



# ALBA Storage Ring Commissioning

Angel Olmos  
(on behalf of ALBA commissioning team)



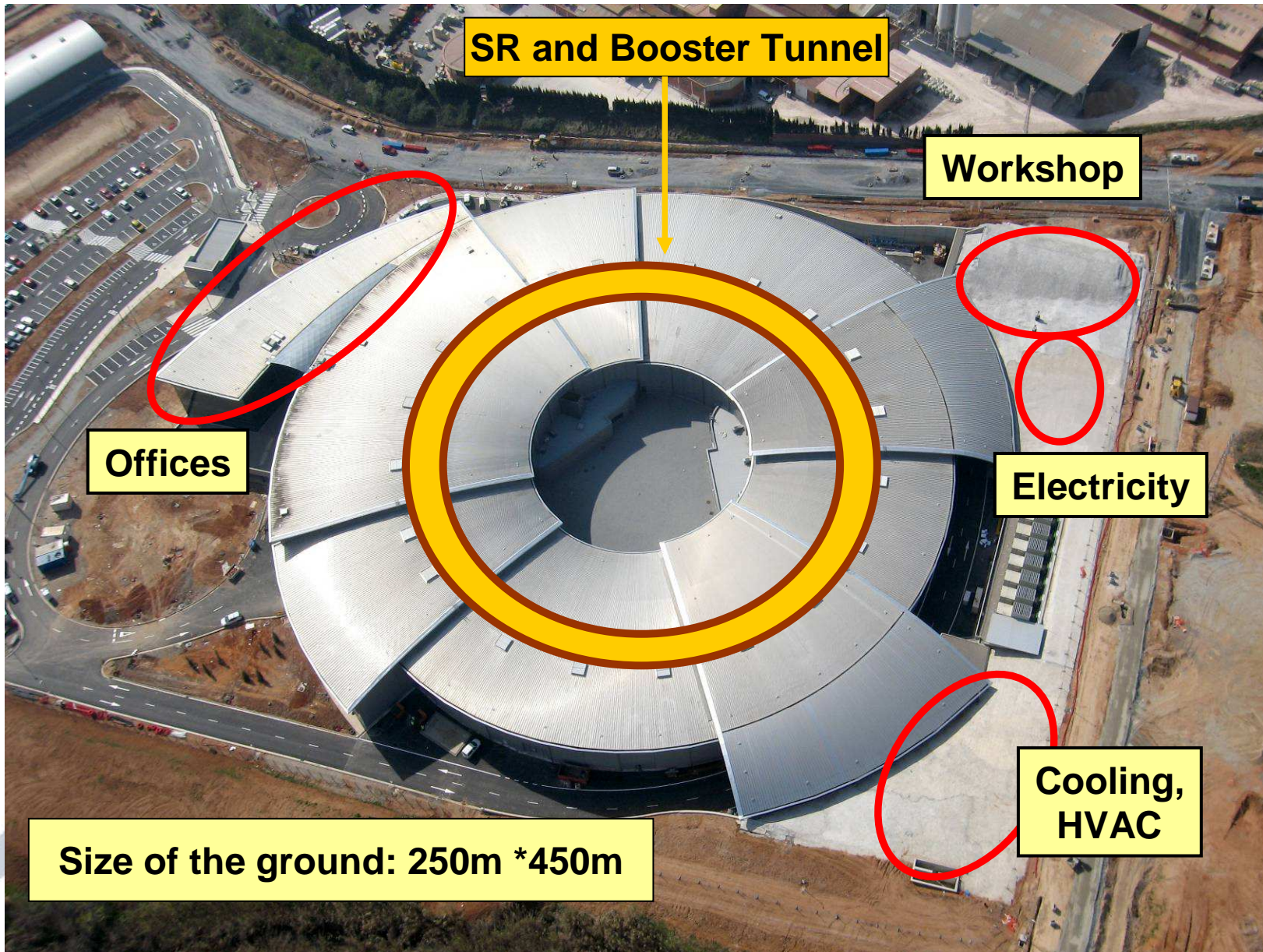
## Content

- 1.) The ALBA project
- 2.) Booster Commissioning
- 3.) SR Commissioning
  - 3a.) Evolution
  - 3b.) Measurements
  - 3c.) Playing with BPMs
- 4.) Machine Protection System
- 5.) Problems with Liberas
- 6.) FOFB system status

## Schedule (on 2010)

ALBA founded	April 03		
ALBA 1st worker	Dec 03		
...			
Start main building works	July 06		
Start Linac installation	Feb 08		
<b>Linac commissioning</b>	<b>Sept - Oct 08</b>		
Booster and SR installation	Feb 09 – Dec 09		
<b>Booster commissioning</b>	<b>Jan 10</b>		
SR Installation	Feb – June 10		
Storage Ring commis.	Sept – Nov 10	→	Mar – Oct 11
Beamlines commis.	Nov 10 – Feb 11	→	Oct - Dec 11
<b>Start of Users Operation</b>	<b>~ May 2011</b>	→	<b>~ Beginning 2012</b>

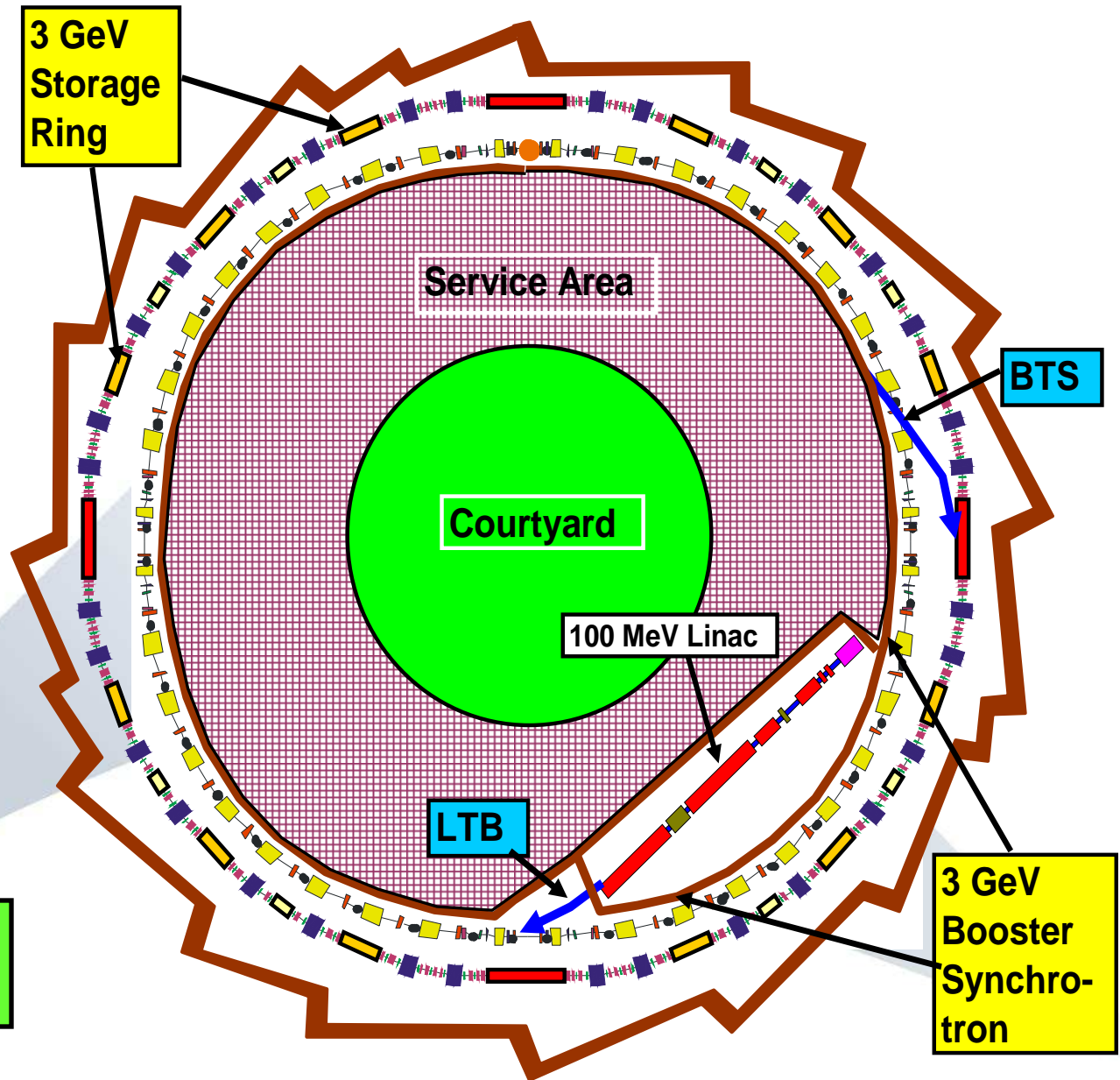
# ALBA Site



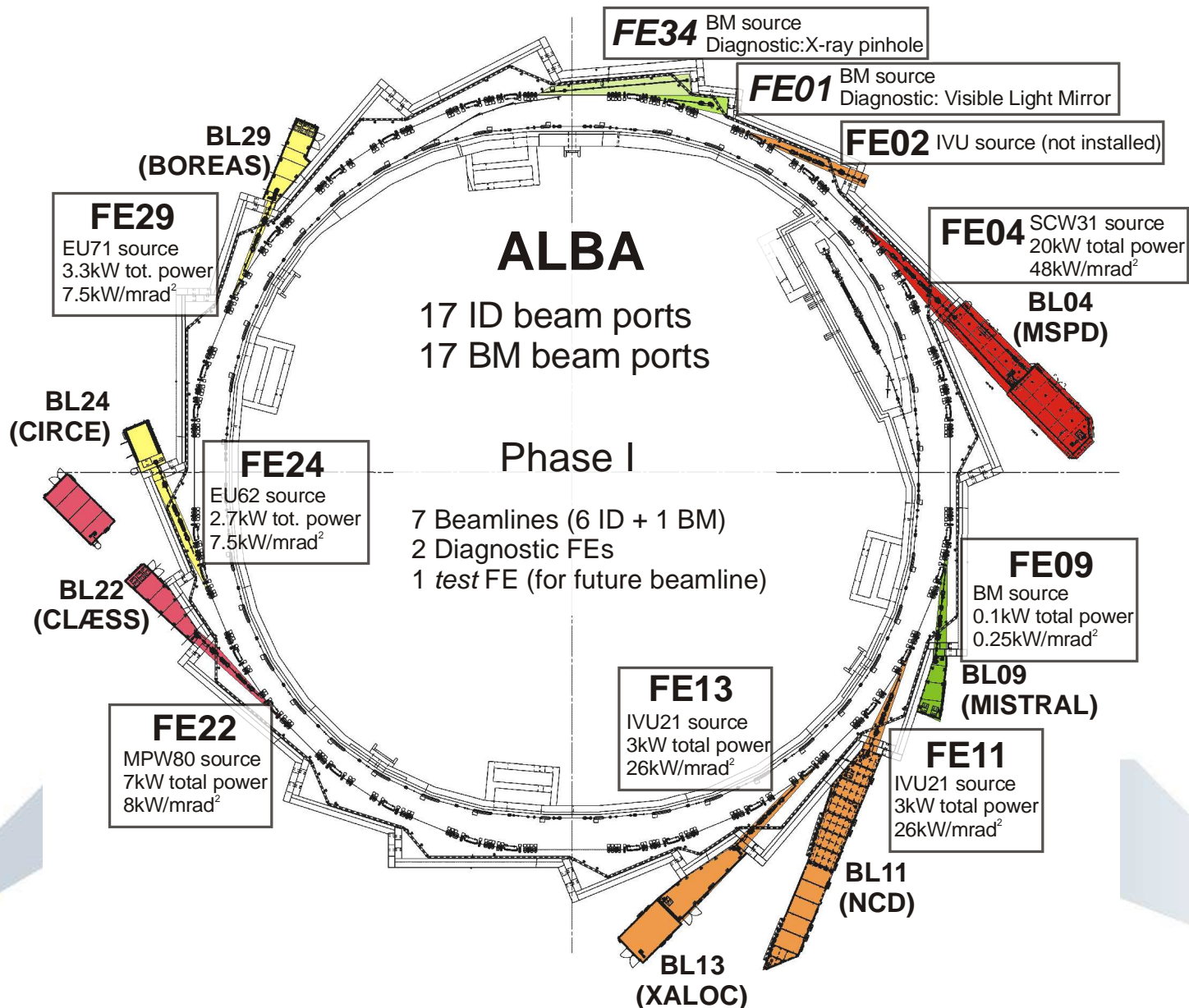
# Accelerators Complex

**Accelerator complex of ALBA:**  
Followed the concept of the SLS to have the booster and the storage ring in the same tunnel

**Storage Ring 268,8m**  
**Booster 249,6m**



# IDs, Front Ends and Beam Lines



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# Booster Commissioning Phases



**- 22.12.2009, 3:00 first beam into the booster**

**- Phase I: 10<sup>th</sup> to 24<sup>th</sup> of January 2010**  
**Cross check all the sub-systems**

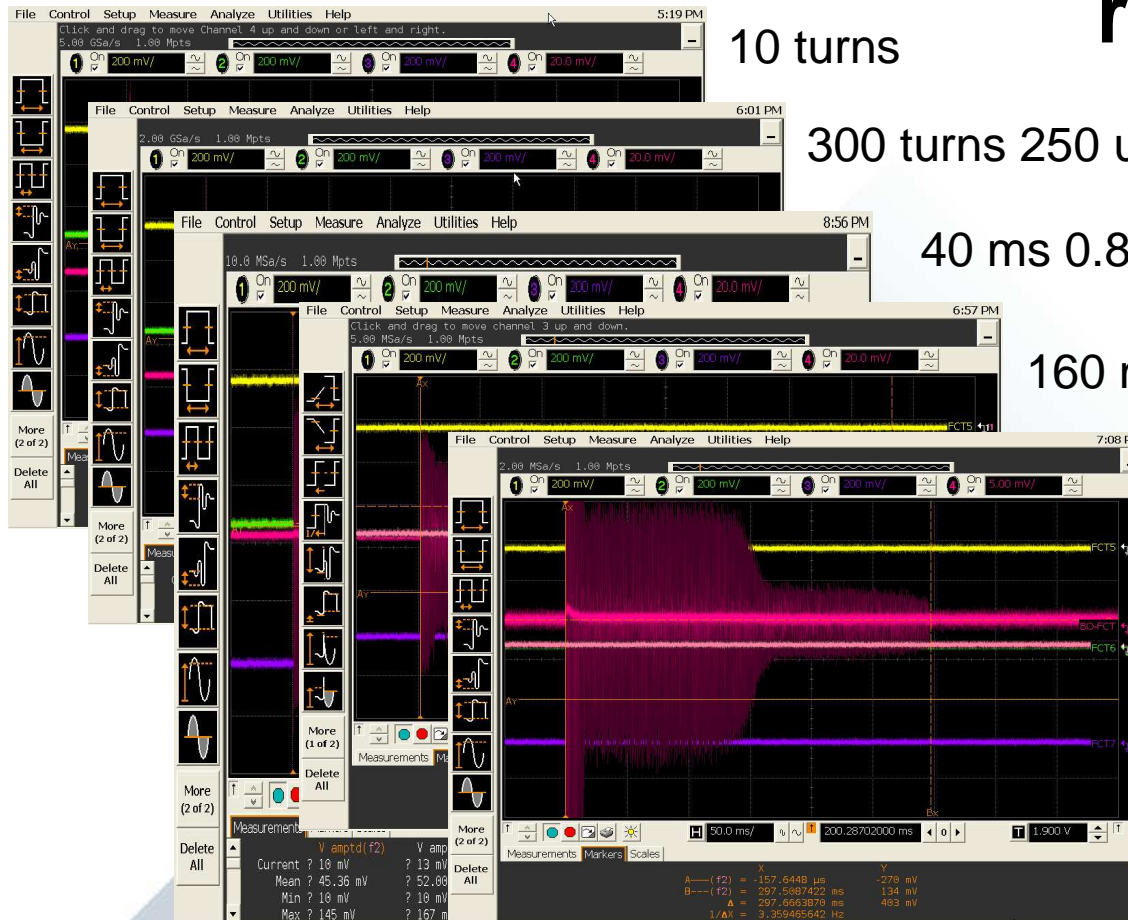
**- Phase II: July 2010**  
**Problems with power supplies**  
**No success and no progress**

**- Phase III: September - October 2010**  
**Tunnel opened in the morning for storage ring**  
**installation and closed in the afternoon for booster**  
**commissioning**



## Results of BO in ramping mode

4 Oct. 2010



10 turns

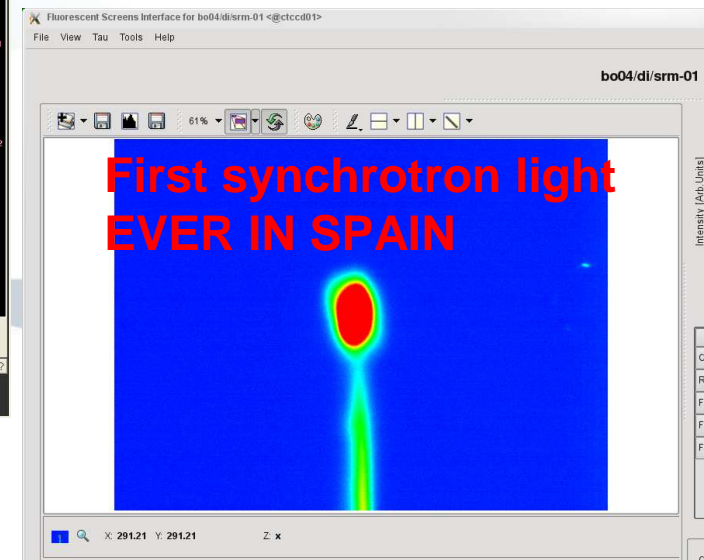
300 turns 250 us

40 ms 0.8 GeV

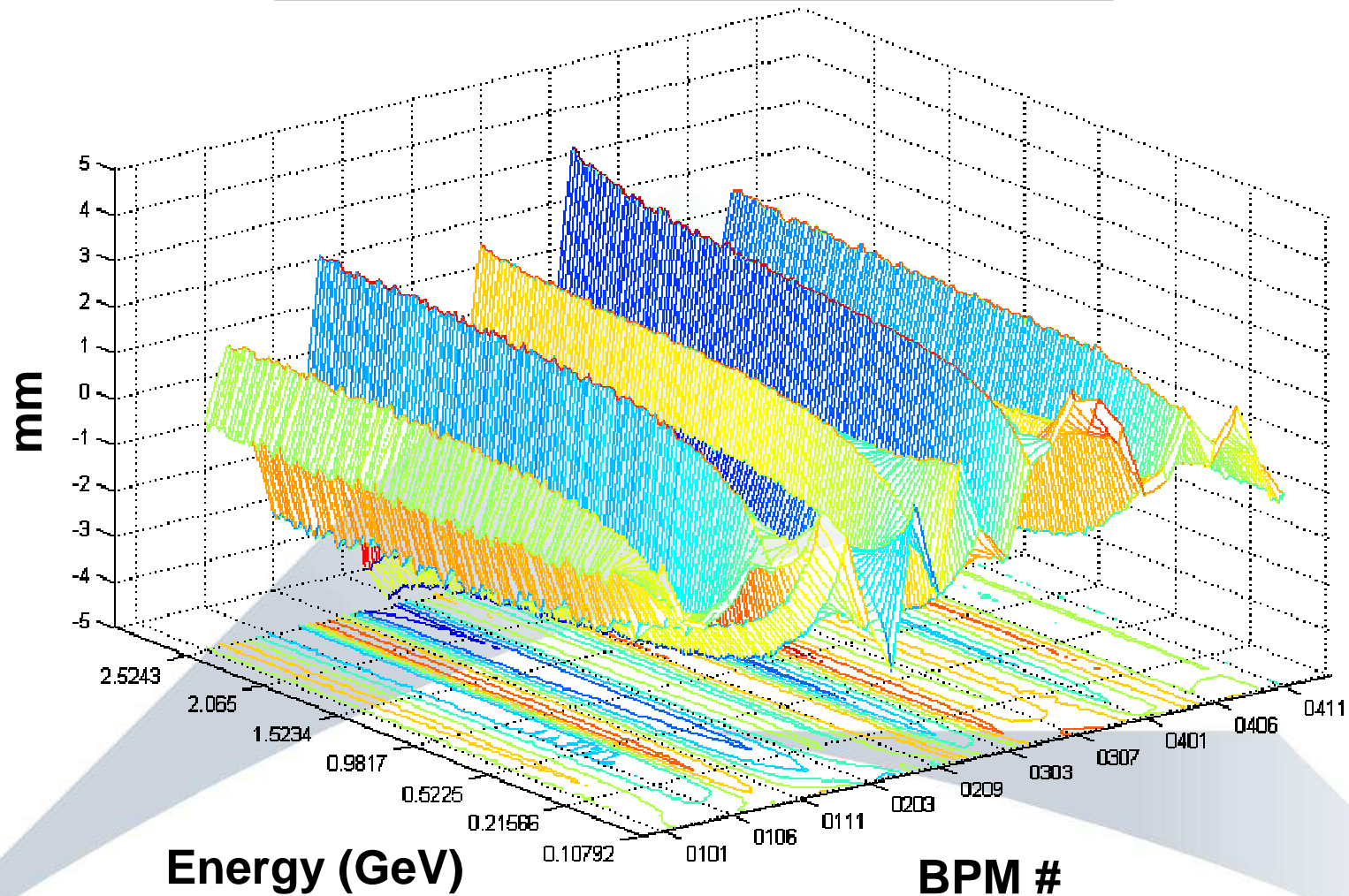
160 ms 3 GeV

297 ms back to 100 MeV

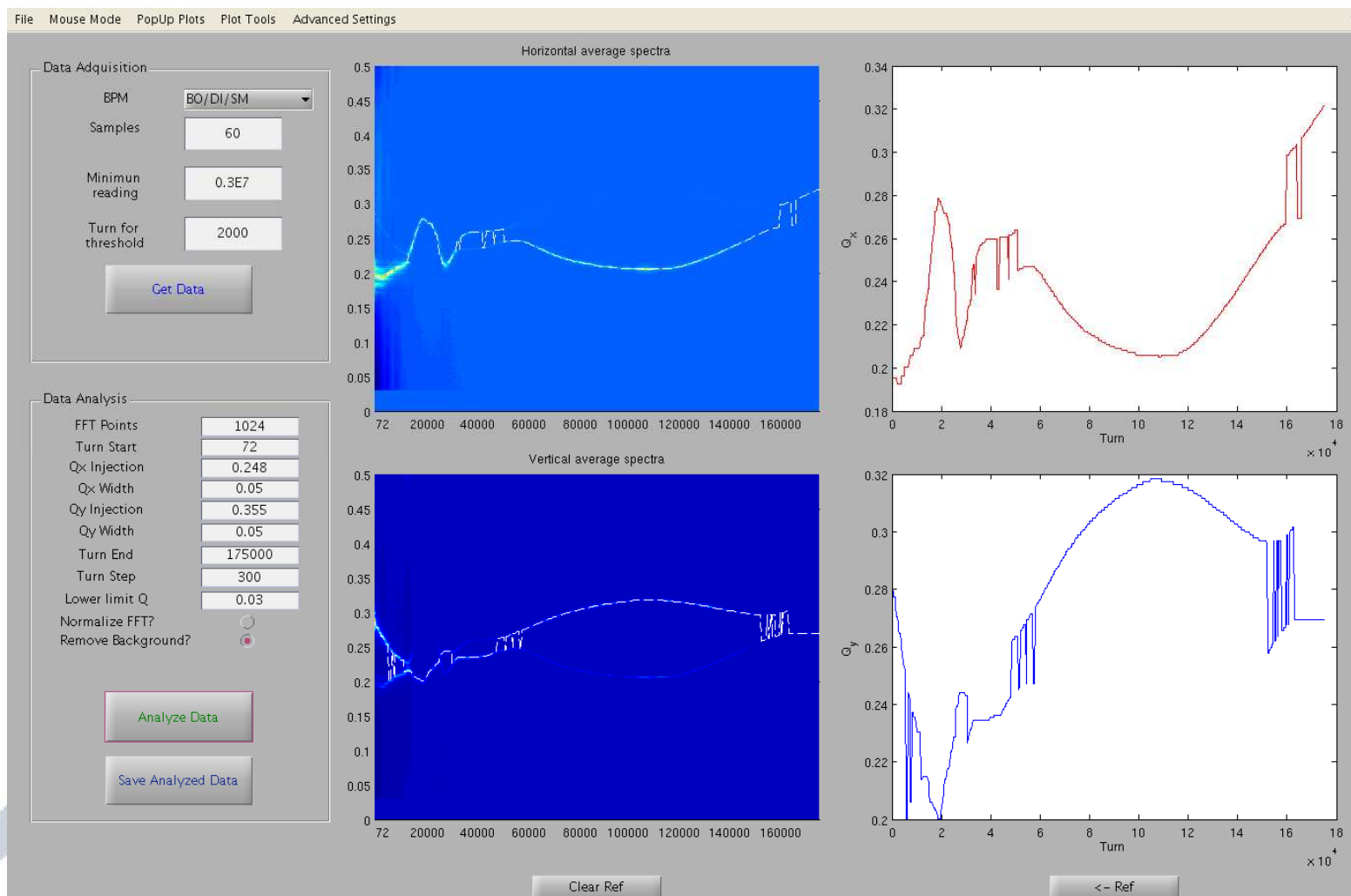
First beam accelerated to 3 GeV and decelerated to 100 MeV



