

# xTCA for XFEL

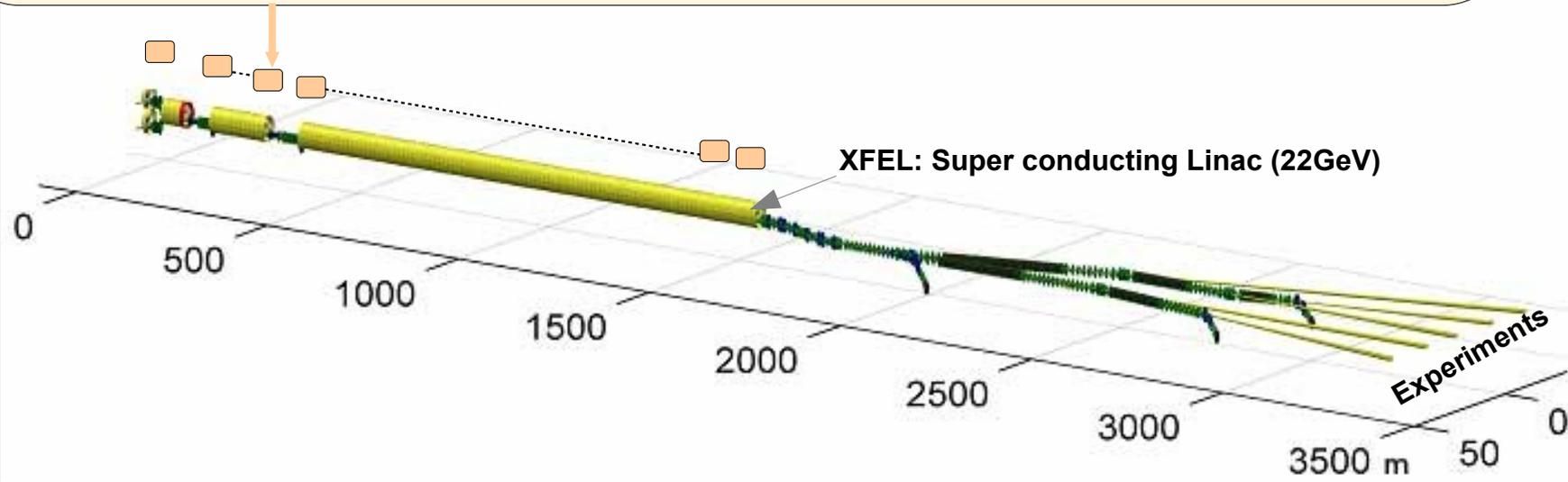
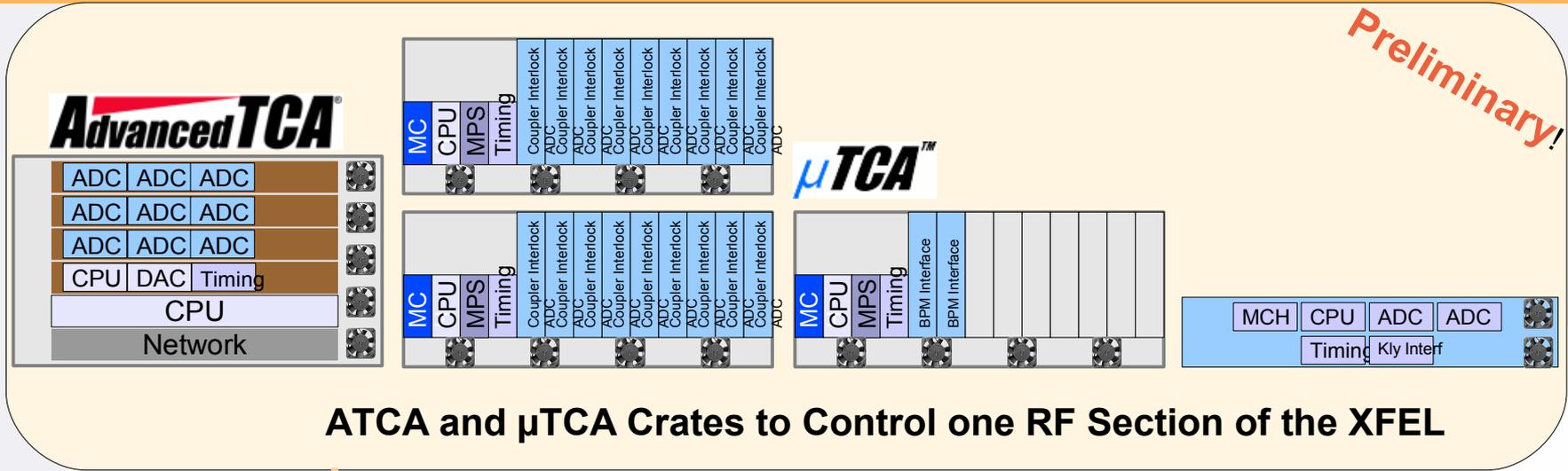
- XFEL
- $\mu$ TCA Evaluation
- $\mu$ TCA Developments
- Experience
- Outlook

