Controls Architecture for the Diagnostic devices at the European XFEL

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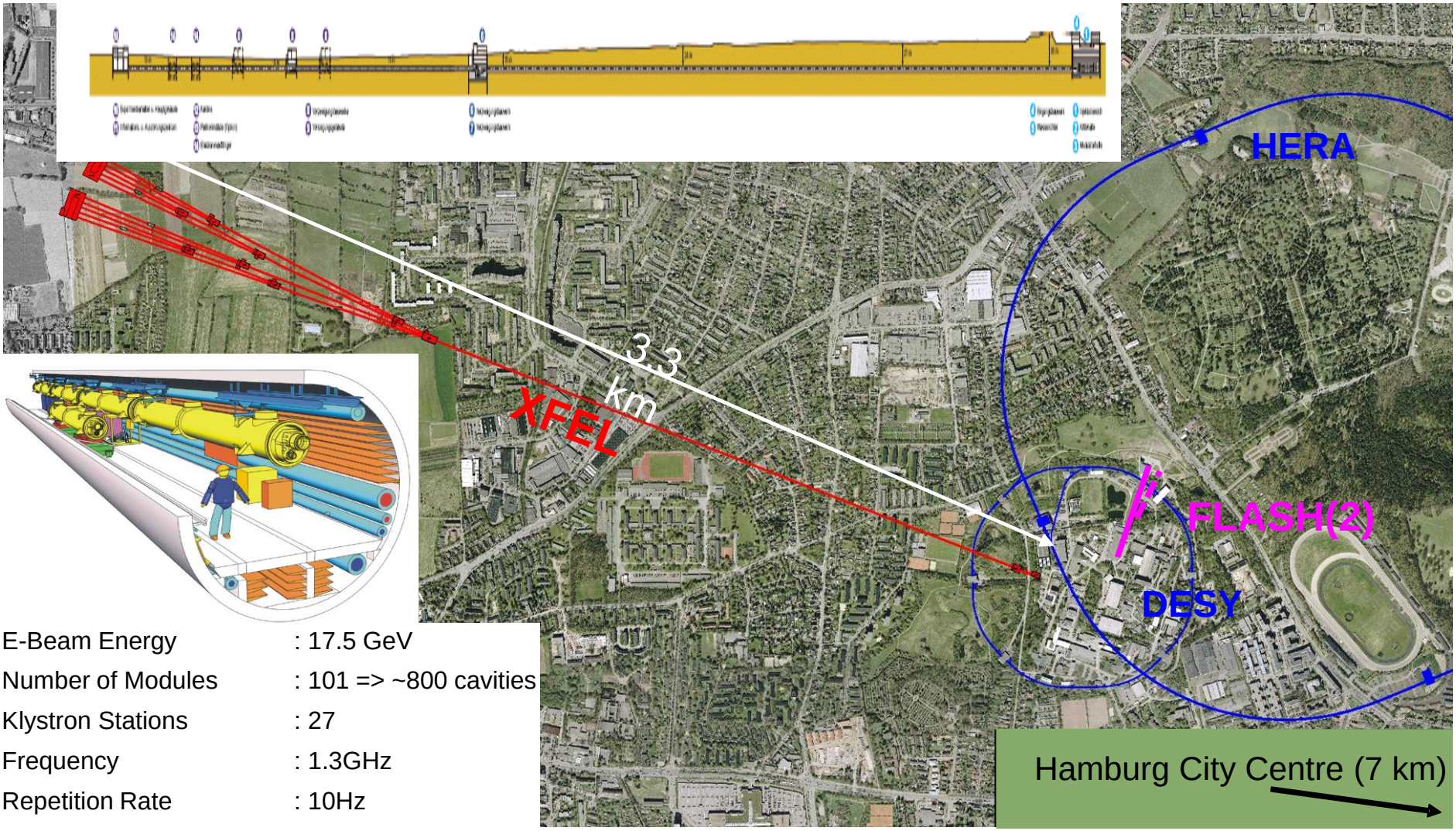
- Outline
  - European XFEL
  - µTCA Hardware
  - IPMI monitoring and control
  - DOOCS server organisation
  - Messaging and data handling
  - Status/Schedule
  - Conclusion



