attocube
WITTENSTEIN group

User Manual

attoDRY2100 | attoDRY2100 XL | attoDRY2200

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1 Notes on This Manual

1.1 Purpose and Availability

This manual applies to the attoDRY2100, the attoDRY2100 XL and the attoDRY2200. All named systems are also referred to as "system" in this document.

The manual explains the installation and operation of the system. It contains instructions for the appropriate use and the maintenance of the system.

- Read this manual before setting up and using the system.
- Always keep this manual easily accessible for all system users.

1.2 Symbols and Conventions

1.2.1 Warning Notes

WARNING
This is a warning information about hazards that can cause death or severe injuries if the suitable precautions are not taken.

CAUTION
This is a warning information about hazards that can cause injuries if the suitable precautions are not taken.

NOTE
This is a warning information about hazards that can cause property damages if the suitable precautions are not taken.

1.2.2 Symbols

For the continuing safety of the operator of this equipment and the protection of the equipment itself, the operator must take notice of the warning symbols and notes throughout this manual and – where applicable – on the product itself.

The following safety symbols are used in this manual:

Hot surface! May cause injury when touched.

Risk of electric shock! High voltage present. May cause injury or death when touched.

General hazard! May cause injury or death if the suitable precautions are not taken.

May cause damage to the product, the process, or the surroundings if the suitable precautions are not taken.

1.2.3 Information Markup

To improve traceability, the following design conventions are used in this document:

- Names of elements like folders, files, screens, options etc. are marked by "double quotes".
- Prerequisites for actions are displayed with a leading check: ✓.
- Instruction steps which are part of a sequence are displayed with a leading ordinal number.
- Instruction steps which are variables or alternative are displayed with leading circle: ○.
- Results of instruction parts are displayed with a leading arrow: →.
- References to parts of graphics are displayed in **bold** cardinal numbers.
- Software input or output text as well as file names are displayed in `monospace` font.
- Variables and wildcards are displayed in *italic* font.
- Keys and buttons are marked by [square brackets].
- References to internal document parts are displayed in orange font.

TIP
This note provides additional information to simplify your work.

1.3 Abbreviations

Uncommon abbreviations are explained in section 13.

2 Declarations

2.1 Declaration of Conformity

For Customers in Europe

CE

This equipment has been tested and found to comply with the EC Directives 2014/30/EU "EMC Directive" and 2014/35/EU "Low Voltage Directive".

Compliance was demonstrated by conformance to the following specifications, which have been listed in the Official Journal of the European Communities:

- Safety EN61010-1-2010
- EMC EN61326-1:2013

For North American Customers

This equipment has been tested and found to comply with the limits for a Class B digital product, pursuant to Part 15 of the FCC Rules and meets all requirements of the Canadian Interference-Causing Equipment Standard ICES-003 for digital apparatus. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

- Reorient or relocate the receiving antenna.
- Increase the separation between the equipment and receiver.
- Connect the equipment to an outlet on a circuit different from that to which the receiver is connected.
- Consult the dealer or an experienced radio technician for help.

Changes or modifications to the product that are not explicitly approved by attocube could void the user's authority to operate the equipment.

2.2 Waste Electrical and Electronic Equipment (WEEE) Directive

Compliance

As required by the Waste Electrical and Electronic Equipment (WEEE) Directive of the European Community and the corresponding national laws, attocube offers all end users within the European Union (EU) the possibility to return end-of-life units without incurring disposal charges.

This offer is valid for attocube's electrical and electronic equipment:

- sold after August 13th, 2005,
- marked correspondingly with the crossed-out "wheelie bin" logo (see logo to the left),
- sold to a company or institute within the EU,
- still complete, not disassembled, and not contaminated.

If you wish to return an attocube unit for waste recovery, please contact attocube or your nearest dealer for further information.

Waste Treatment on Your Own Responsibility

If you do not return an end-of-life unit to attocube, you must hand it to a company specialized in waste recovery. Do not dispose of the unit in a litter bin or at a public waste disposal site.

Ecological Background

It is well known that WEEE pollutes the environment by releasing toxic products during decomposition. The aim of the European RoHS directive is to reduce the content of toxic substances in electronic products in the future.

The intent of the WEEE directive is to enforce the recycling of WEEE. A controlled recycling of end-of-life products will thereby avoid negative impacts on the environment.

3 Safety Information

3.1 Important Warnings

WARNING

Risk of electric shock

Inappropriate handling of the system may cause death, severe injury or material damage.

- Never remove the system's protective covers or attempt any repair or adjustment.
- Immediately shut off the system, disconnect the mains supply and contact attocube in case of any suspected malfunction.
- Never connect any cabling to the electronics when the outputs are enabled.
- Be careful not to create short-circuits on the connectors or anywhere in the cabling.

WARNING

Risk of explosion

Explosions due to overpressure in vacuum chambers may cause death, severe injury or material damage.

- Do never block any overpressure valve connected to the system, e. g. by mounting parts on the outside.
- Do not change the opening pressure of security valves.
- Immediately contact attocube if you suspect any leakage of the vacuum chamber connected to the working system, e.g. due to condensate buildups at inside walls of the vacuum chamber.

CAUTION

General hazard

The system's operation under inappropriate conditions may lead to injury or material damage.

- Do not operate the system outside its dedicated supply voltage or environmental limits as specified in section 4.3.3.
- Do not operate the system unless you are properly trained in the use and handling of mains powered electrical equipment.

NOTE

Surface damages of critical components (as the top flange, the lower part of the vacuum shroud or the feedthrough rings) may interfere with their proper functioning.

- Do not scratch surfaces critical for vacuum sealing or temperature transport.
- Always place removed parts that are critical for vacuum sealing on a soft surface like a piece of cloth. Avoid direct contact of these parts with metal surfaces.

NOTE

Servicing and maintenance is only allowed to persons with explicit authorization of attocube. There are no user serviceable parts on the system. Modified or open electronics are no longer covered by attocube's warranty.

- Do not open the system or its components unless you are explicitly instructed to do so by this manual.
- For servicing and repair always contact attocube.

NOTE

The integrity of the cables, tubings and the entire connection setup as installed by attocube is essential to the system's functioning.

- Do not change any connection of the original wiring between the system components.
- Protect all cables and tubes from being damaged by temporary or permanent weight exposure.
- Never disconnect the helium lines from the helium compressor or the cryostat.

3.2 Third-party Documents

WARNING

Ignorance of third-party documentation

Inappropriate handling of third-party system components may lead to material damage, injuries or even death. attocube assumes no liability for damages resulting from incorrect handling of third-party components.

- Read and obey the third-party documents delivered with your system conscientiously.

Manufacturer documents for the following components are delivered with the system:

- Helium compressor
- Pulse tube system

4 System Description

4.1 General Concept

The system is a cryogenic system that allows the user to easily set up and perform low vibration measurements over the full temperature and magnetic field range. It is capable of achieving temperatures of below 1.8 K without supply of external cryogenic liquids.

The system is loaded from the top for effortless sample exchange and fast thermal turnaround times. It is designed to combine the advantages of a variable temperature cryostat with the ease of use of a cryogen-free system. Special care has been taken to minimize the vibrations caused by the pulse tube cold head.

The system is designed to be used in conjunction with an attocube cryogenic measurement insert that optionally includes a sample heater and a sample temperature sensor. It comes equipped with a superconducting magnet that can be selected by the customer from a variety of solenoid and vector magnets.

The system can be controlled directly via the integrated touch panel or remotely via a webserver application. An API allows for more complex control and configuration options accessible via LabVIEW, MATLAB, Python, C and C#.

4.2 Scope of Delivery

The system consists of the following components:

- main unit, i.e. the cryostat with an optional magnet inside
- support unit including control electronics, pulse tube rotary valve and pulse tube buffer reservoir
- gas handling system (GHS) including helium storage vessel, scroll pump (for low-pressure supply), valves and helium compressor (for high-pressure helium supply)
- the USB flash drive with software, dynamic link library and documentation
- optional magnet power supply (if superconducting magnet is included)

attoDRY2100 and attoDRY2100 XL

Figure 1 Scope of delivery, attoDRY2100 and attoDRY2100 XL

1	Main unit	see section 4.4.2
2	Support unit	see section 4.4.3
3	Gas handling system	see section 4.4.4

attoDRY2200

Figure 2 Scope of delivery, attoDRY2200

1	Main unit	see section 4.4.2
2	Support unit	see section 4.4.3
3	Gas handling system	see section 4.4.4

4.3 Technical Data

4.3.1 Dimensions

The tables below summarize the dimensions of the system components.

> **TIP**
> For further information on the system's technical data, consult the corresponding specification sheet.

attoDRY2100 and attoDRY2100 XL

Note that for systems with vector magnets or solenoid magnets exceeding 9 T the XL versions of the main and support unit will be delivered.

Main Component	Width [mm]	Depth [mm]	Height [mm]	Weight [kg]
Main unit	610	610	1050	183
Main unit XL	700	700	1300	200 – 280 (depending on magnet weight)
Support unit	440	440	1050	70
Support unit XL	440	440	1300	70

attoDRY2200

Main Component	Width [mm]	Depth [mm]	Height [mm]	Weight [kg]
Main and support unit	1450	793	1360	420 – 520 (depending on magnet weight)

Gas handling system

Main Component	Width [mm]	Depth [mm]	Height [mm]	Weight [kg]
Gas handling system (excl. compressor)	646	906	1745	74
Compressor	480	460	620	128

4.3.2 Magnetic Field Strength

attoDRY2100

The system employs a magnet with a field strength of between 9 T and -9 T. The full range is applicable between base temperature (< 2 K) and 300 K.

attoDRY2100 XL and attoDRY2200

The magnetic field strength and temperature range depend on the system's specific magnet.

TIP
Refer to the manual of your magnet for the applicable field strength and temperature range.

4.3.3 Operation Requirements

NOTE
The information in this section applies to the main and support unit.

- For information on third-party components consult the respective manufacturer documentation.

CAUTION
Inappropriate working conditions
The system's operation under inappropriate conditions may lead to injury or material damage.

- Do not operate the system outside its dedicated voltage supply and environmental limits.

CAUTION
Wrong cabling
Inadequate equipment may cause electric shocks or fire.

- Only use power supply cables provided by attocube.

The following environmental limits must be observed when operating the system.

Parameter	Value
Supply voltage	100 V, 115 V or 230 V AC
Line frequency	50 Hz or 60 Hz
Operational area	Indoor use only
Floor vibrations	VC-E, NIST-A or better
Acoustic noise	< 70 dB
Temperature range	5 °C to 40 °C
Relative humidity	20 % to 80 % (non-condensing)
Air quality	Free of excess particulate matter
Distance to highly magnetic materials or other sources of strong magnetic fields	> 1 m for attoDRY2100 For attoDRY2100 XL and attoDRY2200 consult your pre-installation guide.

4.3.4 PC Requirements

The following requirements must be met by the connected PC.

Parameter	Value
Ethernet interface	required, Cat6 cable for 1000 Mbit recommended
Operating system	Microsoft Windows 10 © or higher

4.4 Structure of the System

4.4.1 Connection Scheme

The completely installed system is structured as shown in the following graphic.

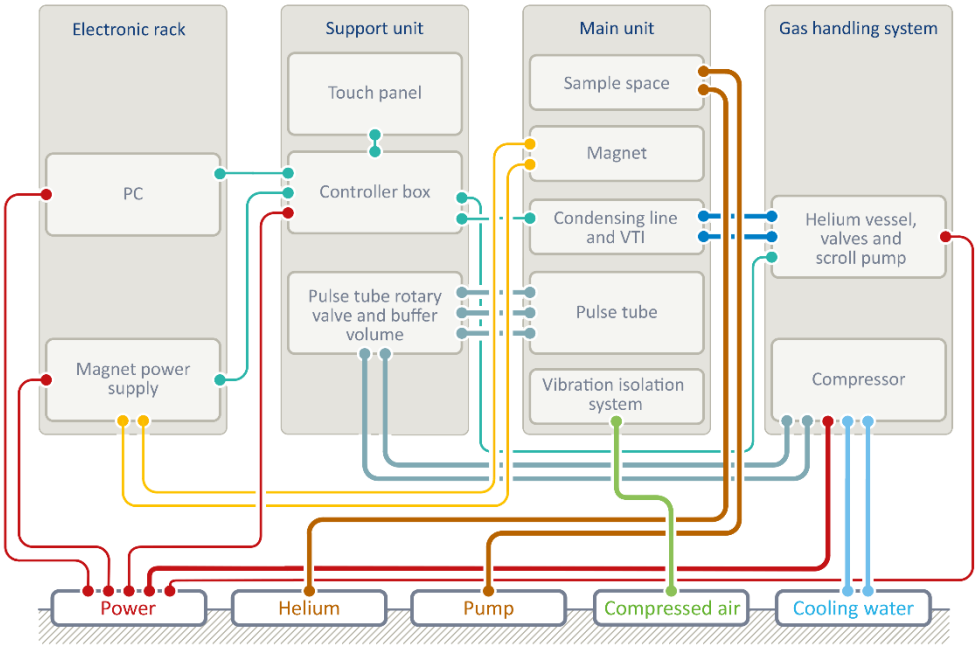

Figure 3 Structure of the system

red	Mains power connections	
yellow	Magnet power connections	
turquoise	Signal connections	
gray	High-pressure helium lines	Supply and return for first cooling circuit
brown	Sample space helium lines	Supply and return for sample space temperature exchange
dark blue	Low-pressure helium lines	Supply and return for second cooling circuit
light blue	Cooling water connections	Supply and return for compressor cooling
green	Compressed air connection	(attoDRY2200 only)

TIP
In attoDRY2200, main unit and support unit are integrated in a combined housing.

4.4.2 Main Unit

The main unit is the core component in which the actual cooling and research takes place. The cool-down is conducted in three stages, which are supplied by two separate cooling circuits (see section 5.1). The sample space has a KF50 top flange to load inserts of up to 49 mm diameter. The length of the insert and the location of the magnetic field center depend on the microscope and the magnet used.

attoDRY2100 and attoDRY2100 XL

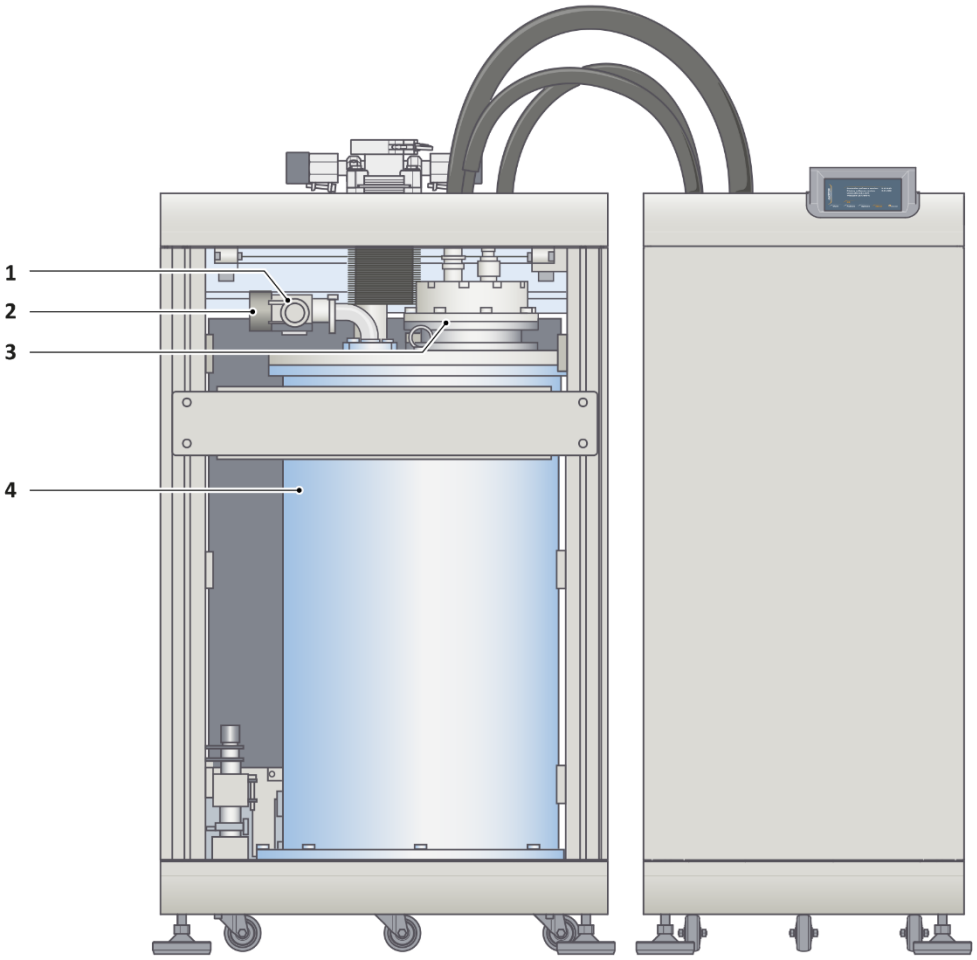

Figure 4 Main unit attoDRY2100 and attoDRY2100 XL, internal components

1	Isolation vacuum interface	For Dewar vessel evacuation
2	Isolation vacuum valve	Open/close the isolation vacuum
3	Pulse tube	
4	Dewar vessel	Isolation vacuum container

attoDRY2200

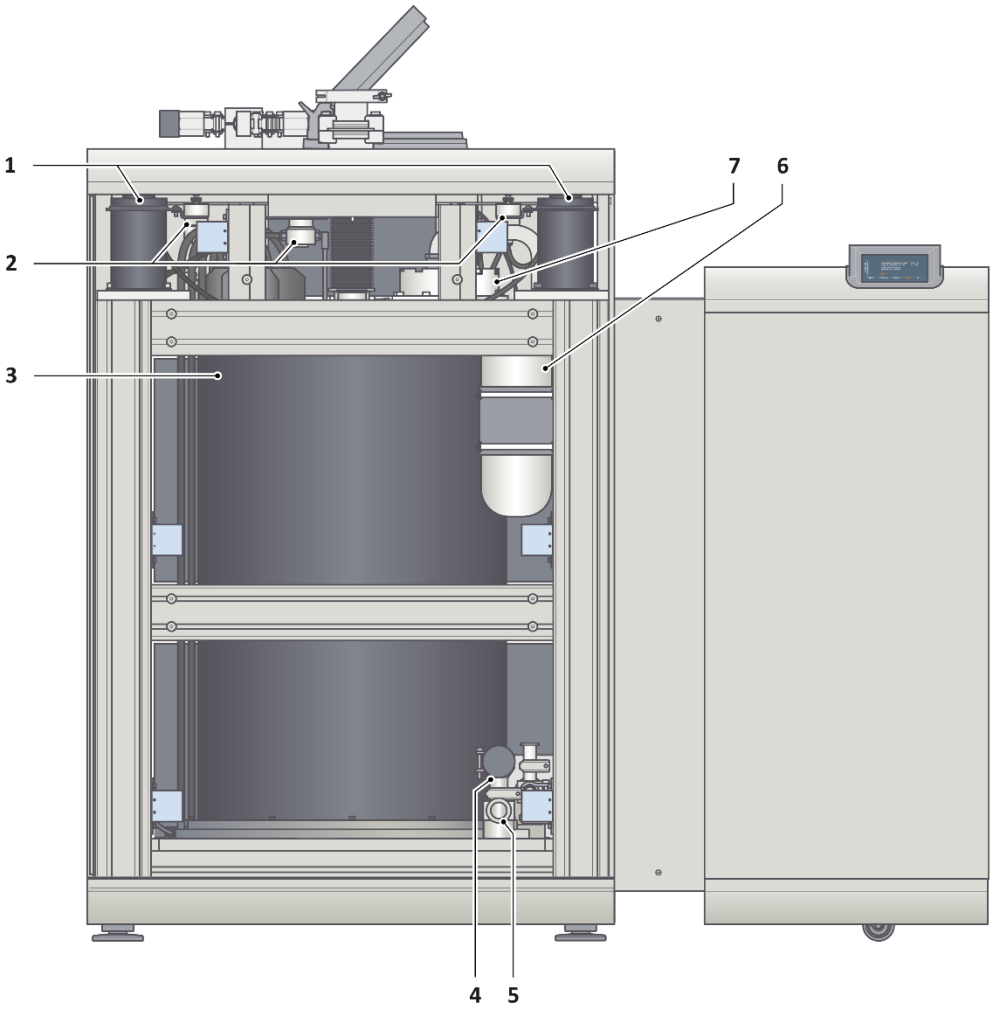

Figure 5 Main unit attoDRY2200, internal components

1	Vibration isolation damper	
2	Vibration isolation valves	
3	Dewar vessel	Isolation vacuum container
4	Isolation vacuum valve	For Dewar vessel evacuation
5	Isolation vacuum interface	Open/close the isolation vacuum
6	Buffer volume	
7	Pulse tube	

4.4.3 Support Unit

The support unit supplies the main unit with helium for the first cooling circuit. To control the helium pressure, it employs the pulse tube rotary valve as well as a helium buffer volume. The high-pressure helium flow for the first cooling circuit is generated by the GHS' compressor the support unit is connected to.

