FEMC DCS status and available devices for $\overline{\text{P}}$ANDA Slow Control

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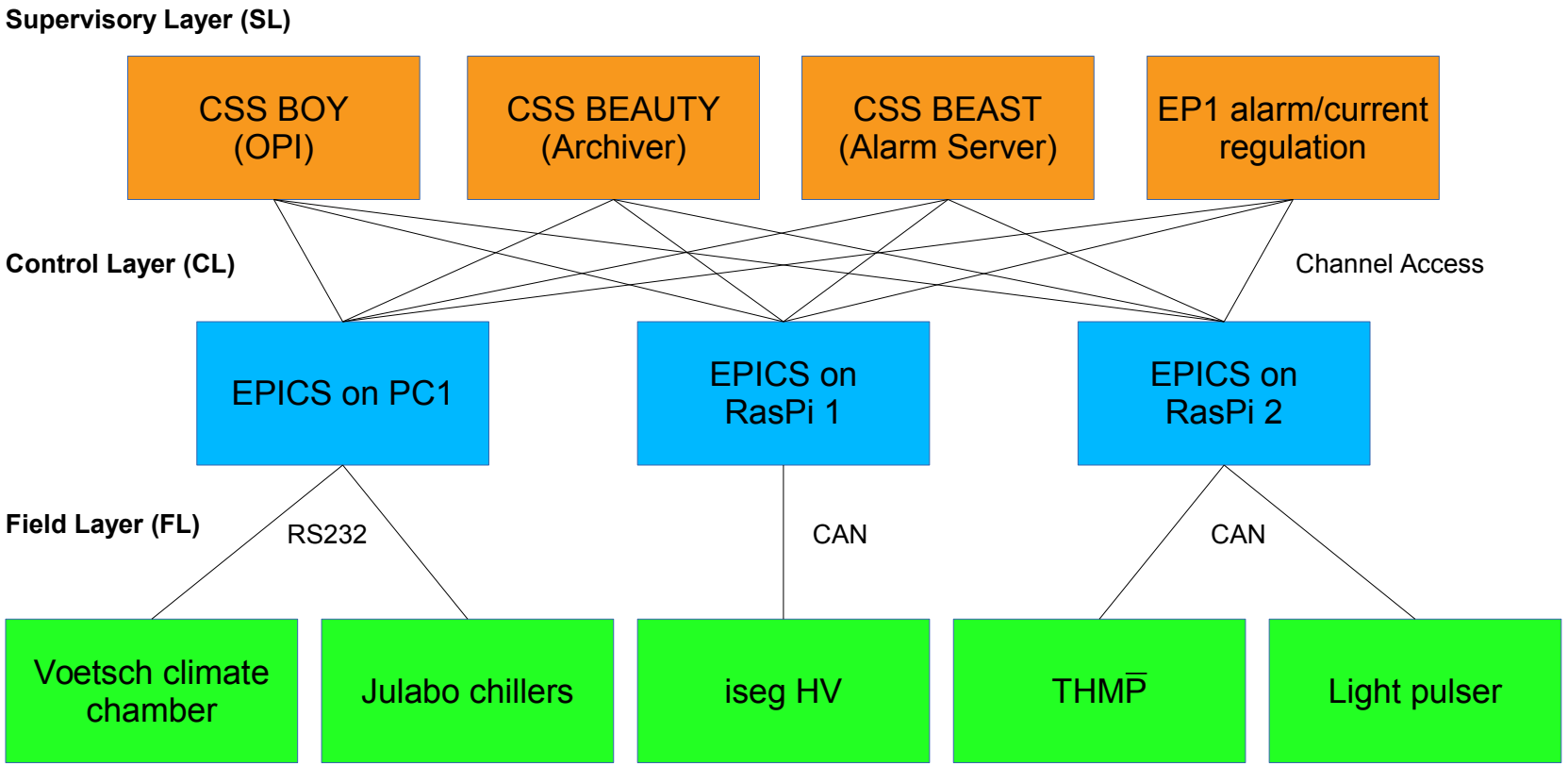
Slow Control for Forward Endcap calorimeter

