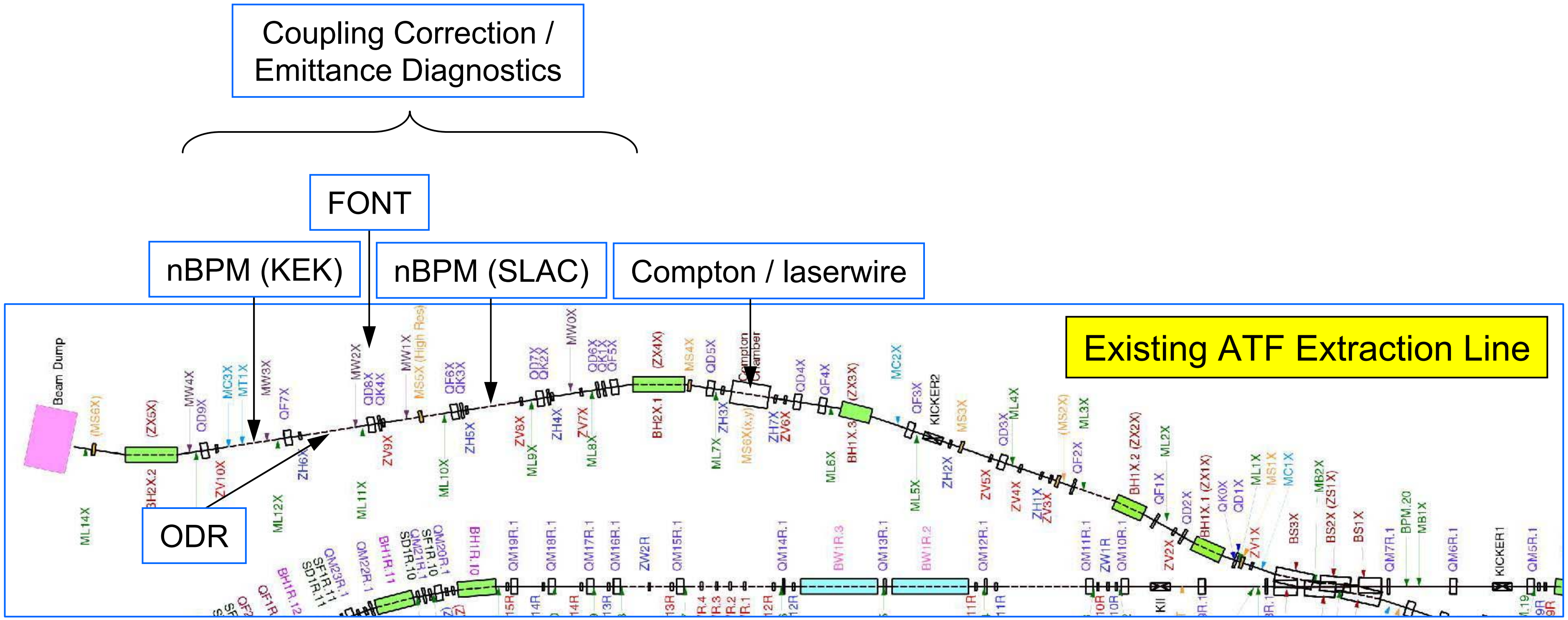
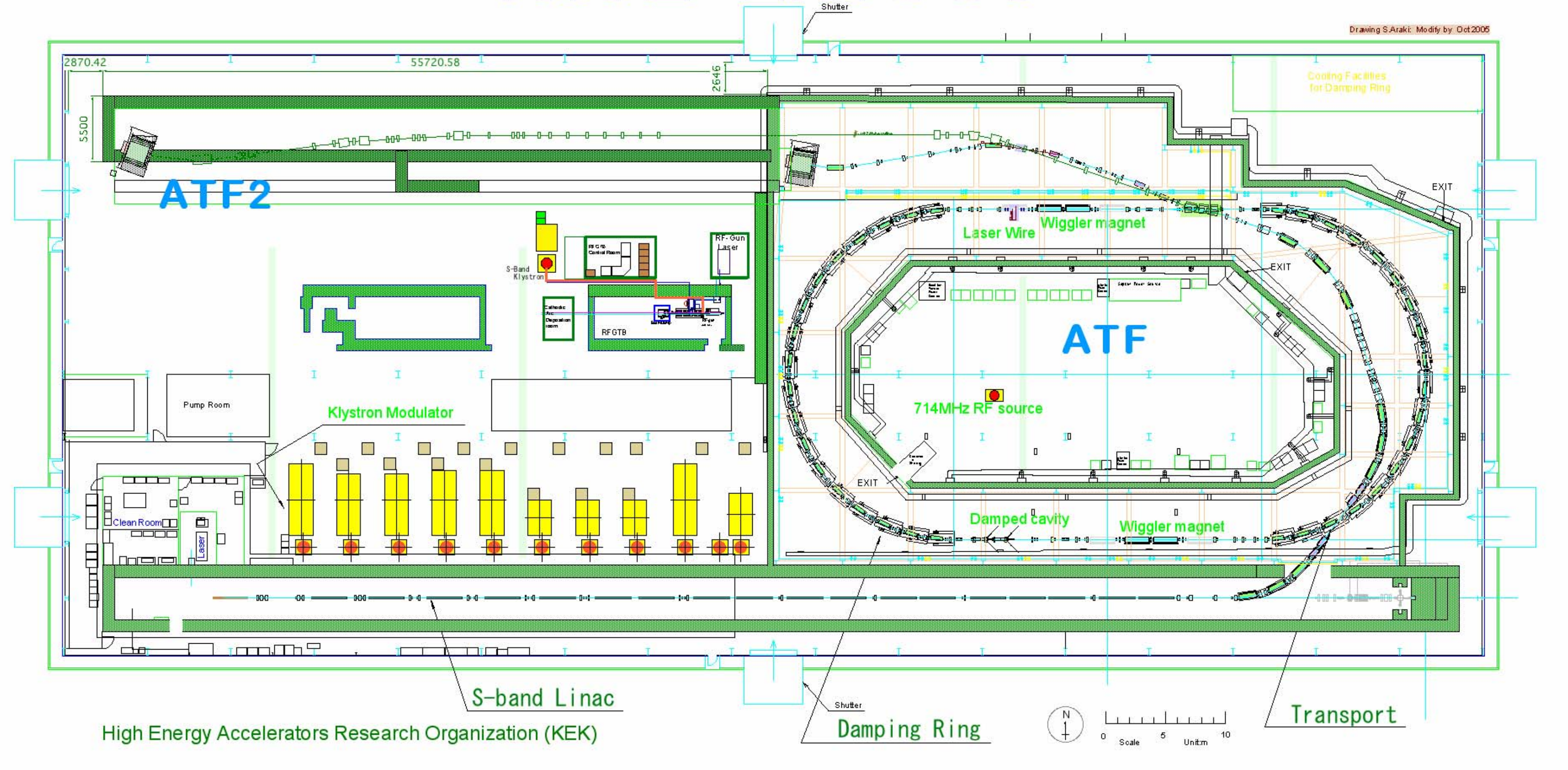
ATF2 Layout/Optics (v3.3)



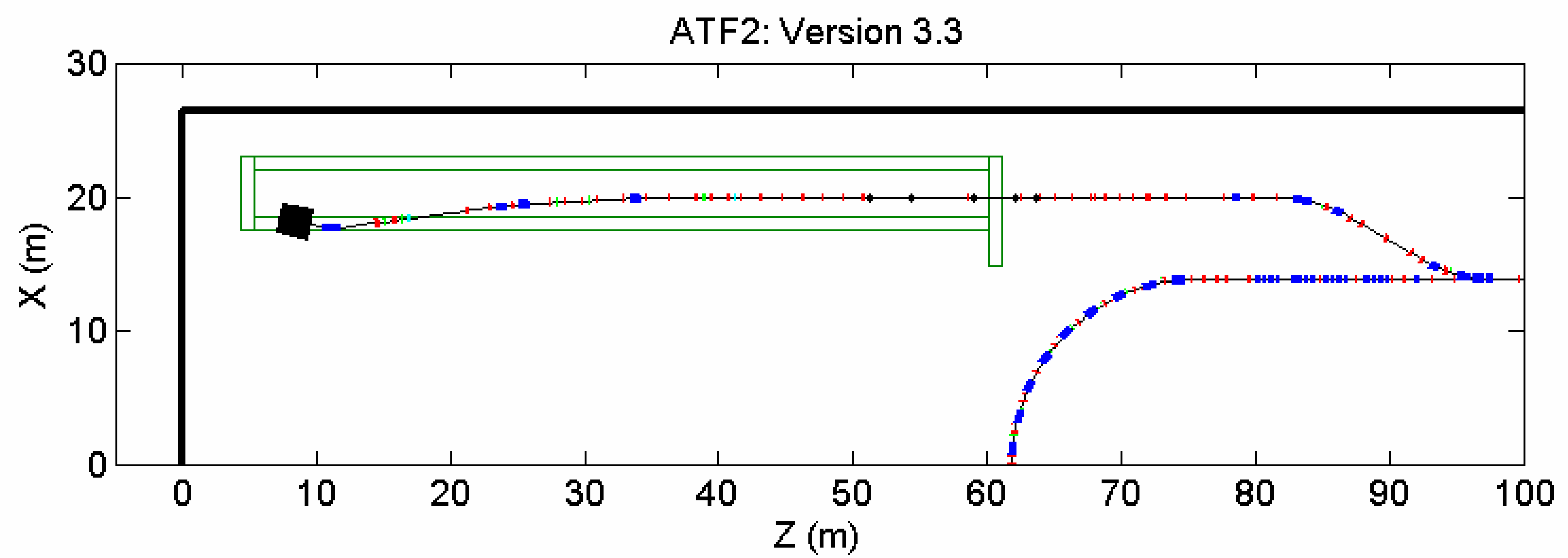
ATF2 LAYOUT



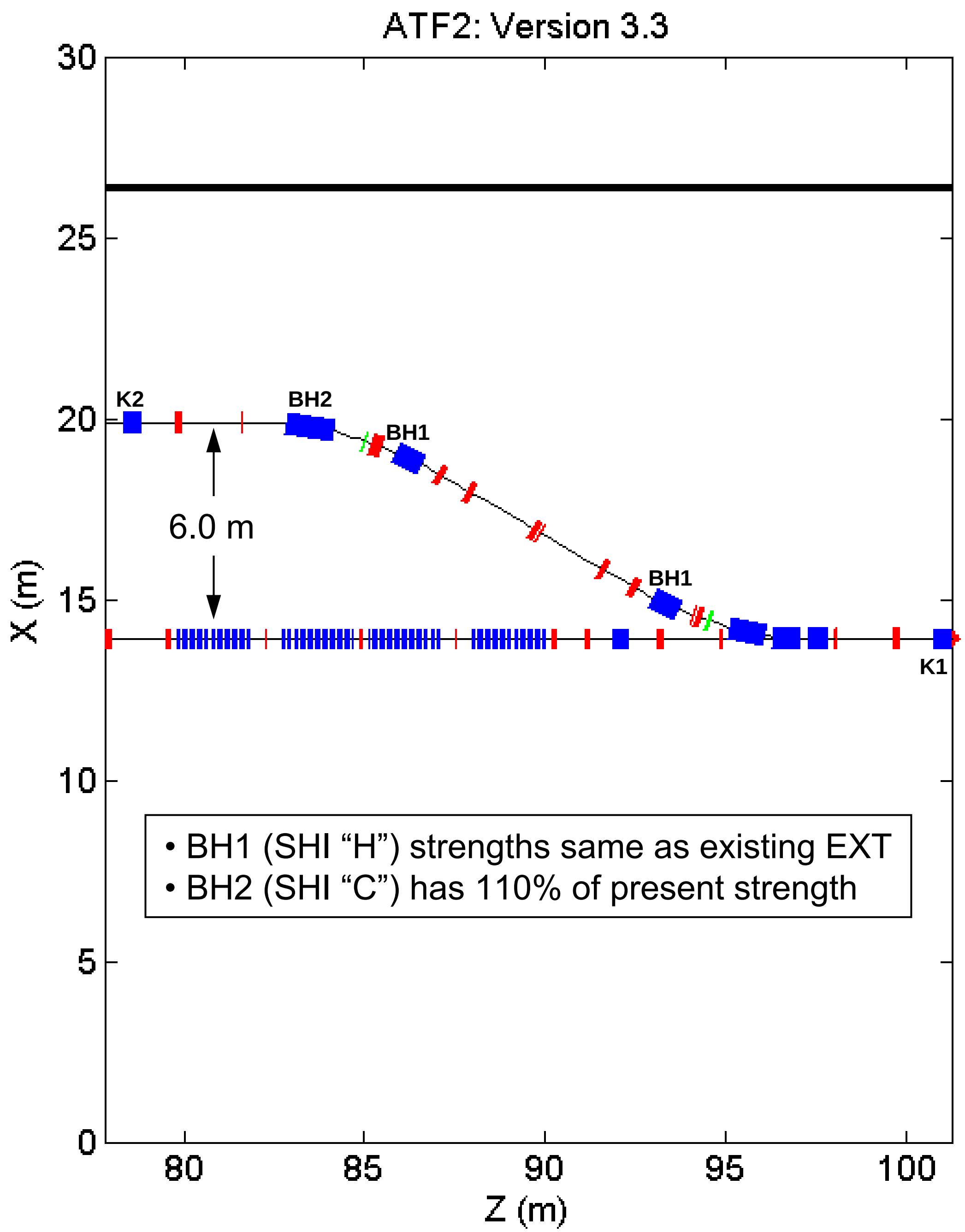
selected at the ATF2 Optics Video Meeting of April 20, 2006

