Emittance Studies in the 2006 Bunch Compressor

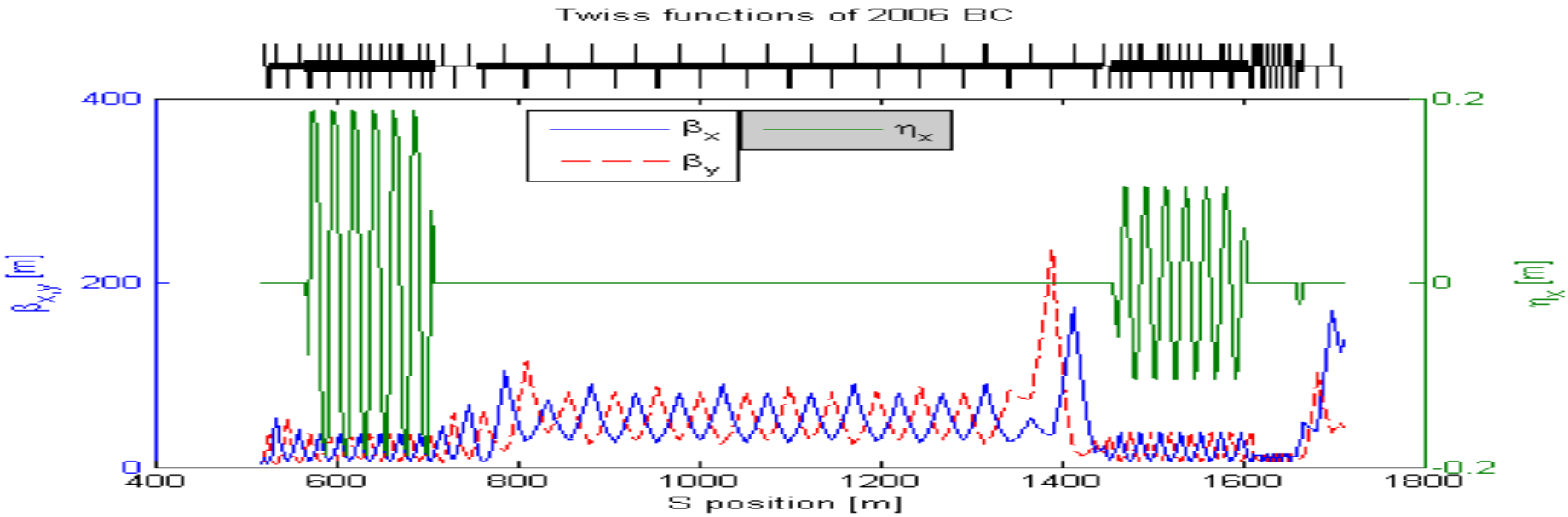
PT

SLAC

Introduction

- At the Daresbury meeting, K. Kubo presented some results for tuning studies of the 2006 Bunch Compressor (BC)
  - **Quite interesting and scary results on quad misalignments and cavity pitches**
- I performed similar studies to try and confirm his results
- In general I found that emittances were better than in K. Kubo's study

2006 BC



- 6 mm x 0.15% longitudinal emittance
- More RF stations in BC2 than are retained in 2007 design
- 1 Quad / 1 CMs in BC1, 1 Quad / 2 CMs in BC2
  - **2007 design goes to 1 Q / 3 CMs in BC2**
- Skew quads in each wiggler for dispersion control
- Emittance station after BC2
- Different RF / wiggler configuration than in 2007 design
  - **Had to redesign because of 9 mm bunch out of DR**

