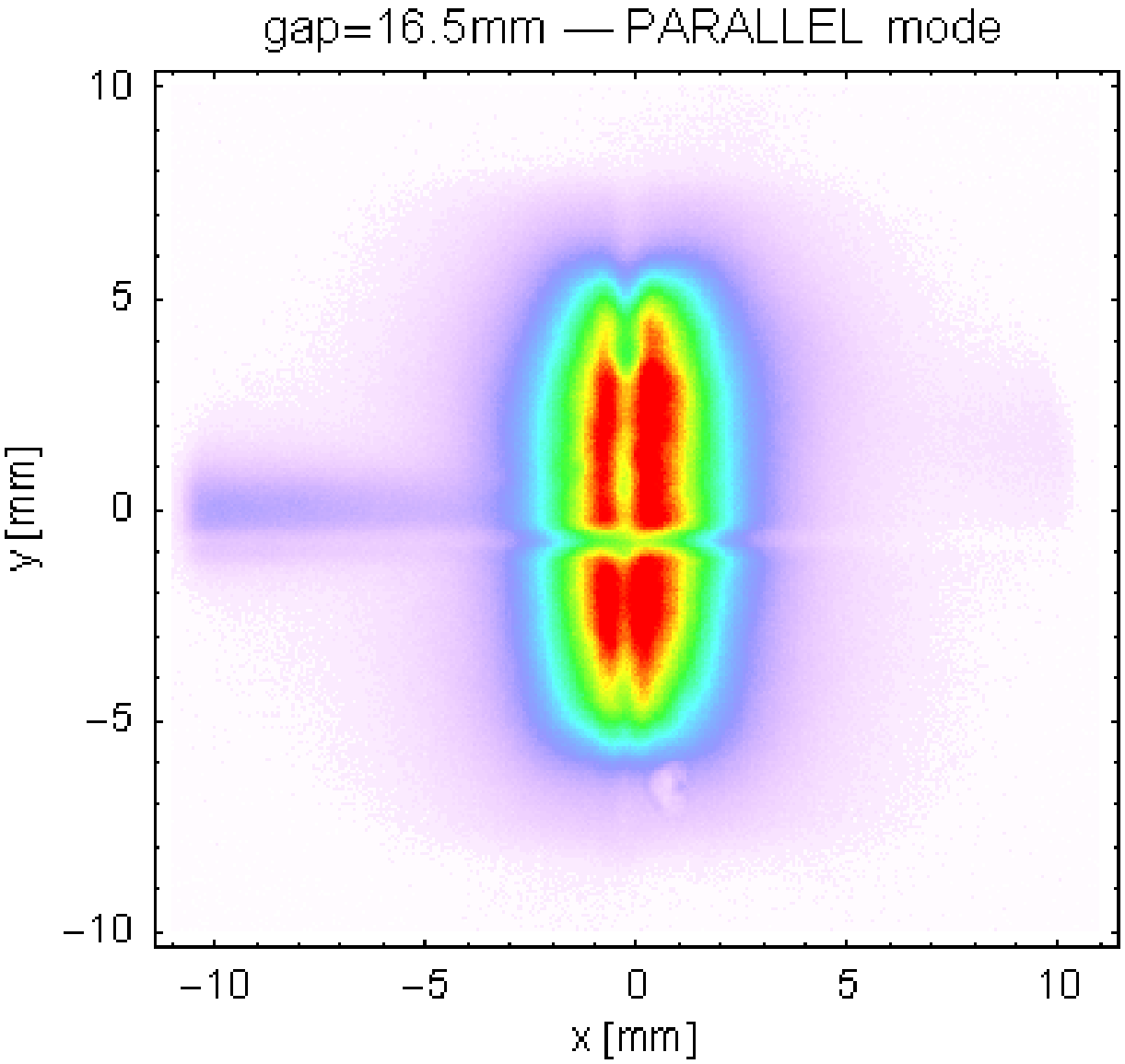
ALBA: COMMISSIONING STATUS

Marc Munoz
on behalf of ALBA Accelerator Division


gap=16.5mm — PARALLEL mode
10
5
0
−5
−10
y [mm]
−10
−5
0
5
10
x [mm]

History of the project

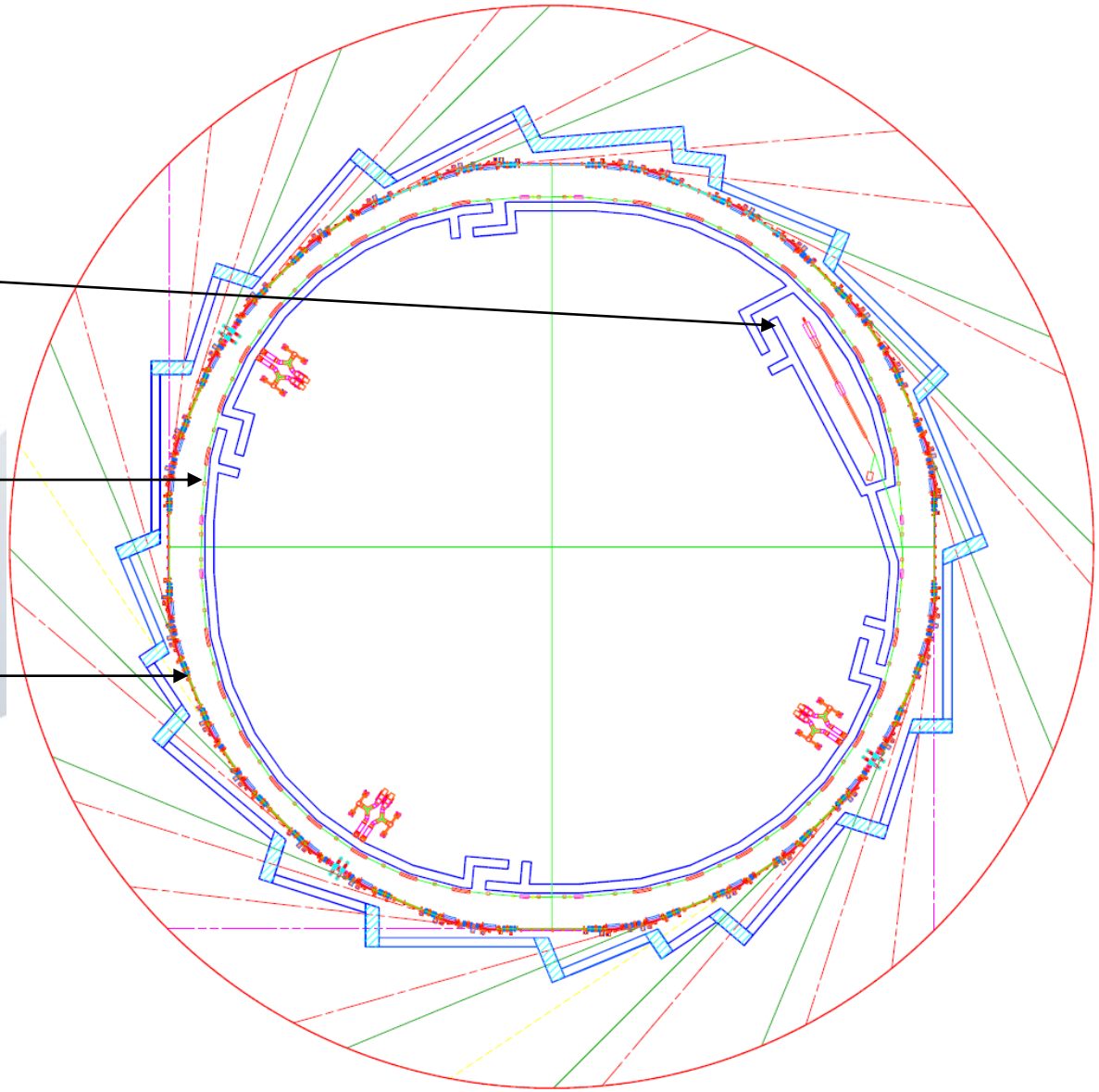
- 1992-4: First plans for a light source in Spain. Creation of the LLS. Recruitment and training of the staff for the preparation of a conceptual design report for a light source.
- 1997: Finishing the conceptual design report
- 2002: Approval of the project by the Spanish- and the Catalonian Government. Site selected in the Valles area, close to Barcelona and to the Universitat Autonoma de Barcelona. CELLS created.
- 2003: Appointment of the General Director (Prof. Joan Bordas).
- 2003: Announcement of the positions for the heads of the 5 divisions.
- 2003-05: Users meeting and workshops to establish the scientific program. 7 beamlines approved.
- 2004-05: Redesign of the machine, Staff recruting
- 2005-08: Building.
- 2007-10: Mechanical installation.
- 2009: Booster commissioning
- 2010: SR commissioning

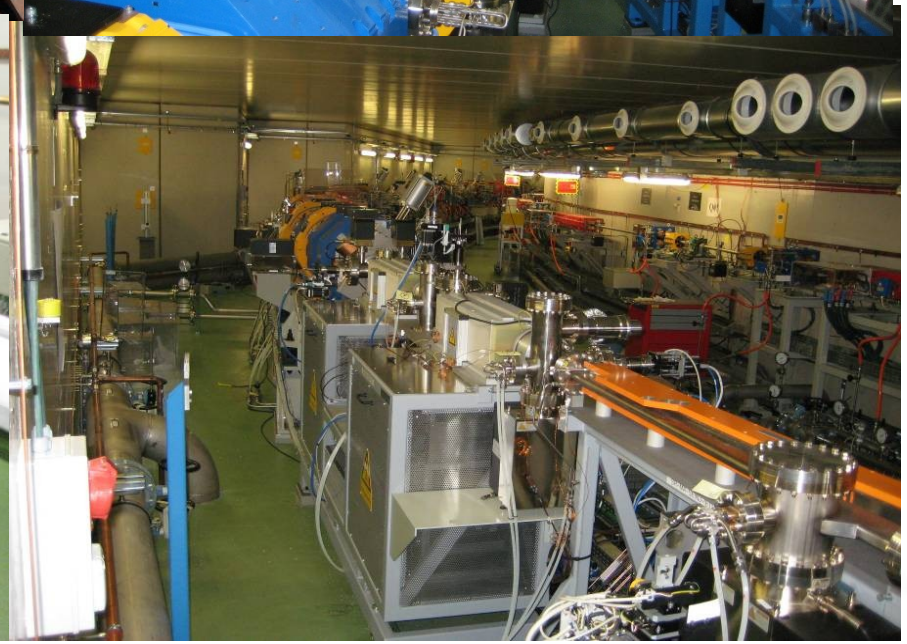
ALBA Accelerators

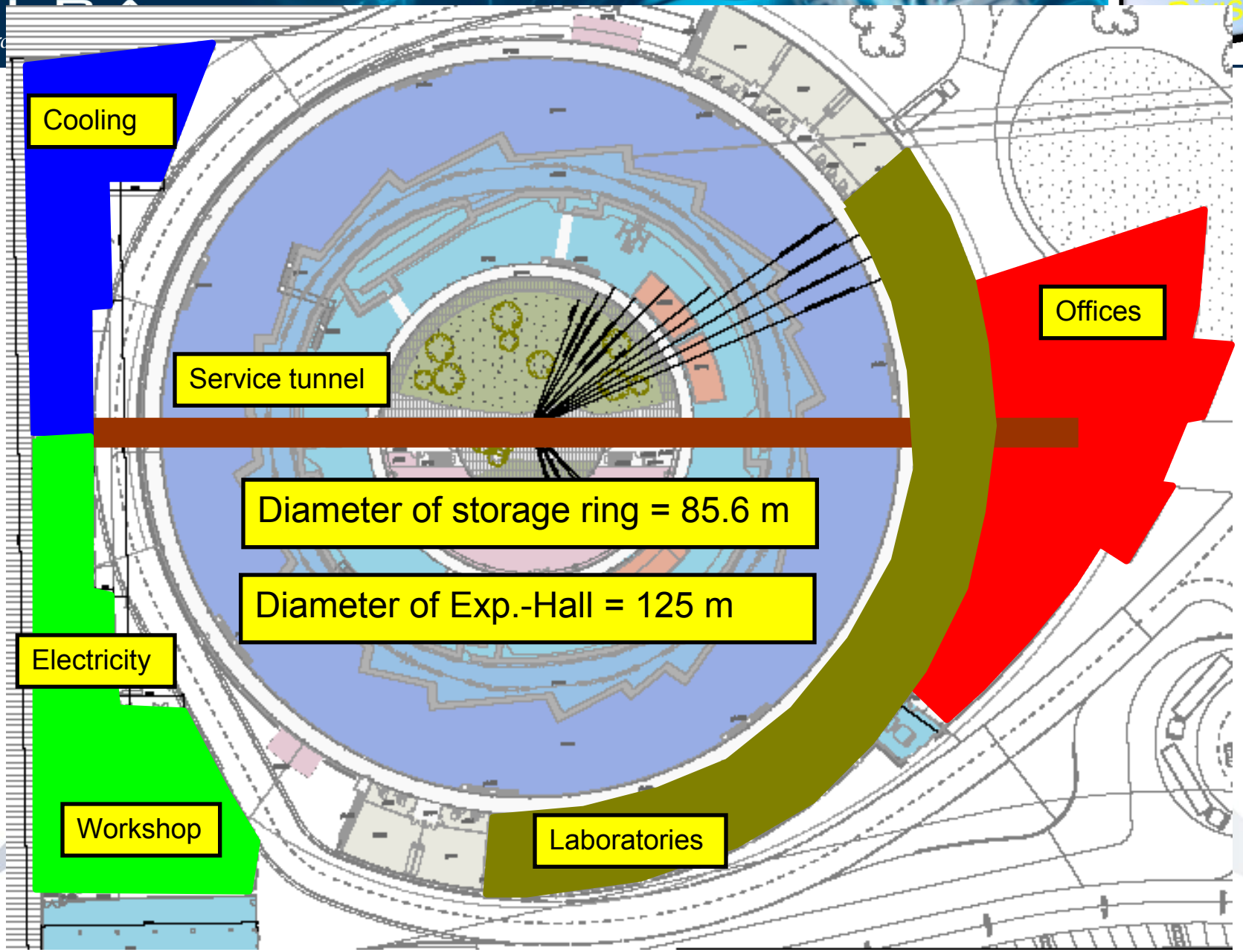
LINAC
100 Mev

BOOSTER
100 MeV – 3 GeV

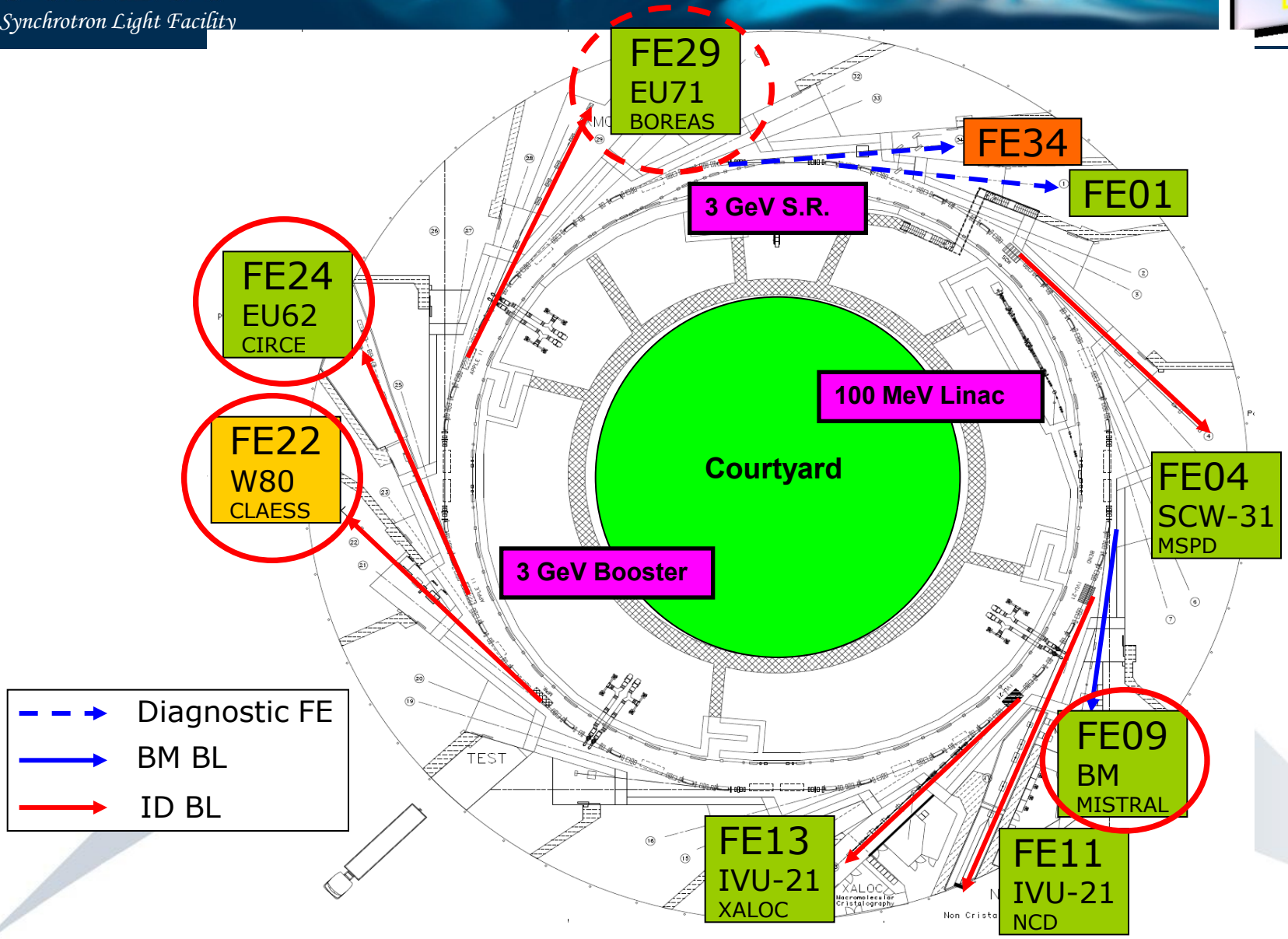
STORAGE RING
3 GeV






Cooling
Service tunnel
Offices
Diameter of storage ring = 85.6 m
Diameter of Exp.-Hall = 125 m
Electricity
Workshop
Laboratories

Fase 1 Beam Lines



Milestones for the Linac

1.) Installation of Linac:	Febr. 2008 to may 2008
2.) First beam out of the Linac:	July 2008
3.) Phase 1 Commissioning of Linac:	October 2008
4.) Acceptance of Linac:	October 2008
5.) Phase 2 Commissioning of Linac:	October 2009
6.) Operation of Linac for booster commissioning:	Dec. 2009 to Jan. 2010
7.) Reparation of Linac structure 1:	April 2010
8.) Restart of Linac:	May 2010
9.) Optimisation of Linac:	June – July 2010
10.) Normal operation of Linac:	since July 2010

Summary:

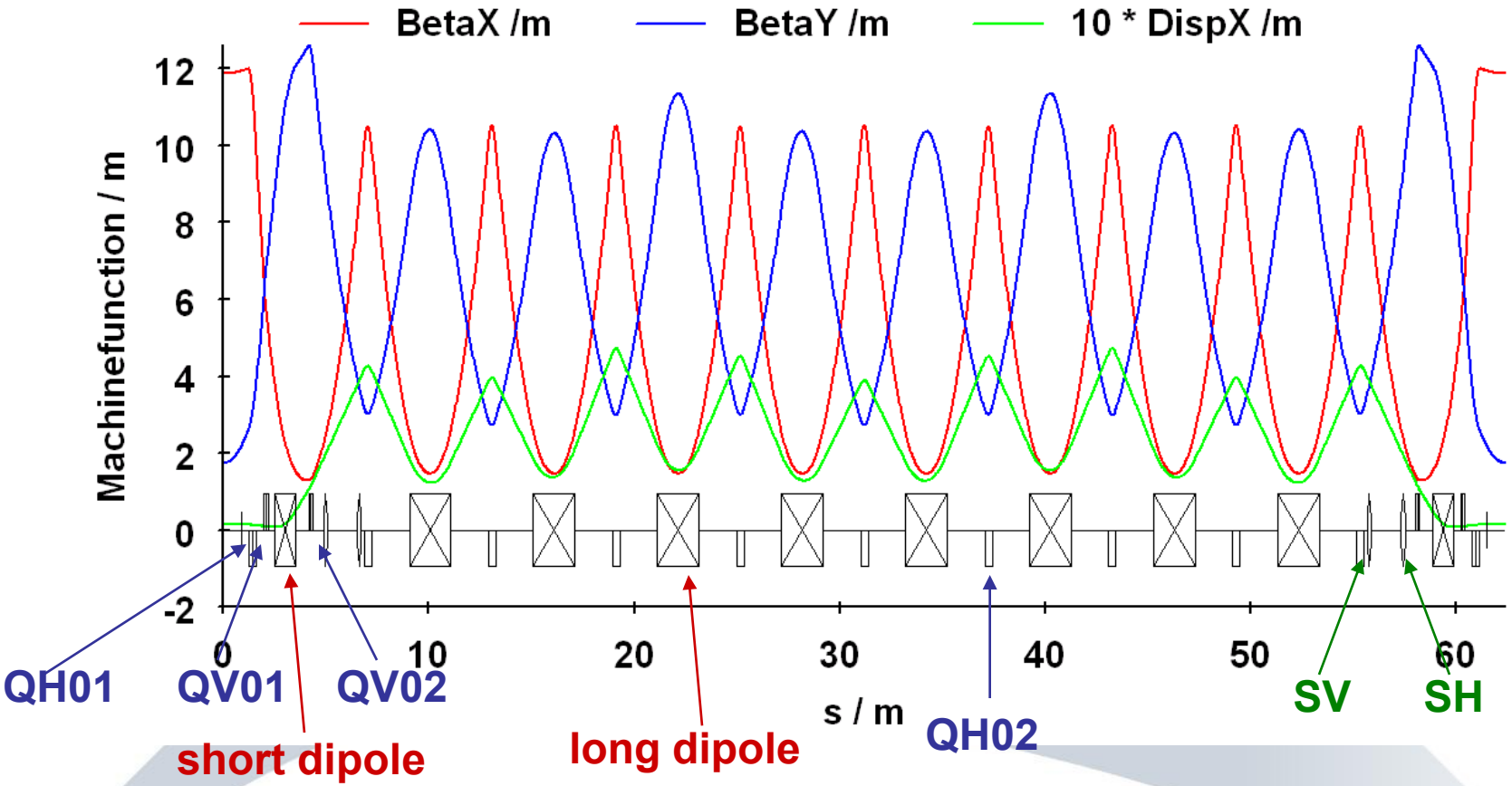
Some specifications of the Linac are much better as given by the specifications (for example the emittance is by a factor 2 smaller). The Linac operation is very reliable for the different modes: long bunch, small bunch, single bunch, large charge (4 nC), small charge (0.5 nC), etc.

Booster synchrotron - Timeline

1.) Mechanical installation of booster:	Jan. 2009 to March 2009
2.) Installation of RF-System :	Febr. 2009
3.) Installation of secondary piping:	July to Sept. 2009
4.) Cooling available:	September 2009
5.) Personal safety system finished:	November 2009
6.) Alignment of booster synchrotron :	Nov. to Dec. 2009
7.) Control system finished:	December 2009
8.) Pre-commissioning of booster components:	Nov. to Dec.2009
9.) CSN- certificate for booster commissioning:	December 2009
10.) First beam in the booster synchrotron :	21st December 2009
11.) Phase 1 of booster commissioning:	10th to 24th Jan. 2010
12.) Phase 2 of booster commissioning:	July 2010
13.) Phase 3 of booster commissioning:	Sept.- Octob. 2010
14.) Extraction of 3 GeV beam out of booster	28th October 2010
14.) Normal operation of booster synchrotron:	since Nov. 2010

Summary: **The booster synchrotron runs reliable. The behaviour of the booster is pretty well understood. It is ready, working as an injector for the storage ring, but we have to make some optimisation.**

Lattice of Booster



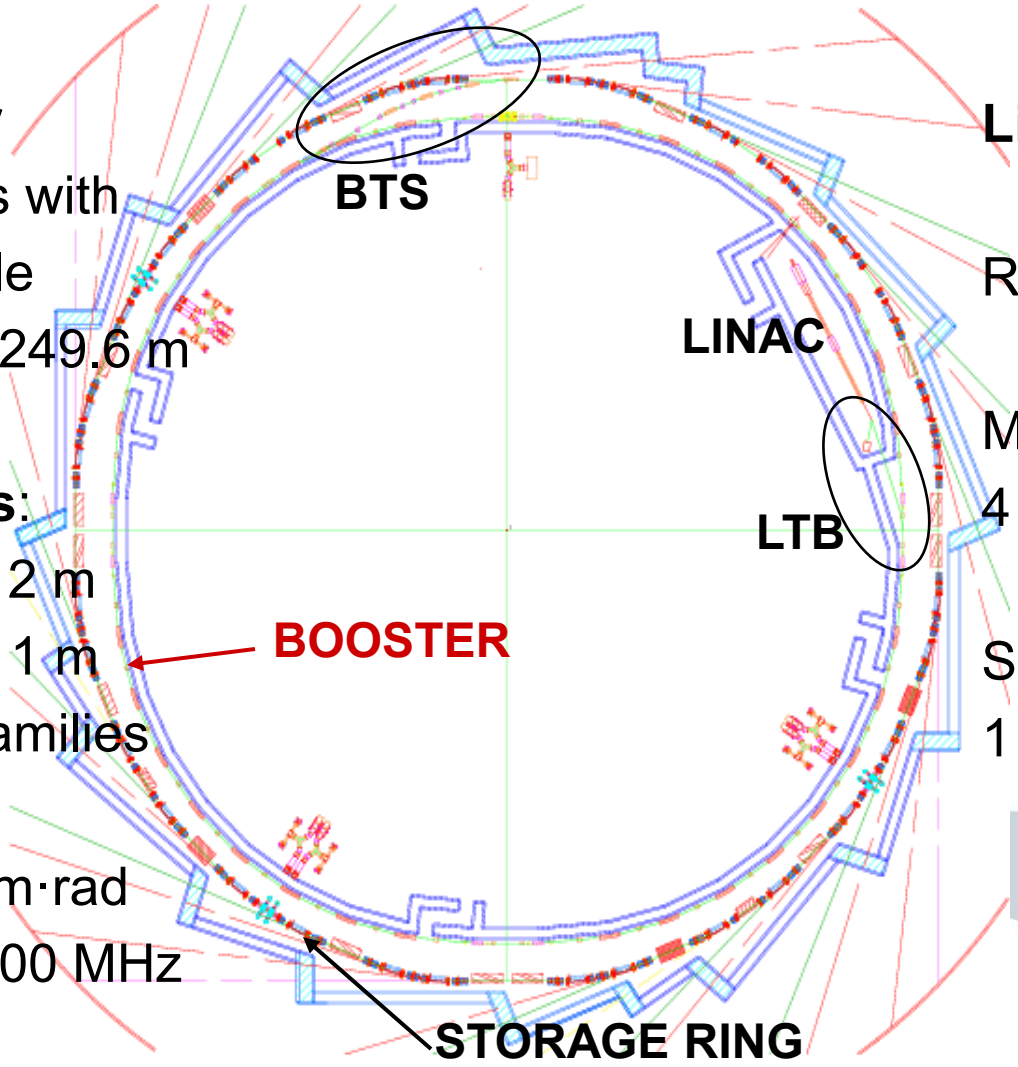
Design working point: $Q_x = 12.42$, $Q_y = 7.38$

Layout Booster

3 GeV Booster
gradient dipoles with
built-in sextupole
circumference: 249.6 m

4 superperiods:
32 long dipoles 2 m
8 short dipoles 1 m
60 quads in 4 families

Emittance 10 nm·rad
RF frequency 500 MHz



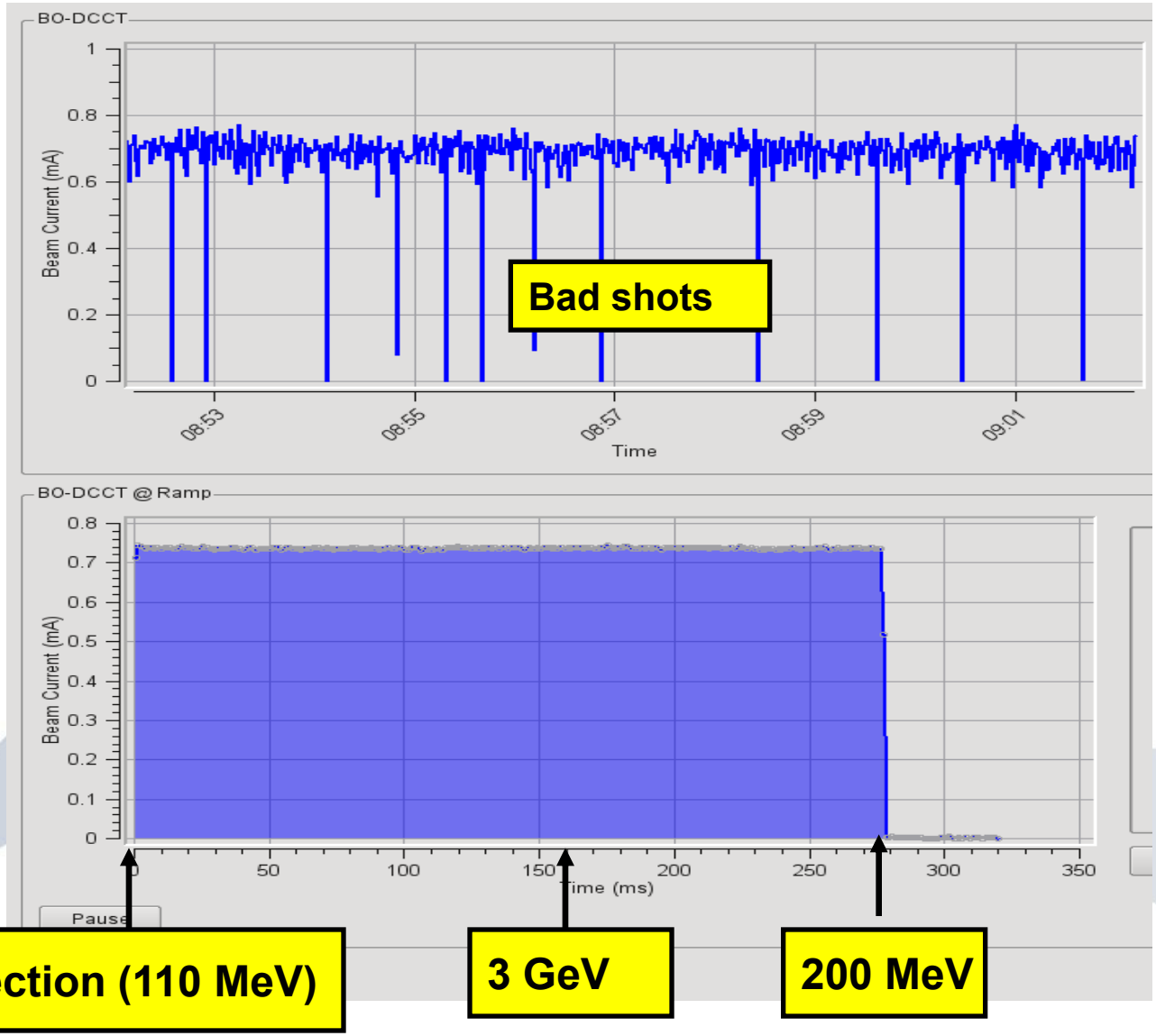
Linac 110 MeV

Repetition rate 3 Hz

Multi bunch mode:
4 nC in 112 ns

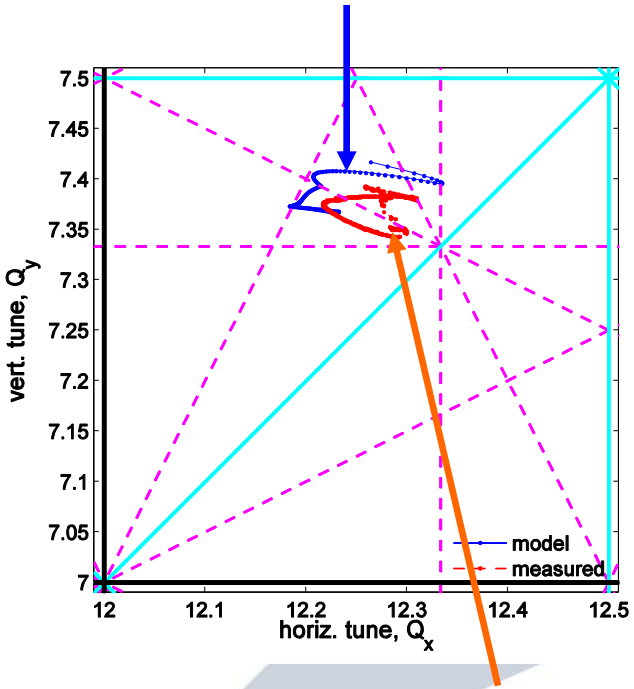
Single bunch mode:
1 nC in 4 pulses (2ns)

Summary of Booster

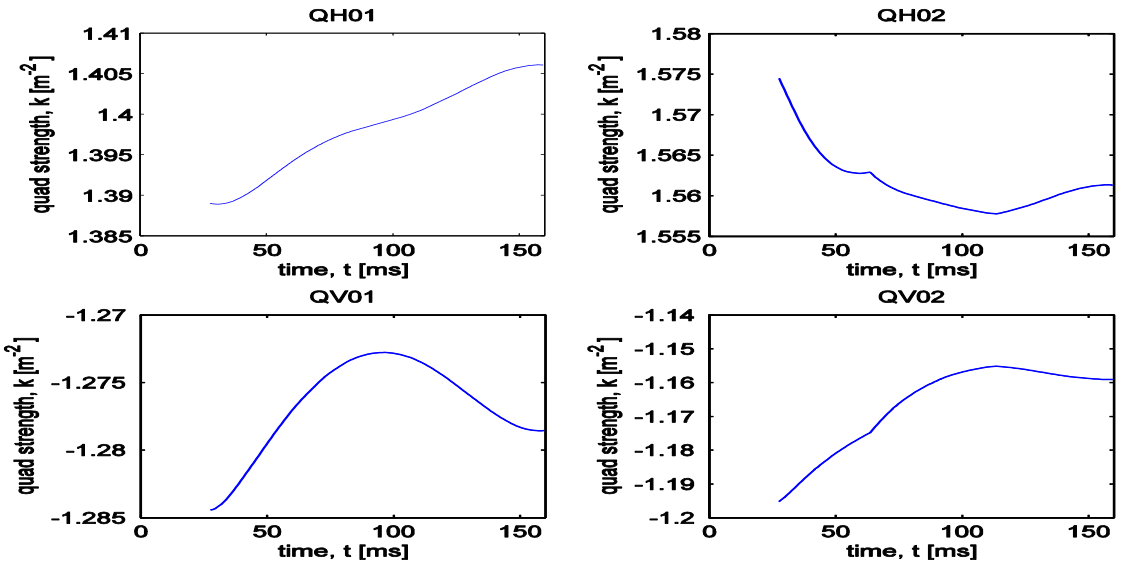


Tunes and Quad-k-Values

measured-model tunes comparison

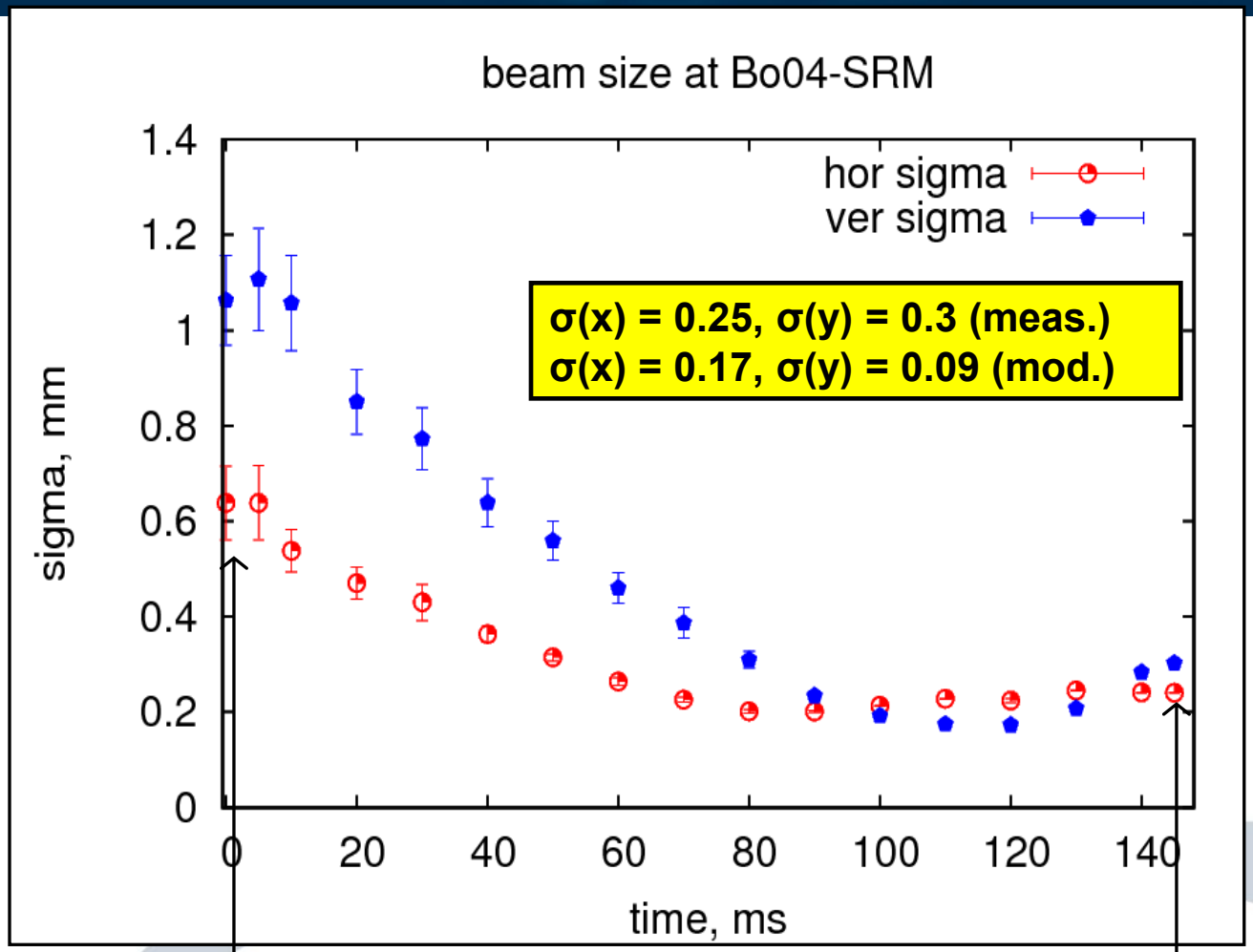


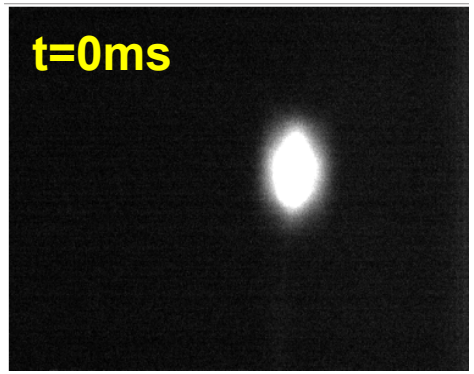
model quad k-values along the ramping according to the calibrations

