Reduced Bunch Number
Damping Ring and Upgrade

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Low-power option

Reduce the number of bunches (2625 → 1312):

→ Smaller circumference damping ring (6.4 km → 3.2 km)

same number of particles per bunch

Same bunch distance

→ same current

1 TeV Upgrade:

→ assumes re-establishment of full RDR bunch number (2625) with the same number of particles per bunch

→ double the current

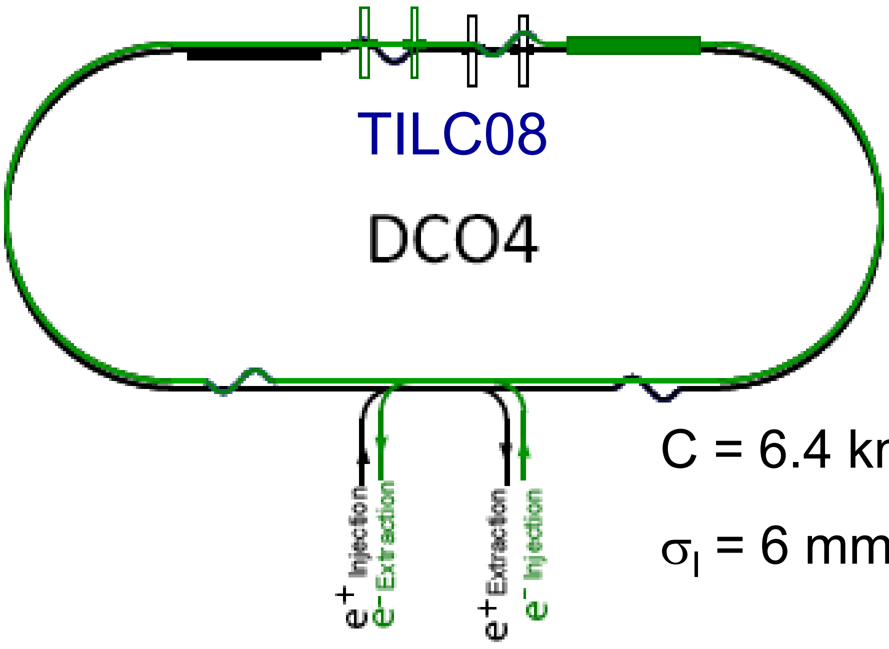
DR Lattice

Low Power option

$N_{bunches}$ 2625 → 1312

Circumference 6.4km → 3.2km

SB2009 lattice has same layout, bunch length and momentum compaction as TILC08 DCO lattice

