Using the Advanced Telecom Computing Architecture xTCA as crate standard for XFEL

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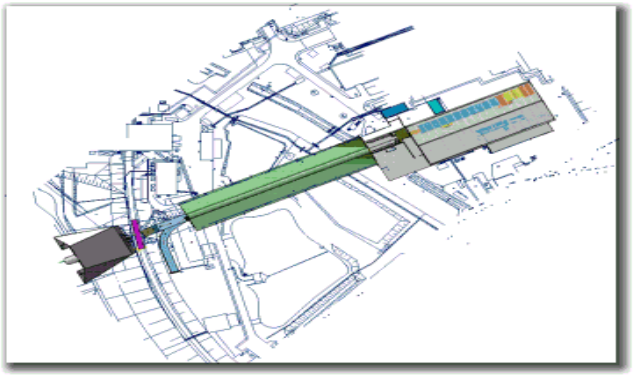
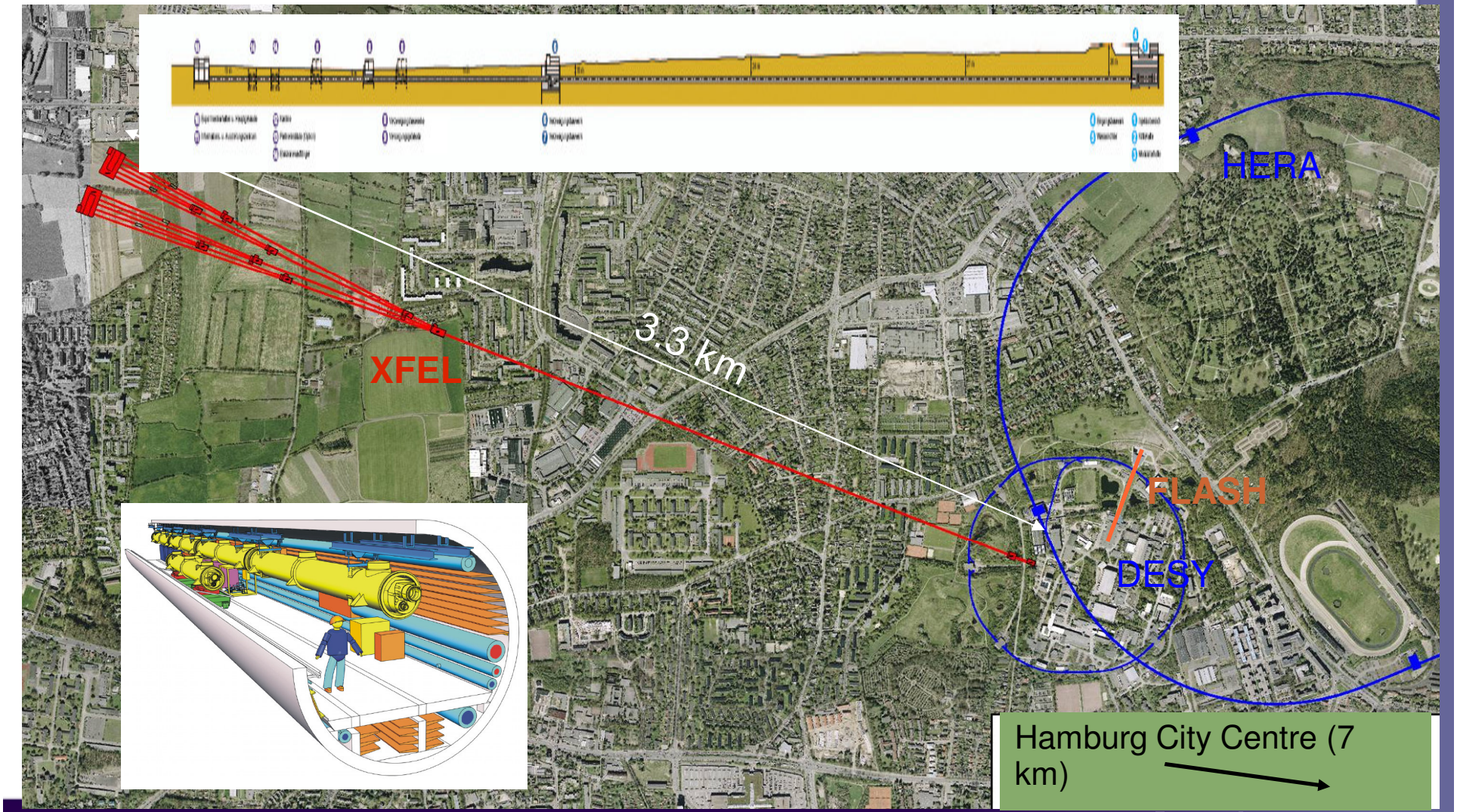
Working in the controls group for FLASH and XFEL

