Fast and stable heating and cooling

RUC - ESS

HUGINN

Peltier-Based Temperature Control

Bo Jakobsen

Department of Science and Environment, Roskilde University

Glass &time

RUC

ess EUROPEAN SPALLATION SOURCE

Huginn
a RUC - ESS collaboration

RUC
Bo Jakobsen
Torben S. Rasmussen
Kristine Niss

ESS
Alexander T. Holmes
Harald Schneider
Anders Pettersson
Arno Hiess

Science case

Speed of temperature-change couples to *measuring time*

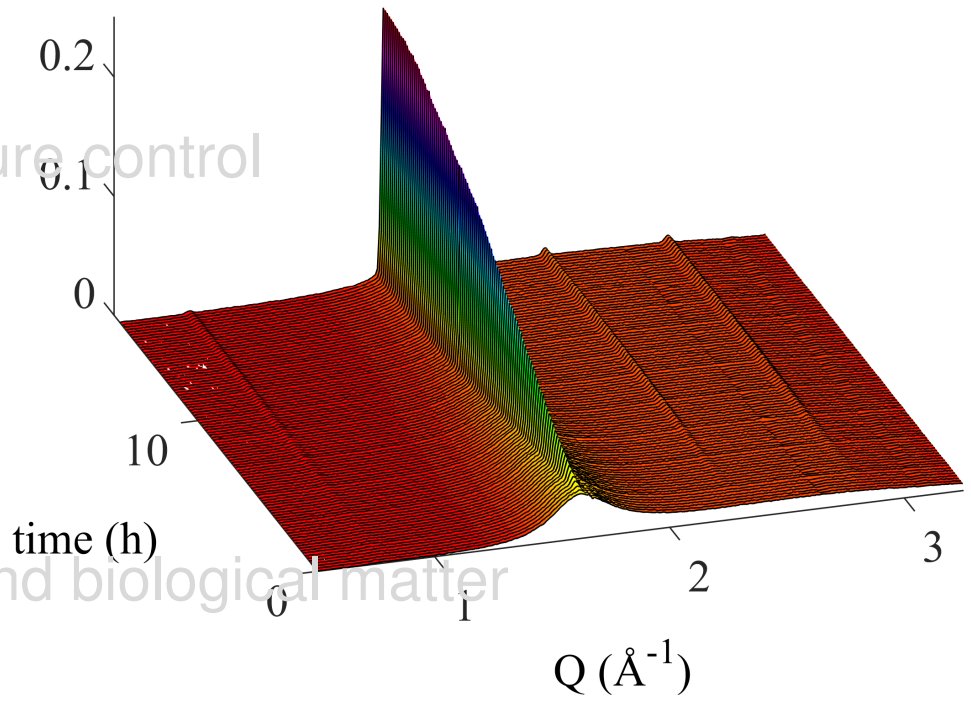
- Total measuring time:
  Limited by the slowest
- Time resolution:
  Limited by the slowest

Traditional cryostats

- Relatively slow
- Optimized for very low T
- Indirect sample temperature control

Focus on 100 K to 350 K

- Traditional:
  Focus on hard matter
- Today:
  Increased focus on soft and biological matter



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The Huginn project

Aim of the project is to utilize Peltier elements for temperature control

- Providing a sample environment with excellent temperature stability
- Allowing for fast change of temperature

Two different devices have been designed and constructed

- A *sub-cryostat insert* for use with general purpose sample cells and different outer cryostats
- A *SANS multi-temperature* cuvette holder

"Huginn: A Peltier-based sub-cryostat for neutron scattering", B. Jakobsen, A. T. Holmes et al., J. of Neutron Research, **21**, 47–57 (2019).

Background

Microregulator

developed at Roskilde University

- Stable outer cryostat ($\approx$ mK)
- Stability improved a factor 10
- Fast temperature jumps

- Sample and Peltier element in close contact
- Sample and outer cryostat weakly linked

- Controlled from common software framework

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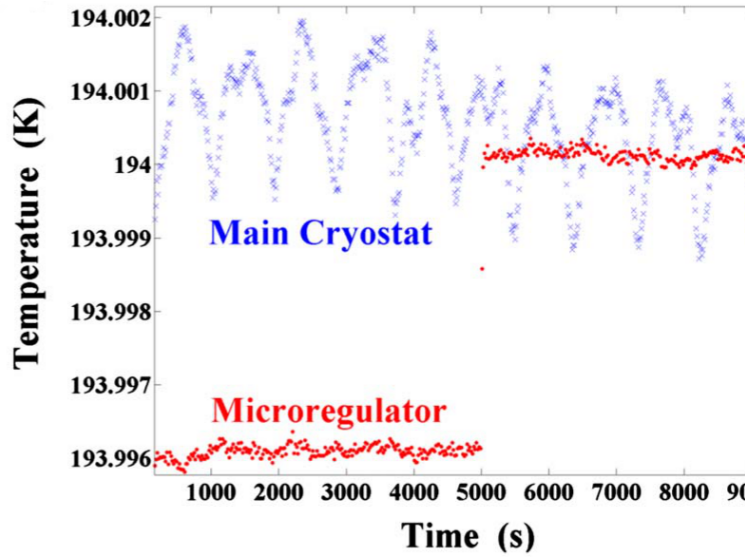

