ATF2 IP Tuning Task Update

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- Goals and methods
- Tuning simulation results
  - Improved sextupole multiknobs
  - RMS vs. beam core fitting
  - Pushed IP beta configurations
  - Results with Shintake monitor resolution data
- IP tuning task group meeting schedule

Tuning Goals and Methods

- Achieve ~35nm vertical spot size as measured by Shintake BSM
  - 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)

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.

Tuning Simulation Steps

- Apply standard errors to FFS + EXT
- Use EXT and FFS feedback for orbit correction
- Perform EXT dispersion and coupling correction
- Perform quad and sext BBA in FFS.
- Final IP tuning only using FFS sextupole multiknobs using x,y and tilt moves and strength tweaks.

Sextupole Multiknobs

	SD4 (x)	SD4 (y)	SF1 (x)	SF1 (y)	SD0 (x)
Waist	1	-0.0006	0.2903	0.0007	-0.0164
Dispersion	0	0.4459	0	1	0
<x'y>	0	-0.6363	0	1	0

- Knobs applied by asking for given dx/dy moves in sextupole BPMs.
  - Iterate through SD4/SF1/SD0 moves until beam passes through correct orbit within +/- sextupole step size (300nm).
- Iterate through linear knobs until no further improvement, then iterate through tilt + dk for all sextupoles and re-apply linear knobs and repeat...

