The Control System For The Linear Accelerator At The European XFEL

Status And First Experiences

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HELMHOLTZ ASSOCIATION

DESY

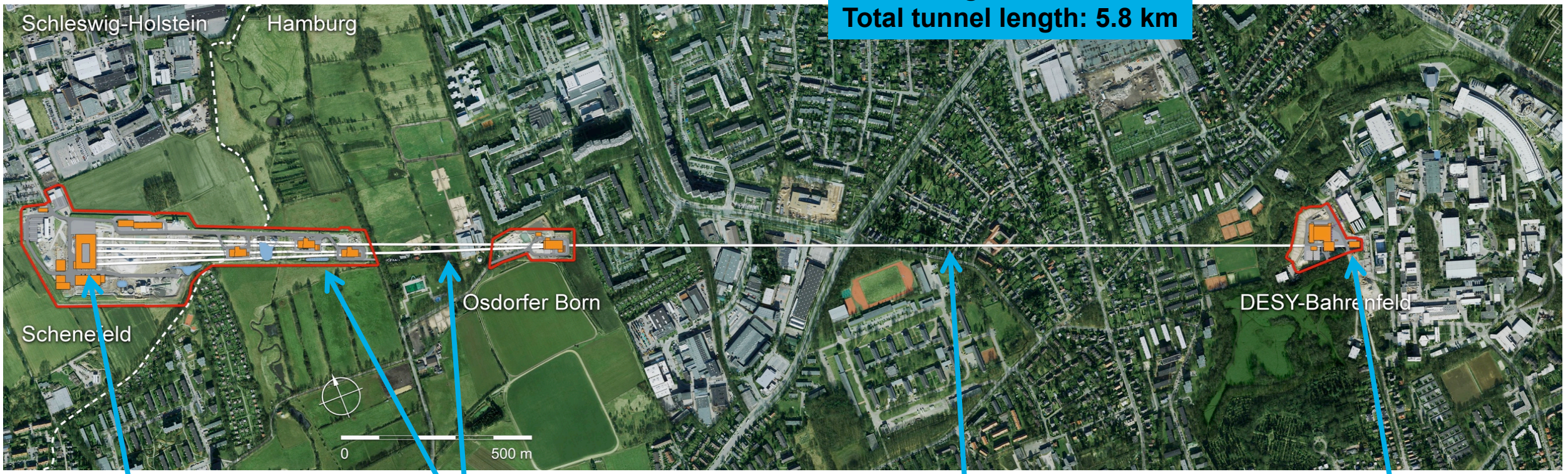
The European XFEL Accelerator

Aerial View and Beam Line Layout

The European XFEL

Aerial View of Hamburg and Surroundings

Length: 3.4 km
