Libera

Libera Global Fast Orbit Feedback

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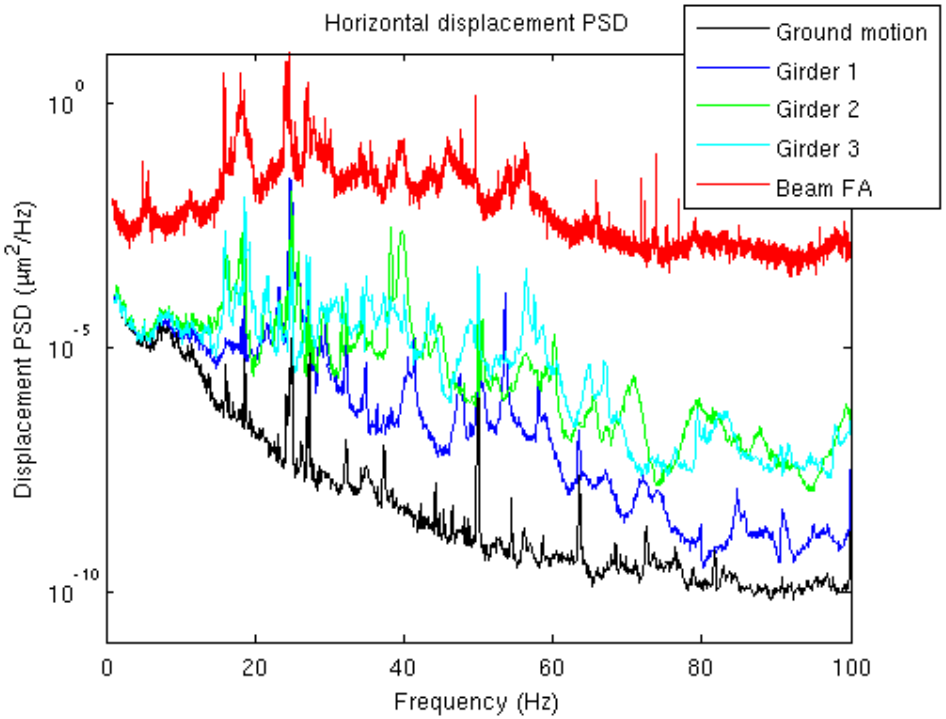
Introduction

- **The Purpose of Global FOFB**
- **FOFB Principle & Topology**
- **Fast Acquisition Data Stream on Libera Brilliance/Electron**
- **FOFB schemes & principles**
  - Libera Grouping & GbE
  - Diamond Communication Controller
  - Hybrid Example @ Elettra
- **Timing Synchronization**
- **Transport Delay & Jitter Measurements**

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 Principle & Topology

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

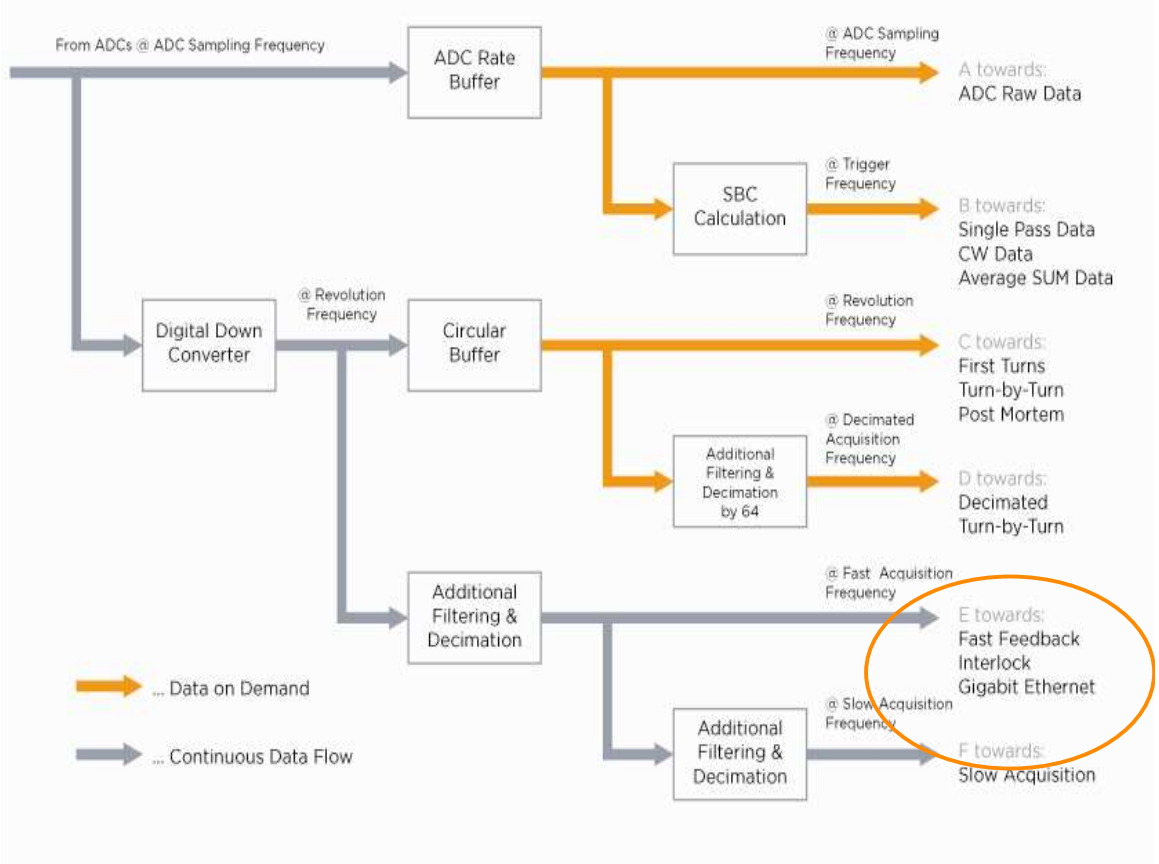
- Multiple BPM devices (x)
- Multiple magnet correctors (m)

