EMC cooling machine prototype

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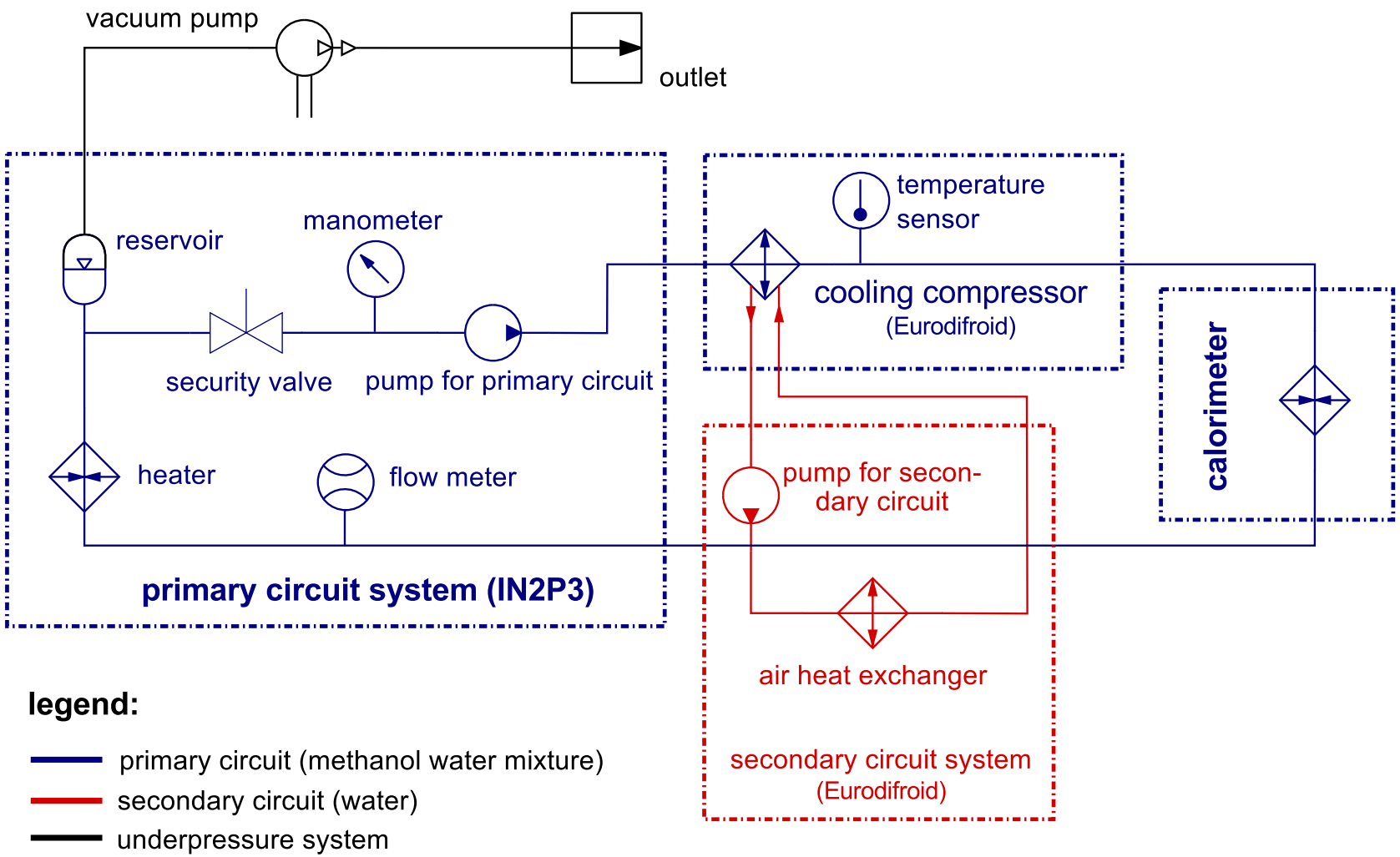
Purpose of the cooling system prototype

- Cooling system intended to be used for testing of the forward endcap EMC at 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)

