Update on Tuning and Feedback Studies for ATF2

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Overview

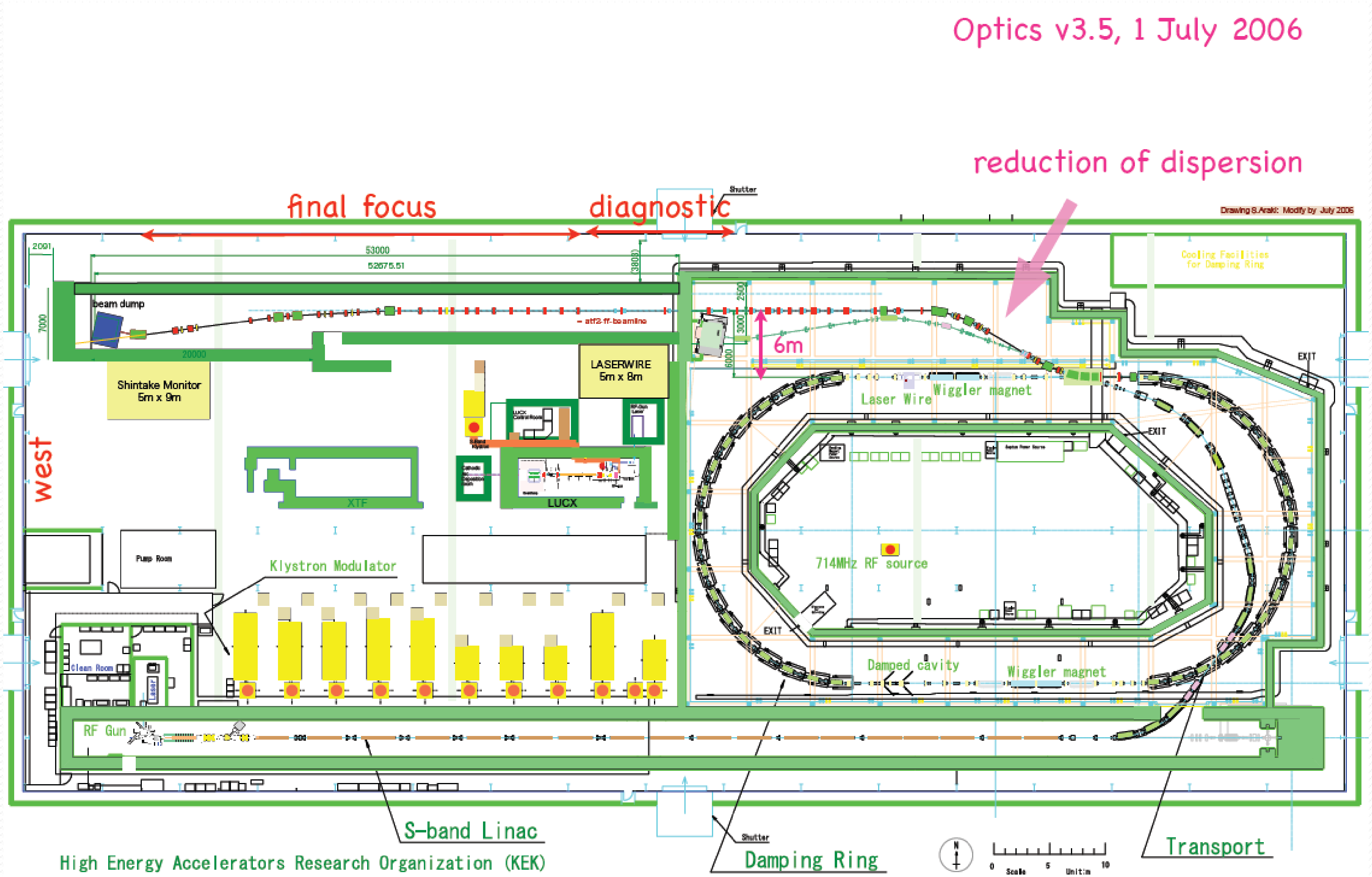
Tuning simulation updates

- Review of tuning simulation.
- Effect of removing 3 quad movers from alignment and tuning simulation.
- Check of mover range.

Feedback simulation studies

- Impact of ‘fast’ jitter sources.
- Long-timescale performance with ground-motion drifts.

ATF2 Final Focus System Test



Tuning Procedure Overview

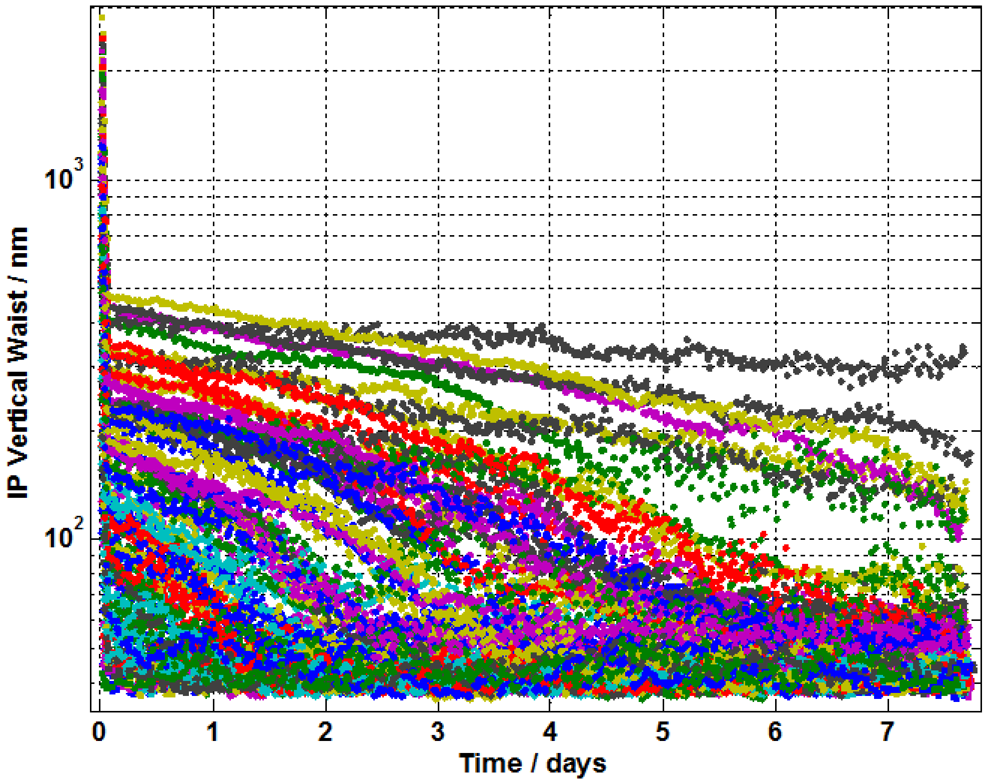
- Apply installation errors.
- Use EXT correctors + BPMs (EXT FB) to get orbit through EXT.
- Use FFS FB to get beam through FFS.
- Correct Dy/Dy' in EXT using skew-quad knobs.
- Correct coupling in EXT using coupling correction system.
- Use FFS FB for launch into FFS.
- FFS Quad BPM alignment using quad shunting with movers.
- FFS Quad mover-based BBA.
- FFS Sext BPM alignment using Sext movers and downstream BPMs.
- Sextupole 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.

Static Error Parameters

- Errors are normally distributed with mean=ref. orbit and quoted standard deviations.
- EXT BPM alignment not directly modeled yet, assume 10um quad-bpm alignment here.
- Model for SM measurement: mean spot size from 90 consecutive pulses +/- 2nm RMS error.
- Poisson-calculated multipole errors now added to FFS dipoles.

x/y/z alignment errors	**200 um**
Quad, Sext / Bend roll alignment	**300 urad**
Initial BPM-magnet field center alignment	**30 um**
dB/B for Quad, Sexts	**1e-4 syst. + 1e-4 random**
Mover step size (x & y)	**50 nm**
BPM resolutions	**100 nm / 2um**
Power supply resolution (FFS/EXT magnets)	**16/11 - bit**
Shintake Monitor Resolution	**2nm**

