



Summary of the 9th MicroTCA Workshop @ DESY 1st – 3rd of December 2020

Holger Schlarb, Group leader MSK/DESY
DESY, 24.08.2021

MicroTCA Workshop goals & motivation ...

Provide an international forum for the regular exchange of information on MicroTCA systems to foster

- **Communication** between researchers from different institutes and areas
- Close exchange of **industry and researchers** on products and services
- **Reuse of existing hardware** in projects to reduce market prices & improve matureness
- Identify and trigger **missing hardware development** (expanding product portfolio)
- Identify and overcome **interoperability** issues (may caused by the various interfaces)
- **Exchange of know-how** to achieve high performance & high availability while providing complex and highly specialized functionalities
- **Forward development** on the MicroTCA standard

Buildup and expand a sustainable MicroTCA ecosystem of Users & Producers

9th MicroTCA Workshop for Industry & Research

Statistics

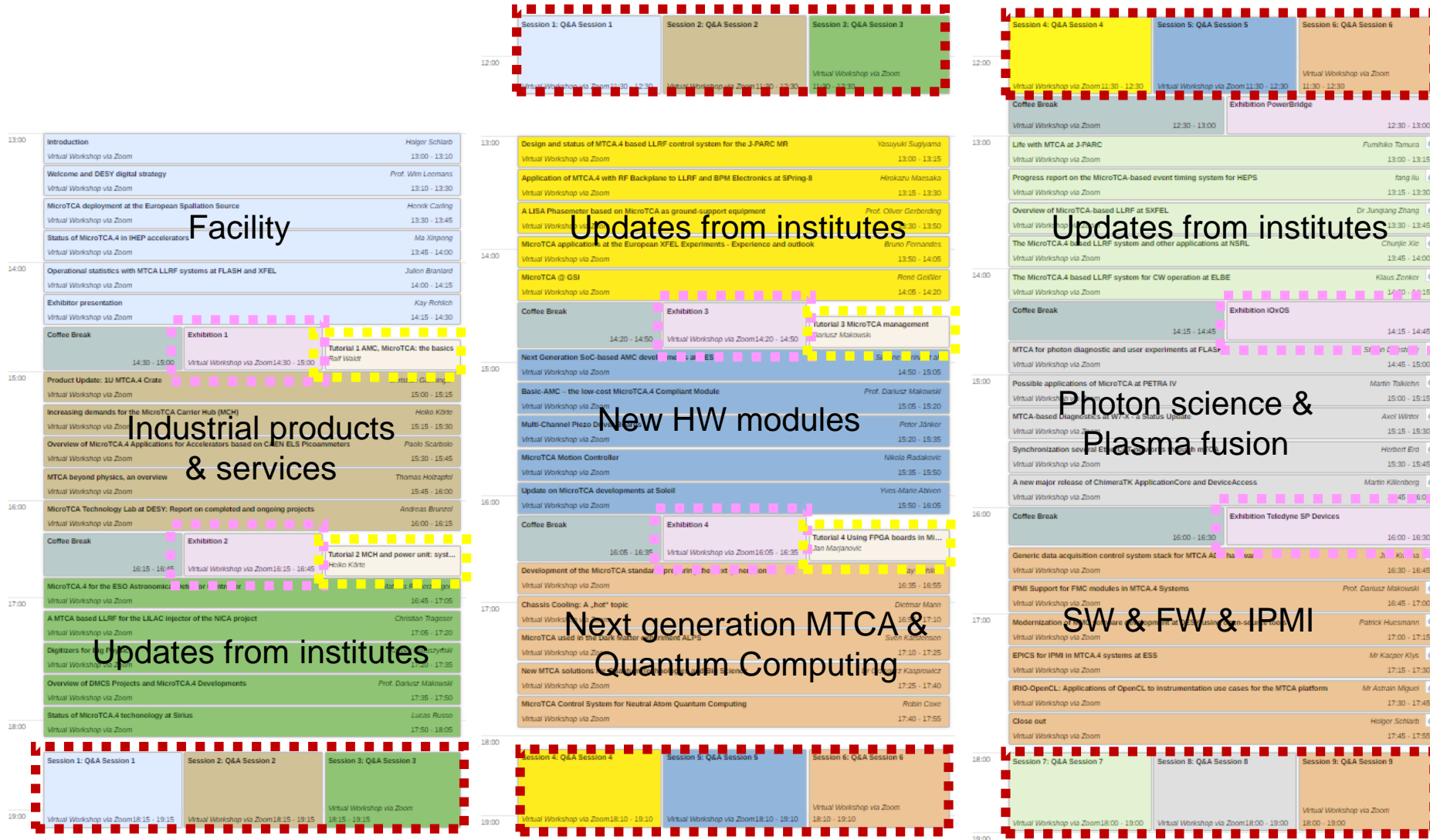
	2020	2019	2018	2017	2016	2015	2014	2013	2012
Participants	197	199	190	183	159	177	188	191	180
Institutes	41	30	22	25	25	31	30	30	25
Companies	22	29	31	25	28	36	39	39	29
Exhibitors	9	12	14	13	14	14	16	16	12
Talks	44	43	43	38	38	45	44	53	42



➔ <https://mtcaws.desy.de/>

Workshop program Tu / We/ Th

9 topical session (not strictly...) with in total 44 talks



Room for moderated discussion sessions



Facility

Updates from institutes

Updates from institutes

Industrial products & services

New HW modules

Photon science & Plasma fusion

Exhibition:



Updates from institutes

Next generation MTCA & Quantum Computing

SW & FW & IPMI

Basic Tutorials



New communities joint ...