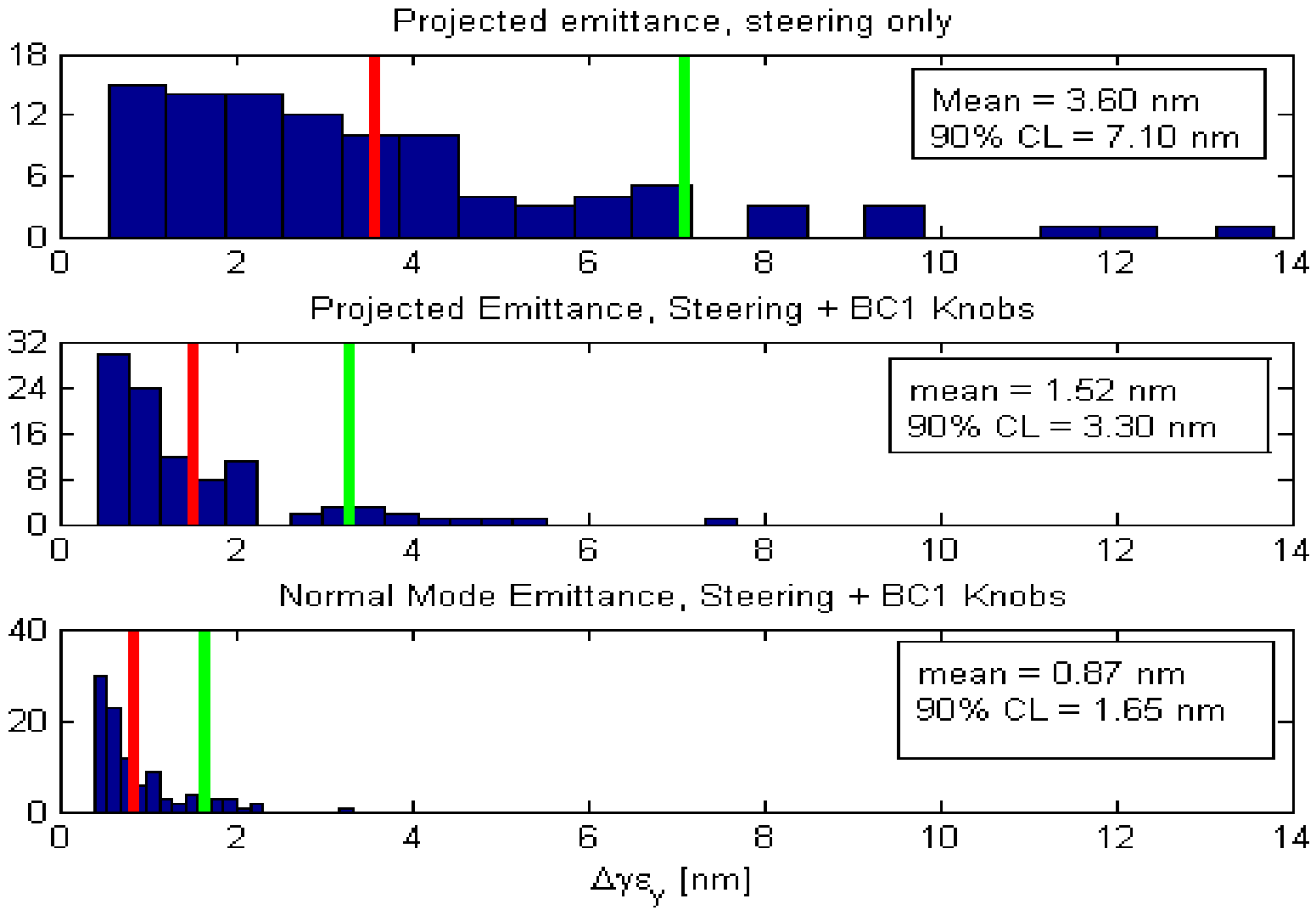
KM Steering

- Simultaneously minimize RMS BPM readings, *and* BPM readings – corrector strengths
- Requires BPM-to-quad offsets be reasonably small
- Assumed 7 um RMS
  - **Was used in previous study**
  - **Estimate of accuracy of quad-shunting technique from FFTB experience**
- Weighting:
  - **Increase χ^2 by 1 for each BPM with a 150 um residual absolute orbit**
    - 150 um RMS alignments of quads to survey line assumed
  - **Increase χ^2 by 1 for each BPM with a 7 um residual orbit when corrector strength subtracted**
- Iterating
  - **Did 3 iterations**
    - Probably overkill – don't think it improved results compared to 2 iterations
- Assumed perfect BPM resolution
  - **This technique is not generally limited by BPM resolution**

