

# The European X-Ray Free Electron Laser And Its MicroTCA-Based Accelerator Control System

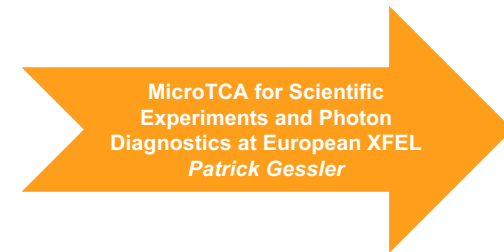
Status Report

Tim Wilksen, DESY  
6<sup>th</sup> MicroTCA Workshop  
Hamburg, 06.12.2017



# Overview

- 1 Overview
- 2 The European XFEL Accelerator
- 3 The Accelerator Control System
- 4 Status And Experiences
- 5 Summary And Outlook

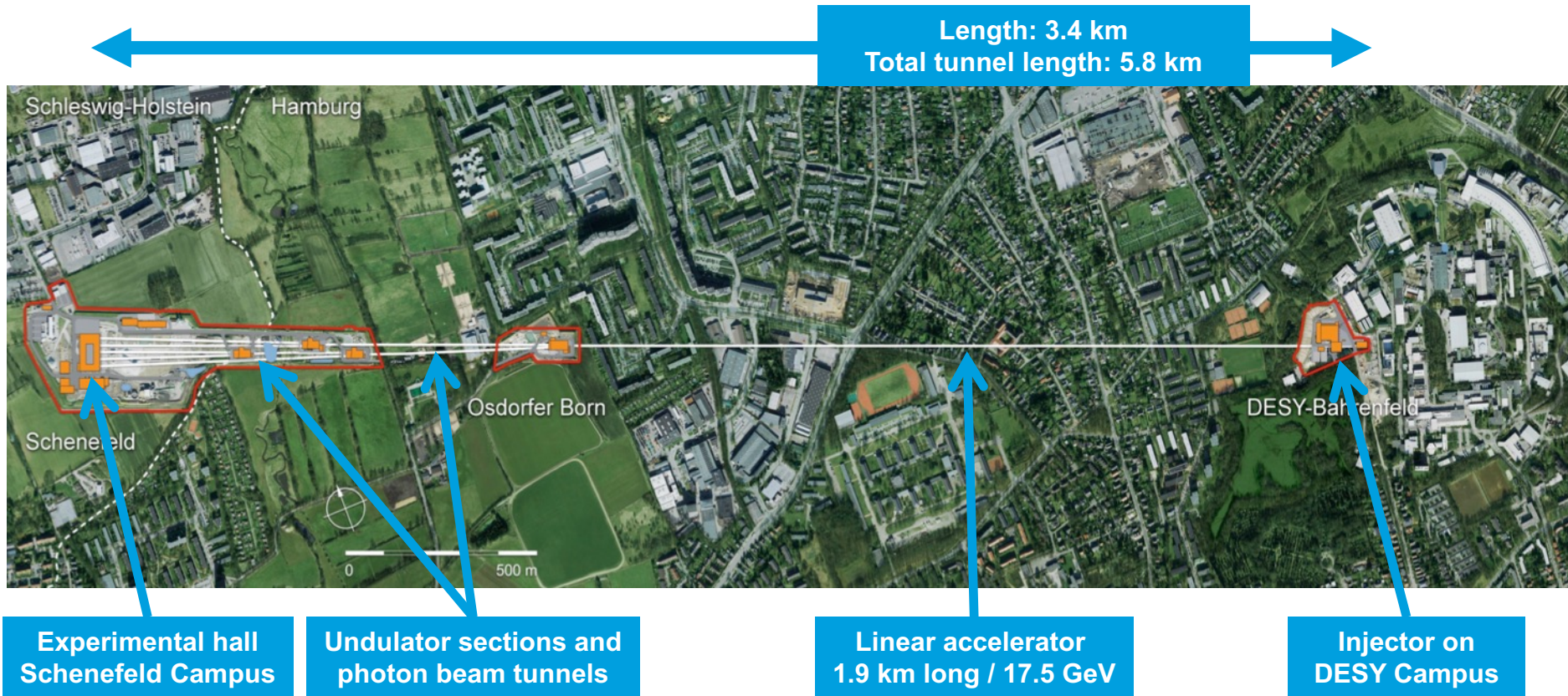


# The European XFEL Accelerator

Aerial View and Beam Line Layout

# The European XFEL

## Aerial View Of The European XFEL



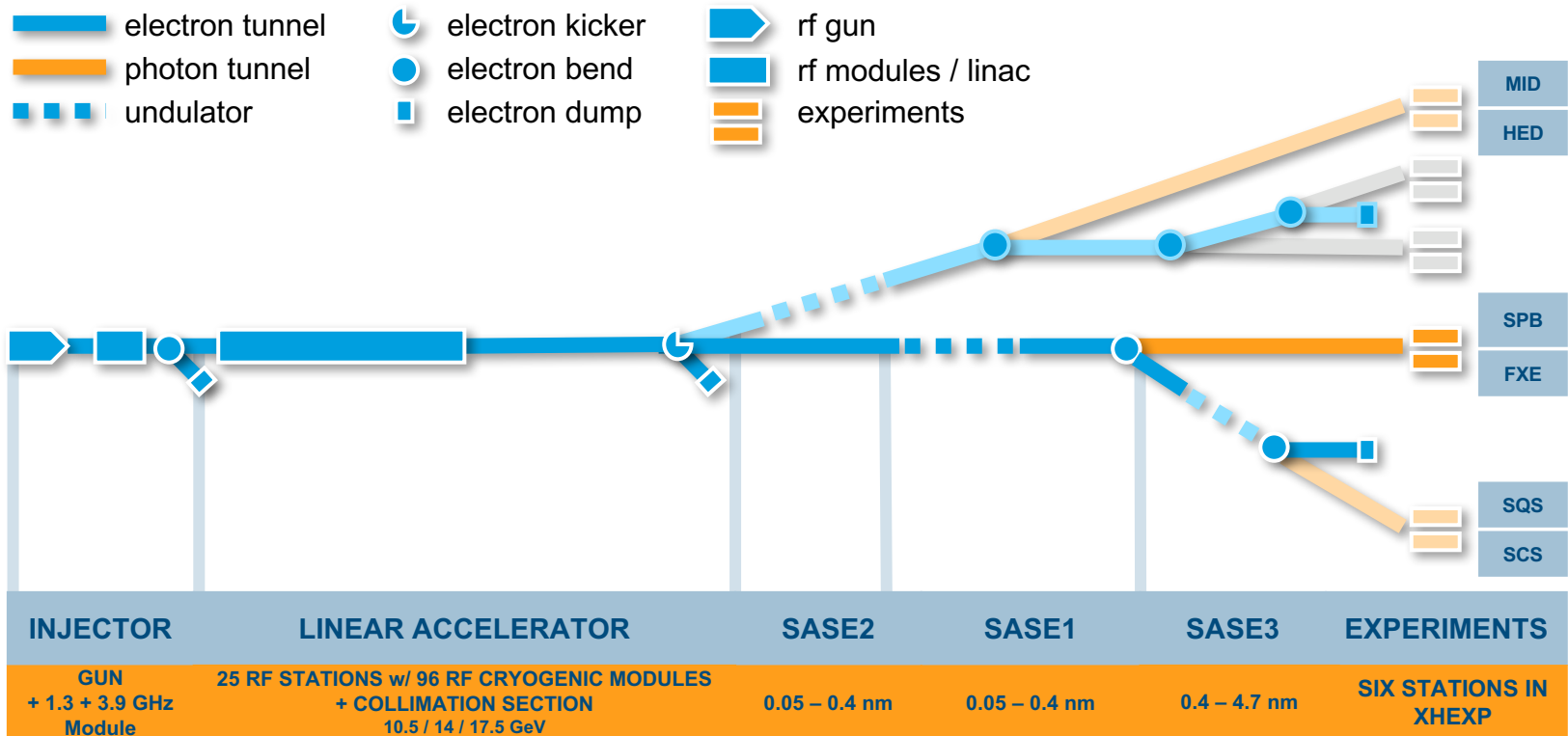
Schenefeld,  
Schleswig-Holstein

Hamburg

# The European XFEL

## Accelerator And Photon Beamline Layout

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



# The European XFEL

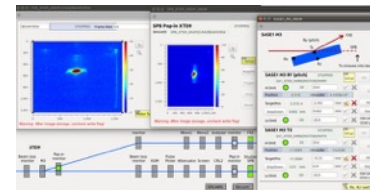
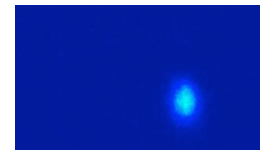
## Accelerator Installation and Commissioning Dates

- 2013** • First operation of RF-Gun started in December 2013
- 2015** • First accelerated beam in injector in December 2015
- 2017** • XTL main tunnel closed on January, 13<sup>th</sup> 2017
- **First beam at 2.5 GeV in accelerator dump on February, 25<sup>th</sup> 2017**
- First beam at 12 GeV in linear accelerator dump on April, 8<sup>th</sup> 2017
- First beam to SASE1 dump on April, 27<sup>th</sup> 2017
- **First production of light on May, 2<sup>nd</sup> 2017**
- Photon light delivered to experiment hutches end of June 2017
- Accelerator SASE1 beam line in production mode since September, 1<sup>st</sup> 2017
- **User runs with two experiments SPB and FXE since September 2017**

LLRF Commissioning  
and First Operation of  
the European XFEL  
*Julien Branlard*

6 Weeks

12 Weeks



# The Accelerator Control System

Implementation

# The Accelerator Control System

## Key Design Elements

<b>Common Software Framework</b>	DOOCS as standard control system software for MicroTCA-based read-out and controls
	System Integration w/ Linux (Ubuntu 16.04 x86_46) as operating system standard and DOOCS for management
<b>Common Hardware Platform</b>	MicroTCA.4 PICMG Standard
	Common set of MicroTCA modules for all systems

