Libera

Libera Fast Orbit Feedback Solutions

Ales Bardorfer, Libera Workshop 2011, Solkan

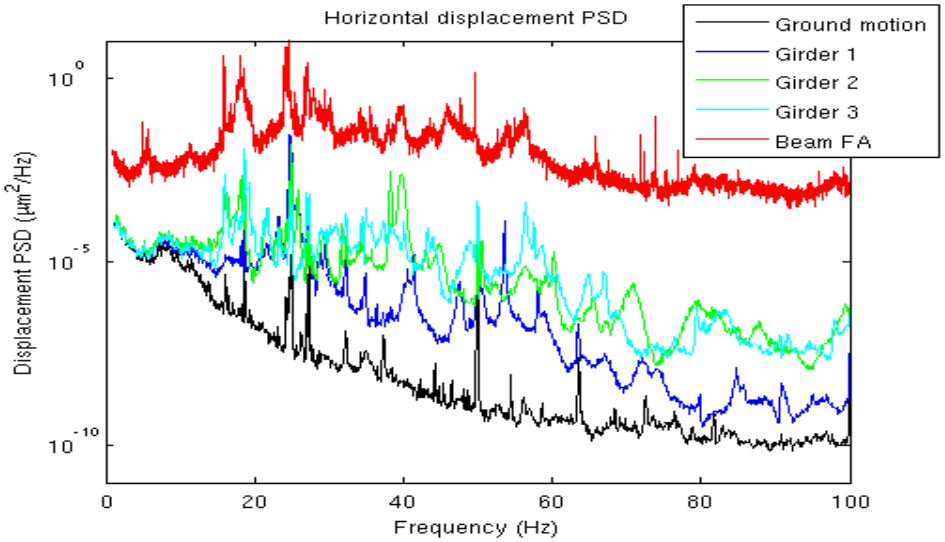
ales.bardorfer@i-tech.si

Instrumentation Technologies

Introduction

- **The Purpose of Global FOFB**
- **FOFB Principles**
- **Fast Acquisition Data Stream on Libera Electron/Brilliance/Brilliance+**
- **Levels of FOFB integration**
  - GDX Module & FPGA based FOFB
  - Libera Grouping & GbE
  - Diamond Communication Controller
  - Hybrid: GbE + RM @ Elettra
- **Timing Synchronization**
- **FOFB in mixed environment**

The Purpose of Global FOFB



- Global FOFB: Global Fast Orbit Feedback
- To decrease the beam emittance
- To stabilize the beam in Storage Ring
- Disturbances:
  - Mechanical vibrations
  - Vacuum pumps
  - Ground motion
  - Electrical power lines
  - Etc.
- Courtesy of Guenther Rehm, Diamond, Libera Workshop 2007

FOFB Principles

$$\begin{bmatrix} m_1 \\ m_2 \\ m_3 \\ \vdots \\ m_k \end{bmatrix} = \begin{bmatrix} r_{11} & r_{12} & r_{13} & \cdots & r_{1n} \\ r_{21} & r_{22} & r_{23} & \cdots & r_{2n} \\ \vdots & \vdots & \vdots & \vdots & \vdots \\ r_{k1} & r_{k2} & r_{k3} & \cdots & r_{kn} \end{bmatrix}^{-1} \begin{bmatrix} x_1 \\ x_2 \\ x_3 \\ \vdots \\ x_n \end{bmatrix}$$

$$\begin{bmatrix} m_1 \\ m_2 \\ m_3 \\ \vdots \\ m_k \end{bmatrix} = VS^{-1}U^T \begin{bmatrix} x_1 \\ x_2 \\ x_3 \\ \vdots \\ x_n \end{bmatrix}$$

