LIBERAs @ ALBA

Libera Workshop'16

A. Olmos

Content

ALBA Status


Current 128.49 mA
Life Time 21h 47m (2771)
Pressure 4.2e-10 mbar
Current
MIRAS BL01 Open M1 23.00 mm
MSPD FE04 Open SCW30 B = 2.102 T
MISTRAL FE09 Open BEND
NCD FE11 Open IVU21 5.87 mm
XALOC FE13 Open IVU21 6.68 mm
CLAESS FE22 Open MPW80 12.90 mm
CIRCE FE24 Open EU62 40.12 mm
BOREAS FE29 Open EU71 44.75 mm
Thursday 09-Jun-2016 14:21:30
Beam for BLs. Top-up.

Content

FOFB – At a glance

GOAL: Achieve orbit stability on the sub-micron level up to frequencies in the 100 Hz range

88 eBPMs (out of 120) and 88 H/V correctors distributed in 16 cells

One xBPM from a Bending Beamline

Liberas running Diamond Communication Controller protocol for data transfer

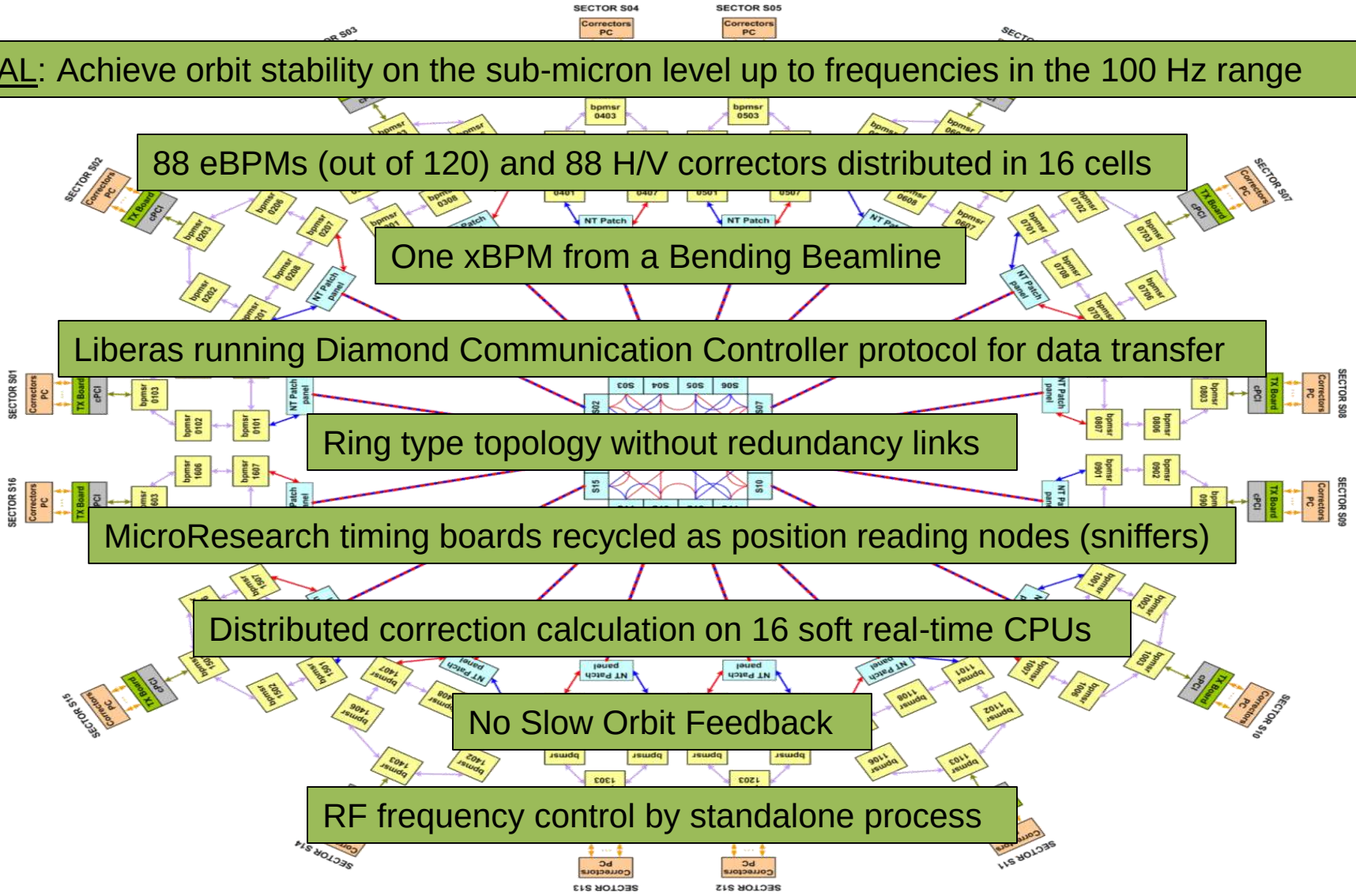
Ring type topology without redundancy links

MicroResearch timing boards recycled as position reading nodes (sniffers)

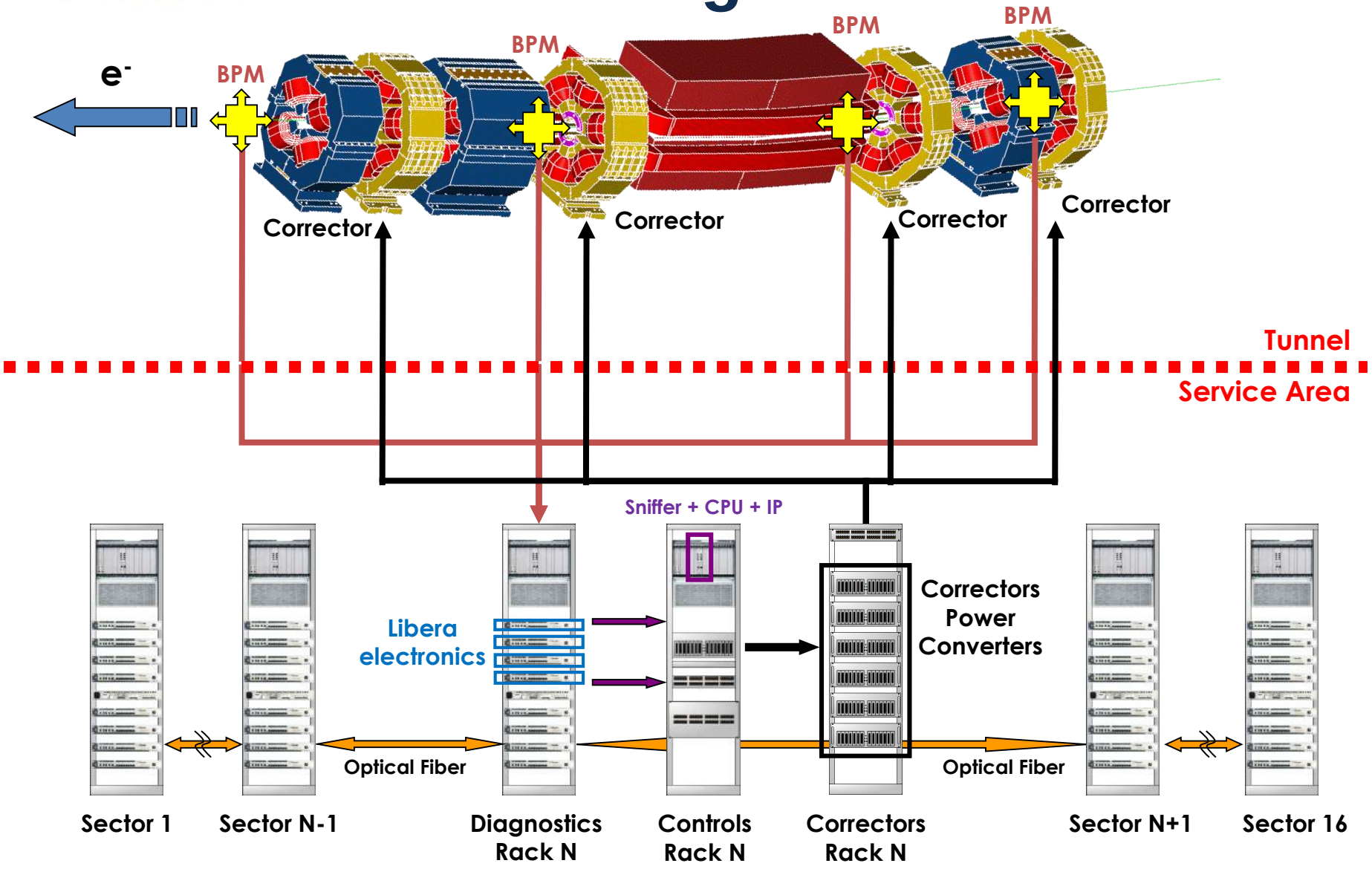
Distributed correction calculation on 16 soft real-time CPUs

