Libera at ELETTRA: prehistory, history and present state

S. Cleva, S. Bassanese, R. De Monte, G. Gaio, M. Lonza, C. Scafuri

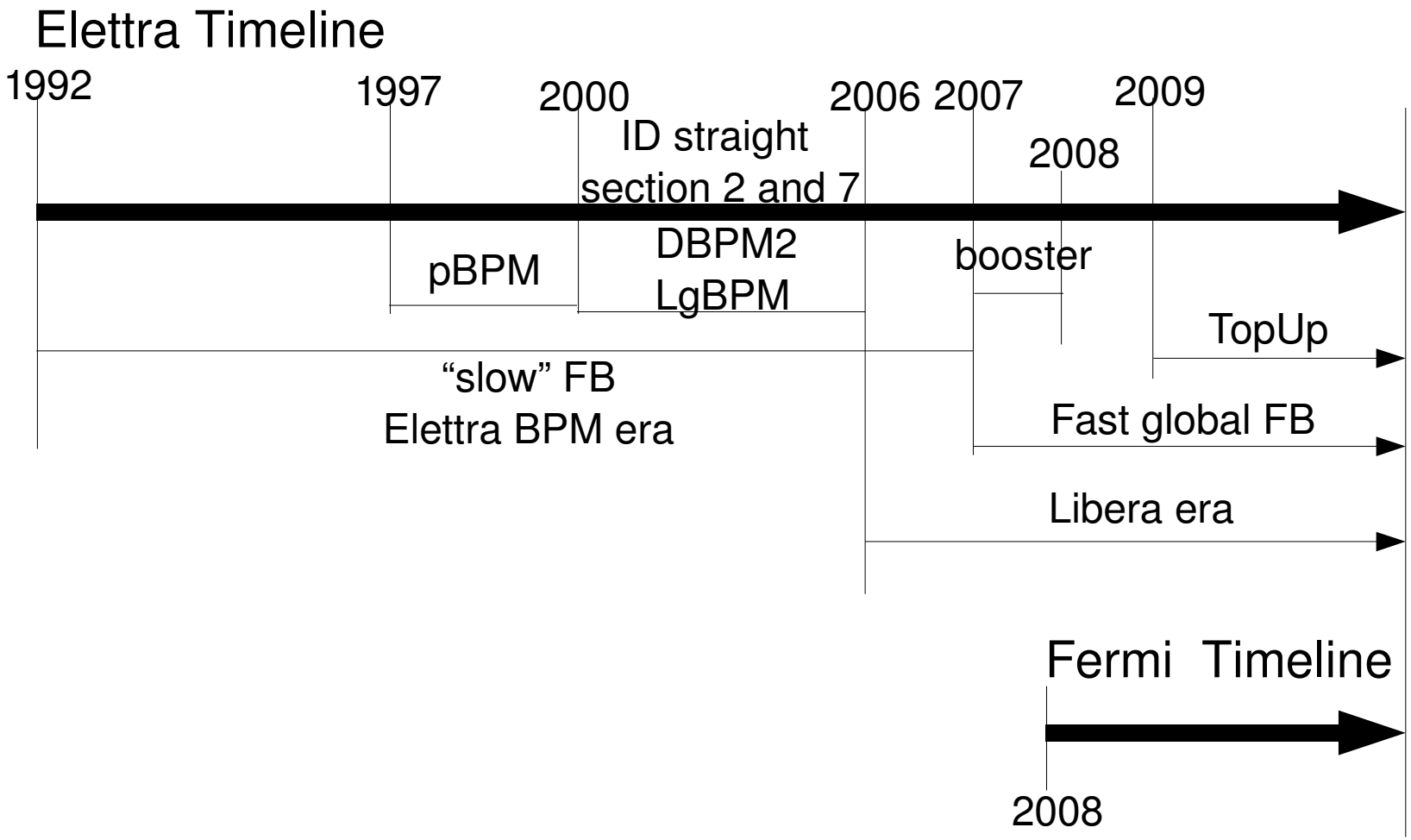
Elettra - Sincrotrone Trieste

ELETTRA and FERMI@Elettra plants

ELETTRA (SR):
Full energy booster
TopUp operation
320 mA@2 GeV
160 mA@2.4 GeV
25 beam lines

FERMI (FEL):
Low emittance photo-injector
1.5 GeV normal conducting linac at 50 Hz
Two undulator chains (FEL-1, FEL-2)
Laser Seeded Free Electron Laser
Photon beam wavelength: 100 to 3 nm

