Control System of the European XFEL Accelerator

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DESY

Real Time Conference 2016
June 9 2016

HELMHOLTZ GEMEINSCHAFT

DESY

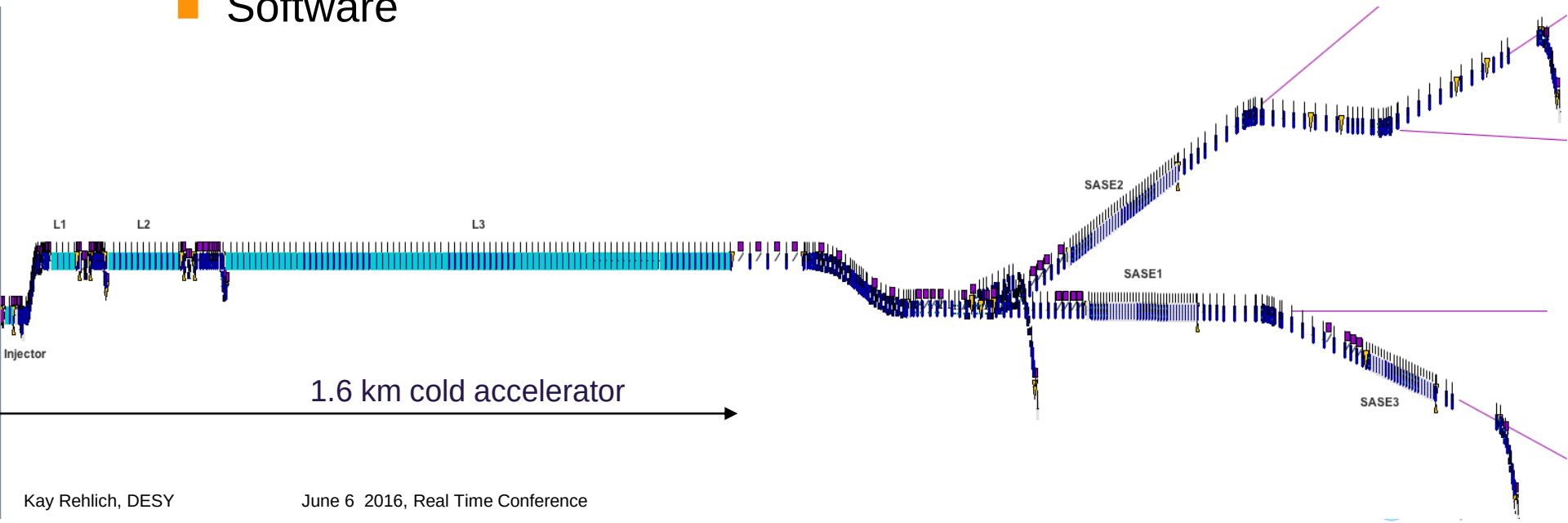
Motivation and Outline

1993 2016

FLASH + FLASH 2

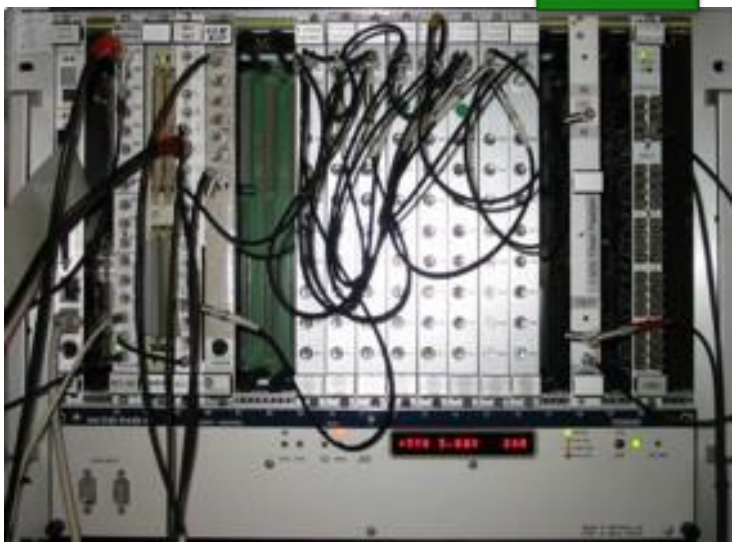
XFEL start

- The used standard
- Architecture
  - Hardware
  - Software

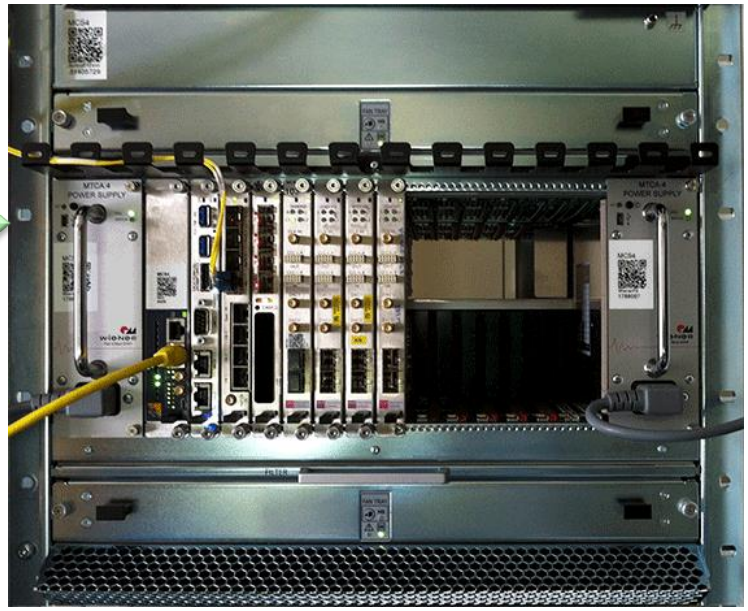


From VME to MicroTCA

- Since 1993 VMEbus



µTCA®

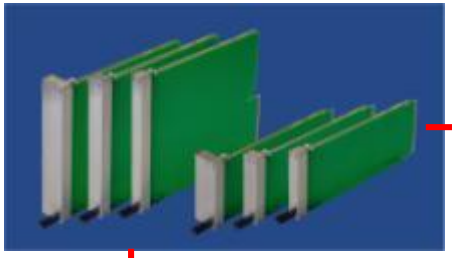


- Most cables from rear
- Interne Clock & Trigger distribution
- Redundant fans
- Redundant power supply optional
- Modern, high-speed data transfer
- Excellent signal quality

PICMG Standards *"Telecom Computing Architecture"*

AdvancedMC™

AMC.0

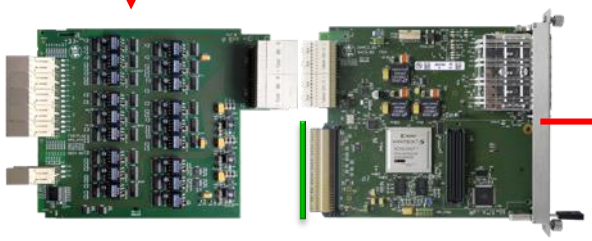


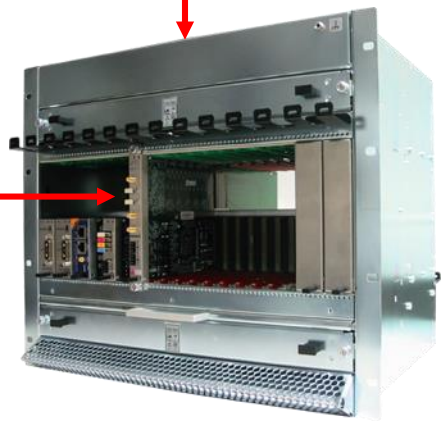
AdvancedTCA®

ATCA®

µTCA®

MTCA.0





MTCA.4

intel

NOKIA

KEYSIGHT TECHNOLOGIES

AMD

ERICSSON

ERNI

HARTING Pushing Performance

Tyco

> 150 Mitglieder

PENTAIR

powerBridge Computer

V.I.

