xTCA evaluation project status and HPM modules development at CERN

xTCA interest group meeting

CERN EP-ESE-BE collaboration

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Outline

- Introduction
- MicroTCA evaluation
- CERN MMC
- AdvancedTCA evaluation
- Pigeon Point based IPMC

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xTCA for LHC experiments at CERN

- Experiments planning to use MTCA & ATCA for upgrades of their back-end electronics
  - MTCA (and ATCA): CMS
  - ATCA: ATLAS
- MTCA and ATCA developments already on-going at CERN and collaborating institutes
  - xTCA Evaluation project
    - Focus effort on infrastructure components (shelves, power supplies, …)
    - Establish a purchasing framework and provide support

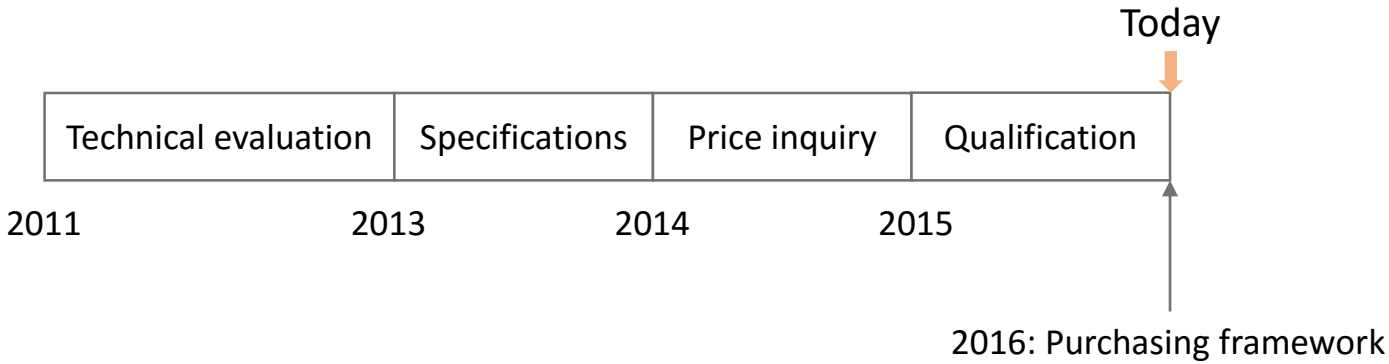
Outline

- Introduction
- MicroTCA evaluation project
  - Introduction
  - Power module
  - Crates
- CERN MMC
- AdvancedTCA evaluation project
- Pigeon Point based IPMC

MicroTCA evaluation project

- MicroTCA evaluation project main goal
  - Specifying MicroTCA infrastructure equipment (shelves and power modules) for use in the LHC experiments
  - Simplifying equipment procurement for CERN users

- Roadmap



MicroTCA power module

- CERN Specifications
  - Output power: 800W
  - Input voltage range: -40V to -60V
  - Payload power:
    - 12V ± 10%
    - 80W per channel
    - Output voltage stability: ±200 mV
    - Maximum output noise and ripple: 100 mV (pk-pk)
  - Management power
    - 3.3V ± 5%
- Selection of the NAT DC840 power module
  - Output power: 840W
  - Compliant (CERN Specs): Yes
  - Pros: Efficiency and IPMI compliance
- Qualification with 3 pre-series units of the NAT power module

MicroTCA power module

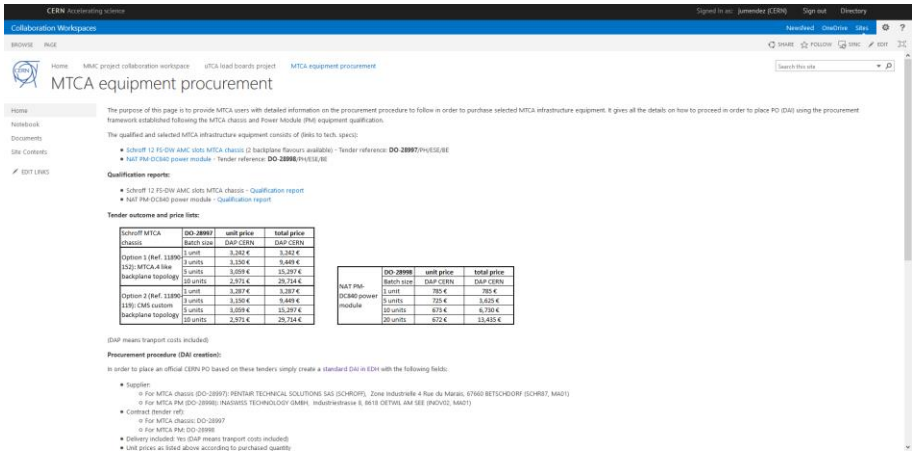
- Qualification tests carried out
  - Functionality (MicroTCA compliance)
  - Load regulation (payload power)
  - Line regulation (payload power)
  - Efficiency
  - Ripple and noise
- Outcome

