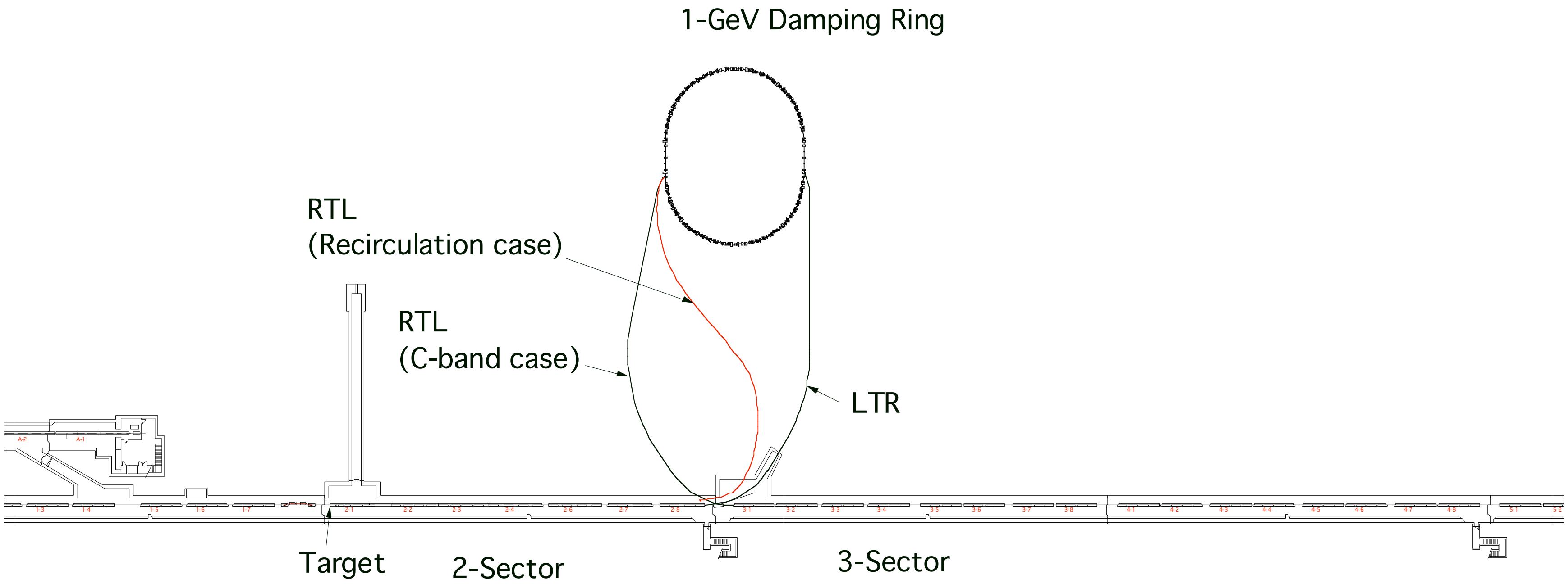
Damping Ring and BT

Kikuchi, M. 2002.2.26 MAC

0. Introduction
- Parameters
- ECS
- DR
- BCS
- Summary

Layout of Beam Lines



0. Introduction

Both upgrade plans (C-band case, S-band recirculation case) need damping rings for both beams.

Reasons:

C-band case:
- shorter bunch for smaller energy-spread (esp. e+)
- low emittance for small aperture of accelerating structures(e+)
- damped beam for smaller energy- and emittance-tail. (e+ and e-)

S-band case:
- waiting time for next RF-pulse (e+)
- damped beam for smaller energy- and emittance-tail. (e+ and e-)