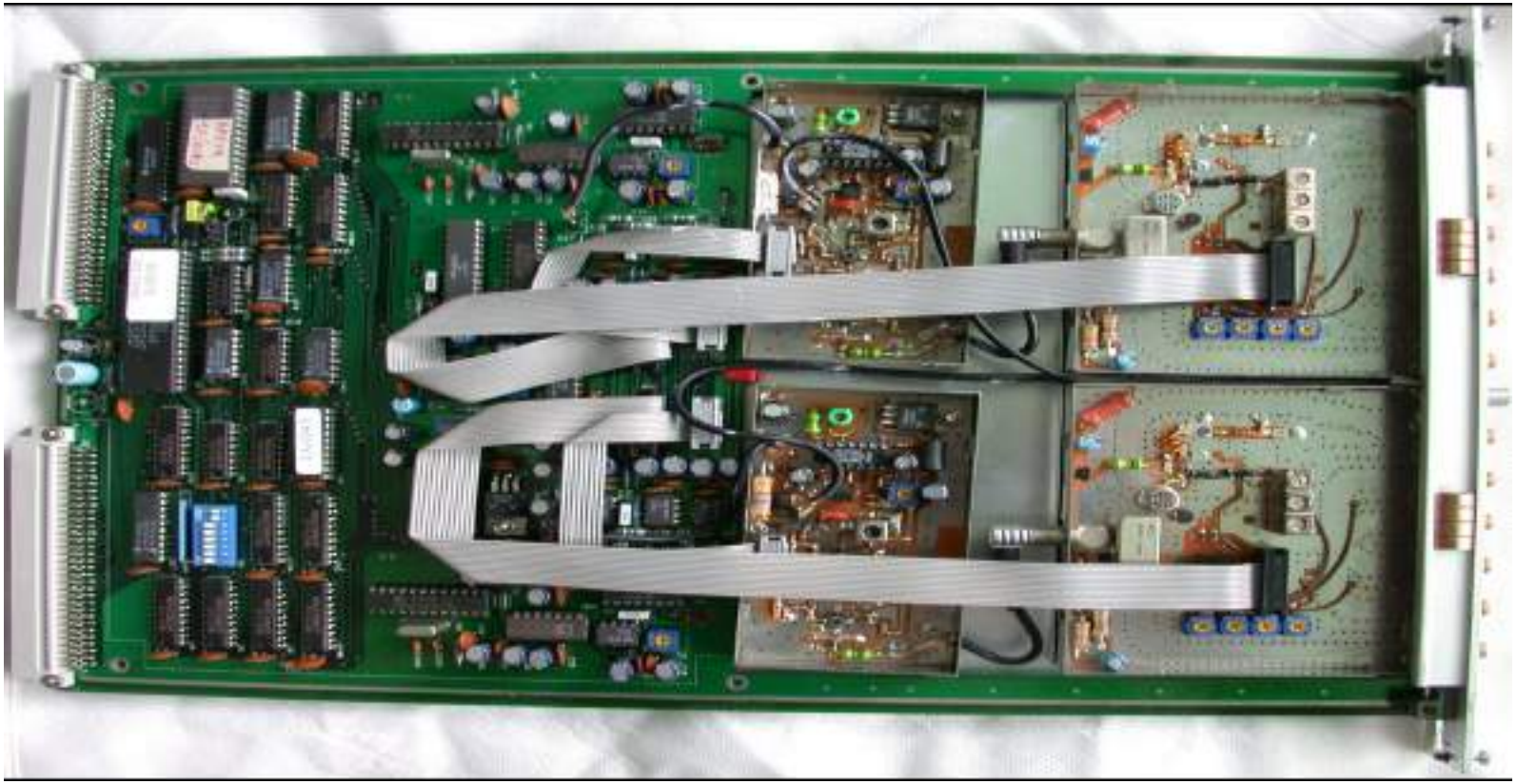
outline


Elettra Timeline
1992
1997
2000
2006
2007
2009
ID straight
section 2 and 7
2008
pBPM
DBPM2
LgBPM
booster
TopUp
“slow” FB
Elettra BPM era
Fast global FB
Libera era
Fermi Timeline
2008

prehistory: ELETTRA eBPM

- 1992 → March 2007
- Analog Multiplexed RF receiver
- 500 MHz BandPass filter – 10 MHz Bandwidth
- 510 MHz mixer → 10.7 MHz IF
- 12 bit ADC
- AGC required for operation of the AM detector in linear zone
- MIL 1533 communication standard for control system interface
- First Turn Mode, Close Orbit Mode, Feedback Mode
- “complete SW handling of the HW ... flexibility”

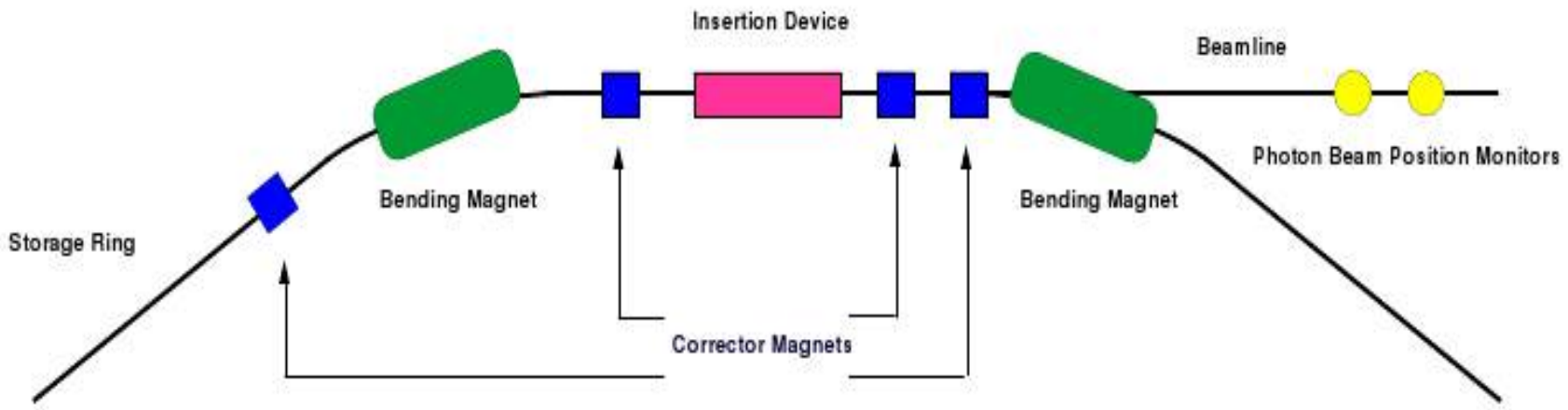
prehistory: ELETTRA eBPM



- SR working in decay mode
- control scheme: closed bump on source points
- controlled params: position and angle of source points
- several “slow FB” running in parallel

