SPPC Parameter Choice and Lattice Design

CEPC PDR APDR DR Lattice Design and Beam Dynamics Study

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Outline

I. SPPC Parameter Choice and Lattice Design :

1. SPPC Parameter Choice and Comparation
2. SPPC Lattice Layout
3. 61km SPPC Lattice Design and DA Study
4. 100km SPPC Lattice Design and DA Study (under way)
5. Summary

II. CEPC Partial Double Ring Lattice Design:

1. CEPC PDR Parameter and Lattice Layout
2. CEPC PDR Lattice Design (61 km)
3. CEPC PDR DA Study and Optimization
4. Summary

III. CEPC Advanced Partial Double Ring Lattice Design:

1. CEPC APDR Parameter and Lattice Layout
2. CEPC APDR Lattice Design (65 km 100km)
3. CEPC APDR DA Study and Optimization
4. Summary

IV. CEPC Double Ring Lattice Design:

1. CEPC DR Parameter and Lattice Layout
2. CEPC DR Lattice Design (61km 100km)
3. CEPC DR DA Study and Optimization
4. Summary

Outline

I. SPPC Parameter Choice and Lattice Design :

1. SPPC Parameter Choice and Comparation
2. SPPC Lattice Layout
3. 61km SPPC Lattice Design and DA Study
4. 100km SPPC Lattice Design and DA Study (under way)
5. Summary

1. SPPC Parameter Choice and Comparation

Table 3: SPPC Parameter List (201609).

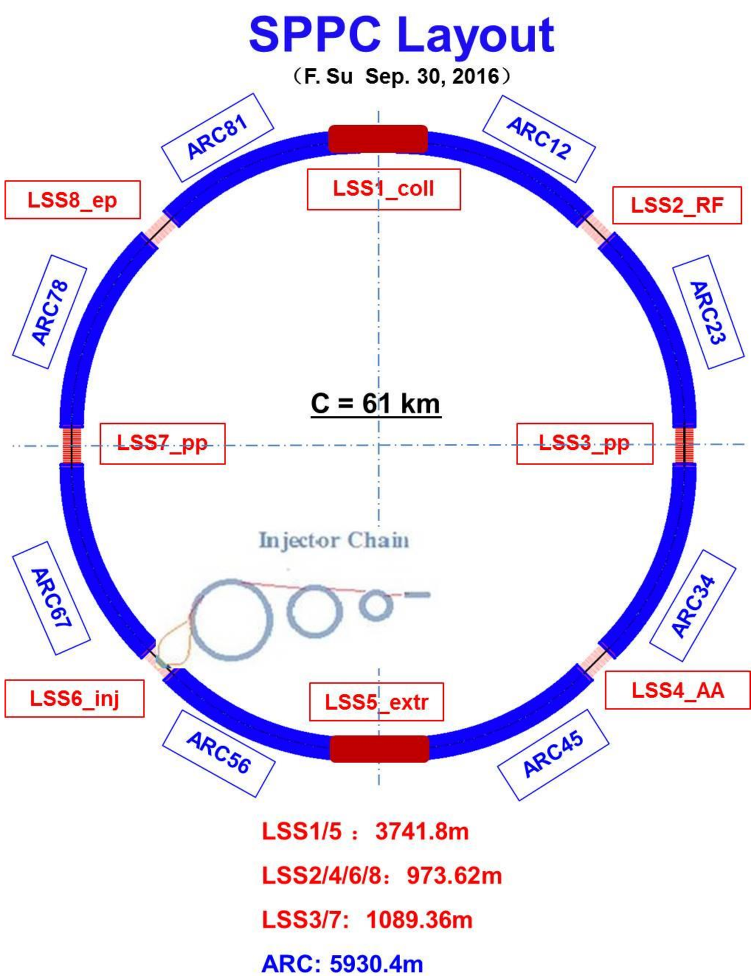
	SPPC (Pre-CDR)	SPPC 61Km	SPPC 100Km	SPPC 100Km	SPPC 82Km
Main parameters and geometrical aspects					
Beam energy[E_0]/TeV	35.6	35.0	50.0	64.0	50.0
Circumference[C_0]/km	54.7	61.0	100.0	100.0	82.0
Dipole field[B]/T	20	19.81	15.62	19.98	19.74
Dipole curvature radius[ρ]/m	5928	5889.64	10676.1	10676.1	8441.6
Bunch filling factor[f_2]	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
Total dipole length [L_{Dipole}]/m	37246	37006	67080	67080	53040
Arc length[L_{ARC}]/m	47146	47443	86000	86000	68000
Straight section length[L_{ss}]/m	7554	13557	14000	14000	14000
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}
Beta function at collision[β^*]/m	0.75	0.85	0.99	0.22	1.06
Max beam-beam tune shift per IP[ξ_y]	0.006	0.0065	0.0068	0.0079	0.0073
Number of IPs contribut to ΔQ	2	2	2	2	2
Max total beam-beam tune shift	0.012	0.0130	0.0136	0.0158	0.0146
Circulating beam current[I_b]/A	1.0	1.024	1.024	1.024	1.024
Bunch separation[Δt]/ns	25	25	25	25	25
Number of bunches[n_b]	5835	6506	10667	10667	8747
Bunch population[N_p] (10^{11})	2.0	2.0	2.0	2.0	2.0
Normalized RMS transverse emittance[ε]/μm	4.10	3.72	3.59	3.11	3.35
RMS IP spot size[σ^*]/μm	9.0	8.85	7.86	3.04	7.86
Beta at the 1st parasitic encounter[$\beta 1$]/m	19.5	18.67	16.26	69.35	15.31
RMS spot size at the 1st parasitic encounter[σ_1]/μm	45.9	43.13	33.10	56.19	31.03
RMS bunch length[σ_z]/mm	75.5	56.69	66.13	14.62	70.89
Full crossing angle[θ_c]/μrad	146	138.03	105.93	179.82	99.29
Reduction factor according to cross angle[F_{ca}]	0.8514	0.9257	0.9247	0.9283	0.9241
Reduction factor according to hour glass effect[F_h]	0.9975	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
Critical photon energy[E_c]/keV	2.73	2.61	4.20	8.81	5.32
SR power per ring[P_0]/MW	2.1	2.03	4.66	12.52	5.90
Transverse damping time [τ_x]/h	1.71	1.994	2.032	0.969	1.32
Longitudinal damping time [τ_ε]/h	0.85	0.997	1.016	0.4845	0.66

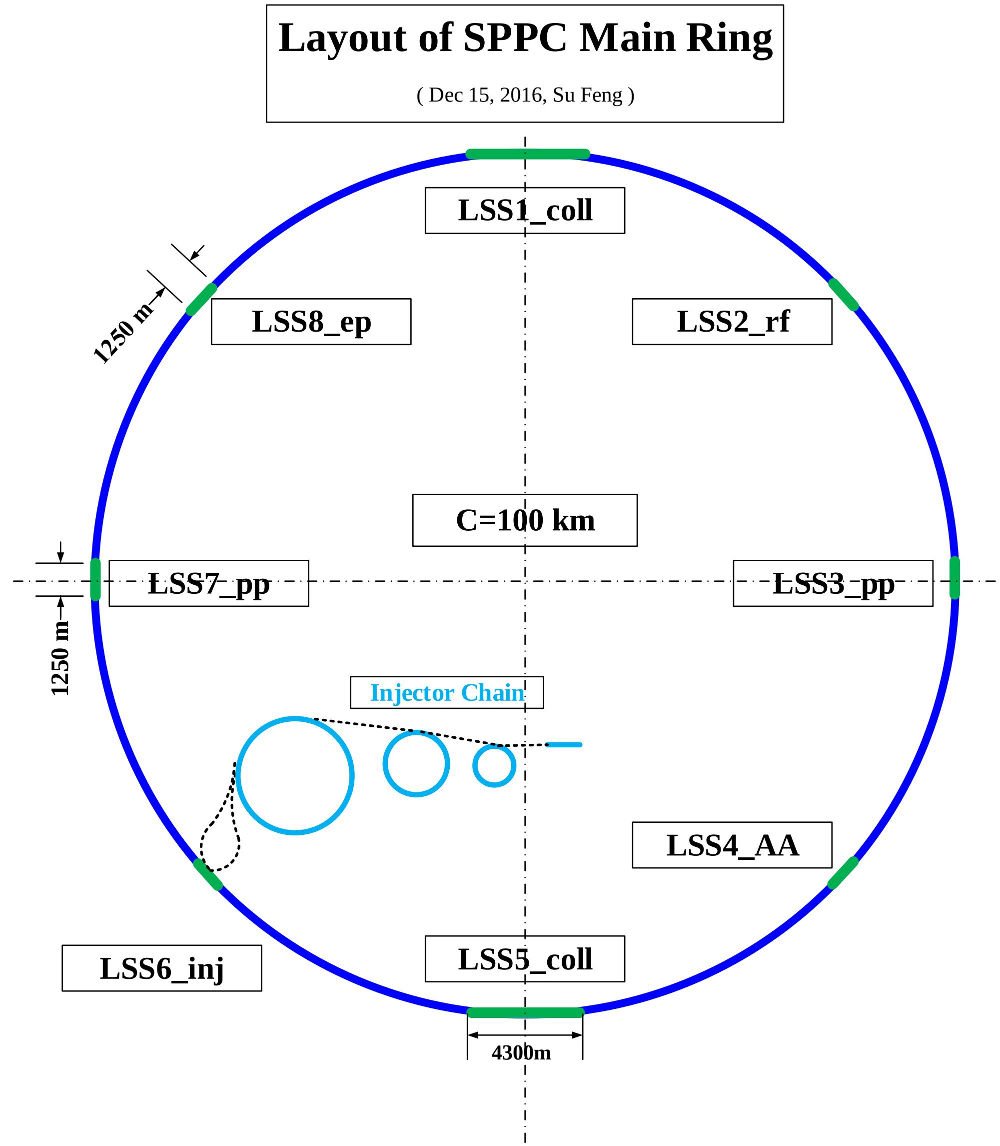
Main Parameter of SPPC Main Ring (Pre-CDR、61km、82km、100km)

Table 4: SPPC Parameter List.

	SPPC (Pre-CDR)	SPPC 61Km	SPPC 100Km	SPPC 100Km	SPPC 82Km
Beam energy[E_0]/TeV	35.6	35.0	50.0	64.0	50.0
Circumference[C_0]/km	54.7	61.0	100.0	100.0	82.0
Dipole field[B]/T	20	19.81	15.62	19.98	19.74
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}
Beta function at collision[β^*]/m	0.75	0.85	0.99	0.22	1.06
Max beam-beam tune shift per IP[ξ_y]	0.006	0.0065	0.0068	0.0079	0.0073
Number of IPs contribut to ΔQ	2	2	2	2	2
Circulating beam current[I_b]/A	1.0	1.024	1.024	1.024	1.024
Number of bunches[n_b]	5835	6506	10667	10667	8747
Bunch population[N_p] (10^{11})	2.0	2.0	2.0	2.0	2.0
Normalized RMS transverse emittance[ε]/μm	4.10	3.72	3.59	3.11	3.35
RMS bunch length[σ_z]/mm	75.5	56.69	66.13	14.62	70.89
Full crossing angle[θ_c]/μrad	146	138.03	105.93	179.82	99.29
Energy loss per turn[U_0]/MeV	2.10	1.98	4.55	12.23	5.76
SR power per ring[P_0]/MW	2.1	2.03	4.66	12.52	5.90

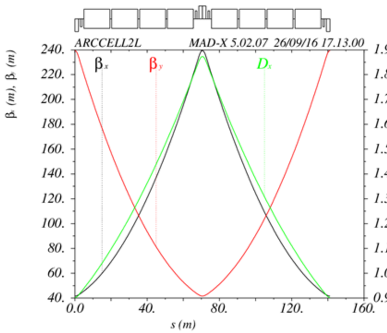
2. SPPC Lattice Layout

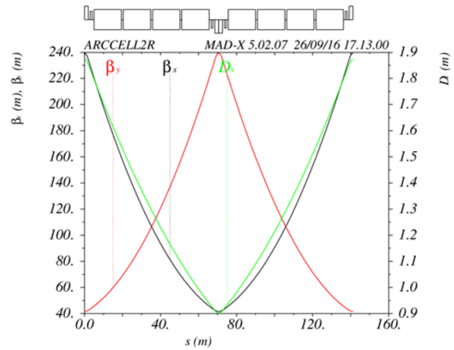




3. 61km SPPC Lattice Design and DA Study

FODO Cell in ARC

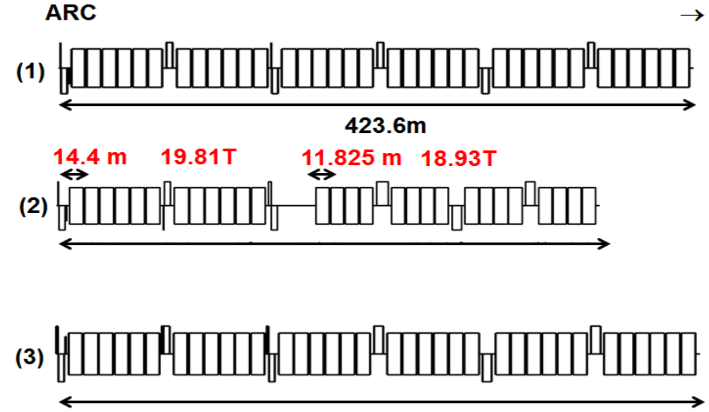




arccell1 | L=141.2m | arccell2

Betax: 239.415/41.632
Betay: 41.632/239.407

Dispersion Suppressor (DS) types

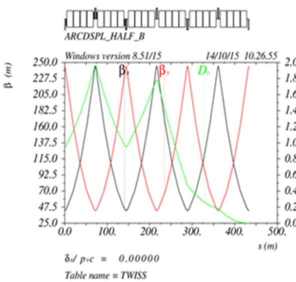


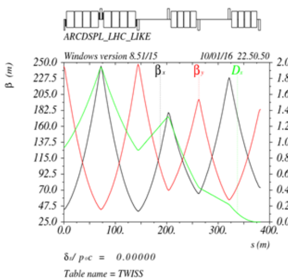
(1) Half Bend (half weak dipoles)

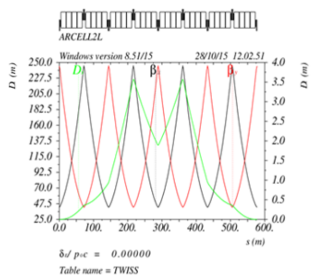
(2) LHC-like

(3) Full Bend
Longer DS but less cells in the Arcs

(1) Half Bend (2) LHC Like (3) Full Bend



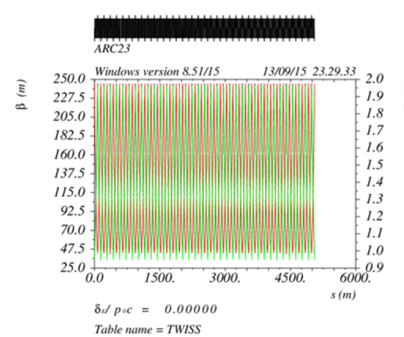


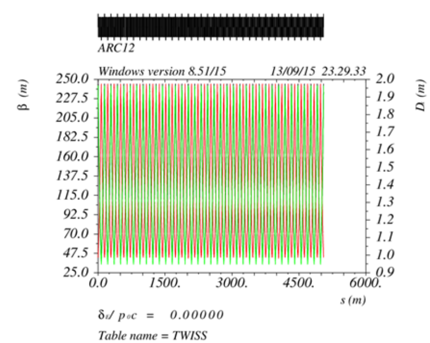


L=423.6(282.4)m | L=382.4m | L=564.8m
0.78 | 0.79 | 0.816

	BDSP1L	BDSP2L	BDSP1R	BDSP2R	B0	
(1)	9.905	9.905	9.905	9.905	19.81	(T)
(2)	18.93	18.93	18.93	18.93	19.81	(T)
(3)	19.81	19.81	19.81	19.81	19.81	(T)

ARC (ARCDSPL,36 CELL, ARCDSPR)