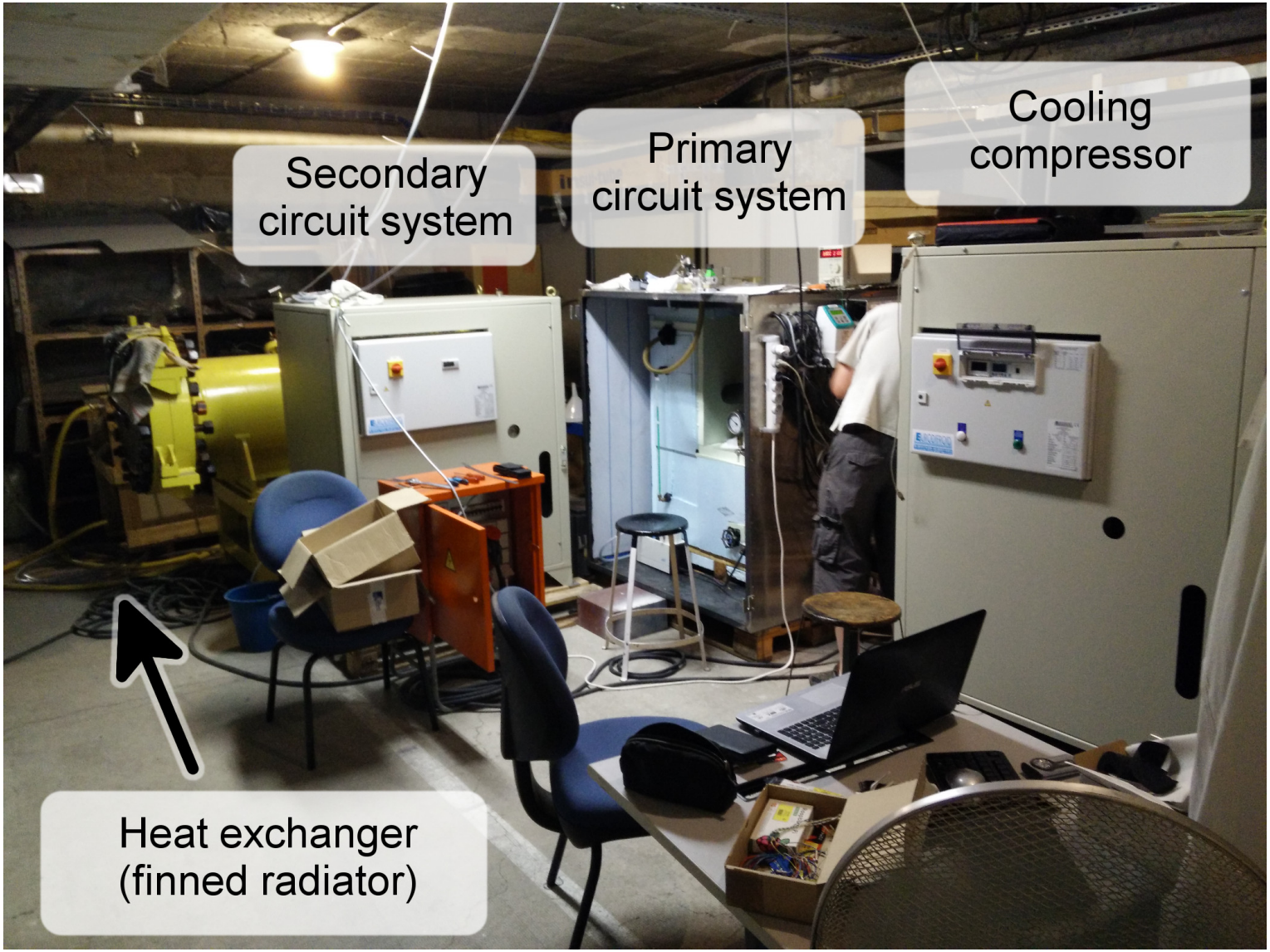
Technical data

- 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 heat exchanger outside
    (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

