CEPC and SppC: Status and Future Plans

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Workshop of the future of fundamental physics

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Contents

- CEPC goals and option studies
- CEPC baseline and alternative options
- CEPC baseline study progress status
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- CEPC accelerator hardware R&D progresses
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Physics goals of CEPC-SppC

- **Electron-positron collider(90, 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**

Precision measurement + searches:
Complementary with each other !

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

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 Organization

Since Sept. 2013

Institutional Board
Y.N. GAO
J. GAO

Steering Committee
Y.F. WANG (IHEP),….

IAC
Young-Kee Kim, ….

Project Director
XC LOU
Q. QIN
N. XU

tasks:
Intl Relation– J GAO
PR – YN GAO
Conf. – J.Shan
CDR – XC Lou et al.
……

CDR Editors

theory	LT Wang et al
accelerator	W Chou et al
detector-simu.	TC Chao et al

Theory
HJ HE(TH)
JP MA(ITP)
XG HE(SJTU)

Accelerator
J. GAO(IHEP)
CY Long(IHEP)
JY TANG(IHEP)

Detector
JoaoCosta(IHEP)
S. JIN(NJU)
YN GAO(TH)

CEPC Funding

HEP seed money

11 M RMB/3 years (2015-2017)

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

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

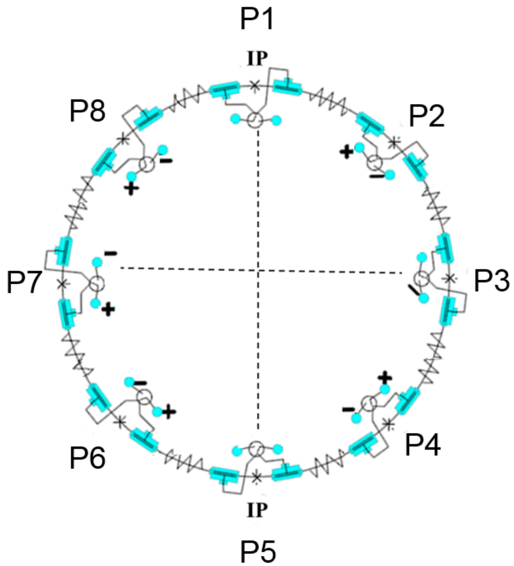
~60M RMB CAS-Beijing fund, talent program

~500M RMB Beijing fund (light source)

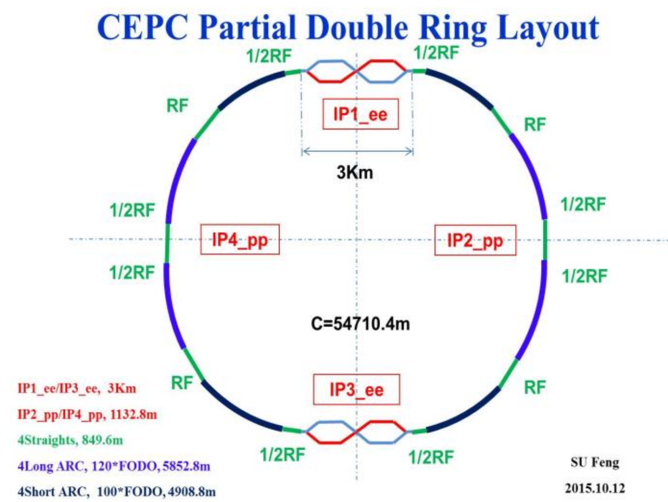
year 2017 funding request (45M) to MOST and other agencies under preparation

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

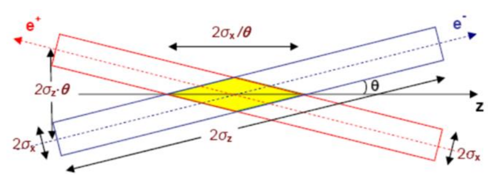
CEPC four options towards CDR



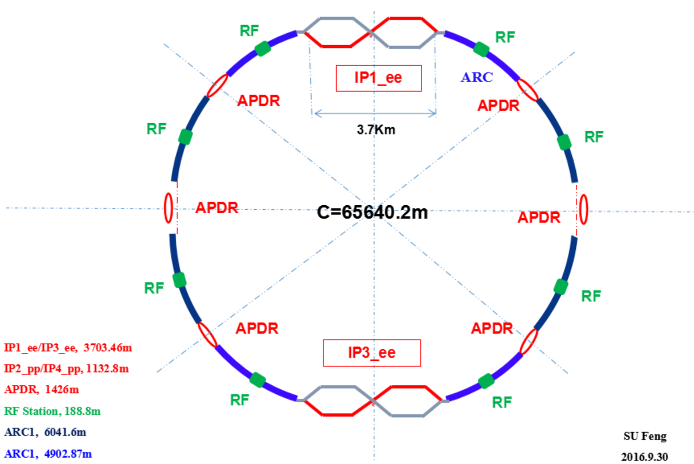
Since Oct 2012



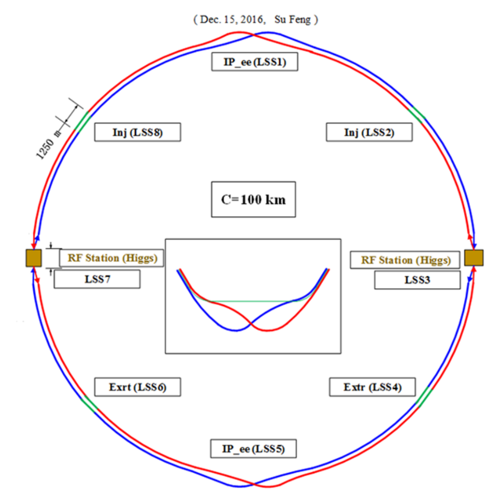
Since May 2015



CEPC Advanced Partial Double Ring Option II

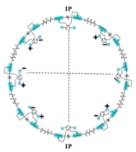
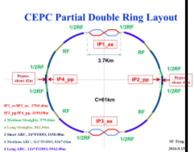
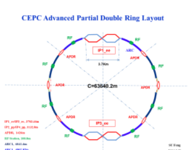
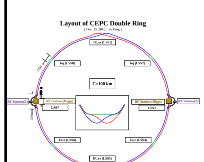


Since May 2016

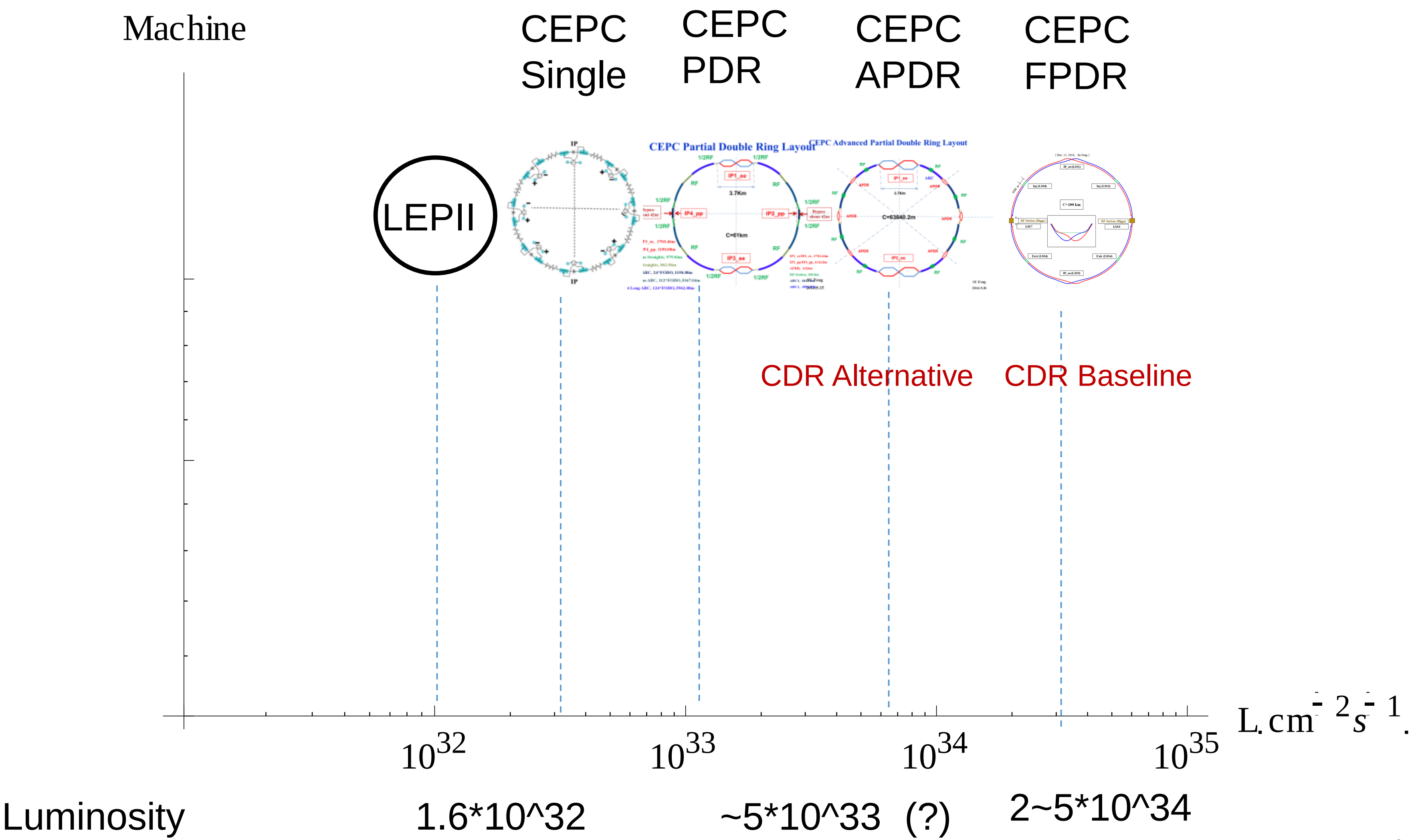


Since Nov 2016

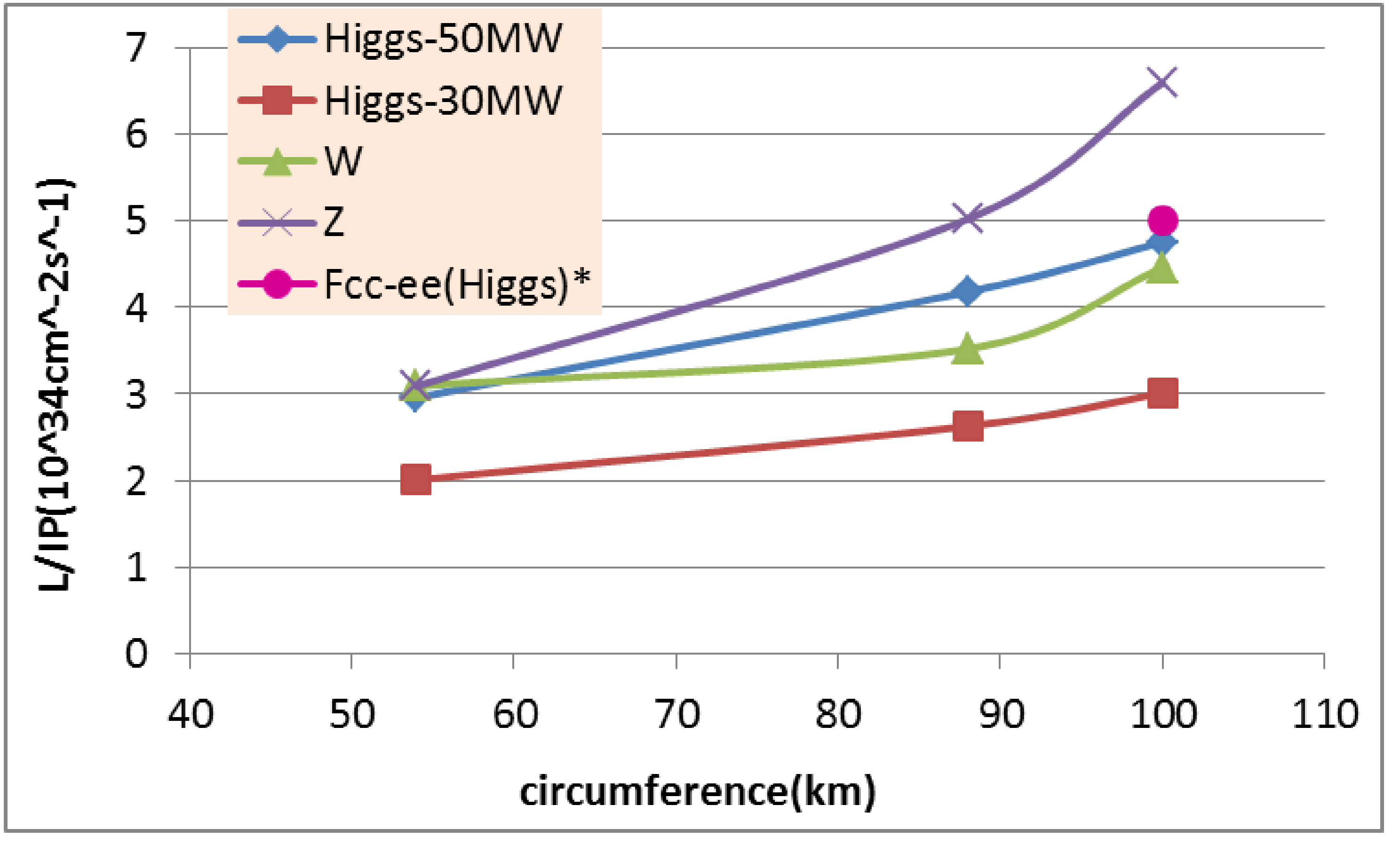
CEPC option characteristics comparison

Option	Pretzel	Sawtooth effect	Beam loading	Dynamic Aperture	Orbit Correction	H luminosity	Z-pole luminosity	AC power	SRF syetem compatible for H and Z
 Single Ring (SR)	Yes ★	Very high ★	Low ★★★★★	Very small ★	Very hard ★	Low ★★★	Very low ★	High ★	Difficult ★★★
 Partial Double Ring（PDR）	No ★★★★★	High ★★	Very High ★	Medium ★★★	Hard ★★	Medium ★★★	Medium ★★★	Low ★★★★★	Difficult ★★★
 Advanced Partial Double Ring （APDR）	No ★★★★★	High ★★★	High ★★★	Medium ★★★	Medium ★★★	Medium ★★★	High ★★★★	Low ★★★★★	Difficult ★★★
 Full Parrtial Double Ring （FPDR）	No ★★★★★	Vey Low ★★★★	Low ★★★★★	Large ★★★★★	Easy ★★★★★	High ★★★★★	Very High ★★★★★	Low ★★★★★	Very good ★★★★★

Machine option luminosity potentials



CEPC Luminosity vs circumference



* Fabiola Gianotti, Future Circular ColliderDesign Study, ICFA meeting, J-PARC, 25-2-2016.

Framework for the CEPC Conceptual Design Report

（2017年1月14日）

1) The baseline CEPC accelerator is a 100km Double Ring configuration of the circumference of 100km with shared SCRF single beam line for electron and positron (this scheme is refered as Hybrid Double Ring or Fully Partial Double Ring design)

2) The booster has the same circumference as main collider ring in the same tunnel with injection energy of 10GeV

3) The injection lianc exit energy for electron and positron is 10GeV

4) There are two IPs

5) The full crossing angle is 30mrad with L*=1.5m (**changed to 2.2m now**)

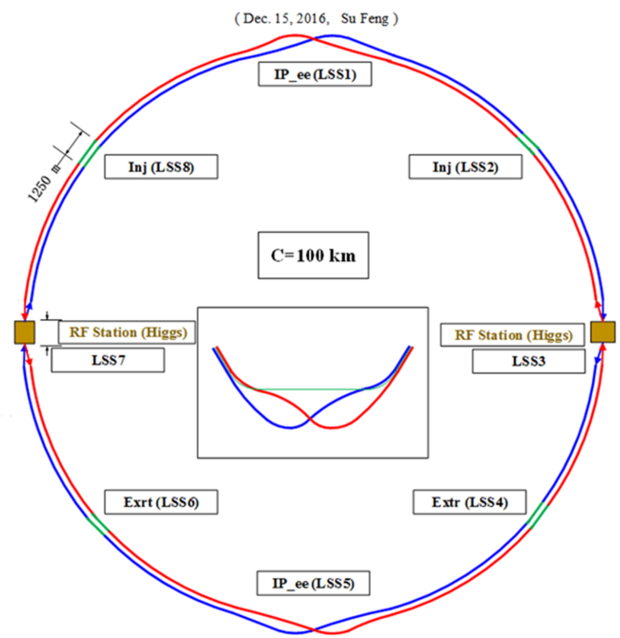
6) The SRF acelerator system for Higgs and Z-pole operator are independent from each other

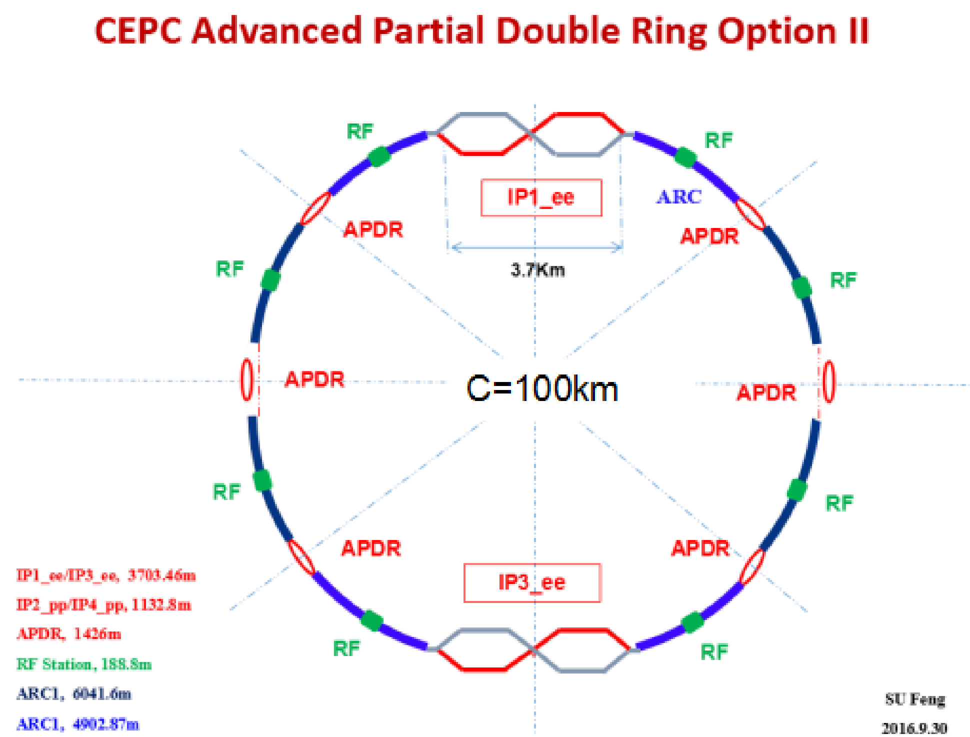
7) The CEPC baseline design is to reach the luminosity higher than 2*10^34/cm^2s at Higgs energy with ~30MW synchrotron radiation power per beam and the luminosity high than 10^34/cm^2s for Z-pole energy

6) The Advanced Partial Double Ring Scheme with 8 partial double ring regions is defined as CEPC Alternative Scheme with the aim of reducing the construction cost and the efforts to study the posible solution to the sawtooth and beamloading effetcts

7) SppC is located the in same tunnel as CEPC simultaneously, with two IPs, and CEPC and SppC could be operated a the same time in principle.

CEPC two shcemes towards CDR





CEPC Baseline Design

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

CEPC Alternative Design

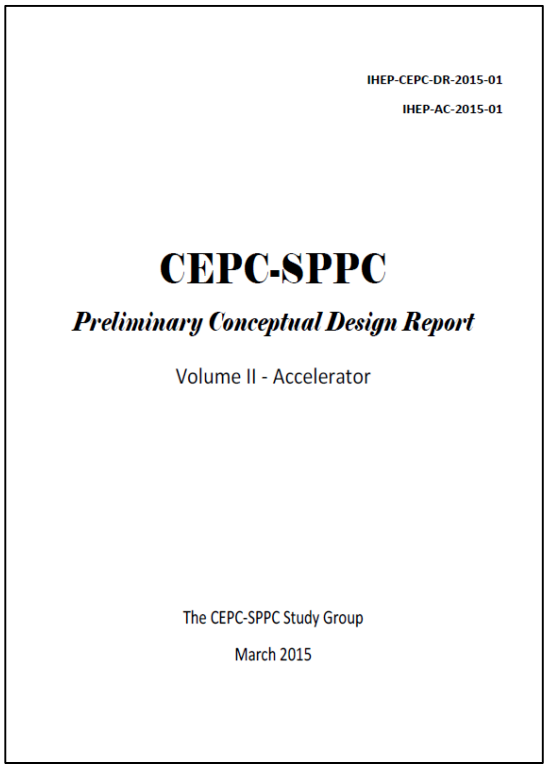
Lower cost and reaching the fundamental requirement for Higgs and Z luminosities, under the condition that sawtooth and beam loading effects be solved

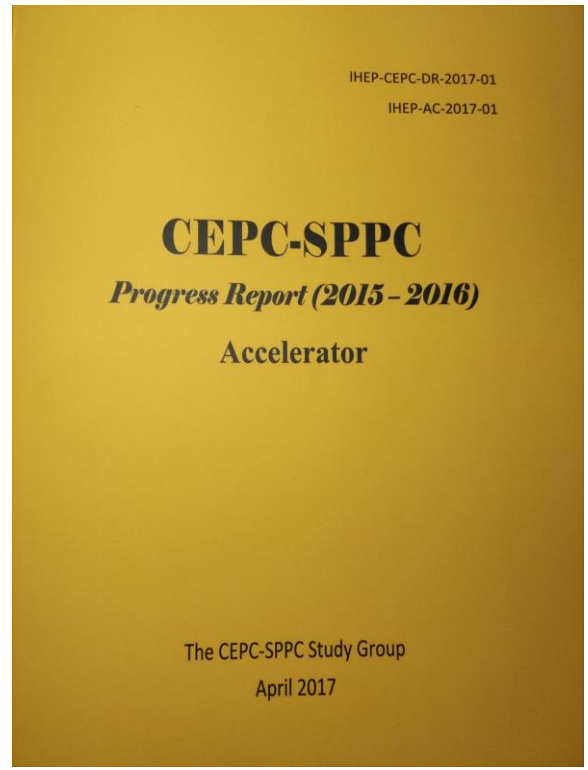
CEPC Main Ring SRF Operation Schemes

（2017年1月14日）

- Ring type, RF layout and fill pattern: double ring with common RF cavity, two RF sections, half ring filled to avoid parasitic collision and transient beam loading
- Operate at different energies: Higgs, W and Z-pole use the same cavity and cryomodule type with different power-on amounts. When W or Z is operating, detune the unused cavities and kept at 2 K to extract HOM power. If limited by beam instabilities and feedback capability, push the unused cavities off beam-line.
- Operate in high luminosity modes: The total cavity number (input power limited), cell number per cavity (gradient and HOM power limited) and klystron number are designed with margin to run in high luminosity or high voltage mode for Higgs, W and Z. Coupling of some input couplers should be about 10 times adjustable.
- Higher luminosity Z upgrade: for possible upgrade of the Z luminosity to higher than 1 x 10^{35} $cm^{-2}s^{-1}$, install separate high current cavities (KEKB/BEPCII type) as RF by-pass.

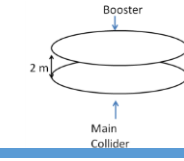
http://cepc.ihep.ac.cn





CEPC CDR will be completed at the end of 2017

CEPC Accelerator Chain



10 GeV

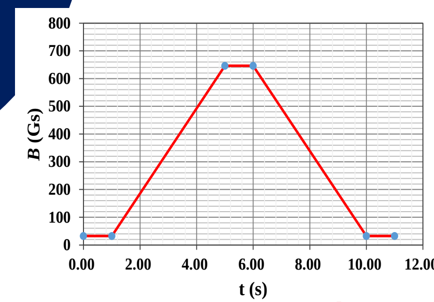
Injector

Electron

Positron

Booster

Energy Ramp
10 ->45/120GeV



Booster Cycle (0.1 Hz)

Three rings in the sane channel:

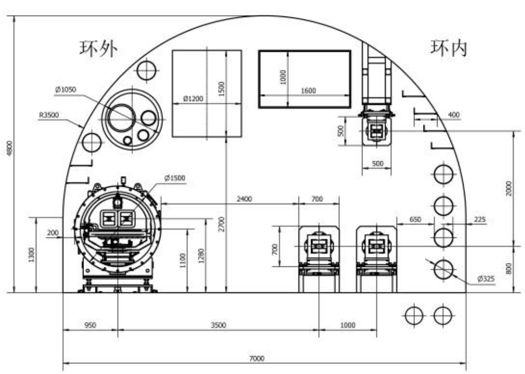
- **CEPC & booster**
- **SppC**

- Double Ring
- Common cavities for Higgs
- Two RF sections in total
- Two RF stations per RF section
- 14 modules per RF station
- 28 modules per RF section
- 56 modules in total
- Six 2-cell cavities per module
- One klystron for two cavities

Main Ring

45/120 GeV

C=100km



Parameters for CEPC double ring

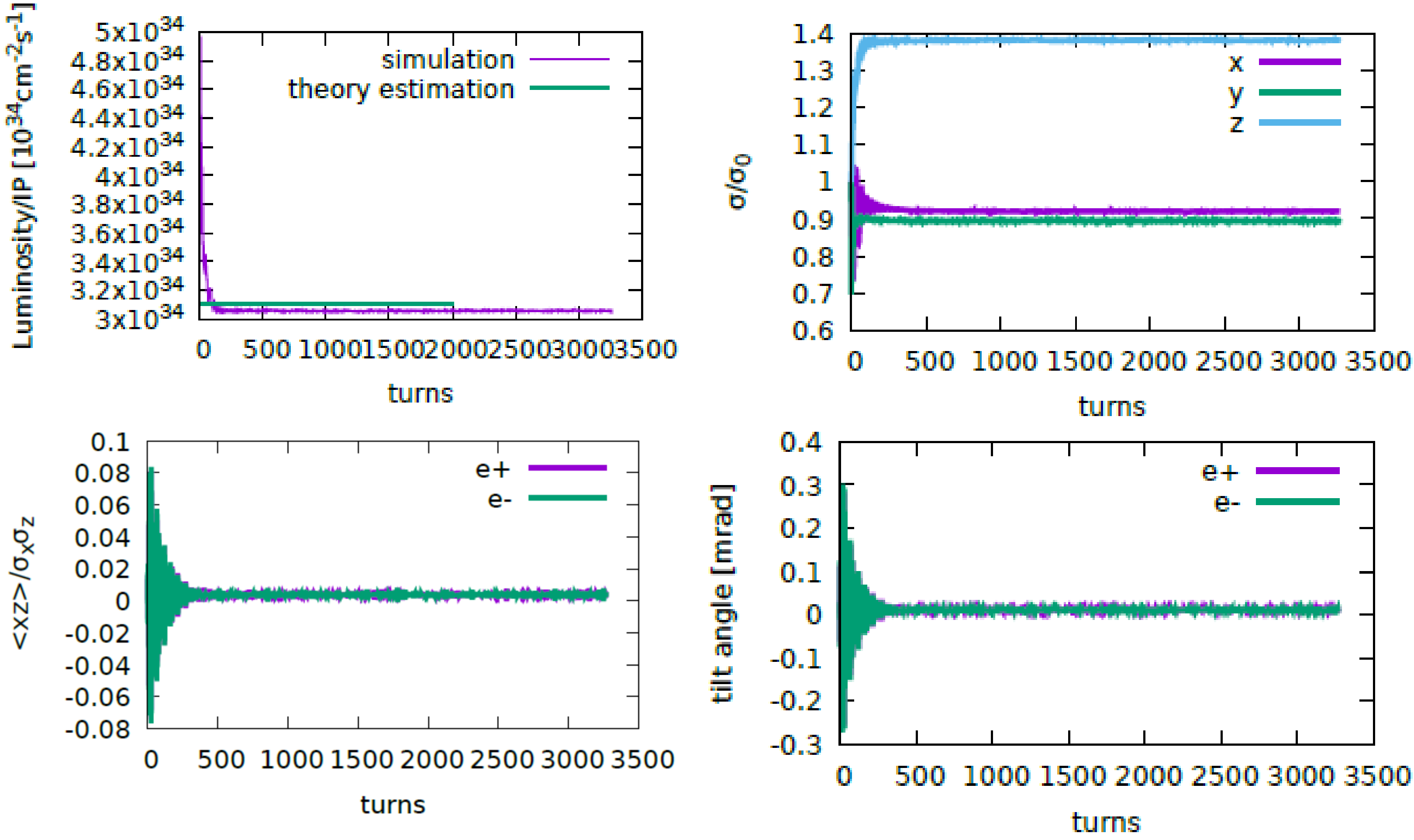
(20170306-100km_2mmβy, D. Wang)

