ATF2 Beam Tuning Progress and Plans

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ILC2010, Beijing

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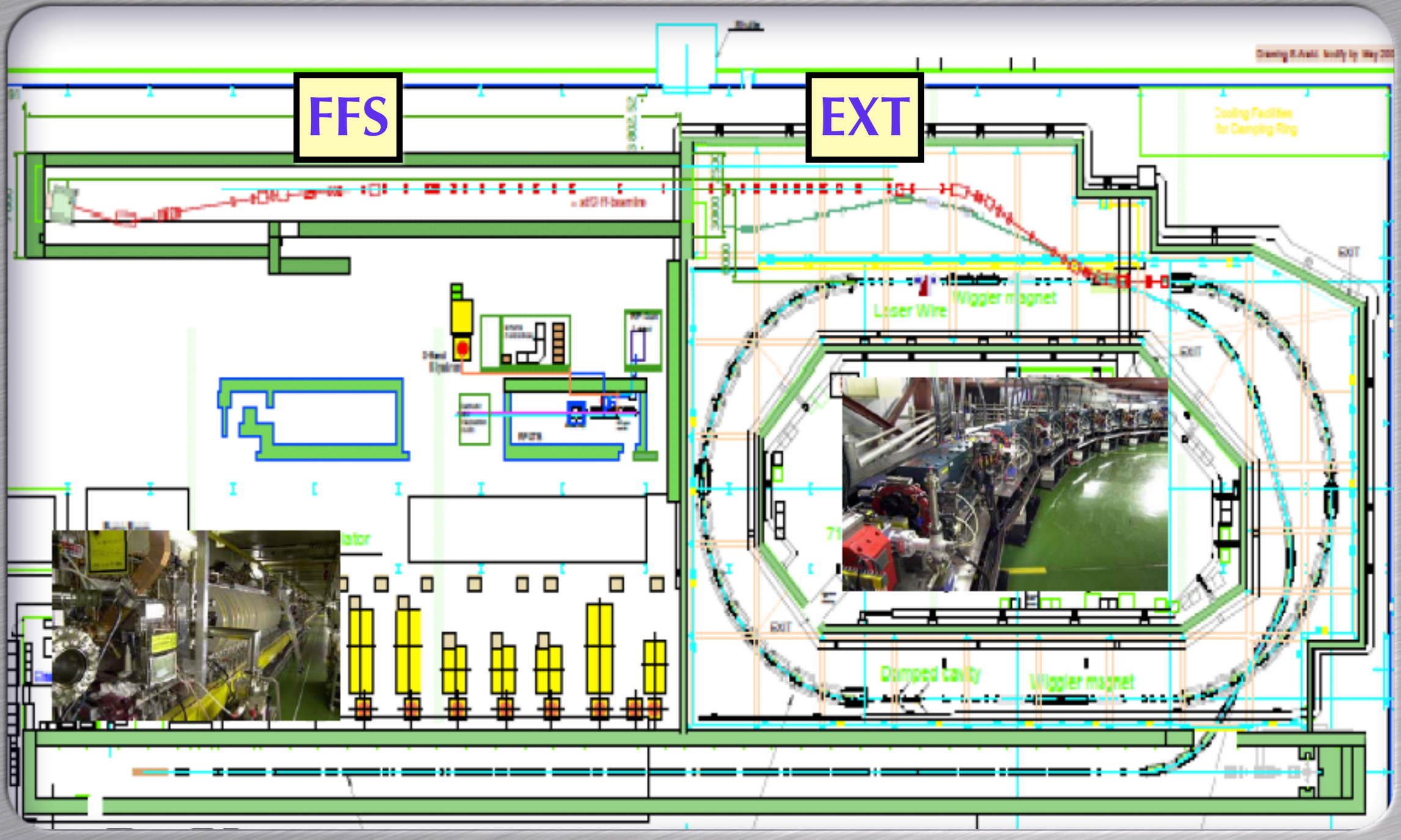
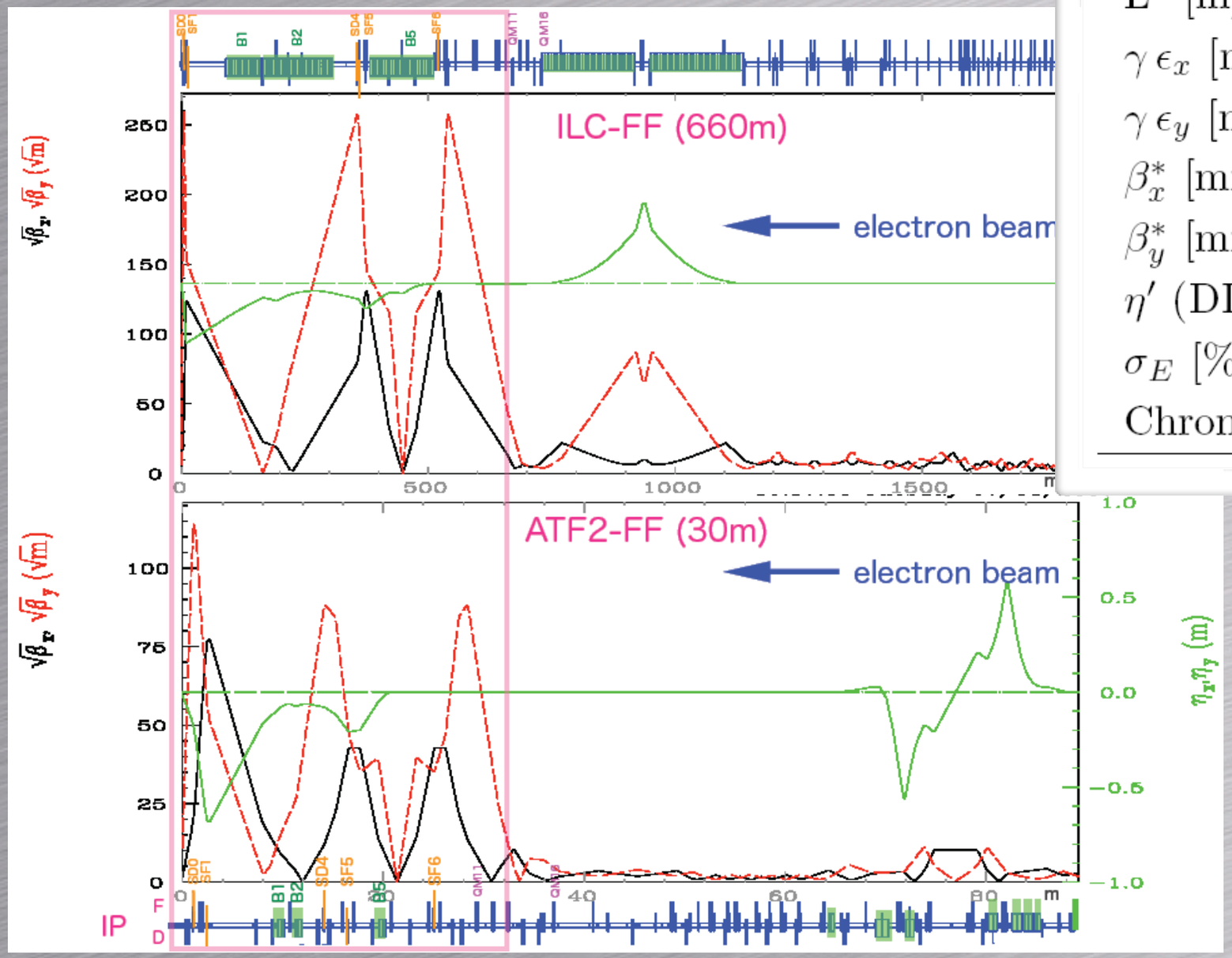
ATF2 Beam Test Facility @ KEK



ATF2 & 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	$\sim 10^4$	$\sim 10^4$

Beam Tuning Steps

- Establish desired optics configuration.
- Establish EXT/FFS orbit and BBA.
- Orbit feedbacks.
- EXT dispersion correction.
- EXT coupling correction.
- Establish IP or post-IP waist at wirescanner, QD0 waist scan, dispersion measurement and tweak. Achieve vertical beam size in range of IPBSM, dispersion, waist shift and coupling in range of sextupole multiknobs.
- Beta matching, DR, EXT, FFS -> IP model checks.
- Spot size tuning with FFS sextupoles and IPBSM.

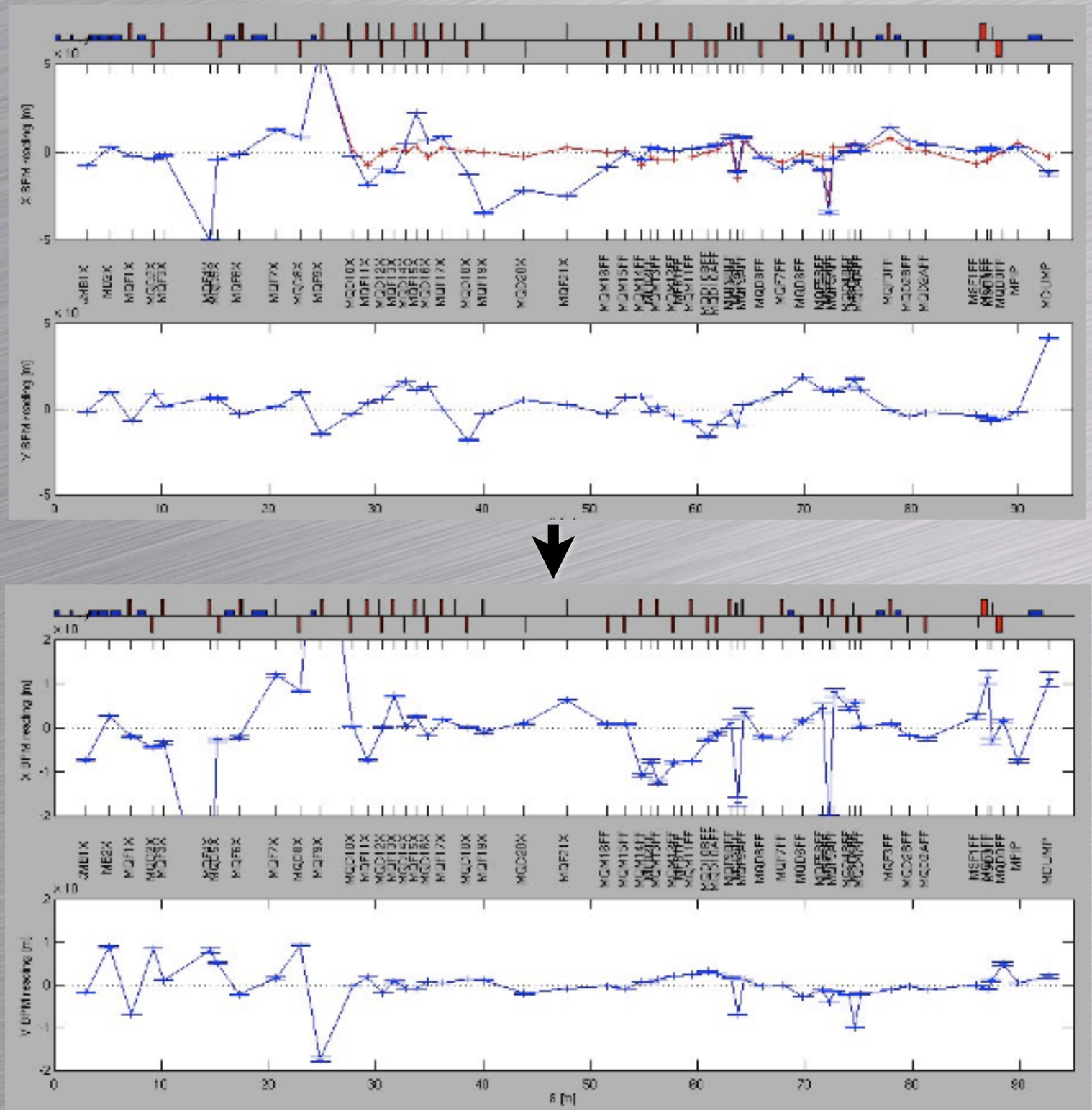
Optics Configuration

- <2010 used 8cm / 10mm IP beta optics (x / y) [20* / 100* design].
  - Target IP y spot size ~500nm.
- January, attempted establishment of design optics.
  - Backgrounds in IPBSM detector 20* larger than requirements for beam size measurement.
- Currently running with 4cm / 1mm [10* /10* design].
  - Target IP y spot size ~100nm.

