xTCA in CMS

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Thanks to many CMS collaborators

Introduction

- **CMS legacy off detector systems are essentially VME based**
  - **DAQ exception: cPCI**
- **Upgrades may profit from more recent technology**
  - **The world is going high speed serial rather than medium speed parallel; VME bus voltage levels are high; performance still adequate though**
  - **AMCs and uTCA was selected as the main candidate a few years ago**
    - ➔ **Unique in its dual specification**
      - ⇘ **Main card in uTCA systems**
      - ⇘ **Mezzanine card on e.g. (commercial) ATCA carriers**
    - ➔ **Does away with custom hardware, e.g. SBC or PCI interface cards in the PC**
    - ➔ **Considerable investment in Expertise behind us**

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Systems with upgrade plans LS1 and LS2

- **Not a one size fits all: Some systems may chose to continue using VME for upgrades**
- **ATCA, VME**
  - **None for the moment**
- **uTCA**
  - **CMS HCAL back end**
  - **Level 1 trigger**
    - **Calorimeter trigger (RCT – GCT)**
    - **Global trigger**
    - **Global Muon trigger**
    - **Drift Tube, overlap, EMU Track Finder and input systems**
    - **TCDS (TCS, TTC, TTS)**
  - **CMS Pixel readout**
  - **CMS GEM1/1**
  - **BRIL**

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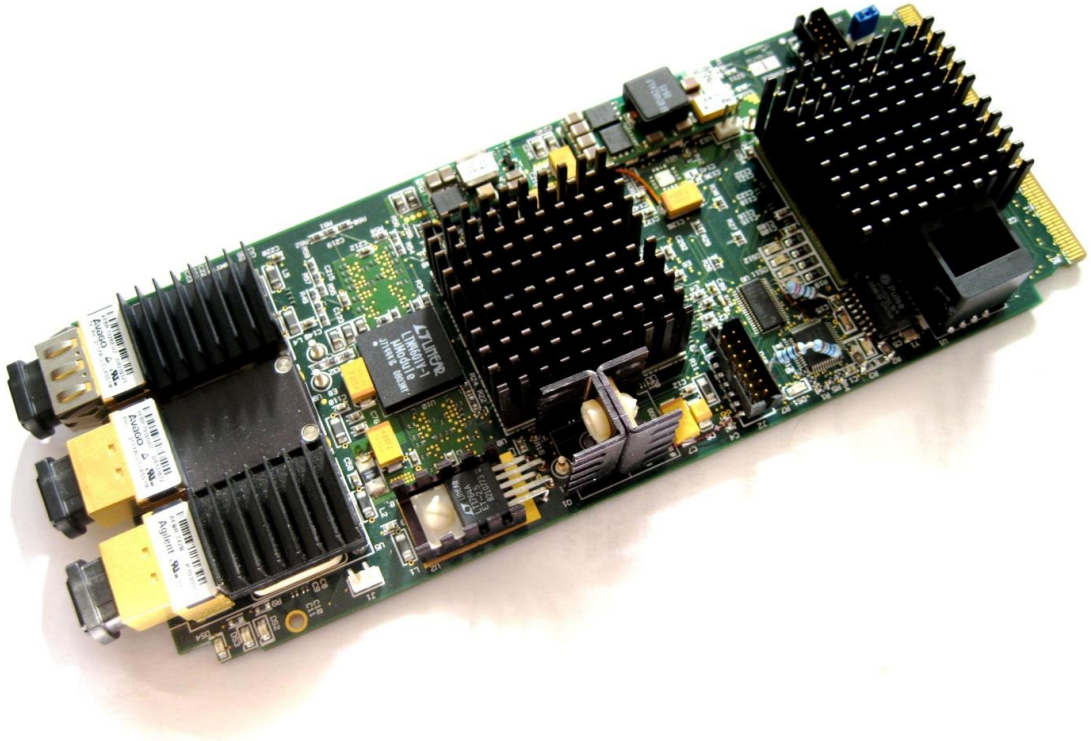
Early development: CMS Matrix card



