Emerging New Electronics Standards for Physics

Progress and Challenges

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For the PICMG xTCA for Physics Collaboration

PICMG-ese

Term	Definition
PICMG	PCI Industrial Computer Manufacturers Group, 250 corporations
ATCA	Advanced Telecommunications Computing Architecture large board
Carrier	ATCA or µTCA board that supports smaller standard board
Shelf	Crate, ATCA (large) or µTCA (small)
RTM/µRTM	Rear/Micro Rear Transition Module
AMC	Advanced Mezzanine Card mounting on ATCA Carrier, µTCA shelf
Micro/µTCA	Crate designed to support AMCs directly
MCH	Micro-Controller Hub Switch module for µTCA shelf
PU, CU	Power Unit (Module), Cooling Unit (fan or fan tray)
IPMI	Intelligent Platform Management Interface
Shelf Mgr	Shelf board hosting IPMI controller (BMC, MMC controllers)
Wide, High	High (vertical module height), Wide (front panel width)
xTCA	ACTA and /or MicroTCA standard platforms

Outline

I. Why xTCA?
II. Lab-Industry Standards Development
III. Lab-Industry Applications Development
IV. Future Challenges
V. Acknowledgments

I. Why xTCA?

I. Why ATCA, μTCA for Telecom?

- PICMG developed *open standards* by fiercely competitive Telecom industry
  - Shares, lowers development costs for all
  - Vastly shortens *time to market* of new *value-added* products within processor blades
  - Higher availability is money in the bank
  - Changes dynamic of locking customers into old-style proprietary platforms, enforces xTCA *interoperability* standards
  - *A major cost-driven shift for the industry*

I. Why xTCA for Physics?

- Original Attraction:
  - Technology: High Availability, managed next-generation platform increasingly necessary for complex physics machines; reducing huge costs of lost productivity ("Opportunity Cost")
- Emerging Major Benefit:
  - Economic: Development shared by Lab-Industry collaboration, reducing costs for all and "time-to-market" for COTS* support critical to acceptance for any new projects, upgrades

*Commercial Off-The-Shelf

I. High Availability Case Study: ILC

- ILC critical need for *high availability* ignited broad interest in ATCA *open standard*
  - Aggregate subsystem reliabilities could deliver only A~0.15 compared to goal of 0.85 overall
  - Controls required A~0.99999 (5-9's) at crate level
  - ATCA achieves by:
    - Core node and N+1 redundant architecture
    - IPMI out-of-band system based on industry-wide standard chips to help predict, avoid shutdown faults
    - Short Mean Time to Repair (MTTR) via early diagnosis, faulted unit isolation, hot-swap capable modules

I. PICMG Enabling Technologies

- PICMG Collaboration
  - Includes ~250 major competitors, technology innovators, supporting industries fueling communications revolution,
  - System, SW, chip & equipment providers
  - Telecom, military, industrial controls
  - Chip and equipment supporting industries respond quickly once new standards set
  - Open standard *requires* multiple sources all critical components
  - PICMG consortium extends, maintains xTCA (and other) standards

1. xTCA Key Platform Technologies

- N+1 redundant crate architectures for *HA* design
- *Multi-gigabit serial backplanes ATCA, μTCA*
- High Density 5-10 GHz bandwidth balanced shielded fabric and edge-card connectors
- *FPGAs w/ imbedded serial Tx-Rx, PPCs*
- Industry standard IPMI, shelf management based on open standard chip sets
- *Flexible board, mezzanine options, adapters for other standard formats enhance adaptability for future*