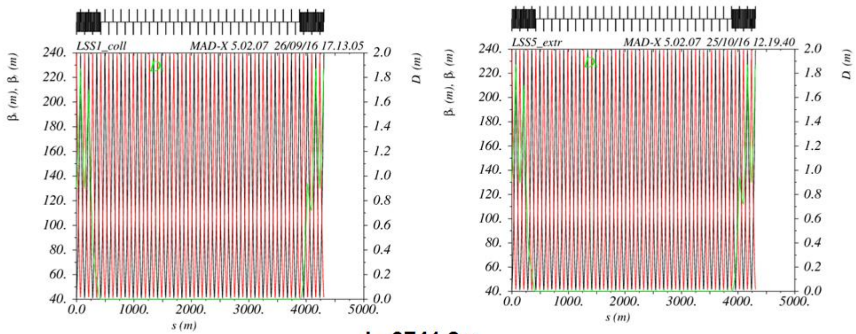
ARC23
ARC45
ARC67
ARC81

L=5930.4m

ARC12
ARC34
ARC56
ARC78

3. 61km SPPC Lattice Design and DA Study

LSS1_coll/LSS5_extr

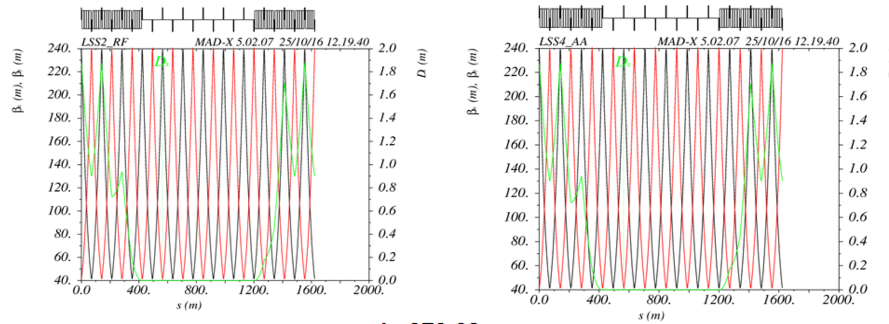


L=3741.8m

ARCDSPL, 26.5*STRCELL, ARCDSPR

423.6m, 3741.8m, 423.6m

LSS2_RF/LSS4_AA

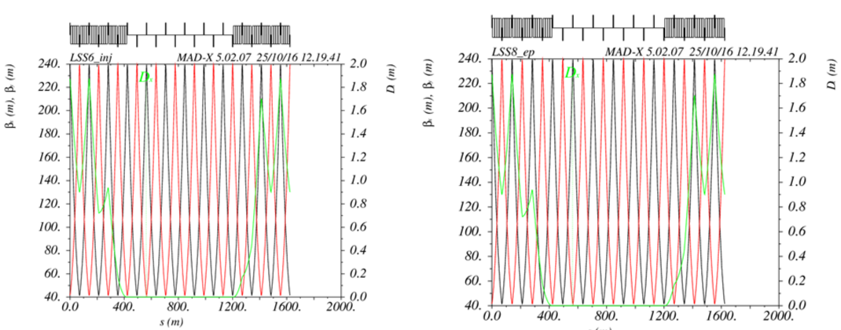


L=973.62m

-ARCDSPR, ARC_to_STR, 6.5*STRCELL, STR_to_ARC, -ARCDSPL

423.6m, 27.91m, 917.8m, 27.91m, 423.6m

LSS6_inj/LSS8_ep

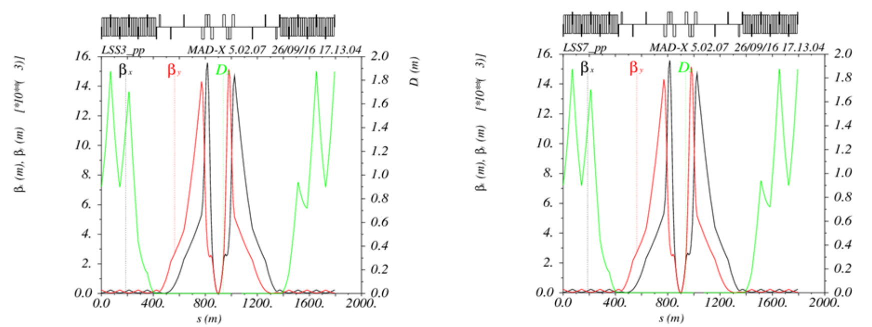


L=973.62m

-ARCDSPR, ARC_to_STR, 6.5*STRCELL, STR_to_ARC, -ARCDSPL

423.6m, 27.91m, 917.8m, 27.91m, 423.6m

LSS3_pp/LSS7_pp



L=1089.36m

ARCDSPL, ARC_to_IR, LSS3_pp/LSS7_pp, IR_to_ARC, ARCDSPR

423.6m, 70.6m, 948.16m, 70.6m,423.6m

β * = 0.75m L*=36m

Crossing angle：146urad

3. 61km SPPC Lattice Design and DA Study

Definition of Dynamic Aperture

1. Real World Dynamic Aperture (RW-DA) Definition → W. Fischer:

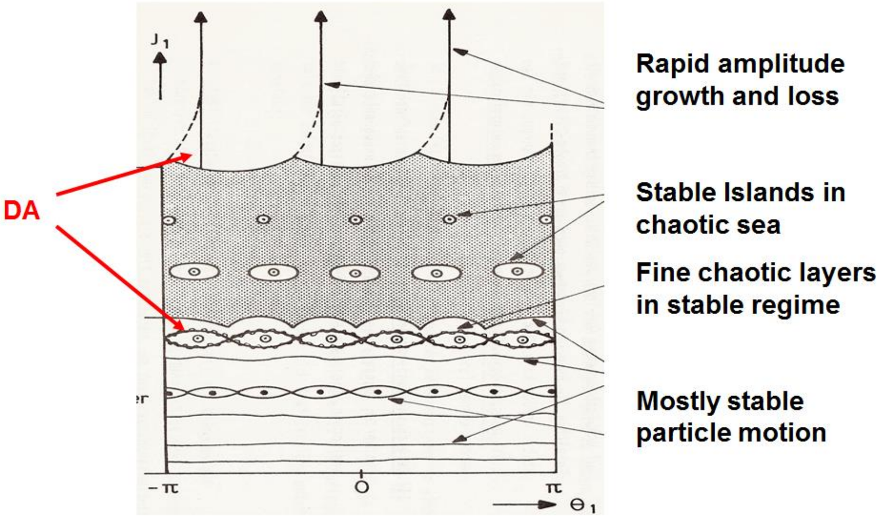
   Largest Amplitude at which particles remain in the accelerator over a time range of interest.

2. Potential Dynamic Aperture (PO-DA) = Onset of global Chaos

   - Largest Amplitude with mainly regular motion.
   - Insignificant chaotic layers within the regular regime will be ignored.
   - However considerable wide "chaotic spikes" have to be taken into account

→ It turns out that the PO-DA is typically too small as RW-DA estimate

Dynamic Aperture Scheme



3. 61km SPPC Lattice Design and DA Study

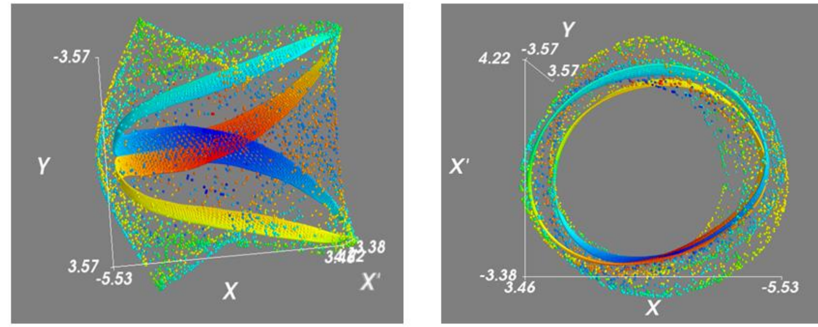
SPPC Main Ring DA *without* low beta pp IR(1/7)

At first, we studied the dynamic aperture of SPPC main ring without interaction region. There are 8 arcs in the main ring and 8 long straight sections. Now we use simple FODO in the long straight section, latter we should optimize the long straight section design for difference use like RF part, injection, extraction and collimation.

Following is the dynamic aperture from Sixtrack.

We can get from the figures that the dynamic aperture is about 22.58 mm (346 σ_x) in horizontal and 49.16 mm (315 σ_y) in vertical.

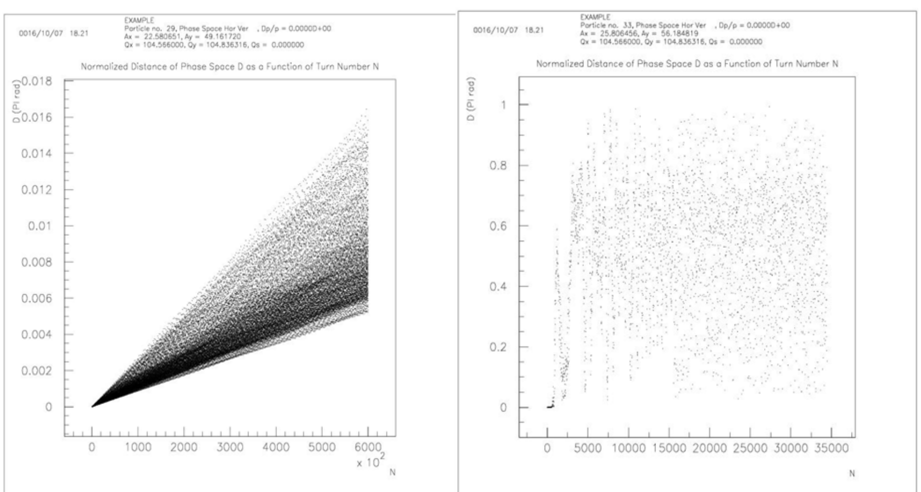
SPPC Main Ring DA *without* low beta pp IR(2/7)



4-Dimension phase space for regular and chaotic motion (cm).

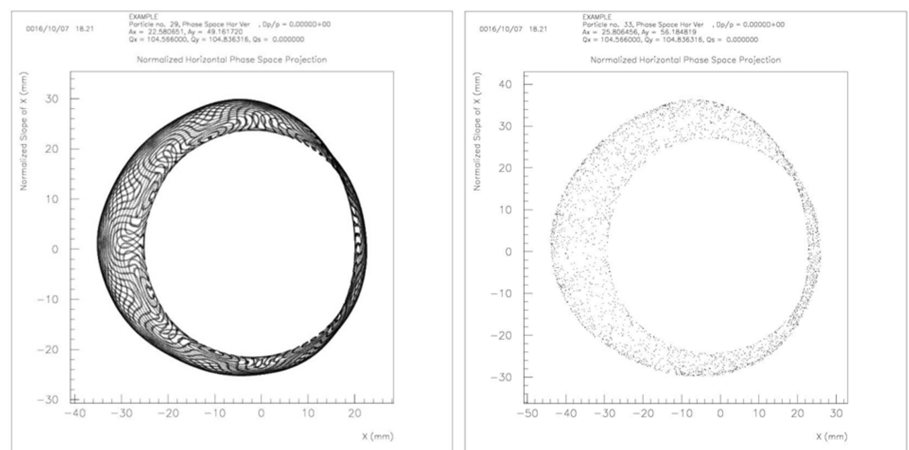
(The solid tie shape shows the regular particles motion which has the largest amplitude, if the amplitude becomes a little larger, the motion will become chaotic, the diffusion points around the solid tie show the chaotic motion. This largest amplitude is the dynamic aperture we want to study.)

SPPC Main Ring DA *without* low beta pp IR(3/7)



Evolution of the distance of phase space for regular (left) and chaotic (right) motion.

SPPC Main Ring DA *without* low beta pp IR(4/7)



Horizontal phase space projections for regular (left) and chaotic (right) cases.

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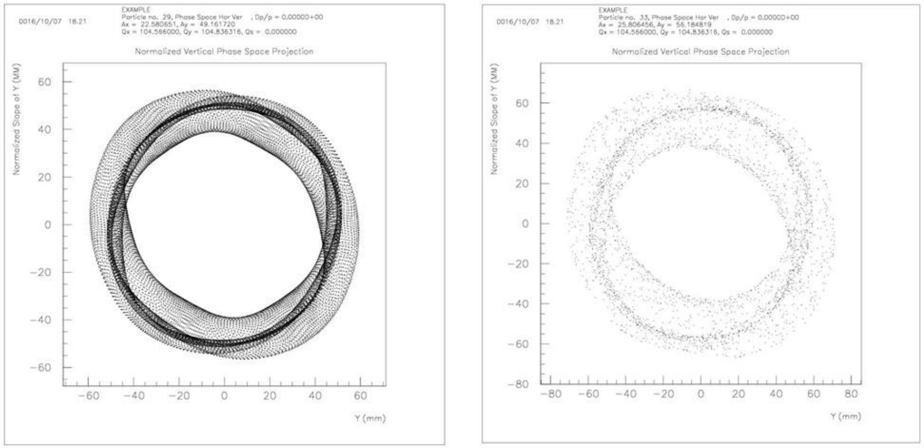
3. 61km SPPC Lattice Design and DA Study

SPPC Main Ring DA *without* low beta pp IR(5/7)



Vertical phase space projections for regular (left) and chaotic (right) cases.

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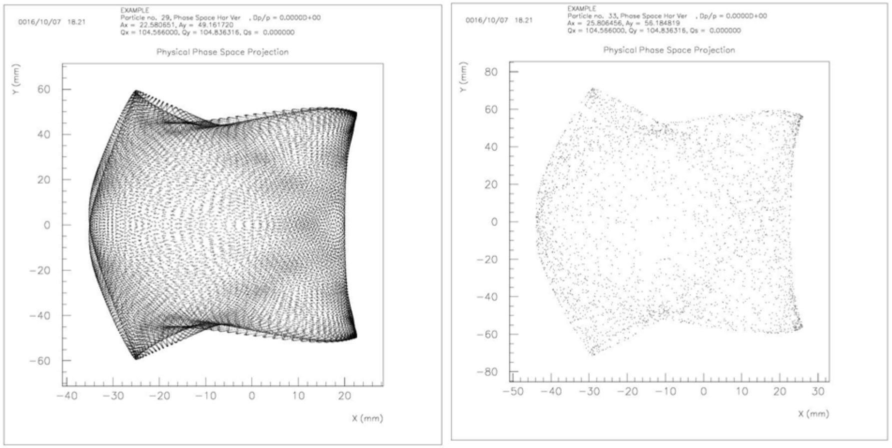
SPPC Main Ring DA *without* low beta pp IR(6/7)



Physical phase space projections for regular (left) and chaotic (right) cases.

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3. 61km SPPC Lattice Design and DA Study

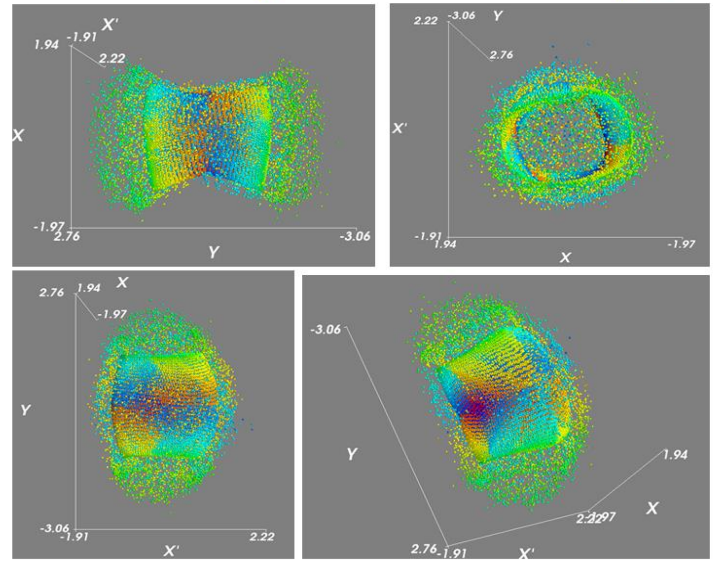
SPPC Main Ring DA *with* low beta pp IR(1/5)

Following is the dynamic aperture with low beta pp interaction region.

The beta function at IP is 0.75m. The maximum beta function in this region is about 9.6 km. The dynamic aperture becomes smaller, 8.22 mm (126 σ_x) in horizontal and 19.73 mm (126 σ_y) in vertical (we keep the same observation point for comparison with the DA without low beta pp IR). At the low beta pp IR point, the dynamic aperture is only 1.089mm (126 σ) in both horizontal and vertical because the beam size is very small (8.647um).

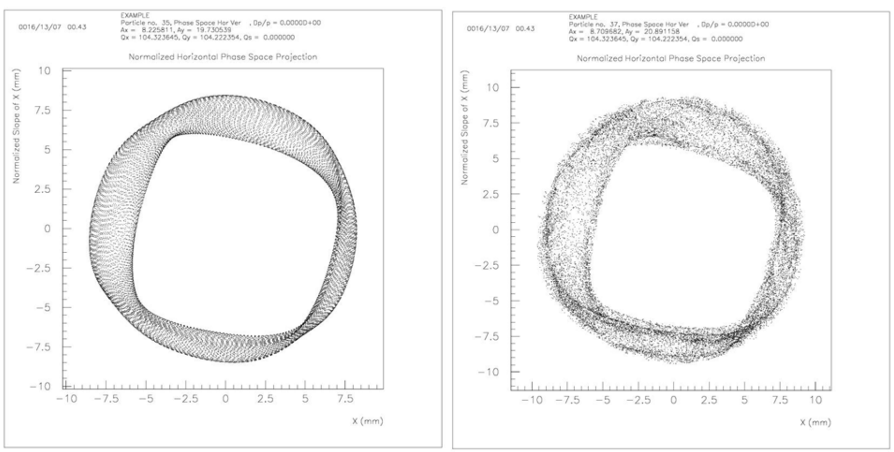
Following figures show the details.

SPPC Main Ring DA *with* low beta pp IR(2/5)



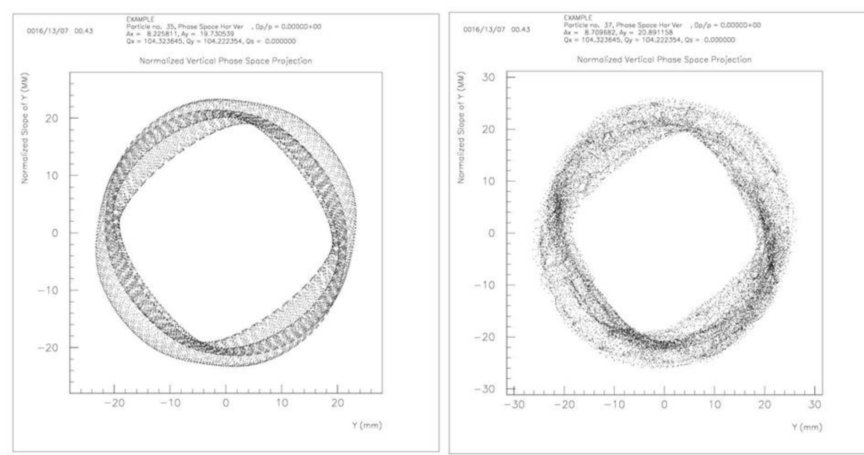
4-Dimension phase space for regular and chaotic motion (cm).

SPPC Main Ring DA *with* low beta pp IR(3/5)



Horizontal phase space projections for regular (left) and chaotic (right) cases.

SPPC Main Ring DA *with* low beta pp IR(4/5)



Vertical phase space projections for regular (left) and chaotic (right) cases.

4. 100km SPPC Lattice Design and DA Study

（under way）

5. Summary

- We optimized the parameter list version201503, we considered the new lattice layout of CEPC （PDR APDR DR） and the combination of CEPC and SPPC. The beam energy and length of long straight sections so as the circumference have a little change. We get the newest parameter list version201609.
- The first version of 61 km SPPC Lattice was designed . Full crossing angle is 146urad. Beta at IP is 0.75um.
- A first Dynamic Aperture study and the preliminary DA is showed and it seems not too small. 126 sigma at IR.
- The deep beam dynamics study is needed.
- 100 km SPPC Lattice is under way.

