The MTCA Based Control System Development for Advanced Accelerators

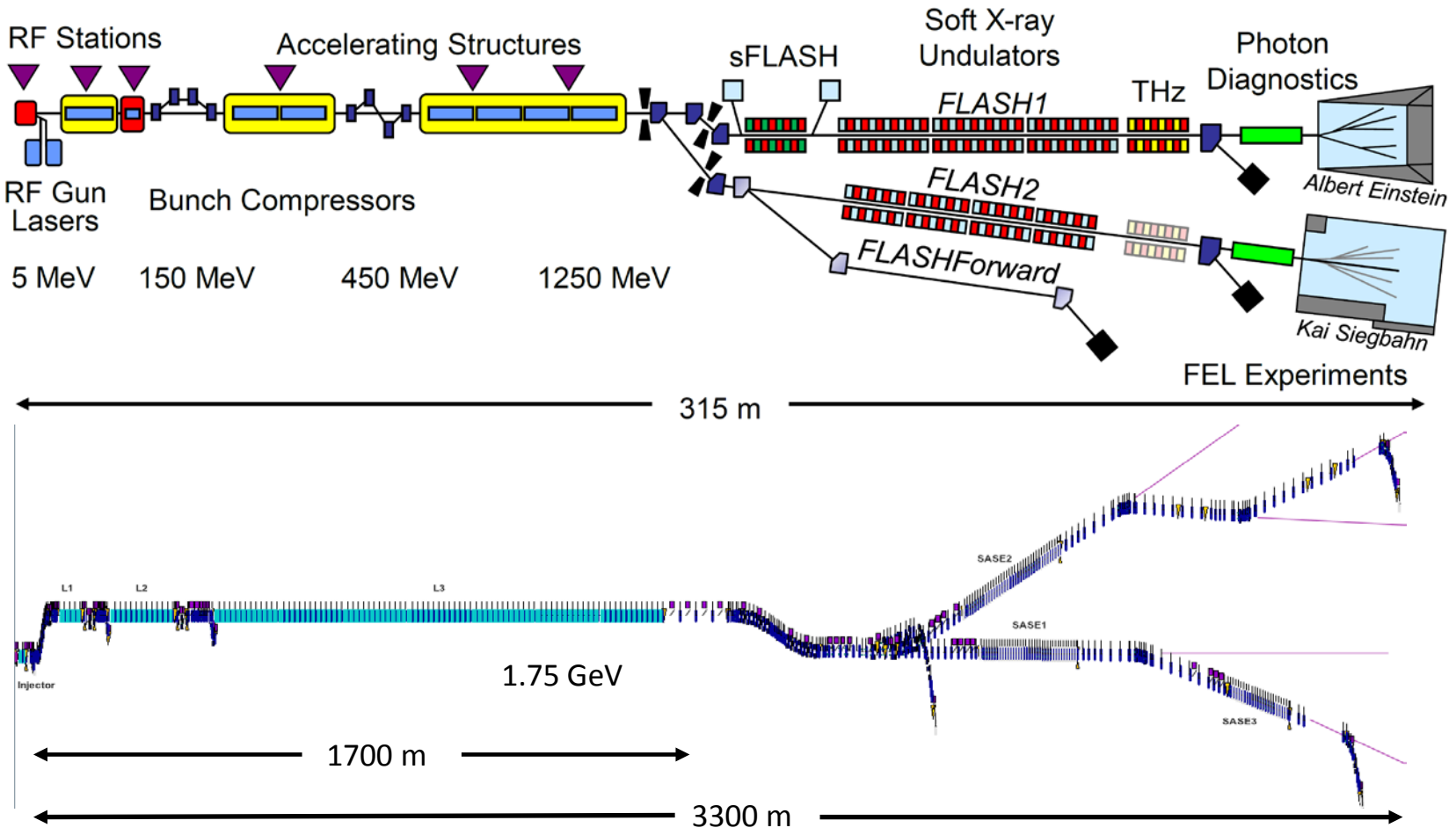
L.Petrosyan

The MTCA Based Control System

We are developing the Control System for :

FLASH
FLASH2

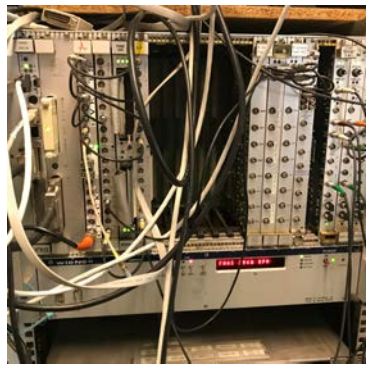
European XFEL

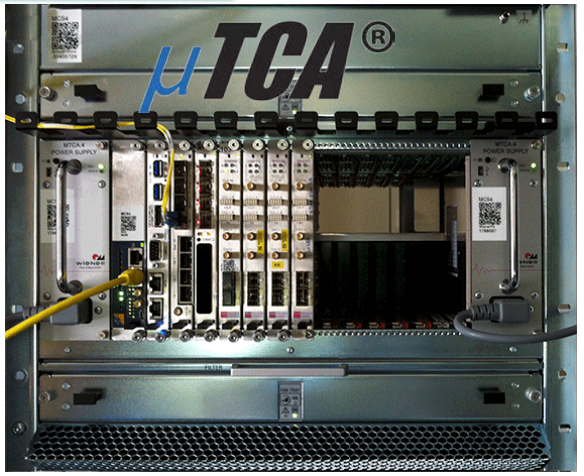


The MTCA Based Control System

UltraSparck CPUs from:
- THEMIS
- FORCE

SOLARIS OS
DOOCS control System
Totally > 80 VME crates





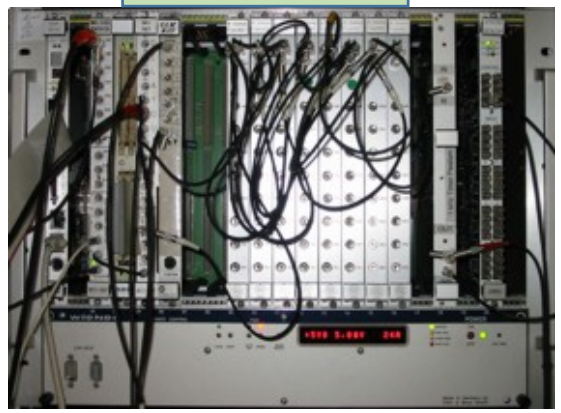
Next Steps:

- ***Update FLASH Control System***
- ***Start FLASH2 (pilot for XFEL)***
- ***Start XFEL***

To achieve high availability in a complex system requires:

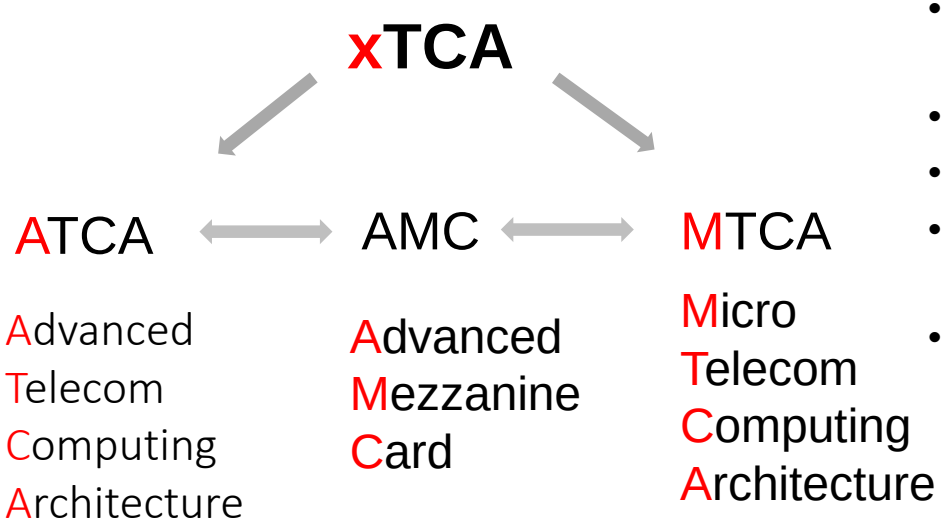
- long term support
- High Data rate
- Scalable modular system
- Well defined Shelf Management
  - administration and monitoring of system resources
  - board protection via electronic coding (e-keying)
- Redundancy
- Hot Swap capability for uninterrupted operation

1993 … VMEbus



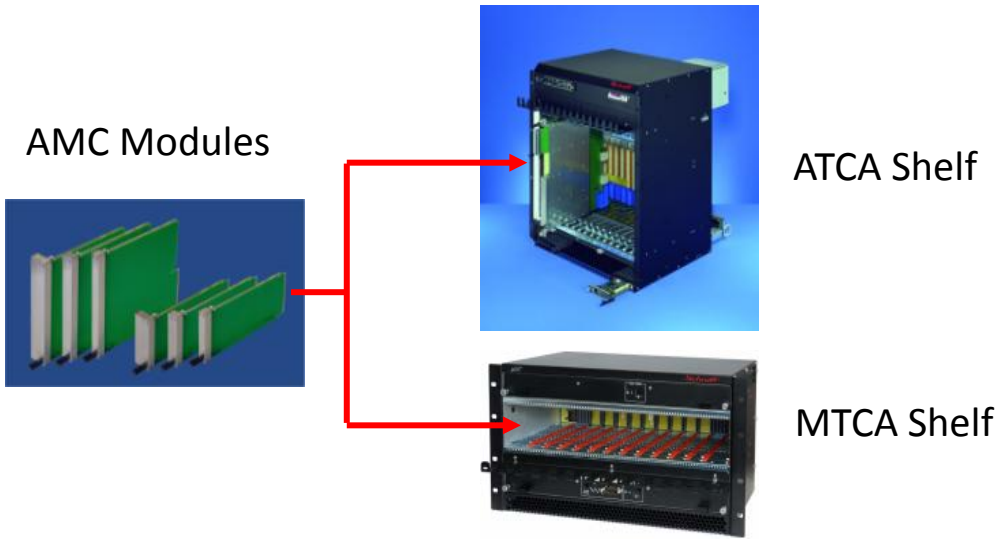
The MTCA Based Control System

The most suitable decision was MTCA which satisfies with everything or to the majority of the above specified requirements



