



# Recent Hardware and Software Achievements for the European XFEL

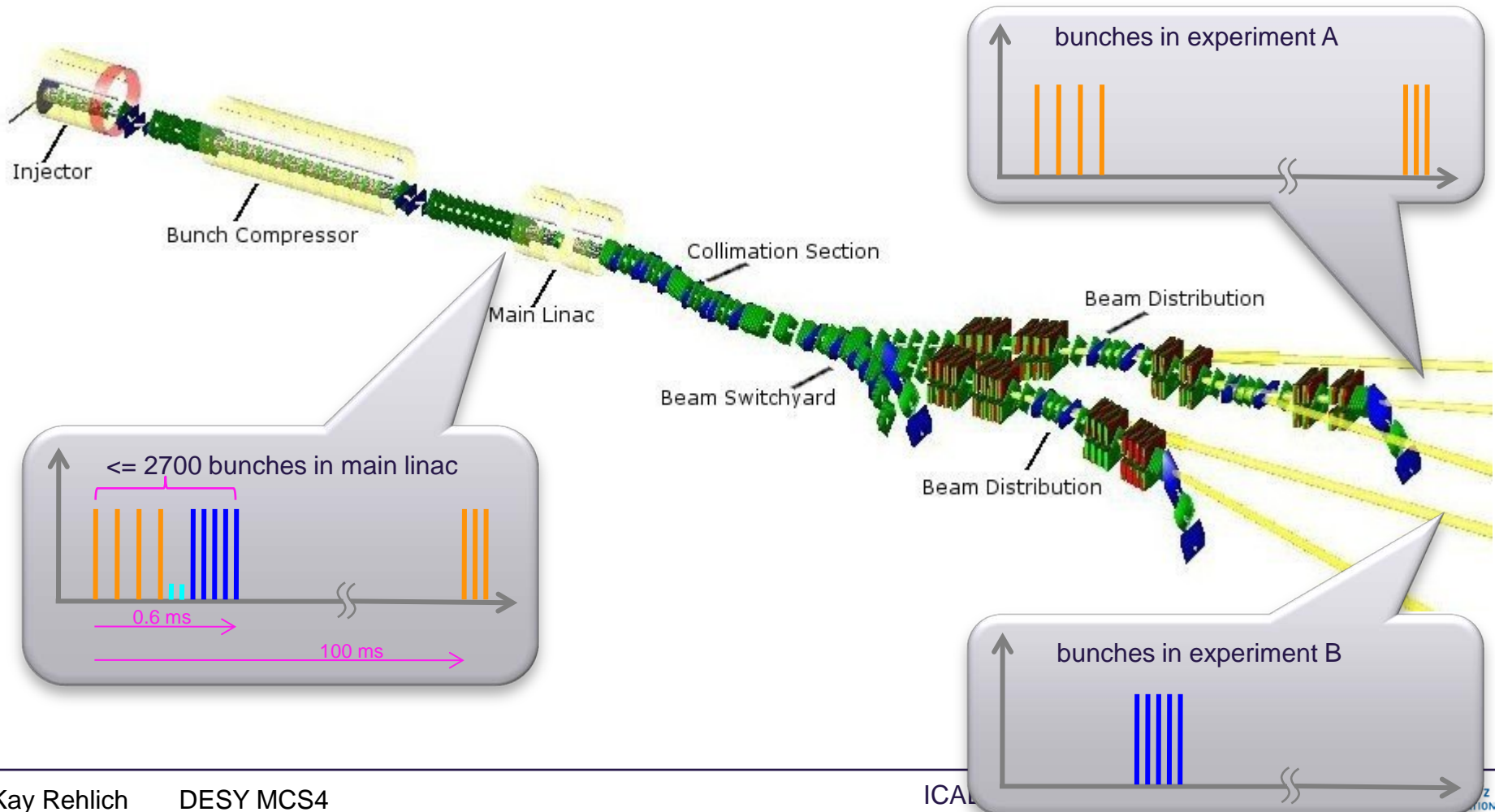
Kay Rehlich

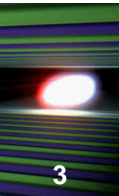
On behalf of the FLASH / XFEL Controls Group



## Motivation

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

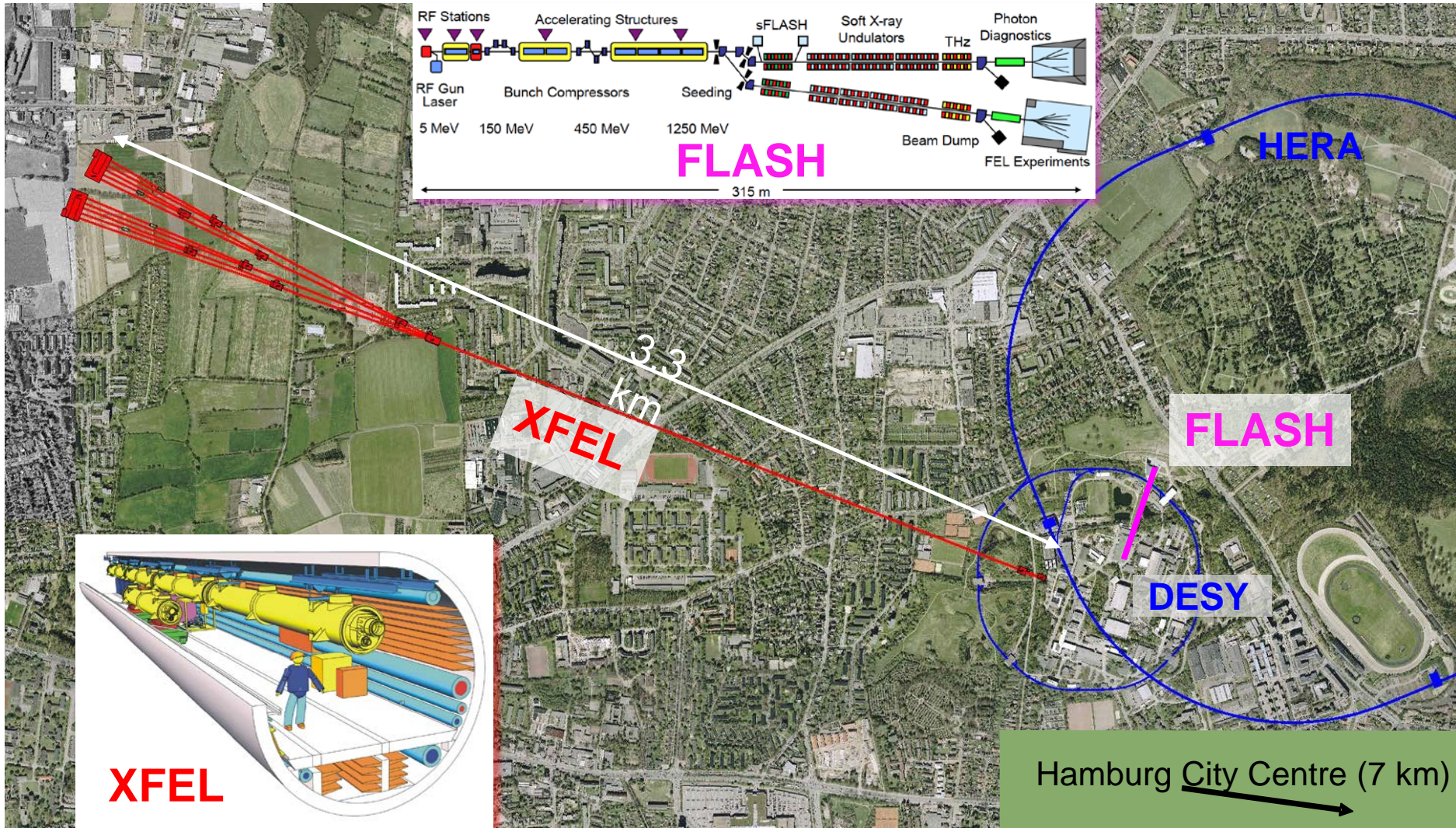
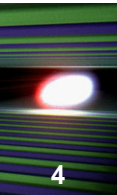




- Synchronization of sub-systems
- Hardware implementation
  - Timing system in  $\mu$ TCA
- Software implementation
  - 0MQ Inter Process Communication
  - DAQ system
- Conclusions



