Summary of Status Towards Goal1 and Future Plans

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15th ATF2 Project Meeting, KEK

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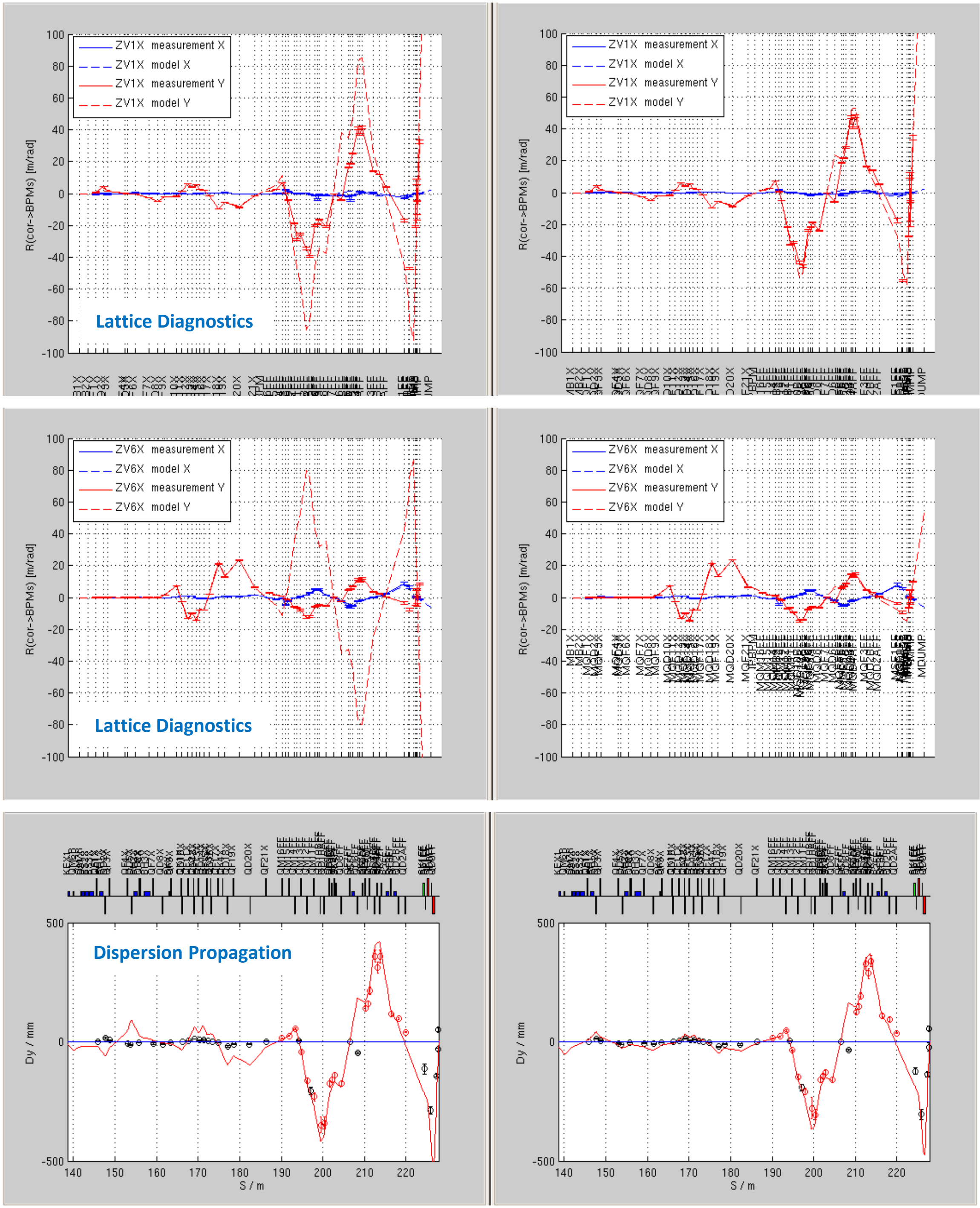
Overview

- ATF2 IP beam size tuning in context of simulations
- Draft prioritised work list moving forward based on discussions at project meeting
- Discussions



QD20X Strength Error?