- 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

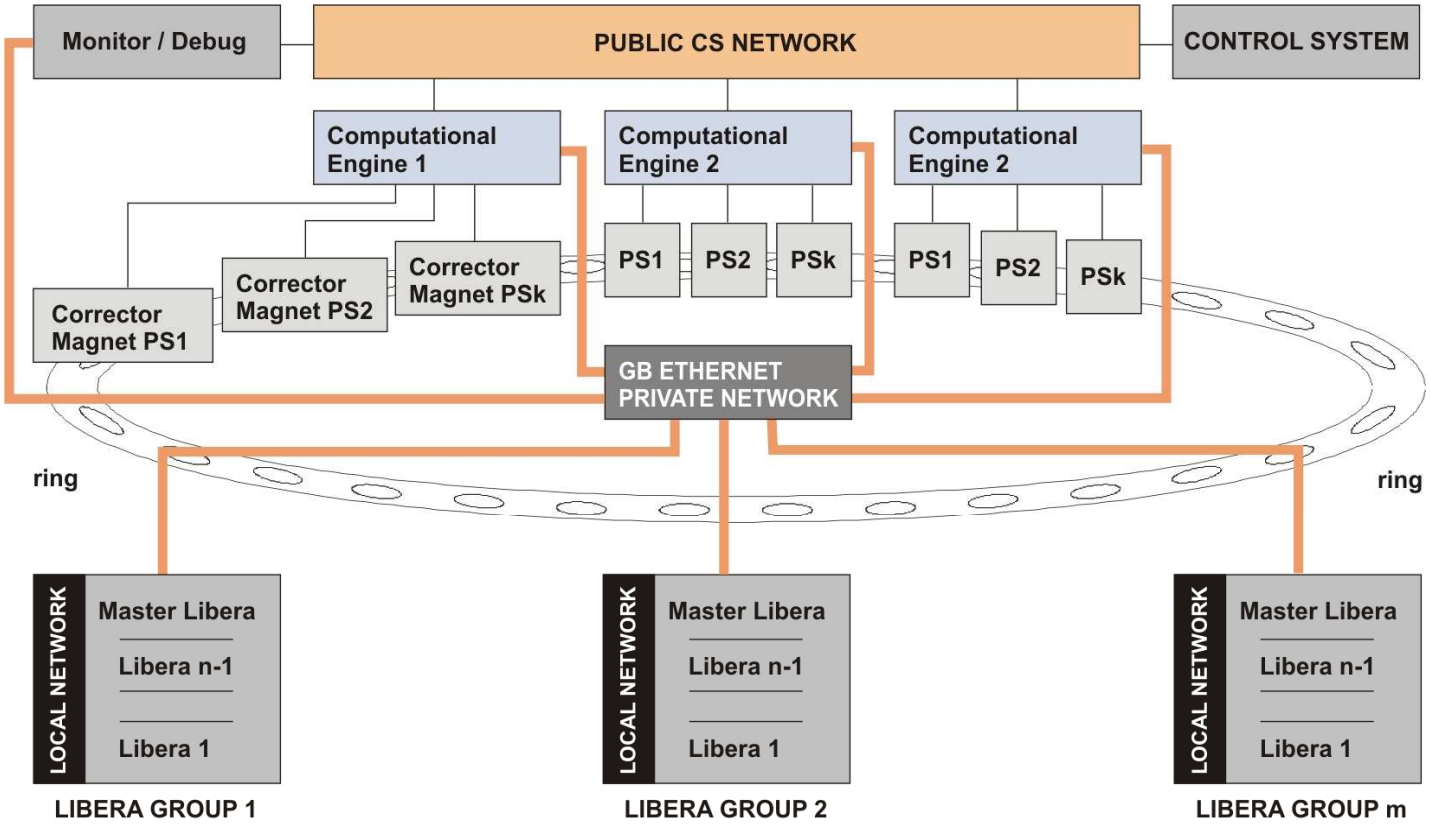
- **Real-Time Stream via HW**
  - Continuous flow
  - ~ 10 kHz
- **FA atom content**
  - Va, Vb, Vc, Vd
  - X, Y, Q, Sum
  - Packet counter & Status



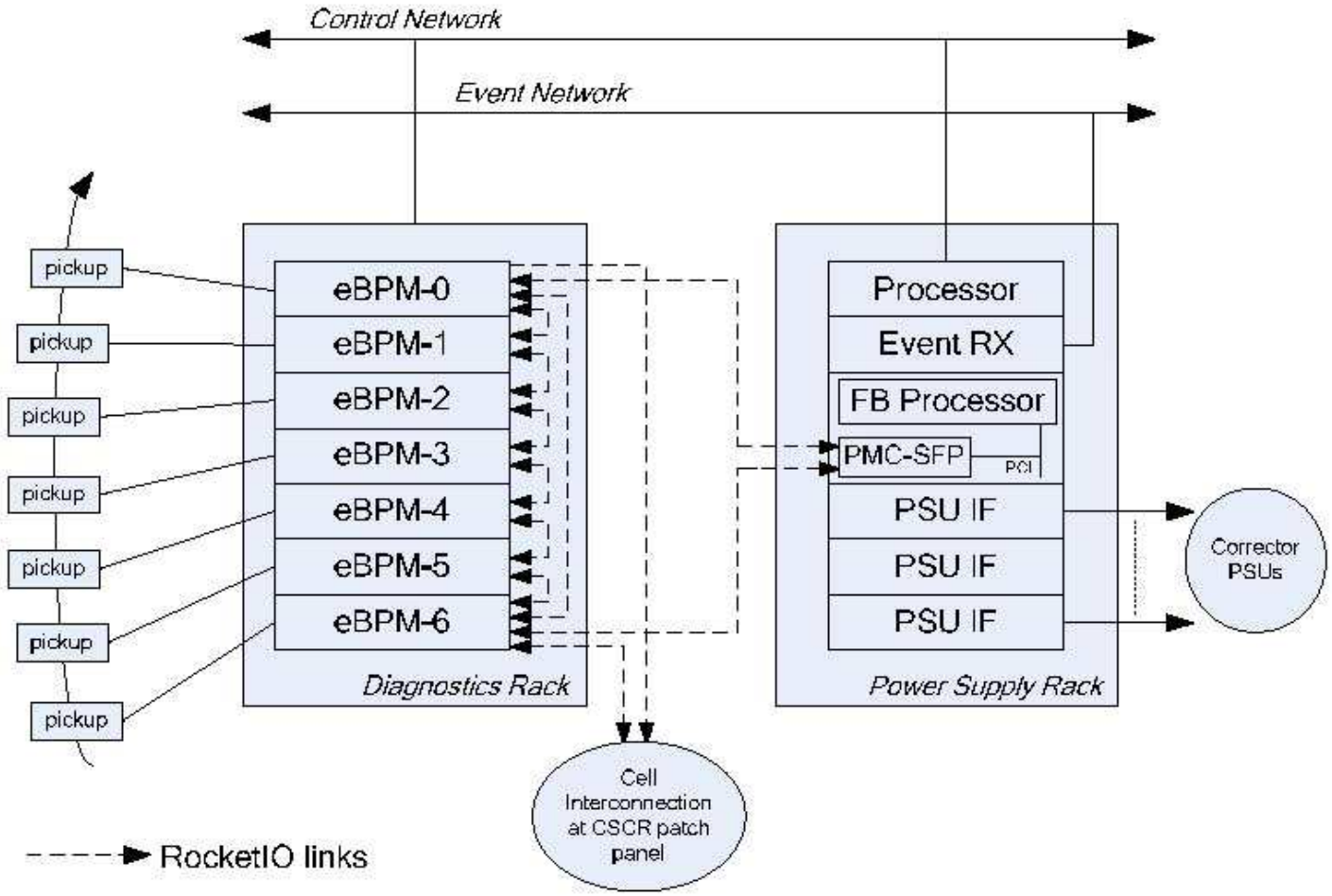
Fast Acquisition (FA) Data Stream – Physical View