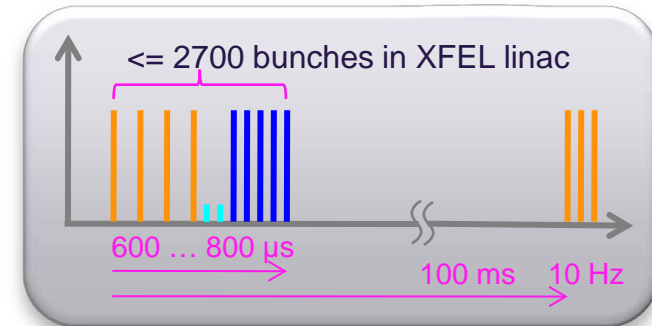
# FLASH and XFEL



# Synchronization of Sub-Systems

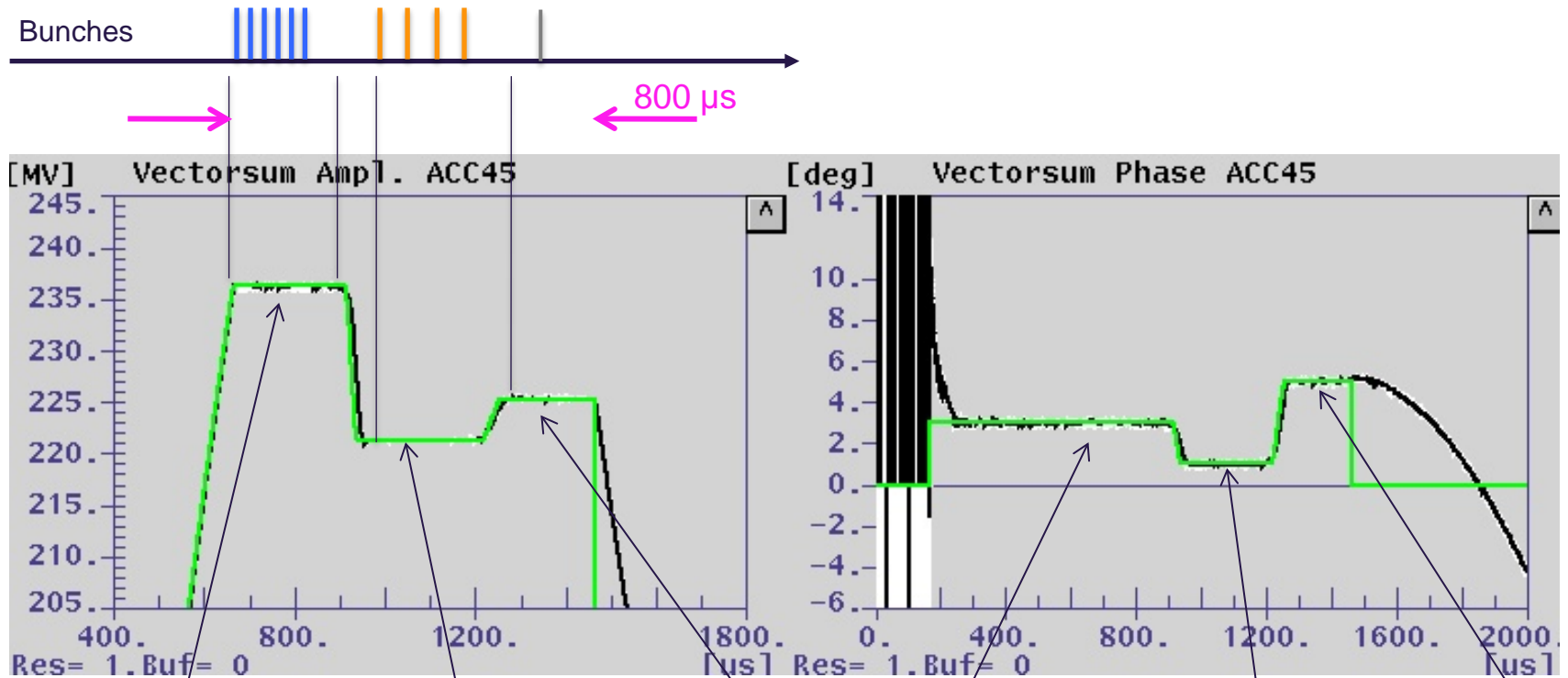
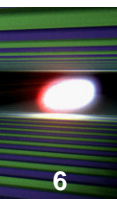
5

- 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



FLASH1

FLASH2

FLASH3

FLASH1

FLASH2

FLASH3

RF response

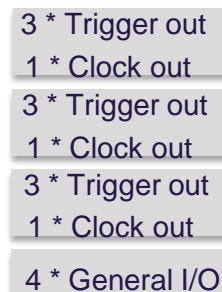
Requested RF Pulse shape



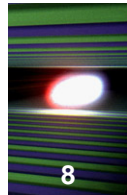
**Transmitter**  
Piggyback  
with link delay  
compensation



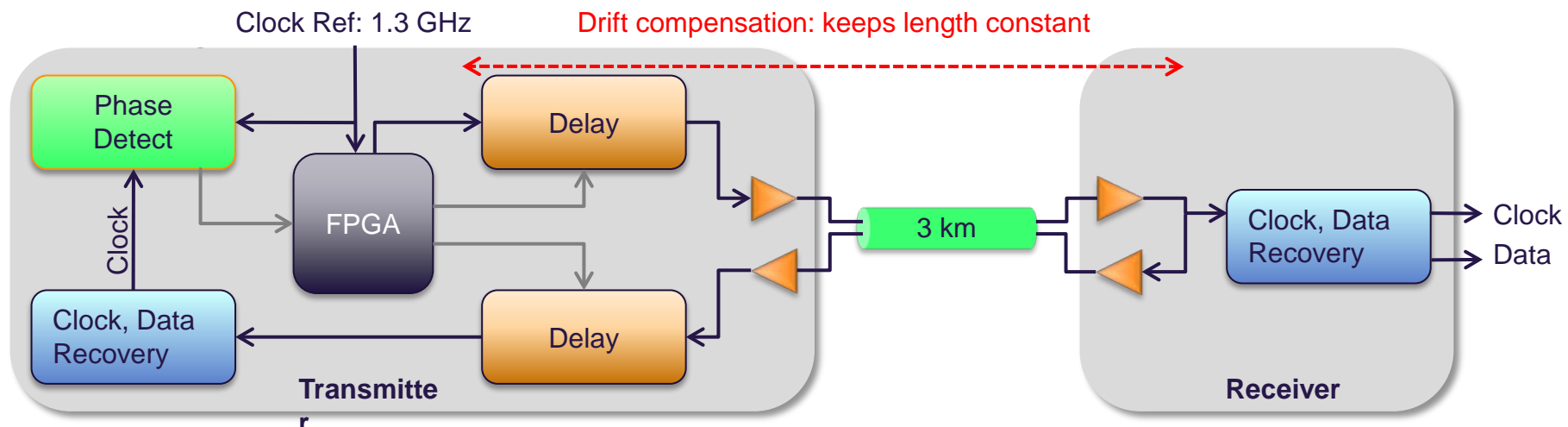
MicroTCA **backplane:**  
TCLKA and TCLKB,  
8 \* M-LVDS



# 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

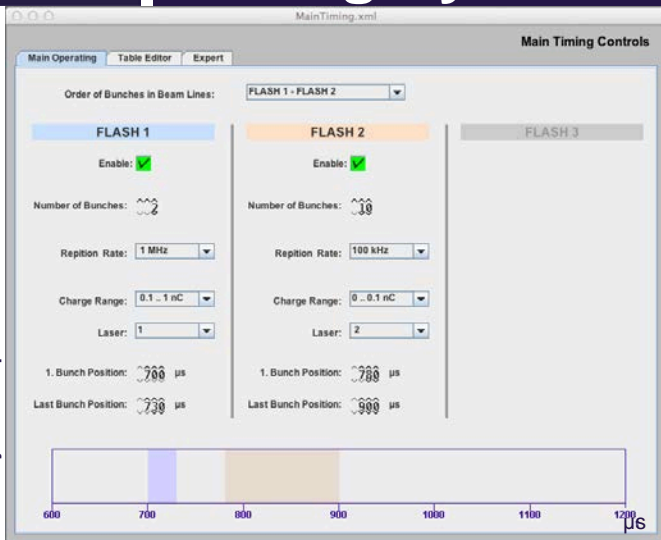




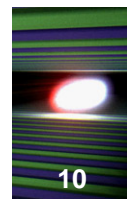
# Timing System: Real Time Configuration Data

9

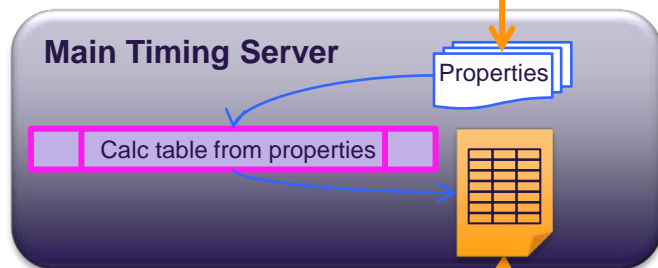
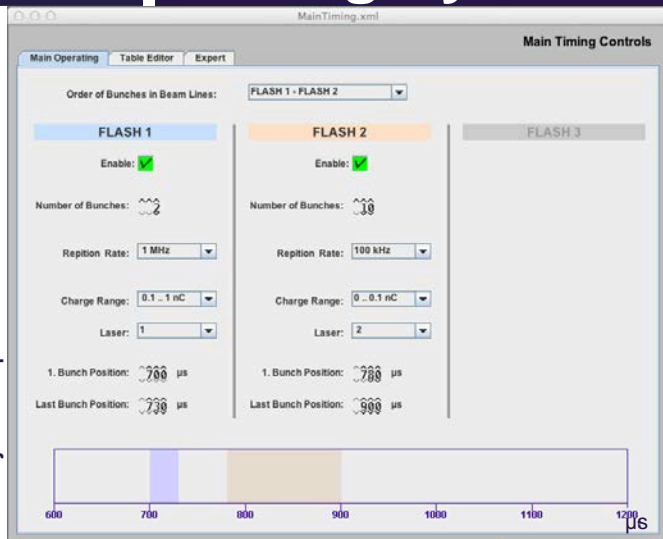
jddd Operations Panel



# Timing System: Real Time Configuration Data



jdd Operations Panel



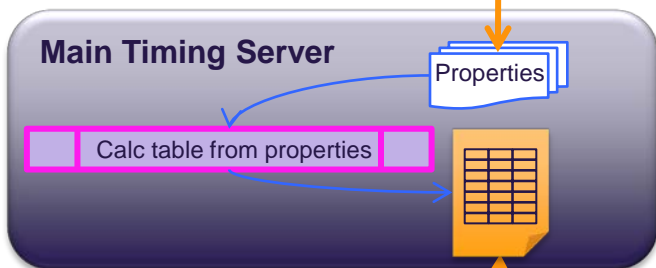
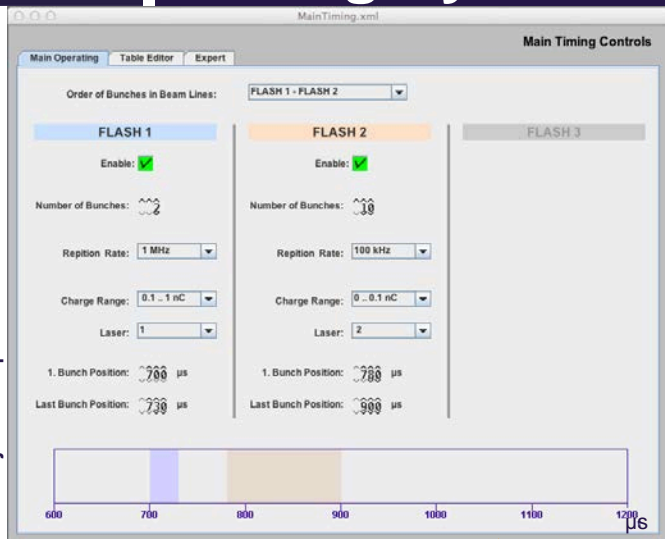
MPS →  
limits



