Motivation

Correction Correction Capabilities at ATF2

Studied Coupling Scenarios

Results

Emittance Measurements in 2012

Impact of Kicker and Septum Misalignments

Simulations

Measurements

Conclusions

Study on Coupling Correction and Emittance measurements

Edu Marin
emarinla@slac.stanford.edu

January 24^{th}, 2013
15^{th} ATF2 Project Meeting
Major issues and the mitigations session

Motivation

Correction Correction Capabilities at ATF2

Studied Coupling Scenarios

Results

Emittance Measurements in 2012

Impact of Kicker and Septum Misalignments

Simulations

Measurements

Conclusions

1. Motivation
2. Correction Correction Capabilities at ATF2
   - Studied Coupling Scenarios
   - Results
3. Emittance Measurements in 2012
4. Impact of Kicker and Septum Misalignments
   - Simulations
   - Measurements
5. Conclusions

Motivation
Correction Correction Capabilities at ATF2
Studied Coupling Scenarios
Results
Emittance Measurements in 2012
Impact of Kicker and Septum Misalignments
Simulations
Measurements
Conclusions

Motivation

The general goal is to explain the observed values of vertical emittance measured at the ATF2 extraction beamline

Coupling correction study:

- Determine the correction capabilities of the coupling section of ATF2 by simulating different coupled beam entering the ATF2-EXT line

Misalignment study:

- Determine plausible conditions of alignment errors of both kicker and septum that reproduce the measurements of the vertical emittance, dispersion, skew quadrupole strengths and orbit

Motivation

Correction
Correction Capabilities at ATF2

Studied Coupling Scenarios

Results

Emittance Measurements in 2012

Impact of Kicker and Septum Misalignments

Simulations

Measurements

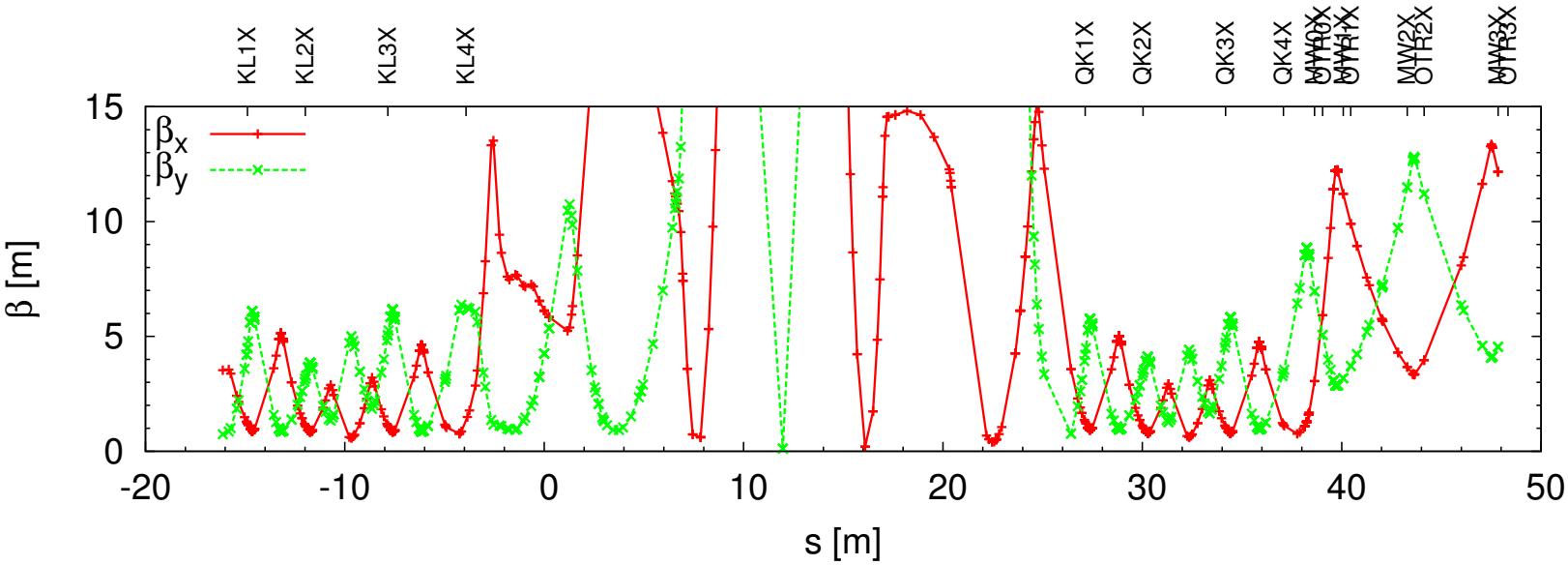
Conclusions

COUPLING CORRECTION CAPABILITIES AT ATF2

Considered Lattice

The MAD-X model of the ATF2 EXT line has been extended by 2 additional upstream sections:

- *Coupling generation beam line*: It is a 4x FODO lattice which accommodates 4 skew thin lens quadrupoles at a convenient phase advance in order to cover the following coupling terms $< x, y >$, $< p_x, y >$, $< x, p_y >$, $< p_x, p_y >$
- *Matching section*: It is meant to match the Twiss functions (β, α and η) at the exit of the coupling generation beam line into the EXT line



