SPPC Lattice Design

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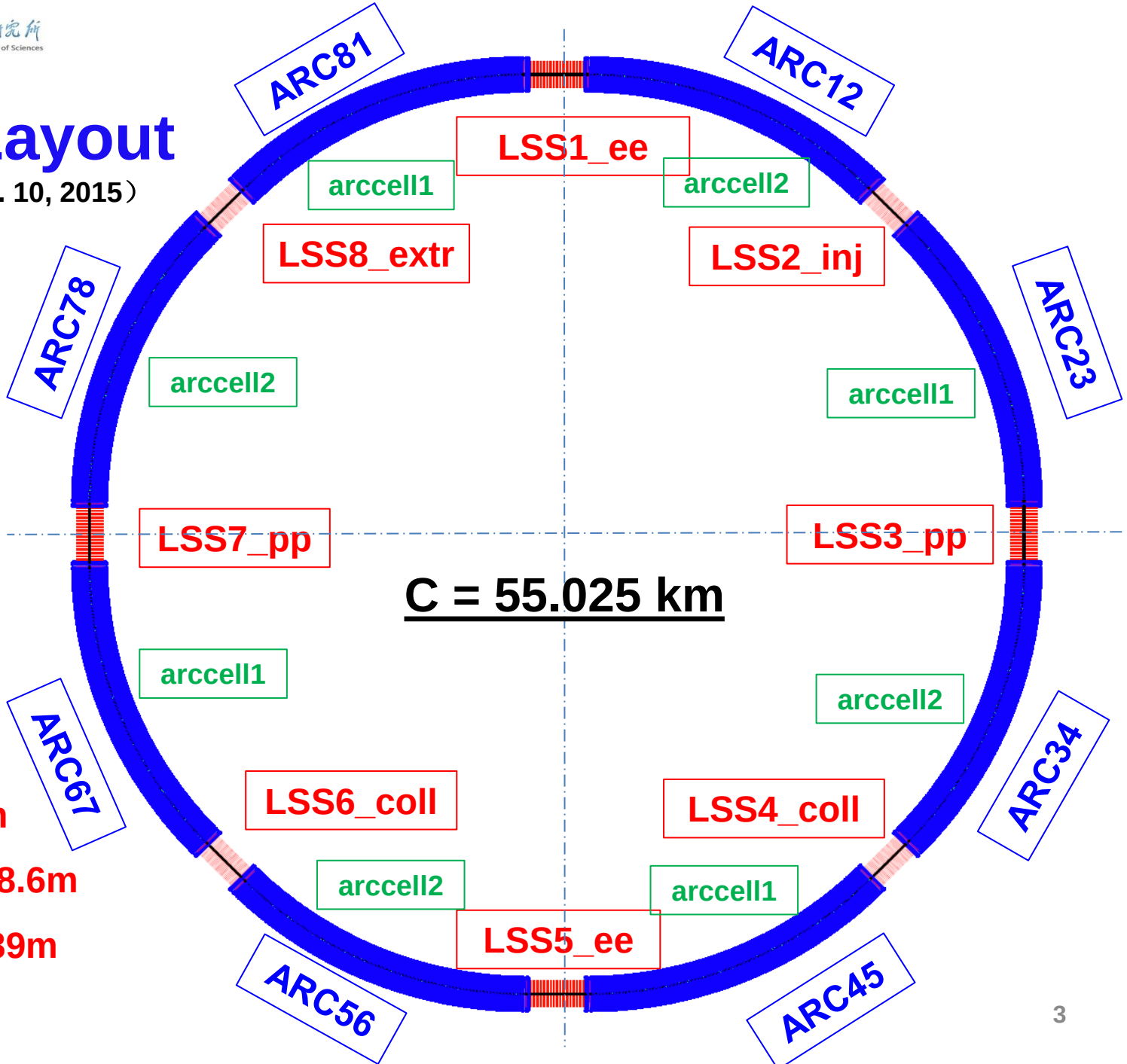
Outline