	Pre-CDR	*tt*	*Higgs*	*W*	*Z*
Number of IPs	2	2	2	2	2
Energy (GeV)	120	175	120	80	45.5
Circumference (km)	54	100	100	100	100
SR loss/turn (GeV)	3.1	7.55	1.67	0.33	0.034
Half crossing angle (mrad)	0	16.5	16.5	16.5	16.5
Piwinski angle	0	1.6	3.19	5.69	4.29
N_e/bunch (10^{11})	3.79	1.41	0.968	0.365	0.455
Bunch number	50	98	644 (412)	5534	21300
Beam current (mA)	16.6	6.64	29.97 (19.2)	97.1	465.8
SR power /beam (MW)	51.7	50	50 (32)	32	16.1
Bending radius (km)	6.1	11	11	11	11
Momentum compaction (10^{-5})	3.4	1.3	1.14	1.14	4.49
β_{IP} x/y (m)	0.8/0.0012	0.2/0.002	0.171/0.002	0.171 /0.002	0.16/0.002
Emittance x/y (nm)	6.12/0.018	3.19/0.0097	1.31/0.004	0.57/0.0017	1.48/0.0078
Transverse σ_{IP} (um)	69.97/0.15	25.3/0.14	15.0/0.089	9.9/0.059	15.4/0.125
ξ_x/ξ_y/IP	0.118/0.083	0.016/0.055	0.013/0.083	0.0055/0.062	0.008/0.054
RF Phase (degree)	153.0	122.2	128	126.9	165.3
V_{RF} (GV)	6.87	8.92	2.1	0.41	0.14
f_{RF} (MHz) (harmonic)	650	650	650	650 (217800)	650 (217800)
Nature σ_z (mm)	2.14	2.62	2.72	3.37	3.97
Total σ_z (mm)	2.65	2.7	2.9	3.4	4.0
HOM power/cavity (kw)	3.6 (5cell)	0.53(5cell)	0.64(2cell) (0.41)	0.36(2cell)	1.99(2cell)
Energy spread (%)	0.13	0.14	0.098	0.065	0.037
Energy acceptance (%)	2	2	1.5		
Energy acceptance by RF (%)	6	2.6	2.1	1.1	1.1
n_γ	0.23	0.23	0.26	0.15	0.12
Life time due to beamstrahlung_cal (minute)	47	50	52		
F (hour glass)	0.68	0.89	0.96	0.98	0.96
L_{max}/IP ($10^{34}cm^{-2}s^{-1}$)	2.04	0.62	3.13 (2.0)	5.15	11.9

Beam-beam simulation-100km (H-HL)

zhangy@ihep.ac.cn

- 161202-100km-2mm-h-highlum, (0.51,0.55,0.037)



New modifications for CEPC

- L*=2.2m (1.5m)
- Crossing angle： 33mrad (30mrad)
- Strength of QD0: 150T/m (200T/m)
- Emittance : 1.31nm (1.56nm)
- Strength of detector solinoid: 3T (3.5T)
- Strength of anti-solinoid: 6.6T (13T)

CEPC parameters toward CDR

	Higgs	*Z-low lum.*	*Z-high lum.*
Number of IPs	2	2	2
Energy (GeV)	120	45.5	45.5
Circumference (km)	100	100	100
SR loss/turn (GeV)	1.61	0.033	0.033
Half crossing angle (mrad)	16.5	16.5	16.5
Piwinski angle	2.28	6.33	6.33
N_e/bunch (10^{10})	9.68	2.3	2.3
Bunch number	420	3510	27000
Beam current (mA)	19.5	38.8	298.5
SR power /beam (MW)	**31.4**	**1.3**	**9.9**
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	0.17/0.0038	0.17/0.0038
Transverse σ_{IP} (um)	20.6/0.085	7.81/0.087	7.81/0.087
ξ_x/ξ_y/IP	0.025/0.085	0.017/0.053	0.017/0.053
RF Phase (degree)	128	151	151
V_{RF} (GV)	**2.03**	**0.069**	**0.069**
f_{RF} (MHz) (harmonic)	650	650 (217800)	650 (217800)
Nature σ_z (mm)	**2.75**	**2.92**	**2.92**
Total σ_z (mm)	2.85	3.0	3.0
HOM power/cavity (kw)	0.42 (2cell)	0.096 (2cell)	0.74 (2cell) half cavities
Energy spread (%)	0.096	0.036	0.036
Energy acceptance (%)	1.1		
Energy acceptance by RF (%)	1.98	1.2	1.2
n_γ	0.19	0.12	0.12
Life time due to beamstrahlung_cal (minute)	63		
F (hour glass)	0.93	0.987	0.987
L_{max}/IP ($10^{34}cm^{-2}s^{-1}$)	2.0	1.0	7.7

CEPC Main Ring SRF Parameters

Zhai Jiyuan 20170706. 100 km, H shared cavities. Main Ring parameter: Wang Dou 20170607 & 20170306	**H**	**Z**	**Z-HL**
Luminosity / IP [10^{34} $cm^{-2}s^{-1}$]	2	1	12
SR power / beam [MW]	32	1.9	16
RF frequency [MHz]	650	650	650
RF voltage [GV]	2.1	0.049	0.14
Beam current / beam [mA]	19.2	54	466
Bunch charge [nC]	15.5	3.5	7.3
Bunch length [mm]	2.9	4.0	4.0
Cell number / cavity	2	2	2
Cavity number in use	336	24	96
Gradient [MV/m]	13.6	8.9	6.3
Input power / cavity [kW]	190	158	335
Cavity number / klystron	2	2	2
Klystron power [kW]	800	800	800
Klystron number	168	12	48
HOM power / cavity [kW]	0.4	0.1	1.8
Cavity number / cryomodule	6	6	6
Cryomodule number	56	4	16
Q_0 at operating gradient	1E+10	1E+10	1E+10
Total wall loss @ 4.5 K eq. [kW]	22	0.7	1.4
Optimal Q_L	9.6E+05	4.9E+05	1.2E+05

Parameter table vs lattice parameters

	Higgs		Z	
	Estimate	Real lattice	Estimate	Real lattice
Emittance (nm)	1.31	1.31	1.48	1.52
α_p (10^{-5})	1.14	1.16	4.49	4.42
U0 (MeV)	1670	1708	34	35
Energy spread (%)	0.098	0.099	0.037	0.038
σ_{z0} (mm)	2.9	2.92	4.0	3.99

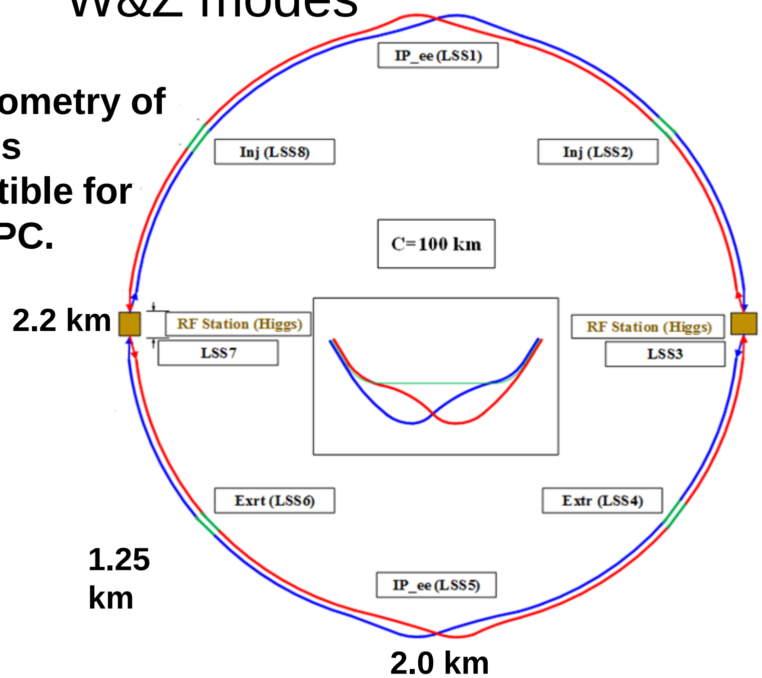
Difference between parameter design and real lattice: < 3%

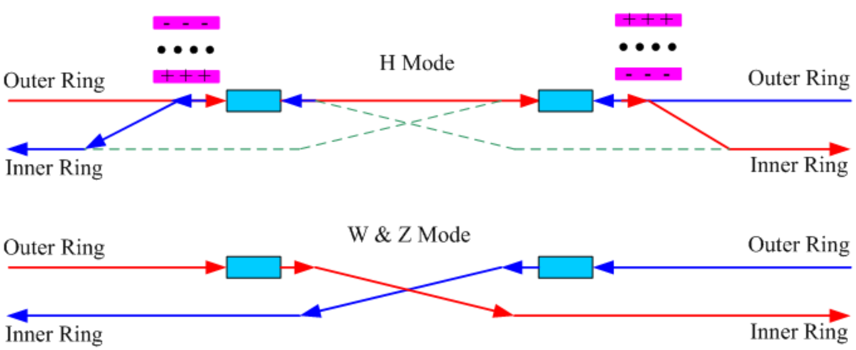
CEPC Double Ring Baseline

Y.W. Wang

- With new parameter list (20170306-100km_2mmβy)
- With new IR parameters L*=2.2m, θc=33mrad, GQD0=150T/m
  - to lower the requirements of anti-solenoid and QD0 field
  - Bsol=6.6T, BQD0=3.3T which are realizable
- Compatible lattices for H, W and Z modes
  - β*, emittance
  - common cavities for H, W and Z modes, bunches filled in full ring for W&Z modes

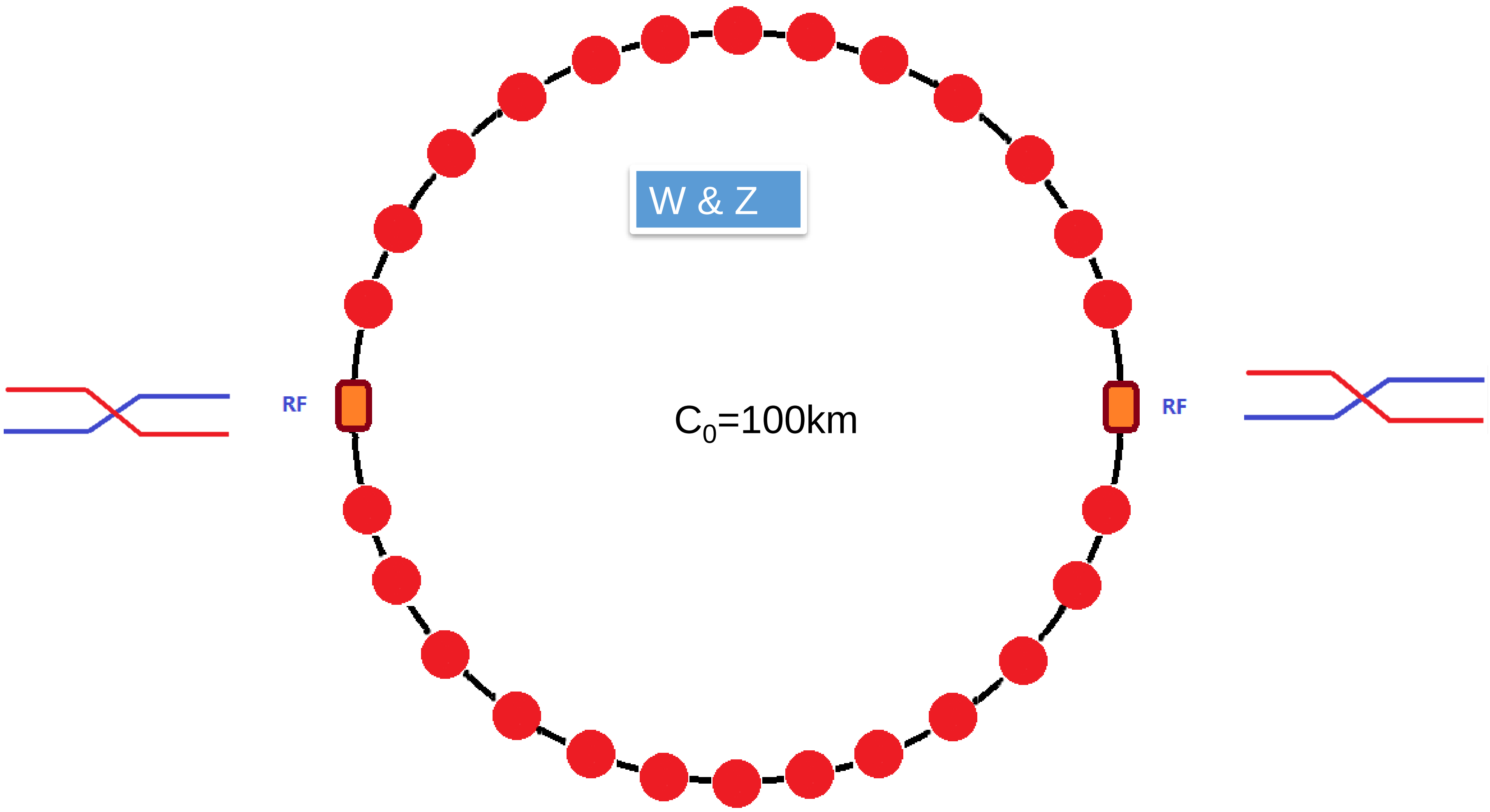
The geometry of CEPC is compatible for the SPPC.





CEPC W and Z bunch distributions

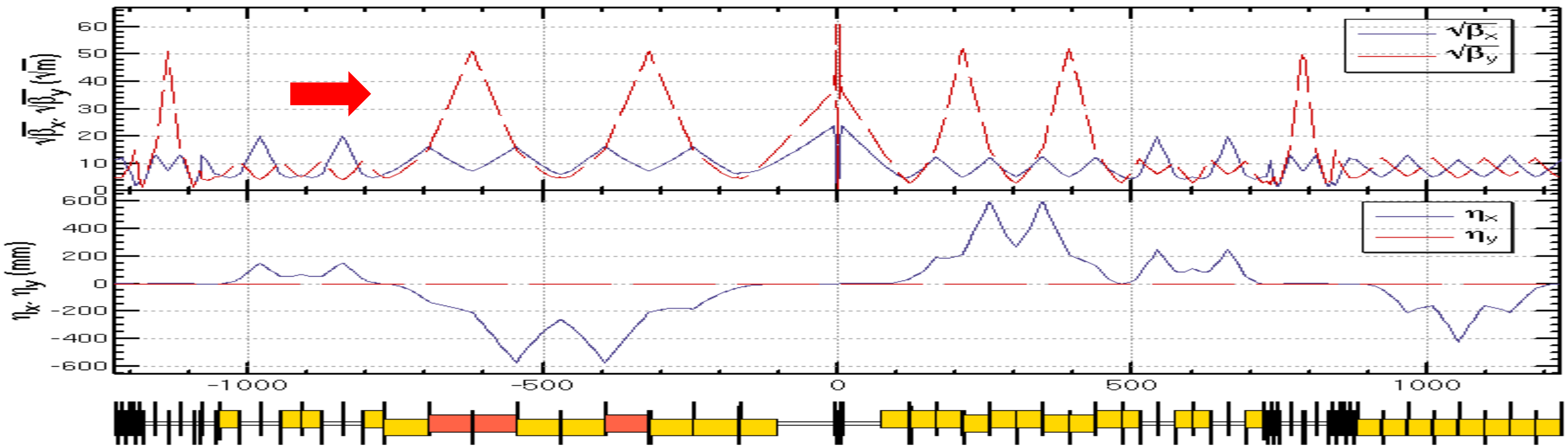
C.H. Yu



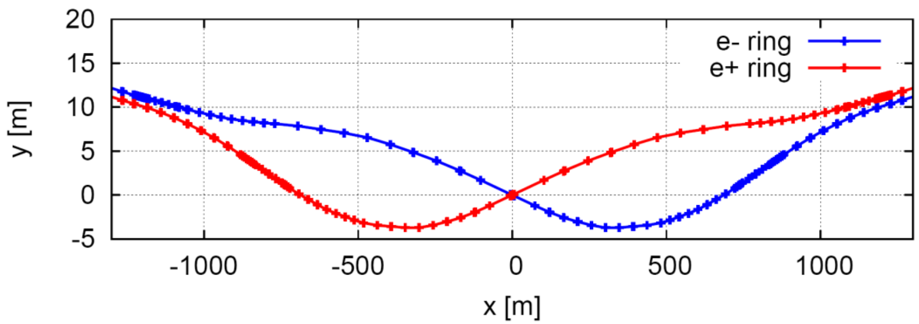
Lattice design for interaction region

Y.W. Wang

- Provide local chromaticity correction
- **L*=2.2m, θc=33mrad, GQD0=150T/m**
- Reverse bending direction of last bends to avoid synchrotron radiation hitting IP
- IR of IP upstream: **Ec < 100 keV within 400m, last bend Ec < 60 keV**
- IR of IP downstream: Ec < 300 keV within 250m, last bend Ec < 120 keV



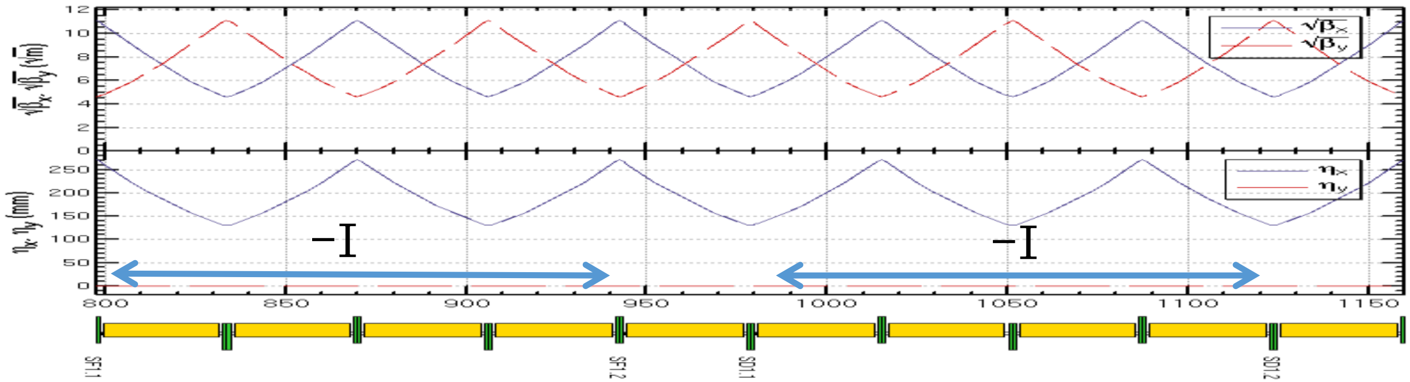
L*= 2.2m
βx*= 0.171mm
βy*= 2mm
GQD0≅-150T/m
GQF1≅100T/m
LQD0=1.73m
LQF1=1.48m

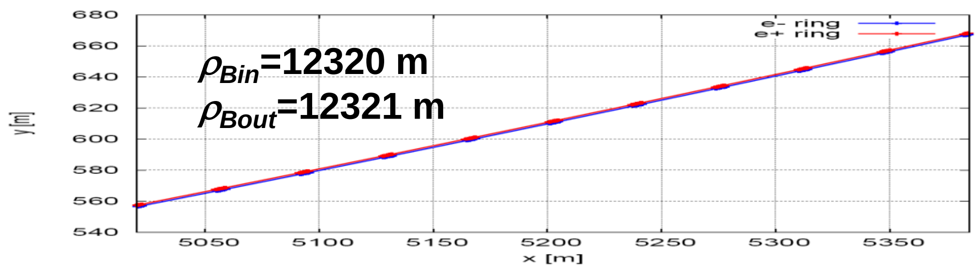


Lattice design for ARC region

Y.W. Wang

- **FODO cell, 90°/90°, non-interleaved sextupole scheme**
  - period N=5cells
  - all 3rd and 4th resonance driving terms (RDT) due to sextupoles cancelled, except small 4Qx, 2Qx+2Qy, 4Qy, 2Qx-2Qy
  - **tune shift dQ(Jx, Jy) is very small**
    - DA on momentum: large
  - **Chromaticity dQ(δ) need to be corrected with many families**
    - DA off momentum: with many families to correct dQ(δ) and –I break down

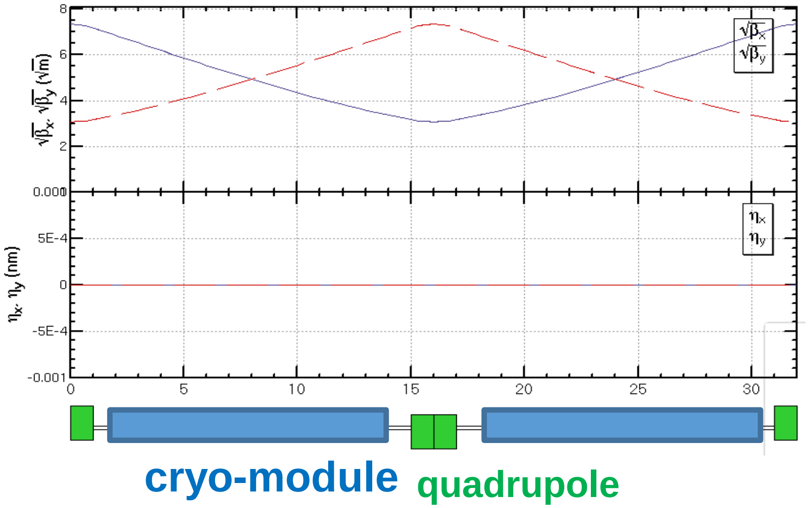




FODO cell for cryo-module

Y.W. Wang

- 336 / 6 / 2RF stations / 2 sections / 2= 7 cells in each section
- get a smallest average beta function to reduce the multi-bunch instability caused by RF cavities
  - 90/90 degree phase advance
  - as short as possible distance between quadrupoles, but should be larger than a module length (12m)

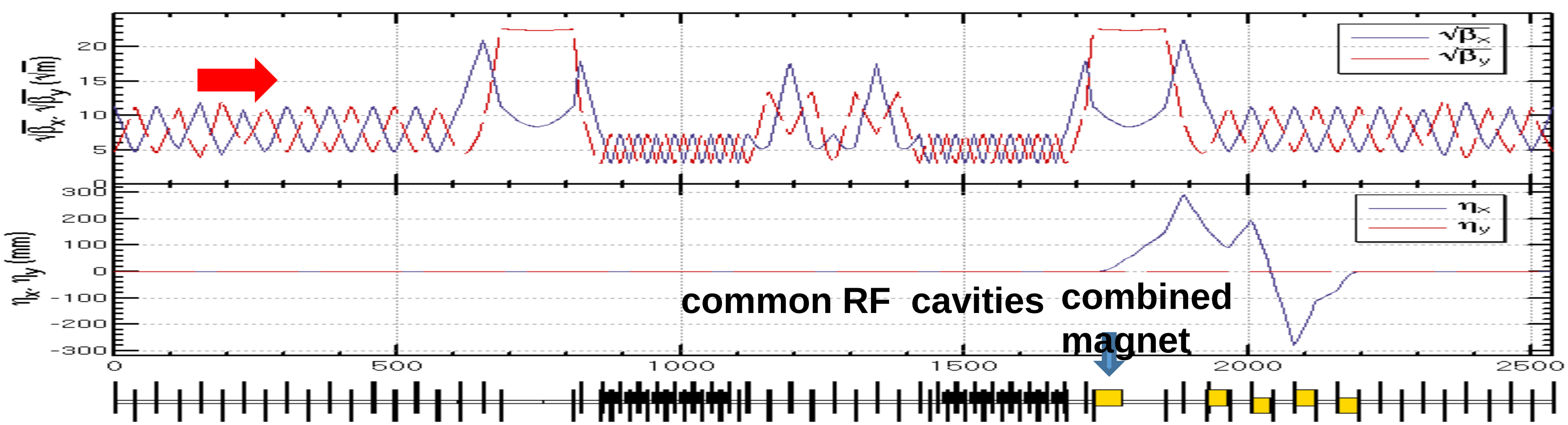


90/90 deg
Half cell: 14m+2m
βmax: 53.8 m
βmin: 9.5 m

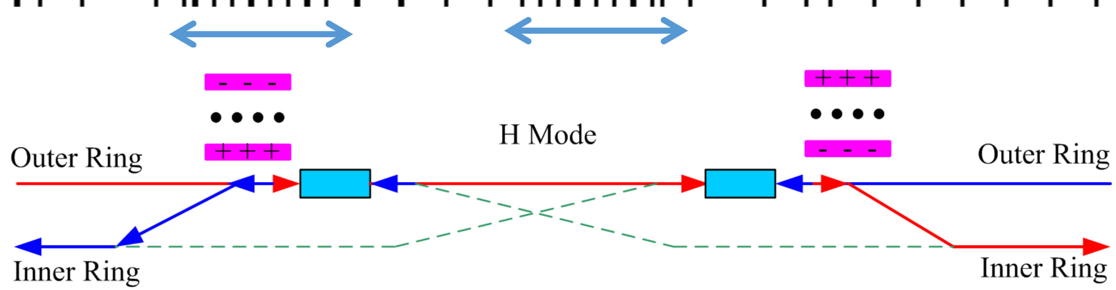
Lattice design of RF region

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: Oide, ICHEP16)
- **RF region divided into two sections for bypassing half numbers of cavities in Z mode**
- Deviation of outgoing beam is Δx=1.0 m for bypassing the cryo-modules



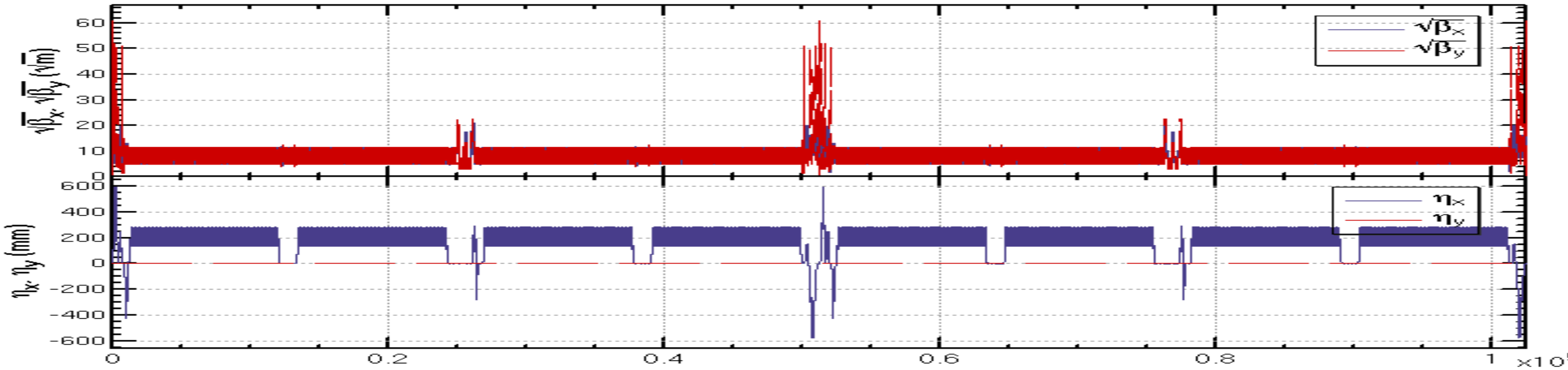
Esep=1.8 MV/m
Lsep=50m
Ldrift=75m
Δx=10cm at entrance of quad

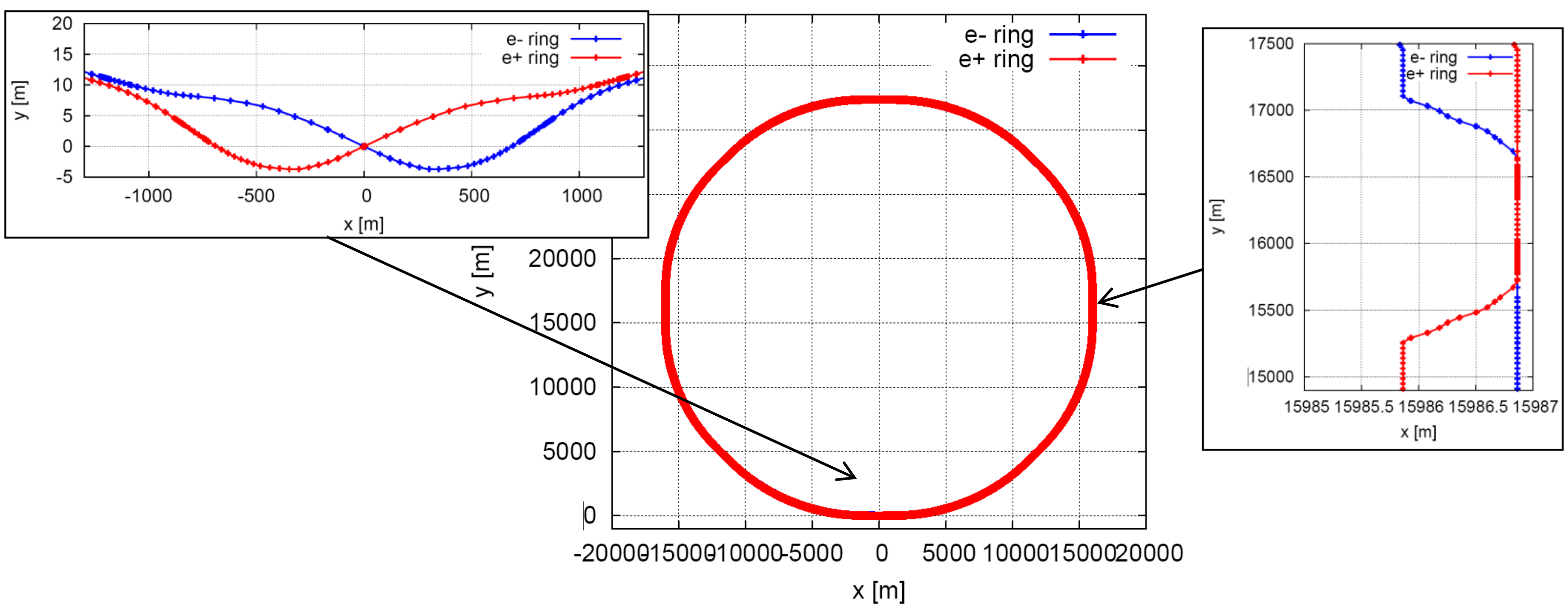


Lattice design for whole ring

Y.W. Wang

- A lattice fulfilling requirements of the parameters list, geometry, photon background and key hardware

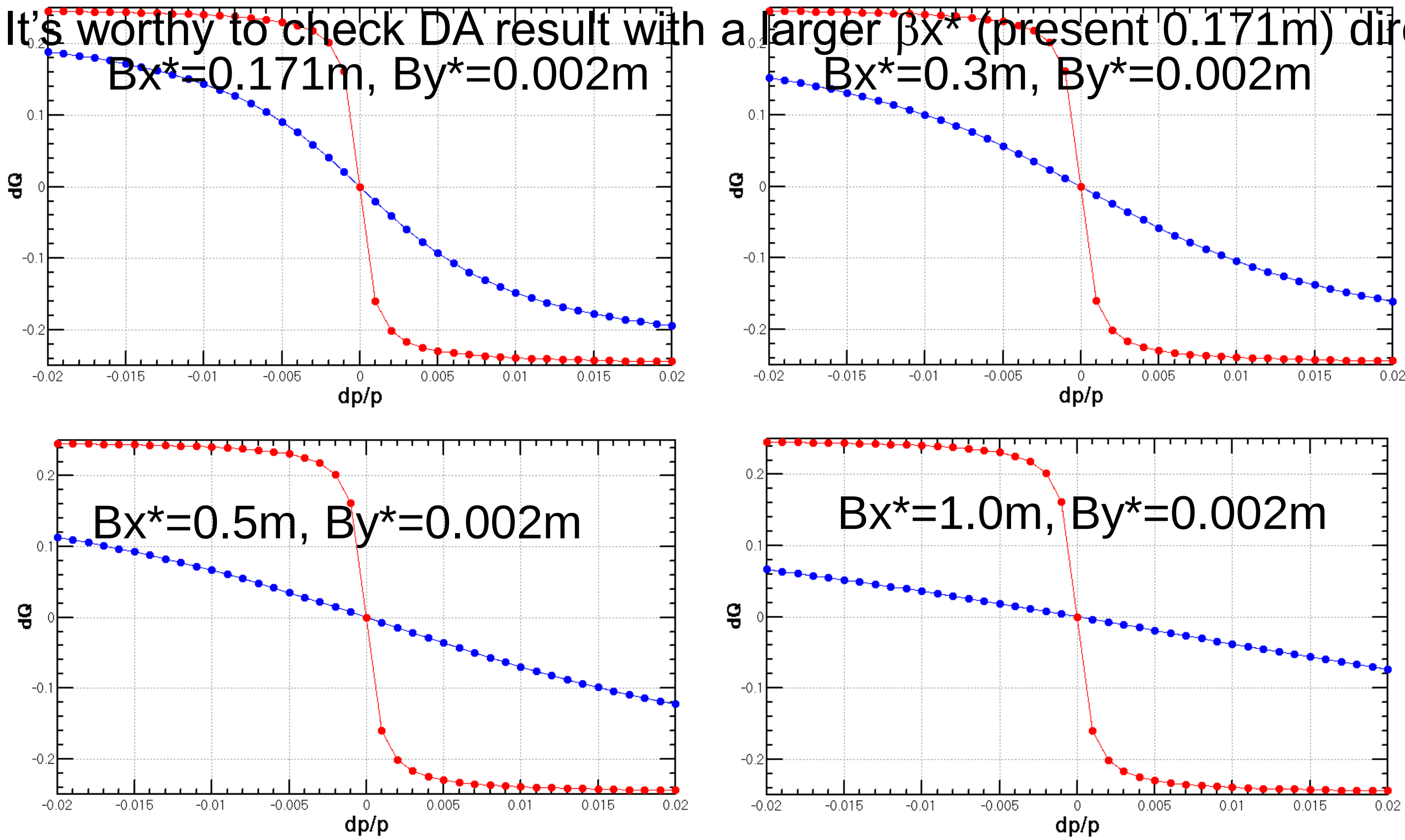




Natural chromaticity vs. βx*

Yiwei Wang

- Significant 3rd order horizontal chromaticity found in interaction region when βx*<0.3m
  - Necessary to make dedicated high order chromaticity correction on horizontal plane
  - It's worthy to check DA result with a larger βx* (present 0.171m) directly.