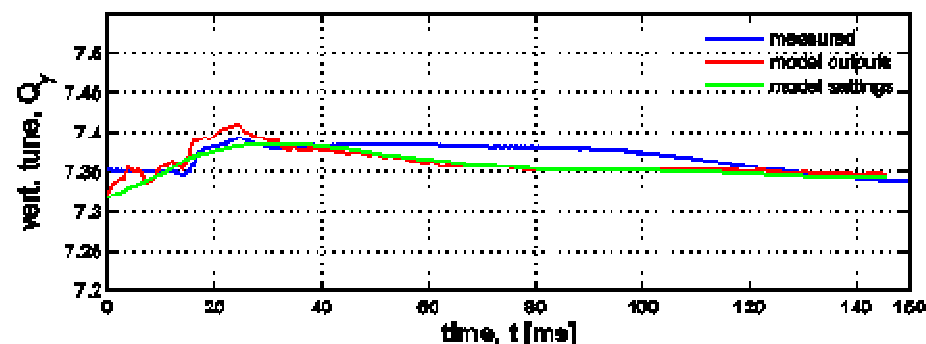
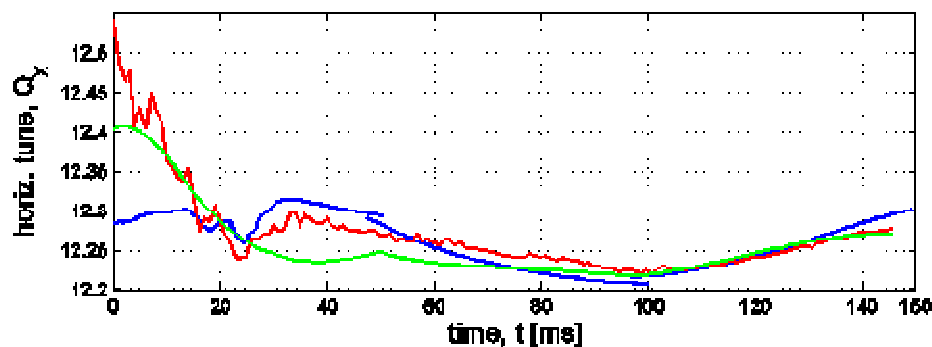
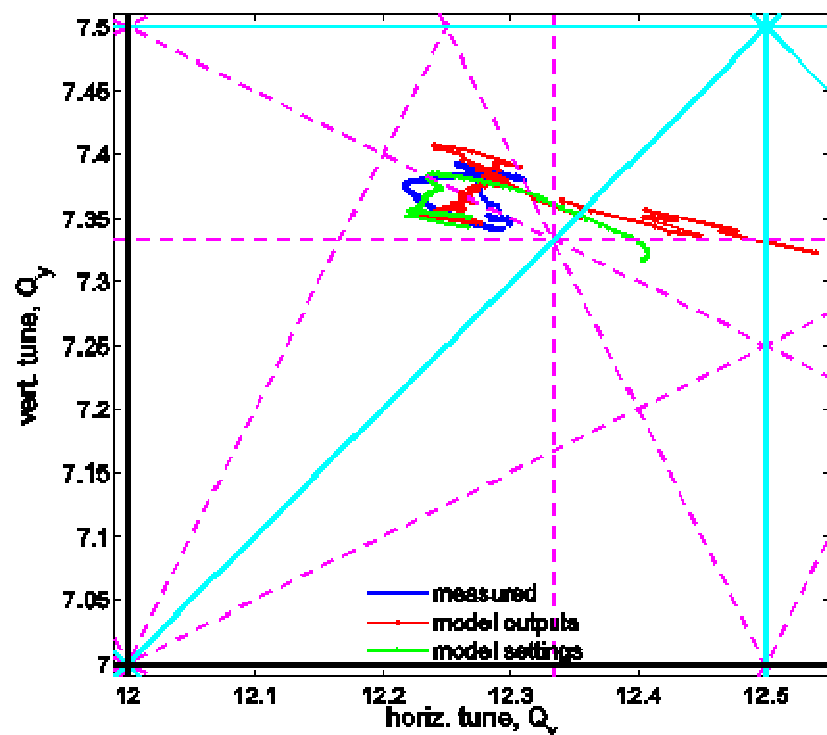
## Vertical orbit change vs. Energy



## Tunes measurement during the Ramping

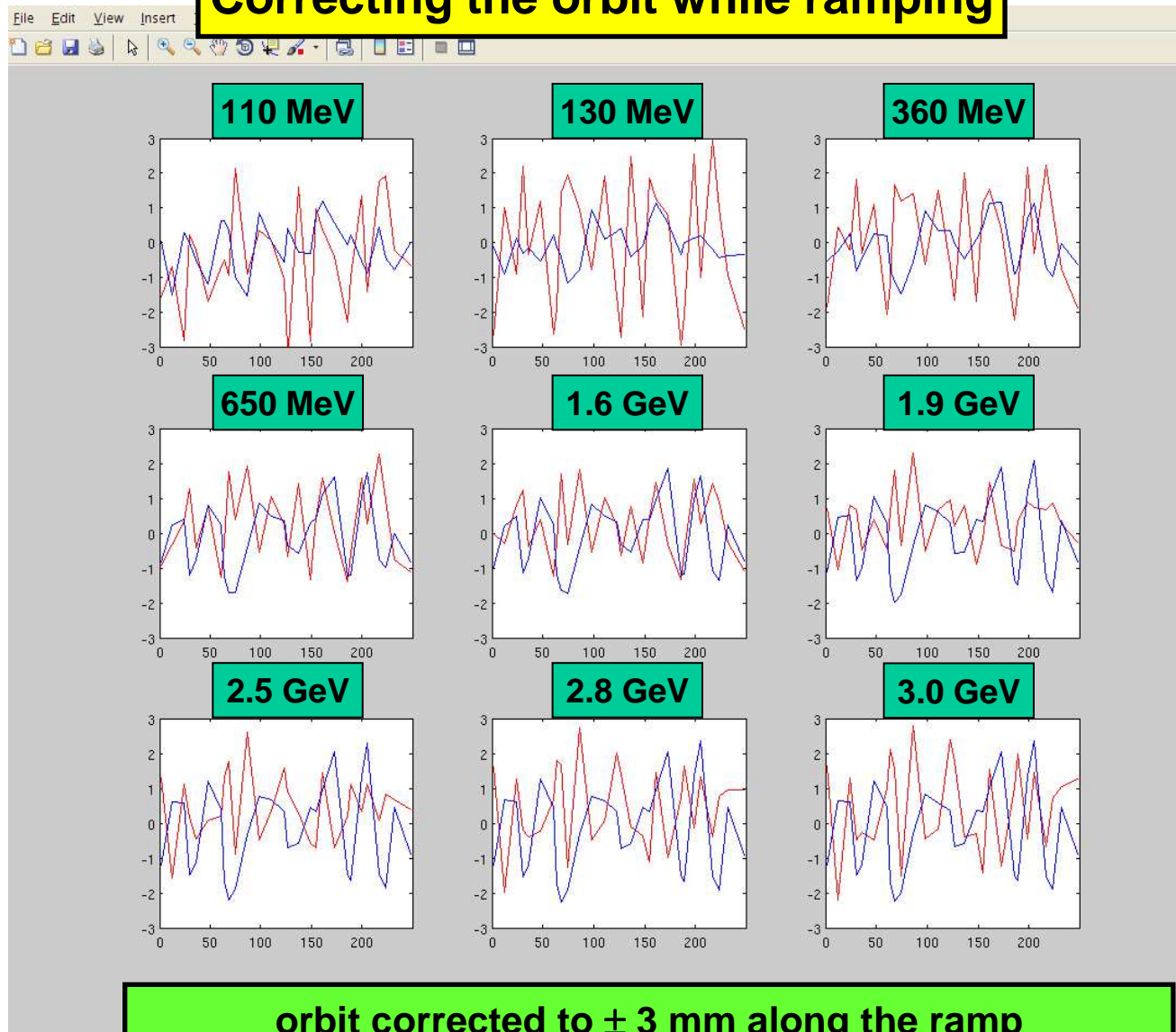


## Tunes measurement during the Ramping

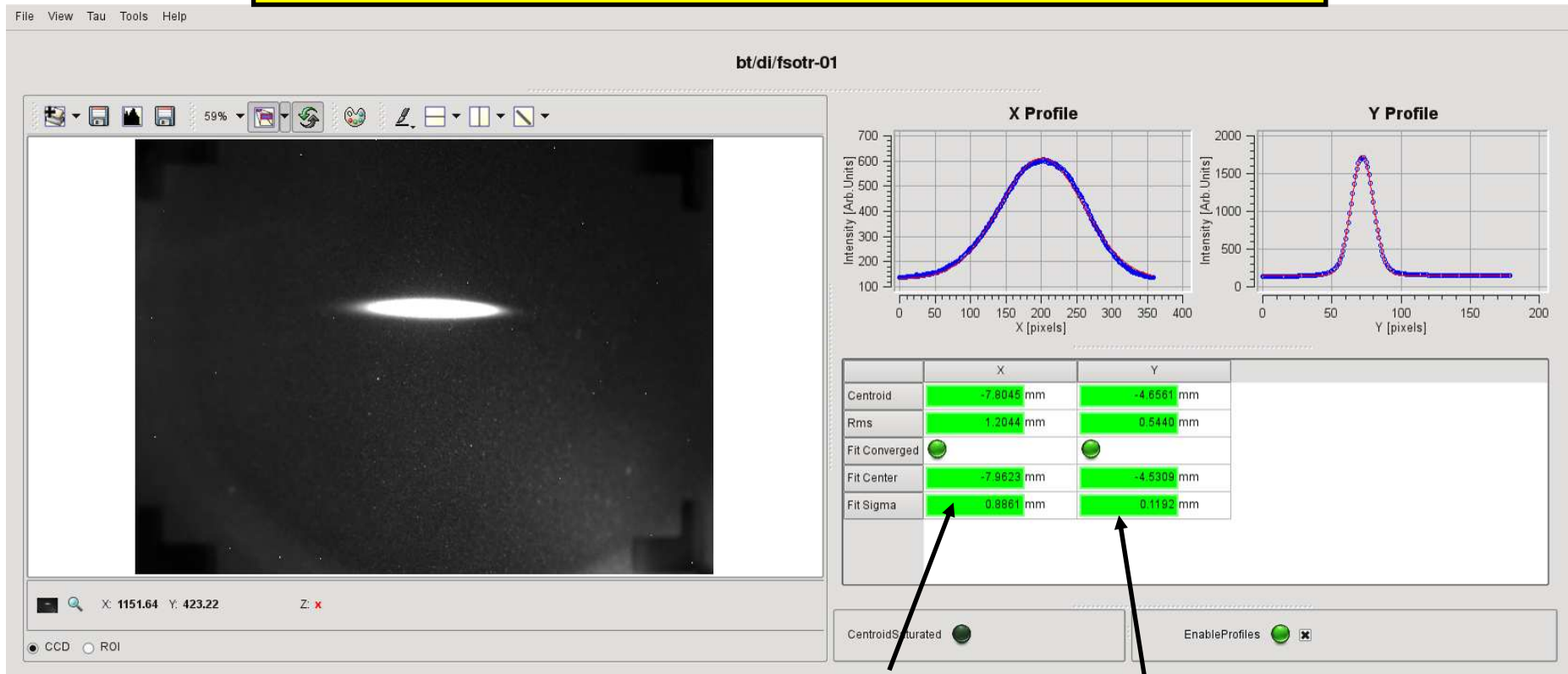


- First beam to 3 GeV: injection on w.p. (12.42, 7.38)
- Large drop of  $Q_x$  at the start due to nonlinear magnet calibration
- Vertical tune is flat: most of the vertical focusing is provided by the gradient bending

## Correcting the orbit while ramping



1st beam extraction to BTS, 28th of October 2010



$\sigma(x) = 0.86 \text{ mm}$ ,  $\sigma(y) = 0.19 \text{ mm}$   
 $\epsilon(x) = 13 \text{ nmrad}$ ,  $\epsilon(y) = 2,6 \text{ nmrad}$

We are 30 % off to the theoretical emittance and have a coupling factor of roughly 20%.

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# Commissioning Evolution

- Waiting for CSN license since October'10
- First try over one week-end (special permission): 4 shifts
- 2 shifts/day for 10 consecutive days
- Normal commissioning: 9 shifts/week
- Total commissioning phase I: <90 shifts (8 hours/shift)

**License arrived (~14 months)**

January						
Su	M	Tu	W	Th	F	Sa
						1
2	3	4	5	6	7	8
9	10	11	12	13	14	15
16	17	18	19	20	21	22
23	24	25	26	27	28	29
30	31					

February						
Su	M	Tu	W	Th	F	Sa
		1	2	3	4	5
6	7	8	9	10	11	12
13	14	15	16	17	18	19
20	21	22	23	24	25	26
27	28					

March						
Su	M	Tu	W	Th	F	Sa
		1	2	3	4	5
6	7	8	9	10	11	12
13	14	15	16	17	18	19
20	21	22	23	24	25	26
27	28	29	30	31		

● 2 shifts  
● 1 shift

April						
Su	M	Tu	W	Th	F	Sa
					1	2
3	4	5	6	7	8	9
10	11	12	13	14	15	16
17	18	19	20	21	22	23
24	25	26	27	28	29	30

May						
Su	M	Tu	W	Th	F	Sa
1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28
29	30	31				

June						
Su	M	Tu	W	Th	F	Sa
			1	2	3	4
5	6	7	8	9	10	11
12	13	14	15	16	17	18
19	20	21	22	23	24	25
26	27	28	29	30		

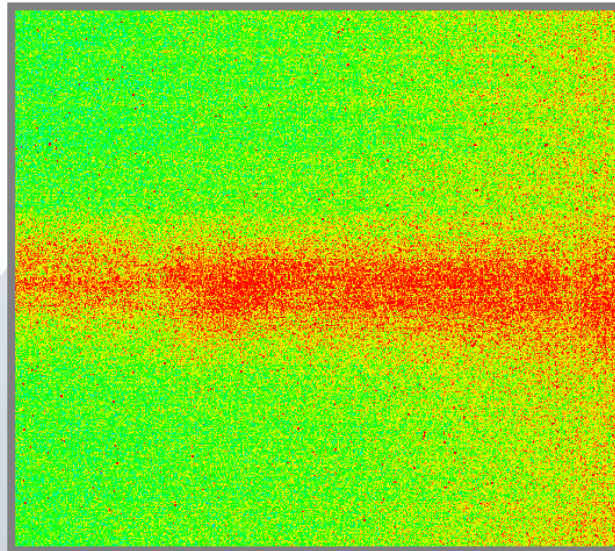
**3 months shutdown for water upgrade**



# Commissioning Evolution

**9th March – First beam into the SR**

09h00 Beam spot at 1st screen on sector 2  
Completely defocused horizontally



**All SR Quadrupoles with wrong polarity**

# Commissioning Evolution

9th March – First beam into the SR

➤ Recabling Quads:

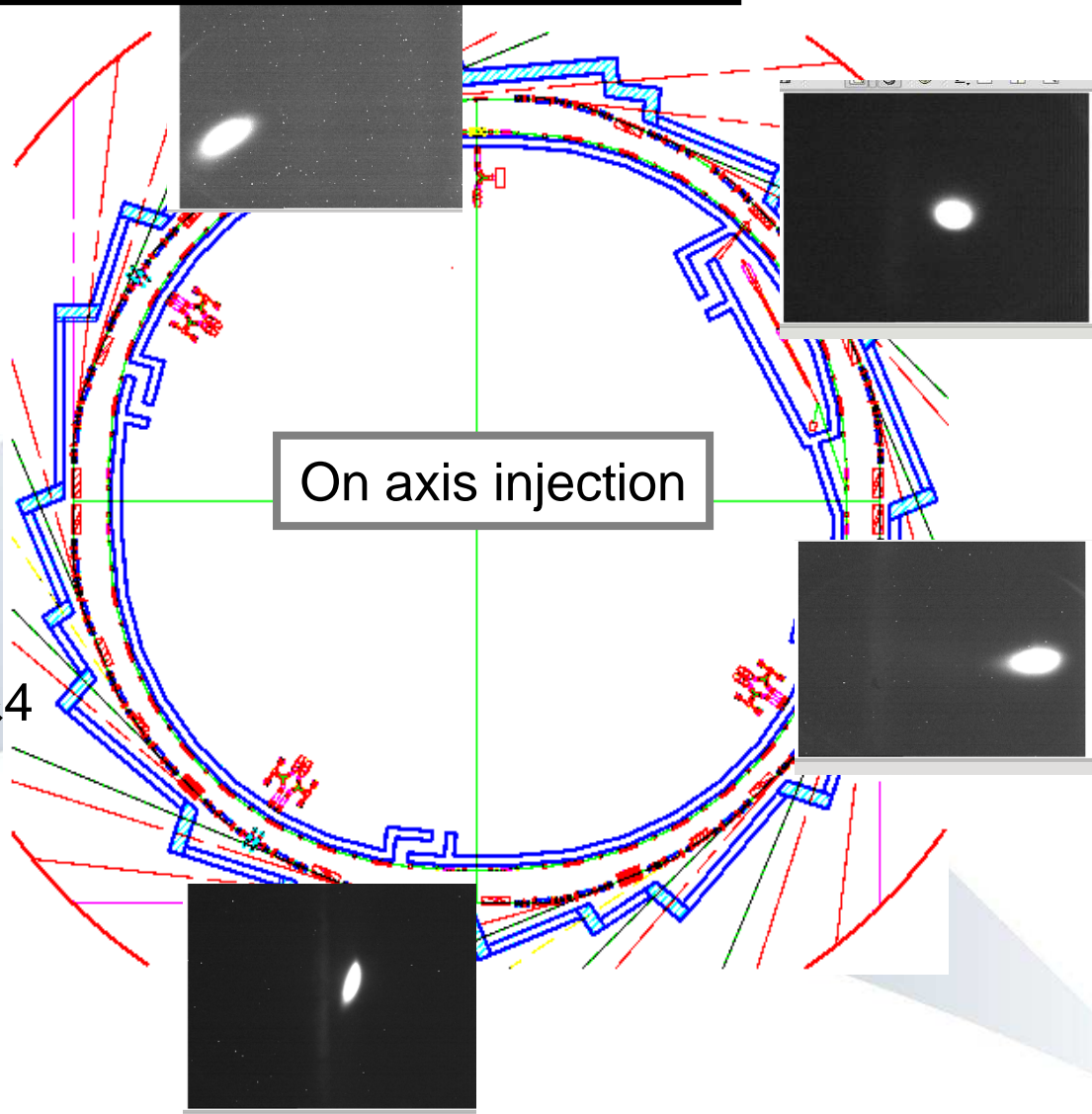
✓ Sectors 1&2

✓ Quadrant 1

✓ Quadrant 2

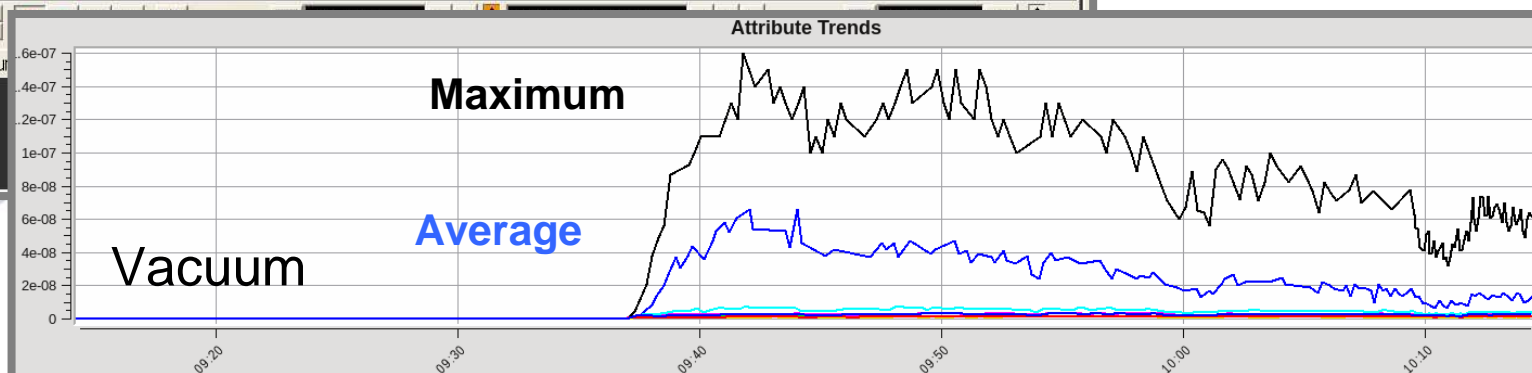
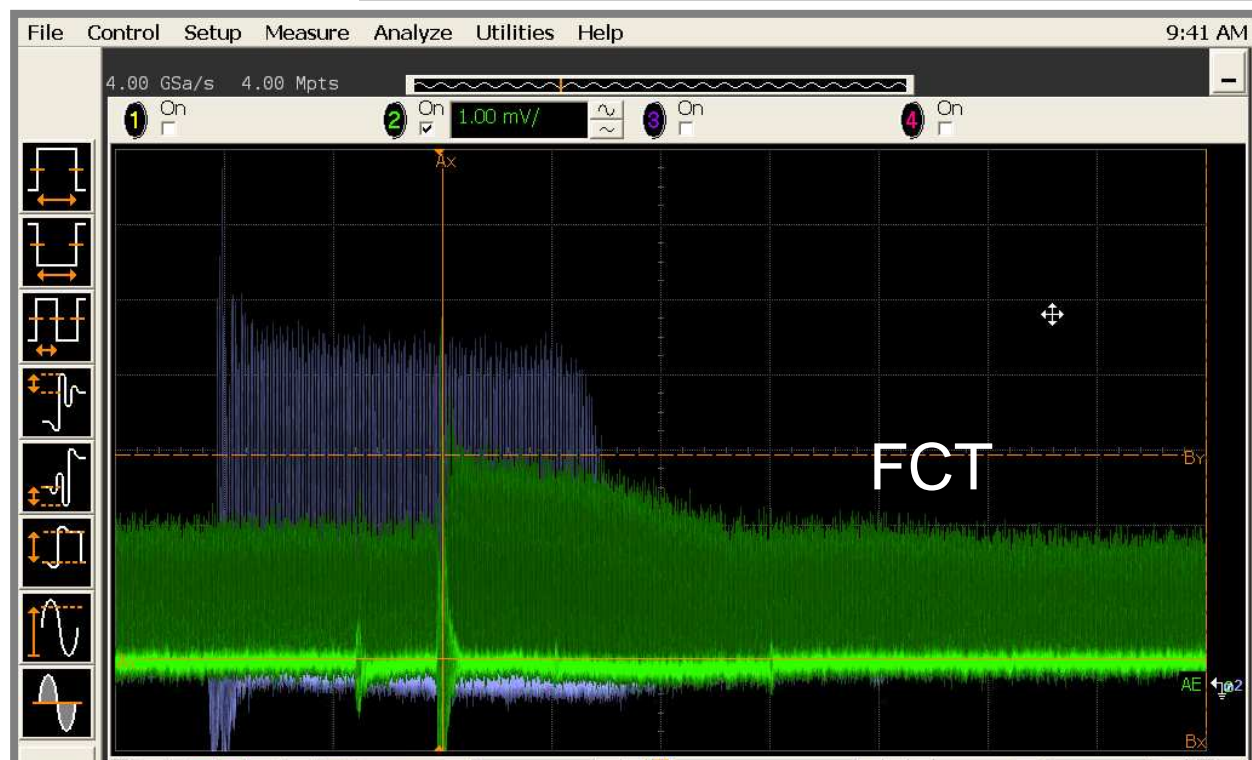
✓ Quadrants 3&4

19h35: 1st turn !



