µTCA @ HEP

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DESY-CMS

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µTCA =

- micro version of
- **T**elecommunications
- **C**omputing
- **A**rchitecture

µTCA =

- industry standard (PICMG:PCI Industrial Computer Manufacturers Group) defining:
  - general mechanical + electrical properties of:
    - shelf, crate
    - boards to be plugged in
  - connectivitity:
    - serial point-to-point links in star topology

outline

- introduction
- parallel - serial, bus - point to point
- TCA and its various variants
- µTCA @ CMS
- conclusion

parallel - serial, bus - point to point

Parallel bus -> Serial link

Parallel Buses Are Dead! (RT magazine, 2006)

What is wrong about "parallel"?
- You need lots of pins on the chips and wires on the PCBs
- The skew on the data lines limits the maximum speed

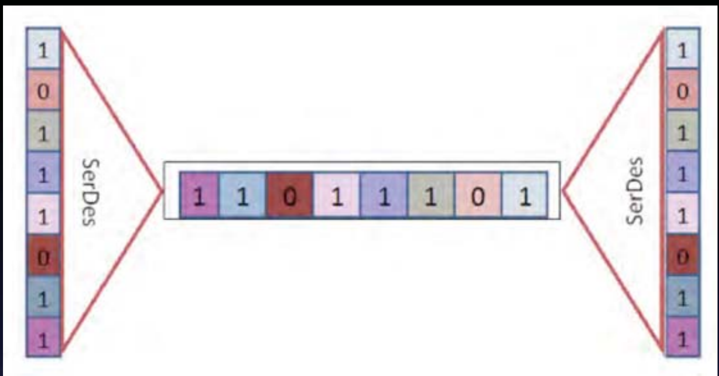
What is wrong about "bus"?
- Speed is a function of the length (impedance) of the lines
- Communication is limited to one master/slave pair at a time (no scalability)
- The handshake may slow down the maximum speed

Dead: centronics, SCSI, PATA, PCI
Replaced by: USB, SAS, SATA, PCIe, Thunderbolt
VMEbus → µTCA

typical data rates

centronics	2.5MB/s		USB	0.012-5Gb/s
PATA	133MB/s		SATA	1.5-6Gb/s
SCSI	5-320MB/s		SAS	1.5-6Gb/s
PCI	133MB/s		PCIe	2.5-8Gb/s x 16 lanes
VME	20-80MB/s		µTCA	?