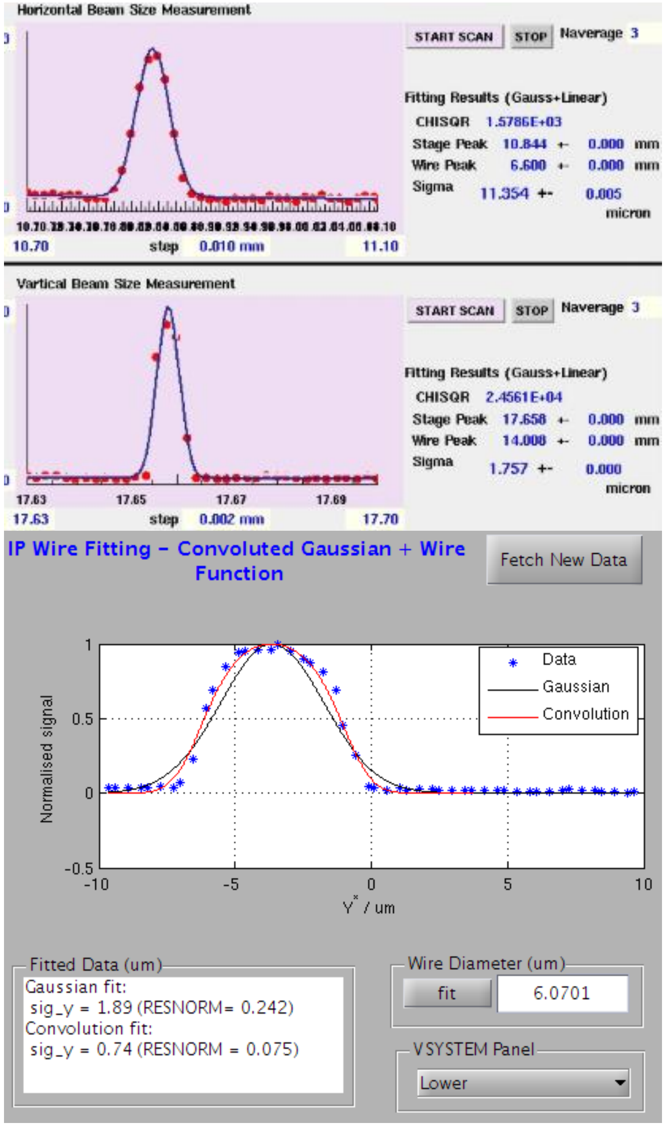
LHS-plots : QD20X ΔKL = 0

RHS-plots : QD20X ΔKL = -4.5%

Connecting ATF2 Tuning Performance to ILC BDS via Understanding of Simulations

- Expected ILC luminosity delivery is reliant on detailed MC simulations of entire BDS tuning process
- Implicit ATF2 goal is to validate these simulations, otherwise can have no confidence in ability for ILC to deliver expected luminosity
  - Taking best possible description of all error sources, does ATF2 tune in the way described by the majority of simulated seeds?
- The route we took to the observed beam size in Dec 2012 not very conducive to such studies, but have a preliminary look now anyway…
- Request for future tuning: make EPICS PVs linked to the multiknob GUI so these can be archived to make it easier to reconstruct all tuning knobs applied.