FLASH

- Linac is 280 m long
- up to 1GeV energy => ~6nm Photon beam
- 2.5 kA peak current
- 5 Kryo Modules with eight 9-cell cavities
- 4 Klystrons to drive Gun and Modules
- VUV FEL light down to 6nm wavelength
- Undulator length is almost 30 m
- shared between Users, XFEL and ILC
- Prototype for XFEL and ILC



X-Ray Free Electron Laser (XFEL)



X-ray Free Electron Laser

- an European project at DESY
- Linac will 1500 m long
- up to 25 GeV energy
- ~100 Kryo Modules with
  eight 9-cell cavities each
- 1 Klystrons to drive 4 Modules
- 1.3 GHz operation
- XFEL photon beam down to 0.1 nm
- German government announced
  to spend 50% of the budget
  == ~350 Mio Euro
- start of civil engineering in 2009

DOOCS features

- **D**istributed **O**bject **O**riented **C**ontrol **S**ystem
- Client / Server system with ONC-RPC
- Implemented mainly in C++
- Local HDD for archiving and configuration
- Every server has its local .conf and .log file
- Hierarchical name space
- Name calls -> query all locations or properties
- Most source of a server is inside a central C++ library
- No central DataBase
- For Solaris, Linux and Windows

http://doocs.desy.de

DOOCS features con,t

- Tight connection to the DOOCS DAQ Poster : TUP010
- A common client C++ API for
  - DOOCS ONC-RPC
  - TINE
  - EPICS
- On top of this API
  - DOOCS Data Display DDD
  - Generic Applications and command line tools
  - MatLab
  - LabView

DOOCS features con,t

- Native Java API : jDOOCS
  - talking to : DOOCS, TINE, Tango, (Epics planned)
- On top of this API
  - jDDD
  - Alarm & Info System
  - jDTool (generic access)

Motivation

- ~300 Crates are required inside XFEL
- We want a manageable and reliable system
- Find today a solution with support for the next 10 years
- Cheaper solution as VME
- Common Hardware and Software standards for all subsystems
- Is xTCA the right platform for XFEL?

Why crates at all ?

- 10 Hz operation at XFEL
- single bunch resolution over the whole macropulse
- very fast analog channels
- about 130 analog I/O channels per RF station
- short cables to the diagnostics devices
- remote management

Evaluation of ATCA and µTCA

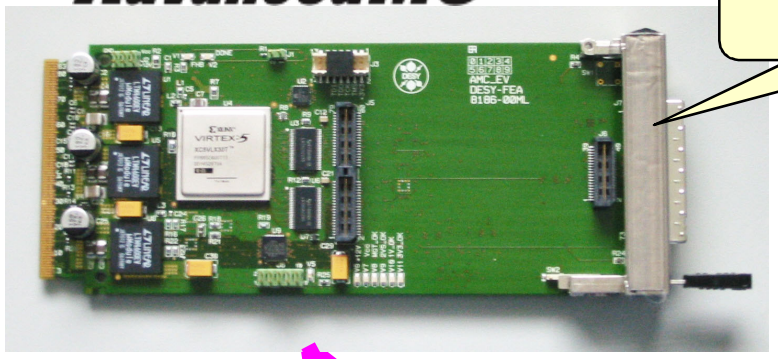
- **Trying crates and modules from different manufacturers**
  - Is it a 'standard' ?
  - Learn to specify a big system
- **Design of hardware (AMC)**
  - Can one understand and implement the specs?
  - Is the analog (ADC) performance sufficient?
- **Design of software**
  - FPGA connection by PCIe
  - Device drivers for LINUX and Solaris
  - IPMI code for the MMC
  - System management
- **ATCA evaluation by the XFEL LLRF group**