The support unit also holds the electronics to control the system's valves, heaters and the GHS' scroll pump, as well as it processes the data received by the temperature sensors. User input is received from a connected PC or directly via the touch panel that is also part of the support unit.

attoDRY2100 and attoDRY2100 XL

Although different in size, attoDRY2100 XL is essentially equal to attoDRY2100 in its appearance and setup.

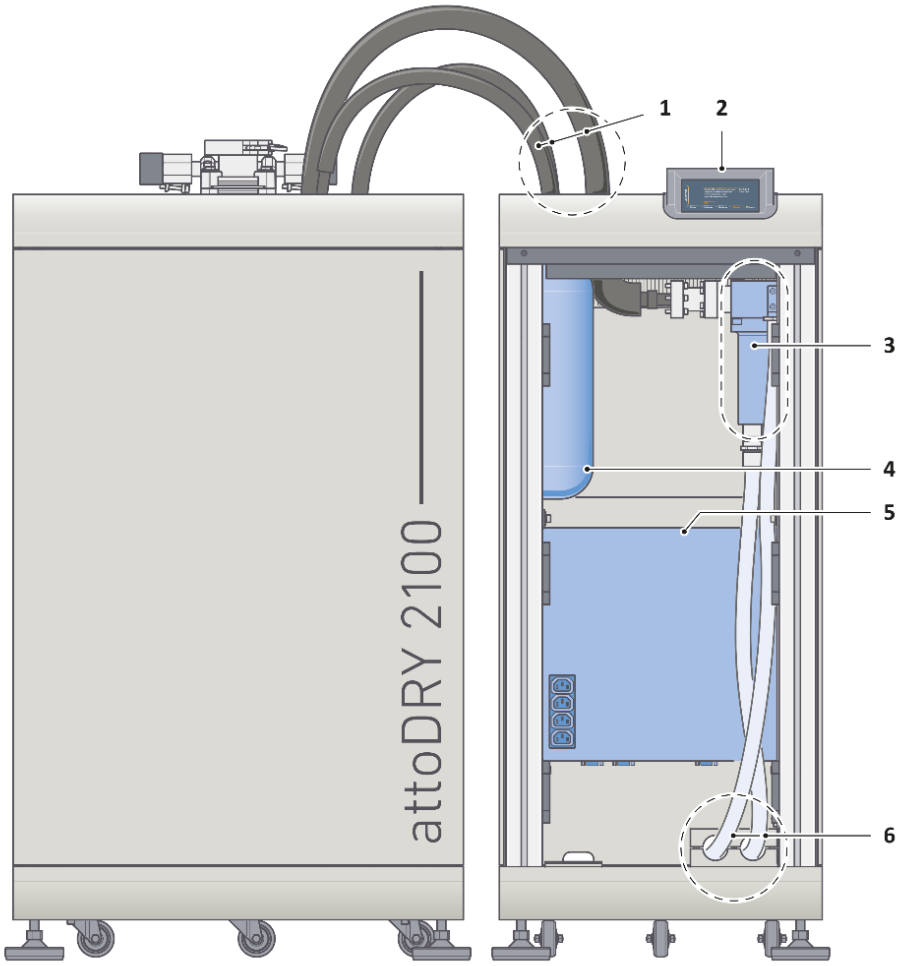

Figure 6 Support unit attoDRY2100 and attoDRY2100 XL

1	Helium supply and return lines	Connection to main unit, for first cooling circuit
2	Touch panel	Control the system
3	Pulse tube rotary valve	Helium pressure control
4	Buffer volume	
5	Control electronics	
6	High-pressure helium lines	Connection to GHS compressor

attoDRY2200

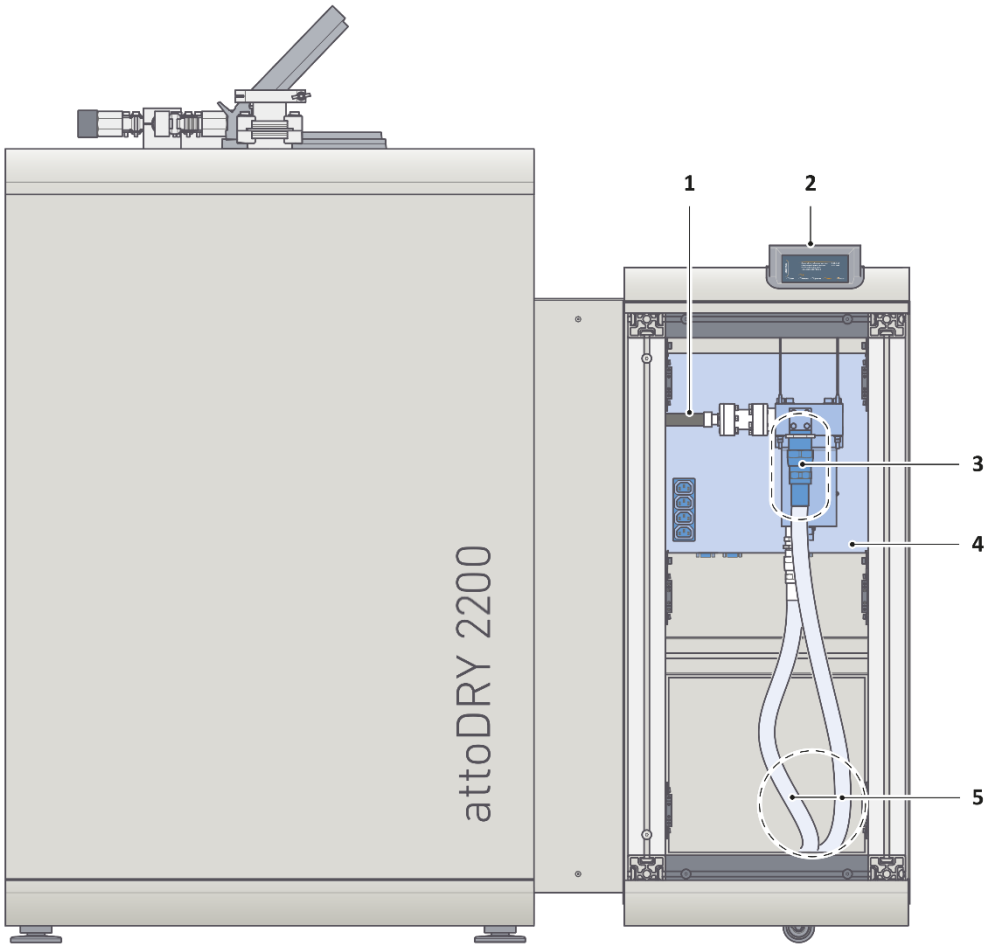

Figure 7 Support unit attoDRY2200

1	Helium supply and return lines	Connection to main unit, for first cooling circuit
2	Touch panel	Control the system
3	Pulse tube rotary valve	Helium pressure control
4	Control electronics	
5	High-pressure helium lines	Connection to GHS compressor

4.4.4 Gas Handling System

The GHS components can be classified into either belonging to the high-pressure or to the low-pressure helium circuit.

The high-pressure helium circuit leads, via the supply unit, to the main unit's first cooling circuit, which is responsible for a temperature reduction down to 4 K. The only GHS component belonging to this group is the helium compressor. It is connected to the support unit by flexible stainless-steel hoses for supply and return flow.

The low-pressure helium circuit directly disembogues in the main unit's second cooling circuit. The respective components are:

- the helium storage vessel
- the scroll pump
- three pressure gauges
- four electrically driven valves

When the main unit's pulse tube has reached its base temperature, helium is pumped into the second cooling circuit with a constant pressure difference between the cryo-in and cryo-out flow from and to the GHS. When the VTI is warmed up, the pressure gradient and helium flow is reduced to decrease the heater power necessary for warming up the sample space.

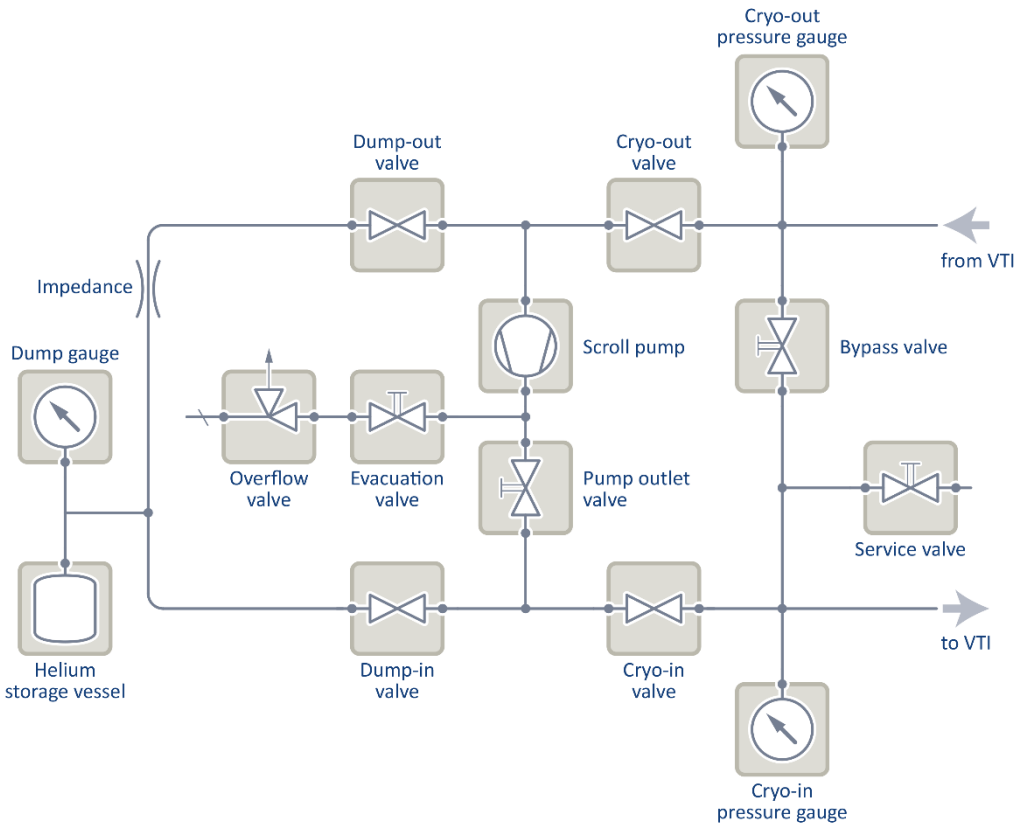

Figure 8 GHS, pump and valves arrangement of low-pressure circuit

4.5 Connection Types and Positions

4.5.1 Main Unit Connection Panel

attoDRY2100 and attoDRY2100 XL

Although different in size, attoDRY2100 XL is essentially equal to attoDRY2100 in its appearance and setup.

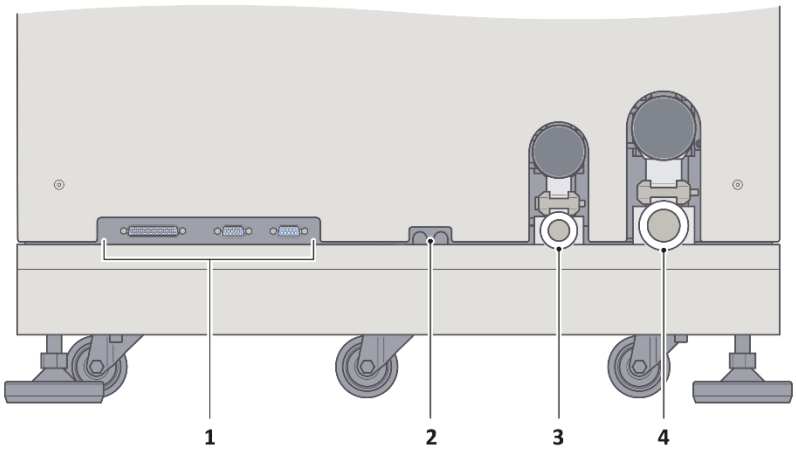

Figure 9 Main unit attoDRY2100 and attoDRY2100 XL, rear connection panel

1	Main unit distribution board	Heater control and temperature feedback connection to support unit
2	Magnet power cable feedthroughs	
3	Cryo-in interface	Low-pressure helium intake from GHS
4	Cryo-out interface	Low-pressure helium outlet to GHS

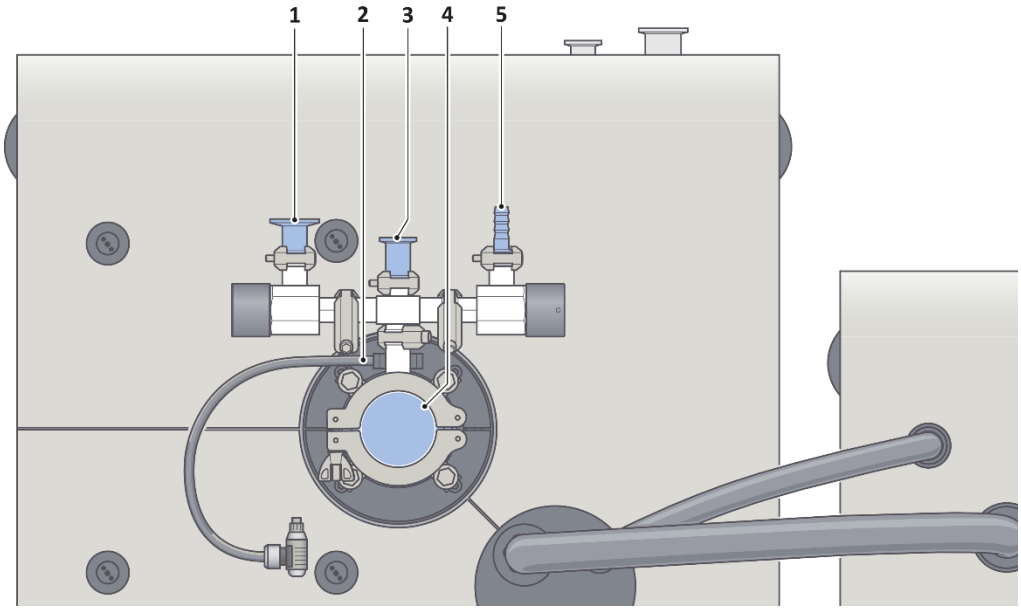

Figure 10 Main unit attoDRY2100 and attoDRY2100 XL, sample space interfaces

1	Helium pump interface	Connection to external helium pump, KF25
2	Sample thermometry cable	Connection to microscope insert
3	Overflow valve	Overflow helium outlet for pressure control
4	Top flange	Receptacle for microscope insert, KF50
5	Helium nozzle	Connection to external helium supply, DN6

attoDRY2200

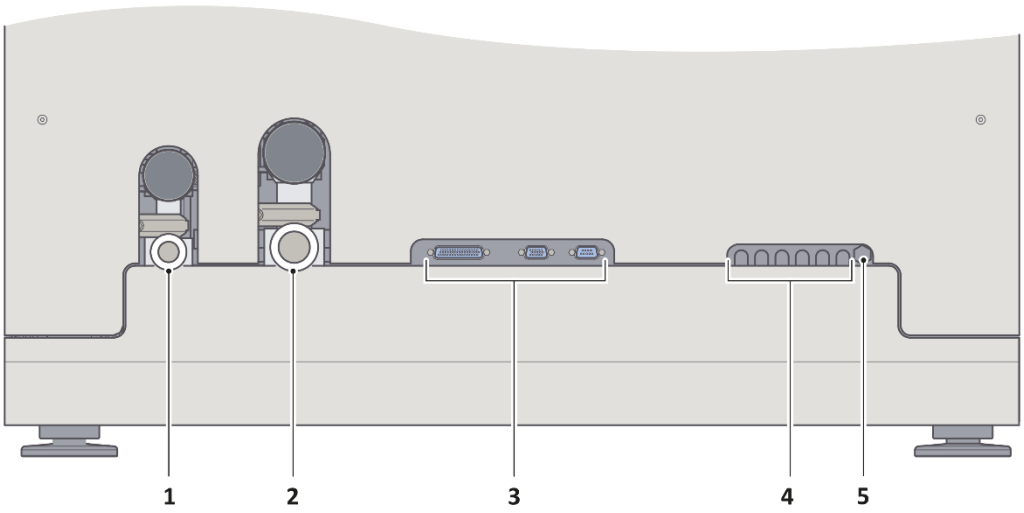

Figure 11 Main unit attoDRY2200, rear connection panel

1	Cryo-in interface	Low-pressure helium intake from GHS
2	Cryo-out interface	Low-pressure helium outlet to GHS
3	Main unit distribution board	Heater control and temperature feedback connection to support unit
4	Magnet power cable feedthroughs	
5	Compressed air interface	Compressed air supply for vibration isolation

