中国科学技术大学
University of Science and Technology of China

Summary on the MicroTCA Workshop in China

Zeran Zhou, USTC

December 2024

The 13th MicroTCA Workshop for Industry and Research, DESY Hamburg

Outline

- Introduction
- Highlights
- Summary

Introduction

2024 MicroTCA/ATCA

for Large Scientific Facility Control International Workshop

Organizer: University of Science and Technology of China(USTC)

Sep.18-Sep.20,2024 Hefei,China

Committees

Chair:

Yalin Lu (Chair) , USTC
Holger Schlarb (Co-chair) , DESY

Program Committee:

Bo Liu (Chair) , SARI
Mark Plesko (Co-Chair) , Cosylab
Jianshe Cao (Co-Chair) , IHEP
Lin Wang , USTC
Paul Chu , Nanjing University
Ruishi Mao , IMP
Zeran Zhou , USTC
Liqun Hu , ASIPP
Rong Liu , Beijing Normal University
Lei Shi , IASF
Junqiang Zhang , Chongqing University

Local Organizing Committee:

Zeran Zhou (Chair) , USTC
Yanfeng Sui (Co-chair) , IHEP
JianYe , Cosylab
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Hongrui Cao , ASIPP
Jie Zhang , IHEP
Hongli Ding , IASF
Min Li , IMP
Qiuping Huang , USTC
Chen Yu , USTC

Shanghai Advanced Research Institute,Chinese Academy of Sciences(SARI)

Institute of High Energy Physics,Chinese Academy of Sciences(IHEP)

Institute Of Plasma Physics Chinese Academy Of Sciences(ASIPP)

Cosylab

Institute of Modern Physics,Chinese Academy of Sciences(IMP)

Institute of Advanced Science Facilities, Shenzhen (IASF)

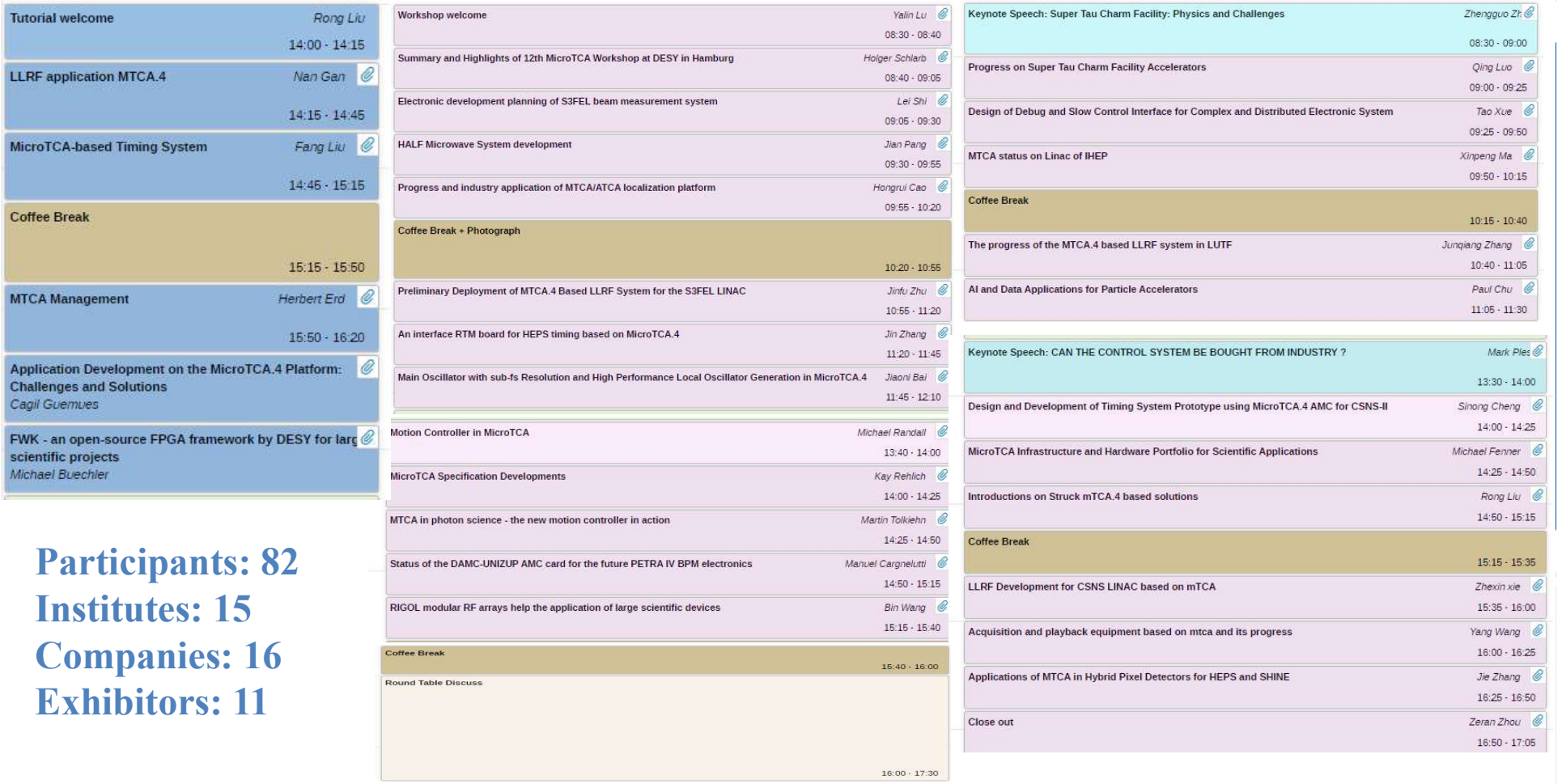
Dalian Institute of Chemical Physics (DICP), Chinese Academy of Sciences