1. SPPC Lattice Layout
2. ARC FODO Cell
3. Dispersion Suppressor Section
4. Long Straight Section
5. IR
6. Summary

SPPC Layout

（Su Feng, Jul. 10, 2015）



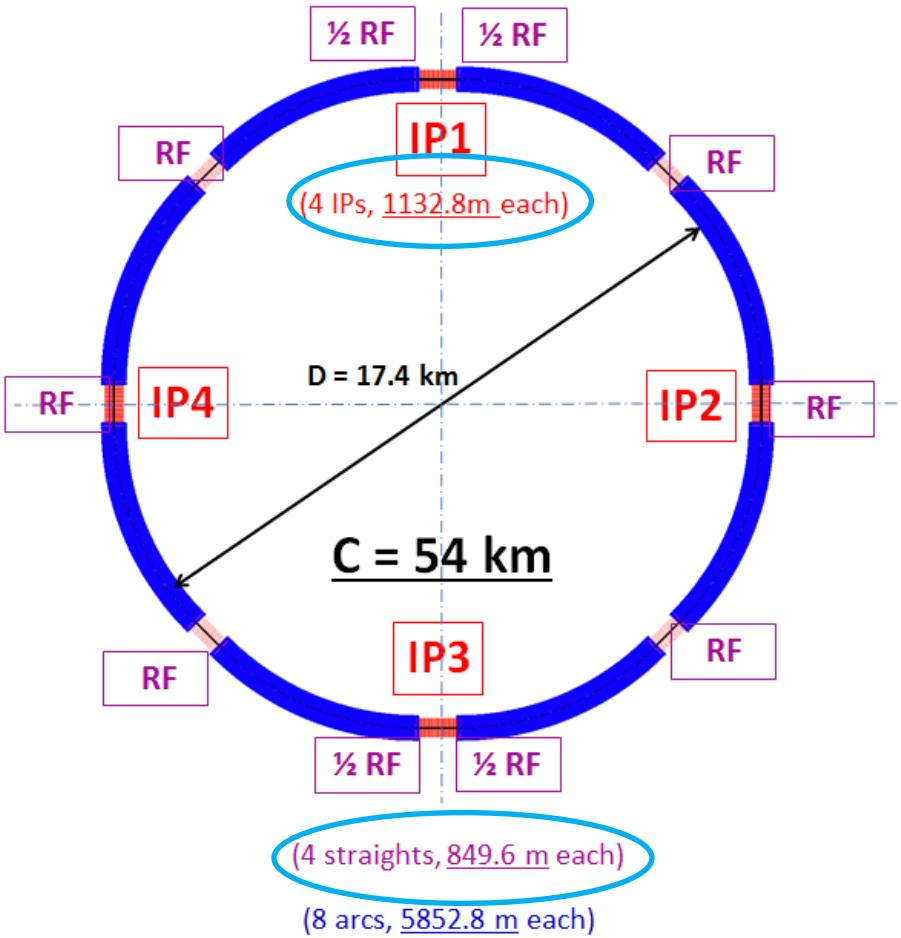
LSS1/5 : 1083m

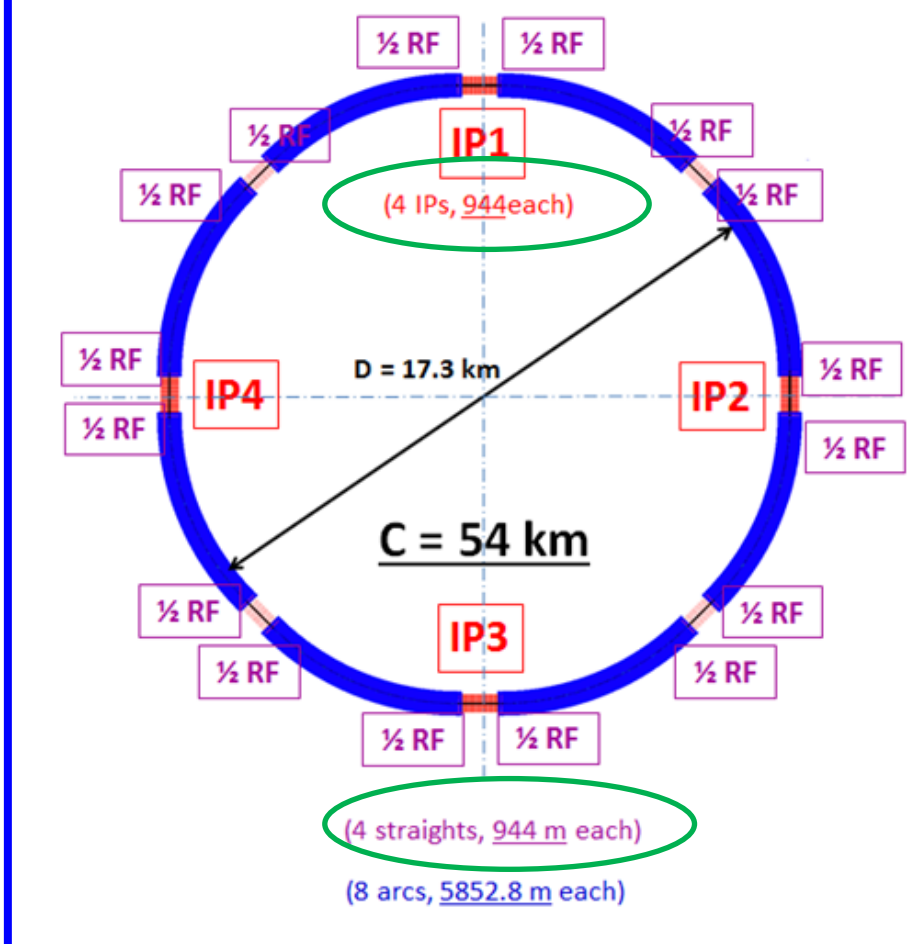
LSS2/4/6/8 : 938.6m

LSS3/7 : 1070.89m

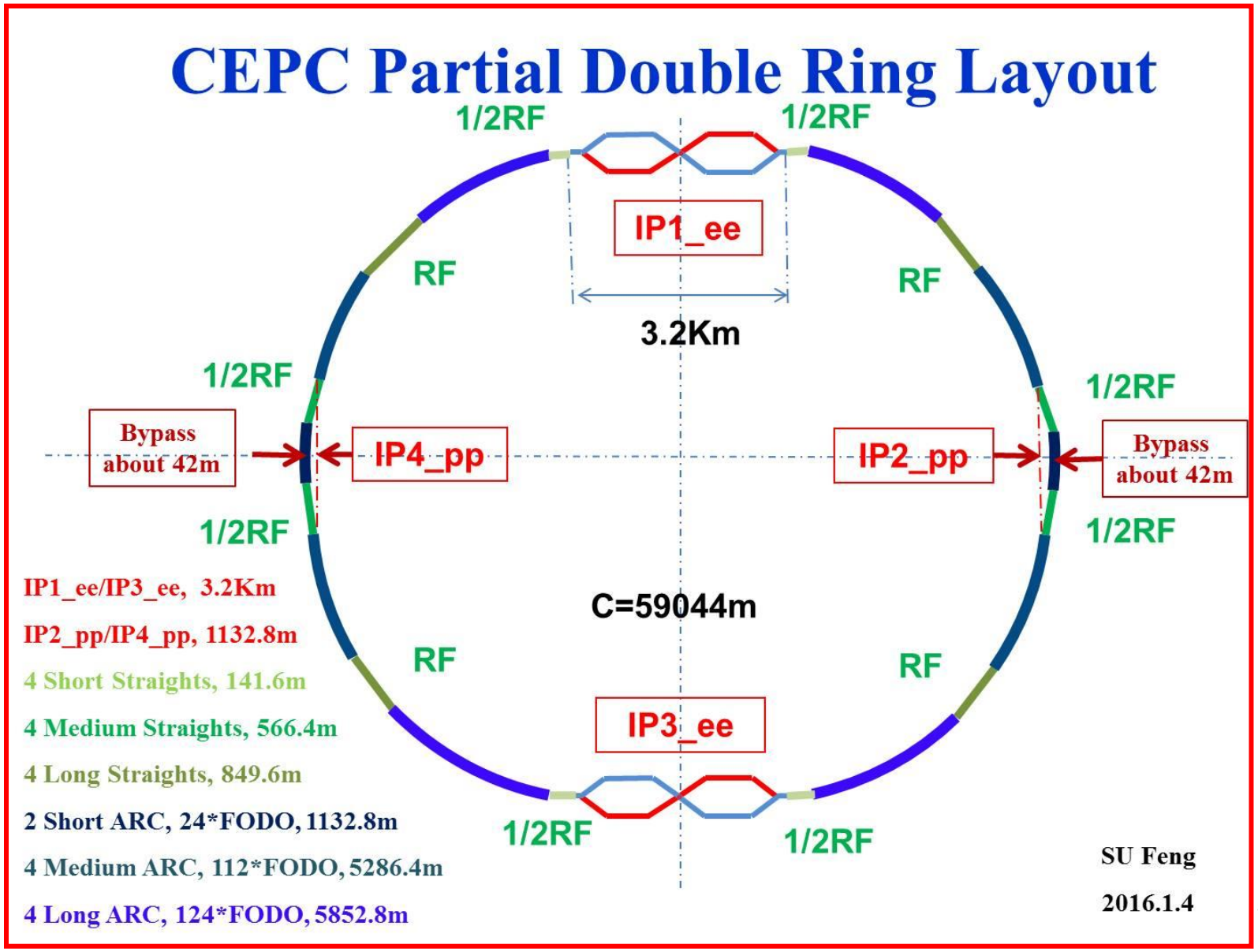
ARC 5920.4m

Layout of two CEPC lattices

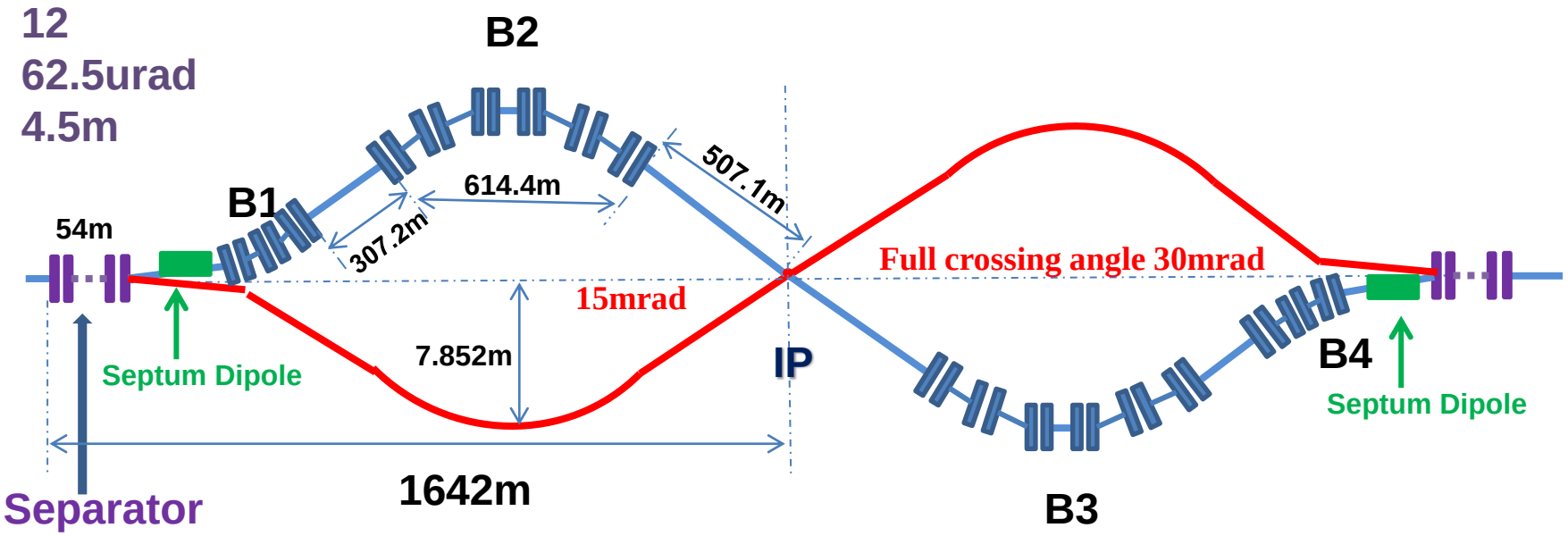


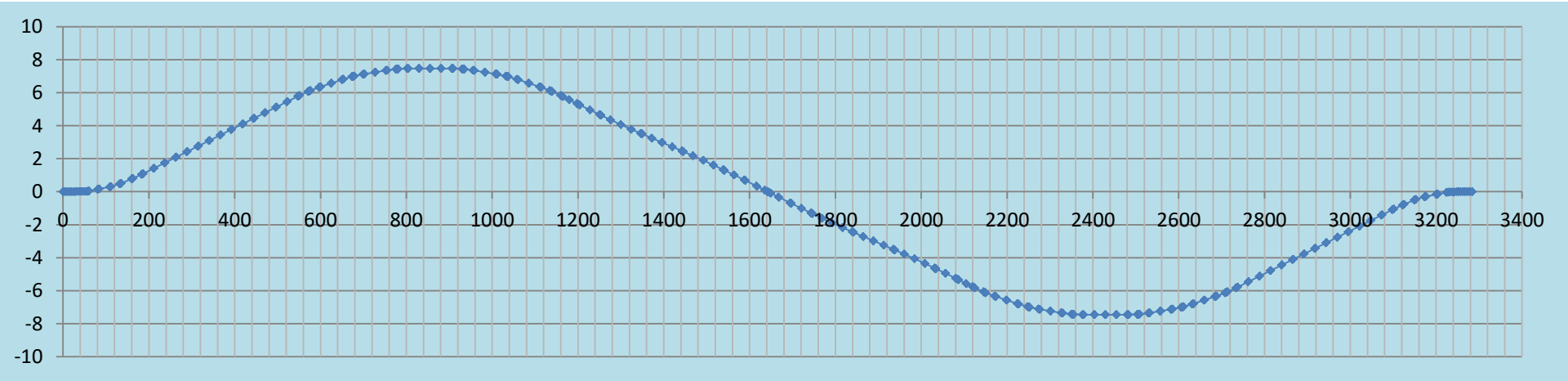


Consideration of CEPC New Layout with PDR



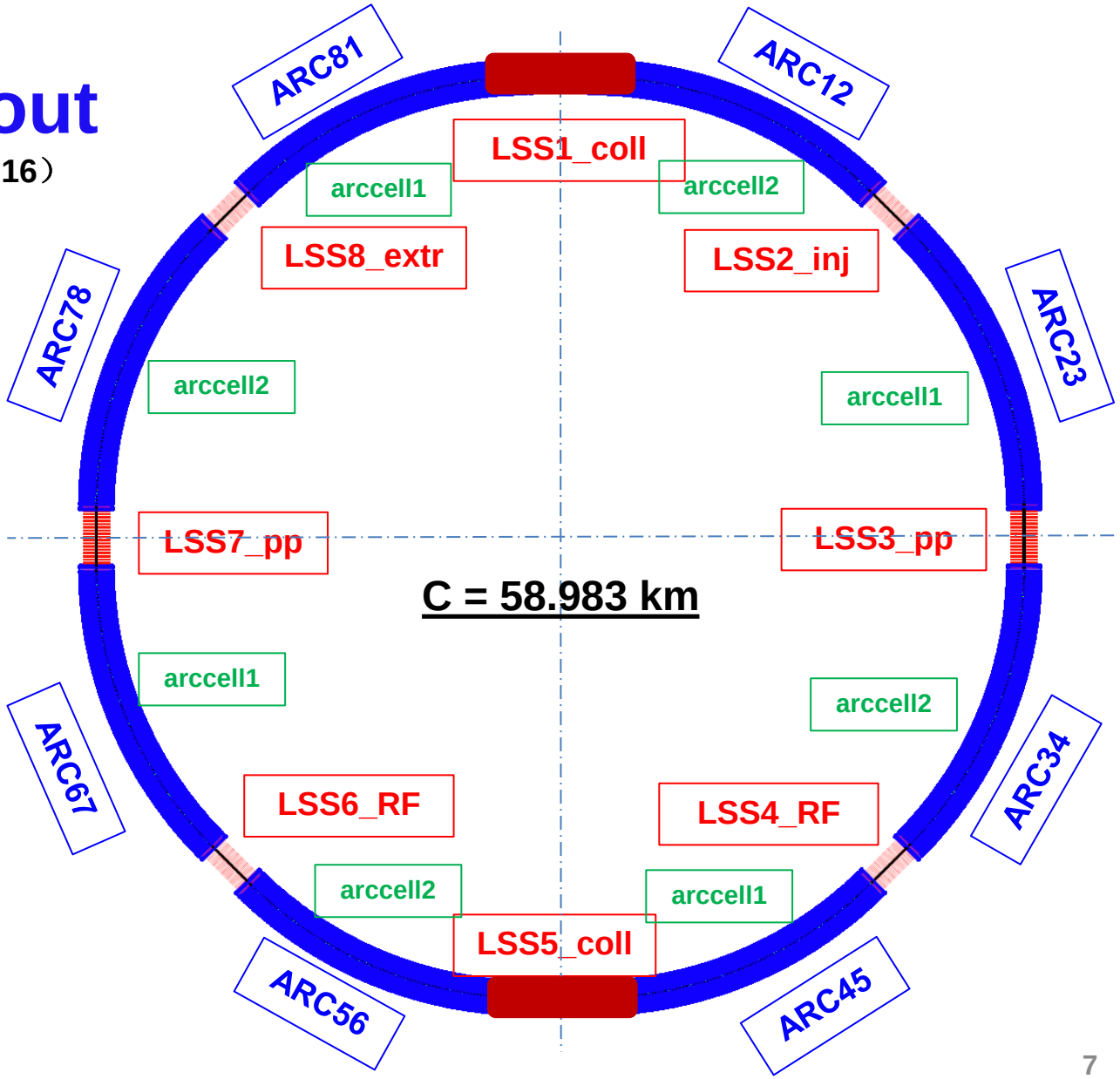
CEPC Partial Double Ring Layout





SPPC Layout

（Su Feng Jan. 10, 2016）



LSS1/5_coll ： 3.2Km

LSS2/4/6/8： 788.31m

LSS3/7_pp: 973.83m

ARC: 5963.2m

Parameter Estimate for ARC CELL

C = 58 Km

LSS = 12 Km

L_{ARC} = 58 – 12 = 46 Km

arc filling factor = 0.8

L_{Dipole} = 46 * 0.8 = 36.8 Km

$$\rho = \frac{L_{Dipole}}{2\pi} = 5856.9\ \text{Km}$$