II. Lab-Industry Standards Development

II. Lab-Industry Standards Milestones

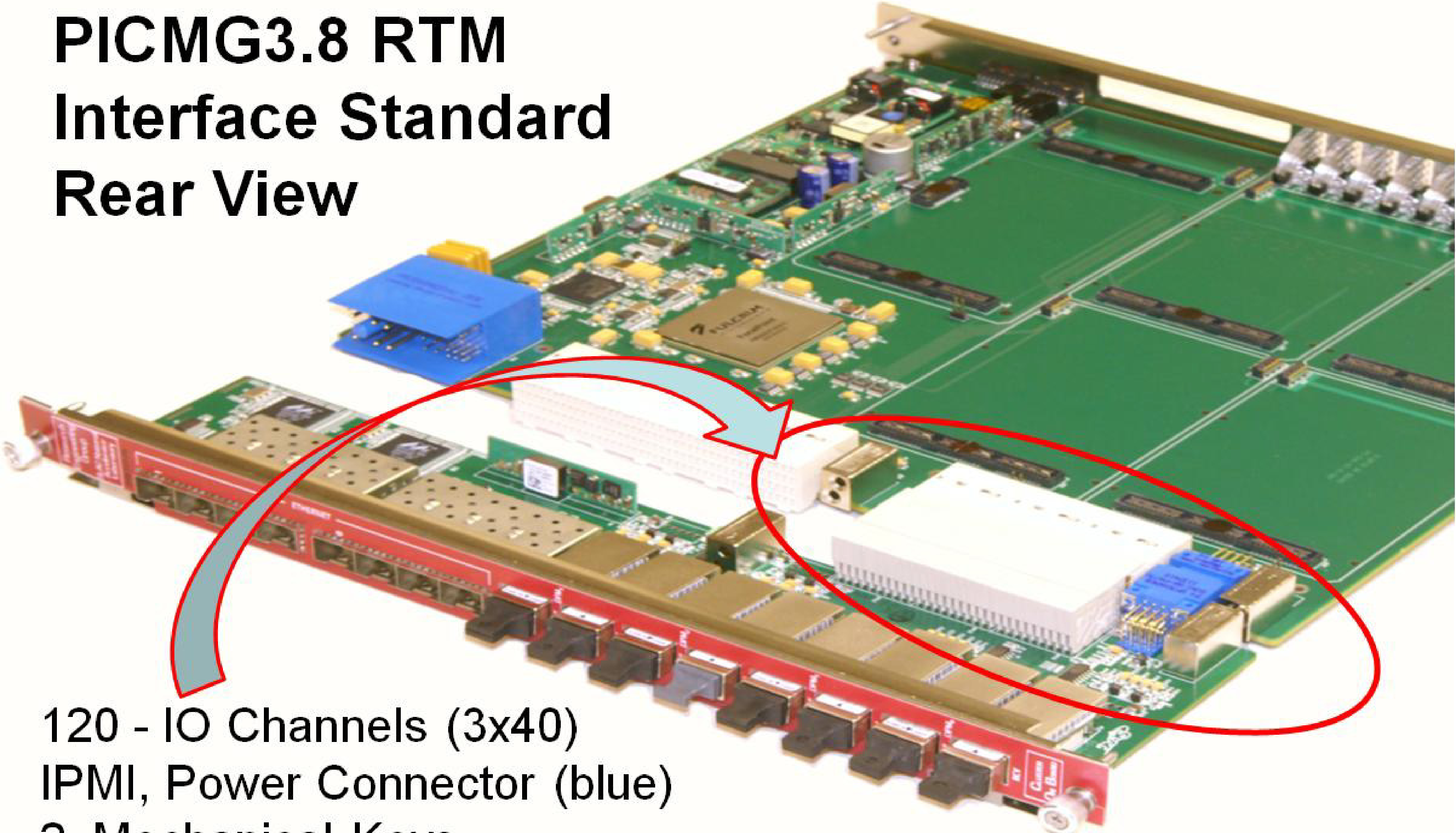
Date	
2004-Nov	IEEE NSS-MIC paper proposing xTCA for physics
2005-July	ATCA proposed as ILC C&I technical, cost model
2007-May	**1st xTCA for Physics Workshop, FNAL, invitation to form PICMG standards group**
2007-Dec	**xTCA proposed for XFEL I&C standard**
2008-Nov	2nd xTCA for Physics Workshop, Dresden, vote to from PICMG WGs
2009-May	**3rd xTCA for Physics Workshop, Beijing, PICMG Committees open for business, weekly meetings start**
2010 - May	4th xTCA for Physics Workshop, Lisbon, first new MicroTCA shelf prototypes demonstrated by 2 vendors
2011-June	MTCA.4, PICMG3.8 extension standards sent to PCIMG for 1st ballot
2011-Aug	**MTCA.4, PICMG3.8 sent to PICMG for final ballot**

II. What Are The Standards?

- ATCA PICMG3.8
  - New RTM interface Specification, 120 high speed channels IO, IPMI management, power via new connector
- MTCA.4
  - Extends double-wide shelf (crate) to include RTM IO, IPMI managed
  - Extends standard backplane with extra layer for timing, interlocks, triggering
  - Compatible with all existing 1-wide AMC products

– *Note on Physics Software Working Group: Due to lack of time the important work of the SWG will not be covered in this presentation*