Orbit Steering / BBA

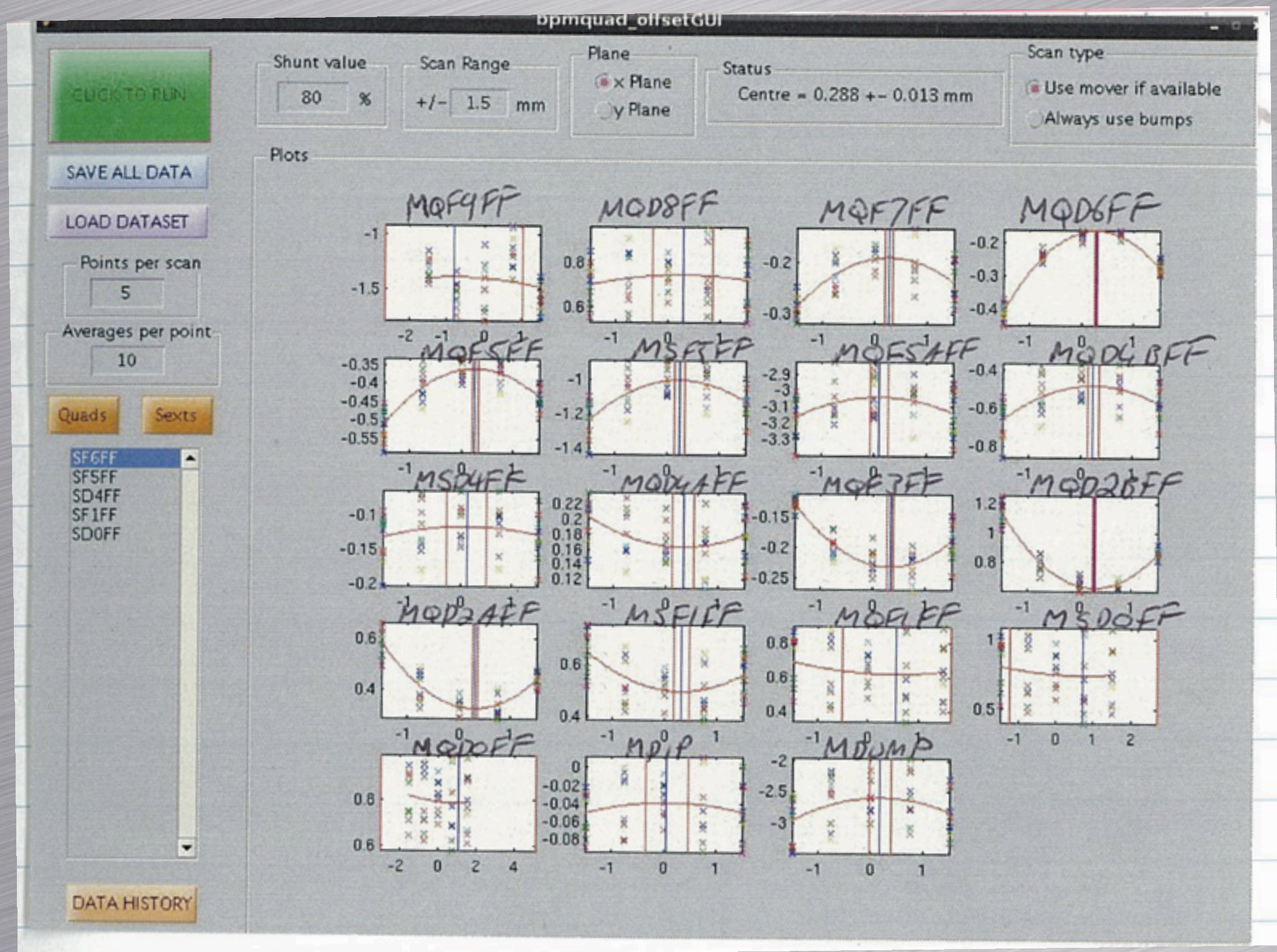
- Initial alignment for good IPBSM backgrounds.
- Use manual BBA method for EXT using screens and Quad shunts.
  - Now have upgraded stripline BPM readout electronics in this region.
  - Work towards automated BPM-based system.
- Steer to (cavity) BPM centers for FFS.

Automatic Steering Correction



Good Online Model enabled successful auto-correction of orbit for first time (Dec 2009).

FFS Sextupole BBA



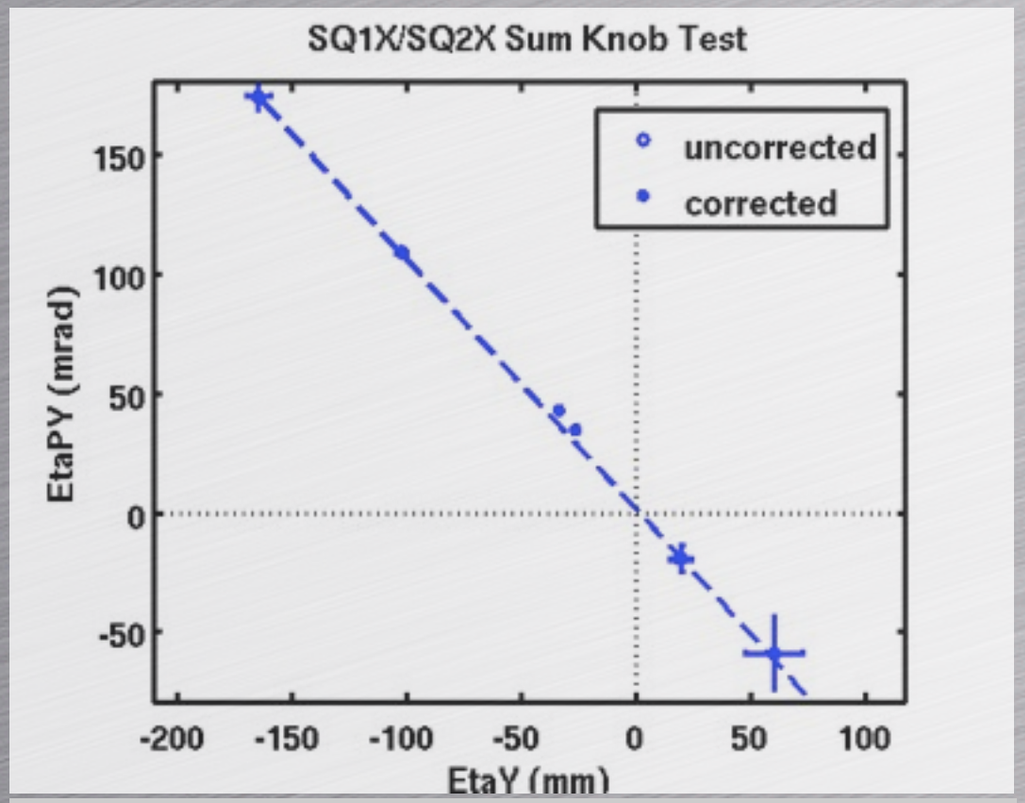
Measured Alignments

FFS Sextupole	Magnet -> Beam (mm)	Magnet -> BPM (mm)
SF6FF	0.29 +/- 0.01 (x) -0.106 +/- 0.02 (y)	1.75 +/- 0.16 (x) 0.604 +/- 0.034 (y)
SF5FF	-0.811 +/- 0.06 (x) 0.012 +/- 0.02 (y)	2.315 +/- 0.11 (x) 0.205 +/- 0.083 (y)
SD4FF	0.226 +/- 0.026 (x) 0.0729 +/- 0.034 (y)	0.395 +/- 0.038 (x) 0.375 +/- 0.029 (y)
SF1FF	0.537 +/- 0.159 (y)	0.42 +/- 0.16 (y)
SD0FF		

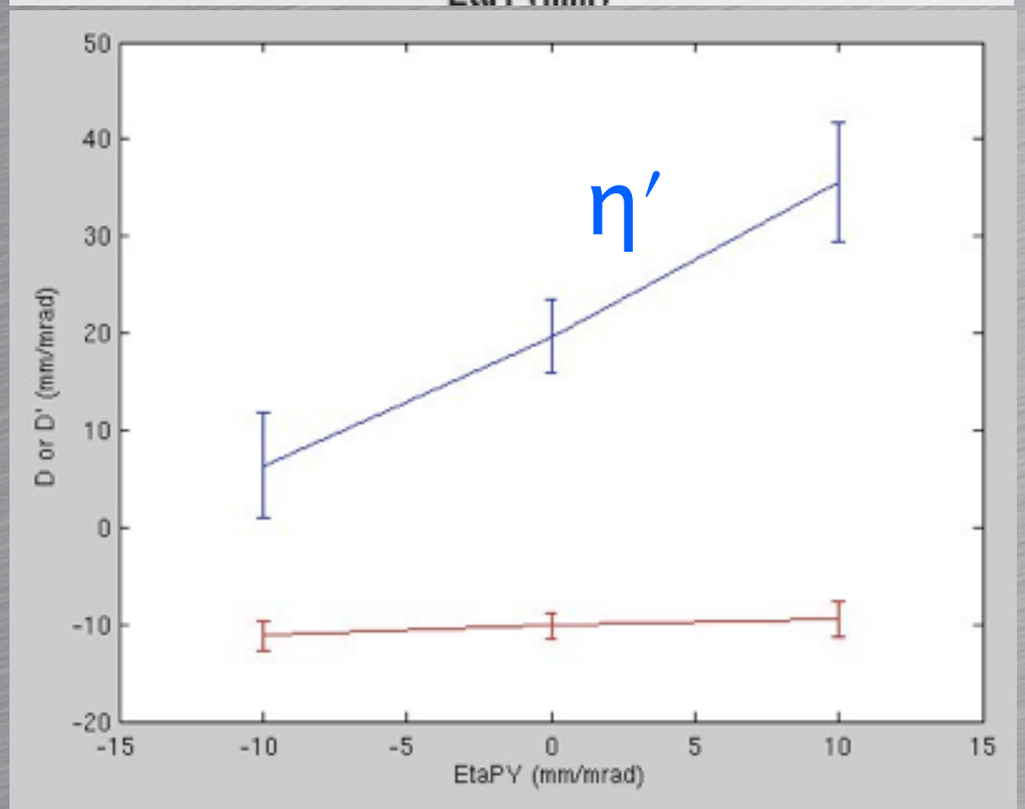
EXT Dispersion Correction

- Measure dispersion on EXT and FFS BPMs using DR freq. ramp.
- Fit to start of dispersion free region of EXT (MQD10X) and correct.
- Horizontal correction with QF1X & QF6X (quads in dispersive region).
- Vertical correction using “sum knob” (QS1X/QS2X skew quads in dispersive region) to simultaneously correct eta & eta’.
  - OK if only source of dispersion inside EXT, if significant incoming dispersion from DR, also need vertical orbit bump for independent eta’ correction.
  - BUT - found problems with practical application of this orbit bump, may have to fix any sources of dispersion from DR locally in future...

