May 2010 Continuous Run Operation

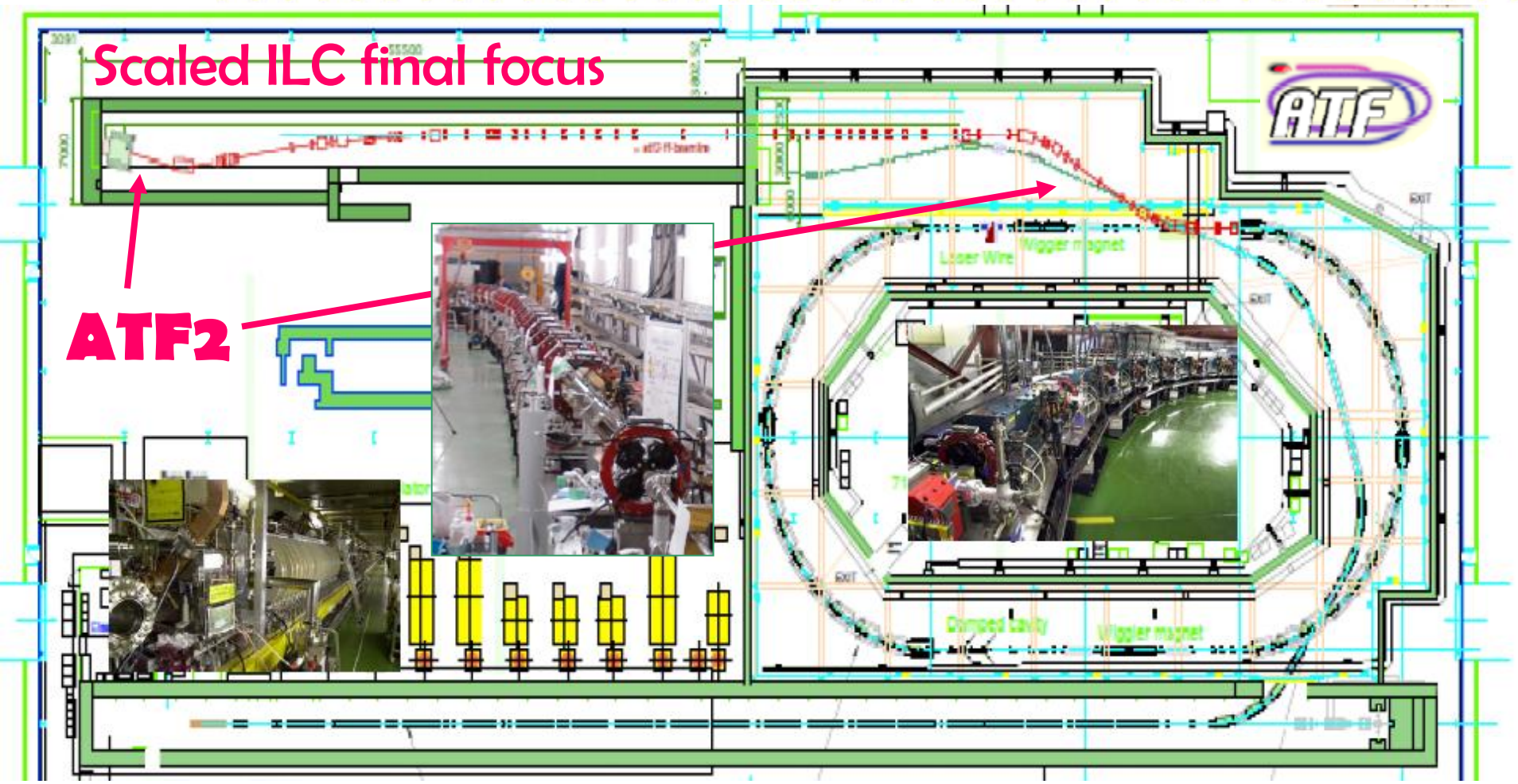
June 30, 2010

10th ATF2 Project Meeting

Andrei Seryi for the ATF2 team

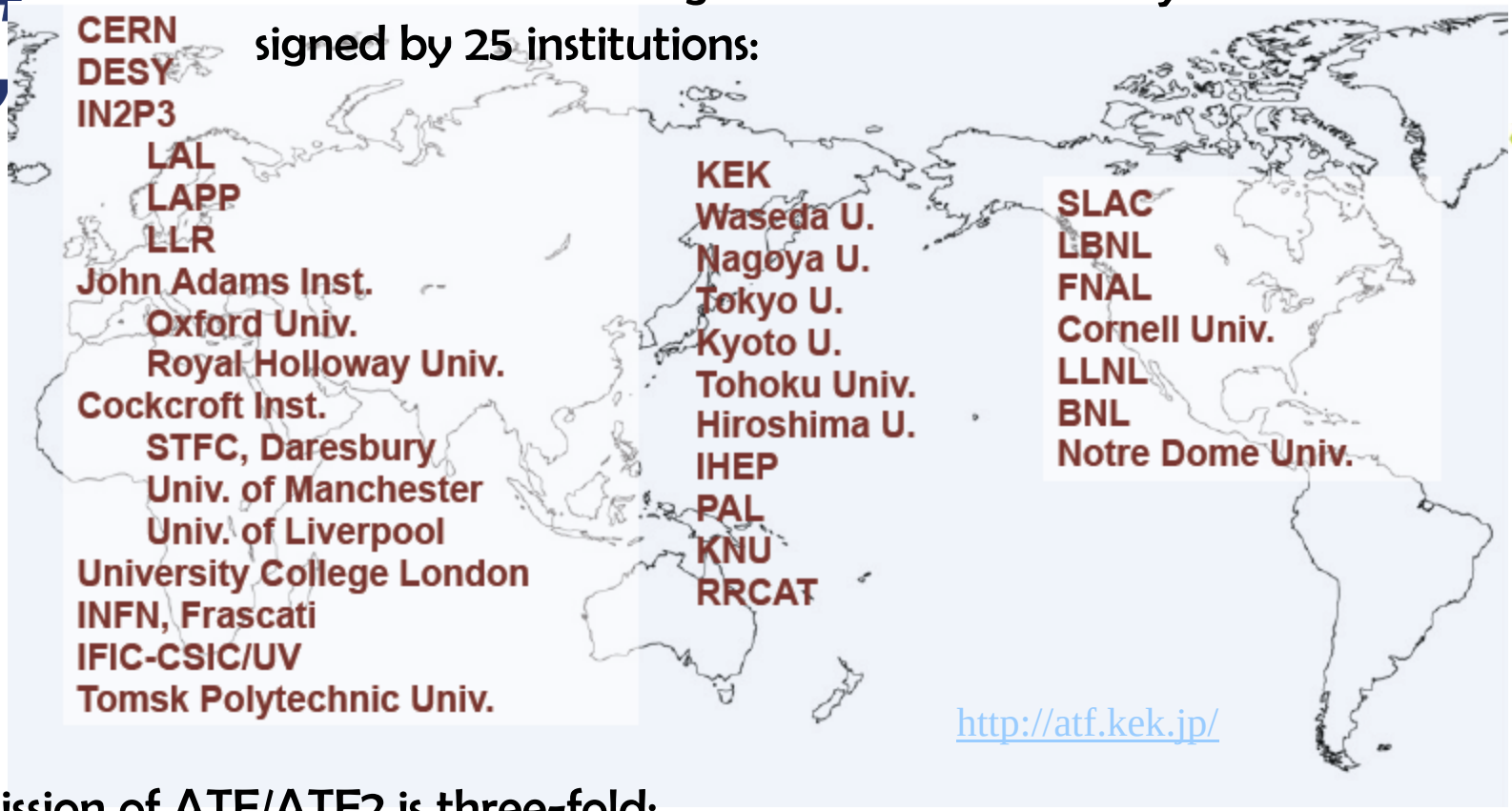
ATF2: model of ILC beam delivery

goals: ~37nm beam size; nm level beam stability



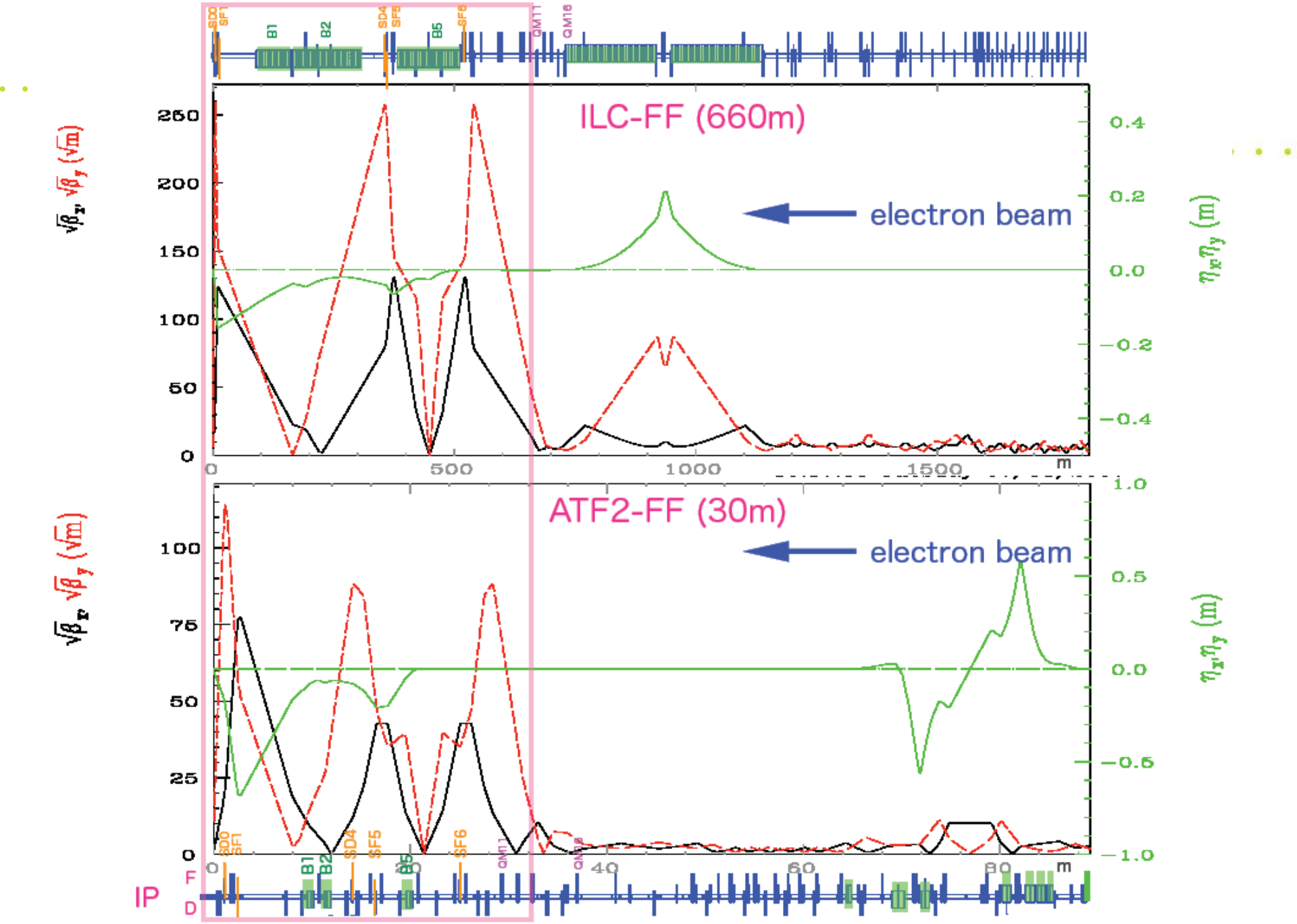
- Dec 2008: first pilot run; Jan 2009: hardware commissioning
- Feb-Apr 2009: large β; BSM laser wire mode; tuning tools commissioning
- Oct-Dec 2009: commission interferometer mode of BSM & other hardware

ATF International organization is defined by MOU signed by 25 institutions:



MOU: Mission of ATF/ATF2 is three-fold:

- ATF, to establish the technologies associated with producing the electron beams with the quality required for ILC and provide such beams to ATF2 in a stable and reliable manner.
- ATF2, to use the beams extracted from ATF at a test final focus beamline which is similar to what is envisaged at ILC. The goal is to demonstrate the beam focusing technologies