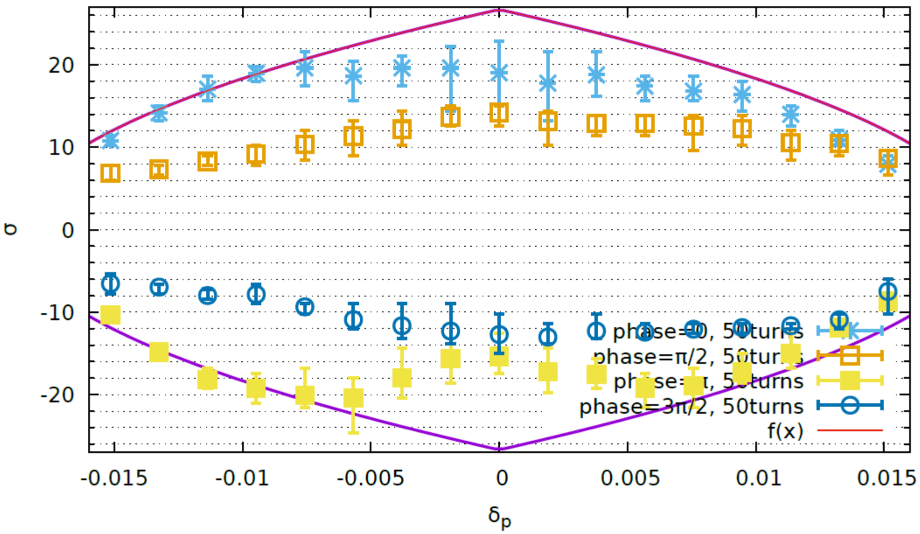
With TELE only

L*=2.2 m, G1=150 T/m, G2=100T/m, d2=0.5m

DA optimized with fluctuation

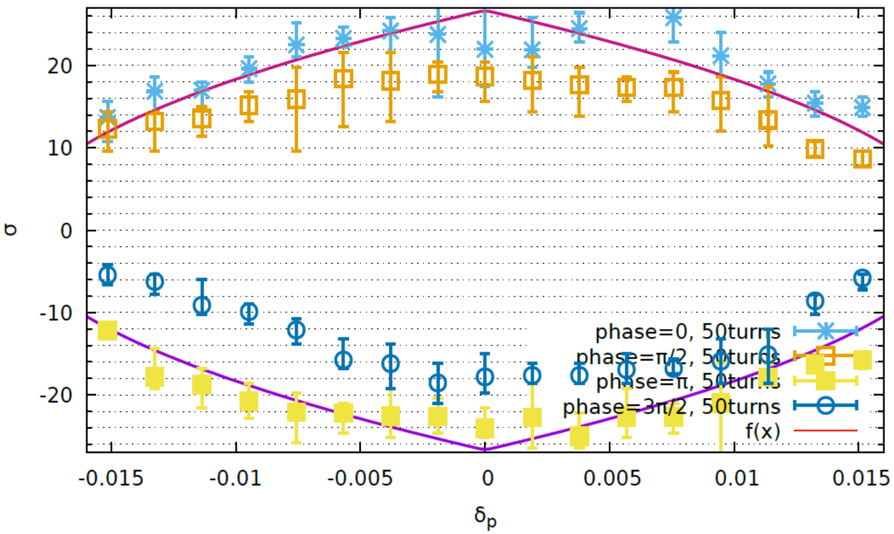
Yuan Zhang, Yiwei Wang et al.

Bx*=0.171m, By*=0.002m



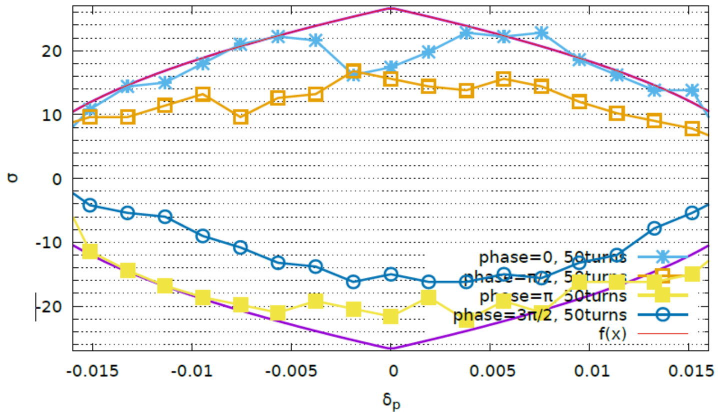
wyw-170713-bx0.171

Bx*=0.37m, By*=0.002m

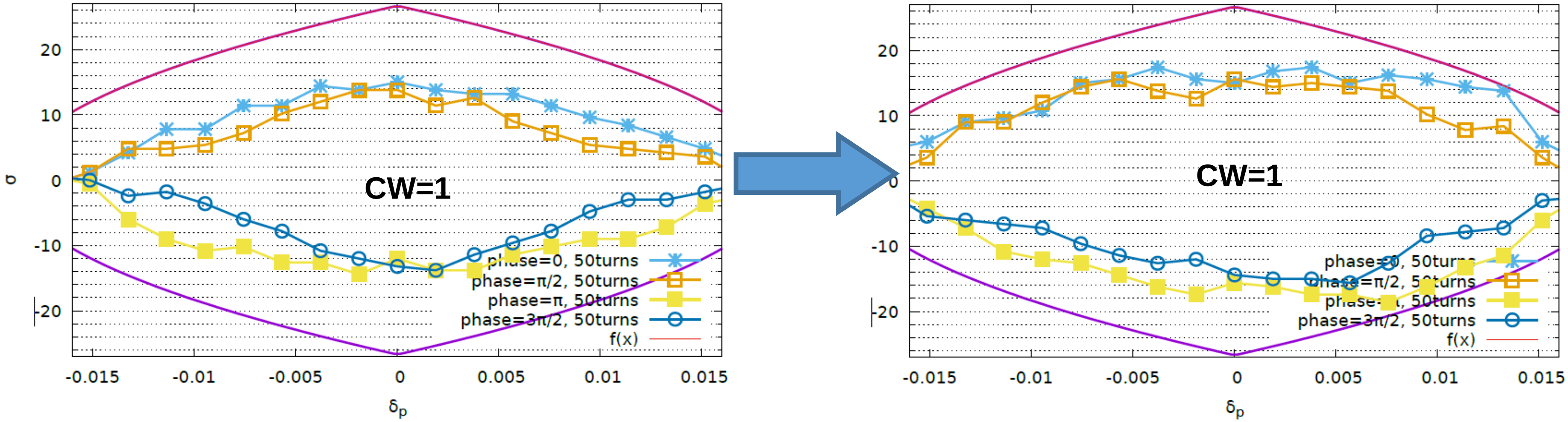


wyw-170724-bx0.37

Optimize DA with Crab Waist



CW=0



Z lattice

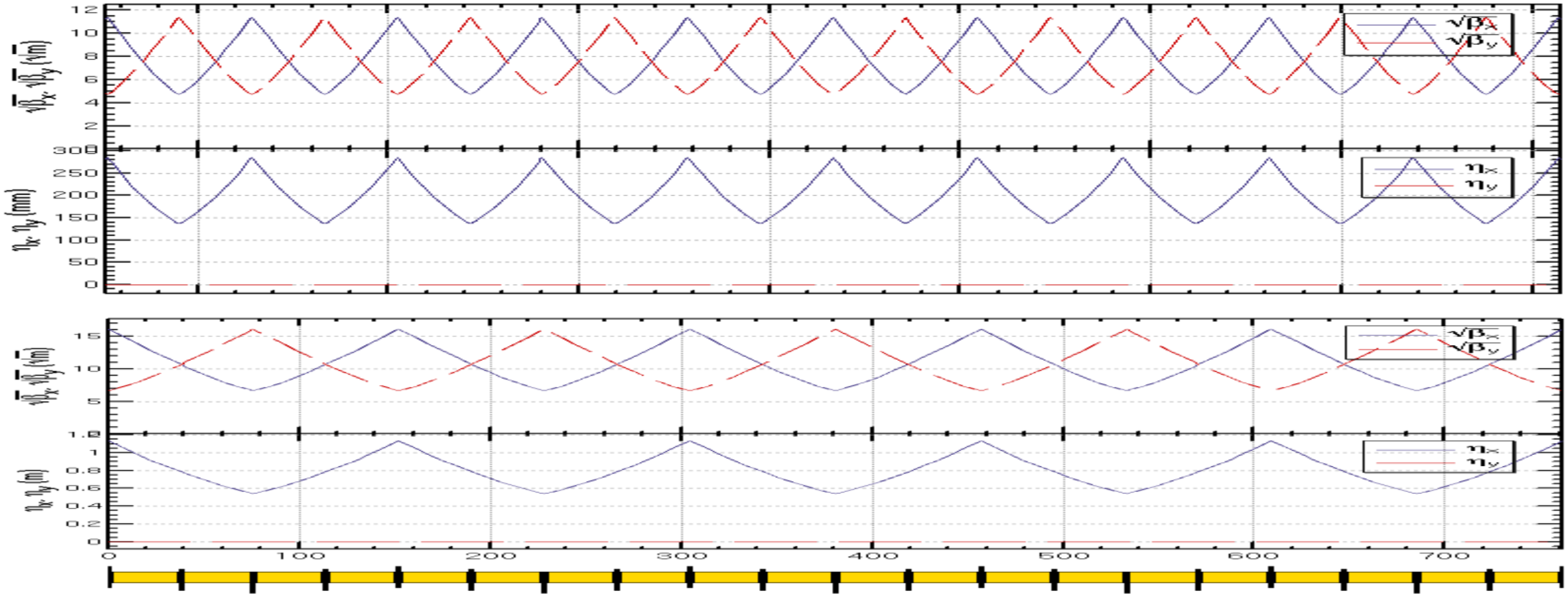
Y.W. Wang

- Z lattice should be compatible with the H lattice
  - Layout of the magnets should be kept except the RF region
    - Keep the geometry of H lattice by keeping all the bends
    - Fulfill the parameters of Z by re-matching the strength of other magnets
  - **ARC region: Two FODO cells combined into one FODO cell in Z mode**
  - **RF region: half numbers of cavities in H mode bypassed in Z mode**
  - Interaction region: matching section re-matched

ARC region

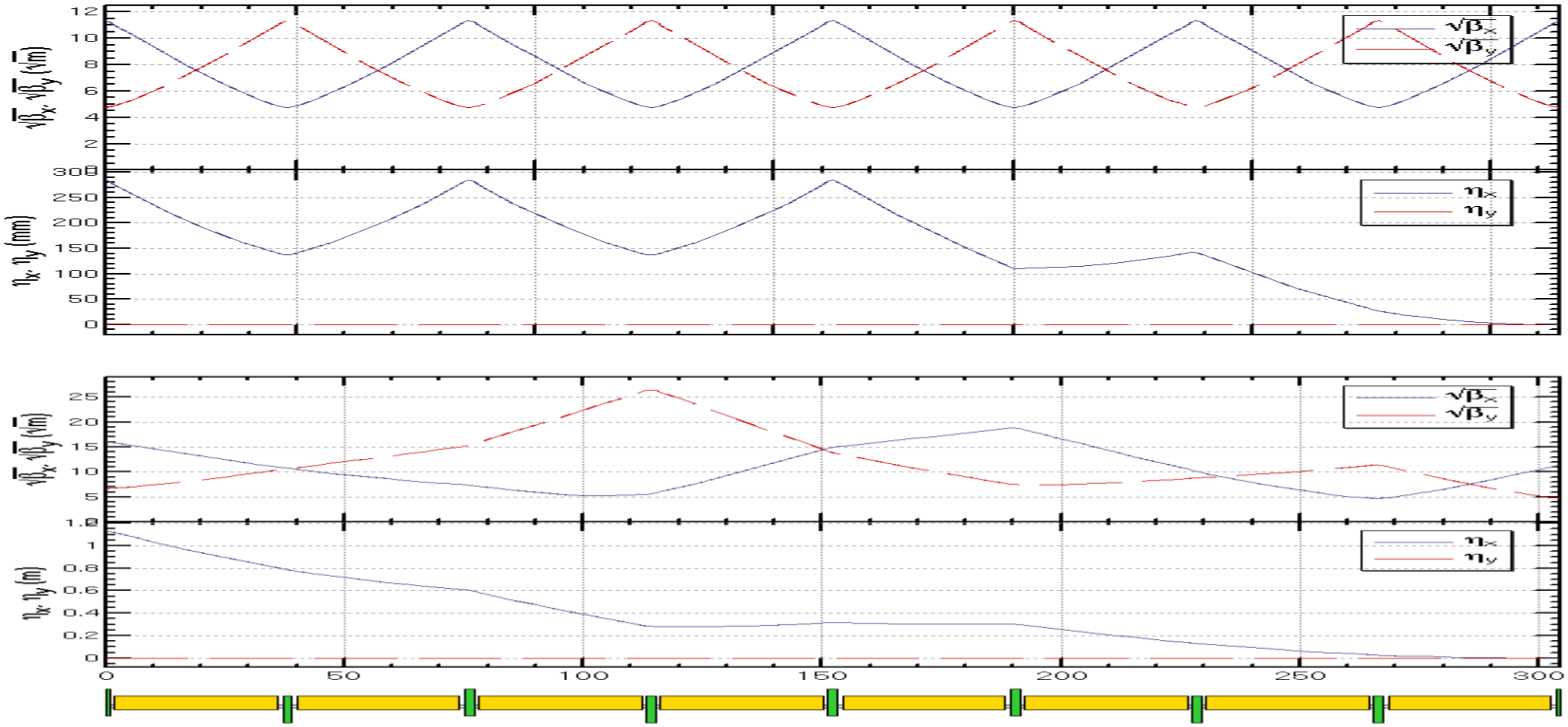
- FODO cells in H & Z lattice
  - Two FODO cells combined into one cell to achieve an adequate emittance for Z mode

$$\epsilon_x = F\frac{C_q\gamma^2}{J_{xd}}\theta^3$$

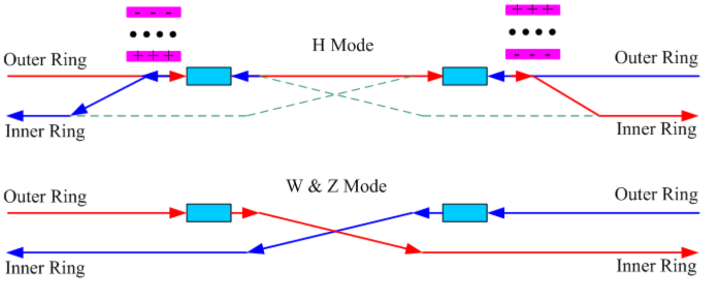


ARC region

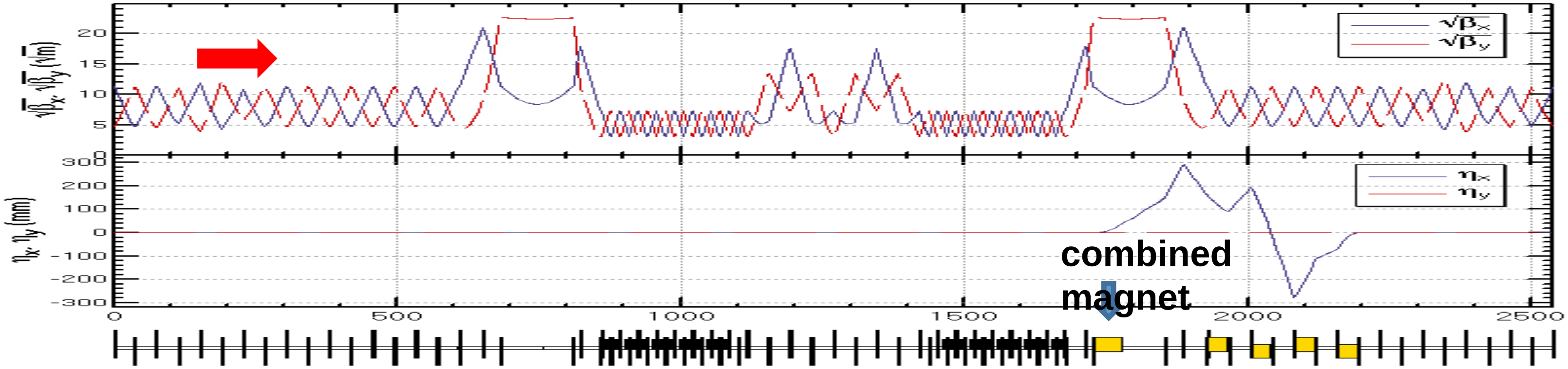
- Dispersion suppressor in H & Z lattice
  - Quadrupoles in H dispersion suppressor combined with two FODO cells re-matched for Z dispersion suppressor

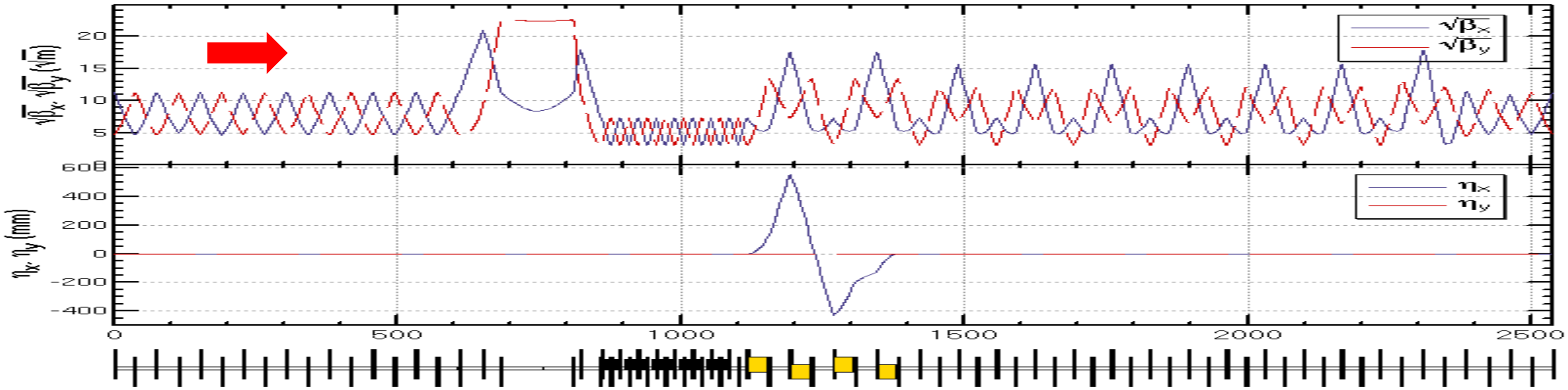


RF region



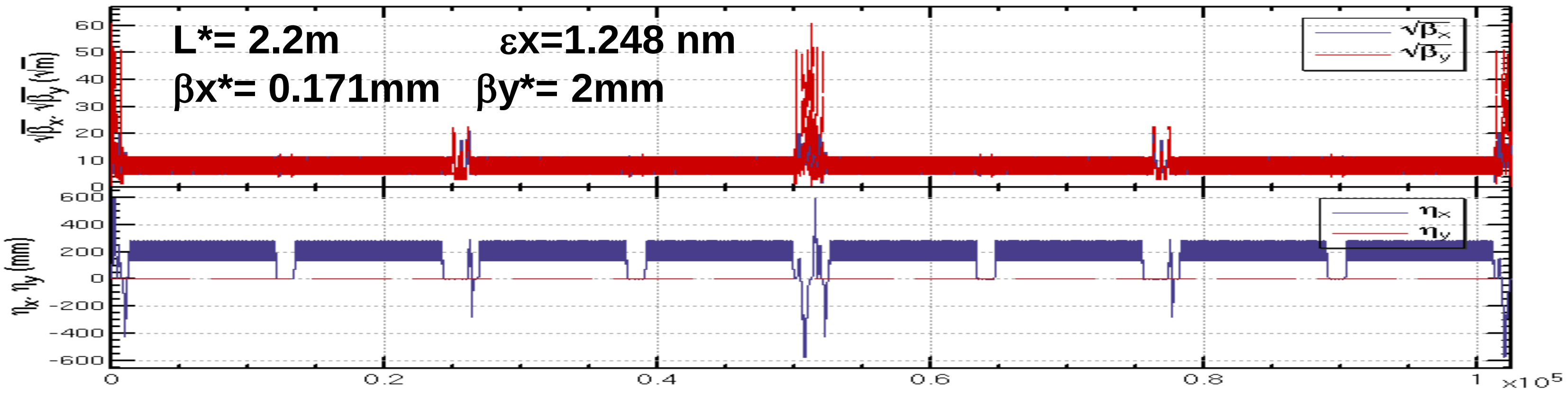
- RF region in H & Z lattice
  - half numbers of cavities in H mode bypassed in Z mode
    - fulfill the RF requirement and allow bunches filled in whole ring