- **Hardware**
  - SFP ports 1 to 4
  - SFP modules
- **Plain module types**
  - Fibre Optic (Grouping, DCC)
  - Molex Cu (Grouping, DCC)
- **Smart module types**
  - SGMII type Cu GbE
  - 1000Base-X fibre optic GbE
- **Hard-Real-Time packet transmission**
- **Stream does not go through SBC**

Libera Grouping & GbE

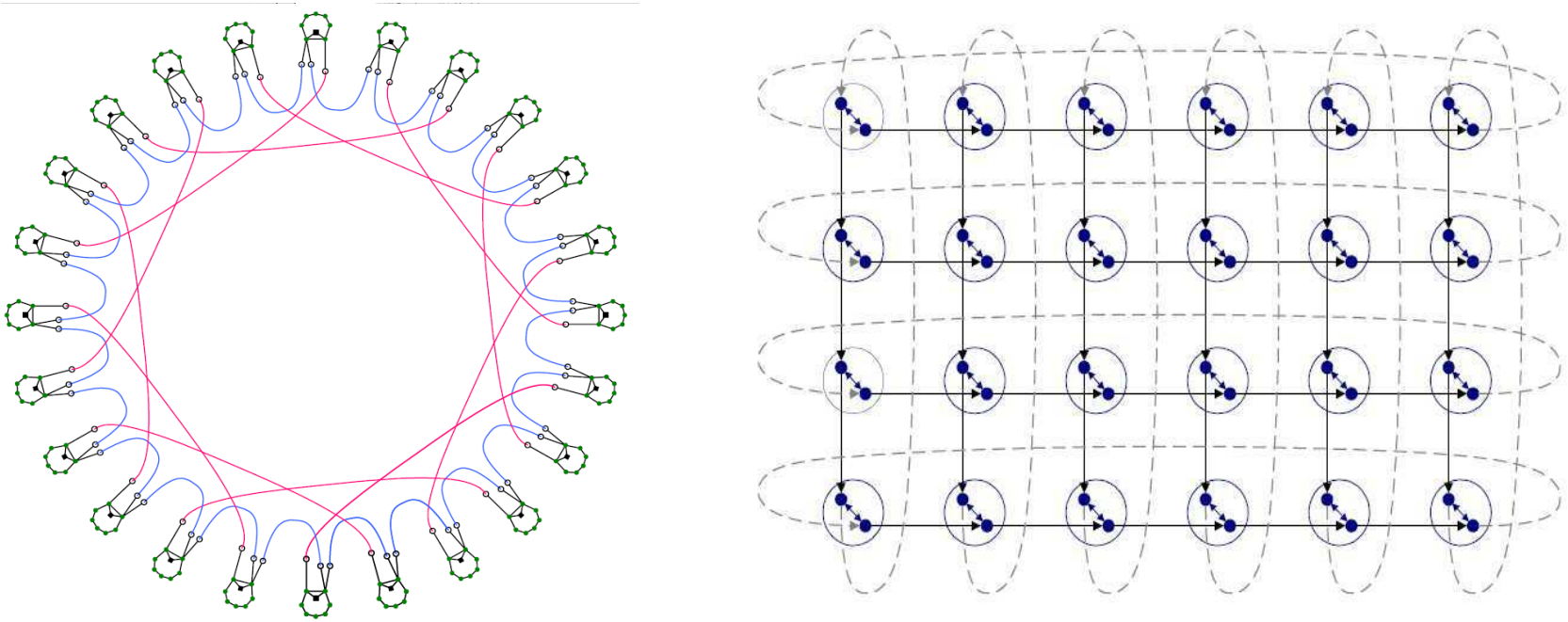


Diamond Communication Controller



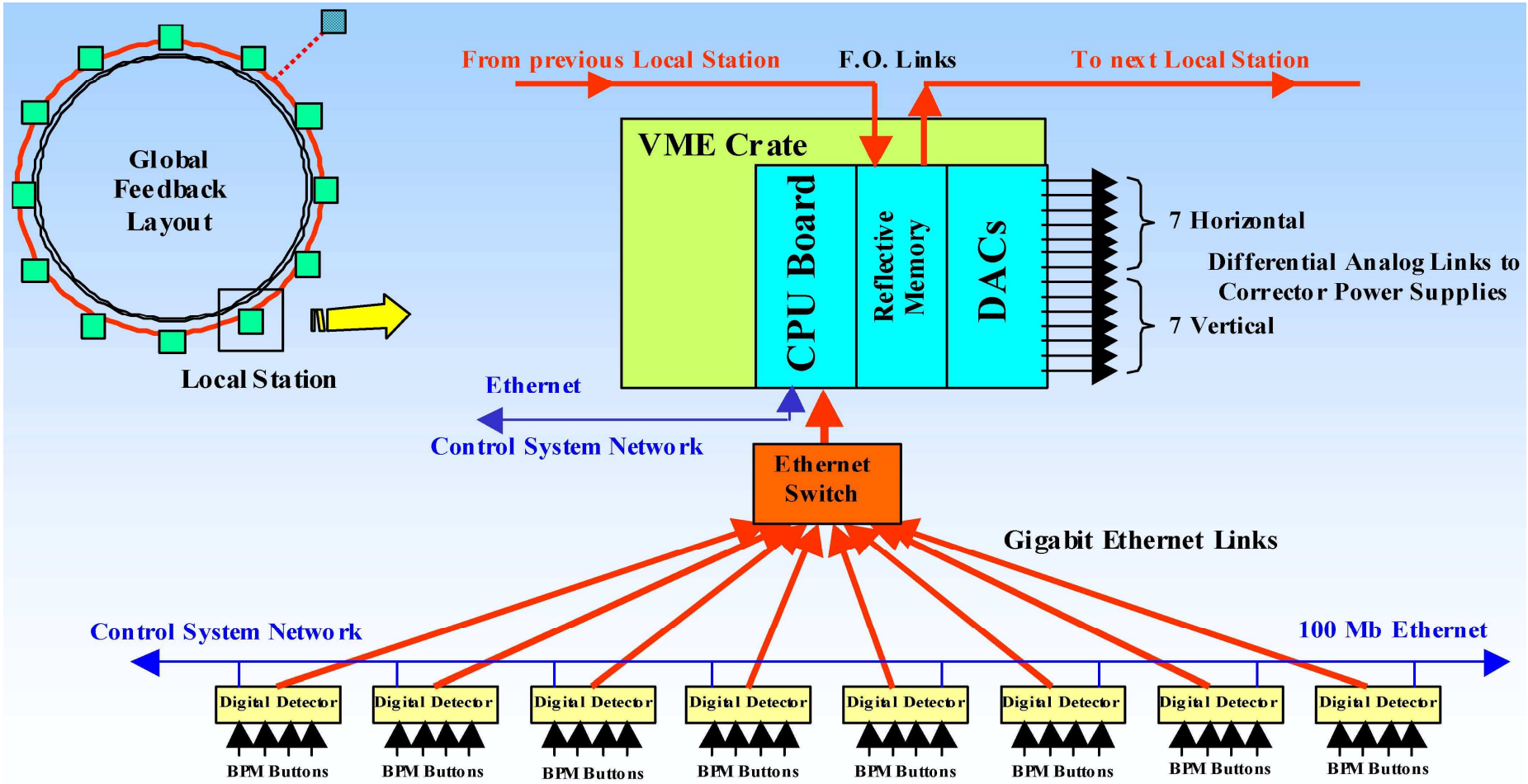
Courtesy of Guenther Rehm, Diamond, Libera Workshop 2007