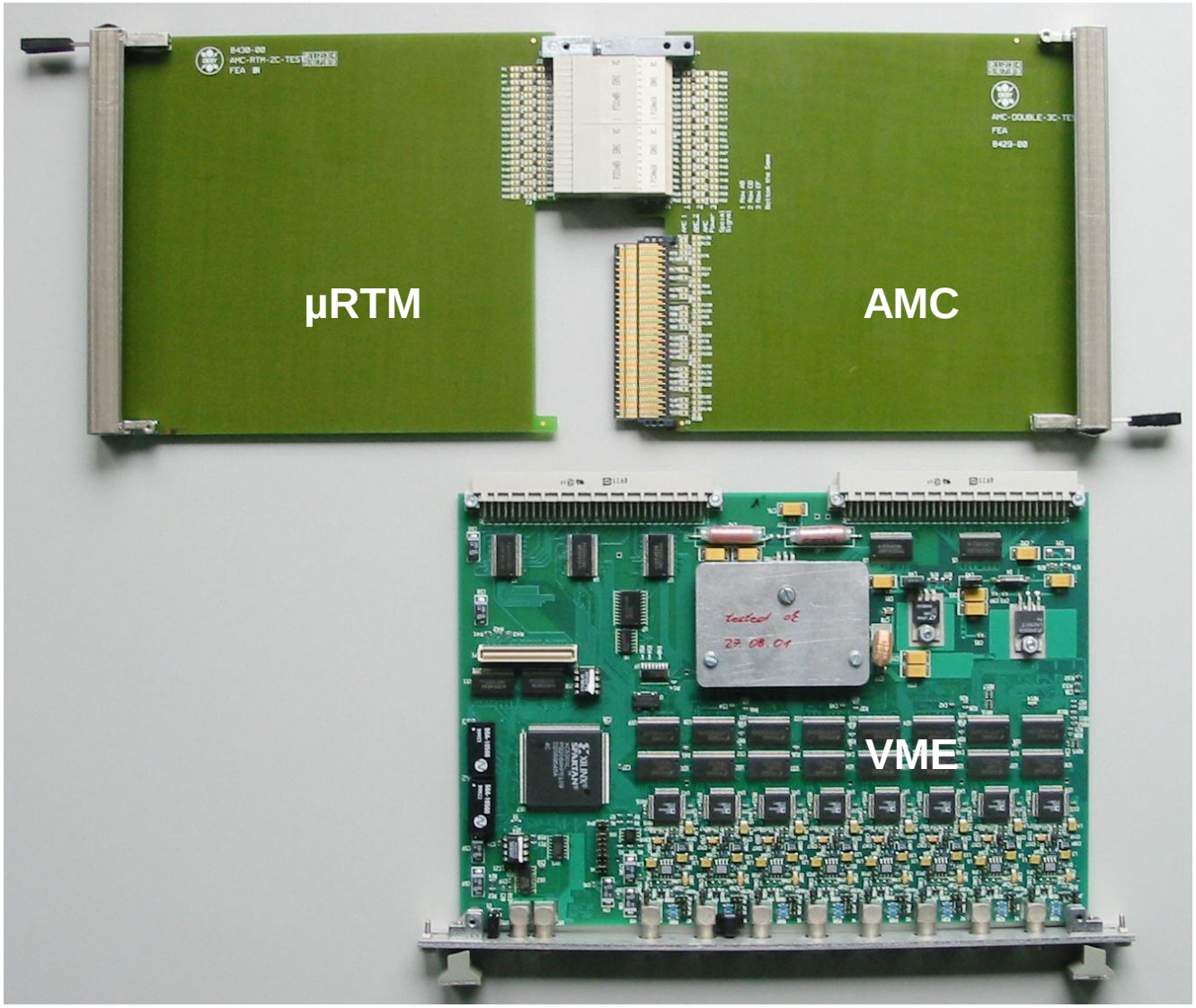
E-Beam Energy	: 17.5 GeV
Number of Modules	: 101 => ~800 cavities
Klystron Stations	: 27
Frequency	: 1.3GHz
Repetition Rate	: 10Hz
Bunches per Pulse	: 2700

