(ILC Sefuri)

ECFA LC2013, DESY

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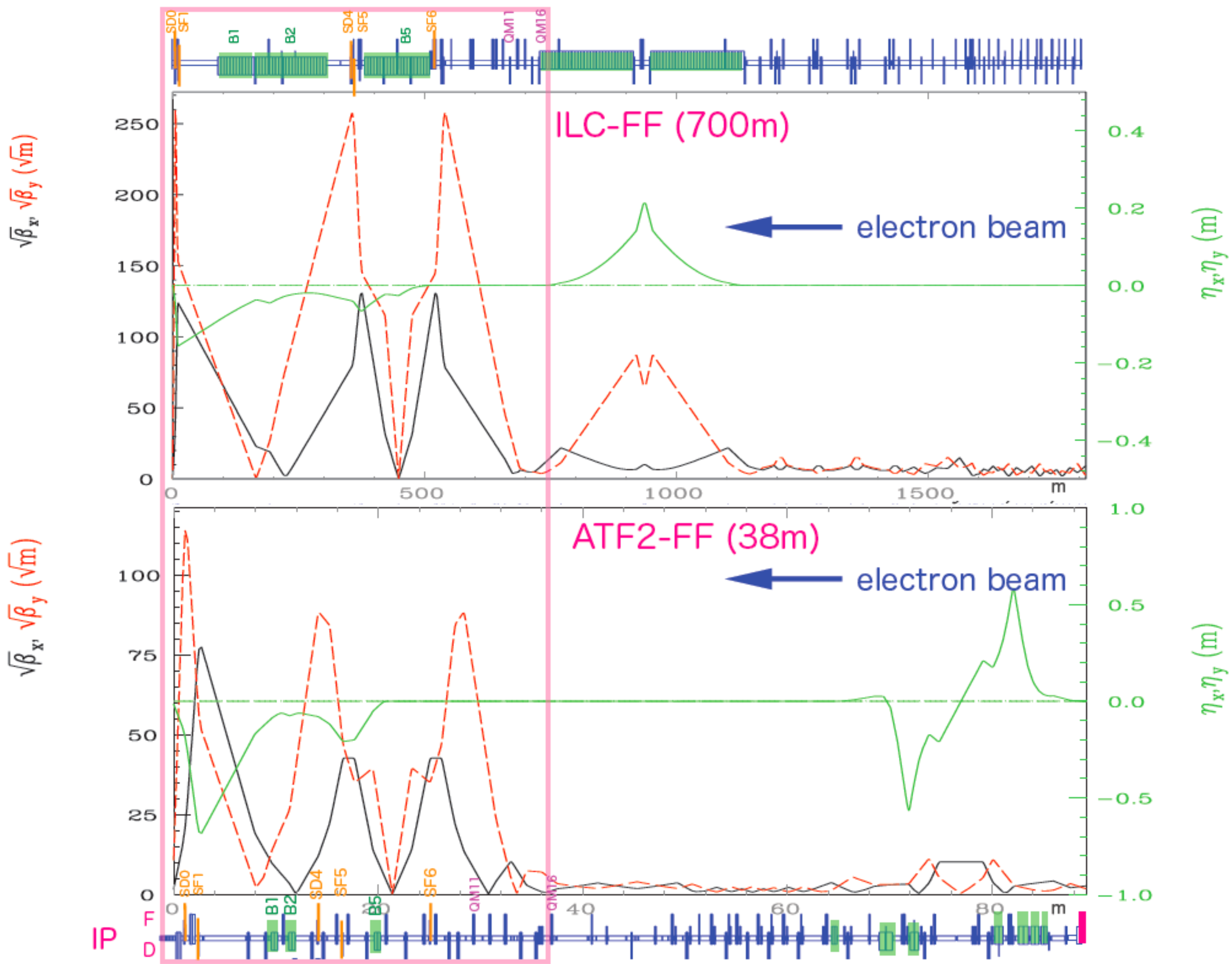
Overview

- **ATF2 FFS now reliably generating IP spot sizes within factor 2 design (<70nm)**
  - Time to start considering comparisons of ATF2 experience with expectations from LC and ATF2 tuning simulations.
- **Design and simulation of tuning simulations, expected results.**
- **The reality at ATF2.**
  - What can be learned?