Outline

II. CEPC Partial Double Ring Lattice Design:

1. CEPC PDR Parameter and Lattice Layout
2. CEPC PDR Lattice Design (61 km)
3. CEPC PDR DA Study and Optimization
4. Summary

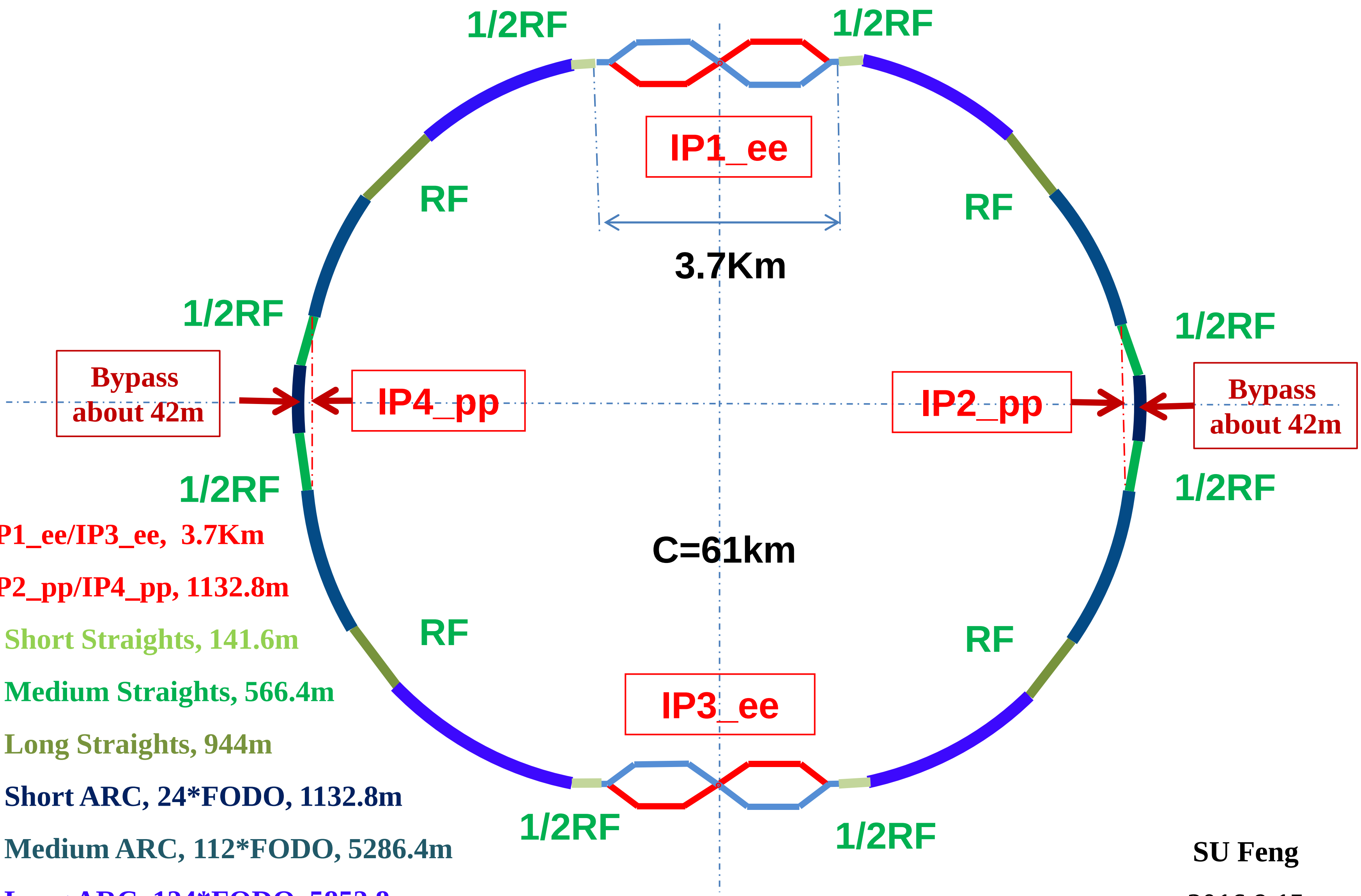
1. CEPC PDR Parameter and Lattice Layout

wangdou20160918

wangdou20160918	***Pre-CDR***	***H-high lumi.***	***H-low power***	***W***	***Z***
Number of IPs	2	2	2	2	2
Energy (GeV)	120	120	120	80	45.5
Circumference (km)	54	61	61	61	61
SR loss/turn (GeV)	3.1	2.96	2.96	0.58	0.061
Half crossing angle (mrad)	0	15	15	15	15
Piwinski angle	0	1.88	1.84	5.2	6.4
N_e/bunch (10^{11})	3.79	2.0	1.98	1.16	0.78
Bunch number	50	107	70	400	1100
Beam current (mA)	16.6	16.9	11.0	36.5	67.6
SR power /beam (MW)	51.7	50	32.5	21.3	4.1
Bending radius (km)	6.1	6.2	6.2	6.2	6.2
Momentum compaction (10^{-5})	3.4	1.48	1.48	1.44	2.9
β_{IP} x/y (m)	0.8/0.0012	0.272/0.0013	0.275 /0.0013	0.1/0.001	0.1/0.001
Emittance x/y (nm)	6.12/0.018	2.05/0.0062	2.05 /0.0062	0.93/0.0078	0.88/0.008
Transverse σ_{IP} (um)	69.97/0.15	23.7/0.09	23.7/0.09	9.7/0.088	9.4/0.089
ξ_x/IP	0.118	0.041	0.042	0.013	0.01
ξ_y/IP	0.083	0.11	0.11	0.073	0.072
V_{RF} (GV)	6.87	**3.48**	**3.51**	**0.74**	**0.11**
f_{RF} (MHz)	650	650	650	650	650
Nature σ_z (mm)	2.14	**2.7**	**2.7**	**2.95**	**3.78**
Total σ_z (mm)	2.65	2.95	2.9	3.35	4.0
HOM power/cavity (kw)	3.6	0.74	0.48	0.88	0.99
Energy spread (%)	0.13	0.13	0.13	0.087	0.05
Energy acceptance (%)	2	2	2		
Energy acceptance by RF (%)	6	**2.3**	**2.4**	**1.7**	**1.2**
n_γ	0.23	0.35	0.34	0.49	0.34
Life time due to beamstrahlung_cal (minute)	47	37	37		
F (hour glass)	0.68	0.82	0.82	0.92	0.93
L_{max}/IP (10^{34}cm^{-2}s^{-1})	2.04	3.1	2.01	4.3	4.48

1. CEPC PDR Parameter and Lattice Layout

CEPC Partial Double Ring Layout



IP1_ee/IP3_ee, 3.7Km

IP2_pp/IP4_pp, 1132.8m

4 Short Straights, 141.6m

4 Medium Straights, 566.4m

4 Long Straights, 944m

2 Short ARC, 24*FODO, 1132.8m

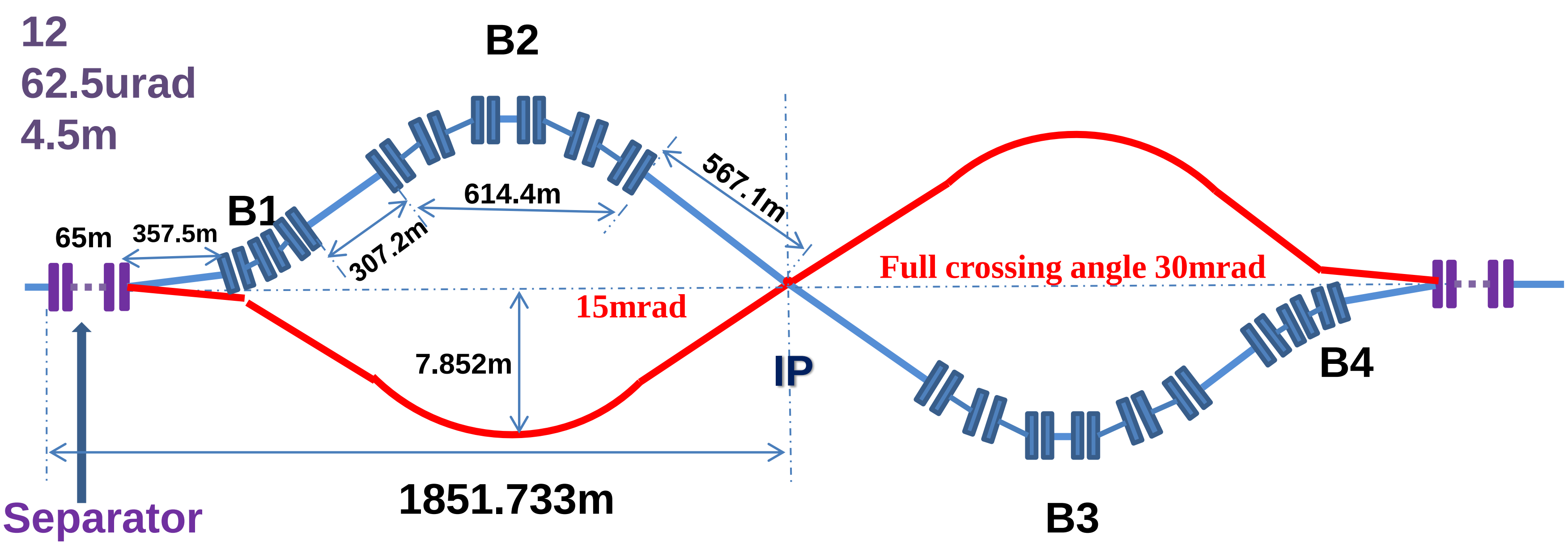
4 Medium ARC, 112*FODO, 5286.4m

4 Long ARC, 124*FODO, 5852.8m

SU Feng

2016.9.15

CEPC Partial Double Ring Layout



For CEPC 120GeV beam:

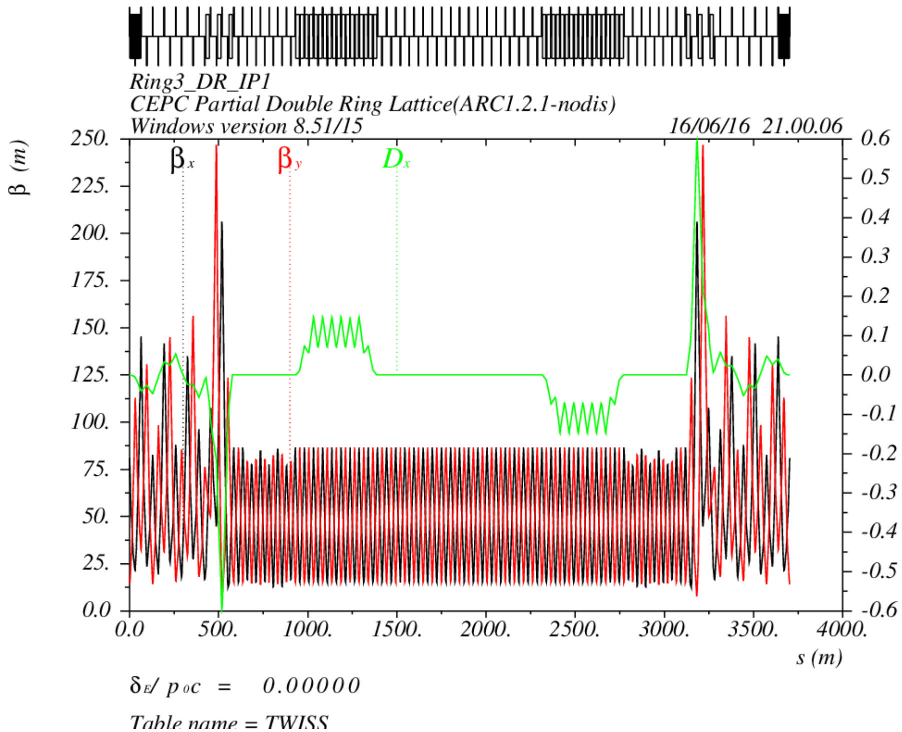
➢**Max. deflection per separator is 66μrad.**

