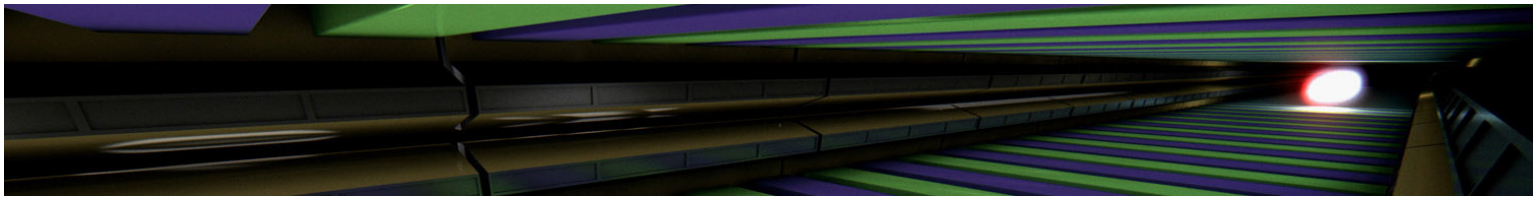


Recent Hardware and Software Achievements for the European XFEL

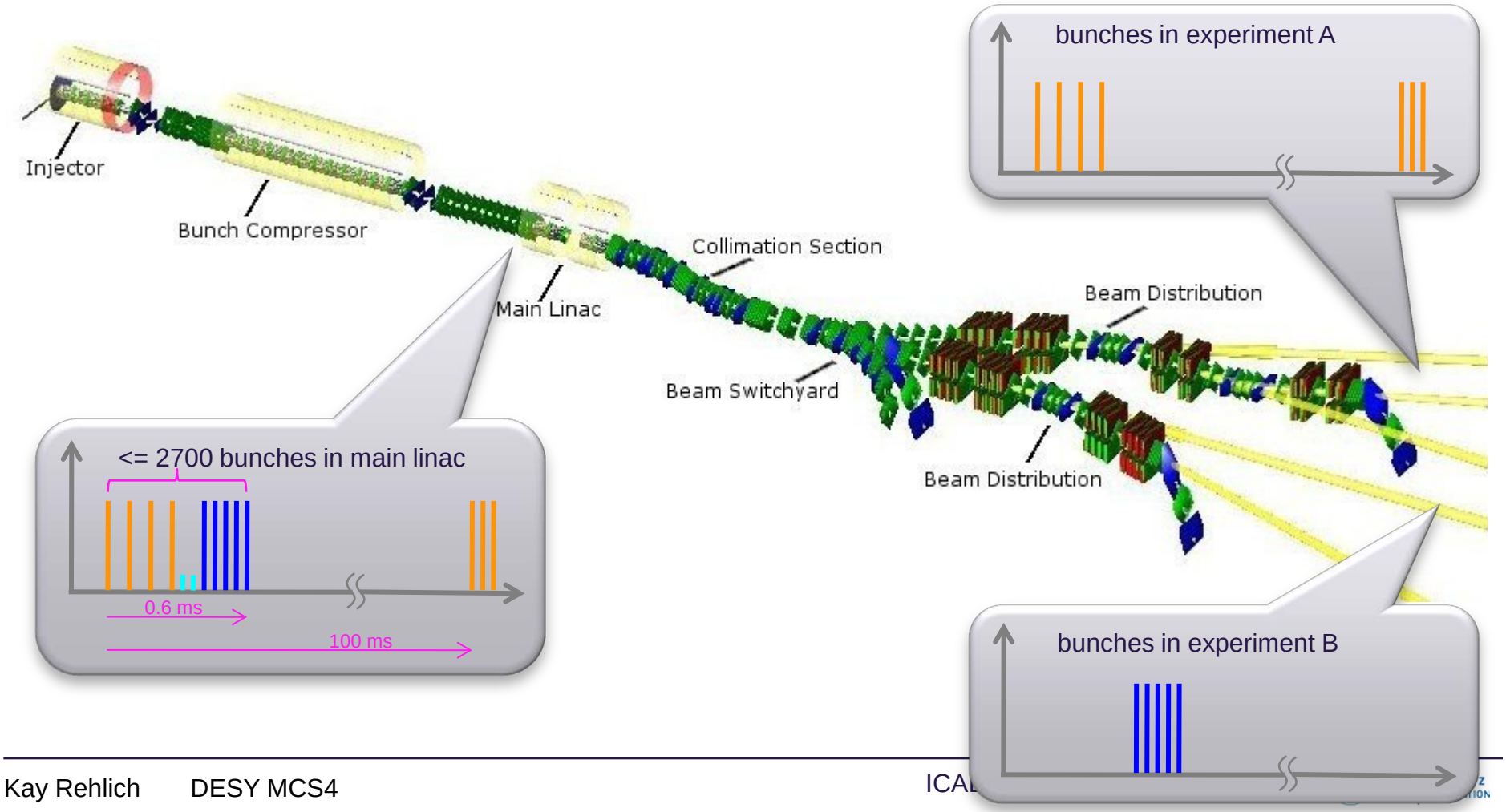
Kay Rehlich

On behalf of the FLASH / XFEL Controls Group

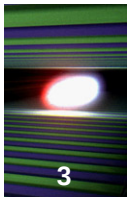
DESY

Motivation

- The XFEL can produce 27 000 bunches per second
- Synchronization of all sub-systems is a challenge



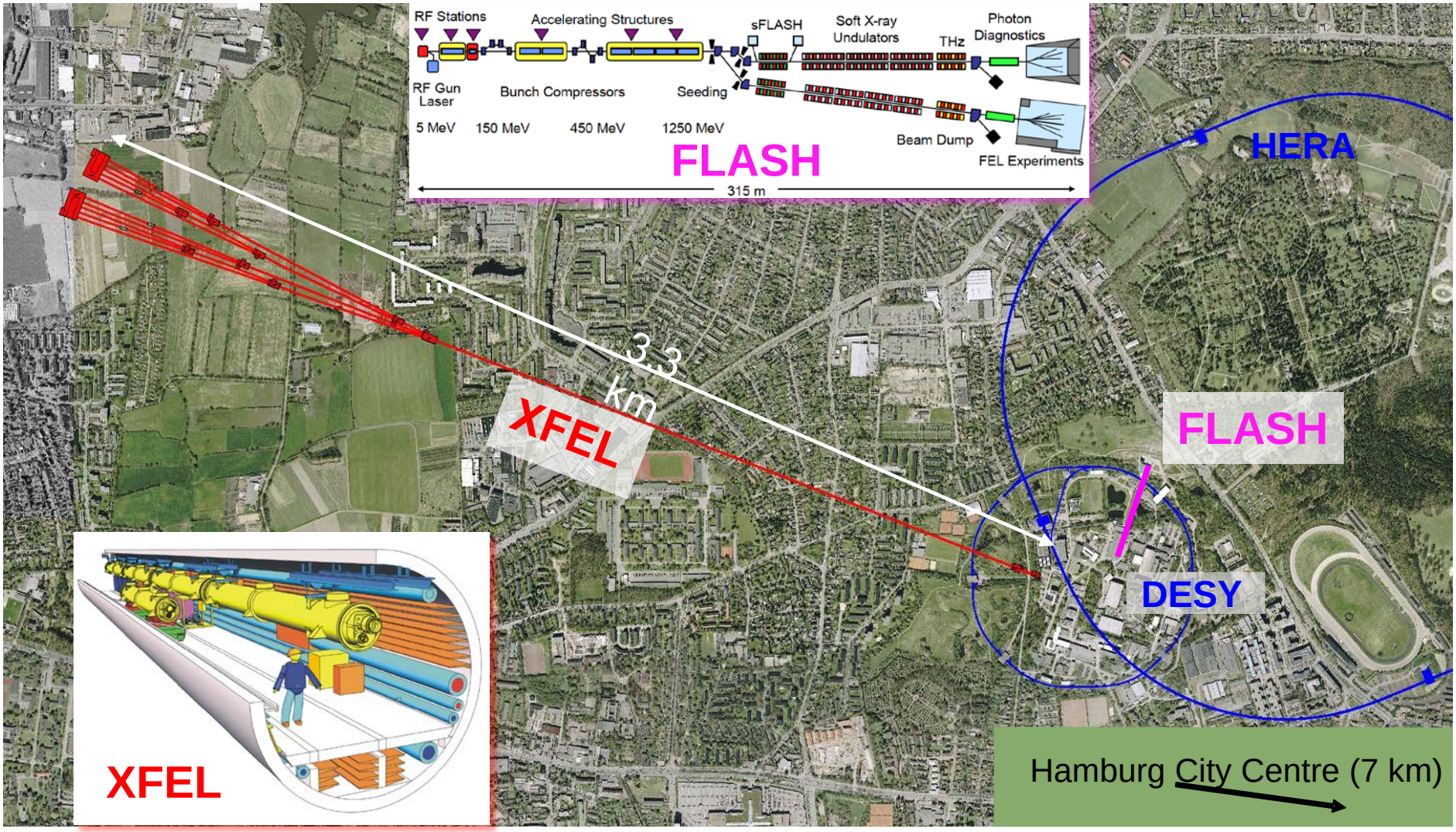
Outline



- Synchronization of sub-systems
- Hardware implementation
  - Timing system in µTCA
- Software implementation
  - 0MQ Inter Process Communication
  - DAQ system
- Conclusions