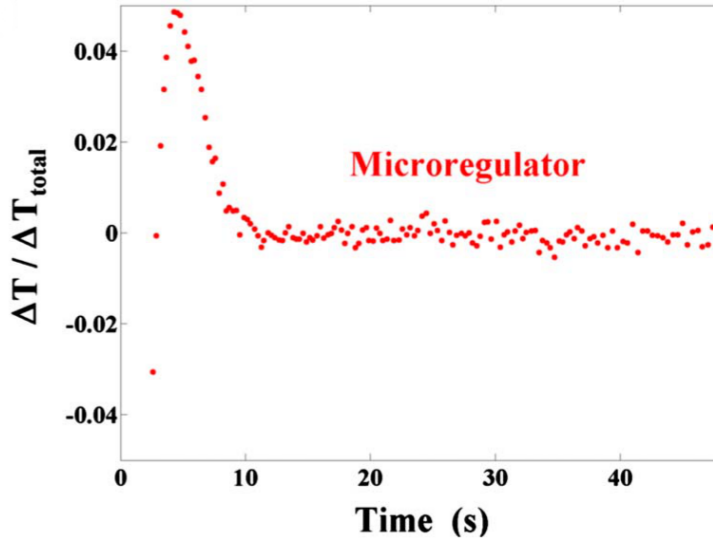

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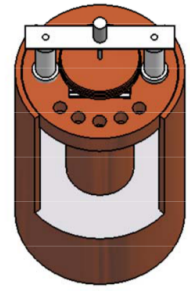