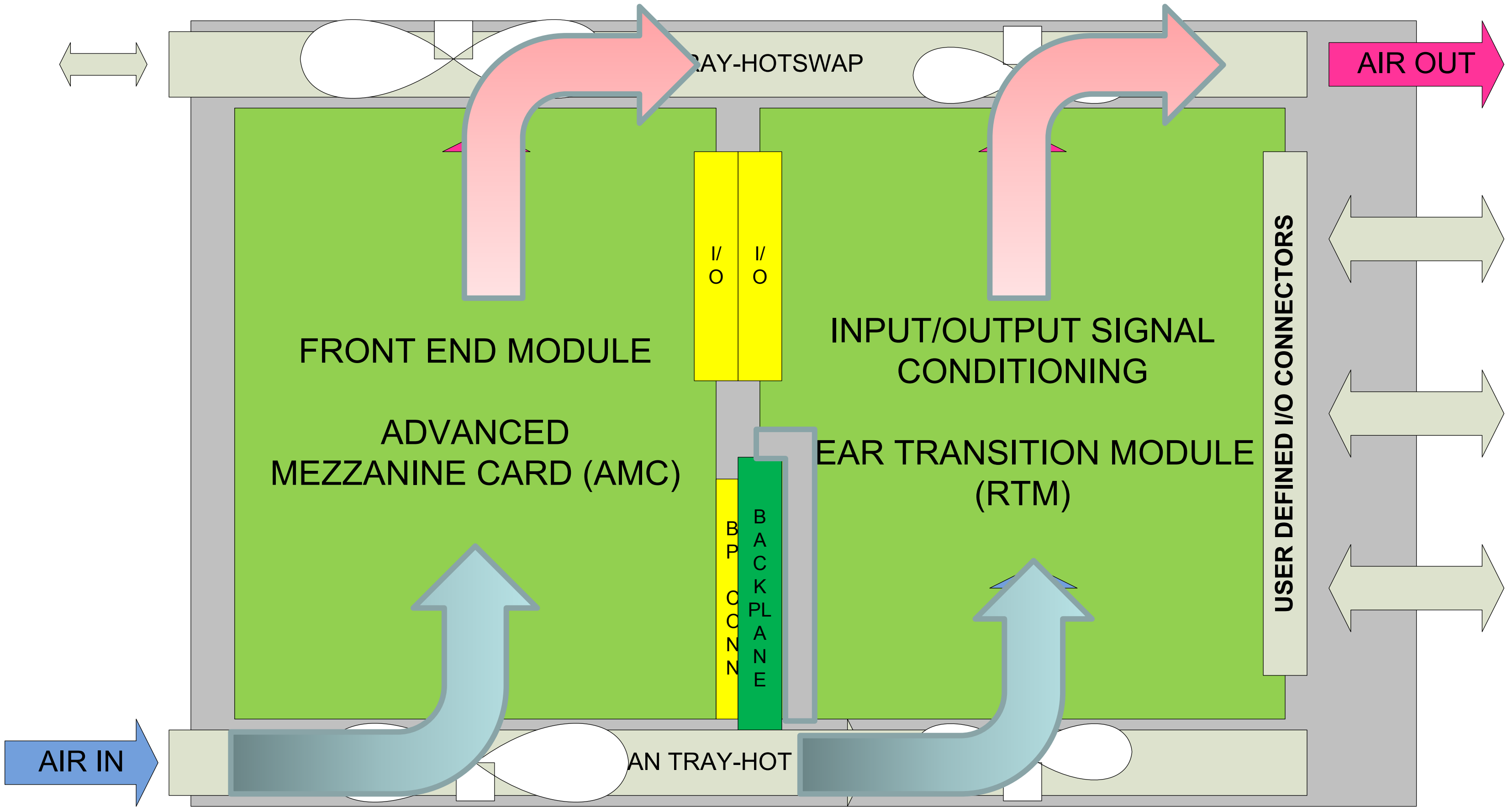
PICMG3.8 RTM Interface Standard Rear View



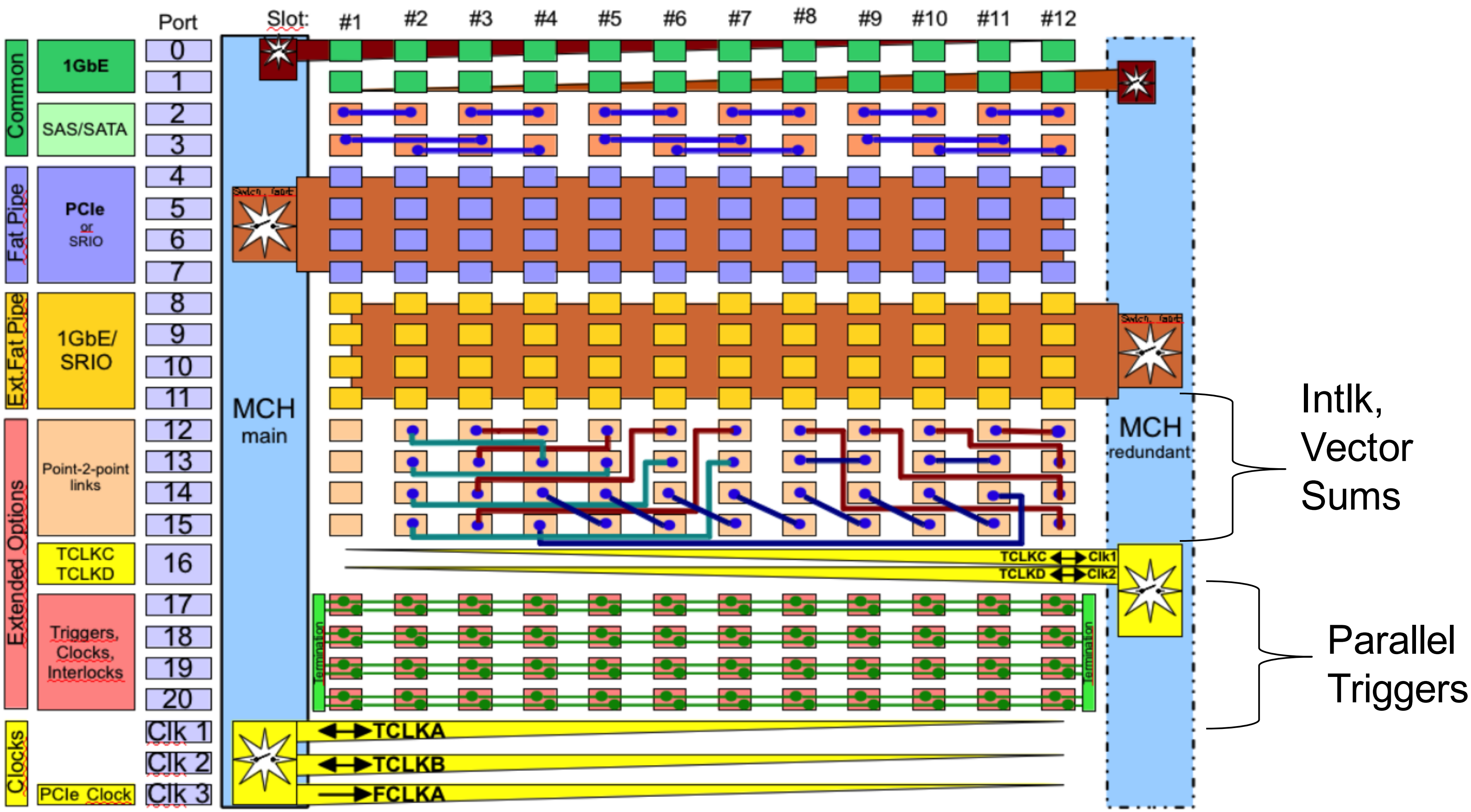
120 - IO Channels (3x40)
IPMI, Power Connector (blue)
2 Mechanical Keys