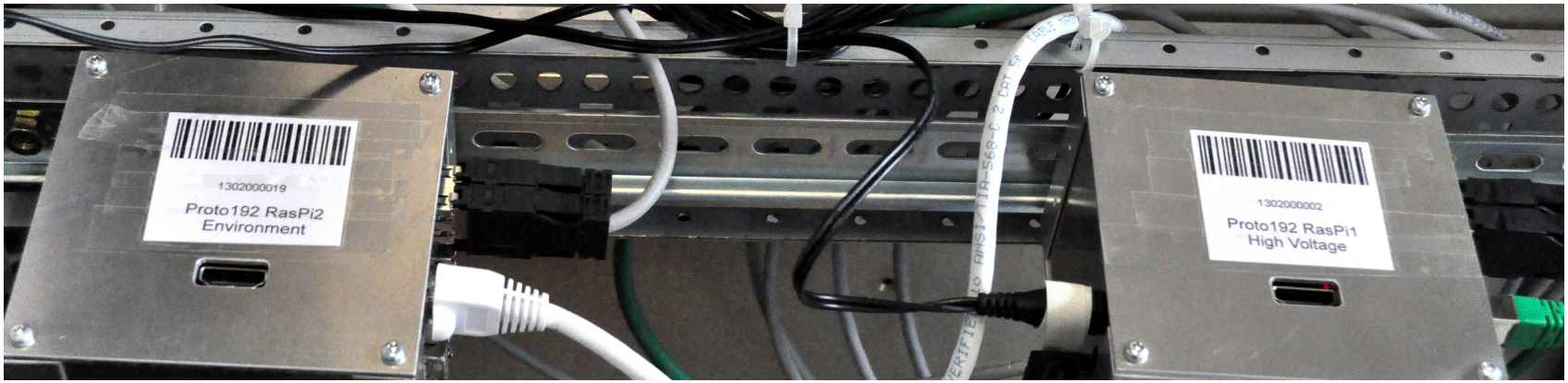
- Slow Control for FEMC developed by Bochum group
- Entirely based on EPICS and CSS
- Controlled devices at prototype "Proto192":
  - iseg high voltage power supplies
  - THM$\overline{\text{P}}$s and light pulser ($\Rightarrow$ second part)
  - Julabo chillers
  - VME crate
  - Voetsch climate chamber
  - Wiener low voltage power supply tested
- Self-developed drivers to operate devices with EPICS ($\Rightarrow$ second part)
- Additional software coupled to EPICS using the Channel Access protocol ($\Rightarrow$ more on that later)

FEMC/Proto192 DCS structure



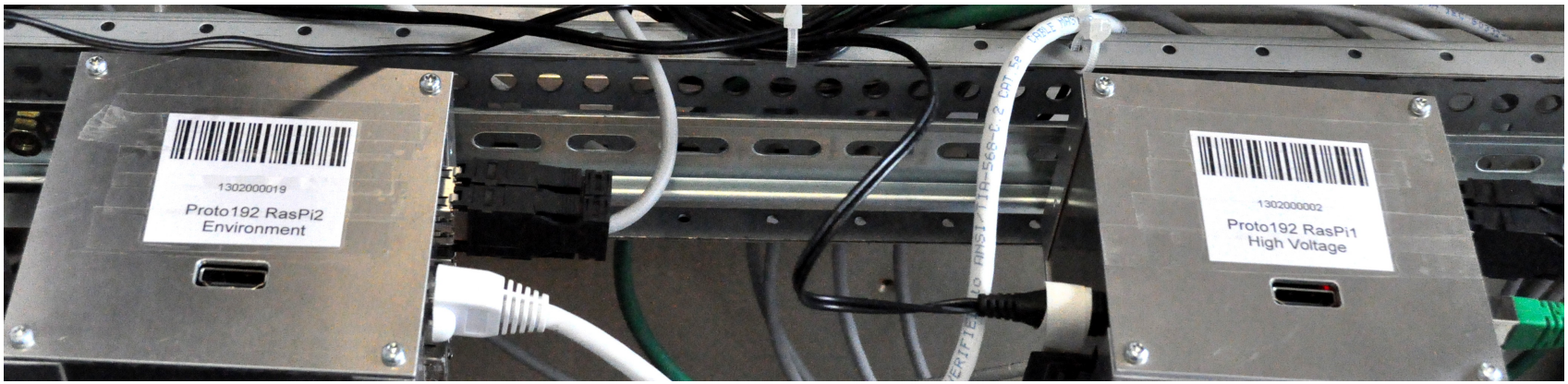
What happened since last DCS session? (1)