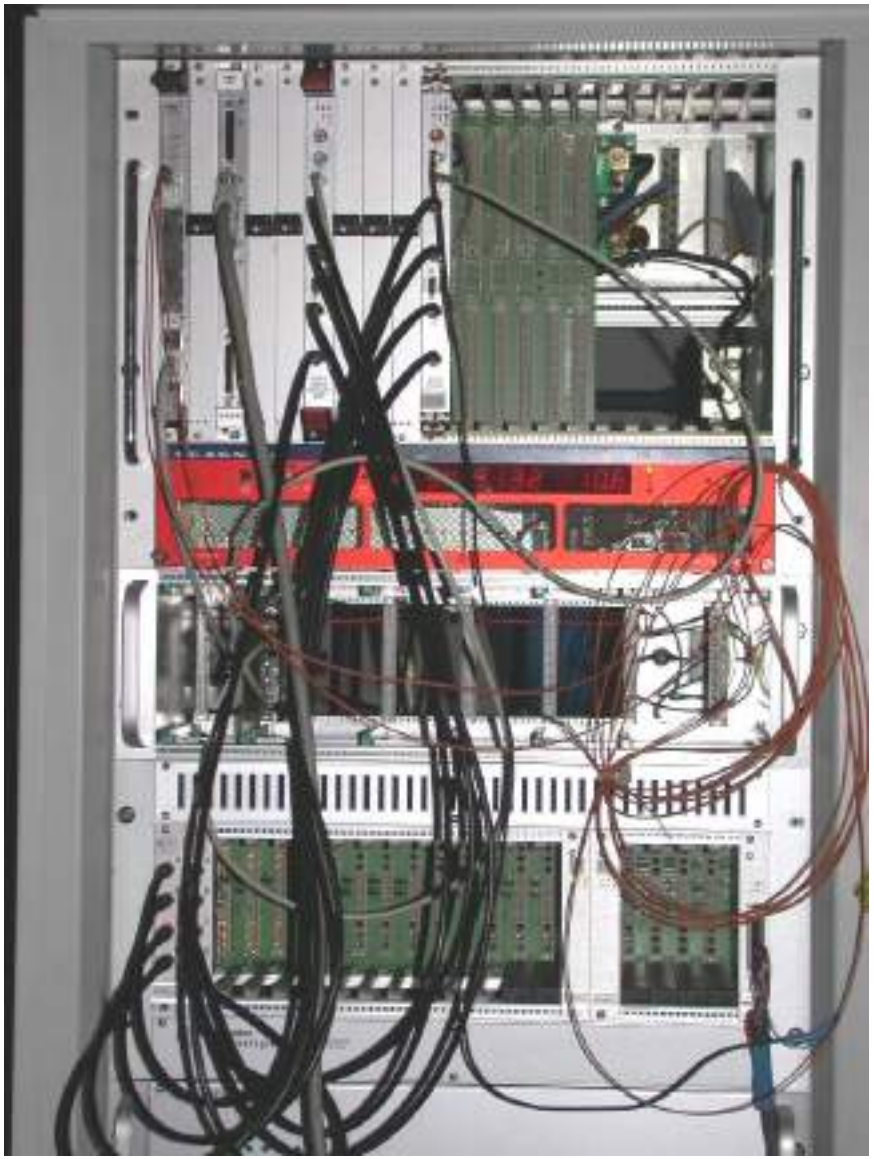
prehistory: Photon BPM

- 1997 → 2000
- ID straight section 2 and 7
- 2 photon BPMs
- controlled params: position and angle of source points
- fast local FB (closed bump)

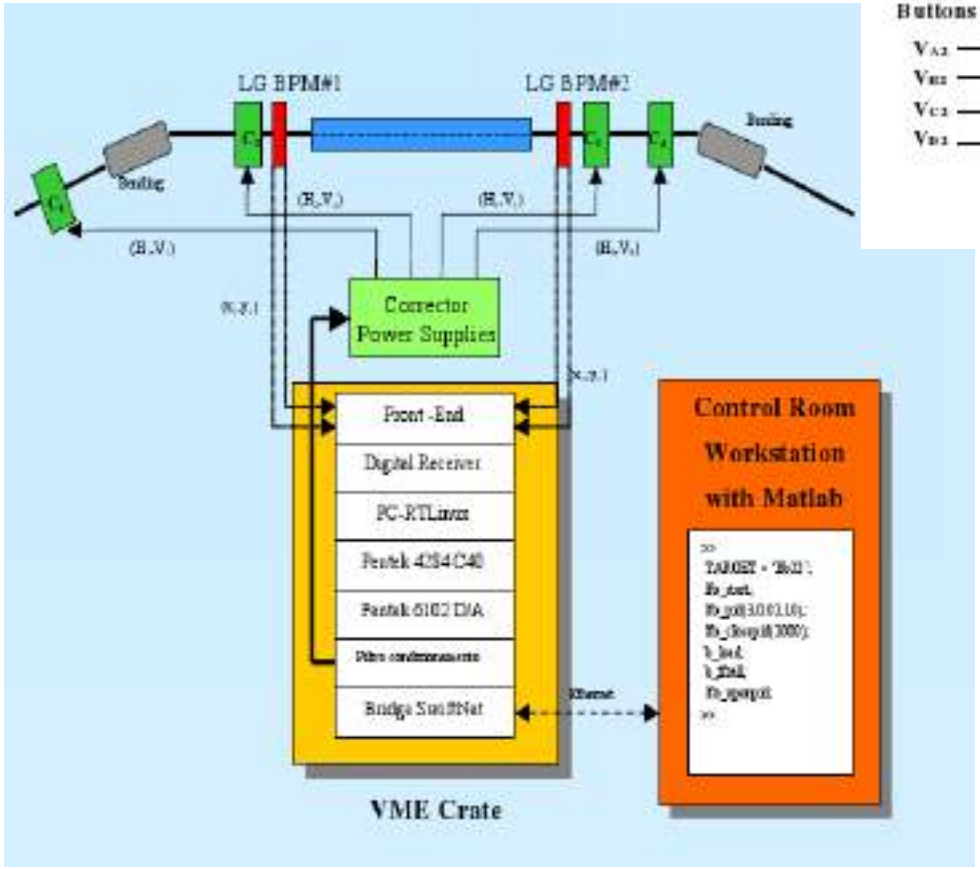


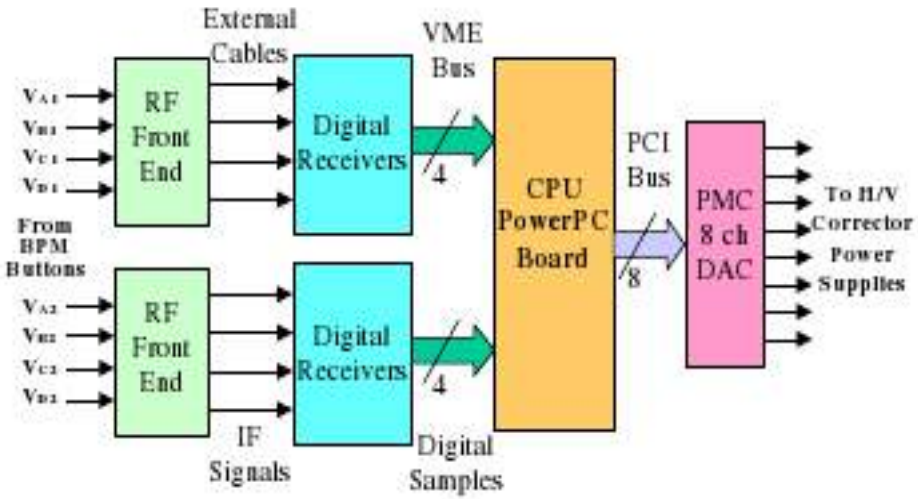
prehistory: LgBPM + DBPM2

- 2000 → 2006
- ID straight section 2 and 7 LgBPM + DBPM2
- DBPM2: Analog FE (RF02) + QDR (4 ch digital receiver – 14bit)
- IF freq. Allocation span: 10 – 70 MHz
- beam pos. measured at 8 kHz rate
- RTAI Linux RT extension (deterministic response)
- local fast FB (closed bump)
- 16 bit DAC generated correction voltage