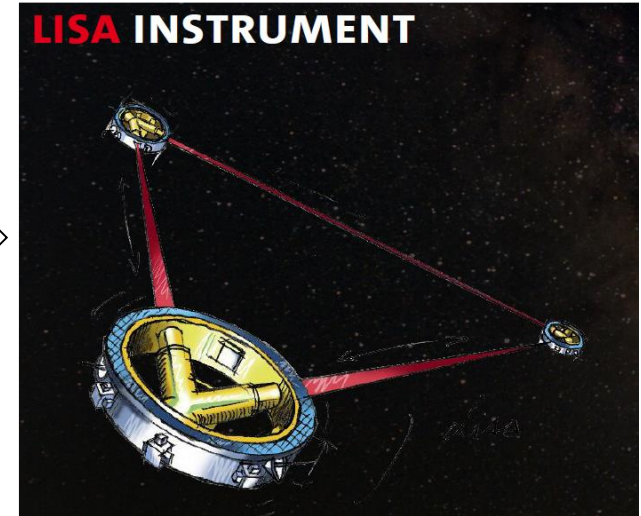
This time contributions from:

Astrophysics Observatories



@Leander Mehrgan (ESO)

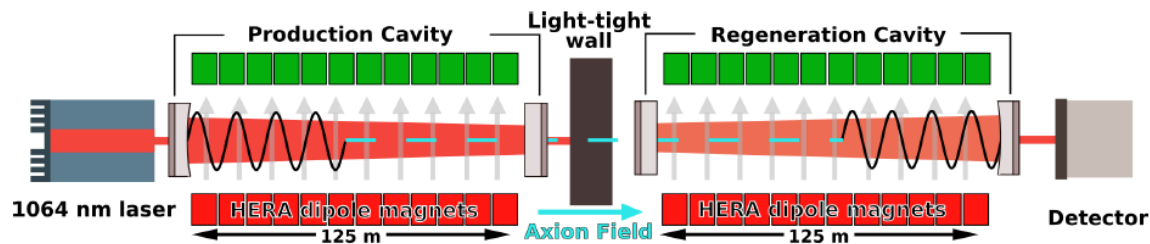
Gravitational Wave Detection



@Oliver Gerberding (UniHH)



Particle Physics: Axion research



@Richard Smith (DESY)

Quantum Computing

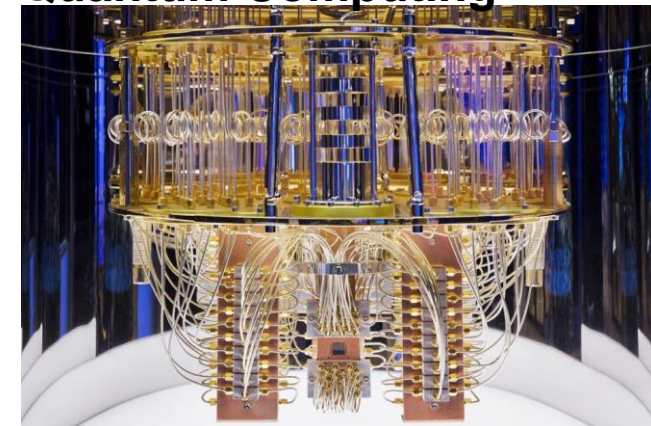
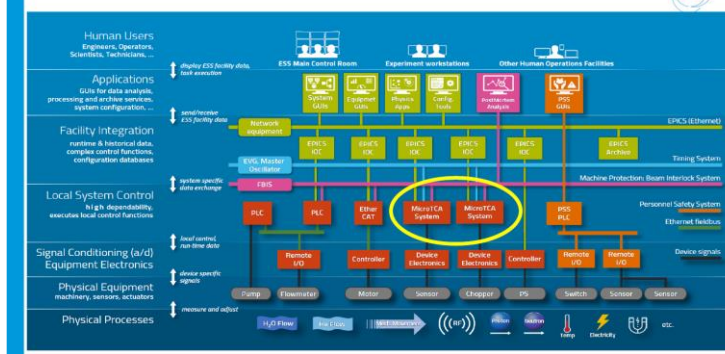