ATCA features

- ATCA == **A**dvanced **T**elecom **C**omputer **A**rchitecture
  - serial, switched bus (GB Enet, PCI-x)
  - redundant, monitored -48V powersupply
- standardized monitoring and management (IPMI)
  - complete redundant setup possible
    - no IO from industry yet
    - too expensive for now

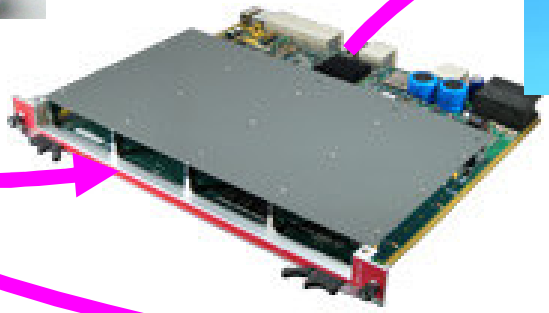
Hardware: xTCA

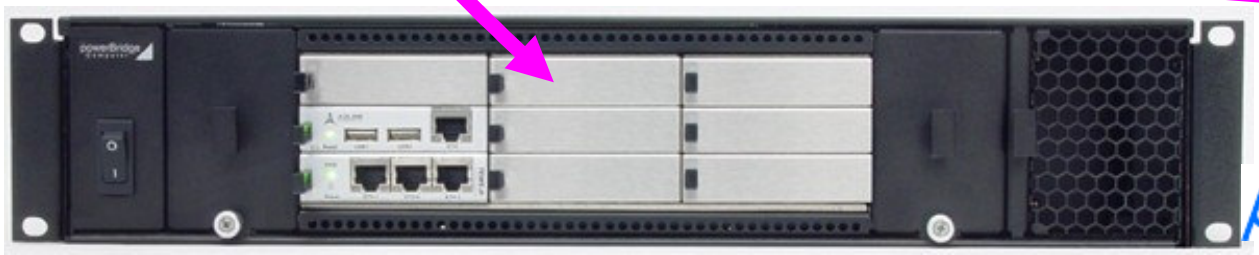
AdvancedMC™



Timing receiver board size

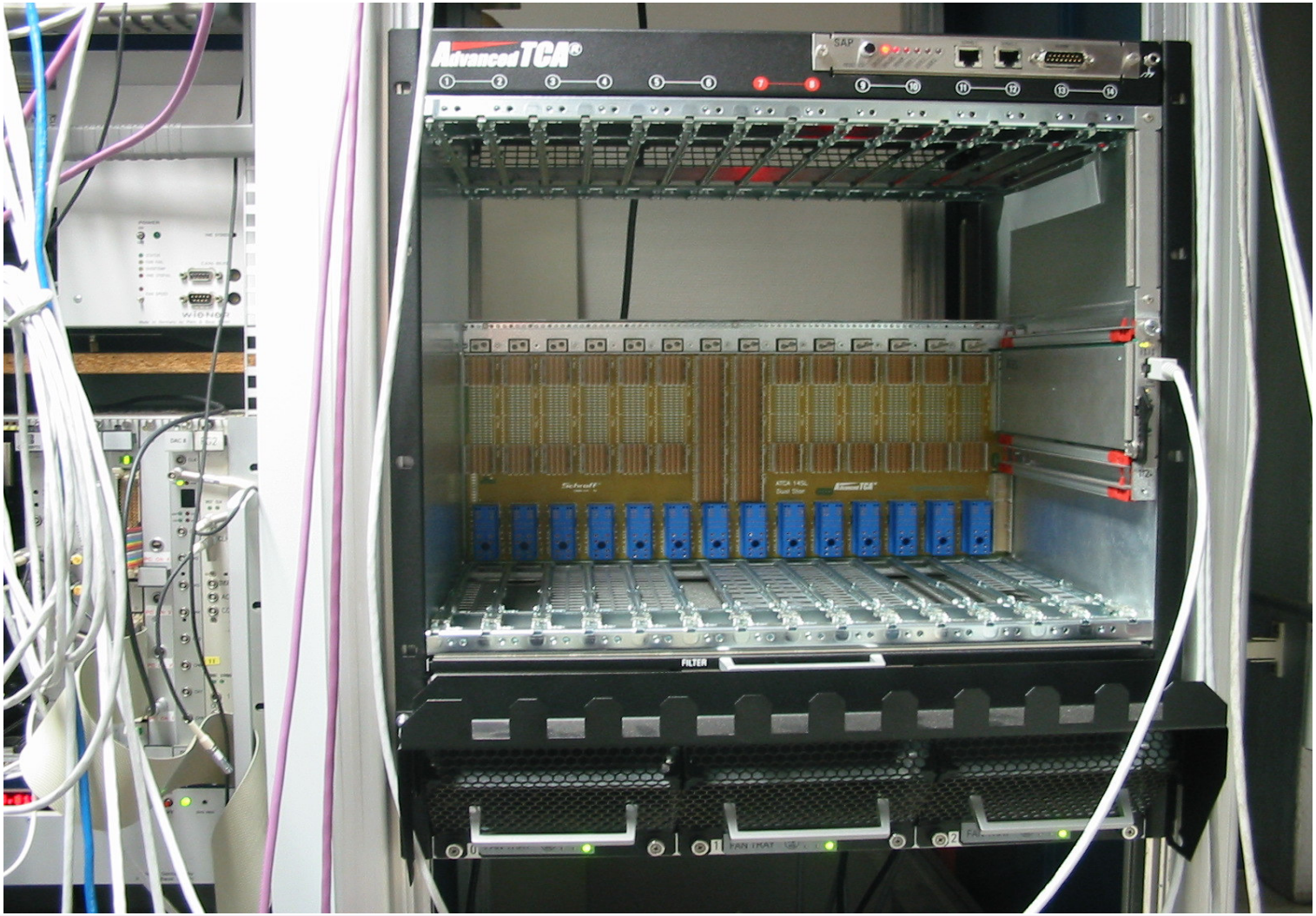