Preliminary schematic diagram

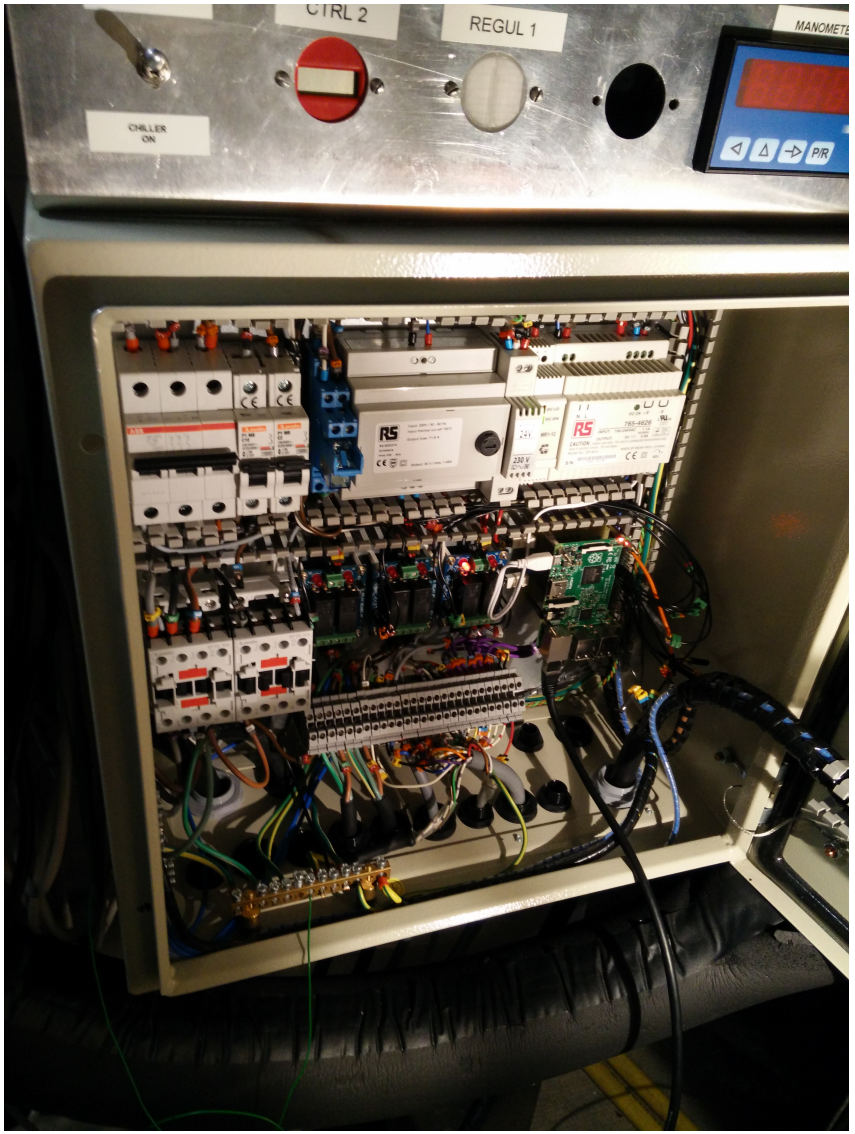


Panorama photo of the setup



Control system

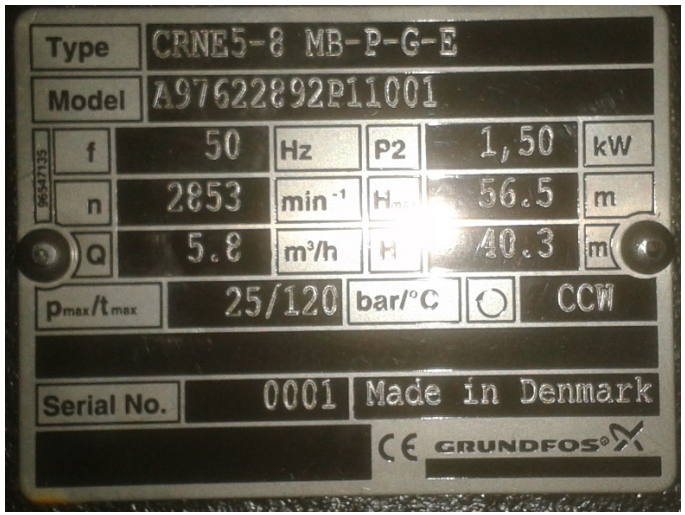
- Raspberry Pi in switchboard
- Relais connected to its GPIOs
- USB-RS485 adapters connected to USB
- Control of pump, flow meter, chiller
- EPICS (DCS software) running on Raspberry Pi
- Connection to rest of DCS via network