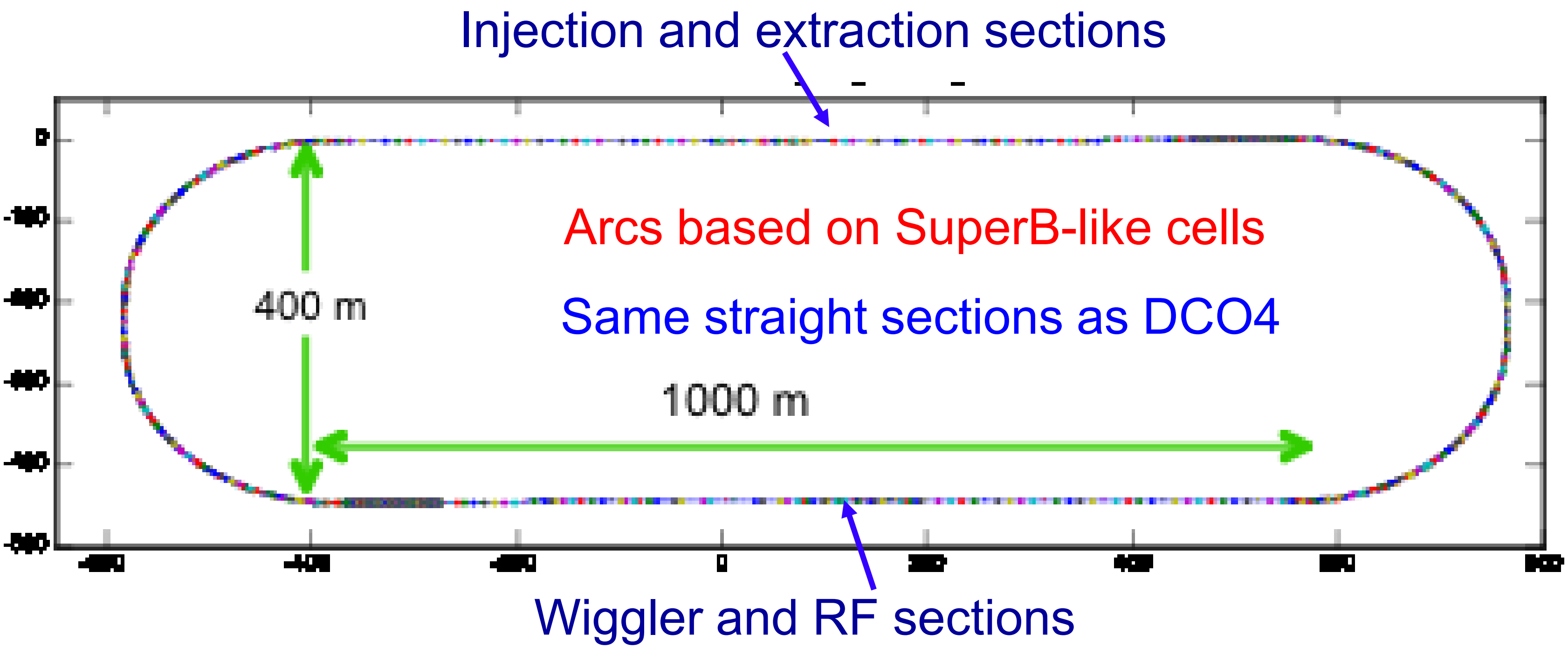


C = 6.4 km

σ_l = 6 mm

Ref. DCO4

Layout of the 3.2km damping rings



Injection/extraction lines of the two rings are superimposed

- RF cavities: 16 ⇒ 6
- Wigglers: 88 ⇒ 32

http://ilcagenda.linearcollider.org/materialDisplay.py?contribId=516&sessionId=11&materialId=slides&confId=2628

http://ilcagenda.linearcollider.org/contributionDisplay.py?contribId=119&sessionId=27&confId=3461

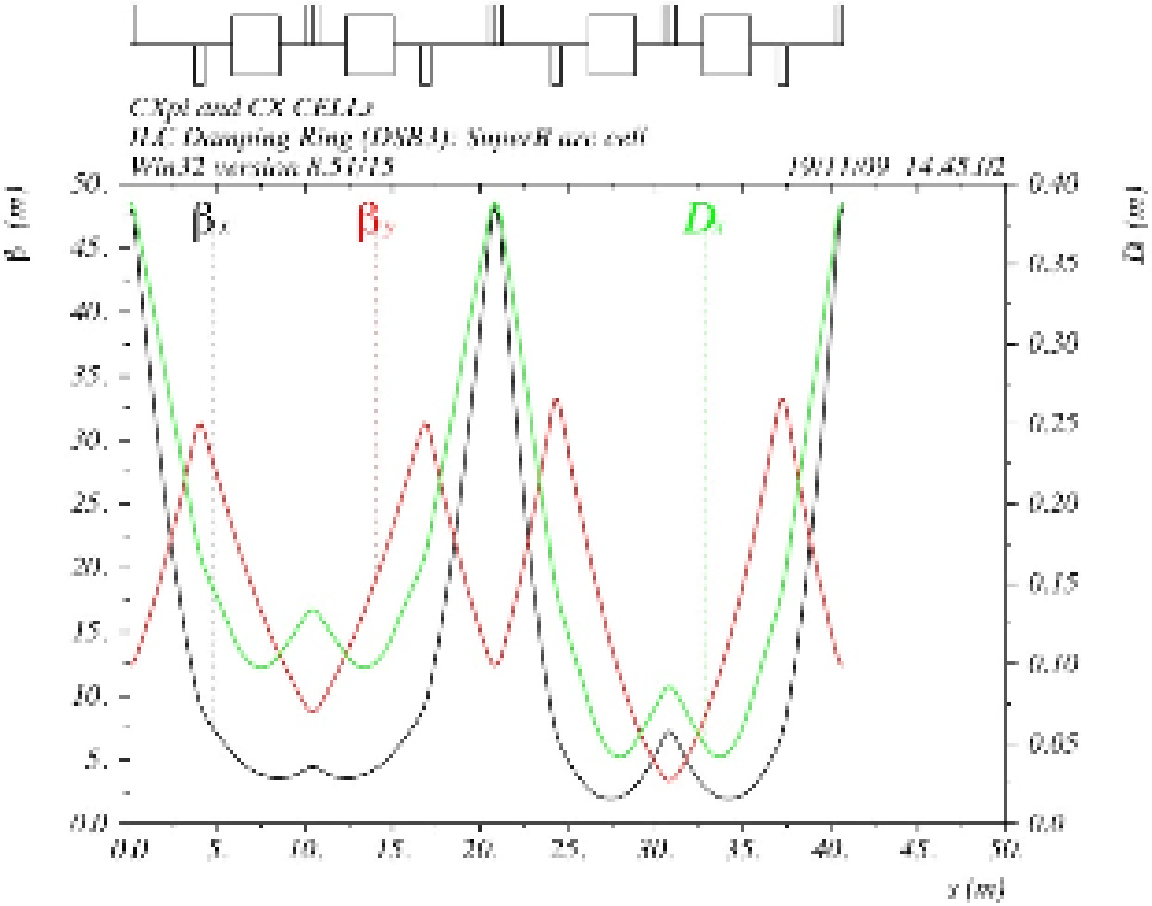
Parameter list for the RDR and the TILC08 version of the damping ring (DCO4) compared with the SB2009 3.2 km ring (DSB3)

