Overview of DMCS Projects and MicroTCA.4 Developments

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Agenda

- Introduction
- Image Acquisition and Processing with MicroTCA.4
- Smart MMC and RMC solution for xTCA systems including FMC support
- High-power piezo driver HPD-400
- Conclusions

Image Acquisition and Processing with MicroTCA.4

Fusion Projects - Plasma Diagnostics

Current collaboration:

- CADAQ lab
- ITER
- IPP W7-X
  - **Axel Winter**

Thu 3/12, 15:15

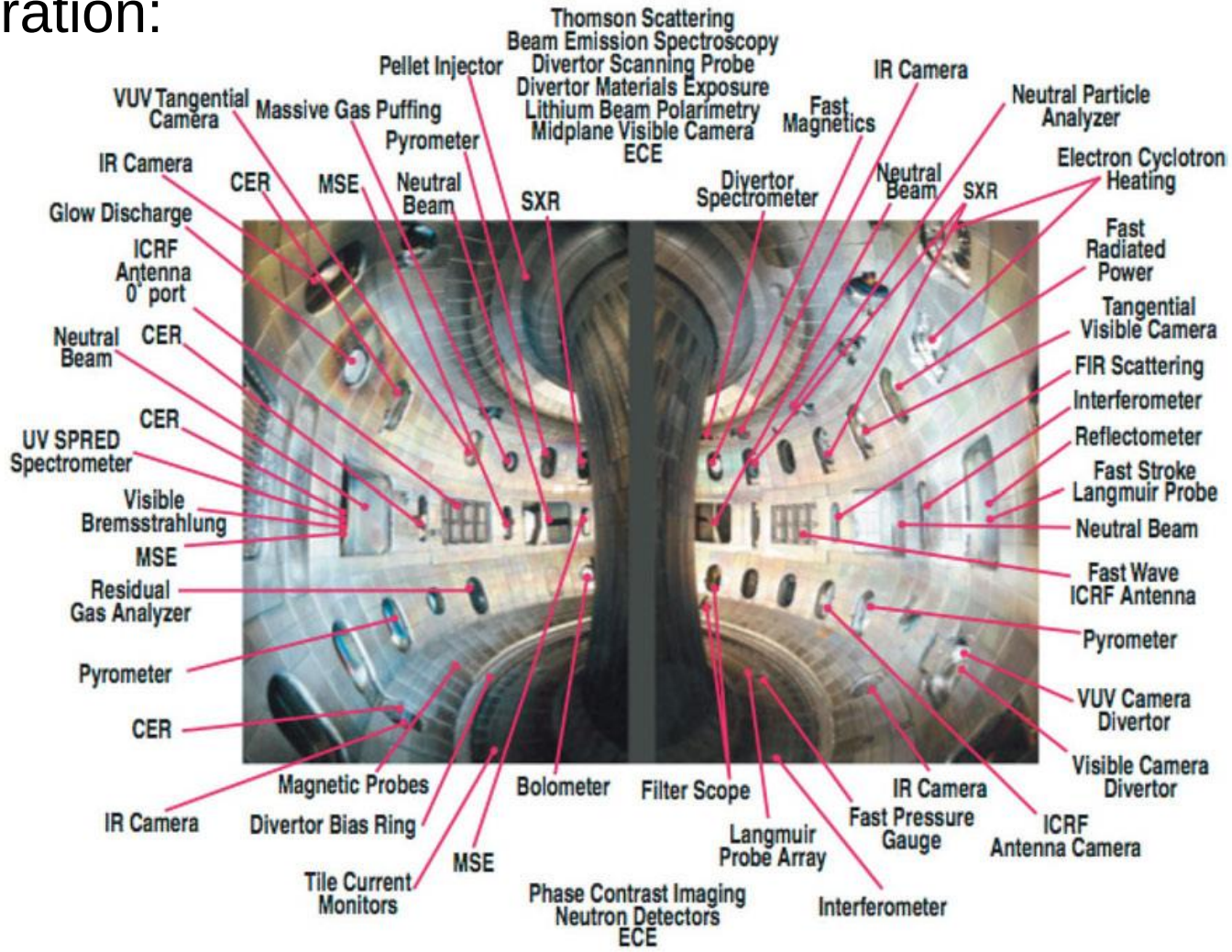


Image Acquisition and Processing – External CPU

Design on various levels:

- New hardware design (frame grabber, FMC modules, PCIe link, etc.)
- Universal firmware and software framework for IAS