that are consistent with ILC requirements. For this purpose, ATF2 aims to focus the beam down to a few tens of nm (rms) with a beam centroid stability within a few nm for a prolonged period of time.
- Both the ATF and ATF2, to serve the mission of providing the young scientists and engineers with training opportunities of participating in R&D programs for advanced accelerator technologies.


ILC-FF (660m)
electron beam
ATF2-FF (30m)
electron beam
IP
F
D
m

ATF2 parameters & Goals A/B

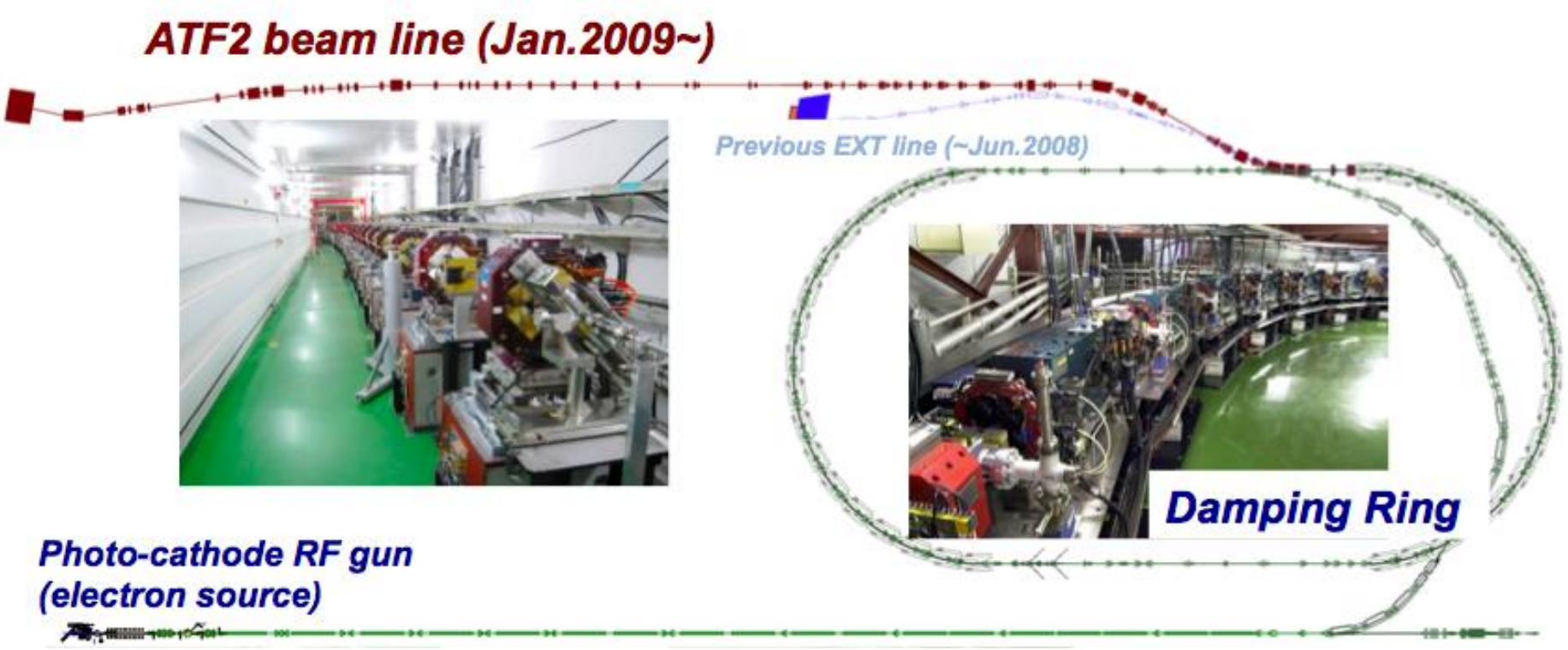
ATF2 proposed IP parameters compared with ILC

Parameters	ATF2	ILC
Beam Energy [GeV]	1.3	250
L* [m]	1	3.5 – 4.2
$\gamma\,\epsilon_x$ [m-rad]	3×10^{-6}	1×10^{-5}
$\gamma\,\epsilon_y$ [m-rad]	3×10^{-8}	4×10^{-8}
β_x^* [mm]	4.0	21
β_y^* [mm]	0.1	0.4
η' (DDX) [rad]	0.14	0.094
σ_E [%]	~0.1	~0.1
Chromaticity W_y	$\sim 10^4$	$\sim 10^4$

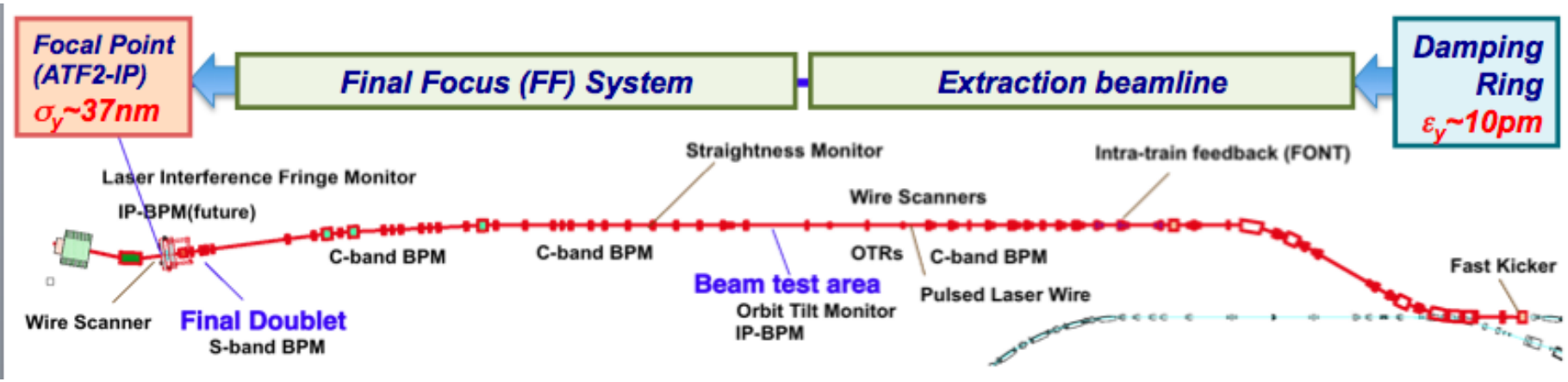
- Scaled design of ILC local-chromaticity correction style optics.
- Same chromaticity as ILC optics.