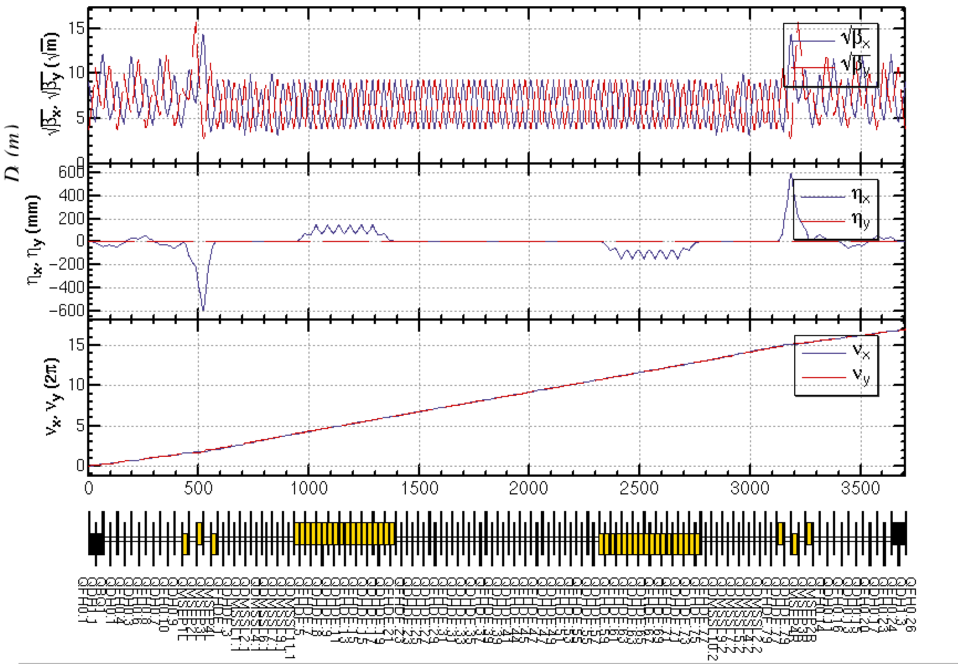
Version 1.0

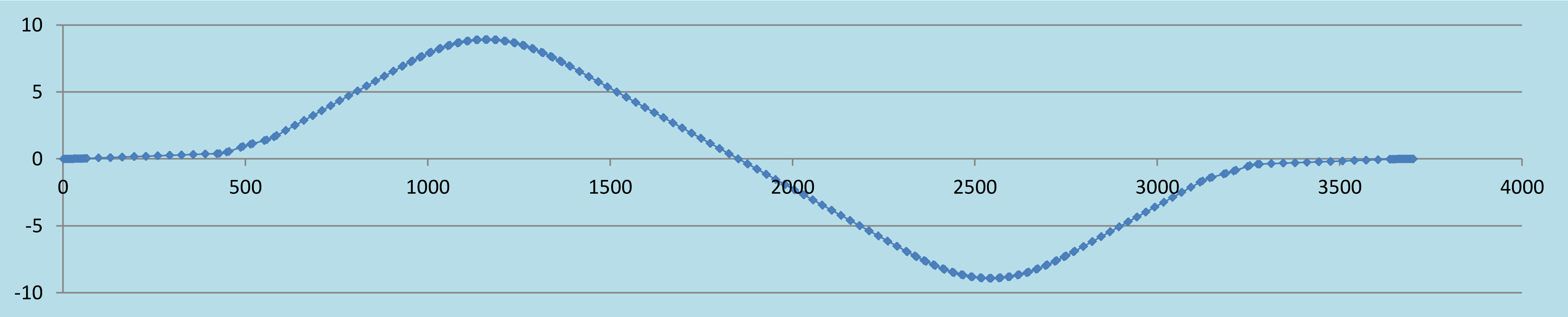
sufeng

2016.9.15

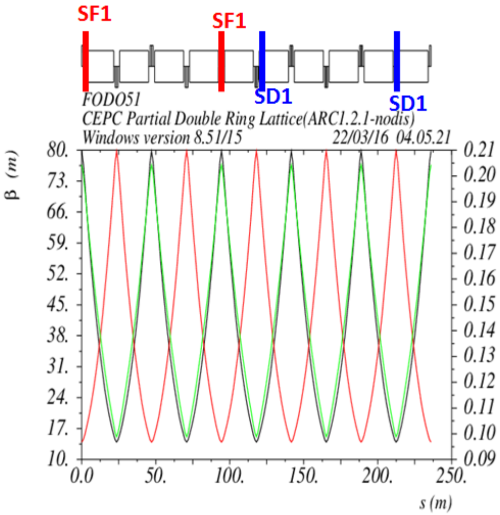
2. CEPC PDR Lattice Design

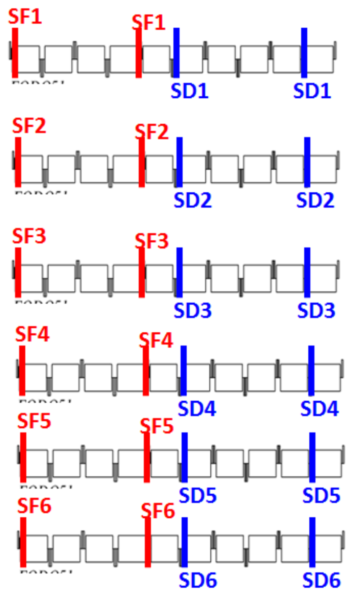




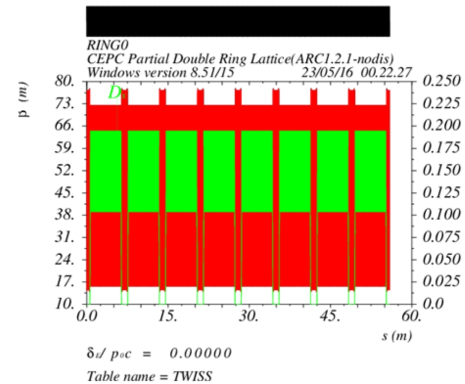


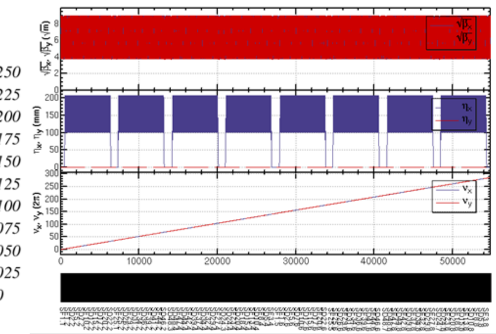
ARC FODO 90/90 non-interleave



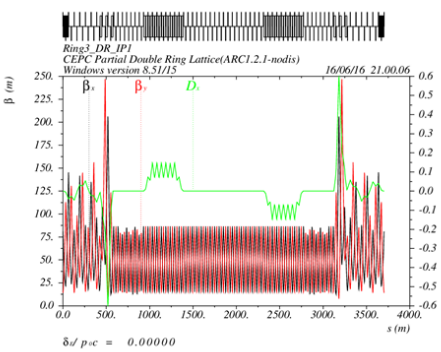


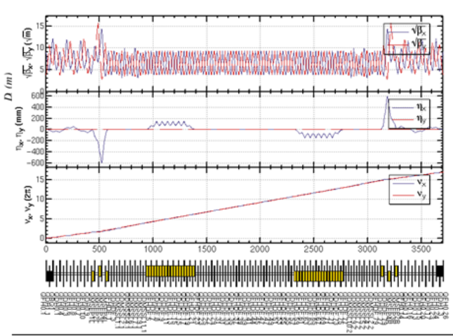
CEPC ARC

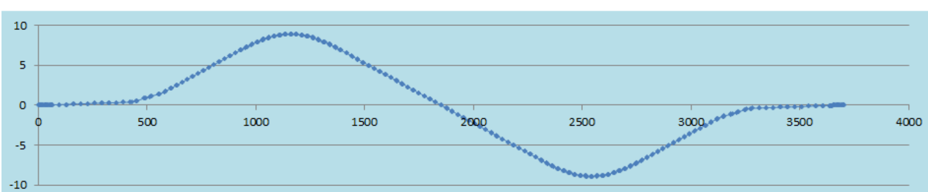




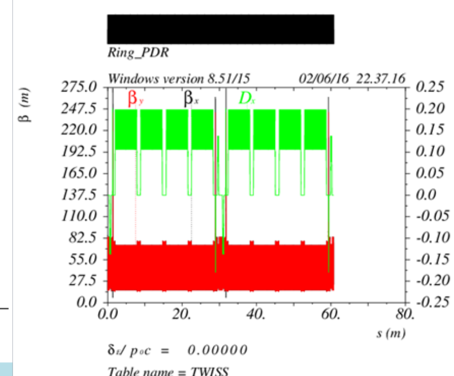
CEPC PDR1.0.3 noFFS

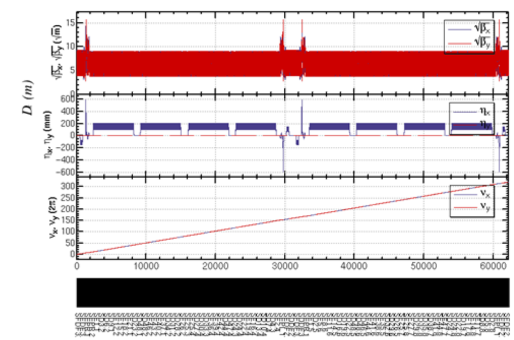




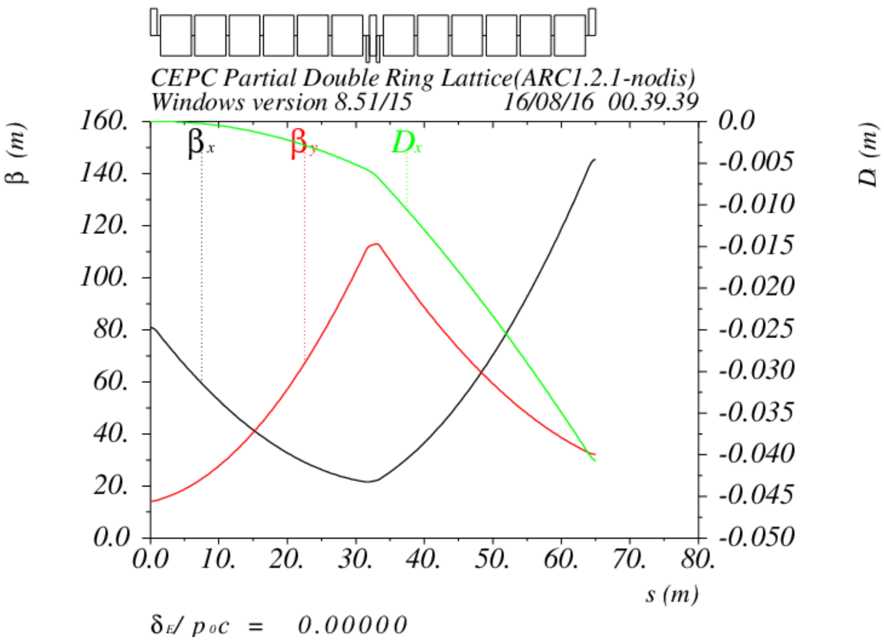


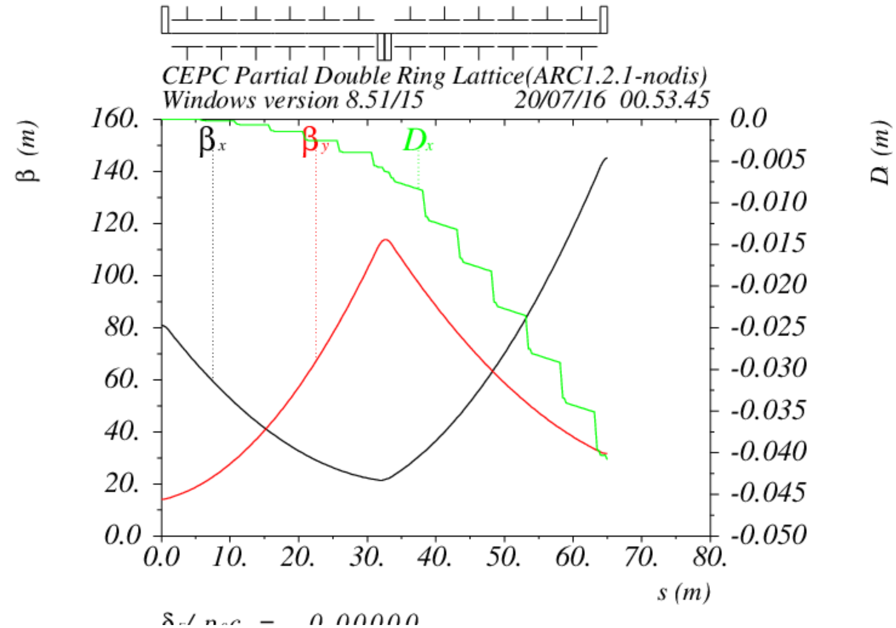
CEPC ARC+PDR

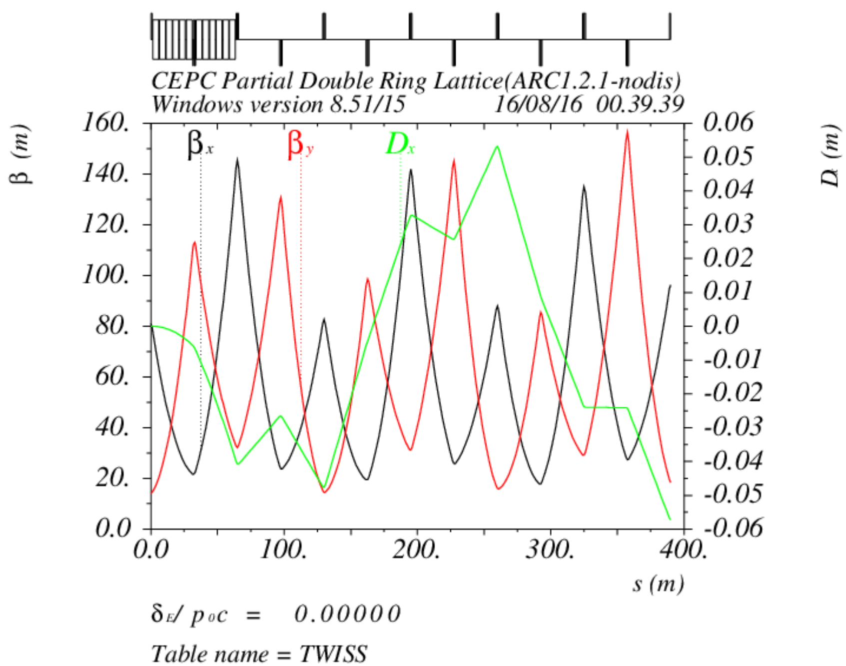


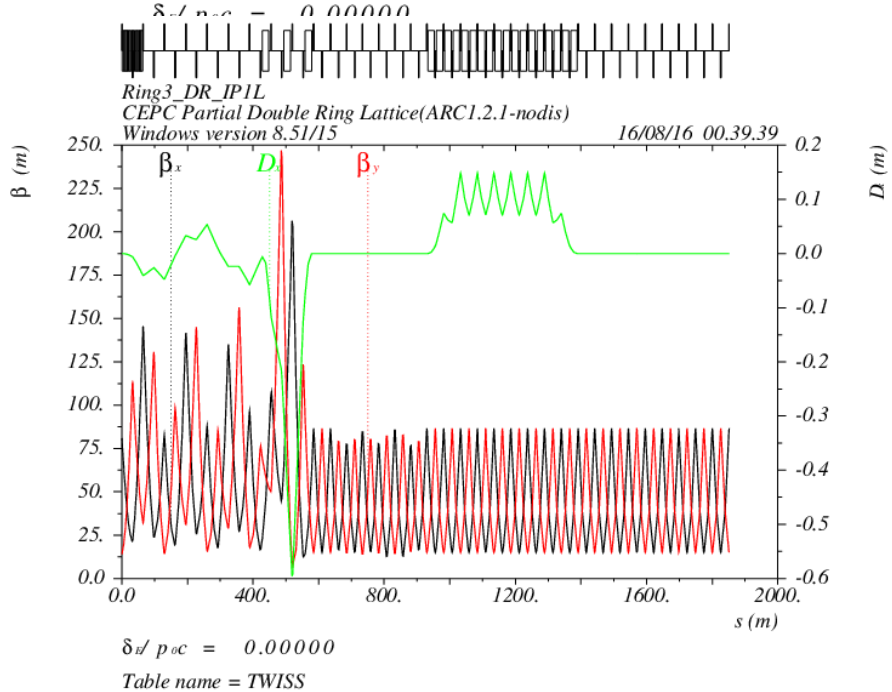


Detail of CEPC PDR1.0.3 noFFS









Electrostatic Separator in LEP

Separator length	4.5 m
Inner diameter of separator tank	540 mm
Electrode length	4.0 m
Electrode width	260 mm
Nominal gap	110 mm
Maximum operating field strength	20 kV/cm
Maximum operating voltage	± 110 kV
Max. deflection per separator at 55 GeV	145 µrad
Conditioning voltage on the test bench	± 200 kV
Conditioning voltage after installation	± 160 kV
Maximum voltage for vernier adjustment	± 35 kV
Range of vernier adjustment at 55 GeV	76 µm
Horizontal good field region (1% limit)	± 80 mm
Maximum tilt per electrode	± 5 mrad
Pumping speed of sputter ion pumps	800 l/s
Pumping speed of sublimation pumps	1300 l/s
Nominal vacuum pressure in the low-beta insertions	$2.7 \cdot 10^{-8}$ Pa
Number of separators per collision point	4
Total number of separators	32
Total number of high voltage circuits	32

L=4.5m

$L_{electrode}$=4.0m

E_{field}=2MV/m

E=55GeV

Angle=145urad

E=120GeV

Angle=66urad

Defocusing Quadrupole

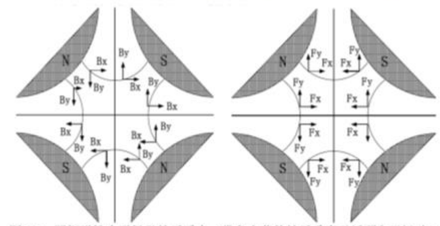
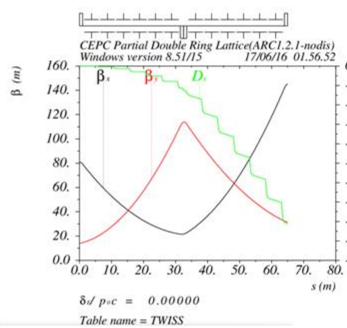
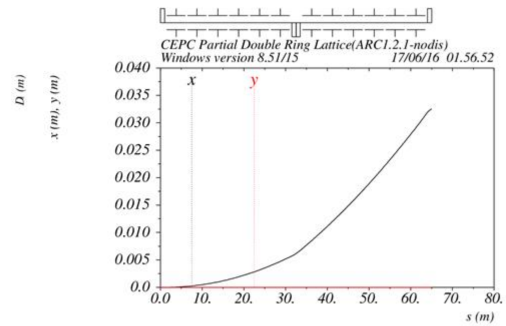


图 2.2 四极磁铁中磁场及粒子受力（带负电荷的粒子垂直于纸面向里运动）

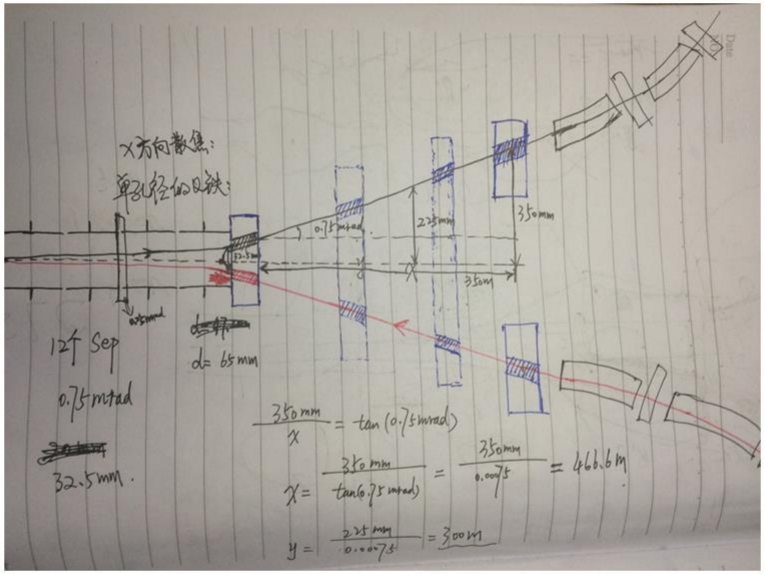




Parameters of Separators sufeng201605

Separator length	4.5	m	
Electrode length	4	m	
Maximum operating field strength	1.875	MV/m	上限 2MV/m
Beam energy	120	GeV	
Maximum deflection per separator at 120GeV	62.5	urad	微弧度
Number of separators per collision point	12*2=24		
Total number of separators (PDR)	24*2=48		
Total number of separators (APDR6)	24*6=144		
Total number of separators (APDR8)	24*8=192		

Dual Aperture Q



According to CEPC Pre-CDR Magnet Parameter

Dipole magnets	
Quantity	1984
Maximum field strength(T)	0.07
Magnetic gap (mm)	80
Bending angle (mrad)	3.17
Magnetic Length (m)	18
Bending radius (m)	6094
Good field region (mm)	100
Core cross section (W*H) (mm)	450*400

CEPC MQ	
Quantity	2304
Bore diameter (mm)	100
Field Gradient (T/m)	10
Magnetic Length (m)	2.0
Core width and height (mm)	700*700
Core length (mm)	1960

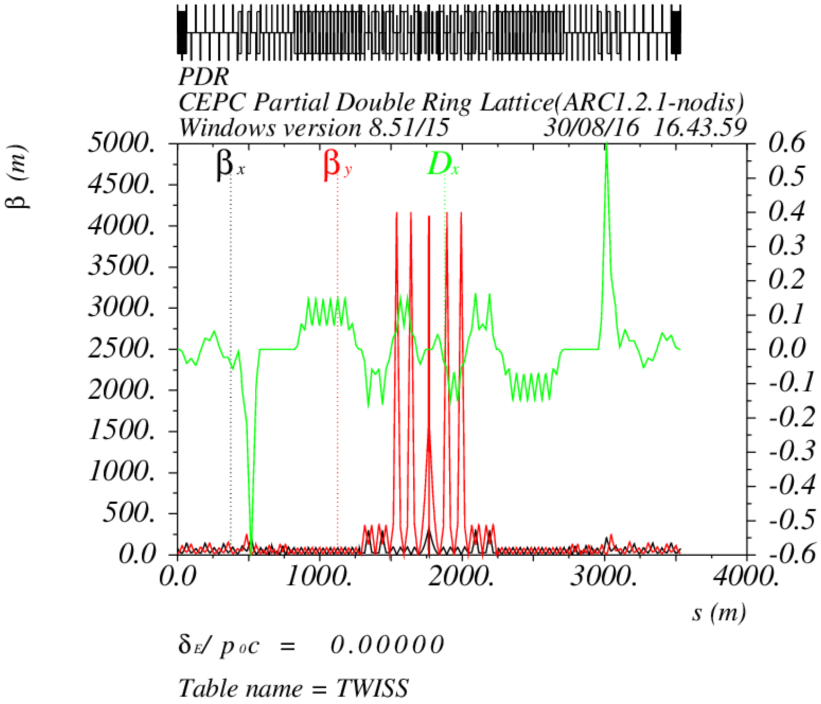
Super Conducting Q in CEPC IR	QF	QD
Field Gradient (T/m)	304	309
Magnetic Length (m)	1.25	0.72
Peak field in coil (T)	7.2	7.1
Coil inner diameter (mm)	40	40
Coil out diameter (mm)	74	74
Cryostat diameter (mm)	400	400
Coil mechanical length (mm)	1500	950