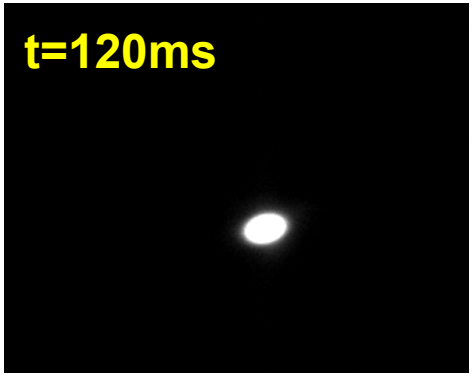


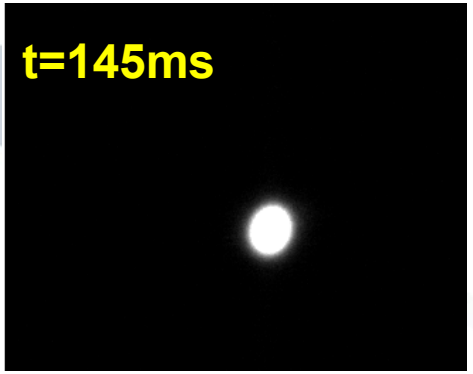
the model of the booster optics in the ramping has a good agreement both at low and high energy, this is very useful to set the power supplies waveforms

Booster Beam Sizes

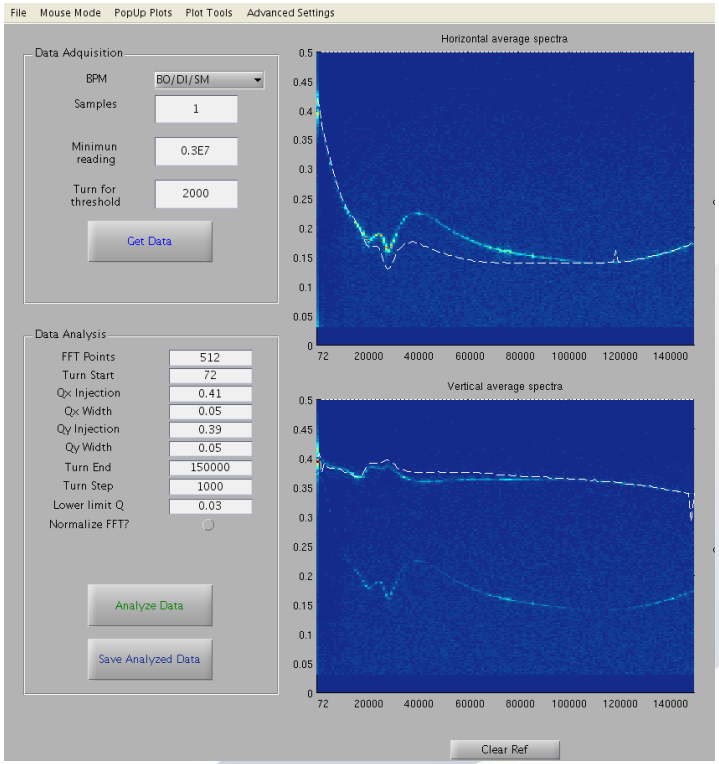


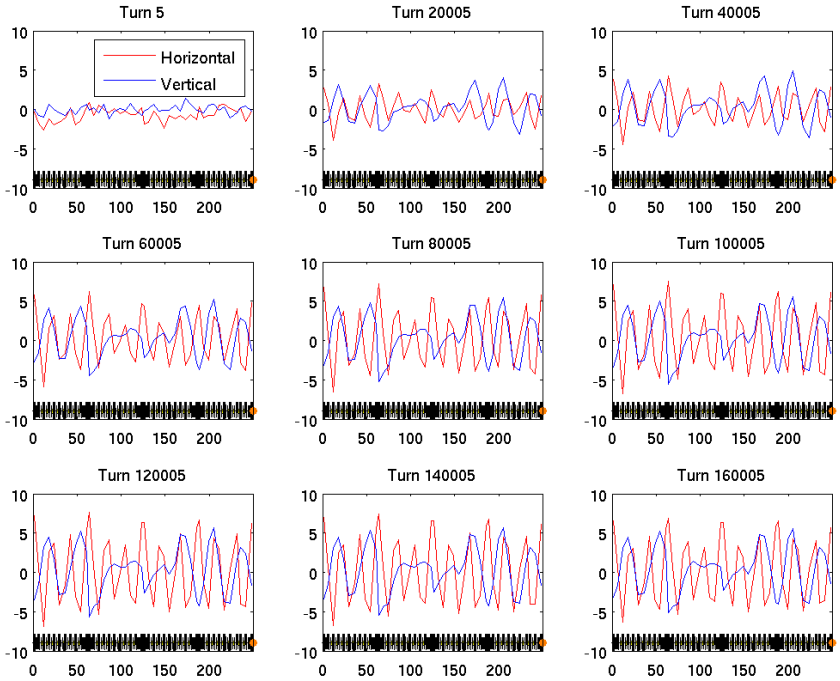






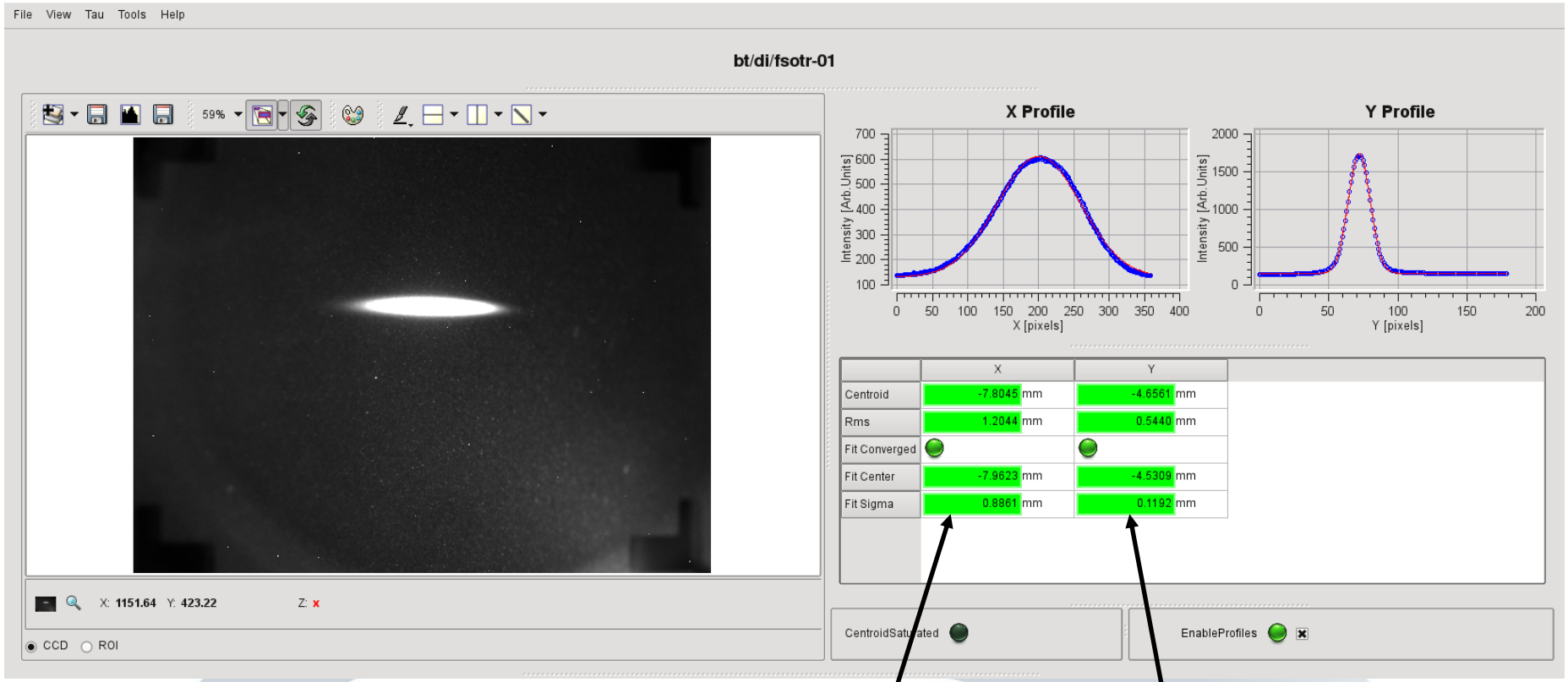
Results of BO in ramping mode





- First beam to 3 GeV: injection on w.p. (12.42, 7.38)
- Large drop of Qx at the start due to nonlinear magnet calibration
- Vertical tune is flat: most of the vertical focusing is provided by the gradient bending
- Orbit blow up, specially in the horizontal plane, ±8 mm

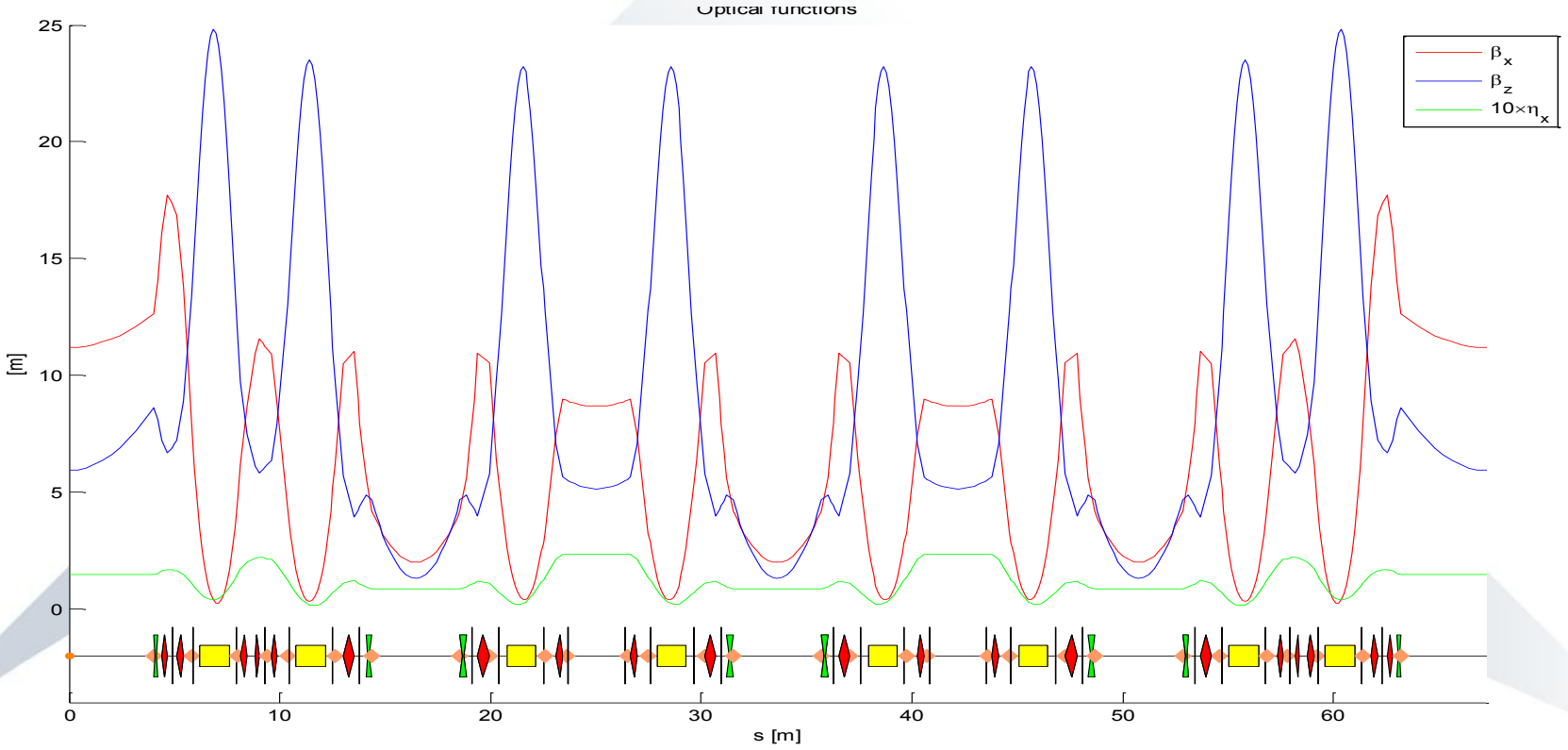
BTS – 1st Beam



σ(x) = 0.86 mm, σ(y) = 0.19 mm
ε(x) = 13 nmrad, ε(y) = 2,6 nmrad

Storage Ring Lattice

- DBA expanded structure
- 16 cells
- Only doublets to save space
- Combined bending magnet with large gradient, 5.65 T/m



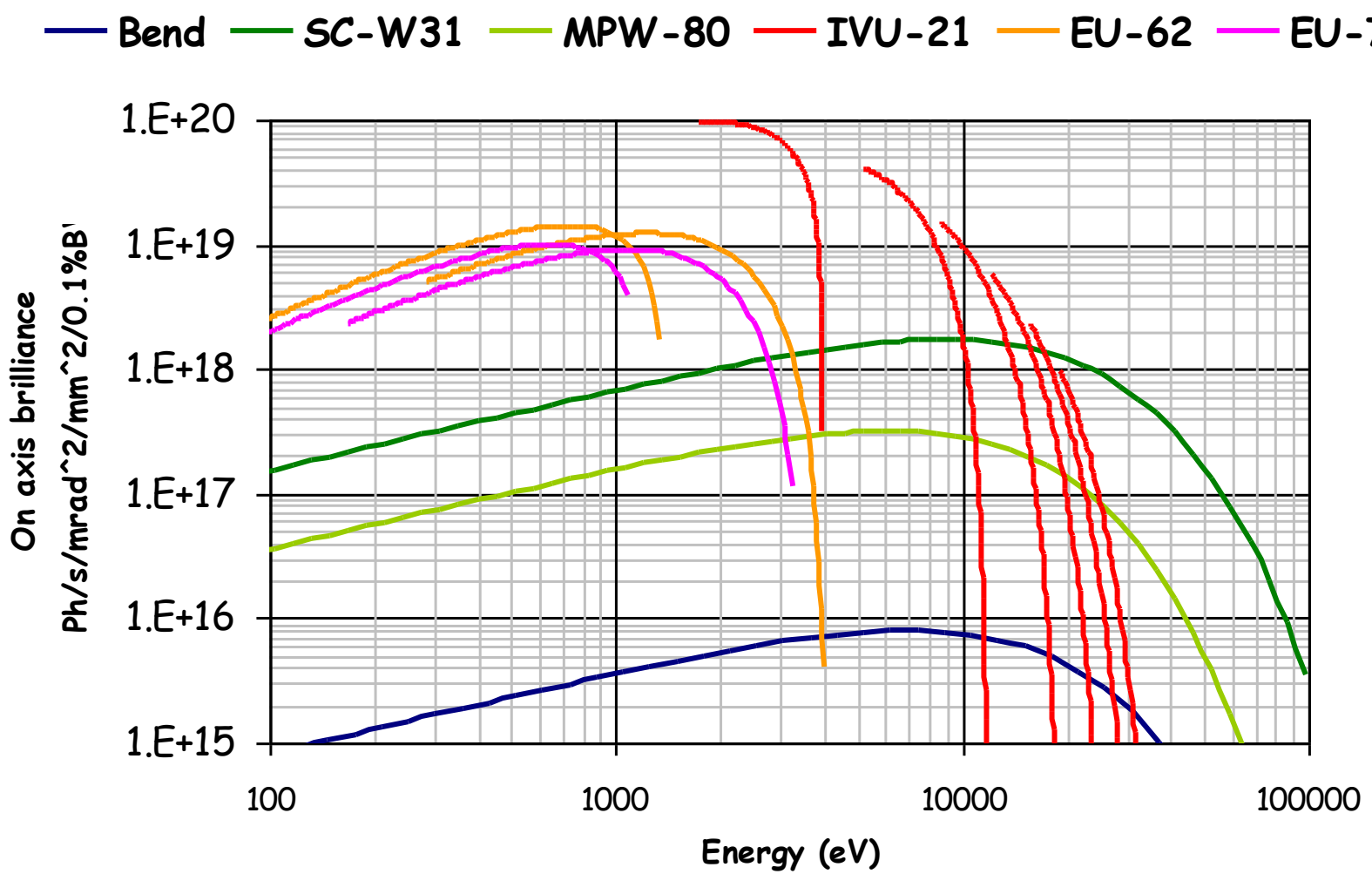
SR Summary

- Parameters

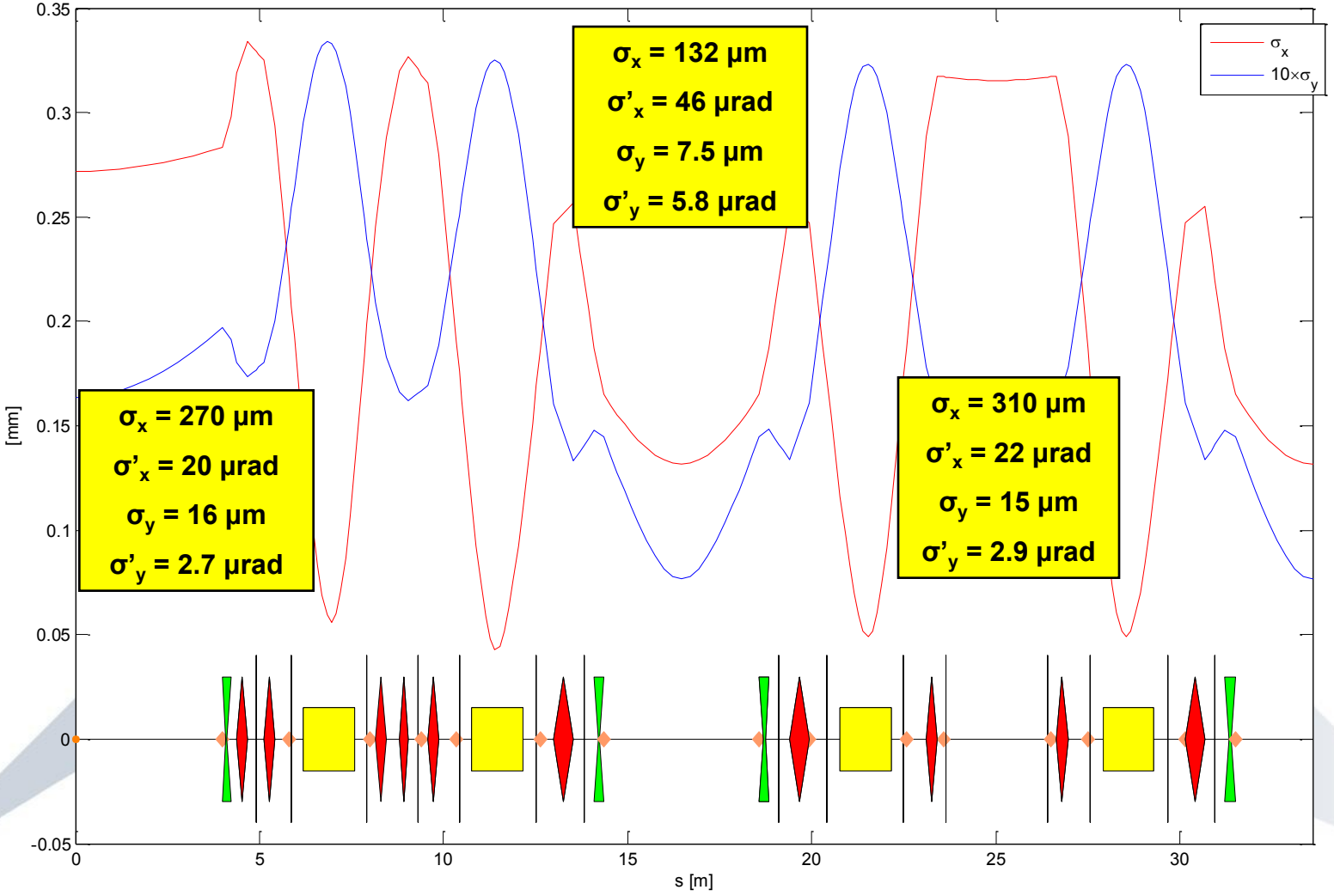
Name	Symbol	Unit	Value
Circumference	C	m	268.8
Energy	E	GeV	3
Horizontal Emittance	ϵ_x	nm-rad	4.3
Horizontal Tune	Q_x		18.178
Vertical Tune	Q_y		8.378
Natural Horizontal Chromaticity	C_x		-38
Natural Vertical Chromaticity	C_y		-27
Momentum Compaction Factor	α_p		8.8×10^{-4}
Second Order α_p	α_2		2.1×10^{-3}
Energy Spread	$\Delta E/E$		1.05×10^{-3}
Revolution Frequency	f_0	MHz	1.115
Horizontal Damping Time	τ_x	ms	4.1
Vertical Damping Time	τ_y	ms	5.3
Longitudinal Damping Time	τ_ϵ	ms	3.1
Horizontal Partition Number	J_x		1.3
Vertical Partition Number	J_y		1
Longitudinal Partition Number	J_ϵ		1.7
Energy Loss per turn	U_0	MeV	1.02

- Remarks:
  - 24 straight sections:
    - 4 x 8 m -> 3 free for ID
    - 12 x 4.3 m -> all free
    - 8 x 2.4 m -> RF, diagnostic
  - 38 % of the circumference for ss.

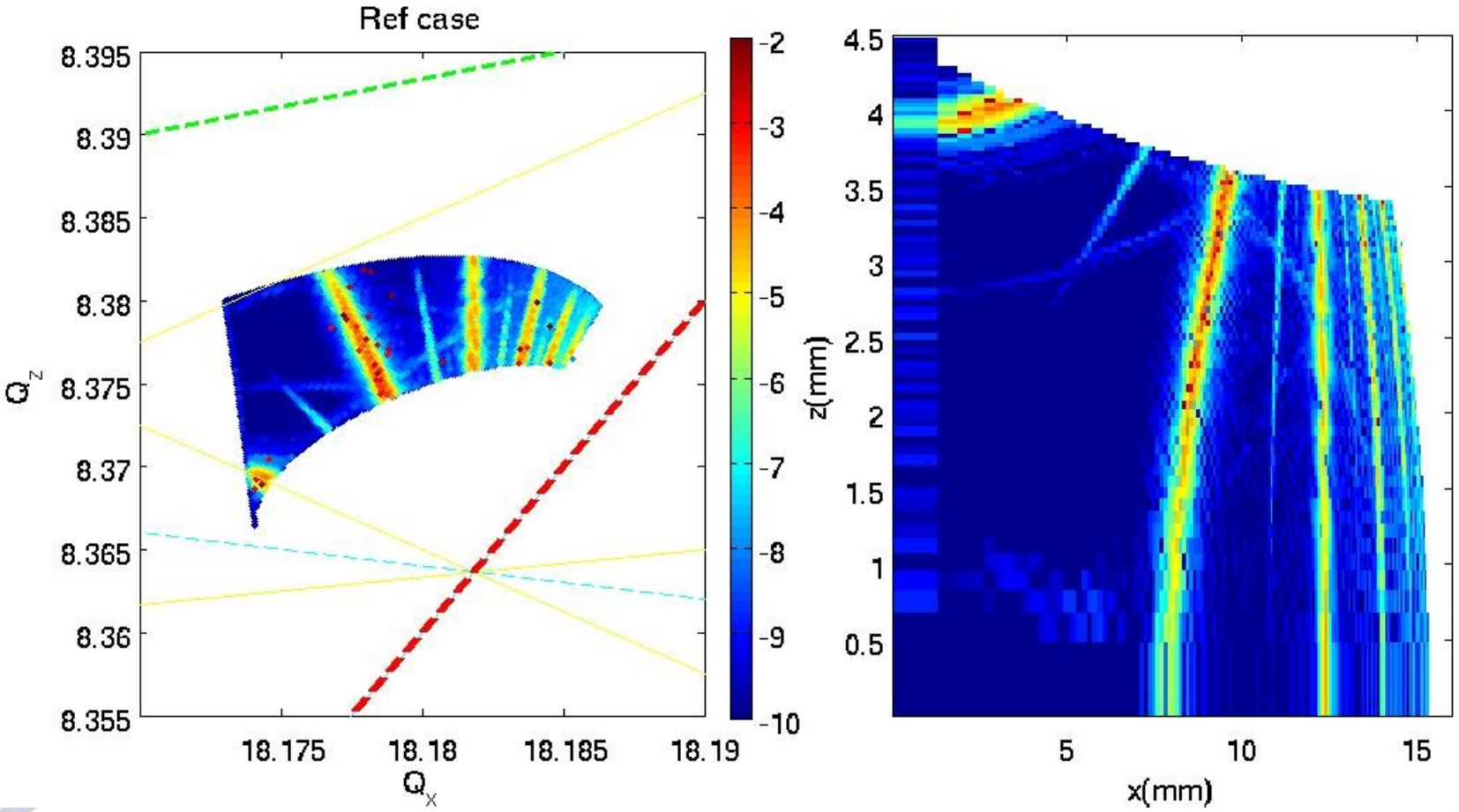
Light Output

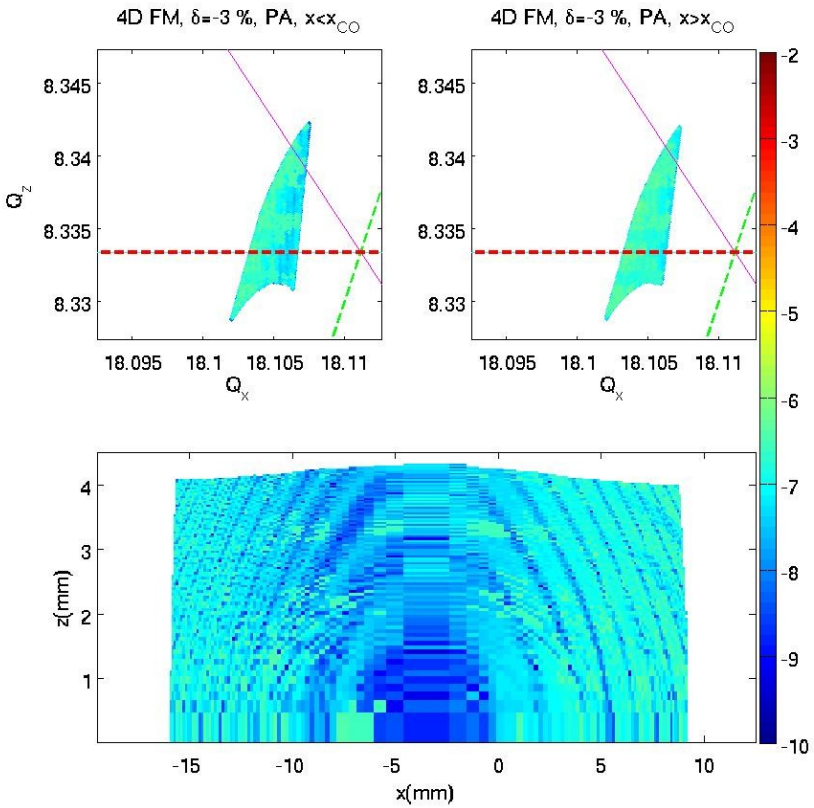


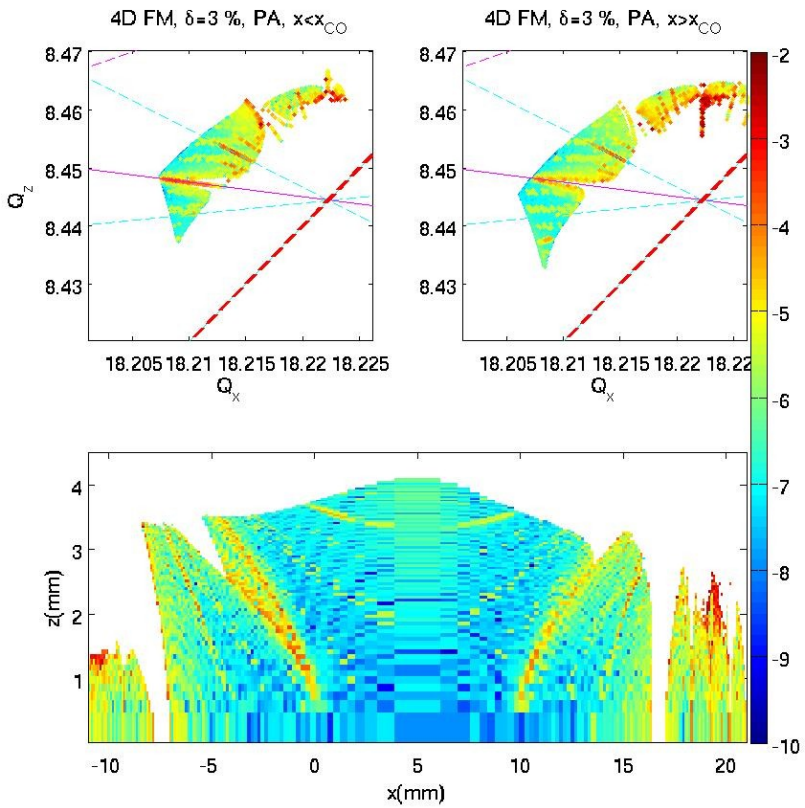
Beam Sizes


σx = 132 µm
σ'x = 46 µrad
σy = 7.5 µm
σ'y = 5.8 µrad
σx = 270 µm
σ'x = 20 µrad
σy = 16 µm
σ'y = 2.7 µrad
σx = 310 µm
σ'x = 22 µrad
σy = 15 µm
σ'y = 2.9 µrad
σx
10×σy
[mm]
s [m]
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
-0.05
0
5
10
15
20
25
30

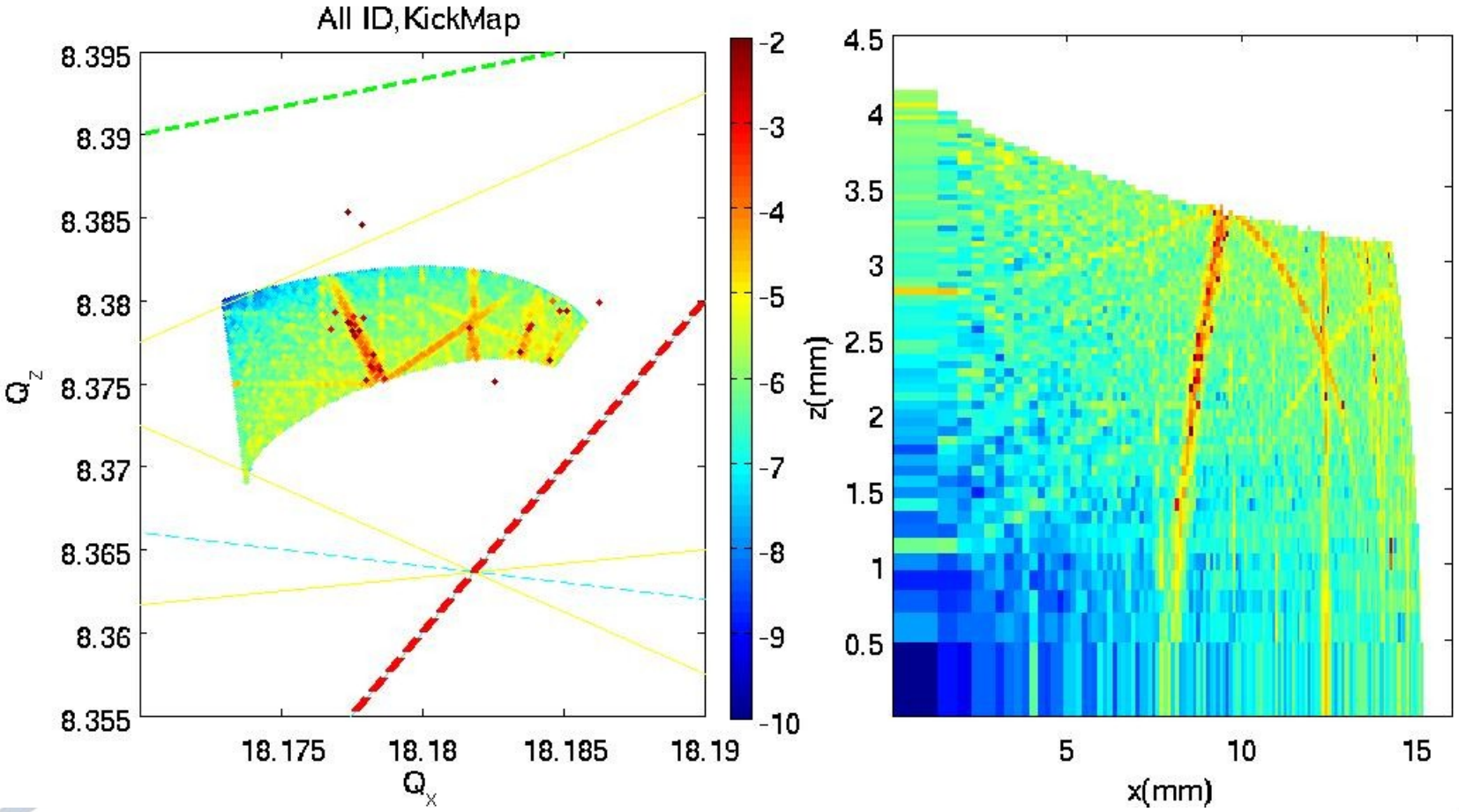
Frequency Map - Ideal

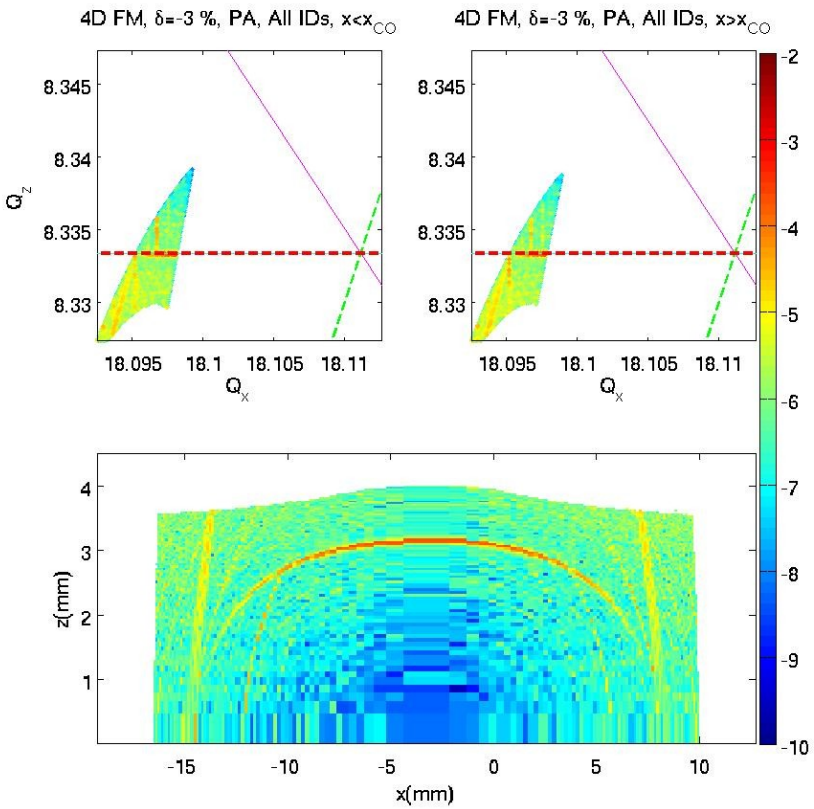


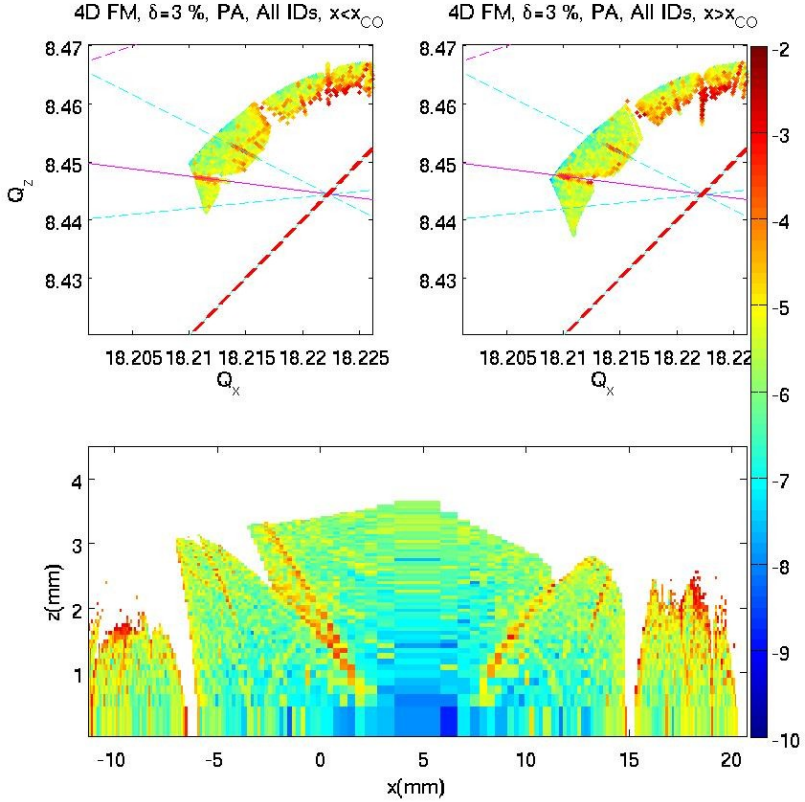

4D FM, δ=-3 %, PA, x<x_CO
4D FM, δ=-3 %, PA, x>x_CO
Q_z
Q_x
z(mm)
x(mm)


4D FM, δ=3 %, PA, x<x_CO
4D FM, δ=3 %, PA, x>x_CO
Q_z
Q_x
z(mm)
x(mm)

Frequency Map - IDs



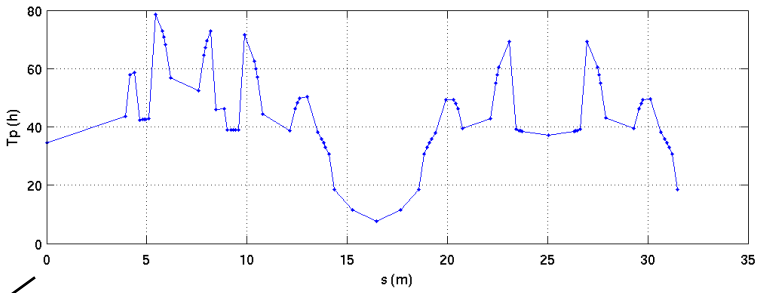

4D FM, δ=-3 %, PA, All IDs, x<x_CO
4D FM, δ=-3 %, PA, All IDs, x>x_CO
Q_z
Q_x
z(mm)
x(mm)

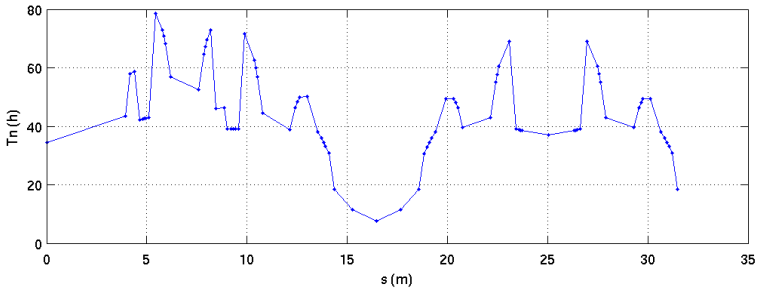

4D FM, δ=3 %, PA, All IDs, x<x_CO
4D FM, δ=3 %, PA, All IDs, x>x_CO
Q_z
Q_x
z(mm)
x(mm)

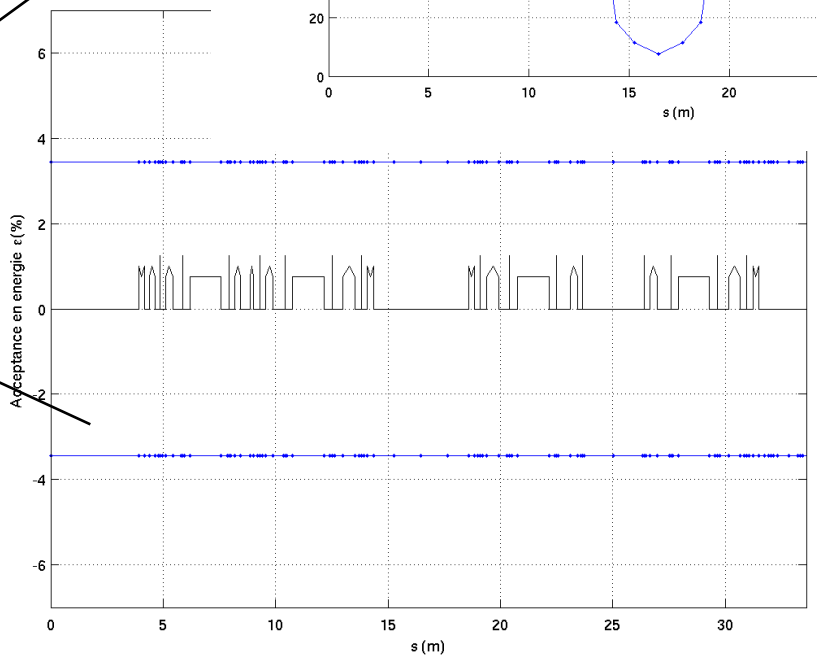
Lifetime

- Touschek
  - 6D tracking with Tracy, introducing a 1% coupling and vacuum chamber
  - For 400 mA:

    τ_T ~30.8 hours.
  - Limited by the RF







Symmetric behavior of the energy acceptance for positive and negative dp. The limiting factor in both cases is the RF.

