Global Fast Orbit Stabilization System FOSS

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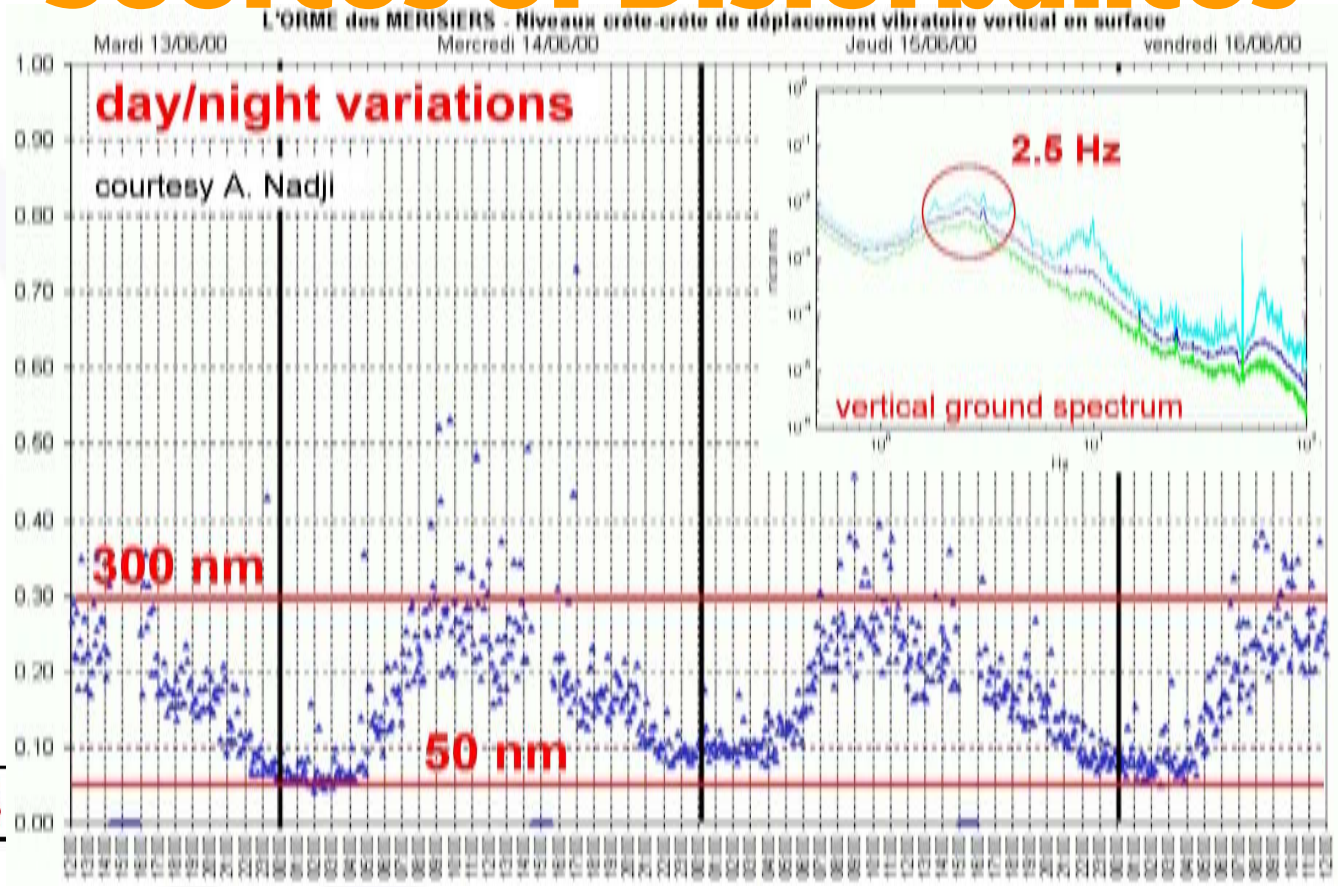
Sources of Disturbances



f [Hz]	Noise Source
3	booster stray fields
12.4	helium-refrigerator
15-50	girder resonances
50	power supplies&pumps

