

# Detector control system for the EMC

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RUHR  
UNIVERSITÄT  
BOCHUM

**RUB**

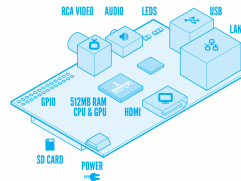
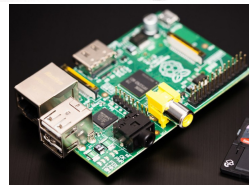
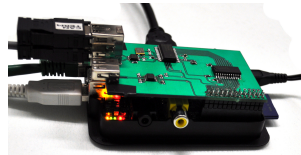


# PANDA slow control standards

- CAN bus should be used for all slow control devices
- Chosen as bus system for PANDA DCS
- Two-wire data bus (differential signaling), data rate up to 1 Mbps
- Most devices of the EMC DCS use CAN bus
- Drivers read out CAN devices and feed the data to EPICS
- EPICS distributes the data to operator interfaces, alarm systems, archive engines, etc.

# RaspberryPi CAN Readout

- Developed by Florian Feldbauer in Bochum and Mainz
- Based on RaspberryPi credit-card sized computer and custom adapter PCB for CAN bus
- One device in laboratory use in Bochum for several months
- More RasPi CAN interfaces currently rolled out
- EPICS drivers for iseg HV successfully tested
- Drivers for other components will be tested in the next weeks



# Temperature and Humidity Monitoring

- **Temperature and Humidity Monitoring Board for  $\bar{P}$ ANDA**
- Developed by Florian Feldbauer, Patrick Friedel, and Mario Fink at RUB during their Master/Diploma studies
- Lightweight solution to monitor environmental conditions:
  - Temperature (high precision)
  - Humidity
  - Air pressure
  - Flux in cooling tube
- Mountable close to/in the detector
- Generation 1 in use at Proto192 (FEMC) for > 3 years
- Gained lots of experience in these years
- Redesigned for final use in  $\bar{P}$ ANDA EMC  $\Rightarrow$  Generation 2
- Distribution to other groups when new RasPI CAN PCBs available

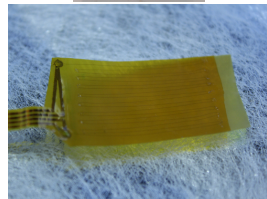
# The mainboard

- Powered by AT90CAN128  $\mu\text{C}$  (16 MHz)
- Connected via CAN bus
- Modular design:
  - Connectors for 8 piggyback boards (PBB)
  - Various types of PBBs for different tasks
- 8 channels per PBB  $\Rightarrow$  64 channels per THMP $\bar{P}$
- 14 bit ADC (Maxim MAX1148)
- Channels multiplexed to ADC
- Low power consumption ( $< 3 \text{ W}$ )



# Temperature Piggyback Board

- Temperature measured by change of resistance of platinum
- Four-wire measurement
- Piggyback board drives a current of 1 mA
- Voltage drop over resistor (Pt100) is measured through separate wires
- Very precise measurement
- Independent of cable length
- Range  $-50^{\circ}\text{C}$  to  $+50^{\circ}\text{C}$
- Resolution  $< 0.05\text{ K}$

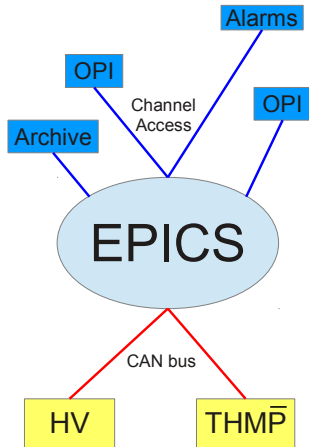


## Other Piggyback Boards

- Humidity (HIH-4000) and pressure (MPX4115A)
  - Same four-wire cables as temperature sensors
  - One wire to power the sensor
  - One wire for readout
  - Two wires common ground
  - Sensor response fed to ADC
- I/O board (planned):
  - Generic communication interface for e.g. relays, end-point switches, safety loops etc.
  - Remote-controllable using the CAN bus of the THMP $\bar{P}$
- Generic interface for new PBB types:
  - New types of PBB without changes to the mainboard
  - PBBs can provide up to 4 V to the ADC
  - Two-wire interface (I<sup>2</sup>C) for direct communication with the  $\mu$ C  
⇒ may need firmware extension

