ASIPP

中能聚控 ZOONENG

Progress in the Localization of MTCA Platforms and Applications

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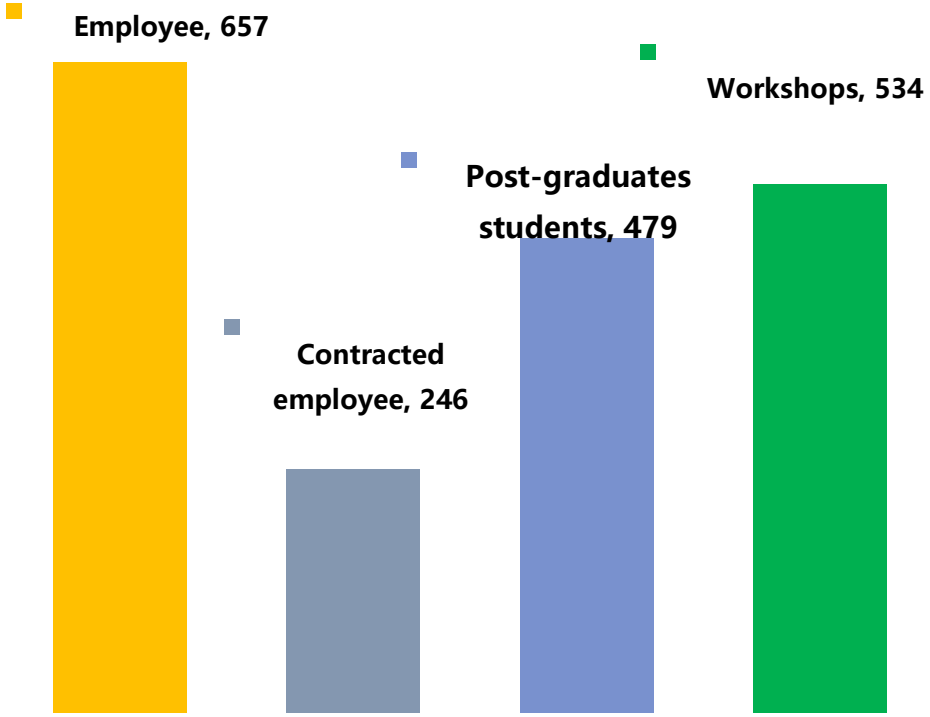
Content

- **Introduce of ASIPP and ZOONENG Corporation**
- Solution for Localized MTCA Chassis
- Other High-Speed Data Communication Platforms
- Development of Plasma Diagnostic Electronics
- Applications in Fusion Device Diagnostics
- Summary

General Information of ASIPP

- **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**.
- **ASIPP organization**: **14** Divisions, **3** Research Centers.
- **Human resource: >1500**



Science island

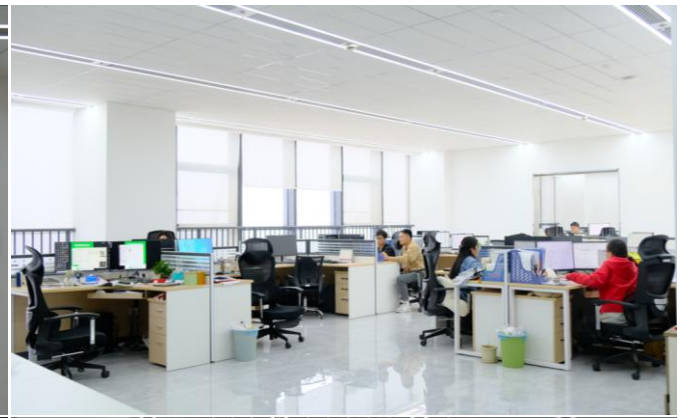
New Energy Research Center

CRAFT

Anhui Zooneng Measurement and Control Technology Co., Ltd.

中能聚控 ZOONENG

- **Zooneng:** The company is founded in **2022,** which is based on innovation results transformation from **Institute of Energy**.
- **Mission: Plasma Diagnostic Electronics + High speed communication hardware platform.**
- **Team Scale:25 Full-Time Members + 4 Core Directions** (Hardware Circuit Design, FPGA/Embedded Systems, Software & System Platforms, Testing & Experimental Research)



合肥科创集团 HEFEI STI GROUP

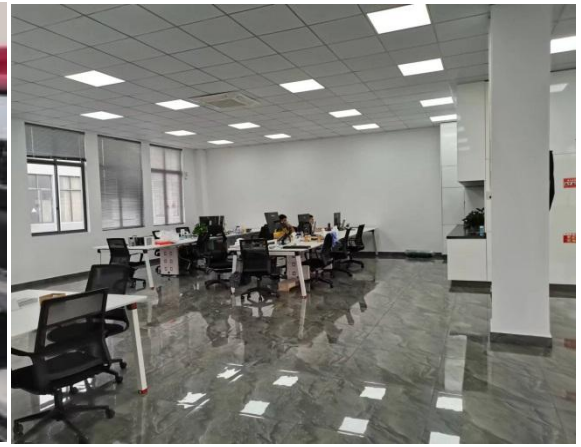
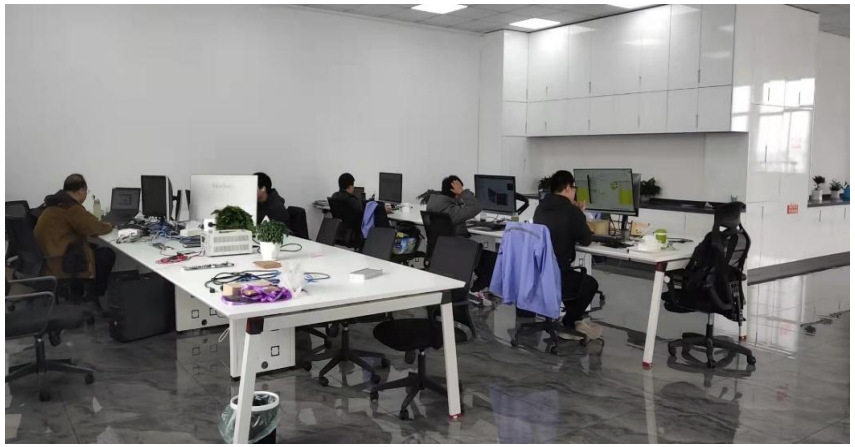
合肥综合性国家科学中心能源研究院 Institute of Energy Hefei Comprehensive National Science Center

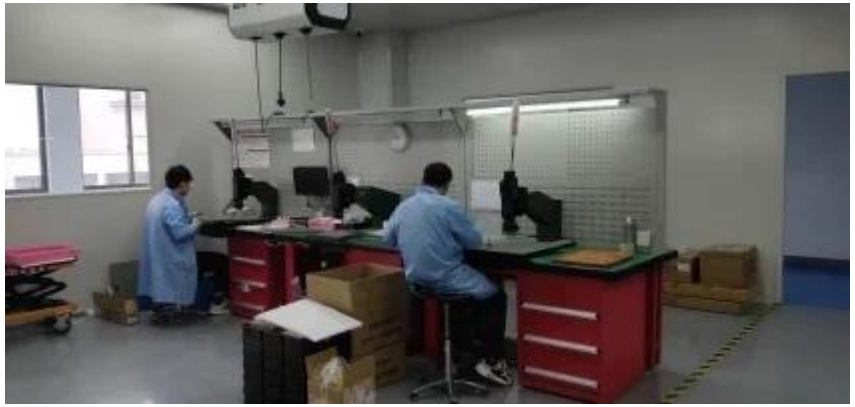
合肥高投 HEFEI HI-TECH VC

合肥创新投

Suzhou Factory

- >50 people, >5000m^2
- Floor 1: Production processing, Inspection; Floor 2: Storage;
  Floor 3: Assembly and testing; Floor 4: Design.

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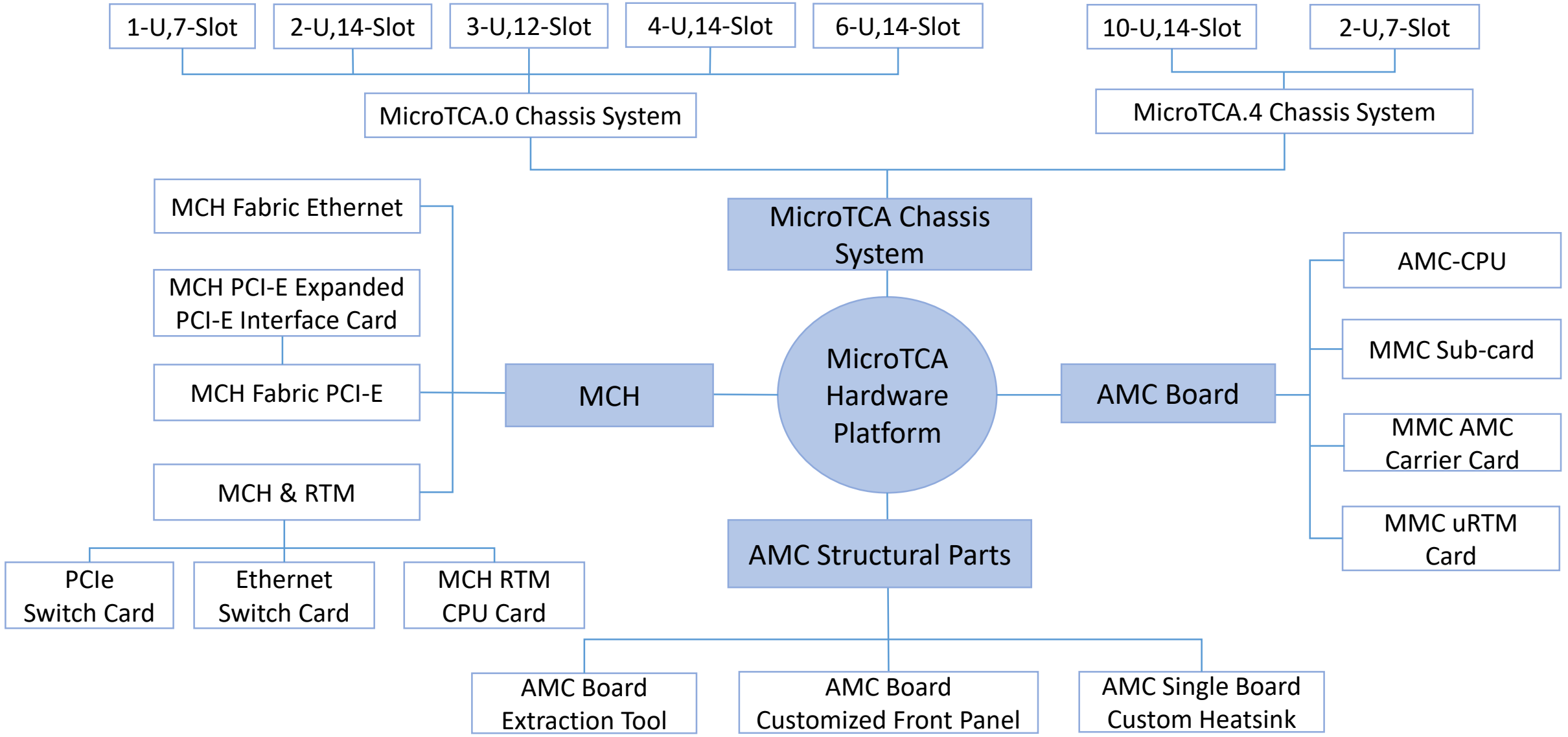
MicroTCA Solution