FOSS Objectives

- Suppression of beam disturbances
  - aperiodic, stochastic: human activity
  - periodic: power supply (50Hz)
- BW ultimately limited by corrector magnets (<500Hz)
- Basic building blocks
  - Libera Electron
  - Fast private communication system
  - Computational engines
  - PS interfaces and corrector magnets

Libera Electron

- **FA data stream:**
  - **10 kHz sampling rate**
  - **-3dB at 2 kHz, gentle slope for minimal latency**
  - **Data available:**
    - **Amplitudes: V_A, V_B, V_C, V_D**
    - **Positions: X, Y(Z)**
    - **Other: ∑, Q**
    - **Status**
      - **Packet time-stamping**
      - **Libera status: Interlock, ADC overflow, ...**
- **Data available on SFP ports directly from FPGA**
- **FPGA communication module is user specific**

Communication System

- Fast
  - 100 Liberas * 40 bytes * 10 kHz = 40 MB/s
    - Not including protocol overhead
  - Multiple MISO systems: serialized position data
- Low latency
  - 1Gb/s: 40 *μs* on one cable
    - No collisions, no duplicates
- Routing!

Computational Engines

- DSP processing for control algorithms
  - CPU clusters/SMP/multiple cores
    - Intra CPU communication??
    - Real - time
  - DSP
    - Boards available with fast network links
    - Fixed architecture
  - FPGA
    - Programmable hardware
- Decreasing ease of programming
- Increasing versatility
- Control algorithms: PID, ...

PS Interfaces and Magnets

- Myriad of interfaces
  - Optics
  - Analogue
  - RS485
  - Network attached PS??
    - Converters (Gb-ethernet 2 xy)
- LP filters
  - latency
- Non homogeneous structure (APS)

