INTERNATIONAL LINEAR COLLIDER

SLAC

Dynamic Tuning Studies for ATF2 FF

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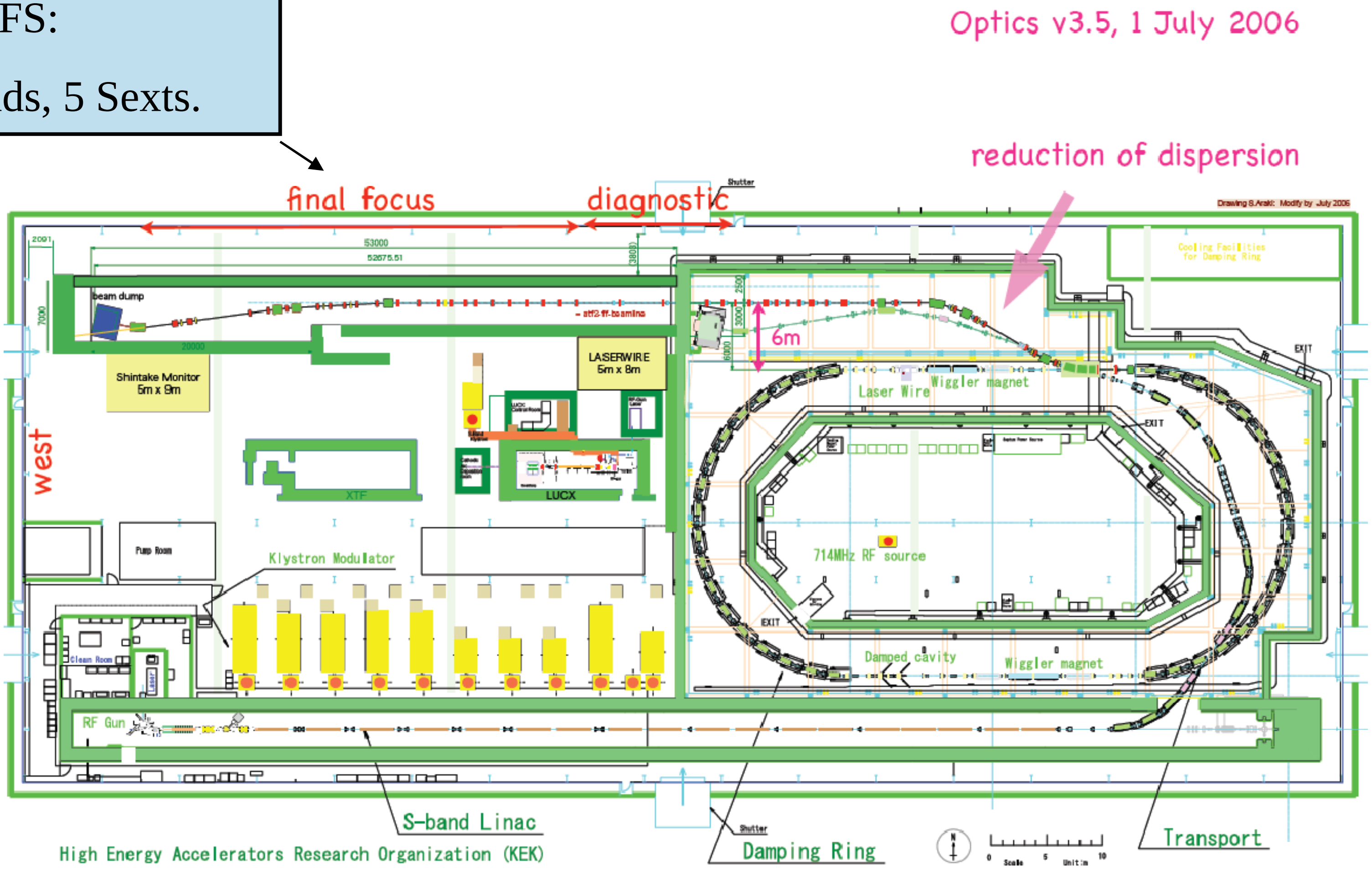
Overview

- Use static BBA and tuning procedure for ATF2 FF as described in Jan ATF2 meeting.
- Use Woodley-tuned v3.6 lattice (dispersion and coupling fixed in diagnostic section)-
  - Add FF errors.
  - Apply BPM alignment, BBA and sextupole tuning knobs for each of 100 seeds.
  - Compare with/without EXT sextupole magnets.
- Throughout tuning process, apply dynamic effects:
  - Ground Motion (Model 'A').
  - Random pulse-pulse component jitter.
  - Random pulse-pulse energy fluctuations.
- Use pulse-pulse feedback to maintain orbit.