AdvancedTCA®





µTCA™

Future Shelfs : ATCA



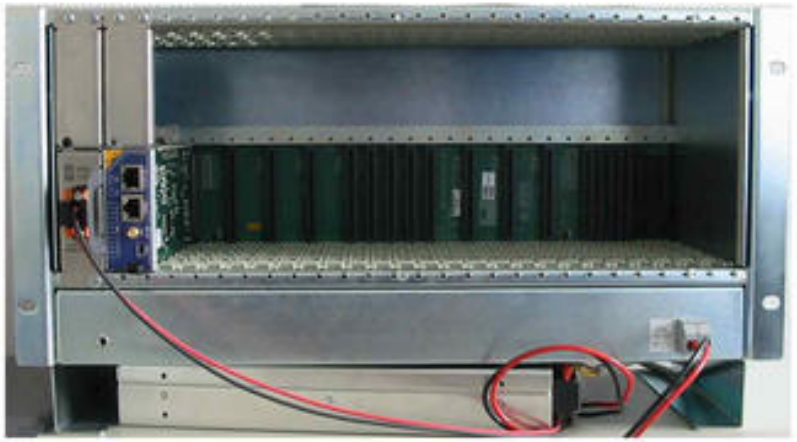
µTCA shelf

12 slot

4 slot

8 slot
low cost
active backplane

double size:
12 slot



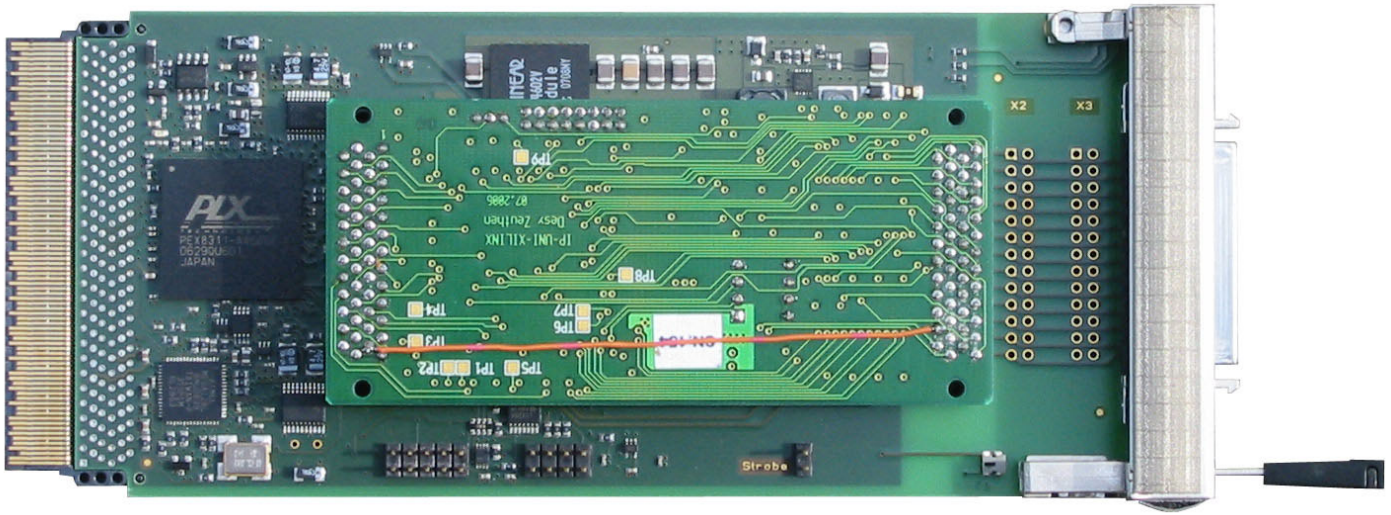
6 slot

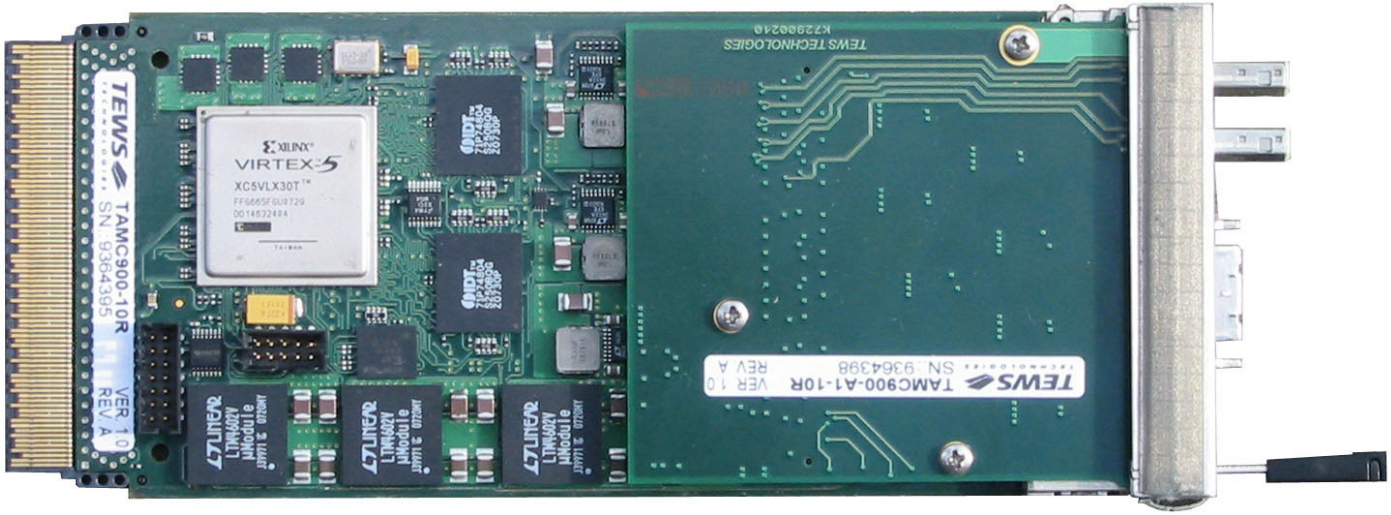