Cooling flow

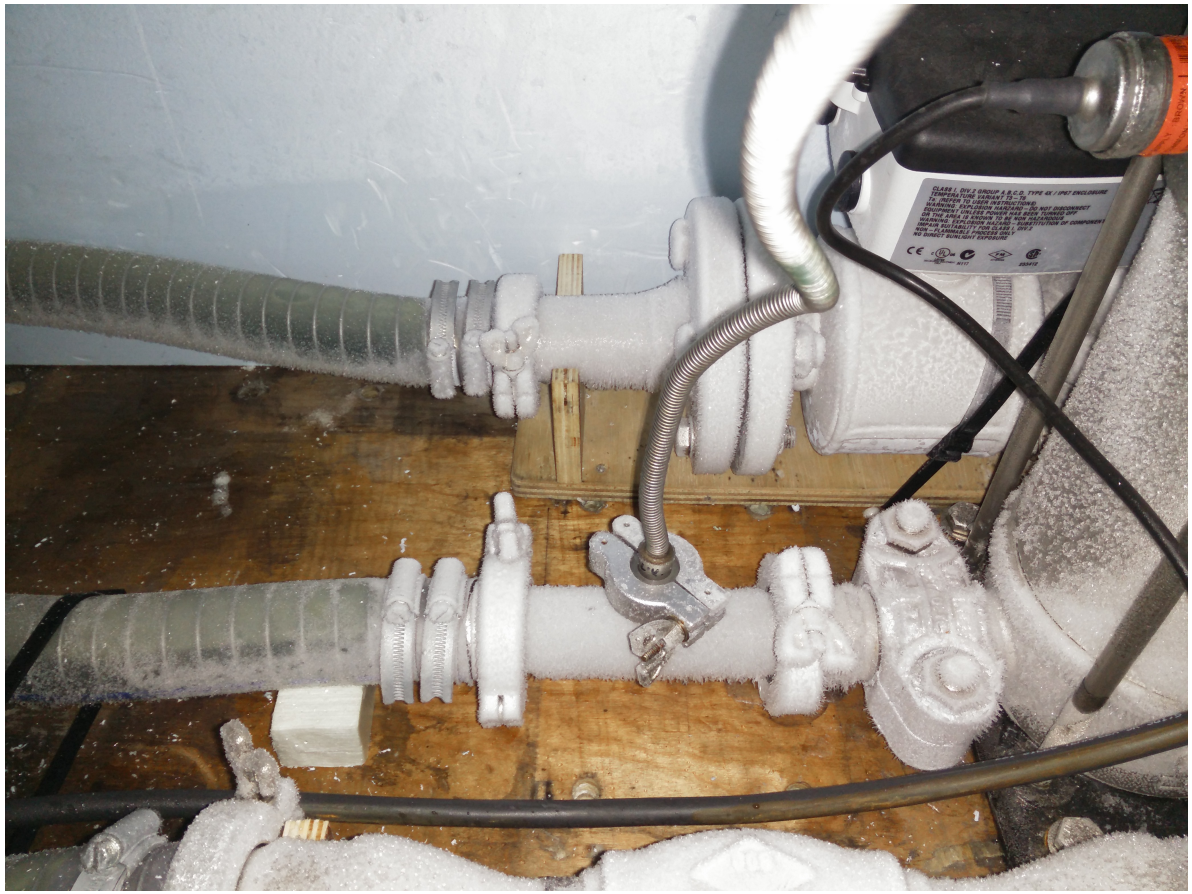
- Primary circuit filled with glycol (Ethan-1,2-diol) at IN2P3
- Flow at $T = -32\,°\mathrm{C}$ with current pump setup: $10\ \frac{\mathrm{L}}{\mathrm{min}}$
- Experience (IN2P3): Factor 2 for methanol-water, i.e. $20\ \frac{\mathrm{L}}{\mathrm{min}}$
- Requirement for forward endcap: $200\ \frac{\mathrm{L}}{\mathrm{min}}$

- Remote control unit for pump has been ordered today
- Flow can be increased
- Maximum for pump
  $5.8\ \frac{\mathrm{m}^3}{\mathrm{h}} \approx 97\ \frac{\mathrm{L}}{\mathrm{min}}$?
- Issue will be investigated when chiller is in Bochum



