EXT Dispersion Correction

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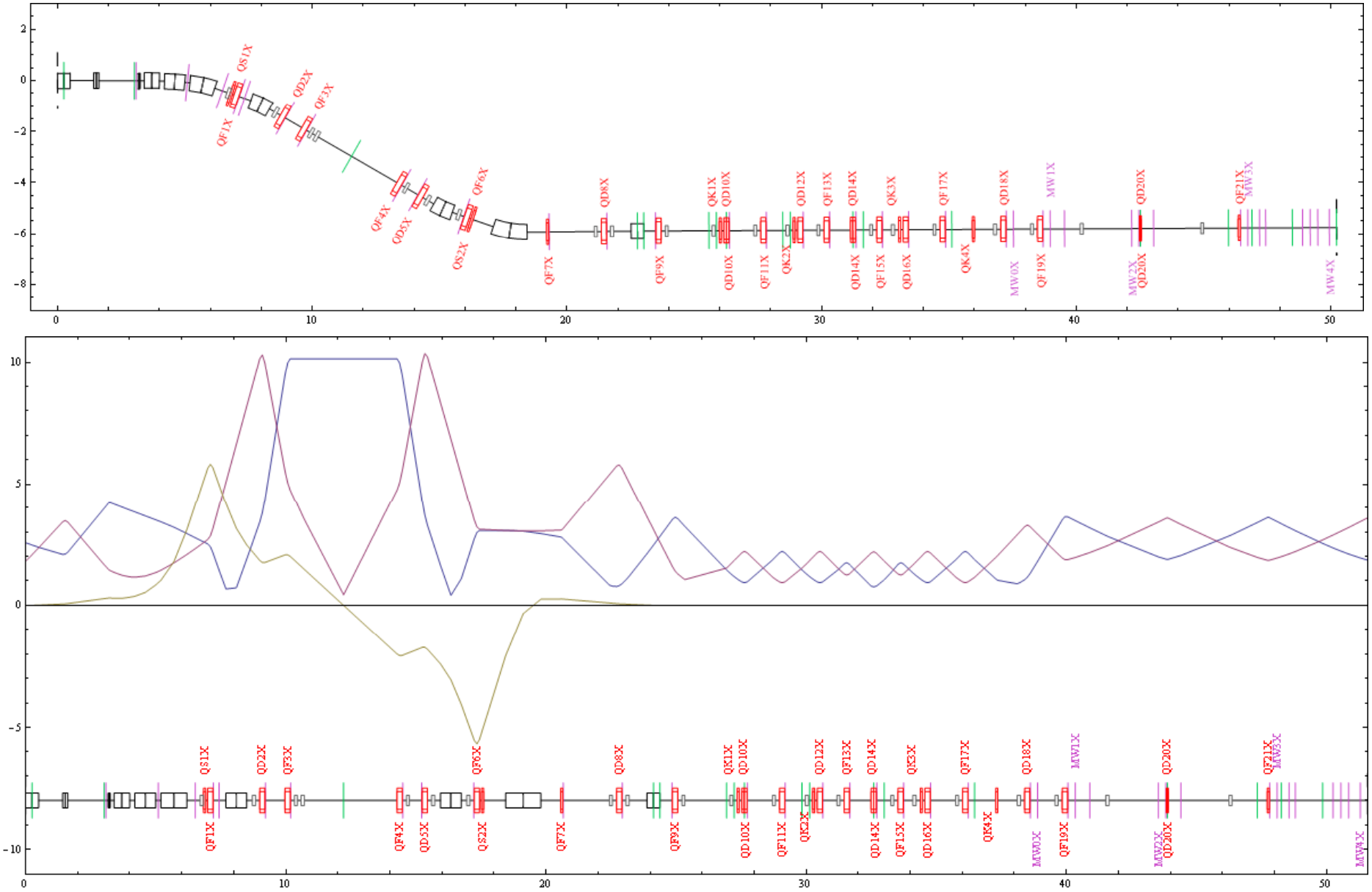
Introduction

- Need to correct horizontal and vertical dispersion at the exit of the EXT line.
- We have:
  - All of the EXT line quadrupoles for the horizontal dispersion
  - QS1-2X and QK1-4X for the vertical plane
    - Also used for coupling correction
- Must minimise the dispersions, but also:
  - Minimise the change in Betas
  - Minimise the induced coupling

ATF EXT Layout



Previous Studies

Simulation Parameters

- use Lucretia[1] simulation code
- included
  - perfect beam from Damping Ring (ε_x=2×10^{-9} m, $\gamma\varepsilon_y$=3×10^{-8} m) … errors begin after extraction septa, unless otherwise noted
  - perfect Final Focus
  - dipole errors[2]: ΔY = 100 μm (rms)
  - quadrupole errors: ΔX = 50 μm, ΔY = 30 μm, Δθ = 0.3 mrad (rms)
  - sextupole errors: ΔX = 50 μm, ΔY = 30 μm, Δθ = 0.3 mrad (rms)
  - BPM resolution: 5 μm (rms)
- *not* included
  - wire scanner rolls: $|\theta| \leq 0.2°$ (uniform)
  - wire scanner beam size errors: $\sigma = \sigma_0(1+\Delta\sigma_{relative})+\Delta\sigma_{absolute}$
  - quadrupole strength errors (ΔK/K)
  - BPM offsets
  - BPM rolls
  - tuning in FF

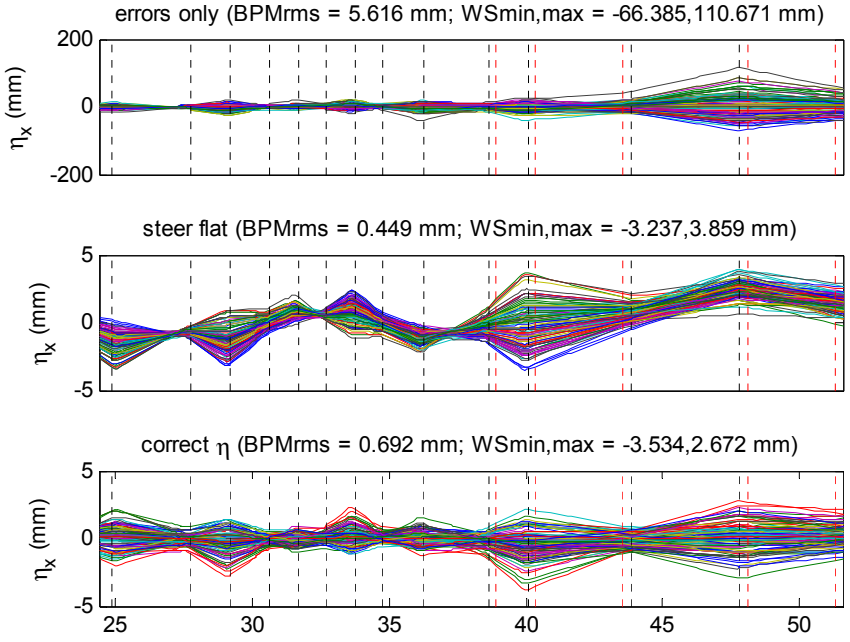
[1] http://www.slac.stanford.edu/accel/ilc/codes/Lucretia/

