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

CEPC Partial Double Ring Lattice Design and DA Study

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Out line

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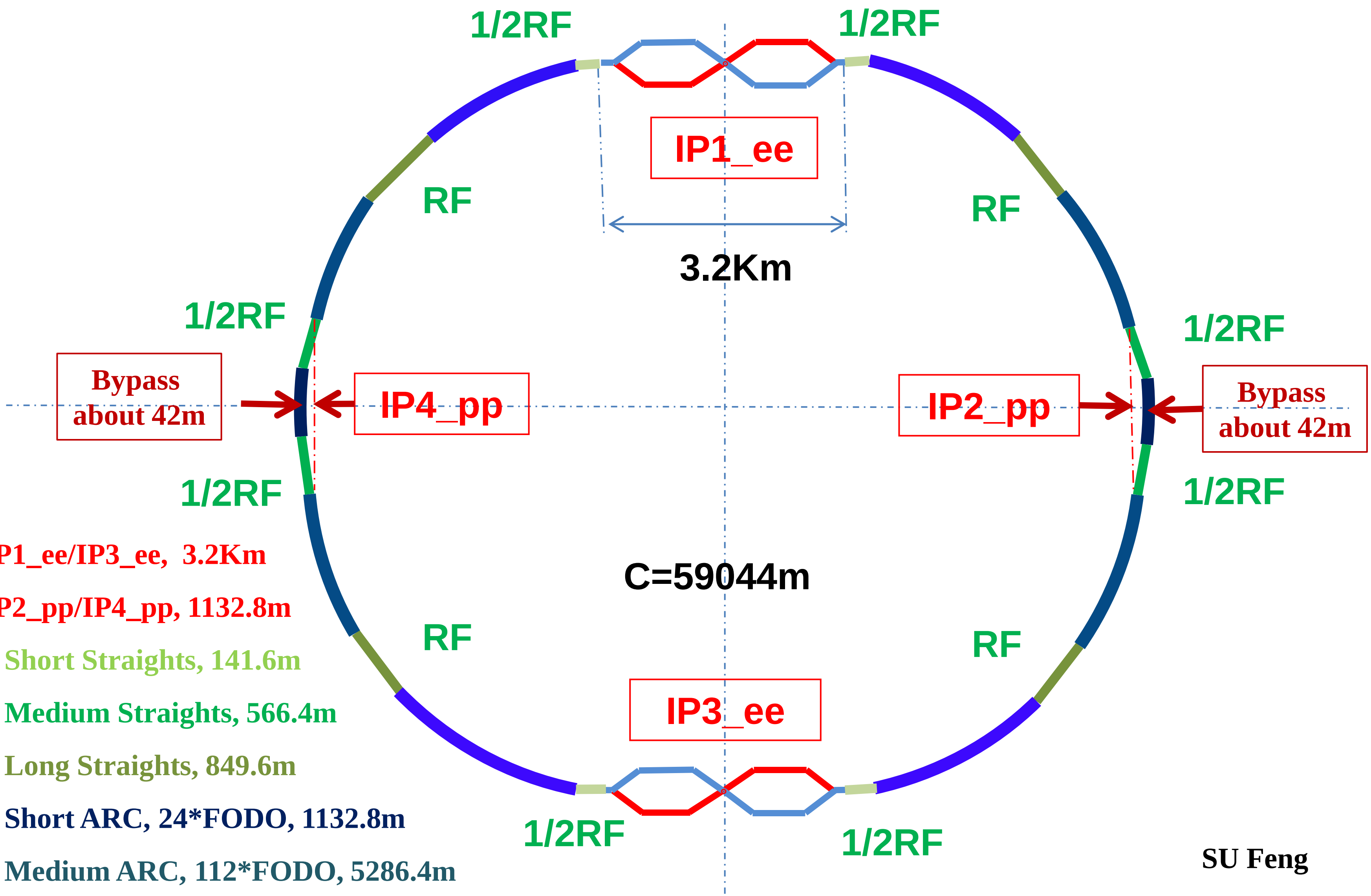
2. CEPC PDR DA without FFS
3. CEPC PDR DA with FFS
4. New FODO cell： 90/90 non-interleave
5. NSGAII & DA Optimization
6. DA Study Strategy and Next Steps
7. Summary

CEPC Partial Double Ring Layout



IP1_ee/IP3_ee, 3.2Km

IP2_pp/IP4_pp, 1132.8m

4 Short Straights, 141.6m

4 Medium Straights, 566.4m

4 Long Straights, 849.6m

2 Short ARC, 24*FODO, 1132.8m

4 Medium ARC, 112*FODO, 5286.4m

4 Long ARC, 124*FODO, 5852.8m

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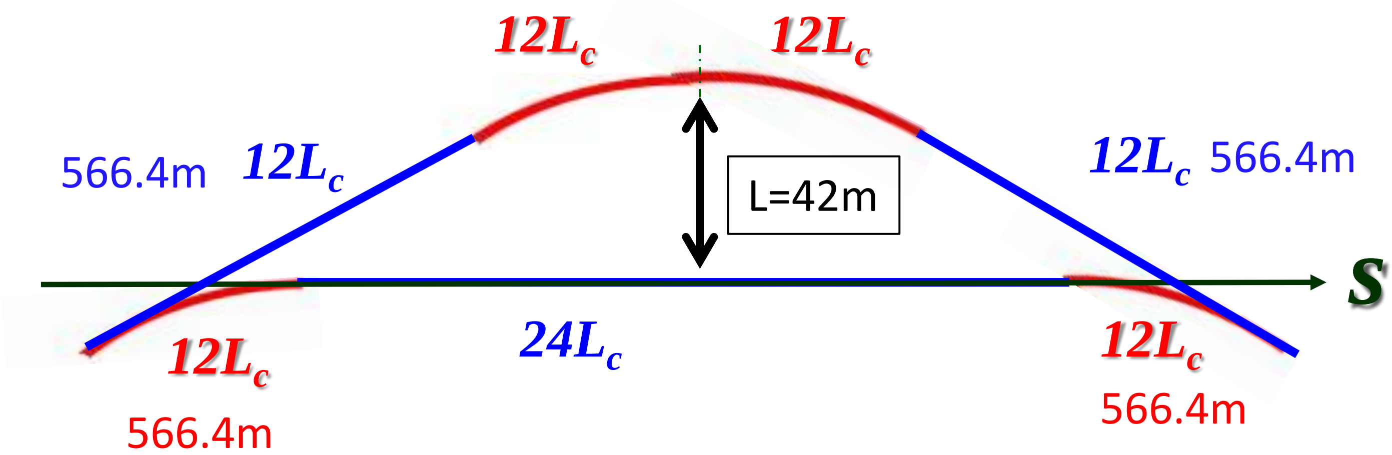
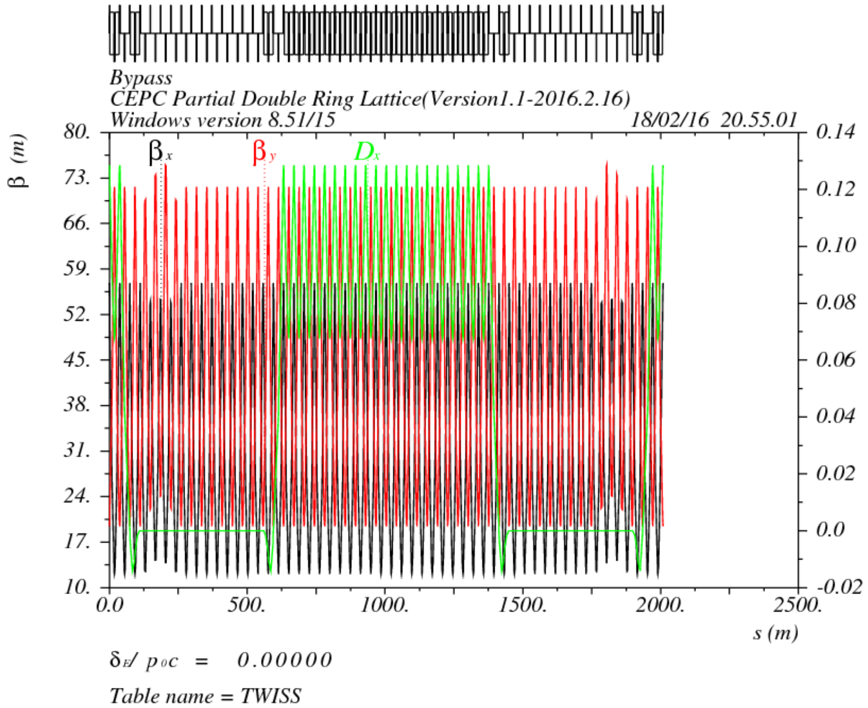
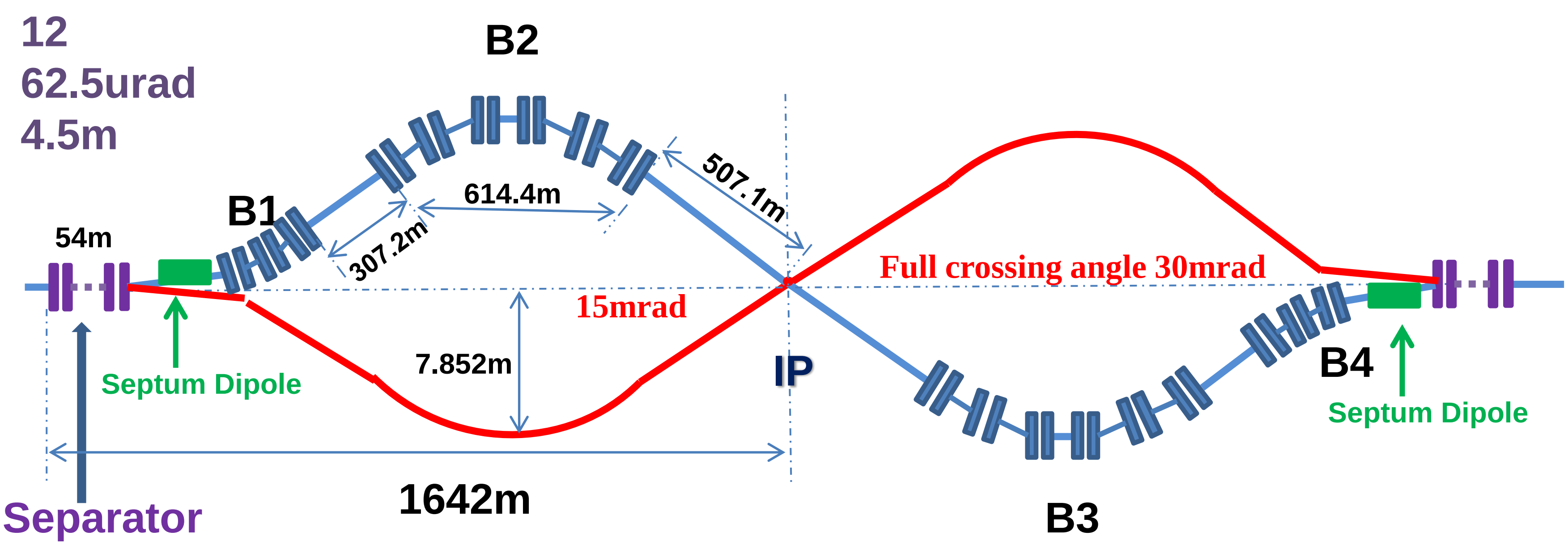
CEPC Bypass at IP2/4





Cell length=47.2m

CEPC Partial Double Ring Layout



For CEPC 120GeV beam:

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

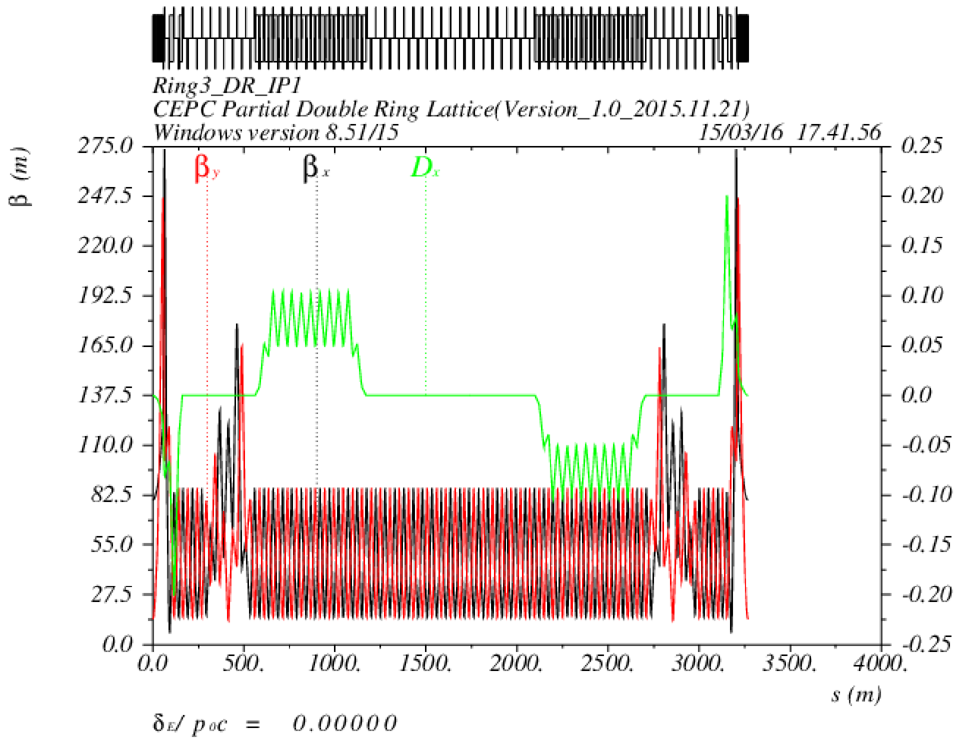
Using Septum Dipole after separator to acquire 15 mrad