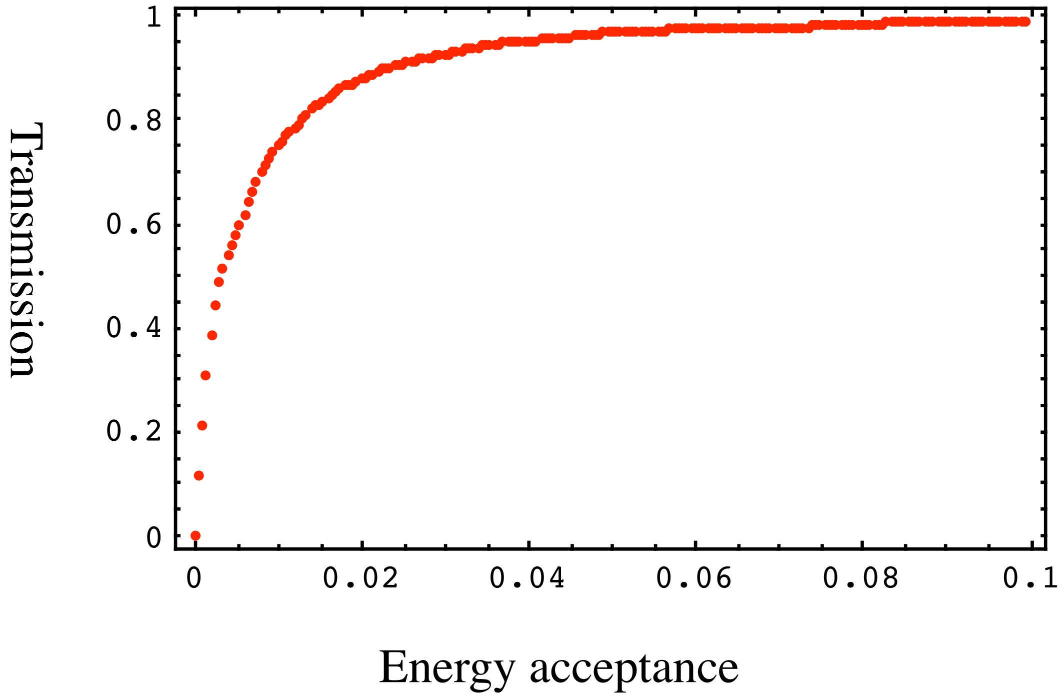
✧ I will talk only on the positron DR.

1. Parameters

1. Beam energy: 1 GeV
2. Beam charge: 2.5 nC/pulse

3. Energy Profile

Realistic simulation by Kamitani and Sakai



Transmission as a function of energy acceptance

E=1.053 GeV

No wake

'01.12.1 Sakai,H.

1. Parameters -2

Energy aperture of 3 % is necessary in order to accommodate 95% of the beam.
---> this requirement is severe for DR.

Energy compression is necessary prior to injection to DR

2. Energy Compression System

To proceed the design, we need a

parameterization of the energy profile

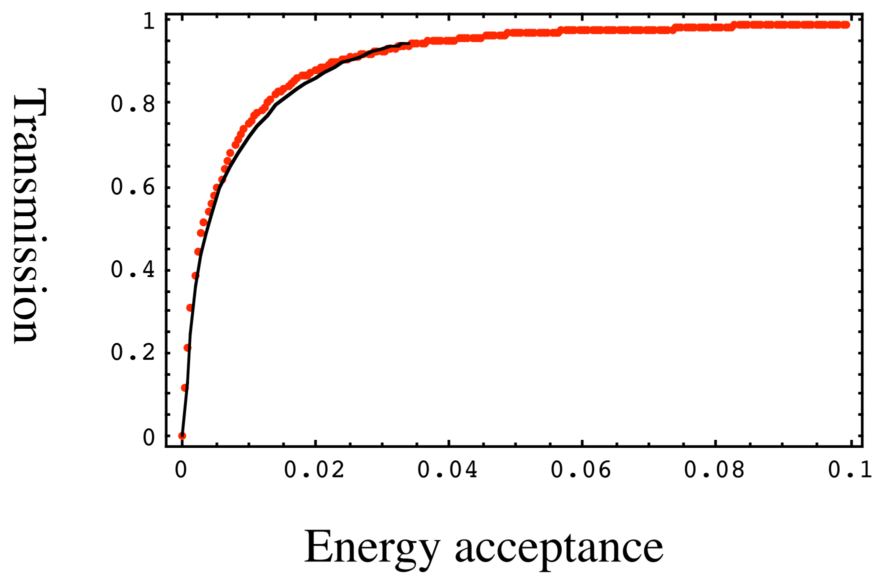
The profile can be reproduced by a simple model of a Gaussian bunch on the crest which has two parameters, bunch length and the intrinsic energy spread