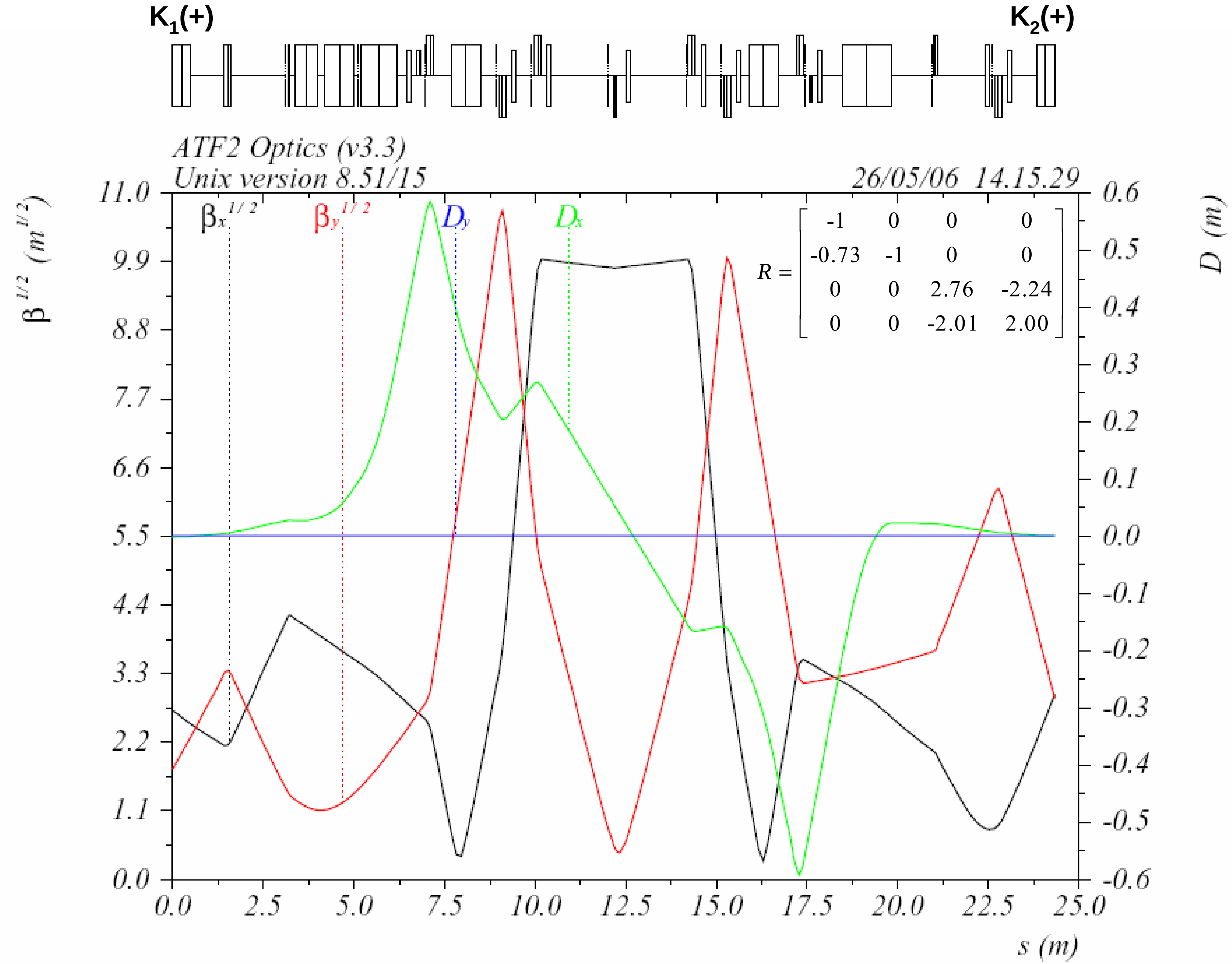
What's New in Version 3.3

- an error in the v3.2 MAD deck was fixed (drift between extraction septa #2 (BS2X) and #3 (BS3X) was incorrectly set to 0.1 m … the correct value is 0.2 m)
- drift distances between quadrupoles and sextupoles in FF lengthened to accommodate FFTB movers (per Okugi-san and Andrei)
- drift distances between IP and dump bend, and between dump bend and dump, set to Tauchi-san's latest values (also length of dump bend)
- number of skew quadrupoles for vertical dispersion correction in EXT increased from 2 to 4 (maybe)
- 2 sextupoles for vertical chromaticity correction in EXT (probably) in addition to the 2 for 2nd order horizontal dispersion
- stripline BPMs and dipole correctors added to EXT



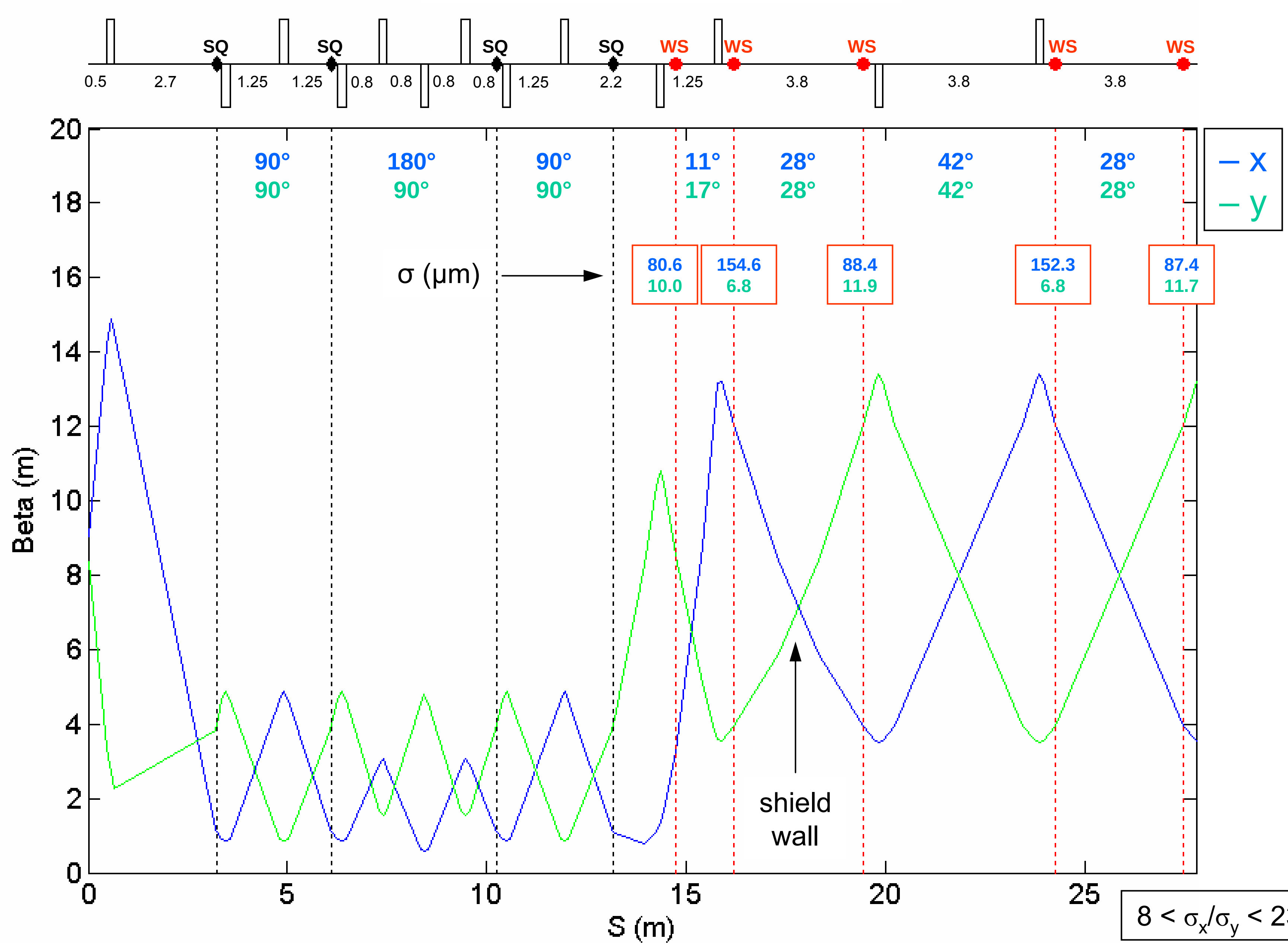
- offset between north DR straight and skew correction / diagnostic section = 6.0 m
- west Assembly Hall wall to IP = 13.3 m
- west Assembly Hall wall to center of dump bend = 11.2 m (L_{bend} = 1.35 m)
- west Assembly Hall wall to exit face of dump = 7.3 m (L_{dump} = 2.3 m)


ATF2: Version 3.3
30
25
20
15
10
5
0
80
85
90
95
100
Z (m)
X (m)
K2
BH2
BH1
BH1
K1
6.0 m
• BH1 (SHI "H") strengths same as existing EXT
• BH2 (SHI "C") has 110% of present strength

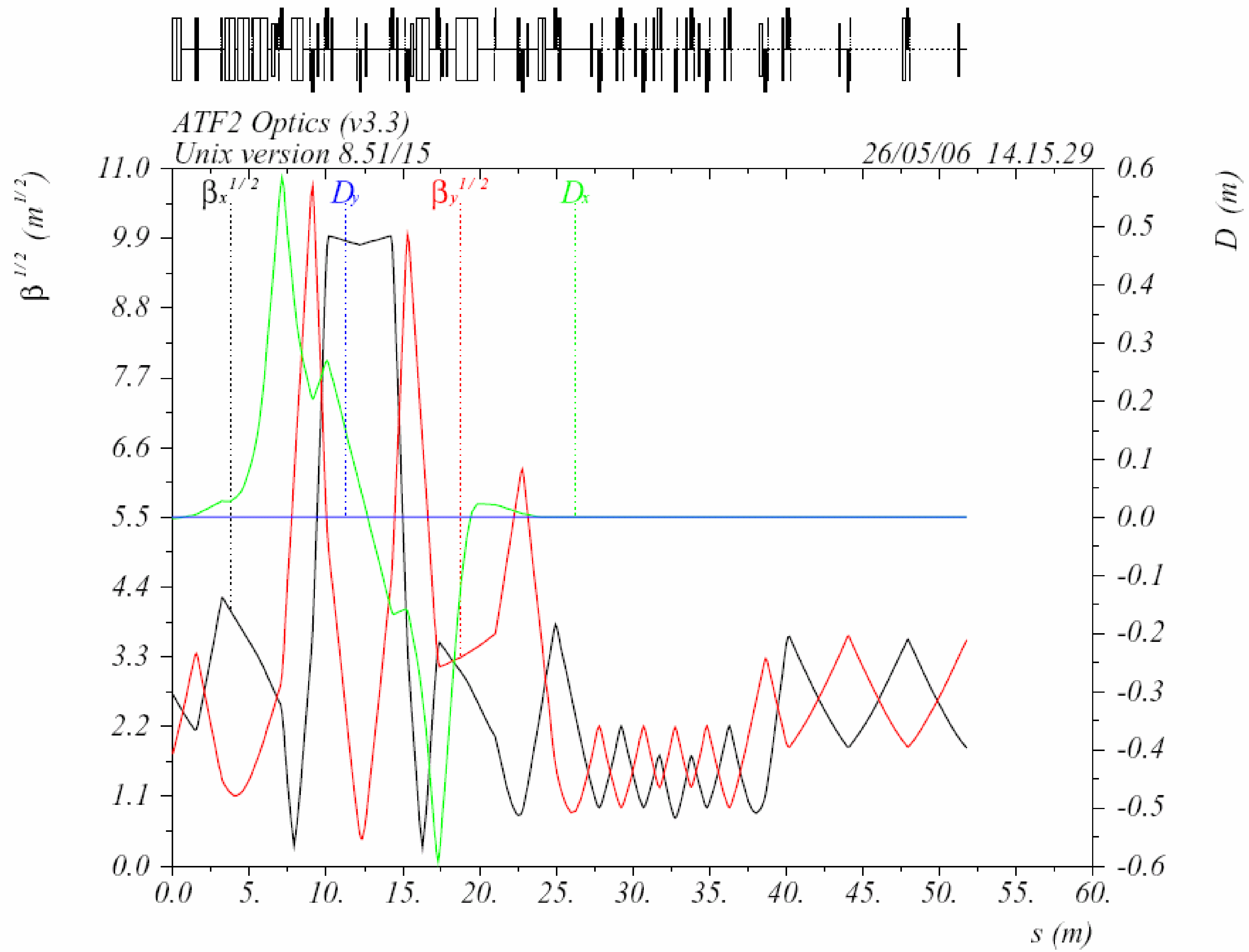


K1(+)
K2(+)
ATF2 Optics (v3.3)
Unix version 8.51/15
26/05/06 14.15.29
β^(1/2) (m^(1/2))
βx^(1/2)
βy^(1/2)
Dy
Dx
D (m)
R =
-1 0 0 0
-0.73 -1 0 0
0 0 2.76 -2.24
0 0 -2.01 2.00
s (m)