Diamond Communication Controller - Topology



Courtesy of Guenther Rehm, Diamond, Libera Workshop 2007

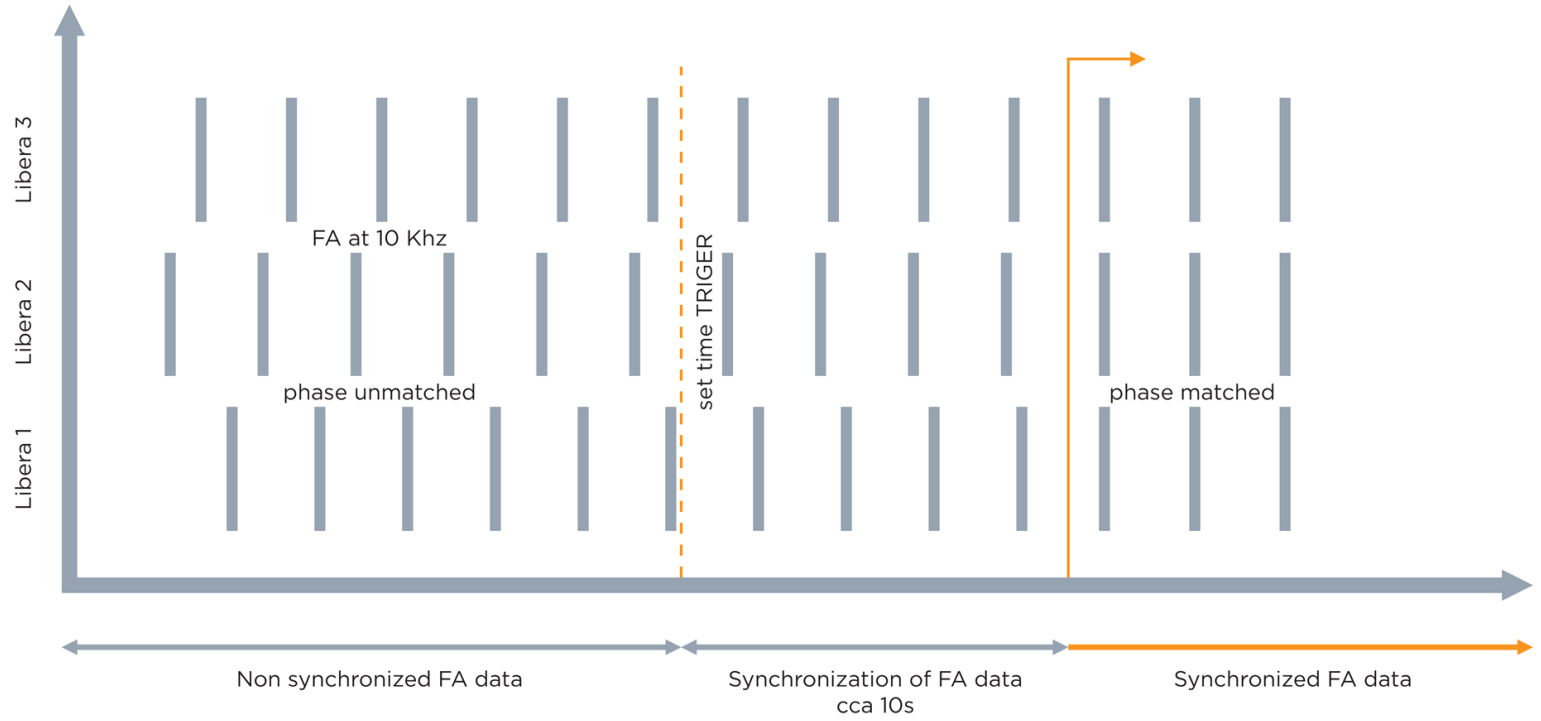
Hybrid Example @ Elettra



Courtesy of Marco Lonza, Elettra, Libera Workshop 2007