Version 1.0

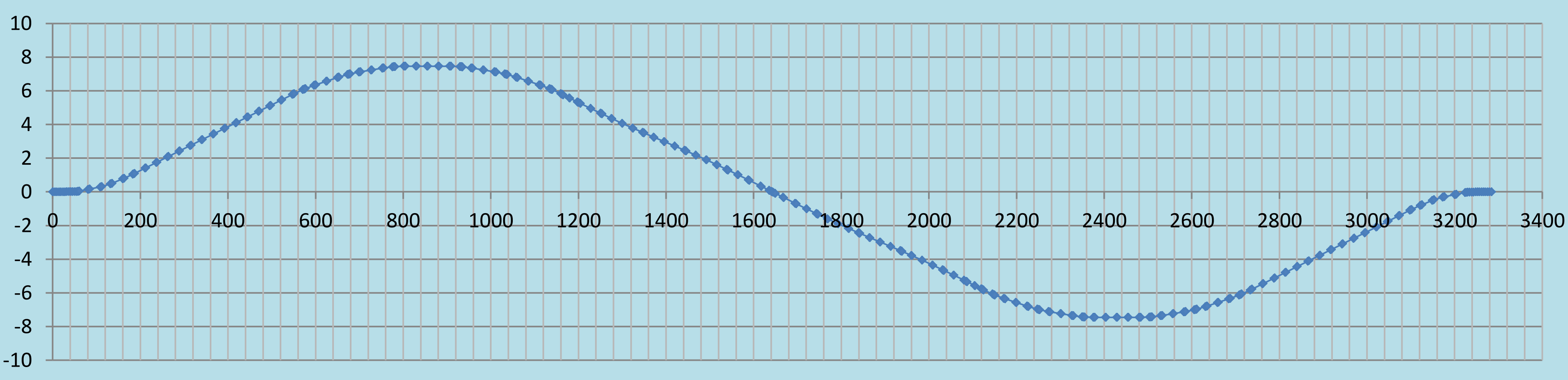
sufeng

2015.12.20

New PDR1.0.1



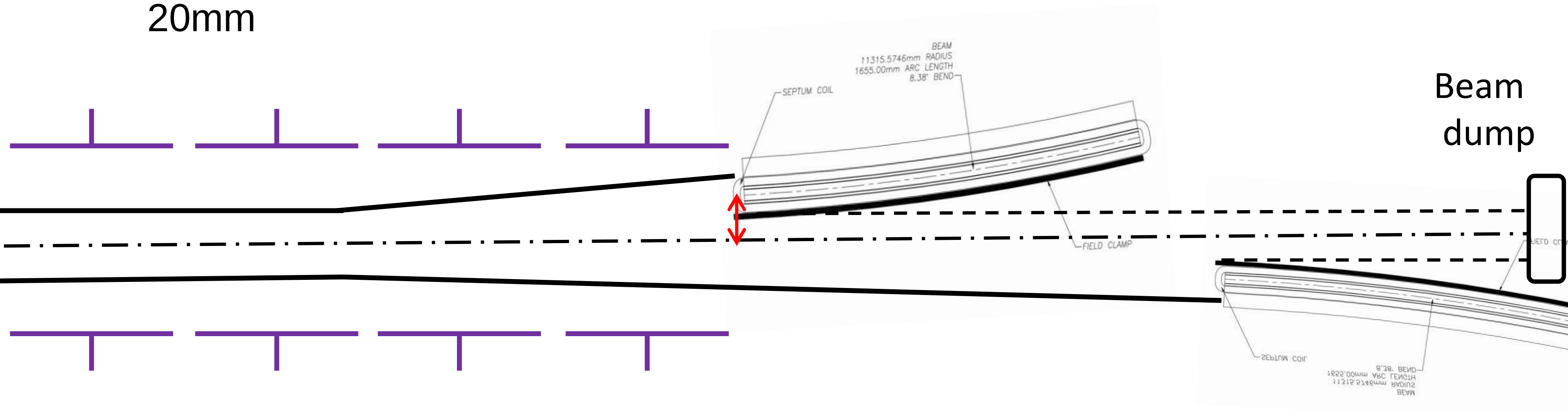
90/90
12cell



Separator with Thin Septum Magnet

Sigmax=697.8um   20sigma=14mm

20mm



Septum Magnet：L=3m

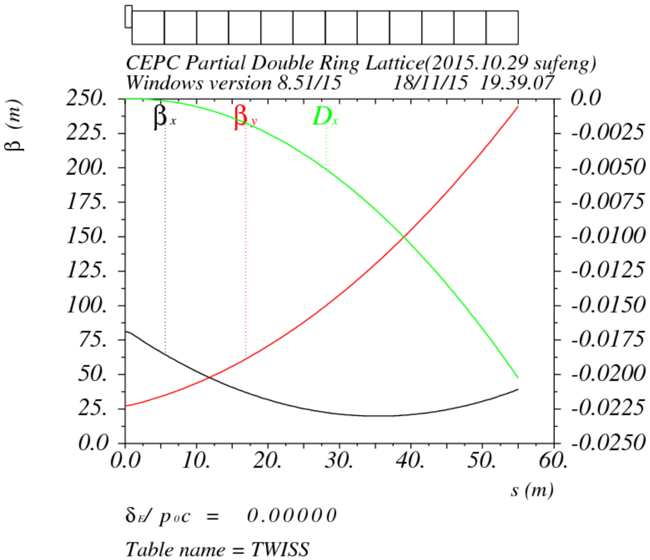
（4.25mrad）thicknes=3-5mm

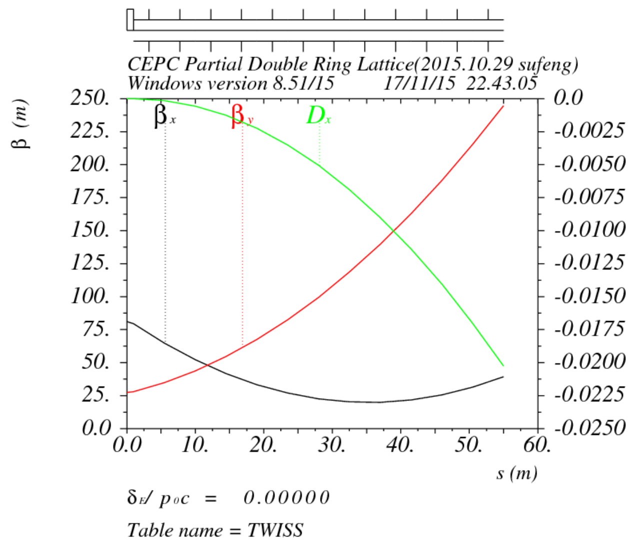
rho=705.822m   B=0.56T

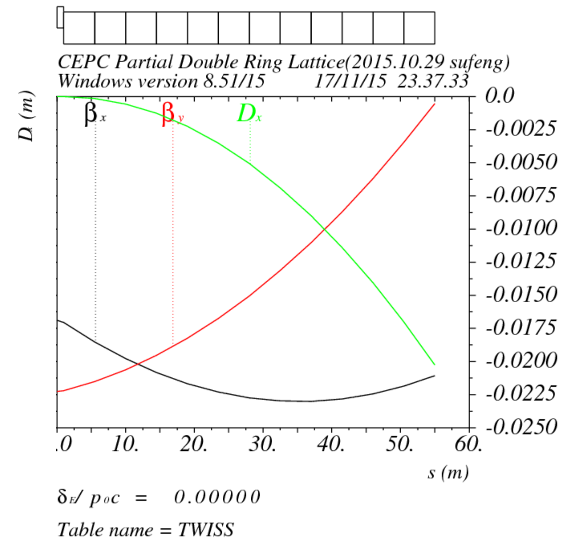
Separator： 62.5 urad
12 个
0.75 mrad

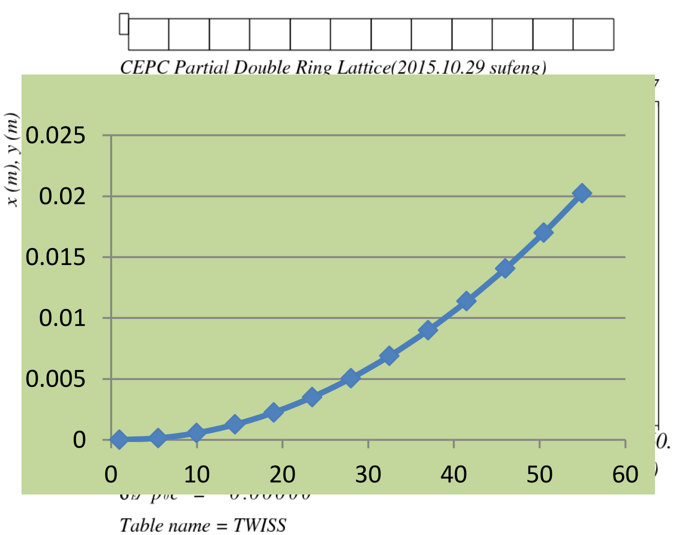
Orbit difference between dipole separator kicker

