Forward Endcap EMC Cooling

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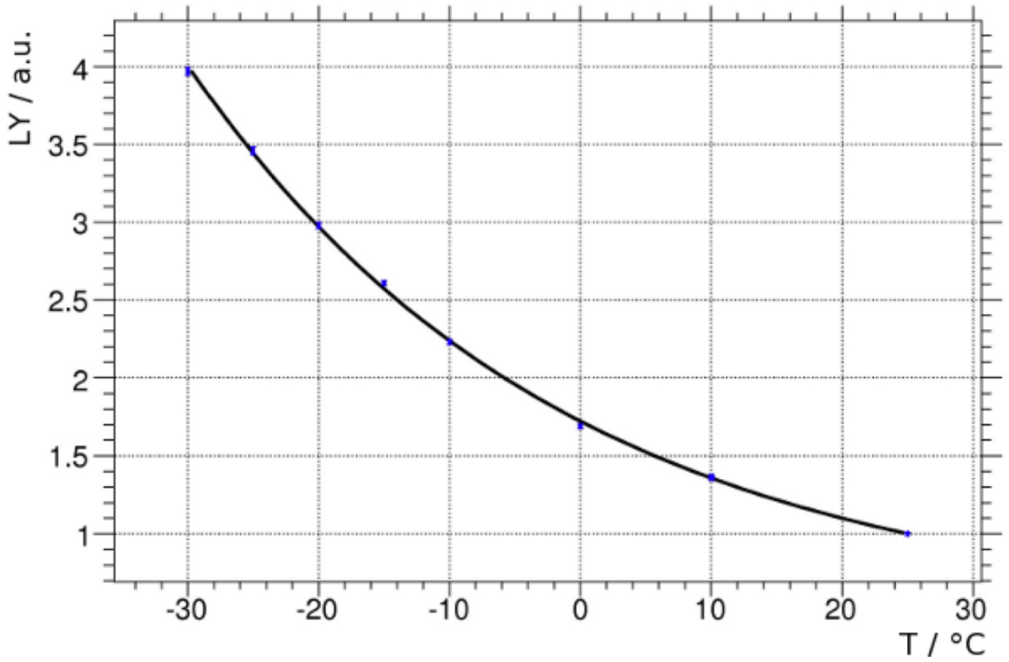
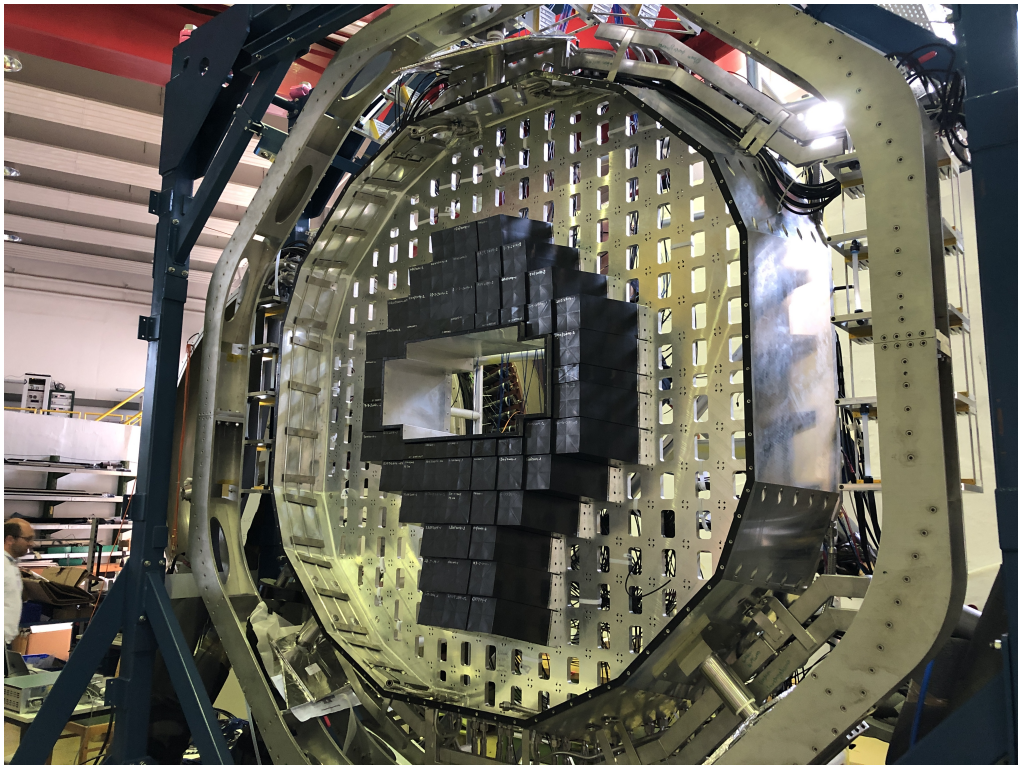
Motivation