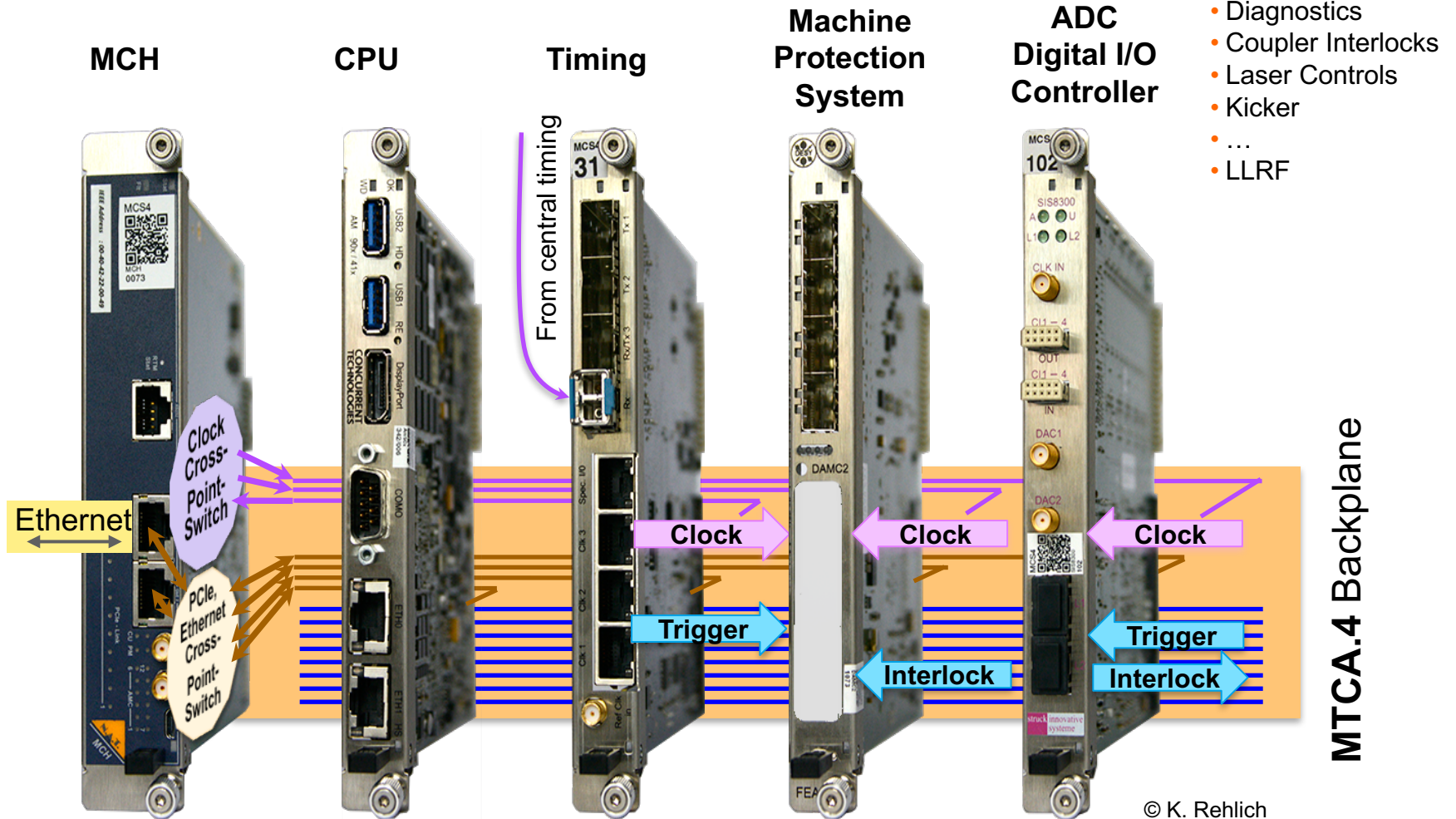


# MicroTCA Common Module Set

Standard set of MicroTCA modules used in the European XFEL accelerator control system

## Common Modules

## Application Modules



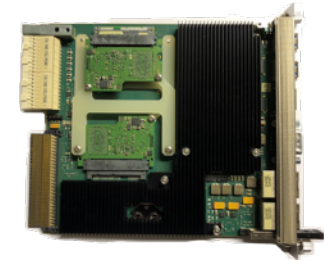
# MicroTCA Modules Accelerator Control System

## Common Module Set



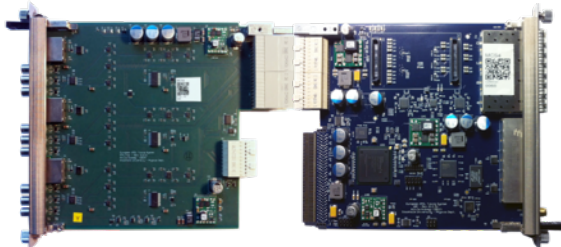
Schroff & ELMA 12 Slot MTCA.4 Chassis

Wiener MTCA.4 1000 W P/S



Concurrent CPU AMC w/ i7-Quad-Core

RTM with 9 Lemo outputs for trigger, clock and data distribution

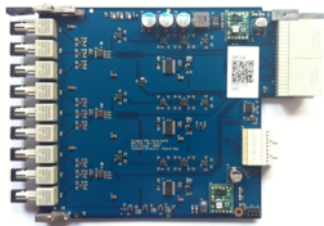


x2Timer / NAMC-psTimer Receiver-Transmitter AMC



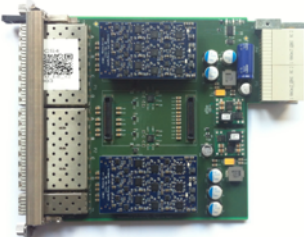
N.A.T. MCH NAT-PHYS(80)