Dipole	Seperator	Kicker

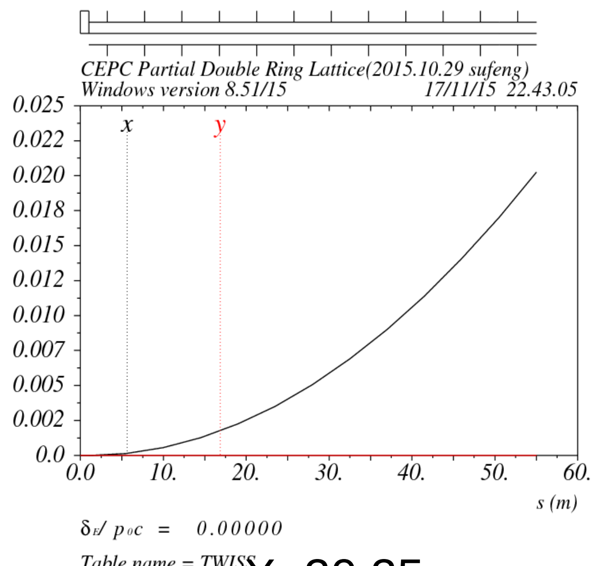




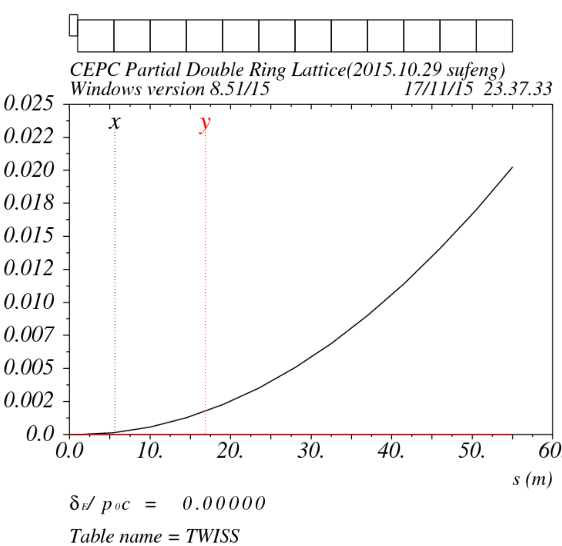




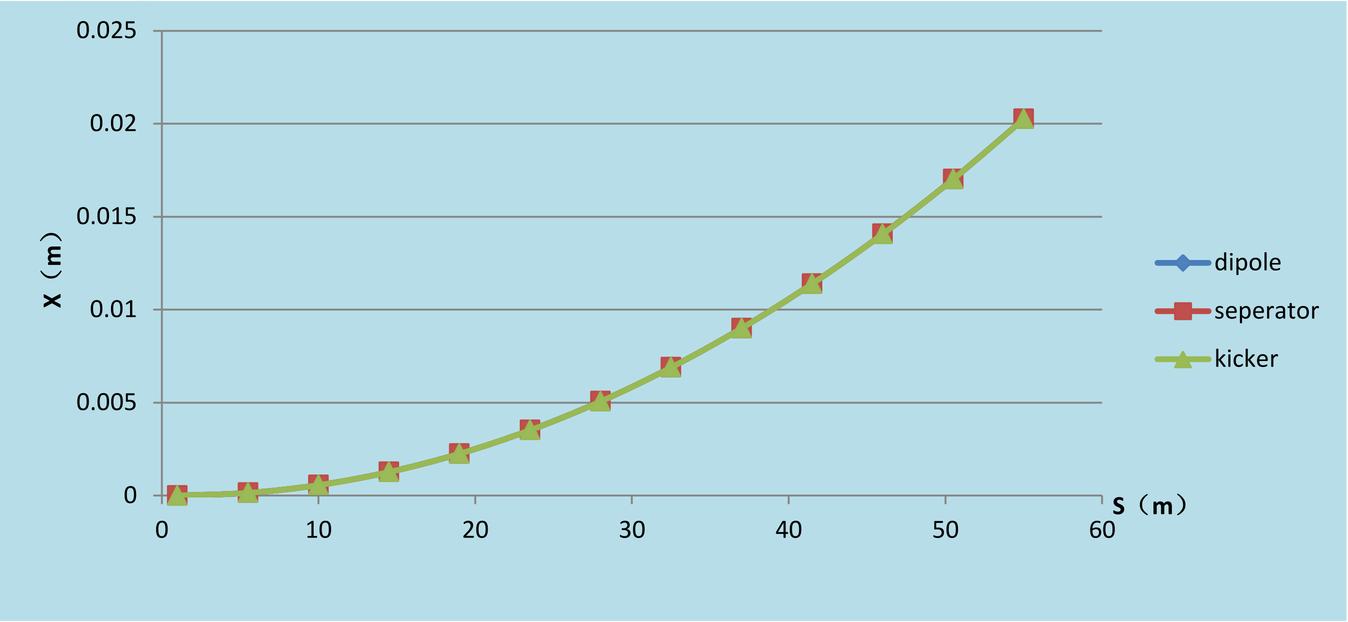
X=20.25mm

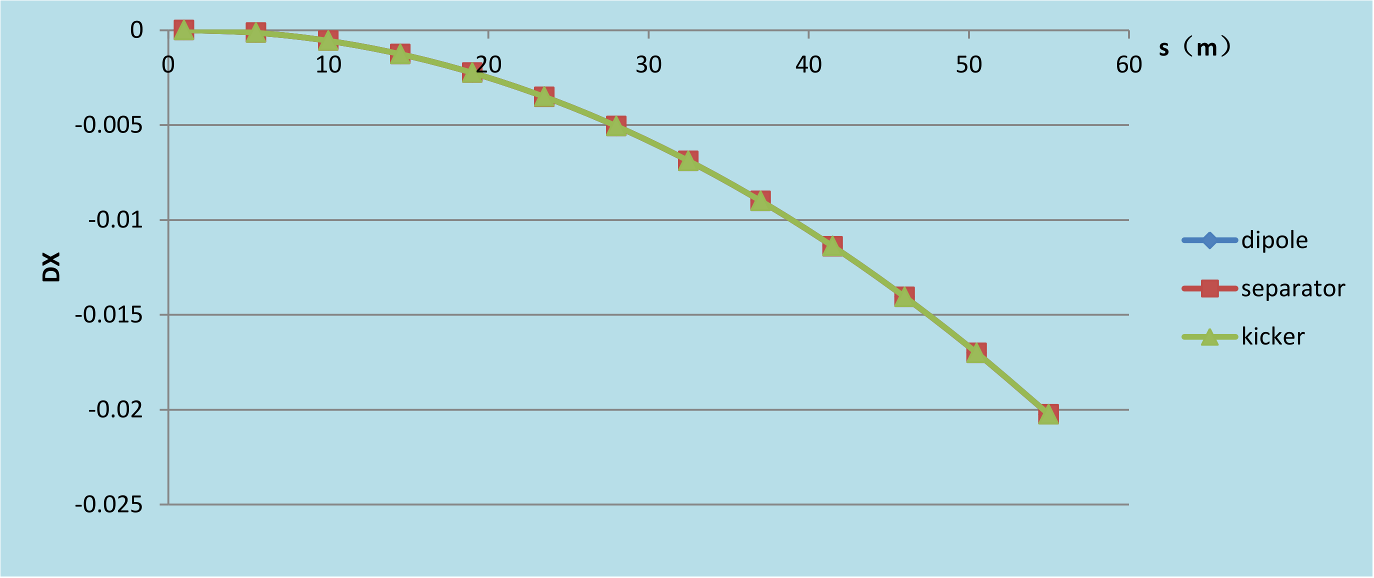


X=20.25mm



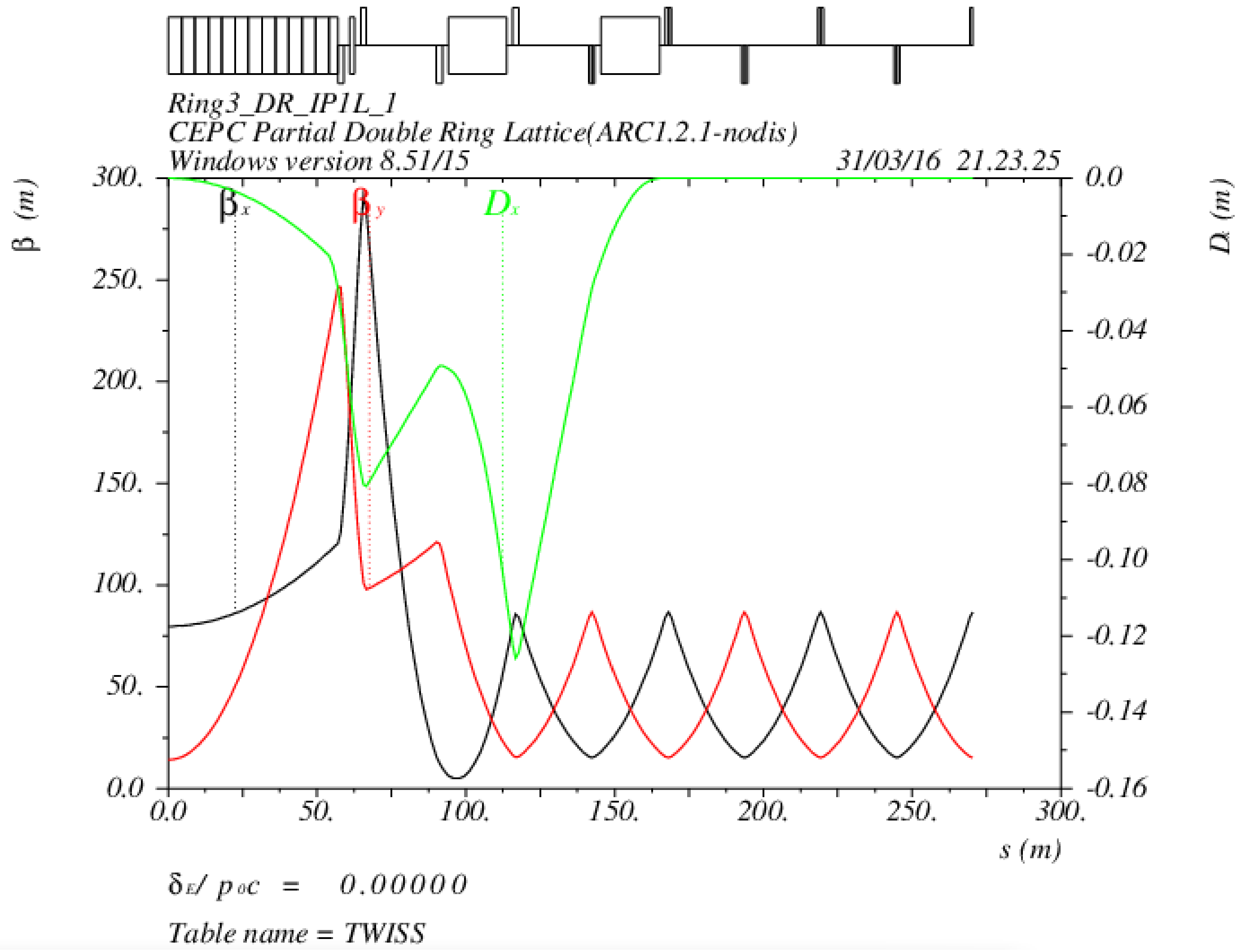
X=20.25mm



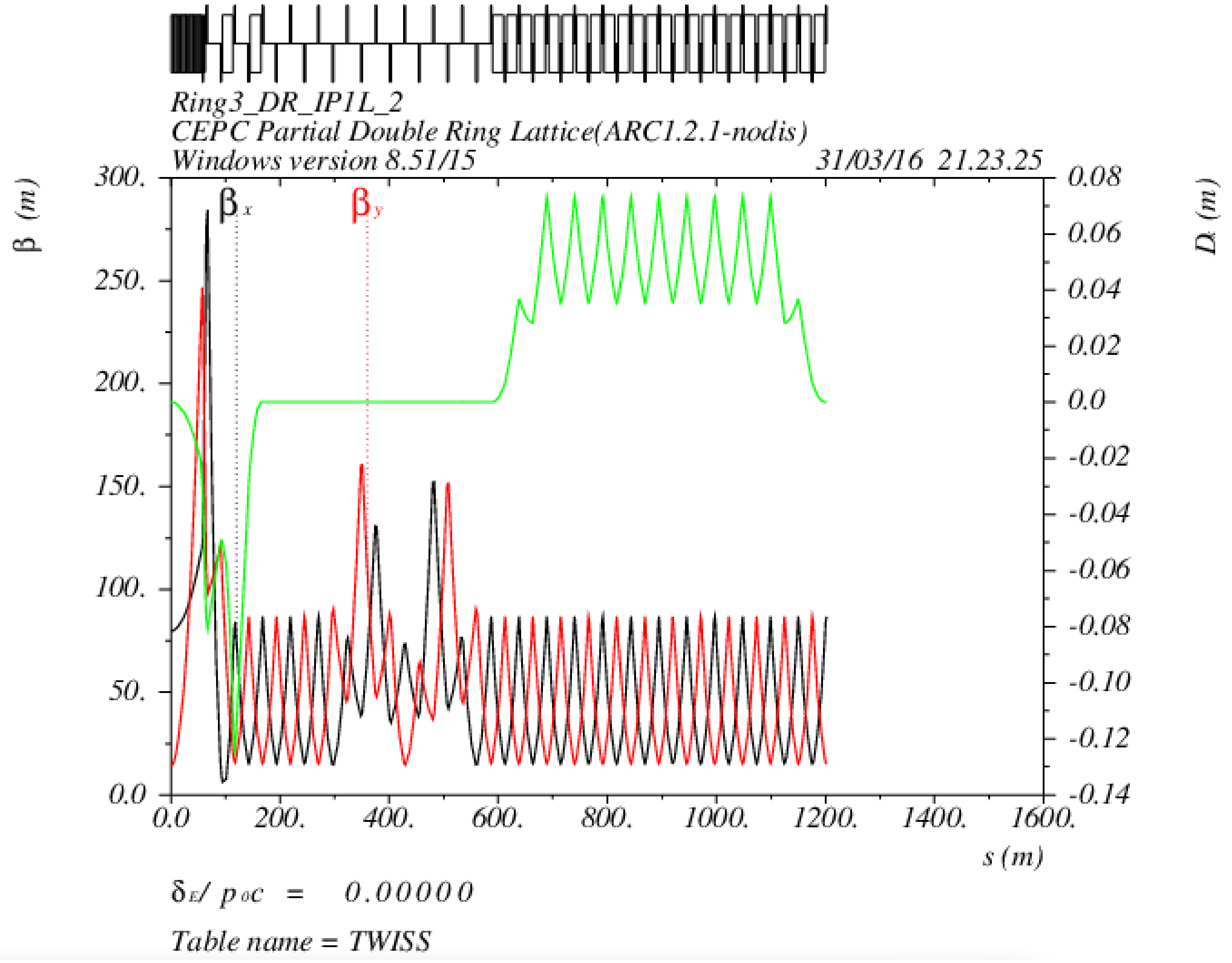


So we use Dipole instead Seperator in lattice now

SEPARATIONMATCHL



RING3_DR_IP1_2

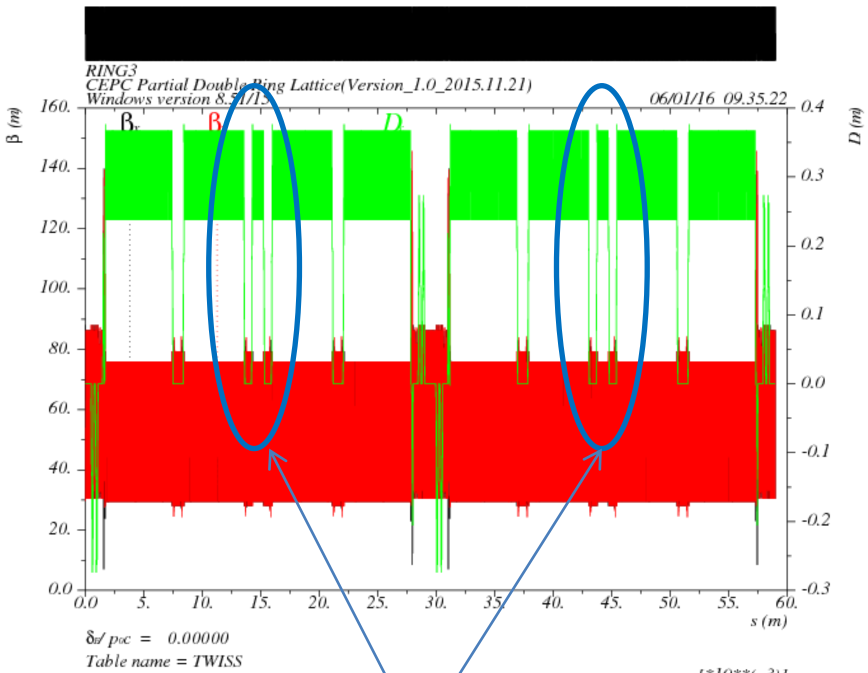


Dipole Strength PDR1.0.1 without FFS

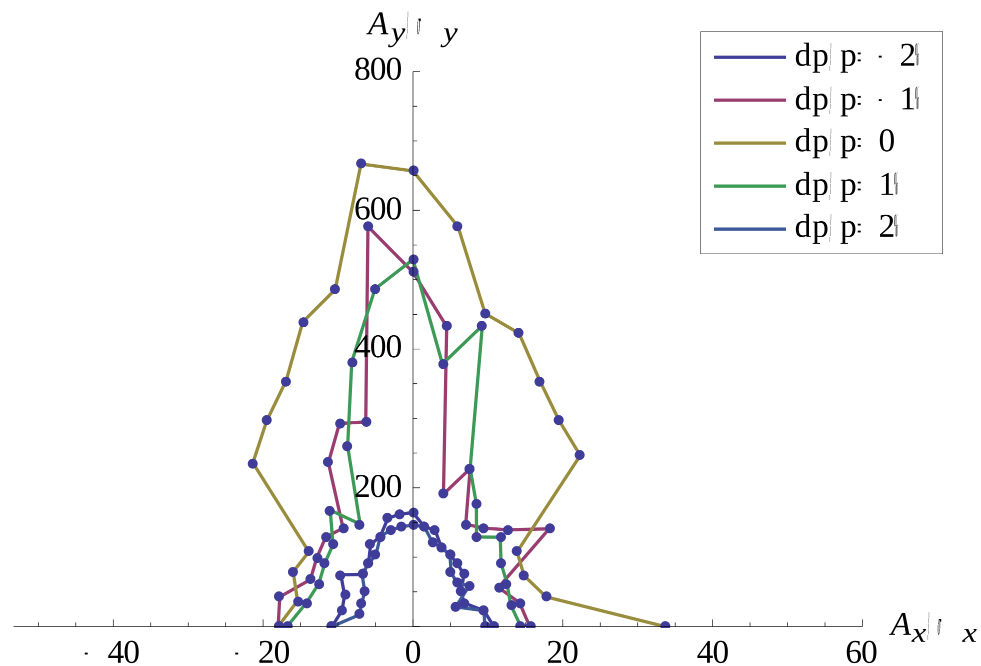
	Angle(mrad)	L(m)	Rho(m)	Brho(E0/c)(T/m)	B(T)	Ek(KeV)	KeV/m
B0	3.205	19.6	6115.44	400	0.06541	626.349	31.956
BSepL	-0.0625	4.5	-72000	400	-0.00556	53.2	11.822
BSeptumL	-4.25	3	-705.822	400	-0.56667	5426.4	1808.8
BMatch1L	1.277	4.9	3837.12	400	0.1042	998.249	203.724
BMatch2L	-7.656	19.6	-2560.08	400	-0.1562	1496.2	76.337
BMatch3L	-3.621	19.6	-5412.87	400	-0.0740	707.647	36.104