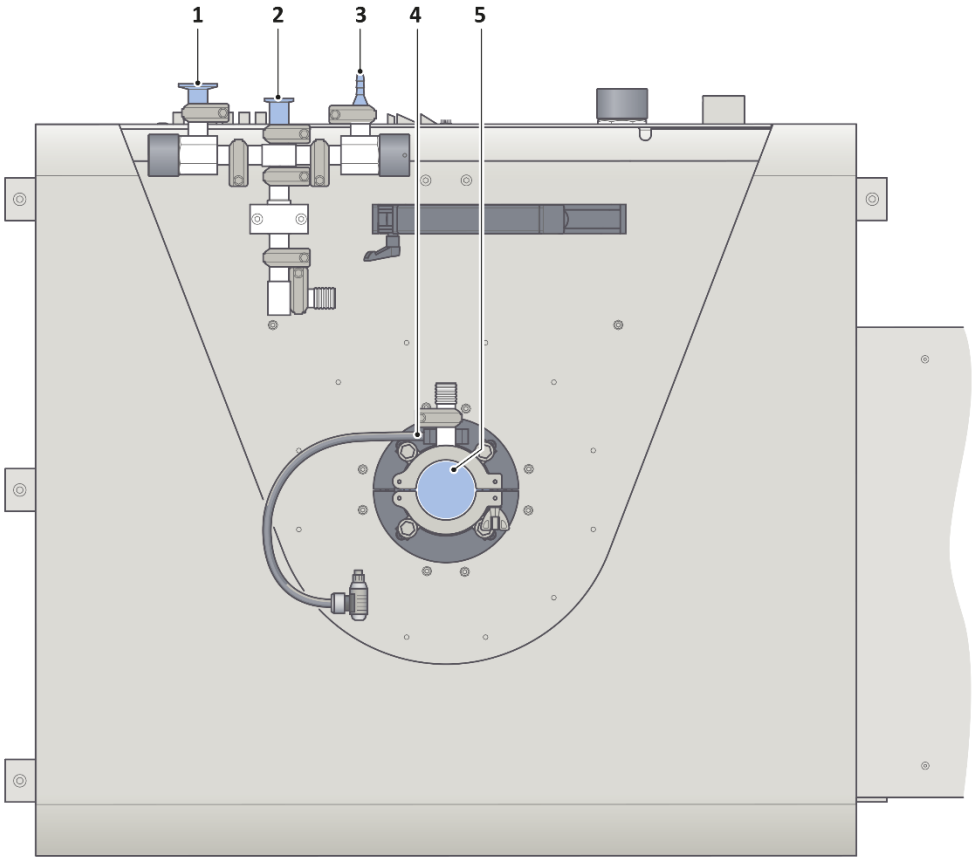

Figure 12 Main unit attoDRY2200, sample space interfaces

1	Helium pump interface	Connection to external helium pump, KF25
2	Overflow valve	
3	Helium nozzle	Connection to external helium supply, DN6
4	Sample thermometry cable	Connection to microscope insert
5	Top flange	Receptacle for microscope insert, KF50

4.5.2 Support Unit Connection Panel

attoDRY2100 and attoDRY2100 XL

Although different in size, attoDRY2100 XL is essentially equal to attoDRY2100 in its appearance and setup.

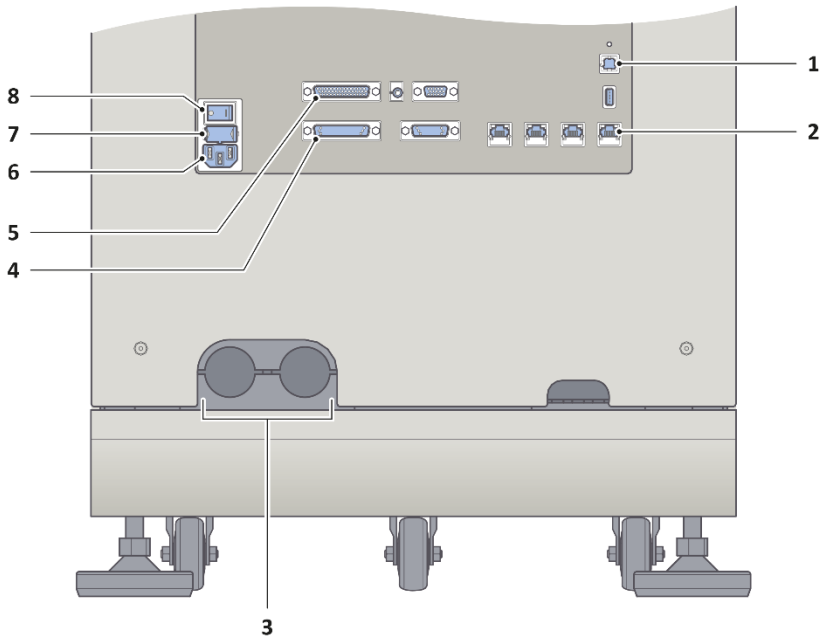

Figure 13 Support unit attoDRY2100 and attoDRY2100 XL, connection panel

1	PC connection interface	
2	Ethernet interface	Connection to network switch, PC or magnet power supply
3	Helium line feedthroughs	Connection to compressor, high-pressure helium supply and return
4	Flow control interface	Connection to GHS, for helium flow control
5	Temperature control interface	Connection to main unit, for heater control and temperature feedback
6	Power supply socket	
7	Fuse compartment	
8	Power switch	

attoDRY2200

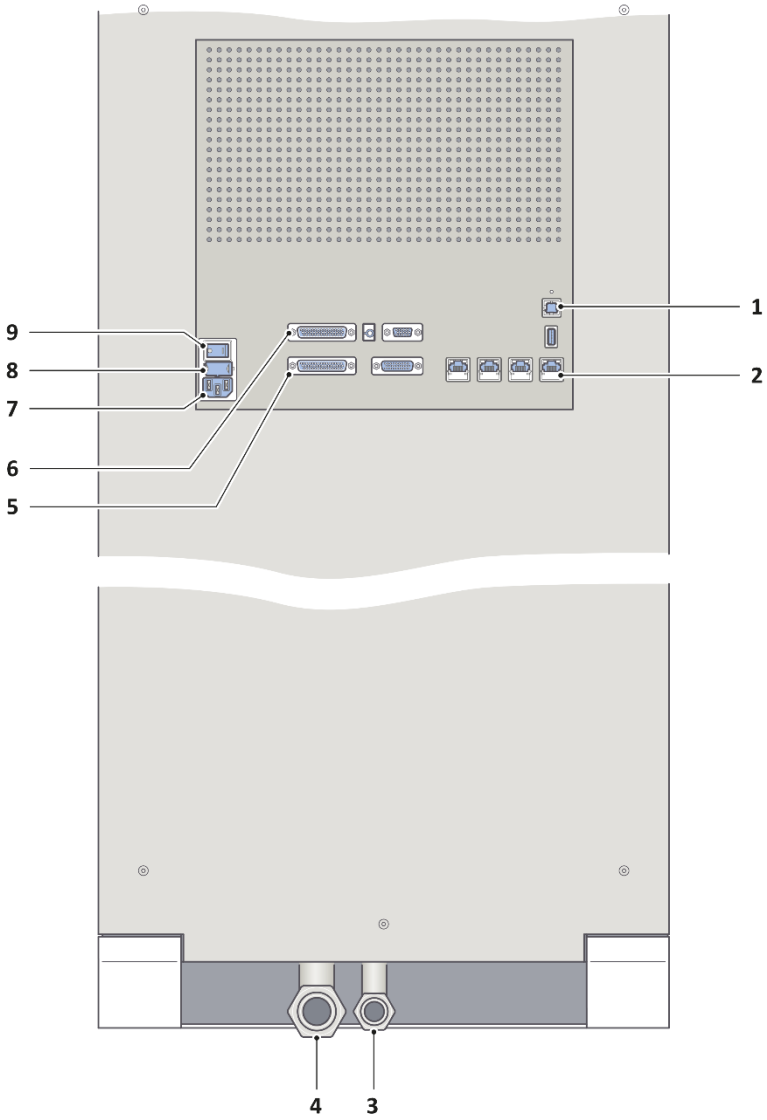

Figure 14 Support unit attoDRY2200, connection panel

1	PC connection interface	
2	Ethernet interface	Connection to network switch, PC or magnet power supply
3	High-pressure helium-in interface	High-pressure helium intake from compressor
4	High-pressure helium-out interface	High-pressure helium outlet to compressor
5	Flow control interface	Connection to GHS, for helium flow control
6	Temperature control interface	Connection to main unit, for heater control and temperature feedback
7	Power supply socket	
8	Fuse compartment	
9	Power switch	

4.5.3 Gas Handling System Connection Panels

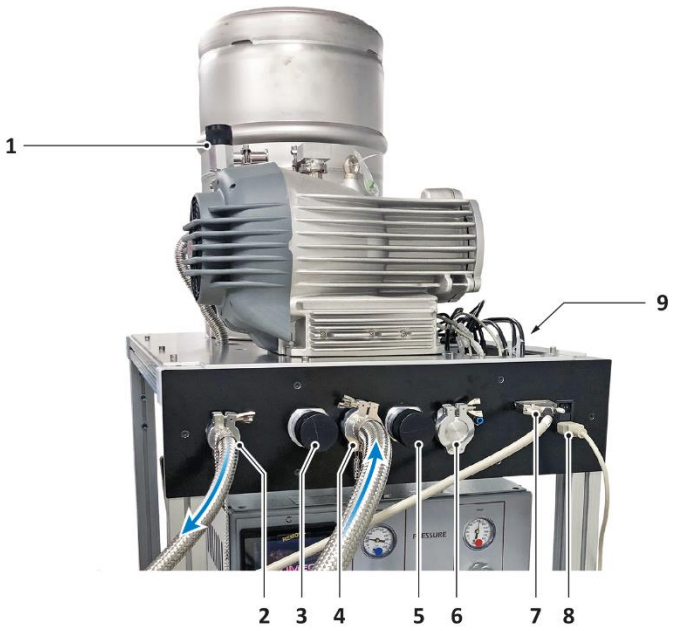

Figure 15 GHS, low-pressure and control connection panel

1	Evacuation interface	For service purposes only
2	Cryo-in line interface	Helium outlet to main unit, KF16
3	Bypass valve	Shortcut cryo-in and cryo-out lines.
4	Cryo-out line interface	Helium intake from main unit, KF25
5	Service valve	Open/close the servicing circuit.
6	Service interface	Helium outlet for servicing purposes, KF25
7	Flow control interface	Connection to support unit, for helium flow control
8	Power supply socket	Mains power connection
9	GHS control connection panel	Signal connections to components internal and external to the GHS

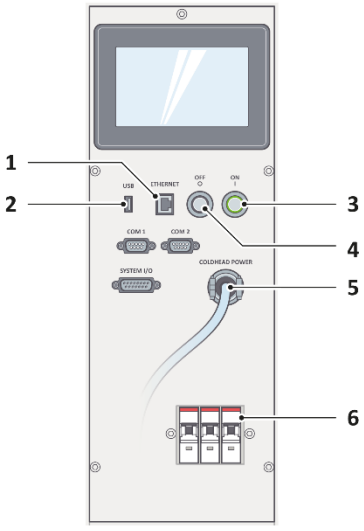

Figure 16 GHS, helium compressor signal connection panel

1	"ETHERNET" interface	Remote control connection to PC
2	"USB" interface	Storage medium connection for performance data and logfile download
3	"ON" button	Switch on the compressor on.
4	"OFF" button	Switch off the compressor off.
5	"COLD HEAD POWER" interface	Connection for pulse tube rotary valve control
6	Mains circuit breaker	

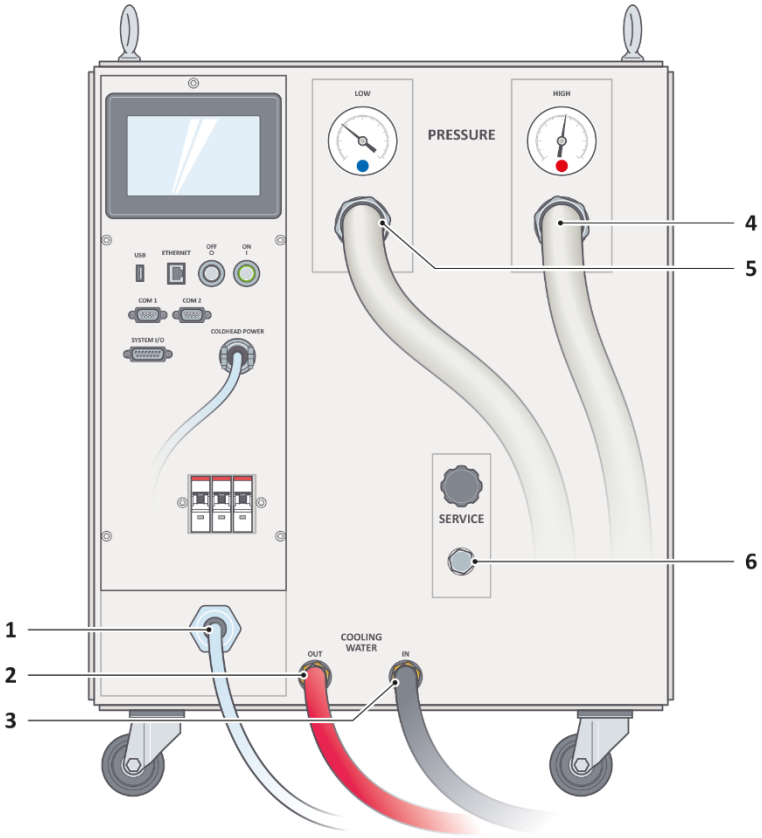

Figure 17 GHS, helium compressor media connection panel

1	Power supply socket	
2	"OUT" interface	Cooling water outlet to customer's site
3	"IN" interface	Cooling water intake from customer's site
4	Helium-out interface	High-pressure helium supply to support unit
5	Helium-in interface	High-pressure helium intake from support unit
6	"SERVICE" interface	Helium outlet for servicing purposes

5 Functional Overview

For easy and user-friendly operation, the main procedures of the system are automated. However, to take full advantage of the system's possibilities (e. g. the expert mode functions), it is necessary to understand the system's working principle (to some level of detail).

5.1 Working Principle

Two circuits with an overall of three cooling stages allow for a sample temperature control in the range of 300 K down to below 1.8 K. The pulse tube of the first circuit is supplied with helium by the high-pressure helium lines coming from the compressor. The gas is cooled down in two subsequent stages to 40 K and 4 K, respectively. Additionally, the 40 K stage is equipped with an integrated cold trap to hold back contaminants.

A second, completely closed helium circuit is used to cool the variable temperature insert (VTI) surrounding the sample space. This circuit's gas is precooled by heat exchangers attached to the 40 K and 4 K stages of the first cooling circuit. The helium pressure is further lowered by means of pressure differences generated by the GHS' low-pressure helium scroll pump connected to the circuit, such that a temperature of below 1.8 K is achieved at the third cooling stage. For warming up the sample, the VTI holds a heater at the bottom of the sample space.

For a proper thermal connection between VTI and sample, the sample space is filled with helium to act as exchange gas. The sample space can be filled with the helium via the pump and helium supply interfaces its interface block is equipped with.

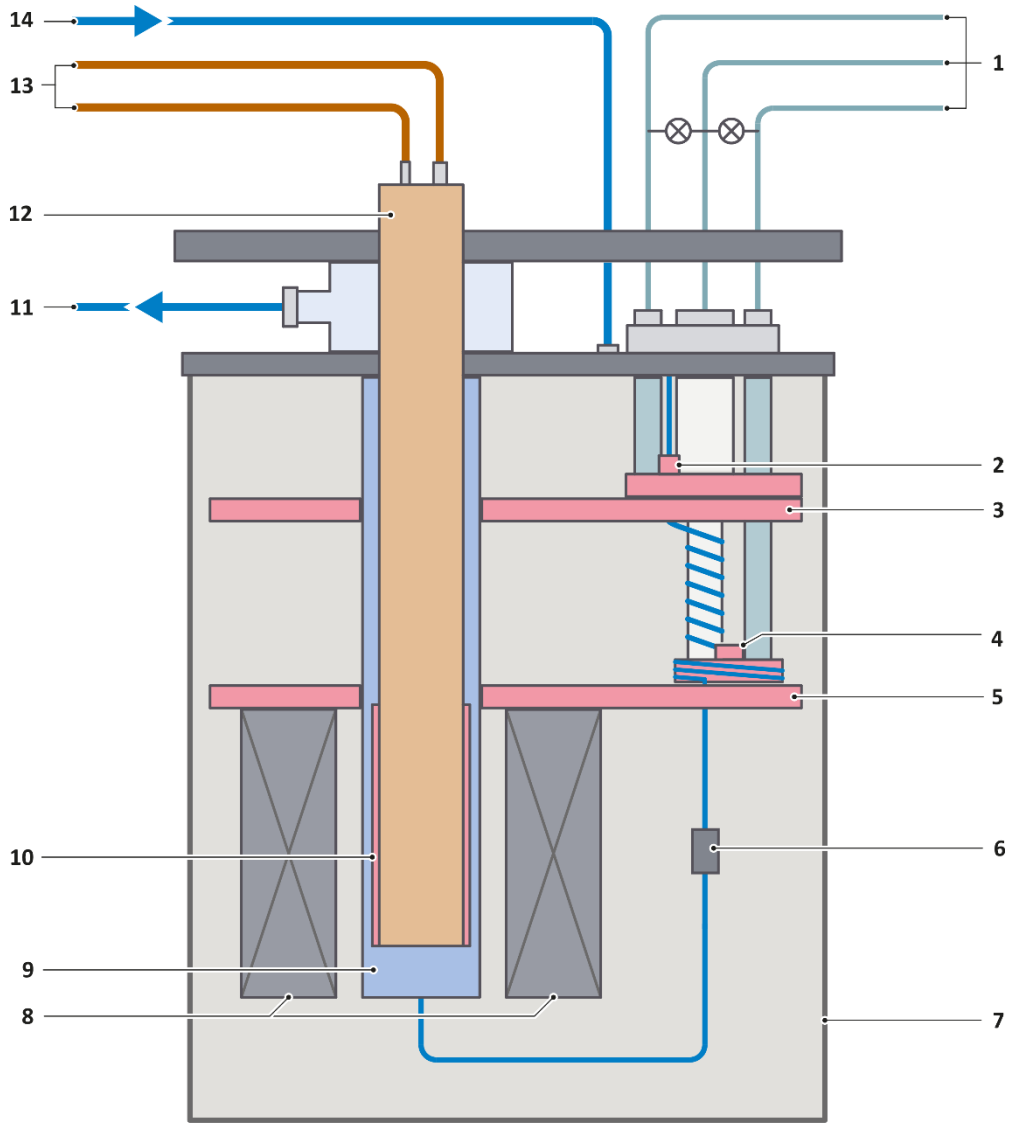

Figure 18 Main unit, cooling circuits and magnets

1	Helium supply and return lines	High-pressure helium connections to support unit
2	Cold trap	Contamination retention
3	40 K stage	Helium cool-down to 40 K
4	Condenser heater	Condensation line warm-up
5	4 K stage	Helium cool-down to 40 K
6	Flow restrictor	
7	Dewar vessel	Isolation vacuum container
8	Superconducting magnet	
9	VTI	
10	VTI heater	VTI and sample space warm-up
11	Cryo-out line	Low-pressure helium outlet to GHS
12	Sample space	
13	Sample space flushing circuit	Connection to external helium supply
14	Cryo-in line	Low-pressure helium intake from GHS

5.2 Cool-Down Procedure

The cool-down procedure cools the sample space from room temperature down to base temperature. It requires the sample space to be entirely filled with helium, with no air left (see section 8.3). As soon as the process is initiated, the system stops heating the VTI and starts condensing the helium.

