SuperB Damping Rings

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SuperB Rings

- SuperB rings have same characteristics as the ILC Damping Rings, that is:
  - Short damping times (τ_s < 10 sec)
  - Small emittance (ε_x < 1 nm)
  - Low emittance coupling (0.25 %)

- Natural candidate is OCS lattice from ILCDR Baseline Design

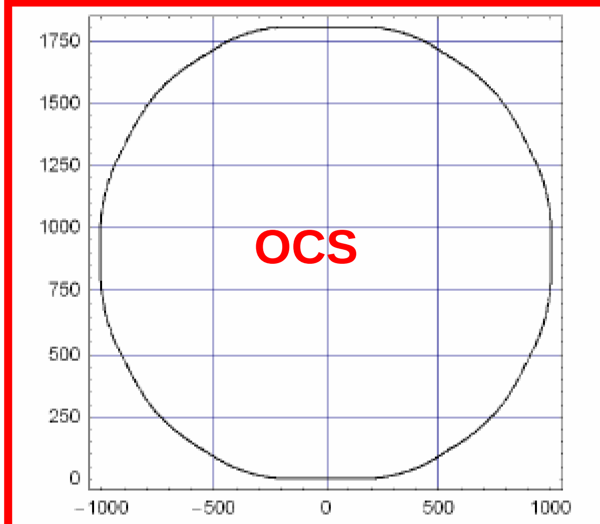
OCS lattice

- 10-fold symmetry with 10 long straight sections
- 8 straight sections contain wigglers and RF cavities, the other 2 can accommodate tune-adjustment sections and injection
- Arc cell is a TME (Theoretical Minimum Emittance), 40 m long, with 72 dipoles 5.6 m long with low (0.2 T) field
- Wigglers are SC, 1.6 T field, 10.4 m long in each section

ILCDR Parameters

Table 2.1: Parameters of the positron damping ring reference lattices.

Lattice	PPA [12]	OTW	OCS [26]	BRU [82]	MCH [82]	DAS [12]	TESLA [72]
Circumference [m]	2824	3223	6114	6333	15935	17014	17000
Energy [GeV]	5.0	5.0	5.066	3.74	5.0	5.0	5.0
Harmonic number	4700	7678	13256	13732	34550	28377	28200
Arc cell type	PI	TME	TME	FODO	FODO	PI	TME
Horizontal tune	47.810	45.164	50.840	65.783	75.783	83.730	76.310
Vertical tune	47.680	24.157	40.800	66.413	76.413	83.650	41.180
Natural chromaticity (x, y)	-63,-60	-88,-74	-65,-53	-79,-87	-90,-95	-105,-105	-126,-60
Momentum compaction $[10^{-4}]$	2.83	3.62	1.62	11.9	4.09	1.14	1.22
Energy loss/turn [MeV]	4.70	8.85	9.33	6.19	19.8	21.0	20.3
Transverse damping time [ms]	20.0	12.1	22.2	25.5	26.9	27.0	[illegible]
Longitudinal damping time [ms]	10.0	6.07	11.1	12.8	13.4	13.5	[illegible]
Natural emittance [nm]	0.433	0.388	0.559	0.377	0.675	0.612	[illegible]
Norm. natural emittance [μm]	4.24	3.80	5.54	2.76	6.60	5.99	[illegible]
RF voltage [MV]	17.76	21.78	19.27	23.16	53.70	48.17	[illegible]
RF frequency [MHz]	500	714	650	650	650	500	[illegible]
Synchrotron tune	0.0269	0.0418	0.0337	0.120	0.150	0.0668	[illegible]
Synchronous phase [deg]	164	156	151	164	158	154	[illegible]
RF acceptance [%]	3.2	2.1	2.0	1.3	1.5	2.8	[illegible]
Natural bunch length [mm]	6.00	6.00	6.00	9.00	9.00	6.00	[illegible]
Natural energy spread $[10^{-3}]$	1.27	1.36	1.29	0.973	1.30	1.30	[illegible]
Particles/bunch $[10^{10}]$	2.4	2.2	2.0	2.0	2.0	2.0	[illegible]
Peak current [A]	76.7	70.0	63.9	42.6	42.6	63.9	[illegible]
Bunch spacing $[\lambda_{RF}]$	2	3	4	4	10	10	[illegible]
Bunch spacing [ns]	4.000	4.202	6.154	6.154	15.38	20.00	[illegible]
Bunches per train	2350	2559	47	36	18	2820	[illegible]
Gaps per train	0	0	8.25	8	4	0	[illegible]
Number of bunch trains	1	1	60	78	157	1	1
Average current [mA]	959	839	443	426	170	159	159
Mean horizontal beta function [m]	13.1	58.0	25.6	57.6	109	106	120
Mean vertical beta function [m]	12.5	63.8	31.0	55.4	108	106	121
Synch. radn. integral I_1 [m]	0.7986	1.158	0.9727	6.365	6.523	1.940	2.071
Synch. radn. integral I_2 $[m^{-1}]$	0.5341	1.006	0.8087	2.248	2.248	2.390	2.314
Synch. radn. integral I_3 $[m^{-2}]$	0.04699	0.1016	0.09992	0.2073	0.2073	0.2190	0.2113
Synch. radn. integral I_4 $[10^{-4} m^{-1}]$	0.3276	1.212	1.488	3.675	3.774	1.914	2.150
Synch. radn. integral I_5 $[10^{-5} m^{-1}]$	0.6342	1.104	1.424	3.043	3.112	3.883	3.206



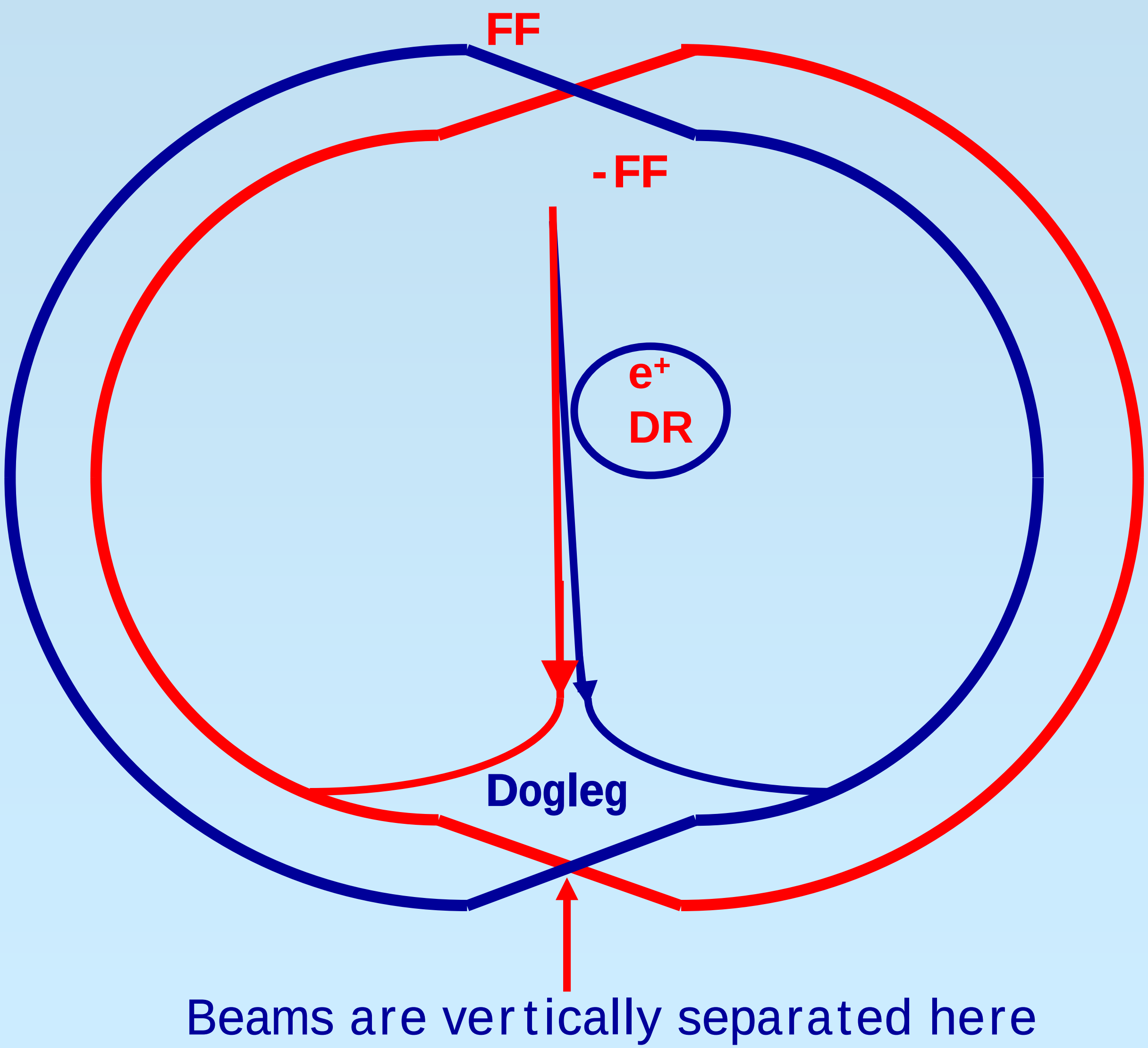
SuperB Rings Parameters

TABLE V: Preliminary Super Flavour Factory collision parameters

	1^{st} LNF Workshop Best Working Point	2^{nd} LNF Workshop Best Working Point
σ_x^* (μm)	30 (1.0 σ_x betatron)	2.67
η_x (mm)	1.5 LER/ -1.5 HER	0.0
σ_y^* (nm)	12.6	12.6
β_x^* (mm)	1.25	8.9
β_y^* (mm)	0.080	0.080
σ_z^* (mm)	0.100	6.0
σ_E^*	$2. \times 10^{-2}$	10^{-3}
σ_E Lum.	10^{-3}	0.7×10^{-3}
ϵ_x (nm)	0.8	0.8
ϵ_y (nm)	0.002	0.002
ϵ_z (μm)	2.0	4.0
θ_x (mrad)	Optional	2*20
$\sigma_z DR$ (mm)	4.0	6.0
$\sigma_E DR$	0.5×10^{-3}	10^{-3}
$N_{\mathrm{part}}(10^{10})$	7.0	2.0
N_{bunches}	12000	12000
I(A)	6.7	1.9
C_{DR} (km)	6.0	6.0
$\tau_{x,y}$ (ms)	10	20
Turns between collisions	50	1
f_{coll} (MHz)	12.0	650
$\mathcal{L}_{\mathrm{singleturn}}(10^{36})$	1.5	1.2
$\mathcal{L}_{\mathrm{multiturn}}(10^{36})$	1.1	1.0

From document presented at CERN Strategy Group and INFN Roadmap: www.pi.infn.it/SuperB/ (March 2006)