RTM with 9 fiber outputs for trigger, clock and data distribution

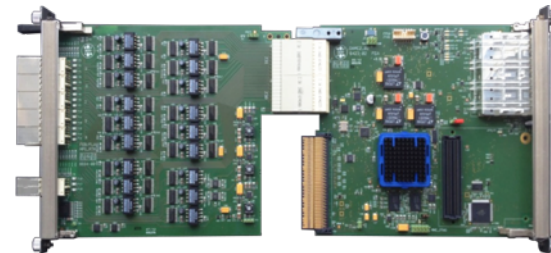


## Timing System

RTM with 9 SFP outputs and length compensated fiber links



RTM w/ 45 + 3 RS422 inputs and 8 outputs



DAMC2 AMC with MPS Firmware

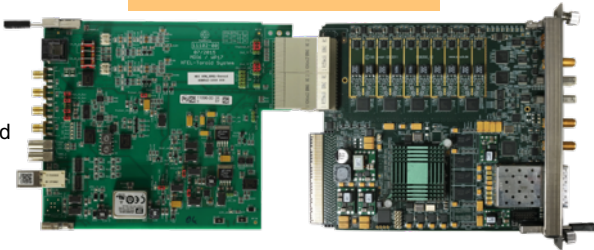
## Machine Protection System

# MicroTCA Modules Accelerator Control System

## Application Modules For Diagnostics And Control Tasks

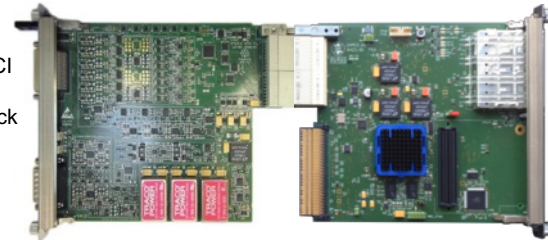
### Toroid System

RTM w/  
input for  
toroid  
signals and  
output to  
MPS



Struck  
SIS8300  
AMC

RTM w/ VHDCI  
inputs for  
coupler interlock  
signals



DAMC2 AMC w/ CPL  
IL Firmware

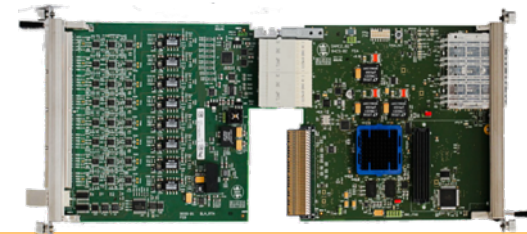
### Coupler Technical Interlock System

### Vacuum And Magnet Controls



ESD 4-Fold CANbus AMC

RTM w/ inputs  
from BLM and  
MPS outputs



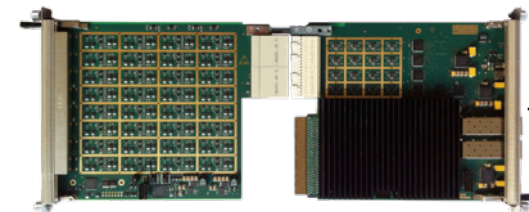
DAMC2 AMC w/ MDI  
Firmware

### Beam Loss Monitor System



ESD Digital-/Analog I/O AMC

### Kicker System



TEWS  
TAMC532  
AMC

### Spectrometer w/ 128 channels



### Gas Monitor Detector

SPDevices ADQ412

MTCA.4 Usage in Longitudinal  
Electron Beam Diagnostics at the  
European XFEL

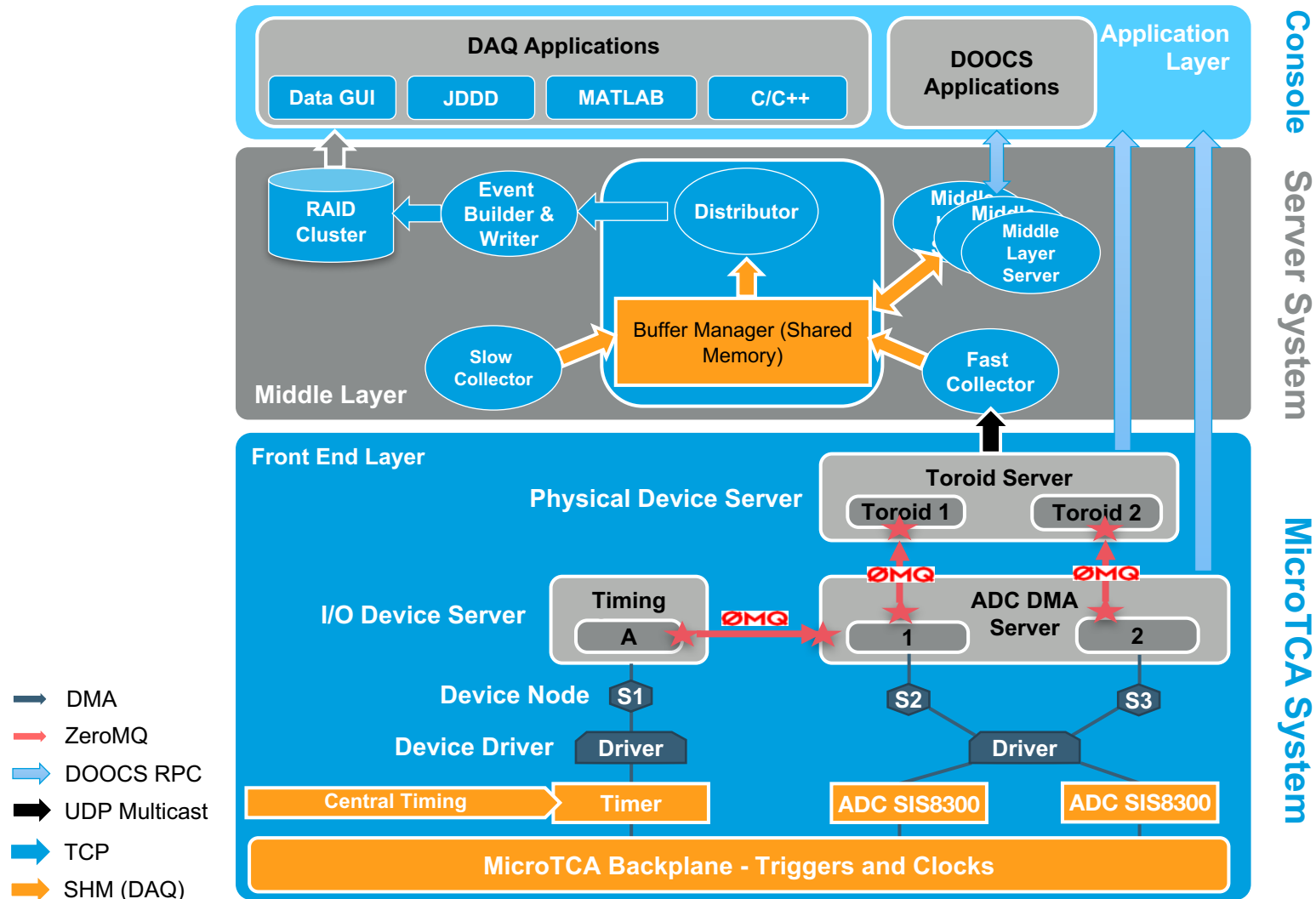
Marie Kristin Czwalińska

Control Hardware and  
Software for Laser Systems at  
DESY and the European XFEL