# Control System Studio

- Developed by DESY, SNS, BNL and others
- Based on Eclipse Indigo RCP
- Three main applications:
  - GUI with operator interfaces
  - Archive Engine
  - Alarm Server
- Communicates with EPICS via network (Channel Access)





# Operator Interfaces

CSS -@hndcap01-

File Edit CSS Window Help

100%

OPI Runtime

Main Cooling Power Supply VME Crate Light Pulsar Power Supply Control

**panda** Slow Control PROTO192 - Power Supply

ON

HV Control Panel **EMERGENCY OFF**

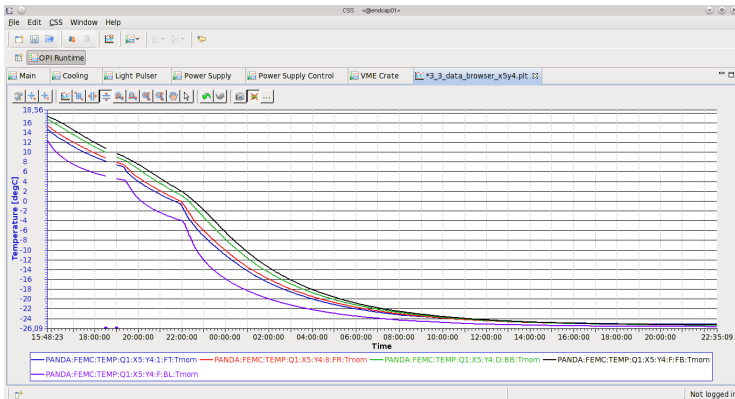
### HV for Photo Detectors

Module	Temperature	Channel	Vmnom	Imnom
Module 0	25,71 degC	Ch0	185,0 V	0,0274 uA
		Ch1	22,2 V	7,969,1140 uA
		Ch2	185,0 V	0,0008 uA
		Ch3	185,0 V	0,0018 uA
		Ch4	185,0 V	0,0011 uA
		Ch5	185,0 V	0,0010 uA
		Ch6	185,0 V	0,0013 uA
		Ch7	184,9 V	0,0014 uA
Module 1	26,14 degC	Ch0	185,0 V	0,0018 uA
		Ch1	185,1 V	0,0017 uA
		Ch2	185,0 V	0,0023 uA
		Ch3	184,9 V	0,0011 uA
		Ch4	185,1 V	0,0004 uA
		Ch5	185,0 V	0,0012 uA
		Ch6	185,0 V	0,0005 uA
		Ch7	185,0 V	0,0007 uA
Module 2	26,01 degC	Ch0	185,0 V	0,0025 uA
		Ch1	184,9 V	0,0019 uA
		Ch2	184,9 V	0,0011 uA
		Ch3	184,9 V	0,0010 uA
		Ch4	184,9 V	-0,0004 uA
		Ch5	185,0 V	0,0001 uA
		Ch6	184,9 V	0,0010 uA
		Ch7	185,0 V	0,0007 uA
Module 3	26,00 degC	Ch0	185,0 V	0,0016 uA
		Ch1	185,0 V	0,0019 uA
		Ch2	185,1 V	0,0017 uA
		Ch3	185,0 V	0,0015 uA
		Ch4	185,0 V	0,0009 uA
		Ch5	185,0 V	0,0003 uA
		Ch6	185,0 V	0,0007 uA
		Ch7	185,0 V	0,0010 uA
Module 4	28,89 degC	Ch0	190,0 V	0,0018 uA
		Ch1	190,0 V	0,0009 uA
		Ch2	189,9 V	0,0010 uA
		Ch3	190,0 V	0,0010 uA
		Ch4	189,9 V	0,0009 uA
		Ch5	190,0 V	0,0001 uA
		Ch6	190,1 V	0,0015 uA
		Ch7	190,0 V	0,0018 uA
Module 5	26,60 degC	Ch0	1.200,0 V	43,2016 uA
		Ch1	1.200,0 V	100,3461 uA
		Ch2	1.200,0 V	100,2382 uA
		Ch3	1.200,0 V	100,4239 uA
		Ch4	1.200,0 V	24,8961 uA
		Ch5	1.200,0 V	75,2471 uA
		Ch6	1.200,0 V	100,2353 uA
		Ch7	1.200,0 V	0,0003 uA
Module 6	27,39 degC	Ch0	1.000,0 V	134,2953 uA
		Ch1	1.000,0 V	94,2694 uA
		Ch2	1.000,0 V	93,8586 uA
		Ch3	1.000,0 V	94,0325 uA
		Ch4	1.000,0 V	133,4312 uA
		Ch5	1.000,0 V	134,1342 uA
		Ch6	1.000,0 V	134,6660 uA
		Ch7	1.000,0 V	133,9891 uA
Module 7	28,77 degC	Ch0	1.000,0 V	67,3239 uA
		Ch1	1.000,0 V	67,1514 uA
		Ch2	1.000,0 V	67,0117 uA
		Ch3	1.000,0 V	67,0258 uA
		Ch4	0,0 V	0,0000 uA
		Ch5	0,3 V	0,0000 uA
		Ch6	0,1 V	0,0000 uA
		Ch7	0,2 V	0,0000 uA