Image <https://www.forbes.com/>

Quick overview on talks in session 1

... incomplete, teaser for looking up presentations

Henrik Carling (ESS)
A layered control system

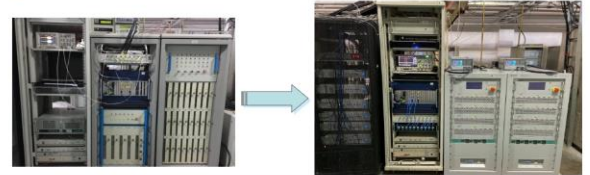


- Integrated Control System (MTCA/EtherCAT/PLC)
- MTCA: Beam Instr. /MPS/LLRF/Timing
- Standardization of HW/SW essential, 1.6 Mio PVs

Ma Xinpeng (IHEP)

1. Applications

- ❑ **Sub Harmonic Bunchers (SHB)**
- ❑ Frequency: 142.8MHz/571.2MHz; PPS:1-50Hz; Pulse duration: 60us;
- ❑ upgraded of RF FE box, SSAs, power meter, timing interface, server, archiver, cabling, firmware of LLRF controller.
- ❑ 2 SIS8300L2/SIS8900 boards for 2 NC bunchers and SSAs
- ❑ Crate: ELMA; MCH: NAT; CPU: Kontron;



- Focus on LLRF systems
- IHEP HW development
- Integration & HW / MMC evaluation

Julien Branlard (DESY)

1. INTRODUCTION MTCA.4 LLRF Systems

Standard crate occupation



~10x @ FLASH ~60x @ XFEL

- LLRF System @ XFEL & FLASH
- Failure analysis & down times
- Radiation induced / PCIe / Exception handling

MicroTCA application areas

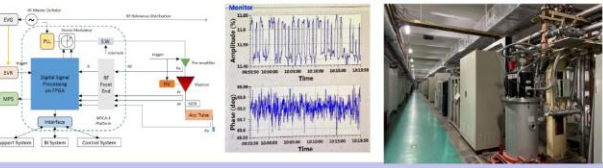
Four major areas requiring MicroTCA solutions

- **Beam Instrumentation**
 - Beam position monitors
 - Beam current monitors
 - Beam loss monitors
 - etc...
- **Machine Protection System**
 - Fast beam interlock system
- **RF Systems**
 - Low level RF system
 - RF local protection system
- **Timing System**
 - Components for the central ESS timing system



1. Applications

- ❑ **1st LLRF for S-band NC e-LINAC of BEPCII**
- ❑ upgraded 15 years old hardware;
- ❑ new MTCA.4/SSA/RFFE, fully digital;
- ❑ monitor RF signals and HV modulator;
- ❑ $\phi < 0.5\text{deg(pp)}$ and $A < 0.2\%$ (pp);
- ❑ 1 SIS8300L2/DWC8VM1: Struck;
- ❑ MCH/CPU: NAT;
- ❑ 5 more in the next 2 months;



5. LLRF on-call statistics

Extracted from on-call ticket tracker (Redmine)

2020 stats not fully representative

- Covid-19

"Setup" is often the root cause

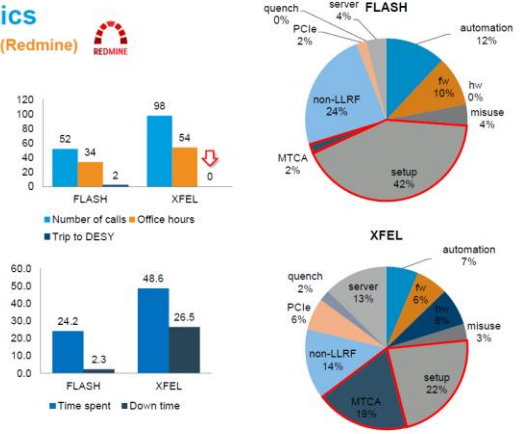
- more automation
- more exception handling

MTCA is more dominant at XFEL

- due to installation in tunnel ?

0 trip to DESY for XFEL

- remote troubleshooting!



Quick overview on talks in session 2

... incomplete, teaser for looking up presentations

Christian Ganninger (nVent SCHROFF)

MTCA.4 1U Crate - Front, Rear and Top View

- eMCH
- AMC slots 1 & 3
- AMC slots 2 & 4
- ESD Wrist Strap Terminal (4 mm banana jack)
- RTM slots
- Ground Terminal (Equipotential bonding)
- AC input with Mains / line switch and fuse
- PSU
- Air filter
- Fans rear section
- Fans front section
- Connector for 3rd party eCLK module

➤ Versatile small system chassis applicable for physics

Heiko Koerte (NAT)

What MicroTCA needs to deliver tomorrow

Challenge:

- Intel CPUs
- FPGAs
- Fast I/O

Interface	Count	Current Speed	Target Speed
1GbE	x1	1Gbps	10Gbps
PCIe	x4	16Gbps	63Gbps
	x8	32Gbps	252Gbps
	x16	63Gbps	504Gbps
ETH	x4	10Gbps	>100Gbps

Timeline from 2006 to today showing evolution from MTCA.0 r1 to MTCA.4 RTMs + timing air.

