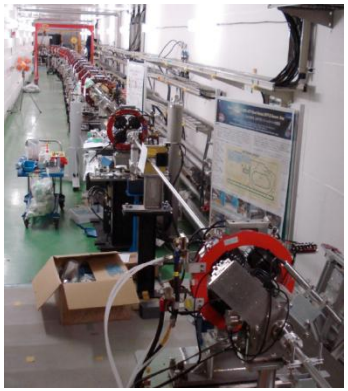
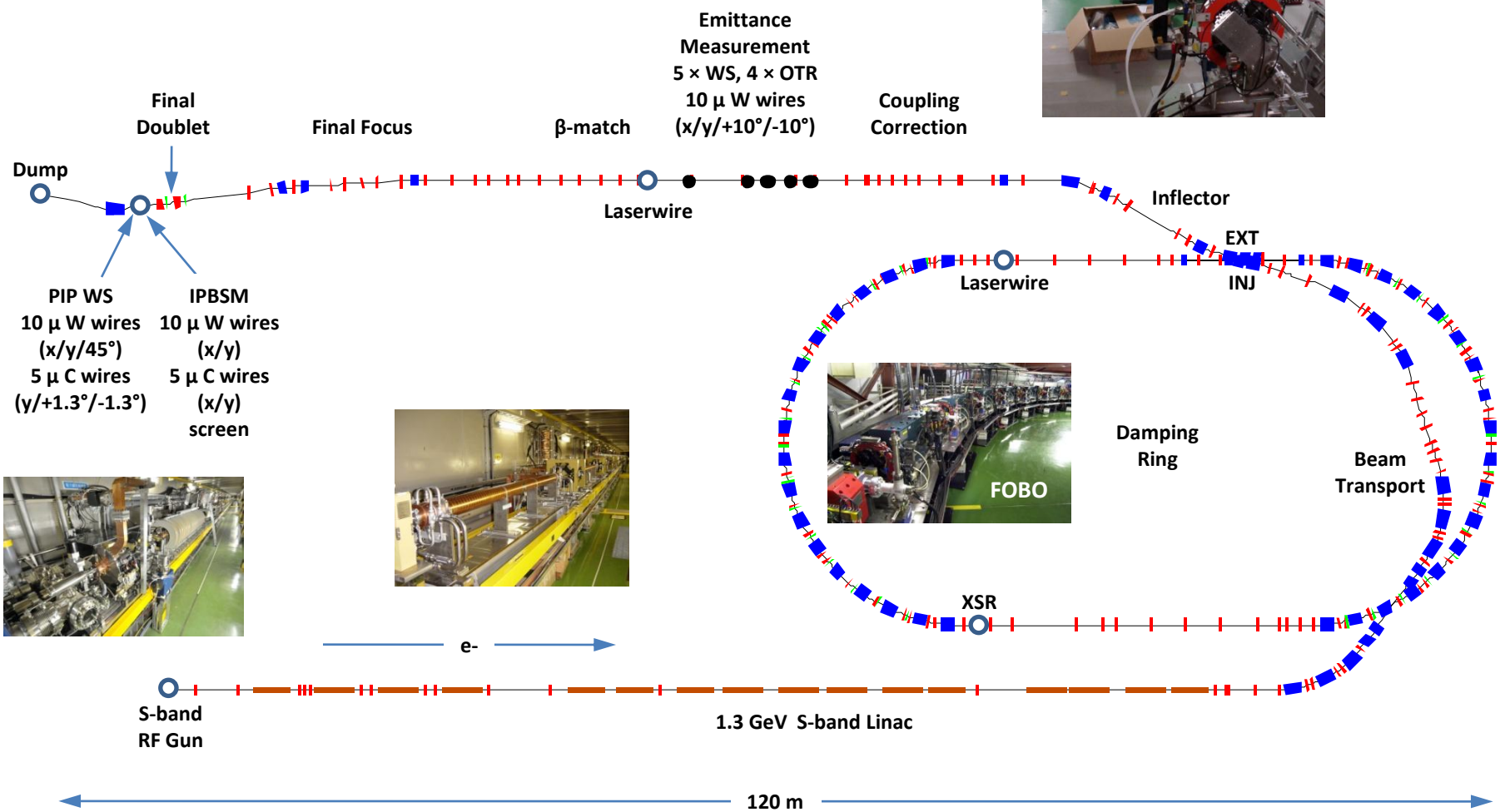
EXT: Summary of activities, software development, and tuning performance

ATF / ATF2 Schematic Layout

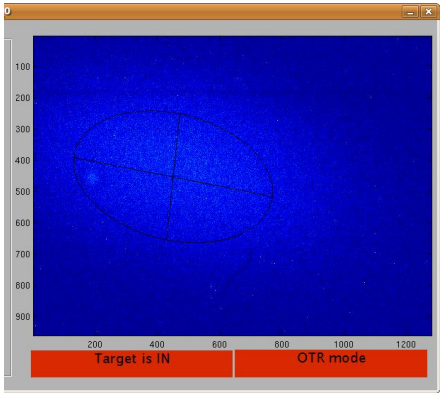




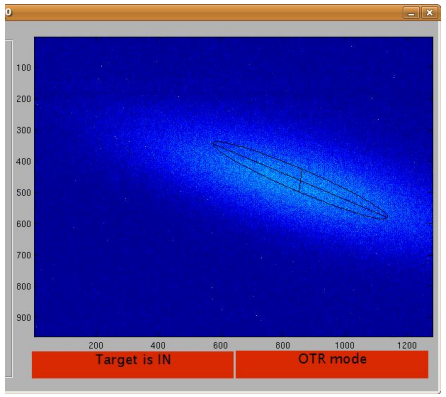
Outline

- EXT tuning
  - dispersion correction
  - emittance measurement
  - coupling correction
- vertical emittance issues
  - extraction kicker voltage
  - DR orbit & extraction trajectory
- EXT / FF BBA results
- EXT Laserwire / ATF2 compatibility mode optics
- magnet TRIM function issue
- Summary and Continuing Work