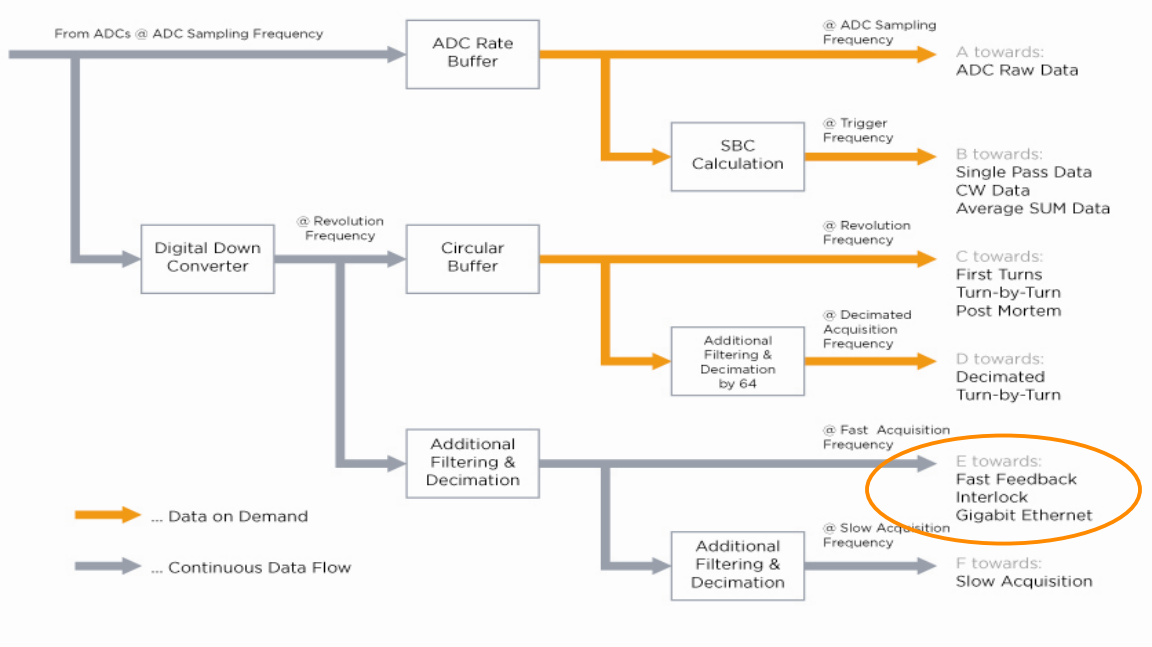
- Multiple BPM devices (x)
- Multiple magnet correctors (m)

- Interdependency – One magnet correction influences the position of the beam at virtually all BPM positions.
- Response matrix R

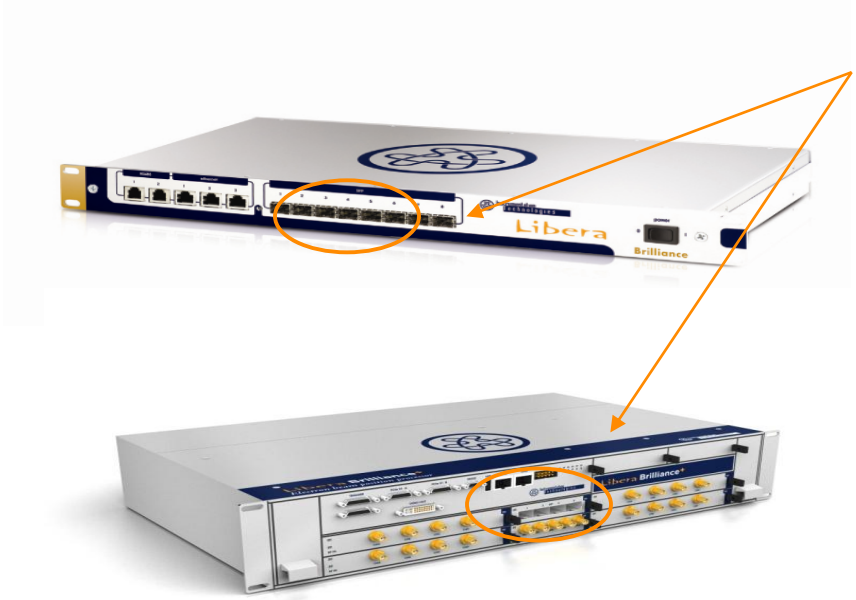
- Global FOFB

Fast Acquisition (FA) Data Stream – Logical View

- **Real-Time Stream**
  - Continuous flow
  - ~ 10/20 kHz
- **FA Atom Content**
  - Va, Vb, Vc, Vd
  - X, Y, Q, Sum
  - Packet counter & Status



