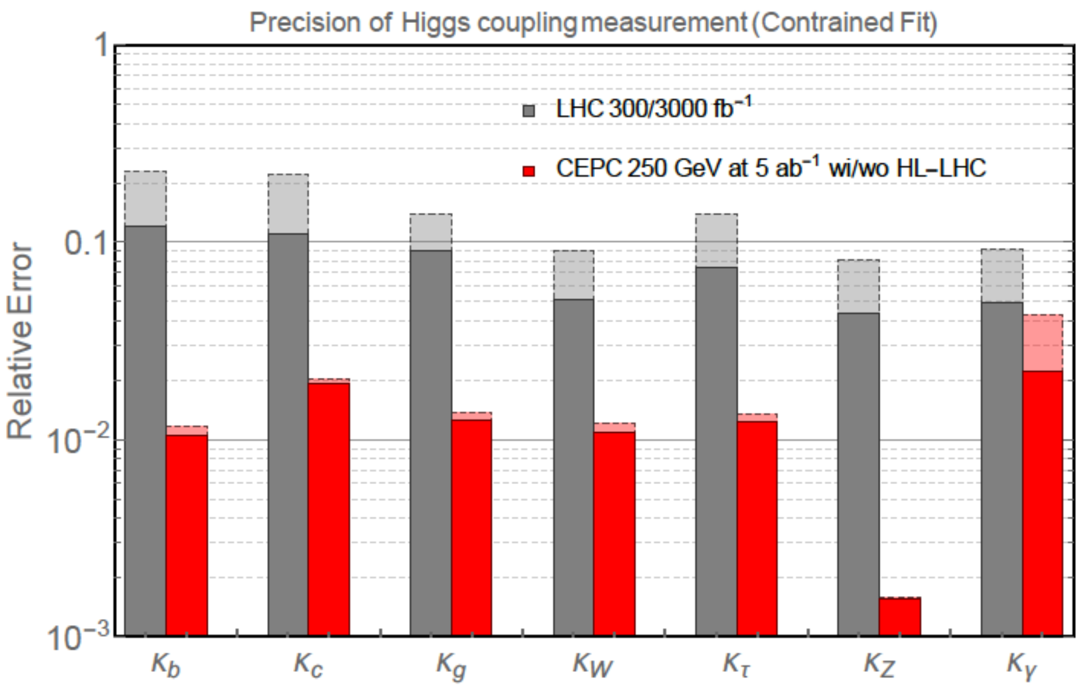
A discovery machine for BSM new physics

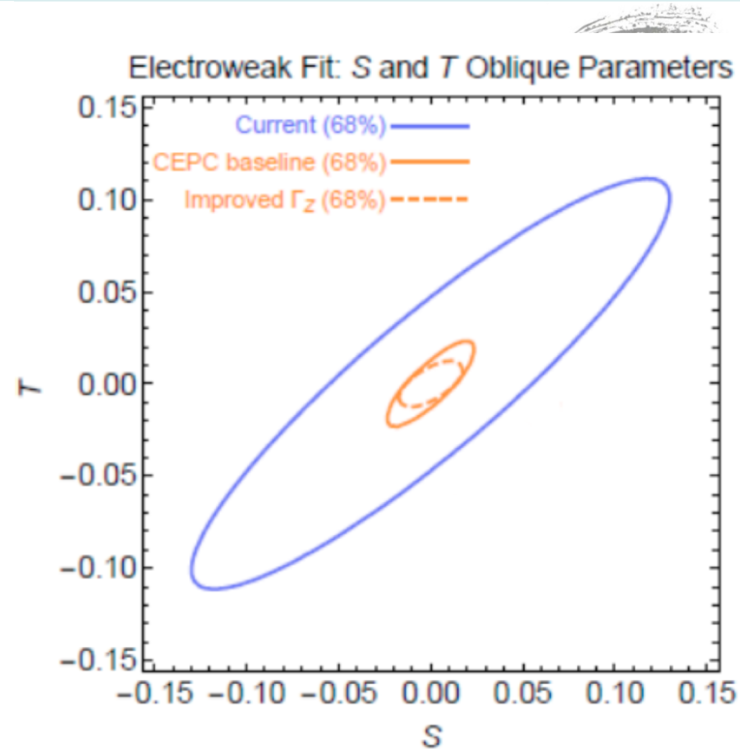
BEPCII will likely complete its mission ~2022;
CEPC – possible accelerator based particle physics program in China after BEPCII

Precision measurement + Discovery: Complementary with each other !



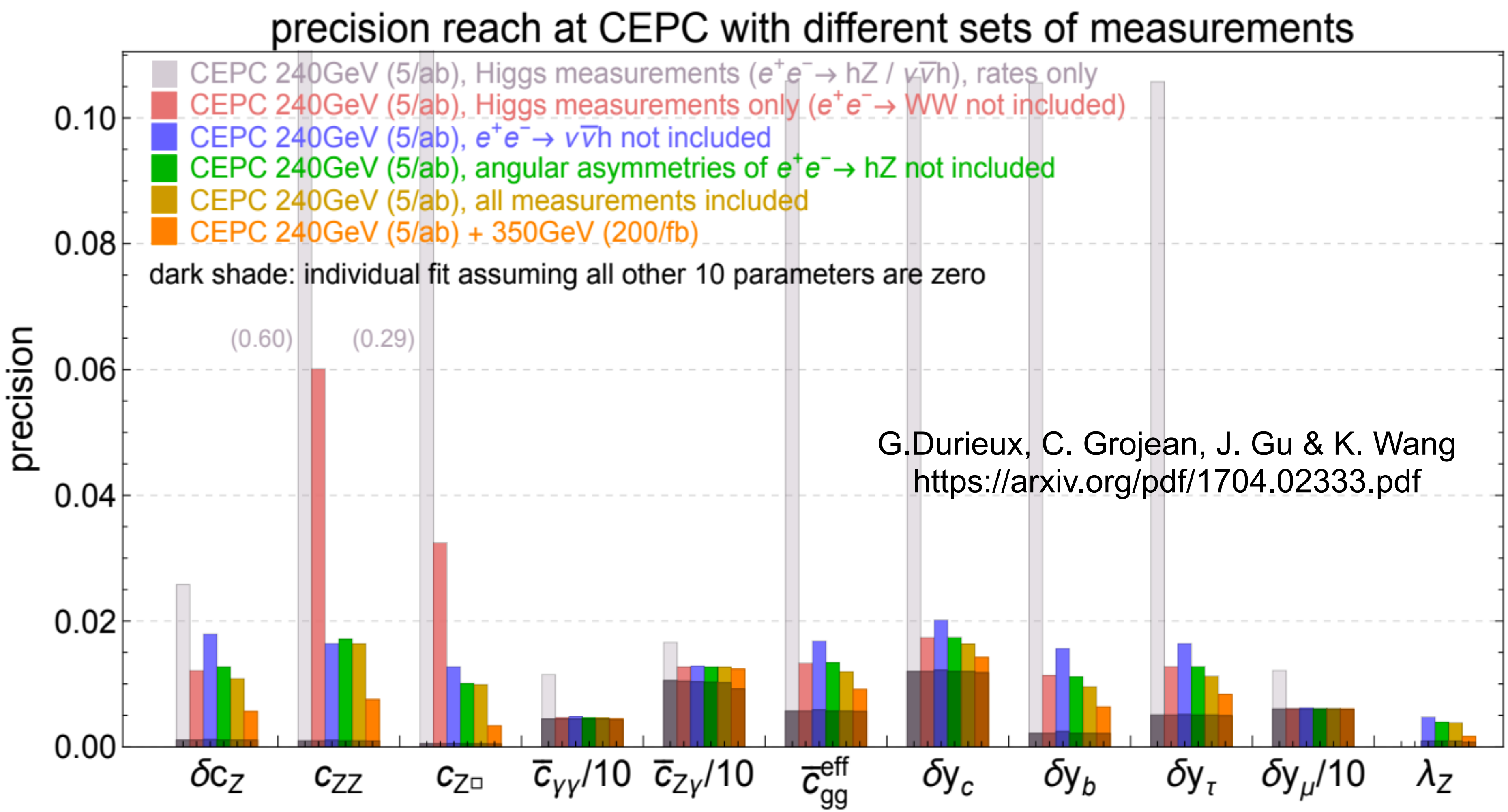
Physics potential





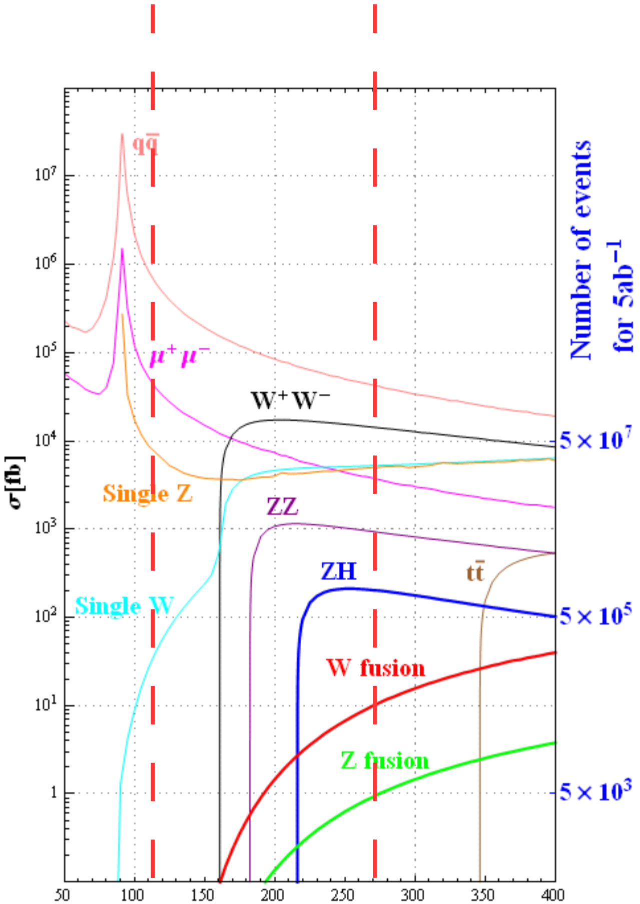
- **The nature of Higgs boson & EWSB, + flavor physics...**
  - **Higgs signal strengths (In kappa framework): expected accuracy roughly 1 order of magnitude better than HL-LHC**
  - **Absolute measurement to the Higgs boson: 2-3% level accuracy of Higgs boson width, 10^{-3} - 10^{-5} up limit to Higgs invisible/exotic decay modes (improved by at least 2 orders of magnitude comparing to HL-LHC)**
  - **Improve EW measurement precision by at least 1 order of magnitude**

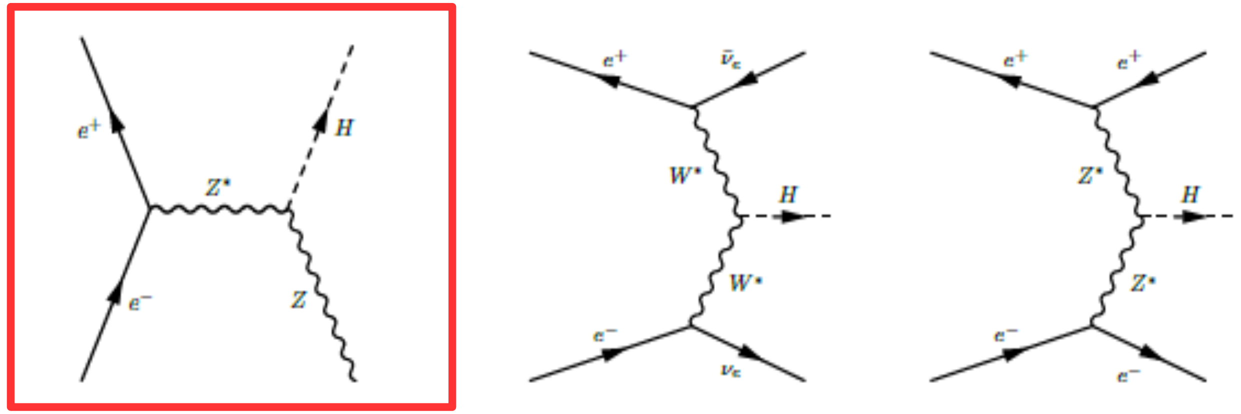
Pheno-studies: EFT & Physics reach



The Physics reach could be largely enhanced if the EW measurements is combined with the Higgs measurements (in the EFT)

Higgs @ CEPC





Process	Cross section	Events in 5 ab^{-1}
Higgs boson production, cross section in fb		
$e^+e^- \to ZH$	212	1.06×10^6
$e^+e^- \to \nu\bar{\nu}H$	6.72	3.36×10^4
$e^+e^- \to e^+e^-H$	0.63	3.15×10^3
Total	219	1.10×10^6

S/B ~ 1:100 - 1000

Observables: Higgs mass, CP, σ(ZH), event rates (σ(ZH, vvH)*Br(H→X)), Diff. distributions

Derive: Absolute Higgs width, branching ratios, couplings

CEPC-SPPC Timeline (preliminary and ideal)

CEPC

current time

2015 | 2020 | 2025 | 2030 | 2035

Pre-studies (2013-2015)

R&D Engineering Design (2016-2022)

Construction (2022-2030)

Data taking (2030-2040)

1st Milestone: Pre-CDR (by the end of 2014) ;
2nd Milestone: R&D funding from MOST (in Mid 2016);
3rd Milestone: CEPC CDR progress Report (by the end of 2016);
4th Milestone: CEPC CDR Report (by the end of Aug 2018);
5th Milestone: CEPC TDR Report and Proto R&D (by the end of 2022);
6th Milestone: CEPC construction start (2022);

SPPC

2020 | 2030 | 2040

R&D and CDR (2014-2030)

Engineering Design (2030-2035)

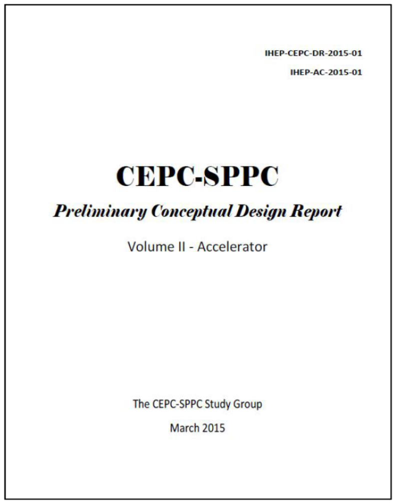
Construction (2040-2050)

Data taking (2045-2060)

- CEPC data-taking starts before the LHC program ends around 2035
- Possibly con-current, and complimentary to the ILC

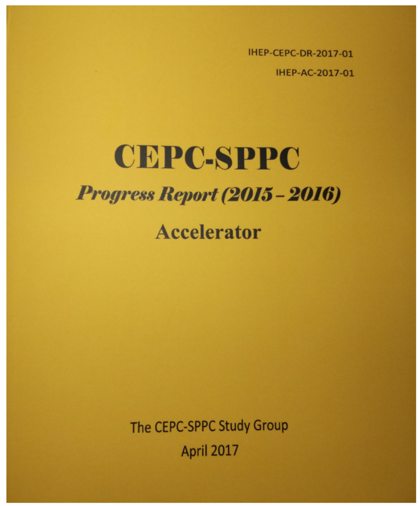
Pre-CDR, Progress report, and CDR are available now

http://cepc.ihep.ac.cn


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

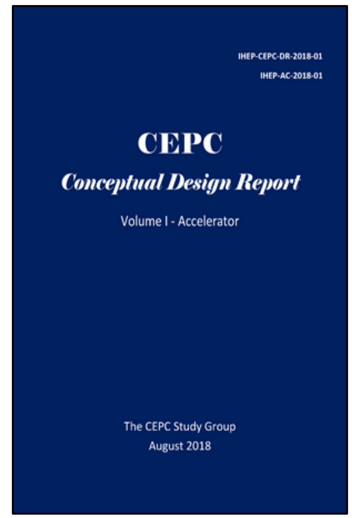
CEPC-SPPC
Preliminary Conceptual Design Report
Volume II - Accelerator

