Alternative Bunch Compressor

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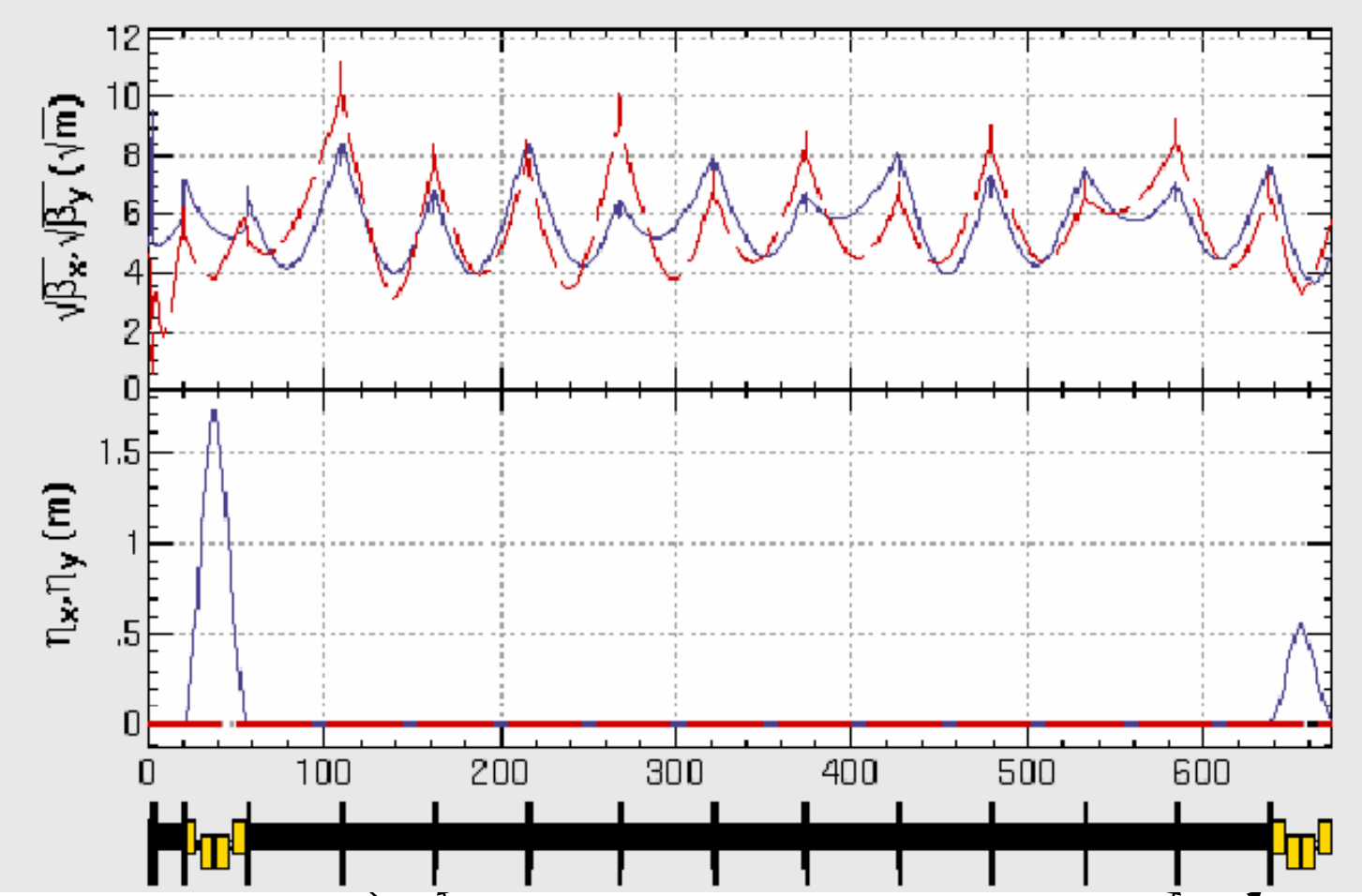
Introduction

- Alternative BC has two rf sections and two chicanes with 4 bending magnets each. Each chicane includes a 34 m lattice of bending.

- Bunch lengths of 6 mm rms and 9 mm rms can be compressed to 0.15 mm rms and 0.3 mm rms in the BC, respectively.

- We performed the lattice tunings to control the emittance growths with conservative machine errors.
  : It was shown that the system was error tolerant.

Designed lattice



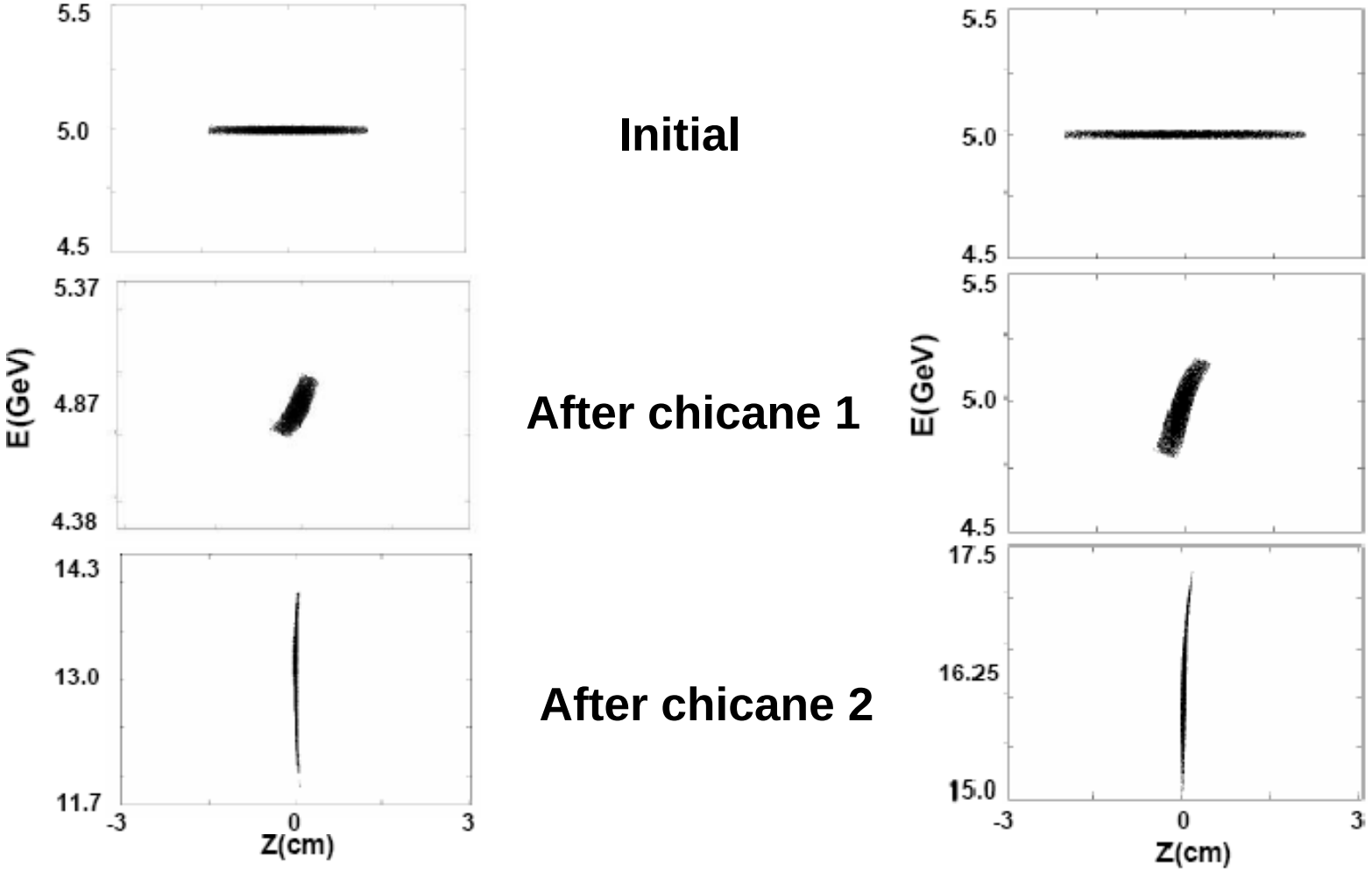
locations of 4 skew quadrupoles

Main parameters in BC

Parameter	Units	Values
System total length	m	680
Quad. in matching section	EA	6
Initial beam energy	GeV	5
Initial bunch charge	nC	3.2
Initial rms energy spread	%	0.15
Initial rms bunch length	mm	6(9)
Initial rms emittance (H/V)	μm	8/0.02
RF voltage in 1st RF section	MV	348
Cavity in 1st rf section	EA	12
Quad. in 1st rf section	EA	2
RF gradient in 1st rf section	MV/m	29
RF phase in 1st rf section	degree	-114(-93)
Bending angle at chicane 1	degree	10.43
Chicane 1 R_{56}	mm	-474.2
End chicane 1 rms bunch length	mm	1.33(1.45)
End chicane 1 energy	GeV	4.86(4.98)
End chicane 1 emittance (H/V)	μm	8.25/0.02(8.31/0.02)
End chicane 1 rms energy spread	%	1.04(1.63)
RF voltage in 2nd rf section	MV	11800 (14080)
Cavity in 2nd rf section	EA	440
Quad. in 2nd rf section	EA	35
RF gradient in 2nd rf section	MV/m	27(32)
RF phase in 2nd rf section	degree	-45(-36)
Bending angle at chicane 2	degree	3.43
Chicane 2 R_{56}	mm	-50.8
End chicane 2 rms bunch length	mm	0.15(0.30)
End chicane 2 energy	GeV	13.26(16.1)
End chicane 2 emittance (H/V)	μm	8.6/0.02(9.14/0.02)
End chicane 2 bunch charge	nC	3.2
End chicane 2 rms energy spread	%	2.6(2.4)

( ) denotes parameters for initial bunch length of 9 mm rms.