**Kay Rehlich**

# Evaluation of ATCA and $\mu$ TCA

- **Trying crates and modules from different manufacturers**
  - ➔ Is it a 'standard' ?
  - ➔ Learn to specify the final system
- **Design of hardware (AMC)**
  - ➔ Can one understand and implement the specs?
  - ➔ Is the analog (ADC) performance sufficient?
- **Design of software**
  - ➔ FPGA code (PCIe, DMA, interrupts, device specific,...)
  - ➔ Device drivers for LINUX and Solaris (incl. Interrupts and DMA)
  - ➔ IPMI code for the MMC
  - ➔ System management
  - ➔ Control system integration (DOOCS)
- **ATCA evaluation by the XFEL LLRF group**

# Geographical Layout of RF Stations



# μTCA Evaluation: Crates

12 slot

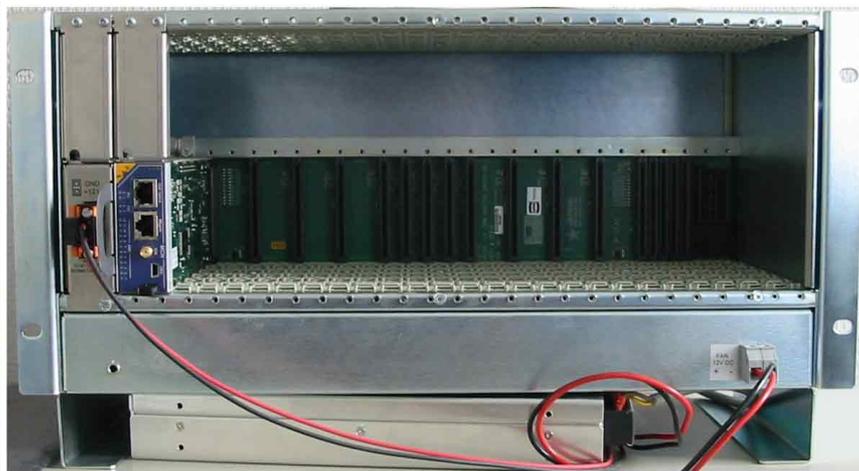
4 slot

8 slot low cost with active backplane

double size:

12 slot

6 slot



# $\mu$ TCA Evaluation: Crates (2)

6 slot low cost with active backplane



double and single size:

@FE  
12 slot

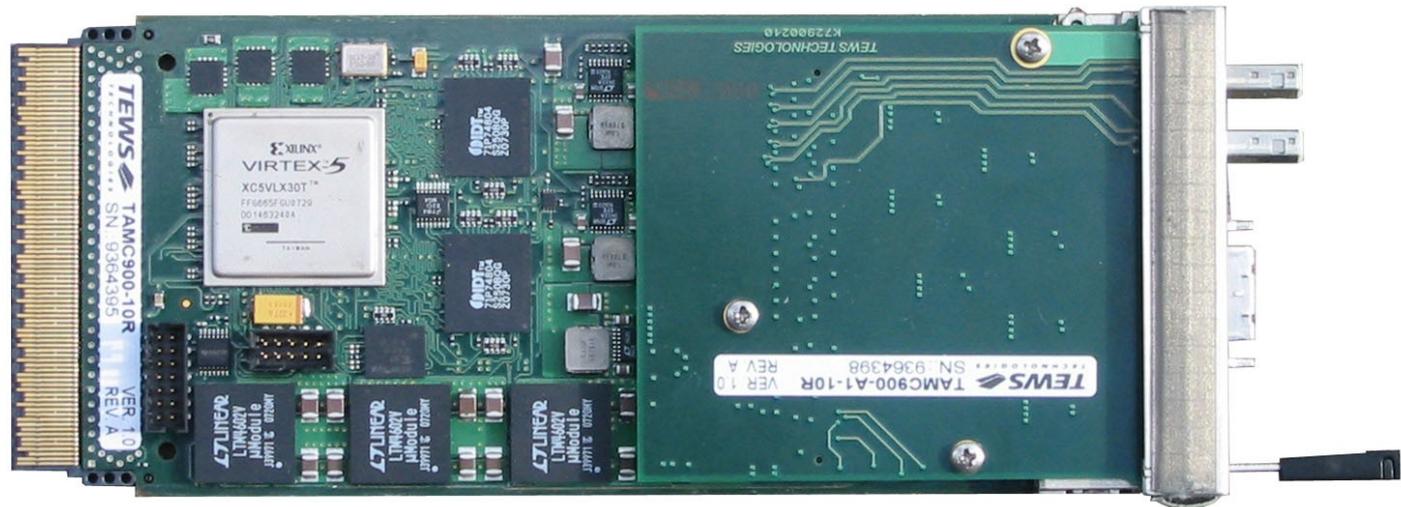
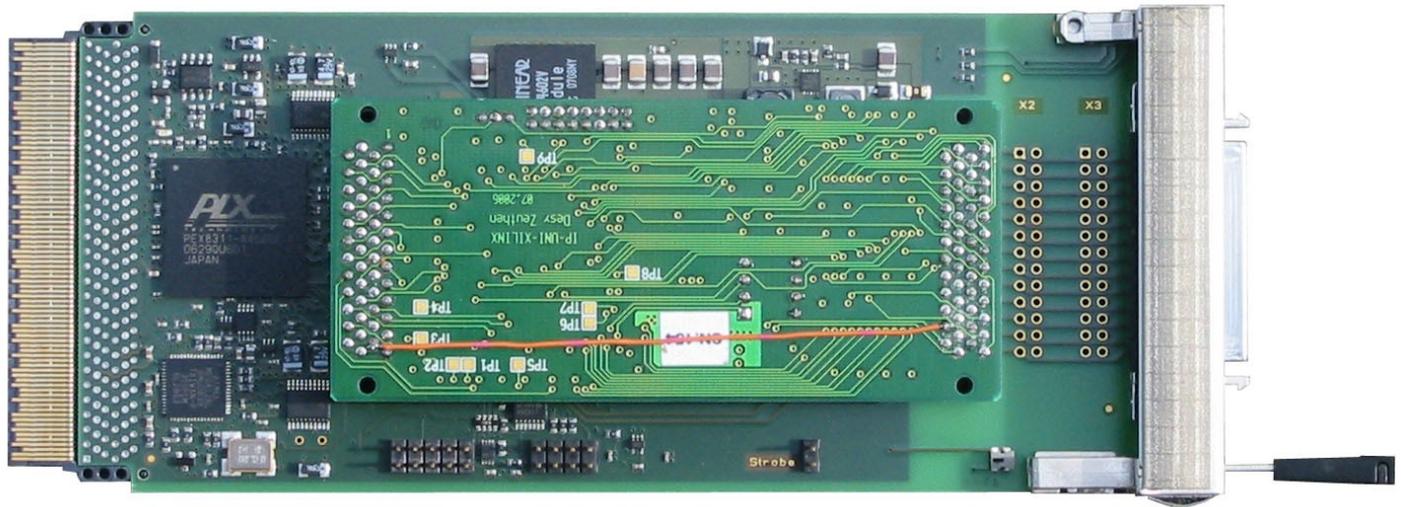