SuperB Schematic Layout

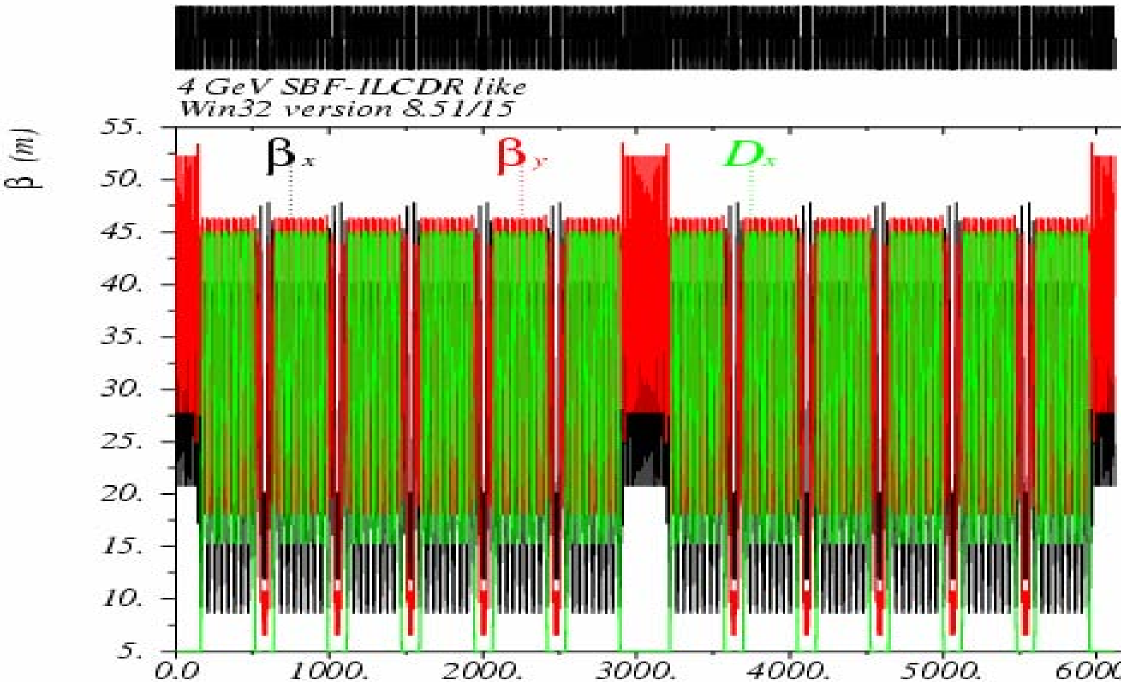


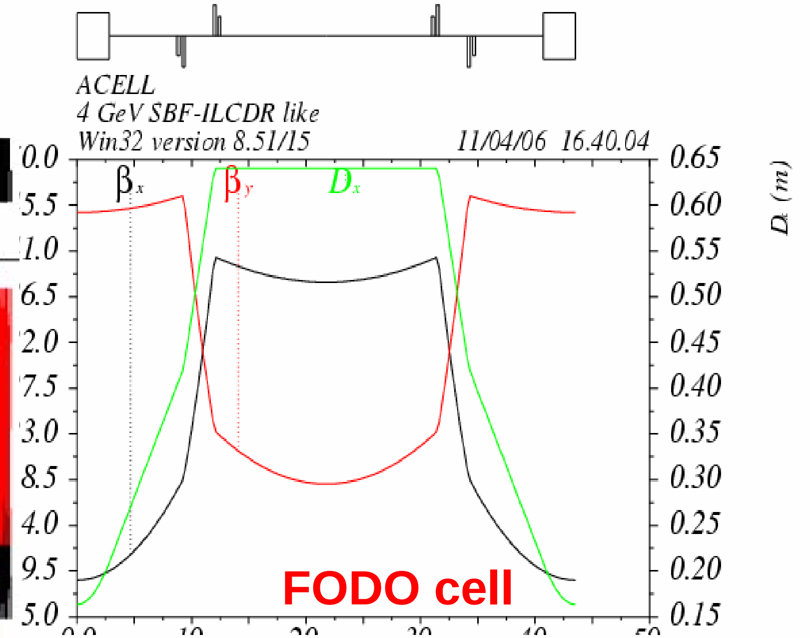
- Rings have asymmetric energies of 4 and 7 GeV
- OCS lattice was scaled from 5 GeV to 4 and 7
- 6.1 Km, 3.2 Km and 2.2 Km long rings were studied
- Emittances and damping times were kept similar for each configuration
- Lattice symmetry was respected
- Fewer and lower field wigglers used (pm ?)
- Longer dipoles were used, when needed
- Preliminary Final Focus (A. Seryi) included

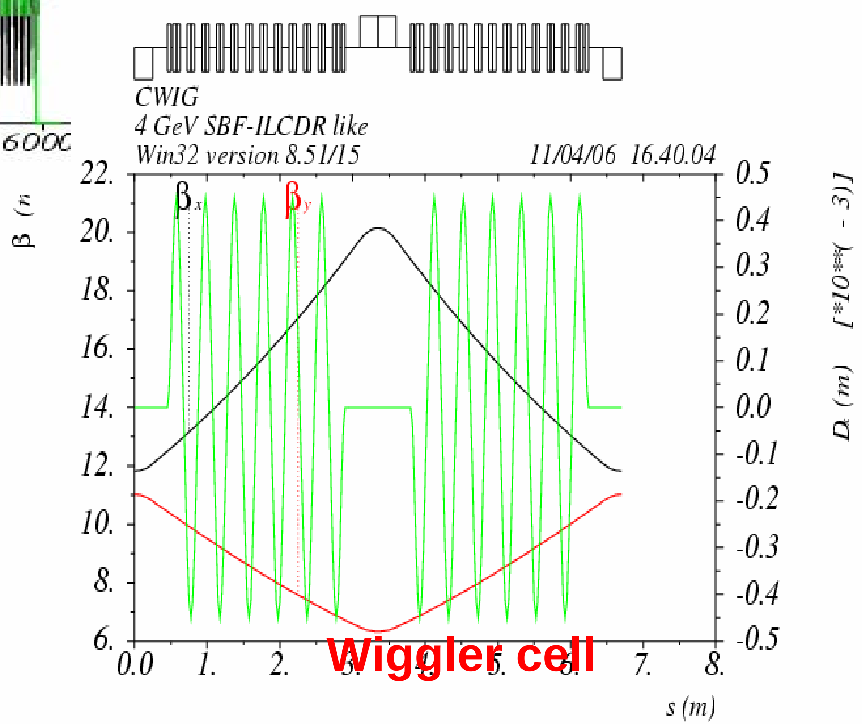
6.1 Km lattice

- OCS lattice: 6.1 Km ILC Damping Rings, 8 wiggler sections
- 4 GeV: same wiggler sections (8) and field, same bend length
- 7 GeV: same wiggler field, less wiggler sections (6), double bend length

