Damping Ring

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KEKB Accelerator Review
Mar. 06, 1998

1. Motivation
2. Damping ring design example
3. Beam quality with DR

Motivation of damping ring

Improve the positron beam quality
to minimize the background to BELLE
and beam loss during injection.

Comparison of positron beam quality
of AR and 3.5GeV Linac.

	Linac	AR
Emittance	2.2 E-7	8.6 E-8
V Emittance	2.2 E-7	< E-8
	(full-width/2)	
Energy spread	0.5 %	0.12%
	0.25%(w ECS)	
	(full)	(2 σ)

LER acceptance is tight in IR(QC2RP).

The present design is consistent
with the Linac positron beam.

We accept all Linac beam(2.5 σ) of
the designed value with some margins.

Energy acceptance of LER is sufficient
from the view point of injection.

DR is located near the energy analyzer section(1 GeV).

In the present design study, the compressor consists of an S-band linac and a chicane.

After the compressor the bunch returned to the linac through an isochronous bend section.

Bunch compressor

Compression	1/10
S-band linac	20 MV
Chicane	1.6 T *1 m bend x 4

Positron beam at 3.5 GeV

Emittance	8.3 E-9 m
Energy spread(2σ)	0.3 %
Bunch length(2σ)	1 mm

Energy spread is limited by σ z of DR.

The objective of the damping ring would be to reduce the beam emittance and to increase the injection acceptance margins.

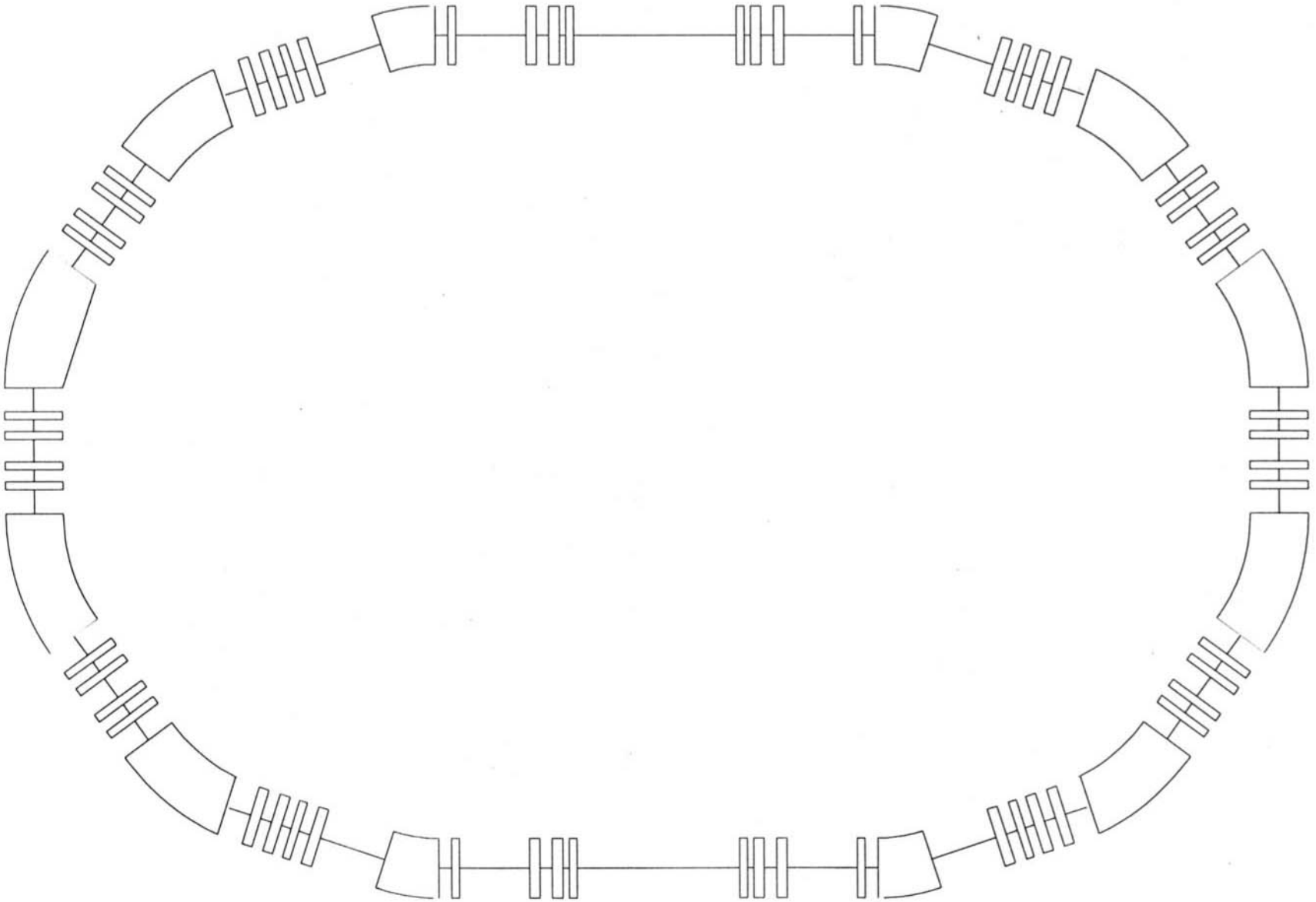
Ring design example (by XIAO, Aiming)

