xTCA for XFEL

- XFEL
- µTCA Evaluation
- µTCA Developments
- Experience
- Outlook

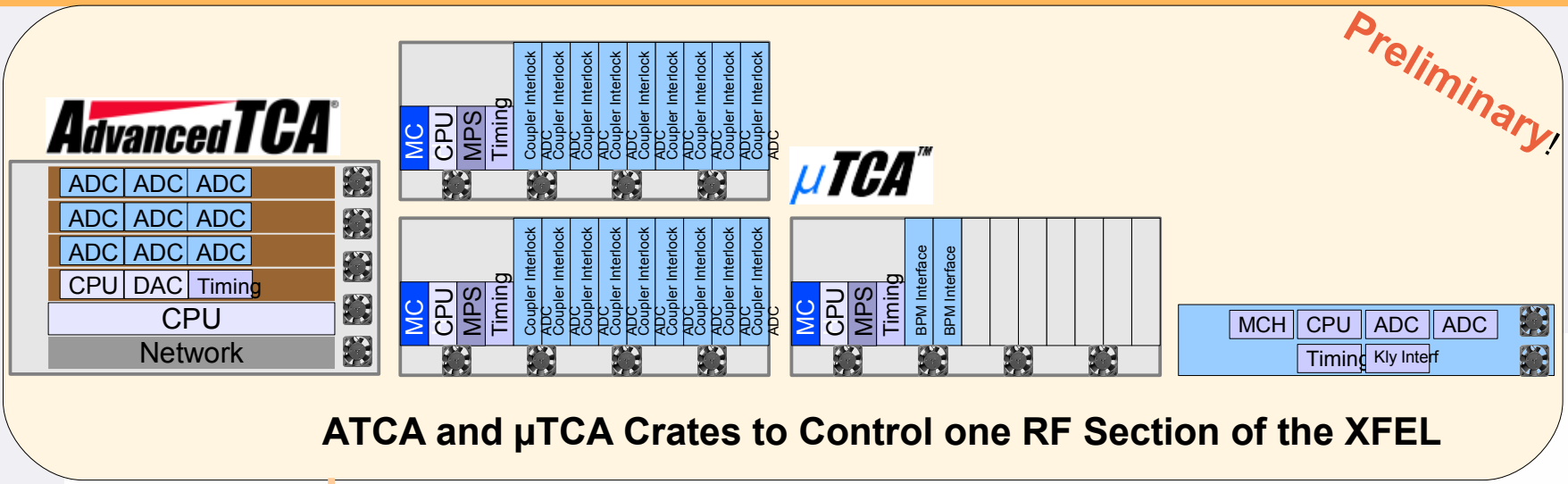
Kay Rehlich

EDMS Nr.: D0000001241061 Rev: A Ver: 1 Status: Released Dat.: 17.11.2008

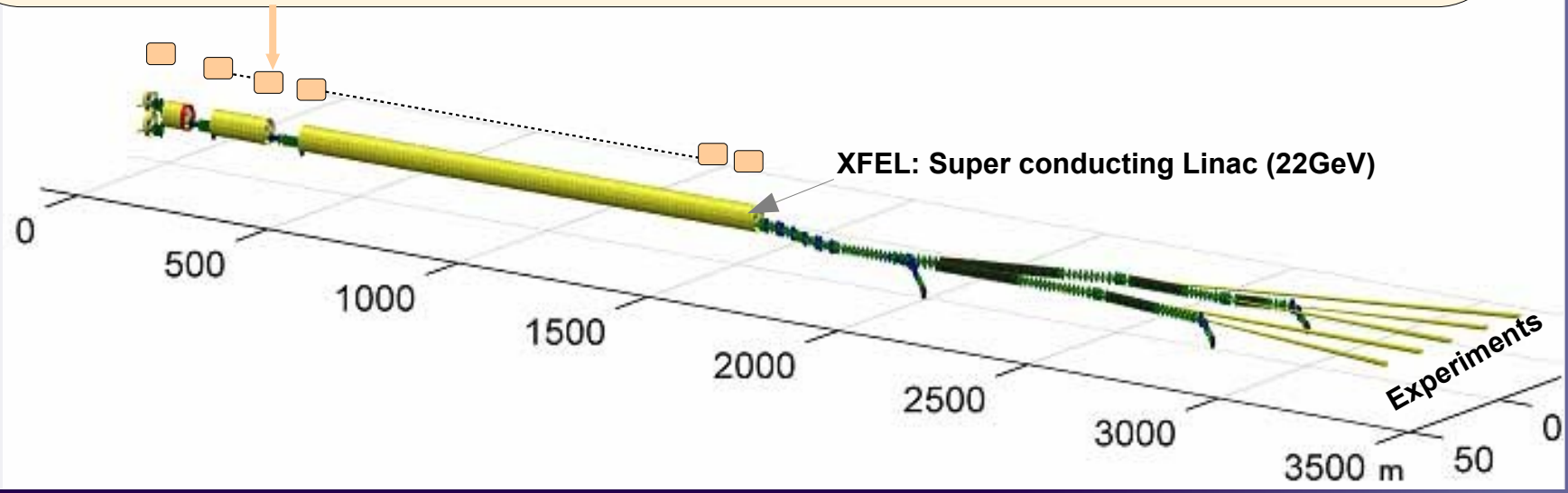
Evaluation of ATCA and µTCA

- **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



