Bunch Compressor KM steering - dispersion bump simulation - Vertical emittance dilution

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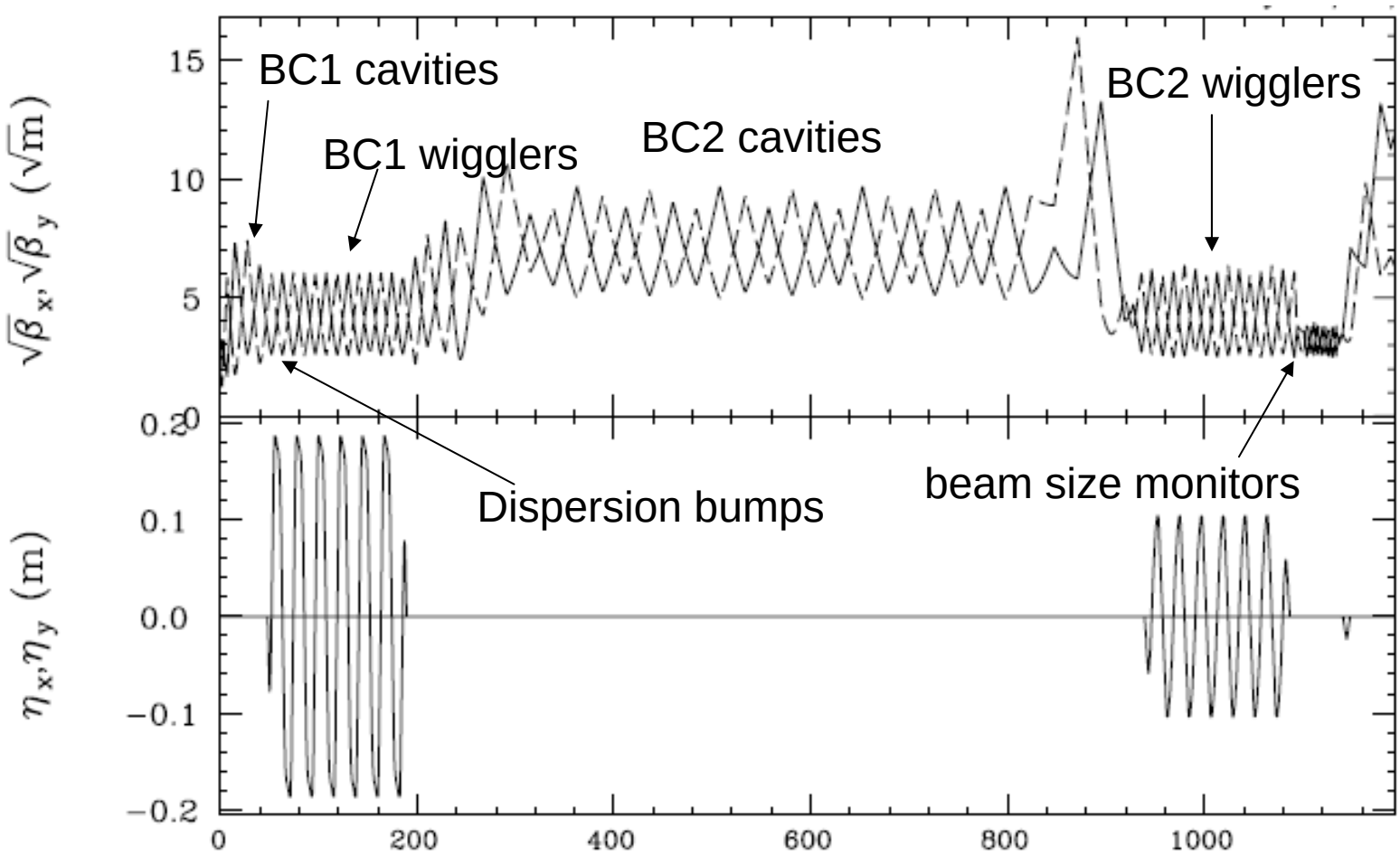
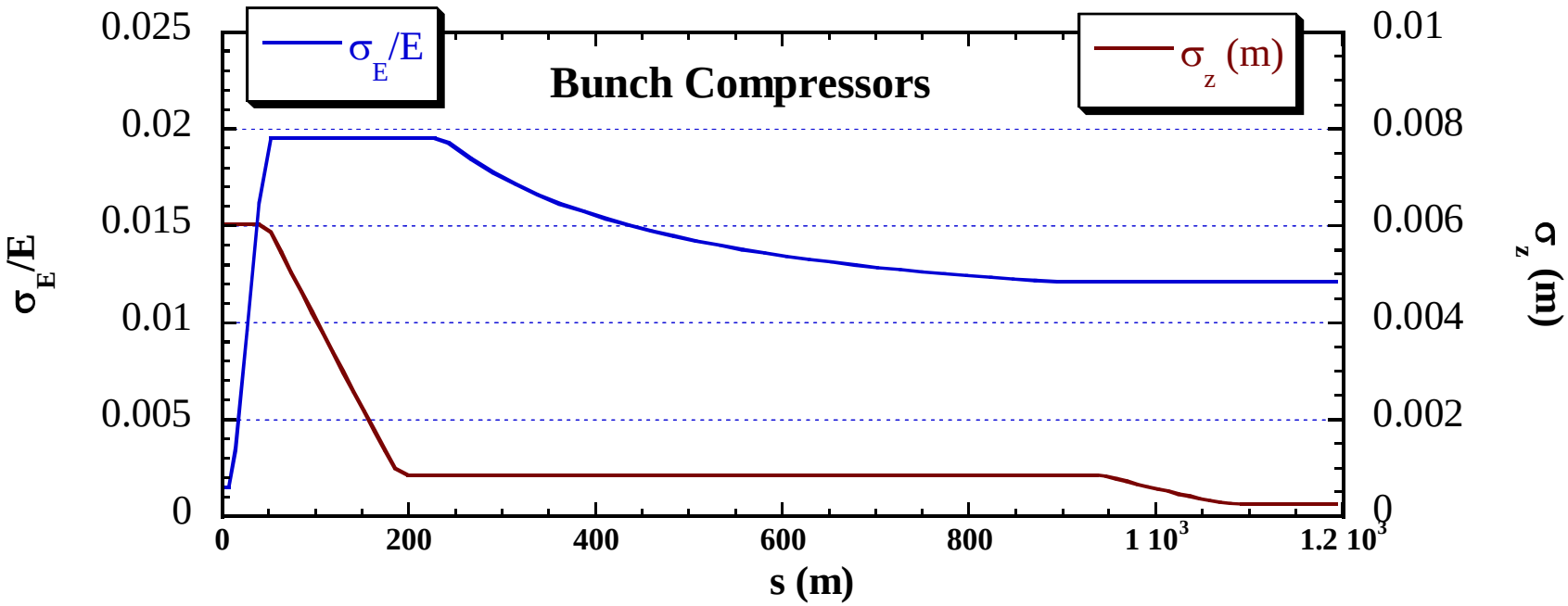
ILC Bunch Compressor, calc. by SAD,
xsif from ILC-GDE RTML web -> SAD Translated by S.Pei (IHEP)