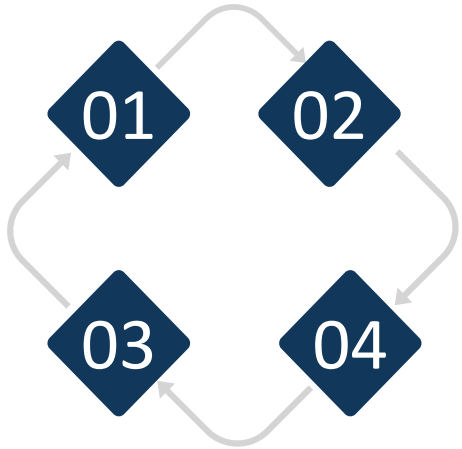
Innovation Points of the MTCA.4 Chassis System

◆ Structural and Usability Innovation

- Steel guide rails replace plastic guide rails, featuring excellent sturdiness and durability
- Extra-large chassis handles + custom-made handles for MCH boards

◆ Heat Dissipation and Reliability Innovation

- 2 hot-swappable fan trays, enabling quick replacement in case of failure
- "Z"-shaped air duct with air intake from the front bottom and air exhaust from the rear top, enhancing heat dissipation efficiency



◆ Power Supply and Compatibility Innovation

- Dual-channel high-power replaceable power modules
- Independent power supply for fan power and board power
- Intelligent PDM parameter adjustment, supporting power-on operation of non-standard AMC cards

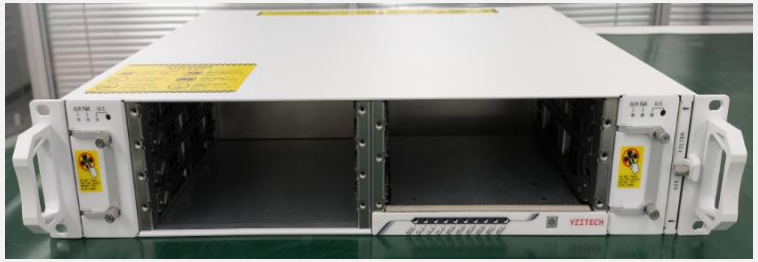
◆ Management and Customization Innovation

- Dual-mode management: compatible with standard IPMI + customized I2C chassis management
- High-speed backplane: compliant with MTCA.4 specifications, supporting 10.3125Gbps differential rate
- Localized R&D: independent and controllable

Complete Solution for MTCA Platform

MTCA Chassis + power(10U)

12 AMC slots, 2 MCH slots, 2 PDM slots



MTCA Chassis + power(2U)

6 AMC slots, 1 MCH slots, 1 PDM slots

AMC DAQ card

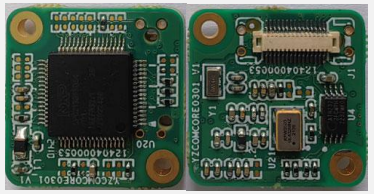
Zynq UltraScale , 4CH
500 MSPS, 6GB DDR4

Up-link card

AMC CPU

MCH

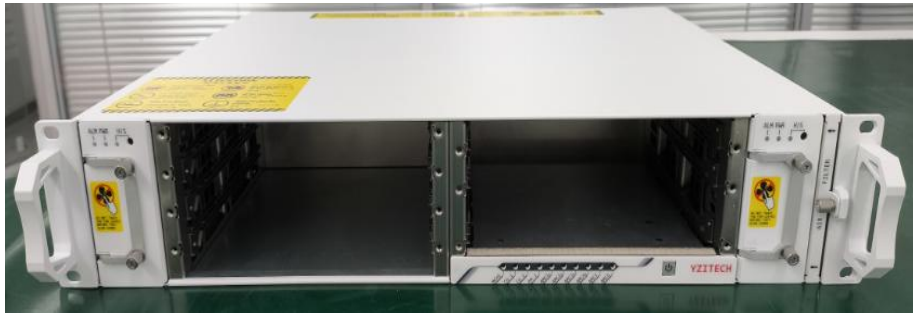
RTM CPU



MMC module

MTCA.4 Chassis

MTCA Chassis（10U）



MTCA Chassis（2U）

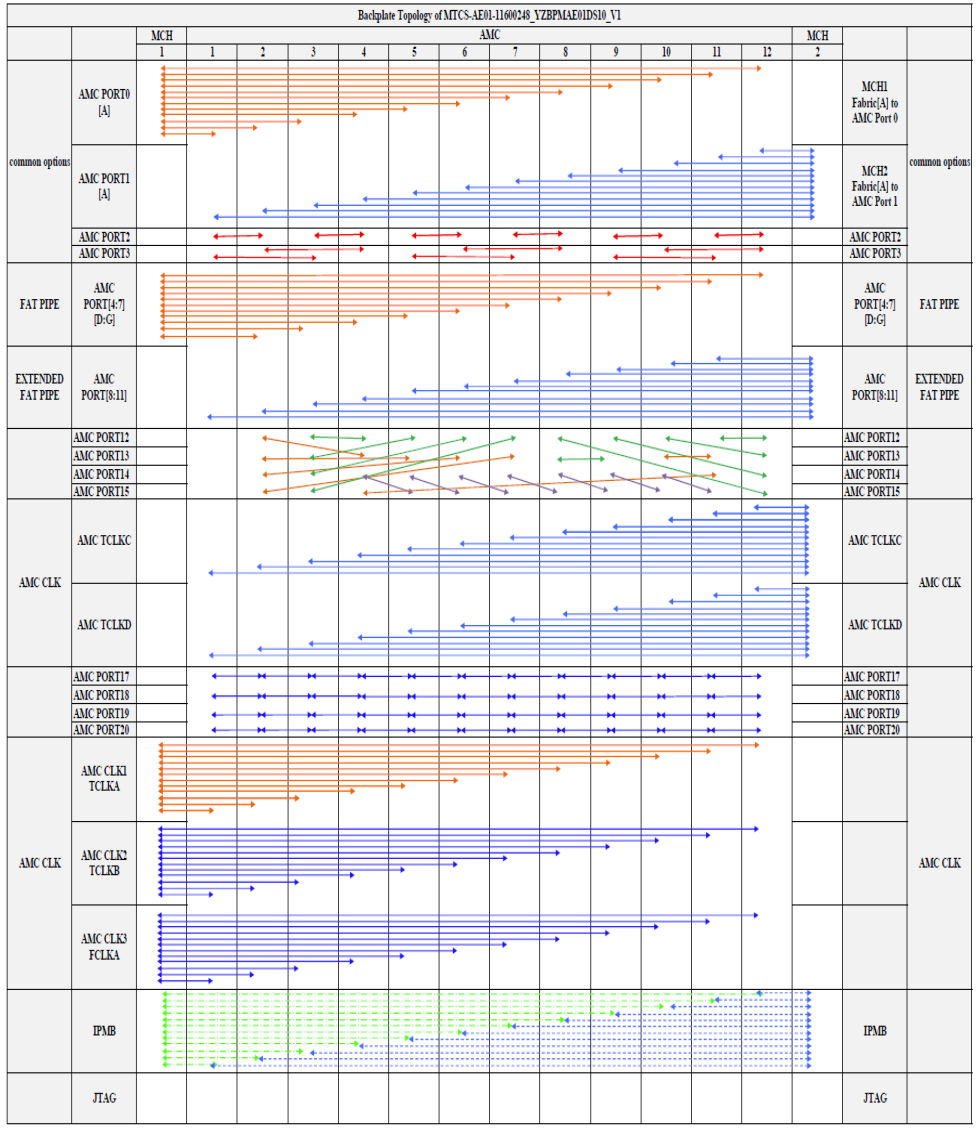
MTCA Chassis(10U):

- 19-inch Rack-mount Chassis,10U-14Slot
- 12× front AMC slots (single/double modules) + 12× rear AMC RTM slots + 2× MCH slots (single/double modules-full size), compatible with 4HP double-width AMC cards
- 2-way 220V AC input; 2×2000W secondary power modules; 1 power distribution board on each side
- Backplane differential rate: 10.3125Gbps
- "Z"-shaped airflow: front-bottom in, rear-top out; 2 hot-swappable fan trays

MTCA Chassis(2U):

- 19-inch Rack-mount Chassis,2U-7Slot
- Front side: 4×4HP AMC.4 + 1×6HP MCH + 2×AMC.0 slots; Rear side: 4×4HP AMC.4 slots
- Backplane differential rate: 10.3125Gbps
- Rear side: 1 set of hot-swappable power supply slots, with built-in dual power supplies
- Two sets of hot-swappable intelligent fan trays, adopting "right-in, left-out" cooling airflow

MTCA.4 BackPlane



Topology: Dual-Star Design for High System Reliability

- With two MCHs as central nodes, the core control architecture is established;
- each AMC module is equipped with two independent physical links directly connected to MCHs.