Christian Mohr

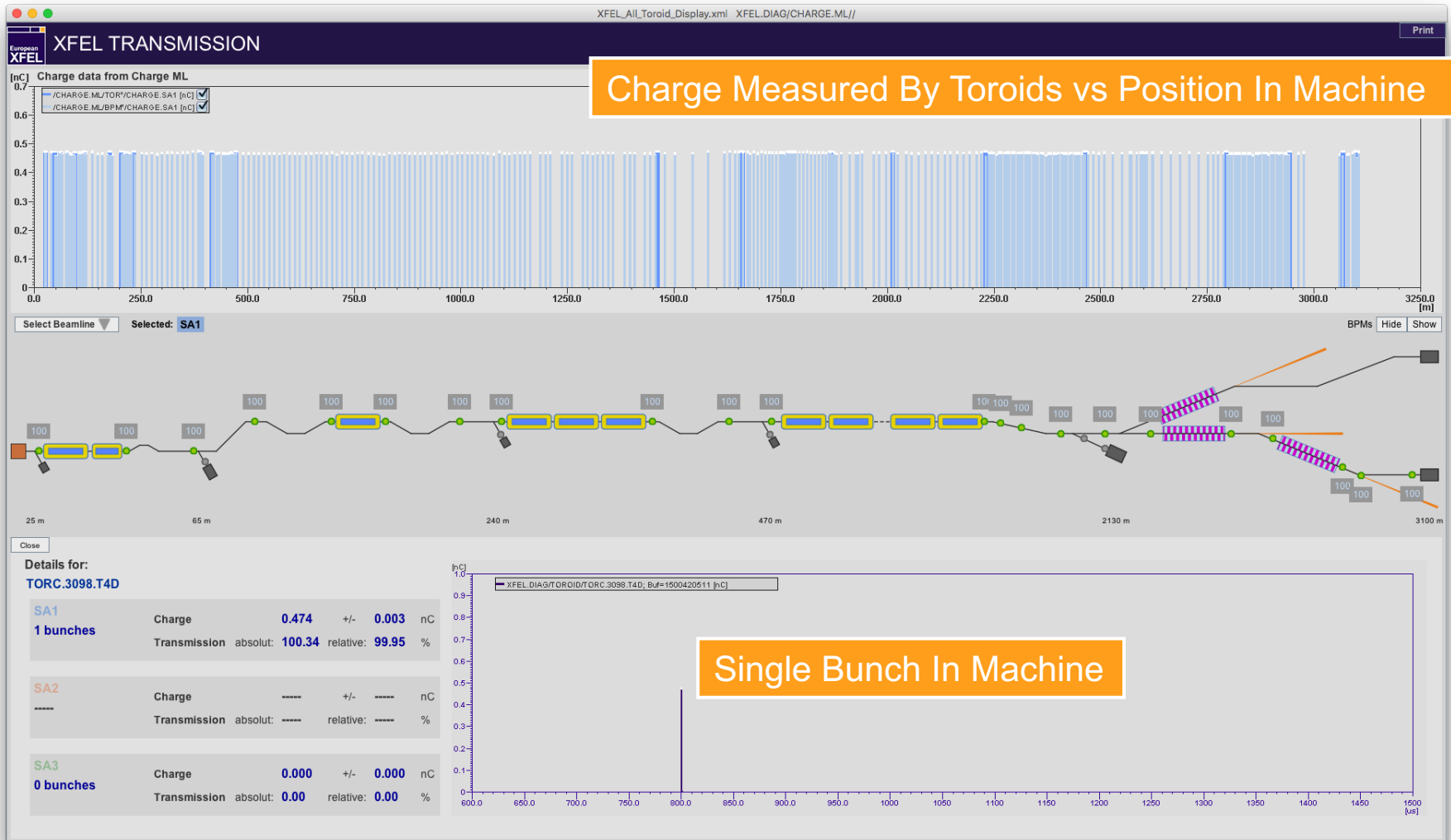
# Server Software on MicroTCA

## Example Read-Out Chain w/ DOOCS Software And DAQ System



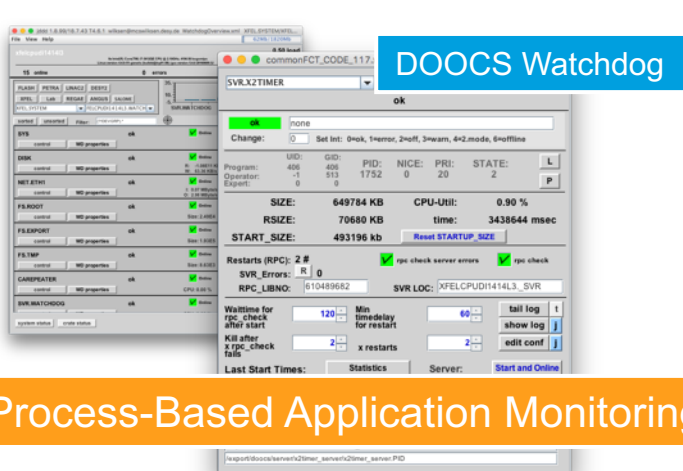
# MicroTCA Server Read-Out

## Example: Transmission Application Based On MicroTCA and DAQ Read-Out Chain



# System Integration

## Integration of MicroTCA Systems Into XFEL Control System And Management



**DOOCS Watchdog**

SVLXZTIMER

Change: 0 Set Int: 4secr, 24off, 3wamr, 4x2mode, 6nofline

Program: UID: 406 GID: PID: NICE: PRI: STATE: L  
Operator: -1 932 1752 0 20 2 p

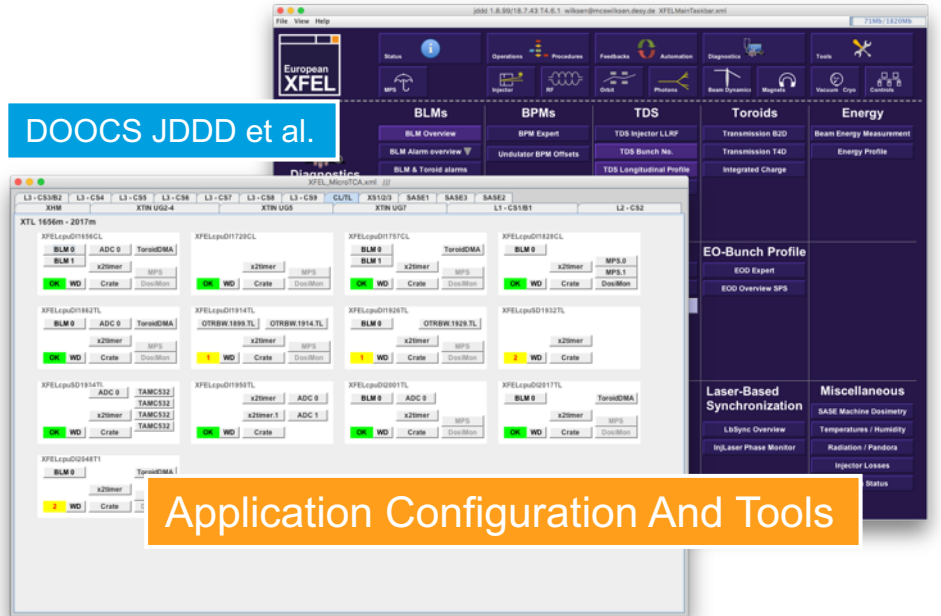
SIZE: 649784 KB CPU-UI: 0.90 %  
RSIZE: 70680 KB time: 3438644 msec  
START\_SIZE: 493196 kb

Restarts (RPC): 2 # rpi check server errors rpi check  
SVR\_Errors: 0 Kill after rpi\_check 2 x restarts 2 edit conf

Waittime for rpi check after start 120 Min timeout for restart 60 show log

Last Start Times: Statistics Server: Start and Online

Process-Based Application Monitoring



**DOOCS JDD et al.**

European XFEL

BLMs BPMs TDS Toroids Energy

BLM Overview BPM Expert TDS Injector LLRF Transmission B2D Beam Energy Measurement

BLM Alarm overview Unipulator BPM Offsets TDS Bunch No. Transmission T4D Energy Profile

BLM & Toroid alarms Unipulator BPM Offsets TDS Longitudinal Profile Integrated CAD

EO-Bunch Profile EOG Expert EOG Overview SPS

Laser-Based Synchronization SASE Machine Desimetry SASE Machine Desimetry

LSync Overview Temperatures / Humidity Radiation / Parasits InjLaser Phase Monitor Injector Losses Status

Application Configuration And Tools



**DOOCS IPMI Crate Management Server**

AMC Module AM 902/411 FRU Info

ICS Adr: FLASH.CRATE/FLASHMCHDIAG6/AMC1/ Slot: 1  
IB Adr: 114 FRU ID: 5

Manufacturer: Concurrent Technologies  
Production Date: Mon May 15 19:19:00 2017  
Serial Number: M26695/007  
Version: unavailable  
MMC version: 3.1