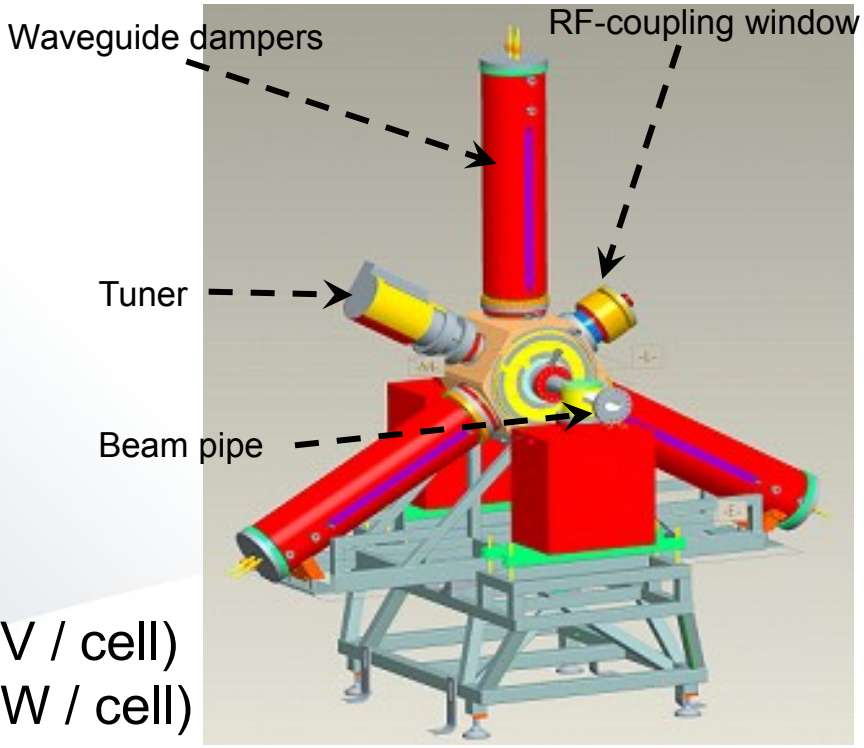
- The effect of quantum lifetime in all three directions is negligible
- Elastic scattering and bremsstrahlung lifetimes have been calculated for a residual N2 pressure of 1 nTorr

Beam lifetime at 400 mA, including 1% coupling and the default vacuum chamber. The inclusion of a 3rd harmonic cavity will increase it close to 25 h.

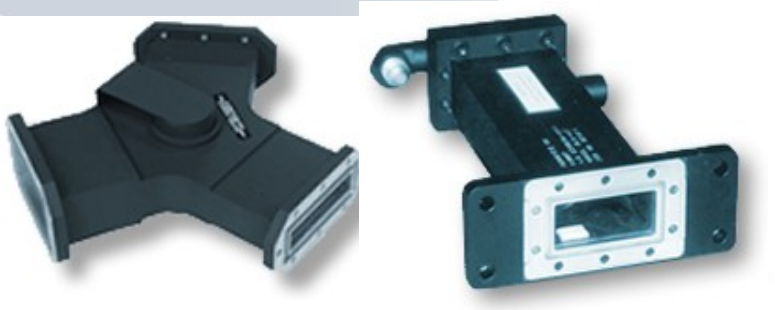
Elastic scattering	≈ 78 h
Bremsstrahlung	≈ 60 h
Touschek	≈ 30 h
Total	16 h

RF Cavity (Dampy)

f	499,654	MHz
Q_0	27000	
Rshunt	3.1	MΩ
R/Q	115	Ω
Cavity power	60	kW
Beam power/cav	87	kW
IPC power	147	kW
Type of cavity	nc (6 Cells/IPC)	
Total Voltage	**3.6**	**MV** (600 kV / cell)
Total Power	**960**	**kW** (160 kW / cell)

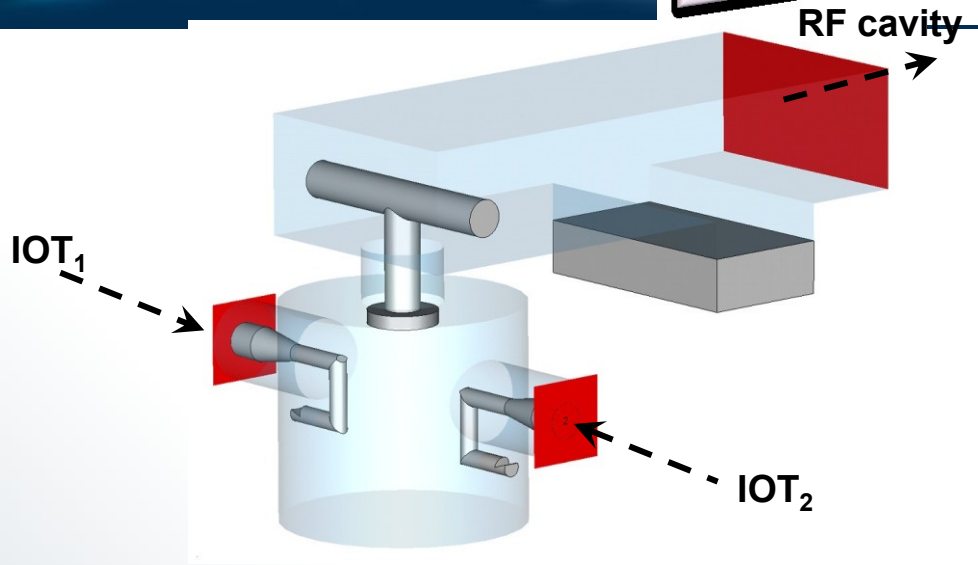


- A SC third harmonic cavity is planned



RF II

- Cavity Combiner
  - 2 Input Ports (80 kW each one)
  - 1 Output Port (150 kW)
  - Insertion losses 0.3 dB
  - Frequency stability 200 kHz
- RF amplifiers (IOT)
  - Inductive Output Tubes at 500 MHz
  - Broadcasting standard
  - 80 kW output power
  - 3 MHz bandwidth at -1 dB
  - 50 Ohm impedance



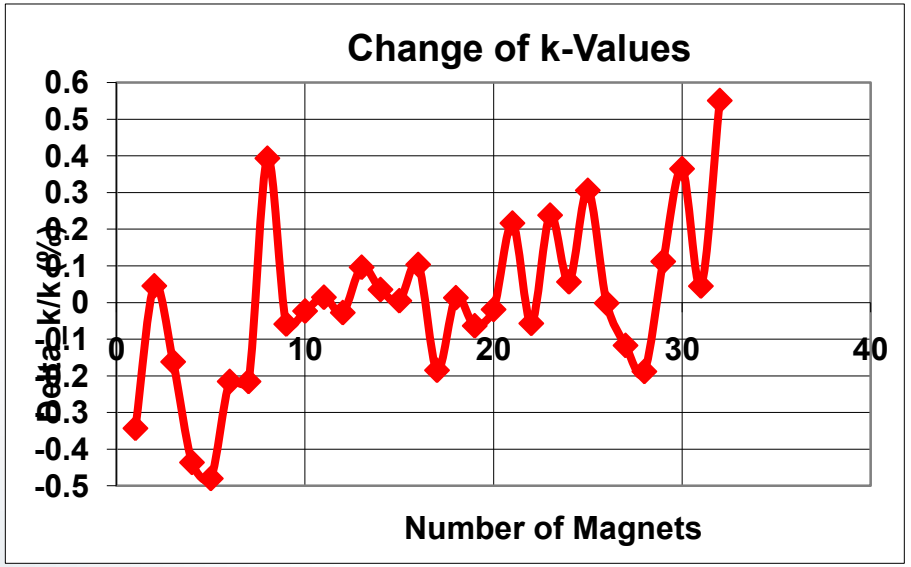
Bending magnet

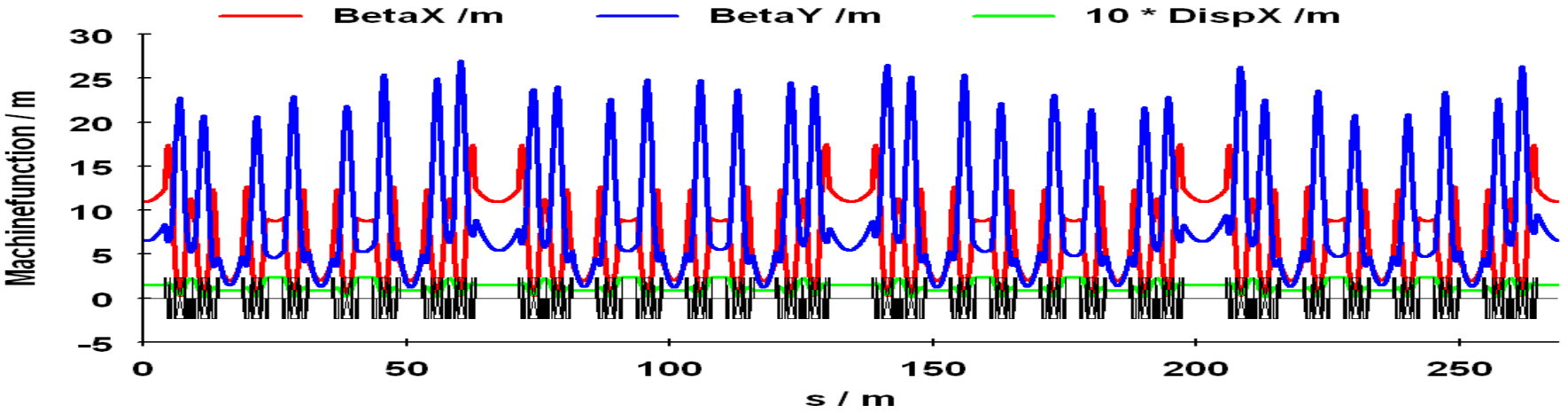
- Combined function with a large gradient.
- All the dipoles measured in house with good accuracy.
- Arranged in the machine to ensure small effect due to the differences of gradient.
- Correction coils avalible to compensate the errors if needed.

Magnetic field:	1.42 T
Bending angle:	11.25 deg.
Bending radius:	7.047 m
Gradient:	7 T/m
Gap:	36 mm
Current:	520 A
Field accuracy:	$<3*10^{-3}$
Grad. accuracy:	$<2*10^{-3}$

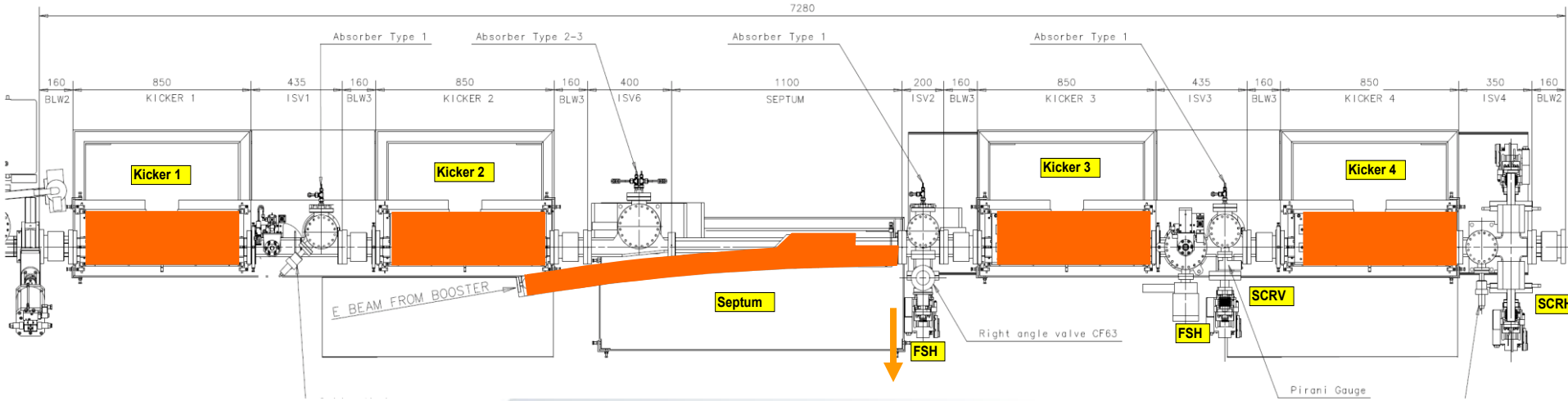
Bending

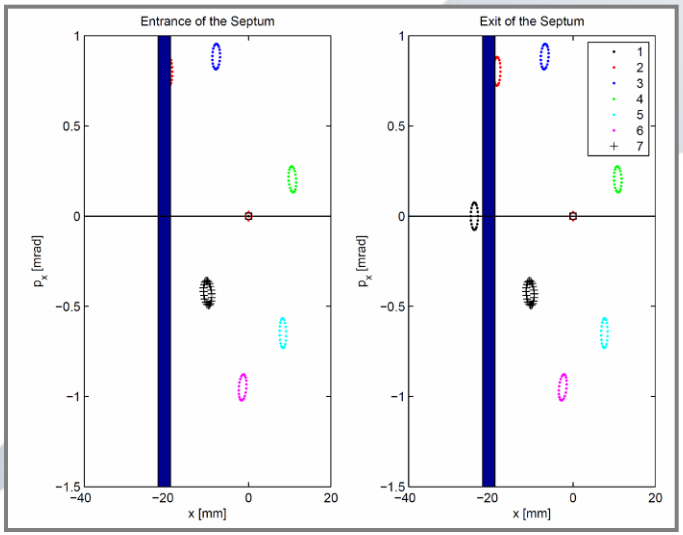
- In the process to cross check this with LOCO

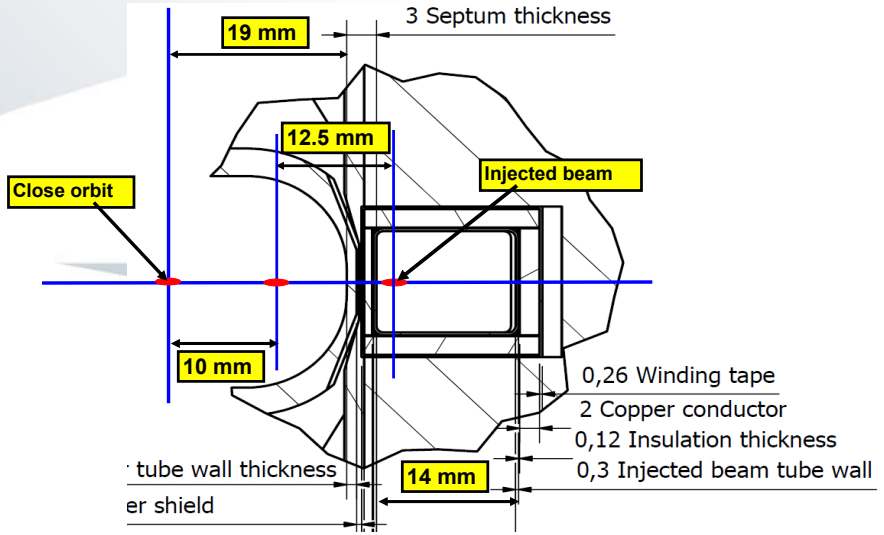




Injection scheme







Diagnostic

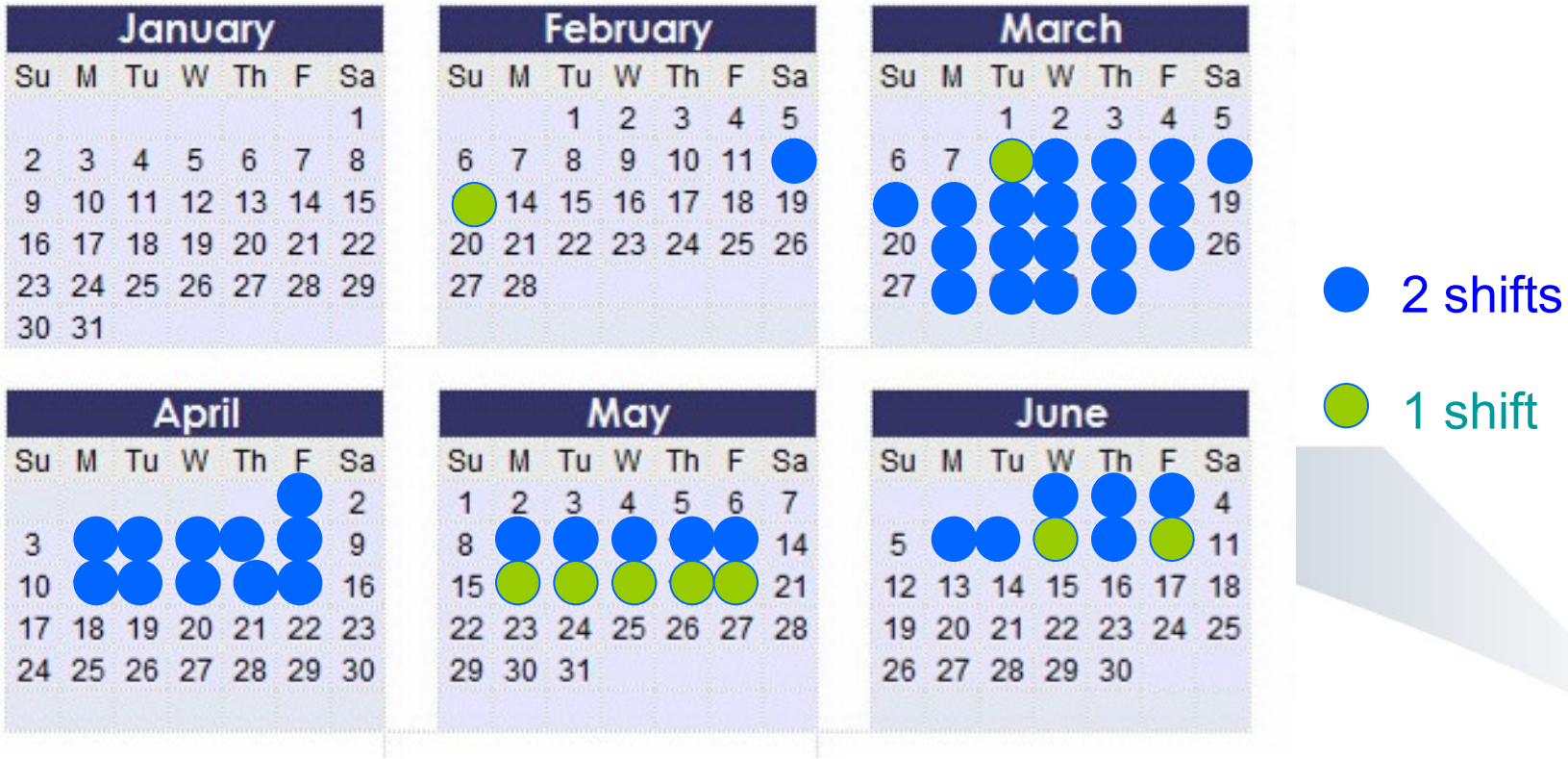
Component	Acronym	# units
Fluorescent Screen “In-air”	FS	5
Fluorescent Screen Horizontal	FSH	2
Beam Position Monitors – Libera Brilliance	BPM	123
DC Current Transformer	DCCT	1
Fast Current Transformer	FCT	1
Annular Electrode	AE	1
Stripline BPM	SBPM	1
Scraper (Hor & Ver)	SCRH & SCRV	1 & 1
Beam Loss Monitors	BLM	128
X-Ray Pinhole Camera	Pinhole	1
Visible Light Monitor	BL34	1

RESULTS FROM SR COMMISSIONING

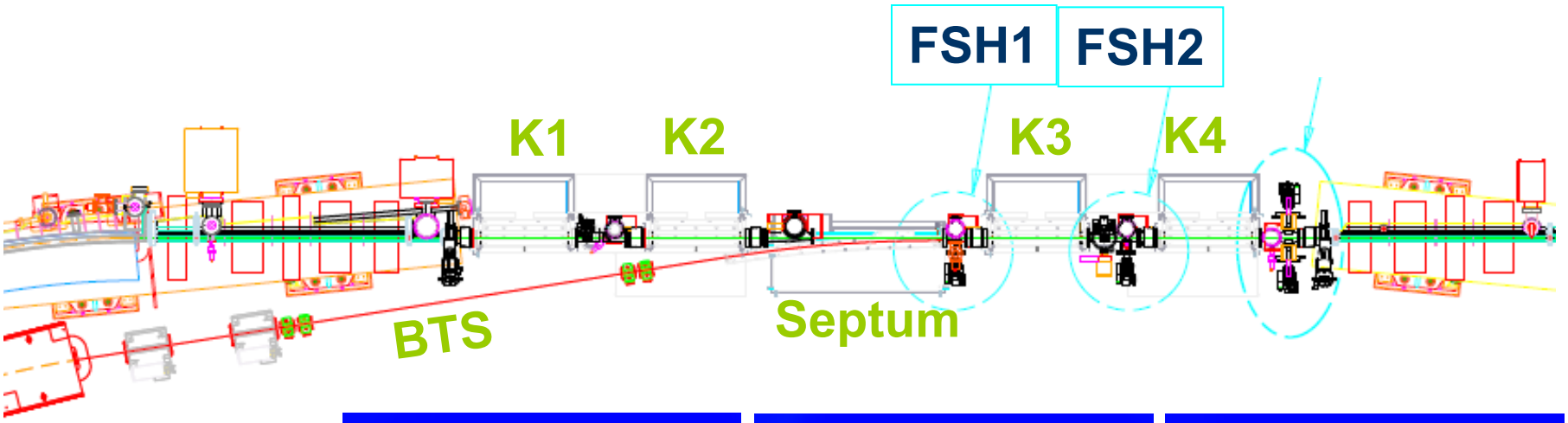
SR Commissioning

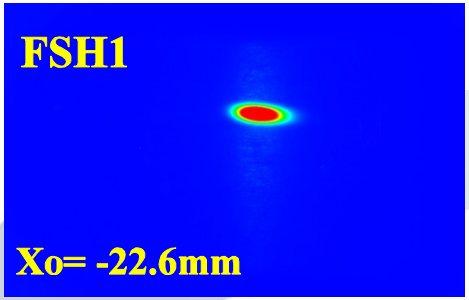
- First try over one week-end: 4 shifts
- 2 intensive weeks: 2 shifts/day for 10 consecutive days
- Normal commissioning: 9 shifts/week

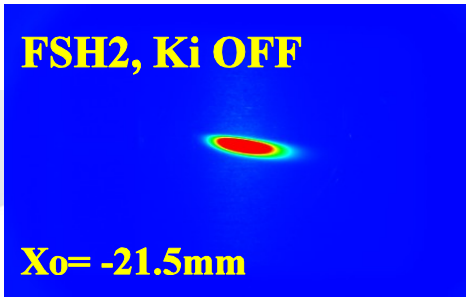
- Total commissioning phase I: 90 shifts (8 hours/shift)

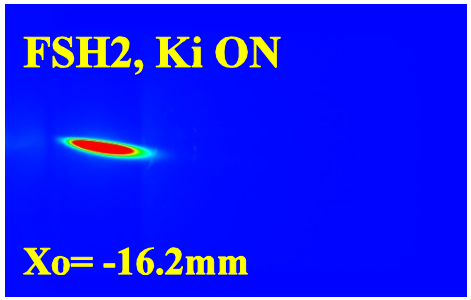


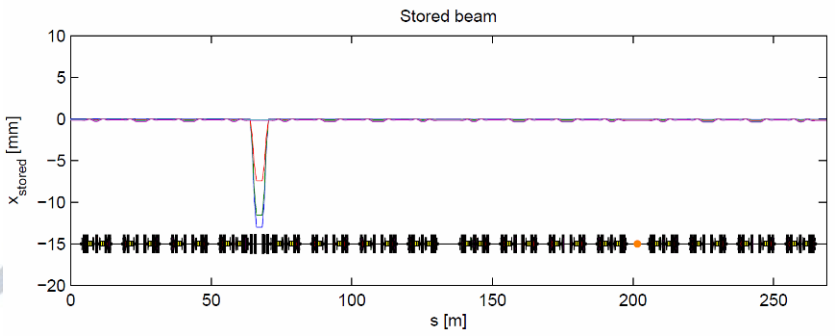
Injection

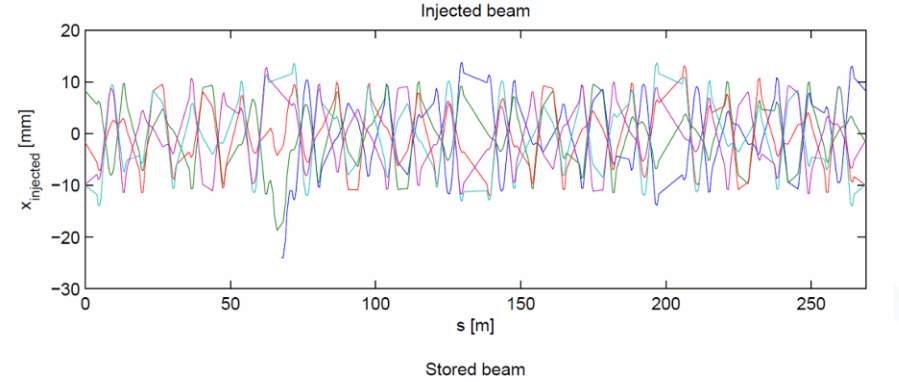

FSH1
FSH2
K1
K2
K3
K4
BTS
Septum


FSH1
Xo= -22.6mm

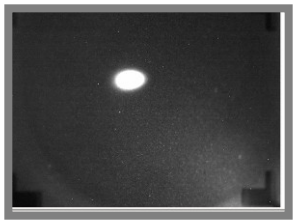

FSH2, Ki OFF
Xo= -21.5mm


FSH2, Ki ON
Xo= -16.2mm

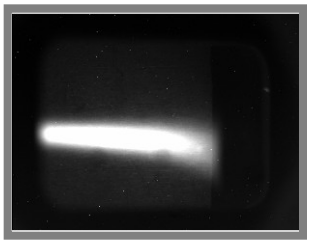

Stored beam
x_stored [mm]
s [m]


Injected beam
x_injected [mm]
s [m]
Stored beam

1st try at week-end (12-13 Feb)

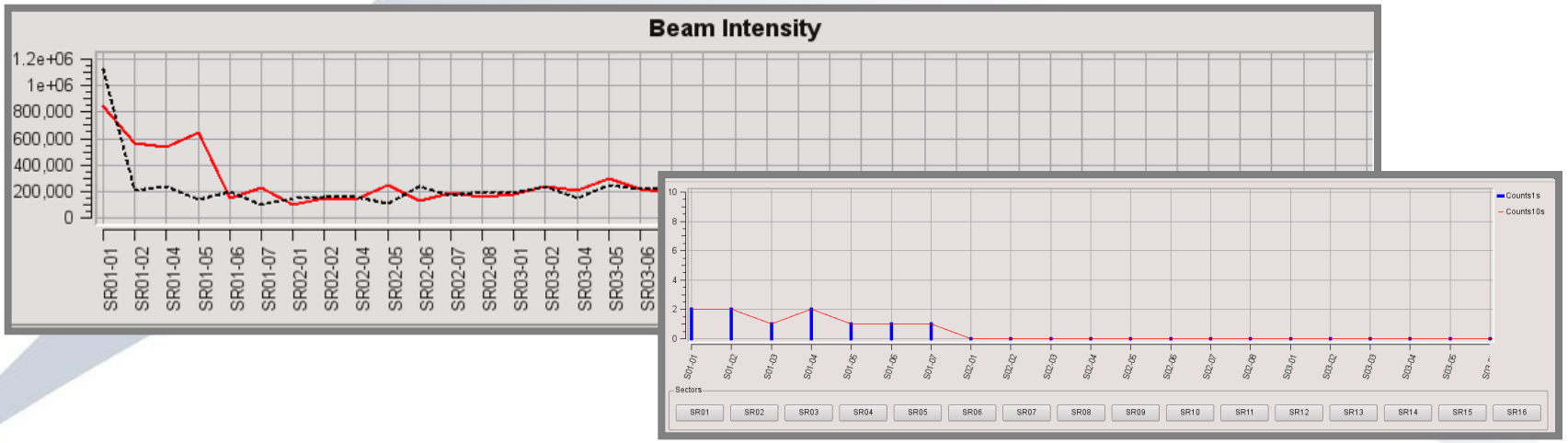


- Straigthforward extraction from the Booster



- Problems to reach the end of the BT: Quad misaligned
  (wrong reference fiducials)

- Beam in SR only for one cell (2 bendings)

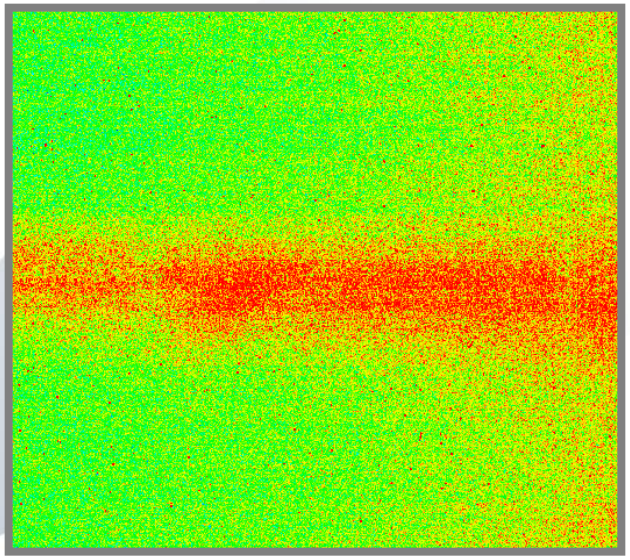


- Stop because a problem with the BO extraction Kicker…

First 4 days … 8 – 12 March

9th March: 09h00

Beam spot at 1st FS, at sector 2, completely defocused horizontally.



