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Update of 3.2 km ILC DR design (DMC3)

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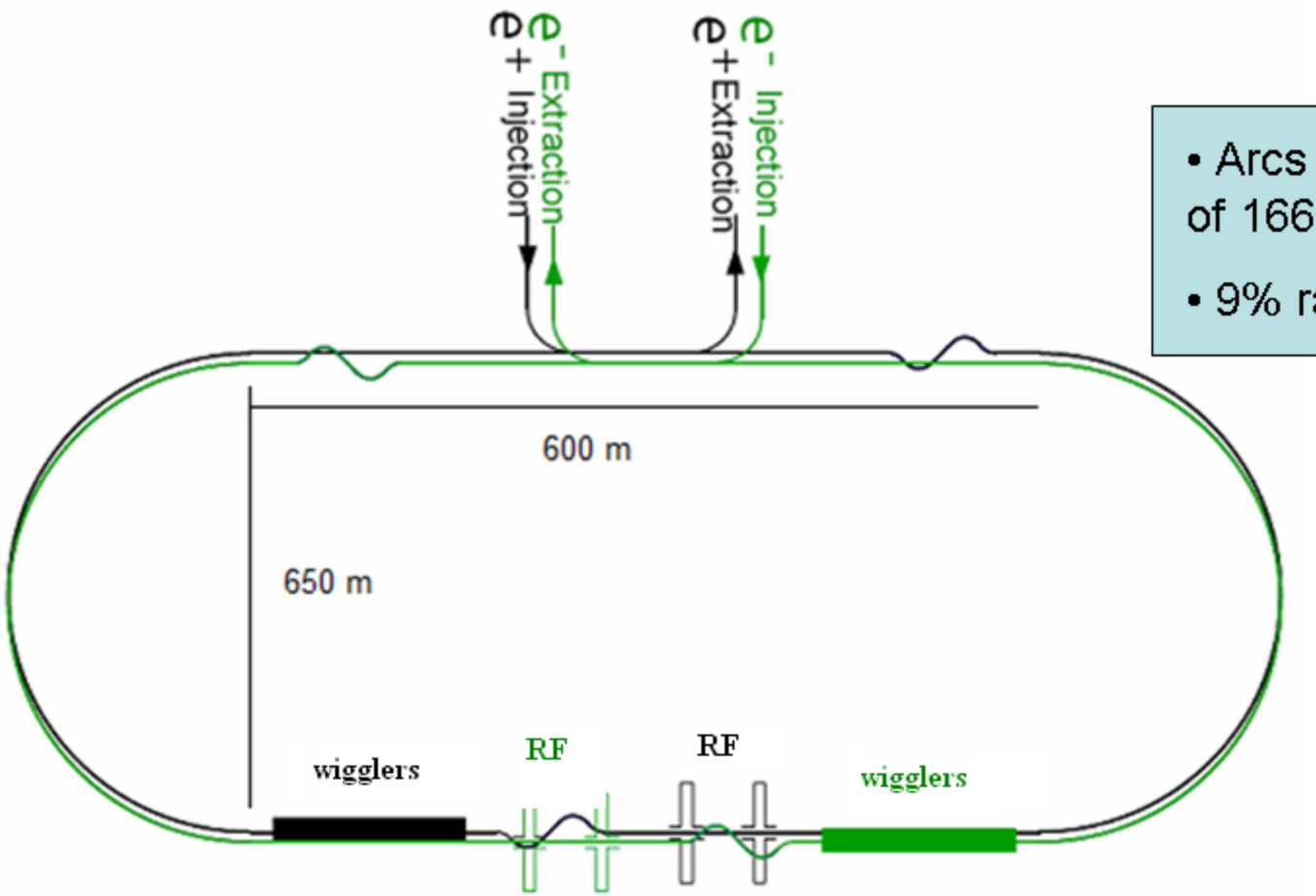
Overall considerations

- Keep the racetrack structure
- Use FODO cell for arc sections
- Keep the damping time a little smaller than 25 ms

  - decided by the repetition frequency (storage time=200ms)
- Keep the nomalised natural emittance ~ 4 um
- The momentum compaction factor is tunable (10^{-4})
- The injection and extraction beam lines for both e+ and e- rings can be in the same tunel
- Locating the rf and wigglers near each other to minimise cryogenic transfer lines. But rf must be upstream to avoid the synchrotron radiation
- Dynamic aperture should not be smaller than 3 times of e+ injection beam size