B2	1.5	19.6	13066.7	400	0.03061	293.143	14.956
B3	-1.5	19.6	-13066.7	400	-0.03061	293.143	14.956
BMatch3R	3.621	19.6	5412.87	400	0.0740	707.647	36.104
BMatch2R	7.656	19.6	2560.08	400	0.1562	619.704	76.337
BMatch1R	-1.277	4.9	-3837.12	400	-0.1042	1496.2	203.724
BSeptumR	4.25	3	705.822	400	0.56667	5426.4	1808.8
BSepR	0.0625	4.5	72000	400	0.00556	53.2	11.822

Survey & Dynamic Aperture

（Version 1.0 –without FFS）



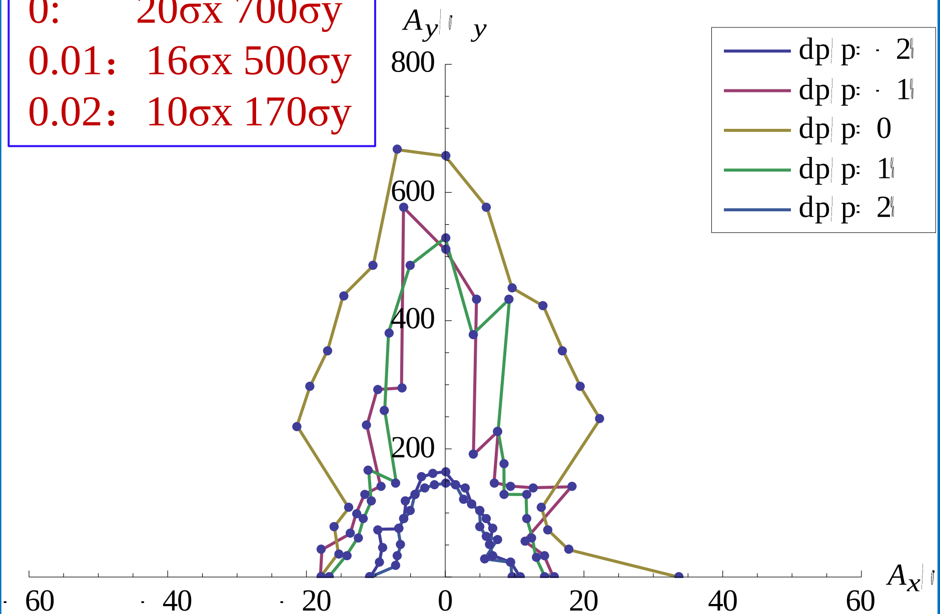
Bypass part at IP2/4



0: 20σx 700σy
0.01: 16σx 500σy
0.02: 10σx 170σy

Dynamic Aperture Comparation

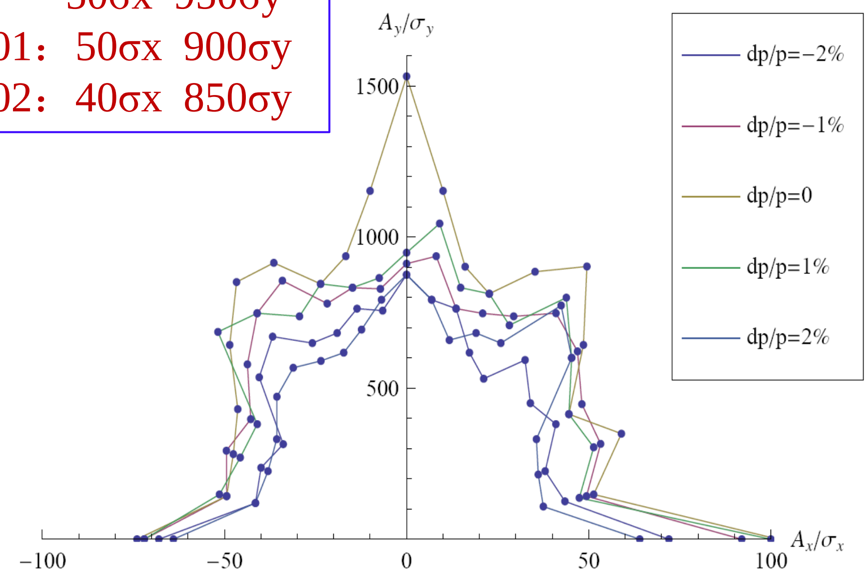
0: 20σx 700σy
0.01： 16σx 500σy
0.02： 10σx 170σy



CEPC Partial Double Ring Lattice

(Version1.0-20160104)

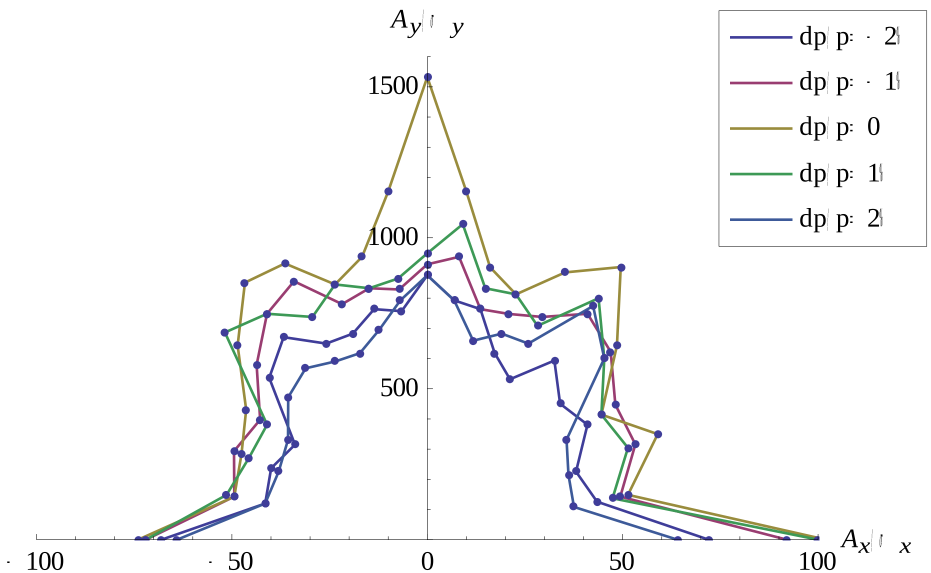
0: 50σx 950σy
0.01： 50σx 900σy
0.02： 40σx 850σy



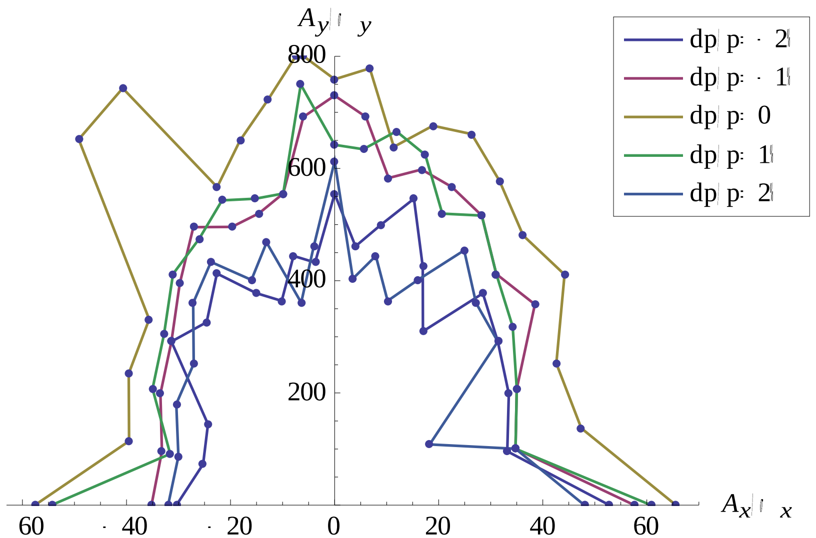
CEPC Main Ring Lattice (without pretzel)

(September 30, 2014 Geng Huiping)