(1) Assess IP Beam Size Corrections

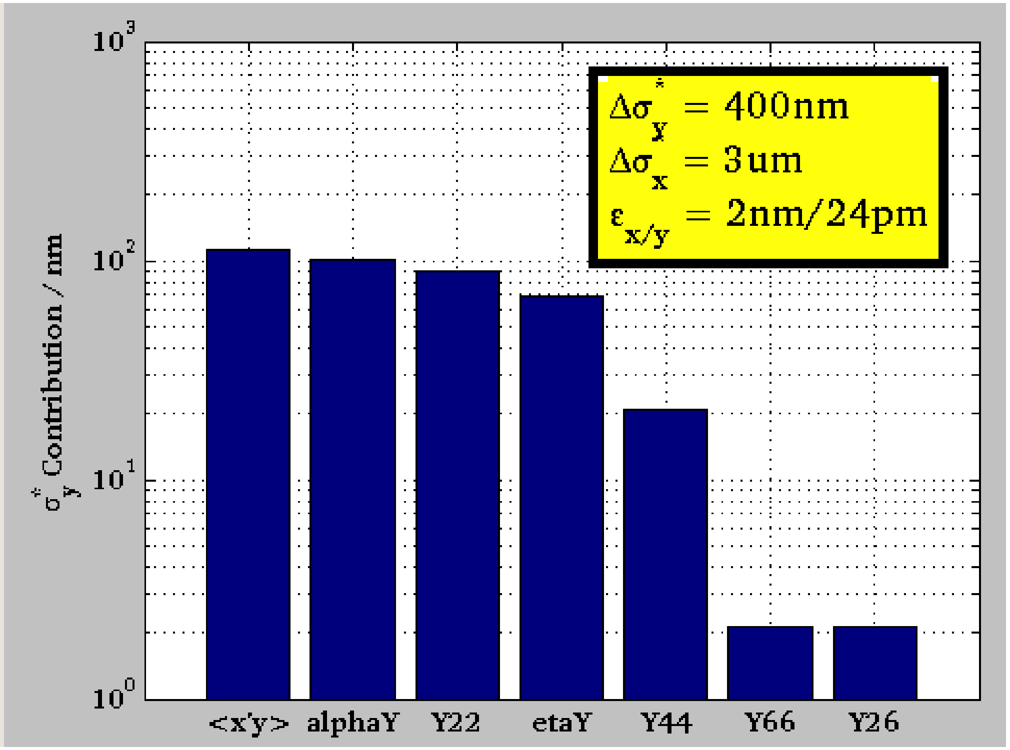


- Define tuning start as set12nov28_1000.dat
  - All initial beam tuning done, no sextupole scans yet
  - Record FFS sextupole positions
    - All zero except SF6FF: [-625, -625] um
- Starting beam size is 11.1 um (x), 750nm (y)
  - Y is using convolution fit (may be an under-estimate if wire diameter estimate not accurate)
- Define end point as set12dec21_1840.dat
  - Vertical beam size @ IP of 70nm
- Look at changes in sextupole positions and skew-sextupole strengths and orbit between two set points & model expected changes to beam size.
  - Get expected IP aberrations by tracking through Model with 1E5 macro particles and fitting 1st and 2nd order correlations at IP

Sextupole-based Tuning

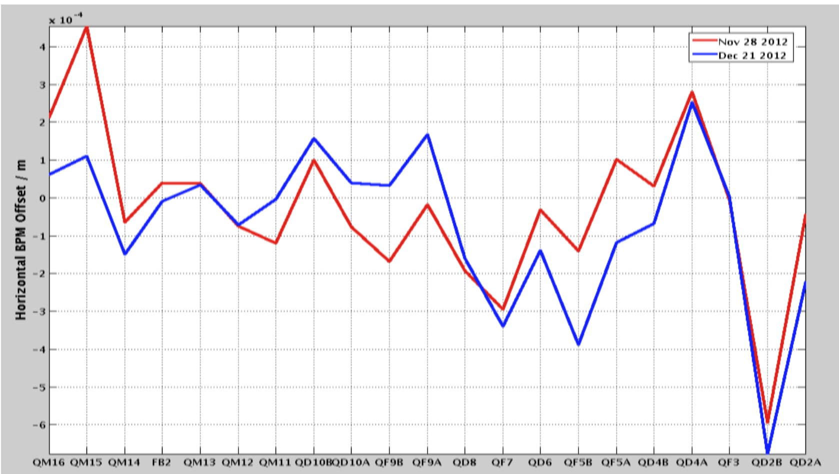
FFS Sextupole	Δx (um)	Δy (um)
SF6FF	-148	-1120
SF5FF	119	0
SD4FF	-29	354
SF1FF	86	37
SD0FF	39	127