SerDes: Serializer/Deserializer

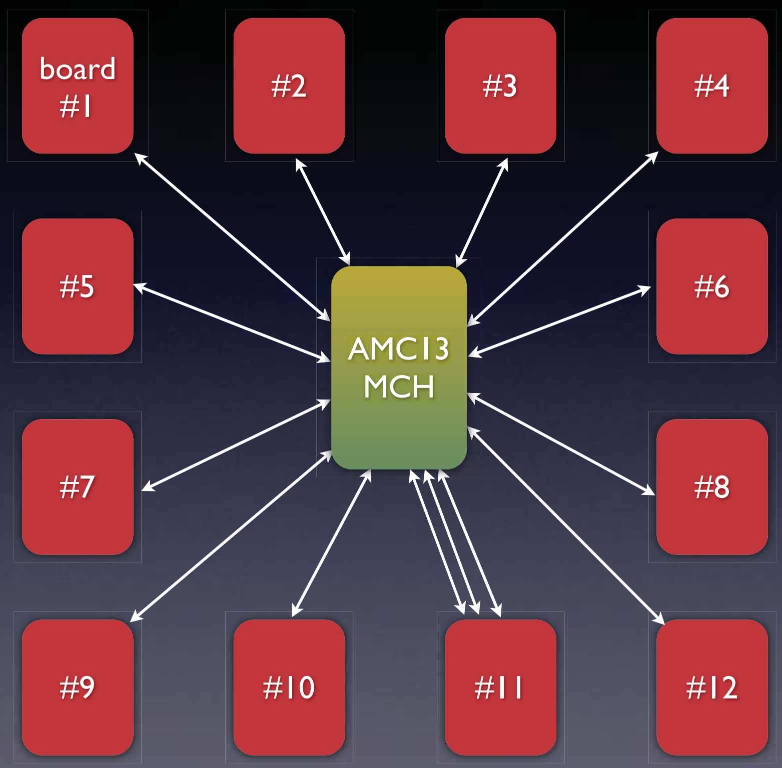


keep it simple:
- no clock, just data

popular: 8b/10b encoding
- 8bits payload in 10bit packets

typical HW unit: **lane, pipe**
- composed of 2 differential signaling pairs = 4 wires
  - one for receiving,
  - one for transmitting data

Star topology



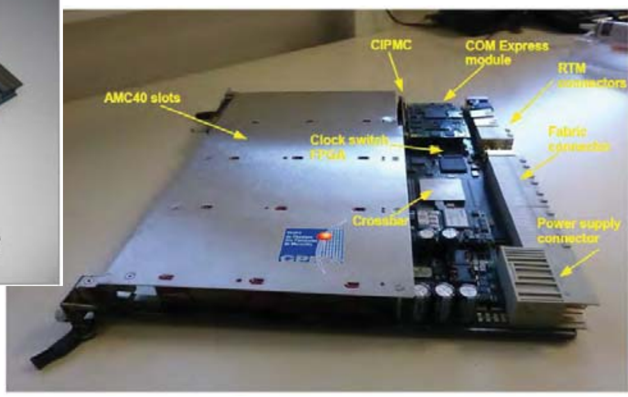
The different flavours of TCA

It started with **ATCA**:
Advanced
Telecommunications
Computing
Architecture

ATCA

- very flexible backplane connectivity
  - serial point-to-point connections
  - Fabrics: dual-star, dual-dual-star, mesh, replicated mesh
- but: large and expensive, high start-up costs
- high-end technology
- applications planned for ATLAS, Belle, xfel

LHCb TELL40



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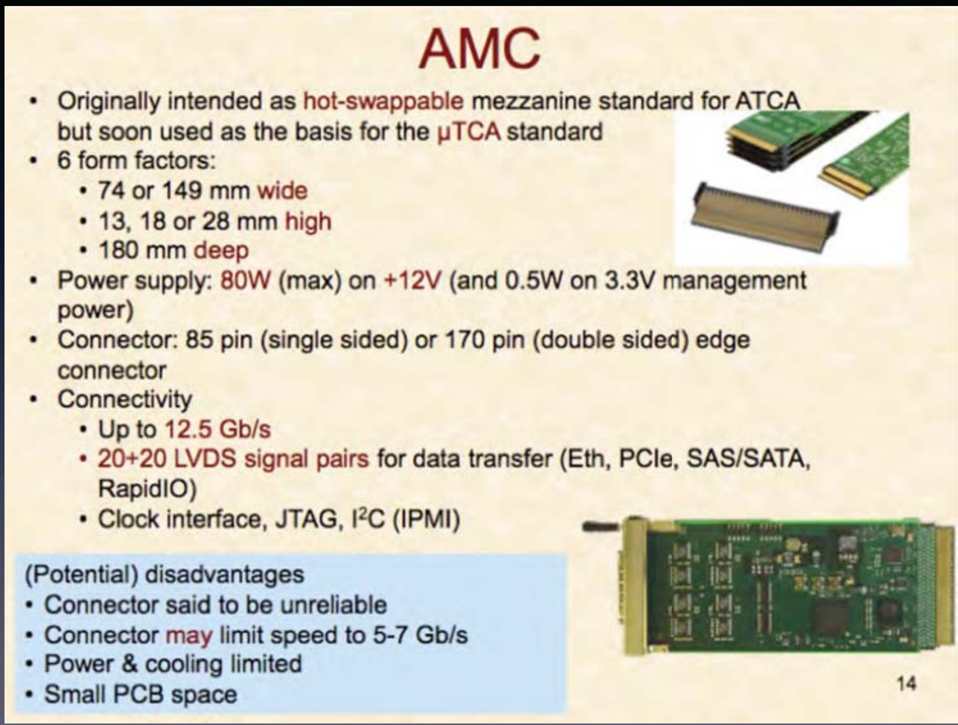
AMC: **A**dvanced **M**ezzanine **C**ard