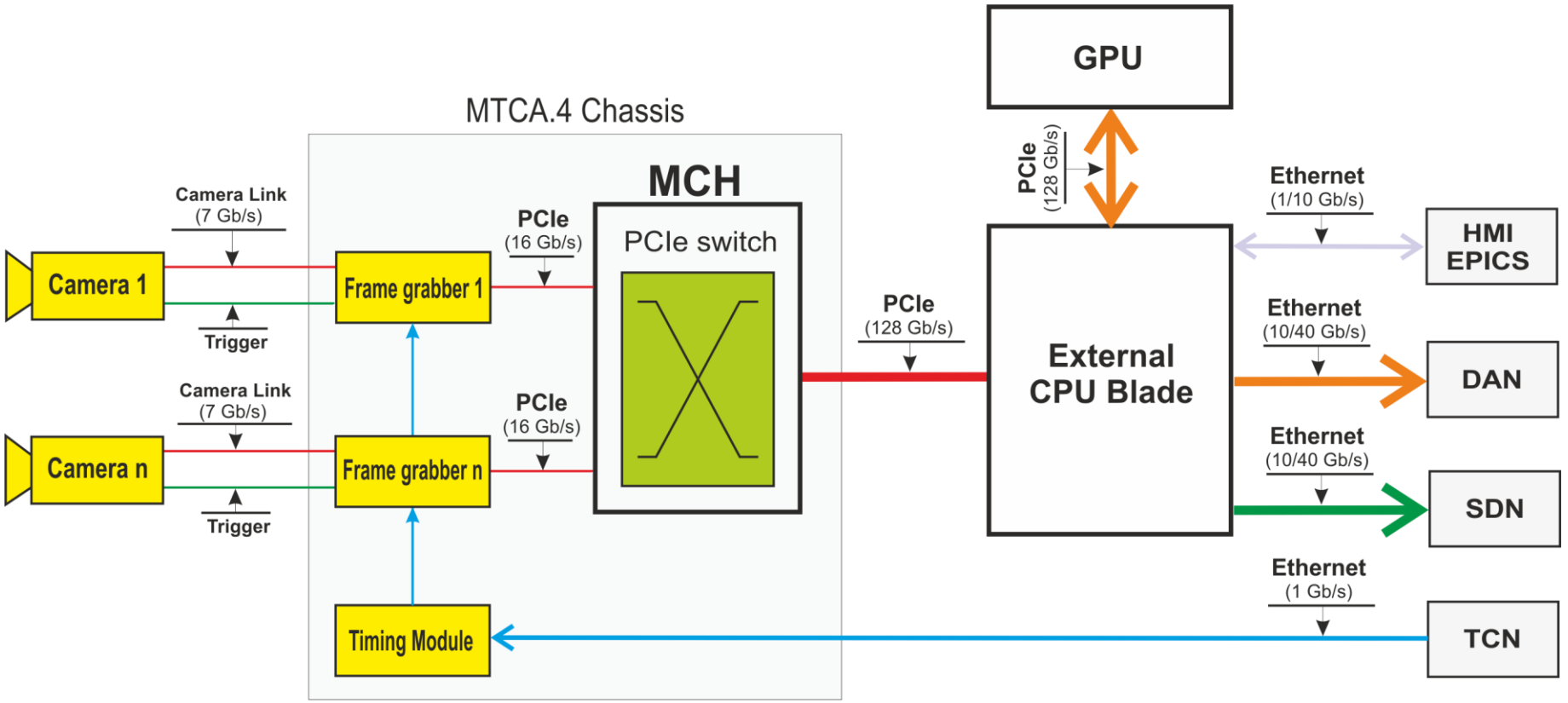
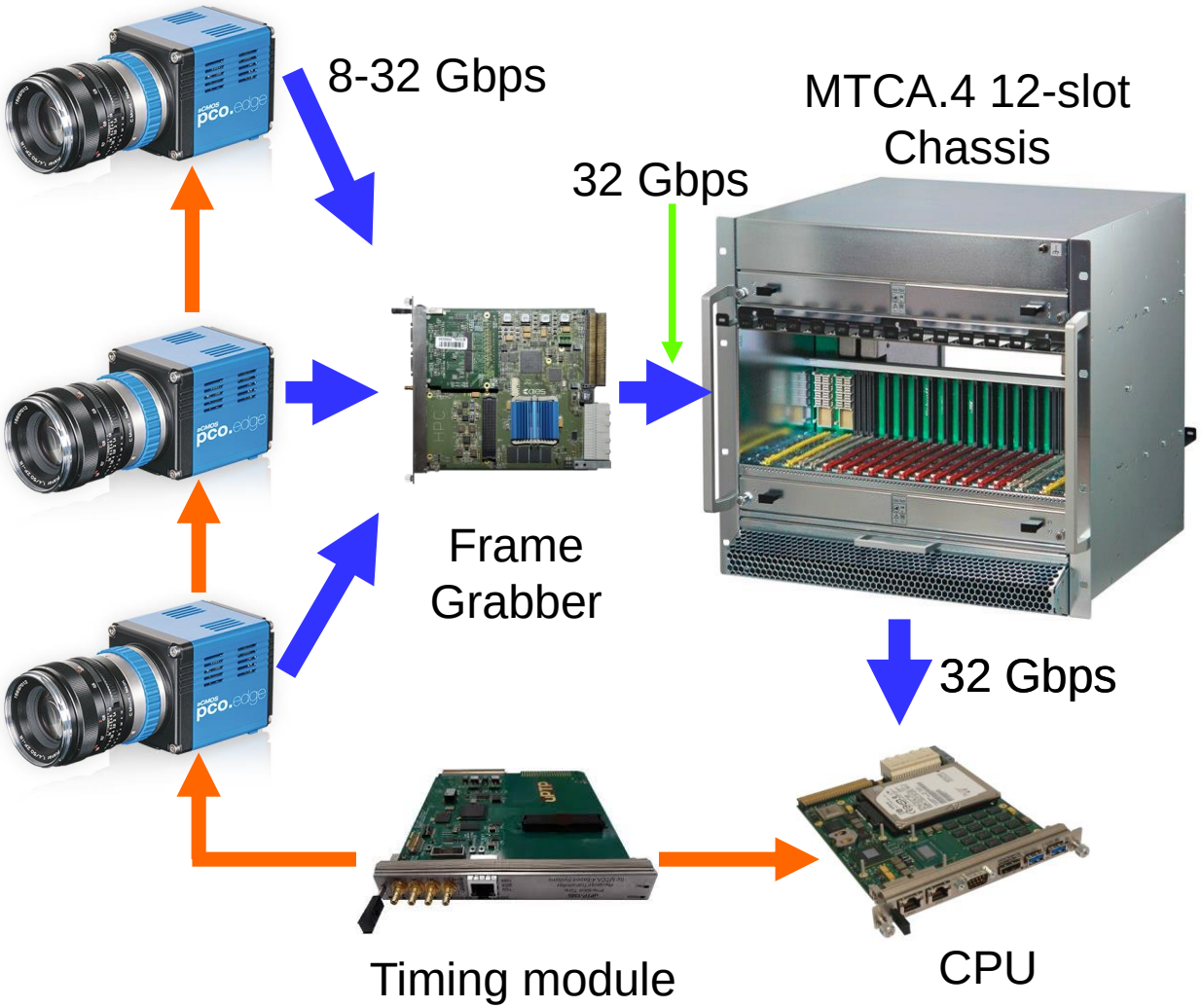