Skew Sextupole	ΔI (A)
SK1FF	-0.27
SK2FF	-2.092
SK3FF	-5.956
SK4FF	-5.263

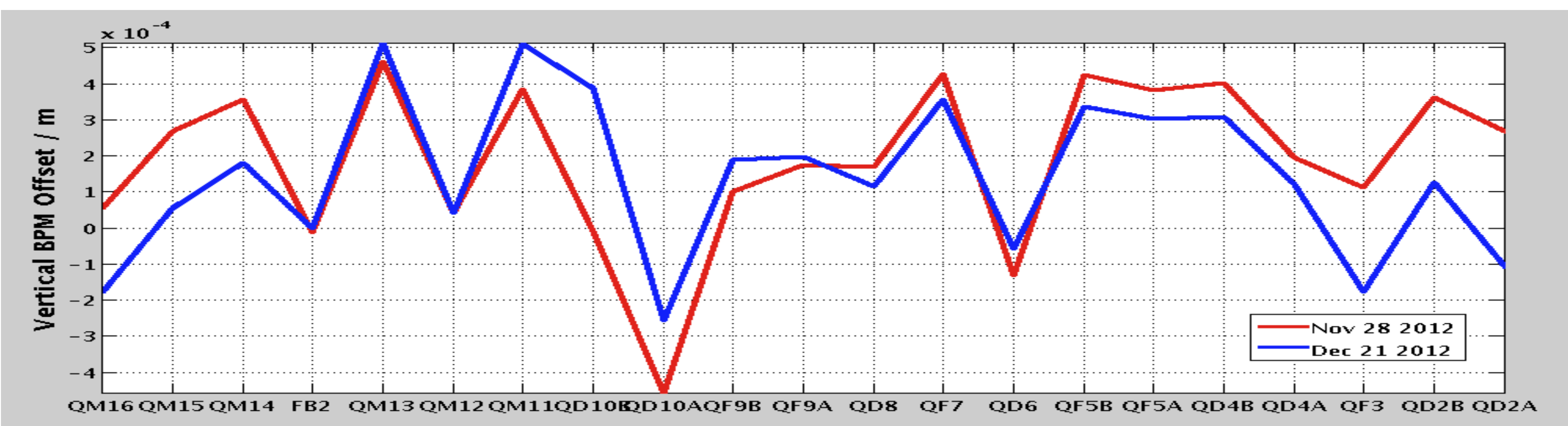


- Modeled response on beam size of tuning changes.
- Strong second order contribution (Y22) of ~90nm.