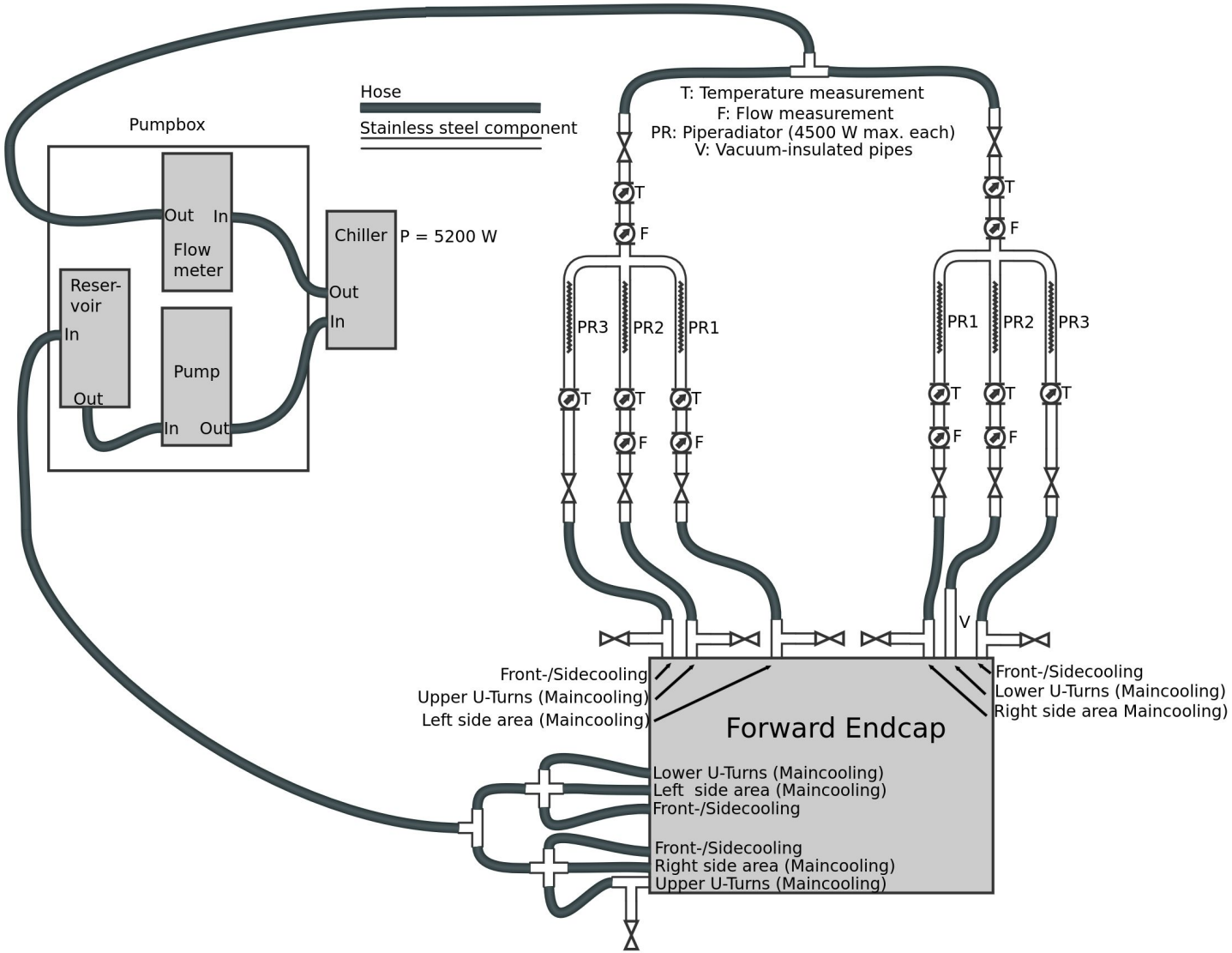
- To reach the desired energy resolution the temperature variation inside the scintillation crystals should not exceed 0.1 °C
  → Temperature variation of coolant also need to be less than 0.1 °C
- In need of a temperature regulation system for coolant
  → Capable of cooling, maintaining and heating