All SR Quadrupoles with wrong polarity

Recabling all quads

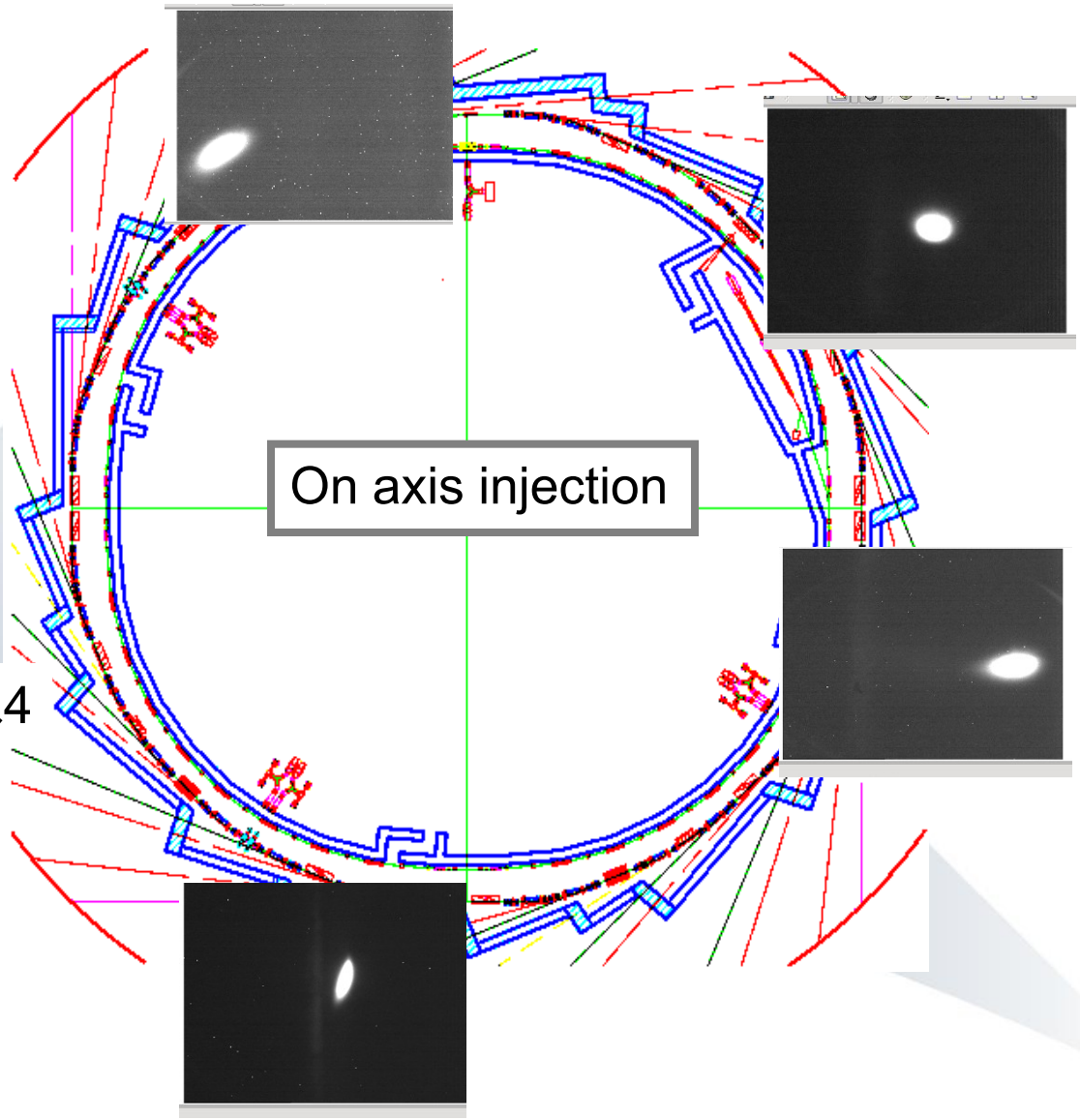
- Recabling Quads:

✓ Sectors 1&2

✓ Quadrant 1

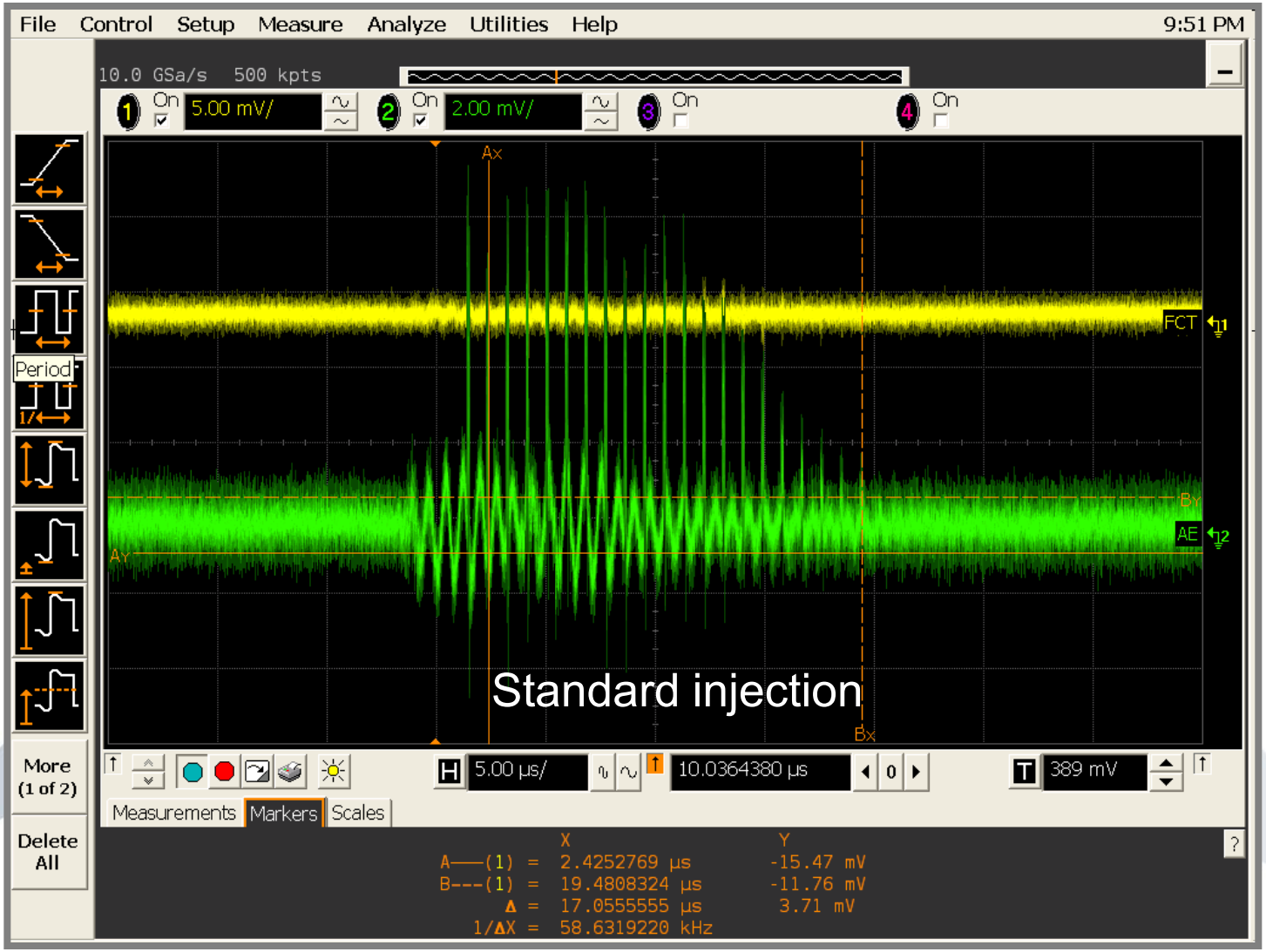
✓ Quadrant 2

✓ Quadrants 3&4



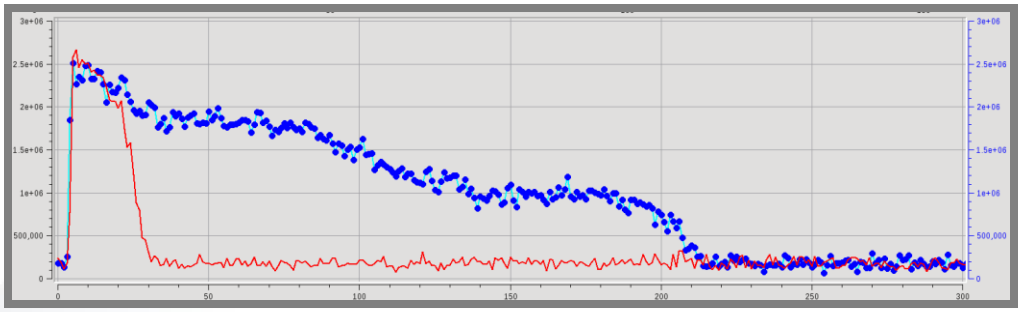
19h35: 1st turn !

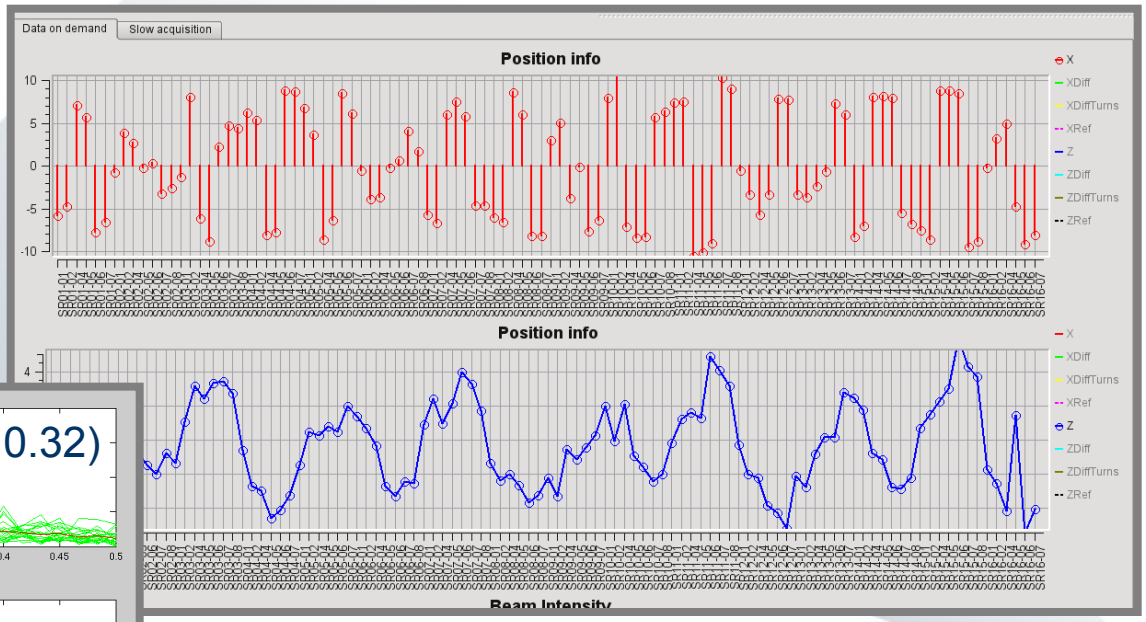
9th March 20 turns

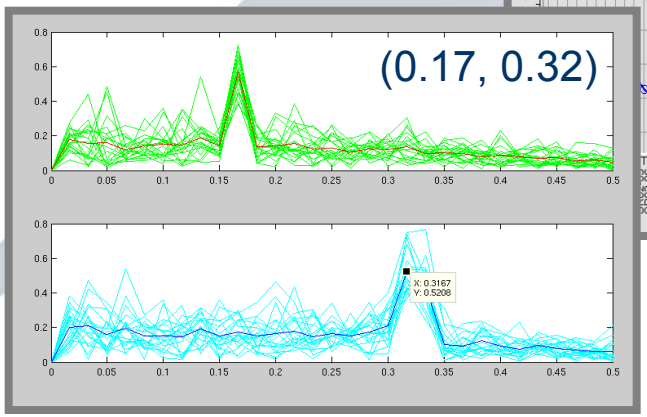


10-13 March: Objective, store beam

- Switching ON RF
- Adjusting injection angle
- Adjusting tune



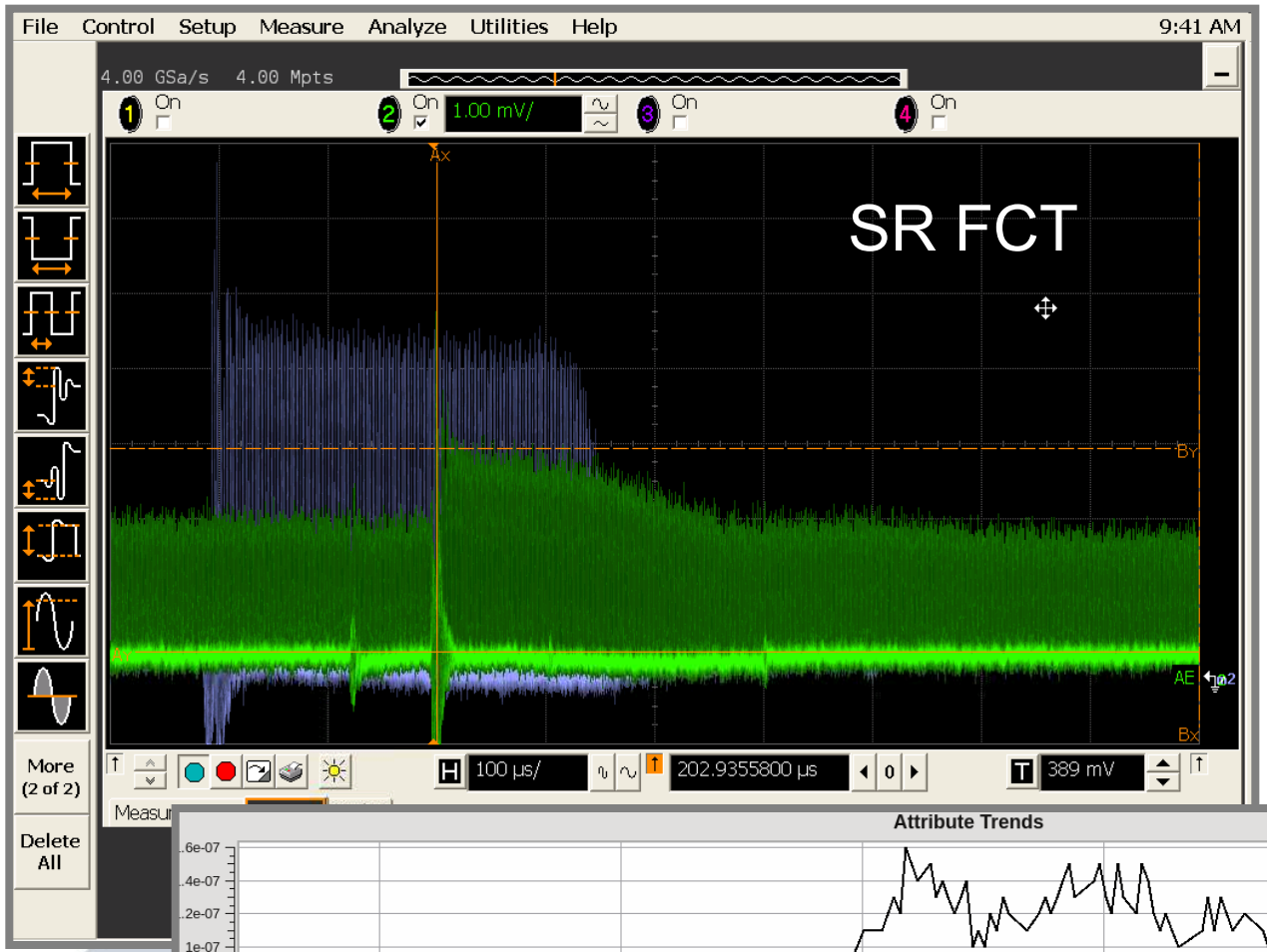


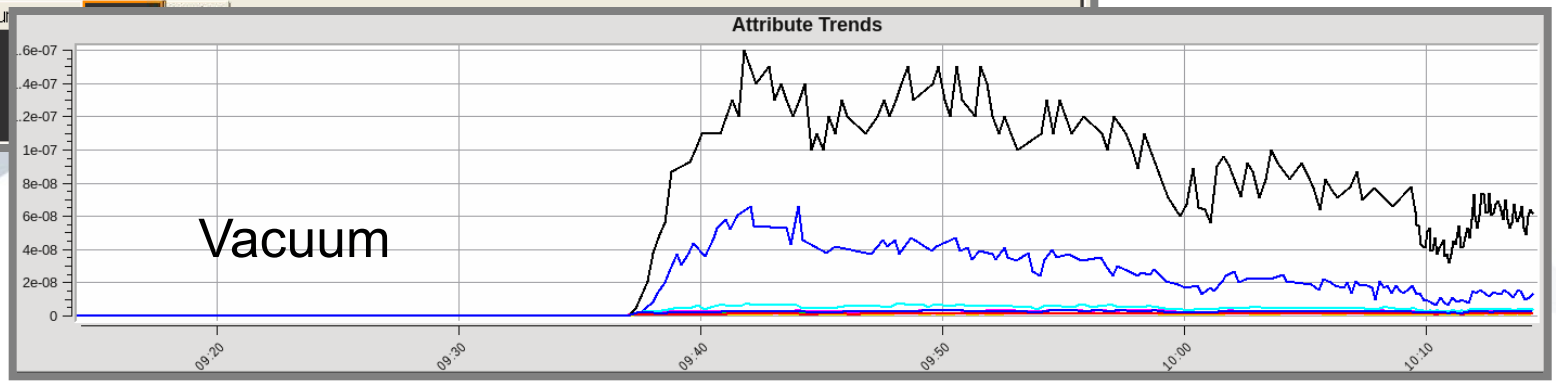


13th March, 9h38: 1 second stored beam

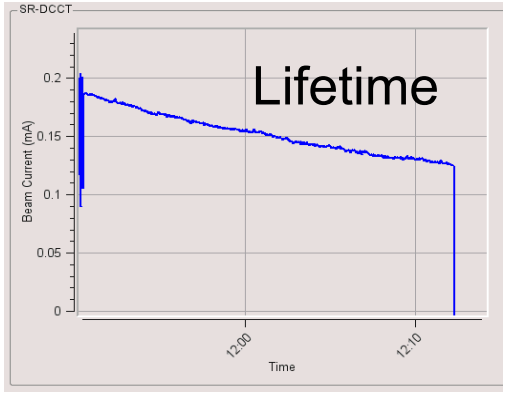
ALBA Synchrotron Light Facility

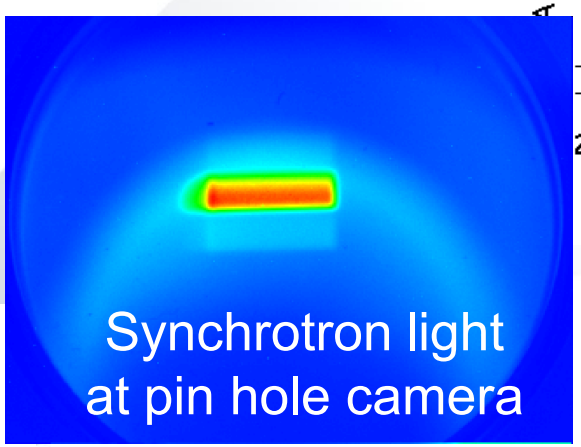
Accelerator Division

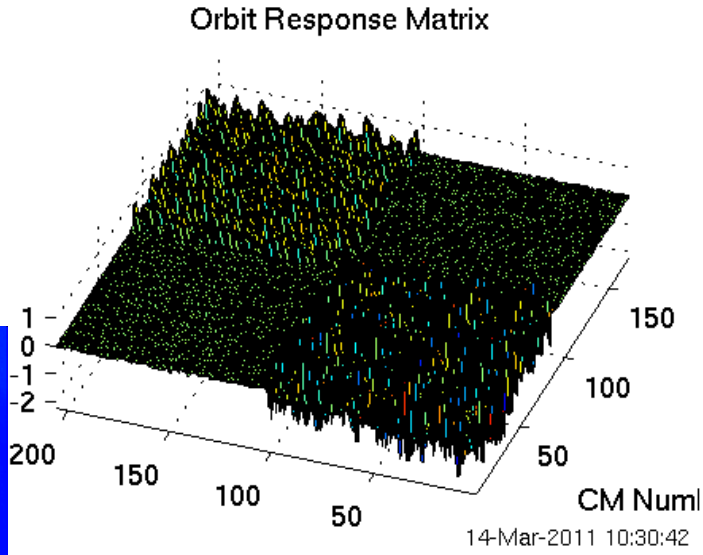


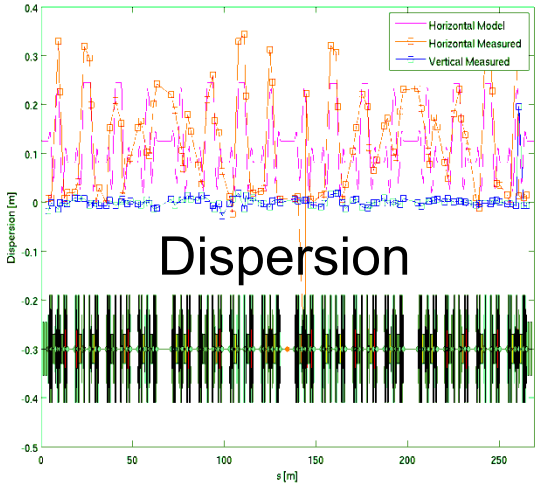


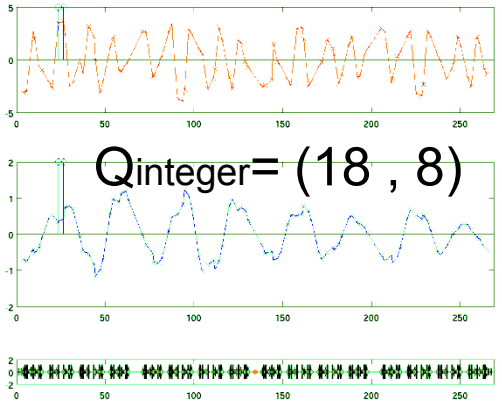
Firsts measurements



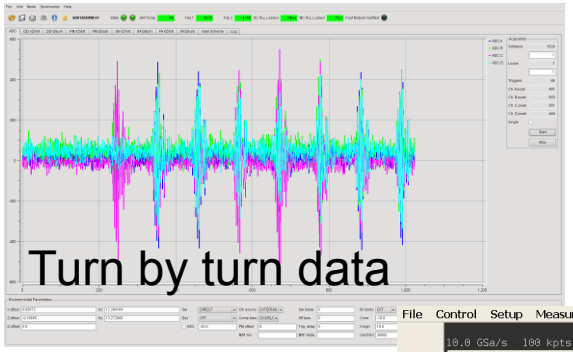


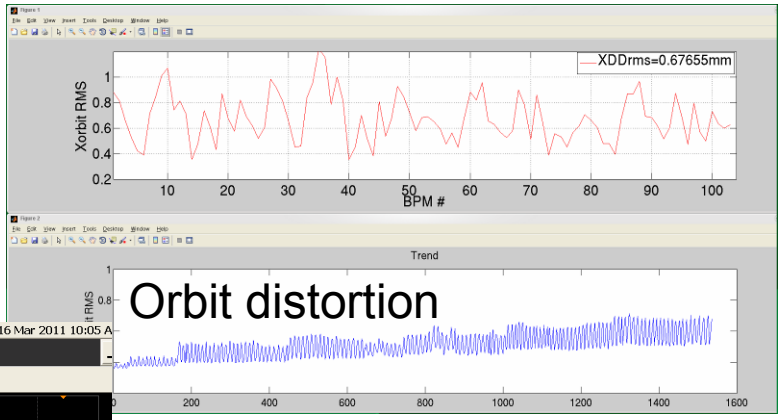


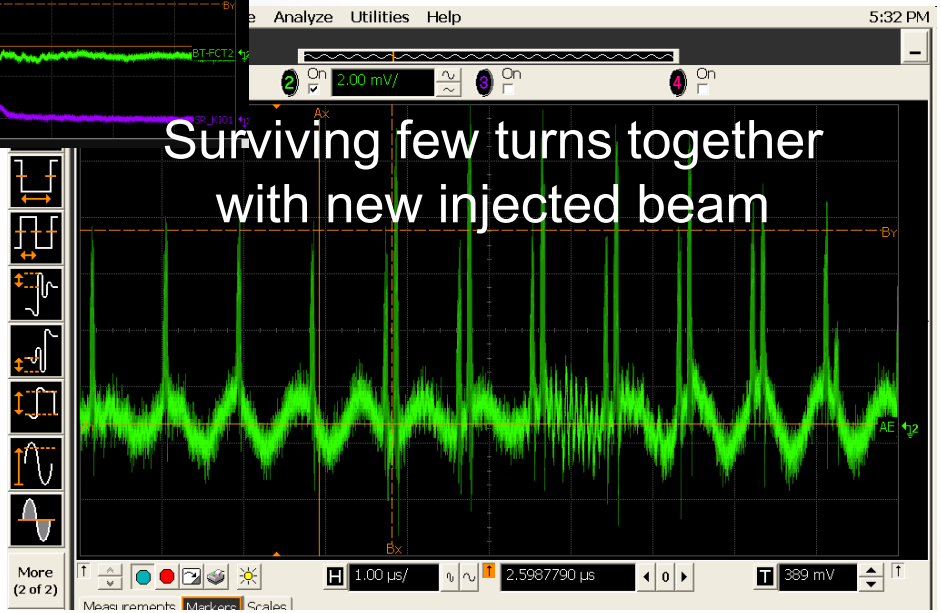




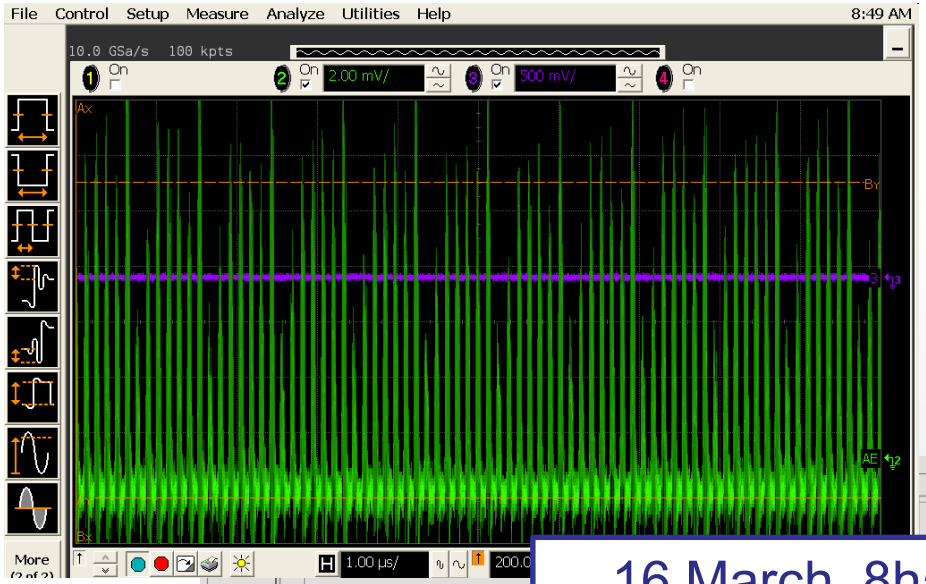
The road to accumulation







1st Accumulation

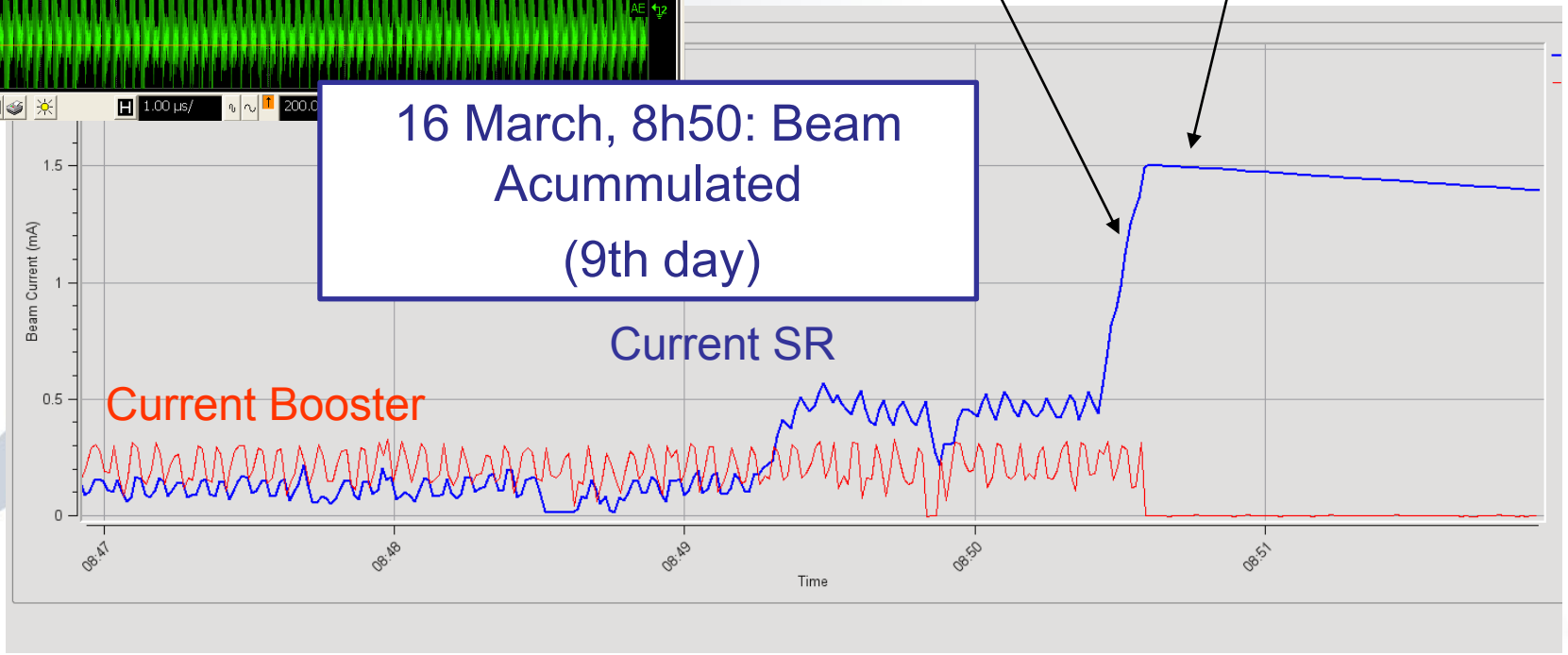


1.5 mA stored

Acummulation

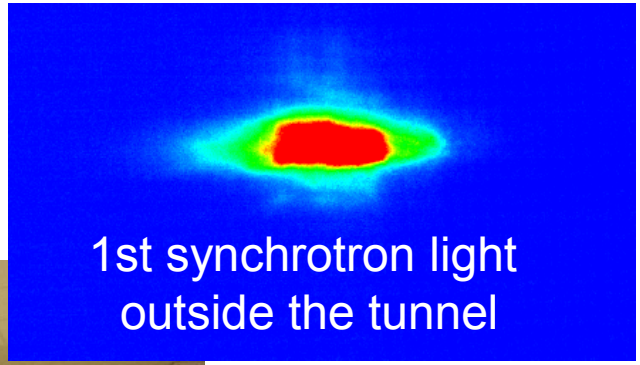
16 March, 8h50: Beam Acummulated

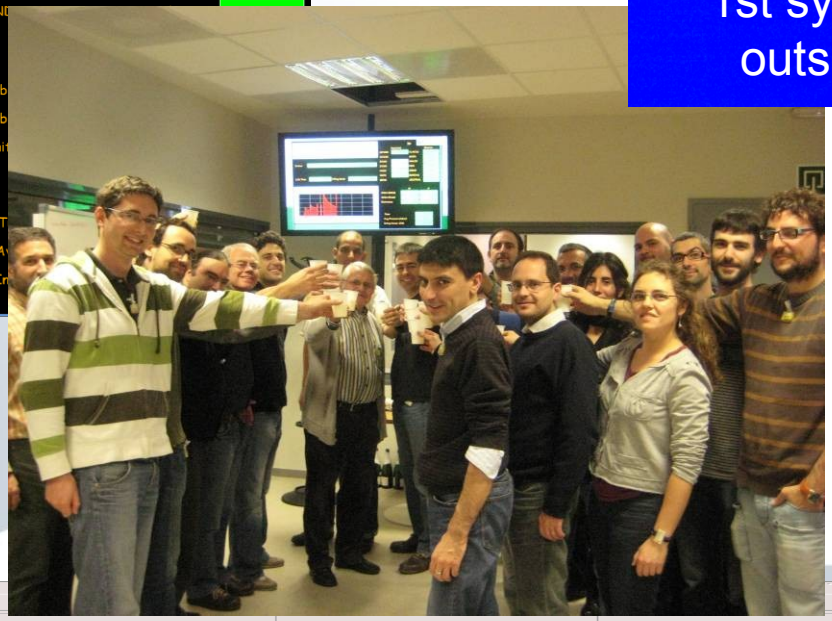
(9th day)

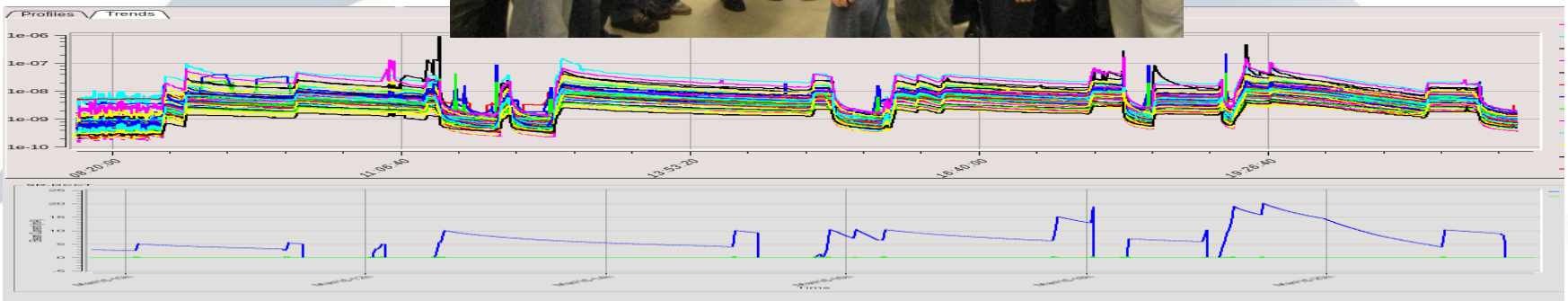


16 March


CURRENT
20.163 mA
Life Time
0h 06m
Status
I*L = 2.04
Filling Mode
56 bunches
CURRENT
Wednesday 16-Mar-2011 19:28:49
ID
Gap (mm)
Shutter
MPW80 298.0 CLAESS Closed
SCW30 MSPD Closed
IVU21 XALOC Closed
IVU21 NCD Closed
EU62 275.5 CIRCE Closed
EU71 273.0 BOREAS ----

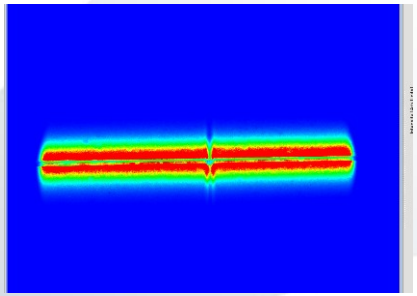

1st synchrotron light
outside the tunnel



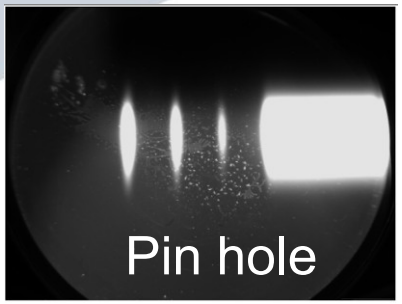

Profiles
Trends

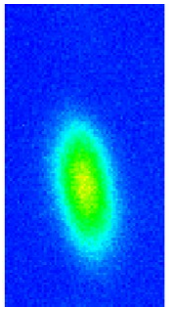
MAXIMUM CURRENT LIMITED TO 20 mA
UNTIL THE Machine Protection System IS OPERATIONAL

Synchrotron Light at Front End 9



and at the Pinhole camera:

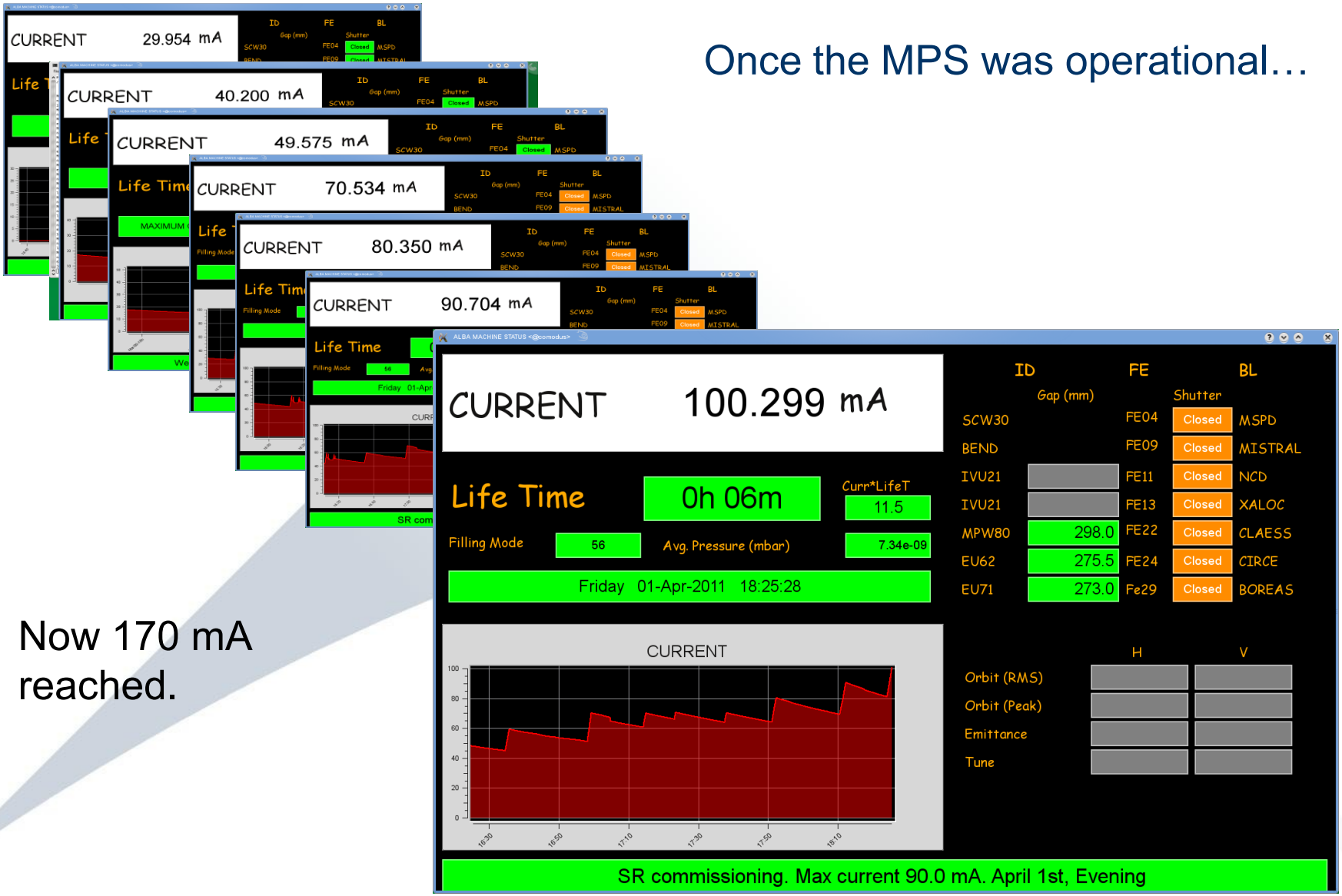




Sigma X = 50 um
Sigma Y = 130 um

The road to 200 mA

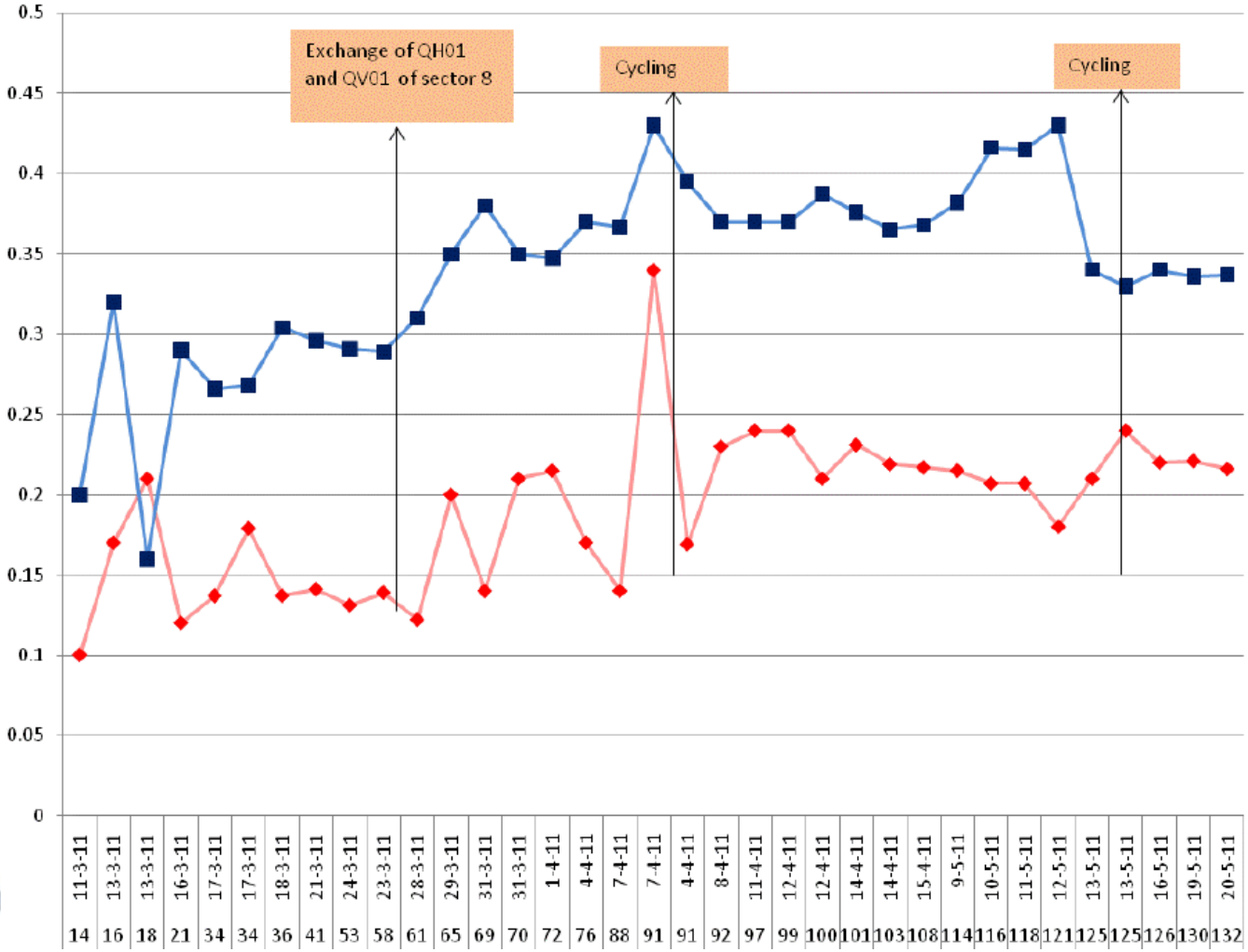
Once the MPS was operational…

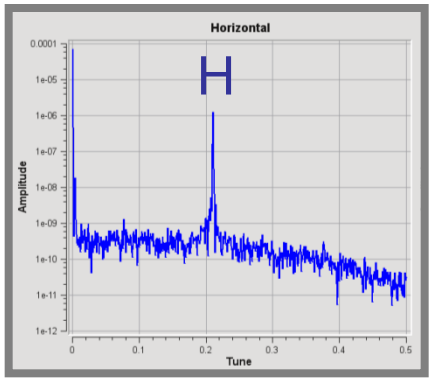


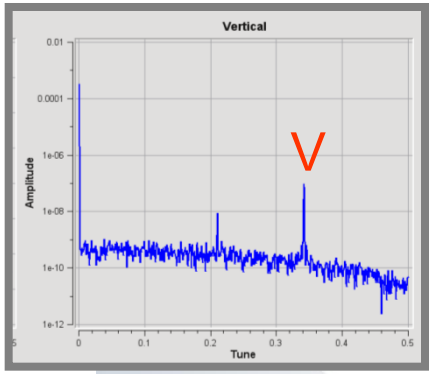
Now 170 mA reached.