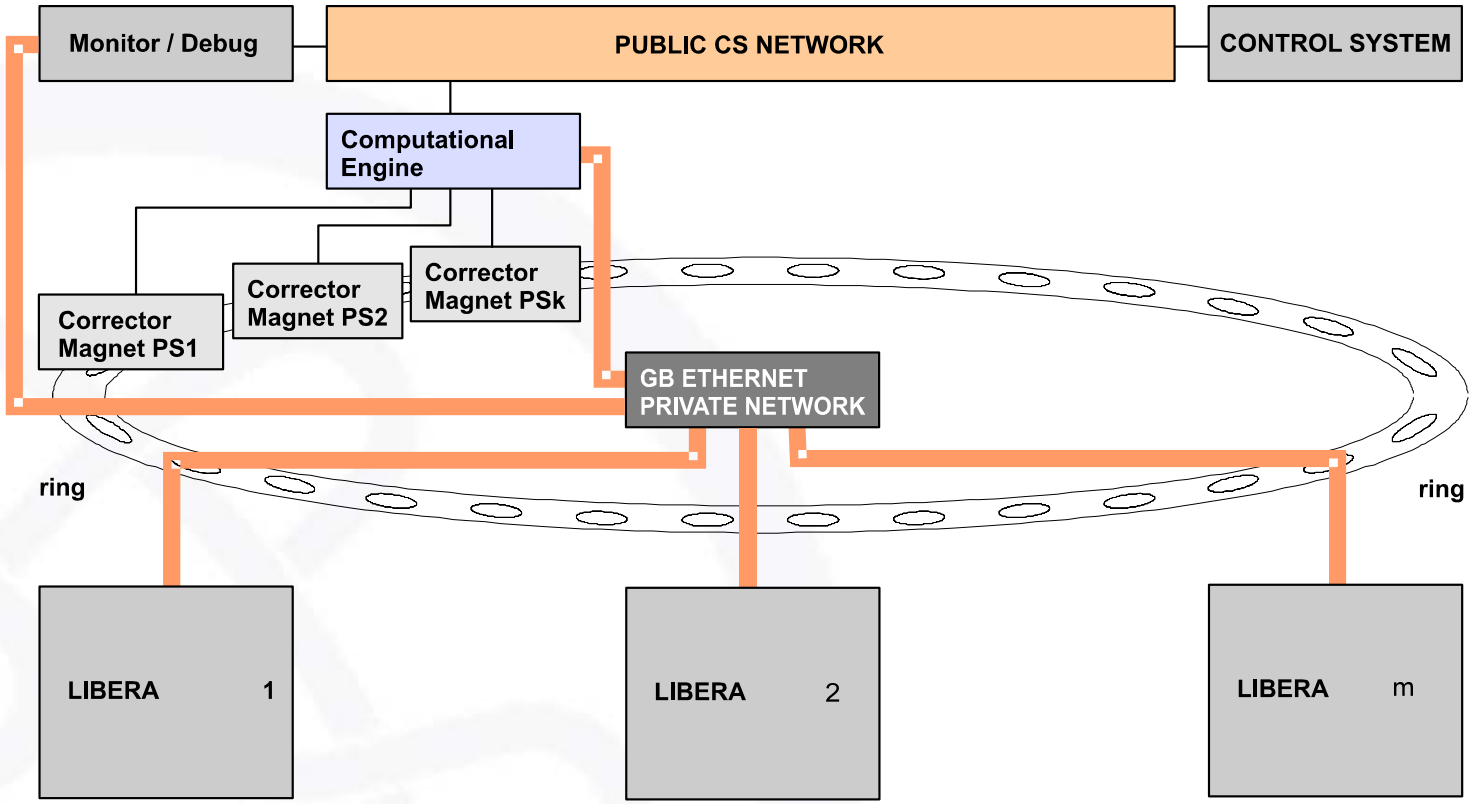
Limitations

- Corrector magnets
  - BW (<500 Hz)
  - Latency
- Communication channel capacities
  - 100 Libera x 10kHz x 12-72bytes = 120 - 720 MB/s
  - Latency (time multiplexed data)
- Latencies
  - Libera: FA filter group delay, ~300 *μs*
  - Communication: 20 – 200 *μs*
  - Comp. engine: 5 – 200 *μs*
    - Algorithm complexity
    - HW used