Cooling Overview



- Forward Endcap produces a heat load of about 2500 W
- Coolant temperature should not rise more than 1 °C inside the Forward Endcap (about -25 °C at inlet)
- This results into a minimum total flow of 50 l/min
- Due to safety margins a minimum total flow 64 l/min is used

Cooling Setup at Jülich



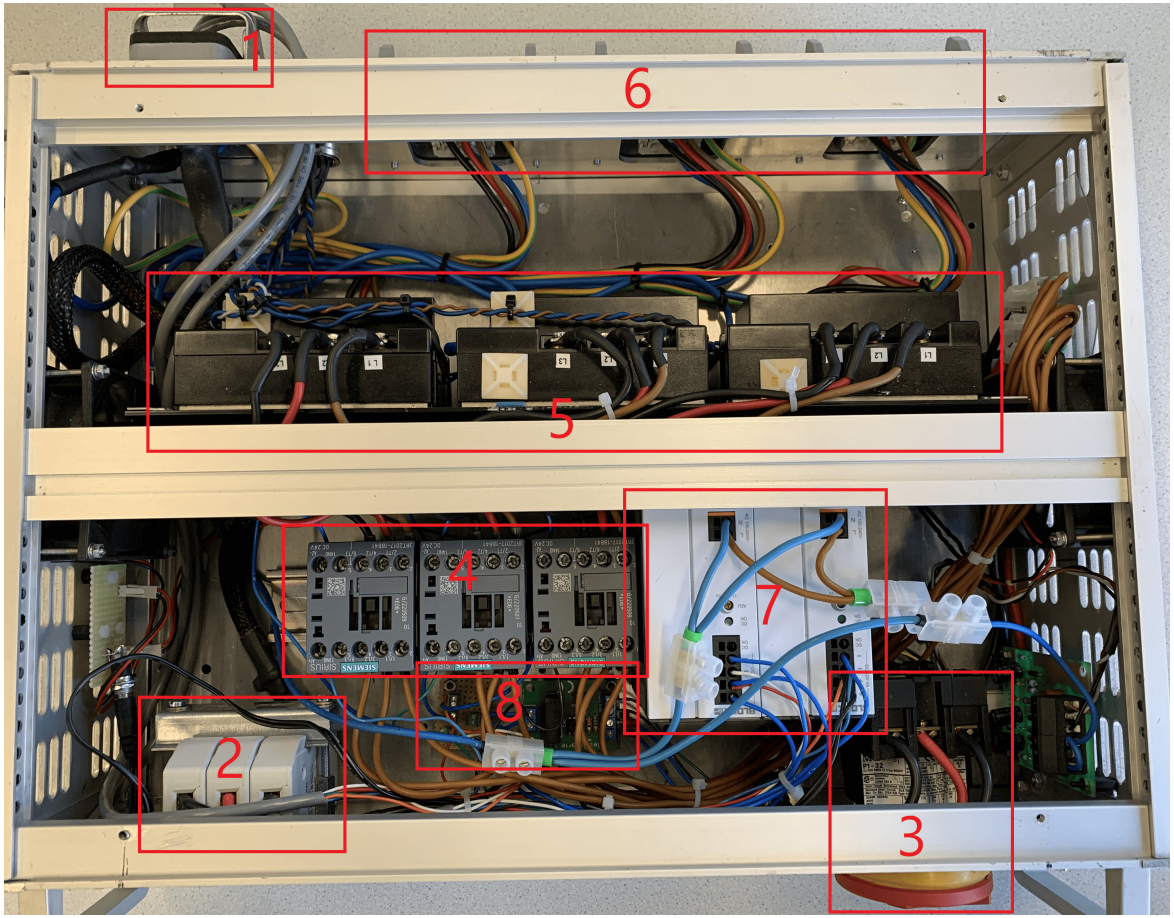
Cooling Setup

1: Reservoir, 2: Pump
3: Filler neck 4: Outlet
5: Flow meter 6: Fill level
7: Inlet 8: System outlet

Temperature regulation for coolant

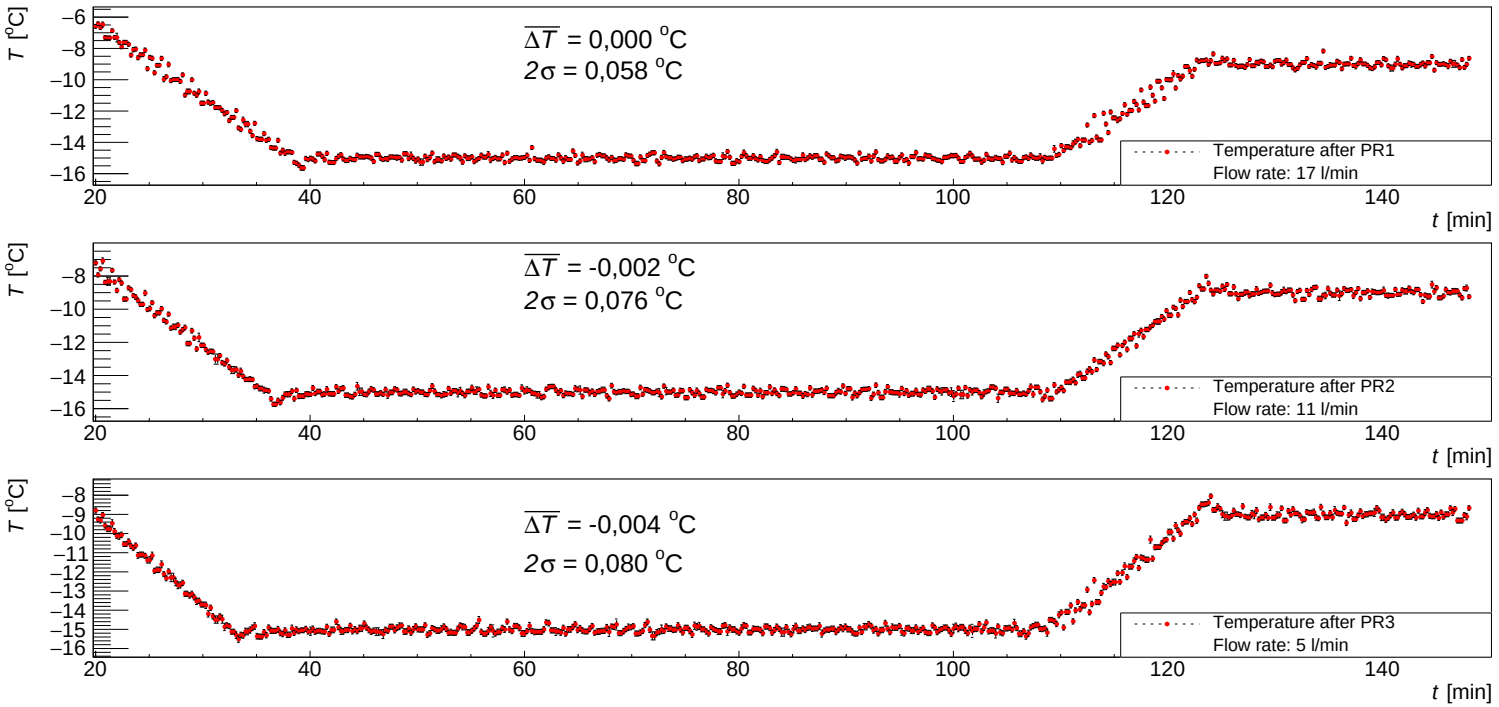
- Chiller always operates with full power
  $\rightarrow$ Temperature regulation just with power of pipe radiators
- Power of pipe radiators needs to be adjusted according to coolant temperature
- Temperature measurement directly after pipe radiators with Pt100 Sensors inside the coolant
- Temperature values are digitized with a developed PCB and read out with a Raspberry Pi
- Power of each pipe radiator will be managed by a PI regulator implemented on the Raspberry Pi
- Each PCB produces three output signals in a range between 0 V and 10 V $\rightarrow$ control voltage for Thyristor controller
- Pipe radiators will be powered by Thyristor controllers