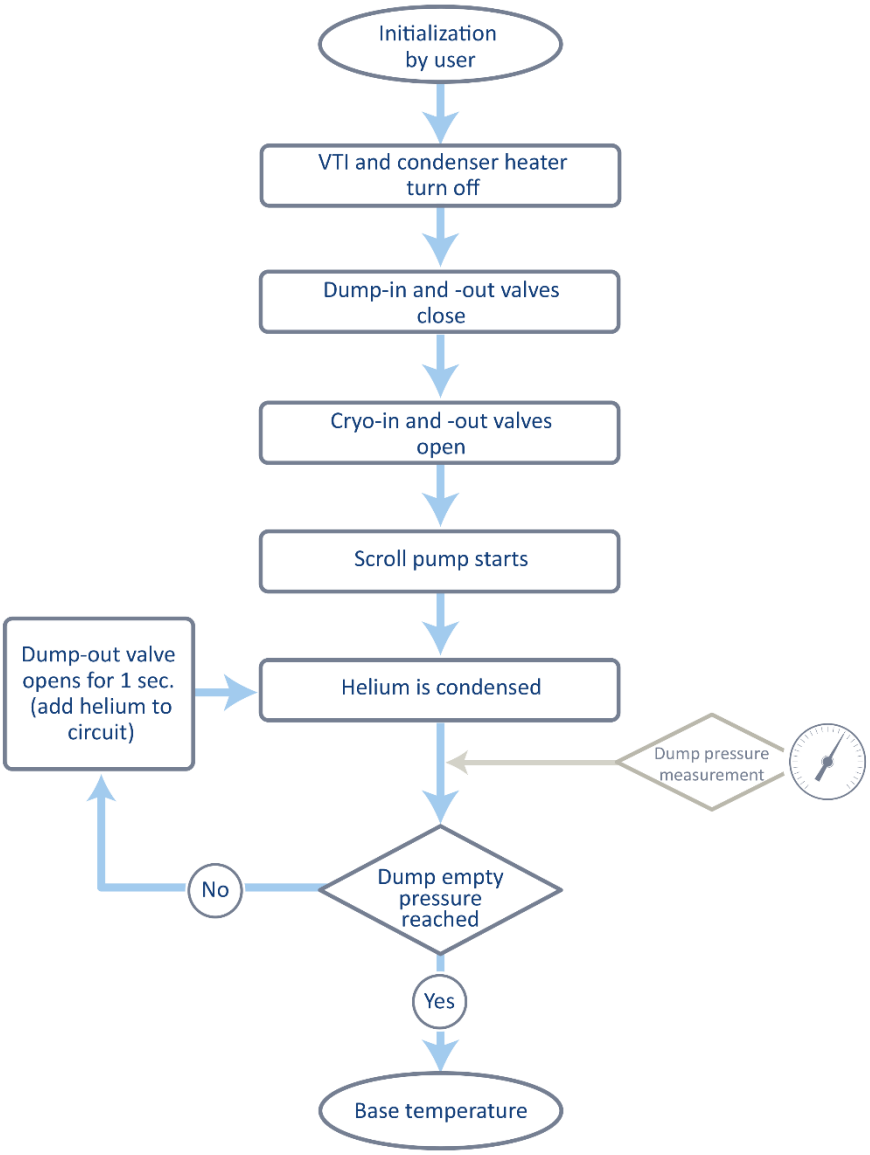

Figure 19 Cool-down procedure, flow chart

TIP

The pressure thresholds relevant for this procedure can be found in your system's specification sheet.

5.3 Sample Exchange Procedure

During the system's sample exchange procedure the sample space is warmed up to room temperature, which is prerequisite for it being opened.

As soon as the process is initiated the system reduces the flow and the amount of helium in the circuits. The VTI heater starts warming with increased power. Opening the sample space is possible when 300 K can be measured at the sample temperature sensor (or the VTI temperature sensor, respectively).

TIP
Typical warming rates do highly depend on the specific experimental setup, but, for an empty sample space, were found to be minimum around 0.5 K/min.

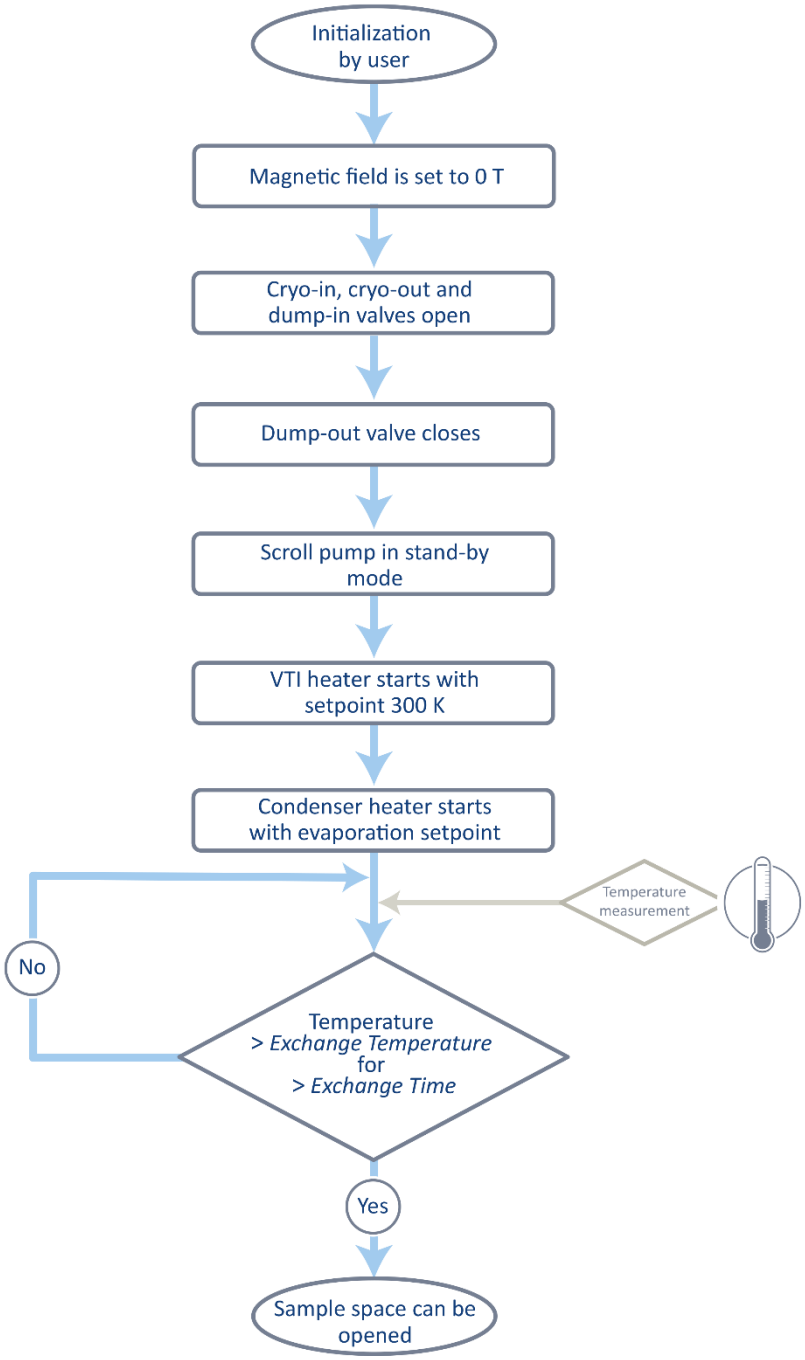

Figure 20 Sample exchange procedure, flow chart

Note that the exchange temperature and the exchange time are preset for each individual system, depending on the actual configuration of system components (e.g. the applied microscope).

TIP
The default exchange temperature and time can be found in your system's specification sheet.

5.4 Temperature Control

To achieve the best compromise of fast thermal response, stability and homogeneity, the sample temperature is usually controlled by both the VTI heater and the sample heater: If a sample temperature sensor is connected, the VTI heater keeps a temperature of 10 K below the user defined target temperature and leaves the further temperature control to the sample heater. For target temperatures below 10 K the VTI heater is switched off.

If no sample temperature sensor is connected, the system applies the setpoint to the VTI sensor and only uses the VTI heater for temperature control.

5.5 Magnetic Field Control

All 9 T magnets are equipped with a persistent mode switch for constant operation without driving voltage applied. Vector magnet systems are usually delivered with no persistent switch installed.

TIP
Refer to the manual of your magnet to check whether it employs a persistent switch.

5.5.1 Field control with persistent switch heater

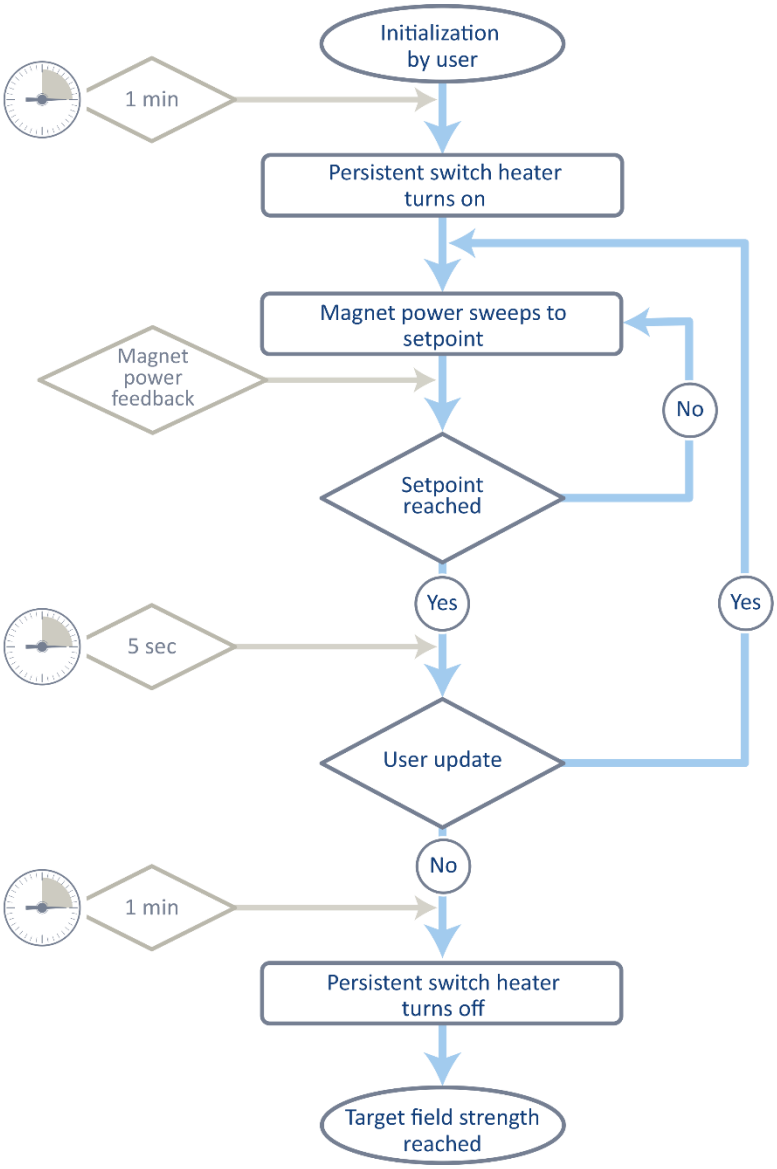

Figure 21 Magnetic field control with persistent switch heater, flow chart

Usually, the user update of the field strength setpoint is performed by customer-specific control scripts via the system's Python API.

5.5.2 Field control without persistent switch heater

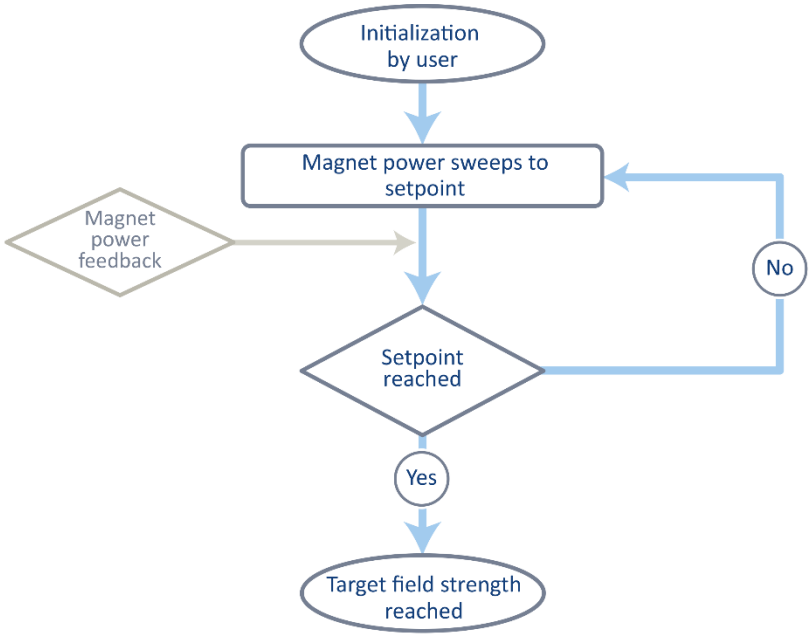

Figure 22 Magnetic field control without persistent switch heater, flow chart

6 Graphic User Interfaces

The basis of the system's control interface is the control system eNSPIRE. It can be accessed by the user via the system's touch panel or as a webserver application on a PC.

Basically, both user interfaces provide the same functions, but the webserver application grants access to some additional options for setting, monitoring and logging the system’s performance data.

6.1 Touch Panel Application

The system features a touch panel for user interaction with the product. The touch panel is located on the top of the support unit and automatically starts up after system switch-on.

6.1.1 Page Composition

The touch panel application's pages have some common elements which are described below.

Overview

The screen of the touch panel is divided into the following sections.

Controls

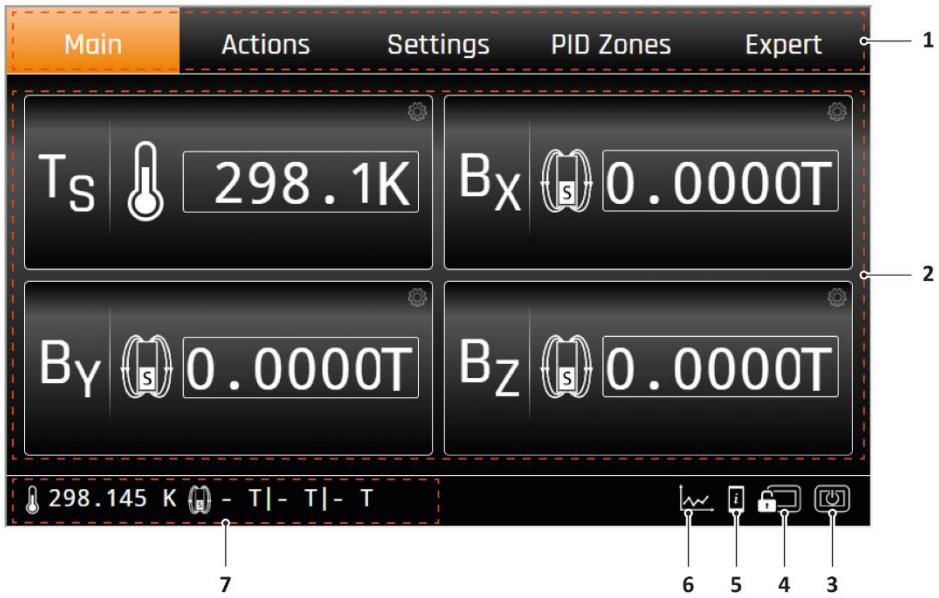

Figure 23 Touch panel screen sections

1	Navigation bar	Switch between pages
2	Control section	Control system and read out information
3	Switch-off button	Switch off the display
4	Lock button	Lock and unlock the display (see below)
5	Information button	Open the "General information" overlay (see below)
6	Live plotting button	Open the "Plot data" overlay
7	Cryostat status bar	Read out the cryostat status (see below)

Cryostat Status Bar

The cryostat status bar provides information about the current temperature and the magnetic field.

Controls

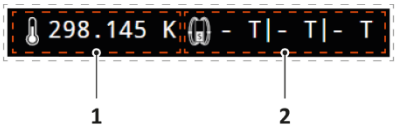

Figure 24 Cryostat status bar

1	Temperature status display	Read out the sample temperature
2	Magnetic field status display	Read out the magnetic field strength in X-, Y- and Z-direction

Lock Button

Via the lock button you can lock the display, to prevent any values from being changed unintentionally. Unlocking is possible with the same button.

Controls

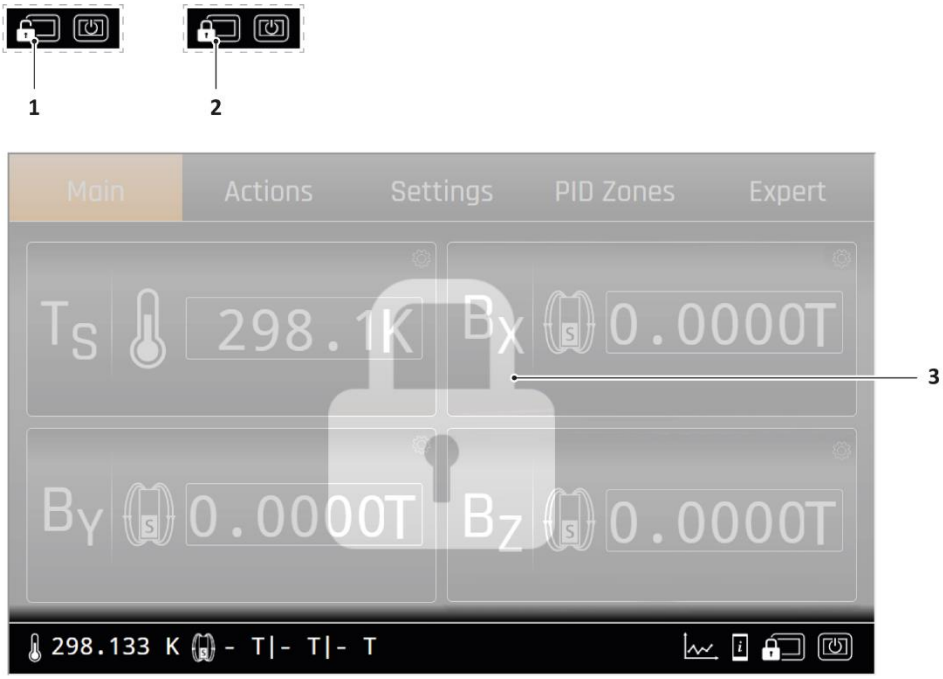

Figure 25 Lock button and locked display

1	Lock button, unlocked	Lock the touch panel
2	Lock button, locked	Unlock the touch panel
3	Control section, locked	Indicates that the touch panel is locked

"General Information" Overlay

The "General Information" overlay provides you with comprehensive information about the system and its current firmware version. It also enables you to reboot the system or to reset it without the need for a PC being connected. The network settings can also be adjusted here.