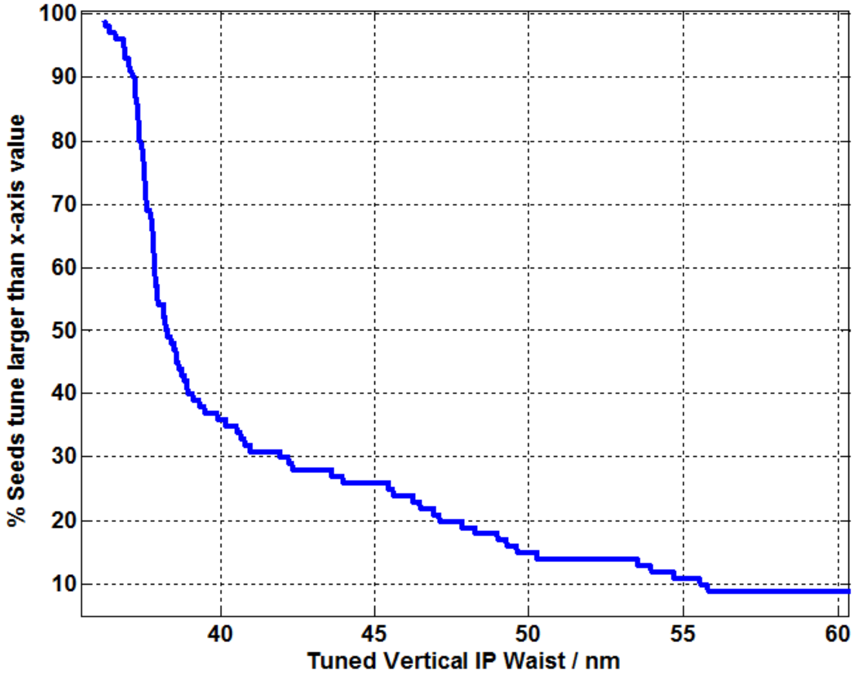
Tuning Results

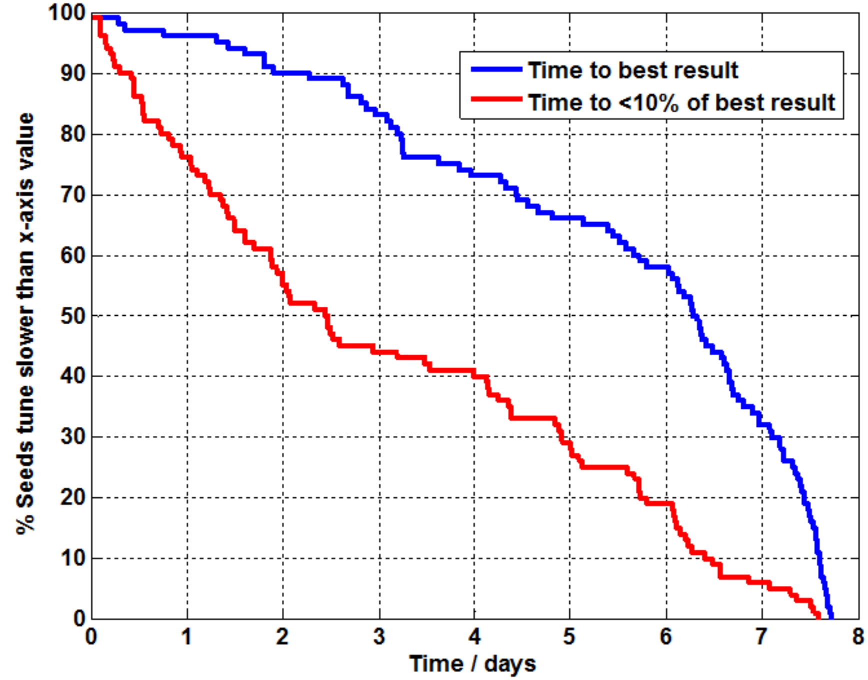


•100 seeds simulated
•90 pulses per measurement
•1.56 Hz
•Take best spot-size seen over 8 days as result for individual seed.

- Fully dynamic tuning simulation (2nm IP waist measurement resolution).
- Iterate tuning knobs.

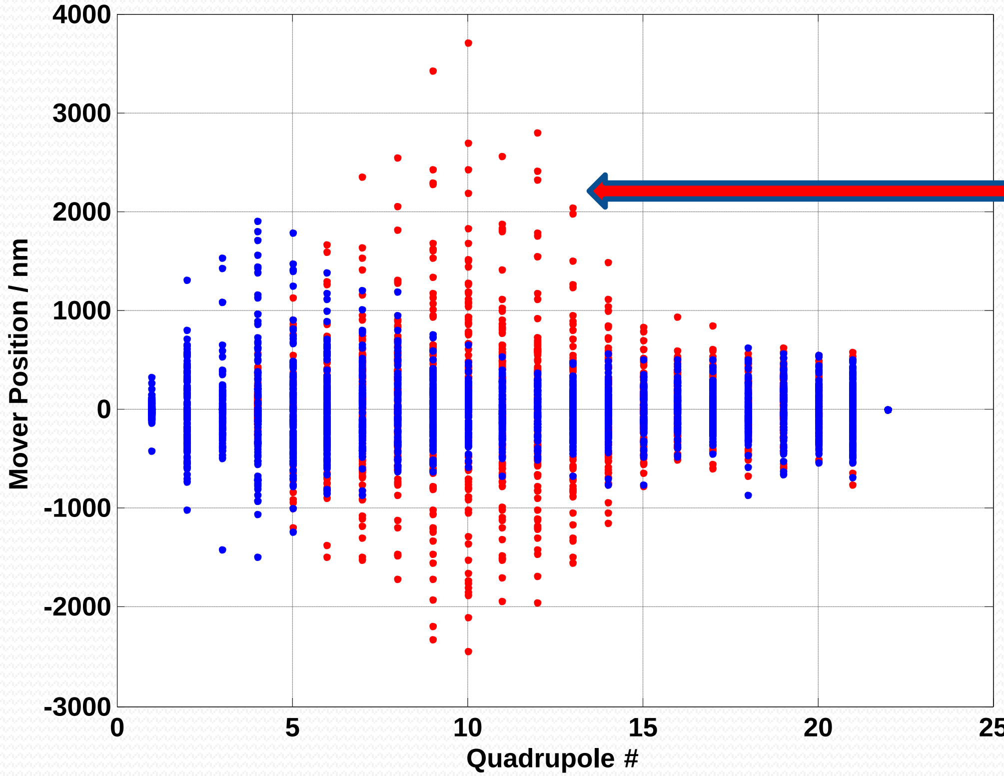
Tuning Results





- 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)

Effect of Removing 3 Quad Movers



Final mover positions, removing first 3 quad movers in FFS

- Final tuned spot-size results unchanged
- Problem with size of vertical quad moves
  - More optimal movers to remove than first 3?
  - Reduce BPM weighting in BBA solution
    - Study effect on tuning performance

Magnet movers in tuning code

- Include mover limits in tuning algorithms
  - Stop simulation if mover attempts to break limit
- 100 seeds – 28 failed due to mover limits
  - 14 during initial steering
  - 10 during BPM-quad alignment
  - 4 during the final sextupole tuning
- The 4% failure for sext tuning may ignored as negligible
  - These could be fixed by realigning the machine.
- 24% failure during initial steering and alignment <u>not</u> negligible
  - Must alter algorithms
    - Tighter constraints on magnet motion?

Feedback Studies

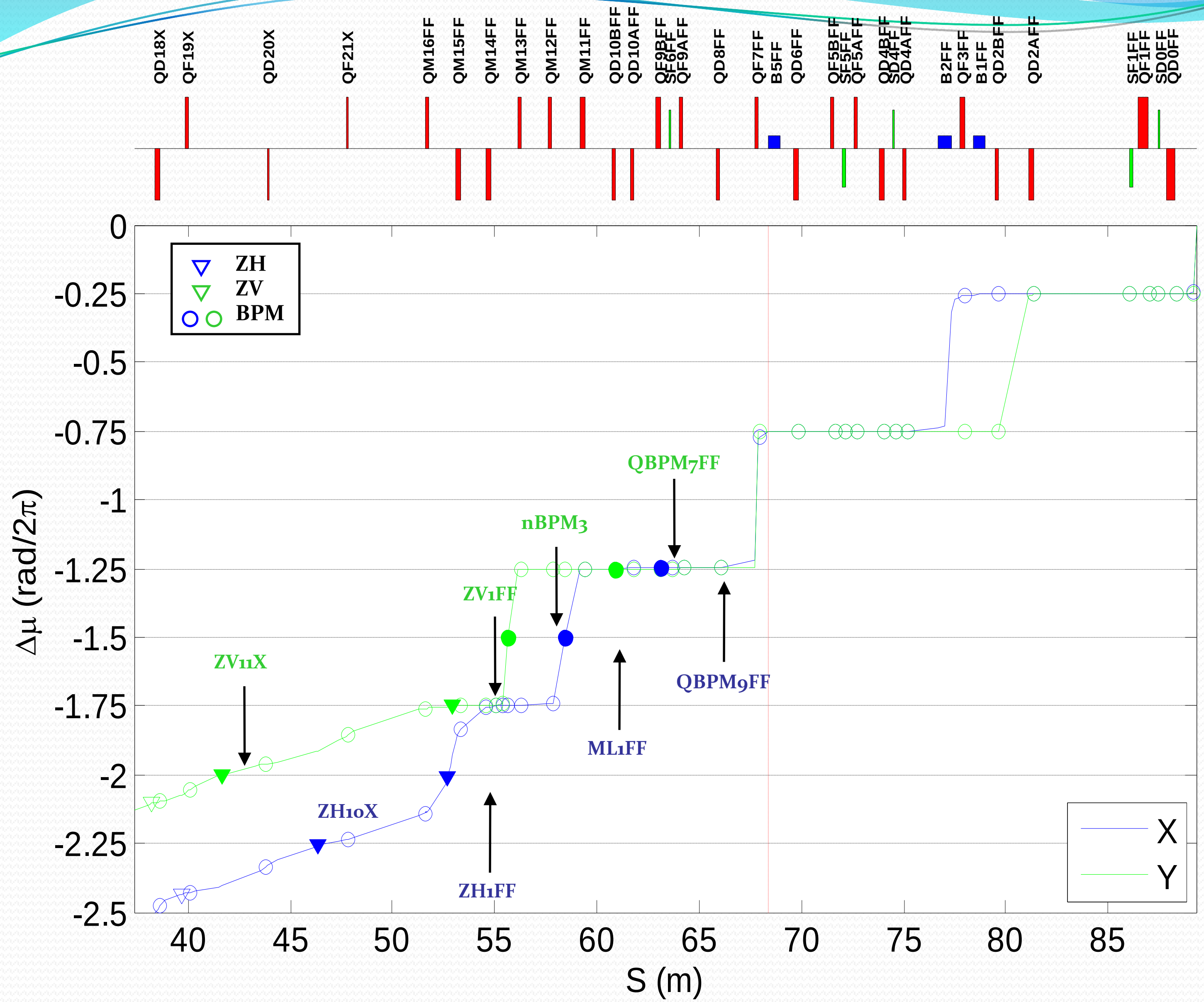
Feedback Model

- Use all available correctors and BPM's in EXT
  - 10 correctors in x, 11 in y
  - 23 BPMs
- Use 2 corrector/BPM pairs at start of FFS in non-dispersive region
- Feedback weights: 0.1 (FFS) 0.01 (EXT)