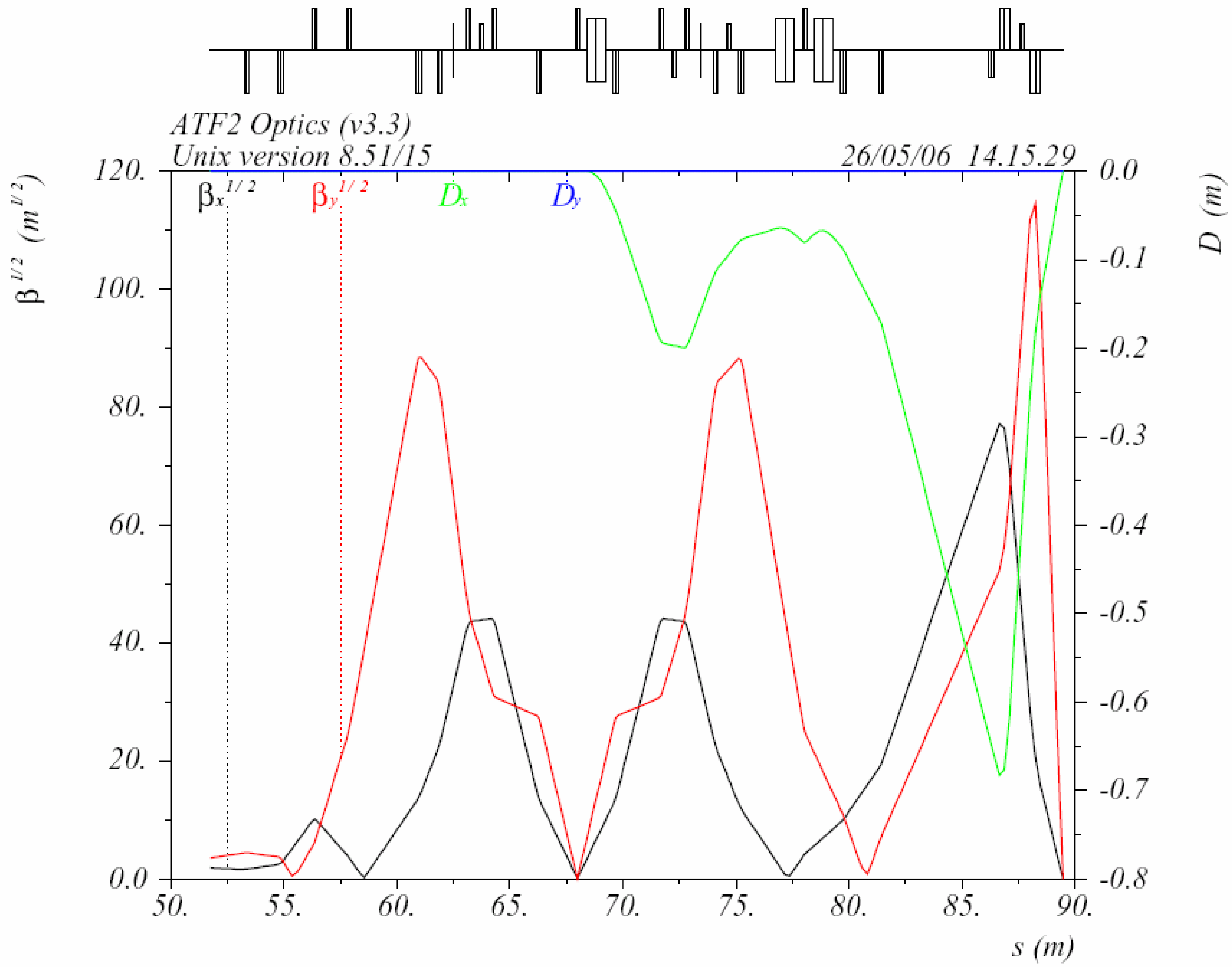
EXT Diagnostic Section (version 3.3)

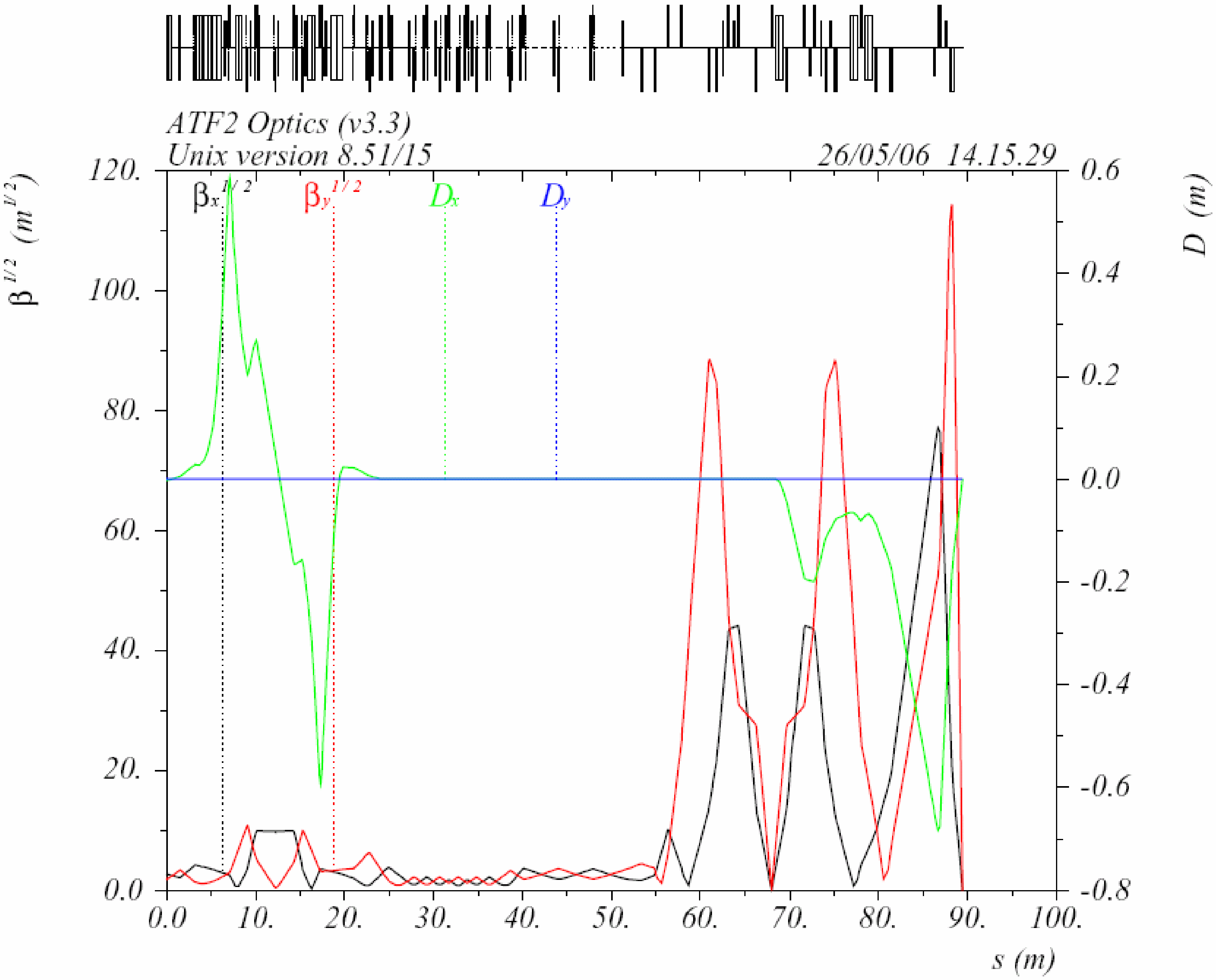


$8 < \sigma_x/\sigma_y < 23$

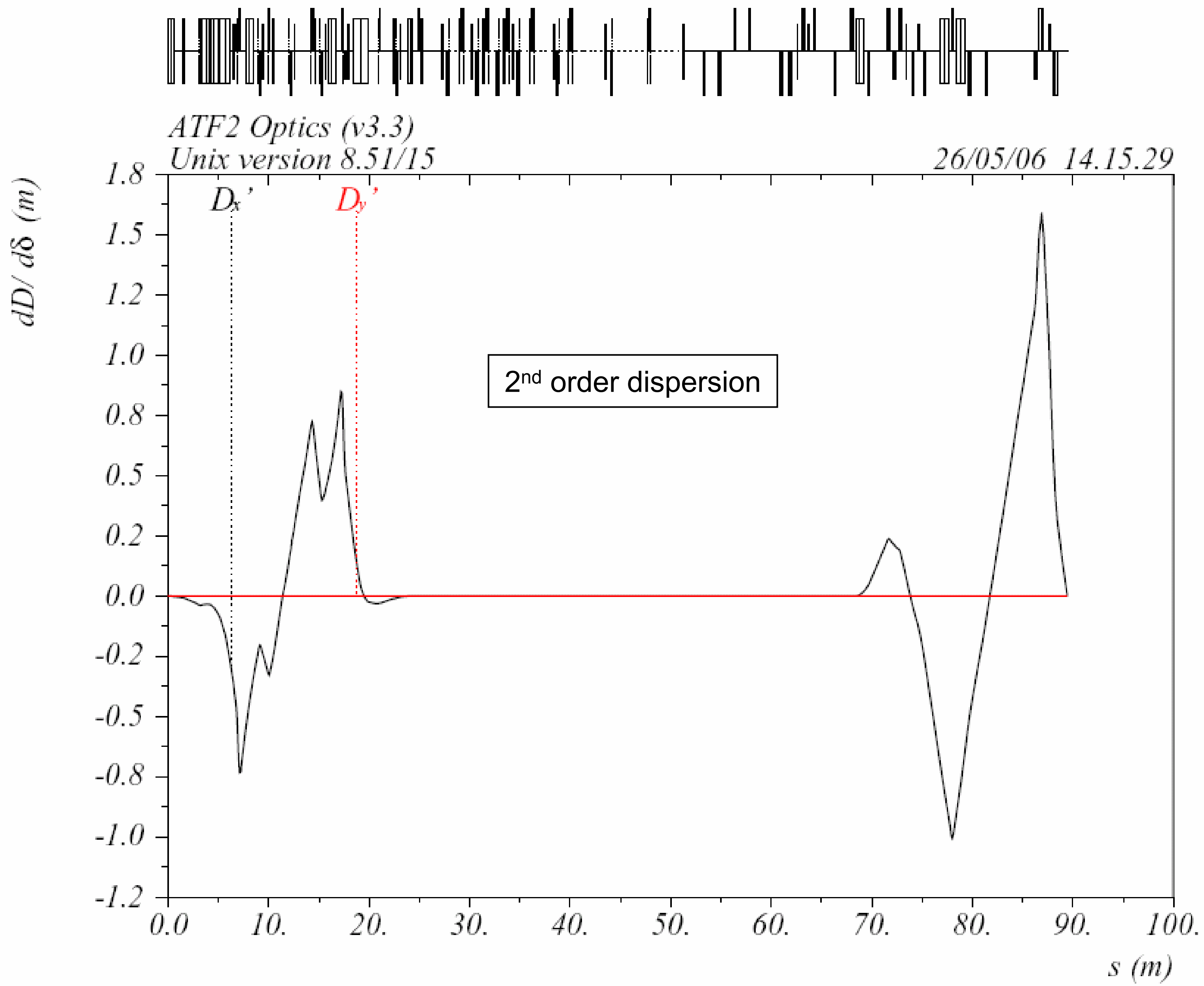


ATF2 Optics (v3.3)
Unix version 8.51/15
26/05/06 14.15.29
β^1/2 (m^1/2)
D (m)
βx^1/2
Dy
βy^1/2
Dx
11.0
9.9
8.8
7.7
6.6
5.5
4.4
3.3
2.2
1.1
0.0
0.6
0.5
0.4
0.3
0.2
0.1
0.0
-0.1
-0.2
-0.3
-0.4
-0.5
-0.6
0.0 5. 10. 15. 20. 25. 30. 35. 40. 45. 50. 55. 60.
s (m)


ATF2 Optics (v3.3)
Unix version 8.51/15
26/05/06 14.15.29
$\beta_x^{1/2}$
$\beta_y^{1/2}$
D_x
D_y
$\beta^{1/2}$ ($m^{1/2}$)
D (m)
s (m)
120.
100.
80.
60.
40.
20.
0.0
-0.1
-0.2
-0.3
-0.4
-0.5
-0.6
-0.7
-0.8
50.
55.
60.
65.
70.
75.
80.
85.
90.



ATF2 Optics (v3.3)
Unix version 8.51/15
26/05/06 14.15.29
$\beta_x^{1/2}$
$\beta_y^{1/2}$
D_x
D_y
$\beta^{1/2}$ $(m^{1/2})$
D (m)
s (m)
120.
100.
80.
60.
40.
20.
0.0
0.6
0.4
0.2
0.0
-0.2
-0.4
-0.6
-0.8
0.0
10.
20.
30.
40.
50.
60.
70.
80.
90.
100.


ATF2 Optics (v3.3)
Unix version 8.51/15
26/05/06 14.15.29
D_x'
D_y'
2nd order dispersion
dD/ dδ (m)
s (m)
1.8
1.5
1.2
1.0
0.8
0.5
0.2
0.0
-0.2
-0.5
-0.8
-1.0
-1.2
0.0
10.
20.
30.
40.
50.
60.
70.
80.
90.
100.