Scale Test of ILC FFS Optics



- **Scaled design of ILC local-chromaticity correction style optics.**
- **Same chromaticity as ILC optics.**
- **At lower beam energy, this corresponds to goal ~37nm IP vertical beam waist.**

Why Test?

- **Complicated "balancing of higher-order terms" in FFS design leads to very tight tolerances**
  - Try to model effects where realistic error conditions destroy properties of FFS
  - Overcome these weaknesses by designing "tuning knobs" and simulate their effectiveness
  - ATF2 can validate this procedure by comparisons of accelerator tuning with expected results from simulations
- **Once tuned, dynamics effects cause drifts on multiple timescales of IP beam size and position**
  - Model all expected sources of dynamic drift and design countermeasures
  - Test in detailed simulations
  - ATF2 experience and implementation of dynamic drift countermeasures will validate simulations
- **By validating simulations of magnitude, effect and mitigation of 'static' and 'dynamic' imperfections we will gain confidence in our ability to design and run similarly designed optics for future high-energy machines**

Designing & Simulating FFS Tuning Procedure

- **Specify full list of error sources**
  - Use measurement data where available
- **Generate multiple lattices with different error configurations from error list**
  - MC simulations performed across, typically, 100 lattices
- **Simulate initial steering/BBA/EXT coupling/EXT dispersion correction etc for each lattice seed**
- **Make a tuning knob to correct most common aberration from 100 seeds**
- **Apply this same knob to all 100 seeds**
- **Repeat last 2 steps until beam size converges**

> - Simulations performed by multiple people using multiple simulation tools
>   - e.g. Lucretia, MAD, MADX, MAPCLASS, SAD, PLACET
> - Critical to avoid systematic errors creeping into simulations and for cross-checking. Very easy to make mistakes.

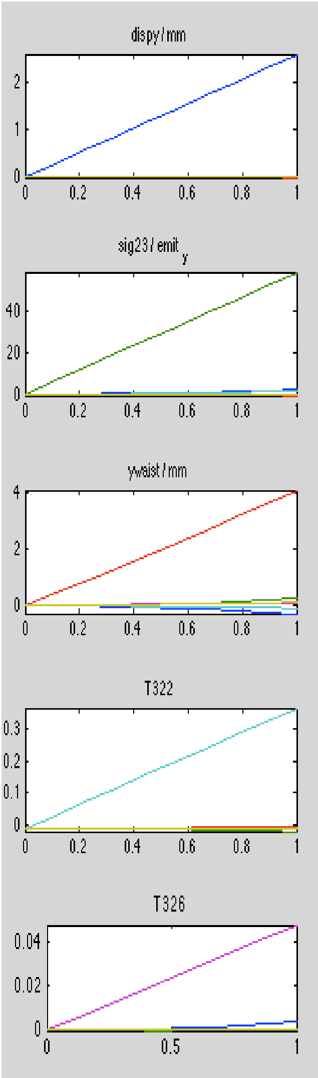
Aberrations @ IP (ATF2)

- **Aberrations generated by lattice imperfections that need to be dynamically tuned are (in order of importance determined by simulation):**
  - <x’y> coupling
  - Vertical waist offset
  - Vertical dispersion
  - Y22
  - Y26
  - Y46

These 2^{nd} order terms also found to be important during ATF2 tuning experience

- **In simulation, tuning of all aberrations by combinations of X/Y sextupole moves**
- **4 skew-sextupoles added in 2012 in ATF2**
  - Motivated by suspected larger than expected multipole components in some magnets.
  - Useful additional tool for orthogonal 2^{nd}-order knobs, gives greater dynamic range to 1^{st}-order knobs by sextupole moves
  - Worth considering for ILC…