L_B = 14 – 15 m

$$n_B = \frac{L_{Dipole}}{L_B} = 2453.3 - 2628.57$$

E0 = 35 TeV

$$\gamma = \frac{35\ \text{TeV}}{938\ \text{MeV}} = 37\,313.4$$

β = 1

$B\rho = 3.1267\ \beta\gamma = 116\,635.29$ Tm

$$B = \frac{116\,635.29}{5856.9} = 19.92\ \text{T}$$

High Field Dipole in Pre-CDR：20T，15m

$$\frac{2453.3}{256} = 9.58 < n < \frac{2628.57}{256} = 10.265$$

n = 10

n_B = 2560

$$\theta = \frac{2\pi}{2560} = 0.002454369$$

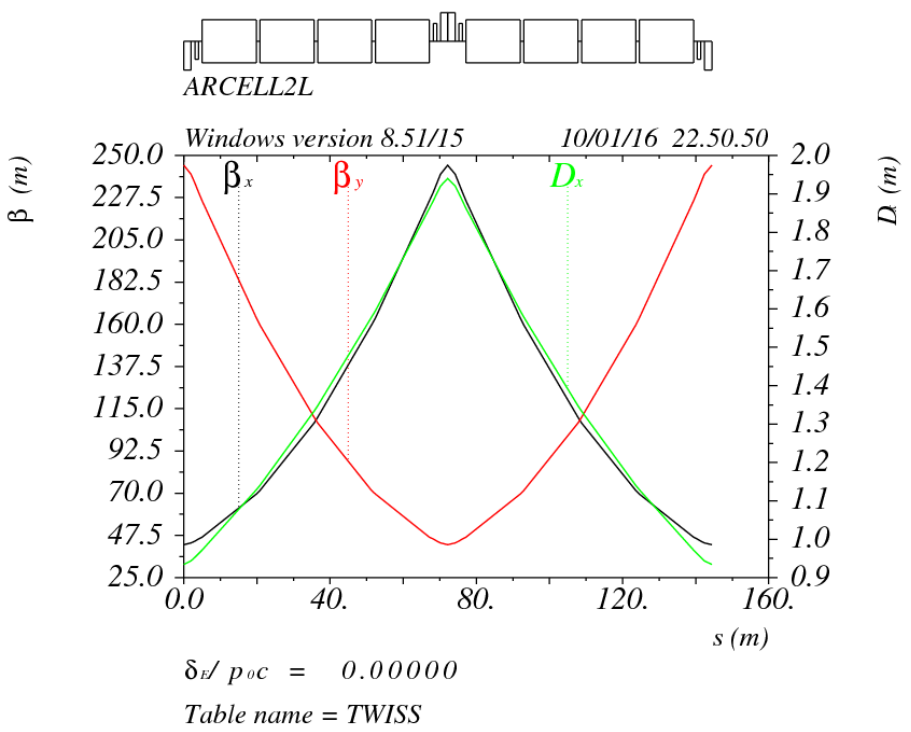
$L_B = \rho\theta$ = 14.375 m

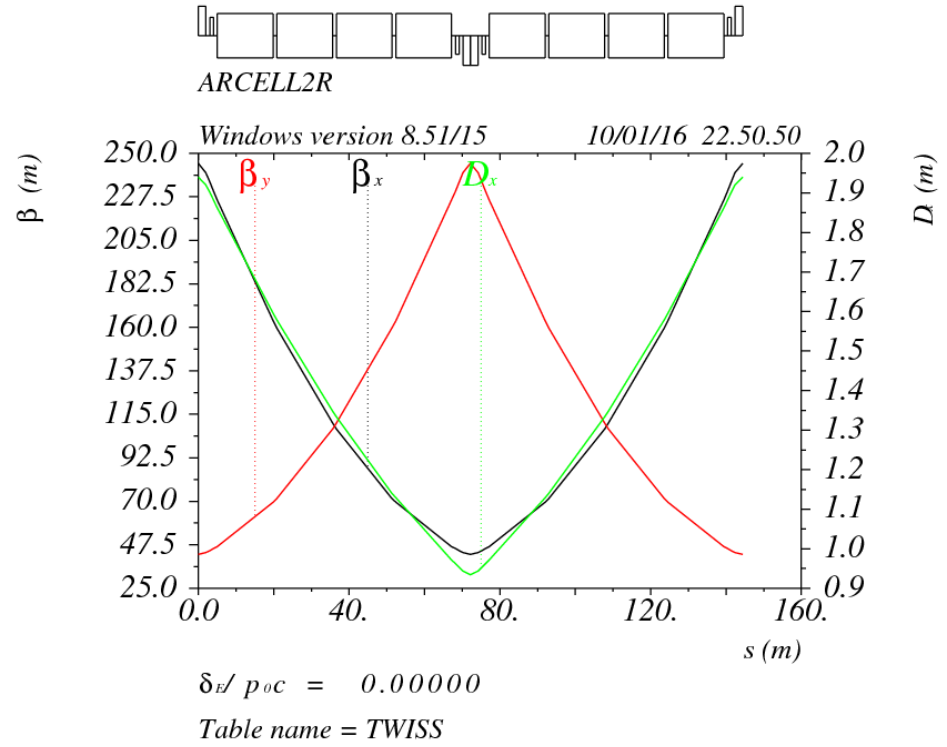
$$L_{cell} = \frac{8 * L_B}{0.8} = 143.75\ \text{m}$$

$$\beta^{\pm} = \frac{\text{Lcell} * \left(1 \pm \text{Sin}[\frac{\mu}{2}]\right)}{\text{Sin}[\mu]} \qquad \alpha^{\pm} = \frac{\mp 1. - \text{Sin}[\frac{\mu}{2}]}{\text{Cos}[\frac{\mu}{2}]}$$

$$D^{\pm} = \frac{\text{Lcell} * \psi * \left(1 \pm 0.5 * \text{Sin}[\frac{\mu}{2}]\right)}{4 * \text{Sin}[\frac{\mu}{2}]^2}$$