Study Jitter Effects

- Fast = 90 pulses
  - Study effects of fast jitter on beam size measurement
  - Orbit jitter => beam size jitter + beam position jitter -> beam size jitter through Shintake monitor measurement process
  - First effort towards integrating a Shintake Monitor simulation
- Slow = hours -> 2 weeks
  - Ground motion causes slow drifts at IP and throughout machine
  - Need to periodically retune to restore beam size

ATF2 pulse-to-pulse feedback devices (v3.7)



IP

IP phase

FD phase

IP phase

FD phase

IP phase

FD phase

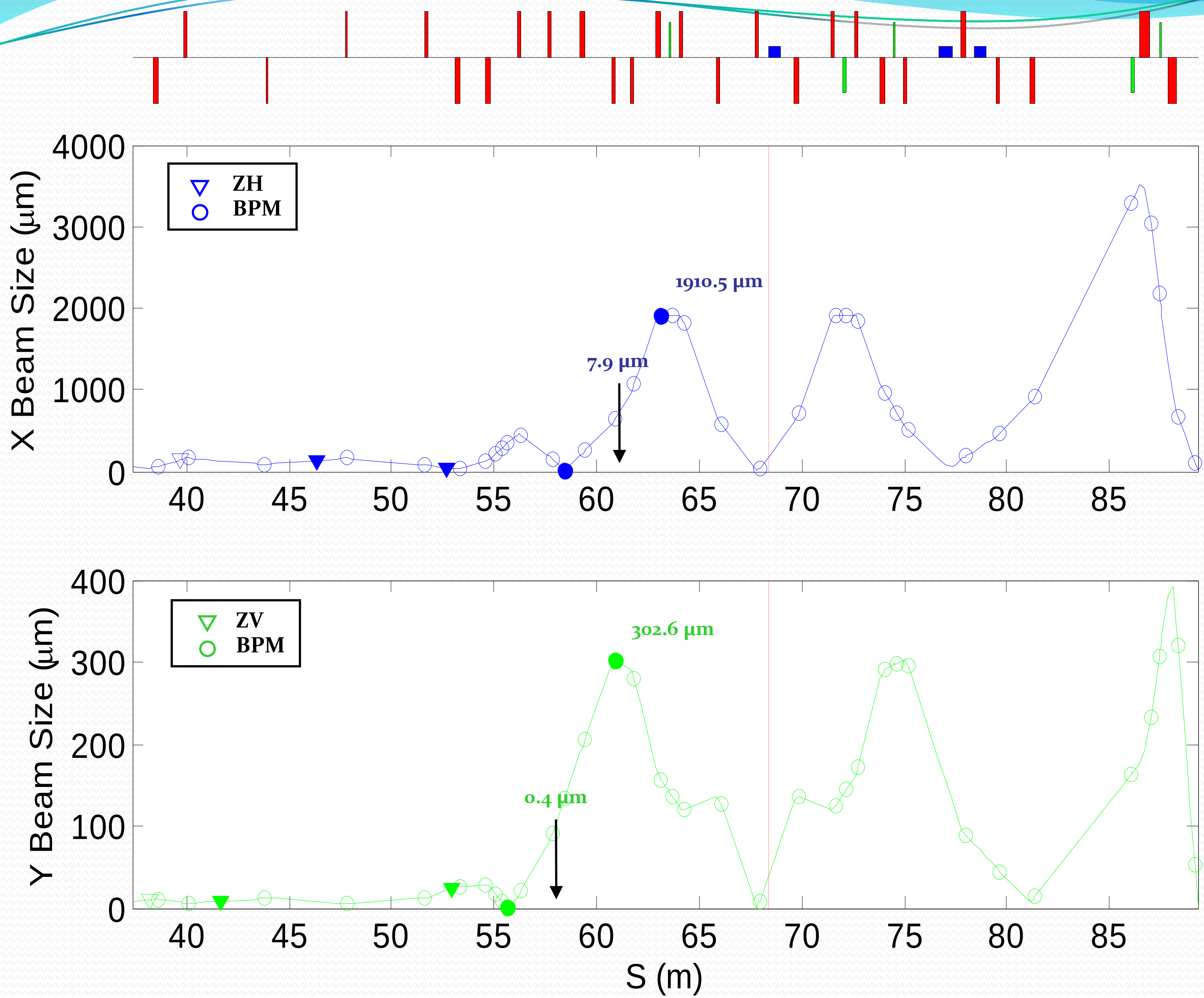
IP phase

FD phase

IP phase

FD phase

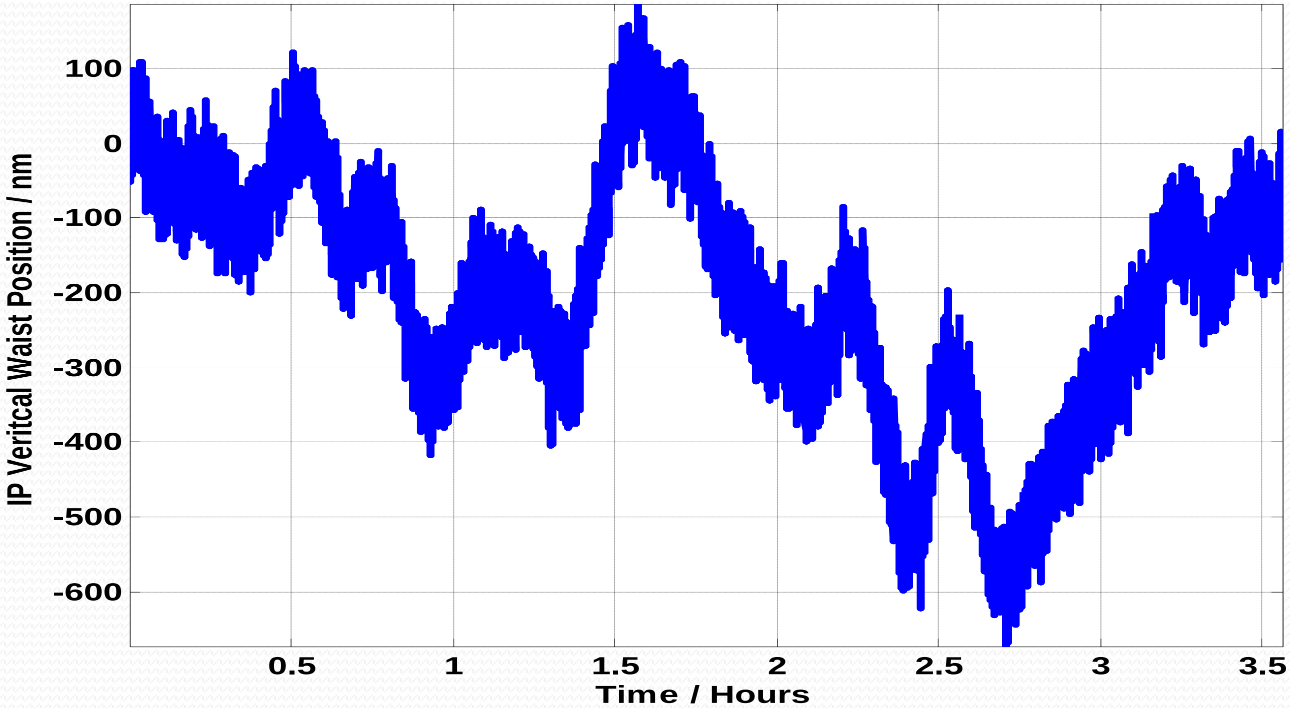
ATF2 pulse-to-pulse feedback devices (v3.7)