ATCA and µTCA Crates to Control one RF Section of the XFEL



µTCA Evaluation: Crates

12 slot

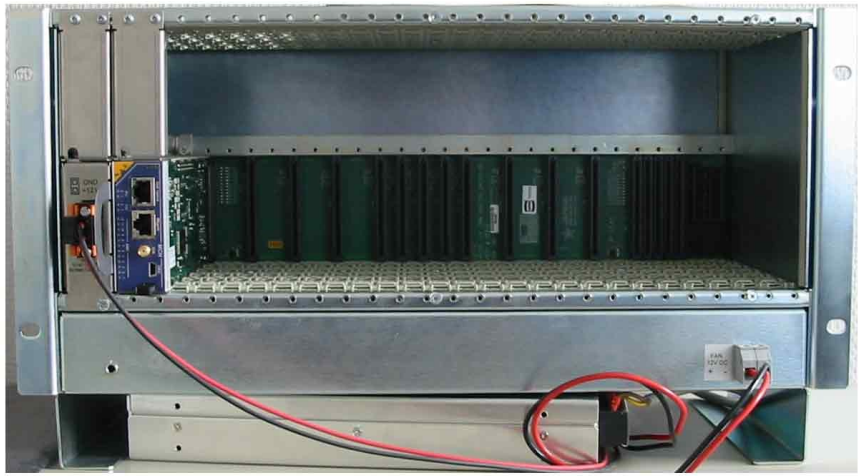
4 slot

8 slot low cost with active backplane

double size:

12 slot

6 slot

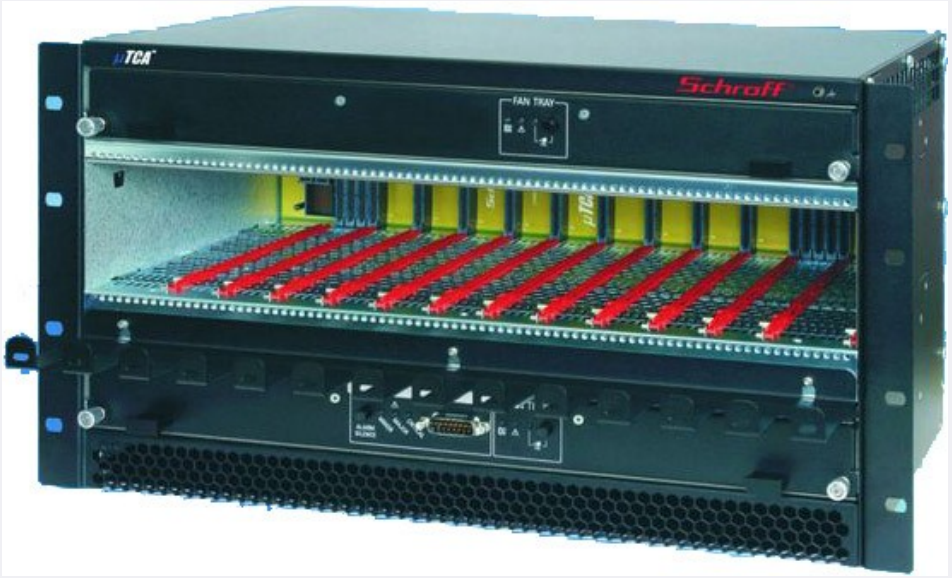


µTCA Evaluation: Crates (2)