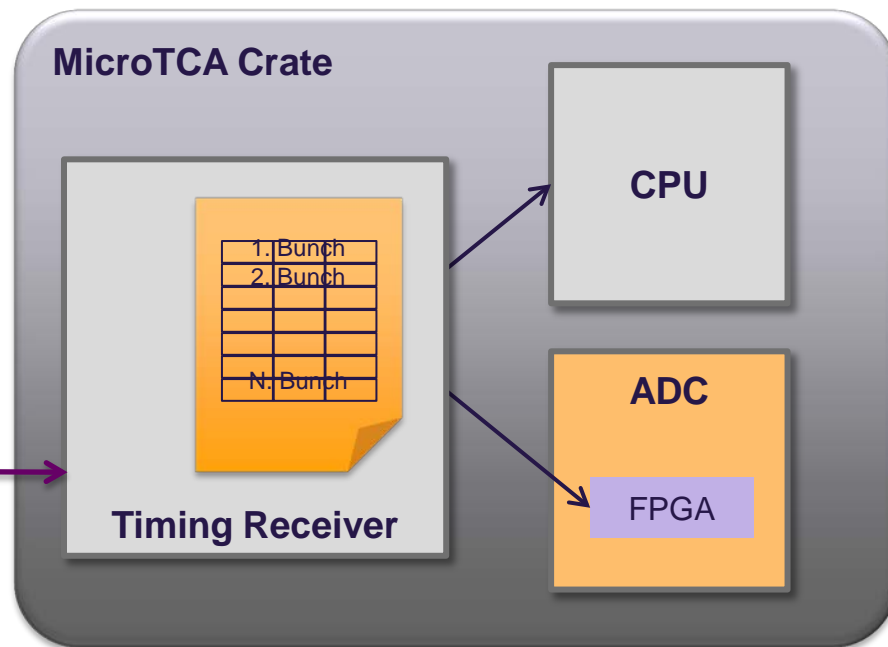
# Timing System: Real Time Configuration Data

11

jdd Operations Panel



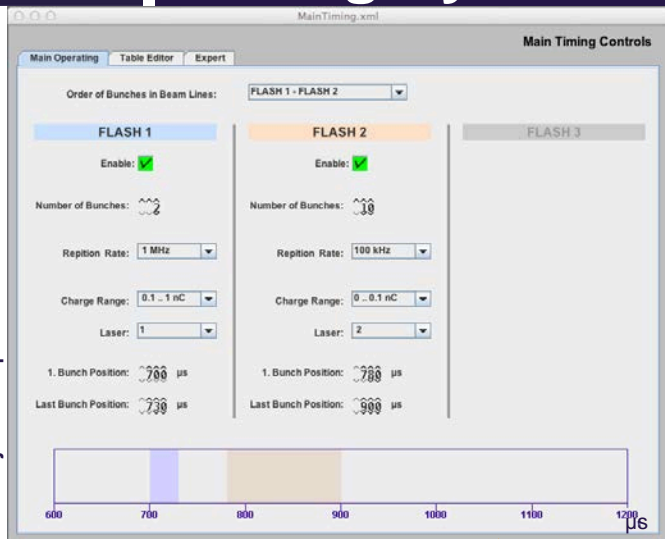
**MPS** →  
limits



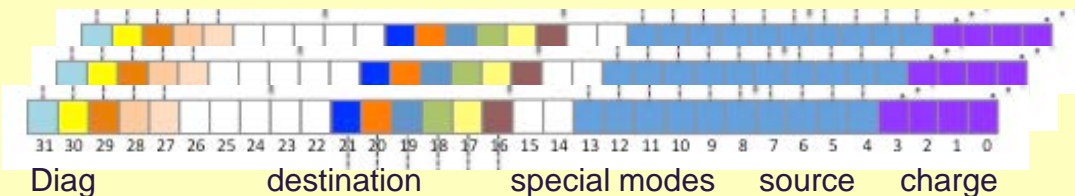
# Timing System: Real Time Configuration Data

12

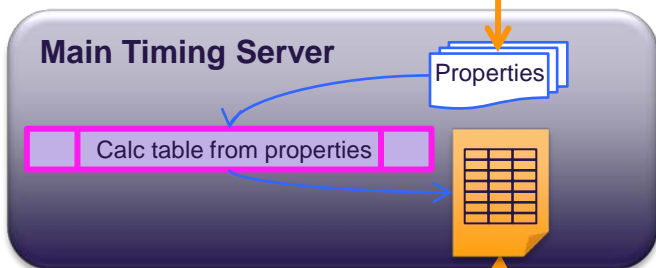
jdd Operations Panel



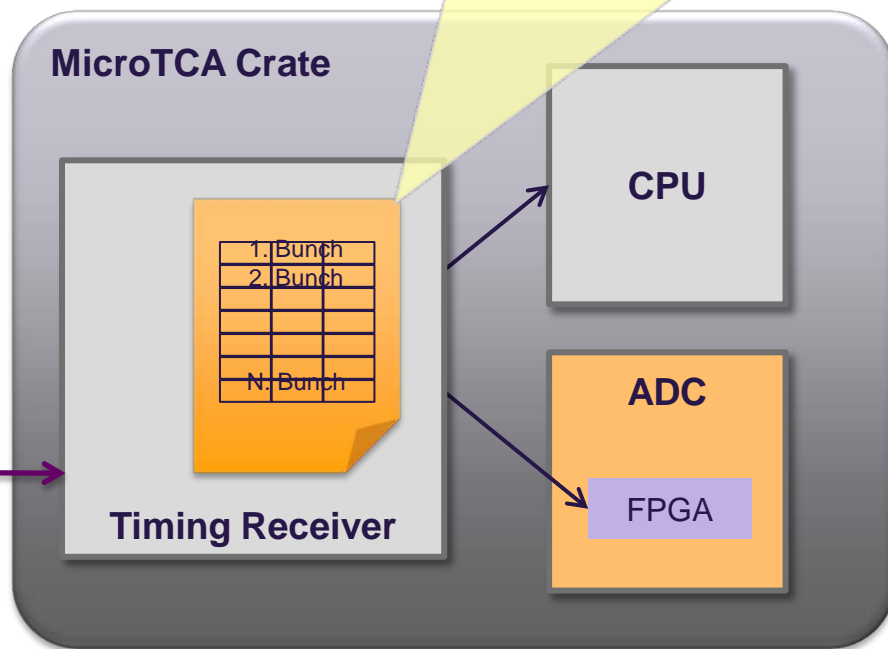
## Bunch Pattern Table: One 32bit word per bunch