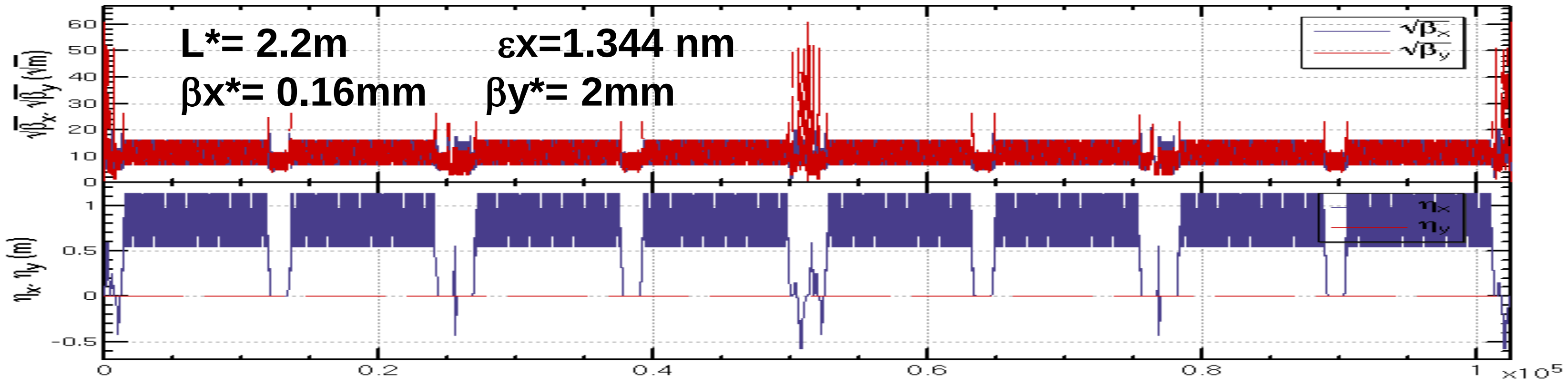




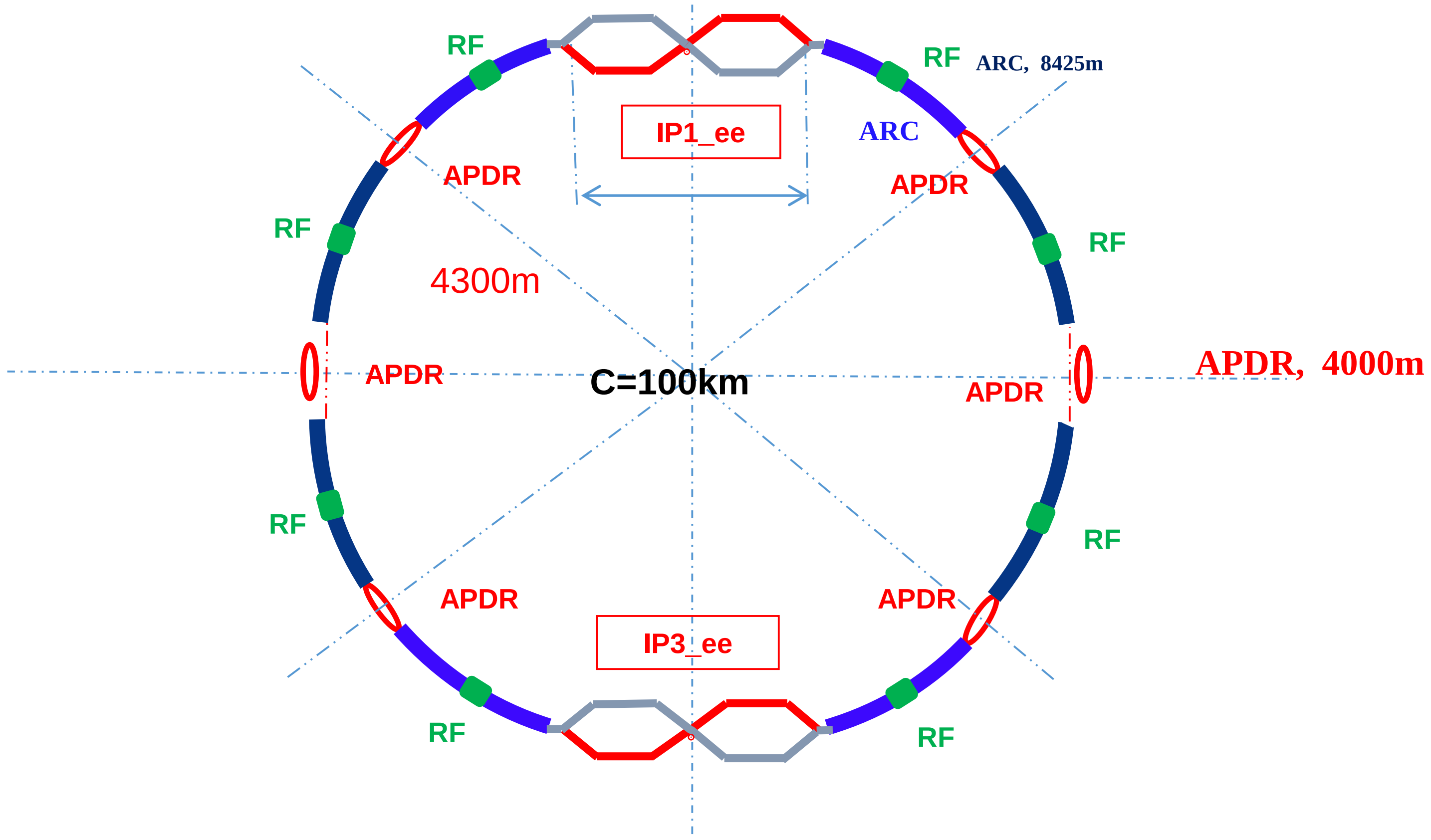
Whole ring

- Whole ring of H & Z lattice

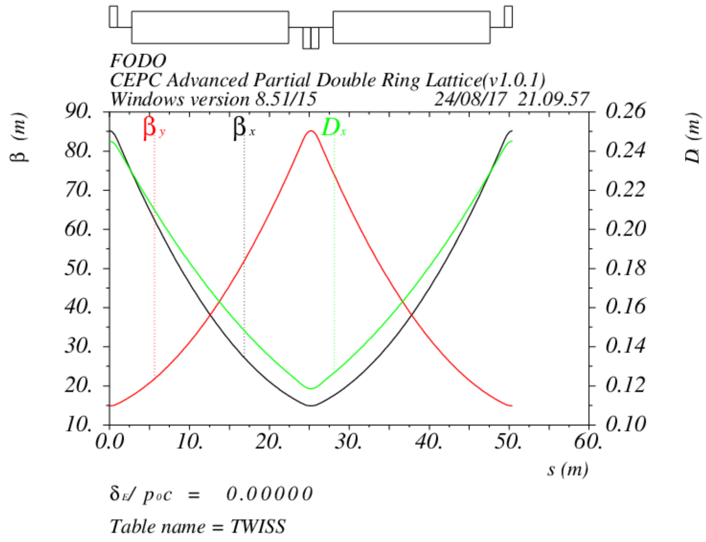


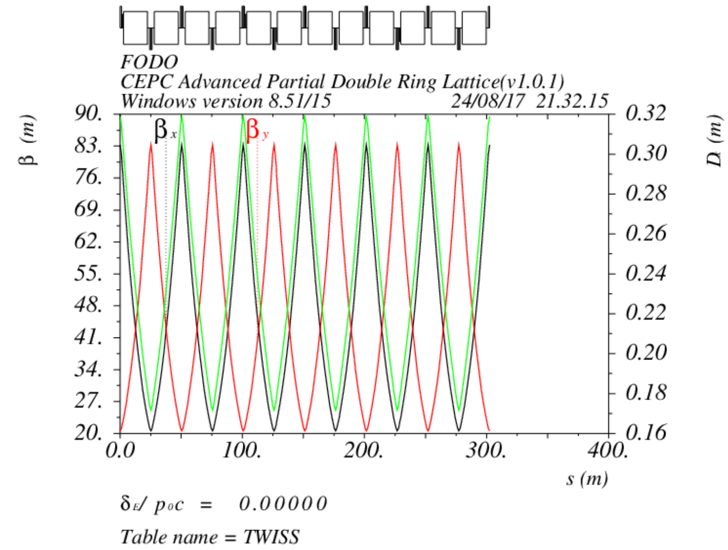


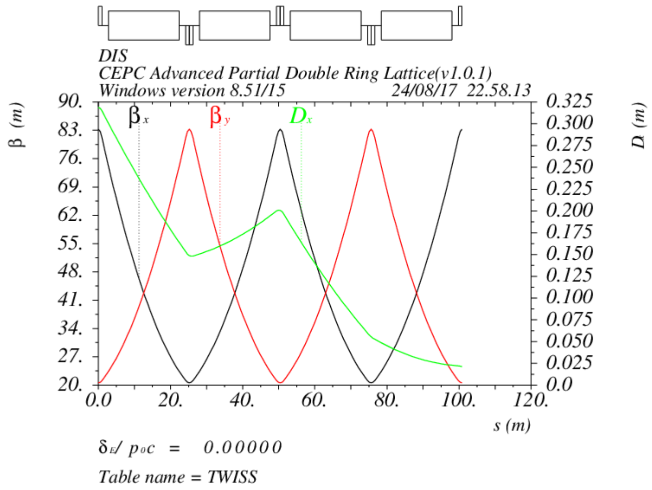
CEPC Advanced Partial Double Ring

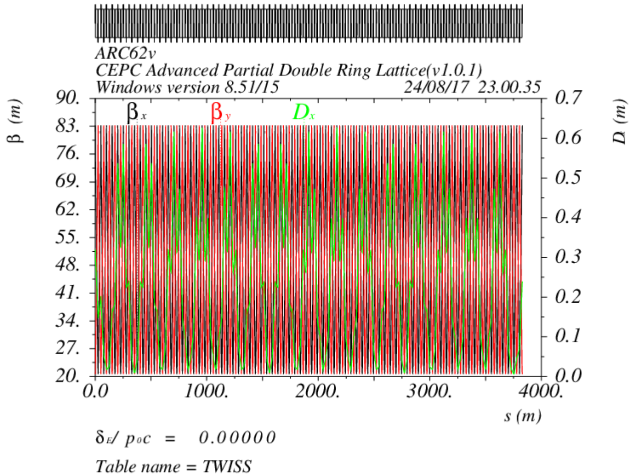


APDR lattice design









CEPC APDR Main Ring RF Parameters

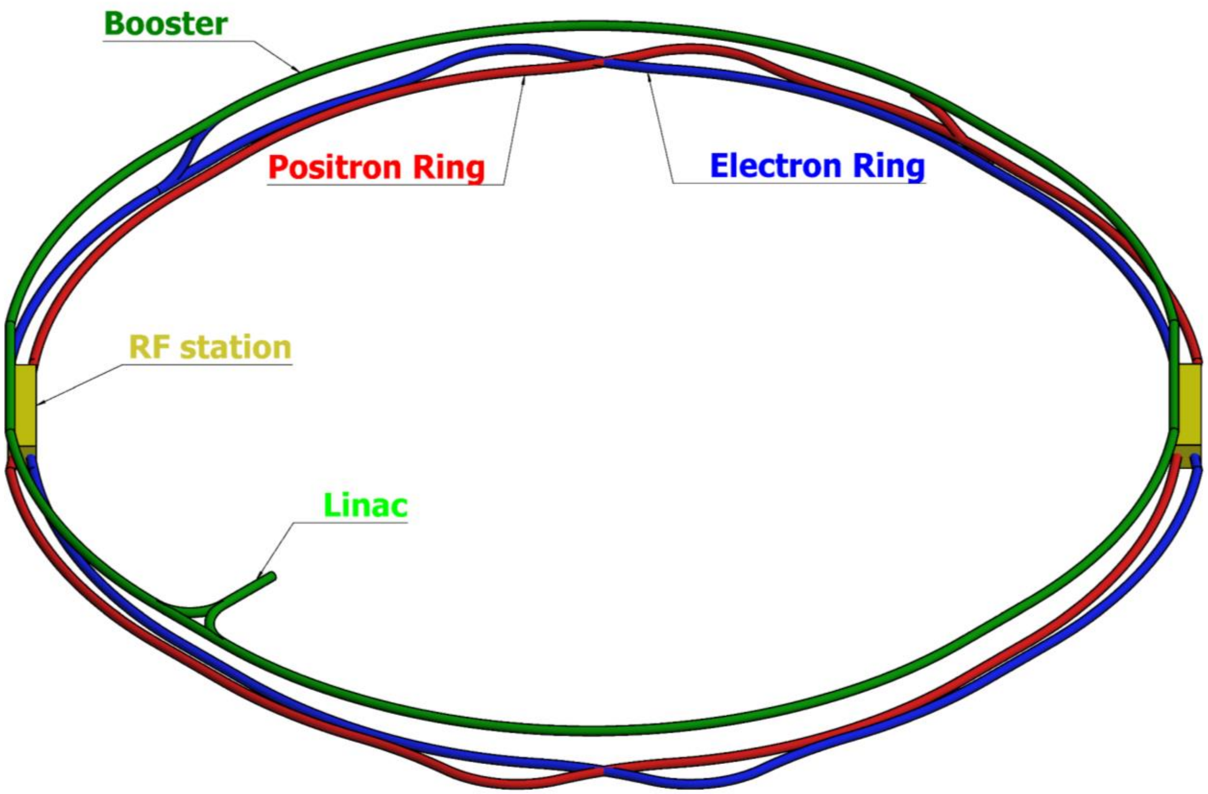
For APDR Z-pole baseline, only the large emittance case can work.

100 km, APDR, crossing angle 33 mrad, 2 IPs, 8 RF stations, 8*4km DR.	**H (baseline)**	**Z(large emittance)**	**Z(Small emittance)**
Beam Energy [GeV]	120	45.5	45.5
Luminosity / IP [10^{34} $cm^{-2}s^{-1}$]	2	1.03	1.03
SR power / beam [MW]	32	2.9	1.8
RF freqeuncy [MHz]	650	650	650
RF voltage [GV]	2.1	0.135	0.049
Beam current / beam [mA]	19.2	85.0	53.9
Pulse current/ beam [mA]	119.7	531.0	336.6
Bunch charge [nC]	15.5	4.80	3.52
Bunch length [mm]	2.9	4	4
Bunches / beam	412	5900	5100
Bunches/ train	103	1475	1275
Bunch spacing in a train [ns]	129.4	9.0	10.5
Train spacing Tg [us]	28.3	28.3	28.3
SR loss / turn [GV]	1.67	0.034	0.034
Syncrotron phase from crest [deg]	37.3	75.4	46.1
Loss factor / cell [V/pC]	0.34	0.27	0.27
Effective length per cavity [m]	0.46	0.46	0.46
R/Q per cavity [Ω]	213	213	213
Cell number / cavity	2	2	2
Cavity number / RF station	42	3	2
RF station number	8	8	8
Cavity number (total)	336	24	16

100 km, APDR, crossing angle 33 mrad, 2 IPs, 8 RF stations, 8*4km DR.	**H (baseline)**	**Z(large emittance)**	**Z(Small emittance)**
Acc. Gradient [MV/m]	13.59	12.23	6.66
Cavity voltage [MV]	6.25	5.63	3.06
Input power / cavity [kW]	190	241	229
Cavity per klystron	2	2	2
HOM power / cavity [kW]	0.40	0.22	0.10
Q_0 at operating gradient	1E+10	1E+10	1E+10
Wall loss / cavity @ 2 K [W]	19	15	5
Pb/ cavity [MW]	0.75	2.99	1.03
Opt. QL	1.0E+06	6.4E+05	2.0E+05
Opt. detuning [kHz]	0.25	1.96	1.70
Cavity bandwidth [kHz]	0.7	1.0	3.3
Cavity stored energy [J]	46	38	11
Ng/N	2.1	2.1	2.1
Ng	218	3133	2708
Max relative voltage drop for 4+4 APDR	7.2%	36.0%	41.9%
Max bunch train phase shift for 4+4 APDR [deg]	6.3	8.6	#NUM!

CEPC Booster Layout

T.J. Bian



Booster Parameters

Tianjian Bian

- **Parameter List**

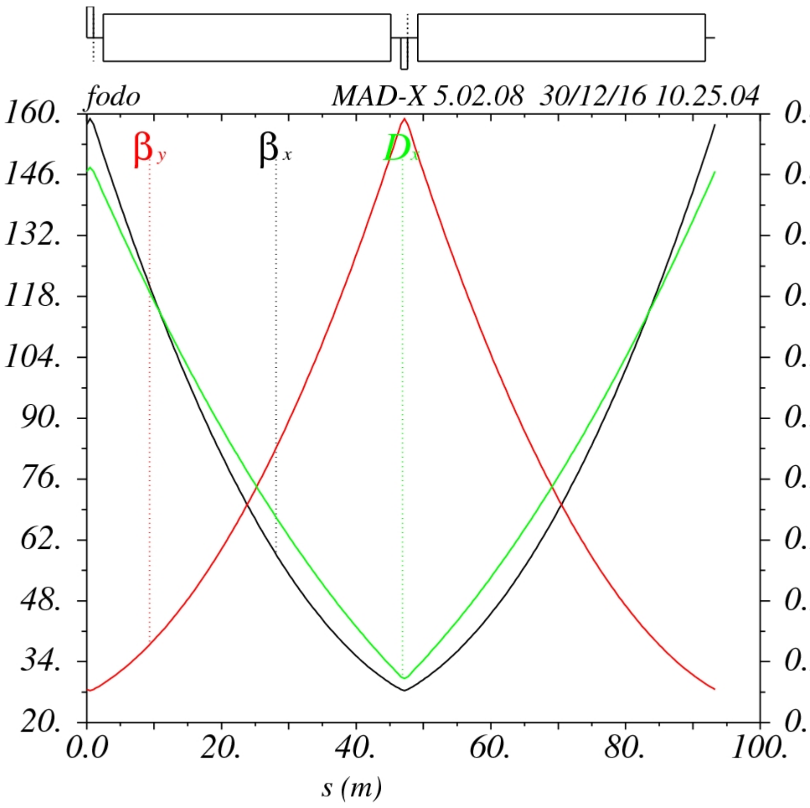
Parameter	Unit	Value
Beam energy [E]	GeV	10
Circumference [C]	km	100
Revolution frequency[f_0]	kHz	2.99
Revolution time[f_0]	mus	333.56
Momentum compaction factor[α]		2.10E-5
Lorentz factor [g]		19569.51
emittance-horizontal[e_x] inequilibrium	m·rad	2.16E-11
injected from linac	m·rad	3E-7
emittance-vertical[e_y] inequilibrium	m·rad	0.011E-11
injected from linac	m·rad	3E-7
SR loss / turn [U0]	MeV	0.064407
Transversedampingtime[t_x]	ms	103.58
Harmonic number [h]		433633

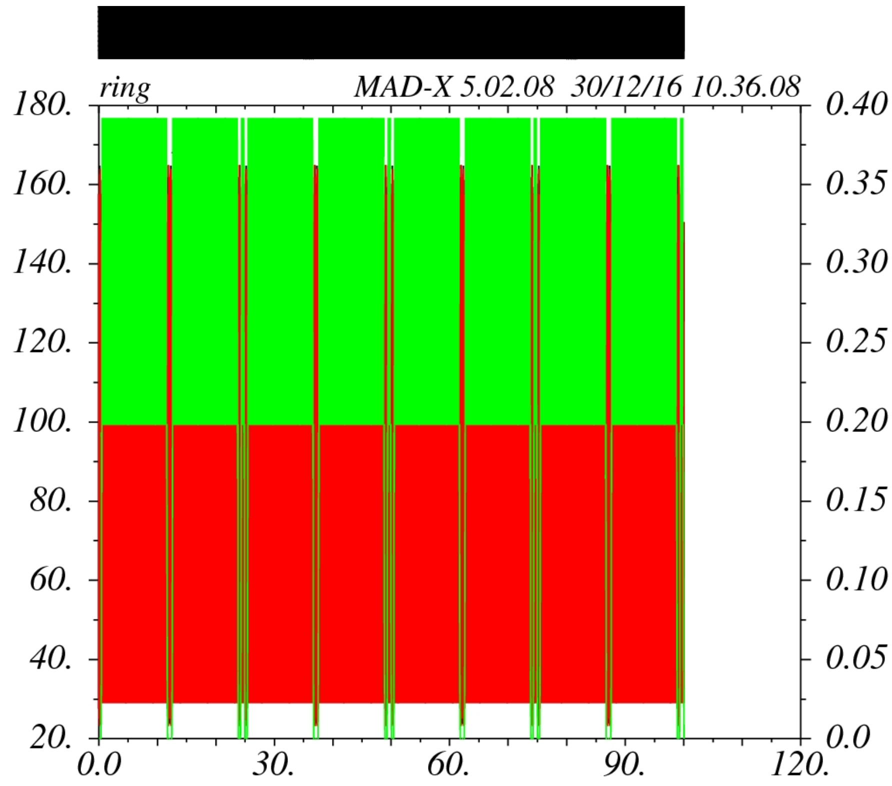
Parameter	Unit	Value
Beam energy [E]	GeV	120
Circumference [C]	km	100
Revolution frequency[f_0]	kHz	2.99
Revolution time[f_0]	mus	333.56
Momentum compaction factor[α]		2.15E-5
Lorentz factor [g]		234834.15
emittance-horizontal[e_x] inequilibrium	m·rad	3.1E-9
injected from linac	m·rad	3E-7
emittance-vertical[e_y] inequilibrium	m·rad	0.0093E-9
injected from linac	m·rad	3E-7
SR loss / turn [U0]	MeV	1337.17
Transversedampingtime[t_x]	ms	0.596
Harmonic number [h]		433633

100km CEPC Booster-1

T.J. Bian

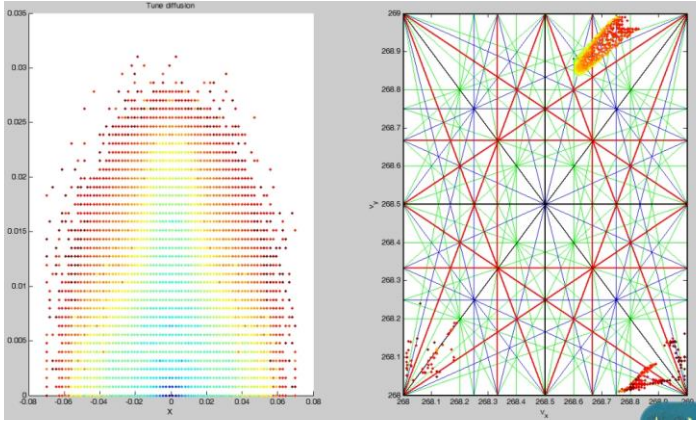
- Lattice
  - 90 degree FODO
  - FODO length: 93.3 meter





100km CEPC Booster-2

T.J. Bian



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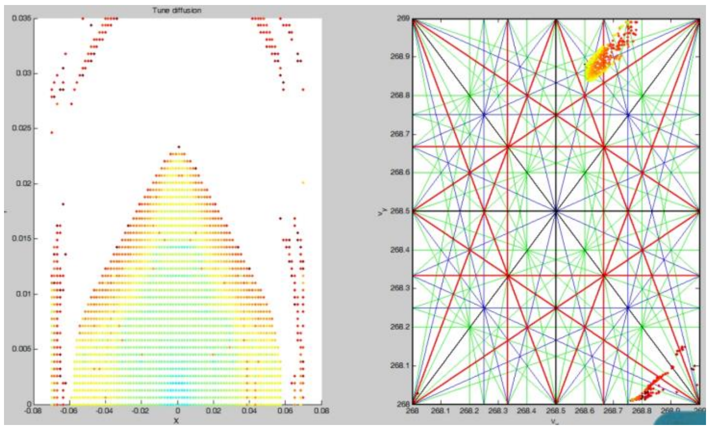

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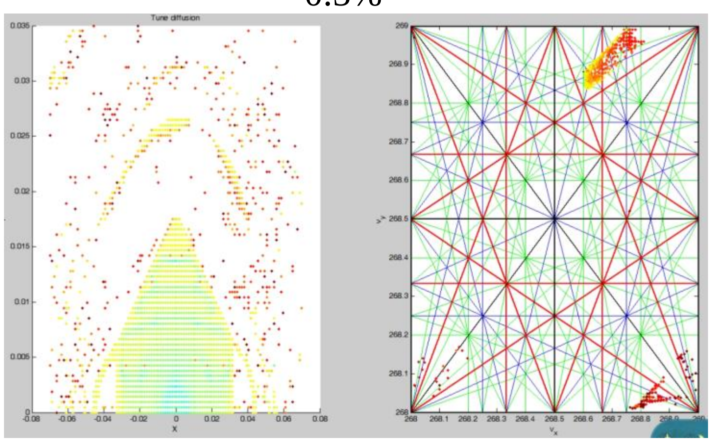


1%

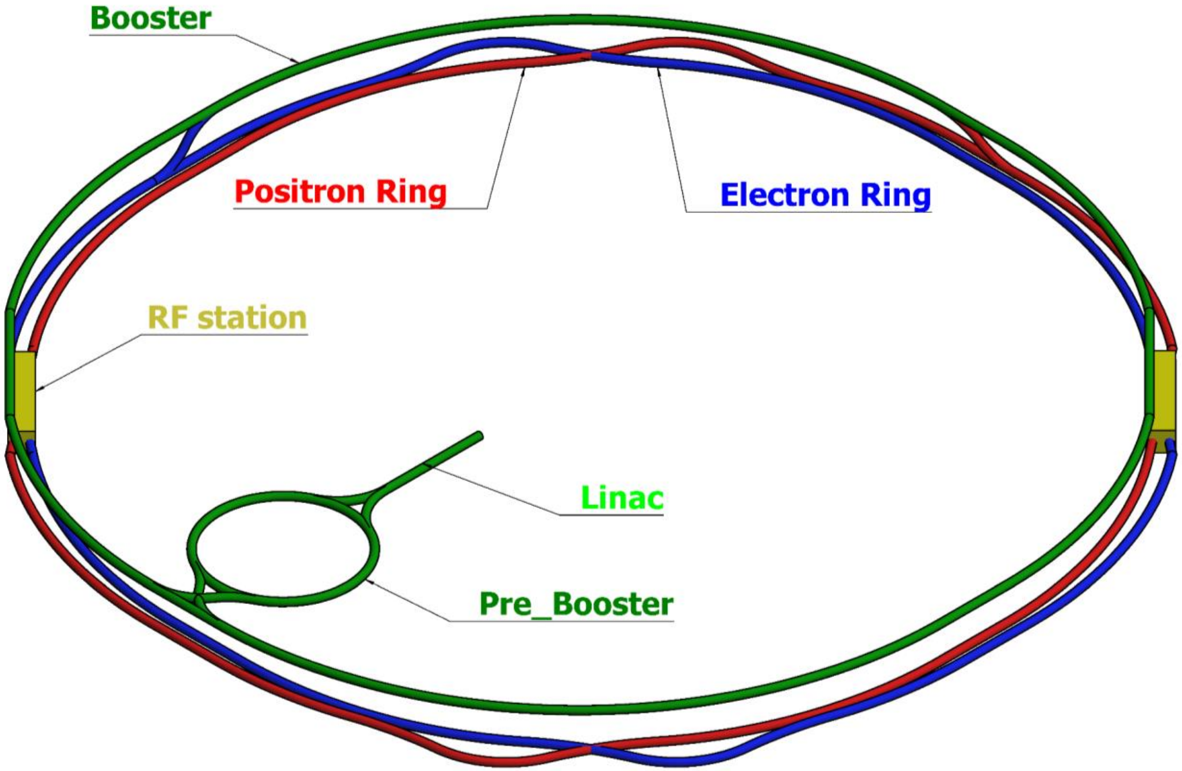
- Geometry terms are minimized.
- Chromaticity can be cancelled order by order.
- First order beta-beat are cancelled.
- Emit : 1.89E-9 m*rad@120GeV
- DA_x=9.5sigma@0%, 8.3@0.5%, 4.6@1%
- DA_y=9.7sigma@0%, 8.3@0.5%, 6.3@1%

CEPC Booster SRF Parameters

J.Y. Zhai

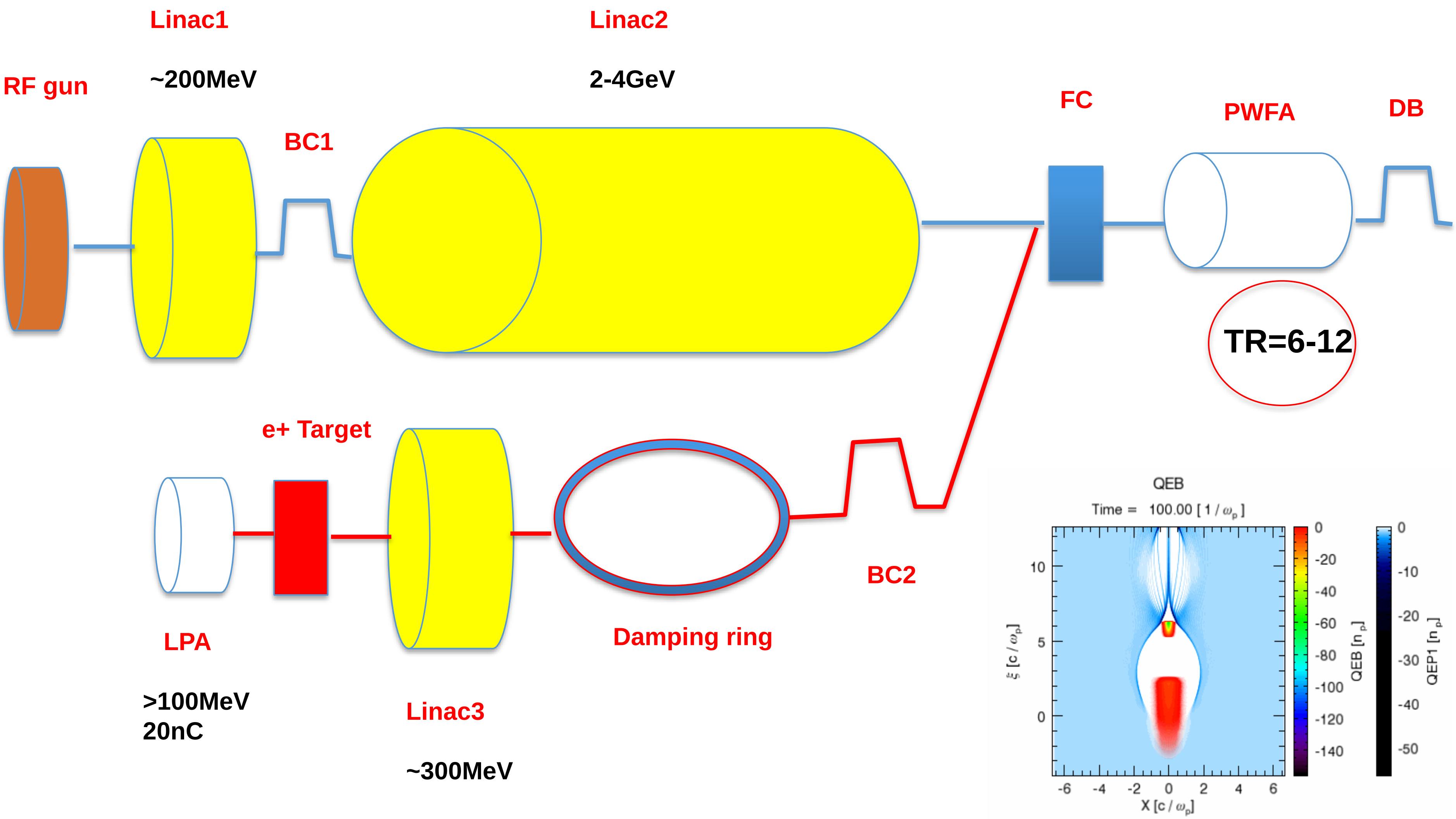
Zhai Jiyuan 20170410. 10 GeV injection. Booster parameter: Cui Xiaohao 20170401	**H**	**Z-HL**
Extraction beam energy [GeV]	120	45.5
Bunch charge [nC]	0.77	0.3
Beam current [mA]	0.37	0.96
Extraction RF voltage [GV]	2.8	0.4
Extraction bunch length [mm]	4.7	1
Cavity number in use (1.3 GHz TESLA 9-cell)	160	32
Gradient [MV/m]	16.9	12.0
Q_L	2E+07	2E+07
Cavity bandwidth [Hz]	65	65
Input power per cavity [kW] (remained detuning 10 Hz)	5.8	2.5
SSA power [kW] (one cavity per SSA)	10	10
HOM power per cavity [W]	0.4	1.6
Cryomodule number in use (8 cavities per module)	20	4
Q_0 @ 2 K at operating gradient (long term)	2E+10	2E+10
Total wall loss @ 4.5 K eq. [kW] (assume CW)	8.4	0.9

Layout of CEPC with pre-booster



A High Energy CEPC Injector Based on Plasma Wakefield Accelerator

Wei Lu



CEPC Linac Injector

C. Meng

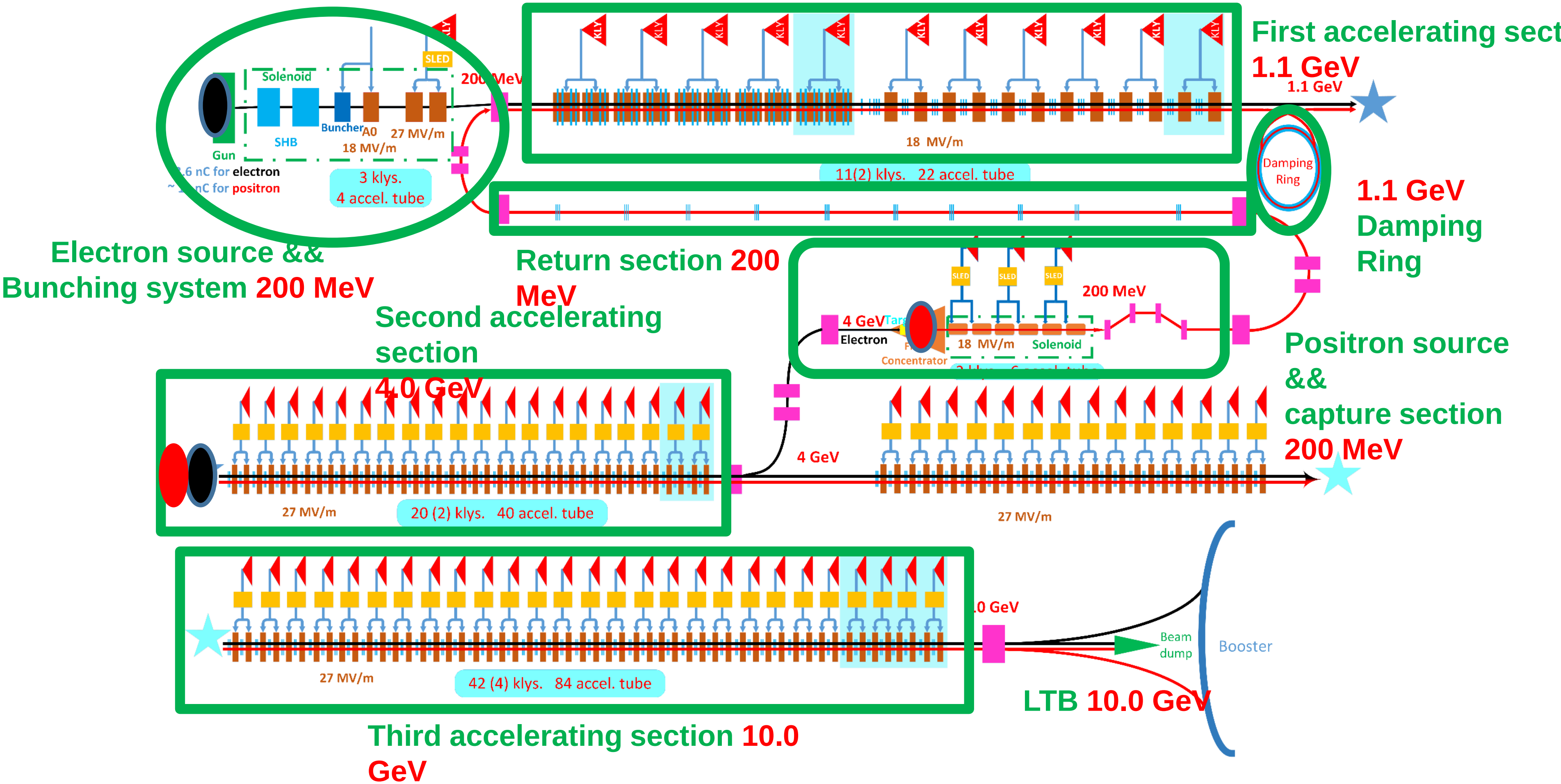
Main parameters of CEPC Linac

- Linac design goal
  - Simple and reliable
  - High availability
  - Linac is "inexistent" for collider Running
  - Always providing beams to meet the requirement