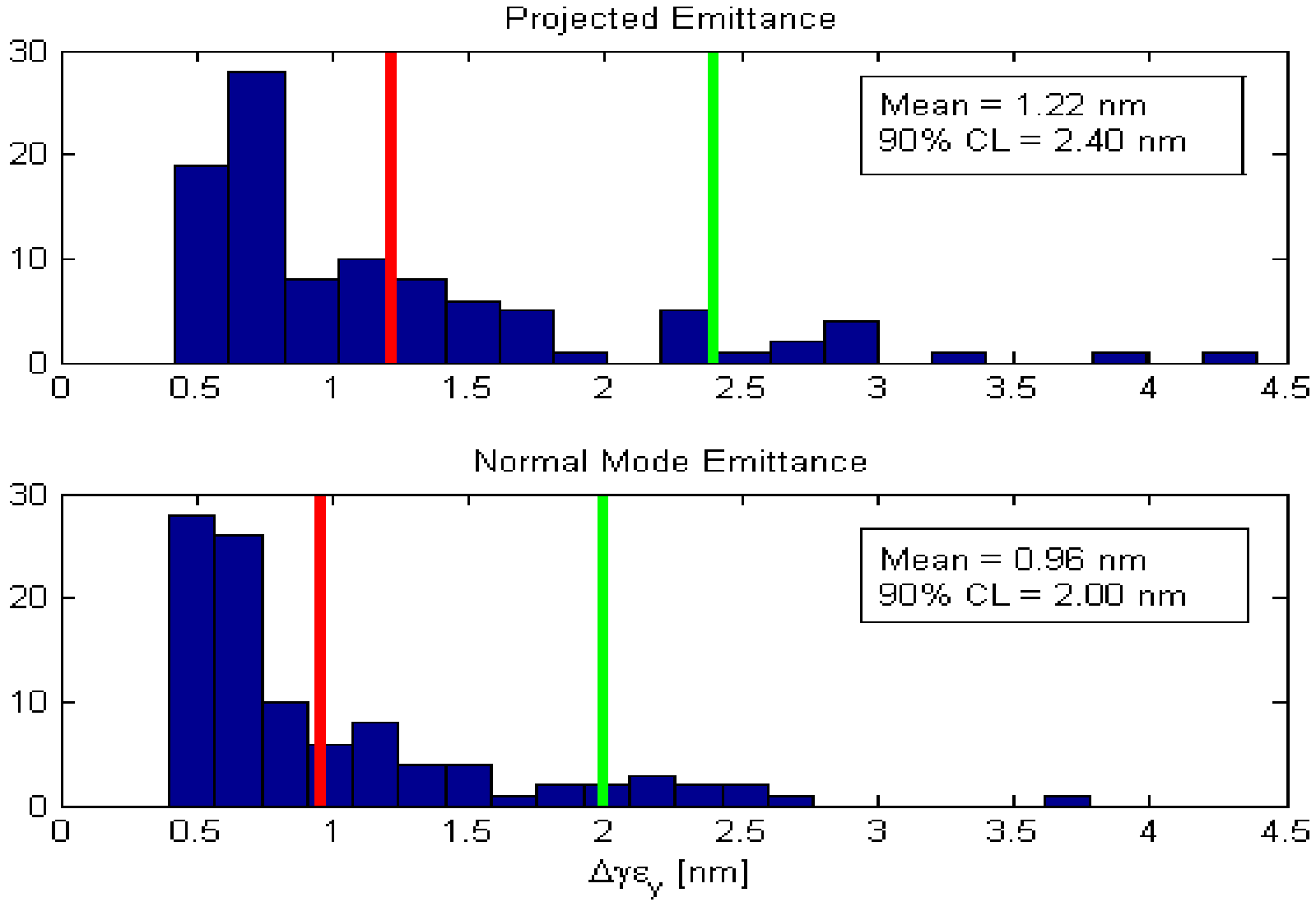
Bump optimization

- 2 pairs of skew quads in BC1, 2 pairs in BC2
- Tune by scanning knob strength, measuring σ^2 on appropriate wire scanner, fitting parabola, accepting best value
  - **Also some fancy logic for handling case when minimum is outside scan range**
- Looked at response of wires to each pair of skew quads
  - **BC1: All 4 wires respond ~equally to each knob**
    - Tune knob 1 using beam size on wire 4
    - Tune knob 2 using beam size on wire 2
  - **BC2: found that phase advance from knobs to wires not optimal**
    - Make a linear combination of 2 knobs, with “mixing angle” of 15° -- makes 1 wire completely non-responsive to each of the 2 knobs
    - Tune knob 1 using beam size on wire 1
    - Tune knob 2 using beam size on wire 3
- No wire resolution limit used (ie, wires are perfect)
- Did 2 studies
  - **Using BC1 knobs only**
    - Original study used only BC1 knobs
  - **Using BC1 and BC2 knobs**
    - 1 iteration of knobs only