Libera Based FOSSes

- Centralized
- Fully distributed
- Hybrid approach

FOSS: Centralized



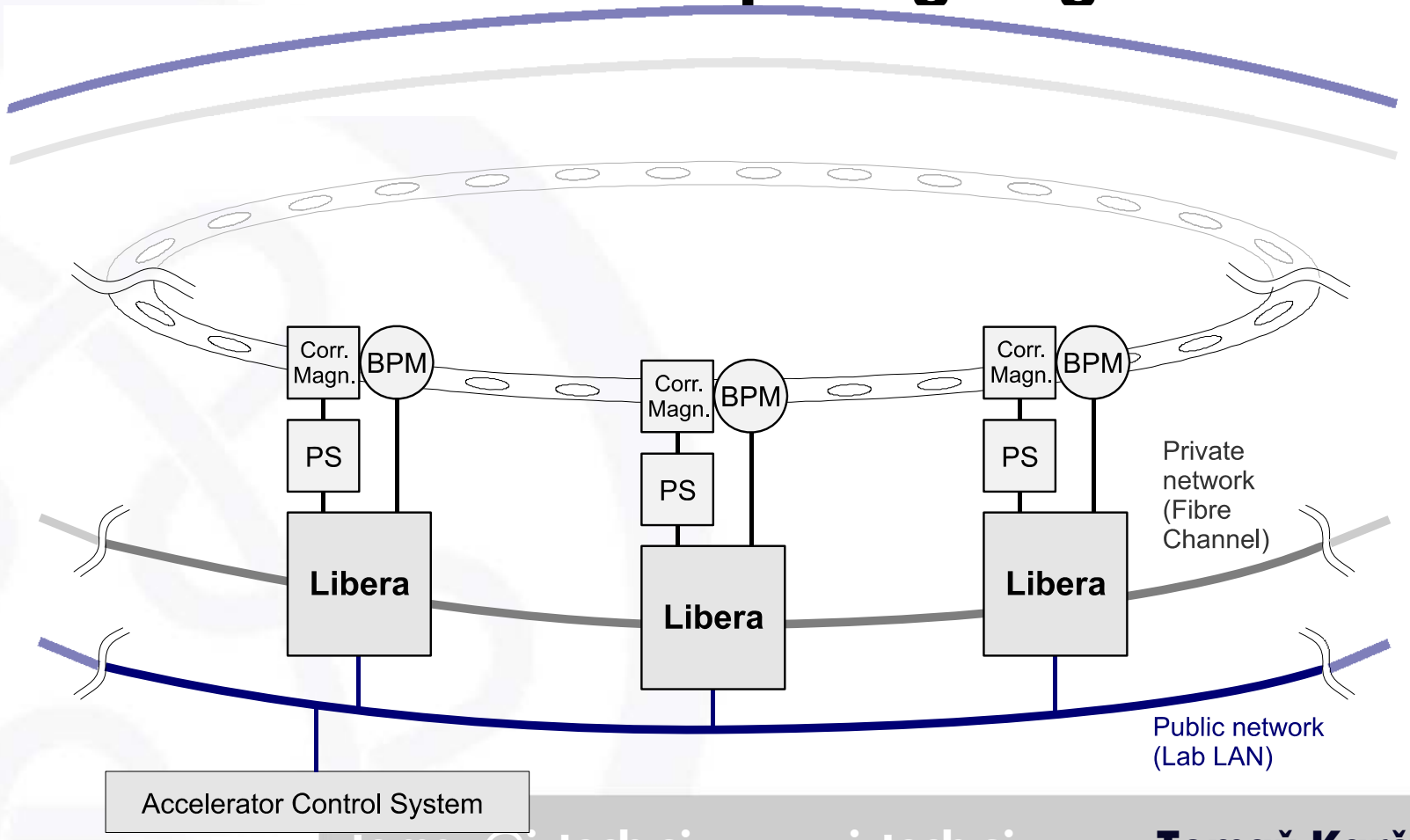
GB Ethernet
100MB Ethernet

FOSS: Centralized

- Libera
  - FA data
  - G-ethernet data stream: standard UDP/IP
- Communication network based
  - Standard G-ethernet for all (COTS infrastructure)
- Computational engines
  - G-ethernet receiving port
  - Single or "SMP" engines (routing!)
- Specific FPGA modules residing in Libera
  - G-ethernet communication controller
- For smaller machines

FOSS: Fully Distributed

- **Libera is also a computing engine**



FOSS: Fully Distributed

- Libera FA data
- Communication network - proprietary
- Distributed computational engines in Libera FPGA
  - PID controller
  - RS485 interface or analogue output to PS (out of the box)
- Specific FPGA modules residing in Libera
  - Communication controller
  - PID controller
  - PS interface

FOSS: Hybrid

- Libera FA data; source only
- (Redundant) communication network
- (Partially) distributed computational engines
- Specific FPGA communication module residing in Libera