	RDR OCS6	TILC08 DCO4	SB2009 DSB3
Circumference (m)	6695	6476	3238
Energy (GeV)	5	5	5
Bunch number	2625	2610	1305
N particles/bunch	2×10^{10}	2×10^{10}	2×10^{10}
Damping time τ_x (ms)	25.7	21	24
Emittance ε_x (nm)	0.51	0.48	0.53
Emittance ε_y (pm)	2	2	2
Momentum compaction	4.2×10^{-4}	1.7×10^{-4}	1.3×10^{-4}
Energy loss/turn (MeV)	8.7	10.3	4.4
Energy spread	1.3×10^{-3}	1.3×10^{-3}	1.2×10^{-3}
Bunch length (mm)	9	6	6
RF Voltage (MV)	24	21	7.5
RF frequency (MHz)	650	650	650
B wiggler (T)	1.67	1.6	1.6
Lwig total	200	216	78
Number of wigglers	80	88	32

Lattices for the 3.2 km ring

- 2 different lattices have been proposed
- DSB3 based on the SuperB arc cell (INFN)
- DMC3 based on FODO cell (IHEP)
- Steps to arrive to a lattice choice at the next GDE meeting in Eugene, March 19 - 23, 2011:
  - 10 January 2011 webex meeting
    - Discussion on 3.2 km Lattice Requirements
  - 19 January 2011, SLAC, ROB A/B, 11:00-13:00
    - Define further steps and procedure for the lattice choice
- The following evaluations are based on the DSB3 lattice