‘Nominal’ Jitter Parameters

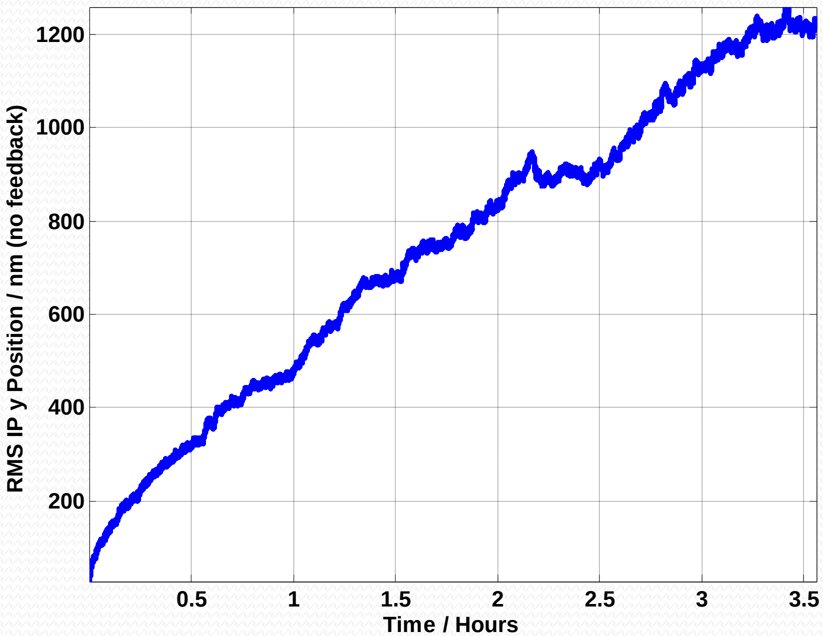
- 0.1 sigma x,x',y,y' RMS ring extraction jitter
  - 13 um/2.8 urad (x/x’) 0.6 um/0.4 urad (y/y’)
- 1e-4 dE/E error
- 10 nm magnet vibration
- 1e-4 strength errors pulse-pulse on corrector magnets
- 100 nm BPM resolution
- ATF fitted GM model
- Simulation performed with 100 random seeds

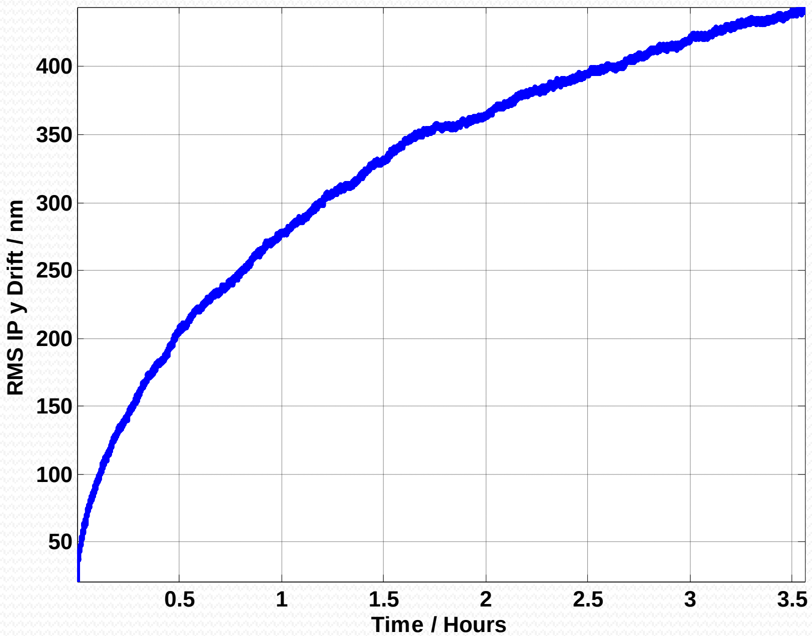
IP Motion



- 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.

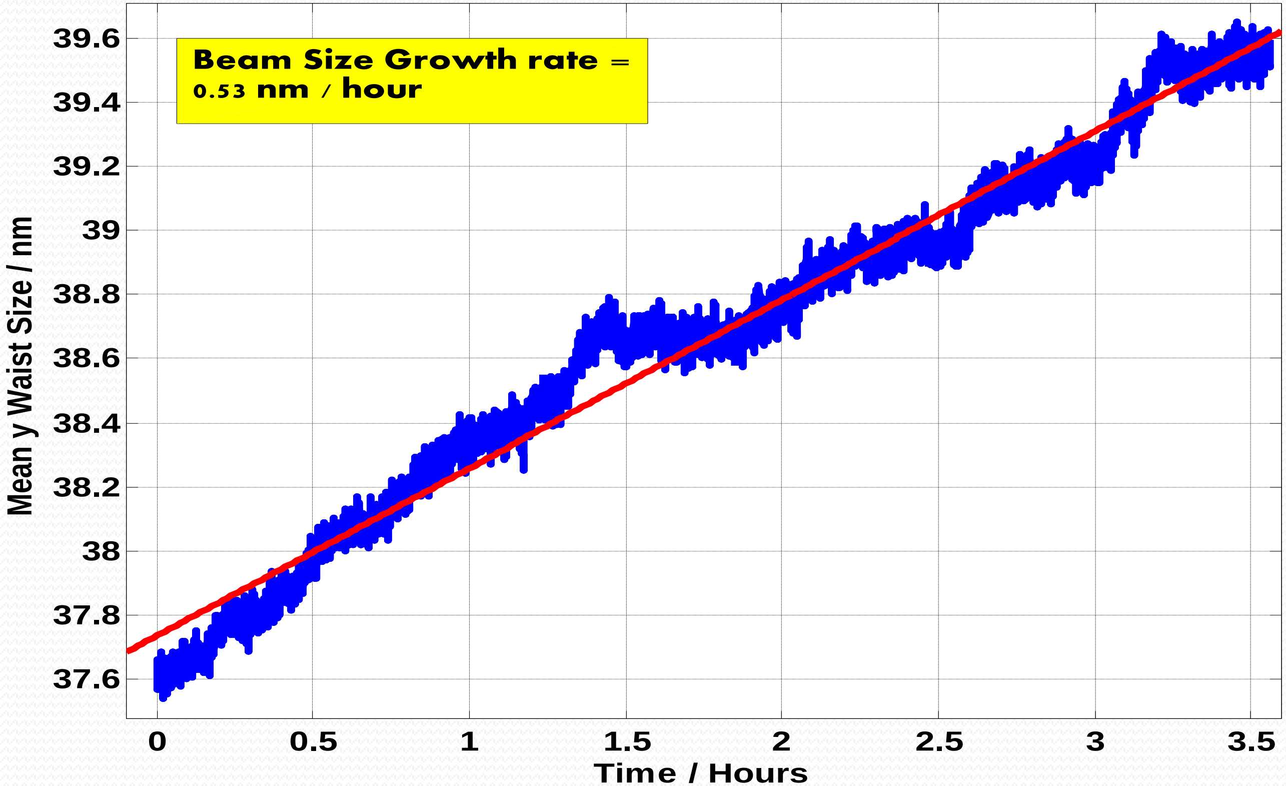
RMS IP Drift





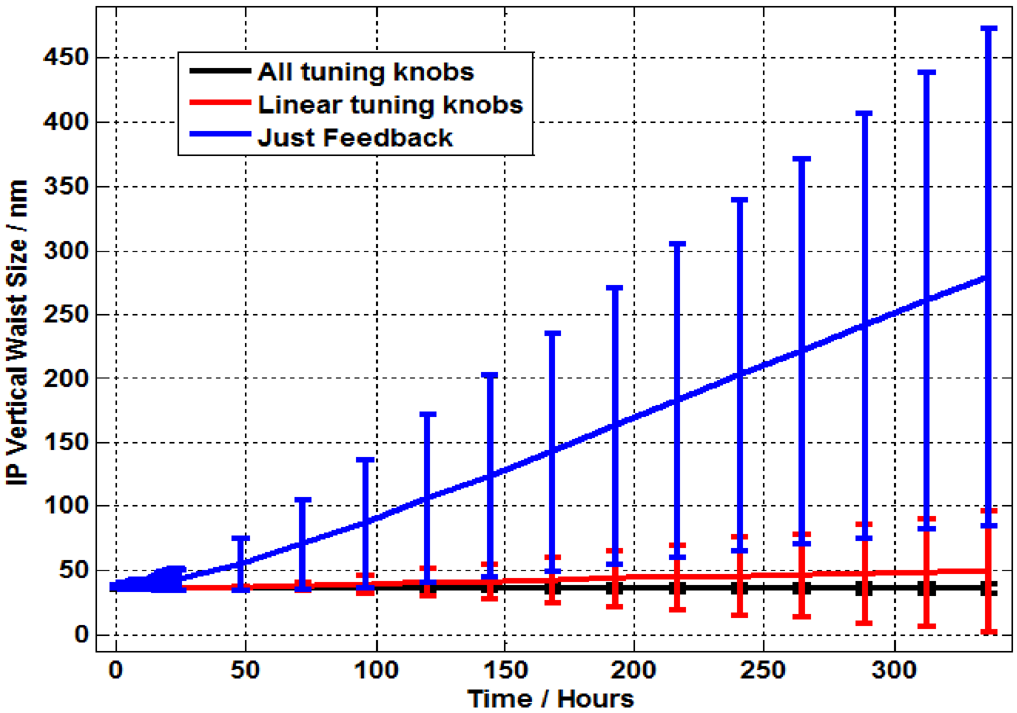
- 20,000 pulses, 100 seeds
- RMS IP y position shown as a function of time without feedback (left) and with feedback (right)