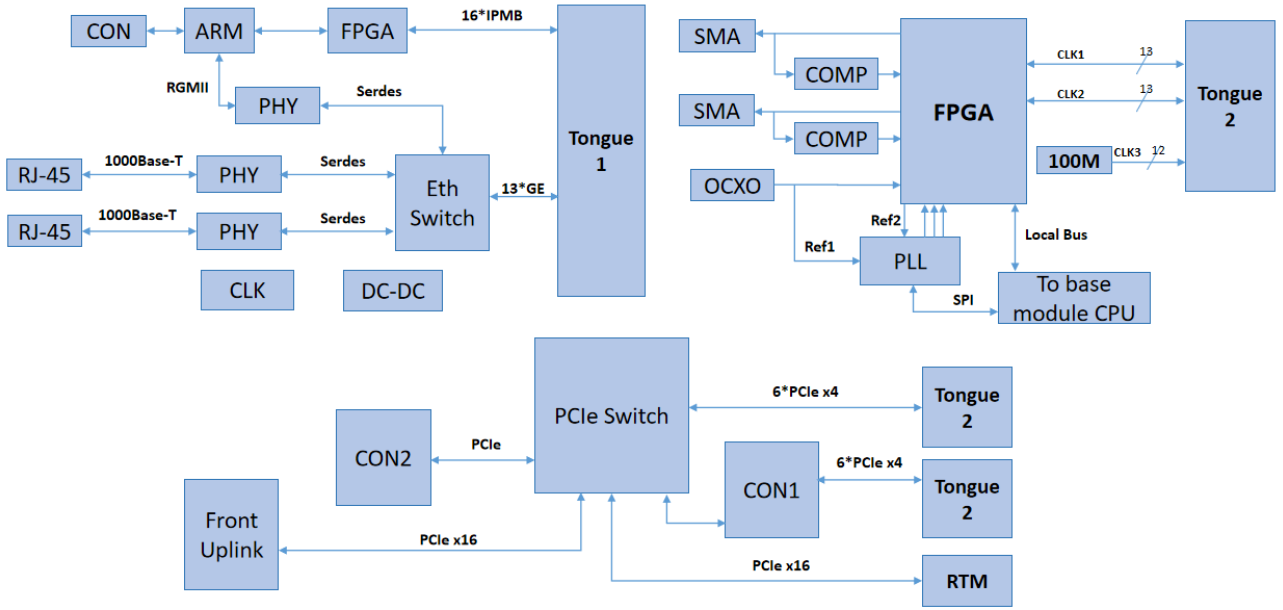
Hardware Expansion: Multi-Slot Configuration for Multi-Scenario Adaptation

- 12× standard AMC slots (compatible with ADC/DAC/Intel CPU/FPGA);
- 12× synchronized µRTM slots (rear I/O expansion, no AMC resource occupation)

Signals & Synchronization: Three Types of Dedicated Circuits Covering Full-Scenario Transmission Needs

- High-speed Data Circuits: Support PCIe Gen3 (8 Gb/s per lane) and 40GbE Ethernet standards;
- Management Signal Circuits: Comply with the IPMI protocol, connect MMC/RMC, and monitor/control hardware status

MicroTCA.4 MCH



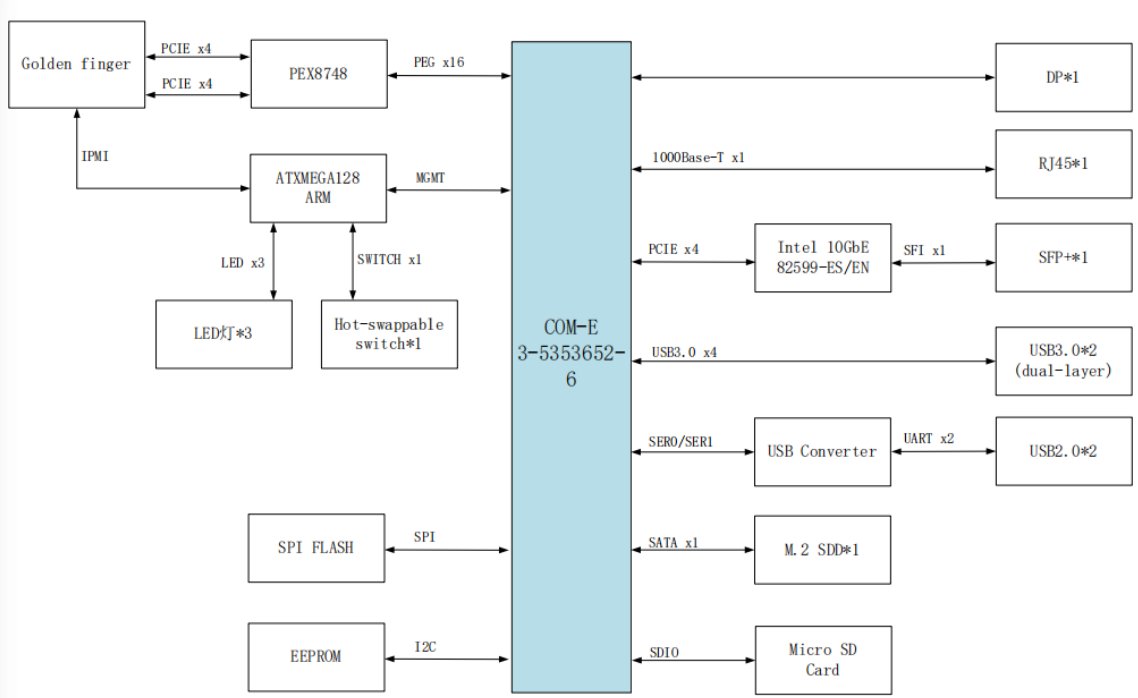
MCH Card(Basic Configuration)

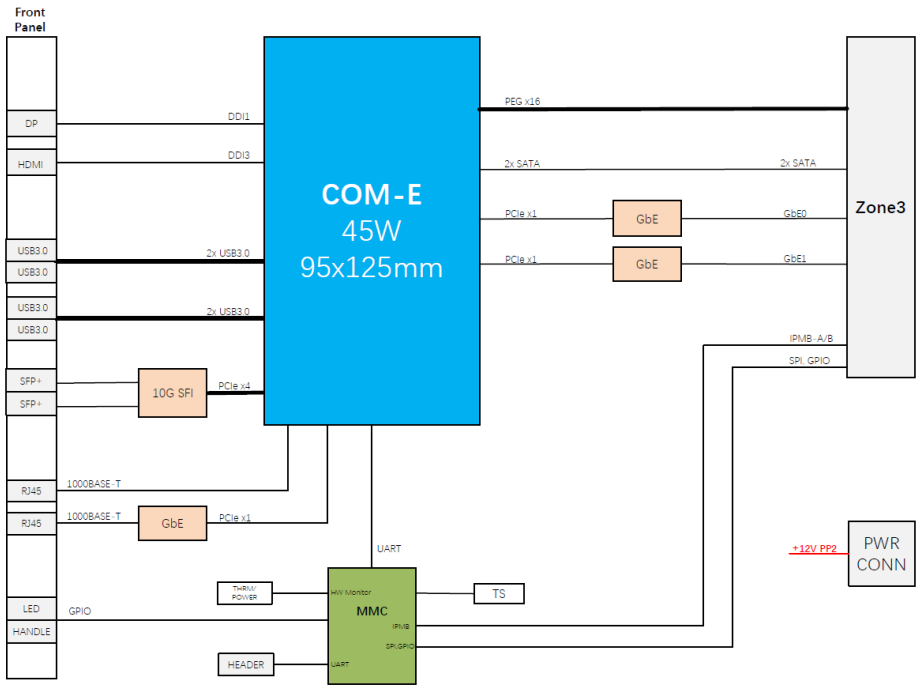
MCH Card(with Optical Port)

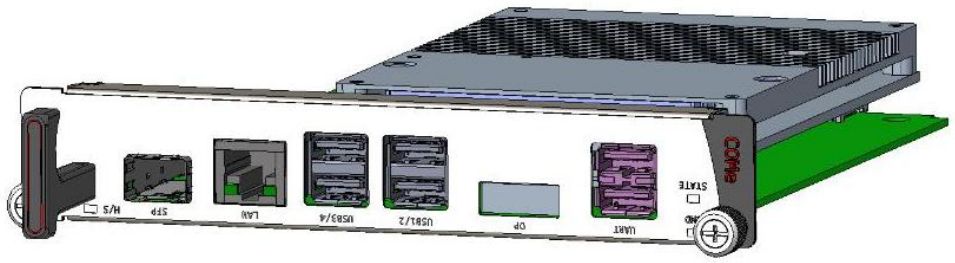
MTCA.4 MCH Card:

- Standard 6HP double-width full-height form factor, power consumption approx. 50W
- iMX6 Dual-Core @1GHz + 1GB DDR3 + 8GB eMMC
- Front panel interfaces: 2 Gigabit electrical ports, 1 USB Type-C Console port, 2 software-configurable SMA clocks (CLK1/CLK2)
- Switching Capability: Port0 Gigabit (12AMC + 1 update channel), PCIe3.0 (12AMC × x4 interfaces)
- Compatible with MTCA.0/4 standard IPMI protocols, supporting customized protocols
- Dual power-on modes: IPMI Management + Non-IPMI Management
- Flexible Expansion: Optional 1×PCIe3.0 x16 / 2×x8 uplink ports