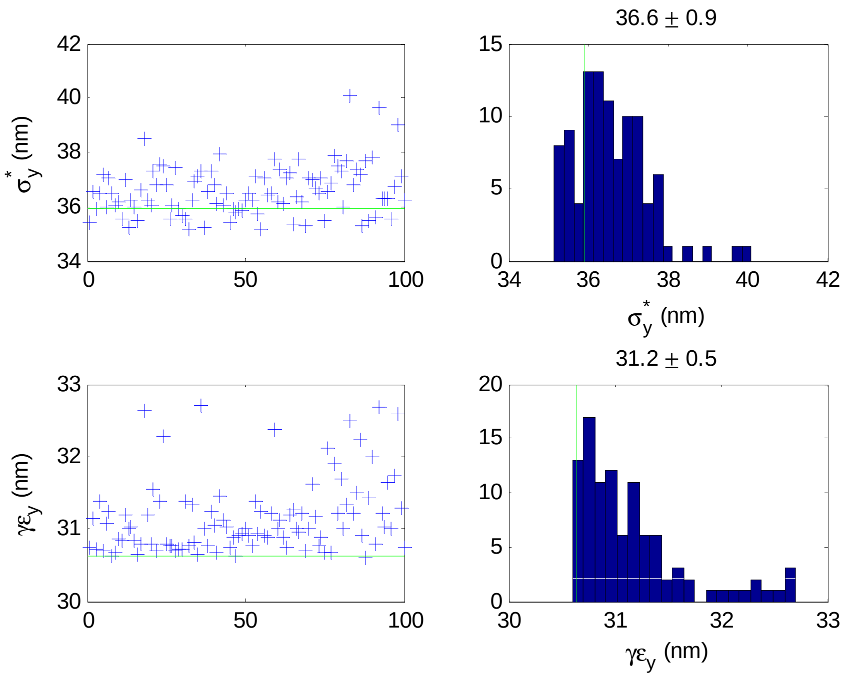
ATF2 Final Focus System

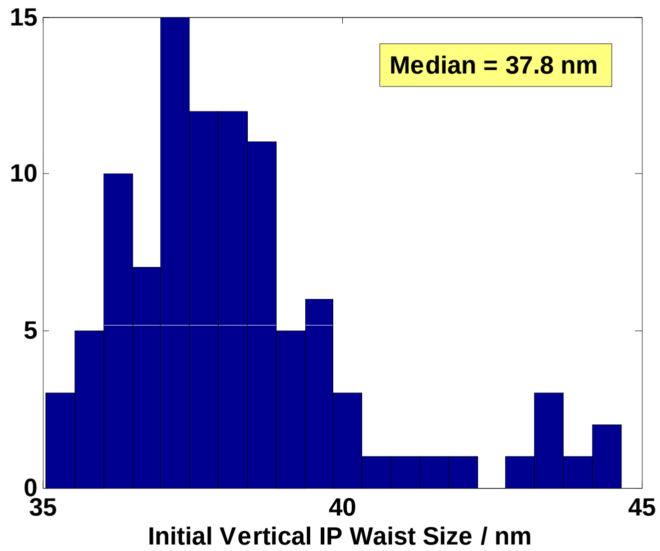
Tune FFS:

22 Quads, 5 Sexts.



Initial Beam Before Errors





- Initial set-up of MW ATF2 lattice with dispersion + coupling correction in diagnostic session gives IP sizes shown on left.
- Right plot after importing lattice into my simulation (using slice beam representation for simulation speed initially). Results relative to these starting conditions.

IP Beamsize Measurement

- Assume IP assembly of cavity BPM + shintake monitor for IP waist position + vertical size measurements.
- Shintake monitor measurement range 35nm – 350nm.
- Also assume presence of wirescanner for >1 micron waist sizes.
- Between 350nm and ~1um, proposal from Honda: use novel nano-pattern target film.
- So, assume a beamsize measurement all the way from initial few microns to target 35nm to tune on.

