xTCA for Instrumentation

Tomasz Jezynski

Deutsches Elektronen-Synchrotron

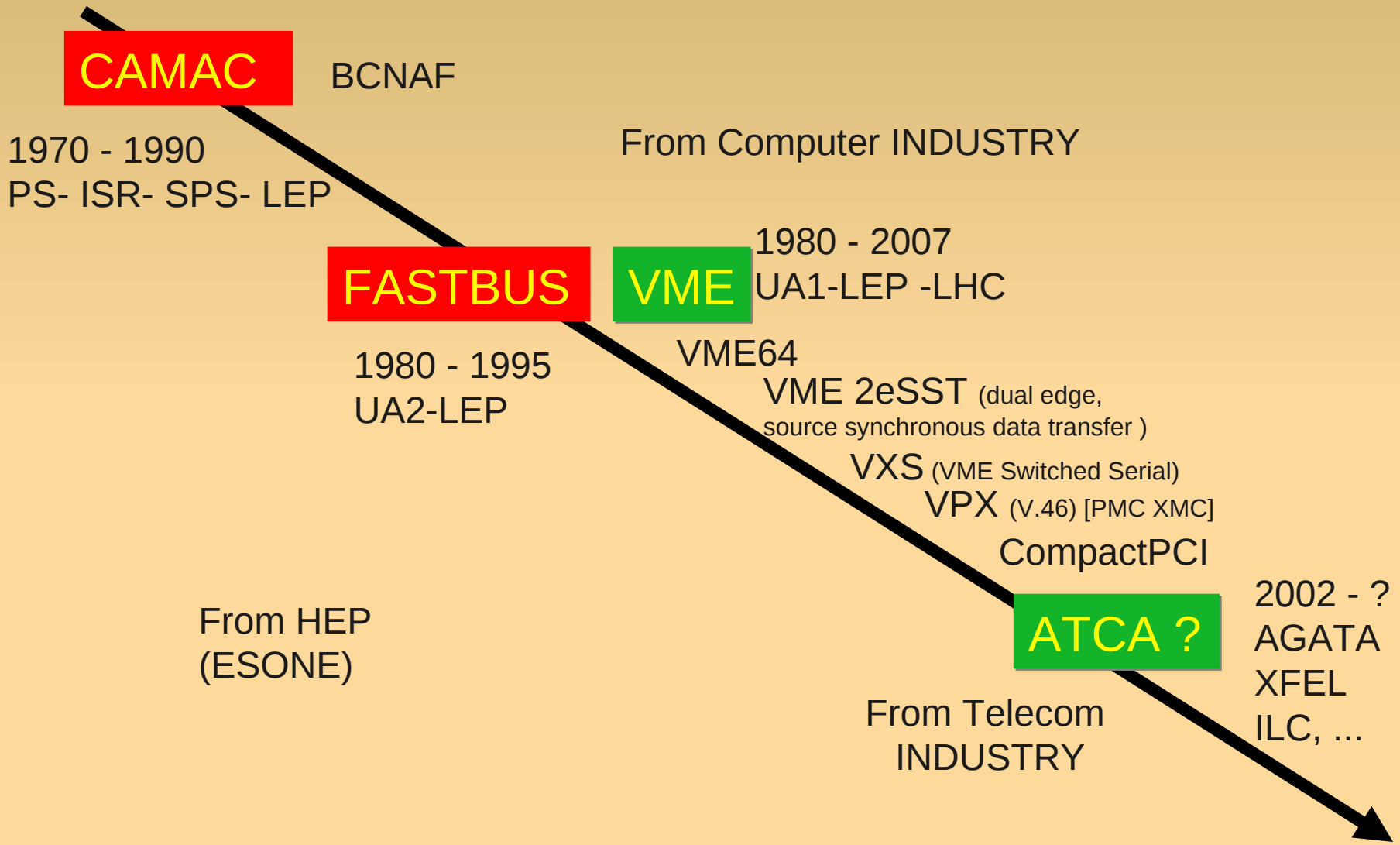
What do we want?
(DAQ, Beam Instr., Accelerators, Trigger)

- Modularity
- Scalability
- Robust

Some additional requirements:

- Serviceability (avoid front panel connection)
- easy upgrade path, flexibility
- Available in the next 20 years *(multi-vendor)*
- Low latency *(fast communication links)*
- Support modern control algorithms
- Limited number of different boards
- Low-cost version available *(monitoring)*
- Reliability, operability and maintainability ...

Evolution of Standards



xTCA

microTCA

MTCA.0 - Micro Telecommunication Computing Architecture (backplane, connectors, power, management, size, cooling, ...)

AdvancedTCA

PICMG 3.0 is the base specification (backplane, connectors, power, management, size, cooling, ...)

- PICMG 3.1 (Ethernet),
- PICMG3.2 (InfiniBand)
- PICMG 3.3 (StarFabric),
- PICMG 3.4 (PCI Express),
- PICMG 3.5 (RapidIO)

PICMG - PCI Industrial Computer Manufacturers Group

xTCA

microTCA

MTCA.0 - MicroTelecommunication Computing Architecture (backplane, connectors, power, management, size, cooling, ...)

AMC

AMC.0 - Advanced Mezzanine Card Base Specification (connector, power, size, cooling)
* AMC.1 PCIx
* AMC.2 Gigabit Ethernet and XAUI
* AMC.3 Storage (ratified)
* AMC.4 Serial RapidIO

AdvancedTCA

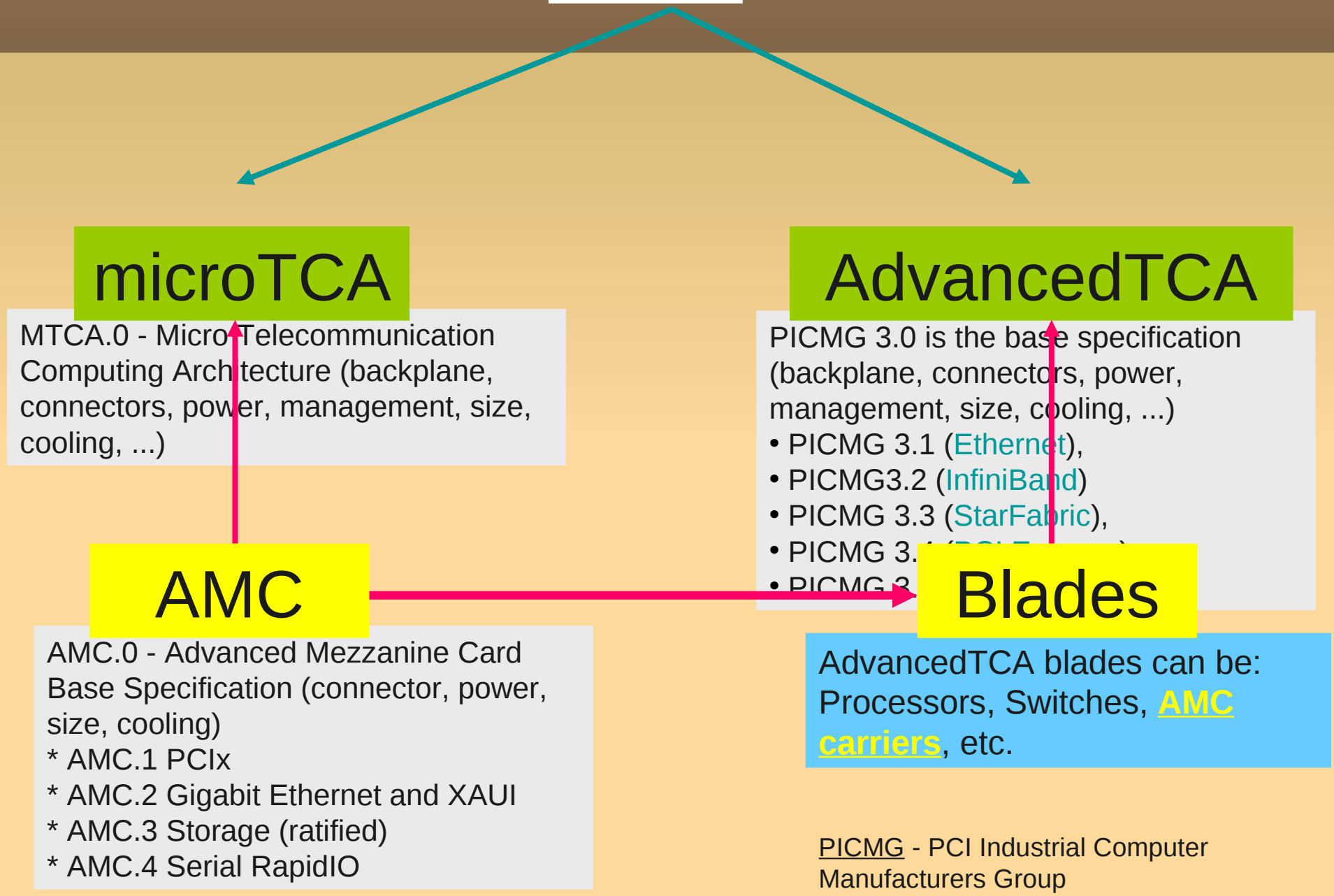
PICMG 3.0 is the base specification (backplane, connectors, power, management, size, cooling, ...)
- PICMG 3.1 (Ethernet),
- PICMG3.2 (InfiniBand)
- PICMG 3.3 (StarFabric),
- PICMG 3.
- PICMG 3.