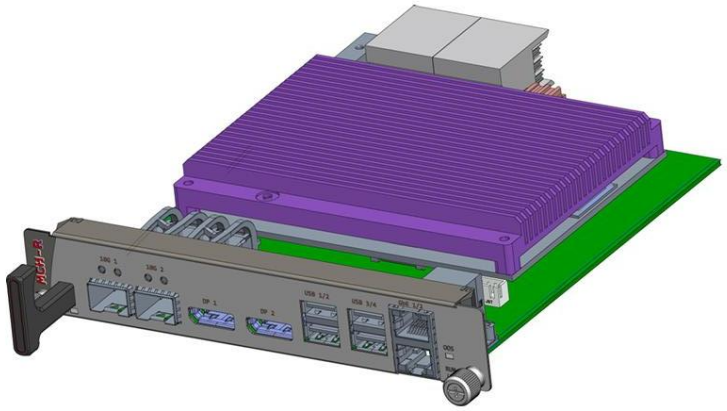
MTCA-CPU





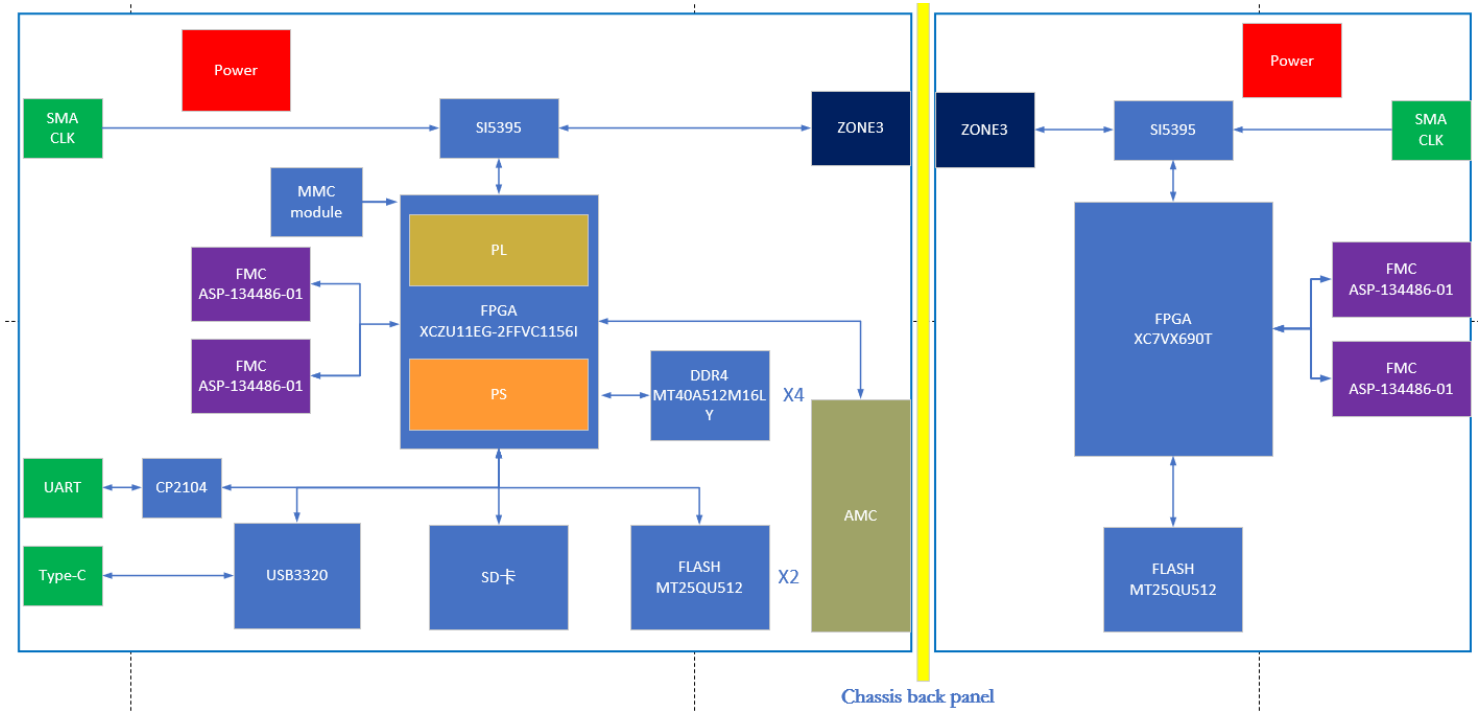


AMC-CPU



RTM-CPU

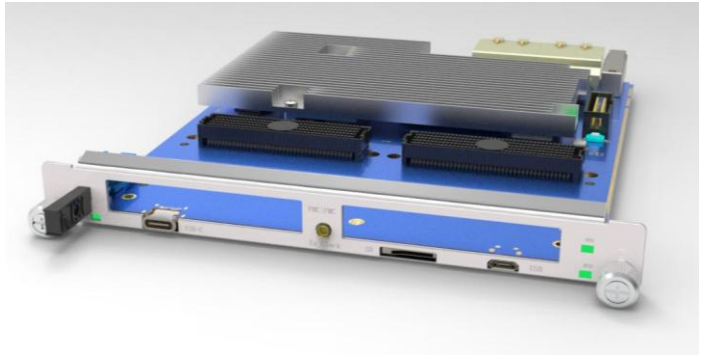
AMC & uRTM



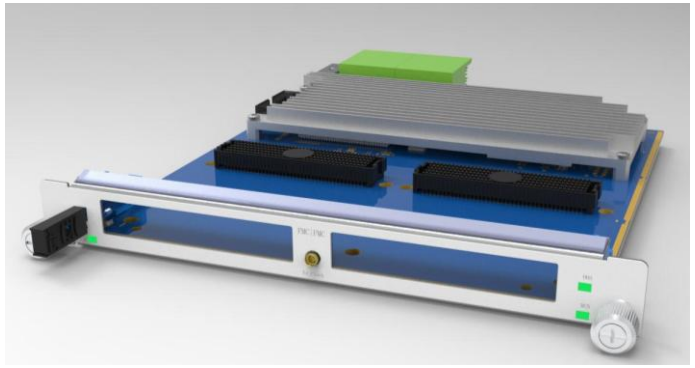
Hardware System Design Block Diagram

AMC Card:

- FPGA: Xilinx Zynq UltraScale+ MPSoC (XCZU11EG-2FFVC1156I) (Industrial Grade)
- Supports FLASH boot (MT25QU512)
- Two standard FMC slots (compatible with LPC standard)
- Memory Configuration: 64-bit 4 GB DDR4 with 2400 MT/s connected to PS - accessible from PL via AXI Bridge
- Supports PCIe Gen3 x4, connected to the chassis backplane via gold fingers
- Supports external clock input



AMC Card



uRTM Card

uRTM Card:

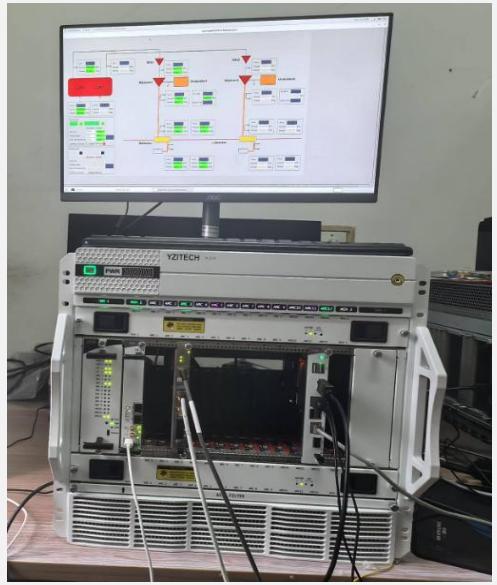
- FPGA: XC7VX690T-2FFG1157
- Supports FLASH boot (MT25QU512)
- Enables clock synchronization with high-performance AMC digital signal processing (DSP) boards
- Two standard FMC slots (compatible with LPC standard)
- Supports external clock input

PCIe Fiber Optic Transmission and Compatibility Testing

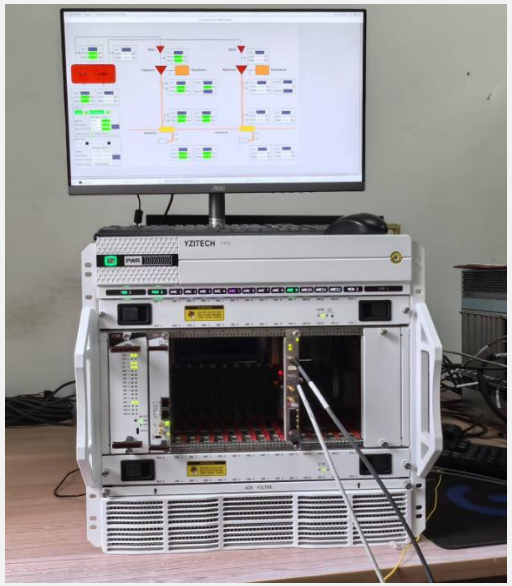
Uplink Card + Optical Fiber + AMC_DAQ Card

- Use the optical port on the MCH and the uplink of the PC to test the read/write (R/W) speed of the AMC DAQ card.

National Synchrotron Radiation Laboratory, University of Science and Technology of China （NSRL)



Low-Level Application of CPU Card



NAT RTM CPU Compatibility Application

- Compatibility Testing of Low-Level Card (Left Diagram)
- Compatibility Testing of NAT RTM CPU (Right Diagram)

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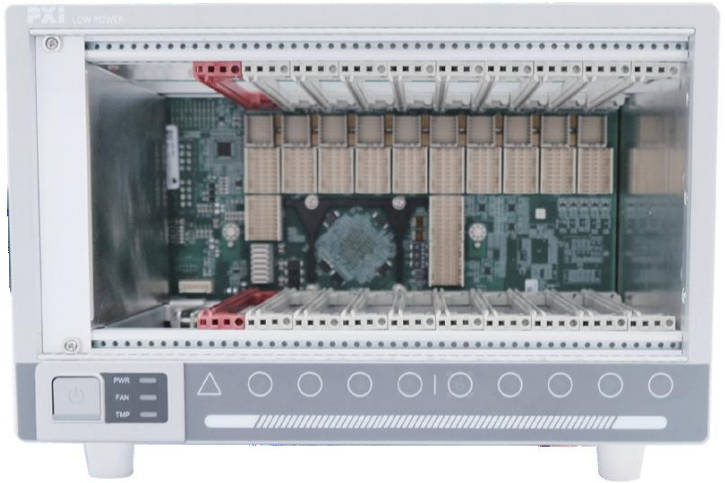
PXIe Platform



10 slots Chassis

main controller

9 slots Portable PXIe chassis + main controller

18 slots chassis + main controller

PXIe Cards (2Msps-1Gsps)