[2] EXT dipoles BH1 and BH2 are assumed to have nonzero sextupole components

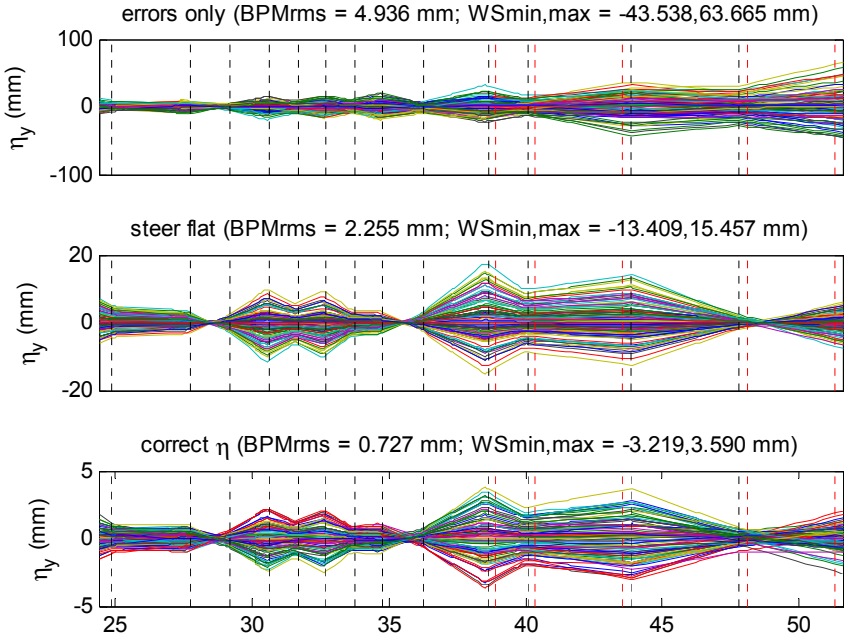
Simulation Procedure

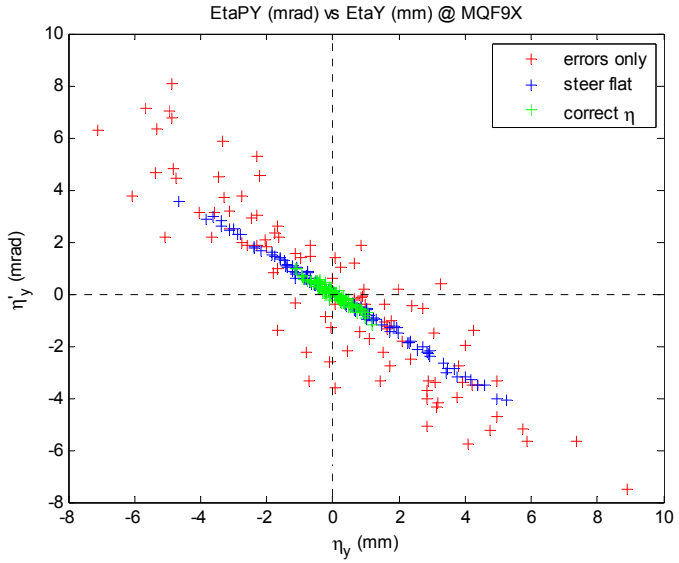
1. apply errors
2. steer flat (EXT only)
3. launch into FF
   - use pulse-to-pulse feedback correctors and BPMs
   - BPMs are perfect
4. measure dispersion in diagnostic section
   - scan input beam energy
   - measure orbits
   - fit position vs energy at each BPM … linear correlation is η
   - back-propagate measured η to start of diagnostic section to get η_0 and η'_0
5. correct dispersion in diagnostic section
   - use QF1X + QF6X multiknobs for η_x and η'_x
   - correct η_y using QS1X + QS2X "sum knob"
6. correct coupling
   - scan skew quadrupoles sequentially
   - deduce projected ε_y from wire scanner measurements
   - set each skew quad to minimize projected ε_y

