

Development of MTCA/xTCA/ATCA based instrumentation for particle physics at IHEP



TIPP2014

Amsterdam, Netherland, June 2-7 2014

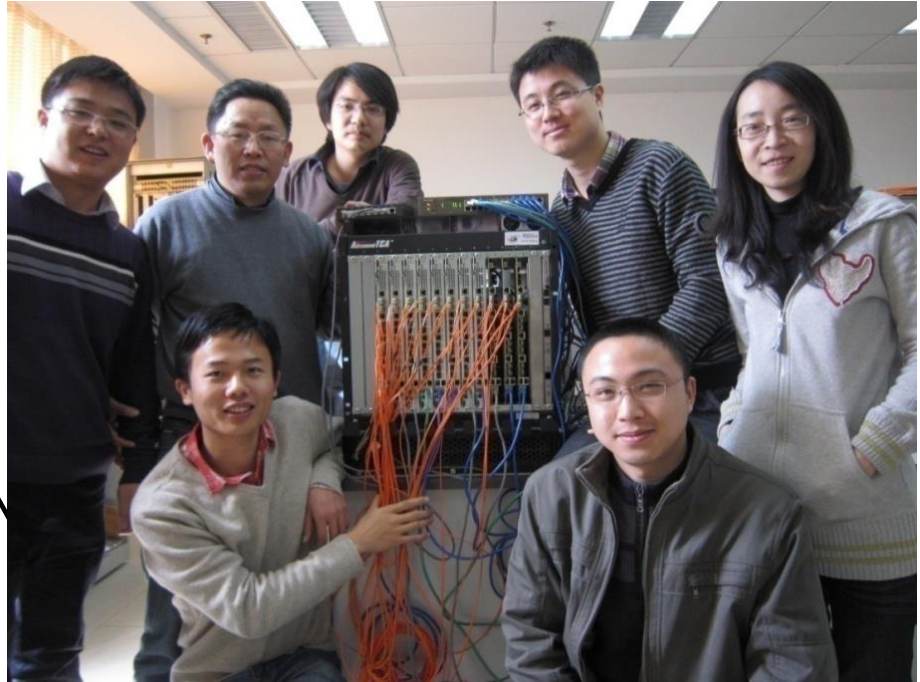
Zhen-AN LIU

TrigLab/IHEP Beijing

Member & Officer PICMG/xTCA for Physics Committee

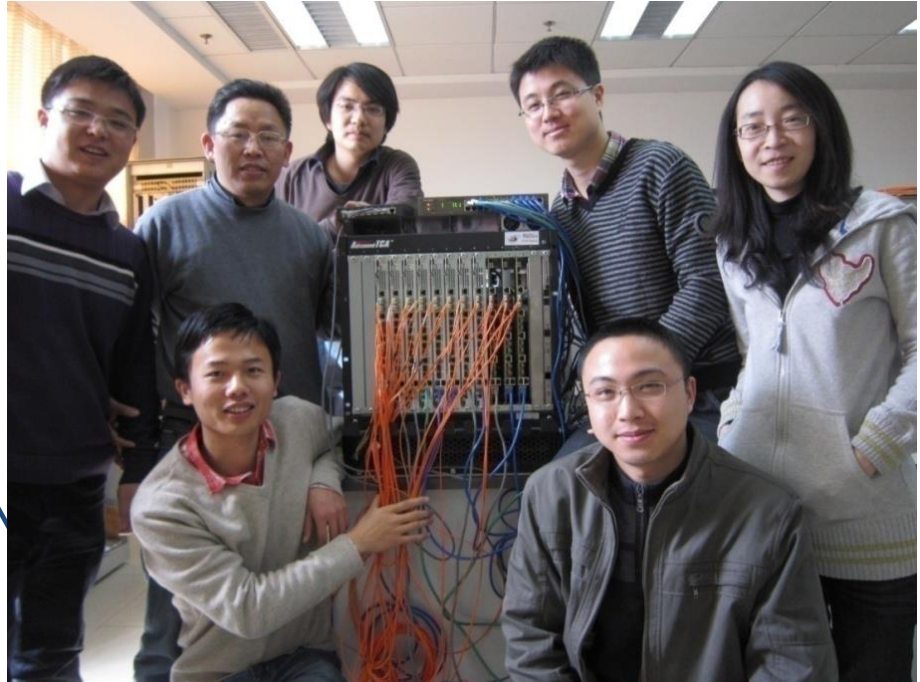
Outline

- Overview of xTCA for Physics
- Activities in IHEP/TrigLab
 - ATCA complaint
 - MicroTCA complaint
 - xTCA complaint
 - IPMC and MMC
- Applications
 - PANDA TDAQ
 - BESIII Luminosity Readout
 - Belle II PXD-DAQ/SVD-DACON
 - TREND FEE and Readout
 - LLRF R&D
 - CMS Mu Trigger concentrator
- Summary



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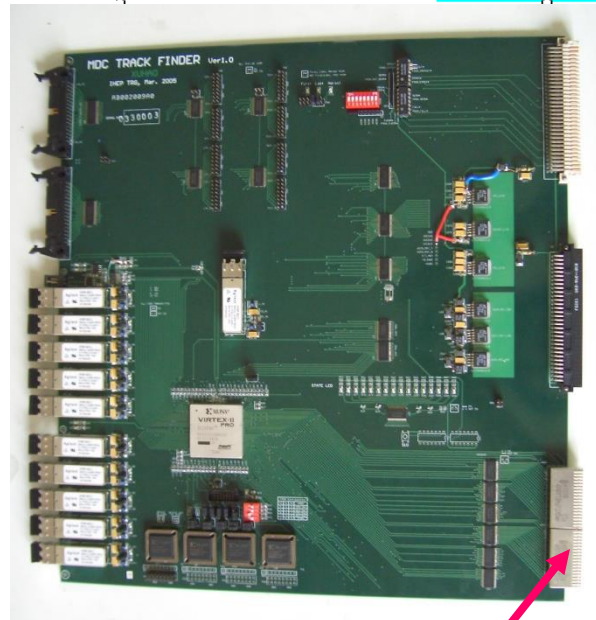
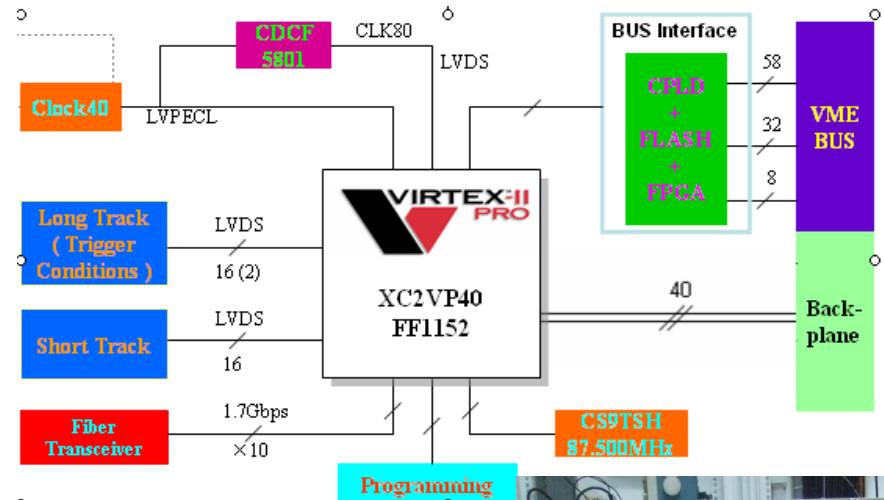
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New Standard again?

- VME (2004) Not satisfactory
 - Higher samples/s ADC
 - Powerful FPGA
 - >1Gbps transmission
 - reconfiguration
 - 1.75Gbps
 - 205Gbps/s synch in BESIII
 -

- Problem
 - Bus bandwidth too low
 - No serial interconnection
 - No Intelligence
 - CUSTOM BUS in BESIII
- New standard is needed



BESIII Module

Private BUS



205Gb/s synch trans. In BESIII 4

What is the new standard?