- ATF2 goal for beam size is ~37nm
- ATF2 goal of 37nm, scaled to 250 GeV, would correspond to 2.7nm (~twice smaller than ILC design value of 5.7nm)
- The intermediate "ILC-scaled" milestone of ATF2 is ~80nm

ATF2 Facility Layout



ATF2 Facility Layout

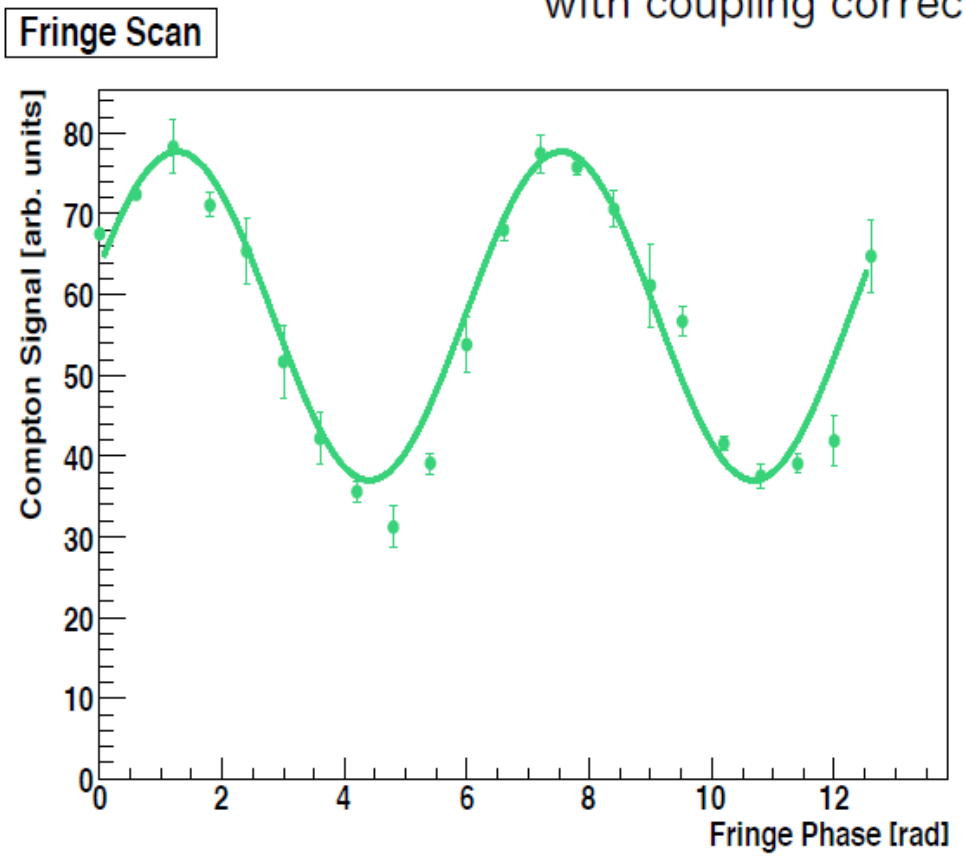


Final Focus System (FFS)
- Scale test of ILC FFS optics

Extraction Line (EXT)
- Extract beam from DR
- Correct for coupling and dispersion errors
- Correctly match beam into final focus system.

Fringe Scan Results (2 degree mode)

with coupling correction at PIP by QK1-4X (rough)

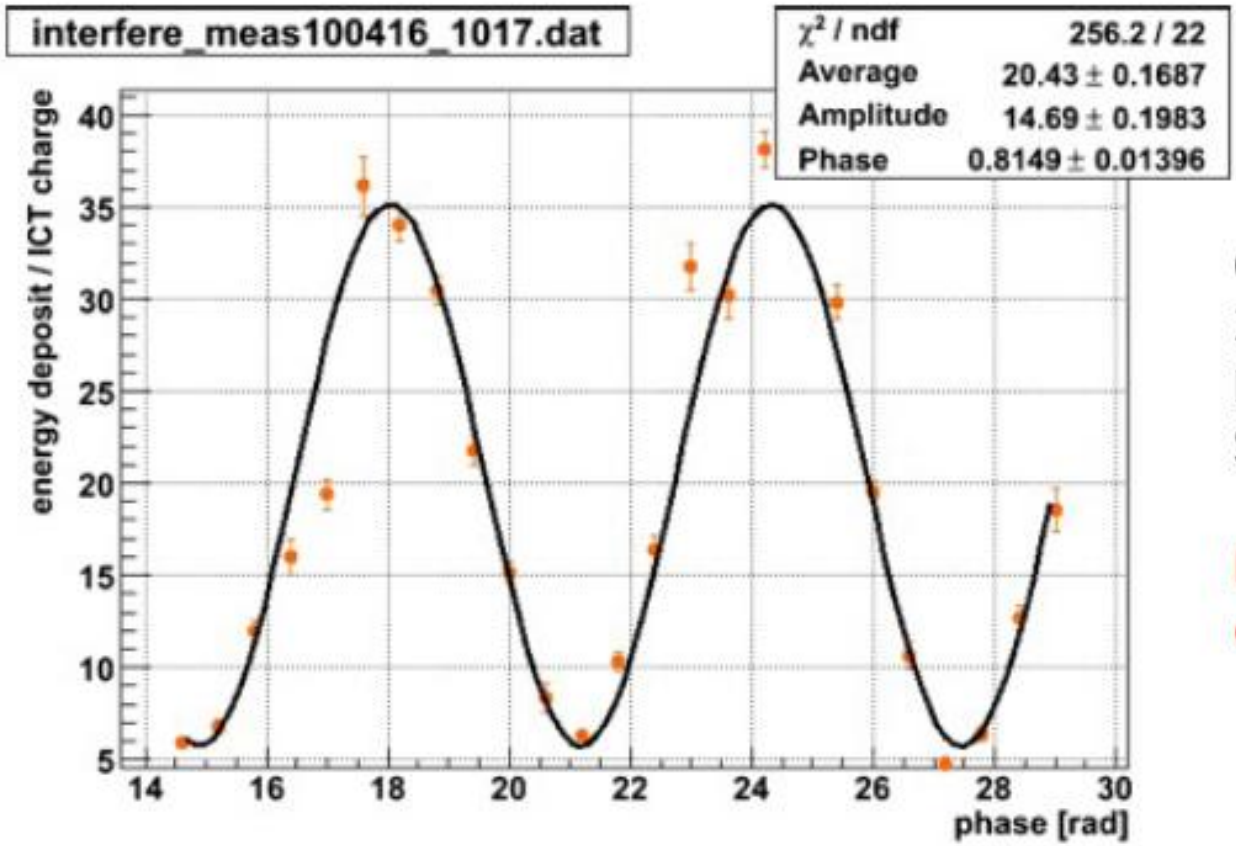


Crossing angle : 2.29 [deg]
Average of 4 bunches/point
Scan range 13.2[rad]
with a step of 600mrad