prehistory: LgBPM + DBPM2



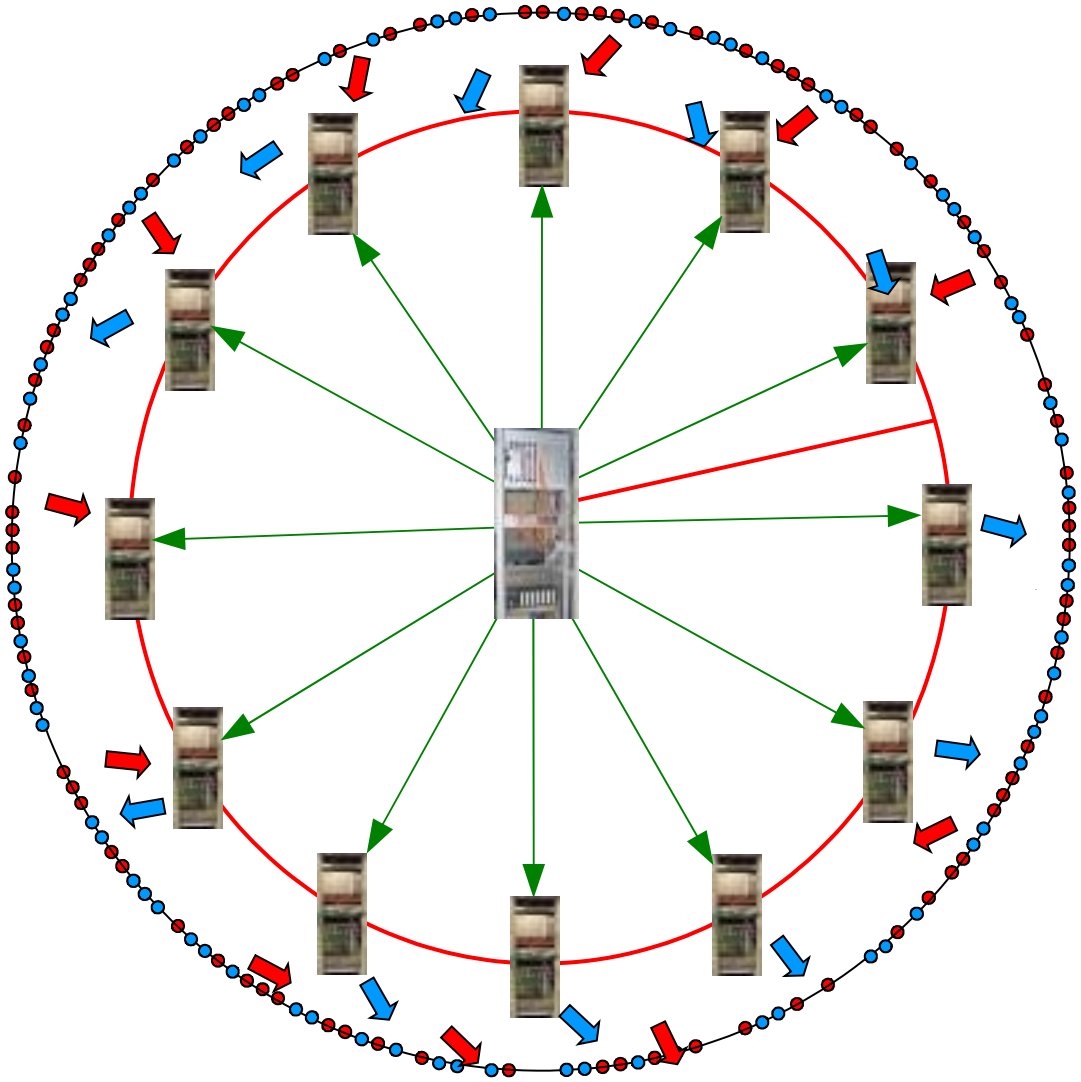


history: 2006 on

- the previously existing RF BPM detectors have been replaced with Libera Electron (12 bit - AD9433) from March 2006 to March 2007 (107 units purchased in 2006, 100 installed)
- installation of the feedback system finished in February 2007
- fast FB loop closed in March 2007
- since beginning of September 2007 the fast global feedback is routinely used during users shifts
- development slowed down in Spring 2008 due to FERMI higher priority
- release 1.42 used up to end of March 2008, then upgraded to 1.82
- Top Up mode for user shifts has been adopted since 2009
- RF amplifier amplitude post mortem data acquired by one Libera since 2009
- BBA procedure since last quarter 2011
- 2012: one Libera is used for tune measurement in the SR

Global Orbit Feedback Architecture

- 96 rohmboidal BPMs all equipped with Libera Electron (82 corrector magnets per plane)
- 12 VME stations with Motorola 6100 CPU boards running Linux (Tango) and RTAI (RT extension for feedback processing)
- feedback stations acquire position data at 10 kHz from Libera Electron through Gigabit Ethernet links
- data shared in real-time through Reflective Memory fibre optics
- 10 kSample/s D/A converters generate the analog correction signals
- Master Station connected to the reflective memory for feedback supervision and data acquisition
- Event system: 1 EVG, 12 EVR, Libera Clock Splitters and fibre optics to distribute MC, SC, PM and Trigger signals



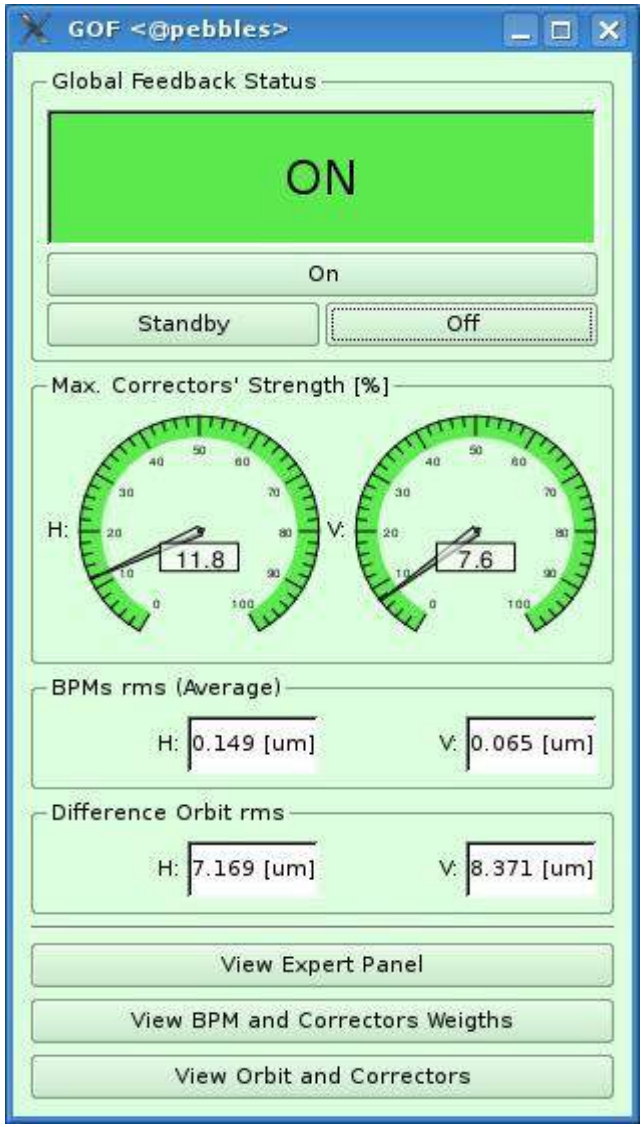
Global Orbit Feedback Architecture

From N-1 GOF Station
F.O. Links
To N+1 GOF Station
GOF Station
CPU
Reflective Memory
DACs
7 Horizontal
Differential Analog Links to Corrector Power Supplies
7 Vertical
±400 mA
±48/70
rad H/V @2GeV
Corrector Setting
DC Setting
Control System Network
Ethernet Switch
Gigabit Ethernet Links
Control System Network
Libera
BPM Buttons