- New CAN controller based on Raspberry Pi rolled out
- Kernel driver for CAN interface tested
- EPICS drivers for hardware support debugged and in use
- Aluminium casings for RasPi/CAN and THM$\overline{\text{P}}$



What happened since last DCS session? (2)

- Created "virtual Proto192" (dummy IOC) for testing new Slow Control software
- Abstraction API for EPICS Channel Access to faciliate the development of e.g. APD screening programs



HV current and alarm border regulation

- Stand-alone C++ application
- Communicating with EPICS using Channel Access
- Software calculates and sets alarm borders according to current operational conditions
- HV current limits adapted to channels status (stable/ramping)

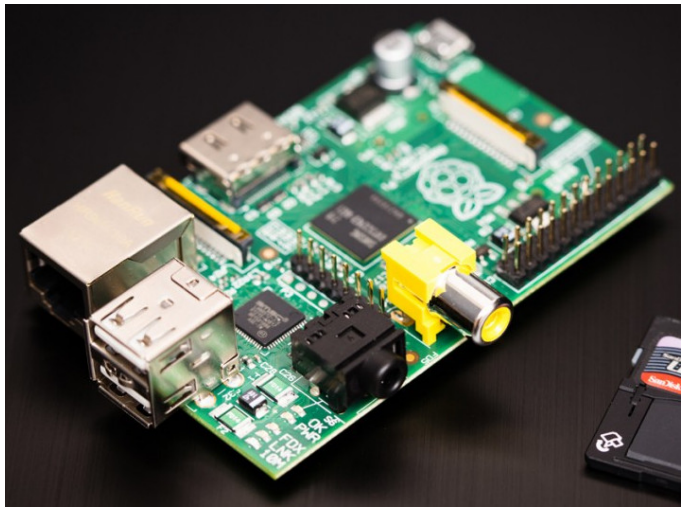
- Plan presented on XLV. Collaboration Meeting
- Used in production at Proto192 since 10 months

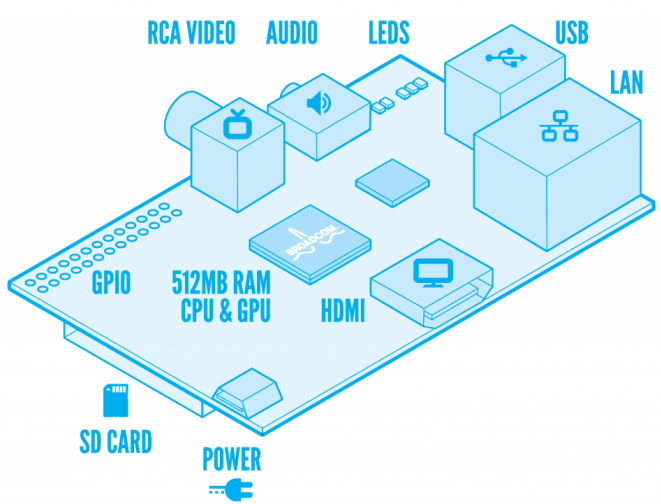
Generic Slow Control devices

- Standardization makes managing a large experiment with many participating groups easier
- Make devices and software developed for forward endcap EMC available to other groups
  - Avoid duplicated effort
  - Save money and time
  - Share experience
  - Reduce maintenance expenses
- Prime examples
  - Raspberry Pi with CAN bus interface
  - Temperature and Humidity Monitoring Board for $\overline{\text{P}}$ANDA (THM$\overline{\text{P}}$)
- Close cooperation between Bochum and Mainz groups