Layout



- Arcs consist of a total of 166 FODO cells
- 9% radiation in arcs

- Straights are similar to 6 km DCO4
- 91% radiation in straights

Main updates

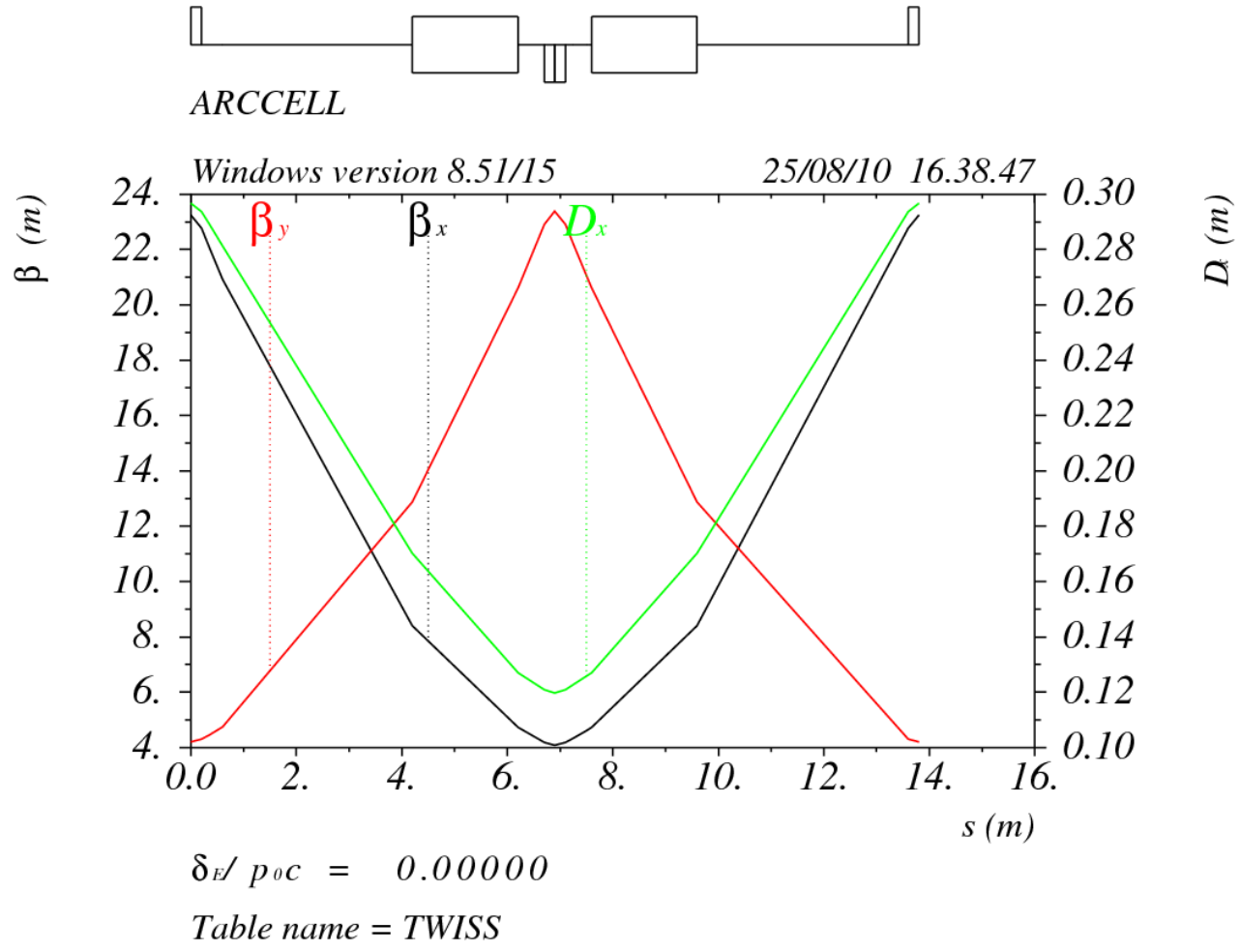
- Replace the 110 degree (DMC1) are cell by 60 degree.

Phase advance per arc cell	60°	75°	90°
Mumentum compaction	6.19×10^{-4}	4.04×10^{-4}	2.77×10^{-4}

