DCS for EMC cooling system

Tobias Triffterer

Experimentelle Hadronenphysik
Ruhr-Universität Bochum

LV. $\overline{\text{P}}$ANDA Collaboration Meeting
30th November 2015

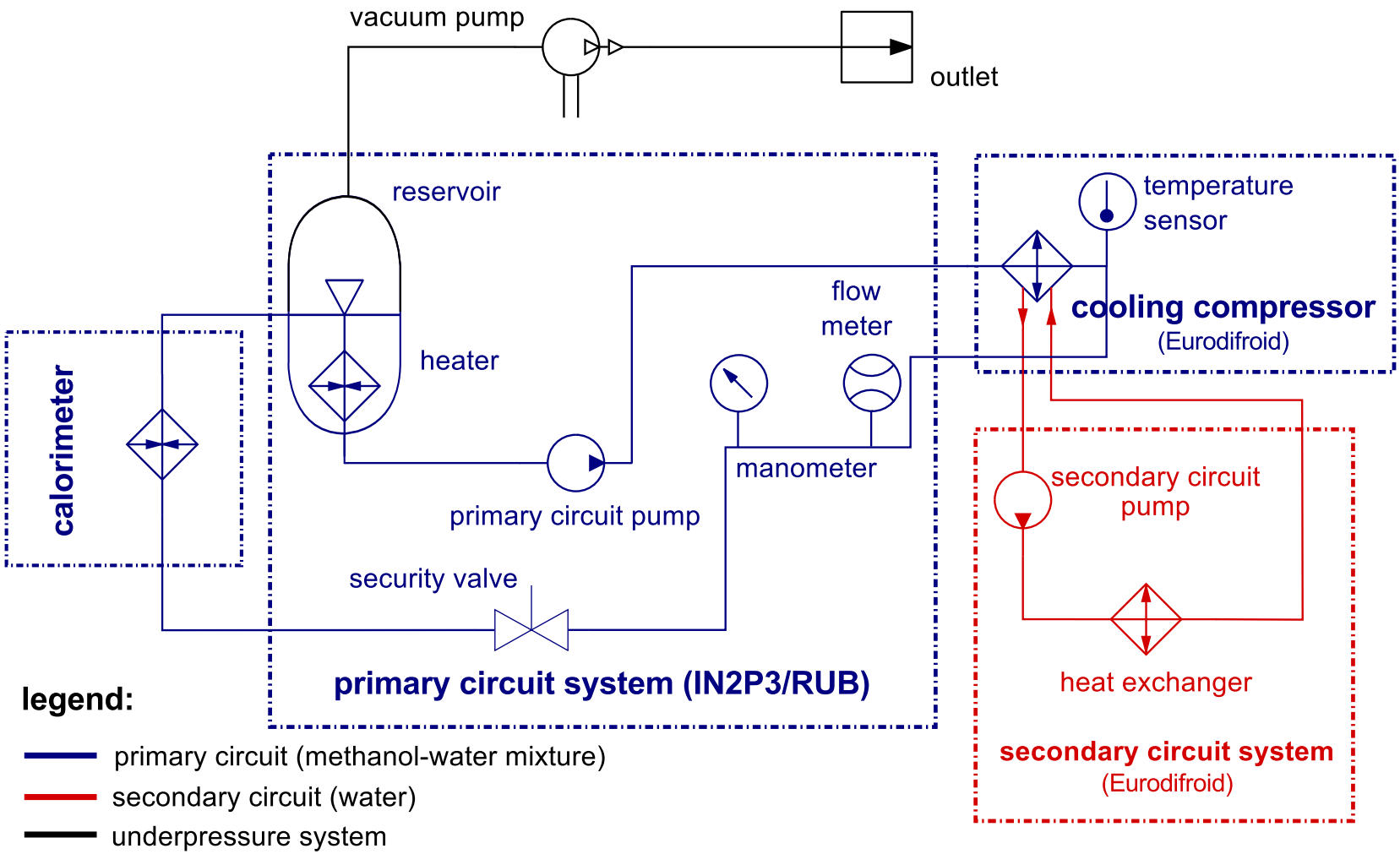
Purpose of the Cooling System Prototype

- Cooling system intended to be used for testing of the Forward Endcap EMC at RUB and FZ Jülich
- Capable of cooling the complete endcap and one barrel slice
- Cooling system for the complete EMC: Scaled-up version of this system (if everything works as intended)
- Work sharing:
  - Hardware designed and built by IN2P3 Orsay
  - Control software created by EP1 Bochum
  - Chiller and heat exchanger bought from French company Eurodifroid
- Total value: $\approx 52{,}000\,€$ (mostly paid by Gießen)

Technical Data

- Power of cooling compressor: 5 kW
- Power of main pump: 1.5 kW
- Underpressure system
- Two circuits connected to chiller:
  - Primary circuit: Coolant flowing through calorimeter
  - Secondary circuit: Transports heat from cooling compressor to facility heat exchanger
    (Alternative: Direct connection to cooling water supply of experiment hall)
- Cooling agent primary circuit: Methanol-water mixture
- Operating temperature: $-32\,^{\circ}\mathrm{C}$
- Reservoir of $\approx 330\,\mathrm{L}$
- Cooling agent secondary circuit: Water