- The initial CMS test engine (2006)
- 16 bidir front panel links
  - Snap12 / pop4
- Fully populated backplane
- 72x72 cross point switch
- Paired with the Aux card
  - TTC, TTS, DAQ

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Matrix conclusion

- **Single width card size is not big; Prefer double width**
  - Creates more constraints than you really need
  - Defendable if plan is to use **only** as mezzanine on ATCA carrier
- **Full height is desirable**
  - Heat sink for e.g. FPGA
    - ➔ CMS generally target lower than industry standard die temp for longevity
    - ➔ Commercial e.g. processors generally idle and will shut down of temp too high, thus different from our case
  - Height of optical components
  - Front panel area
    - ➔ Becomes ~½ of the area on e.g. ATCA, 2/3 of 9U VME and similar to 6U VME

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uTCA

- **Standardize key items in order to ease commissioning and long term maintenance of upgraded systems**
  - **Crate, a.k.a. Shelf**
  - **CMS interface, a.k.a. AMC13**
    - ➔ **Discontinuity in the spec ☺**
    - ➔ **Data Acquisition (DAQ)**
    - ➔ **Trigger Timing and Control (TTC)**
    - ➔ **Trigger Throttle (TTS)**
  - **AMC Module Management Controller (MMC)**
    - ➔ **UW design; very complete, used in e.g. CTP*, MTF*, uHTR, AMC13**
    - ➔ **UK design; also very complete, used in e.g. MP7, FC7**
    - ➔ **DESY/CPPM/CERN design; supported by CERN; includes mezzanine ref design**
  - **Register access software and firmware**
    - ➔ **IPBUS; includes a large software package and firmware**
  - **CMS DCS integration**
    - ➔ **System manager**

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Planned uTCA Ports Use for CMS

A	0	X		Common Options	1	GbE for slow control
	1		X			DAQ / Controls
B	2	X			2	Reserved
	3		X			Synch. Controls, TTS
Clock	TCLKA	CLK1/2		Clocks		Reserved
	FCLKA		CLK1/2			LHC Clock
D-G	4-7	X		Fat Pipes	3, 4	User*
	8-11		X			
H-K	12-15			Extended Fat Pipes		
	16-19					

* Note: Interconnections can be customized by the backplane manufacturer relatively inexpensively.

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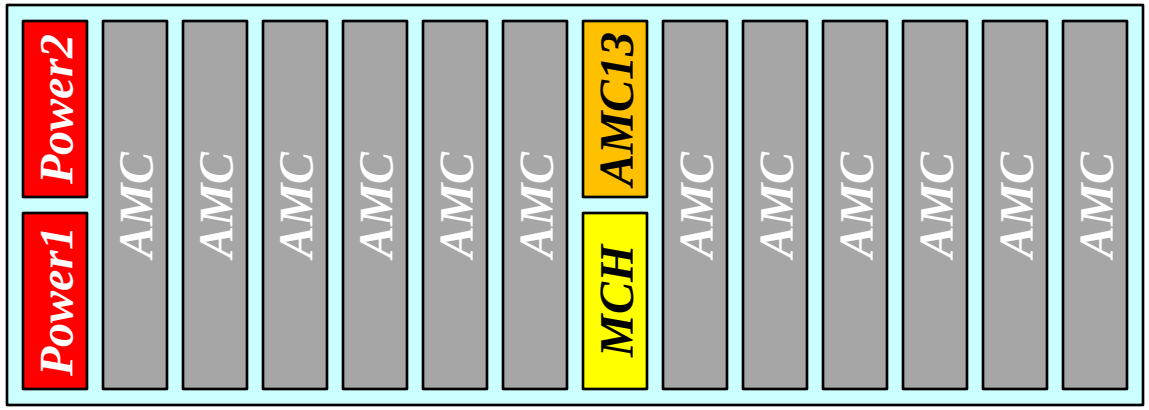
Proposed CMS uTCA Shelf



e.g. Vadatech VT892

- 12 full size double height slots
- Vertical air flow
- Redundant power supply
- Redundant telecom backplane
  - Fabric C and D routed to MCH 1 & 2 tongue 2
  - Fabric E and F routed to MCH 1 & 2 tongue 3 & 4
  - Customizable backplane
    - ➔ additional backplane interconnects (e.g. VT894, VT895)