standard AMC's

IP carrier to connect e.g. legacy FLASH timing

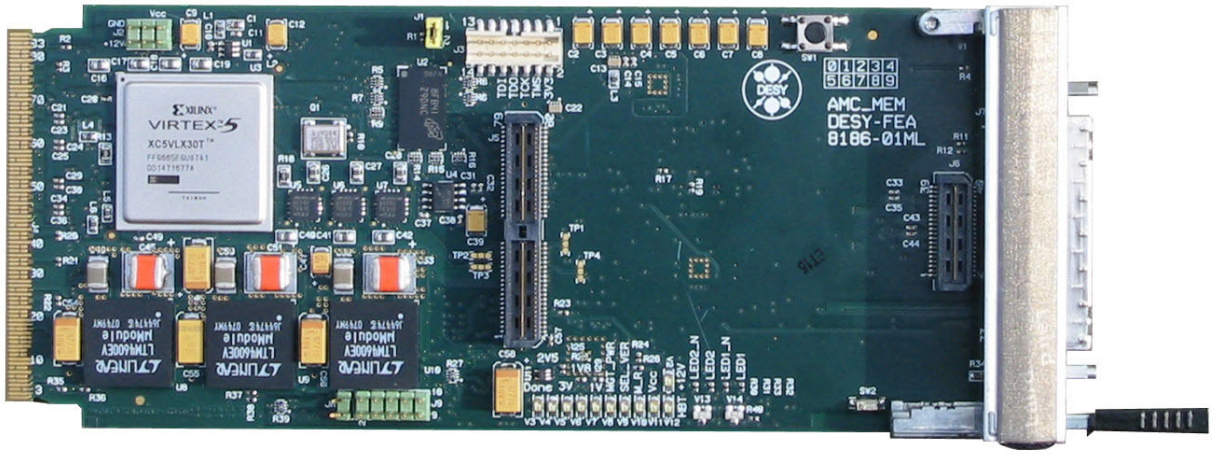
A solution to connect IO to µTCA

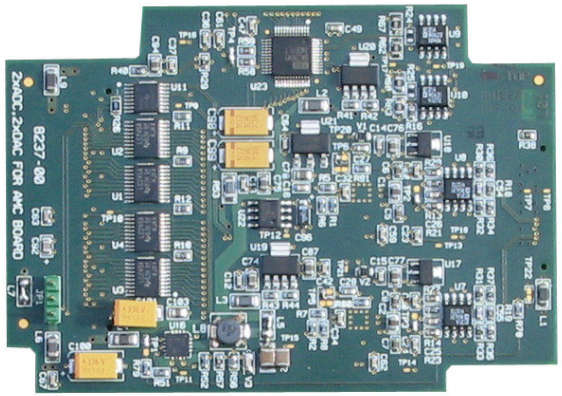
ADC:
8 channel
100 MHz
14 bit,
design contract with Tews





