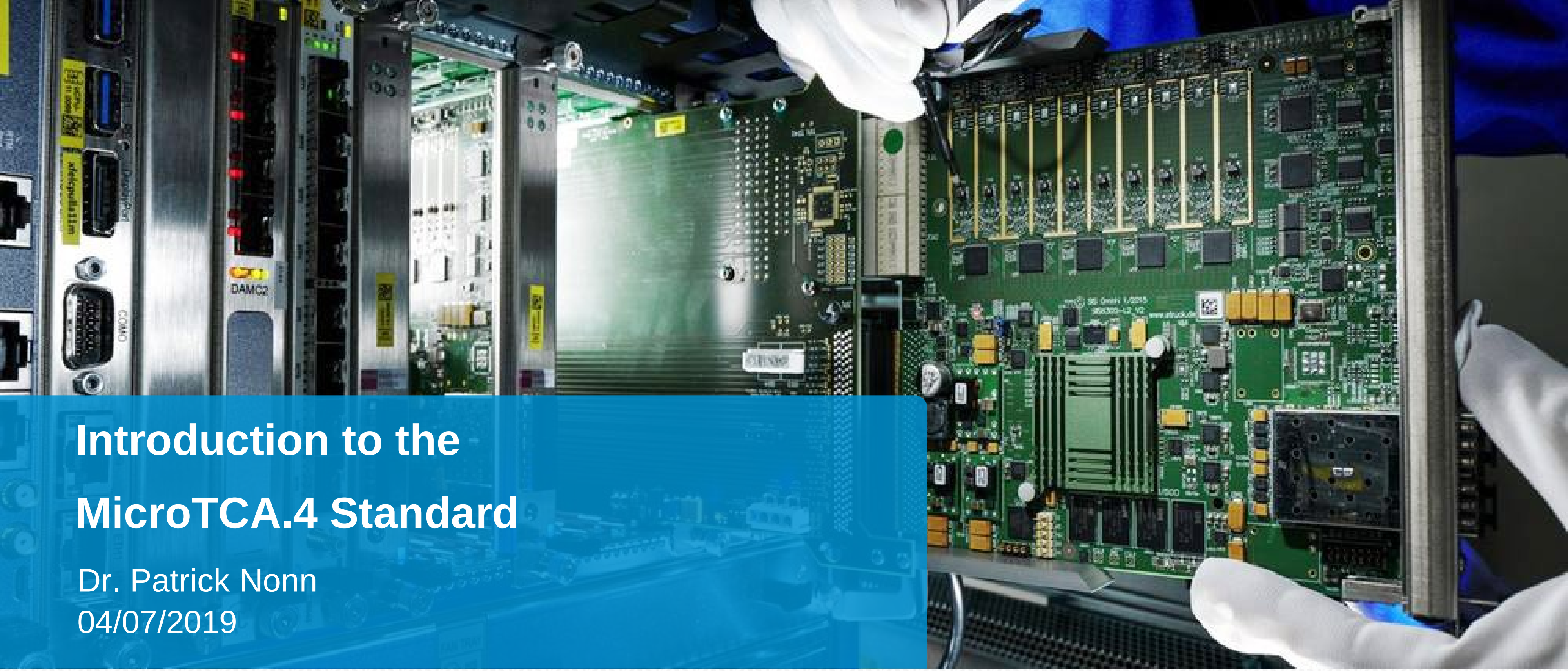



# Introduction to the MicroTCA.4 Standard

Dr. Patrick Nonn

04/07/2019

# AGENDA

1. MicroTCA.4 in a nutshell
   - Motivation
   - Main Components
2. Use Cases
   - LLRF Systems
     - European XFEL
     - LILAC (NICA)
   - GigE Vision
3. What is MicroTCA Technology Lab?
   - Where we come from
   - Services


# What is ...

μTCA®

# Requirements

- European XFEL systems need high availability
  - More Uptime → Redundancy
  - Less Downtime → Remote Management
- Also important:
  - Low-noise signal transport
  - Precision timing
  - Compact form factor
- VME-crates provide none of the above
- Where else are requirements similar? **Telecommunication**

$$Availability = \frac{Uptime}{Uptime + Downtime}$$

# What is MicroTCA?

## Micro Telecommunications Computing Architecture

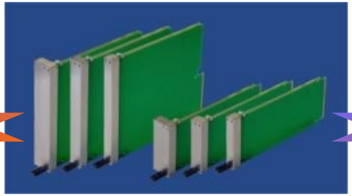
- An open, modular standard for high performance computing system, based on PCI Express
  - Evolved from Advanced Telecommunications Computing Architecture (ATCA)
- AdvancedTCA and MicroTCA both use Advanced Mezzanine Card (AMC) standard
  - Hot-swappable cards
  - Fully managed infrastructure
- Supports redundant power supplies and shelf controller

ATCA Crate

AMC Carrier

MicroTCA Crate

AMC



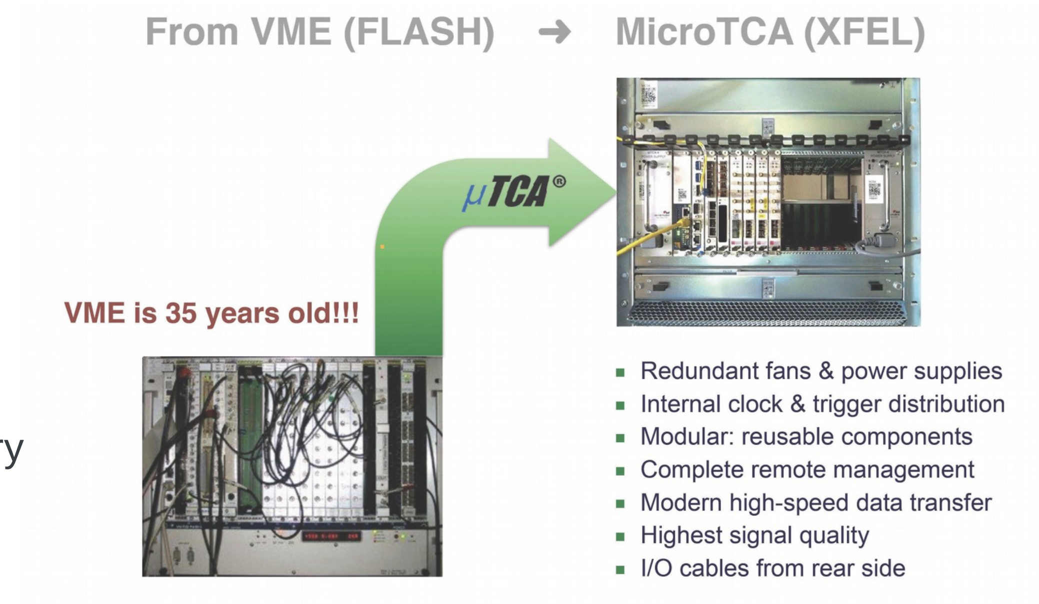
# Motivation for MicroTCA.4 Standard

MicroTCA lacks…

- High precision timing
- Rear input/output

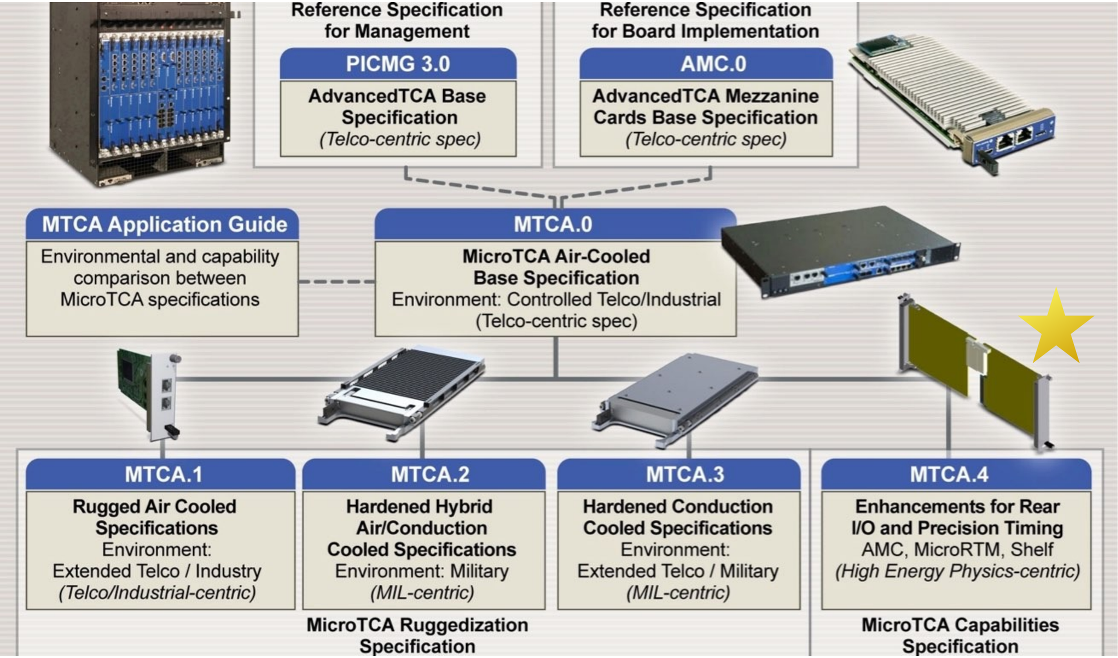
New MicroTCA standard was developed:

- MicroTCA.4
- Specifically for science and similar industry application



# Composition of the MicroTCA Standard

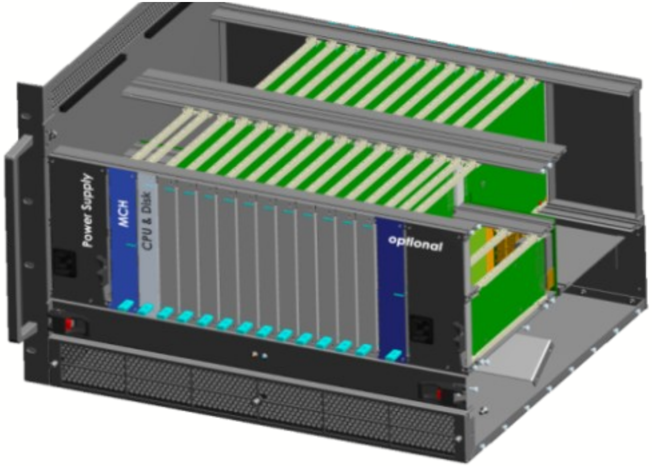
- MicroTCA.0
  - originates in telecommunication
  - base for subsequent standards
- MicroTCA.1 to MicroTCA.3 are various levels of ruggedized variants
- MicroTCA.4 was developed with scientific application in mind



# MicroTCA.4 Hardware: Overview

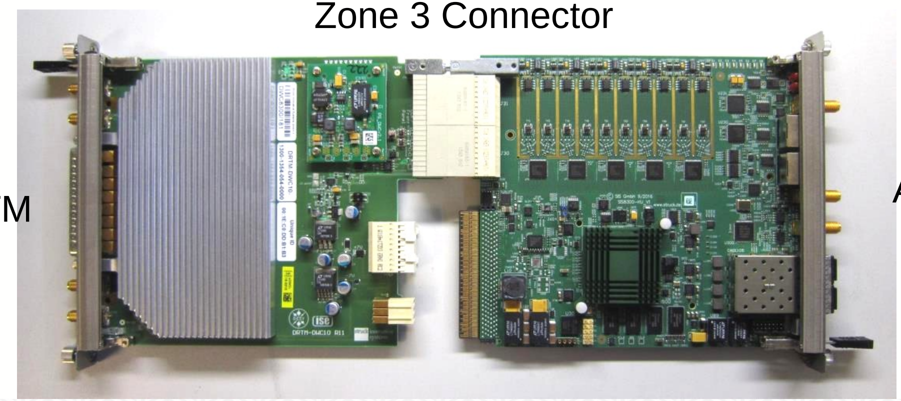
Essential Parts for MTCA.4 System

- Crate with Backplane
- Power Supply Module (PM)
- Cooling Unit (CU)
- MicroTCA Carrier Hub (MCH)
- Advanced Mezzanine Card (AMC)
- Rear Transition Module (RTM)



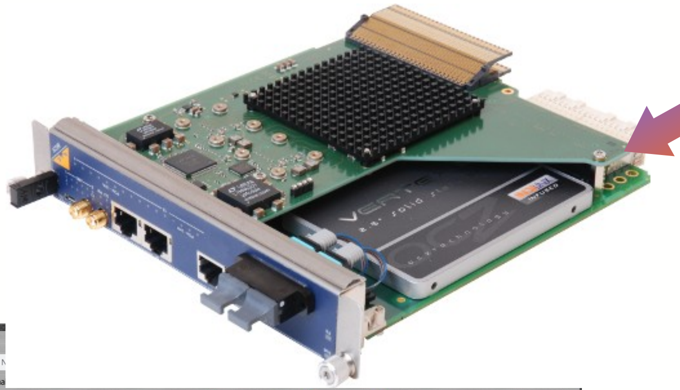

Zone 3 Connector

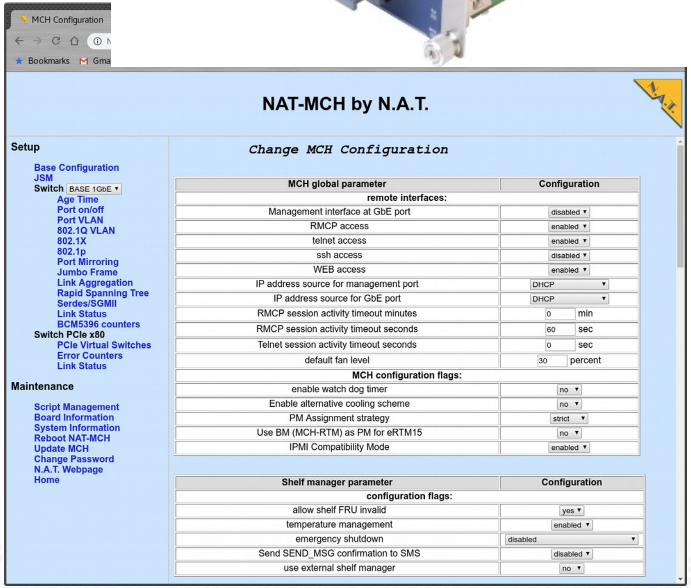
RTM



AMC

# MicroTCA.4 Hardware: MCH




MCH Configuration

Bookmarks

## NAT-MCH by N.A.T.

**Setup**

- Base Configuration
- JSM
- Switch BASE 1GbE
  - Age Time
  - Port on/off
  - Port VLAN
  - 802.1Q VLAN
  - 802.1X
  - 802.1p
  - Port Mirroring
  - Jumbo Frame
  - Link Aggregation
  - Rapid Spanning Tree
  - Serdes/SGMII
  - Link Status
  - BCM5396 counters
- Switch PCIe x80
  - PCIe Virtual Switches
  - Error Counters
  - Link Status

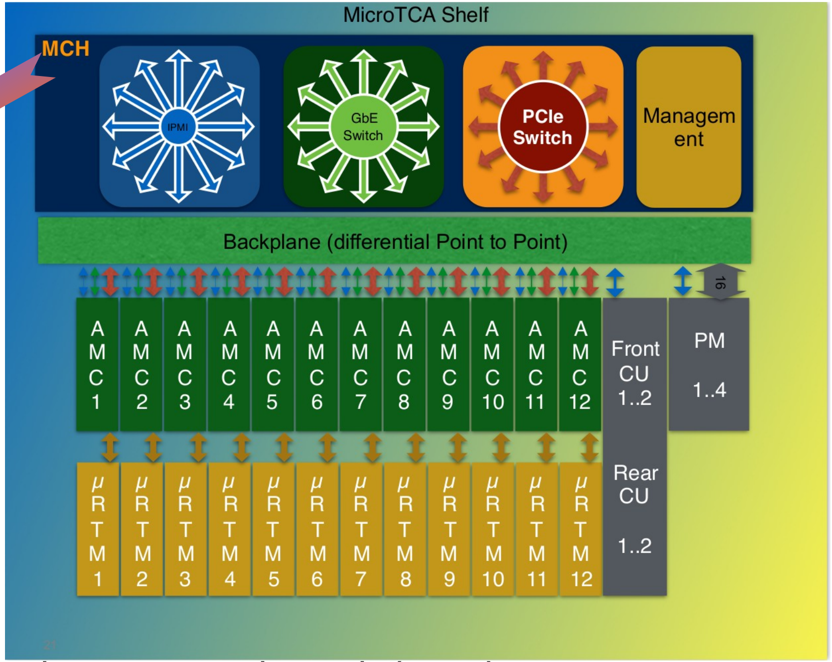
**Maintenance**

- Script Management
- Board Information
- System Information
- Reboot NAT-MCH
- Update MCH
- Change Password
- N.A.T. Webpage
- Home