Temperature regulation for coolant



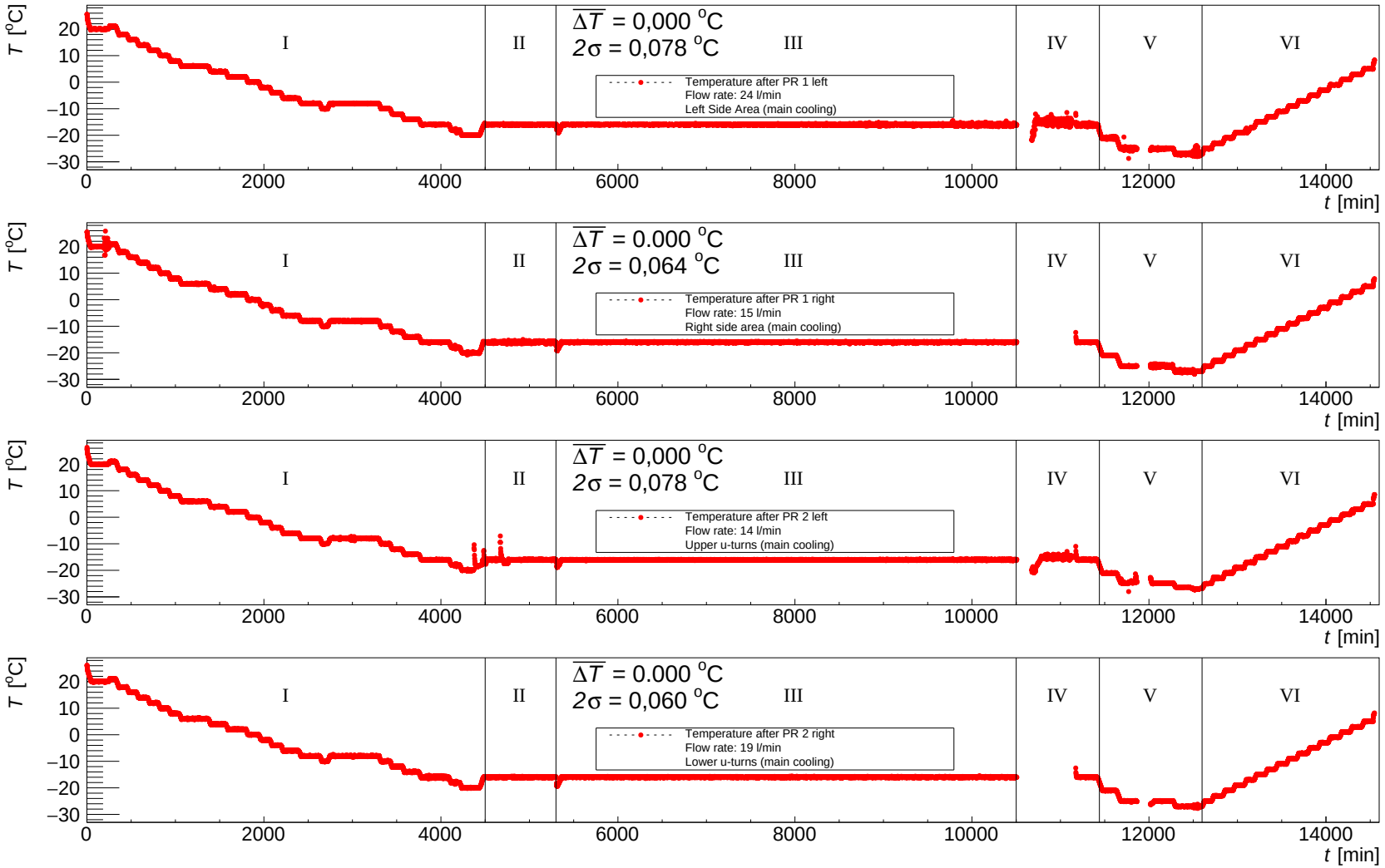
1: Power plug
2: Fuses
3: On/Off switch
4: Power contactors
5: Thyristor controllers
6: PR plugs
7: 24 V power supply
8: Relay card