µTCA

specification for a system that uses PICMG Advanced Mezzanine Cards (AdvanceMCs) directly on a Backplane

MicroTCA is a modular standard. By configuring highly diverse collections of AdvancedMCs in a MicroTCA Shelf, many different application architectures can be easily realized. The common elements defined by MicroTCA are capable of interconnecting these AdvancedMCs in many interesting ways—powering and managing them, all at high efficiency and low cost. (PICMG)

µTCA(2)

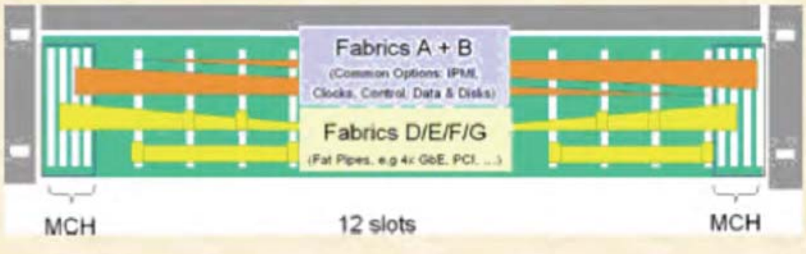
This PICMG MicroTCA specification was written with the following design goals in mind:

- Complementary to AdvancedTCA
- Full conformance with the AMC.0 Module definition
- Favorable cost, size, and modularity
- Target low start-up costs
- Scalable Backplane bandwidth
- Modular and serviceable
- Standardized Shelf management implementation compatible with AdvancedTCA
- Support 300 mm nominal equipment depth and 19 in. nominal equipment width
- Cooling: 20–80 W/AdvancedMC
- Support for extended temperatures (–40 to +65 degrees Centigrade)
- Power: 12 V to AdvancedMCs, in conformance with AMC.0
- Life span: at least eight years
- Backplane bandwidth: SerDes @ 1–12+ Gb/s
- Backplane topologies: Star, Dual Star, Mesh
- Scalable system reliability: from .999 to .99999
- Support any/all AdvancedMC-defined form factors
- Hot Swap/plug-and-play support, in conformance with AMC.0 and consistent with AdvancedTCA

µTCA(3)

- A system standard based on the AMC, standardized in 2006
- Min. signaling speed: 3.125 GHz
- Connectivity:
  - 4 AMC LVDS pairs defined as "Common Options" (2 Eth. & 2 SAS ports) and connect to 1 or 2 MCH boards which provide the switching
  - 8 AMC LVDS pairs defined as (extended) fat pipes (1 or 10 G Eth, PCIe, RapidI/O). Connection to MCH not standardized
  - Remaining 8 LVDS pairs not defined (can be used for rear I/O (but rear I/O not foreseen in uTCA standard))
- System management based on IPMI / I²C
- Hot-swap support for PSU & cooling
- Redundant MCH (µTCA Controller Hub)
- The MCH connector supports up to 84 differential ports (1 port = 2 LVDS pairs). Therefore (only) 7 ports per AMC (based on a 12-slot backplane) can be routed to the switch.