Longitudinal phase space



Initial bunch length of 6 mm **Initial bunch length of 9 mm**

Emittance Tuning

- Correction of vertical dispersion that is generated by skew components was performed by using of 4 skew-quadrupoles in rf linac section.

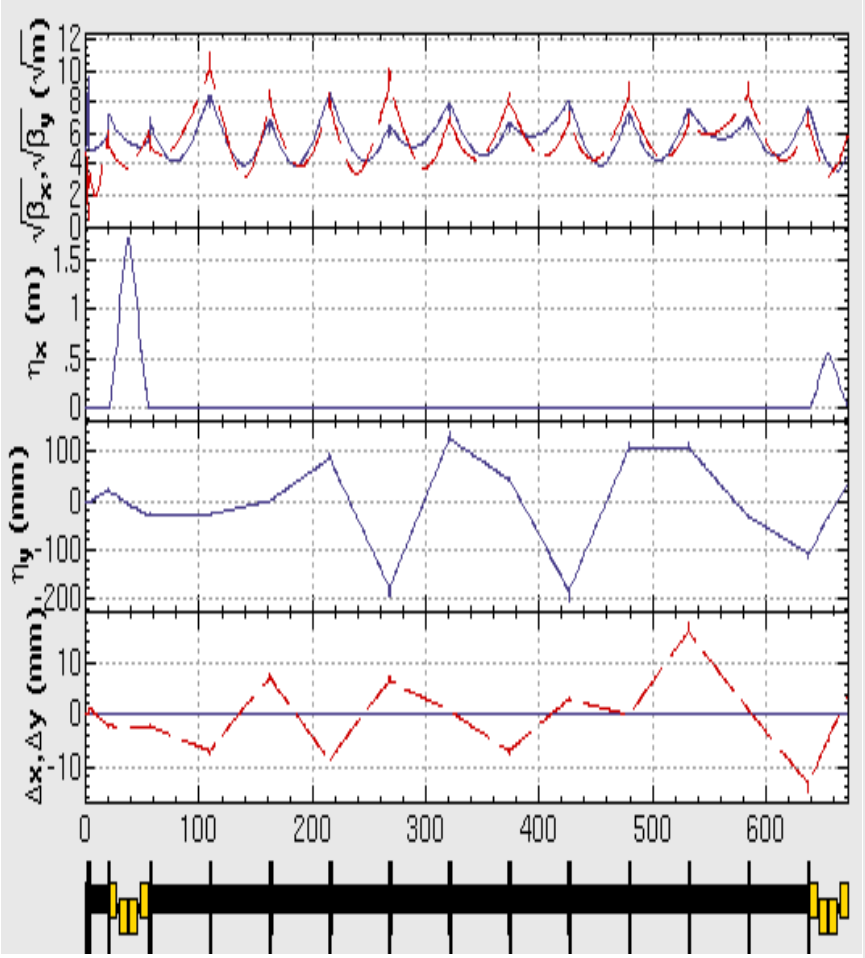
- We performed both dispersion correction and orbit correction at the same time such that they have a minimum value.

Considered 6 machine errors

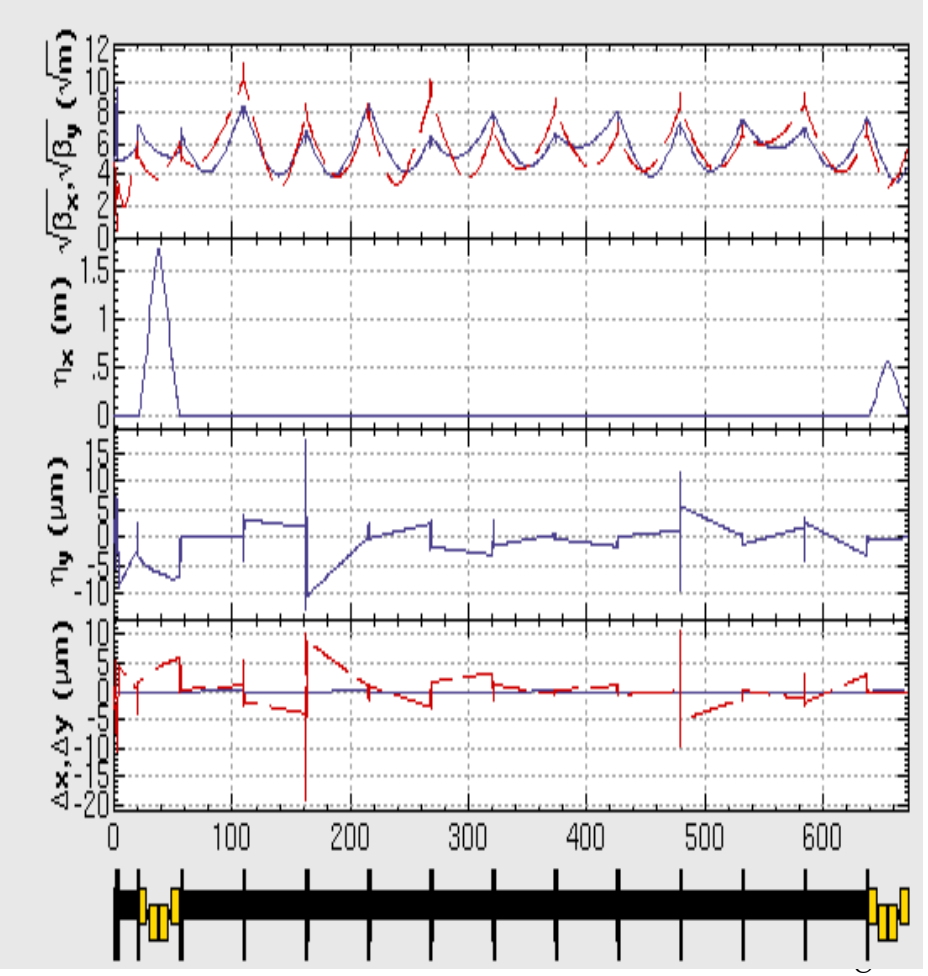
Error	Magnitude
H-misalignment in Q	300 μm rms
V-misalignment in Q	300 μm rms
Rotation in Q	300 μrad rms
V-misalignment in B	300 μm rms
H-misalignment in B	300 μm rms
Rotation in B	300 μrad rms

Lattice distortion due to Q vertical alignment error (300μm rms)