All simulations used SAD. Tracking of macro-particles.

Energy spread and Bunch length vs. s



Simulated cases

Quad offset (μm)	BPM-Quad offset (μm)	Quad rotation (μrad)	Cavity pitch (μrad)	Correction
150	7	0	0	KM
150	7	0	0	KM+bump
0	0	300	0	None
0	0	900	0	None
0	0	0	30	KM
0	0	0	100	KM
150	7	0	300	KM+bump

Kick Minimization

Quad magnet, BPM and steering magnets should be attached.

$$\text{Minimize } r\sum_i (x_i^2 + y_i^2) + \sum_i \left[\left(\theta_{x,i} + k_i x_i\right)^2 + \left(\theta_{y,i} - k_i y_i\right)^2 \right],$$

$\theta_{x(y)i}$: Additional kick angle (additional to designed kick) of steering at i - th quad

$x(y)_i$: Offset from designed orbit at i - th quad

k_i : K - value (inverse of focal length) of the i - th quad

r : Weight ratio : $(\text{Quad - BPM offset})^2 / (\text{Quad offset})^2$

Dispersion bumps

Knobs

- 4 skew quads at the beginning of BC1 wiggler section
- (a) Set opposite strength of a pair of skew quads, -I between them.
- (b) Set opposite strength of another pair of skew quads, -I between them. 90 degree phase difference from the first pair.
- Knob 1: (a) + (b)
- Knob 2: (a) - (b)