Energy	1 GeV
C	50 m (single bunch)
τx	6.8 msec
σz	5.5 mm
σE	6.4 E-4
Emittance	2.9 E-8 m

Choose a low-α lattice(Chasman-Green) to reduce the bunch length.

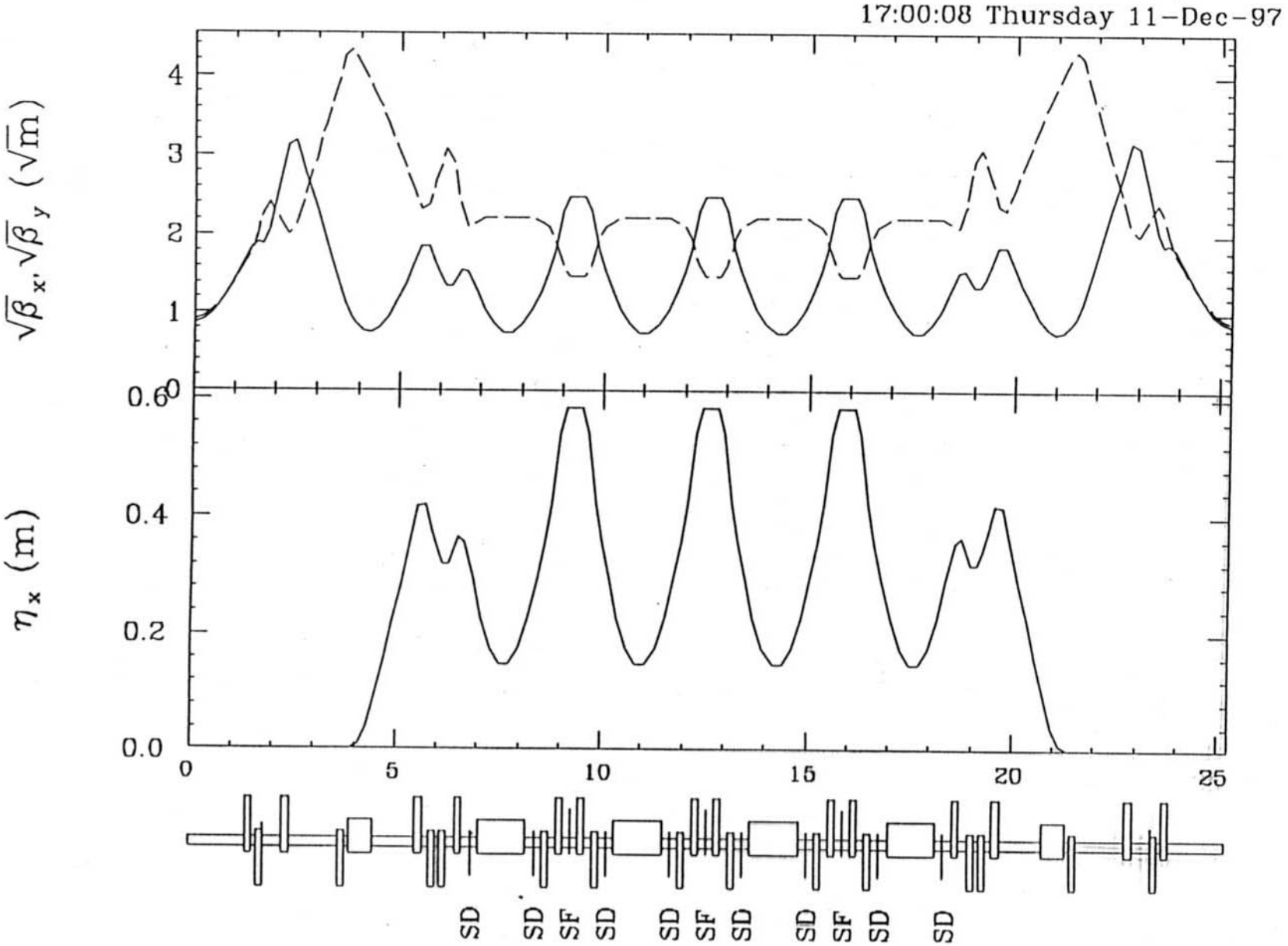
Damping factor: $\exp(-T/\tau E)=2.8$ E-3
at T=20 msec
(Repetition rate of linac:50Hz)