No Slow Orbit Feedback

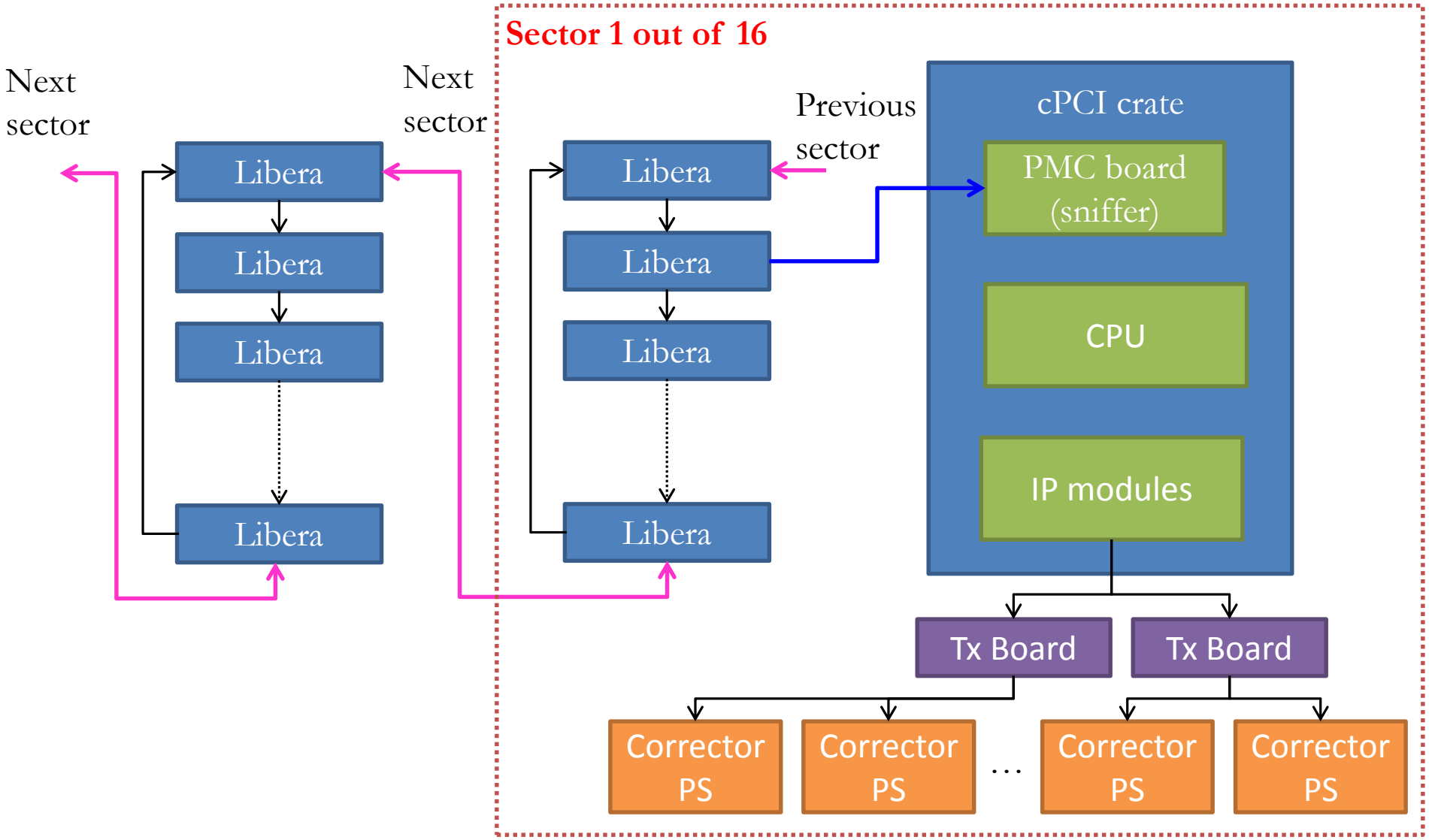
RF frequency control by standalone process



FOFB – At a glance



FOFB – At a glance



Content

FOFB – Equipments

BPM electronics

Libera Brilliance release 2.09 / Libera Photon release 2.41

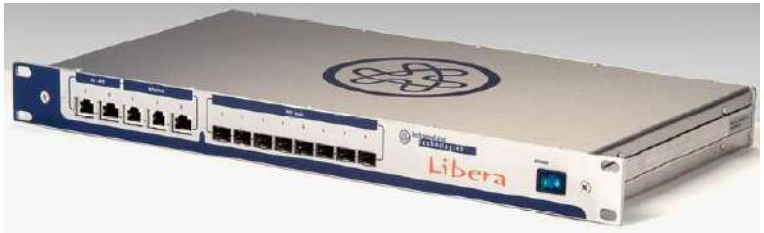
Diamond Communication Controller to handle the position data transfer between units

Optical links from 2 Liberas on each sector are laid to a central patch panel

Routing of each link can be done from-to any sector

A ring-type topology is currently used: Next <--> Previous sectors

Only one optical link is used to send BPMs data to the Sniffer Card



FOFB – Equipments

Sniffer Cards

Electronics that “sniff” the position data of all Liberas @ 10 kHz rate

Decision to re-use some Micro-Research EVR-230 boards that we had in-house

These boards were meant for timing purposes on Beamlines but never installed

Only have one optical link for position data transfer

No redundancy and so low FOFB reliability

Xilinx Virtex-II FPGA is an already obsolete device

Kind integration of CC done by Diamond

The boards were already known by ALBA controls staff

Significant overall cost reduction of the FOFB

FOFB – Equipments

Correction Calculation CPU

Retrieves the position data from the Sniffer Card and performs the calculation of the needed correction setpoints

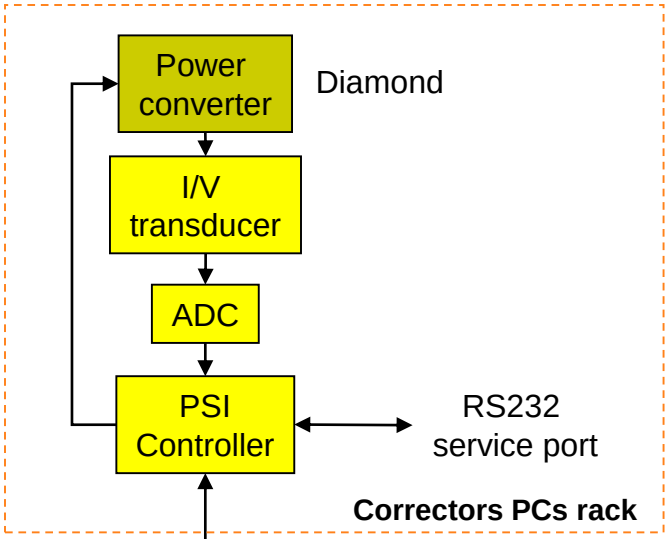
Adlink 4-Cores cPCI-3970 CPU running soft real time Linux 2.6.27

Different Kernel and Linux OS versions were tested because the handling of the interruptions forced CPU dead-times

Processes distributed to different Cores (Read BPM, Calculation, CPU-cPCI stuff)

FOFB – Equipments

Power Converters

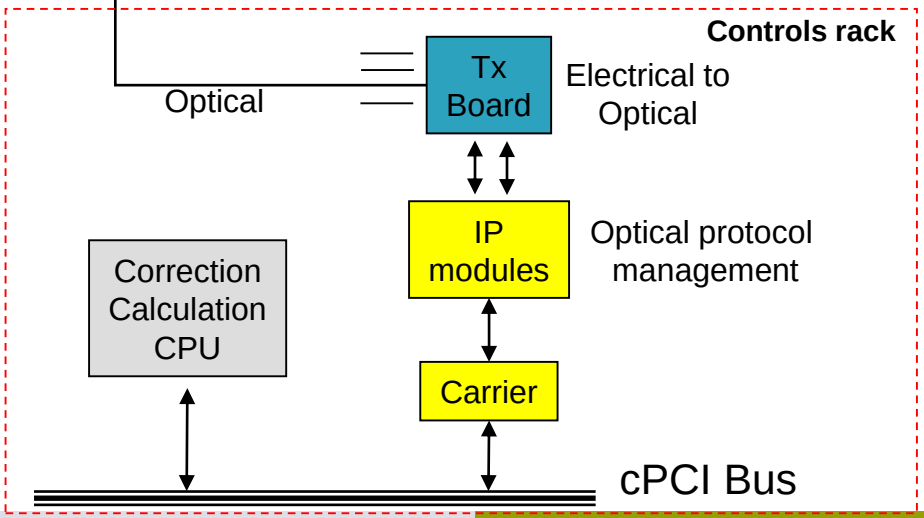


Power Supplies provided by OCEM company

Controller provided by PSI

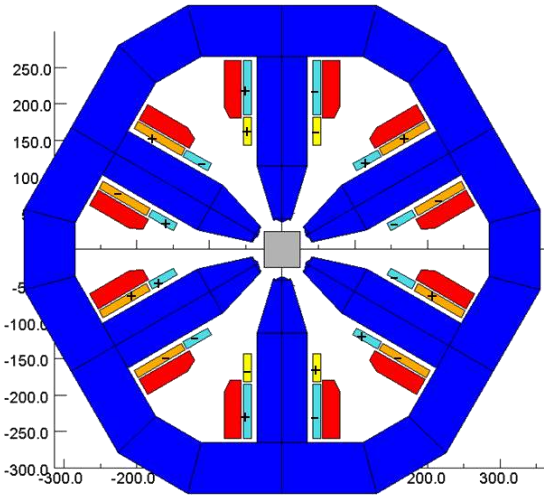
Provide ±1mrad of DC deflection and ±40µrad @ 100Hz

1kHz Bandwidth / 18 bits Resolution



FOFB – Equipments

Correctors Magnets



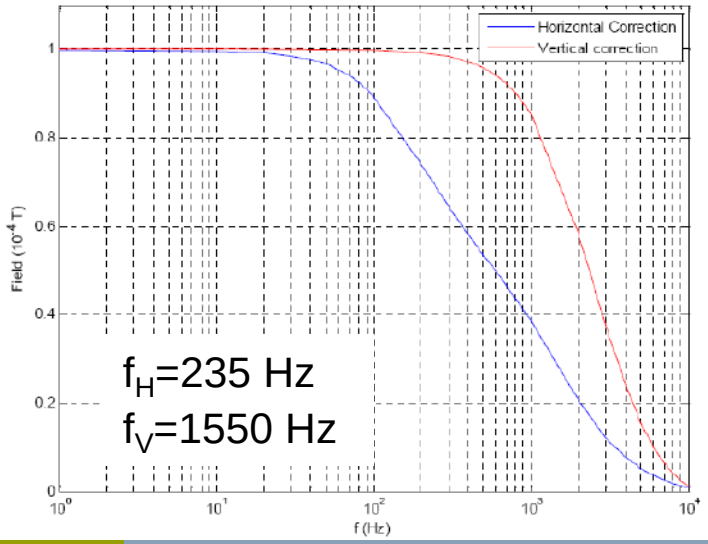
Horizontal Steering

Vertical Steering

Sextupoles have extra wiring to provide H/V beam steering

Eddy currents on the vacuum chamber reduce the effect of the magnetic field at high frequencies

To have a more effective penetration field, chamber thickness was reduced to 2mm in the correctors



Content

FOFB – Implementation

PI control loop + SVD matrix calculation

$$\begin{bmatrix} Ex_6 \\ Ex_7 \\ Ex_8 \\ Ex_9 \\ Ex_{10} \\ Ex_{11} \end{bmatrix} = \begin{bmatrix} iRx_{6,1} & iRx_{6,2} & \cdots & Rx_{6,88} \\ iRx_{7,1} & iRx_{7,2} & \cdots & iRx_{7,88} \\ iRx_{8,1} & iRx_{8,2} & \cdots & iRx_{8,88} \\ iRx_{9,1} & iRx_{9,2} & \cdots & iRx_{9,88} \\ iRx_{10,1} & iRx_{10,2} & \cdots & iRx_{10,88} \\ iRx_{11,1} & iRx_{11,2} & \cdots & iRx_{11,88} \end{bmatrix} * \begin{bmatrix} Dx_1 \\ Dx_2 \\ Dx_3 \\ Dx_4 \\ \vdots \\ Dx_{85} \\ Dx_{86} \\ Dx_{87} \\ Dx_{88} \end{bmatrix}$$

$$\begin{bmatrix} Ez_6 \\ Ez_7 \\ Ez_8 \\ Ez_9 \\ Ez_{10} \\ Ez_{11} \end{bmatrix} = \begin{bmatrix} iRz_{6,1} & iRz_{6,2} & \cdots & iRz_{6,88} & iRz_{6,89} \\ iRz_{7,1} & iRz_{7,2} & \cdots & iRz_{7,88} & iRz_{7,89} \\ iRz_{8,1} & iRz_{8,2} & \cdots & iRz_{8,88} & iRz_{8,89} \\ iRz_{9,1} & iRz_{9,2} & \cdots & iRz_{9,88} & iRz_{9,89} \\ iRz_{10,1} & iRz_{10,2} & \cdots & iRz_{10,88} & iRz_{10,89} \\ iRz_{11,1} & iRz_{11,2} & \cdots & iRz_{11,88} & iRz_{11,89} \end{bmatrix} * \begin{bmatrix} Dz_1 \\ Dz_2 \\ Dz_3 \\ Dz_4 \\ \vdots \\ Dz_{85} \\ Dz_{86} \\ Dz_{87} \\ Dz_{88} \\ Dz_{89} \end{bmatrix}$$