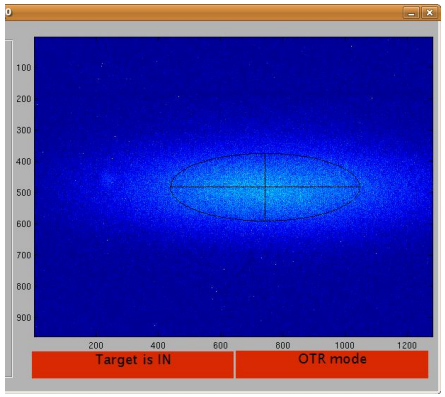
EXT Tuning



OTR0X before corrections



OTR0X after dispersion correction



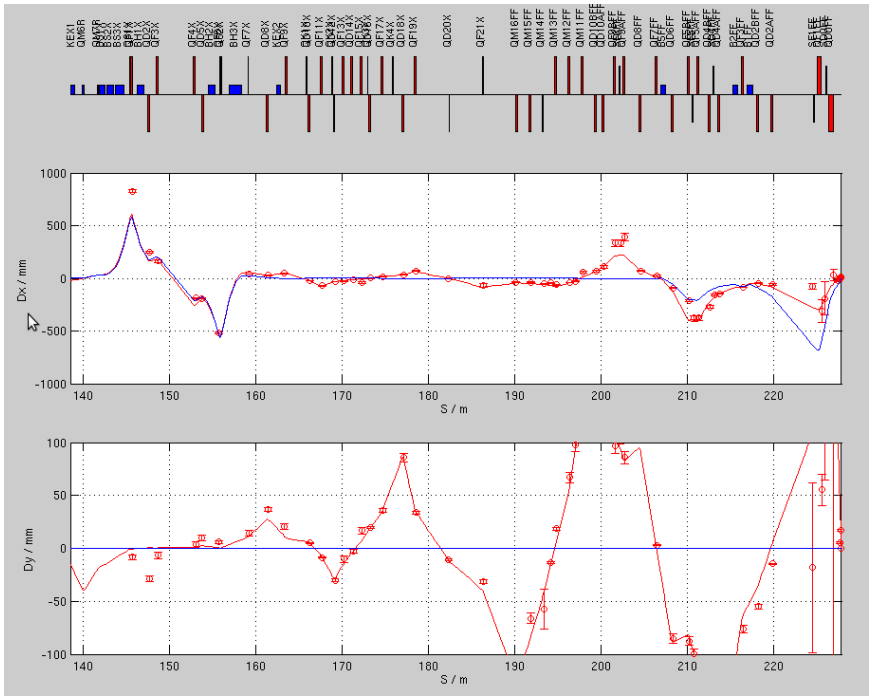
OTR0X after coupling correction

Dispersion Correction

Flight Simulator Dispersion Package GUI

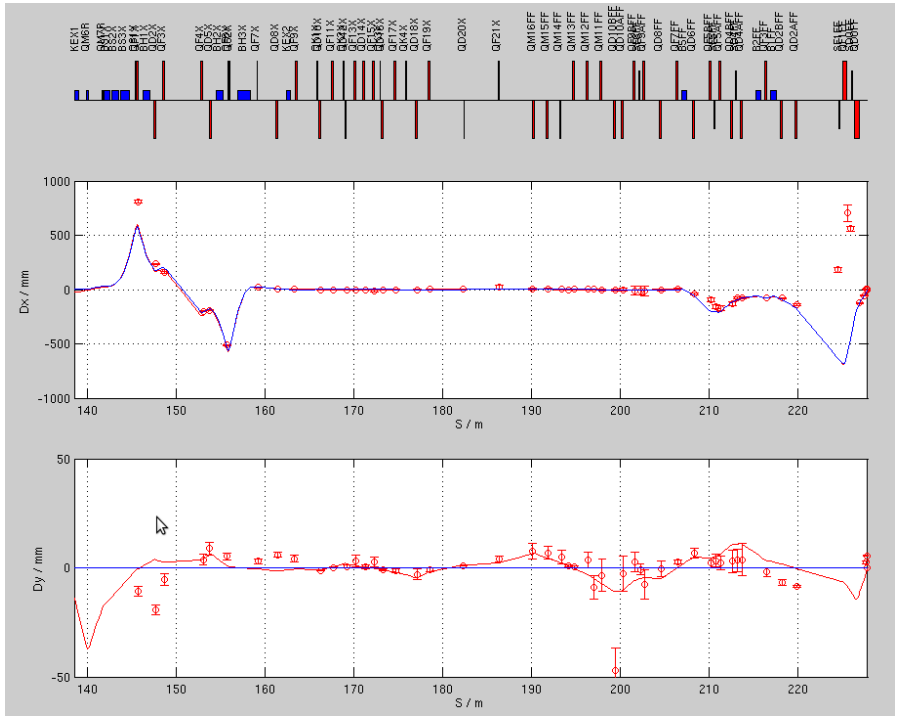
Dispersion Correction (December 7, 2010)

Before Correction



Fitted dispersion values for BEAMLINE element 1923 (IP):
eta x = 6.84 +- 0.134 mm
eta x' = 64.5 +- 2.02 mrad
eta y = 0.405 +- 0.00726 mm
eta y' = -236 +- 3.78 mrad

After Correction

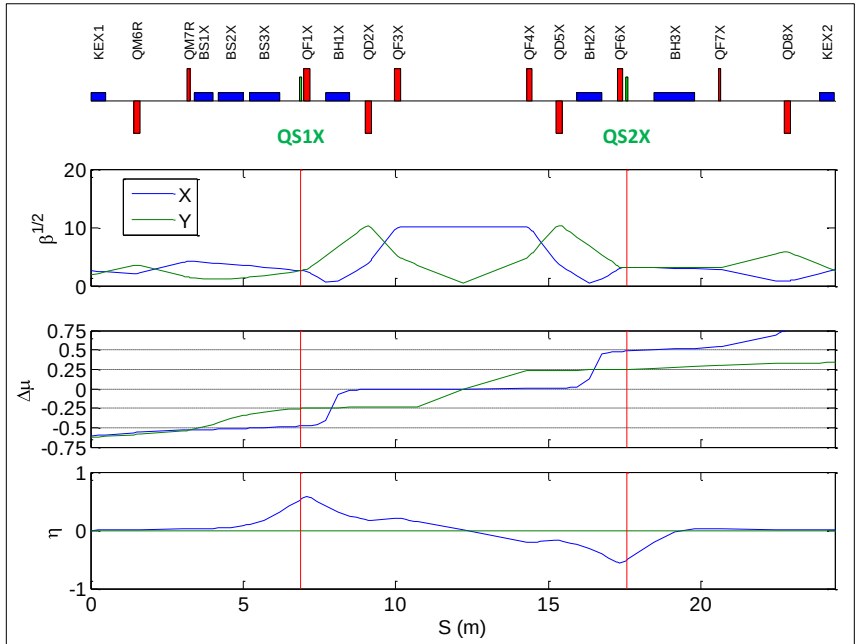


Fitted dispersion values for BEAMLINE element 1923 (IP):
eta x = 0.487 +- 0.152 mm
eta x' = 140 +- 2.31 mrad
eta y = -0.0163 +- 0.00544 mm
eta y' = 12.6 +- 1.93 mrad

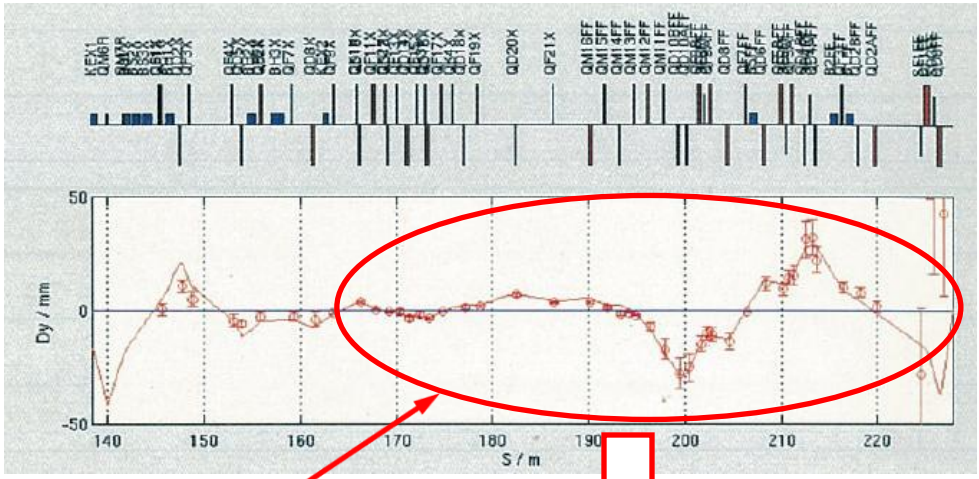
beam **must** be centered in QF1X/QF6X/QS1X/QS2X

Vertical Dispersion Correction

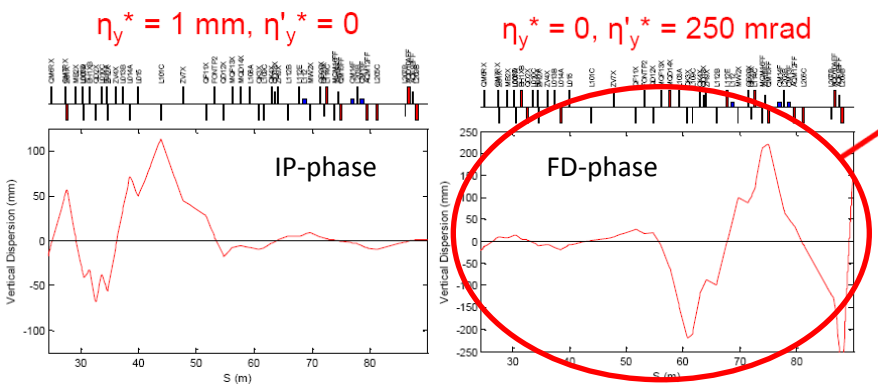
(FD-phase)