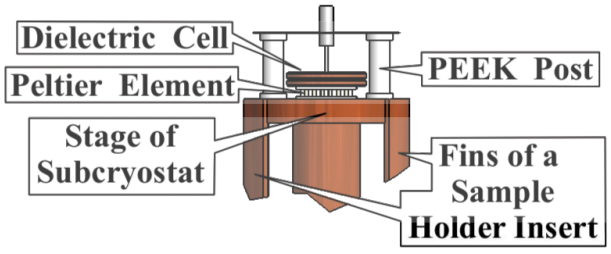

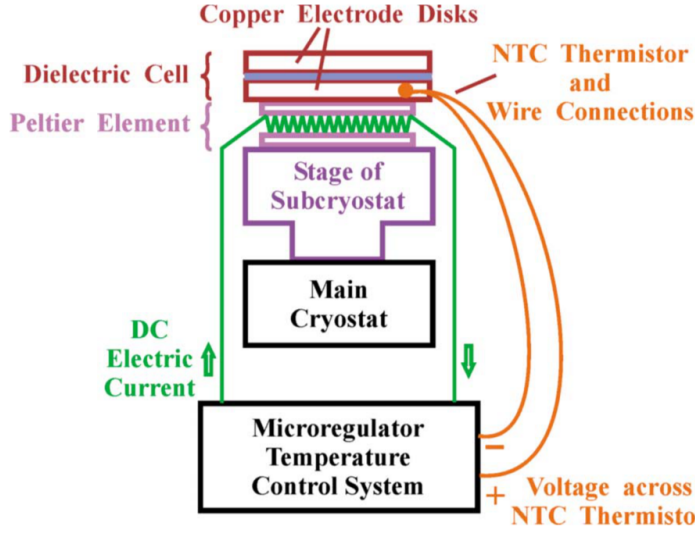

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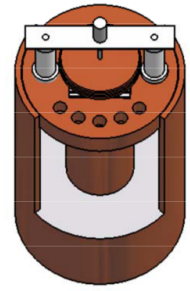
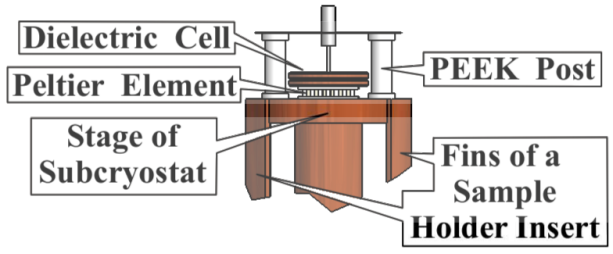
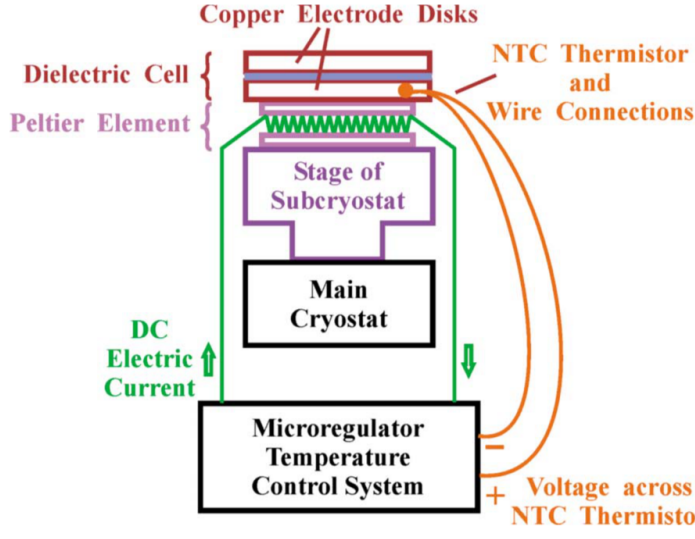
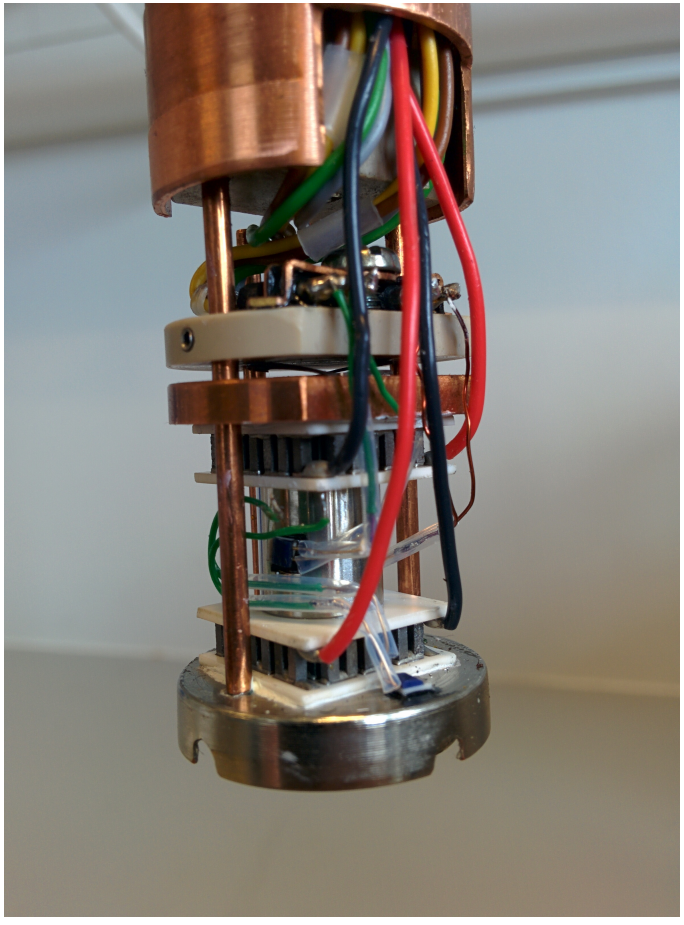






Design process

Three generations of prototypes developed and tested



1st generation
Proof of concept

- For low temperature test in RUC cryostat
- For test of Peltier elements
- Search for electronics

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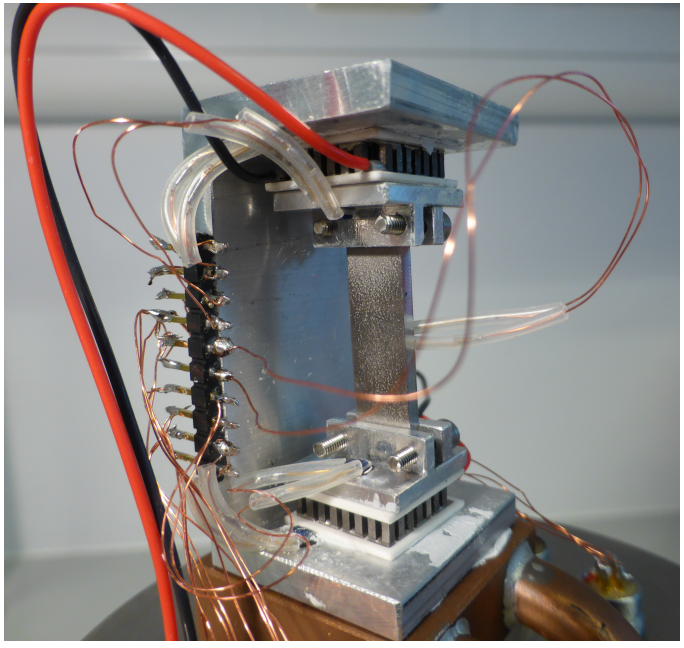

2nd generation
Realistic geometry

- Individually controlled Peltier elements
- Scattering geometry
- Control strategy explored
- Tested using simple liquid cooling