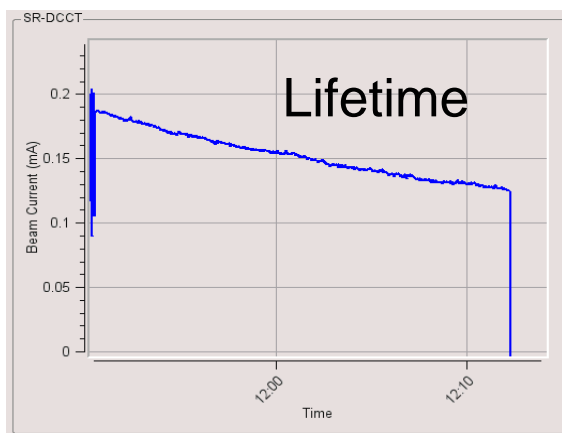
# Commissioning Evolution

13th March - 1 second stored beam

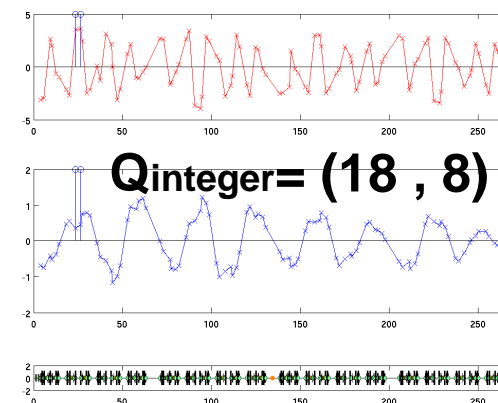
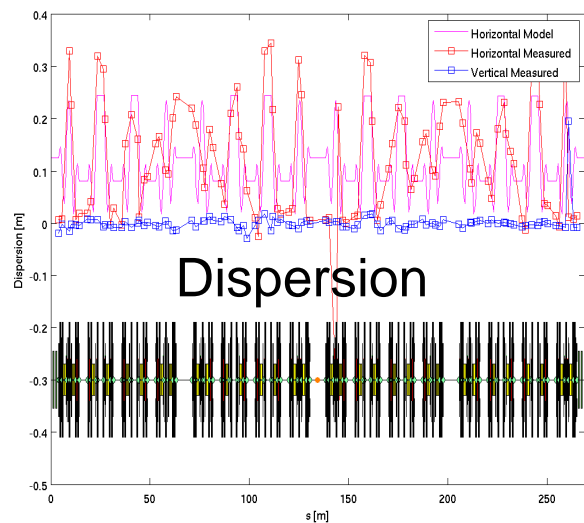
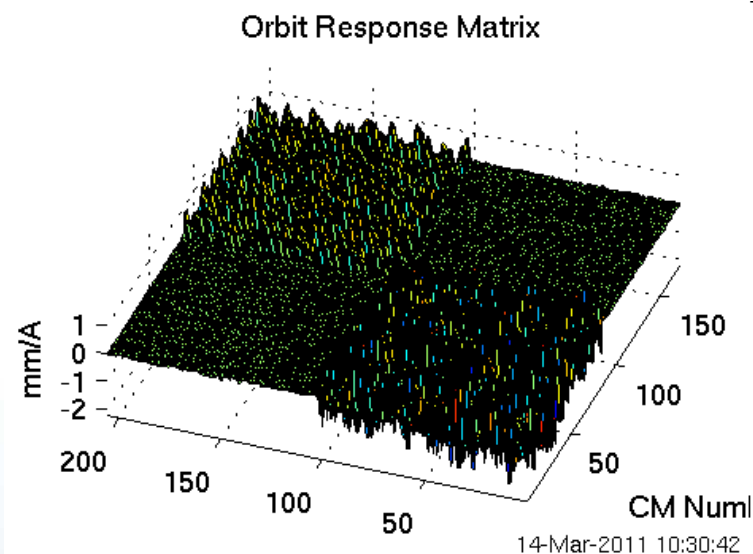


# Commissioning Evolution

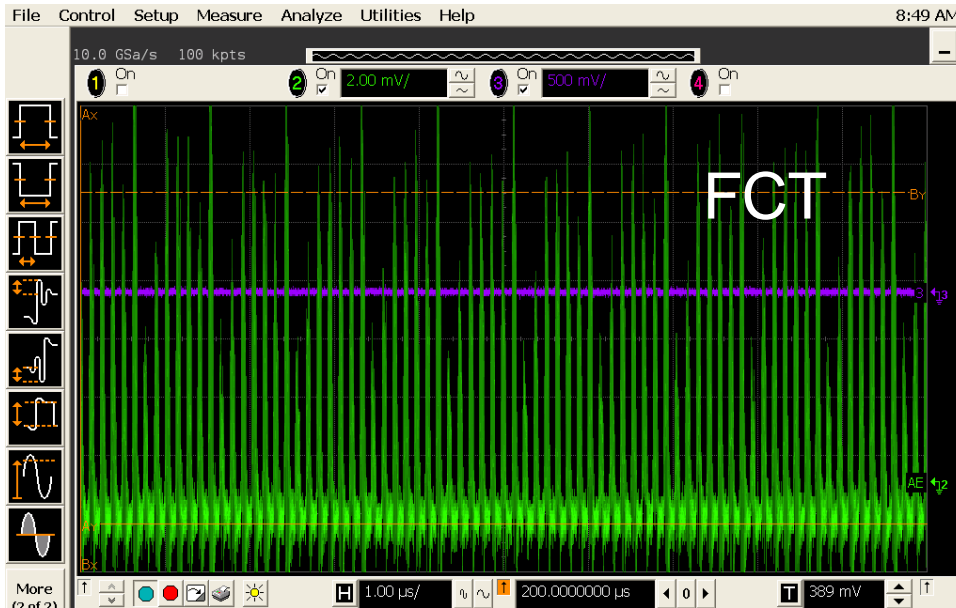
**13-14th March – First measurements**



**Energy  
2.92 GeV**

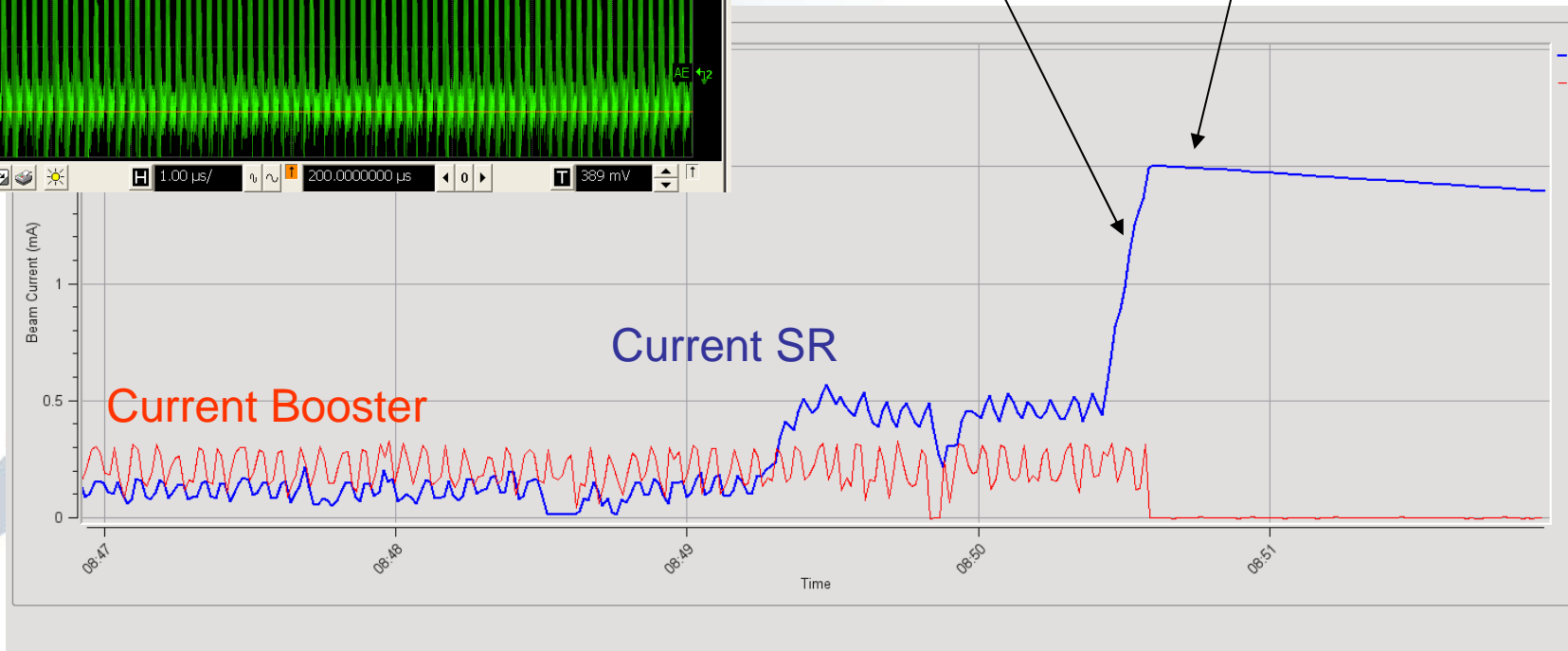


## 16th March - Beam Accumulated



1.5 mA stored

Accumulation



# Commissioning Evolution

16th March - Beam Accumulated

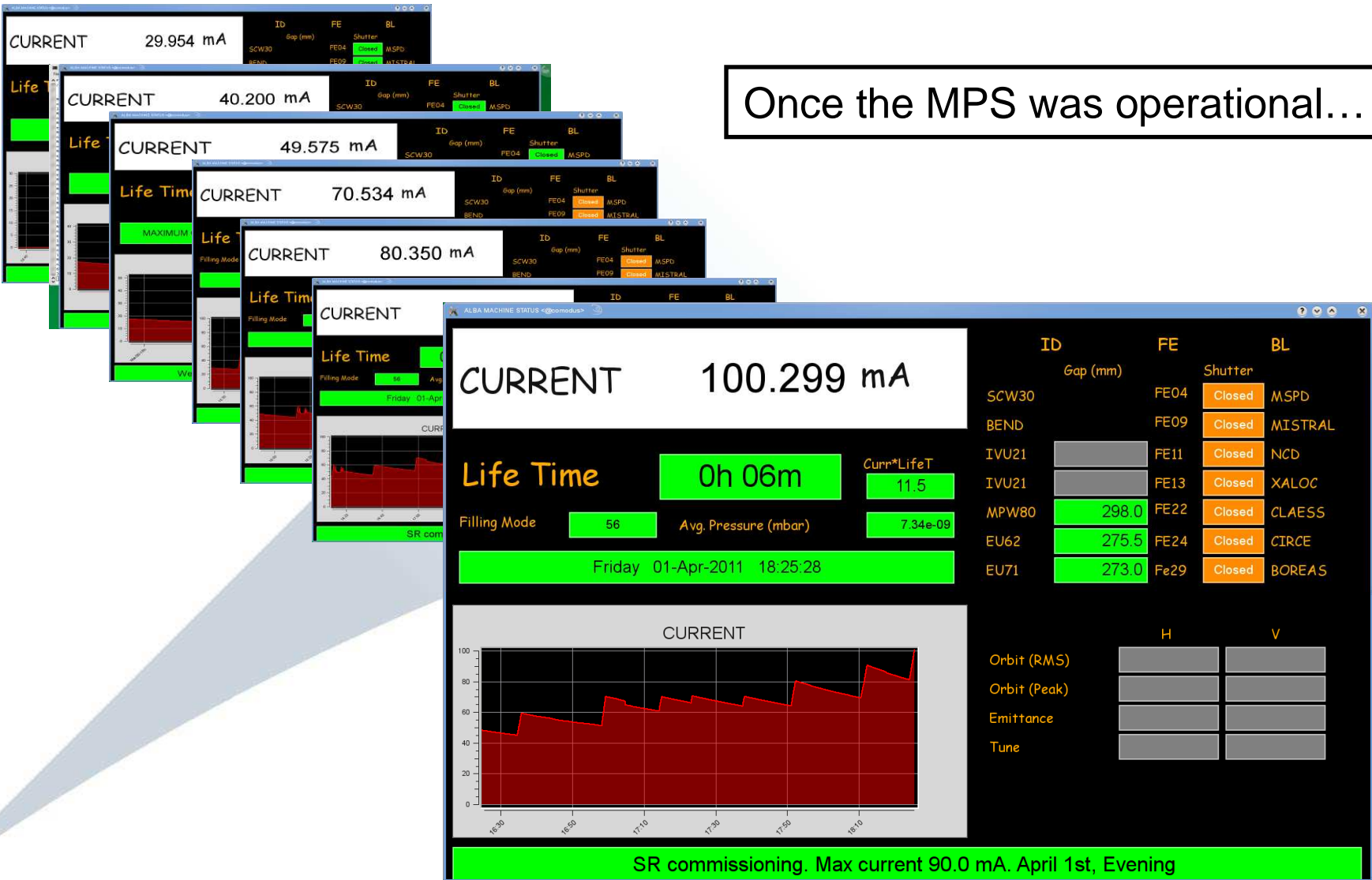


The Accelerator Division celebrating this success

# Commissioning Evolution

23rd March – 1st April

Once the MPS was operational...



**CURRENT** 29.954 mA

**CURRENT** 40.200 mA

**CURRENT** 49.575 mA

**CURRENT** 70.534 mA

**CURRENT** 80.350 mA

**CURRENT** 100.299 mA

**Life Time** 0h 06m

**Life Time** 11.5

**Filling Mode** 56

**Avg. Pressure (mbar)** 7.34e-09

Friday 01-Apr-2011 18:25:28

ID	FE	Shutter	BL
SCW30	FE04	Closed	MSPD
BEND	FE09	Closed	MISTRAL
IVU21	FE11	Closed	NCD
IVU21	FE13	Closed	XALOC
MPW80	FE22	Closed	CLAESS
EU62	FE24	Closed	CIRCE
EU71	Fe29	Closed	BOREAS

Orbit (RMS)

Orbit (Peak)

Emittance

Tune

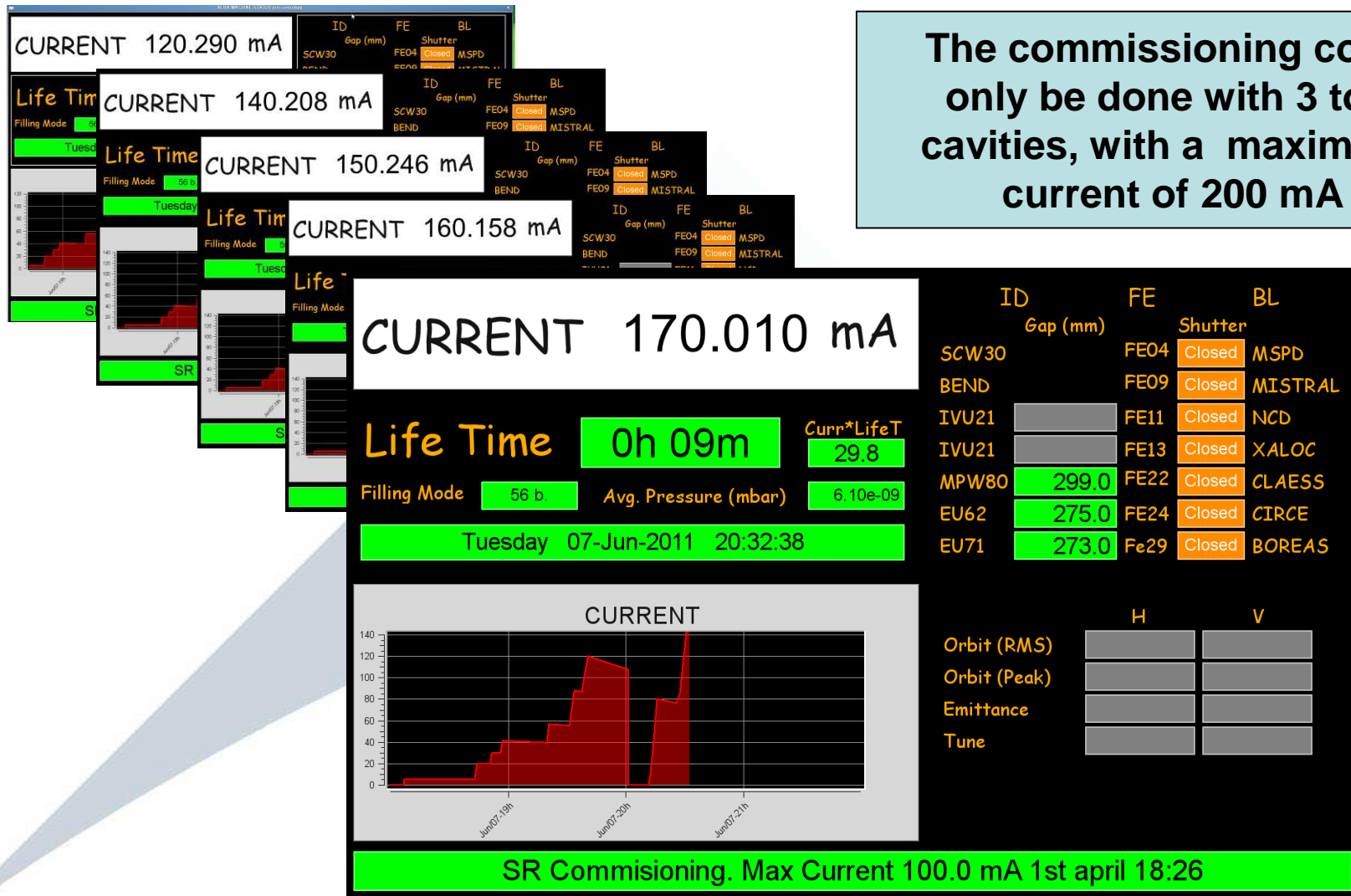
**CURRENT** graph showing current over time from 16:30 to 18:10.

SR commissioning. Max current 90.0 mA. April 1st, Evening

# Commissioning Evolution

The day before last MAC (7th June)

The commissioning could only be done with 3 to 4 cavities, with a maximum current of 200 mA



**CURRENT 120.290 mA**

**CURRENT 140.208 mA**

**CURRENT 150.246 mA**

**CURRENT 160.158 mA**

**CURRENT 170.010 mA**

**Life Time 0h 09m**    **Curr\*LifeT 29.8**

**Filling Mode 56 b.**    **Avg. Pressure (mbar) 6.10e-09**

**Tuesday 07-Jun-2011 20:32:38**

ID	FE	BL
Gap (mm)	Shutter	
SCW30	FE04	MSPD
BEND	FE09	MISTRAL
IVU21	FE11	NCD
IVU21	FE13	XALOC
MPW80	FE22	CLAESS
EU62	FE24	CIRCE
EU71	Fe29	BOREAS

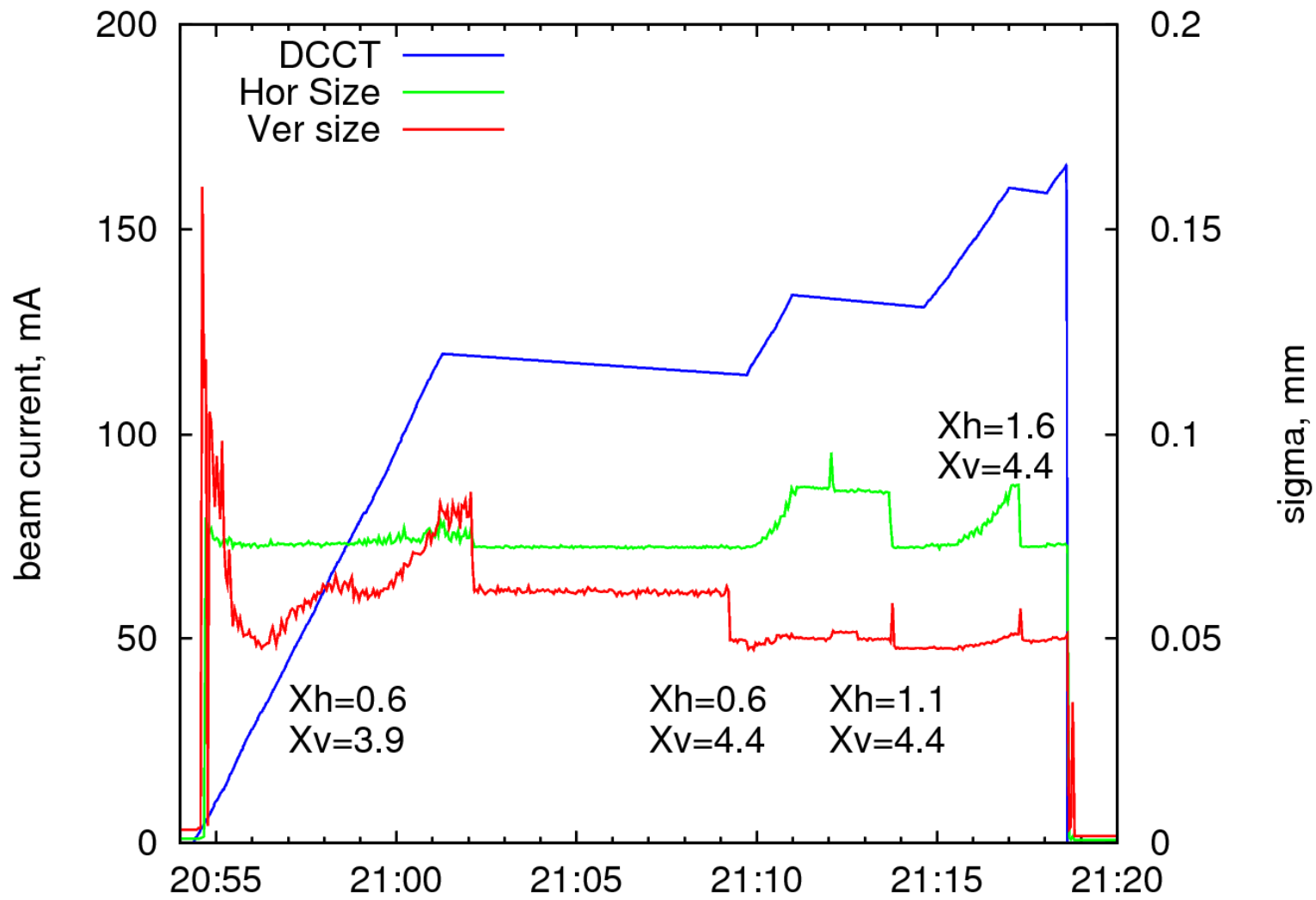
**CURRENT**

SR Commissioning. Max Current 100.0 mA 1st april 18:26



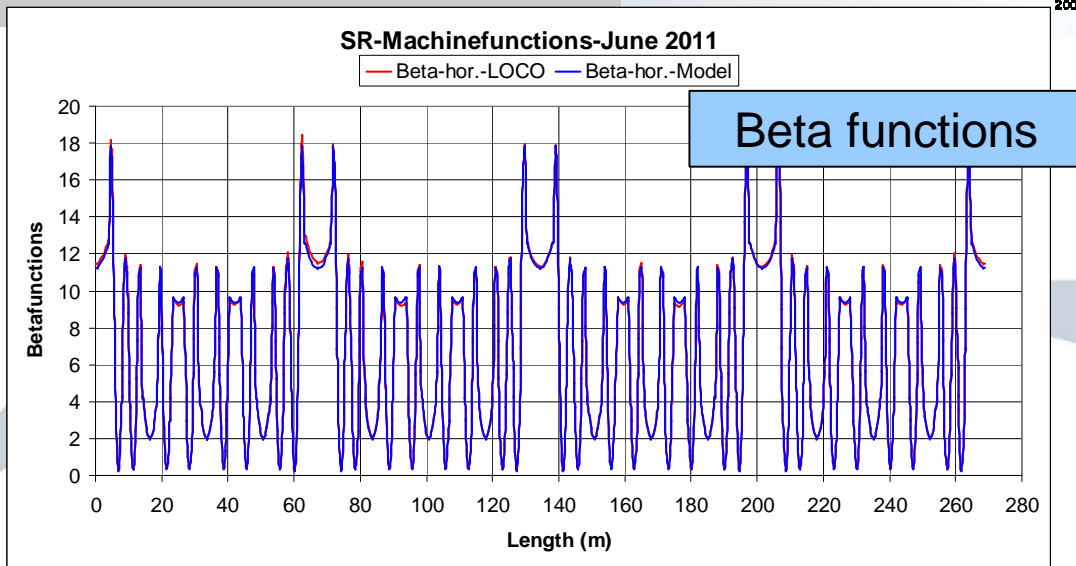
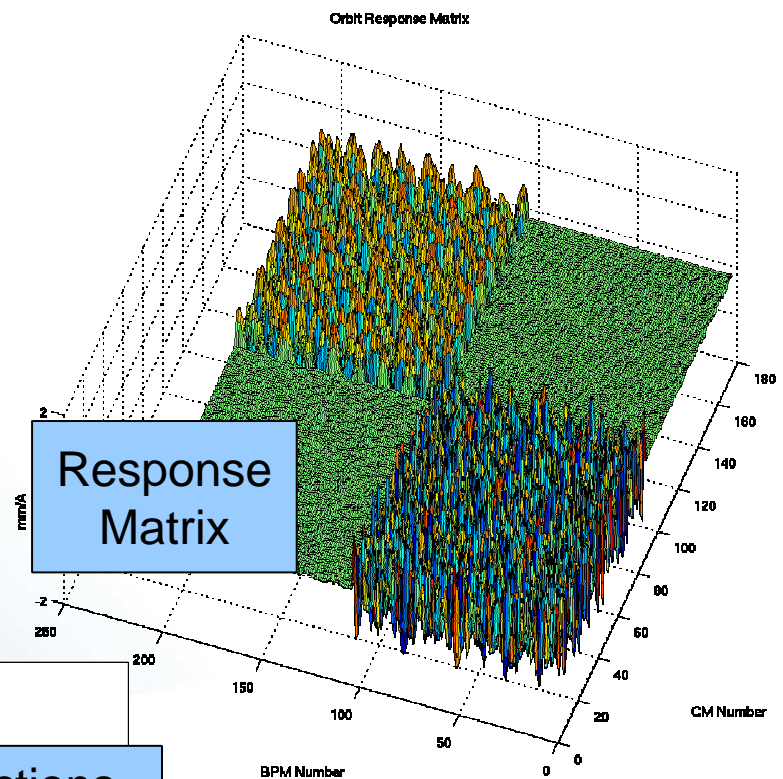
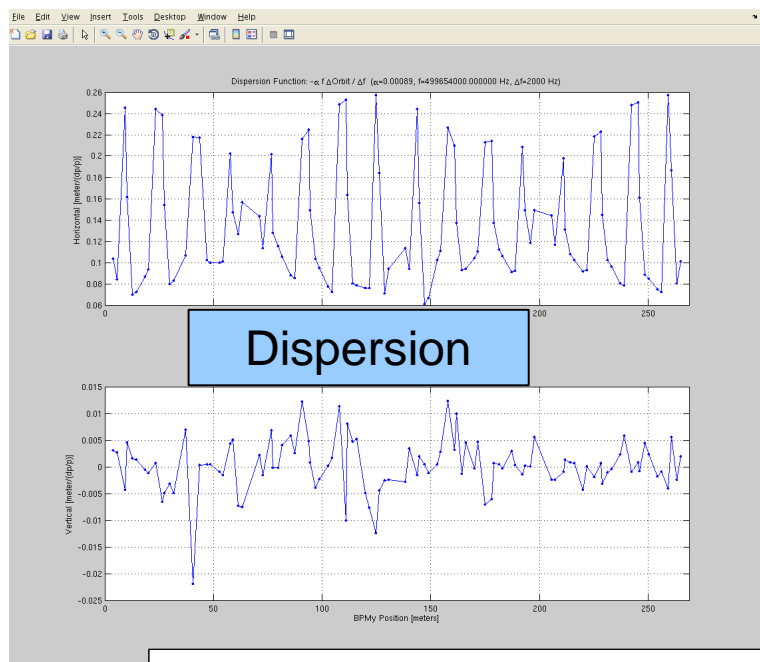
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The day before last MAC (7th June)