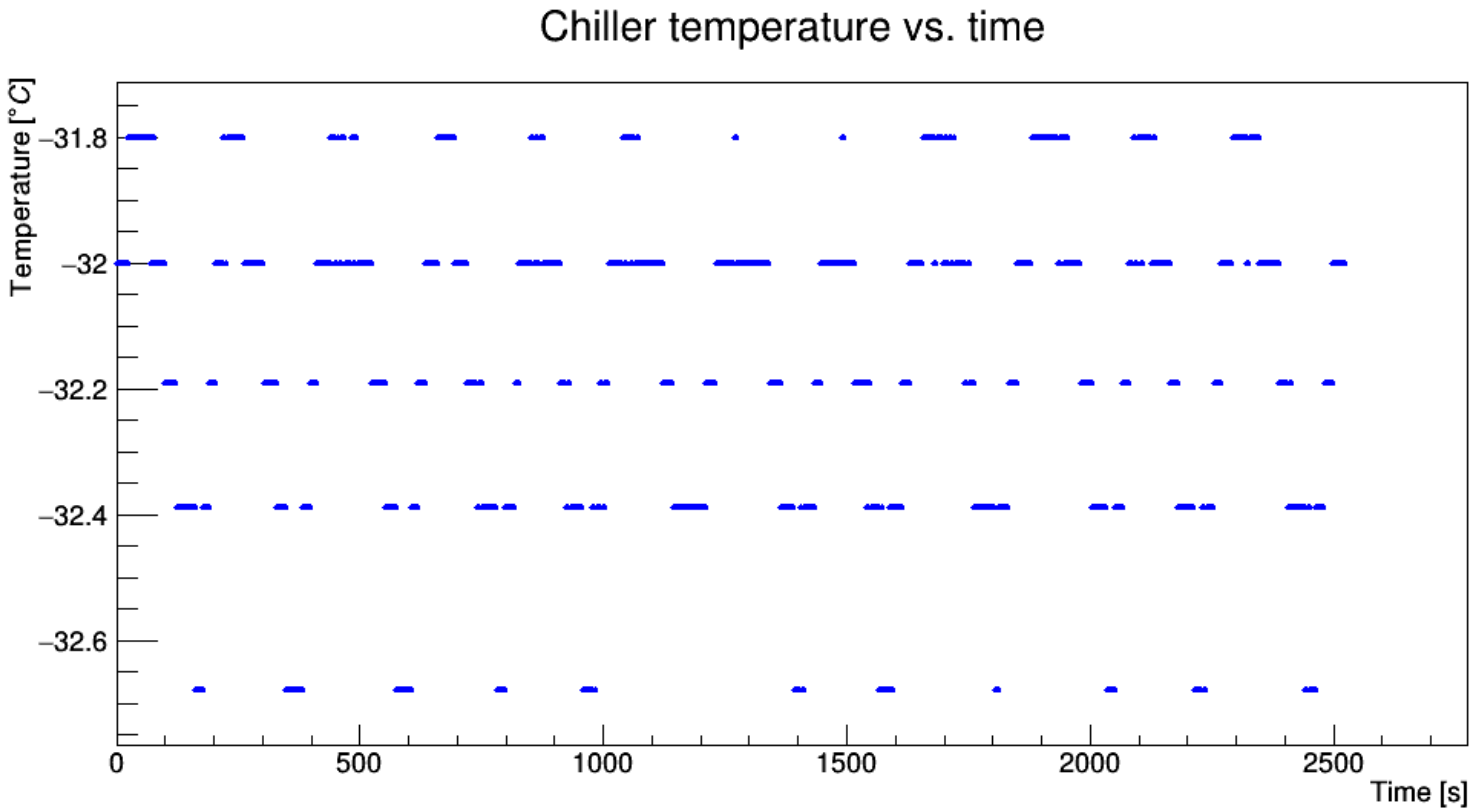
Internal insulation

- Primary circuit system insulated by large foam box
- Air inside $\Longrightarrow$ ice
- Insulation will be reworked in Bochum