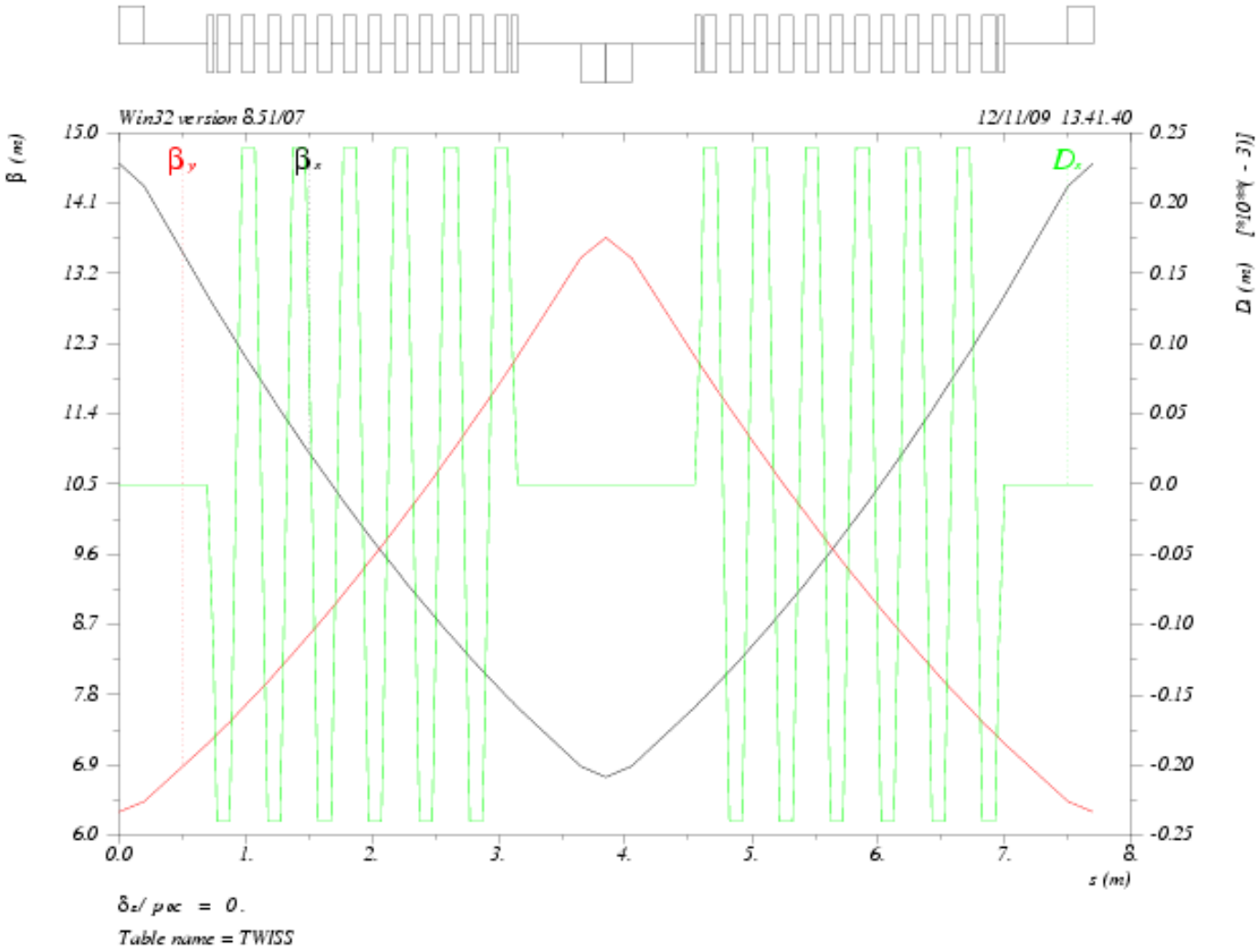
- Increase arc sextupoles from 216 to 332 in order to enlarge the dynamic aperture