FODO CELL in ARC





arccell1

L=144.4m

arccell2

Betax: 244.878/42.57
Betay: 42.569/244.869

ARC CELL

	LQ	DQS	LS	DSB	LB	DBB
SPPC	4m	1m	0.5m	1m	14.375m	1m
FCC-hh	6.3137m	1m	0.5m	2.184m	14.3m	1.36m

B max [T]	G max [T/m]	k1	k2
19.86	582.156	4.9899E-3	0

Pre-CDR：

Dipole: L=15m B=20T

Quadrupole:

D = 45 mm B_{pole}**=16 T**

G=711.1T/m K1=6.097*10^-3

Betax: 244.878/42.57
Betay: 42.569/244.869

(ϵ_n **=4.1um)**

$$\epsilon = \frac{\epsilon_n}{\gamma}$$

E (Collision：35TeV)
(Injection：2.1TeV)

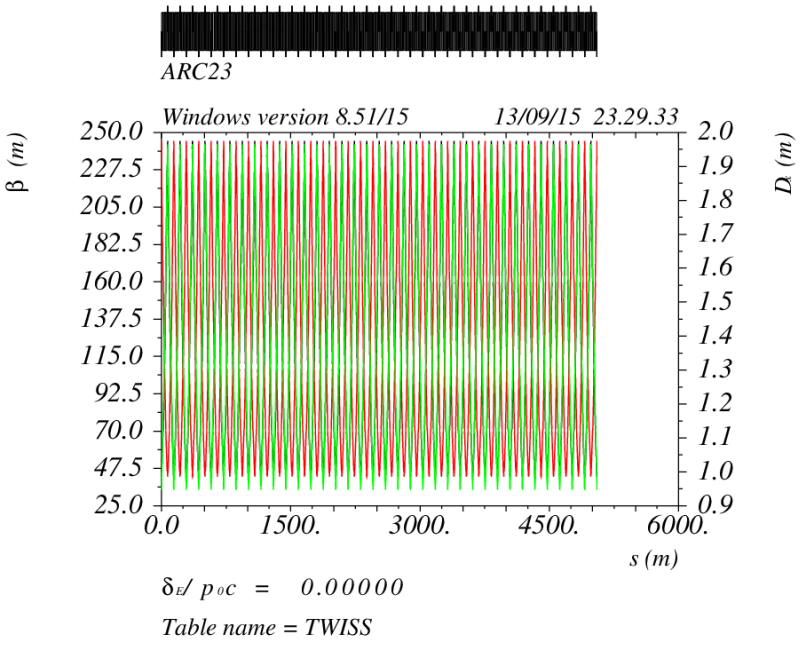
ϵ **(Collision：1.099*10^-10m=0.1099nm)**
（ Injection： 1.83*10^-9m=1.83nm）

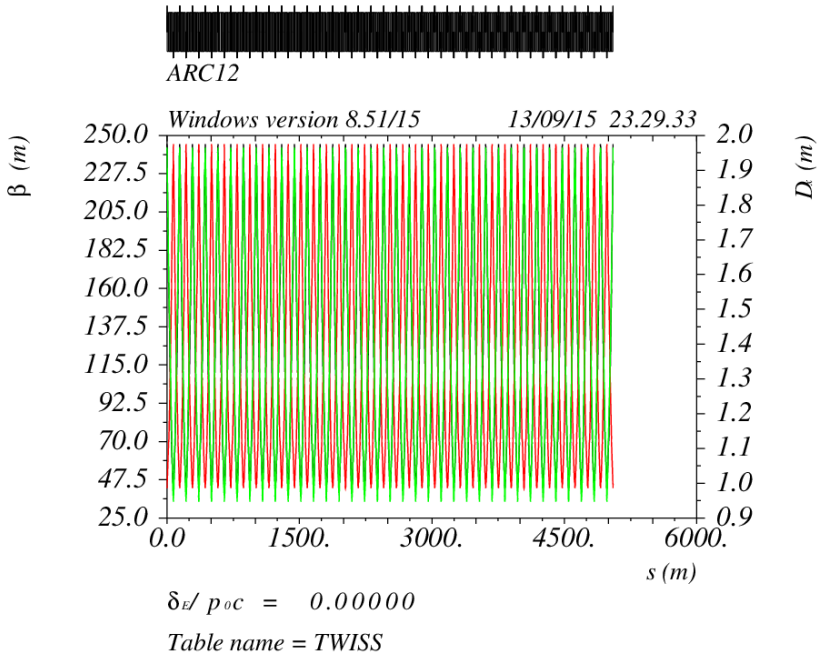
σ（Collision：1.66*10^-4m=166um）
（ Injection： 6.76*10^-4m=676um）