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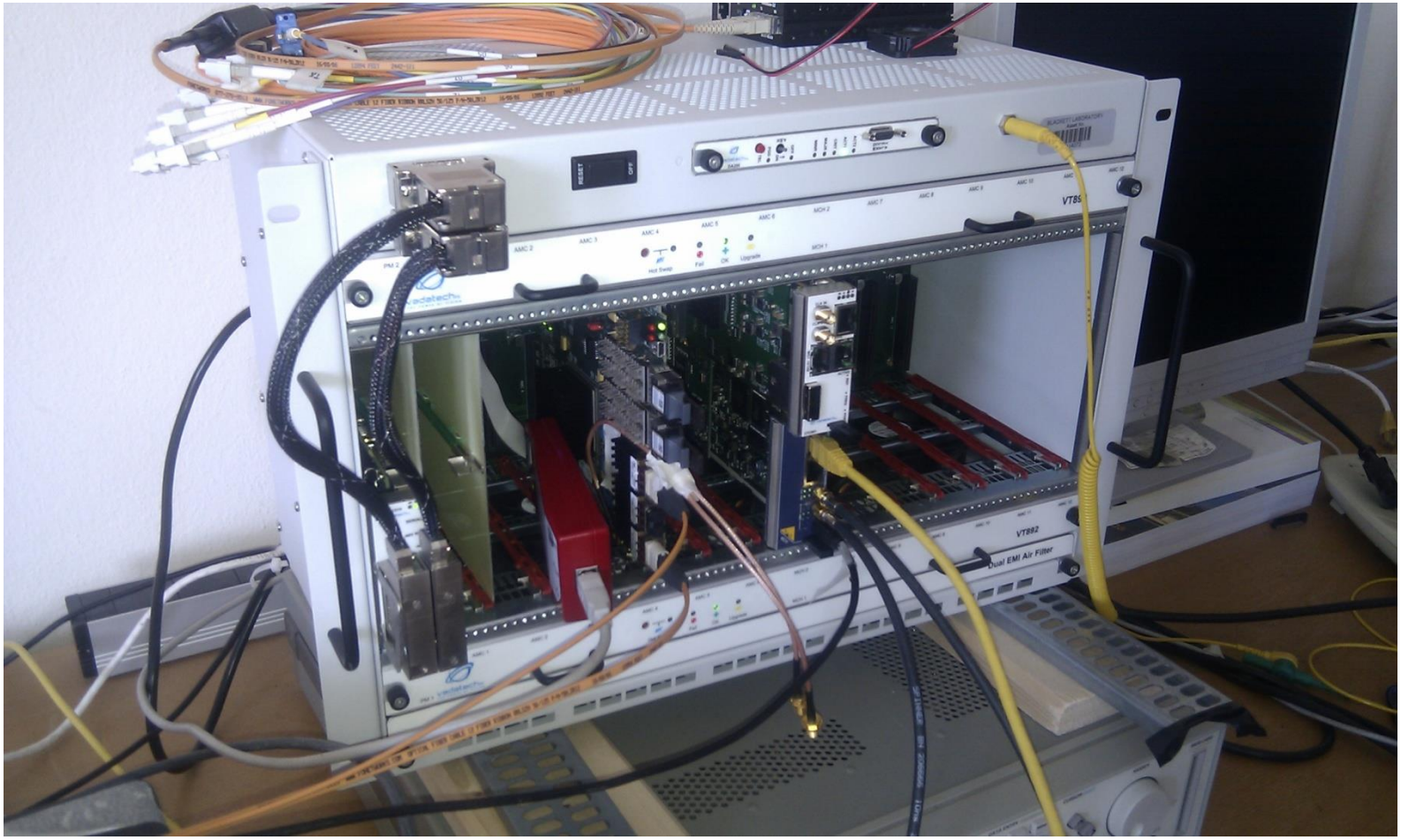
Prototype shelf / crate