Fast Acquisition (FA) Data Stream – Physical View

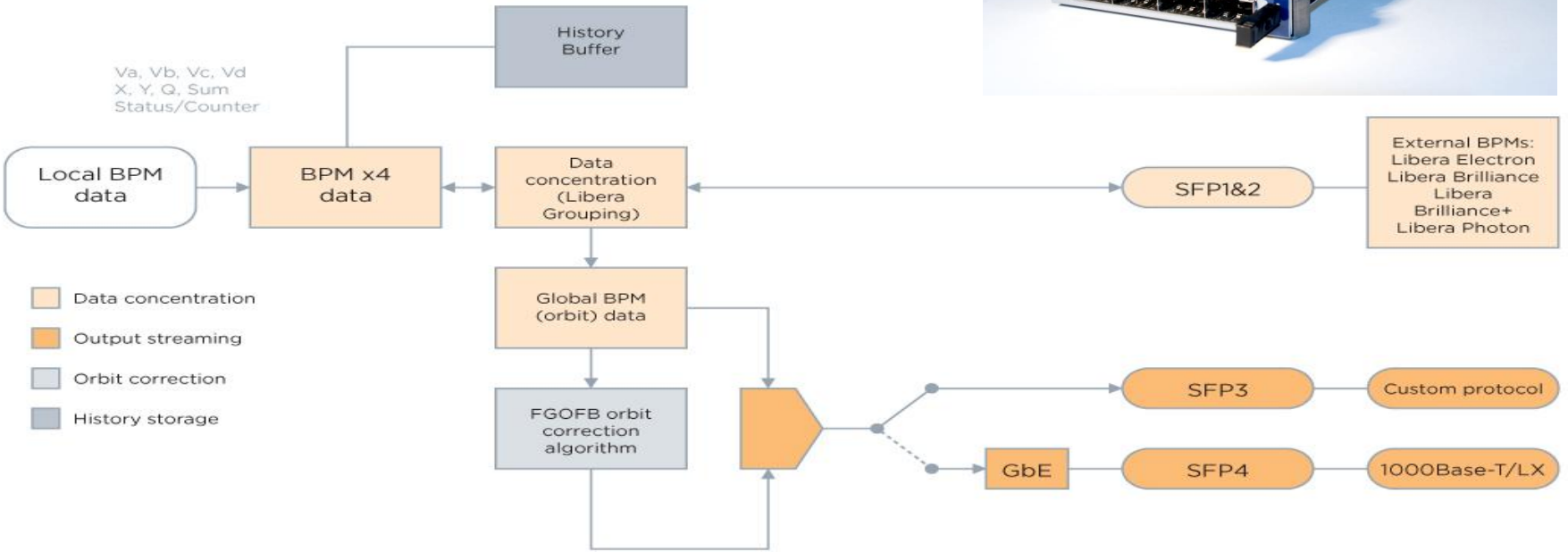


- **Hardware**
  - SFP ports
- **Hard-Real-Time packet transmission**
- **Levels of integration:**
- Orbit/FA data concentration
- FOFB application (magnet corrections)