ELMA Your Solution Partner

vadatech THE POWER OF VISION

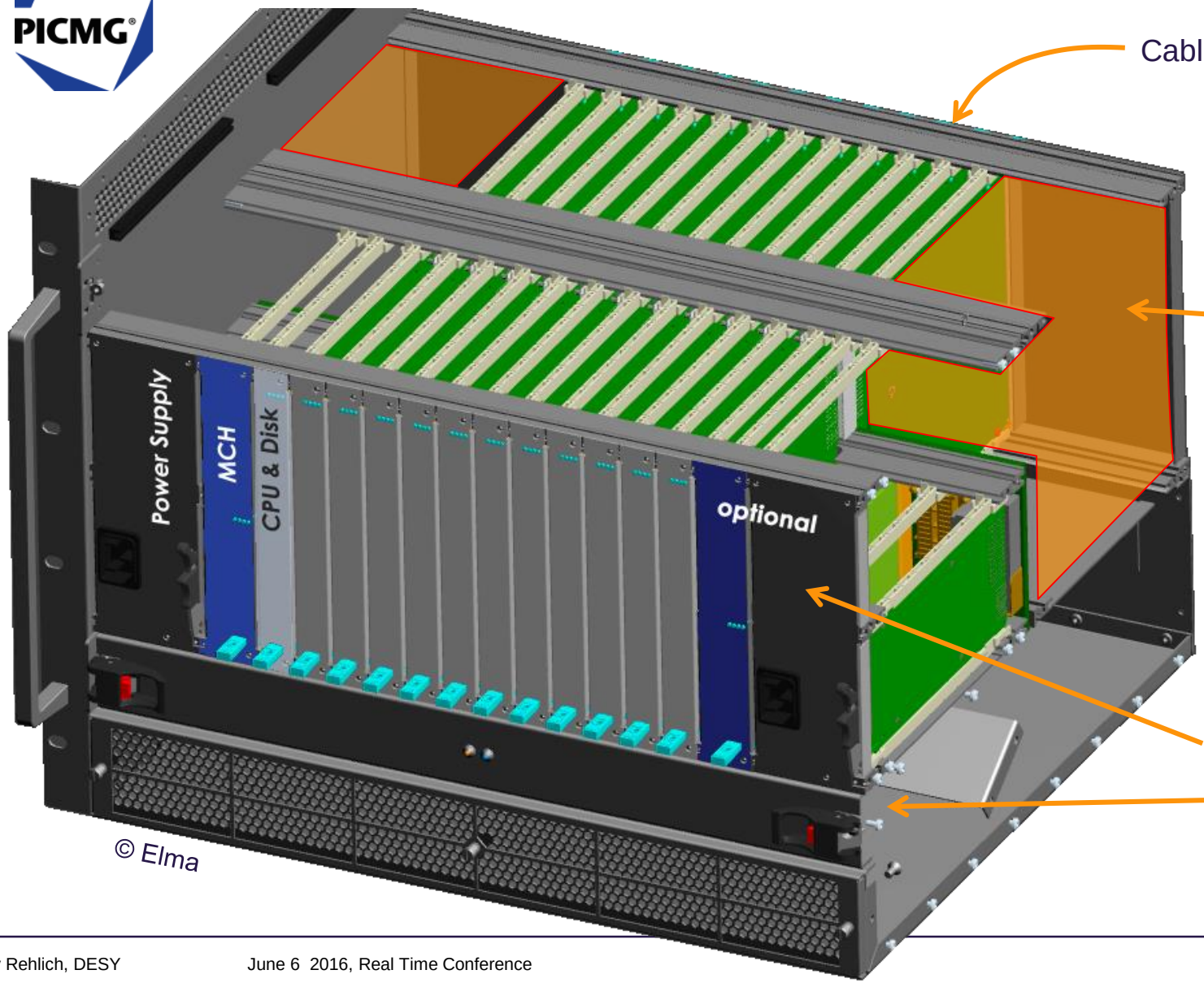
TEWS TECHNOLOGIES

DESY

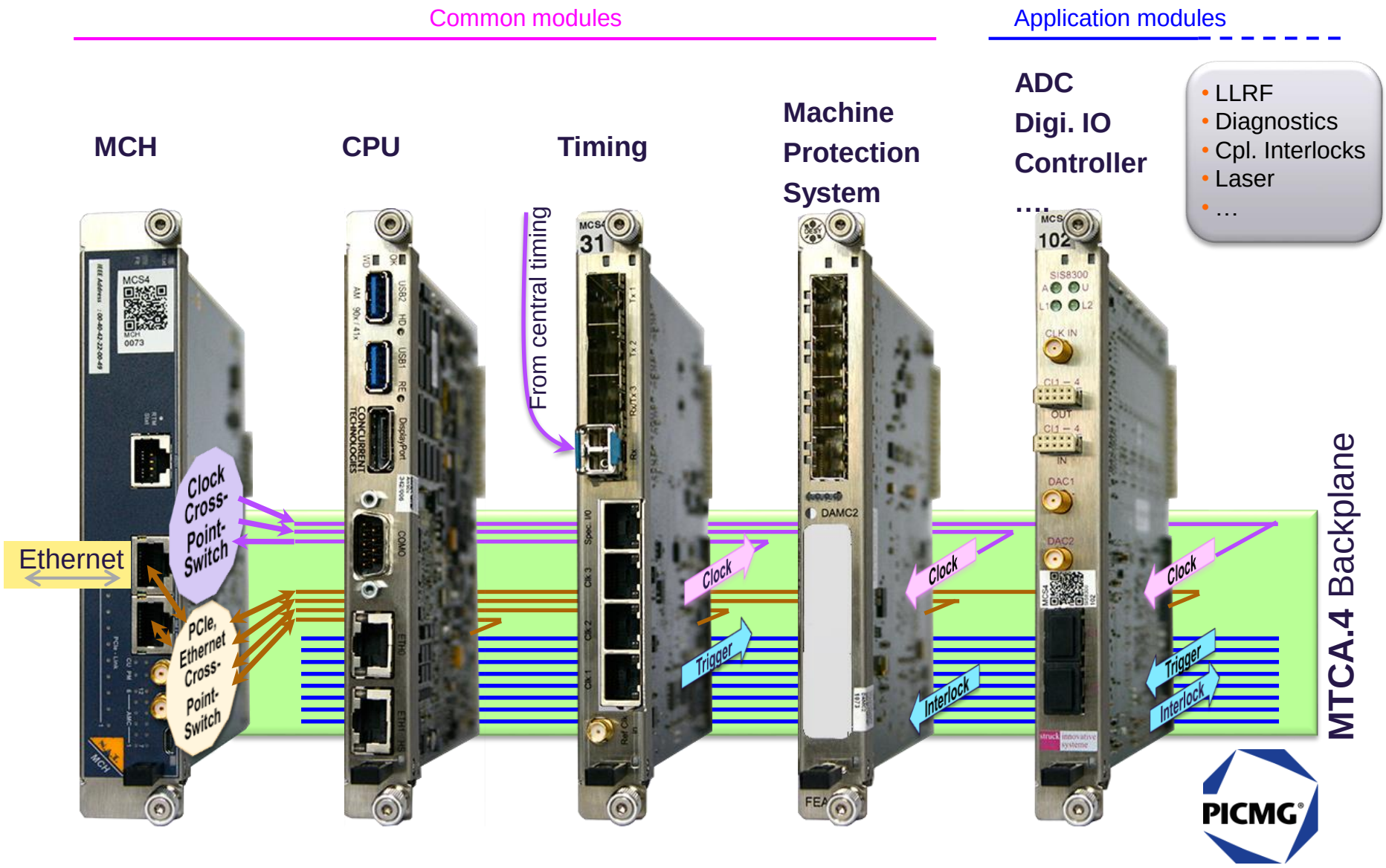
SLAC NATIONAL ACCELERATOR LABORATORY

中国科学院高能物理研究所 Institute of High Energy Physics Chinese Academy of Sciences

MicroTCA.4: Compact and Modular Design



MTCA.4: Clocks, Triggers und Interlocks



Timing System: Synchronization of all Subsystems

Transmitter Piggyback
with 3 channels of
link drift compensation

x2timer /

NAMC-psTimer