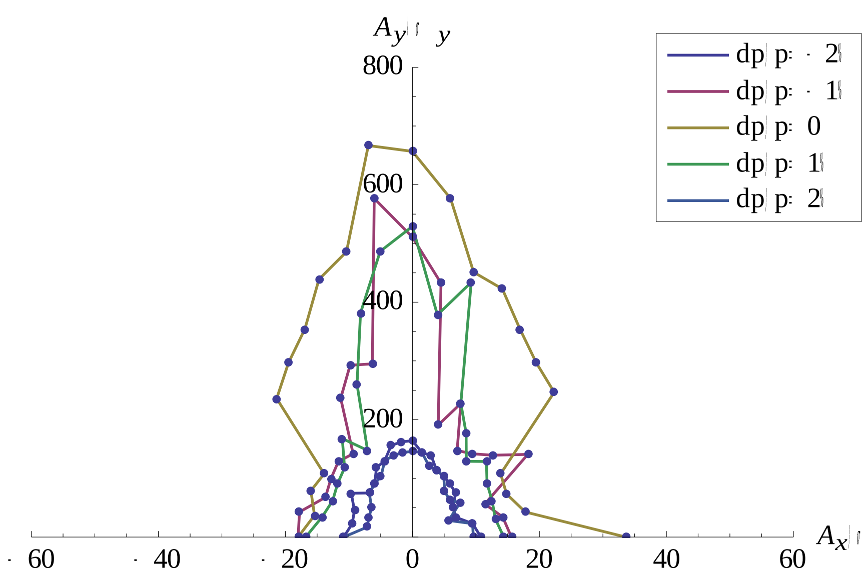
CEPC-Single



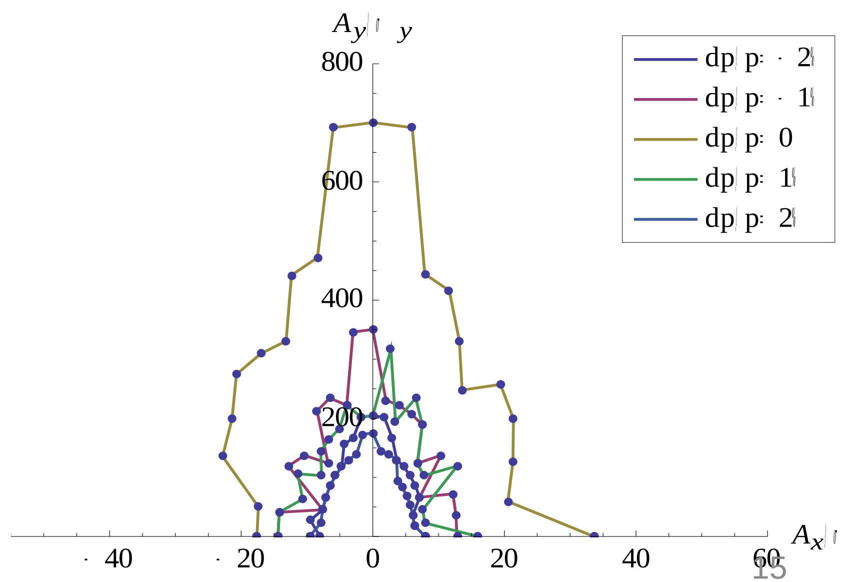
CEPC-Single-Bypass



CEPC-PDR-Bypass



CEPC-PDR-Bypass-PDRnPi



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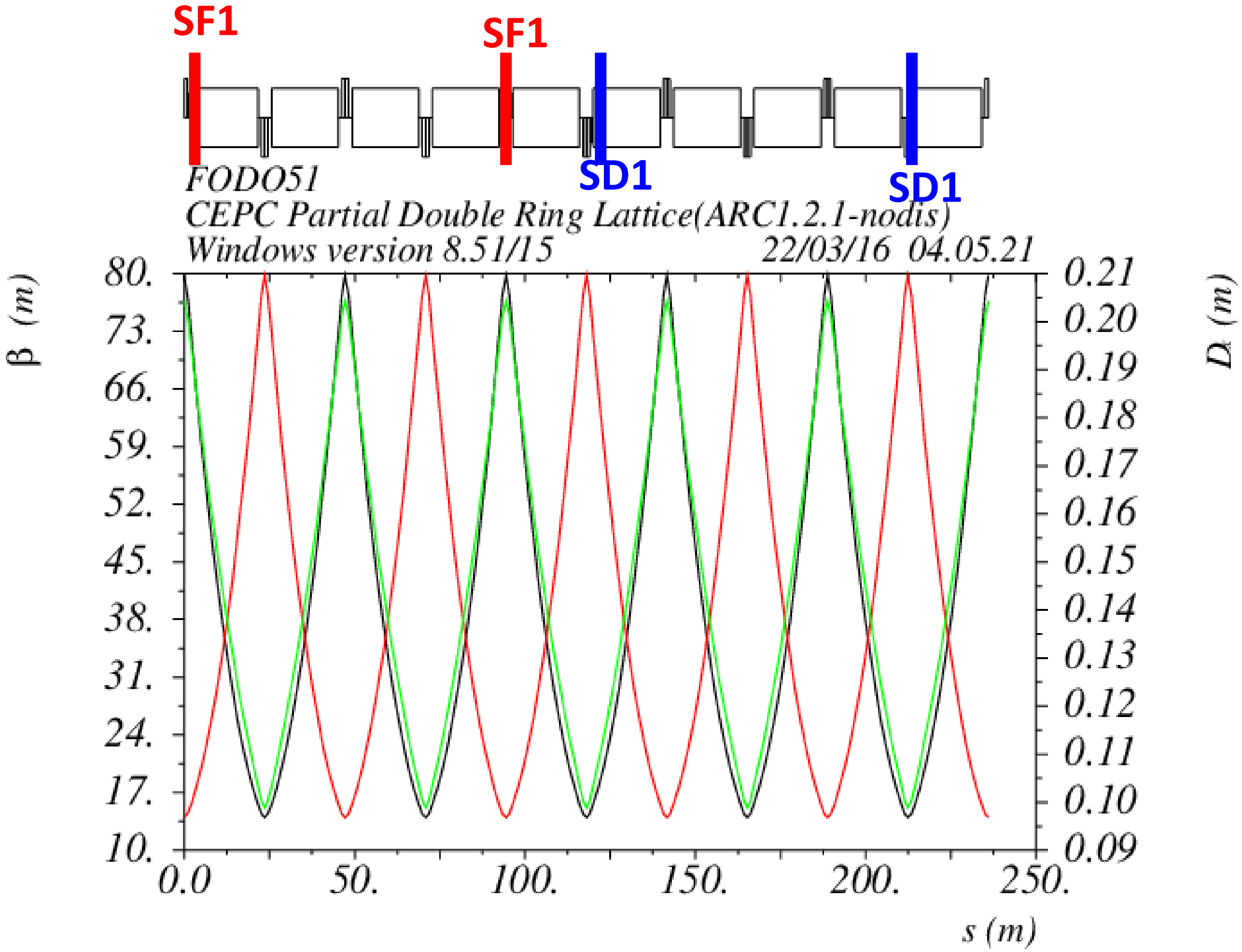
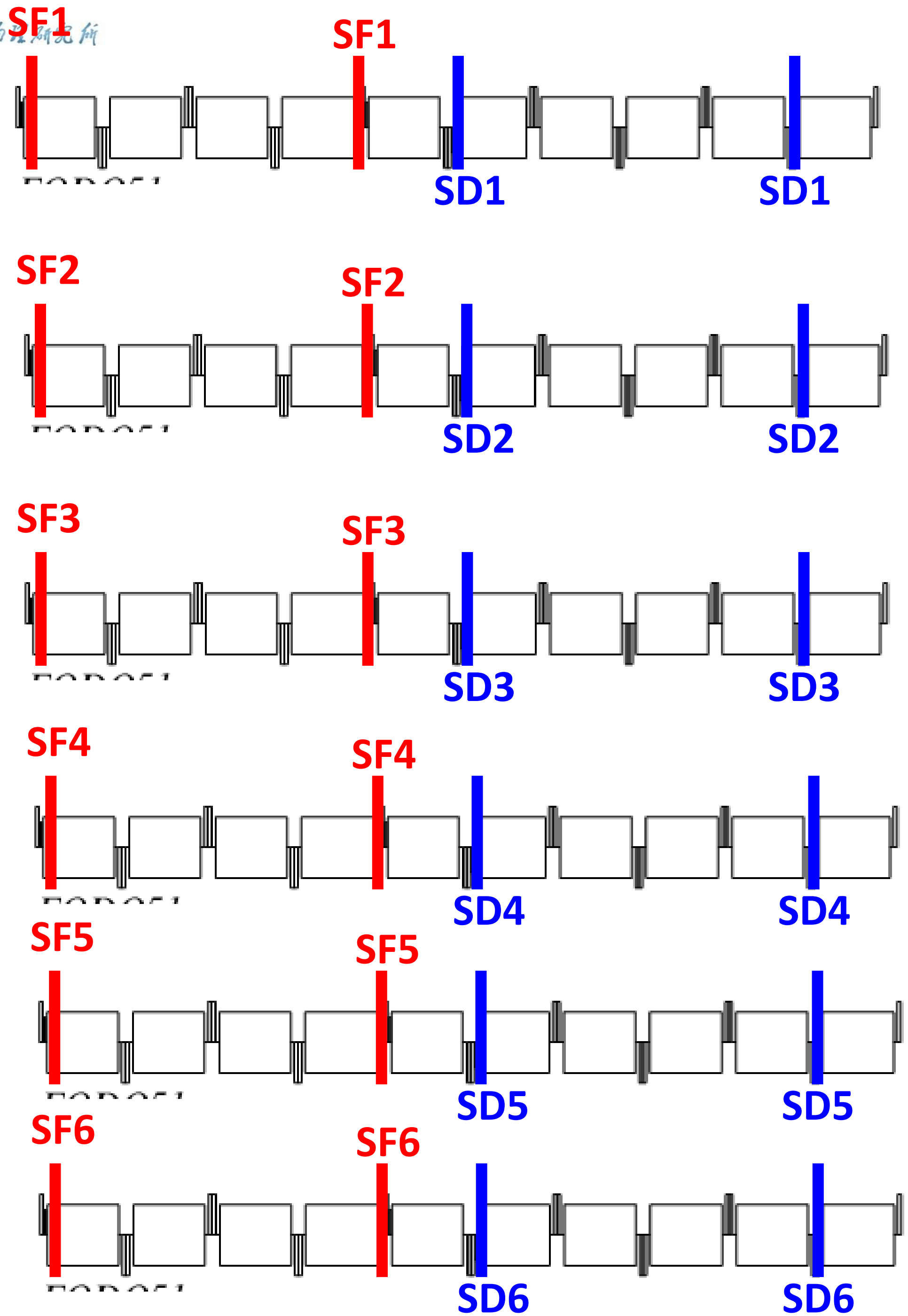
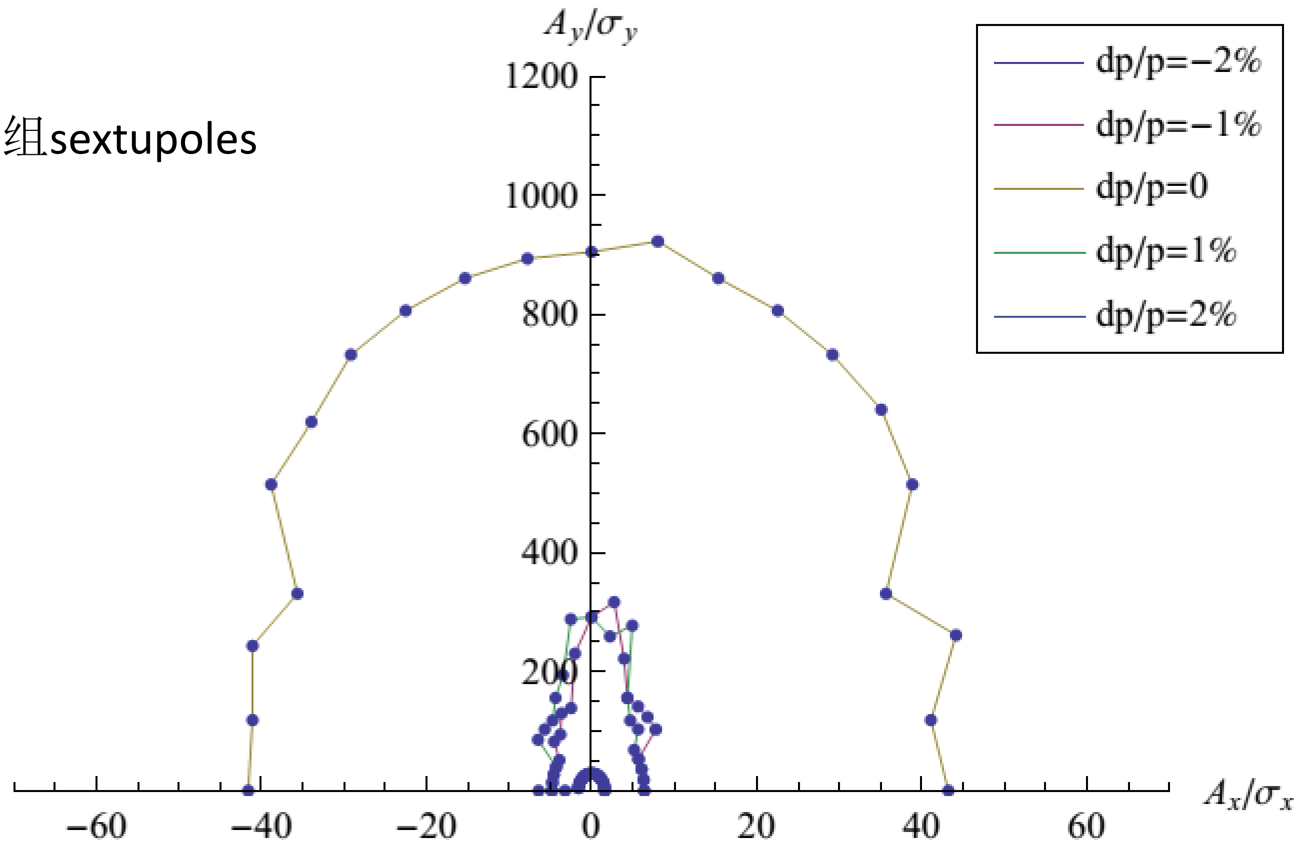
New ARC FODO 90/90 non-interleave




SF1
SF1
SD1
SD1
SF2
SF2
SD2
SD2
SF3
SF3
SD3
SD3
SF4
SF4
SD4
SD4
SF5
SF5
SD5
SD5
SF6
SF6
SD6
SD6

ARC1.2.1-bypass-PDR1.0.1-without FFS (90/90)