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

Sources of Fast Jitter

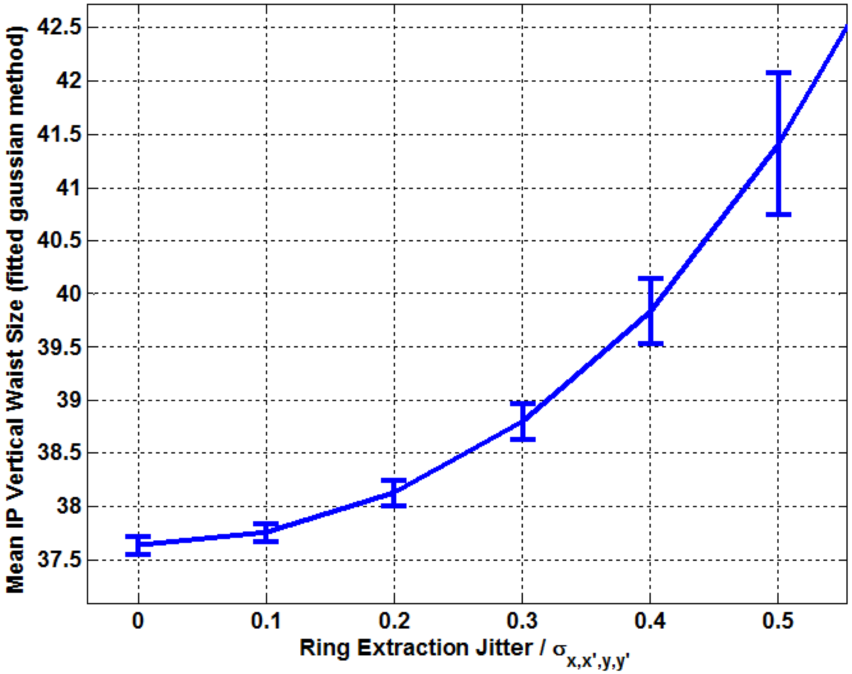
Investigate relative importance of different fast jitter sources

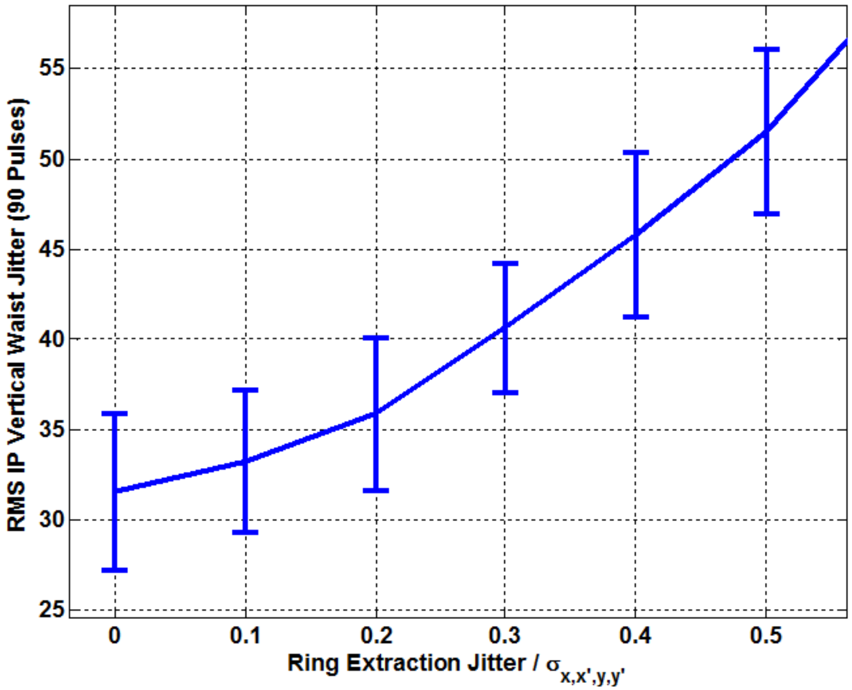
- Shintake monitor simulation **not** used here- just looking at jitter sources
  - Effect of jitter sources on beam size and position jitter during 90 pulses measurement is taken over.
  - 100 random seeds of 90 pulses used for each measurement, starting from a tuned machine.
  - Use Gaussian fit method for beam size measurement.

Jitter sources considered and ranges of jitter simulated

- Following sources on top of 1.56 Hz GM
- Ring extraction jitter (0:0.1:1.0) sigma x,x',y,y'
- Energy jitter (0:2e-4:2e-3) dE/E
- Magnet vibration (0:5:50) nm
- Corrector errors (0:1e-4:1e-3) dB/B
- BPM resolution (0:200:2000) nm

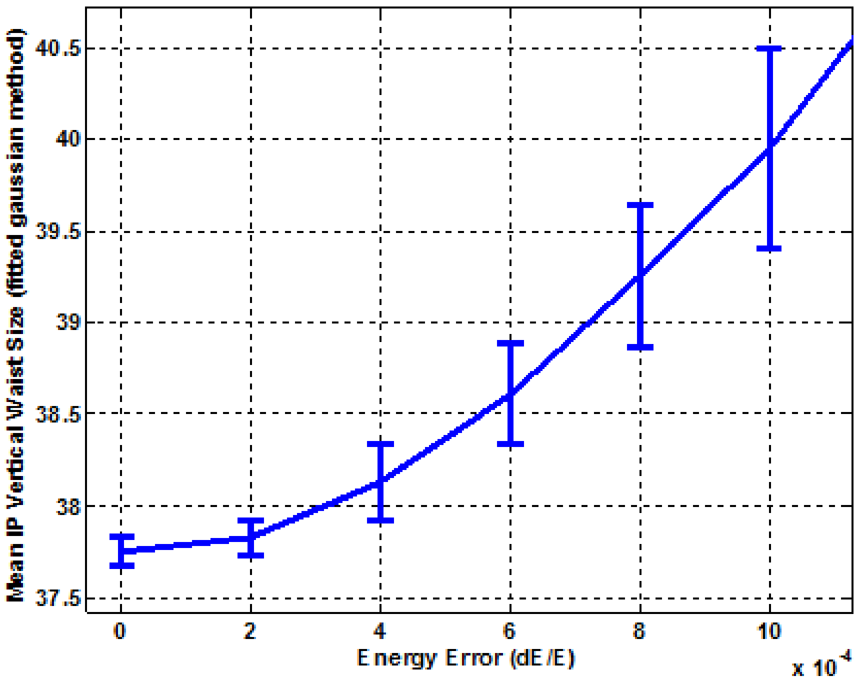
Ring Extraction Jitter

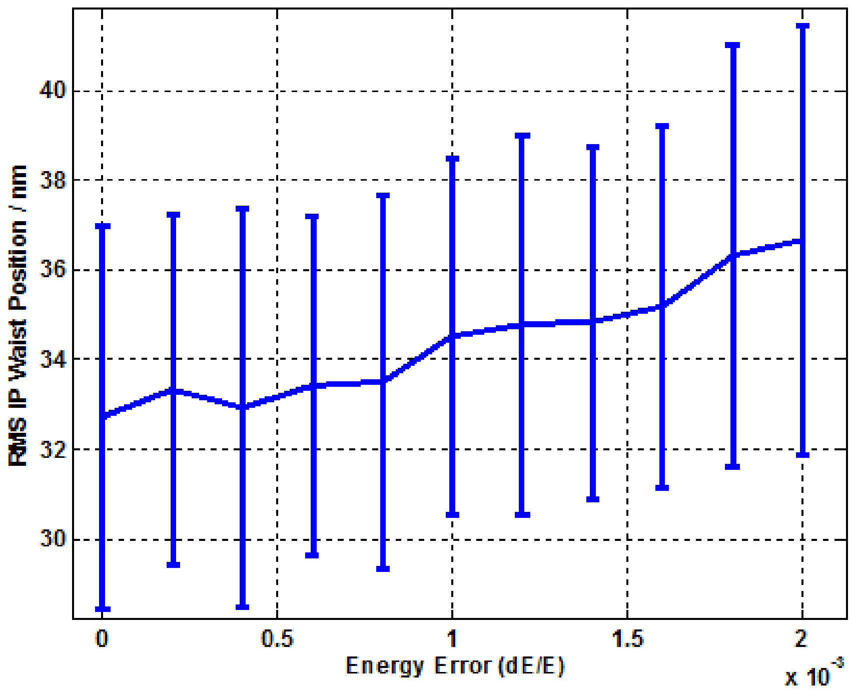




- Mean and RMS IP y waist size (left) and position jitter (right)
- 100 seeds, 90 consecutive pulses tracked for each seed