Tune

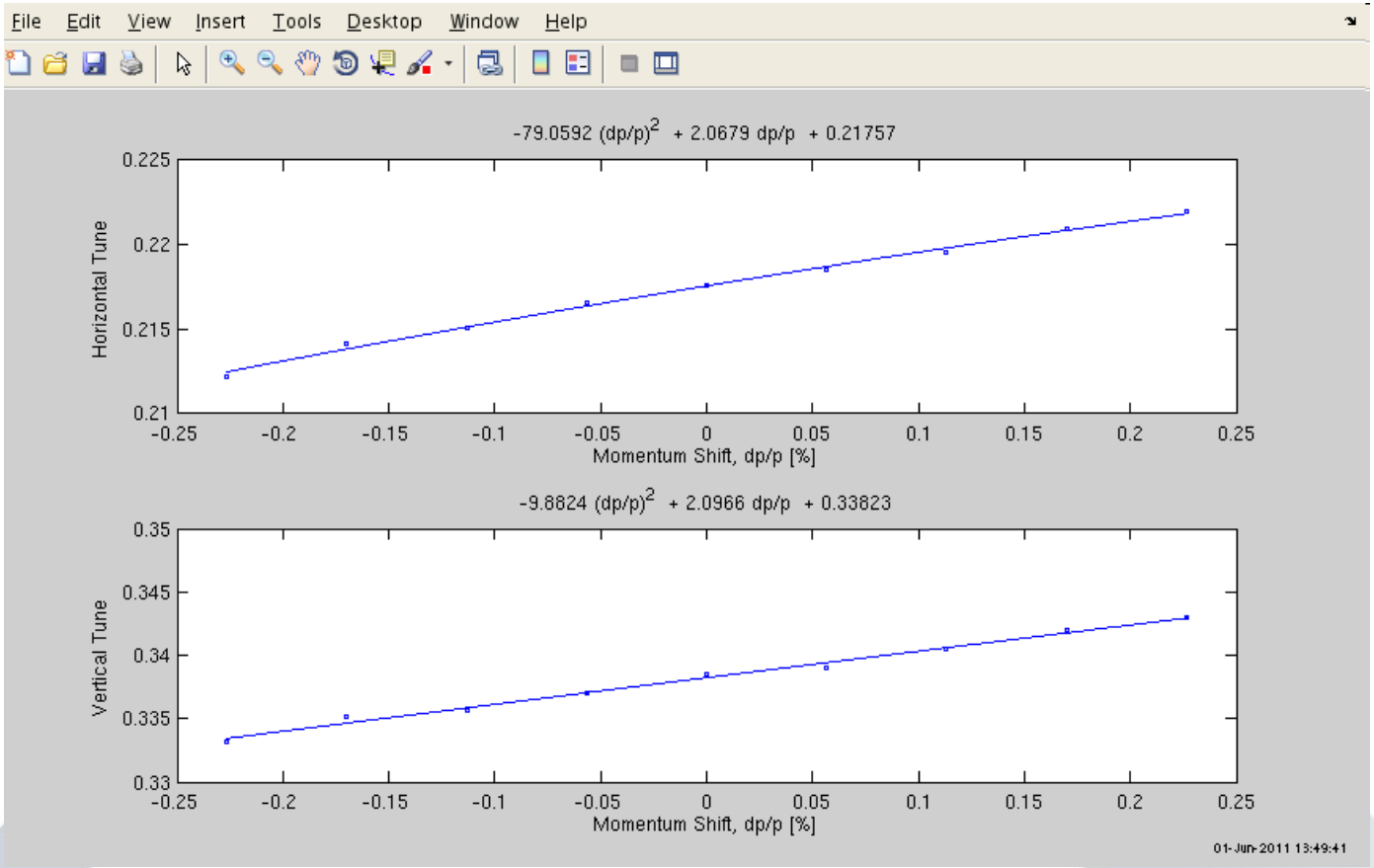
Tune during the commissioning:





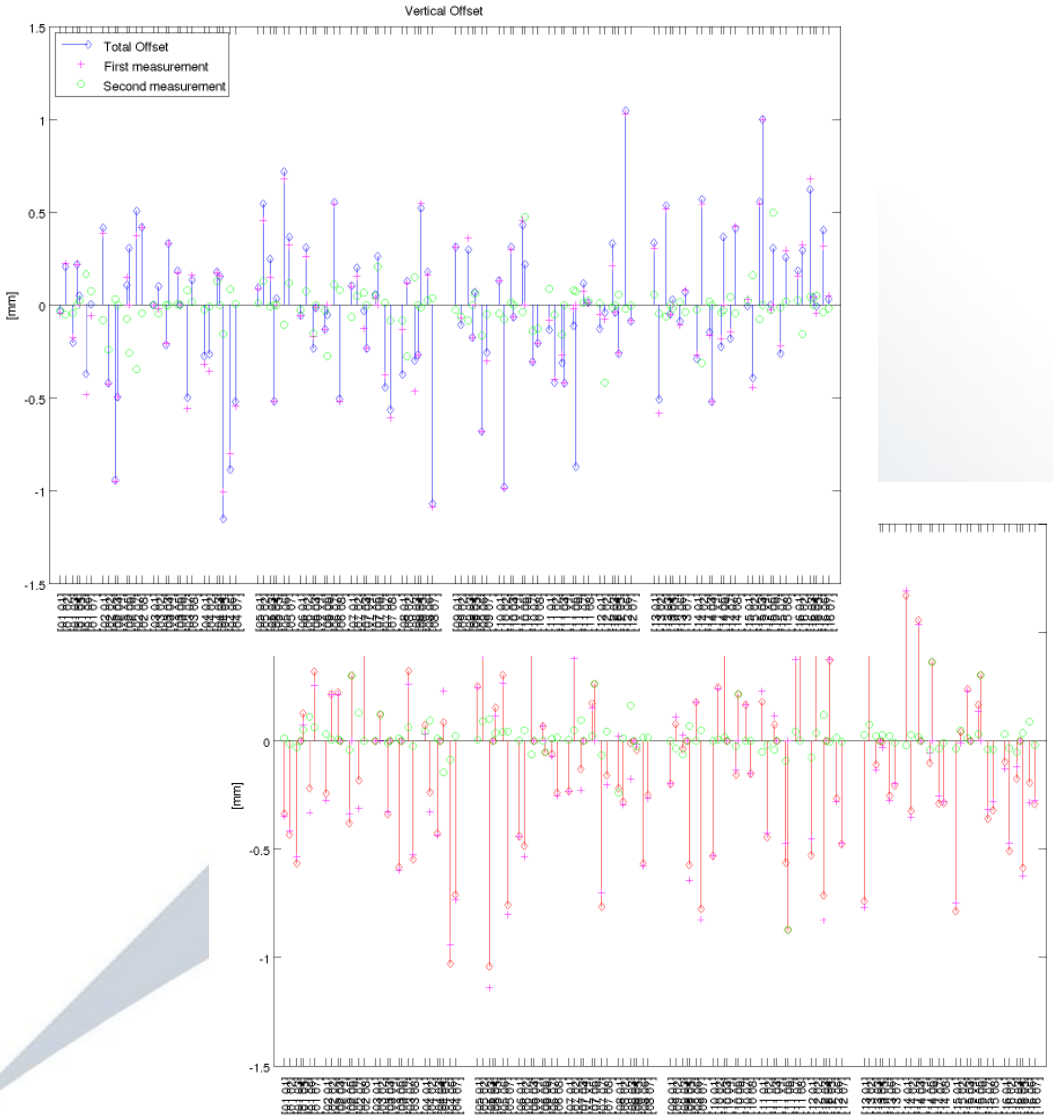


Chromaticity



Normally working with (+2 , +2).
Good agreement with the model

BBA

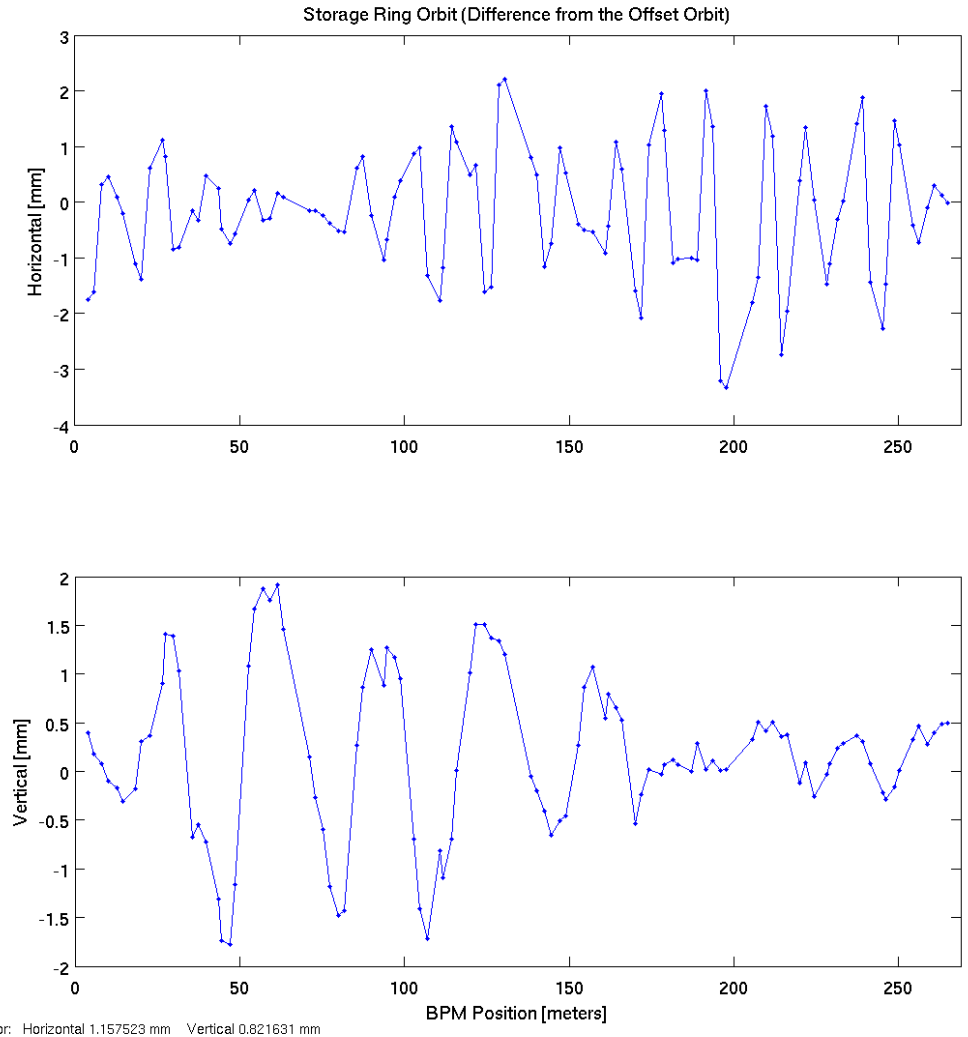


Horizontal offsets:
+1.0 mm to -1.1 mm

Vertical offsets
+0.9 mm to -1.1 mm

Orbit

Raw orbit without correctors



RMS Error: Horizontal 1.157523 mm Vertical 0.821631 mm
Mean Error: Horizontal -0.182247 mm Vertical 0.175041 mm

03-Jun-2011 08:56:36

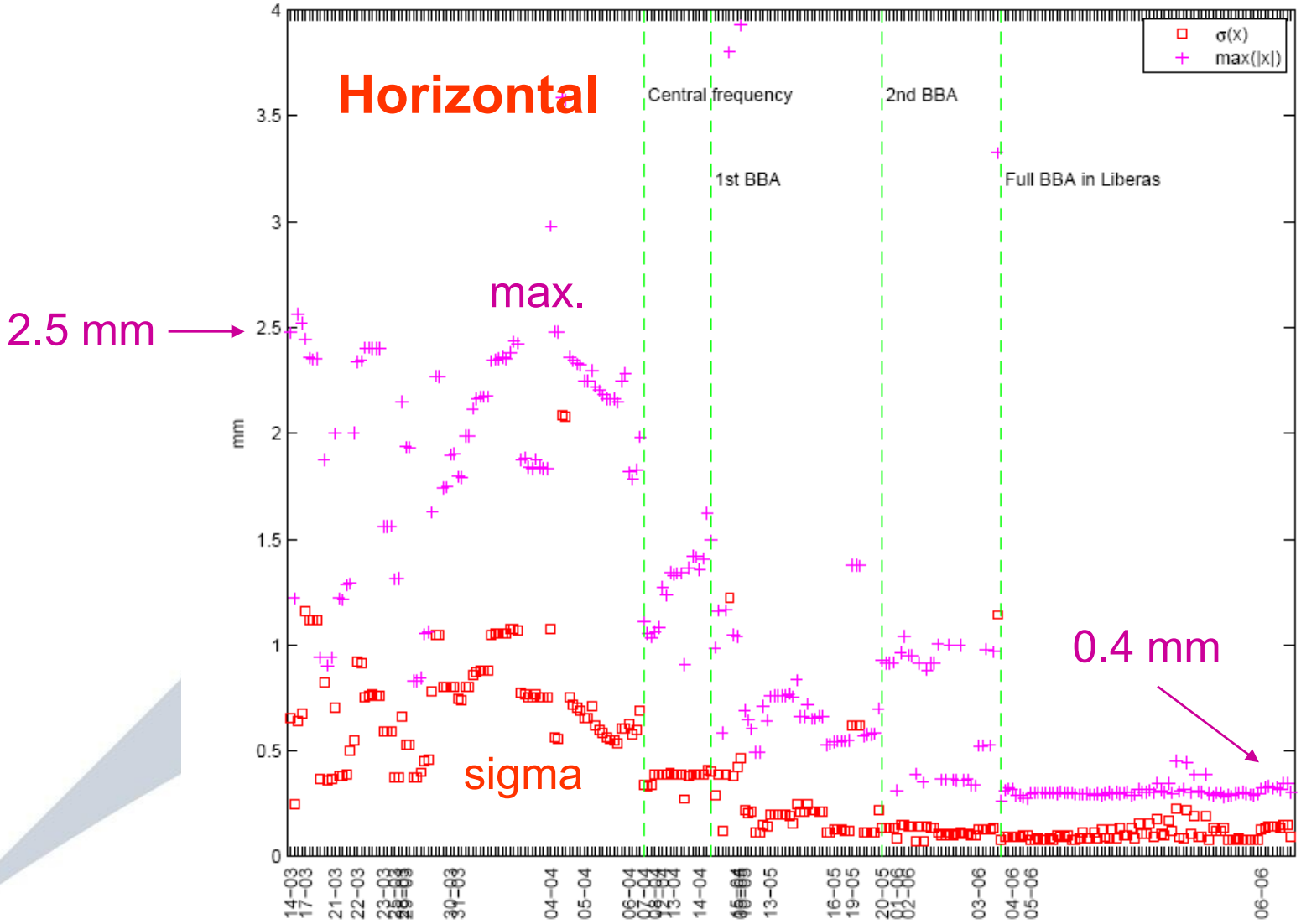
With offsets BBA included

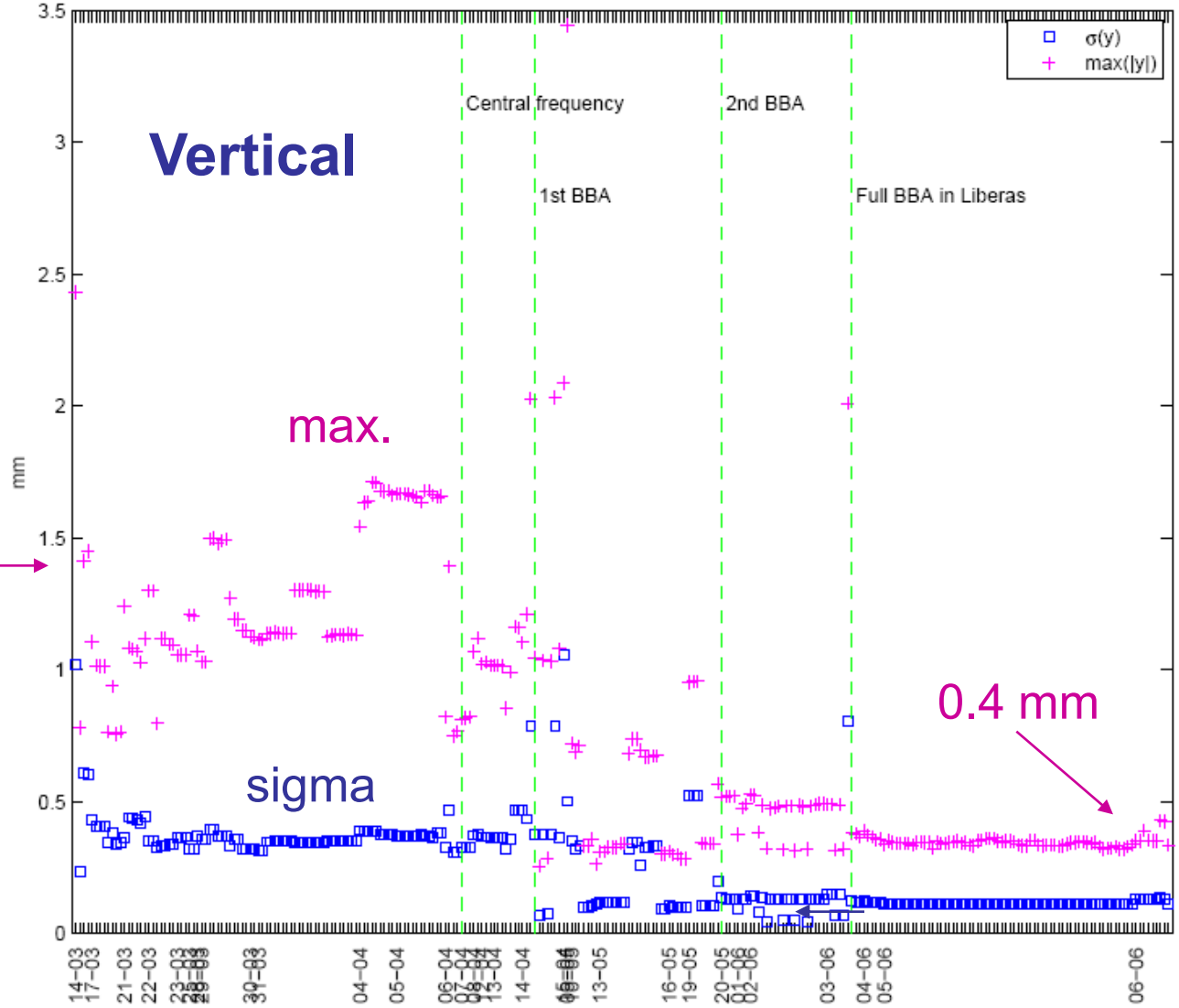
RF frecuency adjusted
from 499.6540 MHz
to 499.6523 MHz

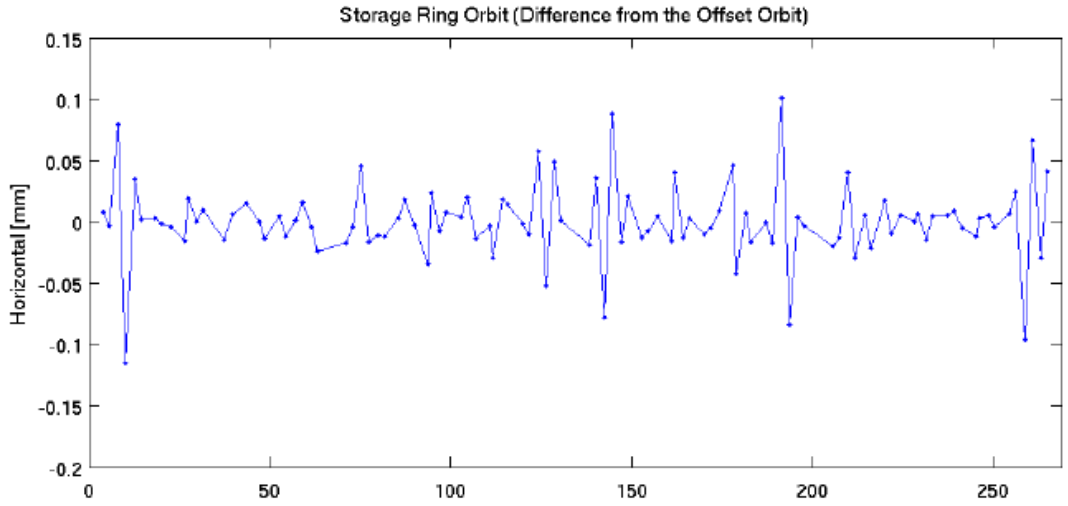
Horizontal orbit < 3mm

Vertical orbit < 2 mm

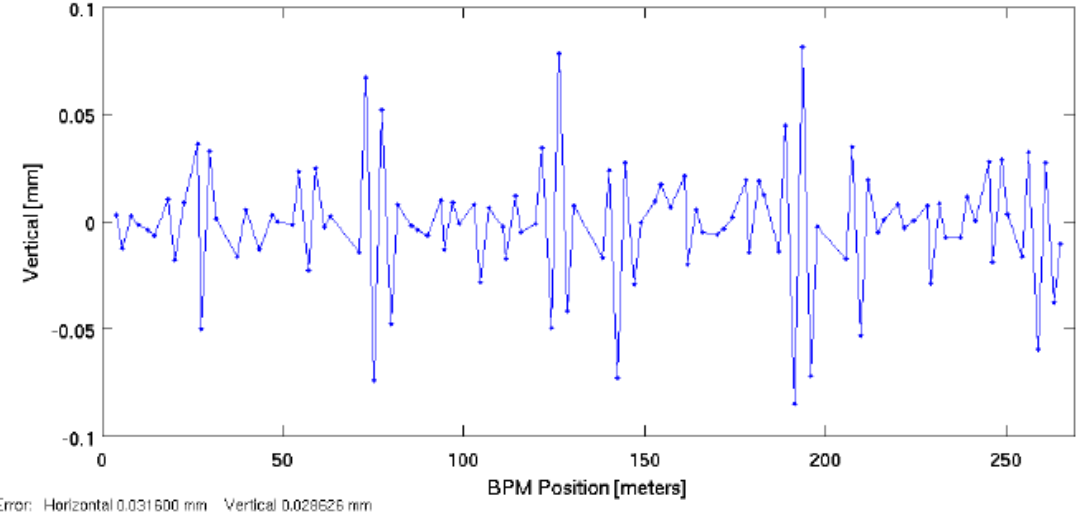
Good alignment


Horizontal
σ(x)
max(|x|)
Central frequency
1st BBA
2nd BBA
Full BBA in Liberas
max.
sigma
2.5 mm
0.4 mm
mm
4
3.5
3
2.5
2
1.5
1
0.5
0


Vertical
σ(y)
max(|y|)
Central frequency
2nd BBA
1st BBA
Full BBA in Liberas
max.
sigma
1.5 mm
0.4 mm
mm
3.5
3
2.5
2
1.5
1
0.5
0
14–03
17–03
21–03
22–03
30–03
31–03
04–04
05–04
06–04
13–04
14–04
13–05
16–05
19–05
20–05
01–06
03–06
04–06
05–06
06–06



Horizontal rms error
32 um

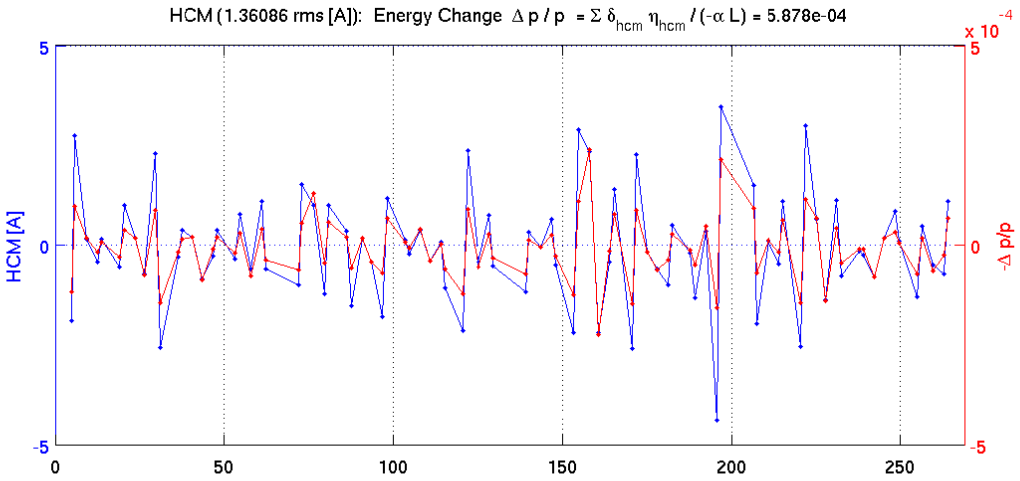


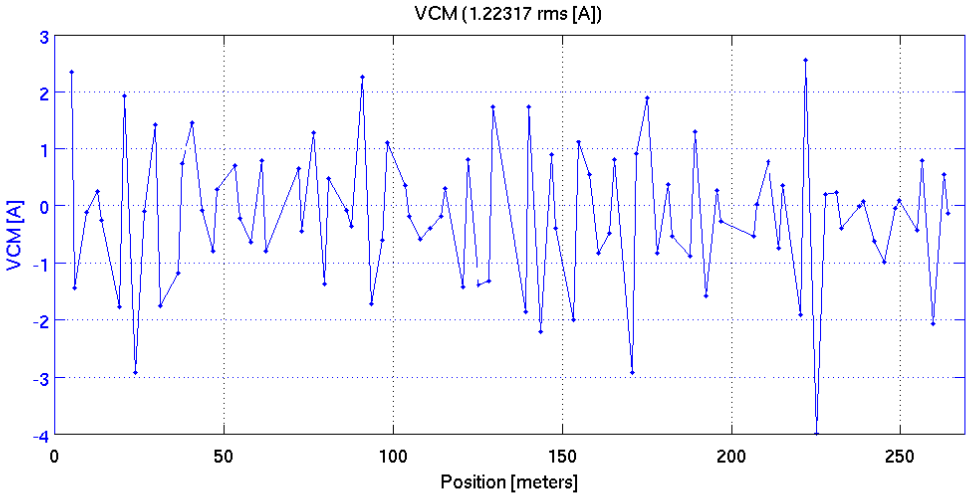
Vertical rms error
29 um

RMS Error: Horizontal 0.031600 mm Vertical 0.028626 mm
Mean Error: Horizontal 0.000352 mm Vertical -0.001128 mm

to reference orbit (BBA to center of quads)

Correctors



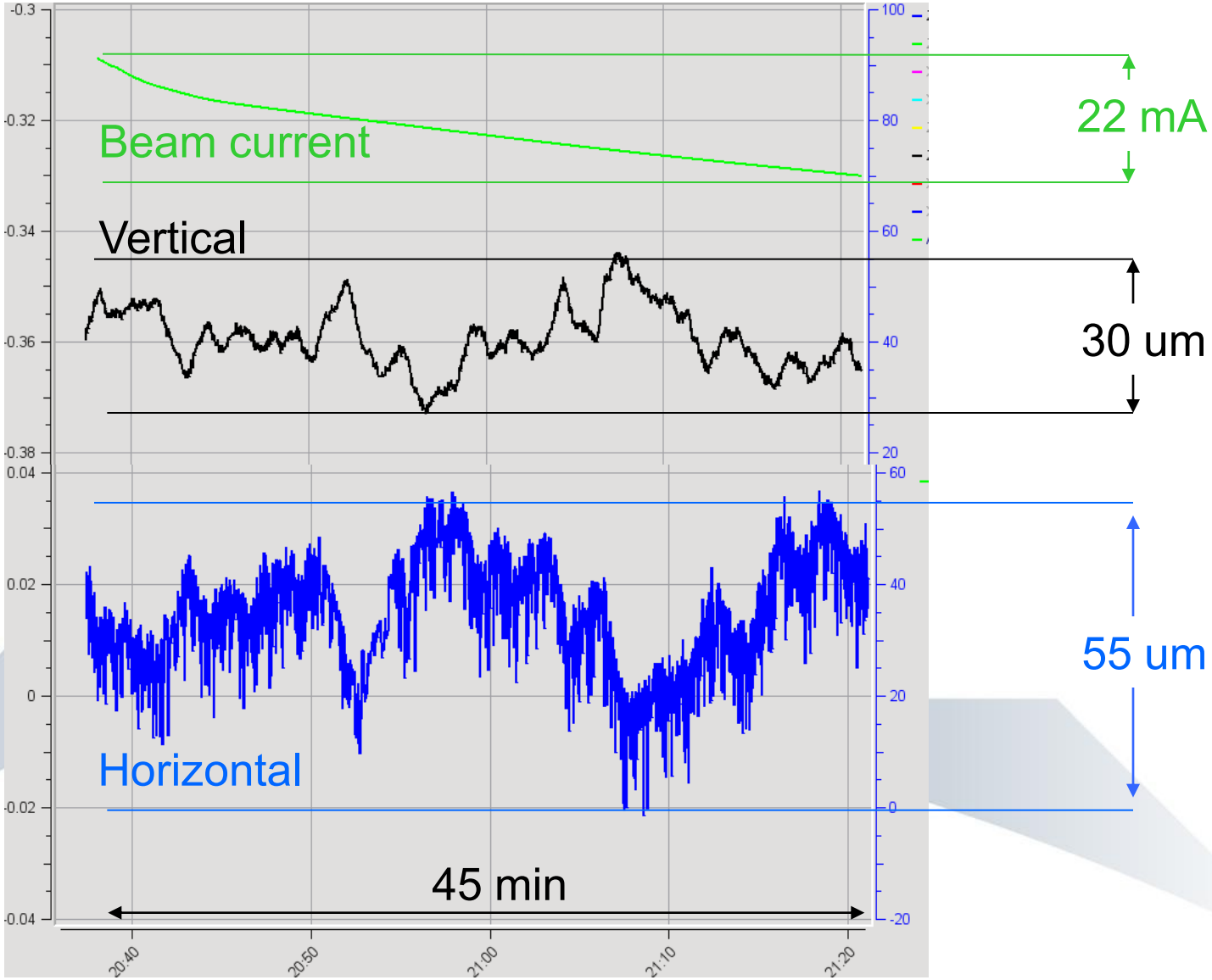


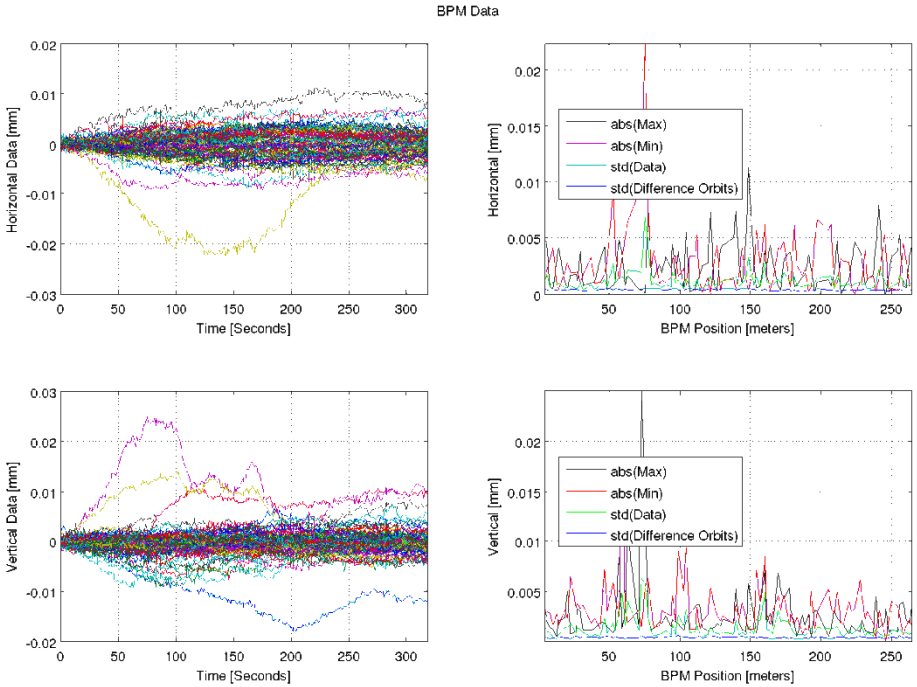
Equivalent energy change using the RF is ΔRF = -261.205 [Hz] ΔL = 0.000140522 [m]