Injected beam is cooled sufficiently by the time of extraction.



△ Special consideration on Lattice Design

* make the structure more tight. using half B for dispersion suppressor.
* diffrent phase advance at H & V plain.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$\sqrt{\beta}_x, \sqrt{\beta}_y$ ($\sqrt{\mathrm{m}}$)
η_x (m)
0
1
2
3
4
0.0
0.2
0.4
0.6
0
5
10
15
20
25
SD
SD
SF
SD
SD
SF
SD
SD
SF
SD
SD

✿ Main Parameters of Magnets.

B:	N_B=8	L_B=1.16m	B_0(at the pole)=1.82T
BB:	N_{BB}=4	L_{BB}=0.58m	B_0(at the pole)=1.82T
QA:	N_{QA}=36	L_{QA}=0.14	B_{0max}(at the pole)*=1.4T
QB	N_{QB}=20	L_{QB}=0.18	B_{0max}(at the pole)*=1.4T
S	N_S=22	L_S=0.1	B''_{max}=234T/m^2

* Assume the radius of vacuum chamber is 50mm.

✿ Requirements of KEKB Damping Ring

Energy	E	1.0	GeV
Emittance	ε	$\leq 5.6\times10^{-8}$	m
Energy Spread	σ_ε	$\leq 1\times10^{-3}$	
Damping Time	τ_x	≤6~7	ms
RF Frequency	f_{RF}	714	MHz

$$\begin{cases} \varepsilon = \mathbf{c_q}\dfrac{\gamma^2}{\rho J_x}\dfrac{1}{2\pi\rho}\int_{dipoles} Hds \\ H = \gamma_x\eta_x^2 + 2\alpha_x\eta_x\eta_x' + \beta_x\eta_x'^2 \end{cases} \quad (1)$$

$$\sigma_\varepsilon^2 = 3.84\times10^{32}\frac{\gamma^2}{J_\varepsilon\rho} \quad (2)$$

$$\sigma_l = \frac{C\alpha_p\sigma_\varepsilon}{\Omega_s} \quad (3)$$

$$\tau_i[ms] = \frac{C[m]\rho[m]}{13.2J_iE^3[GeV]} \quad (4)$$

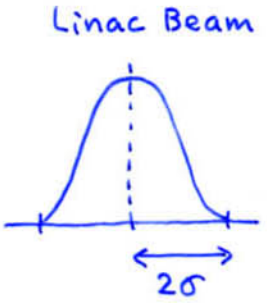
✿ Development of Damping Ring Design (1 bunch mode)