Image Acquisition and Processing with MTCA.4



Micro Telecommunication Computing Architecture:

- High RAMI (Reliability, Availability, Maintainability and Inspectability)
- Extensions for precision timing and synchronization
- Intelligent Platform Management
- Good price to performance ratio

Various Cameras and Interface Standards

Camera Link	2.04 Gb/s, 5.44 Gb/s, 6.8 Gb/s
Camera Link-HS	2.4 Gbps / 128 Gbps
CoaXPress 2.0	n x 6.25 Gb/s (n=4 → 25 Gb/s)
GigaVision	800 Mb/s
10 GigE Vision	10 Gbps
IEEE1394/Fire Wire	0.4 Gb/s (1394a) or 0.8 Gb/s (1394b)
HD-SDI	1.45 Gb/s (max. 2.9 Gbps)

SCD Hercules (CL)

Active Silicon (CXP-12)

Imperx Cheetah (10GigE Vision)

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Supported Cameras with Developed Frame Graber

Mikrotron MC3010

Teledyne DALSA

Allied Vision PIKE F-145

Dalsa Genie TS

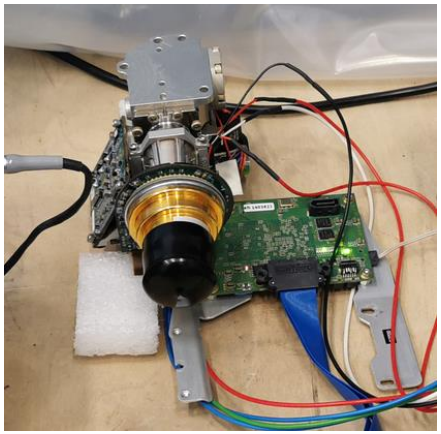
Raptor Cygnet 2.1MP

PCO Edge 5.5

Andor Neo 5.5

Emergent HR-12000-S-C

Supported IR Cameras with Developed Frame Graber



SCD Hercules

IRCAM Caleo 768k L

Universal Frame Grabber Module for MTCA.4

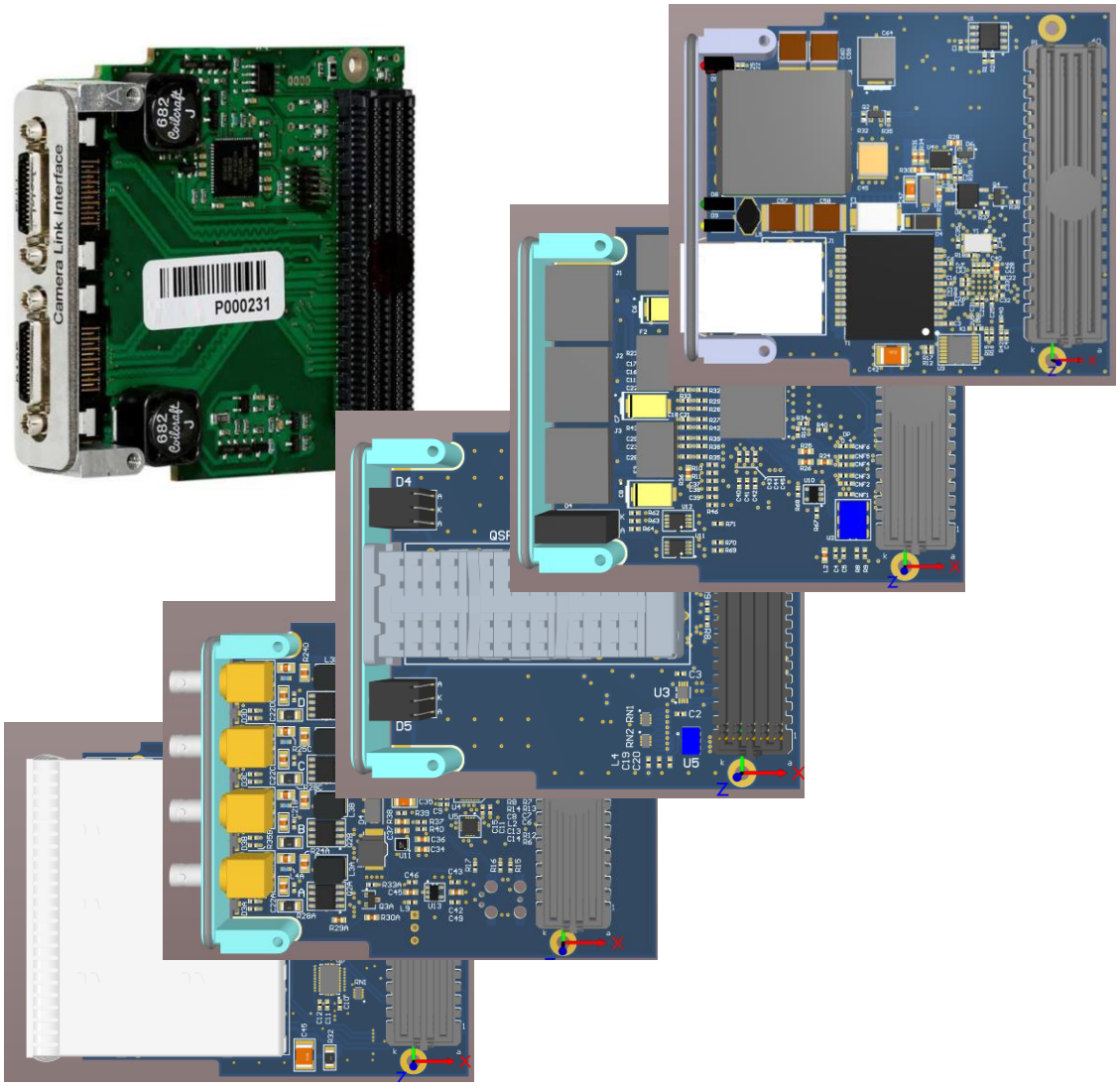
Frame grabber is composed of:

- FMC carrier
- FMC modules supporting various camera interfaces

(8 standards)

In addition we need:

- IP core for selected camera interface
- Dedicated camera library



FMC Carrier Modules

Frame grabber is composed of:

- FMC carrier
  - **Artix 7 FPGA (<6.5 Gb/s)**
  - **Zynx US+ SoC (>6.5 Gb/s)**
- FMC modules supporting various camera interfaces

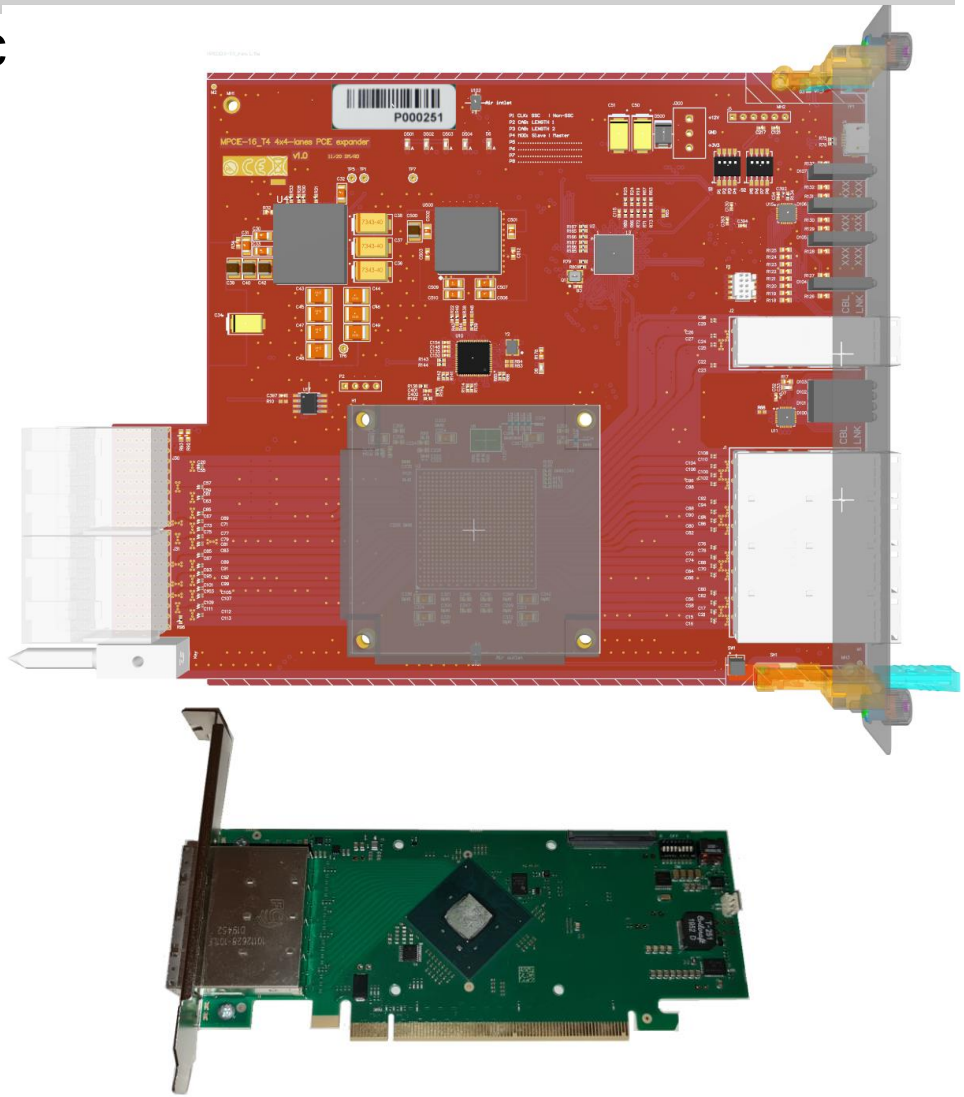
  (8 standards)