DESY AMC



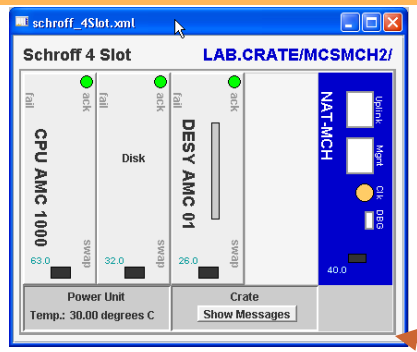


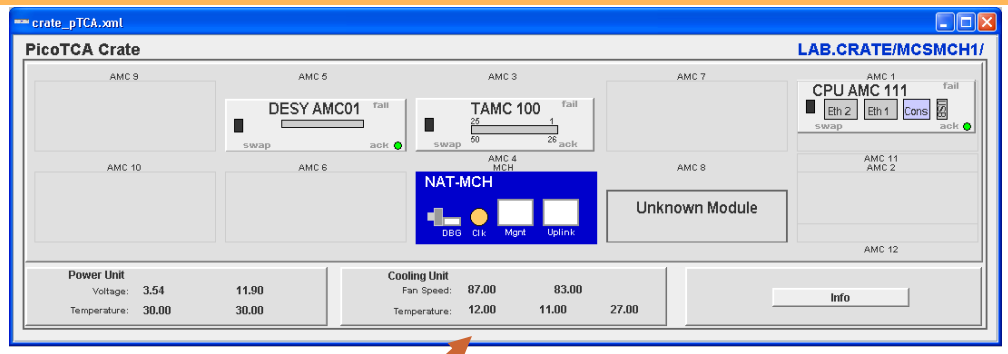
- Development of an 'universal' AMC module
  - Hardware design with Virtex5 and 256MB DDR2 SRAM (1GB/s)
  - FPGA code development with PCI Express interface and DMA
    - 370 MB/s into user space (128byte payload size)
      - DOOCS server and OS driver
  - IPMI code for 'Module Management Controller' (Atmega-128)
    - Piggyback with 2 ADC and 2 DAC channels, 100MHz

IPMI for DESY AMC Board

- IMPI code on Atmel-128
  - Implements version 1.5 functions
  - FPGA code loading in preparation
- IPMI control system integration
  - DOOCS server for ATCA, µTCA and computers
  - IPMI communication via Ethernet to the crates
    - Extracts from IPMI the available information
      - Creates a dynamic list of AMC modules
        - Creates a dynamic list of sensors
  - Archives values and provides reset/boot commands to FPGAs or CPUs
  - Required configuration: one entry per crate (IP name)

DOOCS integration





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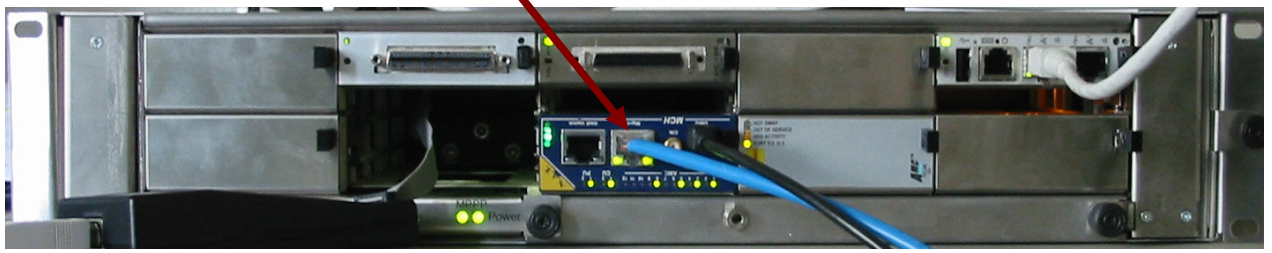
JAVA Application

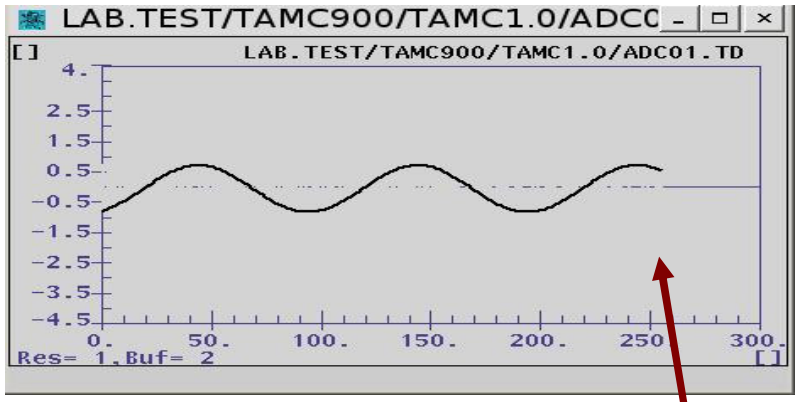
DOOCS TCA Crate Server
automatic configuration from IPMI