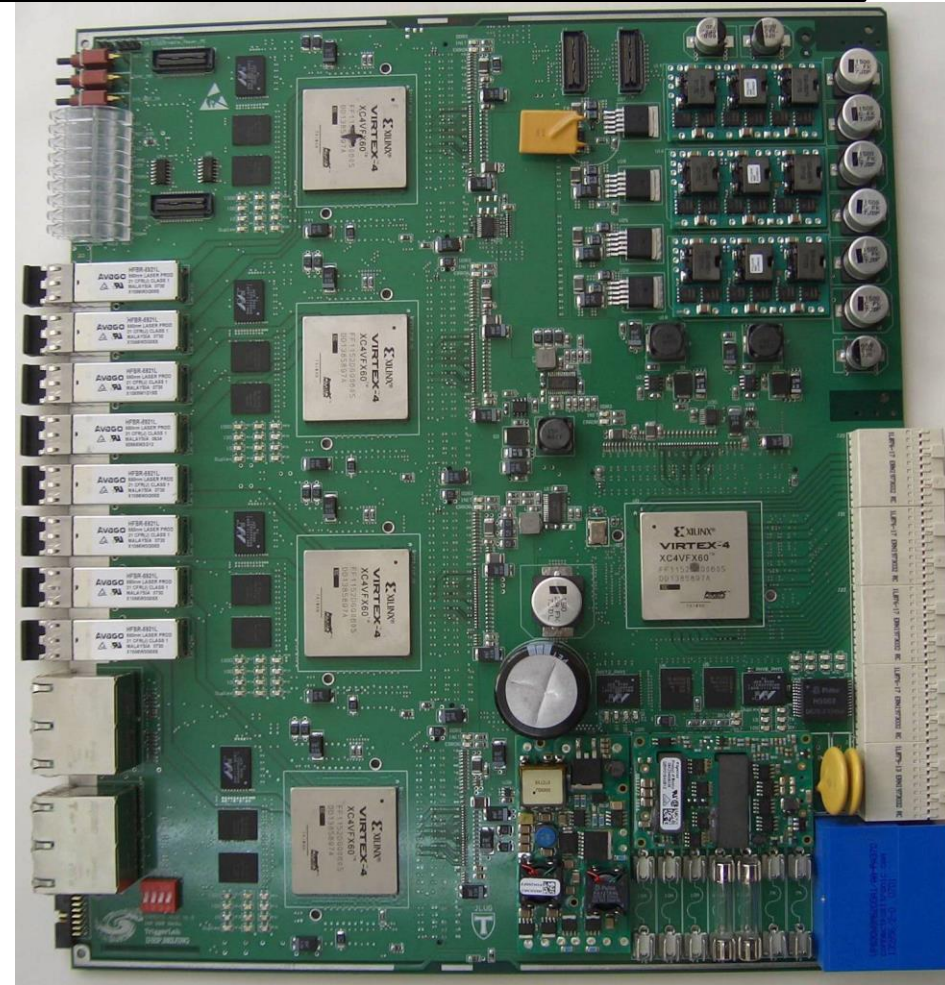
- ATCA
 - Advantages
 - High speed I/O and 10Gb/s interconnections
 - HA ~99.999%
 - IP management
- MicroTCA (MTCA)
 - Advantages of ATCA
 - Half height, compact system
- AdvancedMC (AMC)
 - Modular design

Should we adopt industrial standard again as VME?

Good idea!

Why xTCA for Physics

- ATCA shortages
 - Height 8U, not suitable for machine control
 - No rear transition board yet
 - No control signals ✗
 -
- MTCA shortages
 - No rear transition board yet (HA) ✗
 - No control signals ...
- AMC shortages
 - Inter connection?
 - Control signals?
 - pin signal definition
 - ...



Compute Node designed by IHEP



New standard: xTCA for Physics

xTCA workshops

- International Linear Collider, XFEL
 - 2004 - ATCA, MTCA intro paper NSS-MIC, Rome
 - 2005 – ILC Snowmass Conference + Availability Workshop @ Grömitz on ATCA for *high availability*
 - 2007 – 1st xTCA workshop, IEEE RT2007 Fermilab
 - 2008 – 2nd xTCA workshop, IEEE NSS-MIC Dresden
 - 2009 – **xTCA for Physics subcommittees formed under PICMG**
open source telecom standards ~200 vendors
 - 2009 – 2013 - IEEE Workshops 3-6 at Beijing, Lisbon, Valencia, Berkeley, DESY (1st & 2nd DESY workshops)
 - 2014 - **7th Annual IEEE Workshop Nara Japan last week**, 3rd DESY workshop Dec. 2014

IHEP is a funding member of xTCA

- Slide from Ray Larsen in RT2014

V. Acknowledgments

- Special thanks to SLAC colleagues A. Young, C. Xu, D. Brown, J. Olsen, C. Yee, D. van Winkle, E. Williams, K. Kim, S. Hoobler, T. Straumann, T. Vu and managers E. Carrone, D. Rogind and H. Shoae for continuing to strongly support the xTCA program
- The DESY XFEL team headed by Holger Schlarb, Kay Rehlich and colleagues made major contributions to every aspect of MCTA.4 hardware architecture and development.
- A. Lowell of TripleRing is a major driver of the Software program with D. Makowski, M. Killenberg, L. Petrosyan, P. Gessler, E. Williams et al.
- Thanks to xTCA Founding members DESY, FNAL, IHEP, SLAC, Cypress Point Research & TripleRing Technologies; and member labs IPFN Lisbon, ITER, CERN, LBNL, Sincrotrone Trieste and KEK.
- Thanks to major industry contributors Schroff, Elma, Pentair-Schroff, NAT, Struck, TEWS, Telkoo, Hytec, Vadatech and Wiener for providing critical infrastructure and continuing new initiatives support.



May 25, 2014

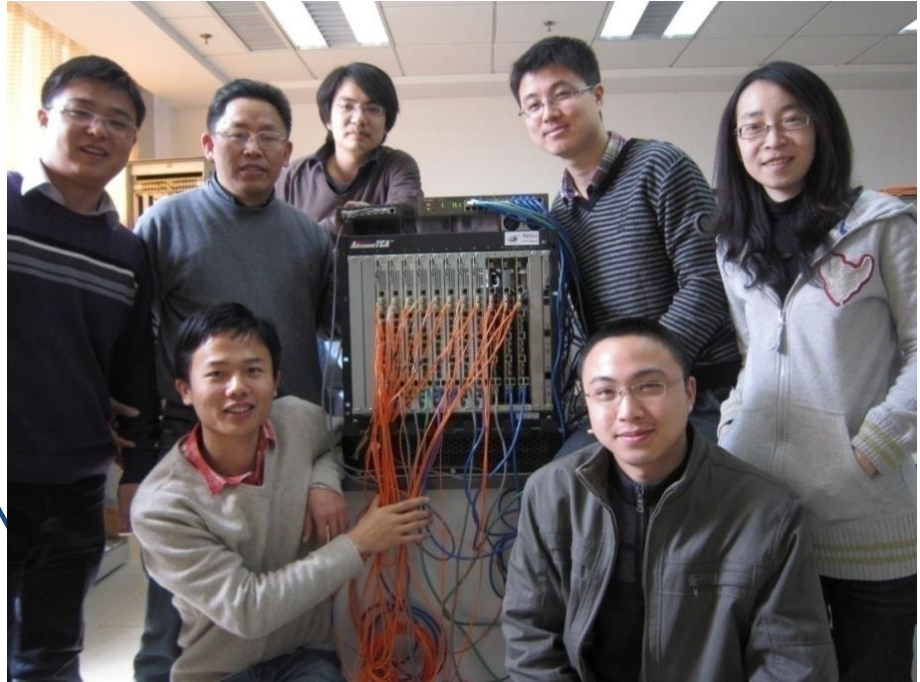
Real Time 2014 MTCA.4 Workshop

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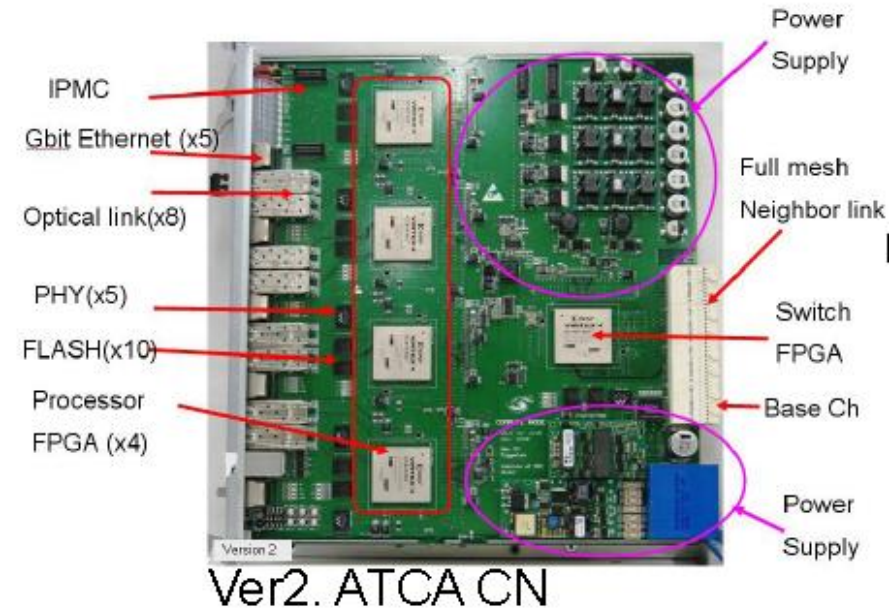
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Activities in IHEP/TrigLab-ATCA

- High Performance Compute Node
 - 5x(Virtex-4 FPGA +2GB DDR2)
- ~53Gbps Bandwidth
 - 5x Gigabit Ethernet
 - 8x Optical Link (6Gbps/ch)
 - 13x RocketIO to backplane
- 2 Embedded PowerPC each FPGA
 - Real time Linux
- ATCA compliant