Blades

AdvancedTCA blades can be: Processors, Switches, AMC carriers, etc.

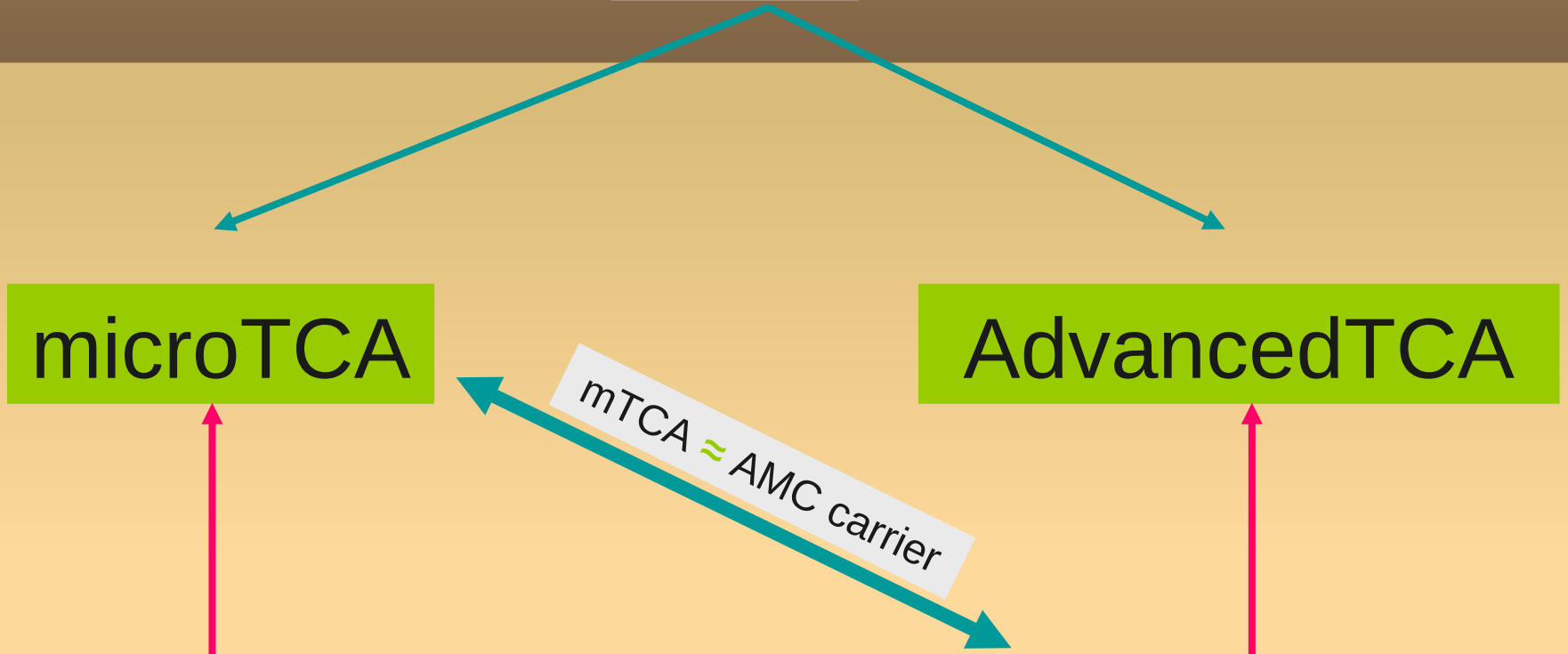
PICMG - PCI Industrial Computer Manufacturers Group

xTCA



PICMG - PCI Industrial Computer Manufacturers Group

xTCA



AMC

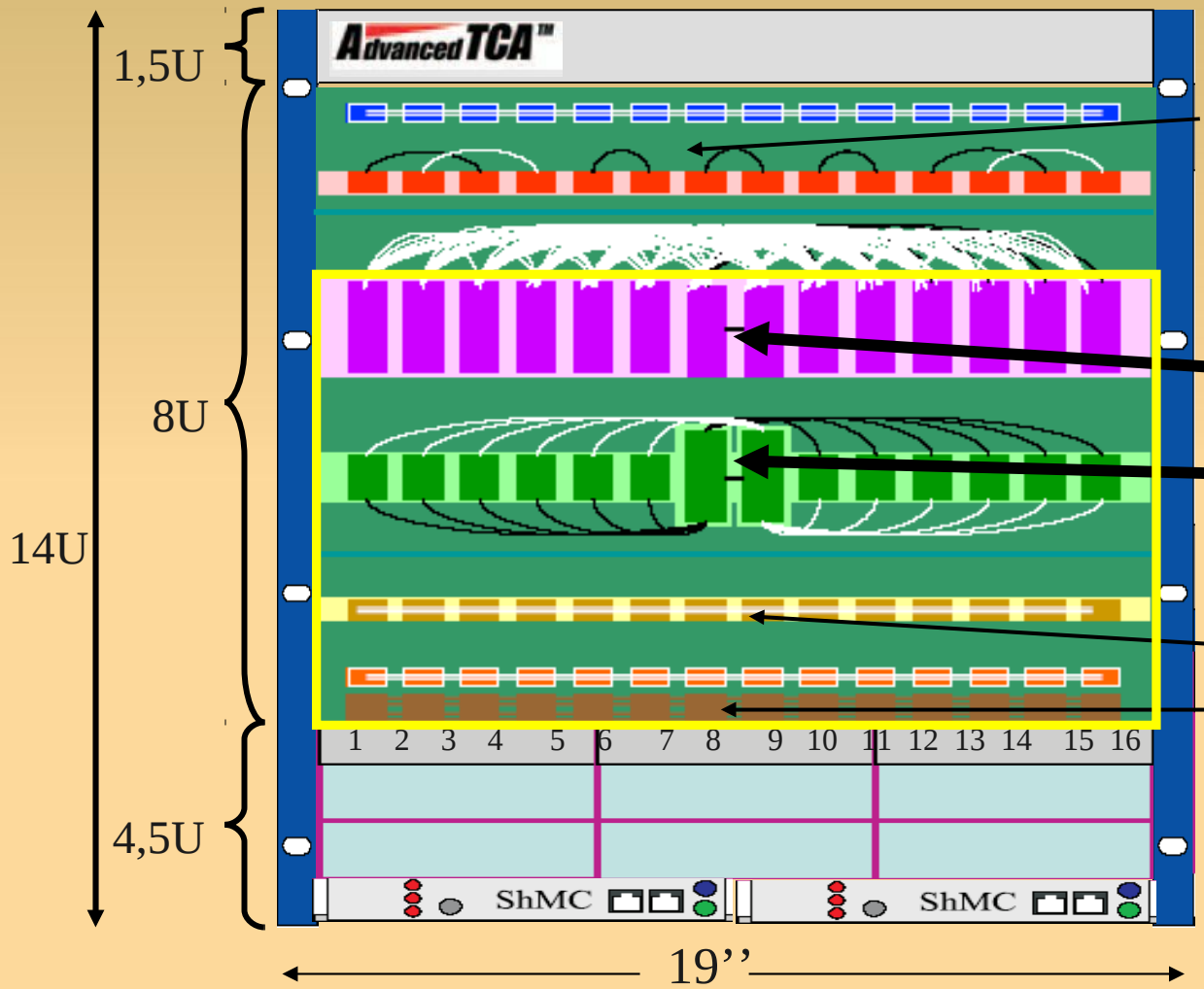
AMC.0 - Advanced Mezzanine Card Base Specification (connector, power, size, cooling)
* AMC.1 PCIx
* AMC.2 Gigabit Ethernet and XAUI
* AMC.3 Storage (ratified)
* AMC.4 Serial RapidIO

Blades

AdvancedTCA blades can be: Processors, Switches, **AMC carriers**, etc.

PICMG - PCI Industrial Computer Manufacturers Group

ATCA crate



ZONE3 – user define

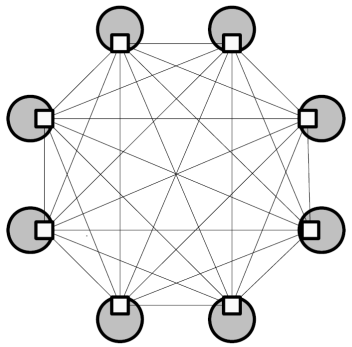
ZONE2 data transport:
Fabric Interface – GbE, PCIEx, ...