DSB3 Optical functions of the arc cells

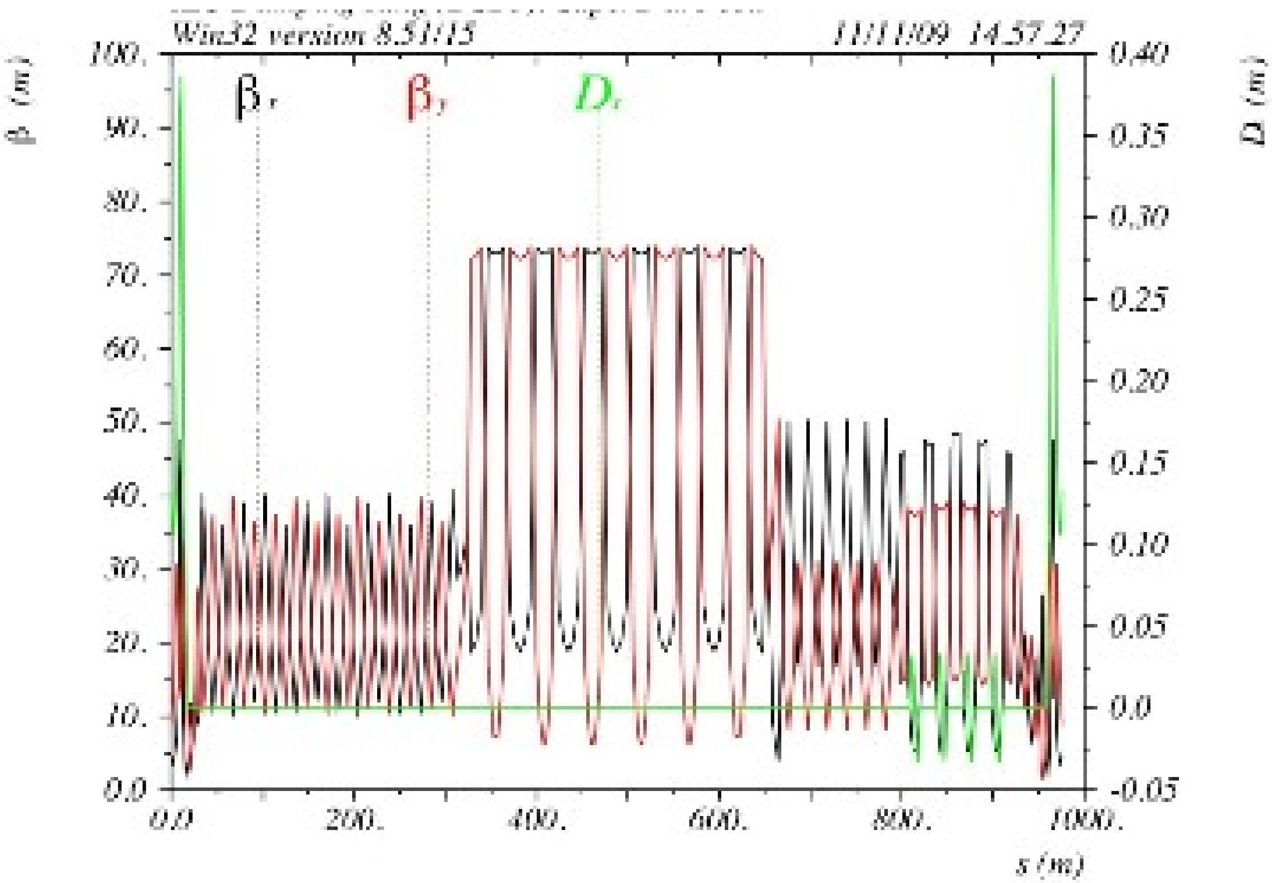


The arc lattice is based on the SuperB arc cells.

2 adjacent cells with very similar but with different phase advance: one is π and the other ~0.75π.

By tuning the phase advance in the second cell, emittance and momentum compaction can be tuned.