Chongqing University(CQU)

Beijing Normal University

Statistics

Indico page: https://indico.pnp.ustc.edu.cn/event/1979/



- Tutorial welcome — Rong Liu — 14:00 - 14:15
- LLRF application MTCA.4 — Nan Gan — 14:15 - 14:45
- MicroTCA-based Timing System — Fang Liu — 14:45 - 15:15
- Coffee Break — 15:15 - 15:50
- MTCA Management — Herbert Erd — 15:50 - 16:20
- Application Development on the MicroTCA.4 Platform: Challenges and Solutions — Cagil Guemues
- FWK - an open-source FPGA framework by DESY for larg scientific projects — Michael Buechler
- Workshop welcome — Yalin Lu — 08:30 - 08:40
- Summary and Highlights of 12th MicroTCA Workshop at DESY in Hamburg — Holger Schlarb — 08:40 - 09:05
- Electronic development planning of S3FEL beam measurement system — Lei Shi — 09:05 - 09:30
- HALF Microwave System development — Jian Pang — 09:30 - 09:55
- Progress and industry application of MTCA/ATCA localization platform — Hongrui Cao — 09:55 - 10:20
- Coffee Break + Photograph — 10:20 - 10:55
- Preliminary Deployment of MTCA.4 Based LLRF System for the S3FEL LINAC — Jinfu Zhu — 10:55 - 11:20
- An interface RTM board for HEPS timing based on MicroTCA.4 — Jin Zhang — 11:20 - 11:45
- Main Oscillator with sub-fs Resolution and High Performance Local Oscillator Generation in MicroTCA.4 — Jiaoni Bai — 11:45 - 12:10
- Motion Controller in MicroTCA — Michael Randall — 13:40 - 14:00
- MicroTCA Specification Developments — Kay Rehlich — 14:00 - 14:25
- MTCA in photon science - the new motion controller in action — Martin Tolkiehn — 14:25 - 14:50
- Status of the DAMC-UNIZUP AMC card for the future PETRA IV BPM electronics — Manuel Cargnelutti — 14:50 - 15:15
- RIGOL modular RF arrays help the application of large scientific devices — Bin Wang — 15:15 - 15:40
- Coffee Break — 15:40 - 16:00
- Round Table Discuss — 16:00 - 17:30
- Keynote Speech: Super Tau Charm Facility: Physics and Challenges — Zhengguo Zh — 08:30 - 09:00
- Progress on Super Tau Charm Facility Accelerators — Qing Luo — 09:00 - 09:25
- Design of Debug and Slow Control Interface for Complex and Distributed Electronic System — Tao Xue — 09:25 - 09:50
- MTCA status on Linac of IHEP — Xinpeng Ma — 09:50 - 10:15
- Coffee Break — 10:15 - 10:40
- The progress of the MTCA.4 based LLRF system in LUTF — Junqiang Zhang — 10:40 - 11:05
- AI and Data Applications for Particle Accelerators — Paul Chu — 11:05 - 11:30
- Keynote Speech: CAN THE CONTROL SYSTEM BE BOUGHT FROM INDUSTRY ? — Mark Ples — 13:30 - 14:00
- Design and Development of Timing System Prototype using MicroTCA.4 AMC for CSNS-II — Sinong Cheng — 14:00 - 14:25
- MicroTCA Infrastructure and Hardware Portfolio for Scientific Applications — Michael Fenner — 14:25 - 14:50
- Introductions on Struck mTCA.4 based solutions — Rong Liu — 14:50 - 15:15
- Coffee Break — 15:15 - 15:35
- LLRF Development for CSNS LINAC based on mTCA — Zhexin xie — 15:35 - 16:00
- Acquisition and playback equipment based on mtca and its progress — Yang Wang — 16:00 - 16:25
- Applications of MTCA in Hybrid Pixel Detectors for HEPS and SHINE — Jie Zhang — 16:25 - 16:50
- Close out — Zeran Zhou — 16:50 - 17:05