Courtesy M. Huffer, SLAC

MTCA.4 AMC-RTM-Shelf Concept



MTCA.4 12-AMC Backplane



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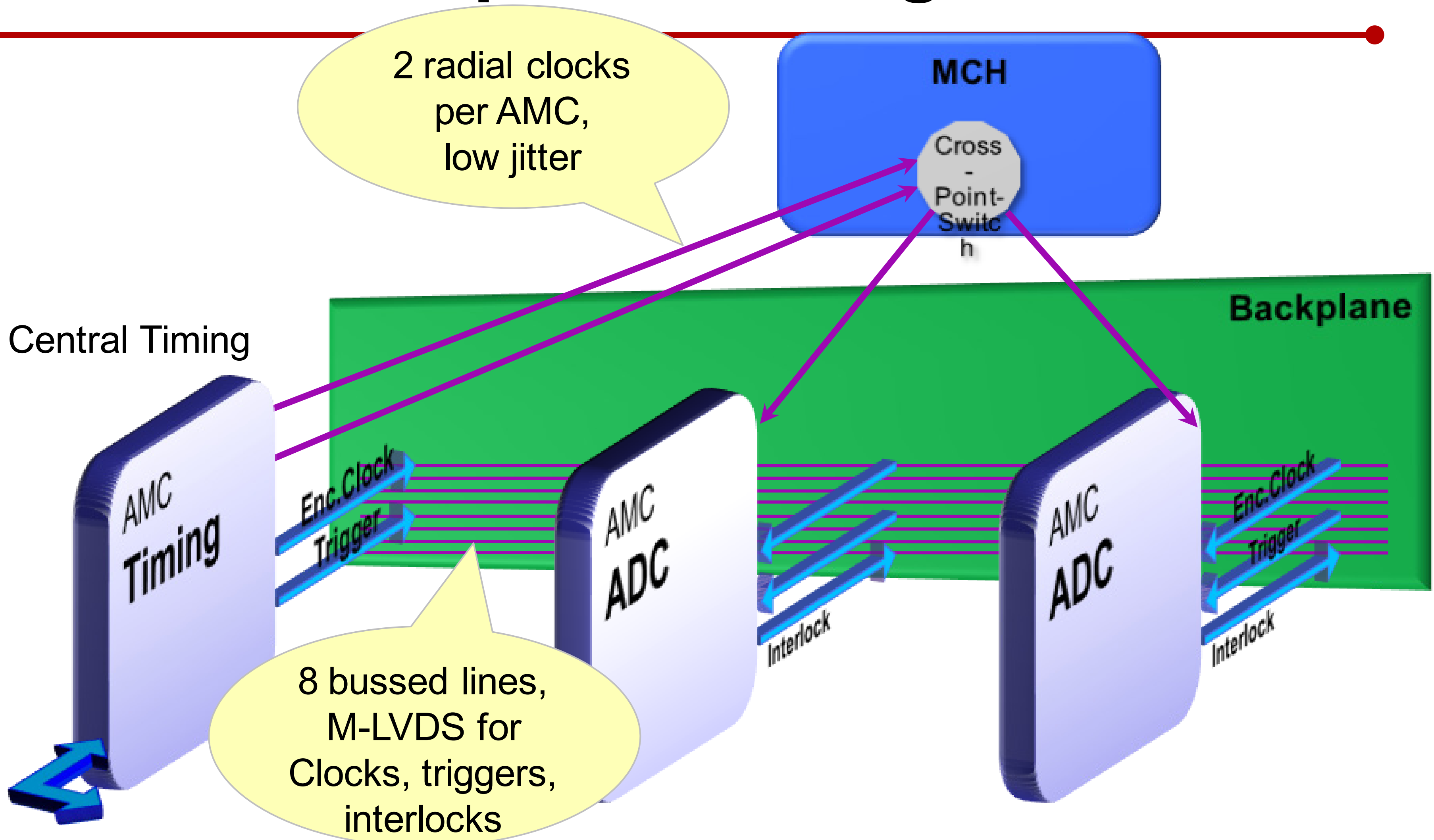
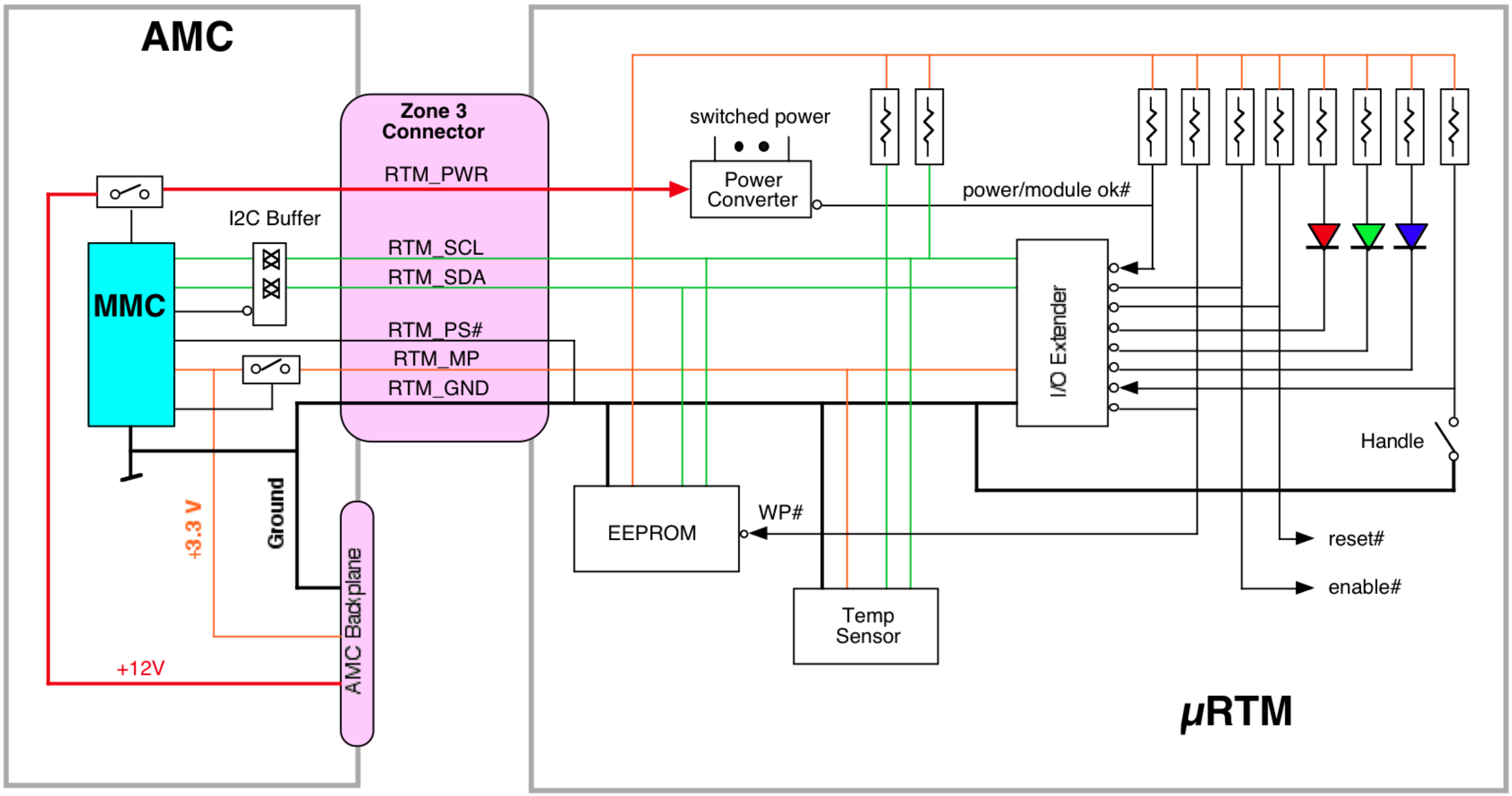
MTCA.4 Backplane Timing Distribution