Software support:

- IP core for selected camera interface
- Common Linux driver
- Dedicated camera library (GenICam)

Scalable PCIe Link to External CPU

- Compliant with MTCA.4.1 spec
- Configurable PCIe link to Root Complex
  - 1x PCIe x16
  - 2x PCIe x8
  - 5x PCIe x4
- Support various modes, including daisy chain
- **PCIe gen. 4 (256 Gb/s)**
- Cable length: 1-10 m
- Support for DMA-over PCIe
  - Image processing with GPU DirectDMA transfers
- Uses NAT-MCH-PHYS80



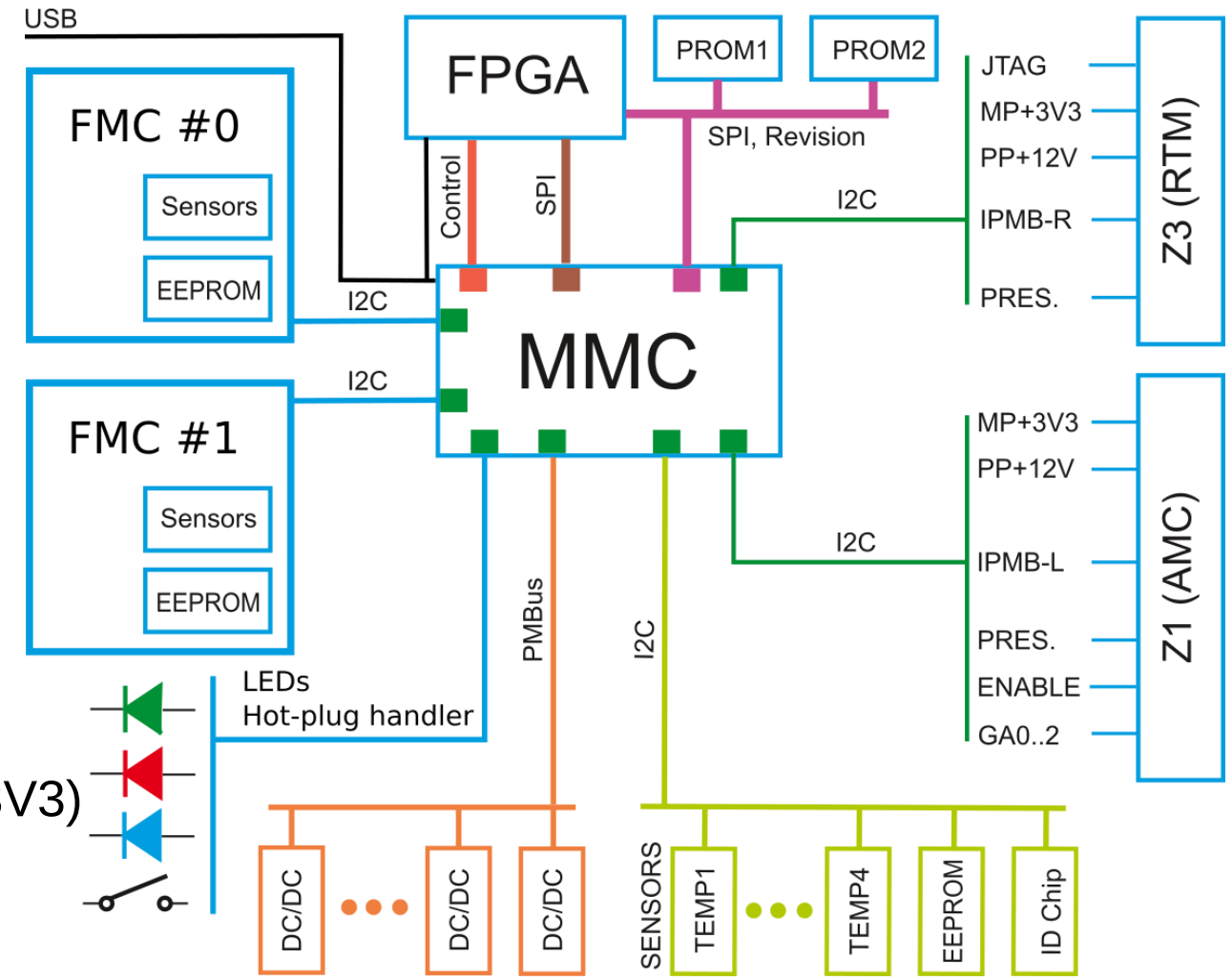
Smart MMC and RMC solution for xTCA systems including FMC support