Base Interface - GbE

ZONE1: power distribution
and slow control (I2C)

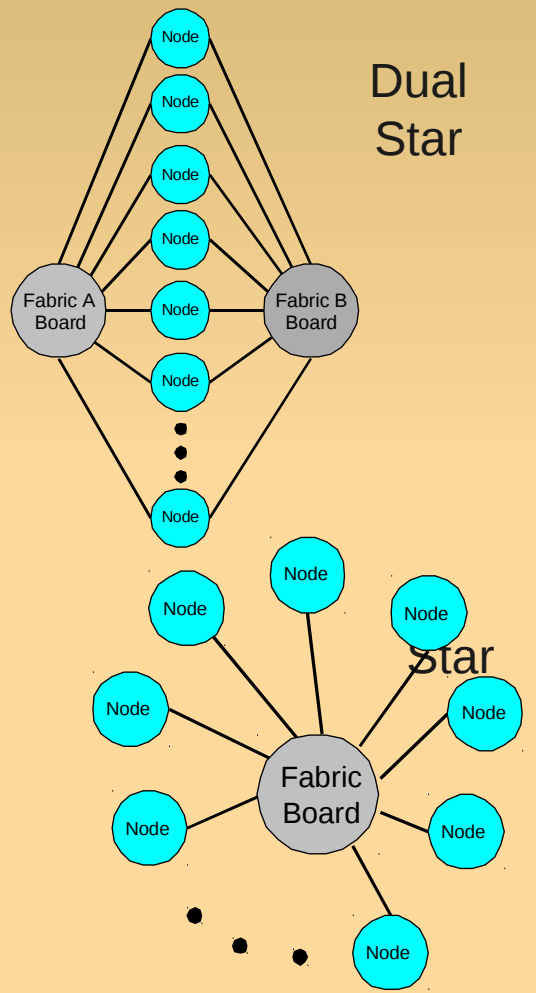
ATCA crate – backplanes

	Logical Slot #	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Connect or	Channel #																
P20	15	16-1	16-2	16-3	16-4	16-5	16-6	16-7	16-8	16-9	16-10	16-11	16-12	16-13	16-14	16-15	15-15
P20	14	15-1	15-2	15-3	15-4	15-5	15-6	15-7	15-8	15-9	15-10	15-11	15-12	15-13	15-14	14-14	14-15
P20	13	14-1	14-2	14-3	14-4	14-5	14-6	14-7	14-8	14-9	14-10	14-11	14-12	14-13	13-13	13-14	13-15
P21	12	13-1	13-2	13-3	13-4	13-5	13-6	13-7	13-8	13-9	13-10	13-11	13-12	12-12	12-13	12-14	12-15
P21	11	12-1	12-2	12-3	12-4	12-5	12-6	12-7	12-8	12-9	12-10	12-11	11-11	11-12	11-13	11-14	11-15
P21	10	11-1	11-2	11-3	11-4	11-5	11-6	11-7	11-8	11-9	11-10	10-10	10-11	10-12	10-13	10-14	10-15
P21	9	10-1	10-2	10-3	10-4	10-5	10-6	10-7	10-8	10-9	9-9	9-10	9-11	9-12	9-13	9-14	9-15
P21	8	9-1	9-2	9-3	9-4	9-5	9-6	9-7	9-8	8-8	8-9	8-10	8-11	8-12	8-13	8-14	8-15
P22	7	8-1	8-2	8-3	8-4	8-5	8-6	8-7	7-7	7-8	7-9	7-10	7-11	7-12	7-13	7-14	7-15
P22	6	7-1	7-2	7-3	7-4	7-5	7-6	6-6	6-7	6-8	6-9	6-10	6-11	6-12	6-13	6-14	6-15
P22	5	6-1	6-2	6-3	6-4	6-5	5-5	5-6	5-7	5-8	5-9	5-10	5-11	5-12	5-13	5-14	5-15
P22	4	5-1	5-2	5-3	5-4	4-4	4-5	4-6	4-7	4-8	4-9	4-10	4-11	4-12	4-13	4-14	4-15
P22	3	4-1	4-2	4-3	3-3	3-4	3-5	3-6	3-7	3-8	3-9	3-10	3-11	3-12	3-13	3-14	3-15
P23	2	3-1	3-2	2-2	2-3	2-4	2-5	2-6	2-7	2-8	2-9	2-10	2-11	2-12	2-13	2-14	2-15
P23	1	2-1	1-1	1-2	1-3	1-4	1-5	1-6	1-7	1-8	1-9	1-10	1-11	1-12	1-13	1-14	1-15



Full mesh

8 pairs between each slot +
EthFabric & Base Interface



Why ATCA ?

Advantages

- scalable shelf capacity up to 2.5Tb/s
- **reliability of up to 99.999%**
- **redundant** power supply
- 48V@200 W/slot with adequate cooling (**redundant**)
- High speed point-to-point serial connectivity via Full Mesh Backplane
- fits our needs very well (modular, scalable, robust).
- Flexible configuration of processing topology according to algorithm within shelf
- **Shelf management** for remote configuration and monitoring

Why ATCA ?

- Disadvantages
  - Not much user experience compared to VME
  - Limited availability of commercial modules (CPUs etc.)
  - Vendor statement : We only do business with large telecommunication companies, not with Universities!

Why xTCA is attractive ?

ATCA/mTCA platforms are attractive because of:

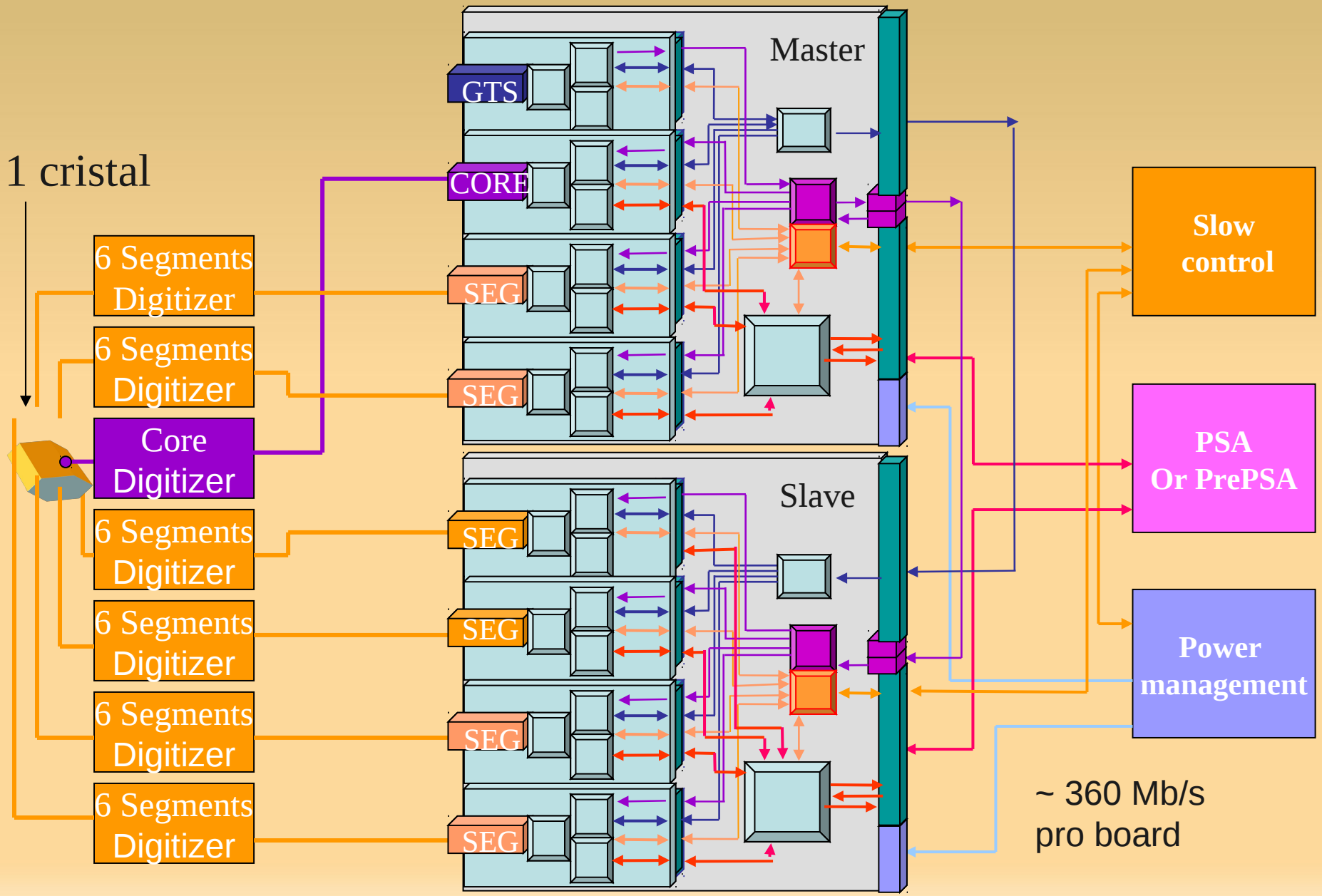
- the modern serial link architecture,
- high availability features and many packaging options.