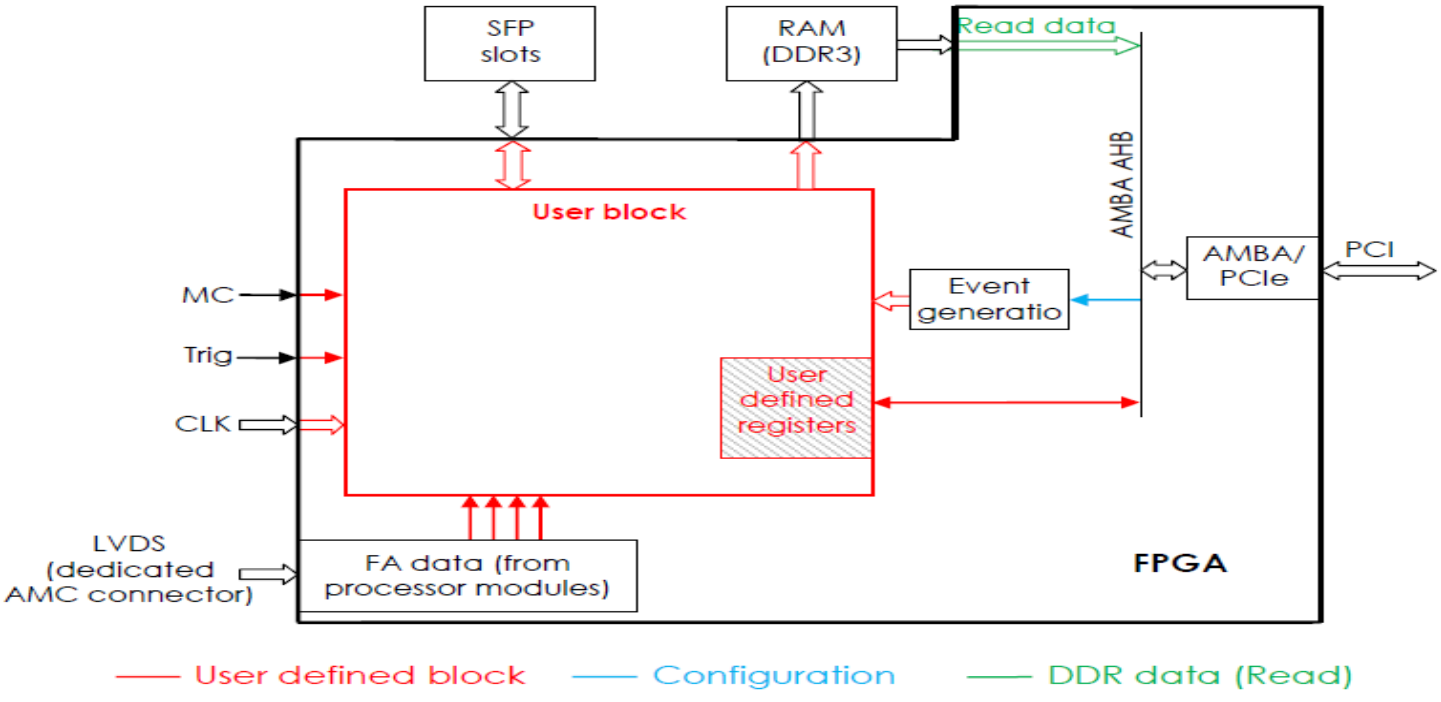
FOFB: Levels of integration

- **Semi integrated (data concentration only):**
  - **Libera Grouping**
  - **GbE**
  - **DCC**
  - **Hybrid (e.g. GbE + RM)**
- **Fully integrated (FOFB application):**
  - **External**
  - **Internal**
  - **Centralized**
  - **Distributed**

GDX Module & FPGA based FOFB



GDX Module FPGA Development Kit



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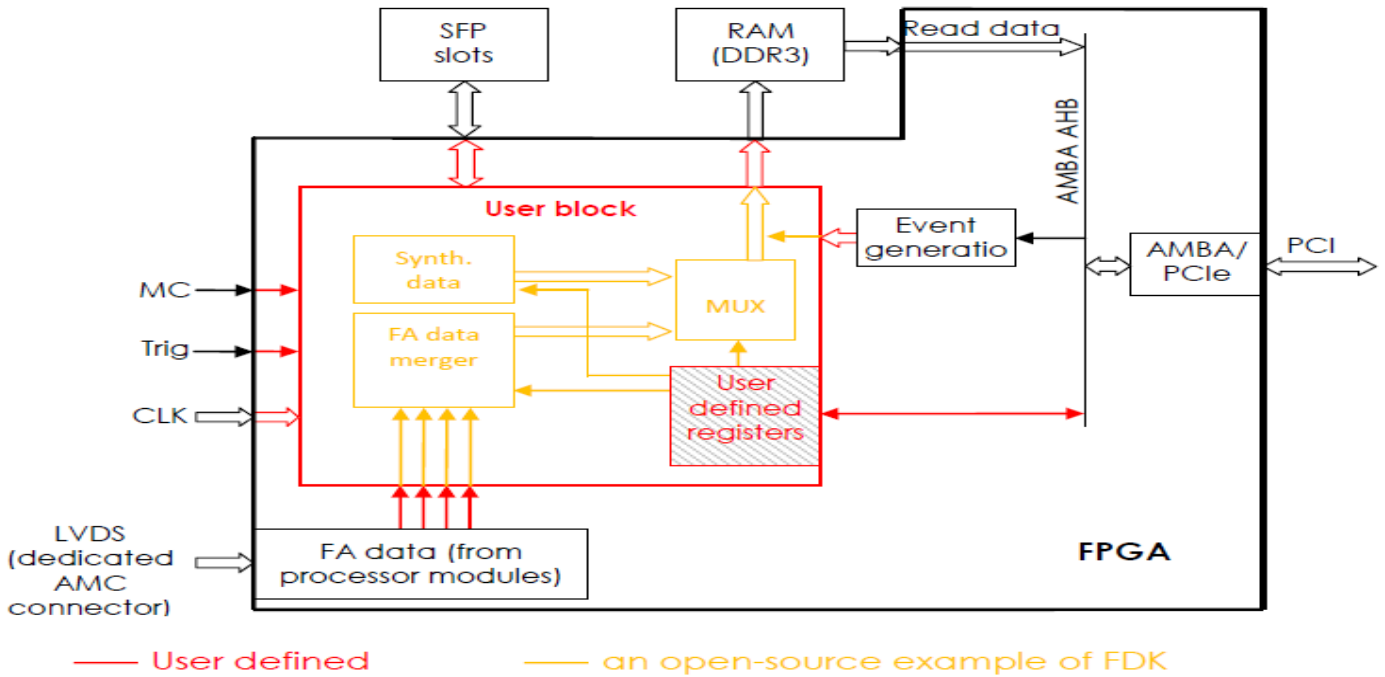
GDX Module & FPGA Development Kit