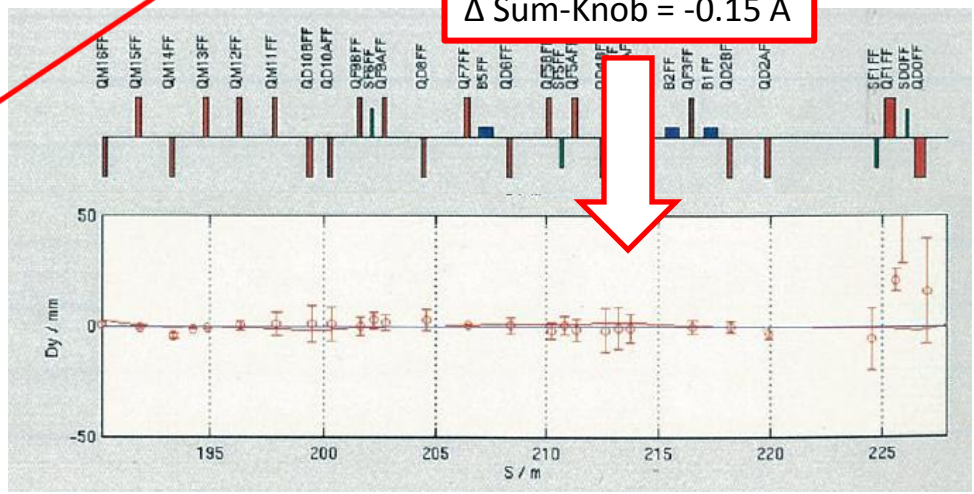
"Sum-Knob": $I_{QS1X} = I_{QS2X}$



Δ Sum-Knob = -0.15 A



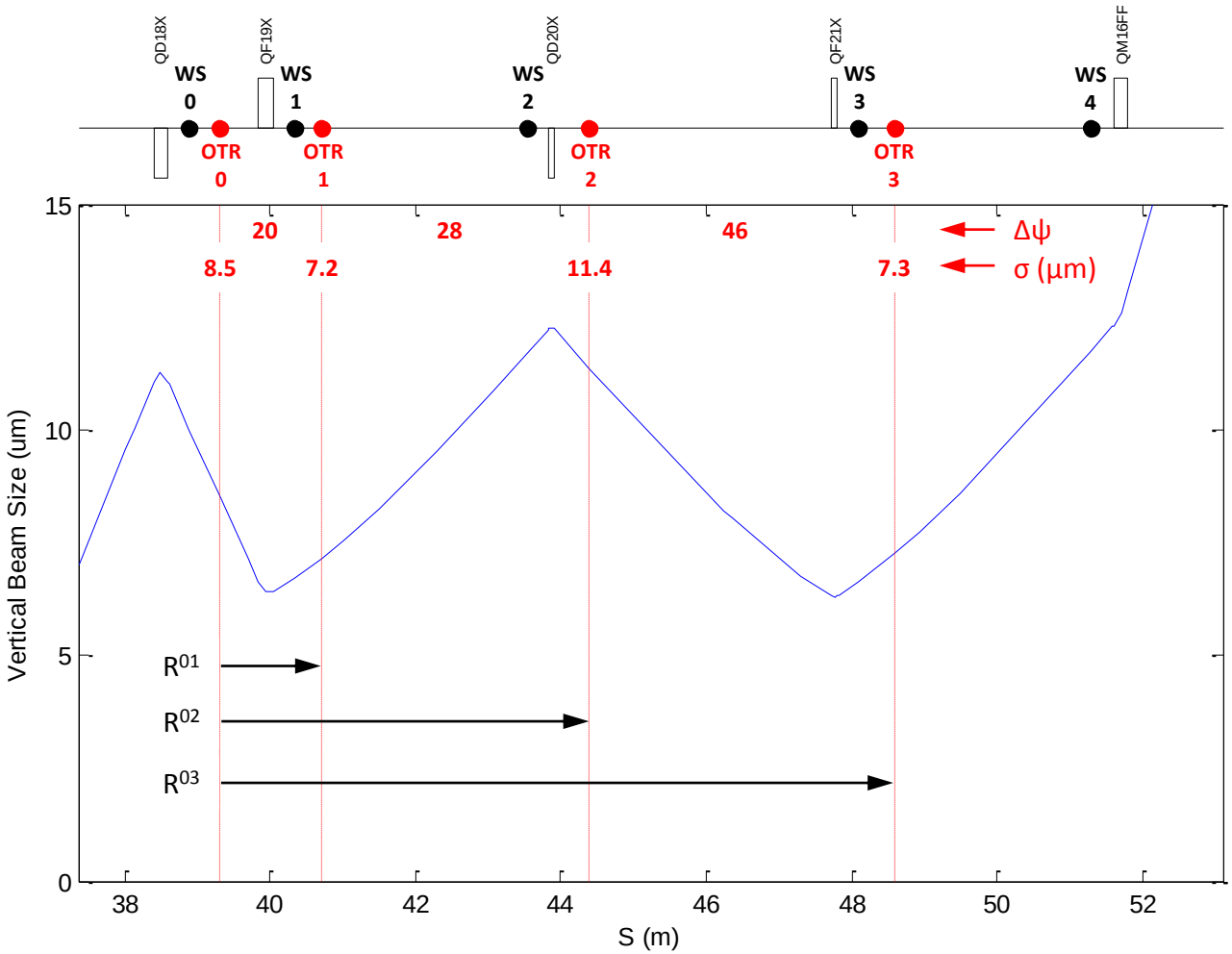
Simulated η_y^* (right) and $\eta'_y{}^*$ (right), back-propagated from IP



Emittance & Coupling Measurement & Correction

EXT Emittance Measurement (OTR)

EXT Diagnostic Section



$$\sigma = \begin{bmatrix} \sigma_{33} & \sigma_{34} \\ \sigma_{43} & \sigma_{44} \end{bmatrix}, \sigma_{34} = \sigma_{43}$$

$$\sigma^n = R^{0n} \; \sigma^0 \; R^{0n}{}^T$$

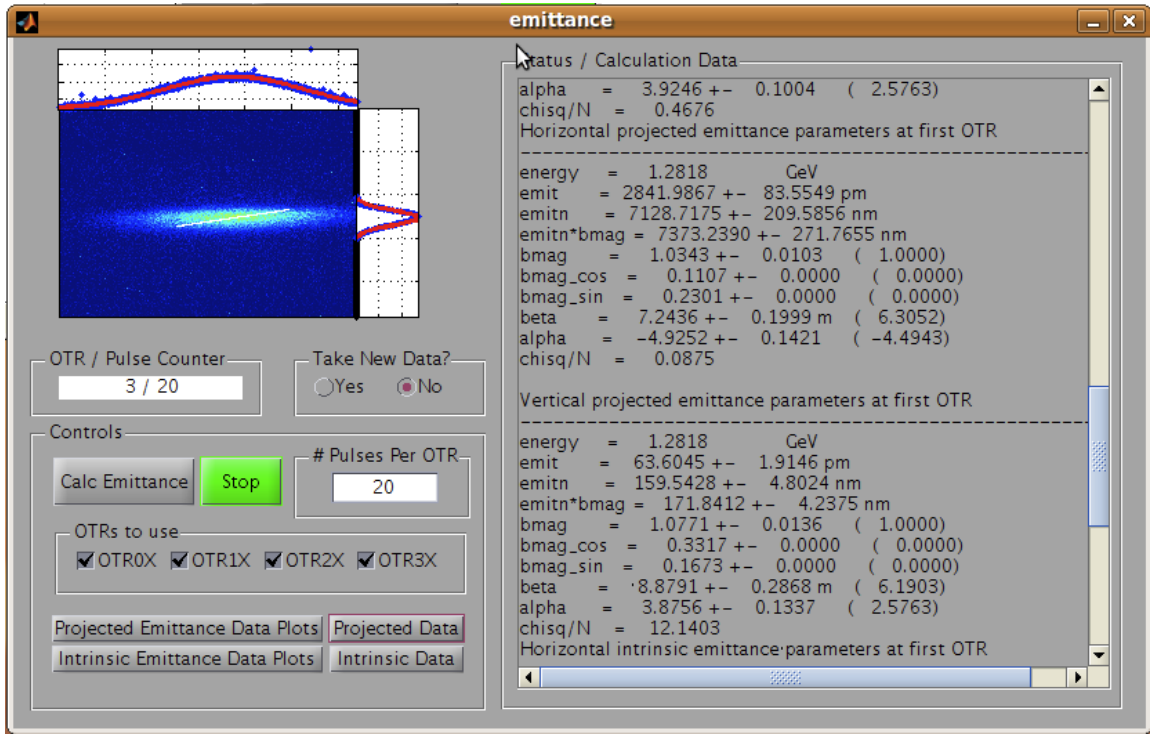
$$A\vec{x} = \vec{b}$$

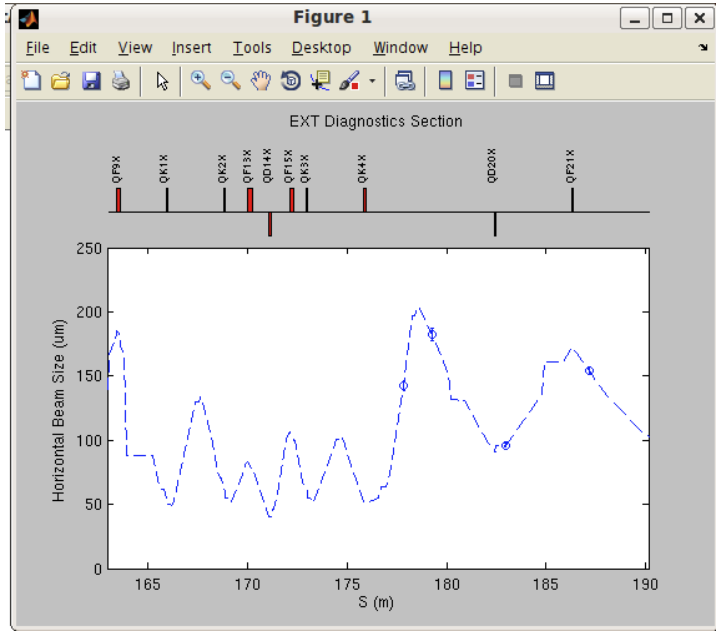
$$\vec{x} = \begin{bmatrix} \sigma_{33}^0 & \sigma_{43}^0 & \sigma_{44}^0 \end{bmatrix}^T$$

$$\vec{b} = \begin{bmatrix} \sigma_{33}^0 & \sigma_{33}^1 & \sigma_{33}^2 & \sigma_{33}^3 \end{bmatrix}^T$$

$$A = \begin{bmatrix} 1 & 0 & 0 \\ R_{33}^{01}{}^2 & 2R_{33}^{01}R_{34}^{01} & R_{34}^{01}{}^2 \\ R_{33}^{02}{}^2 & 2R_{33}^{02}R_{34}^{02} & R_{34}^{02}{}^2 \\ R_{33}^{03}{}^2 & 2R_{33}^{03}R_{34}^{03} & R_{34}^{03}{}^2 \end{bmatrix}$$