  - a focusing sextupole and a defocusing sextupole for every arc cell

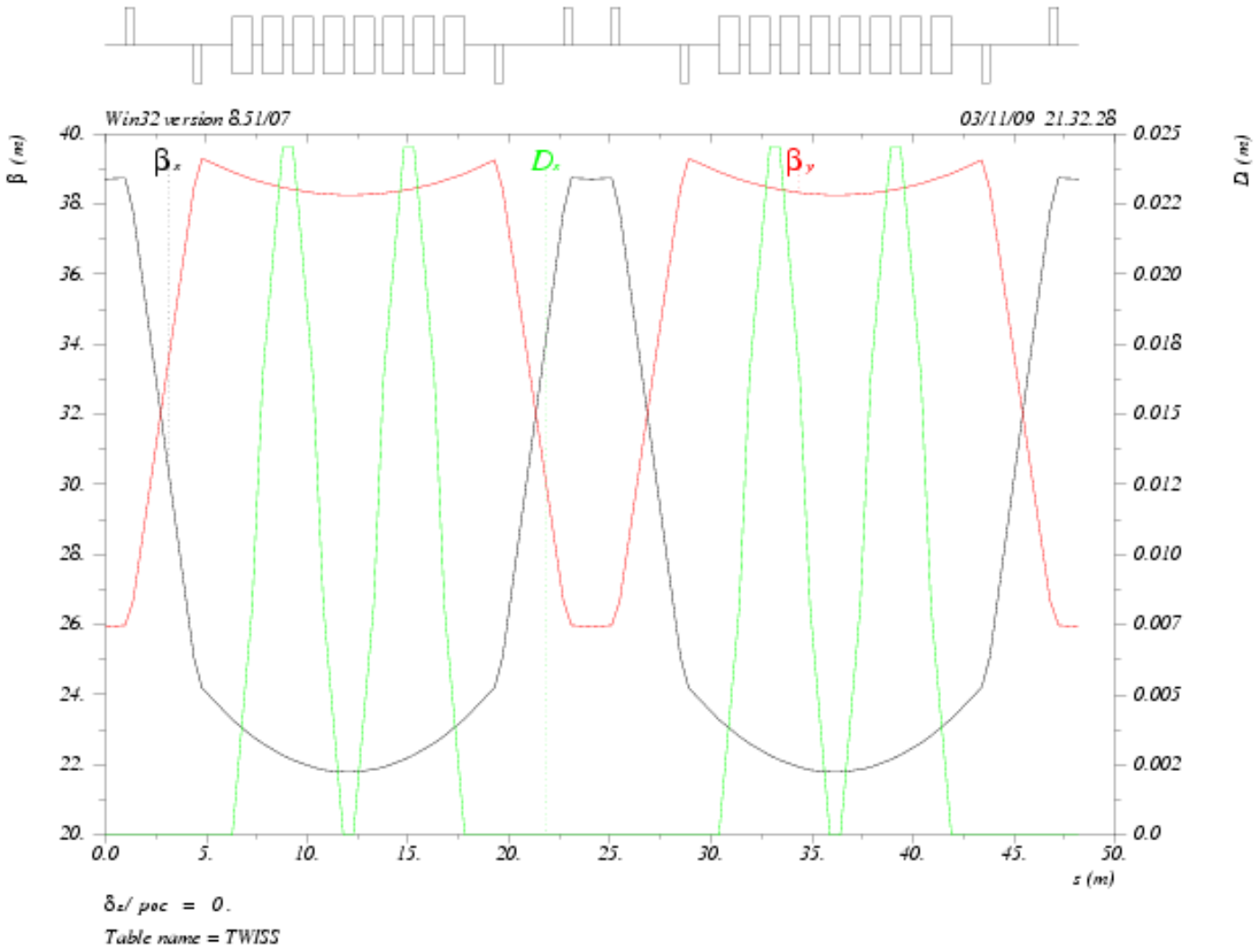
90°arc cell


ARCCELL
Windows version 8.51/15
25/08/10 16.38.47
β (m)
Dx (m)
βy
βx
Dx
24.
22.
20.
18.
16.
14.
12.
10.
8.
6.
4.
0.30
0.28
0.26
0.24
0.22
0.20
0.18
0.16
0.14
0.12
0.10
0.0
2.
4.
6.
8.
10.
12.
14.
16.
s (m)
δE/ p0c = 0.00000
Table name = TWISS