The CEPC-SPPC Study Group
March 2015


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

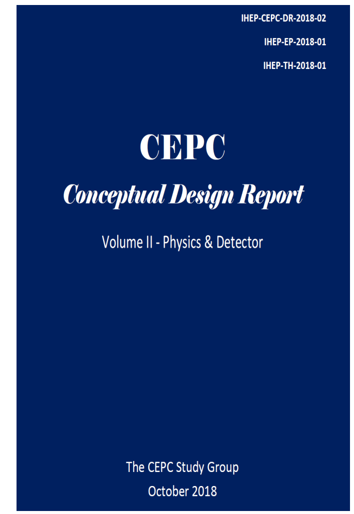
CEPC-SPPC
Progress Report (2015 – 2016)
Accelerator

The CEPC-SPPC Study Group
April 2017


IHEP-CEPC-DR-2018-01
IHEP-AC-2018-01

CEPC
Conceptual Design Report
Volume I - Accelerator

The CEPC Study Group
August 2018


IHEP-CEPC-DR-2018-02
IHEP-EP-2018-01
IHEP-TH-2018-01

CEPC
Conceptual Design Report
Volume II - Physics & Detector

The CEPC Study Group
October 2018

CEPC CDR was released in Aug. & Oct., 2018

Public release of printed CDR volumes in IHEP on 14th Nov., 2018

Progress and updates - CEPC CDR

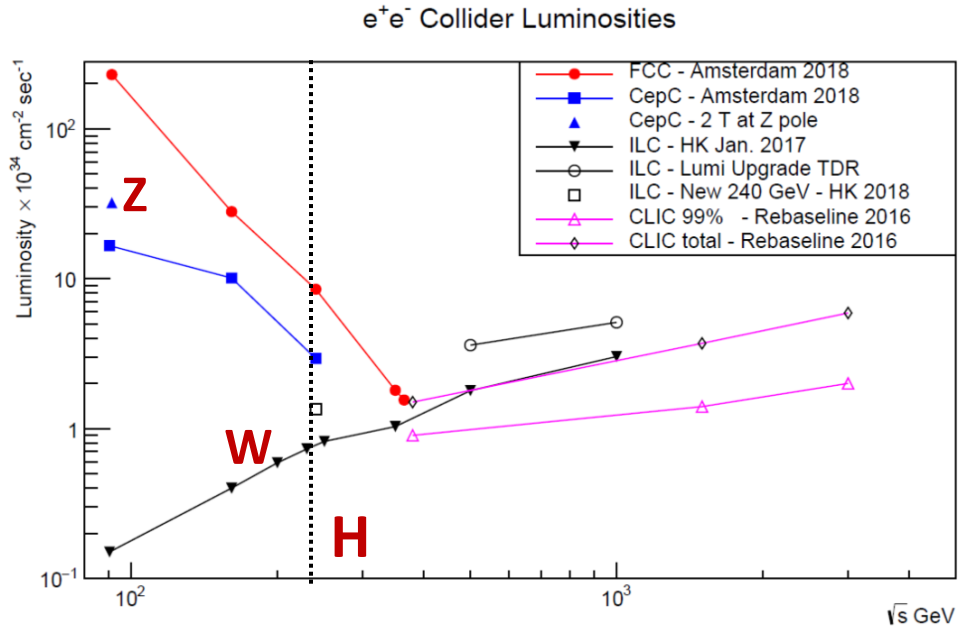
Luminosity vs. CM energy

Circular:

offers higher lumi. @ LE
⇒unprecedented Z,W,+H program
mature technology
HE synchrotron light source (?)
very long term: pp upgrade path

Linear:

very impressive Higgs precision
best Lumi. at higher energies, or only option for VHE



F. Bedeschi, INFN-Pisa

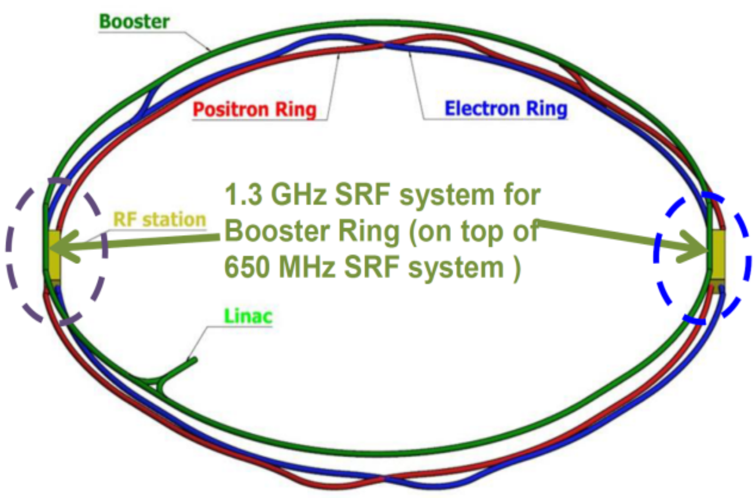
circular & linear colliders are ideally complementary to each other

Progress and updates - CEPC CDR

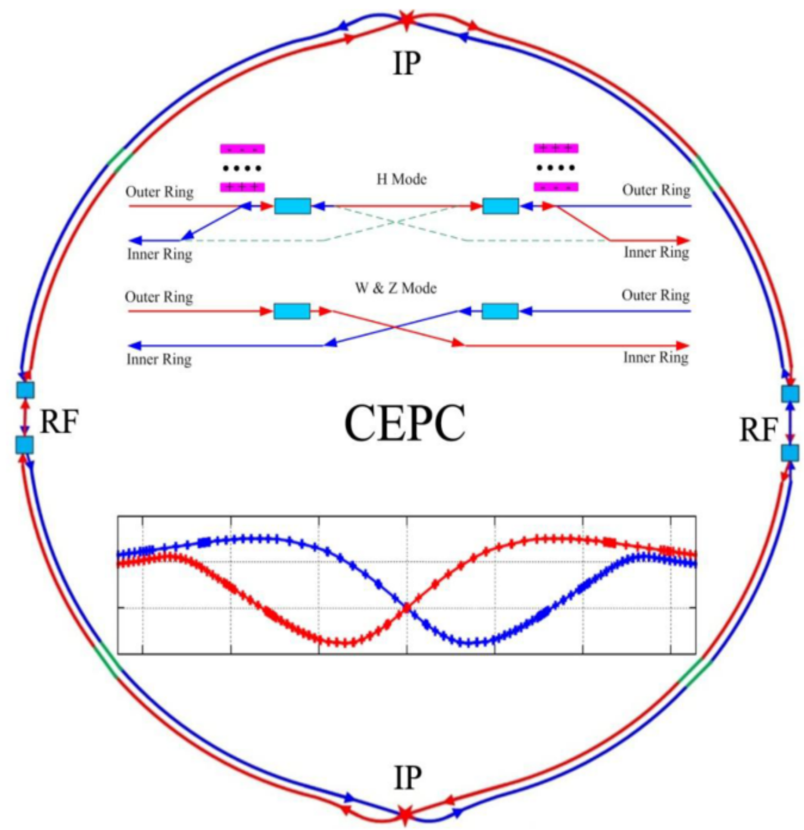
Lumi.	Higgs	W	Z	Z(2T)
$\times 10^{34}$	2.93	11.5	16.6	32.1

Luminosities exceed those in the pre-CDR

- Double ring baseline design (30MW/beam)
- Switchable between H and Z/W w/o hardware change (magnet switch)
- Use half SRF for Z and W
- Could be optimized for Z with 2T detector

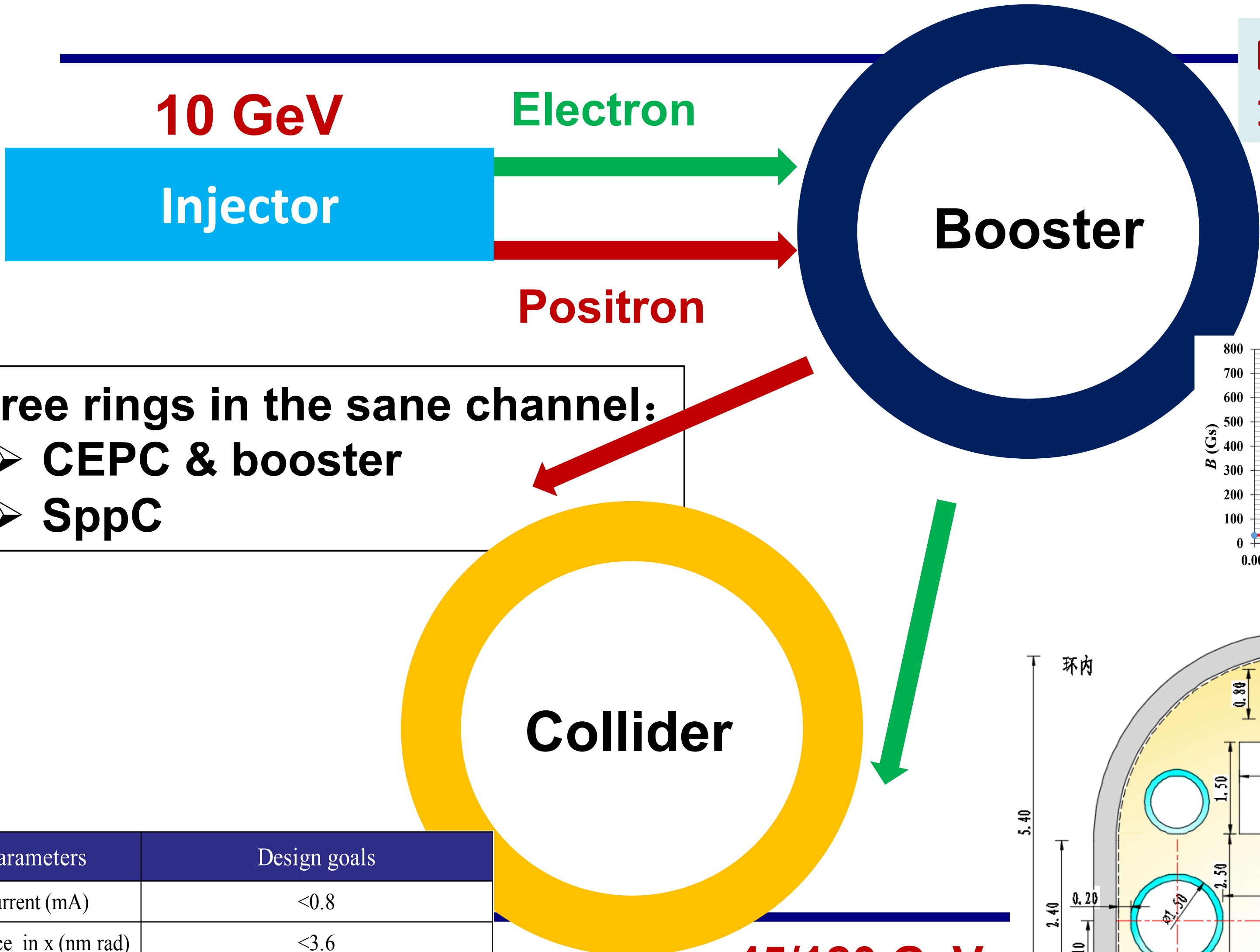


SRF system location of CEPC (two RF stations)

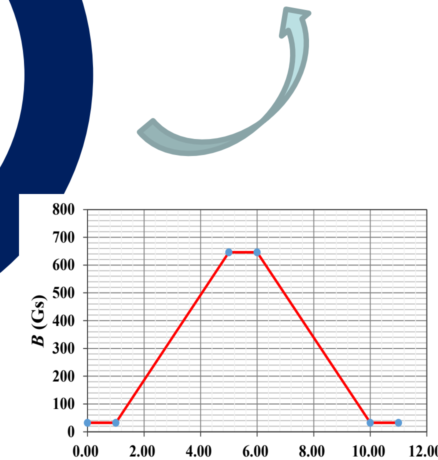


Layout of 650 MHz SRF system for Collider Ring

CEPC accelerator design

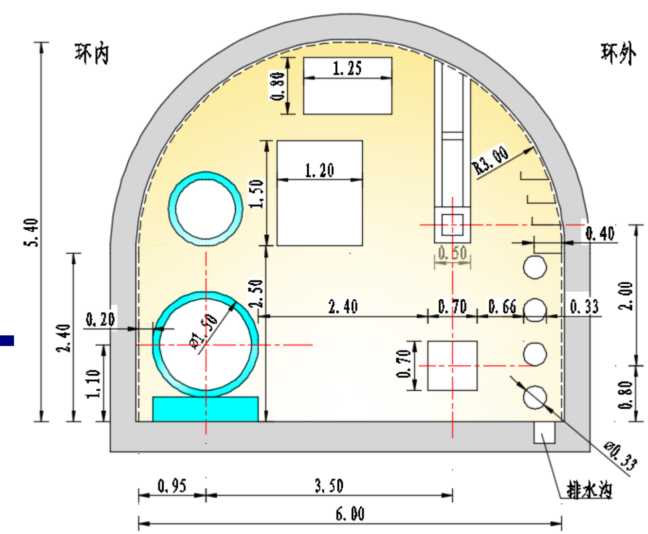


Energy Ramp
10→45/120GeV



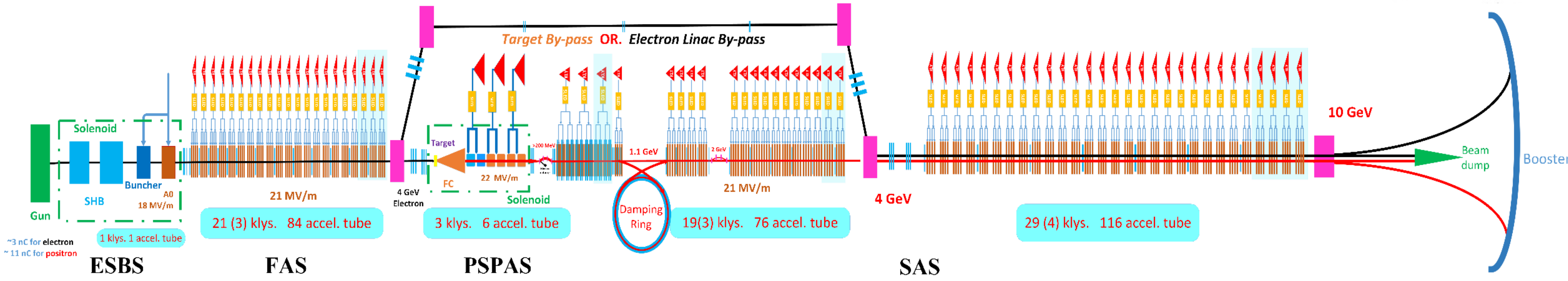
Booster Cycle (0.1 Hz)

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



Parameters	Design goals
Beam current (mA)	<0.8
Emittance in x (nm rad)	<3.6
Dynamic aperture	>3σ (normalized by linac beam size)
Energy acceptance	>1%
Timing	Meet the top-up injection requirements

Injector linac (base-line design)



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**

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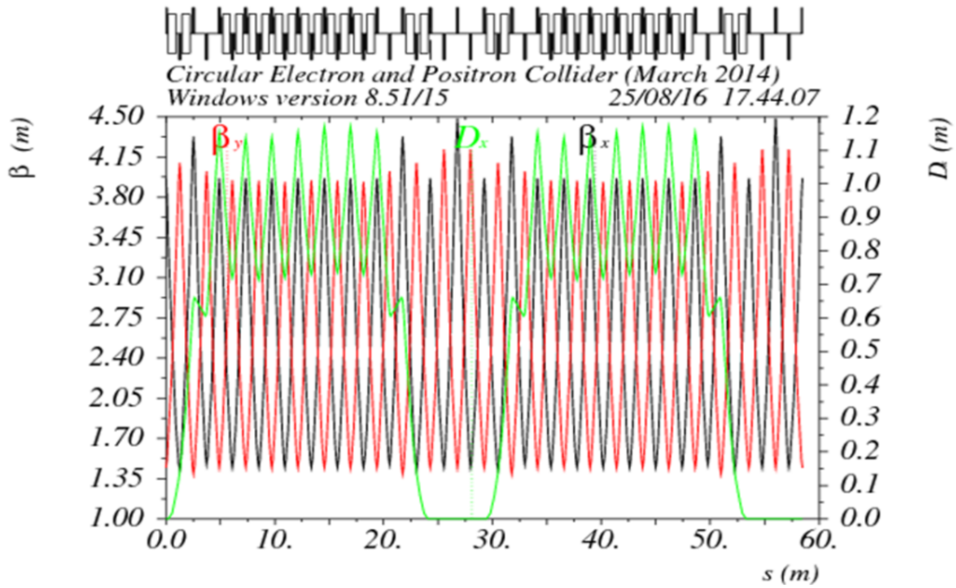
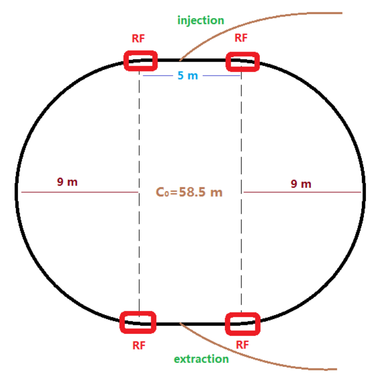
CEPC Linac Injector Damping Ring