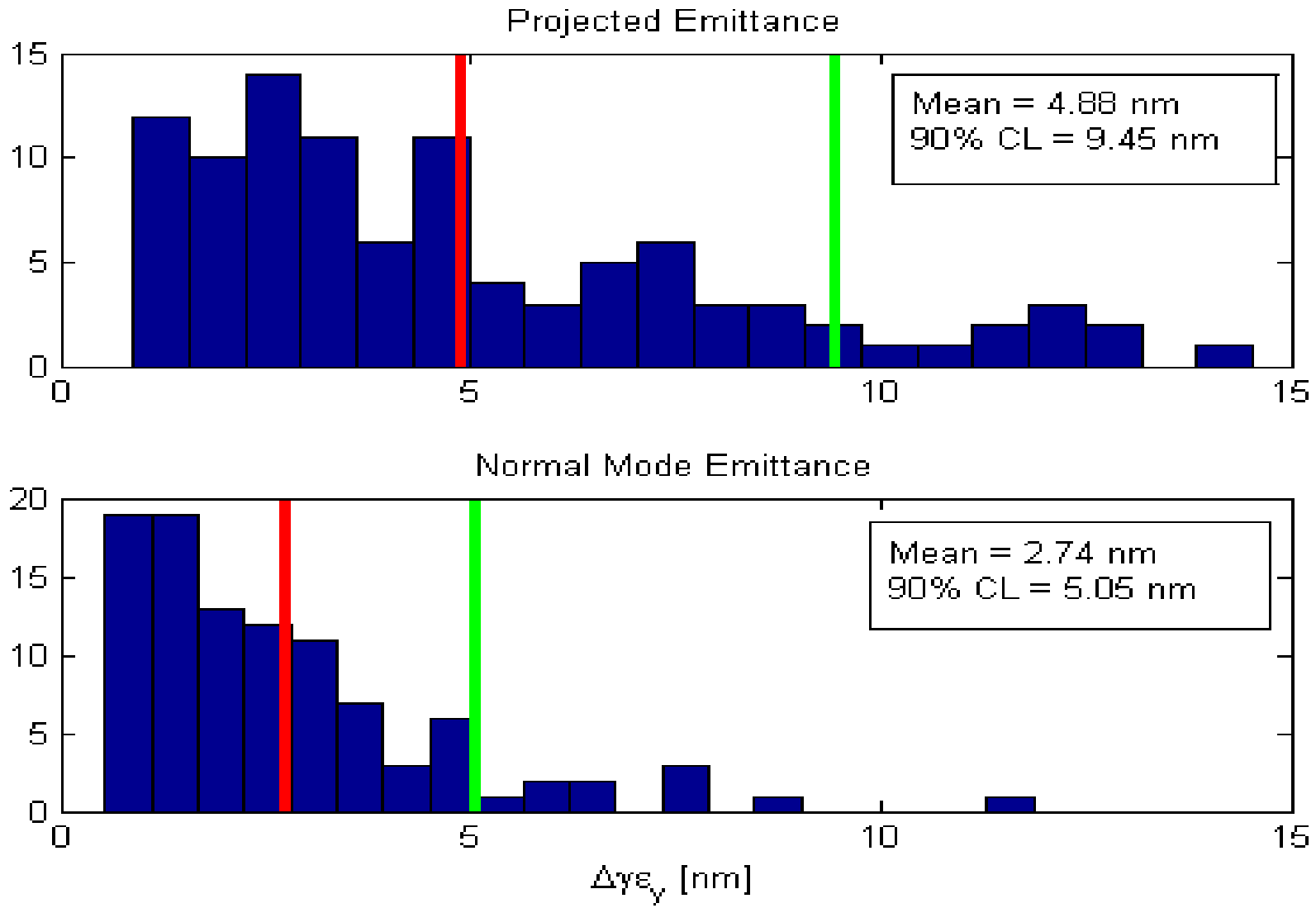
Distribution of Results – Quad and BPM misalignments, KM + BC1 Knobs, 100 seeds