Participants: 82
Institutes: 15
Companies: 16
Exhibitors: 11

Talks: 32（including 5 tutorial talks、2 keynote speeches）& round table discuss

Conference Photos

Industry Exhibitors

Outline

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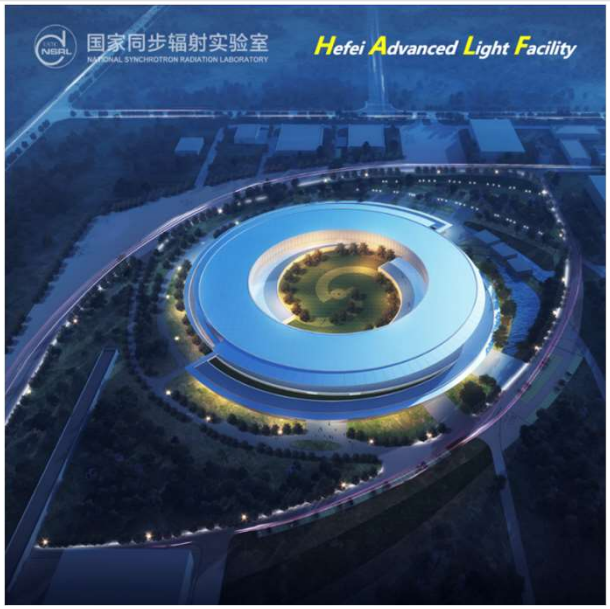
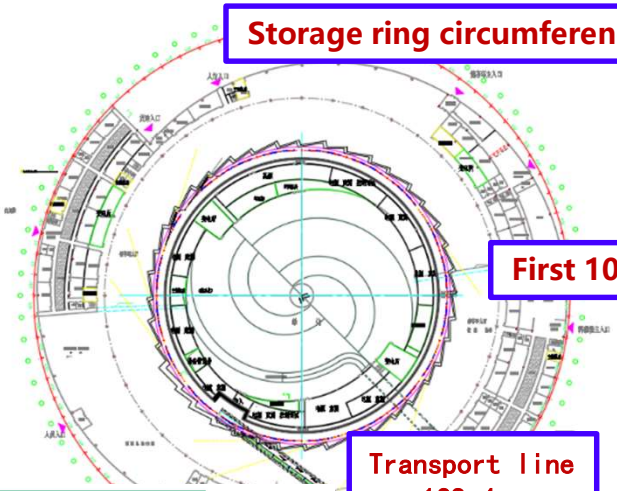
MTCA Applications in HALF



Storage ring circumference~480 m



First 10 Beam line stations

Transport line
138.4 m

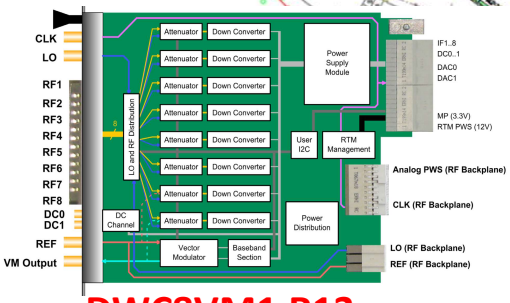
LINAC 2.2 GeV
192 m

Signal Generator

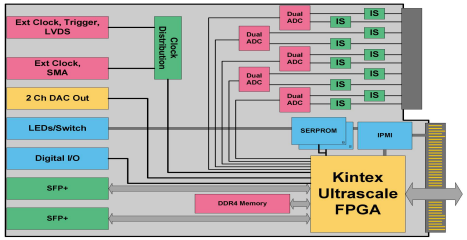
MTCA Processor

Frequency synthesizer

1 kW SSA



DWC8VM1 R13



SIS8300-KU

- Micro-Research Finland Oy
- MTCA based
- MTCA-EVM-300M、MTCA-EVR-300U

MTCA Applications in IHEP & HEPS

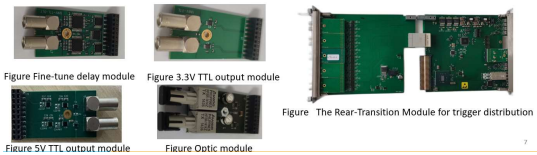
Main parameters of HEPS	
Beam energy[GeV]	6
Circumference[m]	~1360
Emittance[nm.rad]	0.06
Beam current[mA]	200
Cell Units	48
Injection	Top-up
Brightness[phs/s/mm^2/ $mrad^2$/0.1%BW]	$> 10^{22}$