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

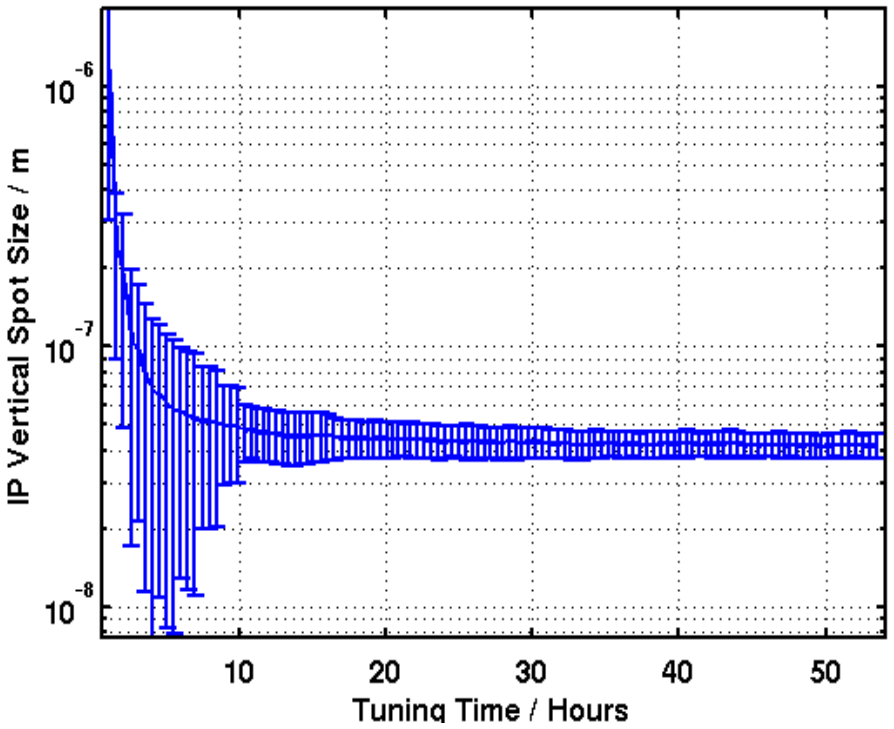
Done

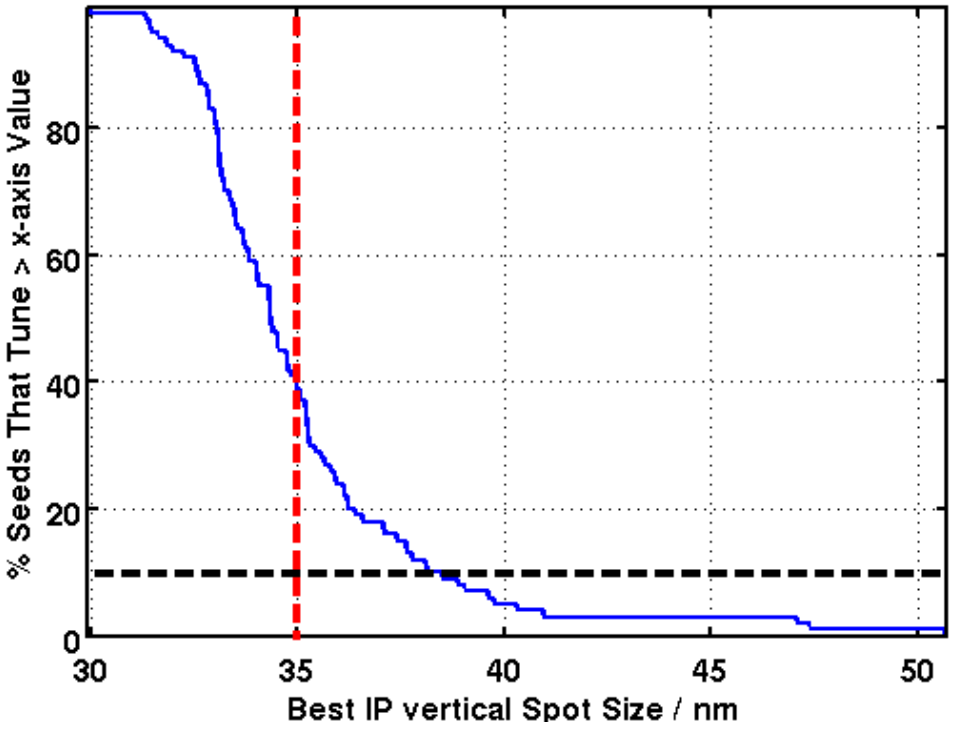
- Error list on wiki
- Also GM- ATF fitted Model
- Also include measured multipoles for final doublet, sextupoles and FFS bends.