Smart MMC and RMC solution for xTCA

- ASIC-like solution:
  - **Miniature size 15 mm x 15 mm x 2 mm**
  - **Cost-effective solution**
- Looking for solution for both:
  - AdvancedTCA (Carrier and RTM)
  - MicroTCA (AMC, RTM)
  - Basic and Advanced versions
- ARM microcontroller
  - 1 or 2 ARM cores
  - Low consumption power
  - Ready to be integrated with RTM
- Programmable logic with 6-7x I2C interfaces
- Under development now at TUL-DMCS

MMC/RMC – MicroTCA Solution #1

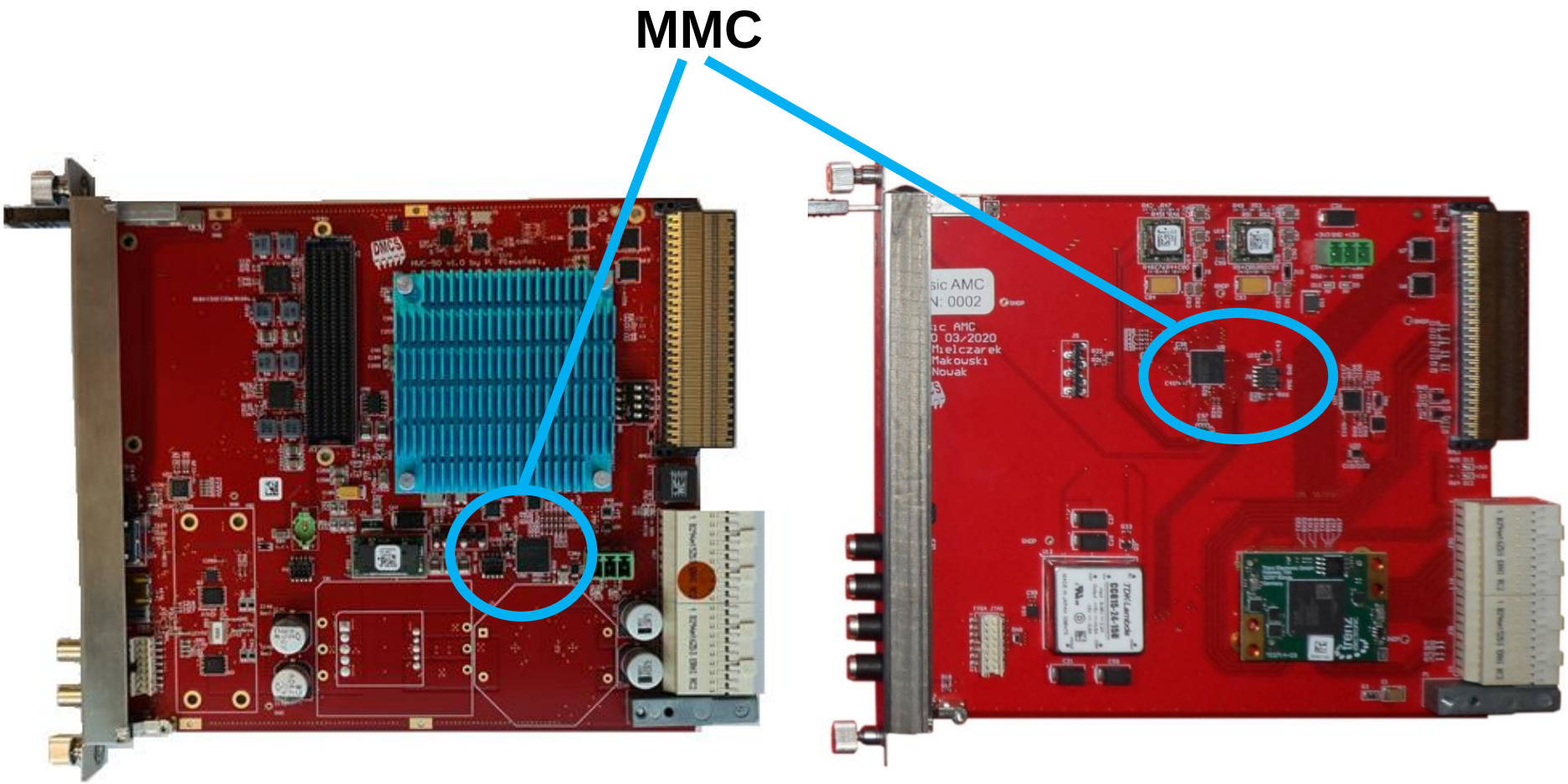
- Support for
  - RTM
  - 2x FMC
  - FPGA
- Interfaces:
  - 6x I2C
  - 2x SPI
  - 2x UART
- Separate power domains:
  - Management (+3V3)
  - Payload (+12 V)