4 GeV, 6.1 Km

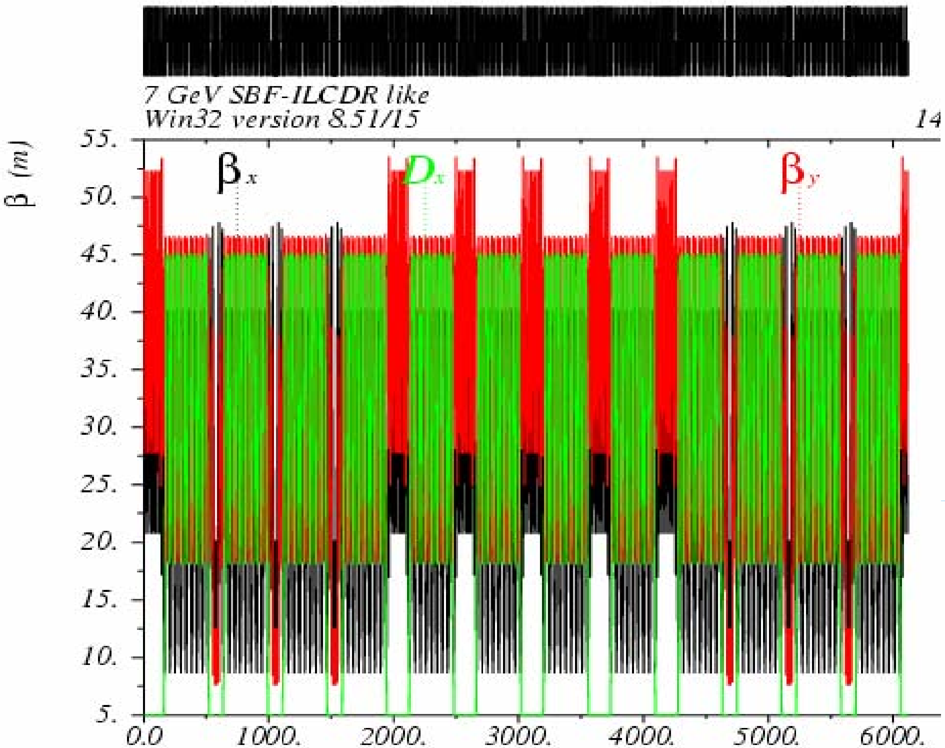


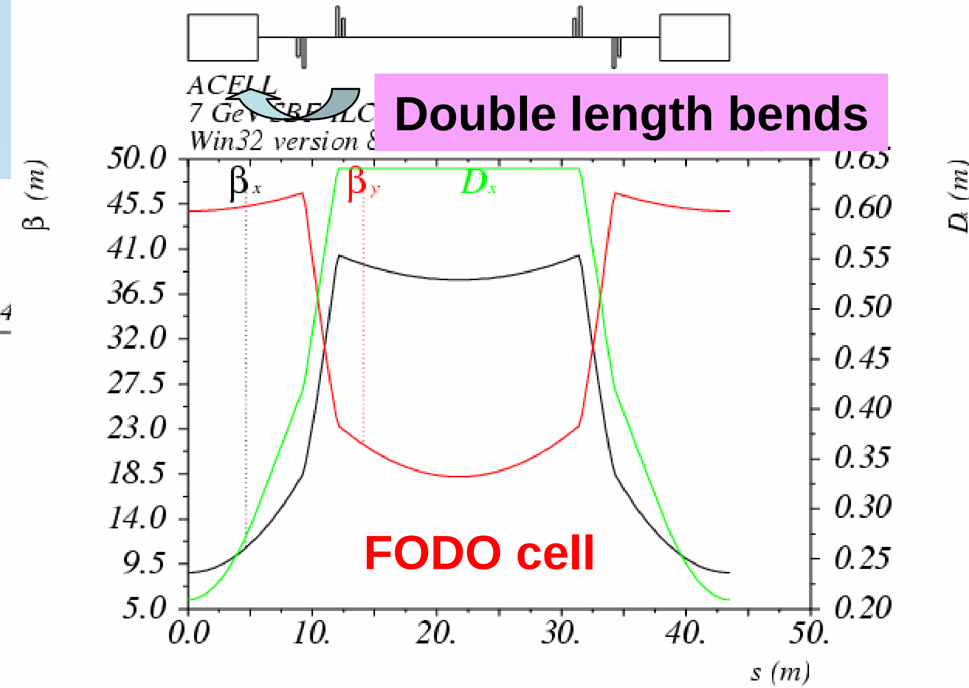


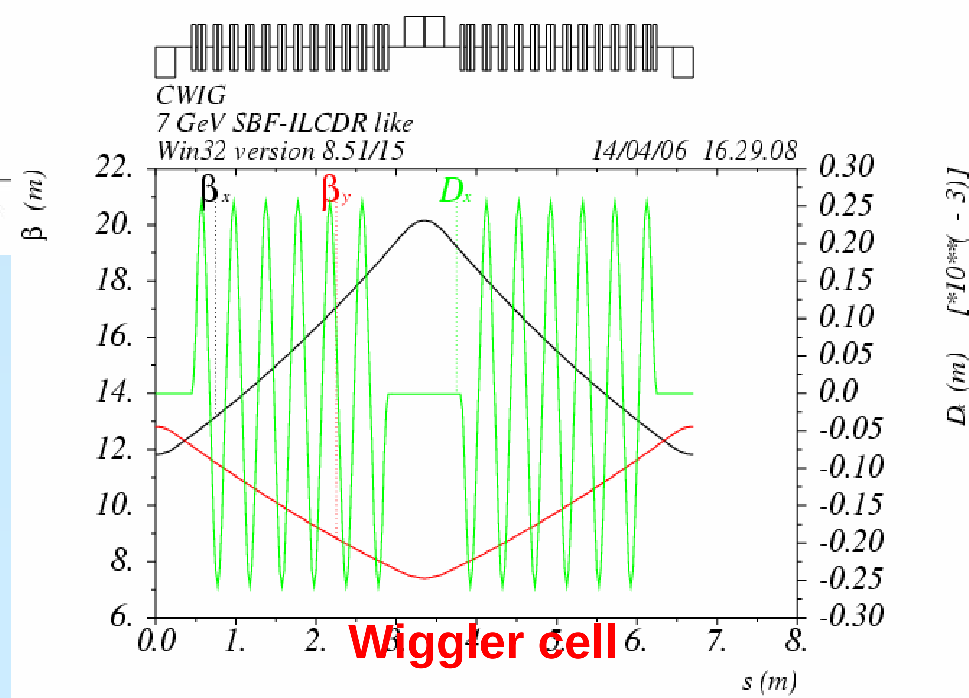


135°/90° FODO cells
8 wiggler cells, 1.6 T

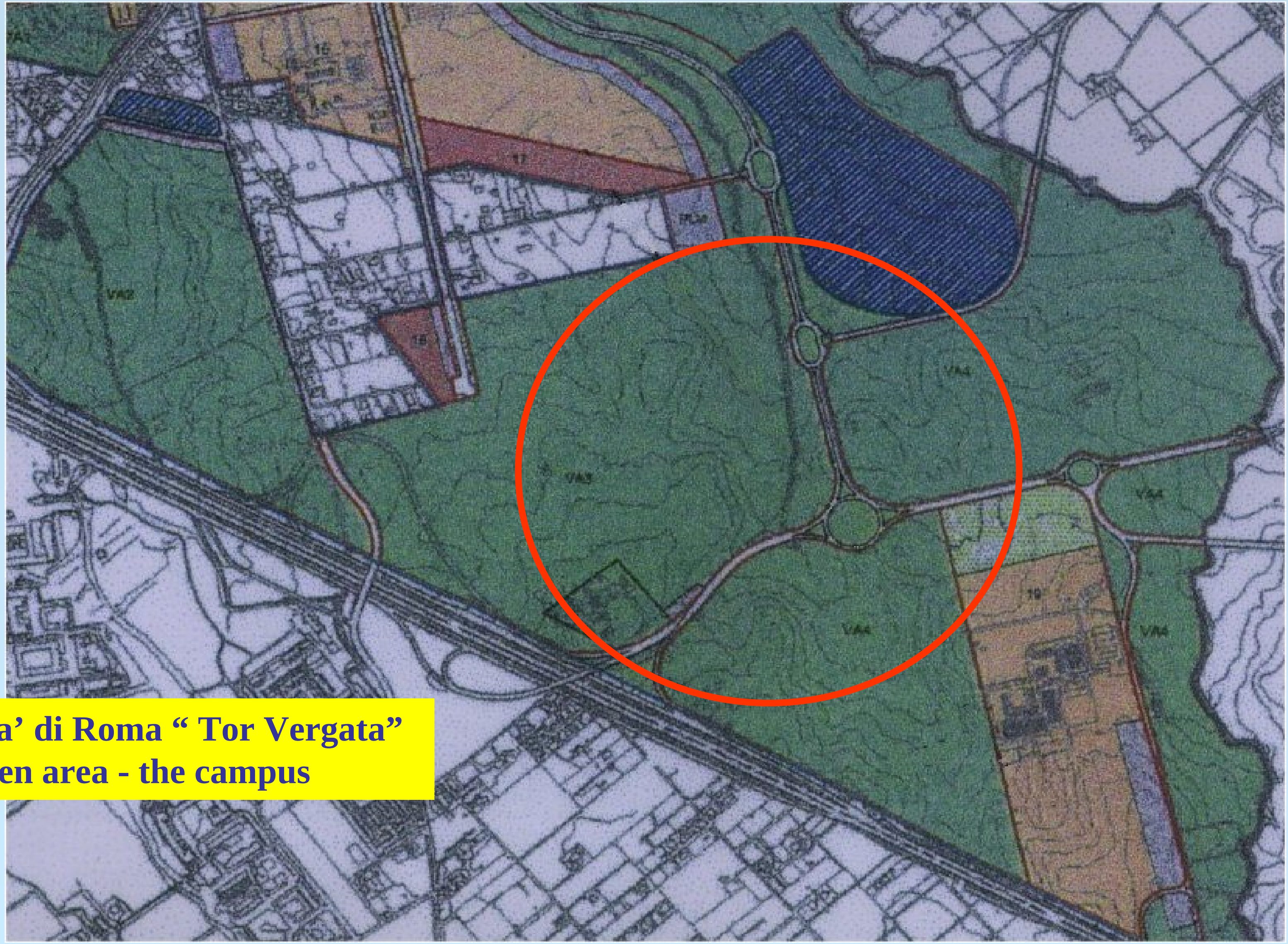
7 GeV, 6.1 Km







135°/90° FODO cells
6 wiggler cells, 1.6 T



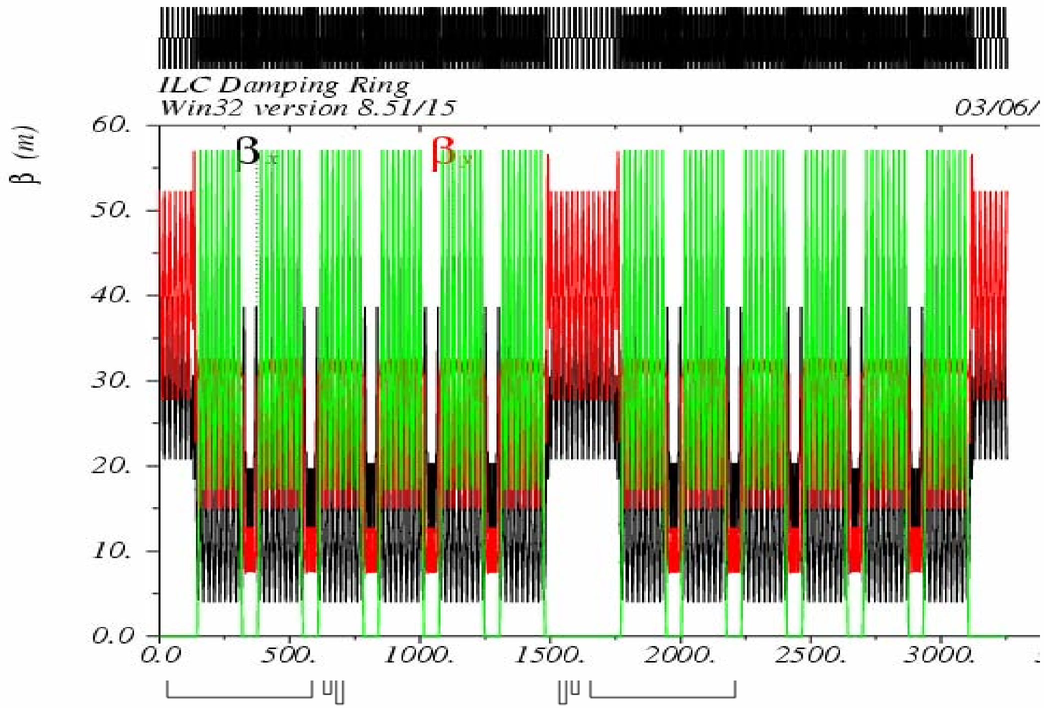
Universita' di Roma " Tor Vergata" green area - the campus

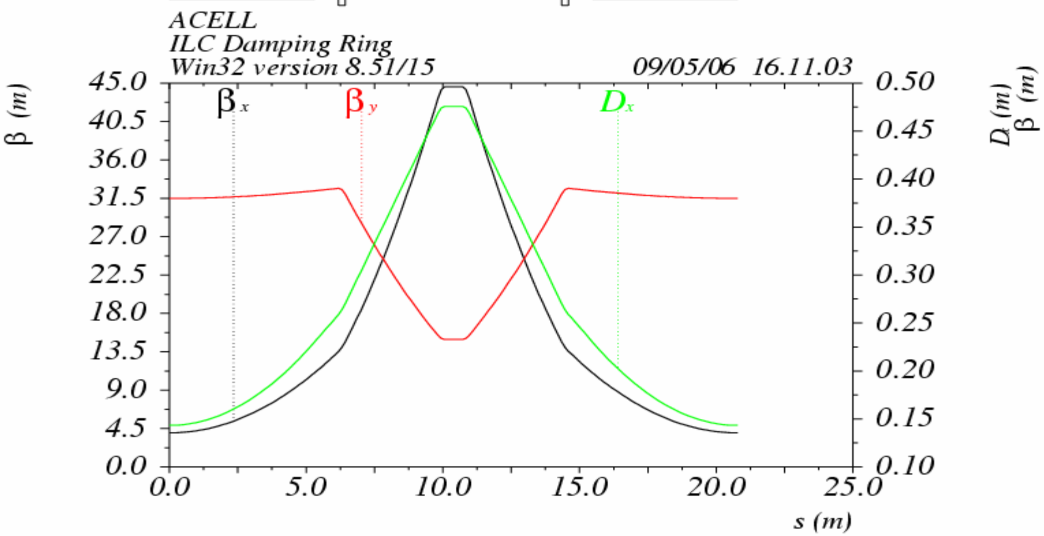
Frascati INFN & ENEA Laboratories

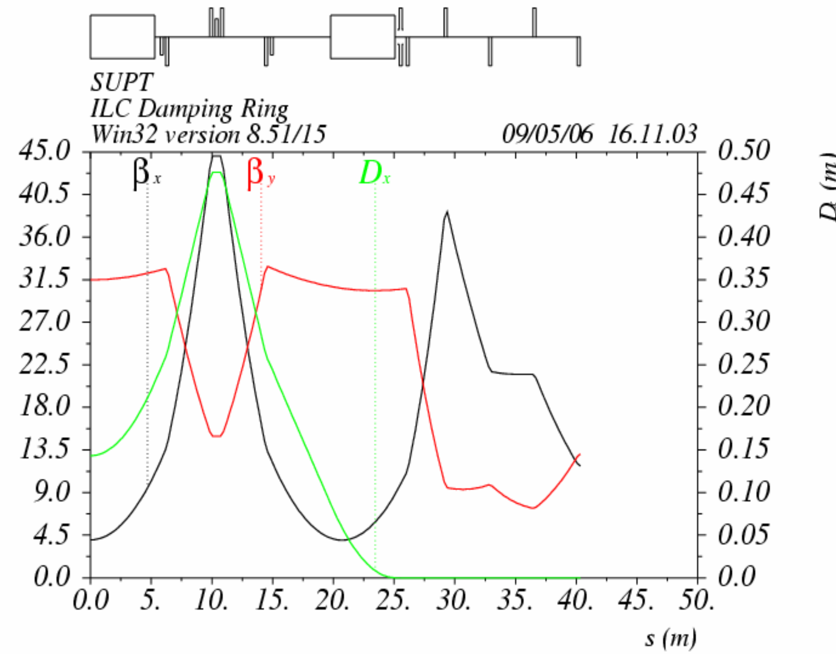
3.2 Km Rings

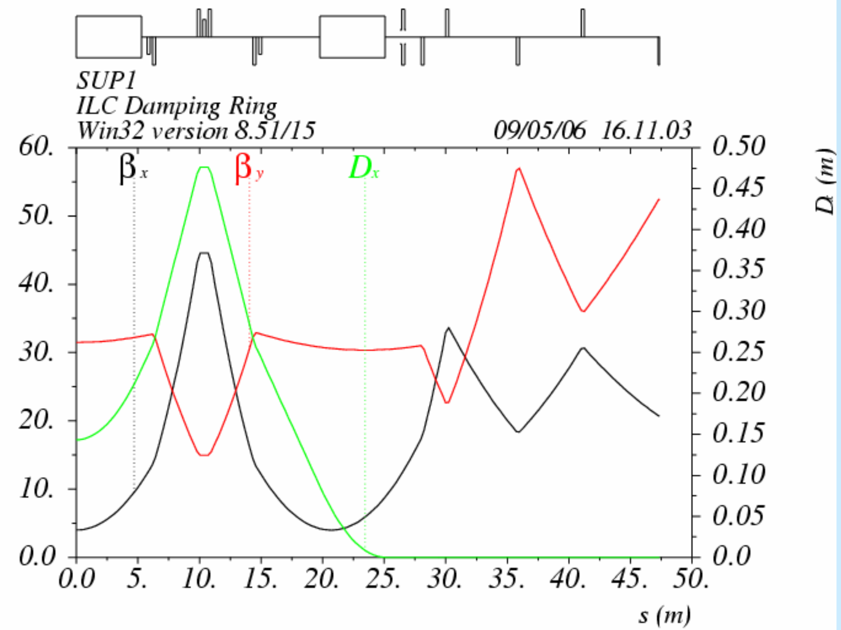
- The OCS lattice has many free drifts and a relatively low number of quadrupoles and bends → quite easy to shorten the ring
- Quadrupole strengths and beta peaks are higher though
- Arc needs higher dispersion for better chromaticity correction → in progress