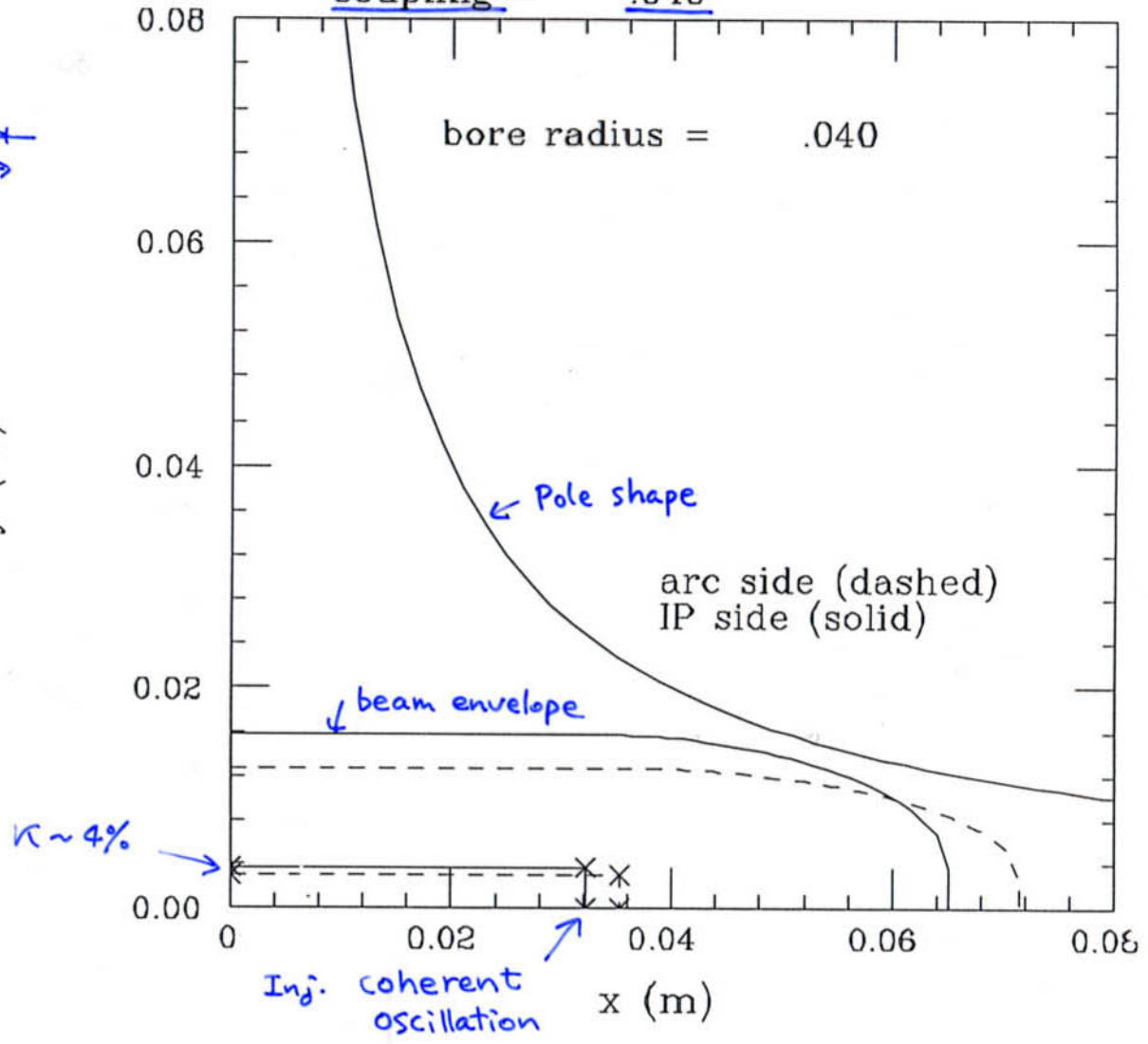
Energy	E	1.0	GeV
Circumference	C	50.5	m
Emittance	ε	2.9×10^{-8}	m
Energy Spread	σ_ε	6.35×10^{-4}	
Damping Time	τ_x	6.8	ms
RF Frequency	f_{RF}	714	MHz
RF Voltage	V_{RF}	0.8	MV
Bunch Length	σz	5.5	mm
Momentum Compaction Factor	α_p	0.018	
Energy Loss/Turn	U_0	0.048	MV
Bucket Height	dV/P_0	0.0147	
Bending Radius	ρ	1.8462	m
Max. Beta Function	$\beta_{xmax}/\beta_{ymax}$	8.2/20.6	m
Acceptance (at $\pm10\sigma_e$)	A_ε	$7.365\times10^{-5*}$	m

