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BPM and Global Feedback for Elettra 2.0

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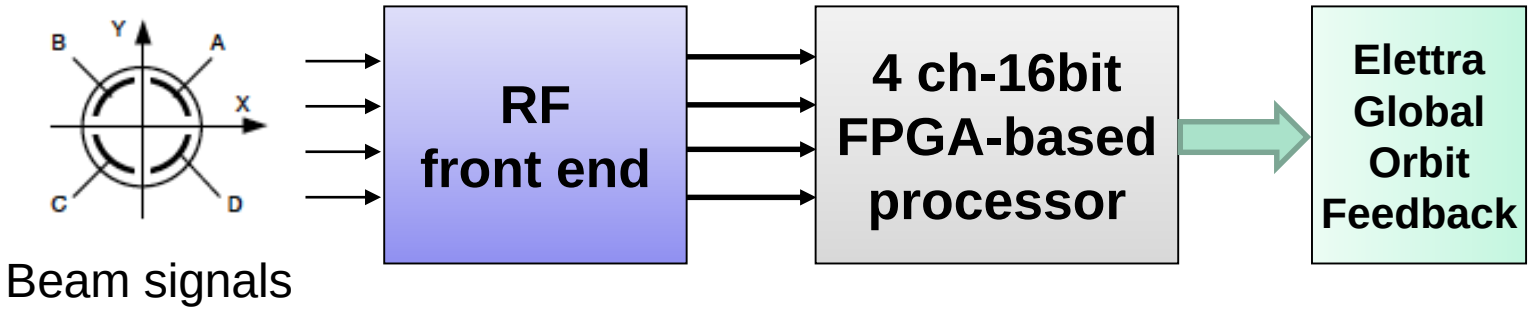
Outline

- Status of Elettra eBPM project
- Current global feedback architecture of Elettra
- Proposed global feedback for Elettra 2.0
- Considerations about data from eBPMs
- Discussion

Status of Elettra eBPM project

- Elettra 2.0: upgrade of the present machine to low emittance
- A prototype of a BPM system based on pilot tone compensation has been successfully integrated in Elettra global orbit feedback *(https://doi.org/10.18429/JACoW-IBIC2018-TUOC01 , IBIC 2018)*
- 200nm resolution at 10 kHz
- Long-term stability better than 500nm in 12 hours
- Capable of self-calibration/self-diagnosis
- Modular system: analog front end + separate digitiser/processor