Parameters

energy = 1.3 GeV
$\gamma\varepsilon_x = 5\times10^{-6}$ m
$\varepsilon_x = 2\times10^{-9}$ m
$\gamma\varepsilon_y = 3\times10^{-8}$ m
$\varepsilon_y = 1\times10^{-11}$ m
$\sigma_z = 8$ mm
$\sigma_\delta = 0.08$ %
$\beta_x^* = 4$ mm
$\beta_y^* = 0.1$ mm
$\sigma_x^* = 2.828$ μm
$\sigma_y^* = 34$ nm

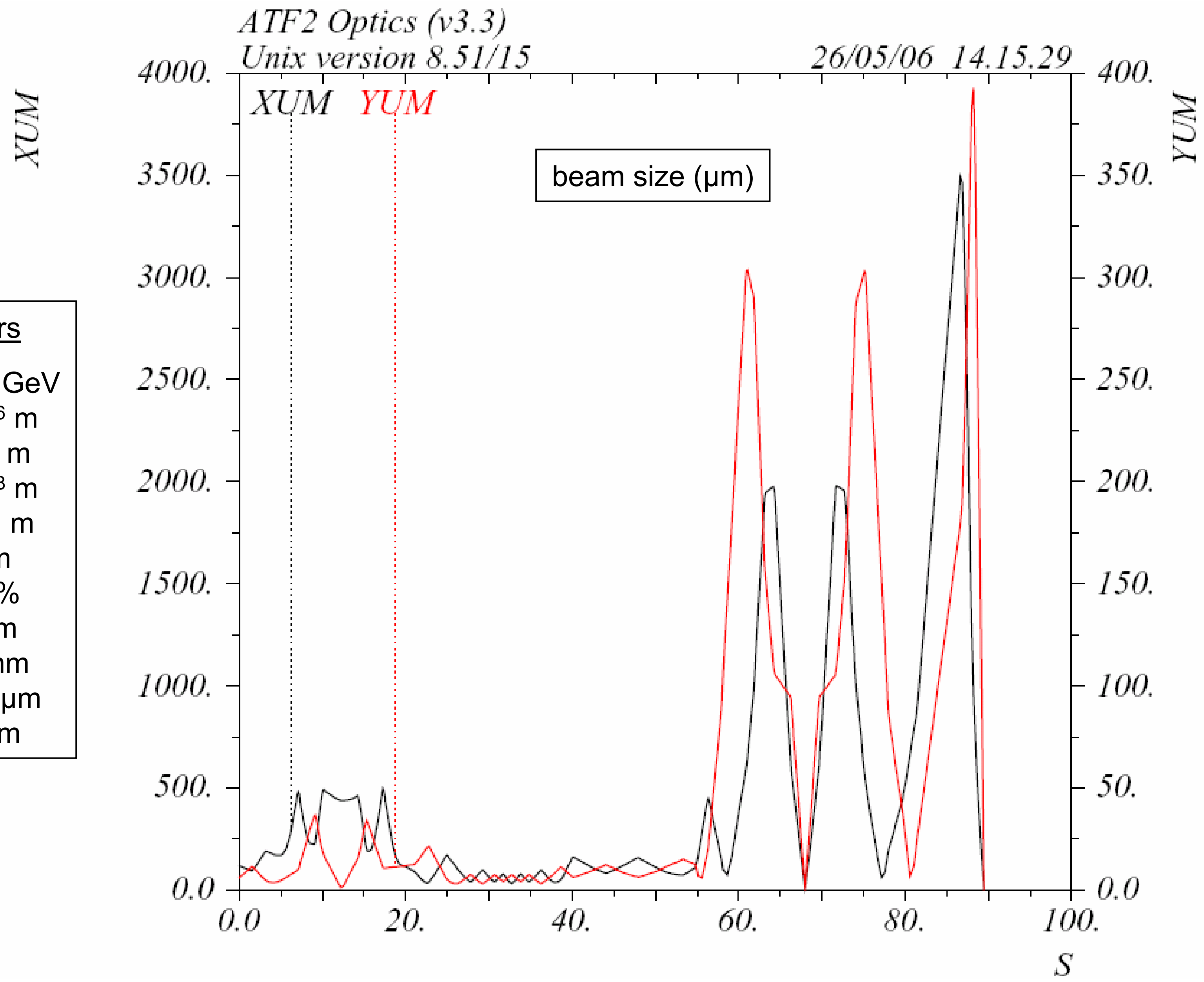


TABLE 1: existing ATF EXT quadrupoles

power supply maximum currents from N. Terunuma email (April 22, 2005)

a note on names: the "quad name" column names the location in the beam line; the "magnet name" column names the physical magnet that presently resides at each location; the "power supply" column names the power supply whose cables come to that location

quad name	magnet name	magnet type	power supply	Imax p.s.	KLmax @ 1.3 GeV	notes
QD1X	QD1Xmag	Hitachi 2	QD1Xps	100	0.6657	
QD2X	QD2Xmag	Hitachi 2	QD2Xps	100	0.6657	
QF1X	QF1Xmag	Hitachi 2	QF1Xps	100	0.6657	
QK0X	QK0Xmag	ECUBE skew	QK0Xps	20	2.7673e-4	
QS1X	QS1Xmag	ECUBE skew	QS1Xps	20	2.7673e-4	
QF2X	QF2Xmag	Hitachi 1	QF2Xps	100	0.2989	
QD3X	QD3Xmag	Hitachi 5	QD3Xps	100	2.1050	
QF3X	QF3Xmag	Hitachi 5	QF3Xps	100	2.1050	
QF4X	QF4Xmag	Hitachi 5	QF4Xps	100	2.1050	
QS2X	QS2Xmag	ECUBE skew	QS2Xps	20	2.7673e-4	
QD4X	QD4Xmag	Hitachi 5	QD4Xps	200	2.1050	use Imax = 100 amps
QD5X	QD5Xmag	Hitachi 5	QD5Xps	100	2.1050	
BH4X	....	....	....	....	....	....
QF5X	QF5Xmag	Hitachi 5	QF5Xps	100	2.1050	
QK1X	QK1Xmag	IDX skew	QK1Xps	5	2.5363e-2	
QD6X	QD6Xmag	Tokin 3393	QD6Xps	100	0.3021	
QK2X	QK2Xmag	IDX skew	QK2Xps	5	2.5363e-2	
QD7X	QD7Xmag	Hitachi 5	QD7Xps	100	2.1050	
QK3X	QK3Xmag	IDX skew	QK3Xps	5	2.5363e-2	
QF6X	QF6Xmag	Hitachi 5	QF6Xps	100	2.1050	
QK4X	QK4Xmag	IDX skew	QK4Xps	5	2.5363e-2	
QD8X	QD8Xmag	Hitachi 4	QD8Xps	200	2.0650	
QF7X	QF7Xmag	Hitachi 4	QF7Xps	100	1.0488	
QD9X	QD9Xmag	Hitachi 4	------	---	2.0650	in series with QD8X

magnetic measurements data file	Imax
ATF$MAG:MAG_KI_Q_HITACHI_1.FOR	140.2
ATF$MAG:MAG_KI_Q_HITACHI_2.FOR	100.2
ATF$MAG:MAG_KI_Q_HITACHI_4.FOR	200.4
ATF$MAG:MAG_KI_Q_HITACHI_5.FOR	100.6
ATF$MAG:MAG_KI_Q_TOKIN_3393.FOR	139.0
ATF$MAG:MAG_KI_Q_IDX_SKEW.FOR	20.0
ATF$MAG:MAG_KI_Q_ECUBE_SKEW	20.0

TABLE 2: ATF2 EXT quadrupoles ("**optimal 2**")

quad name	magnet name	magnet type	power supply	Imax p.s.	KLmax	KL	NOTEs (see below)
QD1X	QD6Xmag	Tokin 3393	QD1Xps	100	0.3021	-0.2500	2
QD2X	QD2Xmag	Hitachi 2	QD2Xps	100	0.6657	-0.2529	
QF1X	QF1Xmag	Hitachi 2	QF1Xps	100	0.6657	0.3554	
QK0X	QK0Xmag	ECUBE skew	QK0Xps	20	2.7673e-4	0.0	
QS1X	QS1Xmag	ECUBE skew	QS1Xps	20	2.7673e-4	0.0	
QF2X	QF2Xmag	Hitachi 1	QF2Xps	100	0.2989	0.2122	
QD3X	QD3Xmag	Hitachi 5	QD3Xps	100	2.1050	-0.5507	
QF3X	QF3Xmag	Hitachi 5	QF3Xps	100	2.1050	0.3238	
QMX	QF5Xmag	Hitachi 5	QF5Xps	100	2.1050	0.7293	3
QF4X	-------	IHEP	------	100	2.5	2.0628	1,4
QS2X	QS2Xmag	ECUBE skew	QS2Xps	20	2.7673e-4	0.0	
QD4X	QD4Xmag	Hitachi 5	QF7Xps	100	2.1050	-1.3399	5
QF5X	QD5Xmag	Hitachi 5	QD5Xps	100	2.1050	0.6193	
BH4X	....	....	....	....	....	....	....
QD5X	QD1Xmag	Hitachi 2	QD6Xps	100	0.6657	-0.3528	2
QK1X	QK1Xmag	IDX skew	QK1Xps	5	2.5363e-2	0.0	
QD6X	QD7Xmag	Hitachi 5	QD7Xps	100	2.1050	-1.2504	
QF6X	QF6Xmag	Hitachi 5	QF6Xps	100	2.1050	1.2504	
QK2X	QK2Xmag	IDX skew	QK2Xps	5	2.5363e-2	0.0	
QD7X	QF4Xmag	Hitachi 5	QF4Xps	100	2.1050	-1.2504	
QF7X	QD8Xmag	Hitachi 4	QD8Xps	200	2.0650	1.6706	6
QD8X	QF7Xmag	Hitachi 4	QD4Xps	200	2.0650	-1.2478	5
QF8X	QD9Xmag	Hitachi 4	------	200	2.0650	1.6706	6
QK3X	QK3Xmag	IDX skew	QK3Xps	5	2.5363e-2	0.0	
QD9X	-------	IHEP	------	100	2.5	-1.2504	1
QF9X	-------	IHEP	------	100	2.5	1.2504	1
QK4X	QK4Xmag	IDX skew	QK4Xps	5	2.5363e-2	0.0	
QD10X	-------	IHEP	------	100	2.5	-0.8436	1
QF10X	-------	IHEP	------	100	2.5	0.8106	1
QD11X	-------	IHEP	------	100	2.5	-0.3753	1
QF11X	-------	IHEP	------	100	2.5	0.3753	1
QD12X	-------	IHEP	------	100	2.5	-0.3753	1

note: IHEP quadrupole needs > 135 amps to reach KL = 2.5

TABLE 3: ATF2 EXT quadrupoles ("**version 3.3**")

quad name	magnet name	magnet type	power supply	Imax p.s.	KLmax	KL	NOTEs
Q1X	QD3Xmag	Hitachi 5	QD3Xps	100	2.1050	1.0465	
QS1X	-------		------	5	2.5363e-2	0.0	new magnet (?)
Q2X	QF3Xmag	Hitachi 5	QF3Xps	100	2.1050	-0.9369	
Q3X	QF4Xmag	Hitachi 5	QF4Xps	100	2.1050	0.6779	
QS2X	-------		------	5	2.5363e-2	0.0	new magnet (?)
Q4X	QD6Xmag	Tokin 3393	QD6Xps	100	0.3021	-0.0141	
QS3X	-------		------	5	2.5363e-2	0.0	new magnet (?)
Q5X	QD4Xmag	Hitachi 5	QD4Xps	100	2.1050	0.7014	
Q6X	QD5Xmag	Hitachi 5	QD5Xps	100	2.1050	-0.9331	
QS4X	-------		------	5	2.5363e-2	0.0	new magnet (?)
Q7X	QF5Xmag	Hitachi 5	QF5Xps	100	2.1050	1.1083	
Q8X	QD1Xmag	Hitachi 2	QD1Xps	100	0.6657	0.3651	
Q9X	QD7Xmag	Hitachi 5	QD7Xps	100	2.1050	-0.6084	
Q10X	QF6Xmag	Hitachi 5	QF6Xps	100	2.1050	0.7049	
QK1X	QK1Xmag	IDX skew	QK1Xps	5	2.5363e-2	0.0	
Q11X	-------	IHEP	------	100	2.1	-1.0237	
Q12X	-------	IHEP	------	100	2.1	1.0237	
QK2X	QK2Xmag	IDX skew	QK2Xps	5	2.5363e-2	0.0	
Q13X	-------	IHEP	------	100	2.1	-1.0237	
Q14X	QD8Xmag	Hitachi 4	QD8Xps	200	2.0650	1.3683	
Q15X	QF7Xmag	Hitachi 4	QF7Xps	100	1.0488	-1.0152	
Q16X	QD9Xmag	Hitachi 4	------	---	2.0650	1.3683	in series with Q14X
QK3X	QK3Xmag	IDX skew	QK3Xps	5	2.5363e-2	0.0	
Q17X	-------	IHEP	------	100	2.1	-1.0237	
Q18X	-------	IHEP	------	100	2.1	1.0237	
QK4X	QK4Xmag	IDX skew	QK4Xps	5	2.5363e-2	0.0	
Q19X	-------	IHEP	------	100	2.1	-0.6833	
Q20X	-------	IHEP	------	100	2.1	0.6552	
Q21X	QD2Xmag	Hitachi 2	QD2Xps	100	0.6657	-0.2989	
Q22X	QF1Xmag	Hitachi 2	QF1Xps	100	0.6657	0.2989	

note: QF2X (Hitachi 1) and one IHEP quadrupole are left over

EXT Performance Simulations (Preliminary)