7 GeV ring, 3 Km

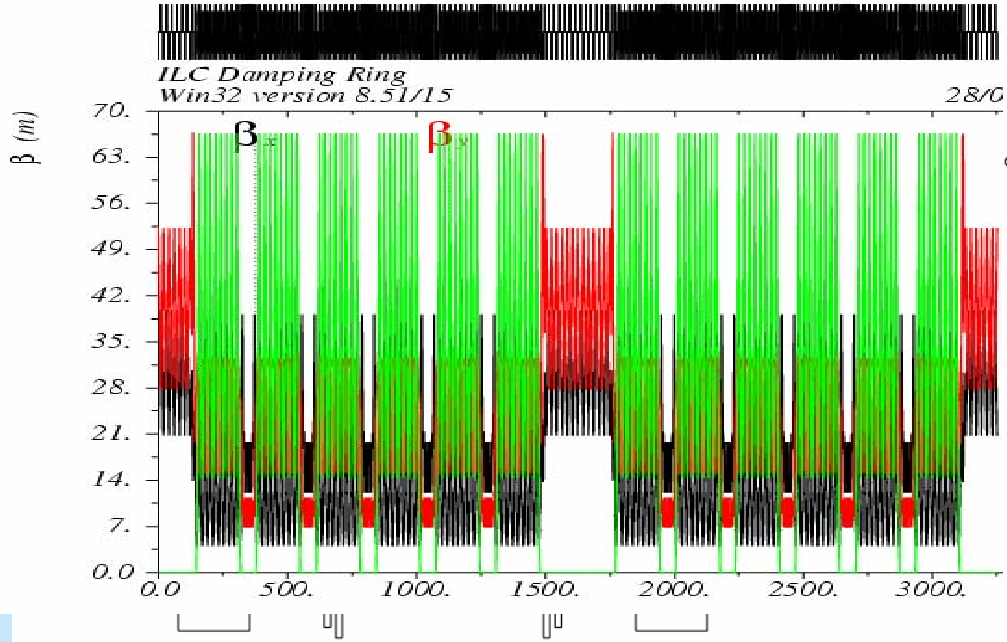


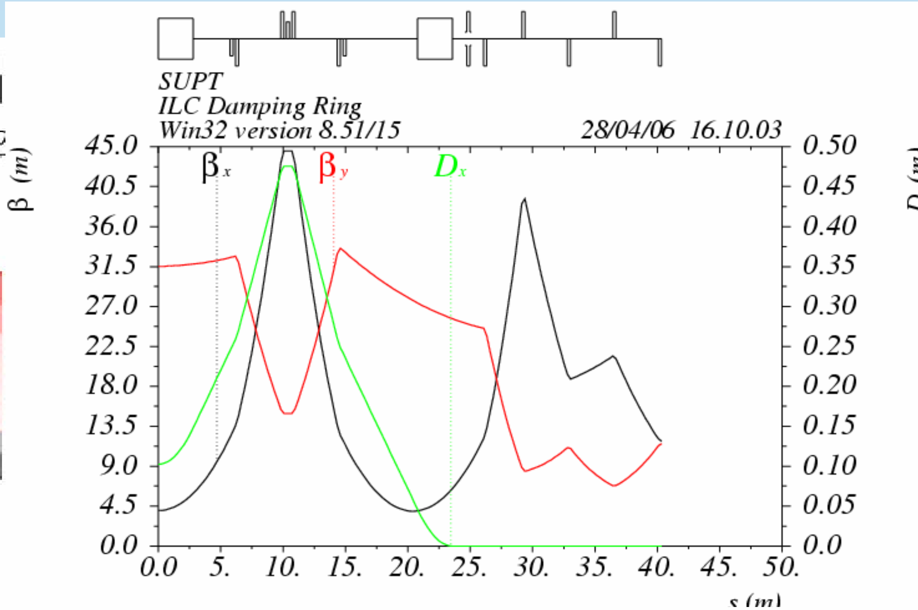


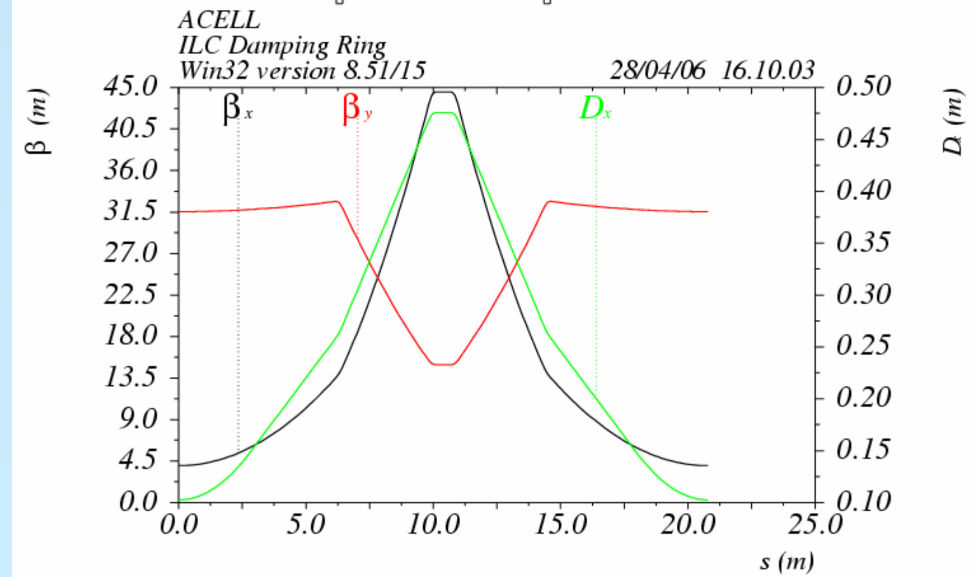


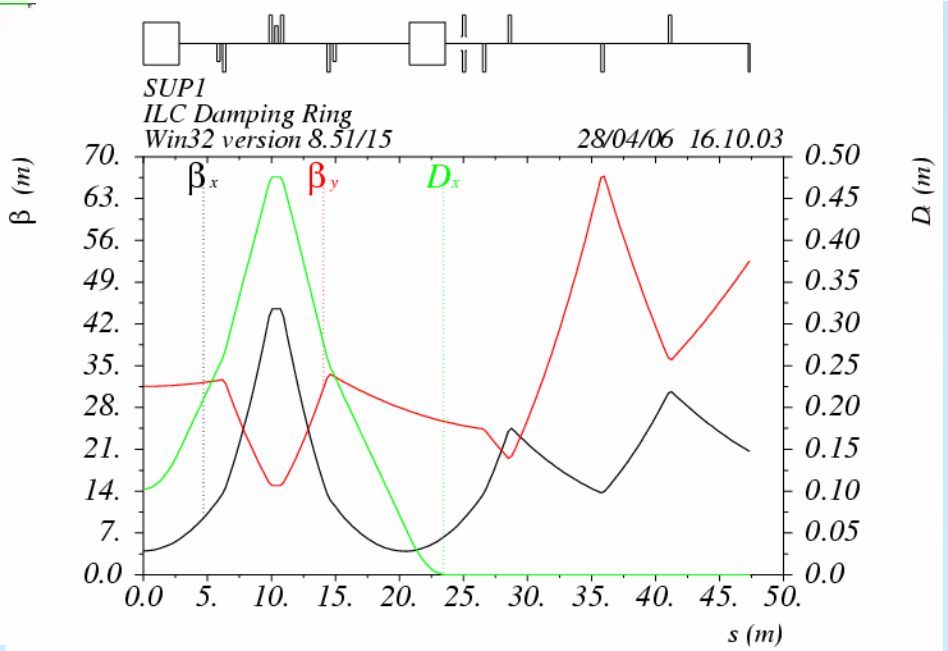


4 GeV ring, 3 Km







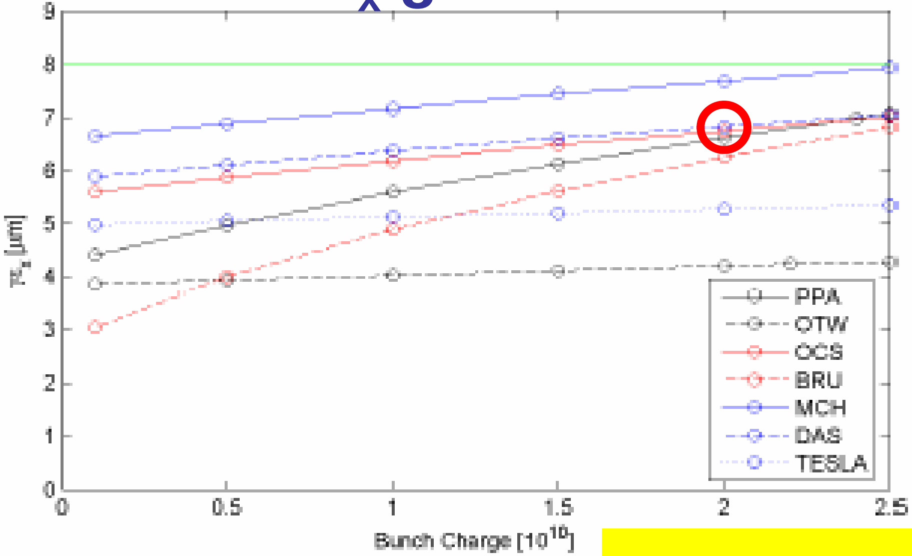


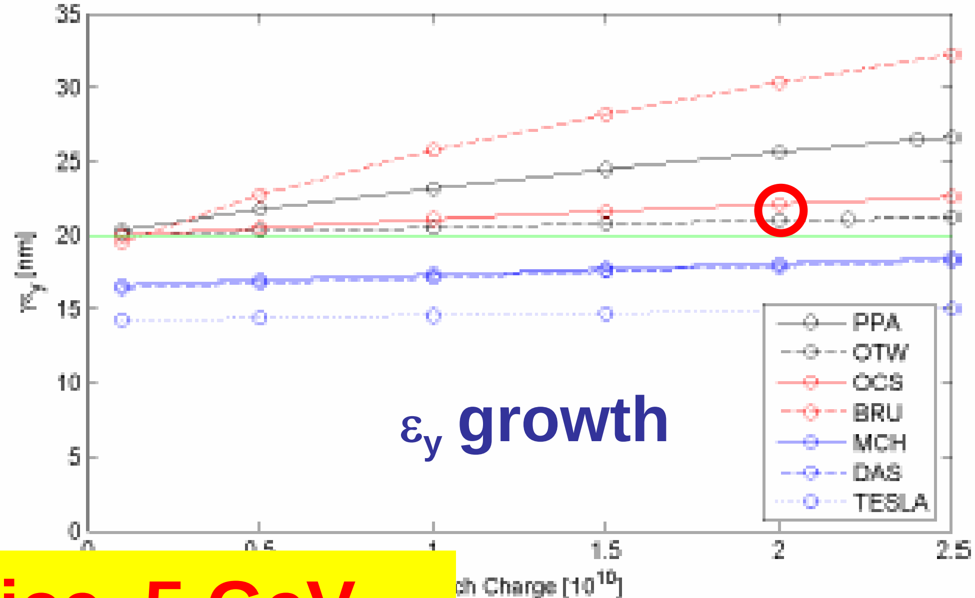
Possible issues of shorter rings

- Same as ILCDR, that is:
  - Dynamic aperture
  - HER e-cloud instability → new electrodes ?
  - LER Intra Beam Scattering
  - Fast Ion Instability → gaps in train