Feedback operation

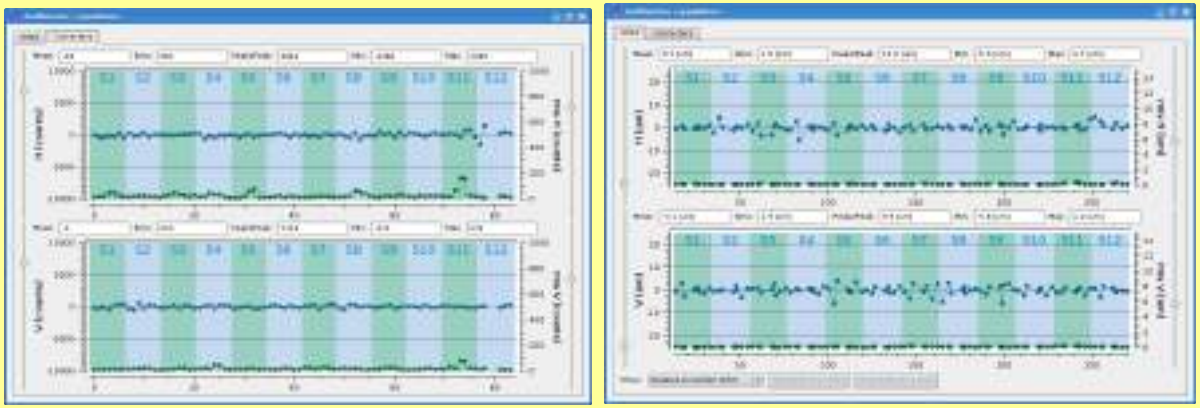
- the fast global feedback minimizes the rms of the whole orbit, ID source points disadvantaged with respect to dedicated local correction
- operators can exclude the correction in one section to permit local orbit adjustment
- operators can modify the weighting of BPMs to privilege the correction at the IDs with respect to global one
- correction algorithm: SVD with singular values reduction (21 s.v.)
- path length drift compensation by RF variation