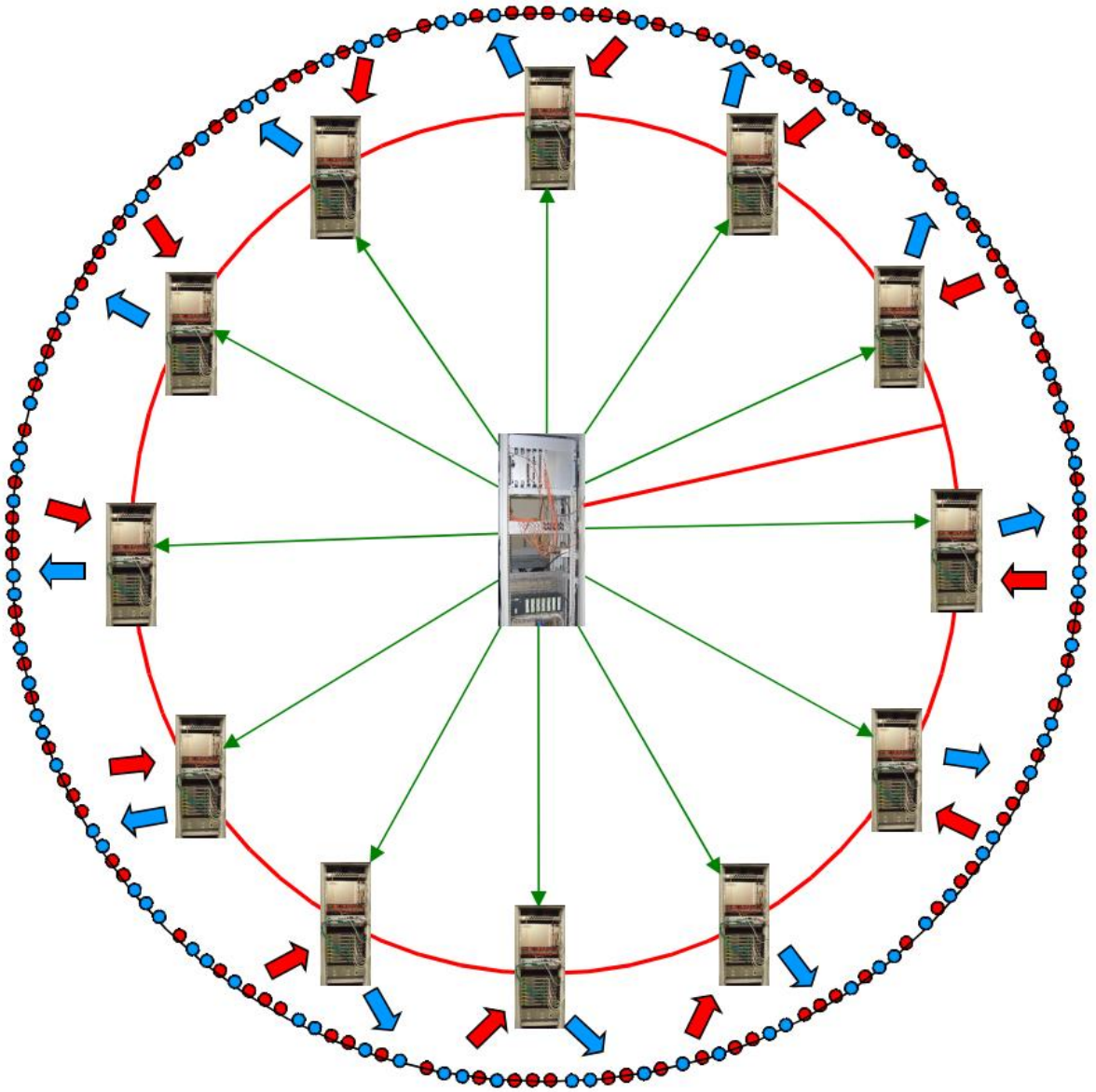
Elettra eBPM project: second phase

- Replace the Beam Position Monitor electronics (8 units) of one of the 12 Elettra section with the new generation of eBPM. The replacement implies the engineering of the already tested prototype in a modular system usable “on field” (sturdy metal boxes)
- “Debug” the system on Elettra 1 first

- Analog front end ready and validated
- Digital part:
  - FMC A/D module with 4 16-bit, 210 MS/s ADCs (designed and tested)
  - Digital carrier board developed in-house based on Altera/Intel Arria 10 FPGA: 2 FMC slots, DDR3 so-dimm, 4 SFP+ modules (up to 10 Gb/s)
  - Common platform for Elettra 2.0 diagnostics? (see Raffaele’s talk)
  - microTCA platform is also considered