E(n) = iR * D
C(n) = C(n-1) + A1*E(n) + A2*E(n-1)

iR = invers Response Matrix
D = Golden Orbit – Current Orbit
C = Correctors setpoint
A1 = (Ki * T/2) + Kp
A2 = (Ki * T/2) – Kp
T = 1 / 5kHz

FOFB – Implementation

Integration of xBPM

Integration of the photon monitor (xBPM) from a Bending source beamline

Libera Photon + Communication Controller used

Control of RF frequency

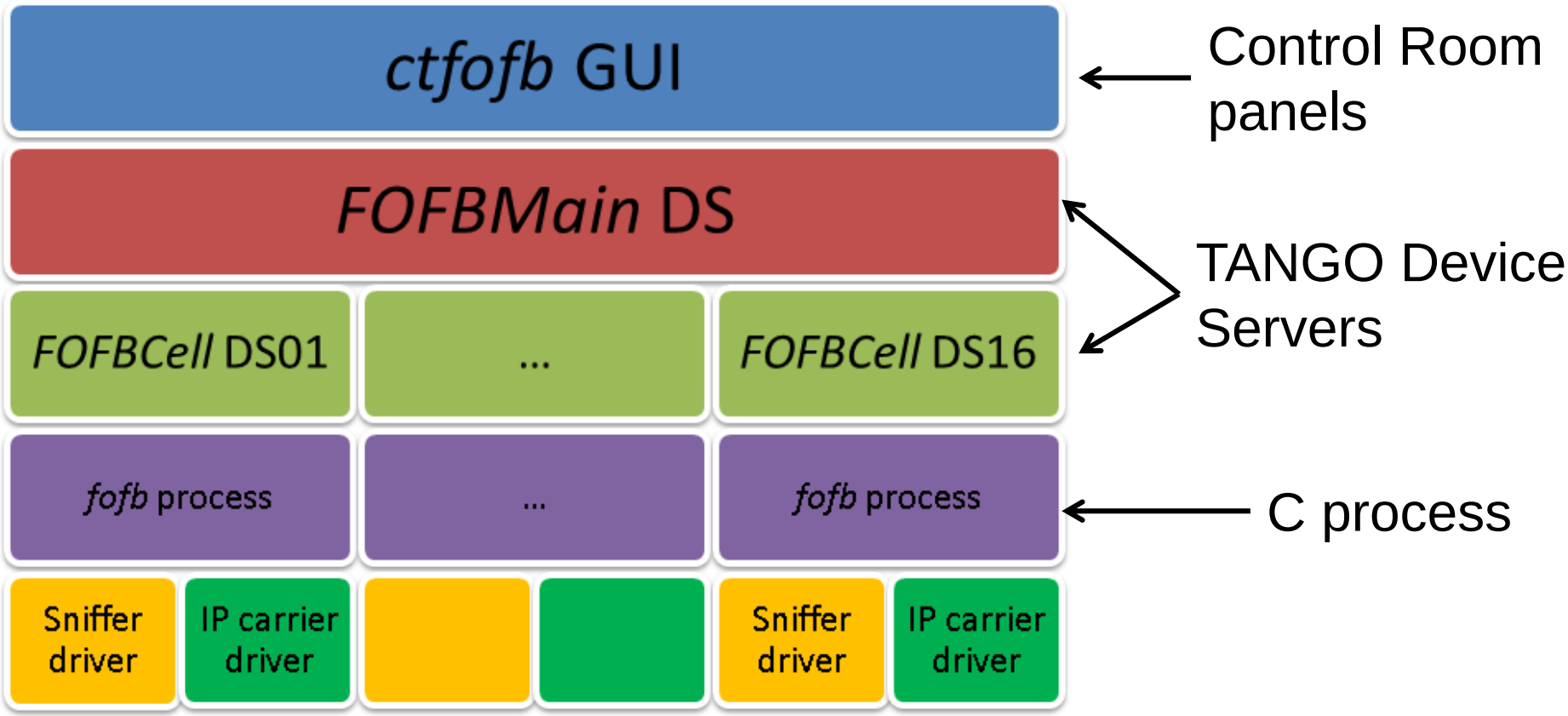
Handling of Interruptions / ACK does not allow FOFB to readback the correctors setting. FOFB just assumes that setpoint is OK

No possibility to set correctors AC and DC by FOFB

External process that monitors dispersive pattern on correctors and change RF frequency

FOFB – Implementation

Distributed software structure



FOFB – Implementation

***fofb* process:**

- Soft real time program forked into 2 processes (parent and child)
- Parent process reads the data from the Sniffer and signals that to the child process
- Child process computes the corrections and applies them into the power supply
- Uses a shared memory mechanism for external communication

TANGO device servers:

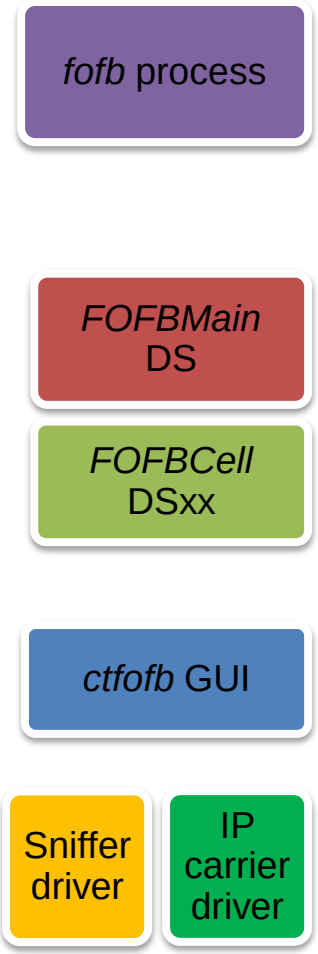
- Provide a TANGO interface to the *fofb* programs
- Manage their configuration and the interfacing with the control room

***ctfofb* GUI**:

- Graphical front end to the TANGO device servers

Sniffer card and IP carrier drivers:

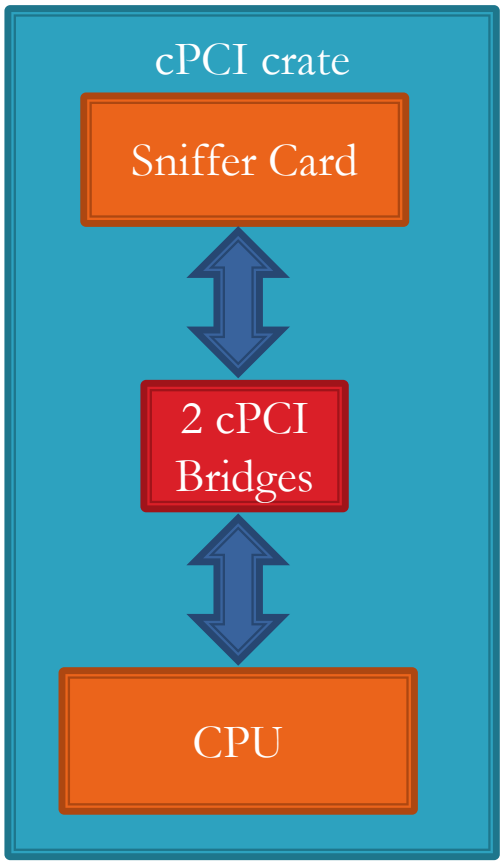
- Sniffer driver was provided by DLS
- Drivers modifications were necessary to warranty the FOFB specs