Considered Scenarios of Coupled Beam

Motivation

Correction
Correction Capabilities at ATF2

Studied Coupling Scenarios

Results

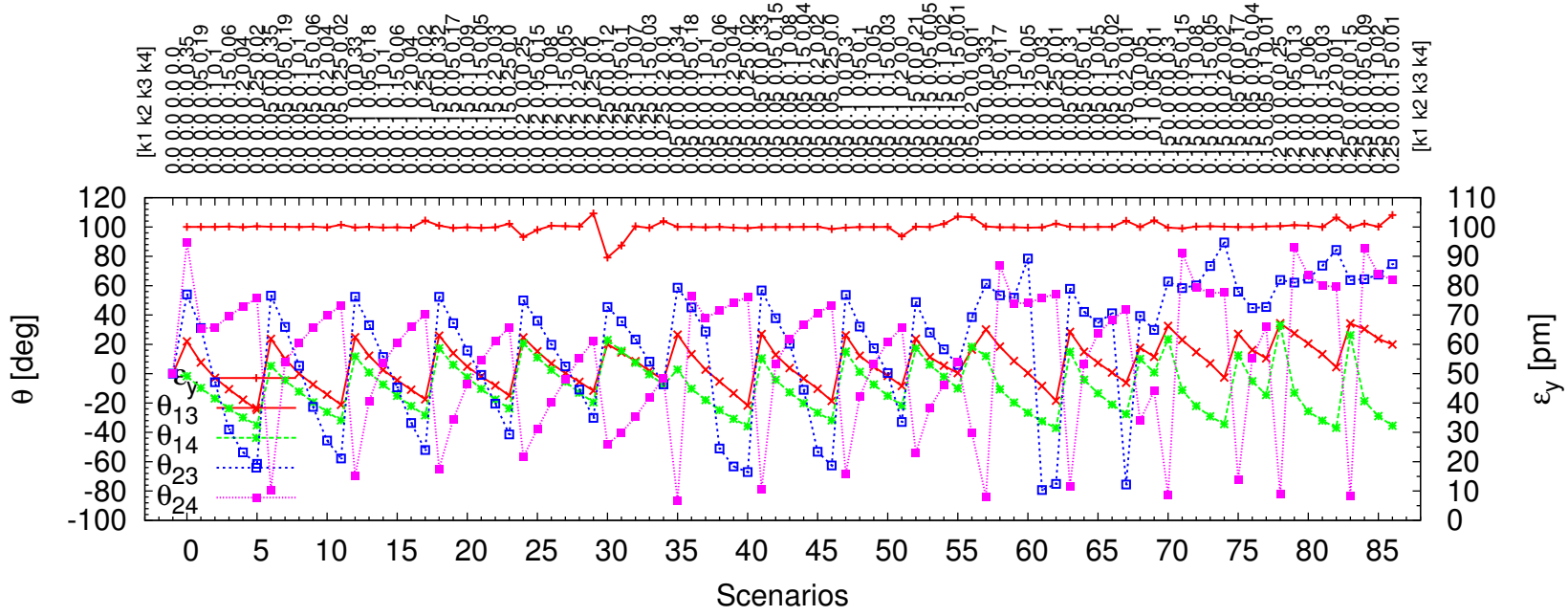
Emittance Measurements in 2012

Impact of Kicker and Septum Misalignments

Simulations
Measurements

Conclusions

The strengths of the upstream four skew quadrupoles (thin lens), namely KL1X, KL2X, KL3X and KL4X are increased until the projected vertical emittance is 100 pm



Coupling Correction Results

The considered algorithms for correcting the coupling:

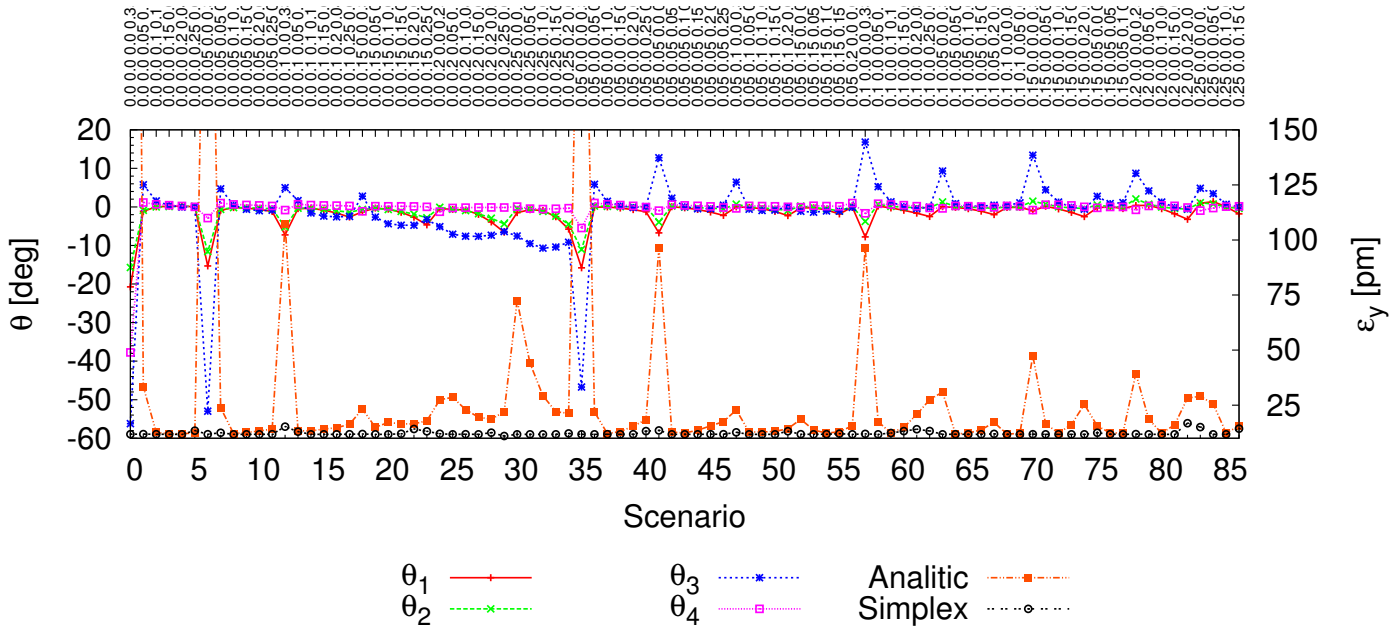
- By zeroing the measured tilts of the beam at the OTRs

The algorithm evaluates the strength of 4-skew quadrupoles $\overrightarrow{K}$ that compensate the measured tilts $\overrightarrow{\theta}_{\text{meas}}$ at the OTRs, according to:

$$\overrightarrow{K} = -\left(R^{-1} \cdot \overrightarrow{\theta}_{\text{meas}}\right) \quad R_{i,j} = \frac{\partial \theta_i}{\partial k_j} \tag{1}$$

where R is the response matrix of $\theta_{x,y}$ when changing the strength of the skew quadrupoles

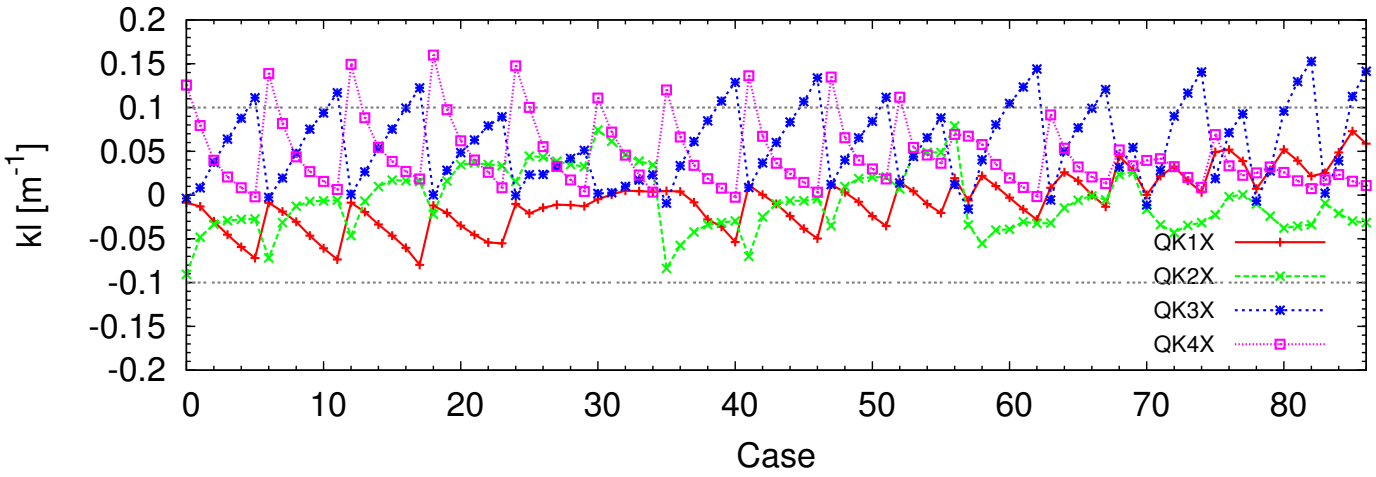
- By a Simplex algorithm that minimises the emittance