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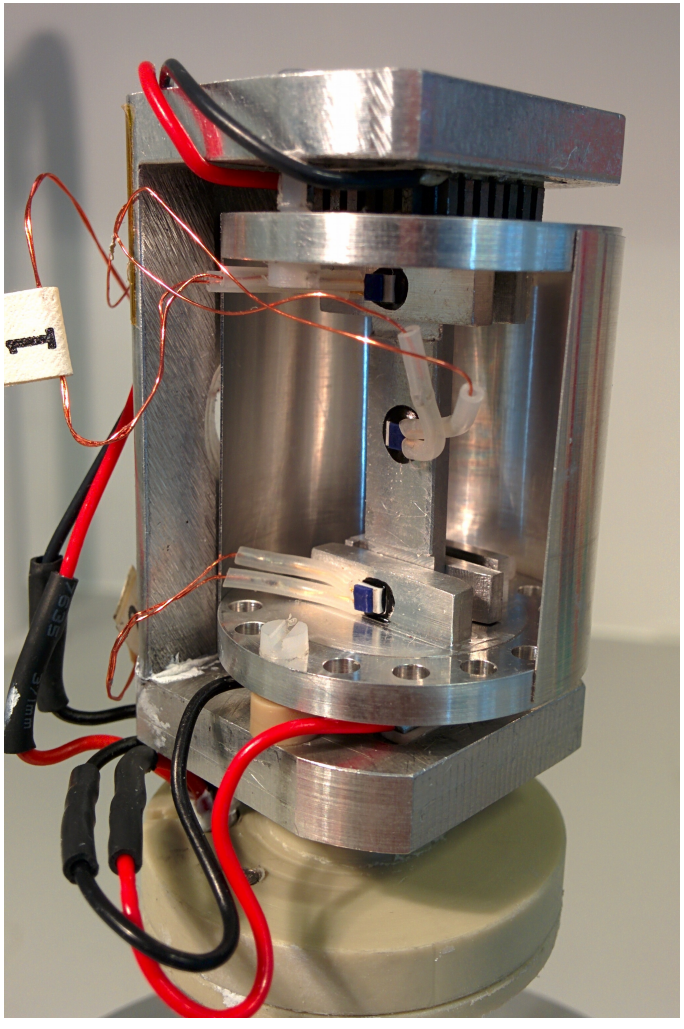
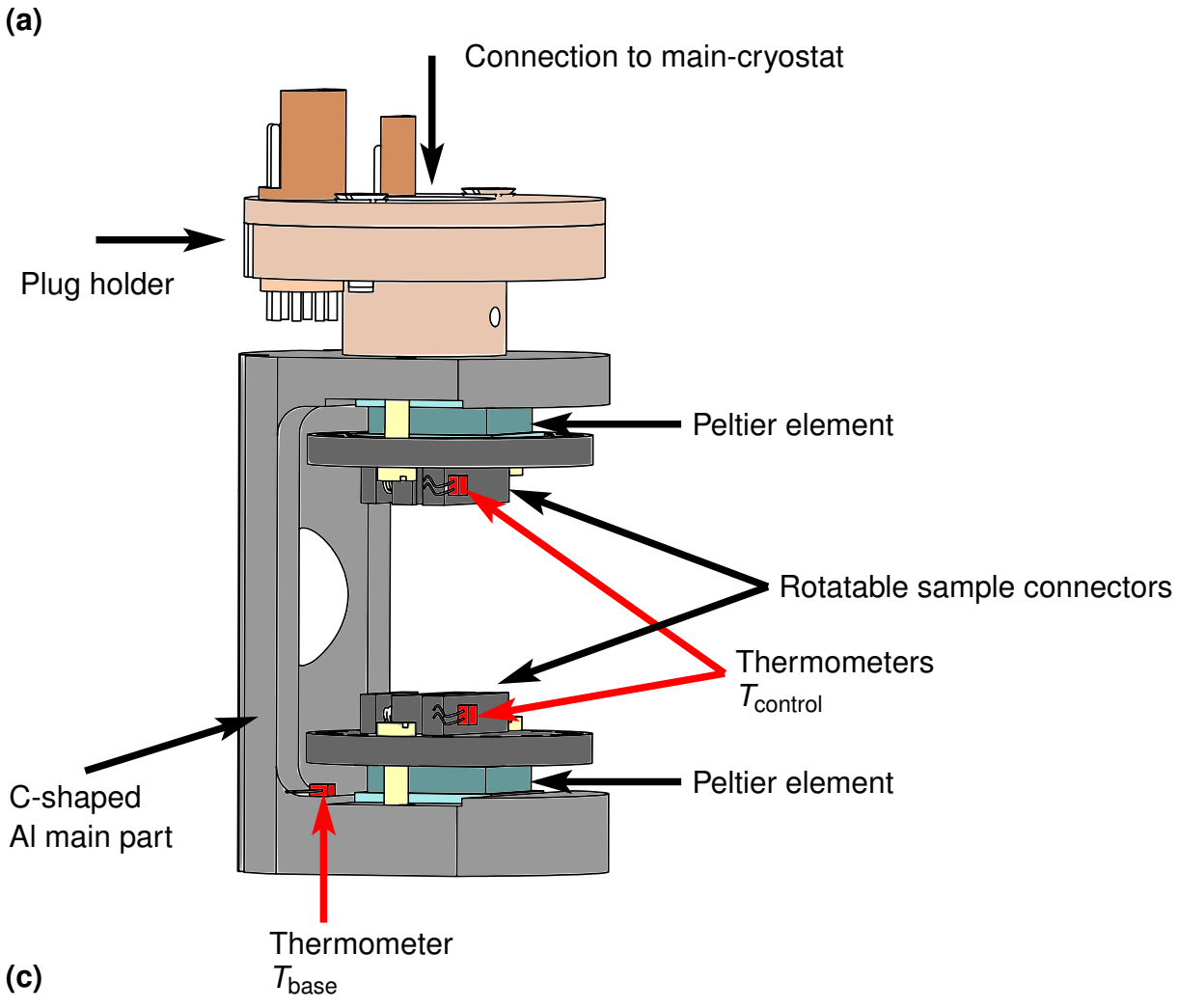


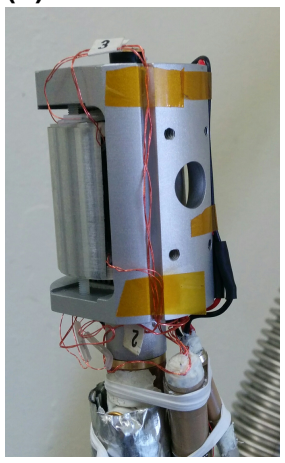
3rd generation
For Neutron cryostats

- Final sample cell holder
- Cryostat compatible geometry
- Software and control strategy finalized
- Tested in ESS low-temperature cryostat