- The basic idea of MTCA is to have a shelf that contains just AMC modules
- Backplane directly accepts AMC modules
- AMCs are interchangeable between ATCA and MTCA
- The infrastructure of a ATCA Carrier was adapted into the MTCA shelf (power, management, switching)
- No rear I/O, power input and all outputs to the front

MTCA is a compact version of the ATCA



> 150 Members

The MTCA Based Control System

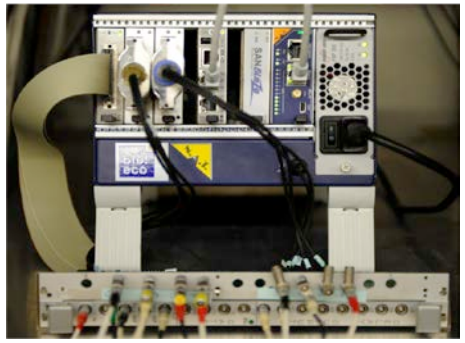
Timeline

- 2002 ATCA Announced by PICMG for Telecom
- 2005 Workshop in Groemitz, presentation from DESY, SLAC
- 2007 XFEL Crate-Standard Workshop
  - MTCA was defined to be used
- 2009 First PICMG Meeting “xTCA for Physics”
- 2011 Official announcement of PICMG Specification
  - MTCA.4 Enhancements for Rear I/O and Precision Timing
- 2011-16 Released, submitted PICMG Guidelines for MTCA.4
  - **http://www.picmg.org/**

DESY

- 2006-09
  - First look to ATCA
  - gradual transition to MTCA
  - A lot of Lab test
  - First prototyp of the DESY Timing board
  - First MTCA crate on FLASH
- 2009-17
  - FLASH upgrade to MTCA
  - FLASH2 and XFEL control system

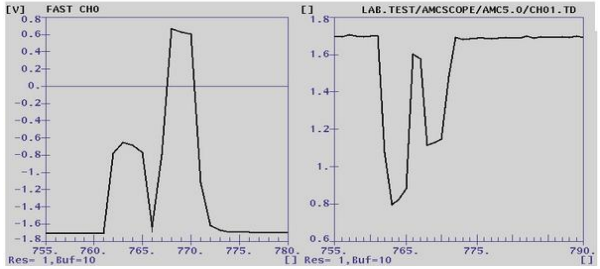
First MTCA crate on FLASH for BPM



ELMA 6 Slot
NAT MCH

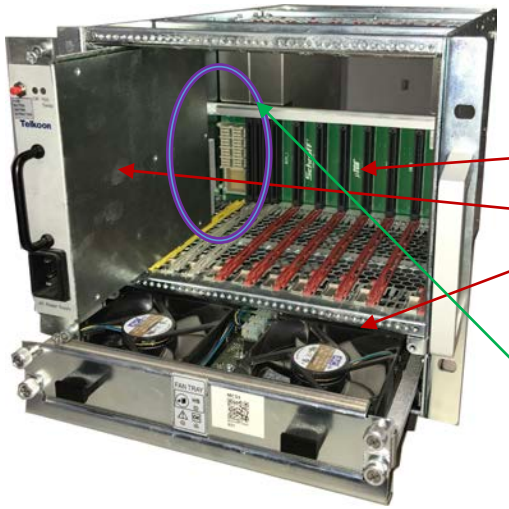
DESY DAMC1 ADC

TEWS TAMC100
IP Carrier with DESY
IP timer board

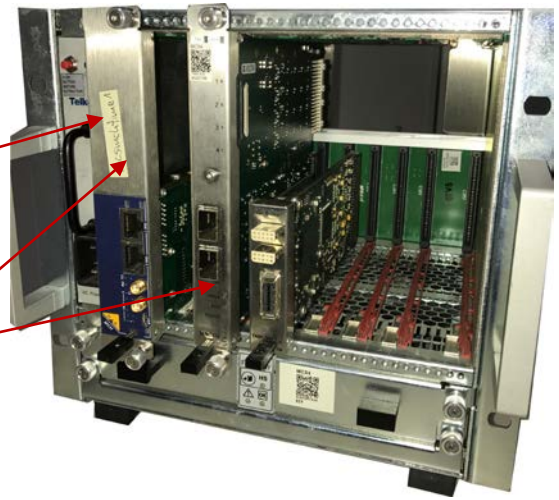


The MTCA Based Control System

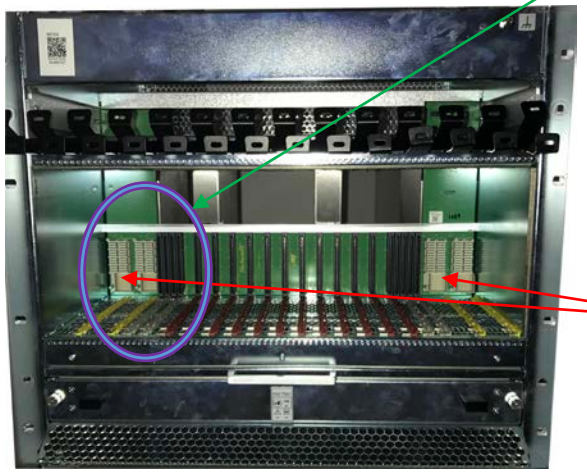
MTCA Elements



- Crate
- Backplane
- Cooling Unit
- Power Module
- MTCA Central Hub (MCH, Shelf Manager)
- AMC Modules (I/O, CPU ….)



On the Backplane there are special Slots for Power Module and Shelf Manager



- For high availability applications all modules are redundant:
- 2 x MCH
- 4 x Power Module
- 2 x Cooling Unit

The MTCA Based Control System

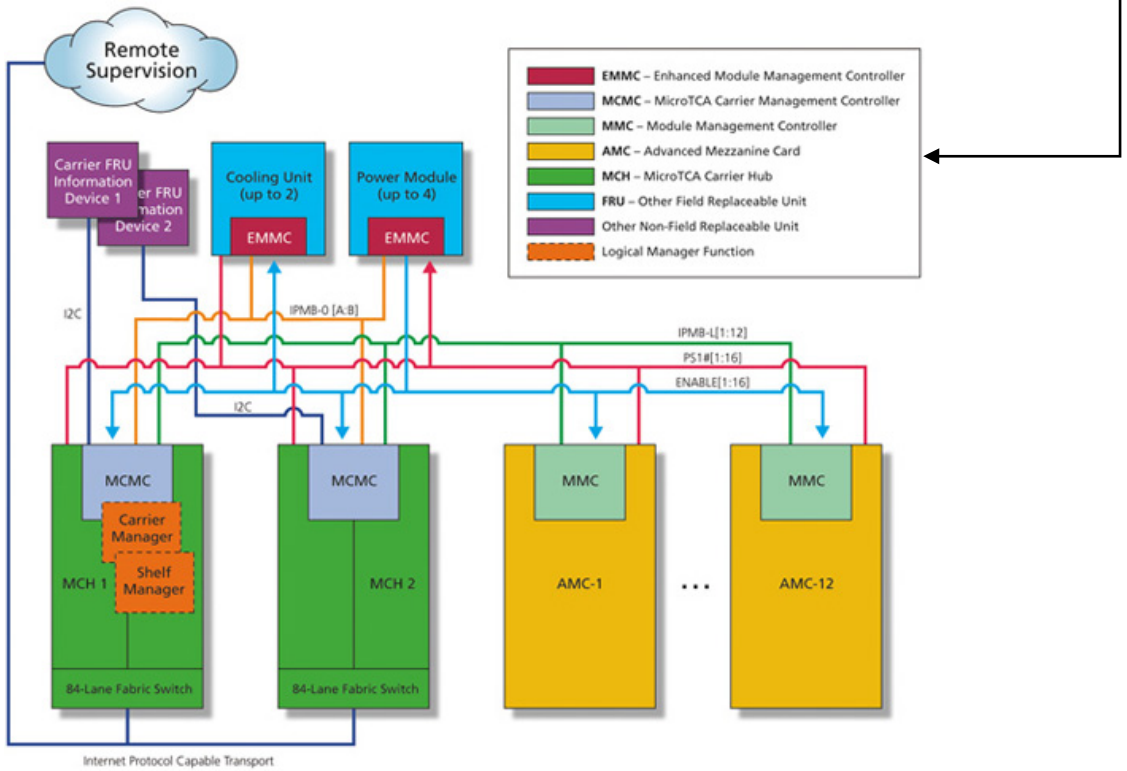
MTCA Chassis/Shelf

- An enclosure that provide the physival support to the MTCA carrier, management Modules, AMCs, Power Modules, Cooling Units and other peripherials
- The chassis sometimes called a Shelf or Crate
- There are crates in defferent sizes

The MTCA Based Control System

FRU - Field Replaceable Unit.