2组sextupoles



NSGA-II & DA Optimization

'npop': 500,
'ngen': 100,
'nobj': 30,
'nvar': 12,

200CPU
T1=40min
T2=70h

cepc_ndr_0099.txt

Variable

SF1.K2
SF2.K2
SF3.K2
SF4.K2
SF5.K2
SF6.K2

SD1.K2
SD2.K2
SD3.K2
SD4.K2
SD5.K2
SD6.K2

Objective

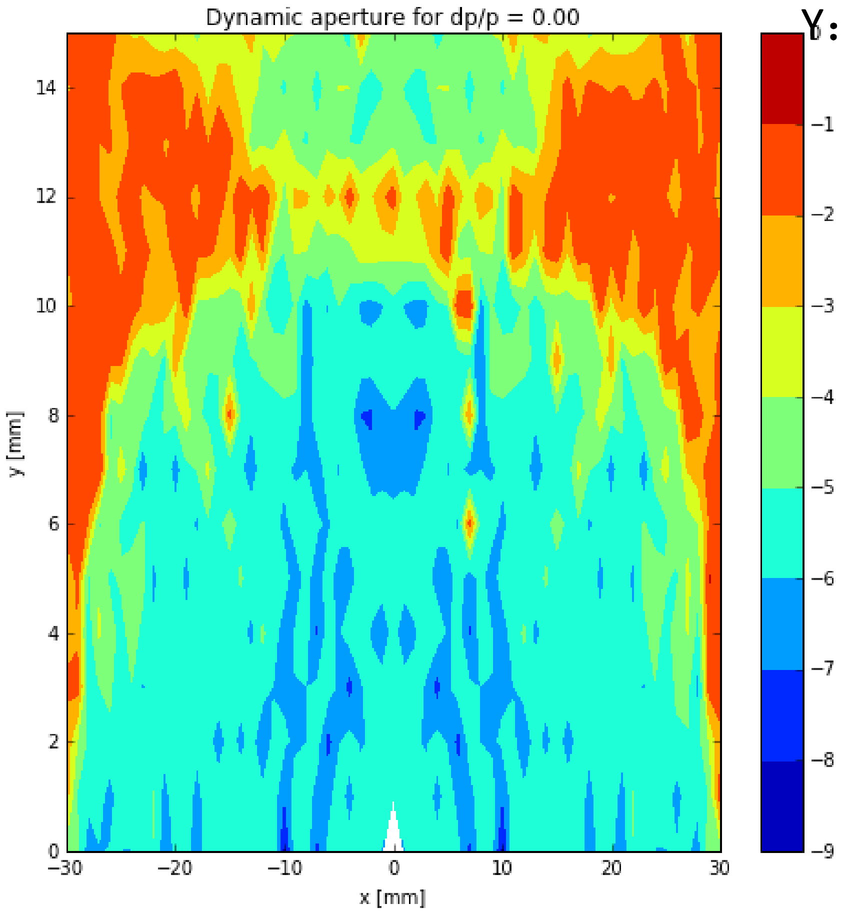
```
p[nvar+0] = abs(nsls2.ring.h1['h30000'])
p[nvar+1] = abs(nsls2.ring.h1['h21000'])
p[nvar+2] = abs(nsls2.ring.h1['h10110'])
p[nvar+3] = abs(nsls2.ring.h1['h10200'])
p[nvar+4] = abs(nsls2.ring.h1['h10020'])
p[nvar+5] = abs(nsls2.ring.h1['h20001'])
p[nvar+6] = abs(nsls2.ring.h1['h10002'])
p[nvar+7] = abs(nsls2.ring.h1['h00201'])

p[nvar+8] = abs(nsls2.ring.h2['h00310'])
p[nvar+9] = abs(nsls2.ring.h2['h11200'])
p[nvar+10] = abs(nsls2.ring.h2['h10111'])
p[nvar+11] = abs(nsls2.ring.h2['h00112'])
p[nvar+12] = abs(nsls2.ring.h2['h30001'])
p[nvar+13] = abs(nsls2.ring.h2['h11110'])
p[nvar+14] = abs(nsls2.ring.h2['h22000'])
p[nvar+15] = abs(nsls2.ring.h2['h00004'])
p[nvar+16] = abs(nsls2.ring.h2['h00400'])
p[nvar+17] = abs(nsls2.ring.h2['h10201'])
p[nvar+18] = abs(nsls2.ring.h2['h20020'])
p[nvar+19] = abs(nsls2.ring.h2['h10021'])
p[nvar+20] = abs(nsls2.ring.h2['h10003'])
p[nvar+21] = abs(nsls2.ring.h2['h21001'])
p[nvar+22] = abs(nsls2.ring.h2['h31000'])
p[nvar+23] = abs(nsls2.ring.h2['h40000'])
p[nvar+24] = abs(nsls2.ring.h2['h20002'])
p[nvar+25] = abs(nsls2.ring.h2['h00220'])
p[nvar+26] = abs(nsls2.ring.h2['h20200'])
p[nvar+27] = abs(nsls2.ring.h2['h20110'])
p[nvar+28] = abs(nsls2.ring.h2['h11002'])
p[nvar+29] = abs(nsls2.ring.h2['h00202'])
```