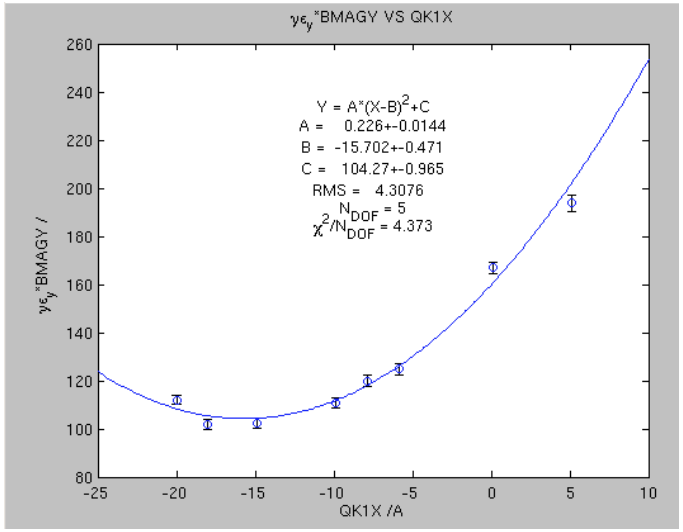
Fast Automatic Emittance Measurement with OTRs

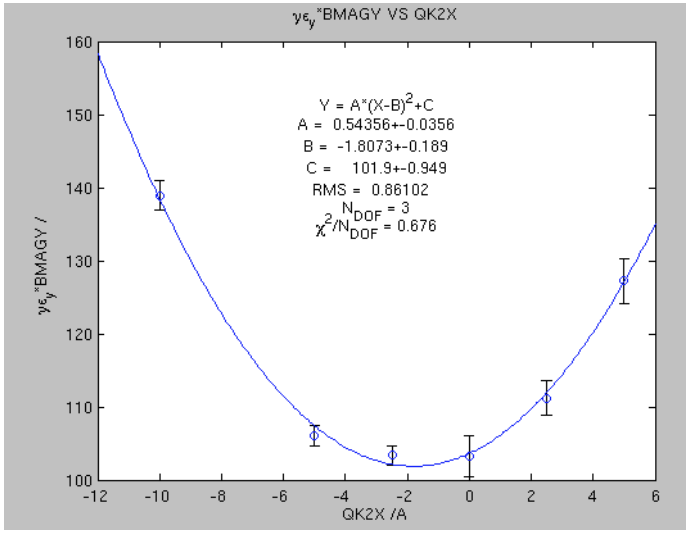


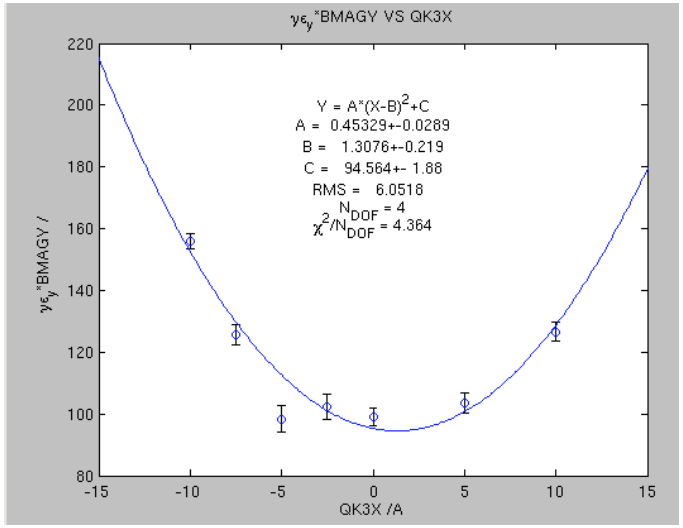


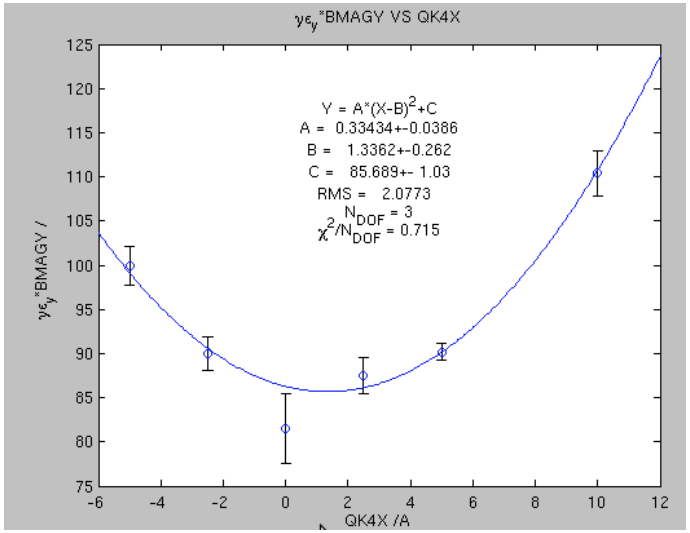
- horizontal beam size too big for OTR … Gaussian fits to projection not so good
  - new camera lens with less magnification? (loss of resolution)
  - variable magnification lens?
- ellipse fit parameters sensitive to background subtraction, windowing, etc.
  - use standard image analysis techniques from light optics (laser folks are familiar with this)
  - ellipse fit parameters can be used to compute projected sizes … compare to direct Gaussian fits

QK Optimization (Dec 13, 2010)

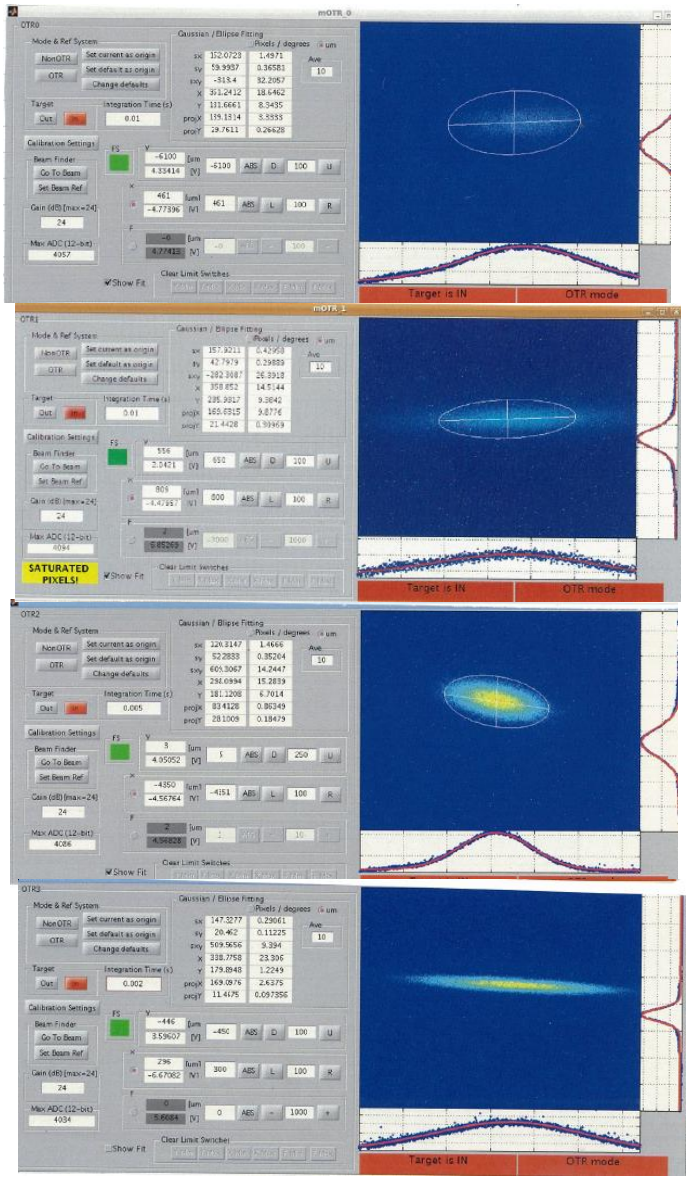








QK Optimization (Dec 13, 2010)