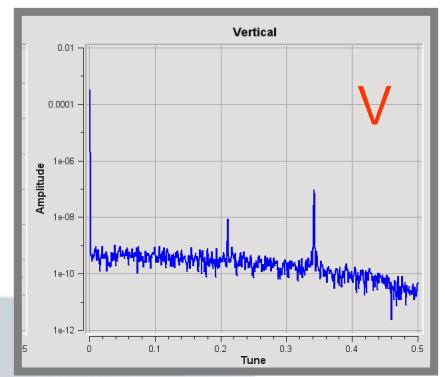
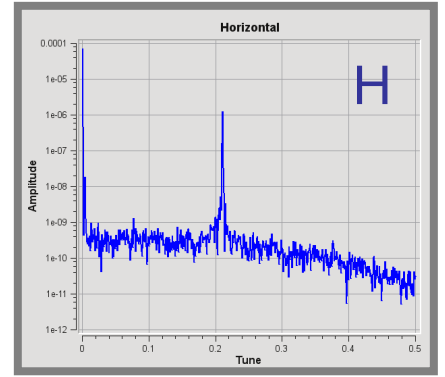
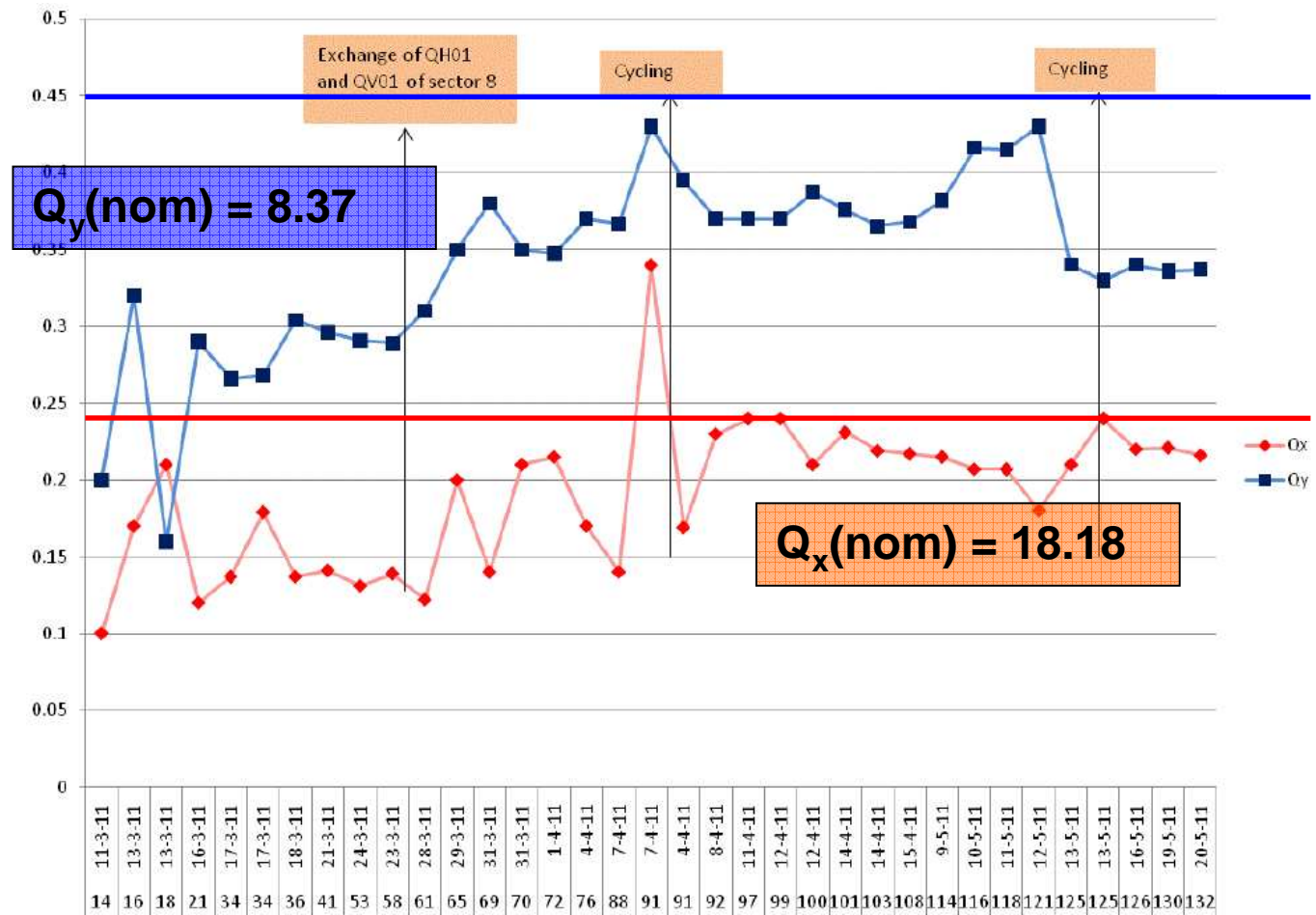
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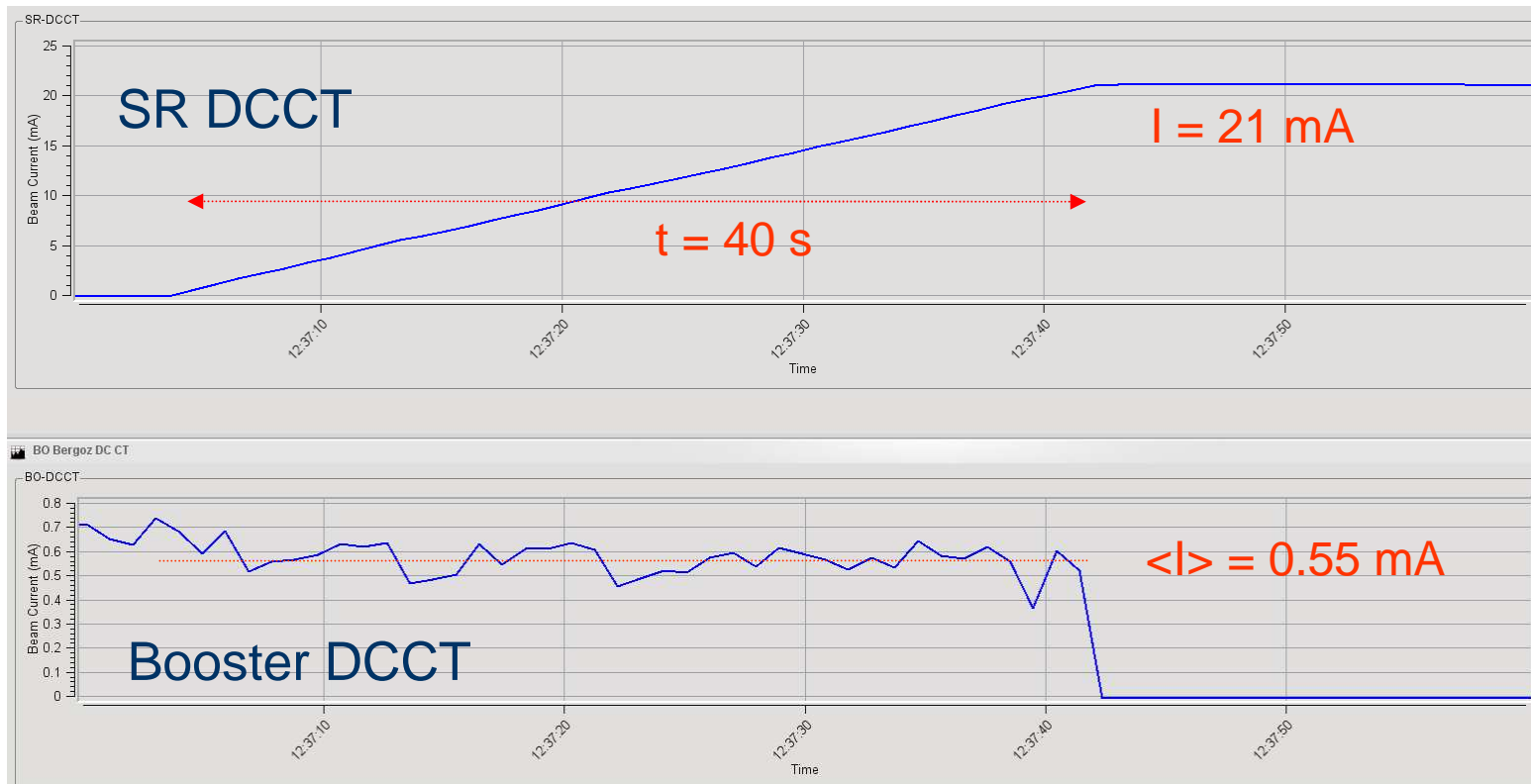


03-Jun-2011 08:13:33

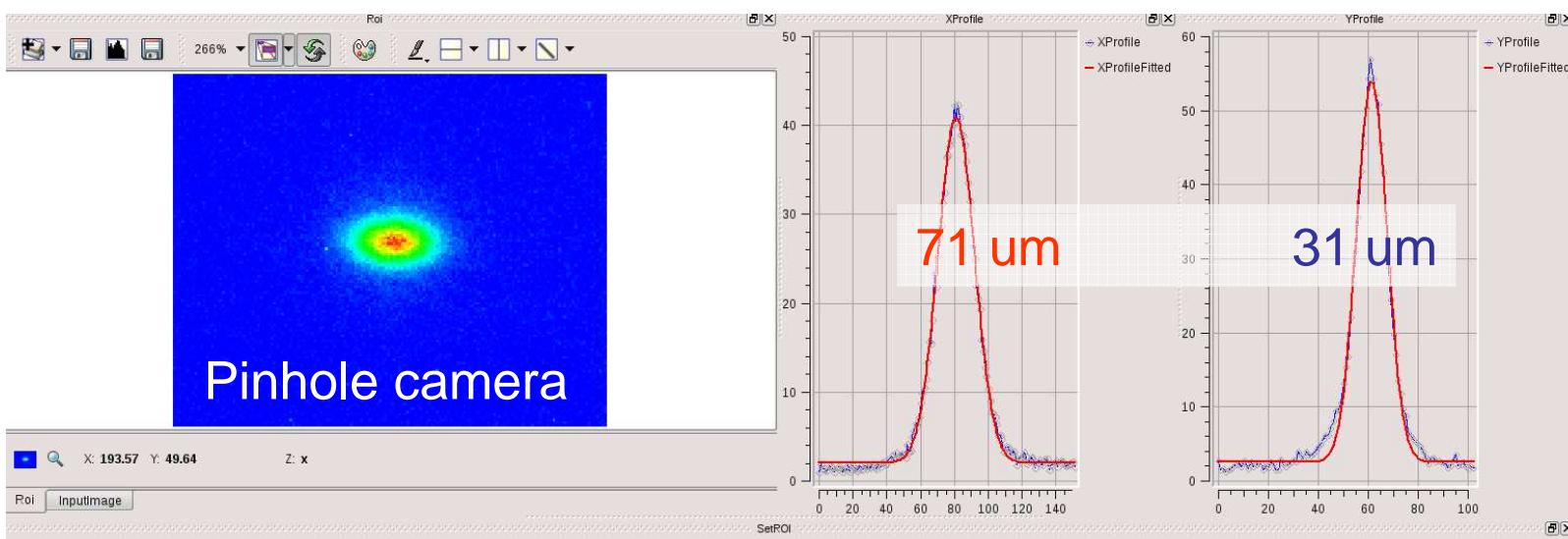
## Tunes during the commissioning



# Injection Efficiency



Injection efficiency ~ 95%

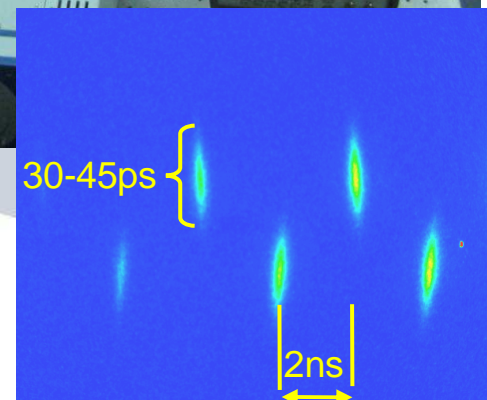
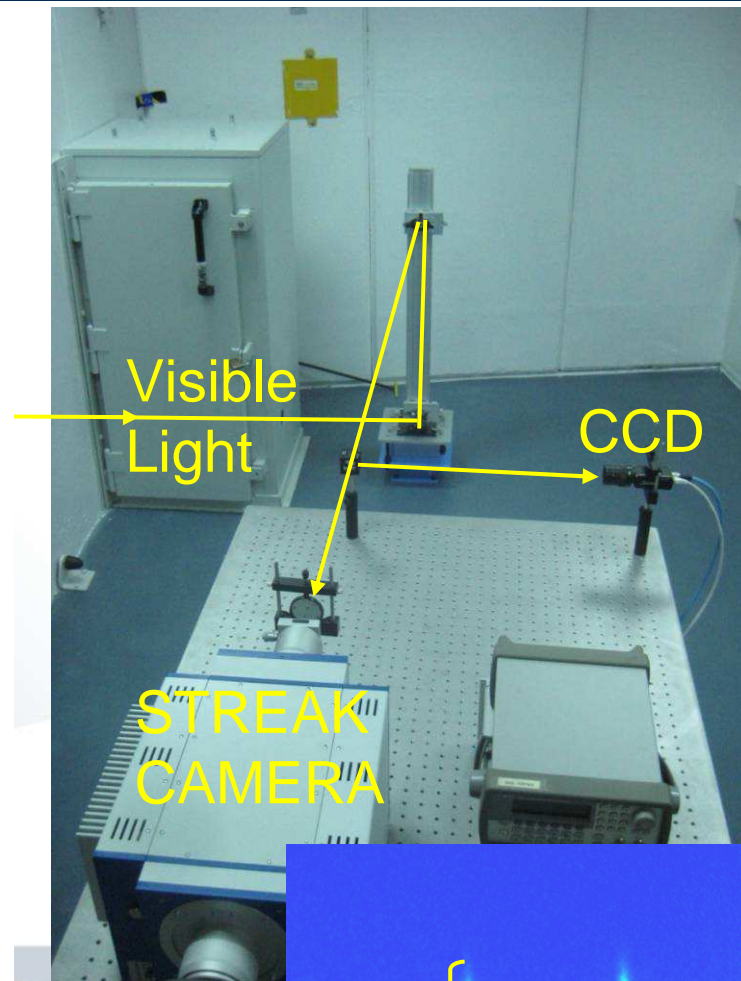
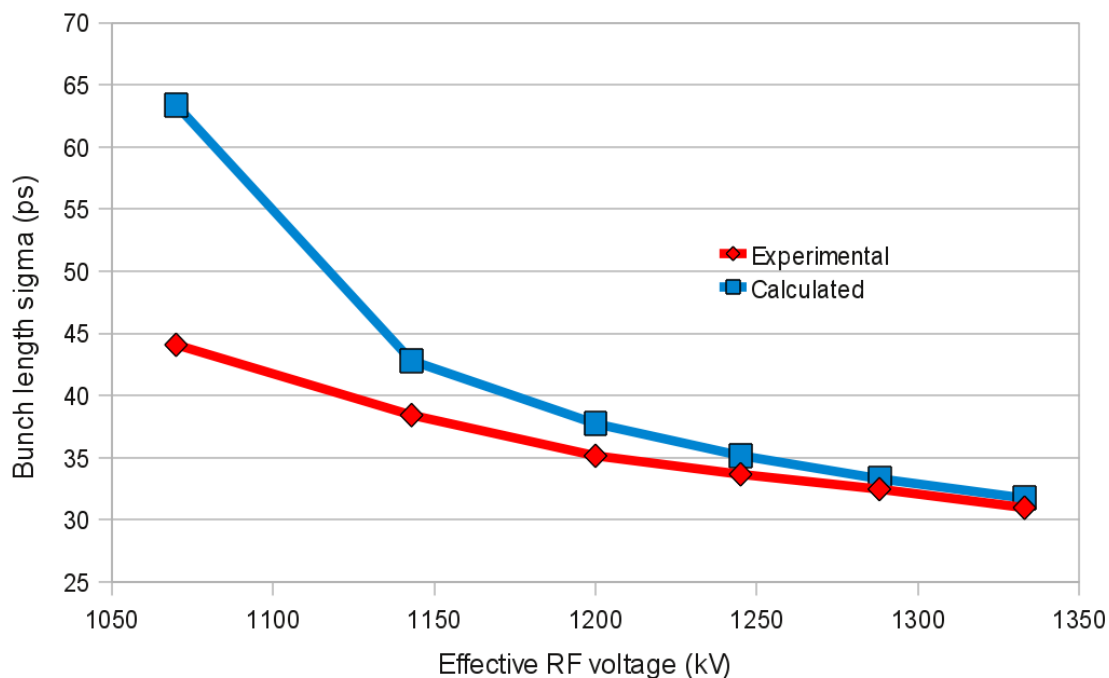


Quite ok with model:  
Emittance = 4.5 nmrاد  
Coupling = 0.4 %

$\sigma(x) = 72 \text{ um}$ ,  $\sigma(y) = 31 \text{ um}$   
 $\epsilon(x) = 6.07 \text{ nmrاد}$ ,  $\epsilon(y) = 0.03 \text{ nmrاد}$   
Coupling = 0.5%

- Visible Radiation from a dipole is extracted using a mirror
- Mirror position (in-vacuum) controlled with thermocouples

Bunch length vs. RF voltage



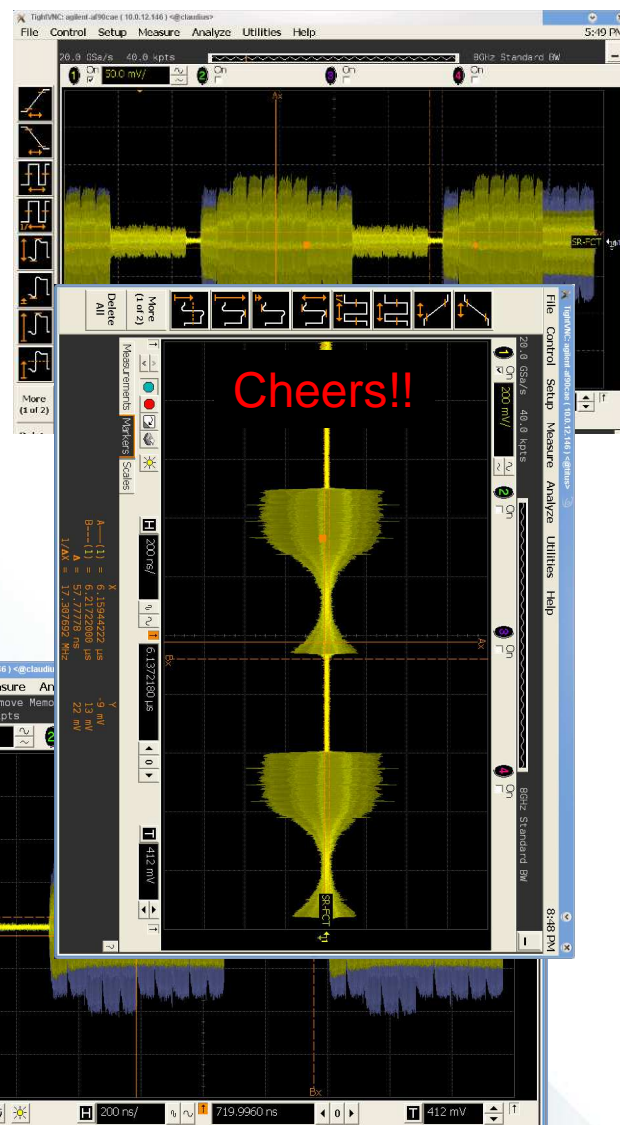
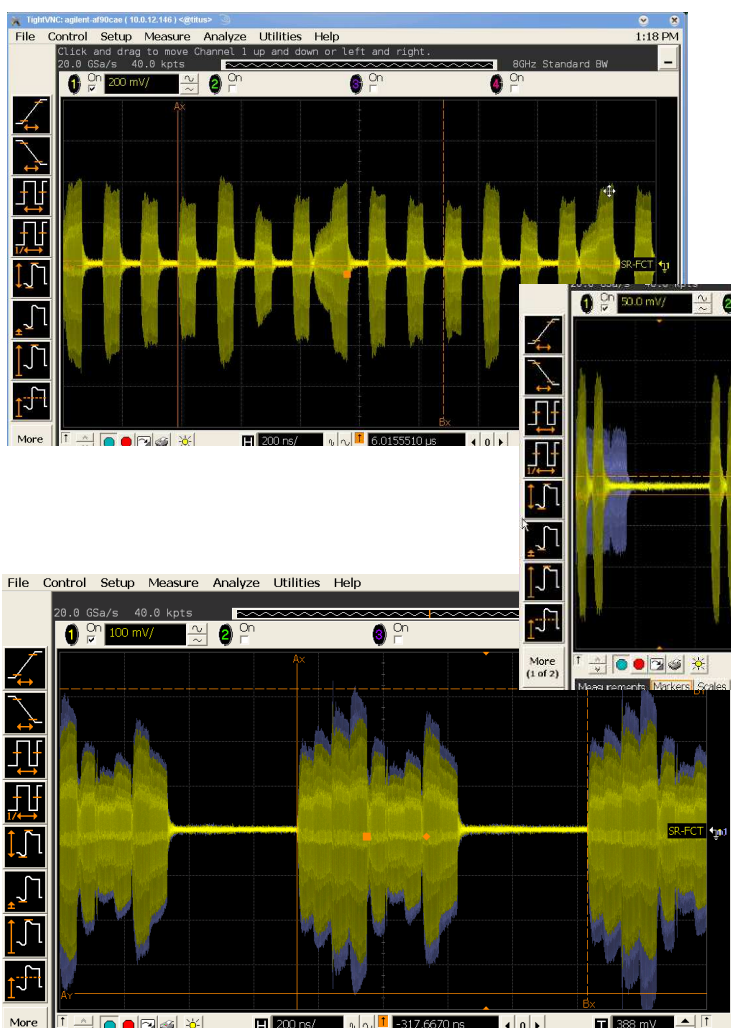
Done with only 3 RF cav.

future 6 RF cav. 3600kV



Bunch length 15ns

# Filling Patterns



Needs improvements 😊



Three insertion devices have been closed:

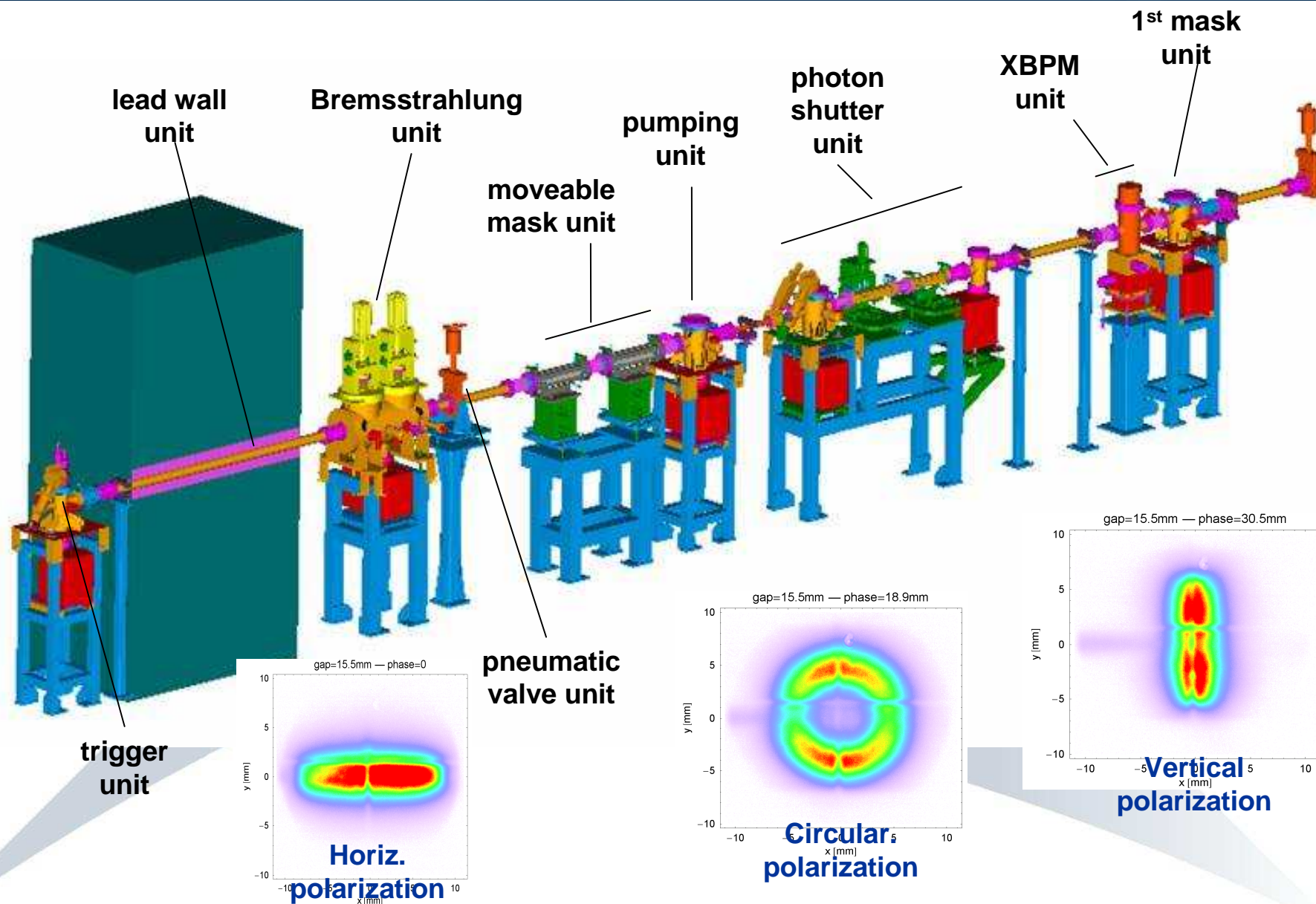
- EU62
- EU71
- MPW80

Without much influence in the machine:

MPW80 - BL22	Gap (mm)	tunes	RMS Orbit Distortion (um)	tunes change (10 <sup>-3</sup> )
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

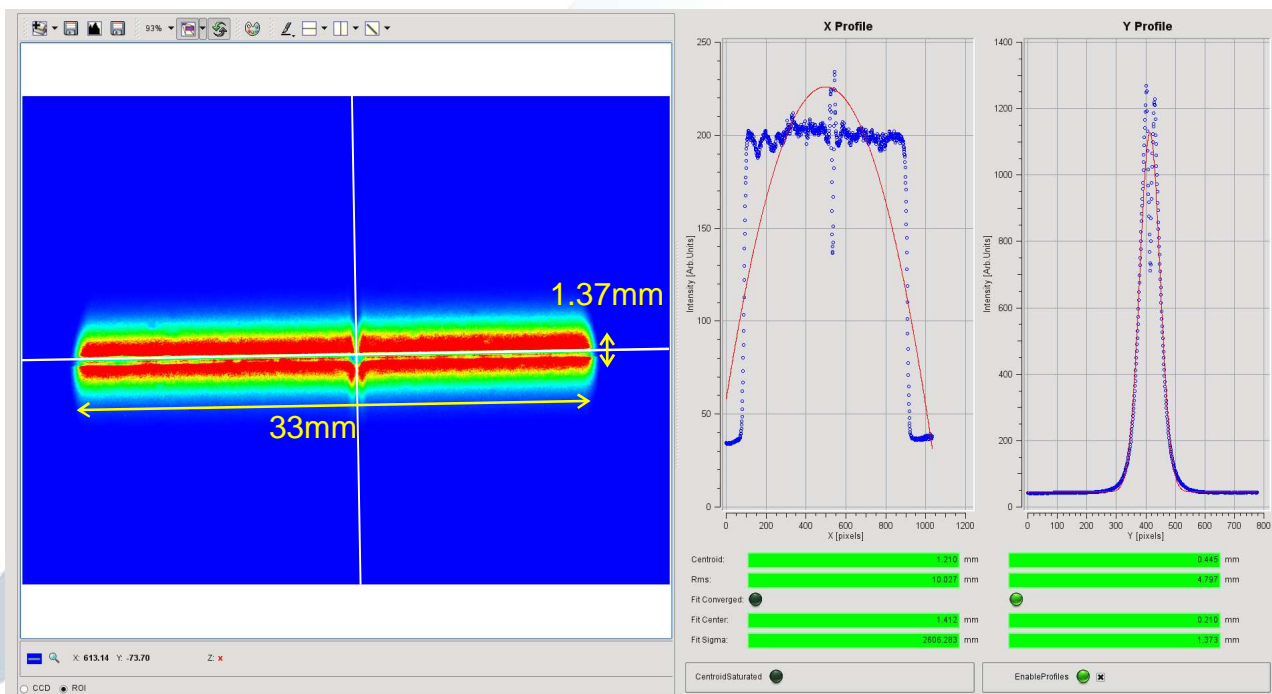
EU71 - BL29	Gap (mm)	Phase (um)	tunes	RMS Orbit (um)	tunes change (10 <sup>-3</sup> )
OPEN	273	0	0.229, 0.376	0 , 0	---
HORIZONTAL (0)	15.5	0	0.230, 0.376	15, 14	+1 , 0
CIRCULAR (pi/2)	15.5	21181	0.228, 0.377	15, 14	-1, +1
VERTICAL (pi)	15.5	35650	0.228, 0.377	16, 15	-1, +1
CIRCULAR (-pi/2)	15.5	-21181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