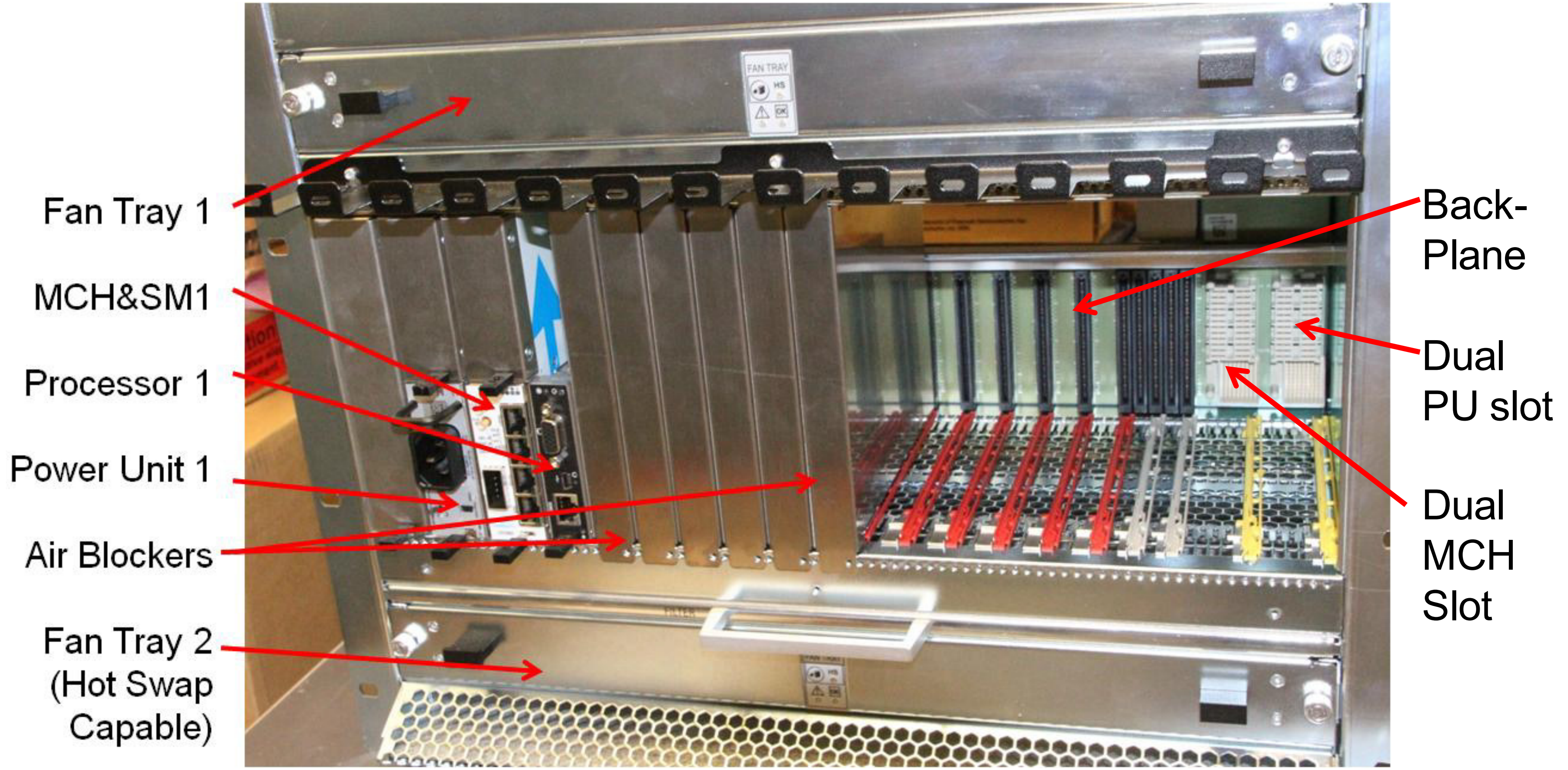


Courtesy K. Rehlich, DESY

µRTM Extended IPMI Circuit



MTCA.4 Compliant Shelf 12 Slot



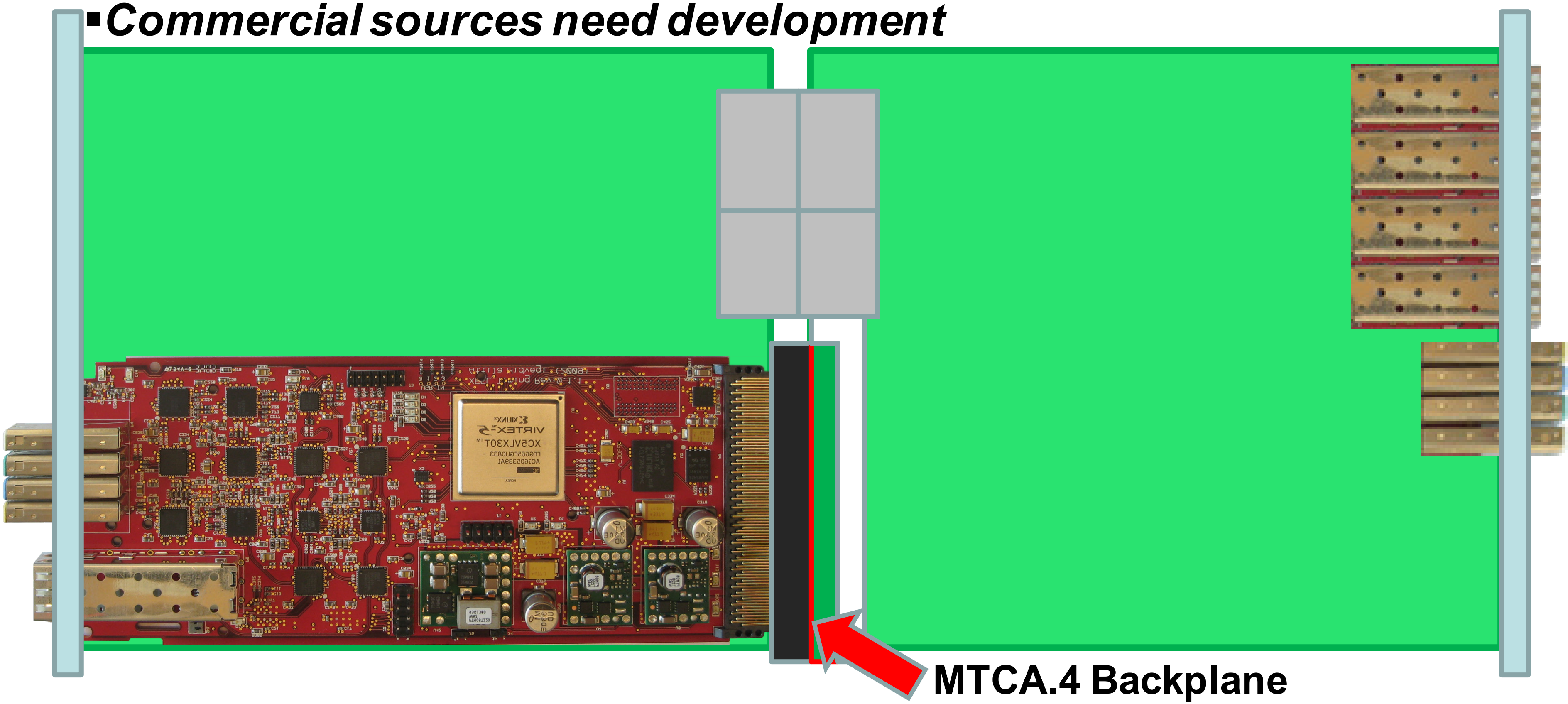
12 Payload AMC-RTMs Dual Star Redundant Front View