*Change MCH Configuration*

| MCH global parameter | Configuration |
|---|---|
| **remote interfaces:** | |
| Management interface at GbE port | disabled |
| RMCP access | enabled |
| telnet access | enabled |
| ssh access | disabled |
| WEB access | enabled |
| IP address source for management port | DHCP |
| IP address source for GbE port | DHCP |
| RMCP session activity timeout minutes | 0 min |
| RMCP session activity timeout seconds | 60 sec |
| Telnet session activity timeout seconds | 0 sec |
| default fan level | 30 percent |
| **MCH configuration flags:** | |
| enable watch dog timer | no |
| Enable alternative cooling scheme | no |
| PM Assignment strategy | strict |
| Use BM (MCH-RTM) as PM for eRTM15 | no |
| IPMI Compatibility Mode | enabled |

| Shelf manager parameter | Configuration |
|---|---|
| **configuration flags:** | |
| allow shelf FRU invalid | yes |
| temperature management | enabled |
| emergency shutdown | disabled |
| Send SEND_MSG confirmation to SMS | disabled |
| use external shelf manager | no |




MicroTCA Carrier Hub (MCH)

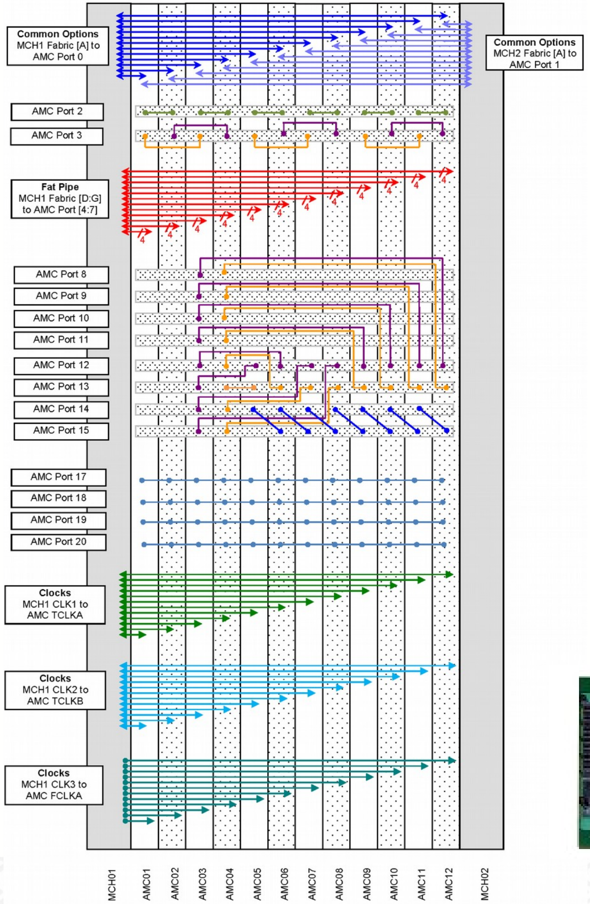
- Platform management
- Remote Access
- Crosspoint switches
- Hot-swap handling

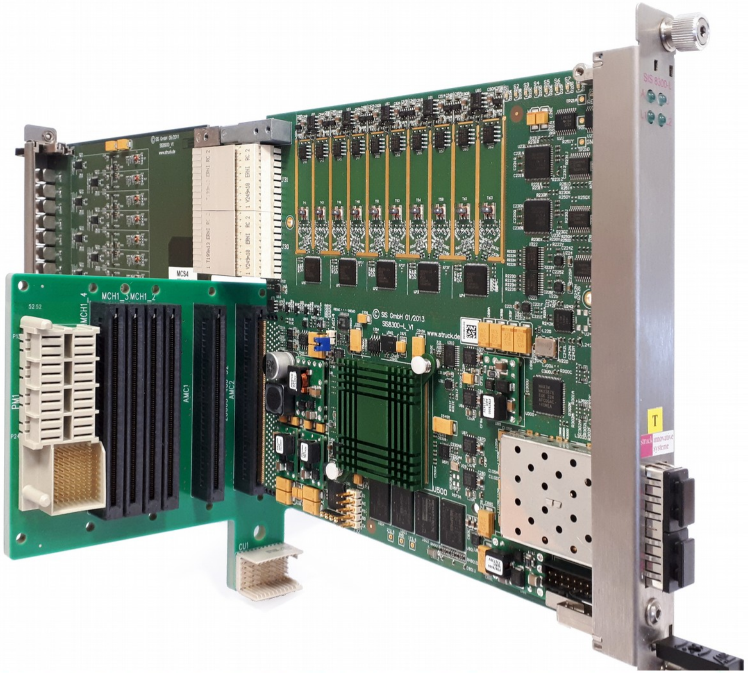
2017 N.A.T. GmbH MTCA.4 Training Slides, Vollrath Dirksen

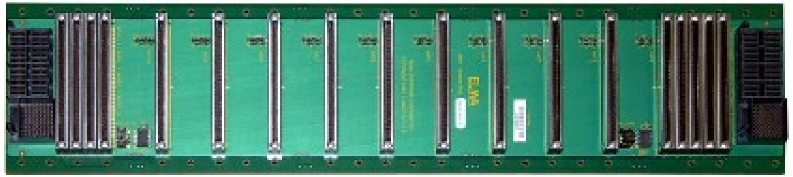
# MicroTCA.4 Hardware: AMC Backplane

Backplane Contents

- GigabitEthernet
- SATA
- PCIe x4 and/or RapidIO
- Clocks
- Interlocks
- Triggers
- JTAG
- IPMI
- Point-to-point Connections