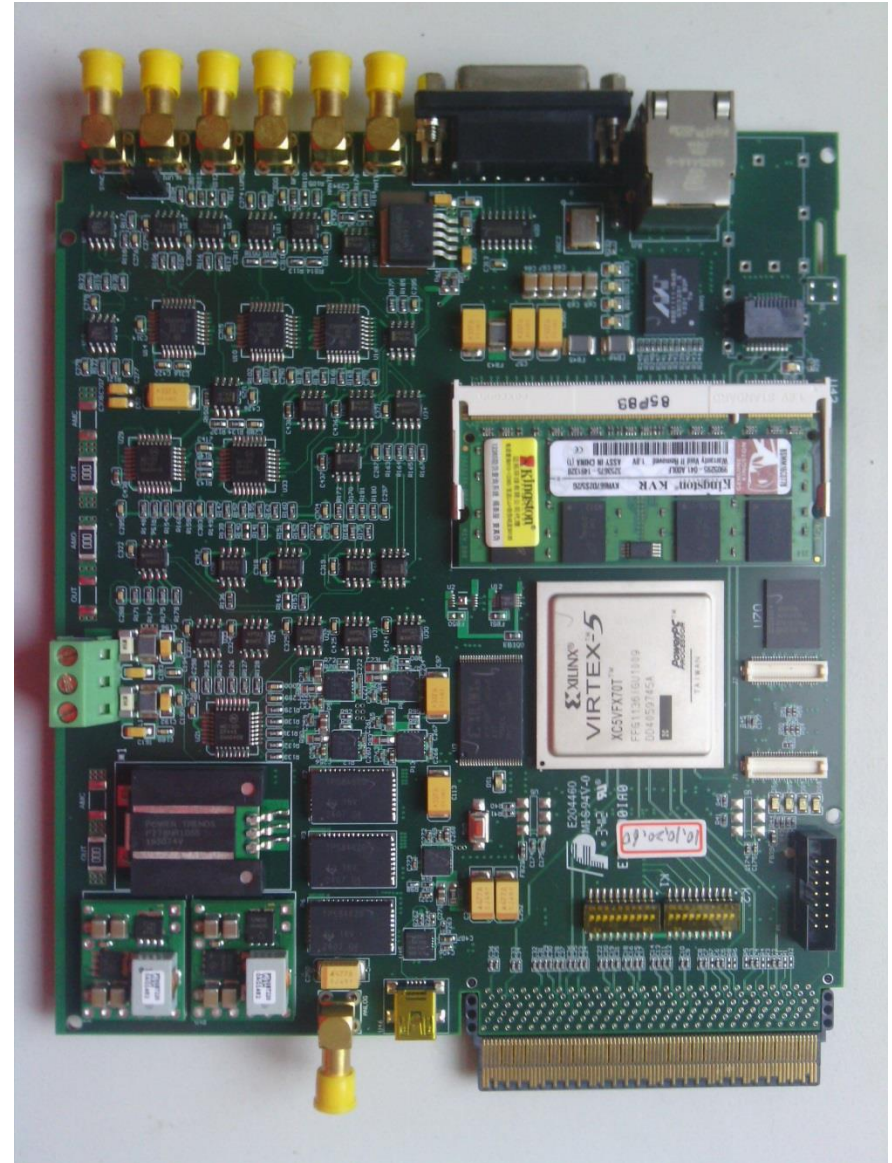
Activities in IHEP/TrigLab-MicroTCA

- Single Width AMC
 - Type 1 for trigger
 - Discriminators
 - Type 2 for CN
 - Virtex 5 XC5V50T
 - 4GB DDR2
 - 1 Ethernet
 - 2 SFP(3 Gbps)
 - Type 3 for DATCON
 - Virtex 5 XC5V70T
 - 4GB DDR2
 - 1 Ethernet
 - 4 SFP+(6.4 Gbps)



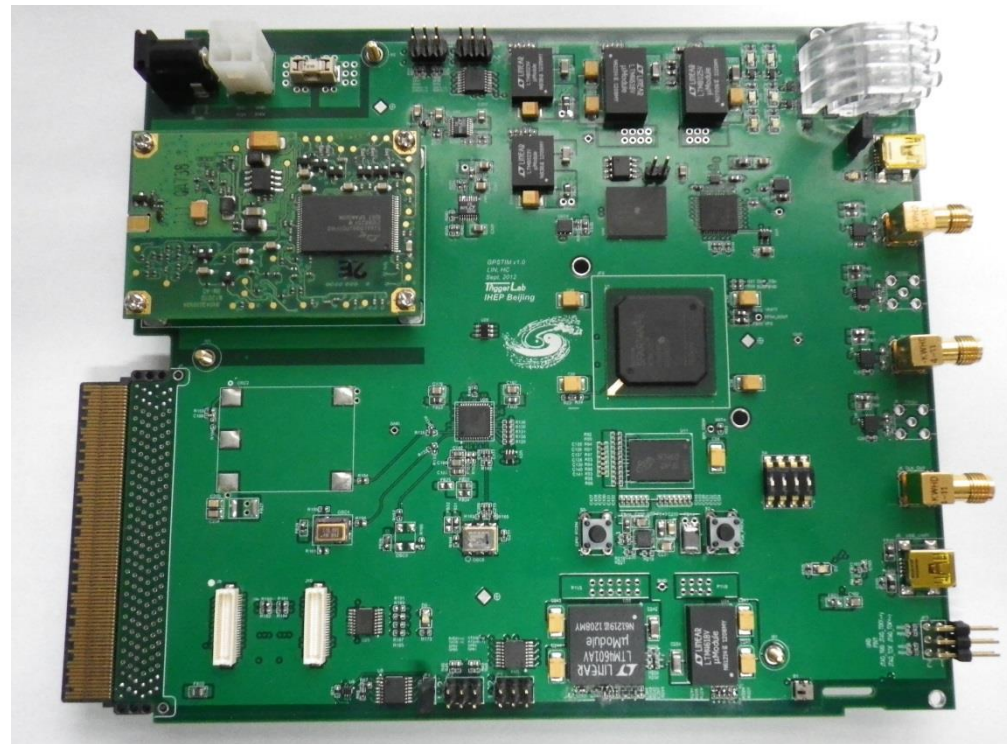
Activities in IHEP/TrigLab-MicroTCA

- Double Width AMC
 - Type 1 for LumiMonitor
 - Up to 6 Signal inputs
 - 2 delayed signal/clock
 - Virtex 5 XC5V70T data processing
 - 2GB DDR2 data buffer
 - 1 Ethernet output
 - 1 SFP(3 Gbps)



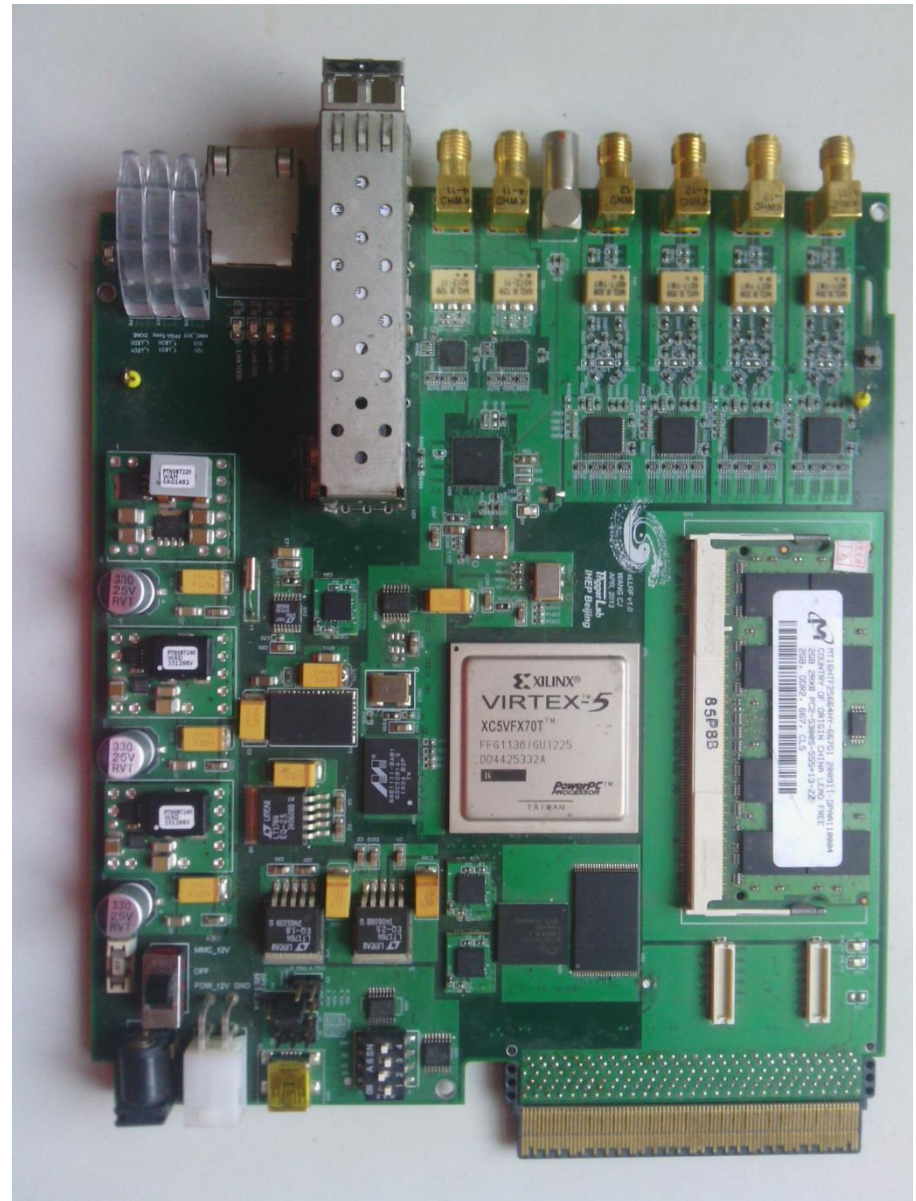
Activities in IHEP/TrigLab-MicroTCA

- Double Width AMC
 - Type 2 for GPS timing
 - Add-on GPS daughter board
 - Fine timing for tagging
 - Spartan 6 processor
 - Trigger inputs
 - USB ports