Dispersion Knobs



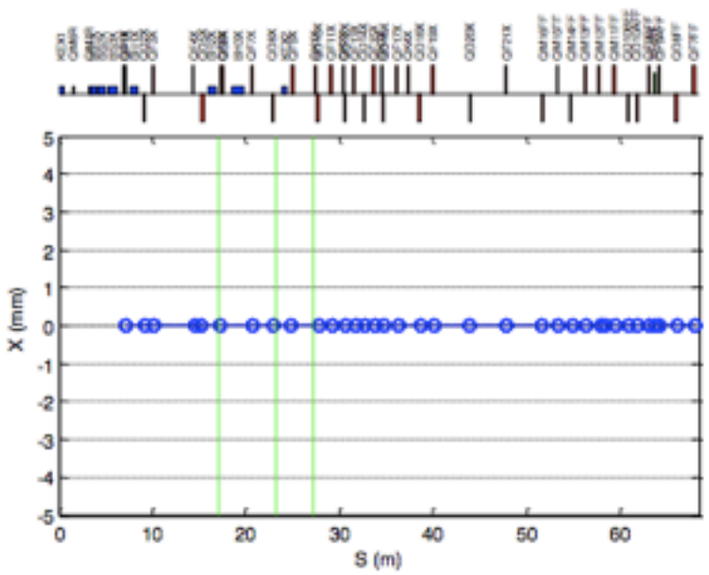
- Sum knob response

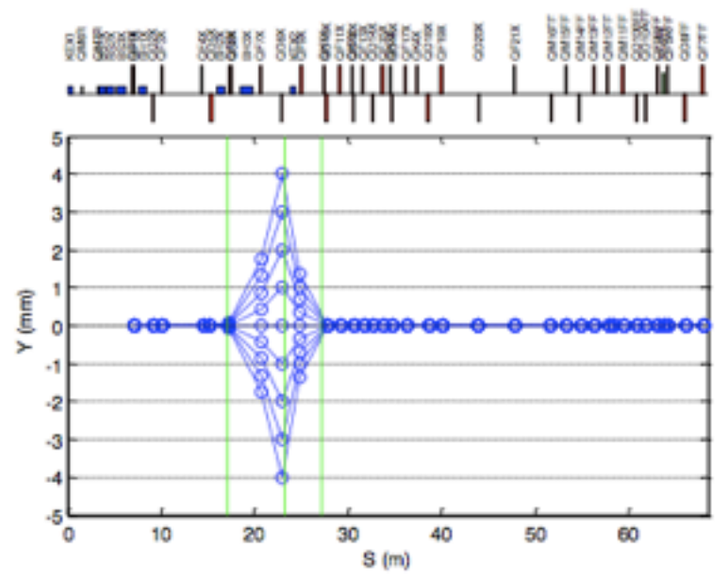


- Vertical bump response (ZV5X, ZV6X, ZV7X)

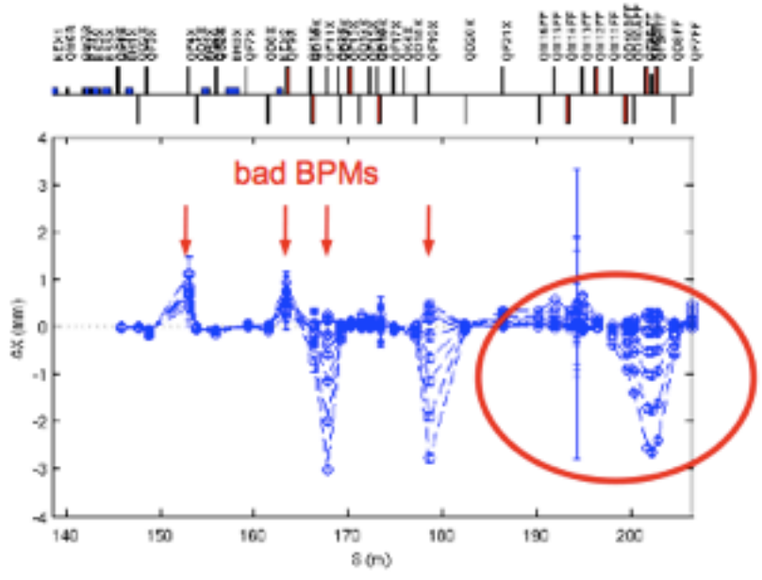
eta′ Bump Not Behaving as Expected

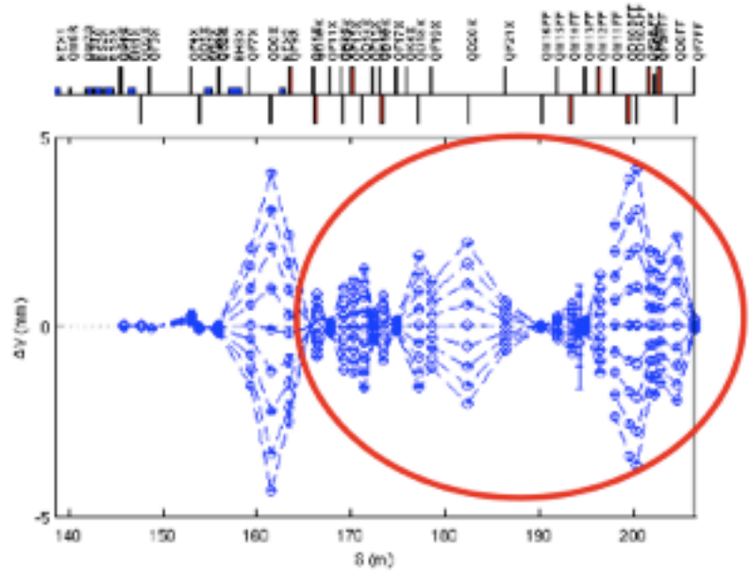
what we expected to see (no kicker multipoles) …