The XFEL diagnostics will be based on µTCA

- **A**dvanced **T**elecom **C**omputing **A**rchitecture (ATCA)
- Scalable modern architecture
  - From 5 slot single … 12 slot double size
- High availability
  - Redundant power and fan optional
  - Well defined management
- Differential links only: high analog signal processing quality

$$A = \frac{E[\text{Uptime}]}{E[\text{Uptime}] + E[\text{Downtime}]}$$

VME vs. µTCA Board Sizes



AMC w/ read I/O:
~ 457 cm²

VME:
~ 345 cm²

LLRF Hardware

- XFEL will be based on the new MicroTCA.4 standard
  - Double size Advanced Mezzanine Card (AMC) modules with complex FPGA and PCIe link to CPU
  - Rear Transition Modules for signal conditioning
  - Precise clock and trigger over the backplane

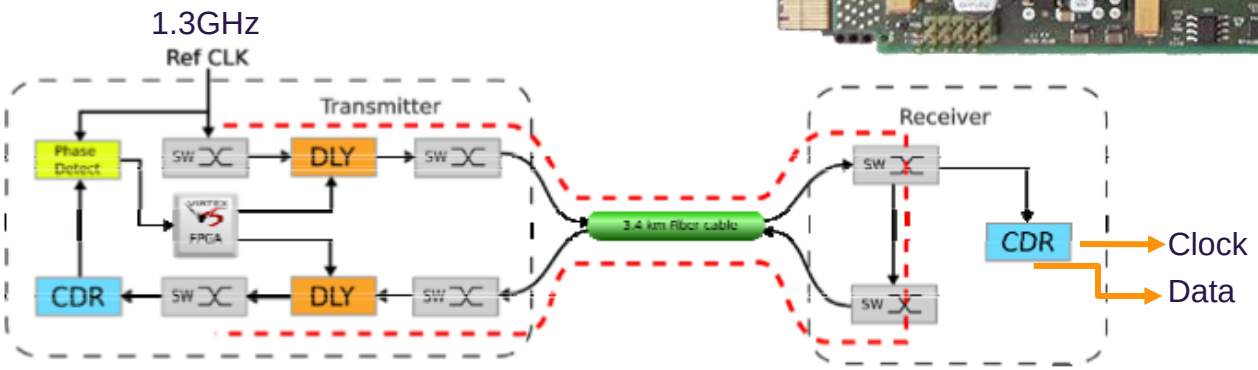
MTCA.4

DWC8300 © DESY

SIS8300 © Struck Innovative Systems

XFEL Timing System: 1. Prototype

- New Timing System
  - Fiber optic links 1.3GHz
  - with drift compensation
  - AMC prototype is receiver and transmitter
  - ps stability (< 5ps RMS)
  - Clock, trigger and event distribution
- Double height version under test



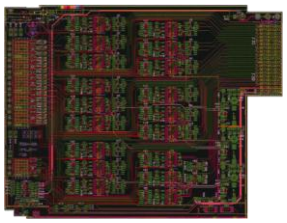
Done by

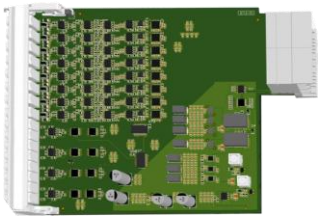
FYSIKUM

Several µTCA boards

RTM

AMC





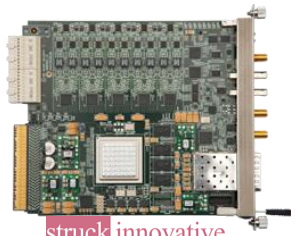
TEWS TECHNOLOGIES

Digital Front

Analog Front

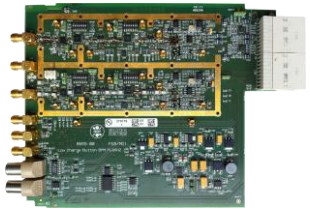
RTM

AMC

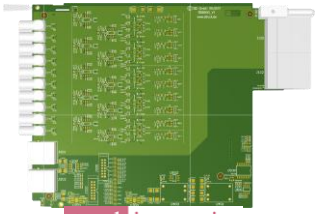


struck innovative systeme

TEWS TECHNOLOGIES



SANBlaze Technology, Inc.