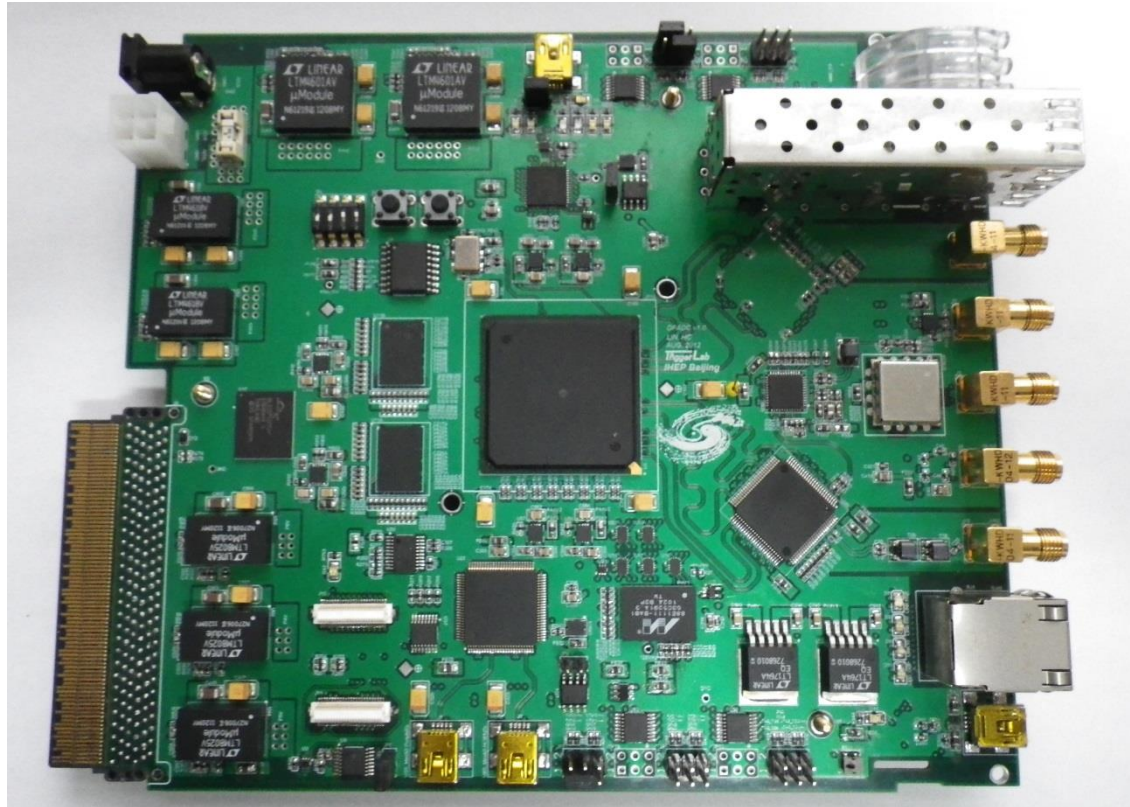
Activities in IHEP/TrigLab-MicroTCA

- Double Width AMC
 - Type 3 for LLRF
 - 4 ADC inputs
 - 120MSPS
 - 1 DAC output
 - Virtex 5 XC5V70T data processing
 - 2GB DDR2 data buffer
 - 1 Ethernet output
 - 1 SFP(3 Gbps)



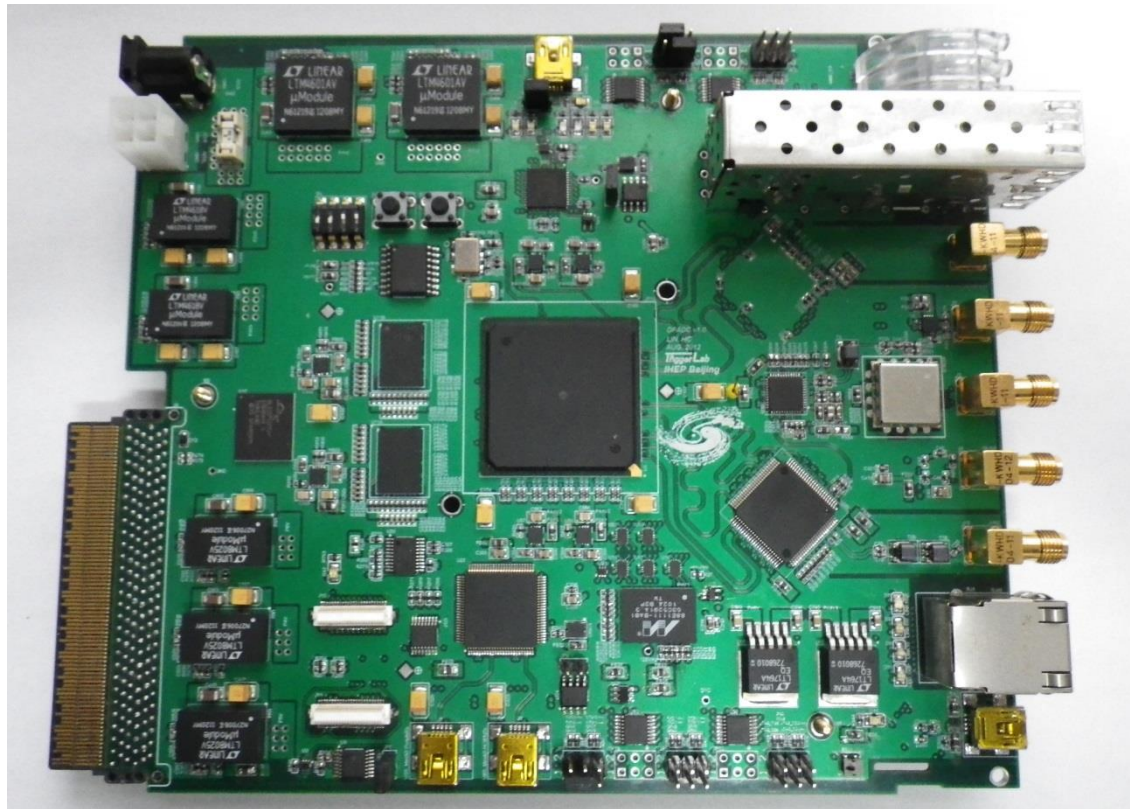
Activities in IHEP/TrigLab-MicroTCA

- Double Width AMC
 - Type 4 for TREND
 - 2 ADC inputs for antennas
 - 250Msp/s
 - Virtex 5 XC5V70T data processing
 - 1 Ethernet output
 - 1 SFP(3 Gbps)
 - USB ports



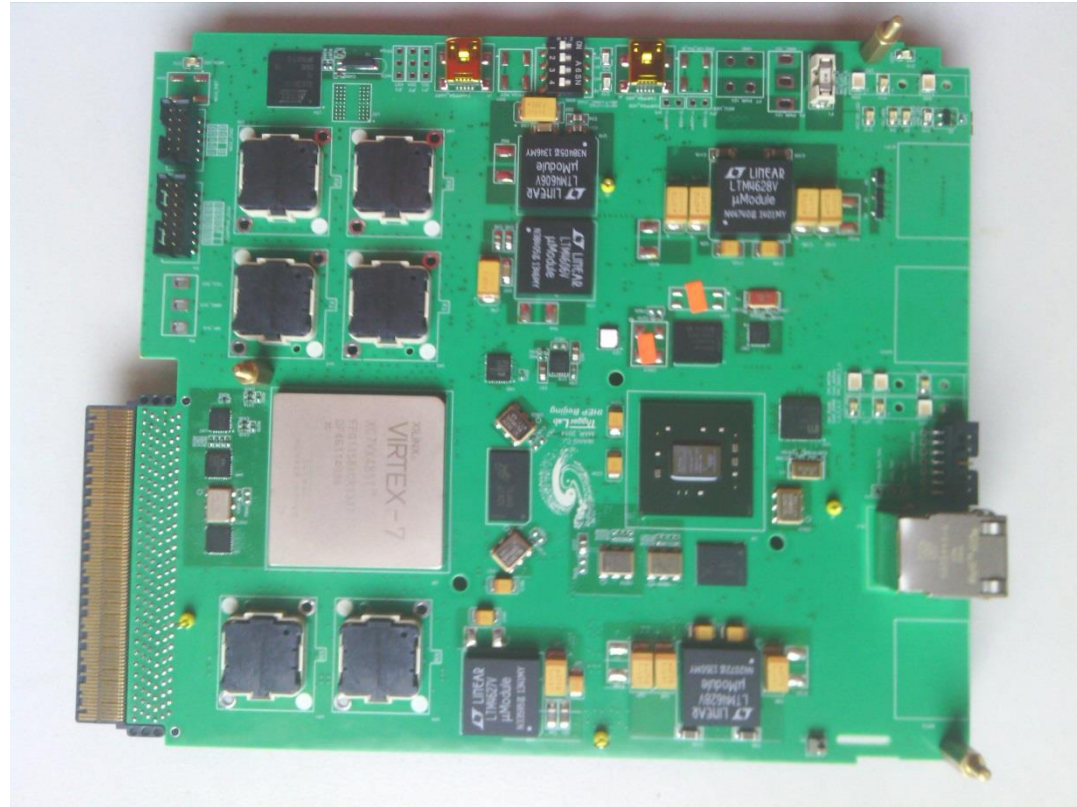
Activities in IHEP/TrigLab-MicroTCA

- Double Width AMC
 - Type 5 for TREND upgrade/GRAND
 - 3 ADC inputs for antennas
 - 500Msps
 - 1 ADC for Sci.
 - Virtex 5 XC5V70T data processing
 - 1 Ethernet output
 - 1 SFP(3 Gbps)