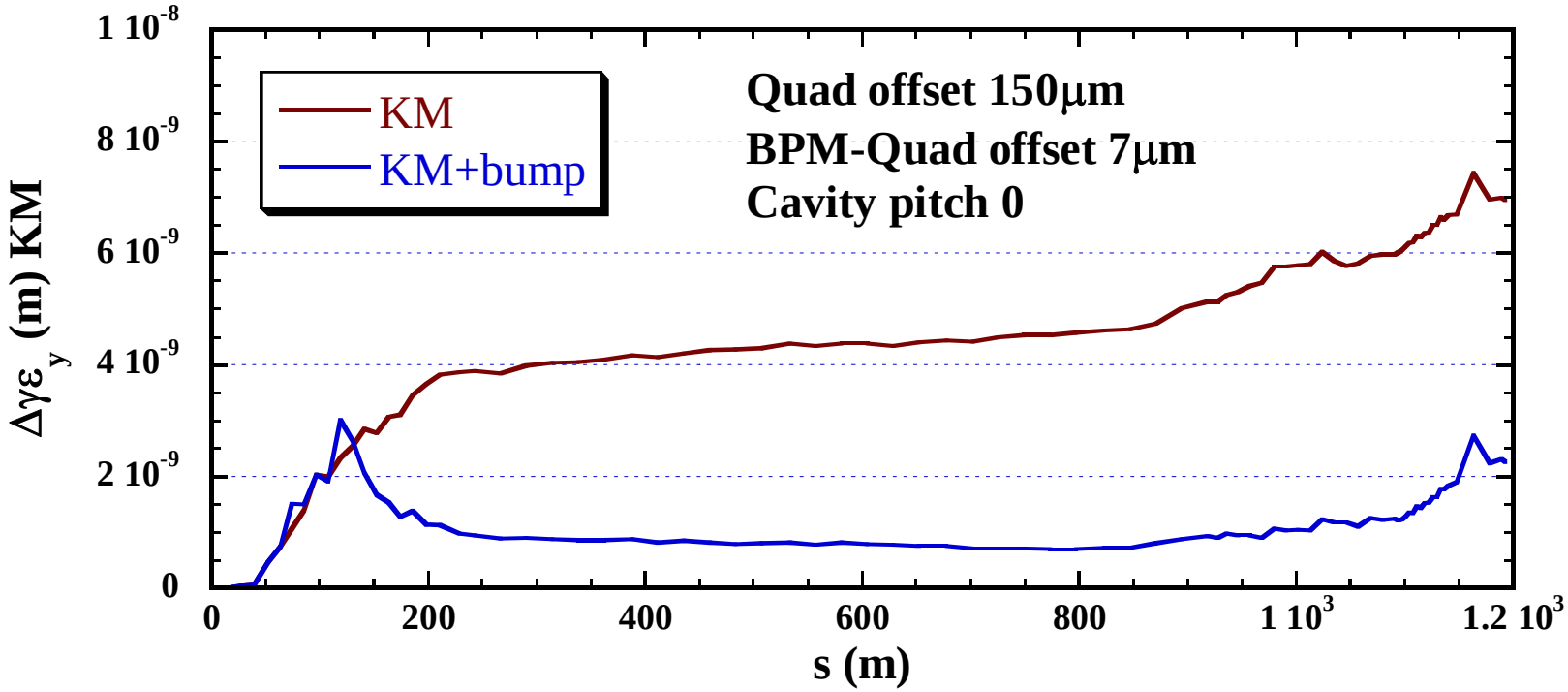
Monitors

- Near the end of the beam line
  - Use three laser wire monitors (beam size monitors)
  - Minimize projected emittance calculated from beam sizes at three locations.