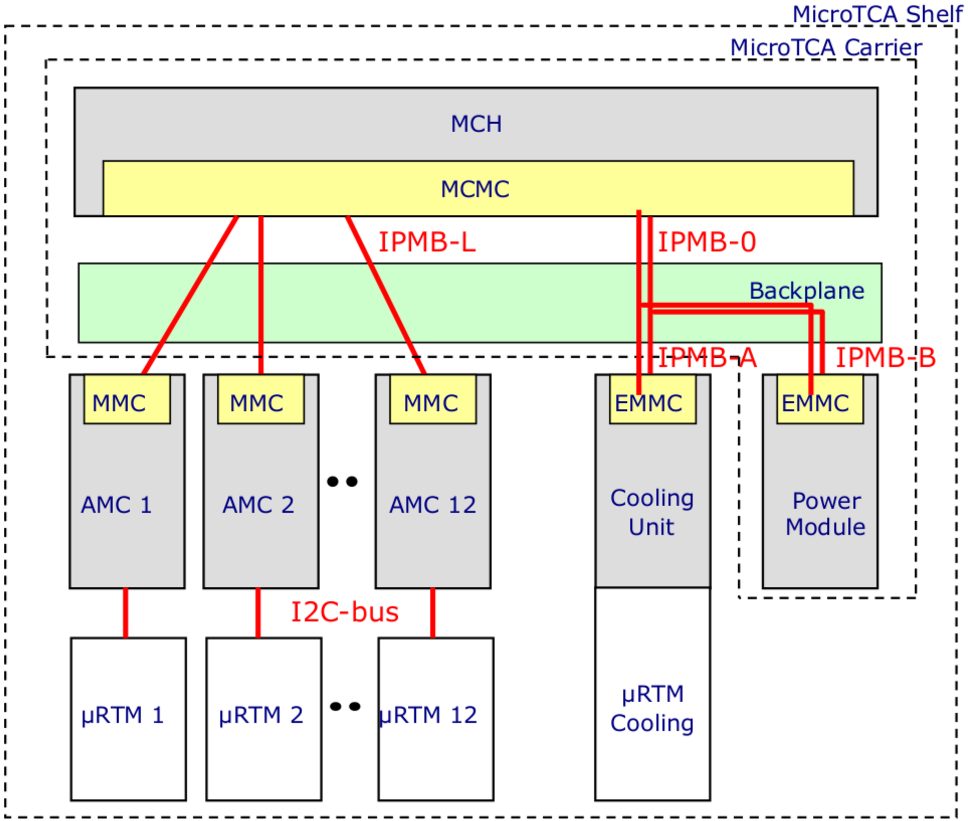


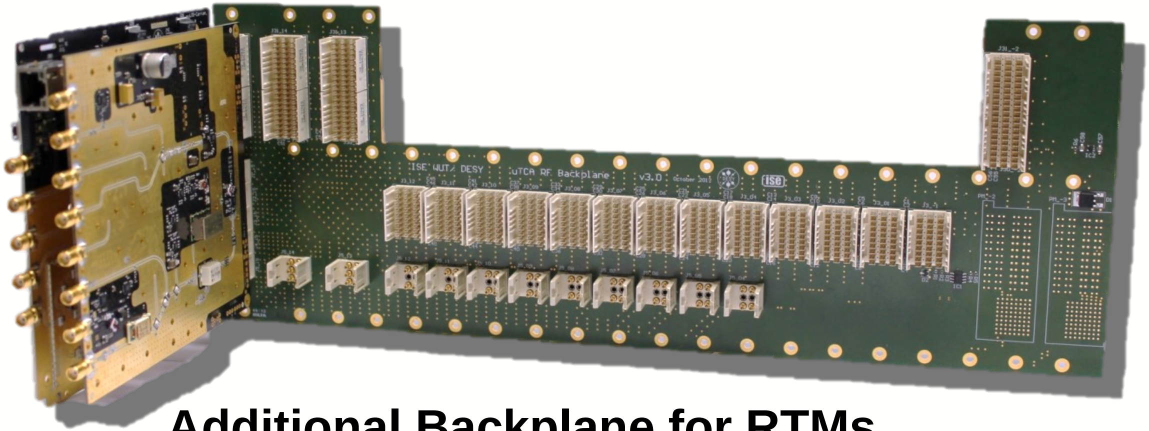


# MicroTCA.4 Management: IPMI Bus

- Intelligent Platform Management Interface
  - Management and monitoring capabilities independent from the host system's CPU
- Led by Intel in Sept. 1998
- I2C based serial bus
- Identify hardware (FRU)
- Hardware diagnostics (tempature, expected current consuption etc.)
- Initiate boot up and shutdown
- Logging of events



# MicroTCA.4.1: RF Backplane




## Additional Backplane for RTMs

- Three extra slots for RF/clock signal generation and distribution modules
- RF signal distribution over backplane, thus reduced RF coaxial cabling usage
- Supports up to 3 extended RTMs (RTMs without AMC)
- Shielding from digital noise from AMCs
- Up to 2 power supply RTMs with low-noise, separated, analog, bipolar power distribution
- MCH-RTM for system management of RTMs

# MicroTCA in Comparison to Competing Standards

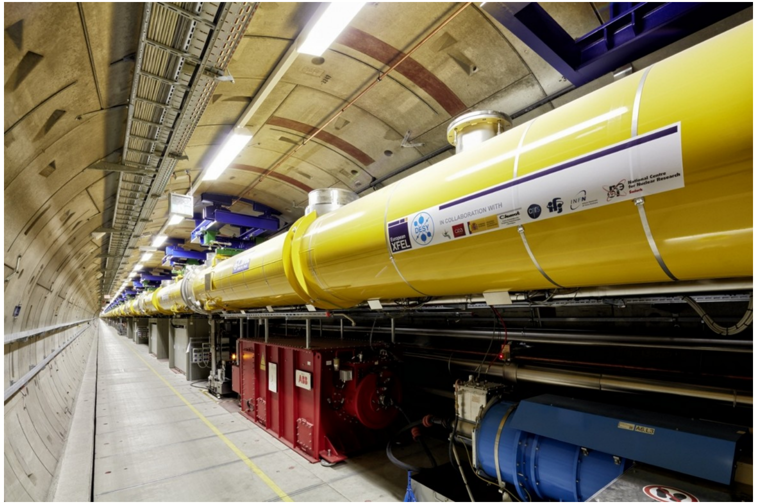
| | ATCA | VME (VXS) | cPCI (serial) | VPX | MicroTCA.4 |
|---|---|---|---|---|---|
| Board size (mm) | very large 280x320 | medium 230x160 | small 100x160 | medium 230x160 | **medium** 150x180 |
| Rear Extension | small | small | (no) | small | **large** |
| Typical power per slot | 450W+ | 200W+ | 120W | 150W | 80W |
| Managed | YES | no | no | (no) | **YES** |
| Lane speed | 10-25Gbps | parallel/6Gbps | 10Gbps | 10Gbps | 10Gbps |
| Application area | Telecom/ Physics | Industry | Industry | Military/ Industry | Physics/ Industry |

# Use Cases of

μTCA®

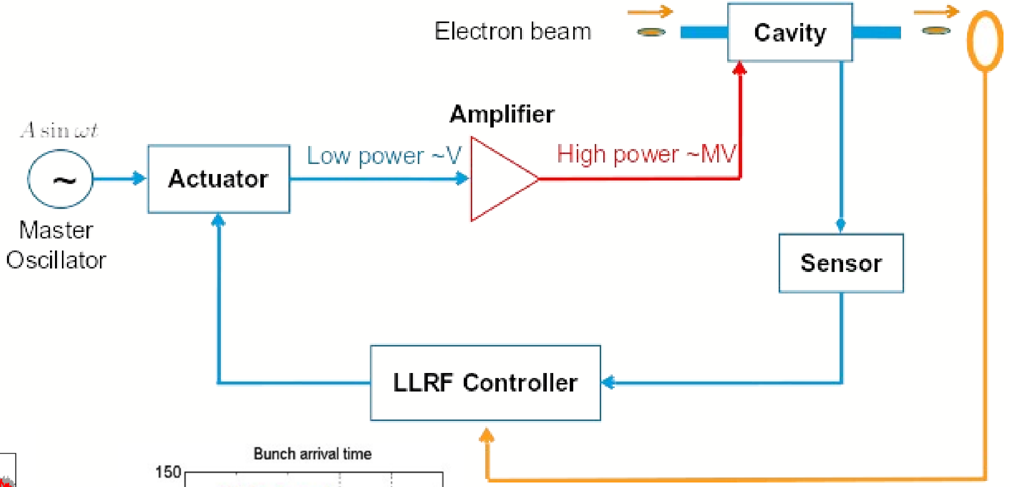
# MicroTCA in European XFEL

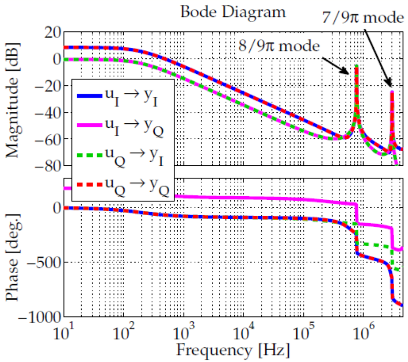

- Biggest success story of MicroTCA
- 800 Superconducting Cavities
- Over 200 MicroTCA Crates ( > 2000 components)
  - LLRF
  - Synchronization
  - Timing
  - Beam Diagnostics

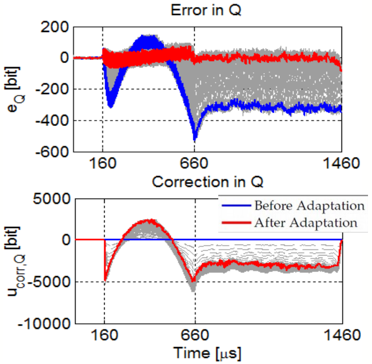


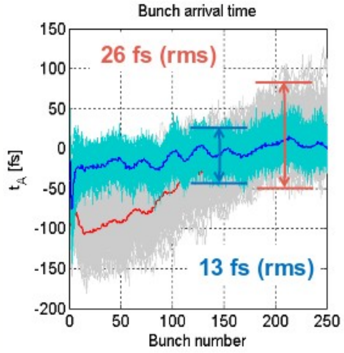
# European XFEL: Precision RF Controls

1. System characterization
2. RF Feedback controller design
3. Iterative learning controller design
4. Beam-based feedback



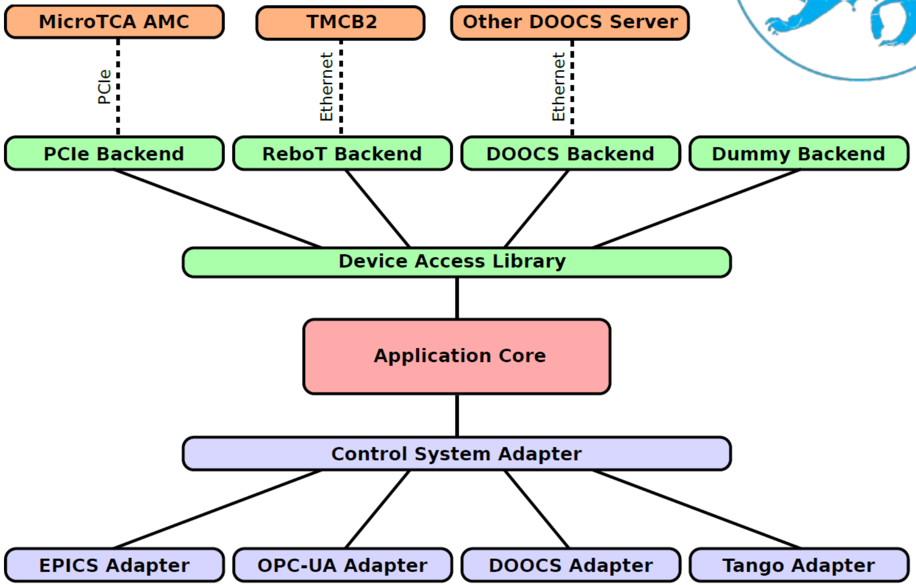




**Specification for RF Field Control**
***ΔA/A < 0.01 % and Δφ < 10 mdeg.***

# European XFEL Software: ChimeraTK

- In order to access the data from the MicroTCA.4 crate bidirectionally over PCIe bus, the ChimeraTK framework was developed at DESY.
- The scope of this toolkit focuses on abstracting specifics of the underlying system, as well as giving the user the ability to create a portable **user applications across different control system choices**
- One application (e.g. LLRF Server) can be adapted for various hardware and control systems