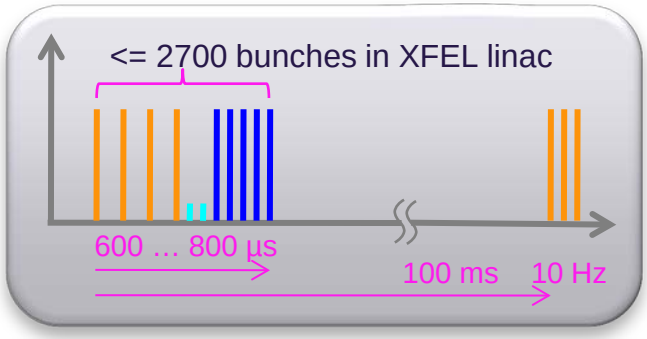
European XFEL

FLASH and XFEL



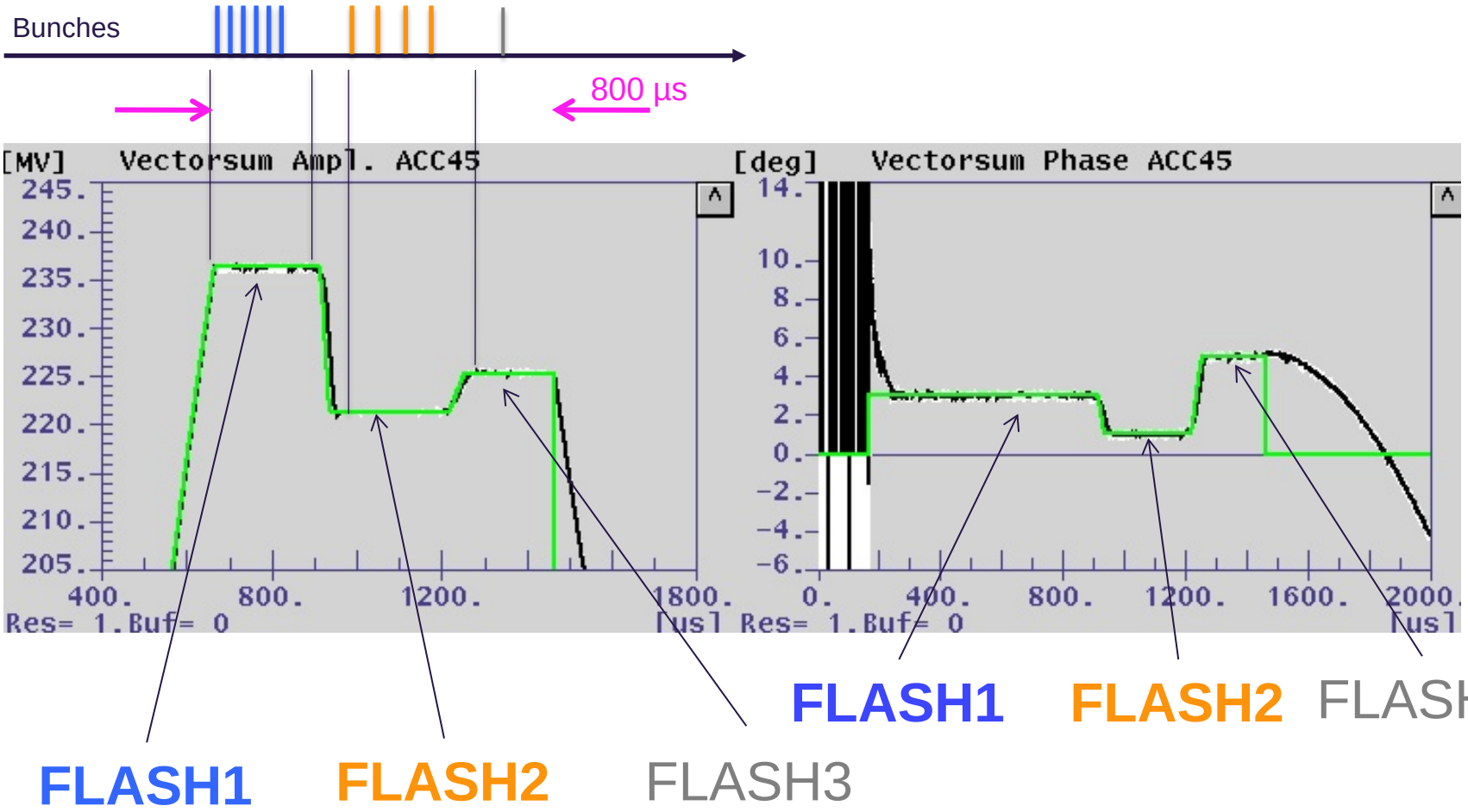
Synchronization of Sub-Systems

- Variable bunch pattern for the users
- Can change with 10 Hz (shot to shot)
- Sub-Systems require the pattern before bunch trains arrive



- The **timing system** distributes the information to
  - Different lasers to generate the desired charges
  - LLRF to set the gradients and phases
  - Loss detection to check the bunches
  - Software to display and archive, learning algorithms, calc. means, etc.
- Transport via dedicated fiber links and MicroTCA backplane

LLRF with different Settings FLASH 1 / 2 / 3



RF response

Requested RF Pulse shape

New MicroTCA Timing Module

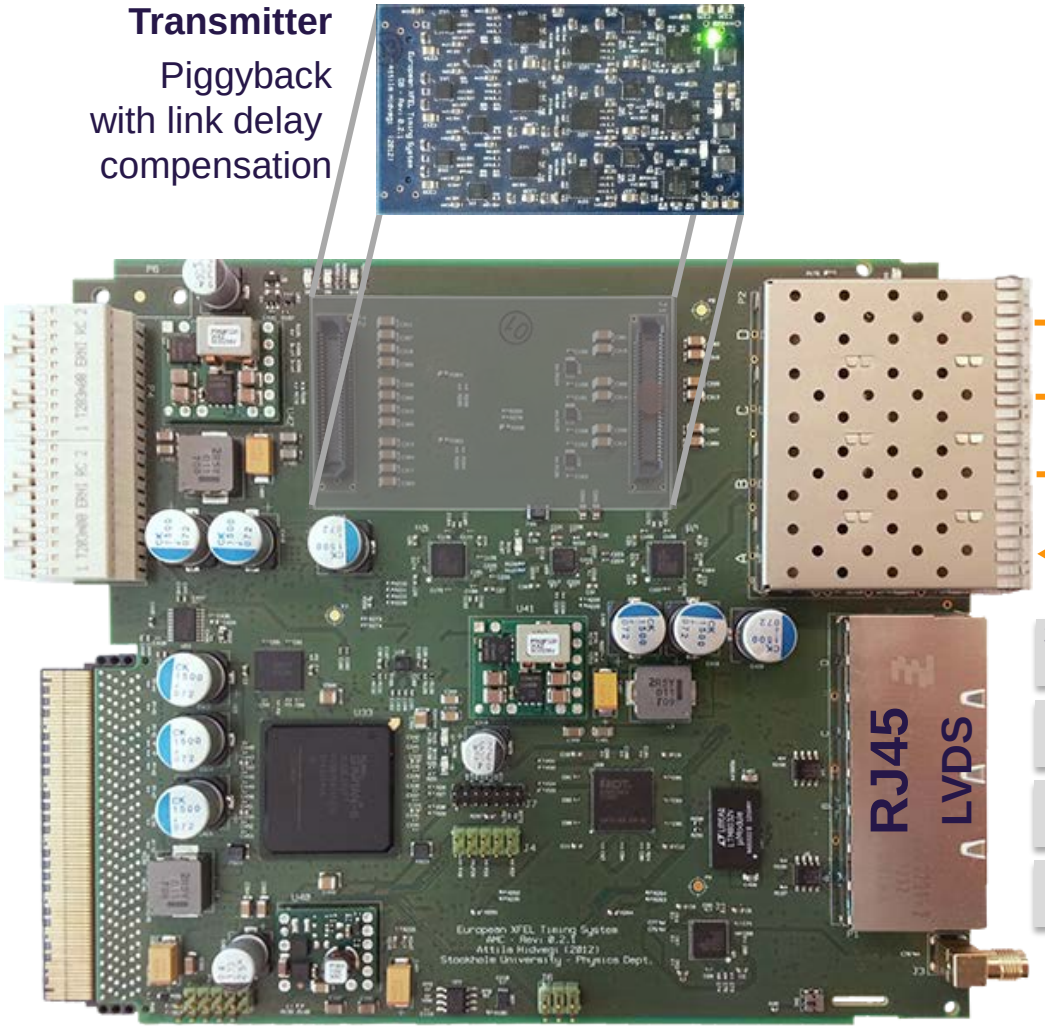
Can be used as a timing **receiver** or **transmitter**

Transmitter
Piggyback with link delay compensation

MTCA.4

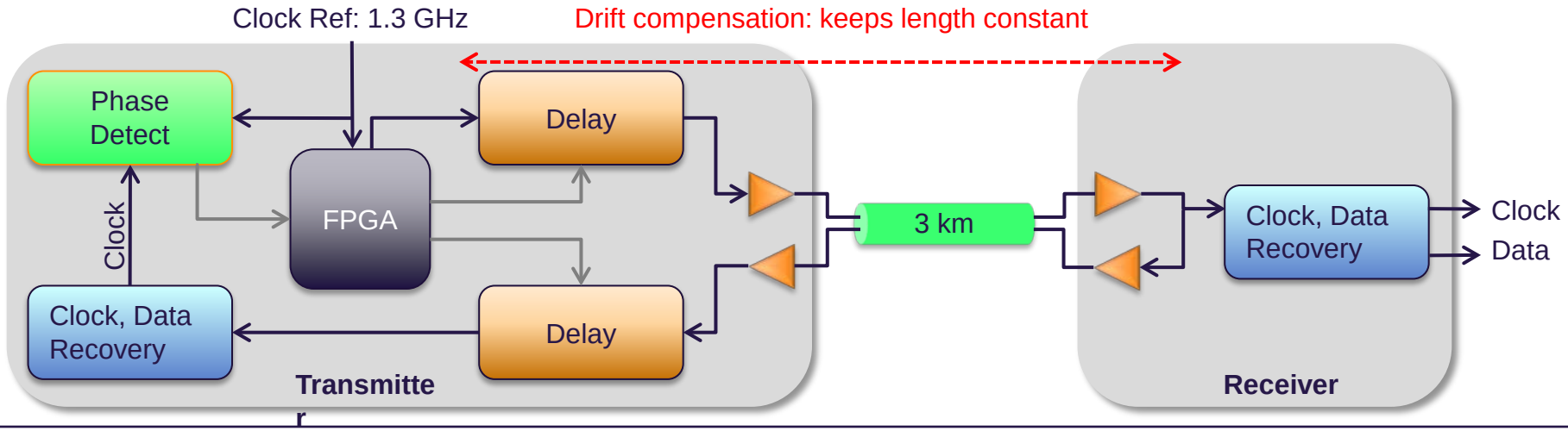
Optional **RTM**:
9 transmitters,
Further triggers or clocks

MicroTCA **backplane**:
TCLKA and TCLKB,
8 * M-LVDS



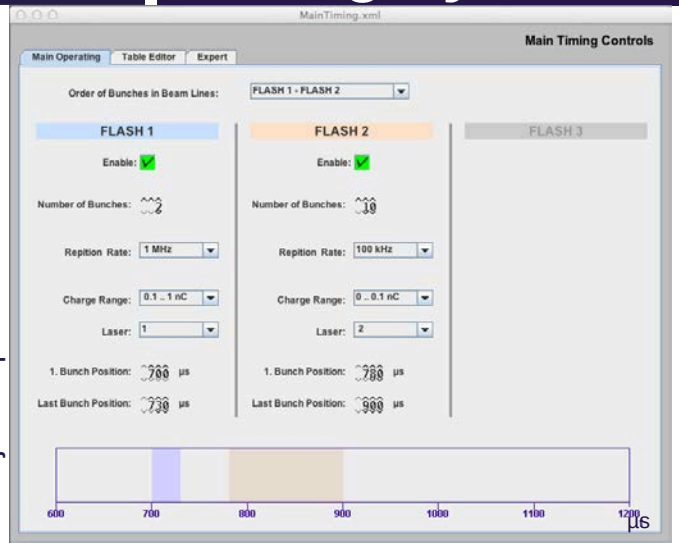
XFEL Timing System

- Fiber optic links @ 1.3GHz
- AMC module is a receiver:
  - It retransmits on one link
  - Or transmits on 3 fiber links with drift compensation (piggyback)
- ps stability (5 …10 ps RMS)
- Clock, trigger and event distribution
- Distribution of data words and tables



Timing System: Real Time Configuration Data

jddd Operations Panel



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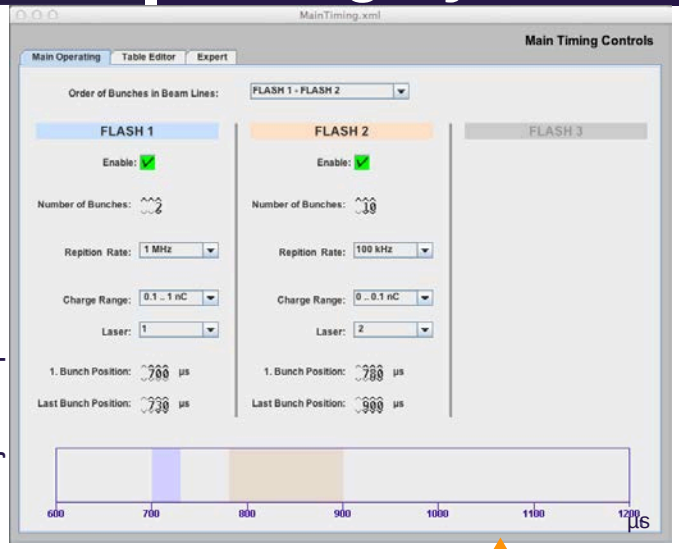
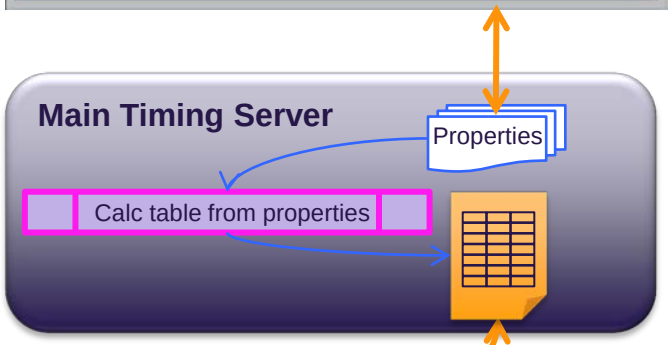
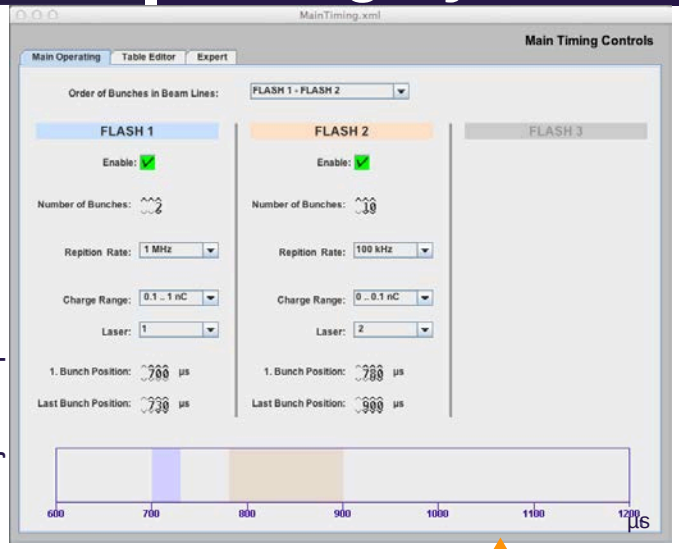