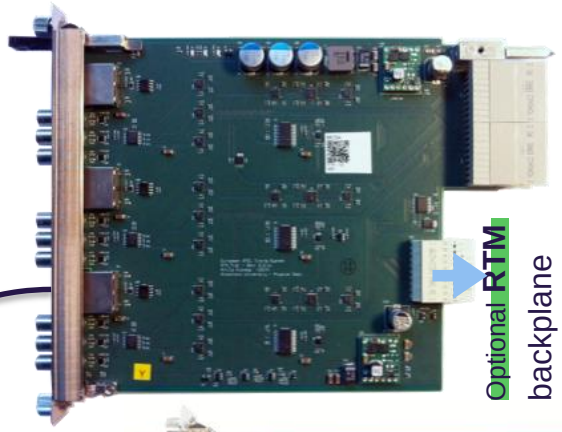
receiver / transmitter / repeater

FYSIKUM

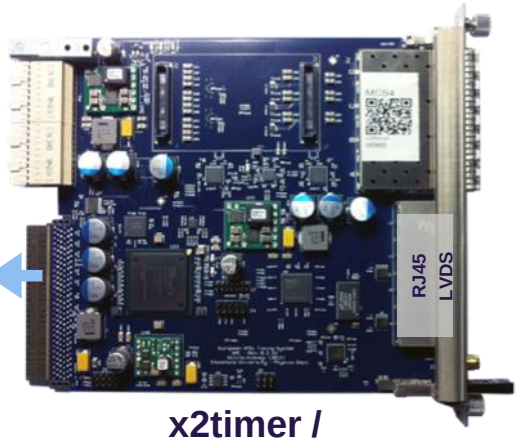
Timing System: Versatile IO

9 Lemo outputs (50 Ohm):
Triggers, Clocks, Data
3 channels with 5ps resolution

> 100 m



Optional **RTM** backplane **AMC**



x2timer / NAMC-psTimer receiver / transmitter

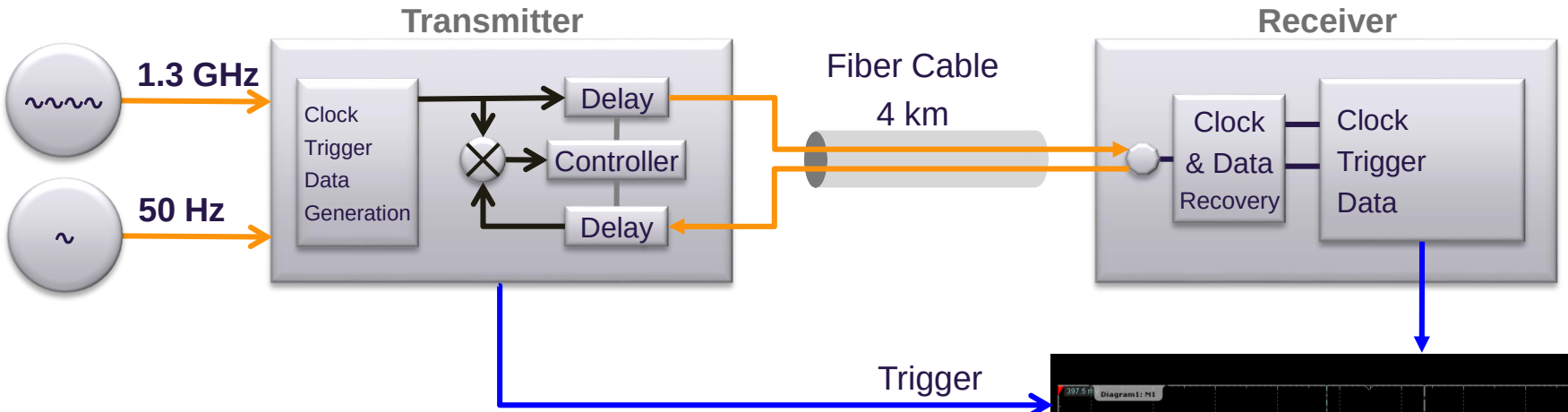
9 SFP outputs:
with length compensated fiber links

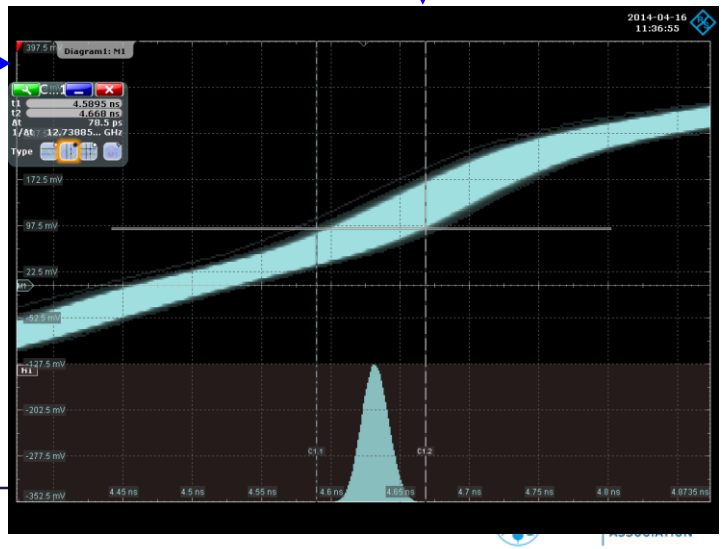
9 Fiber outputs (ST):
Triggers, Clocks, Data
used for modulators