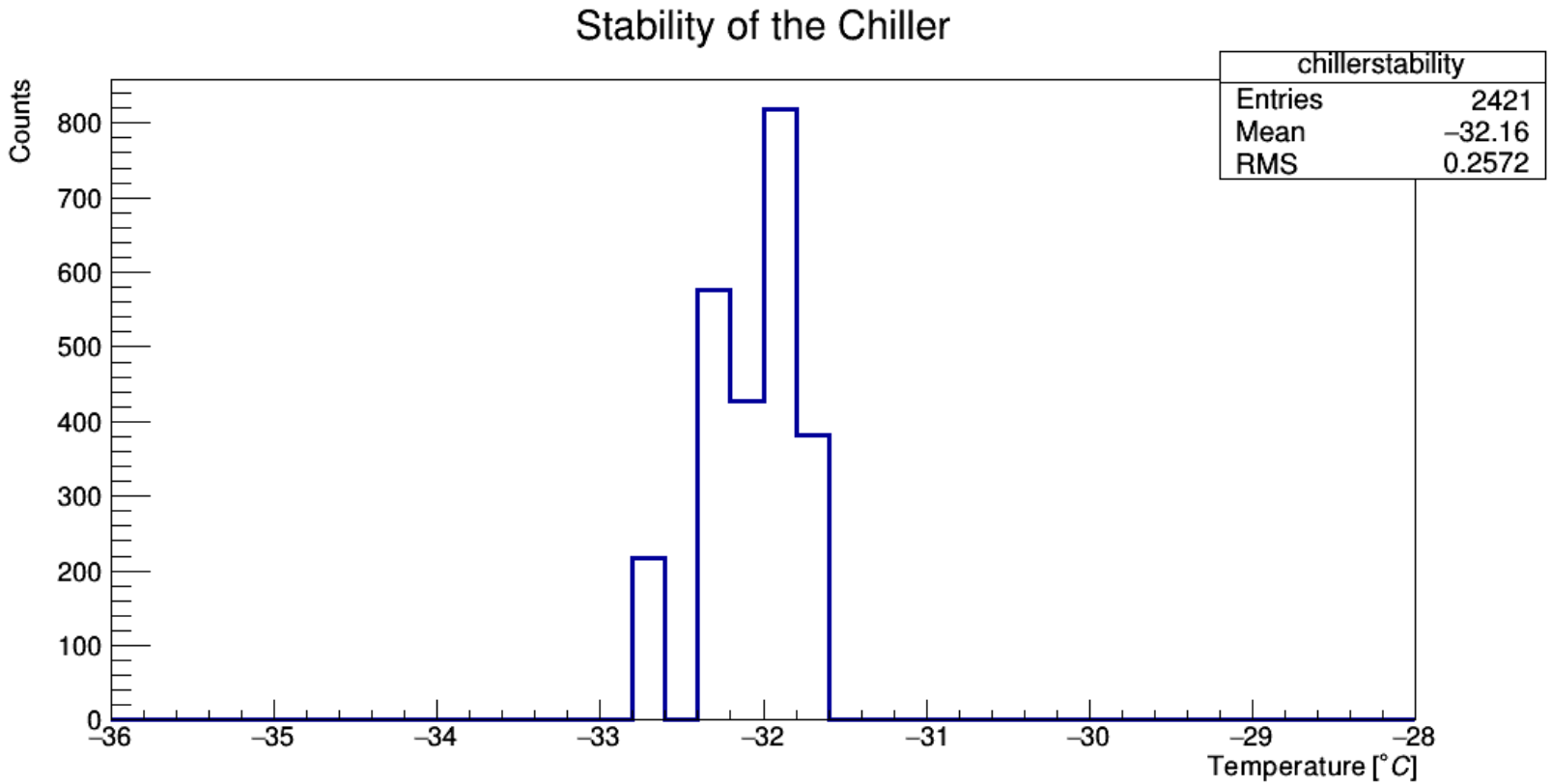
Stability I

- Measured for 42 minutes at $T = -32\,^{\circ}\mathrm{C}$
- Started ca. 30 minutes after reaching target temperature
- Measurement dominated by resolution of chiller sensor



Stability II

- Parameters of chiller regulation can be edited
- Will check if stability can be improved (better parameters or temperature sensor), but already $\frac{\sigma_{\text{rms}}}{\langle T \rangle} \approx 0.1\,\%$



Summary & Outlook

- Cooling system works generally
- Software written for the chiller tested successfully
- Expected arrival in Bochum: Week 39 (21^{st}-25^{th} September)

- Several issues to be sorted out before cooling system is usable for endcap preassembly
- Issue solving will begin in October

The End

Thank you for your attention!