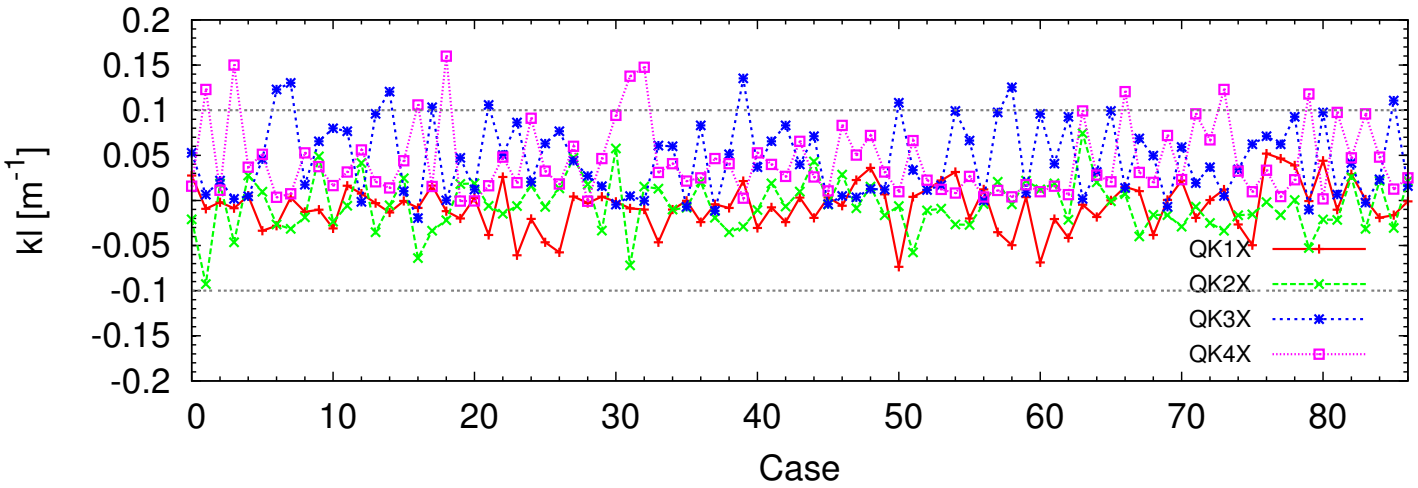
Correction feasibility

Some scenarios demand a B-field that exceeds the maximum current provided by the power supplies

Analytical method (2 iteration):



Simplex:



Motivation

Correction
Correction Capabilities at ATF2

Studied Coupling Scenarios
Results

Emittance Measurements in 2012

Impact of Kicker and Septum Misalignments

Simulations
Measurements

Conclusions

EMITTANCE MEASUREMENTS

Emittance Measurements in 2012

Motivation

Correction Correction Capabilities at ATF2

Studied Coupling Scenarios

Results

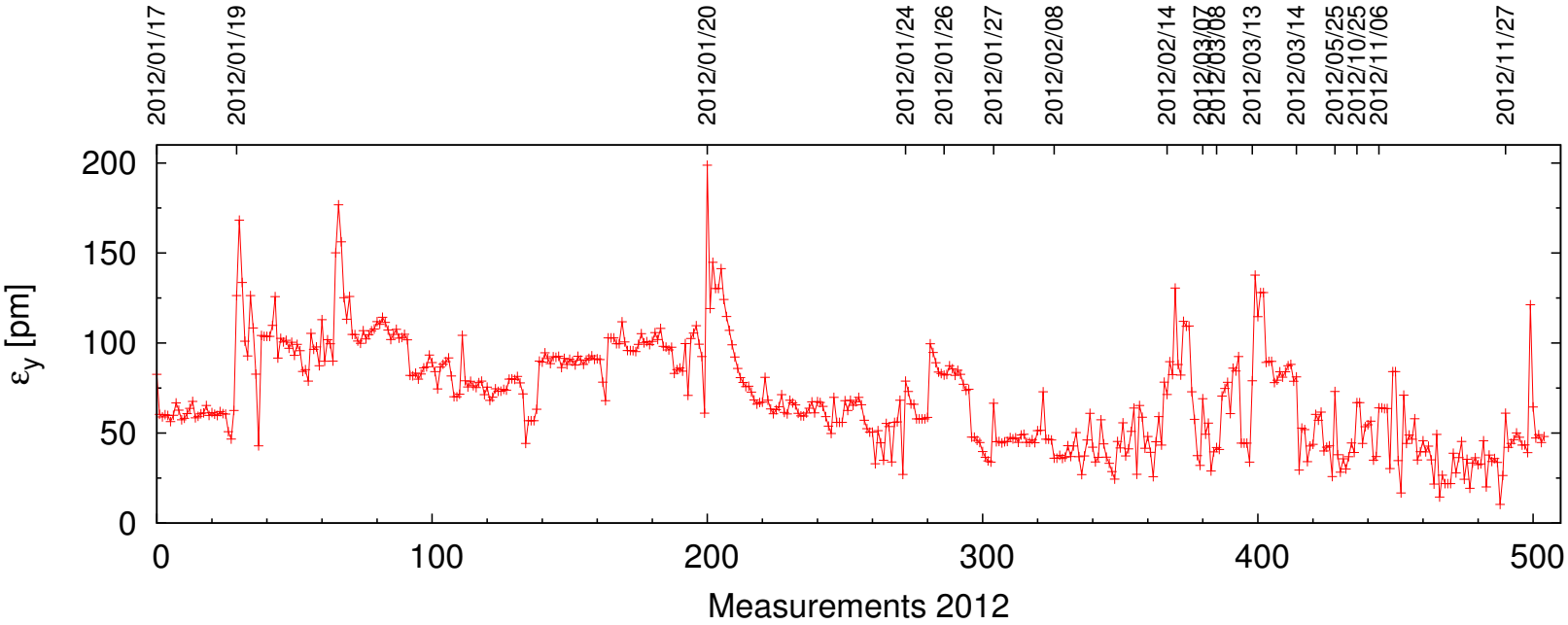
Emittance Measurements in 2012

Impact of Kicker and Septum Misalignments

Simulations

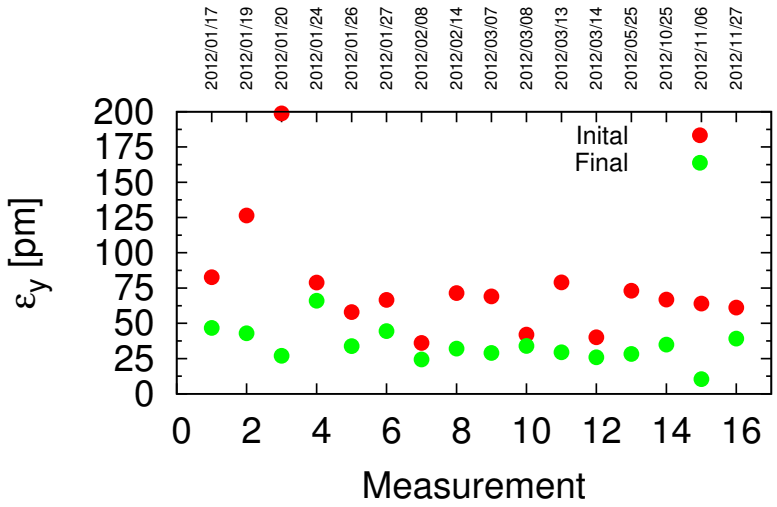
Measurements

Conclusions

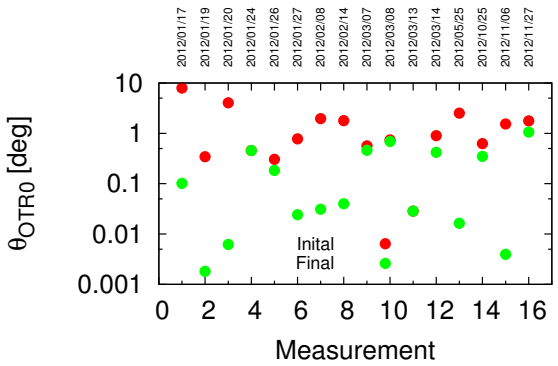


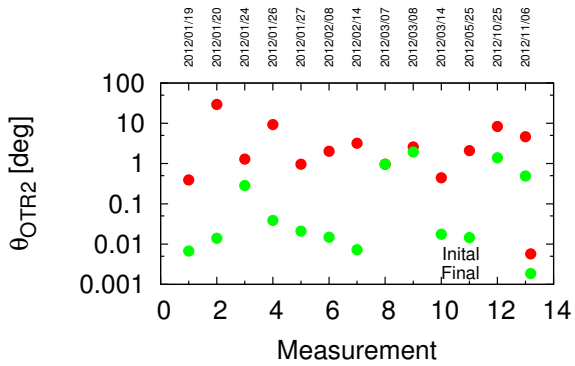
Initial ϵ_y =76±39 pm

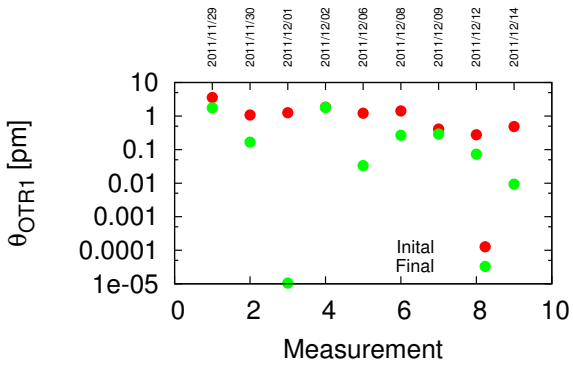
Final ϵ_y = 34±12 pm

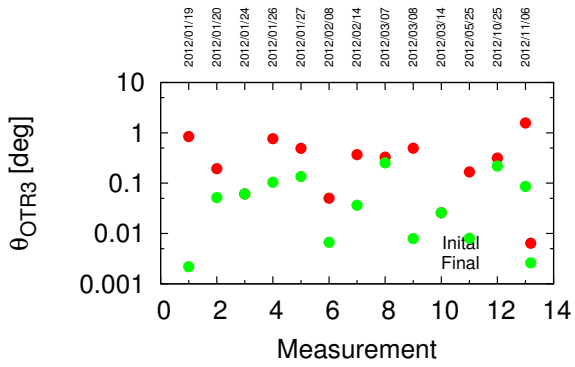


Beam Tilts at OTRs 2012









Mean of the |Tilt| values before and after correction:

OTR0 $\Rightarrow$ θ_0=1.7$\pm$1.9 deg	Final θ_0=0.3$\pm$0.3 deg
OTR1 $\Rightarrow$ θ_1=1.5$\pm$1.7 deg	Final θ_1=0.2$\pm$0.2 deg
OTR2 $\Rightarrow$ θ_2=5.0$\pm$7.6 deg	Final θ_2=0.4$\pm$0.6 deg
OTR3 $\Rightarrow$ θ_3=0.4$\pm$0.4 deg	Final θ_3=0.1$\pm$0.1 deg

Conclusions

- The Simplex algorithm reaches a satisfactory coupling correction for all the considered scenarios
- The present coupling correction algorithm is capable of correcting almost all considered scenarios
- Although, for some scenarios the required currents by the skew quadrupoles are above the PS capabilities, these are unlikely ones

- The initial ϵ_y measured at the extraction line of ATF2 in 2012 was 76 ± 39 pm and the measured initial tilts at all OTRs are below 10 deg