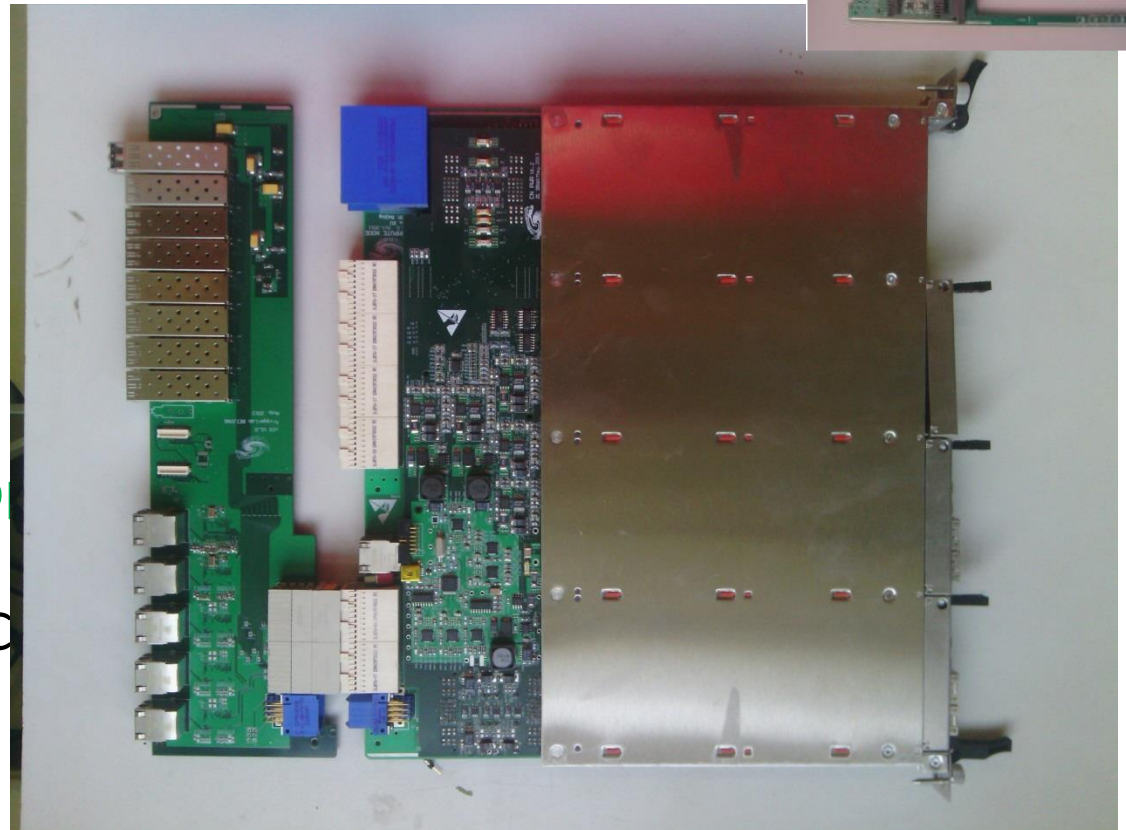
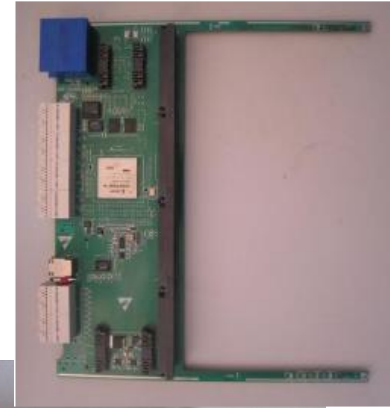
Activities in IHEP/TrigLab-MicroTCA

- Double Width AMC
 - Type 6 for CMS TRG upgrade
 - 48 1.6Gbps inputs
 - 24 9.6/10Gbps output
 - Virtex 7 XC7V485T data processing
 - Kintax 7 for control
 - **1 Ethernet output**

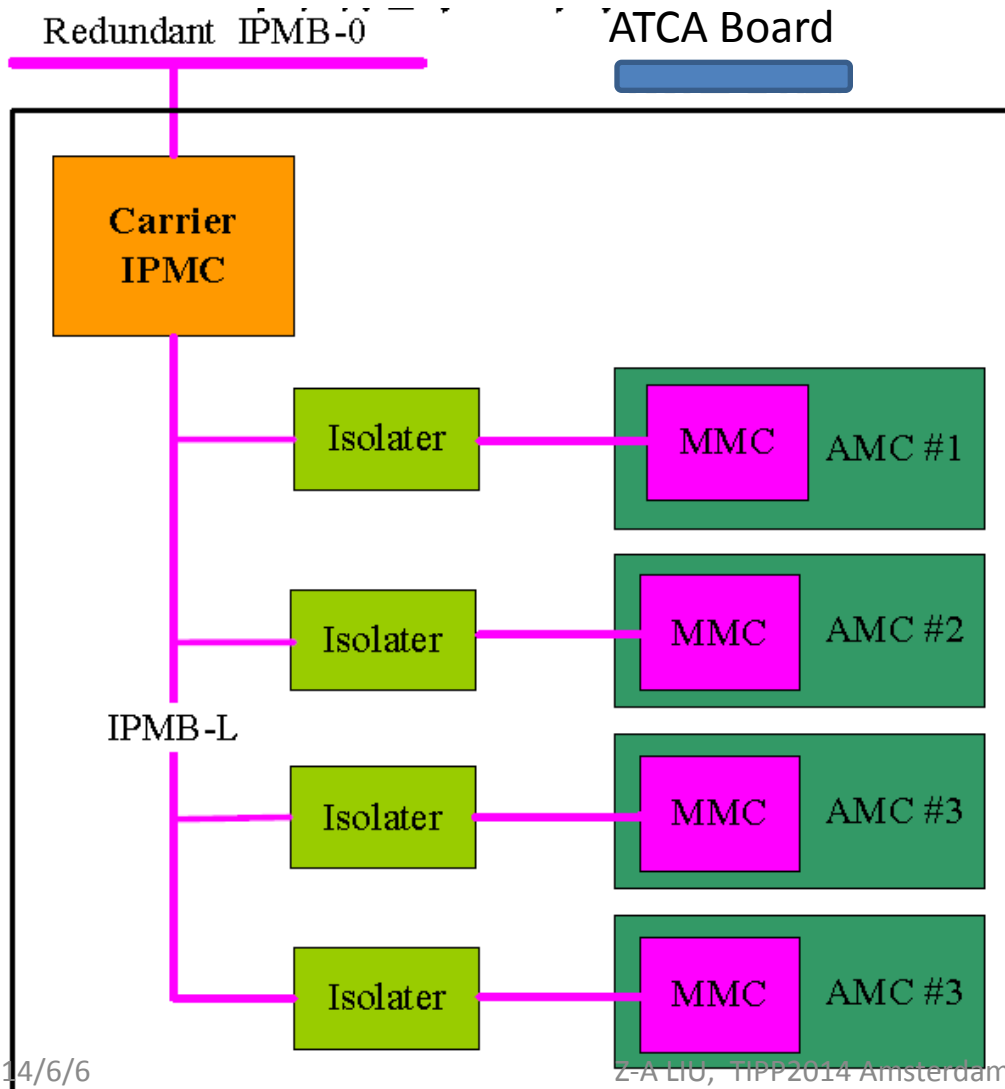


Activities in IHEP/TrigLab-xTCA

- PICMG 3.8
- ATCA Carrier AMC Board
 - 1 Virtex-4 for Routing(13 backplane)
 - 2 GB DDR2
 - Host 4 AMCs
 - JTAG chain
- Add-on Power board
 - Power converters
 - Jtag Port
- AMC
 - 2x Optical Link (6.4Gb)
 - 1 ethernet Panel
 - 2 Embedded PowerPC
 - Real time Linux
- RTM
 - Replacement of panel signals