Not logged in

# Archive Engine

- Background process
- Writes current data into database
- Data browser in CSS GUI to view data from archive



# Alarm Server

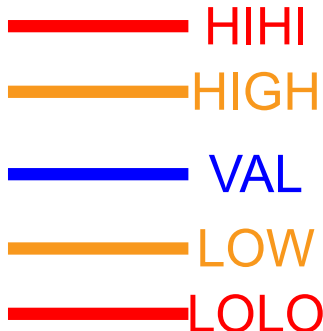
- Background process
- Monitors EPICS data for violation of alarm borders
- Notifies CSS GUIs and can take further action (e-mail etc.)
- Several GUIs in CSS to display alarm states

The screenshot shows a window titled "Alarm Tree" with a dropdown menu set to "proto192". The tree structure is as follows:

- Area: ThinPTs
- Area: Front hull
- Area: Backplate
- Area: Other cooling
- Area: Humidity
- Area: Pressure
- Area: Flow
- Area: HV voltages (MAJOR/HIHI\_ALARM)**
  - PV: epics://PANDA:FEMC:HV:0:0:0:Vmom (MAJOR/HIHI\_ALARM)**
  - PV: epics://PANDA:FEMC:HV:0:0:1:Vmom
  - PV: epics://PANDA:FEMC:HV:0:0:2:Vmom
  - PV: epics://PANDA:FEMC:HV:0:0:3:Vmom (MINOR/HIGH\_ALARM)**
  - PV: epics://PANDA:FEMC:HV:0:0:4:Vmom
  - PV: epics://PANDA:FEMC:HV:0:0:5:Vmom
  - PV: epics://PANDA:FEMC:HV:0:0:6:Vmom
  - PV: epics://PANDA:FEMC:HV:0:0:7:Vmom
  - PV: epics://PANDA:FEMC:HV:0:1:0:Vmom
  - PV: epics://PANDA:FEMC:HV:0:1:1:Vmom
  - PV: epics://PANDA:FEMC:HV:0:1:2:Vmom

## EPICS alarm borders

- Two upper (called “HIGH” and “HIHI”) and two lower borders (called “LOW” and “LOLO”) for each value in EPICS
  - Each border can be
    - “No Alarm”
    - “Minor Alarm”
    - “Major Alarm”
  - Alarm borders are plain double values, no relations etc. possible
- ⇒ Write application to read data from EPICS and set alarm borders



# New EPICS alarm software from Bochum

- Sets alarm borders for HV and temperature and current limits
- Three modes of operation:
  - Maintenance
  - Laboratory
  - Beamtime
- Data sources:
  - HV: Module type, detector type and current set voltage for HV
  - Temperature: Maximum and minimum chiller bath temperature within the last eight hours
- Built to be reusable by other groups

## Maintenance mode

- Maximum set voltage: Hardware limit of module
- Voltage HIGH limit: No limit
- Voltage HHI limit: No limit
- Voltage LOW limit: No limit
- Voltage LOLO limit: No limit
- Temperature HIGH limit: No limit
- Temperature HHI limit: No limit
- Temperature LOW limit: No limit
- Temperature LOLO limit: No limit