Quad offset

KM + Dispersion bump

Vertical emittance increase (average of 100 seeds) vs. s

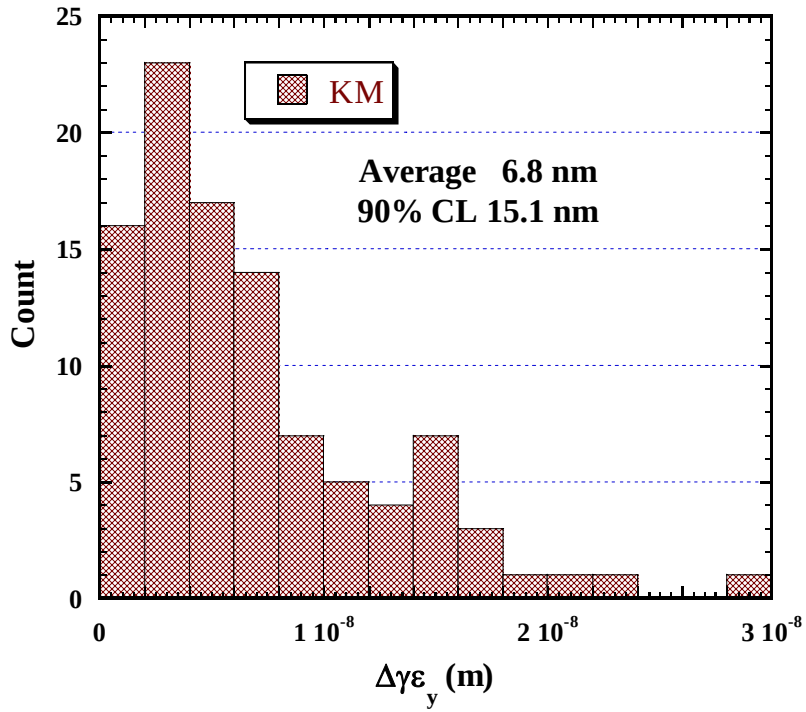


Emittance increase mostly in wiggler sections

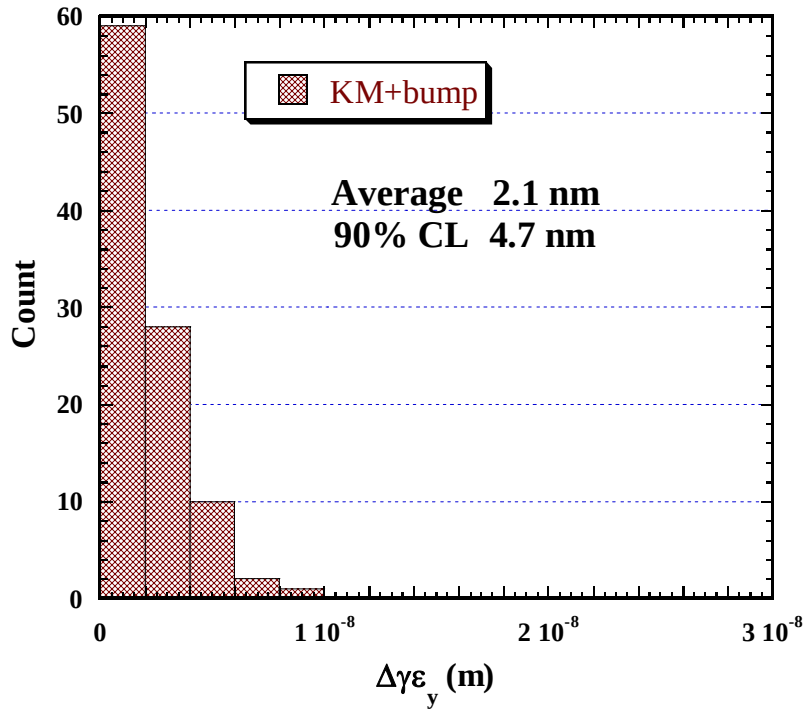
Quad offset - KM + Dispersion bump

Quad offset 150 um, BPM-Quad offset 7 um