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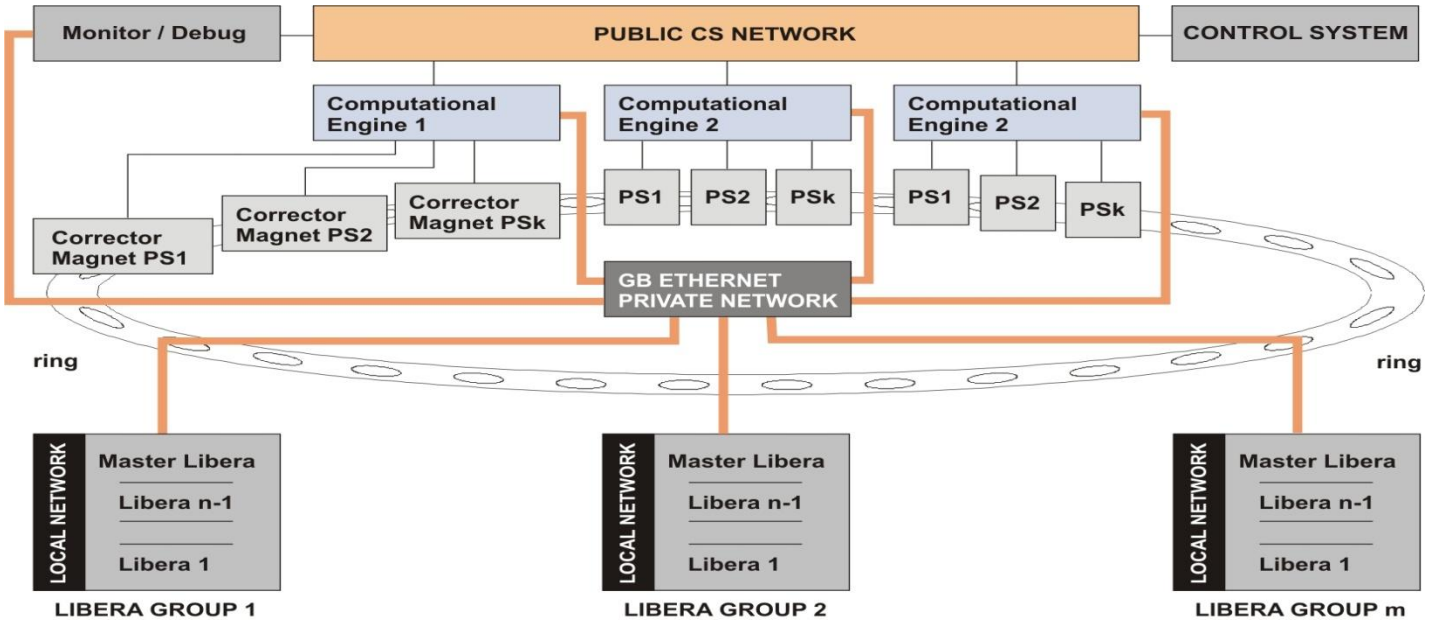
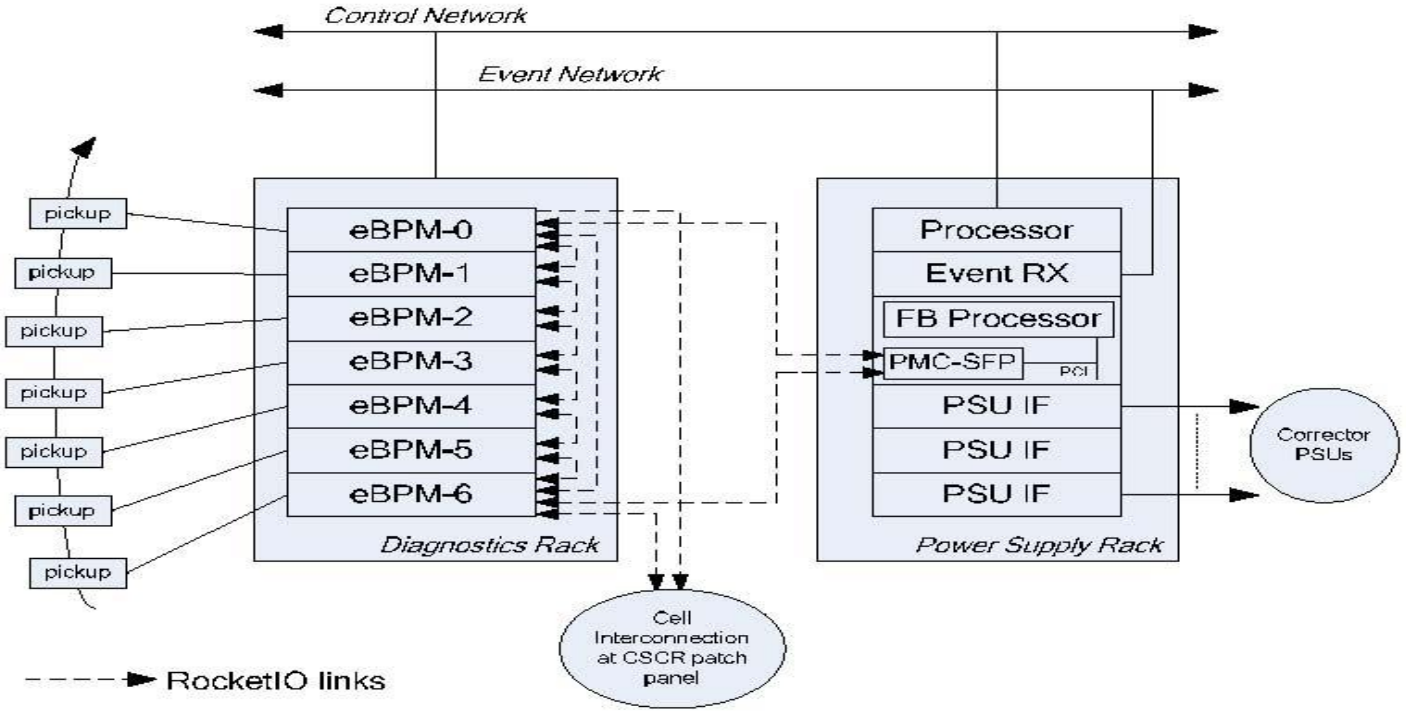
Data Concentration: Libera Grouping & GbE