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).
  - Only faster if not have to do too much averaging.

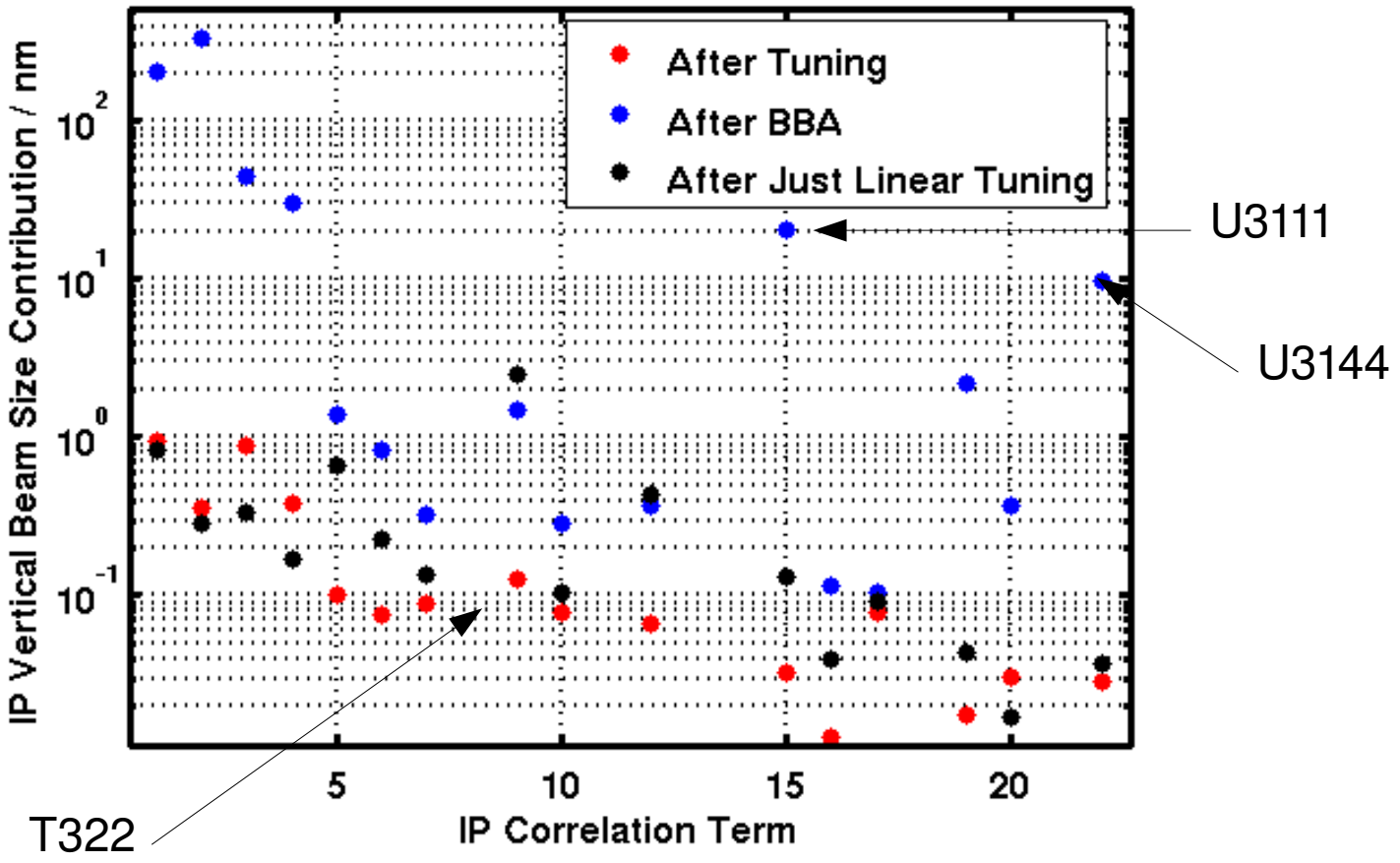
Improved Tuning Results with Better Sextupole Tuning Knobs