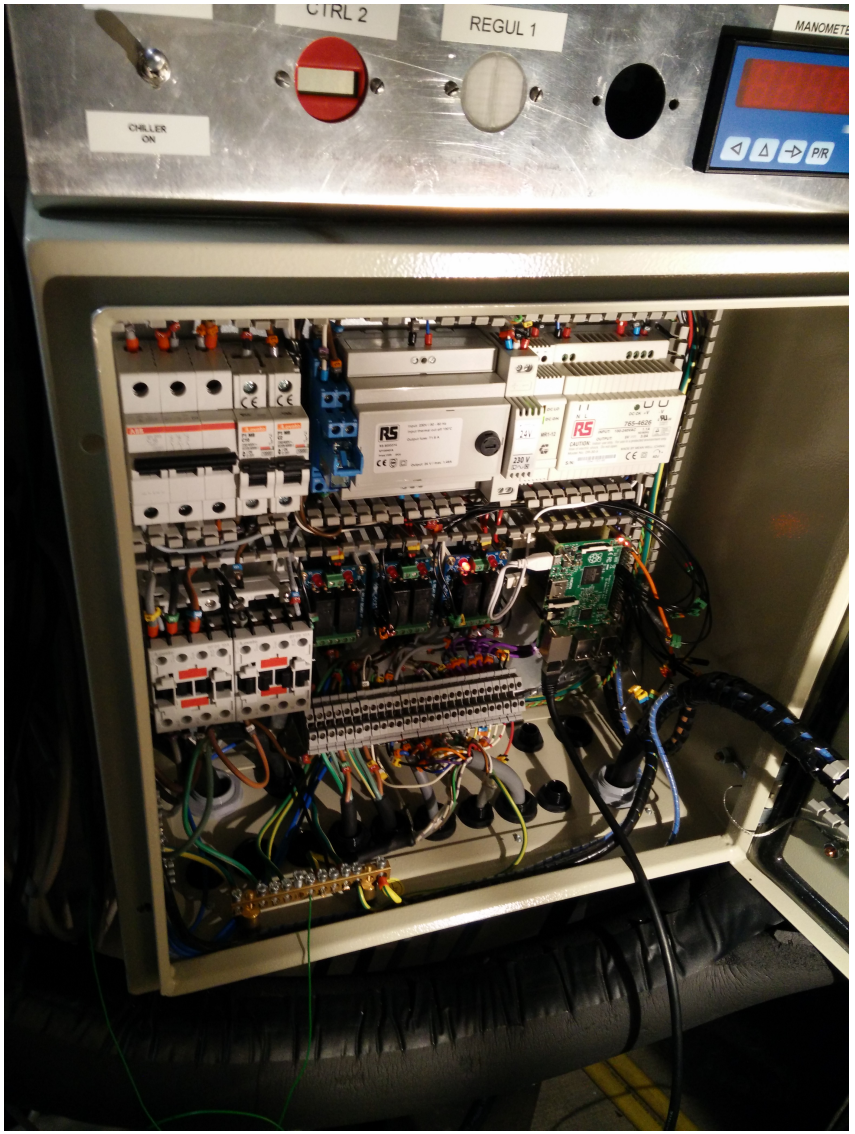
Schematic Diagram



Panorama Photo of the Setup

Control System

- Raspberry Pi in switchboard
- Relais connected to its GPIOs
- USB-RS485 adapters connected to USB
- Control of pump, flow meter, chiller
- EPICS (DCS software) running on Raspberry Pi
- Connection to rest of DCS via network



Accessing the GPIOs

- GPIOs controllable via sysfs (Linux pseudo filesystem): `/sys/class/gpio`
- Directory `gpioN` ($N \in \mathbb{N}$) for each pin
- Files like `value`, `direction`, `active_low` and others to control behaviour of the GPIO pin

- EPICS device support that reads from/writes to these files
- Used with `bo` and `bi` records
- Value of input pins can be checked regularly $\Longrightarrow$ EPICS interrupts
- Extended and ported to BeagleBone Black by Florian Feldbauer

Use of the GPIOs

- Use of output GPIOs: Relais and signals
  - Power switch of pump
  - Run switch of pump
  - Switch pump speed mode
  - Power switch of heater
  - Power switch of flowmeter
- Use in input GPIOs: Status of chiller
  - Compressor failure
  - Flow too low
  - Pressure too low
  - ...

$\Rightarrow$ Generic tool to control various types of equipment

- Code available on GitHub
- `https://github.com/ffeldbauer/epics-devgpio`

Machine Protection

- All important safety precautions hard-wired

$\Rightarrow$ Protection will also work if EPICS has crashed or is not running

- Any problem will cause immediate shutdown of chiller
- EPICS nevertheless important part of the system
- EPICS will learn about the problem via input GPIO and inform staff via alarm system
- Pump and flowmeter part of safety system
- Pump stop or flow $< 7 \frac{\mathrm{L}}{\mathrm{min}}$ will stop chiller and heater

ModBus Overview

- Generic protocol used by devices from many manufacturers
- Operate different devices on one bus
- Usable on RS-232, RS-485 and Ethernet
- Device address: One byte (255 devices max.)
- Common functions (simplified):
  - Read/write single bit (switch, status flag)
  - Read/write register (arbitrary number in 16-bit blocks)
  - Reading/writing several bits/registers at once also possible
  - Bits/registers selected by 16-bit address
- Transmission error detection via CRC

ModBus & EPICS

- Devices read out and controlled via ModBus:
  - Primary circuit pump
  - Flowmeter
  - Chiller
- EPICS support for ModBus written by Mark Rivers: `http://cars9.uchicago.edu/software/epics/modbus.html`
- IOC support and tools available in Florian's repository
- Comprehensive documentation available on website
- Creating IOC configuration straightforward

Summary & Outlook

- Cooling system control via Raspberry Pi works
- EPICS device support for using GPIOs implemented
- Generic tool to control any type of equipment

- Cooling system will be connected to EP1 alarm system in January 2016
- Cooling whole endcap calorimeter will be tested once insulation has been manufactured and delivered

The End

Thank you for your attention!