Total tunnel length: 5.8 km



Experimental Hall Schenefeld Campus

Undulator sections and photon beam tunnels

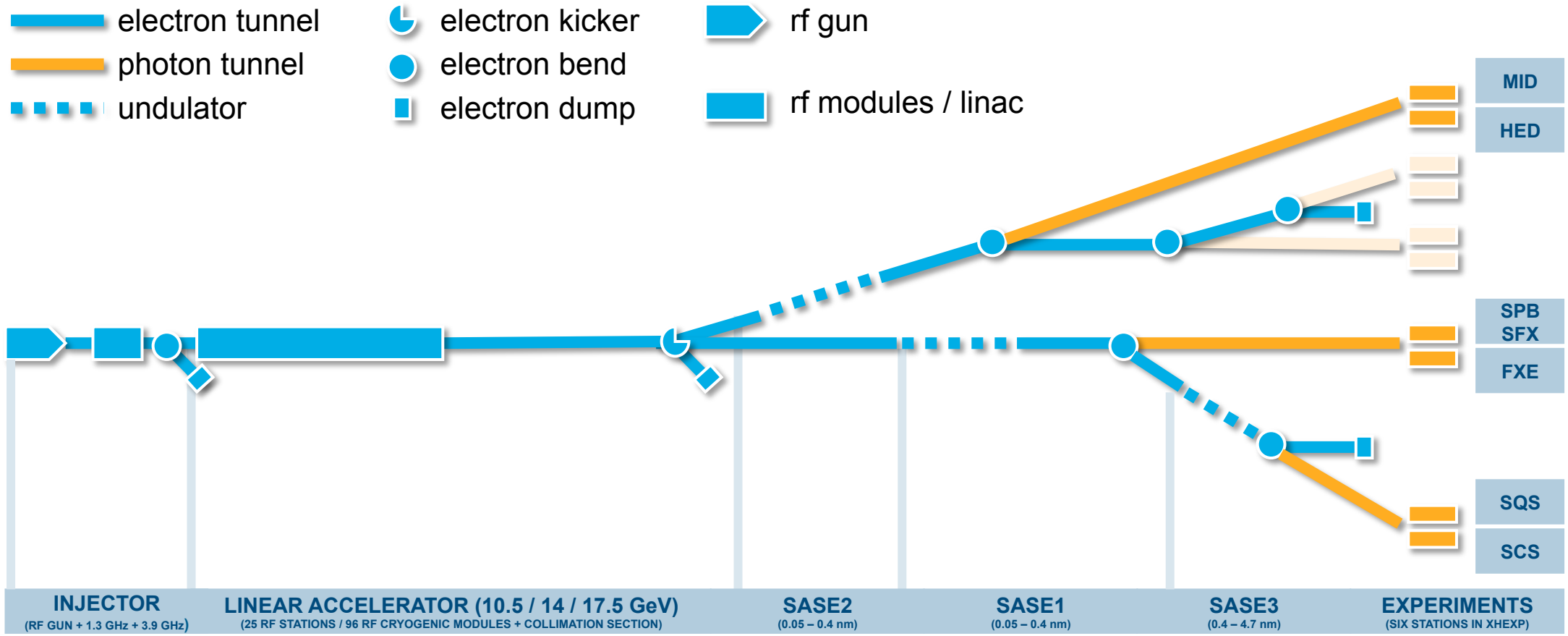
Linear Accelerator 1.9 km long / 17.5 GeV

Injector on DESY campus

The European XFEL

Accelerator And Photon Beamlines

Parameters:
Repetition Rate 1 - 10 Hz
RF Pulse (flat top) 600 µs
Bunches 27000/s
Bunch Charge 0.02 – 1 nC