Access

The "General Information" overlay can be accessed from every page by tapping the information button (Figure 23/**5**).

Controls

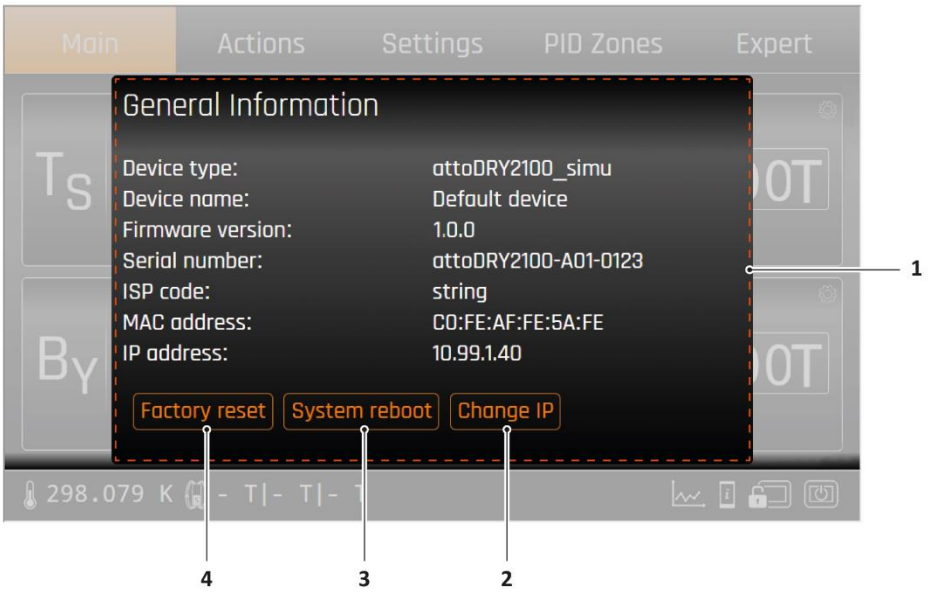

Figure 26 "General Information" overlay

1	"General Information" section	Read out system information
2	[Change IP]	Open the "Networking" overlay (see below)
3	[System reboot]	Reboot the system
4	[Factory reset]	Restore the factory settings

"Networking" Overlay

Access

The "Networking" overlay can be opened by tapping on [Change IP] on the "General Information" overlay (Figure 26/**2**).

Controls

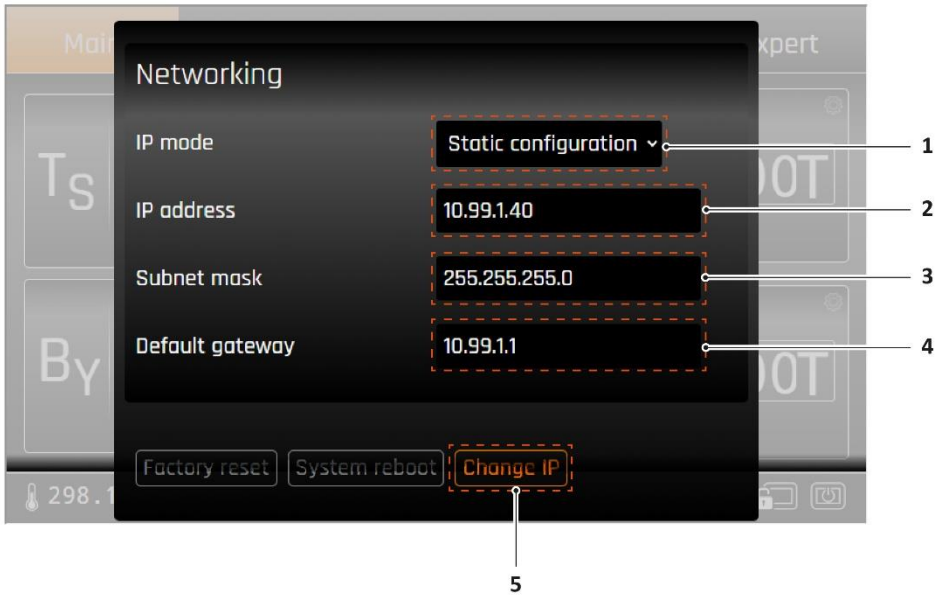

Figure 27 "Networking" overlay

1	"IP mode" field	Select (and confirm) the IP mode
2	"IP address" field	Read out and set the system's IP address
3	"Subnet mask" field	Read out and set the IP subnet mask
4	"Default gateway" field	Read out and set the default gateway address
5	[Change IP]	Close the overlay

TIP

The "IP address", "Subnet mask" and "Default gateway" fields are only visible in IP mode "Static configuration".

"Plot Data" Overlay

The "Plot Data" overlay provides you with detailed information about the system performance and the status of various parameters.

Access

The "Plot Data" overlay can be accessed from every page by tapping the live plotting button (Figure 23/**6**).

Controls

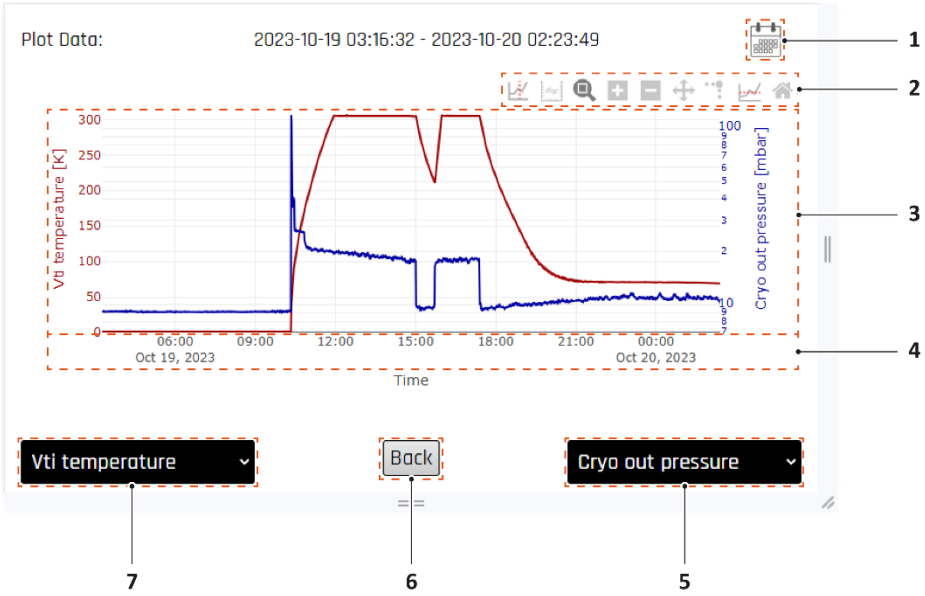

Figure 28 "Plot Data" overlay, example

1	Calendar button	Open the calendar overlay (see below)
2	Graph controls	Control graph functions (see below)
3	Graph section	Displays plots for selected parameters in set time
4	Timeline	Read out and set plotted time section
5	Parameter selection field	Select parameter for display on right-hand Y-axis
6	[Back]	Close the "Plot Data" overlay
7	Parameter selection field	Select parameter for display on left-hand Y-axis

Graph controls

Control element	Function
	Set the earliest point of time to be plotted
	Synchronize Y-axes (only available when displaying the same units)
	Activate/deactivate zooming by area selection
	Zoom in stepwise
	Zoom out stepwise
	Pan through values
	Show/hide spike lines for orientation
	Show/hide mean values for selected parameters
	Return to default plot

Calendar Overlay

The calendar overlay allows to navigate through the timeline by date selection. A period of up to several weeks is accessible.

Controls

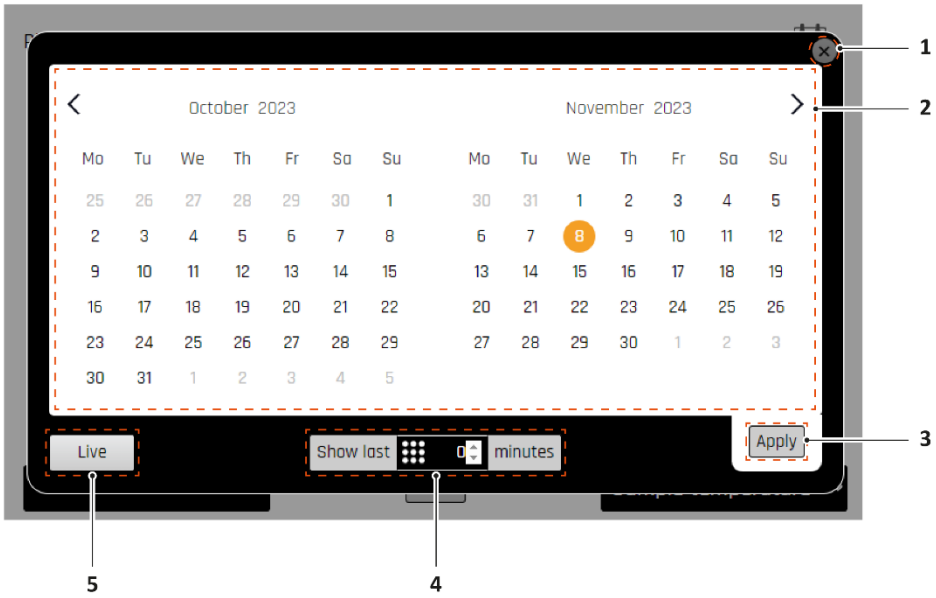

Figure 29 Calendar overlay

1	Close button	Close the overlay
2	Calendar	Select the time period to display by date
3	[Apply]	Apply the selected time period to the plot
4	Minutes selection controls	Set the amount of minutes before the current point of time the records of which shall be plotted
5	[Live]	Close the overlay and plot live data

TIP
It is recommended to download the data and clean the database once a month. Otherwise, longer refreshing times of graphs might occur.

Numerical Input Overlay

Access The numerical input overlay always appears when a field for numerical input is tapped.

Controls

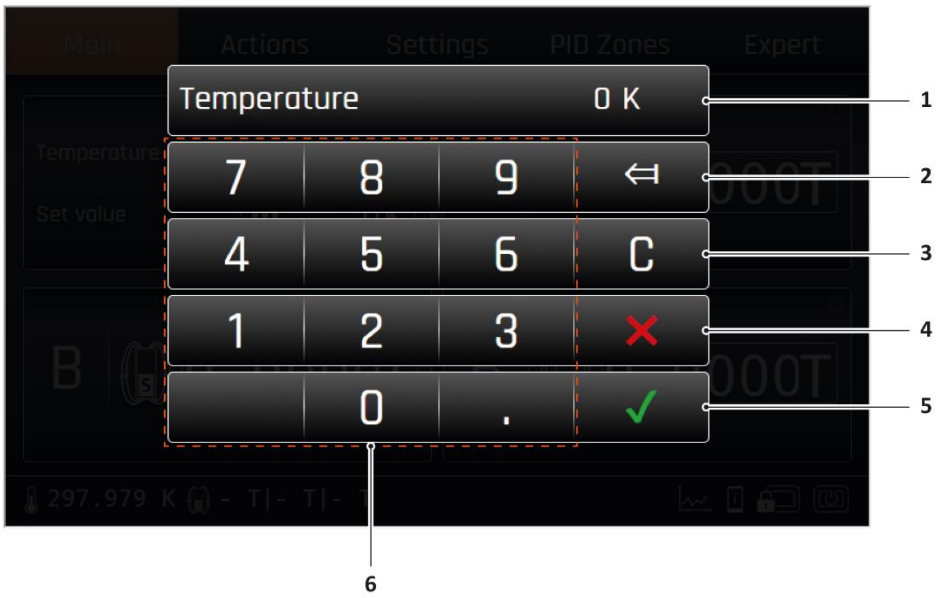

Figure 30 Numerical input overlay, example

1	Parameter display	Read out the parameter to be adapted and its current value
2	[←]	Delete the last digit
3	[C]	Delete the entire input
4	[x]	Discard the input and close the overlay
5	[✓]	Confirm the input and close the overlay
6	Numeric keys	Type in numerical values

6.1.2 "Main" Screen

The "Main" screen provides the controls and displays for the system's basic functions.

Access

The "Main" screen can be accessed by tapping [Main] in the navigation bar.

Controls

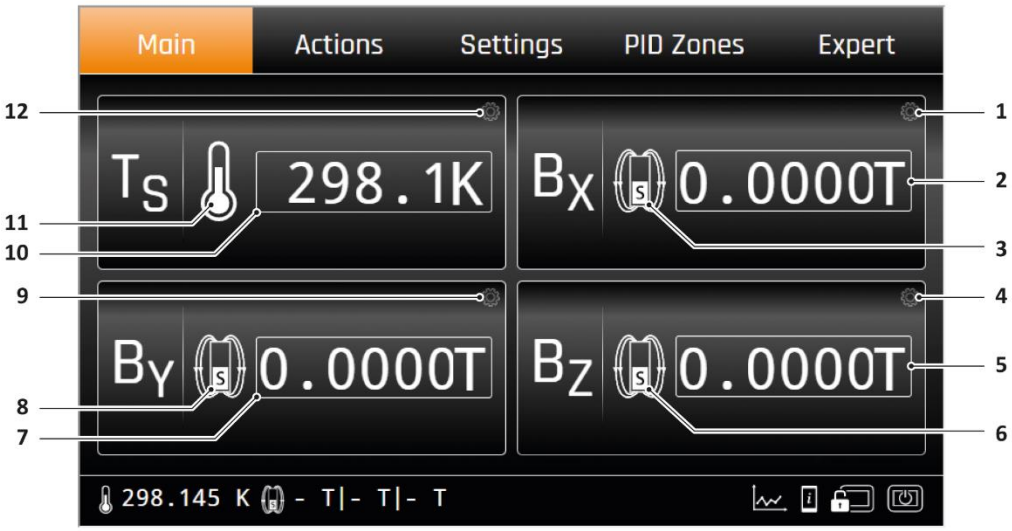

Figure 31 "Main" screen

1	X-direction field strength settings button	Set the magnetic field strength in X direction (see section 8.7)
2	X-direction field strength display	Read out the magnetic field strength in X direction
3	X-direction field strength control button	Activate/deactivate the magnetic field strength control in X direction
4	Z-direction field strength settings button	Set the magnetic field strength in Z direction (see section 8.7)
5	Z-direction field strength display	Read out the magnetic field strength in Z direction
6	Z-direction field strength control button	Activate/deactivate the magnetic field strength control in Z direction
7	Y-direction field strength display	Read out the magnetic field strength in Y direction
8	Y-direction field strength control button	Activate/deactivate the magnetic field strength control in Y direction
9	Y-direction field strength settings button	Set the magnetic field strength value in Y direction (see section 8.7)
10	Sample temperature display	Read out the sample temperature
11	Sample temperature control button	Activate/deactivate the sample temperature control
12	Sample temperature settings button	Set the sample temperature (see section 8.4)

6.1.3 "Actions" Screen

The "Actions" screen provides the controls for the system's automated functions.

Access The "Actions" screen can be accessed by tapping [Actions] in the navigation bar.

Controls

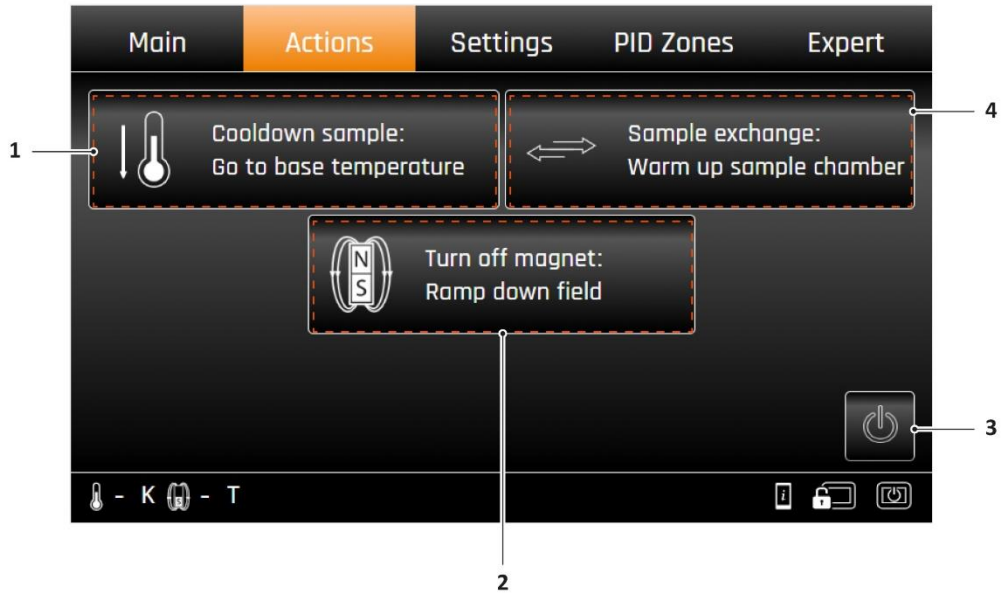

Figure 32 "Actions" screen

1	[Cooldown sample]	Start the cool-down procedure (see section 8.8)
2	[Turn off magnet]	Activate/deactivate the magnetic field
3	Stand-by button	Switch the system to stand-by mode
4	[Sample exchange]	Start the sample exchange procedure (see sections 8.10 and 8.4)

6.1.4 "Settings" Screen

On the "Settings" screen detailed performance data is displayed and the settings for various functions can be adapted.

Access The "Settings" screen can be accessed by tapping [Settings] in the navigation bar.