Fringe Pitch 13.3 um

Modulation = 0.35±0.01
σy = 3.1± 0.03 um
QD0 current at 129 A

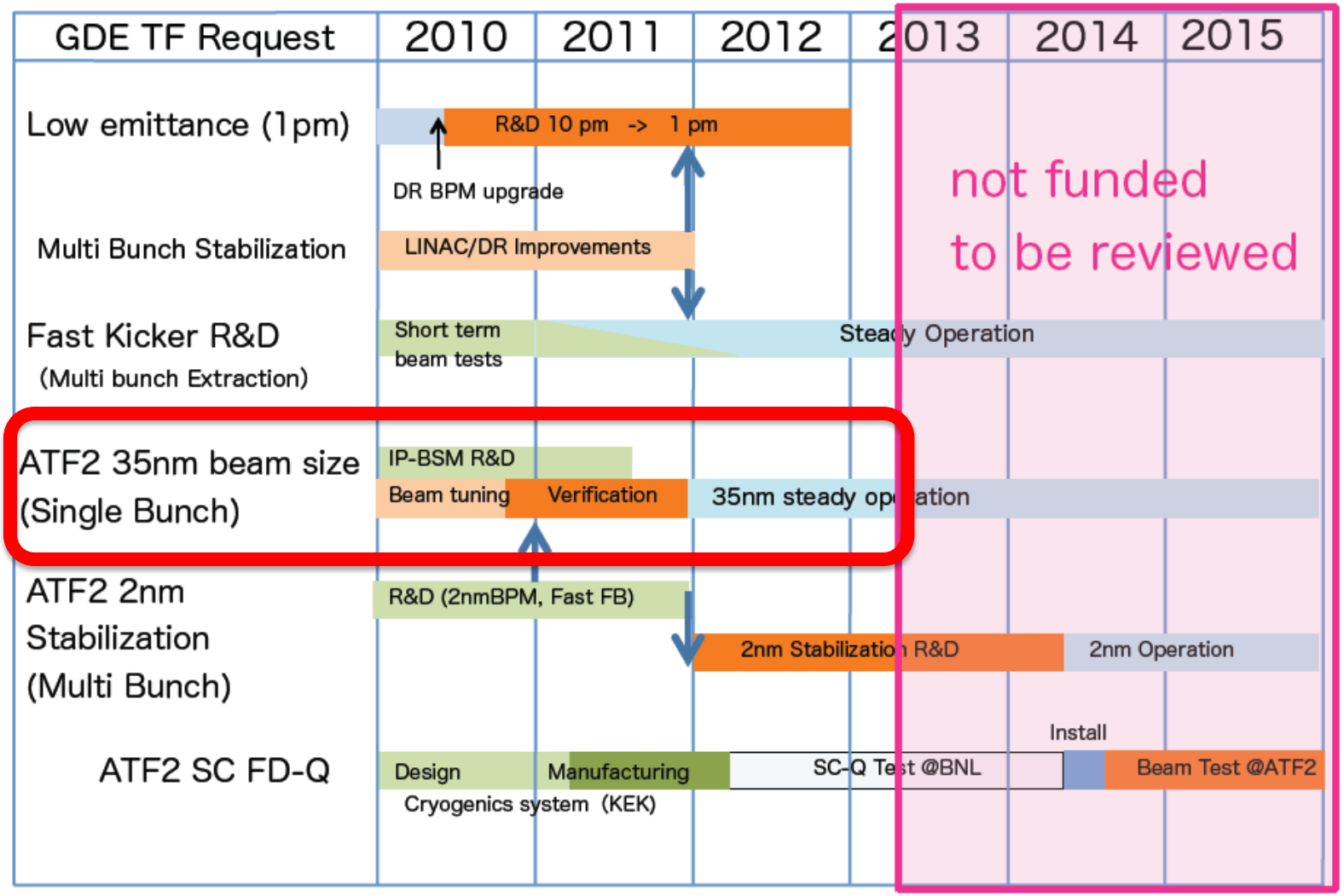
as expected from the PIP beam size measurements !



Crossing angle :4.12 [deg]
20 average
Fringe pitch 600 mrad
Scan range 13.2[rad]

Modulation ~ 0.72
σ_y ~ 950[nm]

ATF long term plan

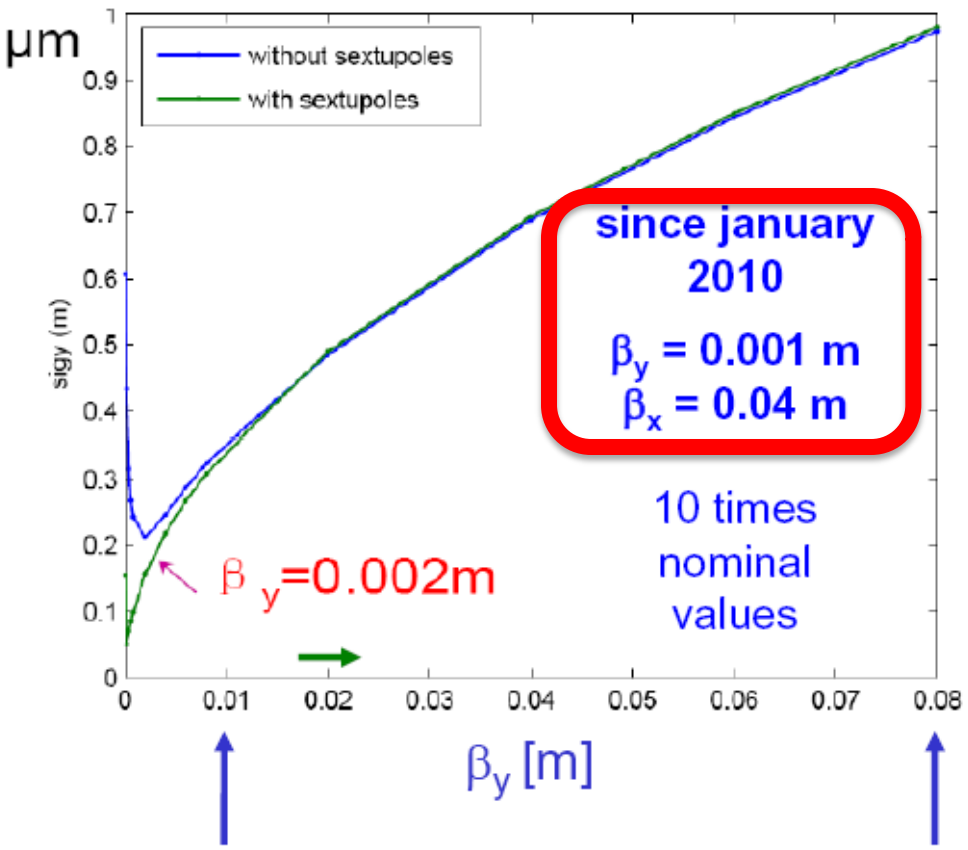


2010年 5月 13日 木曜日

ATF2 Operations & First Continuous Run

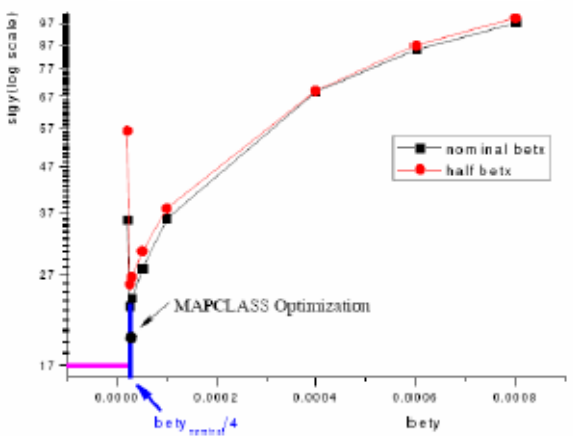
- Initial commissioning started Dec 2008
- 2009 Operations based on "R&D" mode
  - ~50% of shifts allocated to ATF2 commissioning tasks
  - 2-3 weeks operations per month Jan-Jun Oct-Dec
  - Concentrate on isolated hardware and software commissioning items (e.g. cavity BPM system)
  - Test of individual tuning tasks (e.g. correction of EXT dispersion, coupling).
- First "continuous operations" run in May 2010
  - May 17-21, one dedicated week just for ATF2 tuning
  - First merging of full EXT and FFS tuning procedures

Variable β_{IP} at ATF2



nominal value
β_y = 0.0001 m
β_x = 0.004 m

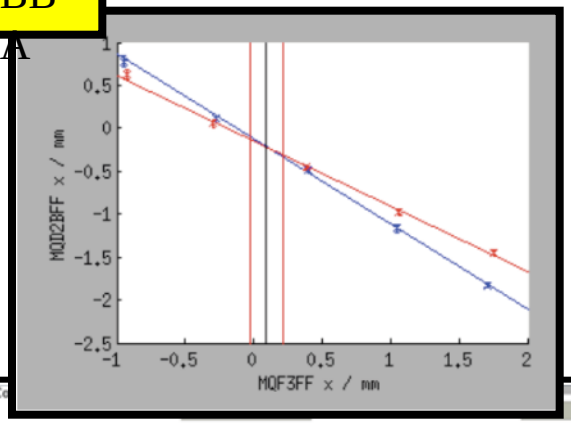
ultra-low β upgrade
factors 2-4



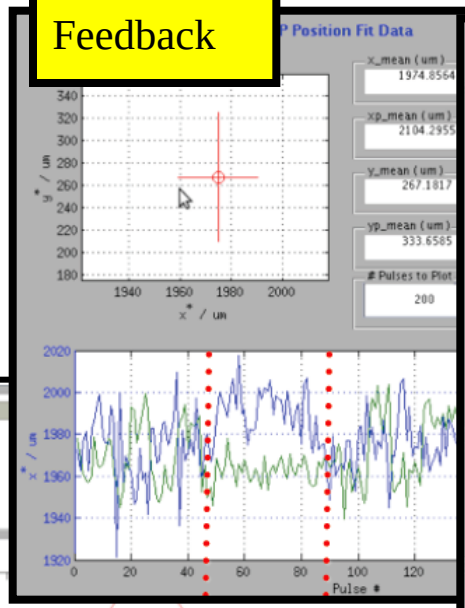
- For May 17-21 run we used 10 x nominal IP beta functions
  - Min y-size for 12pm emittance is ~110nm.