The Accelerator Control System

Concepts and Implementation

Concepts

Specifications and Key Components

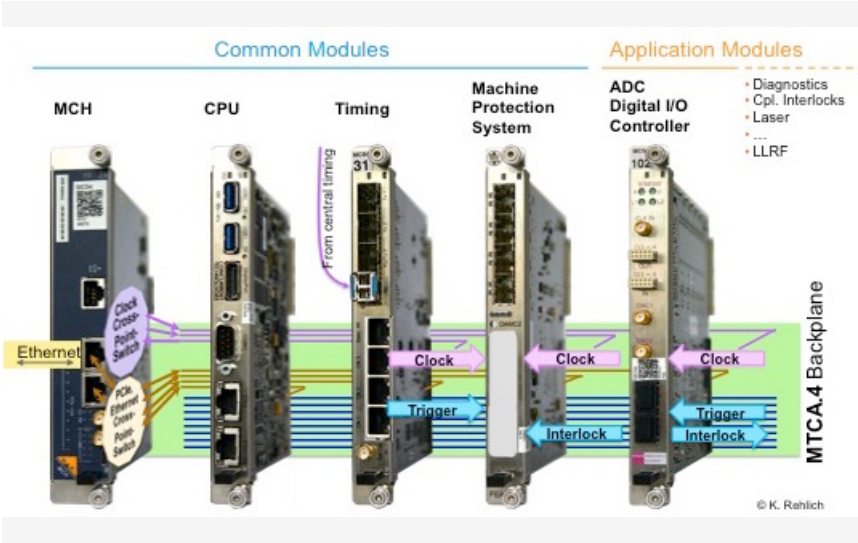
Specifications

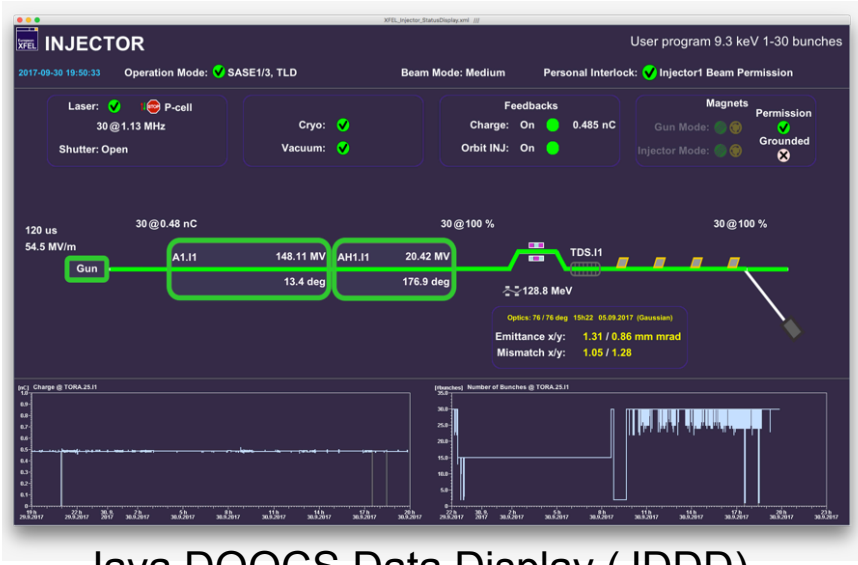
- Standard hardware platform for all front-end device controls
  - Remotely manageable and hot-swap capabilities
- Well-established Software framework based on open source standards
  - For hardware support and applications
- Shot-synchronized acquisition system for online monitoring and offline analysis

Key Components

- MicroTCA.4 as standard hardware platform for front-end devices
  - Beam diagnostics, RF/LLRF controls, vacuum and magnet controls
- MicroTCA.4-based timing system suitable for pulsed accelerators
- DOOCS as control system software framework with integrated TINE and EPICS interface
- Integrated, shot-synchronized bunch-resolved data acquisition system
- Java-based, thin-client GUI for experts and operators plus MATLAB- and Python-based applications