Content

FOFB – Limitations

Problems of Data Transfer on cPCI



Burst Mode should ideally allow BPMs reading within 20us

But burst is stopped after 2 cycles and restarted again

Like that, reading 88 BPMs takes >100us

It can only be warrantied reading at 5kHz

And we will also have problems due to CPU interruptions …

When reading 88 BPMs → 1 cycle lost every 2,4 or 8 seconds

15h tests → 0.007% correction cycles lost

If reading 104 BPMs → 0,009%

If reading 120 BPMs → 0,32%

FOFB – Limitations

Redundancy

Sniffers with only 1 optical port → redundancy is not accomplished

A full sector of correctors can be stopped if a single link goes down

Obsolescence

Liberas and Sniffer cards include already obsolete electronics inside

Correctors Setpoints acknowledgment

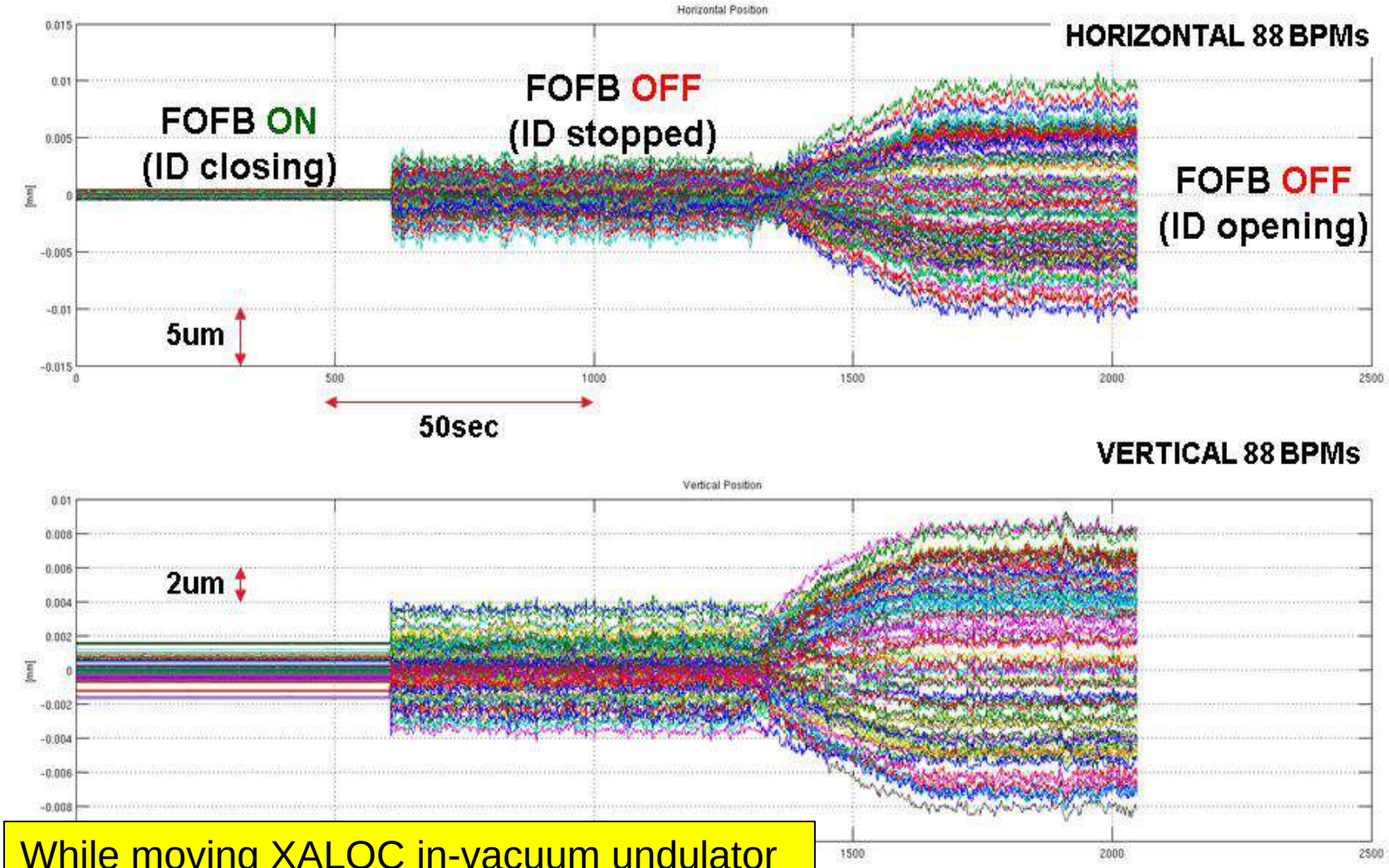
IP carrier driver used a too slow acknowledgment method to be compatible with FOFB needs

The rewritten driver sends the setpoint but does not wait for its acknowledgment

We cannot know if the command was correctly processed by the power converter controller

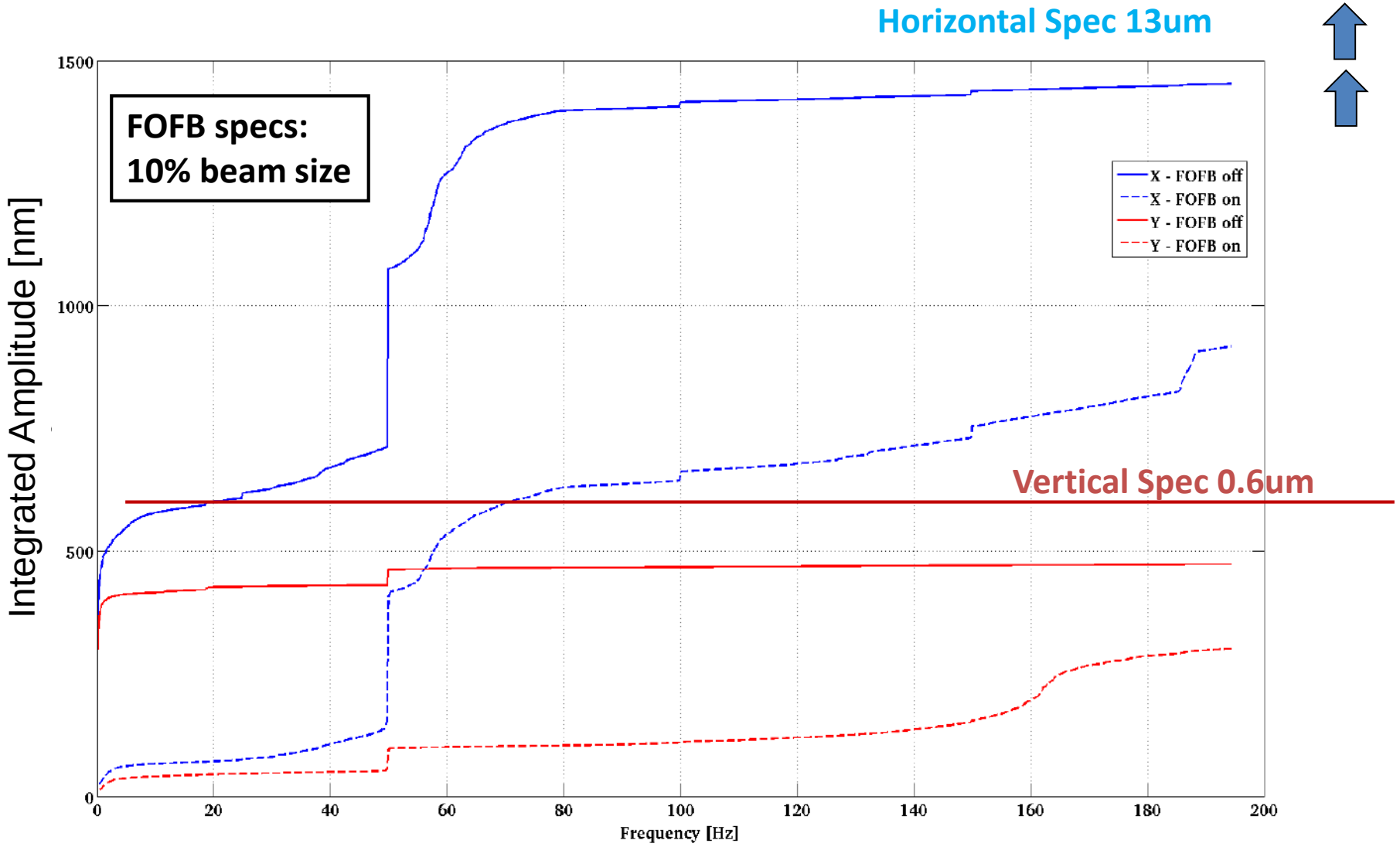
Content

FOFB – In operation



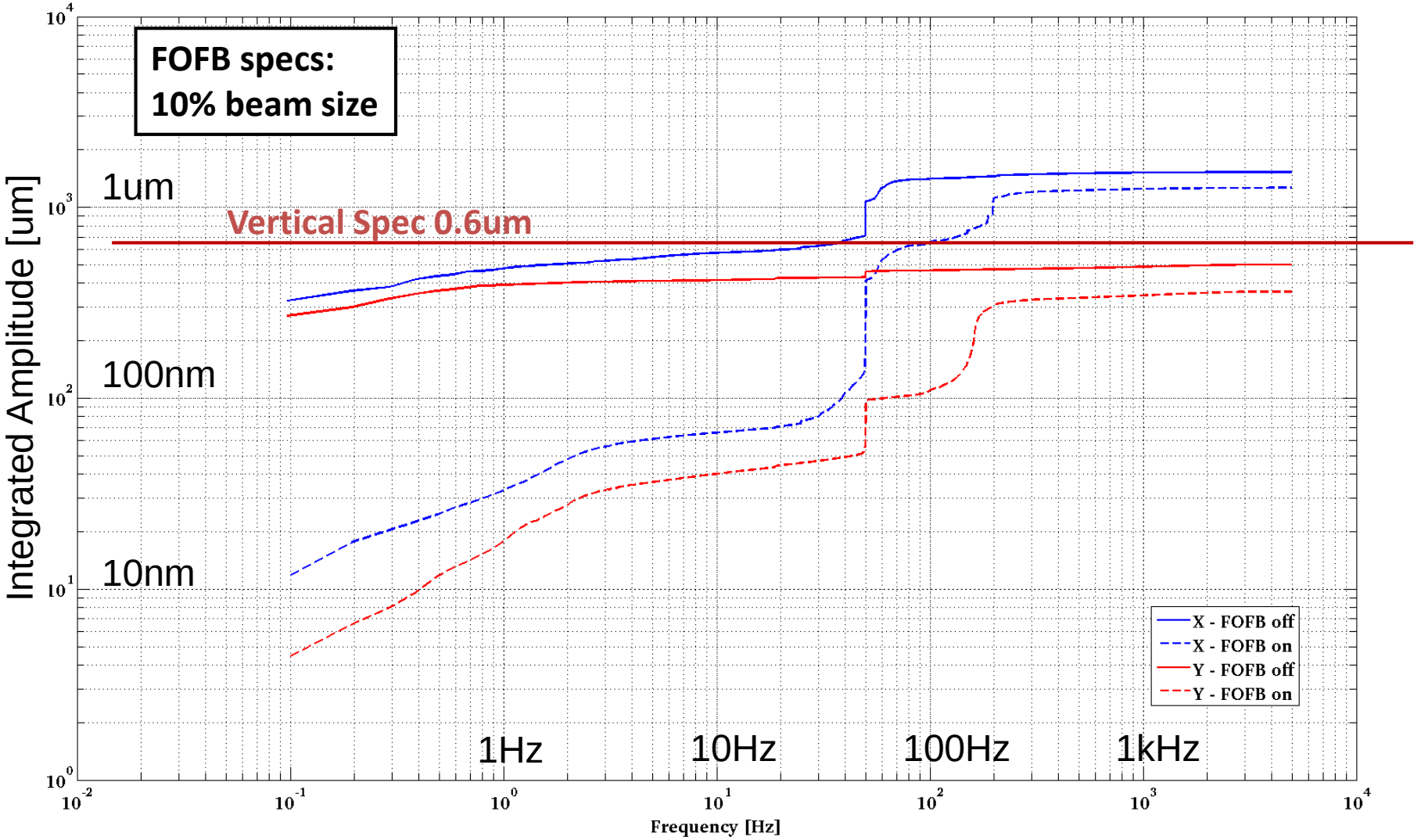
While moving XALOC in-vacuum undulator

FOFB – In operation



FOFB – In operation

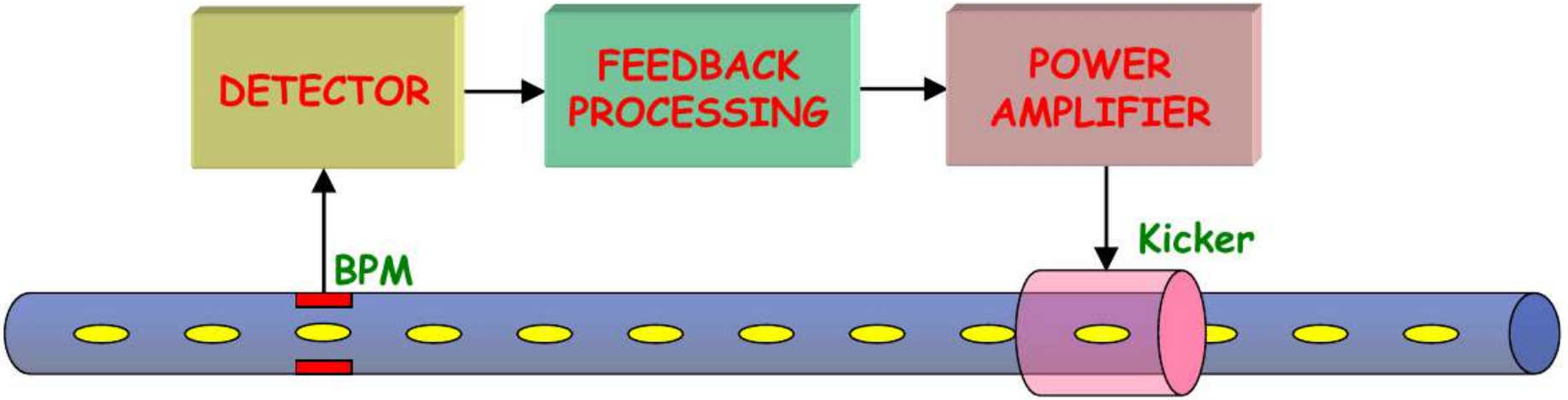
Horizontal Spec 13um



Content

BbB – At a glance

1. The system detects the bunch-to-bunch instability using a BPM
2. Processes the instability and generates the correcting signal
3. Damps the oscillation through a kicker