horizontal dispersion

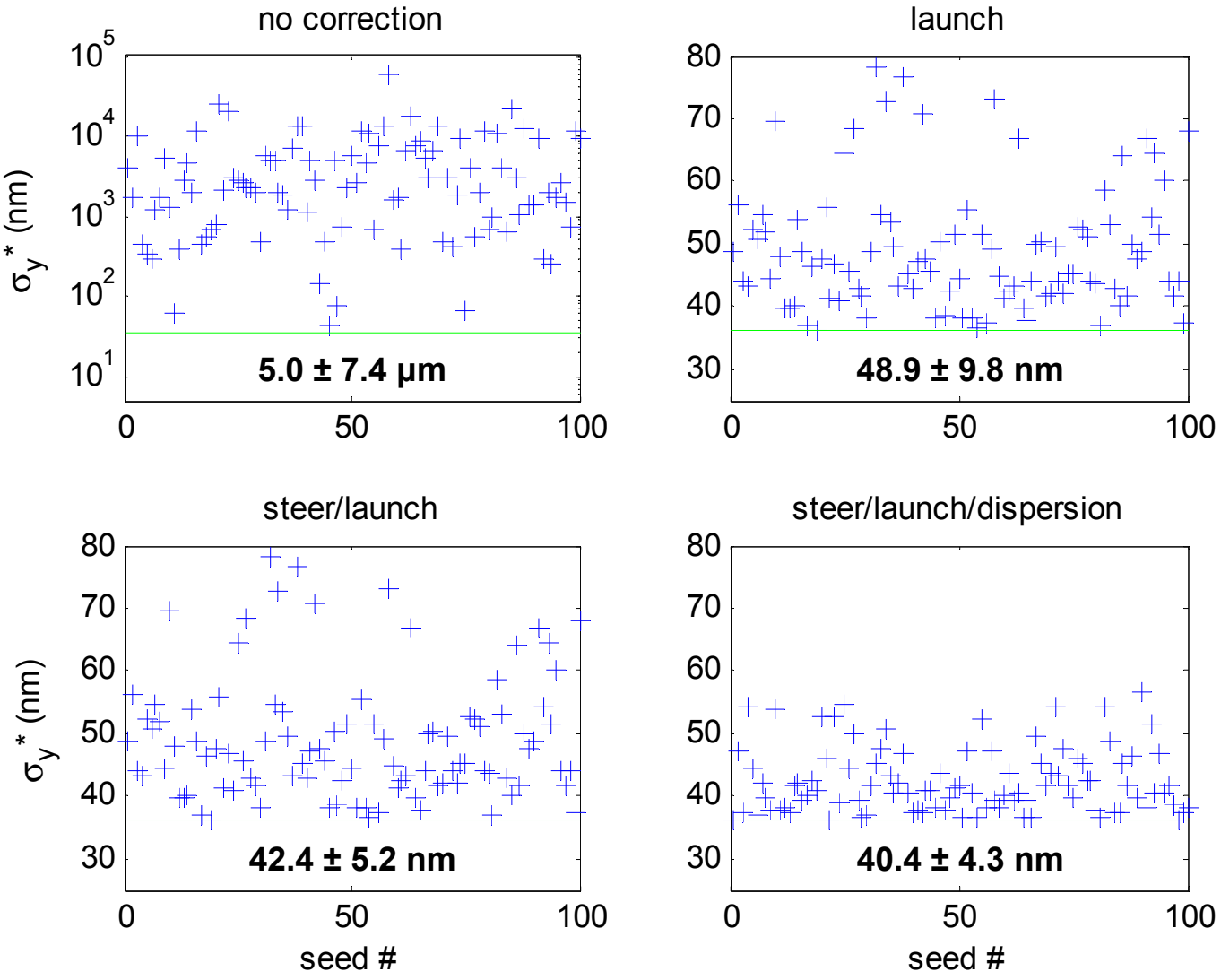


vertical dispersion



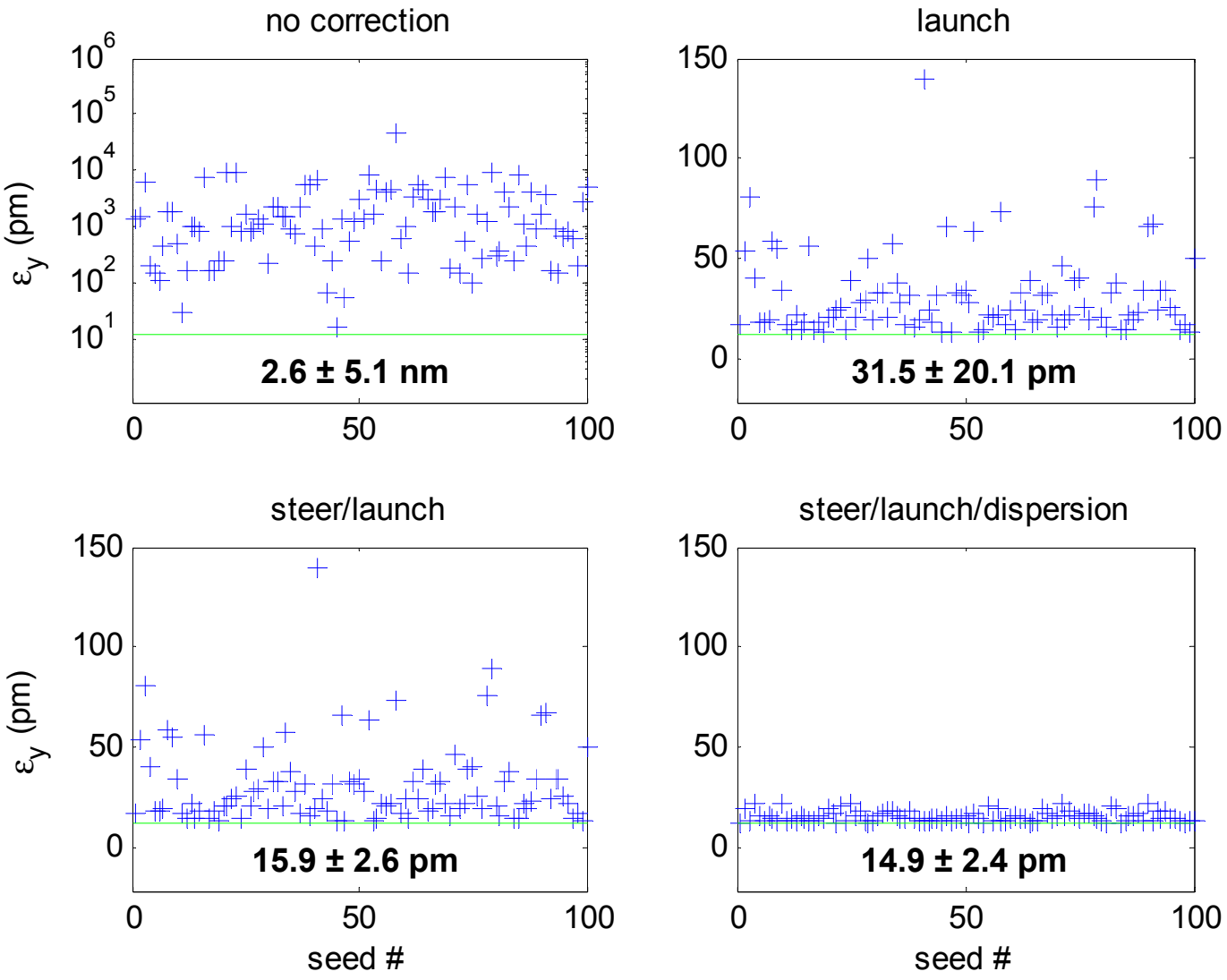


Simulation Results: σ_y^*

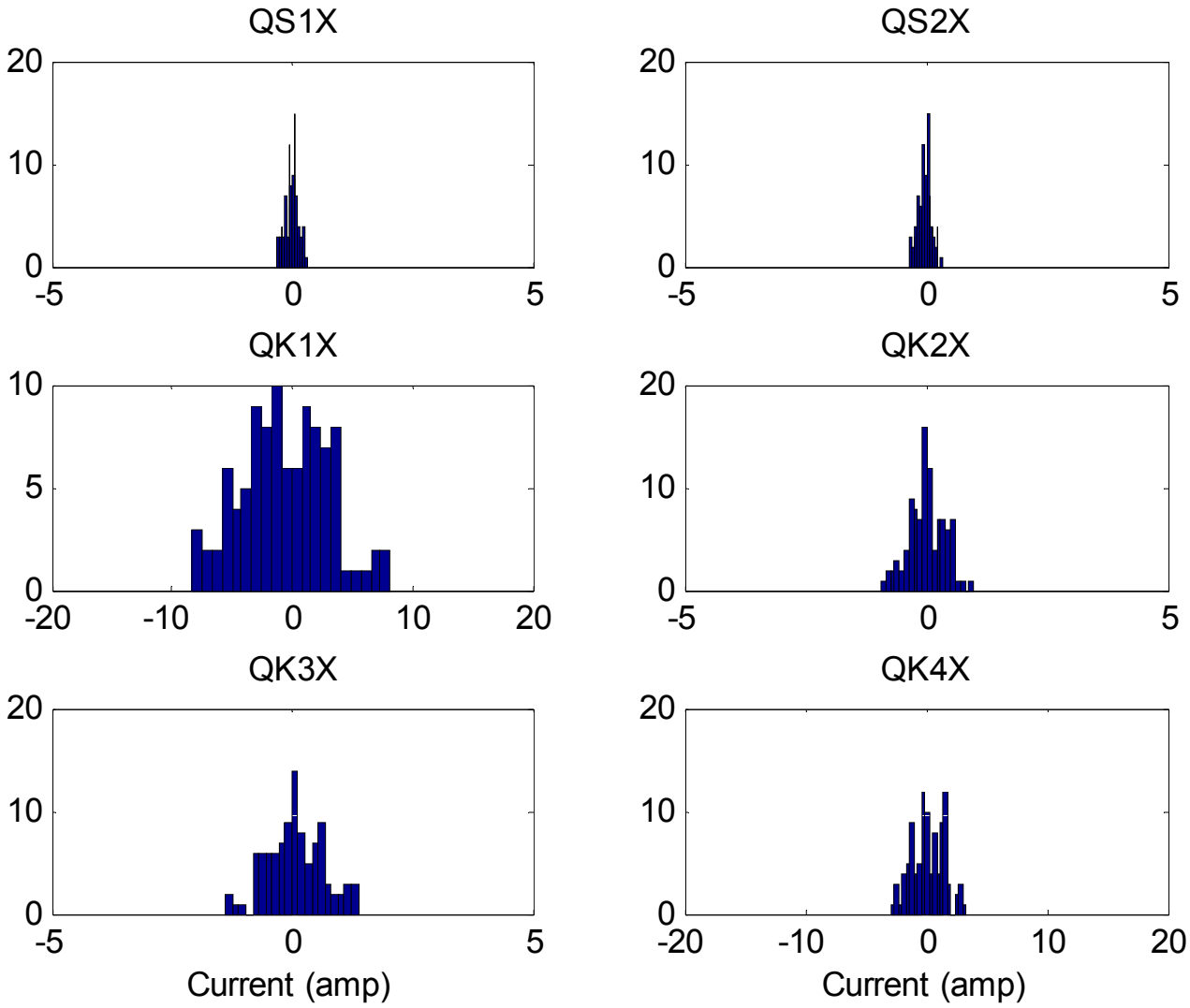


note: green lines show tracking for perfect machine (no errors, no corrections)

Simulation Results: ε_y



Skew Quadrupole Currents



Possible Issues

- It is unclear if we can use QF1X as part of the dispersion correction
  - May need to look at another ‘knob’ combination
- Currently there is an issue with passing off-axis in the QM7R quadrupole
  - Leads to an offset in eta-prime when eta is corrected to zero

Simulation Parameters

- Use MAD-8.23DL Code
- Assume:
  - Perfect damping ring beam