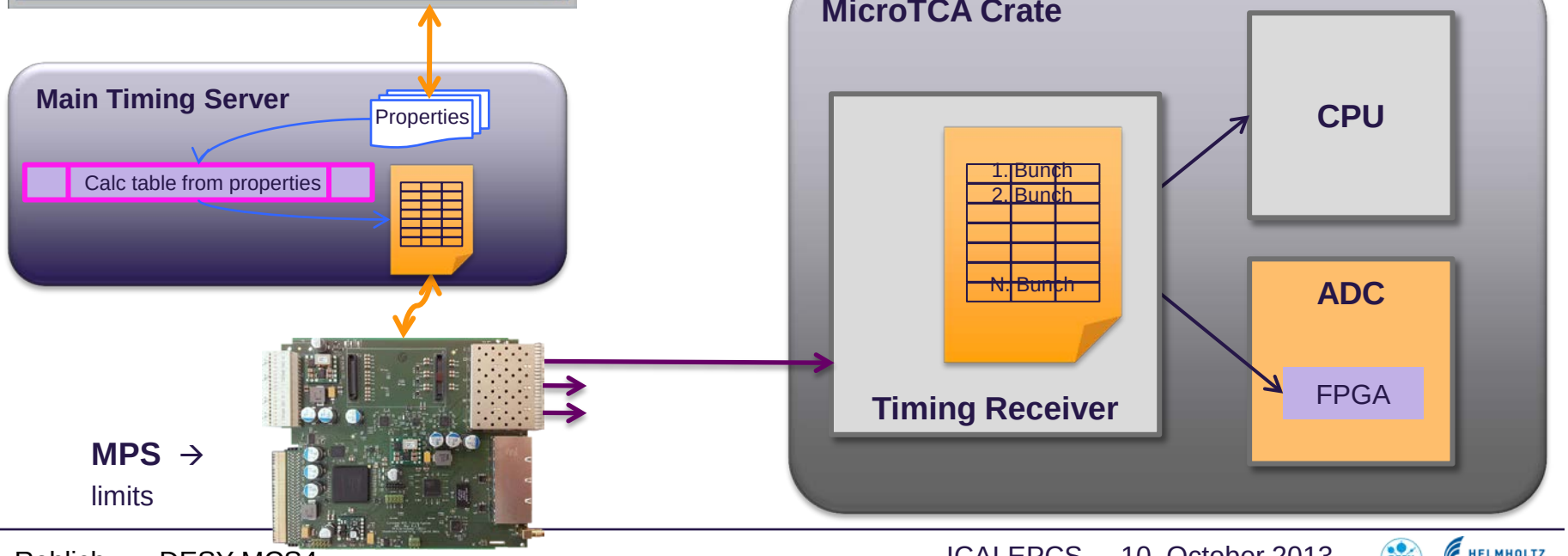


MPS → limits

Timing System: Real Time Configuration Data

jddd Operations Panel





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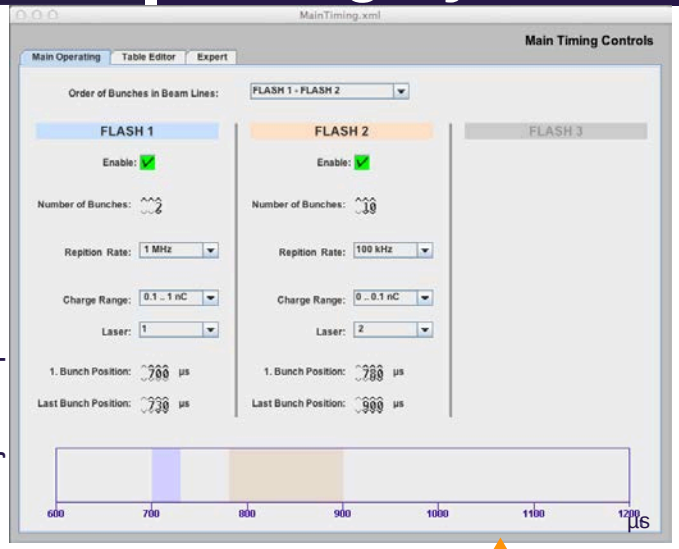
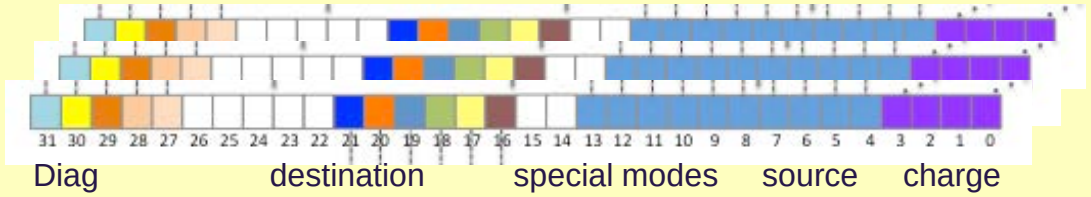
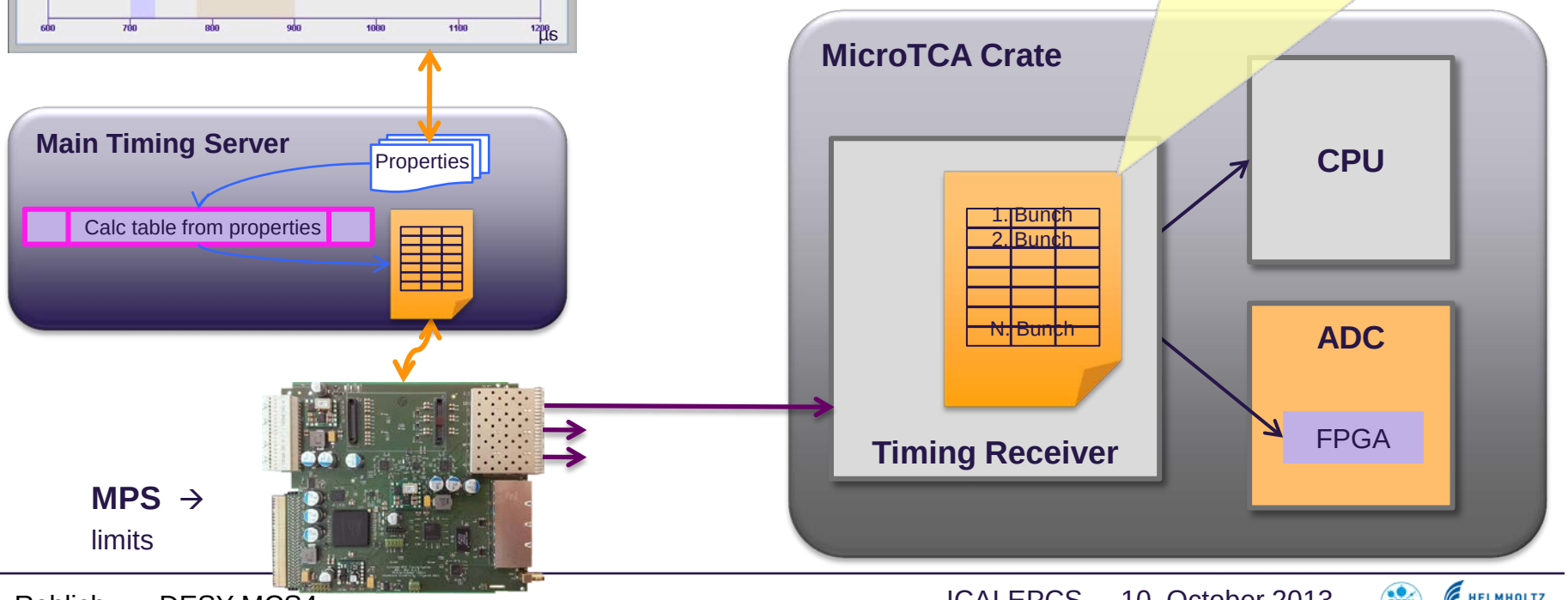