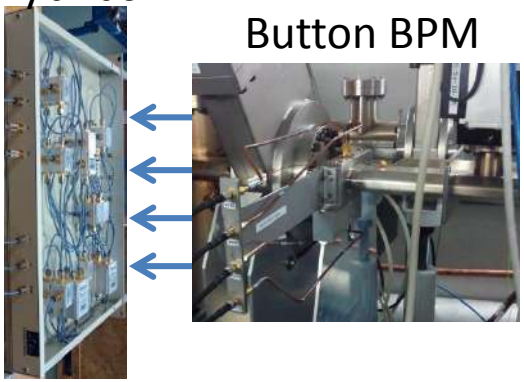


M. Lonza – CAS Diagnostics

BbB – At a glance

Hybrids

Button BPM

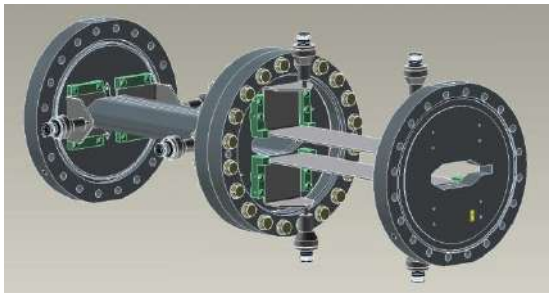


Libera FrontEnd

IFI 100W ampli

Libera BbB - X

Stripline Kickers



Scope

100W atten

Content

BbB – Ported Software

We did a not very successful try with I-Tech Matlab interface

Diamond colleagues offered a collaboration to port Diamond TMBF to ALBA system

1. Migrate the full FPGA code from SystemVerilog to VHDL language
2. Modify the code, graphical interfaces (EDM) and side utilities (scripts) to make them work in ALBA environment
3. Install an “EPICS worm” (EPICS Base) inside our TANGO control system
4. Permanently install Diamond TMBF code in our Liberas BbB (ITech code washed)

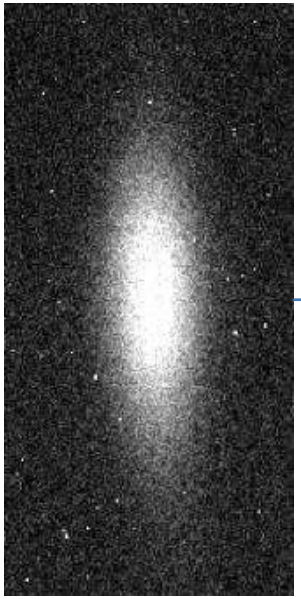
Huge work done by DLS colleagues

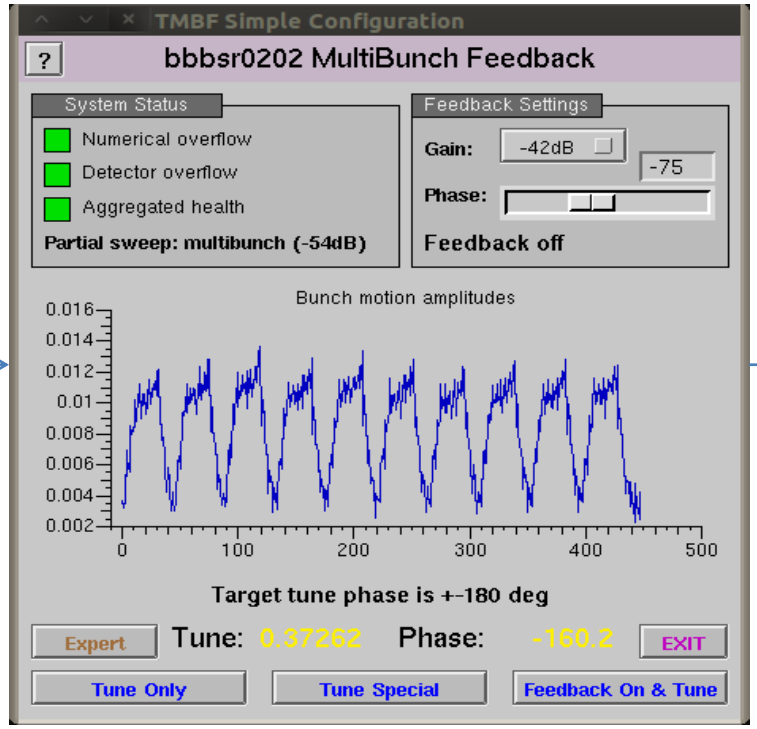
G. Rehm, M. Abbott, I. Uzun

BbB – Ported Software

Commissioning with beam in presence of G. Rehm and M. Abbott (May 2015)

- Inject 100mA, uniform filling, chroms (1.6, 3.4)
- Loop closed just by setting the vertical phase





We also reduce further the ChromV ~ 0, beam was kept stable

Content

BbB – Status

IFI Amplifiers Response

Single Pulse from Libera BbB + Ampli + Kickers + Attenuators

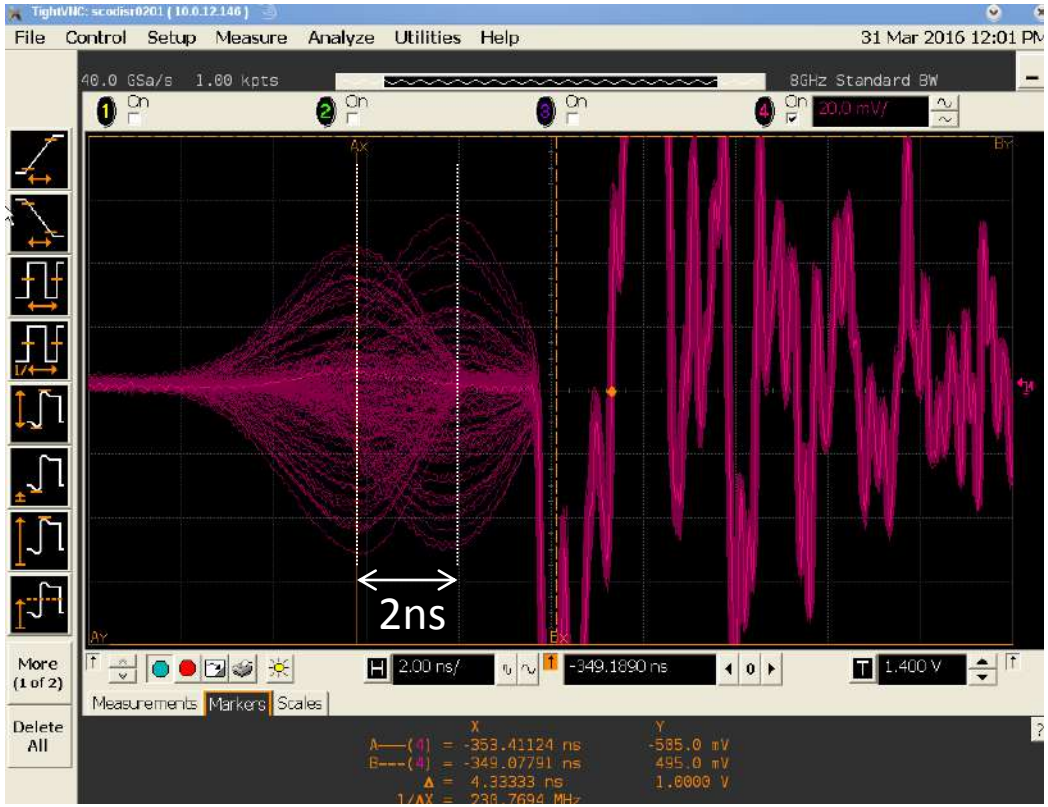
Single Pulse (2ns) from Libera BbB

The amplis **distort** the signal, produce a ~6ns ripple → We will kick adjacent bunches!

BbB – Status

2ns output jump

Under non-understood conditions, the Libera output “decides” to swing between bunches



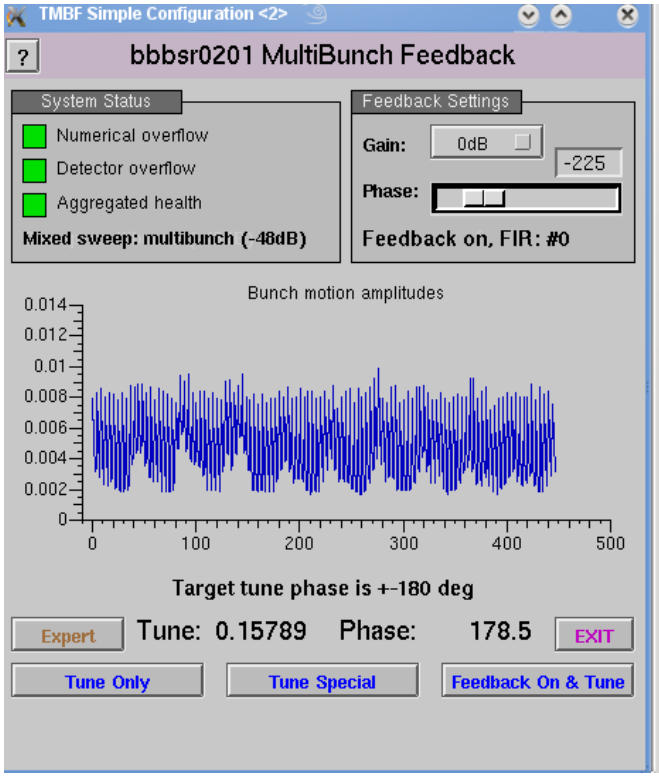
We will kick incorrect bunches!!