UNIVERSITET STOCKHOLMS
FYSIKUM

Timing System: Principle of Operation

- Distributes:
  - Triggers, gates, clocks (10ns … 5ps resolution)
  - Bunch information (charge, destination,…), unique ID





- Link drift compensation:

  Jitter ~10ps RMS

XFEL Injector Operation

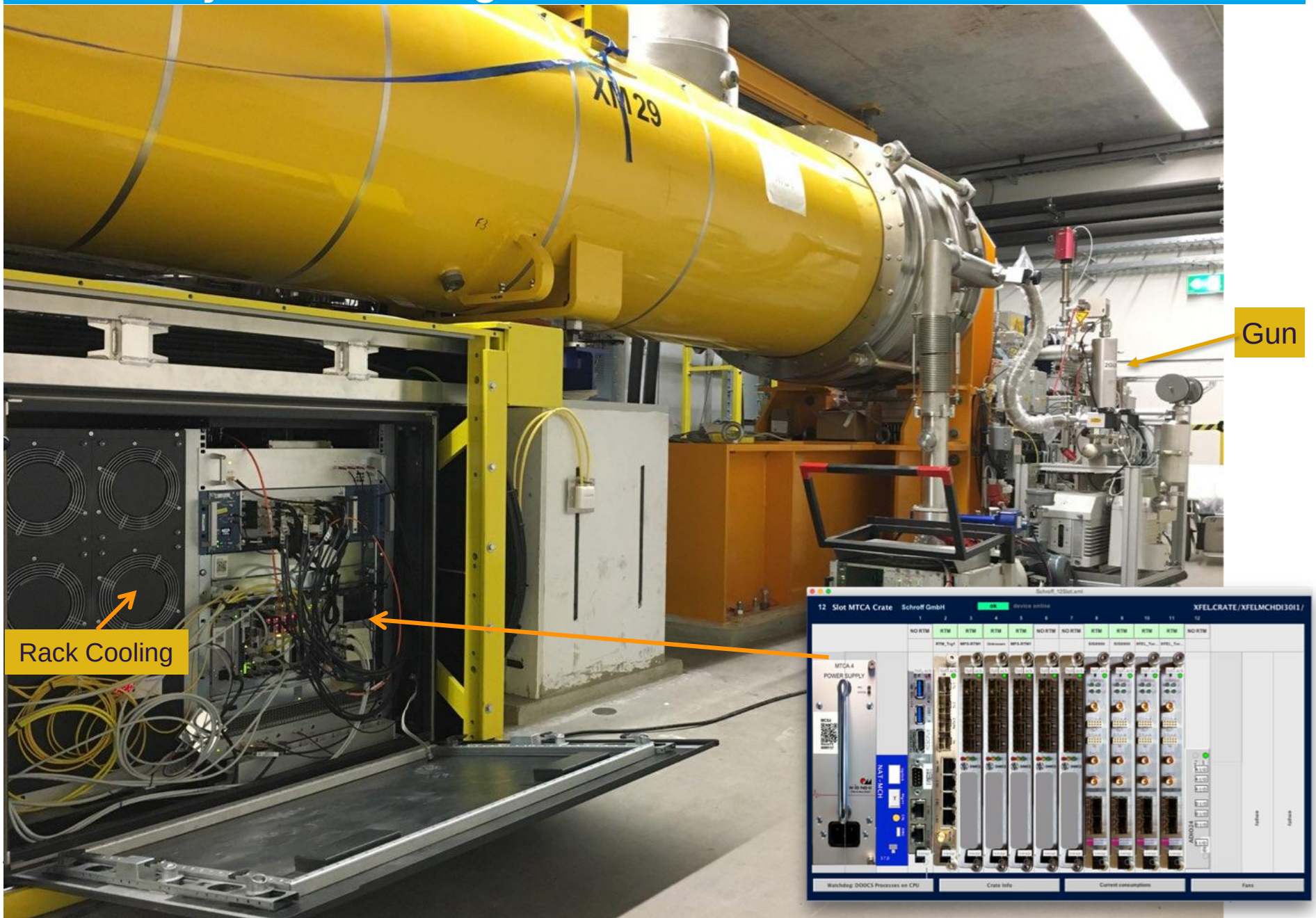
Photo Gun

2 superconducting acceleration modules (1.3 and 3.9 GHz)