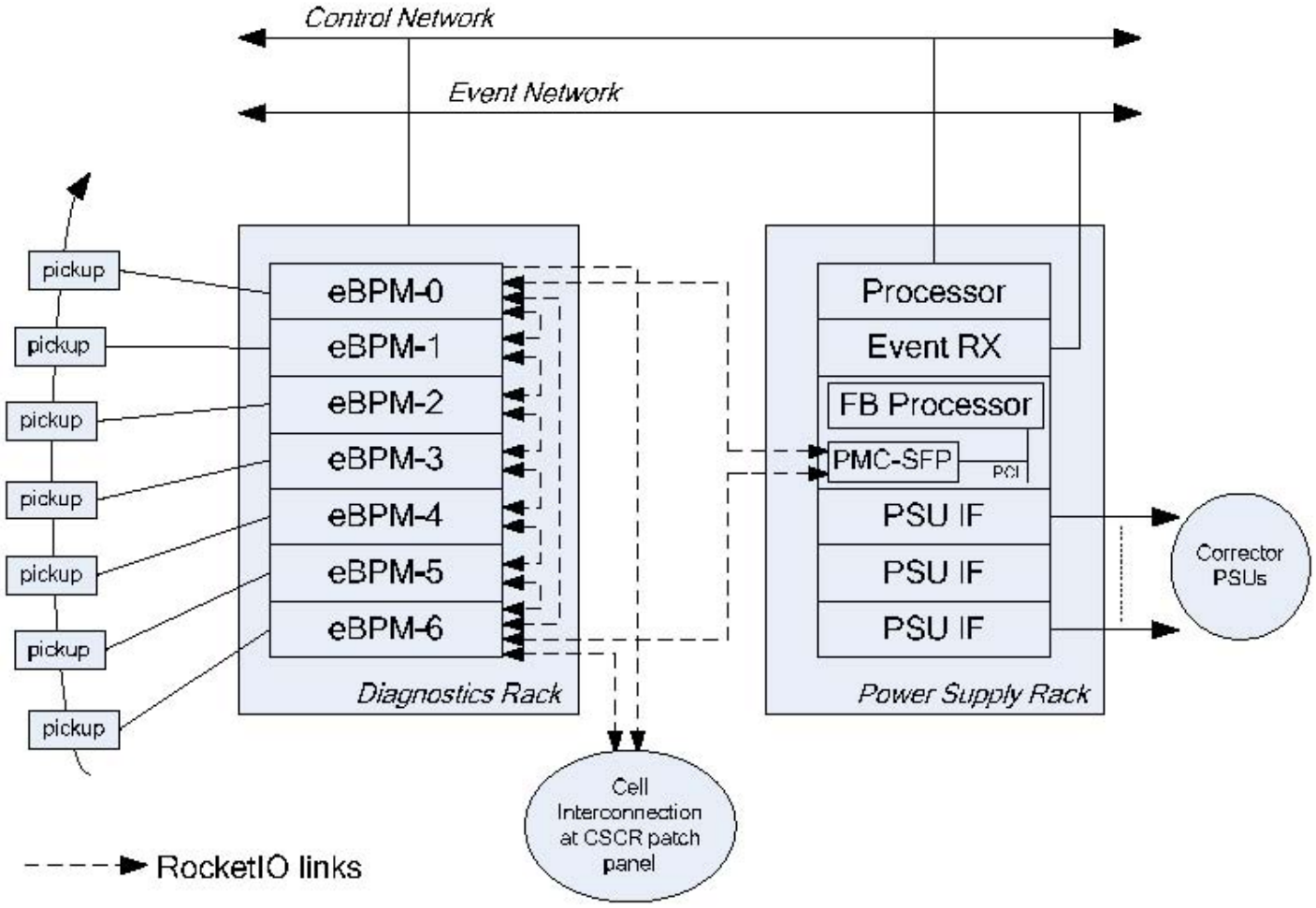
Hybrid Examples

- **Diamond LS:**
  - **Initial design of the fast orbit feedback system for DIAMOND light source**