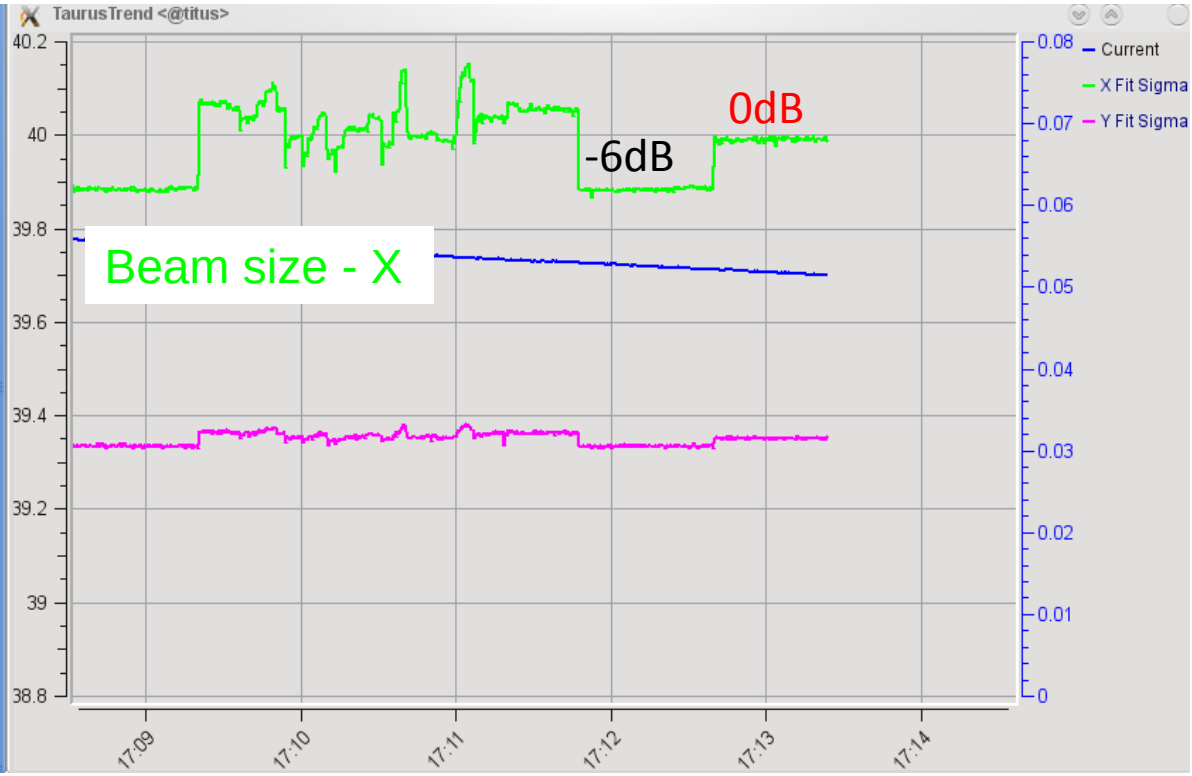
BbB – Status

Horizontal BbB excites @ high gains

Horizontal system damps instabilities up to a given loop Gain

For Gain > -6dB it excites the beam





BbB – Status

- BbB system has been commissioned at ALBA
- An “EPICS worm” has been installed in our Tango-based Control Room
- Quite easy and straight-forward (thanks to Diamond people!)
- … but about 80% of buttons we still don’t know how they work ☺
- System allows several interesting features already tested:
  - Damping instabilities (Main task)
  - Bunch cleaning
  - Sequences to identify unstable modes
  - PLL tune tracking with 1e-5 precision
- So far, only in operation in the Vertical plane

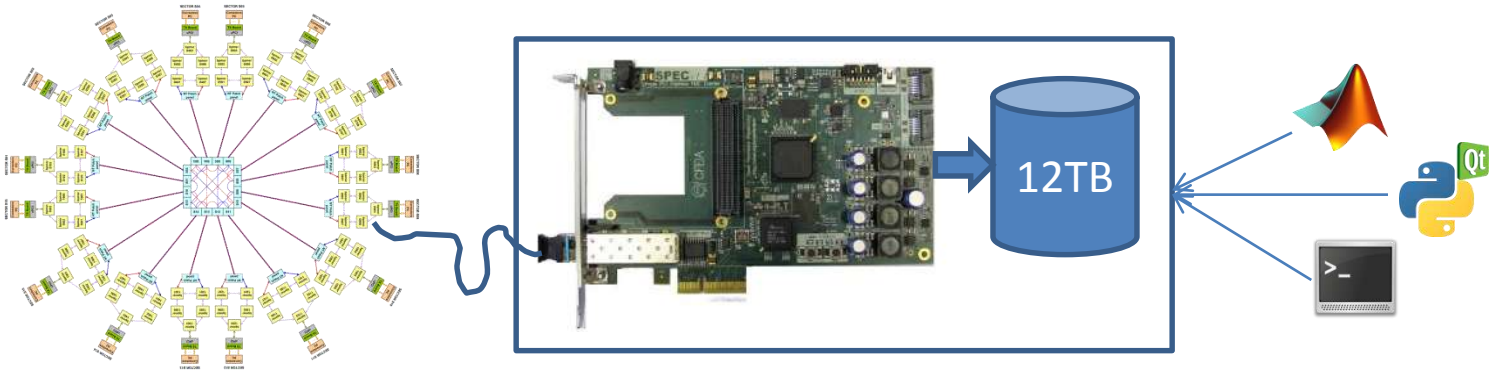
Content

What else – Fast Archiver

System developed by Diamond and used by other facilities since 2011

Server with few HDs allowing many TBytes of archived BPM data @ 10kHz rate

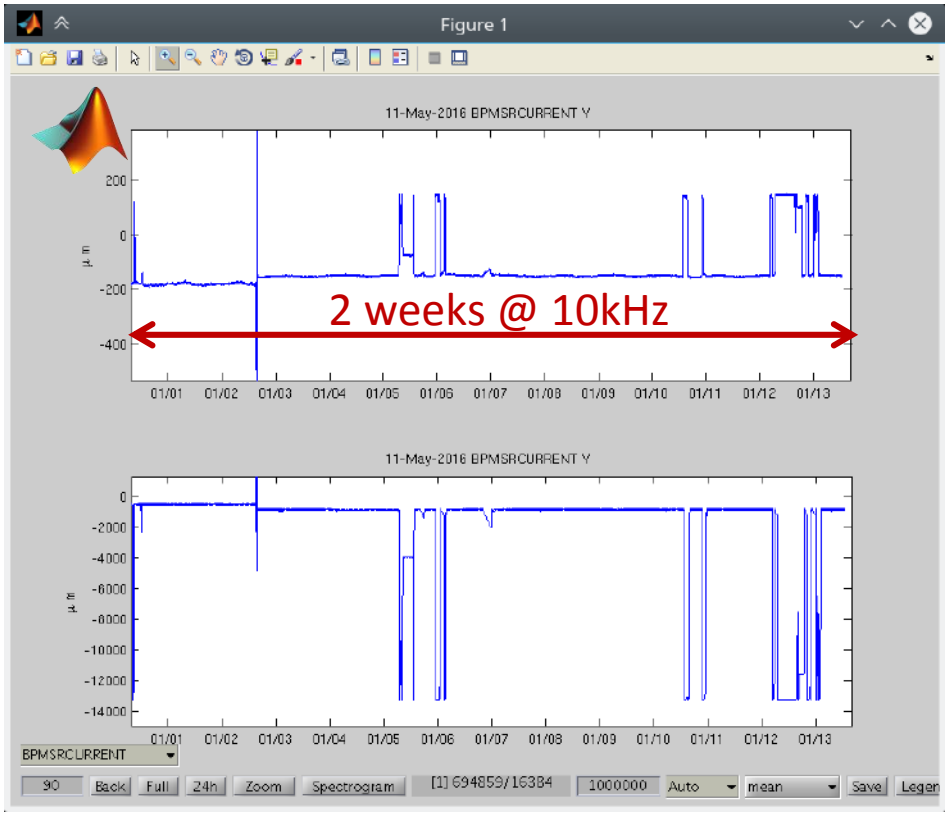
Our current Fast Archiver consists of:
- a PCIe SPEC card as sniffer to the FOFB network
- 12 Tbyte HD in an Industrial PC, allowing for ~2 weeks of data
- BPMs position data @ 10kHz
- Data can be retrieved from Matlab, Python Qt GUI or command line tools



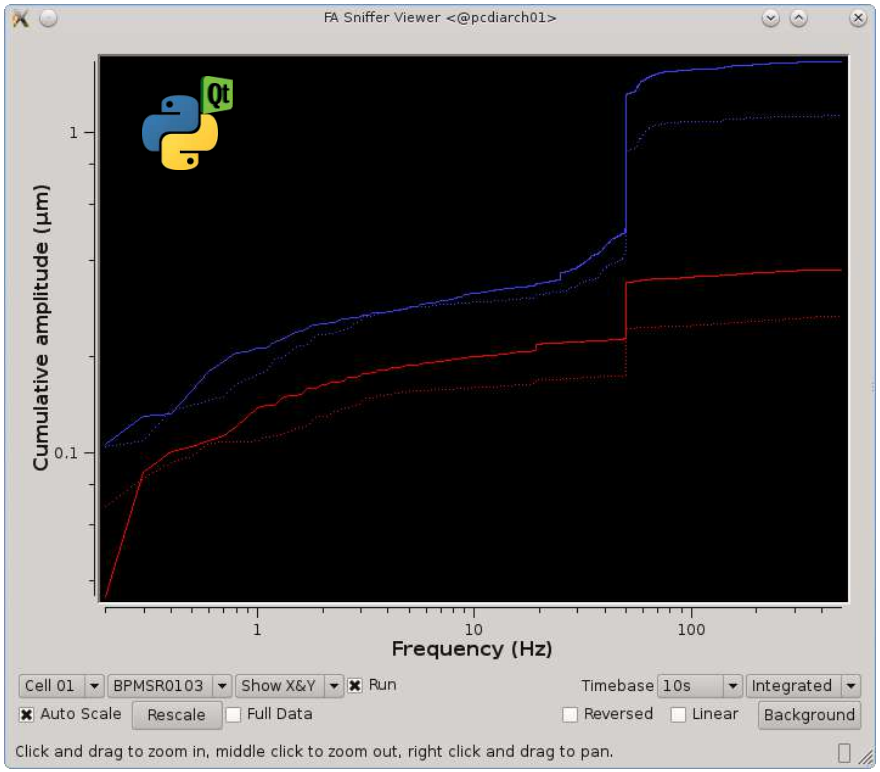
What else – Fast Archiver

Very useful diagnostics tool for FOFB commissioning and continuous BPM monitoring