# Closing Insertion Devices



## 1<sup>st</sup> Photon Beam for Experiments

Photon beam image in FE09 (MISTRAL) Fluorescence Screen

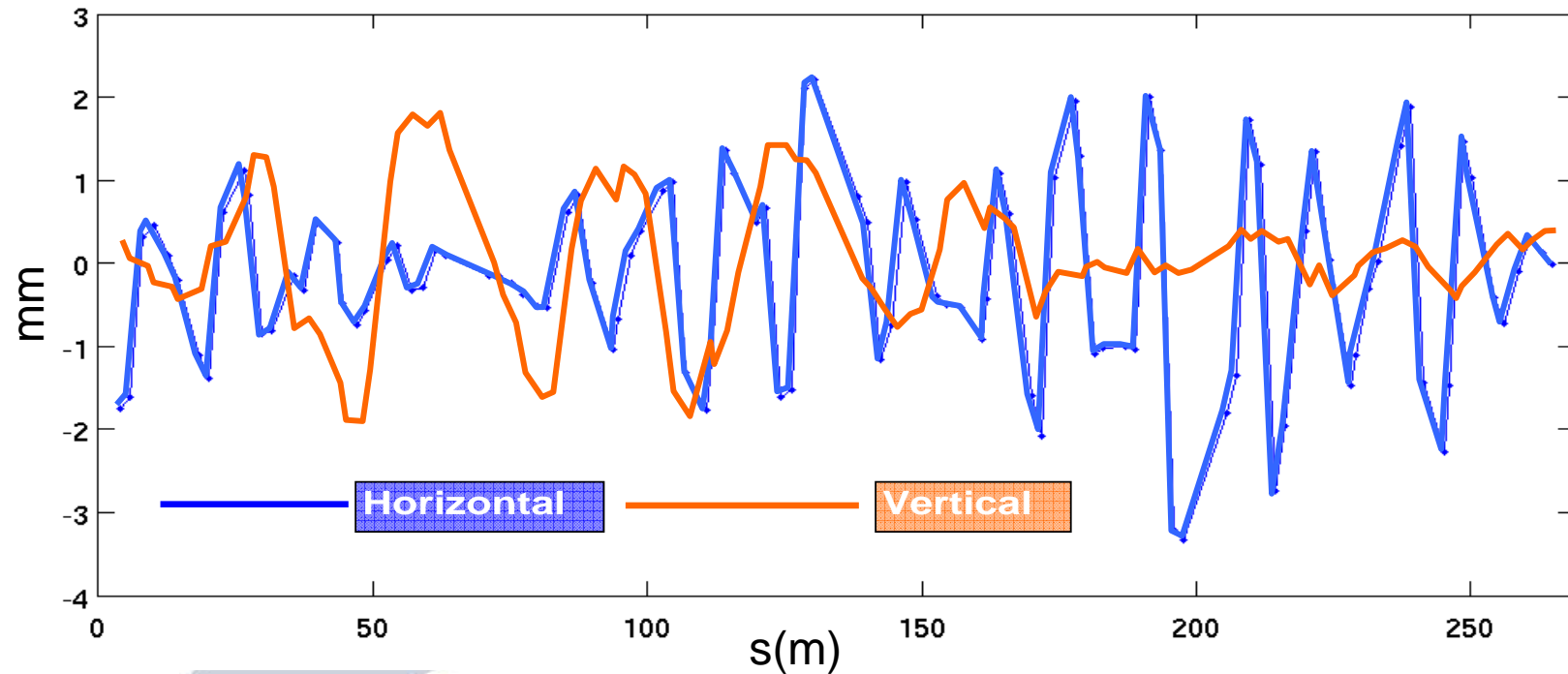


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# Orbit Correction

## Raw orbit without correctors

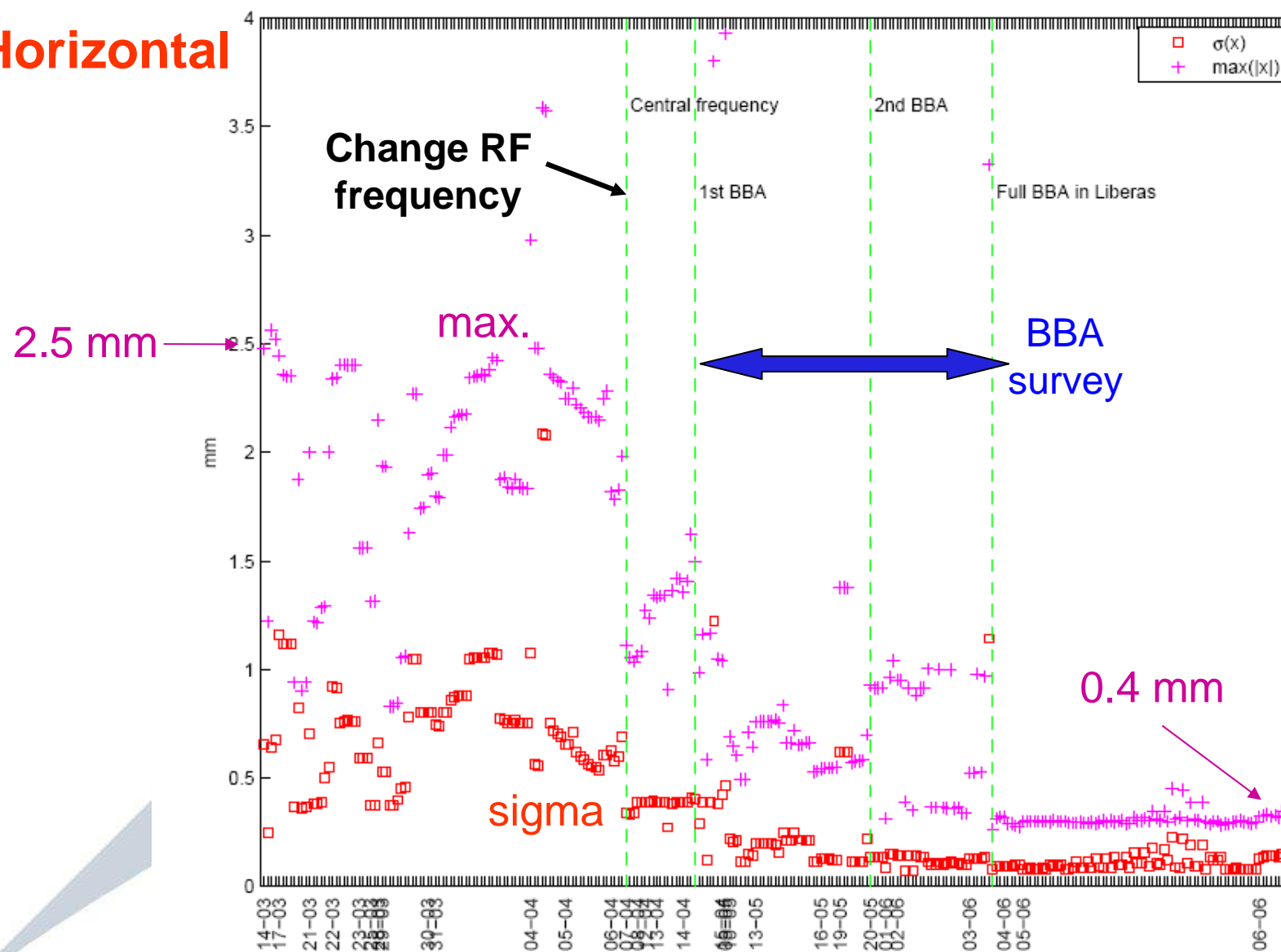


Horizontal orbit < 3mm  
Vertical orbit < 2 mm

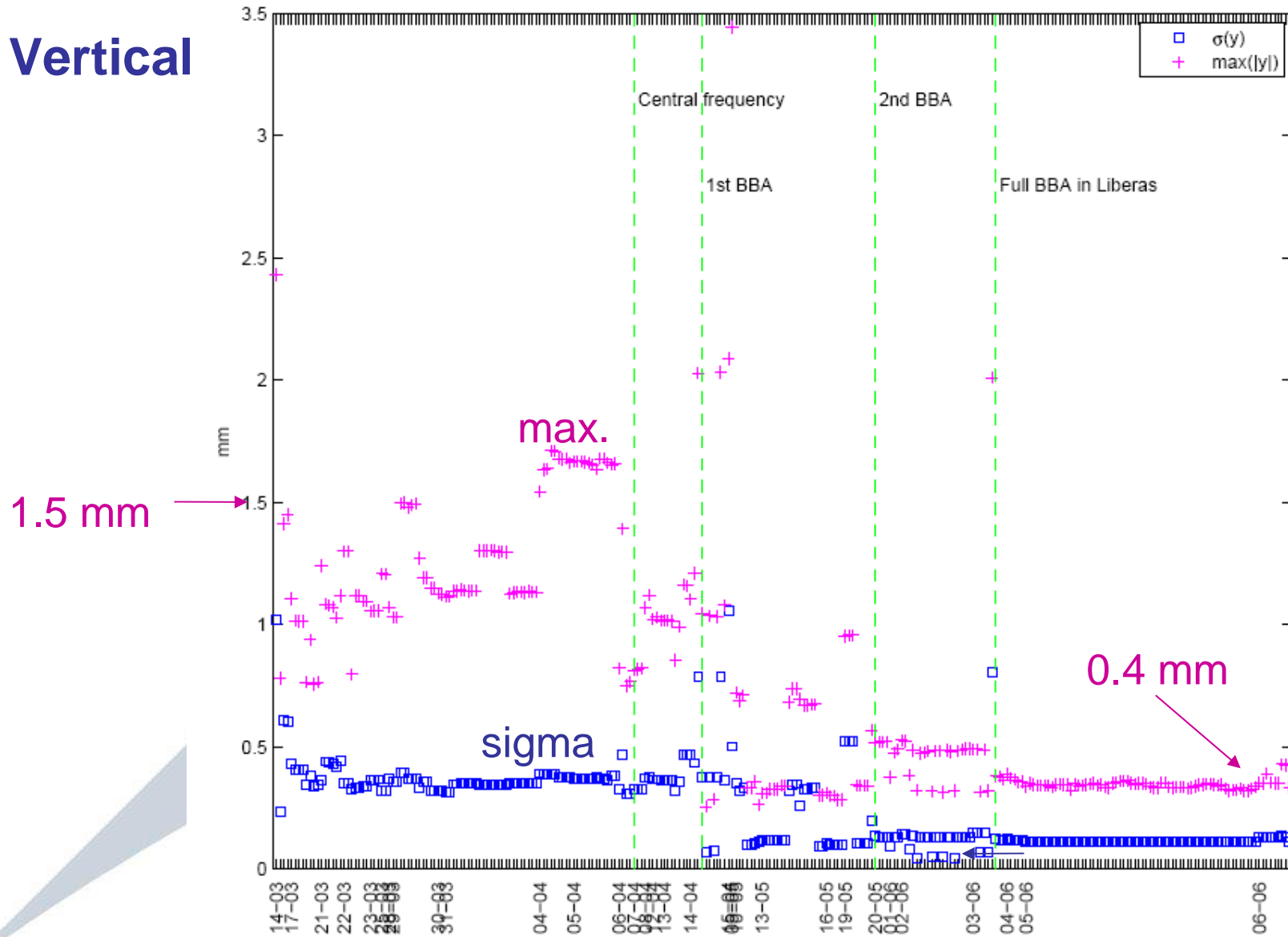


**Good alignment**

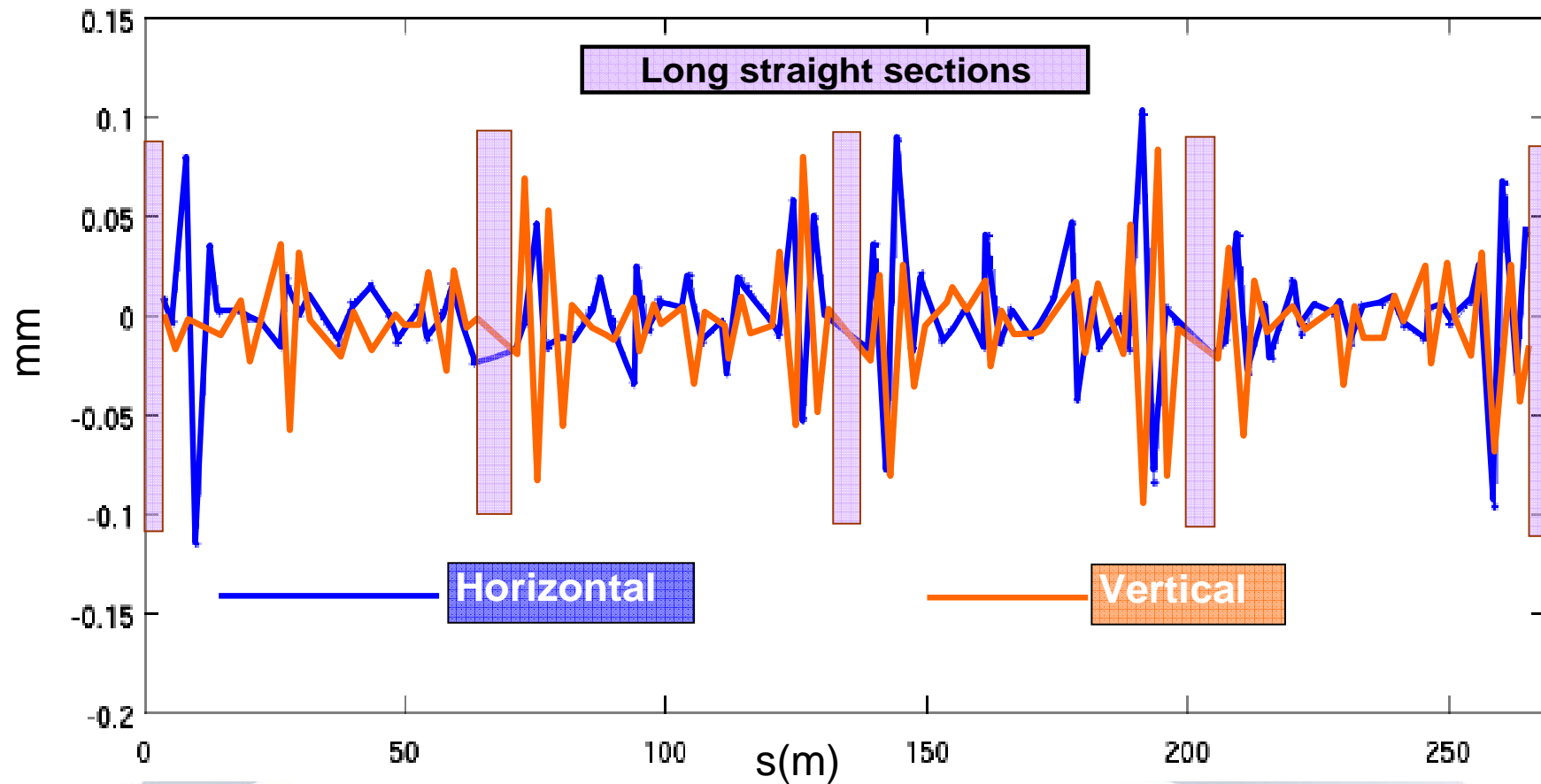
## Horizontal



## Vertical



## Raw orbit with correctors



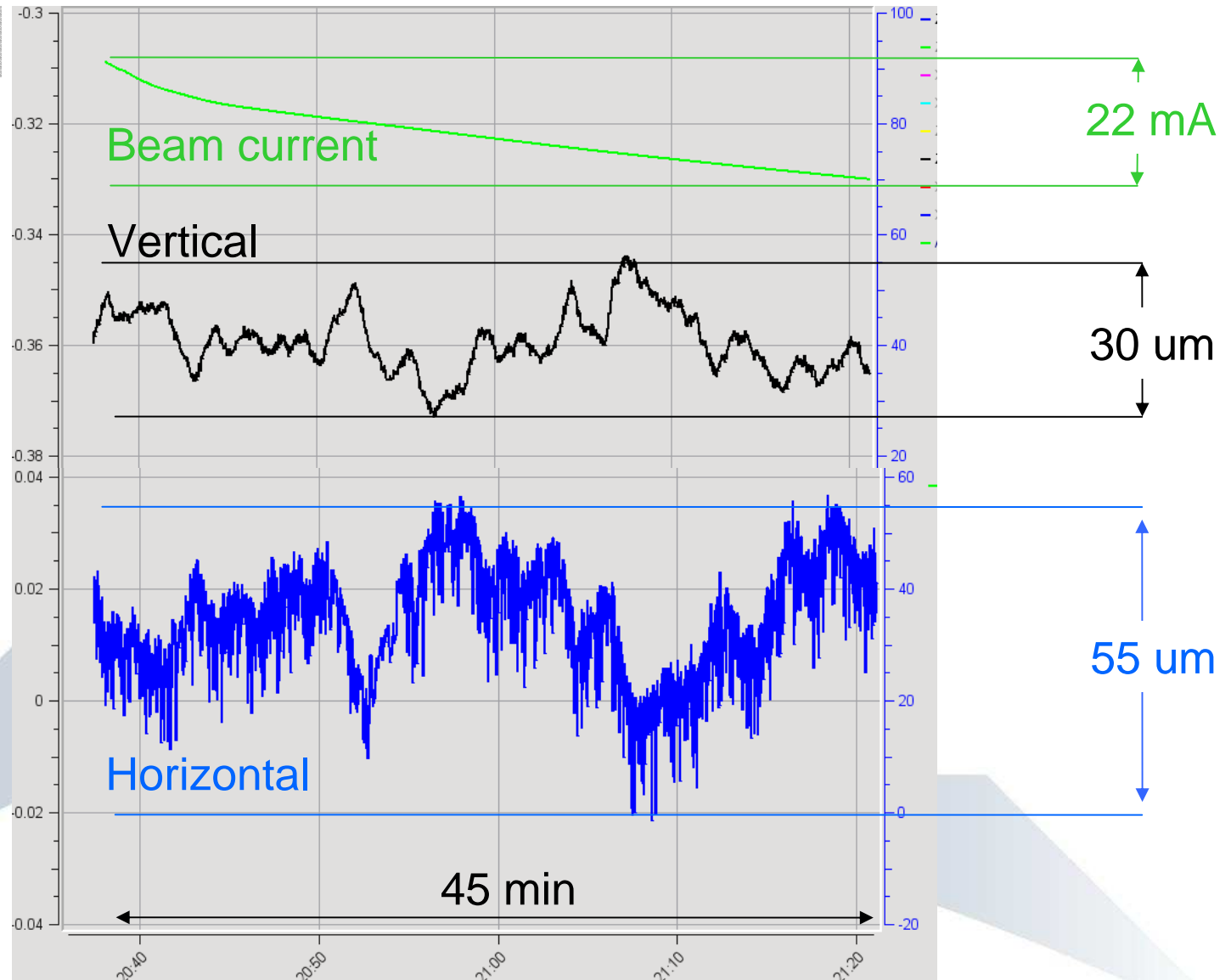
Horizontal rms error  
32  $\mu\text{m}$

Vertical rms error  
29  $\mu\text{m}$

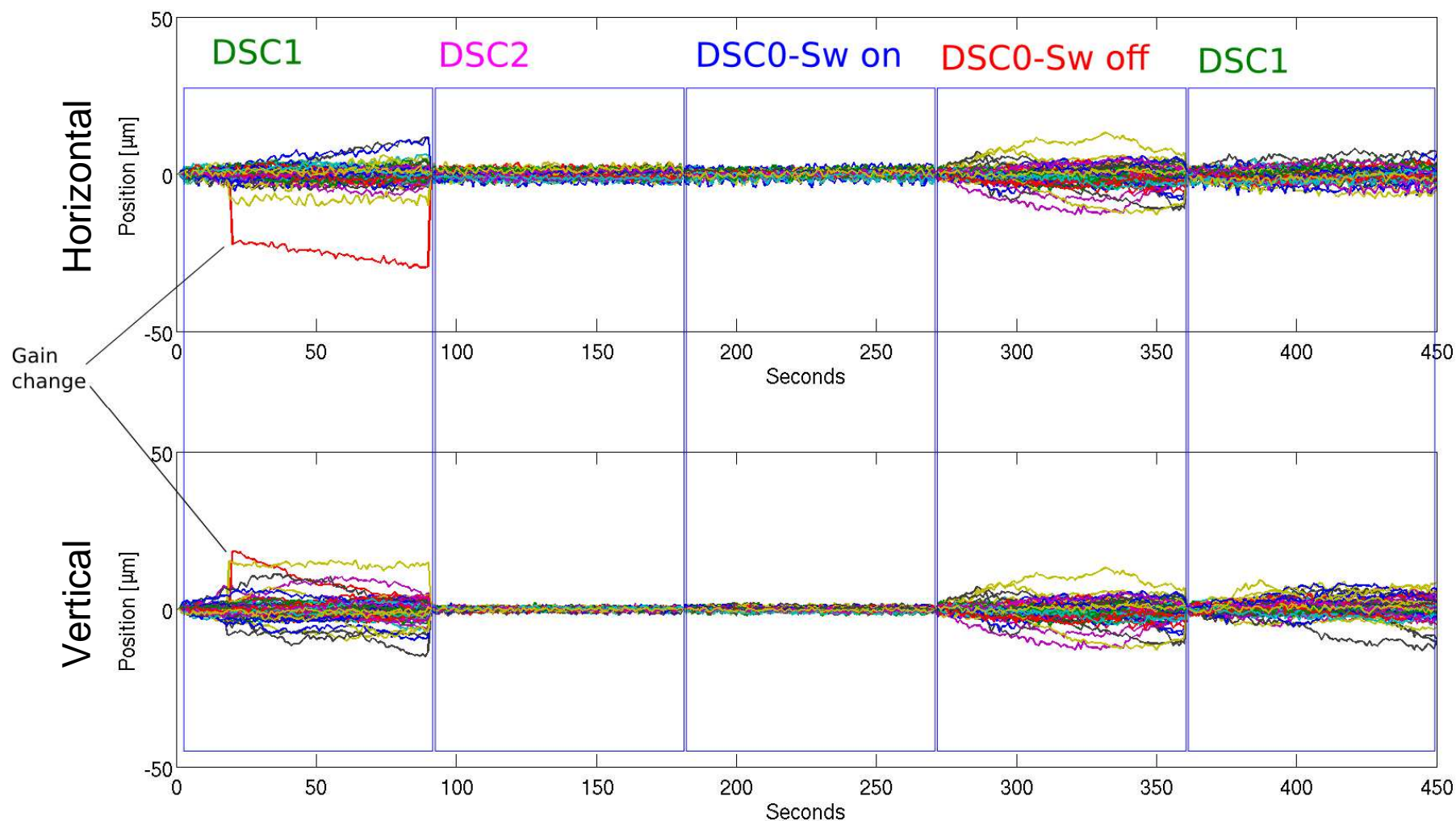


# BPM stability

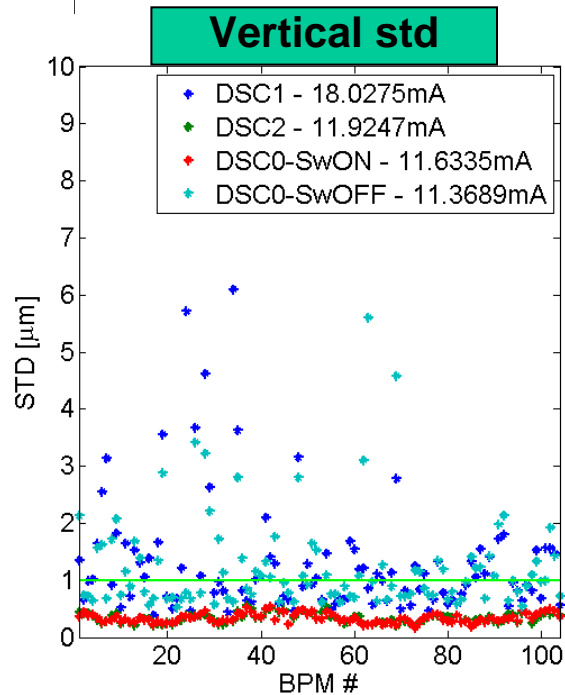
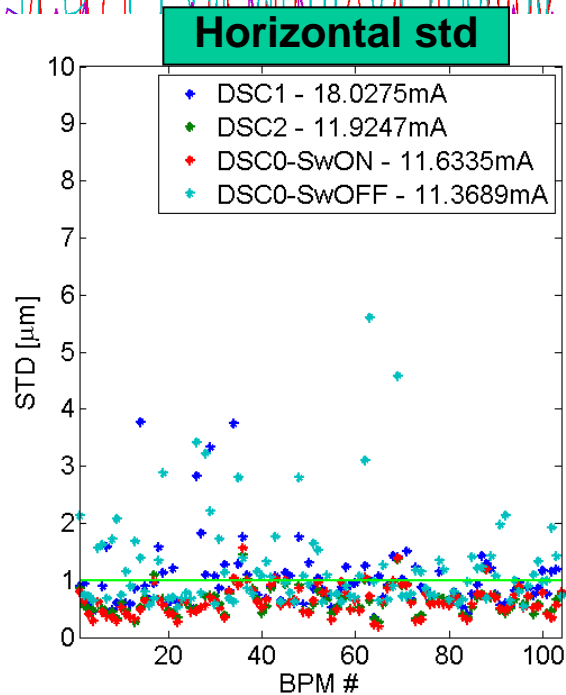
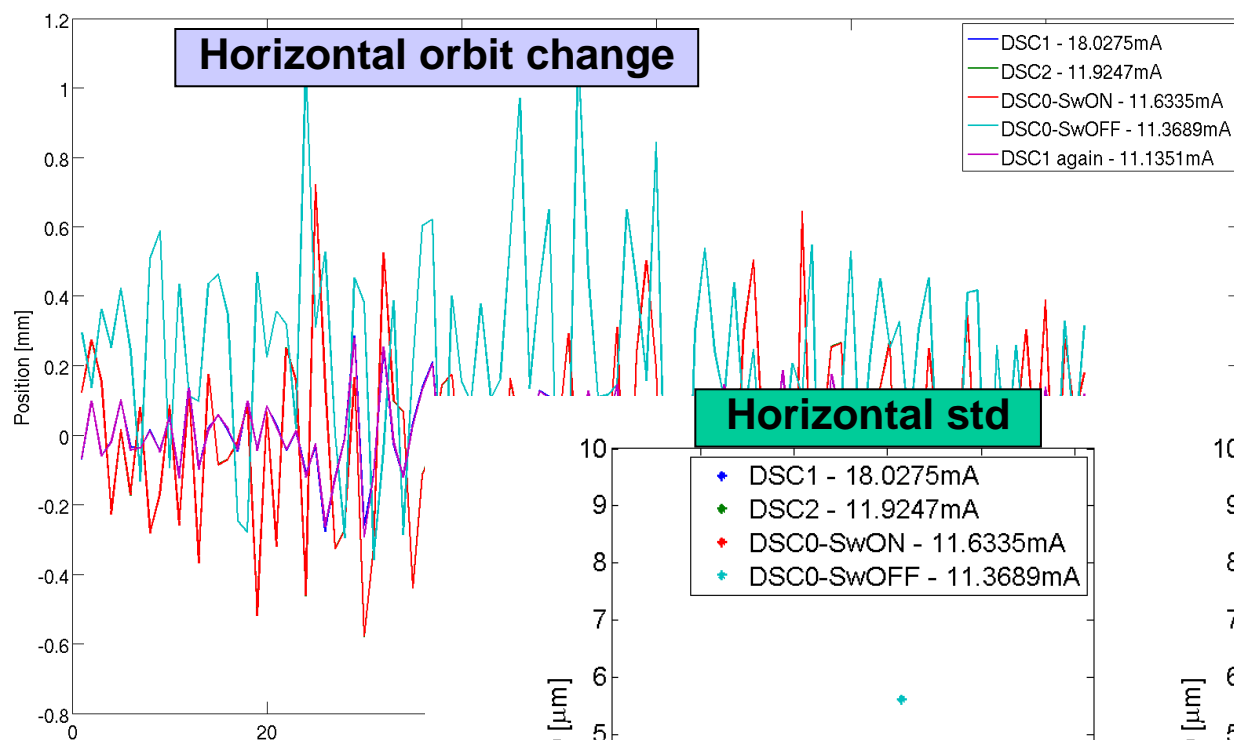
BPM0503