## Laboratory mode

- Maximum set voltage: 450 V for APDs, 1205 V for VPTTs
- Voltage HIGH limit:  $V_{\max}$
- Voltage HIHI limit:  $V_{\max} + 5 \text{ V}$
- Voltage LOW limit: No limit
- Voltage LOLO limit: No limit
- Temperature HIGH limit:  $T_{\max} + 2^\circ\text{C}$
- Temperature HIHI limit:  $T_{\max} + 3.5^\circ\text{C}$
- Temperature LOW limit:  $T_{\min} - 2^\circ\text{C}$
- Temperature LOLO limit:  $T_{\min} - 3.5^\circ\text{C}$

## Beamtime mode

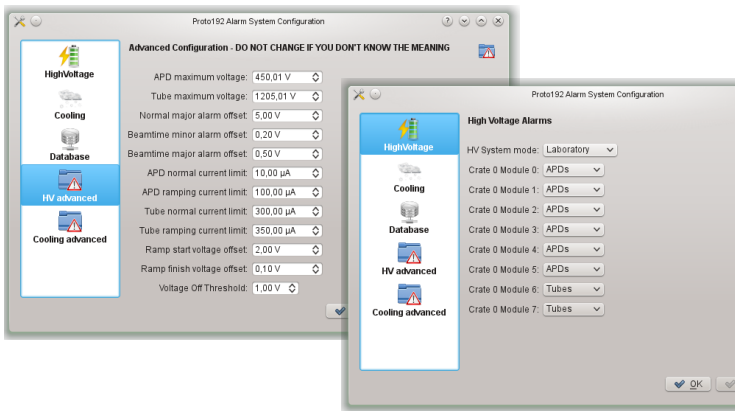
- Maximum set voltage: 450 V for APDs, 1205 V for VPTTs
- Voltage HIGH limit:  $V_{\text{set}} + 0.3 \text{ V}$
- Voltage HIHI limit:  $V_{\text{set}} + 0.8 \text{ V}$
- Voltage LOW limit:  $V_{\text{set}} - 0.3 \text{ V}$
- Voltage LOLO limit:  $V_{\text{set}} - 0.8 \text{ V}$
- Temperature HIGH limit:  $T_{\text{max}} + 2^\circ\text{C}$
- Temperature HIHI limit:  $T_{\text{max}} + 3.5^\circ\text{C}$
- Temperature LOW limit:  $T_{\text{min}} - 2^\circ\text{C}$
- Temperature LOLO limit:  $T_{\text{min}} - 3.5^\circ\text{C}$



## Current limits

- APD channels drain far more current while ramping
- Implementation based on the state machine concept
- Three states:
  - Stable
  - Ramping
  - Off
- Channel off if crate off and  $V_{\text{mom}} < 1 \text{ V}$
- Channel goes to ramping if  $|V_{\text{mom}} - V_{\text{set}}| > 2 \text{ V}$  or  $|V_{\text{set,new}} - V_{\text{set,old}}| > 2 \text{ V}$
- Channel goes to stable if  $|V_{\text{mom}} - V_{\text{set}}| \leq 0.5 \text{ V}$
- Current limits:
  - APDs: Stable  $100 \mu\text{A}$ , ramping  $200 \mu\text{A}$
  - VPTTs: Stable  $250 \mu\text{A}$ , ramping  $300 \mu\text{A}$

# Configurability



- All numbers on the previous slides configurable
- Daemon reacts on config file changes and updates alarm borders

# Application Structure

- Singleton class handling global EPICS resources (EpicsAccessManager)
- Common base class encapsulating all EPICS API calls (EpicsPVbase)
- Classes derived from EpicsPVbase for specific device types, e.g. EpicsHvModule
- Read and change every value, alarm border or severity
- Subscription to any value possible
- Classes for HV control can also be used in applications not dealing with alarm borders but requiring to control the HV

## Current users

- THMP $\bar{P}$  and EPICS/CSS DCS infrastructure already used by
  - Backward endcap group (Mainz)
  - Proto120 barrel prototype
  - Luminosity detector (Mainz)
  - Forward endcap tests in Bonn
  - EMC tests at KVI (Groningen)
- Toolchain ready to be used by other detector groups
- Final version of the THMP $\bar{P}$  available for the final endcap
- Software available in EP1 git repository (ask for access)
- If you have questions: Write me an e-mail

⇒ tobias@ep1.rub.de

## The End

Thank you for your attention!