6 slot low cost with active backplane

double and single size:

@FE
12 slot

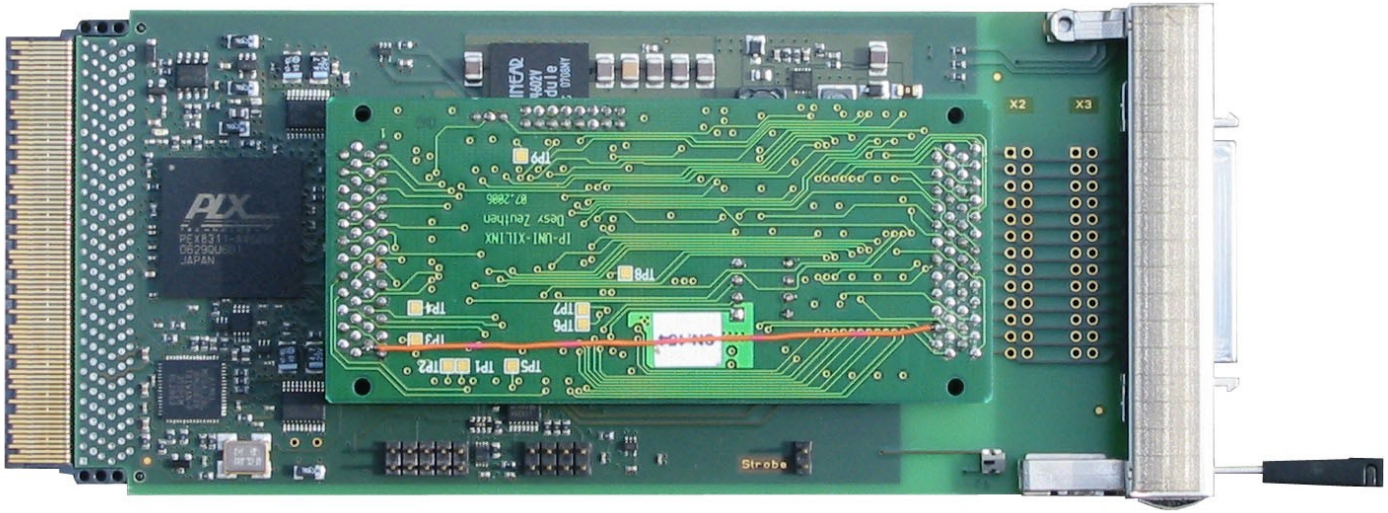


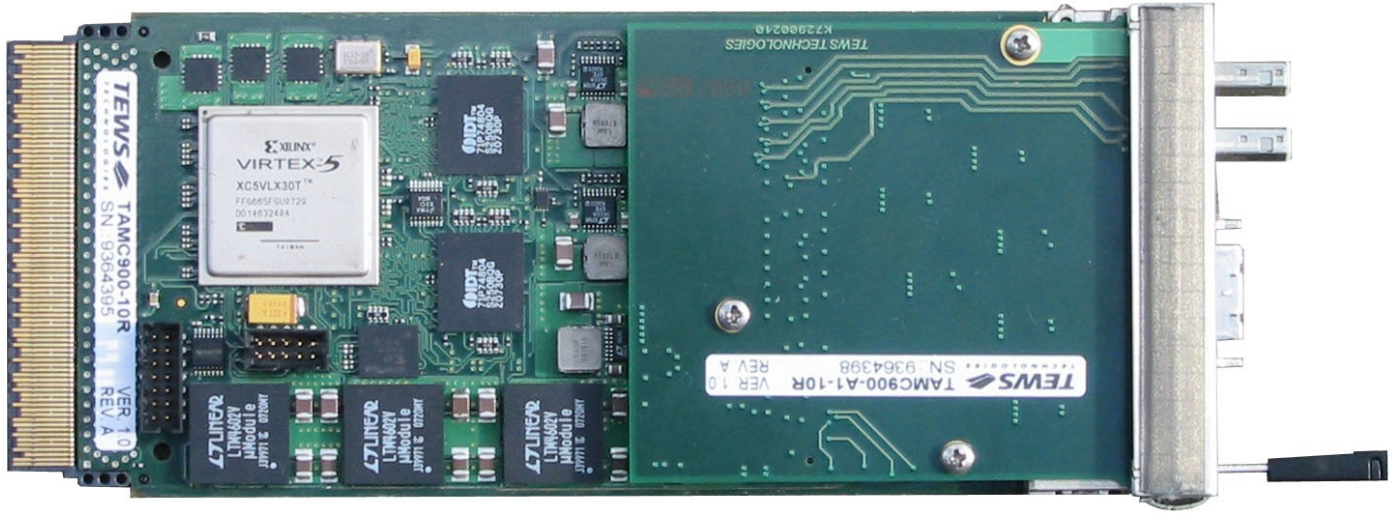
AMC I/O Module Evaluation

IP carrier to connect e.g. legacy FLASH timing

A solution to connect IO to µTCA

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