Temperatures (degrees C)

29.6	2.7	5.7	8.7	11.7	15.7
2017	2017	2017	2017	2017	2017

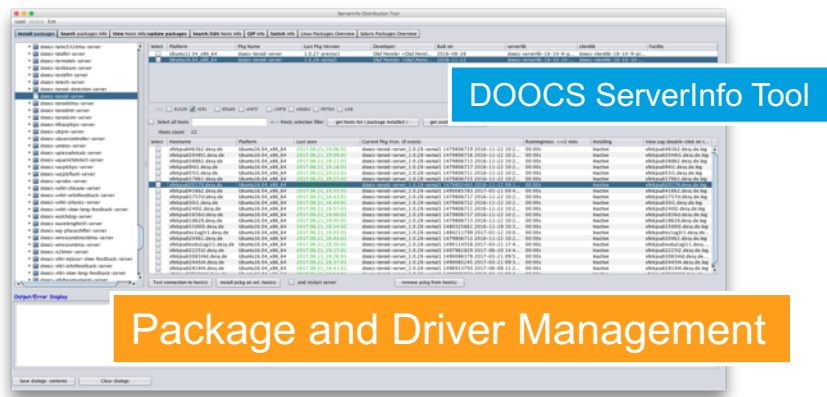
Volts Voltages

14.9	8.0	4.0
2017	2017	2017

Payload

Ports and interfaces

MicroTCA Crate And Module Management



**DOOCS ServerInfo Tool**

Search packages only View from which package Search with filters QP only Search only Line Package Overview Select Package Overview

Name	Profile	Play Name	Last Play System	Description	Build on	Language	OsArch	OsType
libstdc++6	amd64	libstdc++6	amd64	GNU Standard C++ Library v3	2017-05-15 19:19:00	amd64	linux	amd64
libstdc++6	amd64	libstdc++6	amd64	GNU Standard C++ Library v3	2017-05-15 19:19:00	amd64	linux	amd64

Package and Driver Management

# Experiences

First User Runs

# Status

## Some Numbers Of The Accelerator Control System

- More than 9 million addressable DOOCS control system parameters visible in accelerator namespace
- About 600.000 local DOOCS archives plus TINE central archive
- More than 13.000 DOOCS channels from MicroTCA front-ends are sent to the DAQ producing data of up to 30 TB/day
- About 30 different kinds of MicroTCA-based software applications are in use
- Redundant server infrastructure for essential services

**Namespace Browser**

The interface shows a tree view of the accelerator namespace. The left pane lists devices like 'KXEL\_VAC', 'KXEL\_CRATE', and 'KXEL\_DIAG'. The right pane shows a list of 25 values for the selected parameter 'KXEL\_VAC/ABSORBER/KTD2\_V1000M.STATE', including 'STP\_PENDING\_ERROR\_STATUS', 'STP\_NEWERROR', and 'SET\_ONLINE'. Below the browser is a 'Histories' plot showing the value of 'C1.MI.ACC1/PROBE.AMPL.SAMPLE' over time from 11.11.2015 to 21.11.2015. The plot shows a signal fluctuating around 20, with a sharp peak reaching approximately 25 on 16.11.2015.

**MicroTCA Module List**

The screenshot shows two windows: 'XFEL MicroTCA Crates' and 'AMTF MicroTCA Crates'. The 'XFEL MicroTCA Crates' window lists modules like 'KXELMCH1311', 'KXELMCH1312', and 'KXELMCH1313'. The 'AMTF MicroTCA Crates' window lists modules like 'MSKAMCHAMTF1', 'MSKAMCHAMTF2', and 'MSKAMCHAMTF3'. Below these is a detailed table of modules with columns for 'Crate', 'Fans', 'Power Modules', and 'Serial'. The table lists various modules such as 'RTM11', 'RTM10', 'RTM12', 'RTM8', 'RTM5', 'RTM4', 'RTM3', 'RTM2', 'AMC3', 'COOL\_UNIT1', 'COOL\_UNIT2', 'AMC2', 'AMC4', and 'AMC1'.

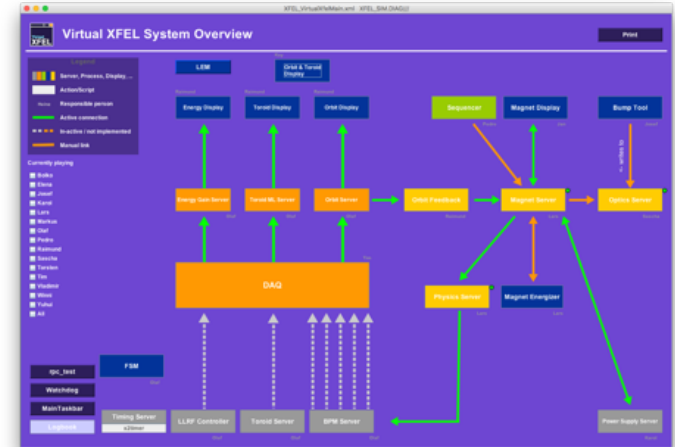
- About 230 MicroTCA systems online as of November 2017
- More than 3000 MicroTCA modules (just AMC, RTM, P/S, MCH) installed at the XFEL accelerator control system
- Timing System: > 300 modules
- ADC AMC kinds: > 400 modules
- DAMC2 variants: > 500 modules