Retrieve 10kHz data from archiver



Live 10kHz BPM data analysis

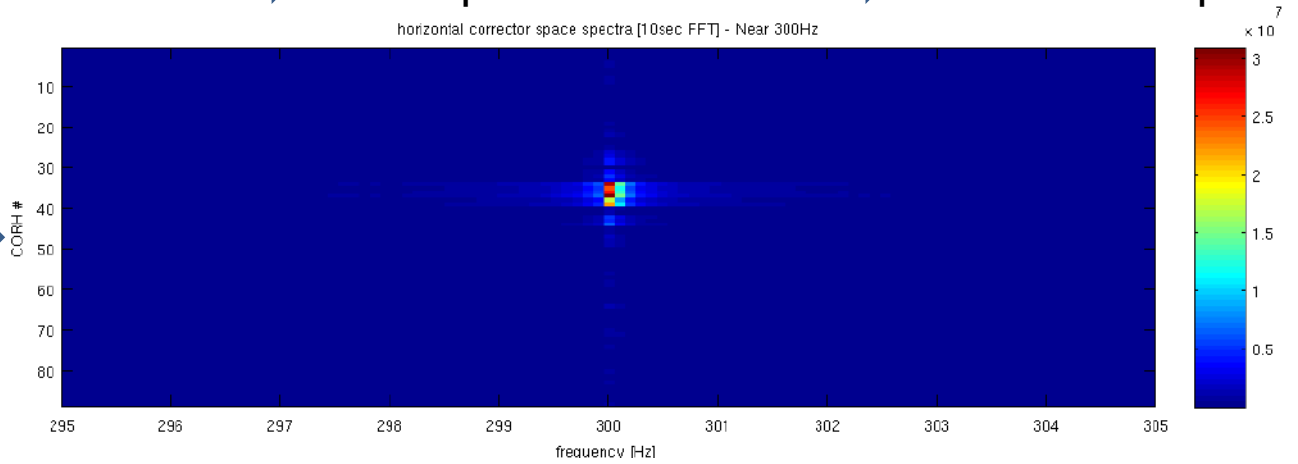


What else – Fast Archiver

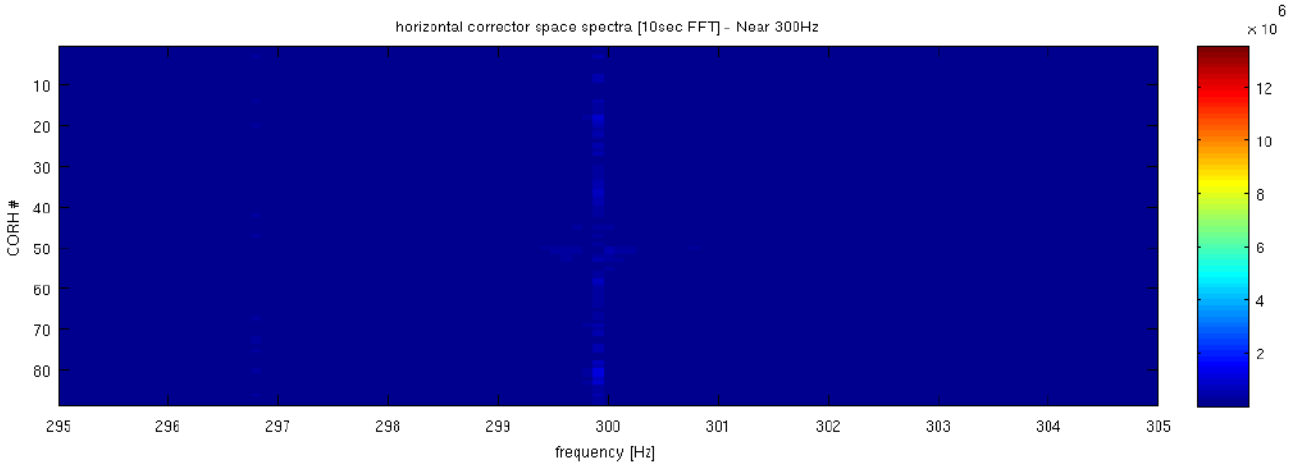
FFT analysis allows localization of possible noise sources