*1: Load variation on all AMCs
*2: Load variation on only 1 AMC

	Test Conditions	Measured	DC840 Specs	CERN Specs
Maximum Power	Vi=-48V	880W	840W	800W
Input Voltage		-39V to -60V	-40V to -60V	-40V to -60V
Load Regulation	-48V input voltage	> 500mV *1 < 200mV *2	10% (±600mV)	**±200mV**
Line Regulation	multi load values, Vin: -40V to -60V	< 32 mV	Not specified	±200mV
Efficiency	Vi = -48V, 40-105% of full power	91.01% (min)	**95.5% (min)**	90% (min)
Ripple	Full power, no CU, 50W x 12	< 250mV (pk-pk)	Not specified	**100mV (pk-pk)**
Current sensors accuracy	Channel out current from 1A to 5A	< 312 mA	Not specified	5% of the max. current (About 400 mA)

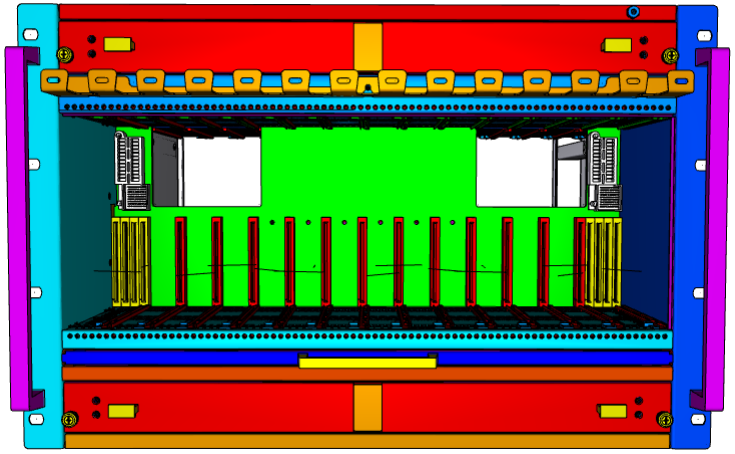
Power module: summary

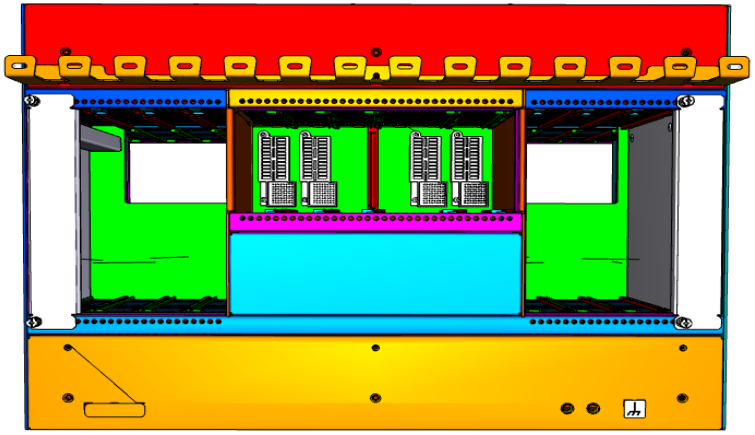
- Most of the results are within the specification
- Qualification process finished successfully
- Qualification report available on request
- Purchase framework is established
  - https://espace.cern.ch/ph-dep-ESE-BE-uTCAEvaluationProject/Procurement/_layouts/15/start.aspx#/SitePages/Home.aspx



- Few issues being addressed by NAT:
  - Detection of critical temperature (thresholds)
  - Detection of input voltage failure
  - Heat sink

MicroTCA shelves





- Specifications
  - Slots:
    - Up to 12 double width/full-size AMCs
    - 2 MCHs
    - 2 PMs (front) and 4 PMs (rear)
    - 6 RTMs
    - 1 JSM
  - 2 interchangeable backplanes
    - Custom backplane connections
    - MTCA.4 compliant
  - Max. output air temperature 55°C (ambient: 25°C and 80W per slots)
  - Vertically cooled (bottom – top airflow)
- Selection of the Schroff crate
  - Compliant (CERN spec): Yes
  - Pros: cooling homogeneity, mechanical robustness and remote support
- Qualification with 3 pre-series units of the Schroff crate