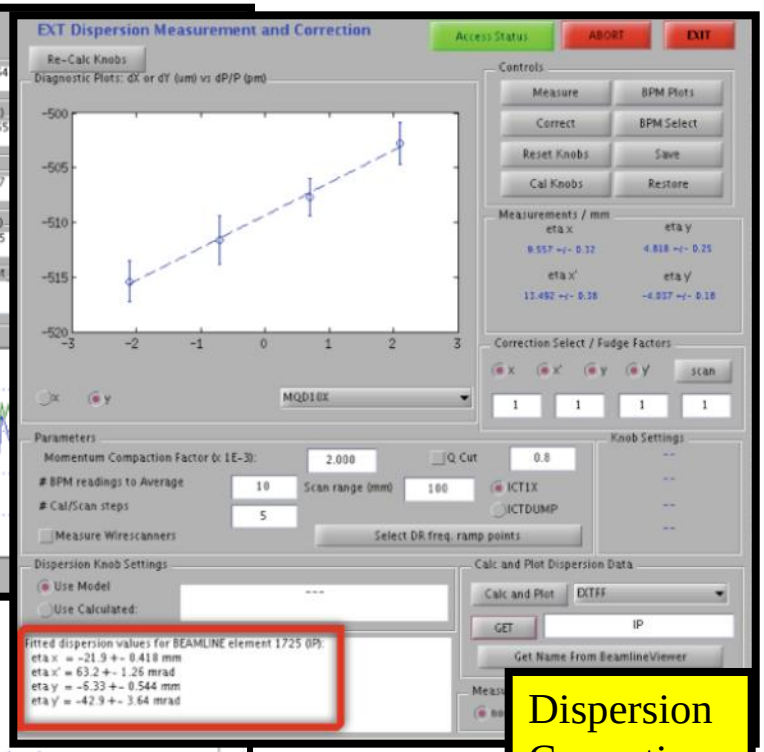
Example of Tuning Tools

BB

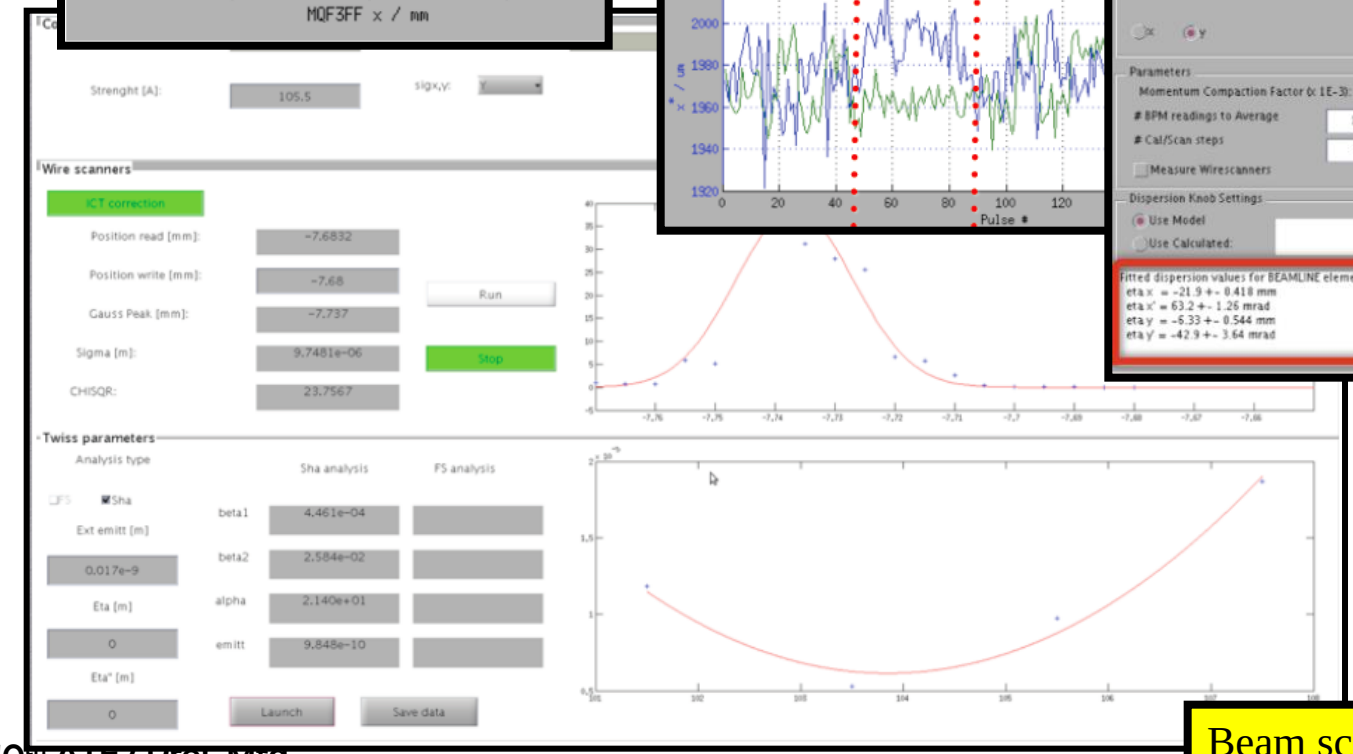


Orbit Feedback





Dispersion Correction



Beam scans

1st ATF2 continuous tuning run May 17-21, 2010

Day	Owl Shift	Day Shift	Swing Shift
MON		[2] **Araki / Miyoshi**	[2,3] **Kubo / Akagi** *Woodley,Edu*
TUE	[3,4] **Hayano / Kim** *White*	[5,6] **Furuta / Bambade** White, Nelson, Edu, *Bambade*	[6,7,8] **Omori / Woodley** Wang, Seryi, *Bolzon*, Jones
WED	[7,8] **Okugi / Shimizu** *White, Edu*, Wang, Jones	[8,9] **Mitsuhashi / White** *Bambade*, Nelson, Kamiya, Yamaguchi	[10,11,(14)] **Terunama / Bolzon** *Woodley*, Seryi, Oroku, Edu
THURS	[12,13,(14)] **Fukuda / Sugiyama** *Woodley*, Wang, Jones, Yamaguchi	[15,16] **Toge / Aryshev** *Okugi*, Neslon, Bambade, Jones, Kamiya, Edu	[15,16] **Naito / Abhay** Seryi, *White*, Bolzon, Oroku, Tauchi
FRI	[15,16] **Kuroda / Kurihara** *Woodley, Edu*, Wang, Kamiya	[15,16] **Sato / Oroku** *Okugi*, White, Nelson, Bambade, Jones, Oroku	[15,16] **Okugi / Yamaguchi** *White*, Bolzon, Seryi, Jones, Yamaguchi

Tuning Procedure (week May 17 – 21)

- DR tuning
  - COD, dispersion, coupling, E match …
- EXT + FFS steering, setup
  - Cav. BPM cal, BBA, steering, background reduction
- EXT tuning
  - Dispersion, coupling correction.
  - Matching into FFS
- FFS tuning
  - Check match conditions at IP
  - "Coarse" IP matching (beta, alpha, dispersion)
    - e.g. "Irwin Knobs", MAD/SAD rematching
  - Fine tuning of IP aberrations with "multiknobs" and IPBSM "Shintake Monitor".
    - Waist, dispersion, coupling, sensitive second-order terms.
    - Sextupole mover-based multiknobs, FD roll scans, EXT skew-quad scans…

Tuning steps for 1st ATF2 continuous tuning run

1. Startup
2. DR tuning
3. EXT & FFS C-band BPM calibration
4. FFS S-band BPM calibration
5. Initial EXT & FFS setup
6. EXT dispersion measurement and correction (x & y)
7. EXT Twiss + emittance calculation at IEX match point (x & y)
8. EXT coupling correction
9. IPBSM preparation
10. Horizontal IP diagnostics
11. Horizontal IP re-matching (if required)
12. Vertical IP diagnostics
13. Vertical re-matching (if required)
14. FFS Model diagnostics (if required)
15. IP multiknob tuning with IPBSM vertical beam size mode
    - IP y waist, dispersion, coupling scans
    - IP x waist, dispersion scans
    - Higher-order terms with dK / tilts
16. IPBSM study
    - Study required at changeover points between crossing modes
    - 2/8 degree mode >~350nm
    - 100nm ~< 30 degree mode ~< 350nm