  - Perfect Final Focus
  - Dipole Errors: Transverse position:100μm (rms)
  - Quadrupole Errors: X=50μm, Y=30μm, T=0.3mrad
  - BPM Resolution: 10μm (*also tested with 0μm*)
- Not Included:
  - Wire scanner errors
  - Strength errors
  - BPM rolls and offsets
  - FF Tuning

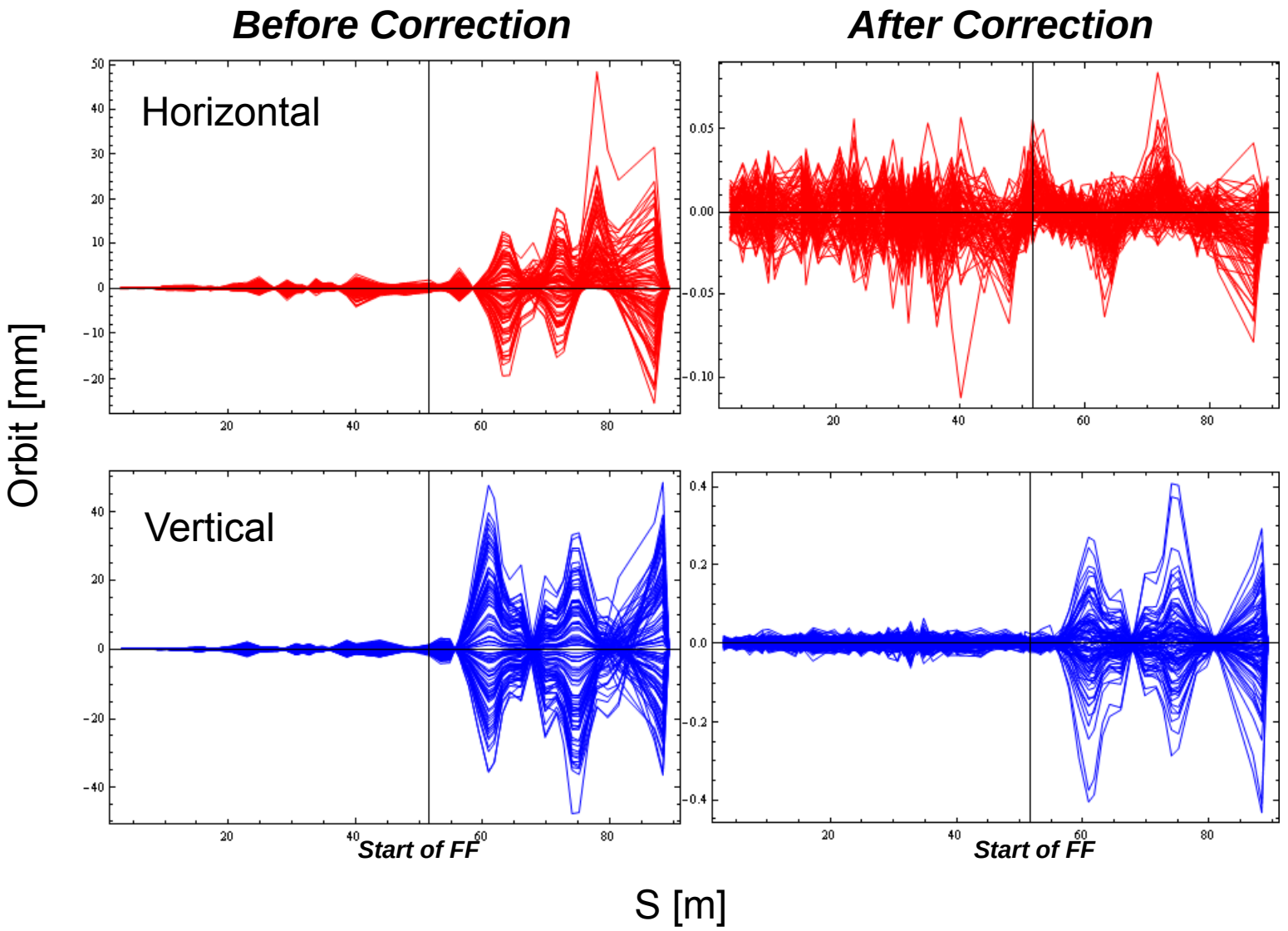
Simulation Method

- Apply Errors
- Steer EXT only, including launch into FF
  - Global SVD based feedback
  - Uses FF launch correctors
- Optimise Dispersion
  - Use Simplex Optimiser with η_x 'knob'
    - Uses QD5X and QF6X (*other combinations possible!*)
  - Use Simplex Optimiser with η_y 'knob'
- Optimise Coupling
  - Minimise sum vertical beam size on wire scanners using QK1X and QK4X