Parameters, lattice 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



Kickers and Septa for damping ring



Component	Length (m)	Waveform	Deflection angle (mrad)	Field (T)	Beam-Stay-clear	
					H(mm)	V(mm)
Septum	2	DC	77	0.13	63	63
Kicker	0.5	Half_sin	0.2	0.0013	63	63

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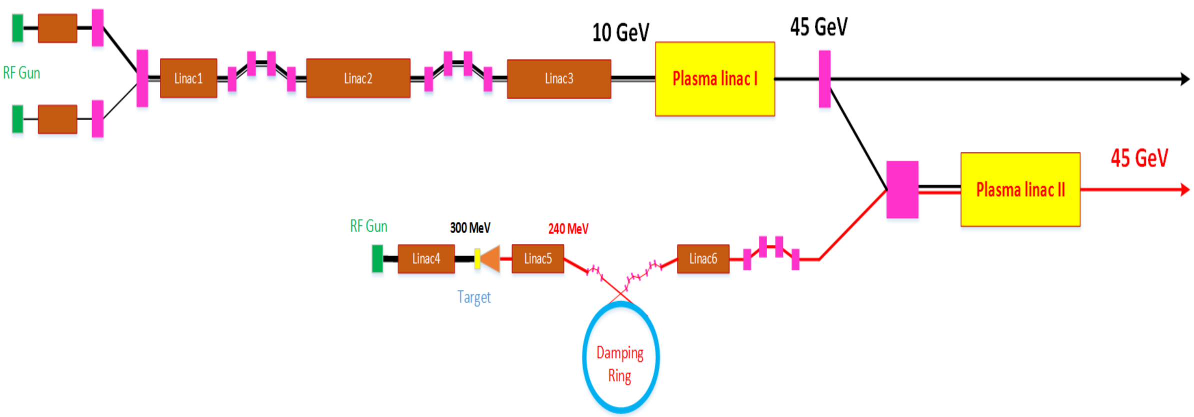
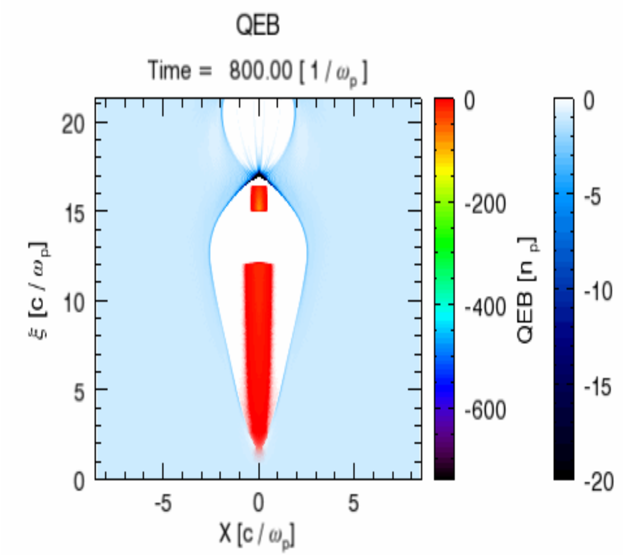
Energy Physics

CEPC Linac Injector alternative: Plasma accelerator scheme up to 45 GeV (single stage)~120GeV (cascade)



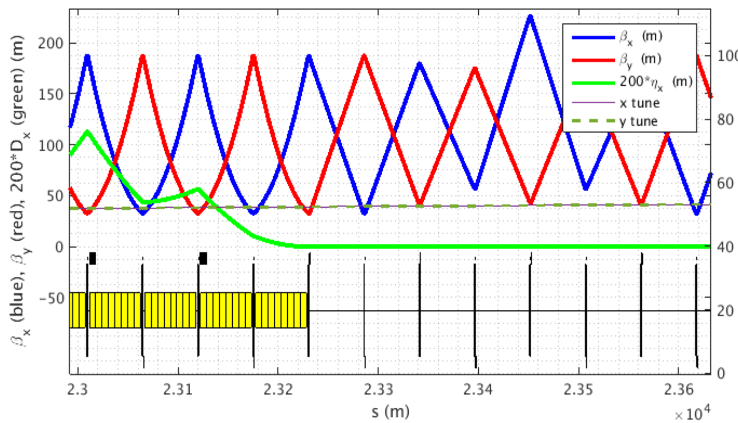


Plasma density $n_0(cm^{-3})$	5.15×10^{16}
Driver charge $Q_d(nC)$	6.47
Driver energy $E_d(GeV)$	10
Driver length $L_d(\mu m)$	285
Driver RMS size $\sigma_d(\mu m)$	10
Driver normalized emittance $\epsilon_{nd}(mm\ mrad)$	10
Trailor charge $Q_t(nC)$	1.25
Trailor energy $E_t(GeV)$	10
Trailor length $L_t(\mu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

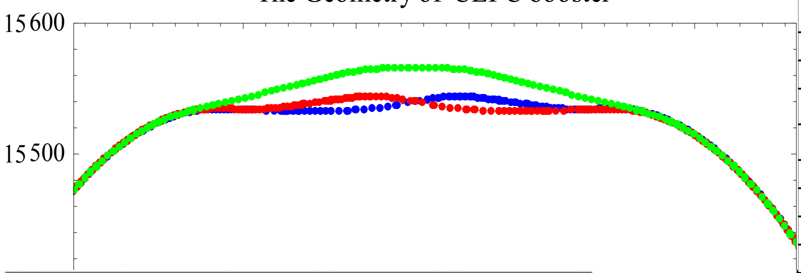
Trailor energy $E_t(GeV)$	45.5
Trailor normalized emittance $\epsilon_{nt}(mm\ mrad)$	98.9
TR	3.55
Energy spread $\delta_E(\%)$	0.7
Efficiency (driver -> trailor)	68.6%

The simulations show that plasma scheme satisfies the CEPC booster requirement

Booster design

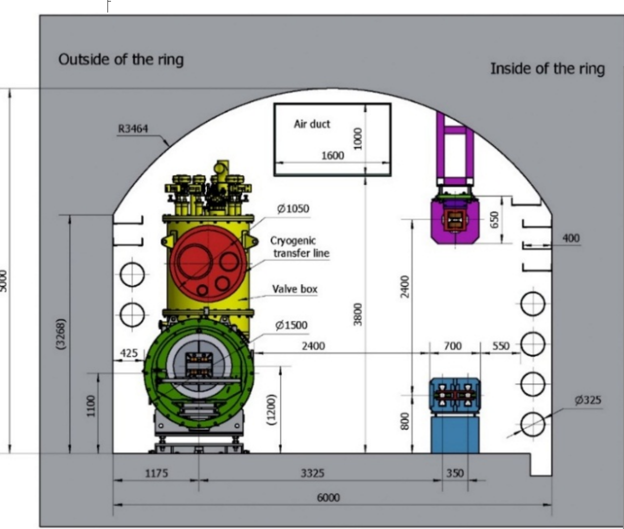


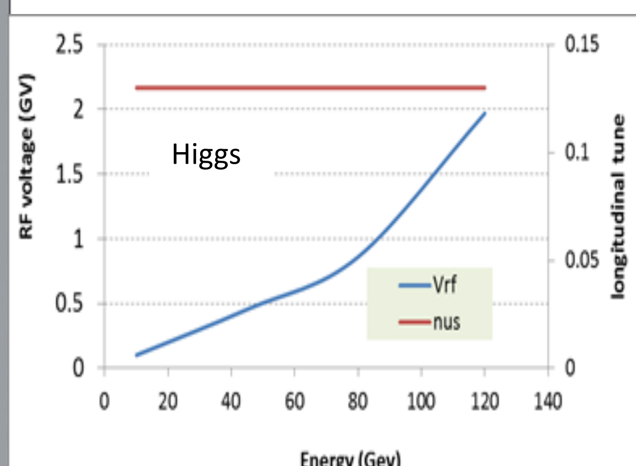
The Geometry of CEPC booster

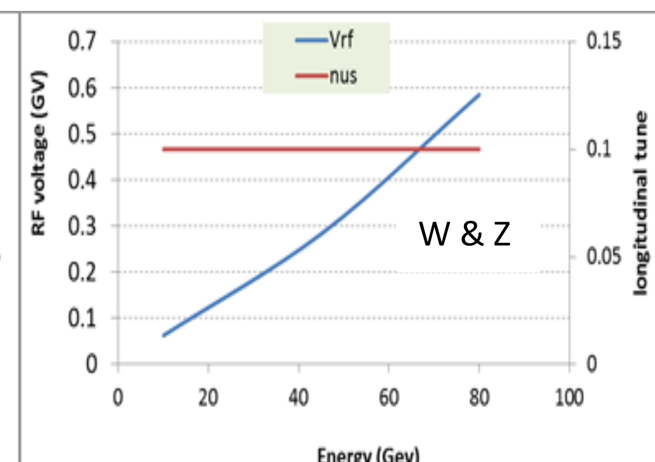


		H	*W*	*Z*
Beam energy @ injection	GeV	10		
Bunch number		242	1524	6000
Single bunch current	μA	2.3	1.8	1.3
Beam current	mA	0.57	2.86	7.51
Natural Energy spread	%	0.0078		
Synchrotron radiation loss/turn	keV	73.5		
Momentum compaction factor	10^{-5}	2.44		
Natural emittance	nm	0.025		

		H		*W*	*Z*
		Off axis injection	On axis injection	Off axis injection	Off axis injection
Beam energy @ extraction	GeV	120		80	45.5
Bunch number		242	235+7	1524	6000
Maximum single bunch current	μA	2.1	70	1.7	1.2
Beam current	mA	0.52	1.0	2.63	6.91
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
Natural bunch length	mm	2.8		2.4	1.3

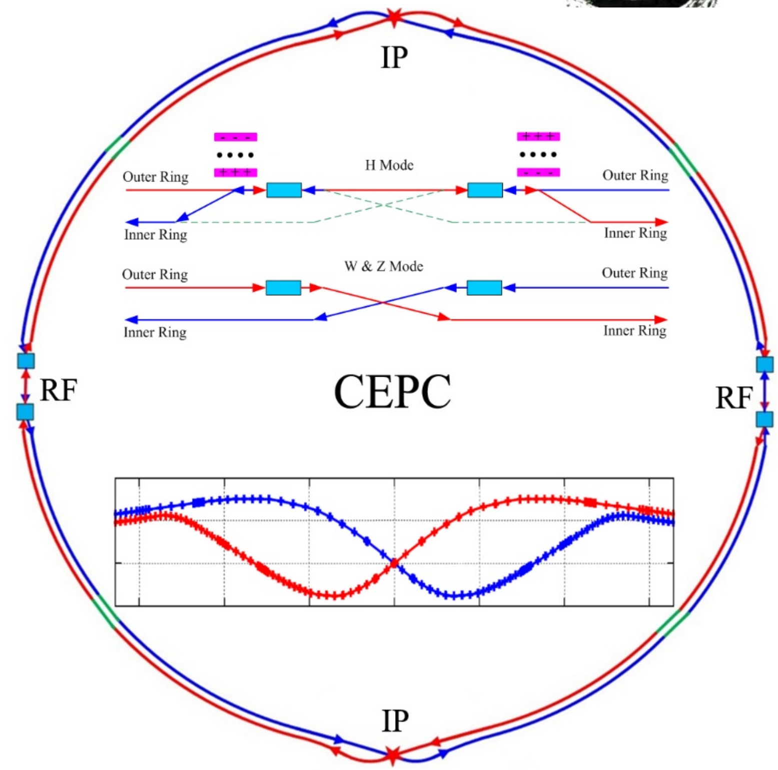


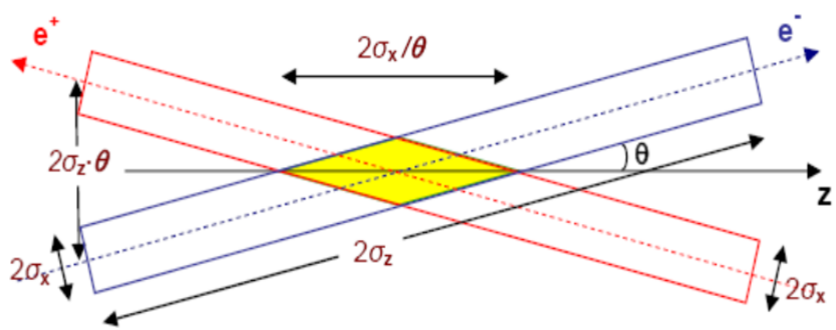




Key parameters of current CEPC ring

- 100km circumference, double ring with 2 IPs
- Matching the geometry of SPPC as much as possible
- Adopt twin-aperture quads and dipoles in the ARC
- Detector solenoid 3.0T with length of 7.6m while anti-solenoid 7.2T
- L*=2.2m, θc=33mrad, βx*=0.36m, βy*=1.5mm
- Maximum gradient of quad 136T/m (3.8T in coil)
- Tapering of magnets along the ring
- Two cell & 650MHz RF cavity
- Two dedicated surveys in the RF region for Higgs and Z modes
- Maximum e+ beam power 30MW & e- 30MW
- Crab-waist scheme with local X/Y chromaticity correction
- Common lattice for all energies.