Bunch Pattern Table: One 32bit word per bunch

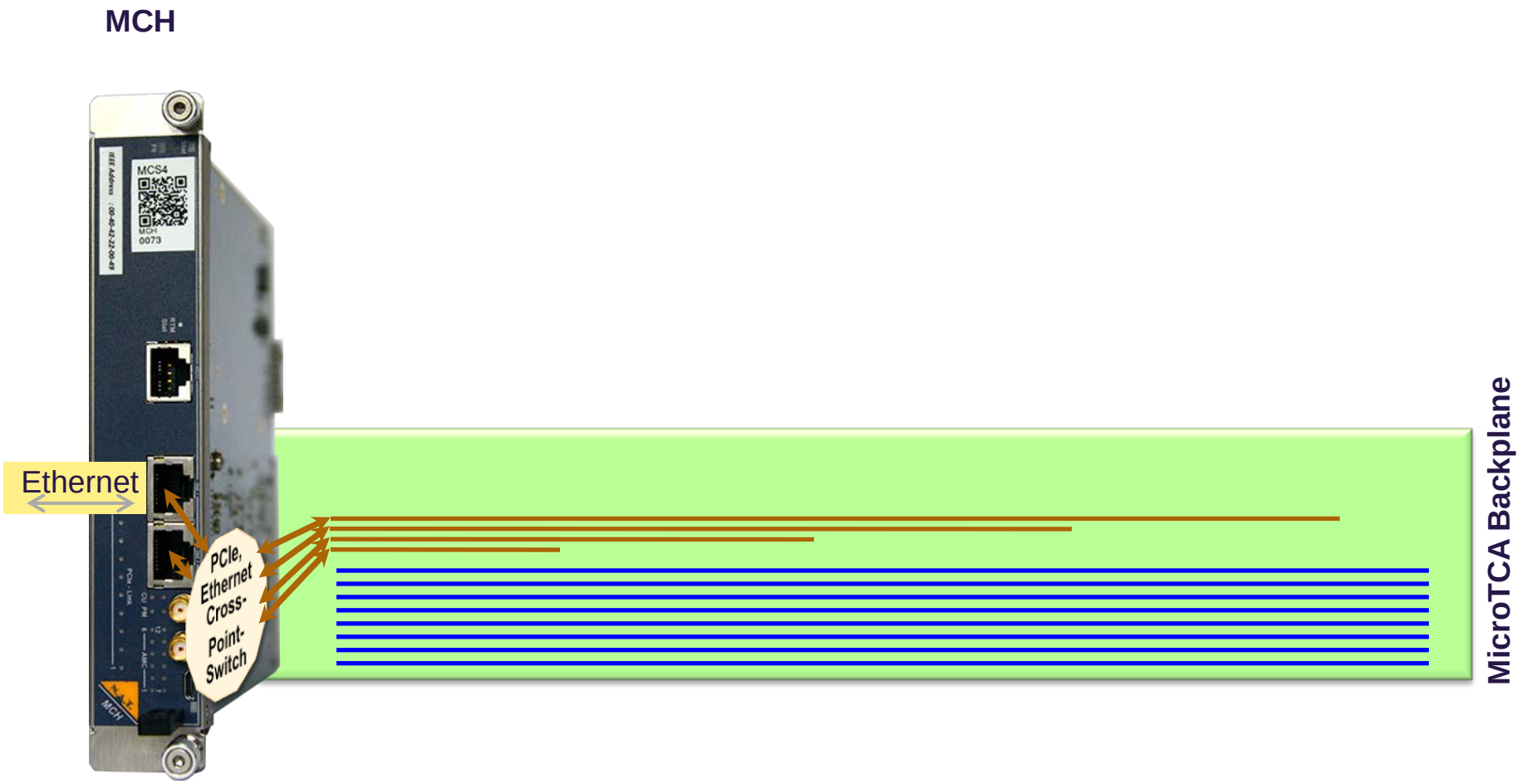


Allowed Modes/Sections: 32bit words per bunch



MPS → limits

MicroTCA.4: Clock and Trigger Distribution



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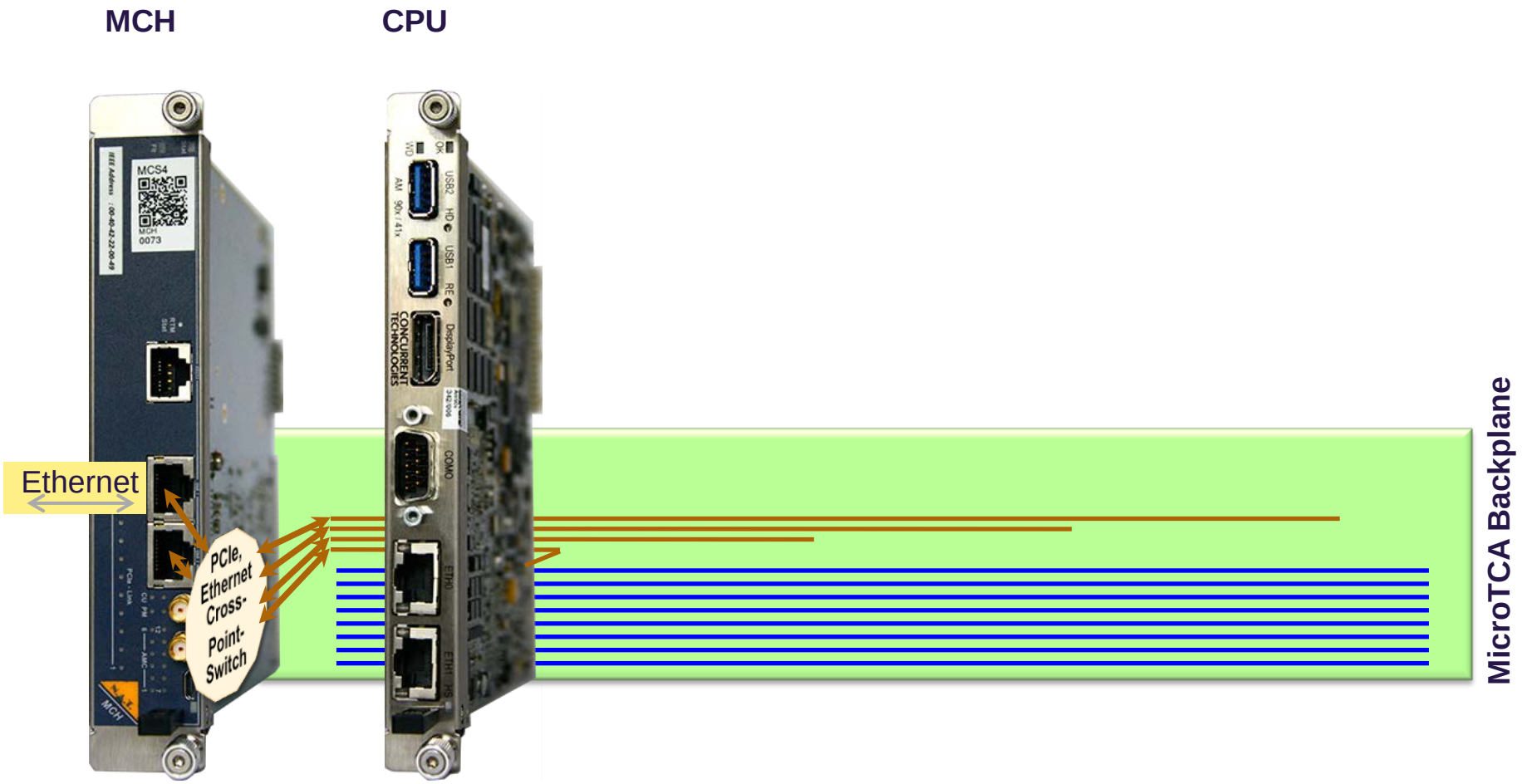

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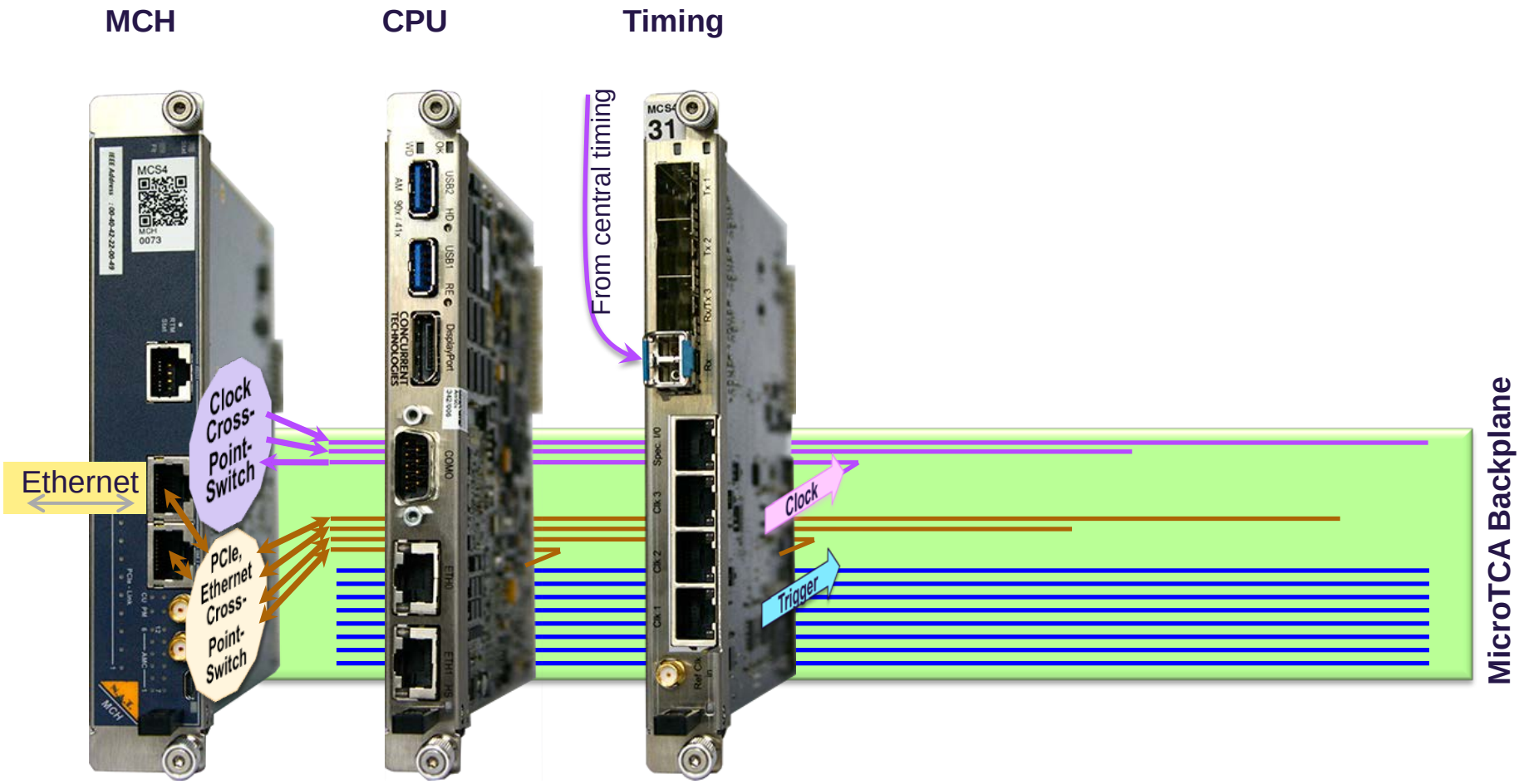

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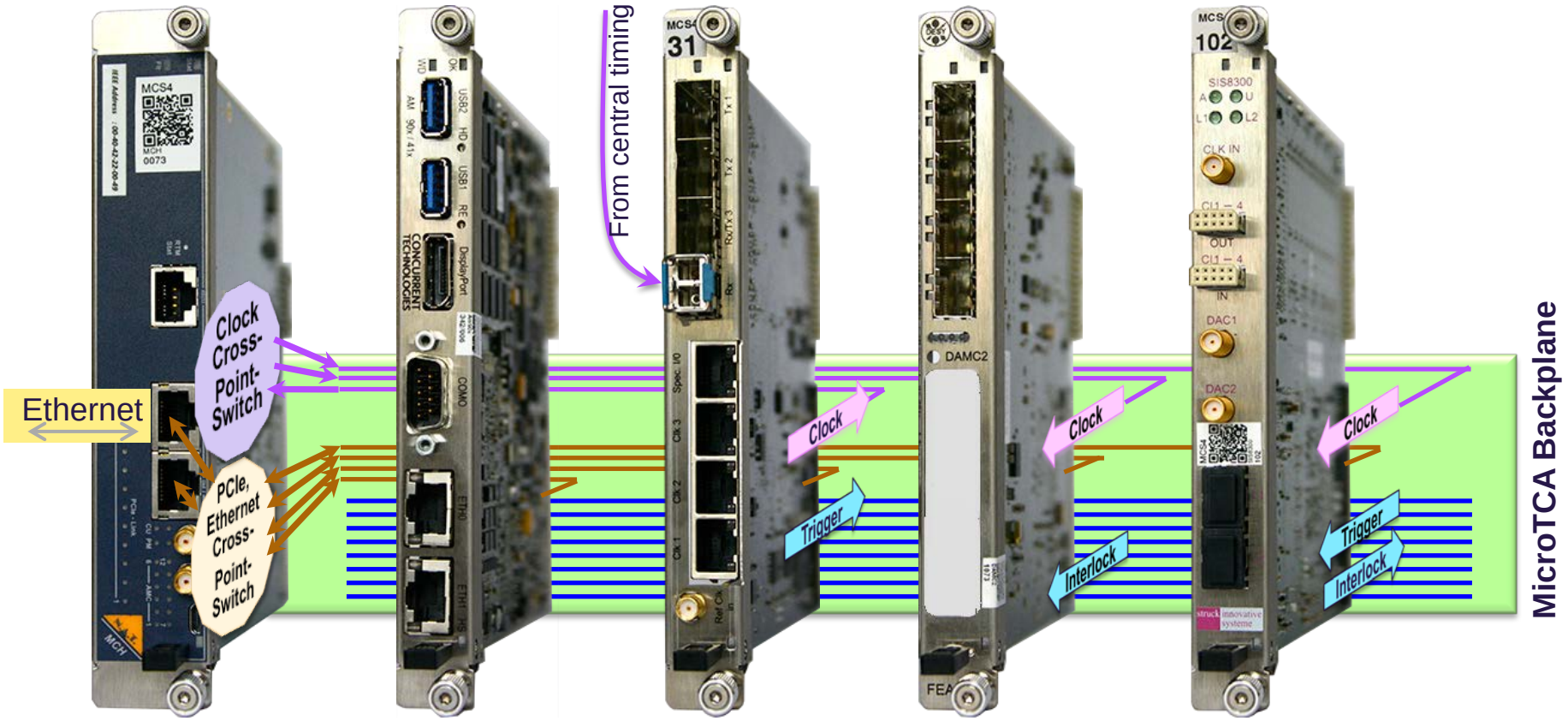
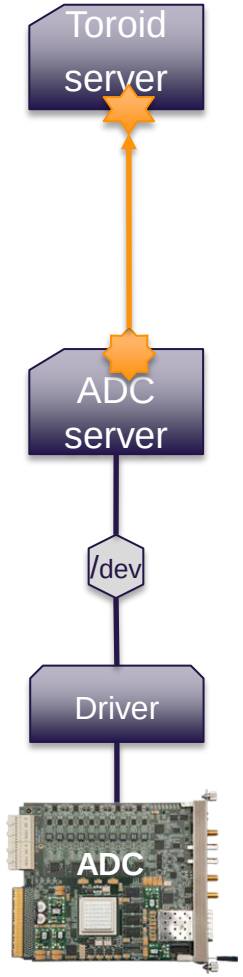
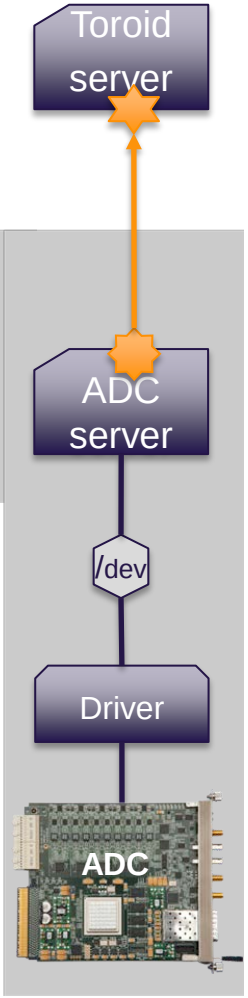