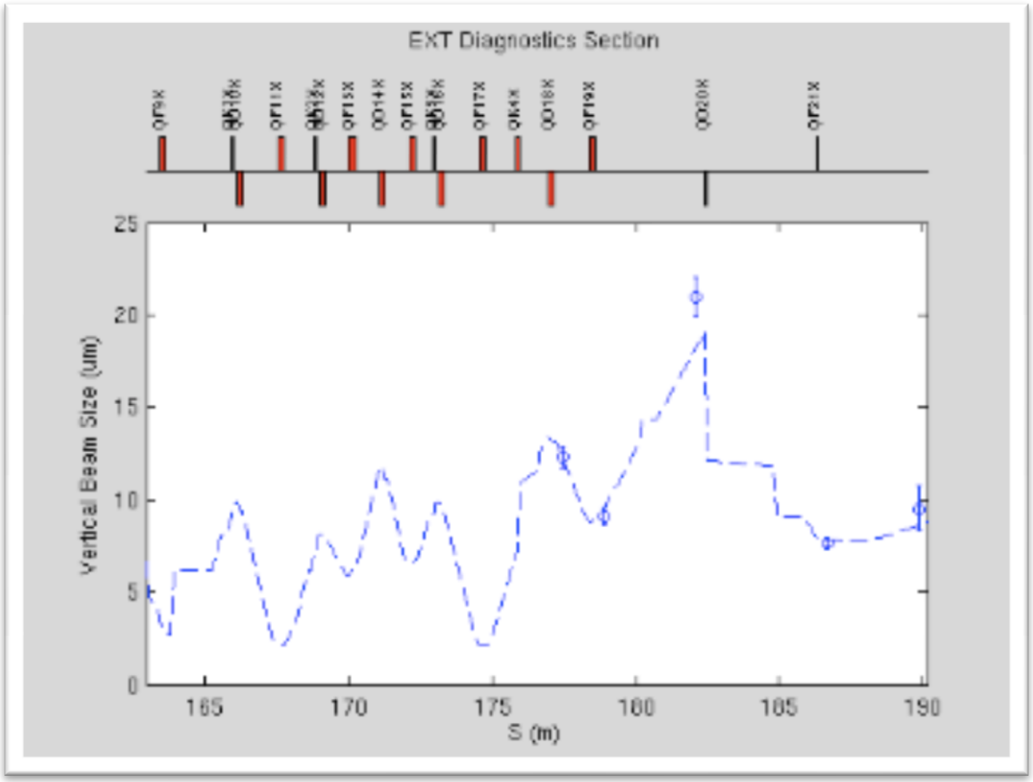
Extracted Emittance

(DR emit_y = 10pm)

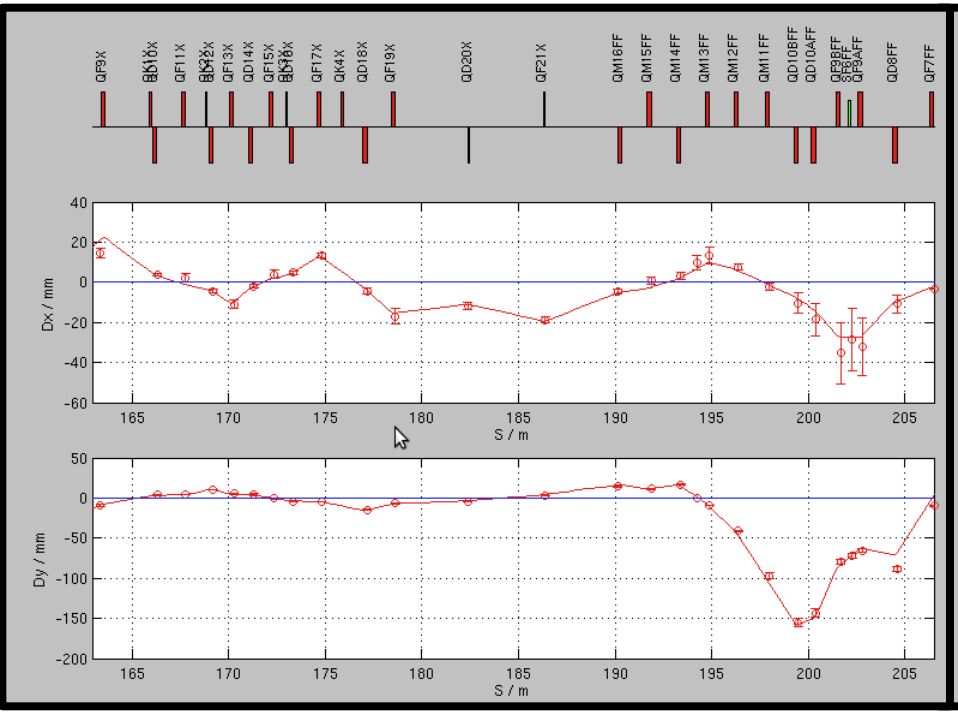
sigt	sigd	sigw	sig
13.63	5.31	2.50	12.30
10.47	4.57	2.50	9.08
23.07	9.20	2.50	21.00
8.97	3.89	2.50	7.68
10.30	3.00	2.50	9.53

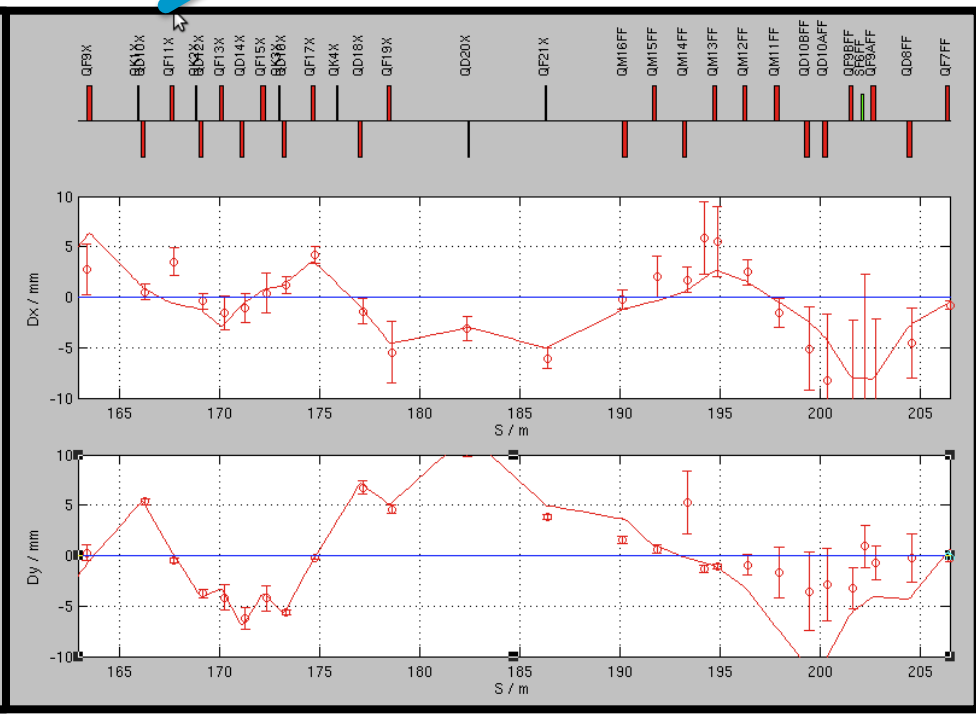
Vertical emittance parameters at MW0X

energy	= 1.2817	GeV	
emit	= 11.7381 +-	2.2922 pm	
emitn	= 29.4427 +-	5.7495 nm	
emitn*bmag	= 42.2019 +-	1.9205 nm	
bmag	= 1.4334 +-	0.2490	(1.0000)
bmag_cos	= 0.0448 +-	0.0000	(0.0000)
bmag_sin	= -0.7150 +-	0.0000	(0.0000)
beta	= 12.6951 +-	2.0753 m	(8.4774)
alpha	= 3.5809 +-	0.4296	(3.0756)
chisq/N	= 7.9155		