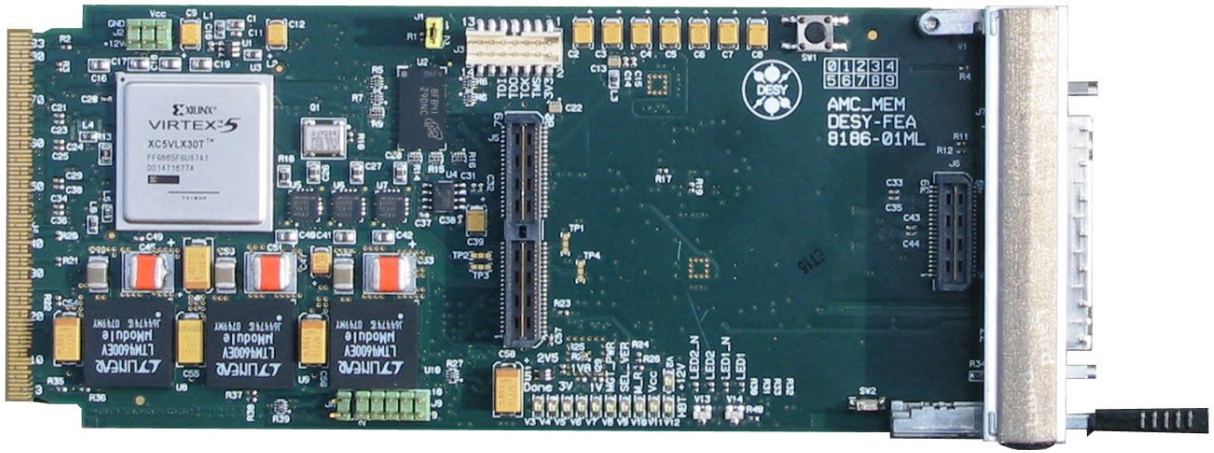


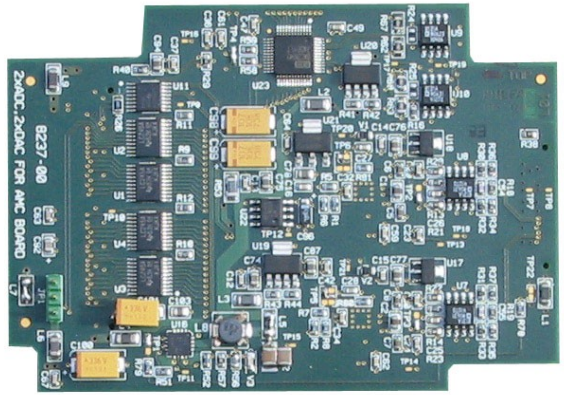
AMC CPU/Disk Evaluation

- 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

EDMS Nr.: D0000000241061 Rev: A Ver: 1 Status: Released Dat.: 17.11.2008

AMC Design Evaluation (DESY)