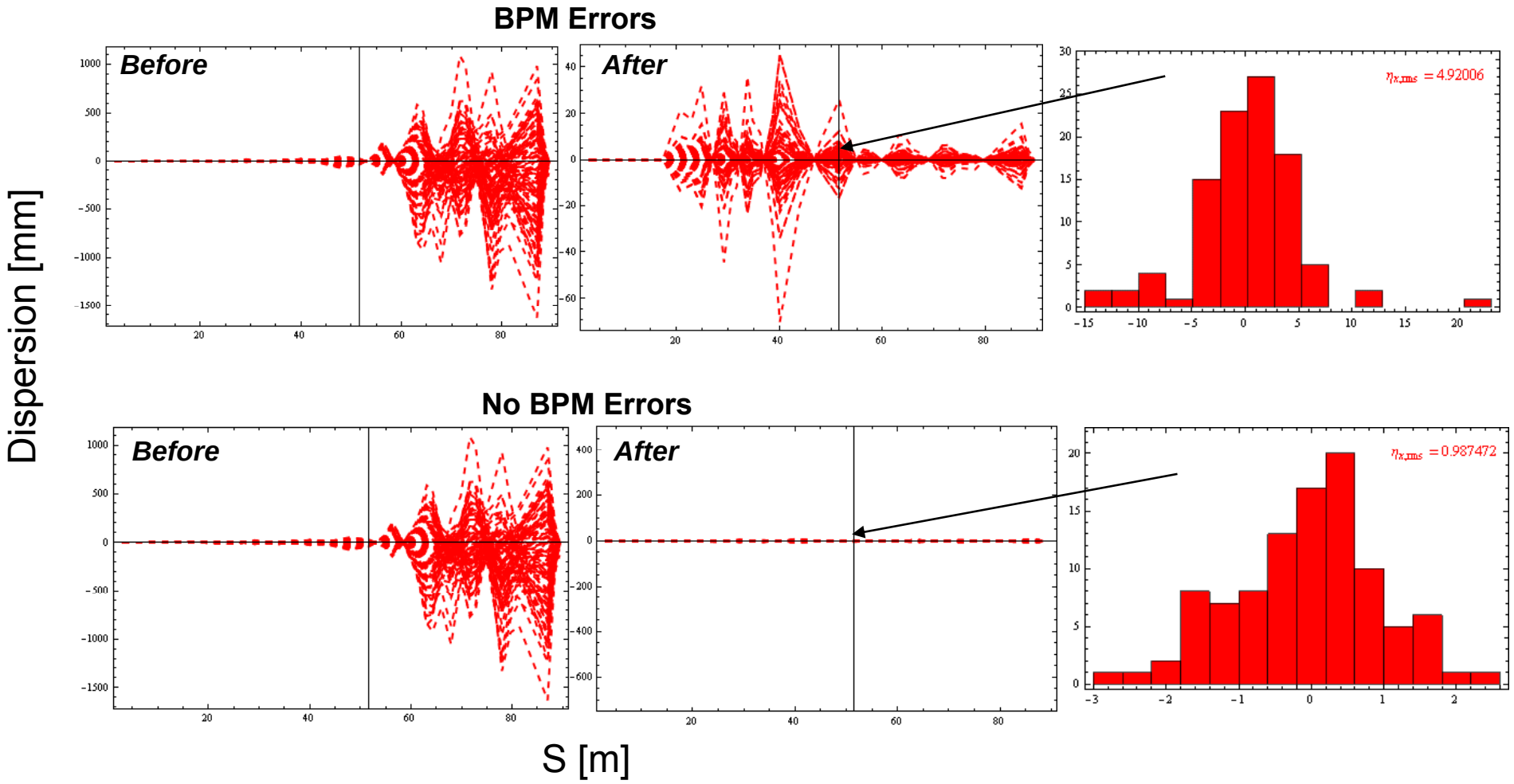
Dispersion Correction

- Dispersion is measured by changing all of the magnets in EXT by set amount (±0.1%) and measuring beam position
- Dispersion is “corrected” by minimising
  - 2 x Dispersion at the last BPM
  - RMS dispersion in the last 8 BPMs
- BPM errors applied each time the orbit is measured