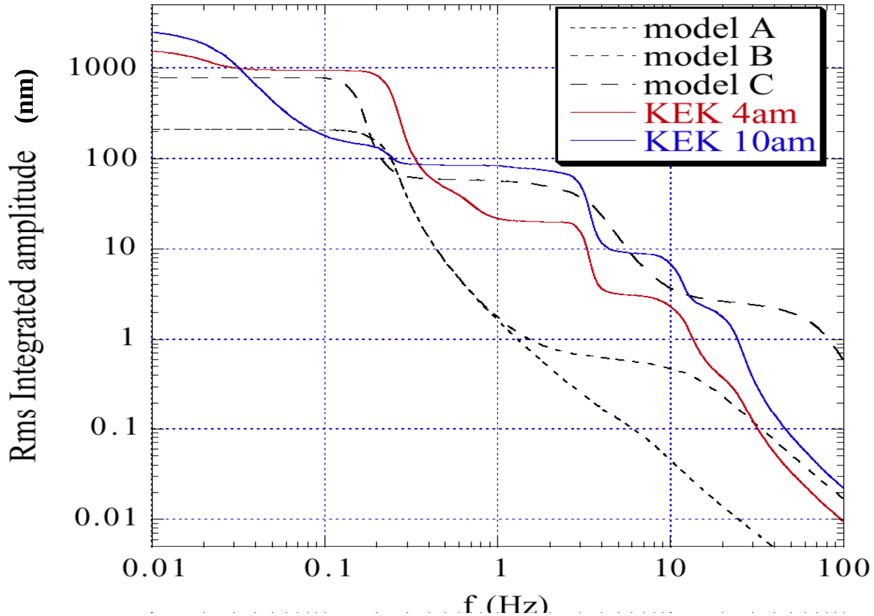
Static Error Parameters

- Assume movers on all FF quadrupoles and sextupoles.
- Cavity BPMs fixed to all FF Quads + Sexts.
- Also assume IP BPM with 5nm RMS resolution.
- Model for SM measurement: mean spot size from 90 consecutive pulses +/- RMS error.

Quad, Sext x/y transverse alignment	**200 um**
Quad, Sext roll alignment	**300 urad**
Initial BPM-magnet field center alignment	**30 um**
dB/B for Quad, Sexts	**1e-3 syst. + 1e-4 random**
Mover resolution (x & y)	**50 nm**
BPM resolutions	**100 nm**
Power supply resolution	**14 - bit**
Shintake Monitor Resolution	**2nm**

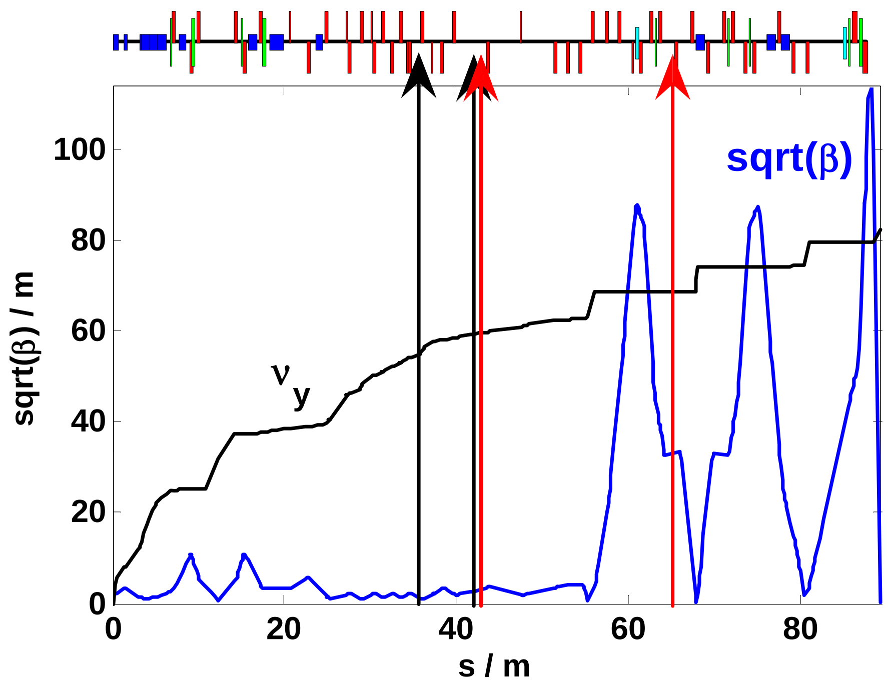
Dynamic Errors

- RMS pulse-pulse errors:
  - Component jitter: 25 nm.
  - Energy error: 5E-4.
  - Ring extraction jitter: 0.1 sigma (x,x',y,y').
- Ground motion, use model 'A'.



