ATF2 IP Spot Size Tuning

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- Goals and methods
- Simulations
  - Initial conditions
  - Performance of IP tuning seen
  - Further work
- Control system integration

Tuning Goals and Methods

- Achieve ~35nm vertical spot size as measured by Shintake BSM
  - ~3.2 um horizontal spot
  - Have ignored horizontal in simulations so far, except that Sextupole knobs were orthogonalised to minimise extra x growth when reducing y.
- Construct multi-knobs to reduce from initial size ~<3um after initial alignment.
  - Sextupole x/y moves, final doublet dk, skew-quads (waist, dispersion, coupling)
  - Sextupole tilts / dk (higher-order IP terms)
- IP measurement speed v.slow w.r.t. ILC (~1 min), need to ensure efficient and orthogonal knobs.

Simulation Studies

- Define realistic starting conditions (100 seeds)
  - Standard installation errors + EXT BBA, disp corr, coupling corr, FFS BBA
- Study performance of IP tuning on 100 seeds including dynamic errors.
- Check h/w limits not exceeded at any point.
- Study effect of dynamic errors on tuned machine.

Errors

Co-ordinate system used here is right-handed. Roll = rotation in x-y plane, pitch= rotation in y-z p

The reference ground motion model for ATF based on measured GM spectra on the DR floor is in t
(also available as a standalone Matlab routine- to be provided here shortly).

Error Parameter	Error magnitude
x/y/z Post-Survey	200 um
Roll Post-Survey	300 urad
BPM - Magnet field center alignment (initial install) (x & y)	30 um
BPM - Magnet alignment (post-BBA, if BBA not simulated) (x & y)	10 um
Relative Magnetic field strength (dB/B) (systematic)	1e-4
Relative Magnetic field strength (dB/B) (random)	1e-4
Magnet mover step-size (x & y / roll)	300 nm / 600 nrad
Magnet mover LVDT-based trim tolerance (x & y / roll)	1 um / 2 urad
C/S - band BPM nominal resolution (x & y)	100 nm
Stripline BPM nominal resolution (x & y)	10 um
IP BPM nominal resolution (x & y)	2 nm
IP Carbon wirescanner vertical beam size resolution	2 um
IP BSM (Shintake Monitor) vertical beam size resolution	use attached data
EXT magnet power-supply resolution	11-bit
FFS magnet power-suppy resolution	20-bit
Pulse - pulse random magnetic component jitter	10 nm
Pulse - pulse relative energy jitter (dE/E)	1e-4
Pulse - pulse ring extraction jitter (x, x', y, y')	0.1 sigma
Corrector magnet pulse-pulse relative field jitter	1e-4

Done

- Error list on wiki
- Also GM- ATF fitted Model
- Also include measured multipoles for final doublet, sextupoles and FFS bends.