Motivation

Correction Correction Capabilities at ATF2

Studied Coupling Scenarios

Results

Emittance Measurements in 2012

Impact of Kicker and Septum Misalignments

Simulations

Measurements

Conclusions

IMPACT OF KICKER AND SEPTUM MISALIGNMENTS

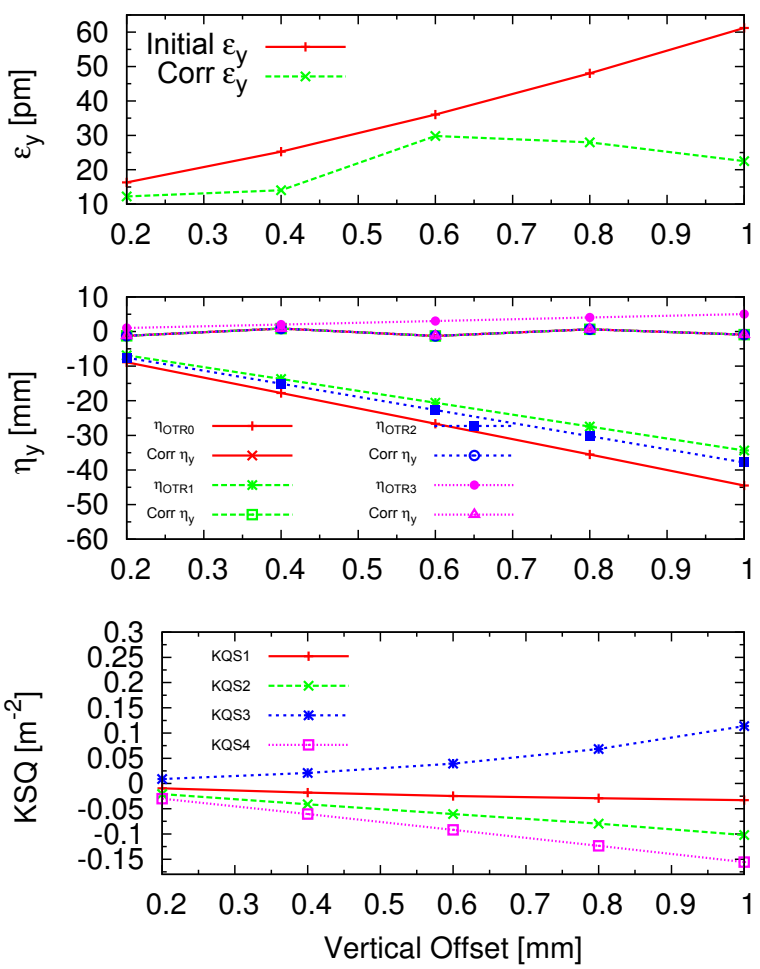
Multipole components

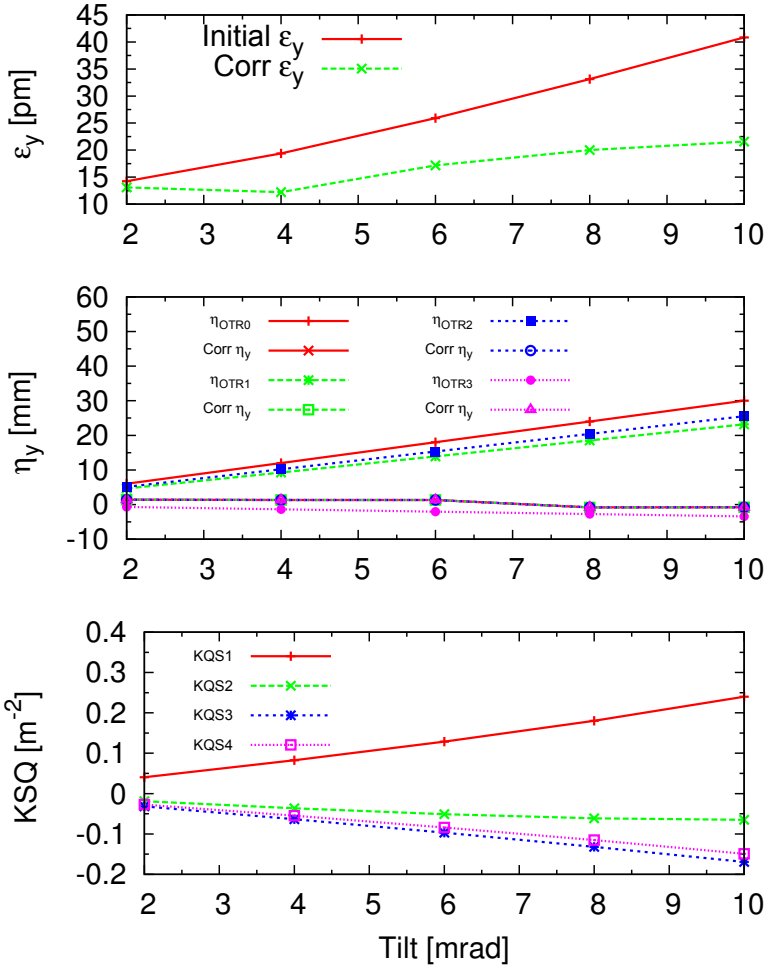
The present multipole components at the kicker (KEX1) and the septum (BH1X, BH2X and BH3X) are:

KEX1MULT:K1L:=-0.01846929 m^{-1} KEX1MULT:K2L:=-3.824591 m^{-2}

BH1XMULT:K2L:=-0.183983746289 m^{-2} BH2XMULT:K2L:=0.183983746289 m^{-2}

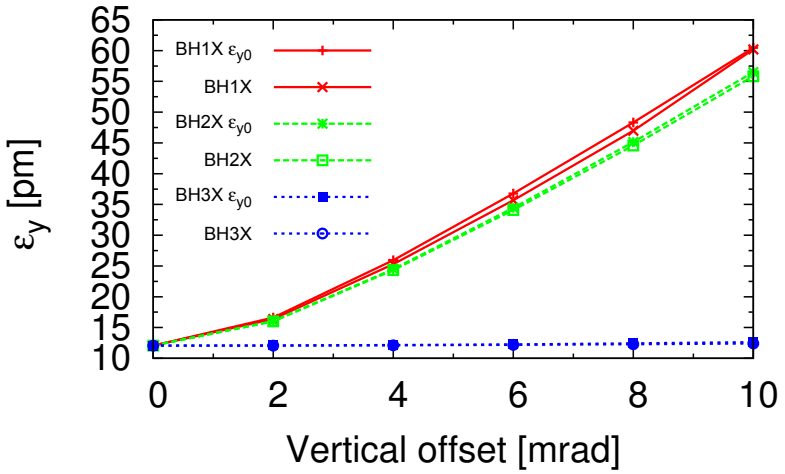
Offsetting and tilting KEX1:

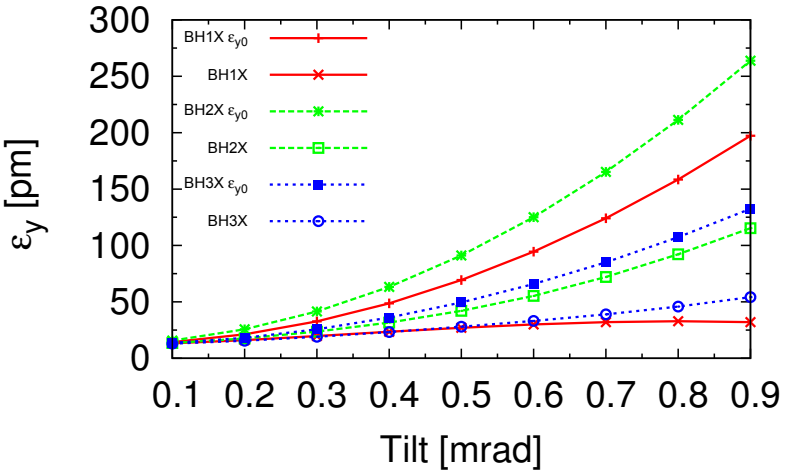




Multipole components

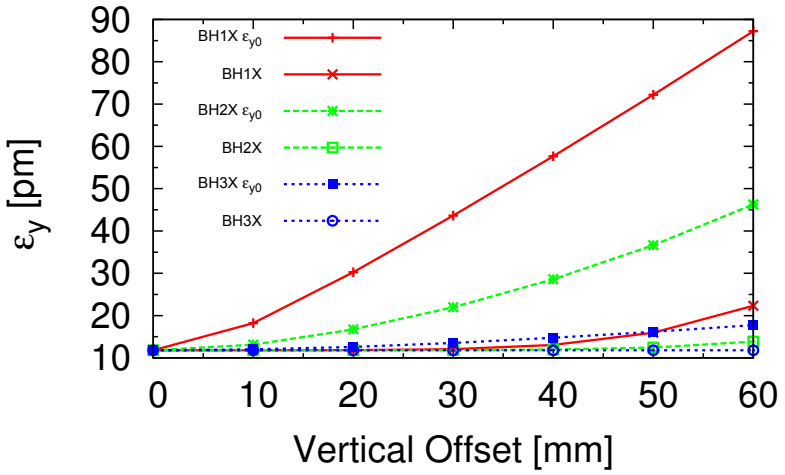
Offsetting and tilting the septum:

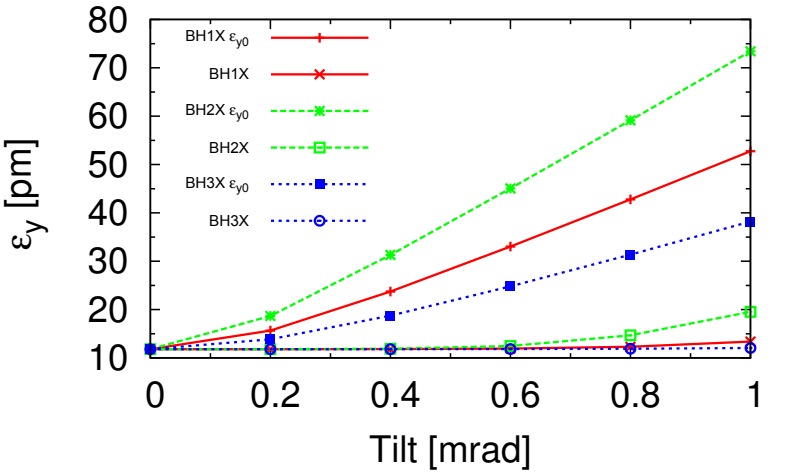




The quadrupole component of the kicker introduce vertical dispersion that needs to be corrected for efficiently applying the mOTR tilt compensation algorithm