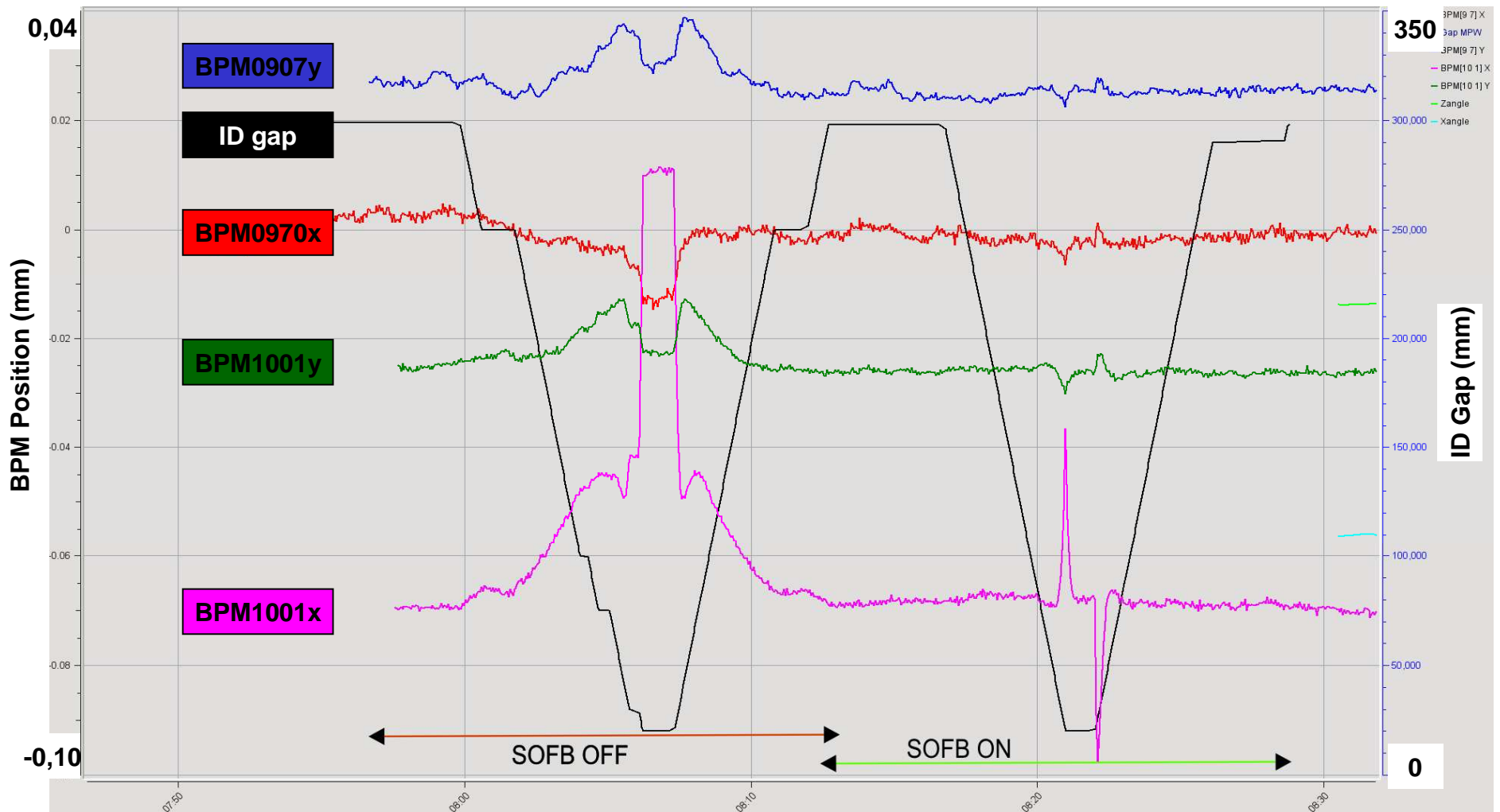


## Changing DSC / Switching



## Changing DSC / Switching



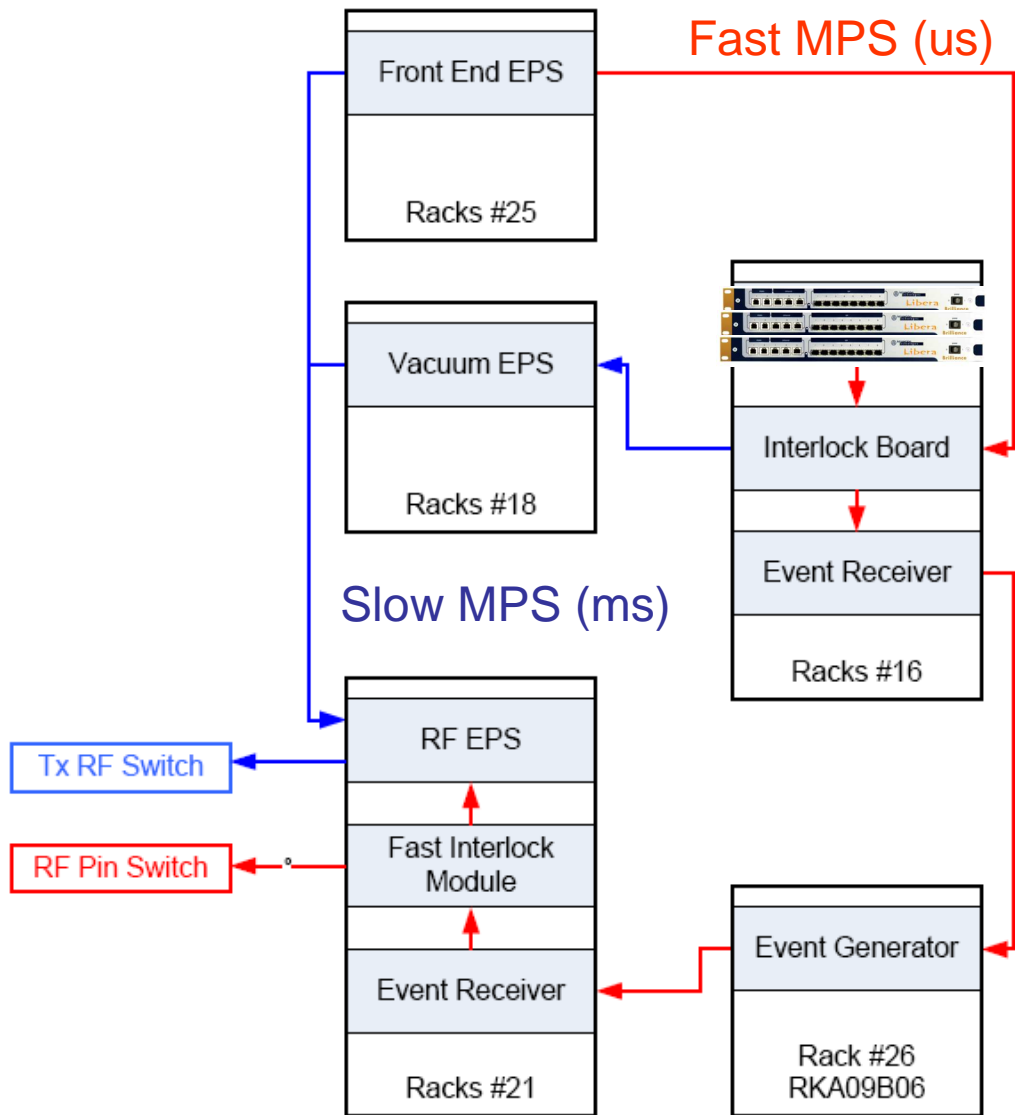


- Running inside Matlab Middle-Layer
- Tested for a few hours without problem
- Compensate the effect of the multipole wiggler
- 0.5Hz as fastest correction for the time being (problem reading/setting correctors)

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# MACHINE PROTECTION SYSTEM



Fast MPS → Through timing event system

Slow MPS → Through EPS PLCs bus

- FRONT END EPS**

*End switches*

  - 1<sup>st</sup> vacuum valve
  - Photon Shutter
  - 2<sup>nd</sup> vacuum valve
  - Protection Shutter
  - Fast vacuum valve

*Water flow switches*

  - All components before the photon shutter

*Vacuum pressure*

  - Vacuum gauges up to the fast valve

**SR VACUUM EPS**

*Vacuum pressure*

  - All vacuum gauges of the Storage Ring

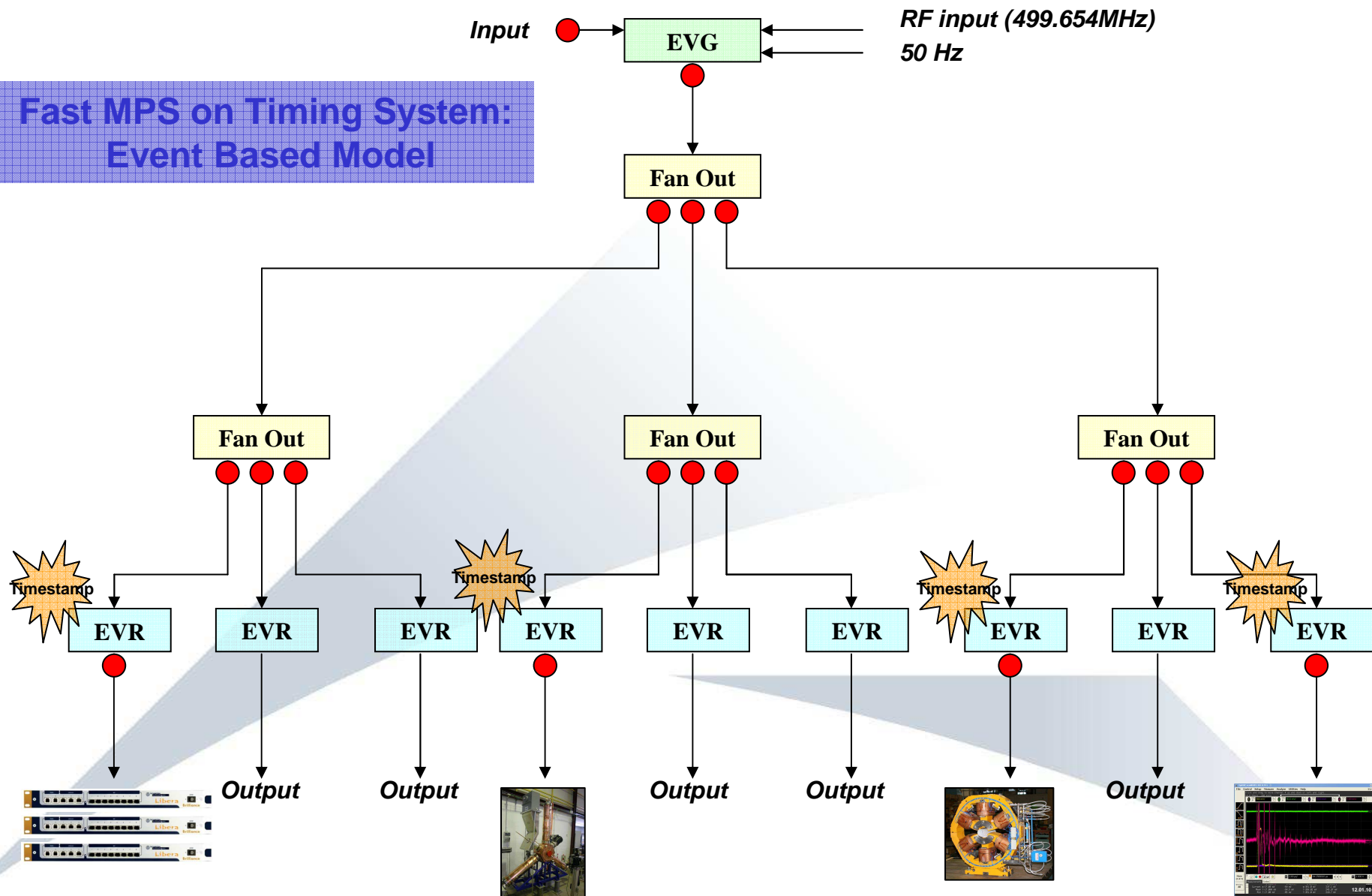
*Water flow switches*

  - All absorbers (crotch and longitudinal)

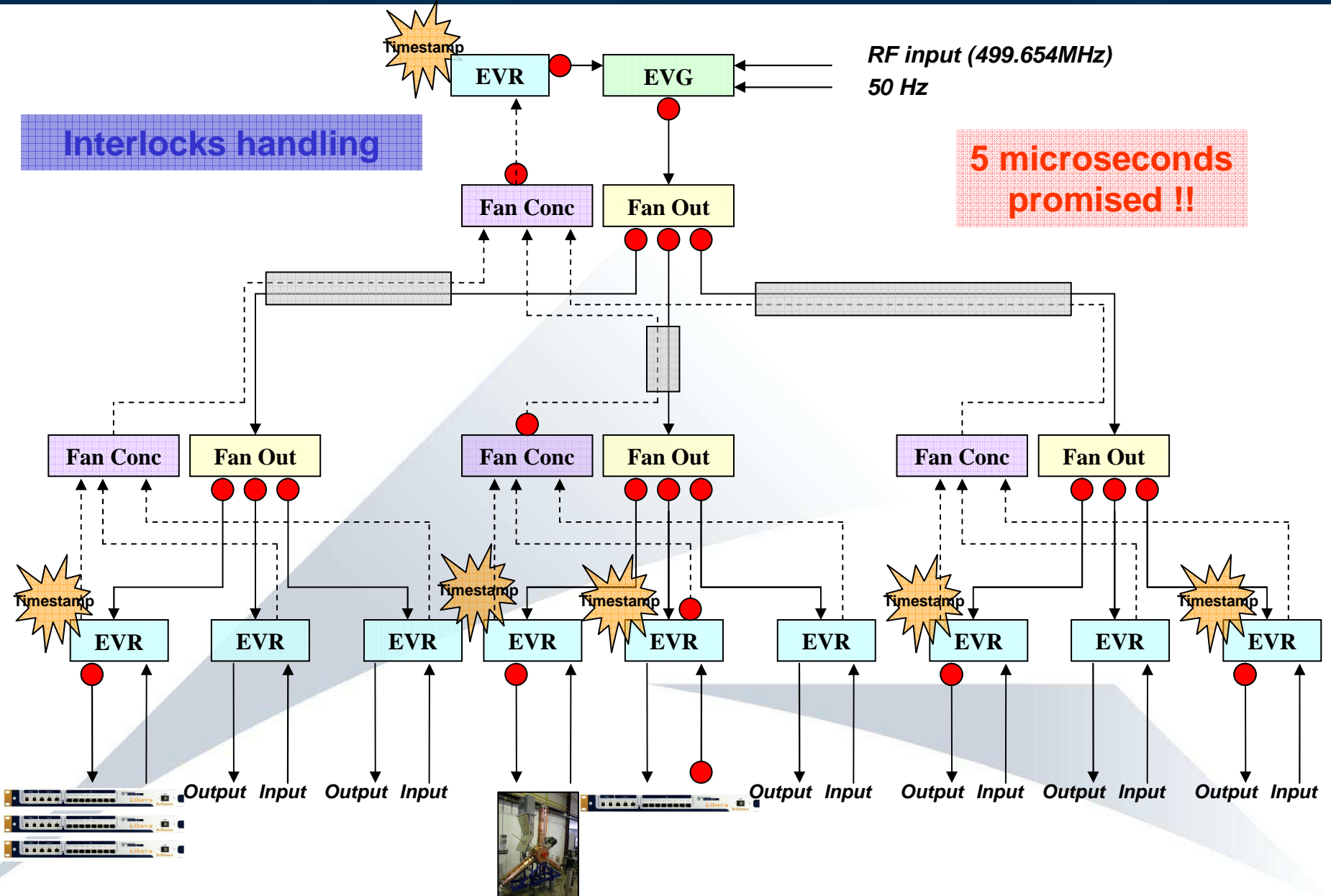
*Vacuum chamber temperature*

  - All thermocouples

Fast MPS on Timing System:  
Event Based Model



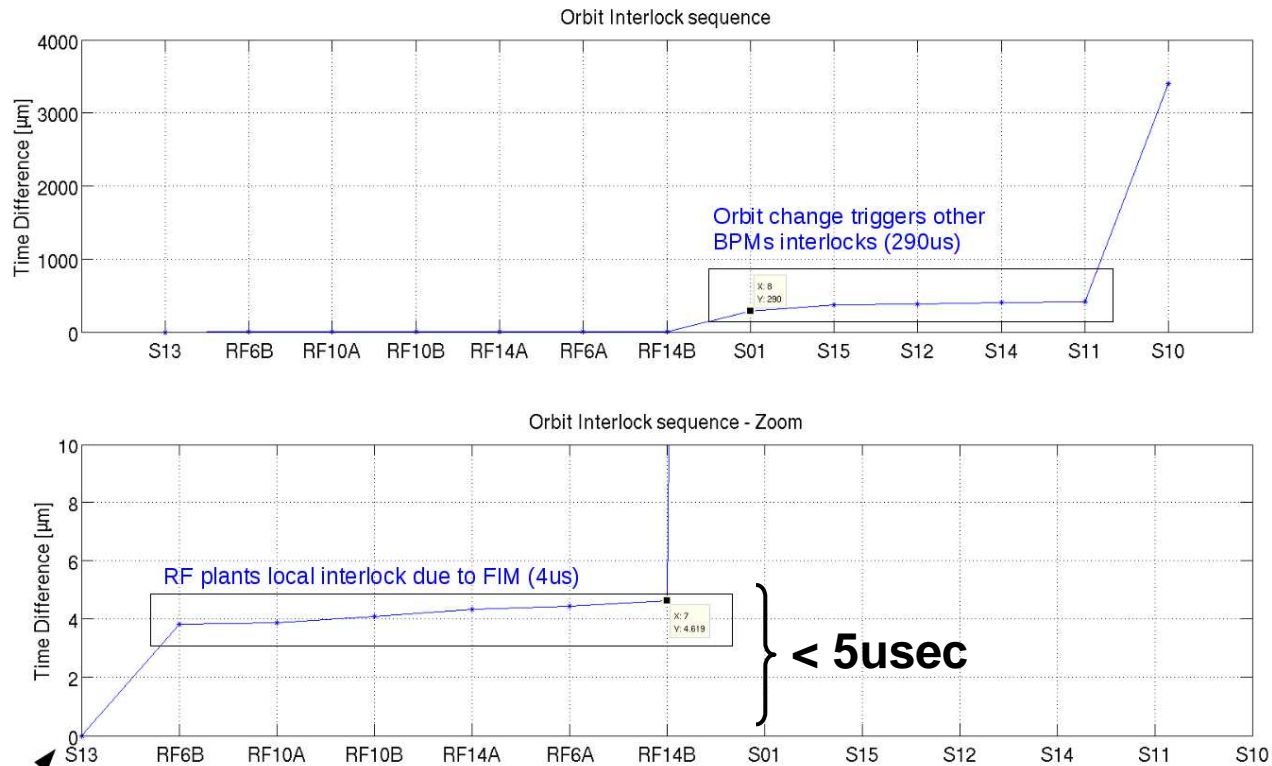
# MACHINE PROTECTION SYSTEM





## Example: Interlock while doing orbit bumps

Event code	Event
44	BPMs Inte
44	BPMs Inte
44	BPMs Inte
50	RF Plant 6
51	RF Plant 1
52	RF Plant 1
53	RF Plant 1
49	RF Plant 6
54	RF Plant 1
32	BPMs Inte
46	BPMs Inte
43	BPMs Inte
45	BPMs Inte
42	BPMs Inte
41	BPMs Inte



Orbit out of thresholds on sector S13

**Fast MPS detects an orbit interlock on sector S13**

--> Interlock event goes up to the Timing Generator and from there down to RF plants

--> RF plants are interlocked <5usec after interlock detection on sector S13 BPMs

--> Beam is killed by RF and 290us after that, the BPMs in other sectors detect the orbit out of thresholds and trigger their interlocks

## Content

- 1.) The ALBA project
- 2.) Booster Commissioning
- 3.) SR Commissioning
  - 3a.) Evolution
  - 3b.) Measurements
  - 3c.) Playing with BPMs
- 4.) Machine Protection System
- 5.) Problems with Liberas**
- 6.) FOFB system status

# PROBLEMS WITH LIBERAS

## MOVEMENT OF LIBERAS UP AND DOWN

- Initial installation of 120 Liberass on Storage Ring (one per BPM)
- 16 units moved to Booster for BO commissioning
- Same units later moved to Lab for testing purposes
- Swapping Liberass 3-4 on each Storage Ring sector (16 units)

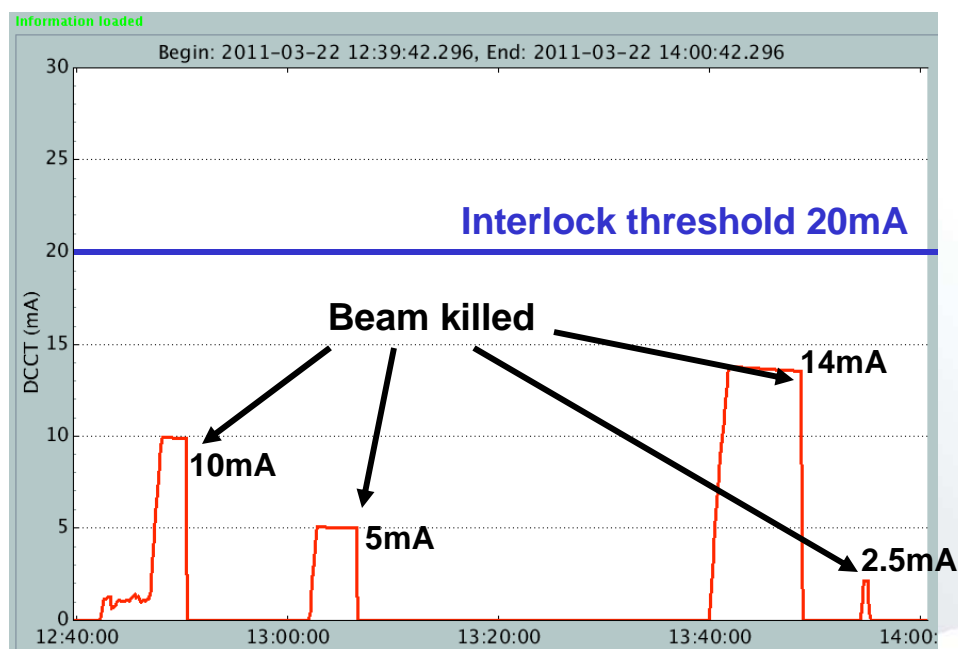
## MPS RELATED PROBLEMS

- Current dependence of position interlocking didn't work on day one
- AGC too slow for high injection rates

## MISCELLANEOUS

- Lost of Triggers and Post-Mortem events
- High ADC counts without beam
- Temperature regulation loops