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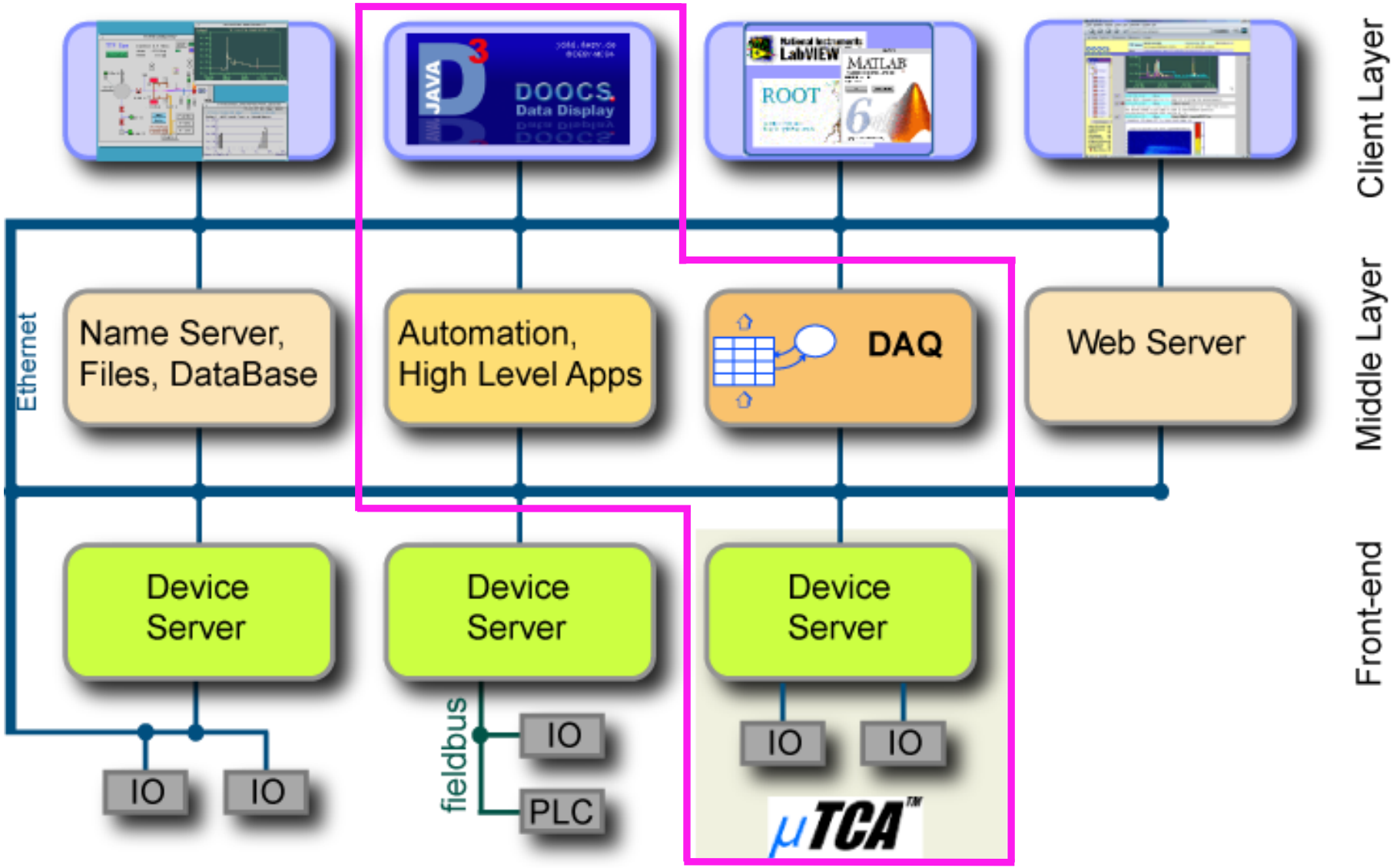
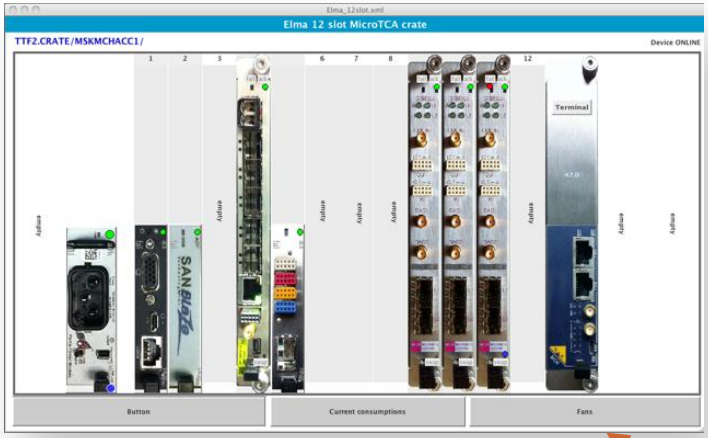
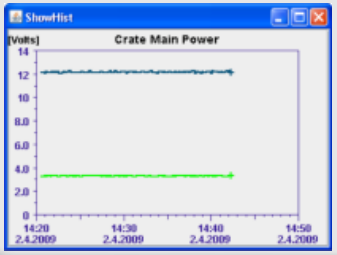
DOOCS Control System Architecture