DR XSR:

ε_y = 14.1 pm

before:

QK1X = -5.9

QK2X = 0

QK3X = 0

QK4X = -5.0

ε_y = 40.4 pm

after:

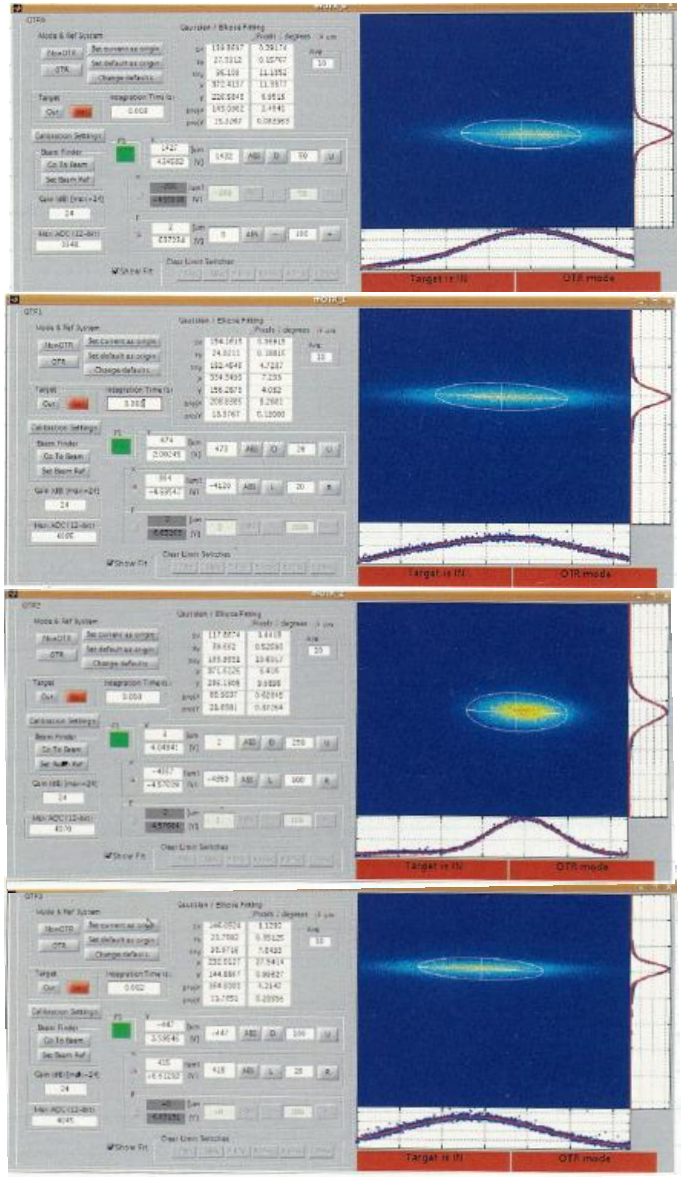
QK1X = -15.7

QK2X = -1.8

QK3X = 1.3

QK4X = 1.3

ε_y = 33.9 pm



Horizontal EXT Emittance Measurements

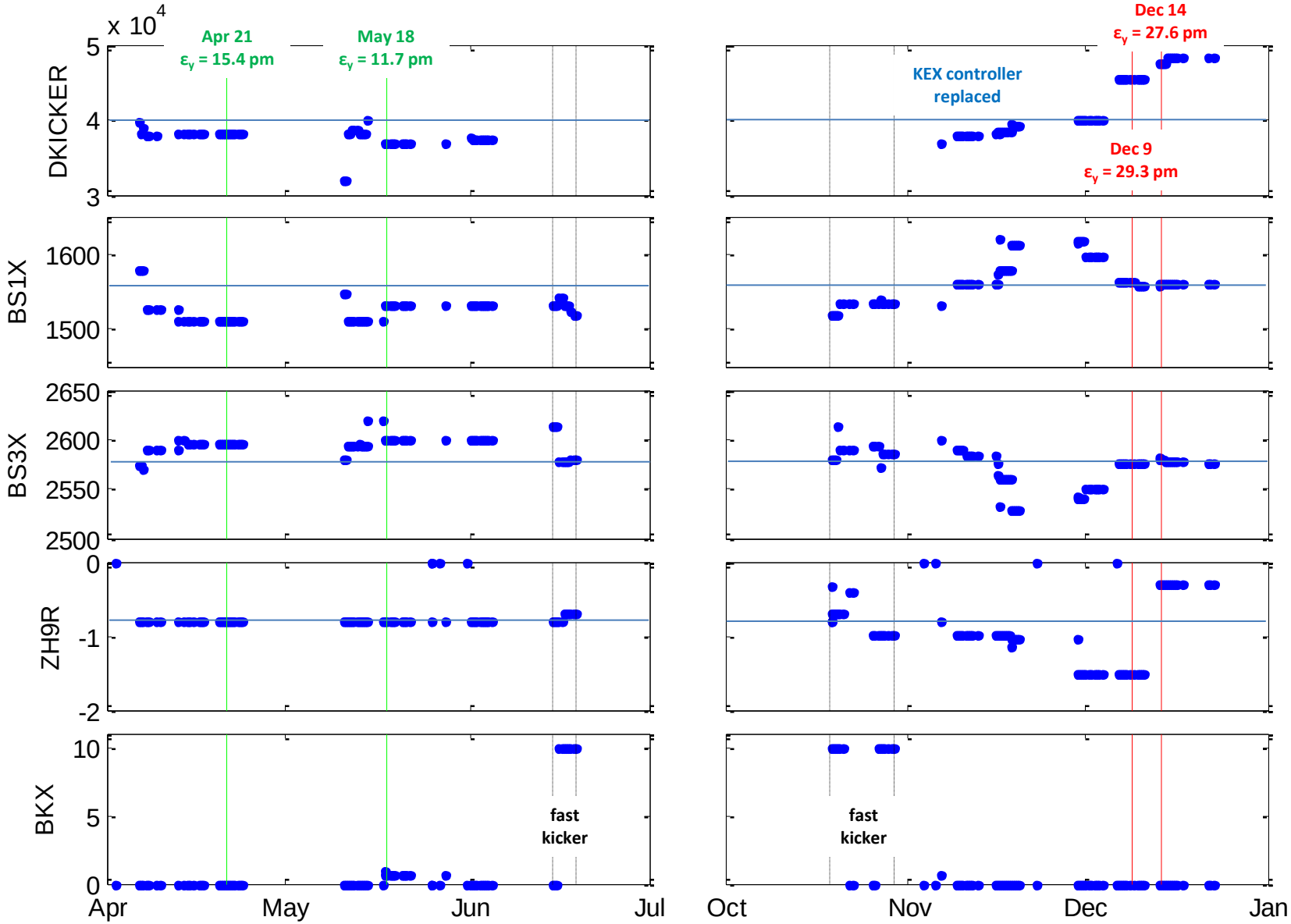
Date	N_{wire}	Emit (nm)	BMAG
Dec 14 2010	4	1.784 ± 0.130	1.10 ± 0.04
Dec 9 2010	4	1.686 ± 0.102	1.08 ± 0.05
Nov 2010 (?)	EXT kicker controller replaced		
May 18 2010	4	1.905 ± 0.078	1.08 ± 0.03
Apr 21 2010	4	1.212 ± 0.065	1.26 ± 0.03
Mar 17 2010	BS3X rolled ~4 mrad (CCW)		
Feb 25 2010	4	1.868 ± 0.336	1.15 ± 0.12
Feb 17 2010	4	negative	
Feb 3 2010	4	1.626 ± 0.095	1.10 ± 0.06
Jan 28 2010			