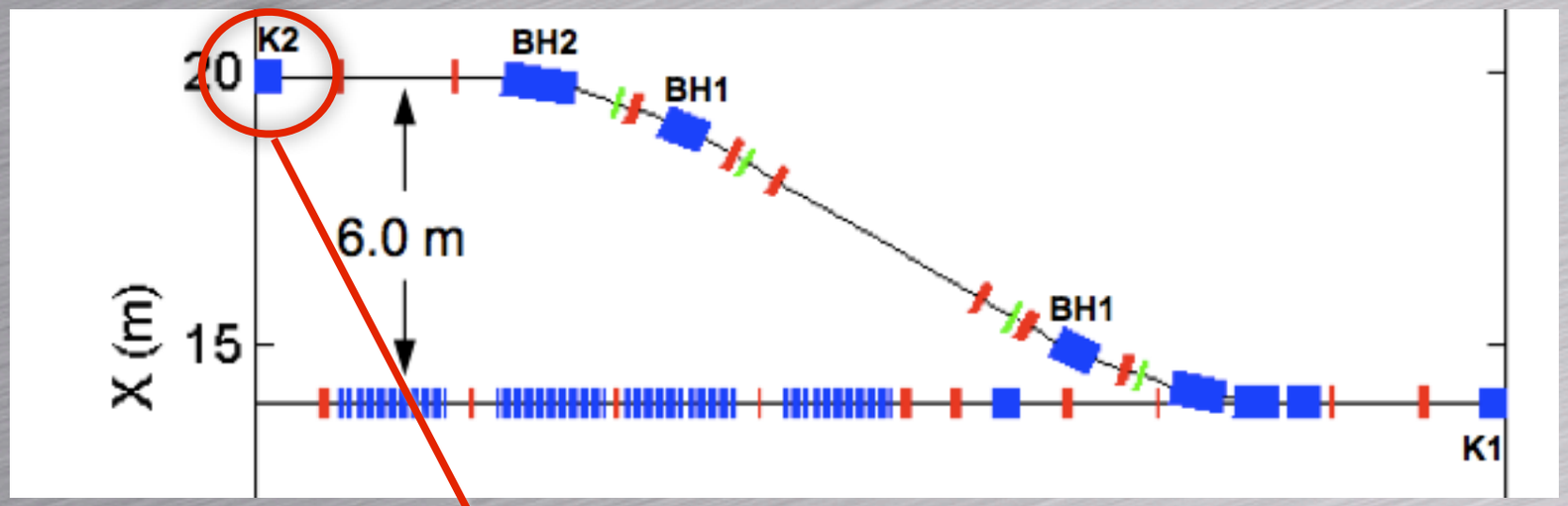


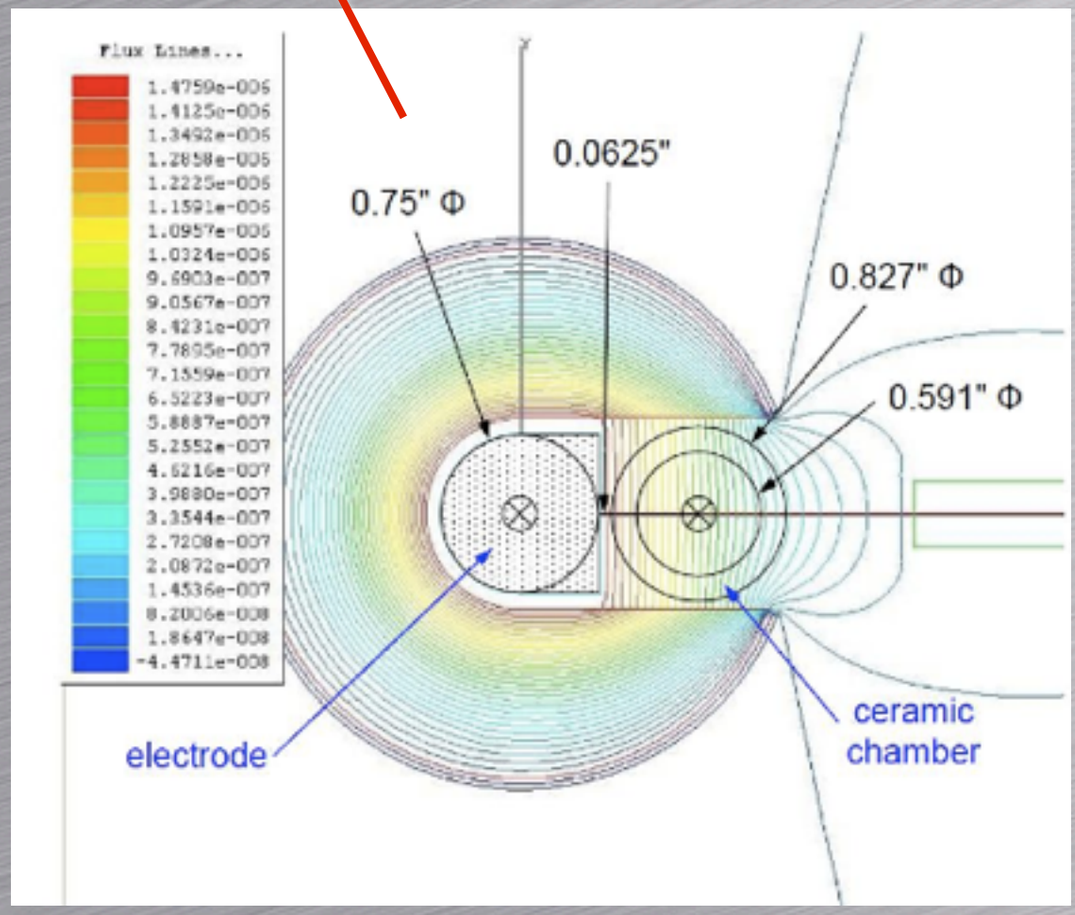
… what we observed

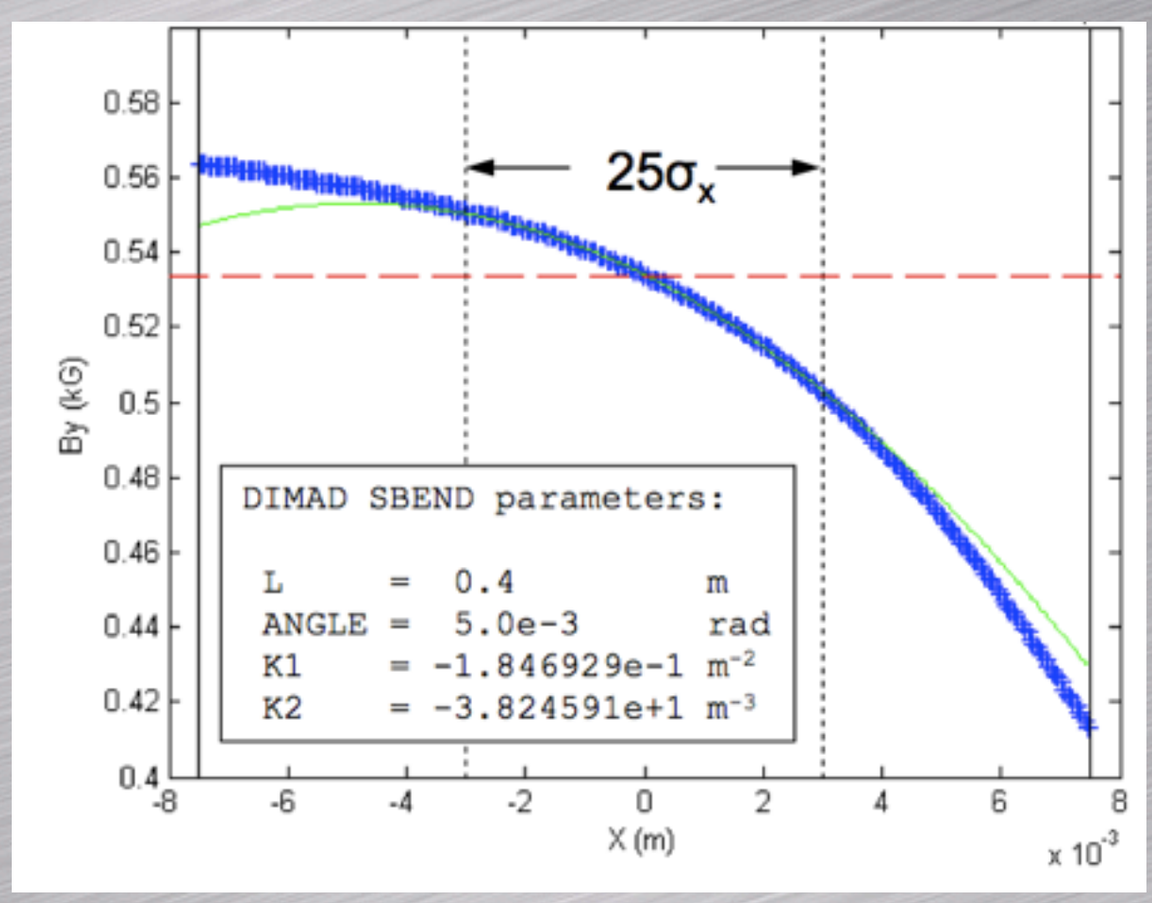




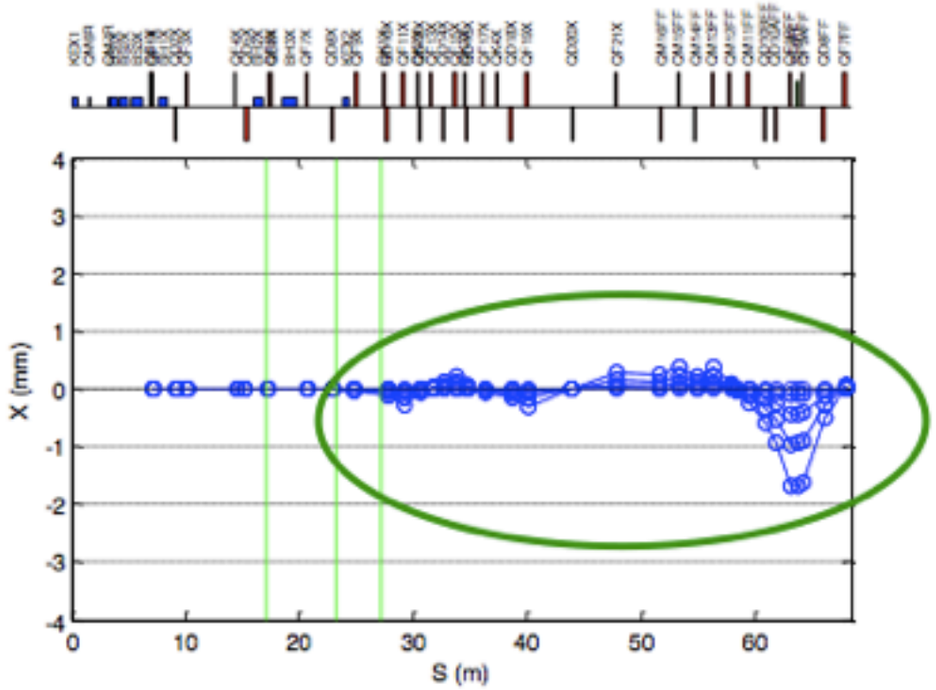
Suspect 2nd Extraction Kicker

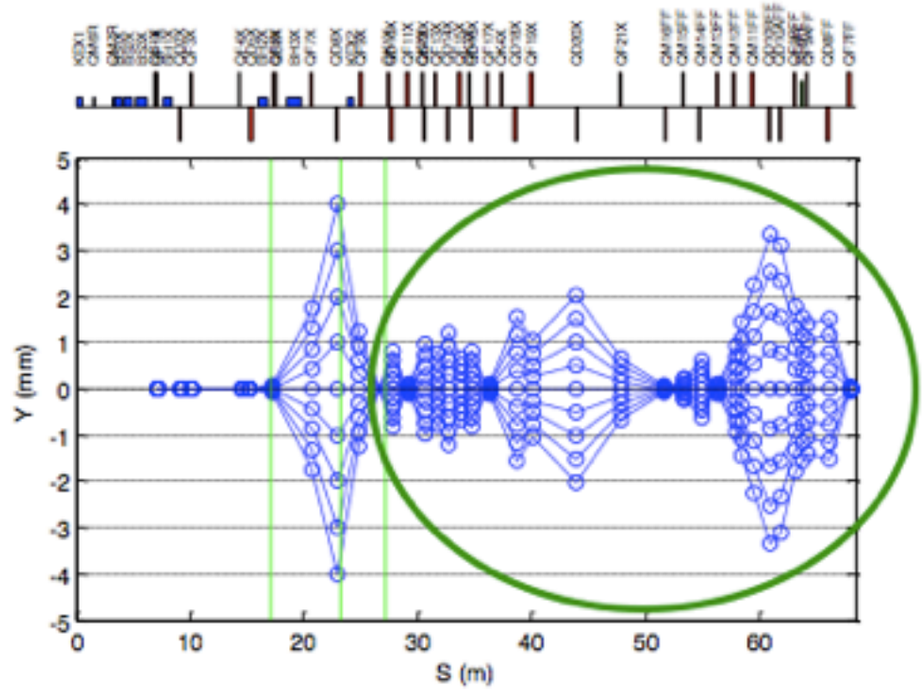




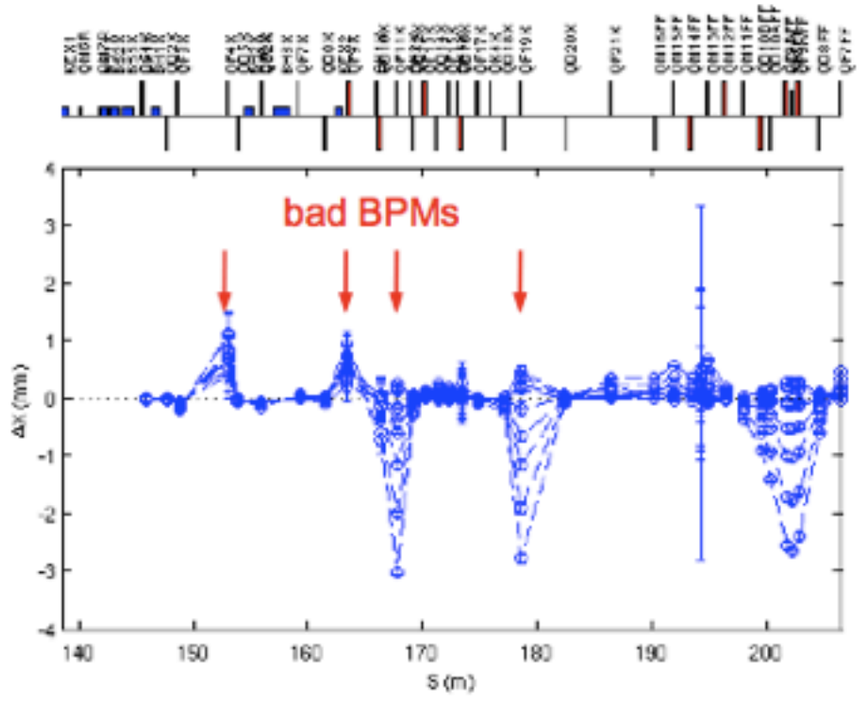


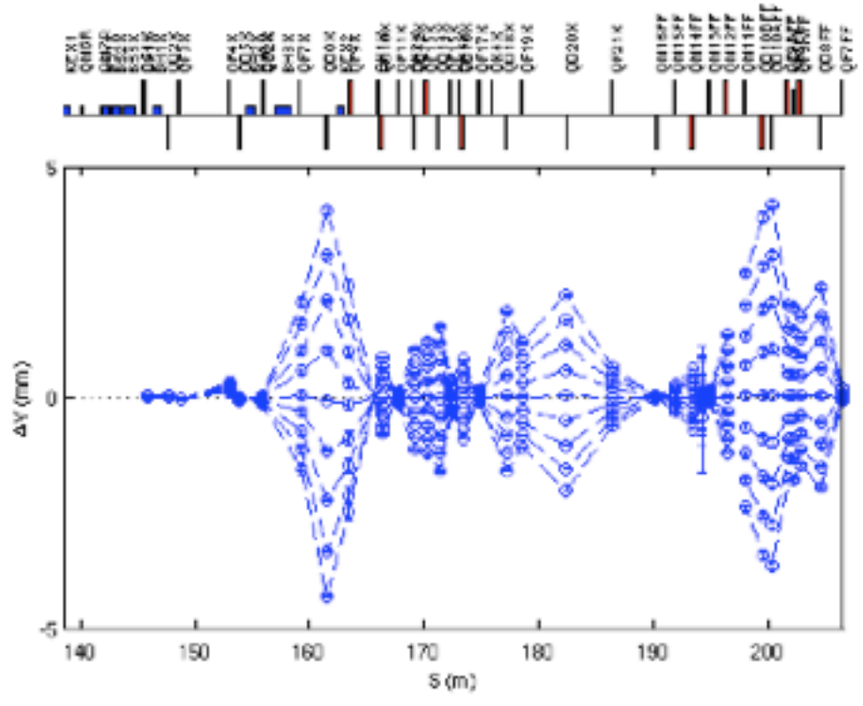
what we expected to see (with predicted kicker multipoles) …