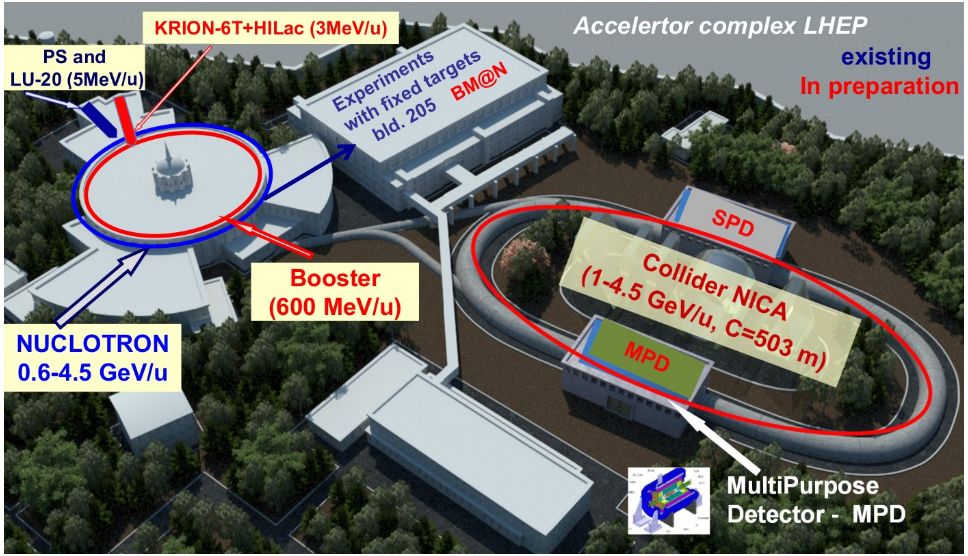


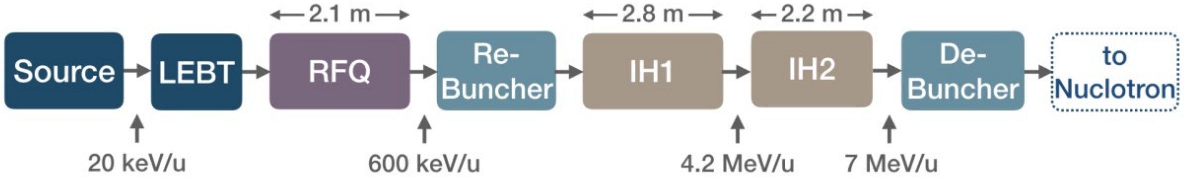

https://github.com/ChimeraTK

# LLRF Project Example: LILAC

## Upgrade of LU-20 to Light Ion Linear Accelerator (LILAC)

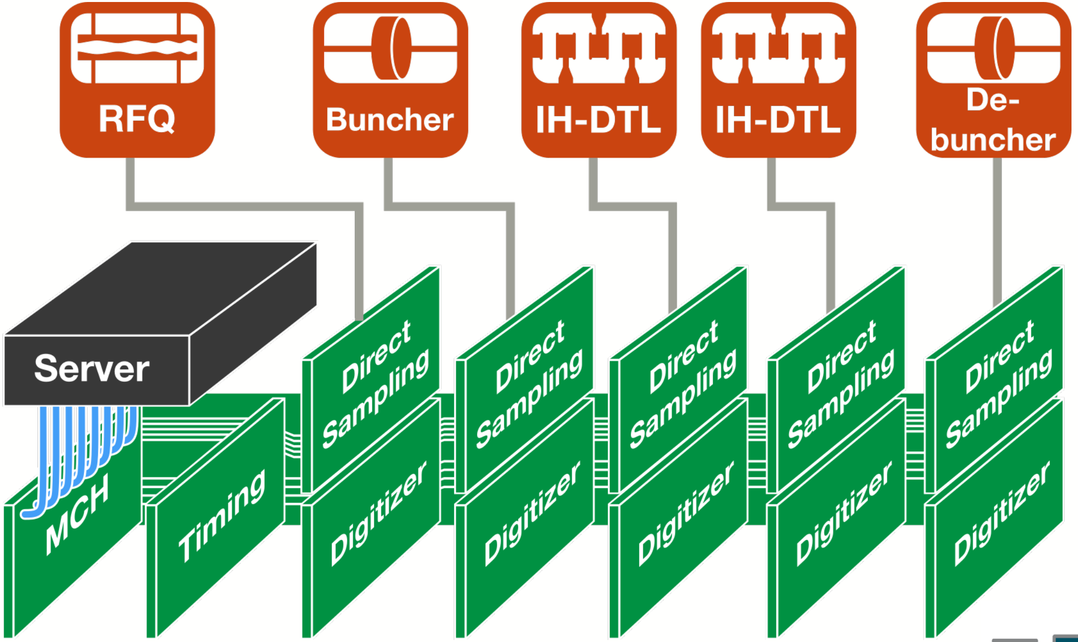
Nuclotron-based Ion Collider Facility
Dubna/ Russia



# NICA LiLAC LLRF Overview


1 – MicroTCA-Crate
2 – External CPU
3 – Signal-/Clock Generator (Master Oscillator)



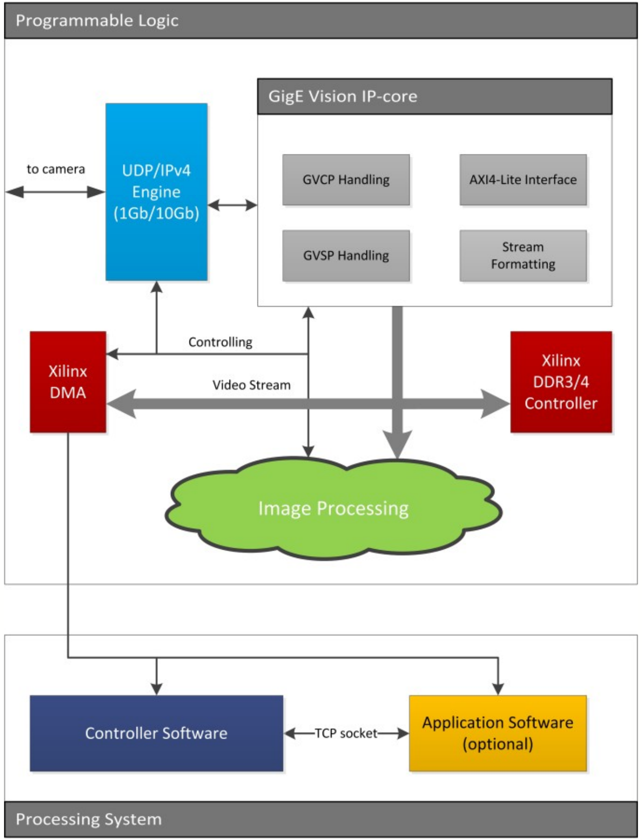

In cooperation with BEVATECH

# DIPC-7050 GigE Vision Stack

System architecture for operating GigE Vision standard compliant cameras in a FPGA/SoC based environment.