MicroTCA.4 Base System

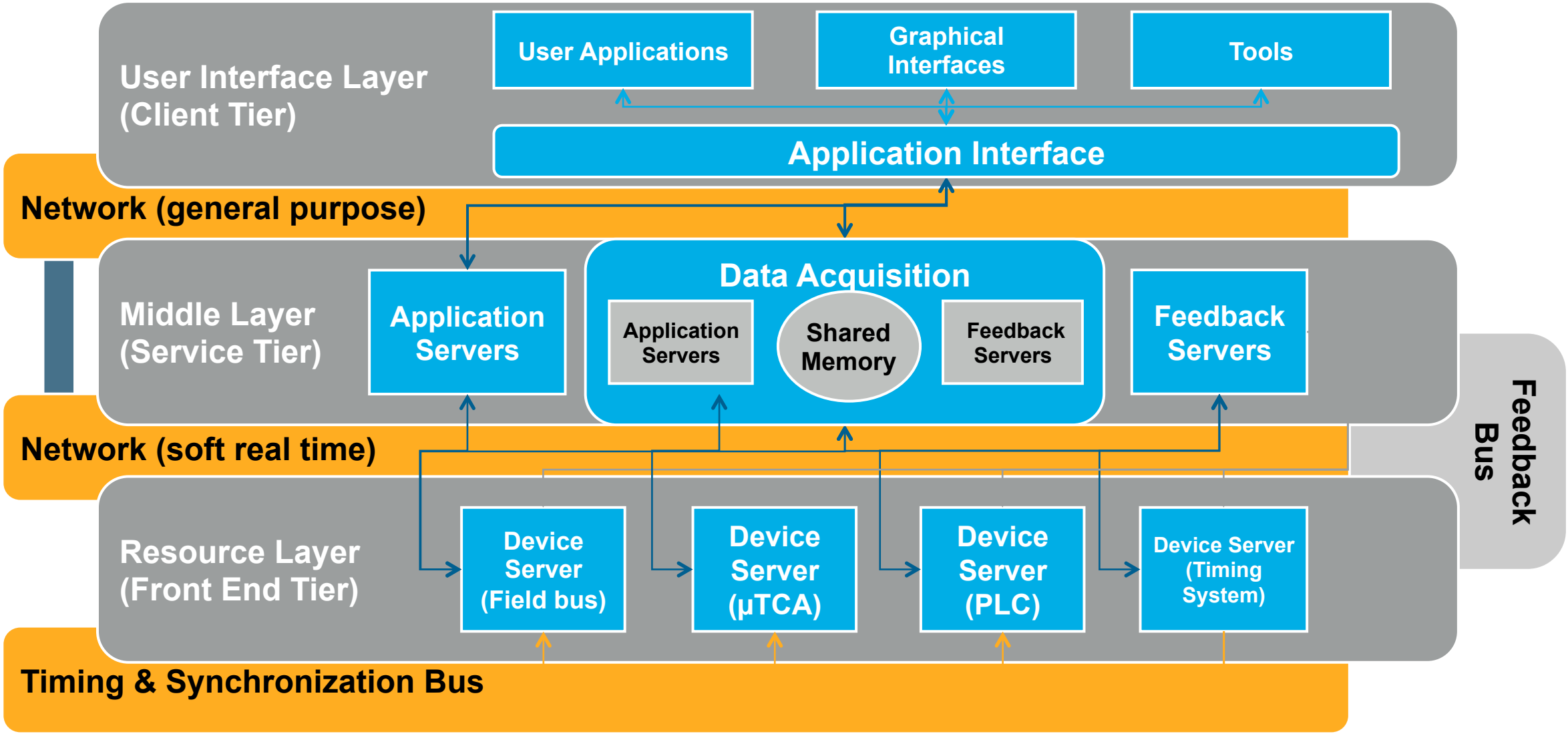