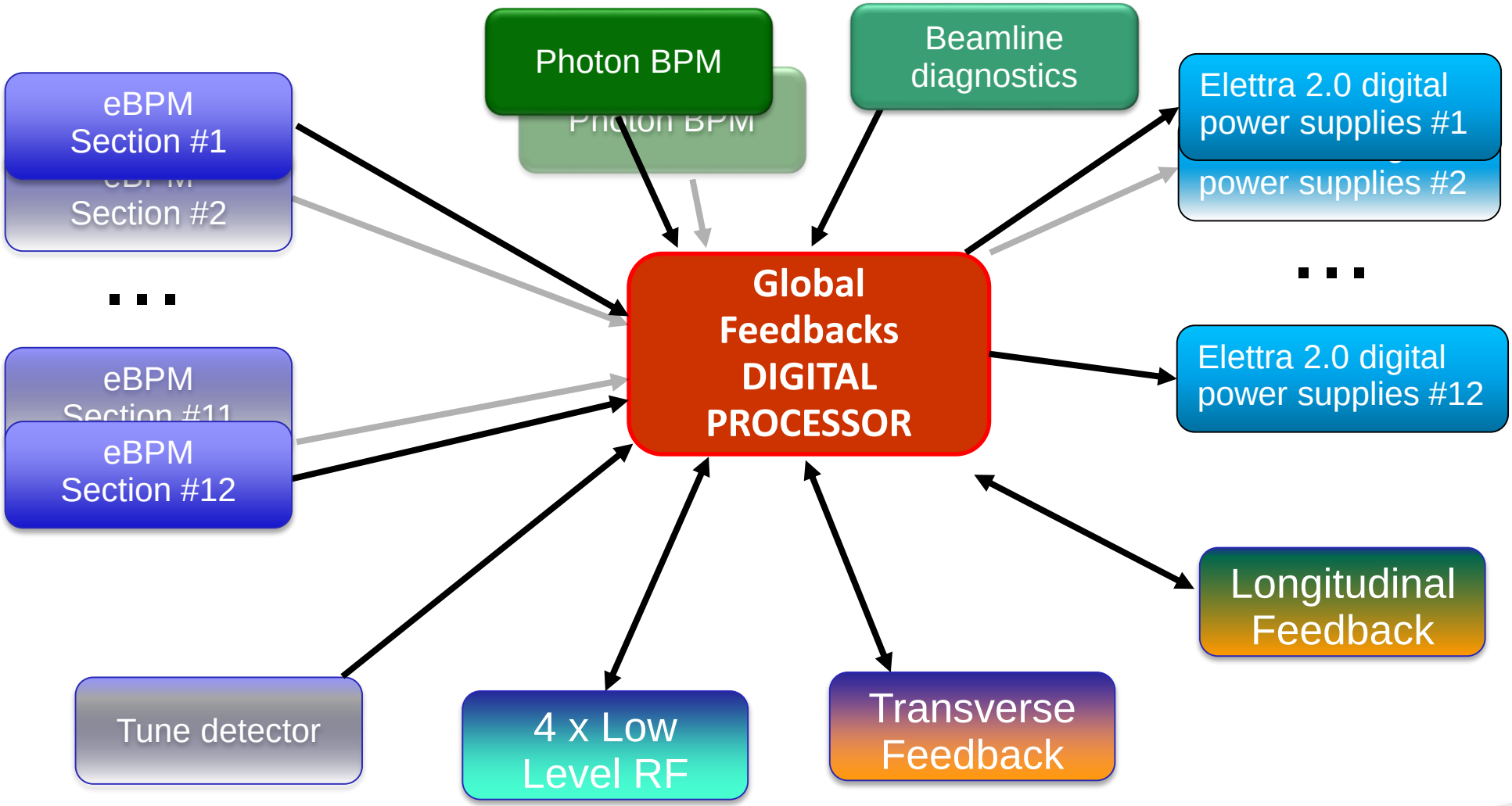
Current Elettra Global Orbit Feedback Architecture

- 12 sections, 8 BPMs per section;
- 96 rhomboidal + 4 low-gap BPMs all equipped with Libera Electron (82 corrector magnets per plane);
- 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 (fiber optic links);
- 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 fiber optics to distribute MC, SC, PM and trigger signals;