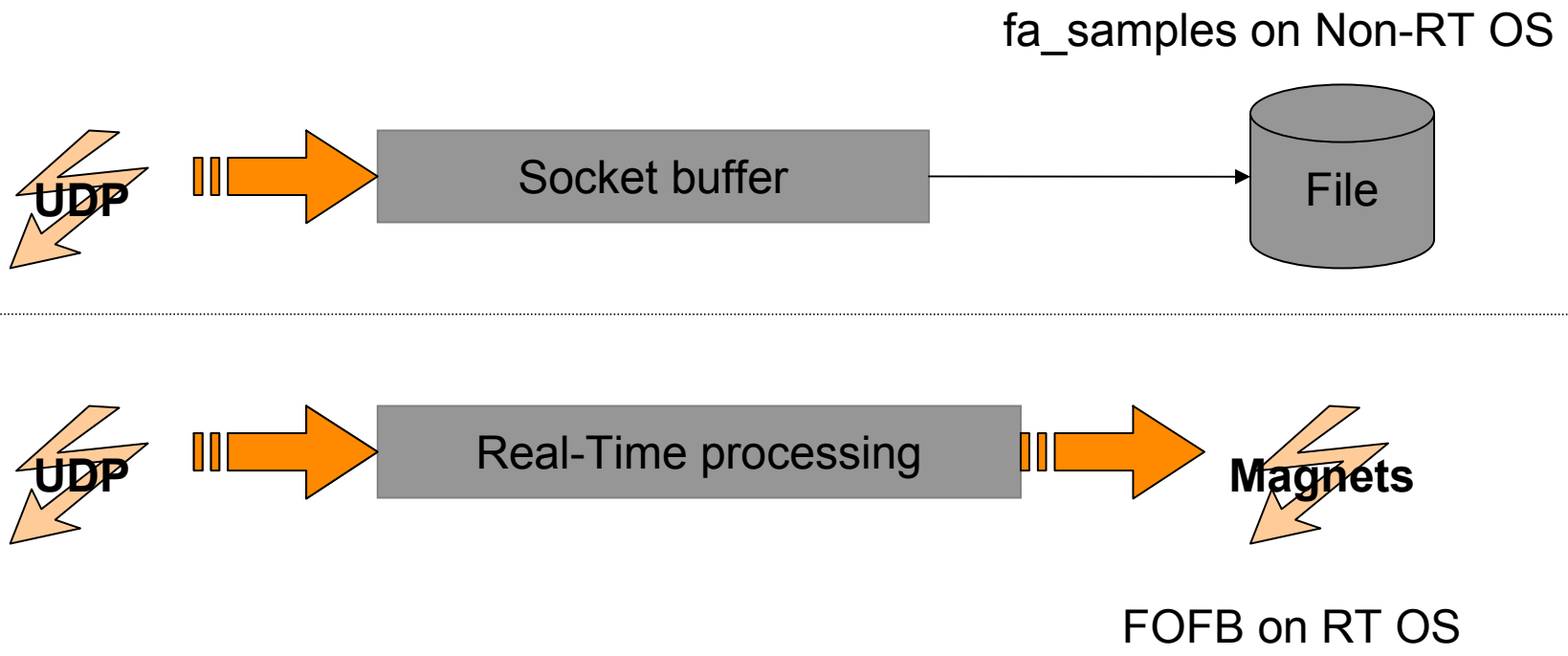
FOFB & Syncronization

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

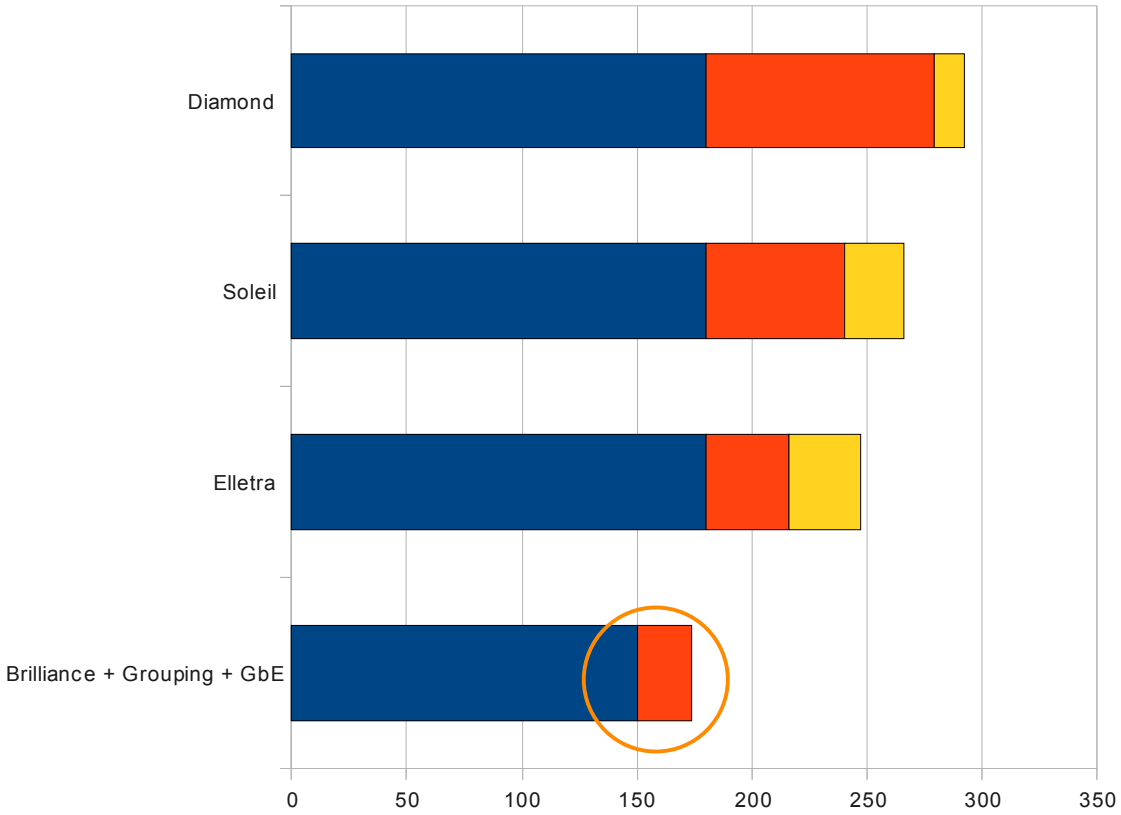


FOFB & Hard-Real-Time