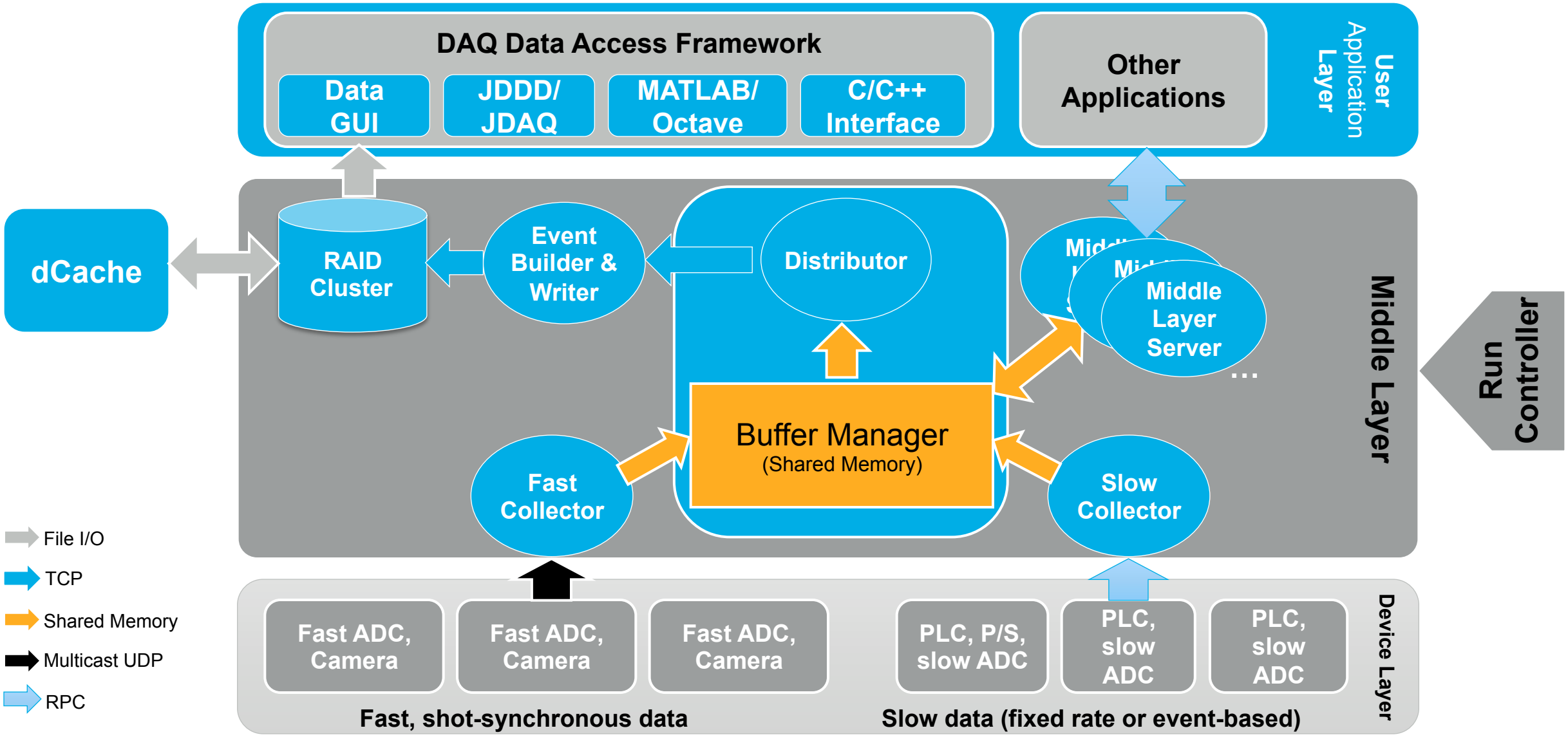
Java DOOCS Data Display (JDDD)