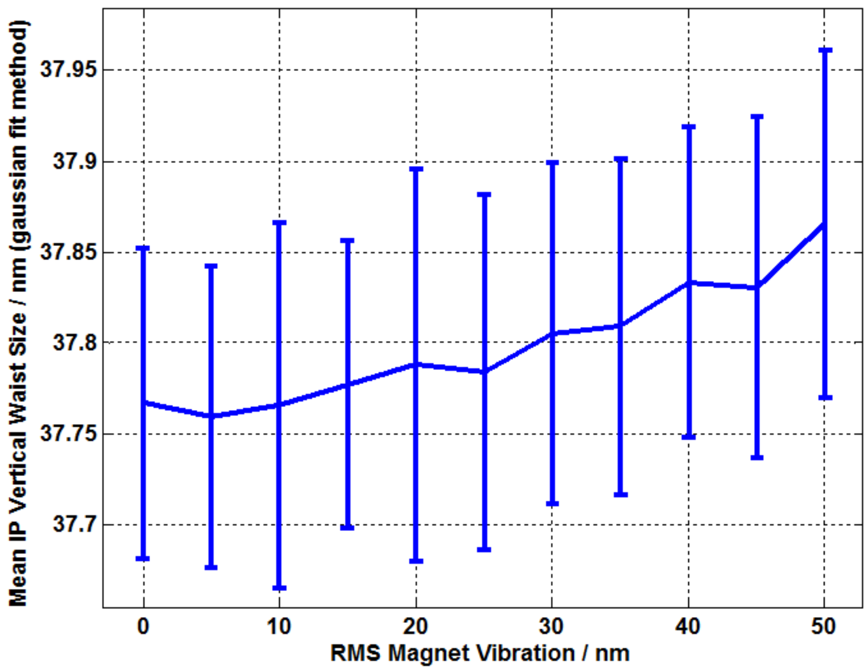
Energy Jitter

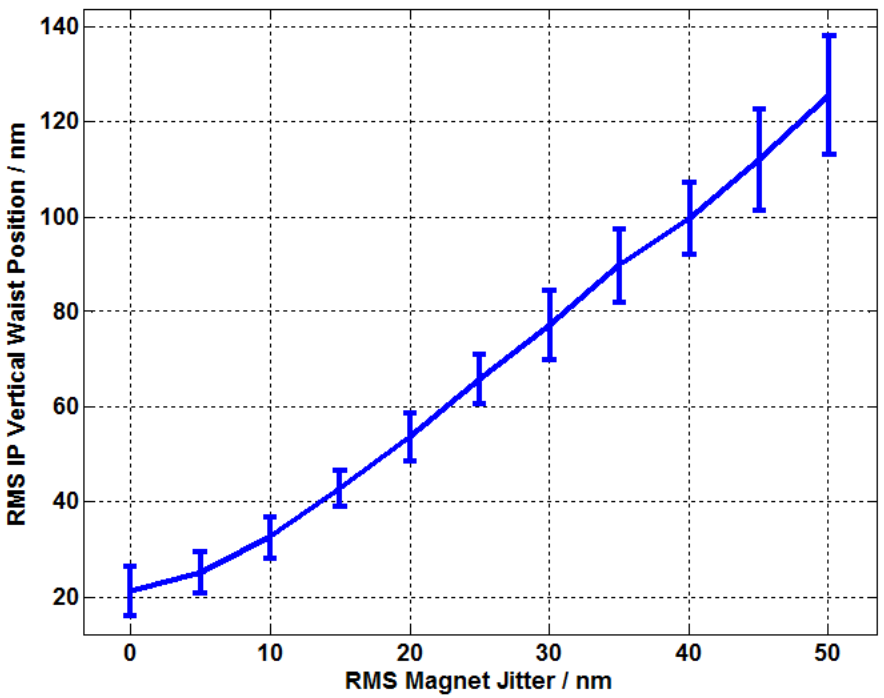




- Mean and RMS IP y waist size (left) and position jitter (right)
- 100 seeds, 90 consecutive pulses tracked for each seed

Magnet Jitter





- Mean and RMS IP y waist size (left) and position jitter (right)
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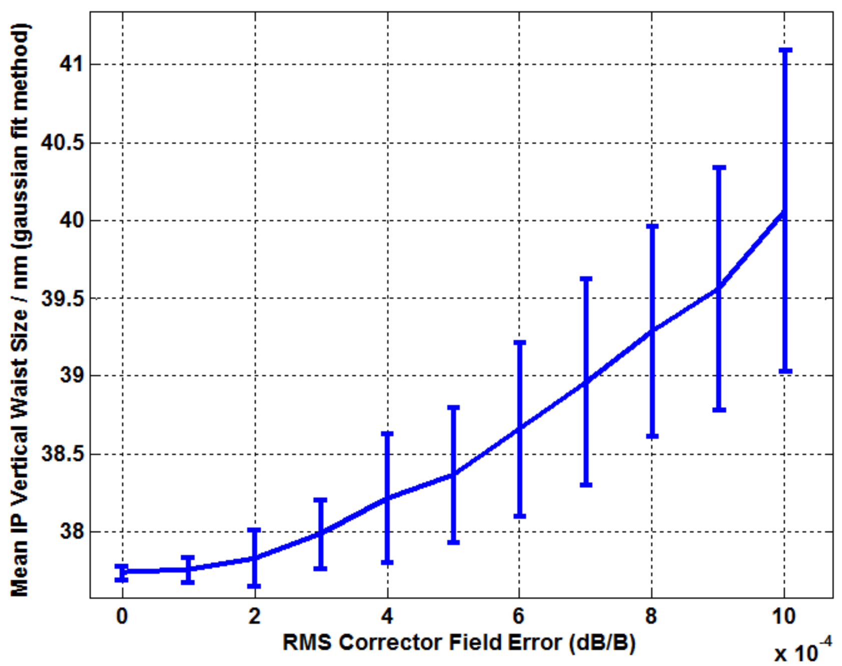
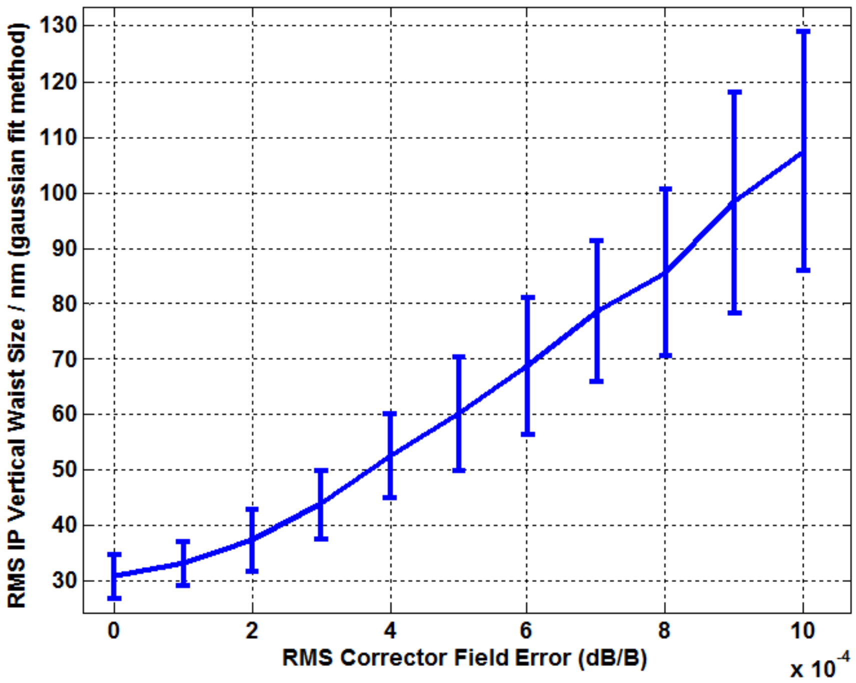
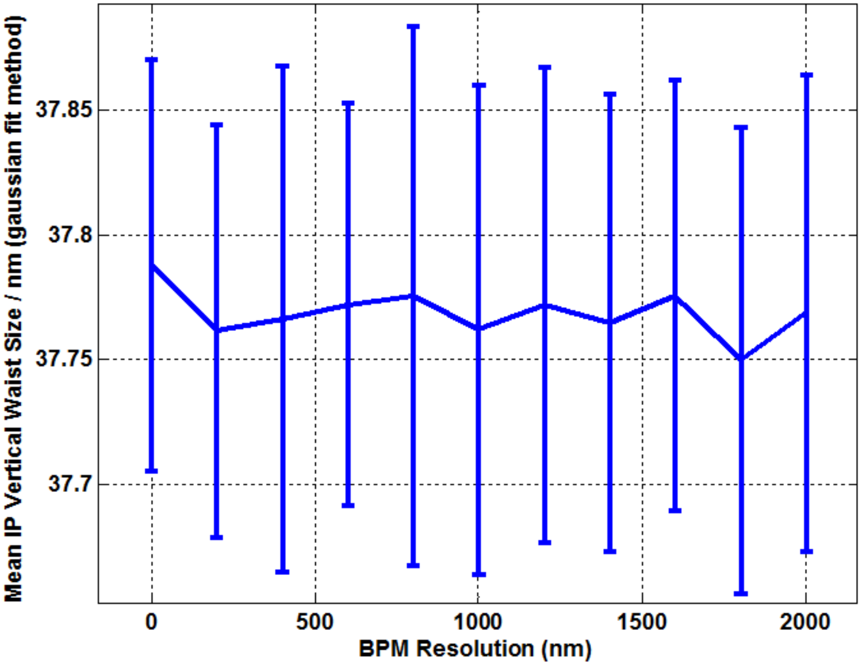
Corrector Field Jitter