Temperature regulation at the lab in Bochum

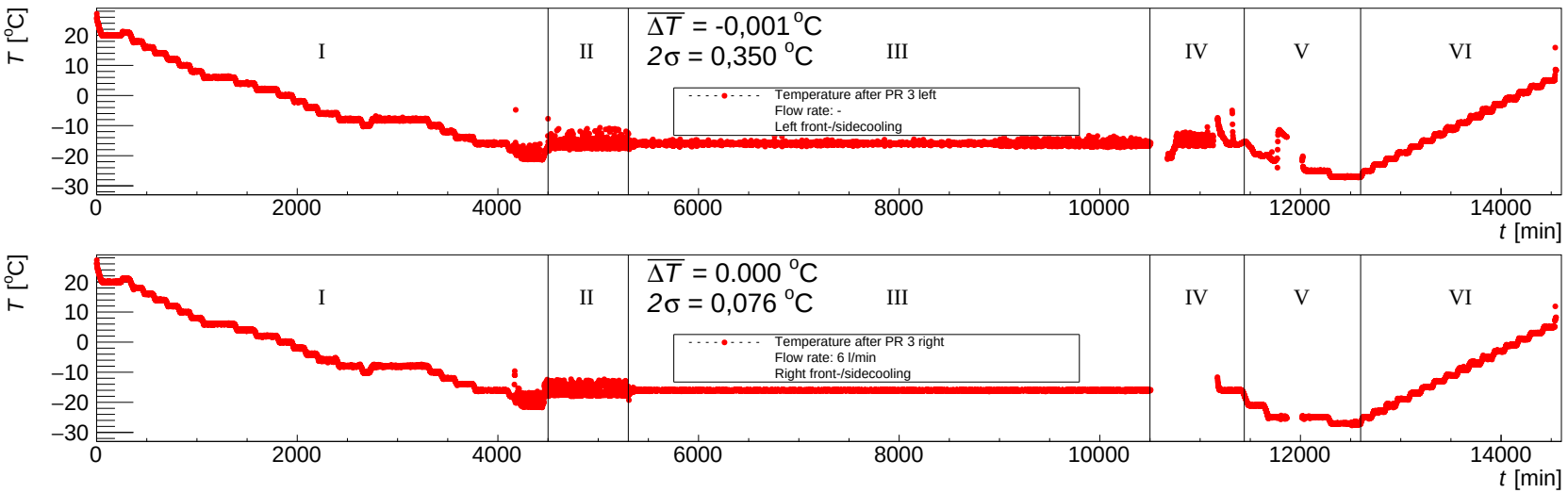


- $|\overline{\Delta T}| + 2\sigma < 0.1\,^{\circ}\mathrm{C} \rightarrow$ Case for temperature means of 3 minutes
- For cooling and heating: Temperature gradients determined by linear fits