Optical functions in the Inj/Extr straight section

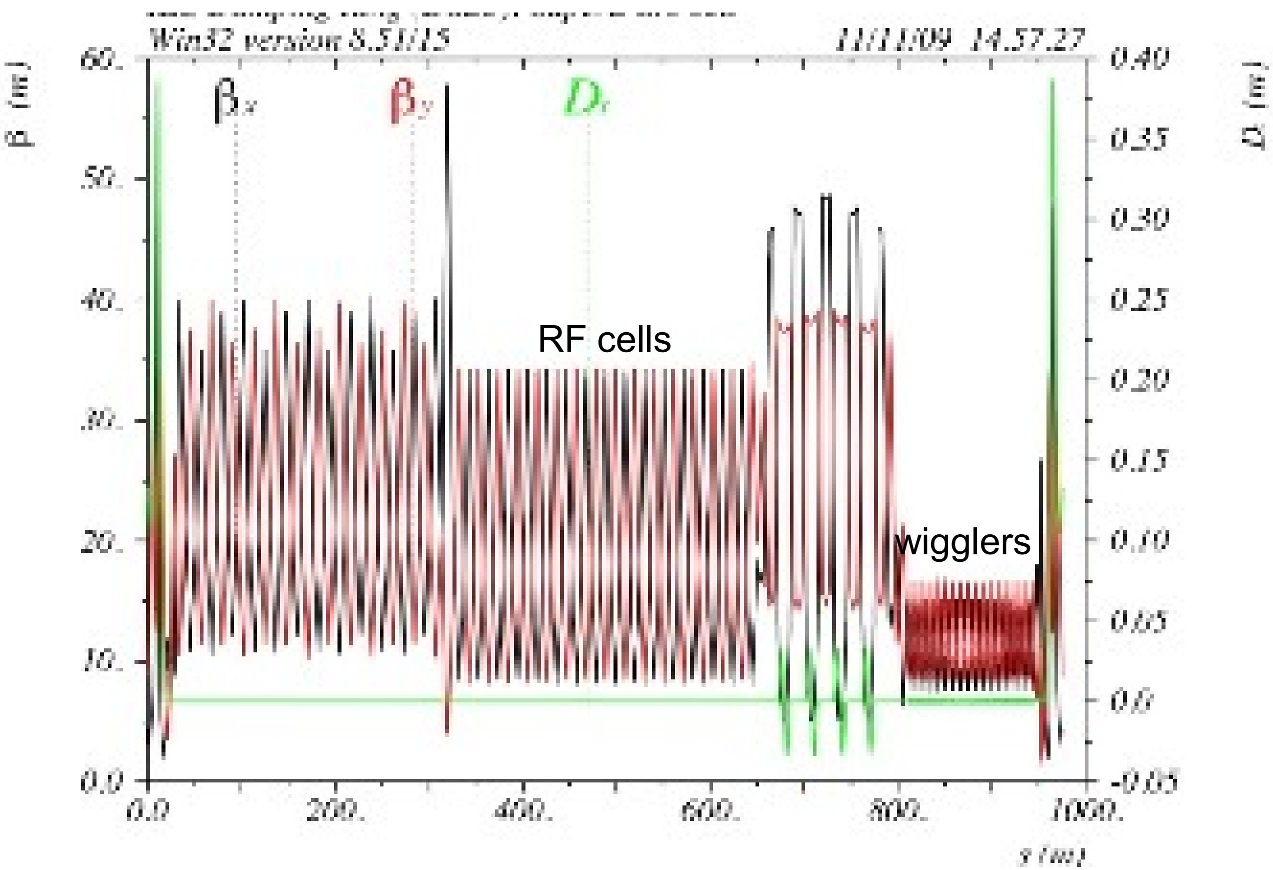


The e^- and e^+ ring are one on top of the other with counter-rotating beams

The injection line entering the electron ring is superimposed on the positron extraction line and vice versa

The lattice of the straight sections is made of the same building blocks as the 6.4km racetrack lattice (DCO4)

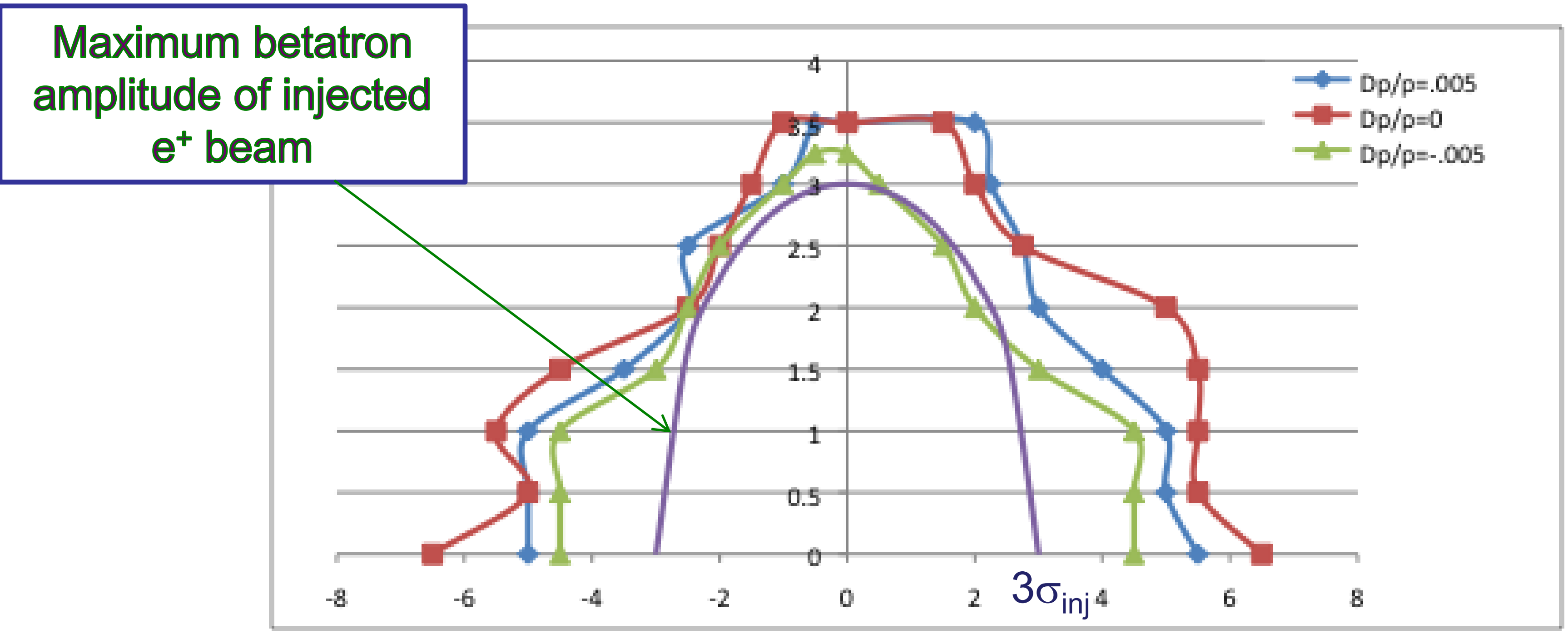
Optical functions in the RF/wiggler straight section



The wiggler straight is located downstream of the RF cavities in order to avoid damage by synchrotron radiation

The RF cavities for each ring are offset from the center of the straight so that they are not superimposed on top of each other