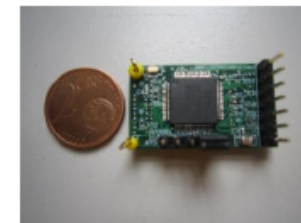
IPMC/MMC design



- ACBA:
IPMC

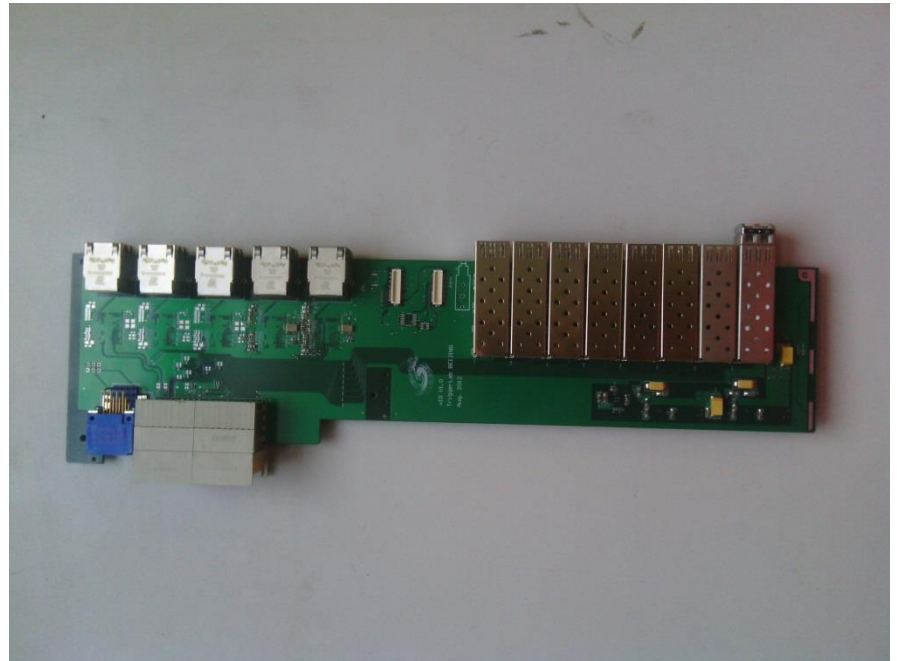


- AMC:MMC



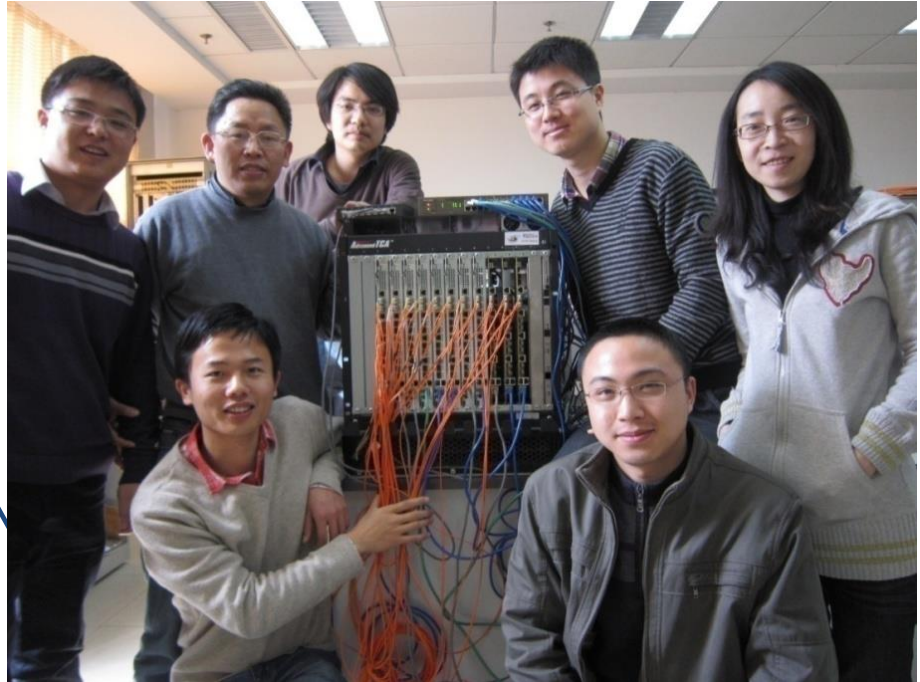
Activities in IHEP/ RTM

- IPMC
 - Power management
 - Temperature monitoring
 - Voltage Monitoring
 - Communication with MMC
- MMC
 - Power management
 - Temperature monitoring
 - Voltage Monitoring
- RTM for PICMG 3.8



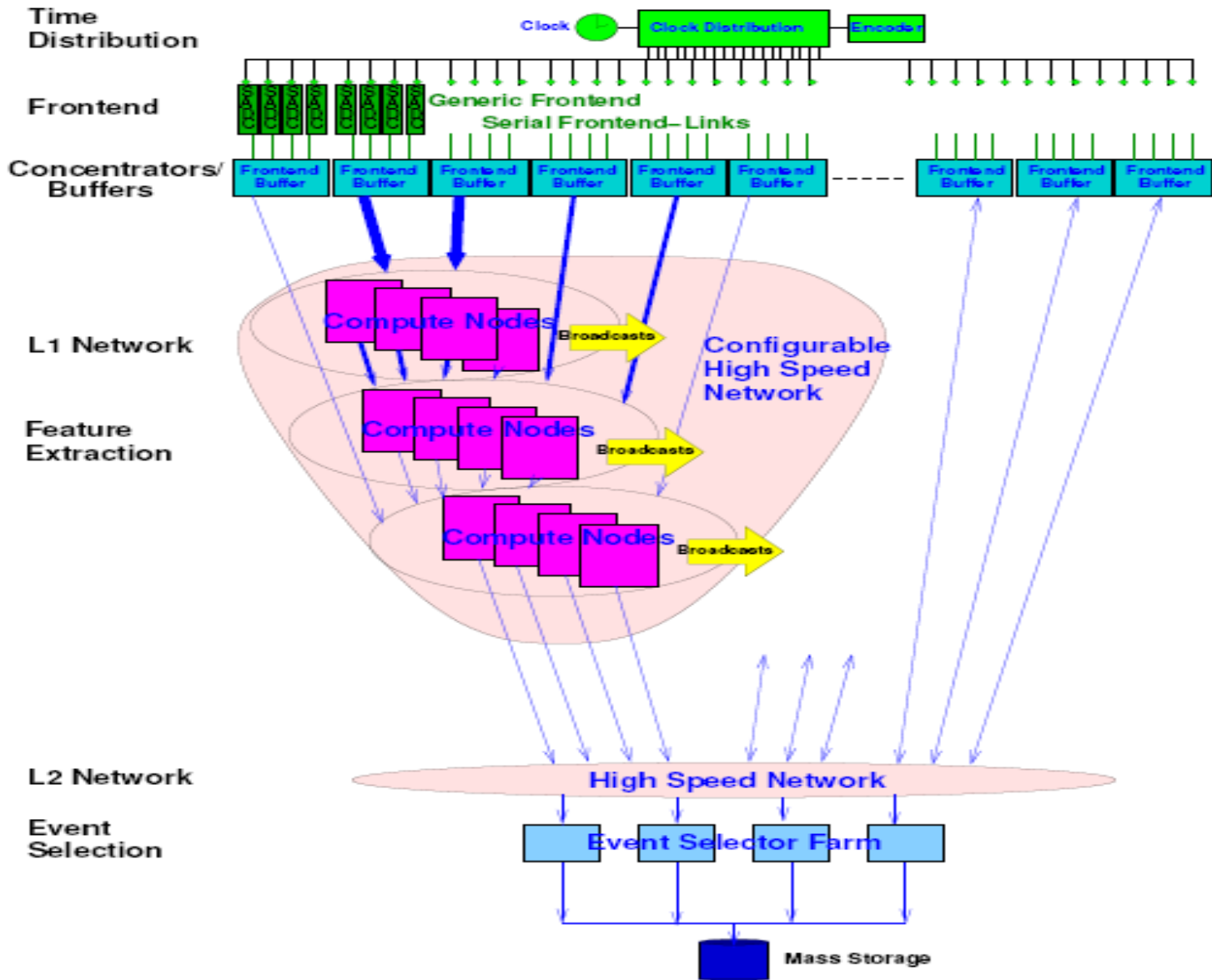
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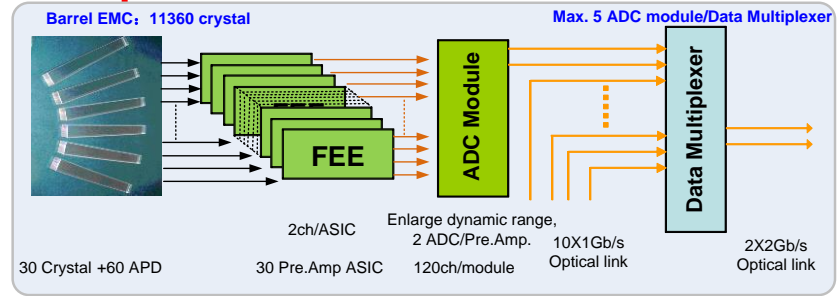
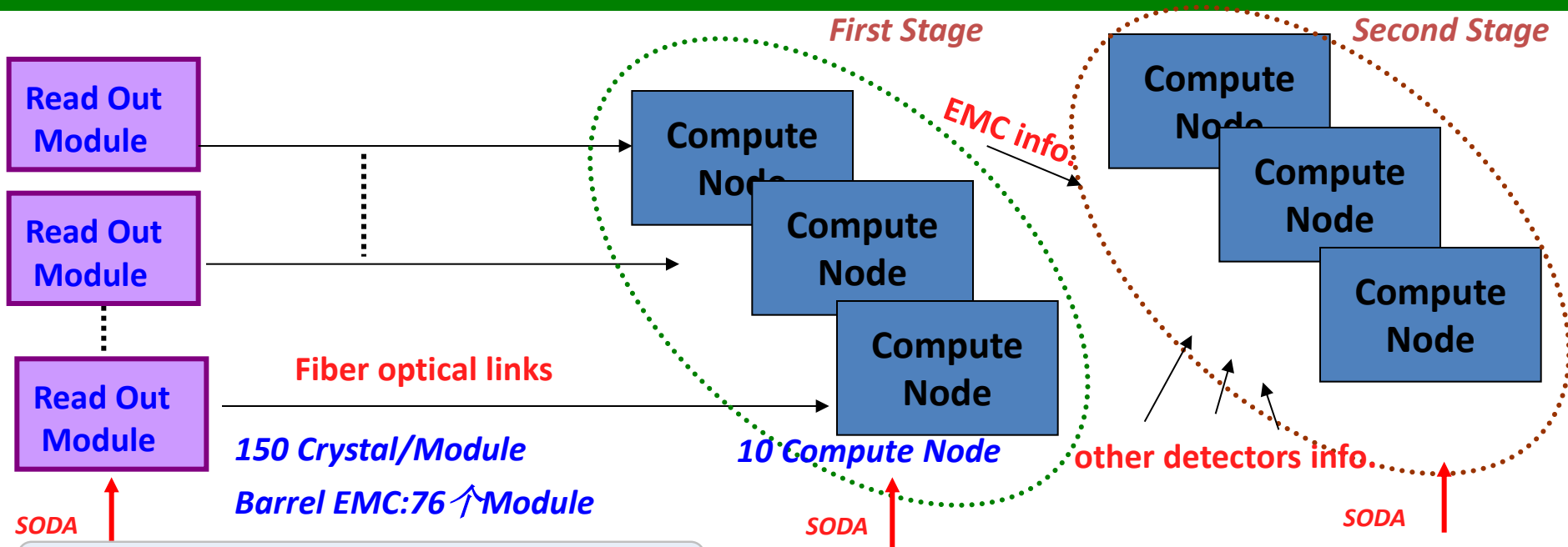