Cooling at COSY in August 2023

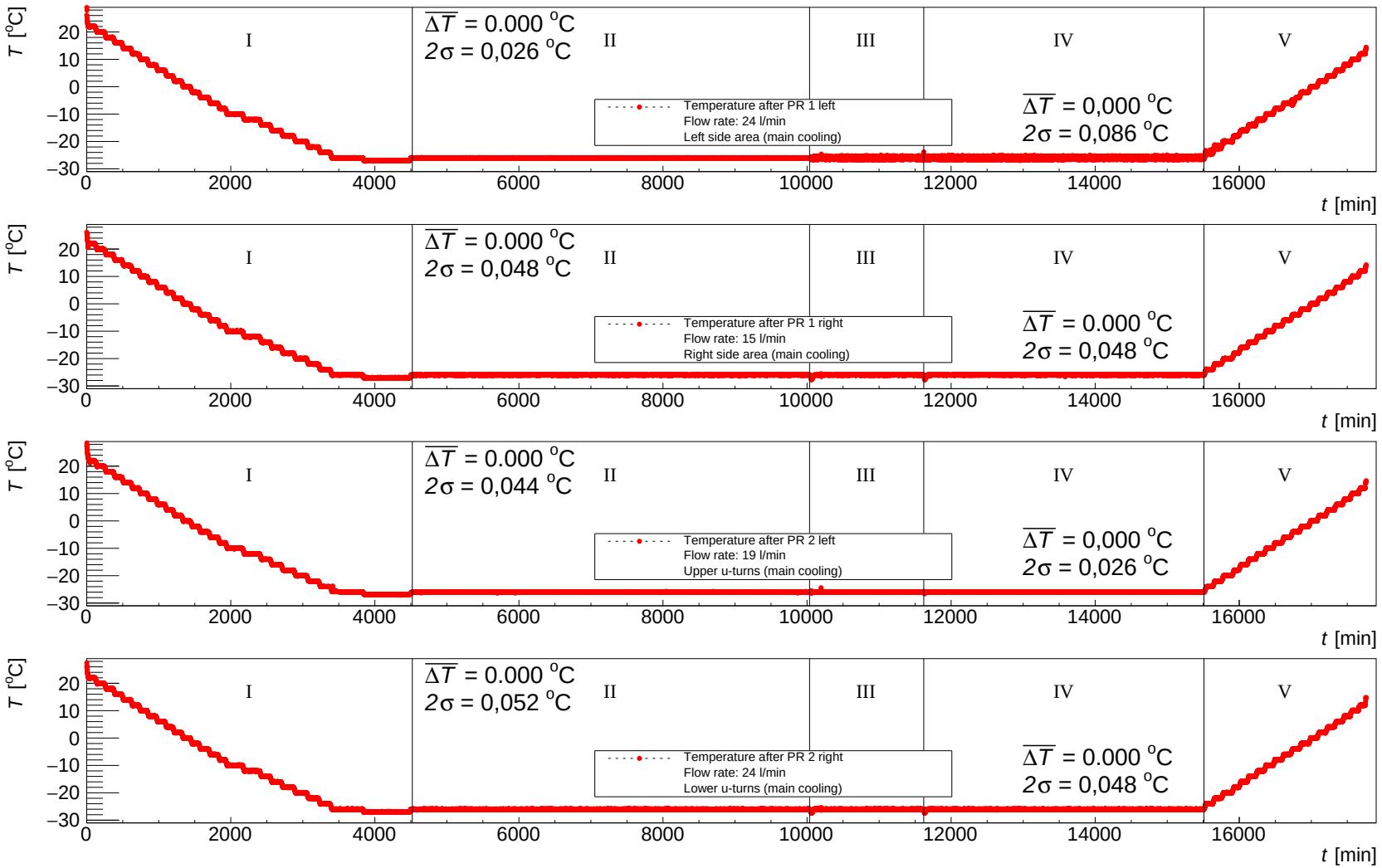


Cooling at COSY in August 2023

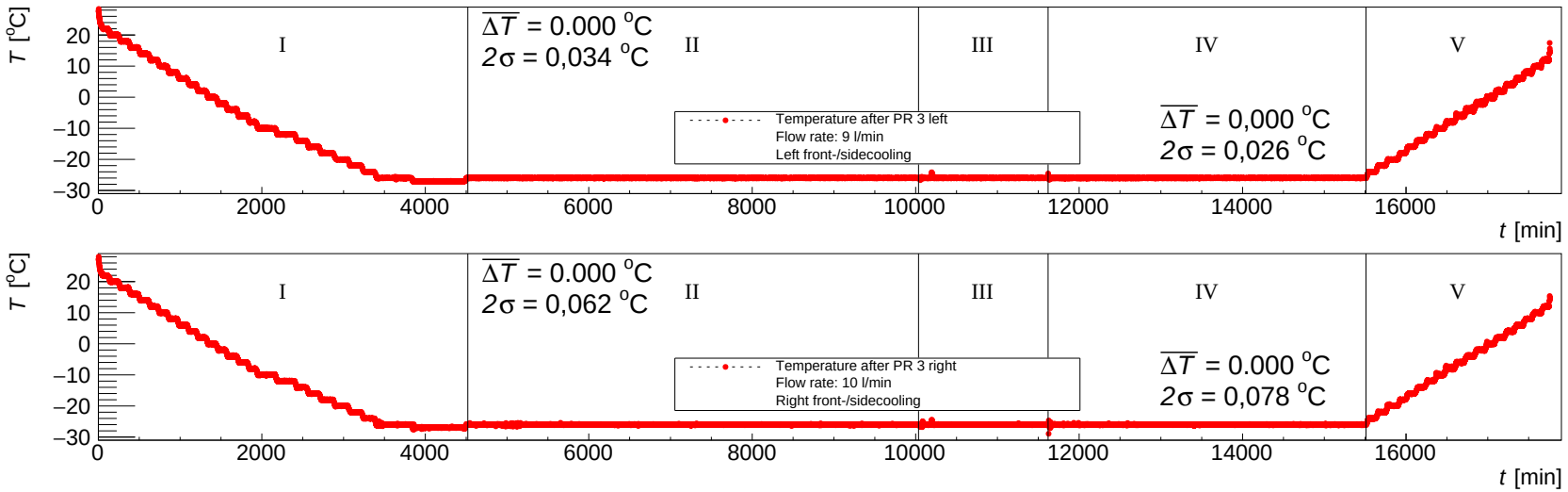


- $|\overline{\Delta T}| + 2\sigma < 0.1\,^{o}\mathrm{C}$ for temperature means of 3 minutes except for PR3 left in phase II and III and PR3 right in phase II
- Possible reason for fault: Air inside the cooling lines

Cooling at COSY in September 2023



Cooling at COSY in September 2023



- $|\overline{\Delta T}| + 2\sigma < 0.1\,^{o}\mathrm{C}$ for temperature means of 3 minutes for all PRs in phase II, III and IV

Optimization of the Cooling

- Integrate cooling EPICS into main EPICS
- Double temperature measurement at important points of system
- New flow sensors so that the flow in all cooling lines can be measured directly
- Utilization of motor control valves
- Usage of a bigger reservoir
- Electronic level indicator for new Reservoir
- Temperature measurement at outlets of Forward Endcap
- Stainless steel pipes for the entire cooling circuit
- Integrate vacuum system

Thanks for your attention!