## Features

- Support for Xilinx 7-Series, Zynq, Ultrascale and Ultrascale+ devices
- AXI4 compliant interfaces
- Synchronization between camera devices using IEEE 1588 or external trigger
- Support for x86 and ARM architectures

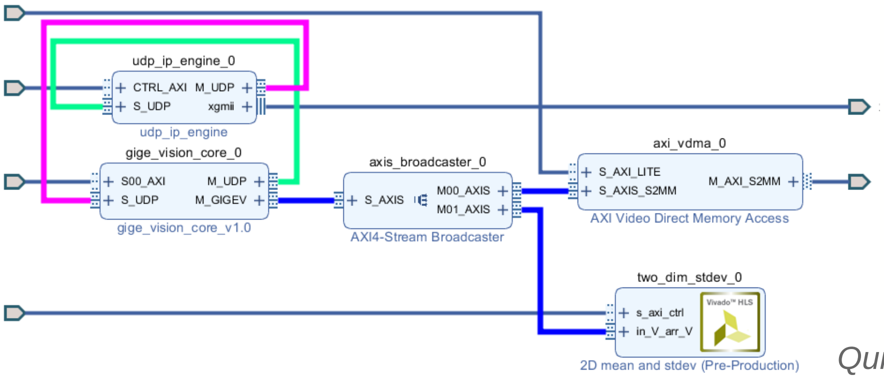


# MicroTCA.4 GigE Vision: Applications

## Camera-based diagnostics for beamlines at PETRA III (DESY)

Typical applications: Scintillator screens for diagnostics of X-ray beams,

- Beam center and its distribution can be calculated from the image
- GigE Vision cameras are a popular choice for such applications



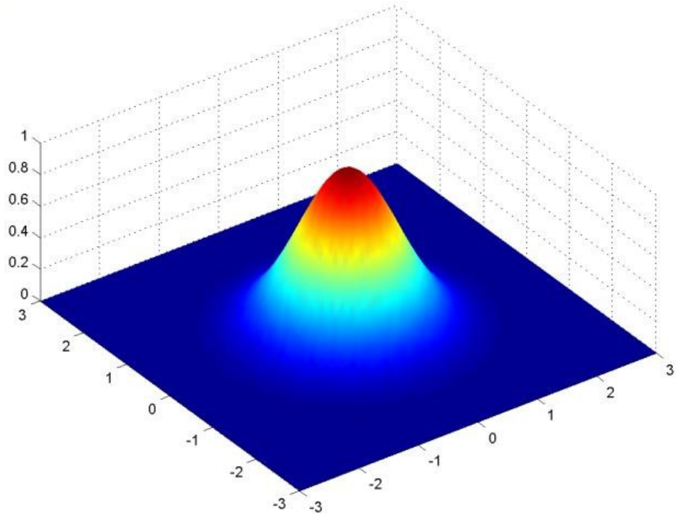



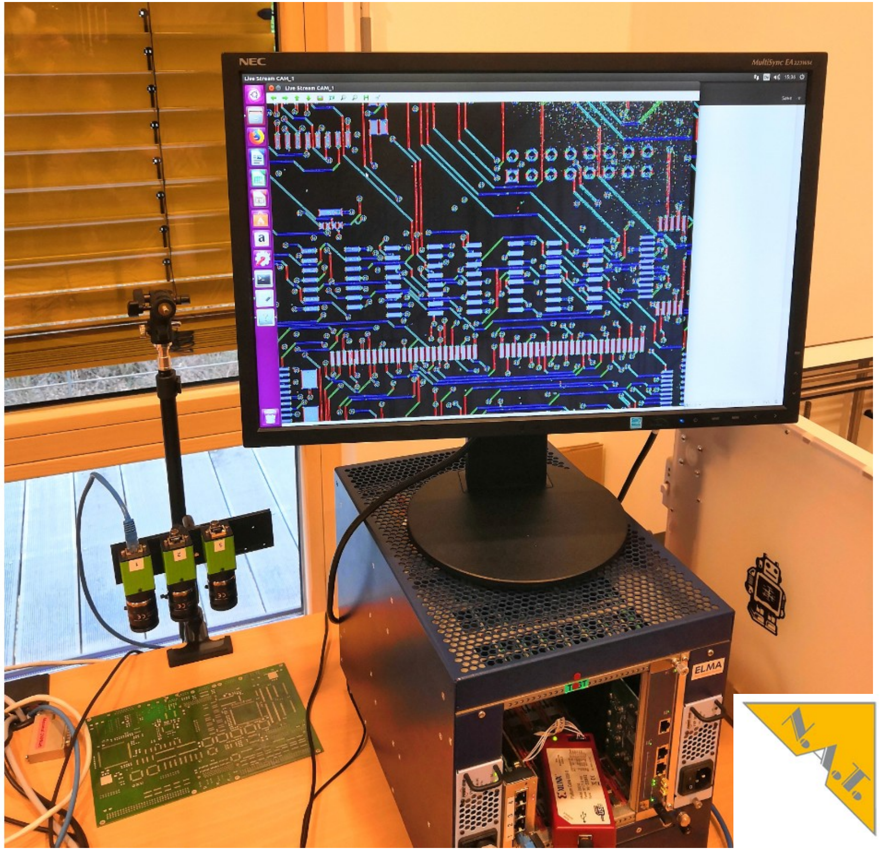
*Fig. Visual representation of a beamline center position calculation*

*Quick setup with Xilinx Vivado IP Integrator*

# MicroTCA.4 GigE Vision: Applications

Quality Assurance

- Automated, optical product testing



# Facilities with MicroTCA Installations

KIT Karlsruher Institut für Technologie

CERN

diamond

ess EUROPEAN SPALLATION SOURCE

IHEP

PAL

HZDR

LNLS sirius

SPring-8

KEK-JAPAN

Oak Ridge National Laboratory

IPP W7-X

HZB Helmholtz Zentrum Berlin

Australian Synchrotron

SOLEIL SYNCHROTRON

CANDLE

SINAP

GSI

SLAC NATIONAL ACCELERATOR LABORATORY

iter

TARLA Turkish Accelerator and Radiation Laboratory in Ankara

FRIB

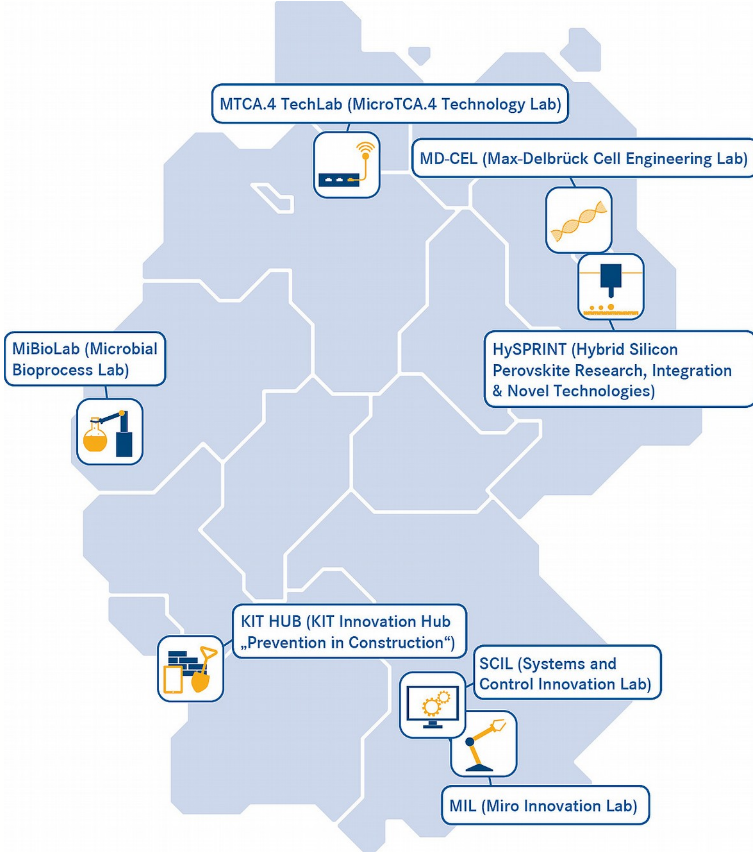
# Introduction

# MicroTCA Technology Lab: Mission

- *Transfer MicroTCA.4 Technology from Science to Industry*
- *Promote and provide support for the science community in regards of MicroTCA.4*
- *Foster the community and support future development*
- *Enabling space for innovative ideas and new business models*

# MicroTCA Technology Lab: A Helmholtz Innovation Lab

- Part of Helmholtz Innovation Labs (HGF Validation Fund)
  - Finance instrument to support the spin-off and technology transfer from scientific and technical inventions or developments from HGF centers to the industry and society
- 5M € over 5 years
- Started renovation for office space + Hiring around Oct. 2016, official opening April 2018