ATCA and Orthogonality Platform

ATCA

Orthogonality

Orthogonality

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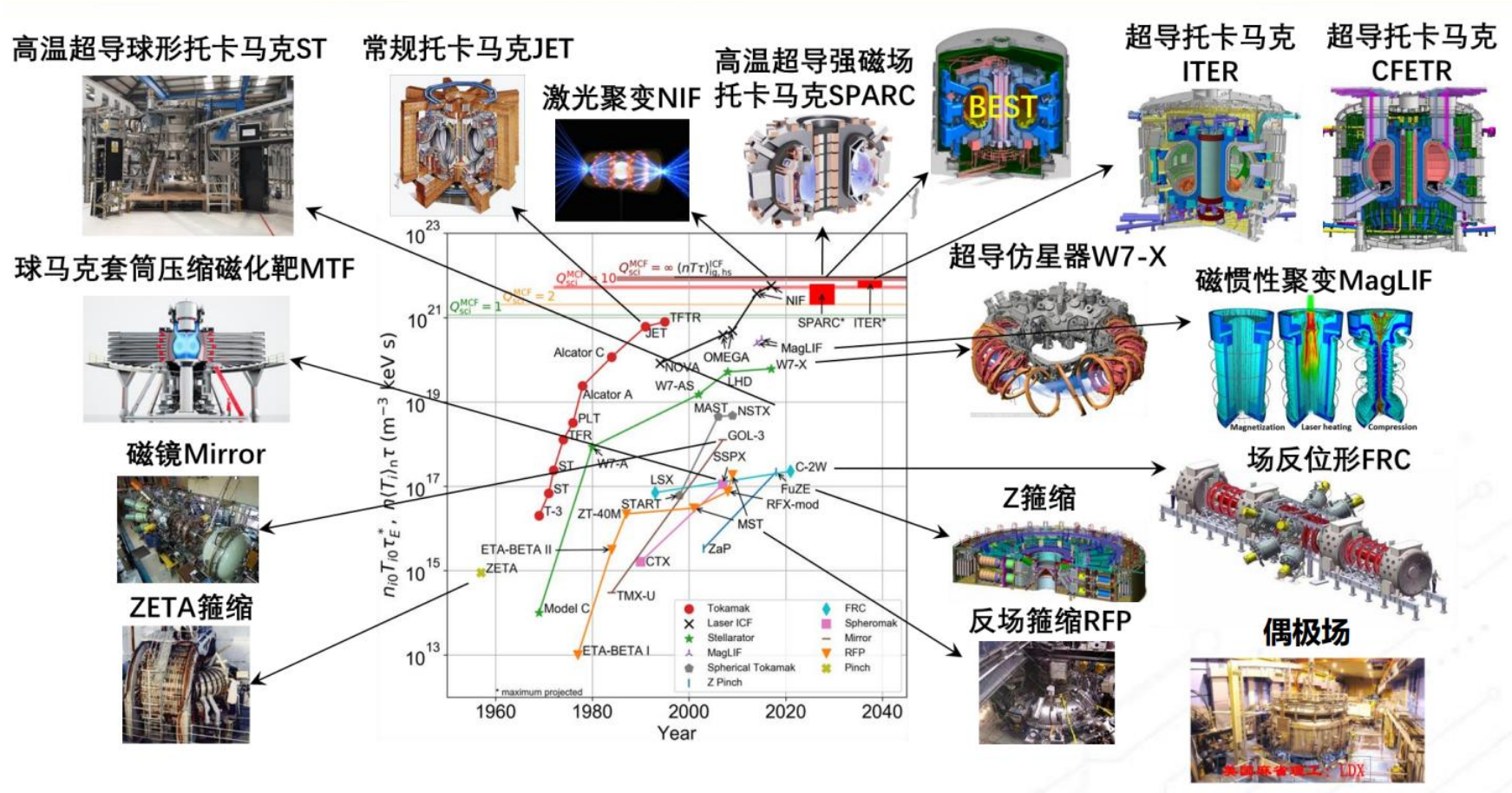
The development path of controllable nuclear fusion

- Controlled Nuclear Fusion
  - Magnetic Confinement
    - Tokamak
    - Stellarator
    - Spherical Tokamak
    - RFP
    - FRC
    - Magnetic Mirror
    - Dipole Field
  - Inertial Confinement
    - Laser-Driven
    - Ion Beam-Driven
    - Electrostatic -Driven
    - Beam-Target / Beam-Beam
  - Magneto-Inertial Confinement
    - MagLIF
    - Spheromak Magnetized Target
    - Z-Pinch



The subsystem of the fusion device

Fusion Reactor Device

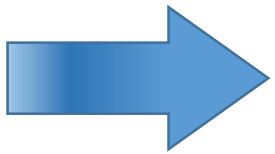
- Main Structure of the Device
- Power Supply System
- Magnets and Superconductivity
- Blanket

■ Diagnostics

- Vacuum

■ Control

- Cryogenics
- Auxiliary Heating System
- Safety Interlock and Radiation Protection



Fusion Reactor Diagnostics System

- **Neutron/Gamma and Safety Diagnostic System(Fusion Power)**
- **Radiation Measurement Diagnostic System (Safety)**
- **Magnetic Measurement Diagnostic System (Fusion Control)**
- Optical Imaging and Spectroscopy Diagnostic System
- Laser-Assisted Diagnostic System
- Microwave Diagnostic System

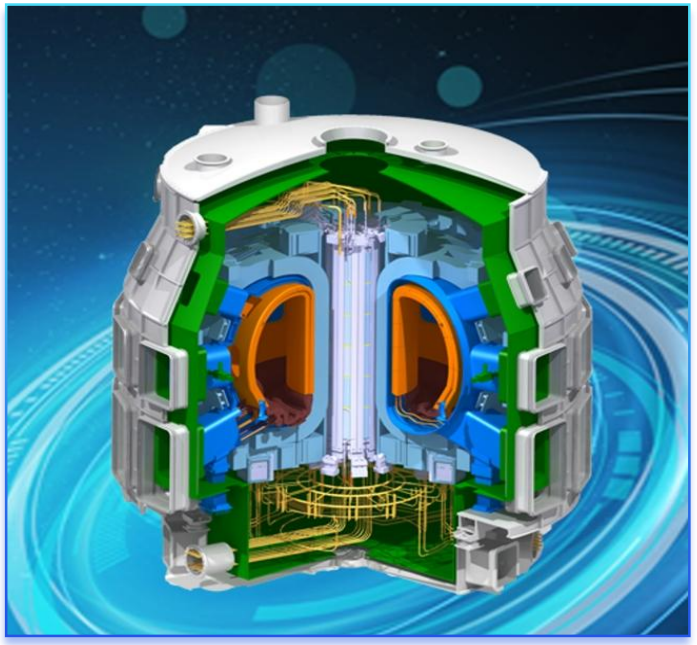
Introduce of Plasma Diagnostic Electronics

Plasma Diagnostic Electronics (PDE):

Plasma Diagnostic + Nuclear Electronics

New Characteristic:

- **Strong Nuclear radiation (Neutron and Gamma)**
- **Strong Static magnetic field (>200mT)**
- **Strong Electromagnetic Interference(EMC)**

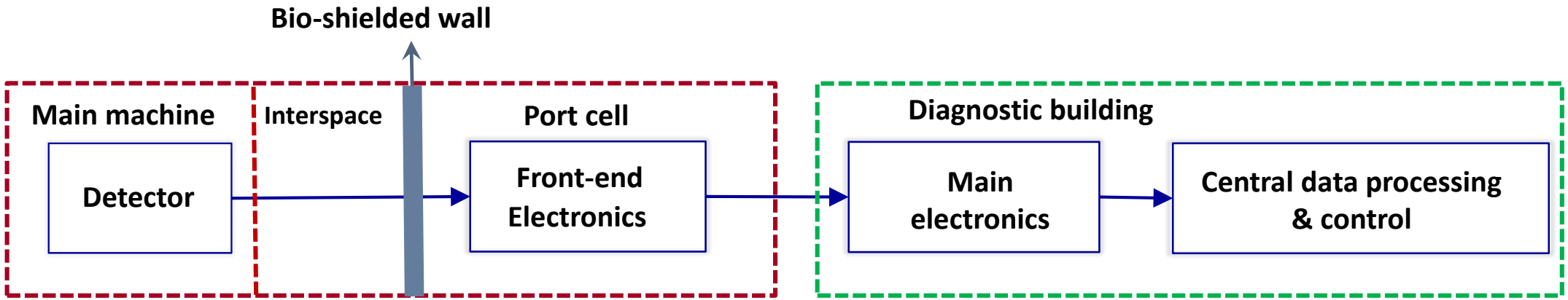


Research Direction:

- **Nuclear measurement (Neutron, Gamma, Soft X-ray, Hard X-ray, high-energy particle, Bolometer, etc.)**
- **Magnetic measurement**
- **Optical camera, spectroscopic, Laser Aided**
- **Microwave**

Architecture of Plasma Diagnostic Electronics

Architecture of PDE:

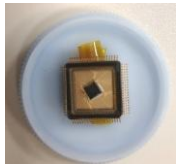


Development History of PDE:

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)

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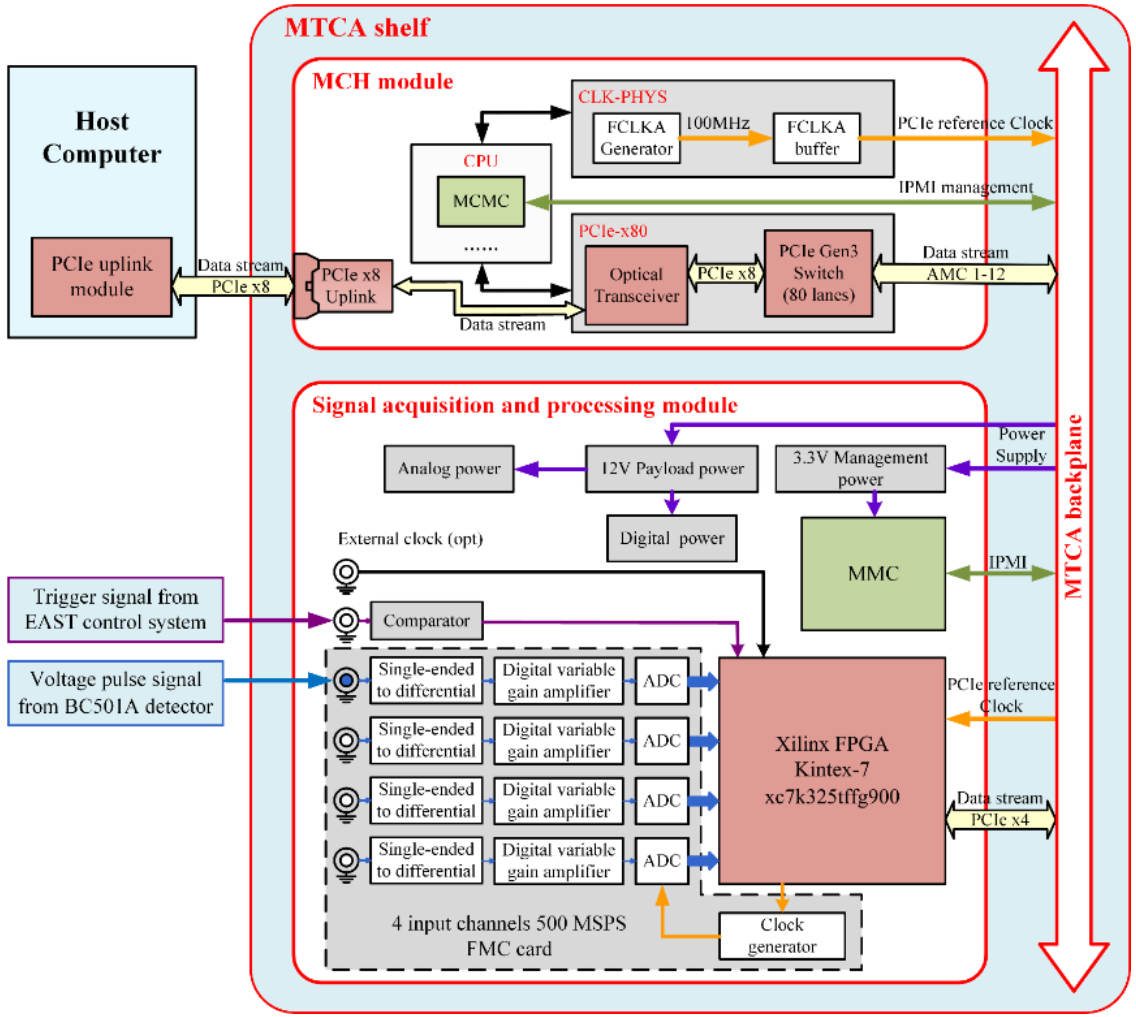
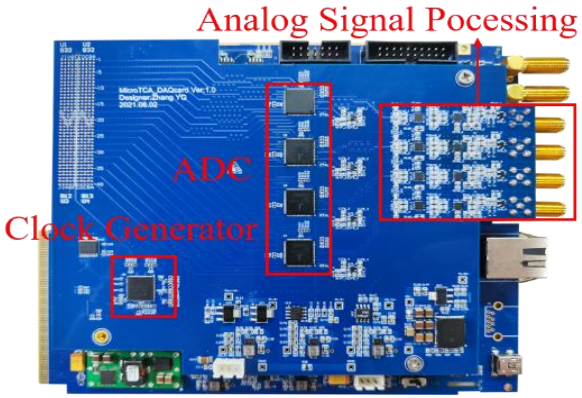
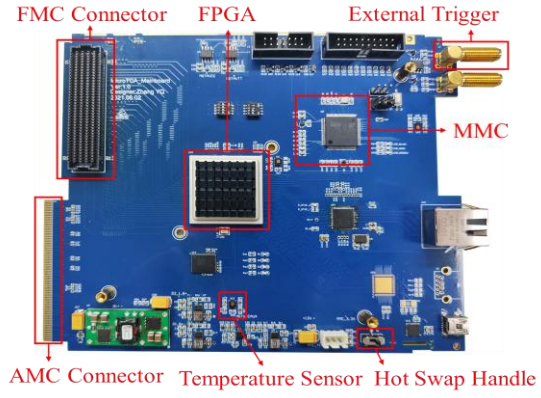
High-Speed Digital Acquisition System