Control Room Panels



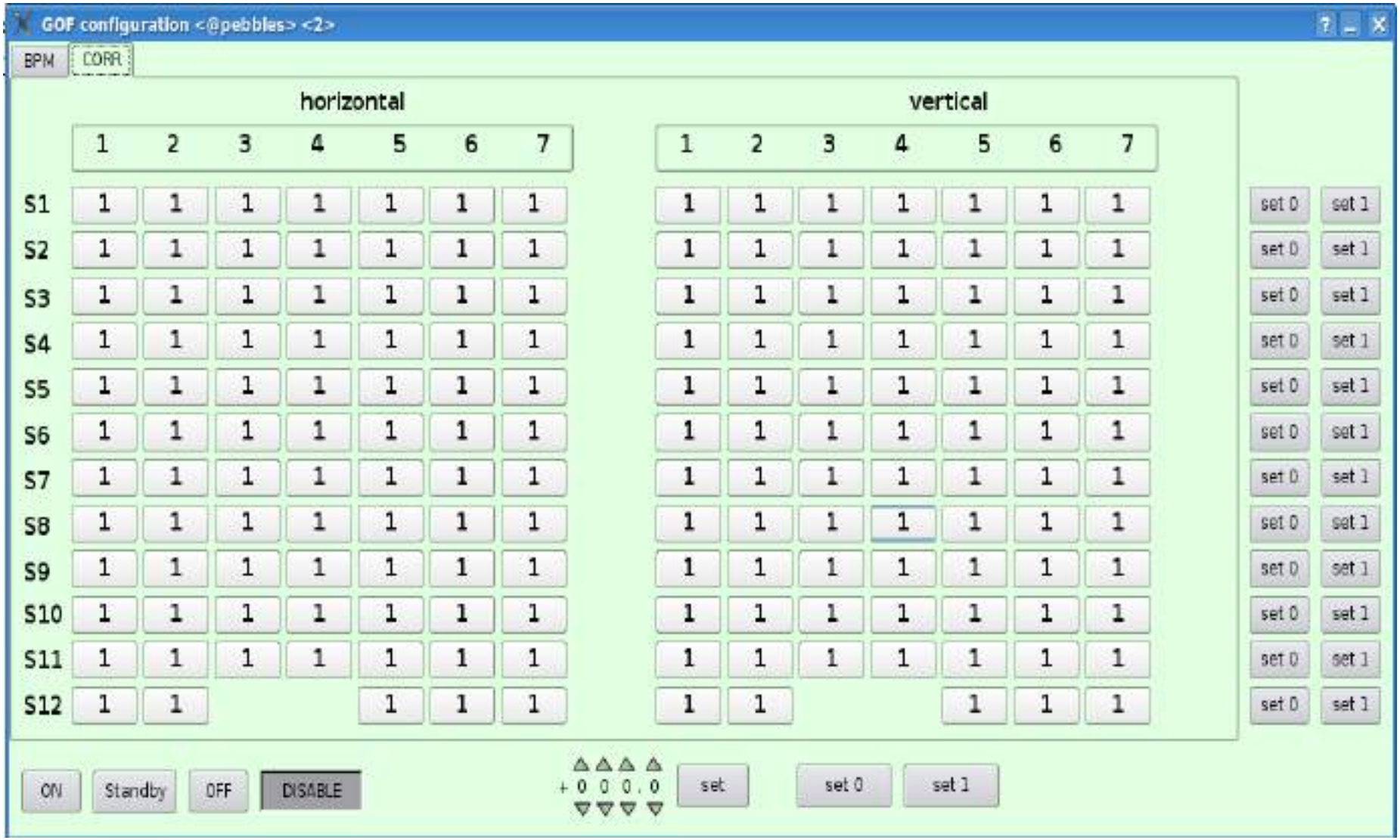
Operator Panel

Expert Panels

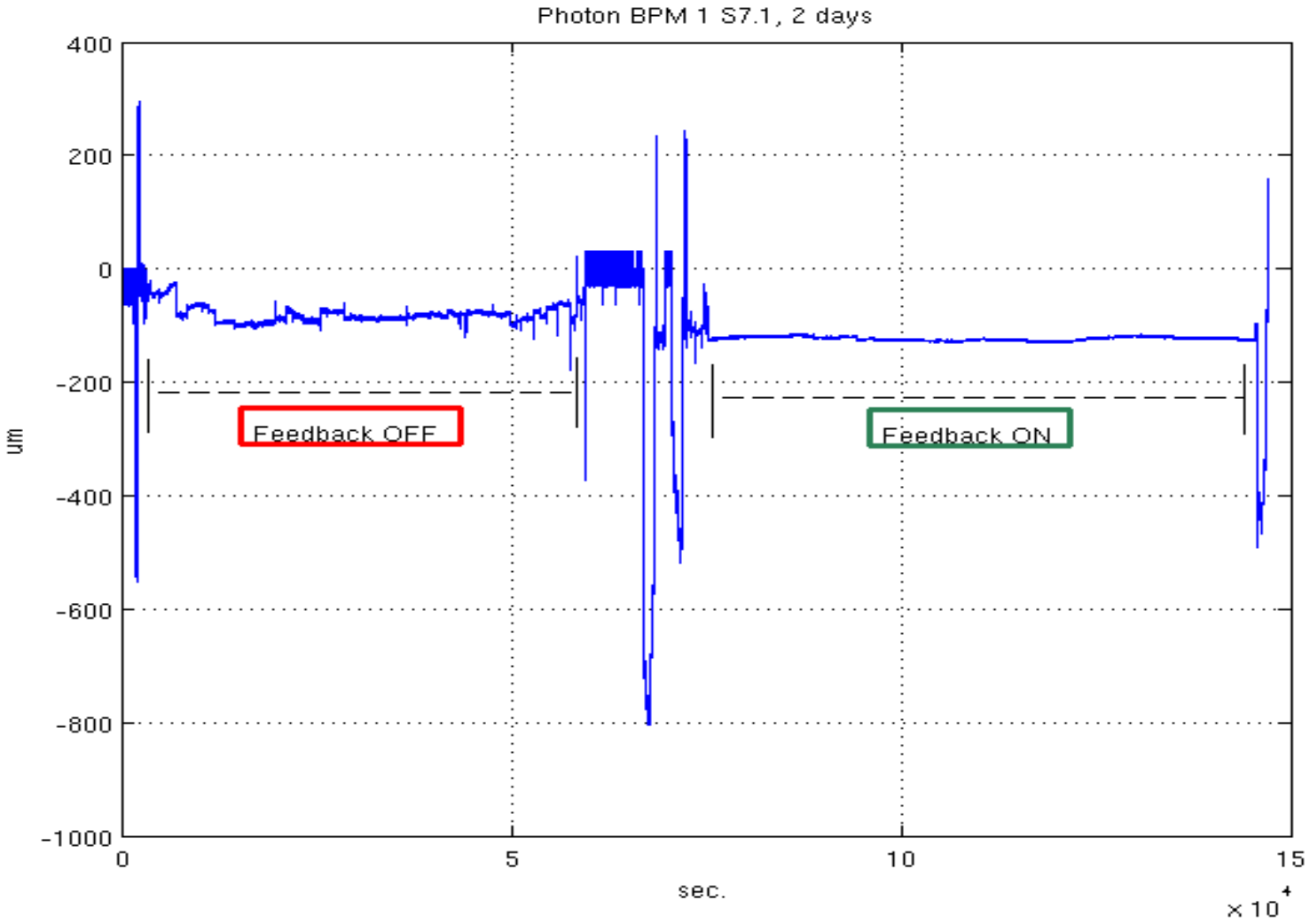


BPMs weights

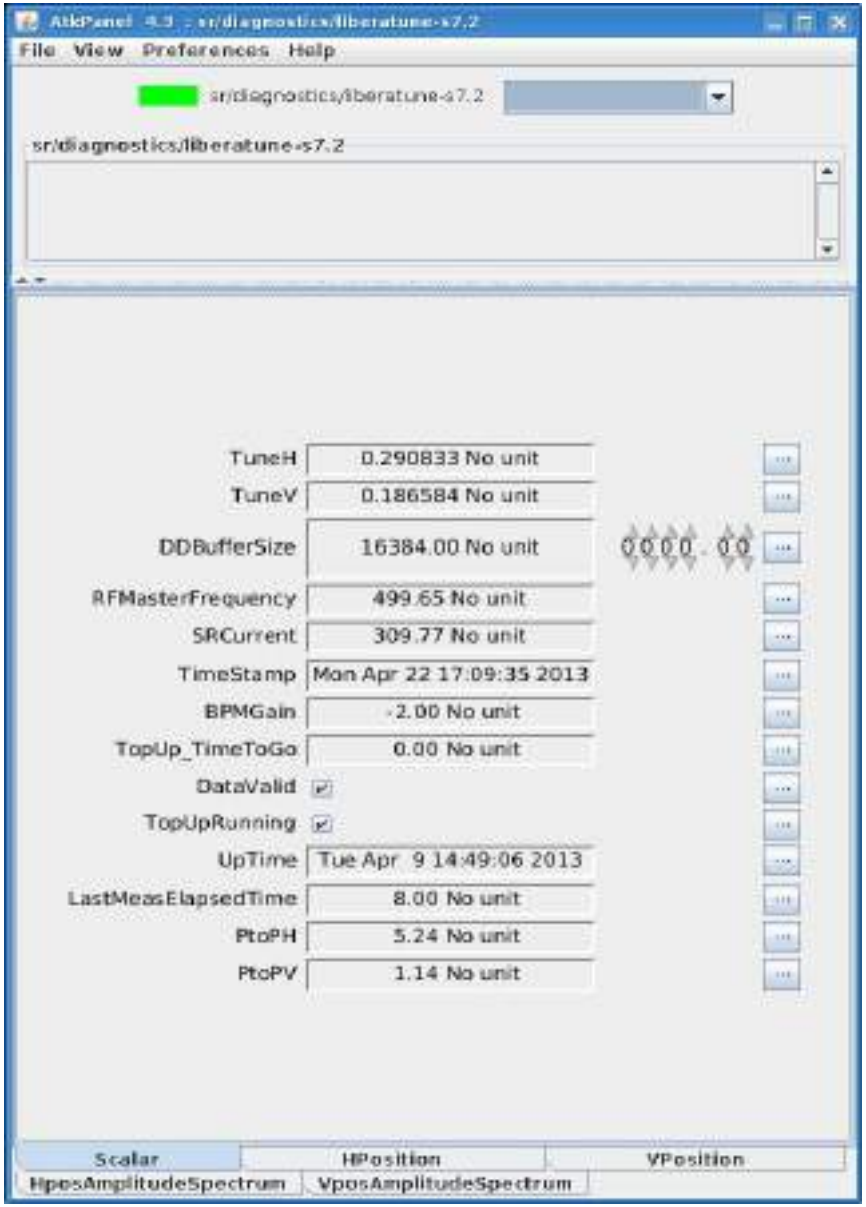
Correctors weights