Controls

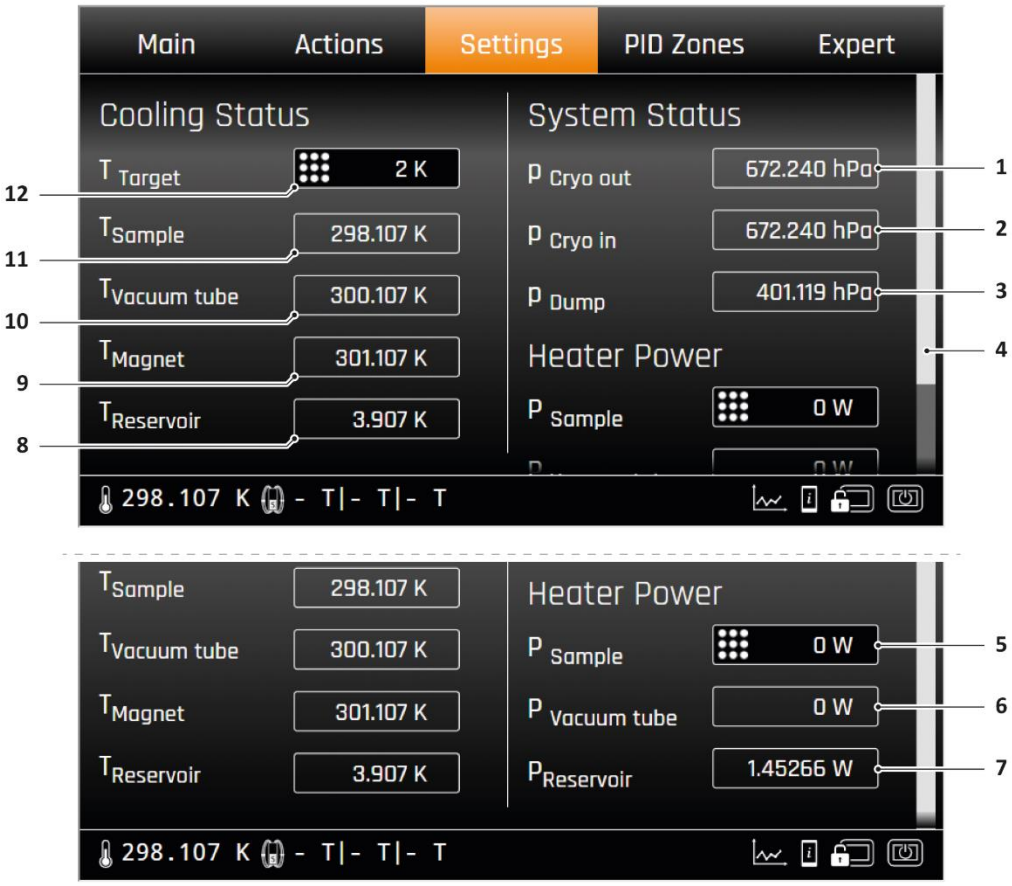

Figure 33 "Settings" screen

1	"P Cryo out" display	Read out the cryo-out pressure
2	"P Cryo in" display	Read out the cryo-in pressure
3	"P Dump" display	Read out the dump pressure
4	Scroll bar	Scroll the screen section
5	"P Sample" field	Read out and set the target sample heater power
6	"P Vacuum tube" display	Read out the VTI heater power
7	"P Reservoir" display	Read out the condenser heater power
8	"T Reservoir" display	Read out the condenser temperature
9	"T Magnet" display	Read out the magnet temperature
10	"T Vacuum tube" display	Read out the VTI temperature
11	"T Sample" display	Read out the sample temperature
12	"T Target" field	Read out and set the target sample temperature

6.1.5 "PID Zones" Screen

On the "PID Zones" screen you can check the status and adapt values of the different heaters and temperature sensors within the system. One tab is available for each of the following components:

- sample heater and temperature sensor ("Sample" tab)
- VTI heater and temperature sensor ("VTI" tab)
- condenser heater and temperature sensor ("Reservoir" tab)
- 40 K stage heater and temperature sensor ("40K" tab)

The following overview describes the "Sample" tab, as a representative example for all the PID settings tabs.

TIP
Note that, for a convenient reading, the following overview is separated into two figures, both of which display one part of the same tab.

Access The "PID Zones" screen can be accessed by tapping [PID Zones] in the navigation bar.

Control Section

The control sections' structure and content are identical for the sample, the VTI, the condenser and the 40 K stage. The section's fields and displays apply to the respective sensor and heater of the system component that has been selected from the navigation bar.

Controls

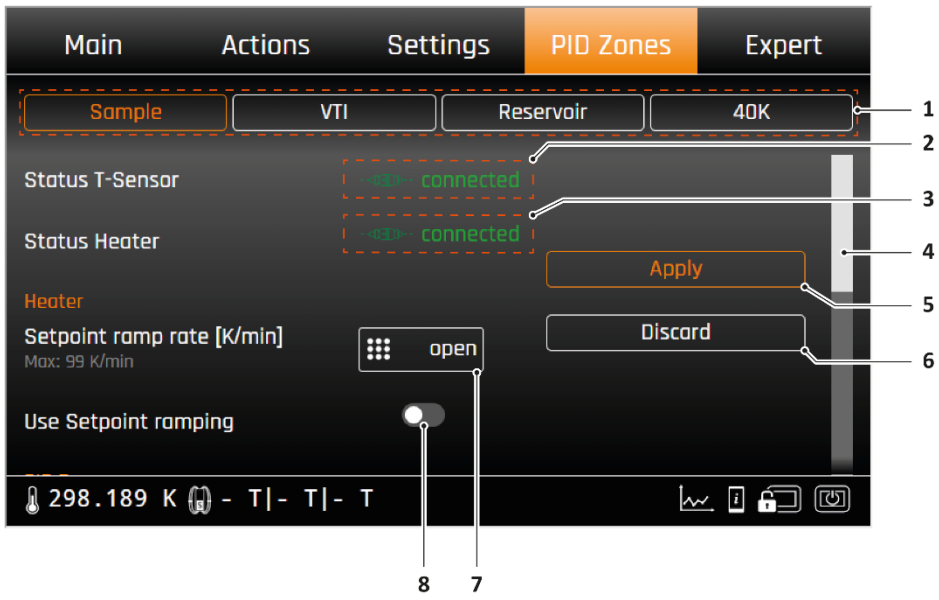

Figure 34 "PID Zones" screen, control section (part 1), example

1	Navigation bar	Switch between controls for the different components
2	"Status T-Sensor" display	Read out the temperature sensor connection status
3	"Status Heater" display	Read out the heater connection status
4	Scroll bar	Scroll the screen section
5	[Apply]	Apply changes
6	[Discard]	Discard changes
7	"Setpoint ramp rate" field	Set the upper limit for the heating ramp rate
8	"Use Setpoint ramping" switch	Activate/deactivate setpoint ramping

Controls

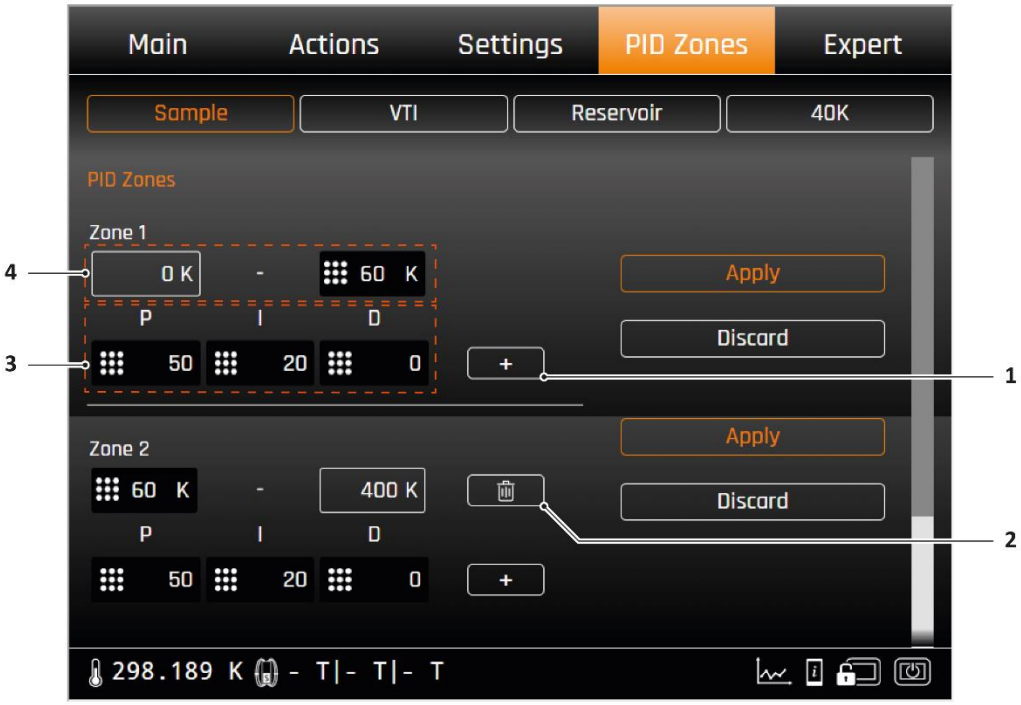

Figure 35 "PID Zones" screen, control section (part 2), example

1	[+]	Add a temperature control zone
2	Delete button	Delete the temperature control zone
3	"P", "I" and "D" fields	Read out and set the control zone's PID values (see section 8.5)
4	Temperature limit fields	Read out and set the control zone's lower and upper temperature limits

6.1.6 "Expert" Screen

The "Expert" screen provides an overview of the main control parameters and manual access to core components of the GHS' low-pressure circuit.

Access

The "Expert" screen can be accessed by tapping [Expert] in the navigation bar.

Controls

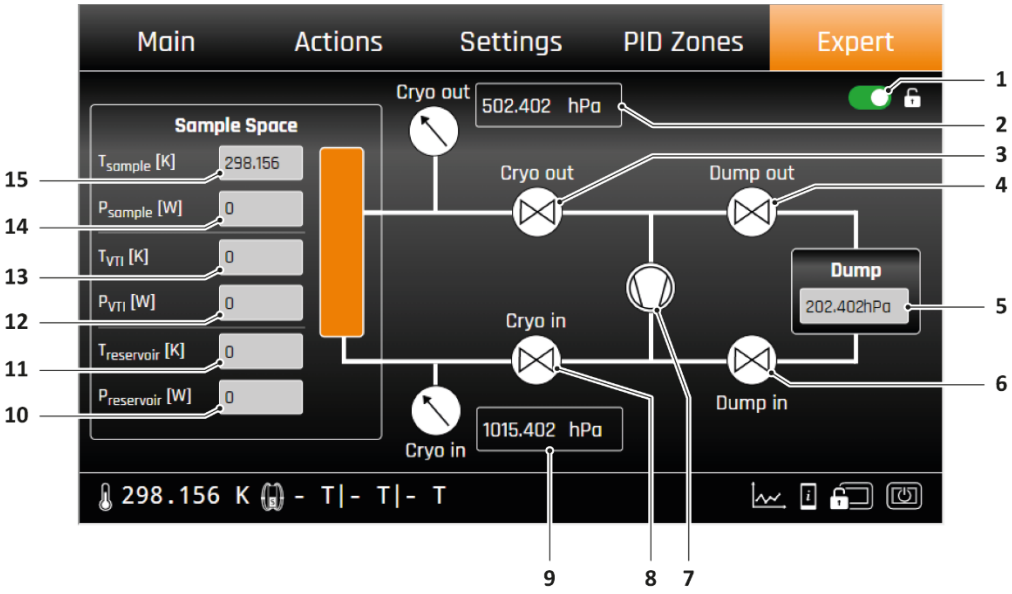

Figure 36 "Expert" screen

1	Locking switch	Lock (white) / unlock (green) access to manual component status changes
2	"Cryo out" display	Read out the cryo-out pressure
3	"Cryo out" valve control	Read out and change the opening status of the cryo-out valve (see section 8.9.2)
4	"Dump out" valve control	Read out and change the opening status of the dump-out valve (see section 8.9.2)
5	"Dump" display	Read out the dump pressure
6	"Dump in" valve control	Read out and change the opening status of the dump-in valve (see section 8.9.2)
7	Scroll pump control	Read out and change the working status of the scroll pump (see section 8.9.3)
8	"Cryo in" valve control	Read out and change the opening status of the cryo-in valve (see section 8.9.2)
9	"Cryo in" display	Read out the cryo-in pressure
10	"P reservoir" display	Read out the condenser heater power
11	"T reservoir" display	Read out the condenser temperature
12	"P VTI" display	Read out the VTI heater power
13	"T VTI" display	Read out the VTI temperature
14	"P sample" display	Read out the sample heater power
15	"T sample" display	Read out the sample temperature

TIP

Note that the color of a symbol indicates the opening/working status of the respective component:

- green: valve open / pump working
- white: valve closed / pump not working

6.2 Webserver Application

The webserver application is an interface to control the system from an external PC.

Access

If the PC and the system are connected to the same LAN and subnet, the webserver application can be started by typing one of the following information into a browser's address line:

- the system's IP address
- the system's serial number (without slashes) followed by `.local`

For further information see section 7.3.

6.2.1 Navigation Bar

The navigation bar allows the navigation between the different screens of the webserver application.

Controls

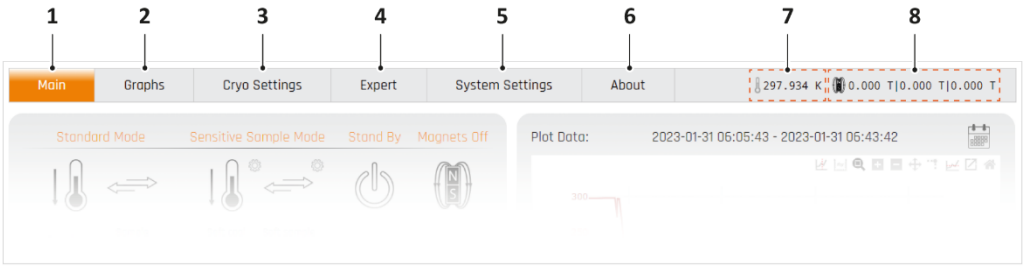

Figure 37 Navigation bar

1	[Main]	Access basic controls and displays on the "Main" screen
2	[Graphs]	Access live plotting data of the system performance on the "Graphs" screen
3	[Cryo Settings]	Access controls to adjust the temperature control parameters via the "Cryo Settings" screen
4	[Expert]	Access overview and manual control of core components of the GHS' low-pressure circuit via the "Expert" screen
5	[System Settings]	Access control of basic system and connection properties via the "System Settings" screen
6	[About]	Access overview and control of extended system and software properties via the "About" screen
7	Temperature status display	Read out the sample temperature
8	Magnet field status display	Read out the magnetic field strength in X-, Y- and Z-direction

6.2.2 "Main" Screen

The "Main" screen provides basic controls and displays for the system performance. Additionally, the screen provides some further possibilities to monitor and log the system's performance data.

Access To open the "Main" screen, click [Main] in the webserver application navigation bar.

Overview

Controls

Figure 38 "Main" screen

1	Actions tile	Activate/deactivate automated system functions
2	"Temperature Control" tile	Monitor and control sample and VTI temperature
3	"Magnet Control" tile	Monitor and control the cryostat's magnetic field strength
4	"Pressure Monitor" tile	Read out the pressure
5	"Plot Data" tile	Monitor and log the performance data

Cryostat Actions Tile

Controls

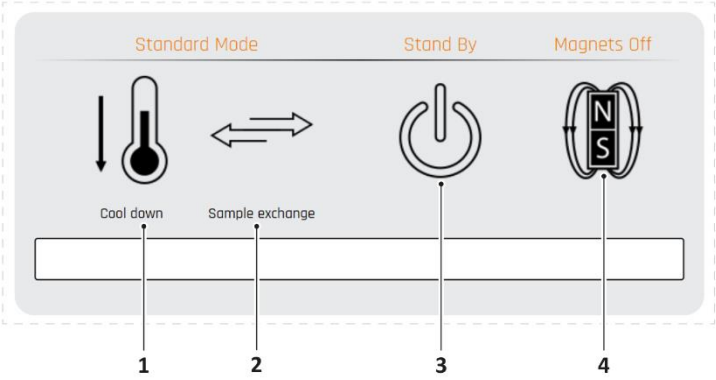

Figure 39 Cryostat actions tile

1	"Cool down" button	Start the cool-down procedure (see section 8.8)
2	"Sample exchange" button	Start the sample exchange procedure (see sections 8.10)
3	"Stand By" button	Switch the system to stand-by, switch off the magnetic field and collect helium back into the dump. Does not switch off the compressor.
4	"Magnets Off" button	Switch the magnets on/off

"Temperature Control" Tile

Controls

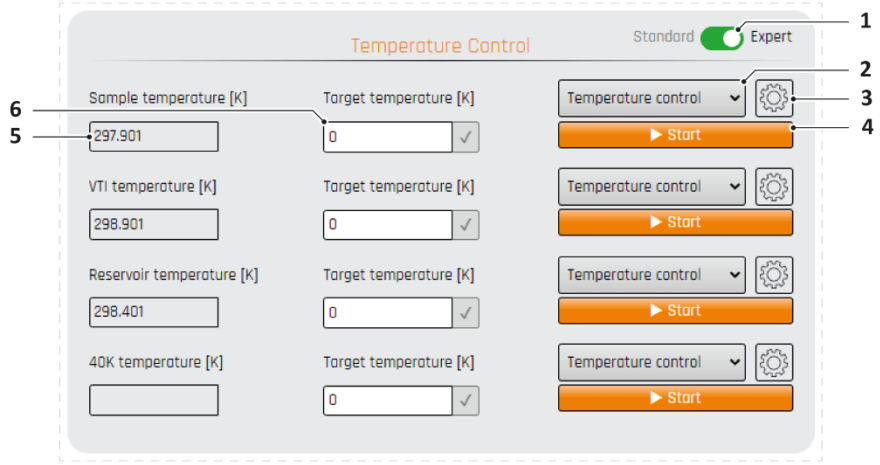

Figure 40 "Temperature Control" tile

1	Expert mode switch	Activate/deactivate condenser temperature and 40 K temperature controls
2	Control mode selection field	Select the heater's control mode
3	Settings button	Open the component's settings tile (see section 6.2.4)
4	[Start]	Start approaching the component's target temperature
5	Temperature display	Read out the component's temperature
6	"Target temperature" setting field	Set and confirm the component's target temperature

"Magnet Control" Tile

Controls

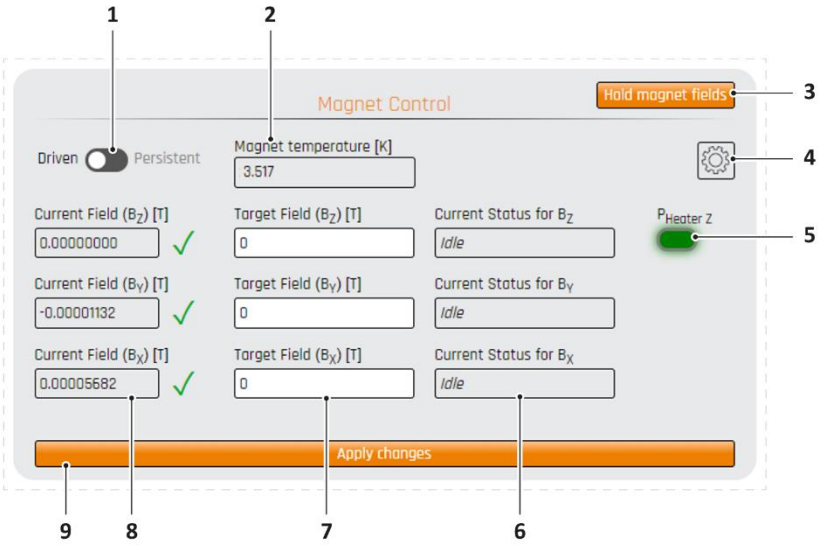

Figure 41 "Magnet Control" tile

1	Control mode switch	Switch between driven and persistent mode
2	"Magnet temperature" display	Read out the magnet temperature
3	[Hold magnet fields]	Immediately stops altering the magnet power and holds the magnet field strength
4	Magnet settings button	Open the "Magnet Control Settings" tile (see section 6.2.4)
5	Heater status display	Read out the status of the magnet's persistent mode heater
6	Operation status display	Read out the magnet's current operation status
7	"Target Field" setting field	Set and confirm the target magnetic field strength in the respective direction
8	"Current Field" display	Read out the magnetic field strength in the respective direction
9	[Apply changes]	Apply the changes

"Pressure Monitor" Tile

Controls

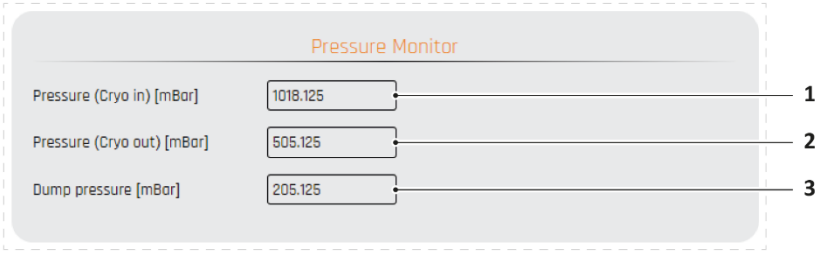

Figure 42 "Pressure Monitor" tile

1	"Pressure (Cryo in)" display	Read out the cryo-in pressure
2	"Pressure (Cryo out)" display	Read out the cryo-out pressure
3	"Dump pressure" display	Read out the dump pressure

"Plot Data" Tile

The content and structure of the "Plot Data" tile equal those of the live plotting tiles as described in section 6.2.3. See there for further information.