Simulation Parameters

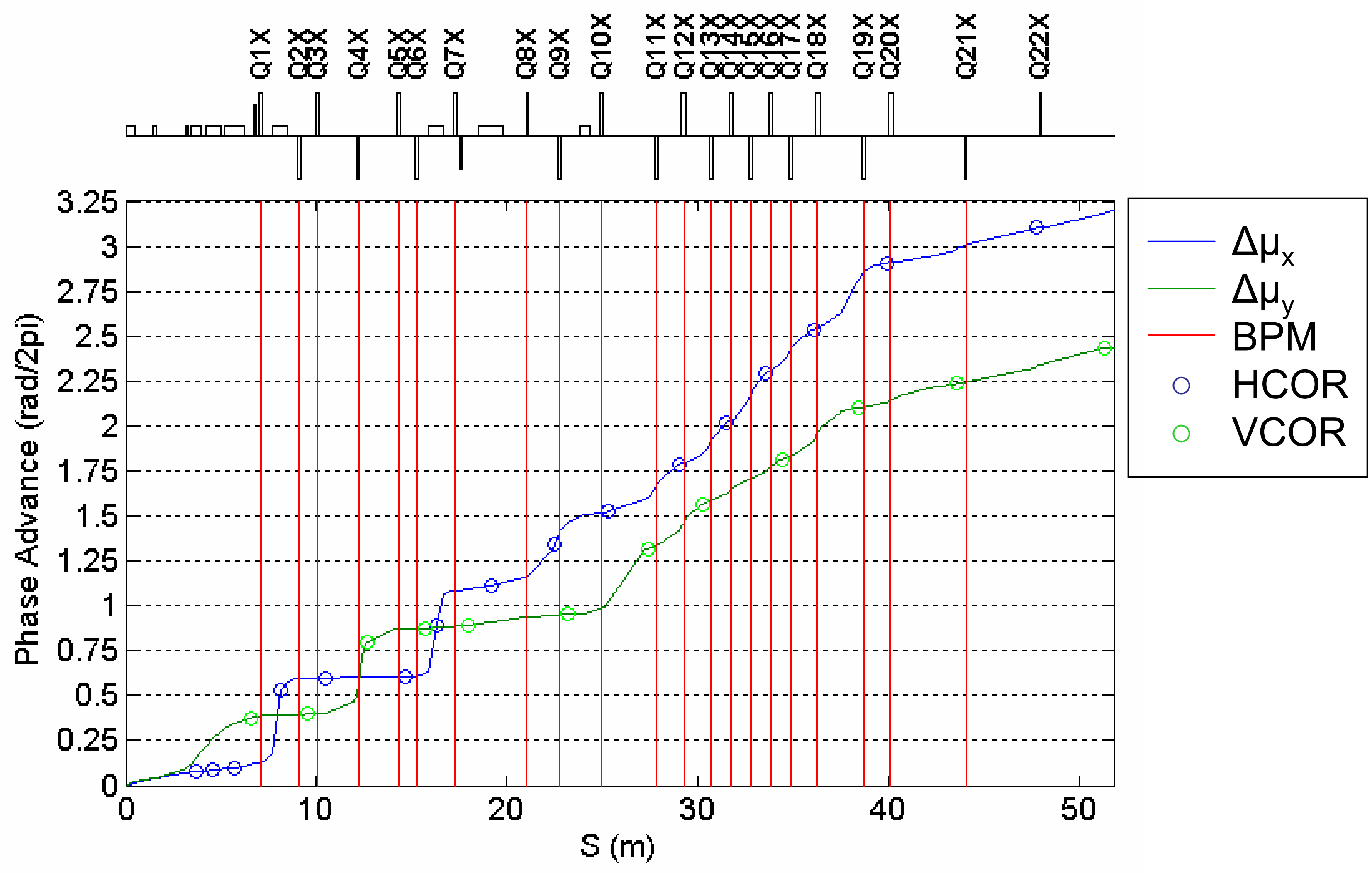
- included
  - perfect beam from Damping Ring (ε_x=2×10^{-9} m, $\gamma\varepsilon_y$=3×10^{-8} m)
  - perfect Final Focus (QM16 to IP)
  - vertical dipole misalignments[1]: 100 μm (rms)
  - horizontal quadrupole misalignments: 50 μm (rms)
  - vertical quadrupole misalignments: 30 μm (rms)
  - quadrupole rolls: 0.3 mrad (rms)
  - BPM resolution: 5 μm (rms)
  - extraction magnet (KEX1,QM6R,QM7R,BS1X,BS2X,BS3X) skew quadrupole errors[2]: $-0.015 \leq KL_{skew} \leq +0.015$ (uniform)
  - wire scanner rolls: $-0.2° \leq \theta \leq +0.2°$ (uniform)
  - wire scanner beam size errors: $\sigma = \sigma_0(1+\Delta\sigma_{relative})+\Delta\sigma_{absolute}$
- *not* included
  - quadrupole strength errors (ΔK/K)
  - BPM offsets
  - BPM rolls
  - tuning in FF

[1]SHI "type H" dipoles are assumed to have nonzero sextupole components
[2]Magnitude of KL_{skew} chosen to give 100% average increase in $\gamma\varepsilon_y$ after steering flat and correcting vertical dispersion

Simulation Procedure

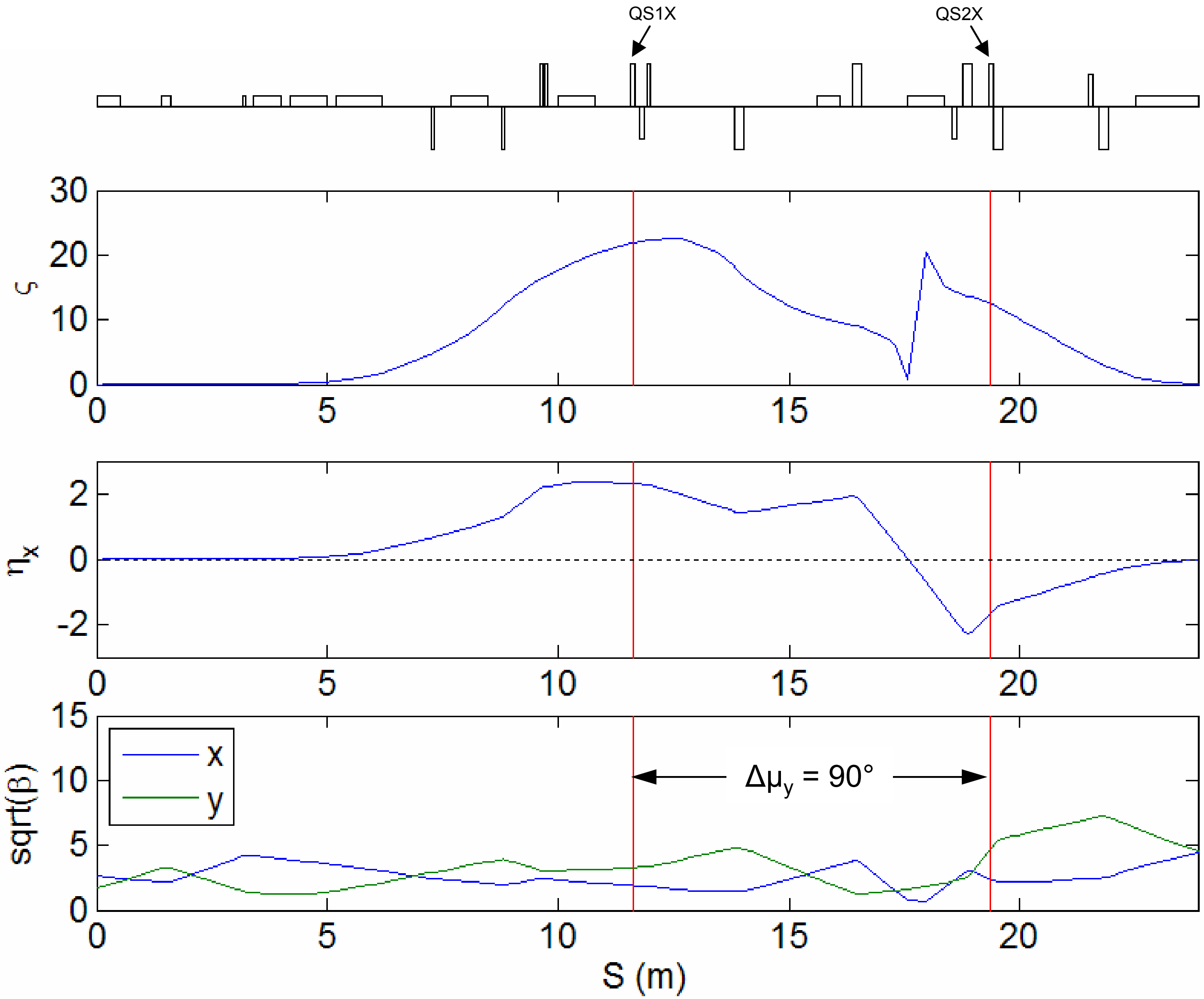
1. apply errors
2. steer flat (EXT only)
3. launch into FF
   - use 2 virtual correctors
   - steer to 2 virtual BPMs (one at the IP and one 90° upstream)
   - virtual BPMs are perfect
4. measure dispersion in diagnostic section
   - scan input beam energy
   - measure orbits
   - fit position vs energy at each BPM
5. correct vertical dispersion in diagnostic section
   - back propagate measured η_y to start of diagnostic section to get η_{y0} and η'_{y0}
   - correct using skew quads (QS1X, QS2X, QS3X, and QS4X) in dispersive region of EXT, minimizing residual coupling
6. correct coupling
   - scan 4 skew quadrupoles sequentially
   - deduce projected ε_y from wire scanner measurements
   - set each skew quad to minimize projected ε_y

EXT stripline BPMs and dipole correctors



BPMs: 14 existing + 8 new; HCORs: 7 existing NKK "type H" + 3 new; VCORs: 10 existing NKK "type V" + 2 new

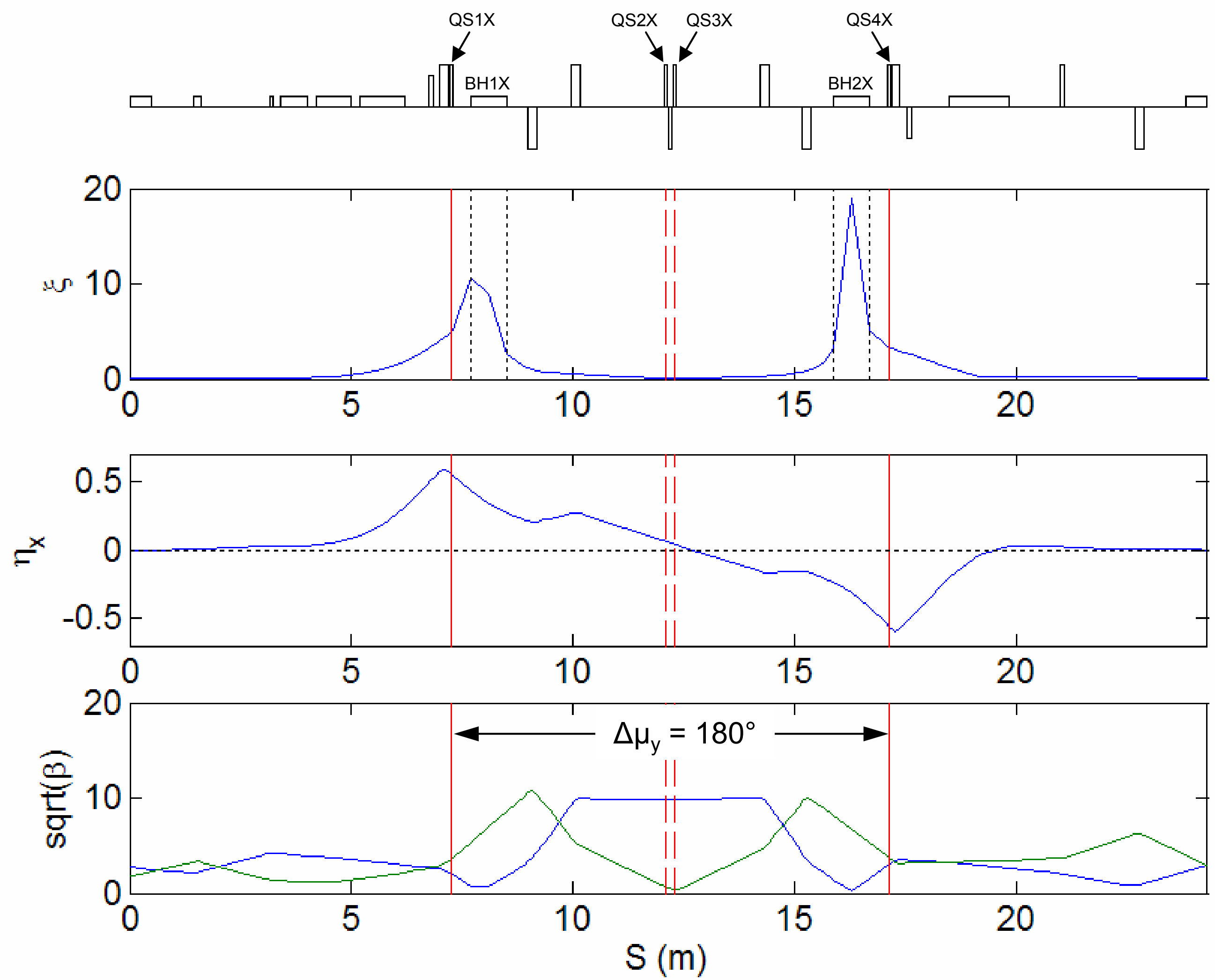
Skew Quadrupoles for Vertical Dispersion Correction: existing EXT



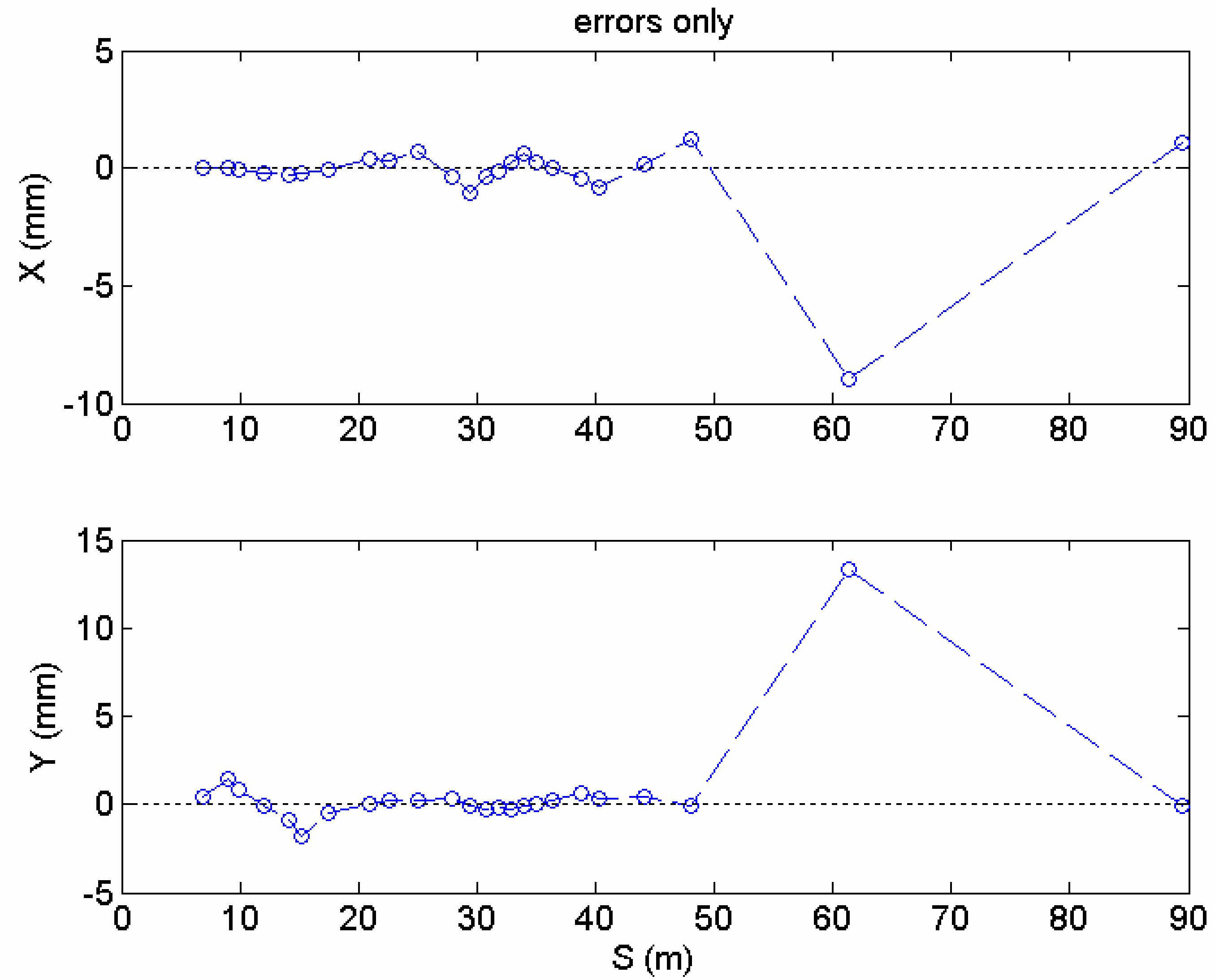
$$\varsigma^2 = \frac{\eta_x^2 \sigma_\delta^2}{\beta_x \varepsilon_x}$$

see ATF-99-03, "Skew Quadrupoles for Dispersion Control in the ATF Extraction Line", by Paul Emma