Dynamic aperture



Parameters for SB2009 low and high power compared to DCO4

	DCO4 High Power	SB2009 Low Power	SB2009 High Power
Circumference (m)	6476	3238	3238
N bunches	2610	1305	2610
N part./bunch	2×10^{10}	2×10^{10}	2×10^{10}
Damping time τ_x (ms)	21	24	24
Emittance ε_x (nm)	0.44	0.53	0.53
Emittance ε_y (pm)	2	2	2
Energy loss/turn (MeV)	10.2	4.5	4.5
Energy spread	1.3×10^{-3}	1.2×10^{-3}	1.2×10^{-3}
Momentum compaction	1.6×10^{-4}	1.3×10^{-4}	1.3×10^{-4}
B wiggler (T)	1.6	1.6	1.6
Wiggler period (m)	0.4	0.4	0.4
Wiggler length (m)	2.45	2.45	2.45
Total wiggler length (m)	216	78	78
Number of wigglers	88	32	32
Bunch length (mm)	6	6	6
Overvoltage	2.1	1.7	1.7
RF Voltage (MV)	21	7.5	7.5
Average current (A)	0.39	0.39	0.78
Beam Power (MW)	3.97	1.76	3.51
N. of RF cavities	16	6	12
Power/cavity (kW)	248	293	292
Voltage/cavity (MV)	1.31	1.25	0.63
Klystron/ring	4	2	4
Power/klystron (kW)	992	880	880

Magnet counts

	DSB3 (3.2km)	DCO4 (6.4km)
Arc dipole length	2.7 m	2.0 m
Arc dipole field (2 types)	0.26/0.36 T	0.27 T
Number of arc dipoles	128	200
Chicane dipole field	0.27 T	0.27 T
Number of 1 m dipoles (in chicanes)	48	48
Total number of quadrupoles	494	692
Quadrupole length	0.6 - 0.3 m	0.3 m
Maximum quadrupole gradient	17 T/m	12 T/m
Total number of sextupoles	280	392
Maximum sextupole gradient	150 T/m^2	215 T/m^2
Total number of correctors (same as RDR)	300	300
Total number of skews (same as RDR)	240	240

RF System Comparison

	SB2009			DCO4
	Low P. 2 rings	High P. 2 rings	High P. 3 rings	High P. 2 rings
Circumf. (m)	3238	3238	3238	6476
N bunches	1305	2610	2610	2610
Damp. time τ_x (ms)	24	24	24	21
Num. of RF cavities (2 rings)	**12**	**24**	**24**	**32**
Power/cavity (kW)	**293**	**292**	**292**	**248**
Voltage/cavity (MV)	**1.25**	**0.63**	**0.63**	**1.31**
Tot. numb. of kly's	**4**	**8**	**8**	**8**

kickers

- A rise and fall time of 3 ns has been already demonstrated in the ATF using a 30 cm long strip-line kicker

- An ILC type beam extraction experiment using 60 cm strip-line kickers has been carried out at KEK-ATF: pulsers peak amplitude 10 kV, repetition rate 3.3 MHz, rise time of the kick field less than 5 ns.
- The multi-bunch beam stored in the DR with 5.6 ns bunch distance was successfully extracted with 308 ns bunch spacing. No deterioration of the extracted vertical beam size was observed (as measured with the laser wire).
- The angle jitter of the single bunch beam extraction was 3.5×10^{-4} rms , better than the requirements for ILC DR extraction ($< 7 \times 10^{-4}$).
- For multi-bunch beam extraction a trigger timing circuit is needed to compensate the time drift of the pulser.
- Very recently 30 bunch extraction with an rms angle jitter ~ 10^{-3} has been achieved. This value can be further reduced by precise tuning of the timing system or by using a feed forward system.