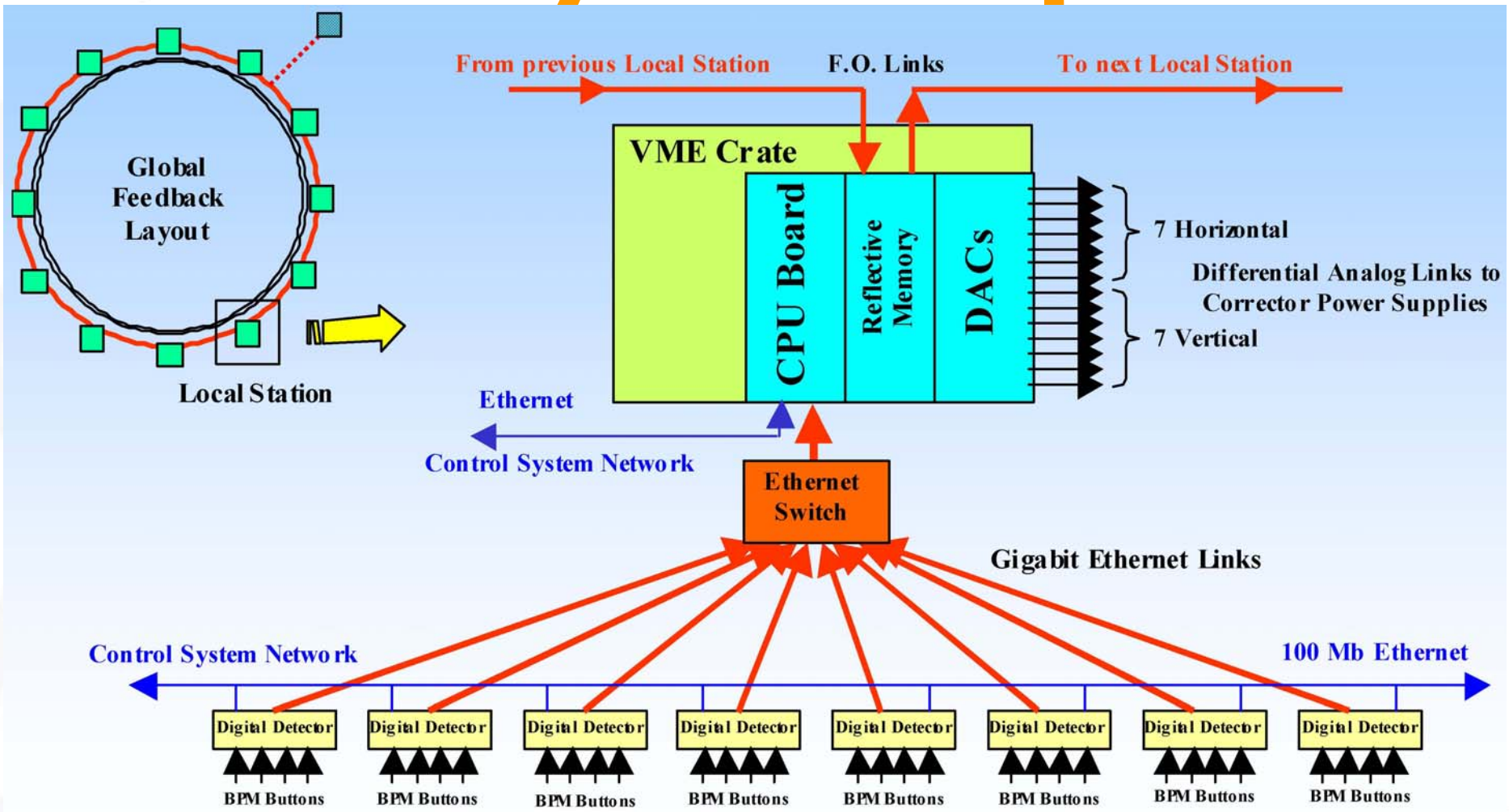
    I. S. Uzun, *et. al.;* ICALEPS 2005
- **Elettra:**
  - **Design of a Fast Global Orbit Feedback System for the ELETTRA Storage Ring**