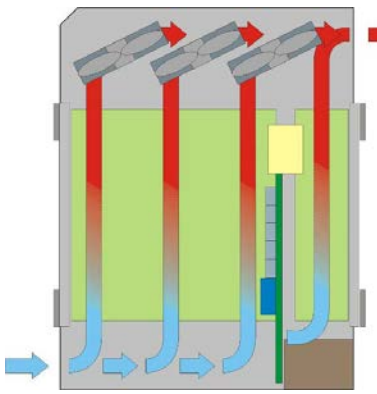
- MTCA Modules can be added or removed inthe field, these are known as FRU
- The FRU are AMCs, MCH, PowerModule and Cooling Unit
- Each FRU has an onboard controller which stores the information of the Unit
- **FRU** data describes the Unit capabilities and used by Shelf Manager



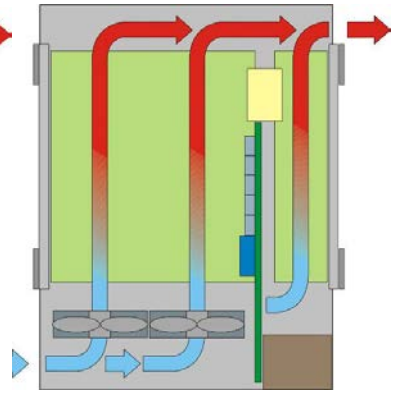
The MTCA Based Control System

Power Module and Cooling Unit

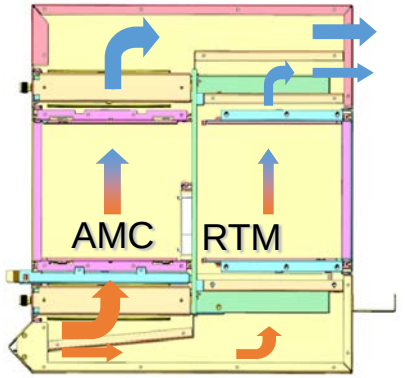
- Power Module
  - input 48VDC or 230VAC
  - Output +12VDC Payload and permanent +3.3VDC for management
  - FRU data
- Cooling Unit
  - Usually fan trays
  - There are different cooling concepts
  - FRU data



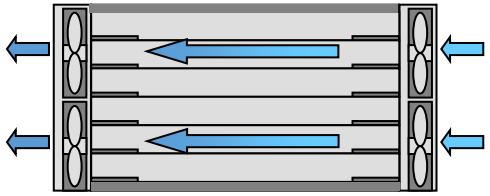
Pull configuration, Front-to-rear



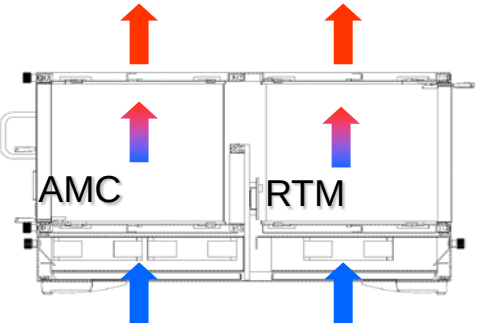
Push configuration, Front-to-rear



Push-Pull configuration Front to rear



Push-Pull configuration Side-to-side

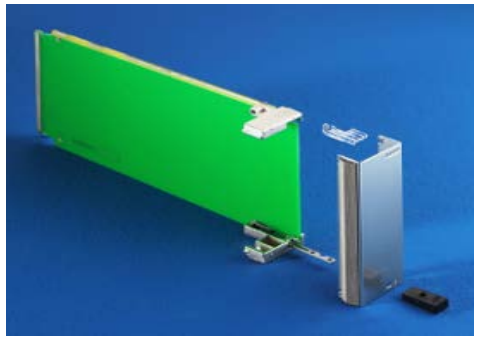


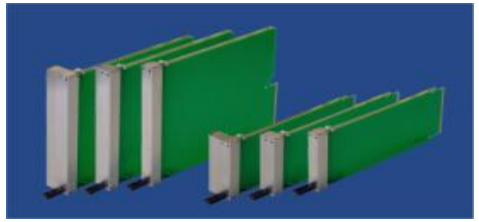
Pull configuration, bottom-to-top

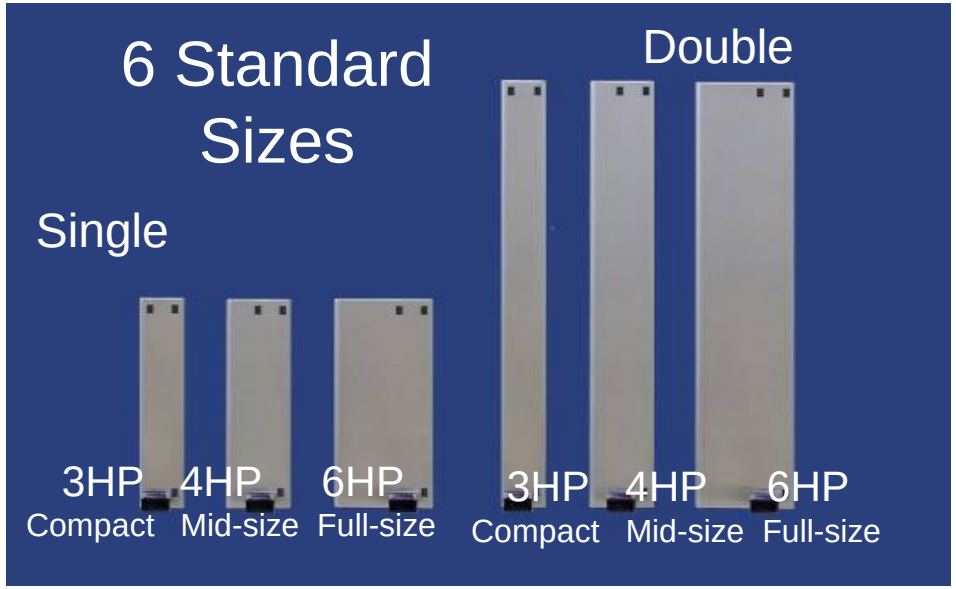
The MTCA Based Control System

AMC

- peripheral devices (digital/analog I/O, CPU …..)
- Initially developed as function extension for ATCA Boards
- The basic idea of MTCA is to have a shelf that contains just AMC modules
- Backplane directly accepts AMC modules
- AMCs are interchangeable between ATCA and MTCA
- Fully integrated into the MTCA management structure
- Hot Swap capability







CONTRON
CPU AMC

DESY DAMC2

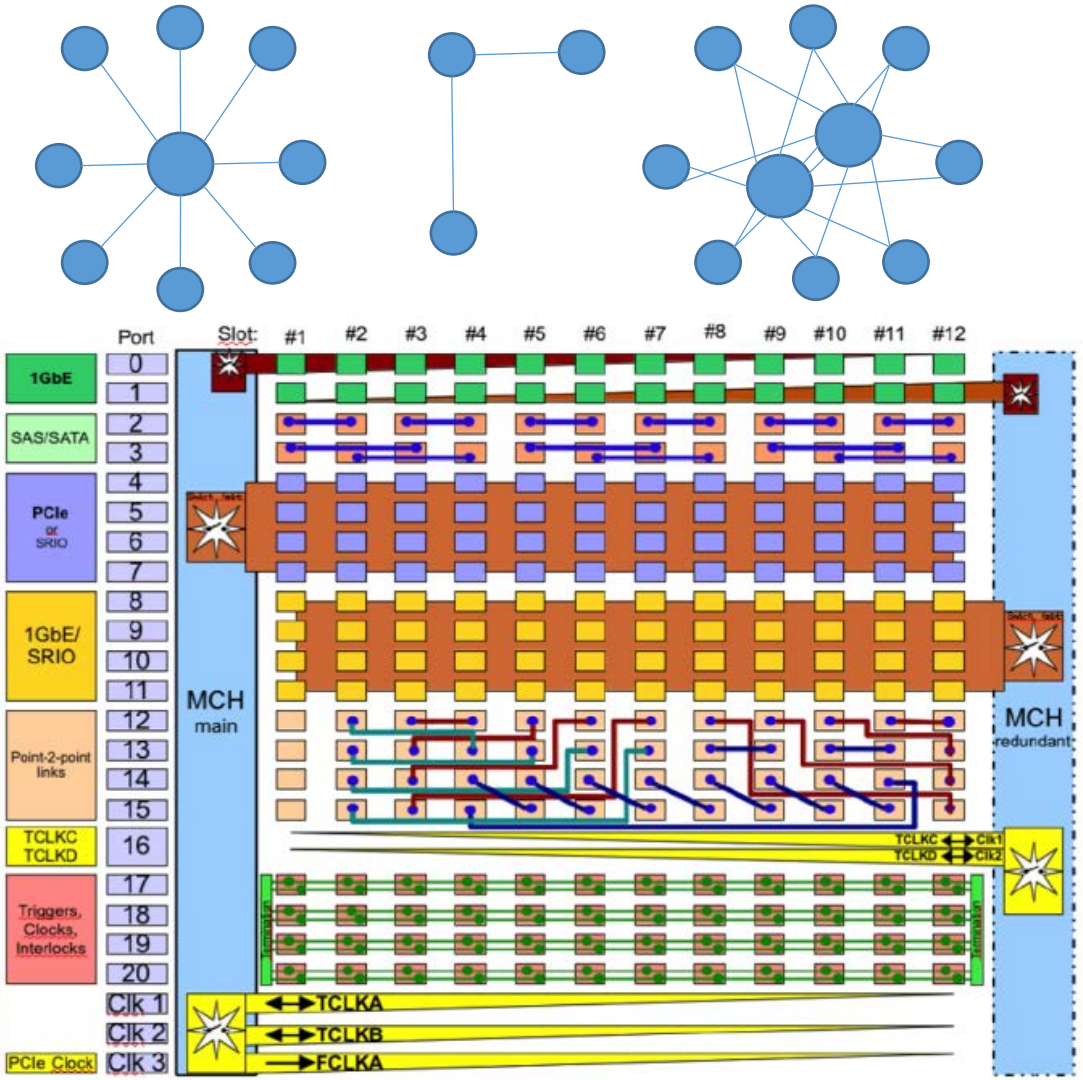
STRUCK
SIS8300
10Ch ADC

ESD
DIGITAL I/O
2Ch ADC/DAC

The MTCA Based Control System

Backplane

- A passive Interface that provides the data, Management and power connections
- The backplane along with the MCH provide virtual carrier interface to the AMCs
- The Backplane and MCH provide Star and point to point connections
- In redundant systems the backplane provides as well the Dual Star connection
- The Backplane divided into zones which are used in various purposes
- FRU data