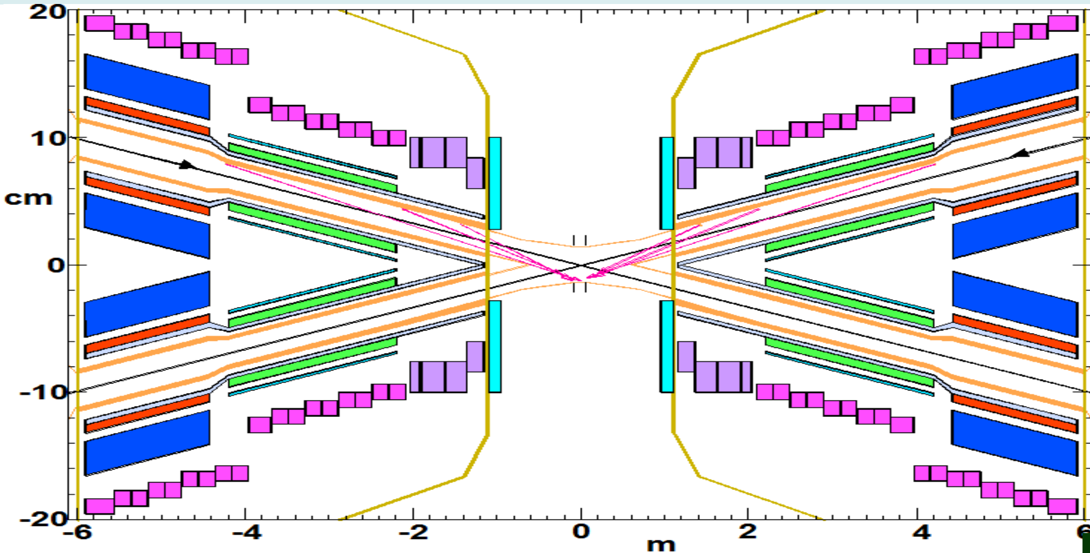


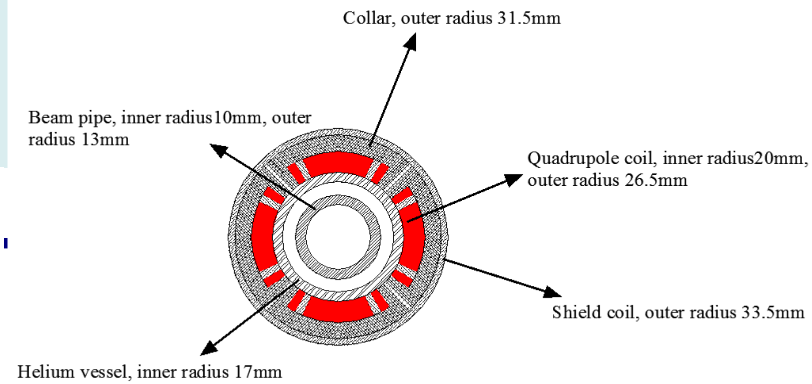


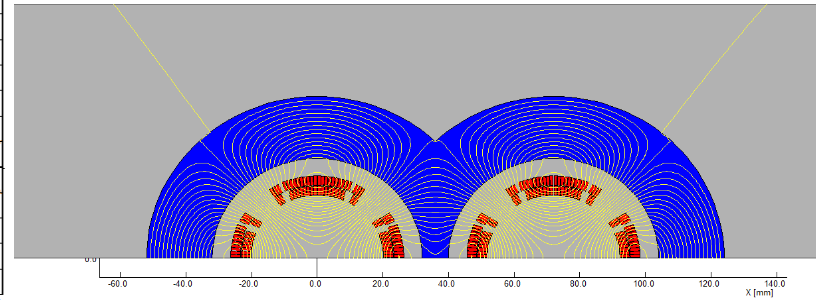
Parameters of CEPC double ring

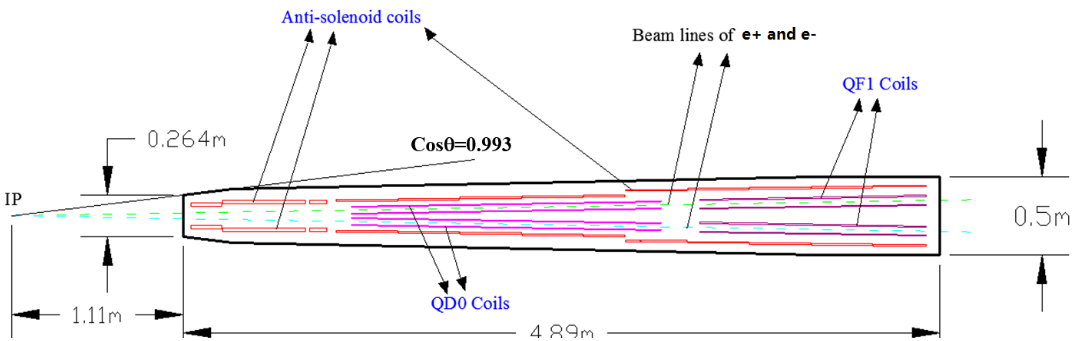
	Higgs	*W*	*Z*（3T）	*Z*（2T）
Number of IPs	2			
Beam energy (GeV)	**120**	**80**	**45.5**	
Circumference (km)	100			
Synchrotron radiation loss/turn (GeV)	1.73	0.34	0.036	
Crossing angle at IP (mrad)	16.5×2			
Piwinski angle	2.58	7.0	23.8	
Number of particles/bunch N_e (10^{10})	15.0	12.0	8.0	
Bunch number (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	
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**

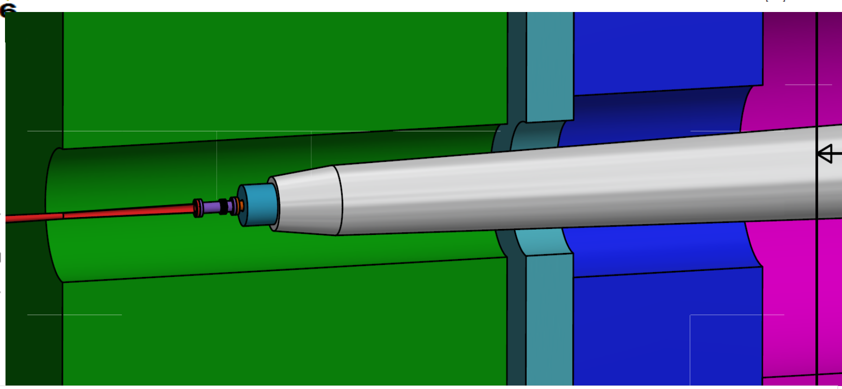
IR Design

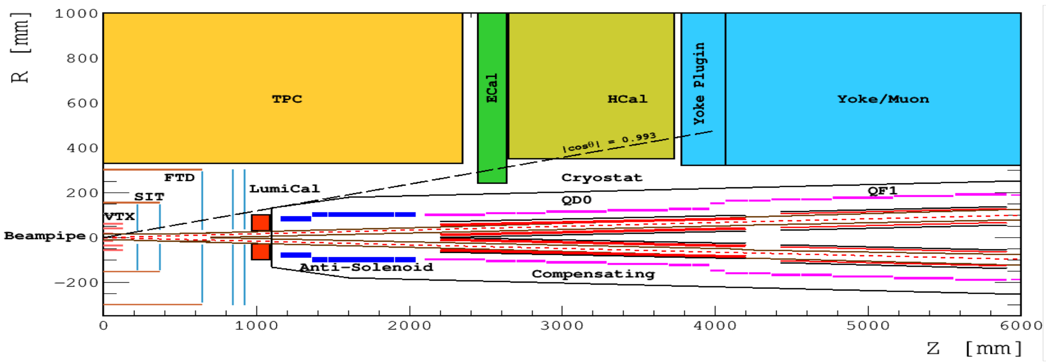

20
10
cm
0
-10
-20
-6
-4
-2
0
m
2
4
6

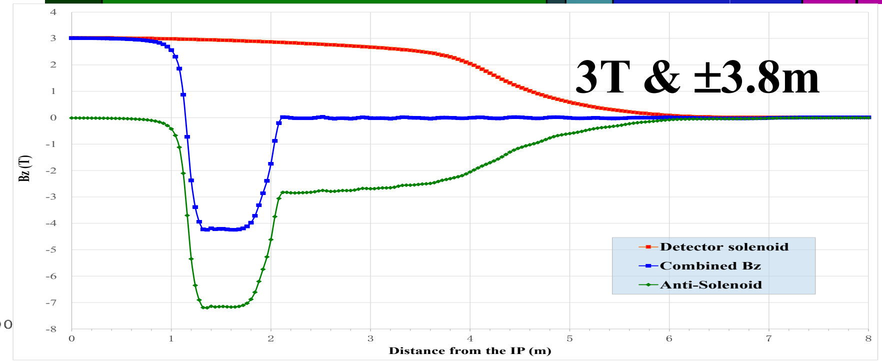

Collar, outer radius 31.5mm
Beam pipe, inner radius10mm, outer radius 13mm
Quadrupole coil, inner radius20mm, outer radius 26.5mm
Shield coil, outer radius 33.5mm
Helium vessel, inner radius 17mm


-60.0
-40.0
-20.0
0.0
20.0
40.0
60.0
80.0
100.0
120.0
140.0
X [mm]

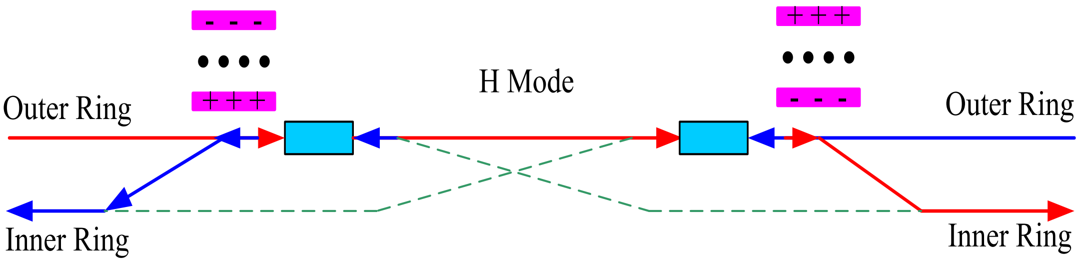

Anti-solenoid coils
Beam lines of e+ and e-
QF1 Coils
0.264m
Cosθ=0.993
IP
0.5m
QD0 Coils
1.11m
4.89m

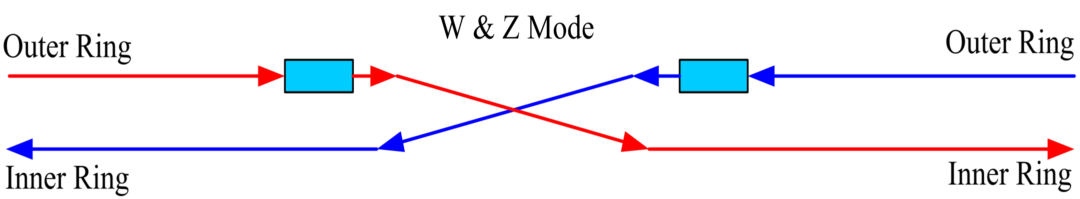


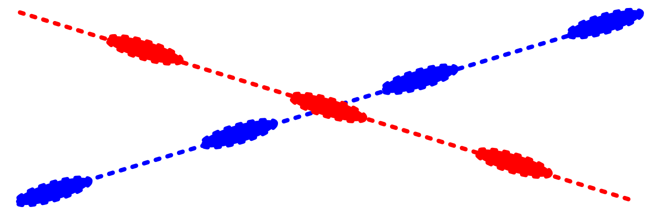

R [mm]
1000
800
600
400
200
0
−200
TPC
ECal
HCal
Yoke Plugin
Yoke/Muon
|cosθ| = 0.993
FTD
SIT
VTX
LumiCal
Cryostat
QD0
QF1
Beampipe
Anti-Solenoid
Compensating
0
1000
2000
3000
4000
5000
6000
Z [mm]


3T & ±3.8m
Bz (T)
Distance from the IP (m)
Detector solenoid
Combined Bz
Anti-Solenoid

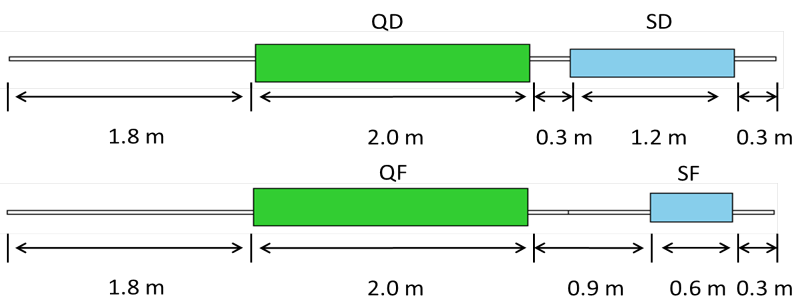
RF & Arc regions

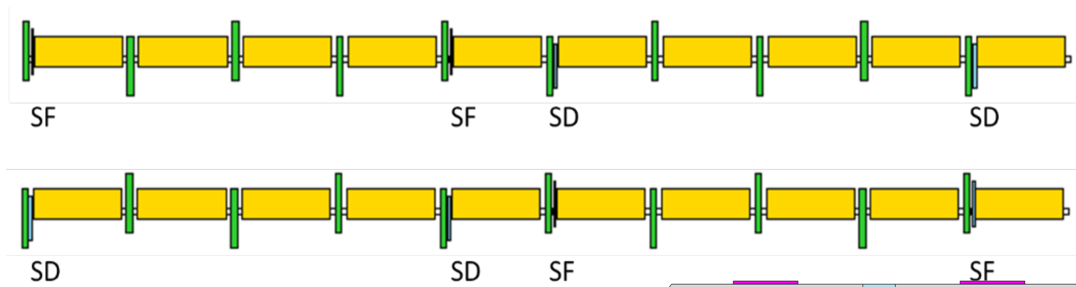


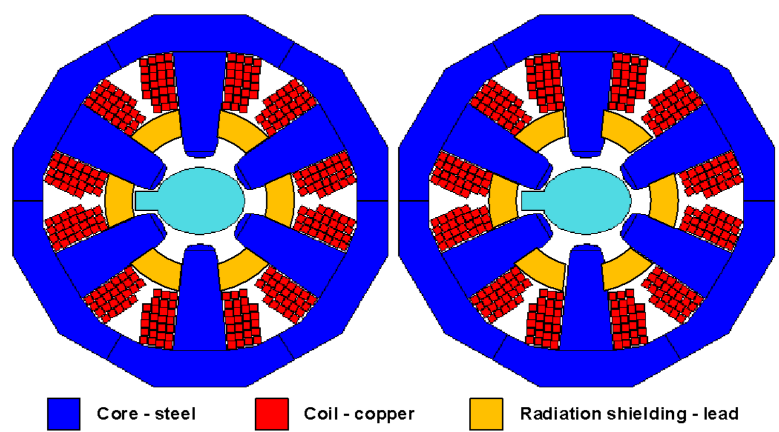


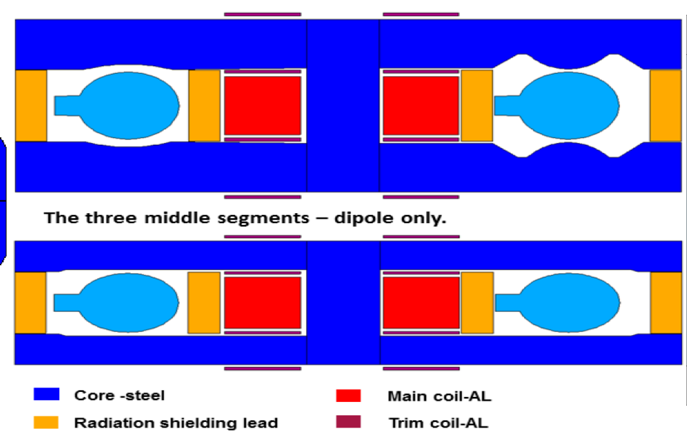


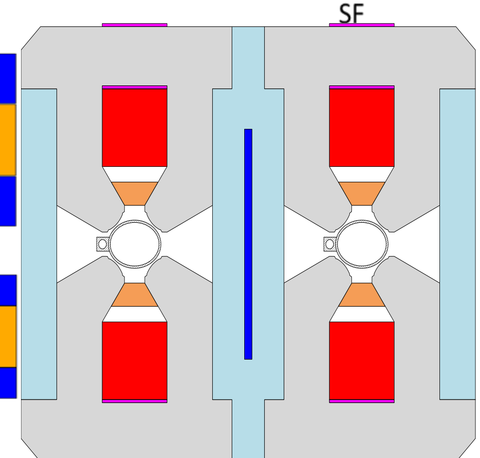
Horizontal Crossing
Longitudinal separation





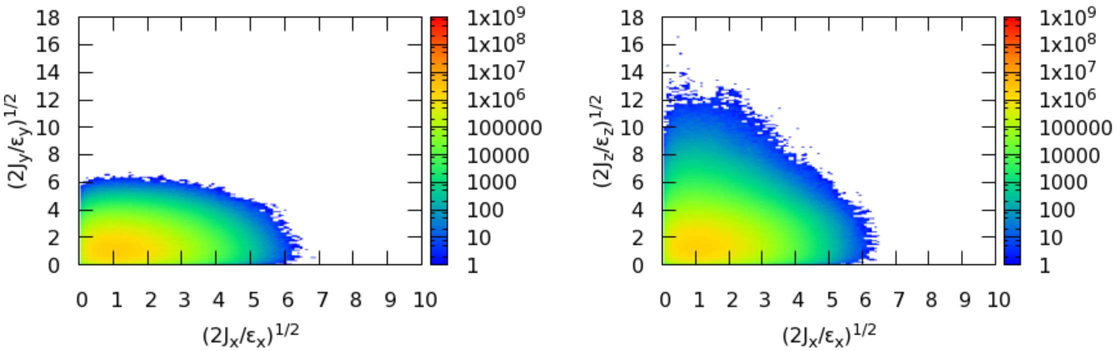






Accelerator physics study

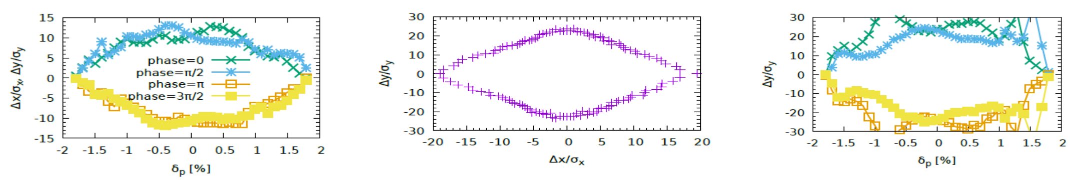
Beam-beam simulation with strong-strong model



Beam tail distribution with crab-waist collision.