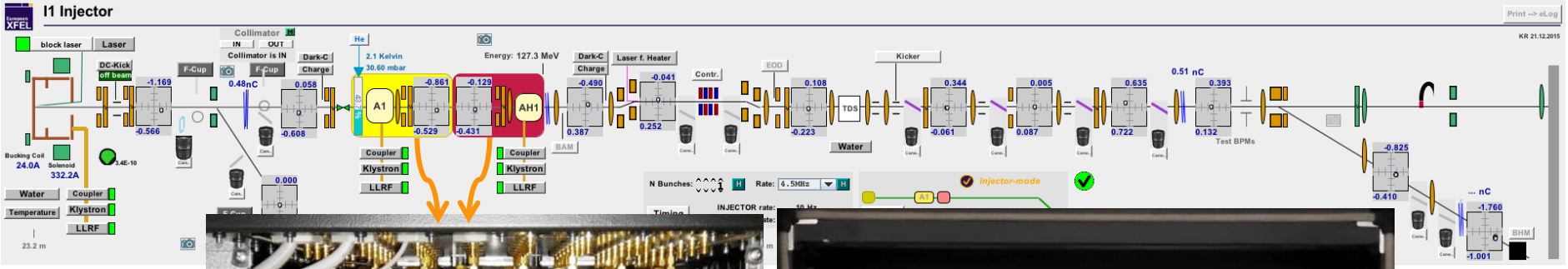
length: 45m

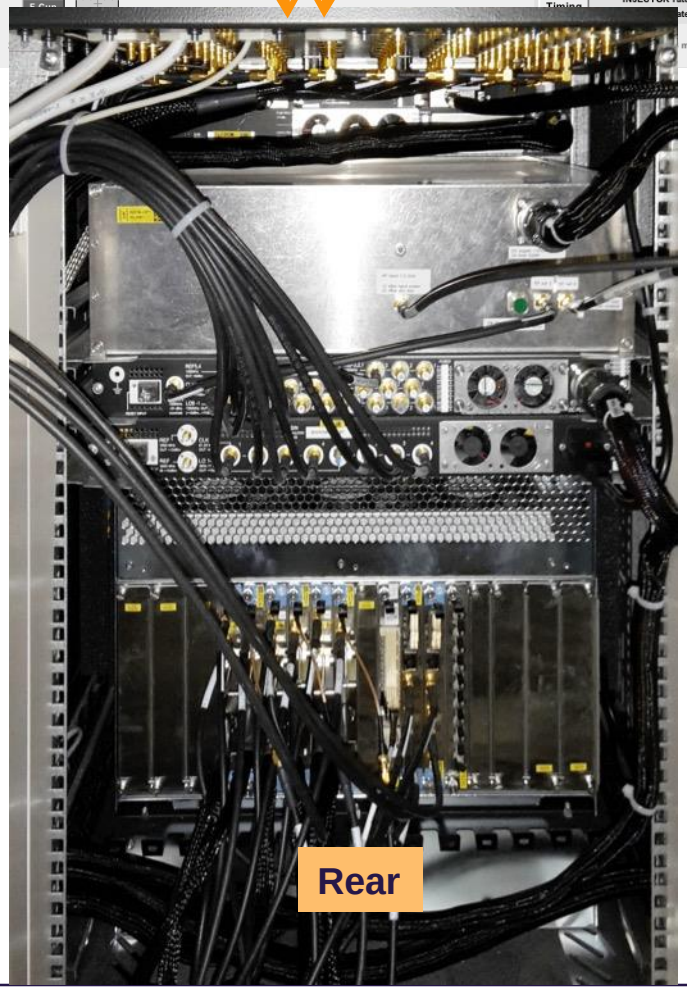
- In operation since Dec. 2015
- Implements most of the XFEL subsystems:
  - Klystron, Modulator, LLRF, BPM, Toroid, Magnet, Laser, Undulator, Vacuum, Water, Camera, Motor, Cryo, Timing, Protection, Dump, …
  - DAQ system, middle layer servers, GUI programs and tools, …
- > $3.3 \cdot 10^6$ control system properties online now (270 000 channels with history)

XFEL Injector: 1. Diagnostics Crate

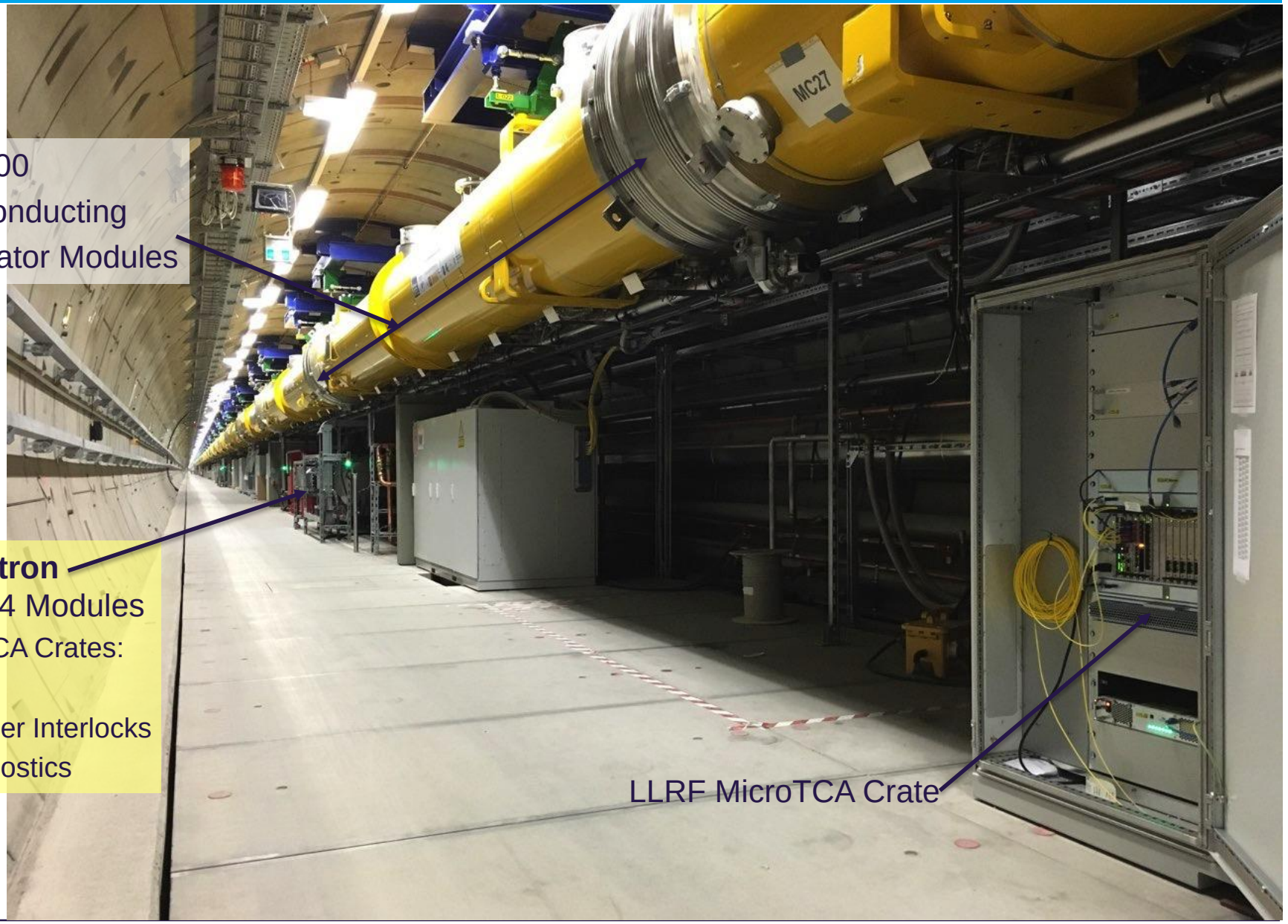


XFEL Injector: Regelung der Hochfrequenz





MicroTCA Crate Inside the XFEL Tunnel



1 von 100
Superconducting
Accelerator Modules

1 **Klystron**
drives 4 Modules
MicroTCA Crates:
2 LLRF
2 Coupler Interlocks
1 Diagnostics