Final design



(b)



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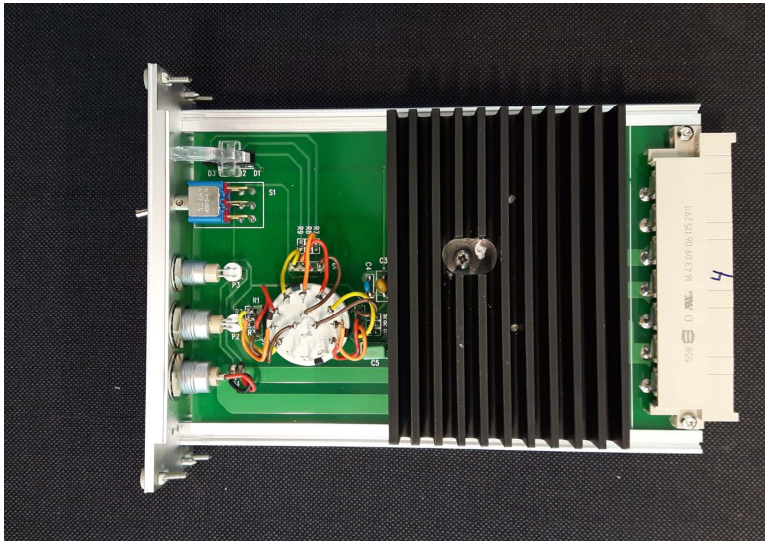
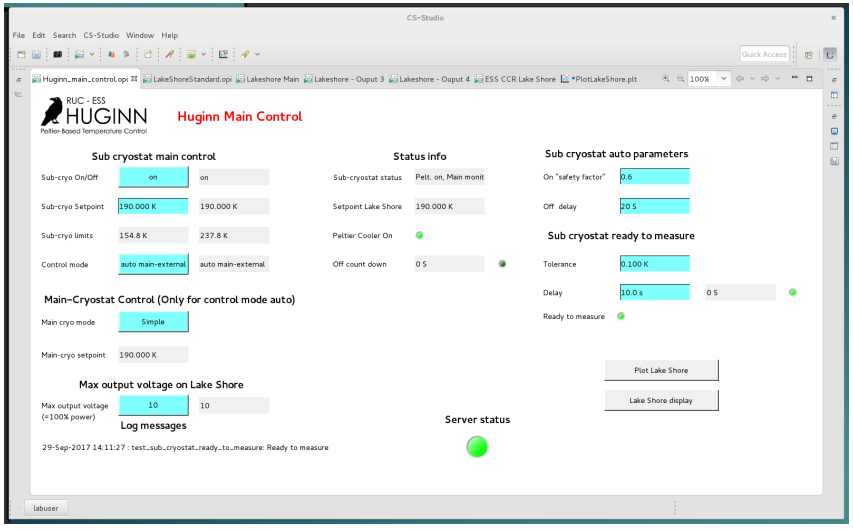
Peltier driver system