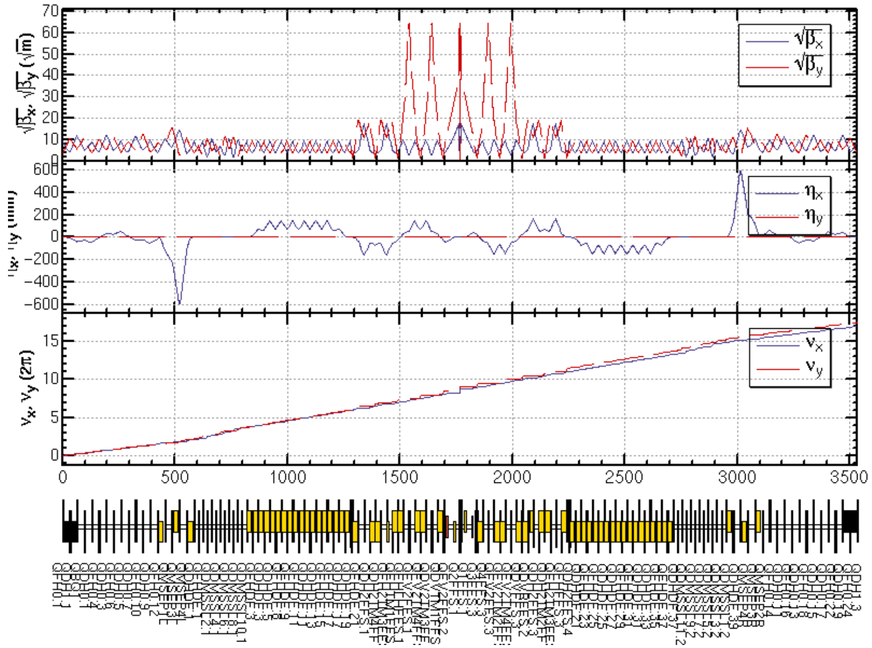
CEPC MS	SD	SF
Quantity	992	992
Aperture diameter (mm)	120	120
Good field region (mm)	100	100
Strength of sextupole field (T/m^2)	180	180
Magnetic Length (m)	700	400
Core width and height (mm)	520	520
Length of iron core (mm)	670	370

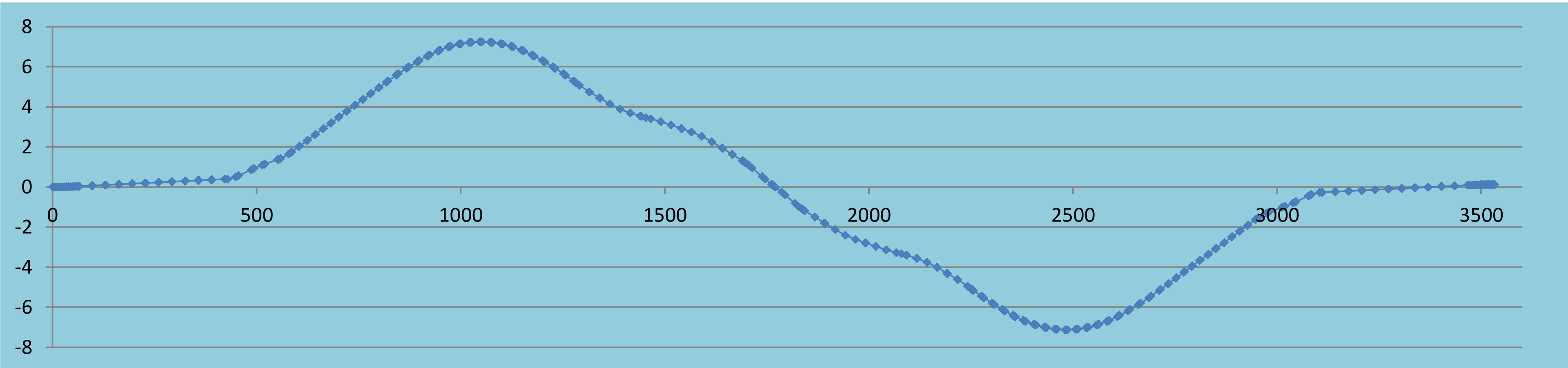
Dipole Strength PDR1.0.3 without FFS

	Angle(mrad)	L(m)	Rho(m)	Brho(E0/c)(T/m)	B(T)	Ek(KeV)	KeV/m
B0	3.205	19.6	6115.44	400	0.06541	626.349	31.956
BSepL	-0.0625	4.5	-72000	400	-0.00556	53.2	11.822
BMatch1L	-8.344	19.6	-2348.99	400	-0.1702	1630.66	83.1967
BMatch2L	1.997	19.6	9814.72	400	0.0407	390.271	19.9118
BMatch3L	-7.653	19.6	-2561.09	400	-0.1562	1495.61	76.3069
B2	2.1428	19.6	9146.91	400	0.04373	418.764	21.3655
B3	-2.1428	19.6	-9146.91	400	-0.04373	418.764	21.3655
BMatch3R	7.653	19.6	2561.09	400	0.1562	1495.61	76.3069
BMatch2R	-1.997	19.6	-9814.72	400	-0.0407	390.271	19.9118
BMatch1R	8.344	19.6	2348.99	400	0.1702	1630.66	83.1967
BSepR	0.0625	4.5	72000	400	0.00556	53.2	11.822

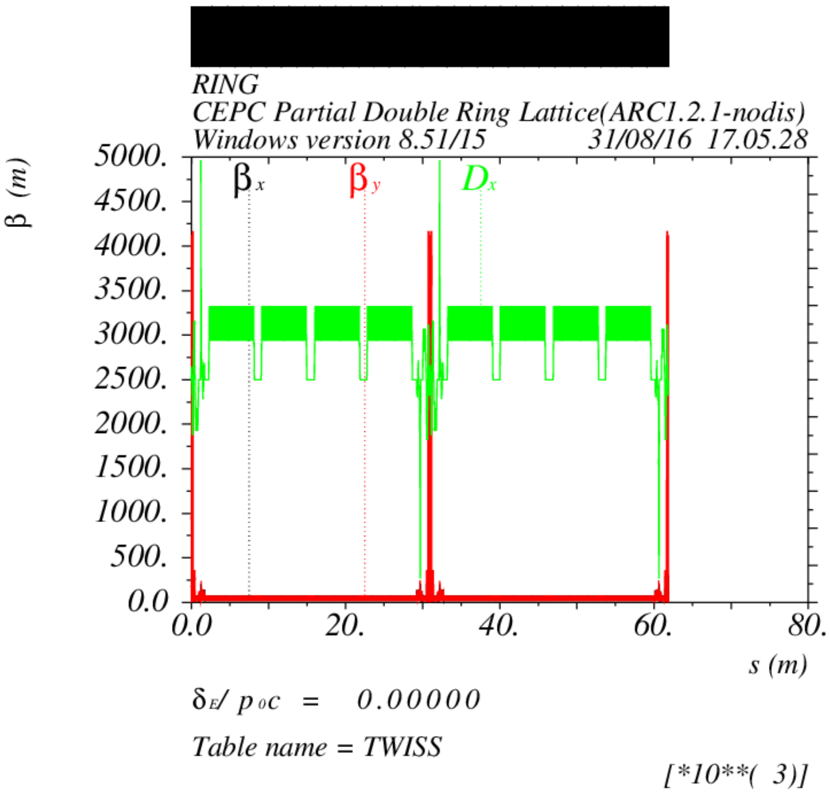
CEPC PDR1.0.3 with FFS _Yiwei20160817

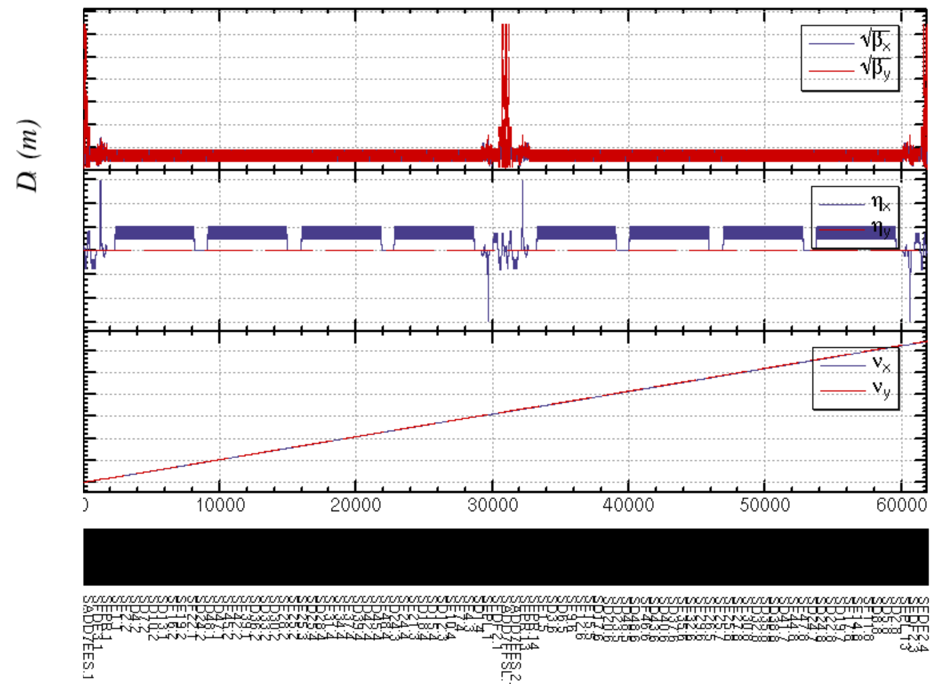






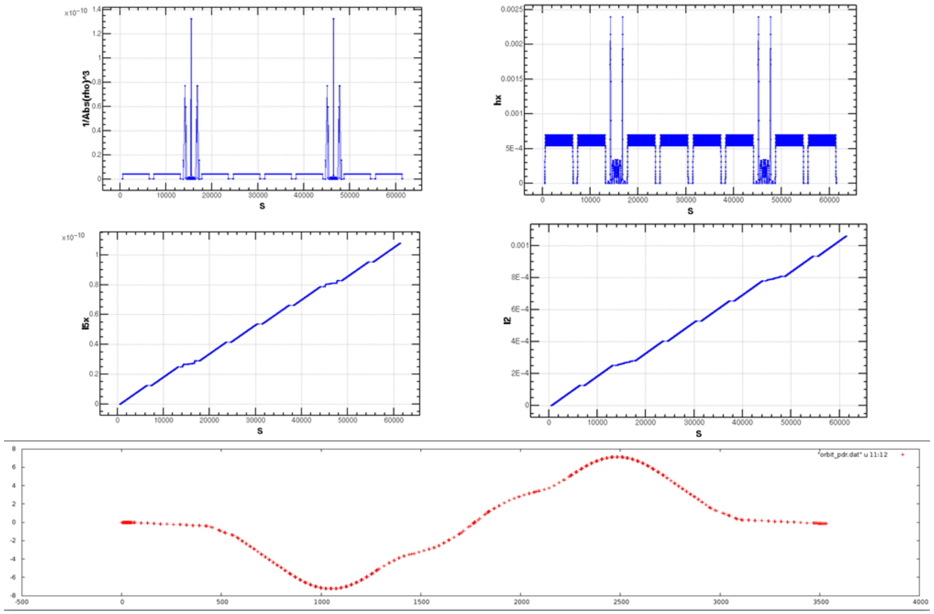
CEPC ARC+PDR_FFS



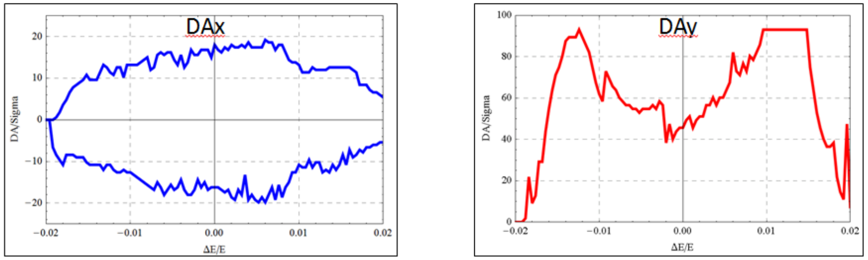


3. CEPC PDR DA Study and Optimization

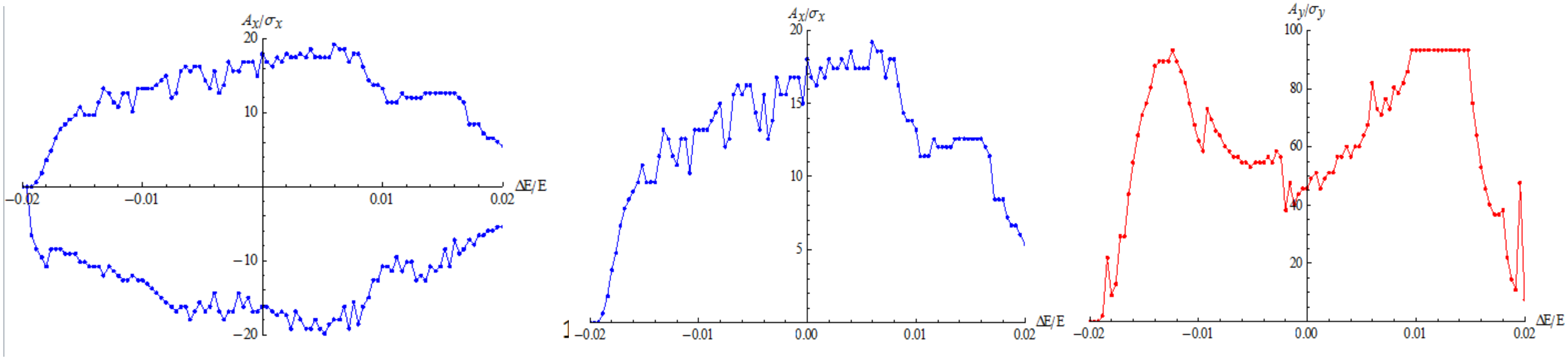
Emittance Increase (2.06nm->2.147368nm)



- Dynamic aperture result
  - W/O error of the magnets
  - Synchrotron motion included, **w/ damping**
  - Tracking with 100 turns
  - Coupling factor κ=0.003 for εy
  - Working point (0.08, 0.22)



Yiwei Wang CEPC预研项目启动会 29



4. summary

- We finished the 61 km CEPC PDR lattice design and showed the dynamic aperture study and optimization.
- We choose double ring scheme for e^+e^- at IP1 and IP3. The total length of this part is about 3.7 km. The full crossing angle for CEPC partial double ring scheme is 30 mrad.
- At the start of the double ring, we need to use electrostatic separator to separate the electron and positron beams. We choose the parameter of electrostatic separator according to the experience on LEP. The maximum operating field strength is 2 MV/m.
- We optimized DA by Multi-objective Optimization Genetic Algorithm (MOGA). The on-momentum dynamic aperture is about 18 σ_x in horizontal and 40 σ_y in vertical. And the off momentum particles dynamic aperture is much larger than before, about 10 σ_x in horizontal for dp/p=1% and 4σ_x in horizontal for dp/p=2%. In vertical, it's also much bigger than before.

Outline

III. CEPC Advanced Partial Double Ring Lattice Design:

1. CEPC APDR Parameter and Lattice Layout
2. CEPC APDR Lattice Design (64km 100km)
3. CEPC APDR DA Study and Optimization
4. Summary

1. CEPC APDR Parameter and Lattice Layout (64 km)

wangdou20160918

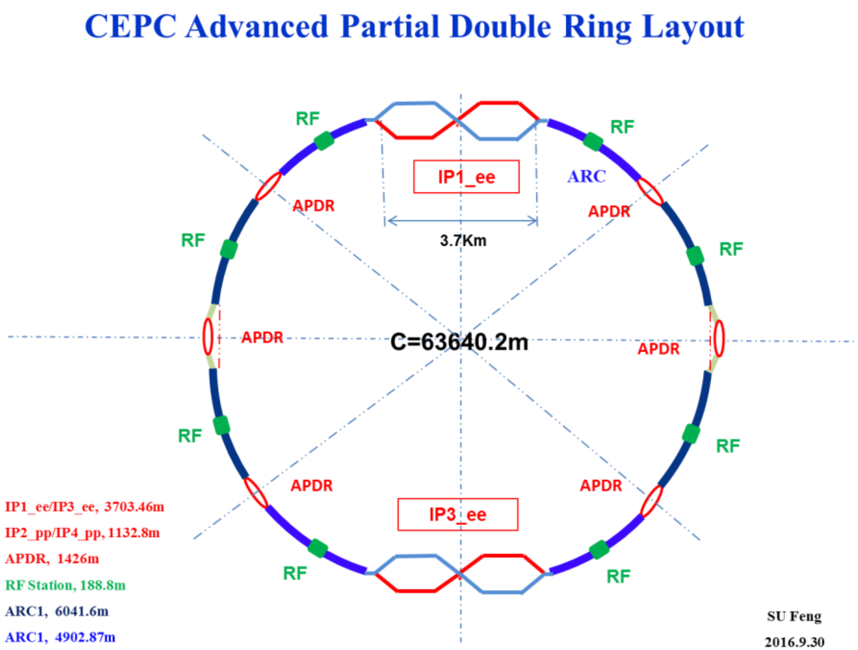
wangdou20160918	***Pre-CDR***	***H-high lumi.***	***H-low power***	***W***	***Z***
Number of IPs	2	2	2	2	2
Energy (GeV)	120	120	120	80	45.5
Circumference (km)	54	61	61	61	61
SR loss/turn (GeV)	3.1	2.96	2.96	0.58	0.061
Half crossing angle (mrad)	0	15	15	15	15
Piwinski angle	0	1.88	1.84	5.2	6.4
N_e/bunch (10^{11})	3.79	2.0	1.98	1.16	0.78
Bunch number	50	107	70	400	1100
Beam current (mA)	16.6	16.9	11.0	36.5	67.6
SR power /beam (MW)	51.7	50	32.5	21.3	4.1
Bending radius (km)	6.1	6.2	6.2	6.2	6.2
Momentum compaction (10^{-5})	3.4	1.48	1.48	1.44	2.9
β_{IP} x/y (m)	0.8/0.0012	0.272/0.0013	0.275 /0.0013	0.1/0.001	0.1/0.001
Emittance x/y (nm)	6.12/0.018	2.05/0.0062	2.05 /0.0062	0.93/0.0078	0.88/0.008
Transverse σ_{IP} (um)	69.97/0.15	23.7/0.09	23.7/0.09	9.7/0.088	9.4/0.089
ξ_x/IP	0.118	0.041	0.042	0.013	0.01
ξ_y/IP	0.083	0.11	0.11	0.073	0.072
V_{RF} (GV)	6.87	**3.48**	**3.51**	**0.74**	**0.11**
f_{RF} (MHz)	650	650	650	650	650
Nature σ_z (mm)	2.14	**2.7**	**2.7**	**2.95**	**3.78**
Total σ_z (mm)	2.65	2.95	2.9	3.35	4.0
HOM power/cavity (kw)	3.6	0.74	0.48	0.88	0.99
Energy spread (%)	0.13	0.13	0.13	0.087	0.05
Energy acceptance (%)	2	2	2		
Energy acceptance by RF (%)	6	**2.3**	**2.4**	**1.7**	**1.2**
n_γ	0.23	0.35	0.34	0.49	0.34
Life time due to beamstrahlung_cal (minute)	47	37	37		
F (hour glass)	0.68	0.82	0.82	0.92	0.93
L_{max}/IP ($10^{34}cm^{-2}s^{-1}$)	2.04	3.1	2.01	4.3	4.48