- Less-demanding availability applications can be met economically by scaling back speed and redundancy.

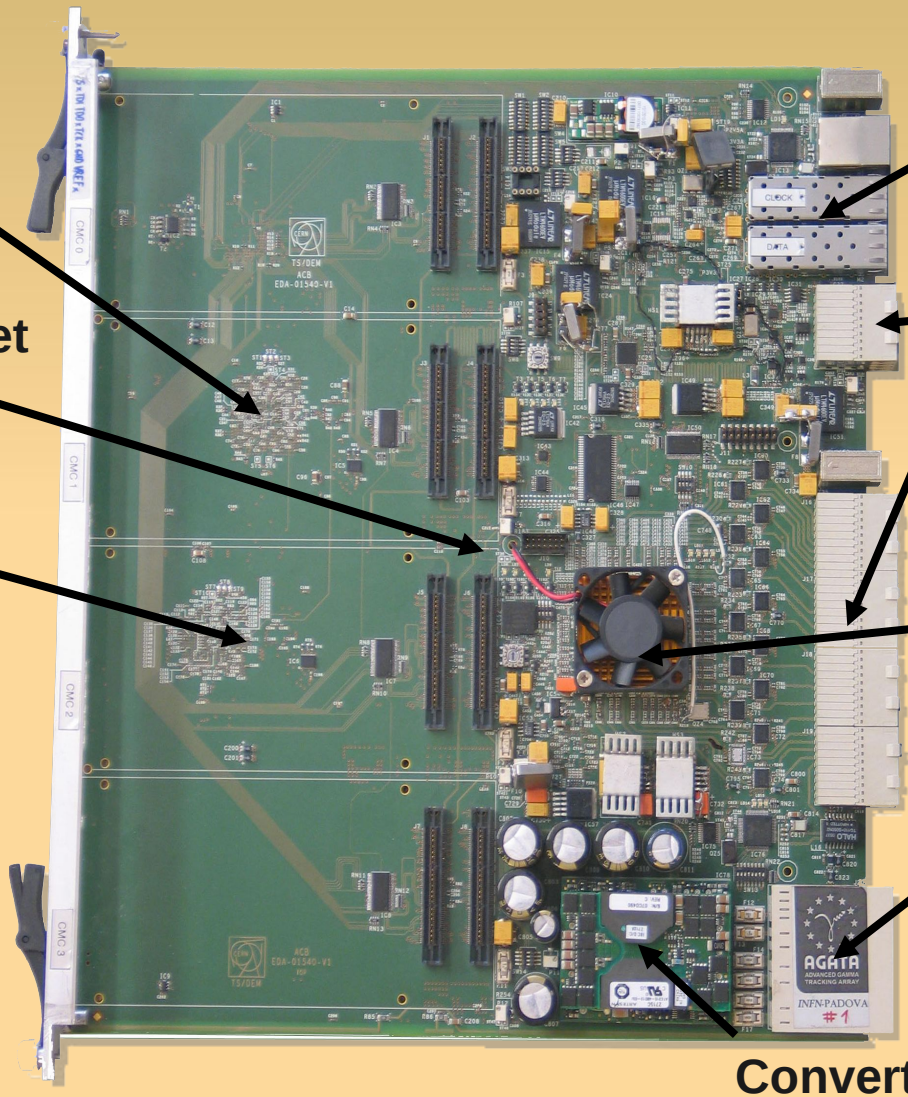
- The ATCA specification was originally targeted at the Telecom industry but has gained a much wider user audience.

AGATA - Structure of the system

"Advanced GAmma Tracking Array"



AGATA – ATCA carrier board



FPGA V4LX25
Trigger

Switch Ethernet

FPGA V4LX25
Switch JTAG
et setup

Sorties optiques
Ethernet

Connections TCLK

Connections
Ethernet et 10Gb/s

FPGA V4FX60
Slow control
Acquisition

Alimentation 48V
et I2C

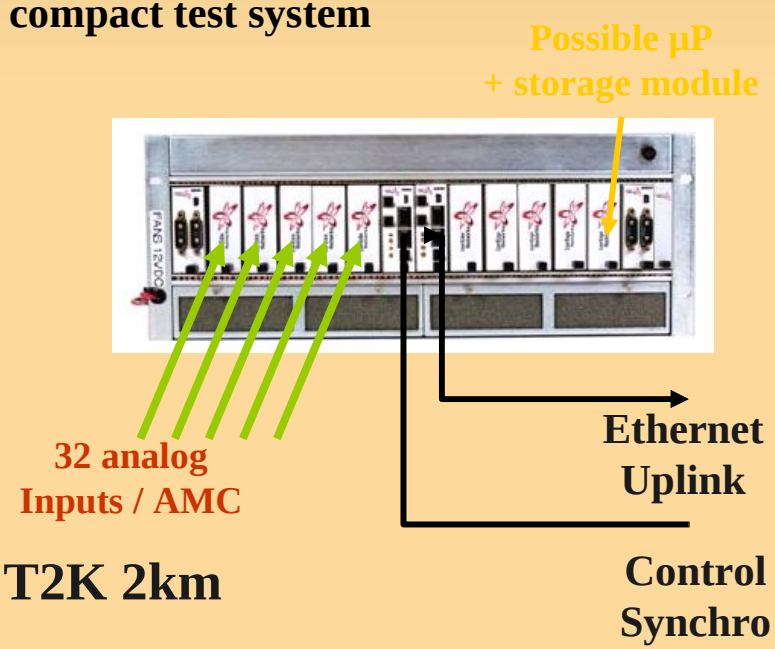
Convertisseur DCDC 48/12V

T2K - DAQ overview

(Tokai to Kamioka)

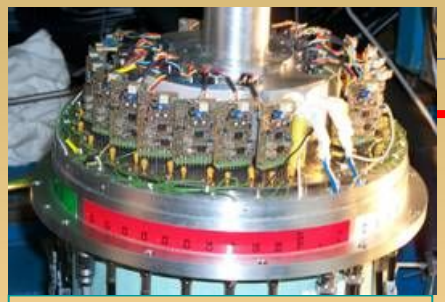
- **First prototype with a dual star 9 AMC slots µTCA shelf + 2 MCH + 1 PwM**
  - **Data acquisition module (AMC) are controlled and read through Gbe Ethernet**
  - **µTCA offers direct Gbe connection to each AMC through the backplane**
  - **MCH (Ethernet switch) use for external interface (data uplink to event building)**
  - **Synchronization could also be made on Ethernet using IEEE 1588 (specific MCH design needed)**
  - **Dual star topology could be used to separate control/synchronization from data readout**
  - **A local AMC processor board can be added to build a compact test system**

- **Full height single width AMC design :**
  - **32 ADC channels inputs on AMC front side**
  - **Gigabit Ethernet output through the backplane**
  - **Cost optimization goal**



This will result in 34 µTCA racks (9 slots) for T2K 2km

EXOGAM2 The EXOGAM2 technical proposal
(GAMMA spectrometer)

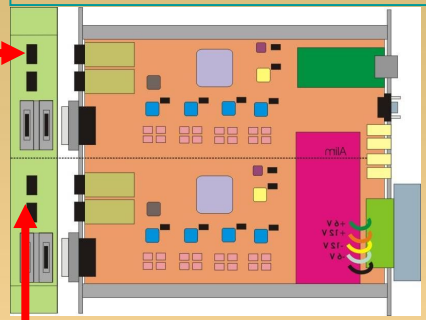


16 clovers = 64 crystals

Differential Preamplifiers

7 differential analog signals per crystal
ICR < 100kHz per crystal

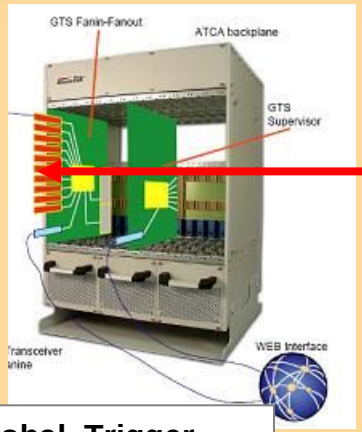
2 crystals / 1 NIM board => 32 NIM boards



Fast Analog to Digital Conversion

1 GTS supervisor and 16 GTS mezzanines

8 links per ATCA carrier
(1.4 Gb/s per ADC channel)

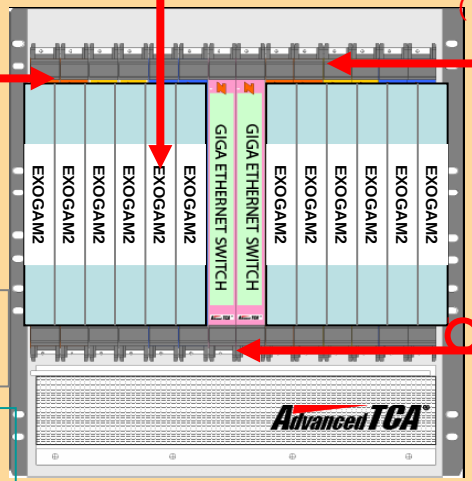


Global Trigger and Synchronization

1 link per ATCA carrier

1 link per ATCA carrier
(2 Gb/s)