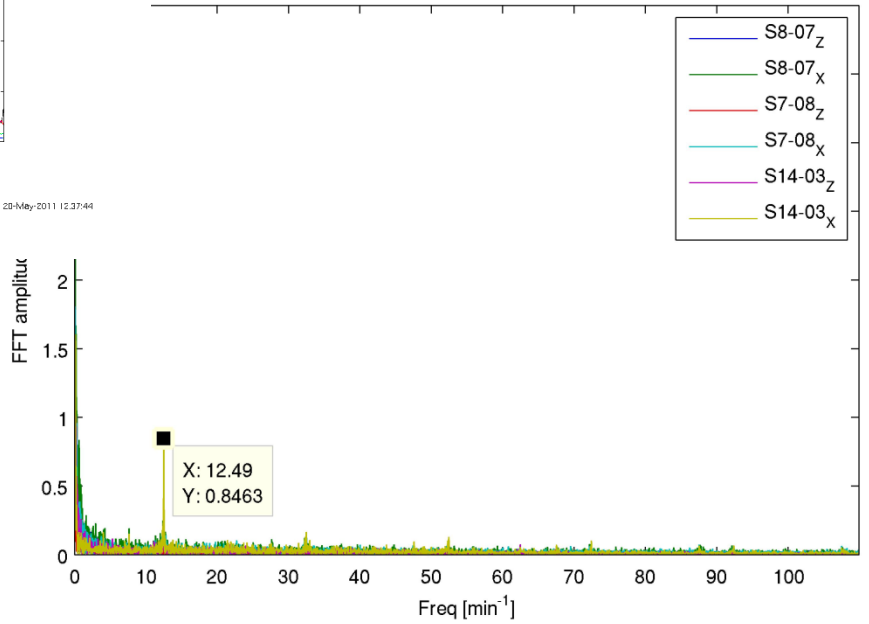
19-May-2011 16:08:36

Orbit Correction: BPM stability

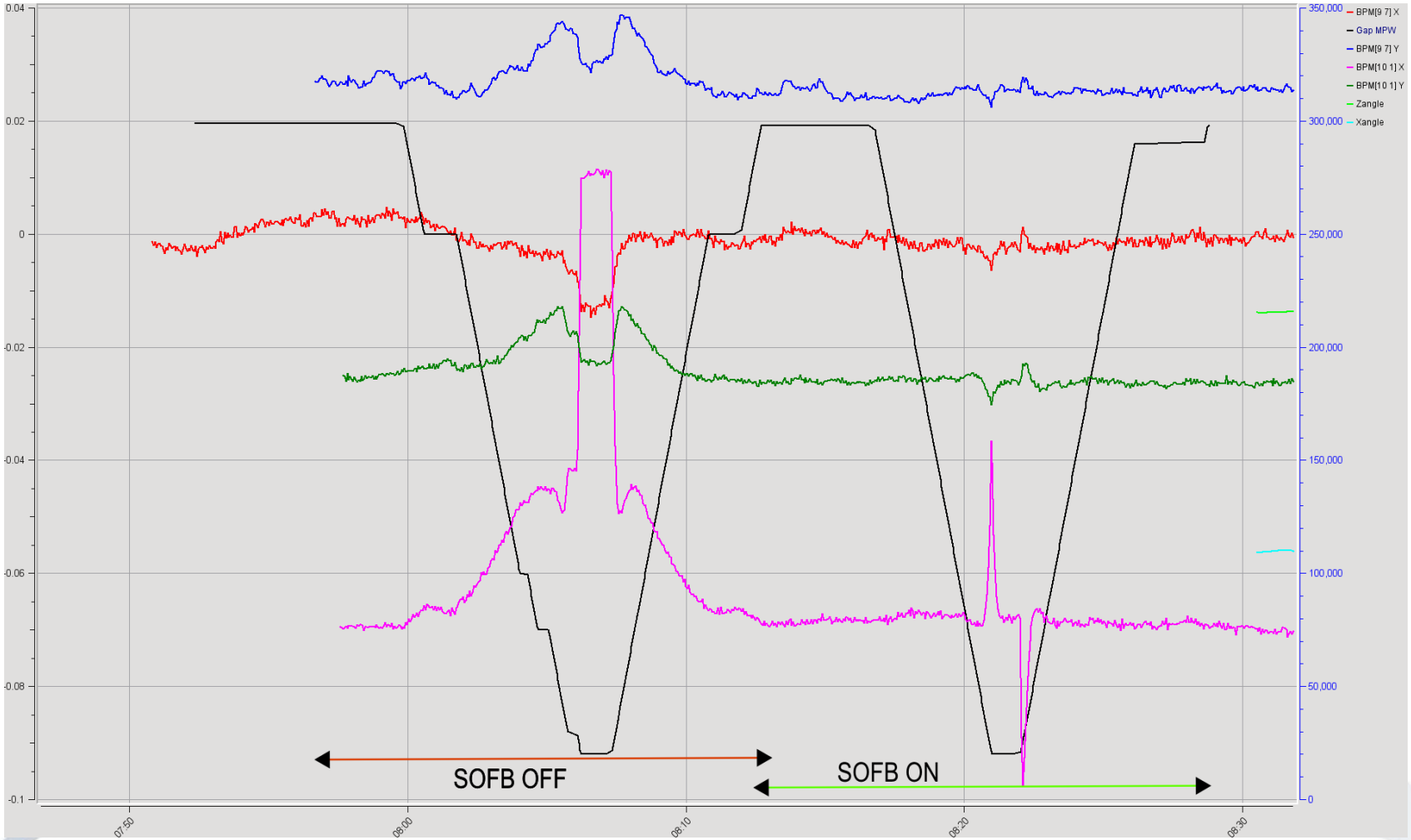
BPM0503



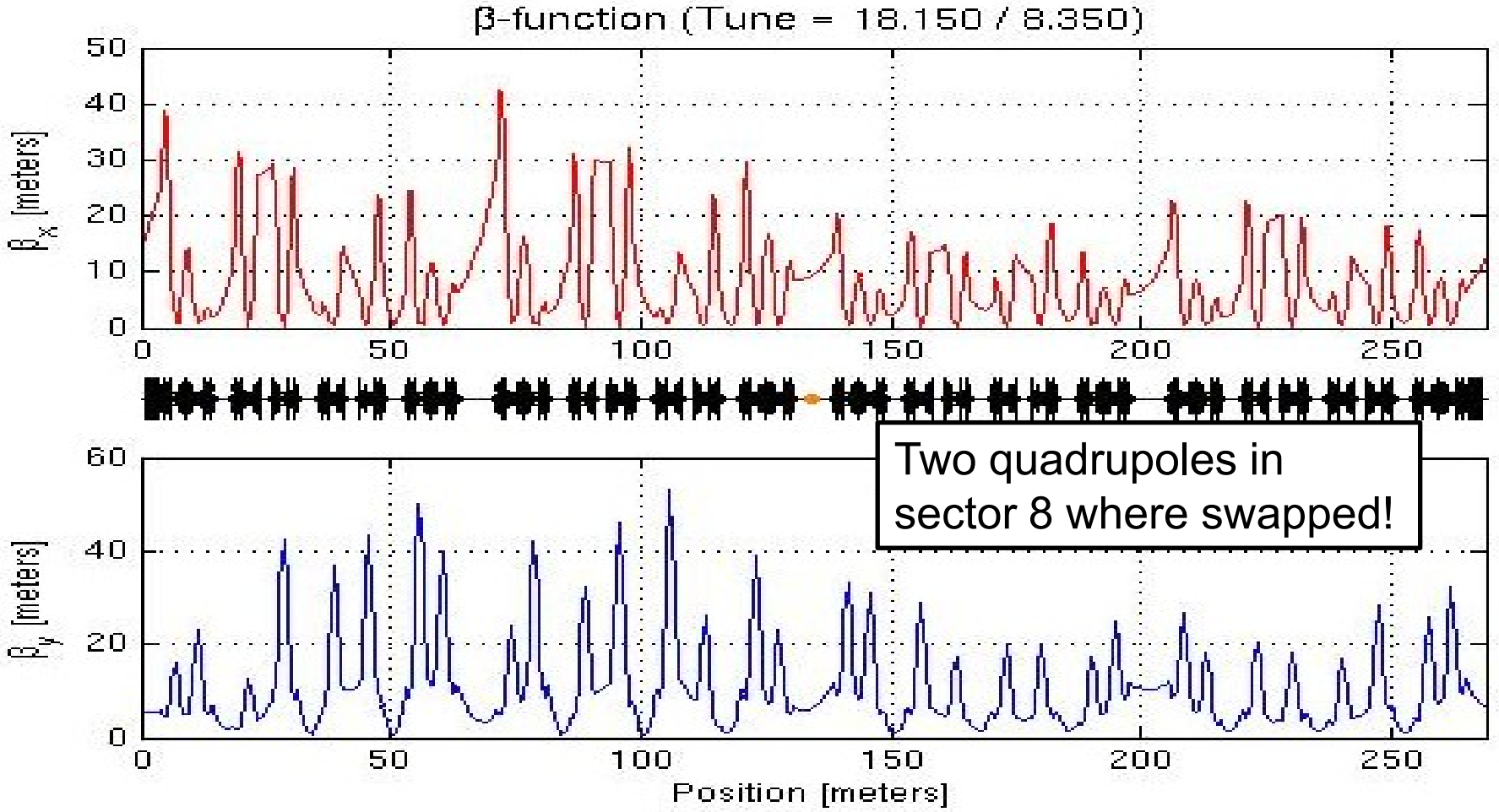

BPM Data
Horizontal Data [mm]
Time [Seconds]
Horizontal [mm]
BPM Position [meters]
abs(Max)
abs(Min)
std(Data)
std(Difference Orbits)
Vertical Data [mm]
Time [Seconds]
Vertical [mm]
BPM Position [meters]
abs(Max)
abs(Min)
std(Data)
std(Difference Orbits)


S8-07Z
S8-07X
S7-08Z
S7-08X
S14-03Z
S14-03X
FFT amplitud
X: 12.49
Y: 0.8463
Freq [min-1]

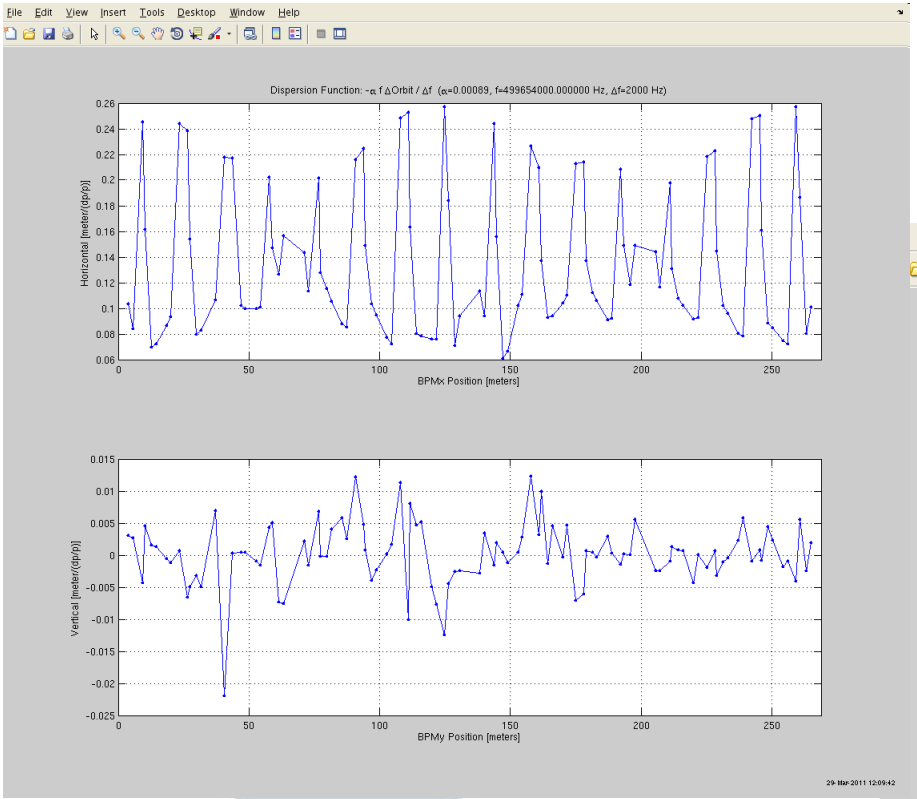
SOFB Test

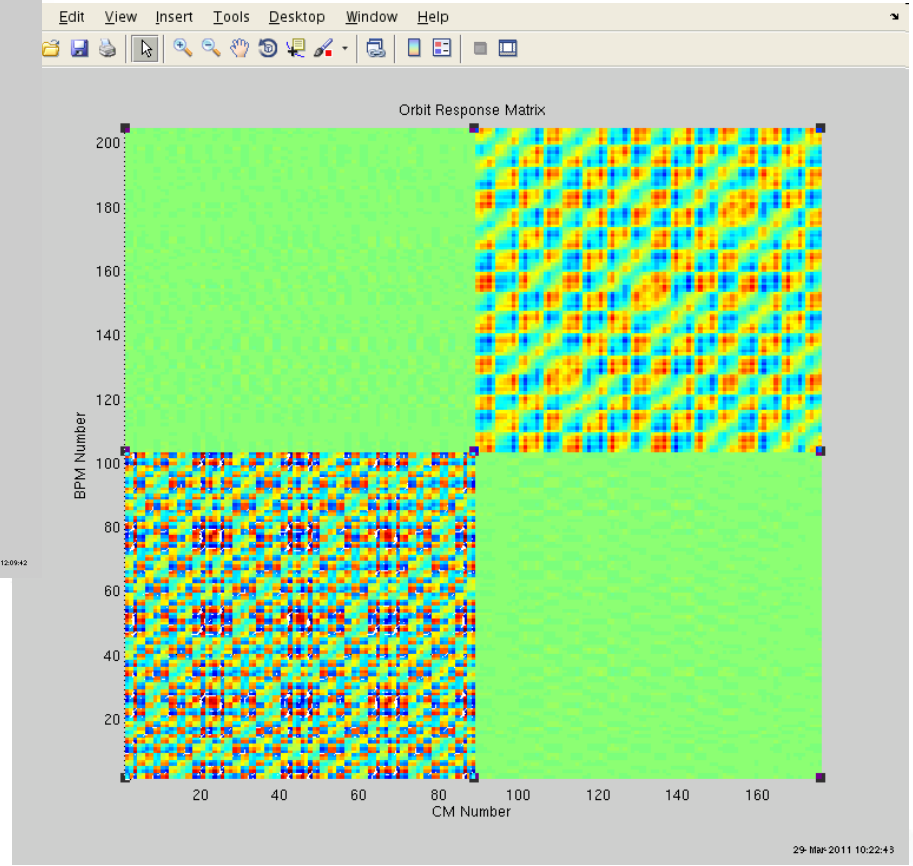

0.04
0.02
0
-0.02
-0.04
-0.06
-0.08
-0.1
350,000
300,000
250,000
200,000
150,000
100,000
50,000
0
BPM[9 7] X
Gap MPW
BPM[9 7] Y
BPM[10 1] X
BPM[10 1] Y
Zangle
Xangle
SOFB OFF
SOFB ON
07:50
08:00
08:10
08:20
08:30

Day 1 Optics - Asymmetric



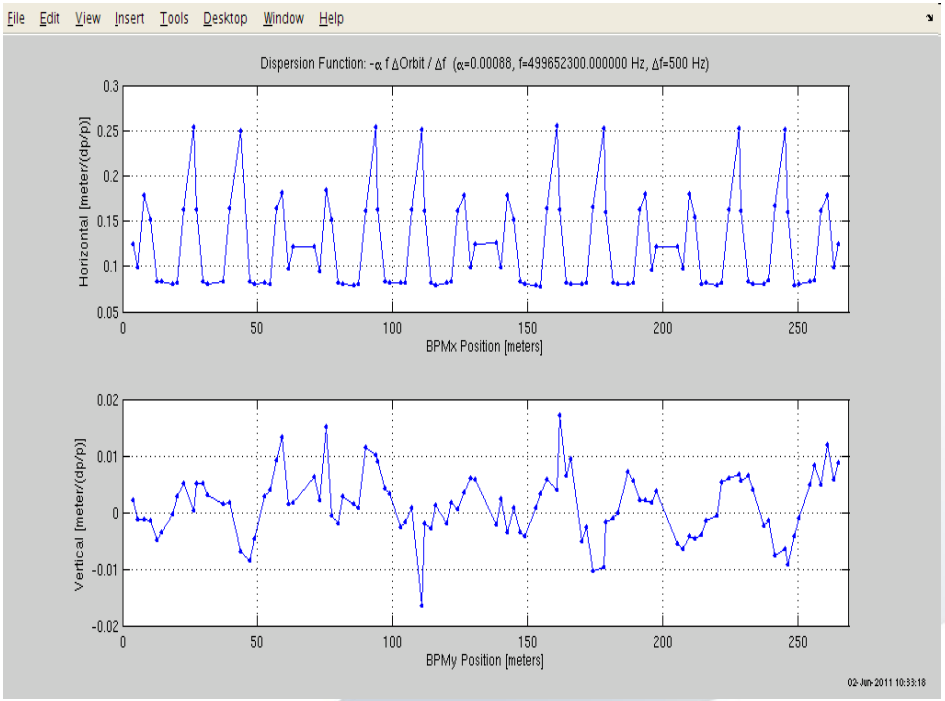
Measurements 17th March



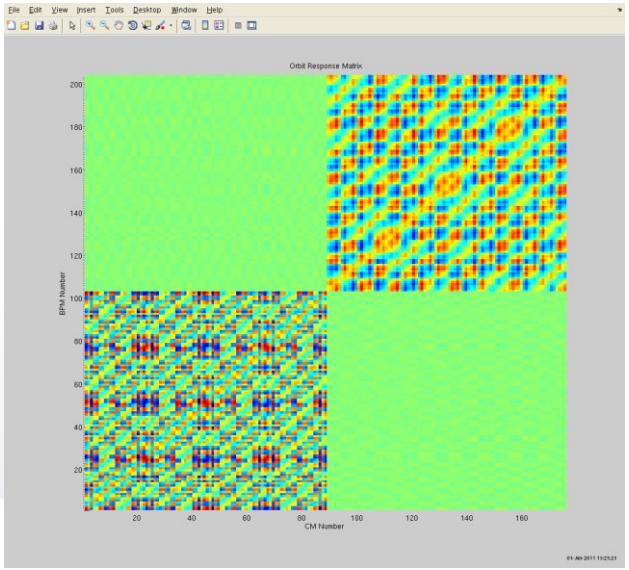


Two quadrupoles S08
have the cables swapped

Correction of the quadrupoles

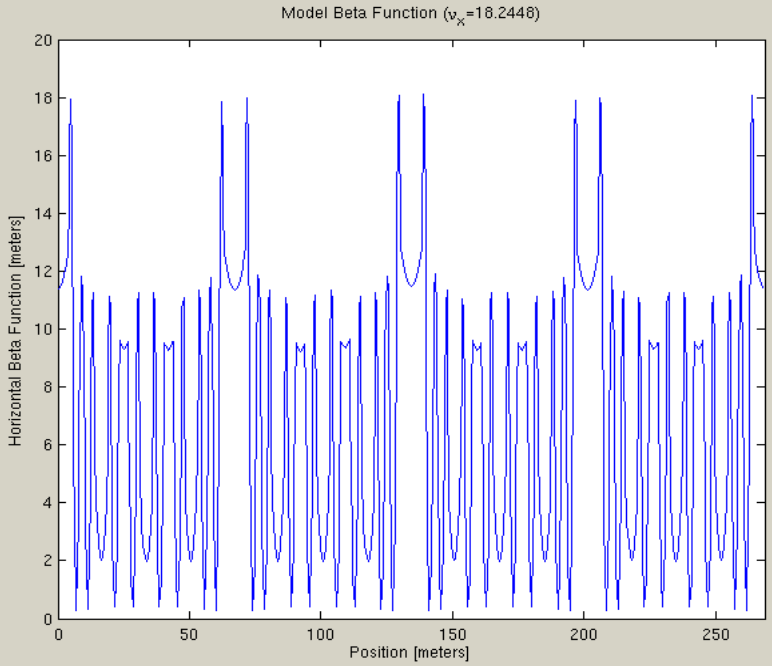


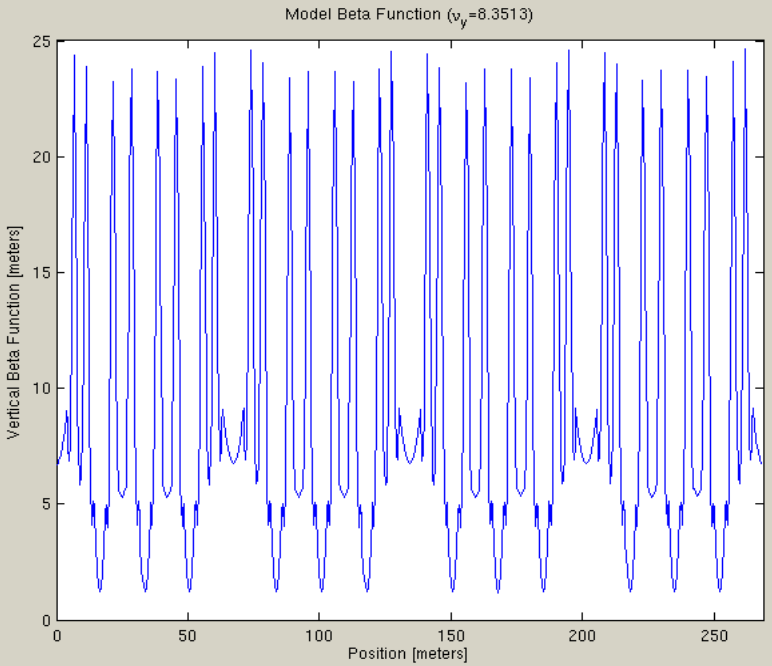
Measurements of June



After recabling and applying LOCO correction

Beta functions

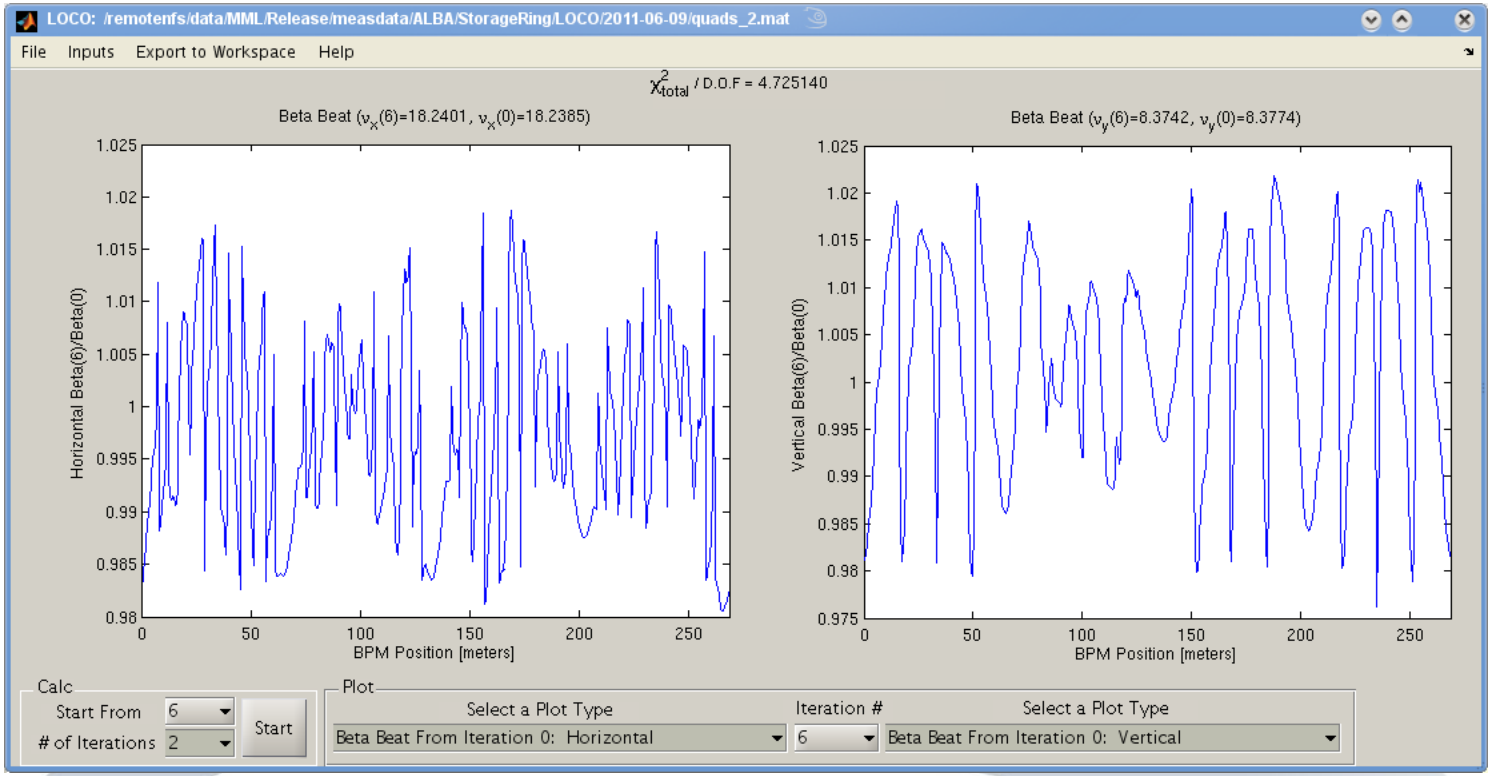




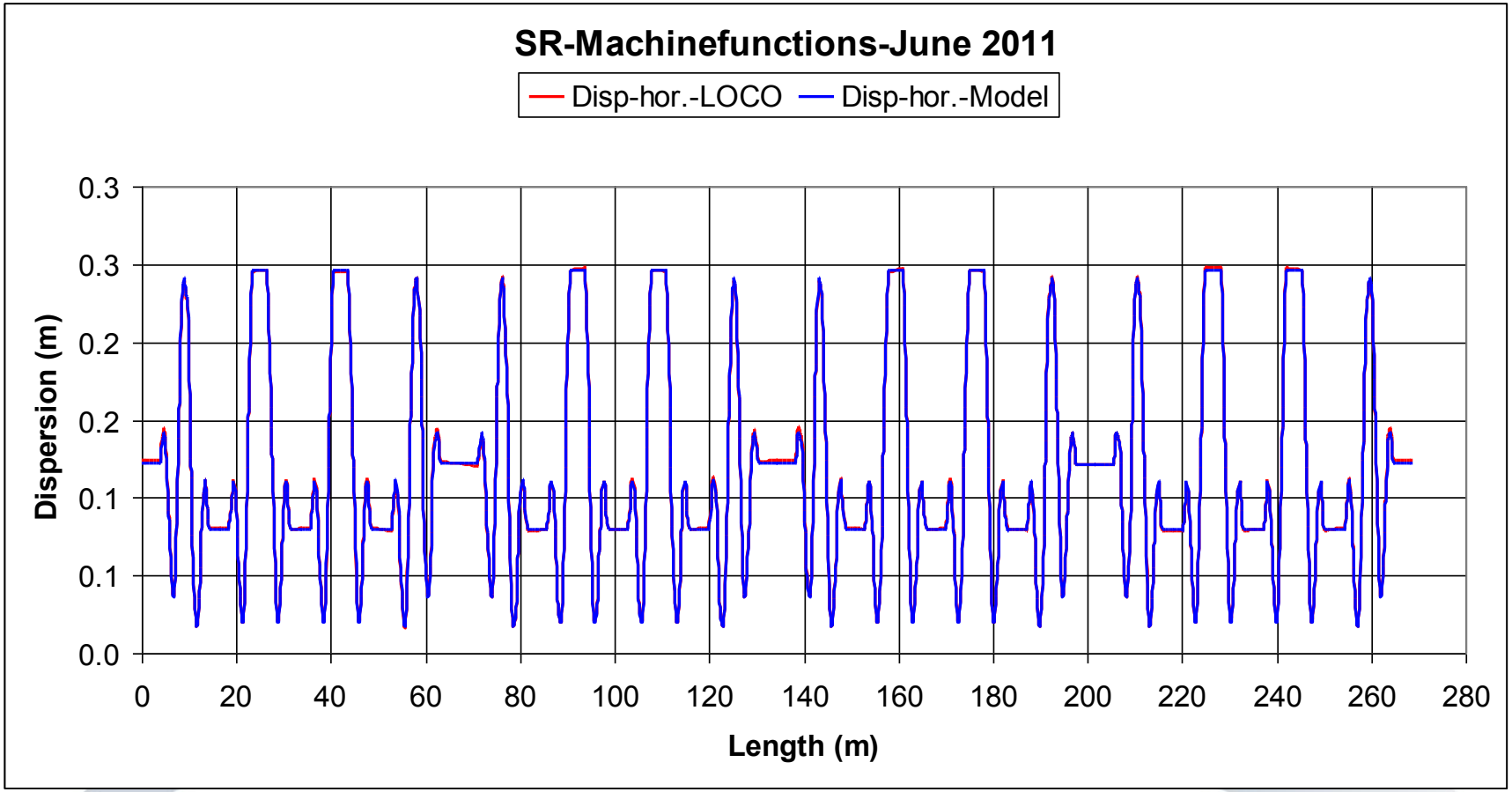
Beta beating < 5%

- adjusting the tune to 0.23
- including a -0.2% gradient error in the bendings

After the best correction



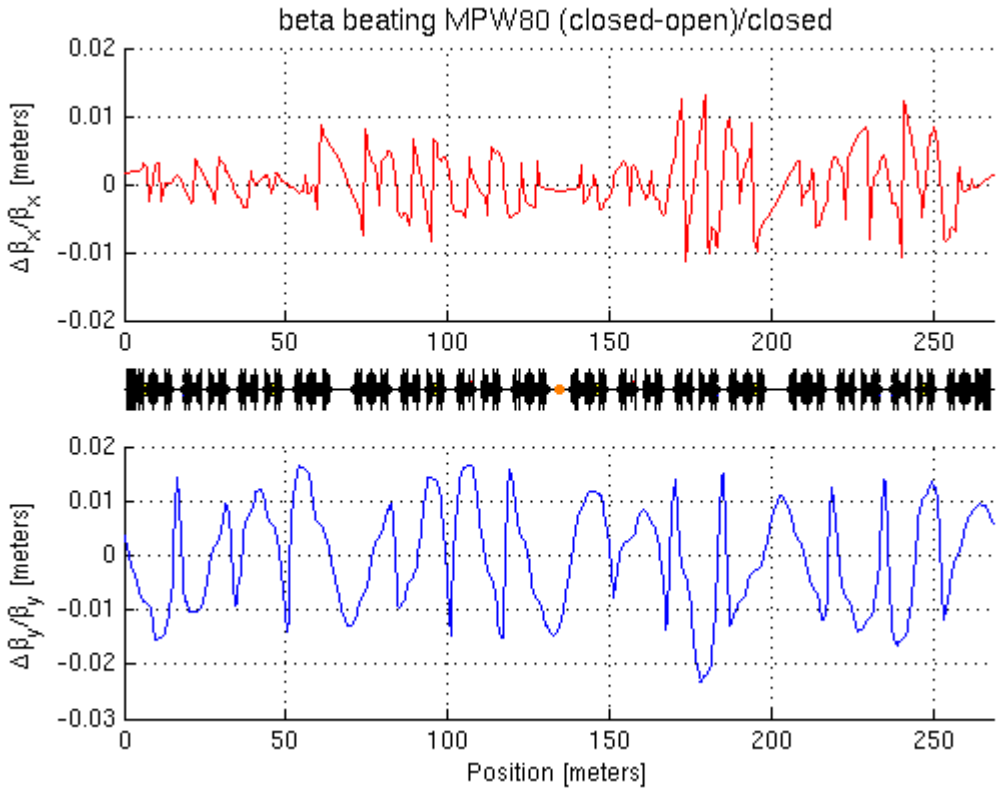
Dispersion



Model vs. Measurements: Very good agreement

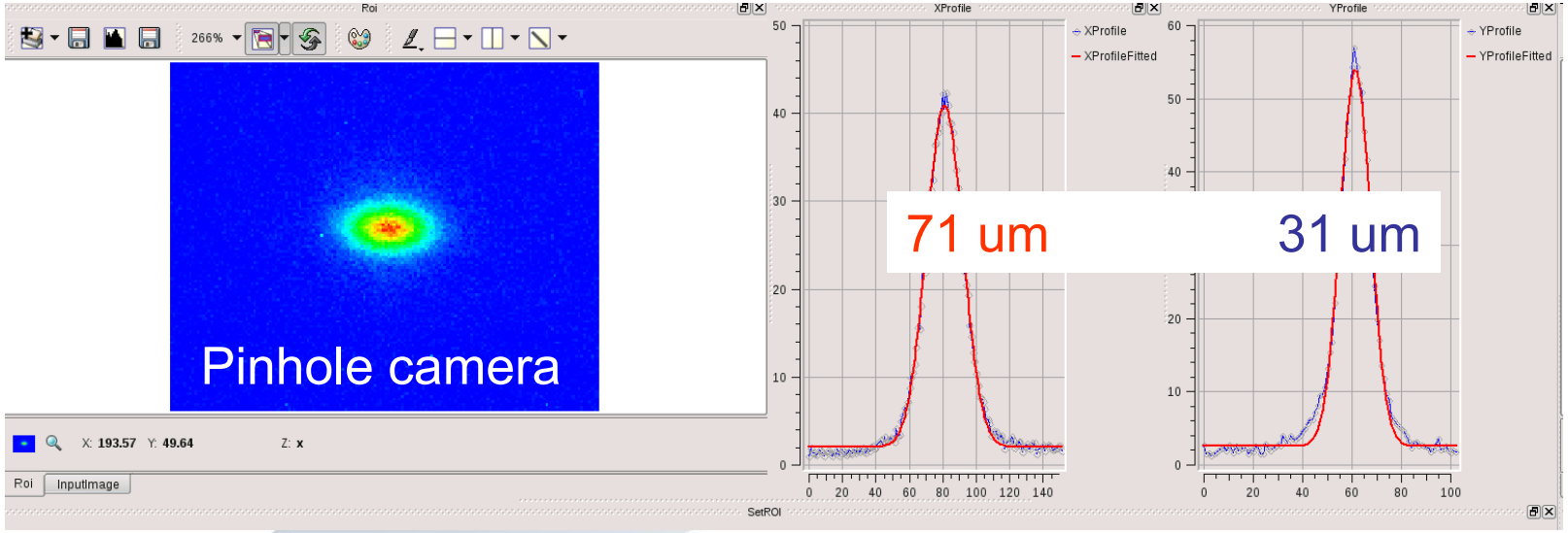
ID effects

- Effect of the MPW



Beam Size

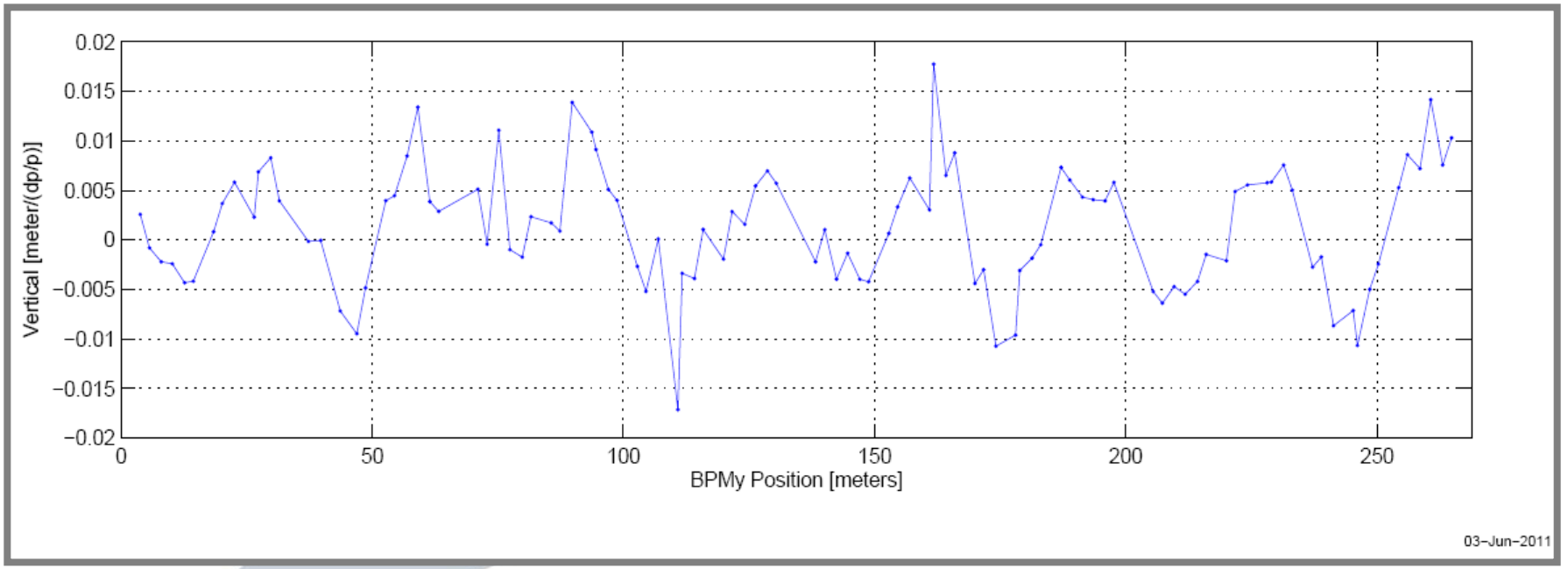
And…



Emittance X = 4 to 6. nmrad
Emittance Y = 0.03 nmrad
Coupling = 0.5% to 2.5%

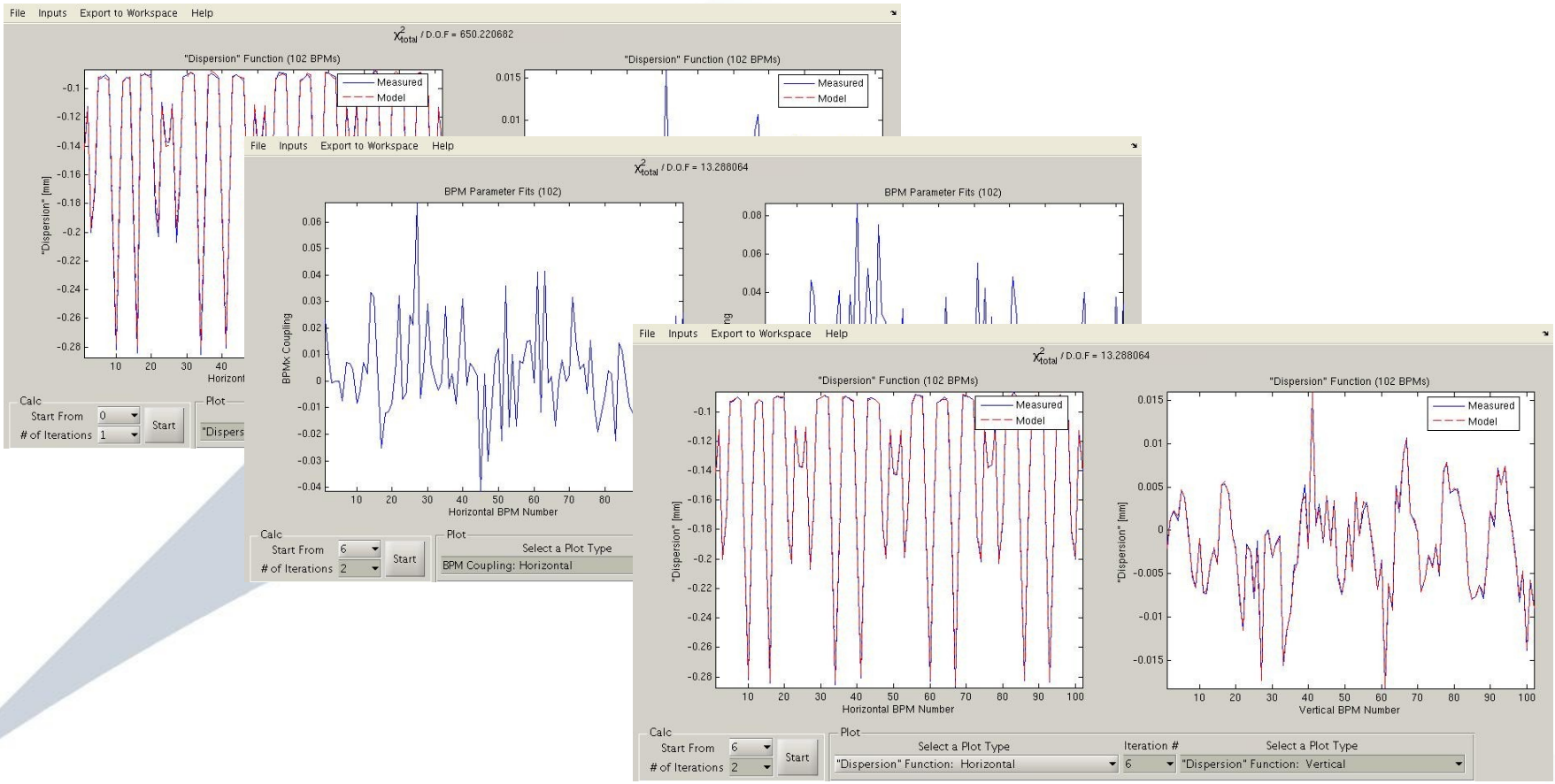
Quite ok with model:
Emittance = 4.5 nmrad
Coupling = 0.4 %