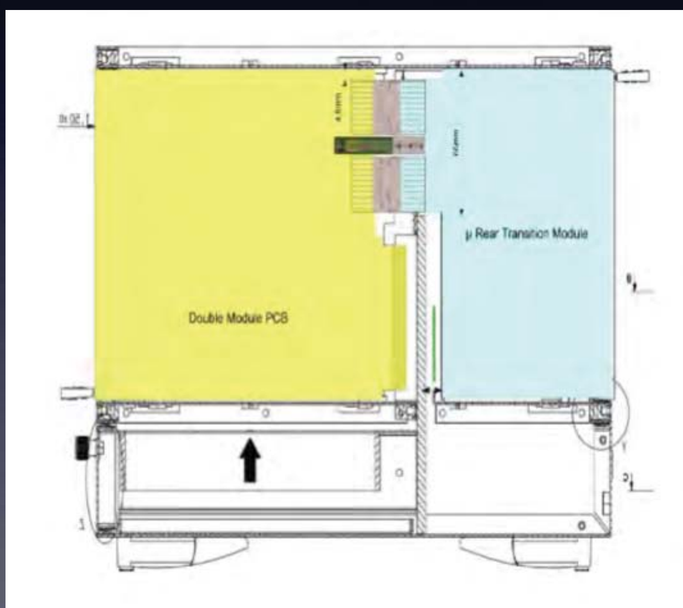
Connector Region	AMC Port #	Signal Conventions				MCH Fabric #
Common Options	0	AMC.2 1000Base-BX				A
	1	AMC.2 1000Base-BX				2/A
	2	AMC.3 SAS				B
	3	AMC.3 SAS				2/B
Fat Pipes	4	AMC.1 x4 PCIE	AMC.4 x4 SRIO	AMC.2 1000Base-BX	AMC.2 10GBase-BX4	D
	5			AMC.2 1000Base-BX		E
	6			AMC.2 1000Base-BX		F
	7			AMC.2 1000Base-BX		G
Extended Fat Pipes	8		AMC.4 x4 SRIO	AMC.2 1000Base-BX	AMC.2 10GBase-BX4	2/D
	9			AMC.2 1000Base-BX		2/E
	10			AMC.2 1000Base-BX		2/F
	11			AMC.2 1000Base-BX		2/G



MTCA.0-4

Physics xTCA or MTCA.4

- "Helmholtz-Gemeinschaft funds commercialisation of a new industry standard of electronic systems" (Desy News)
- driven by XFEL
- extended µTCA:
  - analog electronics on rear transition module
  - compatible with µTCA.0 AMC cards



Frontend - Backend electronics in HEP experiments

- Frontend:
  - close to detector
  - radiation hard
  - limited space
  - restricted heat dissipation
  - analog + digital
- Backend:
  - >10m away from detector
  - digital only
  - data throughput
  - computing power (FPGA)

- µTCA can't be used in frontend
- MTCA.4 not very interesting

µTCA @ CMS

Pros:

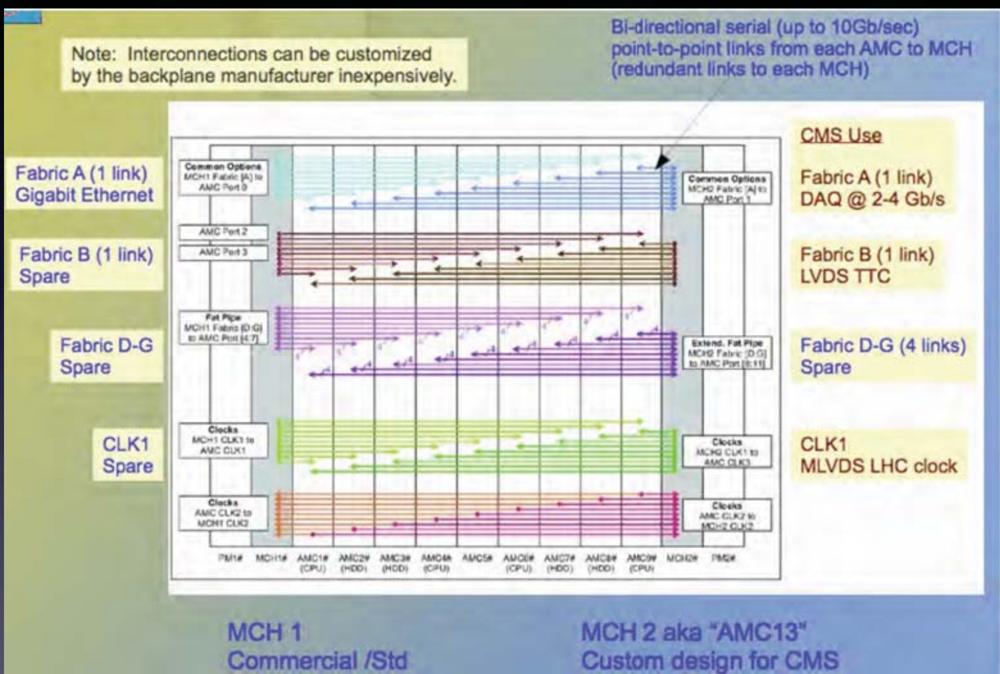
- Star topology
  - ideal for 'event building' at subdetector level
  - one central module collects (preprocessed) data from up to 12 readout modules
  - backplane fast enough, even able to cope with another upgrade level
- crates not too large to fit into existing infrastructure
- AMCs hot swappable
- Redundancy: MCH, PSU, cooling

µTCA @ CMS (2)

Cons:

- complex system management
- complex system management requirements at board level (MMC: Module Management Controller)
- not to much space on AMCs and MCHs

µTCA @ CMS (3)