Simulation Performed

- Use EXT correctors + BPMs (EXT FB) to get orbit through EXT.
- Use FFS FB to get beam through FFS.
- Correct Dy/Dy' in EXT using skew-quad sum knob.
- Correct coupling in EXT using coupling correction system.
- Use FFS FB for launch into FFS.
- FFS Quad BPM alignment using quad shunting with movers.
- FFS Quad mover-based BBA.
- FFS Sext BPM alignment using Sext movers and IP BPM.
- Sextupole mover tuning knobs to get final spot size
  - Vertical IP dispersion and Waist
  - <x'y> coupling
  - Higher order terms collectively through Sext rolls + dK.
- Also use EXT skew-quads to tune other coupling terms.
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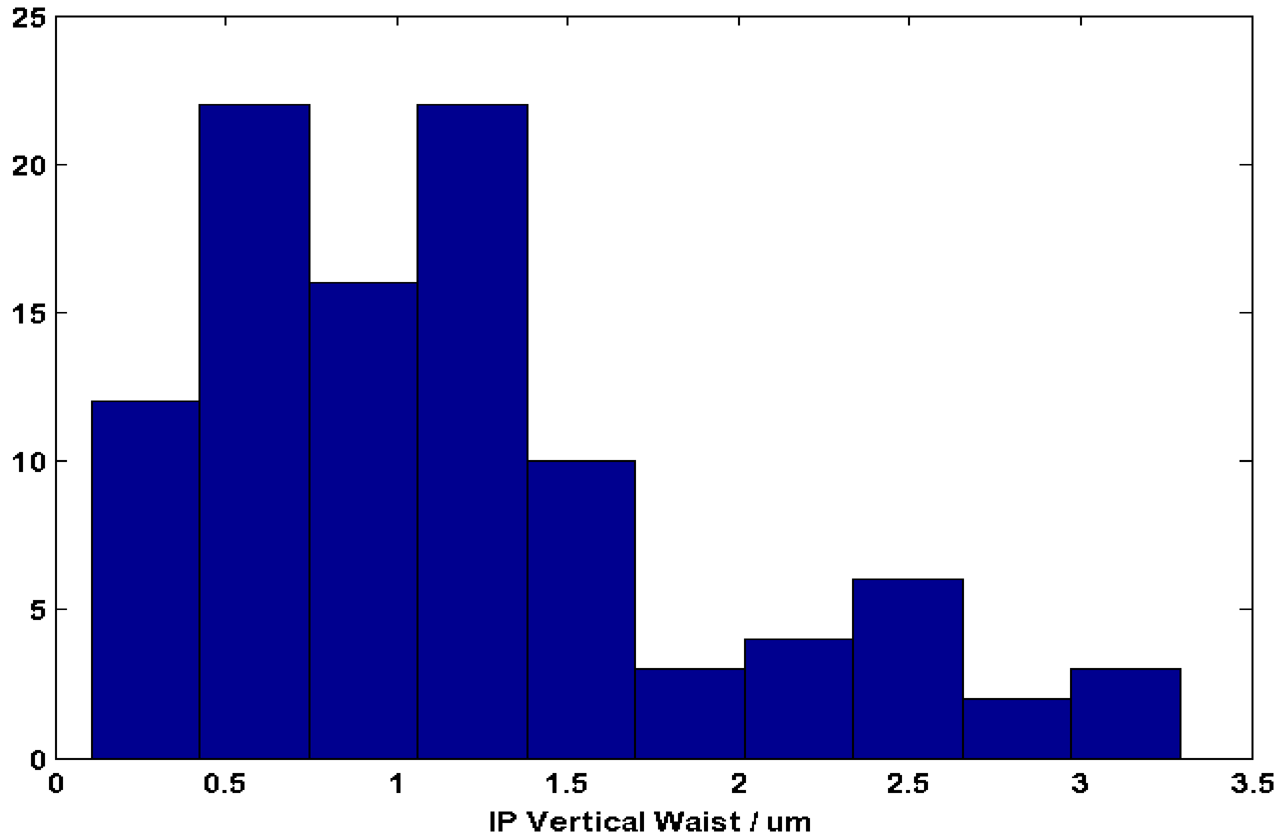
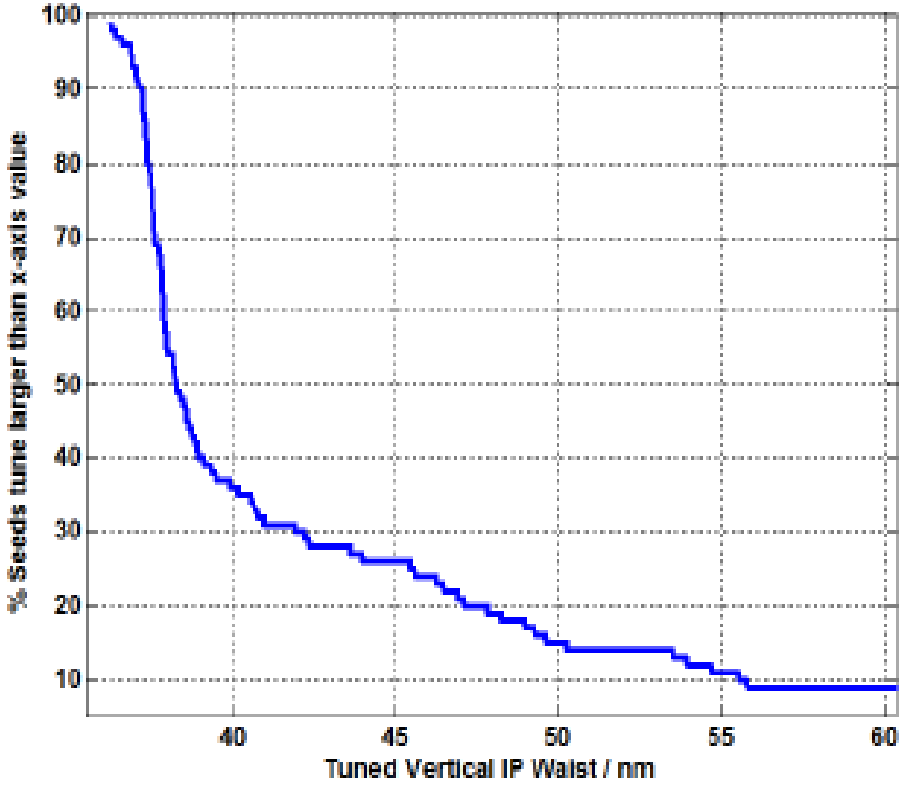
- No attempt to model EXT BBA yet (assume 10um RMS bpm-magnet center offset)
- No attempt to model any lattice matching (Ring - EXT)