# AMC I/O Module Evaluation

IP carrier to connect e.g. legacy FLASH timing

A solution to connect IO to  $\mu$ TCA

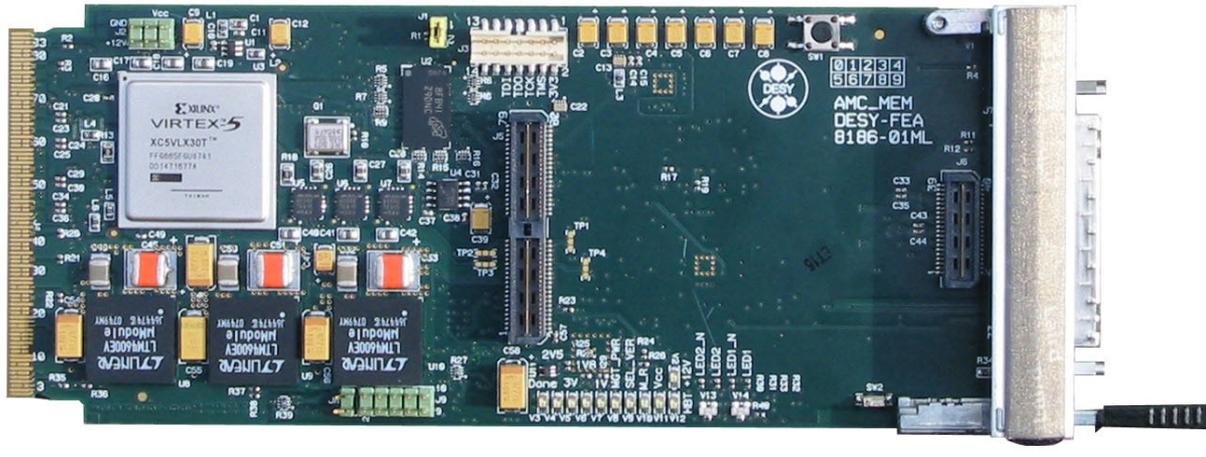
ADC:  
8 channel  
100 MHz  
14 bit,  
design contract with Tews



# AMC CPU/Disk Evaluation

- Performance Technologies AMC111
  - 64bit AMD Turion, single core 2 GHz
  - LINUX (Debian), Open Solaris 11
- ADLINK AMC1000
  - 64bit Intel Core Duo, 1.5 GHz
  - LINUX (Debian)
- Disk Drives
  - SANBlaze
  - GE AMC Telum 200

# AMC Design Evaluation (DESY)



## Development of an 'universal' AMC module

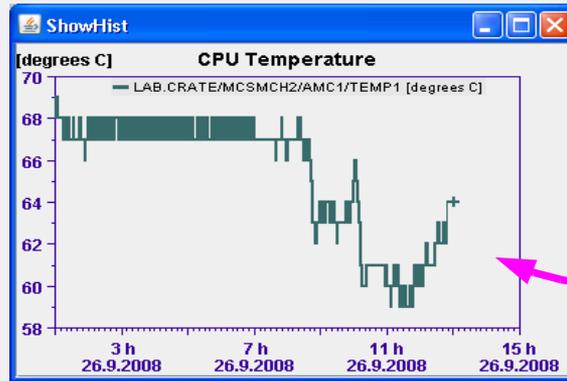
- ➔ Hardware design with Virtex5 and 256MB DDR2 SRAM (1GB/s)
- ➔ FPGA code development with PCIe interface and DMA
  - 370 MB/s into user space (128byte payload size)
- ➔ DOOCS server and OS driver
- ➔ IPMI code for 'Module Management Controller' (Atmega-128)
- ➔ Piggyback with 2 ADC and 2 DAC channels,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

# IPMI Developments

- **IMPI code on Atmel-128**
  - ➔ Implements version 1.5 functions
  - ➔ FPGA code loading in preparation
- **IPMI control system integration**
  - ➔ Control System server for ATCA,  $\mu$ TCA 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)

# IPMI: Dynamic Crate View via DOOCS

All values of the modules are accessible from the control system



**schroff\_4Slot.xml**  
**Schroff 4 Slot** **LAB.CRATE/MCSMCH2/**  
fail ack fail ack fail ack  
CPU AMC 1000 63.0 swap  
Disk 32.0 swap  
DESY AMC 01 26.0 swap  
NAT-MCH 40.0  
Uplink Mgmt Clk DBG  
Power Unit Temp.: 30.00 degrees C  
Crate Show Messages