MMC/RMC – MicroTCA Solution #2

- Programmable solution based on SoC
- Optimised BOM cost: ca 25 EUR per device (RTM support, excluding sensors)
- Provides up to
  - 100 programmable lines with max. 4 voltage domains (1.8 V - 3.3 V)
  - 10 programmable PLD blocks
    - I2C Multi-Master/Slave interfaces
    - Quad SPI transceivers
    - UARTs (virtual COM via USB)
  - USB connection (up to 8 endpoints)
- Tested with 2 AMC modules and 1 RTM
- Working on universal firmware xMC framework supporting standards: AMC (MMC, RMC), FMC, ATCA (IPMC)

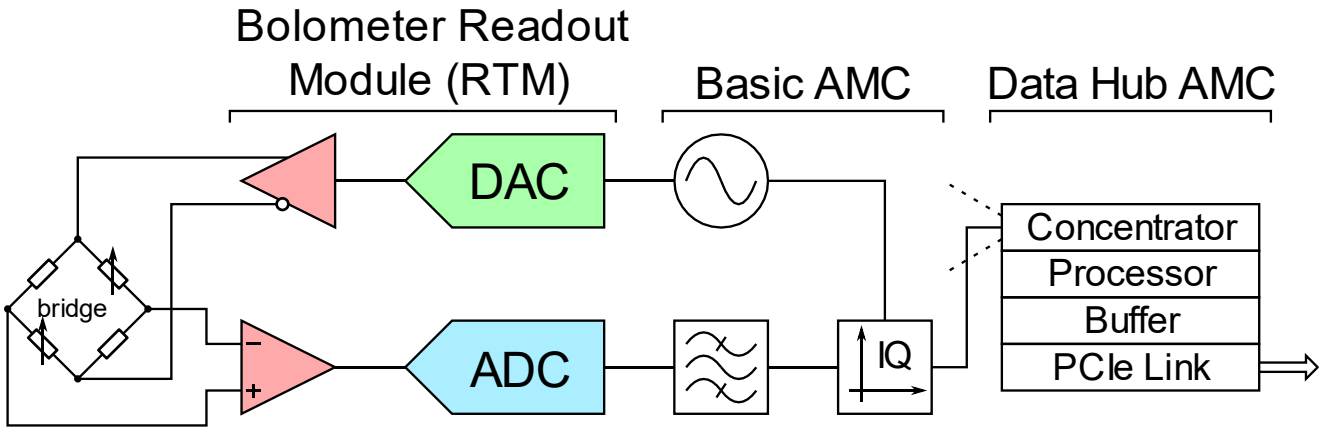
MicroTCA – MMC Implementations



Basic-AMC – the low-cost MicroTCA.4 Compliant Carrier Module

- See presentation on Wed 2/12, 15:05
- See presentation on Thu 3/12, 15:15

Bolometer System for W7X



- The system will span three custom modules and an external sensor
- Application of AC excitation and in-phase detection minimizes the drift
- Not much memory or processing power needed per channel
- Low-latency link to data hub is required