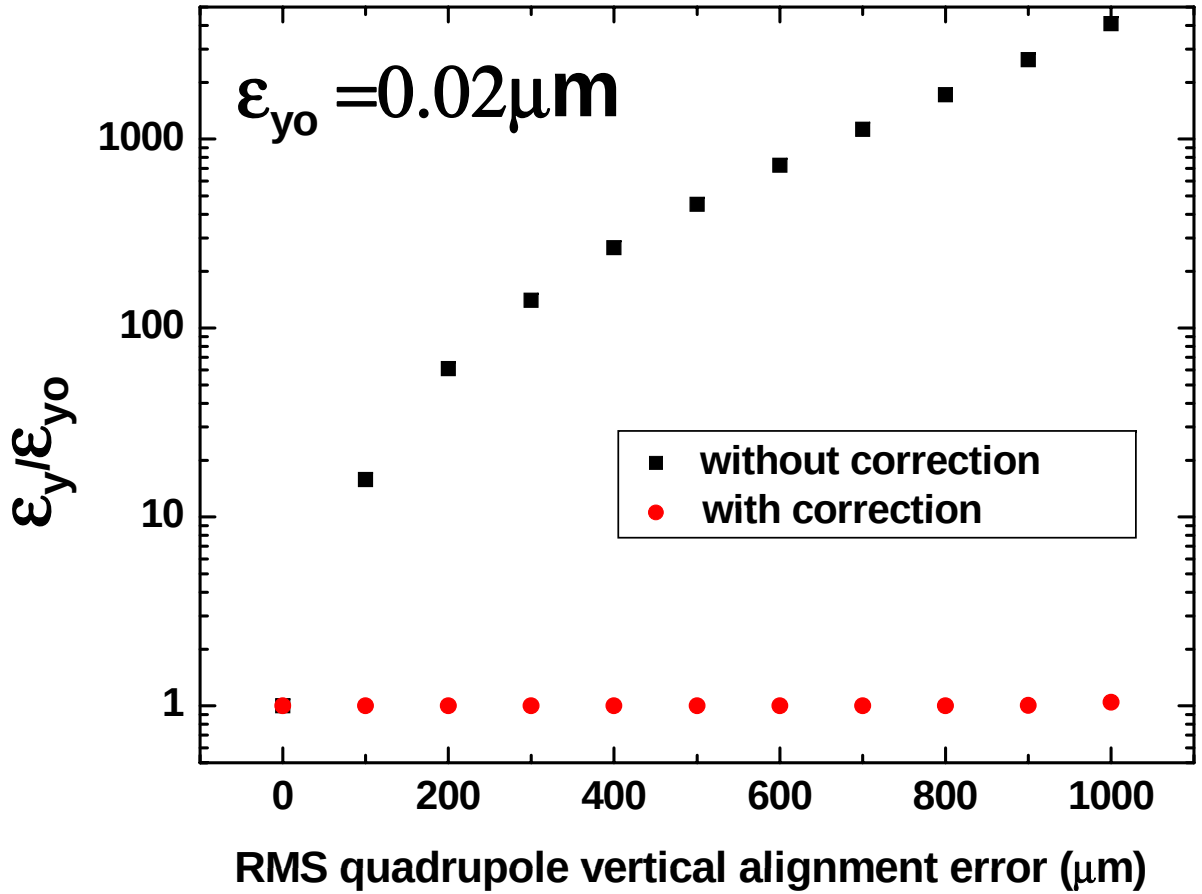
Without lattice correction



With lattice correction

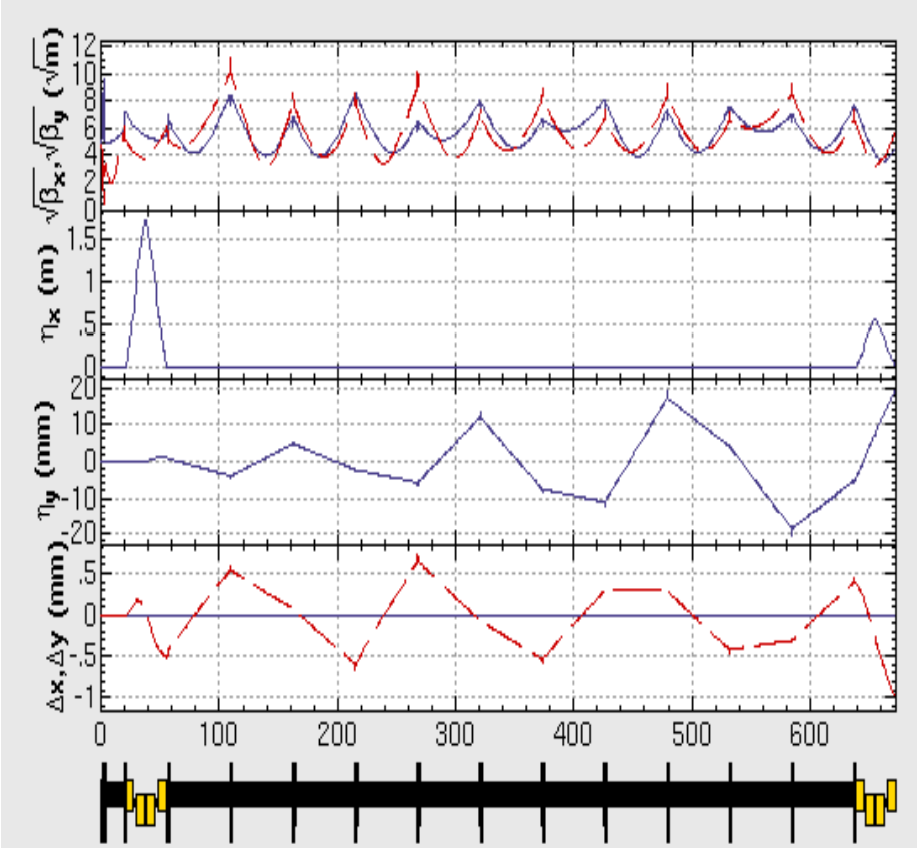


Emittance vs. Q-Vertical alignment error

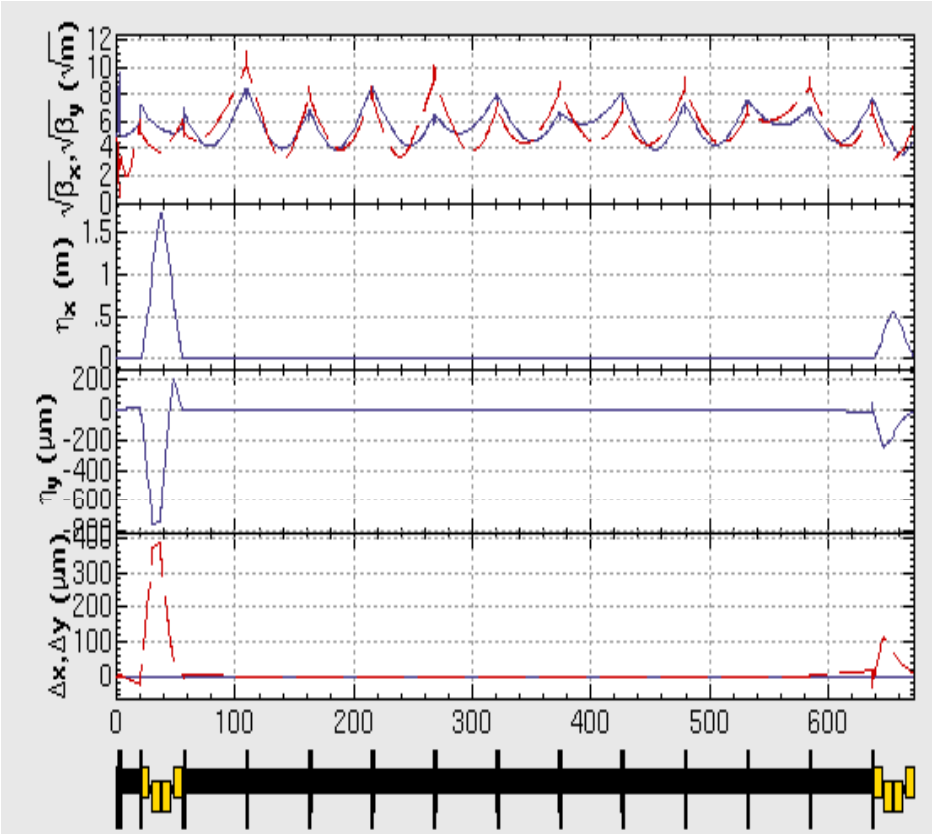


Lattice distortion due to bending rotation error (300 μrad rms)