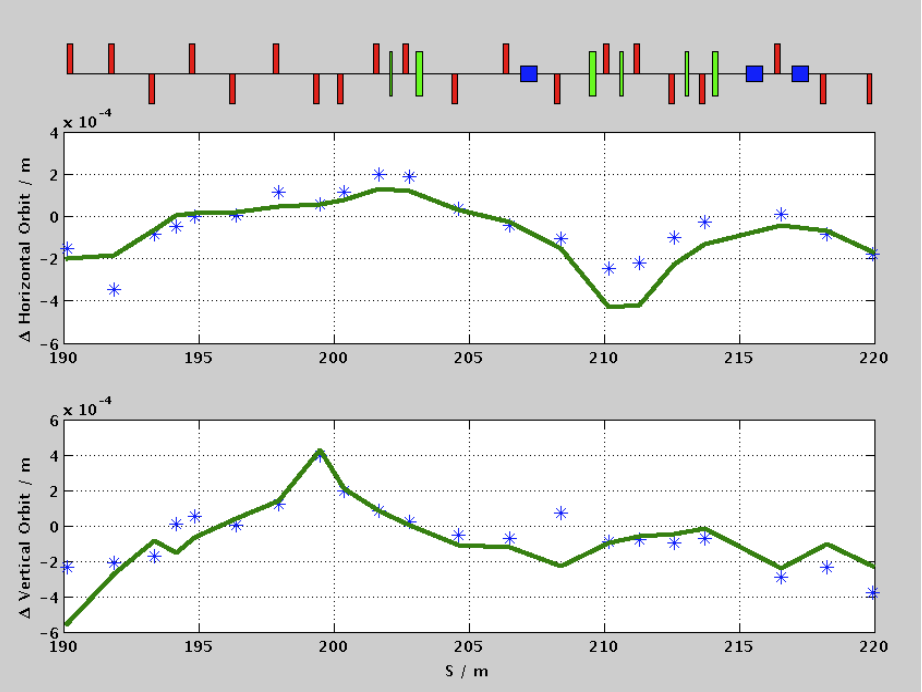
Orbit Changes

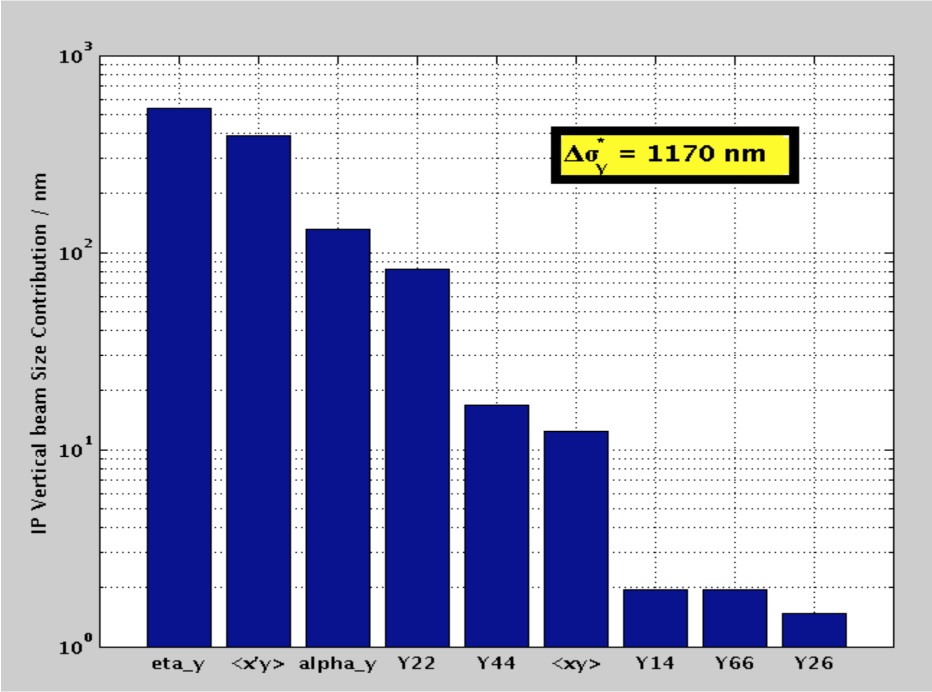


- Orbit averaged over stable few 100 pulses with charge cuts
  - Nov 28 & Dec 21



Fit Orbit Change to Include in Model

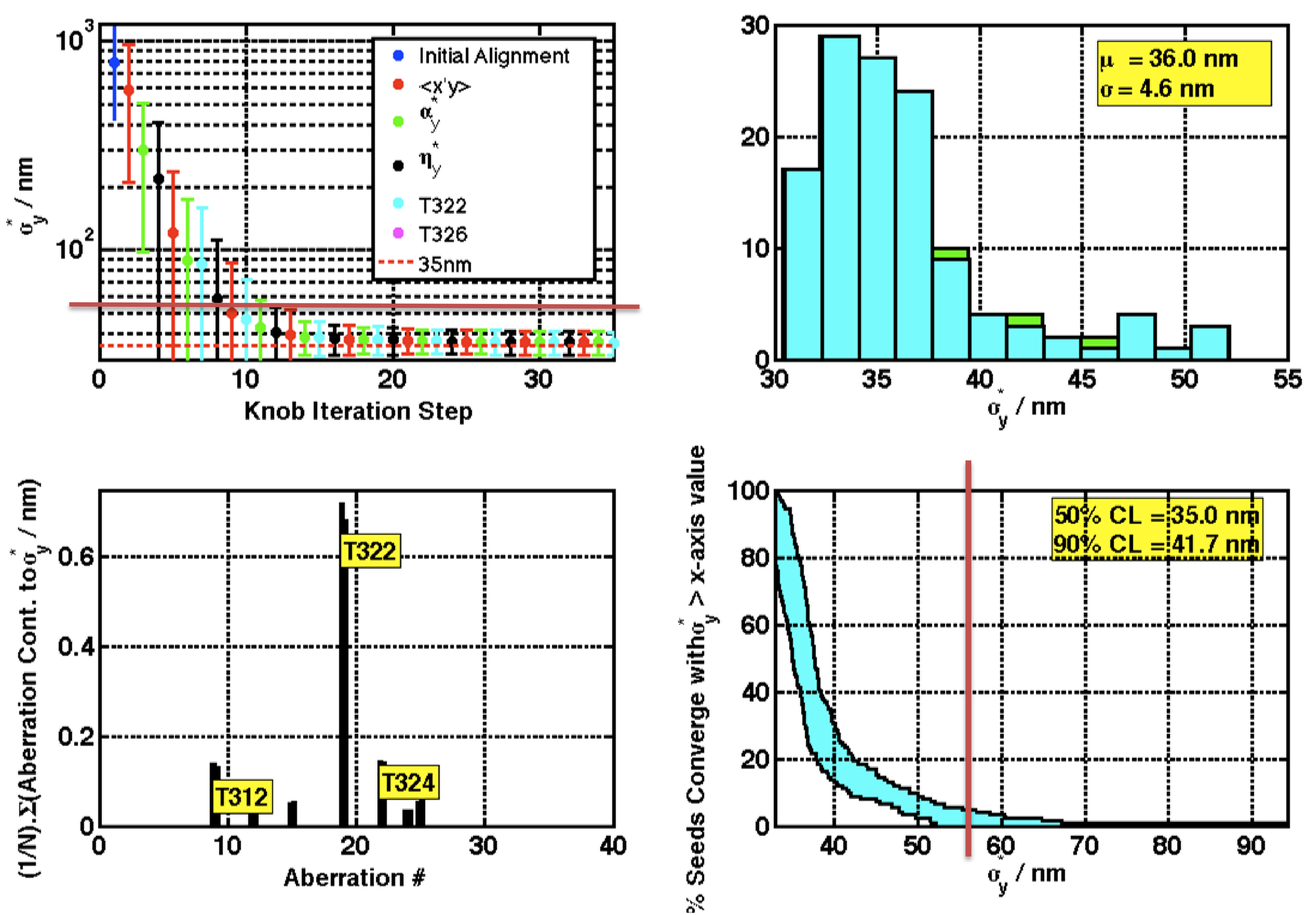




- Significant orbit drift across tuning period
- Include mover position changes in tracking model
- Absolute orbit for sextupoles important but complete BBA not performed this time.
- Also comparing across large change in charge operations