2019/06 Civil starts ✔
2022/02 Linac&Booster start install ✔
2023/03 Linac first beam ✔
2023/08 Booster commissioning ✔
2024/07 Storage ring commissioning ✔
2024/12 First X-ray
2025/12 Project completed and operation

LLRF on BEPCII-U Linac

HEPS Linac LLRF runs stable >1 year

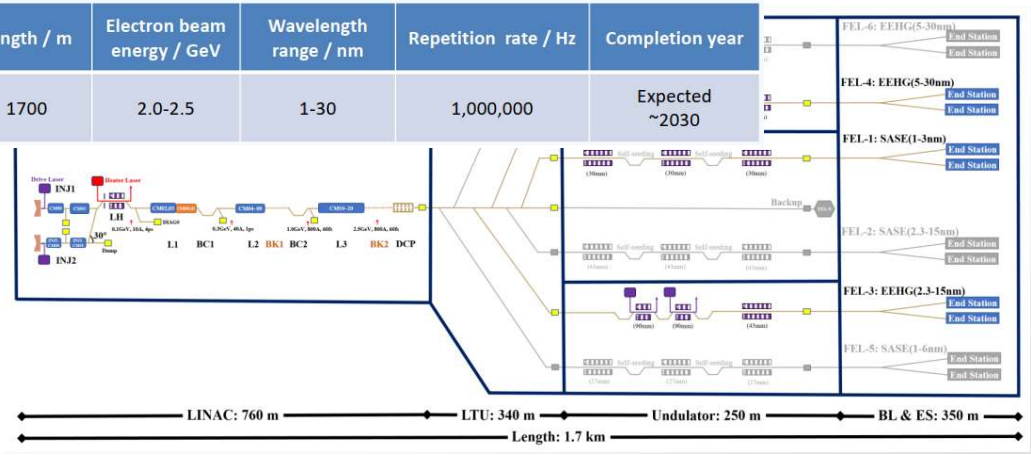
- 6 MicroTCA chassis.



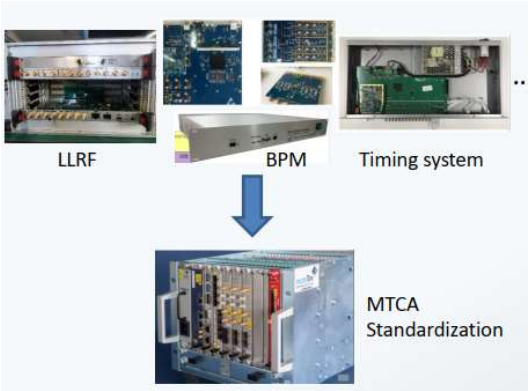
HEPS Timing System

MTCA Applications in S³FEL

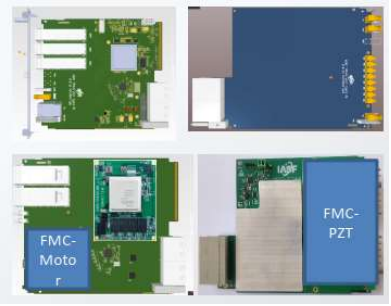
Length / m	Electron beam energy / GeV	Wavelength range / nm	Repetition rate / Hz	Completion year
1700	2.0-2.5	1-30	1,000,000	Expected ~2030



Shenzhen superconducting soft-X-ray free electron laser(S³FEL)



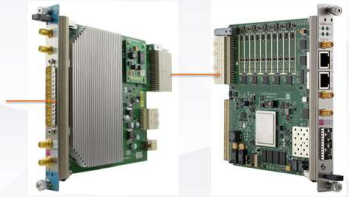
- MTCA.4 Based Hardware will be deployed in both the accelerator and beamline of the S³FEL.
- There are hardware, firmware, software development, and maintenance advantages.