2. Energy Compression System -2

$$\psi(z,E) = f(z,\sigma_z) f(E - E_0 \cos kz, \sigma_E)$$

$$f(x,\sigma) = \exp(-x^2/\sigma^2/2)$$

$$\psi(E) = \int_{-\infty}^{\infty} \psi(z,E)dz$$



The model with

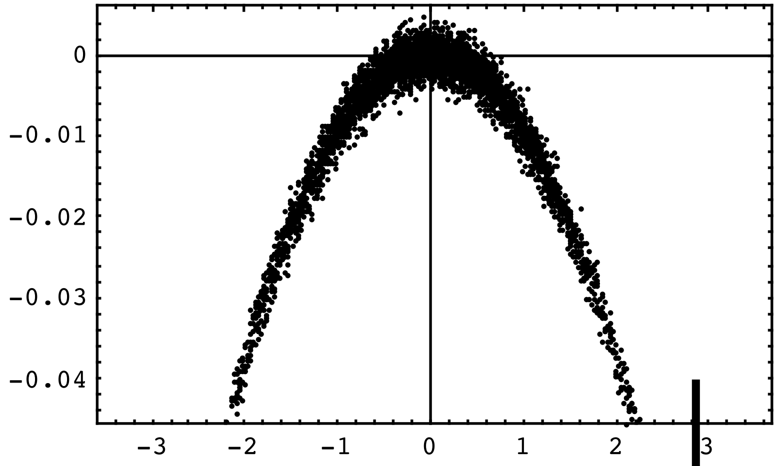
$\sigma_z = 2.3$ mm

$\sigma_E / E_0 = 0.0017$

reproduces the simulation

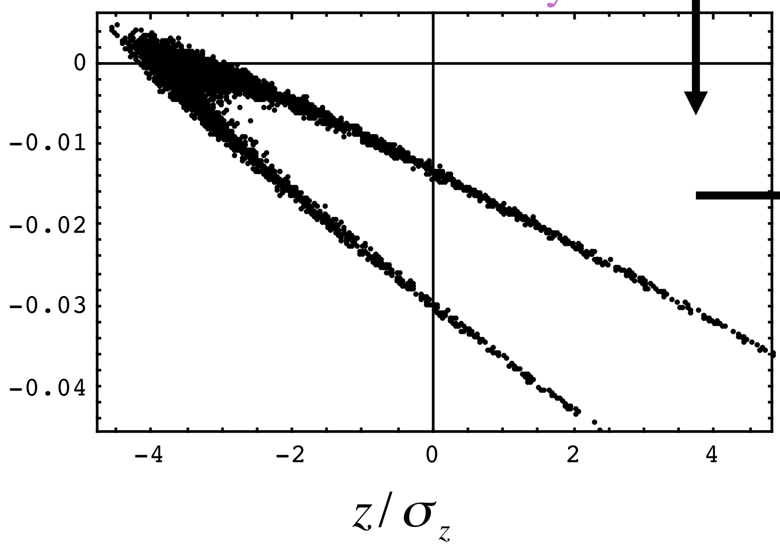
2. Energy Compression System -3

Before ECS

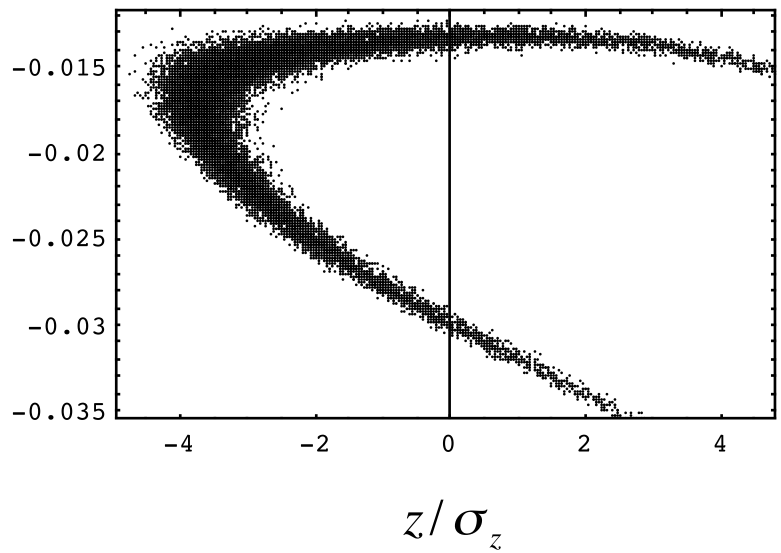