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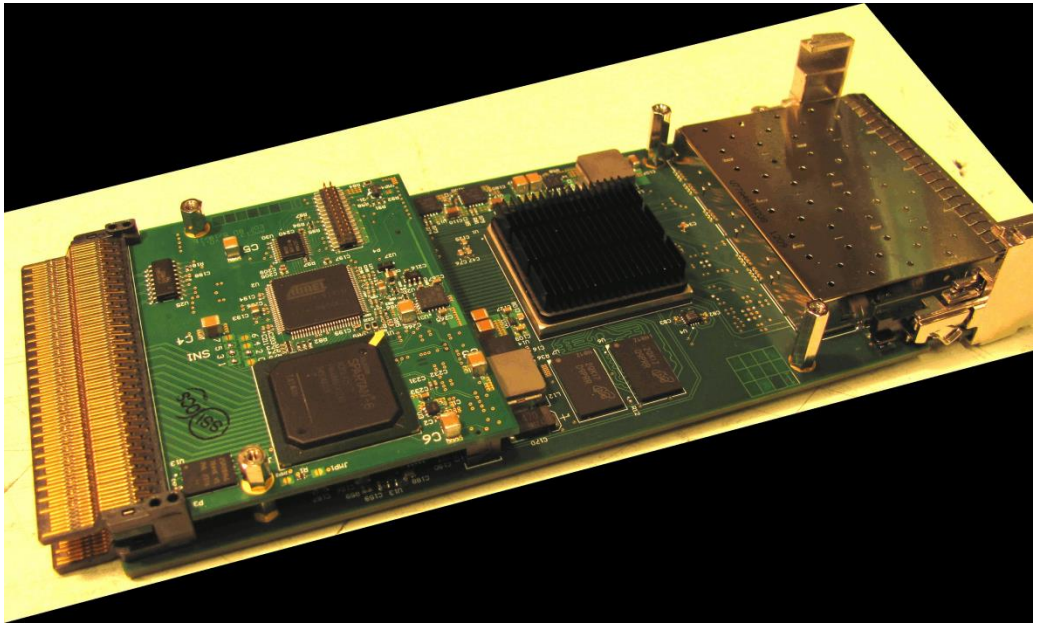
CMS interface

- **AMC13**
  - **T1**
    - ➔ TTC interface
    - ➔ AMC DAQ links over Fabric A
    - ➔ Three 5/10 Gb DAQ links
  - **T2**
    - ➔ Distributes LHC clock and ctrls
      - ⇘ FCLKA and Fabric B
  - **T3–T4**
    - ➔ Service interfaces (base config)
    - ➔ Optional (TCDS)
      - ⇘ TTCMi clock
      - ⇘ TTCMi orbit
      - ⇘ Two level 1 triggers (LVTTL)
      - ⇘ Two auxiliary (NIM) inputs
    - ➔ T3-T4 can be customized



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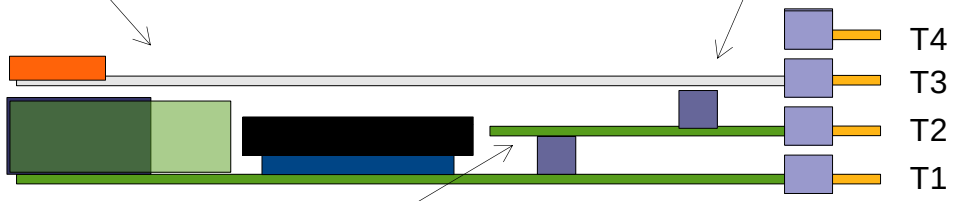
CMS interface: AMC13

•T3 board
•Provides JTAG / LEDs on front panel
•Cross-point switch for trigger applications (could be omitted if some other solution is found for front panel) space

