IP Beamsize Tuning with FFS Multiknobs

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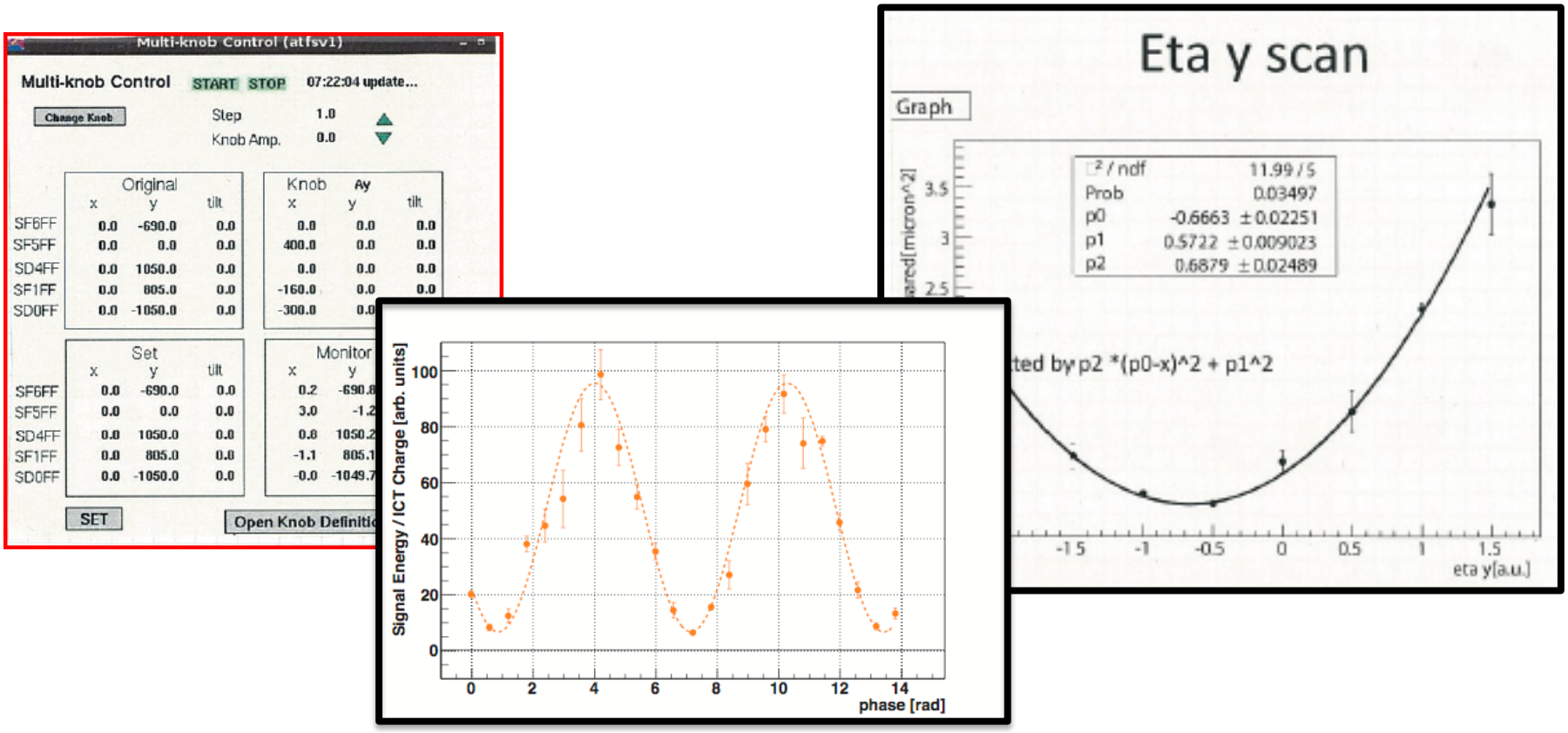
Overview

- Summary of tuning results from May continuous run.
- Summary of tuning simulations for nominal optics.
- Tuning simulations for 10* nominal IP beta optics.
- Investigations for potential error sources to explain observed tuning performance.