## Allowed Modes/Sections: 32bit words per bunch



MPS →  
limits

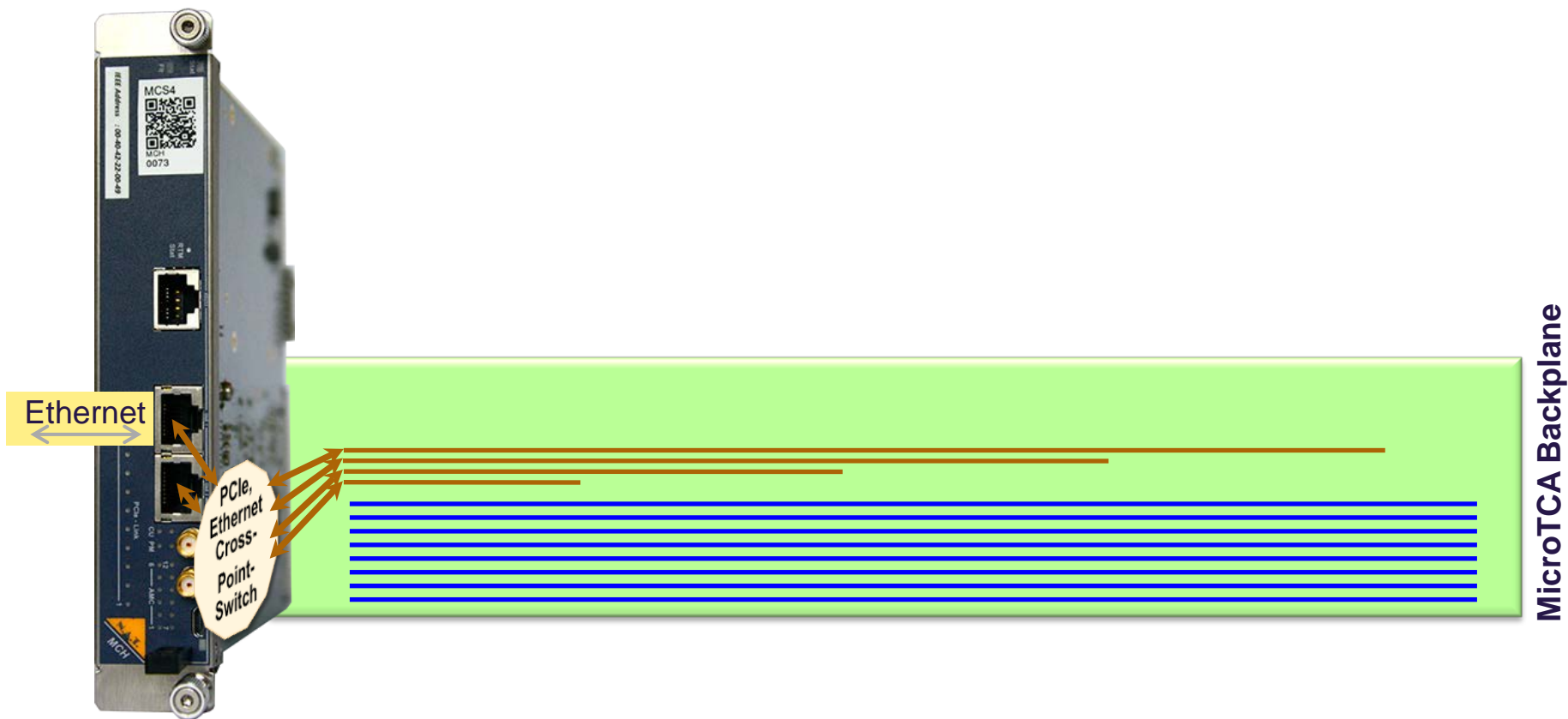




# MicroTCA.4: Clock and Trigger Distribution

13

MCH

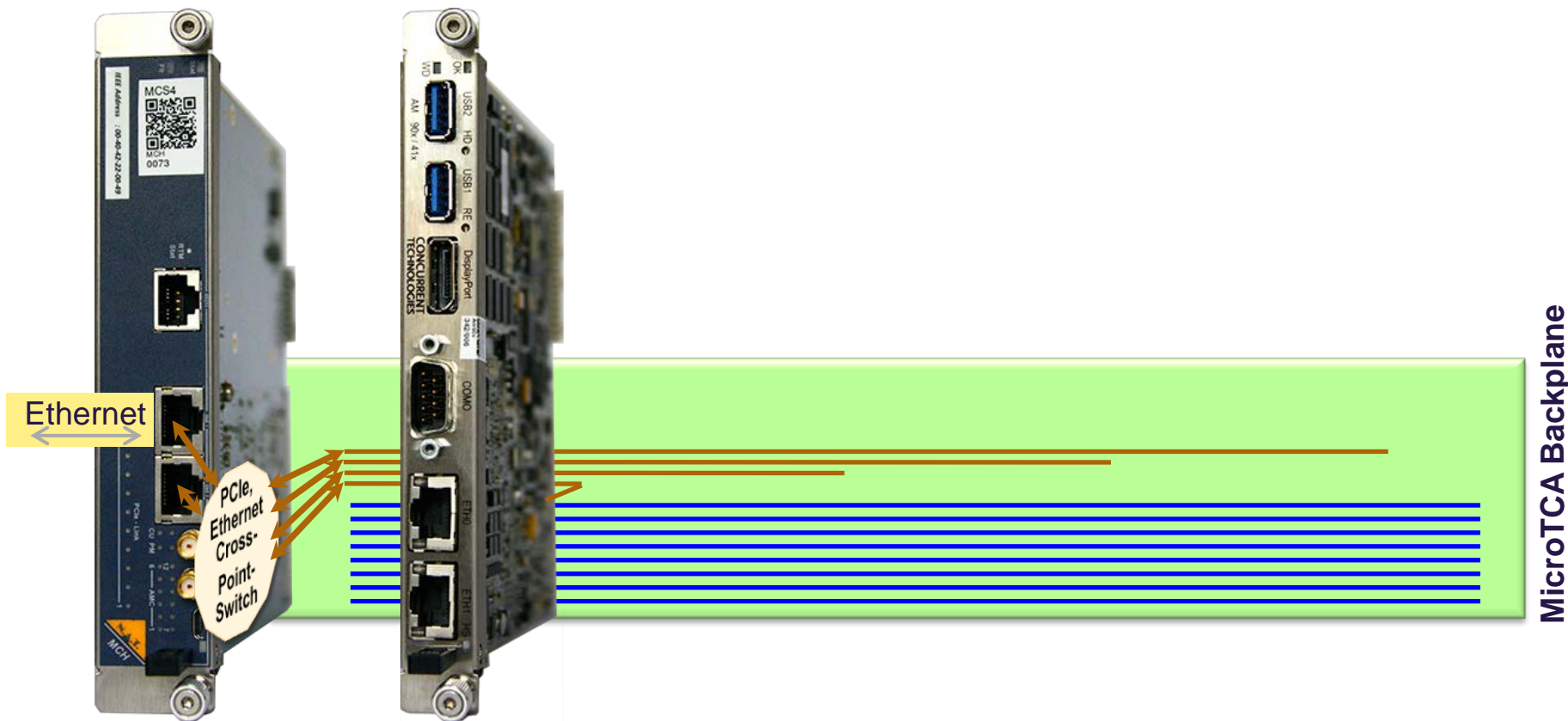


# MicroTCA.4: Clock and Trigger Distribution

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MCH

CPU

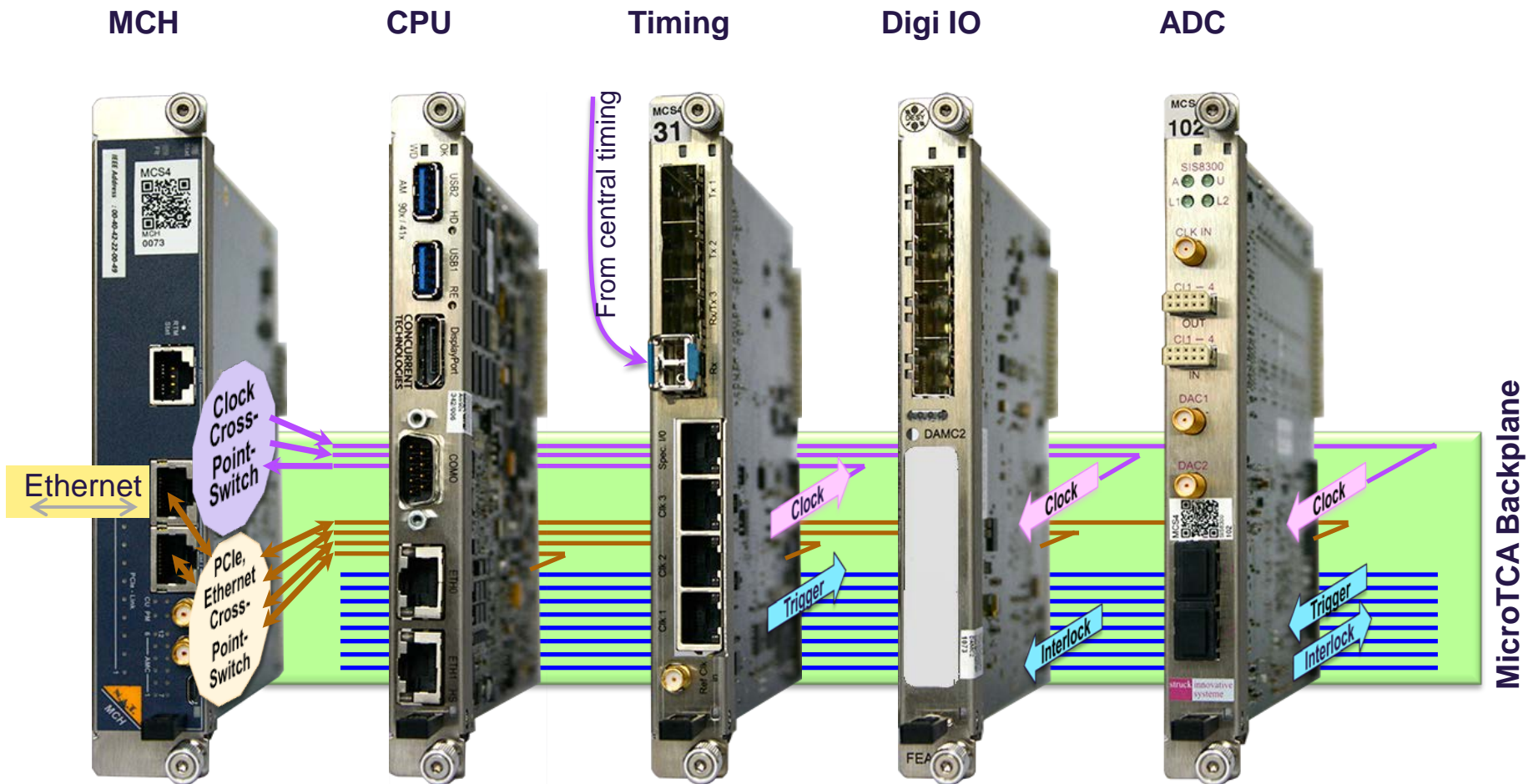


MicroTCA Backplane

## 15



# MicroTCA.4: Clock and Trigger Distribution

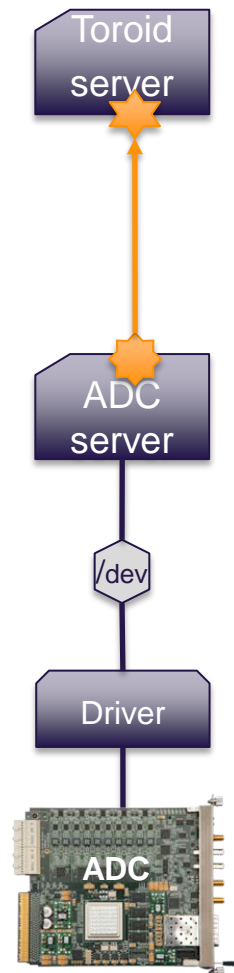


MicroTCA Backplane

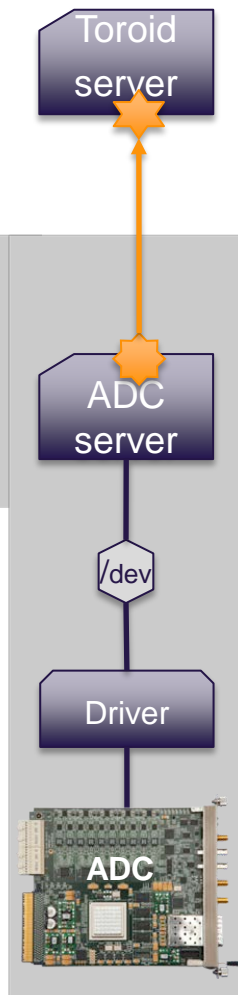


# ZeroMQ Messaging Integration

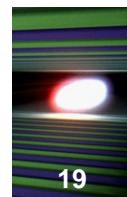
17



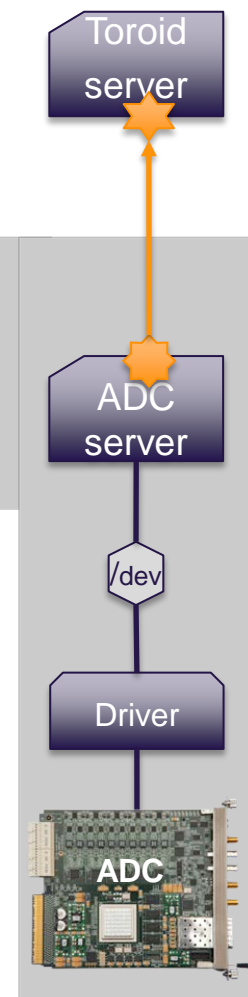
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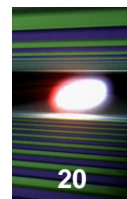
# ZeroMQ Messaging Integration