Pulse-Pulse Feedback Location

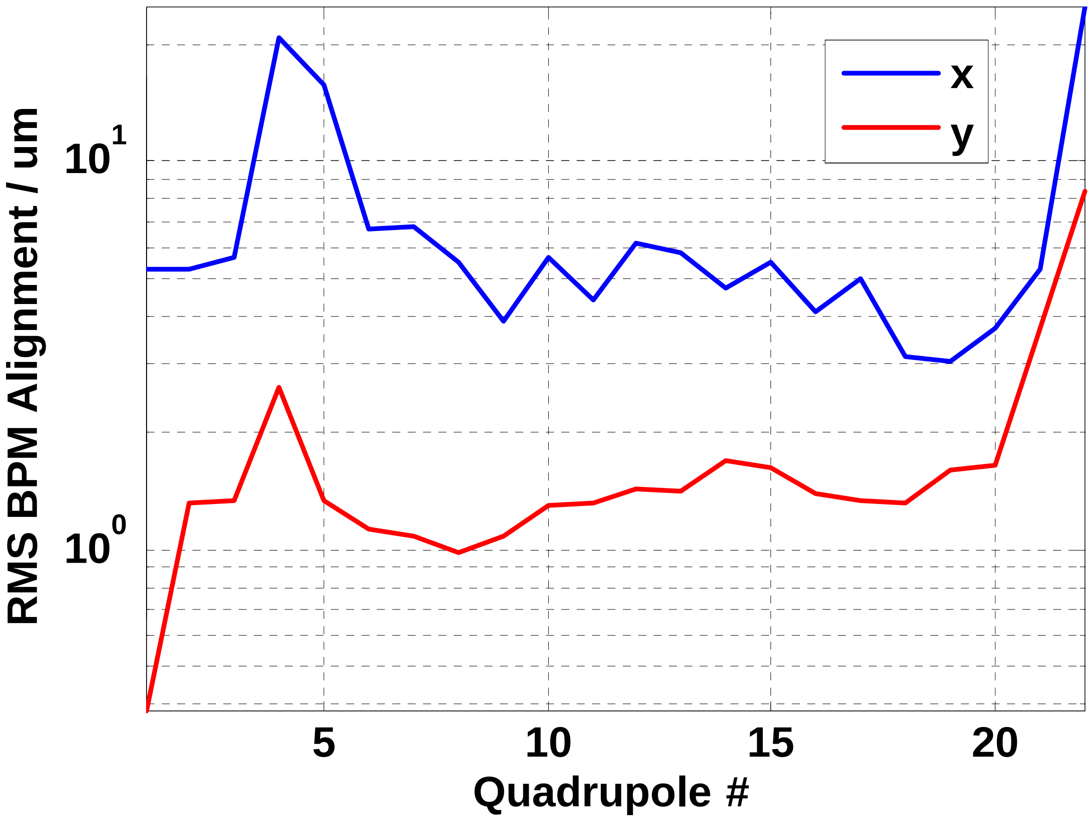
- 2 sets of kicker-bpm pairs for x and for y planes placed with ~90 degree phase separations.
- Vertical placement shown right kickers at s=36.3, 42.5 m; BPMs and s=42.5, 66 m.
- Horizontal similar.



New elements required (not in current deck)

- **Bpm and vertical corrector in Wall**
- **Vertical corrector after QF17X.**
- **Horizontal corrector at s = 58.3 m.**