•Connector to T3 provides:
•Power
•Serial bus (SPI or I2C) from MMC
•Front-panel signals:
•JTAG or SPI for miniUSB
•Status LEDs

Quad SFP+ Cage



•Custom T2
•Clock / controls fanout
•MMC functions (as AMC-13)
•GbE endpoint (from MCH1) for controls

•Custom T1 base board
•TTC receiver; TTS transmitter
•3 SFP+ (up to 10 Gb, e.g. DAQ)
•GbE endpoint (from MCH1) for controls and local DAQ

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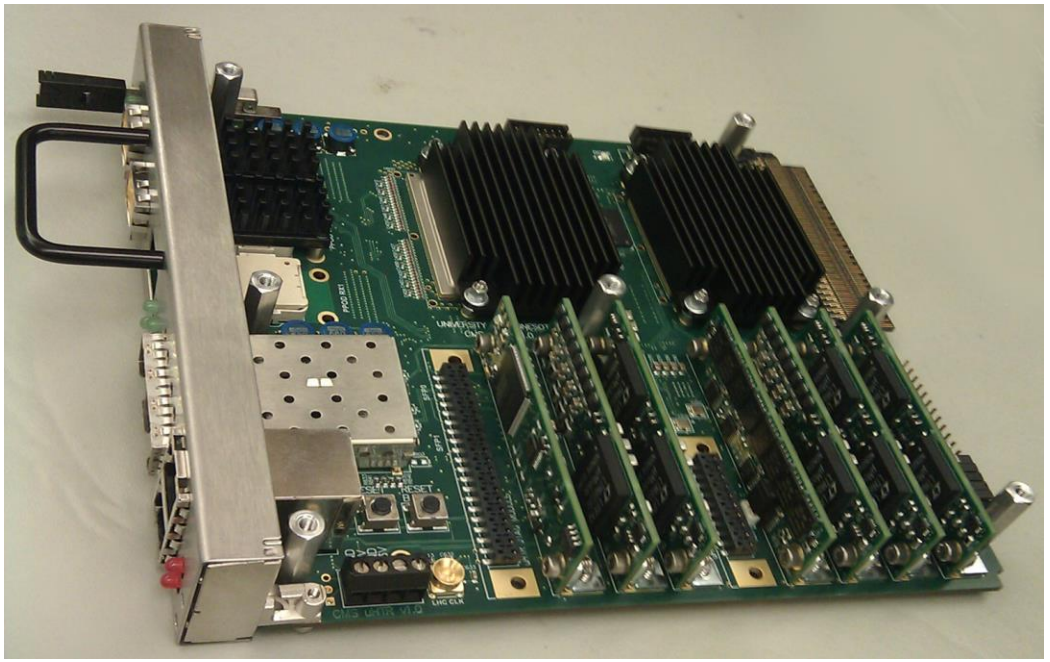
Modules in production in CMS

- **uHTR**
  - HCAL, BRIL
  - FE: XC6VLX240T
  - BE: XC6VLX195T
  - 24 Rx @ 6.4Gb (4.8Gb)
  - 12 Tx @ 6.4Gb (4.8Gb)
  - 2 TRx @ 4.8Gb
  - Ports 4,5,8,9 populated