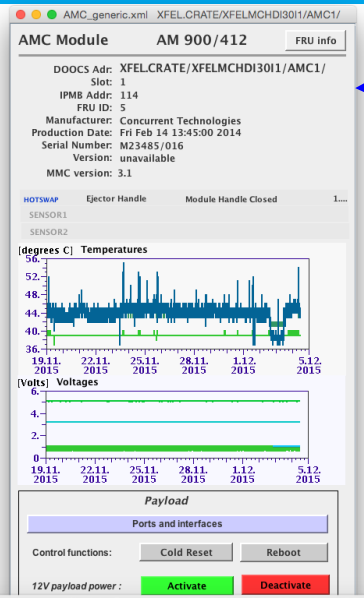
LLRF MicroTCA Crate

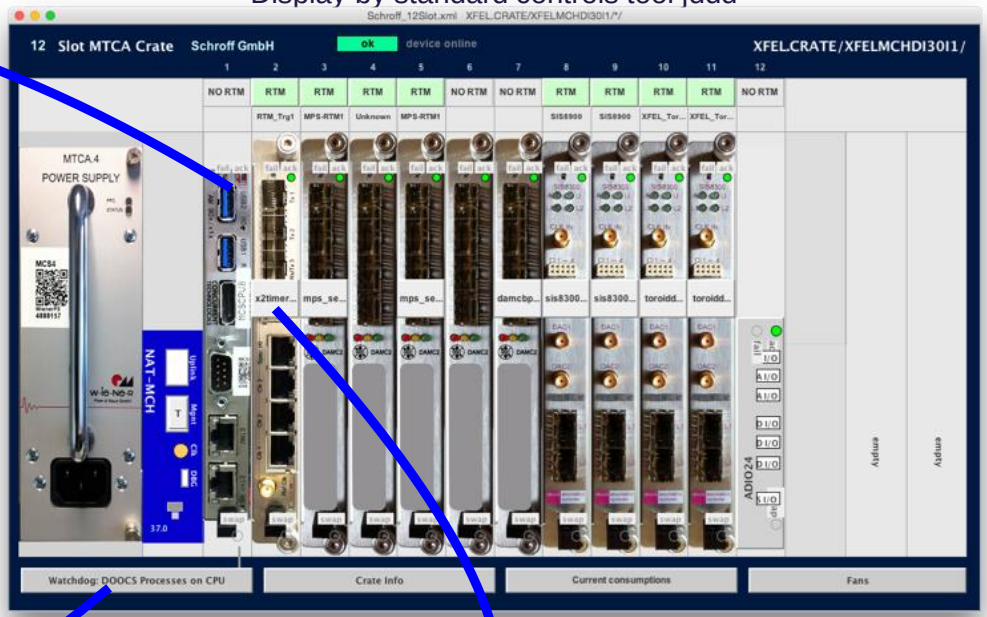
MicroTCA Remote Management

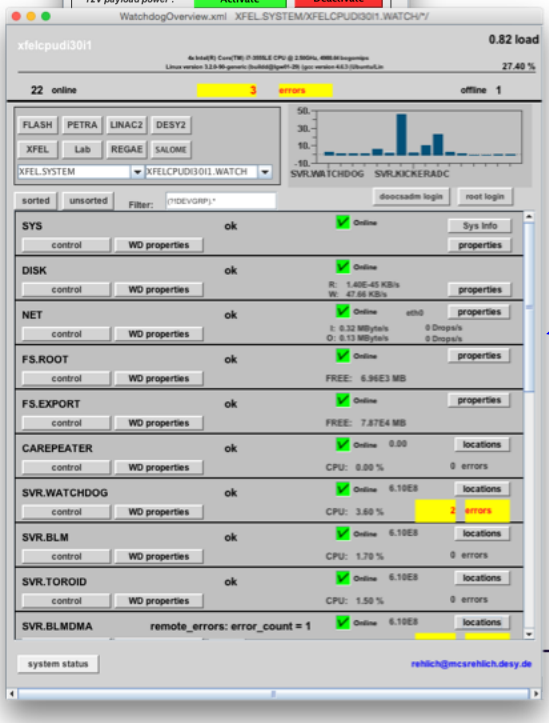
Display by standard controls tool jddd

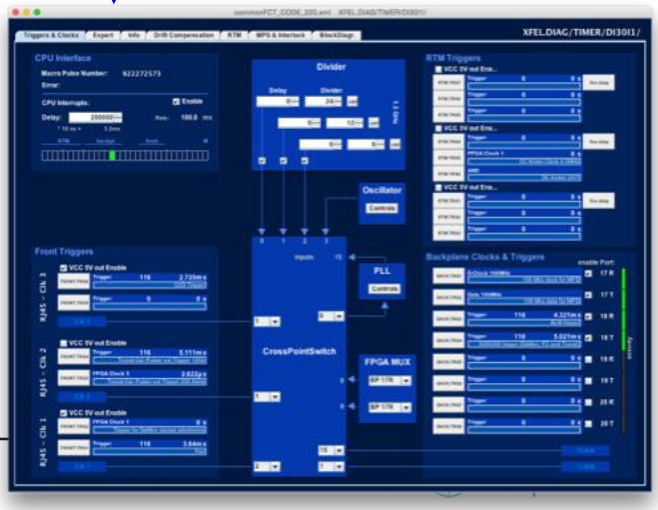
Management View

DOOCS Control System View

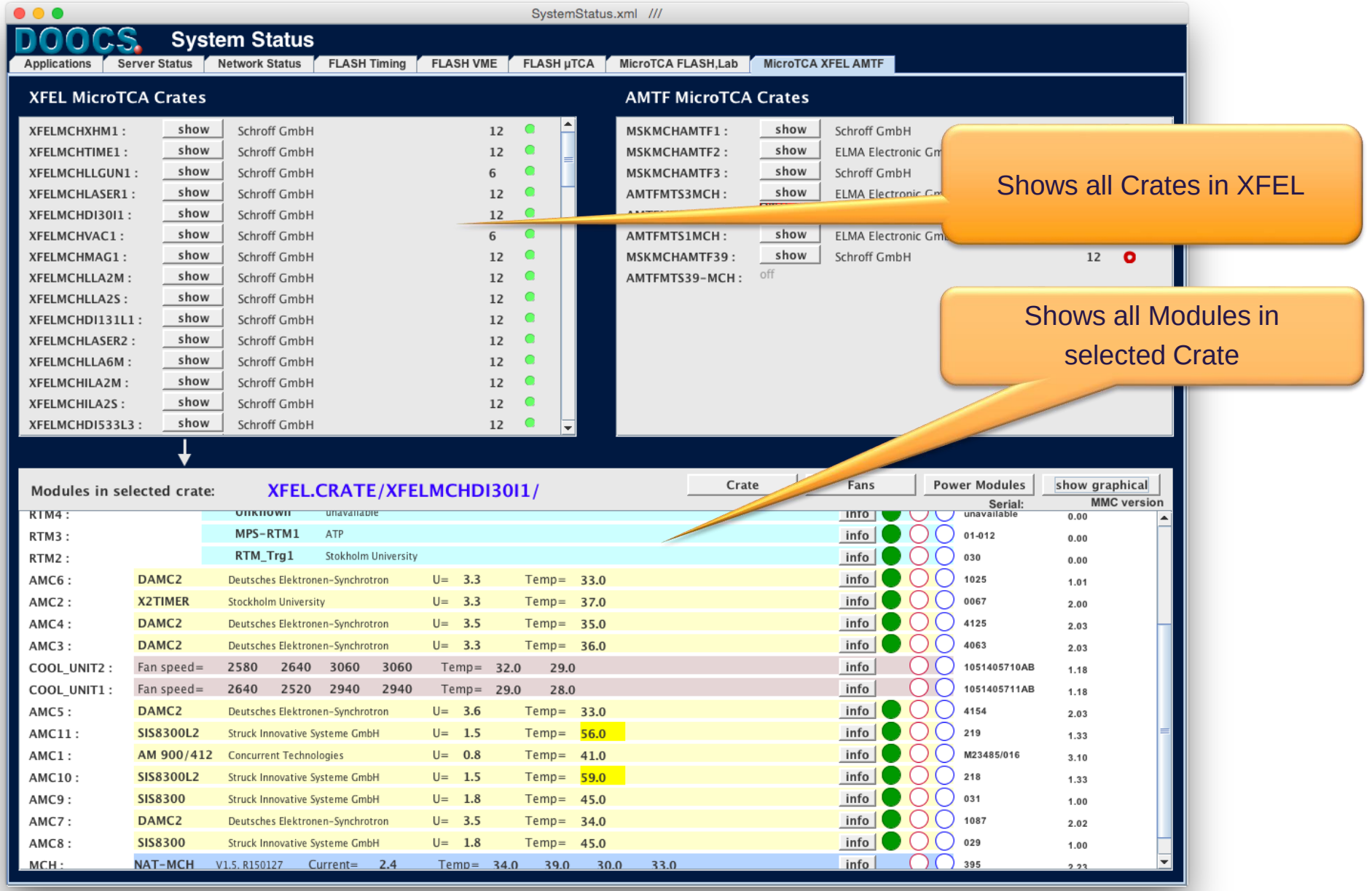




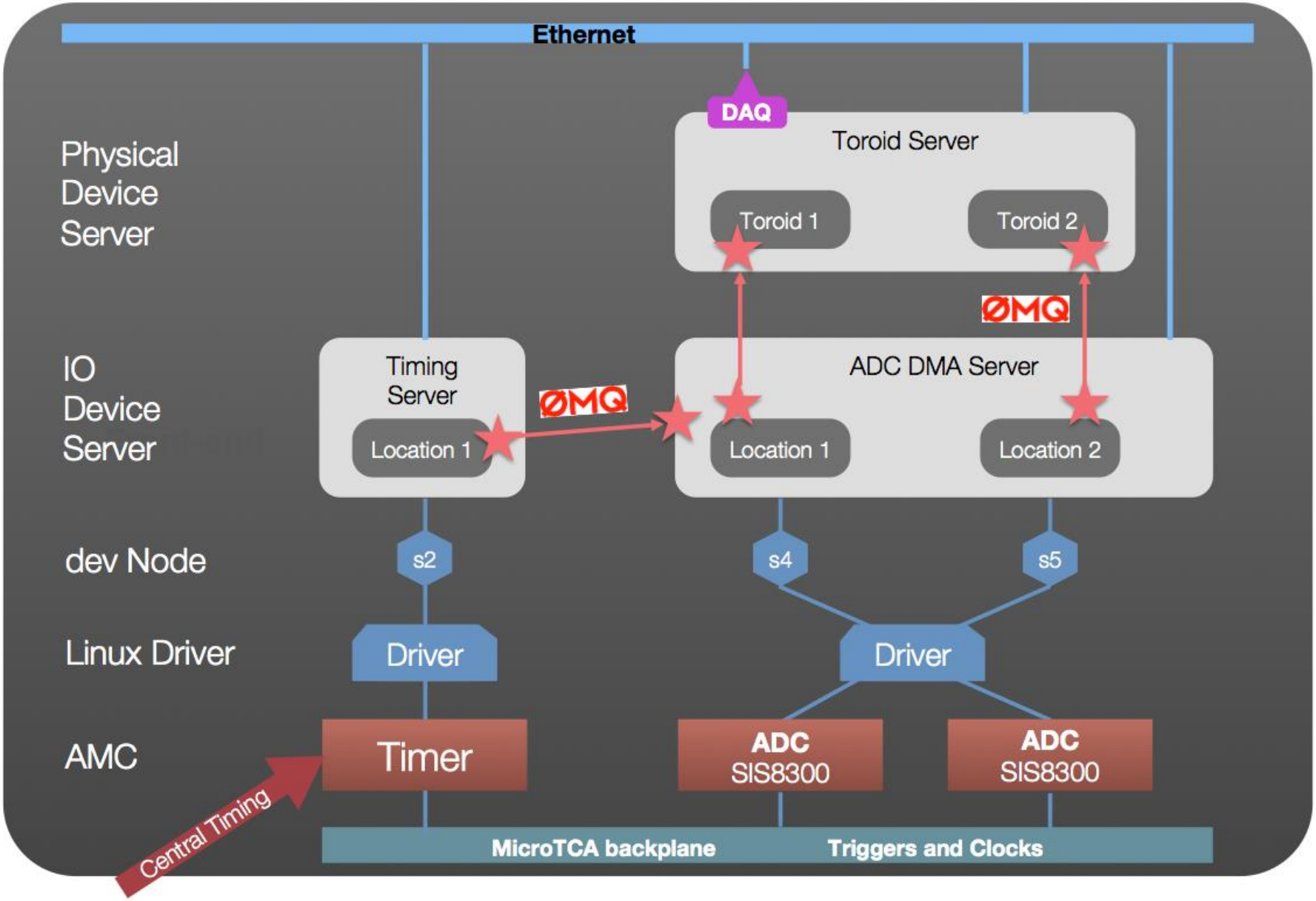




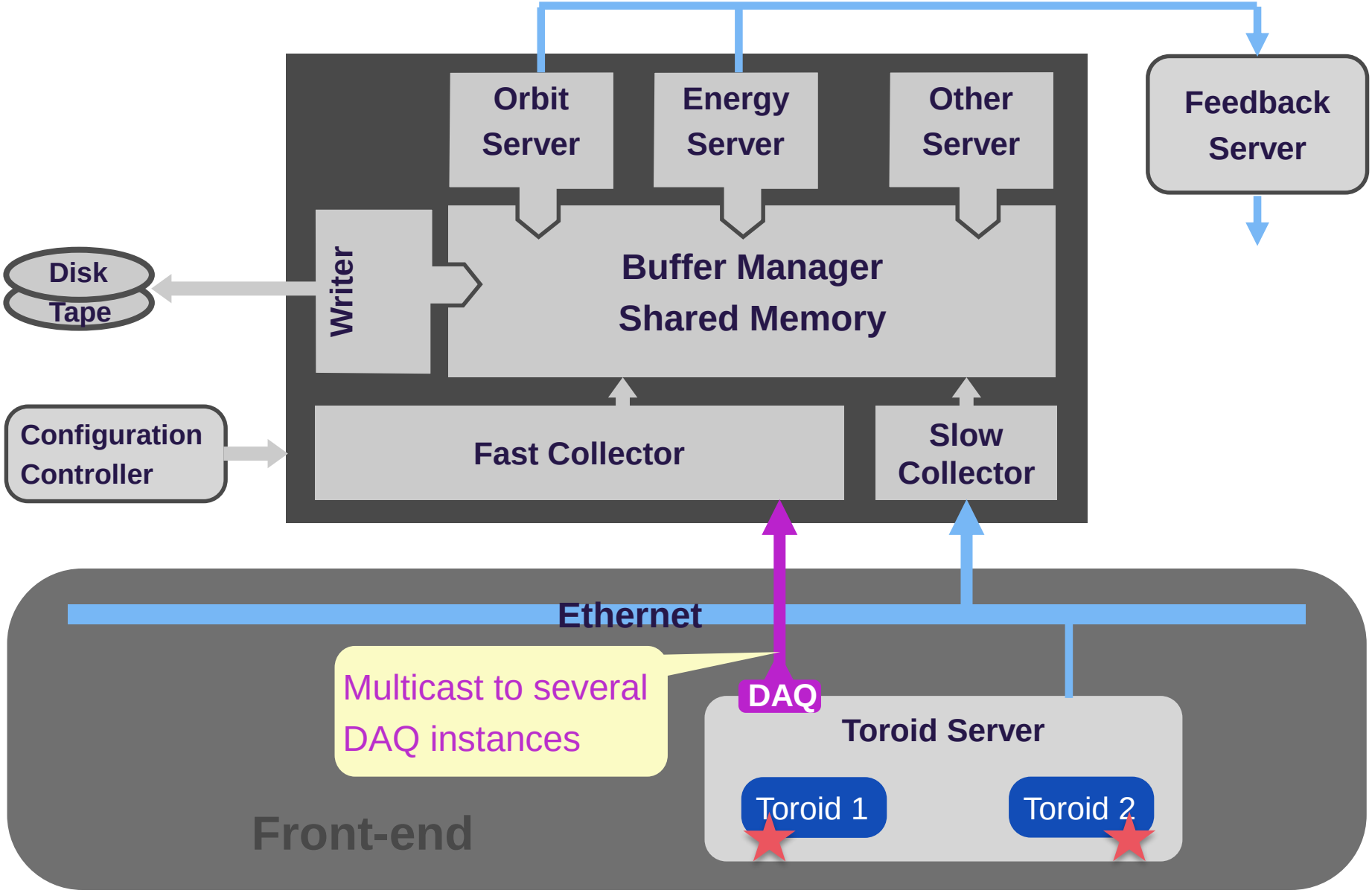