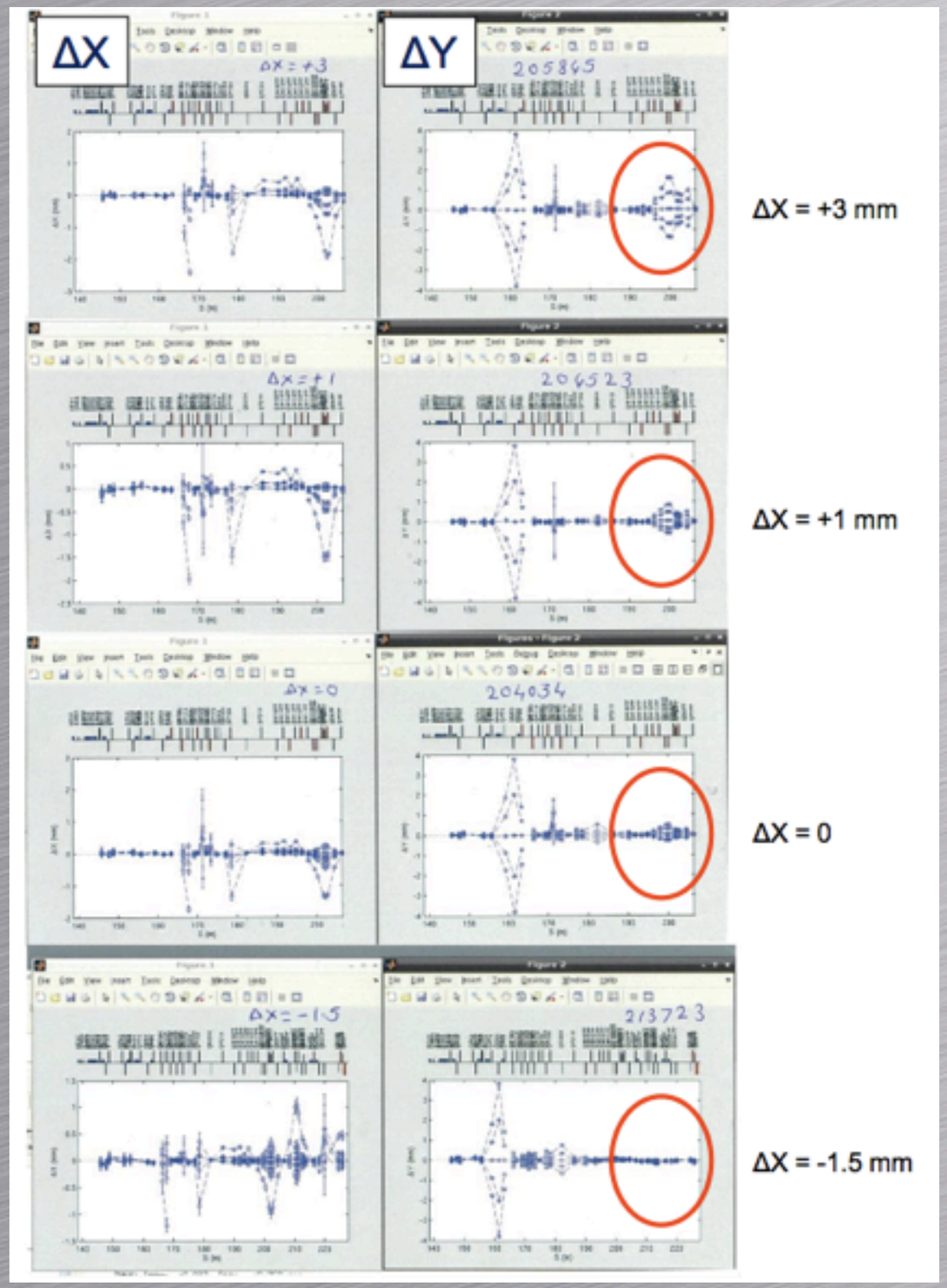


… what we observed





Re-Calculate Bump

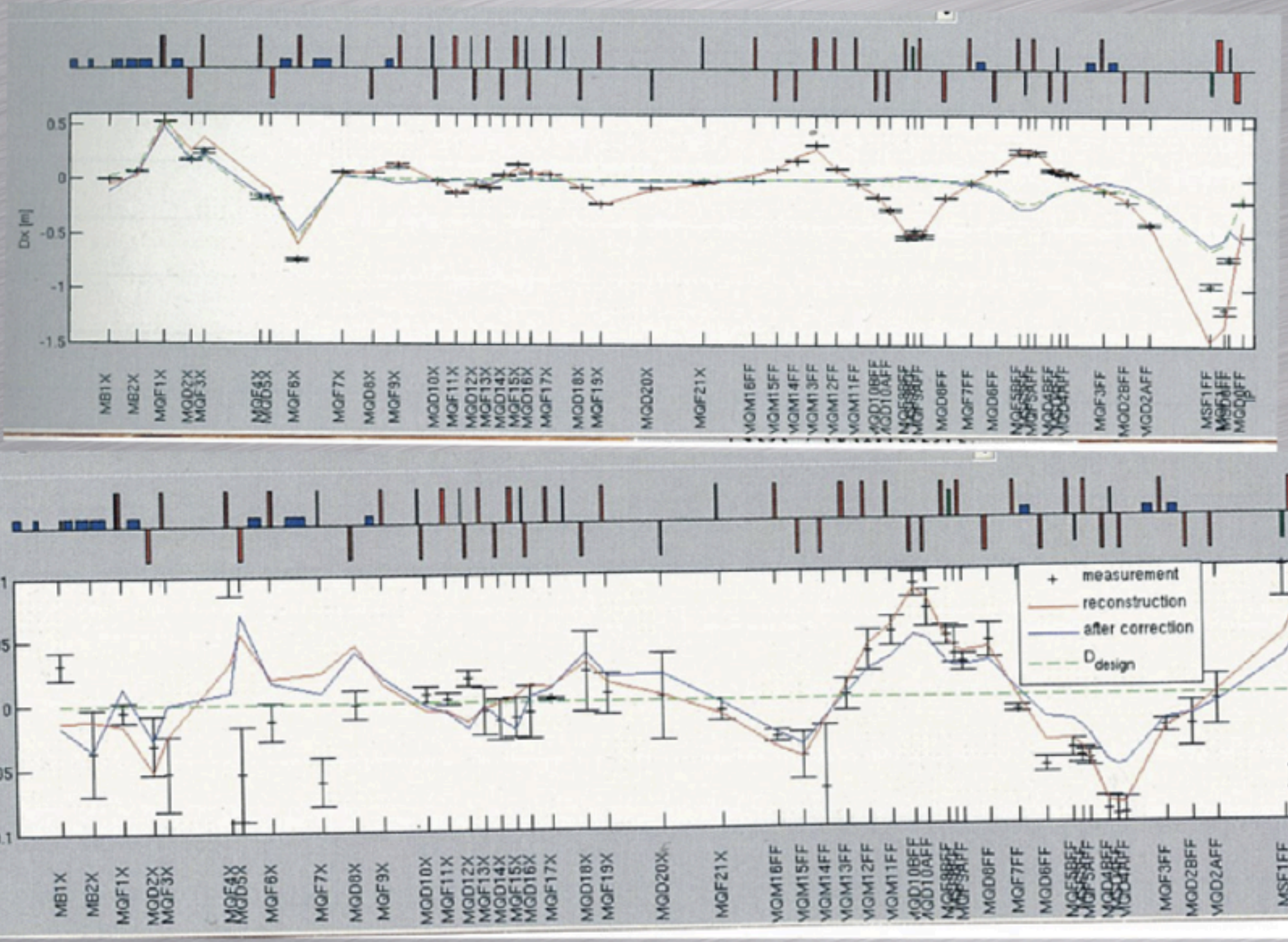


- Re-calculated bump based on predicted on-axis fields.
- Scan x in KEX2 with horizontal bump.
- Find vertical bump closure at 1.5mm.
- Seems to verify suspicion.

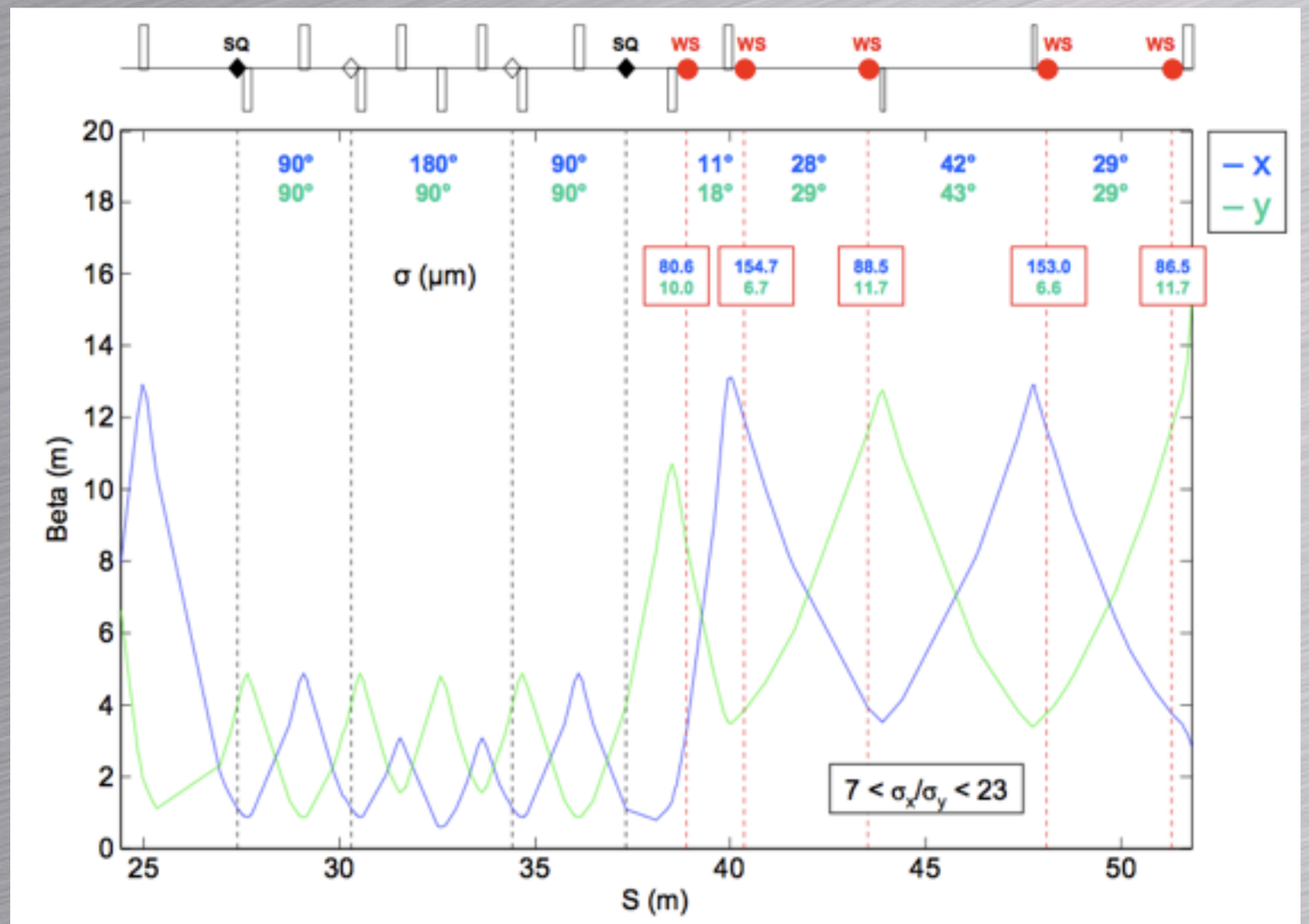
But...

- Backgrounds at IPBSM high with 1.5mm x bump.
- Could re-align kicker, but also suspect strong coupling dependence on vertical bump position.
- KEX2 kicker fields seem to well describe bump effects seen, but should also see large optics mismatch- predict BMAGs 2.8 (x) and 4.3 (y).
  - Measure BMAGX and BMAGY ~<1.1
- Could use more information from scans of kicker apertures vs. measured twiss parameters, would be too slow with wirescanners. Good job for OTRs when installed.

SVD-Based Disp. Meas.



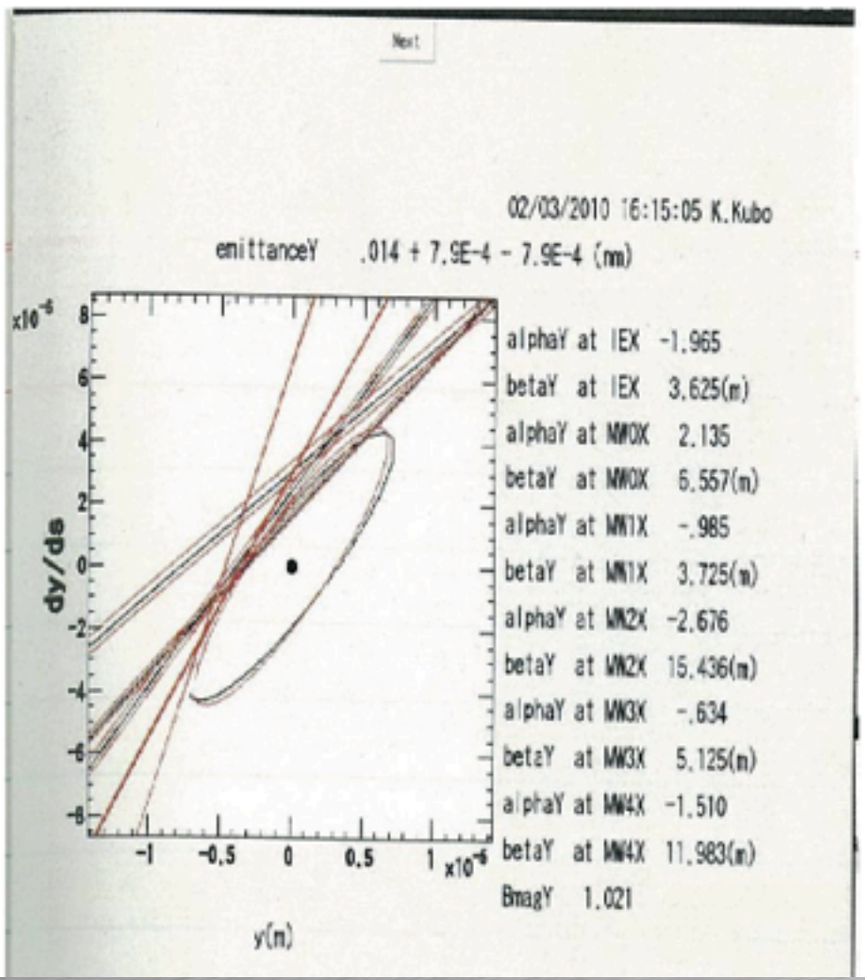
EXT Coupling Correction



"Reduced correction scheme" :

* Scan QK1X/QK3X vs. MW1X y size
* Scan QK2X/QK4X vs. MW3X y size
* Not as good as complete correction (scan QK1-4X vs. vertical emittance), but can be good enough for now and is faster.