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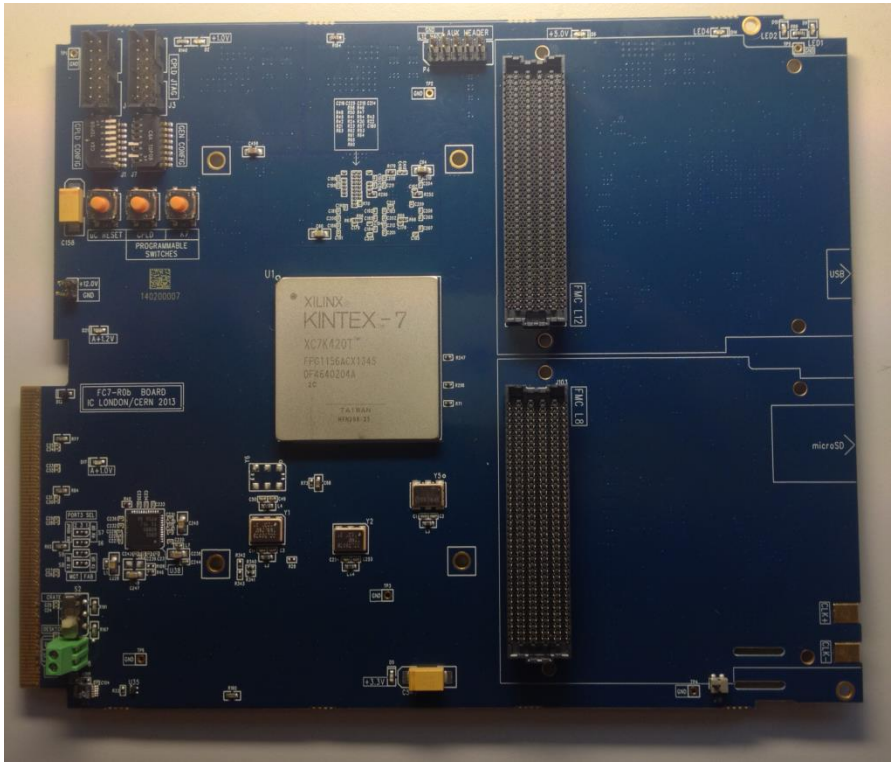
Modules in production in CMS

- **FC7**
  - TCDS, Pixels
  - XC7K420T
  - Two LPC FMC sites
    - ➔ Site 1: 8 TRx @ 10Gb
    - ➔ Site 2: 12 TRx @ 10Gb
  - Ports 4-11 populated



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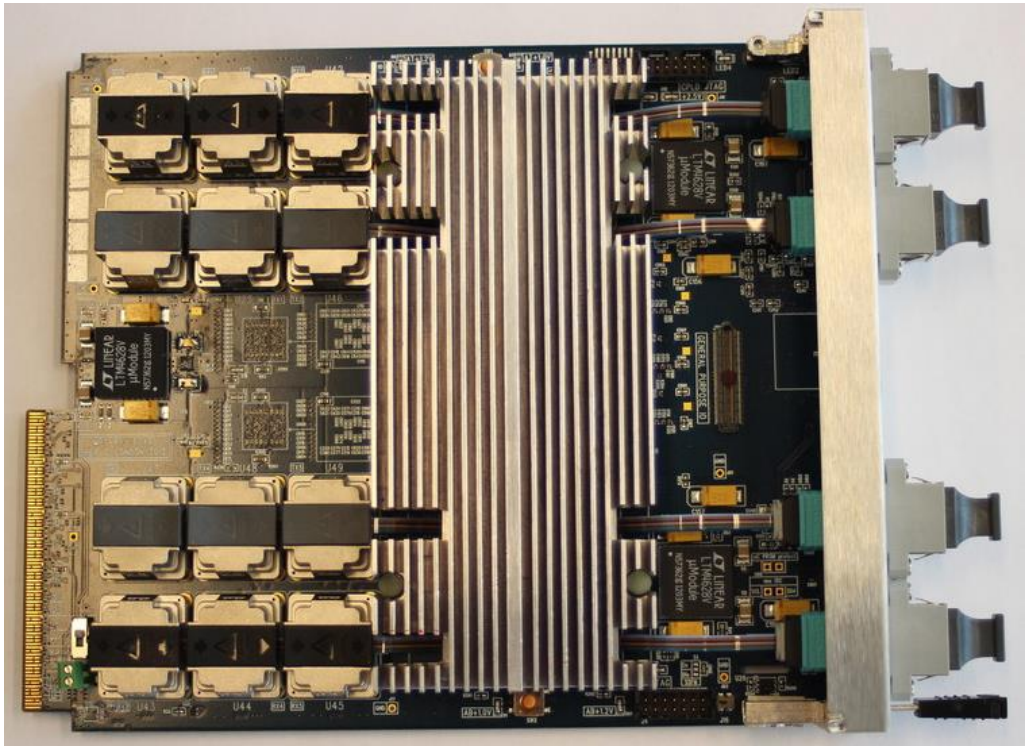
Modules in production in CMS