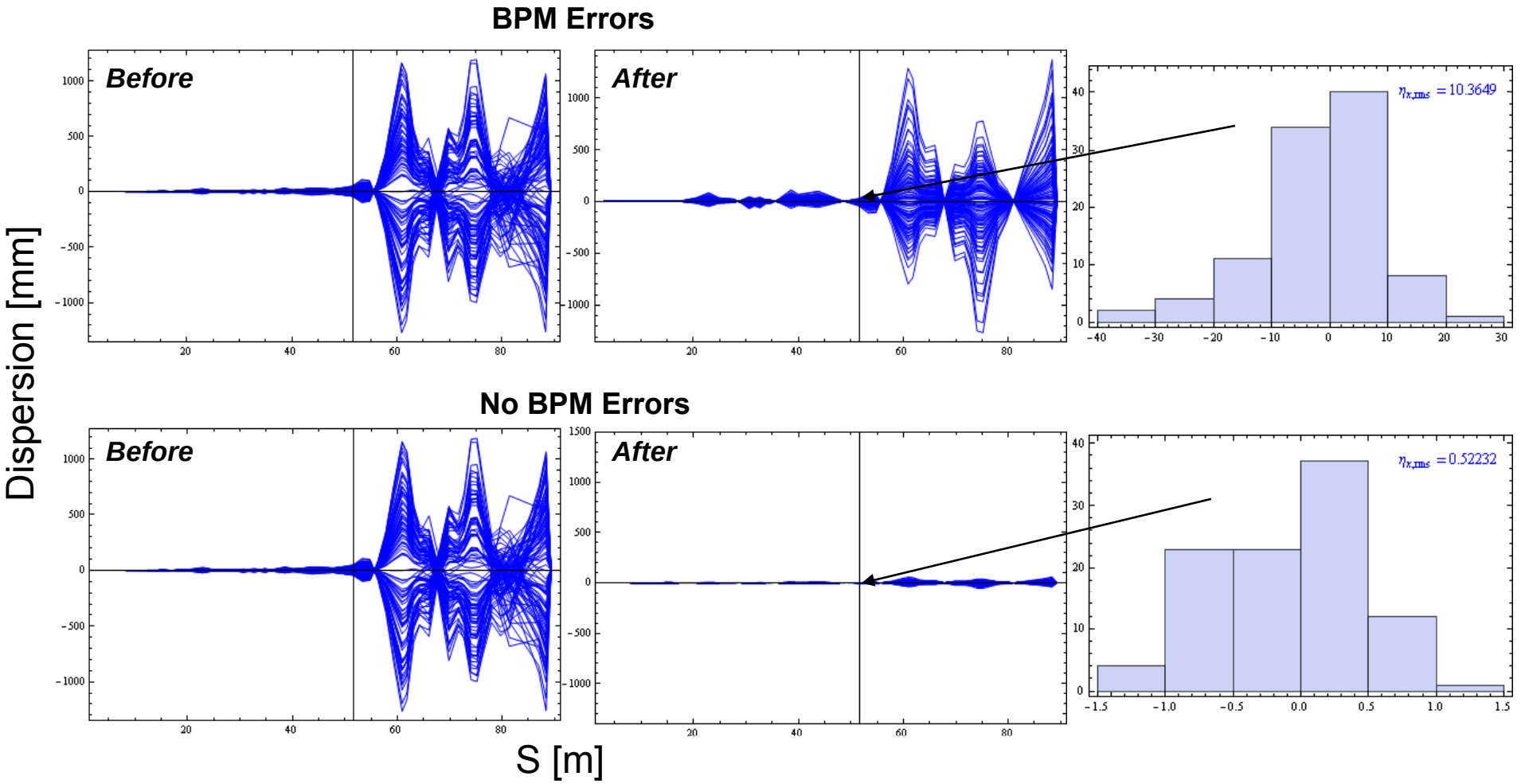
Closed Orbit



Horizontal Dispersion



Vertical Dispersion

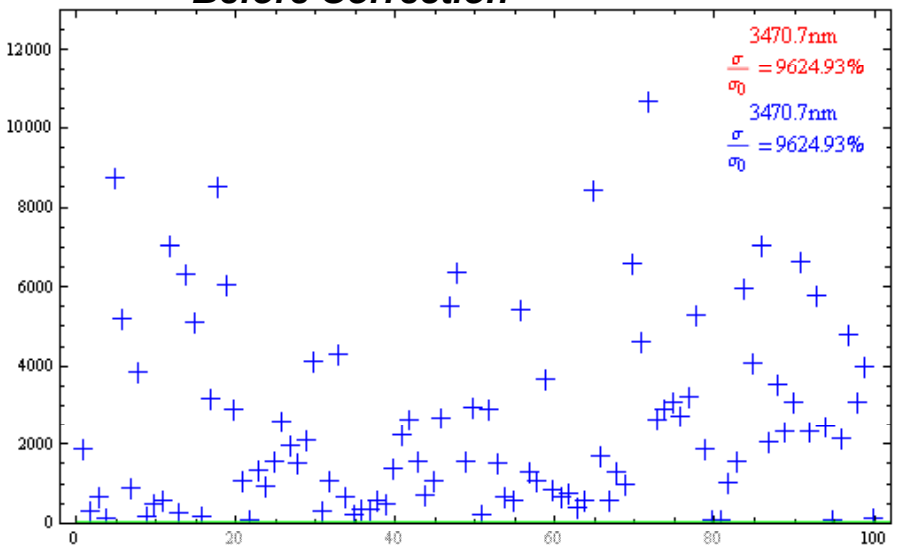


Spot Sizes at IP

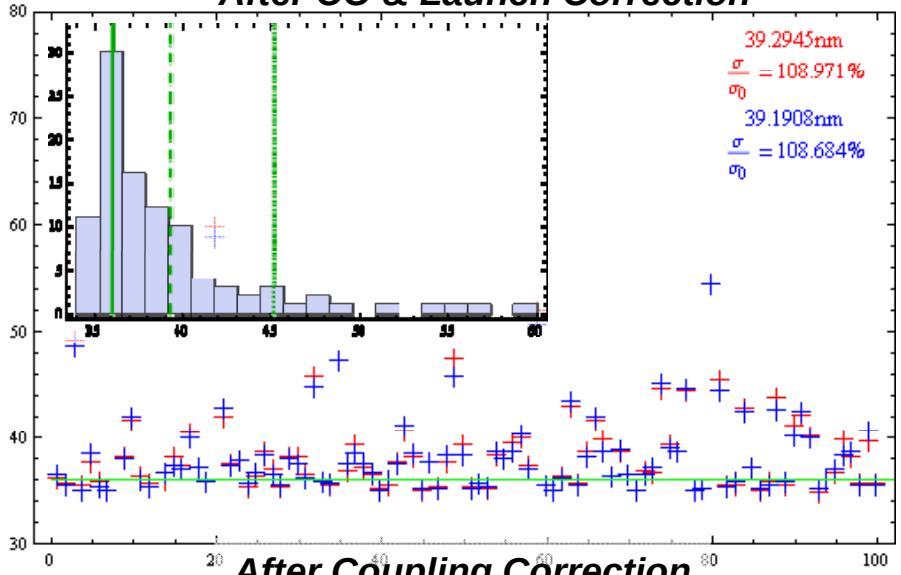
BPM Errors

No BPM Errors

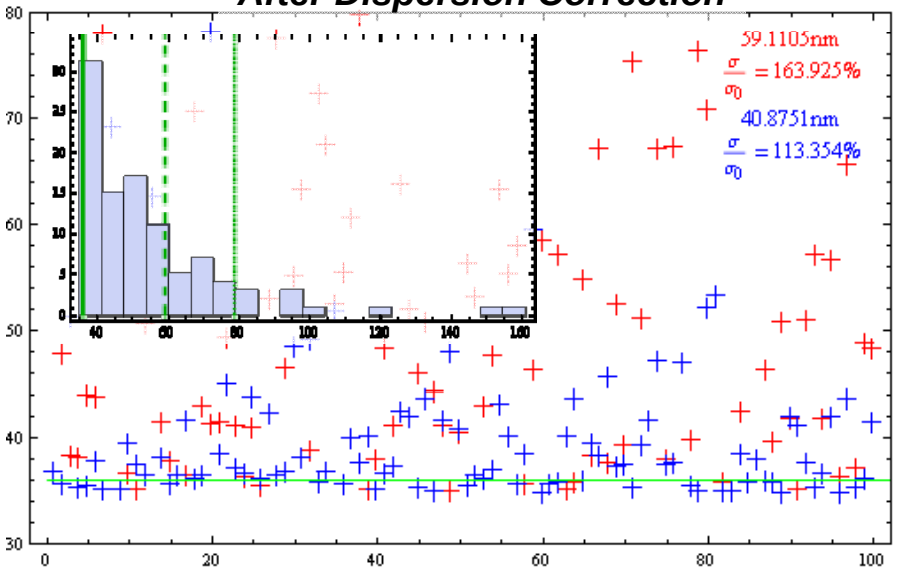
Before Correction



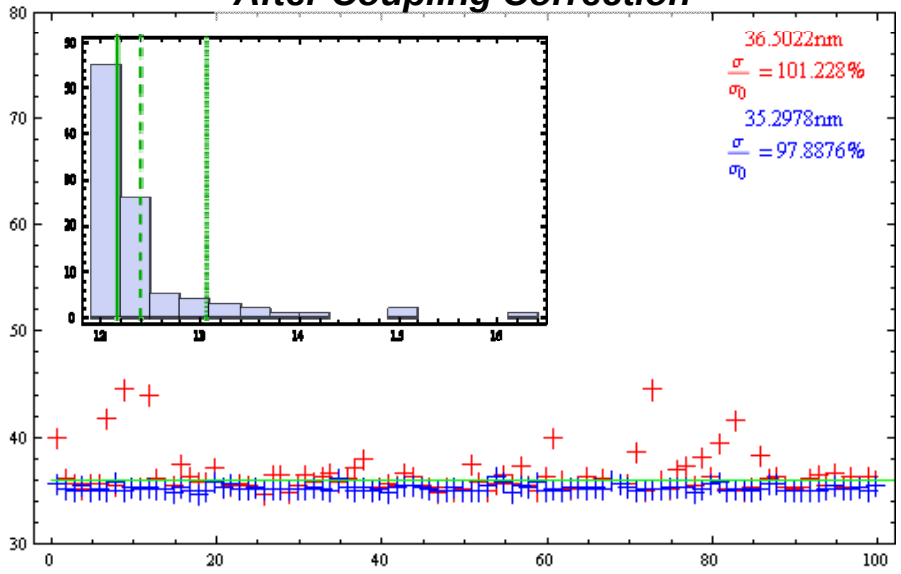
After CO & Launch Correction



After Dispersion Correction



After Coupling Correction

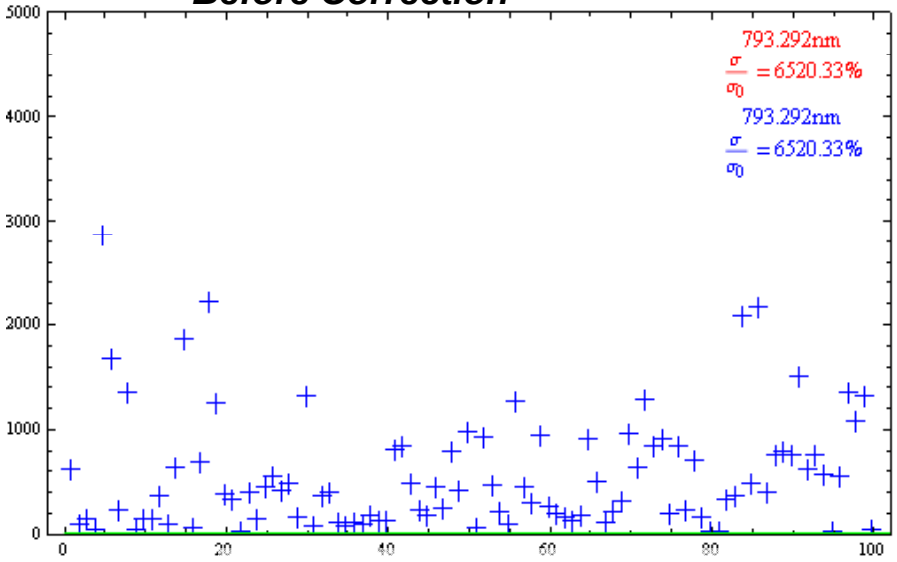


Emittances at IP

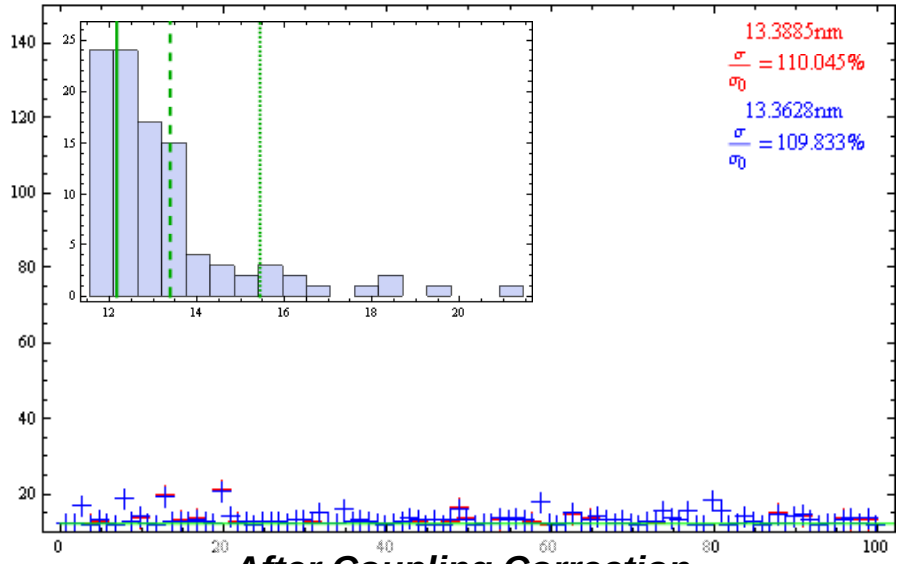
BPM Errors

No BPM Errors

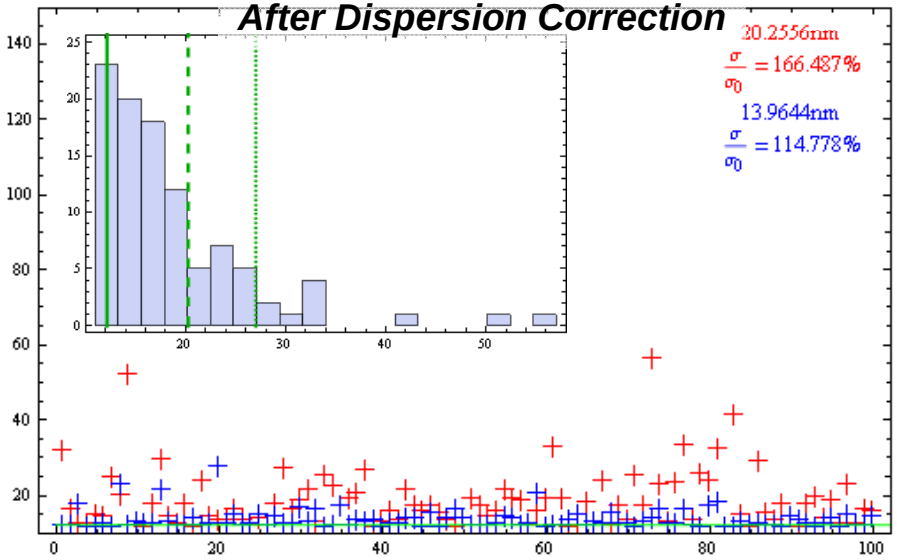