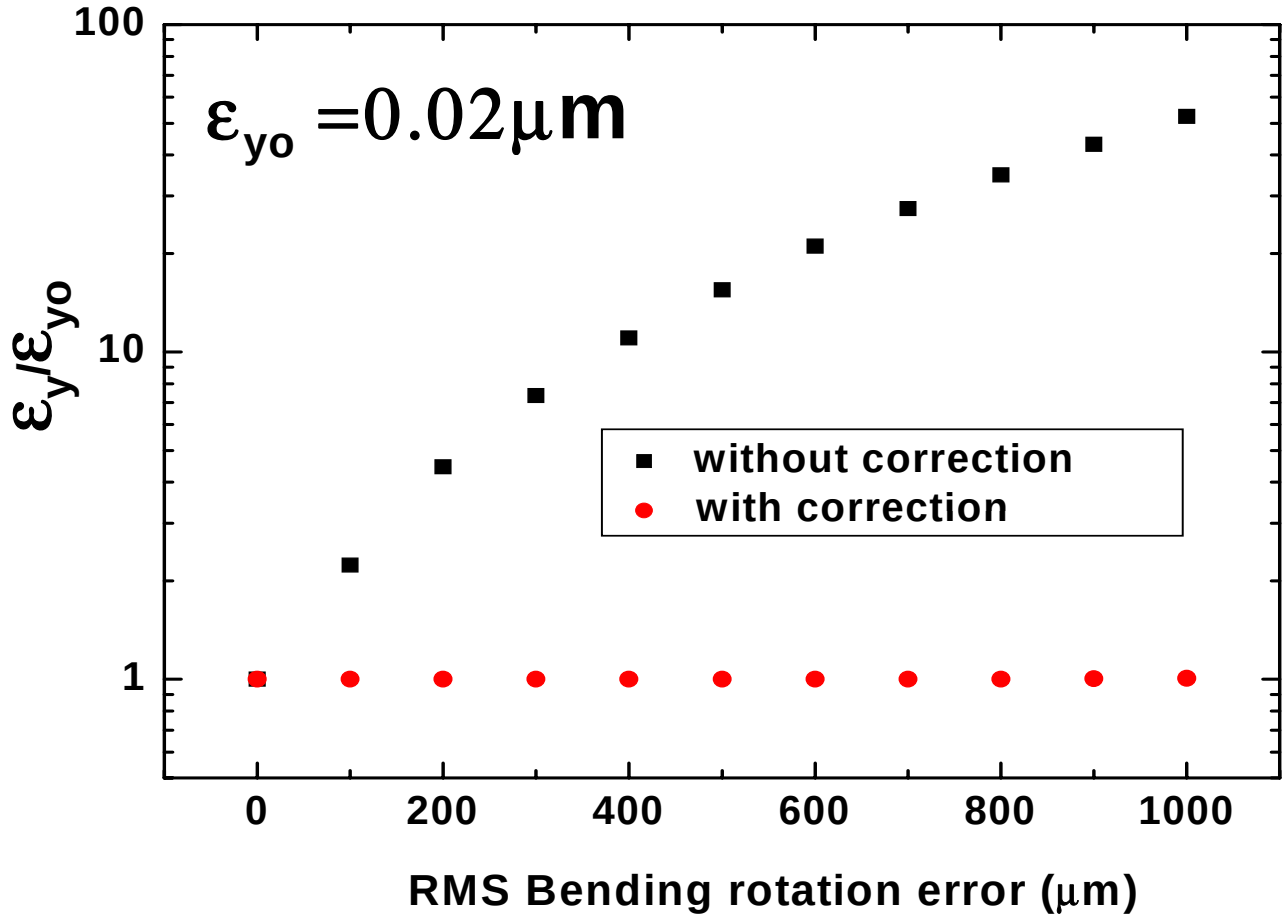
Without lattice correction



With lattice correction

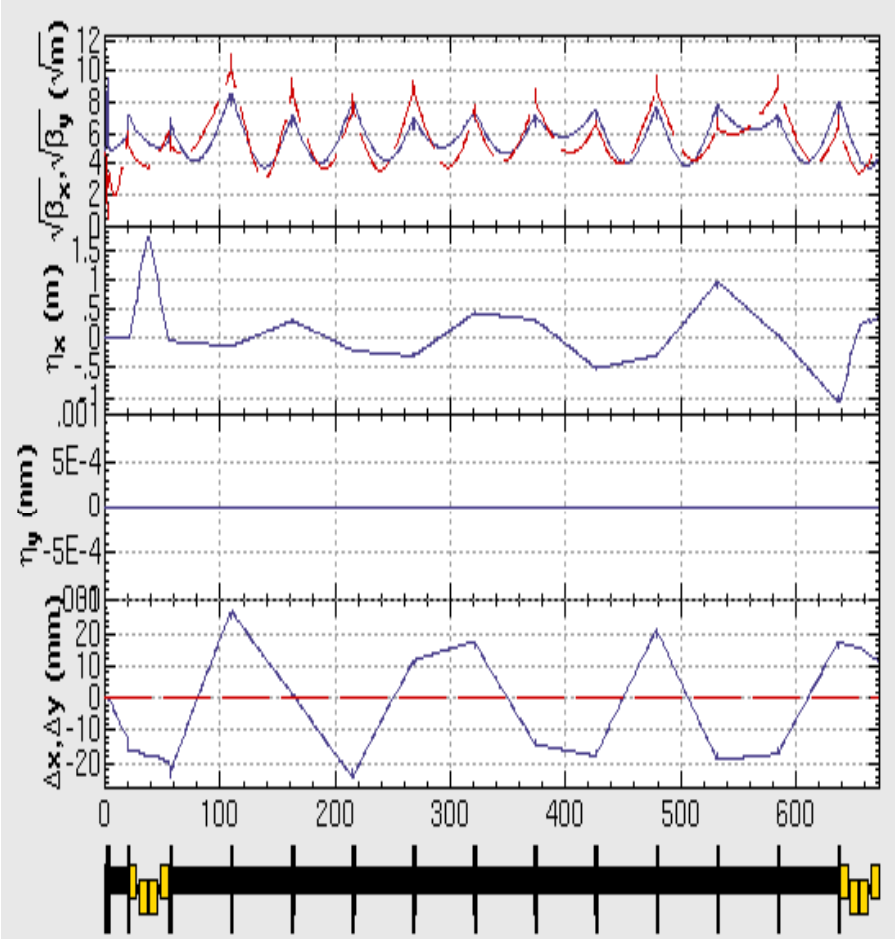


Emittance growth vs. Bending rotation error

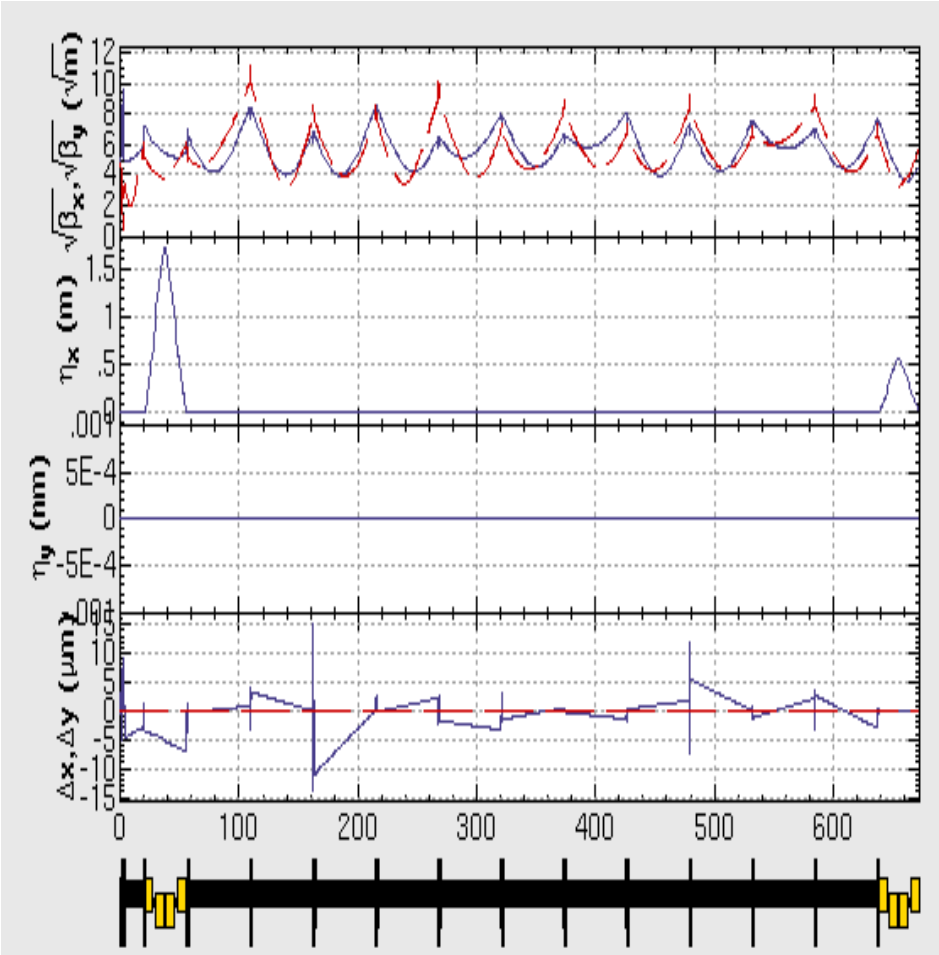


Lattice distortion due to Q-Horizontal alignment error (300 μm rms)