MicroTCA shelves

- Qualification tests carried out
  - Functionality (FRU info, HPM.1 support)
  - Backplane connections
  - AMC, RTM and PM Slots cooling
  - Power distribution
- Outcome

	Test Conditions	Measured	CERN Specs
Mechanical aspect	Visual check	Compliant	Custom configuration
CU functionalities	Operating test	Compliant	Hot swap, HPM.1 support and redundancy
AMC slot cooling	12 ALBs at 80W CU at full speed	25 deg. C max delta	Air outlet < 55°C for 25°C air inlet
PM slot cooling	PM at 800W CU at full speed Ambient 26 deg. C	Absolute brick temp. 72 deg C.	Air outlet < 55°C for 25°C air inlet
RTM slot cooling	6 RTMs at 40W CU at full speed	16 deg. C max delta	Air outlet < 55°C for 25°C air inlet
Backplane voltage drop	80W / slot	207 mV (max)	< 300 mV

- Qualification report available on request

MicroTCA crates: summary

- All of the results are within the specification
- Qualification process finished successfully
- Purchase framework is established in 2016
  - https://espace.cern.ch/ph-dep-ESE-BE-uTCAEvaluationProject/Procurement/_layouts/15/start.aspx#/SitePages/Home.aspx
- Few issues being addressed by Schroff:
  - Separated management of front and rear cooling
  - Slot identification
- Lane quality measurements (VNA) are currently being carried out
  - Compliant with 10Gbe standard
- Recommendations to user:
  - Power module redundancy to be used with care
  - Limitation of the power module to 600W

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- Introduction
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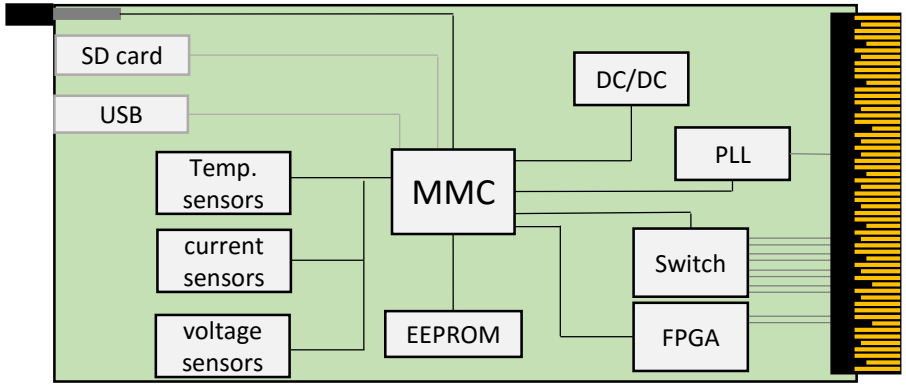
  - Introduction
  - Development roadmap
  - New architecture
  - AMC specific customization (user code)
  - Summary
- AdvancedTCA evaluation project
- Pigeon Point based IPMC

CERN MMC: Introduction

- CERN MMC source code was inherited from DESY / CPPM
- MMC Role
  - Activating / De-activating an AMC card
  - Providing information about the AMC card
    - Maximum current
    - Ports configuration
    - Clock configuration
  - Sending alert events (sensor exceed threshold)
  - Executing IPMI commands
- Features
  - Power management
  - Sensor monitoring
  - Clock and ports management (E-Keying)
  - *Debug terminal (USB)*
  - *FAT32 filesystem (SD Card)*



CERN MMC: Development roadmap

- 2011-2015: MMC V.1.0
  - Basic version
  - Support of the Atmega128 microcontroller
  - User customization difficult
  - E-keying not supported

- 2015: MMC V.2.0
  - Almost all the code was re-written
  - Simplified user customization
  - Improved standard compliance
  - Supported port and clock e-keying feature
  - Supported HPM.1 remote upgrade standard

- 2015-2016: MMC V.3.0
  - New source code architecture
  - Support of 3 different microcontrollers