Parameter	Symbol	Unit	Value
e^-/e^+ beam energy	E_{e-}/E_{e+}	GeV	10
Repetition rate	f_{rep}	Hz	50→100
e^-/e^+ bunch population	$Ne-/Ne+$		$>6.25\times10^9$
		nC	>1.0
Energy spread (e^-/e^+)	σ_E		$<2\times10^{-3}$
Emittance (e^-/e^+)	ε_r	mm·mrad	<0.3
e^- beam energy on Target		GeV	4
e^- bunch charge on Target		nC	10

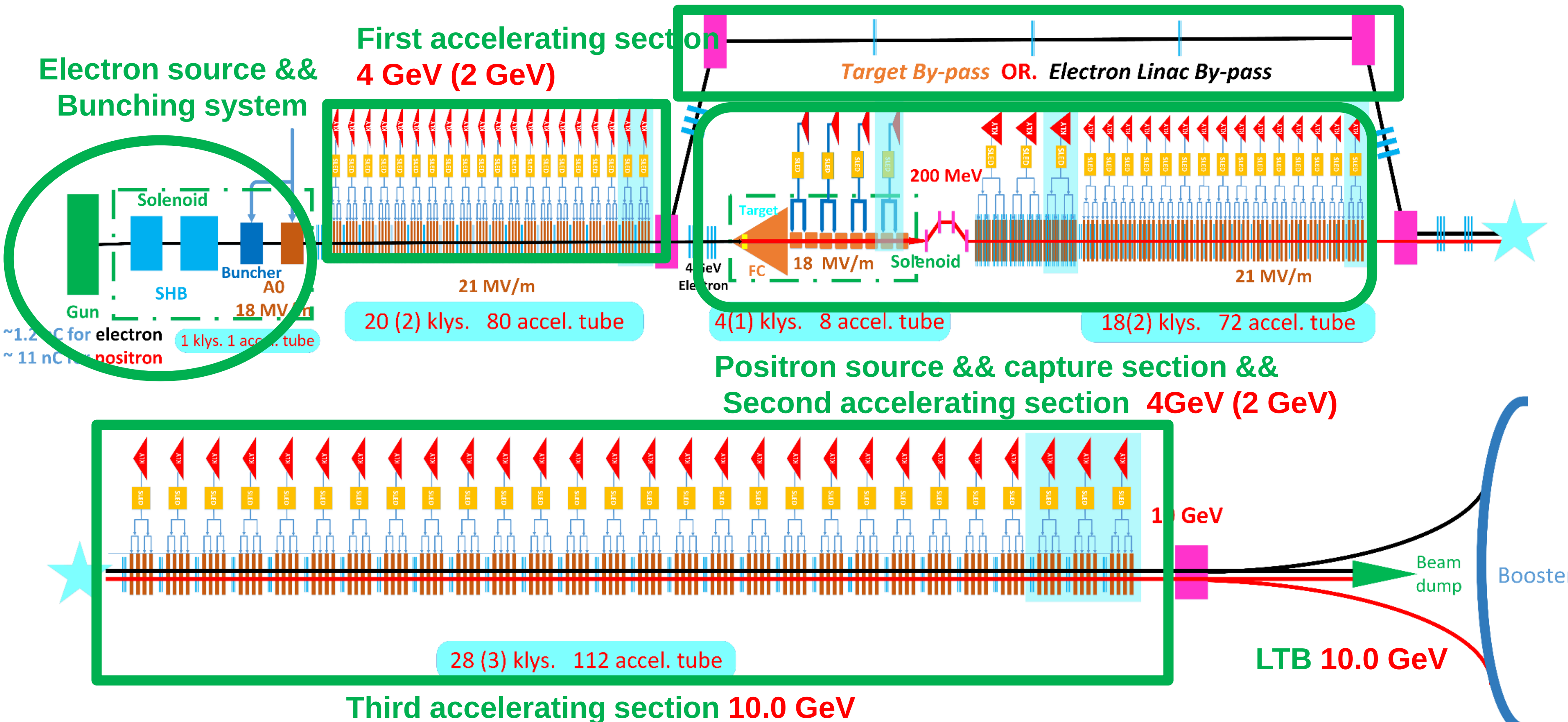
Layout of Linac Injector (I)

C. Meng



Layout of Linac Injector (II)

C. Meng

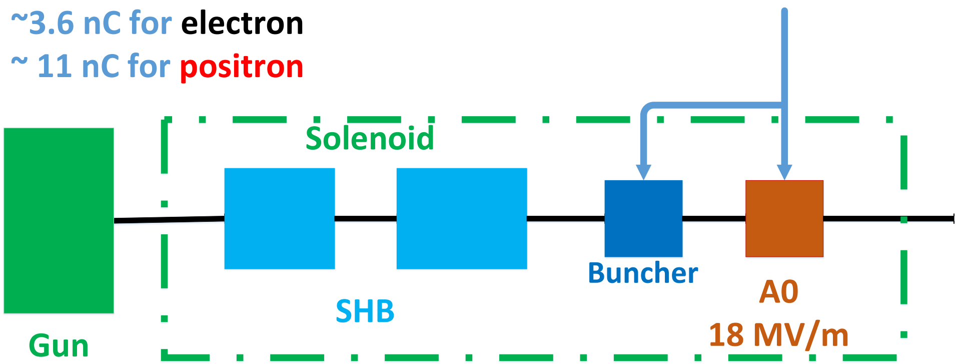


Linac Sources

C. Meng

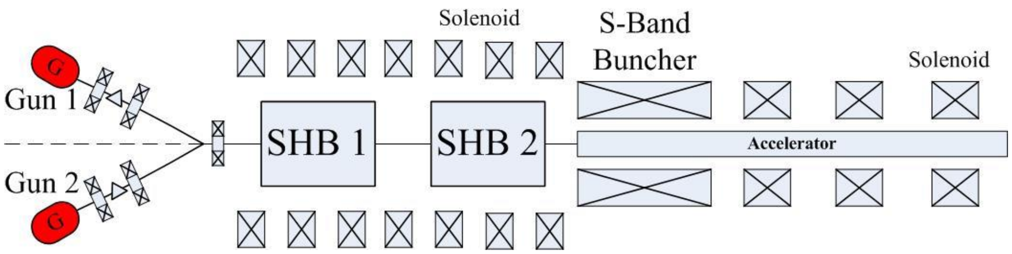
Electron source and bunching system

- **Bunching System**
  - SHB1:   142.8375 MHz
  - SHB2：571.35 MHz
  - S-band Buncher (1): 2856.75 MHz



- **Pre-accelerating structure**
  - S-band accelerator (1): 18 MV/m

- **Solenoid focusing**

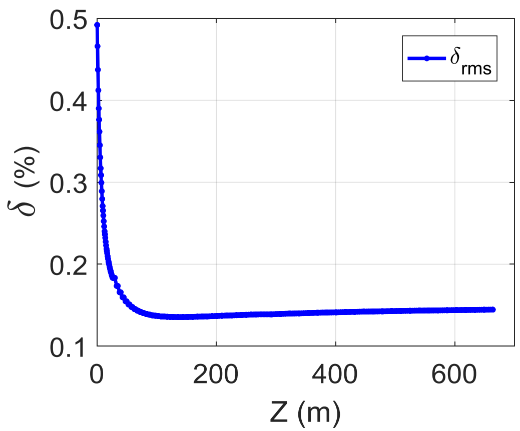


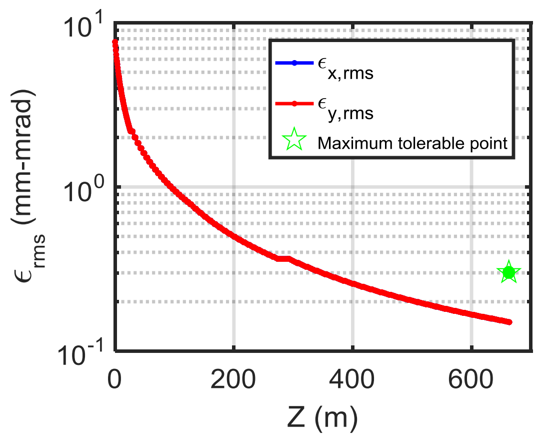
@S. Pei

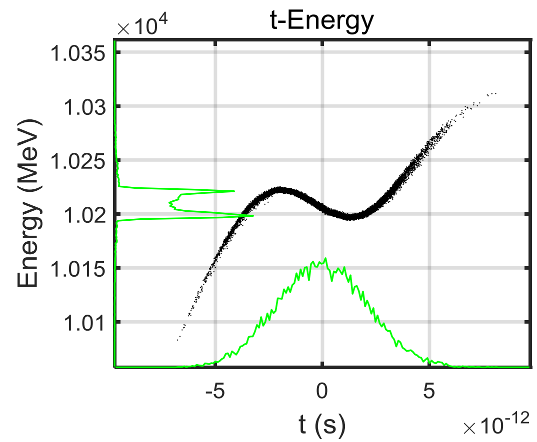
10GeV Linac injecor design

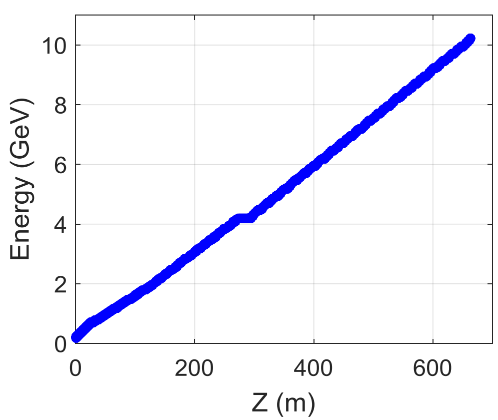
C. Meng

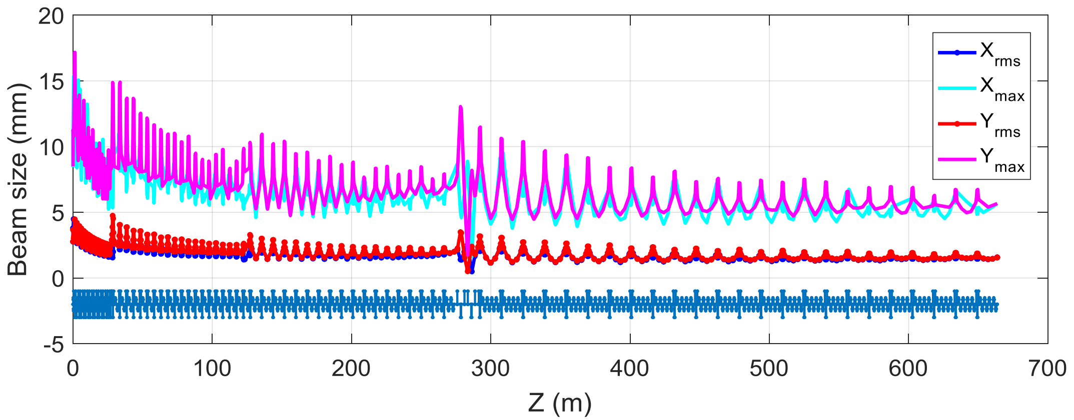
- Beam dynamics results





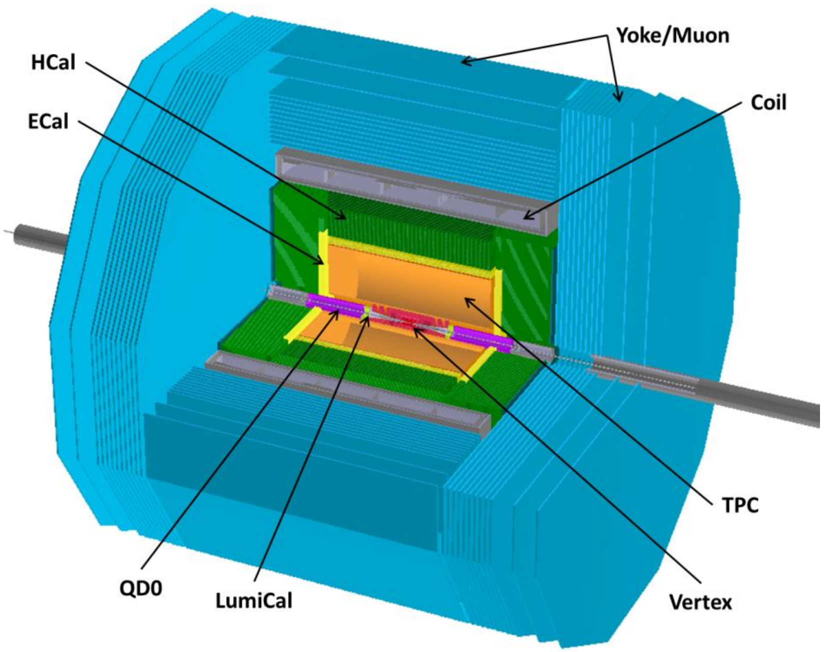






CEPC Detector (preCDR)

X.C. Lou



ILD-like detector with additional considerations (*incomplete list*):

- Shorter L* (**1.5**/2.5m) → constraints on space for the Si/TPC tracker
- No power-pulsing → lower granularity of vertex detector and calorimeter
- Limited CM (up to 250 GeV) → calorimeters of reduced size
- Lower radiation background → vertex detector closer to IP
- …

- **Similar performance requirements to ILC detectors**
  - Momentum: $\sigma_{1/p} < 5\times10^{-5}\ \mathrm{GeV}^{-1}$ ← recoiled Higgs mass
  - Impact parameter: $\sigma_{r\phi} = 5 \oplus 10/(p\cdot\sin^{\frac{3}{2}}\theta)\ \mu\mathrm{m}$ ← flavor tagging, BR
  - Jet energy: $\frac{\sigma_E}{E} \approx 3-4\%$ ← W/Z di-jet mass separation

Sub-detector groups consider design options, identify challenges, plan R&D

Preliminary Layout of CEPC IR

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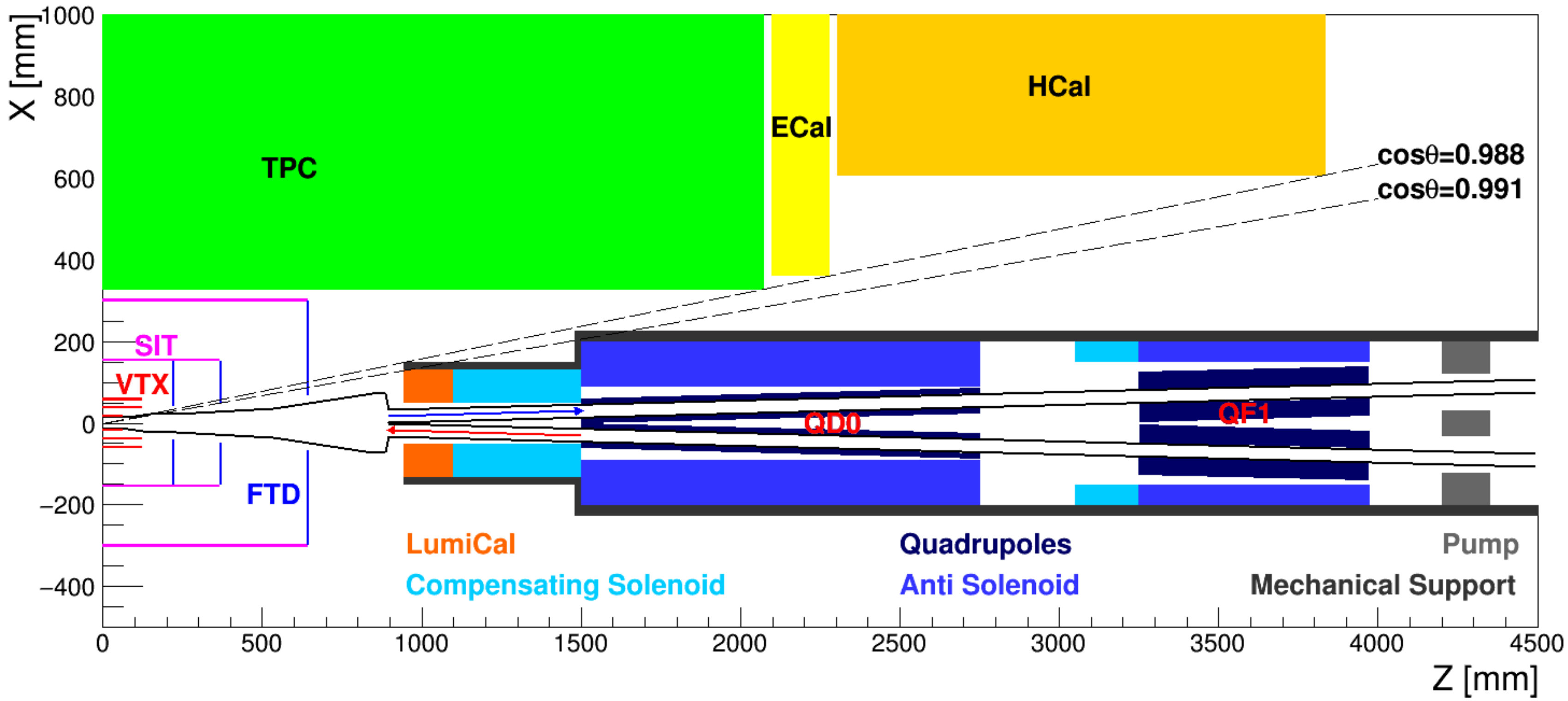
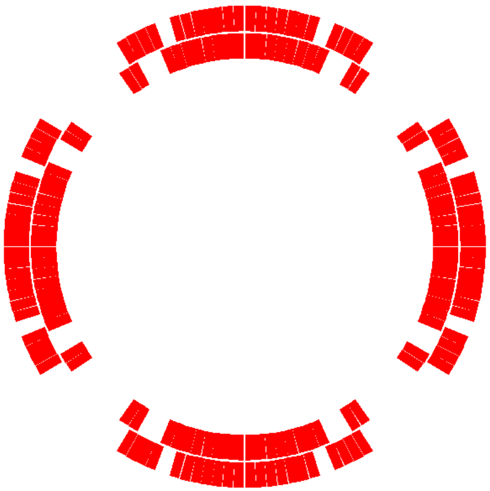


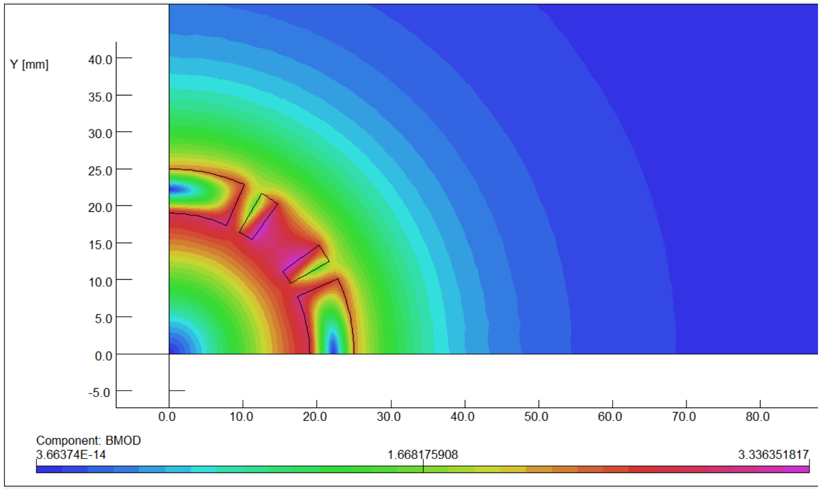
MDI related parameters

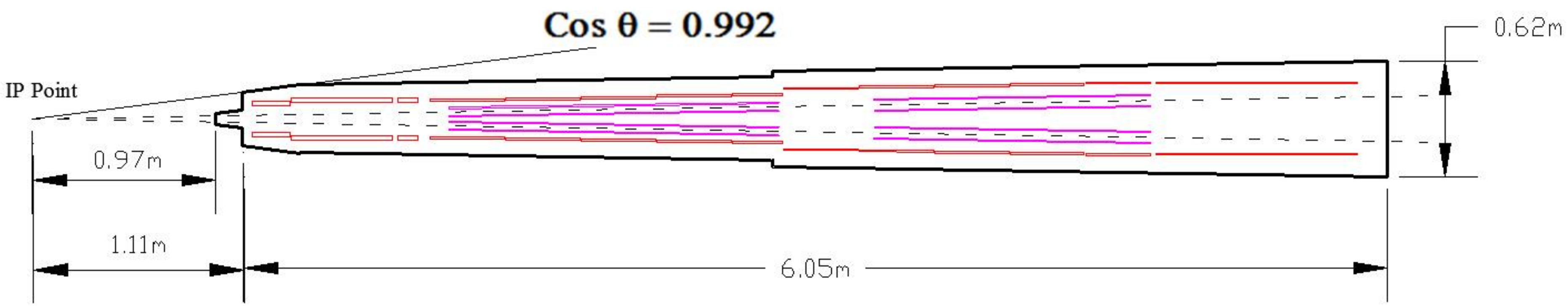
MDI parameters	***old***	***new***
*L** (m)	1.5	2.2
Crossing angle (mrad)	30	33
Strength of QD0 (T/m)	200	150
Strength of detector solenoid (T)	3.5	3.0
Strength of anti-solenoid (T)	13	7.0

Magnetic field of superconducting QF and QD coils



Rutherford cable





SC Magnet Designs

- Updated parameters of the magnets based on the new L* = 2.2 m and lower detector solenoid of B=3 T

Magnet	Gradiant	Length(m)	Inner radius(mm)
QD0	150T/m	1.7489	19
QF1	106T/m	1.4636	26

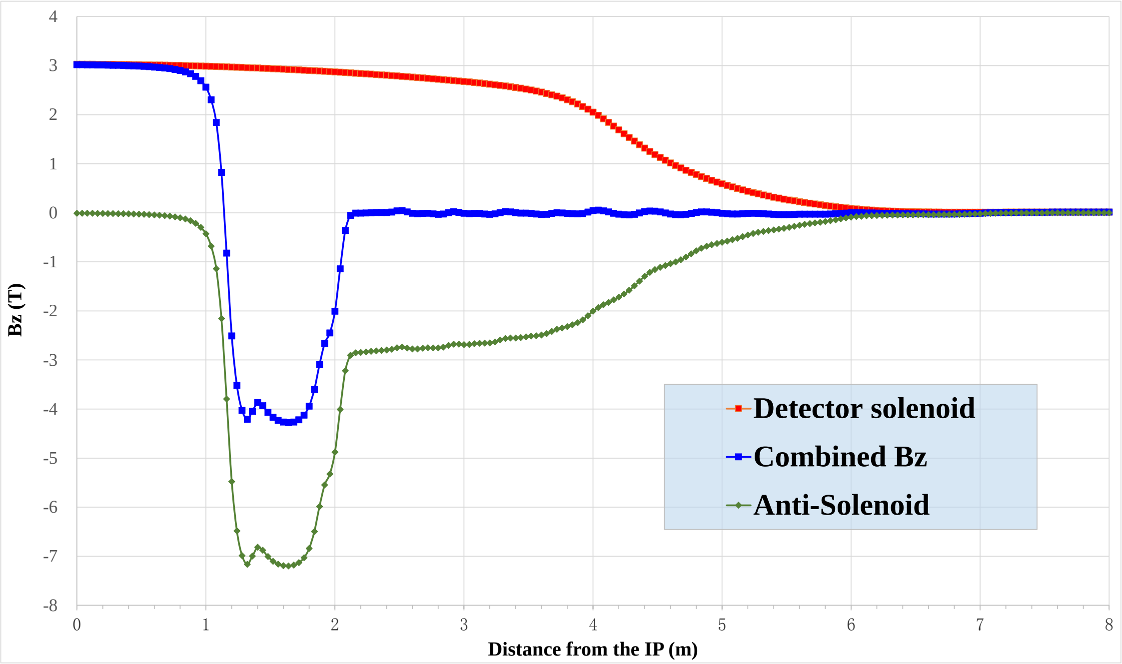
- Weaker QD0/QF1 field strengths would introduce less harder SR photons in the IR → easier collimation and less backgrounds
- Lower compensating solenoid makes it possible to construct the magnet with the cutting-edge superconducting magnet technology → motivation to increase L* (+ clearance between electron/positron beam pipes)

QD0/QF1 parameters

QD0	Horizontal BSC 2（$20\sigma_x$+3）	Vertical BSC 2（$40\sigma_y$+3）	e+ e- beam center distance
entrance	13.73 mm	20.24 mm	72.61 mm
Half	18.06 mm	23.65 mm	101.45 mm
exit	25.94 mm	22.11 mm	130.33 mm
Good field region	Horizontal 25.94 mm；Vertical 23.74 mm		
Effective length	1.7489m		
Distance from IP	2.2000m		
Gradient	150 T/m		

QF1	Horizontal BSC 2（$20\sigma_x$+3）	Vertical BSC 2（$40\sigma_y$+3）	e+ e- beam center distance
entrance	31.84 mm	19.83 mm	146.83 mm
Half	38.46 mm	17.41 mm	170.99 mm
exit	40.54 mm	16.62 mm	195.11 mm
Good field region	Horizontal 40.55 mm；Vertical 19.83 mm		
Effective length	1.4636m		
Distance from IP	4.449m		
Gradient	106 T/m		

Solenoid compensation

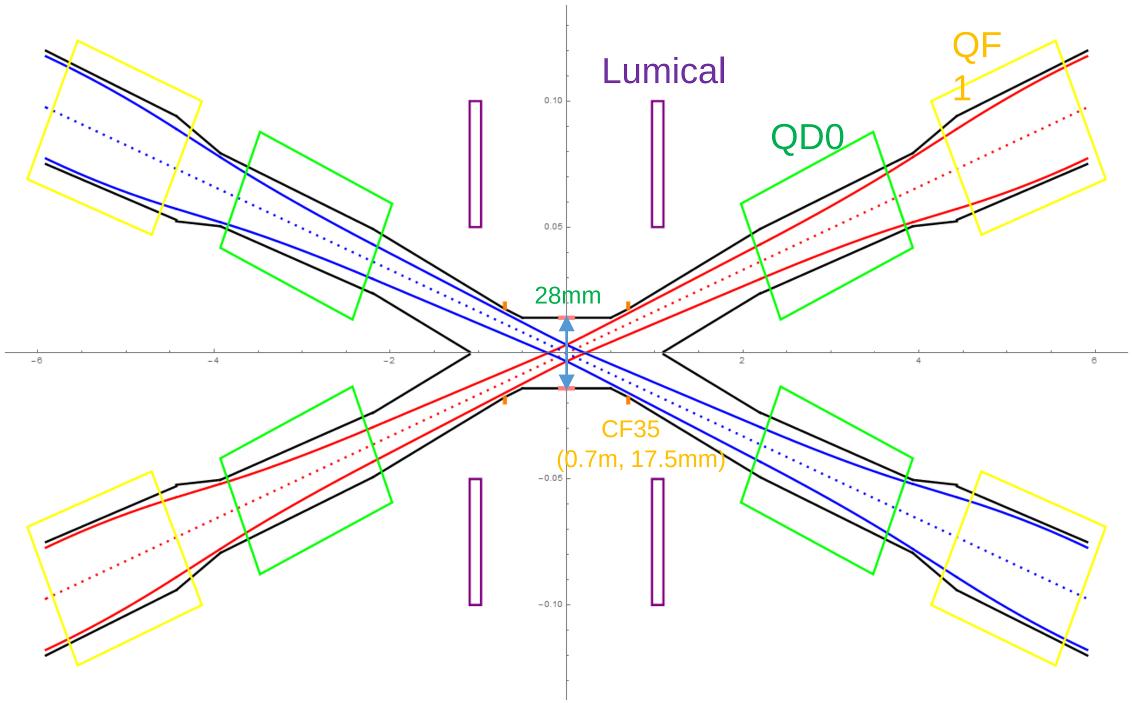


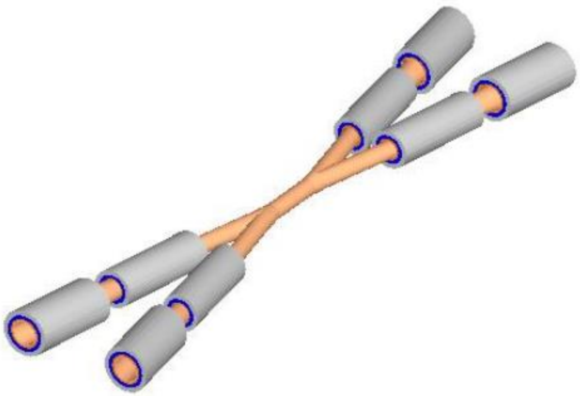
Anti-solenoid divided into parts according to detector solenoid field in longitudinal.
Between IP and QD0:
Compensating solenoid divided into 3 parts；
QD0 region: Screening solenoid 5 parts；
QF1 region: Screening solenoid 6 parts；
After QF1: Screening solenoid 1 part。