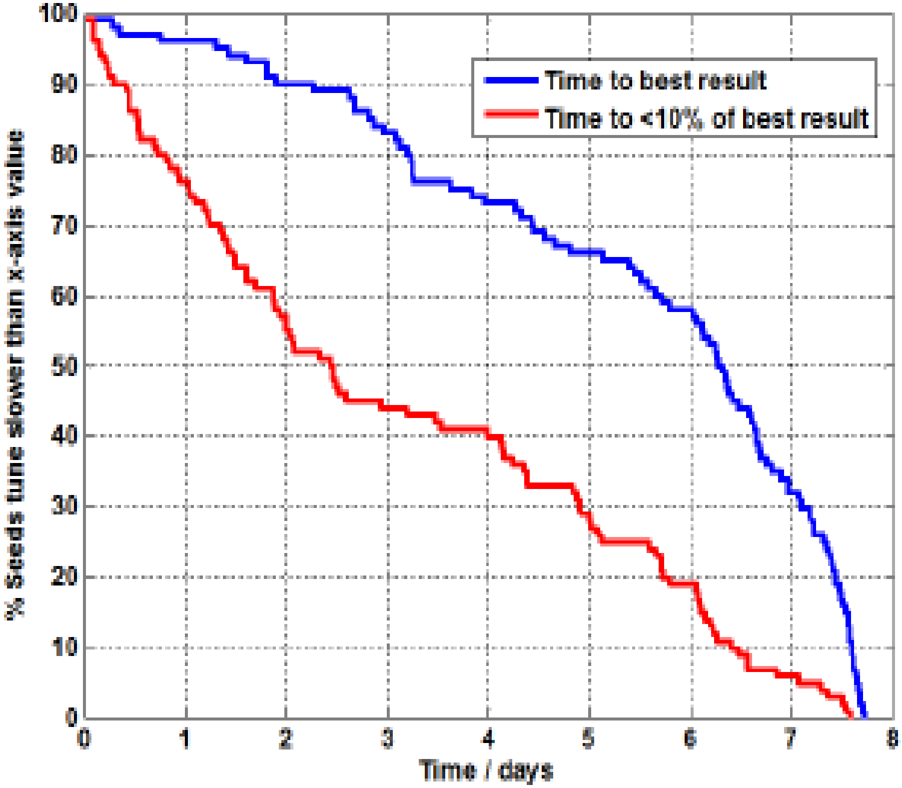
Beamsize after BBA



- IP waist size before sextupole FFS tuning knobs applied (100 seeds).