MTCA.4 COTS Platform Progress

Infrastructure	Description	COTS Availability
Development Shelf non-redundant	6-payload shelf with PU, integral cooling fans	2 vendors
Station Node Shelf dual star redundant	12-payload slot shelf , hot-swappable fan tray(s)	3 vendors
Modular Power Supplies	12V Power Units (PUs) 300/600/900W	2-4 vendors
Hub Controller (MCH) – full featured for timing needed	MCH Controller w/ integral IPMI shelf manager, hot-swap, access to radial timing option	2 vendors Switches for radial timing lines need development
IO Controller Processor (IOC)	Generic AMC processor running Linux, EPICS	2+ vendors
Timing Module	1 or 2-wide AMC (SLAC needs EVR compatible, needs adaptation)	1st units available (U. Stockholm), need COTS sources (2)

MTCA.4 Timing AMC-µRTM 1&2-Wide

- Double-wide design concept in progress DESY-Stockholm University
- Both single & double-wide MTCA.4 compliant
- Double-wide allows rear expansion to multiple receivers
- ***Commercial sources need development***

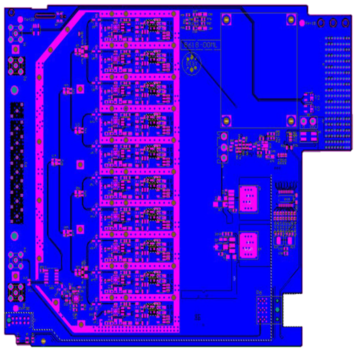
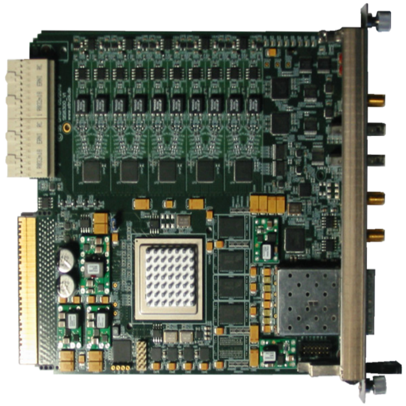


III. MTCA.4 Lab-Industry Applications Development

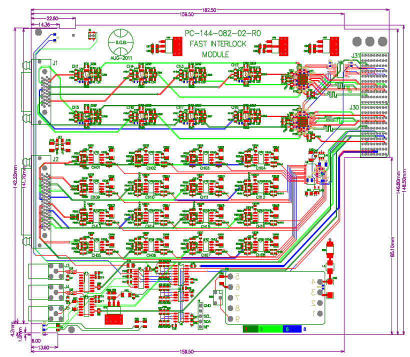
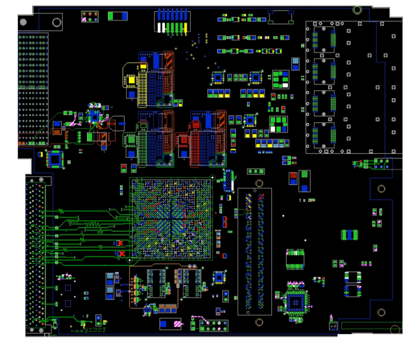
III. MTCA.4 New *Generic AMC* Concept

– COTS support crucial to rapid deployment, project acceptance
– G*eneric AMC* supports multiple *Application-Specific RTMs*
  • Relatively few complex processor designs each support multiple applications
  • Larger volume AMC COTS base
  • Lab-developed μRTM designs also important COTS products
– Adapters (IP, PMC etc) also important Generic AMC COTS products