## BPMs Interlock + Gain did not work for 1.82 release

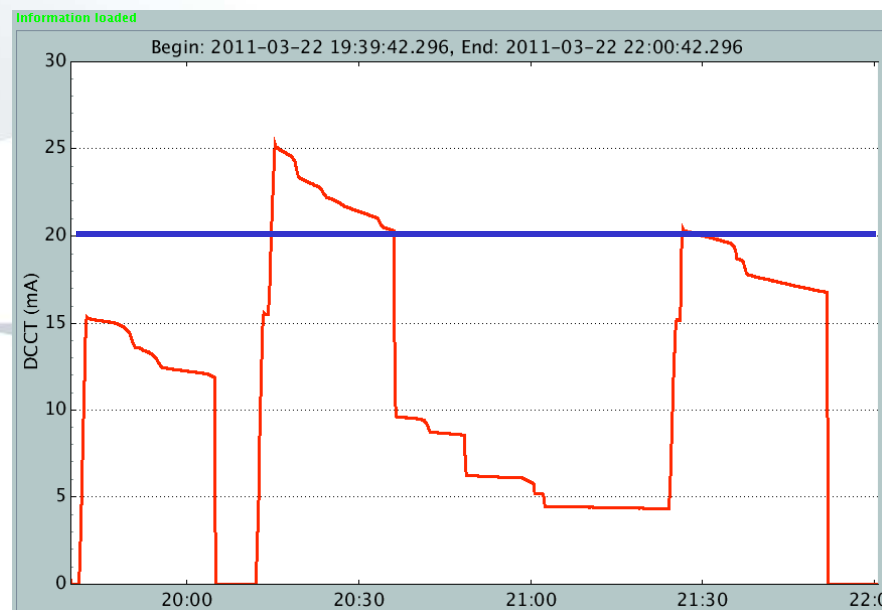


Beam being continuously killed even for currents below preset threshold

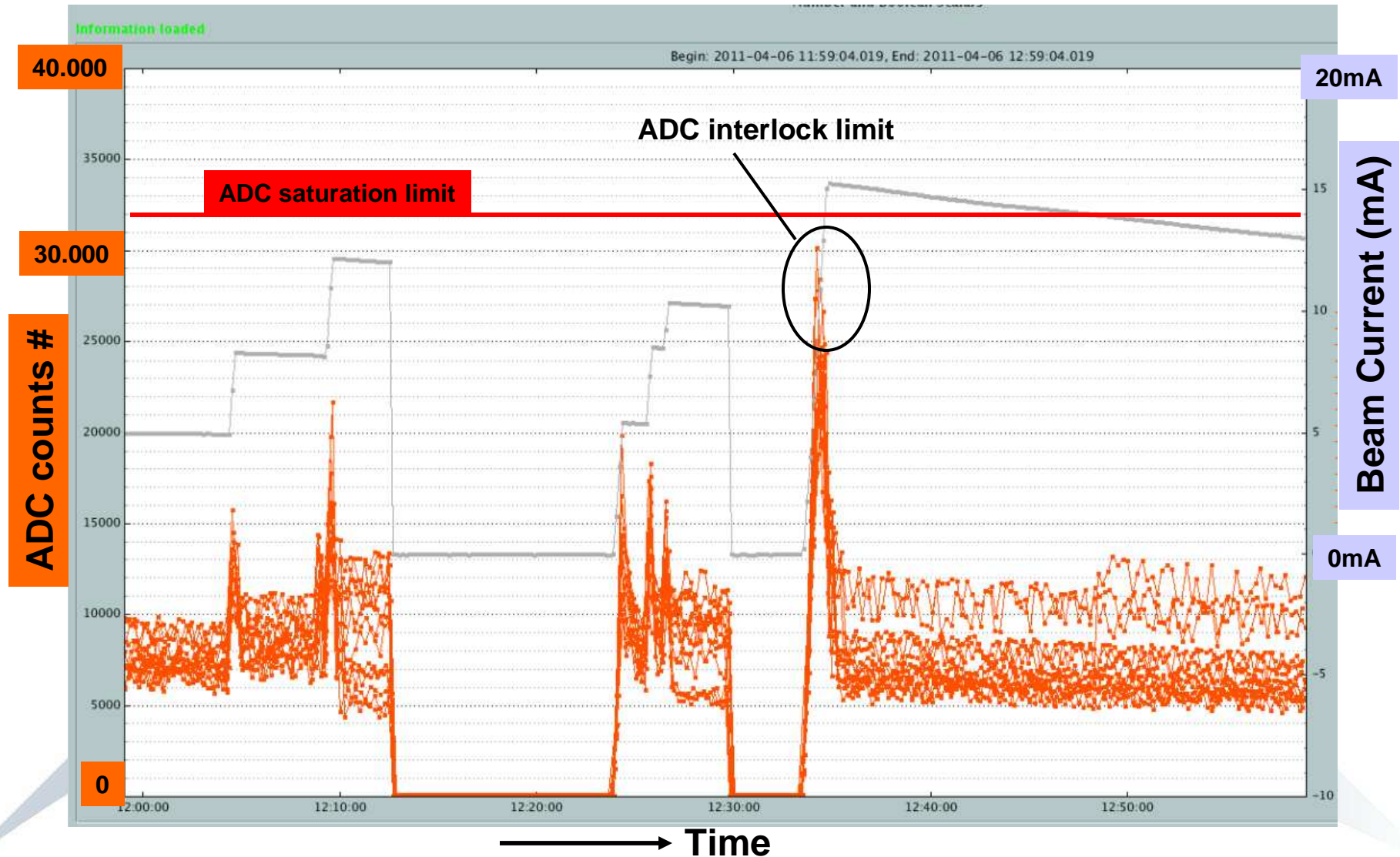
Liberas were *"the guilty guys"*

- We detect the problem on 21 March
- Informed ITech support team same day
- Patch on ITech server the day after
- Problem solved in the afternoon

Thanks guys  
for the effort



## AGC algorithm too slow on 1.82



## AGC algorithm too slow on 1.82

Before upgrade to 2.0

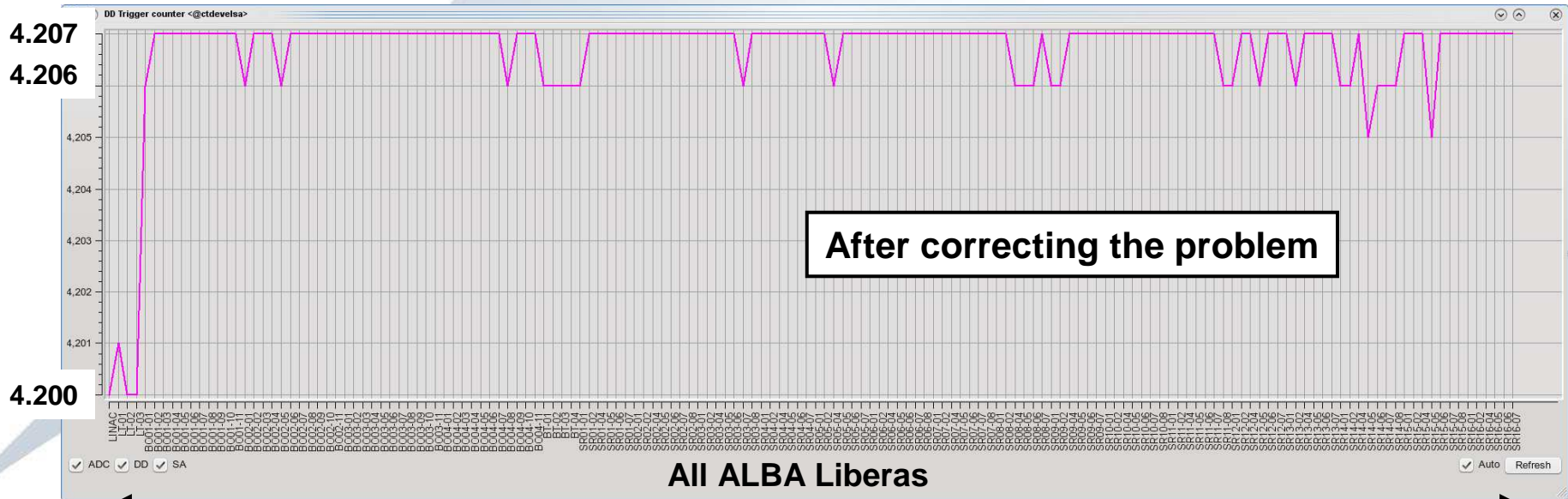


## AGC algorithm too slow on 1.82



# Lost of Events

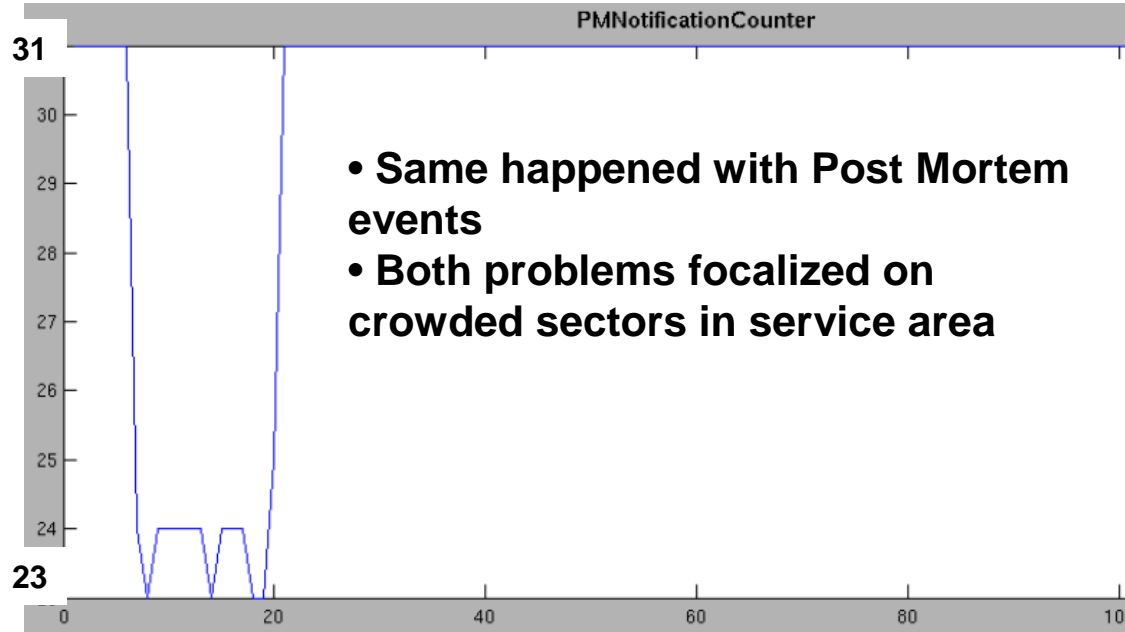
Libera Device Server loses many triggers while they do reach the Libera unit



All ALBA Liberass

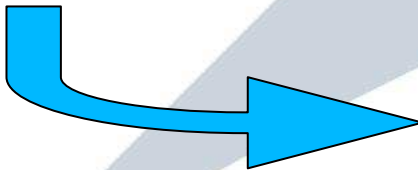


# Lost of Events



- Same happened with Post Mortem events
- Both problems focalized on crowded sectors in service area

- Multicast events of Liberas collapsed sectors sub-net
- *No SA events package* has been used to avoid so many multicast events

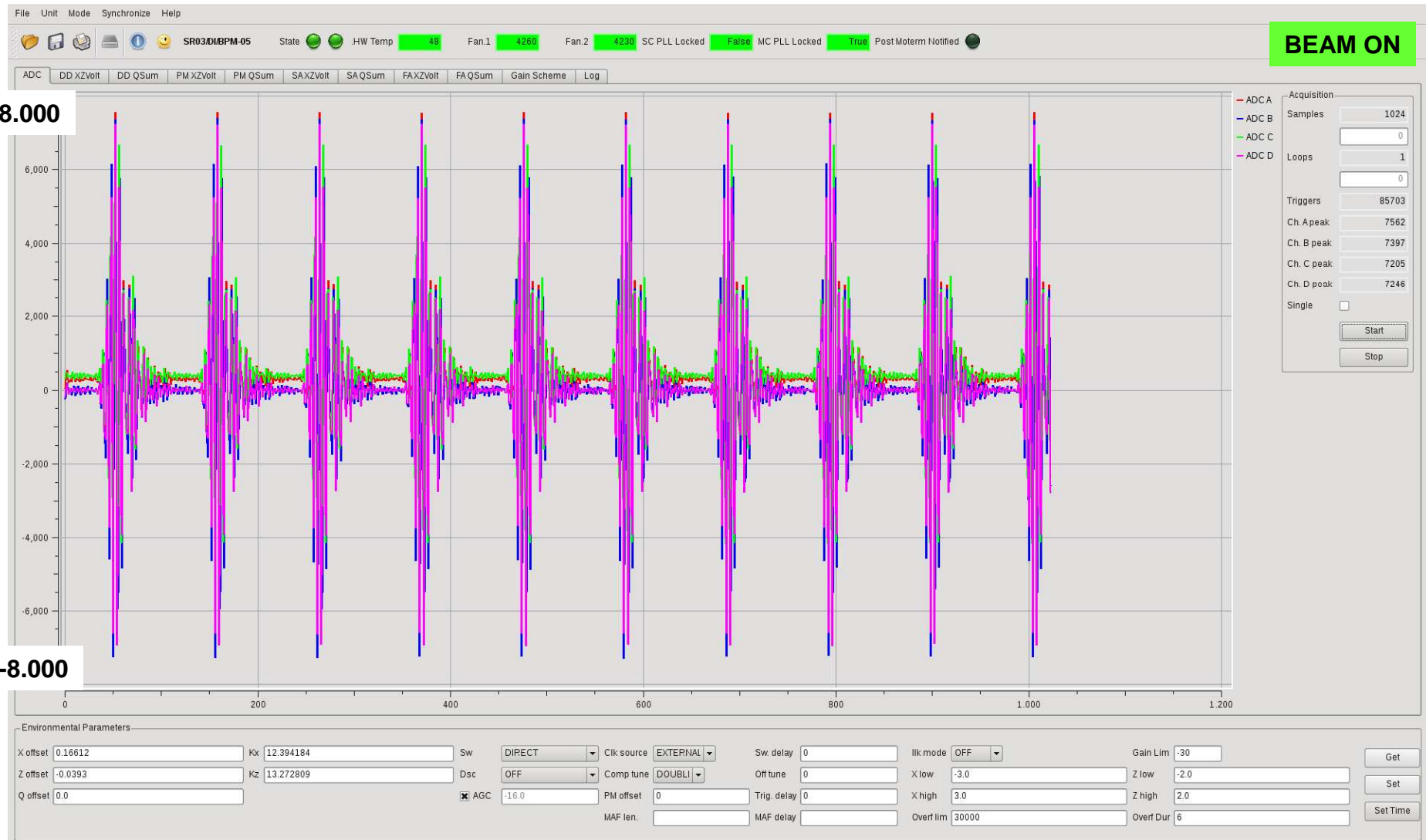


```

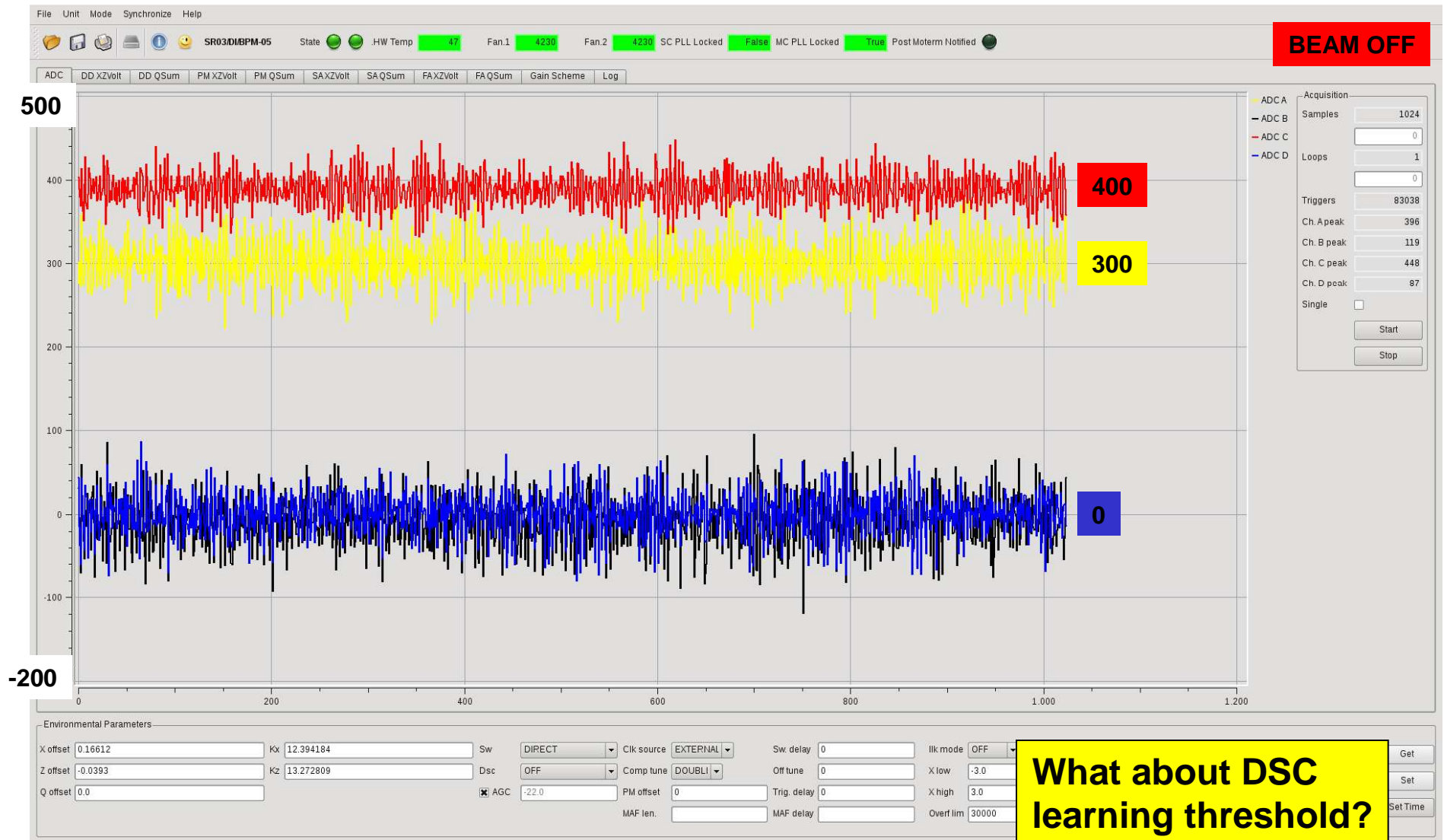
root@xcep:~#
root@xcep:~# test-event 0xffff
id = 64 (TRIGGET), param = 0 (-)
id = 64 (TRIGGET), param = 0 (-)
id = 64 (TRIGGET), param = 0 (-)
id = 64 (TRIGGET), param = 0 (-)
id = 64 (TRIGGET), param = 0 (-)
id = 64 (TRIGGET), param = 0 (-)
id = 64 (TRIGGET), param = 0 (-)
id = 64 (TRIGGET), param = 0 (-)
id = 64 (TRIGGET), param = 0 (-)
id = 64 (TRIGGET), param = 0 (-)
id = 64 (TRIGGET), param = 0 (-)
root@xcep:~#
    
```

```

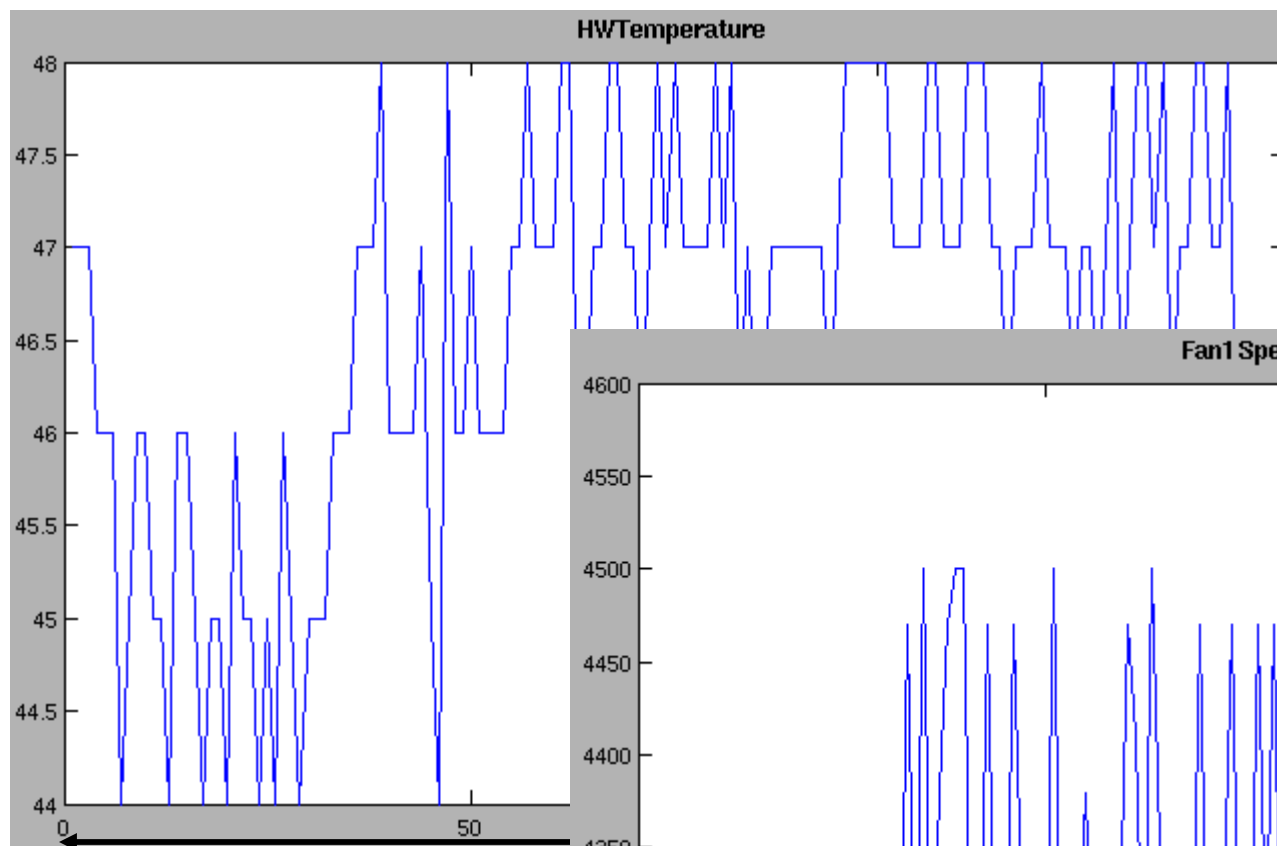
id = 4 (SA), param = 1 (-)
id = 4 (SA), param = 1 (-)
id = 4 (SA), param = 1 (-)
id = 64 (TRIGGET), param = 0 (-)
id = 4 (SA), param = 1 (-)
id = 4 (SA), param = 1 (-)
id = 4 (SA), param = 1 (-)
id = 4 (SA), param = 1 (-)
id = 4 (SA), param = 1 (-)
id = 4 (SA), param = 1 (-)
id = 4 (SA), param = 1 (-)
id = 16 (PM), param = 16384 (-)
id = 4 (SA), param = 1 (-)
id = 4 (SA), param = 1 (-)
id = 4 (SA), param = 1 (-)
id = 4 (SA), param = 1 (-)
id = 64 (TRIGGET), param = 0 (-)
id = 4 (SA), param = 1 (-)
id = 4 (SA), param = 1 (-)
id = 4 (SA), param = 1 (-)
id = 4 (SA), param = 1 (-)
id = 4 (SA), param = 1 (-)
root@xcep:~#
    
```