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



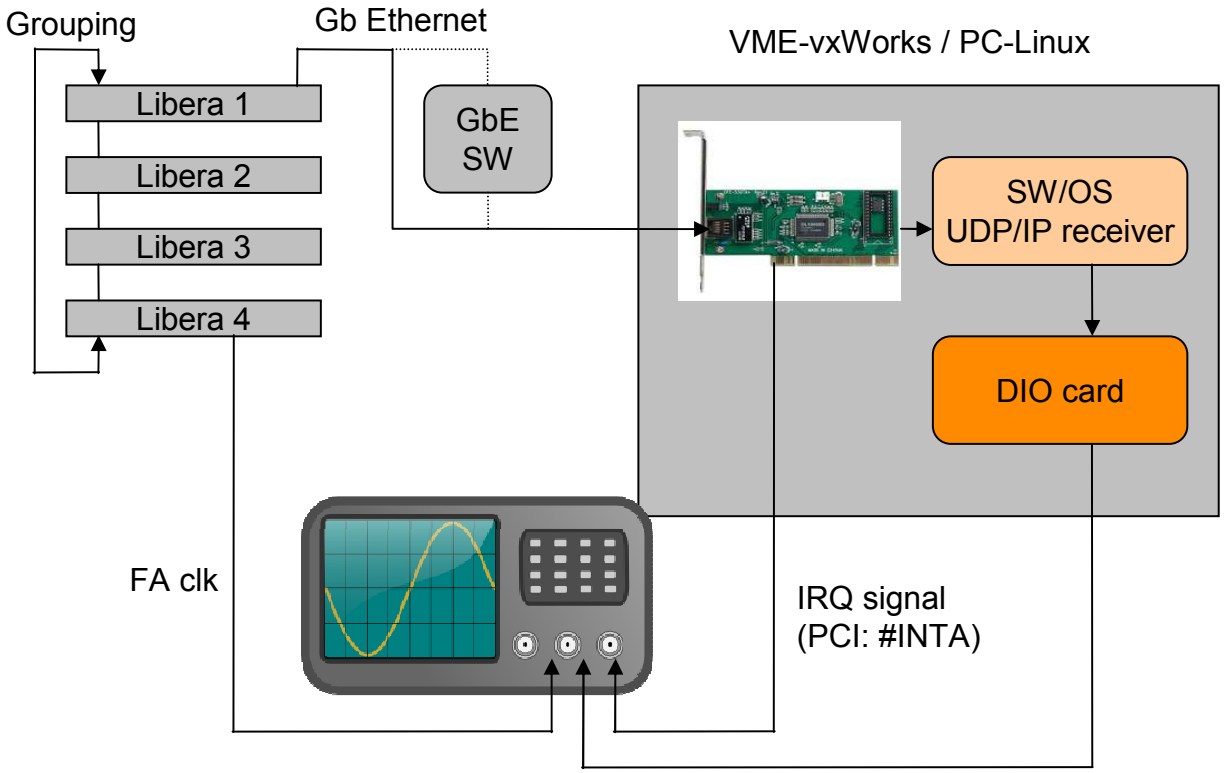
FOFB Time Delay Distribution



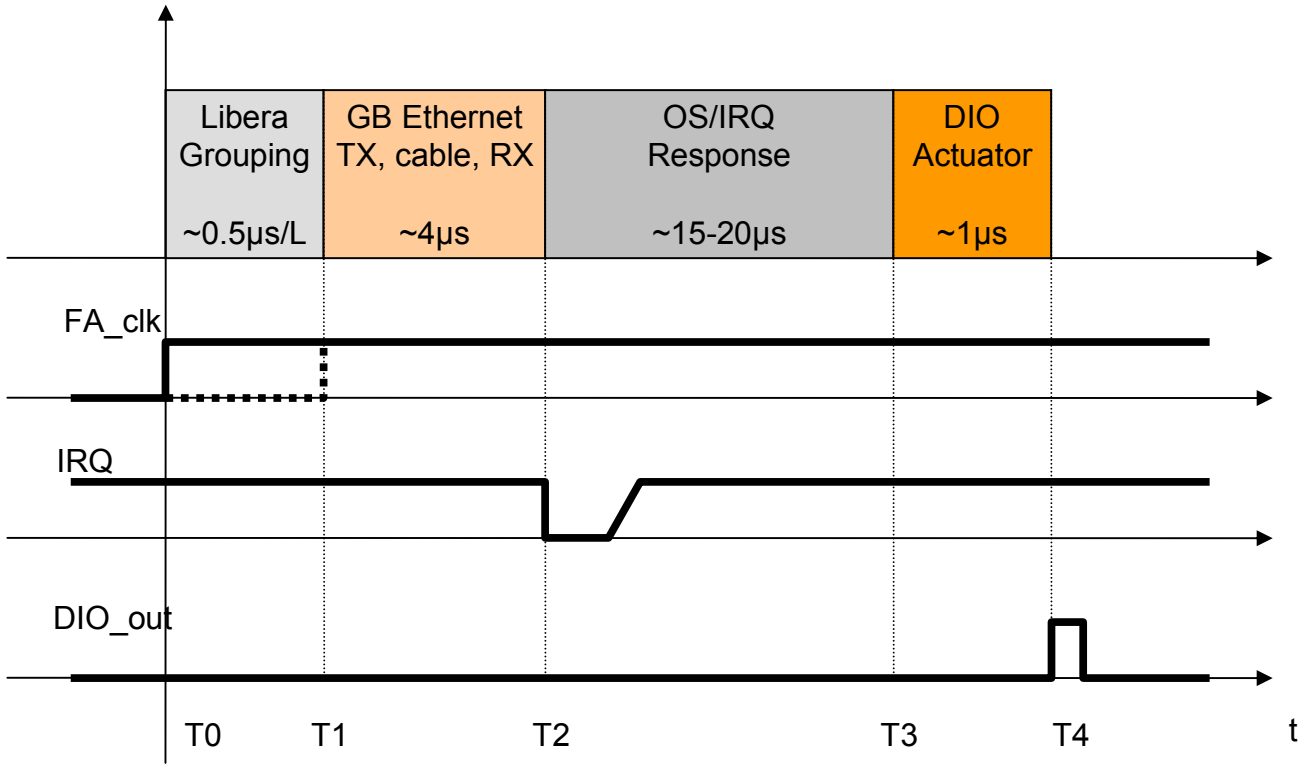
- **Data courtesy of:**
  - Diamond
  - Soleil
  - Elettra