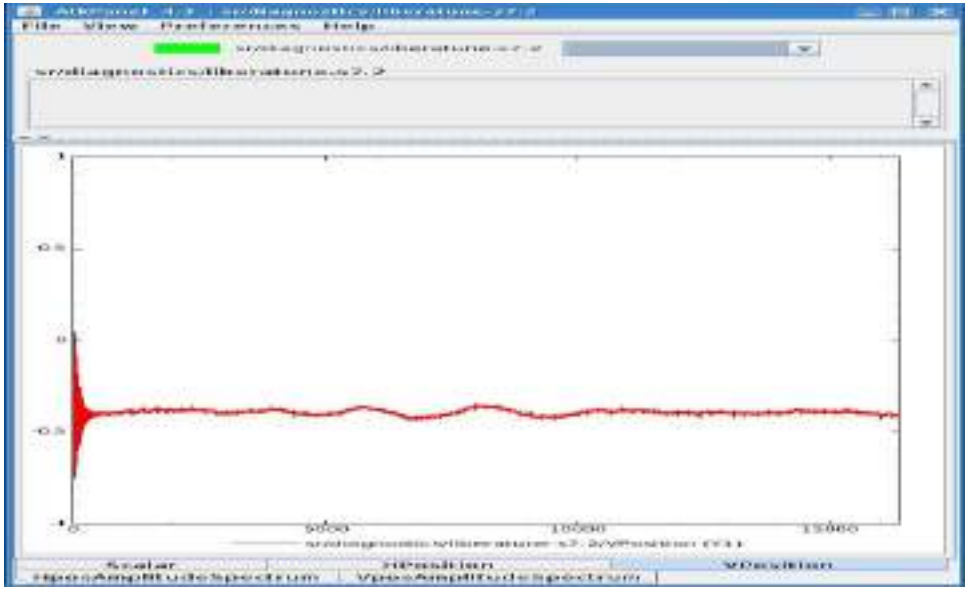


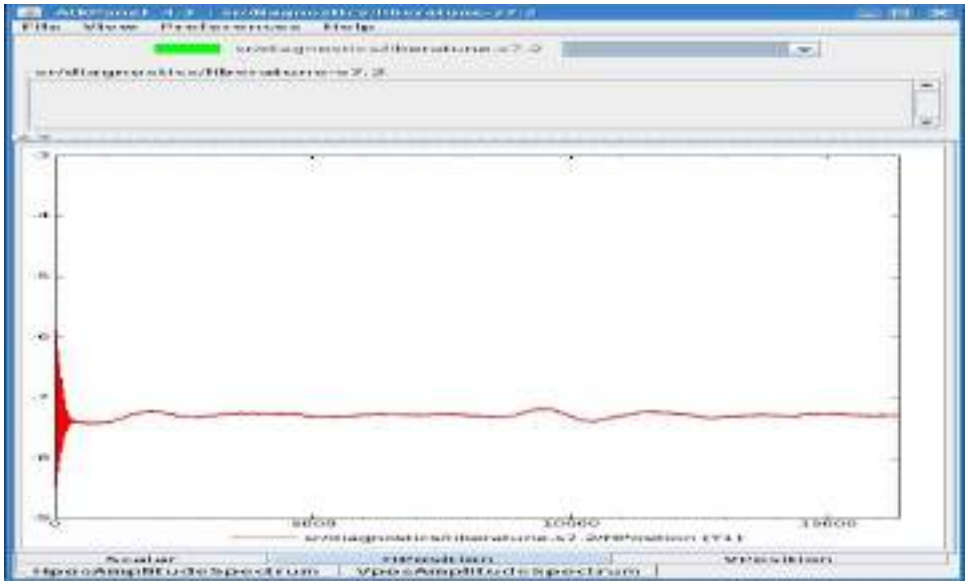
Long term photon beam stability



Tune measurement







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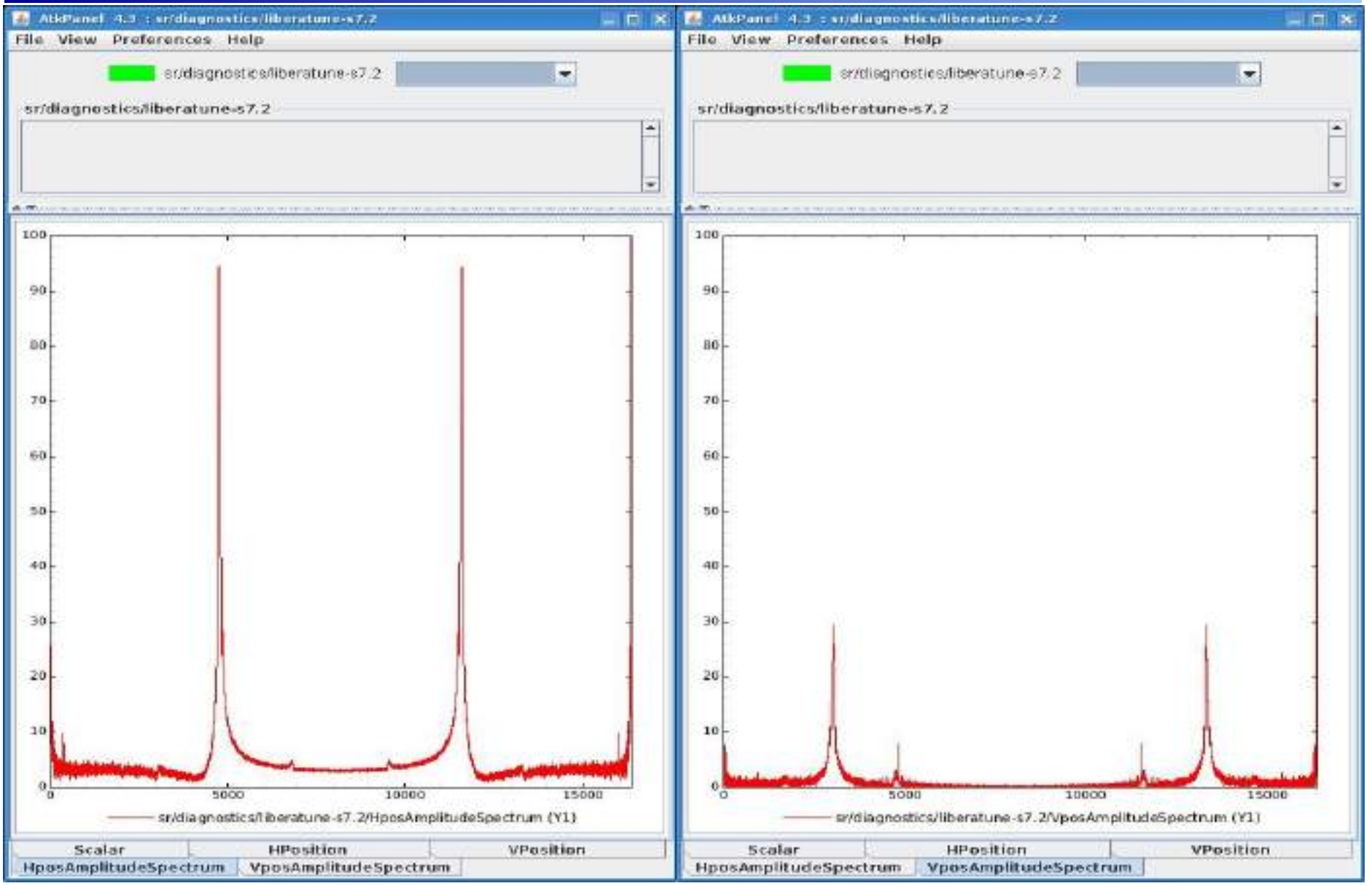