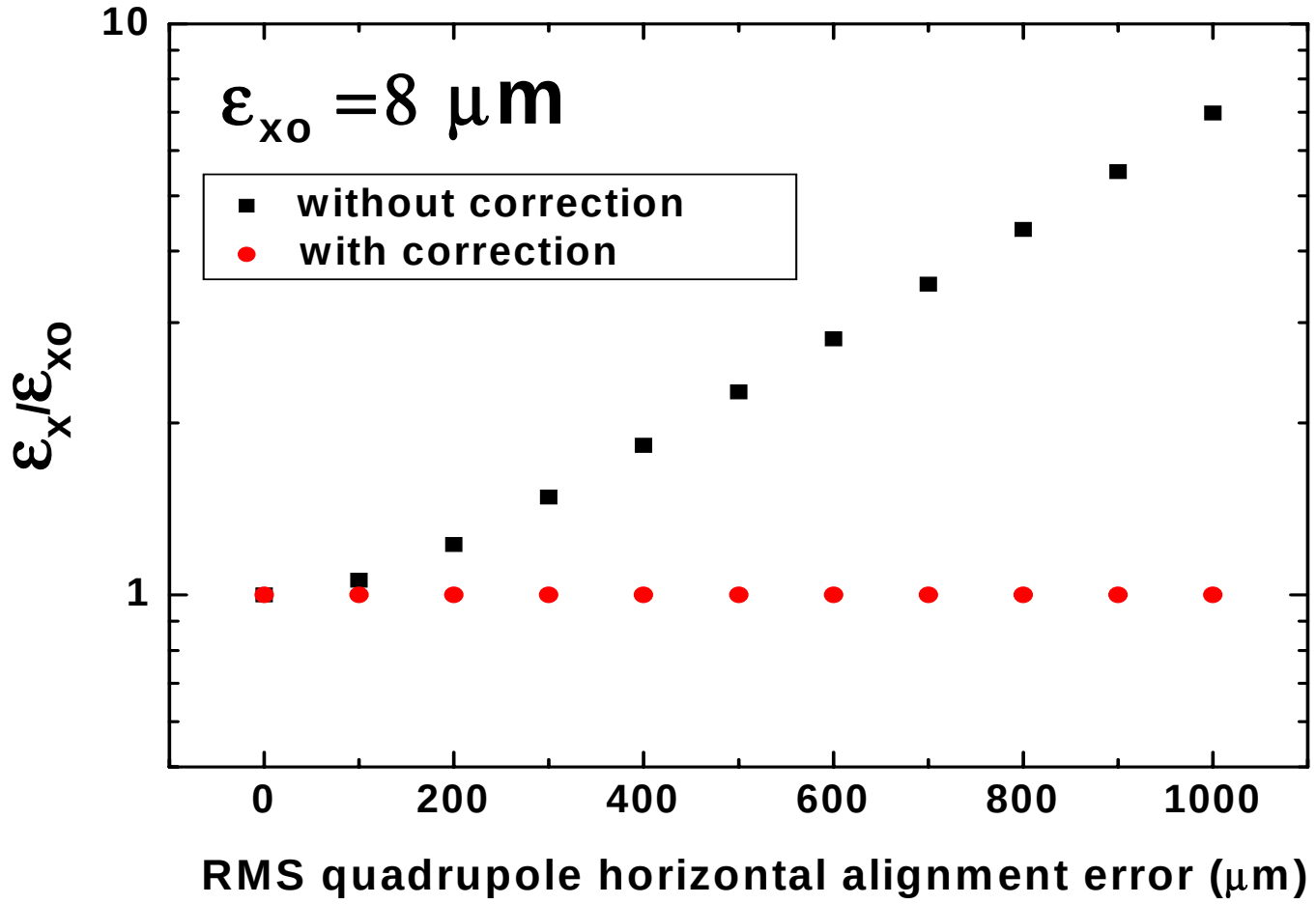
Without lattice correction



With lattice correction

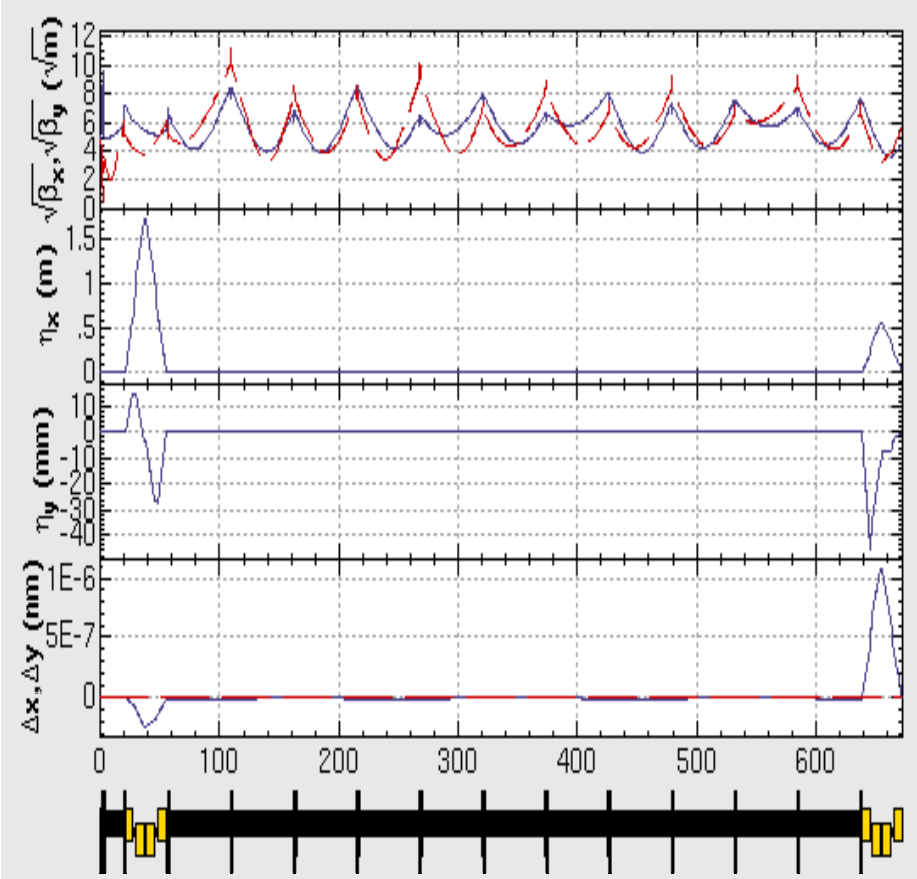


Emittance growth vs. Q-Horizontal alignment error

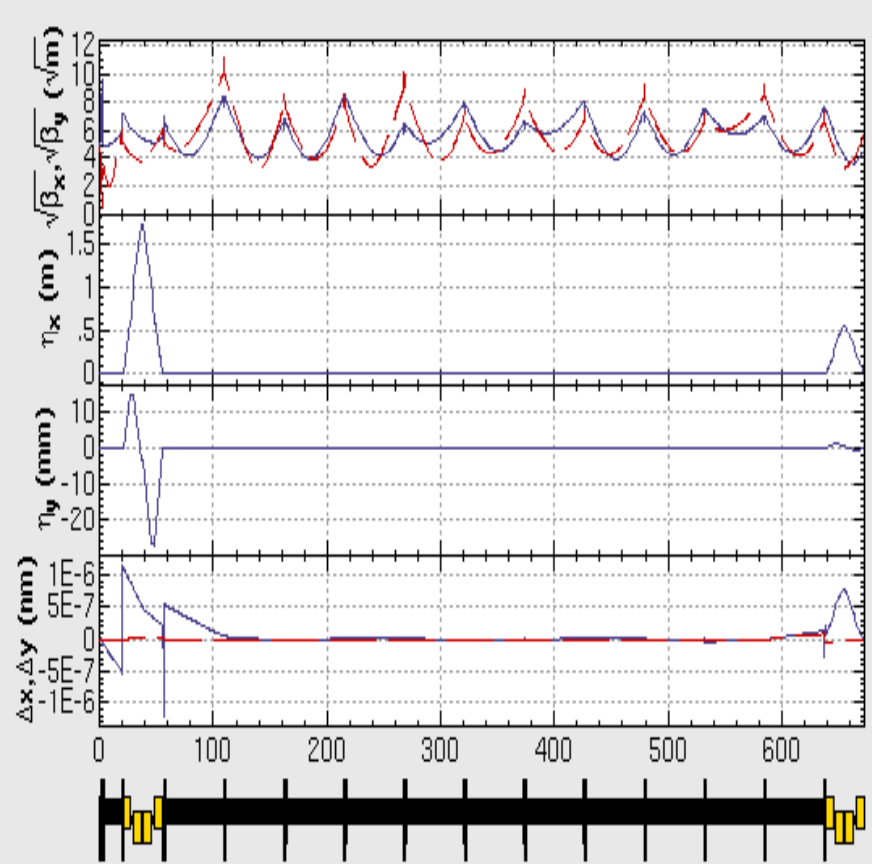


Lattice distortion due to Quadrupole rotation error (300 μrad rms)