R=20*σ$_{Inj}$**=13.52mm**

D=27.04

ARC （ARCDSPL,36 CELL, ARCDSPR）



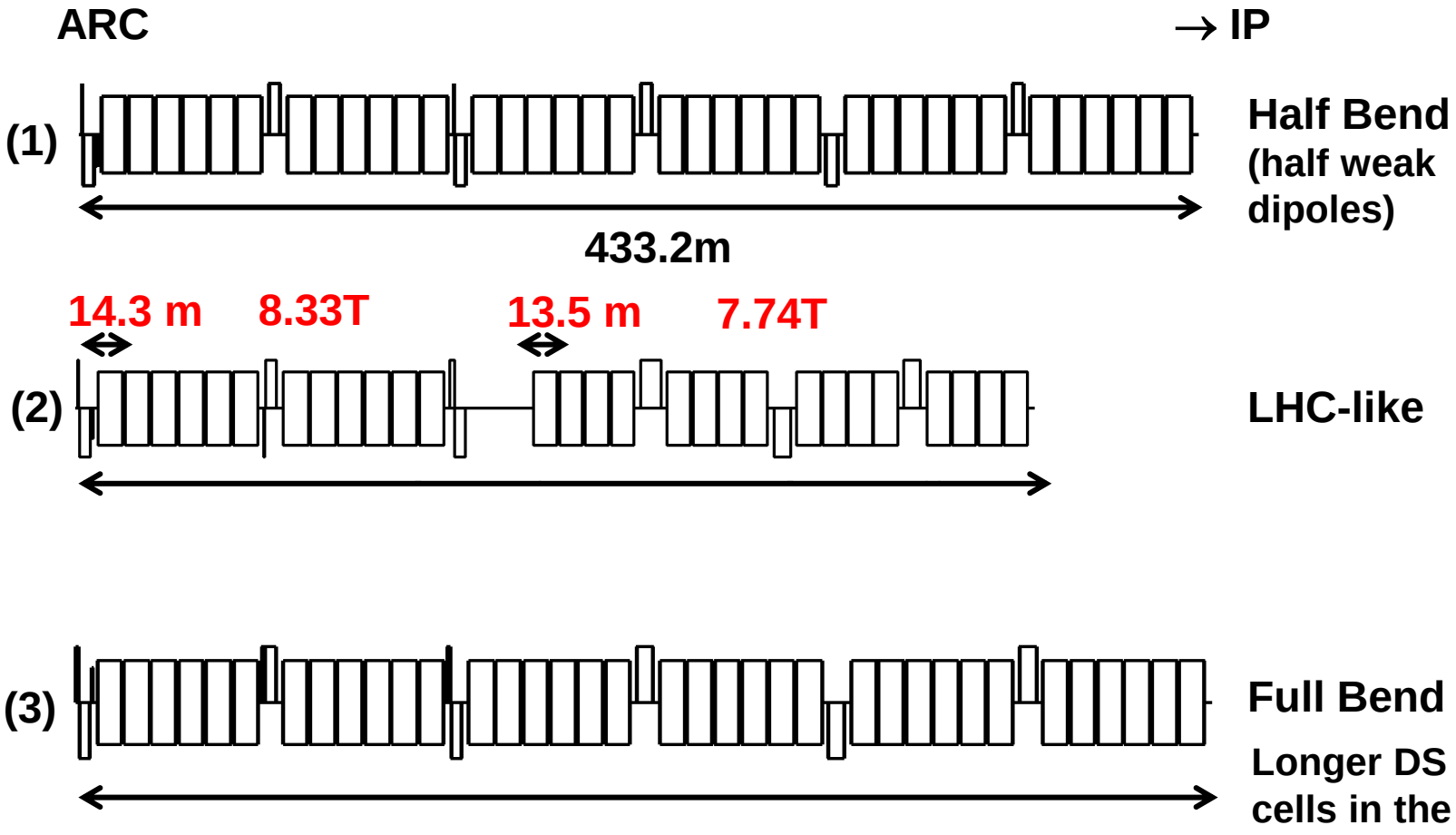


ARC23
ARC45
ARC67
ARC81

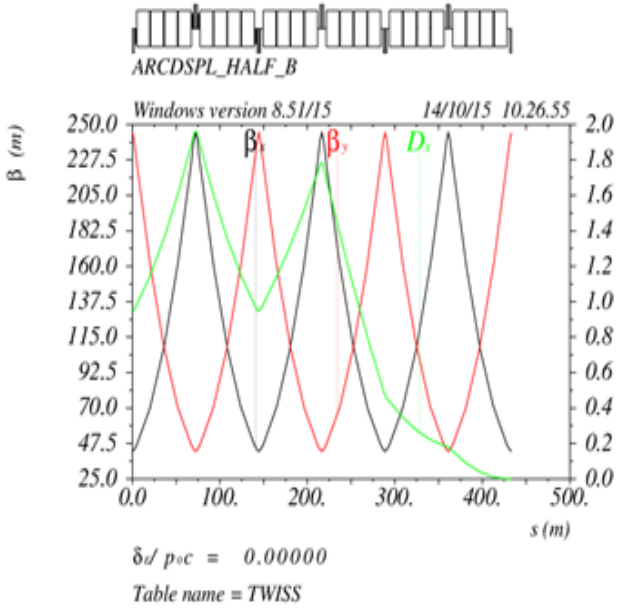
L=5963.2m

ARC12
ARC34
ARC56
ARC78

Dispersion Suppressor (DS) types

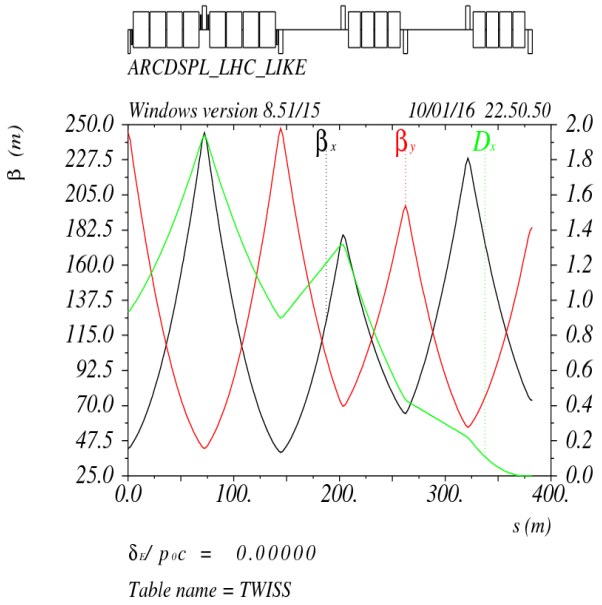


(1) Half Bend



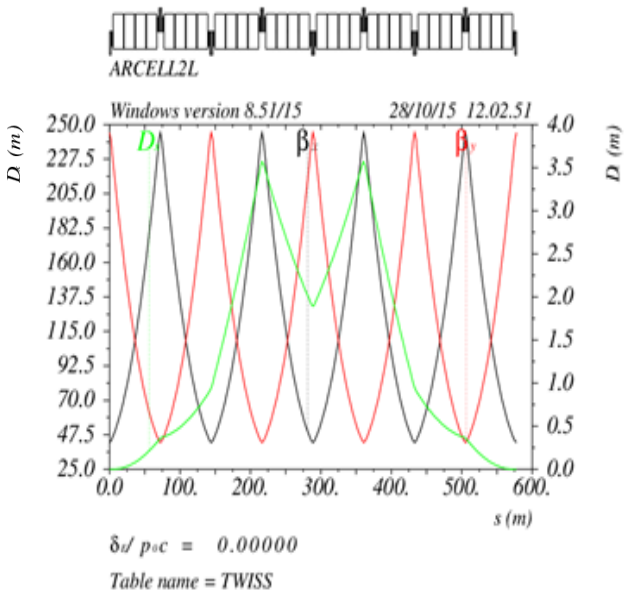
L=433.2m

(2) LHC Like



L=382.4m

(3) Full Bend

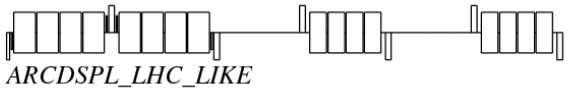


L=577.6m

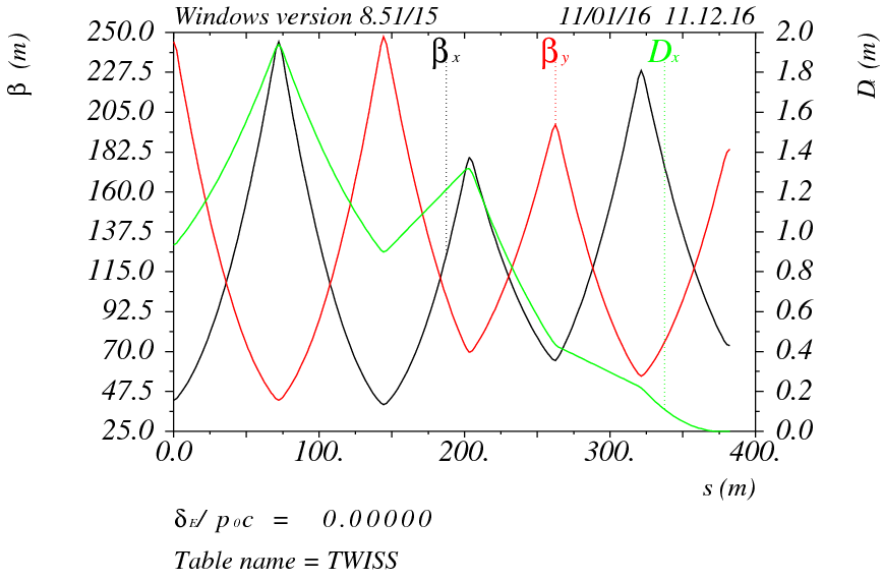
	BDSP1L	BDSP2L	BDSP1R	BDSP2R	B0	
(1)	9.93	9.93	9.93	9.93	19.86	(T)
(2)	18.93	18.93	18.93	18.93	19.86	(T)
(3)	19.86	19.86	19.86	19.86	19.86	(T)

Dispersion Suppressor (DS)