Multi-channel high-precision ADC

■Application
- SBPM/CBPM
- Wire Scanner/Scintillators
- PDs

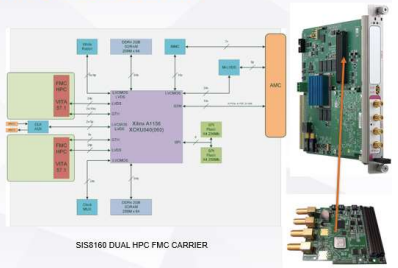
■Specification
- 250Msps,16Bit，700MHz Bandwidth
- Similar with LLRF



High-bandwidth, high-sampling-rate ADC

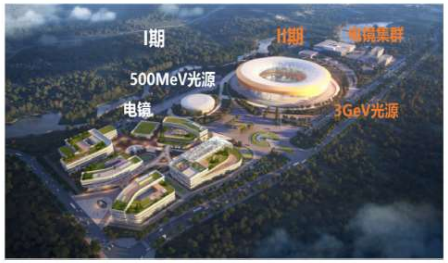
■Application
- Direct sampling of CBPM/BAM.
- Cherenkov BLM.
- TOF,GMD…
- PDs

■Specification
- >2Gsps, 1GHz bandwidth, 12bit



MTCA Applications in LUTF

LUTF is developed in 2 phases, phase I is a pre-research project, including a 500MeV light source and an electron microscope platform; phase II including a 3GeV light source and an electron microscope cluster。
Project duration: 2023.5~2026.5



Parameters	Value	Unit
Energy	0.5	GeV
Ring circumference	76.78	m
Beam current	0.5~1	A
Focusing type	QBA	
Natural emittance	8.56	nm rad
Working point (x, y)	6.198, 3.357	-
Length of straight section	8*4	m
Working frequency	499.8	MHz
Energy loss per turn	4.34	keV
Natural energy spread	0.37×10^{-3}	


Test platform(2024.09.14)


Research building (2024.7.17)


Powerhouse(2024.7.17)

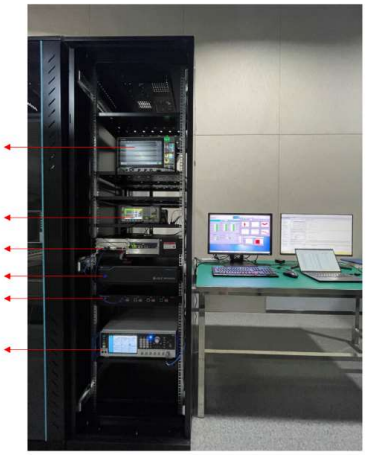

Linac (2024.7.17)

Laboratory for Ultrafast Transient Facility (LUTF)


NATIVE-R2


DWC8VM1

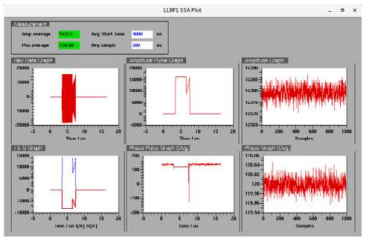

SIS8300KU



LLRF platform

LUTF frequencies

No.	Items	Frequency
1	Main RF	499.79/2998.74MHz
2	LO	474.80/2973.75MHz
3	IF	24.99MHz
4	ADC Clock	124.95MHz


Amplitude and phase stability:
0.01% (rms) , 0.01° (rms)

MTCA Applications in CSNS & CSNS-II

LINAC LLRF → add

Iron — 80MeV H^- — 324MHz Spoke Cavities — 154MeV — 648MHz elliptical Cavities — 303MeV

To rise the beam power

RCS LLRF → upgrade

3 additional 2nd harmonic (MA) cavities

- 1st harmonic cavity
- 2nd harmonic cavity

MA: Magnetic Alloy

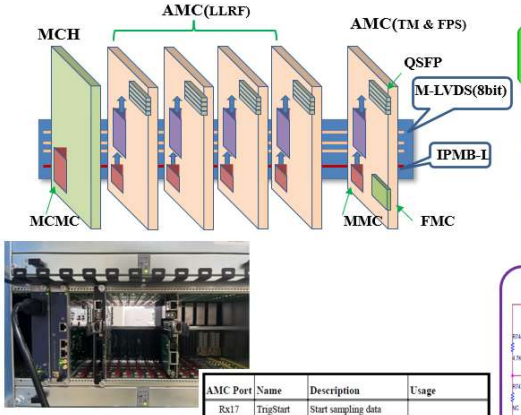
1.6GeV

To improve the beam pass rate and reduce the beam loss

3

China Spallation Neutron Source (CSNS & CSNS-II)