Vertical EXT Emittance Measurements

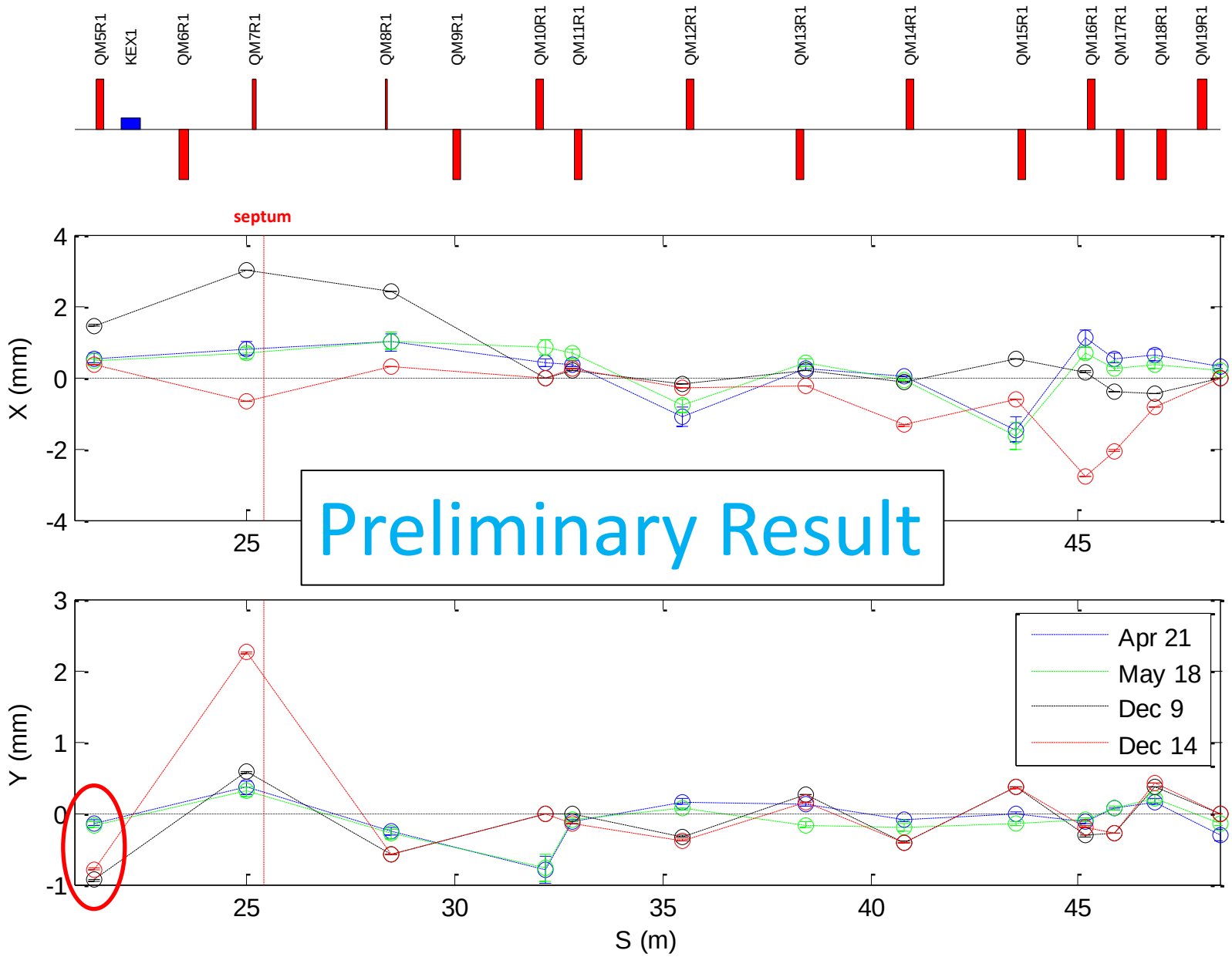
Date	N_{wire}	Emit (pm)	BMAG
Dec 14 2010	5	27.6 ± 1.8	1.09 ± 0.04
Dec 9 2010	4	29.3 ± 3.1	1.05 ± 0.02
Nov 2010 (?)	EXT kicker controller replaced		
May 18 2010	5	11.7 ± 2.3	1.43 ± 0.25
Apr 21 2010	5	15.4 ± 2.0	1.78 ± 0.17
Mar 17 2010	BS3X rolled ~4 mrad (CCW)		
Feb 25 2010	5	22.08 ±0.9	1.19 ± 0.03
Feb 25 2010	5	38.33 ± 1.1	1.10 ± 0.02
Feb 17 2010	5	22.6 ± 1.4	1.15 ± 0.04
Feb 3 2010	5	16.1 ± 0.7	1.06 ± 0.03
Jan 28 2010	5	31.6 ± 1.2	1.03 ± 0.01

Emittance & Coupling
DR Orbit & Extraction Trajectory

SET-file History (Apr-Dec, 2010)