BDSP1L BDSP2L



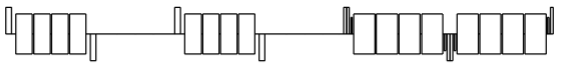
ARCDSPL_LHC_LIKE



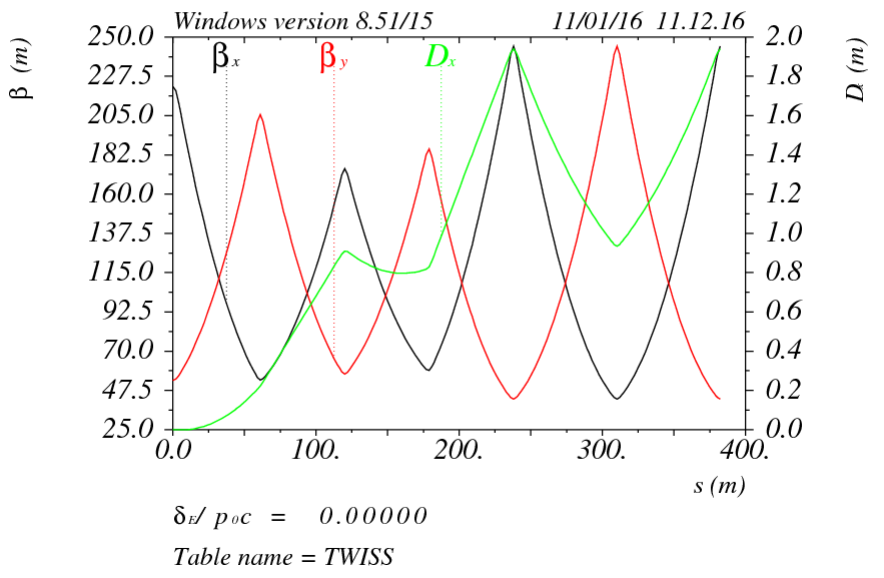
$\delta_E / p_0 c = 0.00000$

Table name = TWISS

BDSP2R BDSP1R



ARCDSPR_LHC_LIKE



$\delta_E / p_0 c = 0.00000$

Table name = TWISS

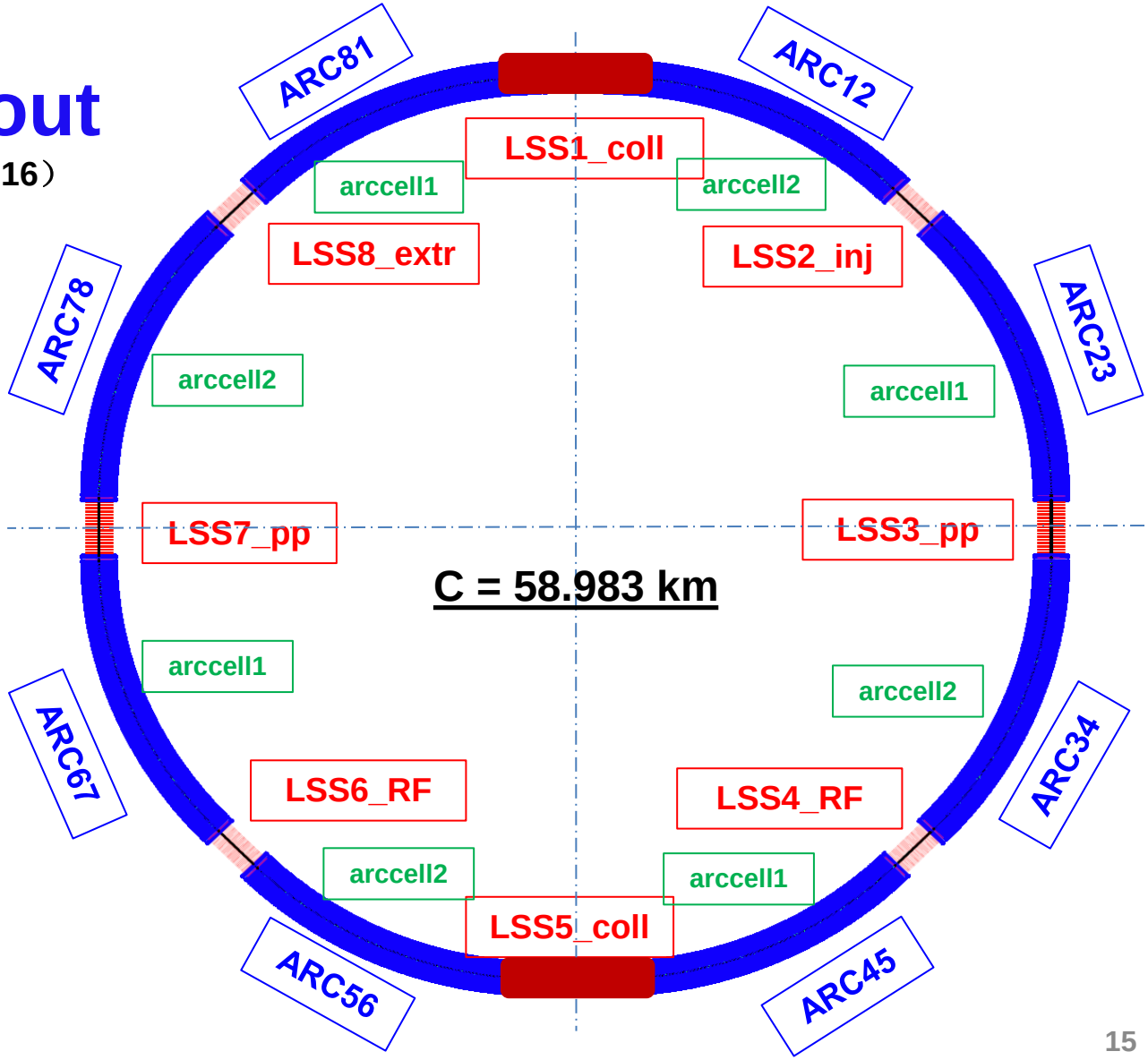
382.4m

	BDSP1L	BDSP2L	BDSP1R	BDSP2R	B0	
B	18.93	18.93	18.93	18.93	19.86	T
L	11.5	11.5	11.5	11.5	14.8	m

Long Straight Section

SPPC Layout

（Su Feng Jan. 10, 2016）



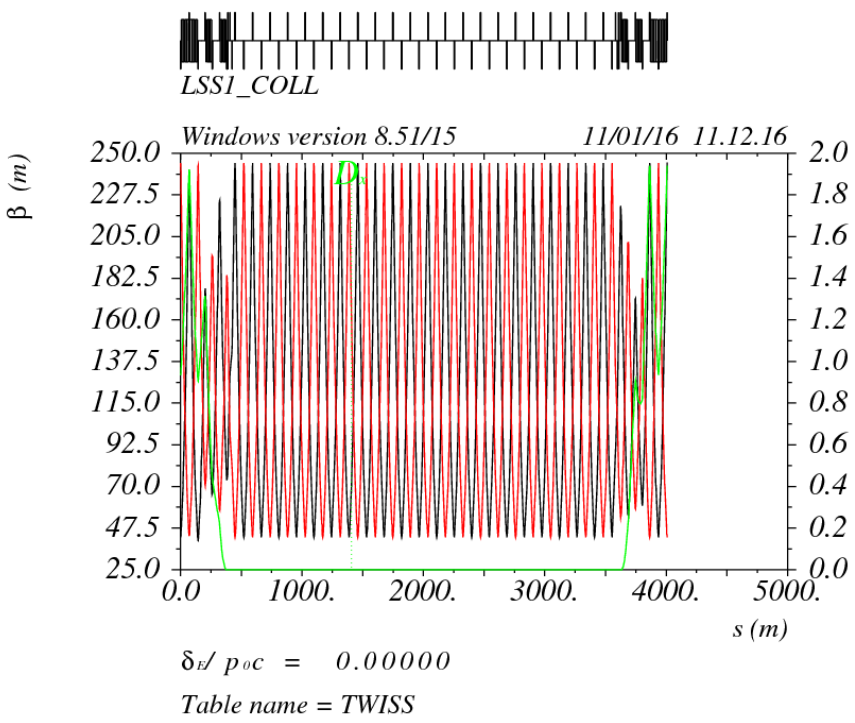
LSS1/5_coll ： 3.2Km

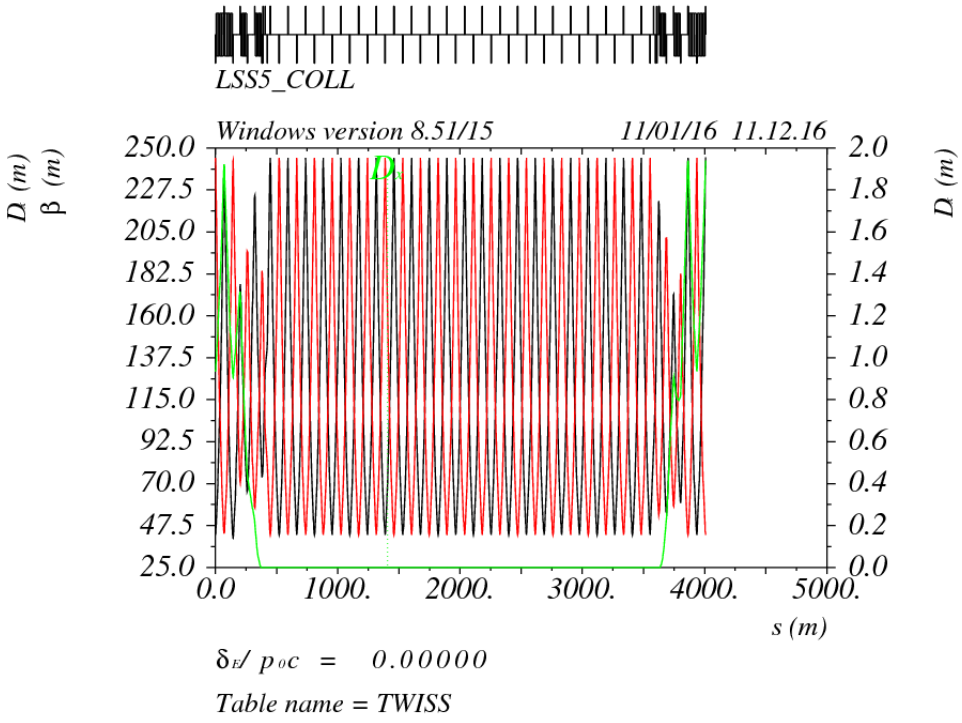
LSS2/4/6/8： 788.31m

LSS3/7_pp: 973.83m

ARC: 5963.2m

LSS1/5_coll



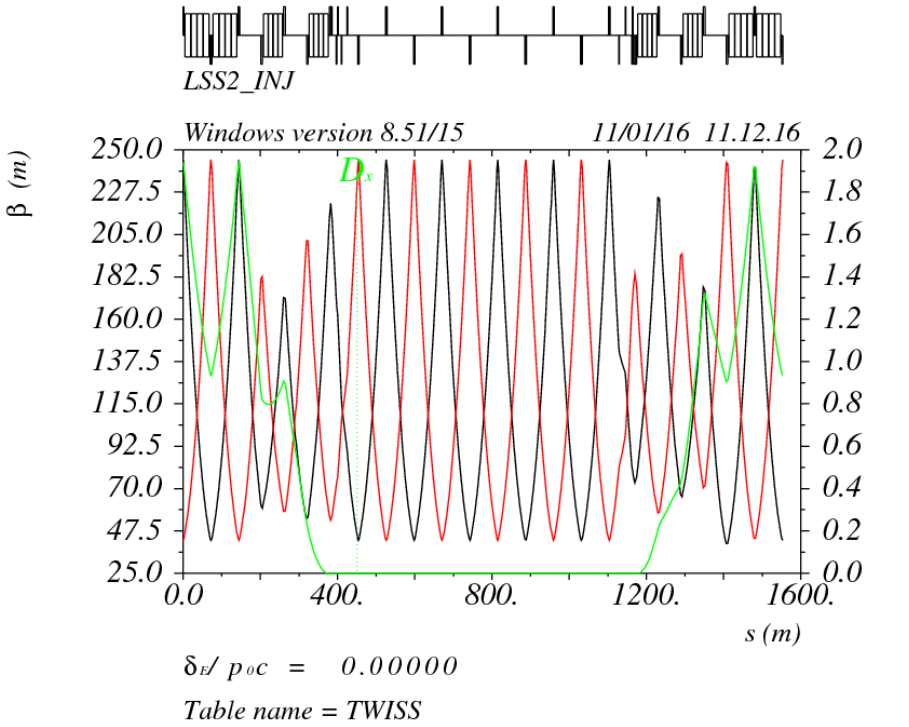