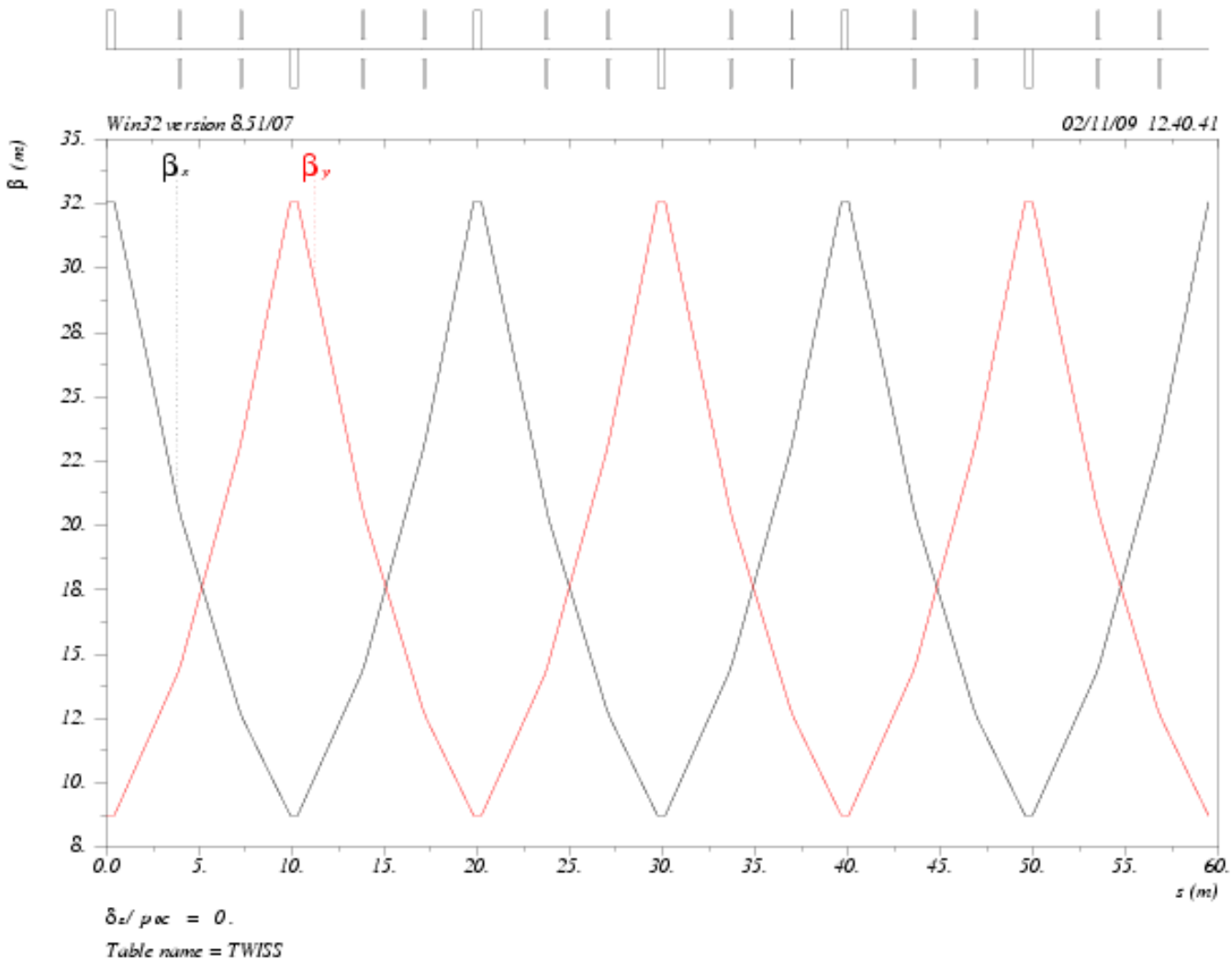
Wiggler cell



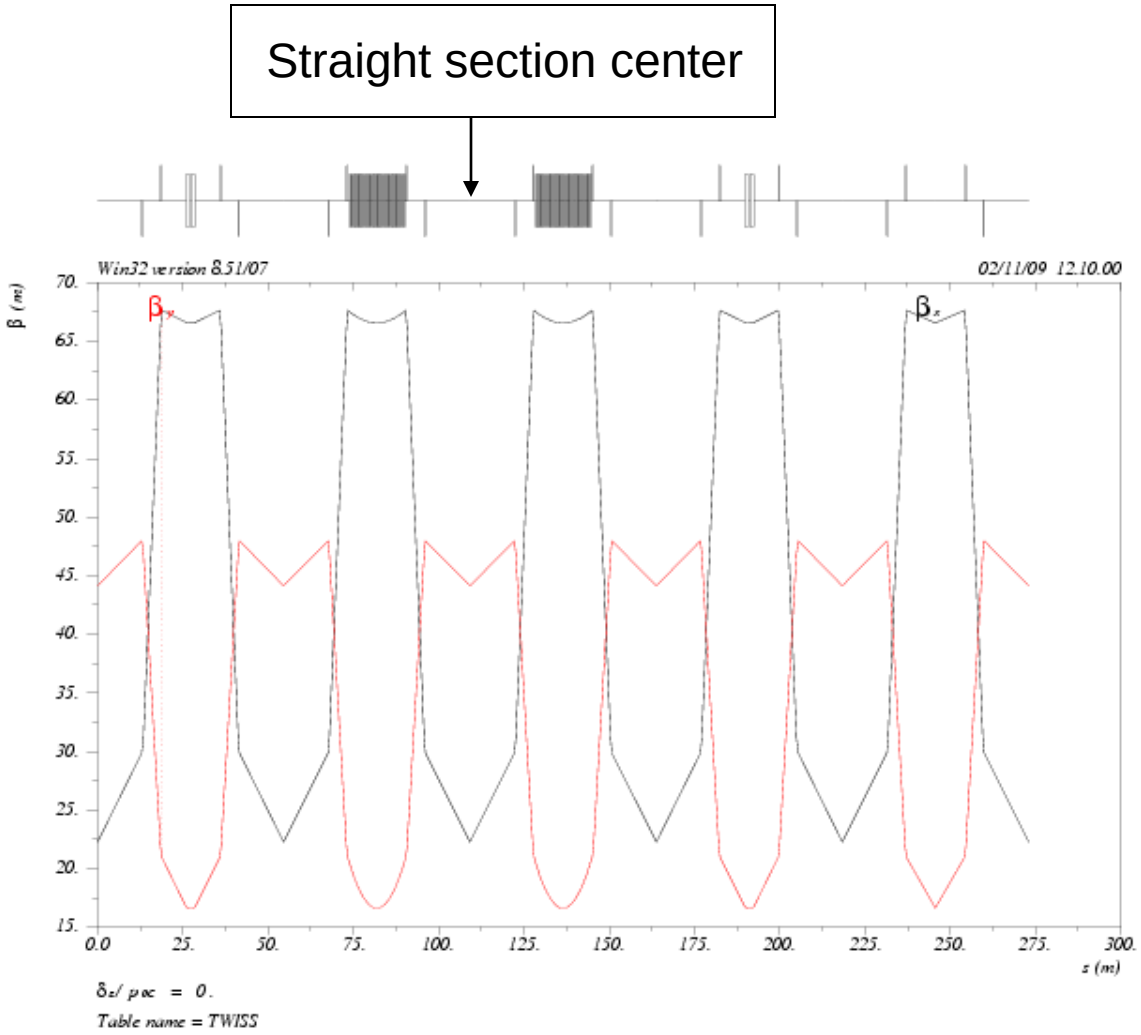
Chicane cell



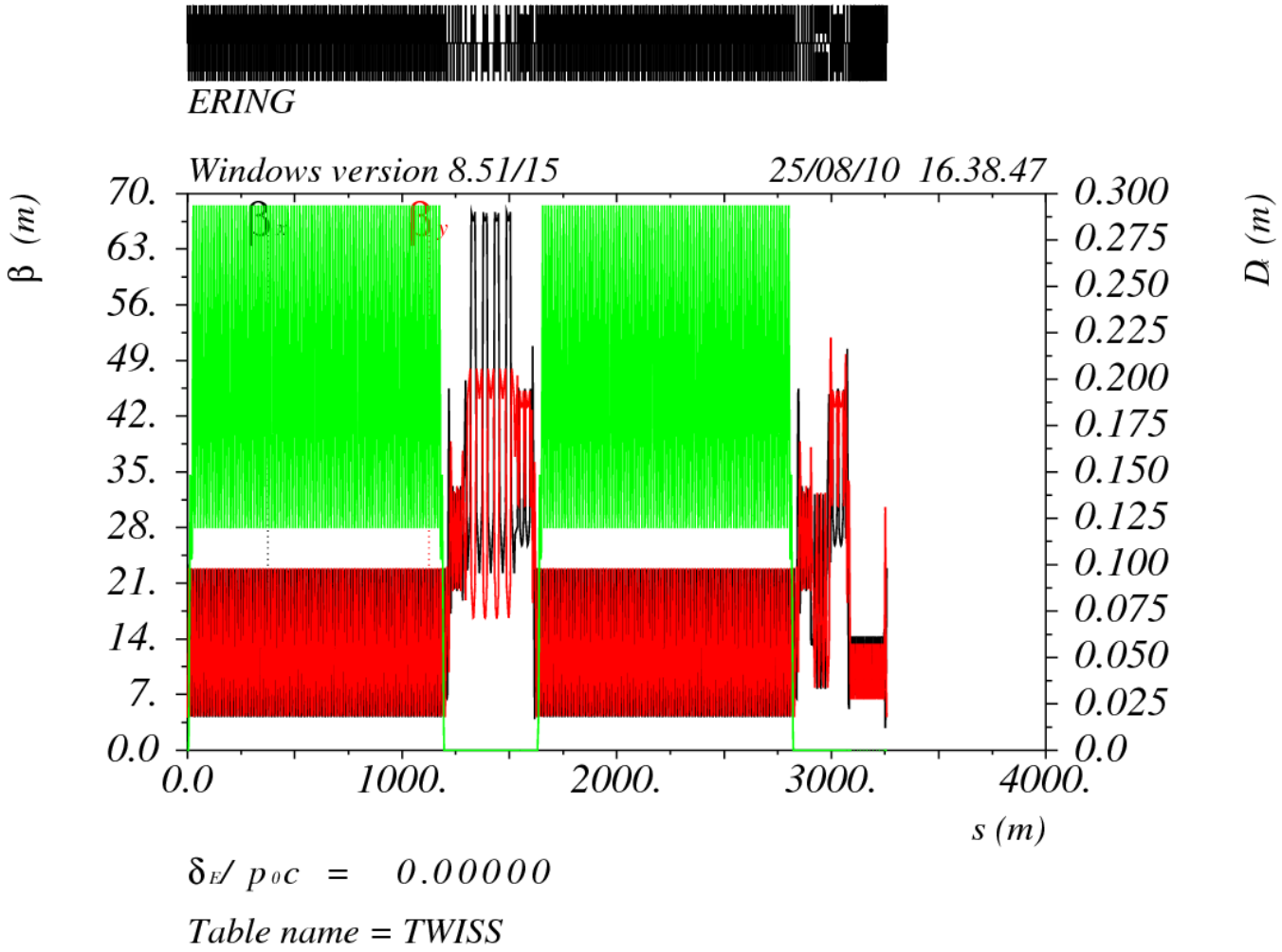
RF section


Win32 version 8.51/07
02/11/09 12.40.41
β (m)
βx
βy
35.
32.
30.
28.
25.
22.
20.
18.
15.
12.
10.
8.
0.0
5.
10.
15.
20.
25.
30.
35.
40.
45.
50.
55.
60.
s (m)
δx/ pac = 0.
Table name = TWISS

Inj/Extr section



Whole ring


ERING
Windows version 8.51/15
25/08/10 16.38.47
β (m)
70.
63.
56.
49.
42.
35.
28.
21.
14.
7.
0.0
0.0
1000.
2000.
3000.
4000.
s (m)
0.300
0.275
0.250
0.225
0.200
0.175
0.150
0.125
0.100
0.075
0.050
0.025
0.0
Dx (m)
δE/ p0c = 0.00000
Table name = TWISS