Correction Results (Feb)



	ε y (nm)	Bmag
Before coupling correction	0.018 ±5.0e-4	1.011
After coupling correction	0.014 ±7.9e-4	1.021

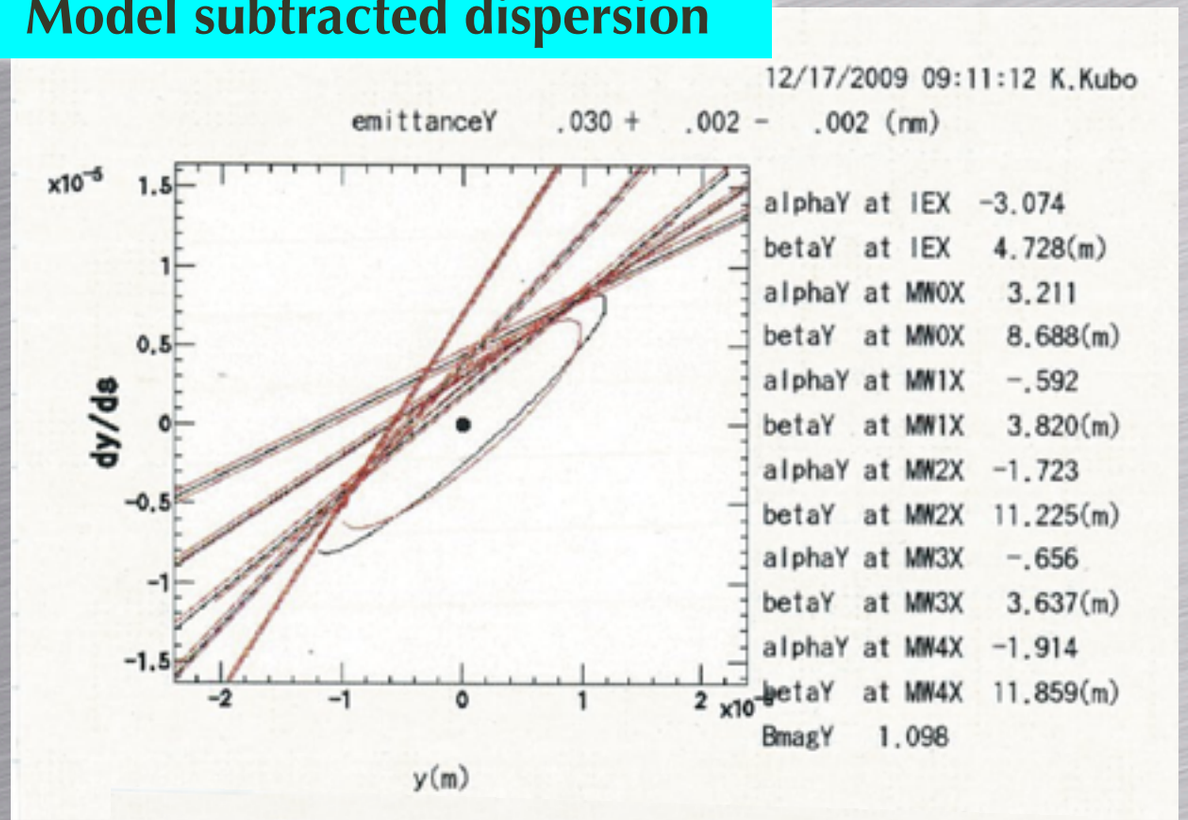
➢ Emittance improved after coupling correction

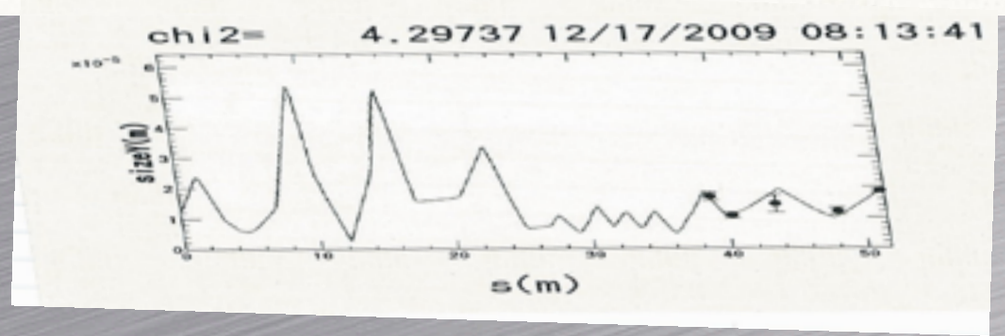
10

- 14pm vertical emittance (design=12pm).
- Full correction has yielded 11pm in the past.
- Typical DR measured emittance ~8pm.

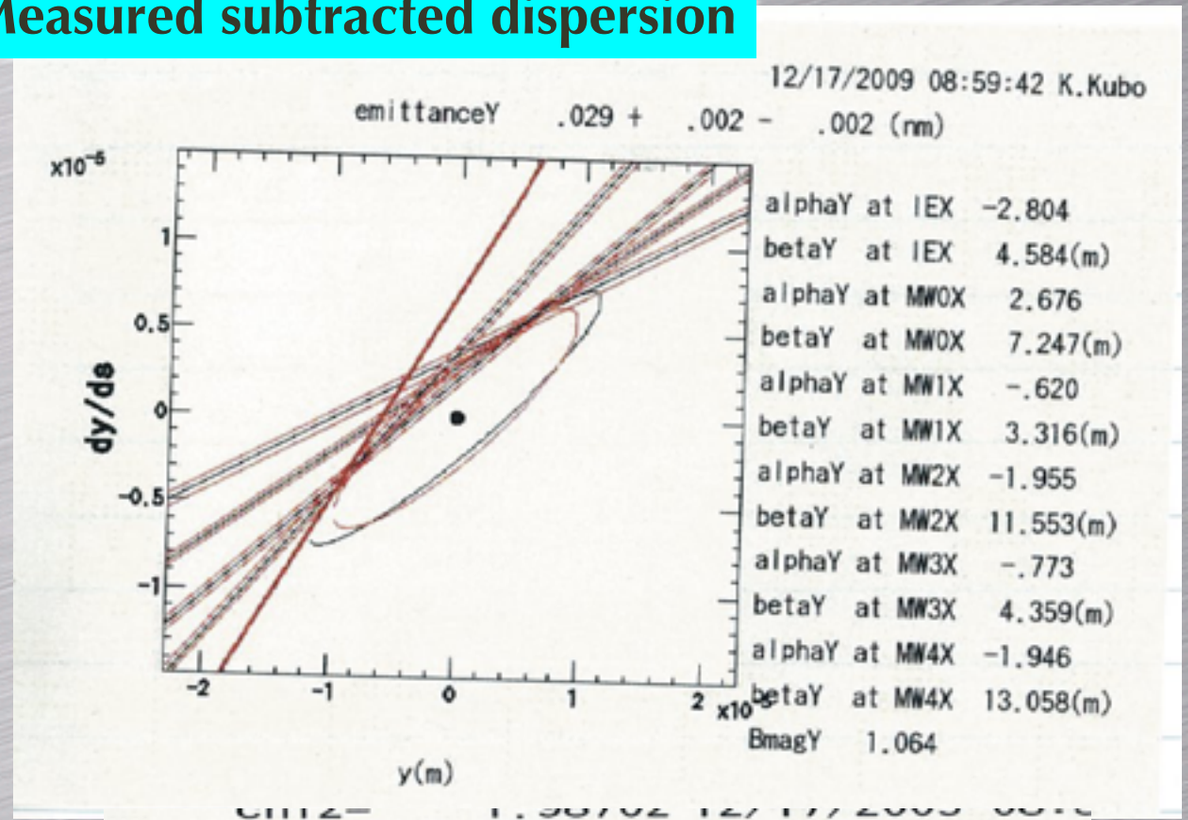
IEX Twiss Measurement (Dec)

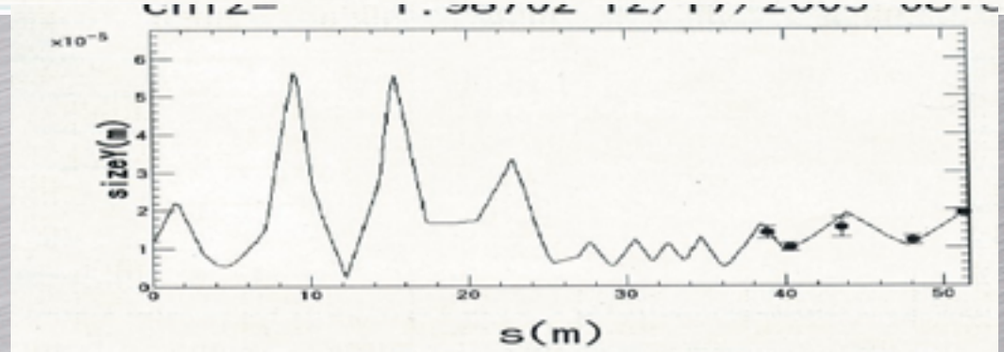
Model subtracted dispersion





Measured subtracted dispersion





From DR measurements and extrapolation to IEX (previous week):