CERN MMC: new architecture

- **HPM**
  - **Application**
    - Application source code (.h, .c)
  - **Drivers**
    - uC drivers source code (.h, .c) ← **driver.h: Low level interface**
  - **User**
    - Configuration file (.h)
  - **uC project**
- **MMC**
  - **Application**
    - Application source code (.h, .c)
  - **Drivers**
    - uC drivers source code (.h, .c) ← **driver.h: Low level interface**
  - **User**
    - **User_code**
    - **Sensors**
  - **uC_MMC project**

CERN MMC: AMC specific customization (user code)

- ❑ General configuration
- ❑ FRU Information
- ❑ Power sequences
- ❑ AMC port and clock e-keying
- ❑ User LEDs
- ❑ User geographical address (specific for benchtop use)
- ❑ Sensors

```
#define LM82                                    \
    {                                           \
        {                                       \
            sensor_number: TEMPERATURE_SENSOR1, \
            init_time: MP_PRESENT,              \
            name: "LM82-IC1",                   \
            i2c_addr: 0x2A,                     \
            p1: POINT(0,0),                     \
            p2: POINT(1,1),                     \
            upper_non_rec: 85,                  \
            upper_critical: 75,                 \
            upper_non_critical: 70,             \
            lower_non_critical: 10,             \
            lower_critical: 5,                  \
            lower_non_rec: 0                    \
        }                                       \
    }
```

CERN MMC: Summary

- New architecture
  - Source code divided in 3 parts: application, drivers and user
  - Standardized sensor interface (drivers)
- Almost all Polaris Tester automatic test passed (standard compliance tester)
  - 26 passed
  - 2 failed (MCH related: p2p connectivity and set blue led command)
- External tools:
  - MTCA C library (including FRU writer and event reader examples)
  - HPM.1 tool (including programing feature)
  - Sensor driver generator
- Used with many AMC cards
  - CERN projects:
    - CMS: TwinMux (Atmega128), MP7/FC7 (AT32UC3A3256), MTF7 (AT32UC3A1512)
    - ATLAS: Liquid Argon (Atmega128)
  - External projects:
    - IN2P3: Nebula, Sirocco, Stereo acquisition system, EX2, Gamahadron
- The CERN MMC source code is based on the GNU-GPL licence
  - https://espace.cern.ch/ph-dep-ESE-BE-uTCAEvaluationProject/MMC_project/default.aspx (Web page)

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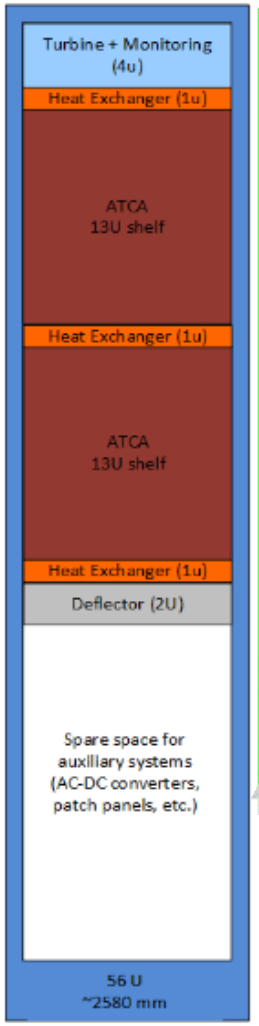
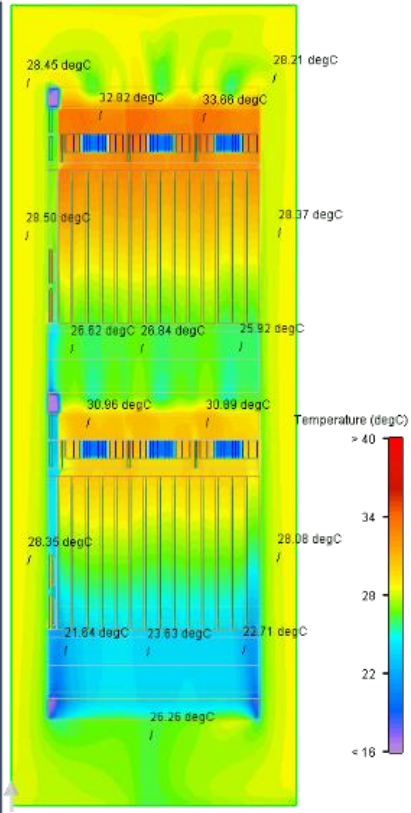
AdvancedTCA: Shelves cooling