KALMAN processing



Digital Processing

1 clover / 1 ATCA carrier
=> 16 carriers

DAQ

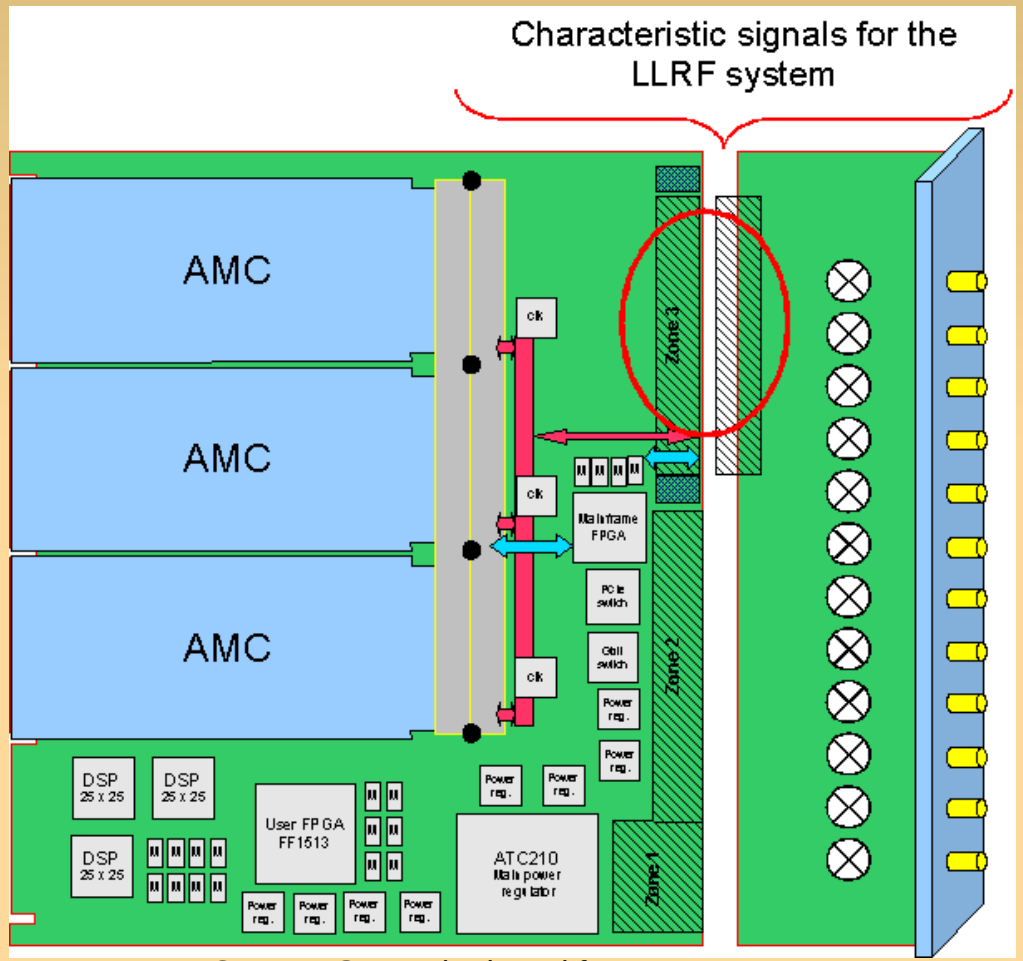
1 link per hub
(3 MB/s per crystal)

DESY - ATCA – AMC carrier blade and RTM

Size:
322 mm x 288 mm

Power dissipation:
Up to 200W

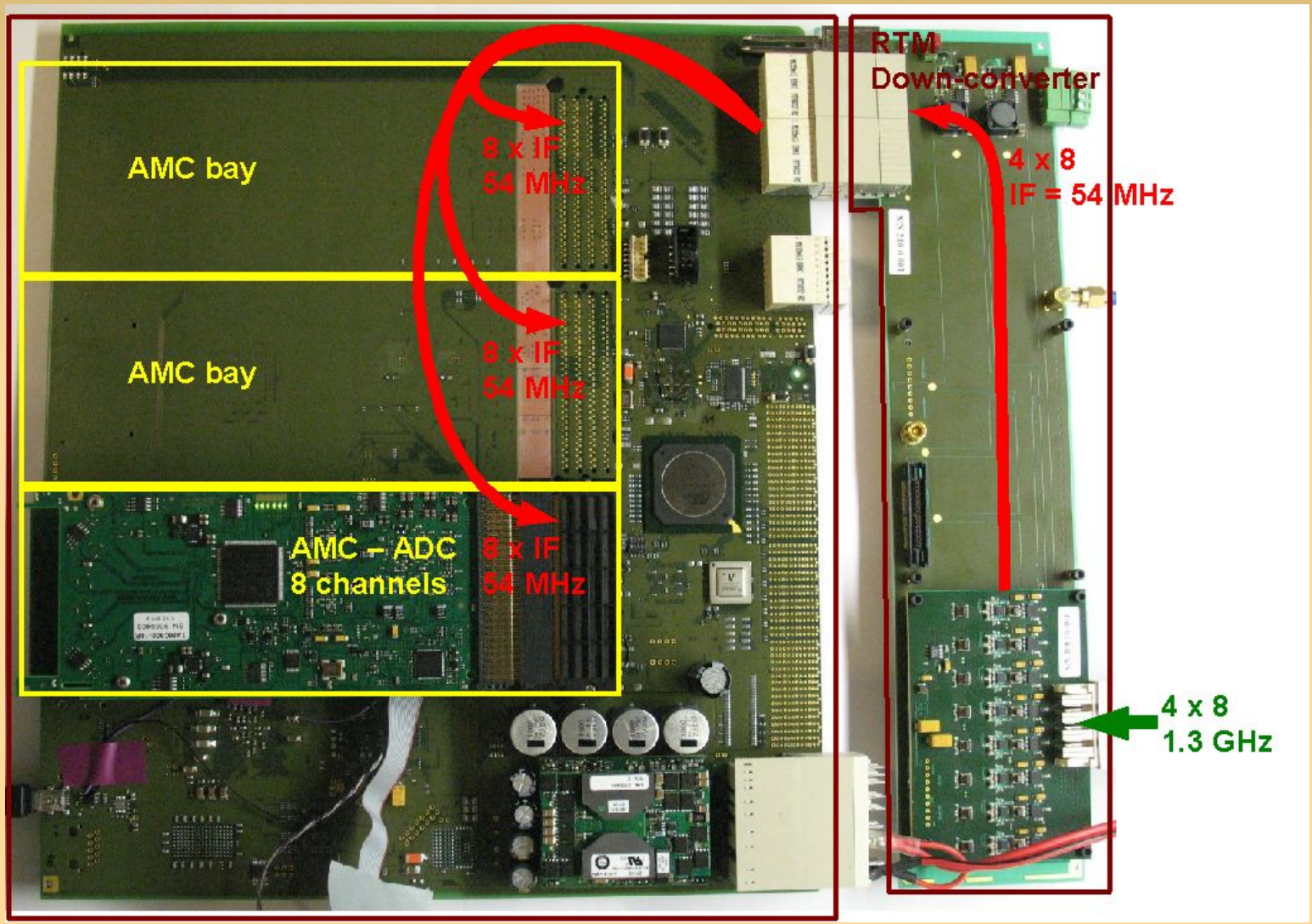
Single (redundant)
Power input – 48V



ATCA – DESY carrier board for LLRF system

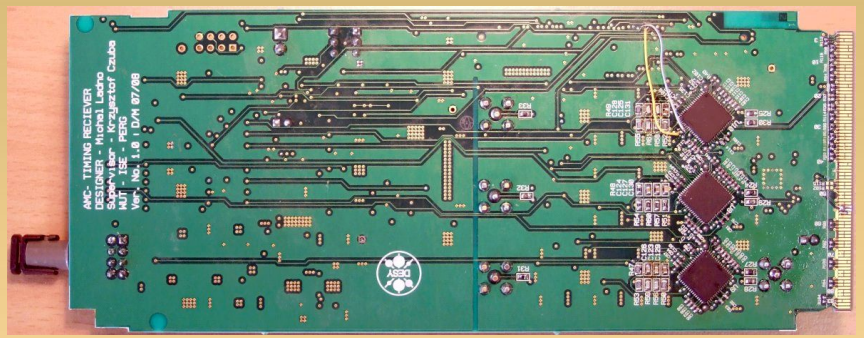
RTM – Rear Transition Module

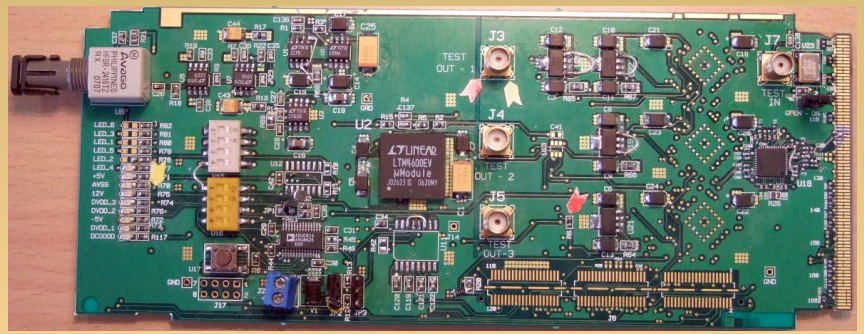
XFEL – carrier board (DESY)