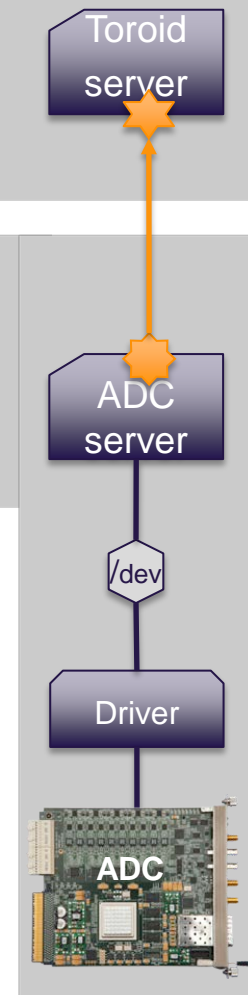
- Data readout controlled by hardware related server (e.g. ADC):
  - Provides configuration of specific hardware
  - Data transport by DMA



# 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):
  - Provides configuration of specific hardware
  - Data transport by DMA

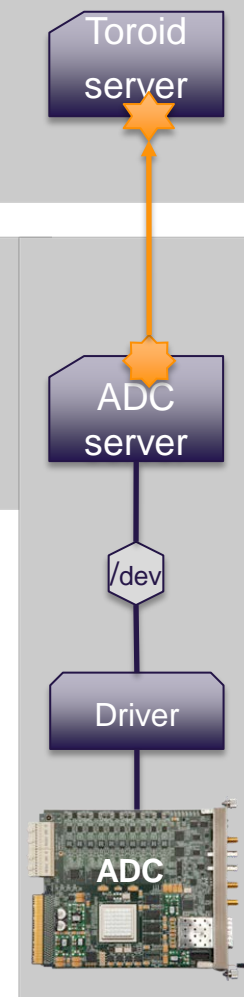




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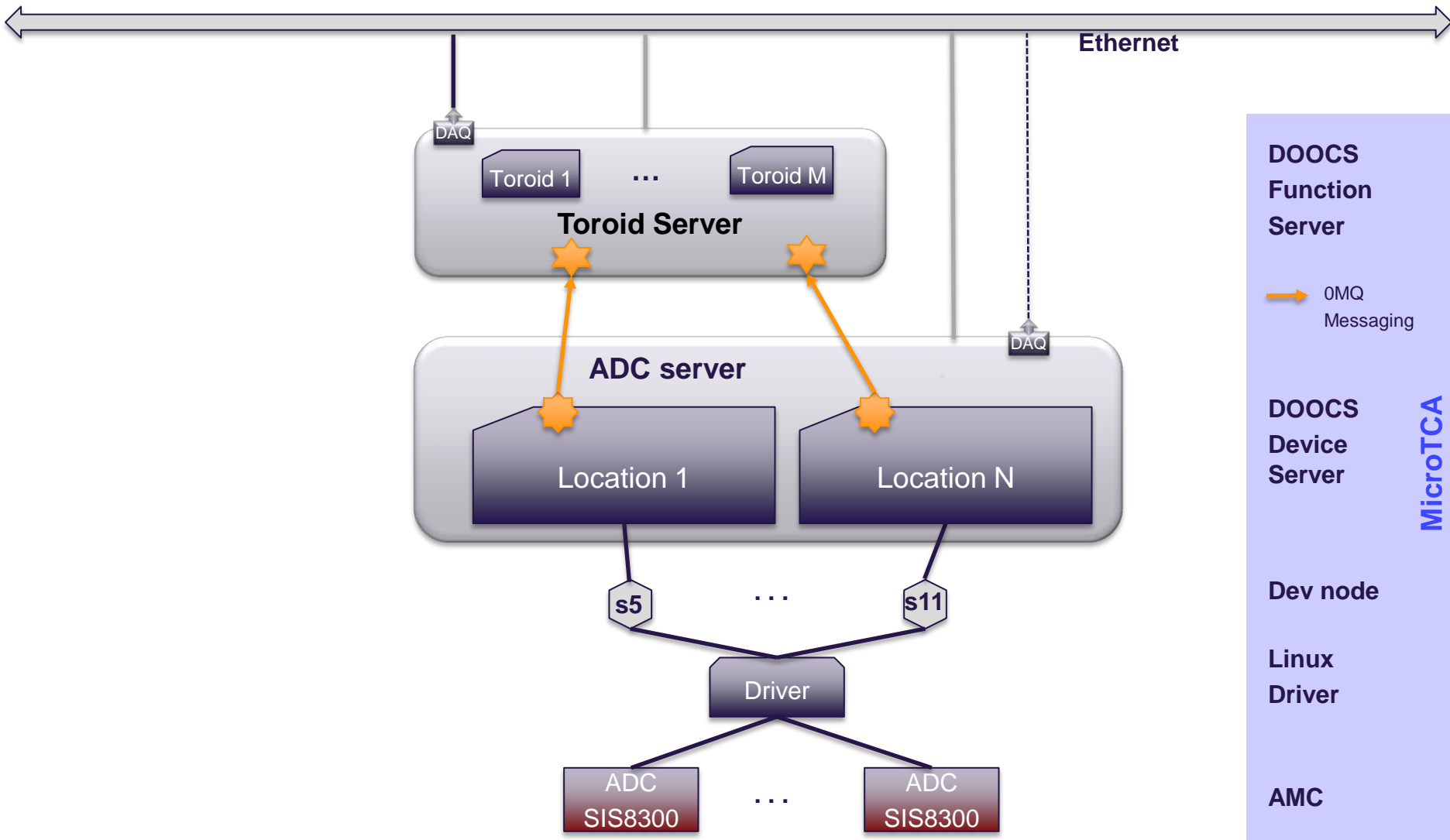
21

- Task specific server (e.g. Toroid, BPM):
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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



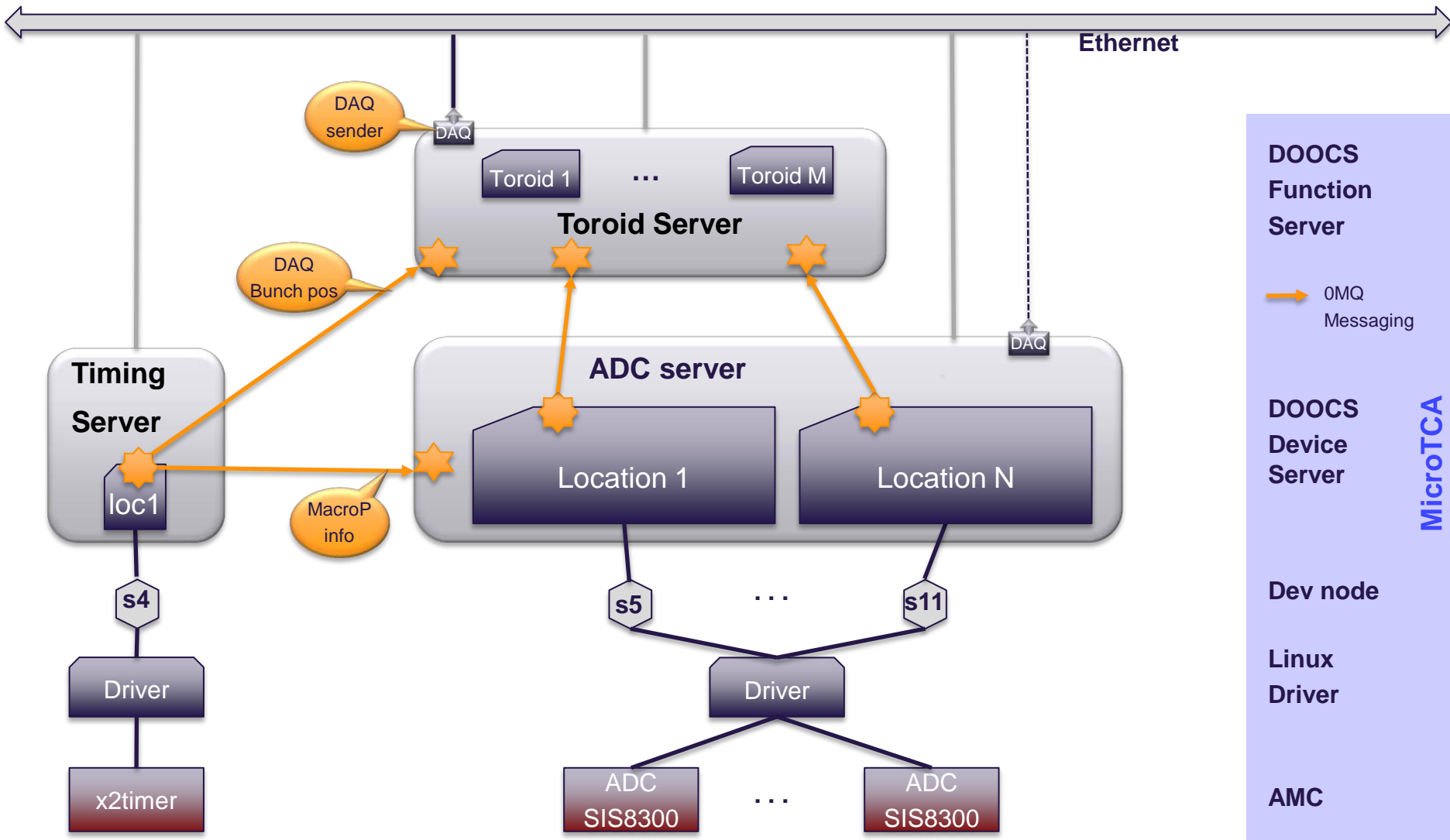
# New DOOCS Software for MicroTCA with 0MQ

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# New DOOCS Software for MicroTCA with 0MQ