LLRF + TM



AMC Port	Name	Description	Usage
Rx17	TrigStart	Start sampling data	Triggers
Tx17	TrigEnd	Stop sampling data	
Rx18	TrigReadOut	Start data transfer to CPU	
Tx18	ClkAux	Low performance clock	
Rx19	Reset	Reset of counter, dividers	
Tx19	Interlock 0	Interlock line 0	3 interlocks to provide 2 out of 3 redundancy
Rx20	Interlock 1	Interlock line 1	
Tx20	Interlock 2	Interlock line 2	

LLRF & TM

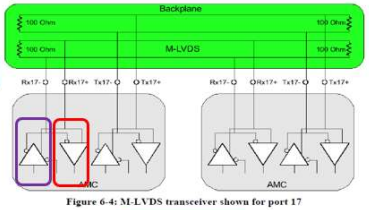
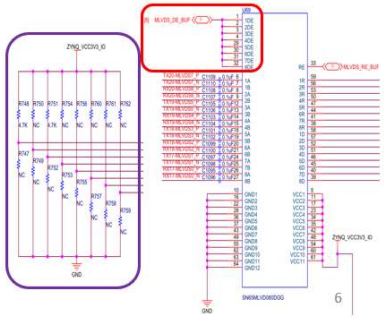


Figure 6-4: M-LVDS transceiver shown for port 17

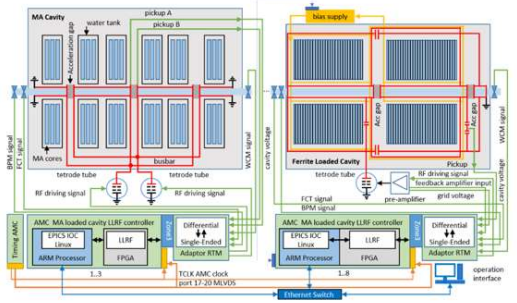


6

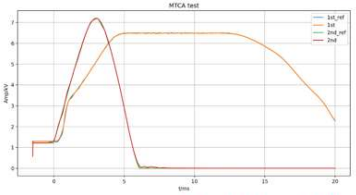
AMC Based on Zynq SOC

For 8 ferrite cavities and 3 MA cavities LLRF

Under development



System Block Diagram of CSNS-II LLRF Control System Based on MTCA.4 Architecture



FPGA project has migrated form CPCI based Controller to MTCA.4 based AMC

It is planned to be completed next summer

Single board debugging has been completed with MA cavity

5

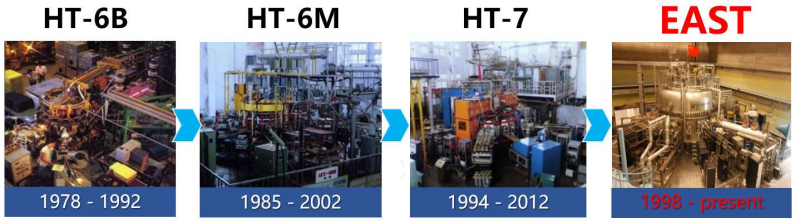
MTCA Applications in ASIPP

Science island

New Energy Research Center

CRAFT

- **ASIPP**: Institute of Plasma Physics, Chinese Academy of Sciences, founded in **Sept. 1978** in Hefei, Anhui Province.
- **Mission of ASIPP**: The research of **fusion energy** based on the **tokamak approach**.

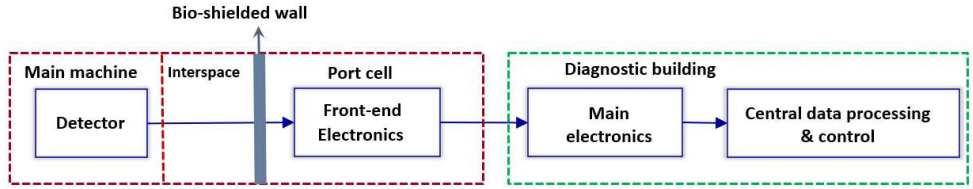


EAST (Experimental Advanced Superconducting Tokamak)

The Institute of Plasma Physics, Chinese Academy of Sciences (ASIPP)

Architecture of Plasma Diagnostic Electronics

Architecture of PDE:



Development History of PDE:

Front end electronics:

Single channel

Multi-Channels + Radiation Hard Chassis

ASIC(32CH/64CH)

Main electronics:

NIM(Only Power)