IP Tuning in May Cont. Run

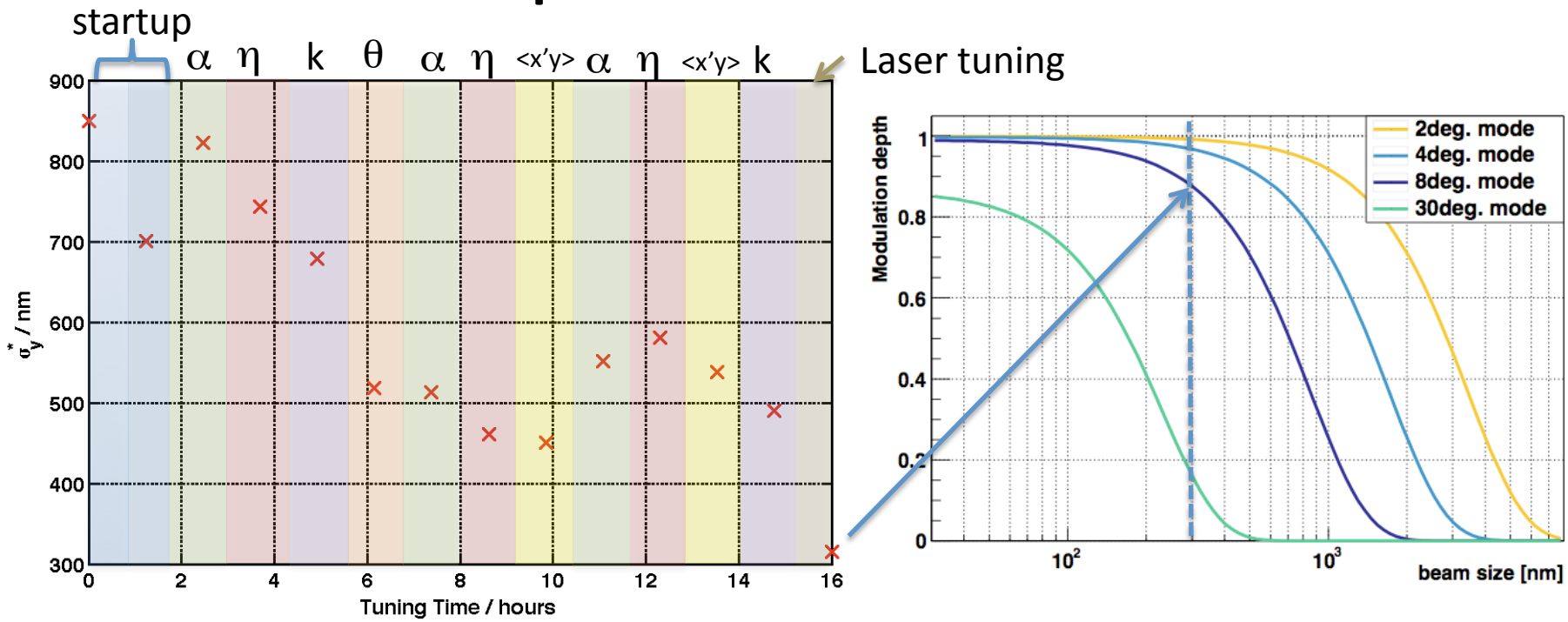
- IP tuning Wed, Thurs Friday (8 shifts).
- Used sextupole multiknobs (FS + Vsystem versions)
  - IP y dispersion, <x'y>, y waist
- QD0FF strength scan
  - Waist position
- QD0FF/QF1FF roll scan
  - Coupling
- Knobs applied iteratively
  - About 30 scans were applied in all over 3 days.
- Min vertical spot size measured = 315nm

IP Tuning with FFS Sextupole Multiknobs



- Iterative use of various knobs to bring down IP spot size by scanning with IPBSM.

IP Tuning Results During Continuous Operations Week



- Tuning from initial setup of 850nm down to 315nm during 2 consecutive shifts (Thursday).
- Beam size cross-checked on IPBSM 8-degree & 30-degree mode.
- Trouble reducing beam size past 300nm in 30-degree mode.

ATF2 Tuning Simulations

- Define realistic starting conditions (100 seeds)
- Standard installation errors (EXT & FFS)
- Study performance of IP tuning on 100 seeds including dynamic errors.
- Perform EXT dispersion and coupling correction
- Perform quad and sext BBA in FFS.
- Final IP tuning using FFS sextupole multiknobs using x,y and tilt moves and strength tweaks.