If assuming $\frac{\Delta p}{p}=0$:



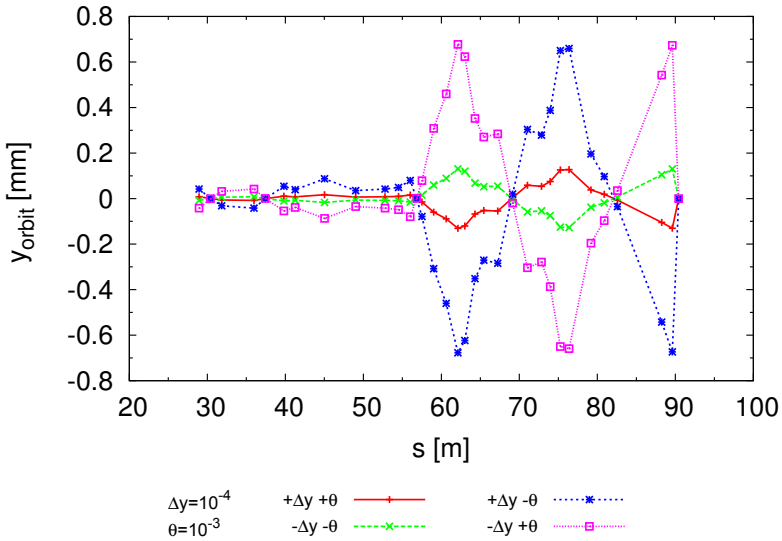


Edu Marin

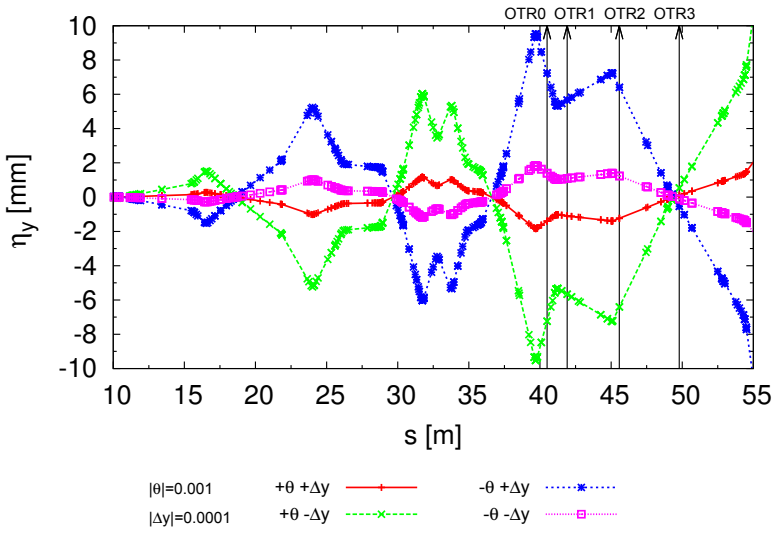
Motivation
Correction Correction Capabilities at ATF2
Studied Coupling Scenarios
Results
Emittance Measurements in 2012
Impact of Kicker and Septum Misalignments
Simulations
Measurements
Conclusions

Orbit and Dispersion of the beam

The vertical beam orbit when offsetting and tilting the kicker are :

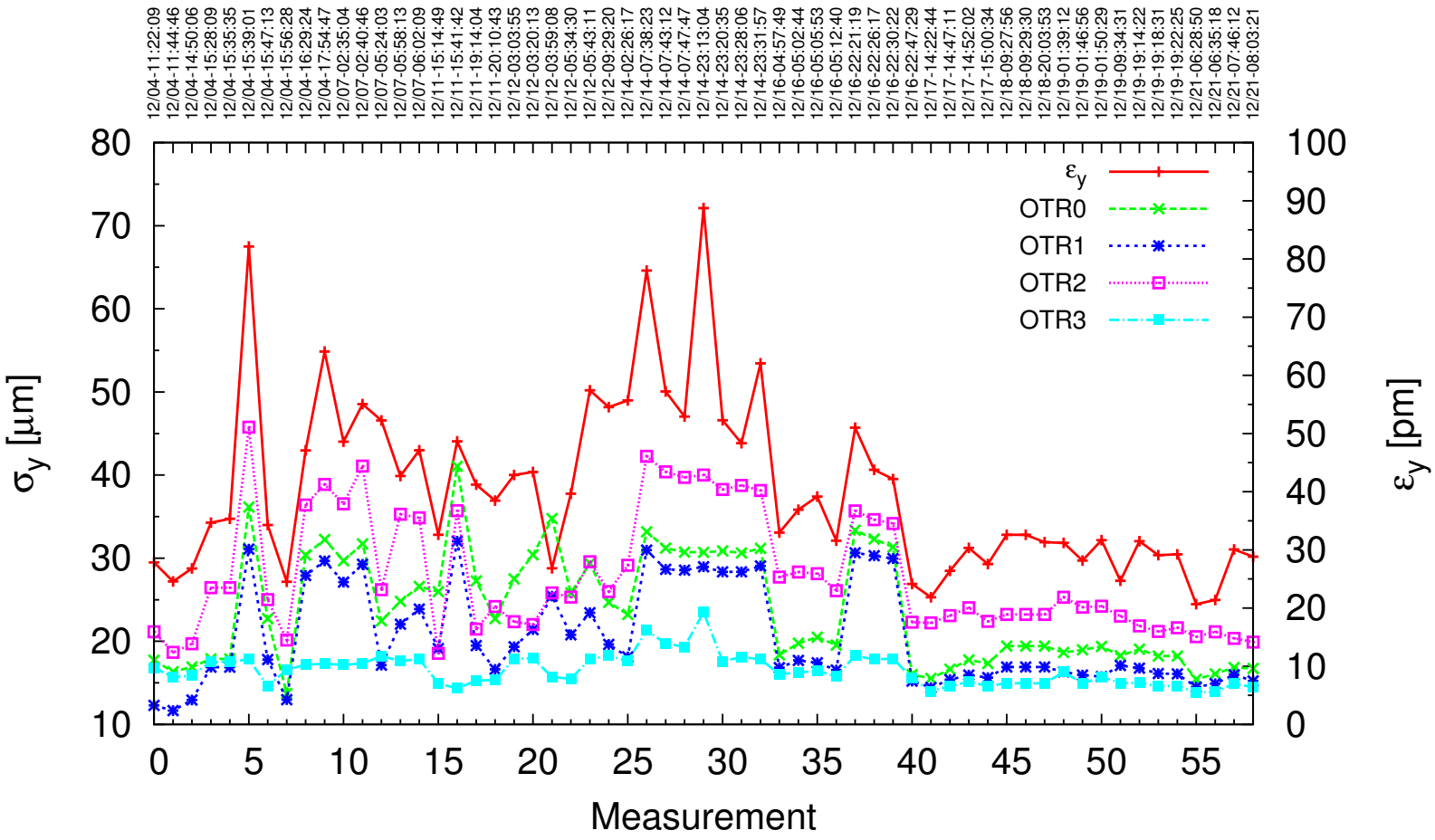


The vertical dispersion when offsetting and tilting the kicker are :