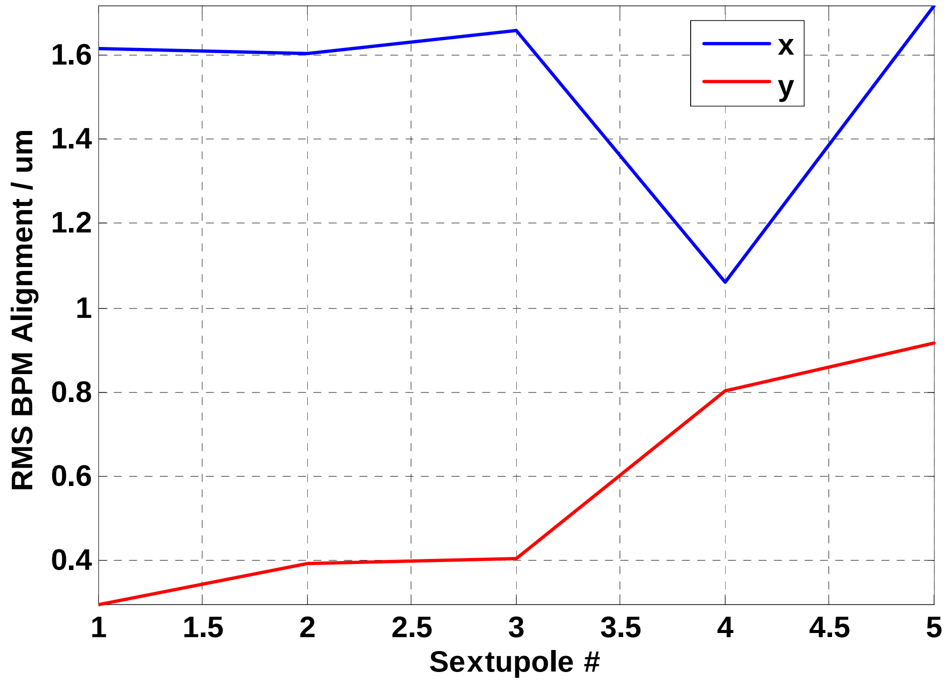
Quad BPM Alignment



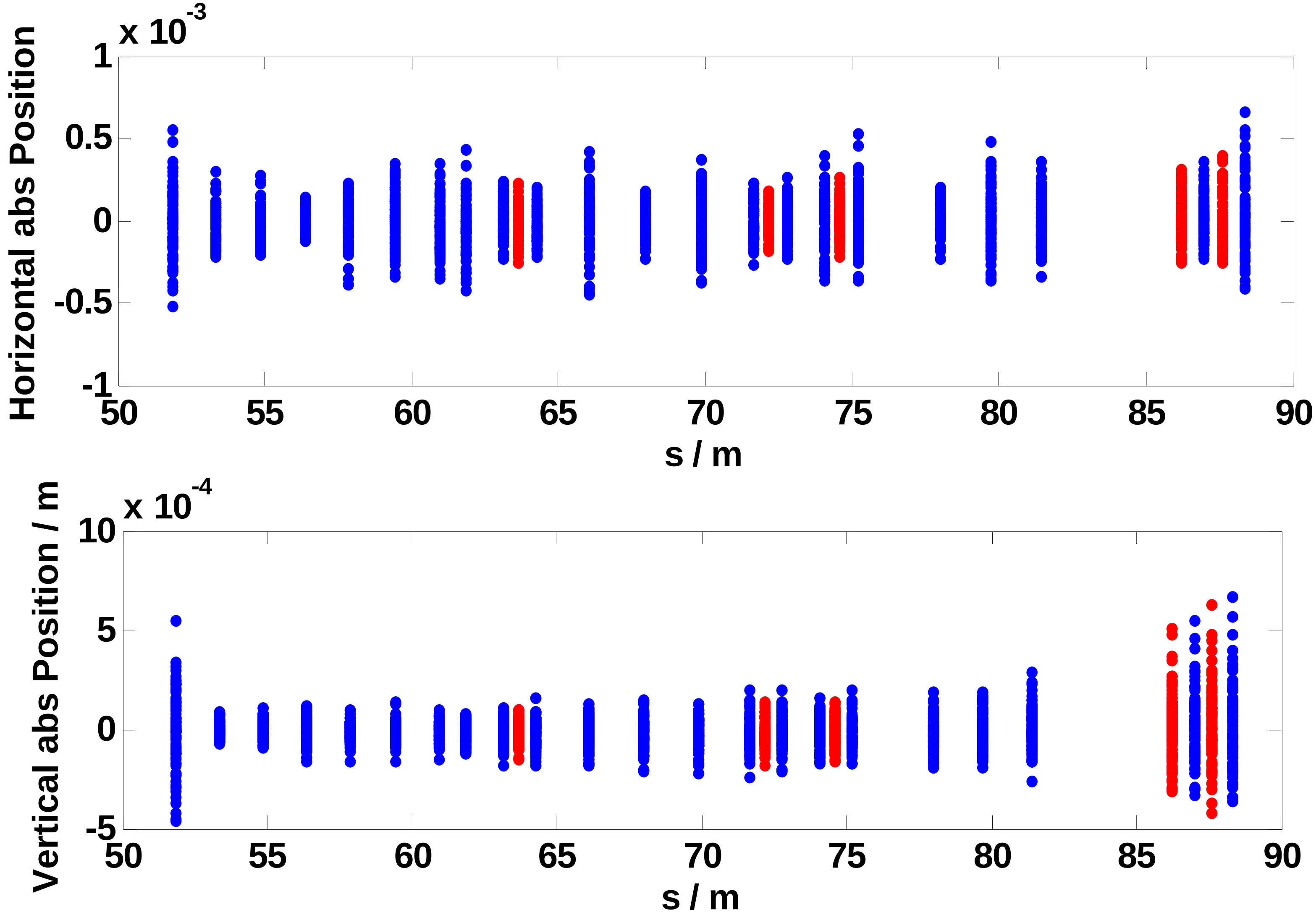
- RMS alignment of Quad field center – electrical center of Quad BPMs (100 seeds).