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DOOCS  
Function  
Server

→ 0MQ  
Messaging

DOOCS  
Device  
Server

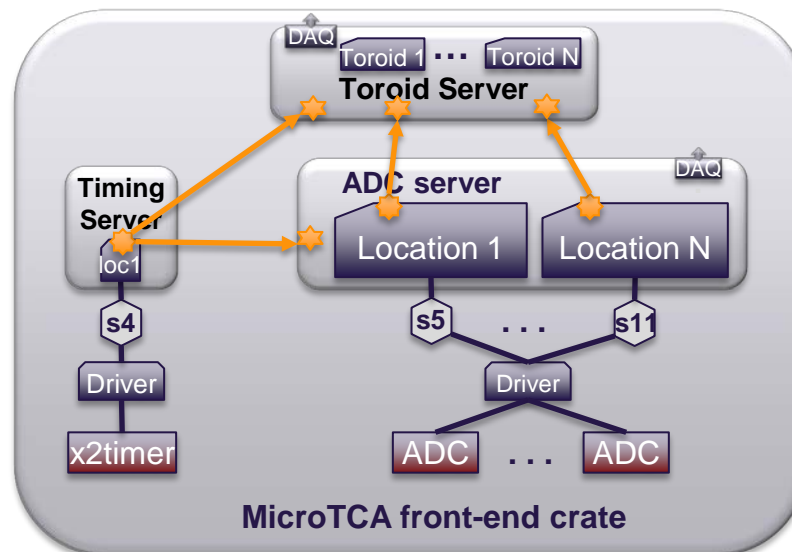
MicroTCA

Dev node

Linux  
Driver

AMC

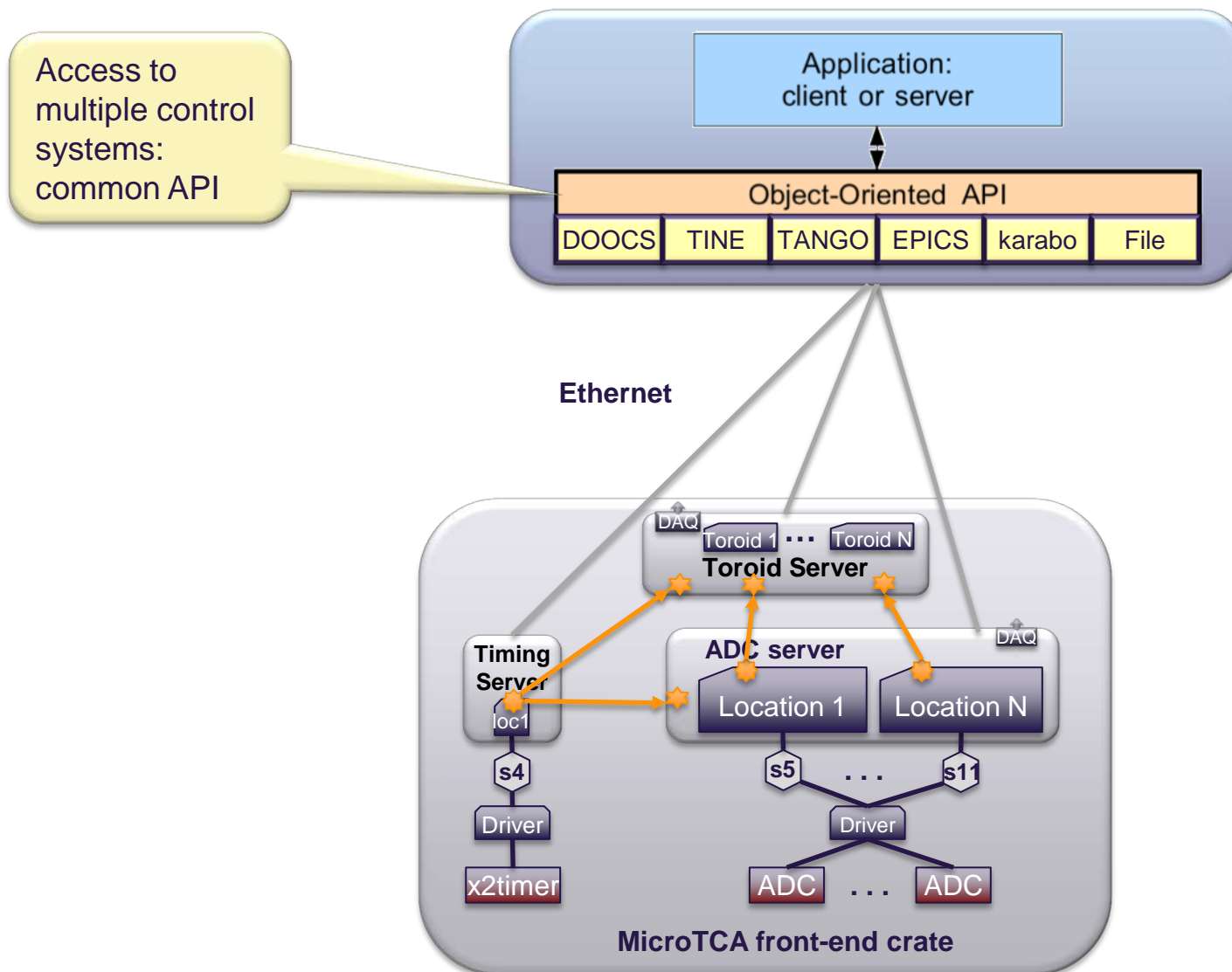
# System Integration





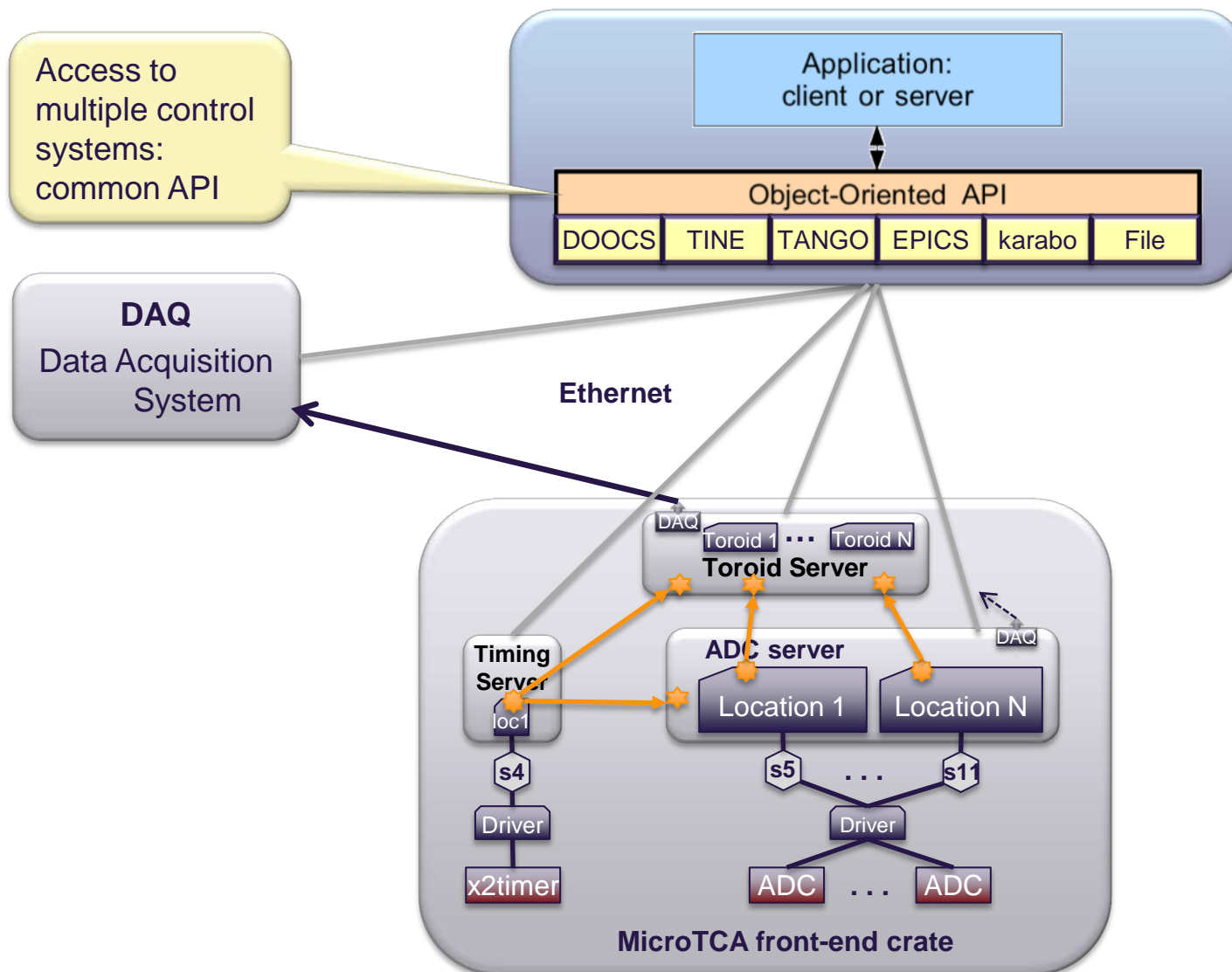
# System Integration

25

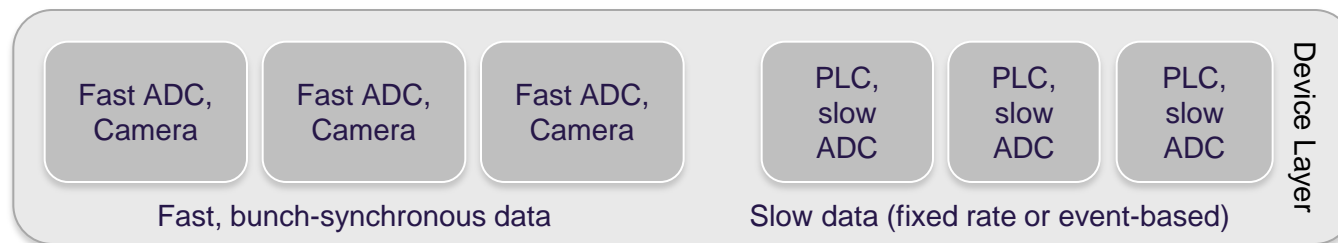
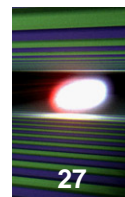