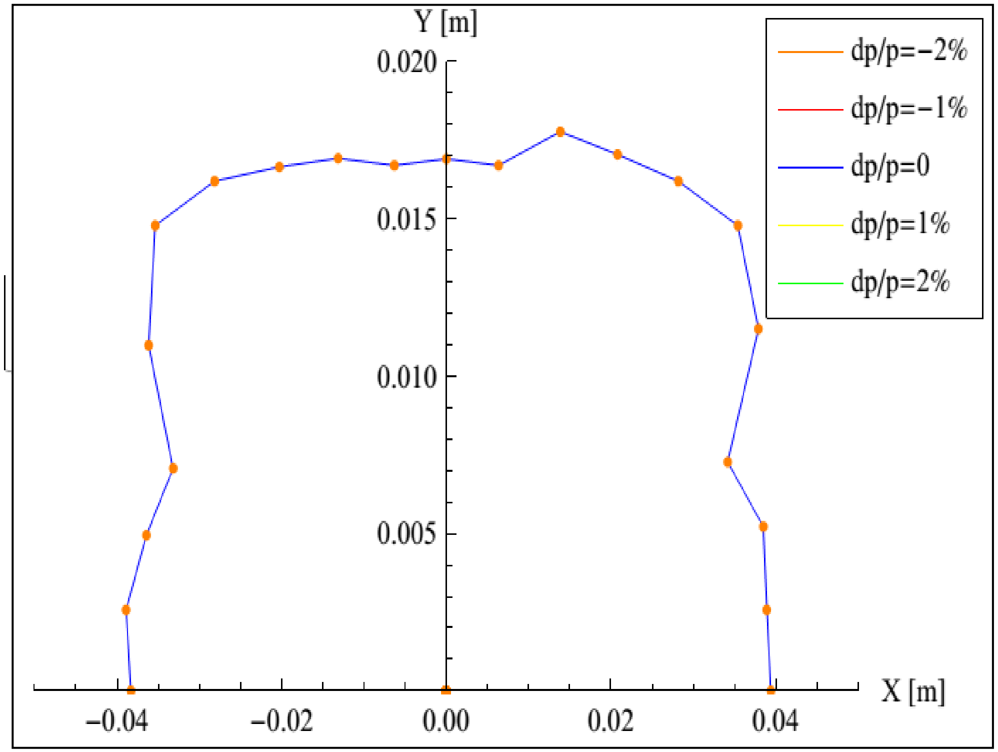
Dynamic Aperture dp/p=0

X： 0.53mm

Y： 0.012mm



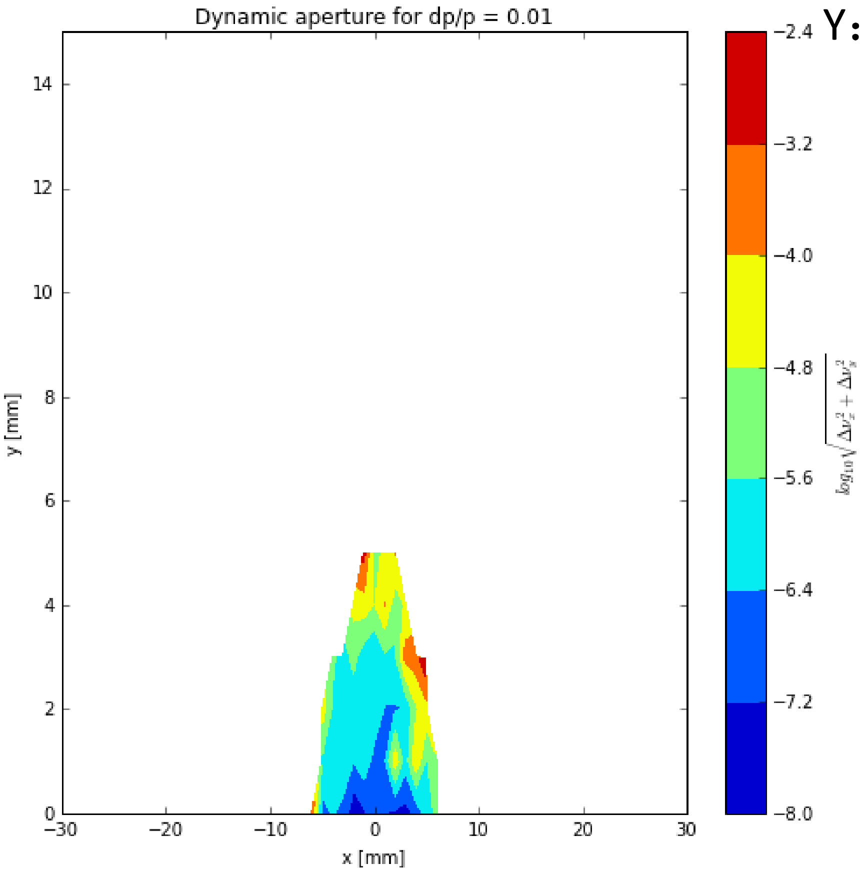
pylatt



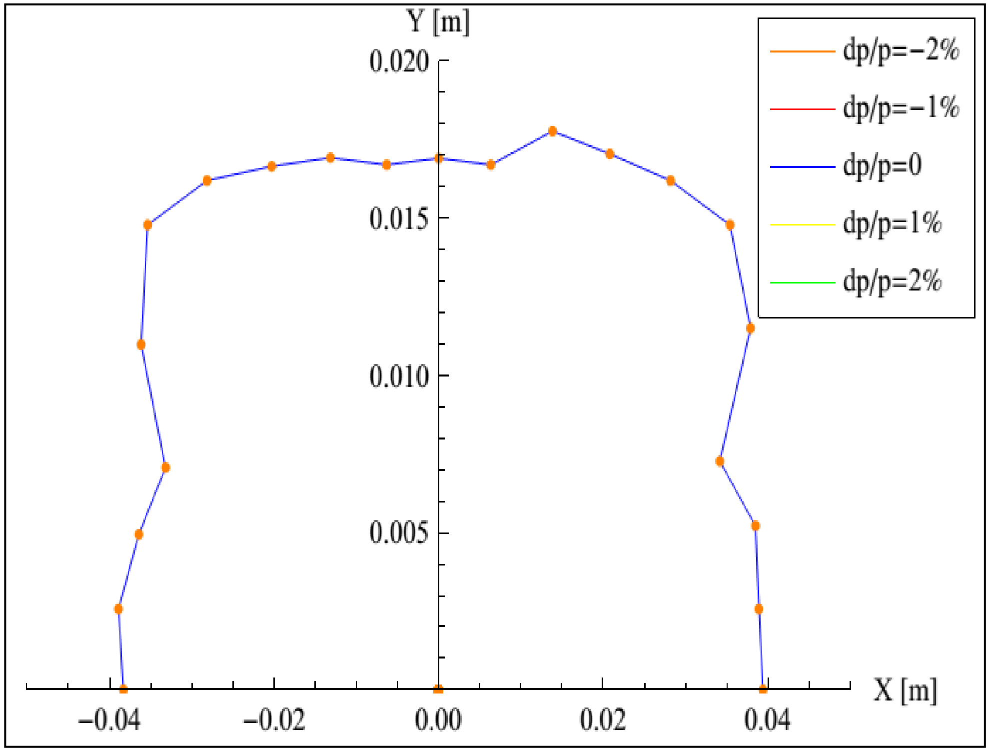
SAD

Dynamic Aperture dp/p=0.01

X： 0.53mm
Y： 0.012mm



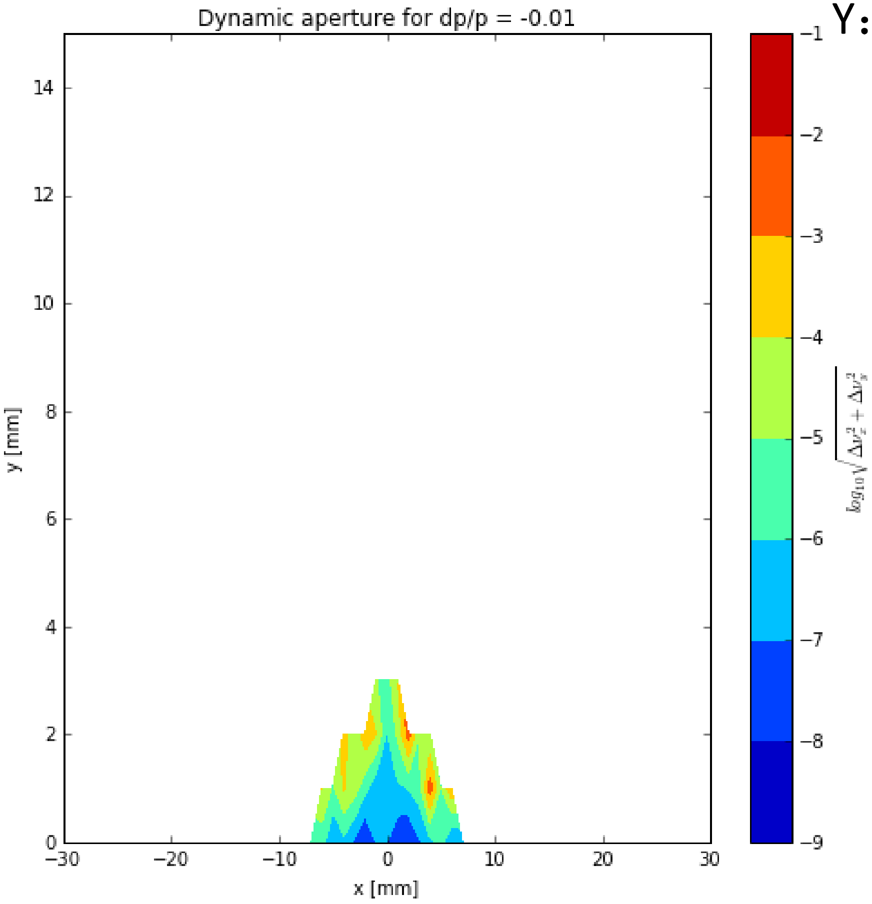
pylatt



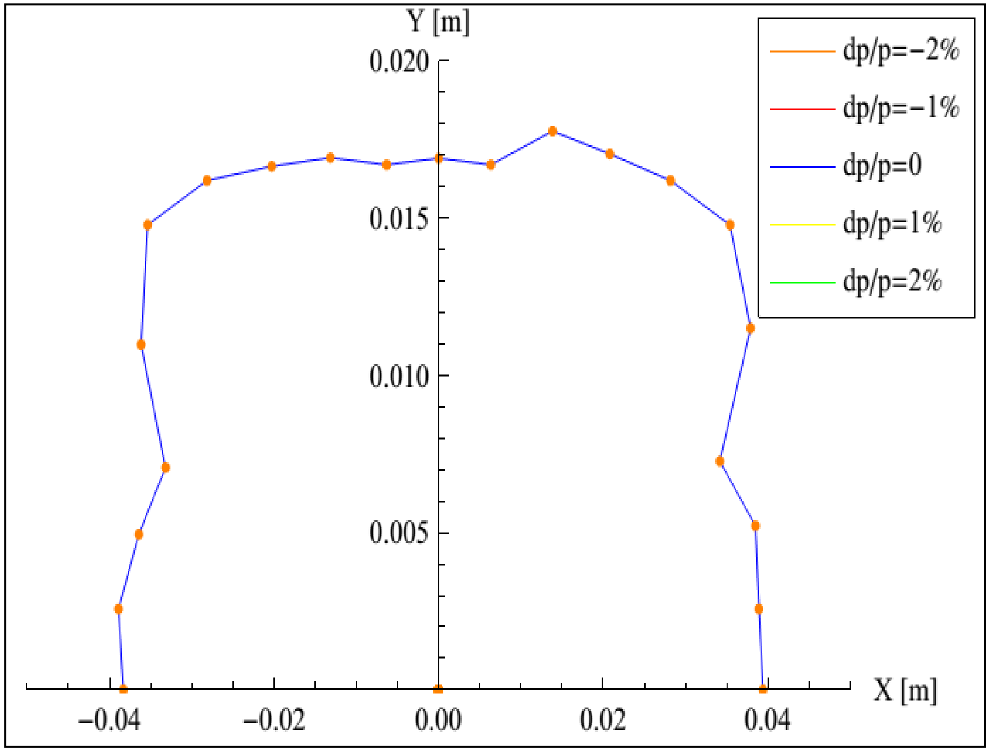
SAD

Dynamic Aperture dp/p=-0.01

X： 0.53mm
Y： 0.012mm



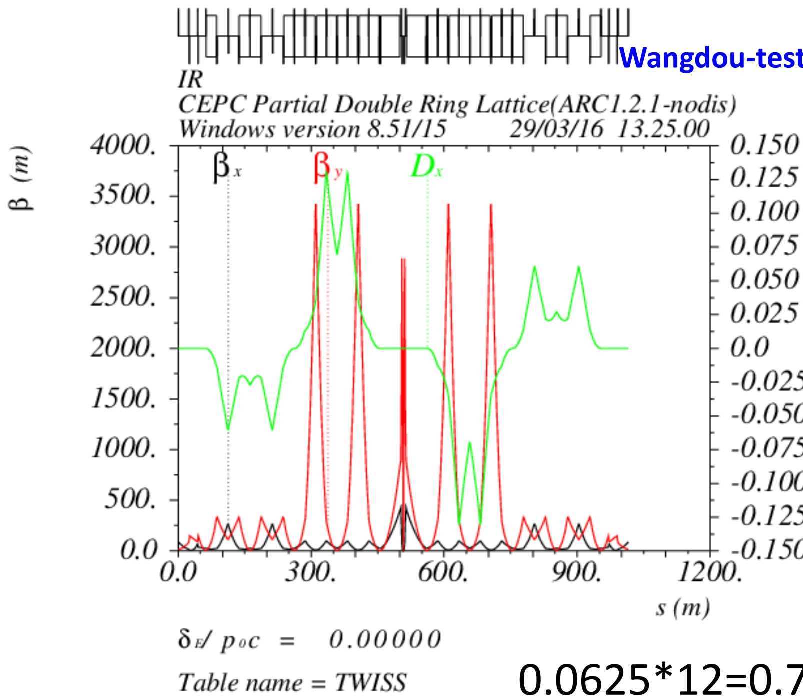
pylatt

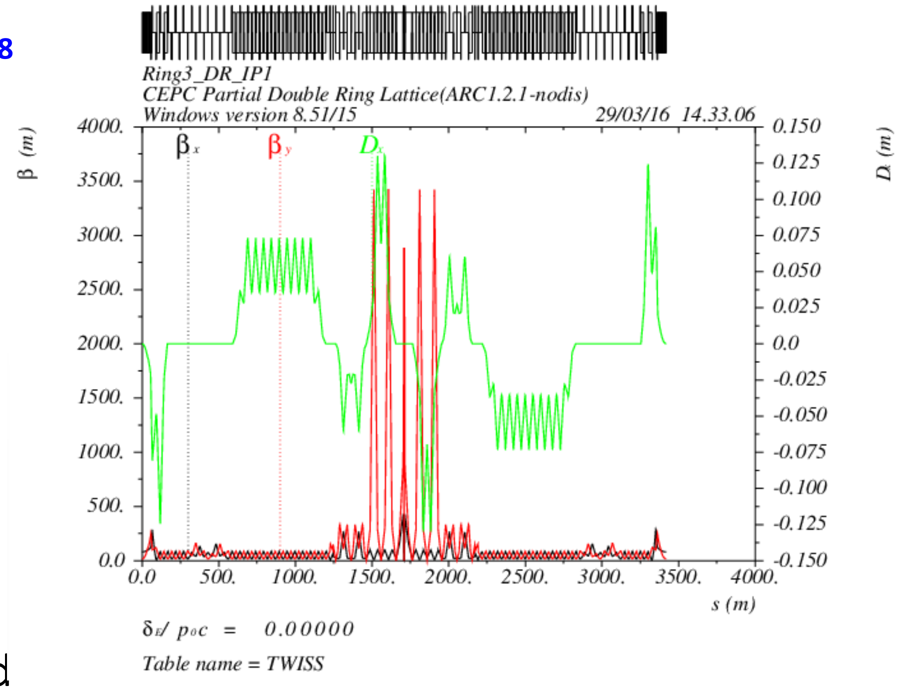


SAD

Orbit ARC1.2.1-PDR1.0.1-FFSa.1.1

Wangdou-test20160328



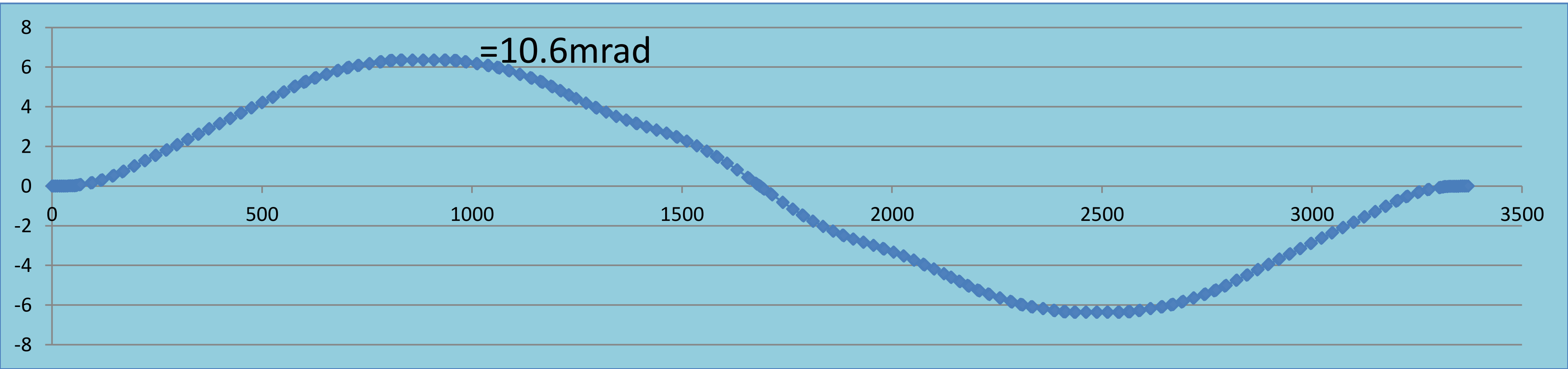


0.0625*12=0.75mrad

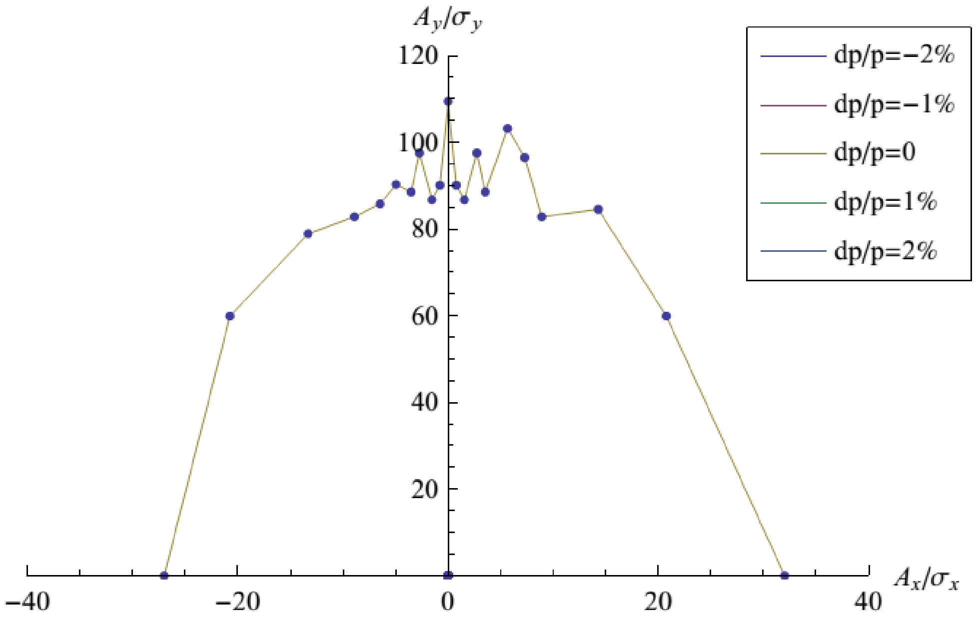
+4.25mrad+5.6mrad

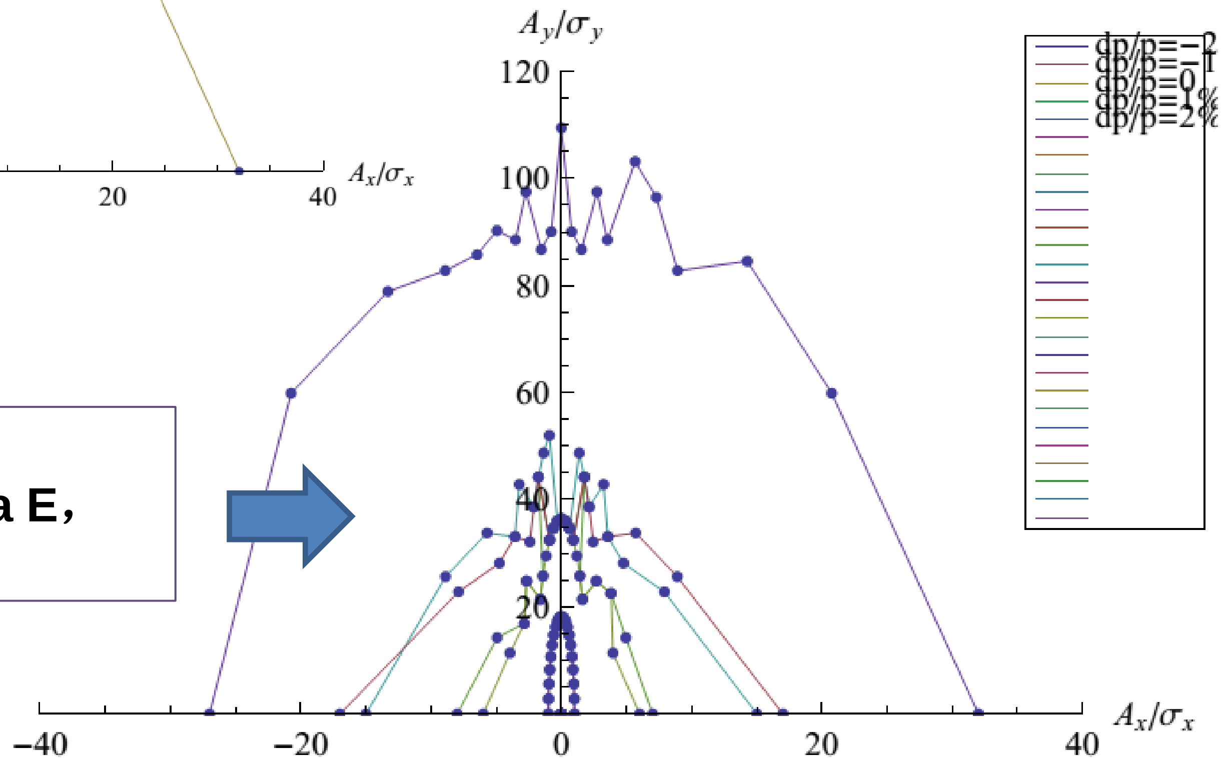
=10.6mrad

4.4+10.6=15mrad



DA with FFS (without optimization)





For details：
Energy spread > 3 sigma E，
DA is 0.

DA Study Strategy and Next Steps

1. Nonlinear driving term:

h_{abcde}， a+b+c+d+e=3， 1st order nonlinear driving term

a+b+c+d+e=4， 2nd order nonlinear driving term

1st order chromaticity: h11001, h00111

2nd order chromaticity: h11002, h00112

Tune with amplitude: h11110, h22000, h00220

……

Which term is more important and has strong contribute to dynamic aperture and need more constraints？（now 0< h11002 and h00112 real part <4000）

2.Population & Generation ?

If each generation has enough population, it will easy to choose the so called well solution for our objective. And the next generation will keep half population from the parent generation and produce half new population. This two parts make up the new generation. Now use 500 population and 100 generation. Is it larger enough to find good solution? Maybe need larger population and generation, like 4000 population and 50 generation.

DA Study Strategy and Next Steps

3. Tune footprint, Tune space, Working point choice:

Now the working point is (0.08, 0.22), the second order chromaticity is about -3300 and -3900, it will quickly to the resonance line. We need to plot FMA analyses the tune footprint, choose a space to fit in. We should consider whether the work point is good. Maybe the injection work point can be another choose for large enough DA, and after injection, we rump the work point to (0.08, 0.22) for the high luminosity requirement.