Tuning Results





- Best achieved vertical waist size for 100 seeds (left)
- Time taken to converge on best waist size, and time to converge within 10% of best waist size (right)

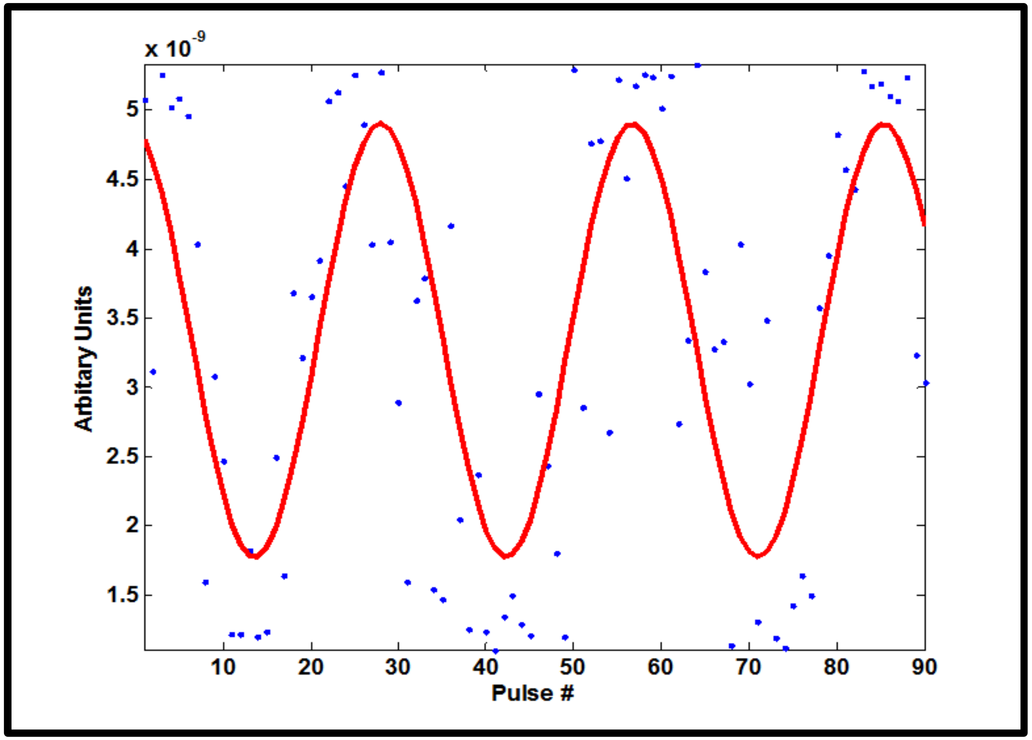
Notes on these tuning results

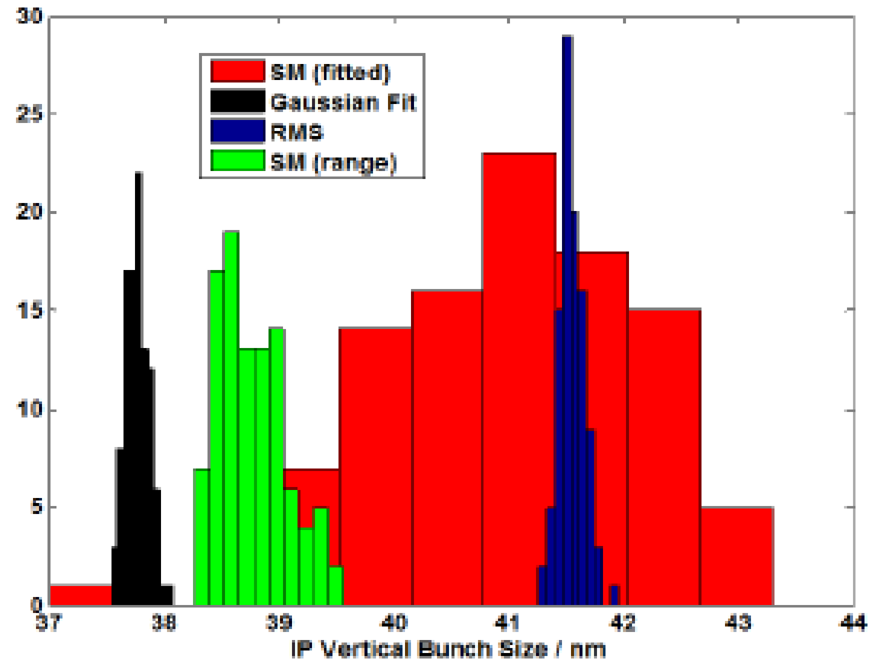
- Knobs based on simple motion of sextupoles
- Only limited attempt made to iterate knobs in most efficient way and to limit range of scans.
- Better to base knobs on reported moves by sextupole bpms (and iterate) to produce more orthogonal knobs
  - Especially when larger moves applied- greater orbit deflections produced
- No attempt to target specific 2nd order terms- just tweak individual sextupole roll's / dk's
  - Tried non-linear optimisation approach- not so successful...