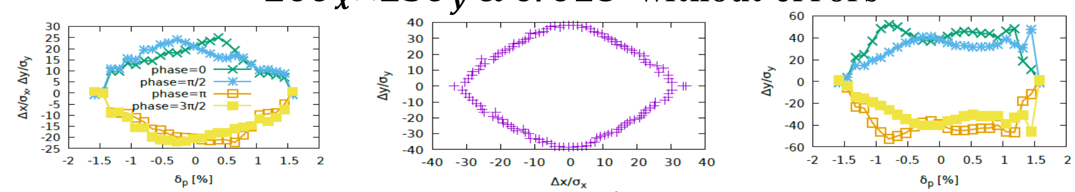
Dynamic aperture optimization

H



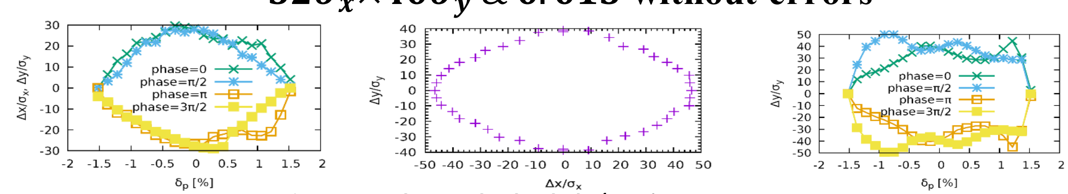
$20\sigma_x \times 23\sigma_y$ & 0.018 without errors

W

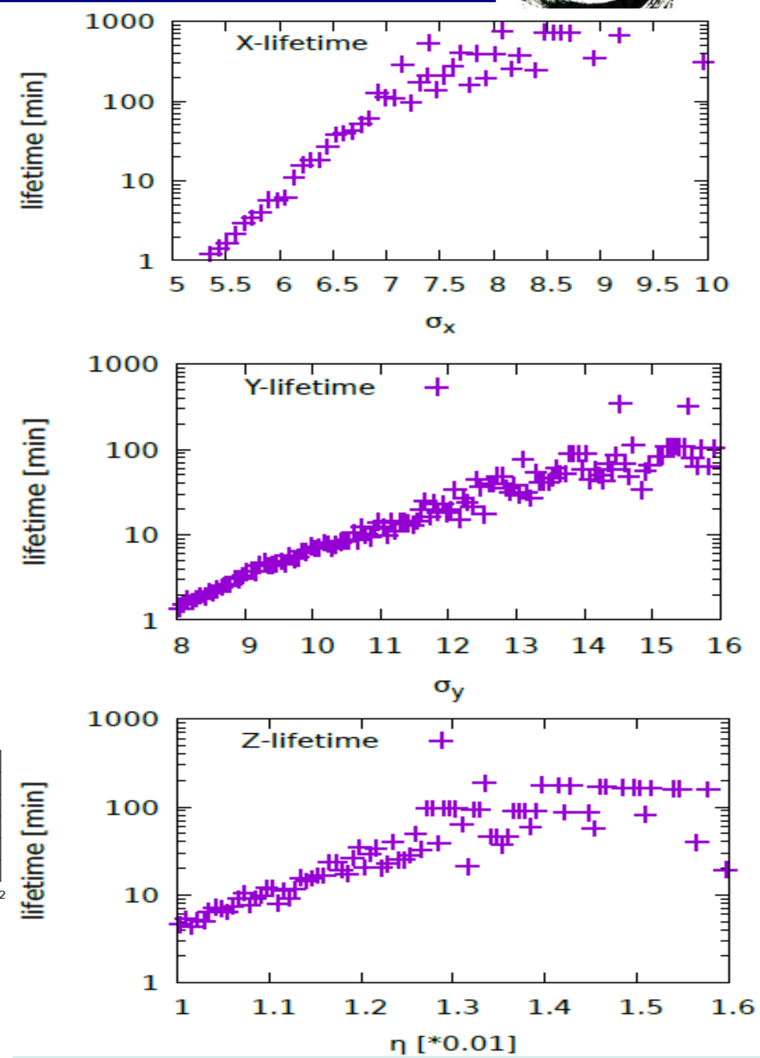


$32\sigma_x \times 40\sigma_y$ & 0.015 without errors

Z

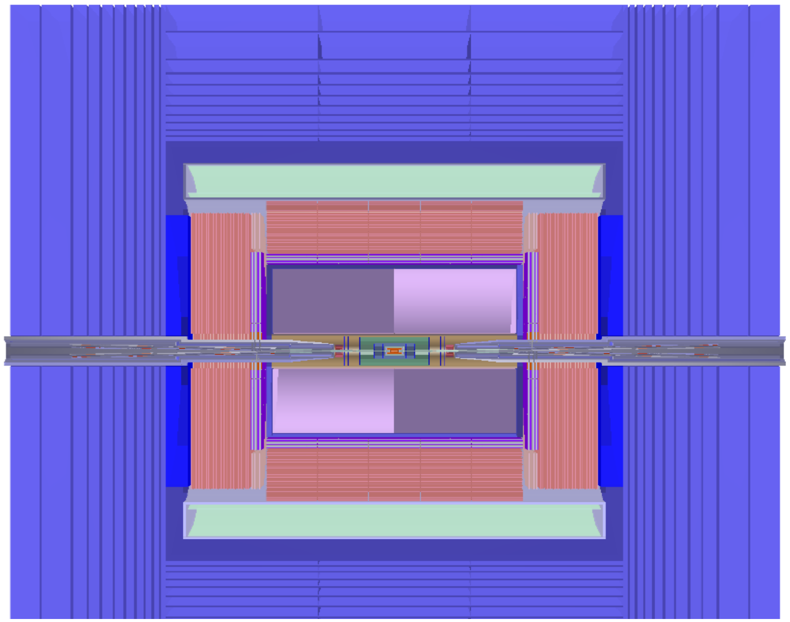


$46\sigma_x \times 40\sigma_y$ & 0.015 without errors



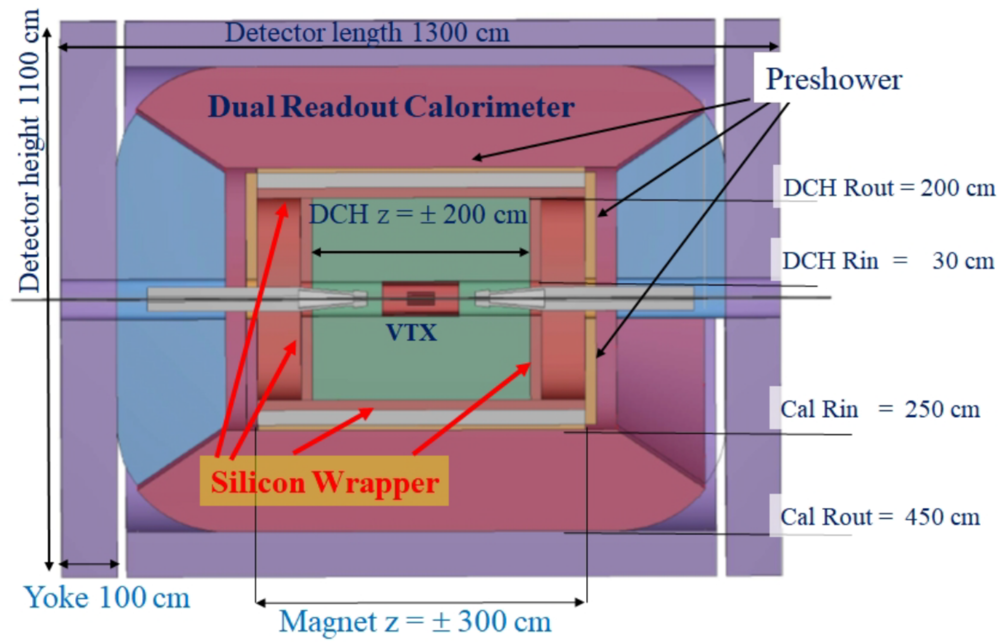
Lifetime with real lattice and beam-beam interaction at Higgs

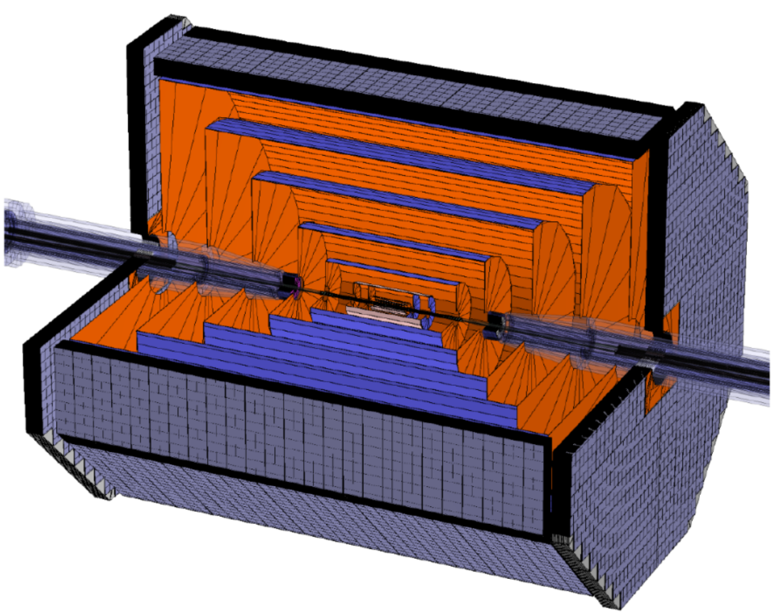
Detector & physics



Baseline detector: pixel vertex detector, silicon inner tracker, a TPC, Si external tracker, ECAL, HCAL, 3 T B-field, embedded muondetector

Alternative detector



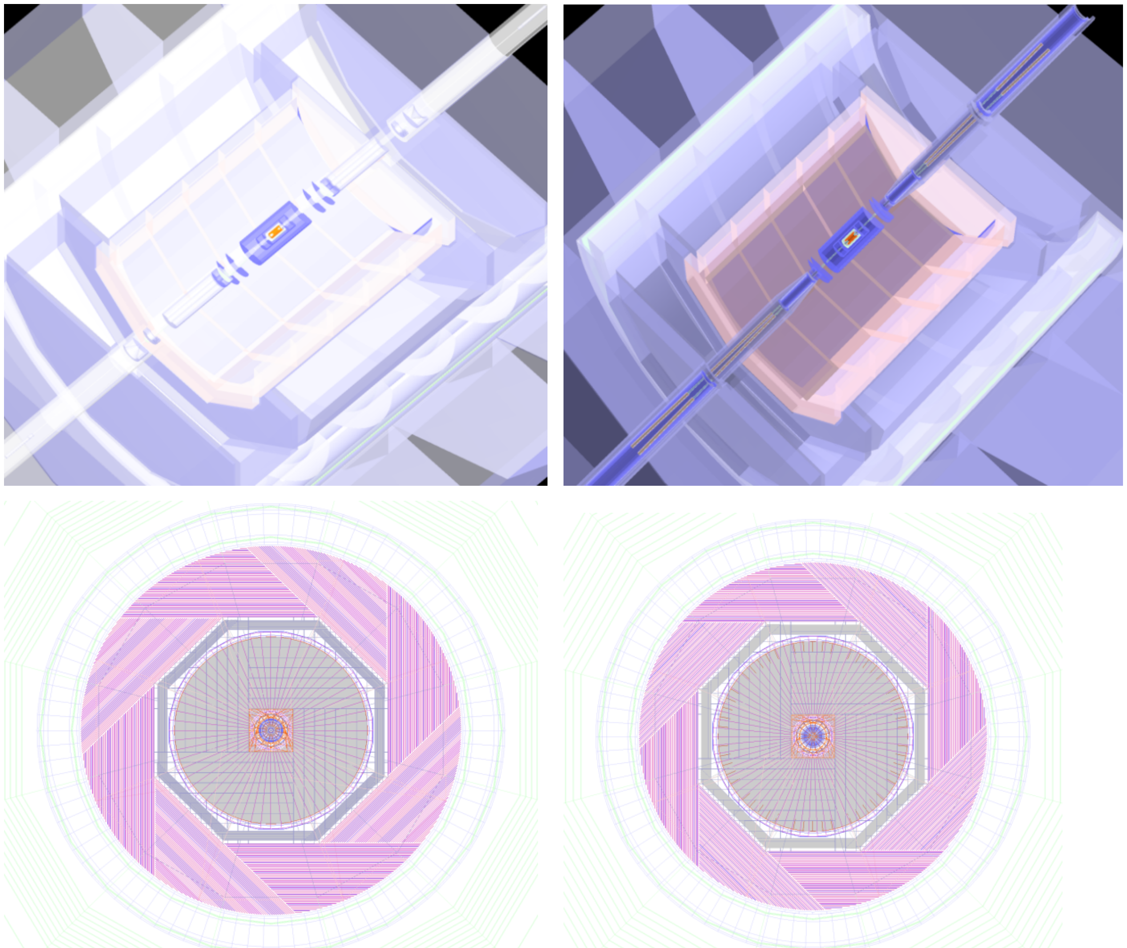


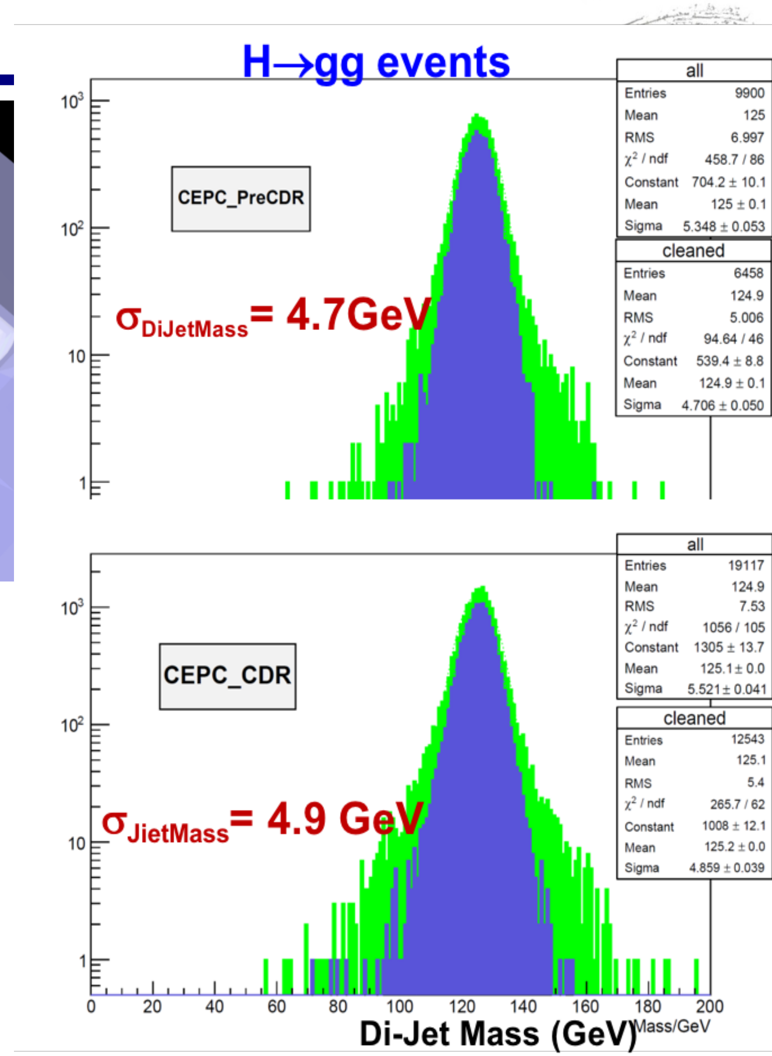
Full silicon tracker +baseline detector

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

CEPC Detector: more compact & updated for CDR

preCDR (2015) → CDR (2018)