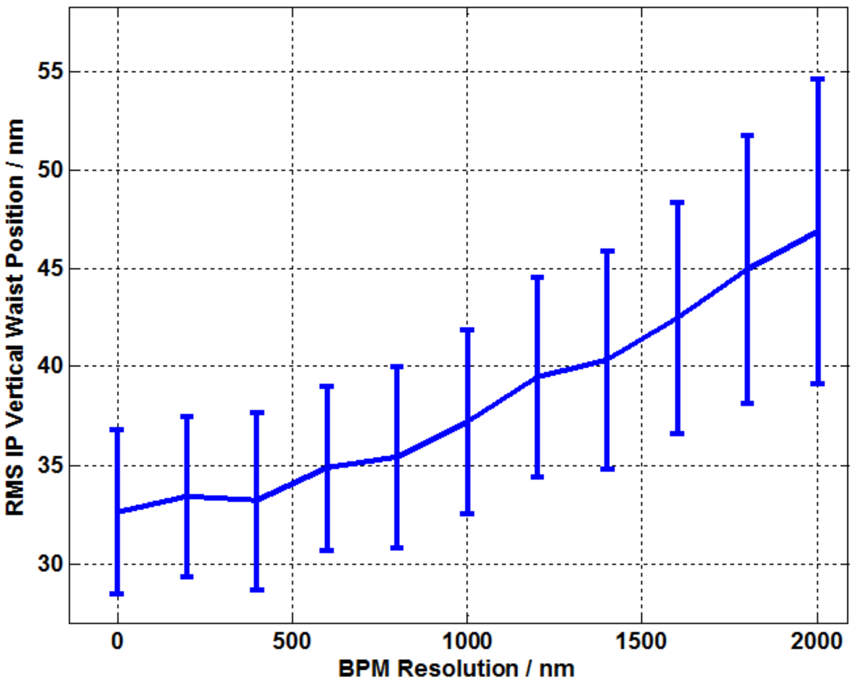




- Mean and RMS IP y waist size (left) and position jitter (right)
- 100 seeds, 90 consecutive pulses tracked for each seed

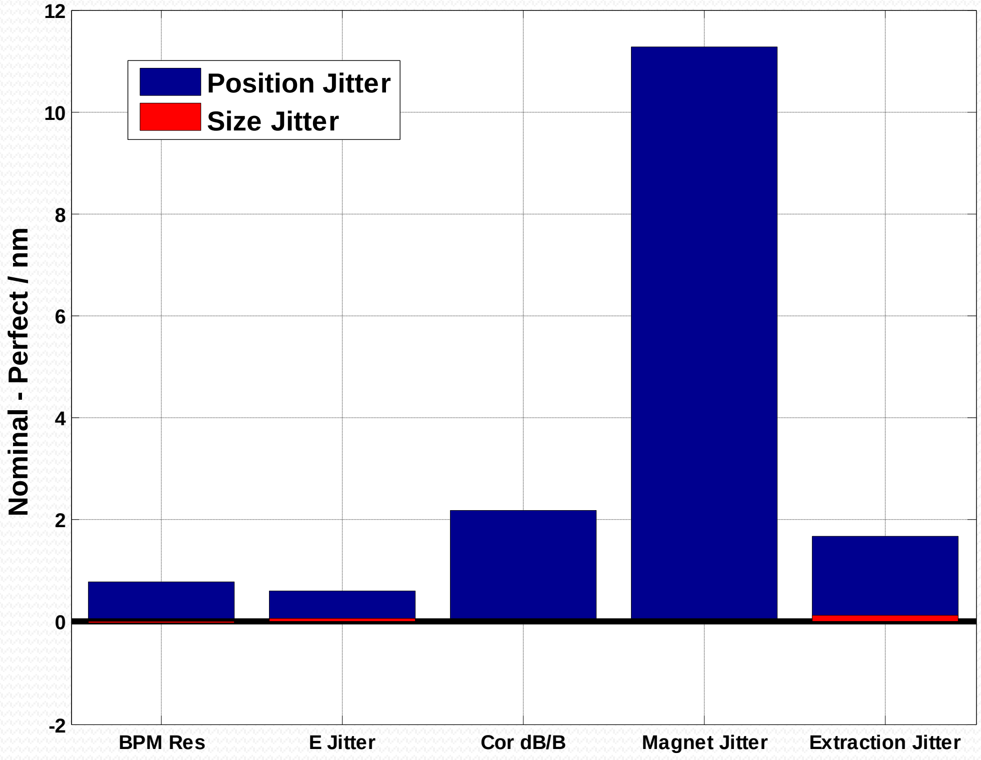
BPM Resolution





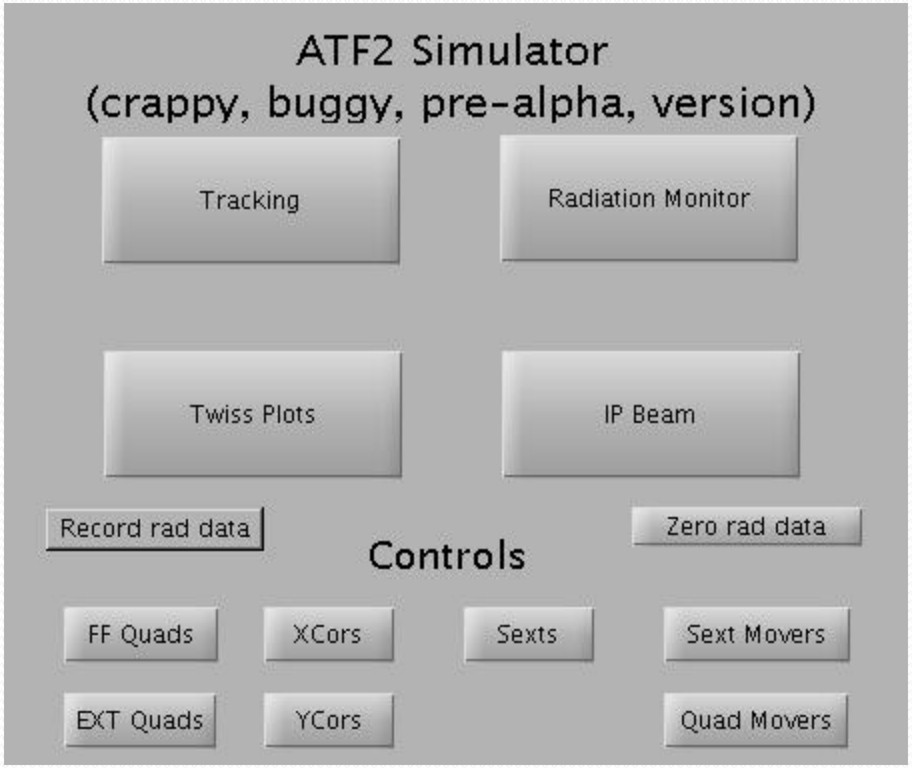
- Mean and RMS IP y waist size (left) and position jitter (right)
- 100 seeds, 90 consecutive pulses tracked for each seed

Fast Jitter Summary



- Chart of improvements made if different jitter sources are removed
- Magnet jitter is clearly dominant, all other sources do not make appreciable differences if removed.