6.2.3 "Graphs" Screen

The "Graphs" screen provides some further possibilities to monitor and log the system's performance data.

Access The "Graphs" screen can be accessed to by clicking on [Graphs] in the webserver application's navigation bar.

Controls

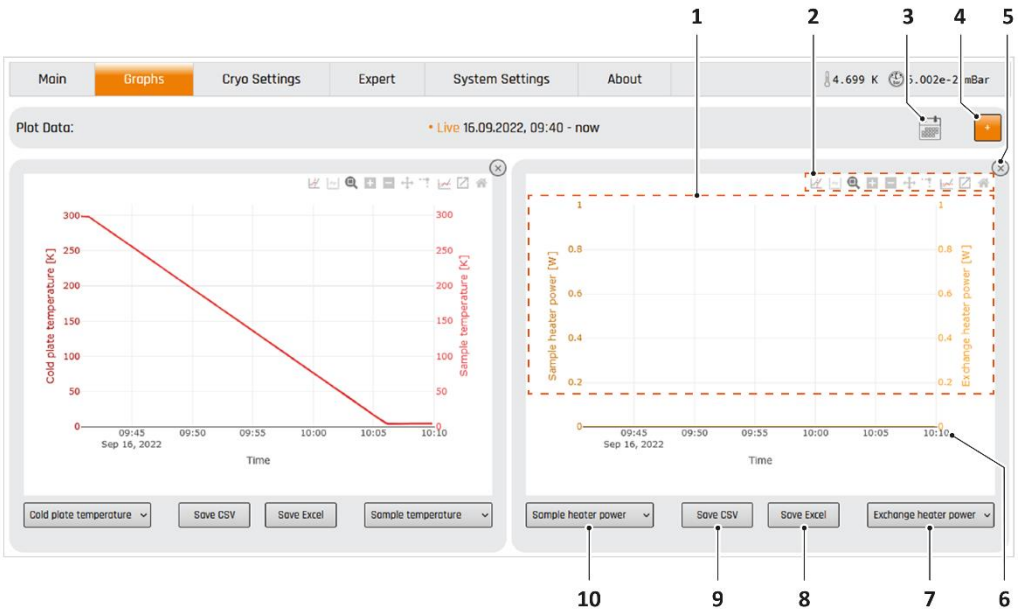

Figure 43 "Graphs" screen

1	Graph section	Displays plots for selected parameters in set time
2	Graph controls	Control graph functions (see below)
3	Calendar button	Open the calendar overlay (see below)
4	Add button	Add a further graph tile
5	Close button	Close the graph tile
6	Timeline	Read out and set plotted time section
7	Parameter selection field	Select parameter for display on right-hand Y-axis
8	[Save CSV]	Save data as .csv file
9	[Save Excel]	Save data as .xlsx file
10	Parameter selection field	Select parameter for display on left-hand Y-axis

Graph controls

Control element	Function
	Set the earliest point of time to be plotted
	Synchronize Y-axes (only available when displaying the same units)
	Activate/deactivate zooming by area selection
	Zoom in stepwise
	Zoom out stepwise
	Pan through values
	Show/hide spike lines for orientation
	Show/hide mean values for selected parameters
	Open plot in new window
	Return to default plot

Calendar Overlay

The calendar overlay allows to navigate through the timeline by date selection. A period of up to several weeks is accessible.

Controls

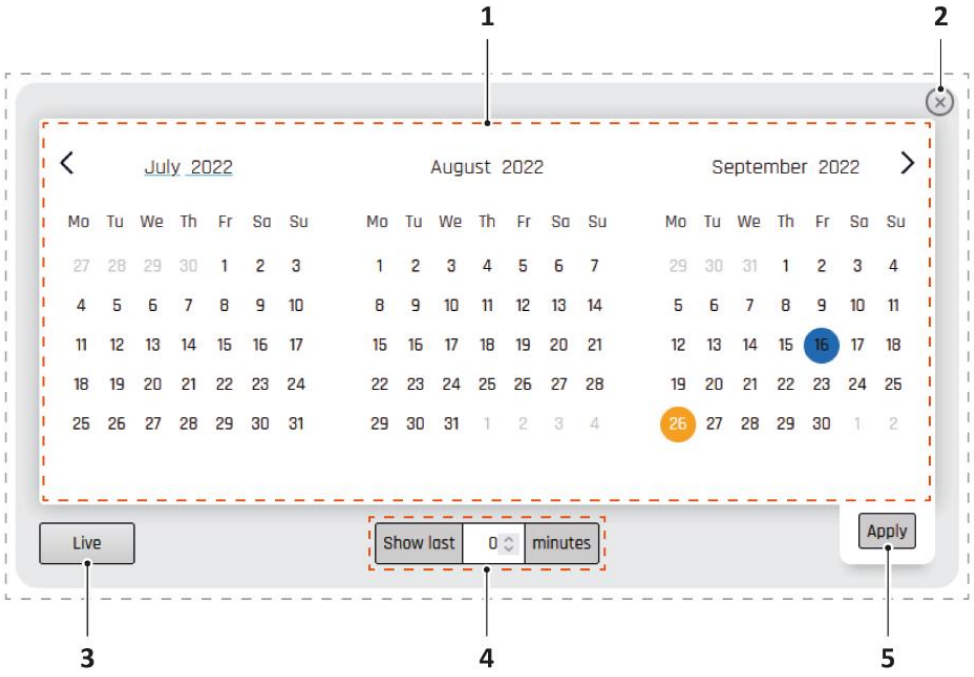

Figure 44 Calendar overlay

1	Calendar	Select the time period to display by date
2	Close button	Close the overlay
3	[Live]	Close the overlay and plot live data
4	Minutes selection controls	Set the amount of minutes before the current point of time the records of which shall be plotted
5	[Apply]	Apply the selected time period to the plot

TIP

It is recommended to download the data and clean the database once a month. Otherwise, longer refreshing times of graphs might occur.

6.2.4 "Cryo Settings" Screen

The "Cryo Settings" screen provides possibilities to set the system's performance data.

Access The "Cryo Settings" screen can be accessed to by clicking on [Cryo Settings] in the webserver application's navigation bar.

Overview

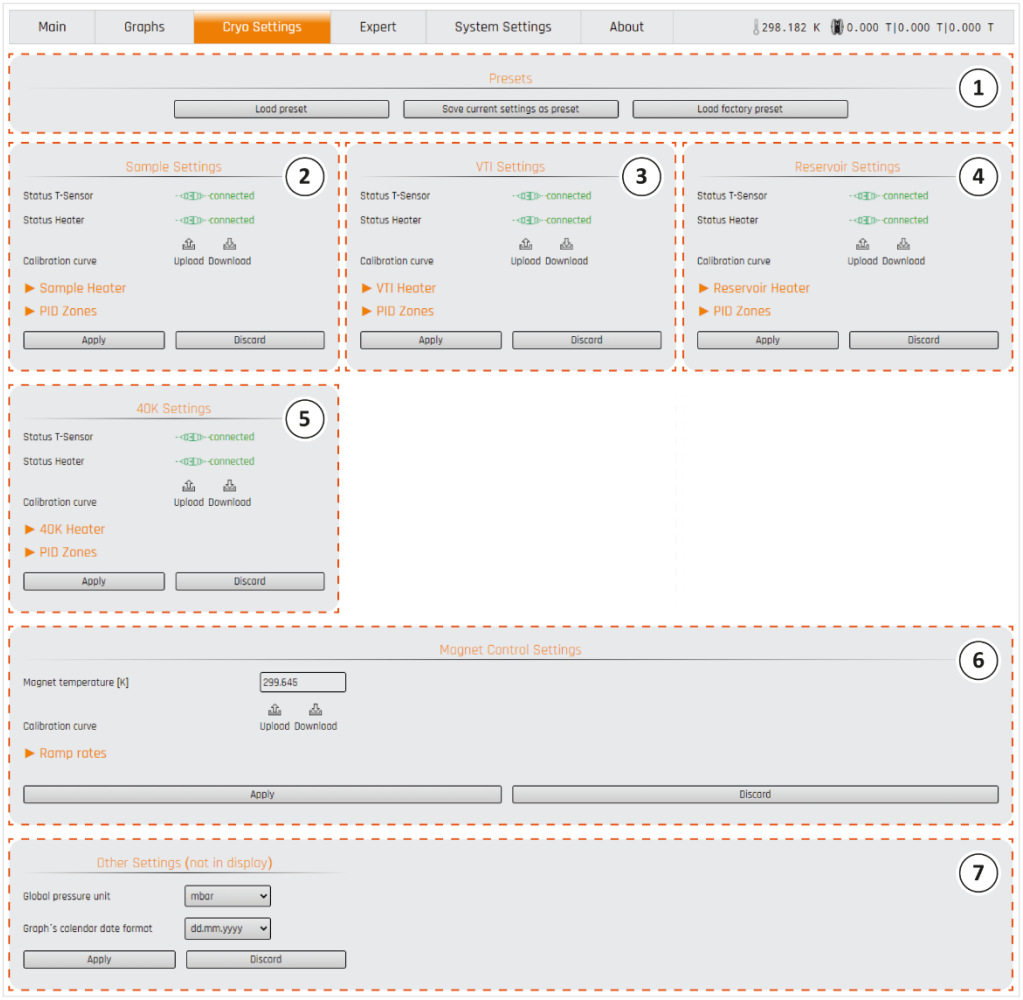

Figure 45 "Cryo Settings" screen

1	"Presets" tile	Load and save preset configurations, restore factory default (see below)
2	"Sample settings" tile	Read out and change the sample temperature control settings (see below)
3	"VTI Settings" tile	Read out and change the VTI temperature control settings (see below)
4	"Reservoir Settings" tile	Read out and change the condenser temperature control settings (see below)
5	"40K Settings" tile	Read out and change the 40 K stage temperature control settings (see below)
6	"Magnet Control Settings" tile	Read out and change the magnet control settings (see below)
7	"Other Settings" tile	Change additional settings (see below)

"Presets" Tile

Controls

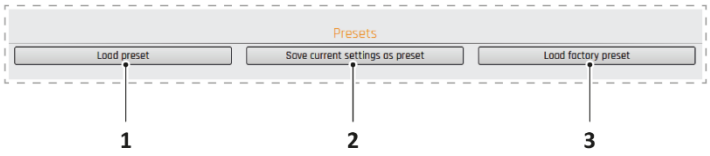

Figure 46 "Presets" tile

1	[Load presets]	Load a preset configuration
2	[Save current settings as preset]	Save the actual configuration as preset
3	[Load factory preset]	Load the factory default preset

Heater and Sensor Settings Tiles

In the heater and sensor settings tiles you can check the status and adapt values of the different heaters and temperature sensors within the system. One tile is available for each of the following components:

- sample heater and temperature sensor ("Sample Settings" tile)
- VTI heater and temperature sensor ("VTI Settings" tile)
- condenser heater and temperature sensor ("Reservoir Settings" tile)
- 40 K stage heater and temperature sensor ("40K Settings" tile)

The following overview describes the "Sample Settings" tile, as a representative example for all the heater and sensor settings tiles.

TIP

Note that, for a convenient reading, the following overview is separated into two figures, both of which display one part of the same tile.

Controls

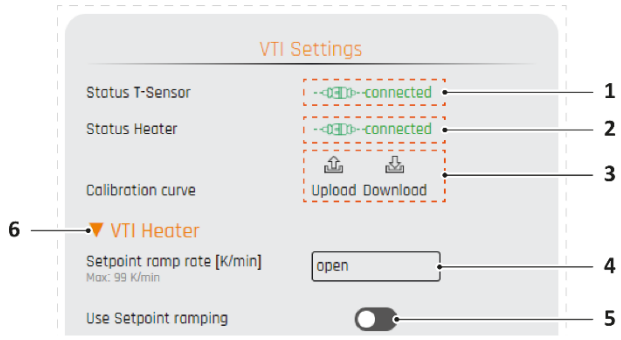

Figure 47 Heater and sensor settings tile (part 1), example

1	"Status T-Sensor" display	Read out the temperature sensor connection status
2	"Status Heater" display	Read out the heater connection status
3	"Calibration curve" controls	Upload/download a calibration curve
4	"Setpoint ramp rate"	Set the upper limit for the heating ramp rate
5	"Use Setpoint ramping" switch	Activate/deactivate the setpoint ramping
6	"VTI Heater" expand button	Collapse/expand the heater controls

Controls

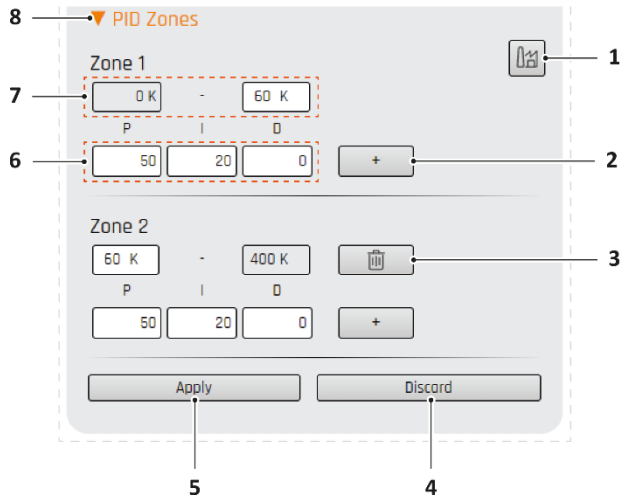

Figure 48 Heater and sensor settings tile (part 2), example

1	Show factory defaults button	Read out the default control zones and PID settings
2	[+]	Add a temperature control zone
3	Delete button	Delete the temperature control zone
4	[Discard]	Discard the changes
5	[Apply]	Apply the changes
6	"P", "I" and "D" fields	Read out ad set the control zone's PID values (see section 8.5)
7	Temperature limit fields	Read out and set the control zone's lower and upper temperature limits
8	"PID Zones" expand button	Collapse/expand the PID zone controls

"Magnet Control Settings" Tile

Controls

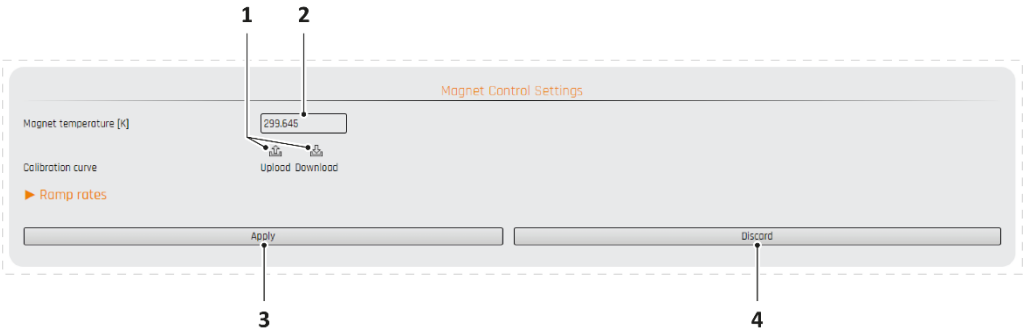

Figure 49 "Magnet Control" settings

1	"Calibration curve" controls	Upload/download the calibration curve
2	"Magnet temperature" display	Read out the magnet temperature
3	[Apply]	Apply the changes
4	[Discard]	Discard the changes

"Other Settings" Tile

Controls

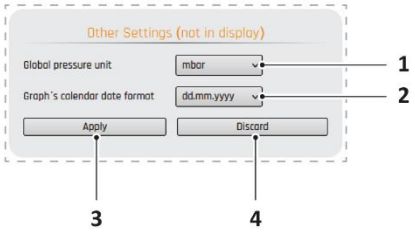

Figure 50 "Other Settings" tile

1	"Global pressure unit" selection field	Select the pressure unit to be used
2	"Graph's calendar date format" selection field	Select the calendar date format
3	[Apply]	Apply the changes
4	[Discard]	Discard the changes

6.2.5 "Expert" Screen

The "Expert" screen provides a graphical overview of the system status.

Access Controls

To open the "Expert" screen, click [Expert] in the header of the webserver application.