ECS parameters	
Compression ratio	1/3
Cavity voltage(S-band)	36.2 MV
R56	-0.41 m

Before Cavity



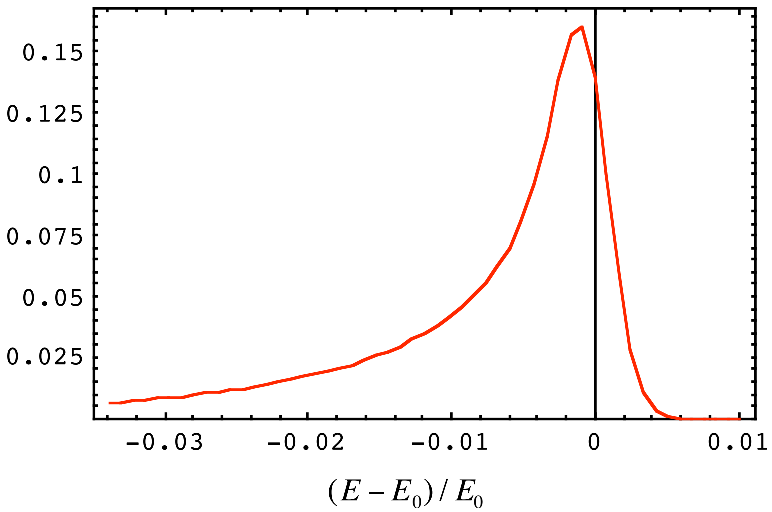
After ECS

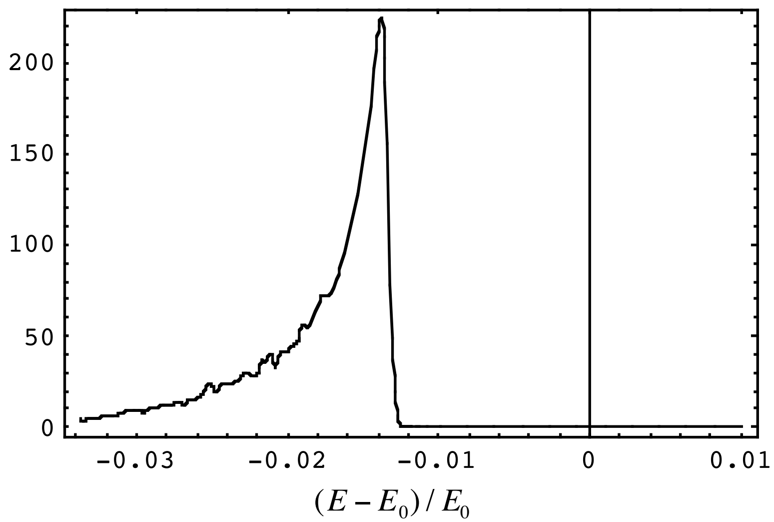


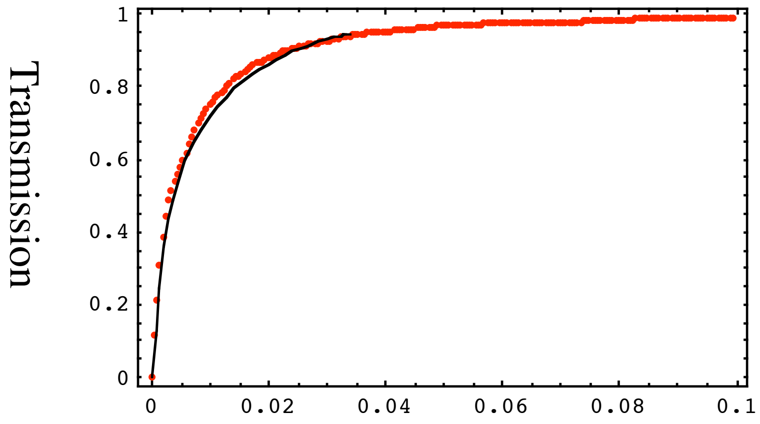
2. Energy Compression System -4

Before ECS

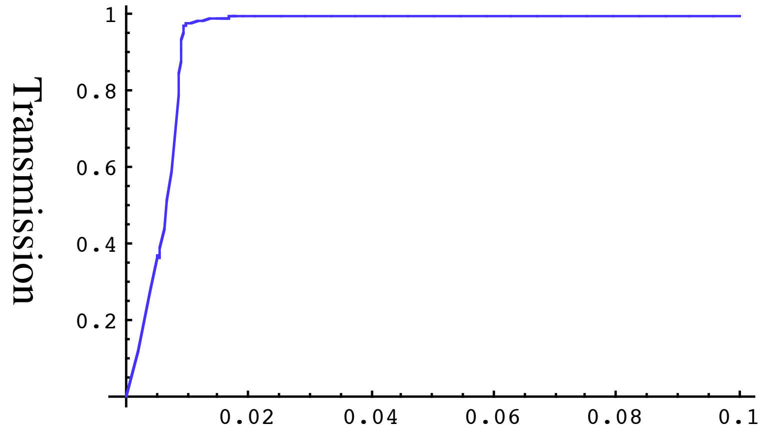
After ECS







Energy acceptance



Energy acceptance

2. Energy Compression System -5

Conclusion:

Requirement of energy acceptance of DR should be 1.5 %

3. Damping Ring

Design study based on
an example of DR with the FODO cell

3. Damping Ring-2 Parameters

Circumeference	106.7	m
Number of bunches	2	
Hor. Damping time	20	ms
Momentum spread	5.44E-04	
Cavity frequency	714	MHz
Cavity voltage	1.0	MV
Momentum acceptance	1.5	%
Bunch length	4.68	mm
Emittance	1.03E-08	m
No. of cells	32	
Pole-tip field: Bend	1.34	T
Quad	0.837	T
Sext	0.296	T