➤ Increasing transmission speed demands

Paolo Scarbolo (CAENels)

Single MicroTCA Chassis Connections along AMC backplane

8x M-LVDS signals:

- GTS Clock (80.5MHz)
- GTS Events
- MPS NPERMIT →
- MPS NOK ←

➤ BLM System (FRIB / ESS)
➤ Photon beam stabilization (Diamond)

Andreas Brunzel (MicroTCA Techlab)

Product Portfolio (2)

New Products

Product	Availability
DMMC Stamp & Break-out Board	Q3/20
DAMC-FMC2ZUP	Q1/21
DAMC-FMC1Z7IO	Q1/21
DAMC-DS812	Q3/21
DIPC-7050 (10GigE Vision)	Q1/20

➤ Hardware devel./ Measurement Services / Trainings / MMC Software / LISA

powerBridge Computer MTCA. Real Market Applications.

test and measurement

- testbeds for avionics
- high speed visual inspection
- Non destructive Testing (NDT)
- spectral analysis
- Hardware-in-the-loop (HIL)

communication

- Telphony gateways
- 5G/LTE basestation (CPRI, OBSAI) Testsystems
- conferencing platforms
- Software defined radio

medical has adopted MTC

- high speed data aquisition
- image processing

others

- Broadcast
- homeland security and

And many, many more....

Thomas Holzampfel (powerBridge)

➤ Industrial Application e.g. HPC traffic control, medicine, ...

➤ Read-time middleware: Vortex DDS

UHH - O. GERBERDING 27.11.2020

PROJECT OVERVIEW

LISA GROUND-SUPPORT EQUIPMENT: DEVELOPMENT OF A PHASEMETER SIMULATOR AND AN OPTICAL TOOLSET (DLR 50 OQ 2001)

The trainings are now held **virtually** via

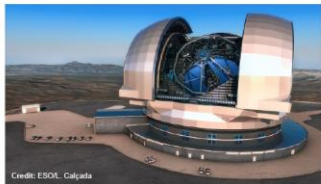
Quick overview on talks in session 3

... incomplete, teaser for looking up presentations (+ SPdevice & Bevatech)

Matthias Richerzhagen (ESO)

Extremely Large Telescope

- First Light: 2025 (planned)
- Primary Mirror: 39.3m
- Primary Mirror Area: 978m²

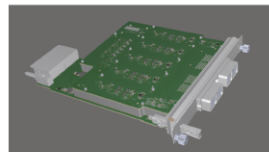


9th MTCAWS, 2nd - 4th Dec 2020, Public

- Detector readout Visible & NIR
- Standard industrial products +
- Customized in house modules (~half/half)

MTCA.4 Modules (In House)

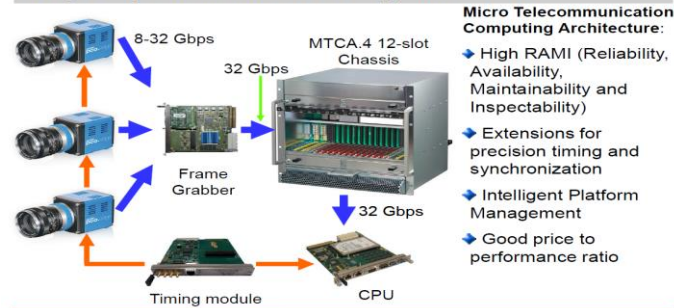
- CMOS Clock/Bias RTM
 - 20 CMOS Bias Channels
 - $2\mu\text{V/K}$ Drift
 - 0..5V
 - 20 CMOS Clock Channels
 - 2.0V to 5V CMOS Clock into 5m cable
- CCD Clock RTM
 - 24 CCD Clock Channels
 - Tri-Level $\pm 15\text{V}$
 - Optional Slope Control
- CCD Bias RTM
 - 24 CCD Bias Channels
 - $\pm 25\text{V}$, low drift



9th MTCAWS, 2nd - 4th Dec 2020, Public

Prof. Dariusz Makowski (Uni. Lodz)

Image Acquisition and Processing with MTCA.4



Dariusz Makowski
MTCA Workshop, December 1, 2020

- Heavily involved in ITER
- Generic frame grabber + MMC develop.
- High voltage PZT driver for ESS

HPD-200 – Revision 2.0

- 2 bipolar actuator channels
 - 200 W (power from external PSM)
 - 100 W (power from MTCA.4 chassis using Zone 3)
 - Working on new MTCA solution for driving power >200 W
- Class-D amplifiers
- Output voltage +/- 190 V (380 Vpp)
- Operating in actuator and sensor mode
- Uses internal or external power supply module (+/- 100 V)
- Tested with capacitive load up to 160 uF



Dariusz Makowski
MTCA Workshop, December 1, 2020

Daniel Tavares (LNLS)

Sirius – the 4th generation light source in Brazil

Outline

- MicroTCA.4 at Sirius
- AMC FMC Carrier
- New Developments and Highlights
- openMMC
- Integration to Control System
- Operations Experience
- Conclusion

- 4th generation Synchrotron light source
- Natural emittance 0.25 nm rad at 3 GeV
- Diffraction-limited for 10 keV photons



- LLRF / BPM / FOFB / Fast correctors
- Mix of Open Hardware & COTS + openMMC
- Comprehensive overview on different issues obs.