Sextupole Mover System

- 5 Mover systems under FFS Sextupoles most important of all movers
- Need to move sextupoles during multi-knobs as quickly and accurately as possible.
- Need accurate move size vs. time vs. accuracy data to properly model (will be provided by JN)
- May need better motor drivers (faster) for these magnets (possible to salvage old nanobpm motor drivers maybe with help from DM)
- Use Sext BPMs as readback, not LVDTs (more accurate and faster).

IP Measurement Process



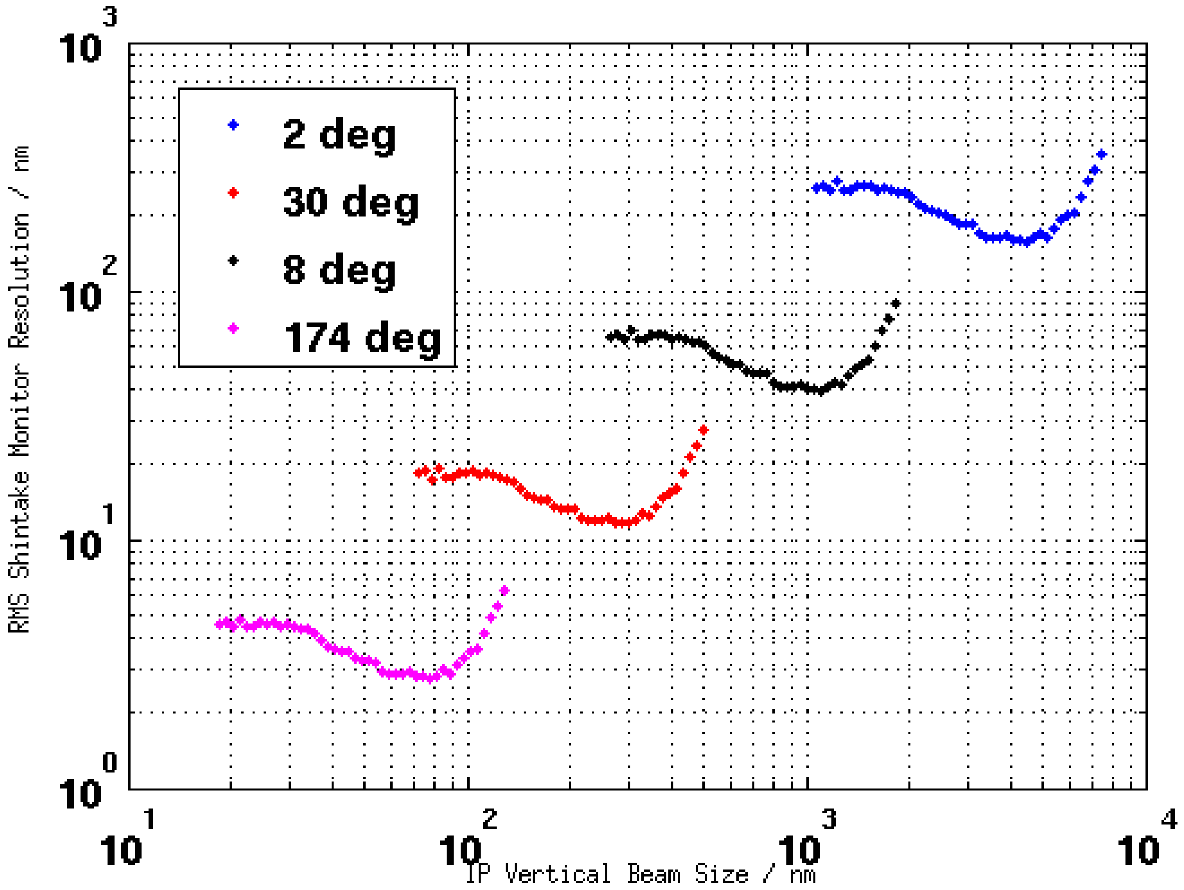


- Can measure (in simulation) the beam size in different ways with different results (at 10% level).