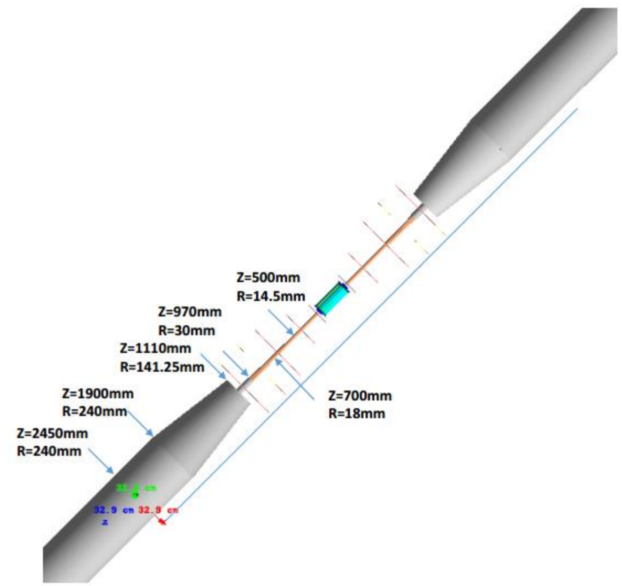
$\int B_z ds$ within 0~2.12m. Bz < 500Gauss away from 2.12m

Beam pipes

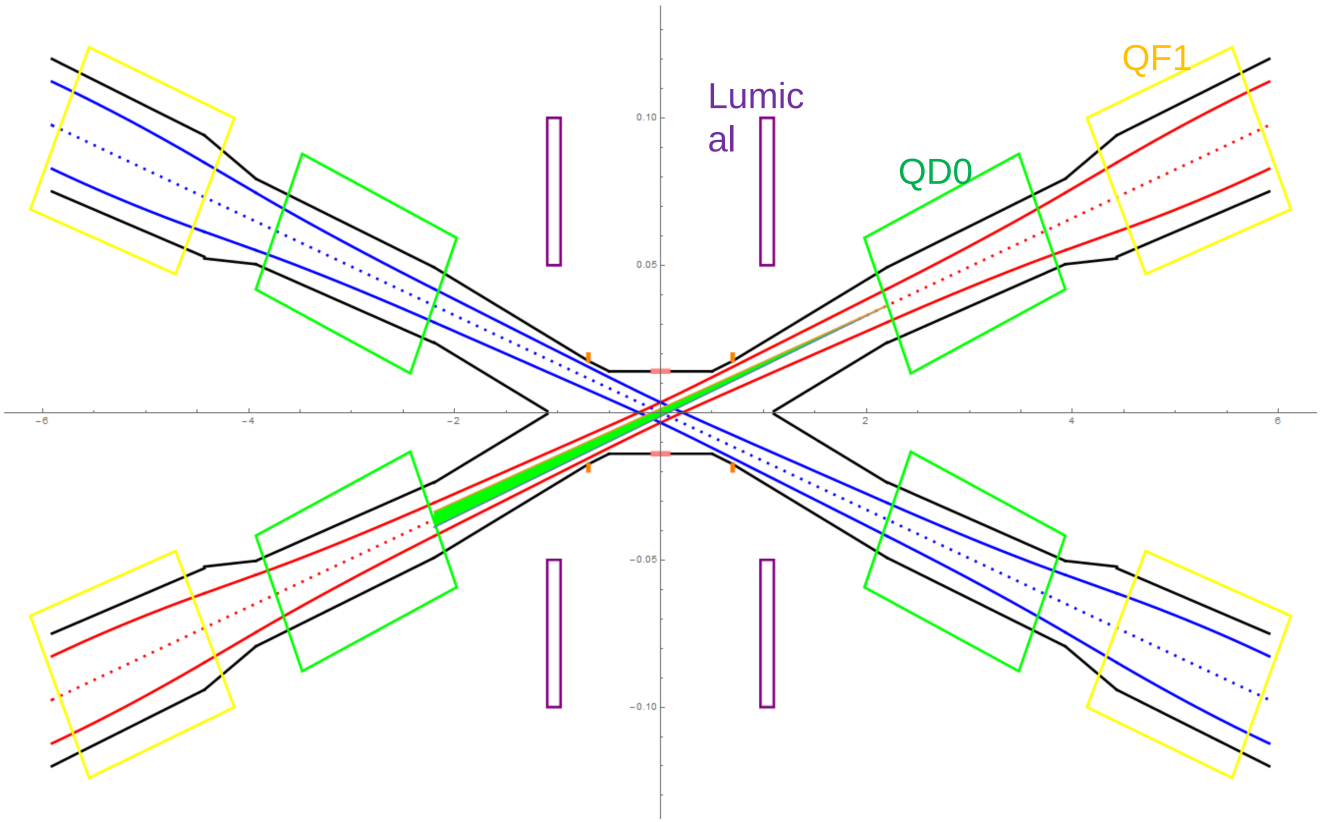
- Electron and positron beam stay clear (magnet, vacuum chamber)→ *important input into the beam pipe shape design , connection from single pipe to double pipe is realized by flange CF35.*
- The central part is Be pipe with the length of 14cm and inner diameter of 28mm.







SR from QD0 in horizontal plane

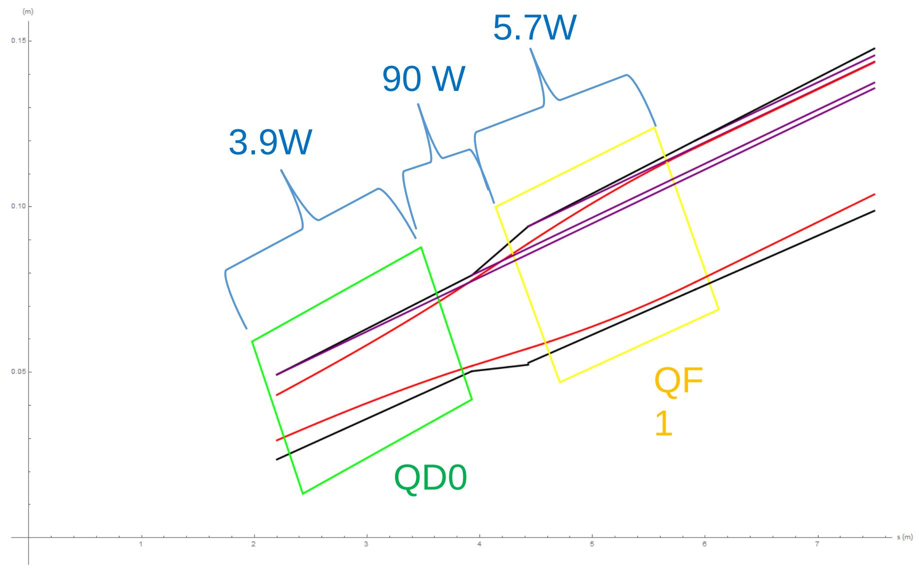


- In the Gaussian distribution beam, particles in 3σ occupies 99.7% of the total amount, 1σ occupies 68.7%, and 2σ occupies 95.5%.
- The total SR power generated by the QD0 magnet is 681.36W in horizontal. The critical energy of photons is about 1343.2keV. (Slice into 6 pieces)

The synchrotron radiation in the IR

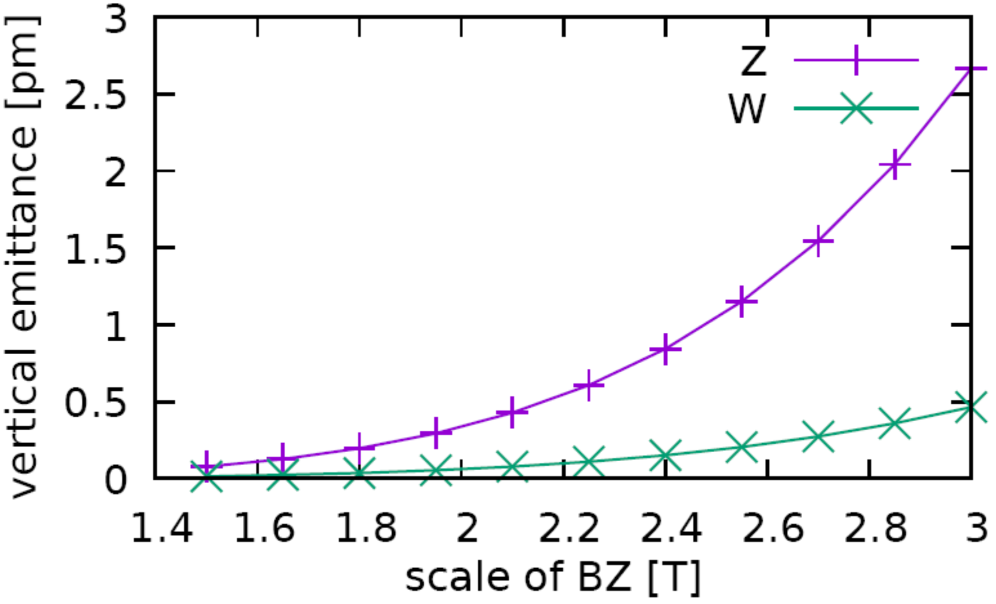
~ β_x^*=0.37m

- Cold vacuum chamber has to be adopted within SC magnet for the sufficient coils space. The design has been accepted by cryogenic system.



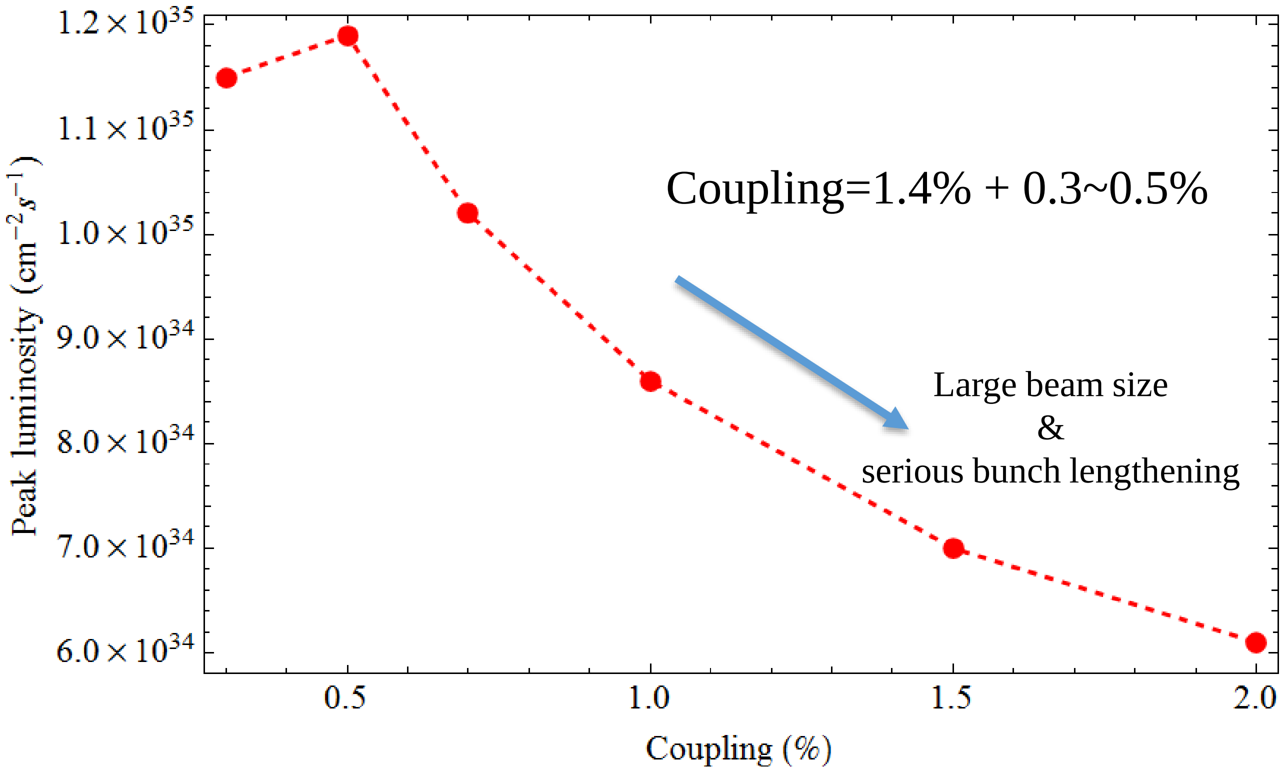
- The synchrotron radiation power within QD0 is 3.9W along 1.73m, on QF1 is 5.7W along 1.48m. The region between QD0 and QF1 is 90 W (0.5m) where has special cooling structure.

Emittance growth caused by the fringe field ofsolenoid



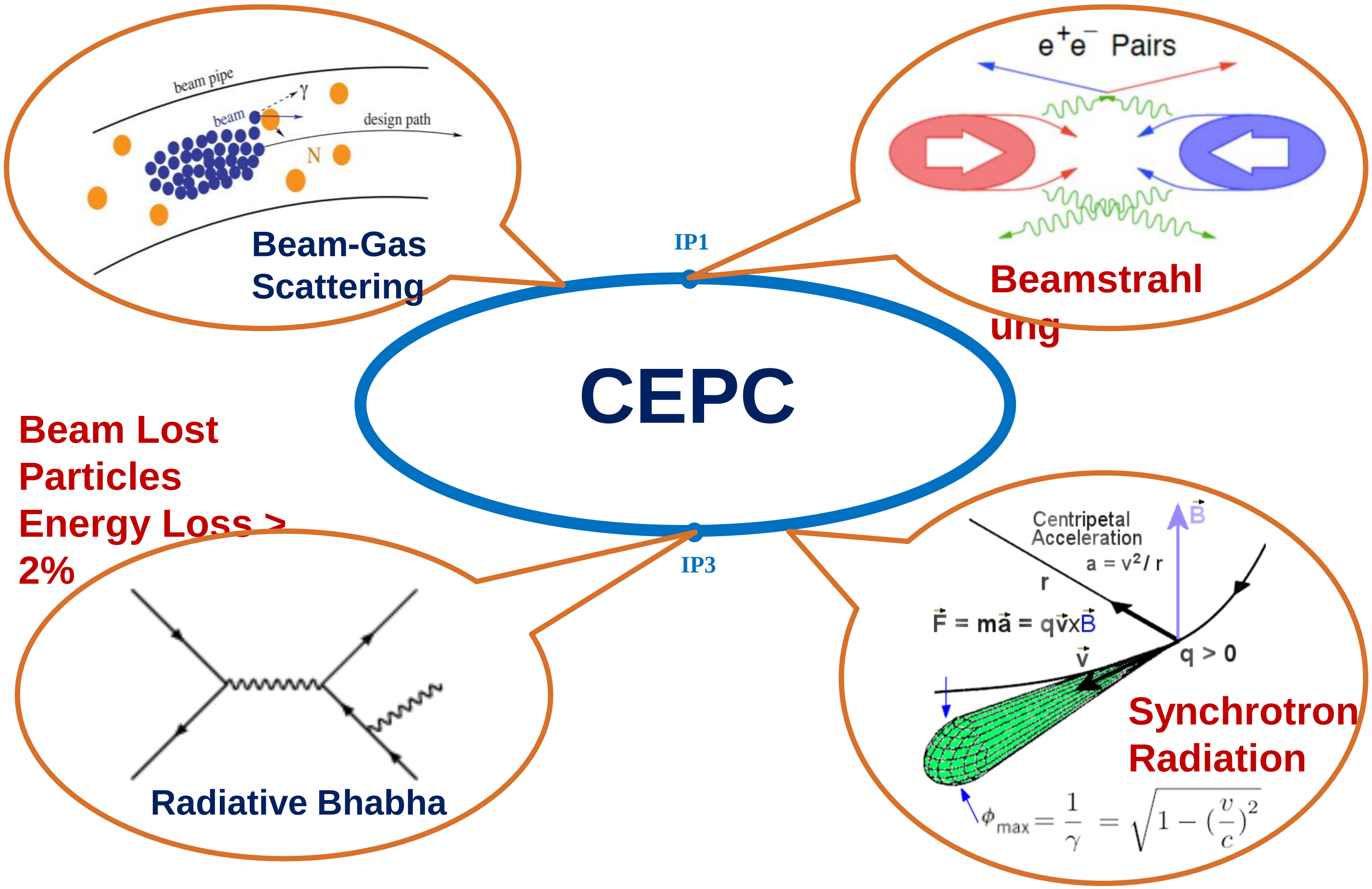
Design $\varepsilon_y/\varepsilon_x$	expected contribution	Current contribution
H: 4.0pm/1.31nm (0.3%)	0.4pm	0.14pm (0.01%)
W: 2.0pm/0.57nm (0.3%)	0.2pm	0.47pm (0.08%)
Z: 1.0pm/0.20nm (0.5%)	0.1pm	2.67pm (1.34%)

Coupling Vs. Luminosity @ Z



For **the 2Cell cavity** operation, if the coupling lose control **$L \approx L_0/2 \sim L_0/4$**

Beam Induced Backgrounds at CEPC



The current design of Lumical detector

LumiCal parameters

IP to Lumi Cal	Front .95 m	Back 1.11 m
Beam pipe	23 mm	26 mm
θ_{inner}	24.2 mRad	23.4 mRad
Acos(.992) = 126.6 mRad	120 mm	140 mm

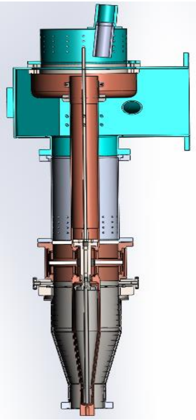
CEPC Accelerator R&D Progress

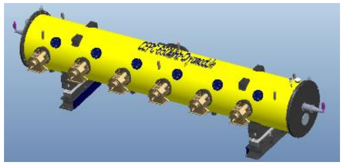
CEPC CDR key design issues and R&D

Accelerator design issues:

CEPC Partial Double Ring (APDR,DR) lattce design and DA Optimization to reach design goal

CEPC Partial Double Ring (APDR,DR) (main ring and booster) RF system designs matching parameters and lattices





CEPC Partial Double Ring (APDR,DR) MDI design

Collective effects

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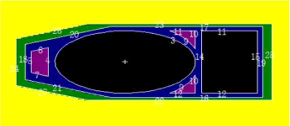
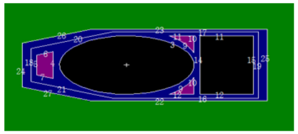
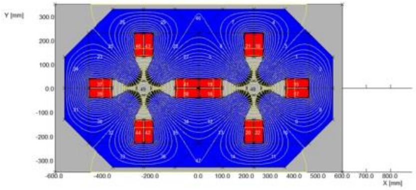
Acceleretor hardare R&D issues

高频系统、功率源系统、低温系统、磁铁系统
电源系统、真空系统、束测系统、控制系统
机械系统、防护系统、准直系统、直线加速器
束流源系统等







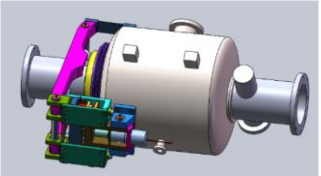
Main Ring SCRF Hardware Specification

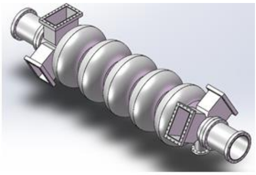
Hardware	Qualification	Normal Operation	Max. Operation
650 MHz 2-cell Cavity	VT 4E10 @ 22 MV/m HT 2E10 @ 20 MV/m	1E10 @ 16 MV/m (long term)	2E10 @ 20 MV/m
1.3 GHz 9-cell Cavity	VT 3E10 @ 25 MV/m	2E10 @ 20 MV/m	2E10 @ 23 MV/m
650 MHz Input Coupler	HPT 400 kW sw	300 kW	400 kW
1.3 GHz Input Coupler	HPT 20 kW peak, 4 kW avr.	< 15 kW peak	18 kW peak
650 MHz HOM Coupler	HPT 1 kW	< 0.2 kW	1 kW
650 MHz HOM Absorber	HPT 5 kW	< 2 kW	5 kW
650 MHz Cryomodule (six 2-cell cavities)	static loss 5 W @ 2 K	static loss 8 W @ 2 K	static loss 10 W @ 2 K
Tuner (MR & Booster)	tuning range and resolution 400kHz/1Hz	200 kHz / 1 Hz	400 kHz / 1 Hz
LLRF (MR & Booster)	amp & phase stability 0.1%, 0.1 deg	amp & phase stability 1%, 1 deg	amp & phase stability 0.1%, 0.1 deg

CEPC SRF R&D Plan (2017-2022)

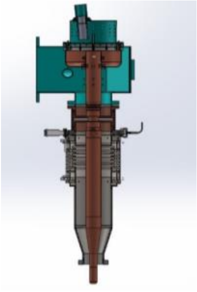
- **Two small Test Cryomodules** (650 MHz 2 x 2-cell, 1.3 GHz 2 x 9-cell)
- **Two full scale Prototype Cryomodules** (650 MHz 6 x 2-cell, 1.3 GHz 8 x 9-cell)
- **Schedule**
  - 2017-2018 (key components, IHEP Campus)
    - high Q 650 MHz and 1.3 GHz cavities, N-doping + EP
    - 650 MHz variable couplers (300 kW)，1.3 GHz variable couplers (10 kW)
    - high power HOM coupler and damper, fast-cool-down and low magnetic module, reliable tuner
  - 2019-2020 (test modules integration, Huairou PAPS)
    - Horizontal test 16 MV/m, Q_0 > 2E10
    - beam test 1~10 mA
  - 2021-2022 (prototype modules assembly and test, Huairou PAPS)

Key Components

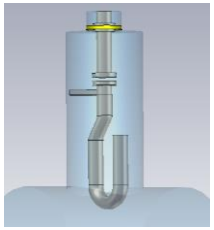


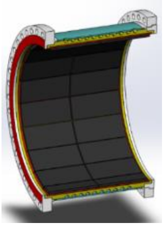


650 MHz
2-cell cavity & tuner
5-cell cavity
Q > 2E10 @ 20 MV/m



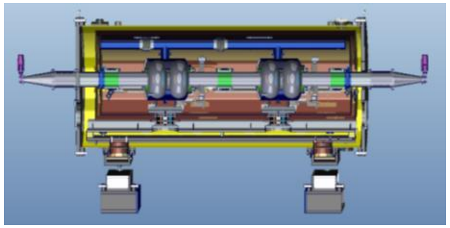
650 MHz
variable coupler
300 kW





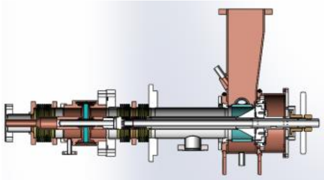
HOM coupler
1 kW

HOM absorber
5 kW



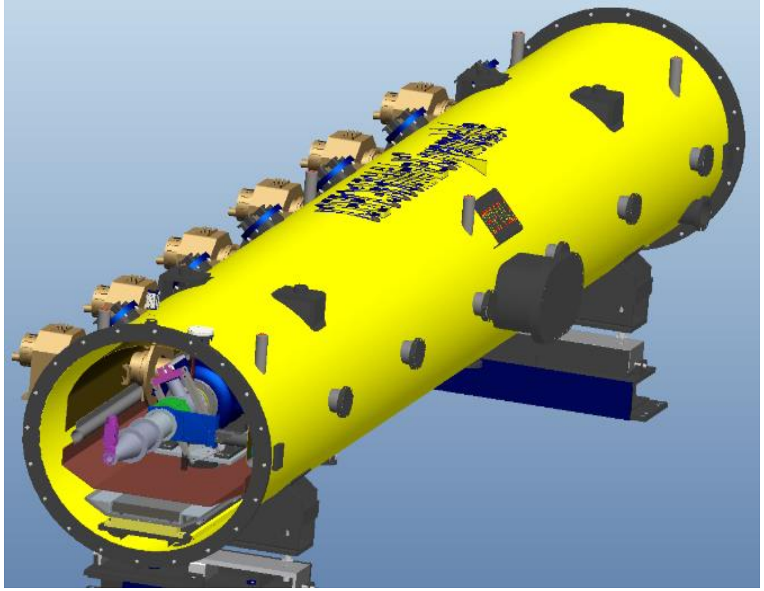
650 MHz & 1.3 GHz cryomodule
< 5 W @ 2K

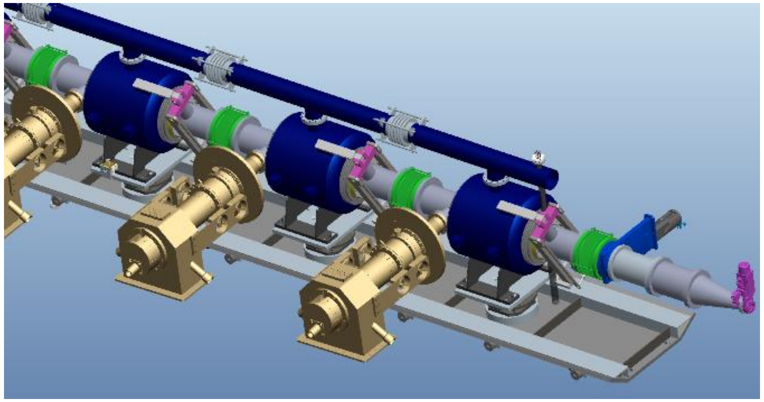
1.3 GHz TESLA cavity (high Q high gradient study)



1.3 GHz
variable coupler
20 kW

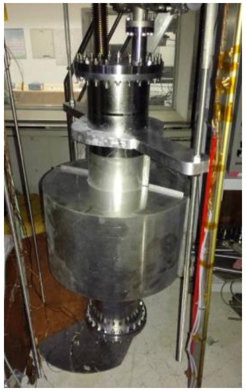
CEPC Main Ring 650 MHz Cryomodule



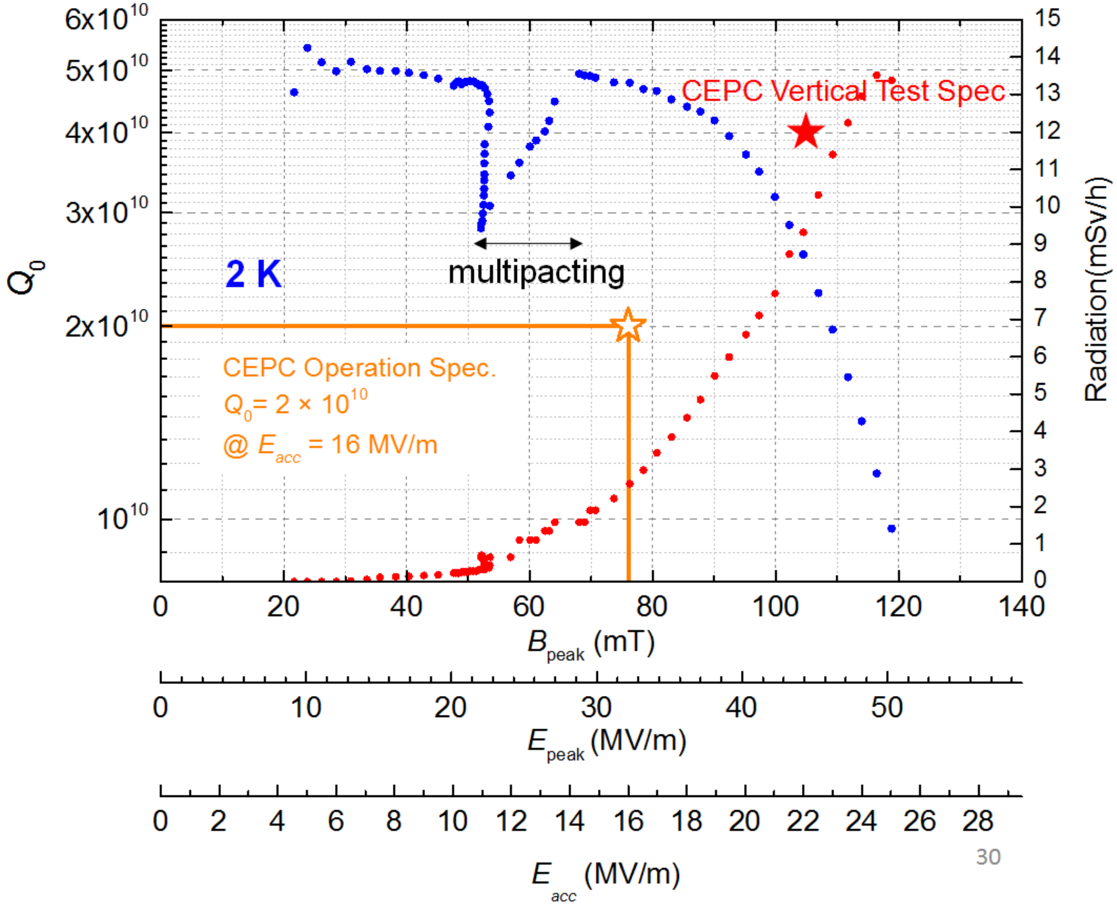


Overall length (flange to flange, m)	9.5
Inner diameter of vacuum vessel (m)	1.3
Beamline height from floor (m)	1.5
Overall weight (t)	16
Cryo-system working pressure (mbar)	31
Cryo-system working temperature (K)	2
Cryo-system pressure stability at 2 K (mbar)	0.1
Diameter of 2-phase pipe, mm	114
2 K heat exchange	1
Number of JT valve	1
Number of cavities	6
Number of coupler	6
HOM absorber	2
Number of 200-POST	6

650 MHz Single Cell Cavity Test before N-doping



- Fine grain, 130um BCP + 3 h 750 C annealing + 30um BCP + 120 C bake 48 h
- After vertical test, this cavity has received N-doping in July and is ready for vertical test again.