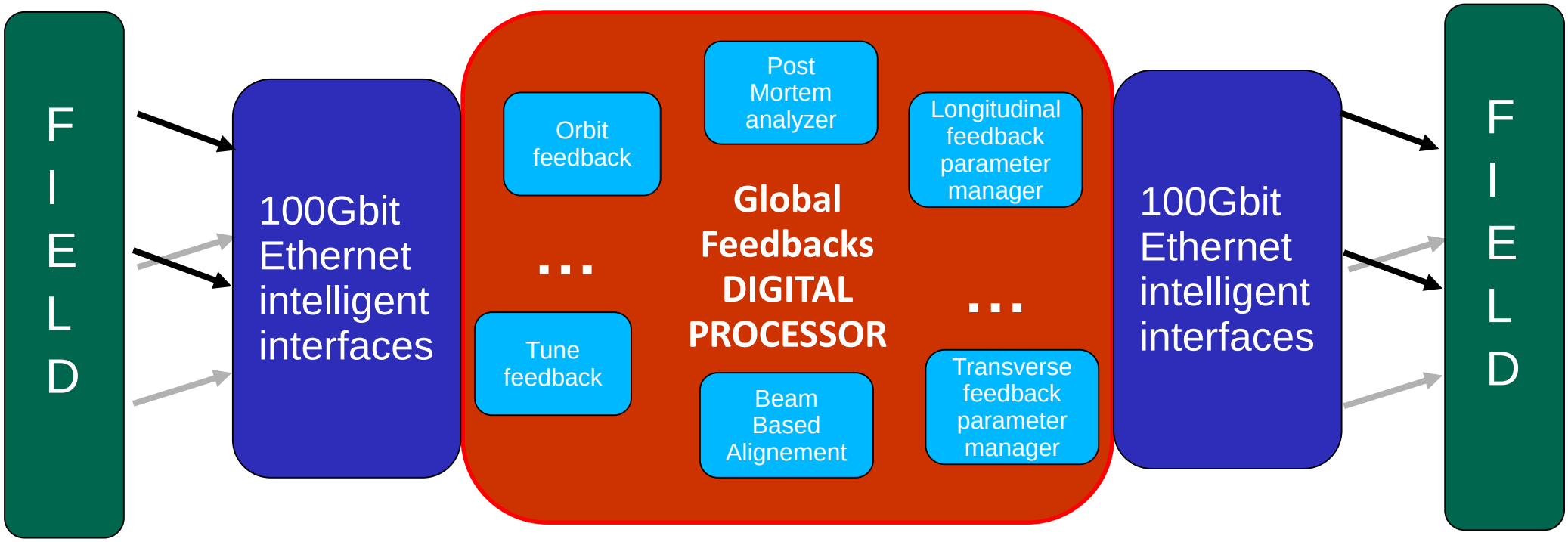


Current Elettra G.O.F. Station

Elettra 2.0 proposed G.O.F. diagram



Elettra 2.0 Global Feedbacks Digital Processor



Parallel tasks inside

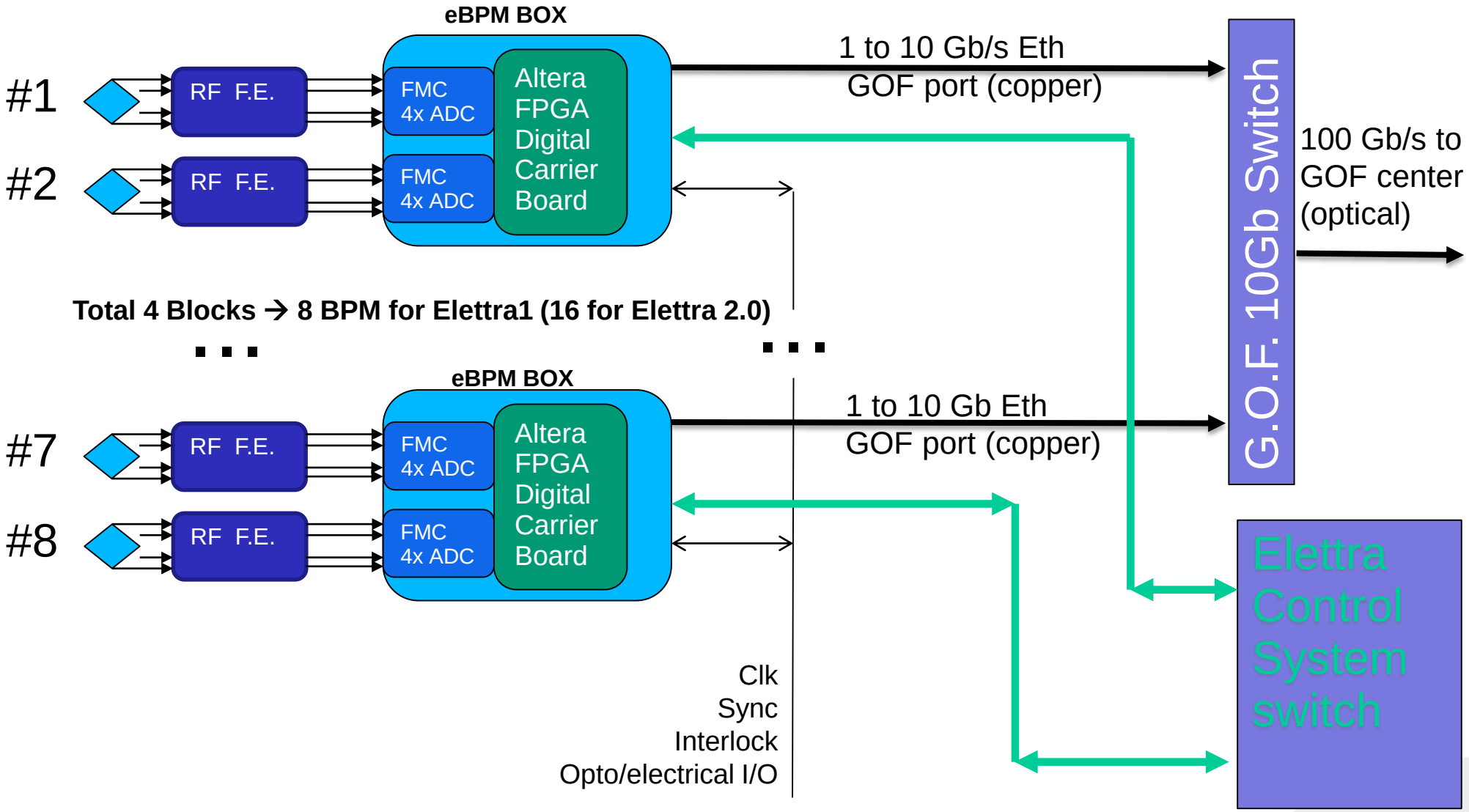
Elettra 2.0 Global Feedbacks Digital Processor