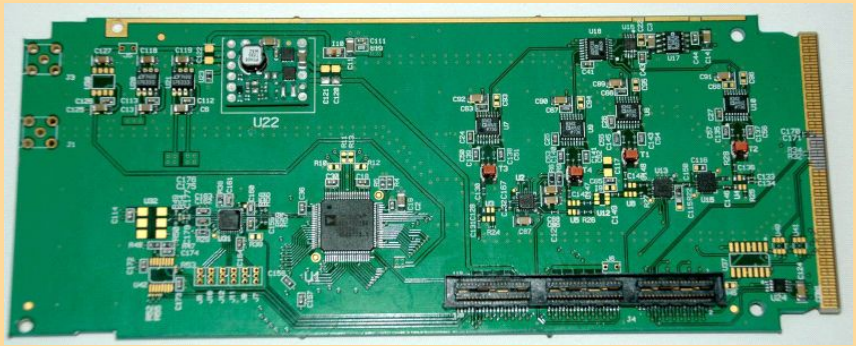


- 8 ch. ADC-AMC
- AMC - Vector Modulator
- AMC - Timing Module
- 8 ch. AMC-DAC
- Down-converter

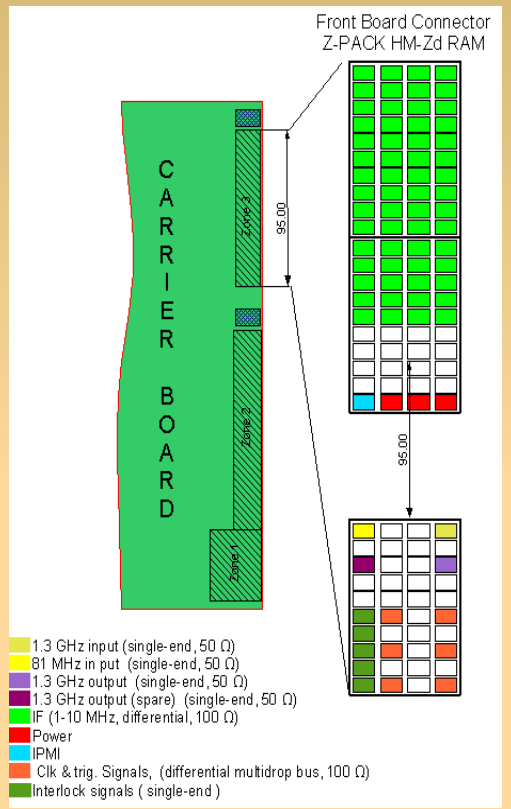
XFEL – AMC modules (DESY)

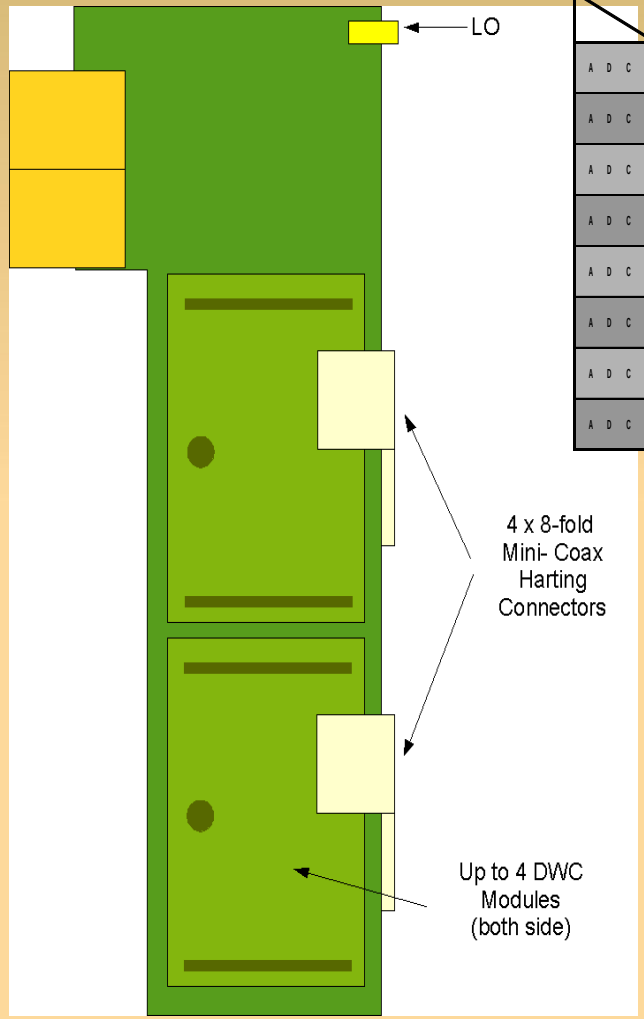




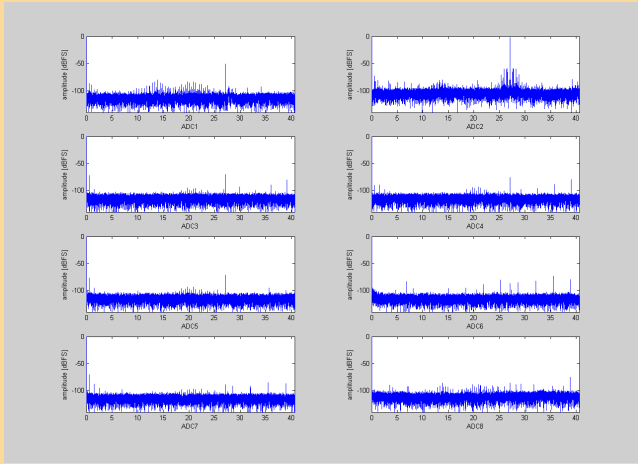


XFEL – RTM (DESY)