- 2nm IPBSM resolution throughout tuning
- No simulation of sext mover time
- No GM during tuning or BPM or IP measurement averaging

IP Correlation Terms

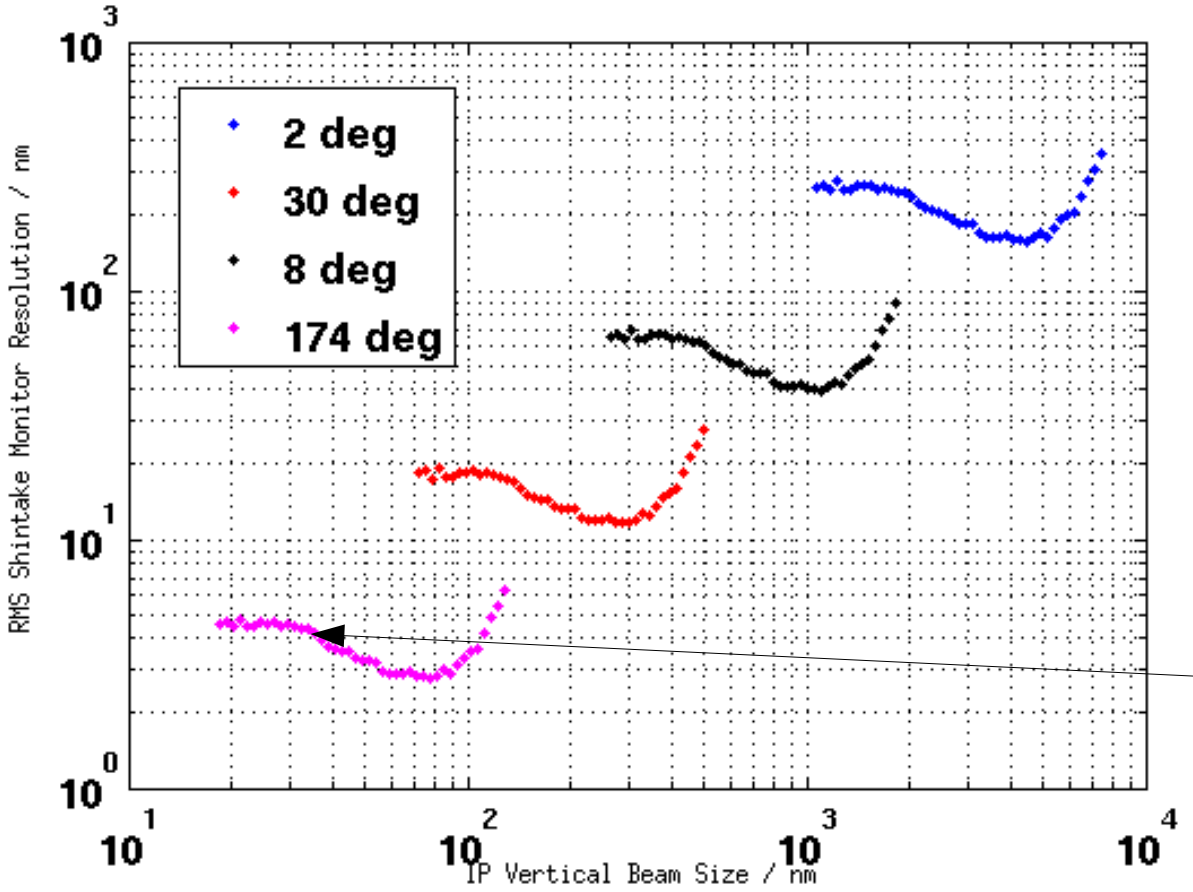


- Median contributions to vertical beamsize from 100 seeds for linear + higher order correlation terms after BBA, linear knobs and all knobs.

IP Measurement Resolution

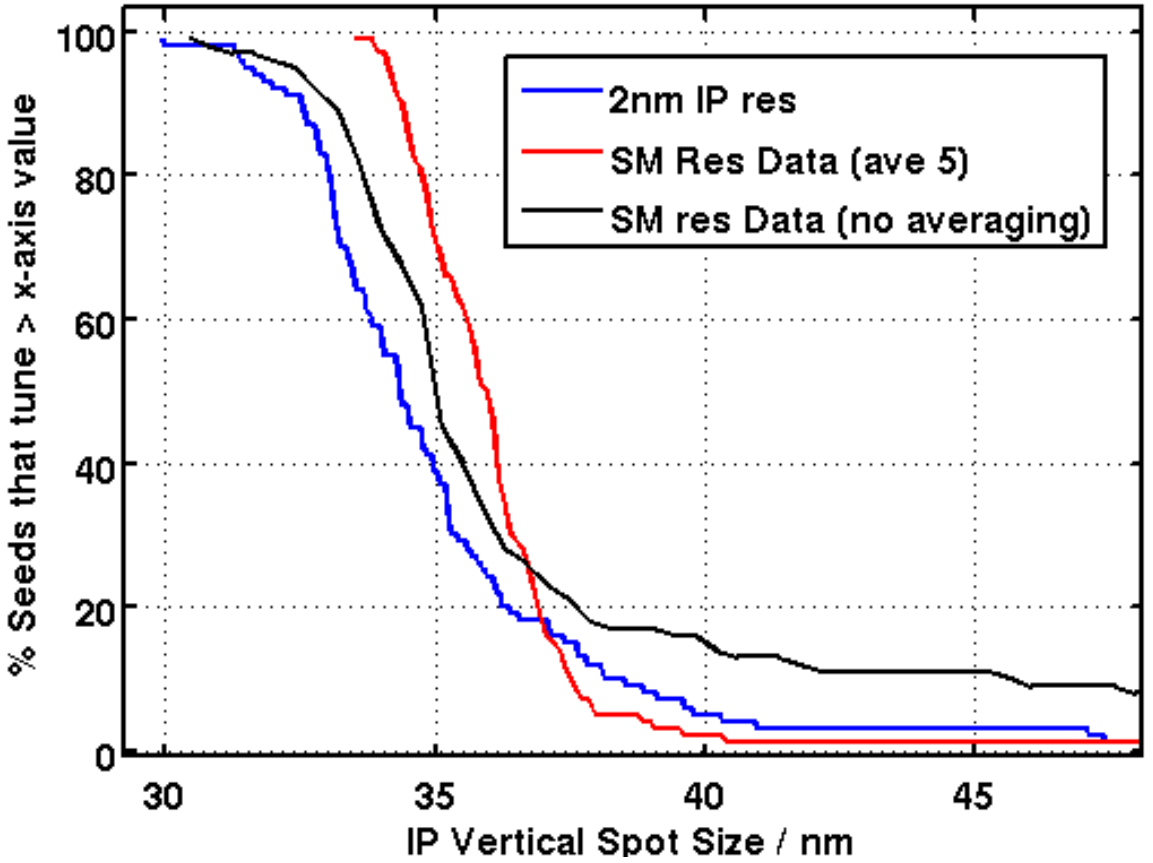
- Can now use calculated resolution data from Tokyo group for Shintake monitor vs. beam size
- Beneficial to integrate more than 1 IP measurement per tuning step (towards end of tuning when spot size is small) ?
  - IP beam size growth over integration time due to various drifts must be small compared to improvement in measurement resolution.
  - Should not drive tuning time to be too long.