CDR CEPC detector:

Double ring geometry & MDI design implemented

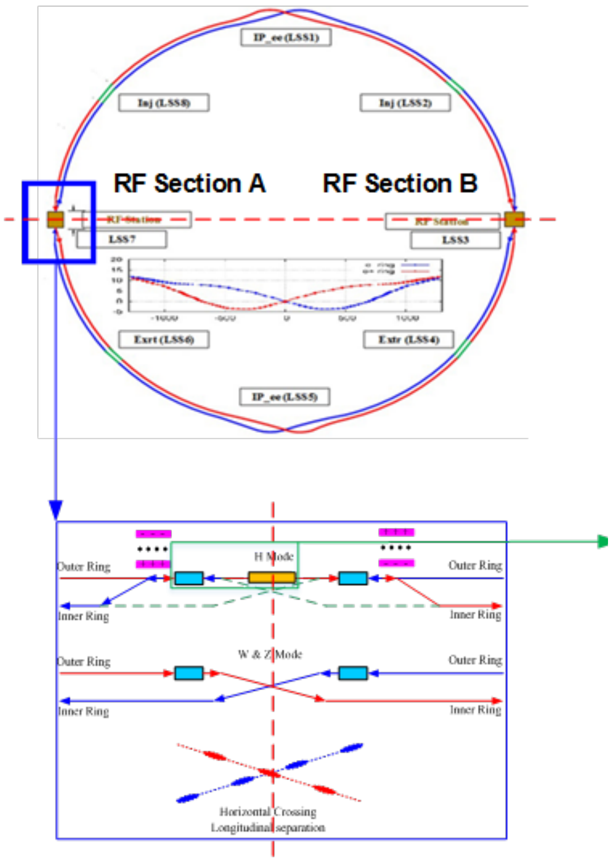
HCAL reduced to 40 layers (from 48 in preCDR)

No visible impact on physics performance

From CDR to TDR

- Refine all sub-systems of damping ring, booster & collider rings
  - All connecting transfer lines matching the collider accelerator chain requirements
  - Detector bakgroud reduction, beam-beam for long lifetime
  - MDI optimization and SC magnets' design
  - Magnets' studies with H, W, and Z all modes
- Upgrade possibility studies
- Key technologies
  - High current positron source
  - High Q superconducting RF cavity and high power coupler
    - Max. operation Q = 2×10^{10}@2K
    - Max. power of high power coupler = 300kW
  - High efficiency klystron
    - ~80% as the goal for 650MHz klystron
  - Large scale cryogenics system
  - Low field dipole magnet (booster)
  - Electro-static separator for deflect two beams

CEPC SRF system layout



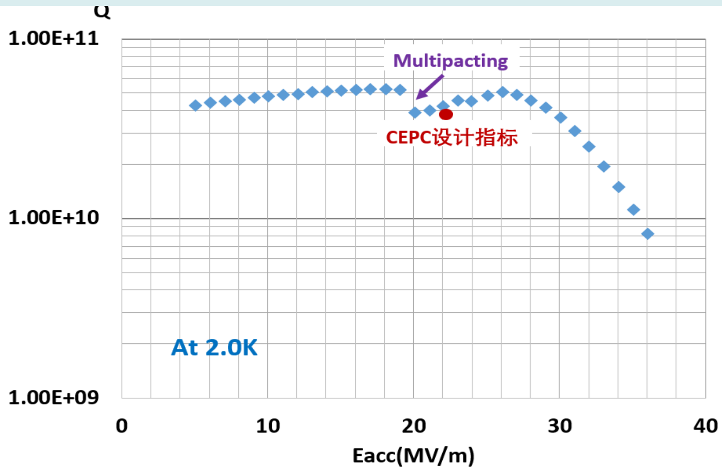
RF Section A

- Two Collider Ring RF Stations CRFA1 (84 cavities in 14 cryomodules) and CRFA2 (84 cavities in 14 cryomodules) (blue)
- One Booster RF Station BRFA (48 cavities in 6 cryomodules) (orange)
- Straight section length between CRFA1 and CRFA2: 368.6 m

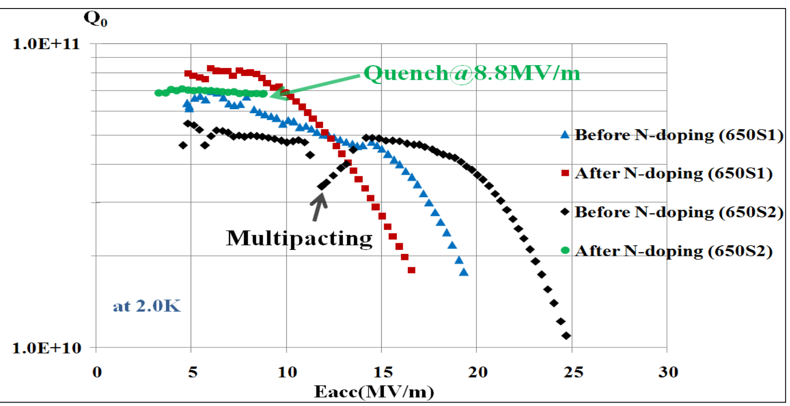
	H	W	Z
Collider Ring	**650 MHz 2-cell cavity**		
Lumi. / IP (10^{34} $cm^{-2}s^{-1}$)	2	4	1
RF voltage (GV)	2.14	0.465	0.053
Beam current (mA)	17.7 x 2	90.2	83.7
Cavity number	336	108 x 2	12 x 2
SR power (MW)	30	30	2.9
2 K cavity wall loss (kW)	6.4	1	0.1
Booster Ring (extraction)	**1.3 GHz 9-cell cavity**		
RF voltage (GV)	1.83	0.7	0.36
Beam current (mA)	0.53	0.53	0.51
Cavity number	96	64	32
RF input power (MW) avg.	0.1	0.02	0.01
2 K wall loss (kW) avg.	0.2	0.1	0.03

- Same cavities for H, W, Z and one-time full installation
- Common collider cavities for H, independent for W & Z

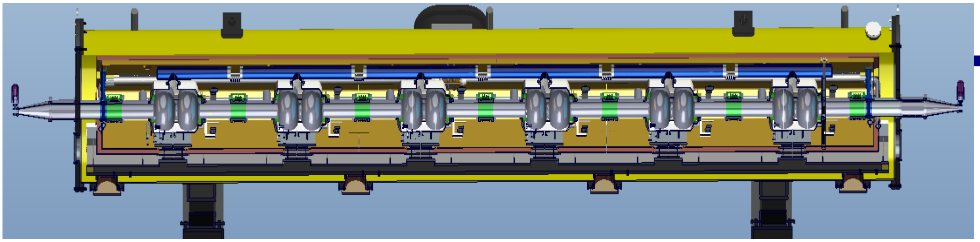
CEPC SRF cavity & cryo-module

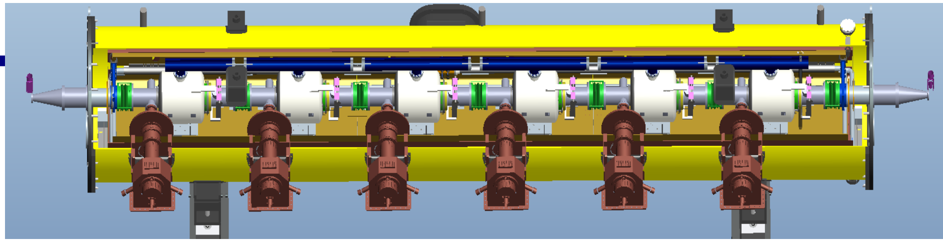


- Vertical test result: Q_0=5.1E10@26MV/m, reaching the CEPC target (Q_0=4.0E10@22.0 MV/m)
- After N-doping, Q_0 increased obviously at low field for both 650MHz 1-cell cavities.



The civil construction of the EP facility is on going, and the commissioning will be at the end of 2018.

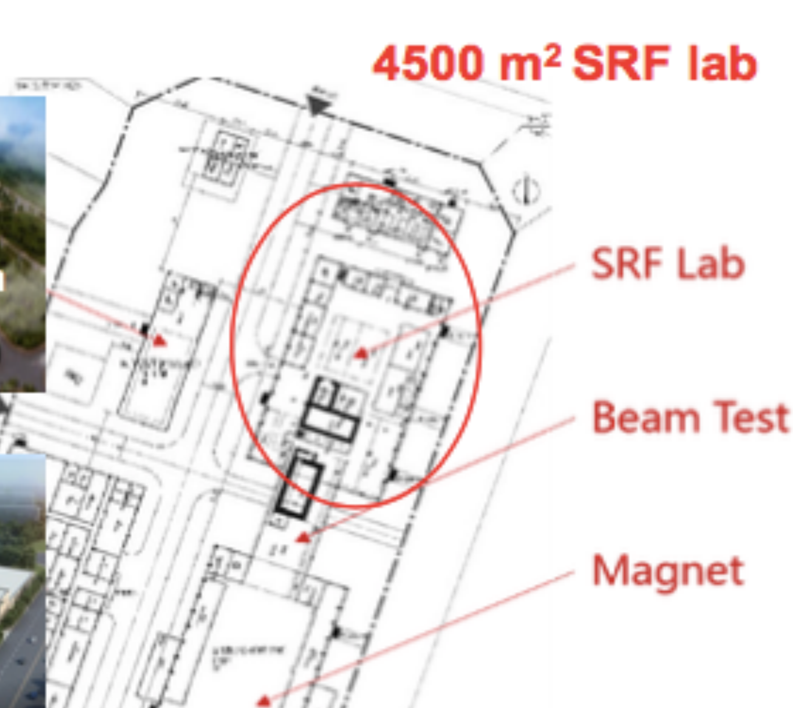




New SRF infrastructure at Huairou District, Beijing

- **Platform of Advanced Photon Source tech. R&D (PAPS), supported by Beijing local government and mainly constructed for the High Energy Photon Source (HEPS), could be used for SRF development**

PAPS
2017 - 2020



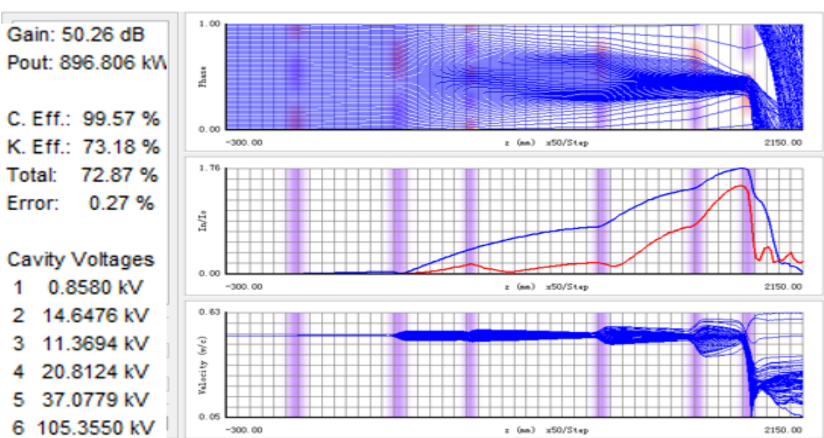
Construction: 2017 – 2020
Ground breaking: May 31, 2017

High Efficiency Klystron Development

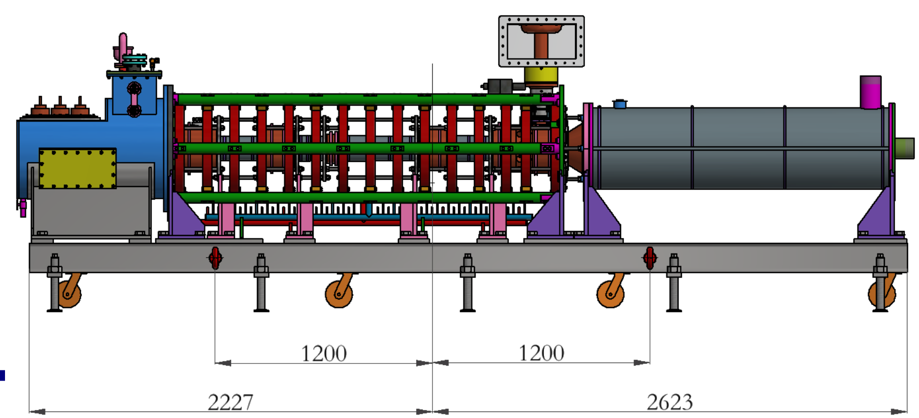
Established “High efficiency klystron collaboration consortium”, including IHEP & IE(Institute of Electronic) of CAS, and Kunshan Guoli Science and Tech.

- **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**



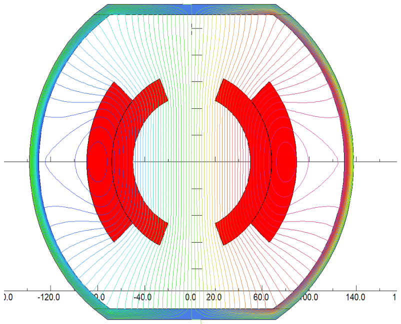
⇨ 73%/68%/65% efficiencies for 1D/2D/3D

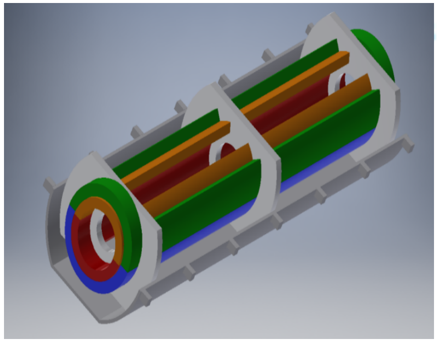


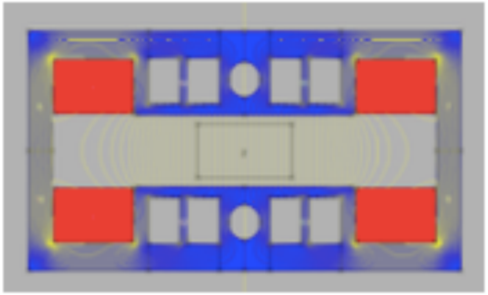
Mechanical design of conventional klystron

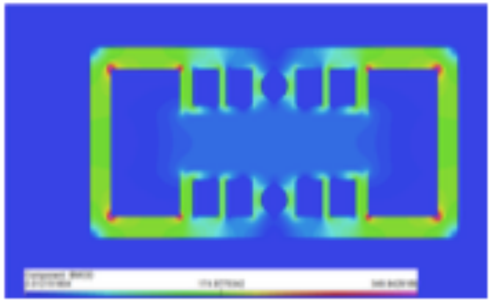
R&D on the low field dipole magnet of booster

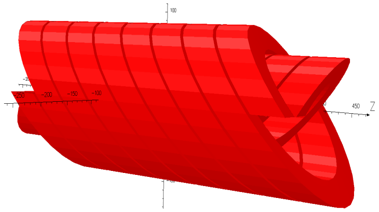
- To verify the magnet design and field simulation, a *1m* long prototype dipole magnet（booster） was developed and measured
  - Supported by IHEP workshop