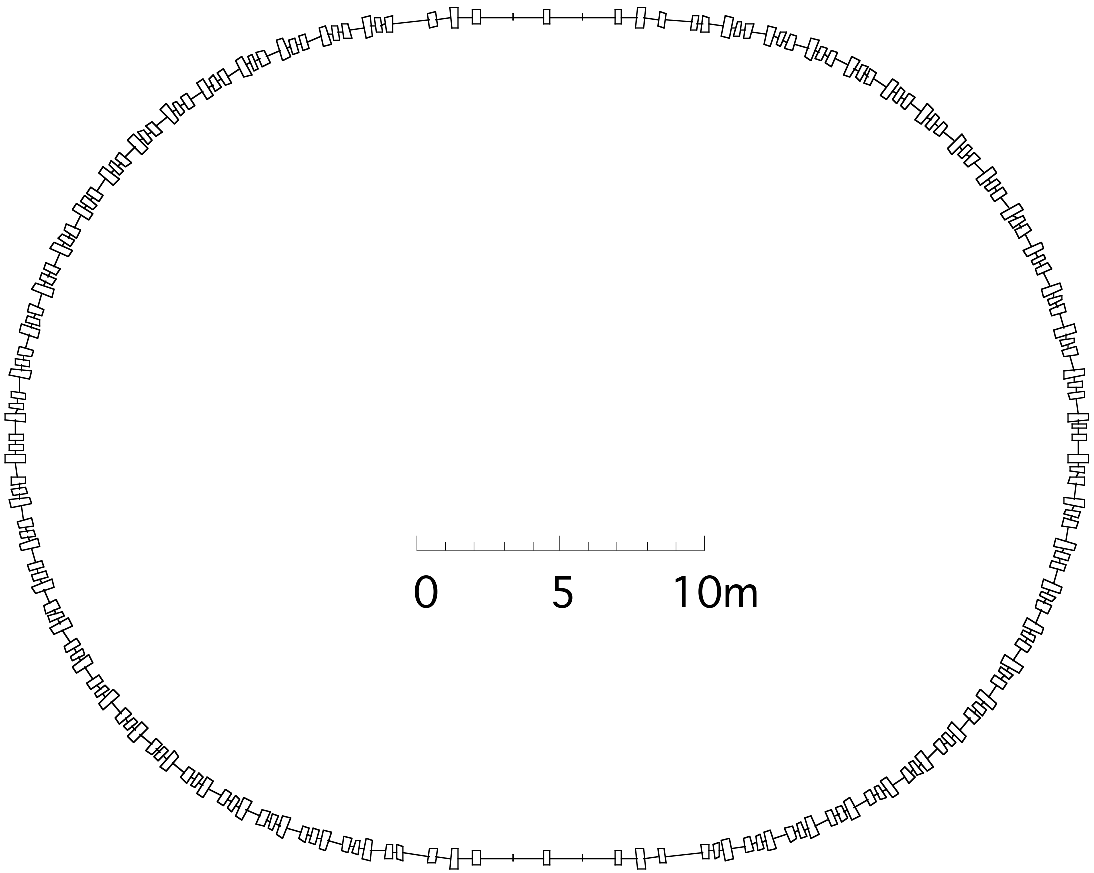
Momentum compaction 0.0089

	Injection	Extraction
Emittance	3.00E-07	4.95E-08
Energy spread	0.6 % *1)	0.16%
Bunch length σz	4.3 mm *2)	4.7 mm

*1) Defined as the largest extension in E-profile devided by 2.5

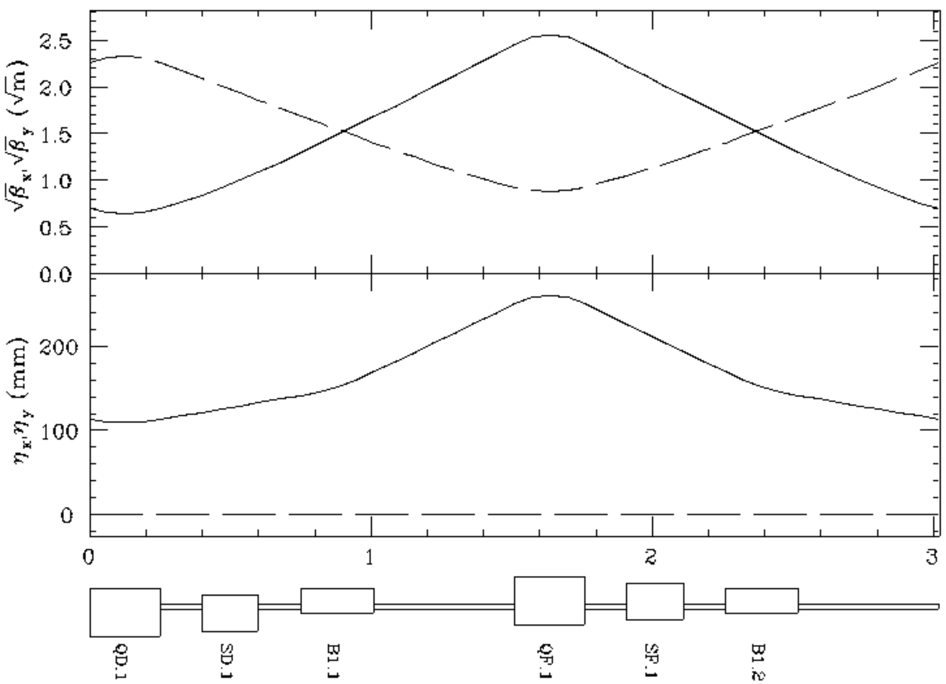
*2) Defined as the largest extension in z-profile devided by 2.5