* 95 times of the injection beam's emmittance.

Aperture at QC2RP

linac emittance (2.5 sigma) = 1.375E−6
injection aperture (x) = 1.300E−5
injection aperture (y) = 2.339E−6
coherent osci. ampl. (x) = 3.184E−6
coupling = .040





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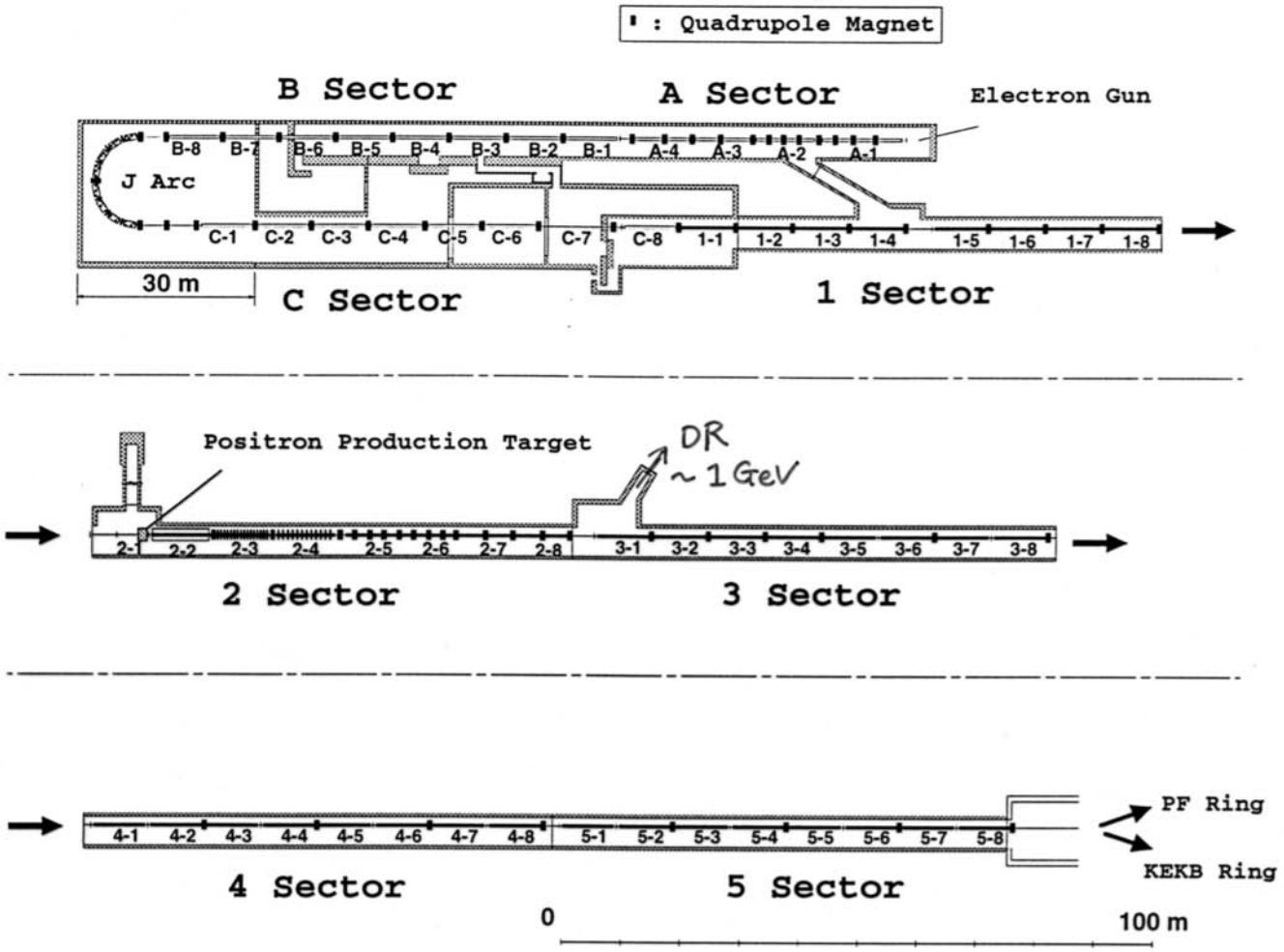
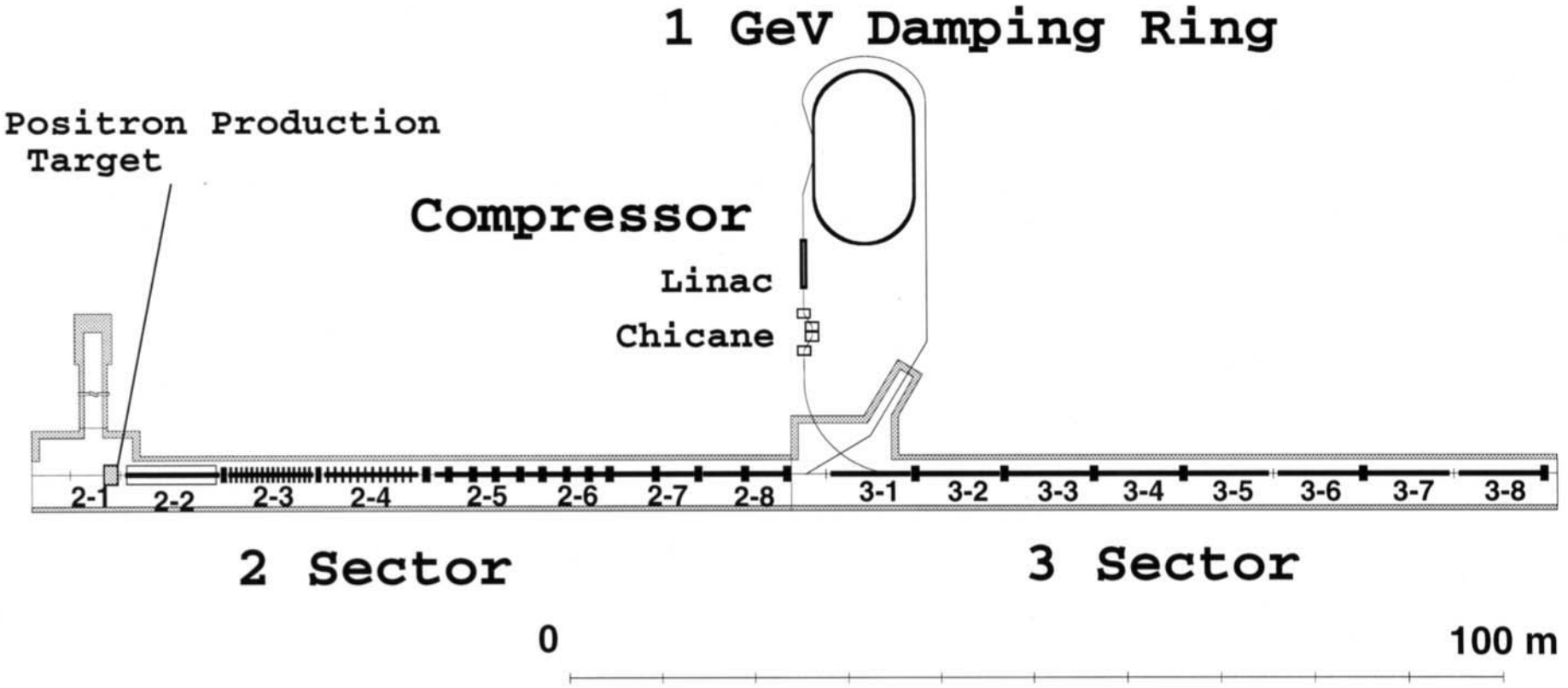
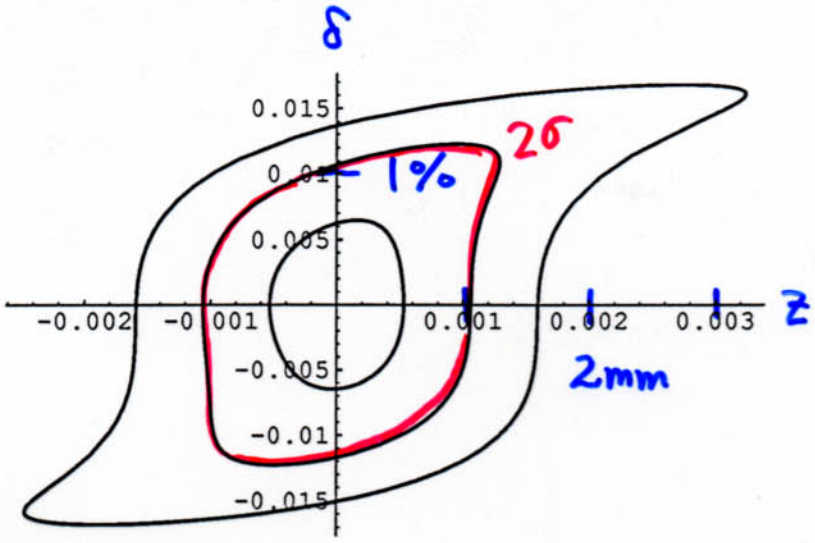
KEKB Injector J-Linac