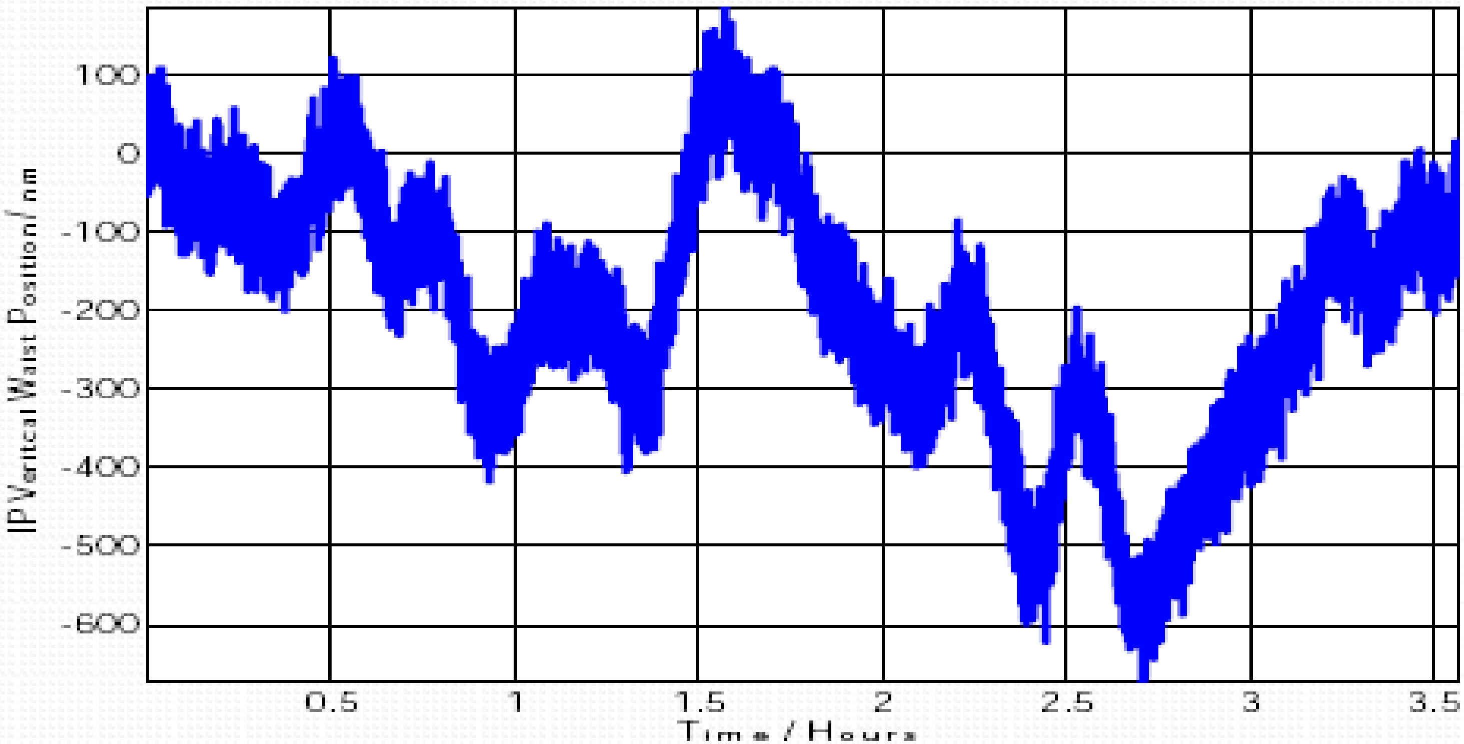
IP Measurement Resolution

- Have calculated resolution data from Tokyo group for Shintake monitor vs. beam size
- Need to estimate tuning time and performance with these data
- Beneficial to integrate more than 1 IP measurement per tuning step (towards end of tuning when spot size is small) ?
  - IP beam size growth over integration time due to various drifts must be small compared to improvement in measurement resolution.