ATF2 Tuning Knobs



Vertical Disperson

<x'y> coupling

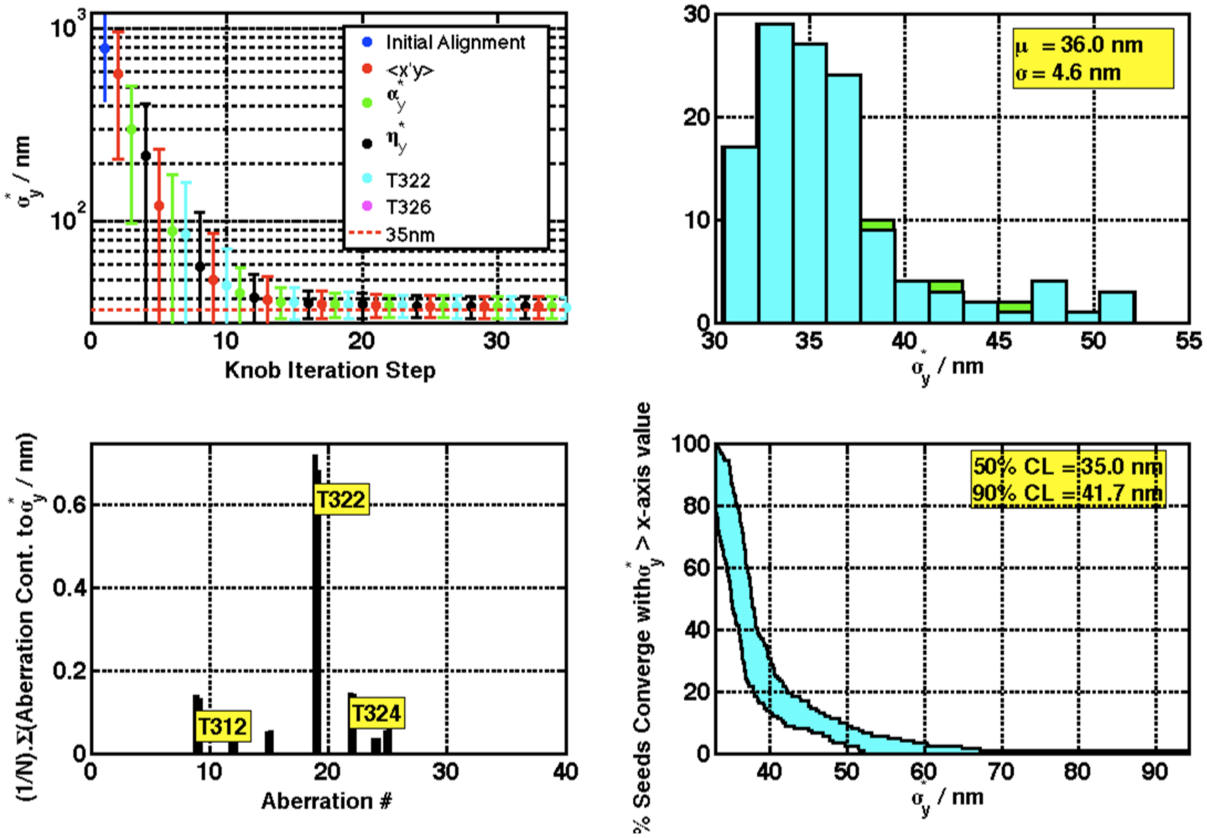
Vertical Waist

T322

T326

- **Orthogonal knobs as shown developed using simulation framework**
  - Also orthogonalise knobs to reduce horizontal dispersion and waist degradation
- **Range of applicability of a given knob given by**
  - Degree of contamination to other aberrations
  - Range of mover system
  - Degradation of orthogonality by lattice/alignment errors
- **The range of aberration correction capability provides the true "dynamic" tolerances of a given lattice design**