VME/VXI

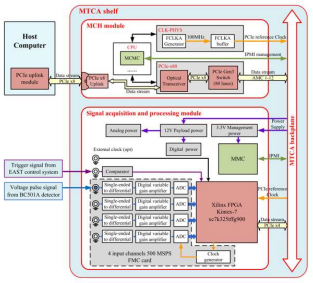
PXIe(10GB/s)

MTCA/ATCA(40GB+/s)

MTCA (10U)

MTCA (2U)

AMC DAQ card + MCH + Uplink + MMC



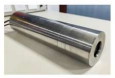
MTCA acquisition system architecture diagram

◆ System design

- MTCA architecture is widely used in fusion control and diagnostics due to its high data transmission rate, high channel density and high reliability **(ITER neutron camera, JET gamma camera, JET gamma spectrum)**.
- The high-speed pulse signal acquisition and processing system based on MTCA architecture is composed of MTCA chassis, MCH main control module, self-developed signal acquisition and processing board, PCIe data transmission card and host.
- The MCH is the control center that monitors the health status of each board and provides x4-PCIe communication links for each board. Extremely high physical event rates, up to several trillion pulse events per second;

MCH

PCIe uplink



EJ301

Applications of MTCA in Hybrid Pixel Detectors for HEPS and SHINE

HEPS AND SHINE

High Energy Photon Source (HEPS)
- Under construction at Huairou District, Beijing
  - Start the user operation in 2025
- Key-Parameters

Parameters	Nominal
Beam energy	6.0 GeV
Emittance	better than 0.06nm×rad
Beam	Higher than 1×1022 phs/s/mm2/mrad2/0.1%BW
Spatial resolution	10 nm
Energy resolution	1 meV
Photon energy	Up to 300keV

- More than 90 beamlines and end-stations
- Ref: http://english.ihep.cas.cn/heps/index.html

Shanghai High repetitioN rate xfel and Extreme light facility (SHINE)
- Under construction at Zhangjiang, Shanghai
  - Start the user operation in 2026
- Key-Parameters

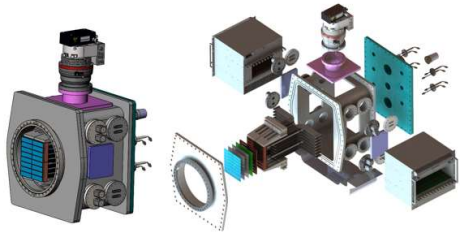
Parameters	Nominal
Beam energy	8.0 GeV
Bunch charge	100 pC
Max rep-rate	1 MHz
Beam power	0.8 MW
Photon energy	0.4 – 25 keV
Pulse length	20 – 50 fs

- 3 beamlines and 10 end-stations
- Ref: https://indico.desy.de/event/21806/

HYBRID PIXEL DETECTORS

Specs	HEPS-BPIX
Mode	Photon counting
Pixel size	140 μm x 140 μm
Threshold	Dual
Detectable energy range	8-20 keV
Frame rate	Up to 2 kHz (continuous readout)
Detector	Scalable: 6M, 2M, 1M, or 150K

https://doi.org/10.1088/1748-0221/19/06/P06038



Specs	STARLIGHT (SemiconducTor Array detectoR with Large dynamIc ranGe and cHarge inTegrating readout)
Mode	Charge-integration
Pixel size	100 μm x 100 μm
Gain	Self-adaptive 3 gains
Dynamic range	1 ~ 10000 photons/pulse @12 keV
Frame rate	12 kHz (continuous readout)
Detector	A 4.2M pixel detector in vacuum, quadrant movable

https://doi.org/10.1088/1748-0221/19/04/c04003

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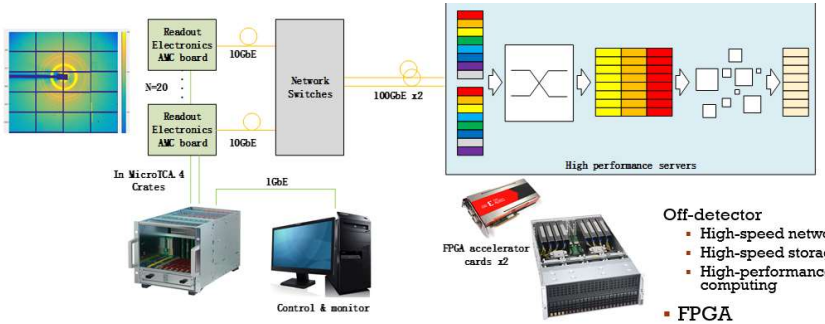
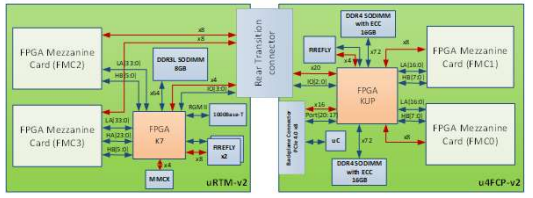