MTCA acquisition system architecture diagram



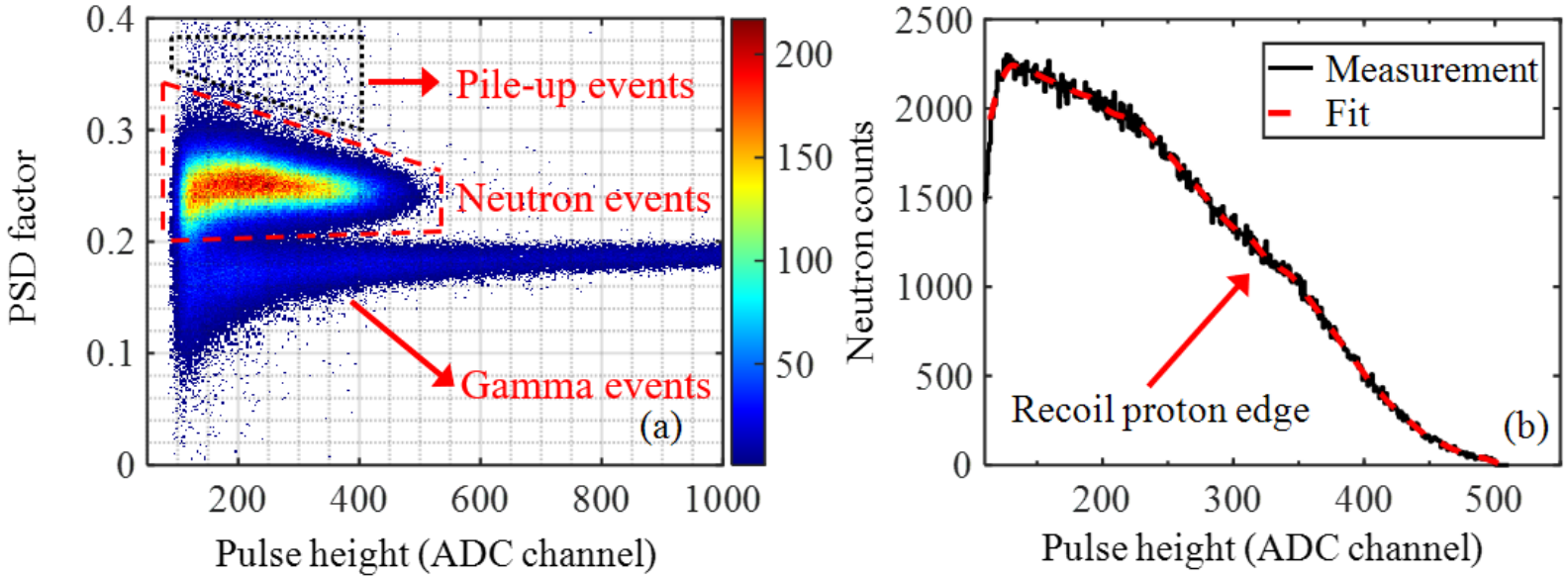


Physical Picture of Equipmen

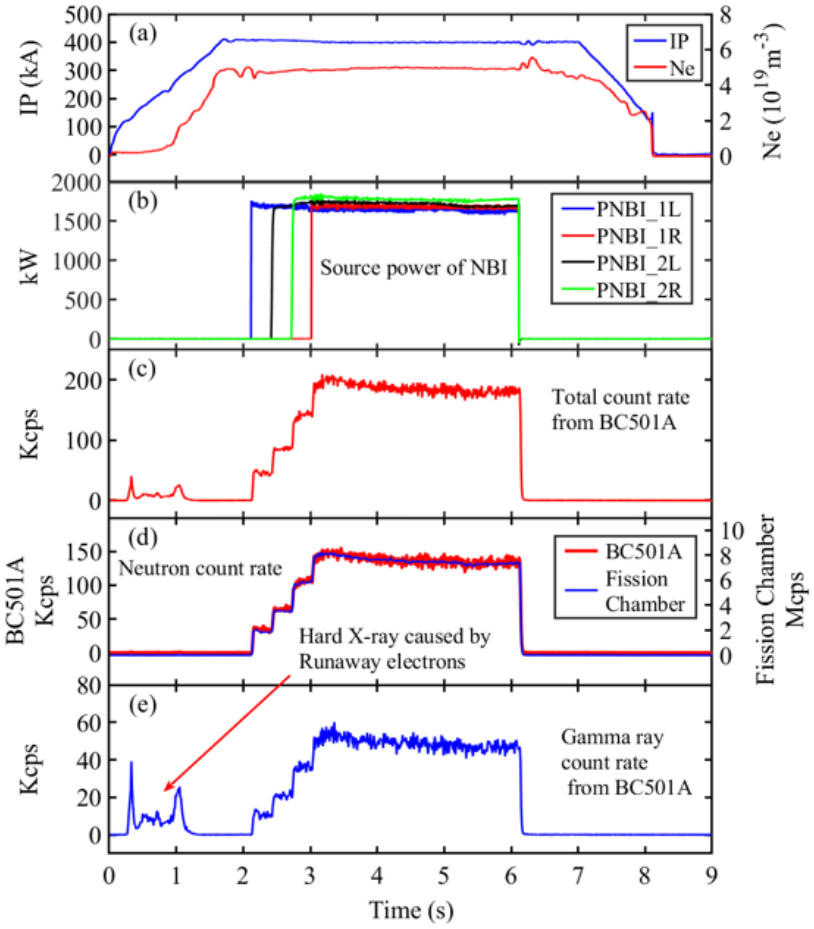
- 4-channel 500 MSPS 14-bit ADC, programmed gain amplifier; **Adjust the signal amplitude, improve the signal-to-noise ratio;**
- X4-PCIe 2.0 communication link, data transmission bandwidth 2GB/s; **Record the complete pulse waveform;**
- Kintex-7 FPGA chip, as the core control chip of signal acquisition and processing board, performs **gain control, ADC control, real-time pulse signal processing algorithm** and **Provides PCIe data transmission ports.**

Applications on the EAST Neutron Energy Spectrum Diagnostic System

- The MTCA high-speed digital acquisition system and the BC501A liquid scintillator detector form a fast neutron detection system, which is used for EAST neutron energy spectrum diagnosis.
- Figure shows the data of the EAST shot 112880 NES system.