Intra Beam Scattering

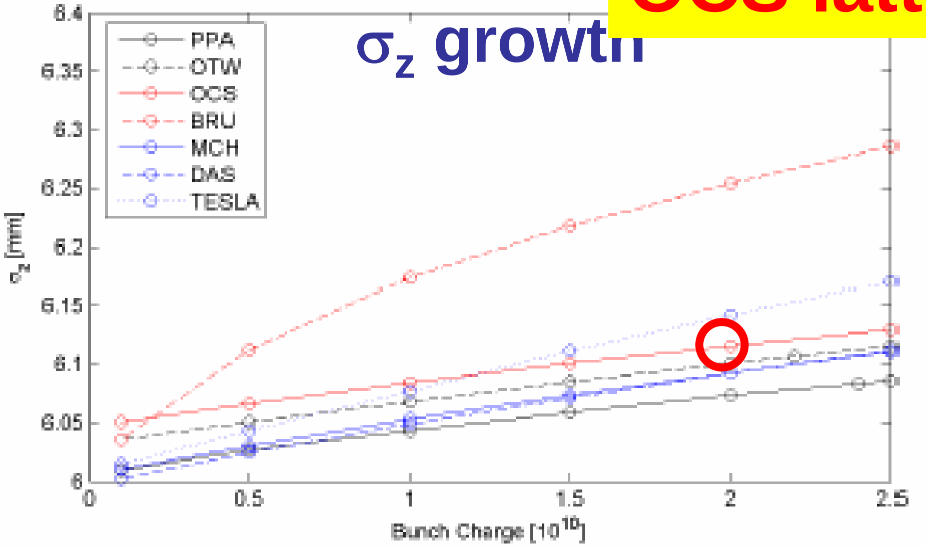
ε_x growth

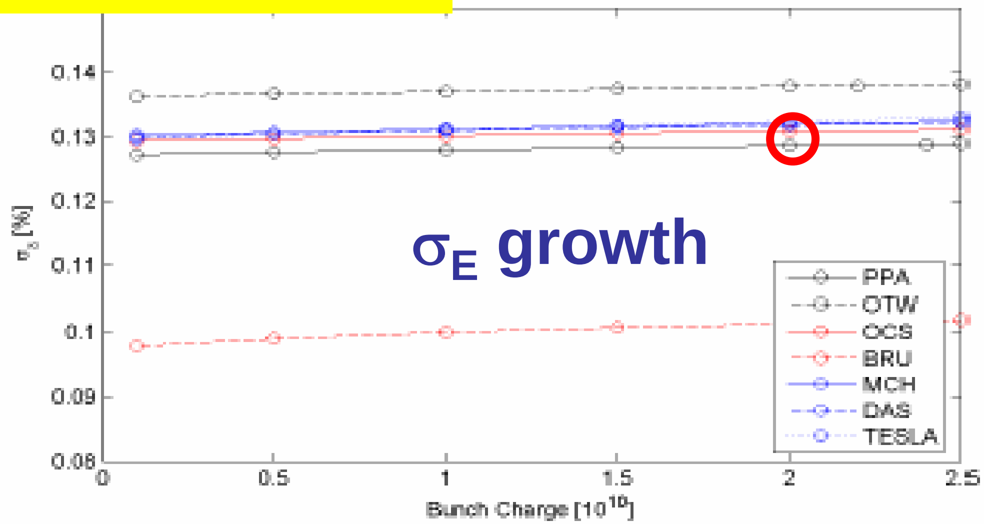




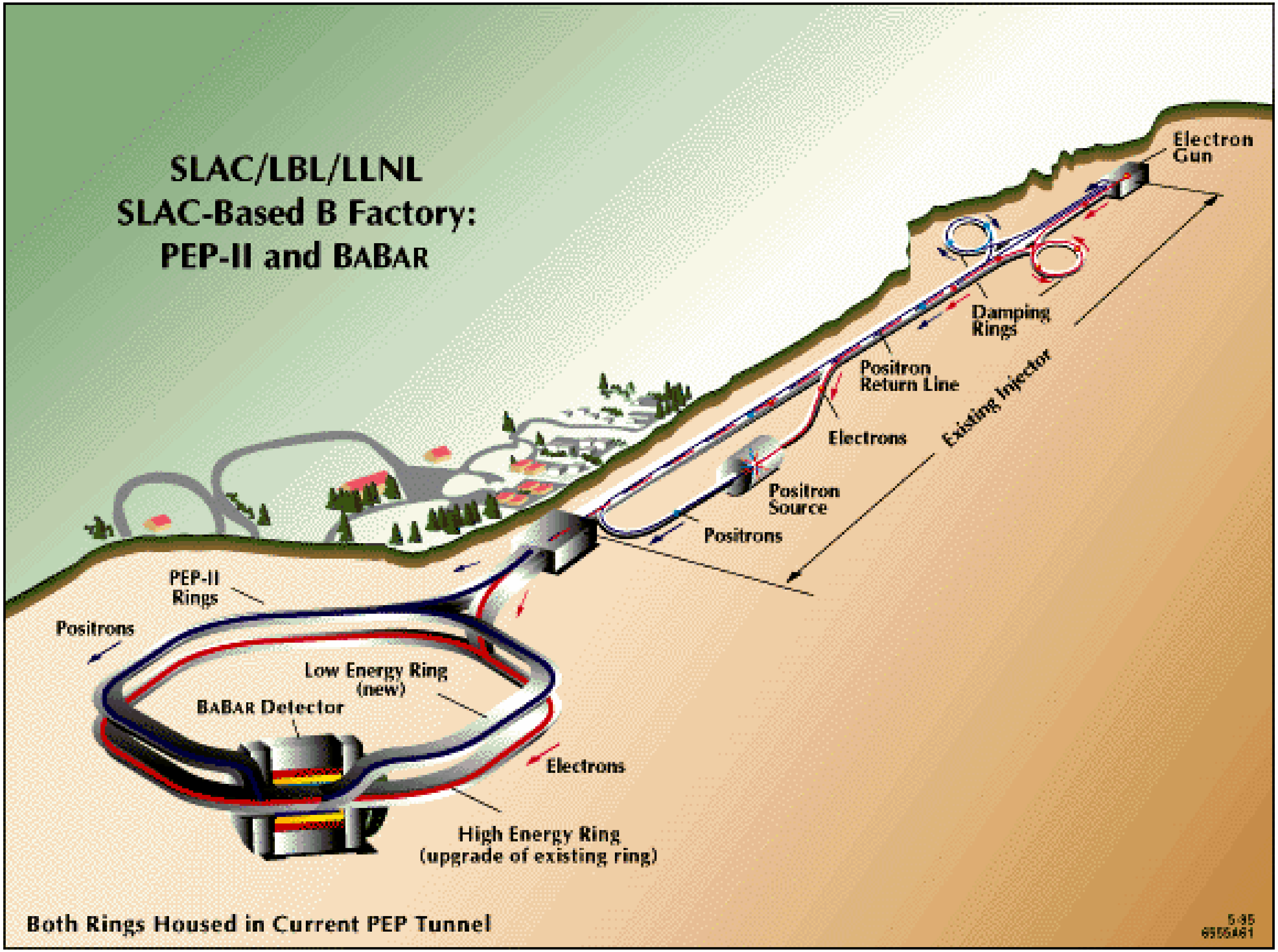
OCS lattice, 5 GeV

σ_z growth





DR Baseline Configuration Document, Feb. 06

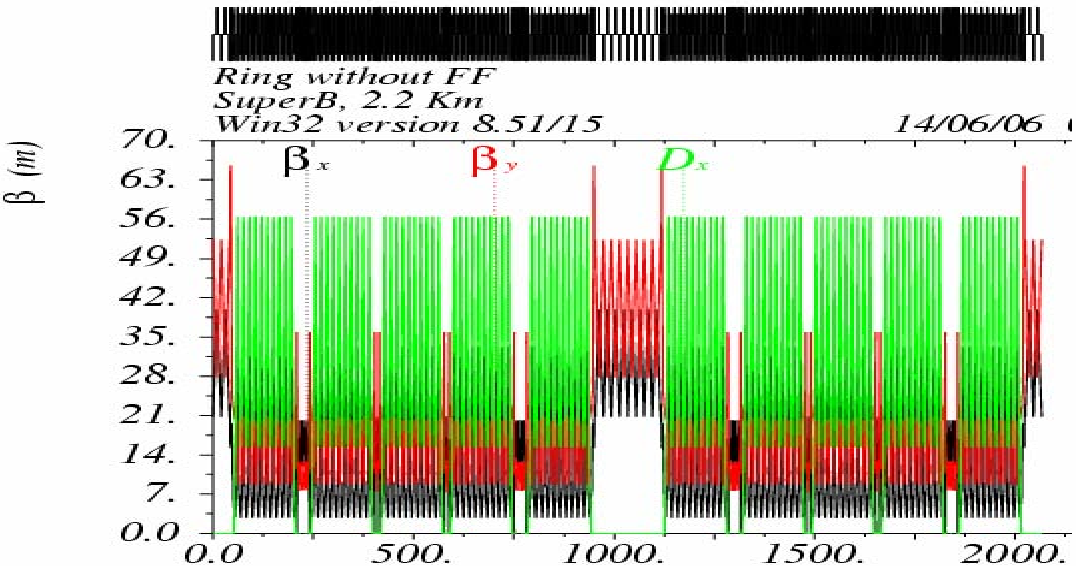

SLAC/LBL/LLNL
SLAC-Based B Factory:
PEP-II and BABAR
Electron Gun
Damping Rings
Positron Return Line
Existing Injector
Electrons
Positron Source
Positrons
PEP-II Rings
Positrons
Low Energy Ring (new)
BABAR Detector
Electrons
High Energy Ring (upgrade of existing ring)
Both Rings Housed in Current PEP Tunnel

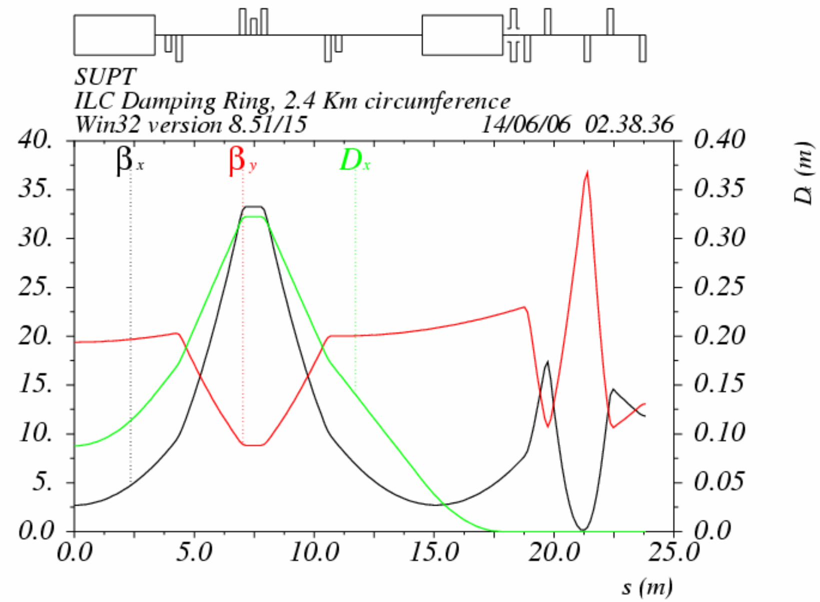
2.2 Km Rings

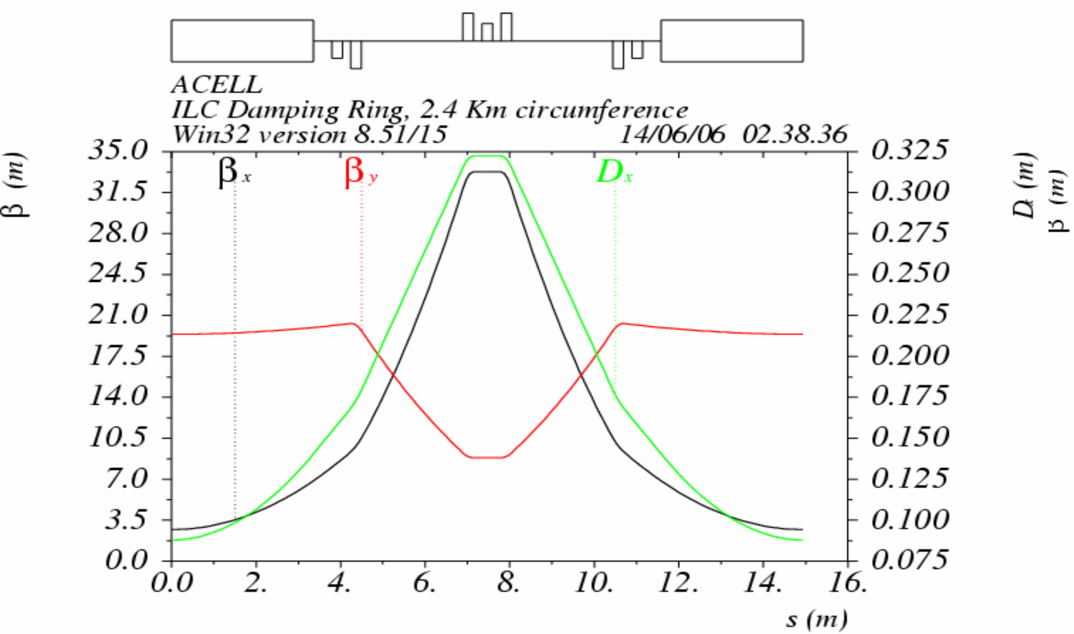
- A first solution was found by:
  - Shortening drifts in dispersion suppressors
  - Eliminating some of the FODO cells
  - Shortening wiggler-free sections in 7 GeV ring
  - Shortening long drift sections in 4 GeV