Vertical Dispersion



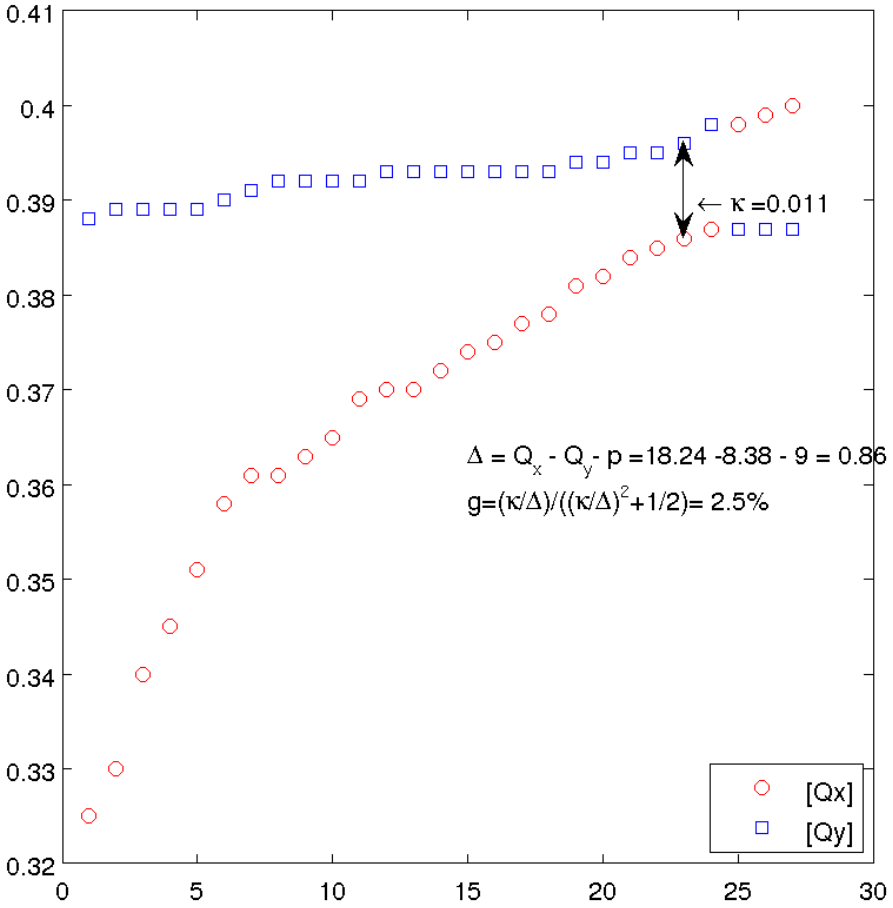
Direct result from the RF change measure
The vertical dispersion is still not well understood

- After some LOCO analysis, we start to have some answers:

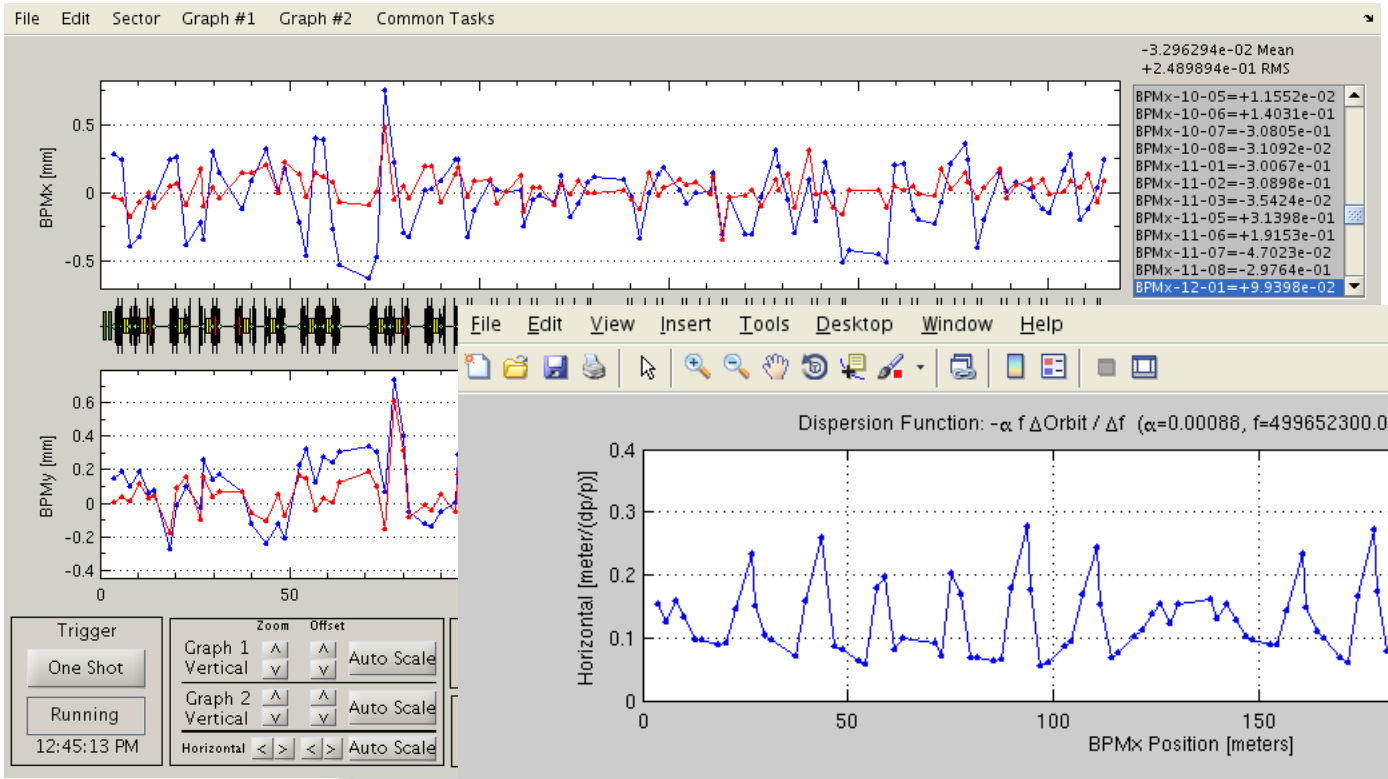


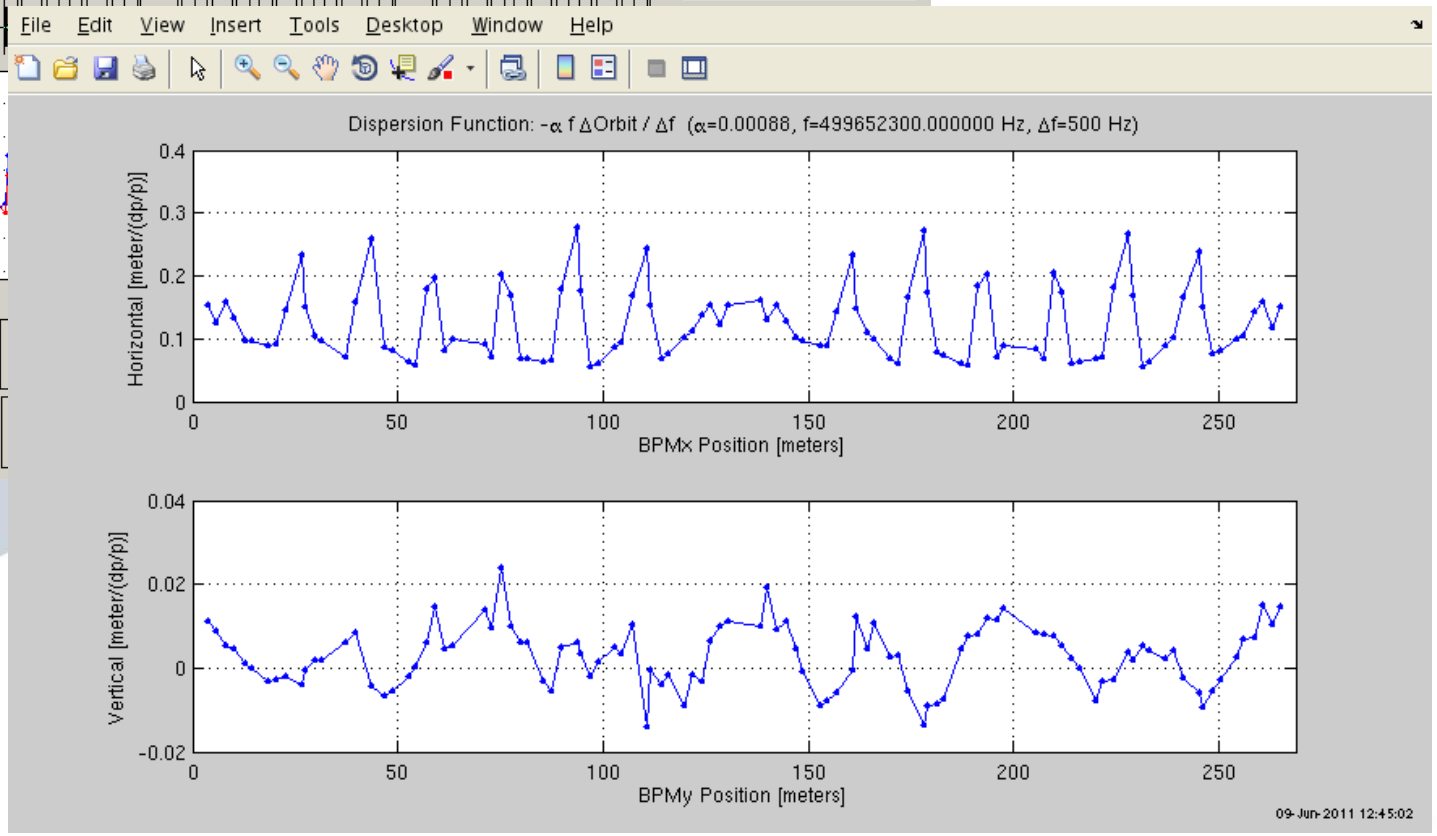
Coupling

- Coupling between 0.5 and 2.5%.



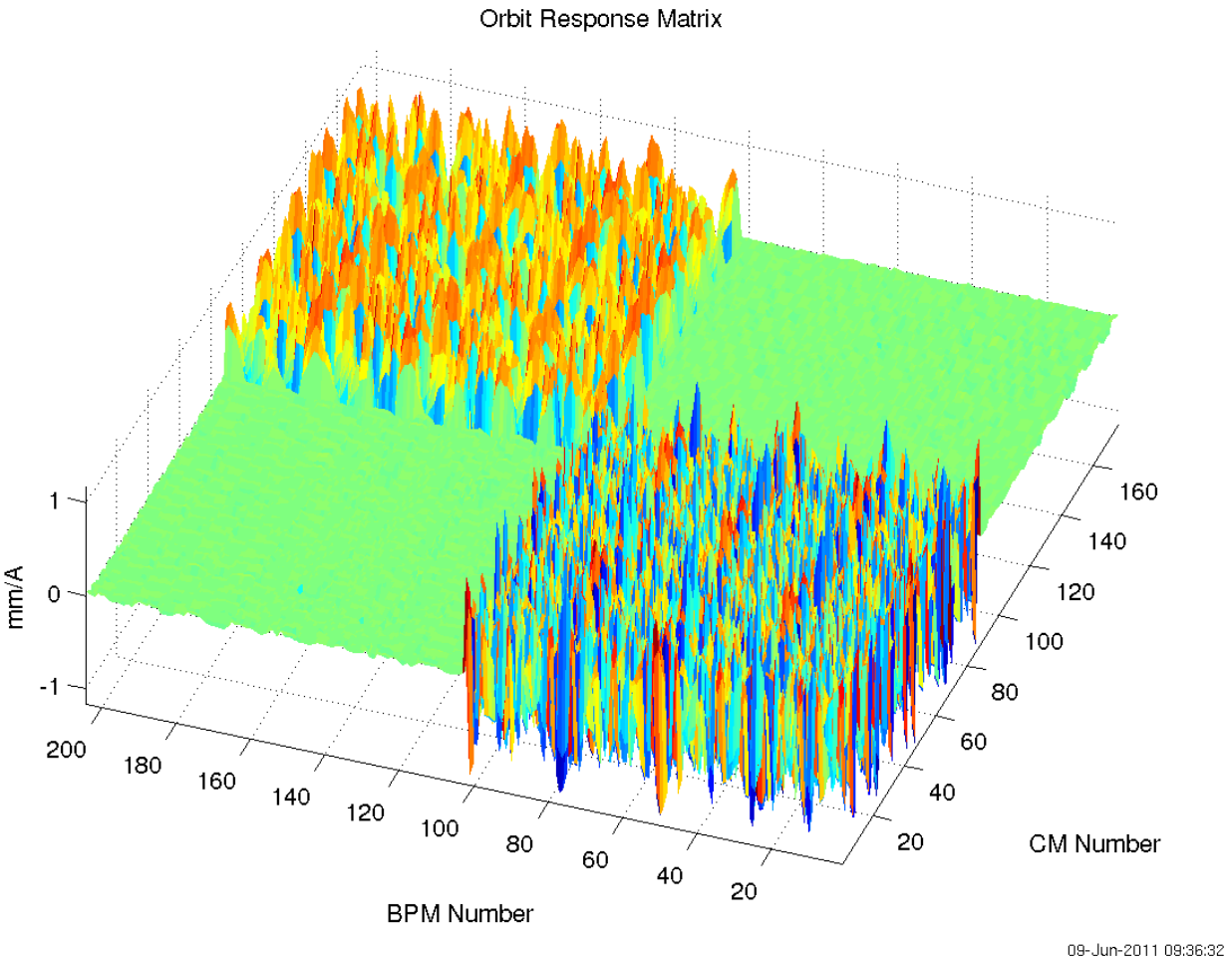
Effect of Sextupoles



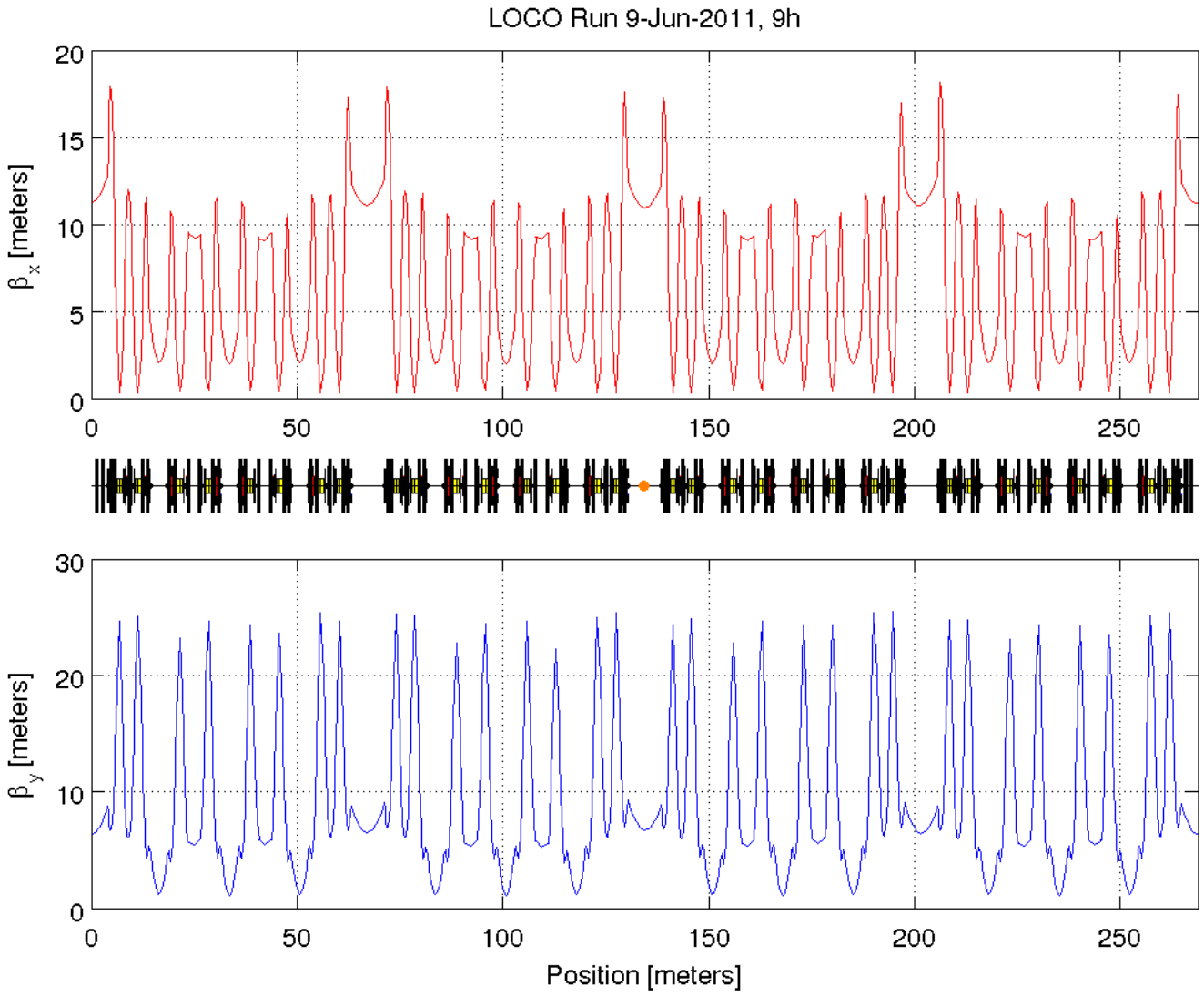


LOCO example

- Data from 9 June, last day of commissioning

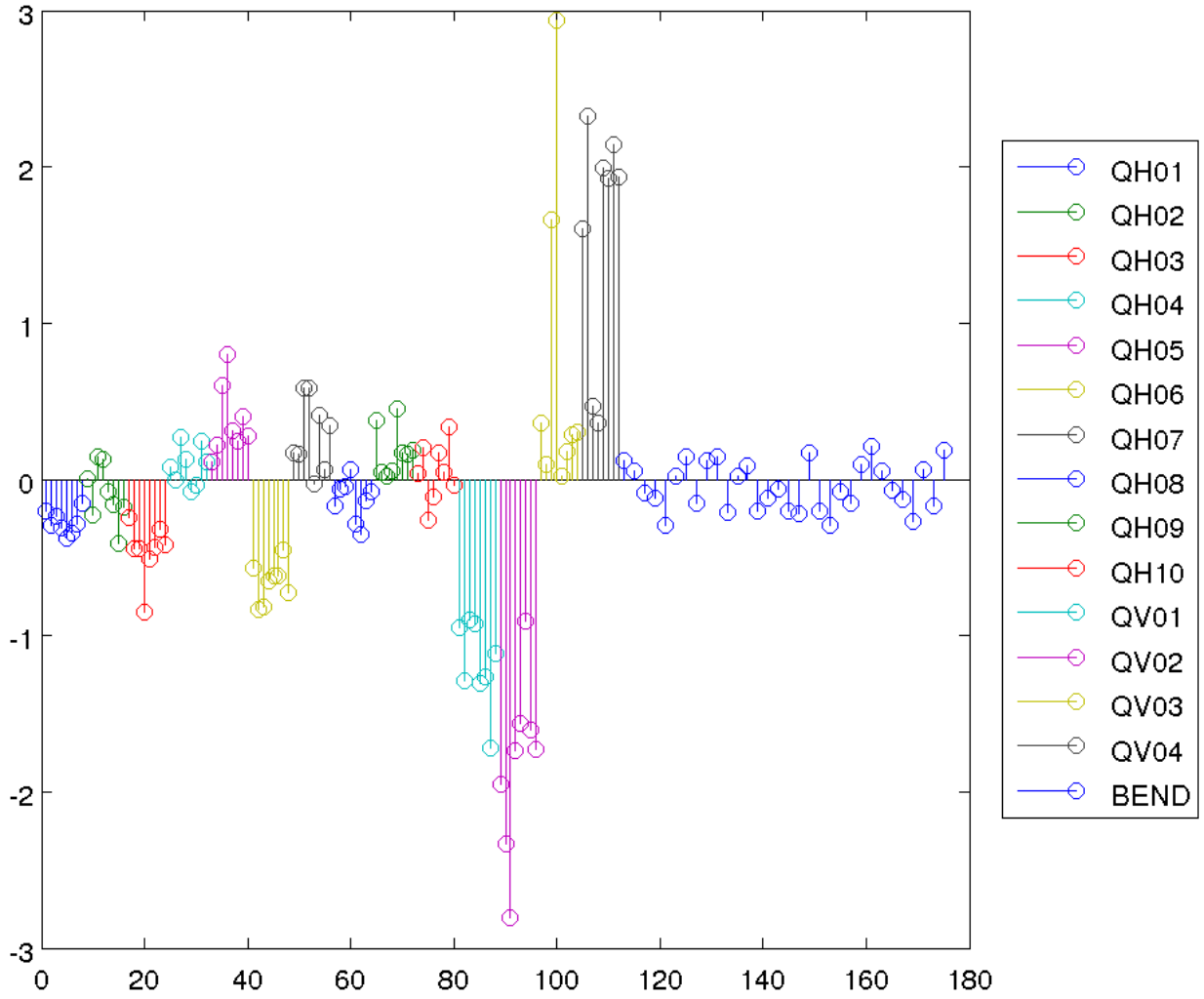


Betas reconstructed

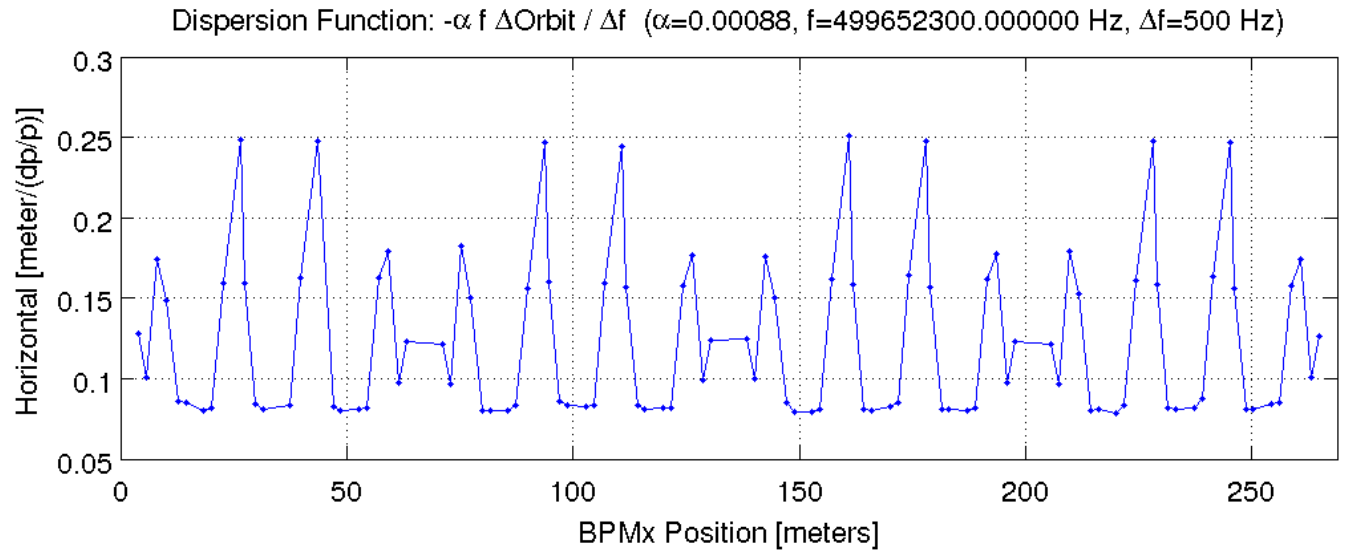


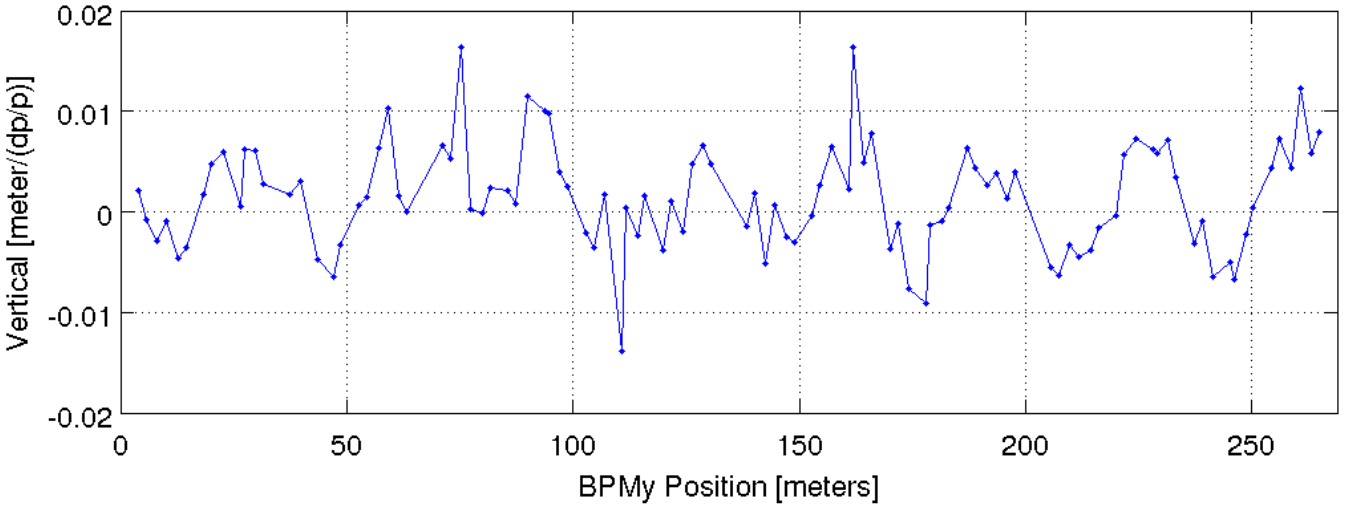
Beta beat:
±5 % peak to peak
in both planes