ATF2 Simulator GUI



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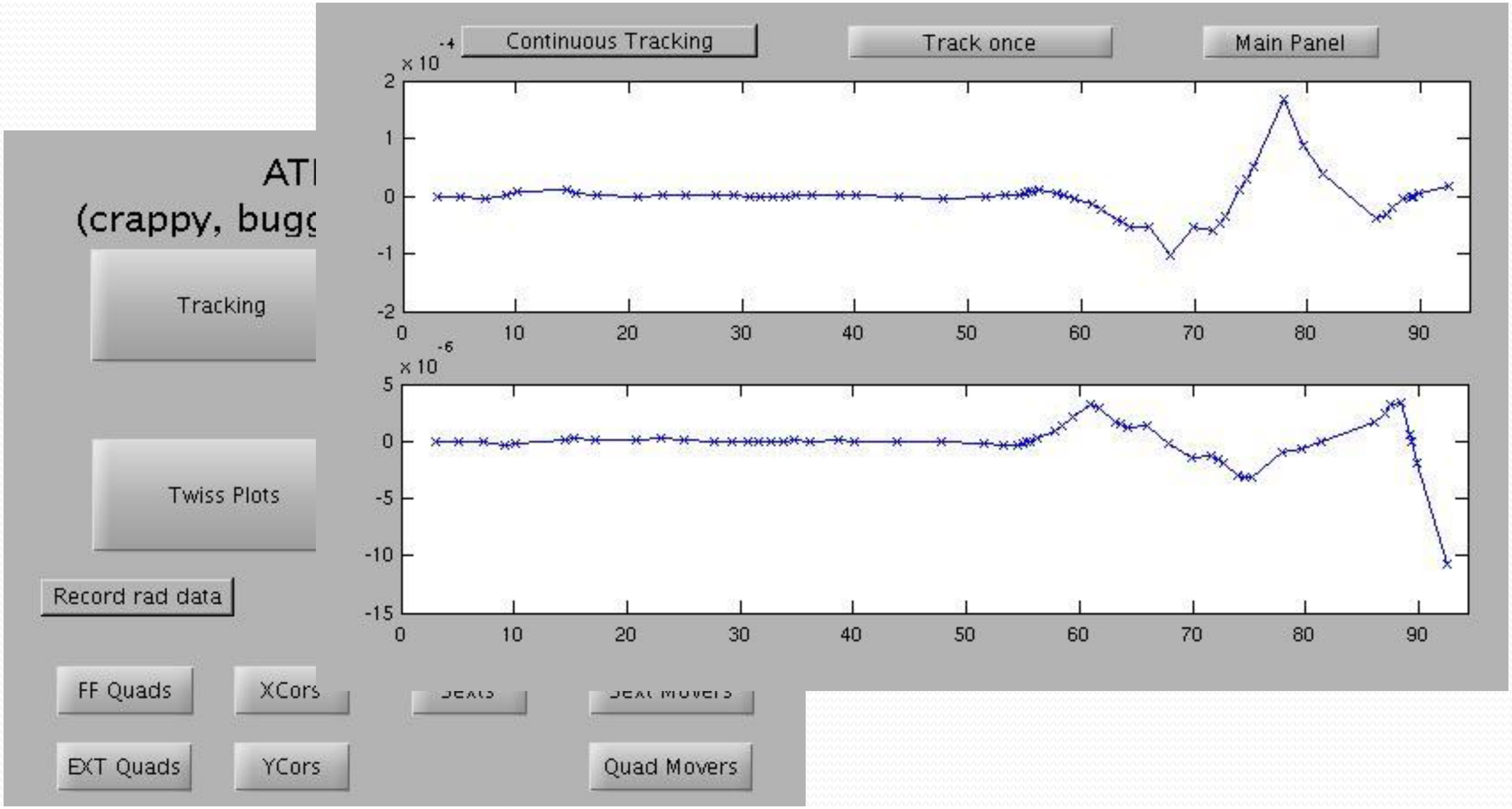
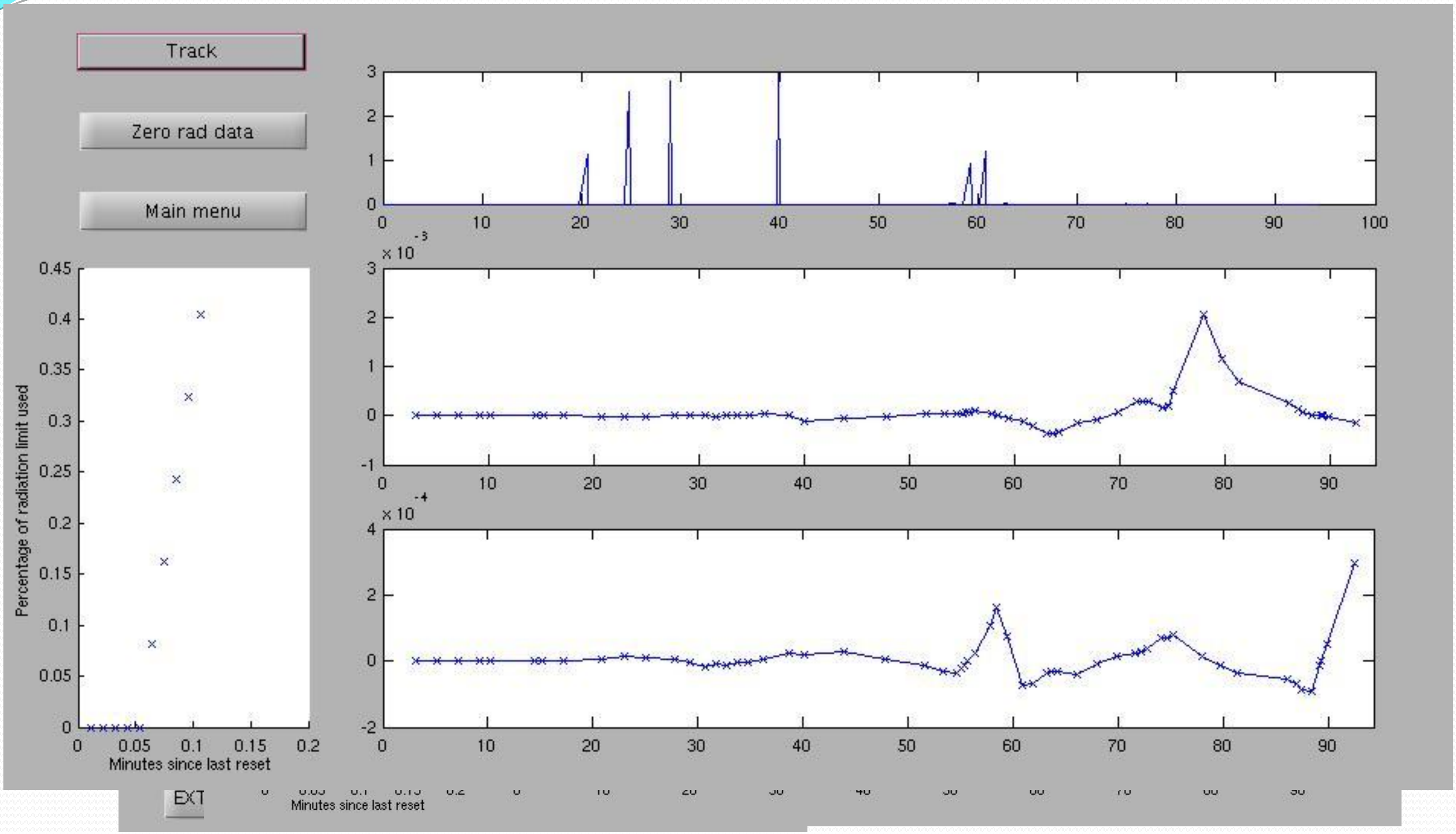
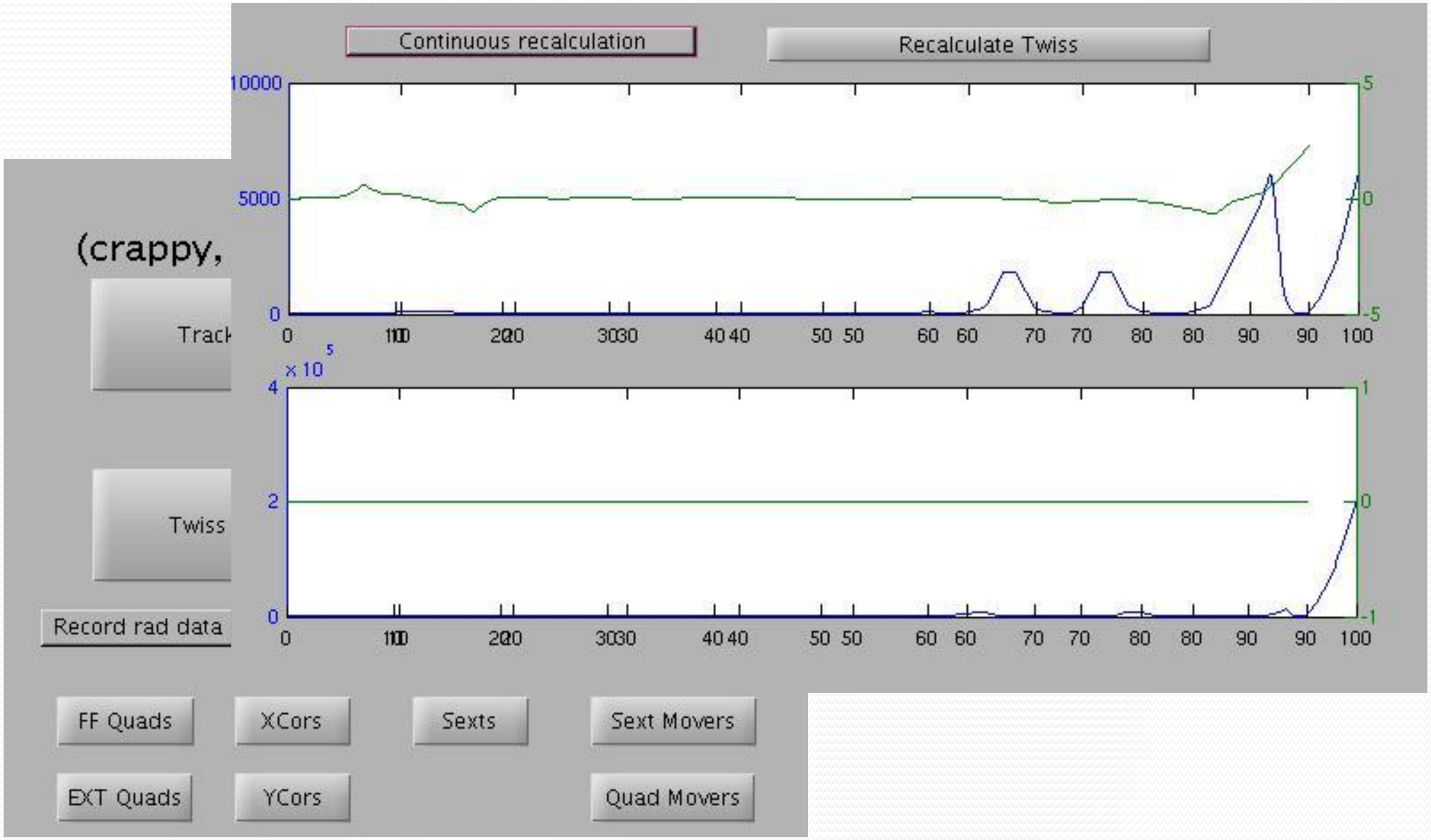




Track
Zero rad data
Main menu
Percentage of radiation limit used
Minutes since last reset
EXT

ATF2 Simulator GUI



ATF2 Simulator GUI