4.Energy acceptance：

2% energy acceptance from Touschek lifetime. The dynamic aperture for 2% energy spread is very small. Is it the limit from FODO structure? The energy spread for FODO lattice need to be study.

DA Study Strategy and Next Steps

5. Error tolerance:

The error tolerance for the magnets in the lattice needs to be considered. This will influence the DA obviously. We need a good DA include the error.

6. Thin lens & thick lens:

Now the calculation is treating the elements as thin lens. If the real elements have real length, it need to integrate the whole length. How will the difference be?

7. 90 72 60 degree FODO cell compare and choose:

We need to compare the FODO cell with different phase advance to choose the better design for DA.

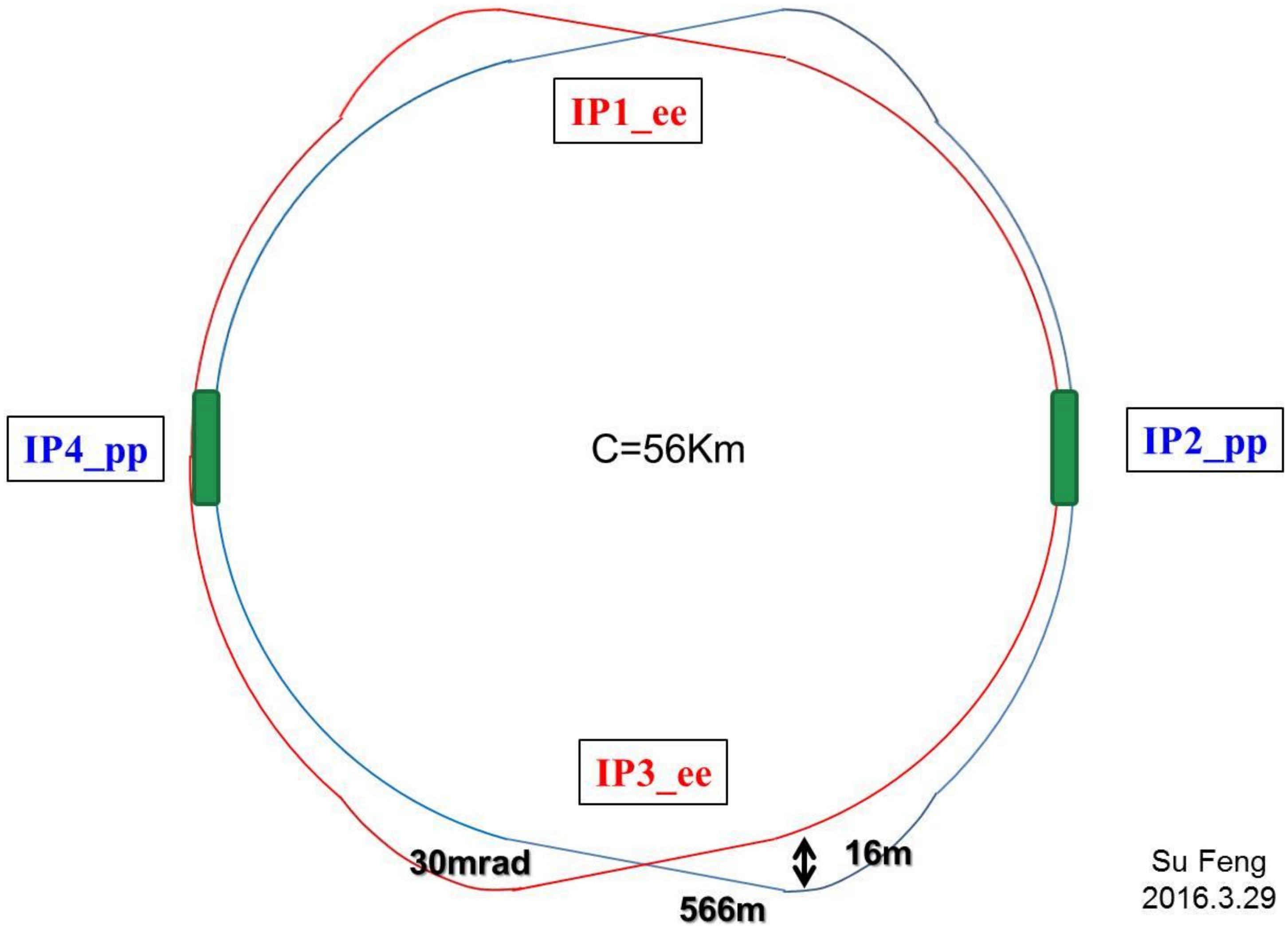
8. How to divided the sextupoles groups?

How many group should the sextupoles to be divided? This needs to try.

9. Converge of sext:

At the end of optimization and calculation, the strength of sextupoles will be converging to a set of invariable values. This can be an aspect to judge whether the solution is good enough.

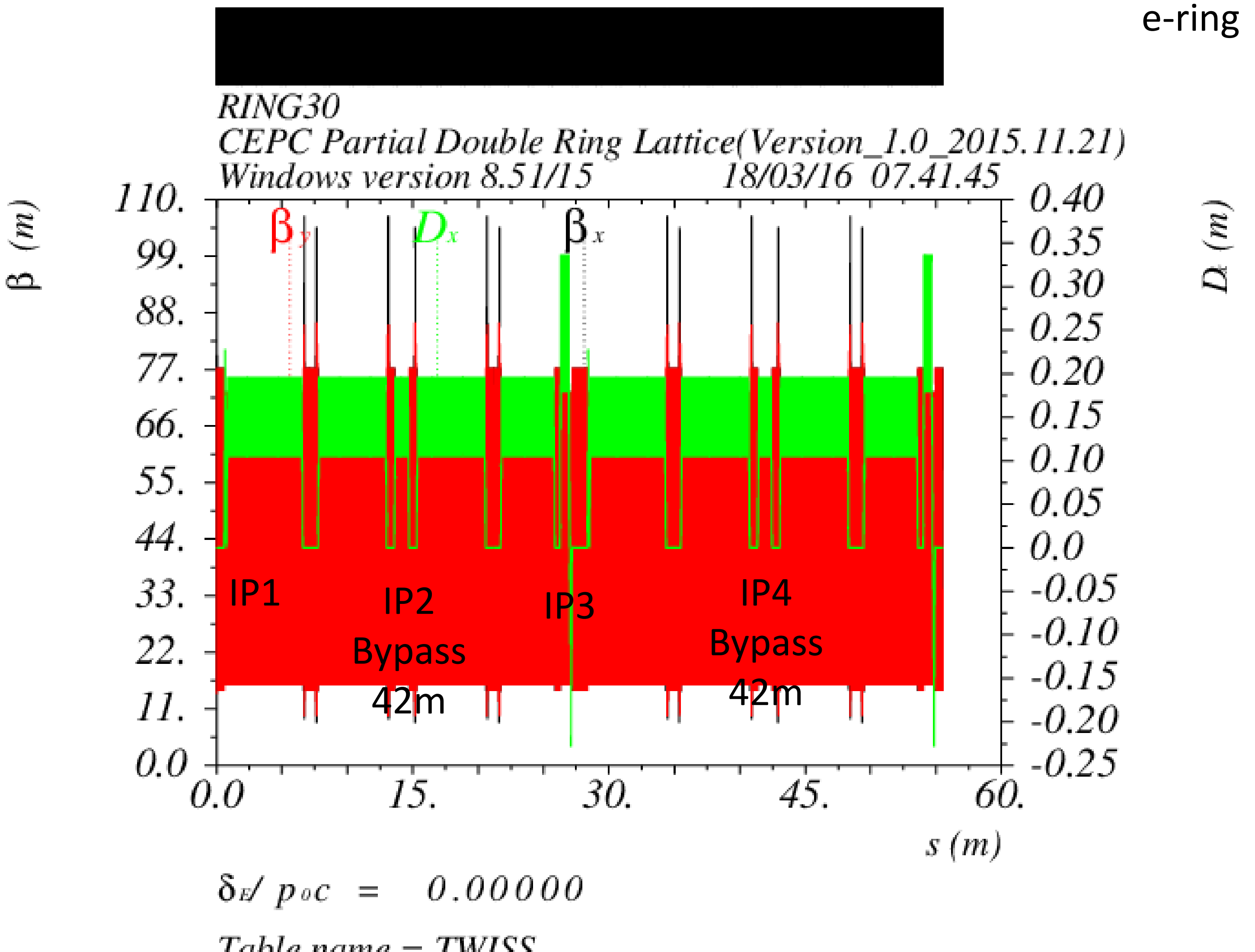
CEPC Double Ring Scheme Layout



Su Feng
2016.3.29

Double Ring Scheme

e-ring



Summary

- The first version of CEPC Partial Double Ring Lattice was designed (Version 1.0). The whole length of CEPC PDR is 3281.27m, full crossing angle is 26mrad, maximum distance between two ring is 14.913m.
- The Dynamic Aperture need to be optimized. Now the DA of CEPC with PDR and Bypass(at IP2/4) and without FFS is better than before, but the DA with FFS is not good enough.
- We may divide the sextupoles into more families to optimize the DA.
- The linear lattice of PDR may also be optimized.

Acknowledge

- Gang Xu, Qing Qin, Yuan Zhang, Yuemei Peng, Qingjin Xu, Yukai Chen, Xiaohao Cui, Zhe Duan, Yudong Liu, ……
- Thanks for your kind help and beneficial discussion!

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Thank You !

Reference

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[5]Oridy, FCC-ee_150917

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