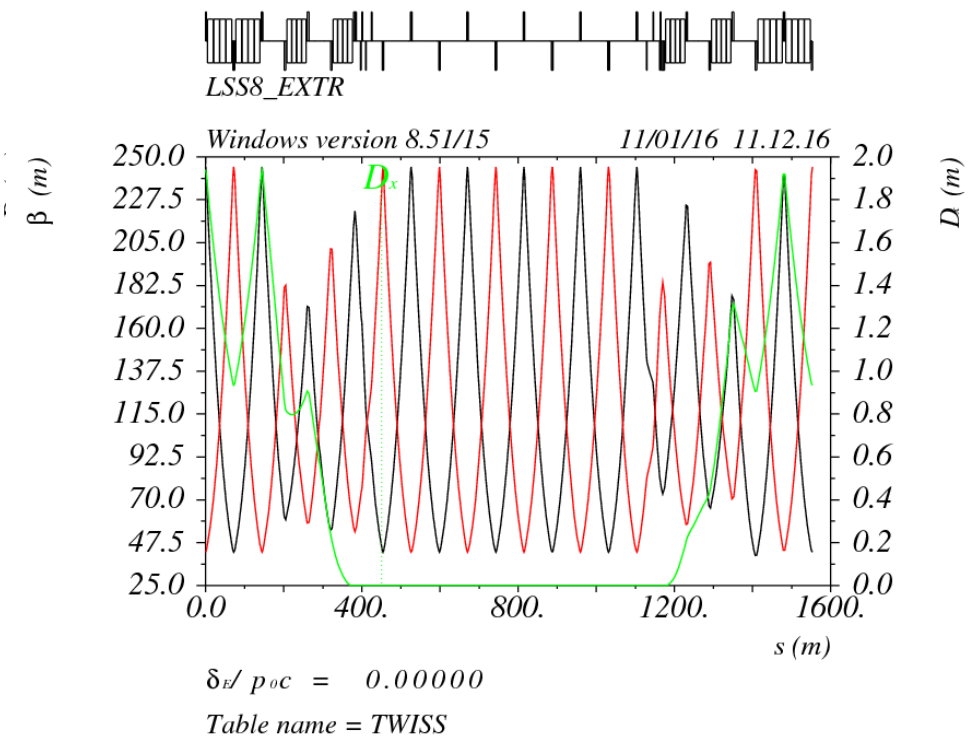
L=3243.106m

ARCDSPL, ARC_to_STR, 21.5*STRCELL, STR_to_ARC, ARCDSPR

382.4m, 71.719m, 3104.6m, 66.789m, 382.4m

LSS2_inj/LSS8_extr



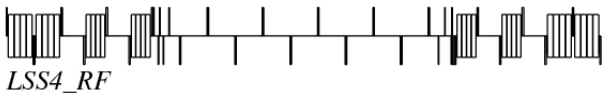


L=788.306m

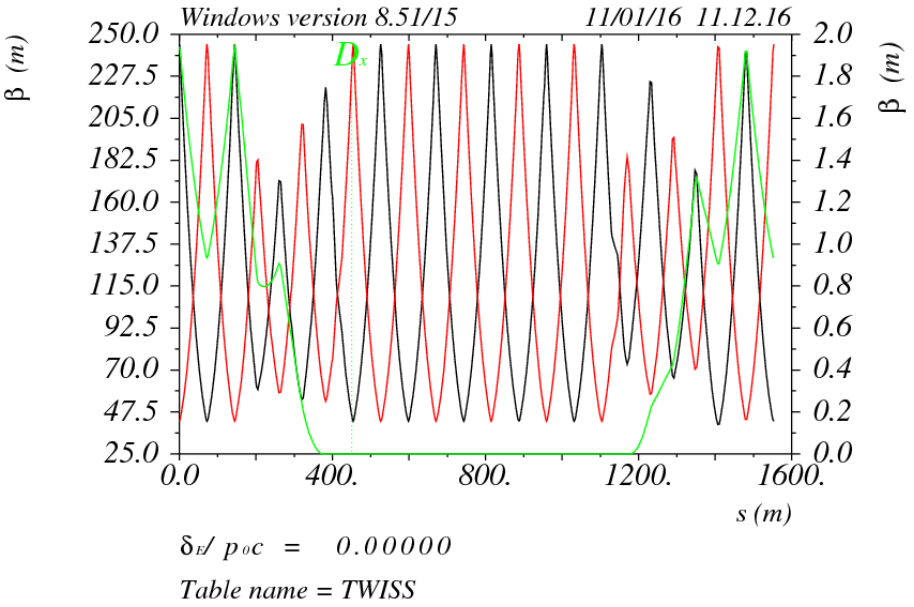
-ARCDSPR, ARC_to_STR, 4.5*STRCELL, STR_to_ARC, -ARCDSPL

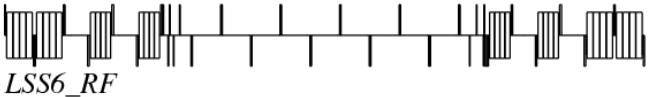
382.4m, 71.719m, 649.8m, 66.787m, 382.4m

LSS4/6_rf

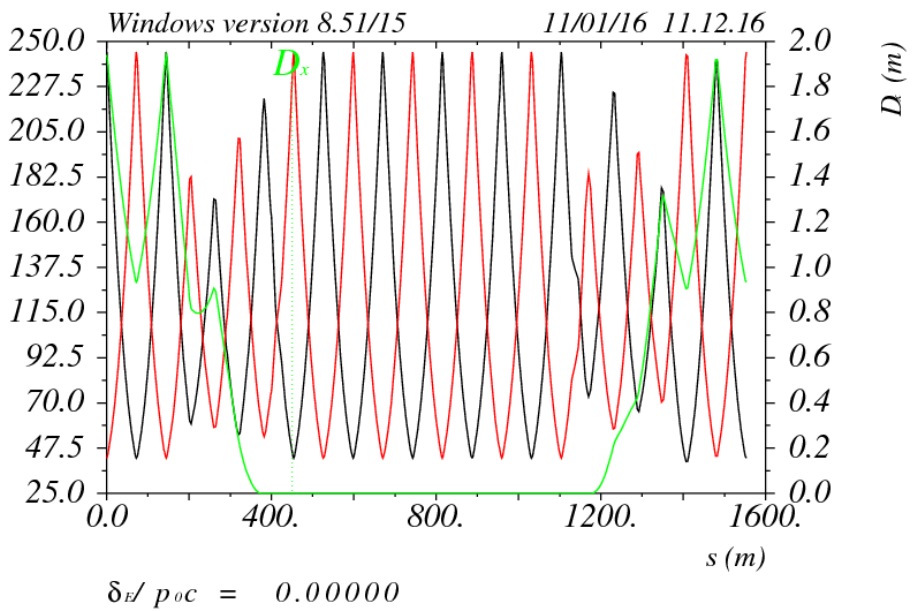


LSS4_RF





LSS6_RF

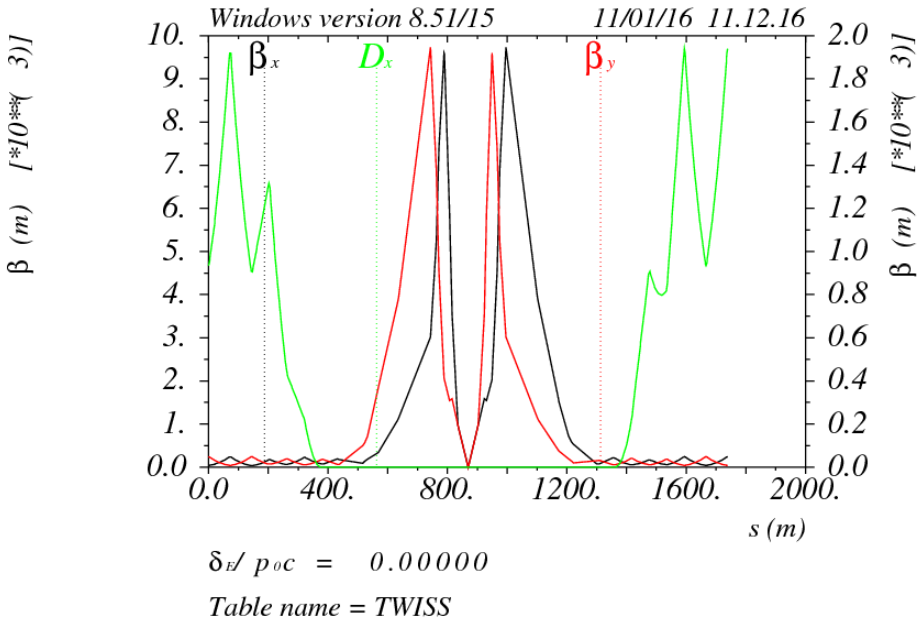


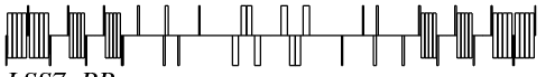
L=788.306m

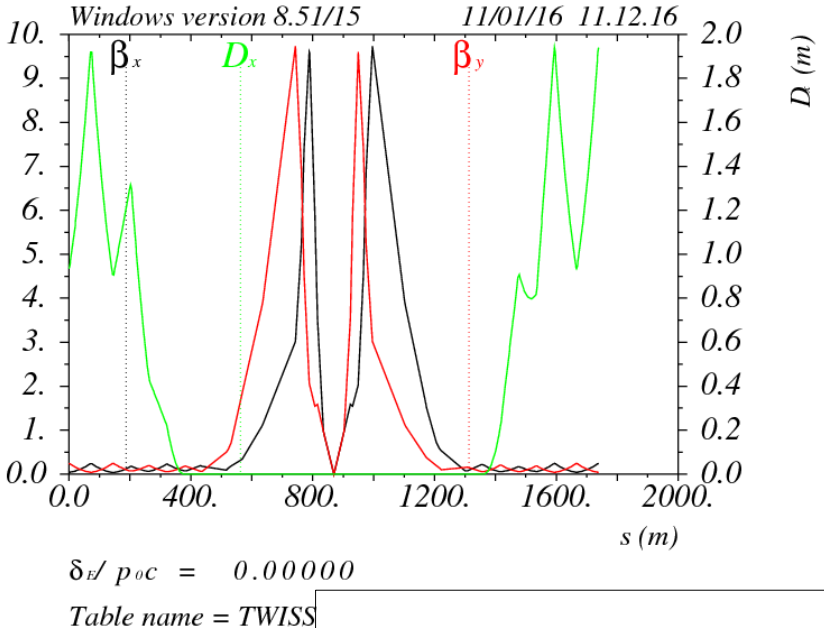
-ARCDSPR, ARC_to_STR, 4.5*STRCELL, STR_to_ARC, -ARCDSPL