Application in PANDA TDAQ

- Compute Node in ATCA, later in xTCA



PANDA EMC TDAQ development System in PANDA

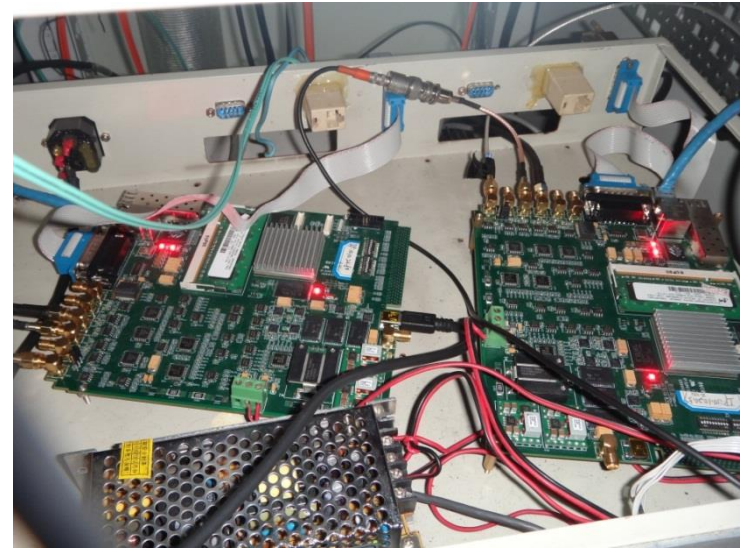


SODA: Synchronization Of Data Acquisition

Task	<ol style="list-style-type: none"> 1. Signal Feature extraction (Time, Amplitude) 2. Data Zero suppression <p>2014/6/6</p>	<ol style="list-style-type: none"> 1. Clustering 2. Cluster Properties extraction 3. Pattern recognition <p>Z-A LIU, TIP2014 Amsterdam</p>	<ol style="list-style-type: none"> 1. Correlation 2. Physical parameters calculation 3. Event building
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Application BESIII LUMI

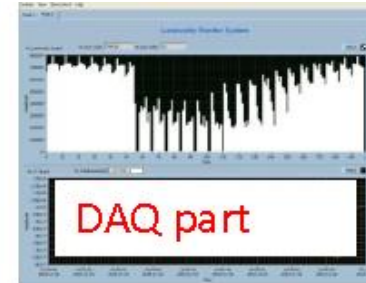
- Successfully running for one year
 - Prototype of xFP card
 - A full-size, Double-width AMC module
 - Embedded system designed
 - Open source Linux system
 - Luminosity IP core
 - Web slow control
 - MTCA complaint