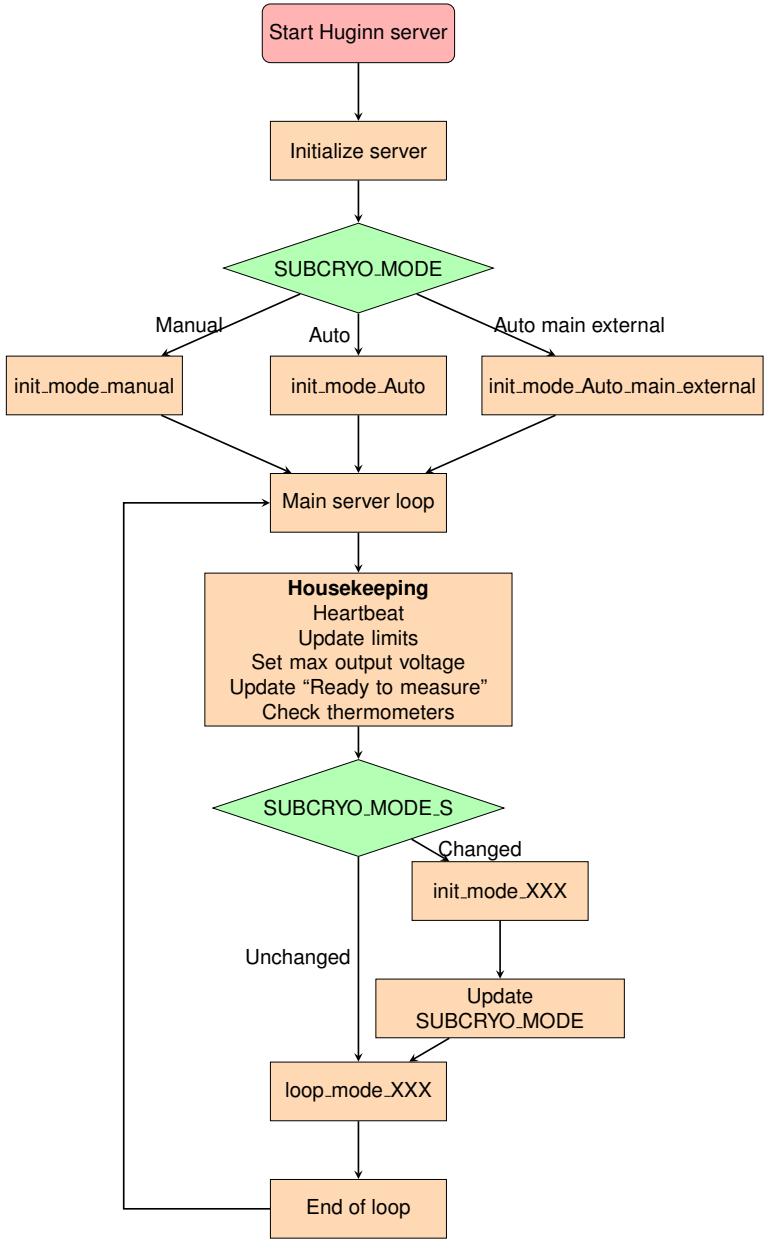


- RUC built Peltier driver cards
- Full rack-mount driver system

Software

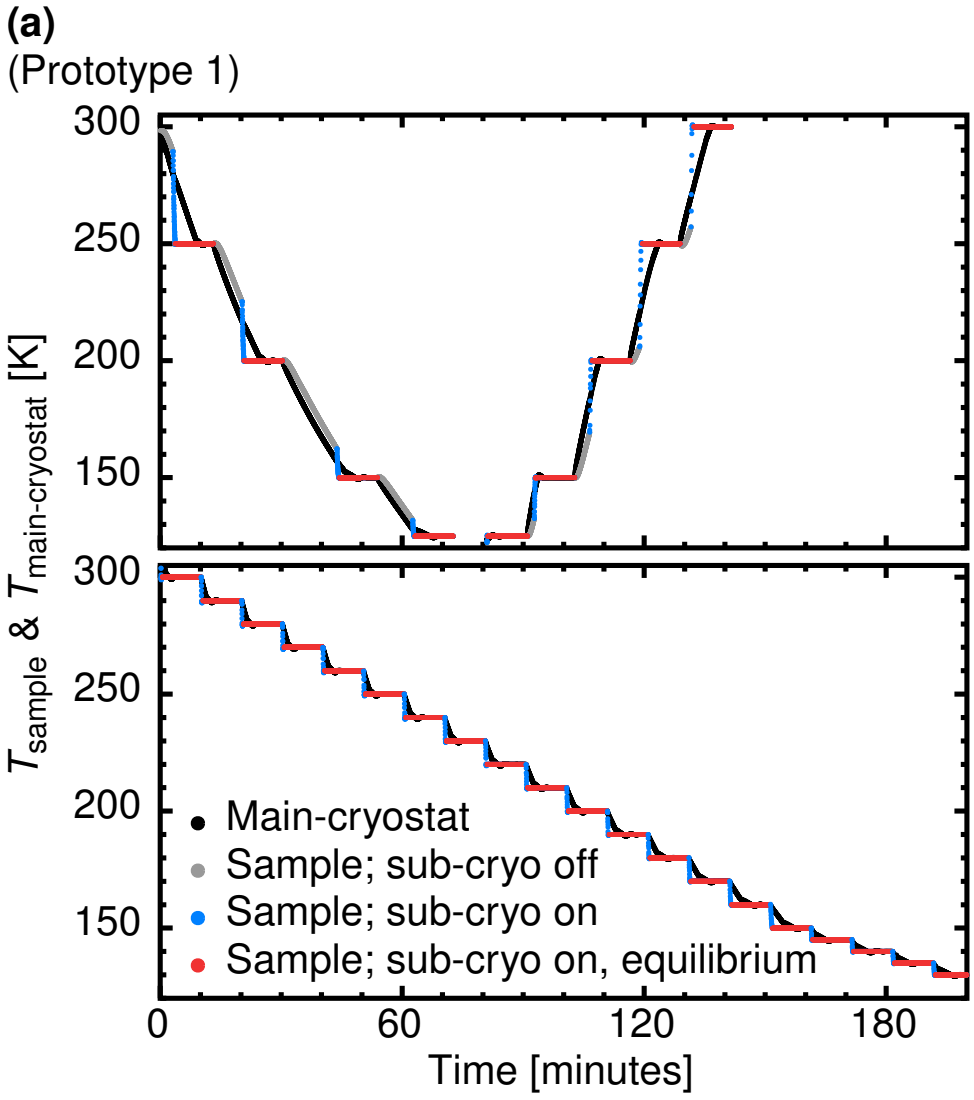


- Control software
- Integration with EPICS control framework