ZeroMQ Messaging Integration

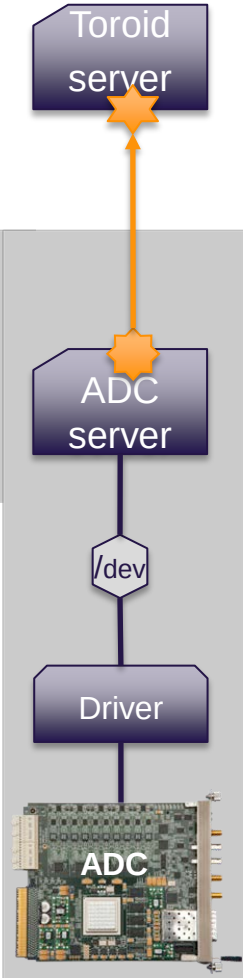


ZeroMQ Messaging Integration



ZeroMQ Messaging Integration

- Data readout controlled by hardware related server (e.g. ADC):
  - Provides configuration of specific hardware
  - Data transport by DMA



ZeroMQ Messaging Integration

- Task specific server (e.g. Toroid, BPM):
  - Receives the raw data from 0MQ
  - Converts it to physical units (e.g. nC, mm)

- Data readout controlled by hardware related server (e.g. ADC):
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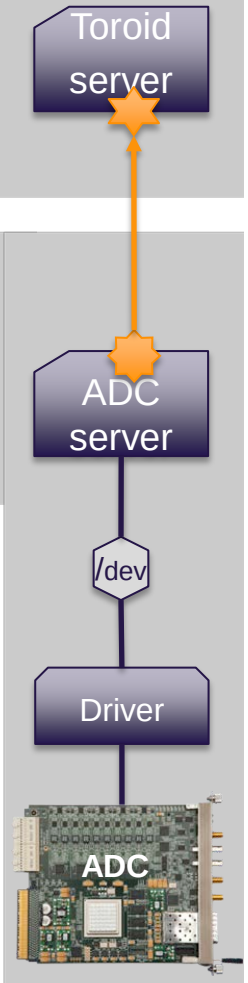

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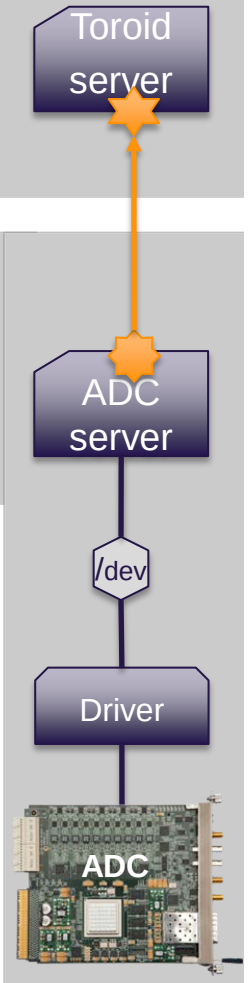
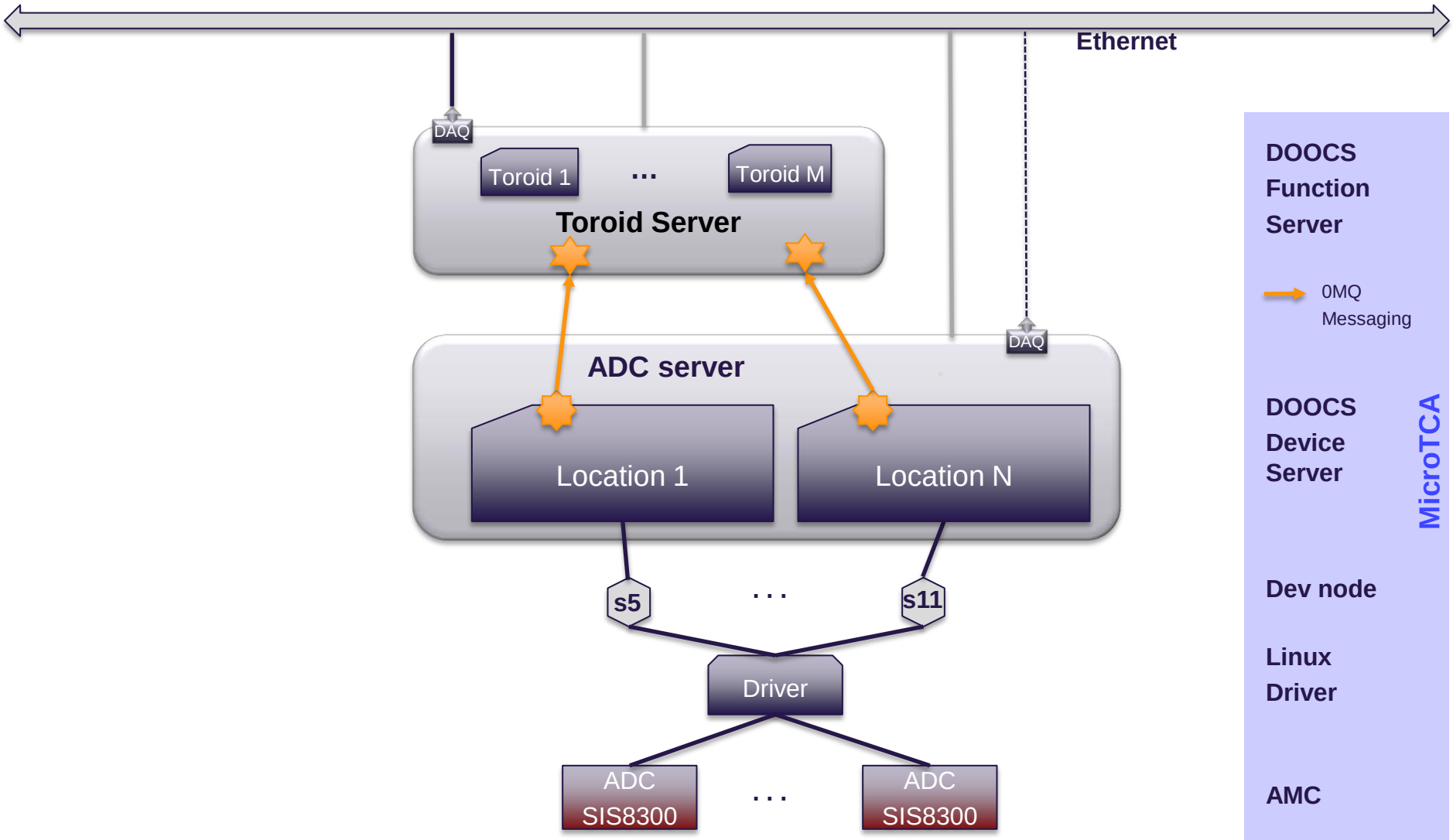
- Data readout controlled by hardware related server (e.g. ADC):
  - Provides configuration of specific hardware
  - Data transport by DMA

- DOOCS front-end servers implement **0MQ** Library:
  - To decouple processes
  - To avoid semaphores between processes
  - To dynamically attach / detach processes to data
  - To receive shot related info from timing
    → learning algorithms