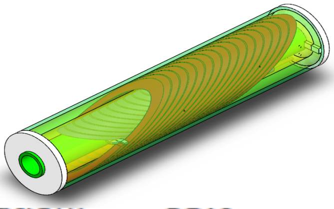


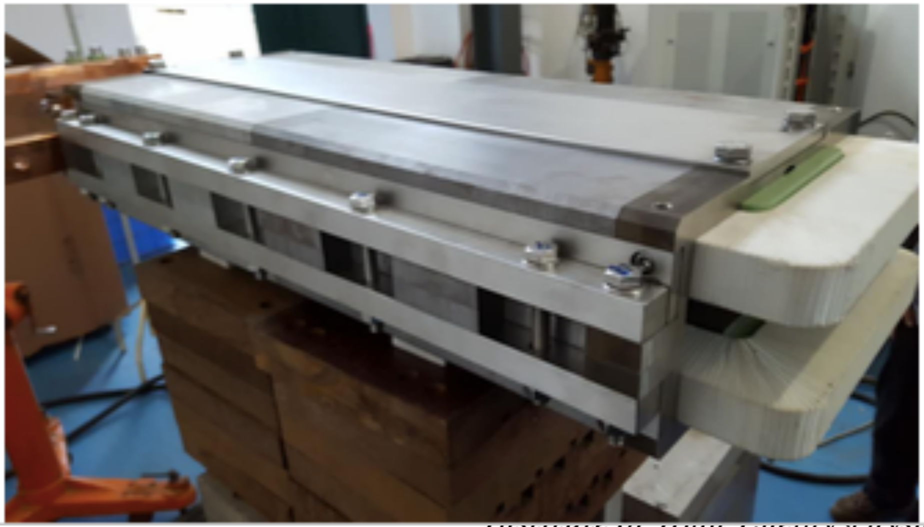




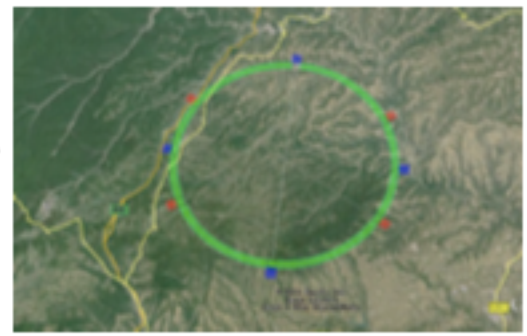








Candidate sites of CEPC

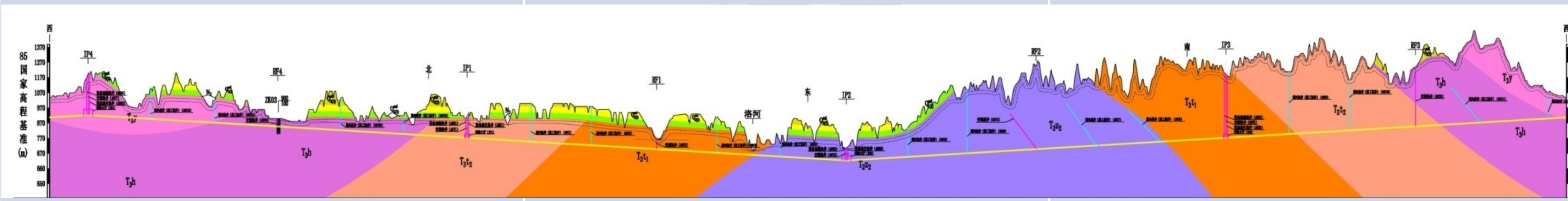


1. QingHuangDao, Hebei（completed preCDR）
2. Huangling, Shaanxi（2017.1 signed contract to exp.）
3. ShenShan, Guangdong, （completed in August, 2016)
4. …

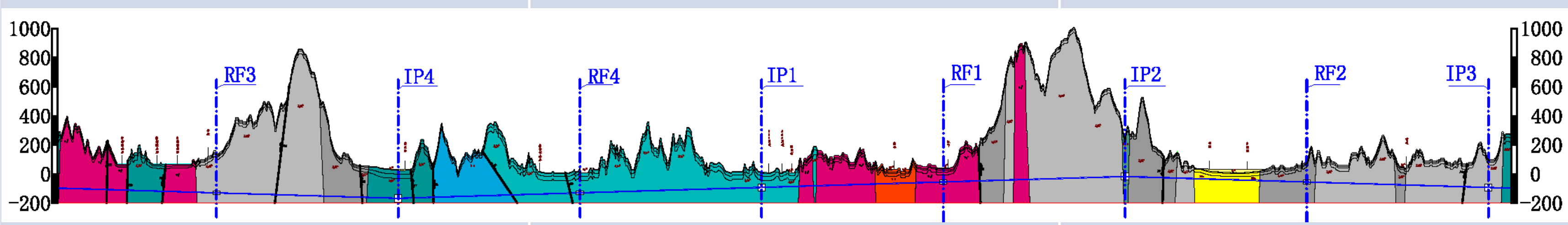
	Huangling	Shen-Shan	Funing
Construction difficulty	Moderate	Relatively difficult	Relatively easy

Project layout

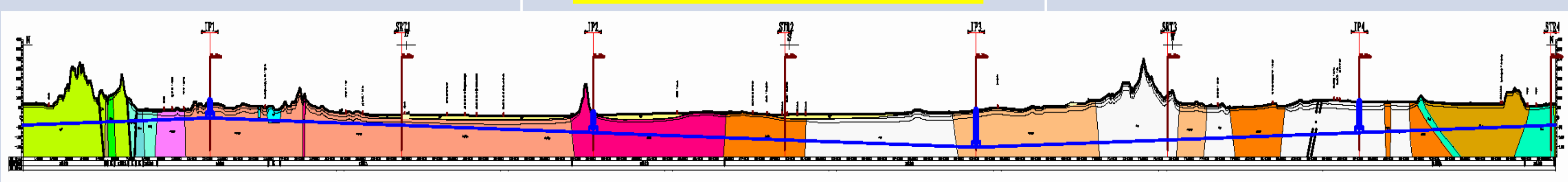
Huangling（100km）

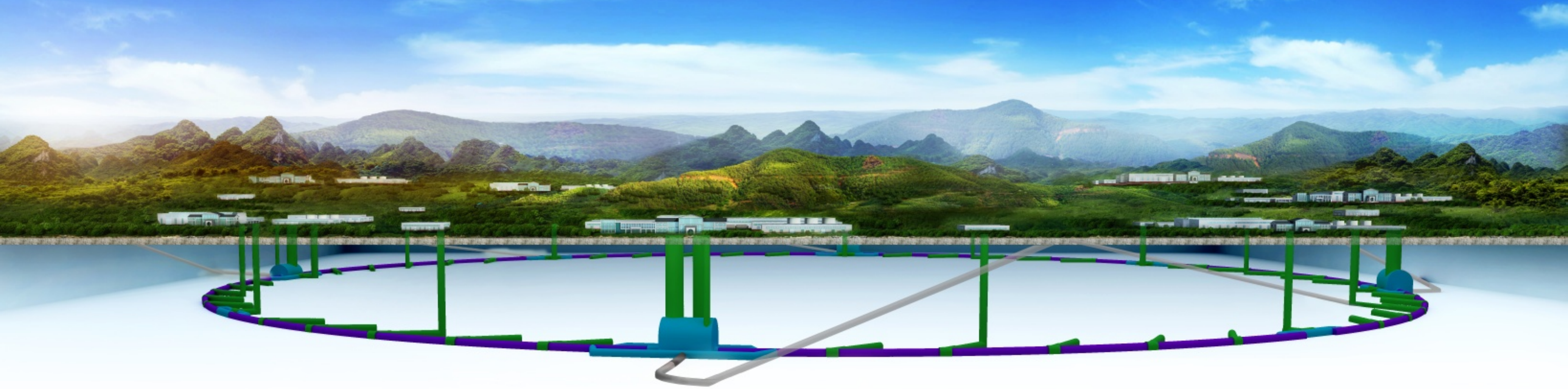


Shen-Shan（100km）

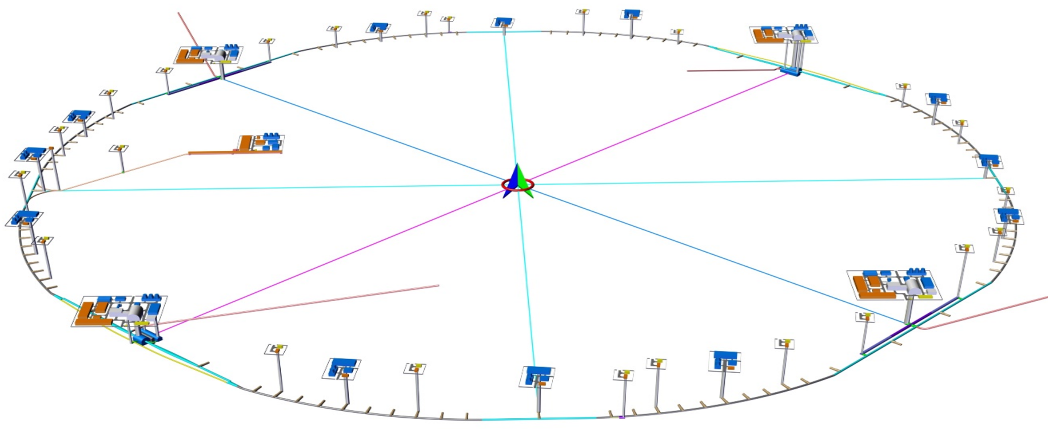


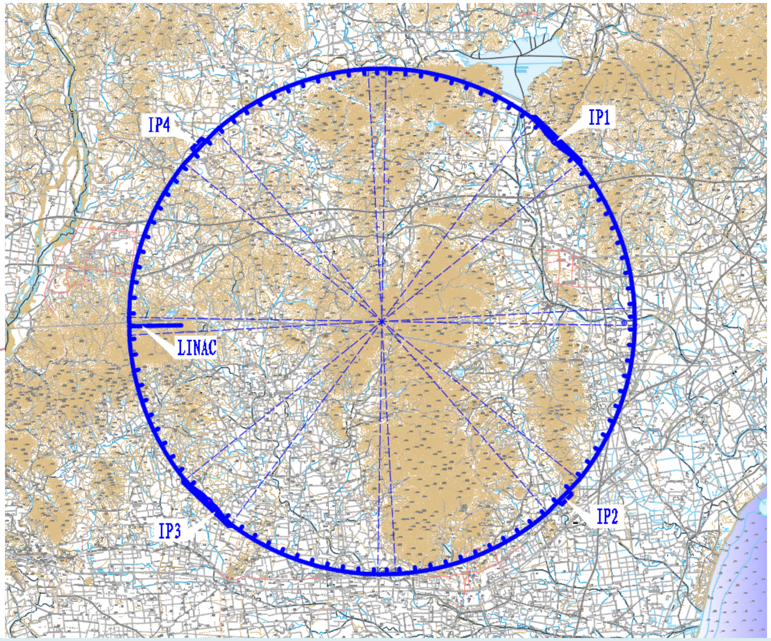
Funing（100km）





CEPC Civil Engineering (Qinhuangdao: 100km, CDR Example)





CEPC is conducting country-wide site visits and study.
Local government agencies are very receptive and supportive to CEPC.
CDR study is based on site 1 (Qinhuangdao).

CEPC power estimation

	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

International collaboration

- Strengthen cooperation with CERN
- Joined CALICE collab., ILD TPC collab., RD collab.s

- First international workshop on CEPC in Europe – Rome 2017

- Next one will in Oxford, UK, April 15-17, 2019

  …

- Fourth CEPC IAC meeting (Nov. 14-16, 2018)

  to focus on international collaboration and other aspects

CEPC funding

HEP seed money

11 M RMB/3 years (2015-2017)

国家重点研发计划
项目预申报书

FY 2016

Ministry of Science and Technology
Requested 45M RMB; 36M RMB approved

项目名称：	高能环形正负电子对撞机相关的物理和关键技术预研究
所属专项：	大科学装置前沿研究
指南方向：	新一代粒子加速器和探测器关键技术和方法的预先研究
推荐单位：	教育部
申报单位：（公章）	清华大学
项目负责人：	高原宁

R&D Funding - NSFC

Increasing support for CEPC D+RDby NSFC
5 projects (2015); 7 projects(2016)

CEPC相关基金名称（2015-2016）	基金类型	负责人	承担单位
高精度气体径迹探测器及激光校正的研究 (2015)	重点基金	李玉兰/ 陈元柏	清华大学/ 高能物理研究所 Tsinghua IHEP
成像型电磁量能器关键技术研究(2016)	重点基金	刘树彬	中国科技大学 USTC
CEPC局部双环对撞区挡板系统设计及螺线管场补偿 (2016)	面上基金	白莎	高能物理研究所
用于顶点探测器的高分辨、低功耗SOI像素芯片的若干关键问题的研究(2015)	面上基金	卢云鹏	高能物理研究所
基于粒子流算法的电磁量能器性能研究 (2016)	面上基金	王志刚	高能物理研究所
基于THGEM探测器的数字量能器的研究(2015)	面上基金	俞伯祥	高能物理研究所
高粒度量能器上的通用粒子流算法开发(2016)	面上基金	阮曼奇	高能物理研究所
正离子反馈连续抑制型气体探测器的实验研究 (2016)	面上基金	祁辉荣	高能物理研究所
CEPC对撞区最终聚焦系统的设计研究(2015)	青年基金	王逗	高能物理研究所
利用耗尽型CPS提高顶点探测器空间分辨精度的研究 (2016)	青年基金	周扬	高能物理研究所
关于CEPC动力学孔径研究(2016)	青年基金	王毅伟	高能物理研究所

IHE

~60M RMB CAS-Beijing fund, talent program

~500M RMB Beijing fund (light source)

year 2017 funding request (45M) to MOST and other agencies under preparation

funding needs for carrying out CEPC design and R&D should be fully met by end of 2018

CEPC – path to realization

Chinese Government: "actively initiating major-international science project…"

国发〔2018〕5号(2018.3.14) http://www.gov.cn/zhengce/content/2018-03/28/content_5278056.htm

- Focuses on "frontier science, large-fundamental science , global focus, international collaboration, …"
- By year 2020, 3-5 projects will be chosen to go into "preparatory stage", among which 1-2 projects will be selected. More projects will be selected in later years.
- The task of selecting the projects, and develop them further falls on the Ministry of Science and Technology (MOST)
- MOST committees formed, are writing the guidelines
- This is a likely path to realize CEPC. We are paying close attention to this opportunity

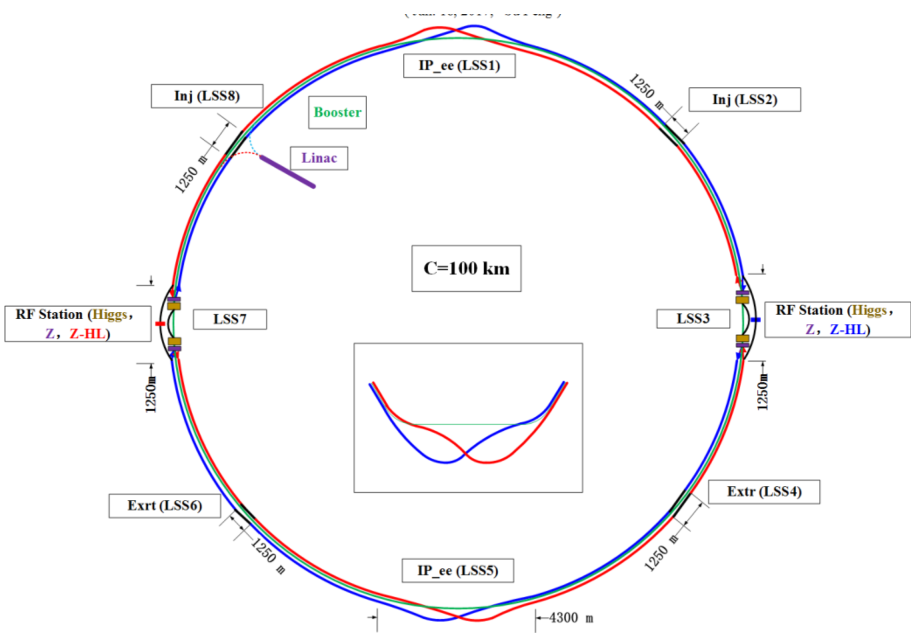
From CEPC to SppC

- SppC Baseline design
  - Tunnel circumference: 100 km
  - Dipole magnet field: 12 T, using full iron-based HTS technology
  - Center of Mass energy: >70 TeV
  - Injector chain: 2.1 TeV
  - Relatively lower luminosity for the first phase, higher for the second phase
- Energy upgrading phase
  - Dipole magnet field: 20 -24T, full iron-based HTS technology
  - Center of Mass energy: >125 TeV
  - Injector chain: 4.2 TeV (e.g., adding a high-energy booster ring in the main tunnel in the place of the electron ring and booster)
- Development of high-field superconducting magnet technology
  - Starting to develop required HTS magnet technology; before applicable iron-based HTS wire are available, models by YBCO and LTS wires can be used for specific studies (magnet structure, coil winding, stress, quench protection method etc.)