- **MP7**
  - **CT layer 2, Muon BTF, uGMT, uGT, GEM, etc.**
  - **XC7VX690T**
  - **72 Rx @ 13Gb**
  - **72 Tx @ 13Gb**
  - **Ports 4-8 populated**
    - ➔ **9-11 LVDS**



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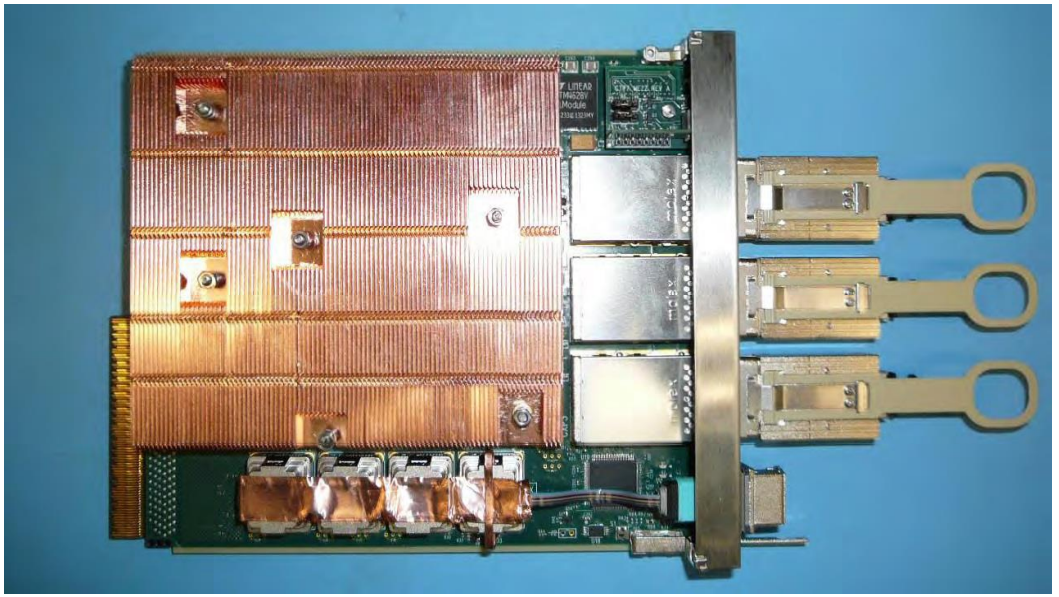
Modules in production in CMS

- **CTP7**
  - **CT layer 1**
  - **XC7VX690T**
  - **XC7Z045**
    - ➔ **GbE endpoing, uP**
  - **67 Rx @ 10Gb**
  - **48 Tx @ 10Gb**
  - **Ports 4-7, 12-15, 17-20 populated (as VT894, VT895)**



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Modules in production in CMS

- **MTP7**
  - Muon OTF, ETF
  - Dual card stack
    - ➔ Occupies two slots
  - XC7VX690T
  - XC7K70T
  - 80+4 Rx @ 10Gb
  - 28 Tx @ 10Gb
  - Pt LUT module
    - ➔ Up to 2GB low latency RAM
    - ➔ Split in banks