MicroTCA.4 at Sirius

- LINAC LLRF Crate – provided by SINAP
 - 3x Struck SIS8300-L2
 - 3x Struck DRTM-DWC8VM1
 - FPGA gateware and software provided by SINAP

Linac LLRF
1 crate



- BPM Electronics and Orbit Feedback Crate
 - Pentair/Schroff 12-slot Crate with JSM
 - N.A.T. PHYS80 MCH + μ RTM COMex CPU
 - Wiener Low Noise 1 kW Power Supply (redundant)
 - CAENels FMC-Pico-1M4
 - CAENels FMC-4SFP+
 - Open Hardware AMC FMC Carrier (AFC)
 - Open Hardware FMC ADC 16-bit 250 MS/s
 - Open Hardware FMC POF (plastic optical fiber)
 - Open Hardware μ RTM 8-SFP
 - Open Hardware RTM Fast Orbit Corrector Power Supply
 - Open source MMC firmware (openMMC)
 - Open source gateware and software for controls and data acquisition

BPM and FOFB
21 crates



Quick overview on talks in session 4

... incomplete, teaser for looking up presentations (+ Photon Exp. EuXFEL)

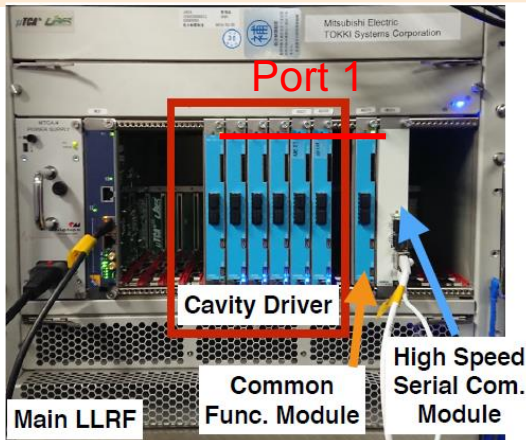
Yasuyuki Sugiyama (J-PARC)

J-PARC
Japan Proton Accelerator Research Complex

Joint Project between KEK and JAEA

- High intensity Proton Accelerator with a LINAC and two synchrotrons.
- Started the beam commissioning from 2006 and achieved the high intensity proton delivery.
- LINAC:** 400MeV negative hydrogen (H⁻) with 40mA (25 Hz)
- Rapid Cycle Synchrotron (RCS):** 3 GeV proton with 1 MW (25 Hz).
- Main Synchrotron Ring (MR):** 30 GeV proton with 500 kW (2.48 s cycle) for ν experiment.

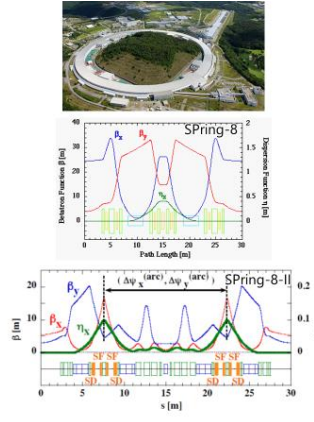
- LLRF + coupled bunch FB in MR
- VME → MicroTCA4.1 advanced design
- RF backplane + Port 1 for data transfer



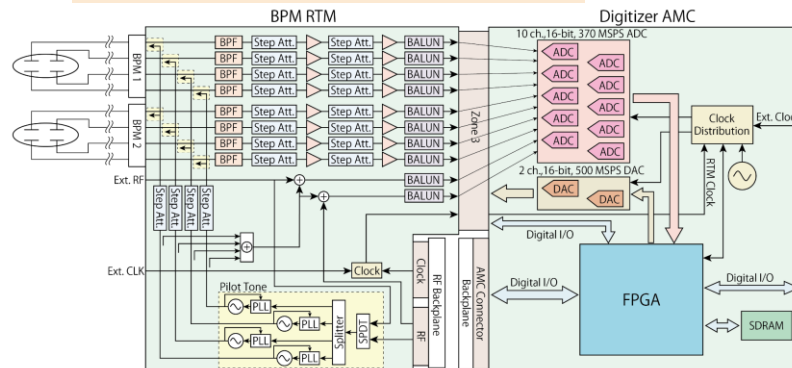
Hirokazu Maesaka (RIKEN)

Introduction

- Spring-8
 - Beam Energy: 8 GeV
 - Lattice: Double-bend achromat (DBA)
 - Natural Emittance: 2.4 nm rad
 - # of cells: 44
 - User service since 1997.
 - Electronics are based on NIM and VME.
- Spring-8 Upgrade Project (Spring-8-II)
 - Beam Energy: 6 GeV
 - Lattice: 5-bend achromat (5BA)
 - Natural Emittance: ~100 pm rad
 - MTCA.4 for high-speed electronics.
 - Low-level RF (LLRF), Beam position monitor (BPM), etc.
 - We started R&D of MTCA.4 ~5 years ago and we are already upgrading these electronics.
- New 3 GeV light source in Japan will also use MTCA.4 for LLRF and beam diagnostic systems.