Libera Tango Device Server

- embedded Tango Device Server (by Nicolas Leclercq - SOLEIL) running in the SBC on top of the Generic Server

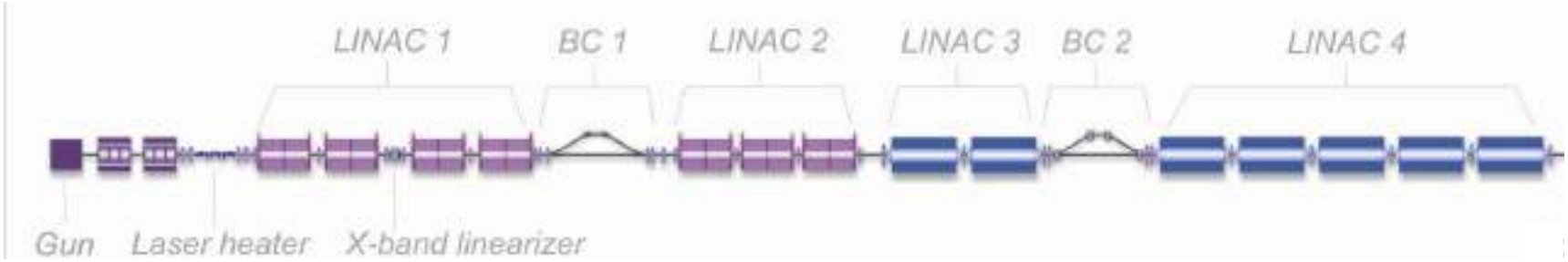
- the Tango server is a “in house” modified version of the one developed for the 1.40 release but does not implement the new functionalities

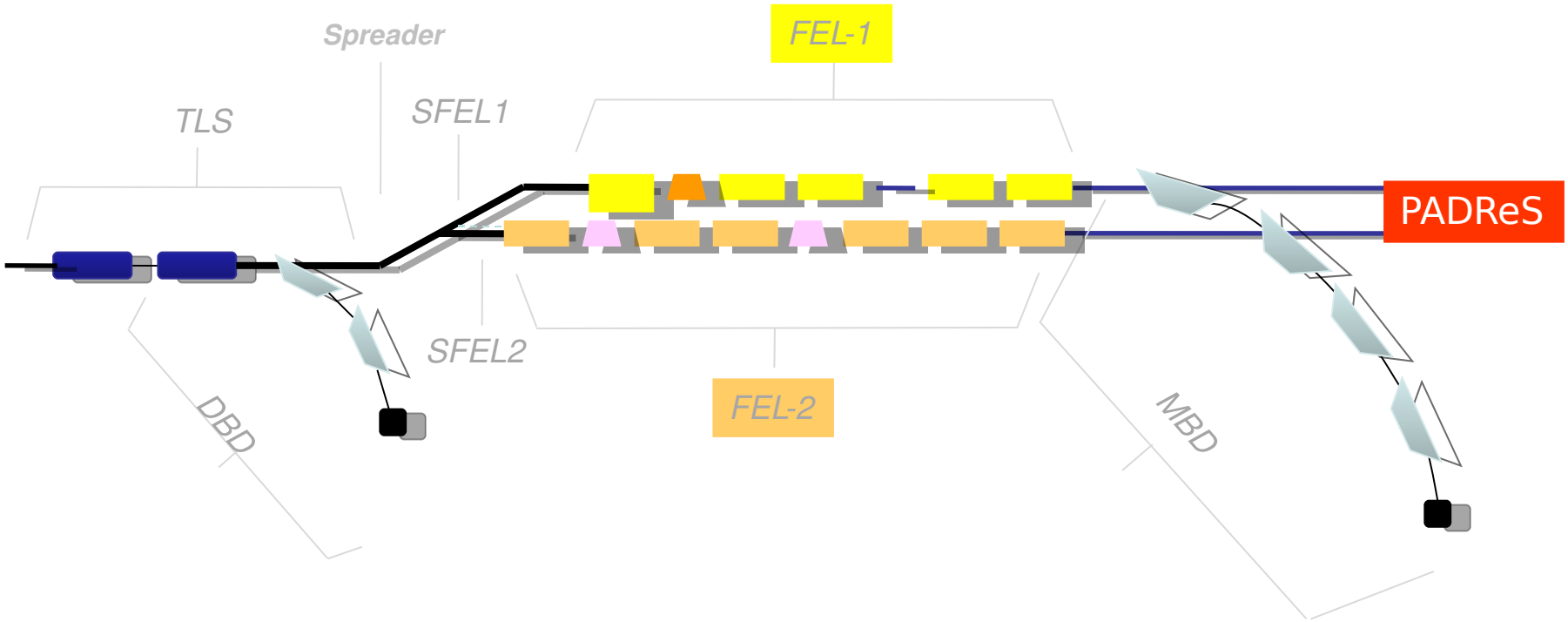
- Tango Device “inside” or “outside” Libera? The behavior of the Tango Server seems different! Tango Server needs debugging directly in the SBC

Future plans

- full implementation of First Turn mode
- Libera based post mortem implementation
- embedded Tango server refurbishing to effectively manage the BBA procedure
- corrector power supplies upgrade (new controller based on BeagleBone)

FERMI: machine layout





Courtesy of S. Di Mitri

Libera at FERMI

- single pass machine (trigger required)
- 55 Libera Brilliance SPPP (16 bit) for the linac stripline BPMs
- in house developed cavity BPM detectors for the undulator area
- CSPI release: libera 2.00 (Sep 24 2009, 14:13:34)
- Gb ethernet custom packet
- increased electrical charge sensibility (350 pC)
- in house developed embedded Tango server
- X and Y offsets can be adjusted at runtime
- Shot to Shot trajectory FB (50 Hz)
- BBA procedure

Additional considerations

- The Libera behaviour is good, apart from:
  - SR: steps in the position readings when changing attenuators (AGC or DSC effect?), not a real problem in top-up
  - SR and FEL: a lot of fan driver faults
  - SR: one analog board failure up to now
  - FEL: a digital board fault (no trigger) occurred in 2012

- “Fast & Better Service” is not suitable for Elettra – Sincrotrone Trieste

Conclusions

- up to now Libera devices, both Electron (SR) and Brilliance SPPP (FEL), have behaved fine
- excellent support from Instrumentation Technologies during the development of the SPPP embedded Tango server
- critical issue (platform A digital board): fan failure, fixing applied only on faulty devices and gradual replacement of the burned out MOSFET
- phasing out of platform A implies a lot of concerns about future upgrades (time, performance, compatibility and costs)
- the historical path of BPM devices at Elettra-Sincrotrone Trieste follows the evolution of embedded systems (SBC), SDR technology, control systems technology and their reciprocal influences → how this evolution as well as the telecom market will affect the evolution of BPM technology?

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