On-detector
- FPGA AMC board
  - Front-end Electronics Control
  - Clock Synchronization
  - Monitoring
  - Data Acquisition

Off-detector
- High-speed network
- High-speed storage
- High-performance computing

- FPGA
  - Data aggregation
  - Data sorting
  - Data compression
  - Real-time algorithm

10



- uRTM-v2
- u4FCP-v1

New Developments from Zooneng

MTCA Chassis + Power(10U)
Supports 12 AMCs, 2 MCHs, and 2 PDMs.

MTCA Chassis + Power(2U)
Supports 6 AMCs and 1 MCH, and 1 PDM.

AMC DAQ card
Zynq UltraScale , 4CH500M sampling rate, 6GB DDR4

中能聚控 ZOONENG

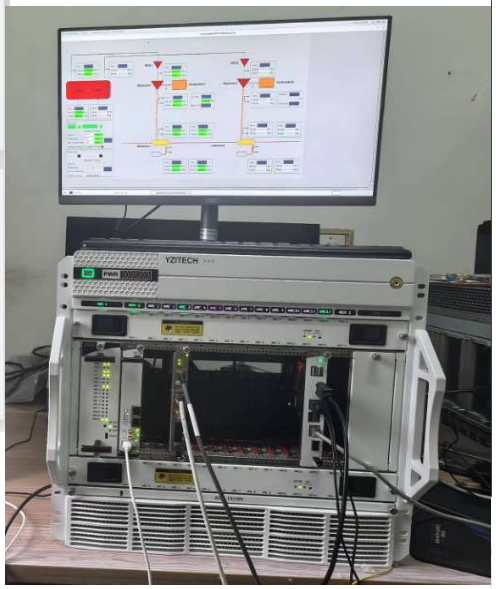
Up-link card

AMC CPU

MCH

RTM CPU

MMC module



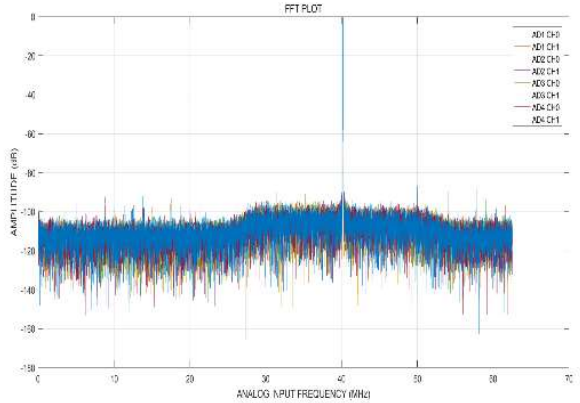
the compatibility between the self-developed MTCA chassis and NAT RTM.

Uplink card + Fiber +AMC_DAQ Application (Communication speed measurement)
Use the optical port on the MCH and the Uplink plugged into a PC to test the R/W speed of the AMC DAQ card

New Developments from Juxun & Everacq

MTCA based signal recorder

AMC board development



炬讯信息 JUXUN ICT

中科采象 EVERACO TECHNOLOGIES

I7-6820HQ CPU：4核心@2.7GHz

16GB DDR4 SRAM；

128G SSD；

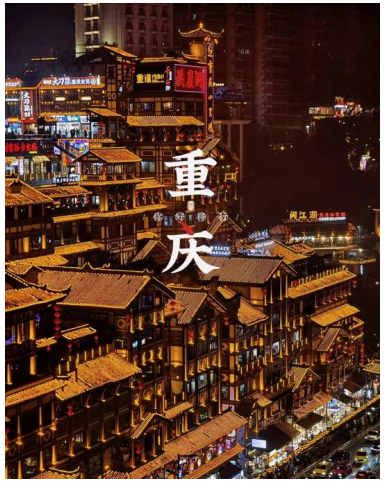
Outline

- Introduction
- Highlights
- Summary

Summary

- 2024 MicroTCA Workshop in China has been held in USTC, Hefei on September 18~20th.
  - Many institutes from China joined the workshop;
  - Several companies released their products.

- 2025 MicroTCA Workshop in China will be going on, probably in Chongqing University (LUTF).





Group Photo of 2024 MTCA China

Thank you for your attention