Performance I

$20\,\%$–$50\,\%$ gain in measuring time



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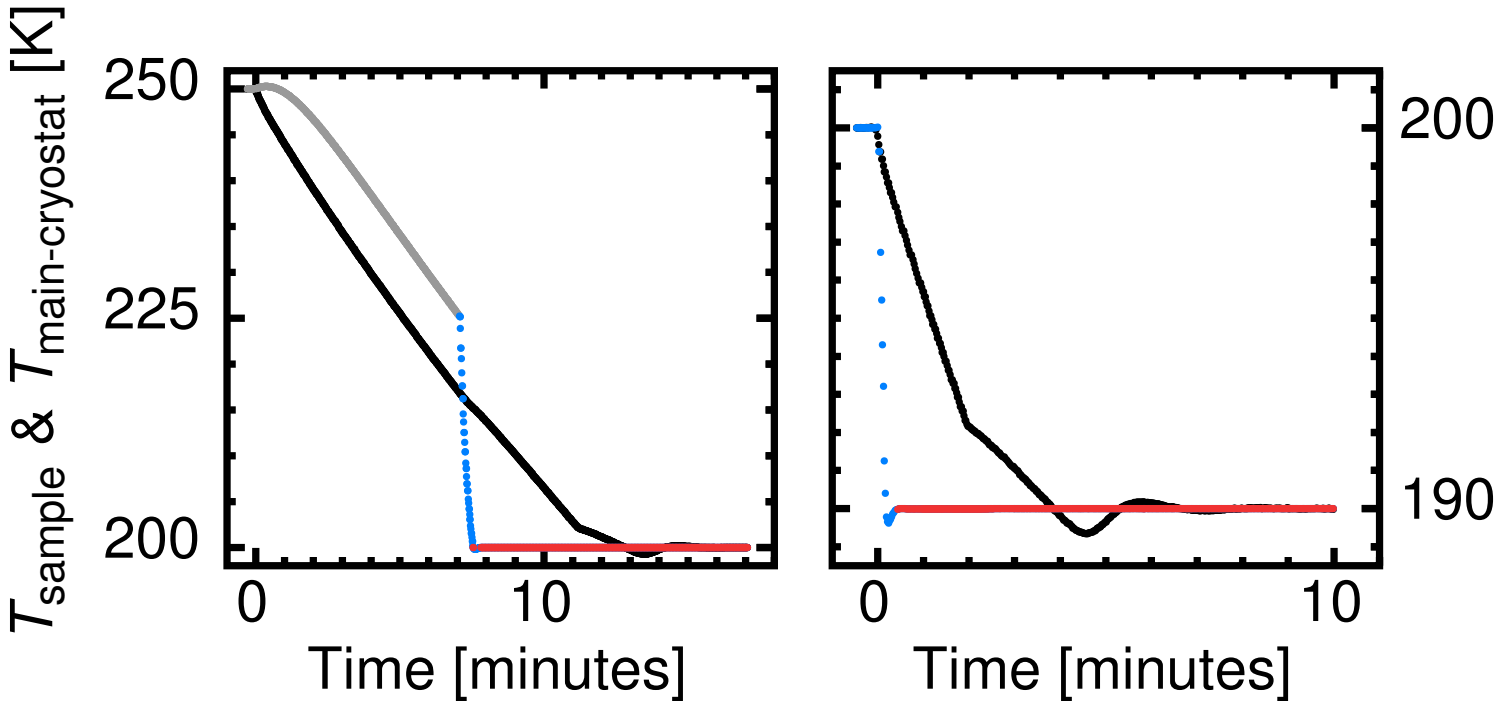
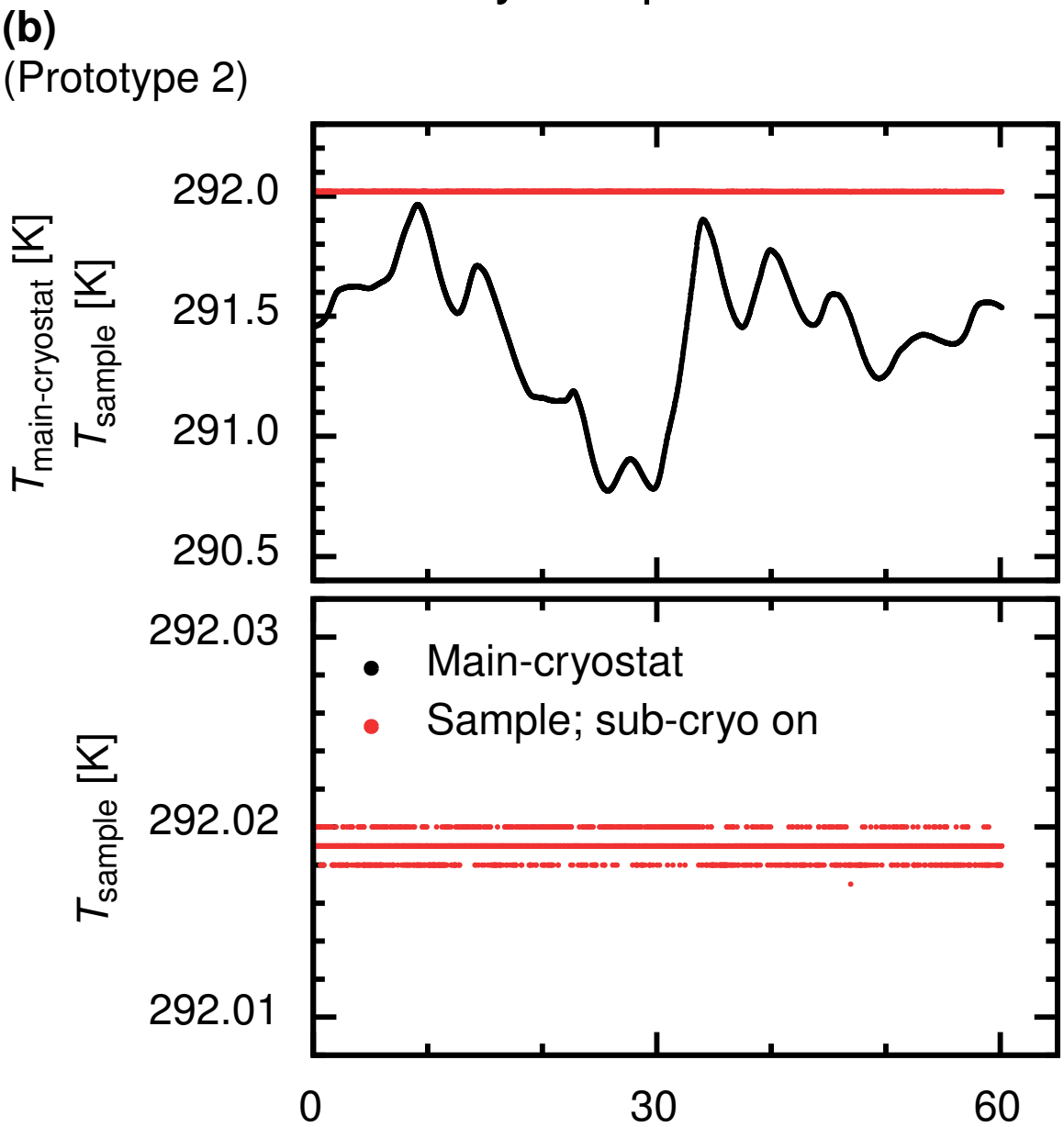