Sextupole BPM Alignment

- Move Sextupole +/- 0.5mm through beam.
- Fit quadratic function to IP BPM response.
- Alignment from minimum of fit.
- RMS alignment results ->

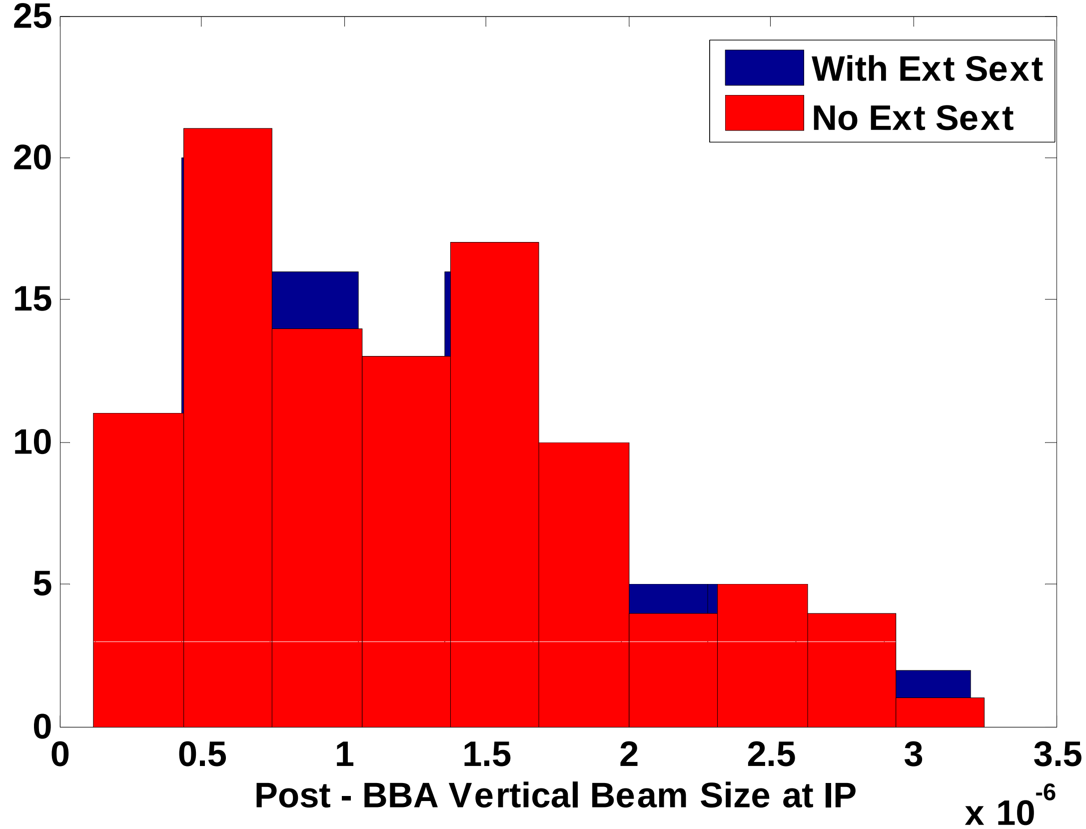


Quad BBA



x 10^-3
1
0.5
0
-0.5
-1
50
55
60
65
70
75
80
85
90
s / m
Horizontal abs Position
x 10^-4
10
5
0
-5
50
55
60
65
70
75
80
85
90
s / m
Vertical abs Position / m