Raspberry Pi (Model B) [Control Layer]

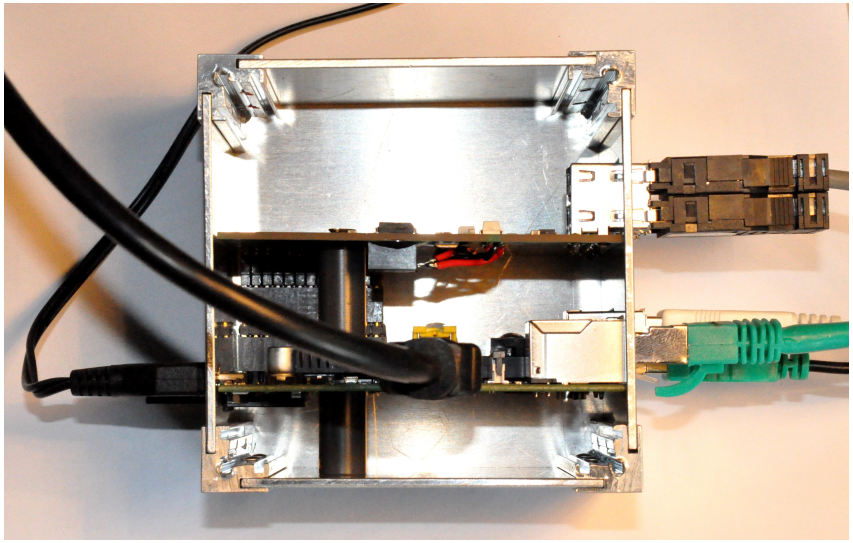
- Credit-card-sized single-board computer
- Powered by BCM2835 SoC
- ARMv6 CPU (800 MHz)
- 512 MB RAM
- Fast Ethernet NIC
- 2x USB 2.0
- HDMI and Composite monitor link
- SD card takes role of hard disk
- Supplied by Micro-USB (mobile phone charger)
- GPIO connectors





CAN adapter PCB for Raspberry Pi [CL]

- Connected to GPIO
- SJA1000 stand-alone CAN controller
- CAN bus chosen as standard bus for $\overline{\text{P}}$ANDA
- Galvanic insulation of CAN bus (optocoupler)
- Data throughput: $\sim 1000 \frac{\text{CAN frames}}{\text{s}}$ at baud rate 125 $\frac{\text{kbit}}{\text{s}}$
- Aluminium casing for shielding

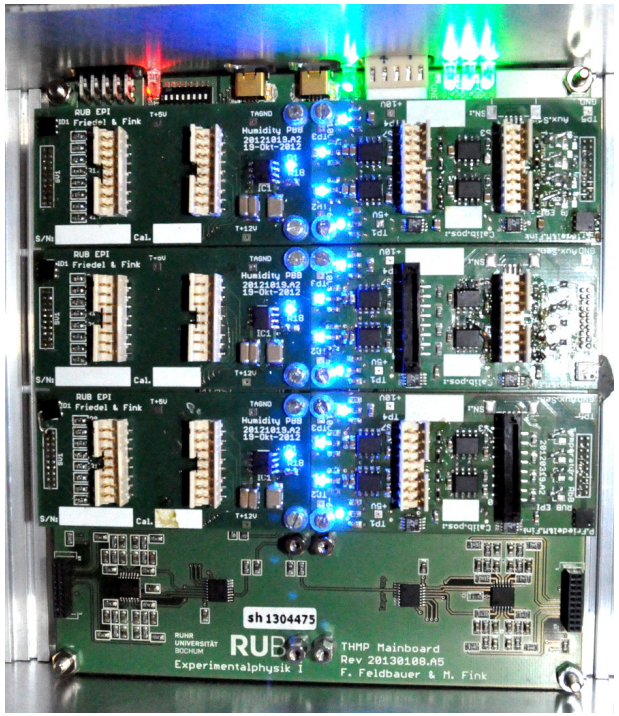


Available from Bochum group at net cost price plus shipping to your institute

Write to: `tobias@ep1.rub.de`

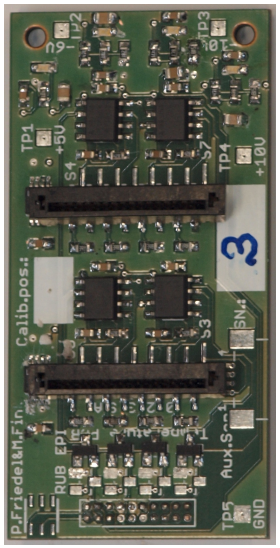
Temperature and Humidity Monitoring [Field Layer]