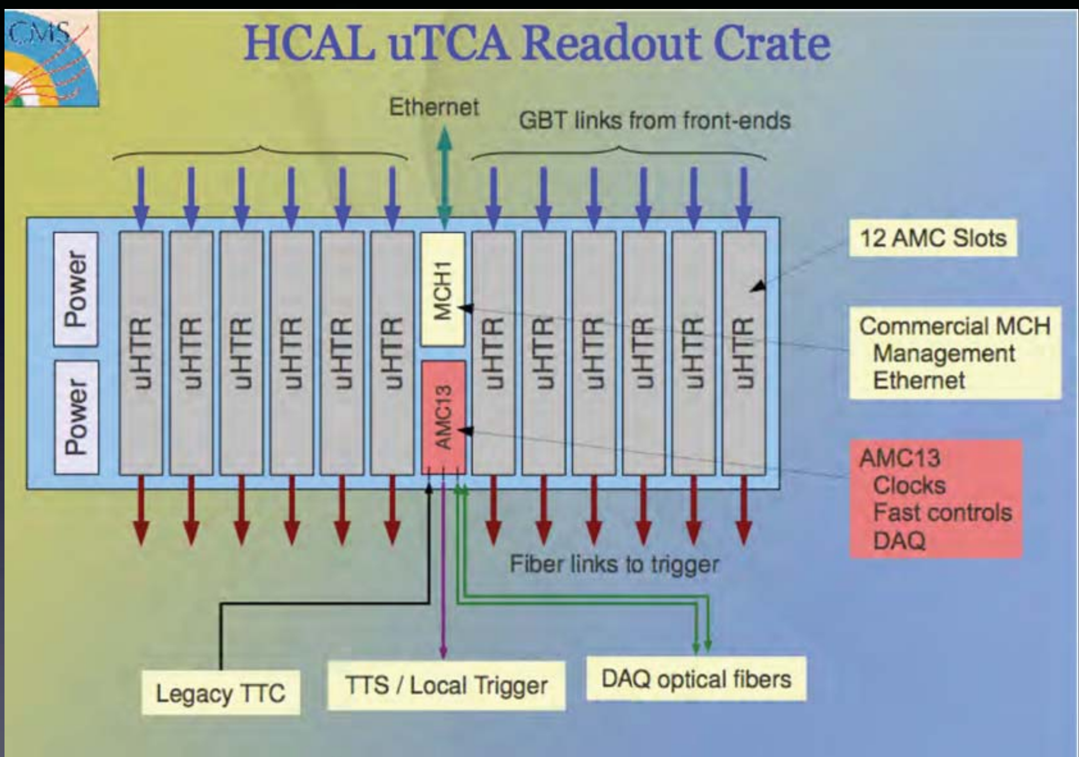


µTCA @ HCAL

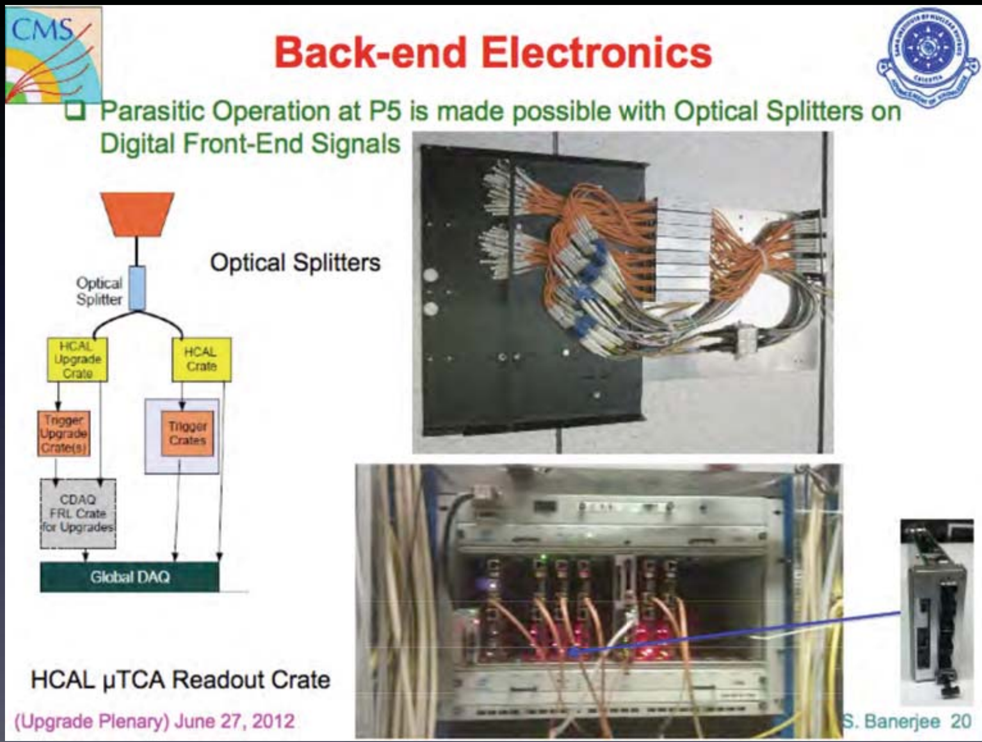
HCAL is upgrading Backend Electronics. Why?

- be ready for 4 times more data
  - current system not able to cope with this
- avoid legacy support for 15 years or more
  - current design based on pre 2000 technology
- reduce complexity
  - reduce number of different boards
  - get rid of many mezzanine cards
- be ready for filter / trigger processes needing much more data from many detector regions in a flexible architecture

µTCA @ HCAL(2)



μTCA @ HCAL(3)



Summary

- μTCA:
  - promising technology
  - very fast and flexible backplane providing serial point-to-point connections
  - relatively low start-up costs
  - hopefully long-living industry standard

Conclusion

- there are alternatives, but TCA seems to be the winner
- ATCA or µTCA used at: DESY, CERN, KEK, SLAC, FAIR, ITER, ESS
- join us
  - CMS
  - XFEL accelerator control
    - Kay Rehlich, Holger Schlarb
  - XFEL daq
    - Chris Youngman, Patrick Gessler