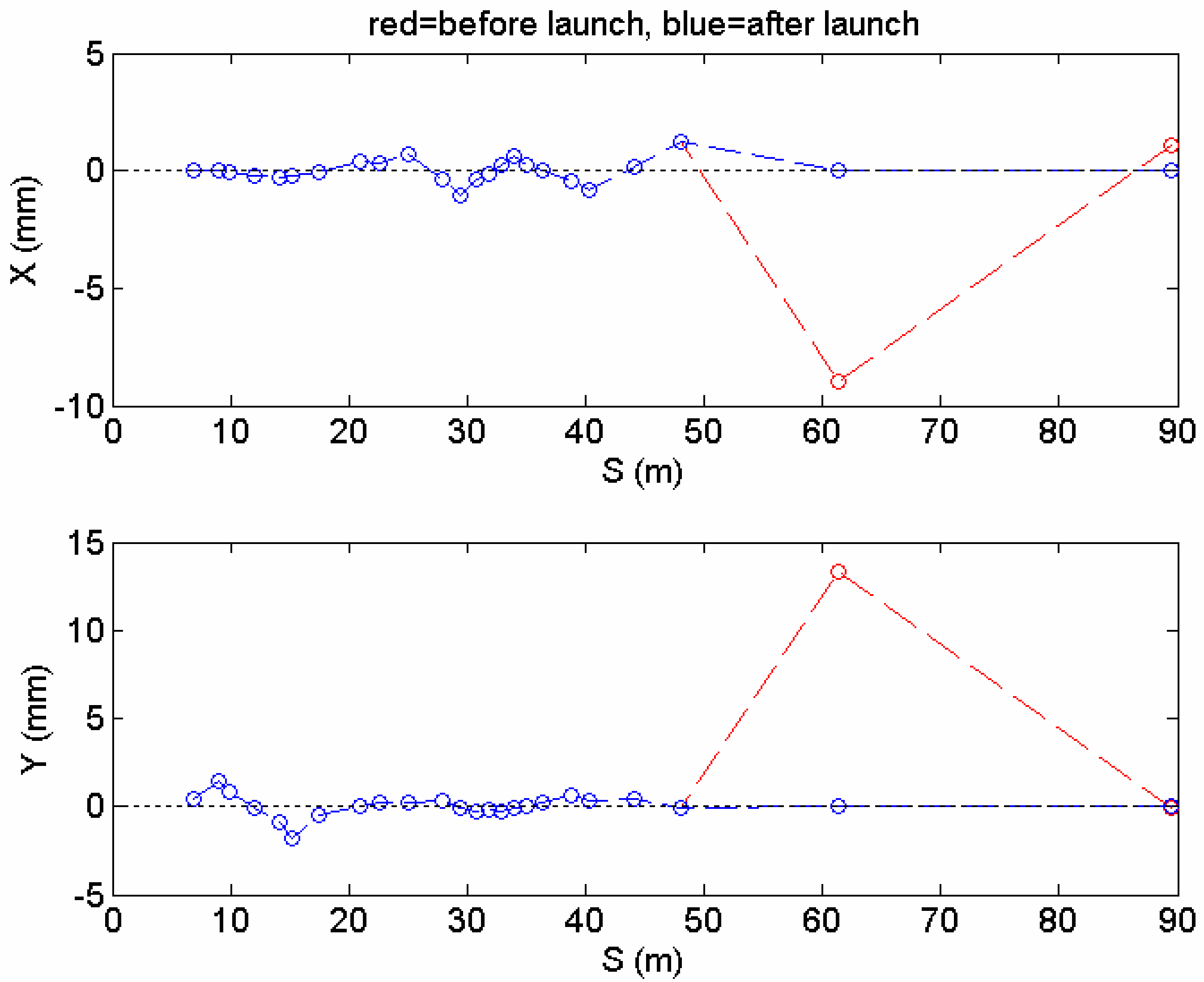
Skew Quadrupoles for Vertical Dispersion Correction: v3.3



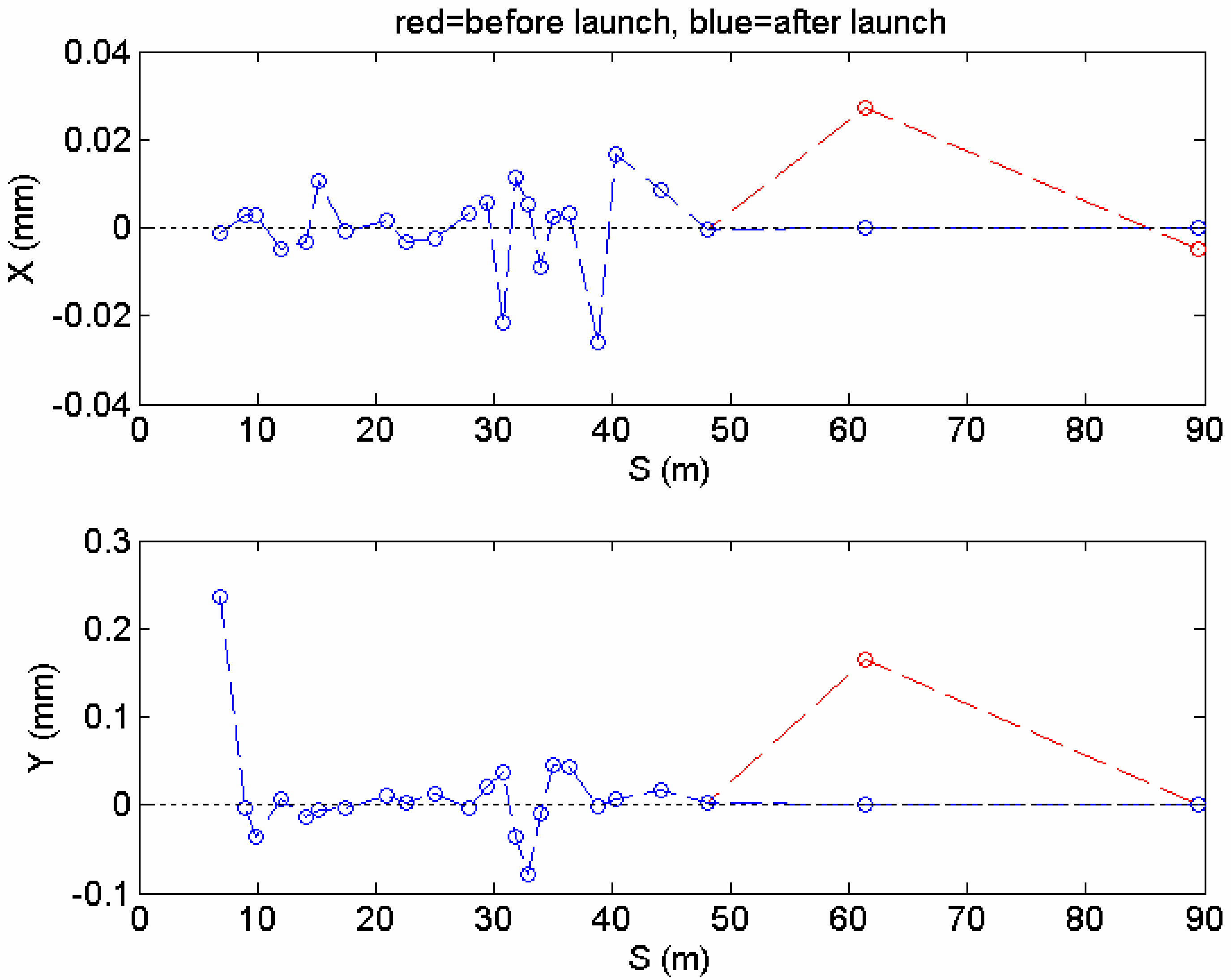
errors only (σ_y*: 10210 nm)



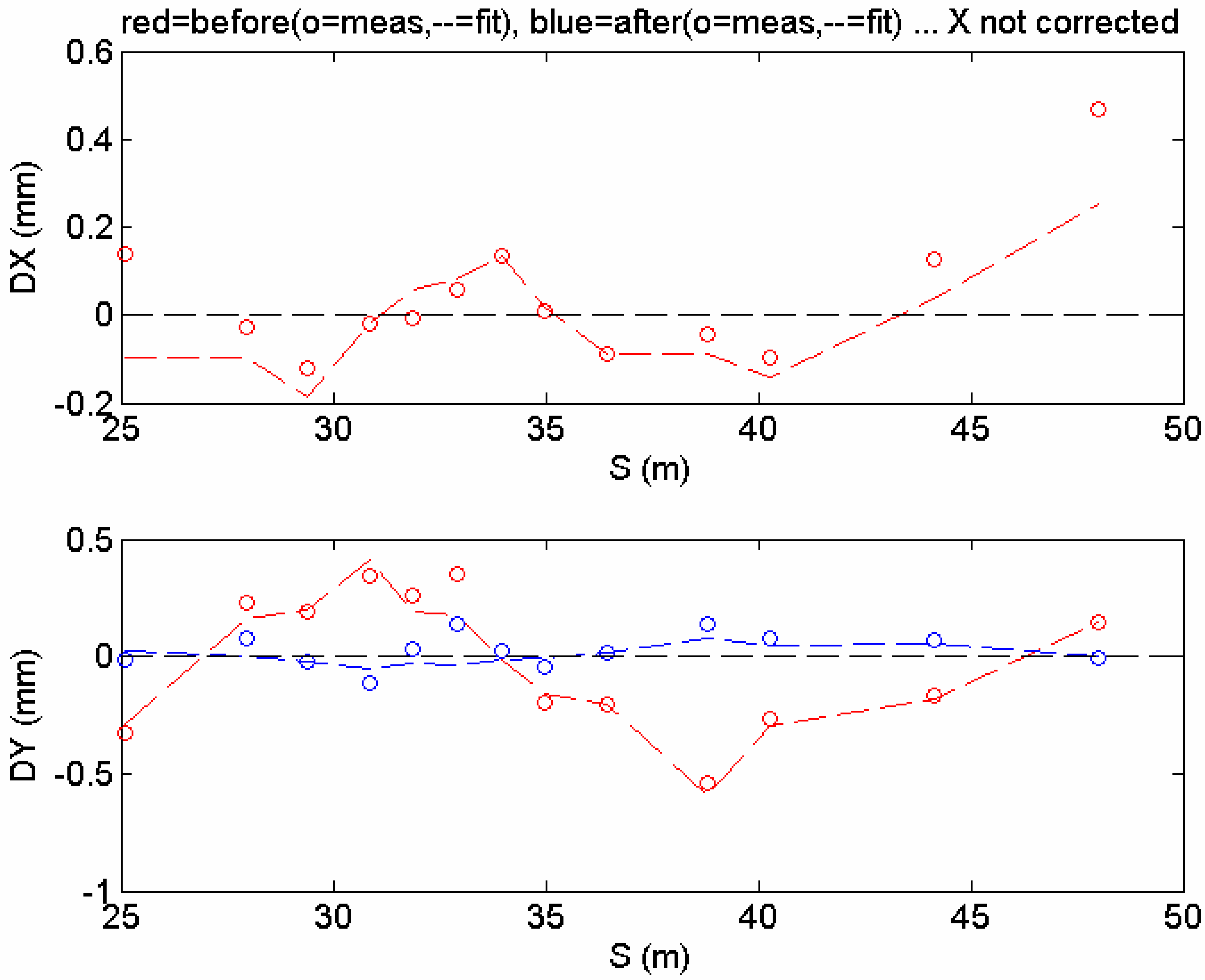
launch only (σ_y*: 10210 nm → 146.8 nm)