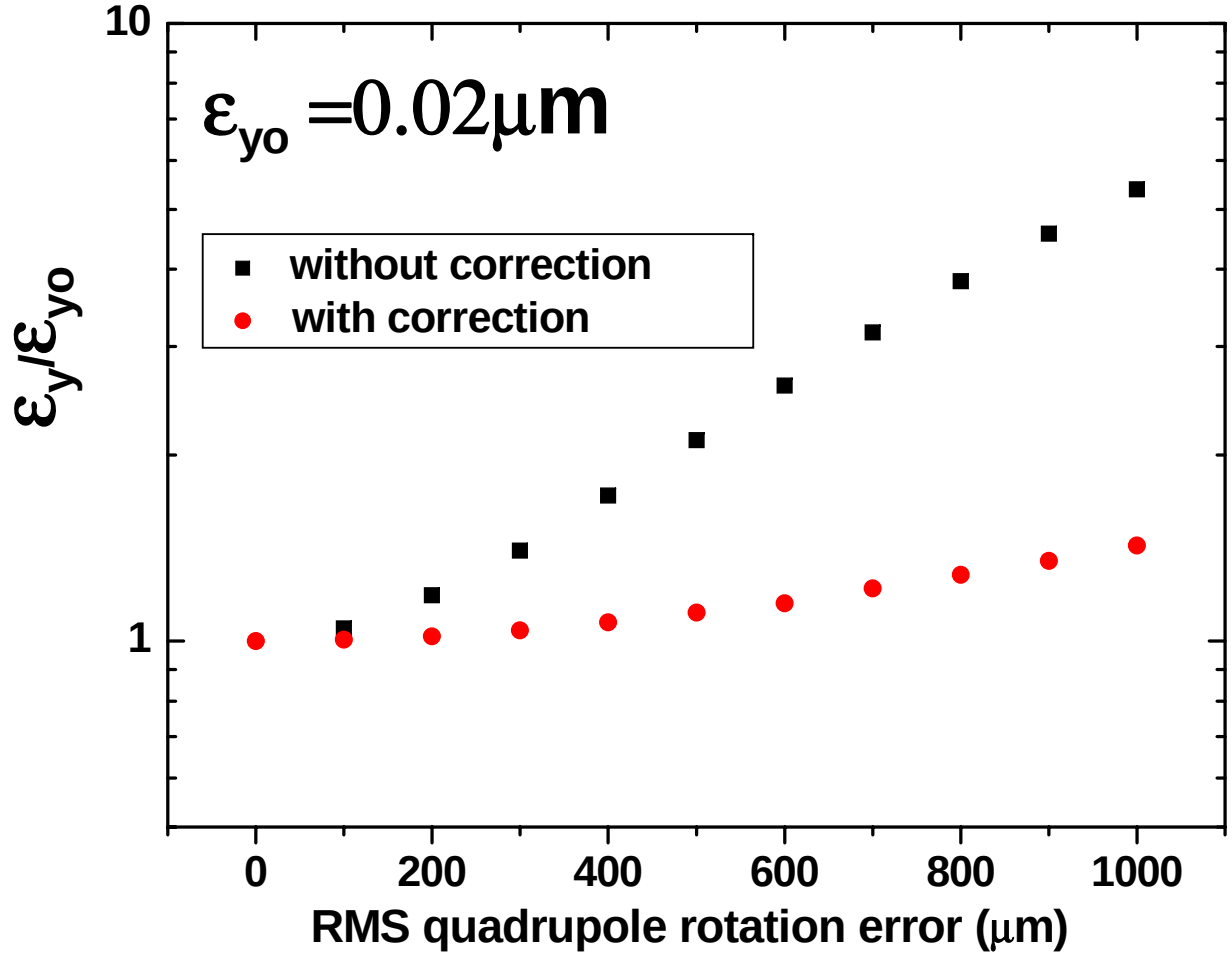
Without lattice correction



With lattice correction

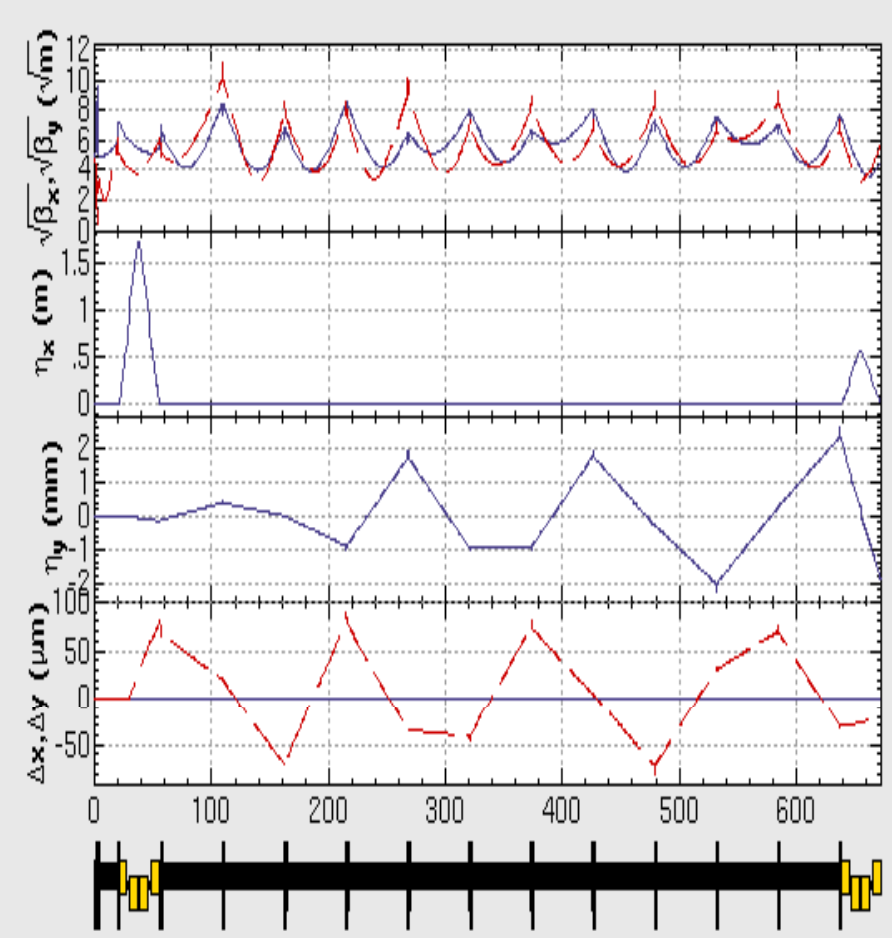


Emittance growth vs. Q Rotation error

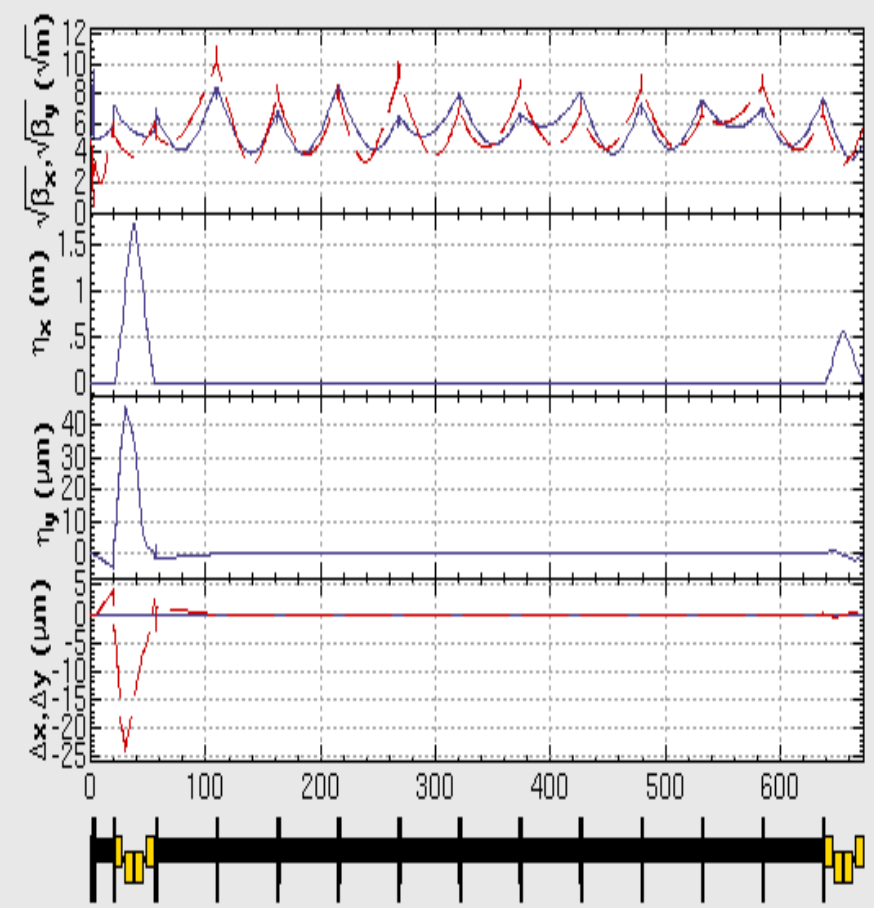


Lattice distortion due to Bending vertical misalignment error (300 μm rms)