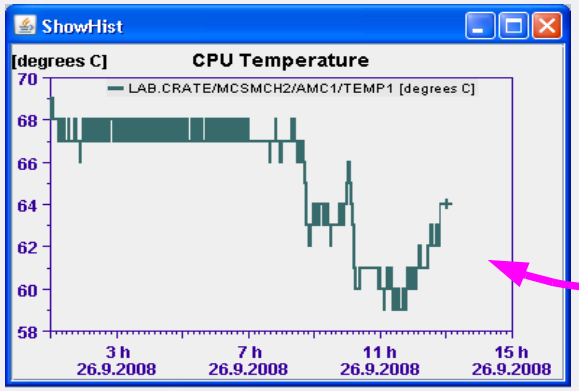
- **Development of an 'universal' AMC module**
  - Hardware design with Virtex5 and 256MB DDR2 SRAM (1GB/s)
  - FPGA code development with PCIe interface and DMA
    - 370 MB/s into user space (128byte payload size)
  - DOOCS server and OS driver
  - IPMI code for 'Module Management Controller' (Atmega-128)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

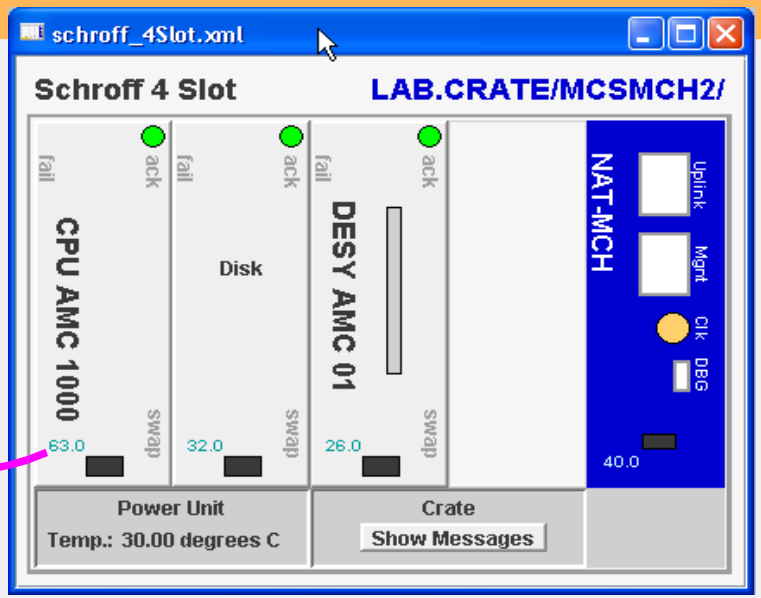
IPMI Developments

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

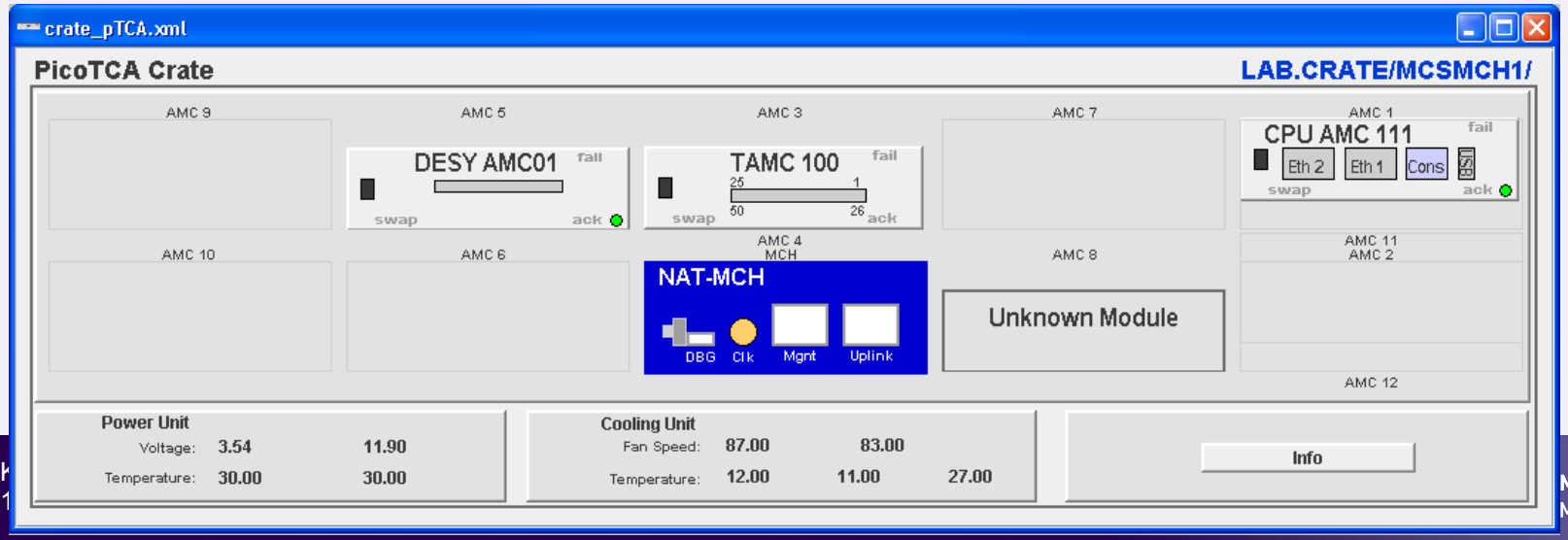
IPMI: Dynamic Crate View via DOOCS

All values of the modules are accessible from the control system





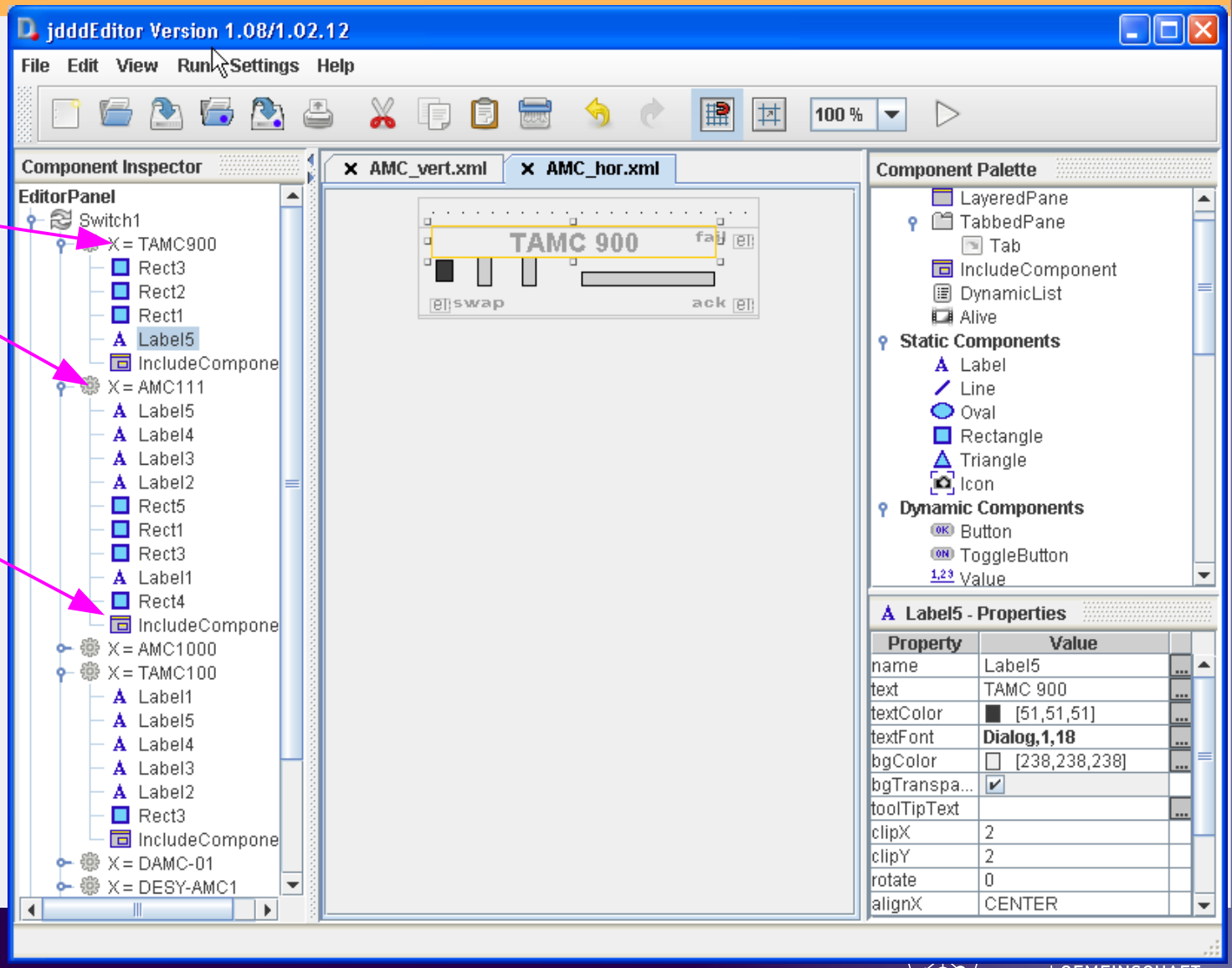
Created by a graphical editor 'jddd', one drawing per crate, one per AMC module