Beamsize After BBA

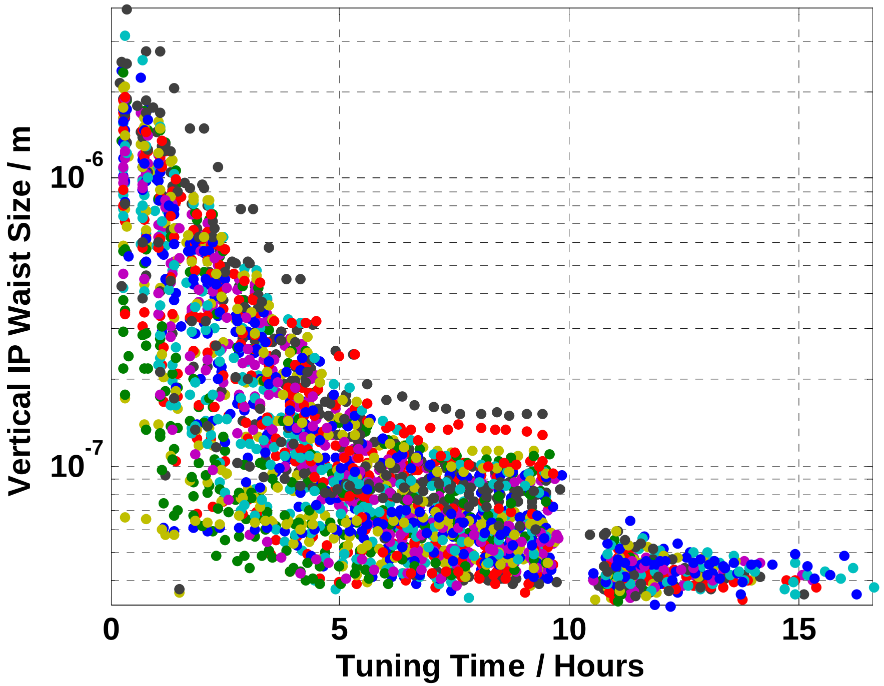


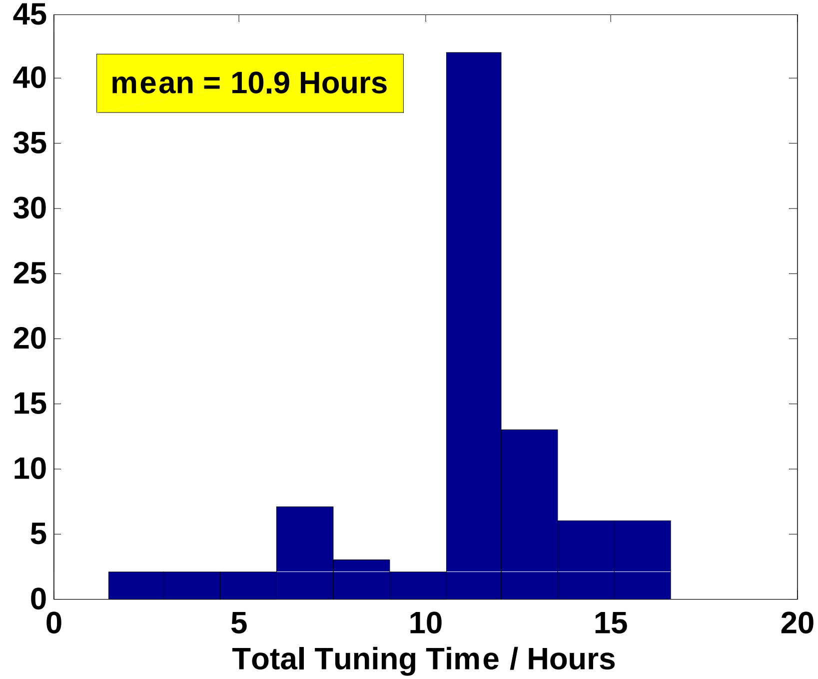
- IP waist size after BPM alignment and BBA.
- Mean spot sizes from 100 seeds: 2.23 um for both cases.

Sextupole Multi-Knobs

- Use orthogonalised x- and y-moves of FFS sextupoles to correct vertical waist and dispersion + <x'y> coupling term.
- Higher-order IP aberration tuning performed by scanning sextupole tilts.
- In simulation, apply iteratively until beamsize within 10% of initial pre-error value.