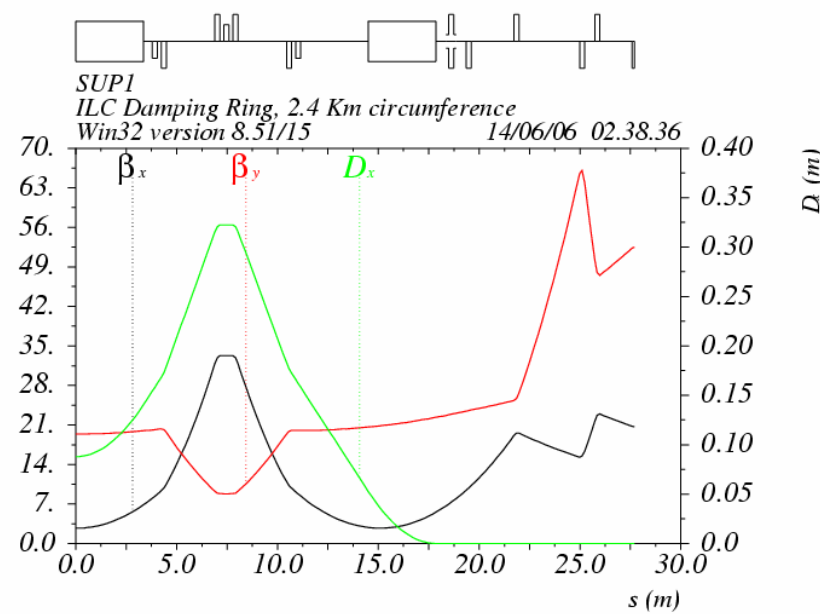
- Preliminary, can be easily improved

7 GeV ring, 2.2 Km

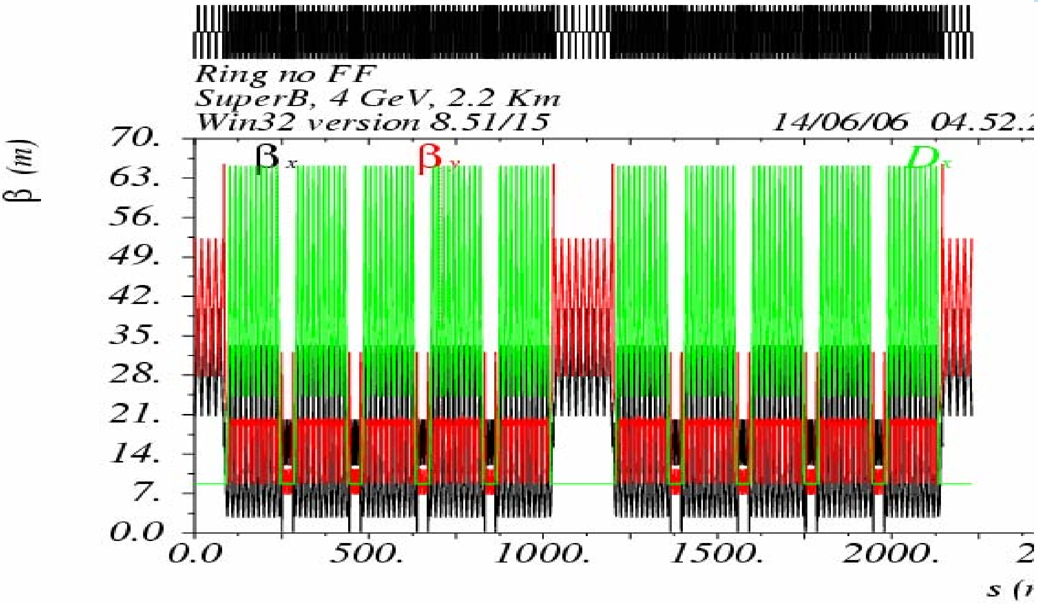


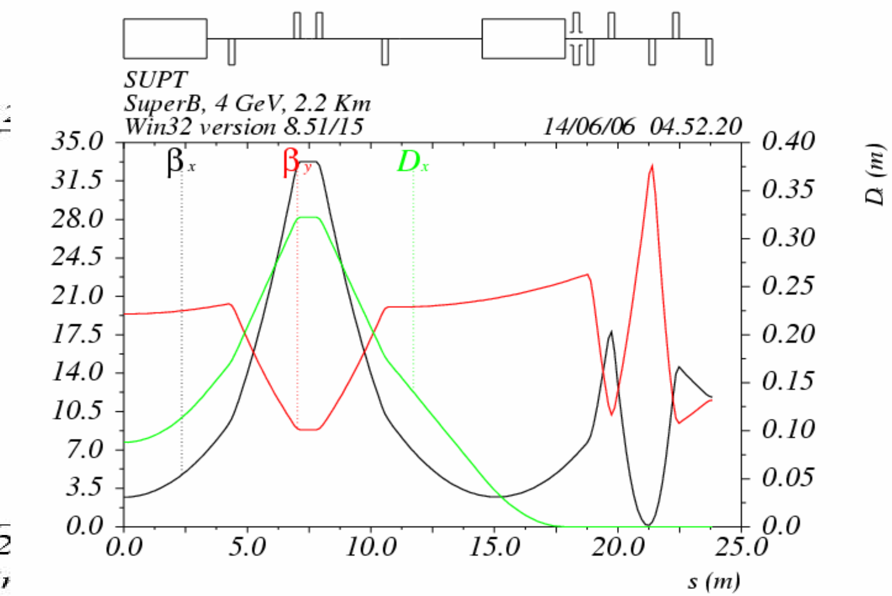


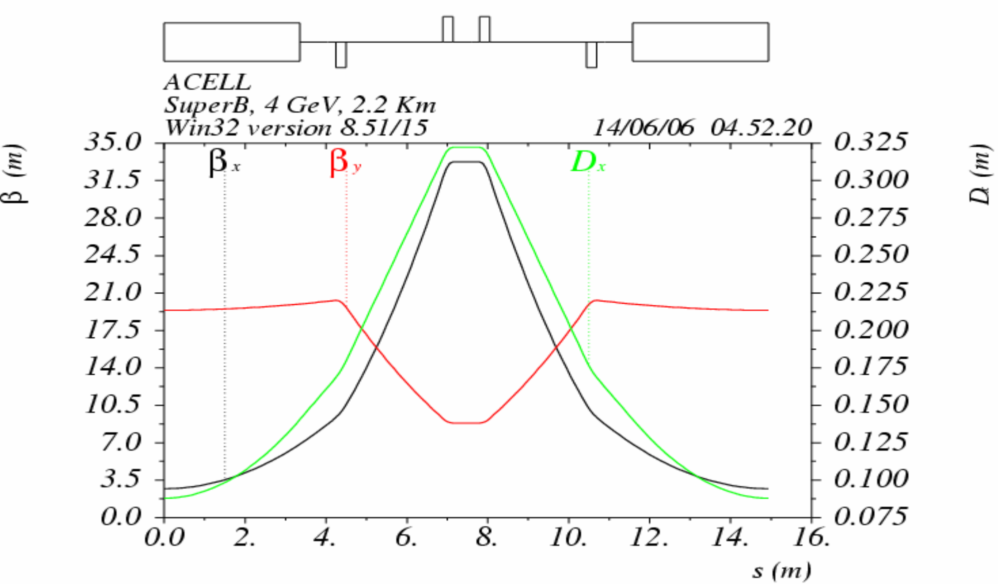


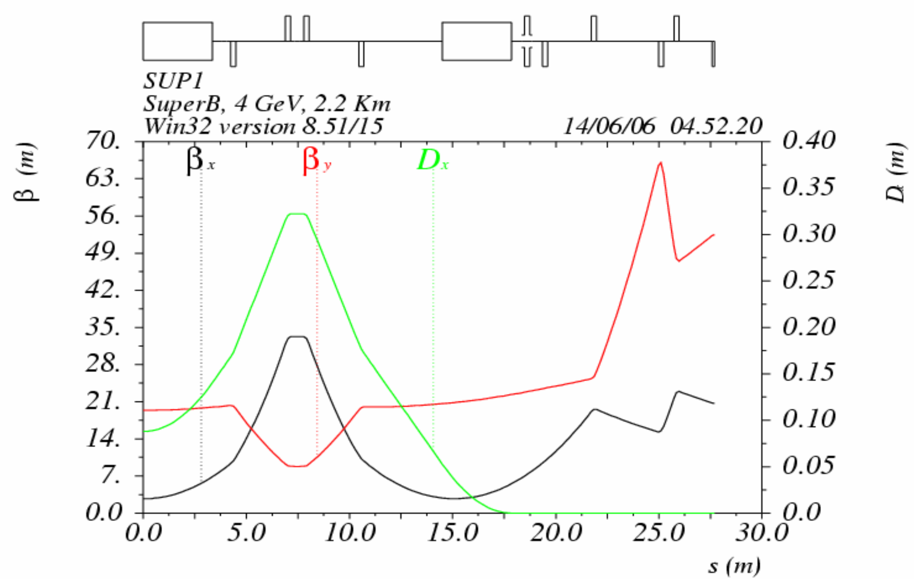


4 GeV ring, 2.2 Km



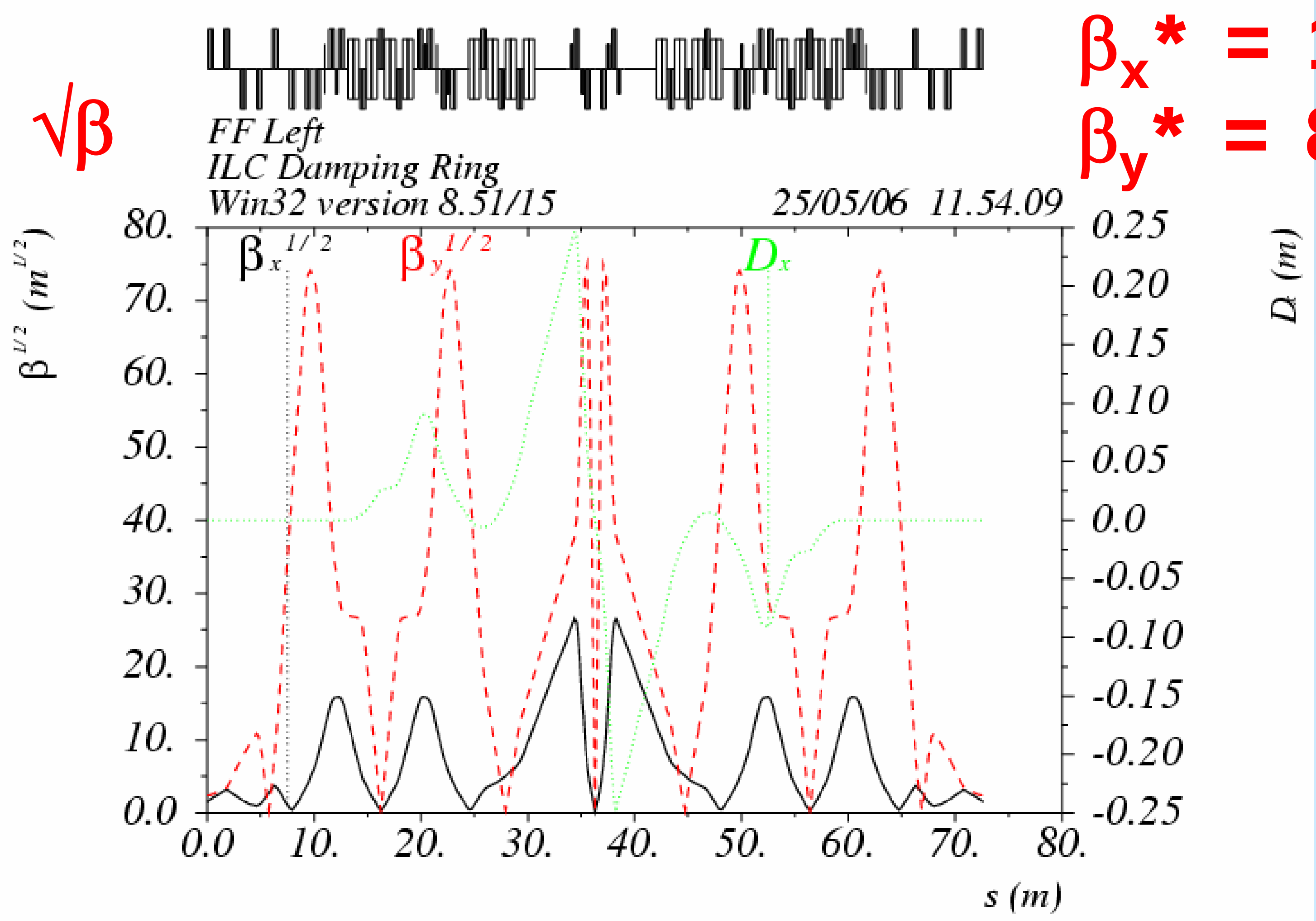






A. Seryi Final Focus (March 06)

$\sqrt{\beta}$

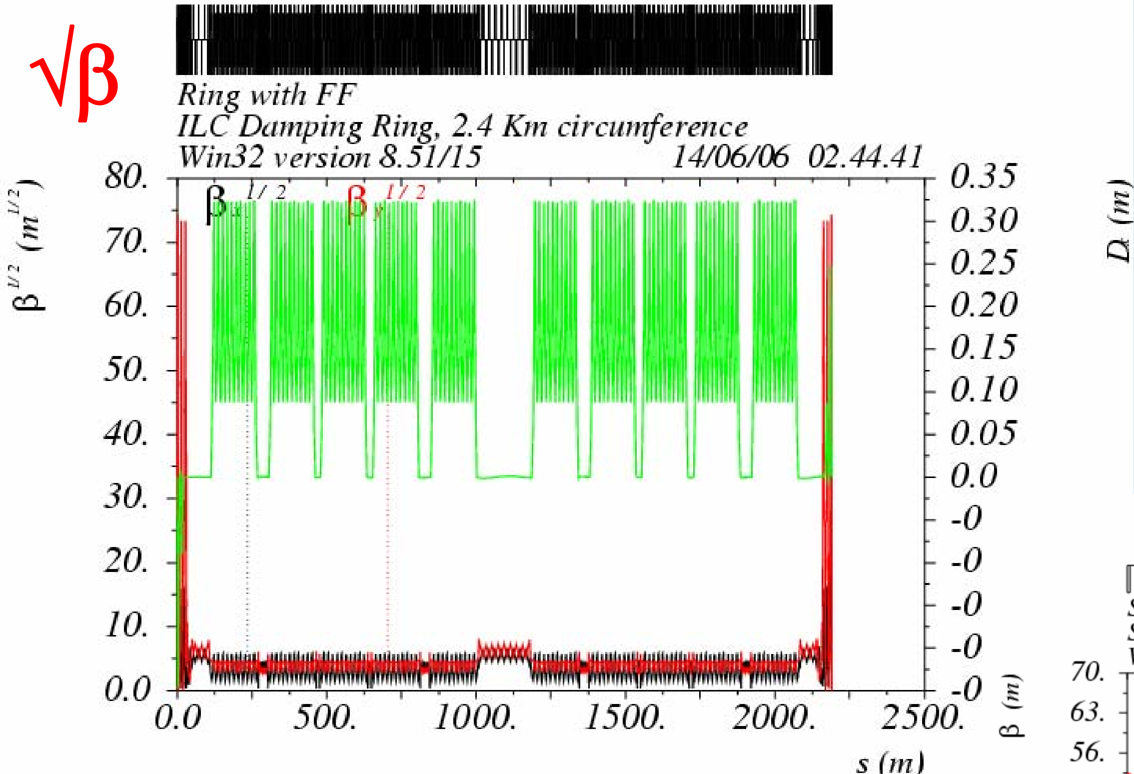


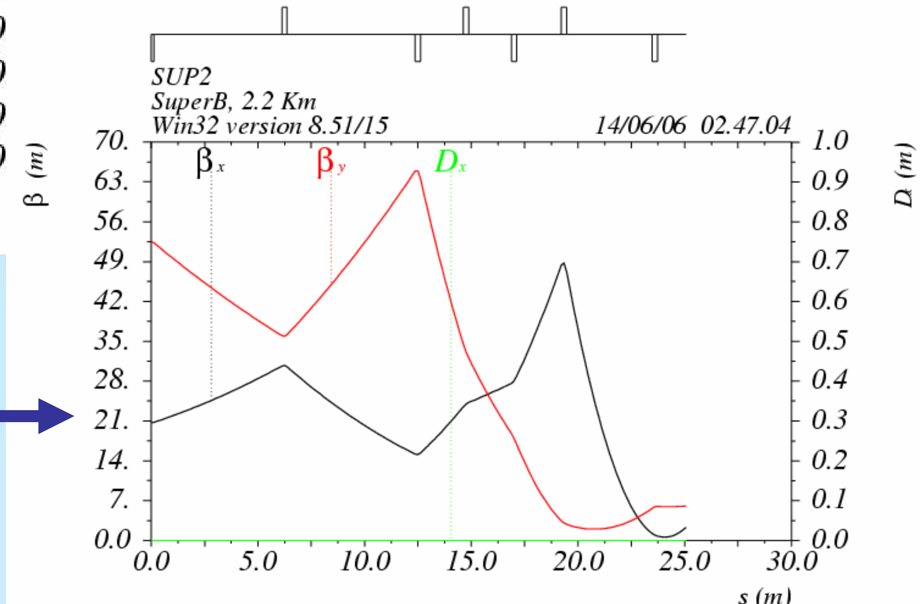
$\beta_x^* = 17.6$ mm

$\beta_y^* = 80\ \mu$

2.2 Km ring with FF

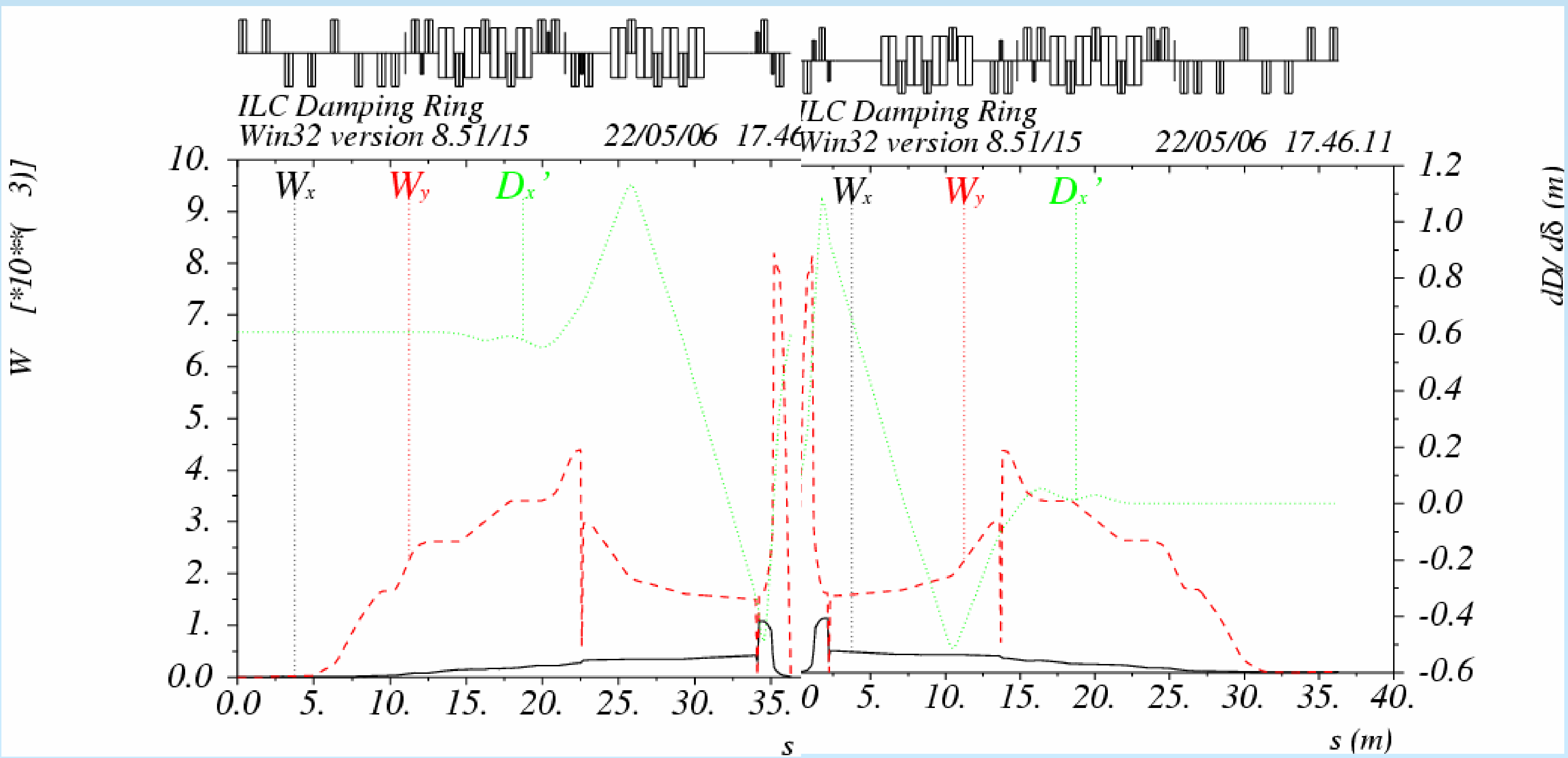
√β





Matching section to FF →

Chromatic functions W_x, W_y and 2^{nd} order dispersion in FF



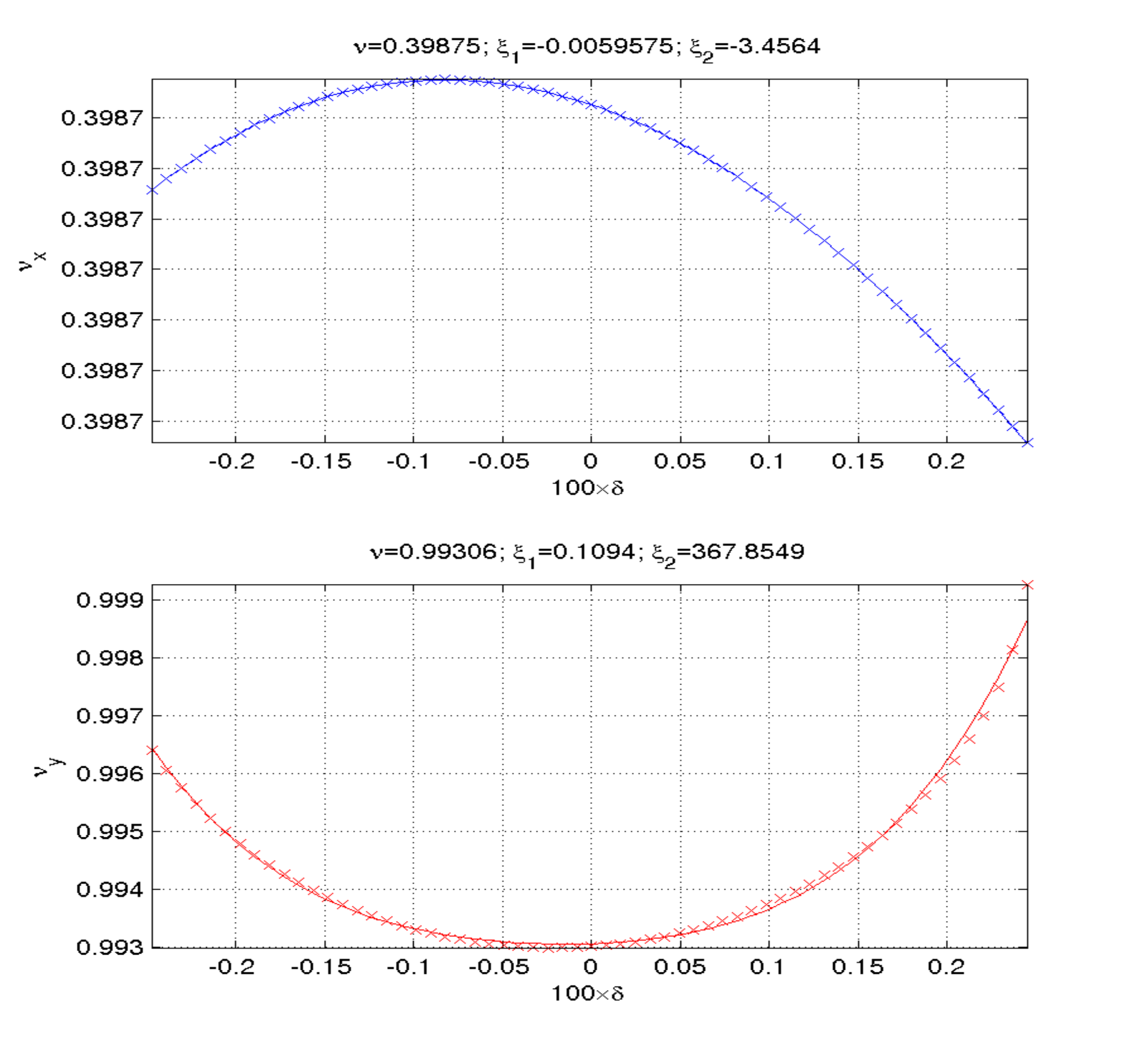
Comparison of Ring Parameters

	4 GeV			7 GeV		
C (m)	6114.	3251.	2230.	6114.	3251.	2230.
B_w (T)	1.6	1.4	1.4	1.6	1.4	1.4