Errors

The reference ground motion model for ATF based on measured GM spectra on the DR (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

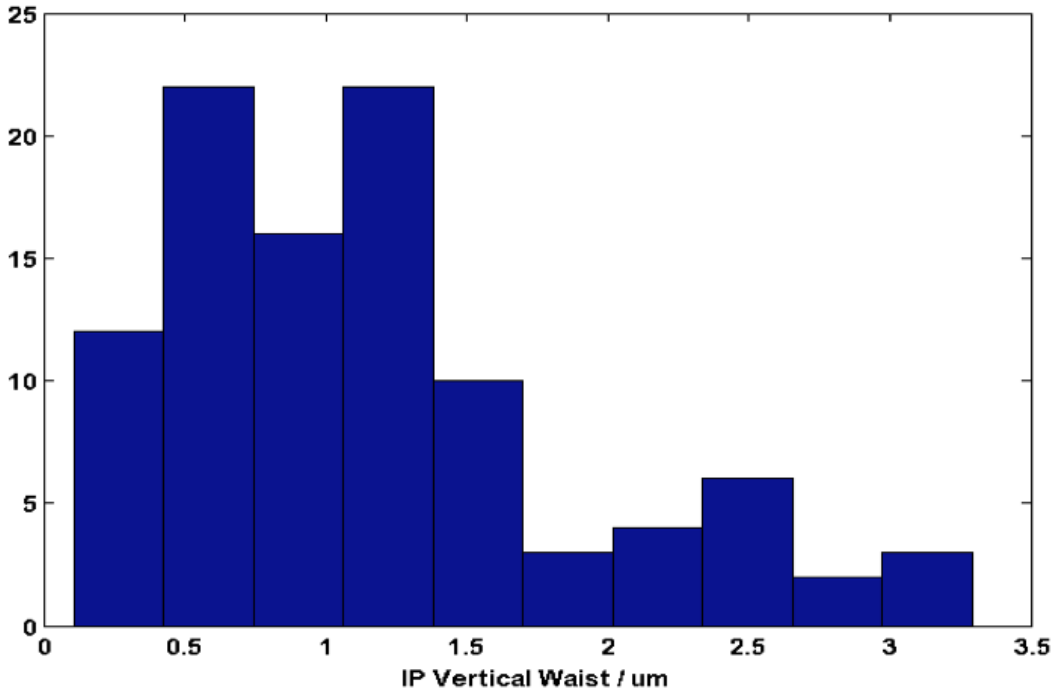
Done

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

Simulated Tuning Process

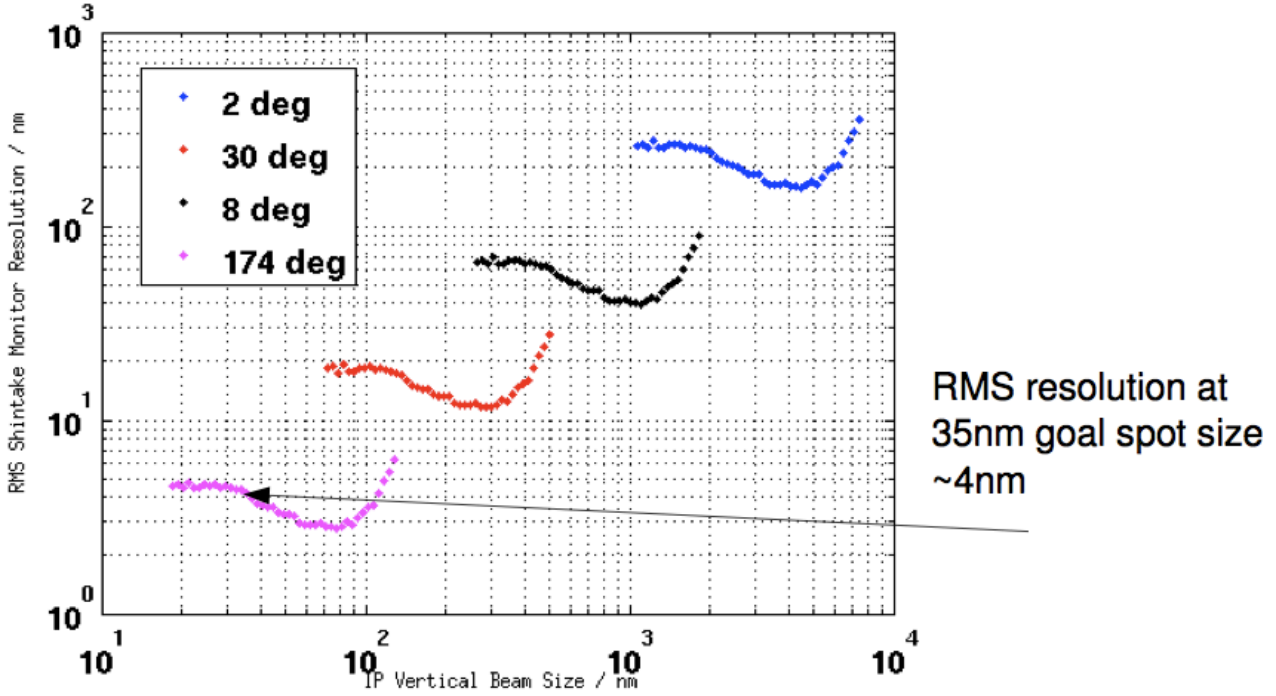
- Use EXT correctors + BPMs (EXT FB) to get orbit through EXT.
- Use FFS FB to get beam through FFS.
- Correct Dy/Dy' in EXT using skew-quad sum knob.
- Correct coupling in EXT using coupling correction system.
- Use FFS FB for launch into FFS.
- FFS Quad BPM alignment using quad shunting with movers.
- 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.
- No attempt to model EXT BBA (assume 10um RMS bpm-magnet center offset)
- No modeling of any lattice matching