    D. Bulfone, *et. al.;* ICALEPS 2005

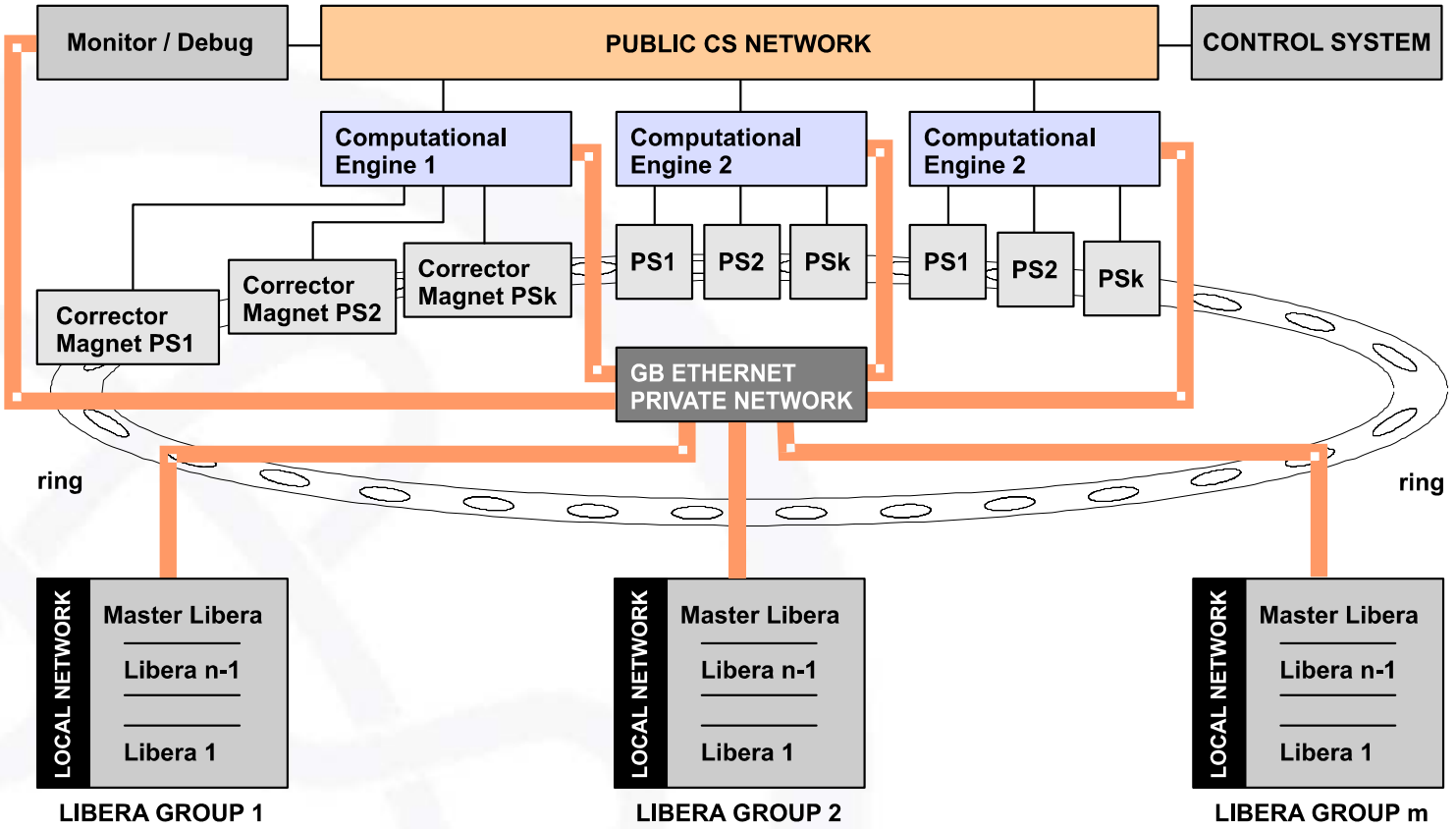
Hybrid Example: Diamond



Hybrid example: Elettra



FOSS: Our Proposal



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100MB Ethernet

FOSS: Our Proposal

- Libera
  - FA data
  - Giga-ethernet data stream: standard UDP/IP
  - Protocol-less data exchange (2 Gb/s)
- Distributed computational engines
  - PID controller
  - Network interface to PS?
- Communication network based
  - Standard G-ethernet for Libera – CPU
  - Protocol-less for Libera – Libera
- Specific FPGA modules residing in Libera
  - G-ethernet communication controller
  - Local network support

FOSS: Our Proposal

- Advantages
  - Standard COTS components
  - Standard protocol – routing, monitor/debug
  - Scalability
  - Comp. engine independent architecture
  - Redundancy if required
  - Friendly to tweaking, maintenance
- Disadvantages
  - Single point of failure in non redundant network – GE switch

Are We There yet?