3. Damping Ring-3 Layout



3. Damping Ring-4 Optics

Normal cell



Phase advance

H:130deg, V:94deg

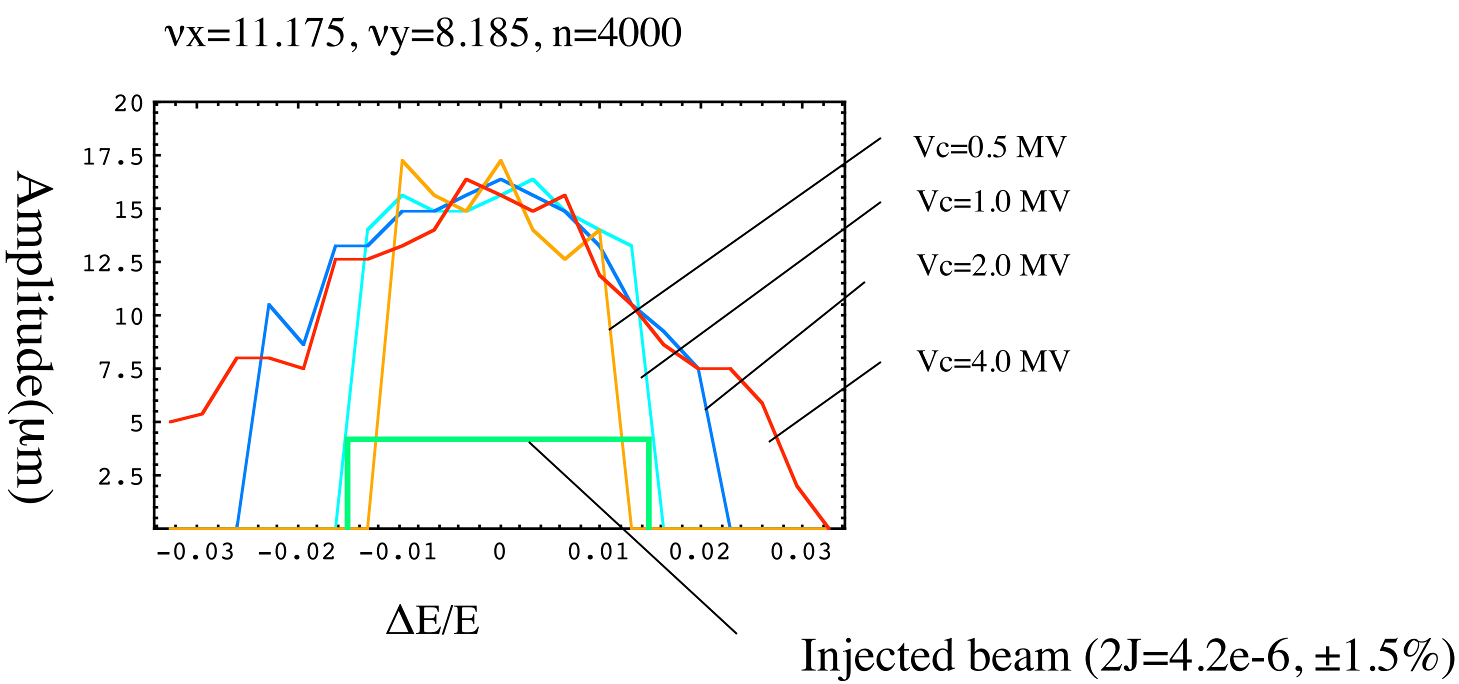
Bend length 0.26 m

Quad length 0.25 m

Sext length 0.15 m

Magnet-to-magnet 0.15 m

3. Damping Ring-5 Dynamic aperture



❑ Proposed ring has large dynamic aperture up to 3% of ΔE/E, which is limited by the bucket height.

4. Bunch Length Compression (BCS)

- Bunch length has to be compressed to match the C-band linac.

Extracted beam:

σz = 4.7mm, σE=0.16 %

Bunch compression ratio: 1/5

BCS parameters	
Compression ratio	1/5
Cavity voltage(S-band)	27.9 MV
R56	-0.59 m

4. Summary

1. We have designed the ECS. The ECS in the LTR line relaxes the energy-aperture requirement to DR from 3% down to 1.5%.
2. The Damping ring with simple FODO cell with 1MV cavity voltage fulfills the aperture requirement.
   ---- Need machine error analyses
3. We found the realistic parameters of BCS in the RTL line.
4. We have found consistent beam-parameters for the LTR-DR-RTL system.