Created by a graphical editor 'jddd', one drawing per crate, one per AMC module

**crate\_pTCA.xml**  
**PicoTCA Crate** **LAB.CRATE/MCSMCH1/**  
AMC 9 AMC 5 AMC 3 AMC 7 AMC 1  
DESY AMC01 fail TAMC 100 fail CPU AMC 111 fail  
swap ack swap ack swap  
AMC 10 AMC 6 AMC 4 MCH NAT-MCH  
DBG Clk Mgmt Uplink  
Unknown Module  
AMC 11 AMC 2  
AMC 12  
Power Unit Voltage: 3.54 11.90  
Temperature: 30.00 30.00  
Cooling Unit Fan Speed: 87.00 83.00  
Temperature: 12.00 11.00 27.00  
Info

# jddd Editor: Example to Create AMC Component

Elements for individual AMC modules

Library element with LED status common to all modules

**Component Inspector**

EditorPanel

- Switch1
  - X= TAMC900
    - Rect3
    - Rect2
    - Rect1
    - Label5
    - IncludeCompone
  - X= AMC111
    - Label5
    - Label4
    - Label3
    - Label2
    - Rect5
    - Rect1
    - Rect3
    - Label1
    - Rect4
    - IncludeCompone
  - X= AMC1000
  - X= AMC100
    - Label1
    - Label5
    - Label4
    - Label3
    - Label2
    - Rect3
    - IncludeCompone
  - X= DAMC-01
  - X= DESY-AMC1

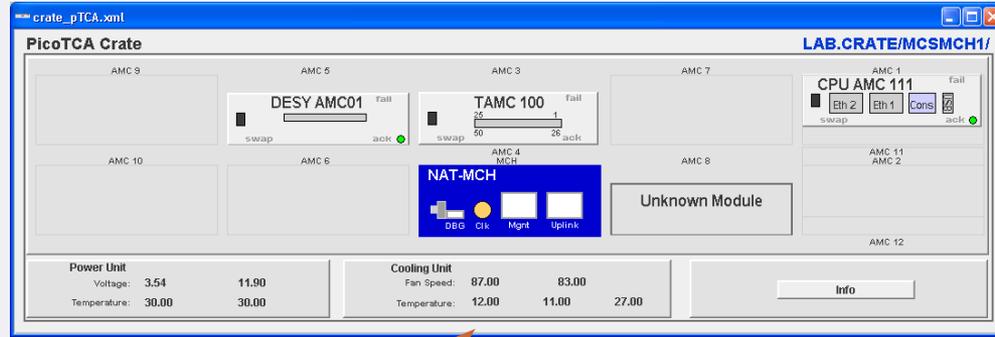
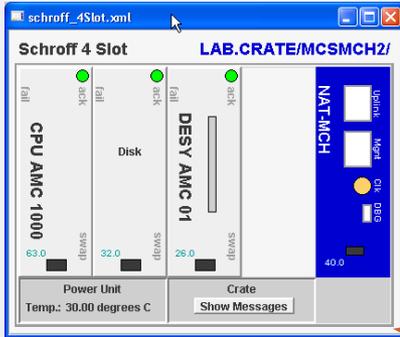
**Component Palette**

- LayeredPane
- TabbedPane
  - Tab
- IncludeComponent
- DynamicList
- Alive
- Static Components**
  - Label
  - Line
  - Oval
  - Rectangle
  - Triangle
  - Icon
- Dynamic Components**
  - Button
  - ToggleButton
  - Value