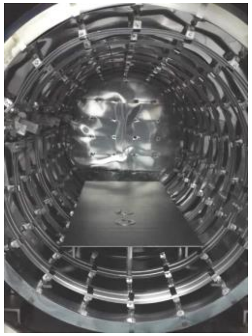


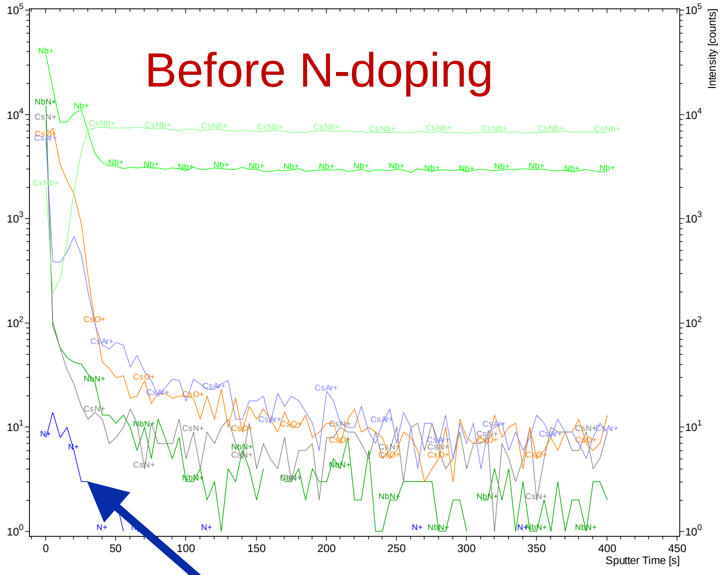
CEPC N-doping studies are undergoing waiting for EP facility to be established in 2018

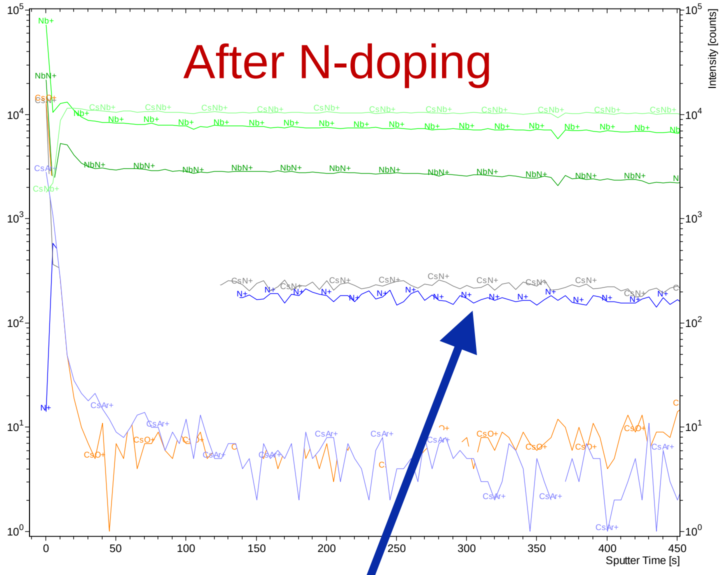
N-doping

P. Sha

- Successful **N-doping in Nb samples**.
- Cavity N-doping planned after undoped cavity vertical test.
- EP facility neccesary for treatment after doping.







Quantity of N increased obviously (blue curve), similar to FNAL result

(Secondary ion mass spectrometry, sputtering rate = 0.14 nm/s)

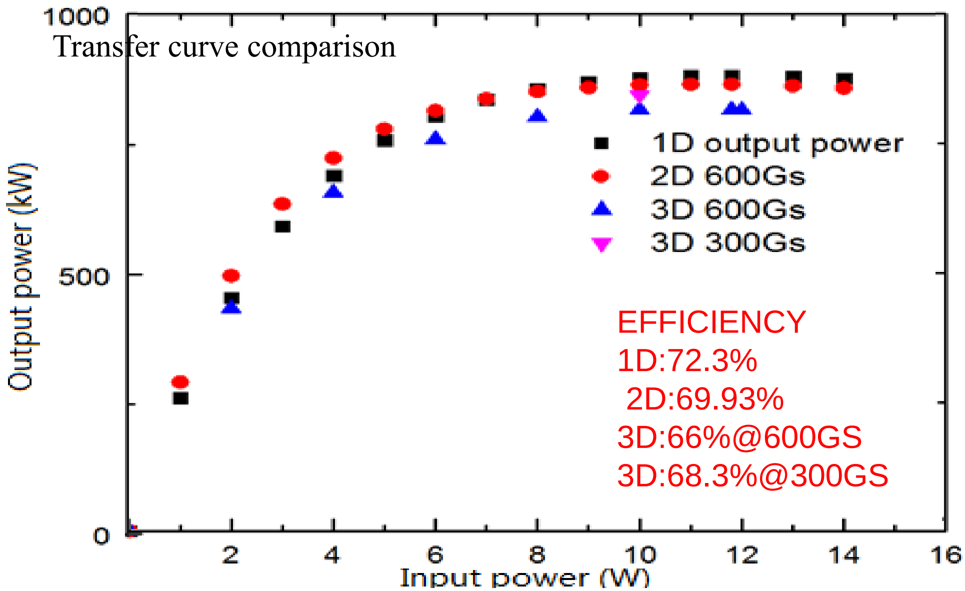
Shanghai Coherent Light Facility (SCLF)

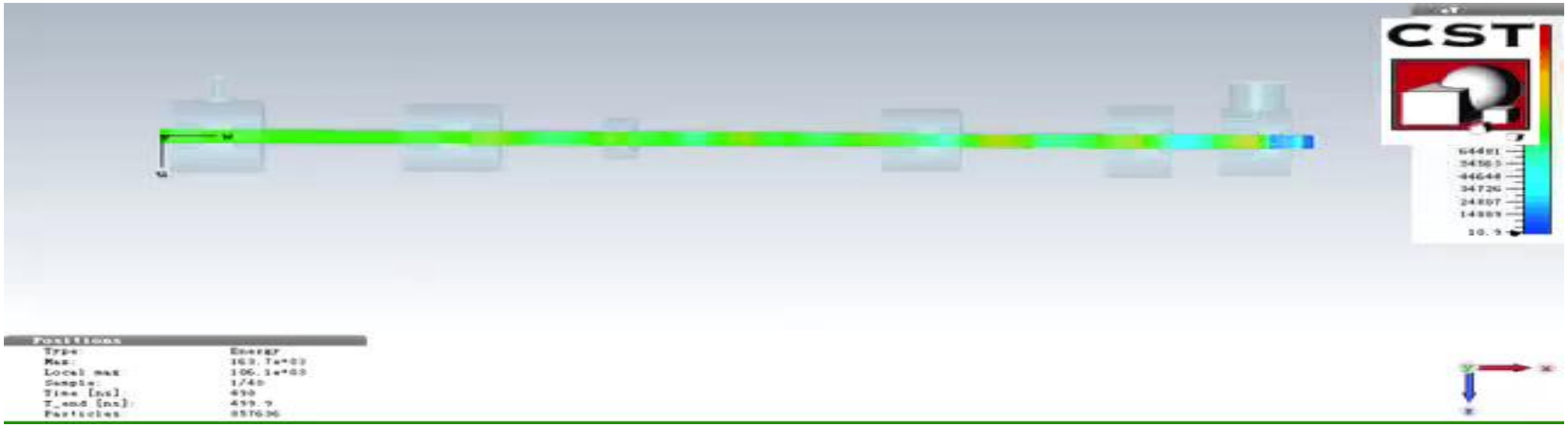
- SCLF is a newly proposed MHz high rep-rate XFEL, based on an 8 GeV CW SRF linac;
- This facility will be built in a 3.2 km long tunnel (38m underground) at Zhang-Jiang High Tech Park, across the SSRF campus in Shanghai;
- This XFEL facility includes 3 undulator lines and ~10 experimental stations in phase one, it can provide the XFEL radiation in the photon energy range of 0.2 -25 keV.
- The project proposal was recently approved by the central government in April 2017, and now it is in the feasibility study phase, aiming at commencing the tunnel construction in 2018 and being completed in 2024.

CEPC klystron traditional design

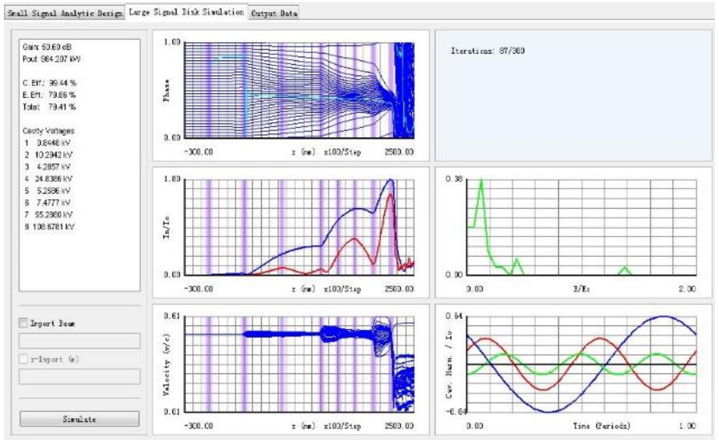
CEPC klystron traditional design parameters

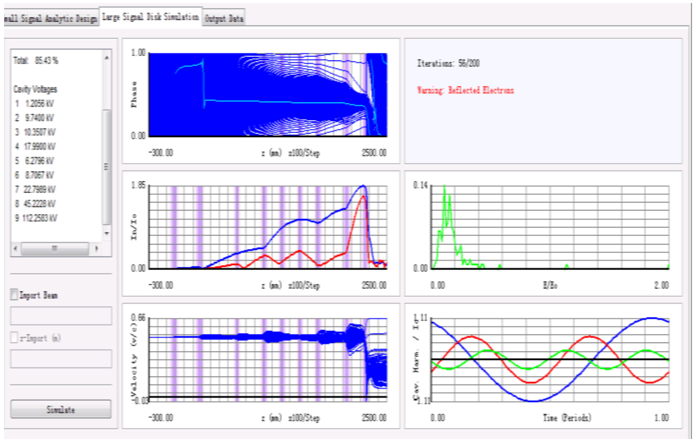
Parameters	Value
Operating frequency	650 MHz
Beam Voltage	81.5 kV
Beam Current	15.1 A
Beam Perveance	0.65 $\mu A/V^{3/2}$
Efficiency at rated Output Power	⩾65%
Saturation Gain	⩾45 dB
Output power	⩾800 kW
1 dB Bandwidth	±1 MHz
Brillouin Magnetic Field	106.7 Gauss
Reduced Plasma Wavelength	3.47 m
Number of Cavities	6
Normalized Drift Tube Radius	0.63
Normalized Beam Radius	0.41
Beam Fill Factor	0.65





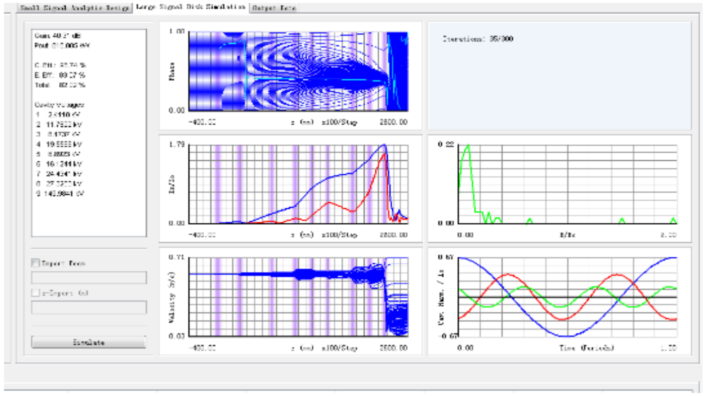
CEPC klystron high efficiency design

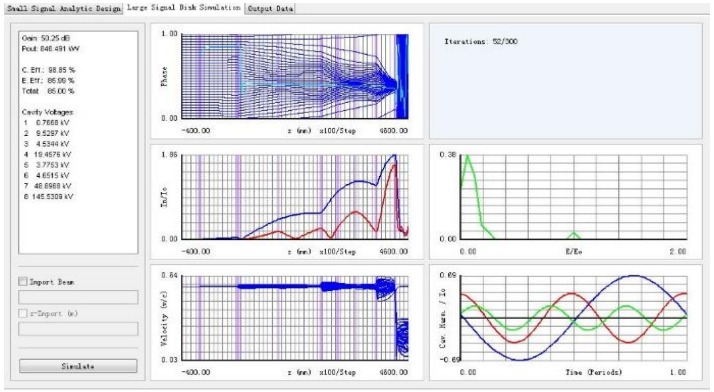




8 Cavities with BAC bunching method
Perveance: 0.65 µp
Voltage: 81.5kV
Efficiency: 79.41%

9 Cavities with BAC bunching method (some reflected electrons)
Perveance: 0.65 µp
Voltage: 81.5kV
Efficiency: 85.43%





9 Cavities with BAC bunching method (short length)
Perveance: 0.25 µp
Voltage: 110 kV
Efficiency: 82%

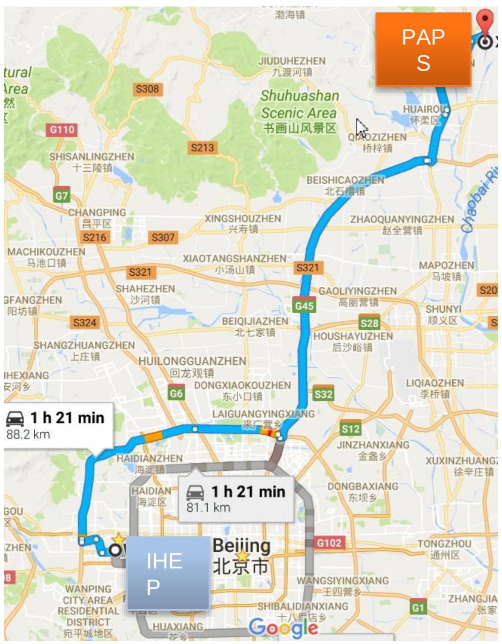
8 Cavities with BAC bunching method (long length)
Perveance: 0.25 µp
Voltage: 110 kV
Efficiency: 85%

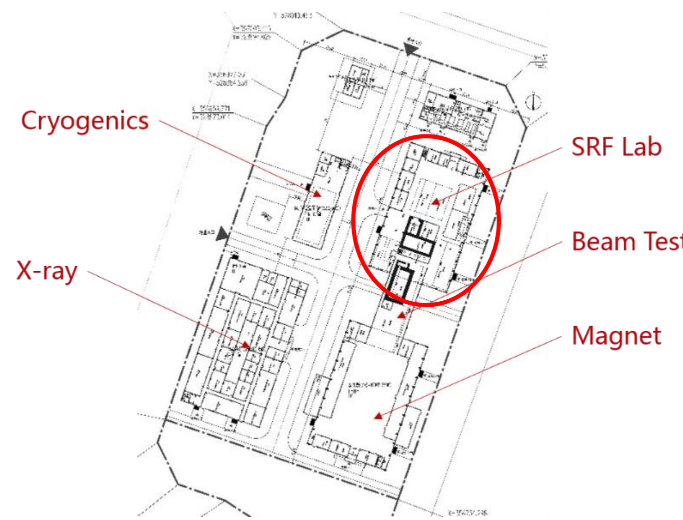
IHEP New SRF Facility

Platform of **A**dvanced **P**hoton **S**ource Technology R&D, Huairou Science Park, Huairou, Beijing

Construction: 2017 - 2019

Ground Breaking: May 31, 2017

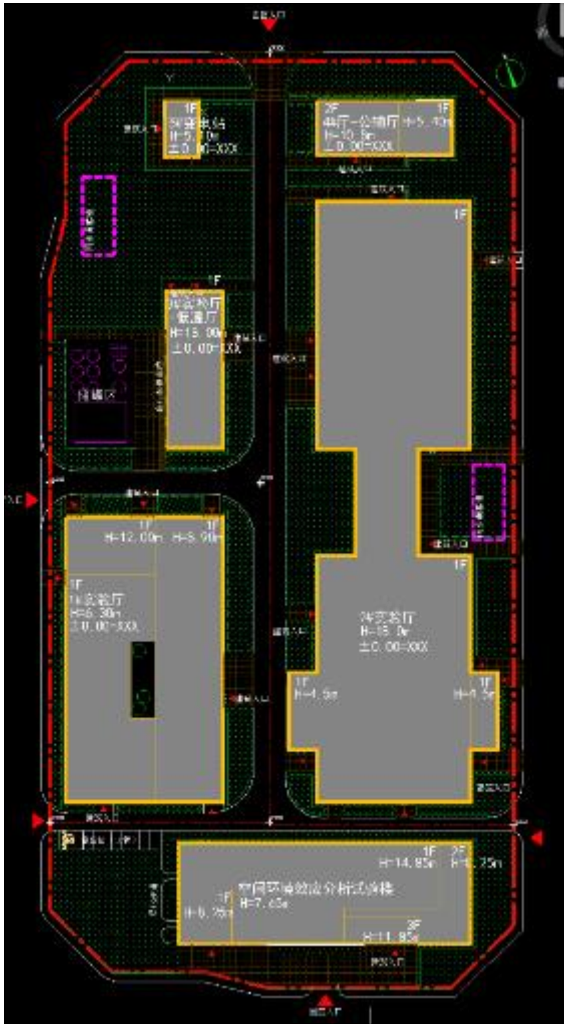




4500 m² SRF lab

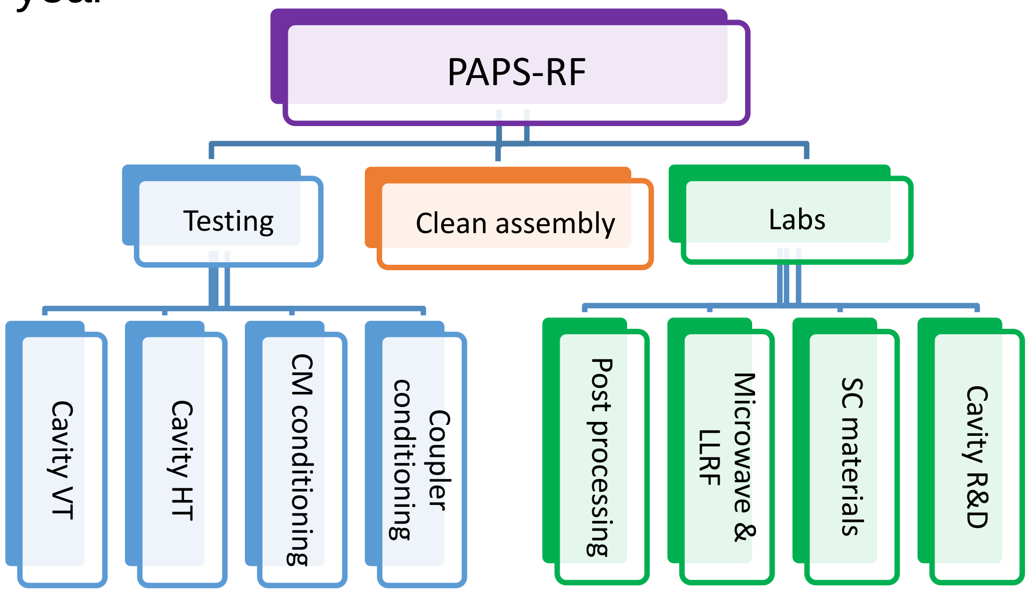
PAPS project overview

- "Platform of Advanced Photon Source Technology R&D", to provide infrastructure for construction of future project.
- Budget: 500M CNY funded by Beijing Gov.
- Construction: 2017.5-2020.6
- Consist of 7 systems:
  - ➢ RF system
  - ➢ Cryogenic system
  - ➢ Magnet technology
  - ➢ Beam test
  - ➢ X-ray optics
  - ➢ X-ray detection
  - ➢ X-ray application



PAPS-RF system

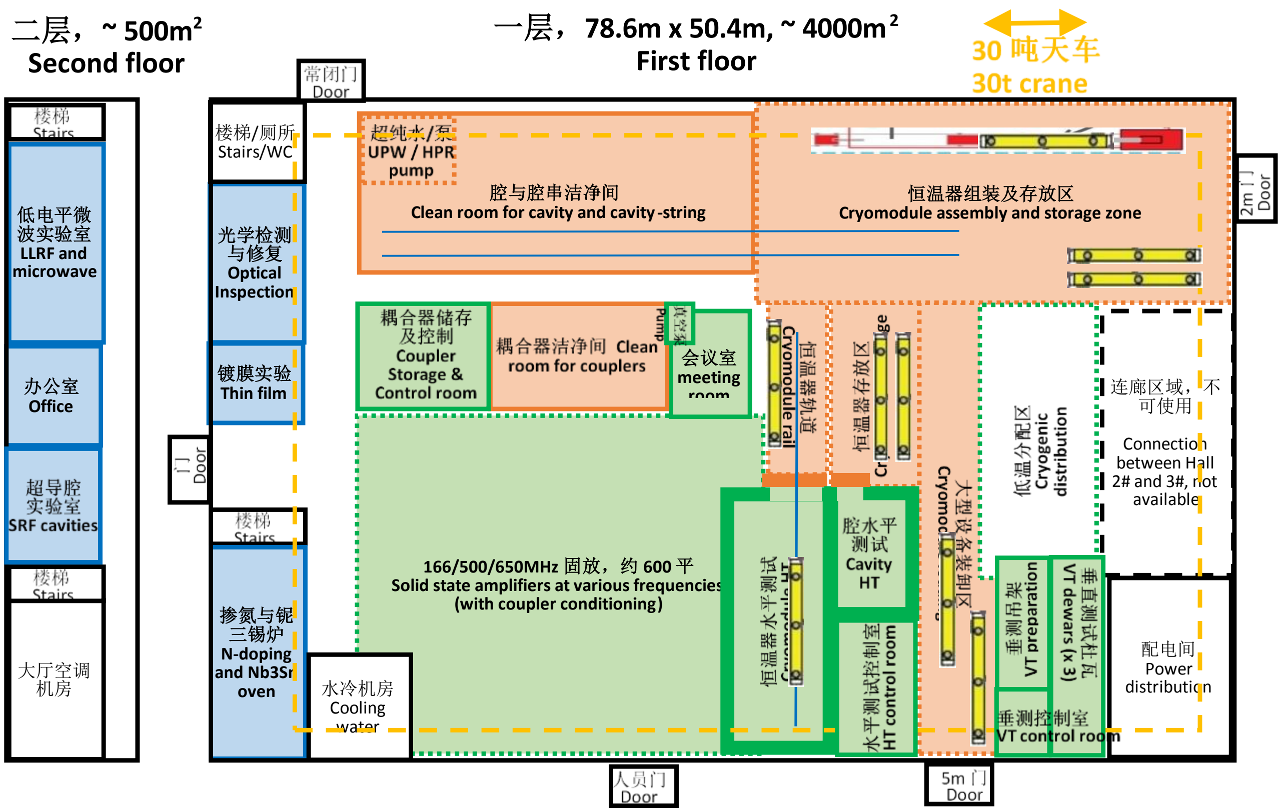
- The PAPS-RF system has two targets :
  - Build a SRF facility
  - Conduct R&D on cavities and ancillaries
- The SRF facility is biased on mass production for SRF projects
  - Post-processing, clean assembly, VT/HT/conditioning of cavities, couplers, and cryomodules.
  - Compatible of 166MHz, 325MHz, 500MHz, 650MHz, and 1.3GHz
  - 200-400 cavities (couplers) per year
  - ~20 cryomodules per year
  - Support R&D on new material and new technology
  - Total area of 4500 m^2
- Cryogenic system: 300W @ 2K



SCRF Lab Layout (4500 m²)

建设世界先进的超导高频实验室，为我国
和世界未来二十年超导加速器发展服务

高能所现有超导高频设施
已不满足未来发展需要



充分考虑了大型超导模组需求：

- 30米长大型洁净间
- 36米长恒温器组装区
- 20米长水平测试站（未来可增加一个以满足批量）
- 同时测试4只9-cell腔的垂测杜瓦2个（具备高Q腔所需的低磁环境和消磁线圈）
- 2.5kW@4.5K低温制冷能力（可同时进行水平测试和垂直测试）
- 专用的耦合器老练洁净间，同时老练8个耦合器
- 充足的腔和模组存放区域
- 合理的工作流程和动线设计

PAPS-RF system progress

- The layout and technical parameters of the PAPS-RF facility have been defined and overviewed by international committee
- The civil construction has started since May 31st, 2017

SppC Progresses

Framework for the SppC Conceptual Design Report

J.Y. Tang

- Baseline design
  - Tunnel circumference: 100 km
  - Dipole magnet field: 12 T, using 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, iron-based HTS technology
  - Center of Mass energy: >125 TeV
  - Injector chain: 4.2 TeV (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.)

SPPC Parameter Choice and Comparation

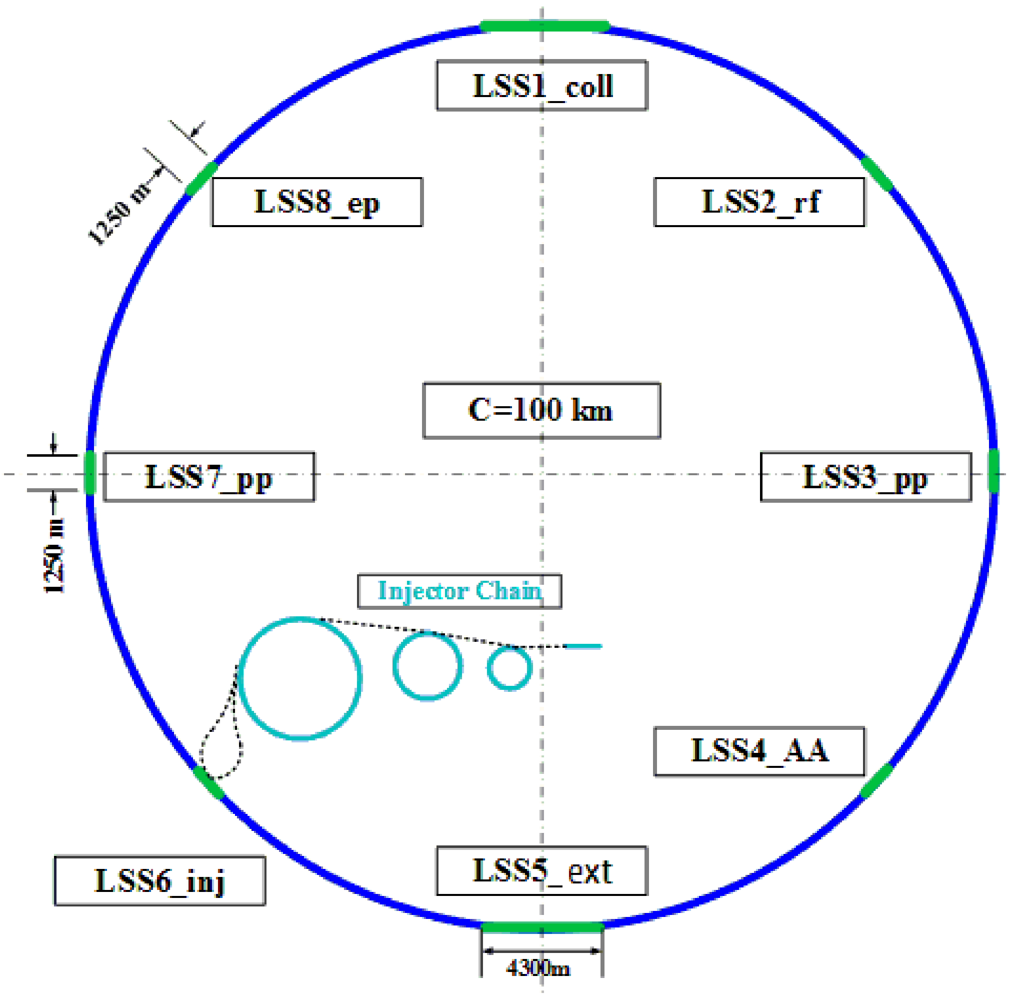
Table 2: SPPC Parameter list(2017.1)[4].[6]

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

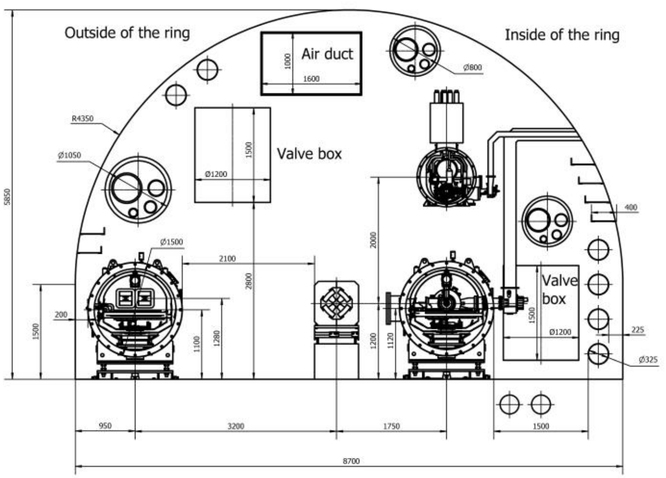
SPPC main parameters (updated)

Parameter	Unit	Value		
		PreCDR	CDR	Ultimate
Circumference	km	54.4	100	100
C.M. energy	TeV	70.6	75	125-150
Dipole field	T	20	12	20-24
Injection energy	TeV	2.1	2.1	4.2
Number of IPs		2	2	2
Nominal luminosity per IP	$cm^{-2}s^{-1}$	1.2e35	1.0e35	-
Beta function at collision	m	0.75	0.75	-
Circulating beam current	A	1.0	0.7	-
Bunch separation	ns	25	25	-
Bunch population		2.0e11	1.5e11	-
SR power per beam	MW	2.1	1.1	-
SR heat load per aperture @arc	W/m	45	13	-