IPMI over Enet

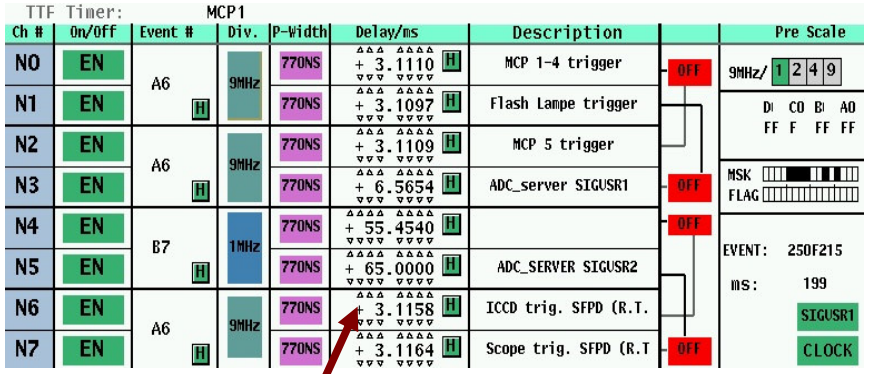


DOOCS integration

2 Mhz Sine wave sampled with 100 MHz



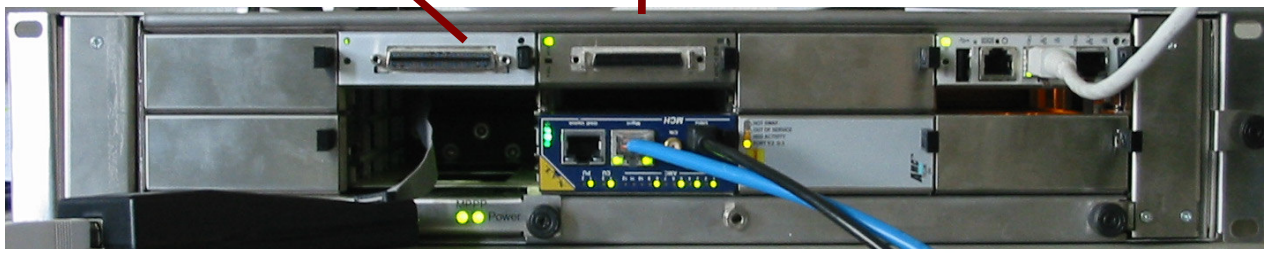
FLASH Timer Server



DOOCS ADC Server
Running on AMC CPU

DOOCS FLASH Timer Server

ADC data via PCI Express



Experience (Problems)

- **Modules are not enabled if IPMI returns wrong stuff**
  - e.g. protocol version 1.0 string (instead of 1.5 or 2.0)
- **Payload Power MUST be switchable**
  - Otherwise: MCH init and CPU booting conflict
- **Fan speed control important**
  - Especial for development crates on a desk
- **Backplane configuration not standard**
  - MCH, CPU and backplane must fit together
- **CPU should have network (PXE) boot feature**
  - Important for large installations
- **PCB with traces too close to the edge can be destroyed**
- **Dynamic configuration of PCIe**
  - OS driver handling; board with one lane was seen by CPU with 4 lanes

Experience (Pros)

- **Management of crates is well defined**
  - Dynamic module and crate info
  - Gives all relevant info
- **Fast data transfers (>400MB/s on 4 lanes PCIe)**
- **Hot-swap**
  - hardware is controlled by the MCH - **great!**
  - software reconfiguration of OS PCIe drivers to be done
- **Good decoupling of modules on the backplane**
- **Good analog performance**

Thank you