Shintake BSM Resolution Data



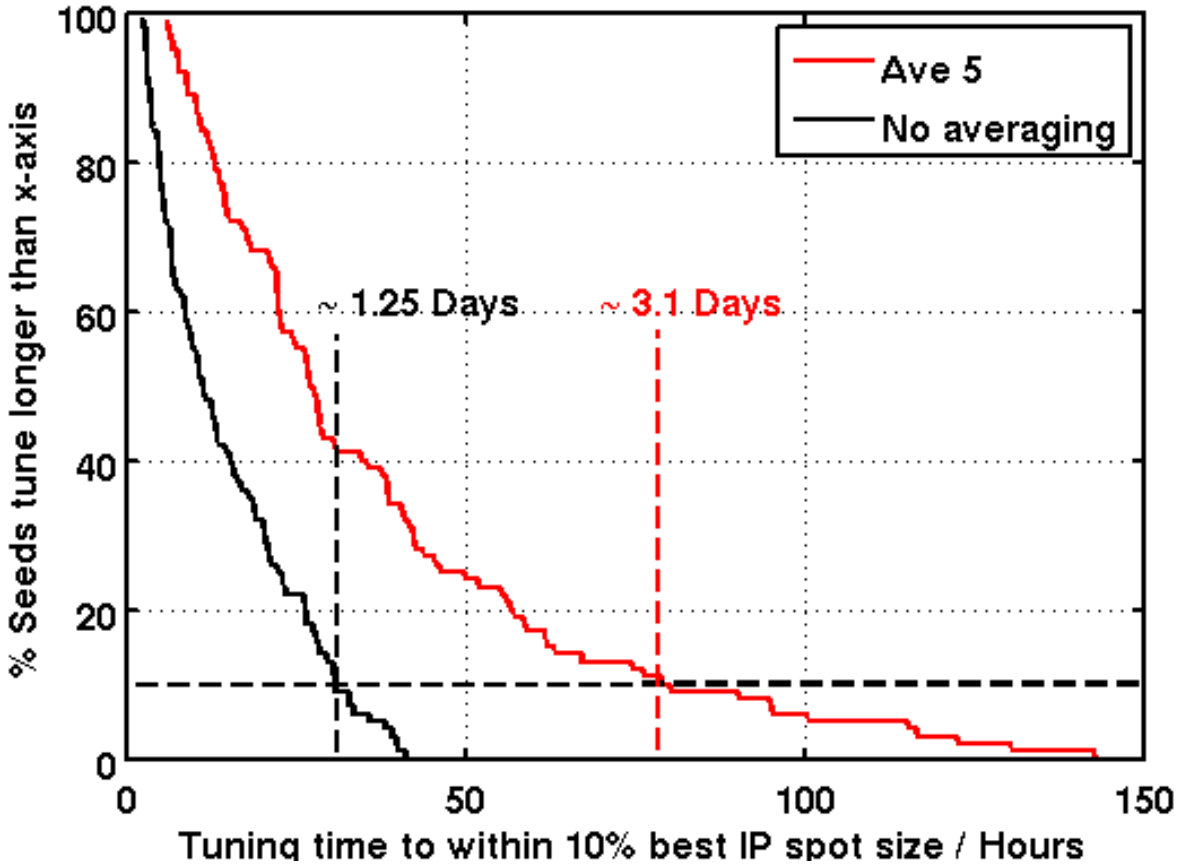
RMS resolution at
35nm goal spot size
~4nm