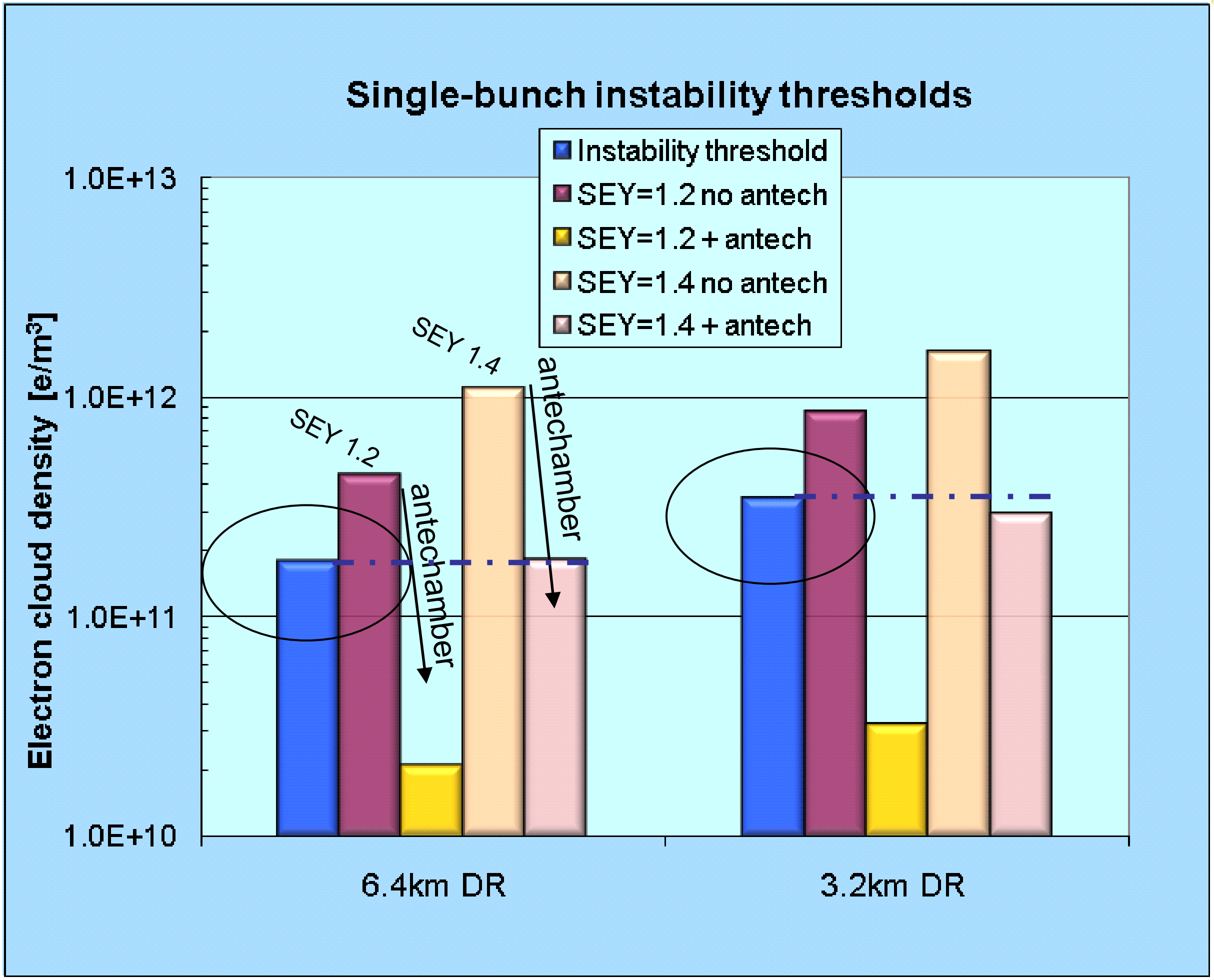
DR Group Comments on 3.2km and 6.4km Ring Options

1. **3.2km ring low power option vs 6.4km ring high power option:**
   a. **The electron cloud effects for these two options are similar. Thus it would be a low risk to move to the 3.2km low power option as the baseline choice.**
   b. **The kicker technology issues are identical for these two options.**
2. **3.2km ring high power option (2600 bunches)**
   a. **Decreasing the bunch spacing to 3ns is expected to result in a significant increase in the EC density in the ring.**
   b. **The kicker technology is more challanging for 3 ns bunch spacing**
   c. **Without further progress on EC mitigation capabilities, it is likely that doubling the number of bunches from the low P option would necessitate the addition of a second positron damping ring.**

ECLOUD issues for 1300 and 2600 bunches will be discussed by Mark in the next talk