Performance II

Temperature on Al dummy sample stable within $1\,\mathrm{mK}$



Performance summary

- Working temperature: $100\,\mathrm{K}$ to $370\,\mathrm{K}$
- $\pm 5\,\mathrm{K}$ changes in equilibrium within minutes
- Difference from outer cryostat: approximate $\pm 15\,\mathrm{K}$
- Improve stability on the bare cryostat performance by at least an order of magnitude

SANS multi-temperature cuvette holder

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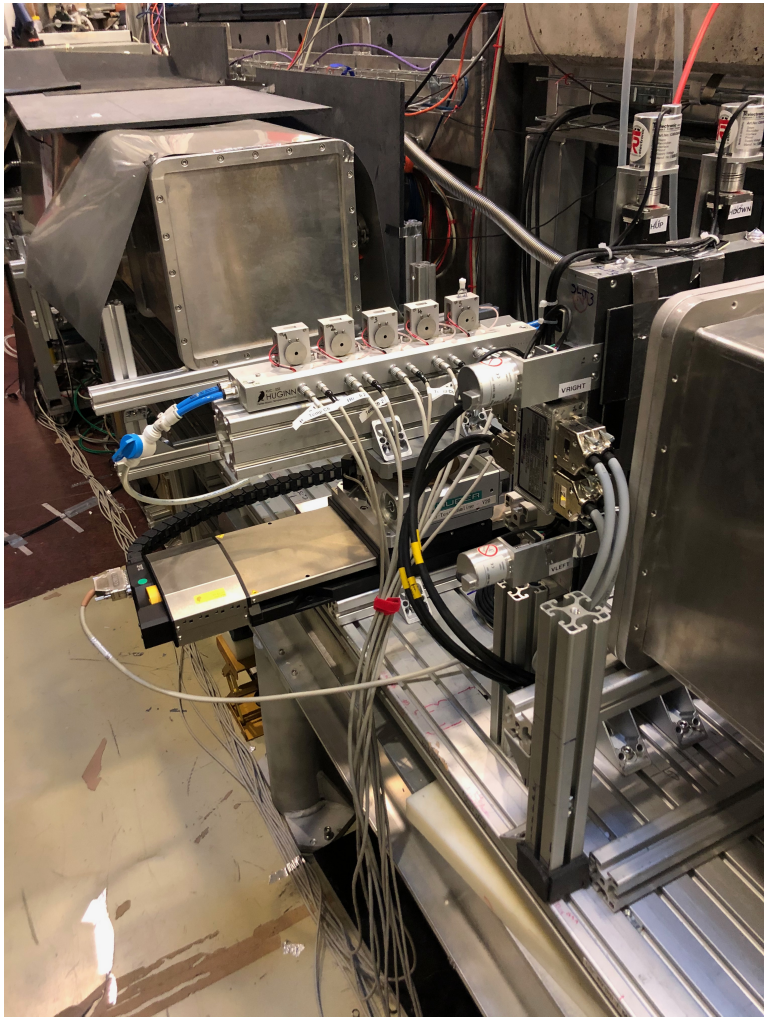

Test at V20 ESS Test Beamline (HZB)
performed by staff from ESS and HZB.

Sample environment development

Why sample environment development at RUC

- Physics at RUC has
  - A full professional electronic and mechanical workshop
  - Experience with large scale experience
- Expertise in control software development
- Optimal for prototype development

Possible industry contributions to sample environment development

- Small series production
  - Electronics
  - Mechanical parts (CNC)
- Optimization of design
  - E.g. FEM calculations
  - Optimization for “easy” production

Thank you for your attention

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