@ Libera workshop 2007

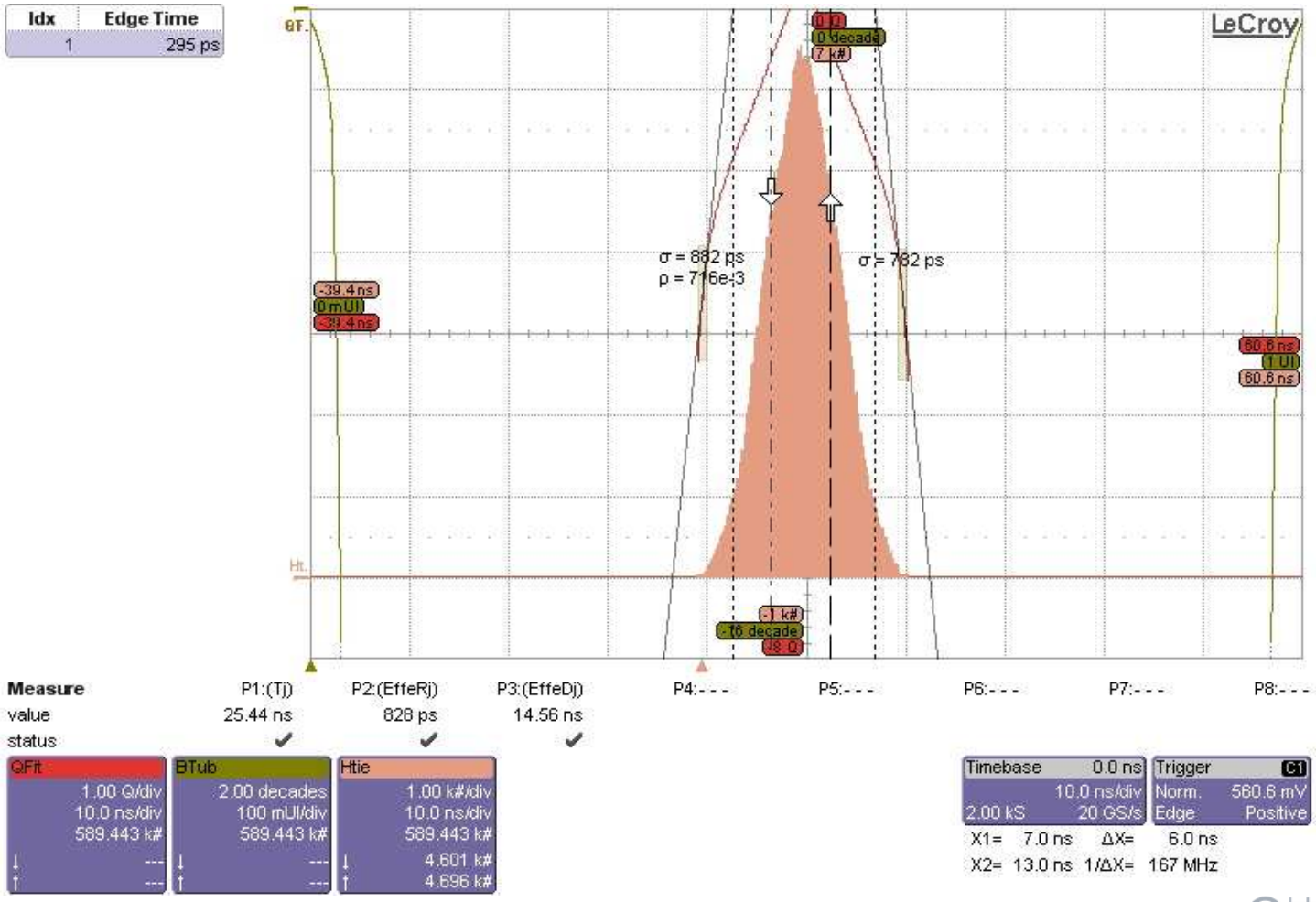
Grouping + GbE Delay & Jitter - Setup



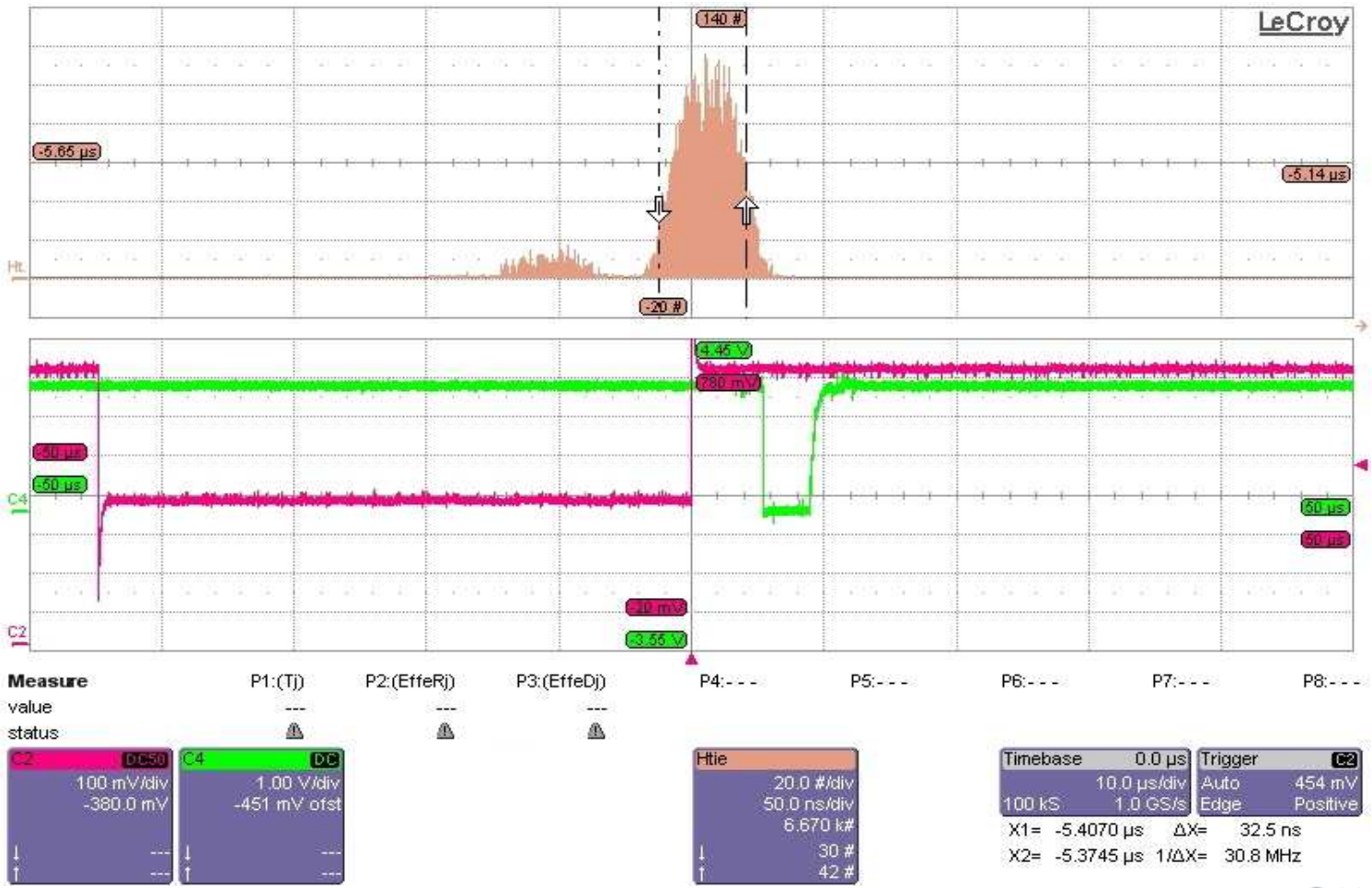
Grouping + GbE Delay - Results



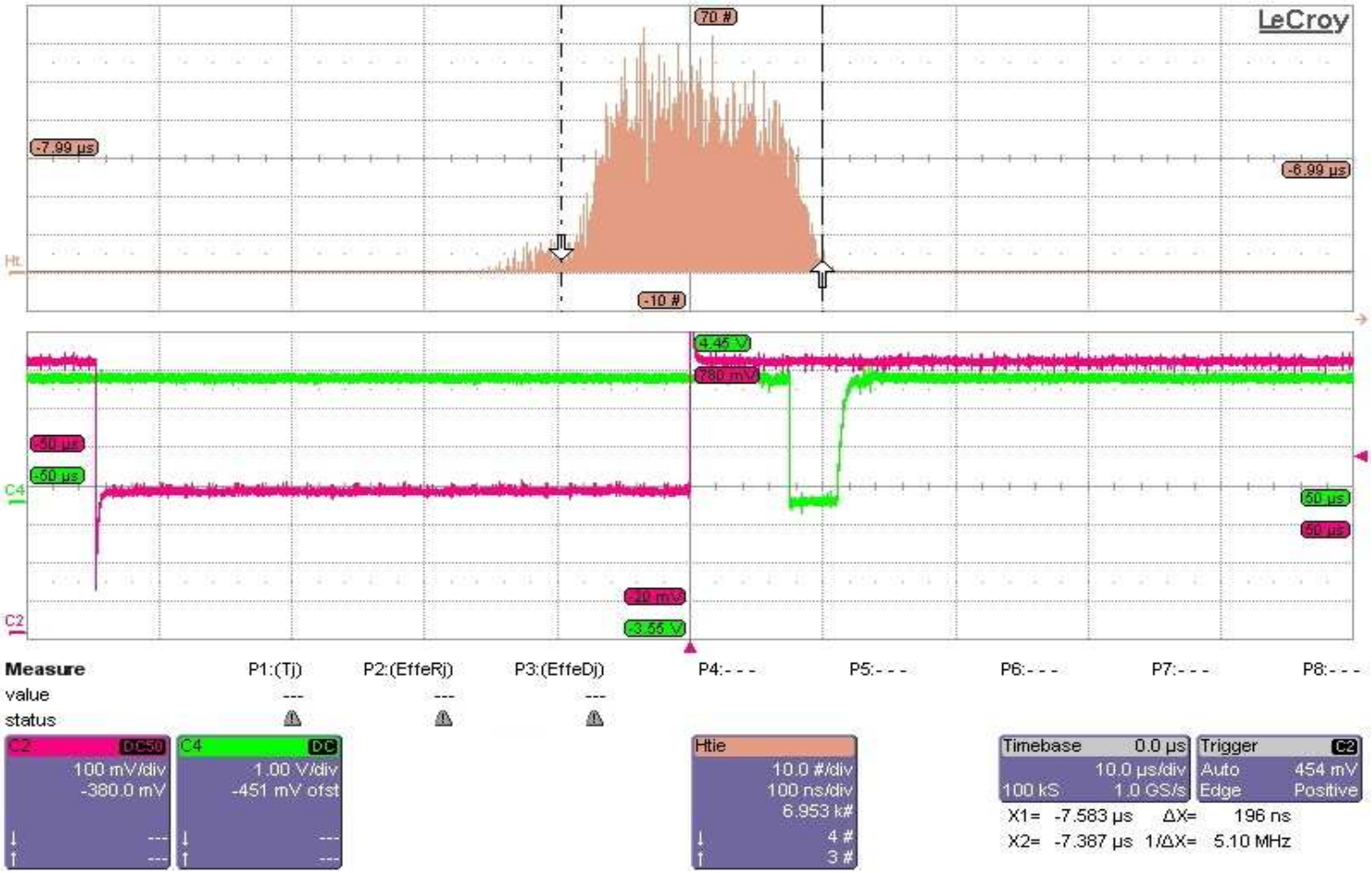
Grouping Jitter – Results ~10 ns



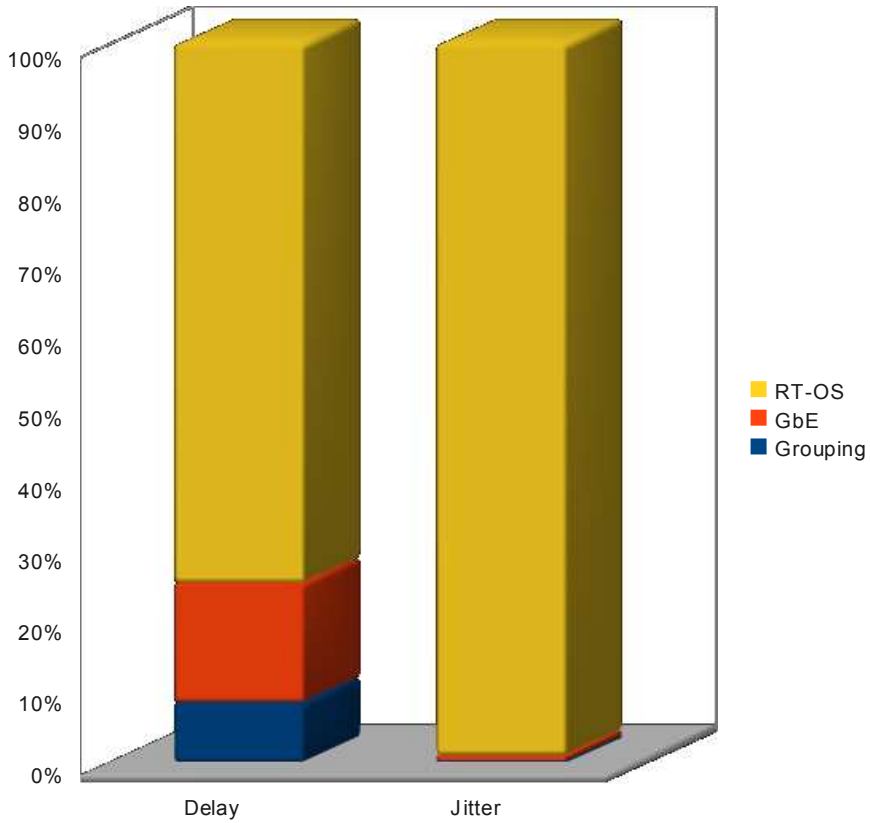
Grouping + GbE Jitter – Results ~40/80 ns



Grouping + GbE Jitter – Results with Switch ~200 ns



Grouping + GbE Delay & Jitter – Results



Transport stage	Delay [µs]	Jitter [ns]
Libera Grouping	0.5 / Libera	10
GbE (TX, cable, RX)	4	40
GbE switch	2	200
OS - vxWorks	16	~20000*
OS - Linux	20	~100000*

Conclusion

- Multiple options available for FOFB on Libera Brilliance
- Open development framework
  - Allows for the implementation of custom FOFB solutions
- Synchronous FA data distribution built in the Libera Brilliance
- Transport delay
  - Major contribution in the RT-OS
  - Minor Libera Brilliance + GbE contribution: ~4-8 µs
- Transport jitter
  - Major contribution in the RT-OS
  - Minor Libera Brilliance + GbE contribution: ~40/80 ns
  - GbE switches are harmless compared to RT-OS determinism