L_{bend}(m)	5.6	5.6	6.72	11.2	10.6	6.72
N. bends	96	96	100	96	96	100
B_{bend} (T)	0.078	0.155	0.125	0.136	0.144	0.218
Uo (MeV/turn)	5.7	4.4	3.5	10.7	6.4	7.
N. wigg. cells	8	8	8	6	4	4
τ_x (ms)	28.8	19.8	17.	26.	24.	14.5
τ_s (ms)	14.4	10.	8.6	13	12.	7.25
ε_x (nm)	0.5	0.38	0.37	0.5	0.565	0.64
σ_E	1.1×10^{-3}	1.1×10^{-3}	10^{-3}	1.3×10^{-3}	1.32×10^{-3}	1.35×10^{-3}
I_{beam} (A)	2.5	2.5	2.5	1.4	1.4	1.4
P_{beam}(MW)	14.	11.	8.8	15.	9.	9.8
P_{wall} (MW) (50% eff)	43.5	30	28	-	-	-

Dynamic aperture

- Preliminary dynamic aperture calculations for the 3 Km ring @ 7 GeV with FF have been performed by A. Wolski
- Studied tune behavior vs energy deviation
- First dynamic aperture & frequency map analysis
- Tunes not optimized → needs work
- Sextupoles not optimized → needs work

Chromaticity vs energy deviation for ideal 3 Km lattice without FF



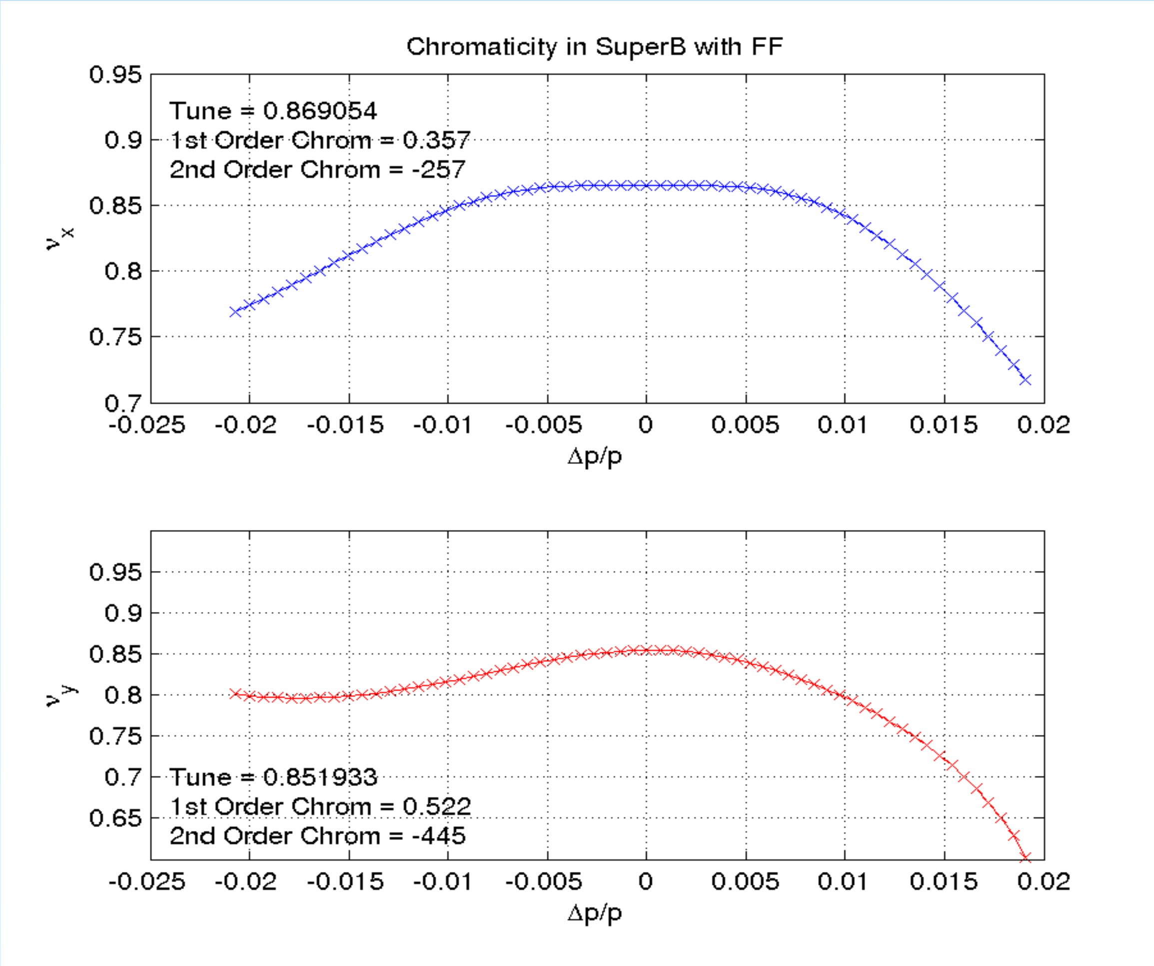