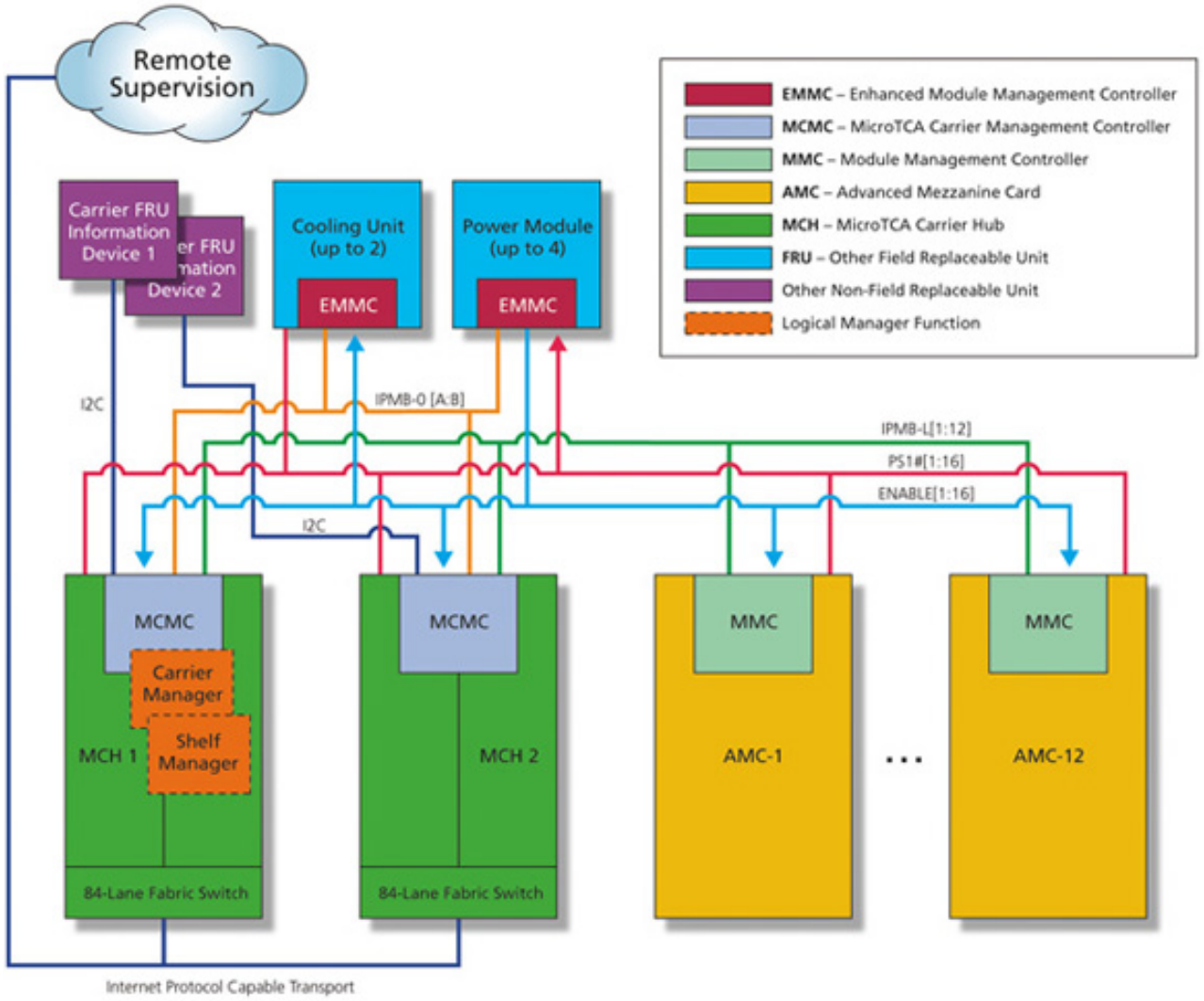
The MTCA Based Control System

MCH - MTCA Central Hub

- The main Management Module
- Enables and controls Modules in MTCA system
- Responsible for data switching
- Uses Inteligent Platform Management Interface (IPMI)
- Provides IPMI Buses such as IPMB-0 and IPMB-L

- IPMB-L
  - Connects the MCMC on the MCH to the MMC on the AMC Modules
  - Radial architecture

- IPMB-0
  - Connects the MCMC on the MCH to the EMMC on the PM and CU
  - Bused architecture

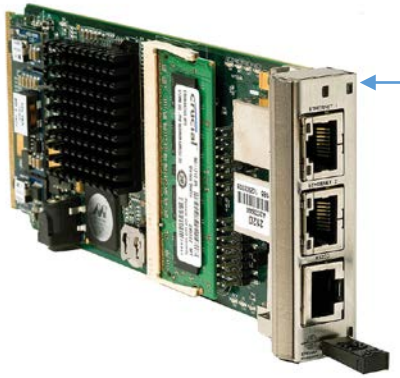


The MTCA Based Control System

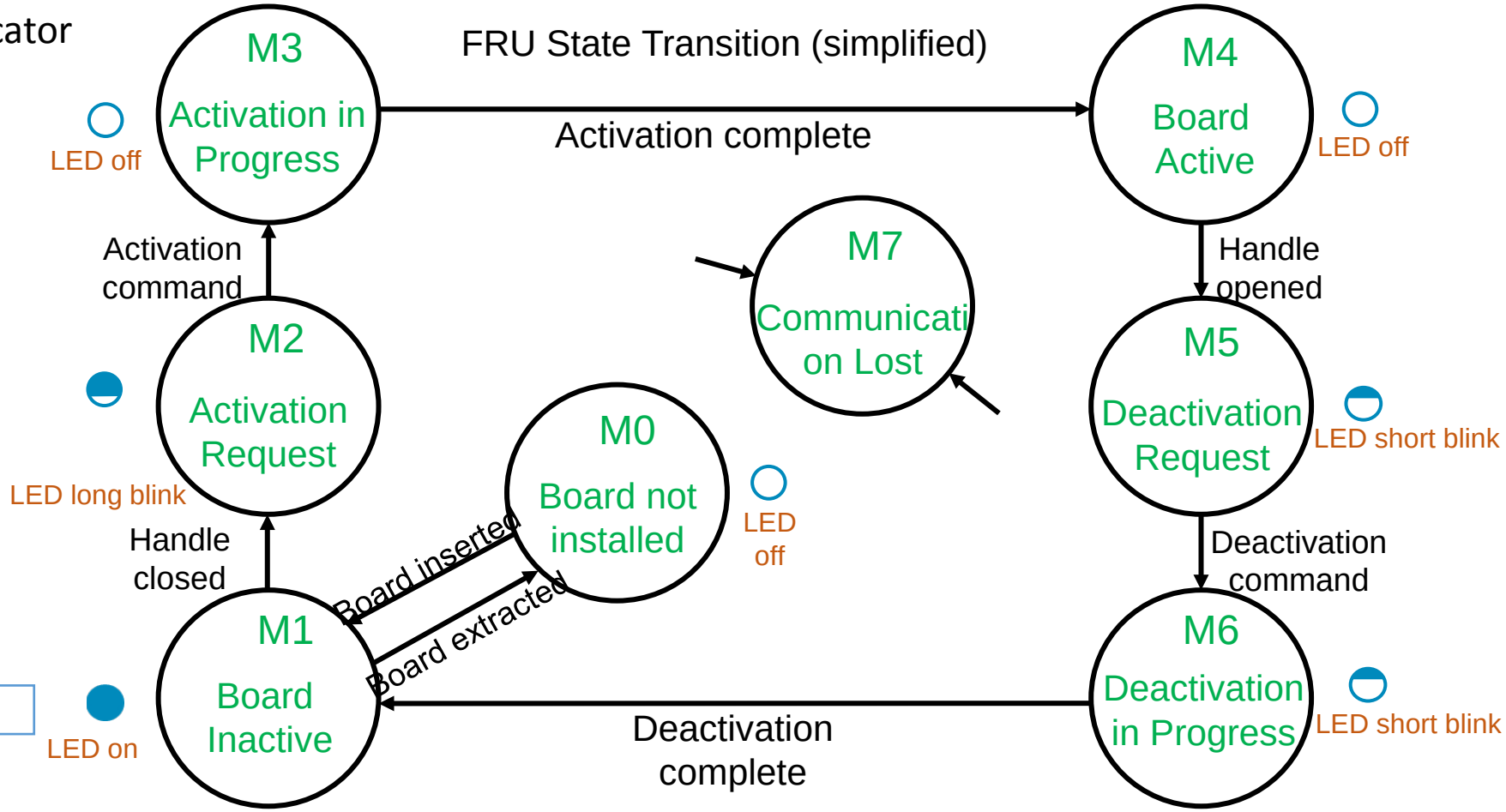
MCH – Module Controller

- AMC passes through various states which are controlled by MCH
- AMC provides front LED indicator
- MCH uses FRU
  - Required connections
  - Power requarements
  - …

Blue HotPlug LED



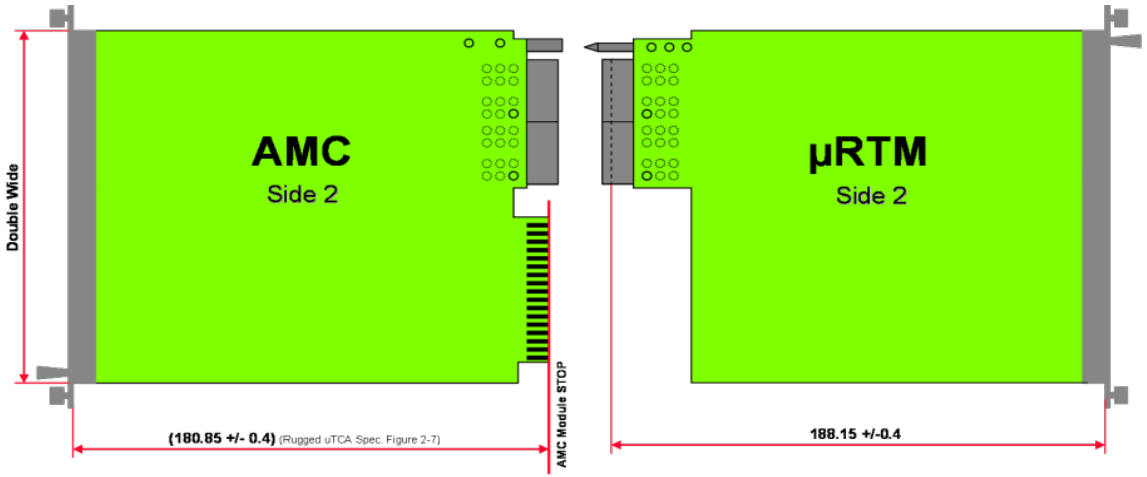
AMC Handel (HotPlug Button)