Shintake BSM Resolution Data



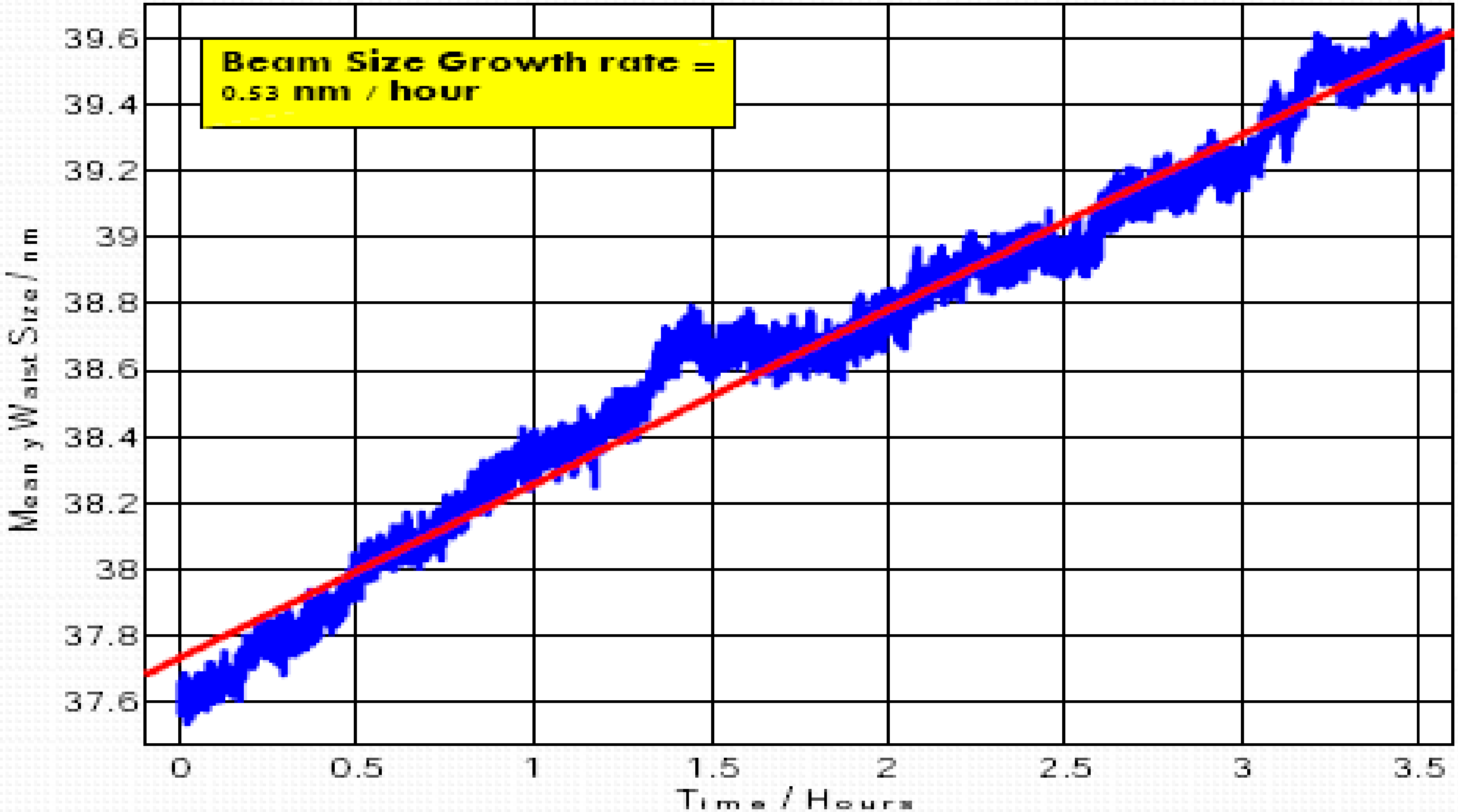
IP Motion



- 20,000 pulses @ 1.56 Hz (1 seed)
- IP vertical position drifts around on scales of a few 100 nm an hour.
- Slow enough that this can be 'de-trended' using Shintake Monitor as IP position monitor.