Before Correction



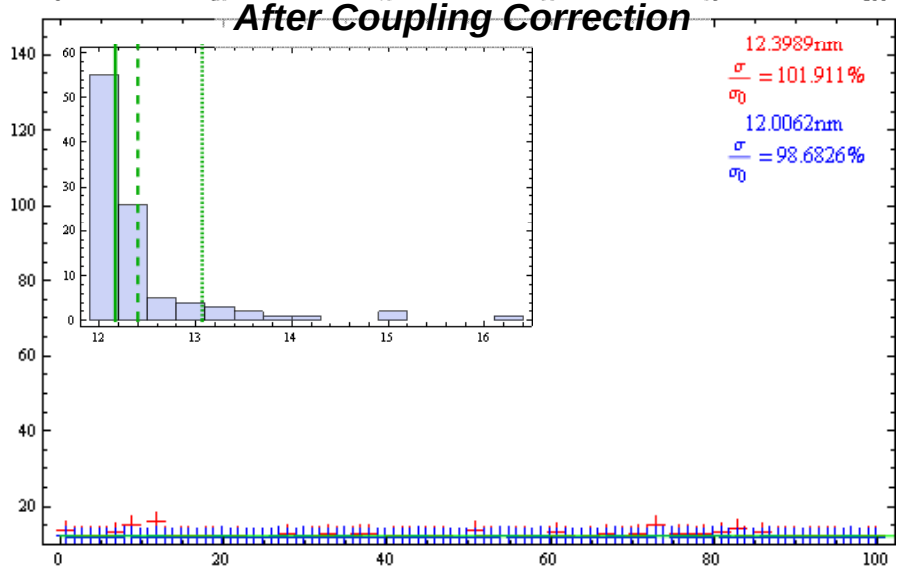
After CO & Launch Correction



After Dispersion Correction



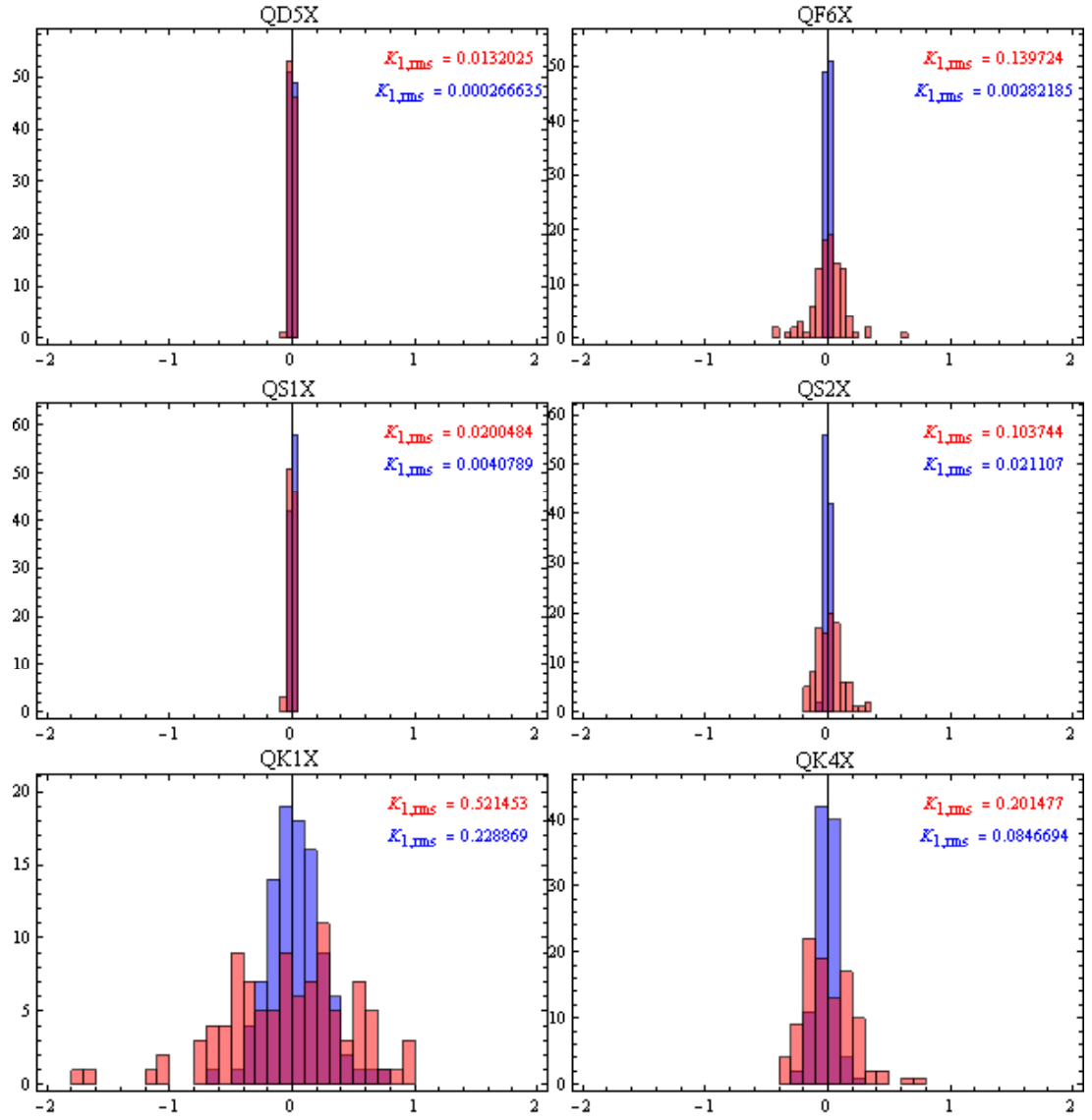
After Coupling Correction



Corrector Magnitudes

BPM Errors

No BPM Errors



Comments

- Have investigated several different combinations of quadrupoles for horizontal dispersion correction
  - All show “similar” results, but with differing strengths
  - Some show larger beta function effects
- Have tried to optimise vertical dispersion correction to deal better with incoming eta’ effects
  - Simulations not yet ready(!), but seem to show a higher tolerance
  - Leads to a larger amount of coupling in the beam, which needs stronger skew quad requirements
- Analysis of dispersion measurement methods, shows that it should be possible to correct the dispersion *without* varying the ring RF
  - Not as accurate, but gives similar results

Next Steps

- Need to add-in realistic damping ring beams
  - Don’t see this having much of an effect!
- Further investigation into QM7R issue (*ongoing*)
- Need to look at using QK1-4X as dispersion correction
  - Optimise which skew do dispersion correction, which do coupling correction