# MicroTCA Technology Lab: Staff and Relations

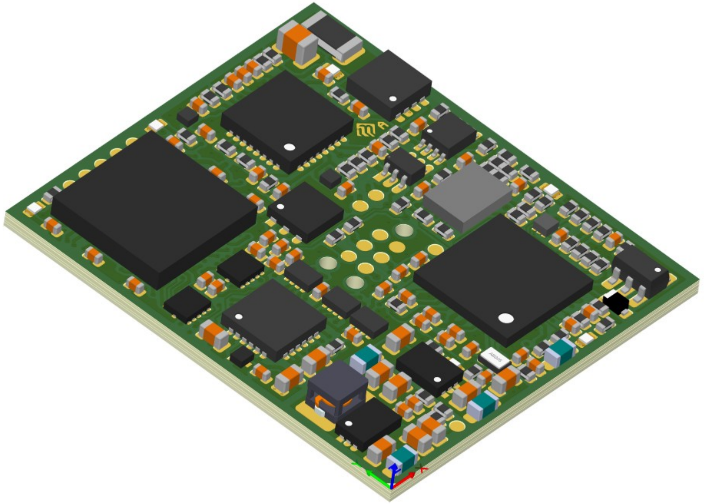
- ~ 10 FTE for MicroTCA Technology Lab
  - Hardware, Firmware and Software Developer
- Close collabration with Machine Beam Control Group of DESY (MSK)
  - >60 FTE (~25 FTE for LLRF)
- MSK Responsibilities:
  - LLRF Control Systems for Accelerator Structures
  - Special Diagnostic Devices
  - Beam Stabilization Systems (transversal/longitudinal) in storage rings & linacs
  - Timing for accelerator infrastructure (e.g. Klystron)

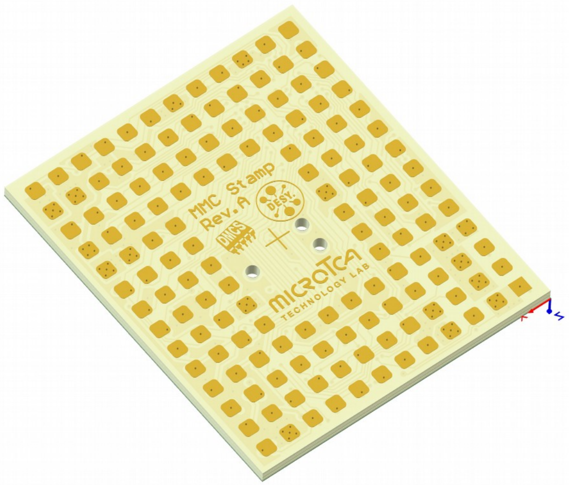
# MicroTCA Technology Lab: MMC Stamp

Module Management Controller (MMC) Stamp: Compact solution to realize IPMI controller on the AMC card.

Speed-up your board design + Prevents reinventing the wheel

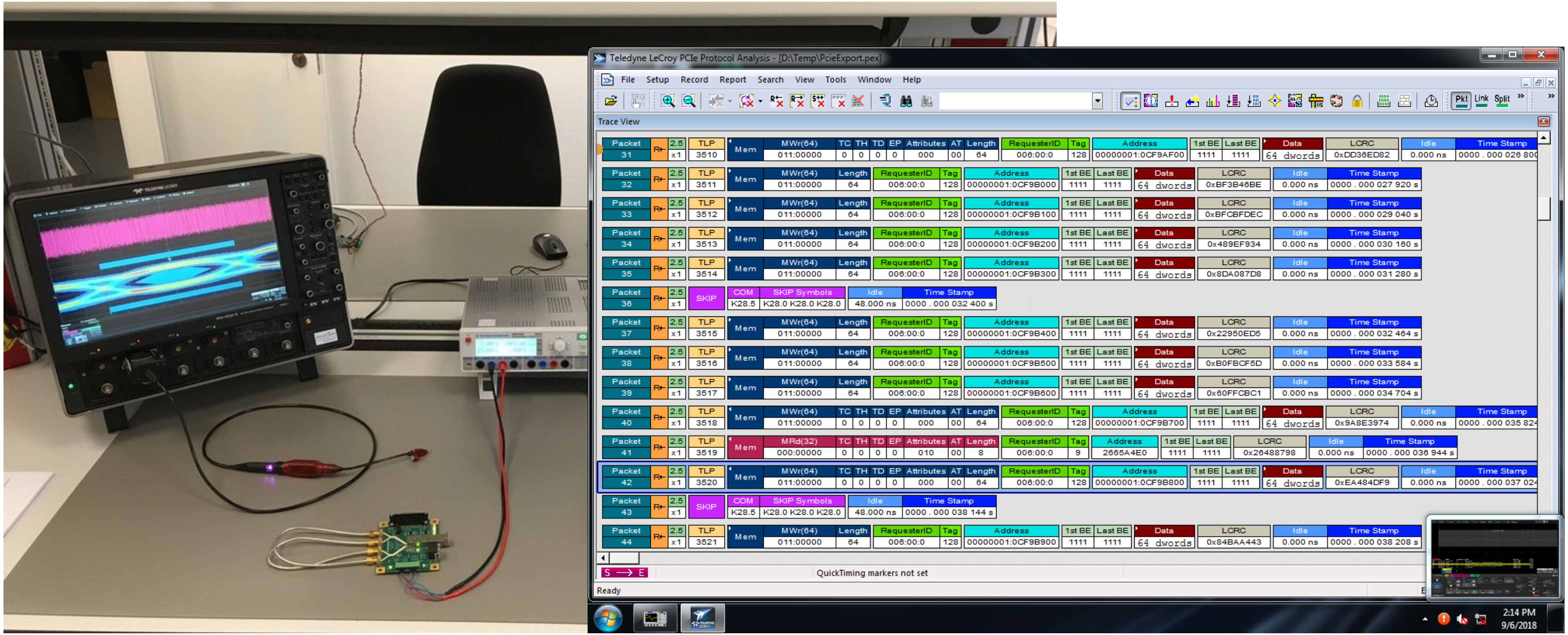
**We also provide Altium Design Templates**





# MicroTCA Technology Lab: Services

Solving high speed signal integrity issues on PCB design, FPGA design etc. using High-end digital measurement equipment (e.g. 80 GSPS LeCroy)



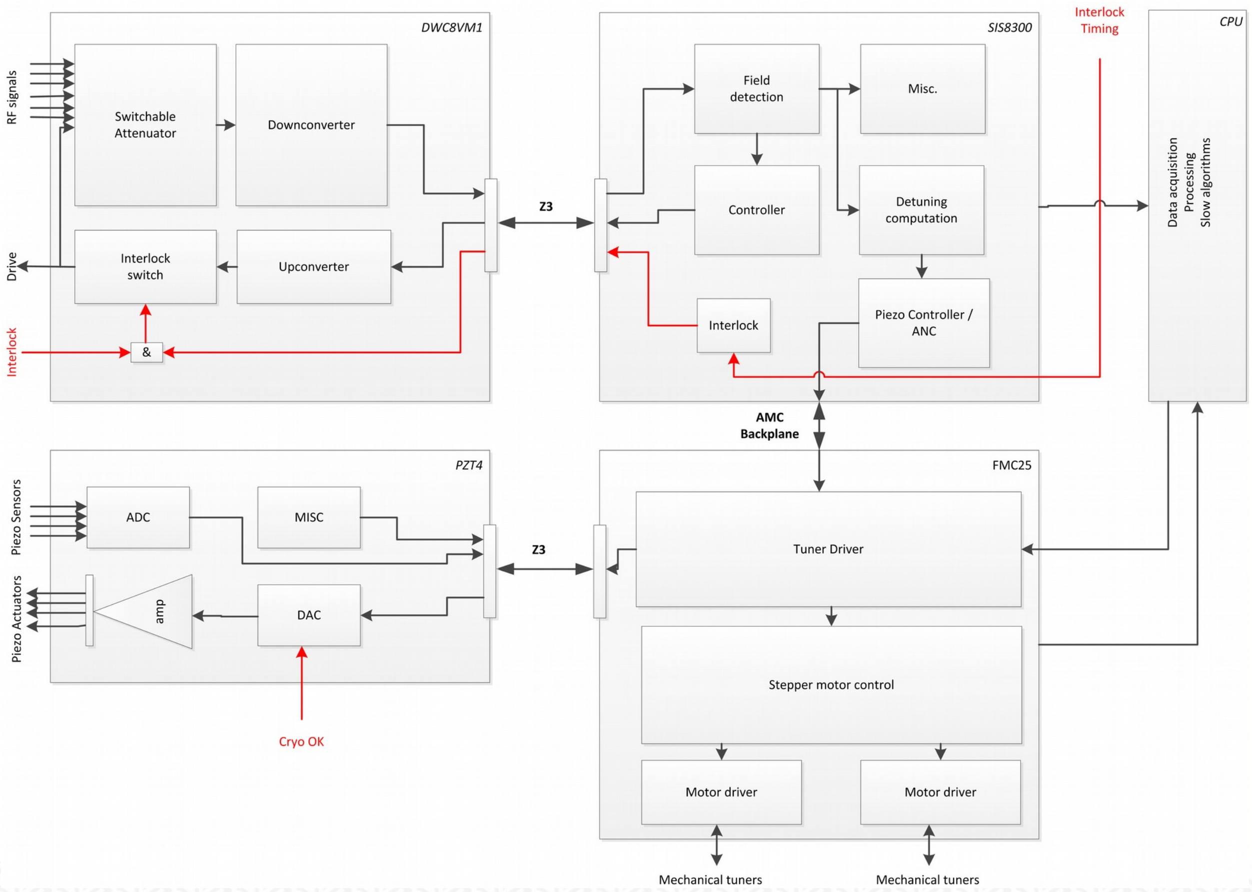
# MicroTCA Technology Lab: Training

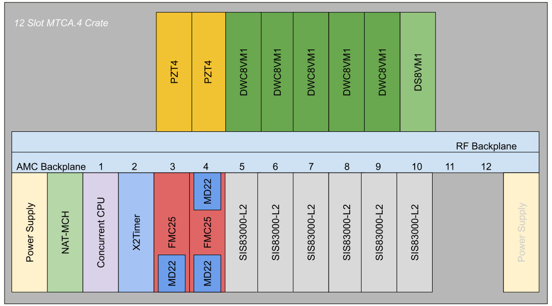
Together with N.A.T. we provide training on MicroTCA