Major parameters of DMC3

Beam energy	5.0 GeV		
Circumference	3258.68 m		
RF frequency	650 MHz		
Harmonic number	7065		
Transverse damping time	23 ms		
Natural bunch length	6 mm		
Natural energy spread	1.26×10^{-3}		
Phase advance per FODO cell	60°	75°	90°
Momentum compaction factor	6.19×10^{-4}	4.04×10^{-4}	2.77×10^{-4}
Nomalised natural emittance	6.27 um	4.45 um	3.58 um
RF voltage	33.0 MV	21.84 MV	15.36 MV
RF acceptance	2.75%	2.58%	2.38%
Synchrotron tune	0.067	0.044	0.03
Working point x/y	38.28/36.21	44.35/42.30	51.23/49.36
Natural chromaticity x/y	-42.3/-41.5	-51.2/-49.9	-63.7/-61.7
Maximum quadrupole gradient	8.5 T/m	9.0 T/m	11.3 T/m
Maximum sextupole gradient	50 T/m^2	88 T/m^2	151 T/m^2

Major parameters of DCO4

Circumference	6476.4 m		
Beam energy	5 GeV		
RF frequency	650 MHz		
Transverse damping time	21.1 ms		
Natural rms bunch length	6.0 mm		
Natural rms energy spread	1.27×10^{-3}		
wiggler	216 m total length; 400 mm period; 1.6 T peak field		
Arc cell phase advance	72°	90°	100°
Momentum compaction factor	2.9×10^{-4}	1.6×10^{-4}	1.3×10^{-4}
RF voltage	32.6 MV	20.4 MV	17.1 MV
Normalized natural emittance	6.4 mm	4.4 mm	3.9 mm
Tunes (x/y)	61.12/60.41	71.12/71.41	76.12/75.41
Natural chromaticity (x/y)	-71.0/-72.6	-89.2/-91.0	-99.8/-100.7

For the same phase advance of arc cell, our design reduced the RF voltage by about 30%.

Magnet parameters

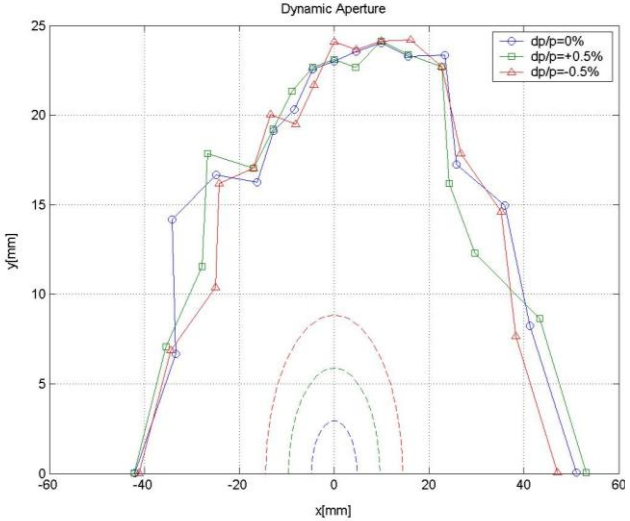
	DMC3	**DSB3**	**DCO4**
Arc dipole length	2.0 m	2.7 m	2.0 m
Arc dipole field	0.154 T	0.26/0.36T	0.27 T
Number of arc dipoles	344	128	200
Chicane dipole length	1.50 m	1.0 m	1.0 m
Chicane dipole field	0.1 T	0.27 T	0.27 T
Number of chicane dipoles	32	48	48
Quadrupole length	0.40 m	0.6/0.3 m	0.3 m
Total number of quadrupoles	474	590	692
Maximum quadrupole gradient	11.3T/m	7.5 T/m	12.0 T/m
Sextupole length	0.25 m		0.25 m
Total number of sextupoles	332	192	392
Maximum sextupole gradient	151 T/m^2	145 T/m^2	215 T/m^2

Wigglers

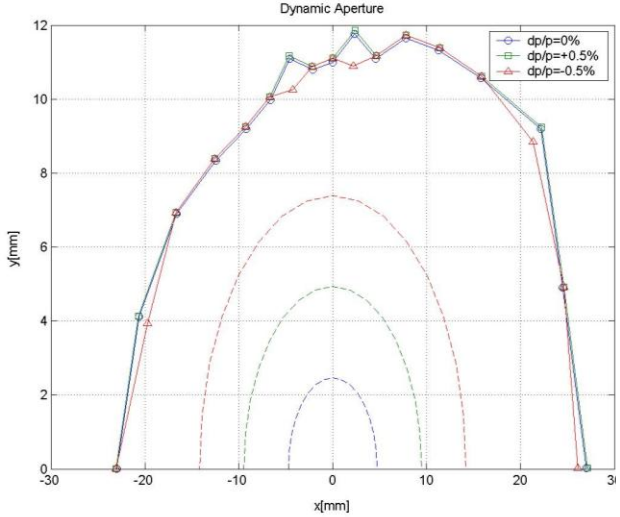
	DMC1	SB2009	DCO4
Wiggler peak field	1.6 T	1.6 T	1.6 T
Wiggler period length	0.4 m	0.4 m	0.4 m
Number of wigglers	40	32	88
Wiggler unit length	2.45 m	2.45 m	2.45 m
Wiggler total length	98 m	78.4 m	215.6 m