Intelligent Platform Management Interface (IPMI)



Management Data is available in all applications



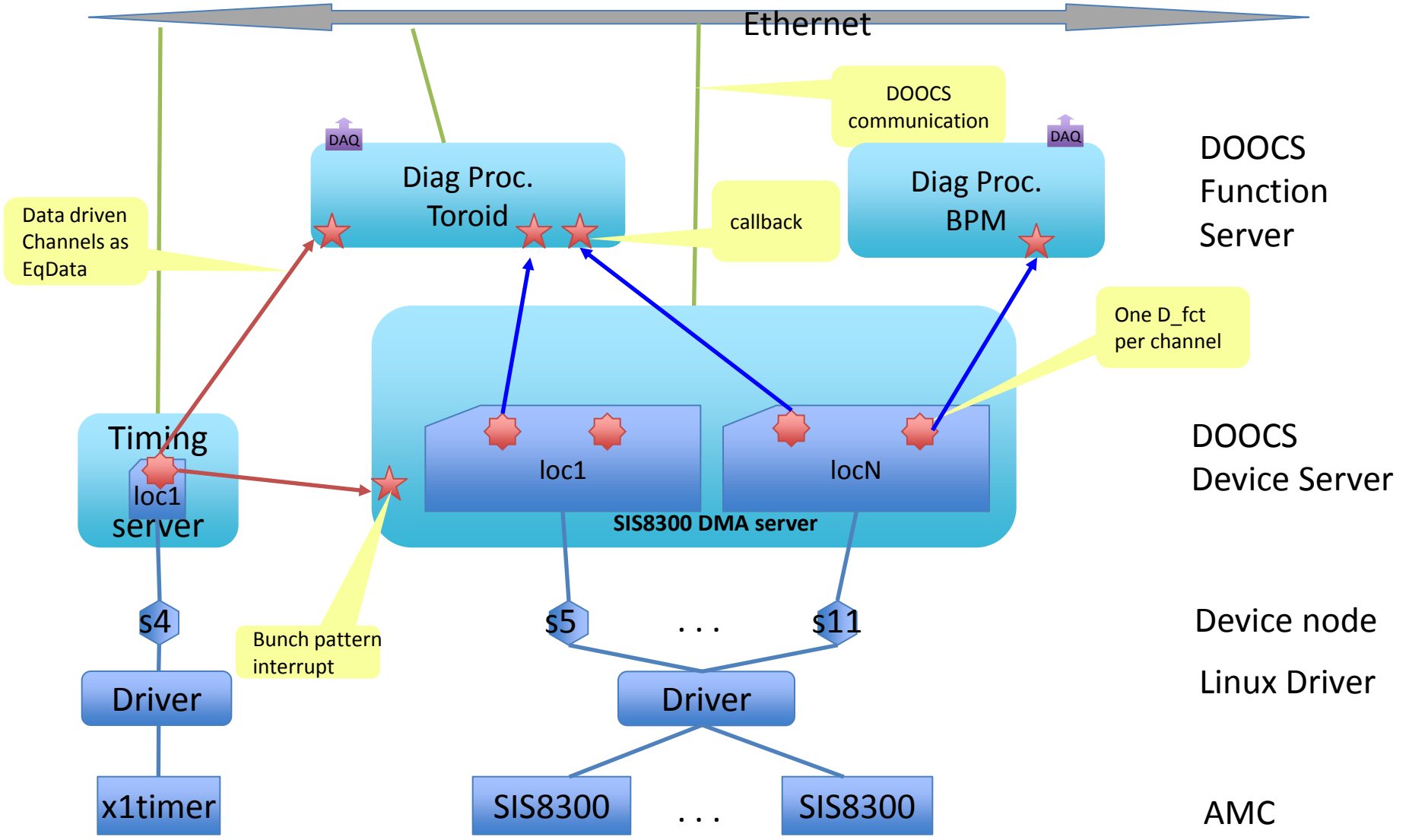
Implemented on **CPU**:
- DOOCS device server
- Linux driver
- Hot-swap support:
  remove a module in a running system