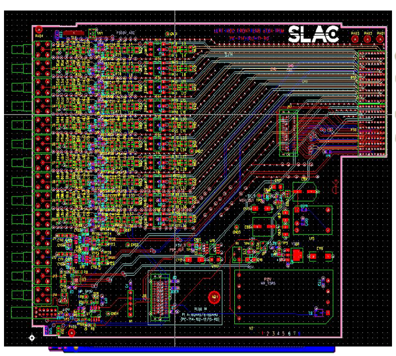
Generic AMC- Application Specific RTM

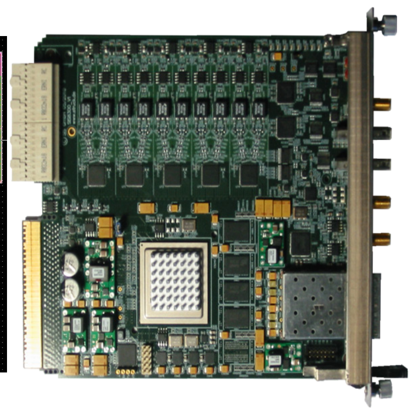



Down-converter RTM & ADC-DAC AMC

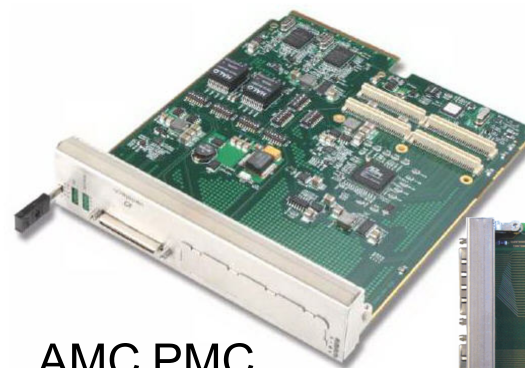



Fast-Slow Interlock ADC RTM & FPGA AMC

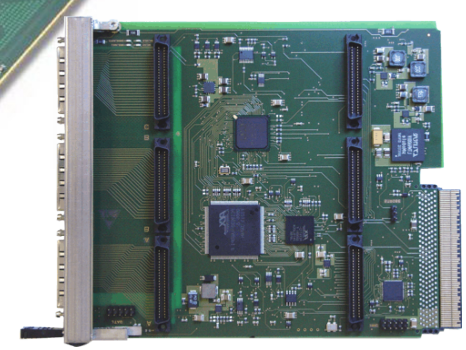




IF Feed through RTM & ADC-DAC AMC



AMC PMC Adapter



AMC 3-IP Adapter

Courtesy DESY, SLAC, Struck, TEWS, Vadatech

MTCA.4 COTS Generic AMC Progress

Generic AMC	COTS Availability	RTM Adapters
10/2 Ch ADC/DAC 16 bit 125 MSPS	1 vendor available 2nd vendor due end FY11	• RF-IF down-mixers • BPM adapter • Photodiodes
4 Ch ADC AMC 14-16 Bit 125 -500 MSPS	1-2 vendors in development	• BPM single bunch • BPM multi-bunch • Beam intensity Toroid • Beam Length
FPGA Virtex/Spartan, FMC optional	1 vendor in development	• Interlocks ADCs12 bits, 8 ch @60 MSps, 16ch@2KSps • Wire scanner interface
AMC Industry Pack Adapter (2-3 IPs)	2 vendors in development	• Stepping motor control • Vacuum control-monitoring • Temp control-monitoring
AMC PMC Adapters	2 vendors	• Timing Rx adapter • Frame grabber adapter

IV. New Standards Challenges

IV. New Standards Challenges

– Lab-Industry standards need to be ongoing
  - Although major opportunities come with new projects and growth, standards solutions must be developed *a priori* or adoption too risky
  - PICMG experience has shown development and deployment can be rapid with lab-industry cost sharing, collaboration on goals
  - Although started just 2 years ago, MCTA.4 can already claim basic COTS support both for *infrastructure* and *applications*

New Standards Challenges 2

- New Standards Risk Factors
  - All new standards pose risk until proven to have staying power over long usage
  - Past physics standards developed from scratch were very risky but 2/3 have lasted 4 decades
  - MicroTCA initial acceptance good but mainly in non-telecom usage (military, industrial control)
  - Initial acceptance, critical support by industry very encouraging
  - MTCA.4 opening new opportunities for MTCA in telecom – new high power shelf w/ 40 Gbps backplane recently announced – also encouraging

Summary Conclusion

– Choices are no standards efforts (let each lab decide on its own) or ongoing lab-industry effort
  - Proof test for xTCA in developmental applications at several labs for several new systems (LLRF, controls)
  - Success depends on lab commitments to invest, promote leading edge technology solutions *for good long-range economic reasons*
  - PICMG collaboration is unique, powerful due to close connections with enabling technology industry partners
  - *Labs face great opportunity to bring lower cost high availability intelligent platforms into common use*

V. Acknowledgments

- The PICMG xTCA for Physics collaboration was sponsored by DESY, IHEP, FNAL, SLAC and now has additional lab members CERN, IPFN Lisbon, ITER, KEK, LBNL and Sincrotrone Trieste. Cypress Point Research and TripleRing Technologies were industry sponsors.
- Enormous credit is due to key contributors from both labs and industry, including Schroff, ELMA, Positronix, TE Systems, Pentair-Schroff, Perfromance Technologies and many others totaling over 40 industry members
- Special thanks to Robert W. Downing who headed the Hardware group developing the two new standards and with Dick Somes former Technical Officer of PICMG constructed and edited both documents with assistance from many members.
- Special thanks to Joe Pavlat, PICMG President for unwavering support and encouragement.