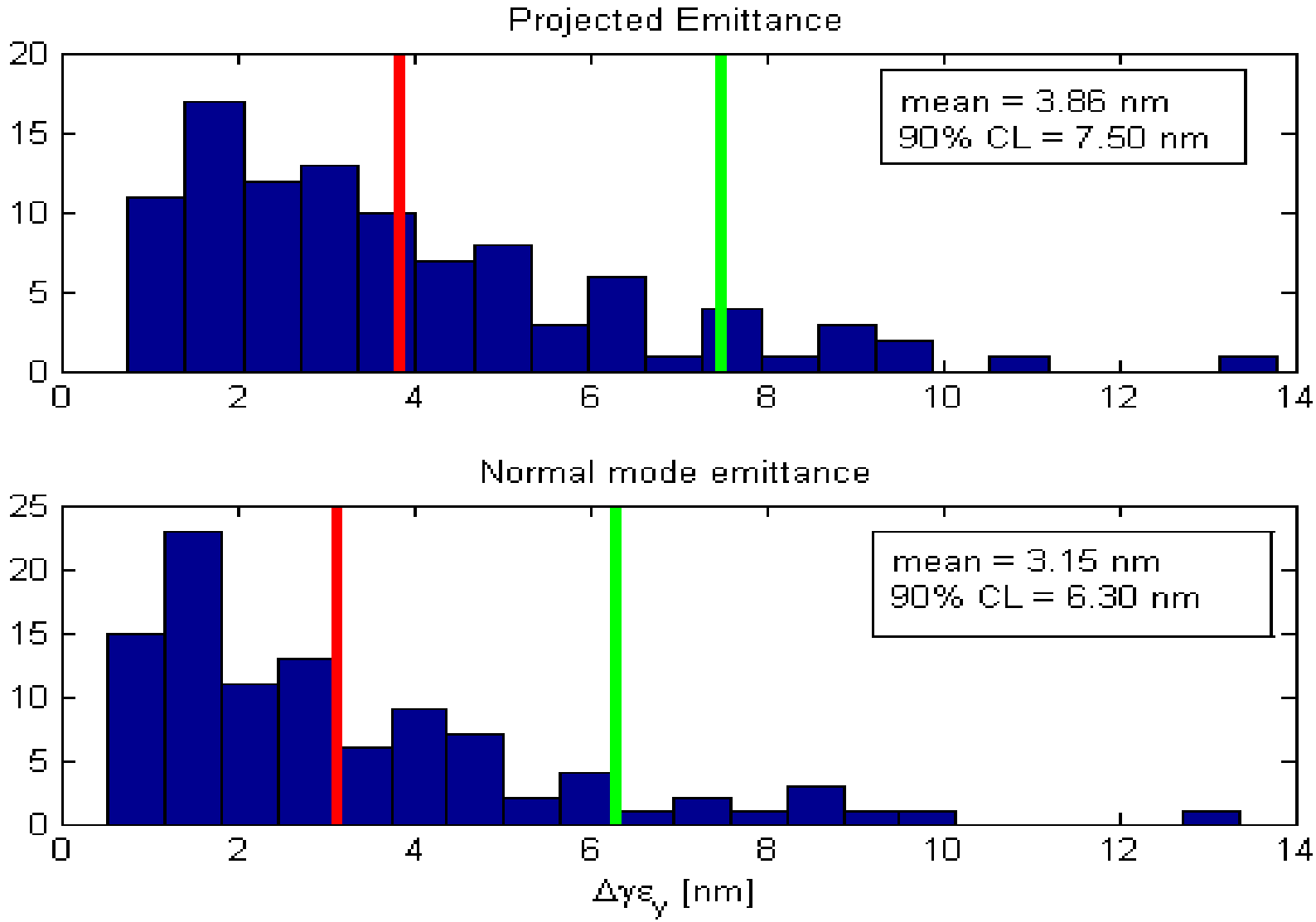
Distribution of Results – Quad and BPM misalignments, KM + BC1+ BC2 Knobs, 100 seeds



Distribution of Results – Quad + BPM misalignments, cavity pitches, KM + BC1 Knobs, 100 seeds



Distribution of Results – Quad + BPM misalignments, cavity pitches, KM + BC1 + BC2 Knobs, 100 seeds



Summary of Results

Quad Offset (μm)	BPM Offset (μm)	Cavity Pitch (μrad)	Knobs	Mean growth (nm)		90% CL Growth (nm)	
				Old	New	Old	New
150	7	0	None	6.8	3.6	15.1	7.1
150	7	0	BC1	2.1	1.5	4.7	3.3
150	7	0	All	–	1.2	–	2.4
150	7	300	BC1	9.2	4.9	17.6	9.5
150	7	300	All	–	3.9	–	7.5

Note: All emittance growths here are projected emittances!

Conclusions

- Emittance growths found in this study were generally smaller than in K. Kubo's study
  - **Including the use of KM steering to correct quad misalignments**
- BC2 knobs seem to somewhat improve projected emittance growth
  - **But make the normal-mode growth somewhat worse**
- Emittance growths are still larger than expected and larger than budget
- These effects will be worse in 2007 design
  - **Larger longitudinal emittance out of DR**

Open questions

- Why do the two studies disagree?
- Why aren't the knobs more effective?
  - **On quad misalignments in turnaround, KM steering + knobs is almost perfect**
- Why does the normal-mode emittance increase when BC2 knobs are used?
- Are we using the correct parameters?
  - **Could fit a Gaussian to the beam projection at the wire instead of looking at RMS**
  - **Could compute emittance from the fitted Gaussians at 4 wires instead of looking at emittance from beam matrix**

Questions / Comments

“What can I do?
All I want is to get next to you!”

-The Police, “Next to You”