  - BPM data valid at lowest charge?

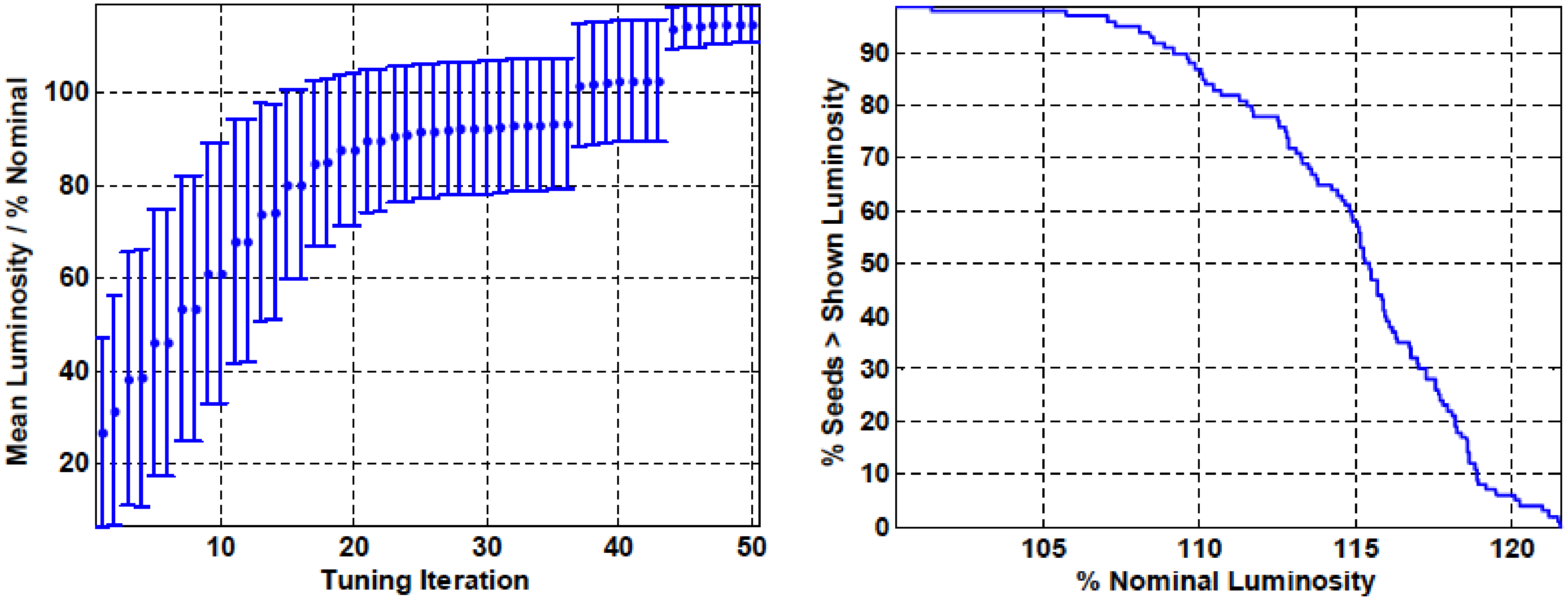
(2) Compare Results to Simulation

- Assume 70nm @ 25pm == 57nm @ 12pm
  - (i.e. have 20nm of uncorrected beam aberrations)
- Where are we on the expected simulated tuning curve?
  - Look at BX10BY1 tuning simulation
- At 57nm, second-order effects are important and we are entering the regime where multiple tuning scans are required to improve on beam size.
- Also difference between RMS and gaussian-core fitted beam size is important here.