Accelerator Control System Model

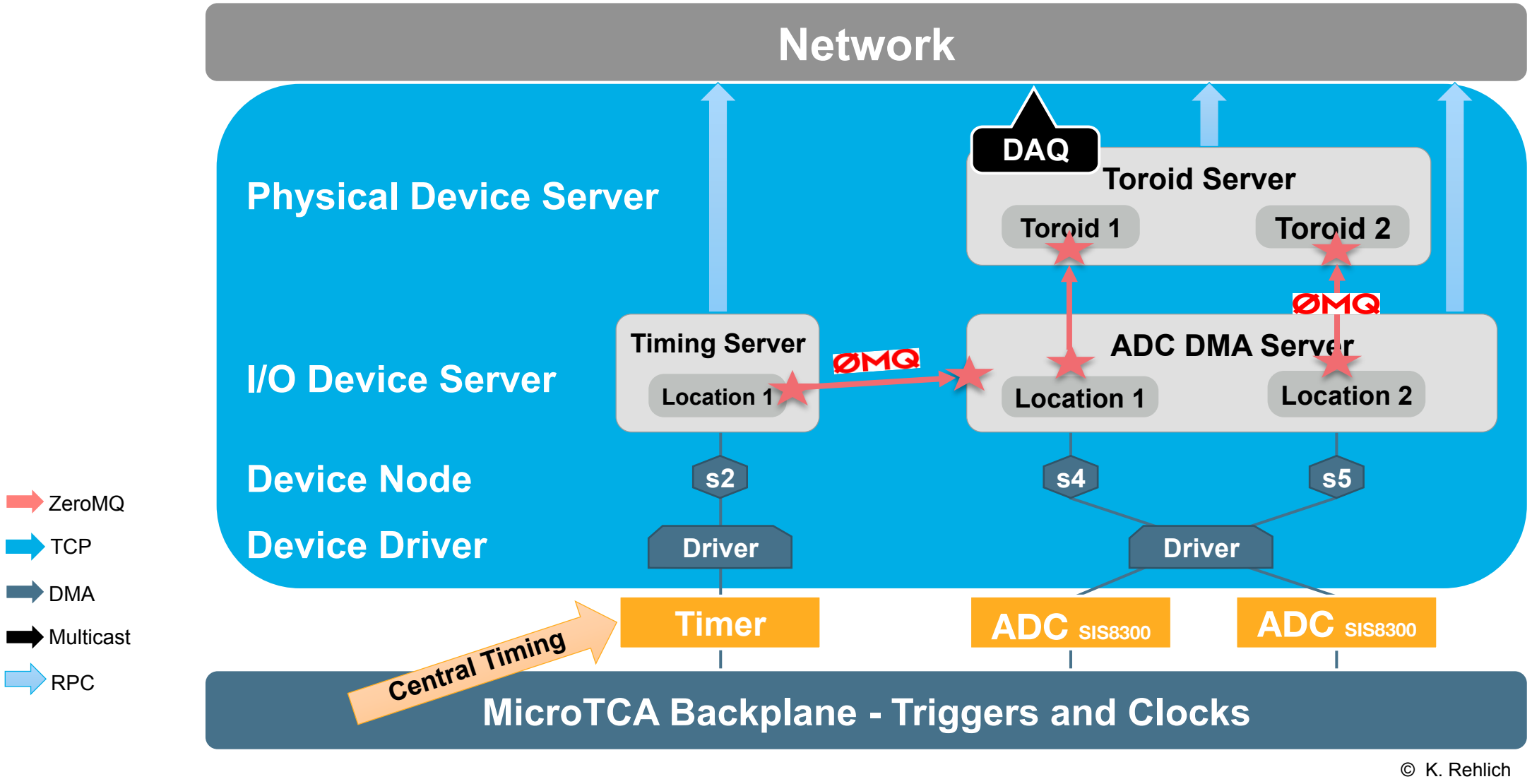
Classic three-layer design of an accelerator control system enhanced by integration of data acquisition system



DOOCS Accelerator Data Acquisition



MicroTCA Server Read-Out Example



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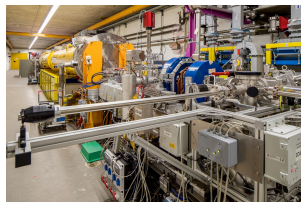
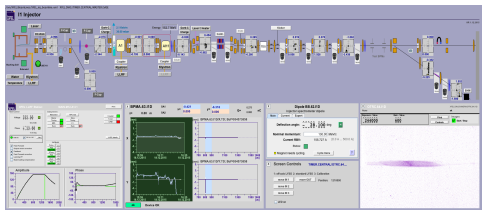
Status – Installation and Commissioning