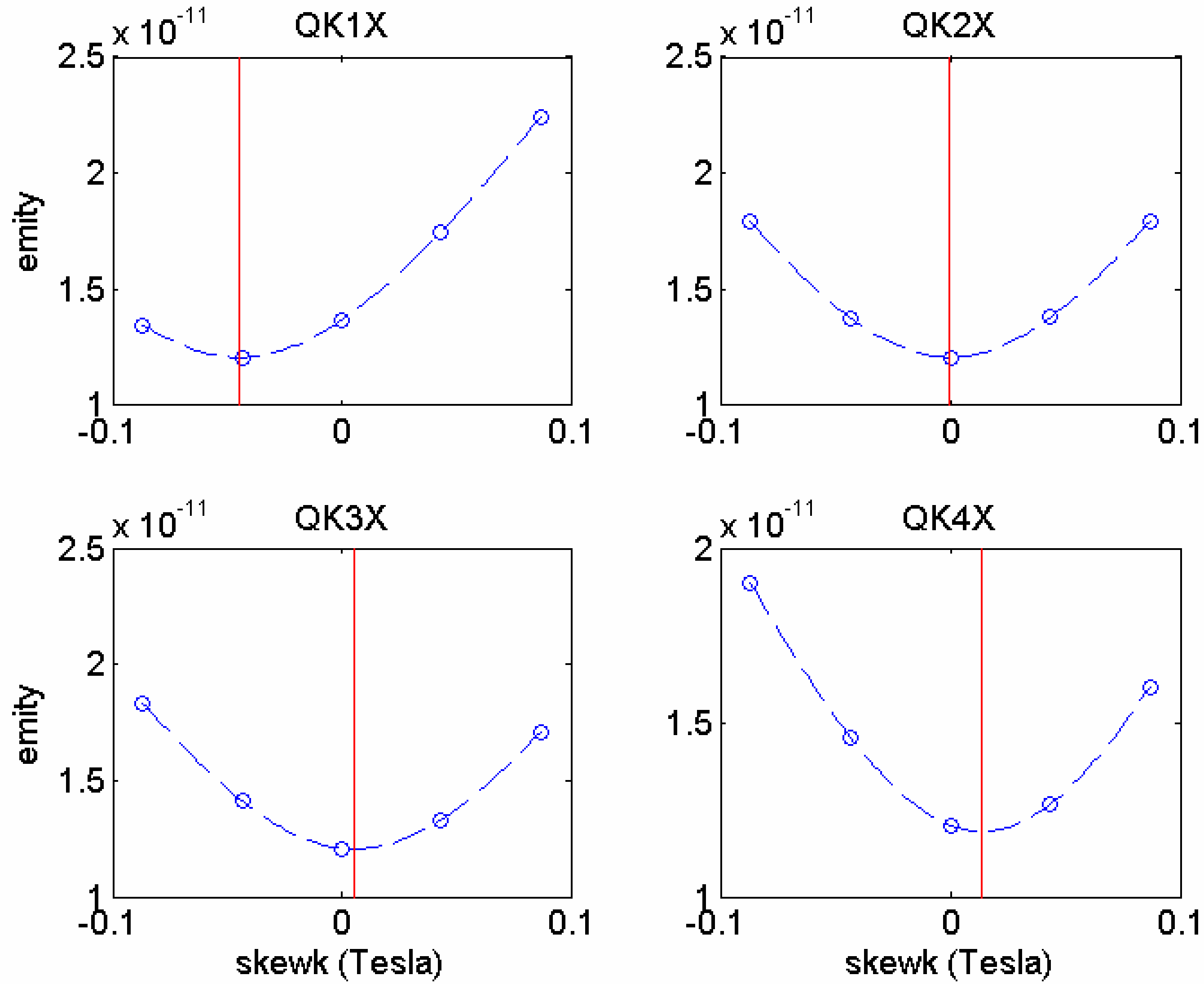
steer flat and launch (σ_y^*: 146.8 nm → 40.0 nm)



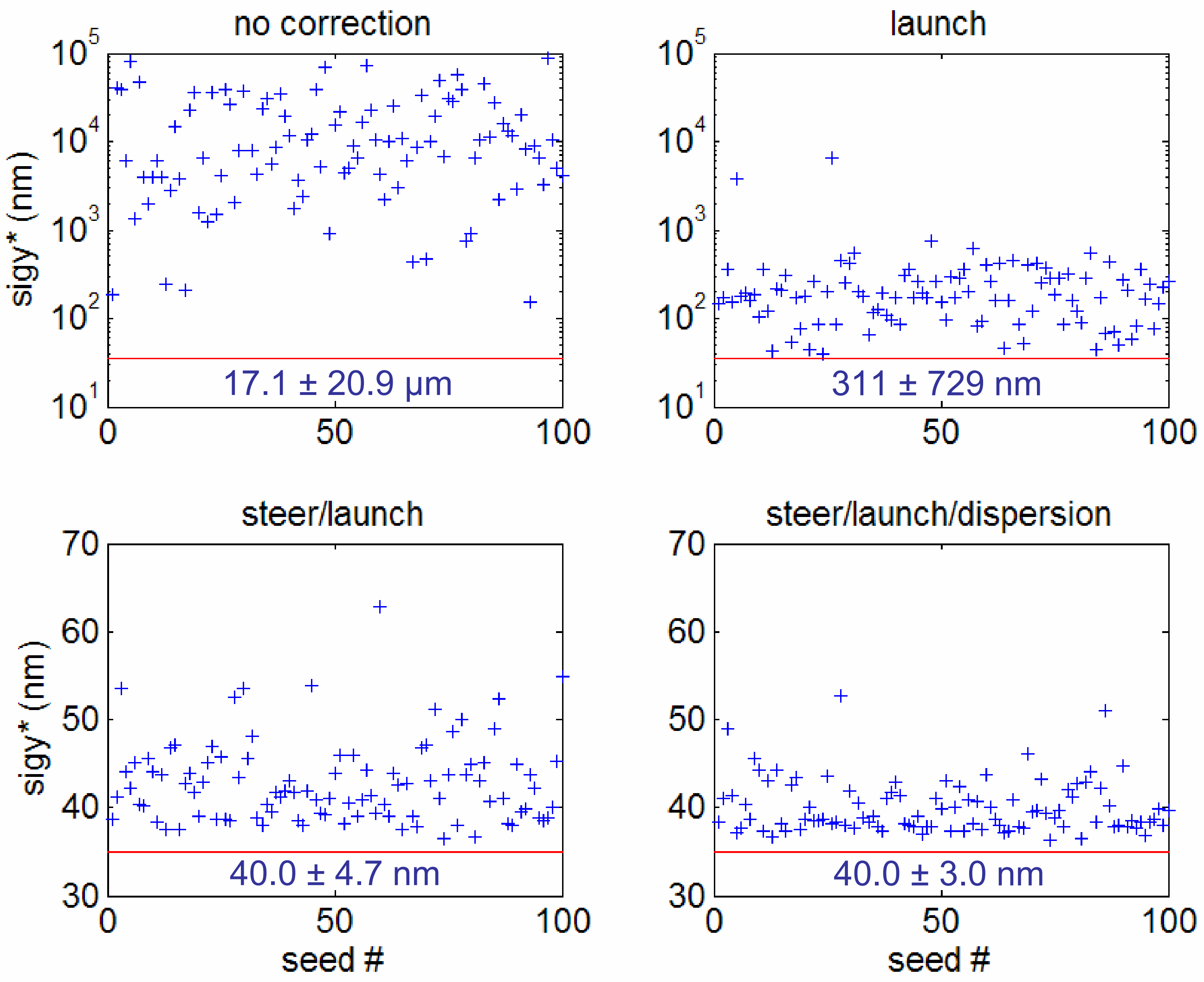
correct η_y (σ_y*: 40.0 nm → 39.9 nm)



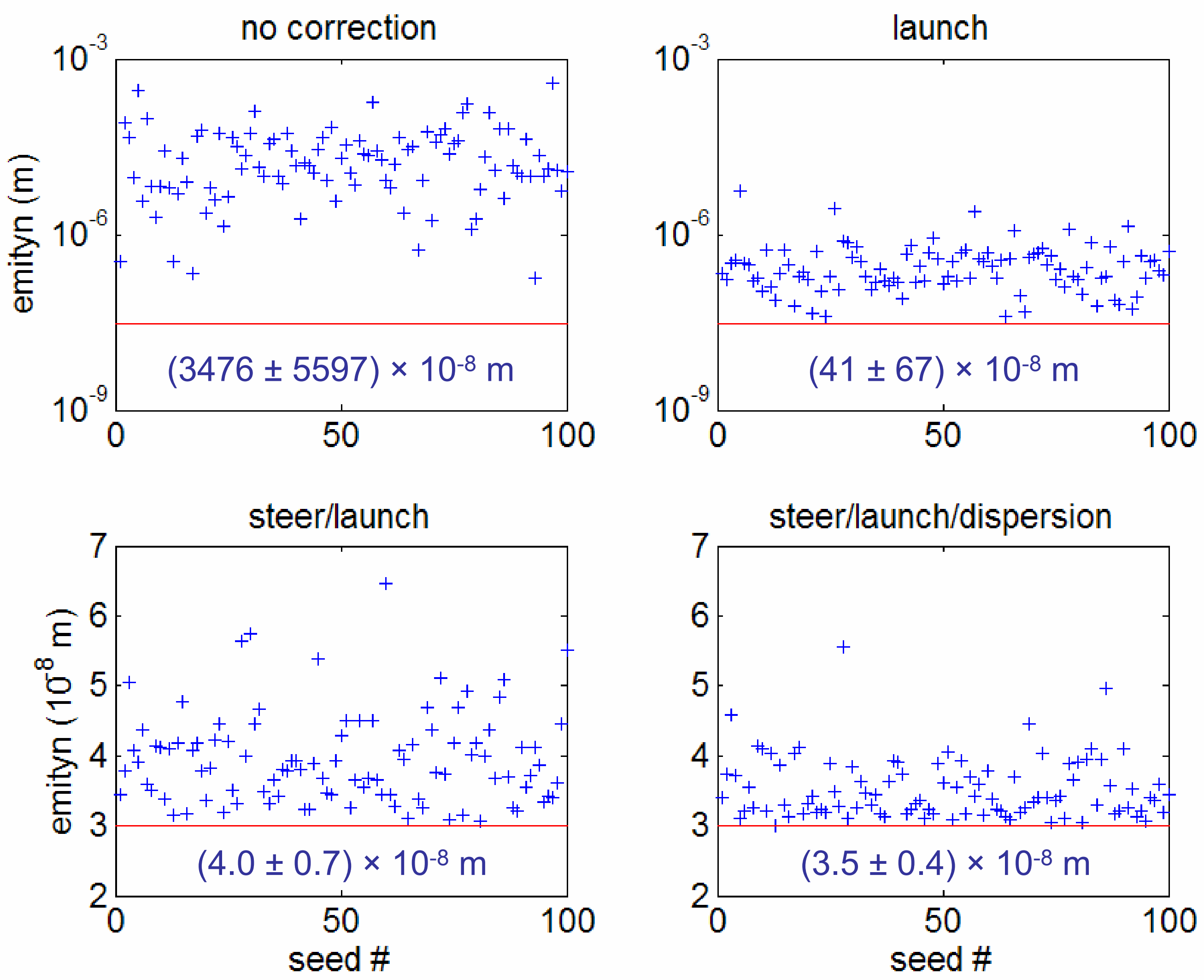
correct coupling (σ_y^*: 39.9 nm → 37.6 nm)