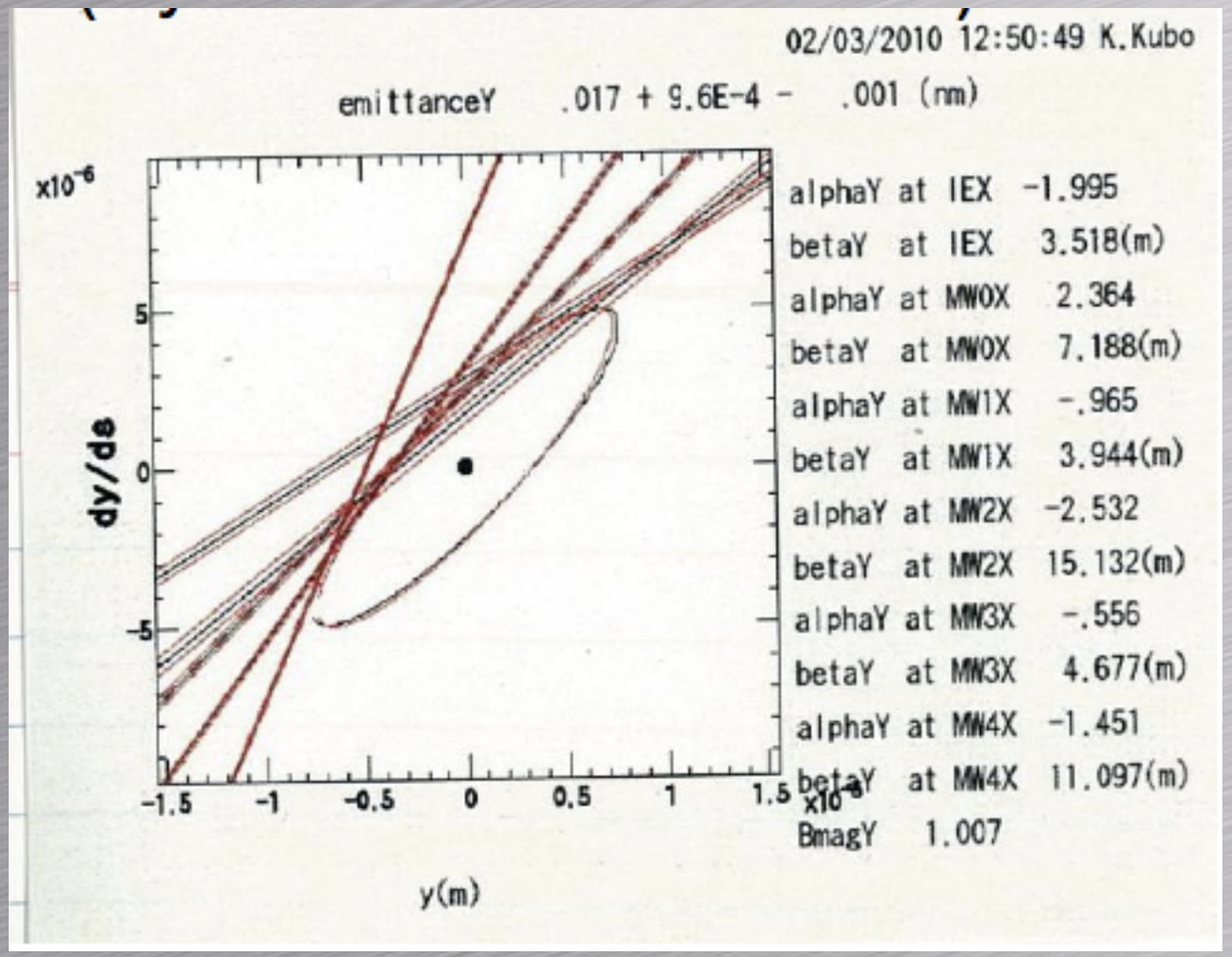
alpha_y = -3.48

beta_y = 4.71m

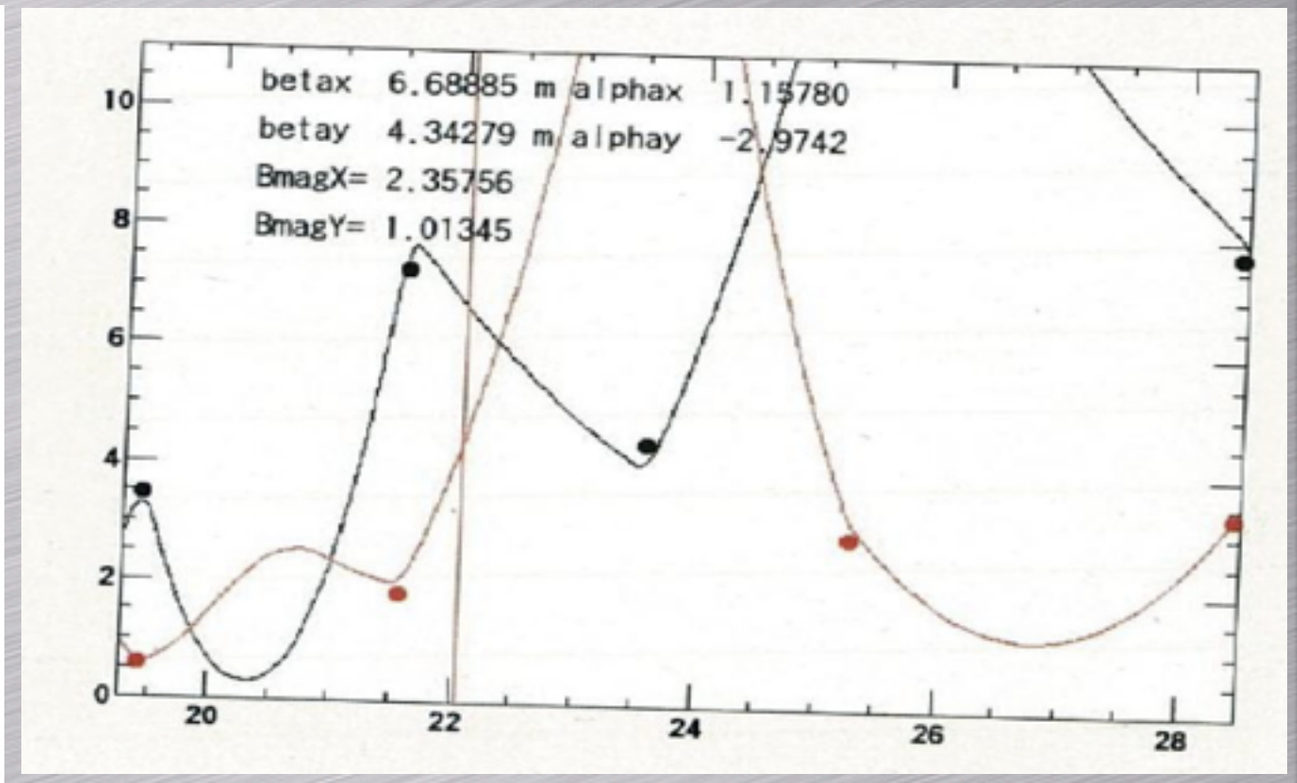
BMAGY = 1.046

IEX Twiss Measurement (Feb)

EXT Measured

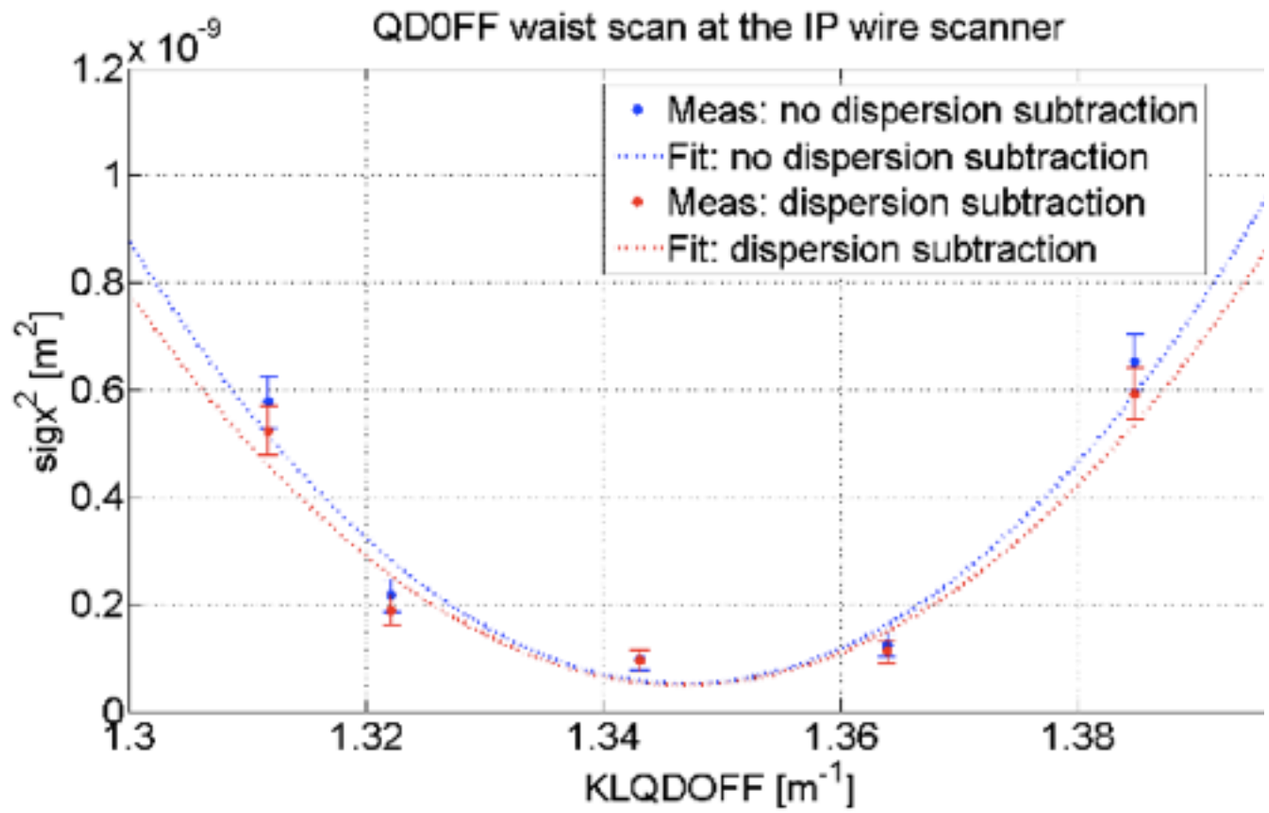


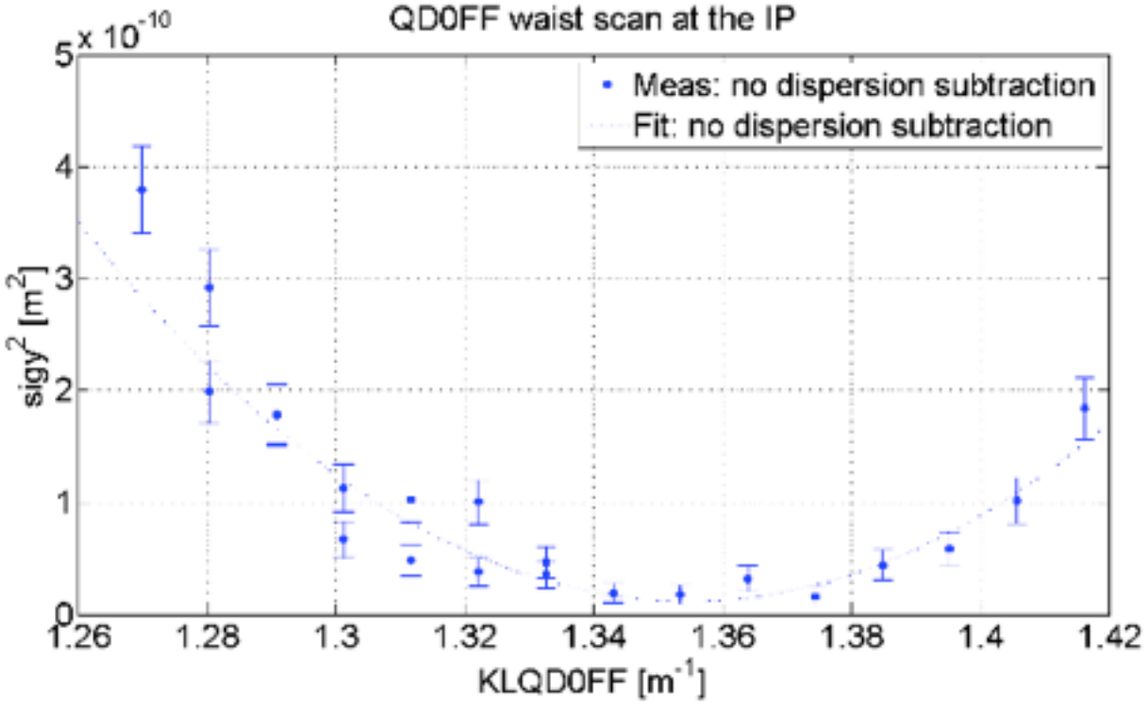
DR Measured



- Need to understand when disagreement between DR and EXT measurements.

IP Measurement

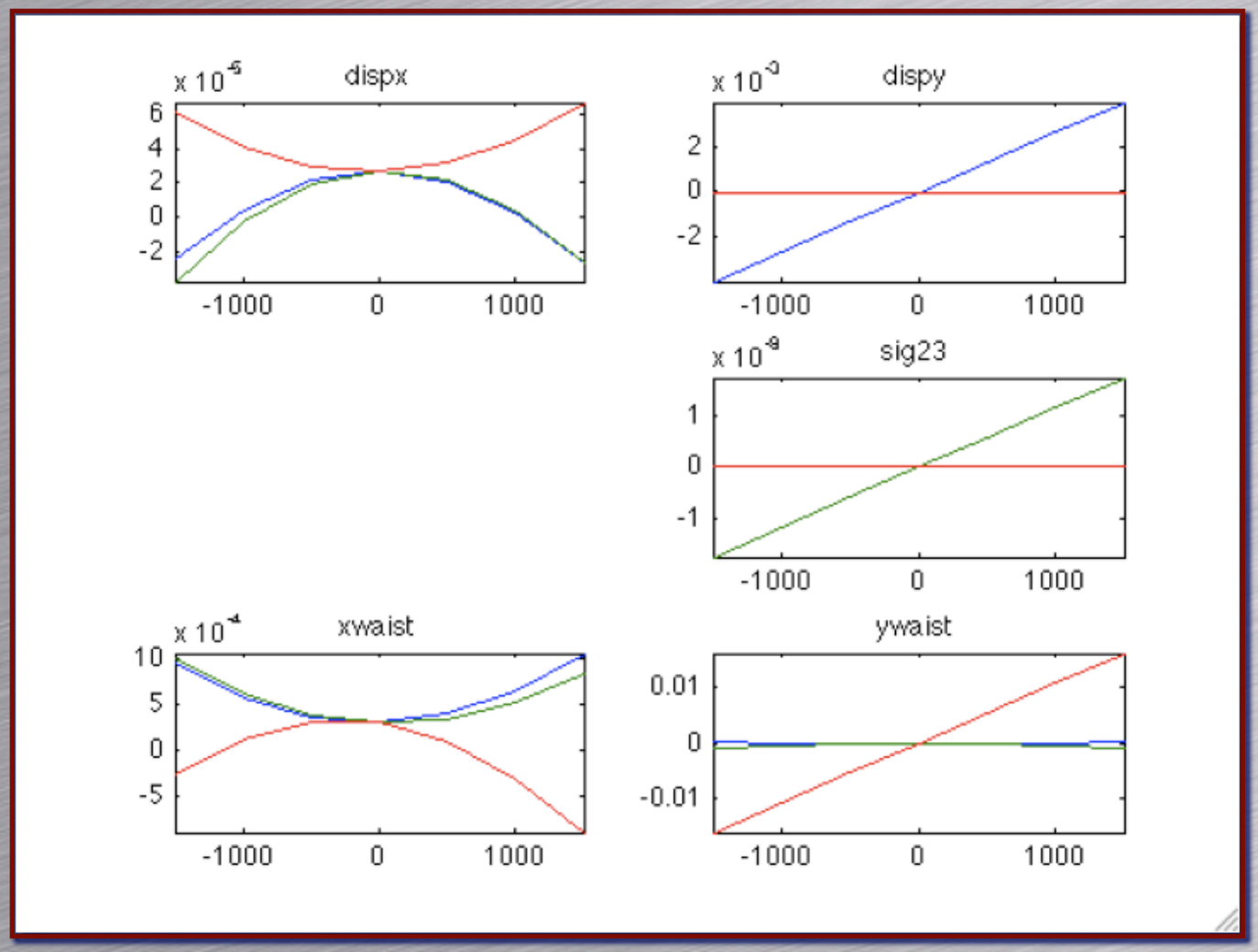




	Beta x [m] (1st Sha method)	Beta x [m] (2nd Sha method)	Emittance x [m]
No dispersion subtraction	0.015	0.022	2.38e-9
Dispersion subtraction	0.016	0.022	2.19e-9