BPMs data → Response Matrix → Correctors space

Sudden 300Hz Horizontal noise →

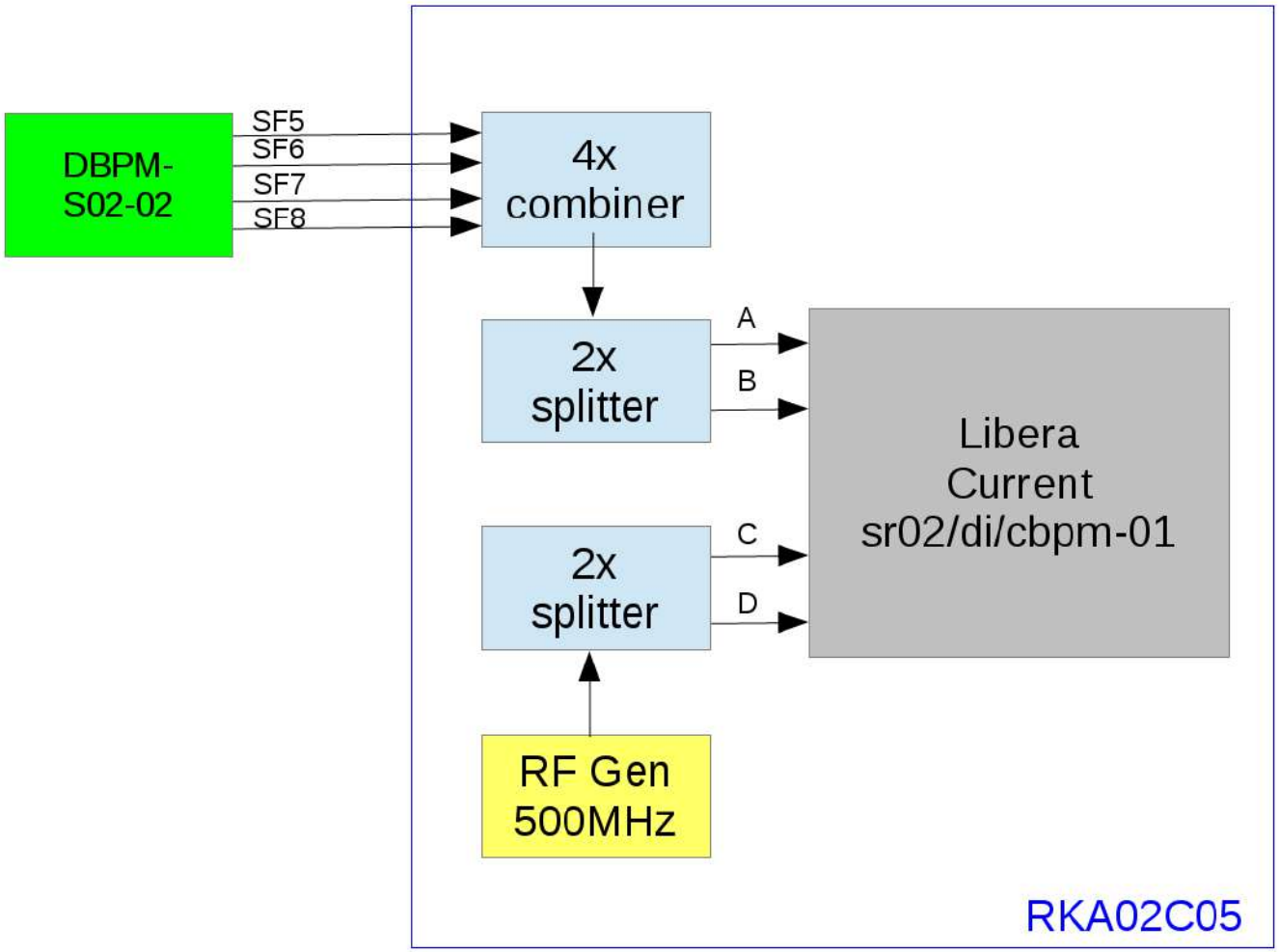


Not there after replacing an identified faulty Quad Power Supply →



Content

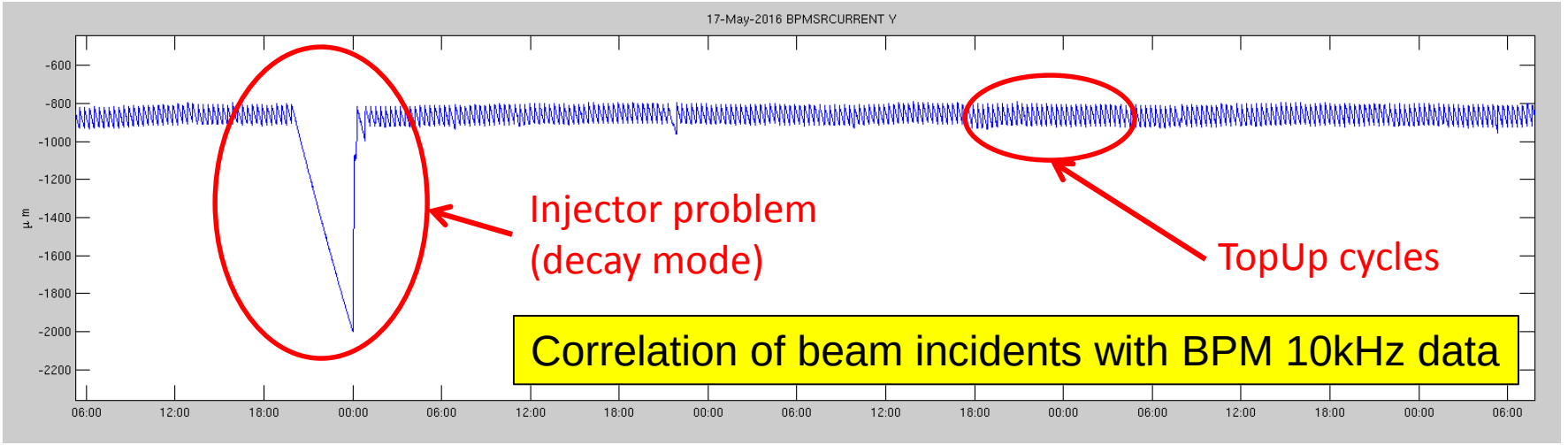
What else – Current BPM

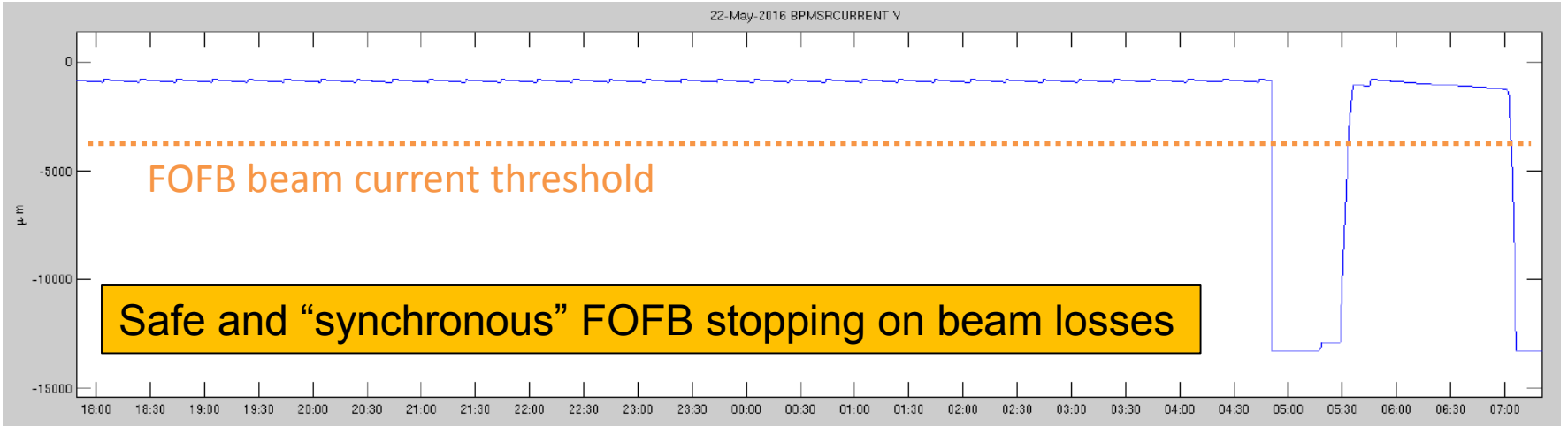


Vertical Position ~ Beam current

10 kHz beam current data integrated in the FOFB network

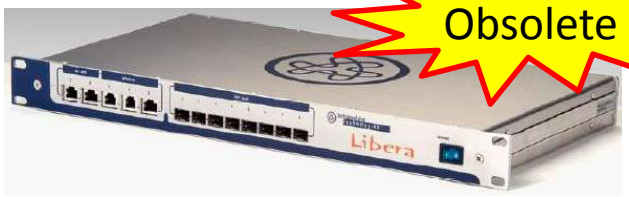
What else – Current BPM





Content

What else – Units summary



Libera Brilliance → LINAC-LTB: 4
Booster: 28
BTS: 4
Storage Ring: 120

Libera Photon → 1 Bending BL xBPM

Not in Libera Books anymore (?)

Libera Bunch-by-Bunch → 1 Horizontal BbB
1 Vertical BbB

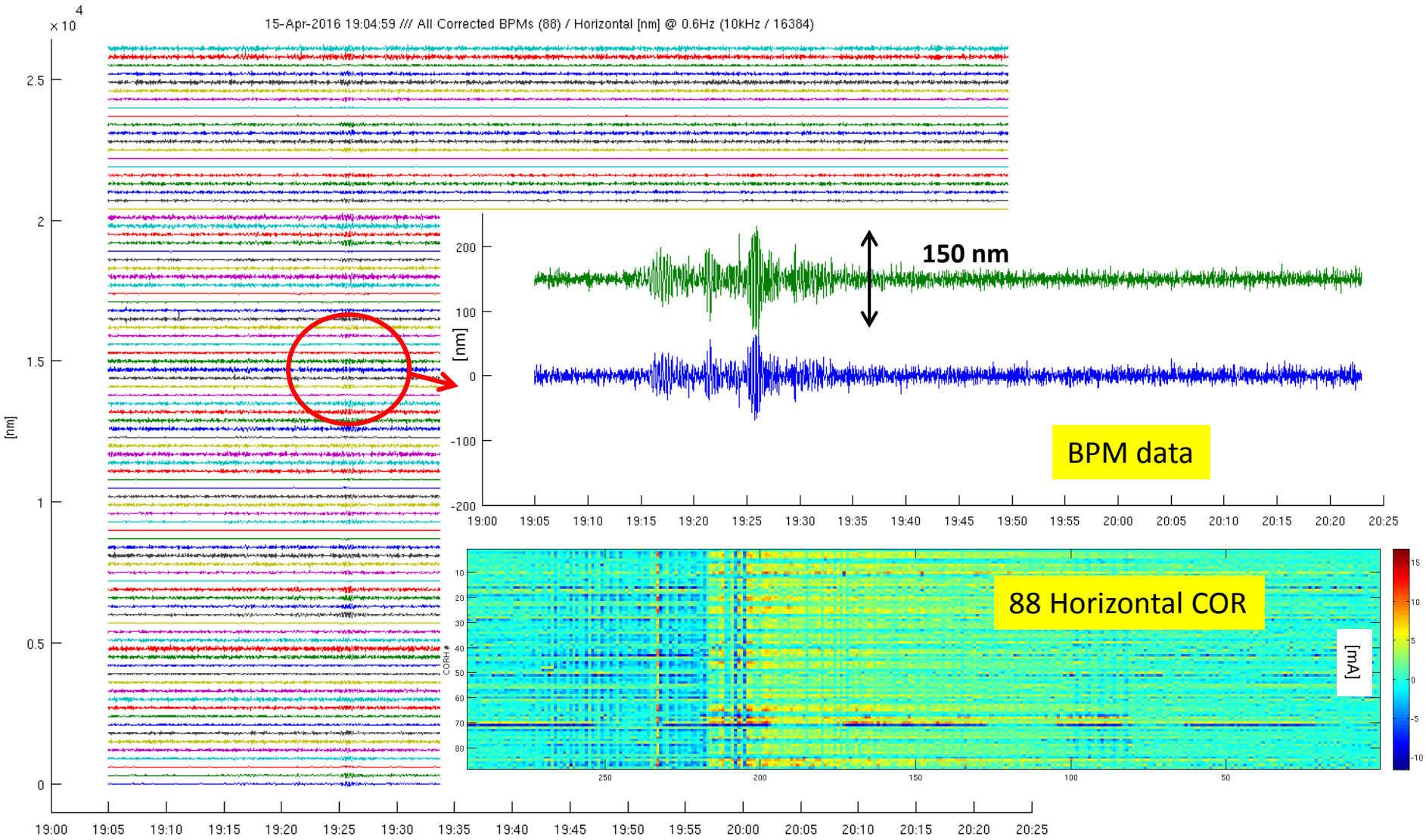
Near future

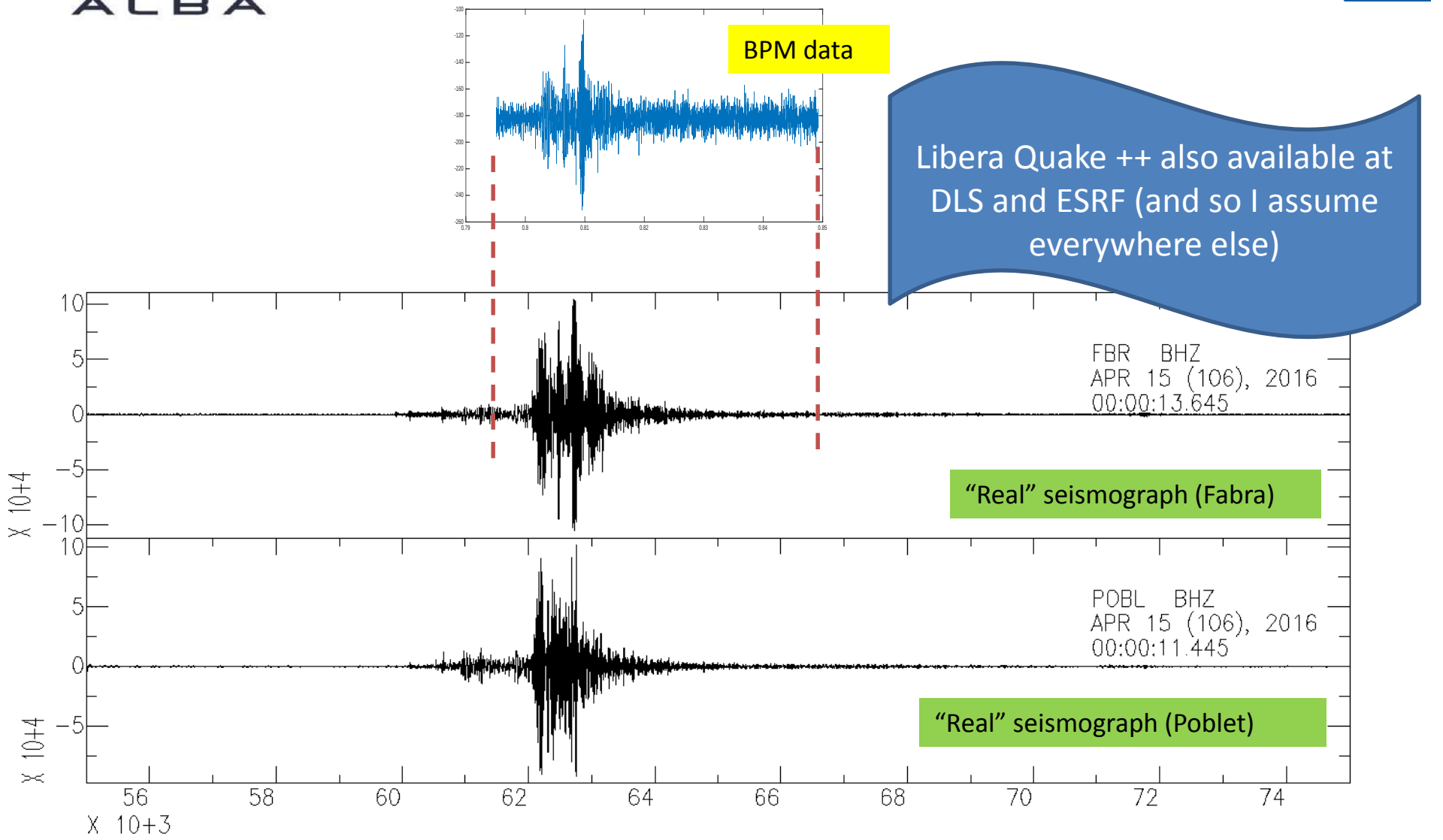
Libera Brilliance + → 1 (2BPMs) CLIC stripline test

Libera Spark EL → To replace 4 BTS

NEW PRODUCT
Libera Quake ++

Japan, April 15th – M: 7.0




BPM data
Libera Quake ++ also available at DLS and ESRF (and so I assume everywhere else)
FBR BHZ
APR 15 (106), 2016
00:00:13.645
"Real" seismograph (Fabra)
POBL BHZ
APR 15 (106), 2016
00:00:11.445
"Real" seismograph (Poblet)
X 10+4
X 10+3

THANKS FOR YOUR ATTENTION !!!