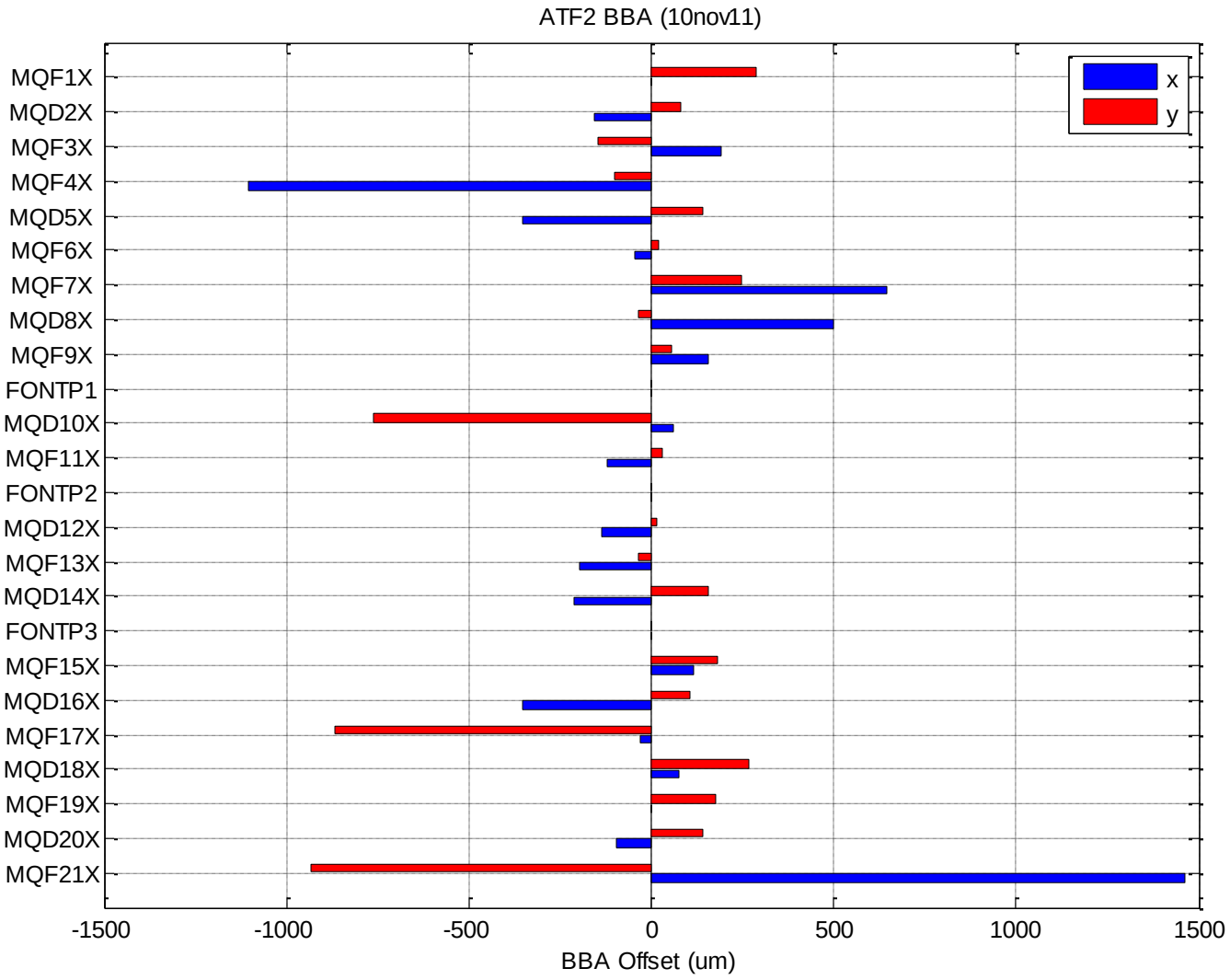


ATF DR: North Straight Section

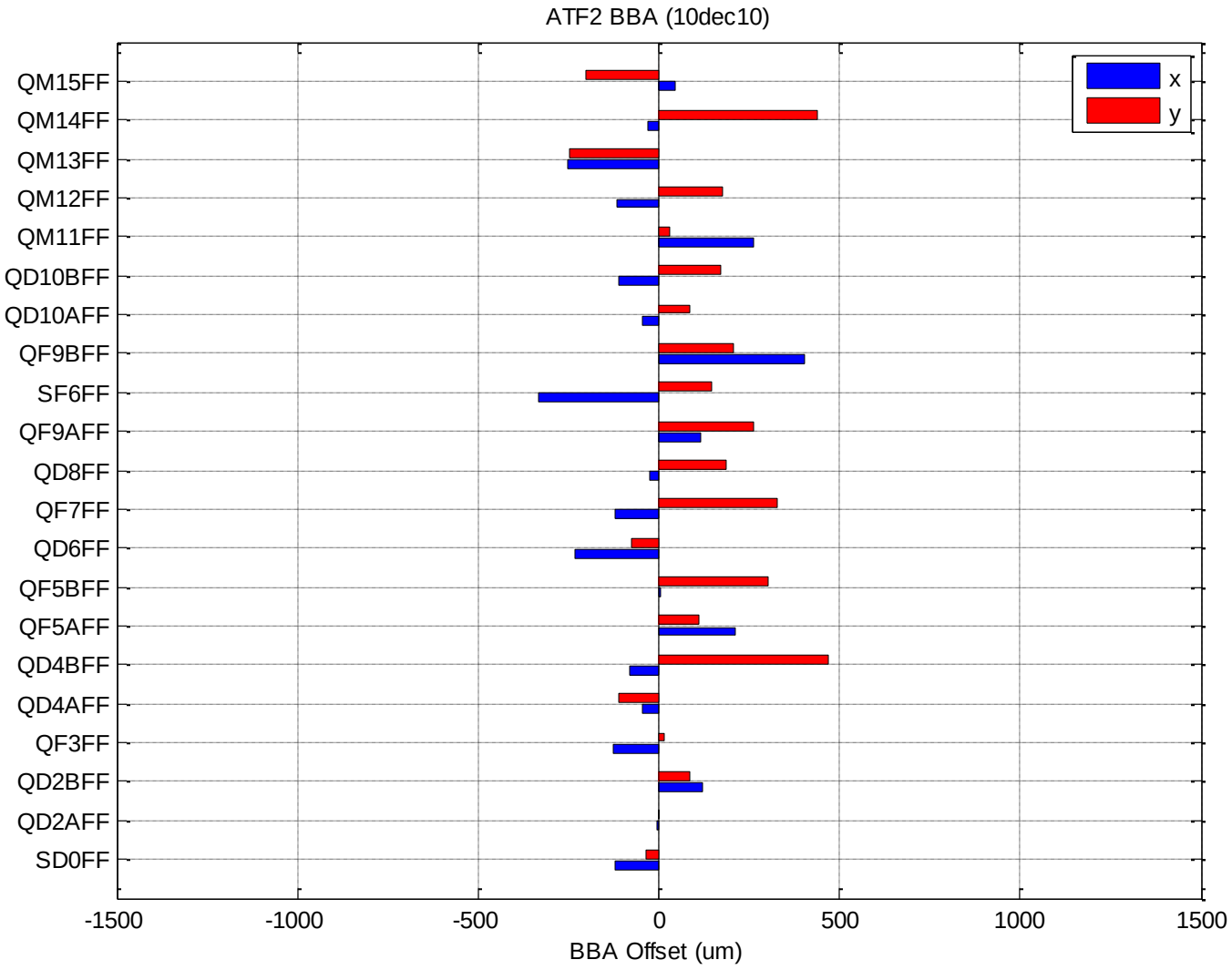


BBA

EXT BBA

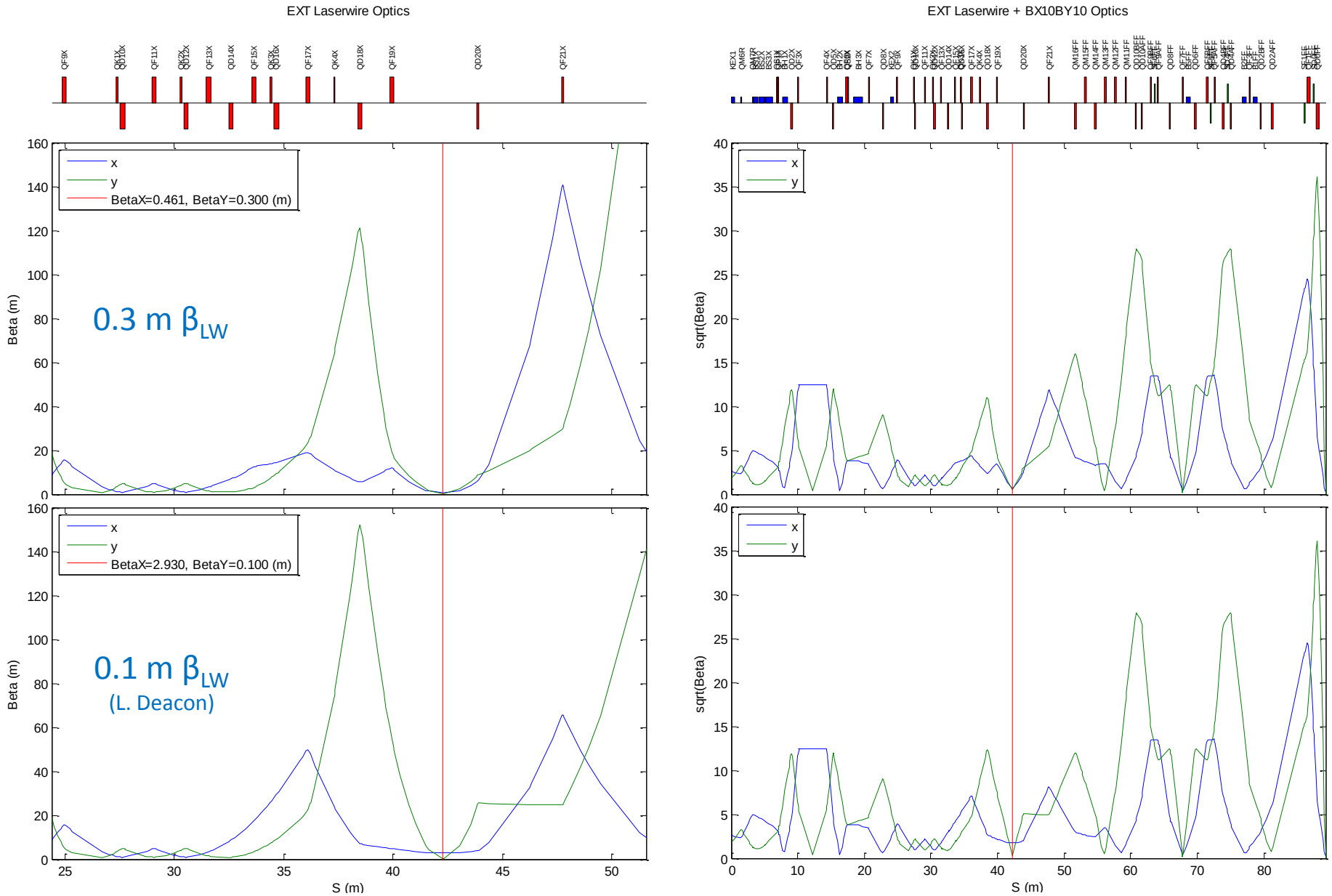

ATF2 BBA (10nov11)
MQF1X
MQD2X
MQF3X
MQF4X
MQD5X
MQF6X
MQF7X
MQD8X
MQF9X
FONTP1
MQD10X
MQF11X
FONTP2
MQD12X
MQF13X
MQD14X
FONTP3
MQF15X
MQD16X
MQF17X
MQD18X
MQF19X
MQD20X
MQF21X
x
y
-1500
-1000
-500
0
500
1000
1500
BBA Offset (um)

FF BBA

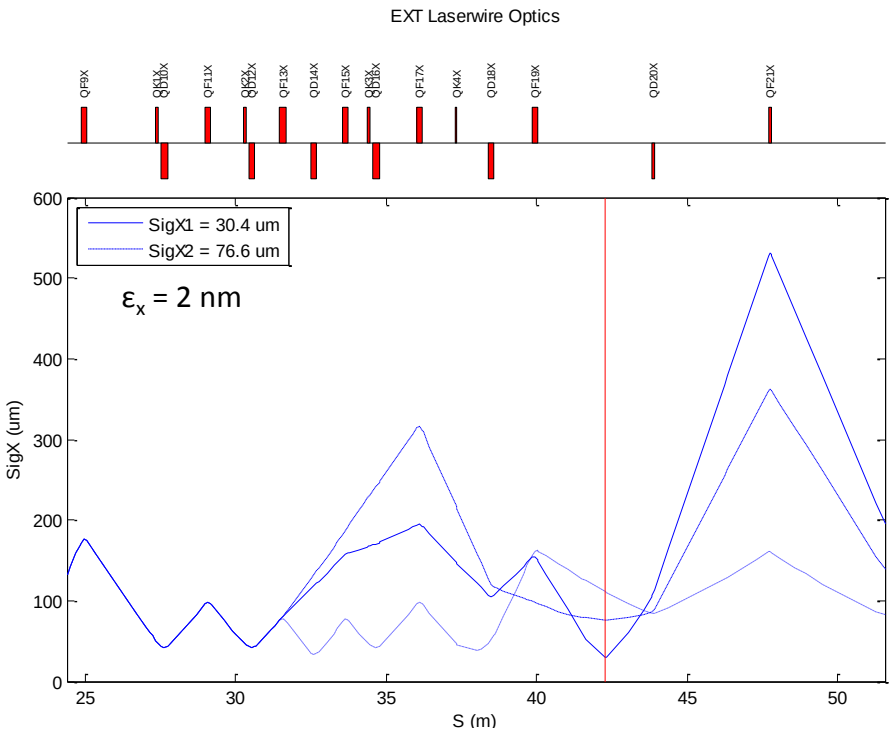

ATF2 BBA (10dec10)
QM15FF
QM14FF
QM13FF
QM12FF
QM11FF
QD10BFF
QD10AFF
QF9BFF
SF6FF
QF9AFF
QD8FF
QF7FF
QD6FF
QF5BFF
QF5AFF
QD4BFF
QD4AFF
QF3FF
QD2BFF
QD2AFF
SD0FF
x
y
-1500
-1000
-500
0
500
1000
1500
BBA Offset (um)