- From distributed to centralized
- Correlation between any active component of the machine
- Complete post-mortem analysis
- Accurate timestamp

Drawbacks:

- High computation power needed (CPU + FPGA?)
- Redundancy needed in case of failure
- High speed links (10 Gb/s – 100 Gb/s?)
- Different topology (star with backbone)

Focus on eBPM: single section



Focus on eBPM: data rate

Present data rate for feedback: approx. **10 kHz** (rev. frequency / 116)

Current UDP packet structure:

- 4 amplitudes (32 bits x 4)
- Sum, Q, X and Y (32 bits x 4)
- Sequence number (16 bits) and ID (16 bits)

Total: 288 bits + IP/Eth overhead (~240 bits) ~ 528 bits

Single BPM: ~5.28 Mbit/s

Section of 8 BPMs: ~42.24 Mbit/s

Future data rate:

- Bandwidth of correctors is a limit
- Still needs for higher bandwidth? => Better knowledge of beam status
- 100 kHz/TbT data rate? => **52.8 Mbit/s - 612.5 Mbit/s per single BPM**
- Minimize the overhead

Focus on eBPM: possible data structure

Increase data rate up to ~48 kHz (rev. freq/24)

Add further data fields to the current packet:

- Packet type flag (8 bits) – *standard* or *long*
- 4 amplitudes (32 bits x 4)
- Sum, Q, X and Y (32 bits x 4)
- Sequence number (32 bits) and ID (16 bits)
- X0,Y0 (32 bits x 2)
- ...
- X23, Y23 (32 bits x 2)

} *on demand (long), 24 TbT positions*

Data rate per single BPM:

- *standard*: 312 bits + IP/Eth overhead = 552 bits x 48 kHz => **26.5 Mbit/s**
- *long:* 1848 bits + IP/Eth overhead = 2088 bits x 48 kHz => **100.2 Mbit/s**

Focus on eBPM: ethernet traffic

Number of BPMs per section: 8 (Elettra 1), probably 12 or 16 for Elettra 2.0

Data rate per section:

# of BPMs	standard	long
8	212 Mbit/s	801.6 Mbit/s
12	318 Mbit/s	1202.4 Mbit/s
16	424 Mbit/s	1603.2 Mbit/s

- No need for 10 Gb/s links between units and switches
- Standard 10 Gb/s uplink for backbone
- Complete knowledge of TbT positions if needed, not for an active feedback but for diagnostic
- Total traffic for 12 sections (worst case): 19.2 Gbit/s

Conclusions/discussion

- Internal development of eBPM is still ongoing
- New feedback system and diagnostics should evolve together
- Always keep in mind:
  - response time of actuators
  - different timescales: BbB – TbT

- Is higher data rate really mandatory for BPM data, especially for new generation machines?
- Noise increases with bandwidth…
- Which are your experiences/feelings about that?

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Thank you!

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