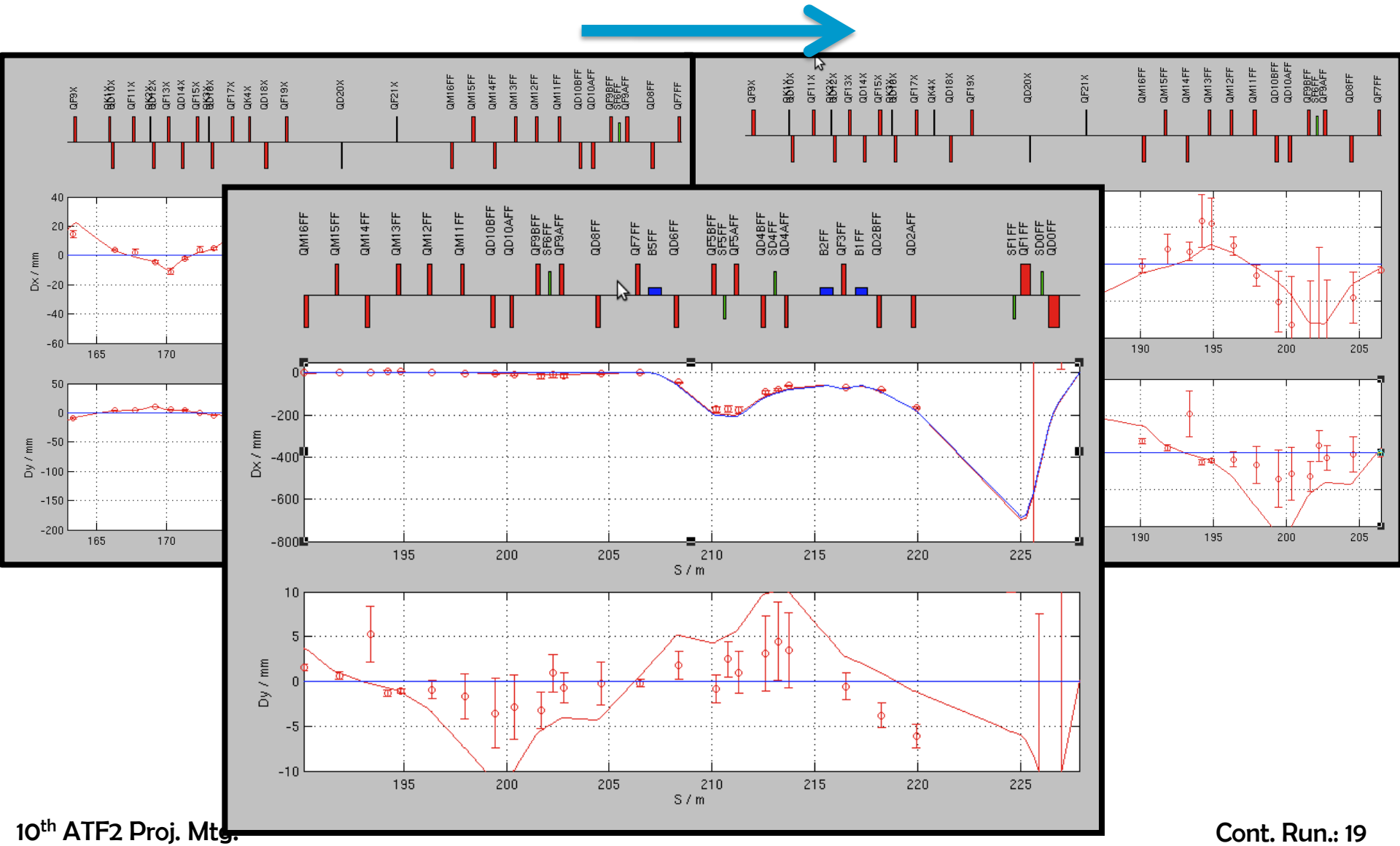
EXT Dispersion Correction



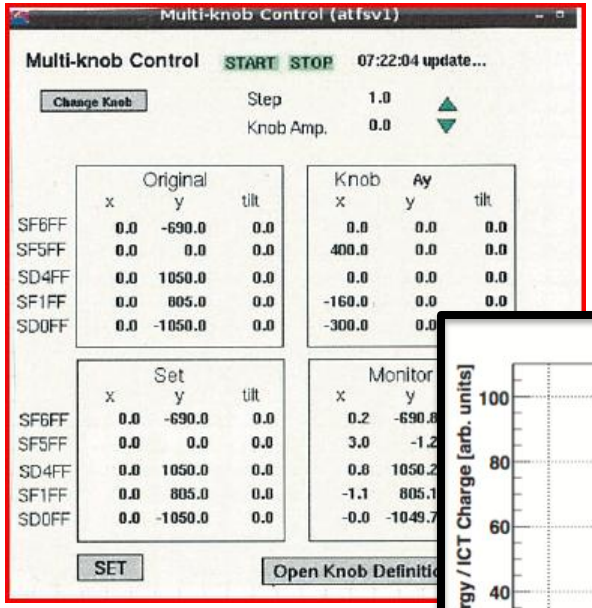


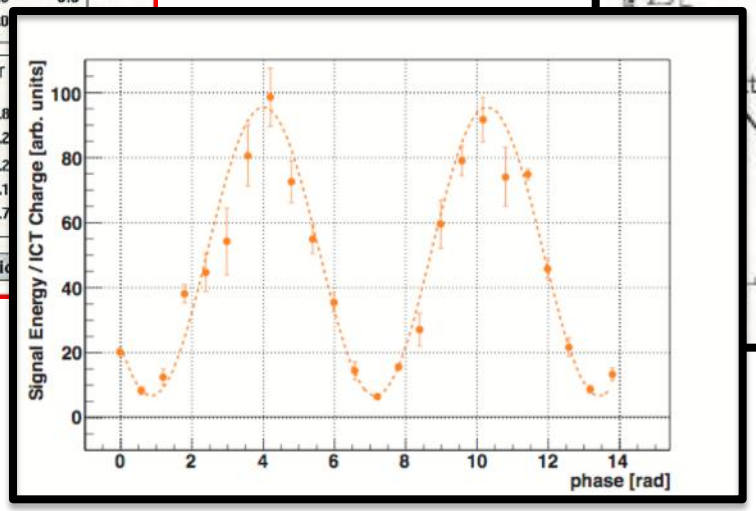
- Dispersion propogation to IP corrected <1mm x/y
- Residual vertical dispersion fine-tuned with FFS Sextupole multiknobs