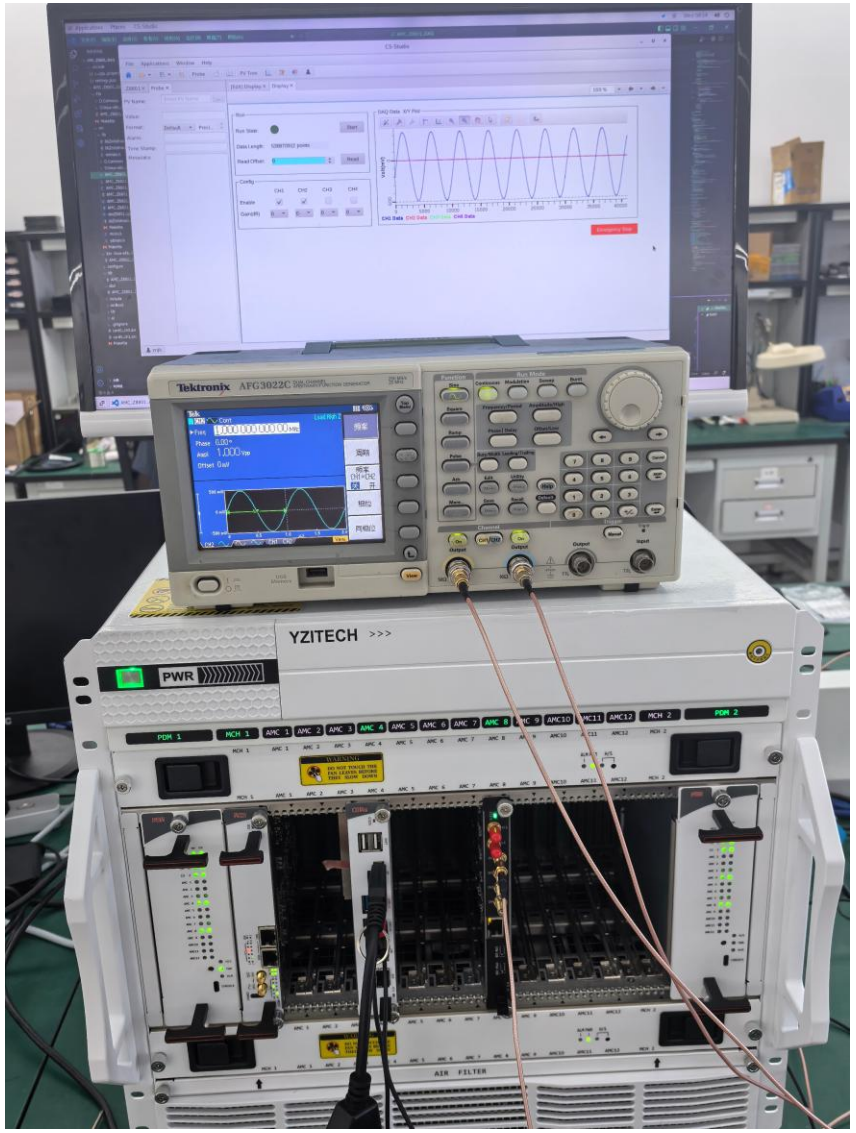


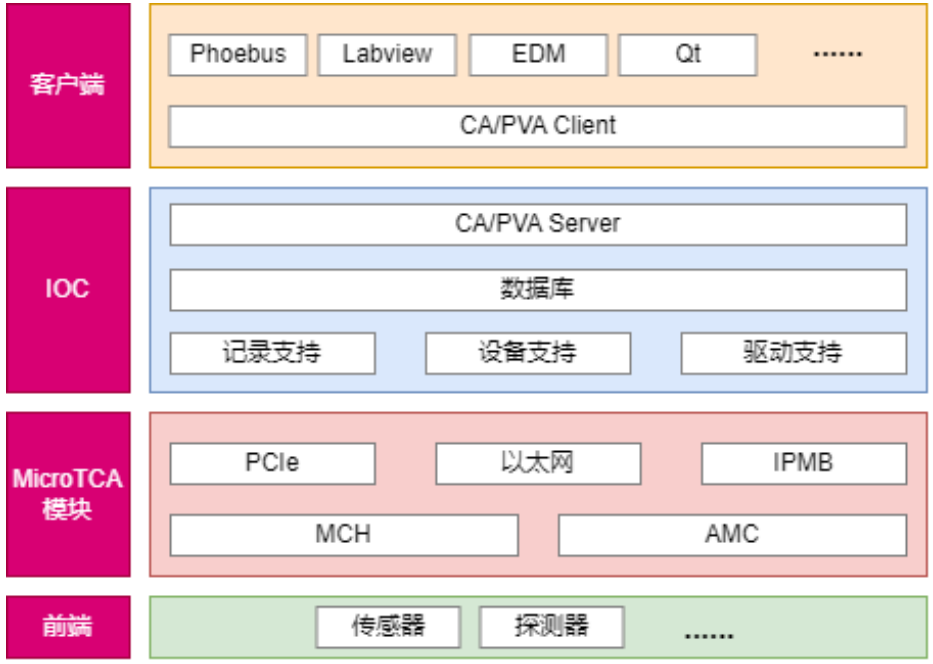
PSD spectrum and neutron pulse amplitude spectrum of EAST shot NO.112880



EAST shot NO.112880 Data

Implementation of the EPICS Control System on MTCA Chassis

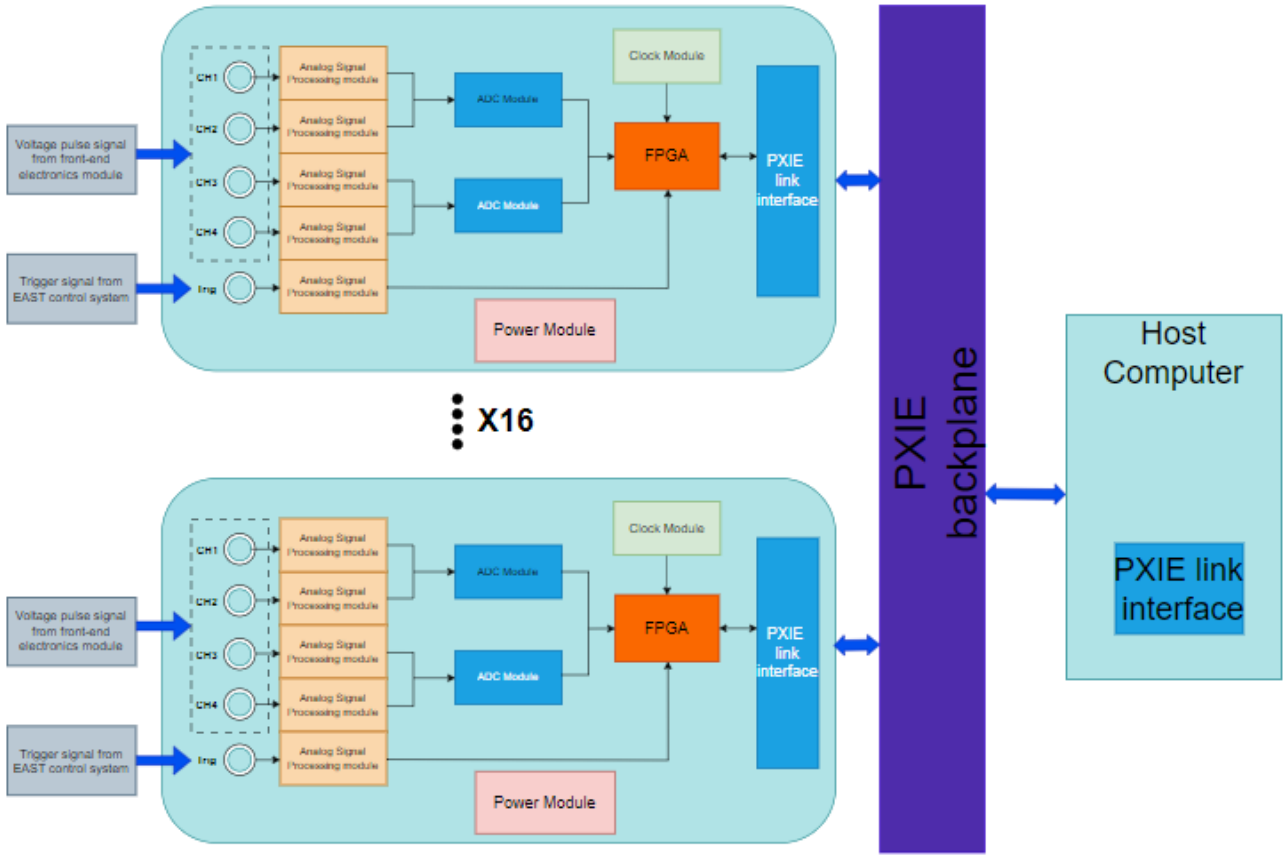




- EPICS driver-MTCA module adaptation completed; client enables real-time data monitoring & parameter configuration.
- MTCA high-bandwidth + EPICS unified management → "distributed acquisition + centralized control" solution, meeting fusion diagnostic multi-module collaboration needs.