processing board
Z-A LIU, TIPP2014 Amsterdam
ze, double-width AMC module

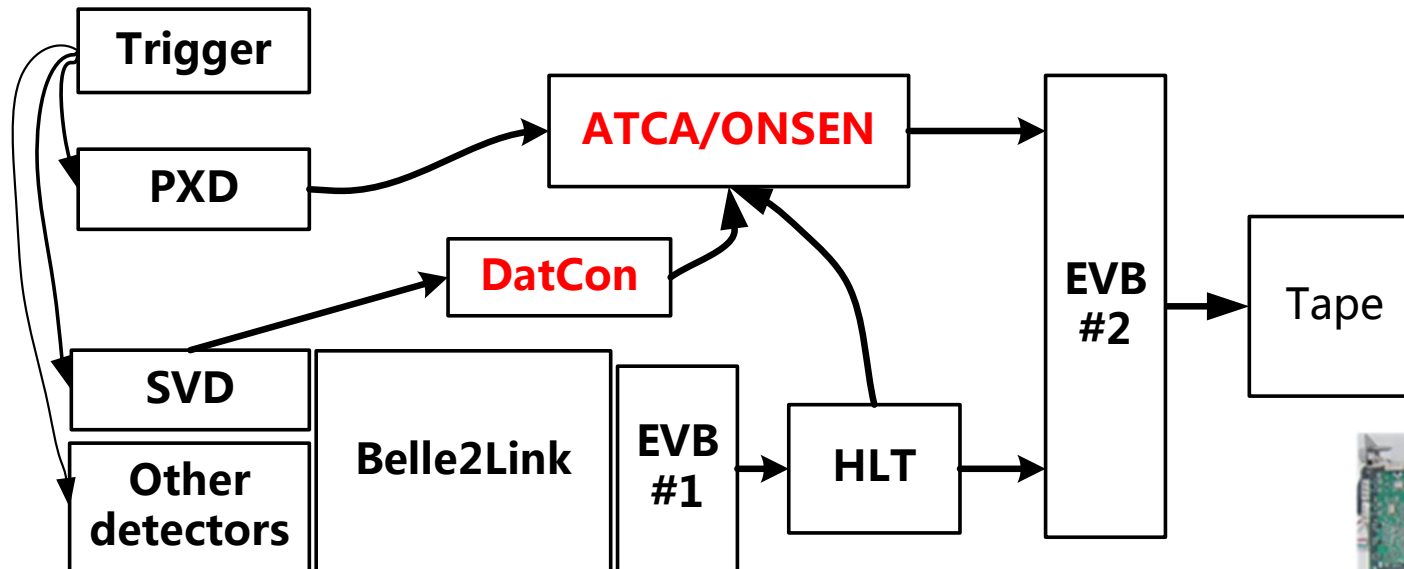


Ethernet

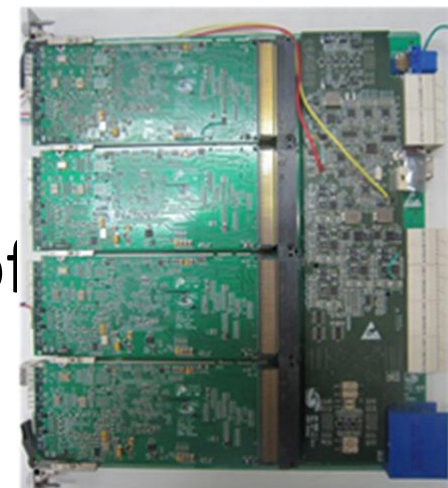


Belle II PXD-DAQ/SVD-DATCON

- PXD/DAQ design in DEPFET Colaboration aimed for Belle II at KEK

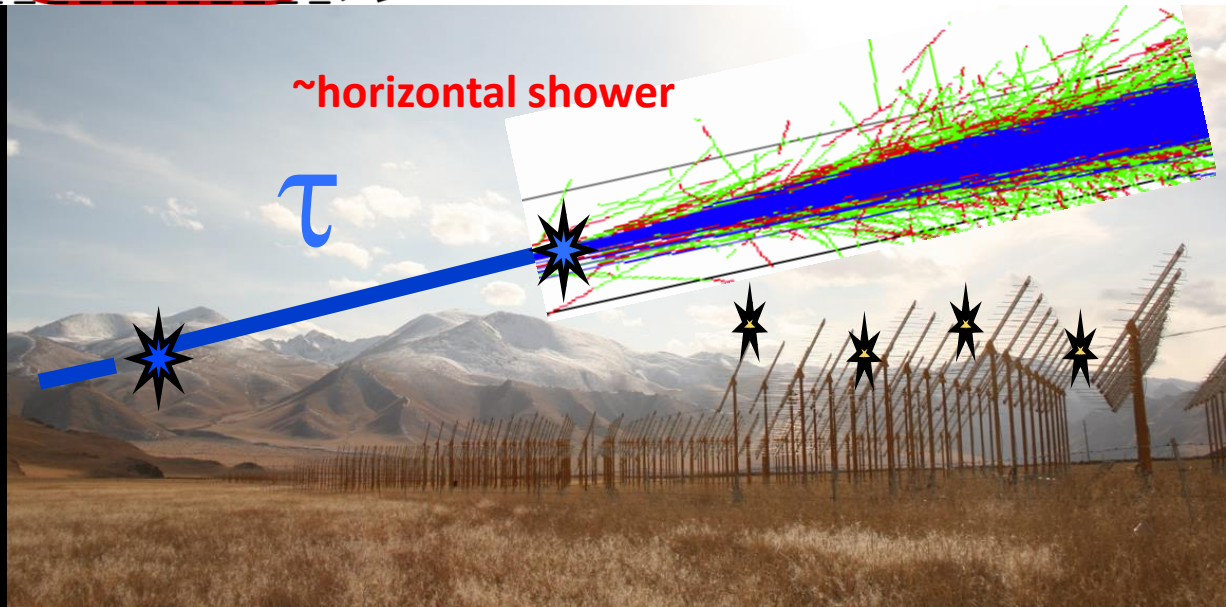
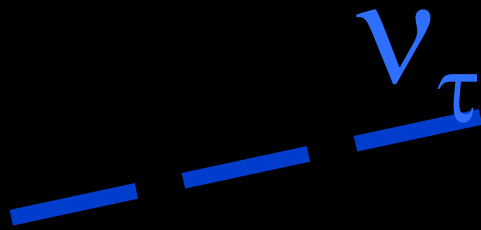
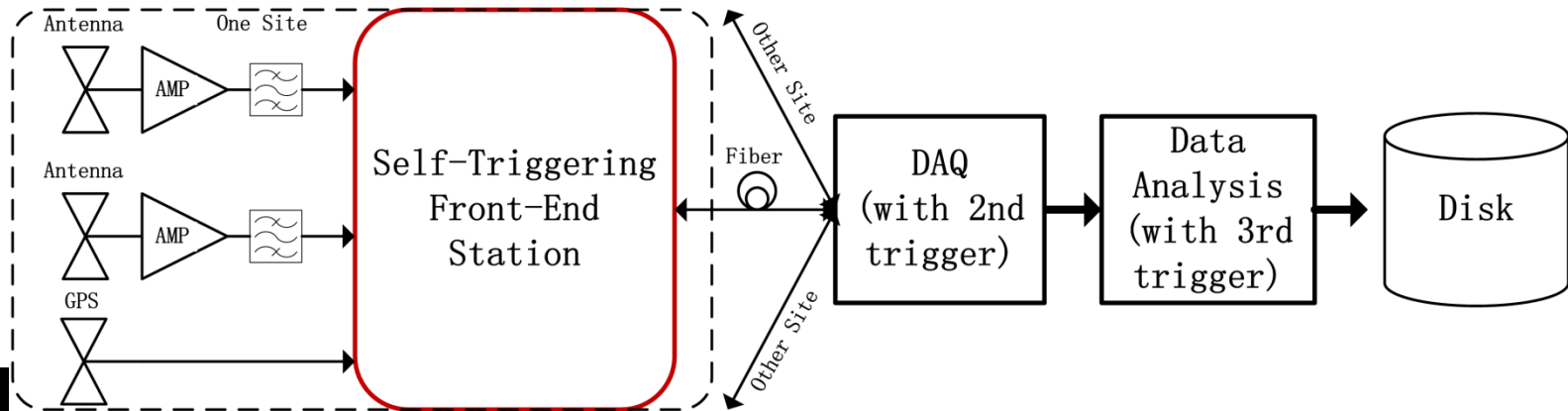


- **ATCA/ONSEN** and **DatCon** both consist of Computer Node compliant to xTCA specification in both MTCA and ATCA shelves.



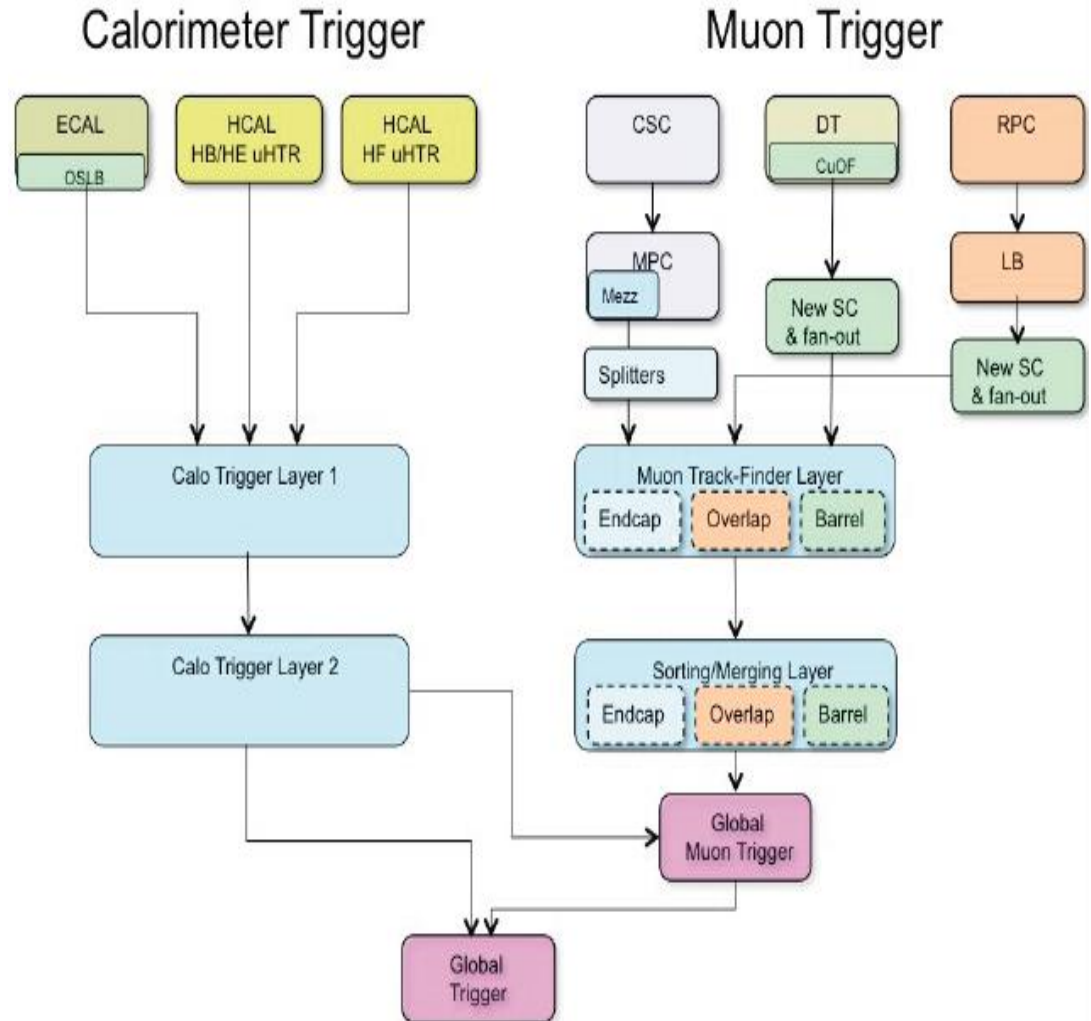
TREND

- All AMC/MTCA/ATCA composed system
- Site test successful



CMS Trigger Upgrade

- Muon/RPC concentrator and fanout
 - 1.6Gbps input
 - 9.6/10 Gbps output
- Prototype undertesting



Summary

- IHEP/TrigLab has designed some building blocks in AMC/MTCA/xTCA/ATCA specification for FEE, trigger and DAQ.
- IHEP is active in xTCA development
- Applications successful in some Experiments

Many thanks for your attention!

backups

What is xTCA?

- ATCA(Advanced Telecommunication Computer Architecture)
 - High speed IO interconnection up to 10Gbps
 - High availability HA~99.999%
 - System intelligence management
- MicroTCA(MTCA)
 - Have advantage of ATCA
 - Half hight of ATCA, compact system
- AdvancedMC(Advanced Mezzanine Card)
 - Filed Replace Unite module(FRU)
- **xTCA for physics:** new standard formed xTCA CCTS committee under PICMG which admits some of ATCA/MTCA/AMC
- **xTCA** for short

xTCA features

- ATCA & MicroTCA Unique Features
 - ATCA board, shelf is first modular computer architecture with completely serial multi-Gbps backplane
 - Serial ports are bidirectional pairs in star or mesh topology
 - Serial bit rate of one port at 2.5 Gbps exceeds data rate of parallel bus backplanes, e.g. VME 32/64 bit word at 10 MHz => 320/640 Mbps (*now 2.5G=>10G=> 40 G*)
 - Architecture based on FPGAs with imbedded SERDES Tx-Rx, LVDS balanced logic
 - High processing power of single ATCA card (Blade)
 - MCH enables module to any other module communication
 - Special low jitter switches for clocks
 - Dual redundancy MCH, Processor, Power Units - optional

xTCA Standards – Hardware Extensions

- Rear Transition Modules
 - ATCA Card => PICMG 3.8
 - Zone 3 area defined but interface left to discretion of vendors
 - Severely limits interoperability of vendor modules
 - Physics developed ATCA Standard RTM Interface
 - Fabric, power, JTAG, IPMI, managed from ATCA
 - MicroTCA Double-Wide Card => MTCA.4
 - MTCA.0 defined double-wide AMC but not Zone 3 or RTM mechanics
 - MTCA.4 developed new crate, RTM, interface, cooling
 - Fabric, power, JTAG, IPMI, managed from AMC
 - RTM hot-swappable