Initial Alignment
<x'y>
α*y
η*y
T322
T326
35nm
σ*y / nm
Knob Iteration Step
μ = 36.0 nm
σ = 4.6 nm
σ*y / nm
T322
T312
T324
(1/N).Σ(Aberration Cont. to σ*y / nm)
Aberration #
50% CL = 35.0 nm
90% CL = 41.7 nm
% Seeds Converge with σ*y > x-axis value
σ*y / nm

ILC BDS (RDR)

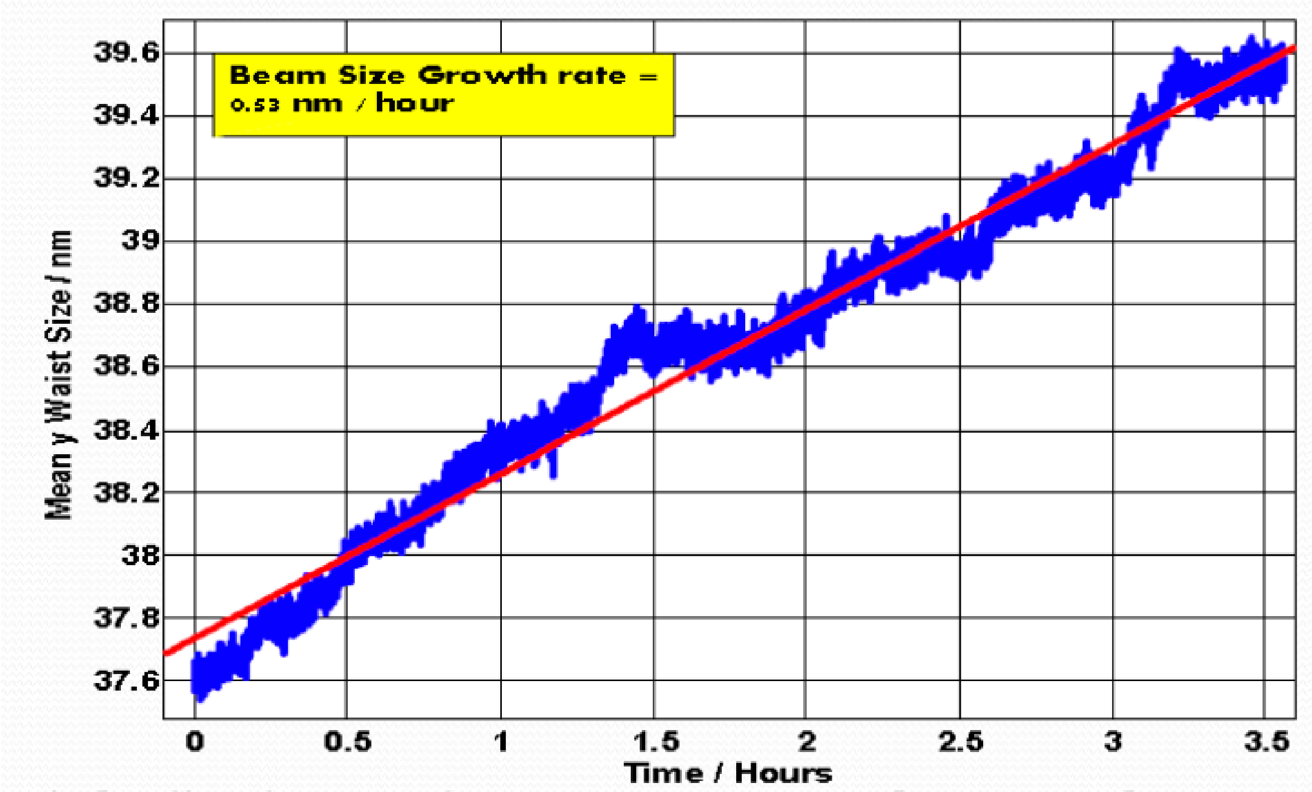


- Tuning time of ILC similar

Summary – LC Simulation Verification

- Ignoring orbit drift effects, model tuning changes account for 400nm of correction (750-350nm)
  - Rest due to wakefield improvements by dropping charge and lengthening bunch &| orbit changes…
- At ~25pm vertical emittance, expect min sigma_y=50nm
  - Remaining 20nm of beam size?
    - Still wakefield dominated? Improvements at even lower charge?
    - Other higher-order contributions due to shorted SD4 coil, SK magnet effects, rotated sextupole?
    - Full round of second-order knob tuning still to be done in 174-mode, maybe can improve on 20nm…
- Current data difficult to use for LC simulation verification
  - Long time period over which tuning takes place (many tuning scans)
  - Large FFS orbit drifts
- Dedicated tuning data for LC simulation verification required.
  - After confirmation of <70nm, go back and attempt to tune down from "initial conditions" using optimal number of tuning steps.

Ground Motion



- Reminder- when get close to goal, beam size drift as function of time due to measured ground motion should become noticeable
  - 0.5nm / hour

Main Priorities

GOING FORWARD TO GOAL 1

Confirm min beam size in 174-degree mode after hardware changes and full round of tuning knobs

Assessment of remaining aberrations:

- Wakefields?
  - Fine-grained charge vs. beam size scans (~0.2E9 steps) to see if reached min or still on downward slope using charge cuts on IPBSM software
  - Go lower than 1E9?
- Non-correctable higher-order aberrations due to un-modeled multipole fields?
  - Try different IP beta_x optics
- Break-down of multiknob orthogonality?
  - Try for better initial conditions to limit sum of sextupole moves
  - Longer-timescale tuning, many iterations of all knobs
  - Alter tuning procedure
    - Automated simplex or dither-style tuning
- <xy> phase coupling
  - alpha_x vs. sigma_y scans (also vs. <x’y> 2-d scans) in 174-mode to determine possibility
  - Try different beta_x optics (consider BX1BY1)
  - <xy> knob using EXT skew-quads & good orbit control in FFS
  - Try to minimise sigma_x after sigma_y tuning with disp_x / alpha_x knobs