- Spring-8 upgrade
- LLRF / BPMs
- Advanced MicroTCA designs



Prof. Oliver Gerberding (Uni. HH)

LISA METROLOGY

$\Delta v_{\max} \approx 15 \frac{m}{s}$

$\Delta f_D \approx 15 \text{ MHz}$

$\Delta L = 10 \cdot 10^{-12} \text{ m}$

$\Delta \phi < 6 \cdot 10^{-6} \text{ rad @ mHz}$

$L = 2.5 \cdot 10^9 \text{ m}$

- LISA Ground-support Phasemeter development
- Uses MicroTCA4.1, RF Backplane, custom RTMs
- Advanced MicroTCA Design .

Preliminary design

W-Ie-Ne-R MTCA.4 1000W PS		NAT-RPM-AC6007	
NAT-MCH-PHYS80		NAT-MCH-RTM-BM-FPGA-COM	Commercial /available
(DAMC-FMC1Z7IO)		DRTM-LISA-ADC	Custom developme
(DAMC-FMC1Z7IO)		DRTM-LISA-ADC	
DAMC-FMC1Z7IO (ADC)	AMC Backplane	DRTM-LISA-ADC	Channel extension
DAMC-FMC1Z7IO (ADC)		DRTM-LISA-ADC	
DAMC-FMC1Z7IO (ADC)		DRTM-LISA-ADC	
DAMC-FMC1Z7IO (ADC)		DRTM-LISA-ADC	
DAMC-FMC1Z7IO (ADC)		DRTM-LISA-ADC	
DAMC-FMC1Z7IO (ADC)		DRTM-LISA-ADC	
DAMC-FMC1Z7IO (ADC)		DRTM-LISA-ADC	
DAMC-FMC1Z7IO (ADC)		DRTM-LISA-ADC	
DAMC-FMC1Z7IO (ADC)		DRTM-LISA-ADC	
DAMC-FMC1Z7IO (ADC)		DRTM-LISA-ADC	
DAMC-FMC1Z7IO (DAC) + FMC SpW		DRTM-LISA-DAC	empty
		DRTM-LISA-FDS	

Quick overview on talks in session 5

... incomplete, teaser for looking up presentations (+ update Soleil)

Simone Farina (DESY)

Next Generation SoC-based AMC Developments at DESY

- DAMC-FMC2ZUP : ZYNQ Ultrascale+ MPSoC FMC+ carrier
- DAMC-DS5G14ZUP : ZYNQ Ultrascale+ RFSoc Digitizer
- DAMC-DS812ZUP : 8 channel 800MSPS 12-bit Digitizer ZYNQ Ultrascale+ MPSoC
- DMMC-Stamp : Turnkey SoM Module Management Controller
- DAMC-FMC1Z7IO : ZYNQ-7000 GPIO extension board and FMC carrier
- DRTM-MXC : Mobile eXpress Module Carrier - Graphics carrier RTM module



High-end

Low-Cost



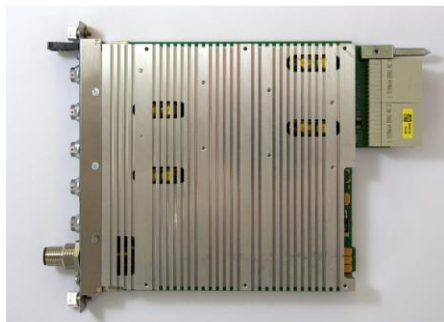
Supplementary modules

Prof. Dariusz Makowski (Uni. Lodz)

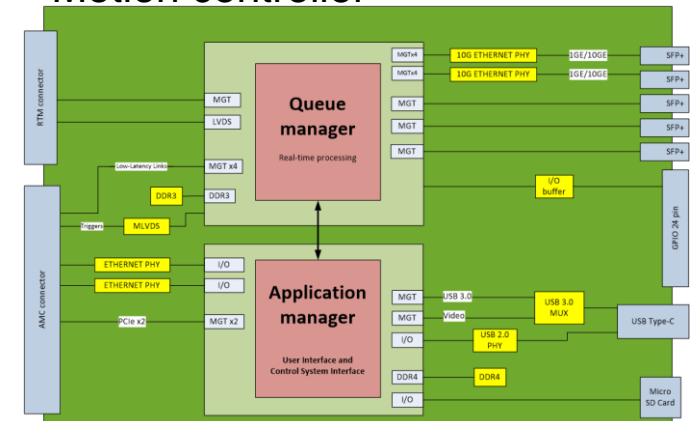


Xilinx Artix

Peter Jaenker (PiezoTechnics)