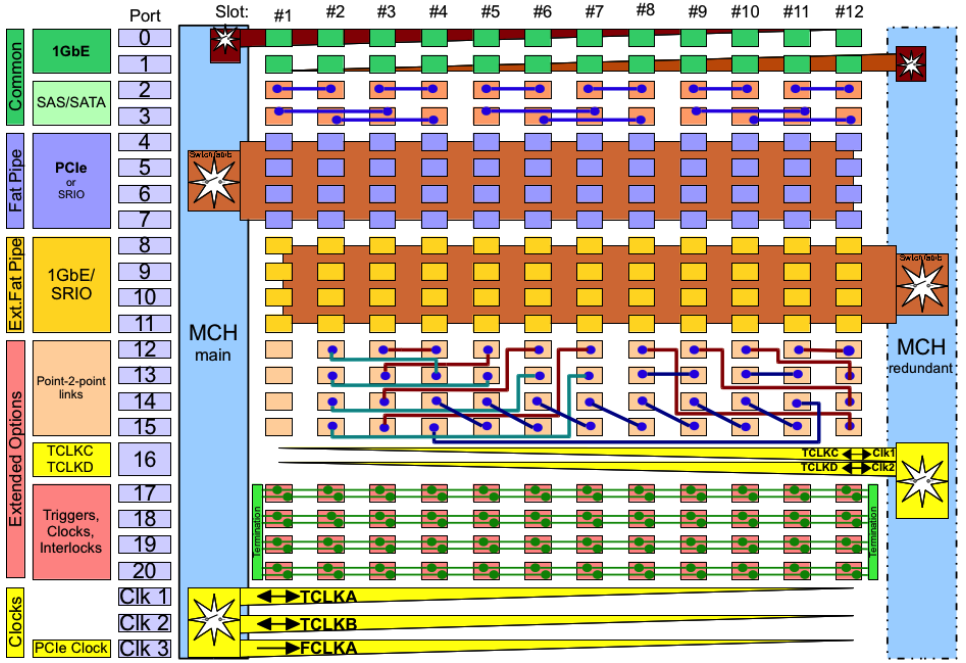
The MTCA Based Control System

MTCA.4

- **Why**
  - **No Rear Transition Module (RTM) defined for MicroTCA**
    - Physics applications typically require a large number of I/O cables. It makes sense to connect them to the rear of the chassis
  - **Special clock and trigger topology**
    - MicroTCA.0 specifies 3 Clocks and AMC.0 R2.0 specifies 4 Telecom and 1 Fabric Clock on the AMC Module. Physics applications typically need additional Clocks and Triggers



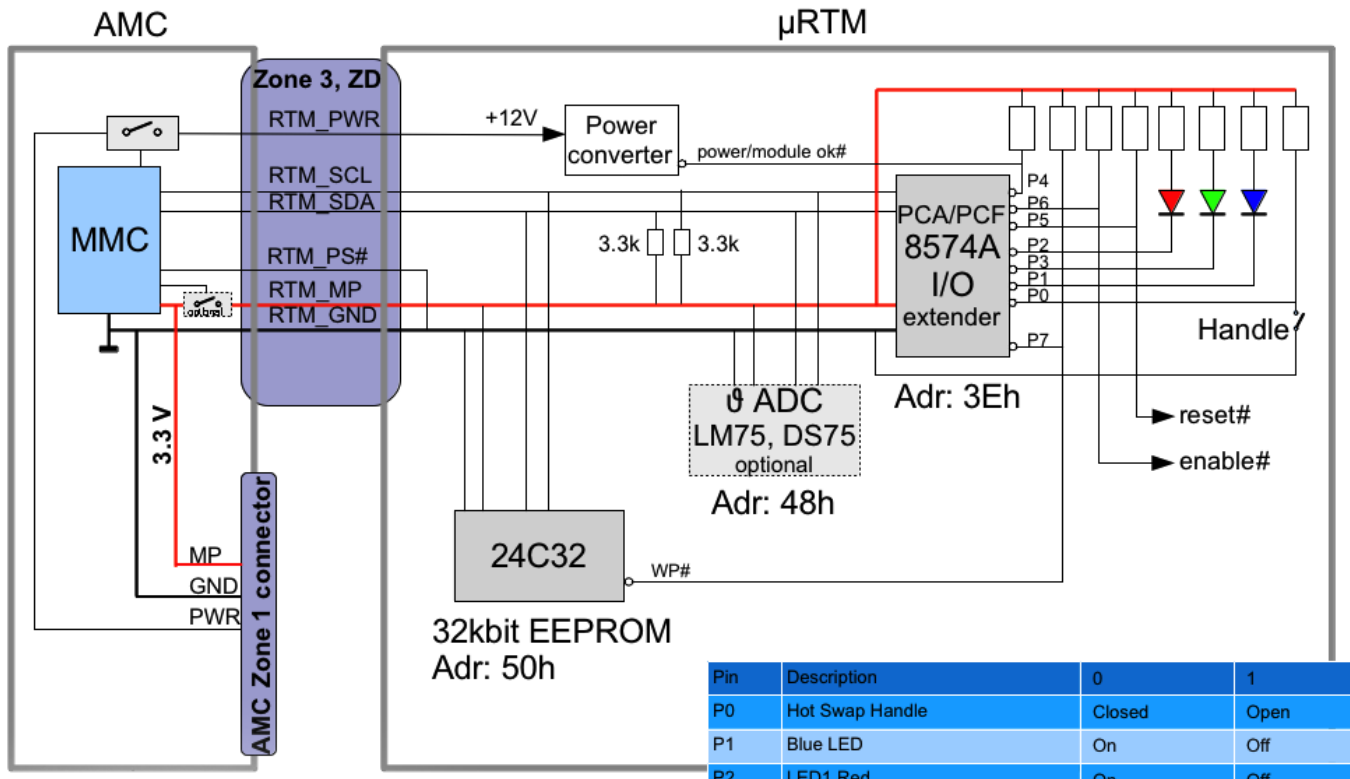
MTCA.4 defines RTM management



The MTCA Based Control System

MTCA.4

New guideline defines RTM management



Pin	Description	0	1
P0	Hot Swap Handle	Closed	Open
P1	Blue LED	On	Off
P2	LED1 Red	On	Off
P3	LED2 Green	On	Off
P4	MRTM Power Good# (Optional)	good	Not good
P5	MRTM Reset# (Optional)	Asserted	Not Asserted
P6	MRTM Enable# (Optional)	Enabled	Disabled
P7	EEPROM Write Protect (Optional)	Write enable	Protected

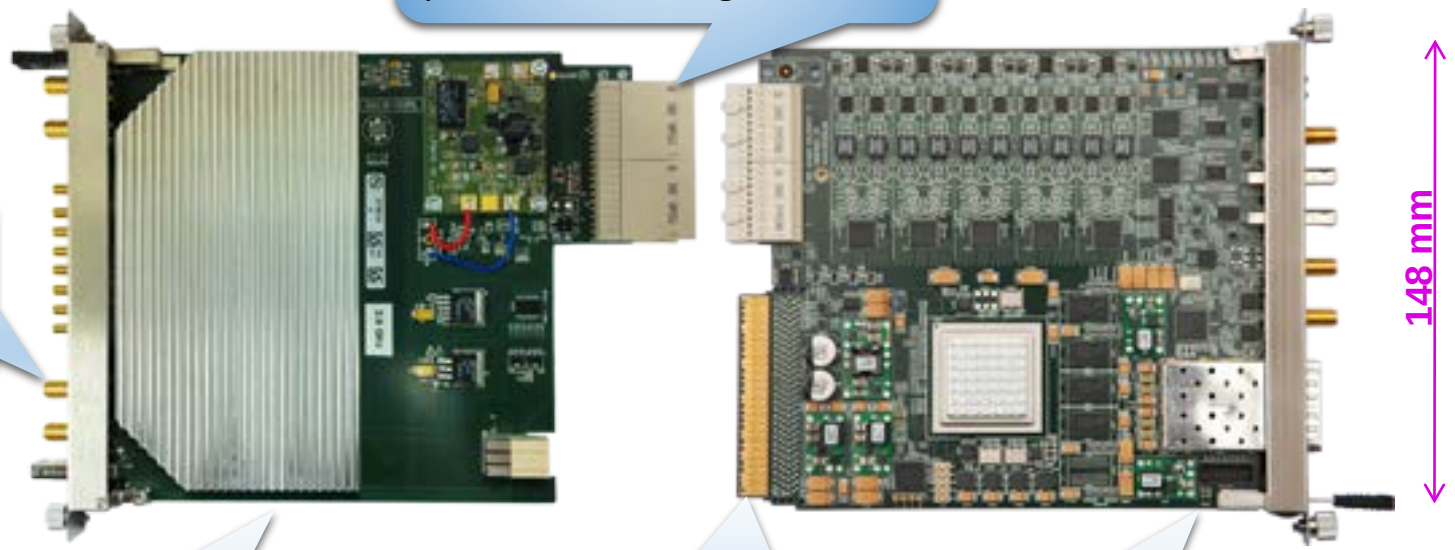
I/O pin assignment of the 8574 I/O extender

The MTCA Based Control System

MTCA.4

Connector:
Analog or digital signals,
power and management

Cables from rear
e.g. SMA
1.3GHz



µRTM:
I/O adapter,
Application specific signal conditioning and cable adapters

AMC connector:
Ethernet and PCIe,
Clock and Trigger

Standard front **AMC**:
FPGA with high speed data links,
complex designs

The MTCA Based Control System

HotPlug

- One of the main characteristics of any computer architecture is reliability and uninterrupted operation.
- The system has to provide a possibility to add and remove devices in run.
- Hot-Plug services provided by Shelf Manager has no connections to user level application.
- Hot-Plug Service in a computer system is generally provided by the central bus.
- The MTCA systems uses the PCIe as a central bus of data transmission.
- The PCIe Hot-Plug is being used relatively long.
- The MTCA system makes its own amendments into general architecture of the PCIe Hot-Plug and in the methods and ways of use.