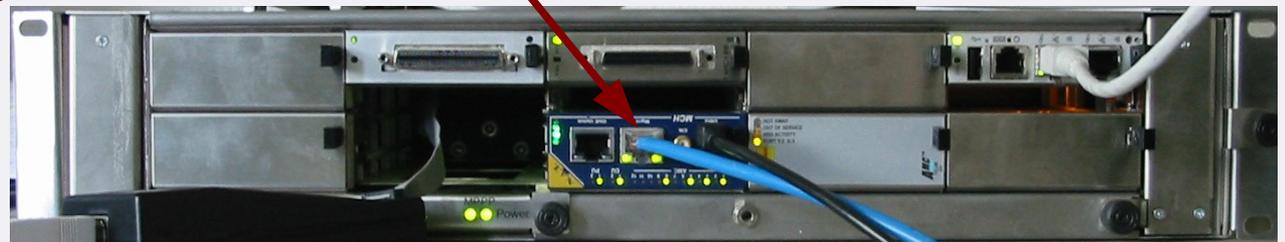
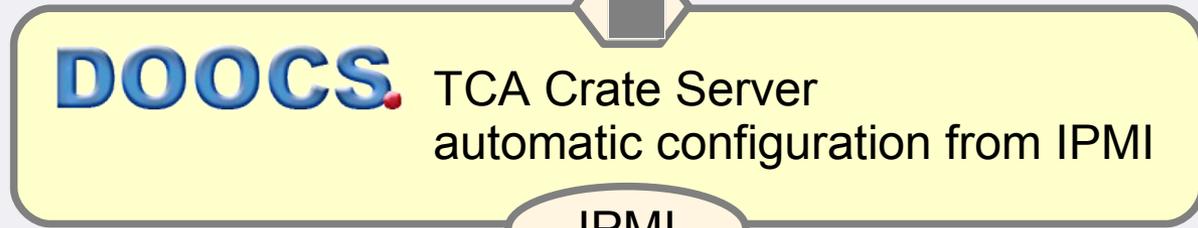
**Label5 - Properties**

Property	Value
name	Label5
text	TAMC 900
textColor	[51,51,51]
textFont	Dialog, 1, 18
bgColor	[238,238,238]
bgTranspa...	<input checked="" type="checkbox"/>
toolTipText	
clipX	2
clipY	2
rotate	0
alignX	CENTER

# DOOCS Integration: Software Architecture



jddd  
JAVA Application



# DOOCS Tools to Access Crate Information

Tree: displays all values of the control system

**Dynamic List of Modules Sensors**

**Dynamic creation of data archives**

**LAB.CRATE/MCSMCH1/AMC1/VOLT1.HIST**

**Voltages in DESY AMC01**

Time (h)	VOLT1 [Volts]	VOLT3 [Volts]	VOLT4 [Volts]	VOLT5 [Volts]	VOLT2 [Volts]	VOLT6 [Volts]
2	~4.5	~1.2	~1.2	~1.2	~1.2	~1.2
6	~4.5	~1.2	~1.2	~1.2	~1.2	~1.2
10	~4.5	~1.2	~1.2	~1.2	~1.2	~1.2
14	~4.5	~1.2	~1.2	~1.2	~1.2	~1.2

**LAB.CRATE/MCSMCH1/AMC1/TEMP1.HIST**

**Temperatures in DESY AMC01**

Time (h)	TEMP1 [degrees C]	TEMP2 [degrees C]
4	~45	~38
8	~45	~38
12	~45	~38
16	~45	~38

# Experience (Problems)

- **Modules are not enabled if MMC 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**
  - ➔ Especially for crates on a developer 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 as 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)
  - ➔ **Solaris supports hot-swap in driver**
- **Good decoupling of modules on the backplane**
- **Good analog performance**

# Wish List

- **Definition of 'Standard Crate(s)'**
  - ➔ AMC board sizes, PCIe ...
  - ➔ Backplanes, power, fans
- **PCIe with multiple CPUs**
- **Power supplies replaceable from front**
- **FPGA code loadable via IPMI**
- **Radiation tolerance of MMC**
- **Redundant power and cooling**
- **IPMI commands to switch off a crate or a module**
- **Software standards**
  - ➔ Interface between FPGA and OS driver

# Next Development Steps

- **Design of a ps stable timing AMC module**
  - ➔ Collaboration with Stockholm University
- **Design of a Machine Protection System**
  - ➔ Distributed fast hardware interlock
  - ➔ Coupler interlock
- **BPM interfacing to AMC**
- **Double size AMC with two piggybacks**
- **400MHz ADC piggyback**
- **Laser diode driver**
- **Test of a system in the accelerator FLASH**
- ...



## Conclusions incl. Dresden Workshop

- **We did it the hard way: crates, CPUs, IO and MCH from different vendors work together**
  - ➔ Very good experience with support from companies
- **Successful design of an AMC FPGA module with ADC**
- **Software integration of components:**
  - ➔ IPMI, FPGA, driver and control system
- **μTCA standard should consolidate more**
  - ➔ The specs are made for customized solutions, we want COTS
- **ATCA and μTCA covers with one technology a wide range from low cost to high performance systems**
- **xTCA platform is a good basis for large installations**
- **growing number of vendors and modules**