382.4m, 71.719m, 649.8m, 66.787m, 382.4m

LSS3_pp/LSS7_pp







L=973.829m

Beta：0.75m

Crossing angle：146urad

ARCDSPL, ARC_to_STR, 21.5*STRCELL, STR_to_ARC, ARCDSPR

382.4m, 71.719m, 973.829m, 66.789m, 382.4m

	K1(m^-2)	G（T/M）	L(M)	βmax
K1.QT.1R	4.9751e-03	580.428	6	3543.69
K1.QT.A2R	-5.2595e-03	-613.668	9	9601.686
K1.QT.B2R	-5.2595e-03	-613.668	9	9601.686
K1.QT.3R	5.3434e-03	623.369	8	9731.53
K1.QM.4R	-2.2804E-04	-266.04	4	3798.29
K1.QM.5R	8.8592E-04	103.36	4	1506.53
K1.QM.6R	-1.2144E-03	-141.68	4	587.87
K1.QM.7R	1.0640E-04	124.133	4	531.25
K1.QM.8R	-4.2431E-03	-495.028	4	162.20
K1.QT.1L	-4.9751e-03	-580.428	6	3543.69
K1.QT.A2L	5.2595e-03	613.668	9	9601.686
K1.QT.B2L	5.2595e-03	613.668	9	9601.686
K1.QT.3L	-5.3434e-03	-623.369	8	9731.53
K1.QM.4L	2.2804E-04	266.04	4	3798.29
K1.QM.5L	-8.8592E-04	-103.36	4	1506.53
K1.QM.6L	1.2144E-03	141.68	4	587.87
K1.QM.7L	-1.0640E-04	-124.133	4	531.25
K1.QM.8L	4.2431E-03	495.028	4	162.20

Q Strength

Pre-CDR：

IR:

D = 60 mm B_{pole} = 20 T

G=666.7T/m K1=5.716*10^-3

R=30mm

20mm=20σ

σ=1mm

β=σ^2/ε=10.03km

Matching section:

D = 60 mm B_{pole} = 16 T

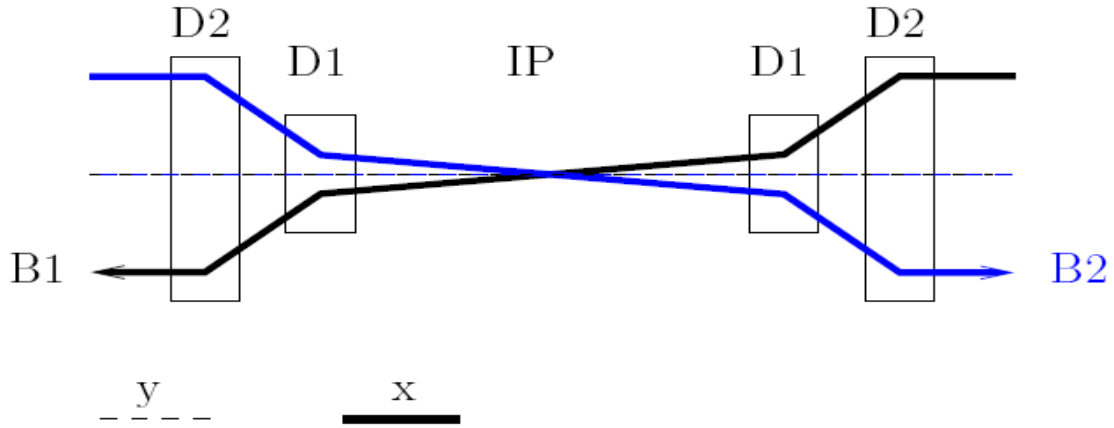
G=533.3T/m K1=4.572*10^-3

Separation Dipole

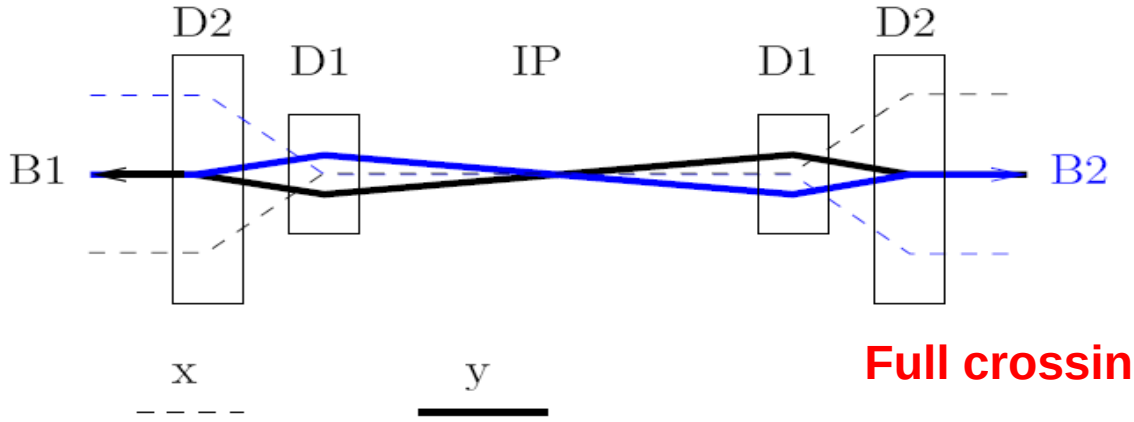
Crossing angle schemes

Crossing angle is achieved:

- for the horizontal plane by powering differently D1 and D2

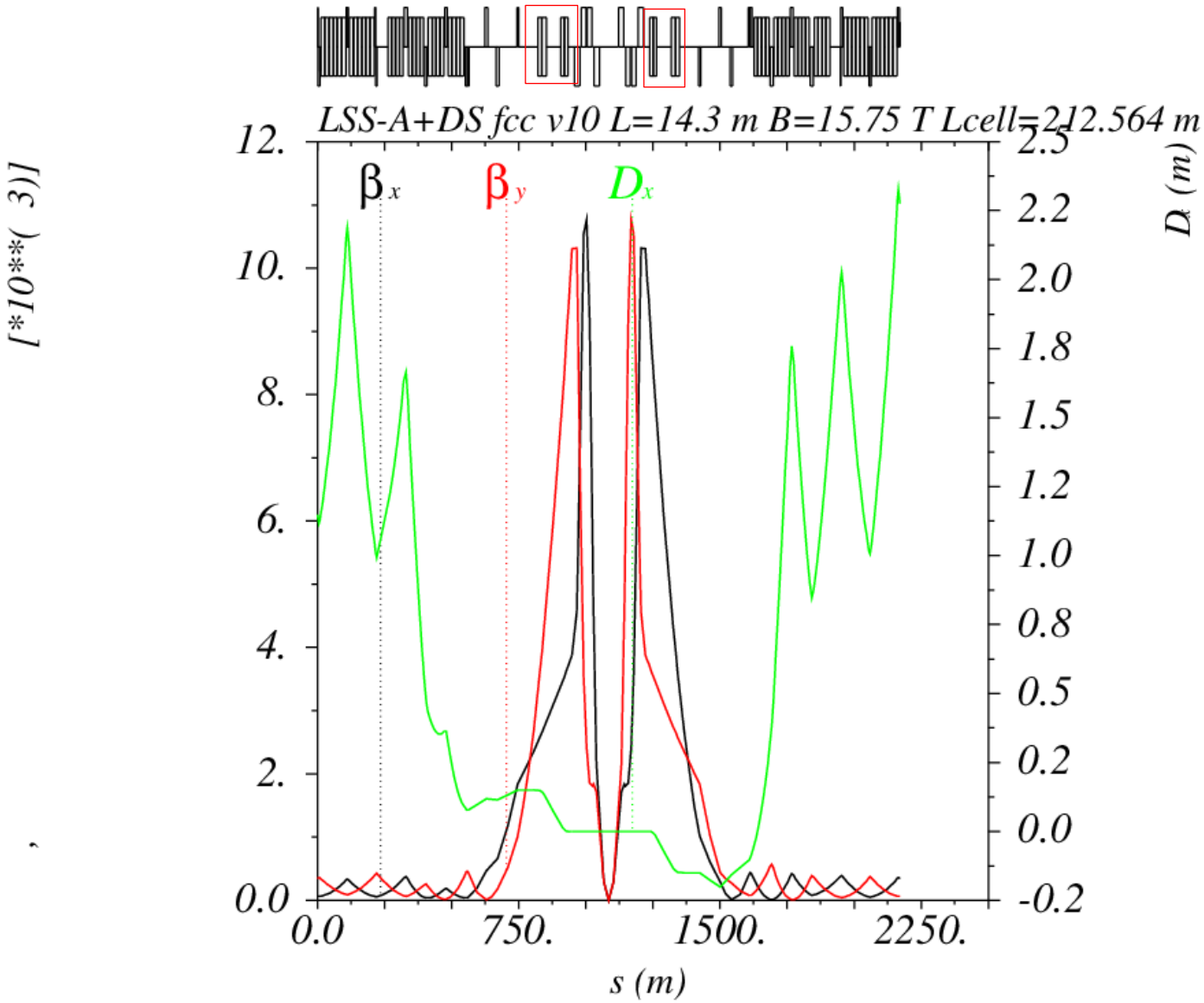


- for the vertical plane by tilting D1 and D2 resulting in a vertical deflection



Full crossing angle=146μrad

Separation Dipole



Summary

- The first version of SPPC Lattice was designed . The whole length and layout is according to CEPC lattice layout. full crossing angle is 146urad.
- Crossing angle and Separation Dipole need to be studied and installation.
- LSS3_pp low-β pp optics need to be studied and optimization.
- The Dynamic Aperture need to be studied: MADX or Sixtrack.

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!

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

Reference

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[2] LHC Design Report, Vol.1, CERN-2004-003.

[3] J. Gao, IHEP-AC-Note-2013-012.

[4]Xiao Ming et al, CEPC_bunch_train _ 2015-8-28

[5]Oridy, FCC-ee_150917

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