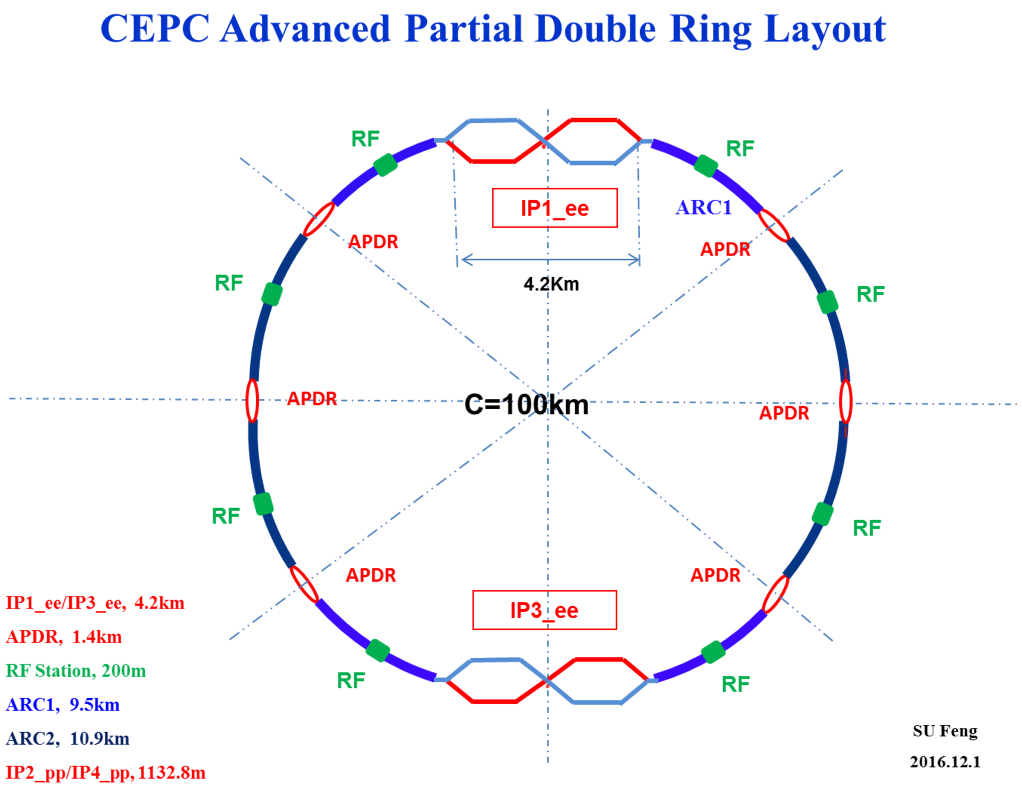
1. CEPC APDR Parameter and Lattice Layout (100 km)

parameter for CEPC partial double ring （wangdou20161115-100km）

	Pre-CDR	*H-high lumi.*	*H-low power*	*Z*
Number of IPs	2	2	2	2
Energy (GeV)	120	120	120	45.5
Circumference (km)	54	100	100	100
SR loss/turn (GeV)	3.1	1.67	1.67	0.034
Half crossing angle (mrad)	0	15	15	15
Piwinski angle	0	2.9	2.9	5.69
N_e/bunch (10^{11})	3.79	0.97	0.97	0.46
Bunch number	50	644	425	1100
Beam current (mA)	16.6	29.97	19.8	24.3
SR power /beam (MW)	51.7	50	33	0.84
Bending radius (km)	6.1	11	11	11
Momentum compaction (10^{-5})	3.4	1.3	1.3	3.3
β_{IP} x/y (m)	0.8/0.0012	0.144 /0.002	0.144 /0.002	0.12/0.001
Emittance x/y (nm)	6.12/0.018	1.56/0.0047	1.56/0.0047	0.93/0.0049
Transverse σ_{IP} (um)	69.97/0.15	15/0.097	15/0.097	10.5/0.07
ξ_x/IP	0.118	0.0126	0.0126	0.0075
ξ_y/IP	0.083	0.083	0.083	0.054
V_{RF} (GV)	6.87	**2.0**	**2.22**	**0.11**
f_{RF} (MHz)	650	650	650	650
Nature σ_z (mm)	2.14	**2.72**	**2.72**	**3.93**
Total σ_z (mm)	2.65	2.9	2.9	4.0
HOM power/cavity (kw)	3.6	0.64	0.42	0.21
Energy spread (%)	0.13	0.098	0.098	0.037
Energy acceptance (%)	2	1.5	1.5	
Energy acceptance by RF (%)	6	2.2	2.2	1.1
n_γ	0.23	0.26	0.26	0.18
Life time due to beamstrahlung_cal (minute)	47	52	52	
F (hour glass)	0.68	0.95	0.95	0.91
L_{max}/IP ($10^{34}cm^{-2}s^{-1}$)	2.04	3.1	2.05	1.19

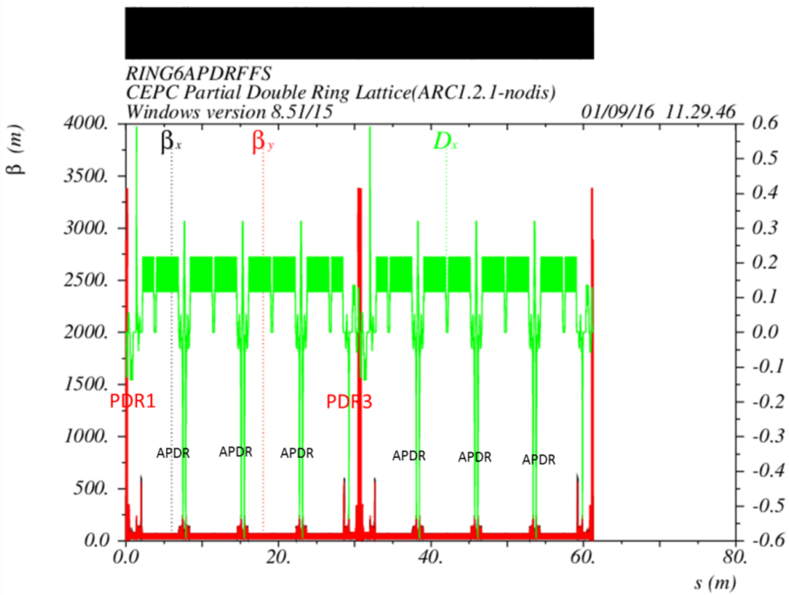
1. CEPC APDR Parameter and Lattice Layout



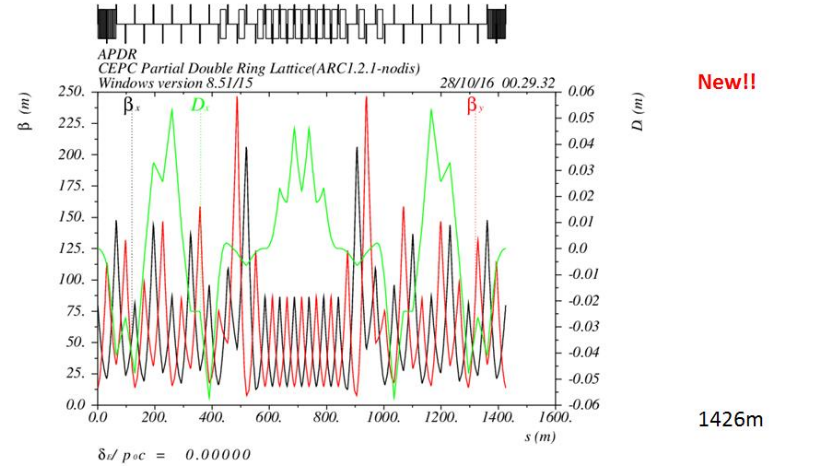


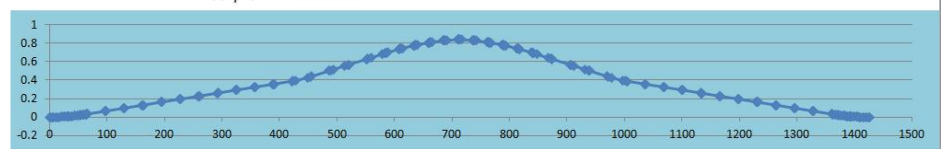
2. CEPC APDR Lattice Design (64 km)

CEPC Advanced Partial Double Ring Optics

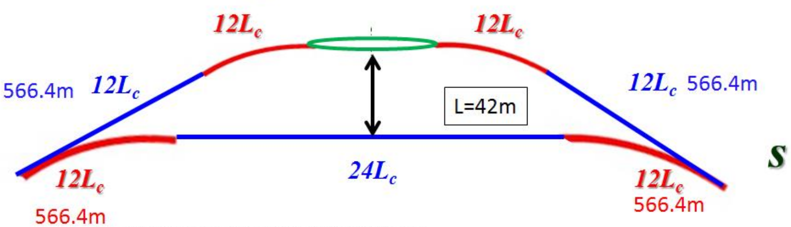


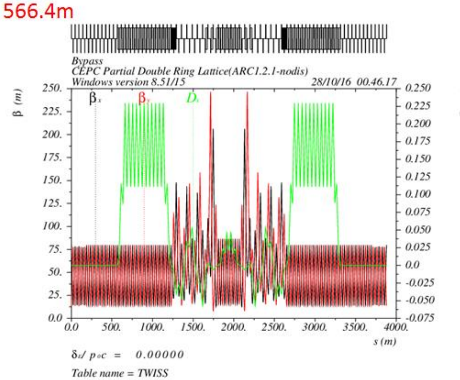
APDR Part





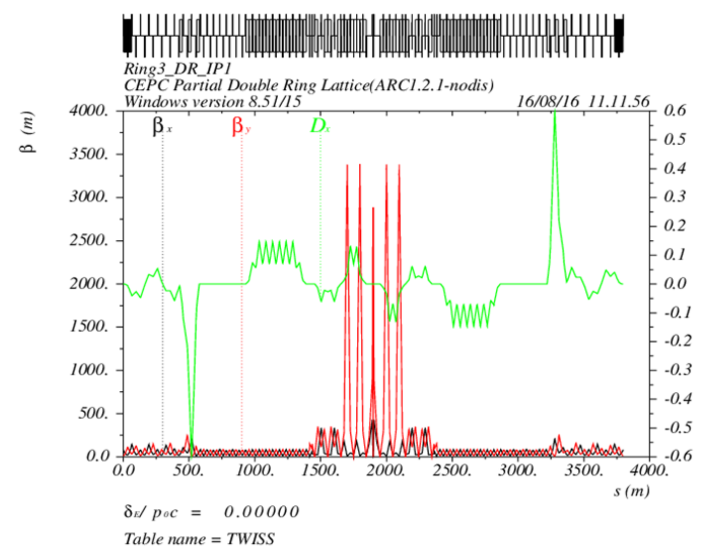
Bypass Part at IP2/4



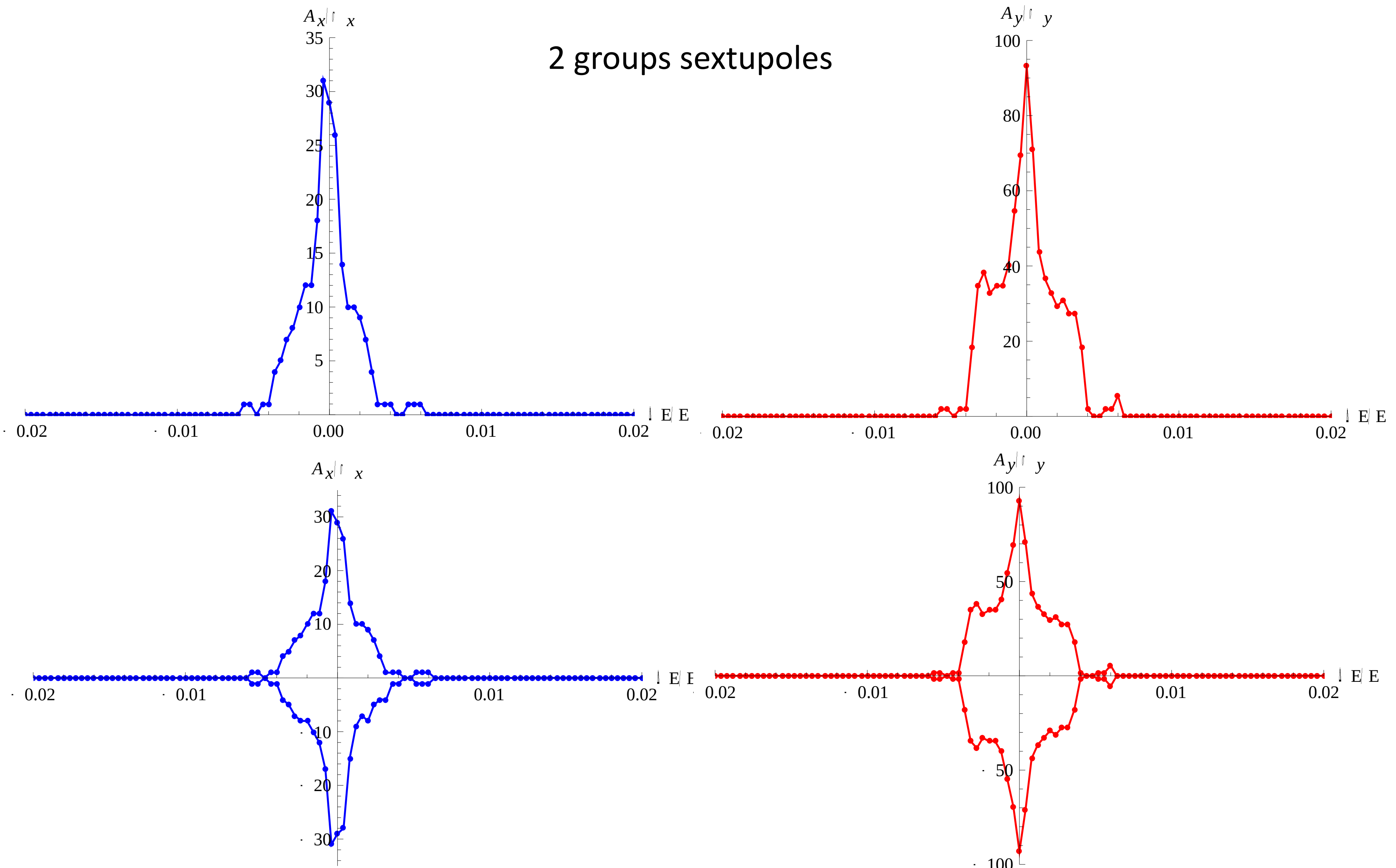


Cell length=47.92m

PDR Part

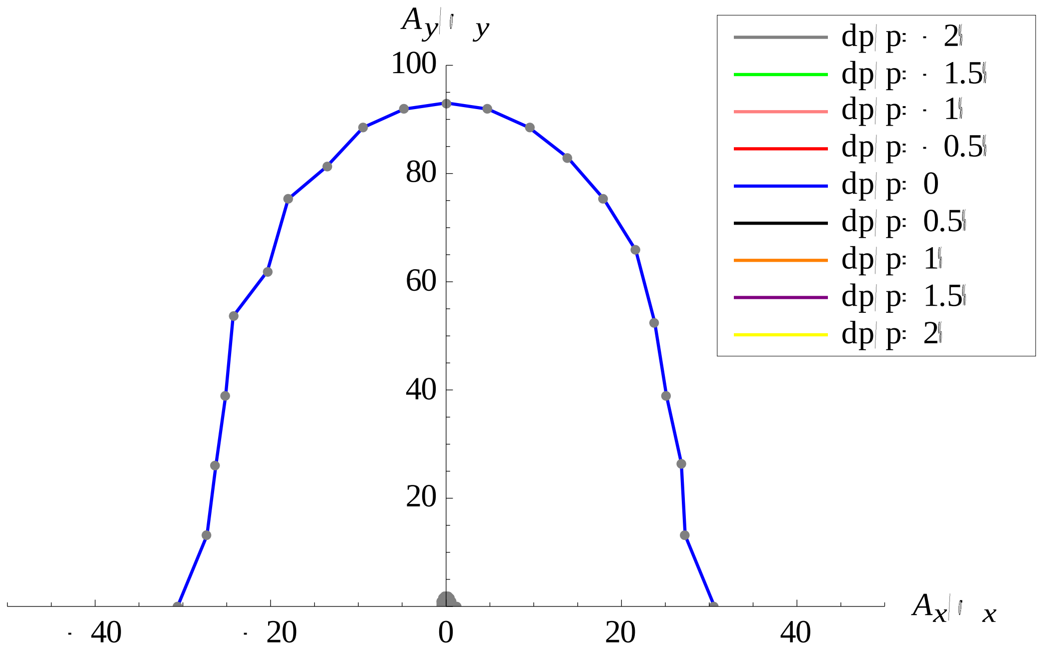


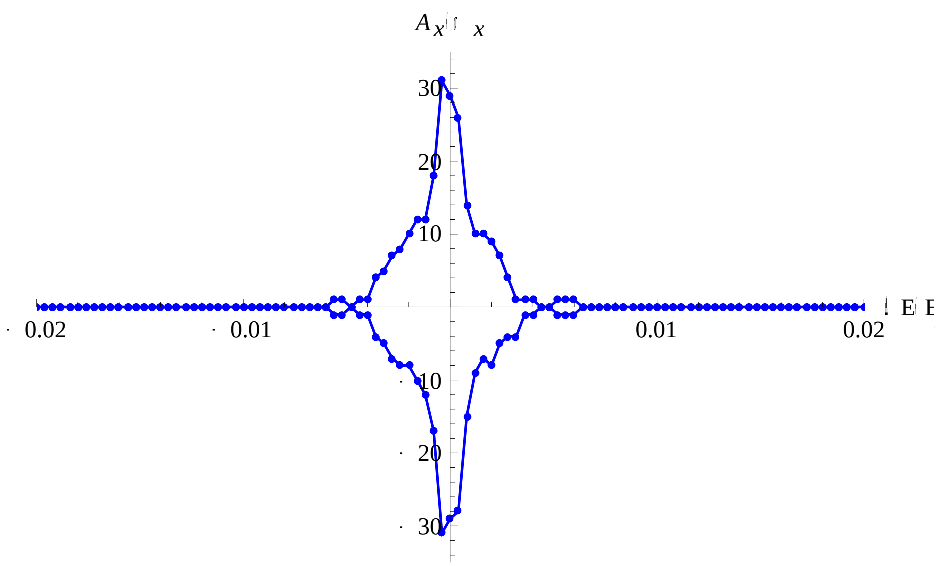
3. CEPC APDR DA Study and Optimization (64 km)