1 GeV Damping Ring
Positron Production Target
Compressor
Linac
Chicane
2-1
2-2
2-3
2-4
2-5
2-6
2-7
2-8
3-1
3-2
3-3
3-4
3-5
3-6
3-7
3-8
2 Sector
3 Sector
0
100 m



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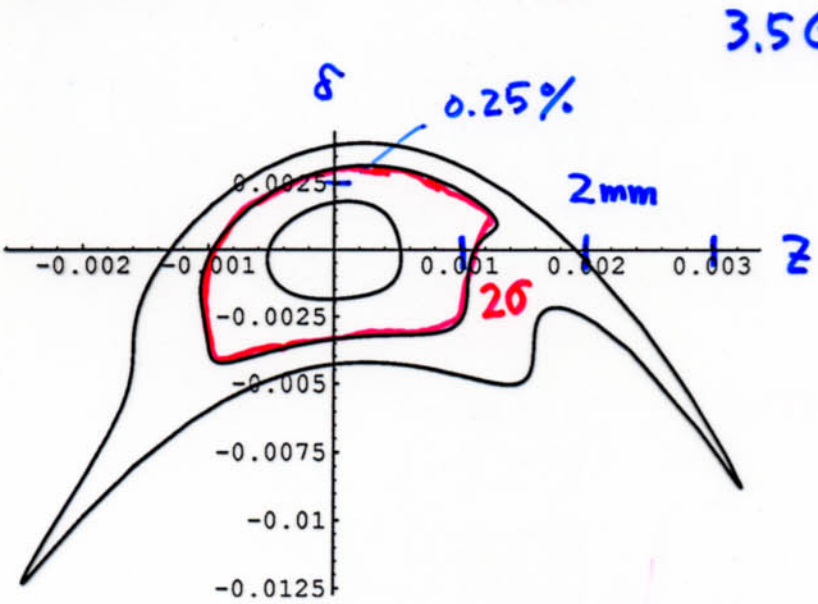

Conclusion

A preliminary 1 GeV damping ring design is presented.

Issues to be solved:
- Injection, extraction design
- Cavity design
- Ring hardware

The DR site can be found near Linac.

Energy spread at 3.5 GeV is determined by the bunch length of DR.

A low-α lattice is promising for reducing the RF voltage.