Gradients reconstructed



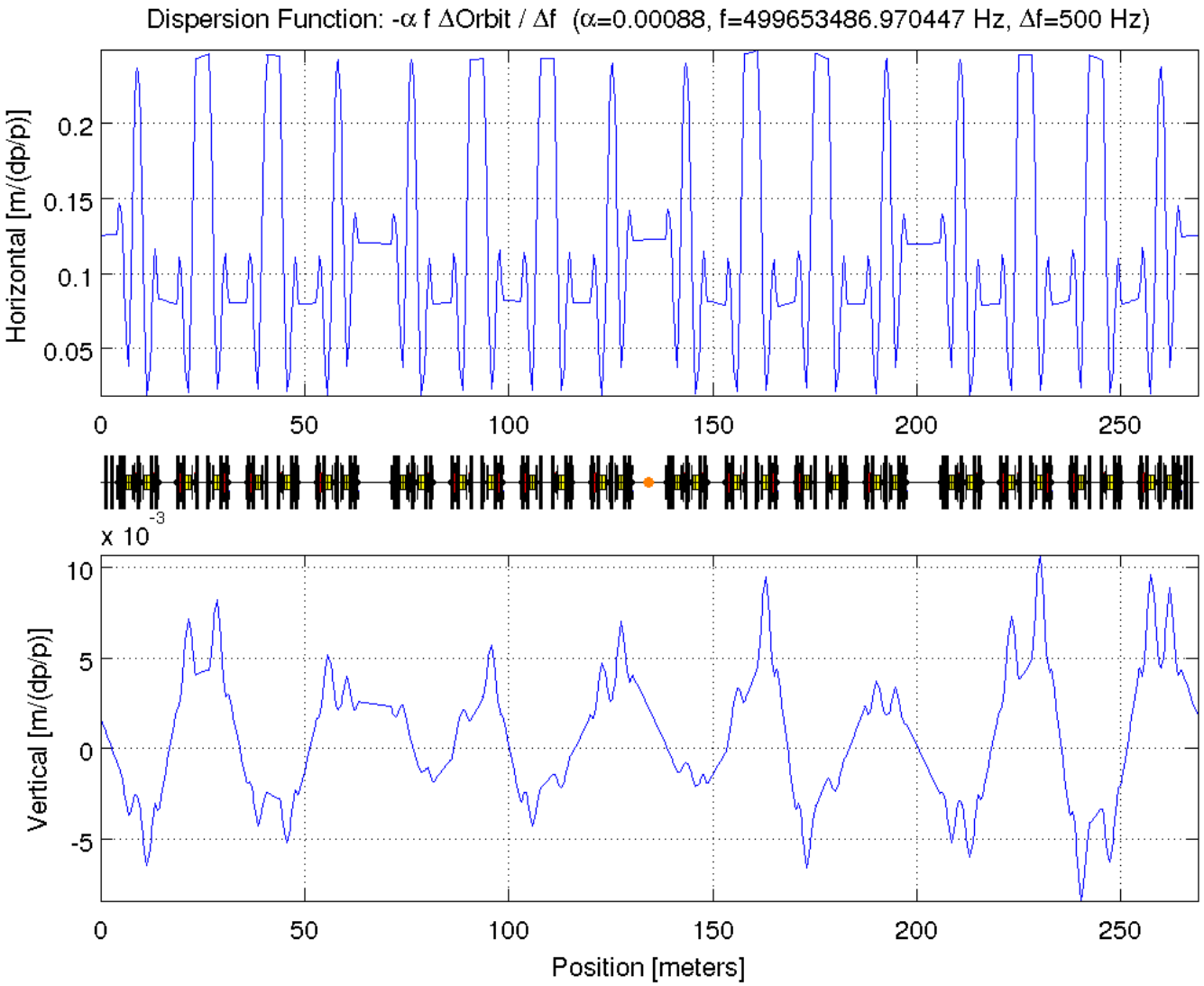
Measured Dispersion



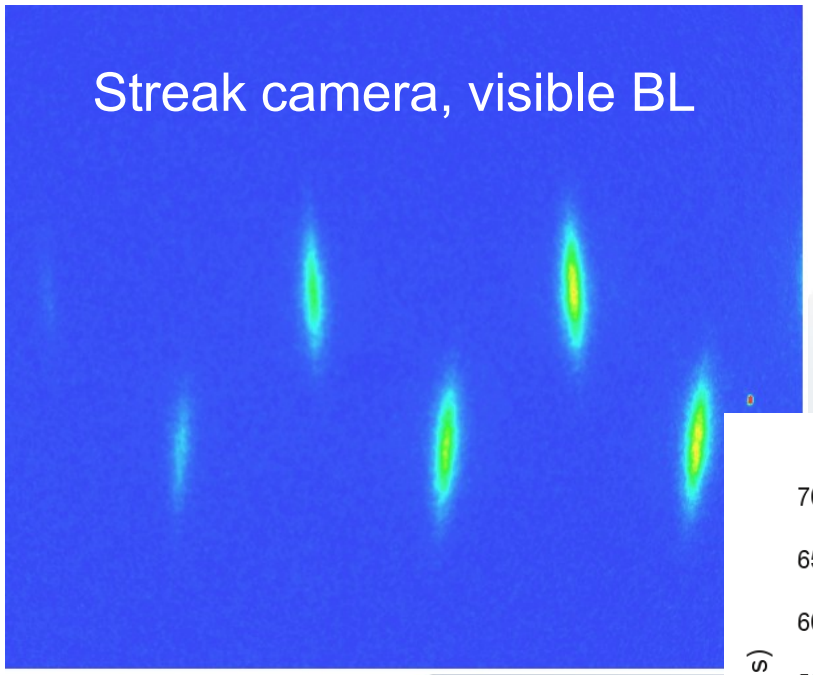


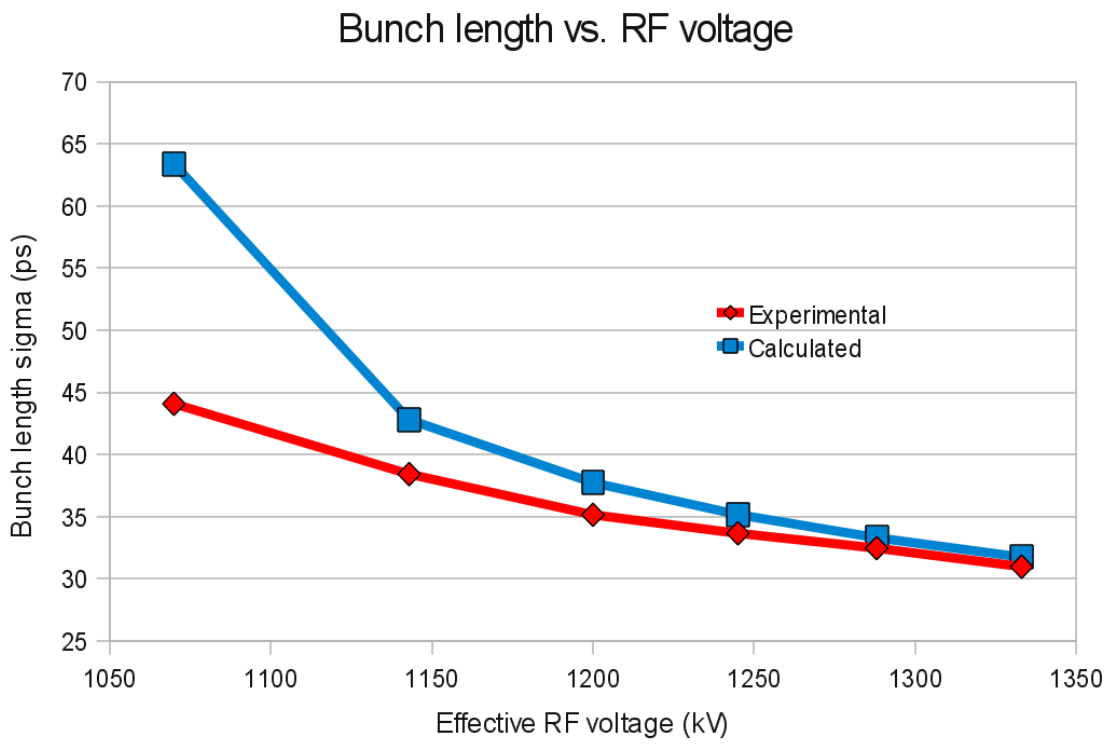
09-Jun-2011 09:35:59

Reconstructed Dispersion



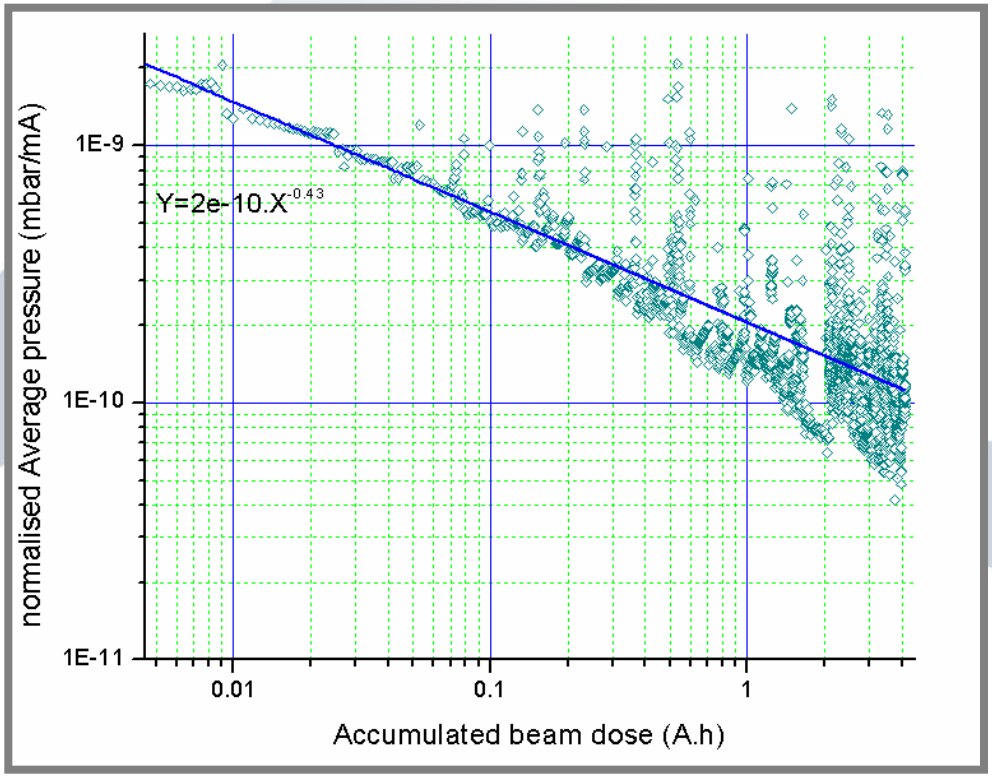
Bunch Length

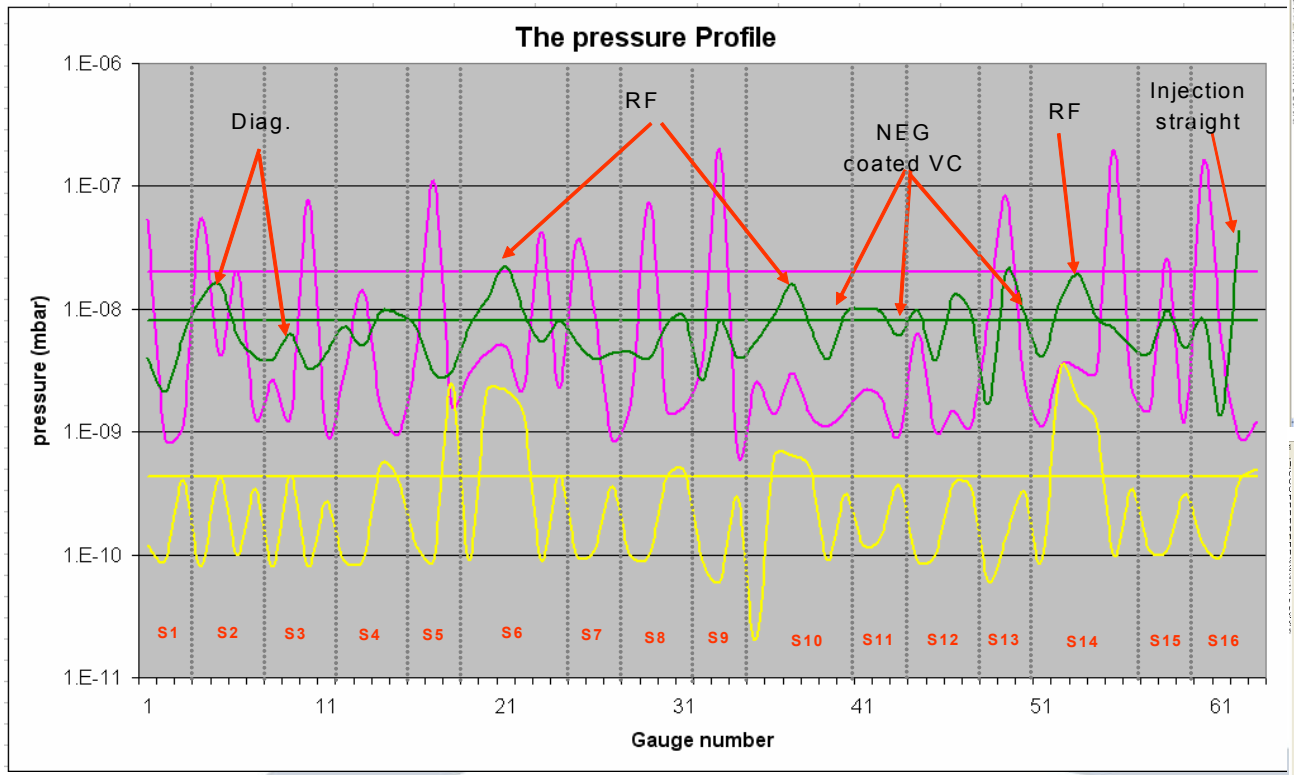


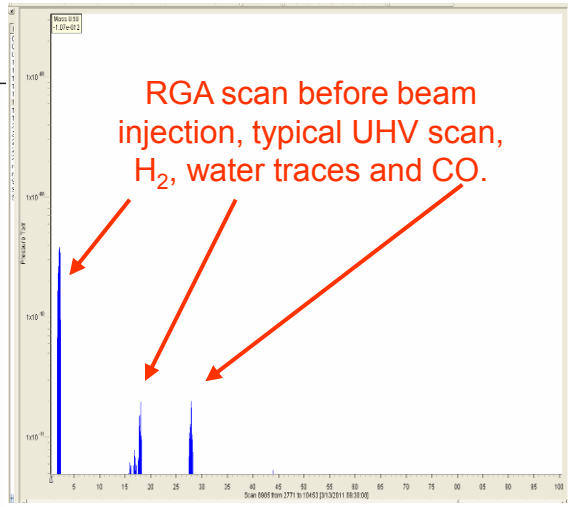


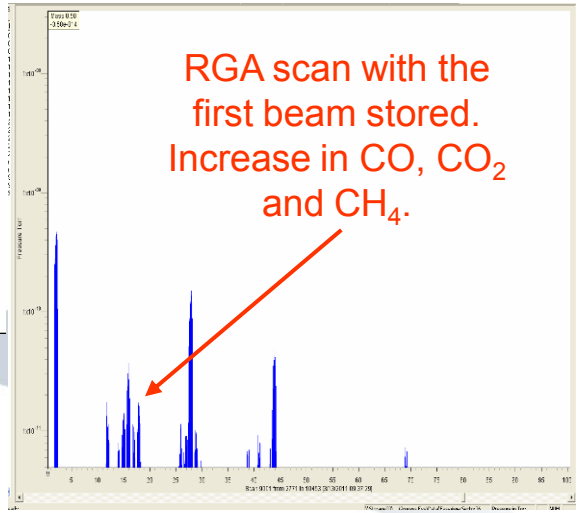
Vacuum performance

- Average pressure before injecting the first beam= 4.10^{-10} mbar
- With the first stored beam in the machine (beam current = 0.1 mA), the average pressure increased to 2.10^{-8} mbar.
- with accumulated beam dose of 4.5 A.h, 80 mA stored beam current, the average pressure of the SR is 3.10^{-9} mbar.









Yellow= base pressure.
Cyan= First stored beam
Green= first stored 100 mA.

Effect of IDs

Three insertion devices have been installed and closed:

- EU62
- EU71
- MPW80

Without much influence in the machine:

MPW80 - BL22	Gap (mm)	tunes	RMS Orbit Distortion (um)	tunes change (10^-3)
OPEN	275	0.229, 0.375	0 , 0	---
1/2 CLOSED	50		11 , 57	
CLOSED	12.7	0.229 , 0.377	13 , 9	0 , 2
OPEN	275	0.229 , 0.376	14 , 14	0 , 1

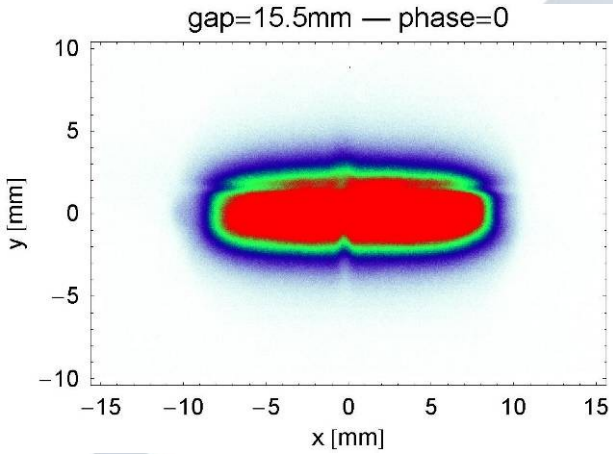
EU71 - BL29	Gap (mm)	Phase (um)	tunes	RMS Orbit (um)	tunes change (10^-3)
OPEN	273	0	0.229, 0.376	0 , 0	---
HORIZONTAL (0)	15.5	0	0.230, 0.376	15, 14	+1 , 0
CIRCULAR (pi/2)	15.5	21181	0.228, 0.377	15, 14	-1, +1
VERTICAL (pi)	15.5	35650	0.228, 0.377	16, 15	-1, +1
CIRCULAR (-pi/2)	15.5	-21181	0.228, 0.377	15 , 15	-1, +1
VERTICAL (-pi)	15.5	-35650	0.228, 0.377	16 , 15	-1 , +1
OPEN	273	0	0.229, 0.376	15 , 16	0 , 0

Light from one ID

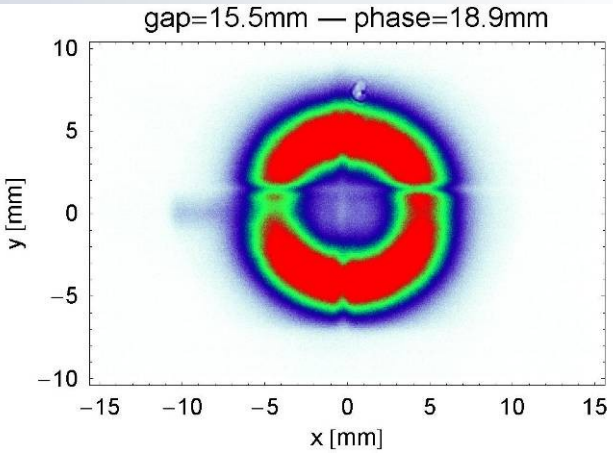
- Screen @ 9.35m from source (middle of straight section)
- Source → APPLEII undulator EU62
- Stored current I=0.8mA

Minimum gap (15.5mm):

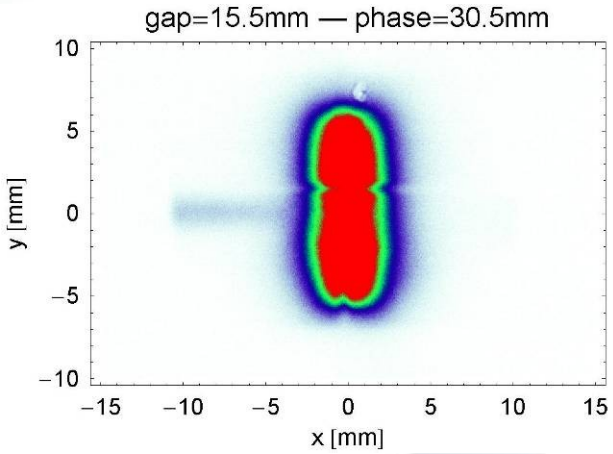
Horizontal mode (K=5.2)



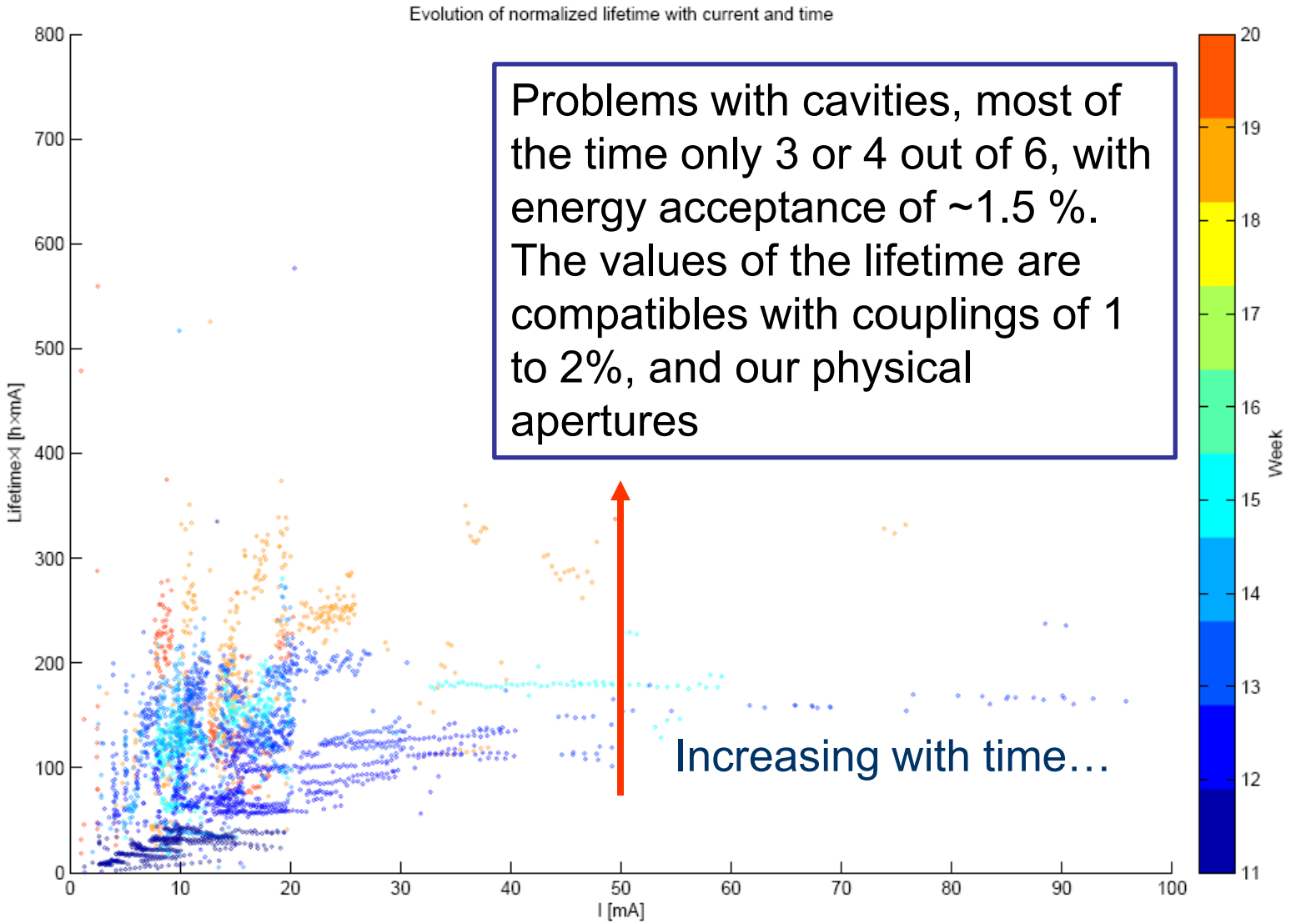
Circular mode (K=3.0)



Vertical mode (K=3.7)



Lifetime

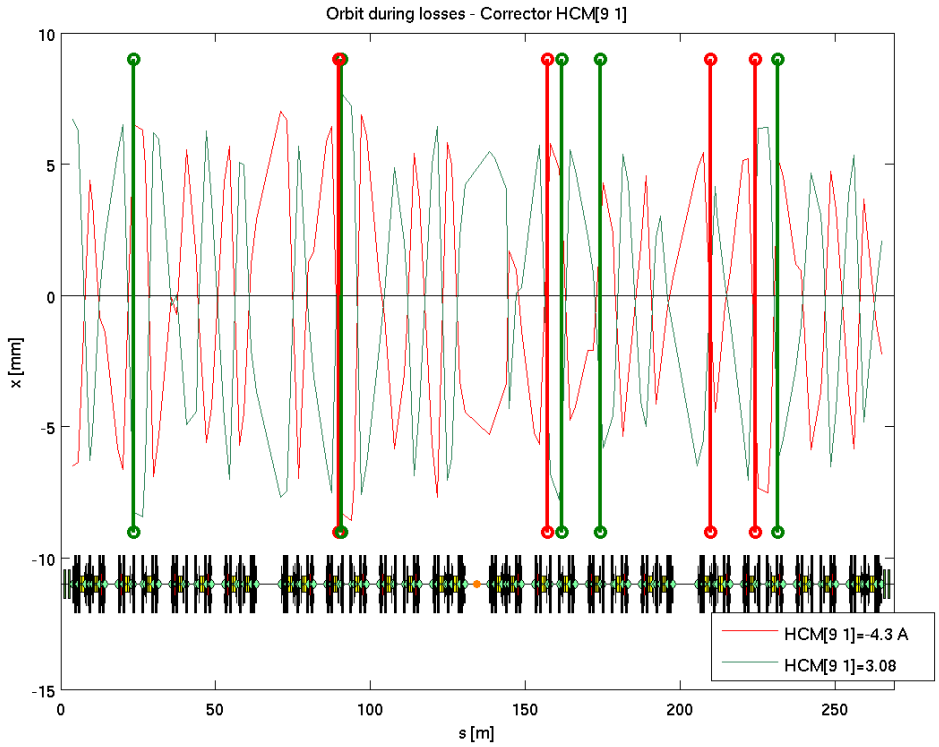


Problems with cavities, most of the time only 3 or 4 out of 6, with energy acceptance of ~1.5 %. The values of the lifetime are compatibles with couplings of 1 to 2%, and our physical apertures

Increasing with time…

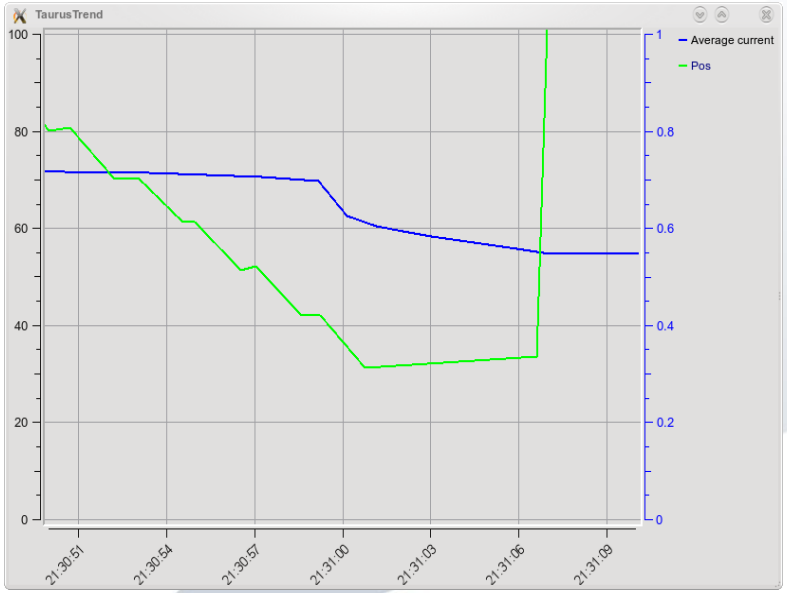
Apertures

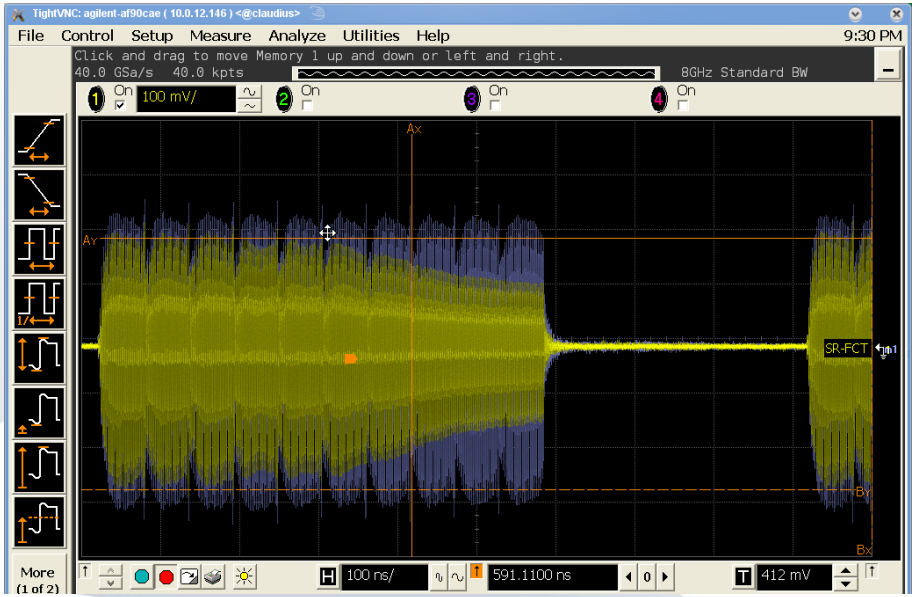
- Bumps and apertures scans performed.
- No obstacle detected.
- Physical aperture close to the theoretical one.



Vertical Instabilities

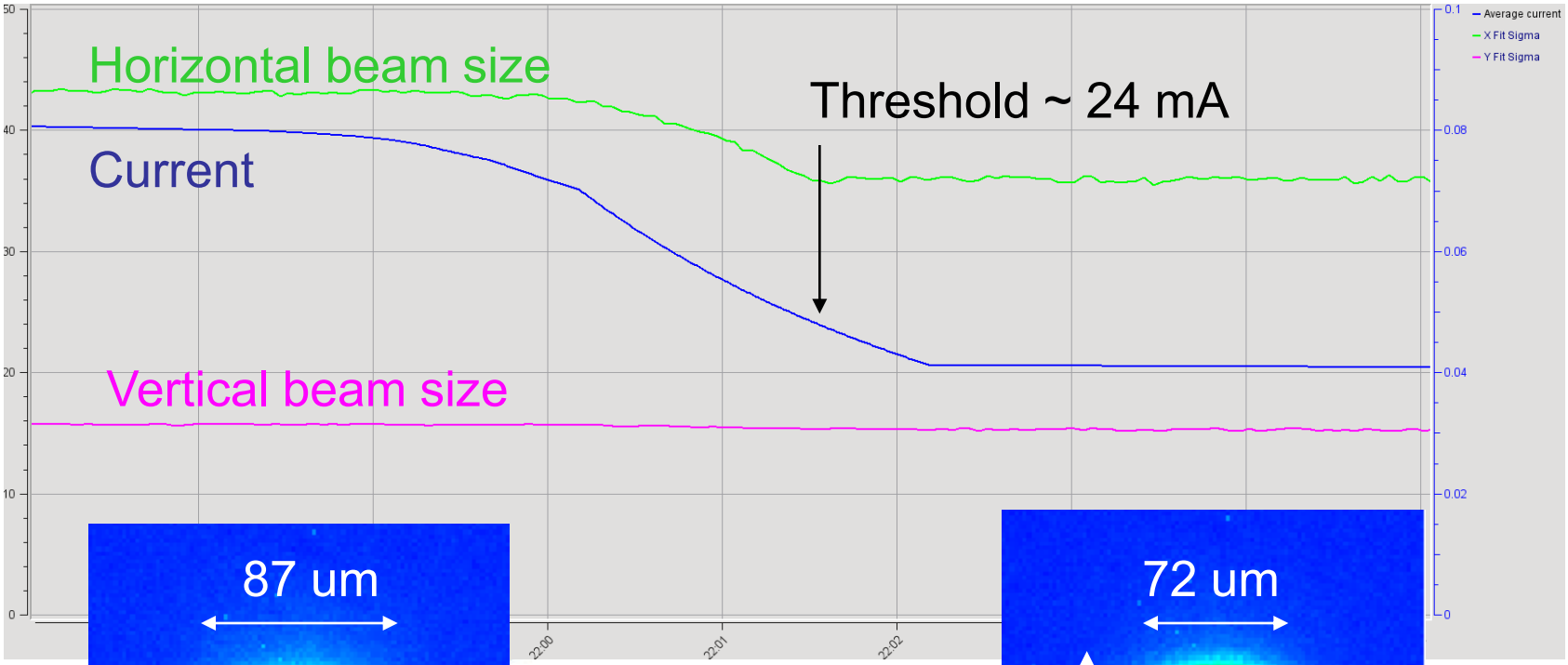
SCRV closed from 10mm to 0.25mm produces beam losses (~20mA) only in the last bunches of the train

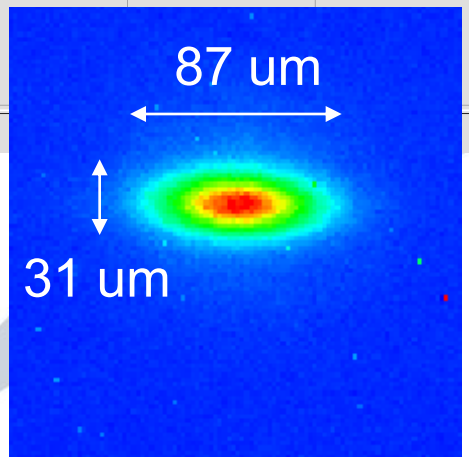




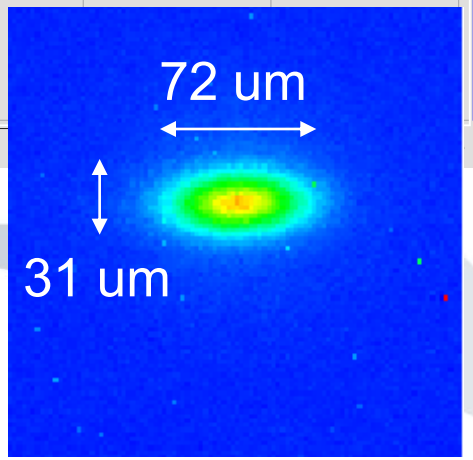
Fast Ions (?)

Horizontal Instabilities

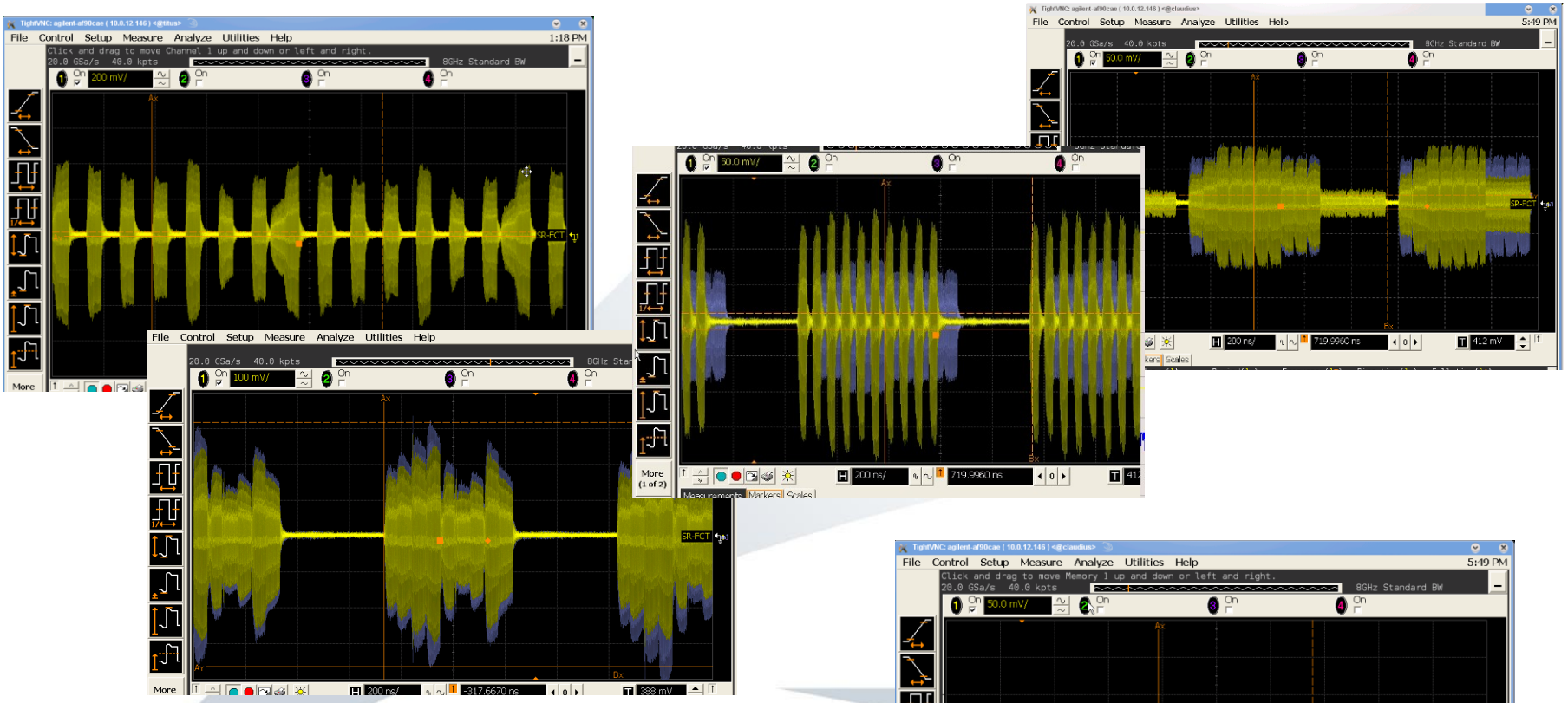




(?)

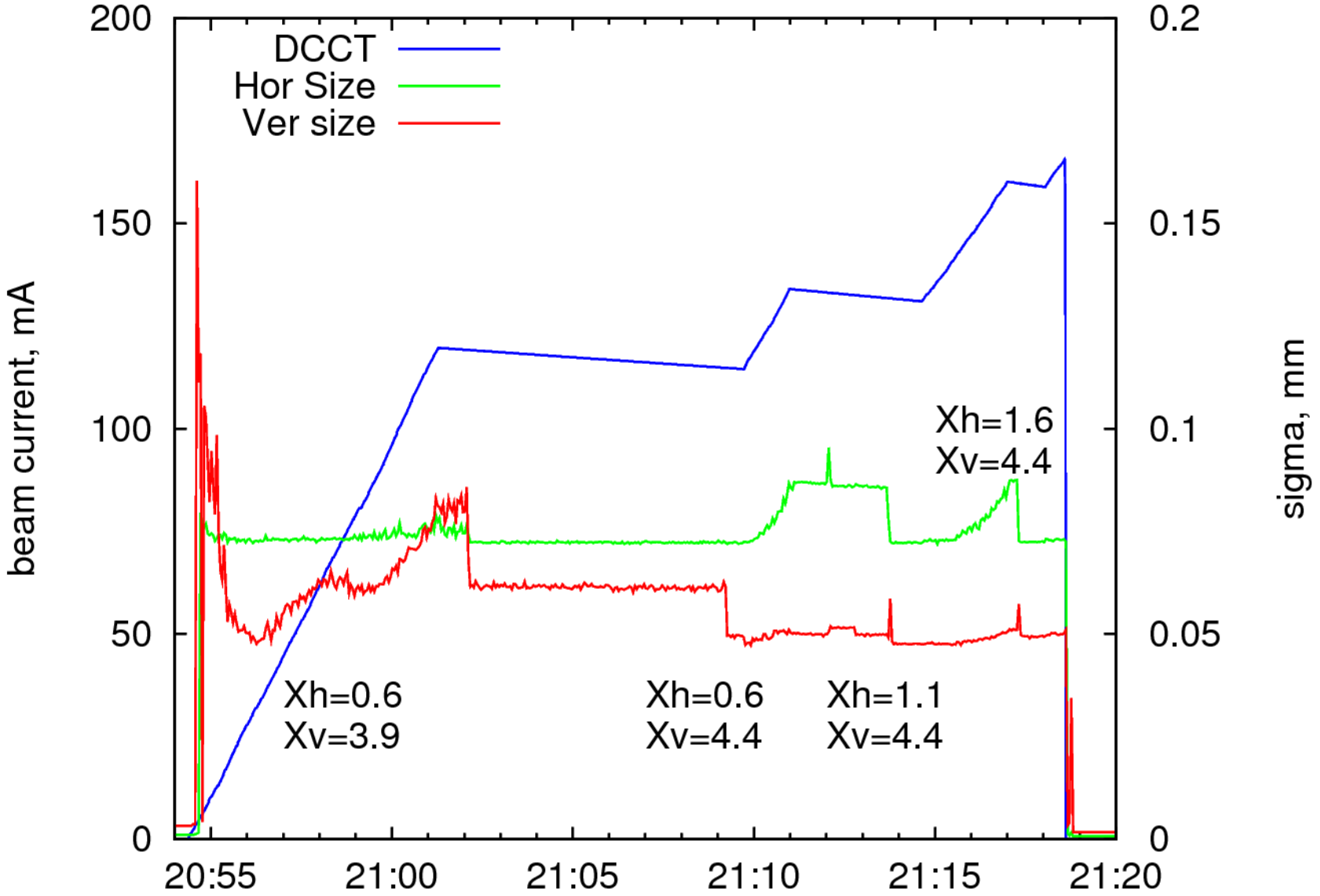


Filling pattern(s)



Needs improvements ☺

How we reach 170 mA



Problems

- RF problems
  LLRF deregulation, water leaks, vacuum leaks, trips ...
- Vacuum problems
  Water configuration, chamber overheating, leaks …
- Diagnostics problems
  Streak camera, Libera electronics, stack FS …
- PS problems
  Wrong cabling, correctors and quadrupoles PS …
  PS from booster are delicate
- Control system problems
  Applications froze, motors, CCD camera, cycling, MPS, PSS, timing …

RF problem

Problems with the ceramics dome of the cavity's pick up loops

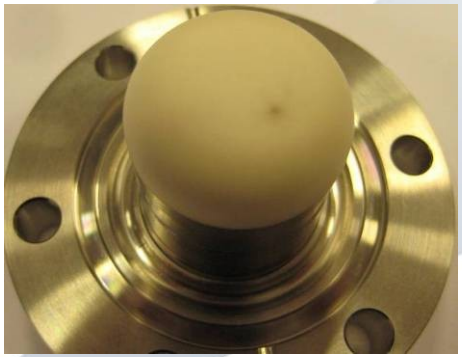
Dampy 00 one leak during conditiong at the RF lab

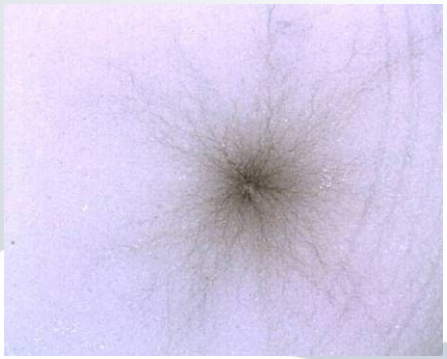
Dampy 06 one leak after bake out at Alba

Dampy 04 one leak during conditioning at Alba

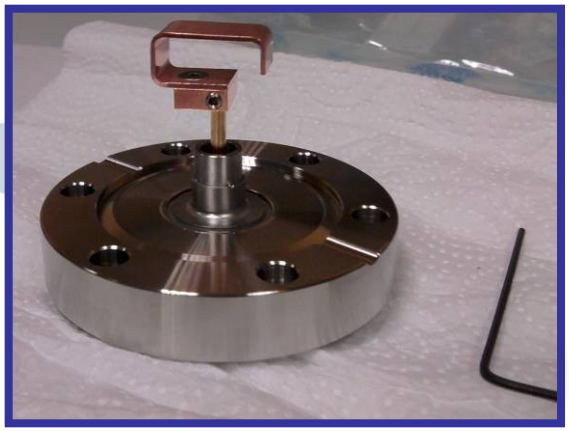
} No visible leak

Dampy 03 two leaks due to sparks during conditioning at Alba and one during commissioning





➢ Prototype of new pick-up loop:
(without ceramic dome)



In summary:

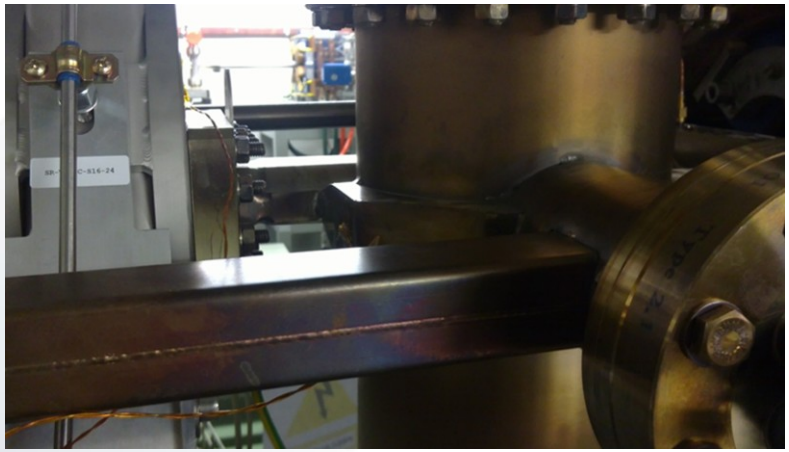
- Water leak → S14B out of order
- Vacuum leak → S10A out of order
- LLRF deregulation → S10B out of order

Most of the commissioning have been done with only three cavities

1350 MV → q = 1.3

Vacuum problem

Synchrotron radiation hitting the vacuum chamber



After placing a thermocouple at the location:

- With 20 mA we reached 80 degrees
- We estimated the chamber heat up to few hundreds of degrees when injecting 100 mA.

- Solved by adding a copper insert in the crotch absorber

Next steps

- Installation IDs
- Slow orbit feedback
- Vacuum cleaning
- Better control filling pattern

Next commissionigng period Sept. 2011

- Fast orbit feedback
- Multibunch feedback

Along 2012

- Machine upgrades:
  - 3rd harmonic cavity
  - Slicing
  - New IDs
  - Skew quads

????

THANK YOU