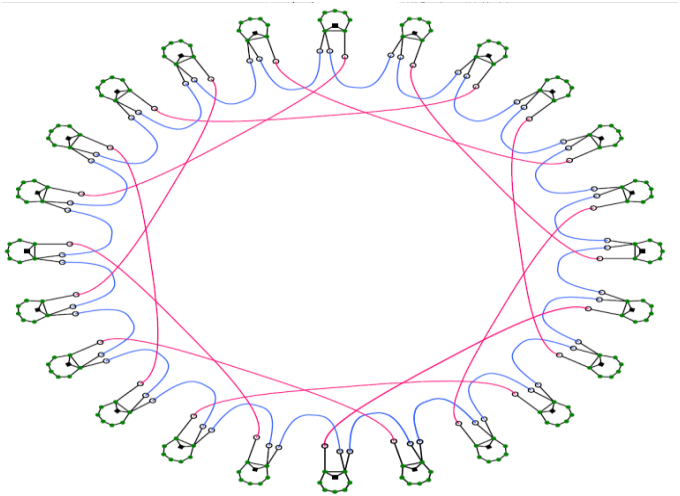


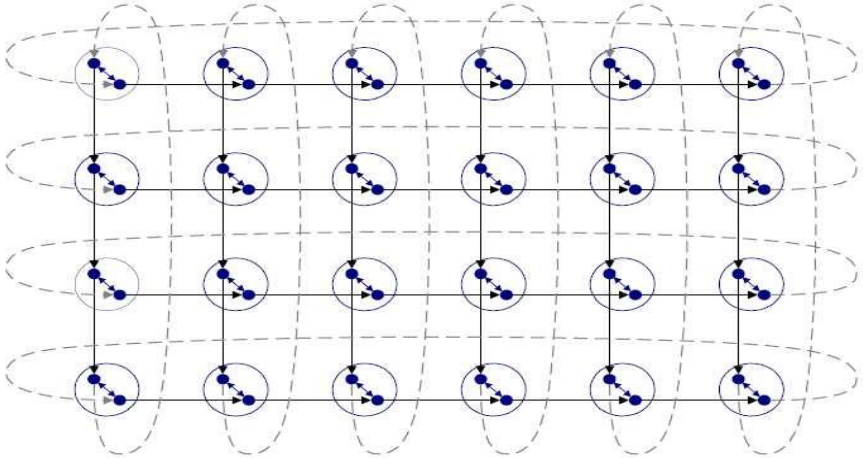
Data Concentration: Diamond Communication Controller