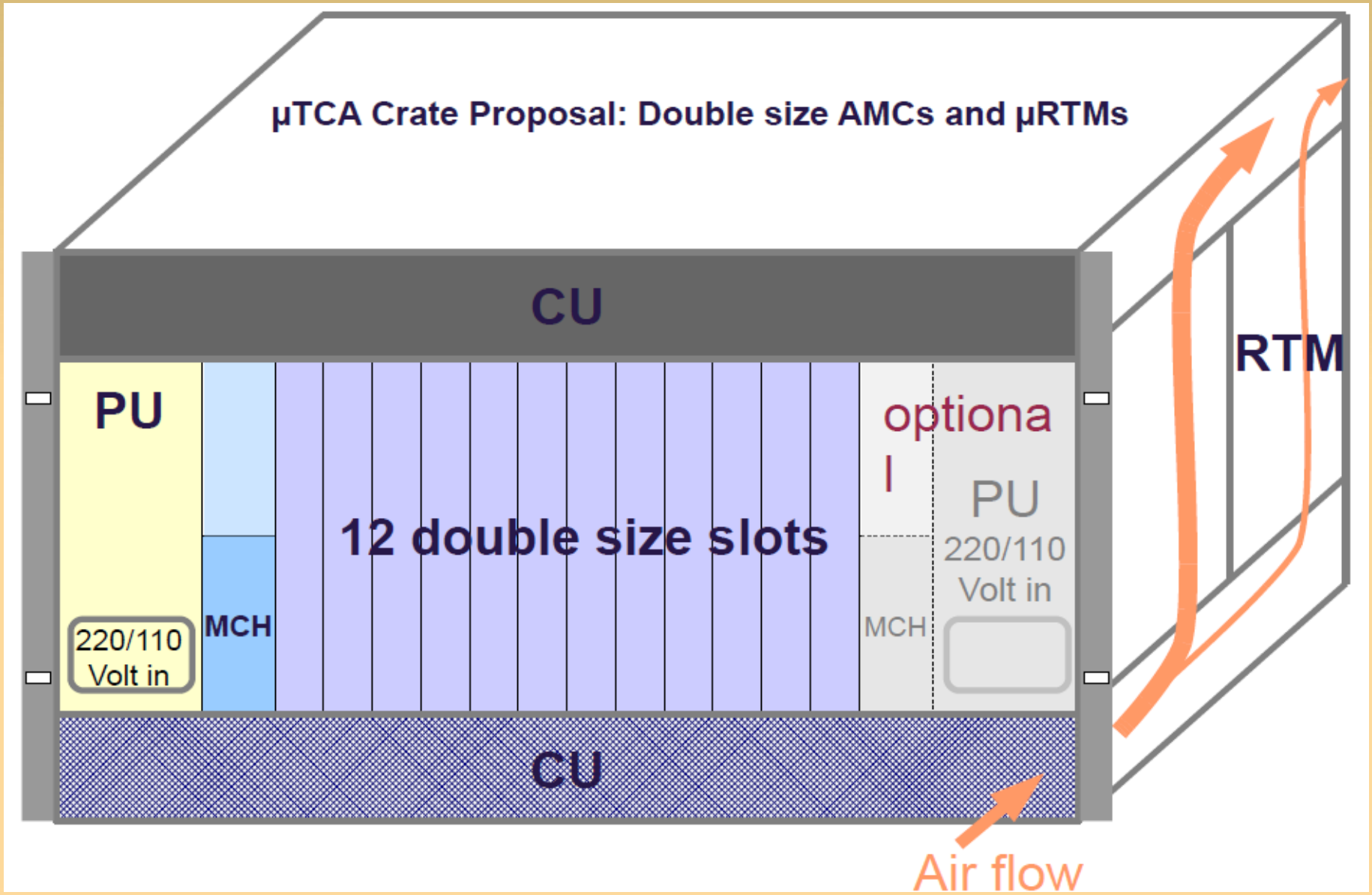




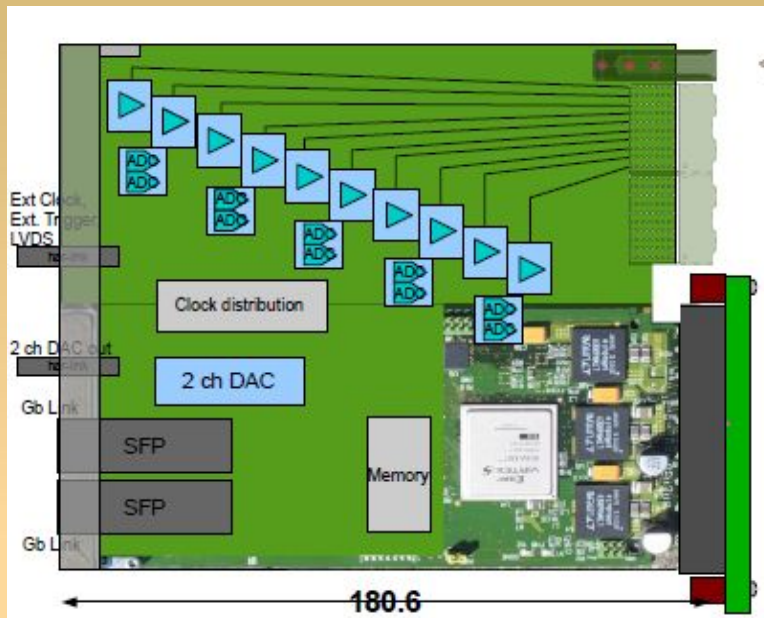
	ADC 1	ADC 2	ADC 3	ADC 4	ADC 5	ADC 6	ADC 7	ADC 8
ADC 1	o-67.8	7-48.1	4-66.8	6-66.3	9-73.7	1-69.9	0-67.1	1-71.3
ADC 2	o-48.3	5-67.7	9-68.1	4-74.0	8-69.3	5-71.0	0-67.8	6-72.6
ADC 3	o-69.5	1-66.4	7-68.0	9-52.4	3-66.0	8-70.3	9-66.9	8-72.6
ADC 4	o-65.5	2-69.5	5-49.0	3-68.0	3-68.8	2-69.8	1-66.6	9-70.7
ADC 5	o-m3.2	7-73.2	7-67.8	1-69.8	2-66.4	4-44.3	5-63.3	0-69.7
ADC 6	o-n2.92	-0.45	0.56	-3.24	17.30	-8.12	4.08	8.28
ADC 7	o-m6.2	2-70.1	8-69.3	9-77.3	1-65.3	4-70.2	7-68.4	7-45.7
ADC 8	o-m0.0	0-63.6	2-62.1	5-69.6	5-67.4	8-62.7	9-52.1	5-64.5

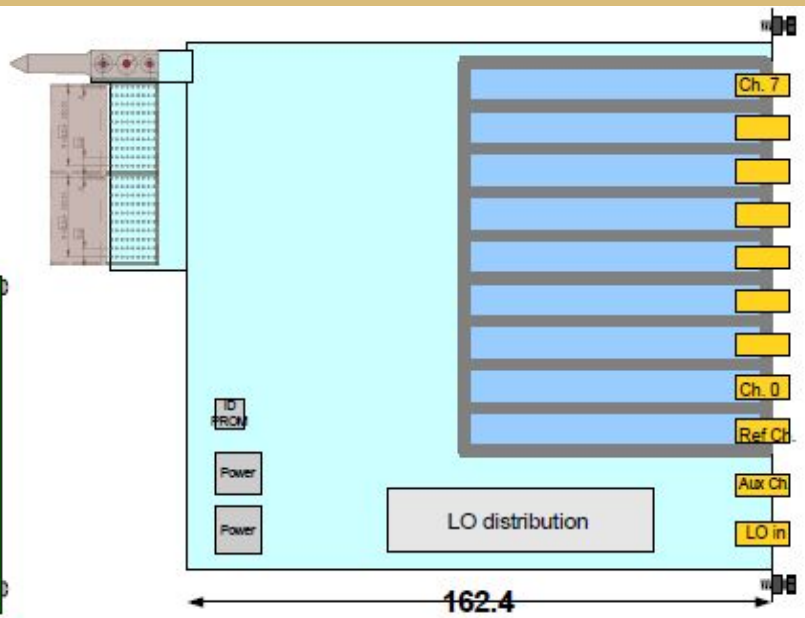


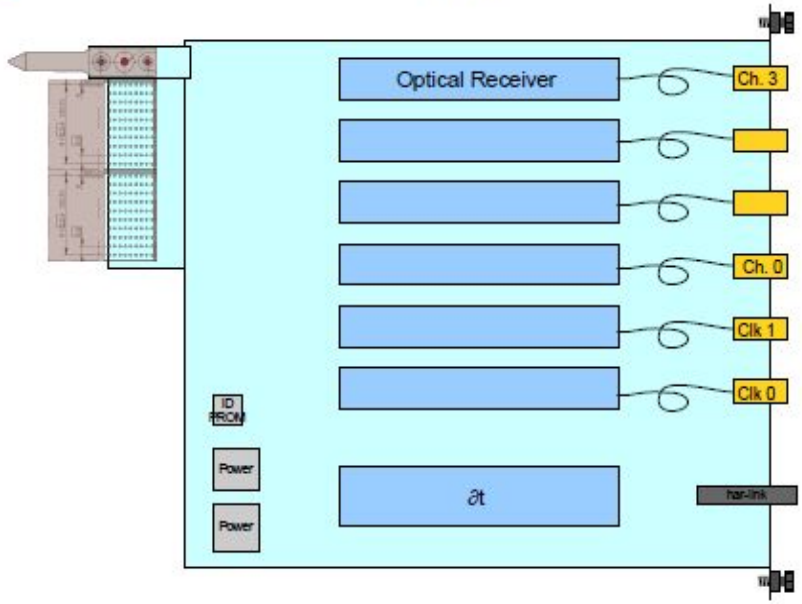
Data: L.Butkowski


µTCA Crate Proposal: Double size AMCs and µRTMs
CU
PU
220/110
Volt in
MCH
12 double size slots
optiona
l
MCH
PU
220/110
Volt in
CU
RTM
Air flow

DESY – AMC modules







- SIS8300
  - 10 ch ADC
  - 16 bit
  - 125MSPS
- RTMs
  - EBPM, BAM
  - RF monitors

Ready Spring 2010

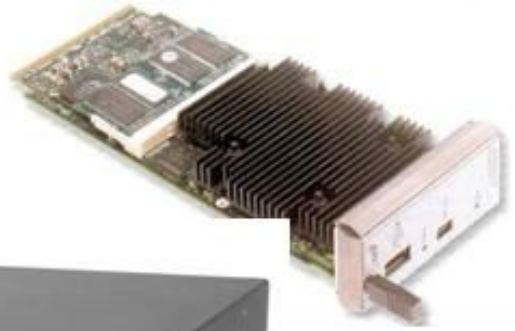
xTCA Components for Evaluation (SLAC)