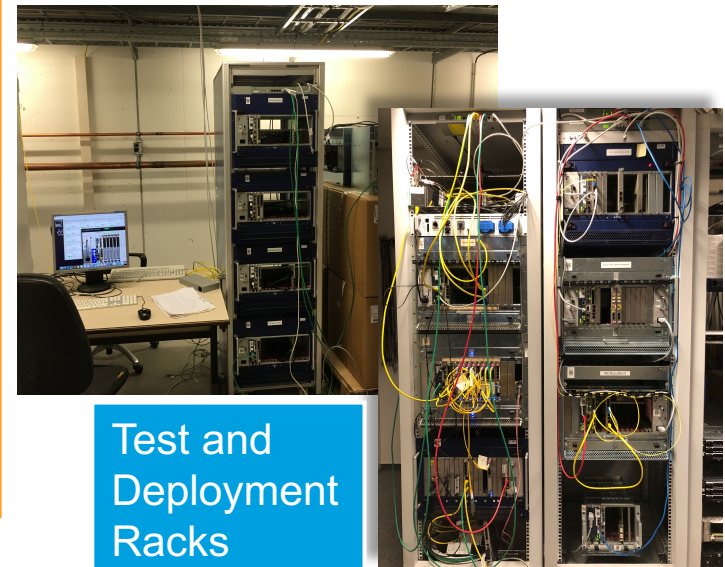
# Experiences

## Some Experiences With MicroTCA Components In The Accelerator Control System

- **FLASH accelerator** has been proven to be extremely useful as a testbed for deploying MicroTCA technology and testing software “in the field”
- **Virtual XFEL** instance helped implementing new software concepts and testing it
- Teething trouble with MicroTCA components and system integration mostly solved by now
- Various smaller issues likely related to operations – e.g. radiation-induced failures (SSD, some electronics)
- **Remote management** of crates and modules through IPMI and **hot-swap capability** paid off well during commissioning stages already
- MicroTCA systems combine several accelerator subsystems – maintenance challenge at this scale
- Teststands (Lab, XFEL setup area) are indispensable even more so after installation and commissioning phase is done



Virtual XFEL System As Testbed



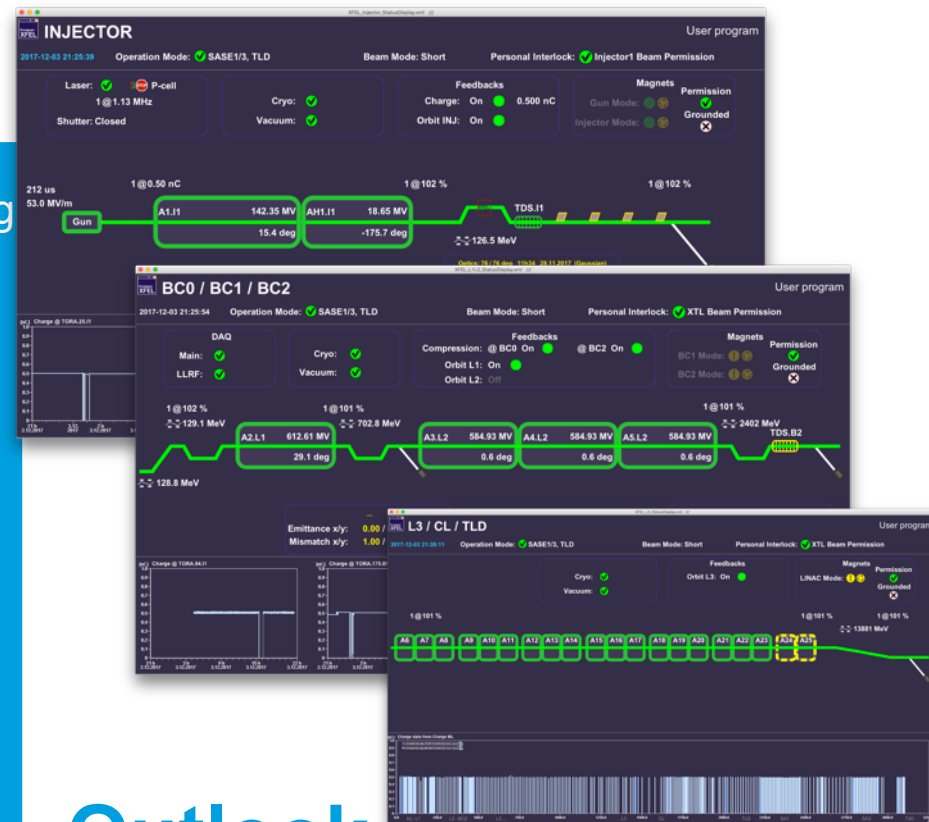
Test and Deployment Racks

# Summary

Conclusions And Outlook

# Summary

- The European XFEL accelerator is operating in production mode serving photon science users
- The control system for the European XFEL linear accelerator has been operable from day one!
- Standardization of hardware and software simplified implementation and deployment
- Fast and successful commissioning of the accelerator control system
- MicroTCA.4 hardware platform well established at the European XFEL



## Outlook

- Start parallel operations with multiple electron and photon beam lines in 2018 – will profit from FLASH experience
- Regular scheduled user runs for photon science experiments
- Long-term experience ...



# Thanks for your attention!

DESY Control Room – XFEL Area



Many Visits By TV Crews ...