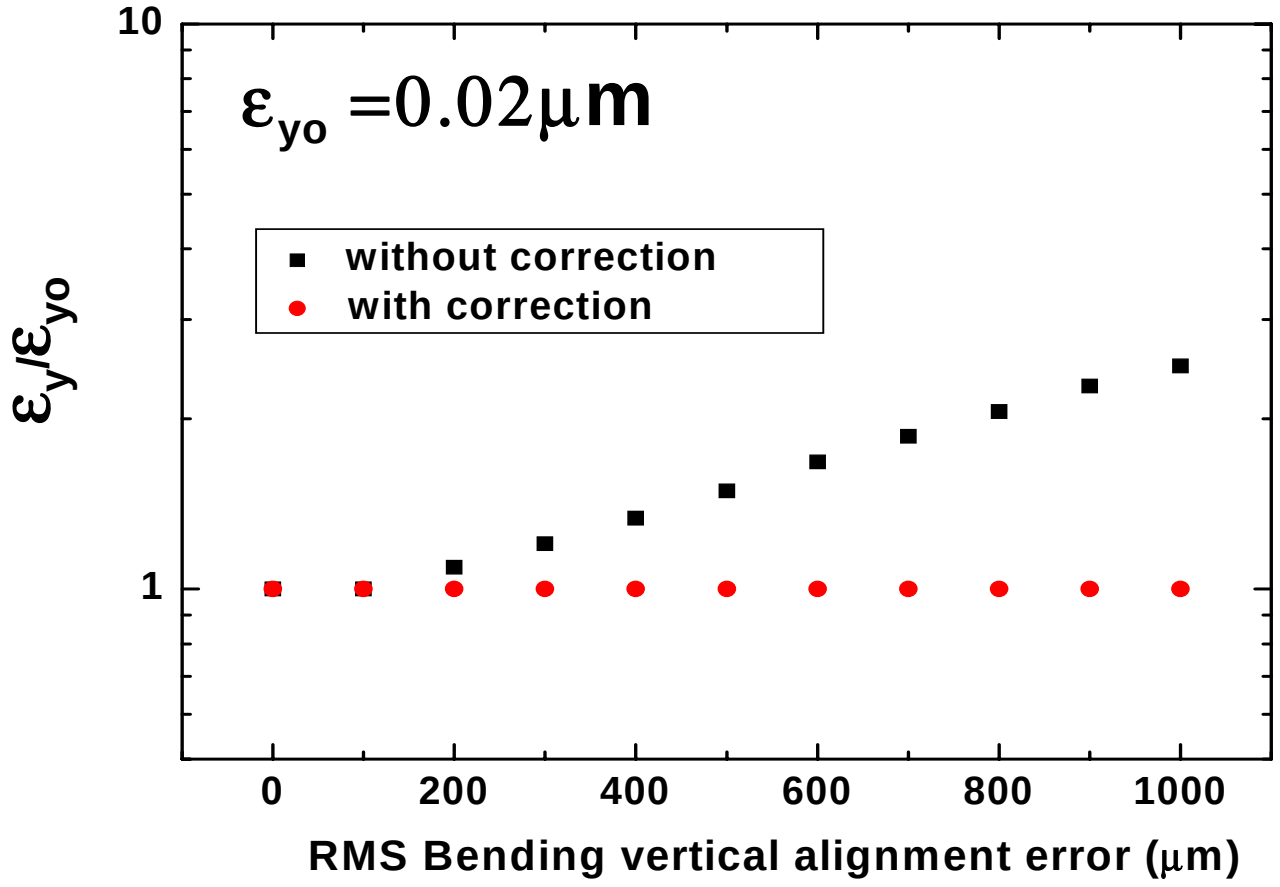
Without lattice correction



With lattice correction

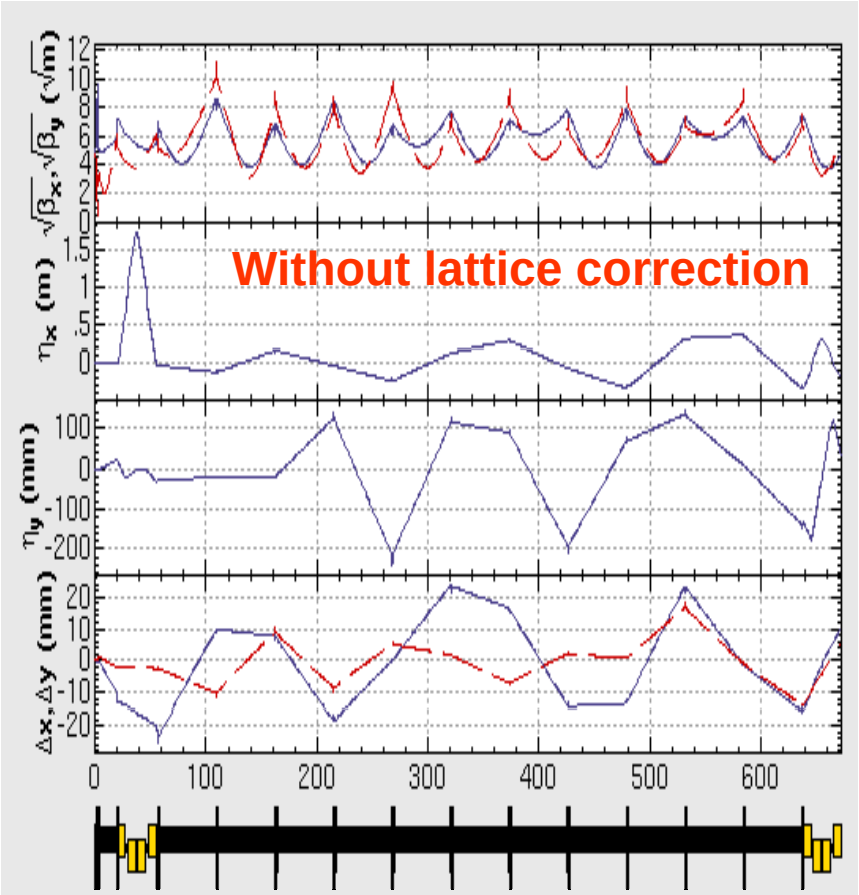


Emittance growth vs. Bending misalignment error

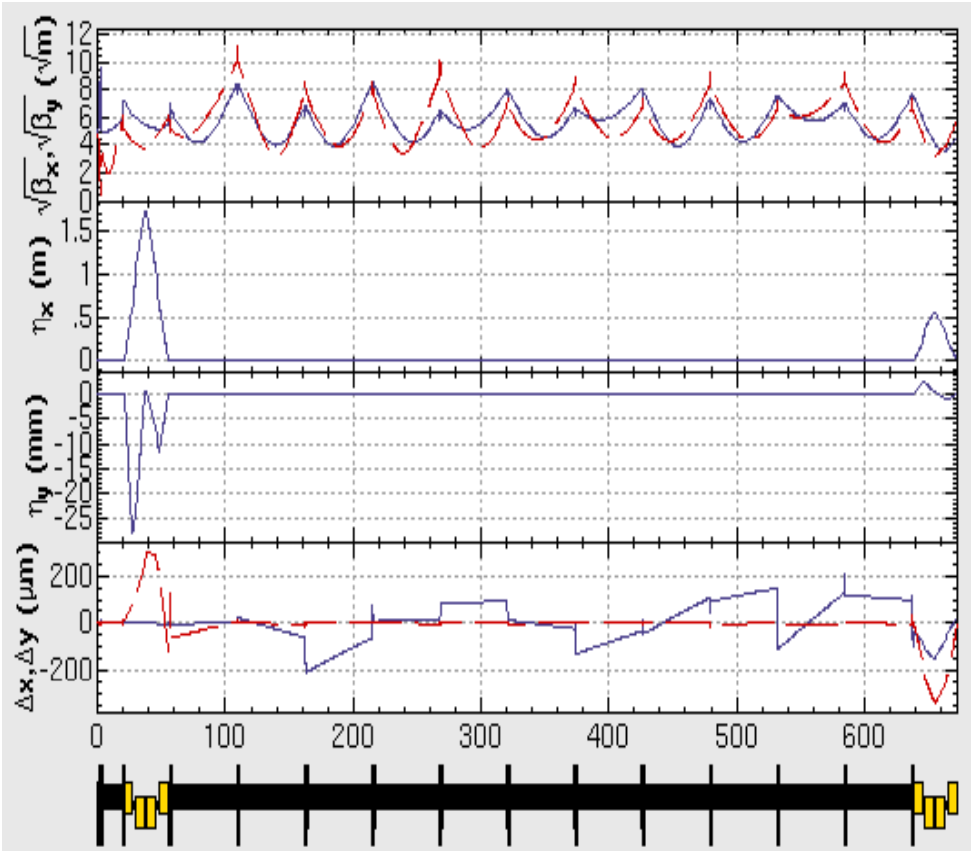


Lattice distortion due to 6 machine errors

Growths of emittance : factors of 1.48 / 254 in H / V



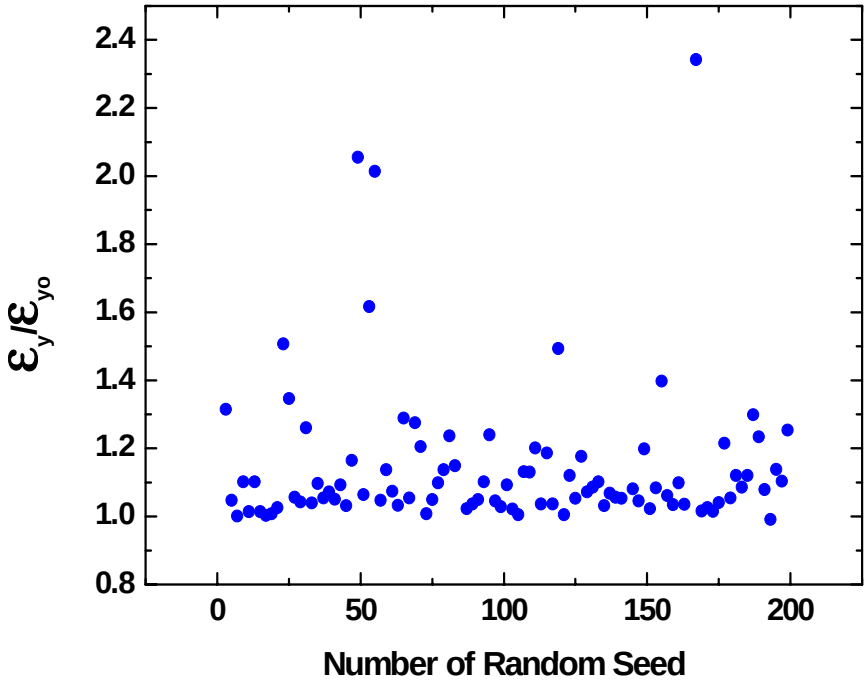
With lattice correction

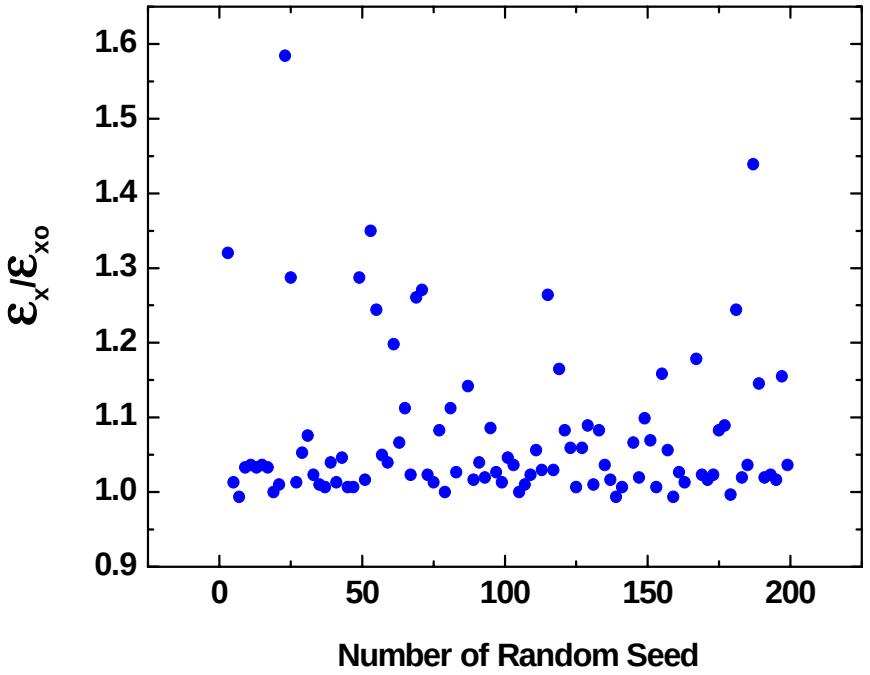


Growths of emittance : factors of 1 / 1.04 in H / V

Effect of random seed number

With 6 machine errors

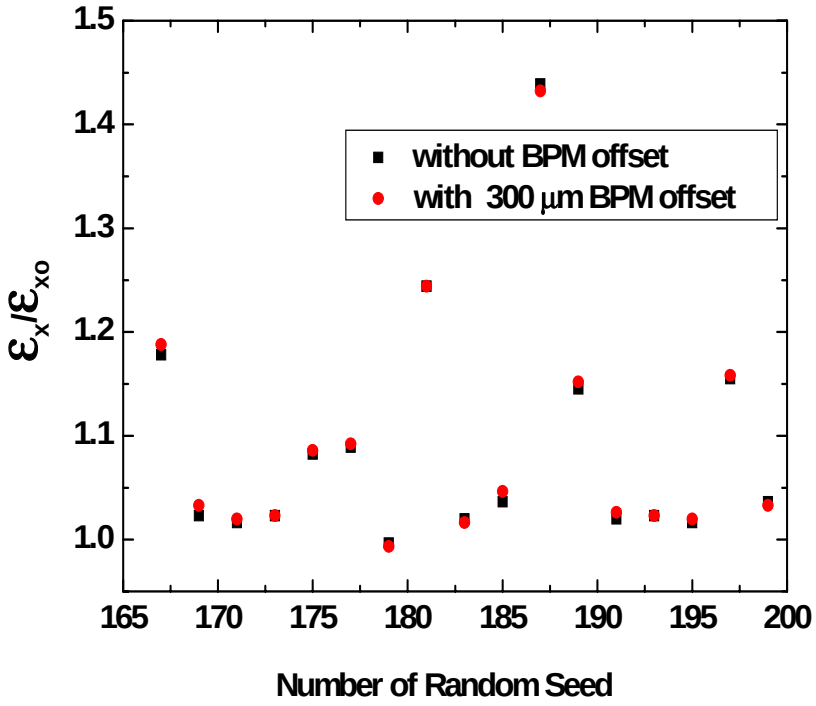


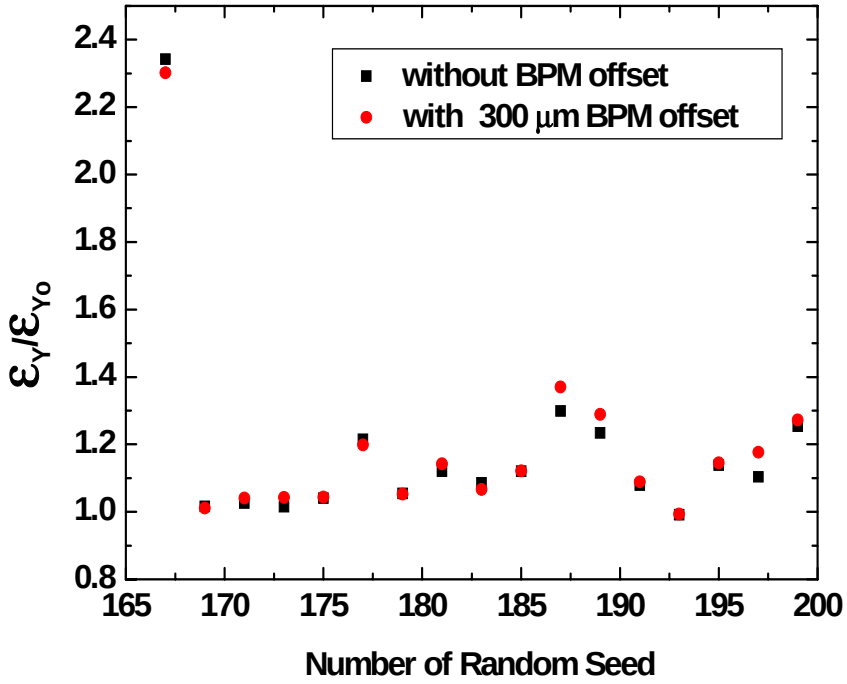


80 and 70 % of seed number shows emittance growth less than 10 % in x and y-direction.

Effect of BPM offset error

With 6 machine errors





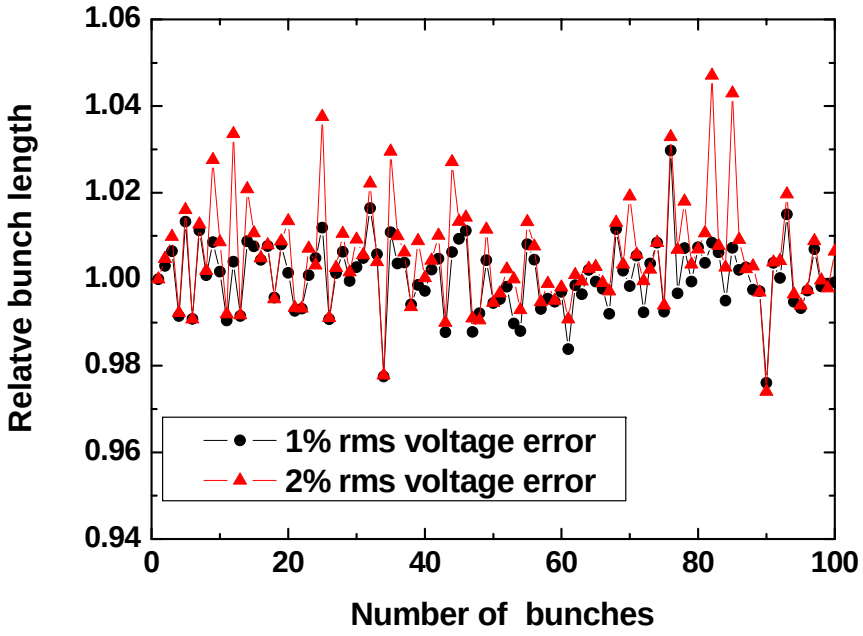
Offset error of 300 μm rms shows negligible emittance growth.

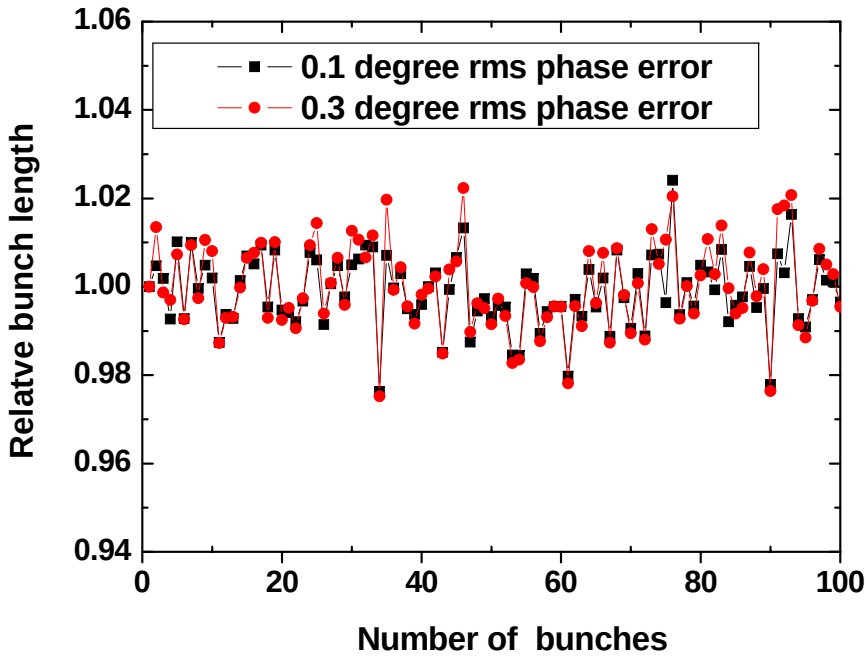
Effects of ISR and CSR on emittances

At Chicane 1	At Chicane 2	ε_x for 6 mm bunch length	ε_x for 9 mm bunch length