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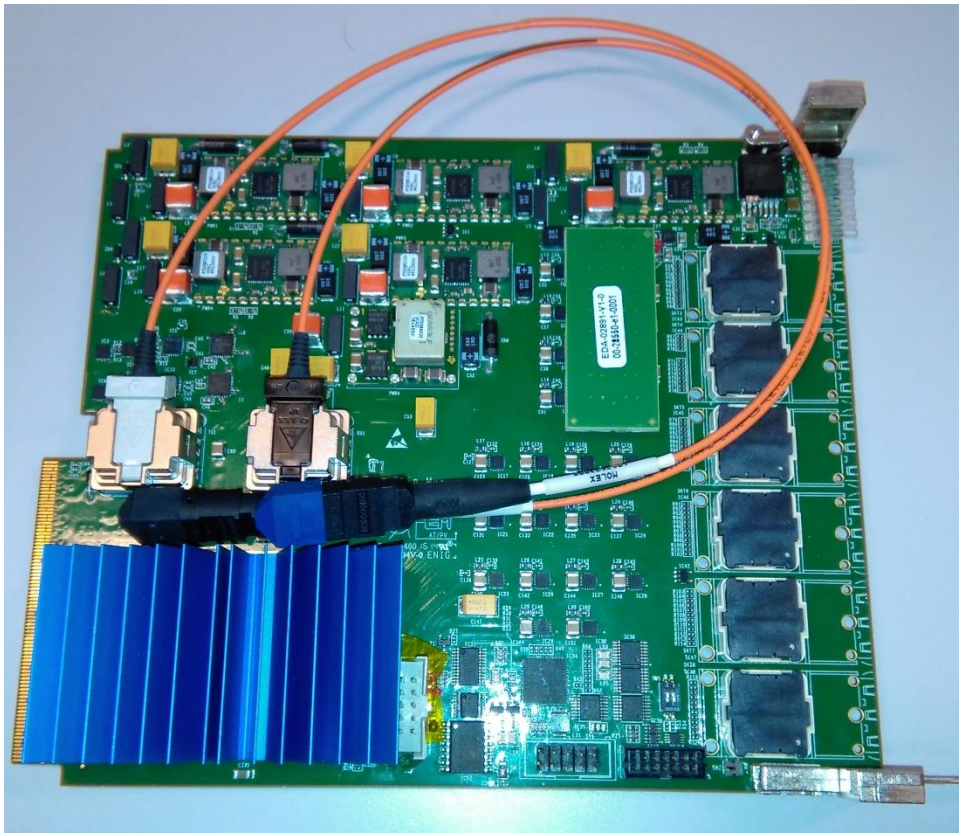
Modules ready for production in CMS

- **Twinmux**
  - DT sector collector
  - XC7VX330T
  - 64 Rx @ 480Mb
  - 12 Rx @ 10Gb
    - ➔ Used @ 1.6Gbps
  - 12 Tx @ 10Gb
  - Ports 4-8 populated
    - ➔ 9-11 LVDS
  - Implements the MMC reference design from DESY/CPPM/CERN



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Commercial Items

uTCA crate
Vadatech or Schroff

Power-One AC/DC (48V) converter

Power Module
NAT or Vadatech

MCH
NAT or Vadatech

Recent shelf

- **Schroff shelf features**
  - **4 power modules**
    - ➔ In the rear of the shelf
    - ➔ 2 in parallel in the front
  - **JSM in the rear**
    - ➔ JSM has been custom developed
      - ⇘ Access to backplane JTAG through – jtag (rotary switch), Ethernet.
  - **Up to six RTMs in the outer slots**
    - ➔ 1-3, 10-12
    - ➔ Not used by CMS to date

uTCA crate
Vadatech or Schroff

Issues

- **Issues with PowerOne**
  - **N+1 Redundant**
  - **Highly efficient**
  - **Monitoring but not control**
    - ➔ **Redundancy complicates things**
  - **20A Circuit breakers are not switches**
    - ➔ **The circuit breakers are only for line protection**
    - ➔ **If used for powering up power modules one by one some power modules may fail to power up properly**

Power-One AC/DC (48V) converter

Summary

- CMS is using almost (?) exclusively mTCA for the phase 1 upgrades
- Most issues are ironed out to a level beyond the capability of the legacy VME systems
  - Monitoring, potential availability, etc.
- Phase 2 being around the corner the door is still open for other standards to enter

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