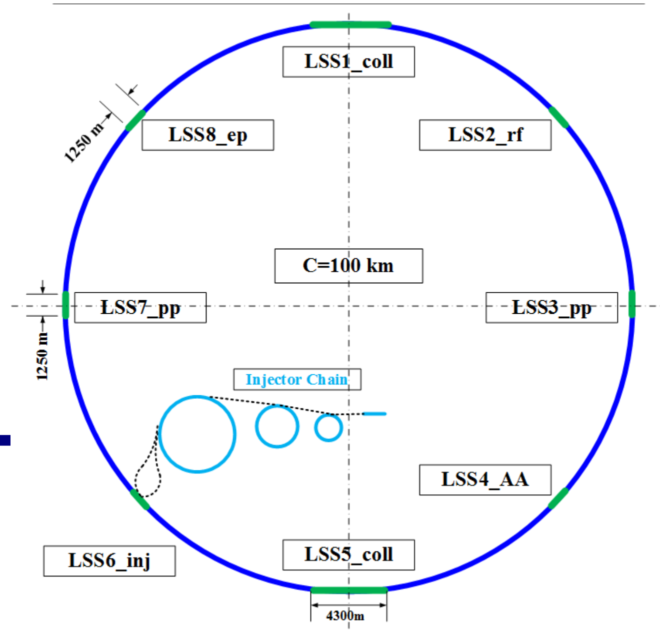
Compatibility between CEPC and SPPC

- CEPC first to be built, with potential to add SPPC later
- Allow ep collision in the future, three machines in one tunnel: e booster, ee double-ring collider, pp double-ring collider (keeping ee detectors together with SPPC in doubt)
- Several rounds of interactions between CEPC and SPPC design teams
- Layout: 8 long straights and arcs, LHC-like DS lattice, lengths for LSSs

CEPC double-ring layout- 100km



SPPC layout- 100km

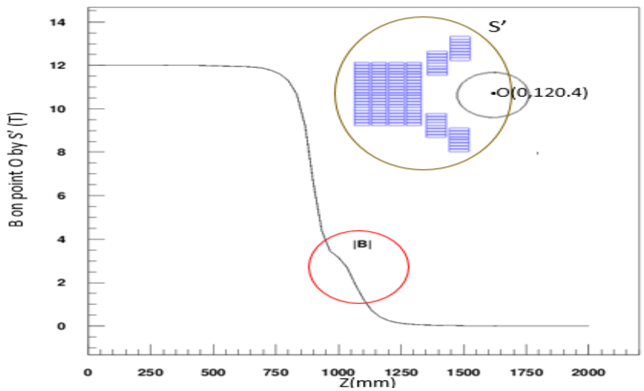


Technical challenges and R&D requirements
-High field SC magnets

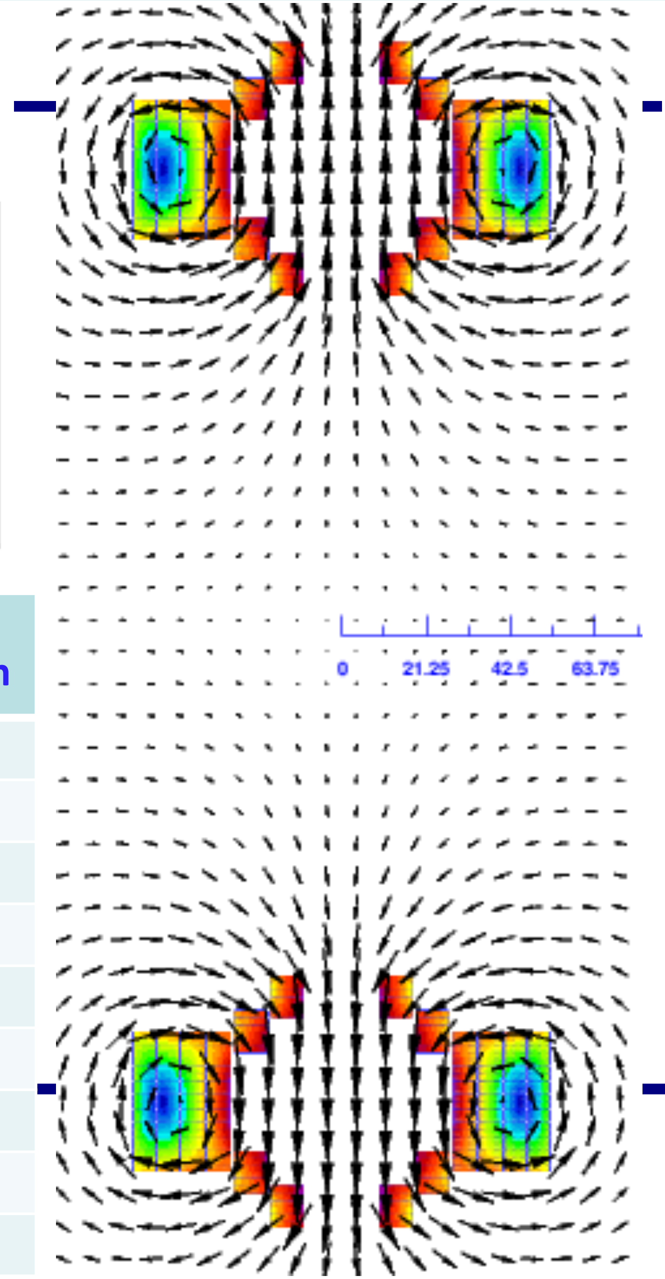
- Following the new SPPC design scope
  - Phase I: 12 T, all-HTS (iron-based conductors)
  - Phase II: 20-24 T, all-HTS
- New magnet design for 12-T dipoles
- R&D effort in 2016-2018
  - Cables, infrastructure
  - Development of a 12-T Nb_3Sn-based twin-aperture magnets (alone, with NbTi, with HTS)
- Collaboration
  - Domestic collaboration frame on HTS superconductors (material, industrial and applications) formed in October 2016
  - CERN-IHEP collaboration on HiLumi LHC magnets

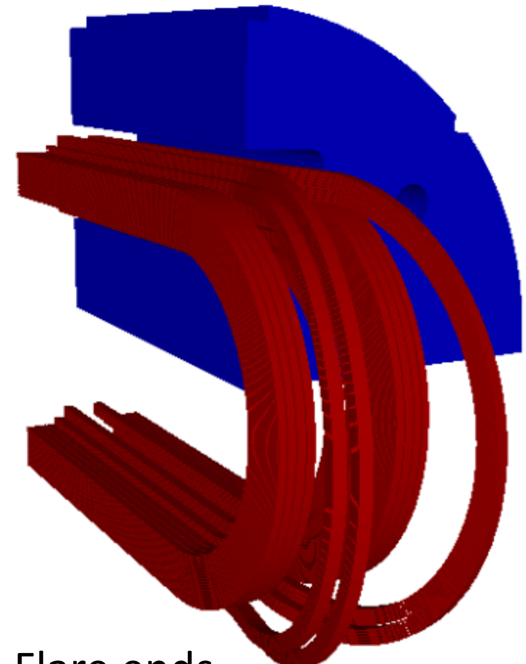
Design of 12-T Fe-based Dipole Magnet

Field quality in the aperture
$<3*10^{-4}$ within 2/3 bore
(ROXIE simulation results)

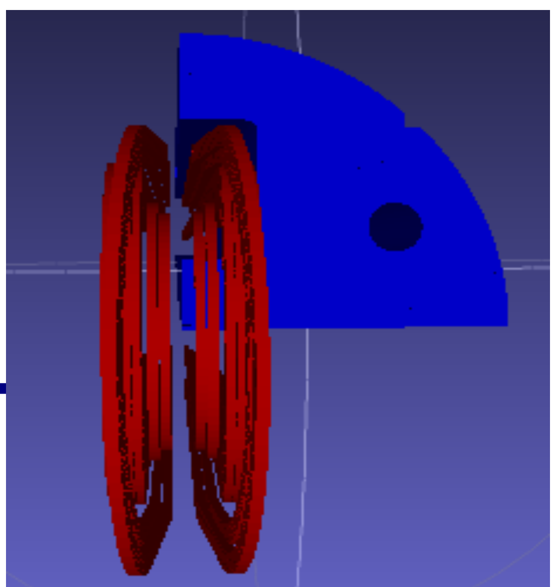


Field quality	2D with R_f=13.3mm	3D with R_f= 8/13.3 mm
b3	0.45	0.79/1.91
b5	1.01	-0.65/-2.24
b7	0.46	0.08/0.67
b9	-0.27	-0.13/-0.22
a2	3.53	-1.00/-2.31
a4	0.49	-0.46/0.69
a6	0.33	0.26/2.49
a8	0.58	-0.12/0.84
a10	2.23	0.06/2.18



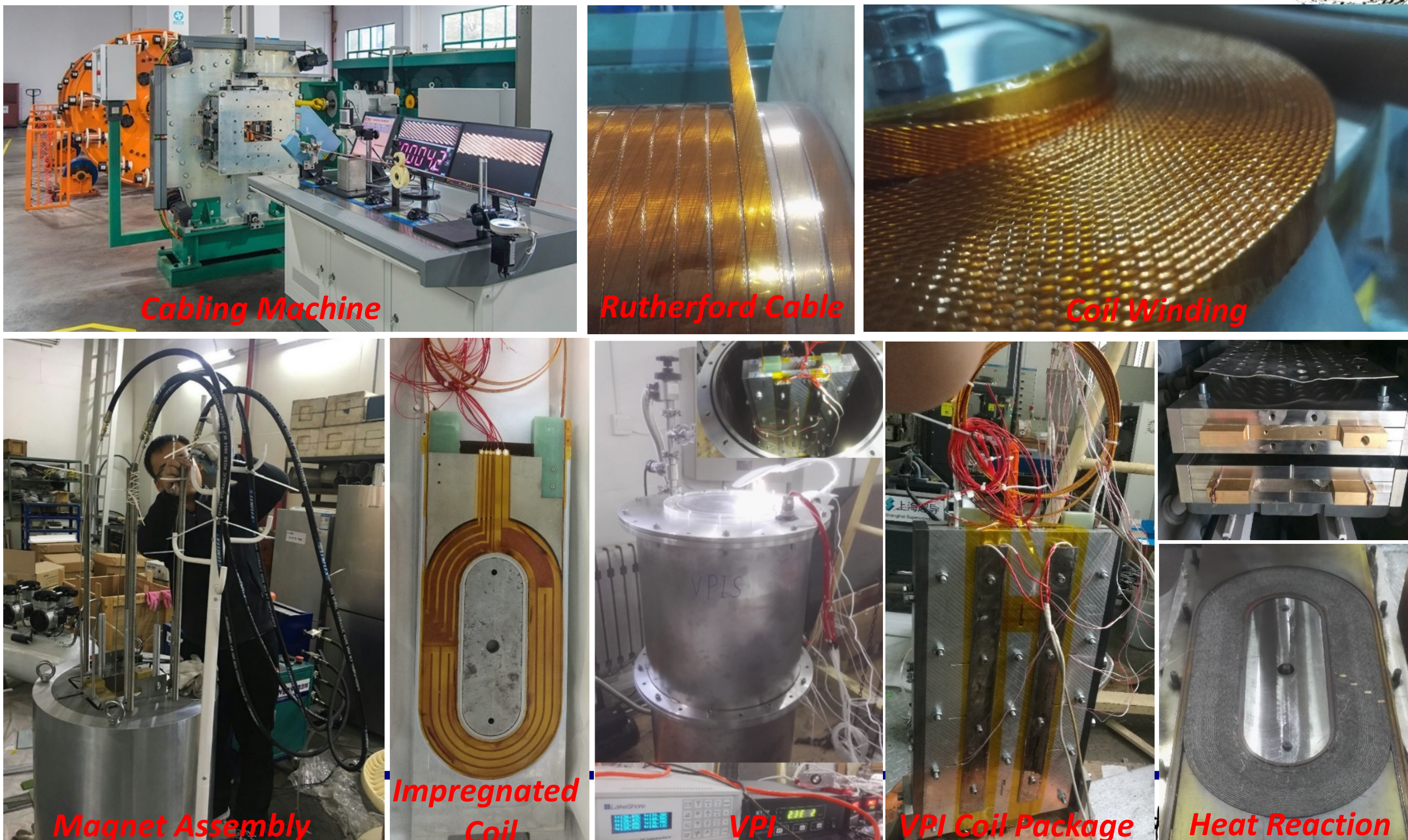


Flare ends



R&D of High Field Dipole Magnets

Fabrication of the 1st model dipole magnet (NbTi+Nb_3Sn)



Institute of High Energy Physics

Domestic Collaboration on HTS

"Applied High Temperature Superconductor Collaboration (AHTSC)" formed in Oct. 2016. Including 18 institutions and companies in China. Regular meeting every 3 months.

- ***Goal :***

a) *1) To increase the J_c of iron-based superconductor (**IBS**) by 10 times, reduce the cost to **20 Rmb/kAm @ 12T & 4.2K**, and realize the industrialization of the conductor;*

b) *2) To reduce the cost of **ReBCO and Bi-2212** conductors to 20 Rmb/kAm @ 12T & 4.2K;*

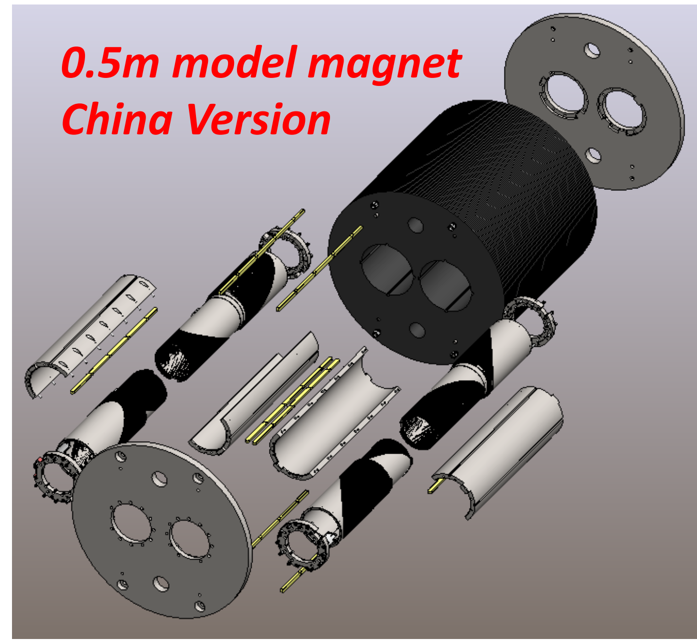
c) *3) Realization and Industrialization of IBS magnets and SRF cavities.*

- ***Working groups :*** *1) **Fundamental sciences** study; 2) **IBS** conductor R&D; 3) **ReBCO** conductor R&D; 4) **Bi-2212** conductor R&D; 5) **Performance** evaluation; 6) **Magnet and SRF** technology.*

CERN & China Collaboration

China will provide 12 units CCT corrector magnets for HL-LHC before 2022

A 0.5m model and 2.2m prototype to be fabricated and tested by June 2019



Fabrication and test of the 1st coil for the 0.5m model magnet @ Xi'an

More collaboration in future is expected between CERN and China!

Summary

1. The CEPC CDR was finished and just public released at IHEP, China, with the design of 100-km double-ring;
2. R&D for CEPC/SppC got the support of funding but need more, especially human resources;
3. Technological systems, both of CEPC and mainly HTS magnet of SppC, are gradually developed, with the support from industry in China;
4. Both CEPC & SppC, a lot of work ahead, and more budget and collaborations on R&D are expected.

Thank you for your attentions !