CSR	CSR	8.28 μm	8.22 μm
ISR	ISR	8.37 μm	8.92 μm
CSR+ISR	CSR	8.42 μm	8.38 μm
CSR	CSR+ISR	8.47 μm	8.90 μm
CSR+ISR	CSR+ISR	8.65 μm	9.14 μm

ISR is a main source to emittance growth.

Fluctuation in bunch length





100 successive bunches due to rf voltage jitter (left) and rf phase angle jitter (right).

bunch compressors
(Nov. 2005)

	Alternative BC	Baseline BC
Bunch length (mm)	0.15	0.15
Energy spread (%)	2.6	2.46
Horizontal emittance (μm)	8.3 (ISR)	8.2 (ISR)
Vertical emittance (μm)	0.02	0.02
Beam energy (GeV)	13	13

* Initial bunch length : 6 mm

Emittance growth
(Nov. 2005)

Errors	Alternative BC	Baseline BC
10 μm BPM resolution	5.85 nm	5.34 nm
500 μm cavity alignment	2.83 nm	3.04 nm
75 μrad cavity rotation	3.14 nm	2.68 nm

* Initial bunch length : 6 mm

By SLAC group

Summary

- Studies on performance, error tolerance and jitter of alternative BC are presented.
- Results on emittance tuning in the alternative BC show that the system is error tolerant.
- More improvements will be performed in the EDR phase.