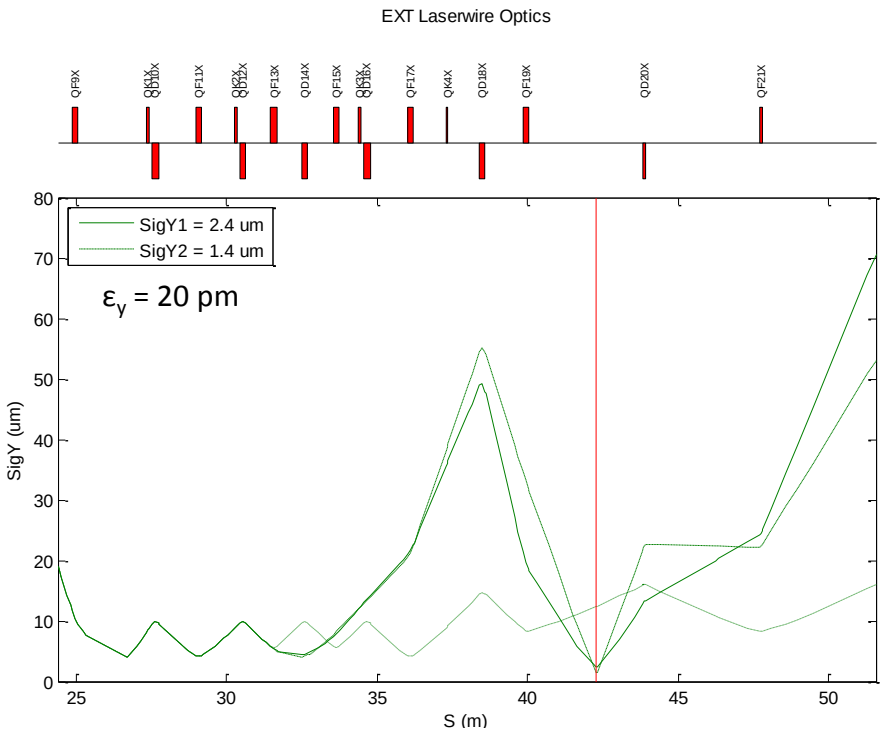
EXT Laserwire / ATF2 Compatibility Optics

EXT LW / ATF2 Compatibility Optics



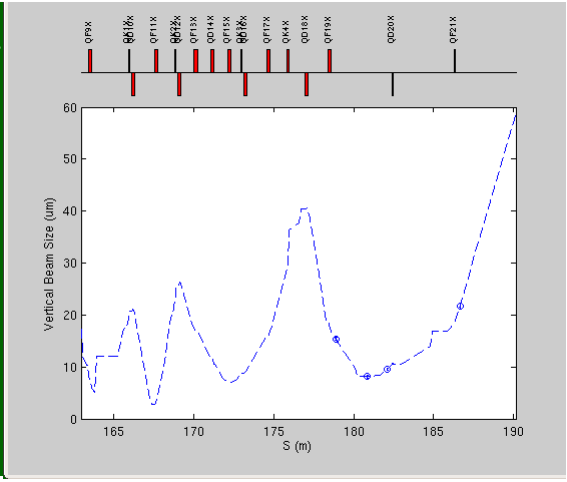
EXT LW / ATF2 Compatibility Optics






```
Vertical emittance parameters at MW1X
-------------------------------------------------------
energy      =     1.2818              GeV
emit        =    45.1692 +-    1.0416 pm
emitn       =   113.3003 +-    2.6126 nm
emitn*bmag  =   296.4674 +-   18.7531 nm
bmag        =     2.6167 +-    0.1518      (   1.0000)
bmag_cos    =    -0.8500 +-    0.0000      (   0.0000)
bmag_sin    =    -0.3626 +-    0.0000      (   0.0000)
beta        =     5.1469 +-    0.1306 m    (  13.1119)
alpha       =     1.6165 +-    0.0675      (   6.5350)
chisq/N     =     0.5962

Propagated vertical spot sizes
----------------------------------
MW1X =   15.2 um (  15.4 +-    0.3)
LW1X =    8.2 um (   8.1 +-    0.3)
MW2X =    9.5 um (   9.5 +-    0.2)
MW3X =   21.9 um (  21.6 +-    0.6)
```



EXT LW / ATF2 Compatibility Optics: some notes

- optics requires polarity flip for QM16FF and QM11FF
- backgrounds for both LW and BSM could be made acceptable
  - relaxed FF optics ("BX10BY10")
  - FF sextupoles OFF
- laser / e- beam collisions found (β_y^{LW} = 0.3 m optics)
- beta-match to LW waist after emittance measurement … failed … cockpit error
- β_y^{LW} = 0.1 m optics not tested yet
- matching to other FF optics (*i.e.* "BX2.5BY1") is OK, too
- see Laura Corner's talk …

Magnet Trim Function Issue

- most magnets have "standard" SET/trim functionality
  - enter a new SET value
  - magnet trims from present value to new value
- some magnets seem to have special SET/trim functionality (for trim rate control?)
  - enter a new SET value
  - SET value increments/decrements from present value to new value in some number of steps
  - at each step, magnet trims from present value to new SET value for that step
- sometimes this process aborts before reaching the final desired SET value
  - SET value is left at an intermediate value
  - there's no way to know that the magnet now has the wrong SET value
- QK1X (Dec 15 2010 04:00)
  - original SET value was -15.7 amp (after coupling correction … ε_y = 34 pm)
  - magnet strength was scanned from -10.7 amp to +10.3 amp (IP spot size tuning)
  - magnet was reset to -15.7 amp … trimming aborted … SET value was left at +1.5 amp
  - coupling correction was destroyed (a subsequent OTR emittance measurement gave ε_y = 54 pm)
  - all subsequent IP spot size tuning was made with QK1X @ +1.5 amp!

Summary & Continuing Work

Summary (1)

- Flight Simulator dispersion measurements
  - fully automatic control of DR RF ramp
  - propagated dispersion values at wire scanners, OTRs, etc. now available to other FS packages
  - jitter-based (SVD) measurement still under investigation
- *model-based* horizontal dispersion correction (η_x and η'_x) works
  - good BBA offset measurements for QF1X/QF6X are <u>critical</u>
  - beam <u>must</u> be centered in QF1X and QF6X for proper correction
  - no empirical fudge factors required
- vertical dispersion correction is still done *manually*
  - sum knob (QS1X=QS2X) is adjusted to minimize FD-phase η_y
- fast OTR emittance measurements are now available
  - magnification changes to widen horizontal field of view (better horizontal projected fits)
  - address sensitivity of ellipse fit to background, windowing, etc. (done, I think ...)

Summary (2)

- full QK-scan minimization of $BMAG_y * \varepsilon_y$ demonstrated
  - ~ 2 hours for full correction
  - minimum ε_y ~ 2x the DR XSR measured value
  - can now envision repeating scans to verify orthogonality of skew correction system
- beam extracted from DR seems to have both ε_y growth and coupling
  - KEX voltage? DR orbit? steering in septum region?
- BBA offsets have been measured for most BPMs
- optics has been developed and tested for simultaneous EXT LW and BSM operation
  - compatibility mode operation with “BY1” optics and IP spot size tuning not yet tested

Continuing Work

- FS dispersion package
  - automate η_y correction
  - continue to study non-invasive jitter-based (SVD) dispersion measurement
- coupling measurement / 4D beam reconstruction
  - use OTR ellipse fit to extract lengths of semi-major and semi-minor axes and tilt angles
  - revisit 4D reconstruction … try Ilya Agapov's "Cholesky decomposition" method?
- DR orbit / extraction trajectory / ε_y / coupling
  - need EPICS access to DR BPMs (closed orbit & extraction buffer)
  - check dependence of ε_y and coupling on DR orbit (*i.e.* vertical offset/angle at KEX1)
  - save orbits more frequently!
- and ...