Beamsize After BBA



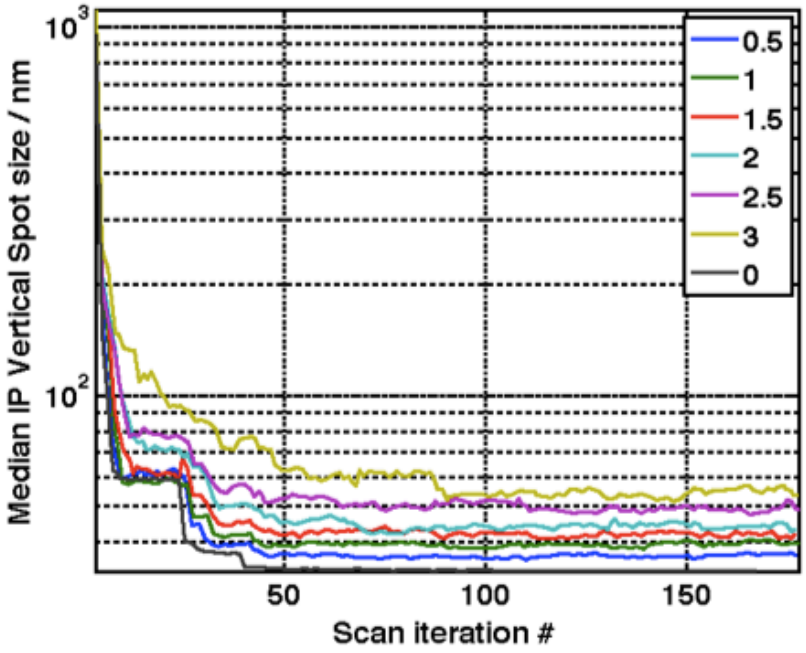
- IP waist size before sextupole FFS tuning knobs applied (100 seeds).