SPPC Layout

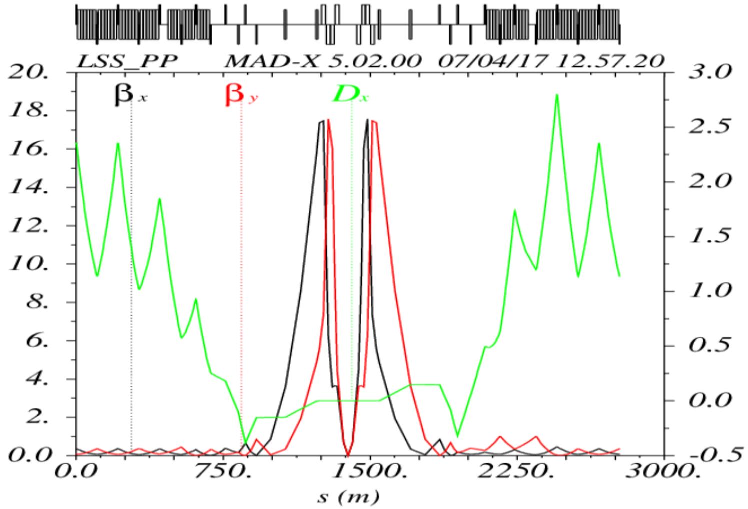


Tunnel cross-section

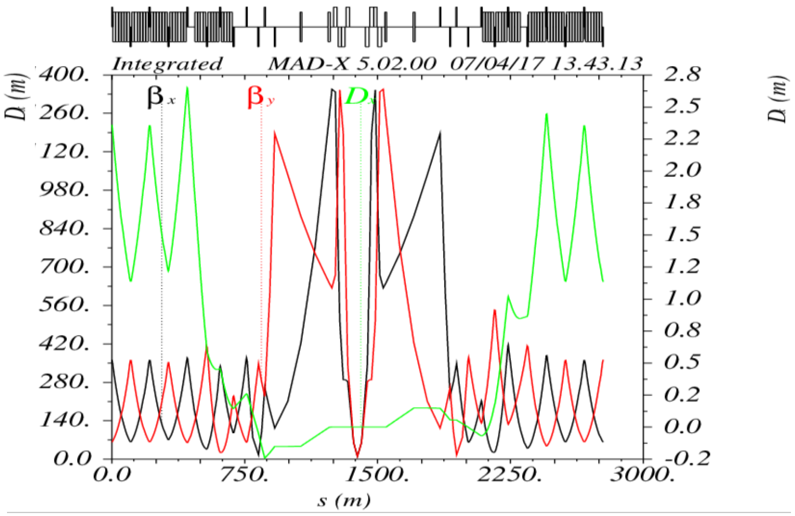


SppC lattice design

- Different lattice designs
  - Different schemes (100 TeV and 75 TeV @100 km)
  - Lattice at injection
  - Compatibility between CEPC and SPPC
  - Arc cells, Dispersion suppressors, insertions



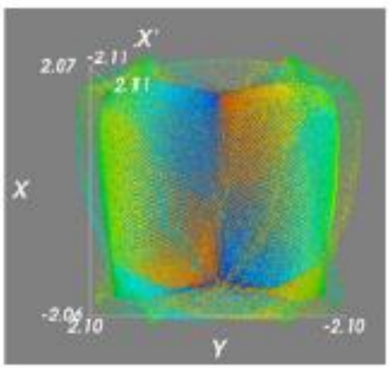
IP: at collision

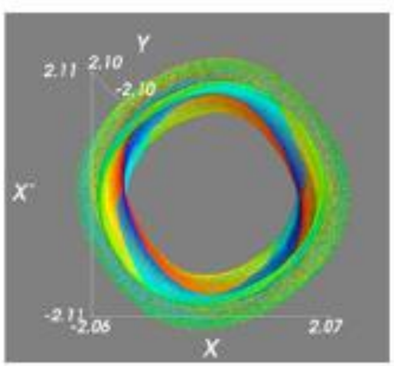


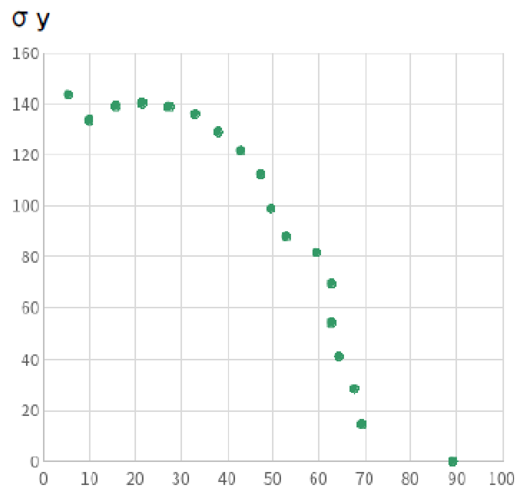
IP: at injection

Dynamic aperture study

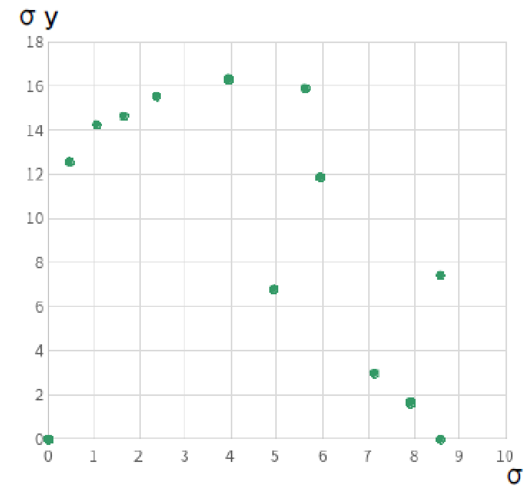
- At collision energy
- At injection energy
  (Sixtrack code)



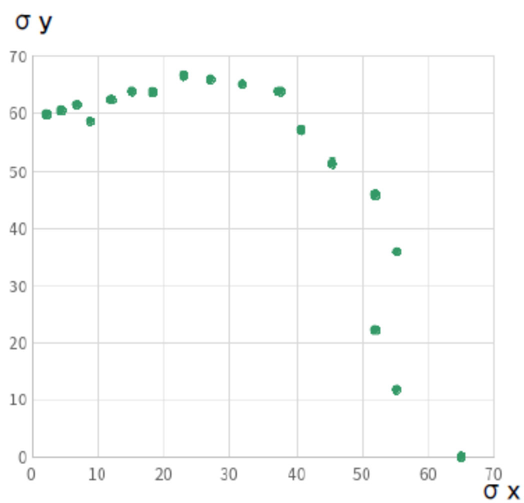




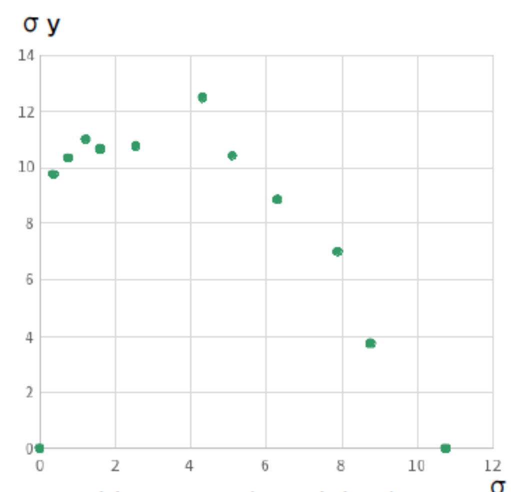
Adding sextuple without dipole error
(chromaticity corrected)



Adding sextuple and dipole error
(chromaticity corrected)



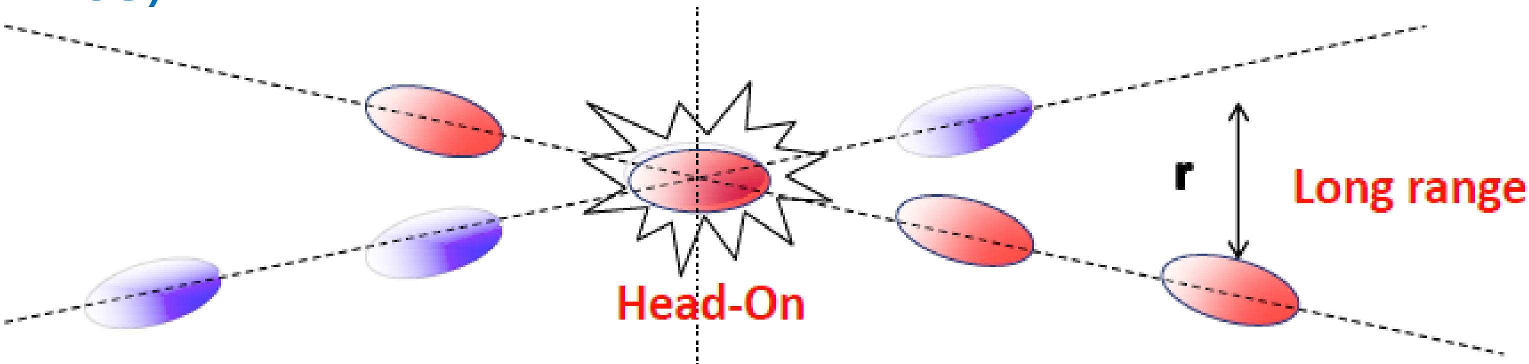
Adding sextuple without dipole error
(chromaticity corrected)



Adding sextuple and dipole error
(chromaticity corrected)

Beam-beam effects

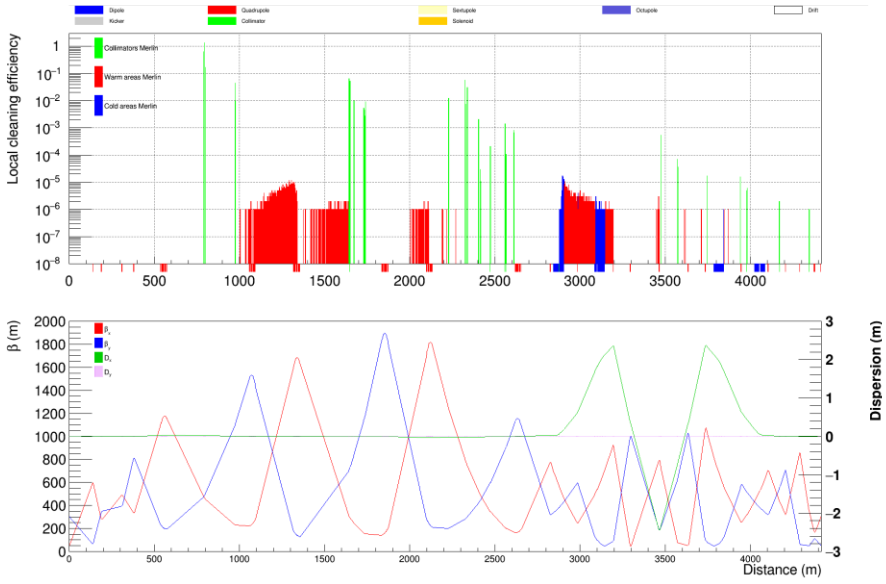
- Studying different effects (just started)
  - Head-on interaction
  - Long-range interaction
  - Pacman effects
  - Orbit effects
  - Coherent beam effects
  - BB compensation methods (Electron lens, Compensation wires)



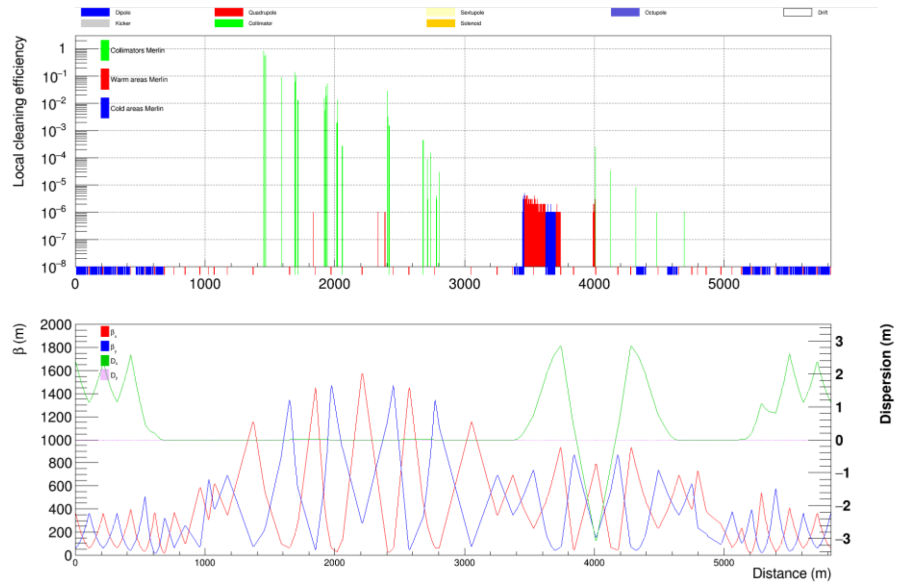
SPPC: normal bunch (164 LRBBI) Pacman bunch (82~164 LRBBI)

Collimation study

- We further develop the concept of combining betatron and momentum collimations in a same long straight section
- Recently we make a new design for the transverse collimation section, by introducing protected large-aperture superconducting magnets and add an additional collimation stage
  - Simulations show good effect

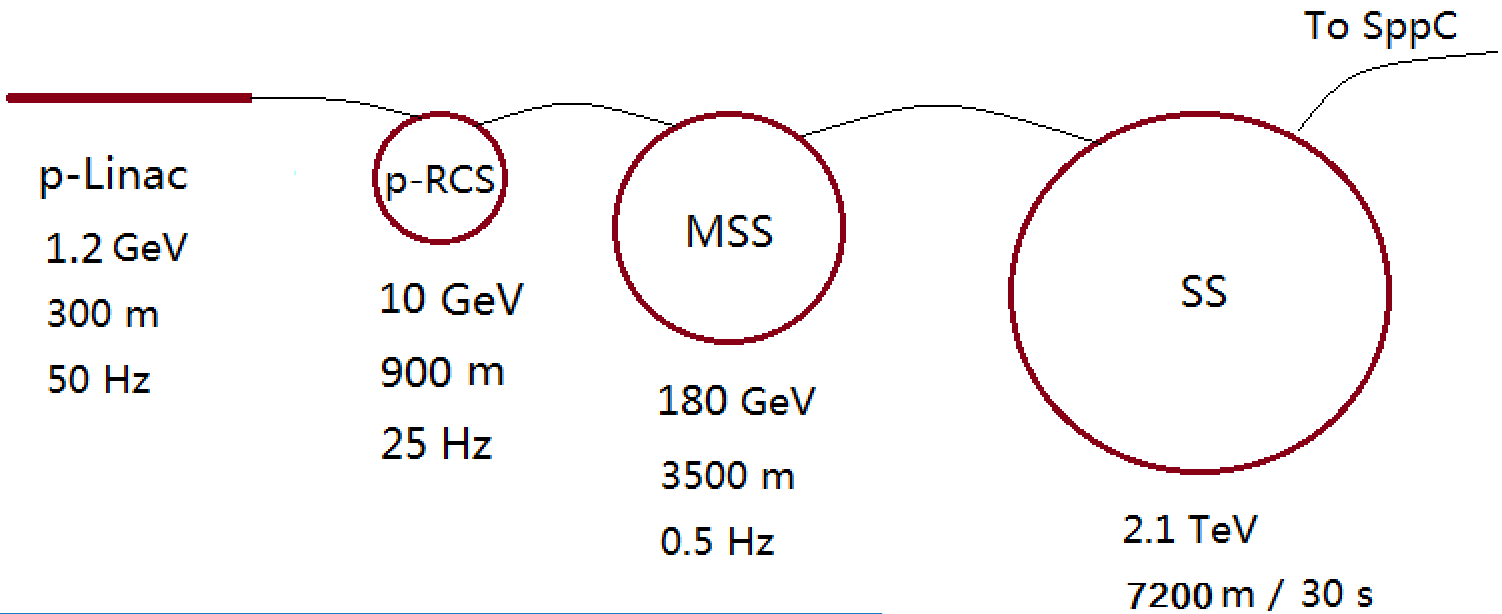


With RT magnets in beta-collimation



With SC magnets in beta-collimation

Injector chain
(for proton beam)



p-Linac: proton superconducting linac

p-RCS: proton rapid cycling synchrotron

MSS: Medium-Stage Synchrotron

SS: Super Synchrotron

Ion beams have dedicated linac (I-Linac) and RCS (I-RCS)

Major parameters for the injector chain

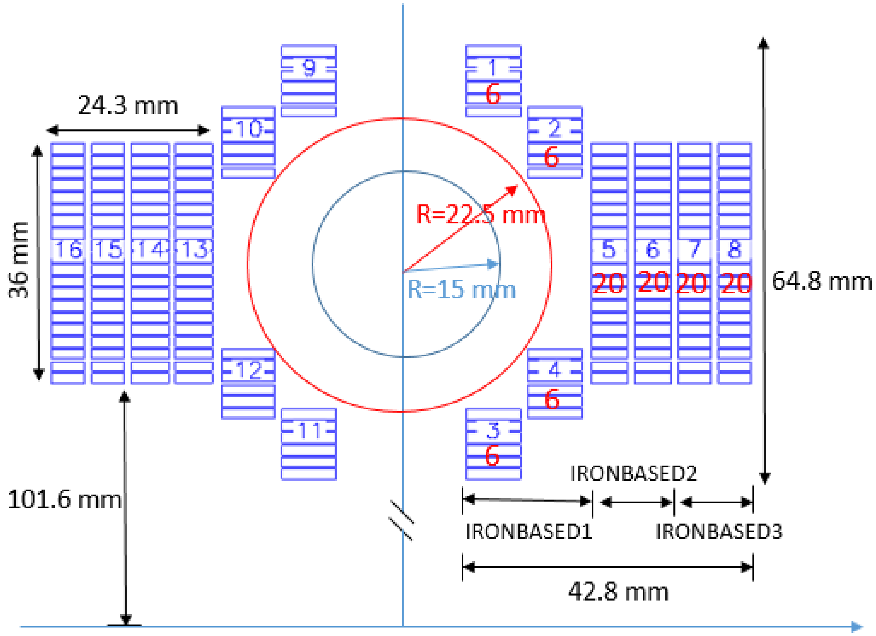
	Value	Unit		Value	Unit
p-Linac			MSS		
Energy	1.2	GeV	Energy	180	GeV
Average current	1.4	mA	Average current	20	uA
Length	~300	m	Circumference	3500	m
RF frequency	325/650	MHz	RF frequency	40	MHz
Repetition rate	50	Hz	Repetition rate	0.5	Hz
Beam power	1.6	MW	Beam power	3.7	MW
p-RCS			SS		
Energy	10	GeV	Energy	2.1	TeV
Average current	0.34	mA	Accum. protons	1.0E14	
Circumference	970	m	Circumference	7200	m
RF frequency	36-40	MHz	RF frequency	200	MHz
Repetition rate	25	Hz	Repetition period	30	s
Beam power	3.4	MW	Protons per bunch	1.5E11	
			Dipole field	8.3	T

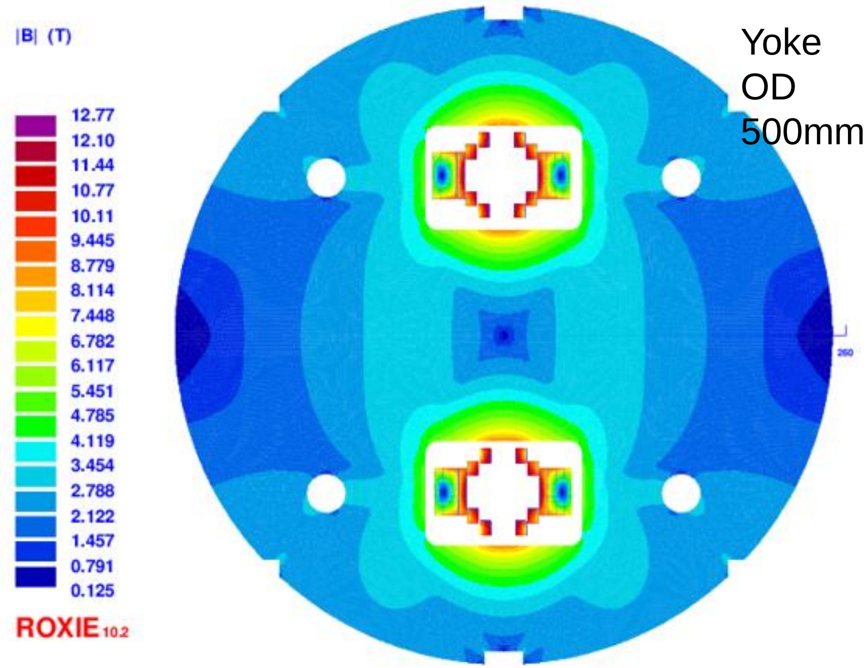
Technical challenges and R&D requirements -High field SC magnets

- 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

C. Wang, E. Kong (USTC), Q. Xu et al.





Yoke OD 500mm

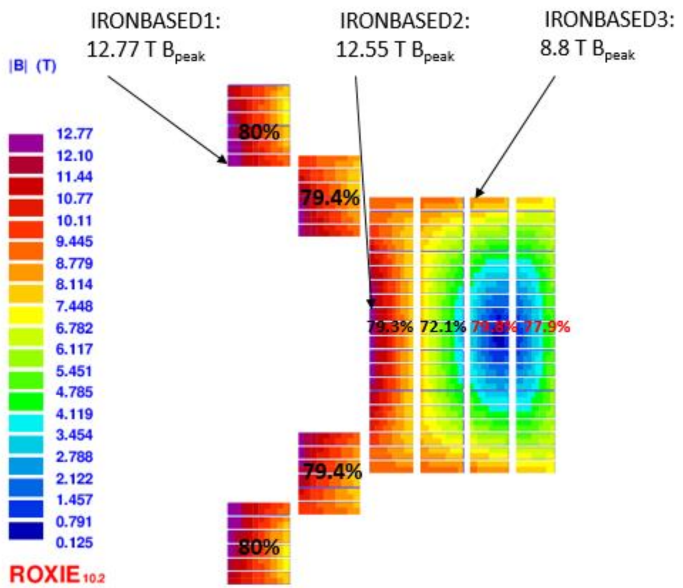


Table 1: Main parameters of the cables

Cable	Hight	Width-i	Width-o	Ns	Strand	Filament	Insulation
IRONBASED 1	8	1.5	1.5	20	IRON-BASED	FE-BASED	0.15
IRONBASED 2	5.6	1.5	1.5	14	IRON-BASED	FE-BASED	0.15
IRONBASED 3	5	1.5	1.5	12	IRON-BASED	FE-BASED	0.15

Table 2: Main parameters of the strand

Strand	diam.	cu/sc	RRR	Tref	Bref	Jc@ BrTr	dJc/dB
IRON-BASED	0. 802	1	200	4. 2	10	4000	111

For per meter of such magnet, the required length of the iron-based strand: 6.08 Km

Domestic Collaboration on HTS

In October 2016, A consortium for High-temperature superconducting materials, industrialization and applications was formed in China, with participation of major research and production institutions on HTS.

China is actually leading the development of Fe-HTS technology in the world; world-first 100-m Fe-HTS wire was made by CAS-Institute of Electrical Engineering in the last year .

Other important issues

CEPC International Collaboration Status

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)
- ✓ IHEP-KEK (Japan) MoU (Sept 2017)

International workshop and meetings on CEPC accelerator:

- ✓ The 6th IHEP-KEK SCRF Collaboration Meeting has been held on July 14-15 at IHEP

Meeting purposes:

1) Disussion on the IHEP Huairou SC Platform
2) ILC and CEPC SC technology issues and collaboration
3) ILC and CEPC SC industralization plans
4) ILC and CEPC SC collaboration

CEPC Site Selection Progresses

Bejing

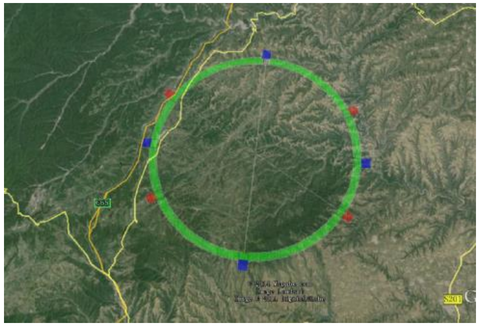
Baoding (xiong an)

Tianjin

4

1

2



3

1) Qin huang dao，Heihe （Completed in 2014）

2) Huanging，Shanxi（Completed in 2017)

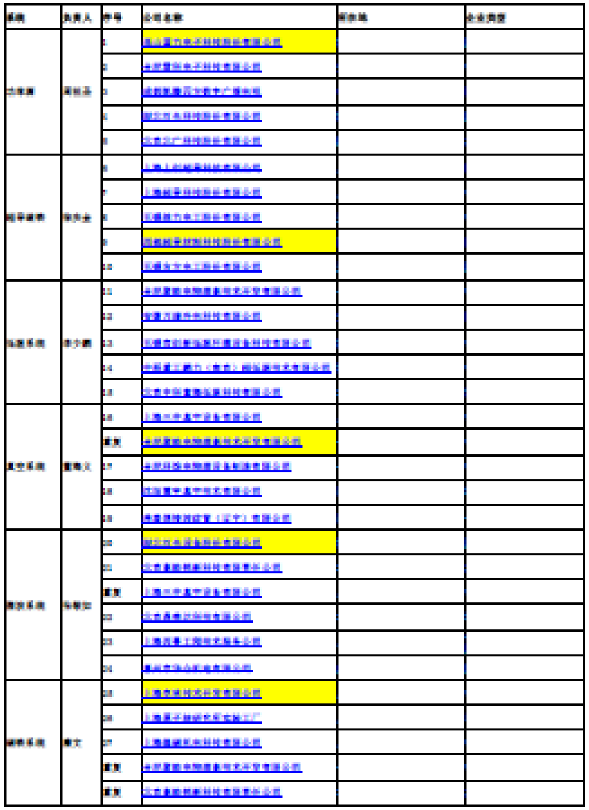
3)Shen shan，Guangdong (Completed in 2016)

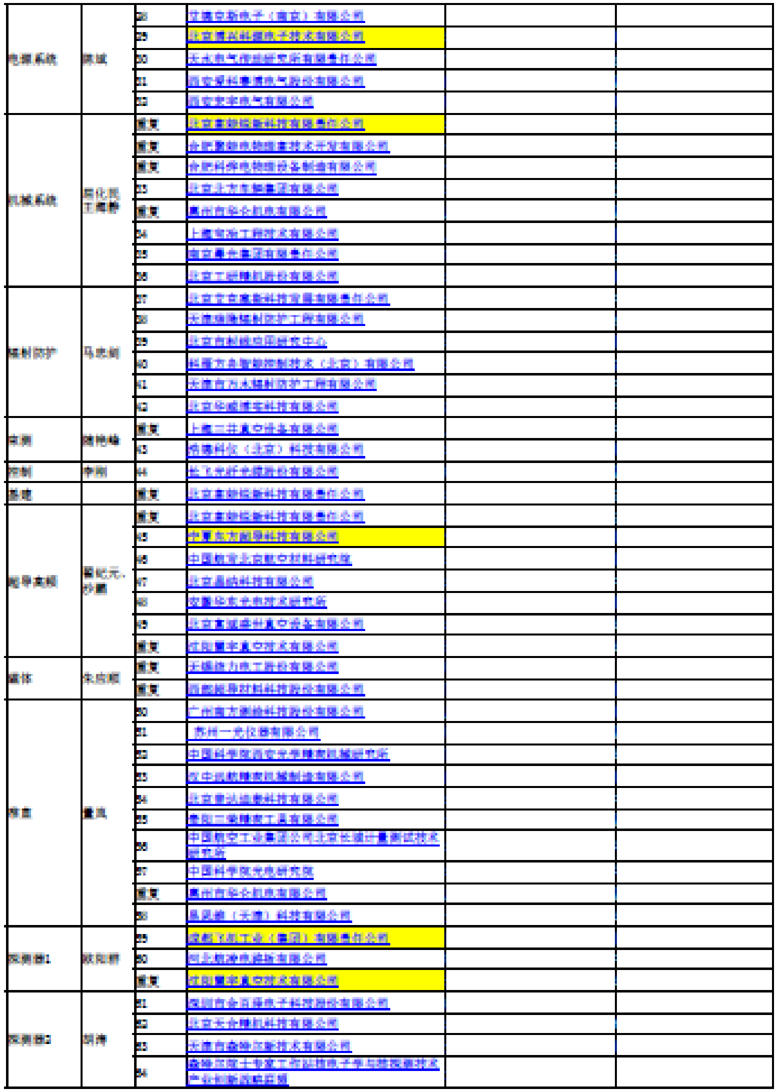
4) Baoding (Xiong an), Hebei (Started in August 2017, near Beijing ~200km to the south)

China Enterprise Consortium Promoting CEPC

Enterprise Consortium

- helps & guides industry;
- win their support for CEPC;
- enhance CEPC quality, reduce cost;
- ……





To be established on Nov. 7, 2017

International Workshop on CEPC

- a major workshop on CEPC
- global collaboration
- examines R&D status
- CDR – draft chapters
  - a major push
- CEPC organization update

Please come to this workshop

Nov 6~8, 2017, IHEP, China

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

Concluding remarks

- CEPC-SppC shapes well towards CDR with clear physcis goals and with Fully Partial Double Ring Scheme of 100km as CEPC baseline and Advanced Partical Double Ring (APDR) Scheme as alternative
- 100km CEPC accelerator baseline design progress well
- Fund from MOST succeded in June 2016 (36M RMB)
- CEPC-SppC CDR to be finished both for accelerator and detector at the end of 2017
- Design and key technologies' R&D plan progress well
- In addition to international collabotaion in general, synergies of CEPC/SppC with LCC(ILC, CLIC) and FCC(e+e-,pp) are very important for the future of HEP community
- Young generations are the key forces to realize the goals

Thank you for your attention

Thanks go to

CEPC-SppC accelerator team and international collaborators