Nikola Radakovic (DESY)
Motion controller



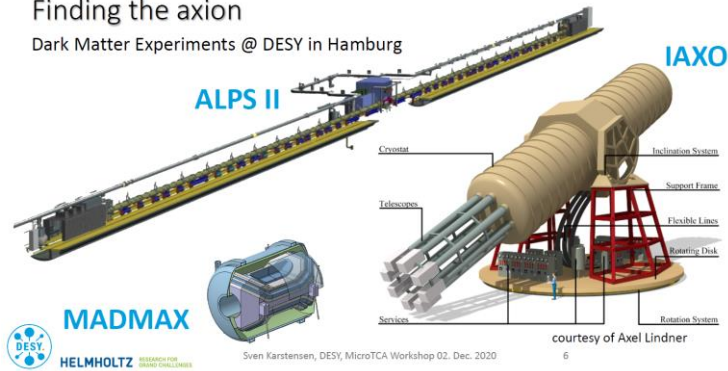
Quick overview on talks in session 6

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Sven Karstensen (DESY)

Finding the axion

Dark Matter Experiments @ DESY in Hamburg

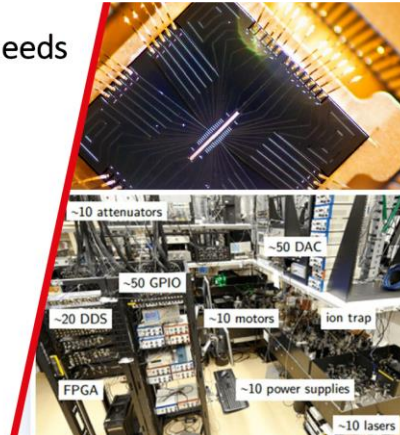


- Axion research (dark matter research)
- Significant DAQ effort, 6m continues op.
- Makes use of existing HW/SW from acc.

Grzegorz Kasprovicz (Cryotech)

Ion trap experiments - needs

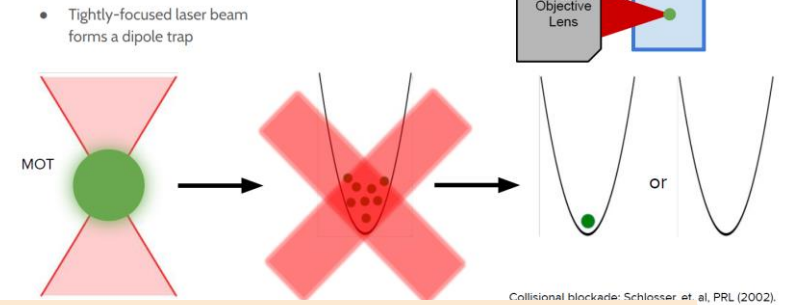
- microsecond response times, sub-ns synchronization
- control system:
 - flexible and modular
 - well tested
 - easy to build and reproduce
- multi-channel processing
- ultra-low noise (order of nV) DAC
- laser intensity servos
- laser frequency stabilization
- fast ion state readout and modification



- Requires larger control system and various modules
- Core: MicroTCA, AMC & RTM are developed
- Follow open source HW

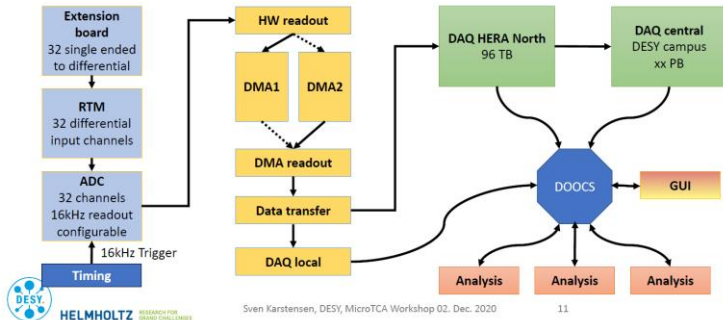
Robin Cox (Atom Computing)

Trapping a Single Atoms in an Optical Tweezer

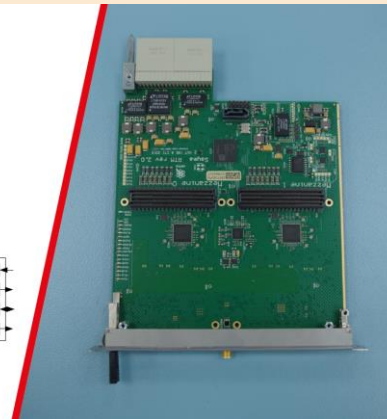
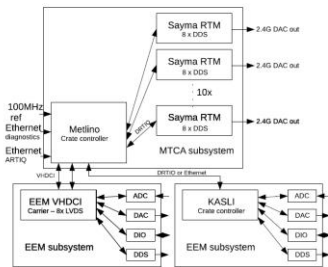


- Neutral atoms traps in an array
- Specialized RF waveforms for manipulation
- COTS & Custom design (since not yet avail)

TEWS TAMC532 32channel ADC data flow



Sinara Ecosystem



Why MicroTCA 4?