Back up slides

Compare thresholds for 6 km and 3km DR

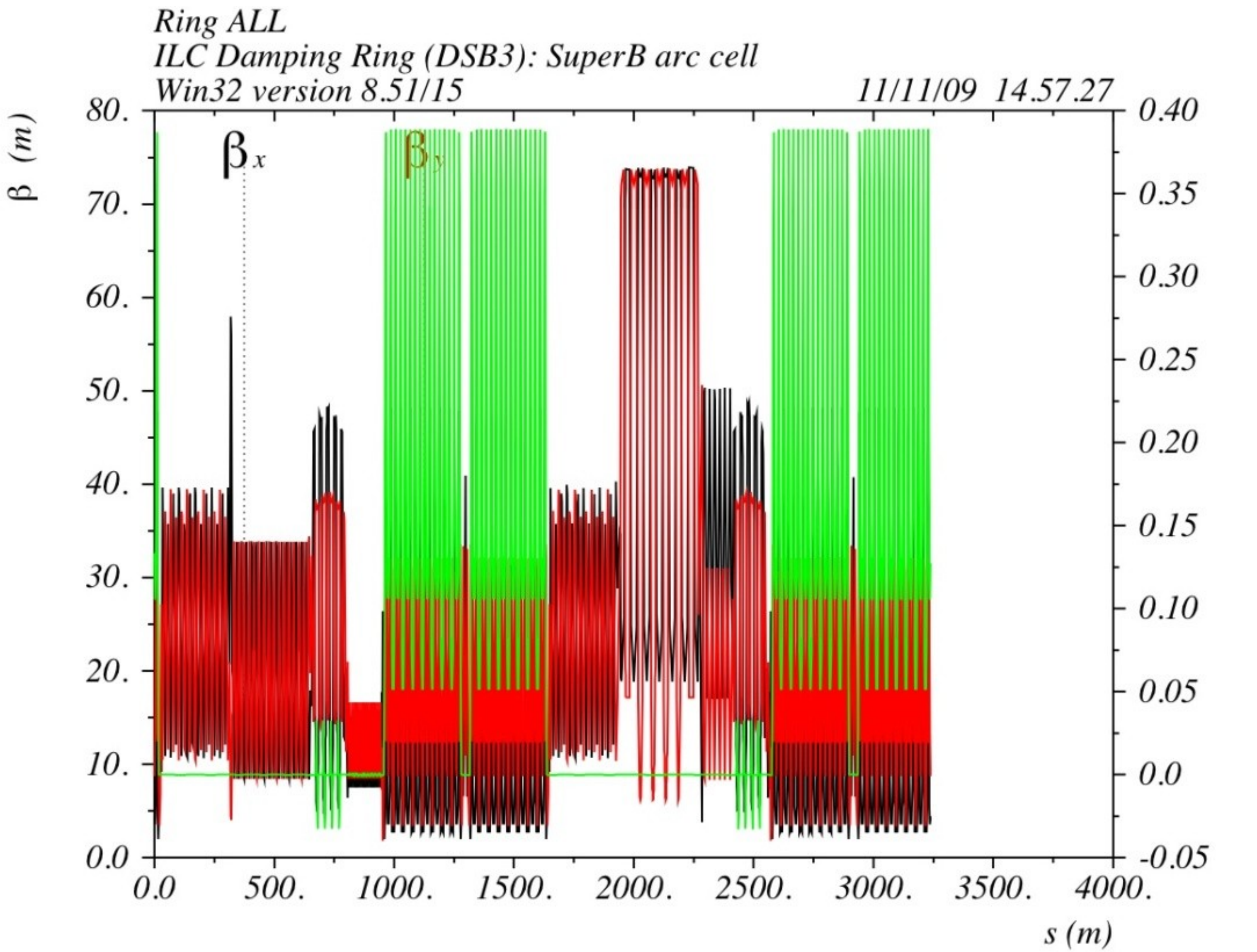


Simulation Campaign 2010: compiled data of build-up simulations compared with the simulated beam instability thresholds. Overall ring average cloud densities are shown for the 6 km and 3 km rings. The surface Secondary Electron Yield (SEY) determines the cloud build-up and density level.

Base for Recommendation and Risk Assessment

- With respect to the RDR baseline, the EC risk level for adopting a reduced 3km Damping Ring while maintaining the same bunch spacing is: Low.
- The acceptable surface Secondary Electron Yield (SEY) may strongly depend on issues not yet thoroughly investigated such as beam jitter and slow incoherent emittance growth. Refined estimations of the photoelectron production rate by simulations will better define the maximum acceptable SEY.
- Reducing the positron ring circumference to 3-km eliminates the back up option of 12 ns bunch spacing (safer e- cloud regime) and may reduce the luminosity margins.
- In the event that effective EC mitigations cannot be devised for a 3km damping ring, an option of last resort would be to add a second positron damping ring.

Optical functions of the 3.2km damping ring



M. Biagini

Fast Ion Instability

"Simulations on the Fast-Ion Instability in the International Linear Collider Damping Rings", Eun-San Kim and Kazuhito Ohmi, Japanese Journal of Applied Physics 48 (2009) 086501

The simulation results show that the bunch-by-bunch feedback of about 50 turns is sufficient to suppress the fast-ion instabilities in the
damping ring. It is estimated that the tune shifts in the beam due to the ions are small.