Courtesy of Guenther Rehm, Diamond, Libera Workshop 2007

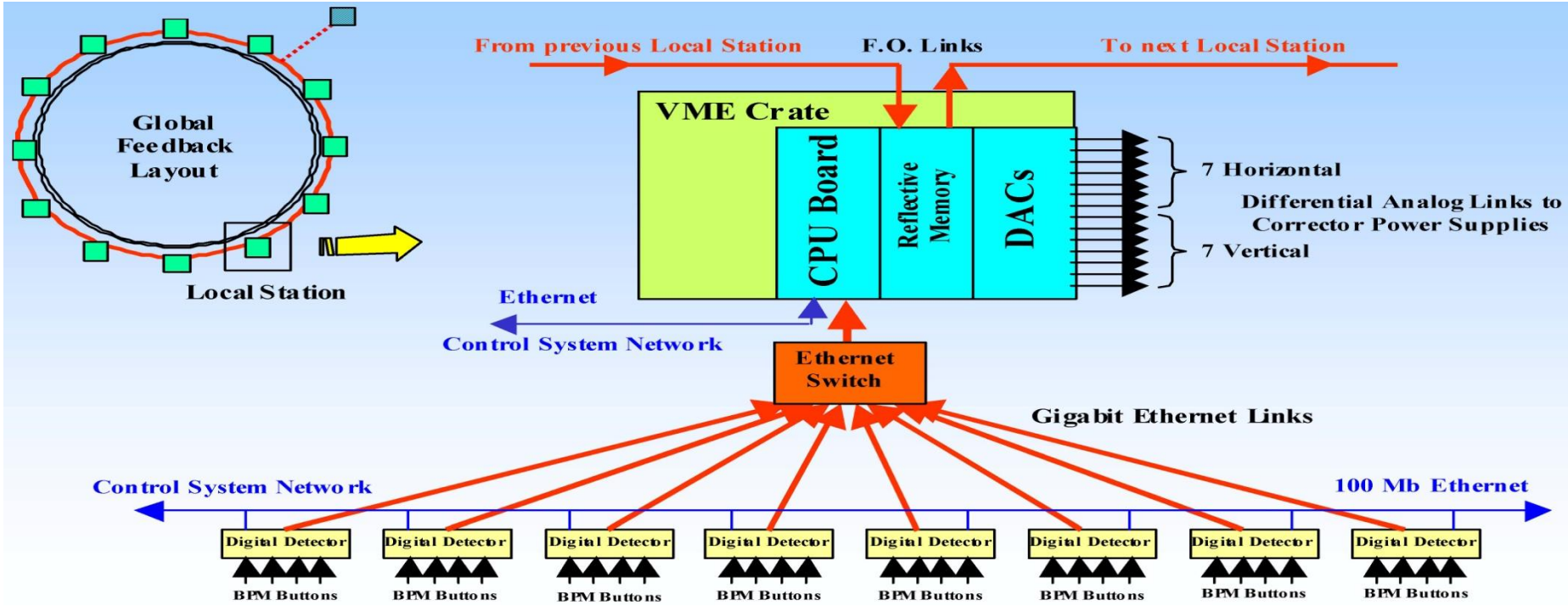
Diamond Communication Controller - Topology