KM only



KM + bump

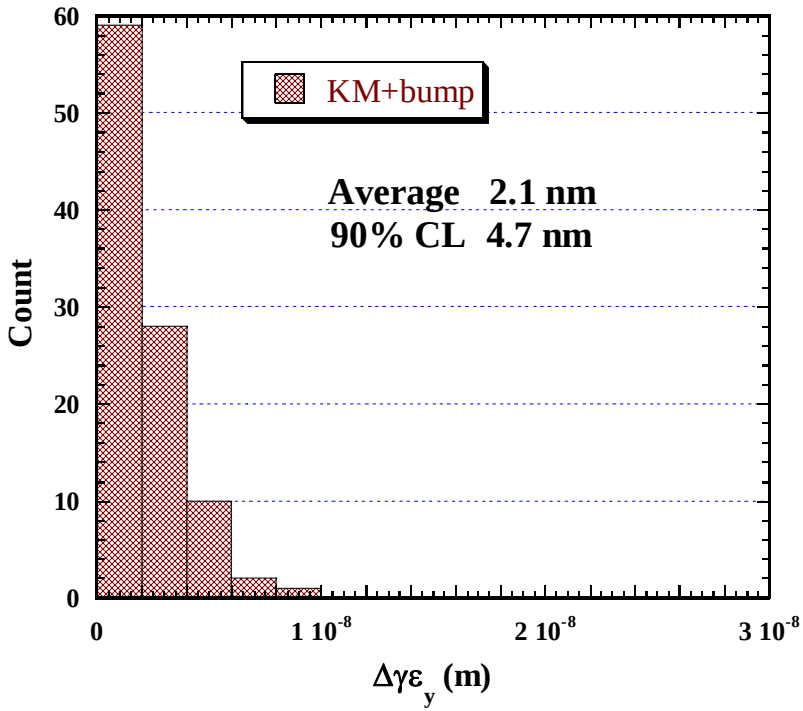


Quad offset - KM + Dispersion bump

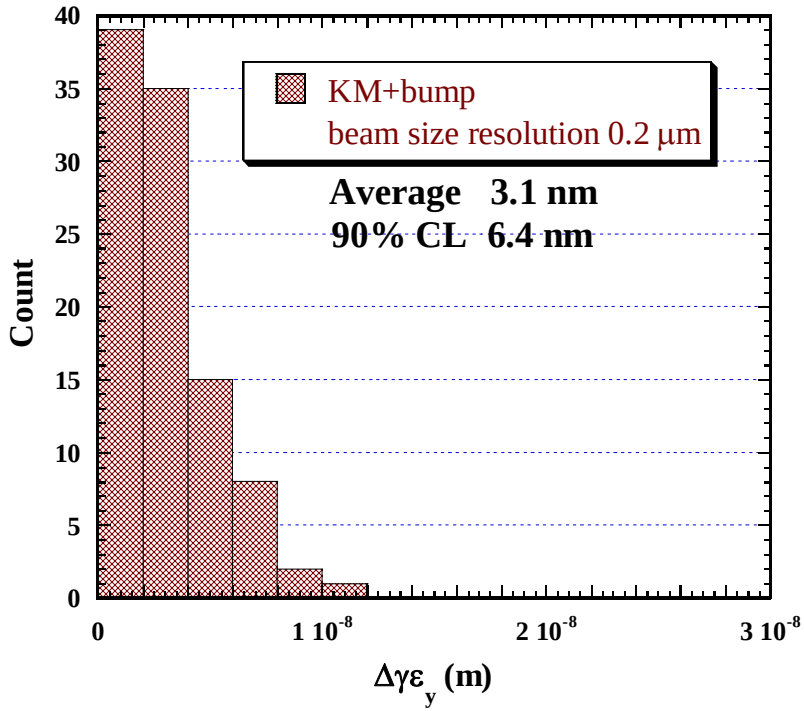
Accuracy of beam size monitor

Quad offset 150 um, BPM-Quad offset 7 um

Perfect beam size measurement

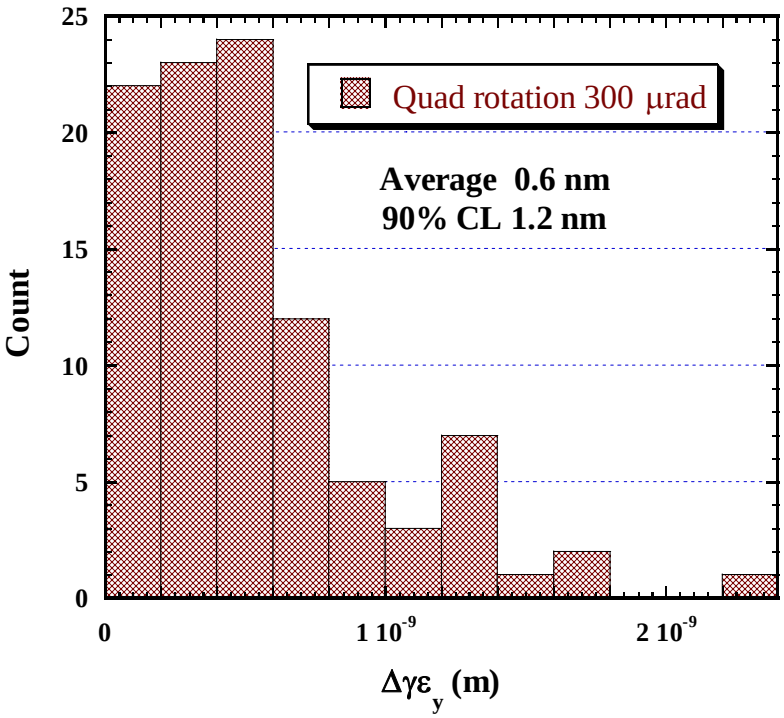