DMC3 dynamic aperture

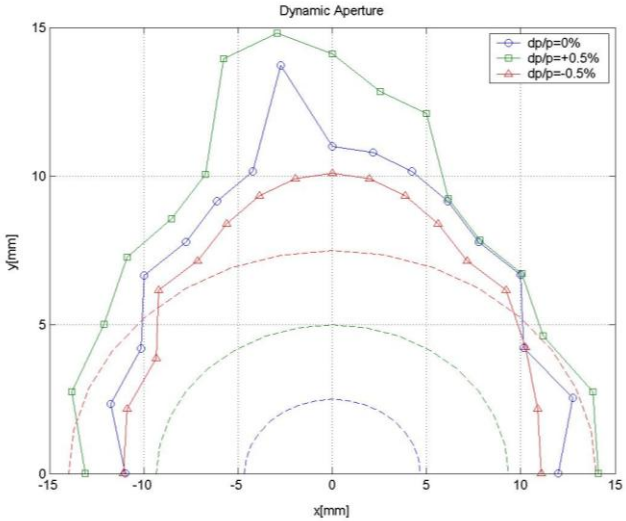
60°



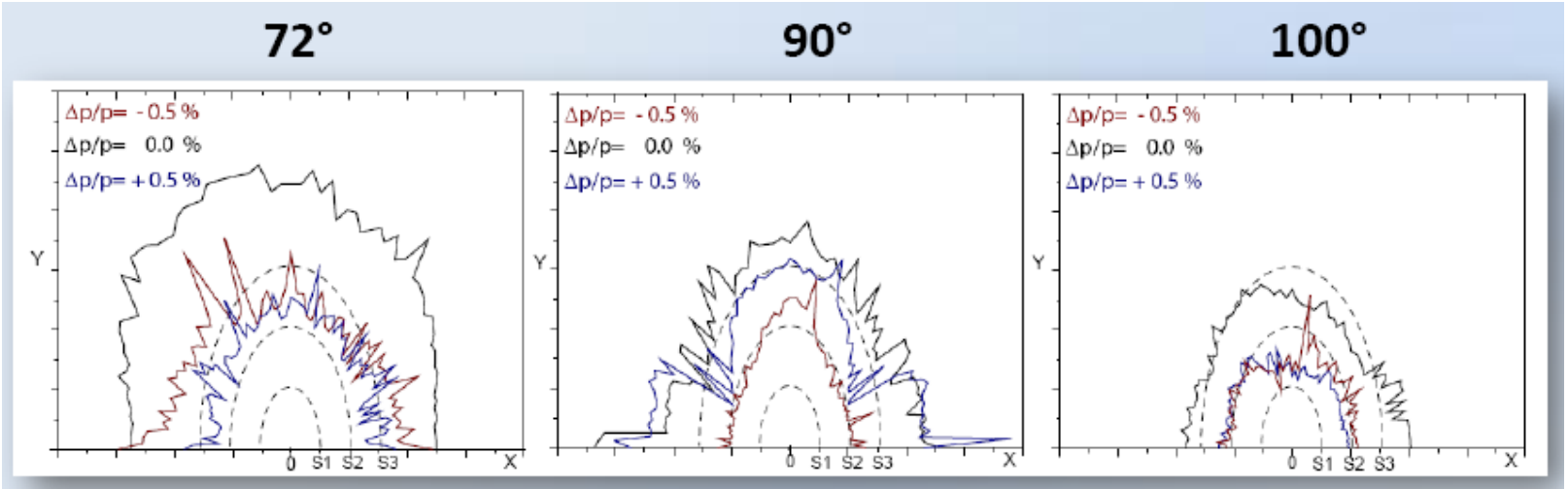
75°



90°



DCO4 dynamic aperture



summary

- Our design satisfies all the principal requirements for the 3.2 km ring.
- The momentum compaction factor is tunable in a large range (2.7×10^{-4} ~ 6.2×10^{-4}).

  - Allows 6 mm rms bunch length with the total rf voltage from 15 MV to 33 MV, 30% smaller than DCO4.
- The total number of magnets for DMC3 is about 10% less than DCO4.
- Dynamic aperture looks good.

  - good for higher momentum compaction factor

  - becomes smaller at lower momentum compaction factor because of small dispersion