Measurements during December 2012

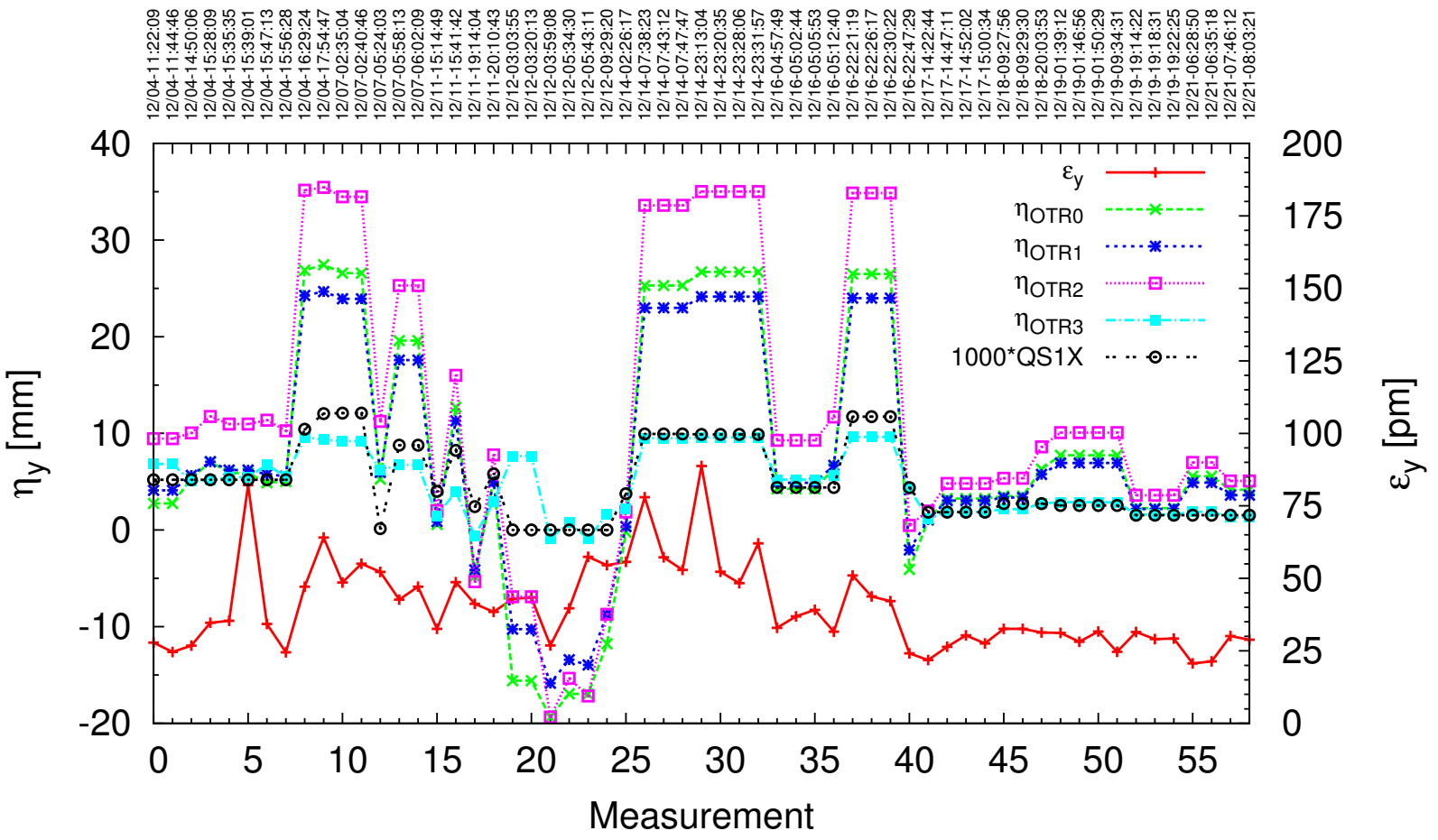
Measured vertical beam size at the OTRs:



Beam sizes at the OTRs are dominated by dispersive effects (next slide...)

Measurements during December 2012

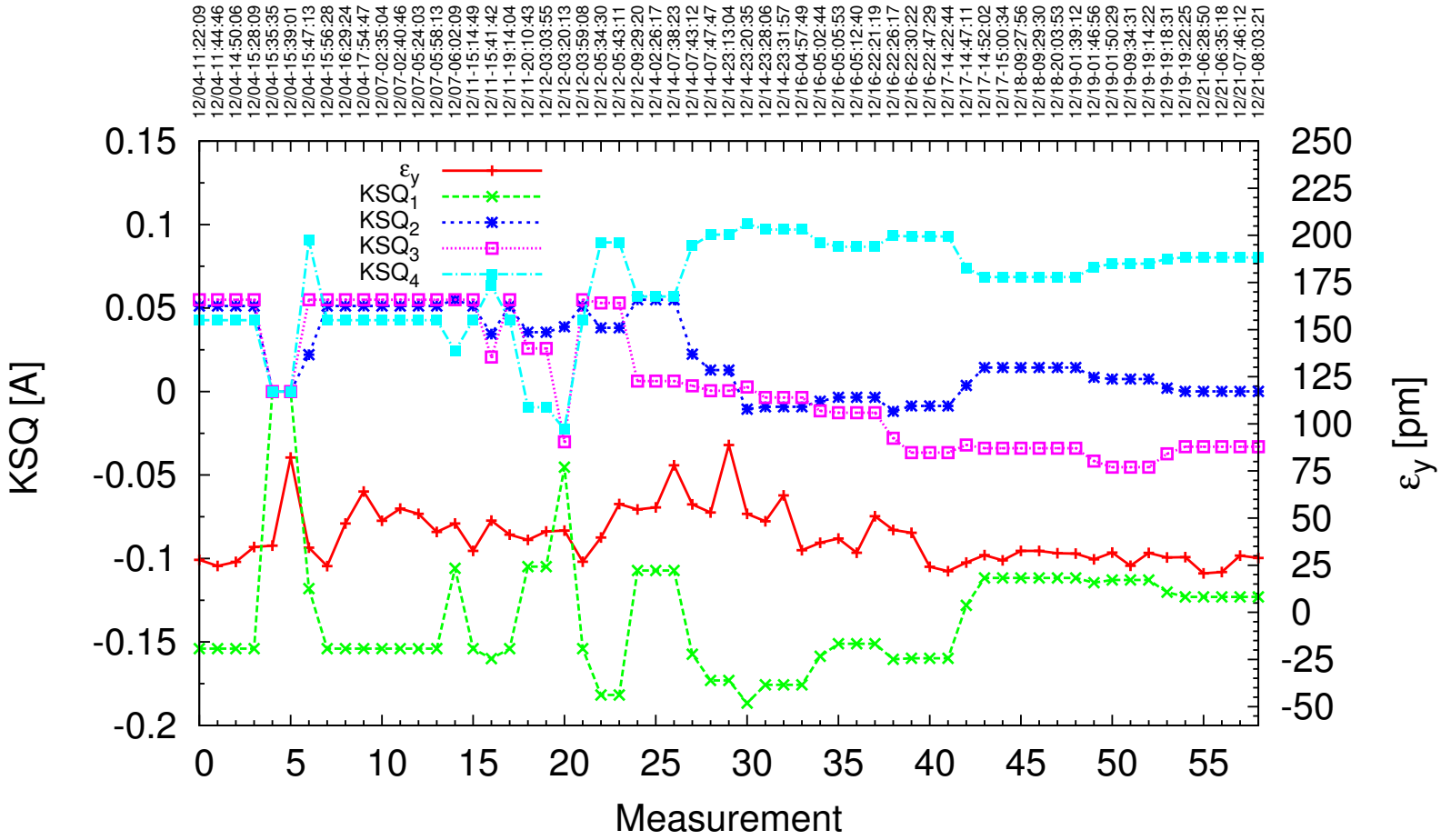
The vertical dispersion values at the OTRs are obtained from the projection of dispersion measured at the BPMs:



A positive dispersion value is found in almost all scenarios at all OTRs

Measurements during December 2012

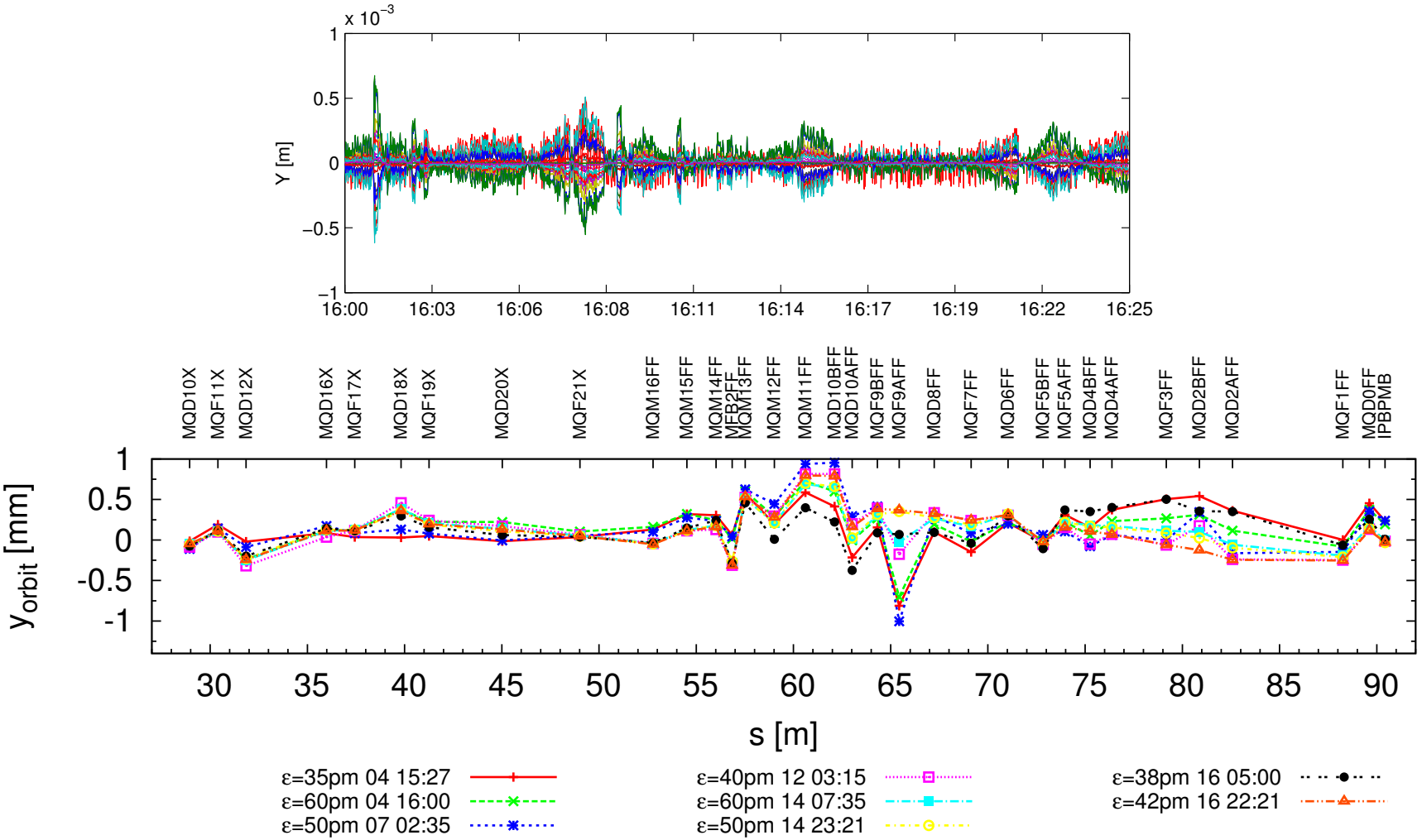
Strength of the skew quadrupoles:



For the second half of measurement we found a strong negative QS1X, positive values for QS2X and QS4X which compensate for each other and small negative current for value for QS3X

Measurements during December 2012

The vertical orbit at the BPMs for 11 different measurements during Dec'12:



A displacement of the orbit within $\approx 200 \mu m$ is observed from QD16X up to the FFS

Group of Measurements

I have identified 12 different measurements that correspond to different setting conditions of one of the following observables: emittance, skew quadrupole strengths, dispersion and orbit

Meas.	Time	$\epsilon_{x,y}$	$SQ_{1,2,3,4}$	$\eta_{y,0,1,2,3}$
		[nm / pm]	[10^{-2} A]	[mm]
1	12/4 15:30	1.7, 35	-8/3/3/2	6/7/11/5
2	12/4 15:40	1.7, 82	0/0/0/0	33/27/36/15
3	12/4 17:00	1.7, 53	-15/5/5/4	26/24/34/9
4	12/12 03:30	1.7, 43	-7/3/0.2/-2	-15/-10/-6/7
5	12/14 07:30	1.8, 63	-16/1/0.8/1	26/23/34/10
6	12/16 05:00	1.7, 35	-16/-0.5/-1/9	5/5/10/5
7	12/16 22:25	1.7, 46	-15/-0.1/-3/10	26/23/34/10
8	12/17 14:50	1.7, 30	-11/1/-3/7	3/3/5/2
9	12/19 01:40	1.6, 30	-11/1/-3/7	7/6/10/3
10	12/19 19:15	1.5, 30	-11/0.3/-3/8	2/2/3/1
11	12/21 06:25	1.3, 21	-12/0/-3/8	5/4/7/2
12	12/21 07:45	1.8, 29	-12/0/-3/8	4/4/5/1

KEX1 Tilt inferred from Okugi-san during day shift on Dec 13th 2012 was ≈100mrad (*http://atf.kek.jp/twiki/bin/view/ATFlogbook/Log20121213d)*

Summary

- The alignment errors of the Kicker and Septum might explain the larger values of the vertical emittance
- It is observed that smaller values of the emittance are measured when the dispersion is corrected in the order of mm
- Alternatively, reducing the beam charge decreases the emittance

Next steps:

- Determine the alignment errors conditions of the kicker and septum that better match the current observables (vertical orbit, dispersion and the skew quadrupoles strengths) for the 12 group of measurements