Beam size resolution 0.2 um

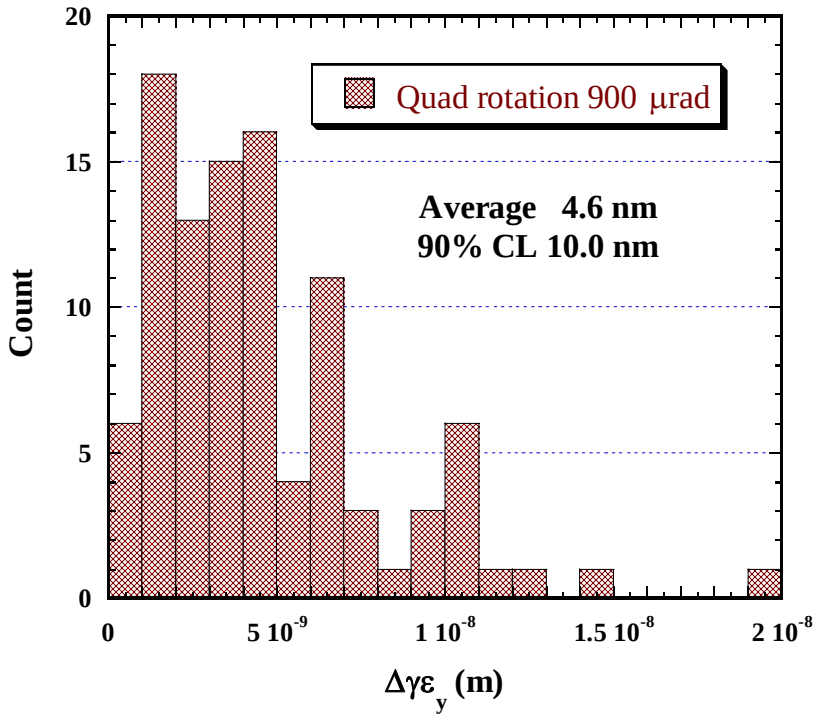


Quad rotation error, No correction

Quad rotation 0.3 mrad rms



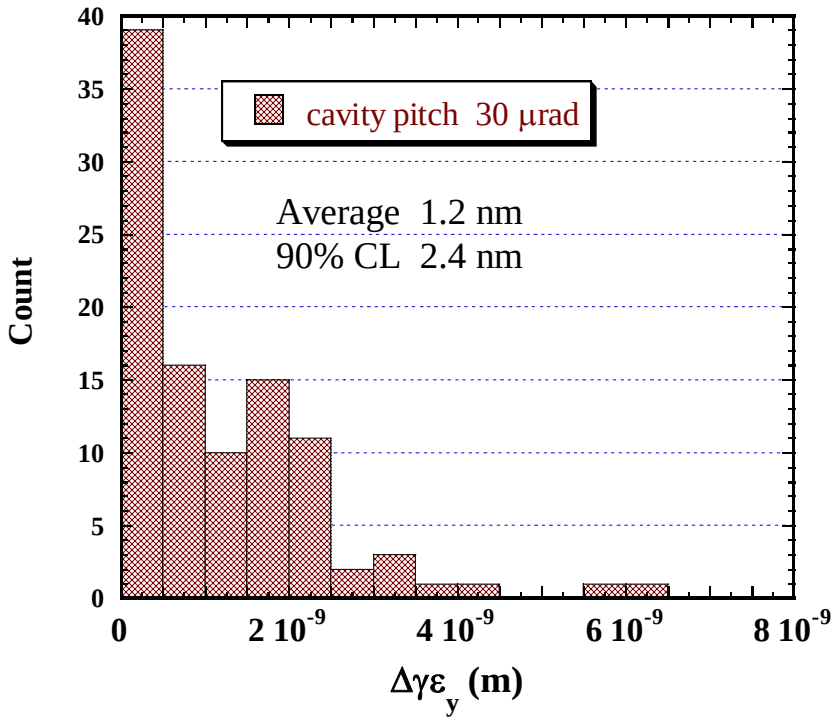
Quad rotation 0.9 mrad rms



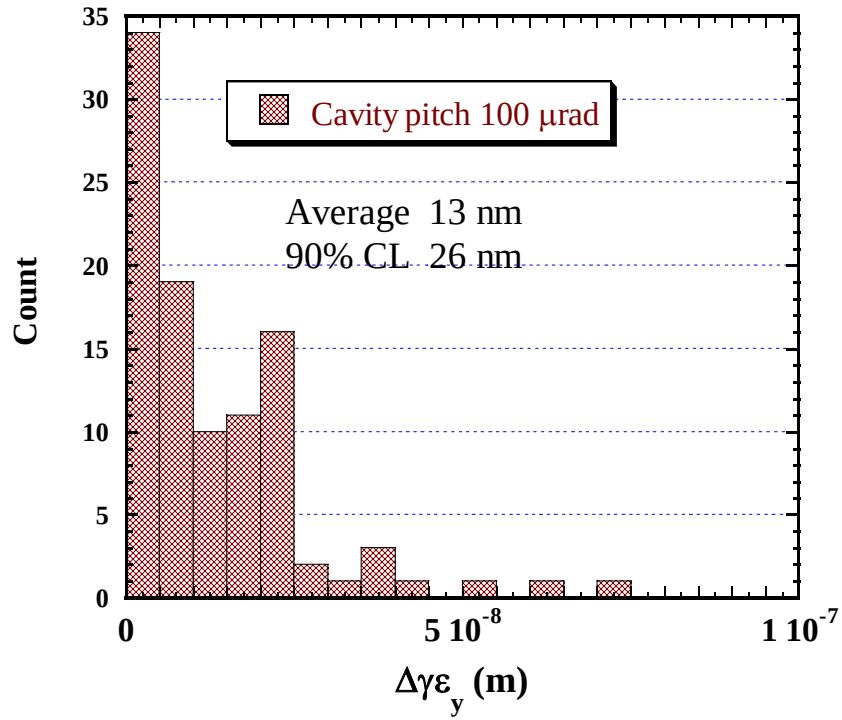
Probably, quad rotation is not very important