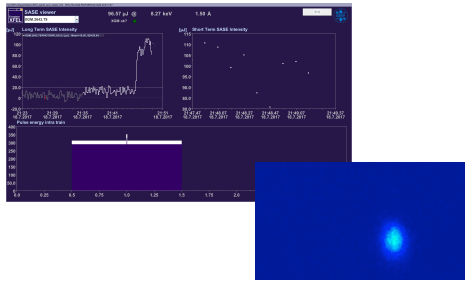
First User

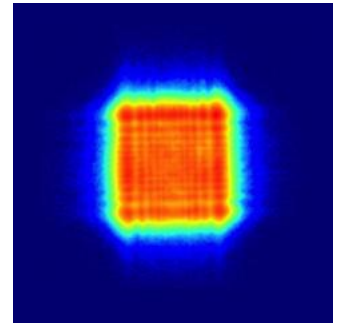
Installation And Commissioning Stages

Stages Of Control System Installation and Commissioning









First RF-Gun Operations (Conditioning) December 2013

Injector Installation Completed

First Beam Injector December 2015

Linear Accelerator Tunnel Installation Completed

First beam 2.5 GeV Linear Accelerator February 2017

First Beam 12 GeV Linear Accelerator April 2017

SASE 1 Beam Line Installation Completed

First Lasing May 2017

First Photon Beam To Experiments June 2017

SASE Production For Users At SASE1 September 2017

Installation Of SASE2 Completed

2013 2014 2015 2016 2017 2018

Statistics

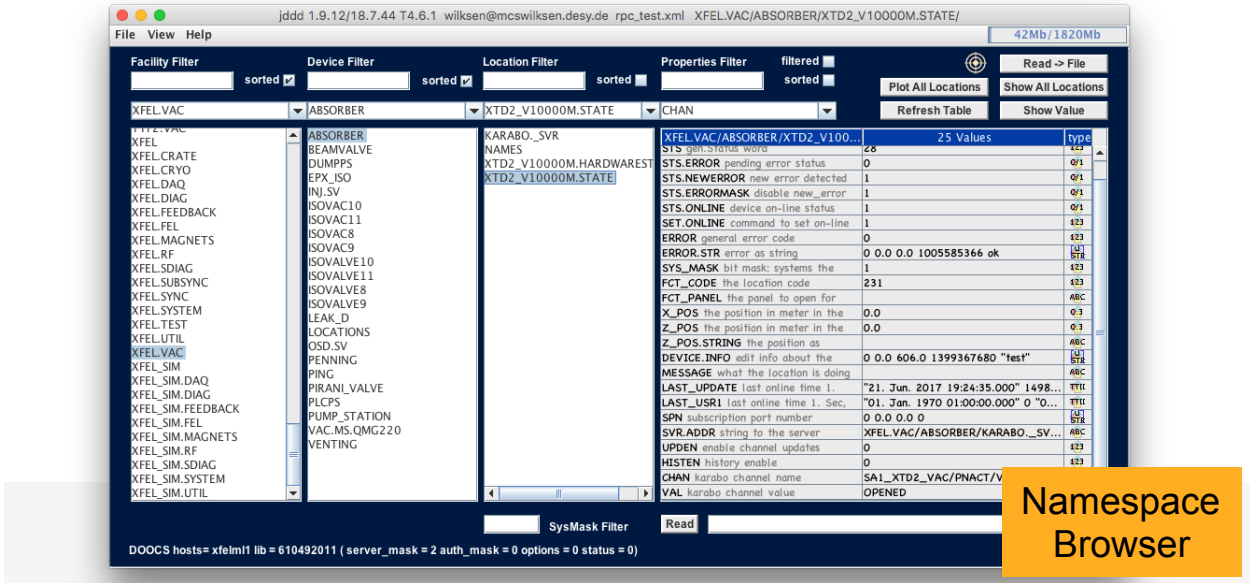
Some Numbers Of The Accelerator Control System