- Goals:
  - Common specifications for shelves
  - Asses the possibility to re-use existing racks system or specify rack infrastructure for horizontally cooled crates
- AdvancedTCA shelves cooling simulation (CERN rack)
  - Simulation have been performed
  - Rack improvement had been proposed
  - Report available on request
- AdvancedTCA shelves cooling measurements (CERN rack)
  - Detailed by Claudio Bortolin
    - ATLAS ATCA cooling evaluation project



ATCA rack



Thermal simulation view

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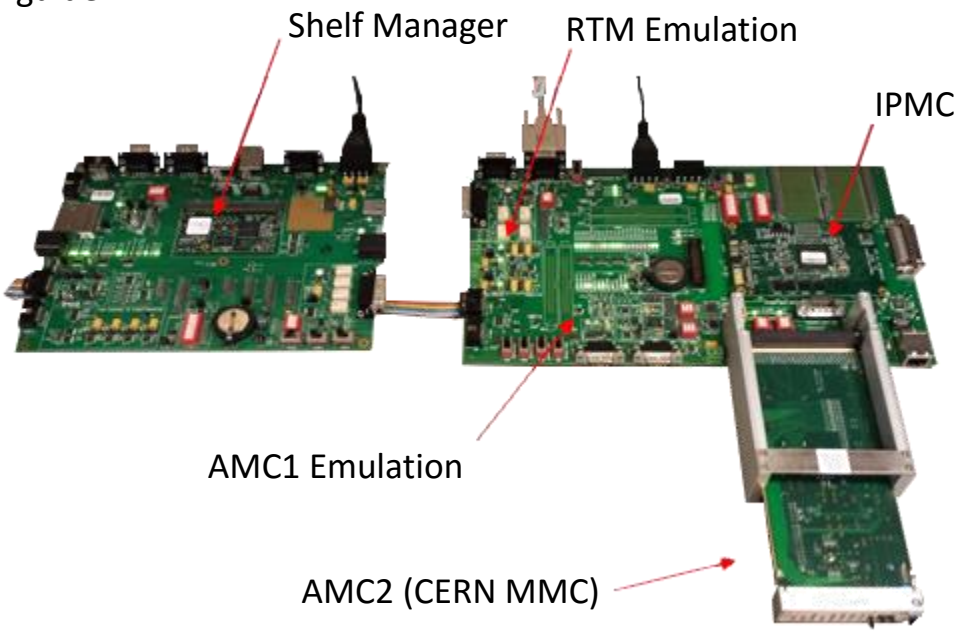
CERN IPMC: Introduction

- Based on the Pigeon Point solution
- Licence: EP-ESE-BE (xTCA Evaluation Project)
  - Licence for use at CERN
  - Software and Hardware documentation
  - Starter kit
  - User guide



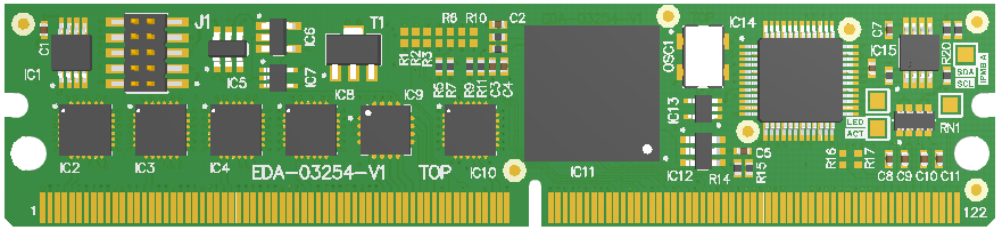
CERN IPMC: Evaluation of the Pigeon Point solution

- Pigeon solution was evaluated using the starter kit IPMC mezzanine card
- Adapter card (CERN) was used to evaluate the solution with existing ATCA blade

CERN IPMC

- Status:
  - Evaluation of the Pigeon Point solution
  - Study of the design feasibility of a mezzanine
  - Design of the CERN IPMC mezzanine
- Roadmap (2016):
  - Prototype production (on going)
  - Debug of the CERN IPMC mezzanine
  - Creation of a user space into the source code
  - Goal: Make the mezzanine available to CERN users/developers

IPMC mezzanine card top view



Summary

- MicroTCA:
  - Evaluation of commercial modules finished
  - Specifications written
  - Qualification almost finished
  - Purchase framework is established
- AdvancedTCA:
  - Evaluation is almost finished
  - Writing specification has just started
- MMC:
  - New release is available on SVN
- IPMC:
  - Prototype will be debugged and used as a demonstrator

Thank you

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