Cavity Pitch - KM steering

Cavity pitch 30 urad rms



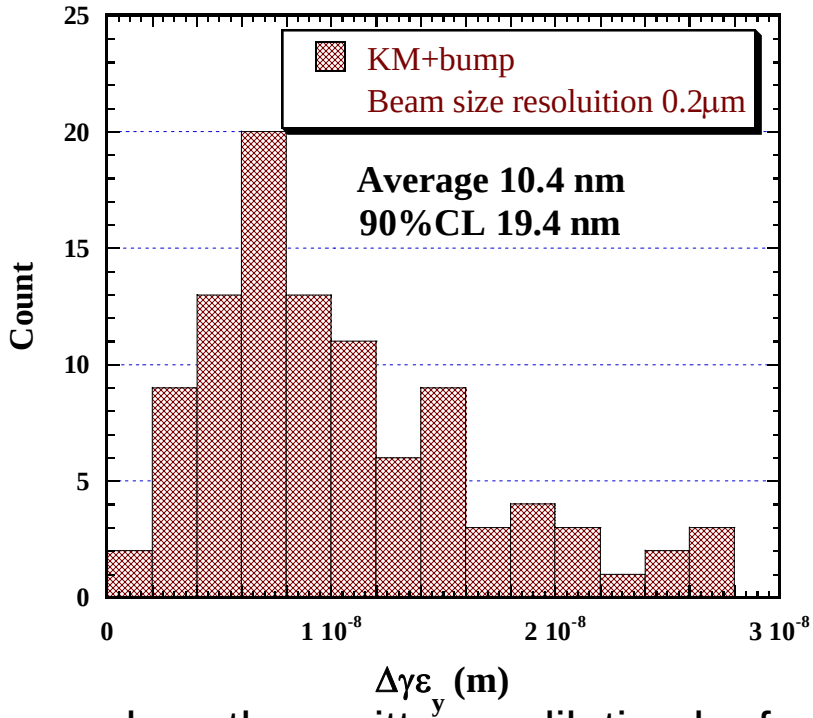
Cavity pitch 100 urad rms



KM is not effective for cavity pitch

Quad offset + Cavity Pitch - KM + bump

Quad offset 150 um, BPM-Quad offset 7 um,
Cavity pitch 300 urad, Beam size resolution 0.2 um