New DOOCS Software for MicroTCA with 0MQ



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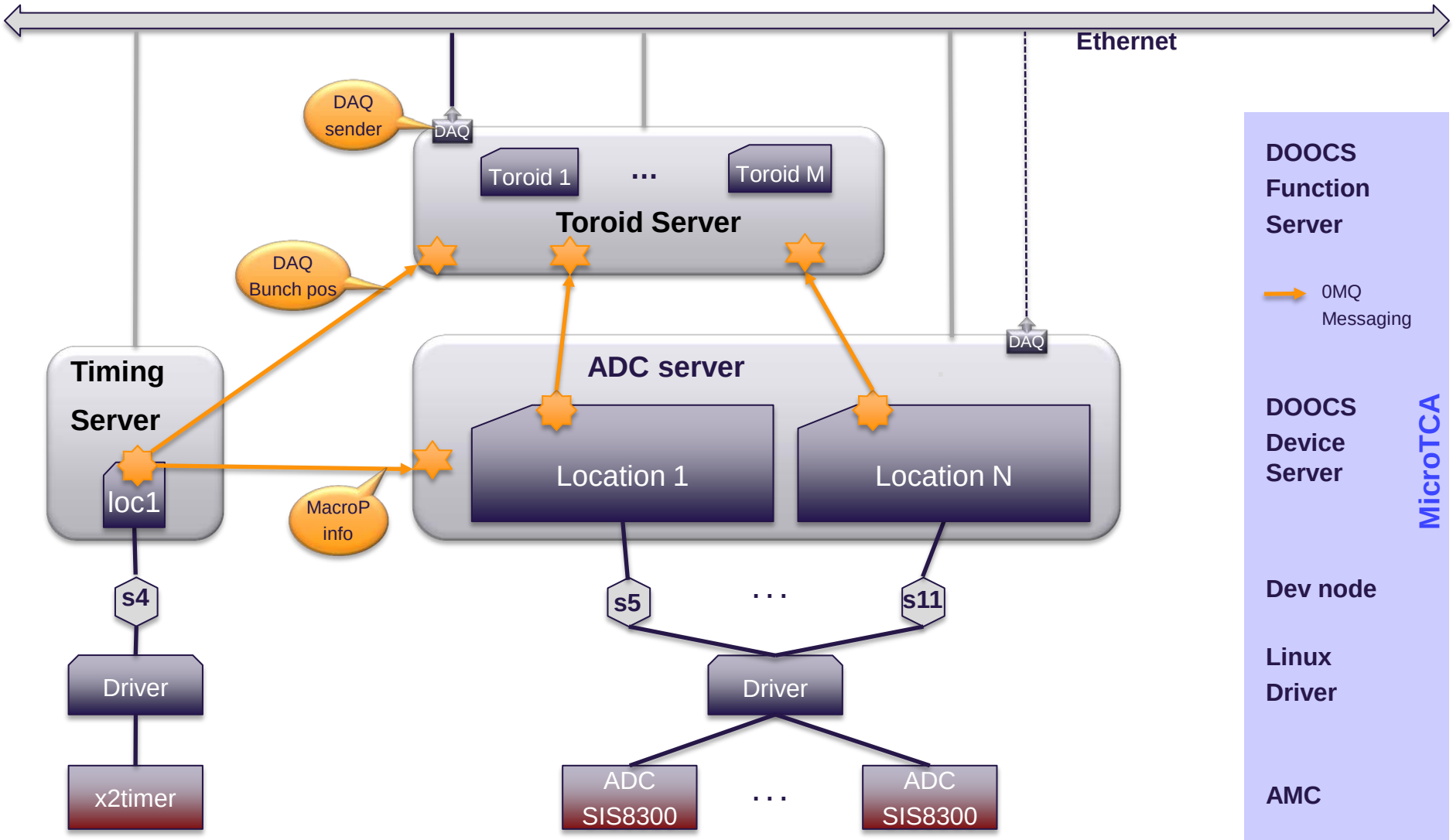
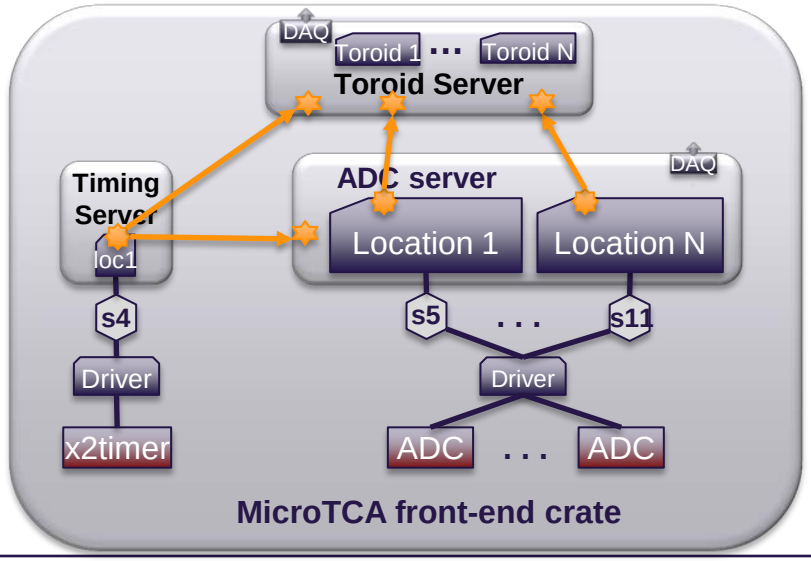
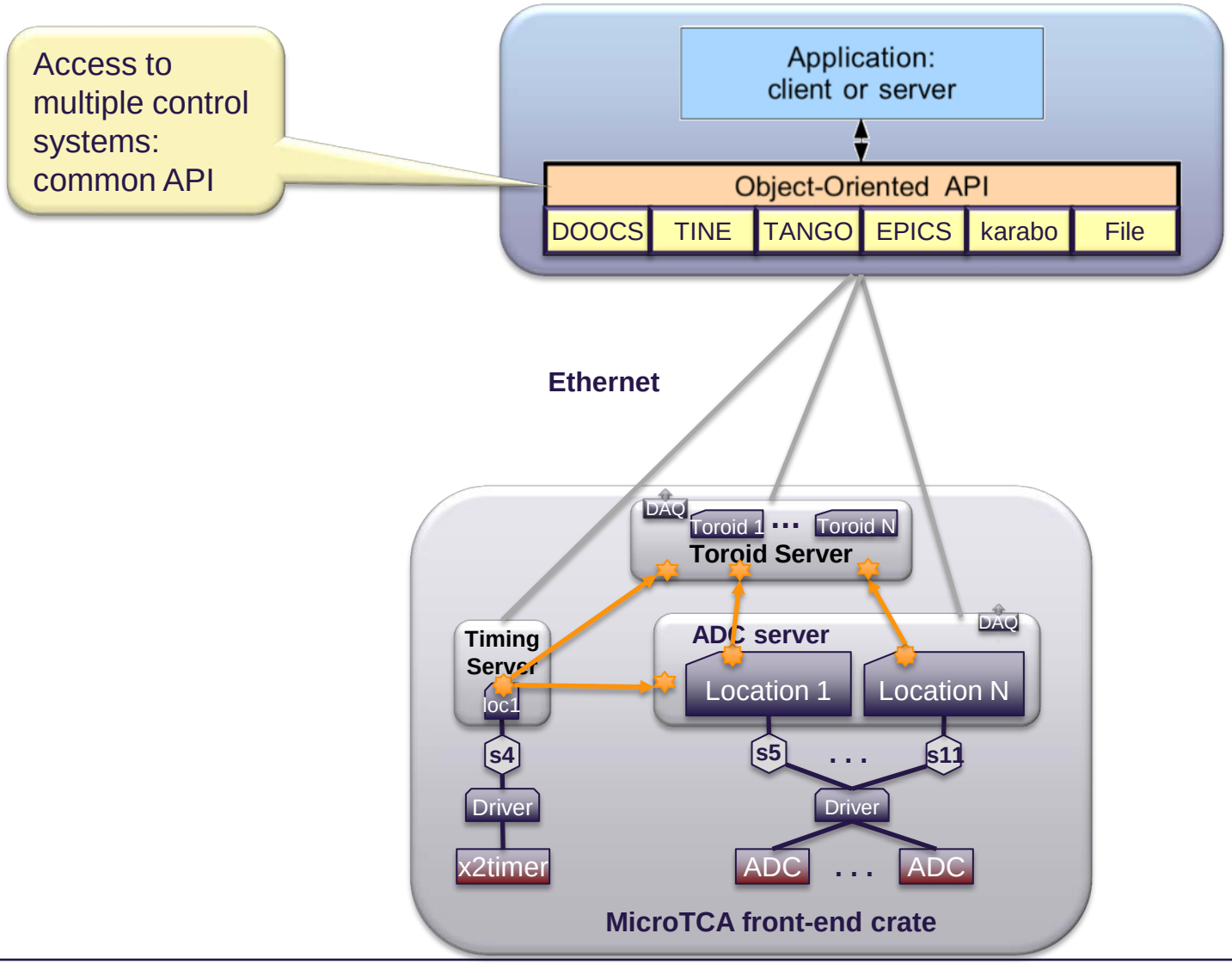


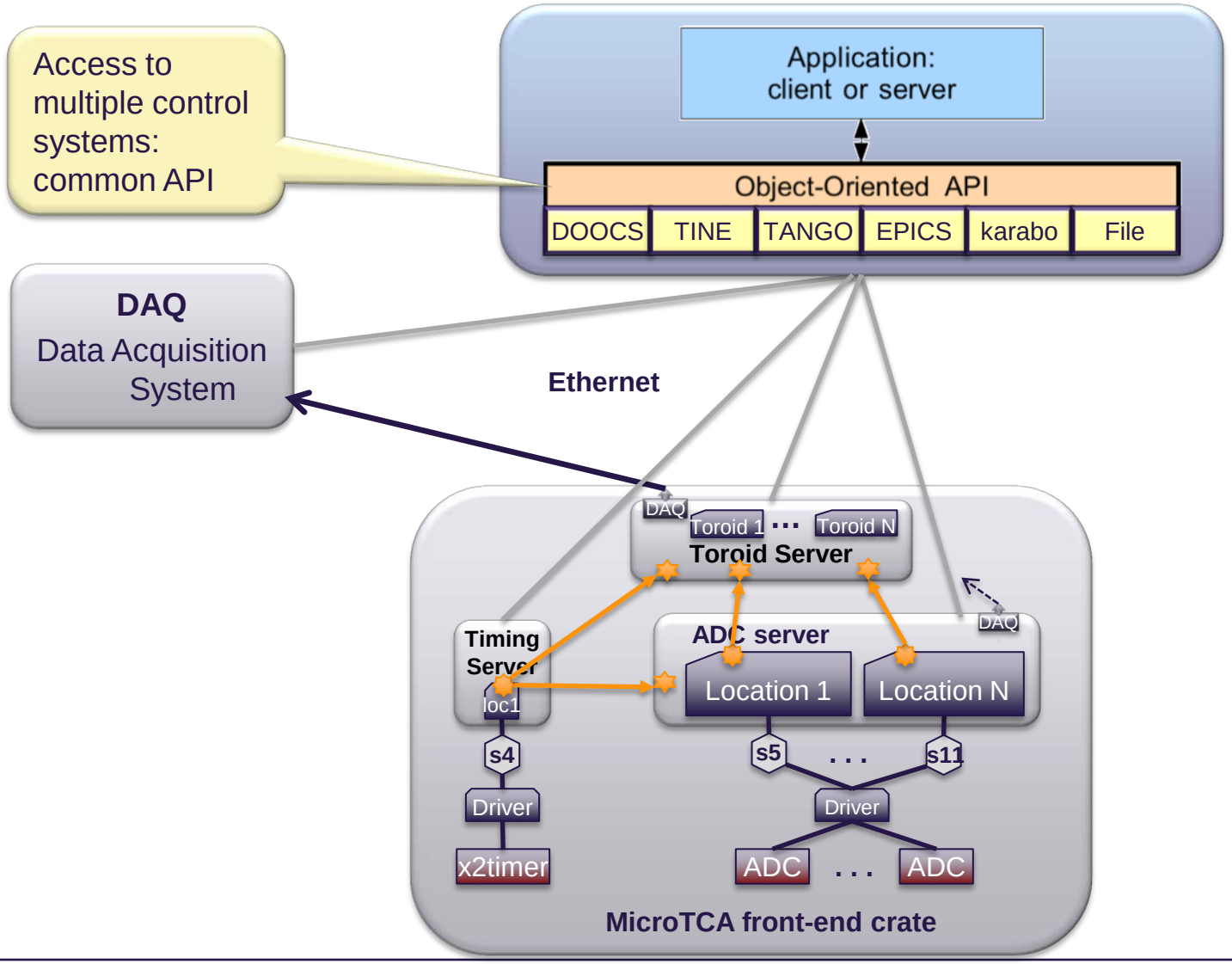
System Integration



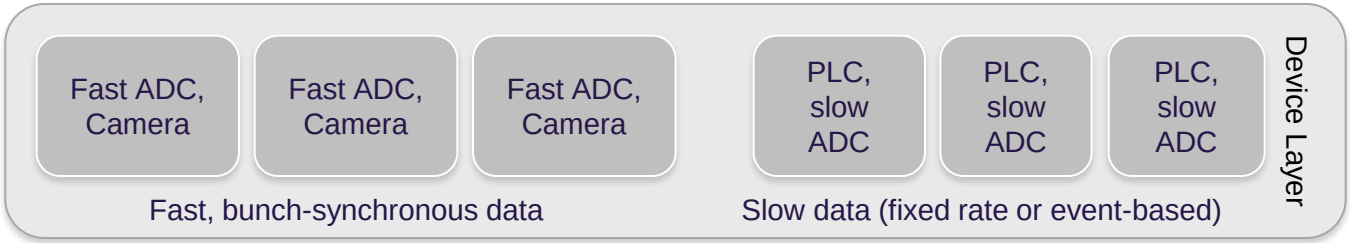
System Integration



System Integration



The Data Acquisition System (DAQ)