ATF2 Tuning Simulation



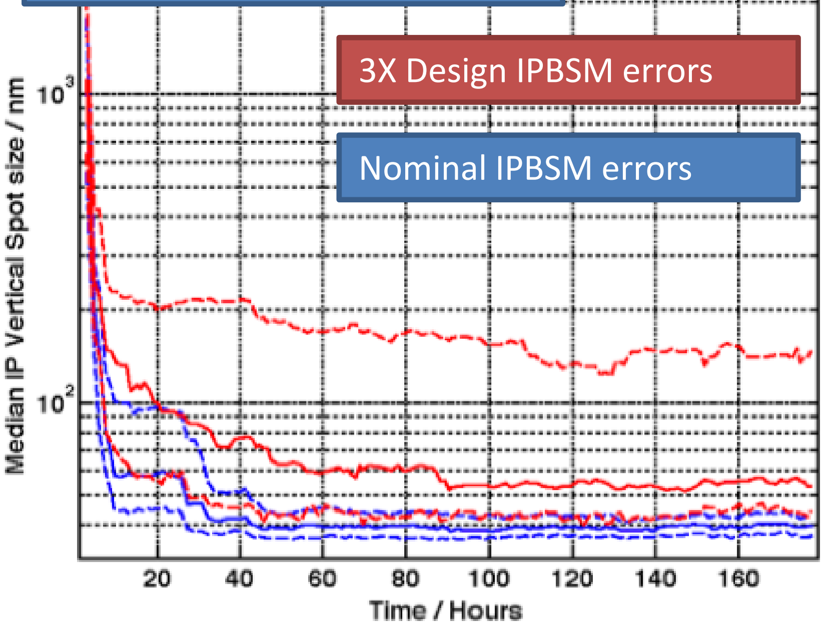
- Simulated tuning performance for a specific lattice design
- Lattice/tuning designs and simulations performed using different platforms by different groups for cross-checking
  - Lucretia, SAD, MADX (MAPCLASS), Placet