Improve Understanding of Wakefield Sources & Try Mitigation Techniques

- Repeat orbit and beam size measurements at highest possible extracted charge (>=1e10)
- "Wakefield steering"
  - Improvements to FFS steering software to steer preferentially in high-beta regions and to BPM centres
  - Study steering software, try and get best possible optics modeling etc to aim for ~<50um orbit
- Physical re-alignment of magnets
- Dipole cavities instead of REF on mover
- Think about any possible charge or background dependent systematic effects for IPBSM processing software
- Study expected impact of IPBPM wakes
- Hardware changes:
  - Remove CAV dipoles in high-beta regions
  - Reduction in beampipe radius changes
  - Shield bellows

Understanding and Correction of Extracted Emittance Growth from DR

- Some specific suspects from December ops
  - Woodley: BS3X skew-sextupole field
  - Okugi: large roll of KEX1
- Analysis from Edu
  - Try to fit a unique set of offsets/rolls to KEX1,BS1X,BS2X,BS3X that explains all Dec measurements
  - If analysis looks promising, try suggested mechanical re-alignment
- Further study of different extracted orbits to find coupling-free extraction
  - 2010 perfect extracted emittance == no coupling
- Bumps etc hard to do around extraction
  - Try mechanical iterative roll/offset alignment changes of devices checking extracted emittance after each change
- High-order multipole fields responsible for increased vertical emittance by coupling changing horizontal beam size?
  - Look for non-linear kicks in jitter/orbit bump tests
  - Simulate and see if required fields would be noticeable in OTR images

Resign to Continuing Ops @ Low Charge

- Setup of systems to make beam operations easier at these charges
  - e.g. ICT readout scaling, BPM calibration & setup for 1E9
- Or setup at high charge, then drop
  - Disruptive when linac drifts and have to repeat
- Results valid at low charge?
  - Also lower energy spread
  - To get same expected chromatic beam size growth, lower IP beta_y? (factor 2)
    - Makes tuning more difficult (requires finer cancelation of geometric aberrations of increased chromaticity correction)
    - Already lower W than new ILC parameters, maybe good idea anyway?
    - Ultra-low beta study has shown QD0 multipoles to be a problem when try to lower beta_y below 0.1mm
  - Need high charge for Goal 2

“Those to whom everything is clear are unhappy people.”

- *Louis Pasteur*