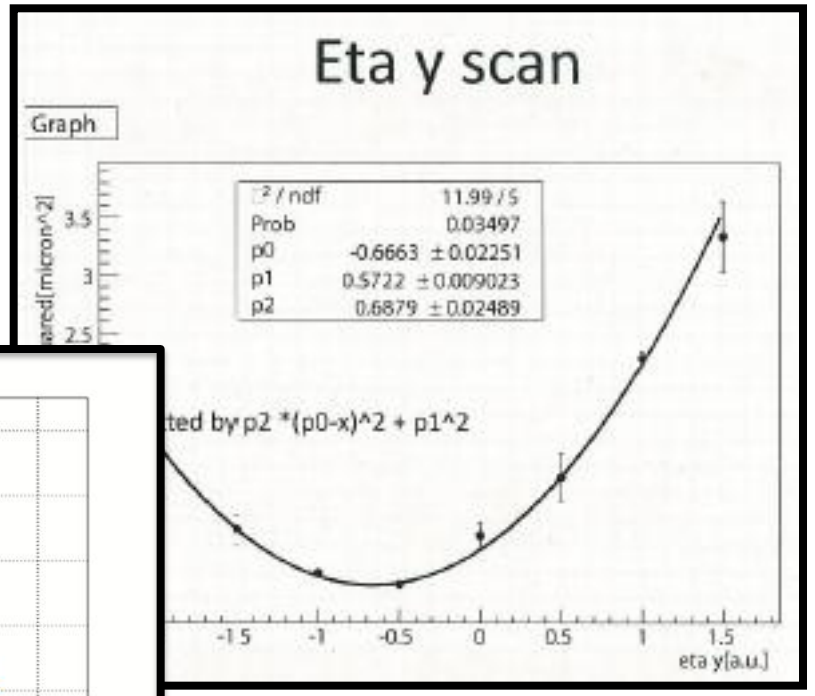
EXT Dispersion Correction



IP Tuning with FFS Sextupole Multiknobs

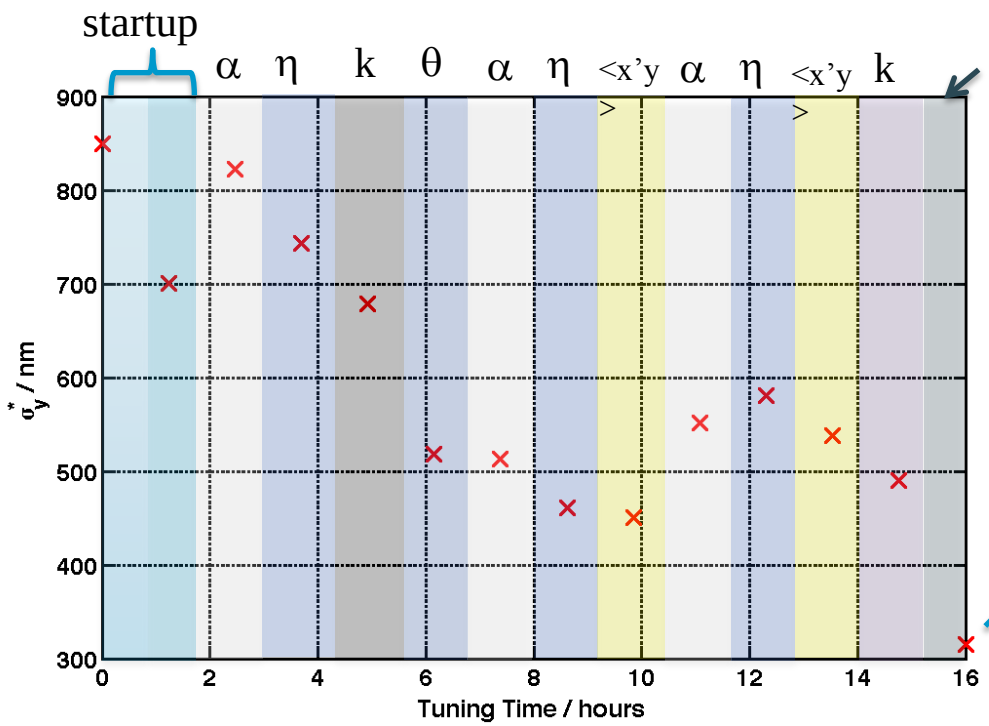


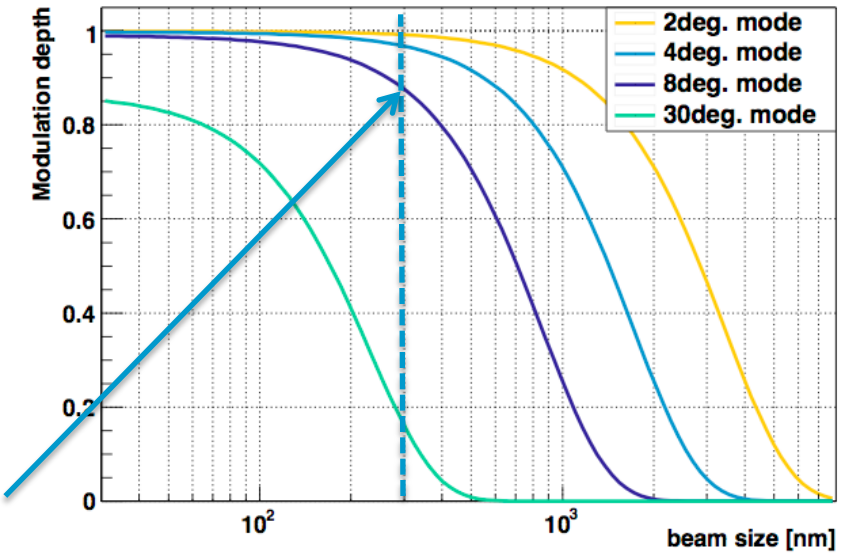




- Iterative use of various knobs to bring down IP spot size by scanning with IPBSM.

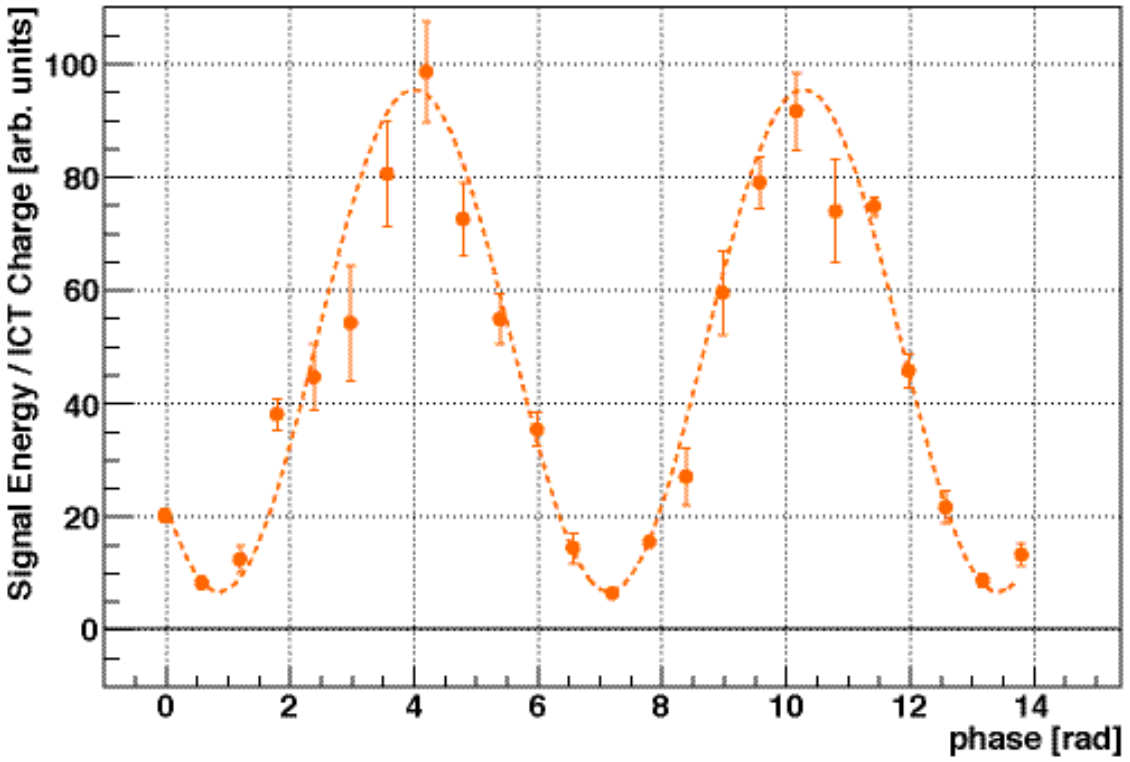
IP Tuning Results During Continuous Operations Week





- Tuning from initial setup of 850nm down to 300nm during 2 consecutive shifts onThursday.
- Beam size cross-checked on IPBSM 8-degree & 30-degree mode.
- Trouble reducing beam size past 300nm in 30-degree mode as do not have the resolution to scan higher beam sizes.

Best result of continuous tune week: May 17-21, 2010



Yoshio Kamiya and Shintake monitor group.
Modulation Depth = 0.87 @ 8.0 deg. mode
Beam Size is 310 +- 30 (stat.) +0-40 (syst.) nm

[atf2-commissioning 380] ATF2 continuous operations week...

- We completed our first 1 week "continuous operations run" of ATF2 tuning, May 17 - May 21. During the run we reached a minimum IP vertical spot size of about 300nm. The run was a successful integration of tuning tasks tested in past shifts and has provided a lot of information on how to move forward from here. Below is a brief bullet-point summary of events during the week, more detail can be found on the wiki (http://atf.kek.jp/collab/md/atfwiki/?Scheduling%2F2010May17May21).
- DR tuning (ey ~10pm)
- 10* IP beta_x/beta_y optics loaded for EXT+FFS (4cm/1mm)
- Magnets standardised
- EXT dispersion correction
- EXT ey measured at ~11pm, no coupling correction required
- Cavity BPM systems calibrated
- ...

[atf2-commissioning 380] ...ATF2 continuous operations week

- ...
- Beam size brought to ~normal in x <2um in y at IP with W and C wirescanners (some wirescanners cut during scanning)
  - x and y waists brought to IP with alpha knobs
  - y beta function looks correct to within ~20% from PIP measurements with waist at IP
- vertical beam size acquired with IPBSM, starting size ~850nm
- Beam size reduced to 300nm with sextupole waist, coupling, dispersion multiknobs, qd0 current and roll scans.
- Beam size verified in 30-degree and 8-degree IPBSM modes.
- Could not scan with 30-degree mode as could not resolve larger size beam
- Attempted IP beta reduction to 0.5mm, but could not re-acquire beam
- Switch back to 8-degree mode, restore optics and tune back to ~350nm (reproducibility!)

Glen White (SLAC), on behalf ATF2 commissioning team.

Beta-squeeze

- Attempted to squeeze beta from 1mm to 0.5mm to ease transition from 8deg to 30deg mode
- Positive:
  - Background did not noticeably increase
- To be taken into account in future:
  - The matching quads involved in β-squeeze ("Irwin knob") were not BBA-ed. Large orbit, need to re-steer, in meantime beam size also drifted up. Could not observe beam in BSM in 30deg mode after the squeeze...
  - The β-squeeze will likely be required (to jump from 30 to 174deg). May attempt two-step squeeze (after proper BBA of the beamline):
    - Within single BSM mode: Start with β, tune beam size down, at 2/3-way-down increase to 2β, continue tuning down to the edge of BSM mode, then squeeze again to β and switch the BSM mode

Identified issues, ideas & prospects

- Need to ease "jumping" from 8deg to 30deg mode
  - Can we enlarge angle for 8ded mode to ~10deg?
  - Use beta-squeeze to jump between modes, but ensure in advance that beta-squeeze works within single BSM mode (BBA for quads done, etc)
  - Need to reduce drift (increase) of beam size (both e-beamline & laser lines issue)
- Final doublet mounting & alignment precision (rotation)
- Additional possibilities for tuning (not yet tried)
  - Minimize sigma_x from time to time
  - Measure & check chromaticity (& verify values of sextupoles)
  - Analysis and correction of critical R matrix elements
- Apparently need a more handy online tool
  - to quickly verify how various knobs, suggested to be tried, are expected to act
  - This may become a more comprehensive online model with guesstimated errors, which would be gradually reduced, based on measurements and analysis

Summary

- First dedicated attempt at tuning ATF2 beamline in the week of May 17-21 was proven to be very useful
- 300nm vertical beam size at IP waist achieved
  - Factor of ~4 from the intermediate "ILC scaled" milestone of ~80nm
- The 300nm size measured by 8deg mode and reproduced by measurement with 30deg BSM mode
  - Increasing the overlap between 8deg & 30deg modes and/or better prepared β-squeeze would simplify tuning in the future
- Improvements discussed & some being implemented
- Need to plan and prepare for the next "continuous operation runs" for the Autumn-Winter of 2010