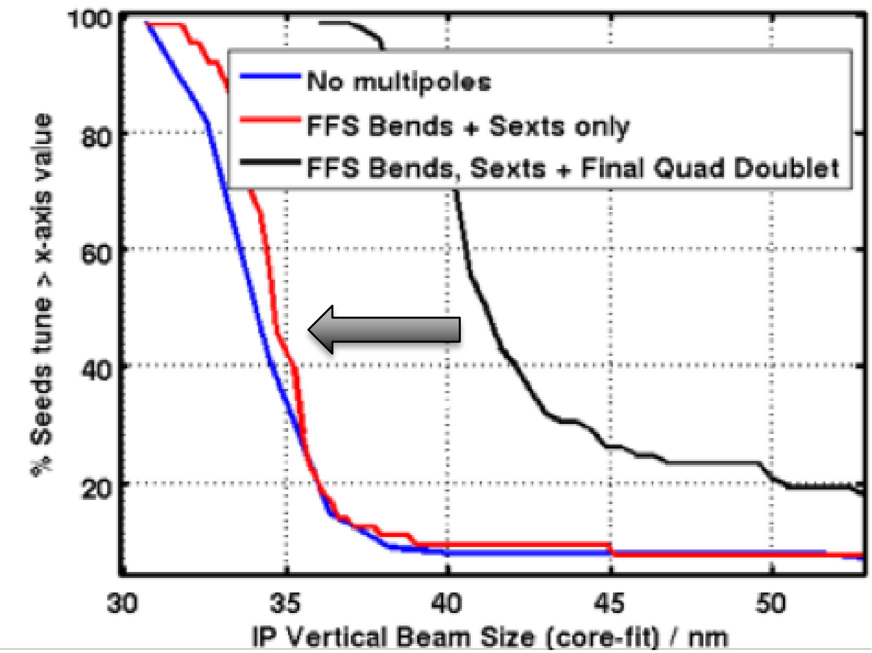
Simulated Long-Timescale Tuning at ATF2

Median, 10% and 90% CL vertical beam sizes at IP shown from 100-seed simulation

3X Design IPBSM errors

Nominal IPBSM errors



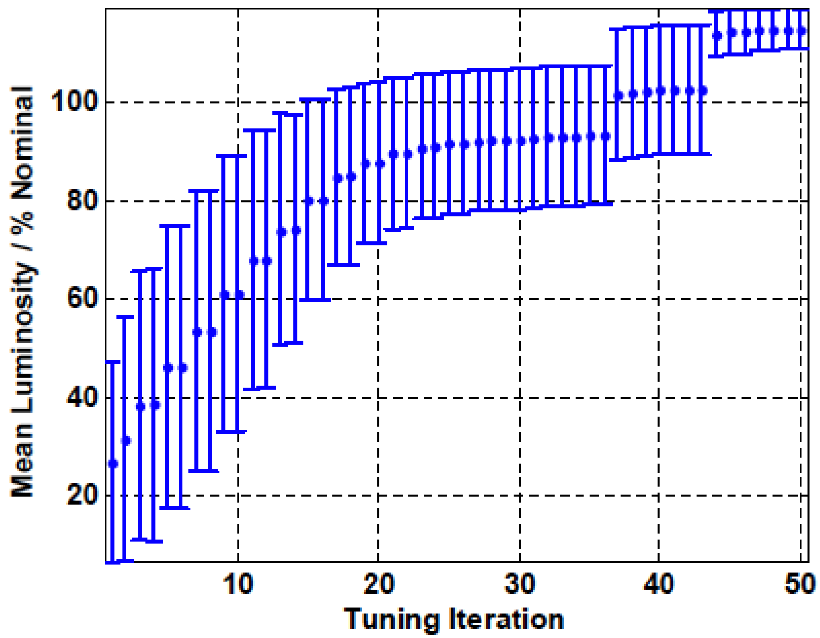


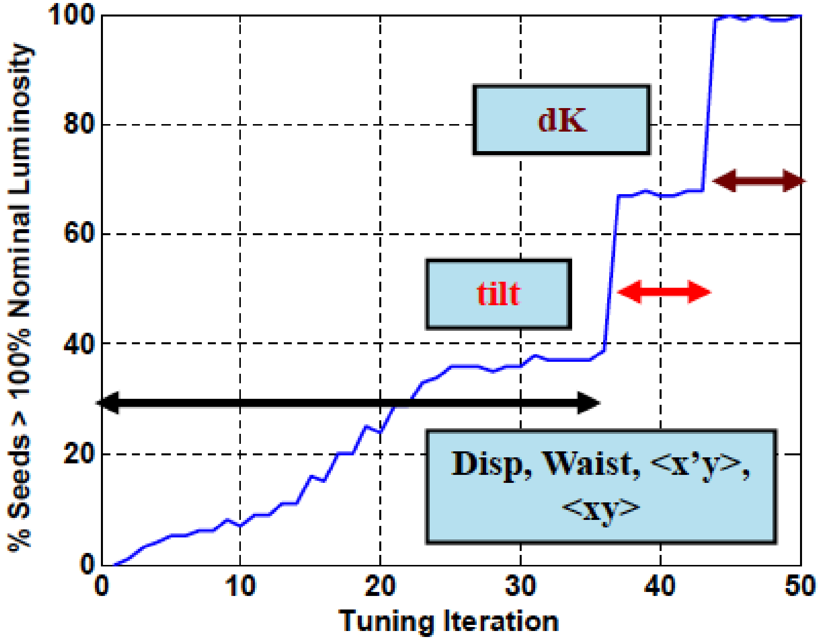
	20 mrad	10 mrad	1 mrad	< 100urad
σ_y (50% CL)	137 nm	90.0 nm	38.3 nm	34.8 nm
σ_y (90% CL)	190 nm	73.4 nm	47.6 nm	41.8 nm

- Tuning results with IPBSM rotation (including <xy> knob)

- **Tuning performance over long timescale, including dynamic effects.**
- **RHS: best observed beam spot per seed over LHS time period.**
- **Results dependent on IPBSM performance**