# High ADC counts w.o. Beam



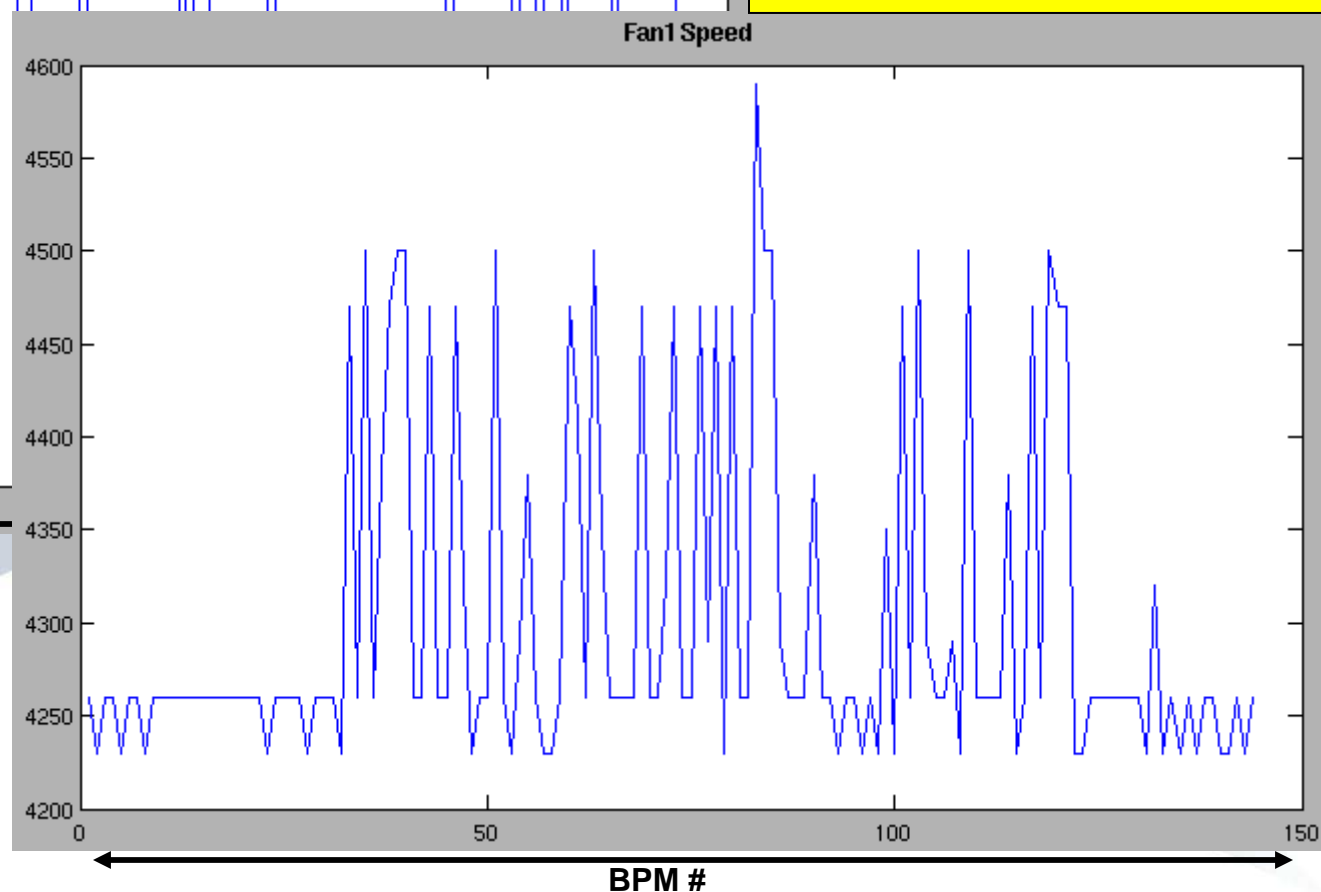
# Temperature regulation



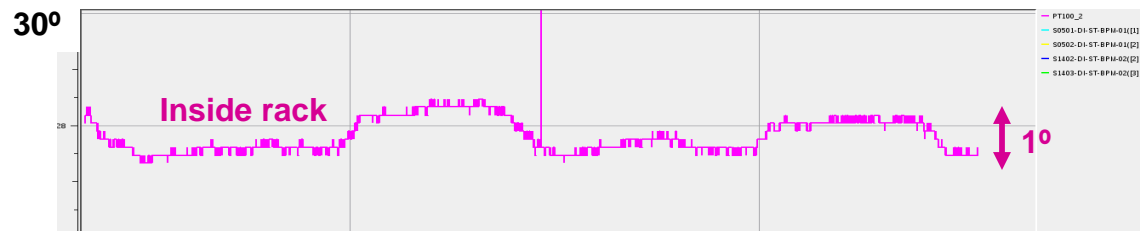
**ALBA Liberas  
normal operation**

Temp from 44° to 48°

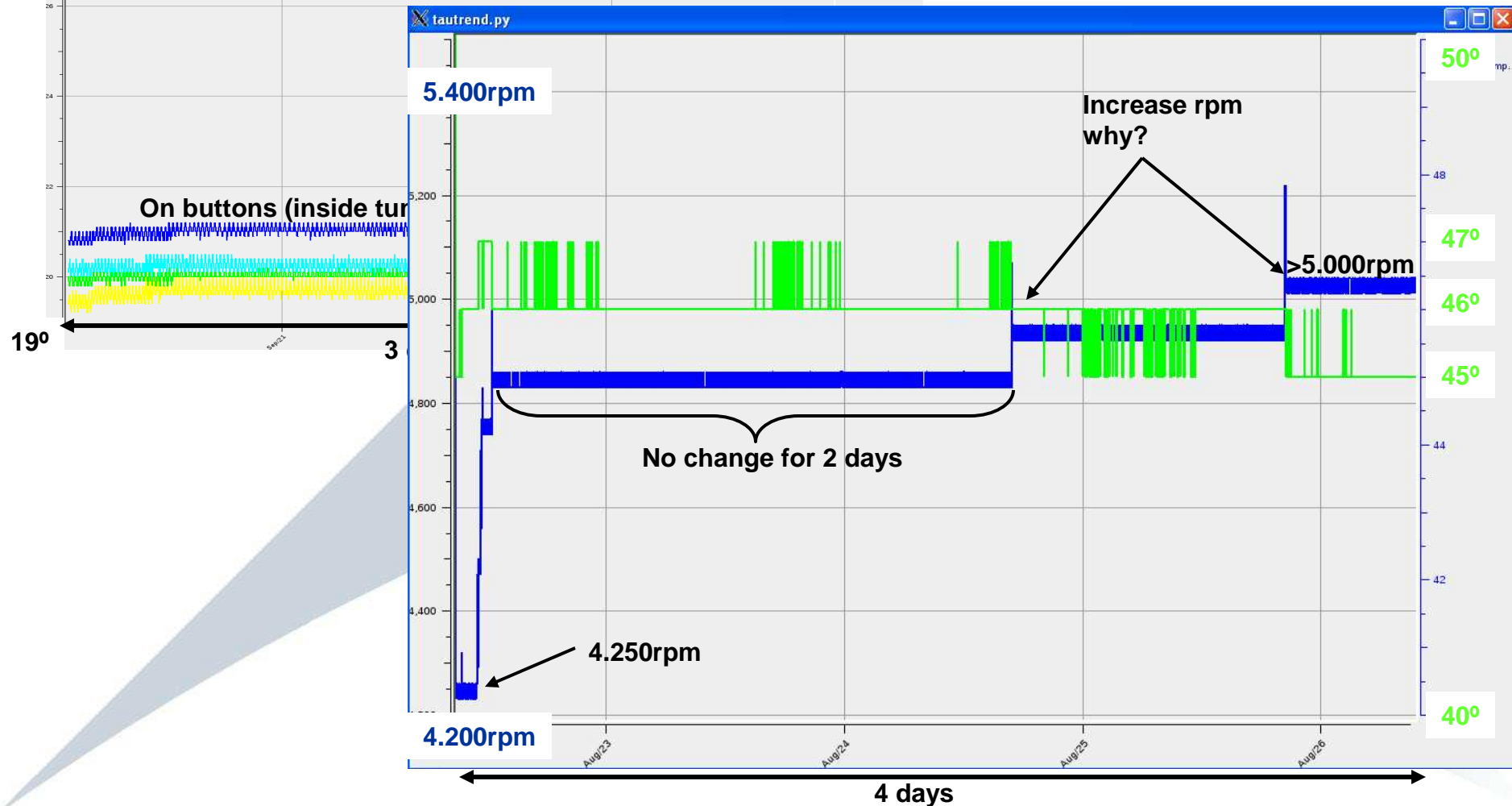
RPM from 4.200 to 4.600



# Temperature regulation



Some Liberas do weird control

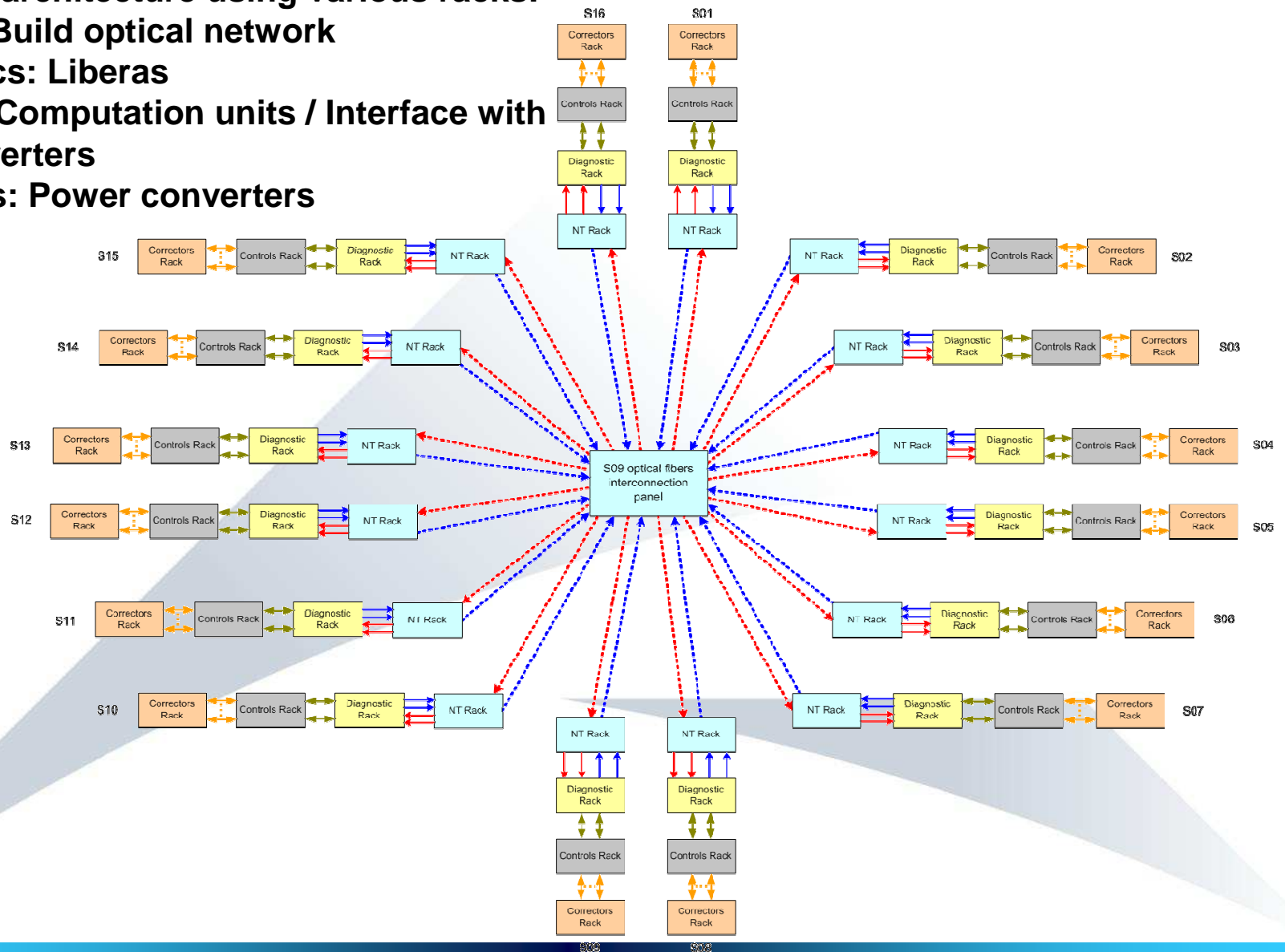


## Content

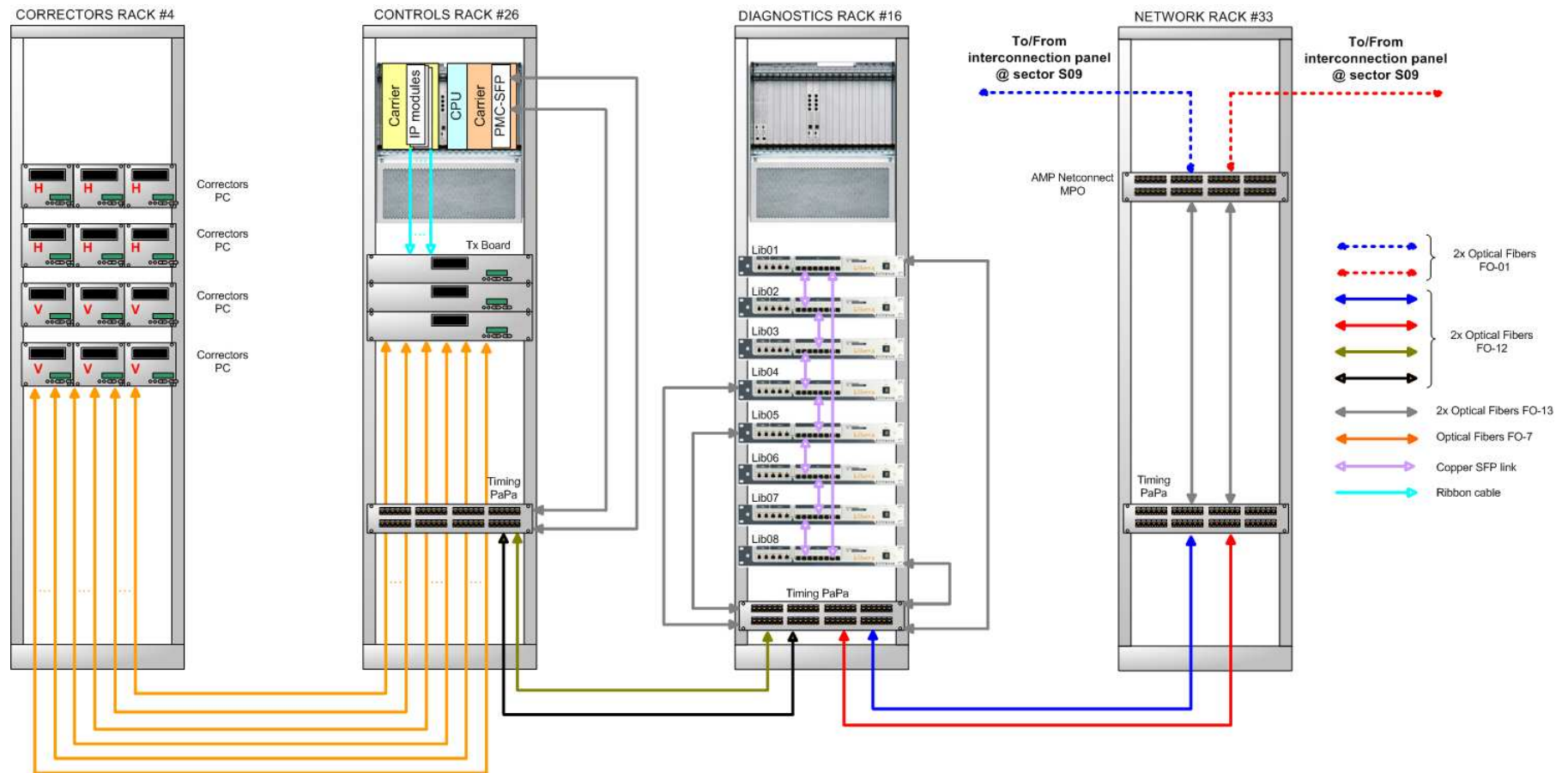
- 1.) The ALBA project
- 2.) Booster Commissioning
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## Distributed architecture using various racks:

- Network: Build optical network
- Diagnostics: Liberas
- Controls: Computation units / Interface with power converters
- Correctors: Power converters



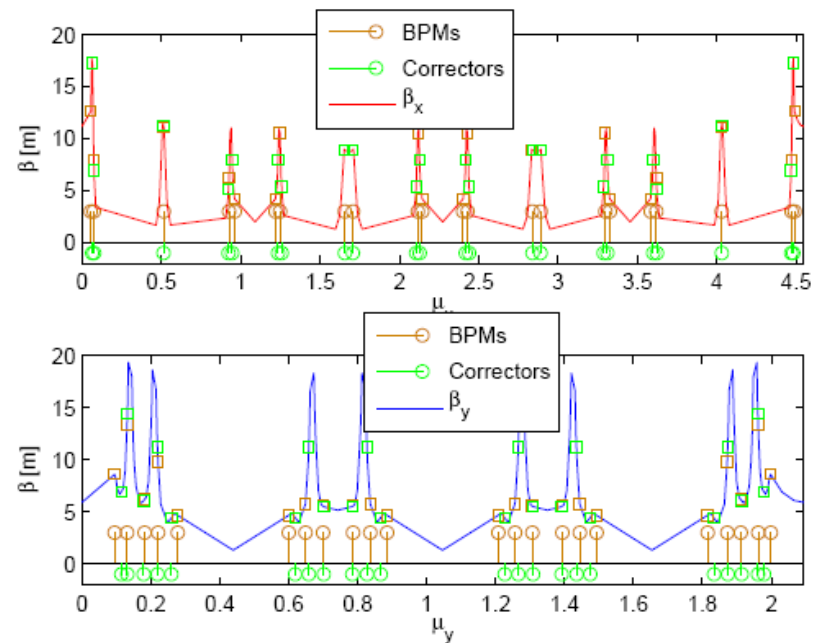
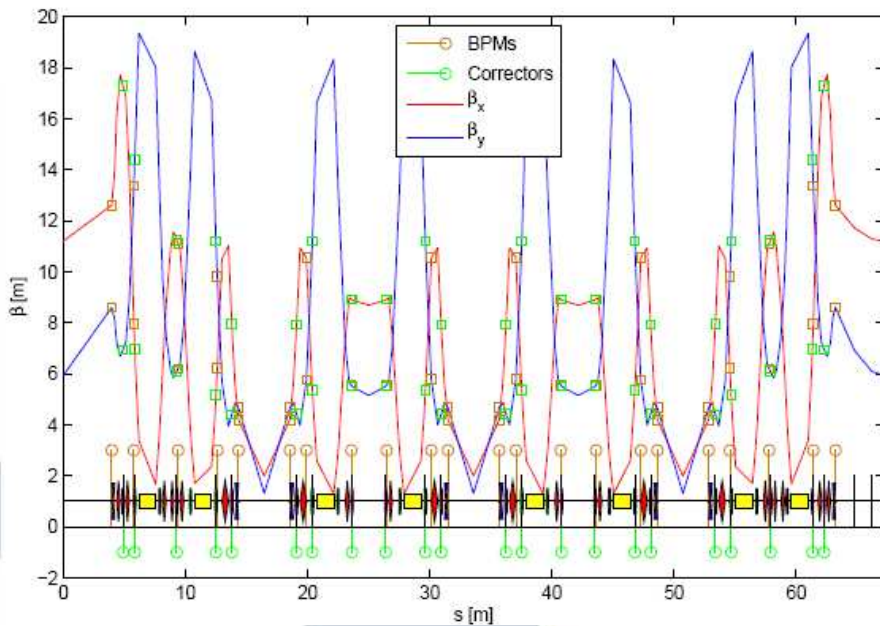
## ONE SECTOR DEVICES AND CONNECTIONS





## CORRECTION CALCULATION

- Even though we have 104 (120) BPMs and their corresponding Liberass, only position data from 88 BPMs will be used for orbit correction → **Why?**



- Representation of  $\beta$  functions vs. phase advance shows that some BPMs give almost the same information (same info = no info)

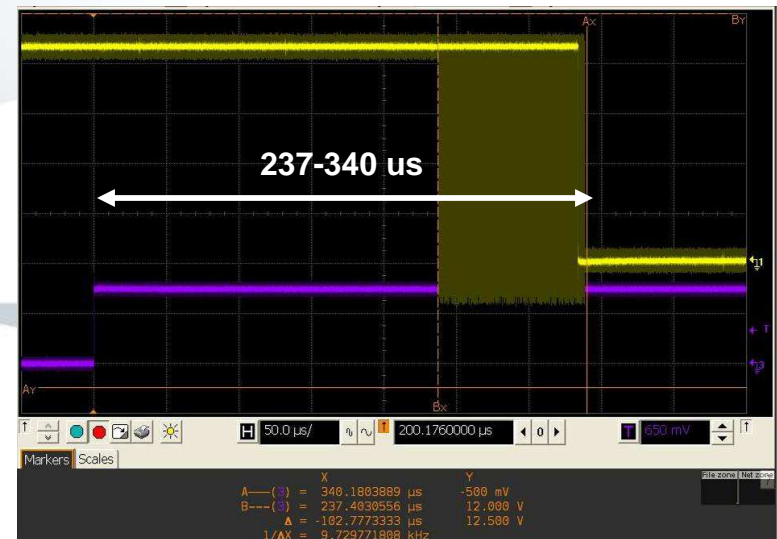
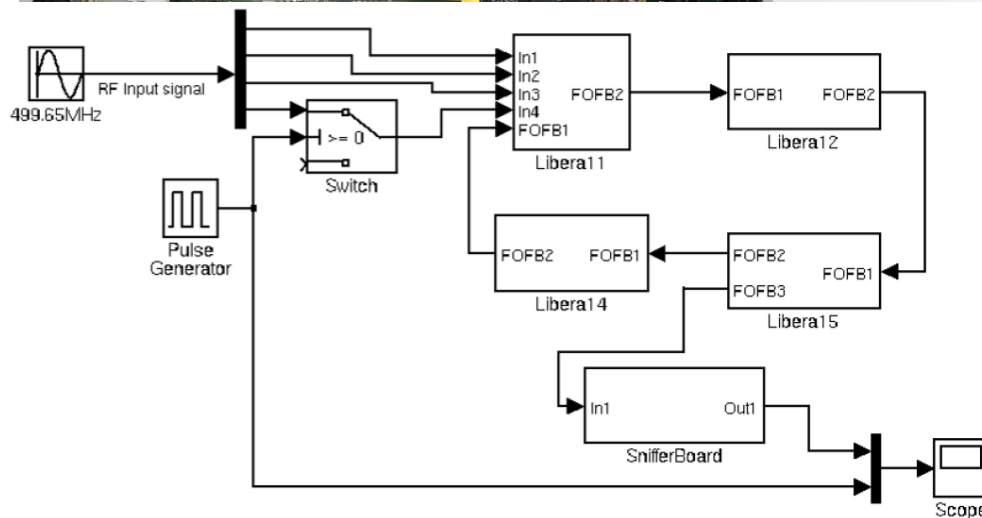
“Possible fights between BPMs / Correctors”, Beam dynamics people

## BPMs DATA TRANSFER

- Distribution of data using Diamond Communication Controller
- ESRF lend us one of their sniffers Virtex-II FPGA boards for testing purposes

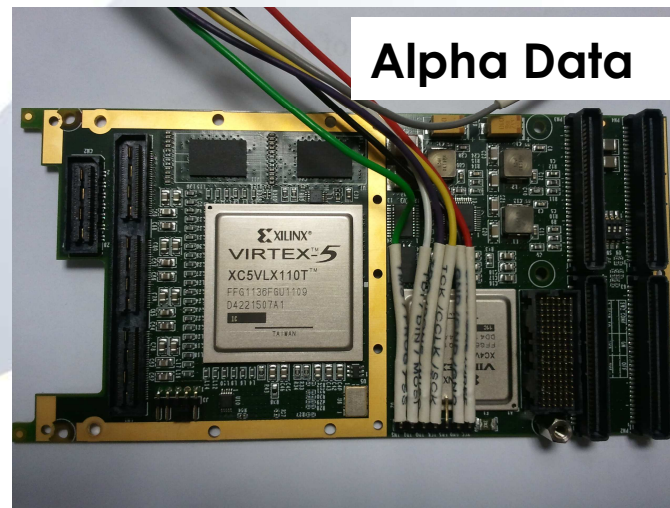
- 1- Modify sniffer code for latency meas. on ALBA design
- 2- 10sec of FA data using Device Server not yet done

### Curtiss Wright



## BPMs DATA TRANSFER

- Market survey to analyze FPGA vendors and models
- Decision to buy Virtex-5 Alpha Data ADM-XRC-5T1
- Prototype unit + carrier **on stock** (Curtiss Wright 20 weeks delivery)
- 16 units: **8-10 weeks delivery** (Curtiss Wright 20 weeks)
- Price for 16 boards + carriers **33% cheaper**



- **Wrong delivered carrier**
- **2 months delay** for optical SFP transceivers





# Next steps

- Keep on with SR & Beamlines commissioning
- Slow orbit feedback
- Vacuum cleaning
- Better control of filling pattern

- Fast orbit feedback
- Multibunch feedback
- Topping up
- ...

## Beamtime Calender, March 2011-December 2011 (final)

SR commissioning	SR	SR commissioning
BL commissioning	BL	BL commissioning
Users operation	UO	User Operation
Shut down	NO	No accelerator operation
Holiday		
Hardware test	HW	No accelerator operation, but I/O Installation, DC tests

	March	April	May	June	July	Aug.	Set.	Oct.	Nov.	Dec.
Weekday	Uay Week	1-10 15-22 Uay Week	1-10 15-22 Uay Week	1-10 15-22 Uay Week	1-10 15-22 Uay Week	1-10 15-22 Uay Week	1-10 15-22 Uay Week	1-10 15-22 Uay Week	1-10 15-22 Uay Week	1-10 15-22 Uay Week
Mo	9					1 31	HW HW			
Tu	1	BO				2	HW HW		1	
We	2	BO	SR	Off	1 SR	3	Off		2	BL
Th	3	BO			2 SR	4	Off	LI BO	3	SR
Fr	4				3 SR	5			4	BL
Sa	5				4 SR	6			5	
Su	6				5 SR	7			6	
Mo	7 10				6 23	HW HW	4 27	HW HW	8 32	HW HW
Tu	8	SR			7 SR	HW HW	5	Off	9	Off
We	9	SR	SR	Off	8 SR	HW HW	6	Off	10	Off
Th	10	SR	SR		9 SR	HW HW	7	Off	11	Off
Fr	11	SR	SR		10 SR	HW HW	8	Off	12	Off
Sa	12	SR	SR		11	HW HW	9		13	
Su	13	SR	SR		12	HW HW	10		14	
Mo	14 11	SR	SR		13 24	HW HW	11 28	HW HW	15 33	HW HW
Tu	15	SR	SR		14	HW HW	12	Off	16	Off
We	16	SR	SR	Off	15	HW HW	13	Off	17	Off
Th	17	SR	SR		16	HW HW	14	Off	18	Off
Fr	18	SR	SR		17	HW HW	15	Off	19	Off
Sa	19	SR	SR		18	HW HW	16		20	
Su	20	SR	SR		19	HW HW	17		21	
Mo	21 12	SR	SR		20 25	HW HW	18 29	HW HW	22 34	SR
Tu	22	SR	SR	Off	21	HW HW	19	Off	23	LI BO
We	23	SR	SR		22	HW HW	20	Off	24	RF
Th	24	SR	SR		23	HW HW	21	Off	25	RF
Fr	25	SR	SR		24	HW HW	22	Off	26	RF
Sa	26	SR	SR		25	HW HW	23		27	
Su	27	SR	SR		26	HW HW	24		28	
Mo	28 13	SR	SR		27 26	HW HW	25 30	HW HW	29 35	SR
Tu	29	SR	SR	Off	28	HW HW	26	Off	30	LI BO
We	30	SR	SR		29	HW HW	27	Off	31	LI BO
Th	31	SR	SR		30	HW HW	28	Off		
Fr		SR	SR			HW HW	29	Off		
Sa		SR	SR			HW HW	30			
Su		SR	SR			HW HW	31			
Mo					30 22	SR			31 44	
Tu					31	SR				

Status 24.02.2011

Week 16 Easter  
 Week 20 Tunnel closed, all services available, Power Supplies Test  
 Weeks 23-33 Installation of in-vacuum and SCW  
 Week 36 Tunnel closed, all services available, Power Supplies Test

**SR** 13 weeks

**BL** 7 weeks

**Off** 19 weeks

**LI BO** 3 weeks

**US** 3 weeks

## **Commissioning**

ALBA Accelerators and Controls teams

## **Slides providers**

F. Perez, D. Einfeld, U. Iriso, M. Muñoz, O. Matilla

## **Computing support**

J. Moldes, M. Niegowski, R. Montaña

## **FOFB**

J.M. Koch, F. Epaud, X. Serra, J. Moldes, O. Matilla, G. Rehm,  
K. Scheidt, N. Hubert, ...

## **I-Tech support team**