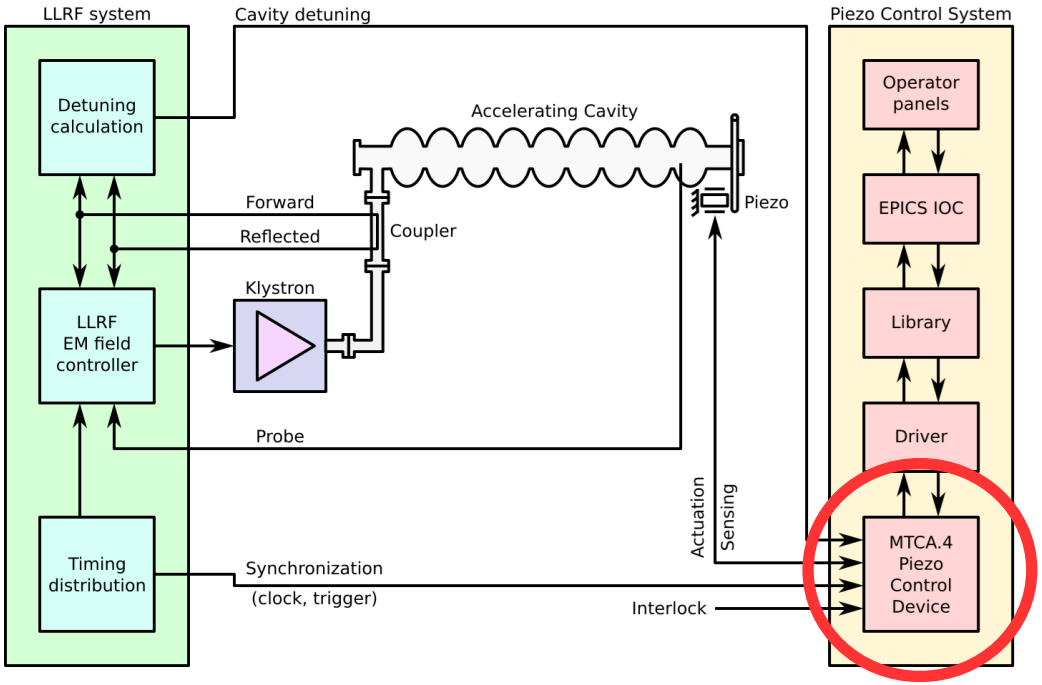
Basic-AMC Features

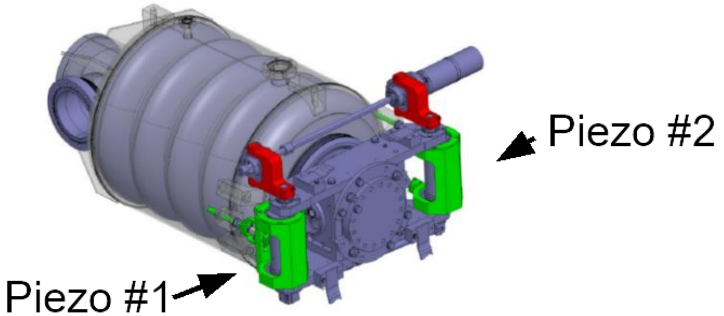
- Based on cost-effective TE0714 FPGA module
- Offers multi-gigabit connectivity:
  - PCIe x2 gen.2 link
  - two additional custom links, up to 6.25 Gb/s
- 90 FPGA I/O signals on Zone 3 and three LVDS clocks (the clocks are also connected to the FPGA)
- The PCB has only 6 metal layers, including two full ground planes

High-power piezo driver HPD-400

High Power Piezo Driver - Motivation

- This work is being done in frame of the Polish in-kind delivered by the **Polish Electronic Group (PEG)** within in-kind agreement signed between PEG and ESS on 2016-11-08, (together with Schedule AIK 8.2, signed 09.2017, ESS-0060409)
- Department of Microelectronics and Computer Science, Lodz University of Technology as a member of PEG consortium is responsible for piezo driver system delivery for elliptical cavities of ESS linac.





ESS cavity with 2 piezo actuators

Piezo Actuators Planned for ESS Accelerator

Cavity type	Piezo actuator type
Medium Beta cavities	Noliac NAC 2022 H30
High Beta cavities	Noliac NAC 2022 H30
Spoke cavities	Noliac NAC 2022 H72

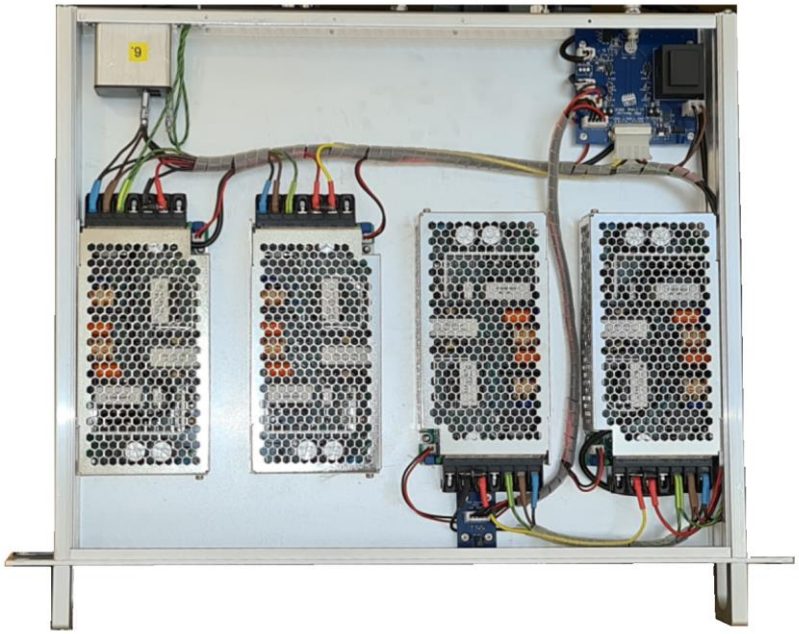
Piezo type	Noliac NAC 2022 H30	Noliac NAC 2022 H72
Dimensions	10 x 10 x 30 mm	10 x 10 x 72 mm
Cell material	NCE51F	NCE51F
Number of cells	14	35
Total capacitance	5.54 µF	13.86 µF
Max. free stroke	46.2 µm	115.5 µm
Blocking force	4200 N	4200 N
Max. operating voltage	200 V	200 V
Max. operating temperature	200°C	200°C

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

Piezo Power Supply Module PPSM-200

- **Provide power supply +/- 100 V**
- **Maximum power ~400 W**
- Selected power supply modules with good MTBF (>2.000.000 hours)
- **Build in diagnostics and simple management**
- Unified internal connectors – simplify manufacturing and maintenance



Thank you for your attention