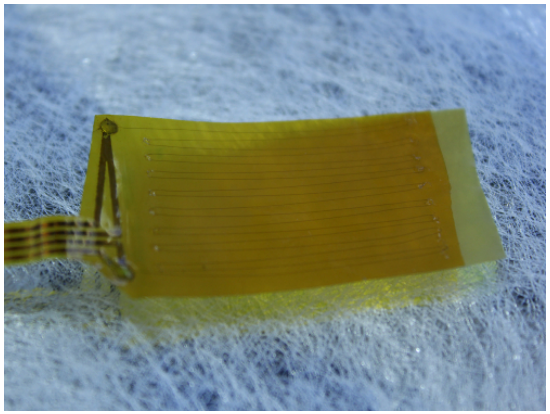
- Close monitoring of environmental conditions (temperature, humidity, pressure) necessary
- Temperature and Humidity Monitoring Board for $\overline{\text{P}}\text{ANDA} \Rightarrow \text{THM}\overline{\text{P}}$
- Modular design: Mainboard with 8 slots for piggyback boards
- Maxim 14bit ADC
- Sophisticated filtering for cancelling out noise
- CAN readout



Temperature Piggyback Board [FL]

- 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 $-50\,^{\circ}\mathrm{C}$ to $+50\,^{\circ}\mathrm{C}$
- Resolution < 0.05 K





Other Piggyback Boards [FL]

- Humidity (HIH-4000) and pressure (MPX4115A)
  - Same four-wire cables as for temperature sensors
  - One wire to power the sensor
  - One wire for readout
  - Two wires common ground
  - Sensor response fed to ADC
- 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^2C) for direct communication with the μC
    $\Rightarrow$ may need firmware extension

Software and Drivers [SL/CL/FL]

- Drivers for Raspberry Pi CAN interface licensed under GPL
- Available on Florian Feldbauer's GitHub repository:
  `https://github.com/ffeldbauer/epics_RPi_can`

- Other software available in EP1 git repository:
  - THM$\overline{\text{P}}$ firmware
  - THM$\overline{\text{P}}$ test/debug application
  - THM$\overline{\text{P}}$ calibration data
  - API to control iseg HV supplies (and others) via EPICS
  - Alarm and current border regulation software
  - EPICS databases and protocol files
- For access, write to: `tobias@ep1.rub.de`
- $\overline{\text{P}}$ANDA-specific version of CSS

Costs

- Net cost prices for parts of aforementioned devices:

Raspberry Pi with EPICS on SD card	44.04 €
Raspberry Pi CAN adapter PCB	136.41 €
Aluminium casing	12.12 €
THM$\overline{\text{P}}$ mainboard	342.08 €
Aluminium casing	17.66 €
Temperature PBB	110.12 €
Pressure/humidity PBB	25.01 €
THM$\overline{\text{P}}$ power cable (2 m)	11.93 €
CAN bus cable (1 m)	10.56 €
CAN bus terminator	3.72 €

Our agenda for the next months

- Finish hardware design for second generation light pulser
- Modify firmware to store calibration on pulser itself
- Adapt EPICS drivers to new light pulser communication protocol

- Next beam test with Proto192 scheduled in July

$\Rightarrow$ First test of alarm handling under beam conditions

- E-mail alerts if an alarm occurs and nobody is in the lab

Summary

- RasPi/CAN interface ready for production use
- Slow Control chain with EPICS and CSS built and tested at "Proto192" forward endcap calorimeter prototype
- Devices developed available to all $\overline{\text{P}}$ANDA groups

Thank you for your attention!