5-Slot Shelf w/Dual Processors & Hub Switcher

14-Slot Shelf

SLAC DAQ 2Gb/s/Ch

AMC 105 MS/s 8 Ch 14 bit ADC



AMC Module

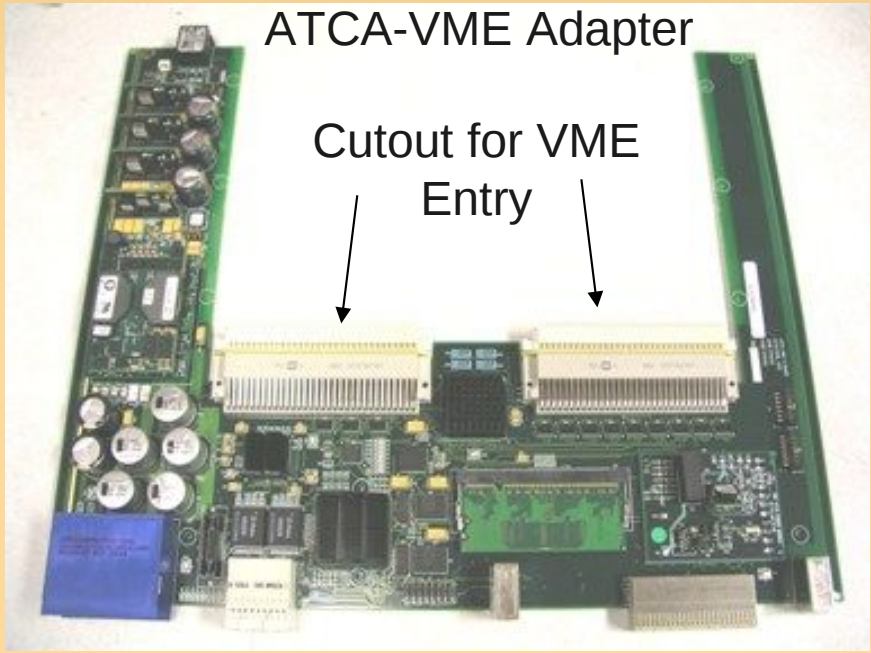
µTCA 6 Slot 1U Shelf, Imbedded Shelf Mgr (SM) & MCH, Non-Redundant PS & SM

SLAC NATIONAL ACCELERATOR LABORATORY

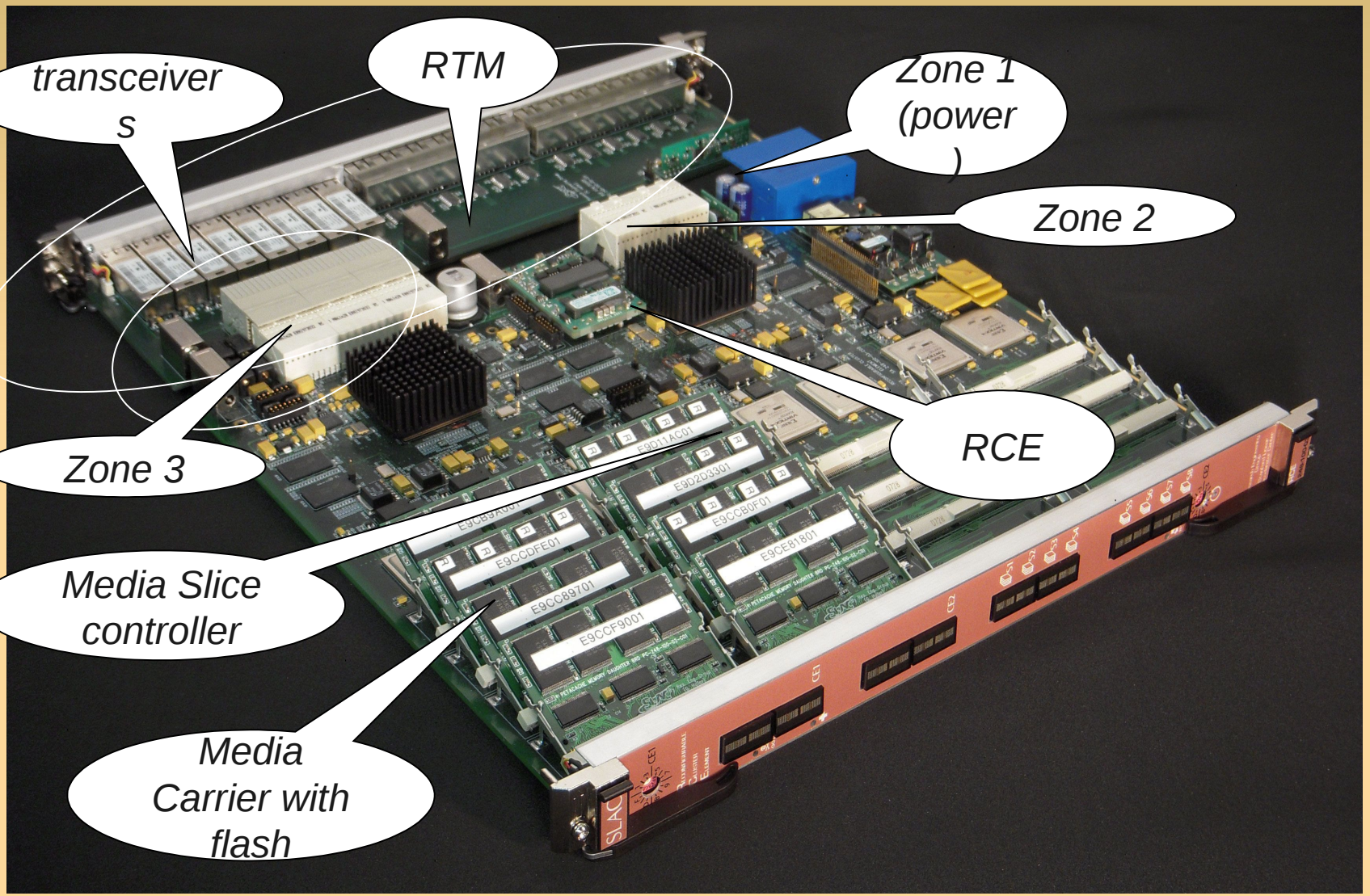
R&D Interlocks & Controls (SLAC)

- Fast Fault Finder (F3)
  - Serves both fast, slow interlocks via FPGA imbedded code, filtering
  - Slow signals via Rear Transition Module (RTM), fast via FP coax
  - All channels digitized to 16 bits at 20 MHz (fast), 10 KHz (slow), DC coupled

VME F3 w/ Rear Transition Module



RCE board + RTM (SLCA)



HA Instrument Platform Standardization Initiative

- xTCA for Physics Coordinating Committee Under PICMG
  - Growing number of labs using xTCA products need:
    - Analog & Digital IO for AMC, ATCA, MicroTCA
    - HA software design for full xTCA management, redundancy features
    - Fast timing and synchronization
    - Rear Transition Module scheme for AMC/MicroTCA
  - Two ATCA workshops held 2007 & 2008 led to proposal to form standards committee under PICMG
    - Workshops planned for RT2009 (Beijing, May 09), Fusion Meeting (Aix-en-Provence, June 2009), NSS-MIC 2009 (Orlando, October 09)
  - PICMG Technical Subcommittee proposal approved ~2/15/09
    - Call for Participation concluded with 41 companies, 4 labs, 60 individuals signed up
    - Other lab participation from diverse fields expected later

Progress and Issues

- CCTS Draft Statement approved *(Coordinating Committee Technical Subcommittees)*
  - Formal statement to be approved by full committee on 3/10/09
- WGTS SOW statements to be developed *(Working GroupsTechnical Subcommittees)*
- Major issues for early WGTS
  - COTS hardware, firmware, software solutions for physics to save development, maximize interoperability
  - I/O signals into AMC modules, carriers, MicroTCA
  - Rear Transition Modules for ATCA, MicroTCA
  - Standard lines for timing, synchronization, triggering, calibration
  - Down-select communication protocols
  - Software interfaces for existing lab Controls standards
  - Avoiding special solutions for physics that fragment market and lose advantages of broad industry support

xTCA for Physics CC Membership

Corporate Members	Corporation/Institution	Committee Members
1	Adlink	1
2	Advanet	1
3	Alcatel-Lucent	1
4	Arroyo Technology Consultants	1
5	Astek	1
6	BittWare	1
7	Carlo Gavazzi	1
8	Communication Automation	1
9	Cypress Point Research	1
10	DESY	5
11	Diversified Technology	1
12	Elma	3
13	Elma/Bustronic	1
14	Emerson	1
15	FNAL	2
16	Foxconn	1
17	Gage	1
18	GE Fanuc	1
19	Huawei	1
20	Hybricon	1
21	IHEP	2
22	Intel	2
23	Jblade	1
24	Kontron	3
25	Linear Tecxhnology Corp	2
26	Lecroy	1
27	N.A.T.	1
28	National Instruments	1
29	PCI Systems	1
30	Pentair/Schroff	2
31	Performance Technologies	3
32	PICMG Japan	1
33	Pigeon Point Systems	1
34	Pinnacle Data Systems	2
35	RadiSys	2
36	Rittal/Kaparel	2
37	SAIC	1
38	Scan Engineering Telecom	1
39	SLAC National Accelerator Lab	2
40	Triple Ring Technologies	1
41	Yamaichi	1
41	**Totals**	60

Rev. 021209

xTCA™

PICMG® PhysRTM.0
Revision 1.0 Draft 0.1b

AdvancedTCA Rear Transition Module for Physics

August 10, 2009

PICMG®

Open Modular
Computing Specifications