MicroTCA Crate Management View



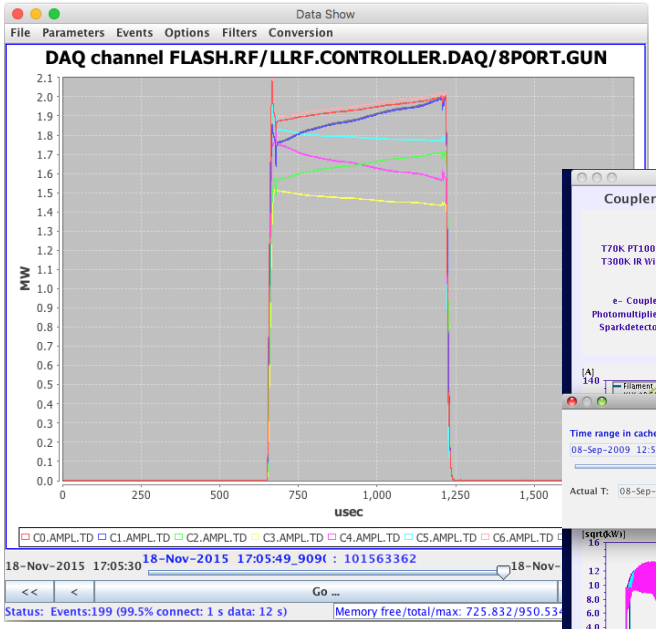
DOOCS Control System Data Flow



DOOCS Data Acquisition System

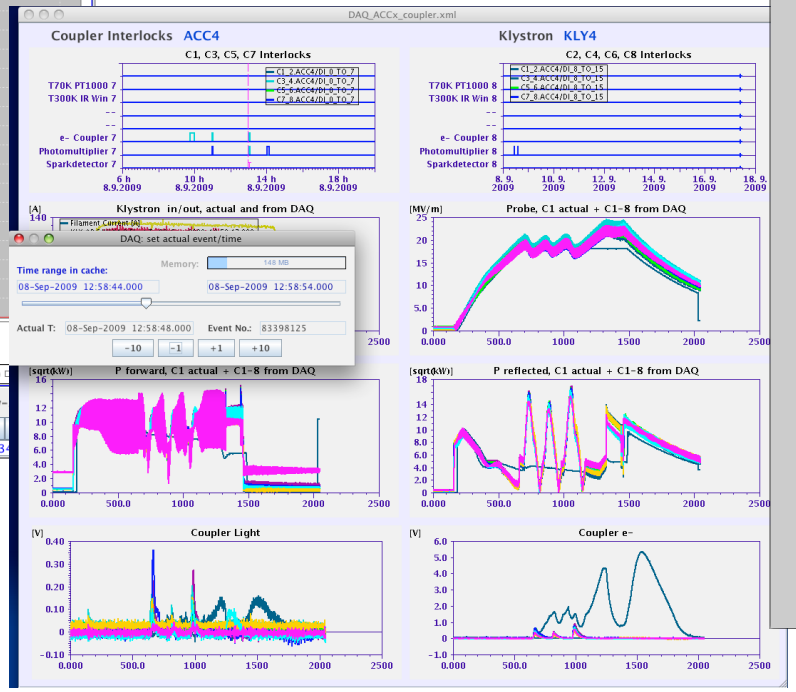


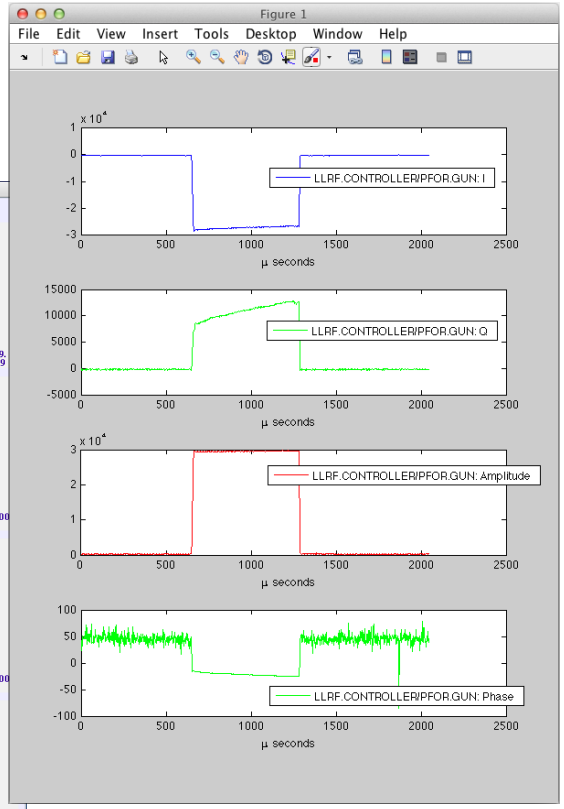
Analyze all Shots with Bunch Resolution



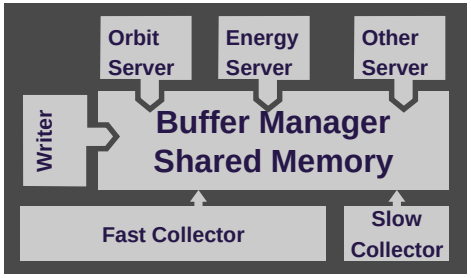
DAQ GUI

Jddd: GUI editor





MATLAB



DAQ Maintenance Panel (Example: FLASH)

Storage Streams

Attached Processes

Data Collectors

Distributed Front-ends

Summary

- **PICMG Standard**
  - Started 2009 → MTCA.4 published 2011
    - Q2 2016: MTCA.4.1 extensions
  - Other projects can benefit from the standard
- **XFEL** fast Diagnostics and Controls platform is μTCA™
  - Final installation **> 200 MicroTCA.4 Crates**
  - Injector is fully operational since Dec. 2015
  - Linac cool-down will start Oct. 2016
- Critical Hardware and Software is successful in operation

Thank you!