- A random collection of box instruments is not scalable.
- Active hardware ecosystem (much of it open source) driven by accelerator control for high energy physics at CERN, DESY, SLAC, and [sinara-hw](http://sinara-hw.com) (ARTIQ).
- Many COTS FPGA Mezzanine Cards (FMCs): CoaXPress imager interface, Digital Trigger Distribution
- (European) Commercial Vendors: NAT Europe, Schroff, Creotech, Caen Els, Struck, IOxOS, etc.
- Custom Development (we'd buy it now if we could, but...): RFSoc AMC, RF/Microwave FMCs/RTMs.
- Also considered VPX, but not widely used in physics and mil/aero environmental specs are overkill.



Quick overview on talks in session 7...9

... incomplete, teaser for looking up presentations

Fumihiko Tamura (J-Park)
Life with MTCA at J-Park

Liu Fang (J-Park)
HEPS timing system

Junqiang Zhang (SINAP)
LLRF system SXFEL
crate to control two power sources. The MicroTCA.4 crate

Chunjie Xie (NSRL)
LLRF HLS/IRFEL

Stefan Duester / Martin Tolkiehn (DESY)
Photon Experiments FEL / PETRAIII

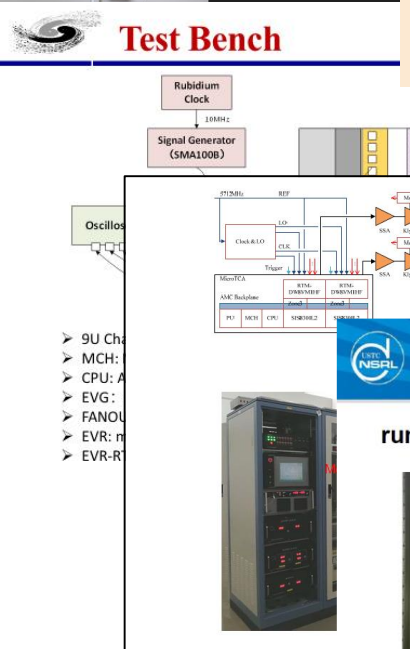
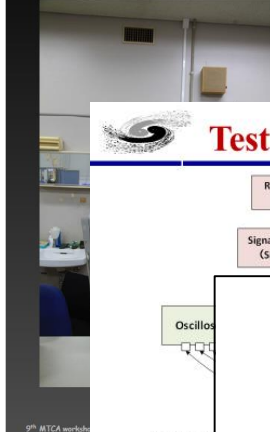
Axel Winter (W7-X)
Plasma Fusion

Herbert Erd (NAT)
EtherCAT – MTCA Bridge
Synchronization (data-stuffing)

Martin Killenberg (DESY)
ChimeraTK

Miquel Astrain (Uni. Madrid)
IRIO-OpenCL

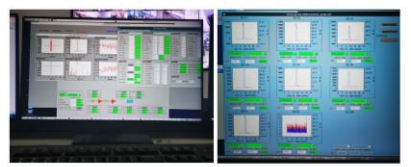
Lightweight is justice



running status of LLRF



1. MicroTCA.4 crate
2. power amplifier
3. frequency synthesis system
4. signal source



the digital LLRF system upgrade was completed in 2018



Klaus Zenker (HZDR)
LLRF CW Elbe

Take away from 9th MicroTCA Workshop

- **Virtual Workshop format**

- worked out surprisingly well (44 talks!) but **no real substitute for face-to-face**
- **Q&A session** was very important and triggered discussion
- Exhibition & **Industry** reasonable well integrated (unlike to other VC)

- **Ecosystem & community**

- Within 12 month **many new developments** have take place & being presented
- Significantly **more “expert”** are now around the world e.g. starting new /own developments
- **New communities & newcomers** joining (beyond accelerator community)
- **Local WS** for community expansion and dissemination of MicroTCA standard important

- **Hot topics:**

- SoC's / SW & FW Sharing / Integration external infrastructure / IMPI for FMC / Interop. issues
- Starting: Real-time Machine Learning on edge computing & Quantum Computing appl.

Participation of Industry Exhibitors



Thanks to


Advisory committee:

Kay Rehlich (Chair)	DESY
Holger Schlarb (Chair)	DESY
Henrik Carling	ESS
Paul Chu	IHEP, China
Tobias Hoffmann	GSI
Thomas Holzapfel	powerBridge
Christian Ganninger	nVent - Schroff GmbH
Heiko Koerte	N.A.T.
Rong Liu	Beijing DAQ Technology Co. Ltd
Dariusz Makowski	Lodz University of Technology
Charles Roberts	ORNL
Ian Shearer	Vadatech
Fumihiko Tamura	J-PARC Center, Japan
Axel Winter	MPI Plasmaphysik
Zeran Zhou	NSRL, USTC, China

Valuable input for shaping the workshop!!!

Try to cover ecosystem adequately:

Regions
&
Institutes
&
Communities
&
Industry



10th MicroTCA Workshop

7 -9 December 2021
DESY, Hamburg

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The 10th MicroTCA Workshop for Industry and Research will be held from 7-9 December 2021 at DESY.

The main topics of the workshop are:

- Applications in research facilities
- Applications in industry
- New Products
- Future of standard and interoperability
- Software and firmware

The registration will open in September 2021.