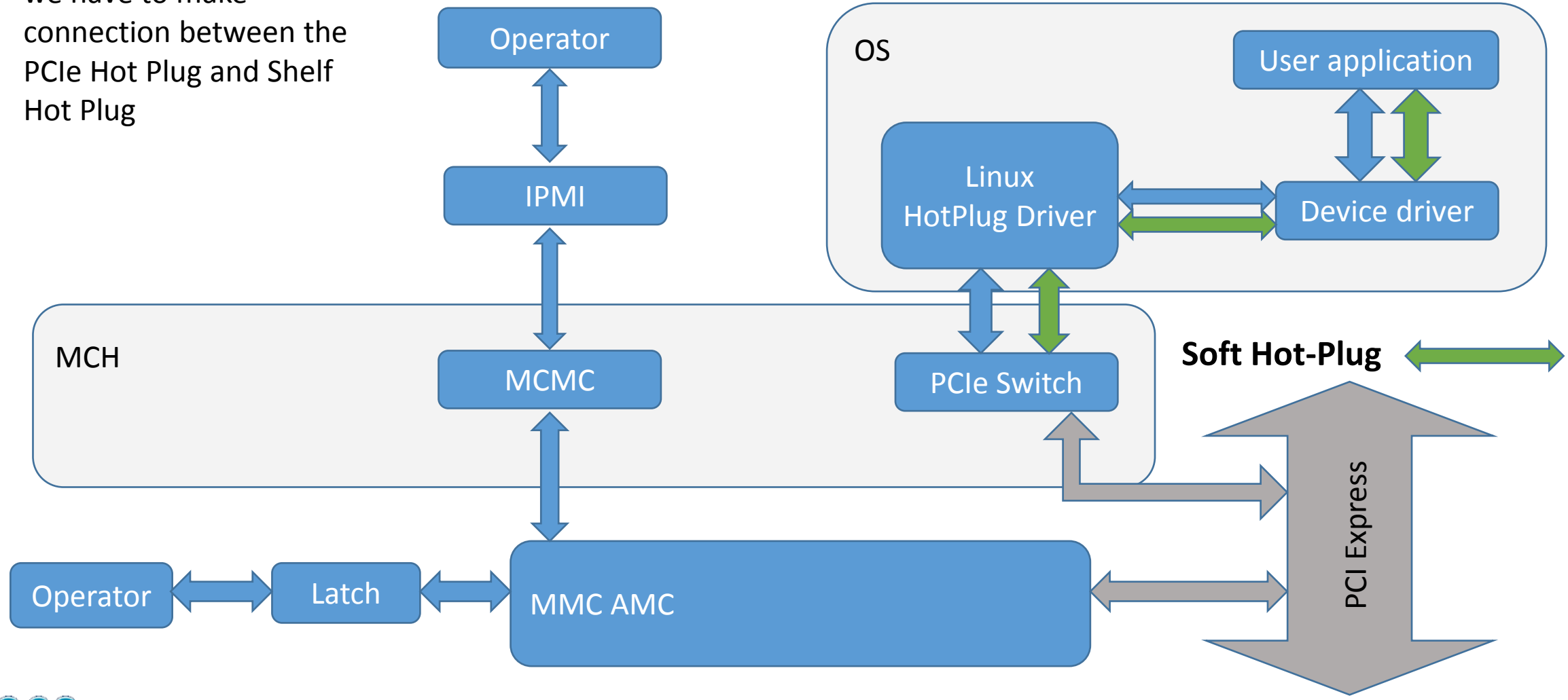
For MTCA systems using PCIe as the base link the Hot-Plug provided by the following various subsystems:

1. PCIe Hot-Plug controller enclosed in the PCIe root or switch ports, with the Standardized Software Interface
2. MTCA Shelf Manager, MMC controller
3. Hot-Plug services supplied by IPMI
4. Hot-Plug services supplied by OS (Hot-plug driver and user notification subsystems)

The MTCA Based Control System

PCIe HotPlug on MTCA

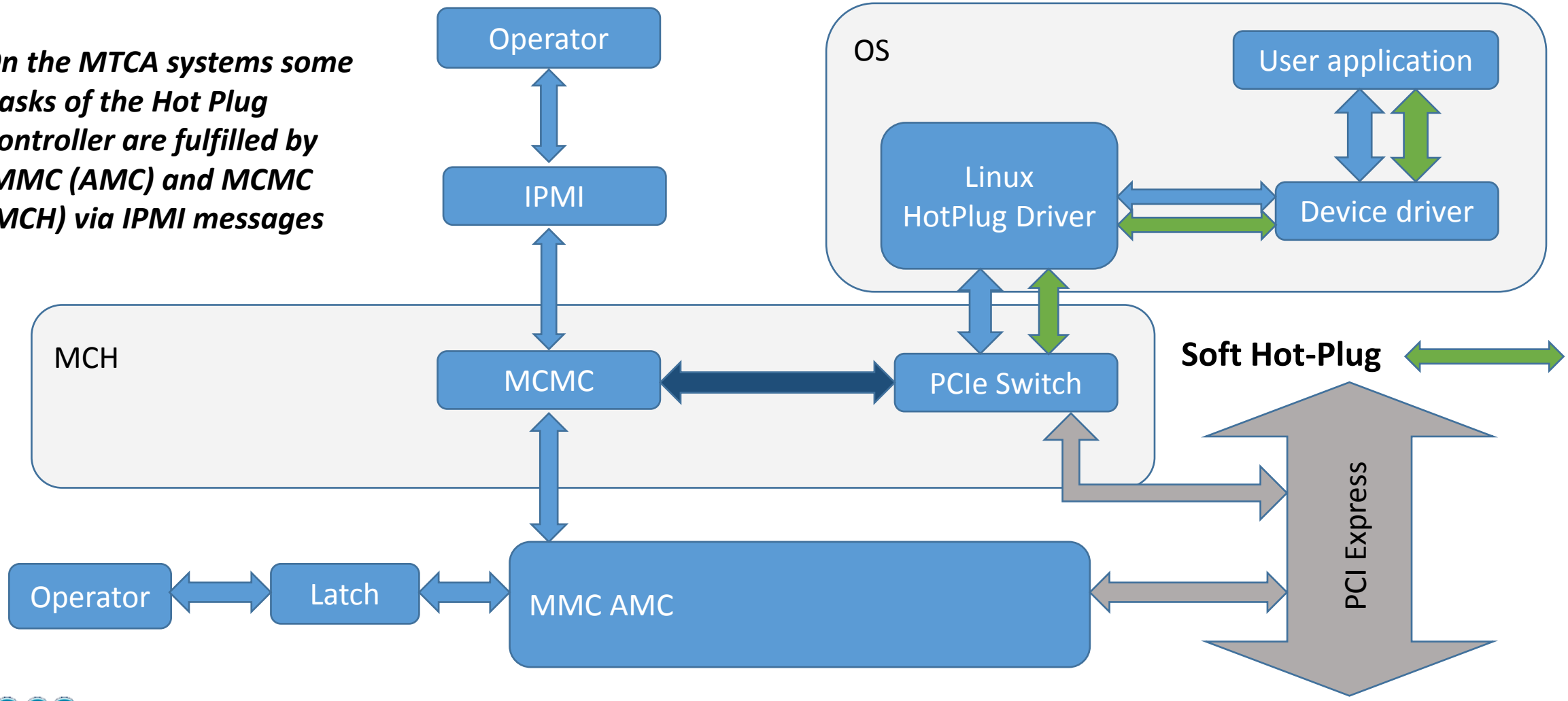
we have to make connection between the PCIe Hot Plug and Shelf Hot Plug



The MTCA Based Control System

PCIe HotPlug on MTCA

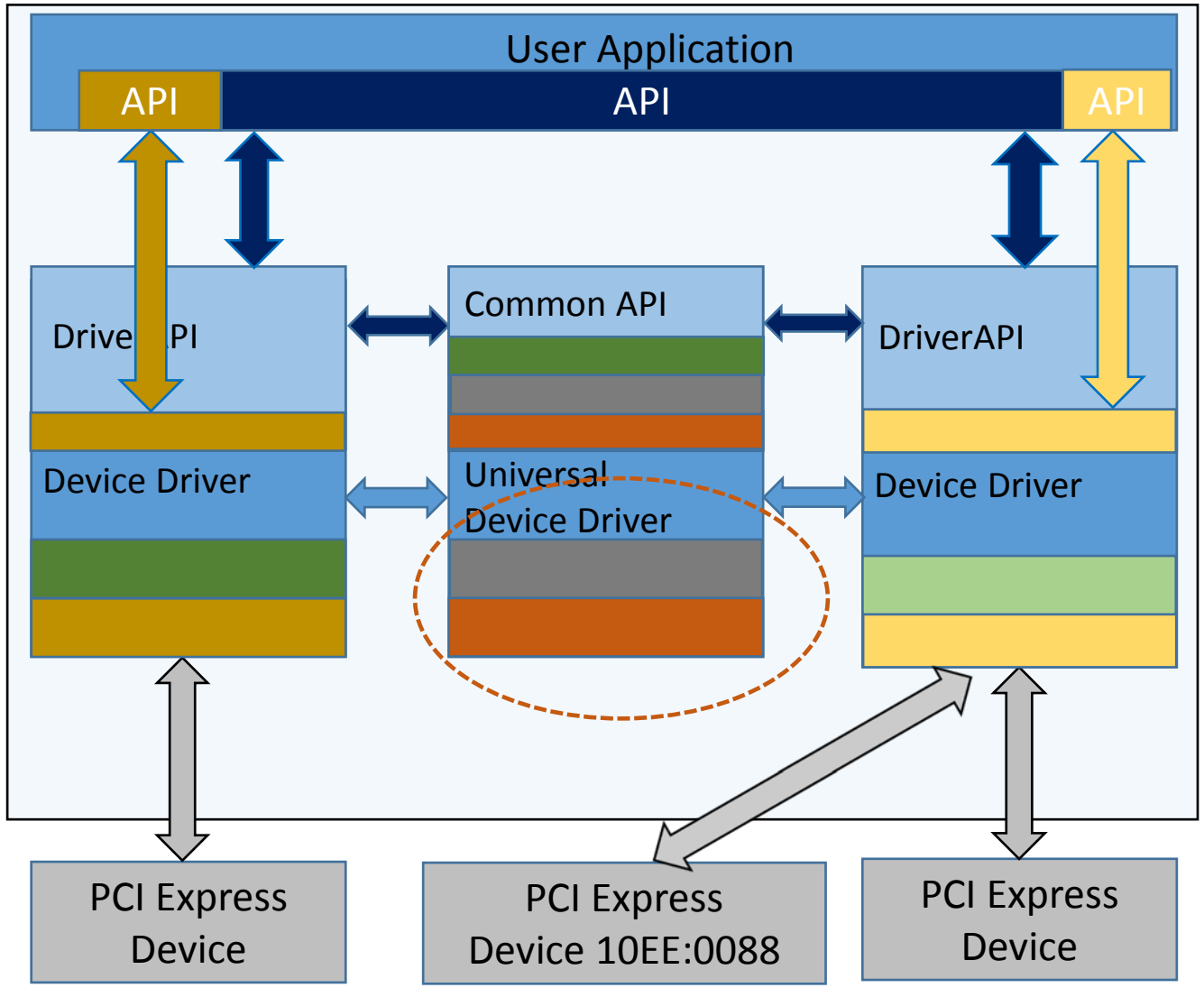
On the MTCA systems some tasks of the Hot Plug Controller are fulfilled by MMC (AMC) and MCMC (MCH) via IPMI messages