- **Basic Course (2 days):**
  - Introduction to the Hardware
  - Hands-on exercise: Setting up MCH
- **Advanced Course (2 days):**
  - PCI Express and IPMI
  - Hands-on exercise: Maintenance tasks

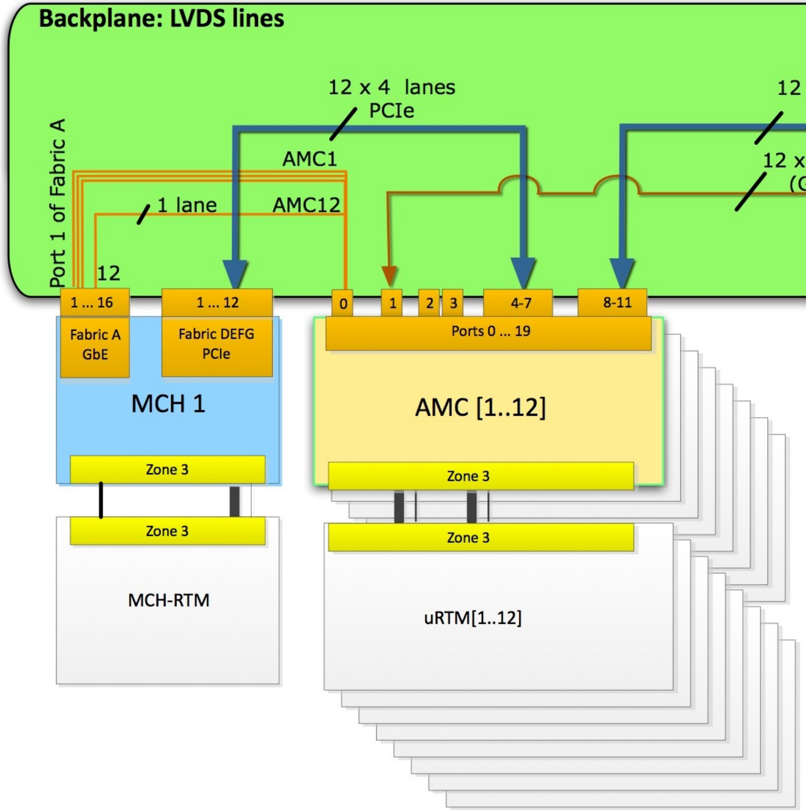

Thank you
for listening

# Example: LLRF and Tuning Control



# MicroTCA.4 Hardware: MCH

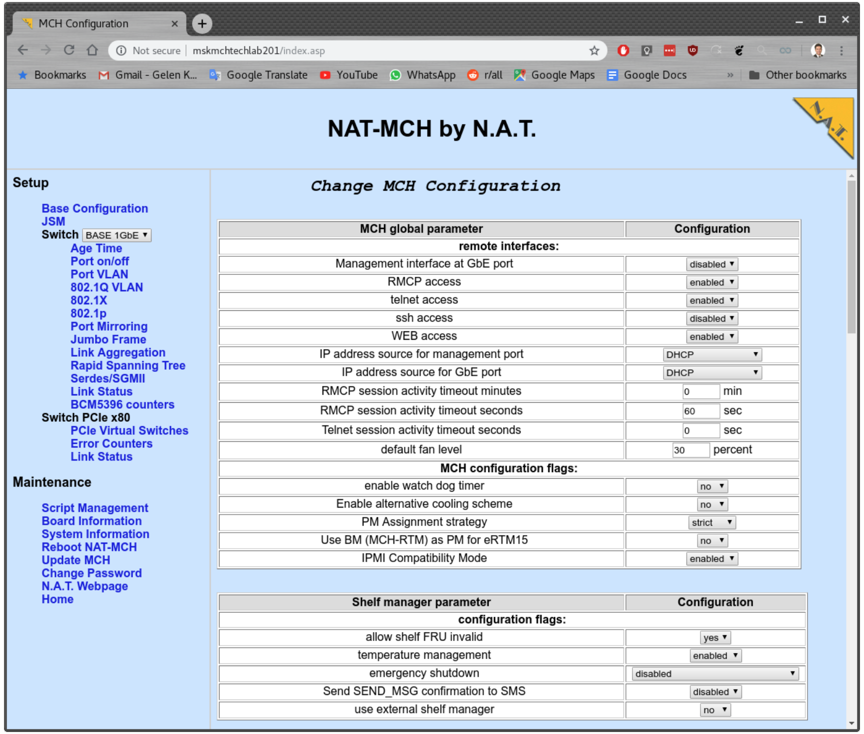


# MicroTCA.4 Hardware: Scalability

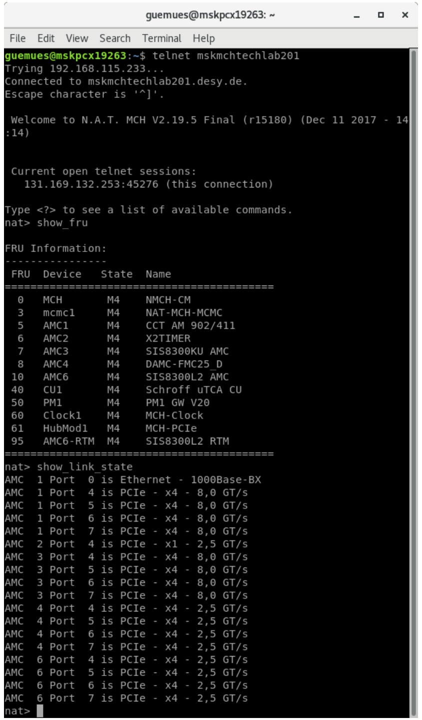
Simple

Complex

# MicroTCA.4 Management: Interface




Web Interface




Telnet (Terminal)

# MicroTCA Technology Lab: Our Partners

| | |
|---|---|
| Bevatech GmbH | CAEN ELS s.r.l. |
| el-spec GmbH | EMCOMO Solutions AG |
| N.A.T. GmbH | nVent Schroff |
| powerBridge GmbH | Rohde & Schwarz |
| Teledyne SP Devices | Struck Innovative Systeme GmbH |
| VadaTech | WIENER Power Electronics GmbH |

# MicroTCA Technology Lab: The Team

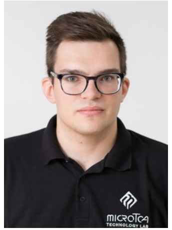
Thomas
Head of Techlab

Michael
Hardware Dev.

Simone
Hardware Dev.

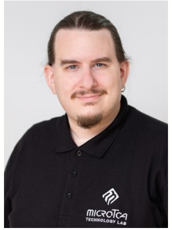
Johannes
PhD. / Hardware Design

Sven
FPGA Firmware Dev.

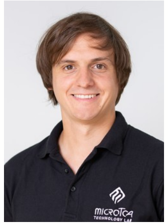


Jan
FPGA Firmware Dev.

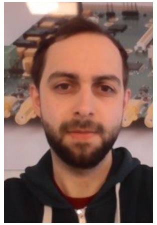
Çağıl
LLRF Expert/
FPGA Firmware Dev.



Patrick
LLRF Expert



Christoph
Software Dev.



Aaron
Software Dev.

# European XFEL Software: ChimeraTK GUIs

- The ChimeraTK software toolkit has control system adapters to EPICS, DOOCS and OPC-UA
- Adapters for other control systems can be added by everyone
- Control System Studio (CSS) LLRF Panels available for free on Techlab Gitlab