	Beta y [m] (1st Sha method)
No dispersion subtraction	0.57e-3

Sextupole Knobs



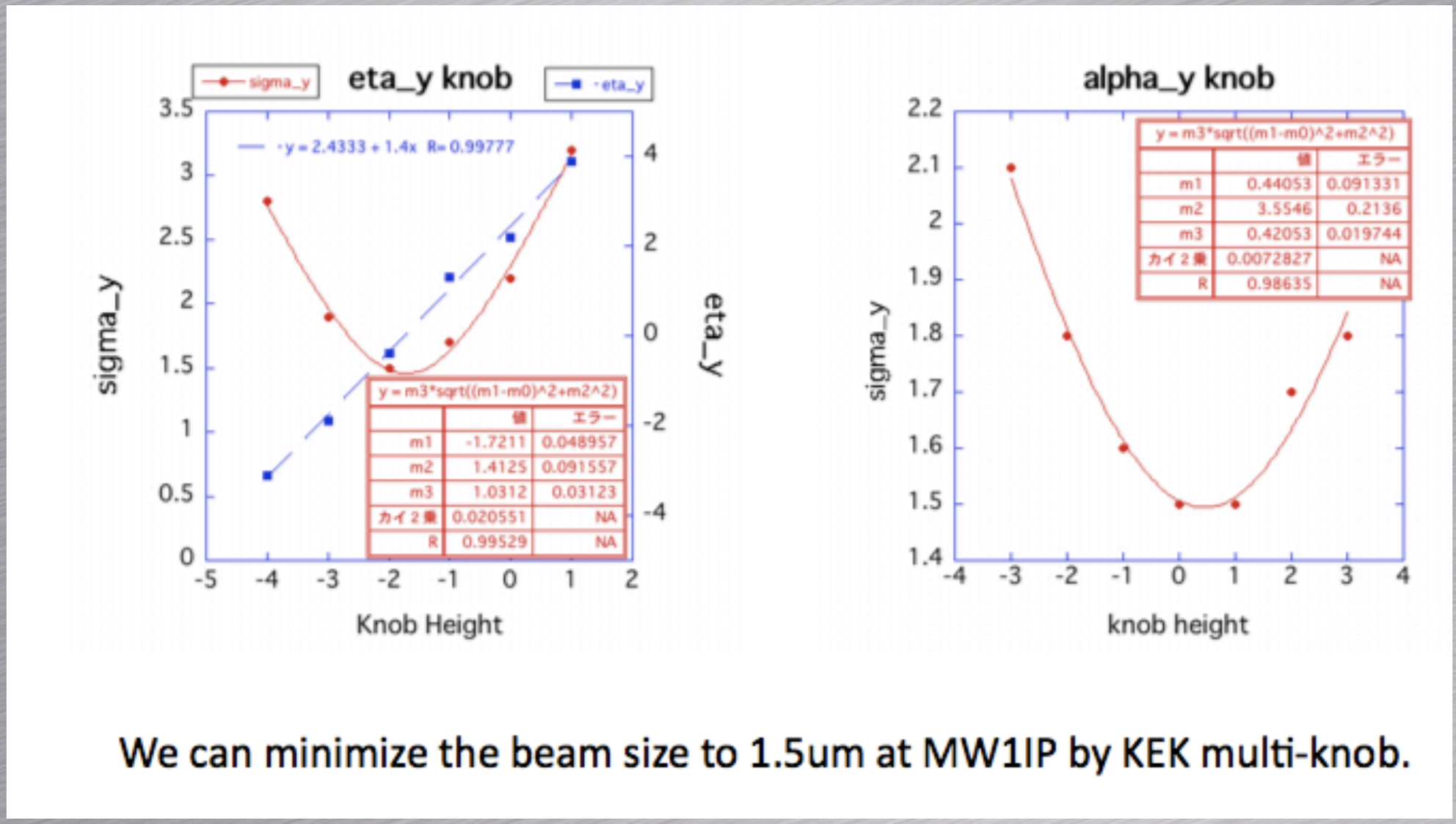
- Use FFS Sextupoles on movers to remove IP aberrations.
- Vertical moves for <x'y> and dispersion, horizontal moves for waist shifts.
- Range limited by range of movers
- Can also use mover roll for non-linear terms.

Max range of Knobs:
- DispY = 4mm
- <x'y> = 2e-9
- Y Waist = 2cm

Non-orthogonality (max % effect by other knob)

Disp Y	<x'y>	Waist Y
0.06 %	0.004%	5.9%

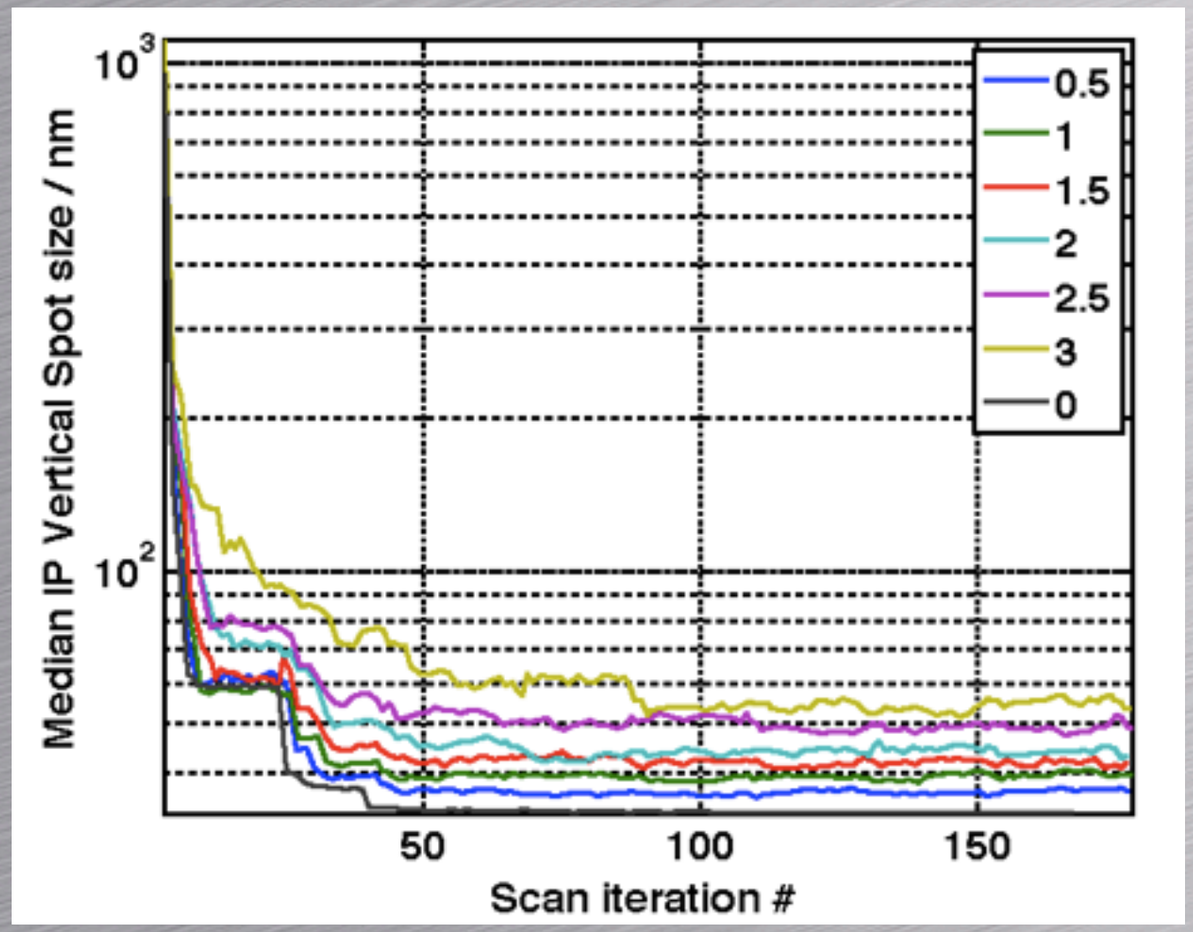
Sextupole Multiknob Application

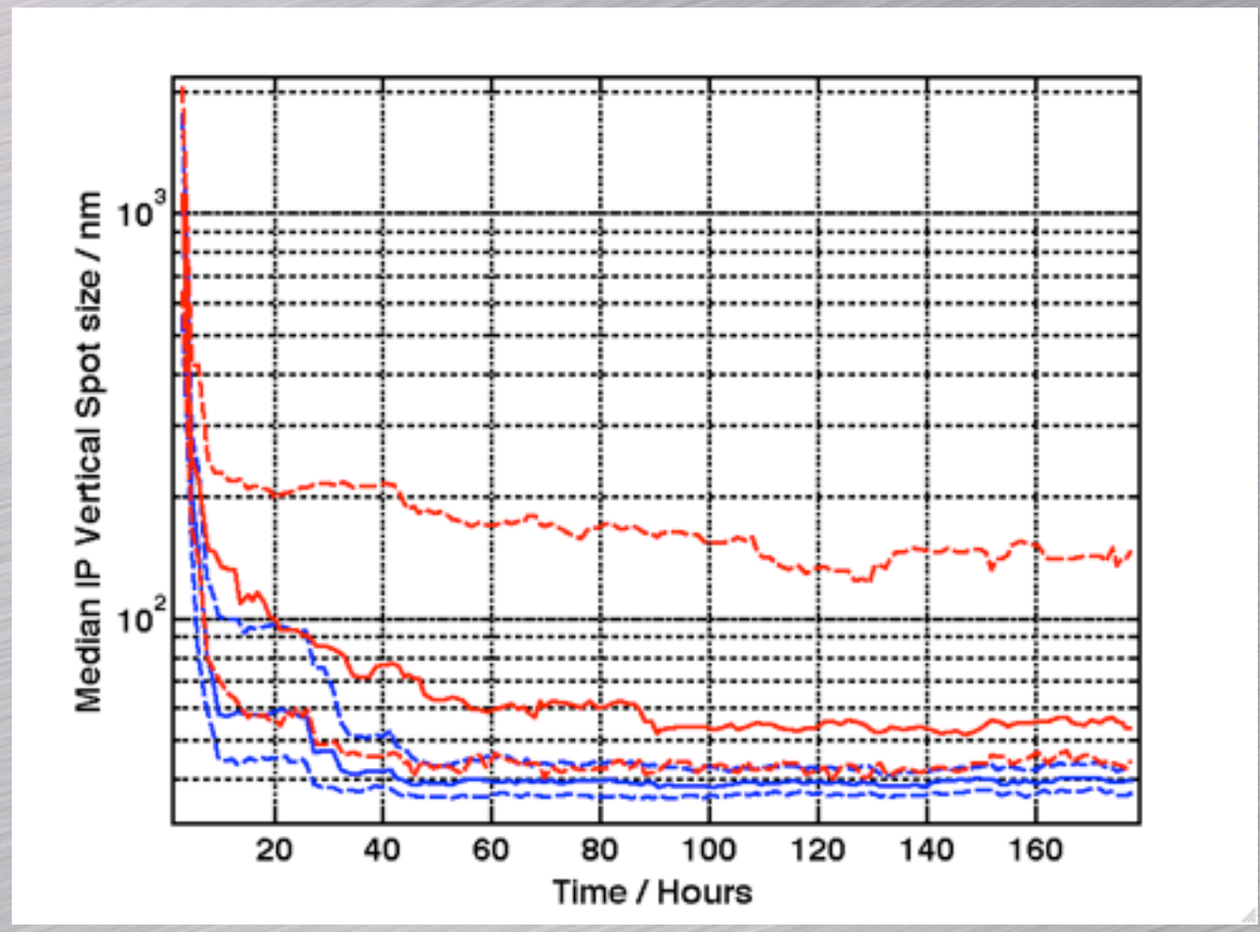


We can minimize the beam size to 1.5um at MW1IP by KEK multi-knob.

- PIP carbon wirescanner measured vertical beam size.

Tuning Simulation





- Simulations suggest it can take ~>2 days of continuous tuning to reach close to design IP spot size goal.
- Need to plan and prepare for continuous ATF2 tuning operations.

Plans Apr - June 2010

- April
  - IP tuning with IPBSM.
  - Test implementation of FFS FB.
  - Prepare for May continuous running week.
- May
  - OTR installation?
  - 17-21 continuous ATF2 tuning.
    - 15 shifts
    - Need to demonstrate required tuning software, have good co-ordination of manpower etc...

ATF2 Goals

- ~100nm Spot size by June (30 degree IPBSM mode).
- ~35nm by end 2010 (174 degree IPBSM mode).
- Reliably generate 35nm by end 2011.
- nm-level stabilization 2012.
- “Pushed beta” optics
  - Learn about tuning difficulty vs. FFS chromaticity, IP beamsize <25nm.