The MTCA Based Control System

Universal Driver

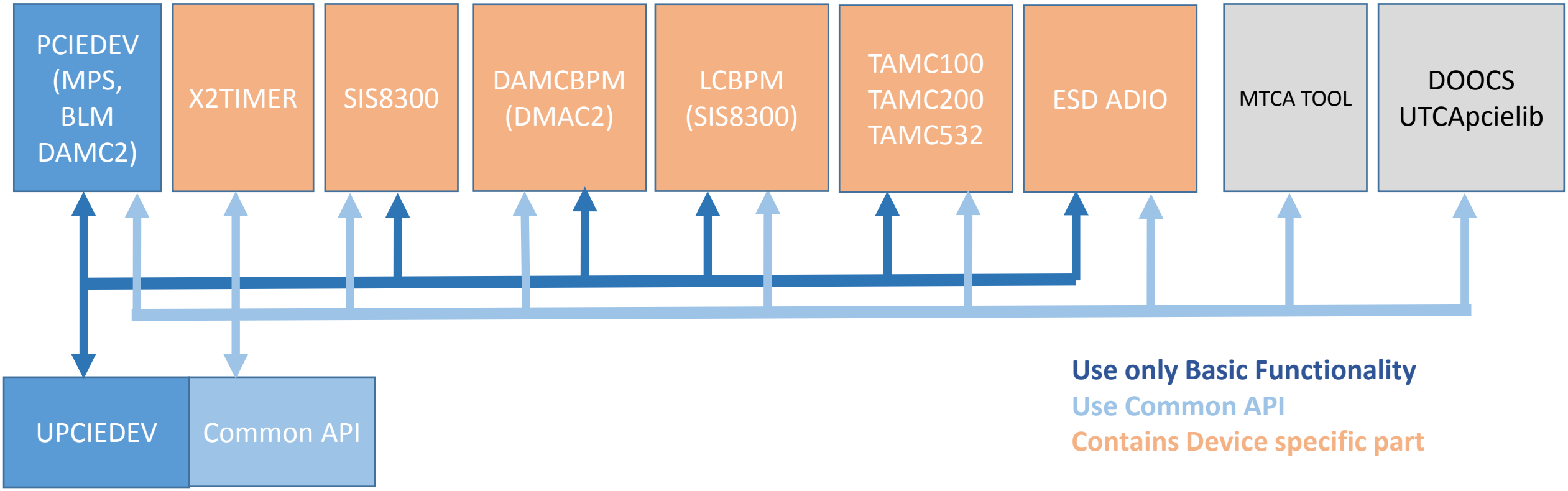
- Split Device Driver into two parts follow the Linux Device Driver stacking Model
- Add all common functionality and API into universal part
- this approach facilitates creation of new drivers and user applications
- The Device Driver created on the top of ***universal*** driver has all necessary PCI Express functionalty
- It could be binded to any PCI Express Device, whichfacilitates integration of new devices into the existing software



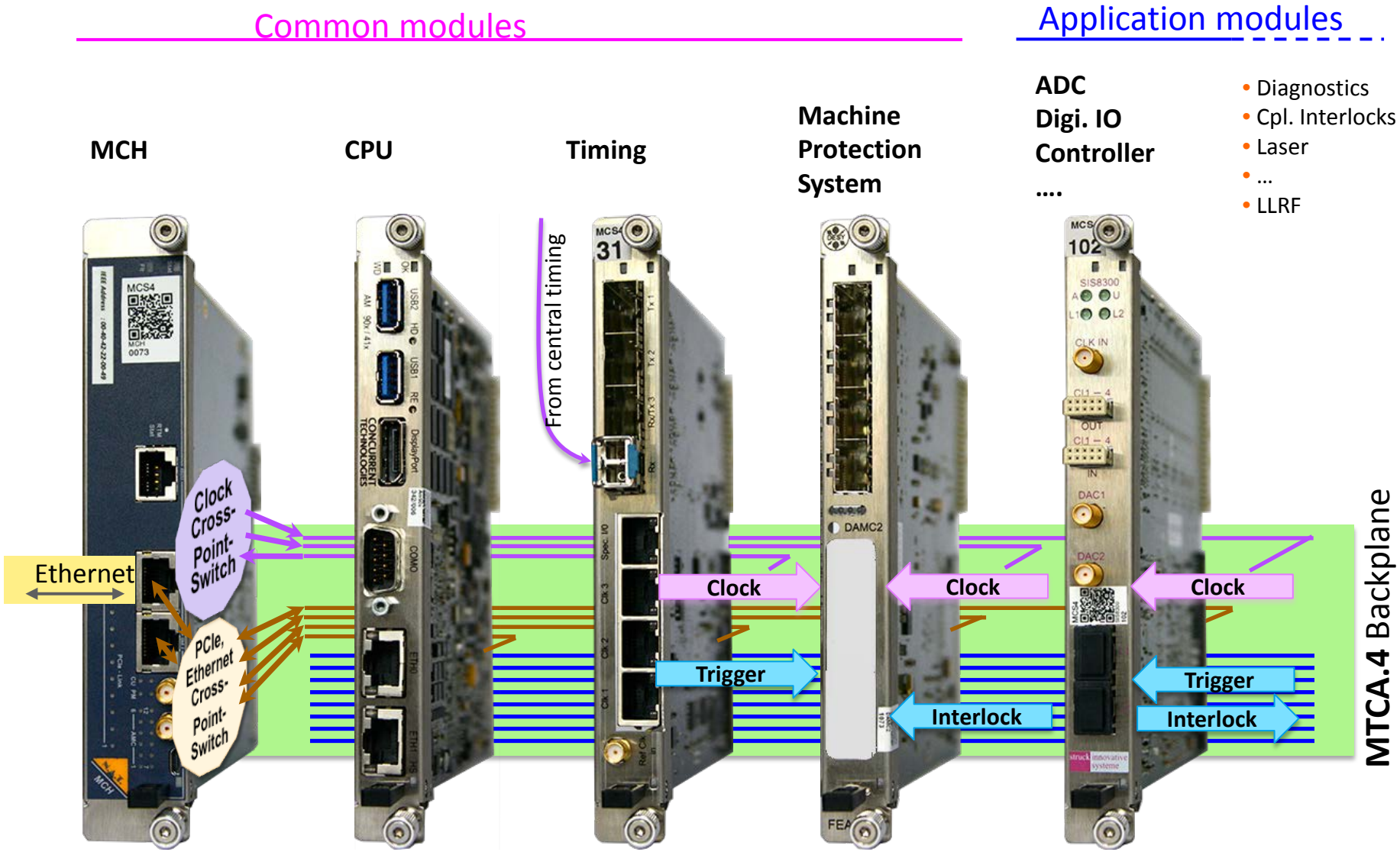
The MTCA Based Control System

Universal Driver Status

- this architecture was developed in DESY group MCS4 and till today with success is used
- the following drivers, tools and libraries are developed used



The MTCA Based Control System



The MTCA Based Control System

- Diagnostics
  - Photon energy and position, GSPS
- Special Diagnostics
  - Cameras
  - Kicker
  - Spectrometer
- Magnets & Vacuum
- CPU

Accelerator Control

STRUCK SIS8300
125MSPS 10ch 16bit ADC

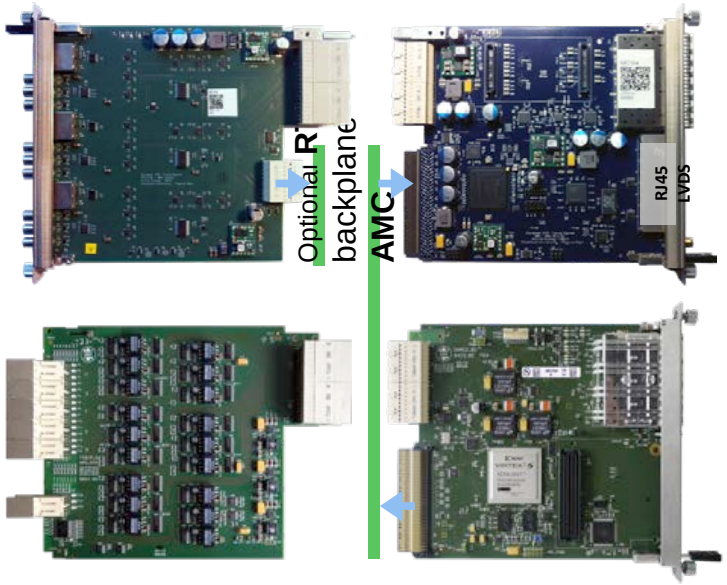
SP Devices: ≦ 7 GSPS ADC

Kontron: 4* Ethernet IO

DESY X2TiMER
Timing and synchronization
DAMC2 Starter Board
MPS (machine protection system)