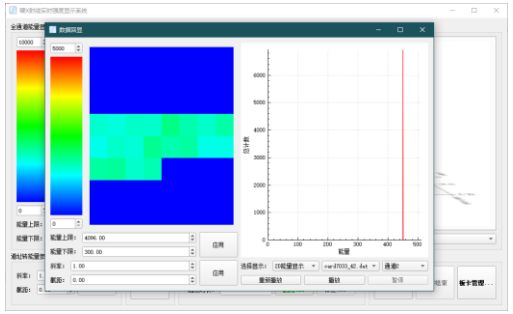
PXIe Diagnosis

2D Hard X-ray Diagnostic System

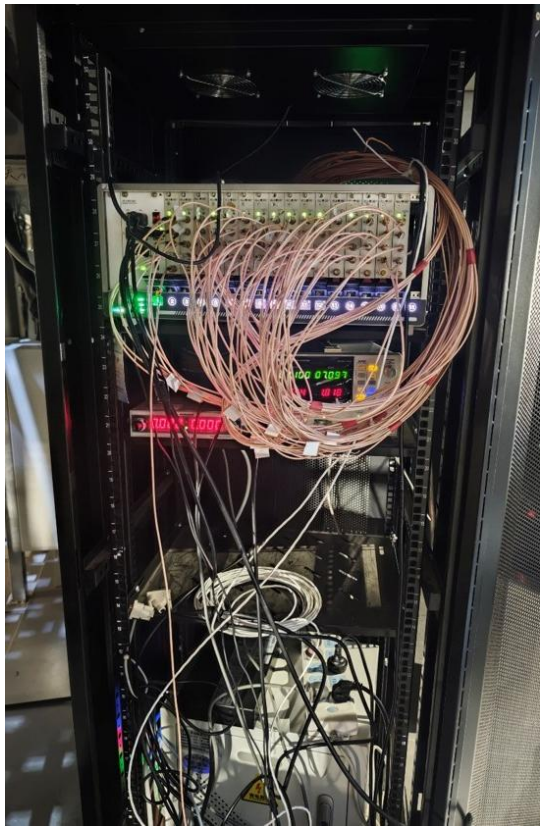


Acquisition System Architecture Diagram

PXIe Card （20M）



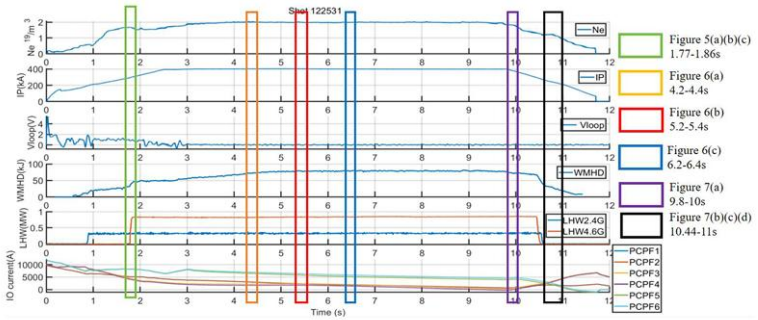
Human-Computer Interaction

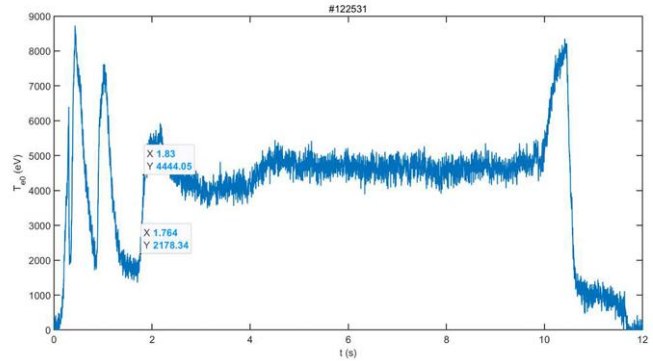


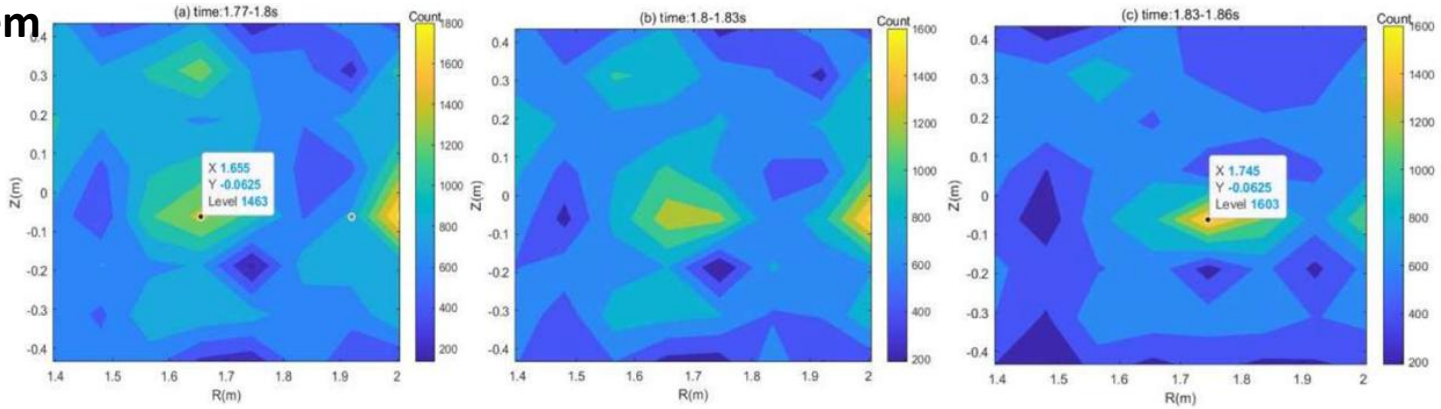
Physical Device Image

PXIe Diagnosis

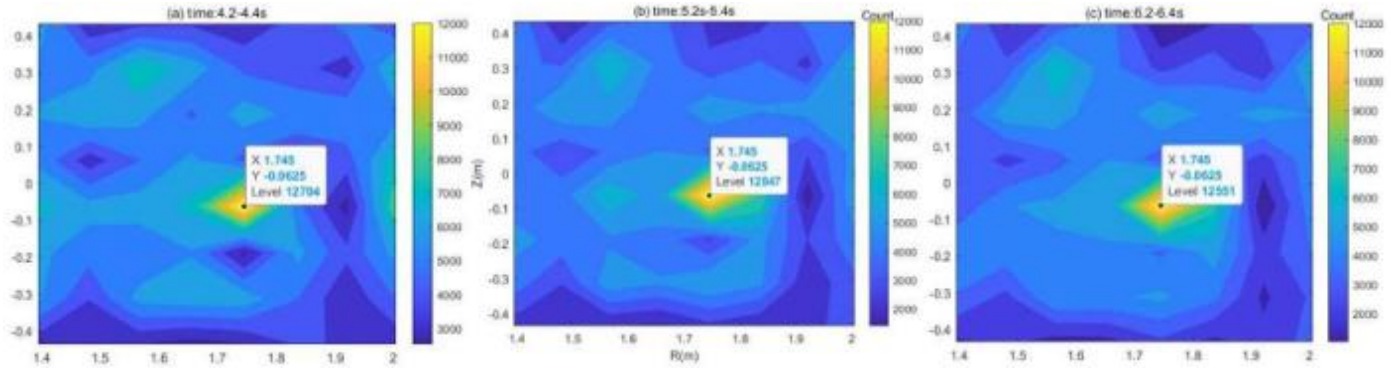
- **Application in EAST Hard X-ray Diagnostic System**



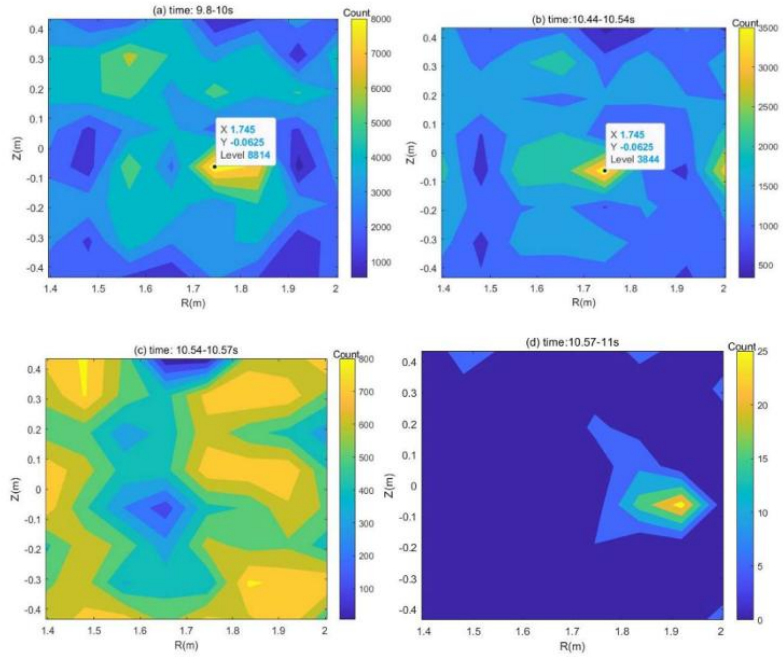




LHW Deposition Position Changes (Ascent Phase)



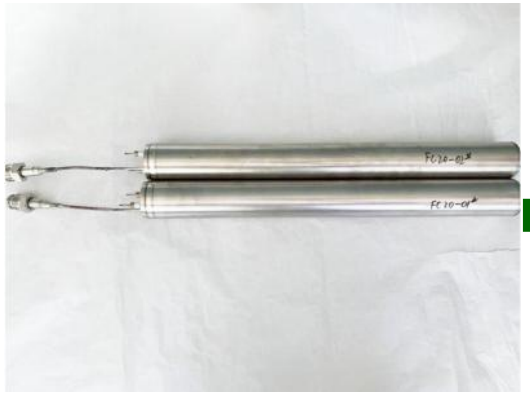
LHW Deposition Position Changes (Flat Top)



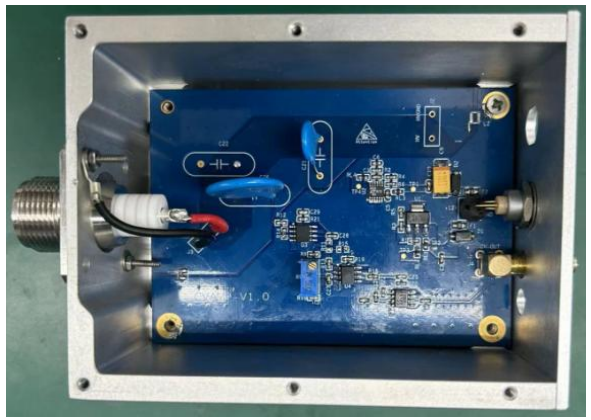
LHW Deposition Position Changes (Descent Phase)

PXIe Diagnosis

- The neutron flux monitoring system mainly uses fission ionization chambers or micro-fission chambers as detectors.
- The main electronics system of NFM (Neutron Flux Monitor) includes three operating modes: pulse counting, Campbell integration, and current.



Fission Ionization Chamber Detector

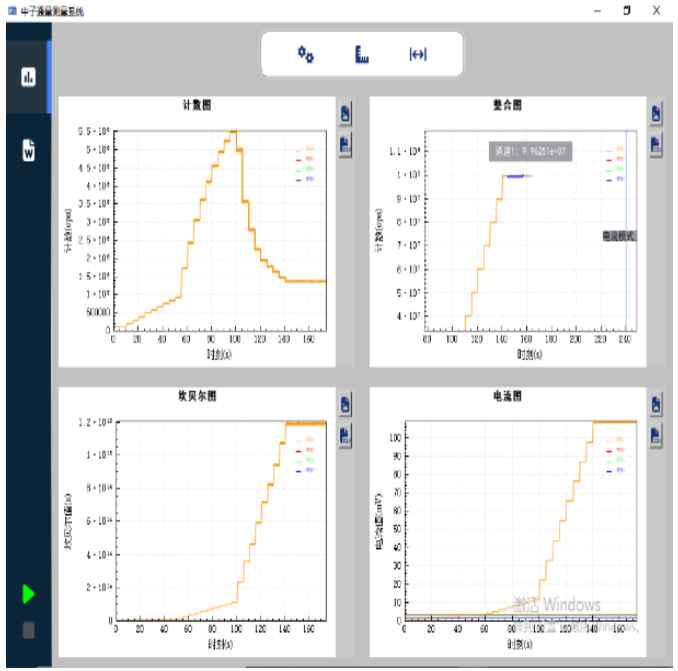


Preamplifier

Main Electronics Signal Acquisition and Processing System

Main Electronics Board

9 slots Chassis



Human-Computer Interaction

Content

- Introduce of ASIPP and Zooneng Corporation
- Solution for Localized MTCA Chassis
- Other High-Speed Data Communication Platforms
- Development of Plasma Diagnostic Electronics
- Applications in Fusion Device Diagnostics
- **Summary**

Summary

Accurate measurement of plasma is key to the stable and efficient operation of nuclear fusion. With its end-to-end advantages of "accurate acquisition, efficient processing, flexible integration, and stable operation", the MTCA platform plays an increasingly important role in the field of fusion diagnostics.

- By building a high-speed data acquisition and control system, it meets the demands for high speed and high channel density in plasma diagnostics via high-speed sampling modules. It also enables efficient data transmission to the host computer through multiple data buses, ensuring accurate measurement of plasma parameters.
- For the large volume of diagnostic data generated in fusion experiments, it can integrate high-performance processors and large-scale storage units to support real-time data processing and analysis.
- With its modular design, it allows rapid hardware expansion based on experiment scale and diagnostic requirements, adapting to various diagnostic subsystems of fusion devices and reducing the complexity and cost of system upgrades.
- Equipped with hot-swap capability and redundant design, it enables component replacement and maintenance without system interruption, greatly reducing failure risks and ensuring continuous, uninterrupted fusion experiments.

Thank you for your attentions!

Comments and questions are welcome