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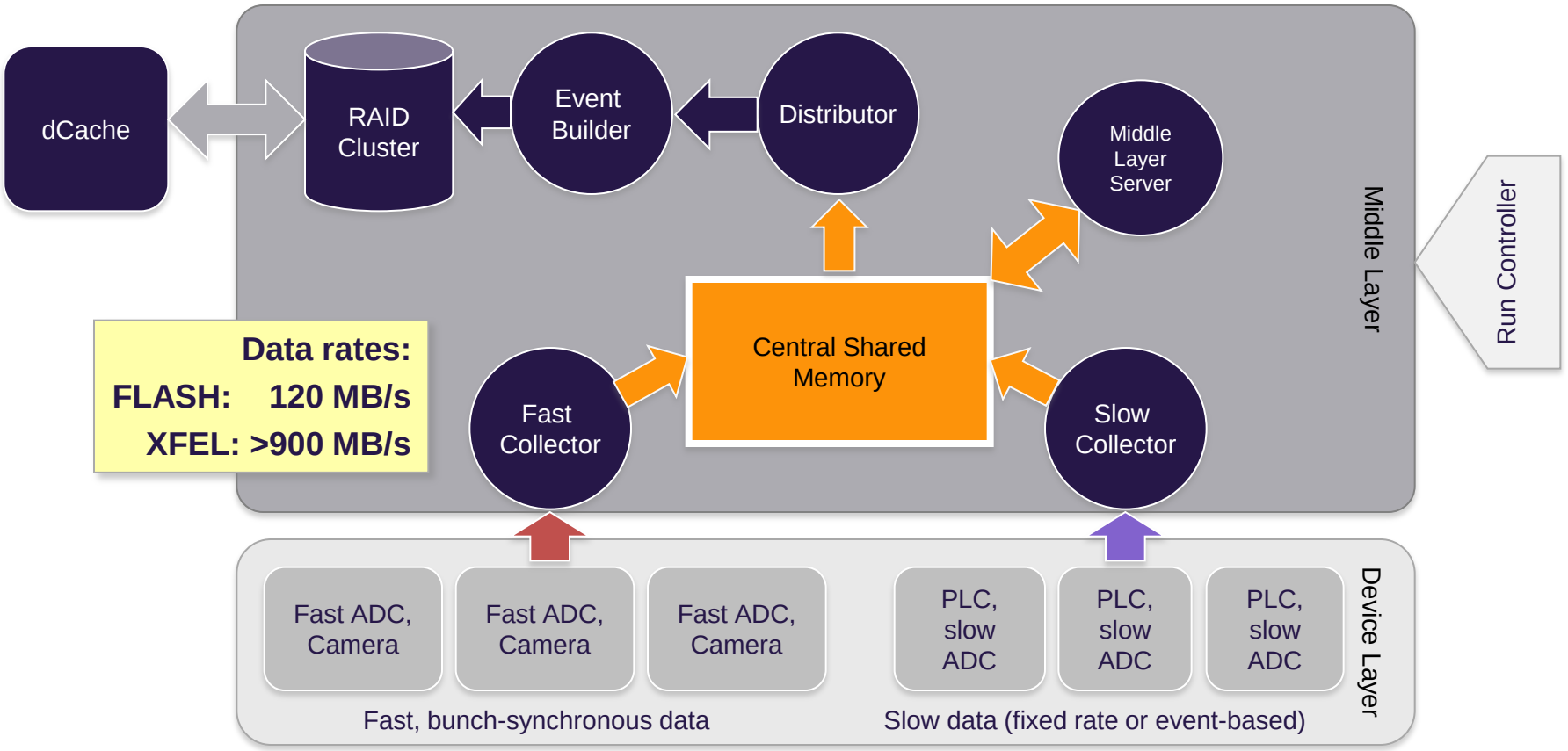

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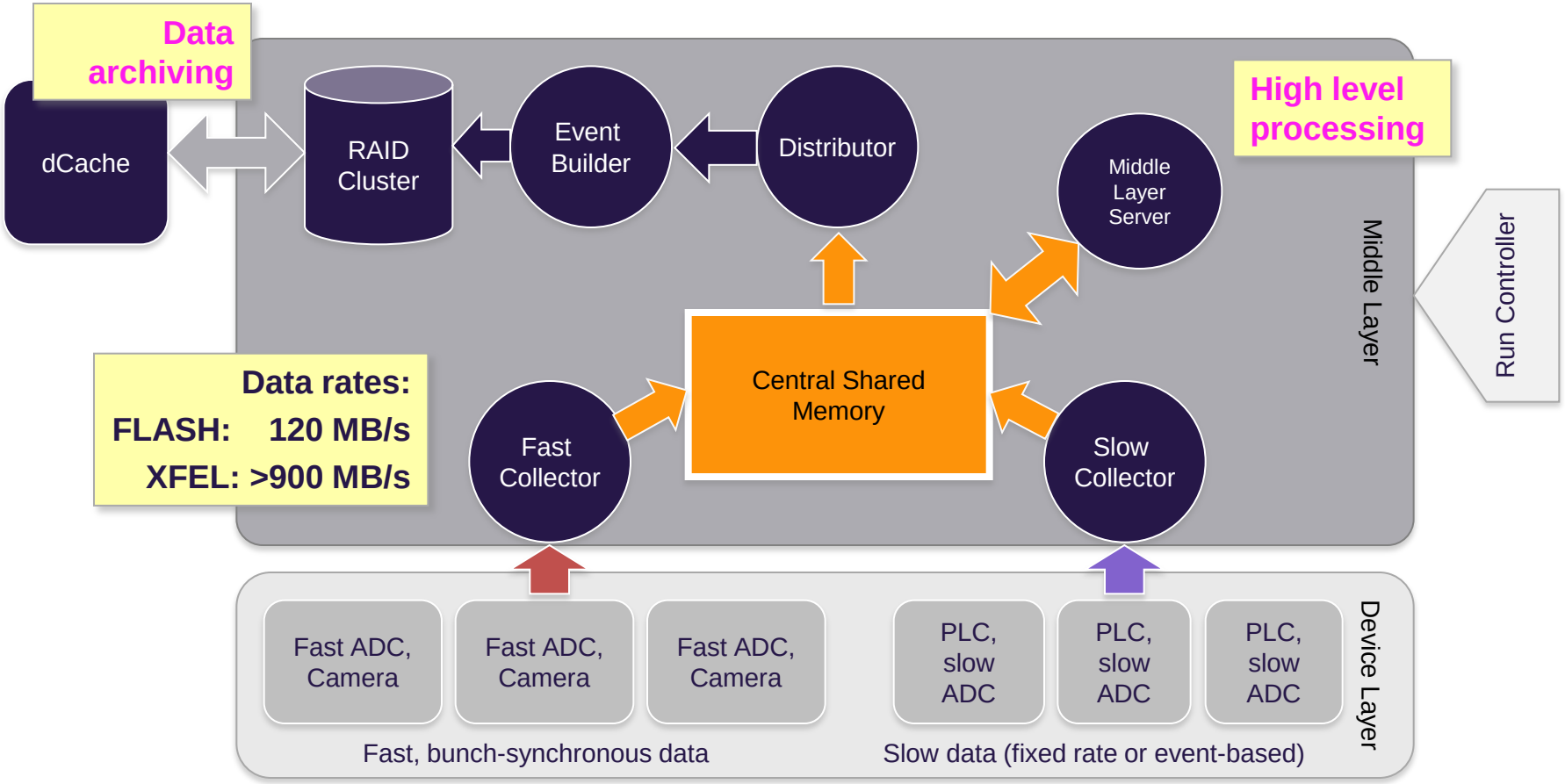

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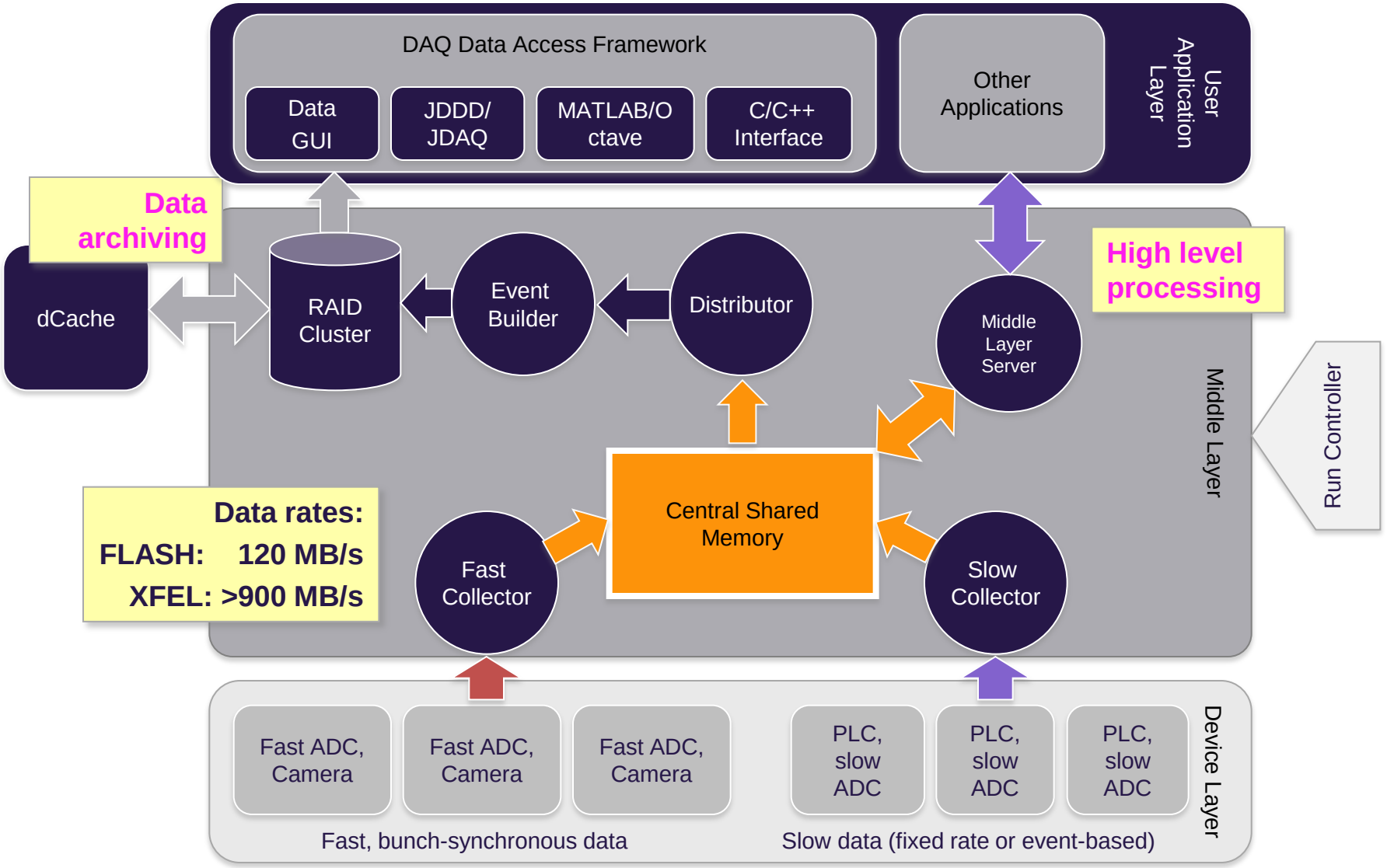