ILC BDS Tuning Simulation

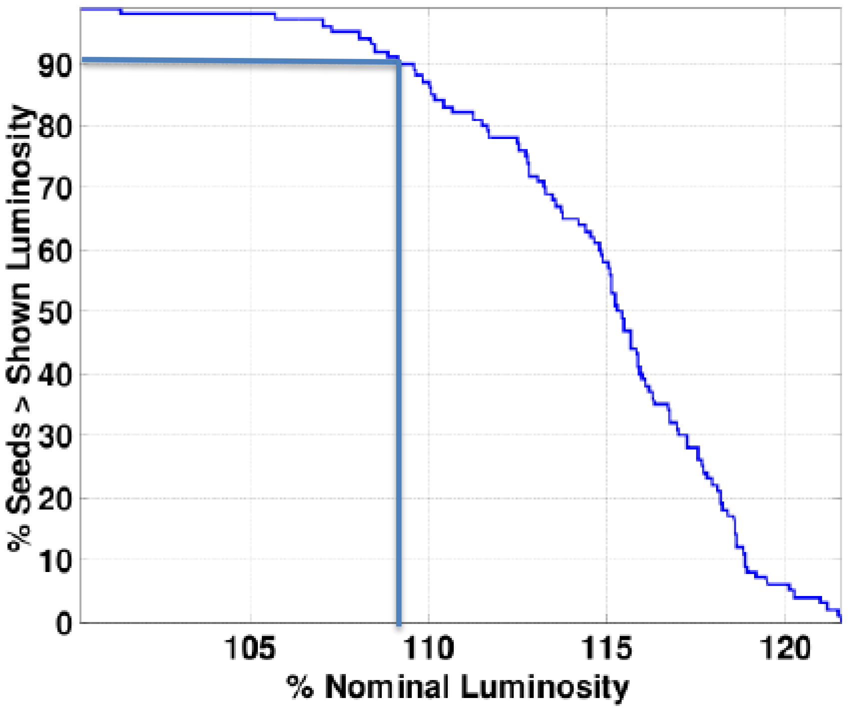




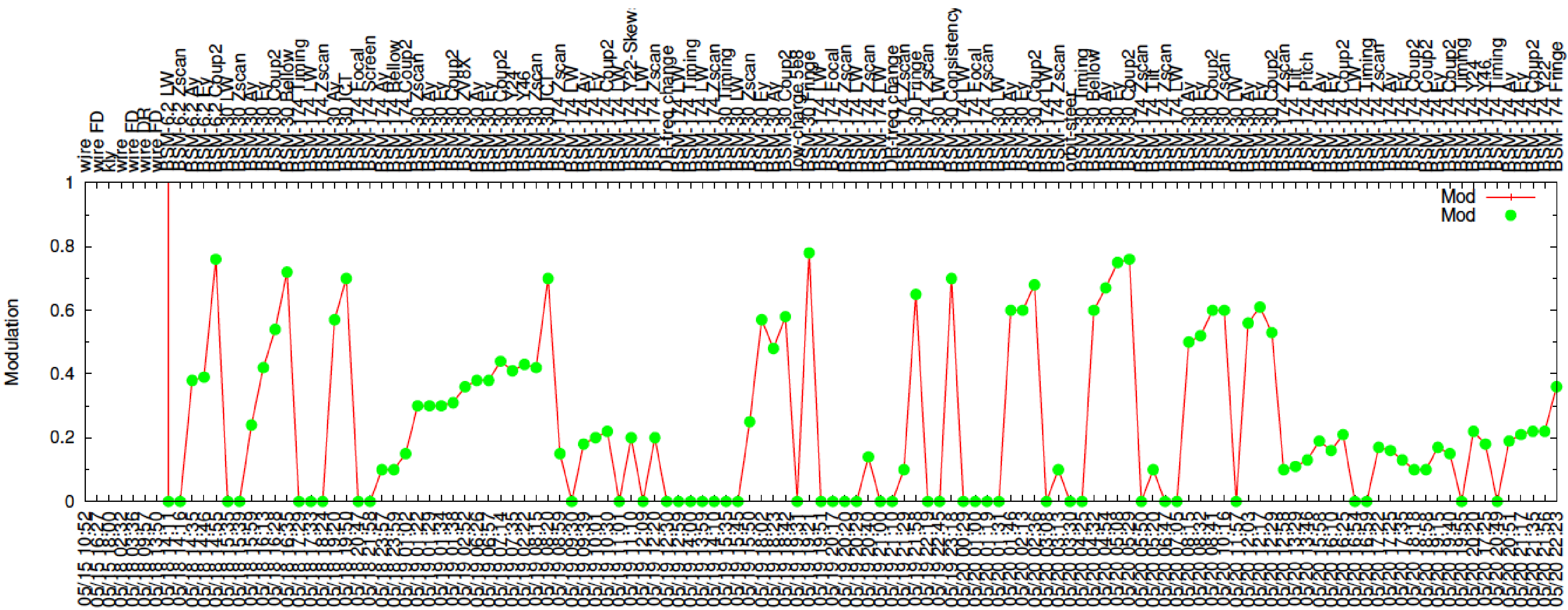
- **Tuning simulation similar to ATF2**
  - No specific 2nd-order knobs tried here though, could lead to improvements.
  - Includes dynamic effects (of slow-drift type corrections, not fast-feedback)