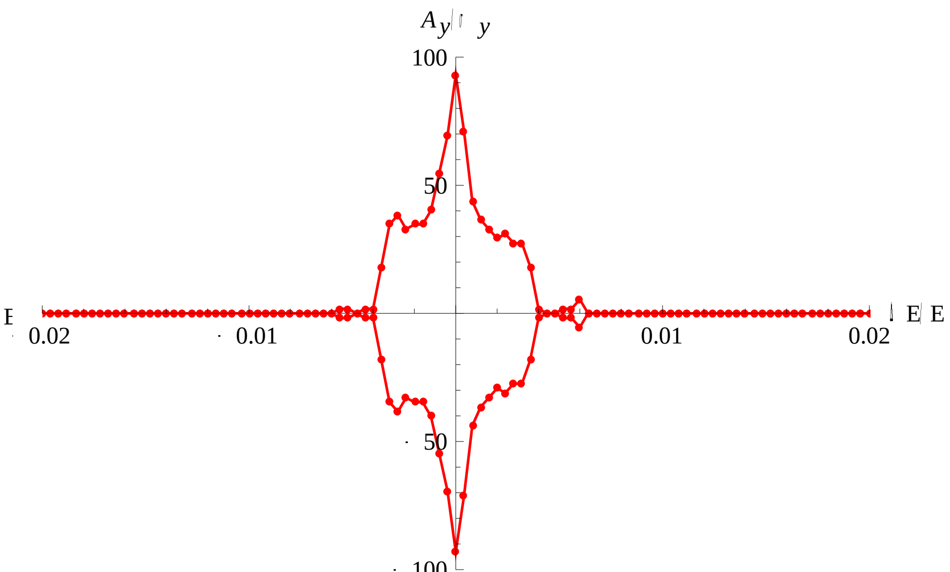


3. CEPC APDR DA Study and Optimization (64 km)

2 groups sextupoles







4. Sunnary

- We finished the 64 km CEPC APDR lattice design and showed the dynamic aperture study and optimization.
- We choose double ring scheme for e^+e^- at IP1 and IP3. The total length of this part is about 3.7 km. The full crossing angle for CEPC partial double ring scheme is 30 mrad.
- We add 6 double ring part in CEPC PDR to solve the beam loading problems from RF system. And it seems work.
- The lattice design become much more complex. And the orbit can’t be corrected easily.
- The DA optimization is also a hard work.
- We also start the 100 km CEPC APDR lattice design.

Outline

IV. CEPC Double Ring Lattice Design:

1. CEPC DR Parameter and Lattice Layout
2. CEPC DR Lattice Design(61km 100km)
3. CEPC DR DA Study and Optimization
4. Summary

1. CEPC DR Parameter and Lattice Layout (61 km)

wangdou20160918

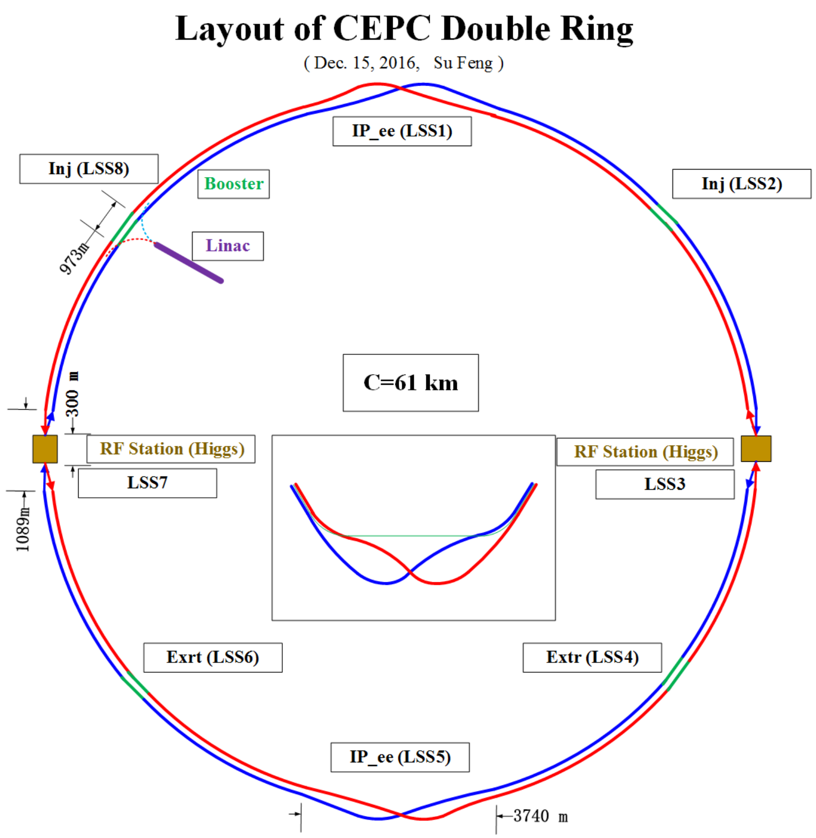
wangdou20160918	***Pre-CDR***	***H-high lumi.***	***H-low power***	***W***	***Z***
Number of IPs	2	2	2	2	2
Energy (GeV)	120	120	120	80	45.5
Circumference (km)	54	61	61	61	61
SR loss/turn (GeV)	3.1	2.96	2.96	0.58	0.061
Half crossing angle (mrad)	0	15	15	15	15
Piwinski angle	0	1.88	1.84	5.2	6.4
N_e/bunch (10^{11})	3.79	2.0	1.98	1.16	0.78
Bunch number	50	107	70	400	1100
Beam current (mA)	16.6	16.9	11.0	36.5	67.6
SR power /beam (MW)	51.7	50	32.5	21.3	4.1
Bending radius (km)	6.1	6.2	6.2	6.2	6.2
Momentum compaction (10^{-5})	3.4	1.48	1.48	1.44	2.9
β_{IP} x/y (m)	0.8/0.0012	0.272/0.0013	0.275 /0.0013	0.1/0.001	0.1/0.001
Emittance x/y (nm)	6.12/0.018	2.05/0.0062	2.05 /0.0062	0.93/0.0078	0.88/0.008
Transverse σ_{IP} (um)	69.97/0.15	23.7/0.09	23.7/0.09	9.7/0.088	9.4/0.089
ξ_x/IP	0.118	0.041	0.042	0.013	0.01
ξ_y/IP	0.083	0.11	0.11	0.073	0.072
V_{RF} (GV)	6.87	**3.48**	**3.51**	**0.74**	**0.11**
f_{RF} (MHz)	650	650	650	650	650
Nature σ_z (mm)	2.14	**2.7**	**2.7**	**2.95**	**3.78**
Total σ_z (mm)	2.65	2.95	2.9	3.35	4.0
HOM power/cavity (kw)	3.6	0.74	0.48	0.88	0.99
Energy spread (%)	0.13	0.13	0.13	0.087	0.05
Energy acceptance (%)	2	2	2		
Energy acceptance by RF (%)	6	**2.3**	**2.4**	**1.7**	**1.2**
n_γ	0.23	0.35	0.34	0.49	0.34
Life time due to beamstrahlung_cal (minute)	47	37	37		
F (hour glass)	0.68	0.82	0.82	0.92	0.93
L_{max}/IP (10^{34}cm^{-2}s^{-1})	2.04	3.1	2.01	4.3	4.48

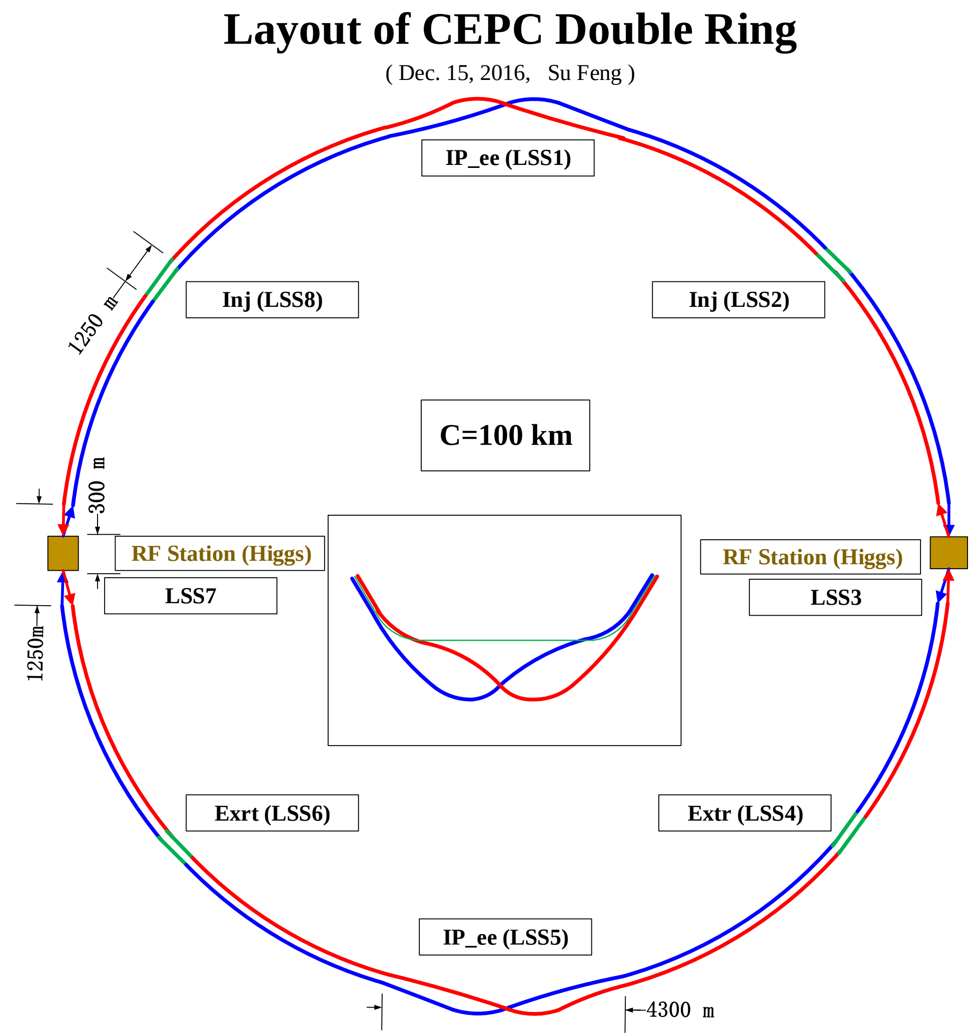
1. CEPC DR Parameter and Lattice Layout (100 km)

parameters for CEPC double ring （wangdou20161202-100km_2mmβy）

	Pre-CDR	**H-high lumi.**	**H-low power**	**W**	**Z**	
Number of IPs	2	2	2	2	2	2
Energy (GeV)	120	120	120	80	45.5	45.5
Circumference (km)	54	100	100	100	100	100
SR loss/turn (GeV)	3.1	1.67	1.67	0.33	0.034	0.034
Half crossing angle (mrad)	0	15	15	15	15	15
Piwinski angle	0	2.9	2.9	3.57	5.69	5.69
N_e/bunch (10^{11})	3.79	0.97	0.97	1.05	0.46	0.46
Bunch number	50	644	425	1000	10520	65716
Beam current (mA)	16.6	29.97	19.8	50.6	232.1	1449.7
SR power /beam (MW)	51.7	50	33	16.7	8.0	50
Bending radius (km)	6.1	11	11	11	11	11
Momentum compaction (10^{-5})	3.4	1.3	1.3	3.1	3.3	3.3
β_{IP} x/y (m)	0.8/0.0012	0.144 /0.002	0.144 /0.002	0.1 /0.001	0.12/0.001	0.12/0.001
Emittance x/y (nm)	6.12/0.018	1.56/0.0047	1.56/0.0047	2.68/0.008	0.93/0.0049	0.93/0.0049
Transverse σ_{IP} (um)	69.97/0.15	15/0.097	15/0.097	16.4/0.09	10.5/0.07	10.5/0.07
ξ_x/ξ_y/IP	0.118/0.083	0.0126/0.083	0.0126/0.083	0.0082/0.055	0.0075/0.054	0.0075/0.054
RF Phase (degree)	153.0	131.2	131.2	149	160.8	160.8
V_{RF} (GV)	6.87	**2.22**	**2.22**	**0.63**	**0.11**	**0.11**
f_{RF} (MHz) (harmonic)	650	650 (217800)	650 (217800)	650 (217800)	650 (217800)	
Nature σ_z (mm)	2.14	**2.72**	**2.72**	**3.8**	**3.93**	**3.93**
Total σ_z (mm)	2.65	2.9	2.9	3.9	4.0	4.0
HOM power/cavity (kw)	3.6 (5cell)	0.64 (2cell)	0.42 (2cell)	1.0 (2cell)	1.0 (1cell)	6.25(1cell)
Energy spread (%)	0.13	0.098	0.098	0.065	0.037	0.037
Energy acceptance (%)	2	1.5	1.5			
Energy acceptance by RF (%)	6	2.2	2.2	1.5	1.1	1.1
n_γ	0.23	0.26	0.26	0.26	0.18	0.18
Life time due to beamstrahlung_cal (minute)	47	52	52			
F (hour glass)	0.68	0.95	0.95	0.84	0.91	0.91
L_{max}/IP ($10^{34}cm^{-2}s^{-1}$)	2.04	3.1	2.05	4.08	11.36	70.97

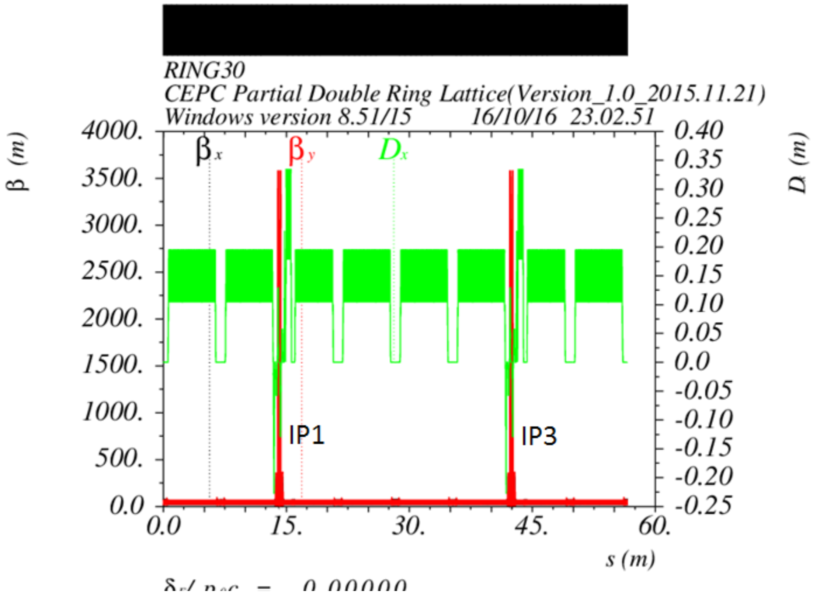
1. CEPC DR Parameter and Lattice Layout





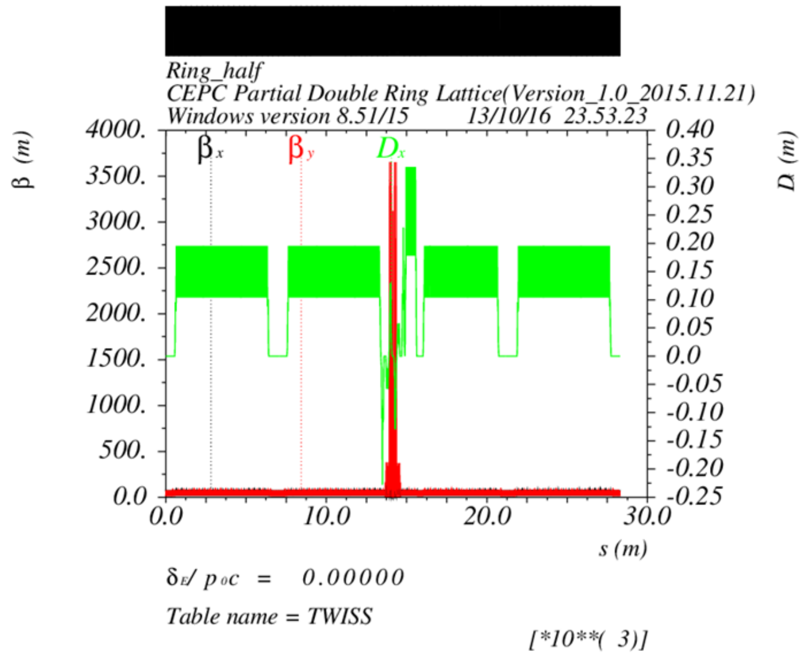
2. CEPC DR Lattice Design (61km)