MicroTCA Remote Management

Panel created by **jddd**

MicroTCA Remote Management

Panel created by **jddd**

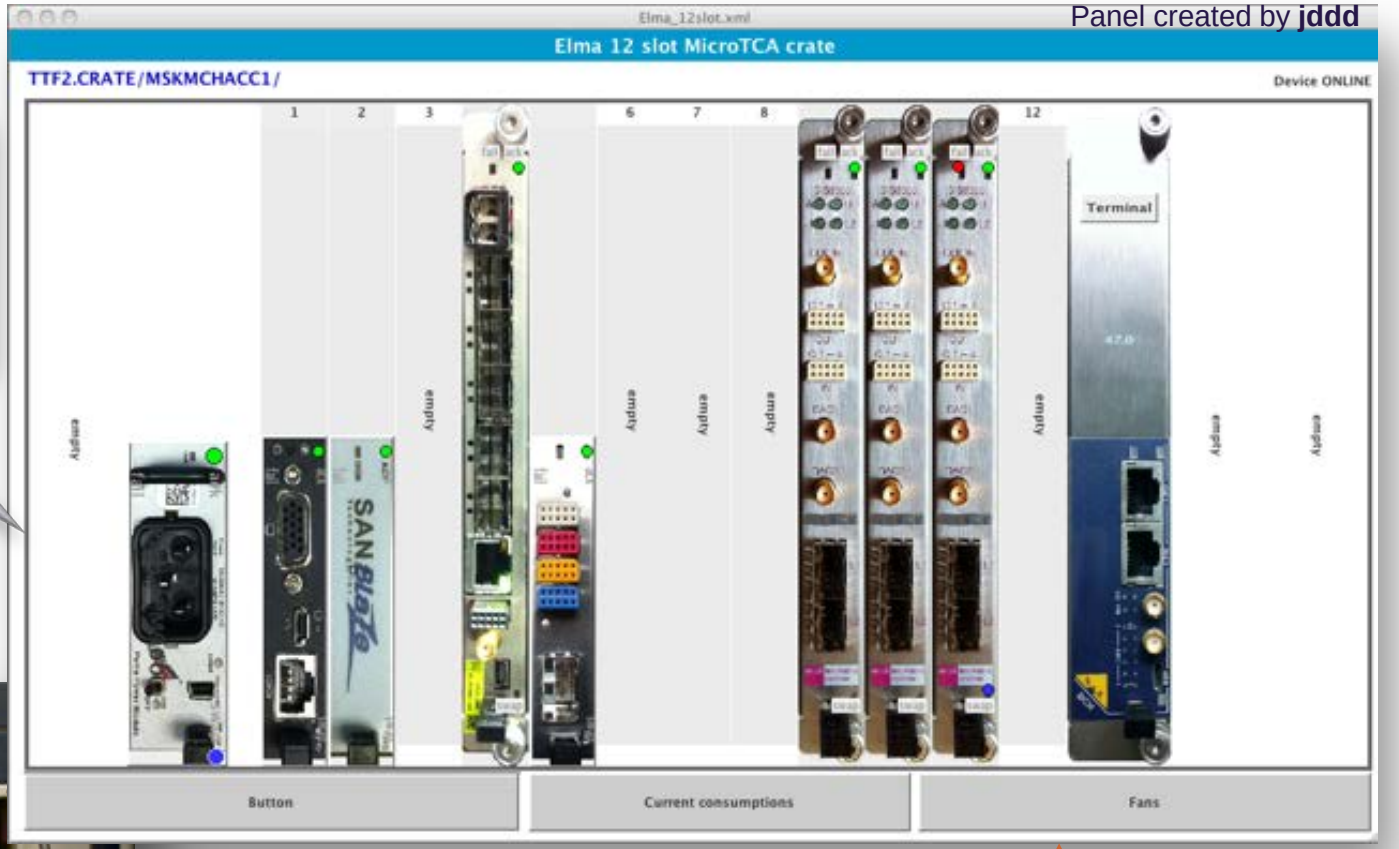
IPMI

DOOCS µTCA IPMI Server

MicroTCA Remote Management

Panel created by **jddd**

Online status of modules:
- Is-inserted, fault, …
- Temperatures, voltages
- Reset, power on/off
- Act. Power consumption



IPMI

DOOCS µTCA IPMI Server

MicroTCA Remote Management

Panel created by **jddd**

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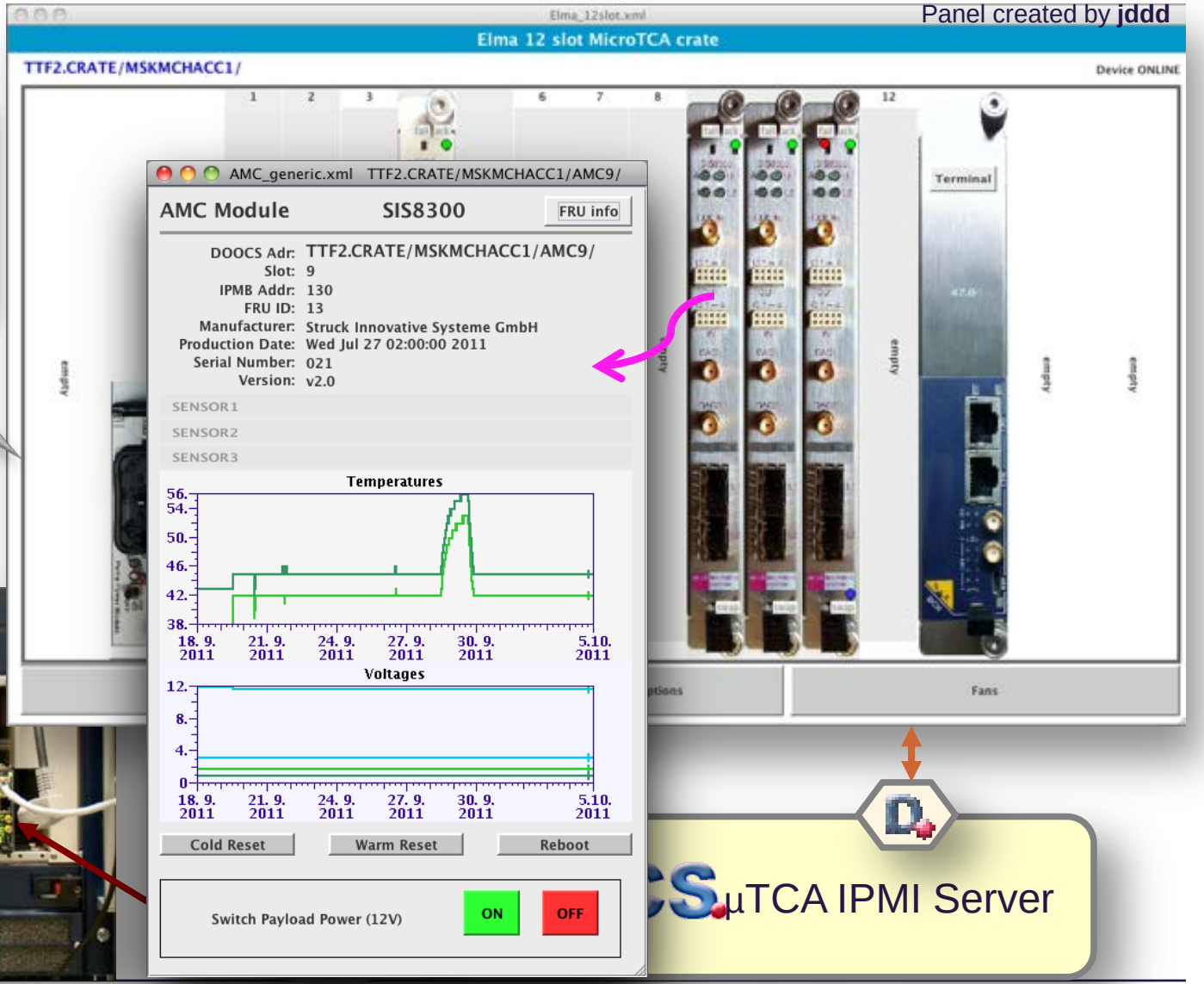
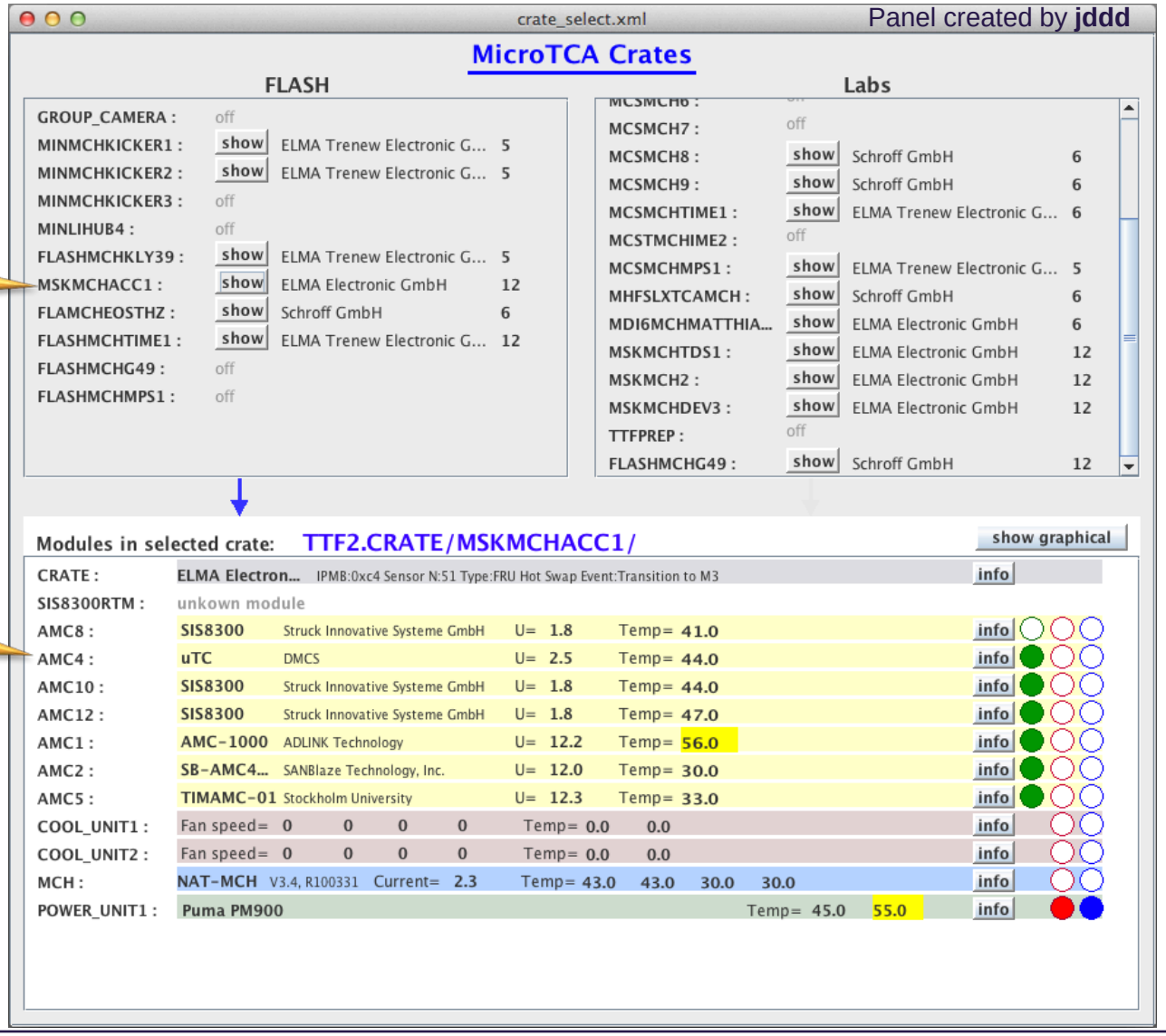


µTCA IPMI Server

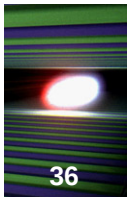
MicroTCA Crate Overview

Shows all Crates Ordered by Name

Shows all Modules in Selected Crate



Conclusions

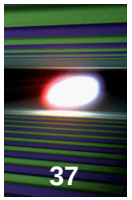


- Successful system tests with key MicroTCA modules based on MTCA.4 standard @ FLASH
- MicroTCA integration in DOOCS:
  - New 0MQ inter process communication
  - Hot-swap, Linux driver with DMA, device server, management
- Synchronized data processing implemented:
  - On timing and ADC and controls hardware
  - On device servers, including ZeroMQ
  - On middle layer data processing and storage
  - On client applications (e.g. jddd)

More Info:
http://doocs.desy.de

European XFEL

XFEL & FLASH Contributions @ ICALEPCS2013



Sven Karstensen	TUCOCA01	XFEL Machine Protection System (MPS) Based on uTCA
Elke Sombrowski	TUPPC104	jddd: A Tool for Operators and Experts to Design Control System Panels
Raimund Kammering	THPPC121	Feedbacks and Automation at the Free Electron Laser in Hamburg (FLASH)
Kay Rehlich	THPPC093	The New Timing System for the European XFEL
Wojciech Cichalewski	THPPC135	From Pulse to Continuous Wave Operation of TESLA Cryomodules - LLRF Sys
Jaroslaw Szewinski	THPPC140	uTCA Upgrade of the Readout Electronics for the Bunch Arrival Time Monitor a
Christian Schmidt	THPPC122	High Performance and Low Latency Single Cavity RF Control Based on MTCA.
Thomas Walter	MOPPC081	The Case of MTCA.4: Managing the Introduction of a New Modular Electronic C
Holger Schlarb	FRCOBAB02	Ultra-fast Longitudinal Feedbacks for the European XFEL
Lukasz Butkowski	TUCOCA09	Klystron Measurement and Protection System for XFEL on the uTCA Architectu
Tomasz Jezynski	THPPC094	Managed Precision Clock and RF Signal Distribution over Custom RF-backplan
Julien Branlard	THPPC072	Superconducting Cavity Quench Detection and Prevention for the European XF
Burkhard Heisen	FRCOAAB02	Karabo: An Integrated Software Framework Combining Control, Data Managem
Nicola Coppola	TUPPC046	Control Using Beckhoff Distributed Rail Systems at the European XFEL