Demonstrating ILC Luminosity Performance with Simulations

- **ILC RDR parameters**
- **Tuning procedure for BDS followed including consideration of dyamic effects due to ground motion + component jitter.**
  - Include pulse-pulse feedback (cascaded linac + BDS)
  - Include 6nm BDS emittance overhead
- **Need to add luminosity loss due inter-pulse dynamics including mitigation by intra-pulse feedback (2 loops in BDS at IP angle and position phases)**
  - Worst-case (K-model GM, and TESLA-era linac HOM's) + 8% lumi loss.
- **Expect ~90% seeds to provide nominal luminosity**



The Reality… May 2 week Cont. Run

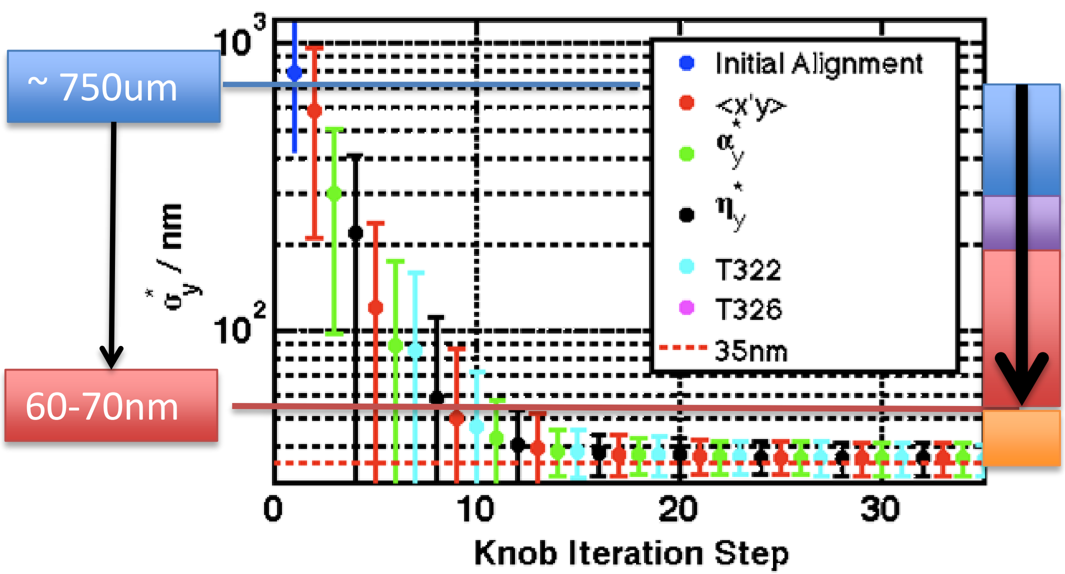


- **Summary of all scans during 2 week ops period**
  - *Summary plot courtesy of Edu.*

Dec 2012 Results

SIMULATION

Estimated Tuning Effects



Not required 2013
(bad sext coil or mag. material in skew-sext ??)

linear knobs ~400nm

~~**non-linear knobs ~100nm**~~

wakefield + steering effects ~150nm

remaining 25-35nm to reach min beam size for measured emittance and IP beta

- **Compare with ~600nm expected beam size without chromatic correction system.**

ATF2 Practice – Deviation from Simulation Plans

- **"Coarse" initial tune-up**
  - FD rotation, waist find with FD, matching, initial dispersion correction
- **<xy> @ IP ?**
  - *(IPBSM tuning)*
  - ILC? (rotational alignment of e- and e+ sides?)
- **Skew-sextupoles**
  - Consider additional high-order devices added to ILC BDS?
- **Wake tuning devices**
  - Cavity and bellows on movers
  - Include such as contingency for ILC?

Other Lessons Learned to Apply to ILC?

- Post-IP emittance measurement?
- FFS IP image point?
  - Split QF7
- More IP-phase access in FFS
- Tune-up IP
  - Dedicated “3rd” IP similar to ATF2 IP installation
- Really need cavity BPMs in FFS high-beta regions?