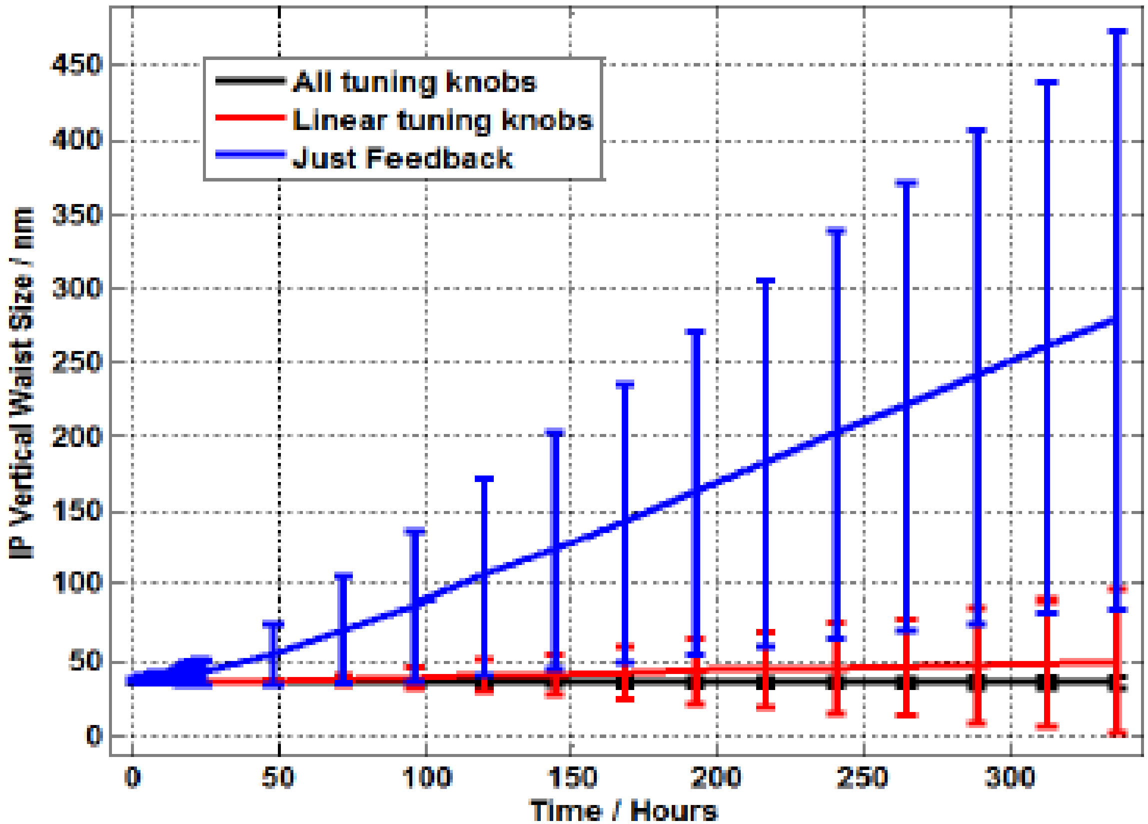
- Fast jitter effects at IP removed from Shintake monitor readout using very high resolution IP BPM

Beam Size Growth



- With feedbacks on, y beam size at IP as a function of time
- Mean of 100 seeds shown
- Growth rate ~ 0.5 nm per hour

Long – Timescale Performance



At each point, none, linear (waist, dispersion and coupling) and full tuning knobs (include sextupole strength and tilt scans) applied. For blue, red and black respectively.

- Vertical IP beam size over 2 week period
- Mean and +/- 1 sigma RMS from 100 seeds shown at each point