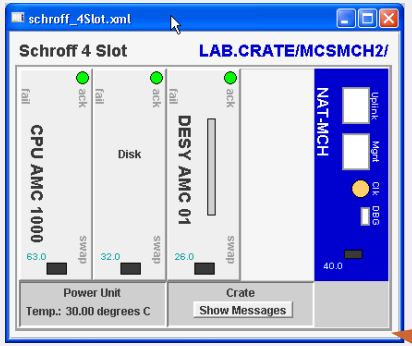
jddd Editor: Example to Create AMC Component

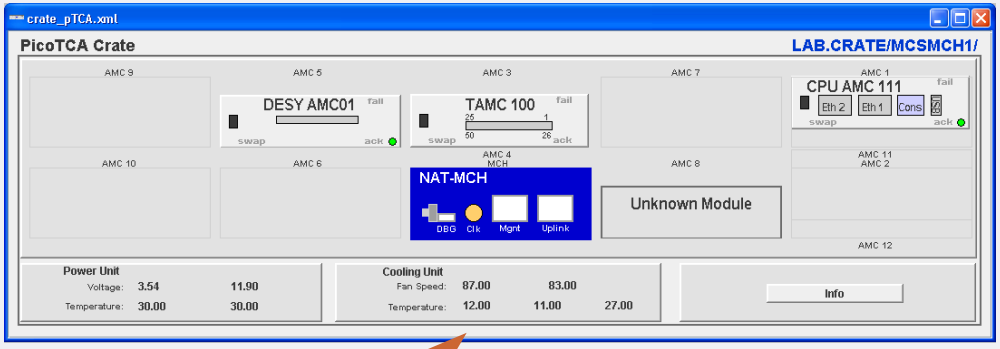
Elements for individual AMC modules

Library element with LED status common to all modules



DOOCS Integration: Software Architecture



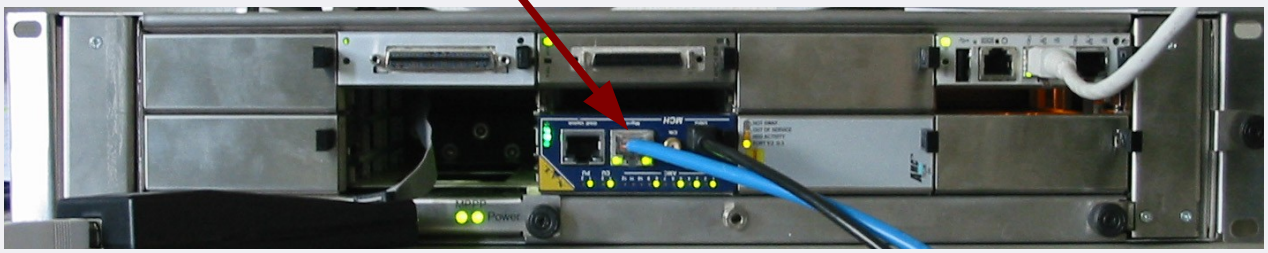


jddd

JAVA Application