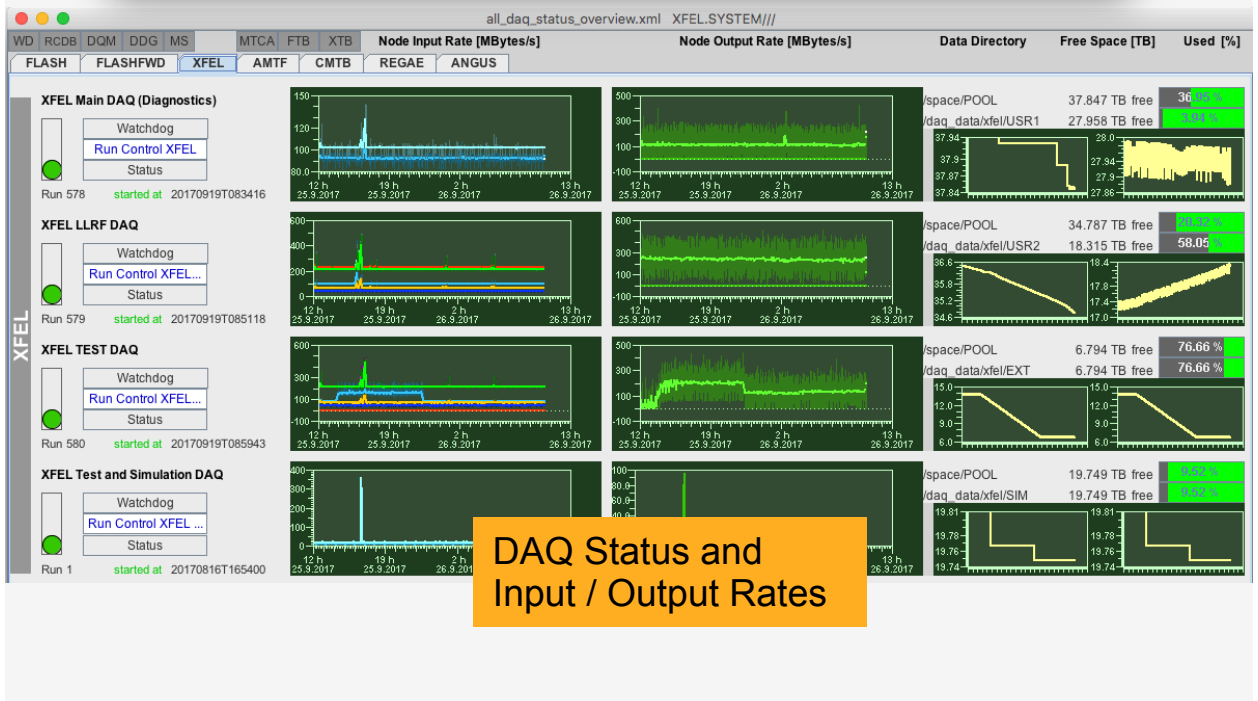
System Statistics

- About 300 MicroTCA systems and server installed
- More than 9 million control system parameters visible in accelerator namespace
- About 600000 of local DOOCS archives plus TINE central archive
- More than 800 different device types and 38000 locations

Data Acquisition System Statistics

- Running since first day of RF-gun operations
- Four instances for diagnostics, RF/LLRF
- About 1.5 GB/s sustained input rate
- More than 13000 complex DOOCS channels
- Compressed data rate to disk up to 30 TB/day
- Virtual XFEL instance for test and simulation





Experiences

Commissioning and First Operations

Experiences

Commissioning and First Operations

Installation and Commissioning

- Staged installation posed challenge to parallel commissioning of completed sections but doable ✔
- Staged commissioning process required to have accelerator control system infrastructure and common software in place from day one ✔
- With ongoing installation phases workflow, tools and experience improved; paid off already for maintenance ✔

Design

- Well-known software frameworks and expertise on site saved time for implementing required controls applications
- FLASH as “prototype” and test-bed facilitated launching the MicroTCA hardware for the European XFEL accelerator
- Virtual XFEL turned out to be a useful tool for testing new concepts and software – learned “on the way”

XFEL Control System WP 28

Conceptual Design Report

Version 03/12/10

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Conclusions

- The control system for the European XFEL linear accelerator has been operable from day one!
- MicroTCA.4 hardware platform well established within the accelerator control system
- Standardization of hardware and software simplified implementation, deployment and maintenance -> reliability and availability
- Fast and very successful commissioning of the accelerator control system

Outlook

- Accelerator control system components installation completed this month for second electron beam line
- Upcoming commissioning of two photon beam lines
- Operations with multiple electron and photon beam lines and – will profit from FLASH experience
- Regular scheduled user runs
- Upcoming challenges prompted by photon science experiments

Thanks for your attention!

DESY Accelerator Control Room
- XFEL Area -