Courtesy of Guenther Rehm, Diamond, Libera Workshop 2007

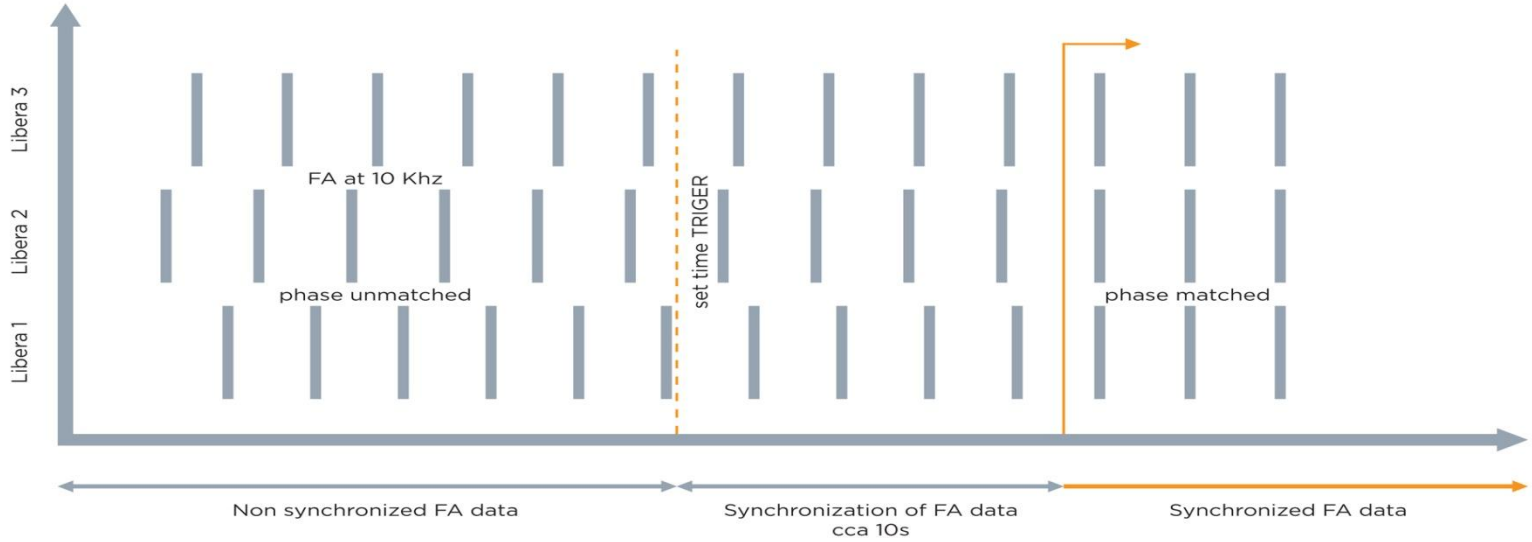
Data Concentration: GbE + RM @ Elettra



Courtesy of Marco Lonza, Elettra, Libera Workshop 2007

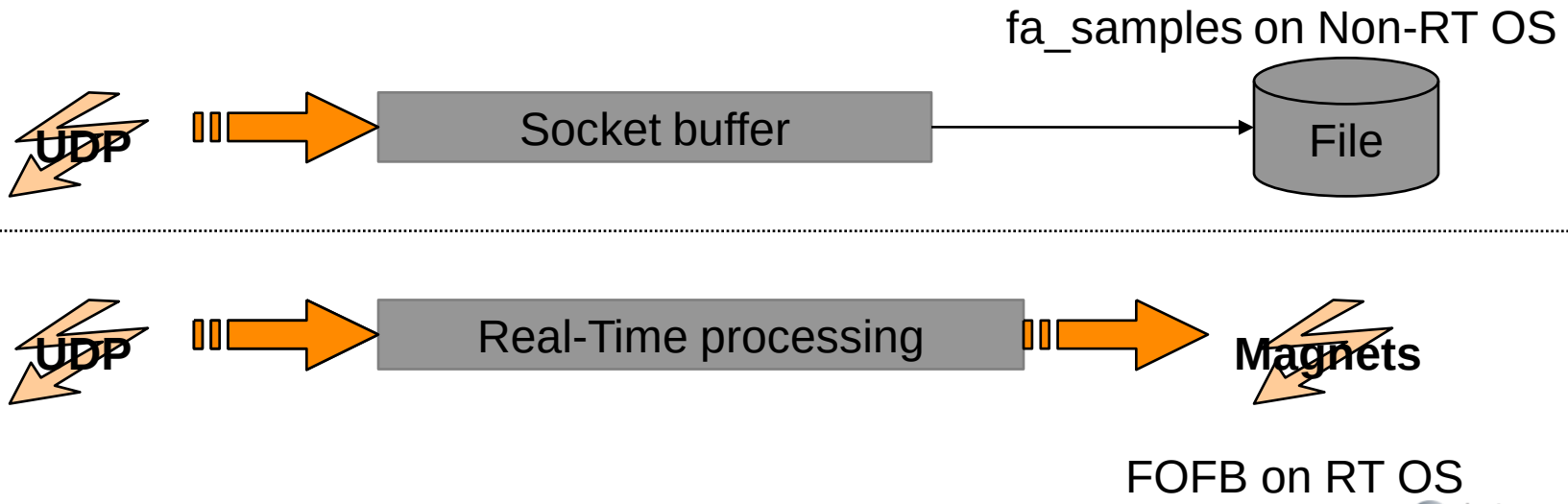
FOFB & Syncronization

- **Timing synchronization is a must for proper FOFB/Grouping/DCC operation!**
- **Time-out role**



FOFB & Hard-Real-Time

- **FOFB is a feedback control**
- **All digital feedback controls rely on constant processing interval T**



FOFB in Mixed Environment

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Conclusion

- **Multiple options available for FOFB:**
  - Semi integrated
  - Fully integrated
- **Open development framework (FDK)**
  - Allows for the implementation of custom FOFB solutions
  - Data concentration
  - FOFB algorithm calculation
  - Streaming to magnet correctors
- **Synchronism is built in all Libera instruments by design**
- **GDX Module enables fully integrated FPGA based FOFB**
- **FOFB now possible in mixed environments (Libera Electron/Brilliance/Brilliance+)**

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