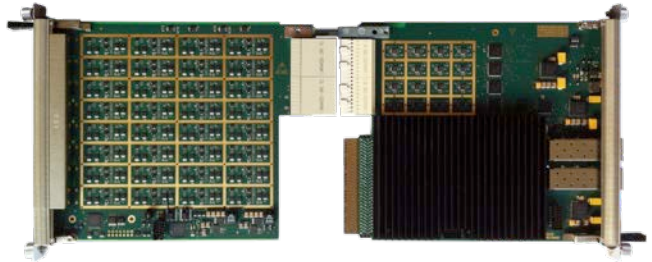
Tews: 16 * RS-232 IO

ESD: Digi/analog IO



Concurrent
CPU: i7 Quad-Core
PCIe Gen3
Redundant SSD
Remote console

ESD: 4* CAN IO



Tews: 32ch 14bit ADC, 60GSPS

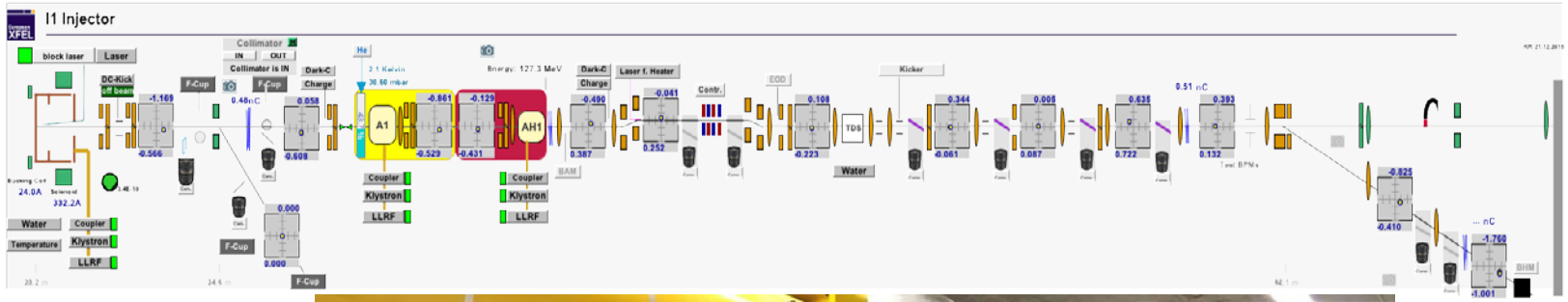
The MTCA Based Control System

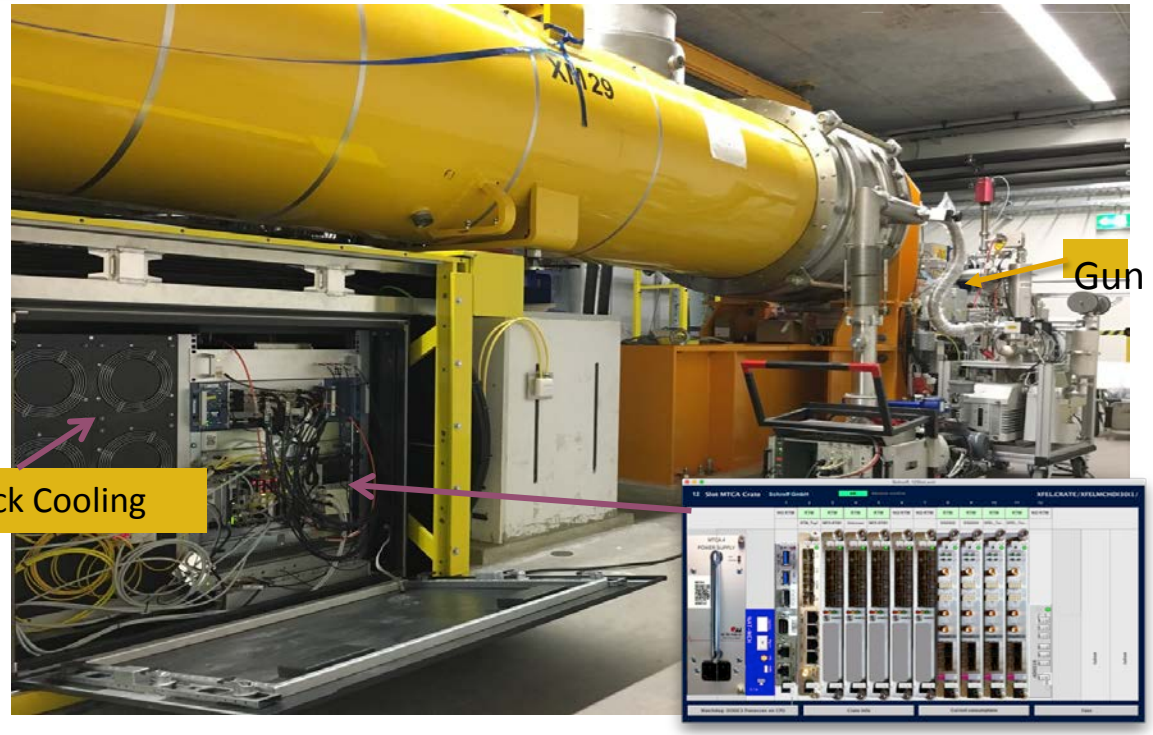
Total Number of MicroTCA crates :

- **FLASH**
  - **VME > 10 MTCA**
- **FLASH 2**
  - **MTCA > 20**
- **XFEL**
  - **MTCA > 200**

- LLRF
- Coupler Interlocks
- Diagnostics
- Special Diagnostics
- Vacuum, Magnets
- Experiments

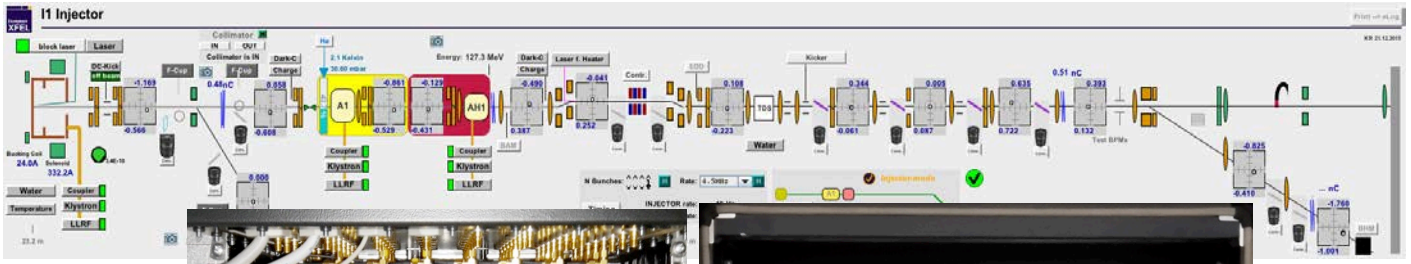
Accelerator Control

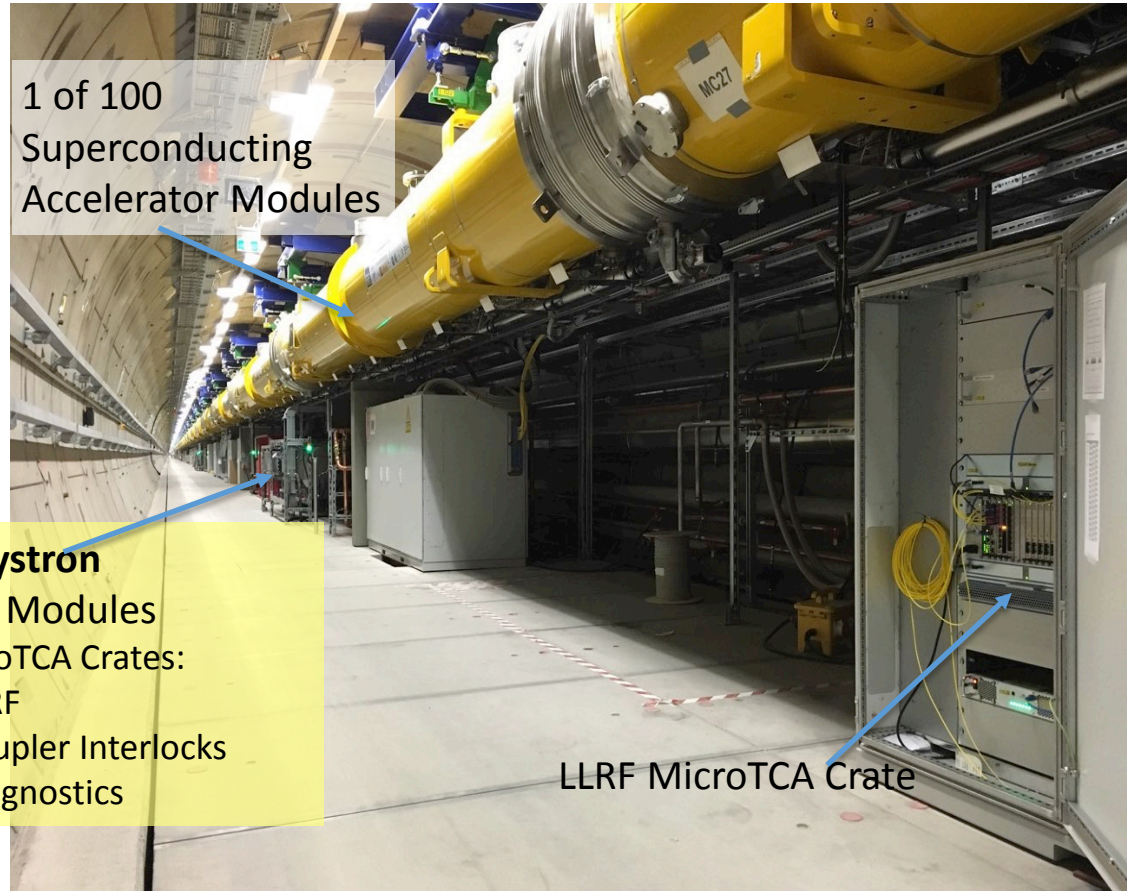




The MTCA Based Control System

Accelerator Control





The MTCA Based Control System

Accelerator Control, Conclusion

The MTCA is proved to be:

- Reliable system 24/7
- Thanks to support of PICMG, it is simple to integrate components of third-party firms, or design own one
- Thanks to Shelf-Management and PCIe Hot-Plug, Uninterrupted replacement of the spoiled components
- Fast growing community and COTS components in market
- Meets requirements of the Modern Control Systems

→ **MTCA.4** is a good platform for large installations in industry and science

Thank You

doocs.desy.de

mtca.desy.de