Multi-Knob Tuning Results

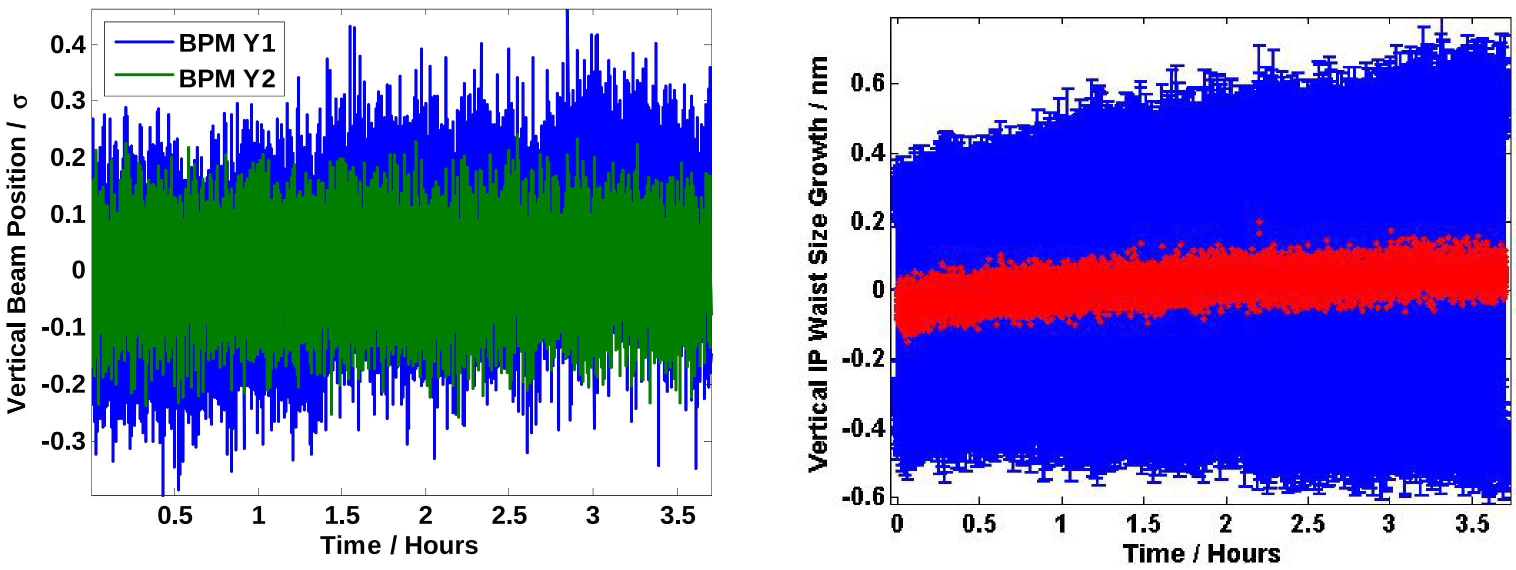




- Multi-knobs iteratively applied until IP beamsize growth over initial conditions is <10% (~<40nm).

Feedback Performance

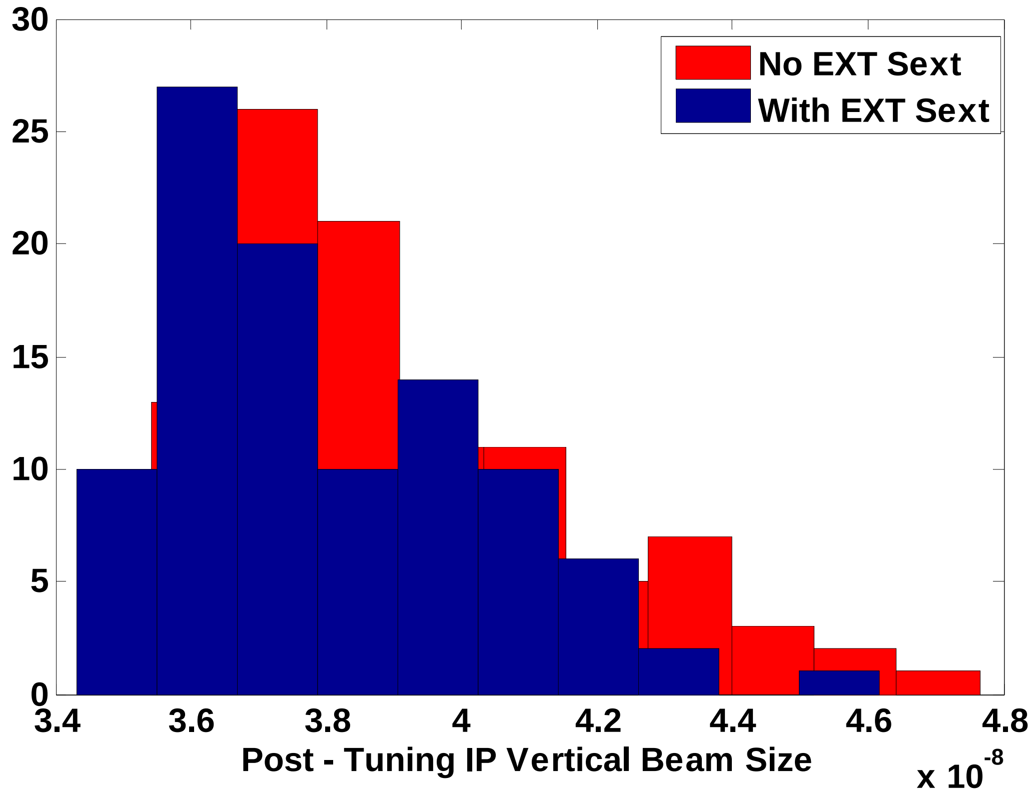
- After tuning, run simulation for 20,000 pulses and look at time evolution of spot size.
- Using simple gain feedback (gain of 0.1 used here- not optimised).
- In this case, rate of beamsize growth ~0.6 +/- 0.5 nm per day.



Future GM Implementation

- Adding in concept of ‘technical noise’ to Lucretia.
- This will allow transfer-functions to be tied to girders like in Liar to study e.g. stabilization effects in the final doublet magnets / IP.

Tuning Results



- Best vertical spot-size achieved for each 100 seed simulation of tuning.
- Median results: 37.6 nm with EXT sext, 38.6 nm with the sextupoles removed.
- Compare with median FFS error-free results post MW tuning: 37.8nm.

Summary and Other Work

- Alignment and tuning still works under dynamic conditions (such as modeled here).
- Repeat with GM B,C,K and in future use parameterization from ATF measurements.
- Blindly applying tuning procedure with EXT sextupoles removed gives similar performance- some improvement with re-tuning of EXT section in this configuration expected.
- Need better simulation of SM measurement and magnet mover response…