A. Wolski

x tune

y tune

Chromaticity vs energy deviation for ideal 3 Km lattice with FF

A. Wolski



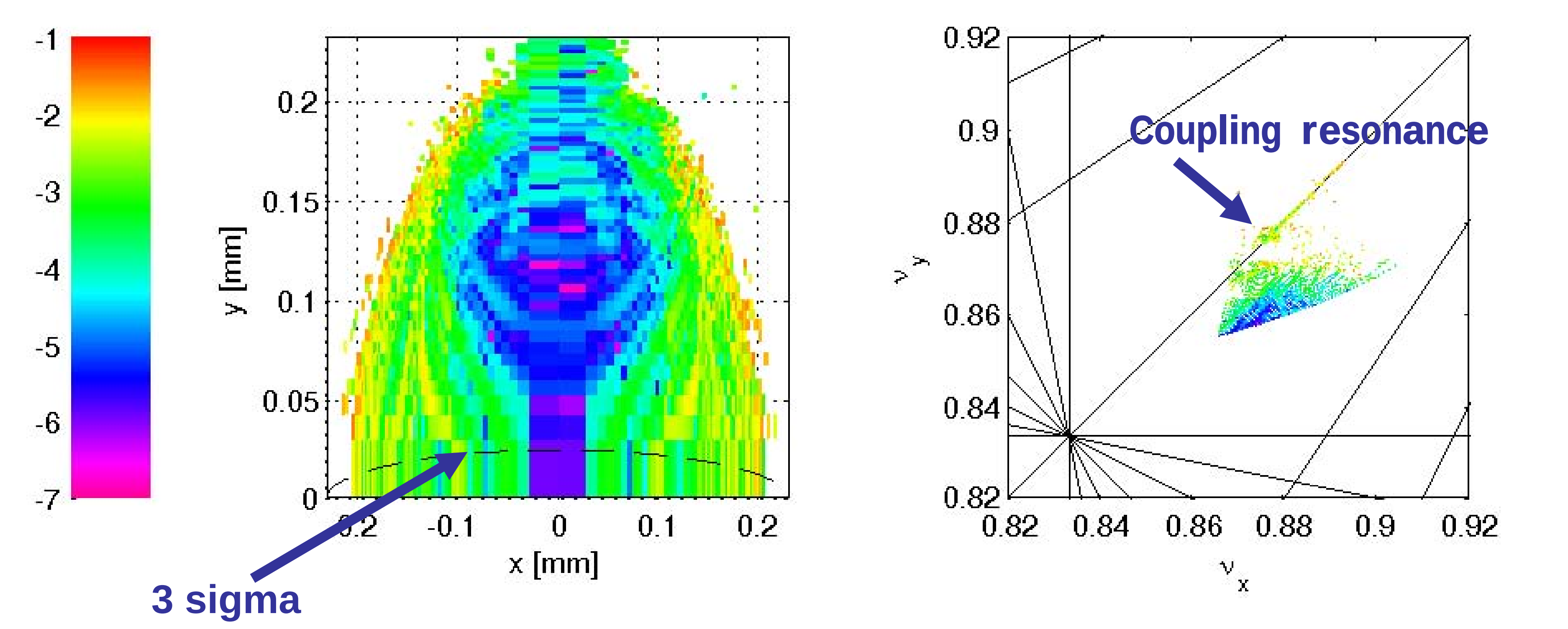
x tune

y tune

Energy acceptance between 1% and 2%

Dynamic aperture for "ideal" lattice with FF (3 Km, 7 GeV)

A. Wolski



Coordinate space

Tune space

Frequency map analysis, sextupoles tuned for 0 chromaticity

Conclusions

- 3 rings with asymmetric energies have been studied by scaling the ILCDR OCS lattice
- Final Focus has been inserted in all
- They all look reasonable
- A lot of work is still needed:
  - Optimization of arc cell
  - Dynamic aperture optimization
  - Dependence of vertical emittance from errors
  - Collective effects
- Beam instabilities will be different due to different energies and need to be studied especially for the LER
- There is full synergy with ILCDR as requested