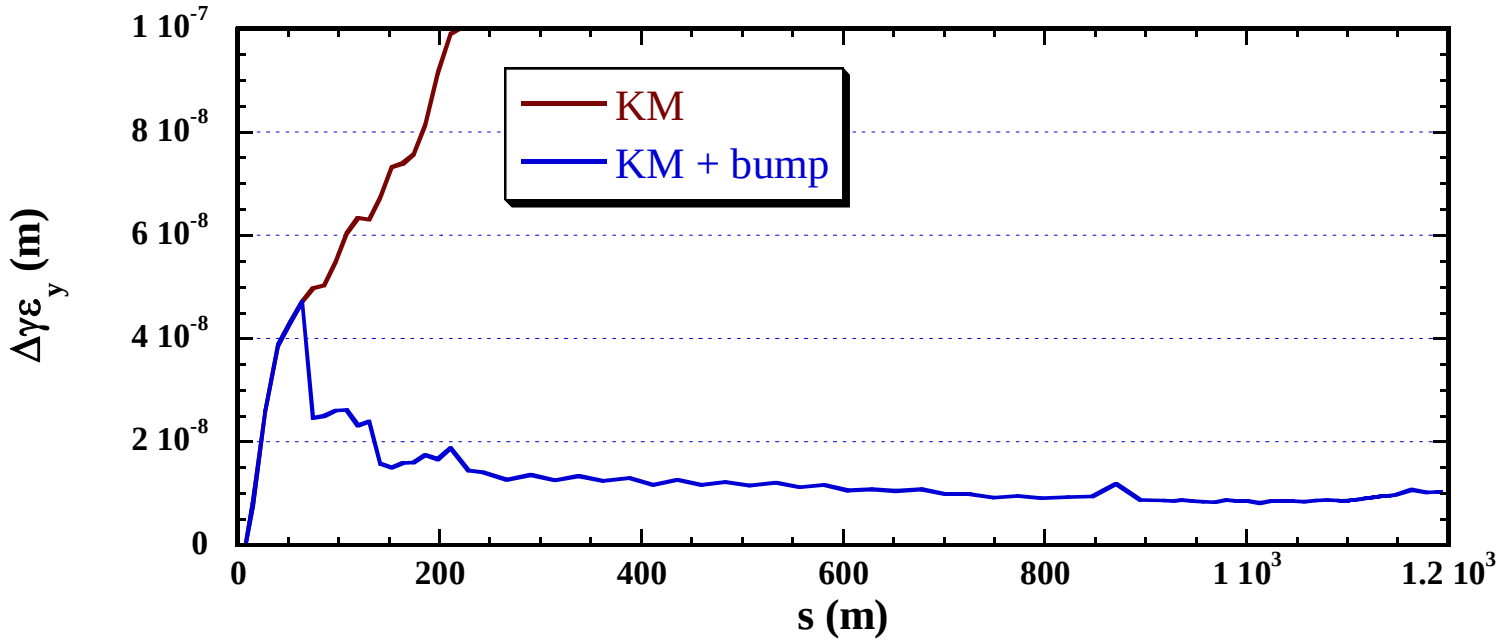


Dispersion bump reduce the emittance dilution by factor about 10.
But not satisfactory.

Quad offset + Cavity Pitch - KM + bump

Quad offset 150 um, BPM-Quad offset 7 um,
Cavity pitch 300 urad, Beam size resolution 0.2 um

Vertical emittance increase (average of 100 seeds) vs. s



Emittance increase in the cavities of BC1

Summary of simulation results

Quad offset (μm)	BPM-Quad offset (μm)	Quad rotation (μrad)	Cavity pitch (μrad)	Correction	Average $\Delta\gamma\varepsilon$ (nm)	90%CL $\Delta\gamma\varepsilon$ (nm)
150	7	0	0	KM	6.8	15.1
150	7	0	0	KM+bump	2.1	4.7
150	7	0	0	KM+bump*	3.1	6.4
0	0	300	0	None	0.6	1.2
0	0	0	100	KM	13	26
150	7	0	300	KM+bump	9.2	17.6
150	7	0	300	KM+bump*	10.4	19.4

* Beam size resolution 2 um

Summary

- Assuming Kick Minimization steering (KM) only:
  - Quad offset 150 um and BPM-Quad offset 7 um are too large.
- Assuming KM+Dispersion bumps:
  - Quad offset 150 um and BPM-Quad offset 7 um are nearly tolerable. Not satisfactory.
- Quad rotation ~300 urad is no problem
- Cavity pitch error cannot be well corrected by KM + dispersion bumps
  - (300 urad is tolerable in main linac using DFS, etc..)

Result is not satisfactory. Need more studies.

- Misalignment in warm section and cold section should be set differently ?
- Better bumps ?
- Corrections changing cavity voltage/phase, like DFS ?