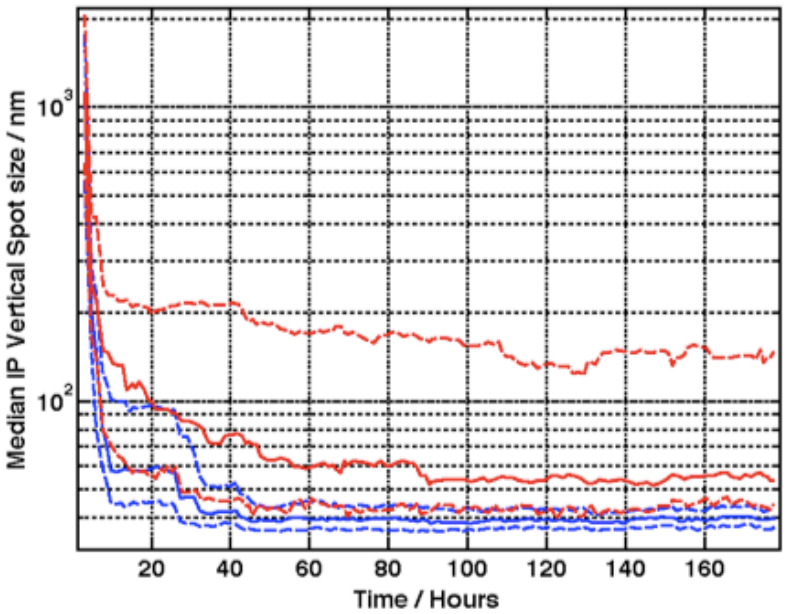
IPBSM Resolution



- In results shown, scale above data by: 0.5, 1, 1.5, 2, 2.5, 3

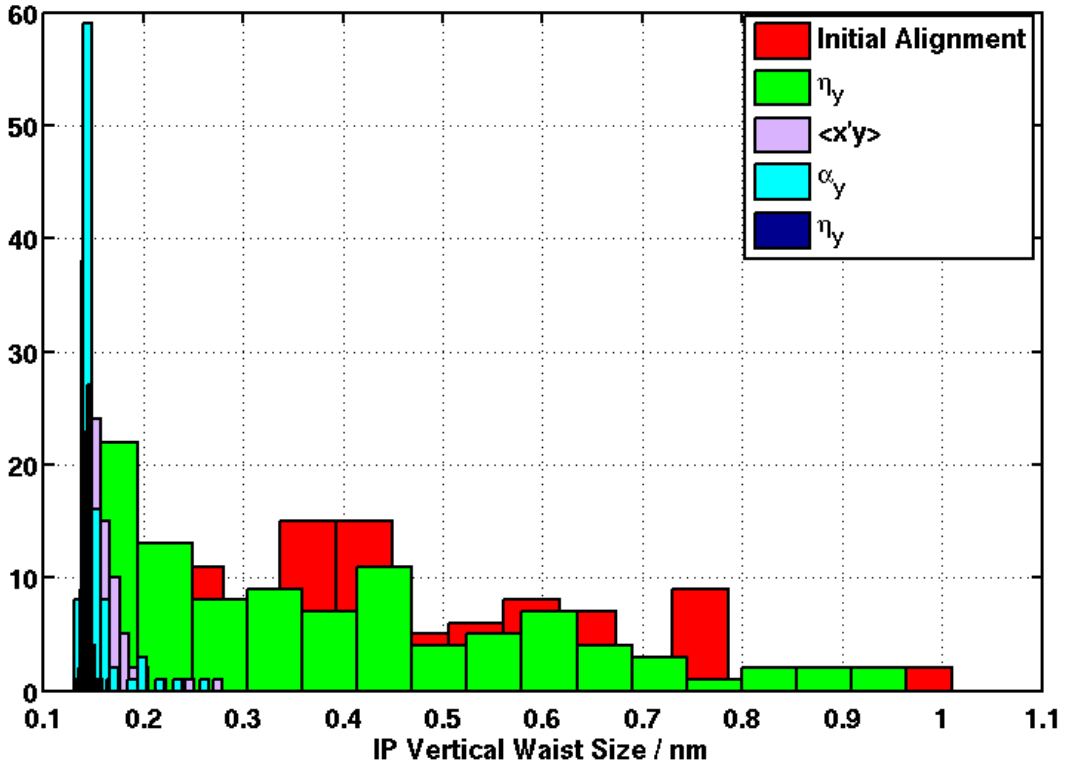
Median Tuned Spot Size





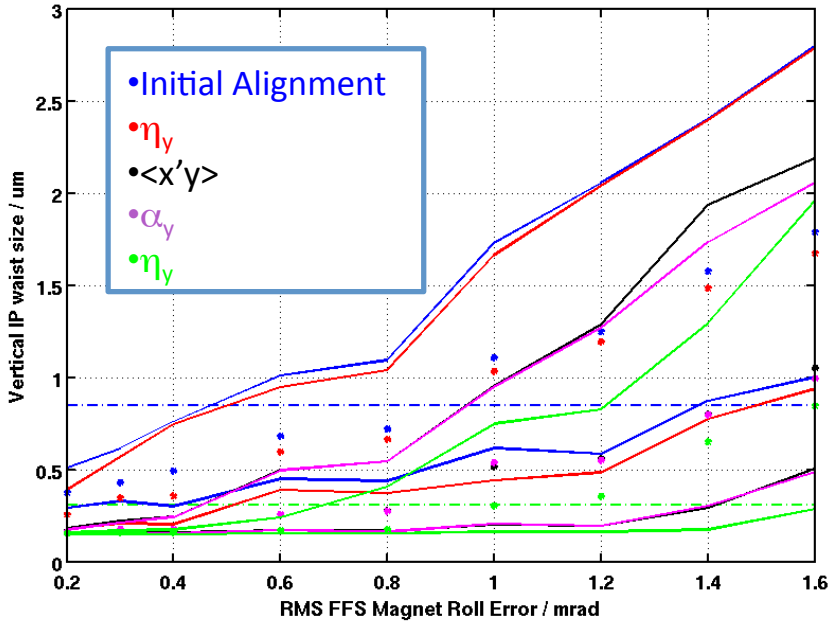
- From 100 simulated seeds - median IP beam size at each scan iteration point (left plot).
- The right plot shows 50% (median), 25% and 75% C.L. for the cases of scale factor 1 (blue points) and scale factor 3 (red points).

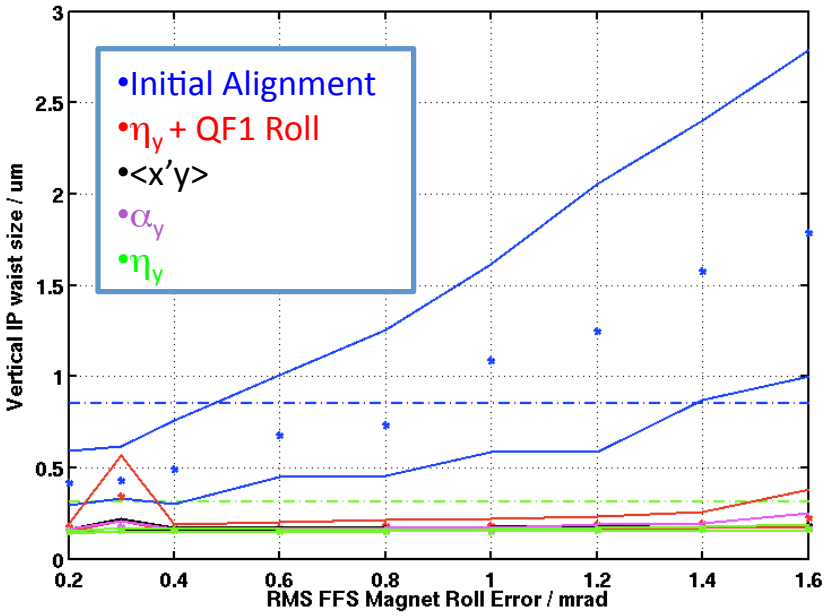
10* IP β* Optics Tuning Simulation (normal errors)



- 20pm Vertical emittance used.
- Simulation quickly converges to ~140nm design IP vertical spot size after just 4 applications of linear tuning knobs.

Simulated Tuning with Varying FFS Magnet Roll Errors





- Points show median results, lines 25% and 75% CL for 100 simulated seeds with gaussian distributed errors.
- Achieved IP waist vertical size after each of 3 tuning knobs applied.
- Right plots show addition of QF1 roll minimisation before multiknobs applied.

Why Wasn't Easier in Practice to Reach 140nm?

- Sextupole multiknobs not correct / not orthogonal
  - Check dispersion knob against measurements
  - Check BBA, roll alignment, strength calibration, polarity of FFS sextupole magnets.
  - Phase advance correct between sexts? Response matrix checks…
- Dominant error terms at IP other than α_y, $\langle x'y \rangle$, η_y
  - Check possible error sources in model.
  - Magnet roll/offset/strength error tolerance plot with these aberrations removed.
- Large time-dependent IPBSM measurement drifts
  - Need to successfully do nothing! Multi-hour steady-state running in <500nm regime to test systematics of IPBSM + feedbacks etc.
- Beam not well matched at IP
  - Post-IP carbon wire measurement with beam at IP indicated beta-function approximately correct.
  - Irwin knob reduction of beta-function by factor 2 attempted with no observed improvement in beam size.
  - More thorough check of beta-function possible next time?