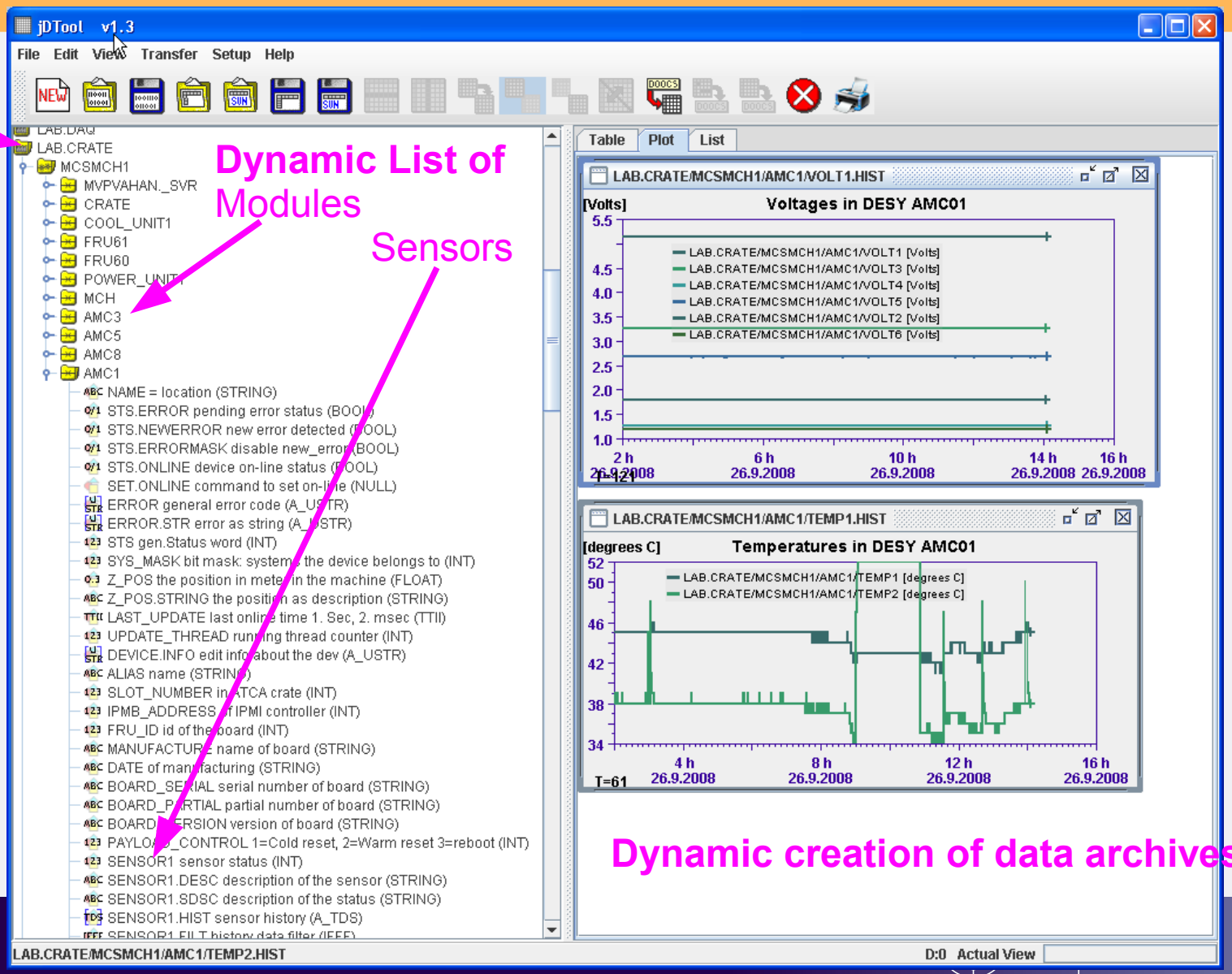
DOOCS TCA Crate Server
automatic configuration from IPMI

IPMI



DOOCS Tools to Access Crate Information

Tree: displays all values of the control system



EDMS Nr.: D0000001241061 Rev: A Ver: 1 Status: Released Dat.: 17.11.2008

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