DOOCS xTCA IPMI Server

IPMI

MCH (MicroTCA Carrier Hub)
- Crate Manager
- Provide Ethernet switching
- Manage HotSwap

Front-end Architecture: example Toroid



ZeroMQ © zeromq.org

ØMQ

The Intelligent Transport Layer

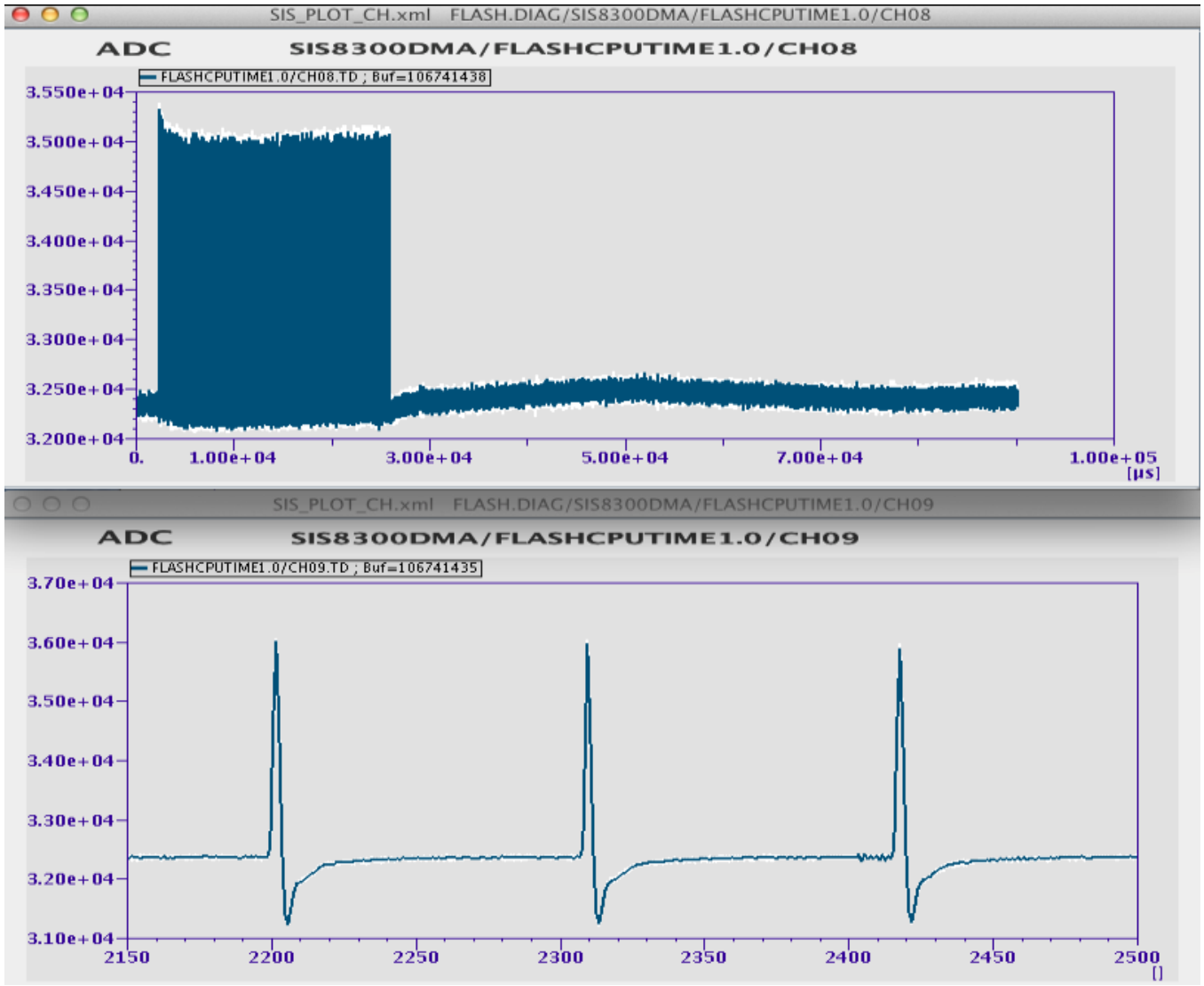
- The socket library that acts as a concurrency framework
- Faster than TCP, for clustered products and supercomputing
- Carries messages across inter process communication(IPC), TCP, and multicast
- Connect N-to-N via fanout, pubsub, pipeline, request-reply
- Asynchronous I/O for scalable multicore message-passing apps
- Large and active open source community
- 30+ languages including C, C++, Java, .NET, Python