Results with IPBSM Resolution Data



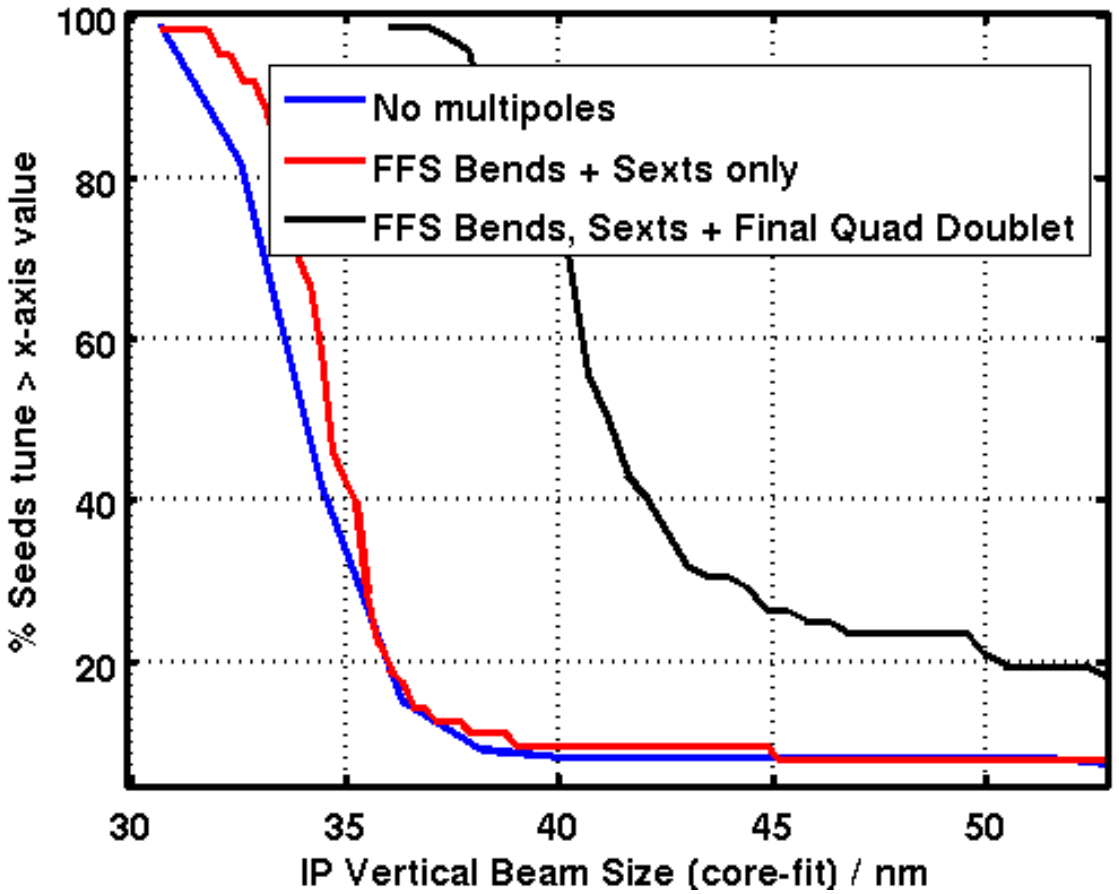
- Tuning performance using IPBSM resolution data.

Tuning Time



- Tuning time with and without averaging of IP spot size measurements with IPBSM

Include Measured Magnet Multipole Components



- Measured multipoles of final doublet have major impact on beam size (mainly due to sextupole component).
- Need to re-match optics for these conditions before tuning.

Summary

- Results and timescale look promising.
- Tuning on RMS vs. beam core makes significant difference to results.
  - Maybe impossible to tune below ~35nm using RMS
- Things still to add to simulations
  - Sextupole mover realism
  - Dynamic effects during tuning
  - Check mover ranges
- Simulation results stored (100 seeds) for post-alignment and post-tuning cases on SLAC ATF2 ftp server (link from wiki). Formats supported: Lucretia & AML