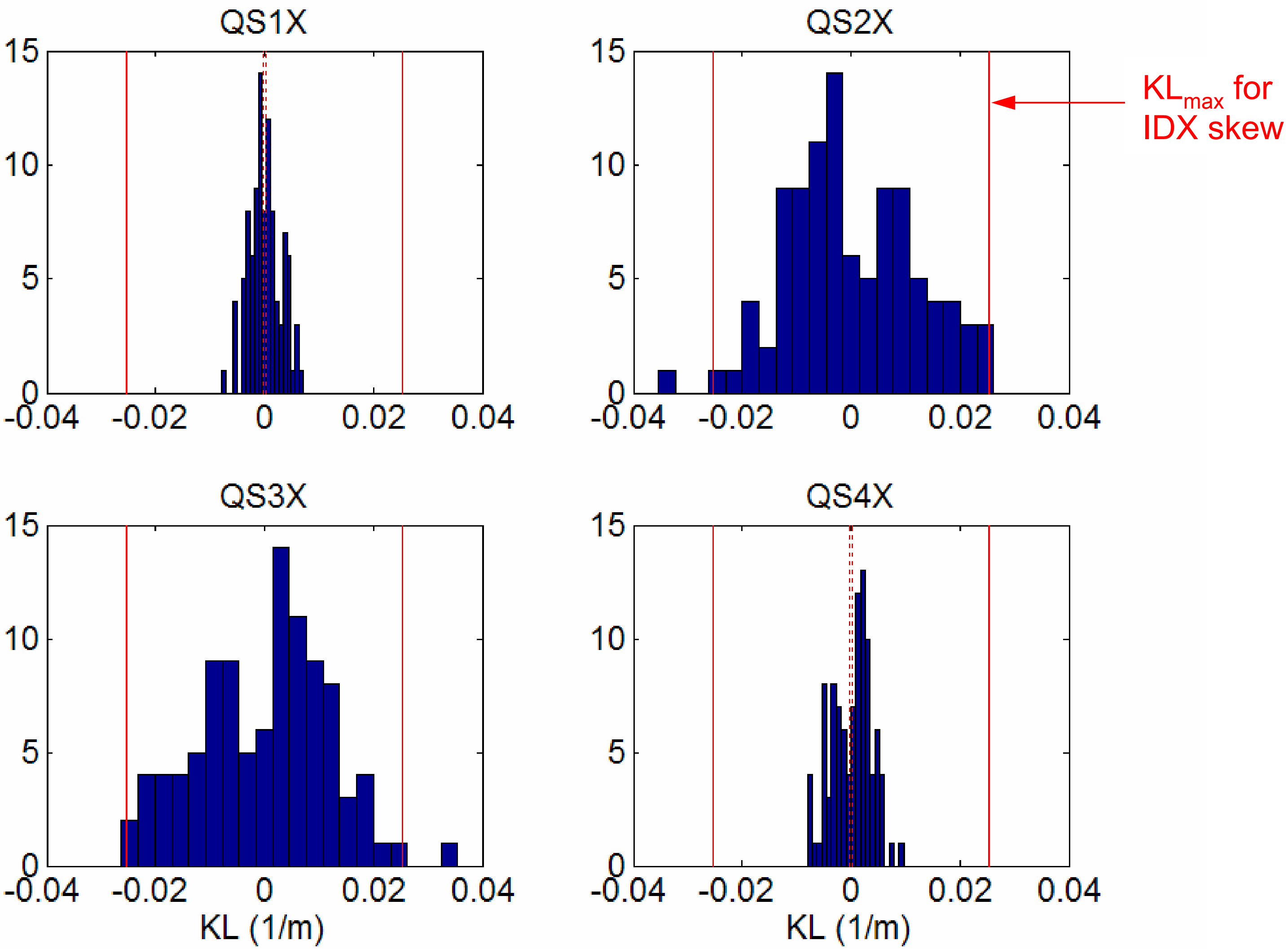
Simulation Results (1): σ_y^*



Simulation Results (2): $\gamma\varepsilon_y$

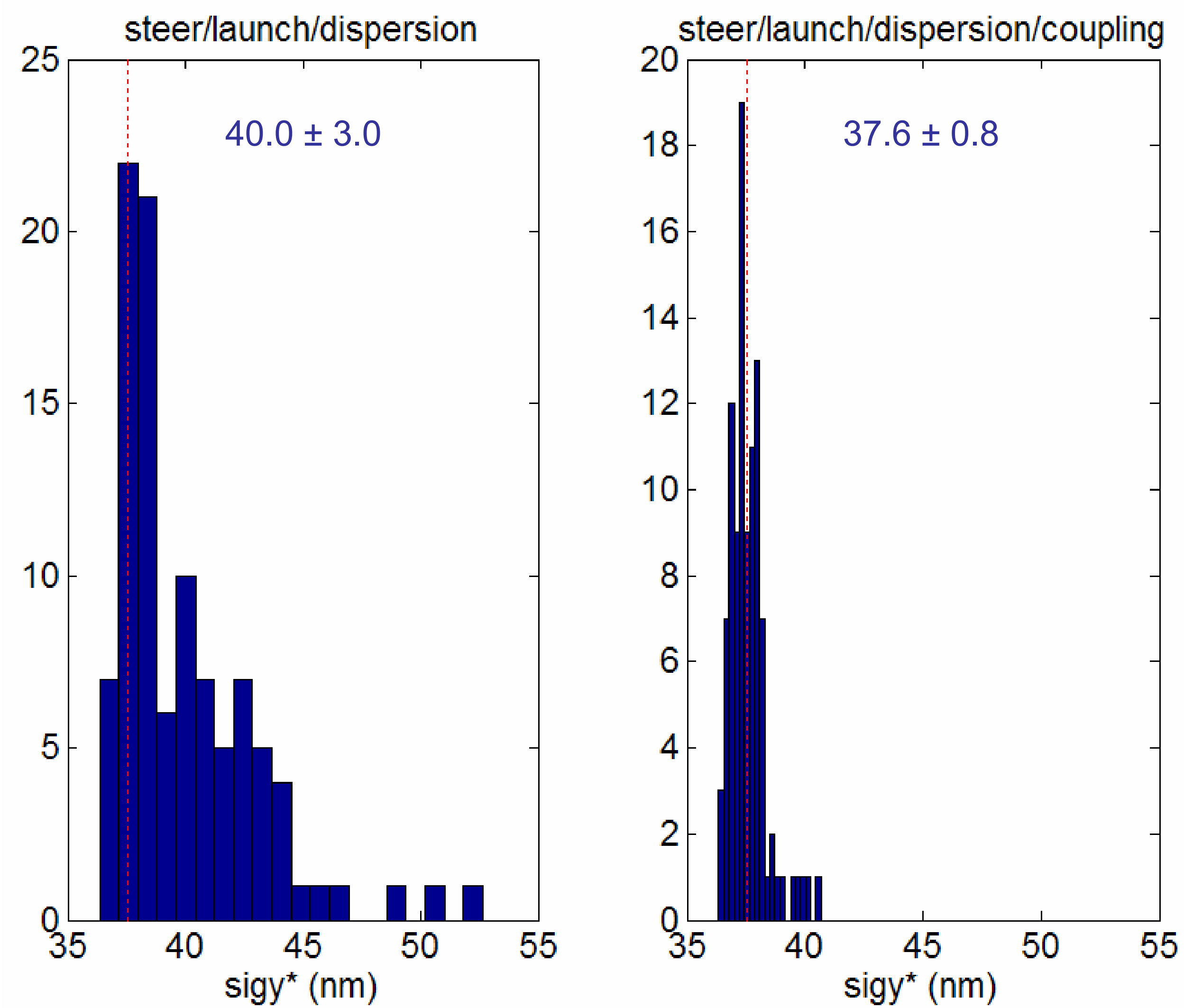


Dispersion Correction Skew Quads



QS2X and QS3X are equal and opposite … fighting

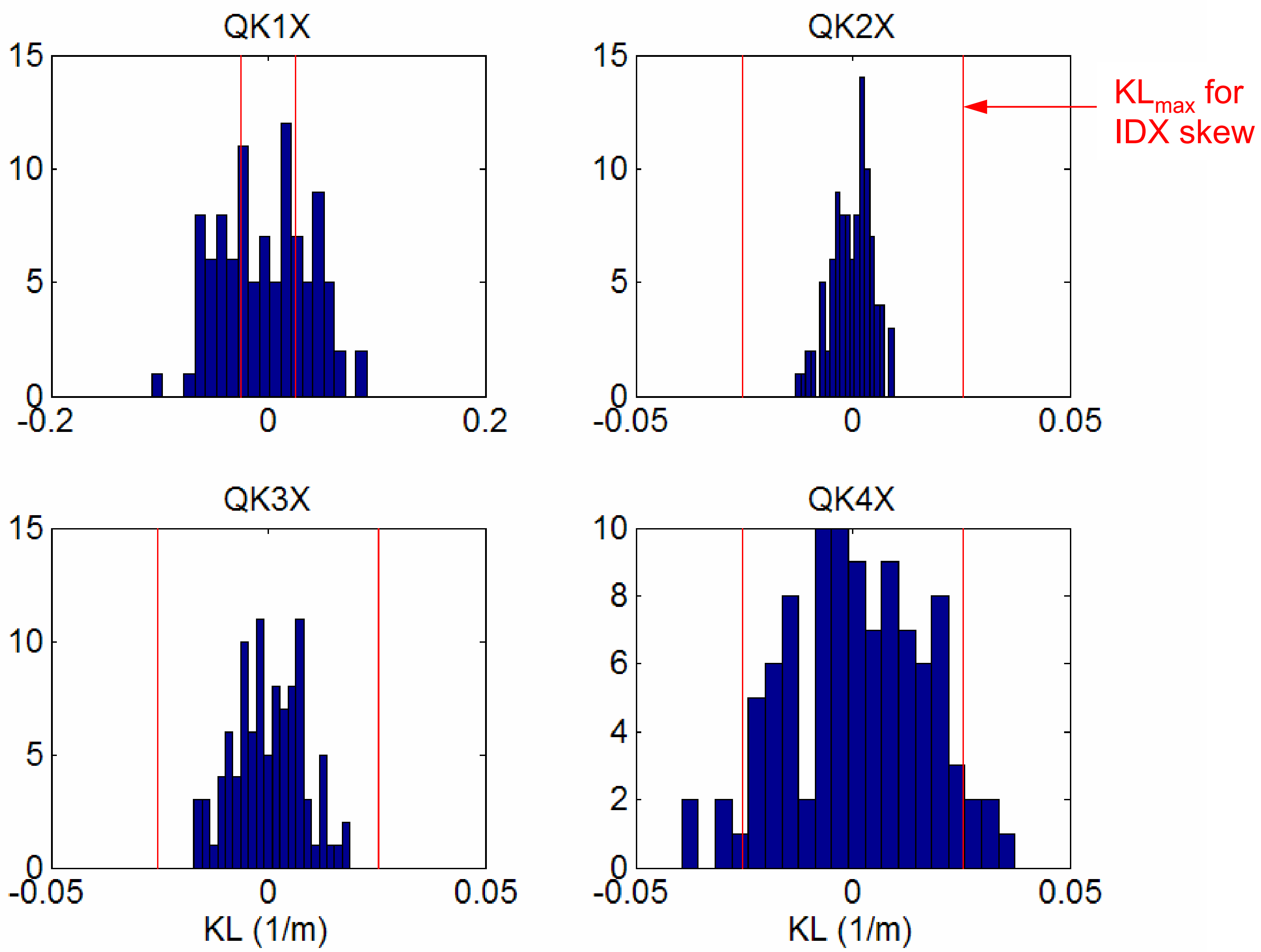
Simulation Results (3): σ_y^*



perfect wire scanners (no measurement errors) were used during coupling correction

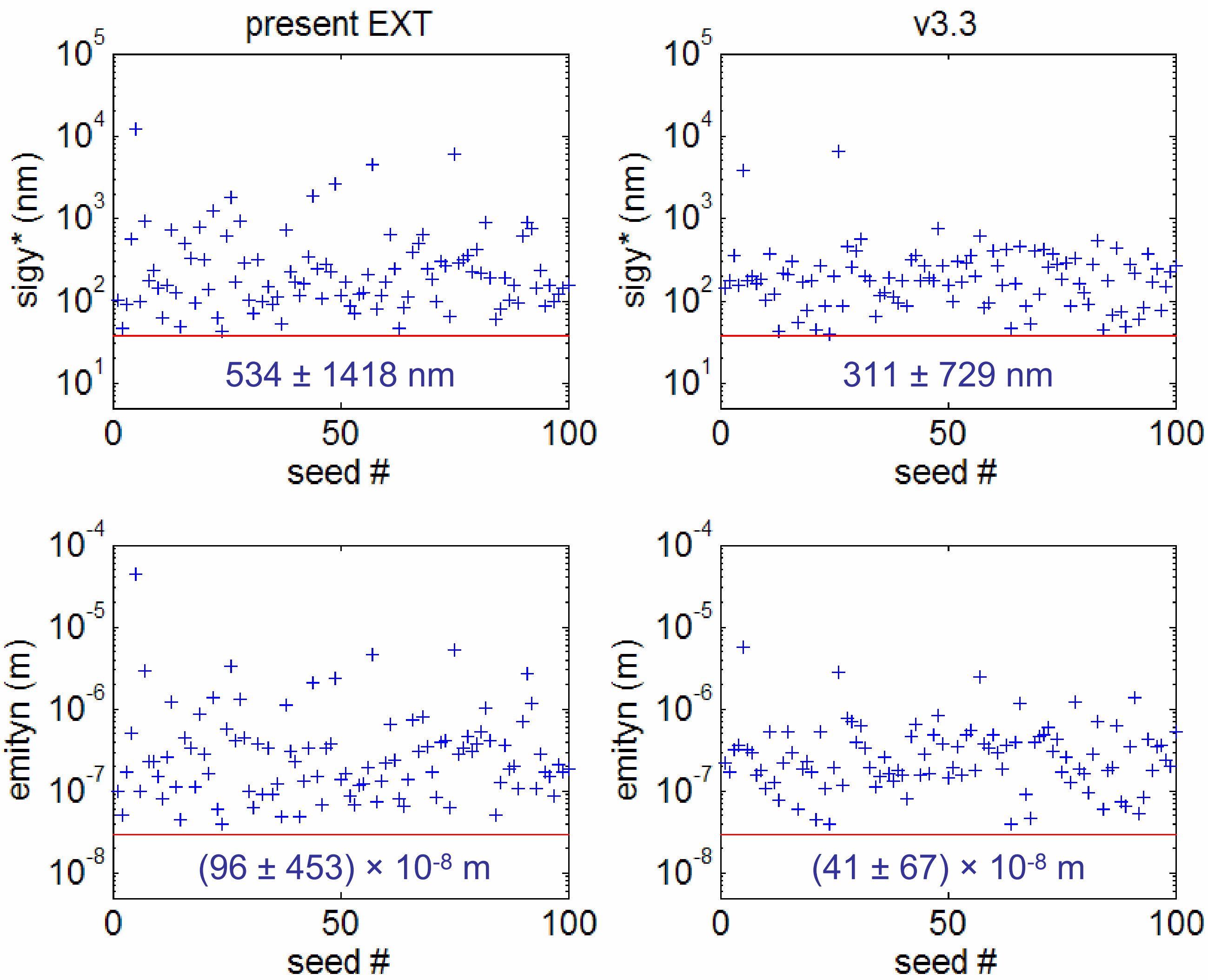
note: red dotted lines show tracking for perfect machine (no errors, no corrections)

Coupling Correction Skew Quads



QK1X is too strong … because of dispersion correction?

old vs new: launch only (no extraction skews)



(Inconclusive) Conclusions

- vertical dispersion correction with 2 skew quadrupoles creates coupling … solution with 4 skew quadrupoles seems not optimal yet … needs more work
- coupling correction quads (QK1-4X) seem strong, given the assumed errors … due to vertical dispersion correction?
- further study of correction schemes and (perhaps) adjustment of optics in dispersive part of EXT are required before we can decide on how many skew quadrupoles we need and how strong they need to be
- maybe more on this during the meeting …

Version 3.3 Issues

- skew quadrupoles and vertical dispersion correction
- is the IP still far enough from the west Assembly Hall wall at 13.3 m?
- MAD deck for FF is still a bit sketchy … need to put in BPMs, correctors, etc.
- need to do more misalignment/correction and performance simulations (including realistic wire scanner resolutions … what is “realistic”)
- vertical chromaticity in EXT … put in a 3rd and or 4th sextupole?
- need new kicker cables (kickers are 8.2 m / 35 ns further apart)
- laserwires on both sides of EXT enclosure shielding wall … light path?