# System Integration

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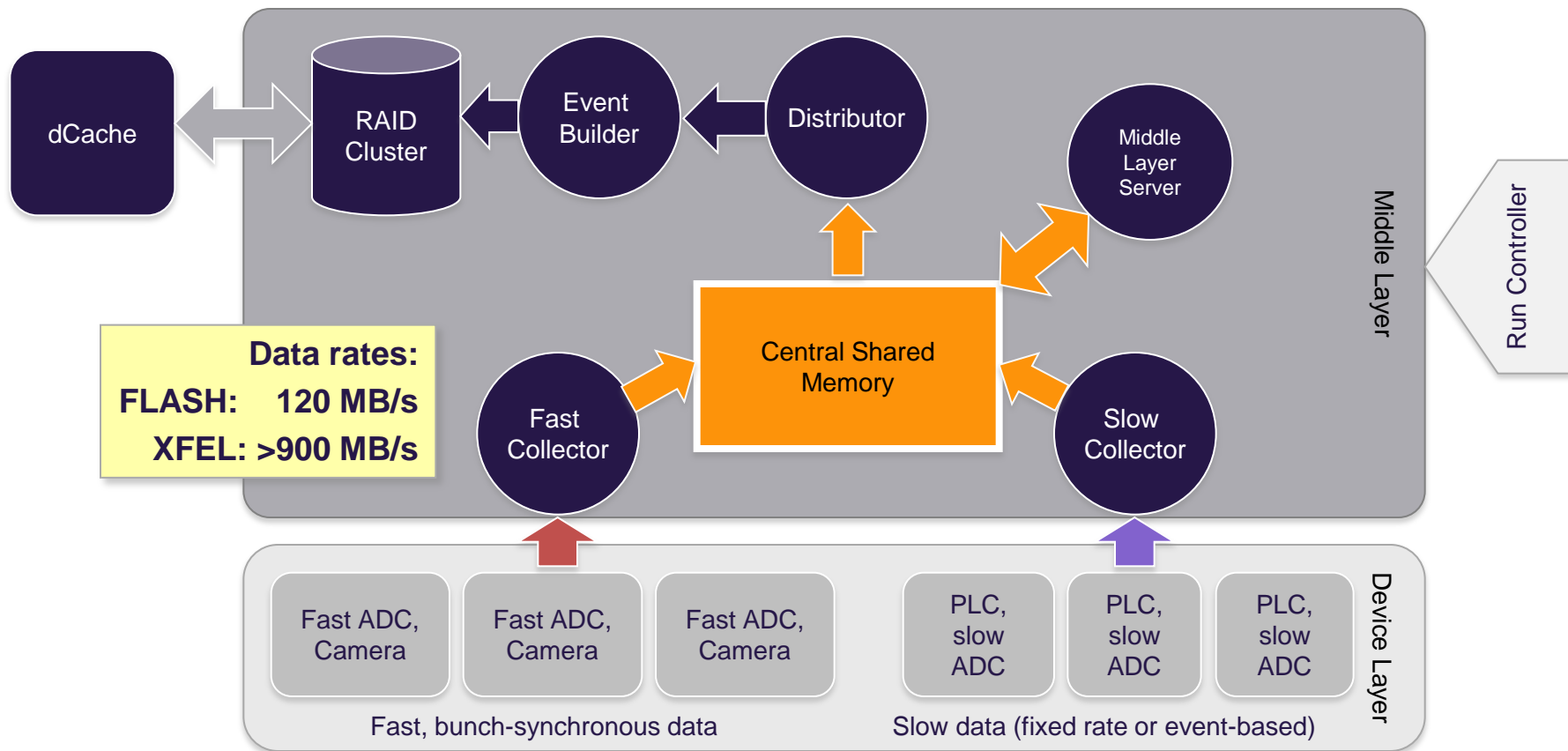


# The Data Acquisition System (DAQ)

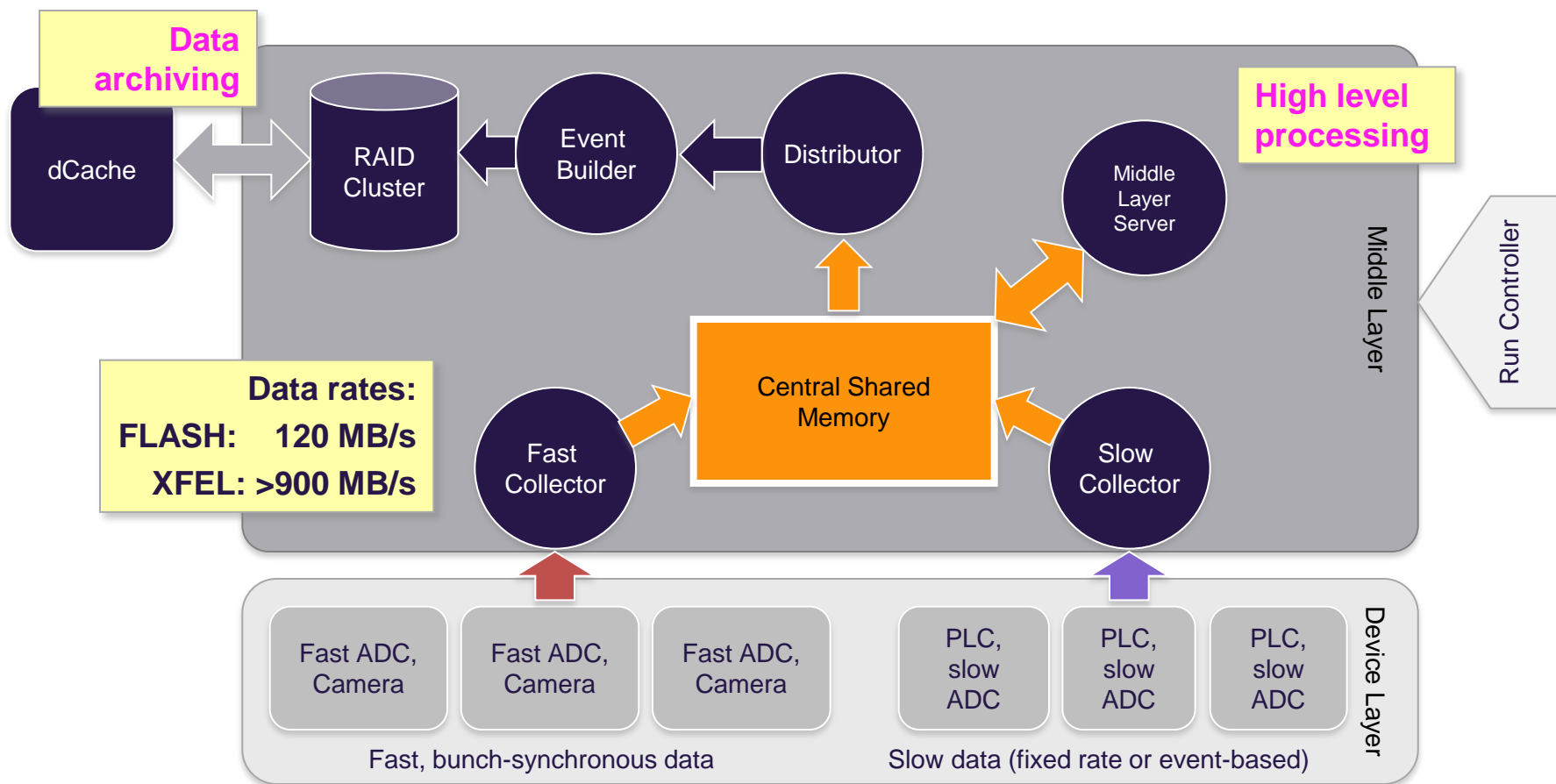


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28



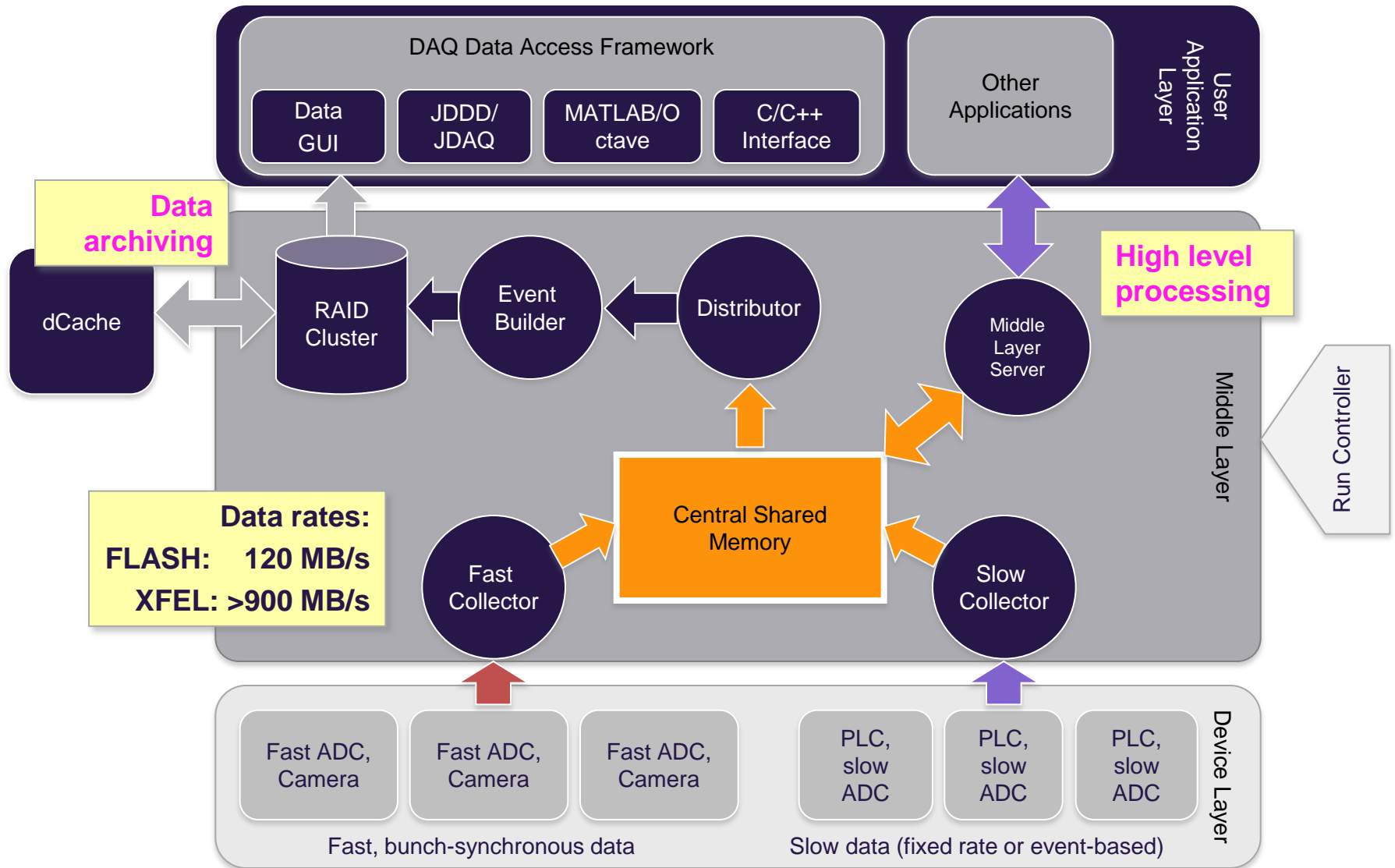
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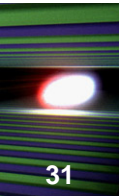