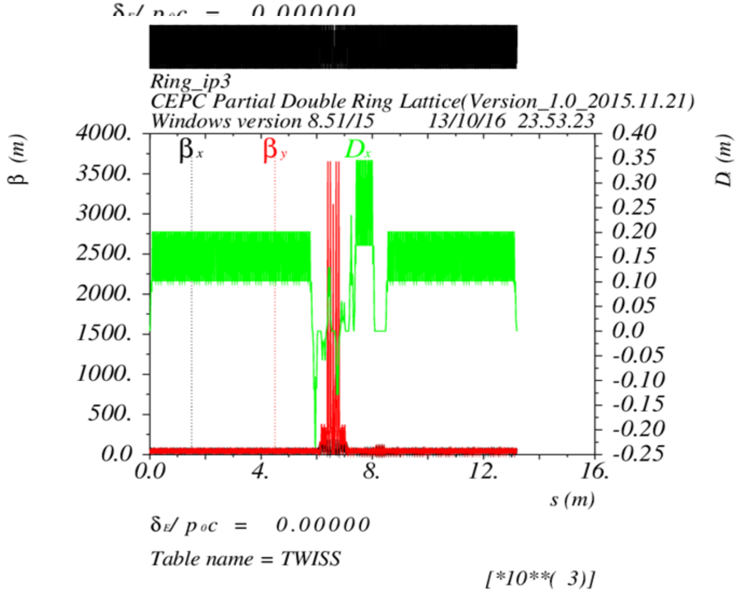
Double Ring Scheme



e-ring

Half Ring





2. CEPC DR Lattice Design (100 km)

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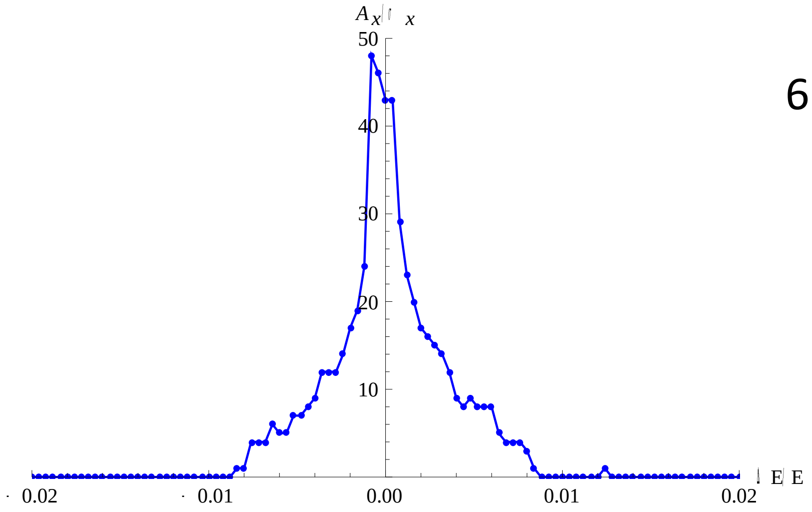
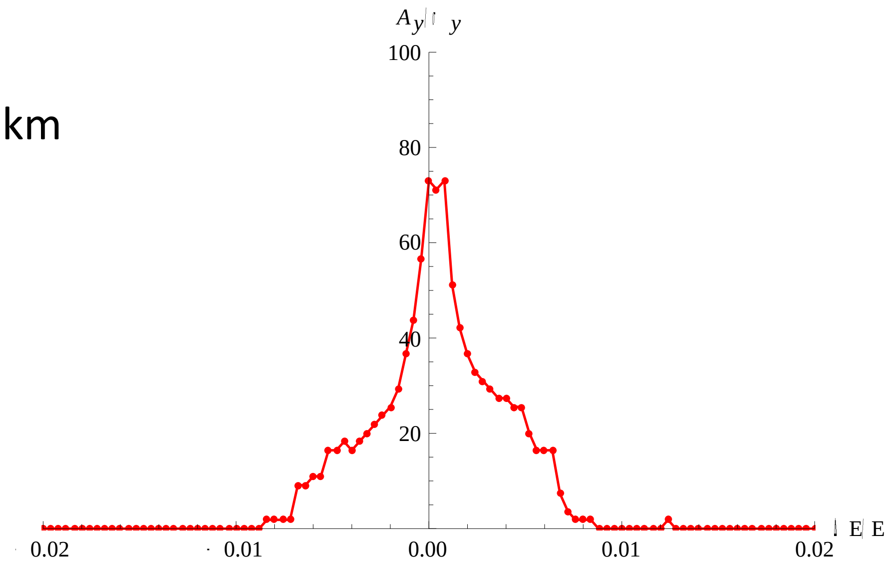
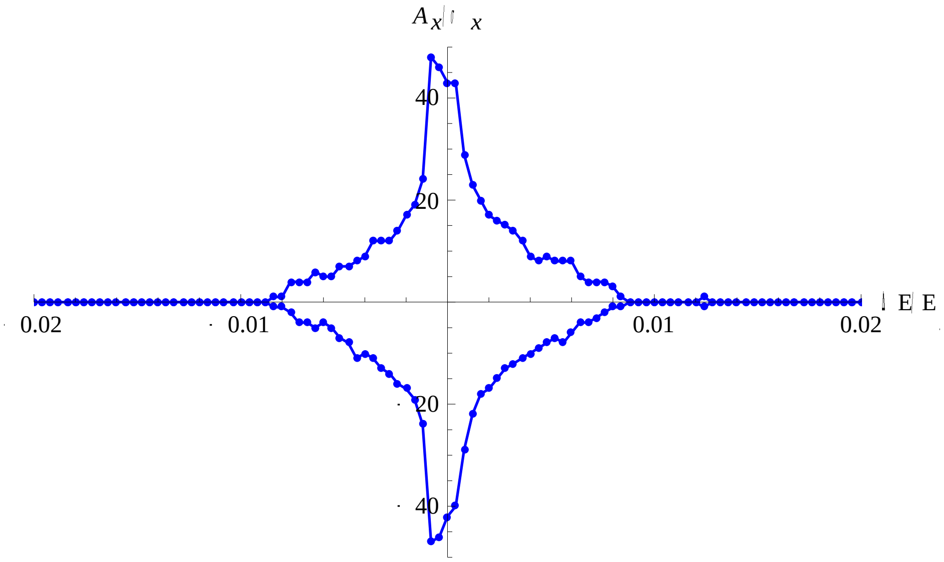
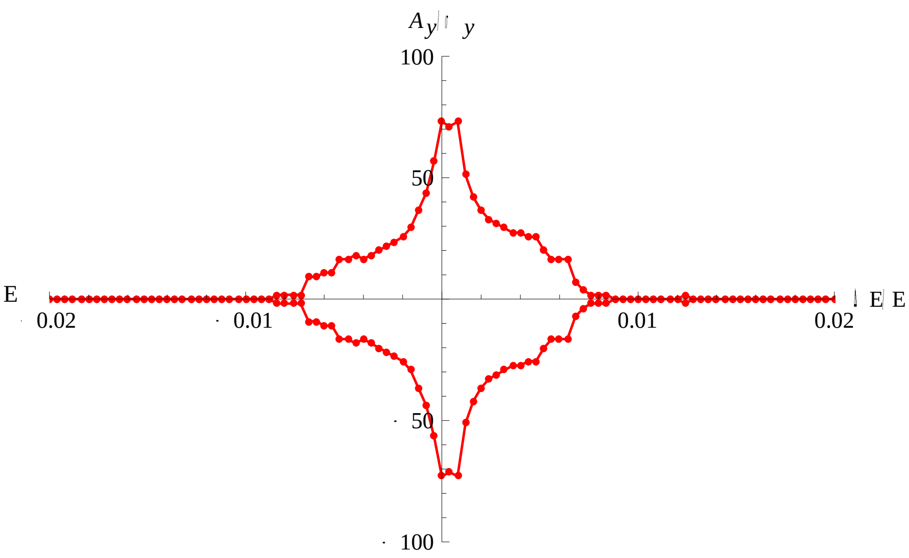
3. CEPC DR DA Study and Optimization(61 km)



61km

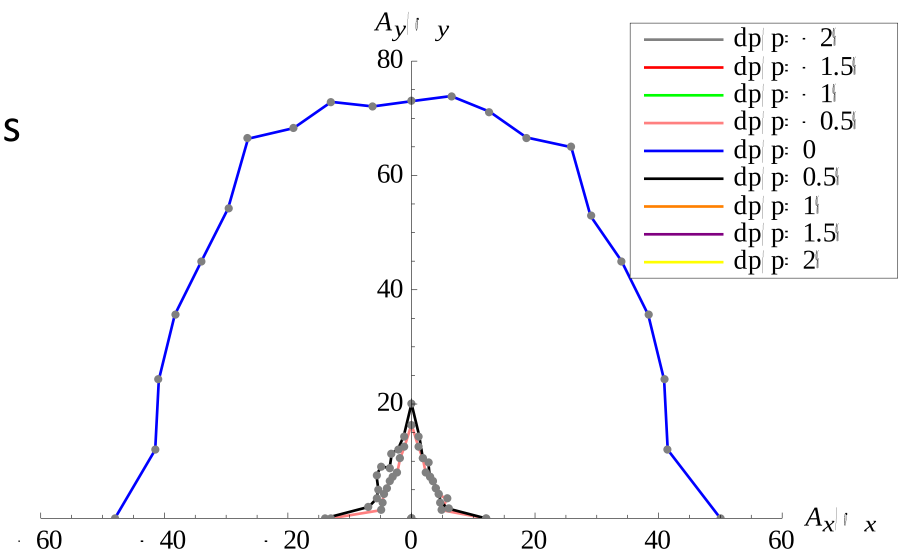


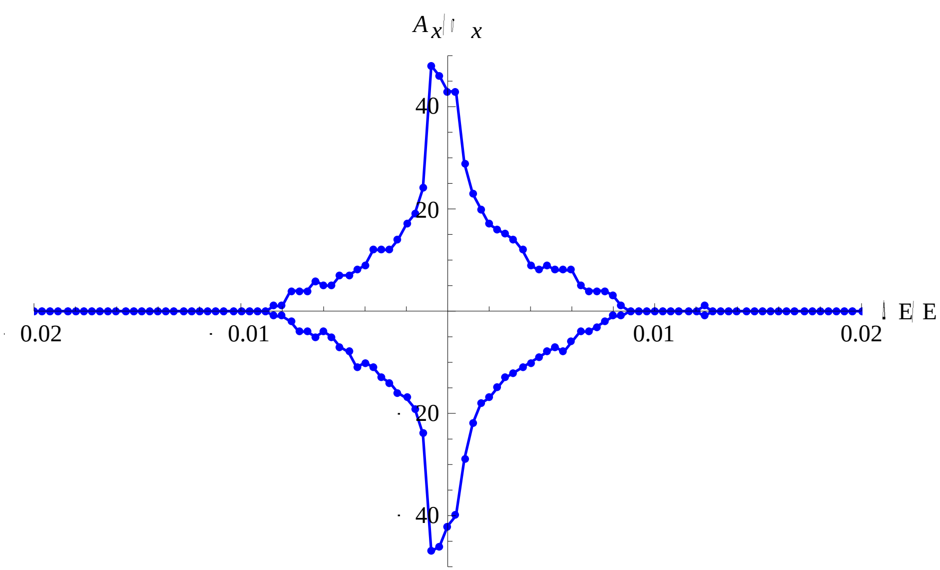


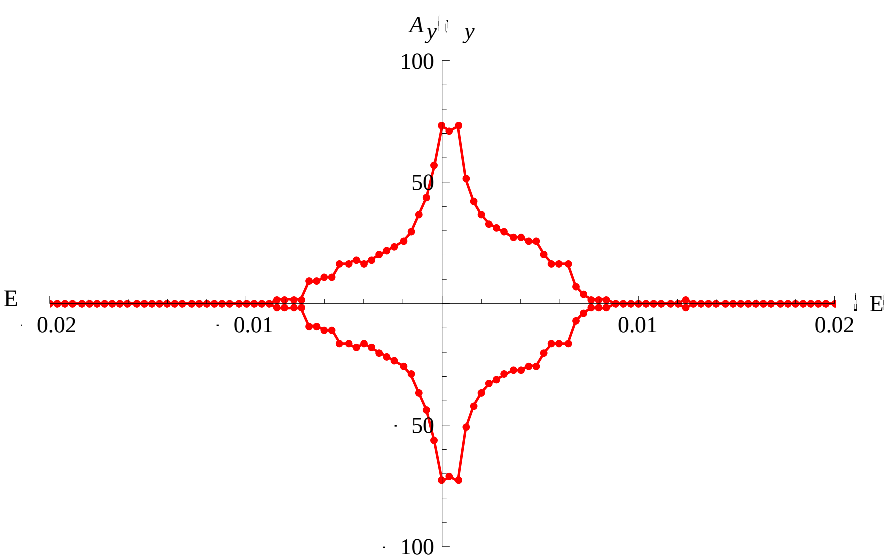


3. CEPC DR DA Study and Optimization(61 km)

2 groups sextupoles





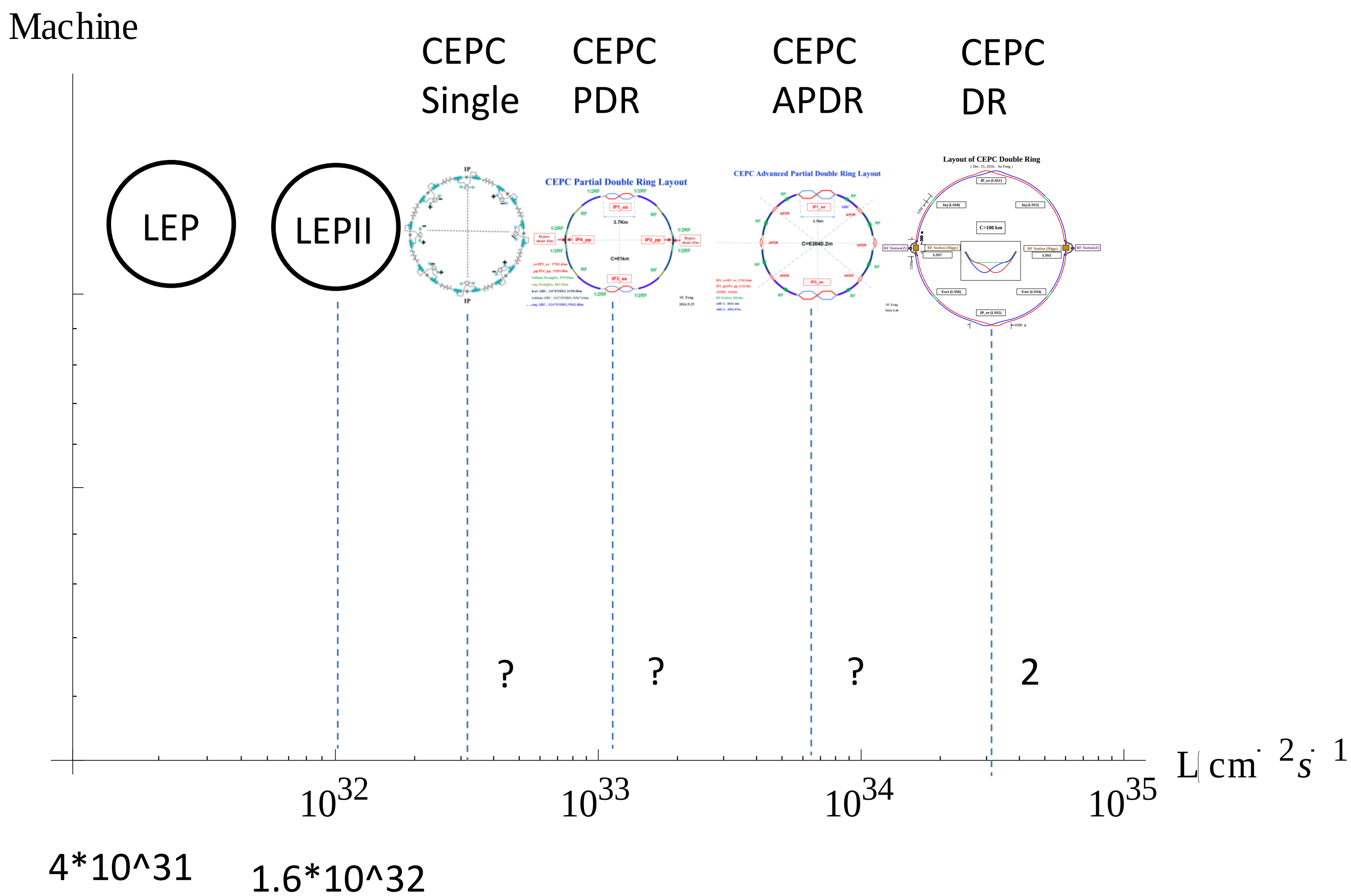


4. Summary

- We finished the 61 km CEPC DR lattice design and showed the dynamic aperture study and optimization.
- The lattice layout is very likely with FCC-ee.
- The lattice design and the DA optimization is a little easier.
- We also start the 100 km CEPC DR lattice design.

Thank You !

backup



Machine
CEPC Single
CEPC PDR
CEPC APDR
CEPC DR
LEP
LEPII
CEPC Partial Double Ring Layout
CEPC Advanced Partial Double Ring Layout
Layout of CEPC Double Ring
?
?
?
2
10^{32}
10^{33}
10^{34}
10^{35}
$L(cm^{-2}s^{-1})$
4*10^31
1.6*10^32