✓ It was easy to integrate into our DOOCS system

✓ It runs stable

✓ Fast and reliable reconnects after restarts of processes in the chain

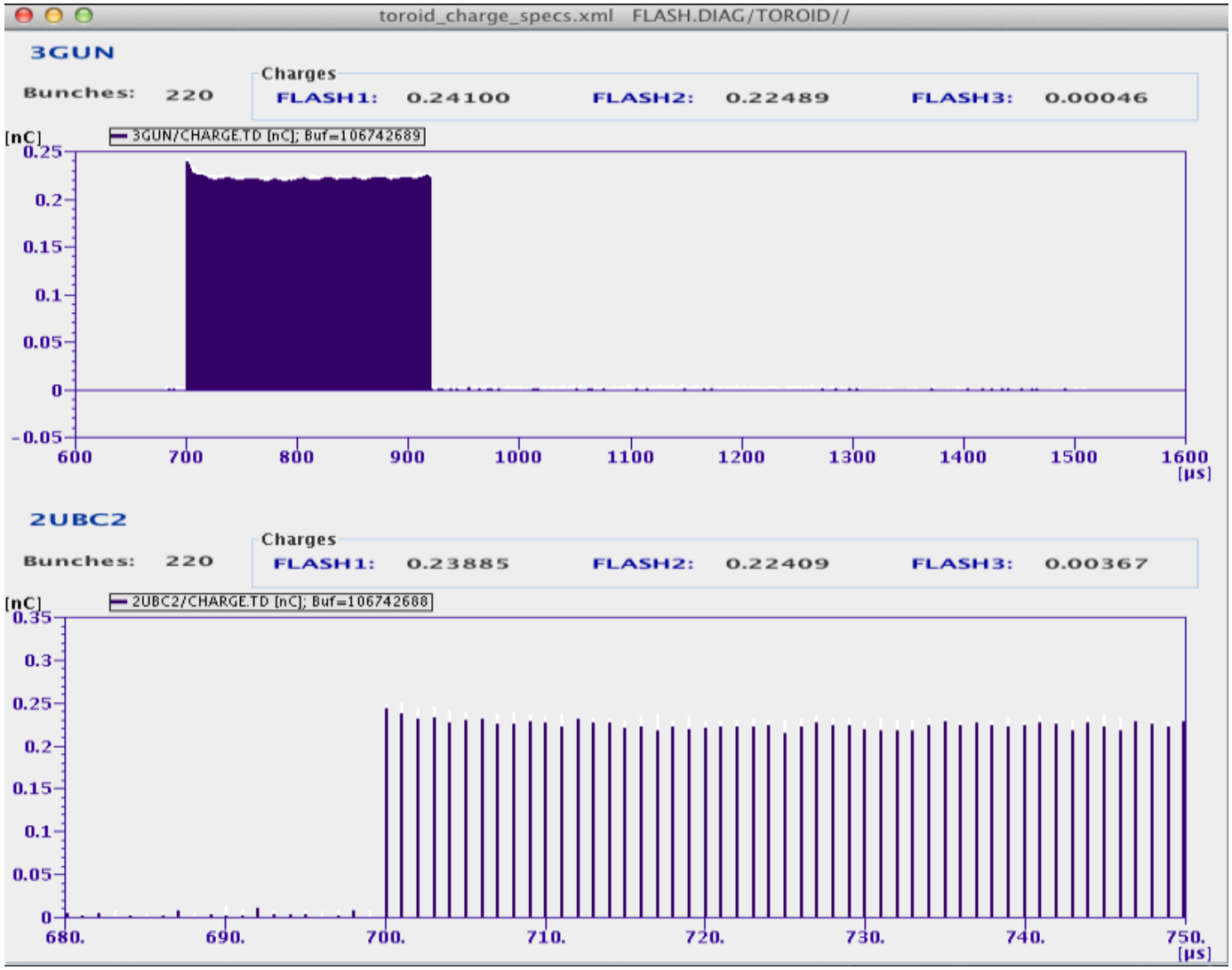
SIS300 DMA server @ FLASH



Raw Signal
from ADC
90000 samples
== 830µs

Raw Signal
from ADC
Zoomed in to
show 3 bunches

Toroid server @ FLASH



Charge reading from Toroid server 220 Bunches 1MHz RepRate

Charge reading from Toroid server Zoomed in around first bunches

Some test results

- On Core-Duo 1.5 GHz CPU (low end CPU)
- Source Code not yet optimized
  - Additional buffer copy into Messaging system
- Test results (90KB buffer, 108 MHz sampling, 10Hz operation)
  - SIS8300 DMA server with 10 ADC channels
    - ➔ ~6 % CPU usage
    - ➔ Toroid Server with 10 locations
    - ➔ ~12 % CPU usage
- Latency from Driver to toroid-server (all processing included)
  - ✓ ~4ms for one channel
  - ✓ ~22ms for 10 channels
- => only little overhead by the Messaging system

Status/Schedule

- µTCA™ Hardware available
- Messaging Software based on ØMQ is include in DOOCS server library
  - First successful tests
  - Available since May 2012
- XFEL Timing system
  - First hardware is available
  - DOOCS Server available since May 2012
  - Connection to FLASH timing is done since June 2012
- DMA Server for SIS8300 including Messaging Software under development
  - First test are done
- Toroid Server including Messaging Software under development
  - First successful test are done

Conclusion

- XFEL fast diagnostics and controls will be based on µTCA™
- ØMQ message passing is included in the DOOCS core
- Hardware and Software tested and proven
- Complete installation planned for spring 2013 at FLASH
- FLASH2 will run with µTCA™ after the shutdown in summer 2013
- XFEL installation in 2013/2014

Thank You for Your Attention!

More Info:

http://doocs.desy.de

Nov. 2012

Oct. 2009