# The Data Acquisition System (DAQ)

30



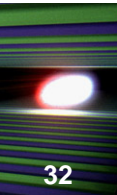
# MicroTCA Remote Management



Panel created by jddd



# MicroTCA Remote Management

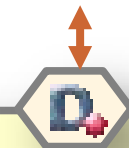


Panel created by jddd



IPMI

DOOCS<sub>μ</sub>TCA IPMI Server



# MicroTCA Remote Management

Online status of modules:

- Is-inserted, fault, ...
- Temperatures, voltages
- Reset, power on/off
- Act. Power consumption



Panel created by jddd



IPMI

DOOCS<sub>μ</sub>TCA IPMI Server



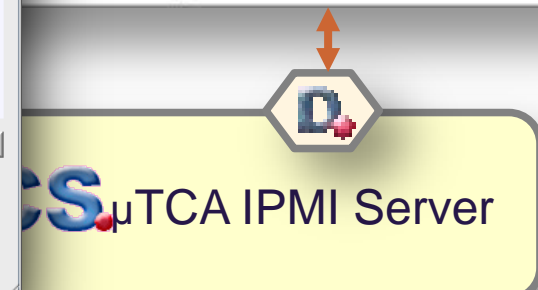
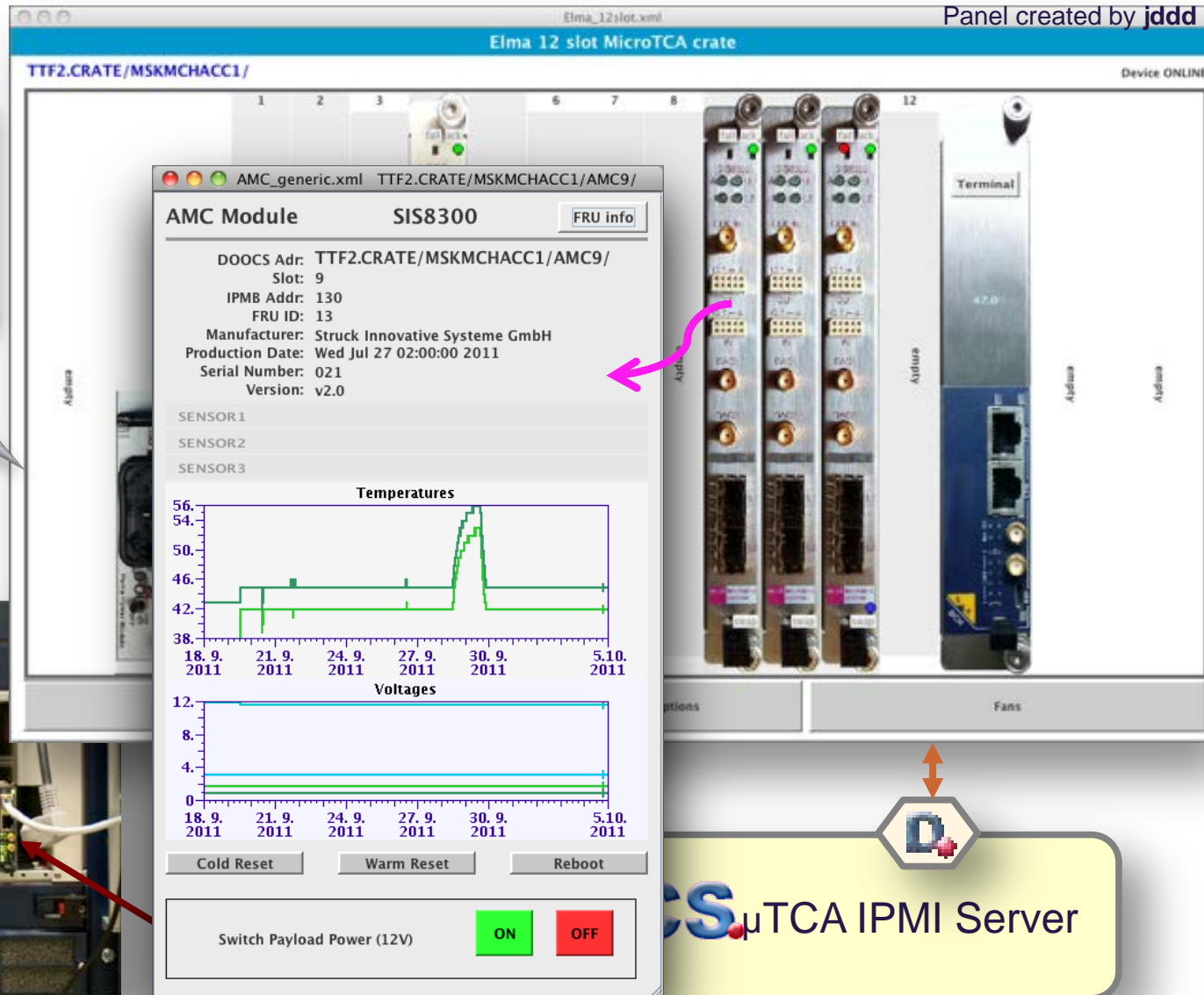
# MicroTCA Remote Management

34

Panel created by jddd

Online status of modules:

- Is-inserted, fault, ...
- Temperatures, voltages
- Reset, power on/off
- Act. Power consumption





# MicroTCA Crate Overview

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Shows all Crates  
Ordered by Name

Shows all Modules  
in Selected Crate

crate\_select.xml Panel created by jddd

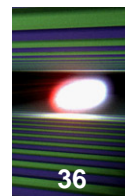
### MicroTCA Crates

FLASH		Labs	
GROUP_CAMERA :	off	MCSMCH6 :	off
MINMCHKICKER1 :	<a href="#">show</a> ELMA Trenew Electronic G... 5	MCSMCH7 :	off
MINMCHKICKER2 :	<a href="#">show</a> ELMA Trenew Electronic G... 5	MCSMCH8 :	<a href="#">show</a> Schroff GmbH 6
MINMCHKICKER3 :	off	MCSMCH9 :	<a href="#">show</a> Schroff GmbH 6
MINLIHUB4 :	off	MCSMCHTIME1 :	<a href="#">show</a> ELMA Trenew Electronic G... 6
FLASHMCHKLY39 :	<a href="#">show</a> ELMA Trenew Electronic G... 5	MCSTMCHIME2 :	off
MSKMCHACC1 :	<a href="#">show</a> ELMA Electronic GmbH 12	MCSMCHMPS1 :	<a href="#">show</a> ELMA Trenew Electronic G... 5
FLAMCHEOSTHZ :	<a href="#">show</a> Schroff GmbH 6	MHFSLXTCAMCH :	<a href="#">show</a> Schroff GmbH 6
FLASHMCHTIME1 :	<a href="#">show</a> ELMA Trenew Electronic G... 12	MDI6MCHMATTHIA...	<a href="#">show</a> ELMA Electronic GmbH 6
FLASHMCHG49 :	off	MSKMCHTDS1 :	<a href="#">show</a> ELMA Electronic GmbH 12
FLASHMCHMPS1 :	off	MSKMCH2 :	<a href="#">show</a> ELMA Electronic GmbH 12
		MSKMCHDEV3 :	<a href="#">show</a> ELMA Electronic GmbH 12
		TTFPREP :	off
		FLASHMCHG49 :	<a href="#">show</a> Schroff GmbH 12

Modules in selected crate: [TTF2.CRATE/MSKMCHACC1/](#) [show graphical](#)

Module	Manufacturer	U=	Temp=	Info	Color
CRATE :	ELMA Electron...	IPMB:0xc4 Sensor N:51 Type:FRU Hot Swap Event:Transition to M3		<a href="#">info</a>	
SIS8300RTM :	unknown module				
AMC8 :	SIS8300	Struck Innovative Systeme GmbH	U= 1.8 Temp= 41.0	<a href="#">info</a>	Green
AMC4 :	uTC	DMCS	U= 2.5 Temp= 44.0	<a href="#">info</a>	Green
AMC10 :	SIS8300	Struck Innovative Systeme GmbH	U= 1.8 Temp= 44.0	<a href="#">info</a>	Green
AMC12 :	SIS8300	Struck Innovative Systeme GmbH	U= 1.8 Temp= 47.0	<a href="#">info</a>	Green
AMC1 :	AMC-1000	ADLINK Technology	U= 12.2 Temp= 56.0	<a href="#">info</a>	Green
AMC2 :	SB-AMC4...	SANBlaze Technology, Inc.	U= 12.0 Temp= 30.0	<a href="#">info</a>	Green
AMC5 :	TIMAMC-01	Stockholm University	U= 12.3 Temp= 33.0	<a href="#">info</a>	Green
COOL_UNIT1 :	Fan speed= 0 0 0 0		Temp= 0.0 0.0	<a href="#">info</a>	Red
COOL_UNIT2 :	Fan speed= 0 0 0 0		Temp= 0.0 0.0	<a href="#">info</a>	Red
MCH :	NAT-MCH V3.4, R100331	Current= 2.3	Temp= 43.0 43.0 30.0 30.0	<a href="#">info</a>	Blue
POWER_UNIT1 :	Puma PM900		Temp= 45.0 55.0	<a href="#">info</a>	Red



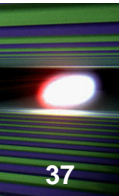


- Successful **system tests** with key MicroTCA modules based on MTCA.4 standard @ FLASH
- **MicroTCA integration** in DOOCS:
  - New 0MQ inter process communication
  - Hot-swap, Linux driver with DMA, device server, management
- **Synchronized data processing** implemented:
  - On timing and ADC and 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>

# 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