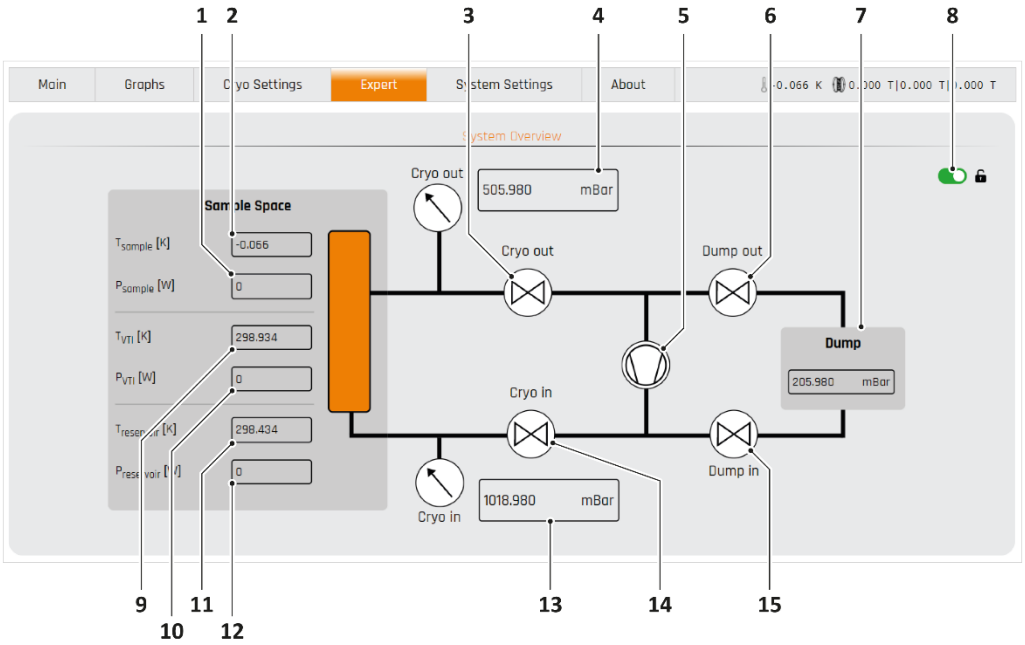

Figure 51 "Expert" screen

1	"P sample" display	Read out the sample heater power
2	"T sample" display	Read out the sample temperature
3	"Cryo out" valve control	Read out and change the opening status of the cryo-out valve (see section 8.9.2)
4	"Cryo out" display	Read out the cryo-out pressure
5	Scroll pump control	Read out and change the working status of the scroll pump (see section 8.9.3)
6	"Dump out" valve control	Read out and change the opening status of the dump-out valve (see section 8.9.2)
7	"Dump" display	Read out the dump pressure
8	Locking switch	Lock (white) / unlock (green) access to manual component status changes
9	"T VTI" display	Read out the VTI temperature
10	"P VTI" display	Read out the VTI heater power
11	"T reservoir" display	Read out the condenser temperature
12	"P reservoir" display	Read out the condenser heater power
13	"Cryo in" display	Read out the cryo-in pressure
14	"Cryo in" valve control	Read out and change the opening status of the cryo-in valve (see section 8.9.2)
15	"Dump in" valve control	Read out and change the opening status of the dump-in valve (see section 8.9.2)

6.2.6 "System Settings" Screen

On the "System Settings" screen you can

- adapt certain controller and connection properties,
- update the system's firmware,
- upgrade its feature package.

Access To open the "System Settings" screen, click [System Settings] in the header of the webserver application.

Overview

Controls

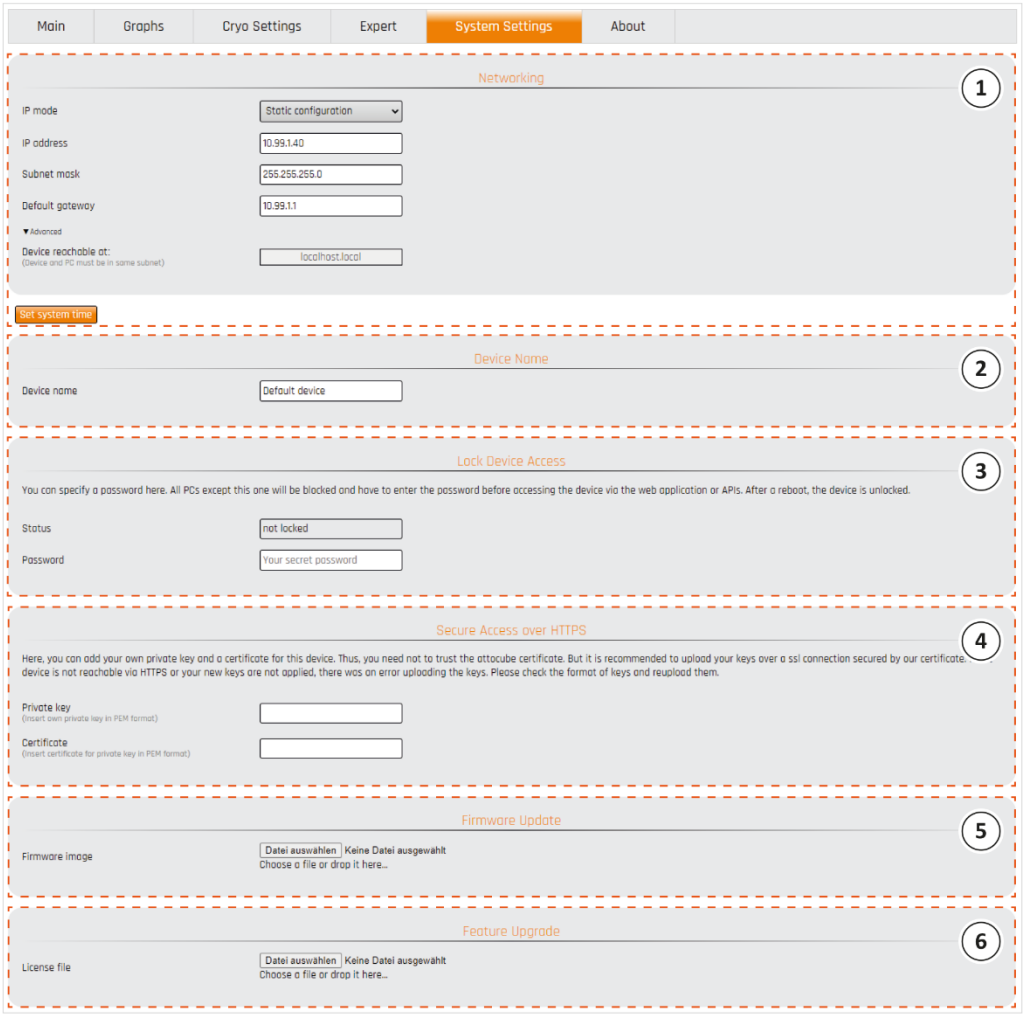

Figure 52 "System Settings" screen

1	"Networking" tile	Adapt the network settings (see below)
2	"Device Name" tile	Rename the system (see below)
3	"Lock Device Access" tile	Lock the system (see below)
4	"Secure Access over HTTPS" tile	Enable secure HTTPS access (see below)
5	"Firmware Update" tile	Update the system's firmware (see below)
6	"Feature Upgrade" tile	Activate features and upgrades (see below)

"Networking" Tile

In the "Networking" tile you can adapt the network settings used by the system for connection to a LAN.

Controls

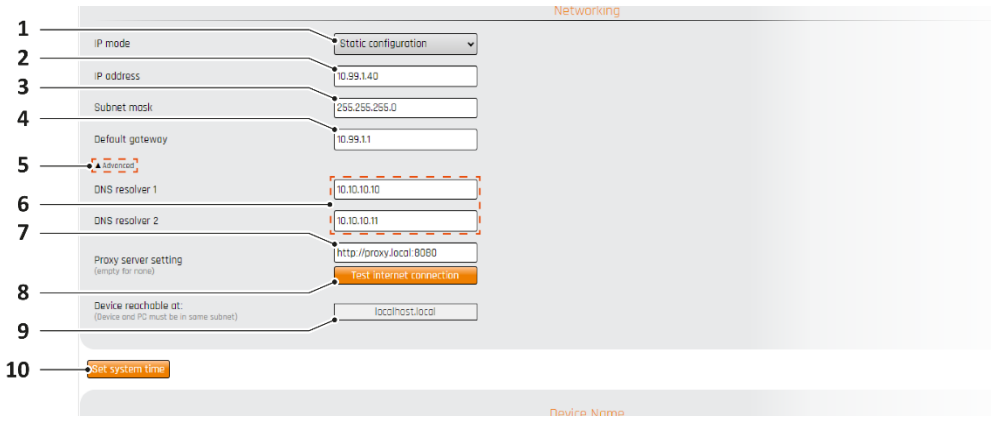

Figure 53 "Networking" tile

1	"IP mode" field	Select (and confirm) the IP mode
2	"IP address" field	Read out and set the system's IP address
3	"Subnet mask" field	Read out and set the IP subnet mask
4	"Default gateway" field	Read out and set the default gateway address
5	"Advanced" expand button	Collapse/expand additional controls
6	"DNS resolver" fields	Set DNS resolver addresses
7	"Proxy server setting" field	Read out and set the proxy server address
8	[Test internet connection]	Test the internet connection
9	"Device reachable at" display	Read out the system's DNS name
10	[Set system time]	Set the system time in the "Set system time" overlay

TIP
The "IP address", "Subnet mask" and "Default gateway" fields are only visible in IP mode "Static configuration".

"Device Name" Tile

The "Device Name" tile allows you to label the system.

Controls

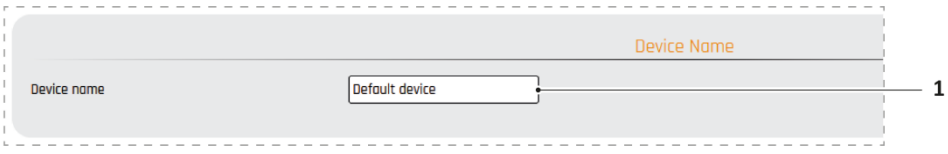

Figure 54 "Device Name" tile

1	"Device name" field	Read out and set the system name

"Lock Device Access" Tile

Controls

Figure 55 "Lock Device Access" tile

1	"Status" display	Read out system locking status
2	"Password" setting field	Set system unlocking password

"Secure Access over HTTPS" Tile

Controls

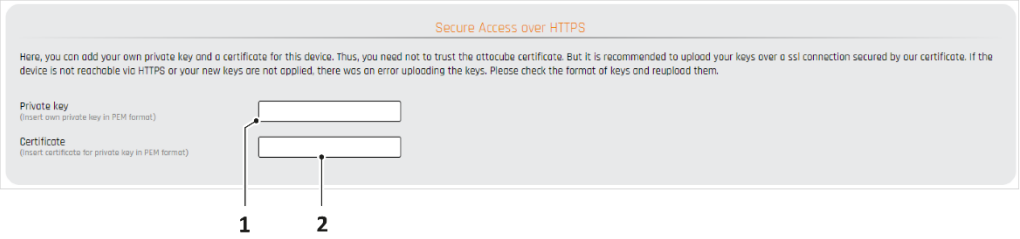

Figure 56 "Secure Access over HTTPS" tile

1	"Private key" field	Enter the private key
2	"Certificate" field	Enter the certificate for the private key

"Firmware Update" and "Feature Upgrade" Tiles

Controls

Figure 57 "Firmware Update" and "Feature Upgrade" tiles

1	"Firmware image" button	Upload a firmware image file
2	"License file" button	Upload a feature license file

6.2.7 "About" Screen

The "About" screen enables you to reset or reboot the product and provides you with comprehensive information about

- the product itself, the software used, and the features and upgrades activated,
- the manufacturer,
- sources of integrated software parts,
- activated licenses.

As most of the screen contents are self-explanatory, only the functions relevant for troubleshooting are explained here in more detail.

Access To open the "About" screen, click [About] in the header of the webserver application.

Controls

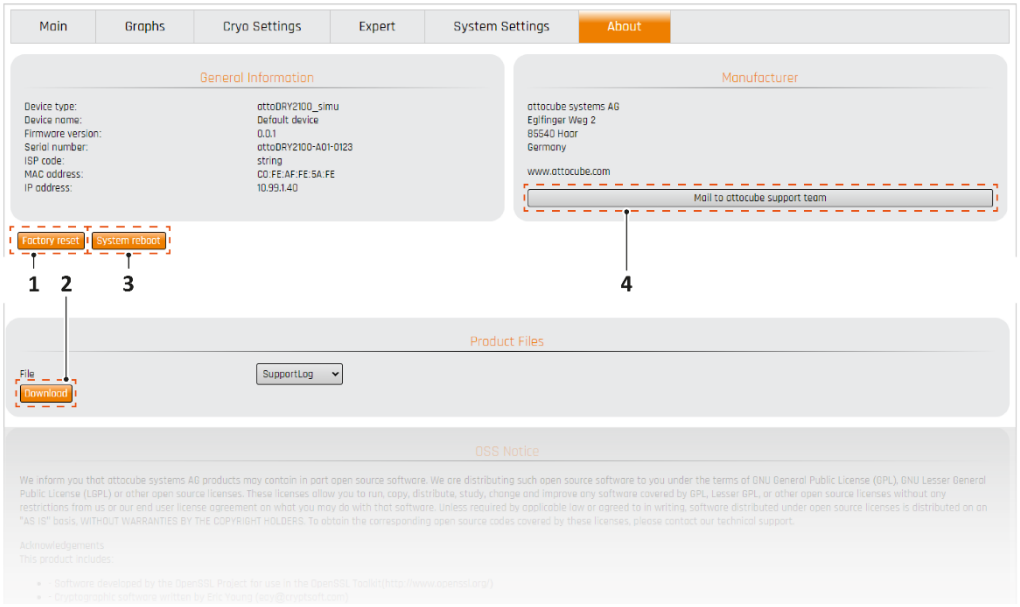

Figure 58 "About" screen (excerpt), troubleshooting functions

1	[Factory reset]	Reset the system to the default settings
2	[Download]	Download the log file selected from the drop down menu
3	[System reboot]	Reboot the system
4	[Mail to attocube support team]	Open a prepared mail to the attocube support team

7 System Setup

The basic system comes completely installed by attocube. However, for changes of the experimental setting, for reasons of convenience or for an extended range of working options, further installation and configuration may become necessary.

This chapter gives instructions on the installation and setup of specific integral or peripheral system components.

7.1 Setting Up the Damping System

TIP
This section applies to attoDRY2200 only.

attoDRY2200 provides a damping system to isolate the experimental setting from mechanical forces caused by the operation environment. This damping system has to be set up in advance of the first operation.

1. Connect the compressed air supply tube to the system's compressed air interface (see section 4.5.1).
2. Open the compressed air supply with a pressure of 3 bar.
3. Grab the front panel of the main unit on both sides and carefully pull it off.
4. On the main unit's rear panel, remove the 8 fixing screws. Use an Allen key, size 3.
5. Remove the rear panel.
6. On the first vibration isolation valve, adjust the red leveling screw such that the sensor lever is leveled.

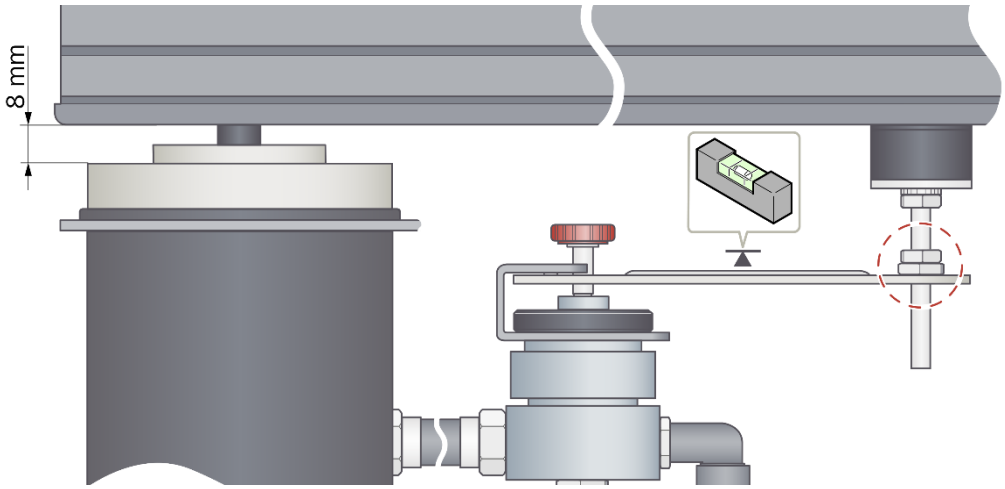

Figure 59 Setting up the damping system, steps 6 to 10.

7. On the far end of the sensor lever, loosen the (upper) counter nut. Use an open-end wrench, size 10.
8. Pre-adjust the (lower) spacing screw such that the gap between the floating plate's lower end and the upper end of the nearest vibration isolation damper measures a height of about 8 mm. Use an open-end wrench, size 10.
9. Repeat steps 6 to 7 for both remaining vibration isolation valves.
10. If required, readjust all spacing screws such that the gap between the floating plate and all dampers measures about 8 mm.

11. On the rear vibration isolation valves, adjust the spacing screws to level the floating plate in X direction. Use a short spirit level to check the leveling.
12. On the front vibration isolation valve, adjust the spacing screw to level the floating plate in Y direction. Use a short spirit level to check the leveling.
13. Verify that the floating plate is leveled and that all the gaps between the plate and the dampers measure 8 mm (± 1 mm). If required, repeat steps 11 to 13.
14. Tighten all the spacing screws' counter nuts.
15. Place and fix the main unit's front and rear panel.

7.2 Connecting to the Voltage Supply

CAUTION

Wrong cabling!

Inadequate equipment may cause electric shocks or fire.

- Always use power supply cables provided by attocube.

- Connect the power cable to the mains supply socket.

7.3 Setting Up the Communication

7.3.1 Configuring the Network Settings

If you are not using the system as DHCP server, its IP address and the network configuration must be adapted, to operate the system within a LAN.

NOTE

Assigning an unavailable IP address or one which has already been assigned to another system, will cause networking problems.

- Make sure the chosen IP address is available for your network and is not already in use.

Touch Panel

✓ The PC fulfills the requirements specified in section 4.3.4.
✓ PC and system are connected to the same LAN.
✓ The "General Information" overlay is opened (see section 6.1.1).

1. Tap on [Change IP].
   → The "Networking" overlay opens.
16. Tap into the field, the value of which you want to adapt.
17. Adapt the value to your network specification.
18. Confirm the upcoming prompt with [Ok].
    → A pen symbol indicates that the value has been adapted.
19. If required, adapt further networking settings accordingly.
20. Tap on [Change IP].
21. Note down the system's IP address or the system's serial number.
22. On your PC, open a browser window.
23. Enter the system's IP address or serial number (without slashes) followed by `.local`.
    → The webserver application opens.

7.3.2 Connecting the Magnet Power Supply

For all systems equipped with a superconducting magnet an Ethernet switch is used. The magnet power supply must be connected to the support unit

- either via an Ethernet switch that is provided by attocube together with the magnet power supply,
- or via the 19" electronics rack, if present.

TIP
For the magnet power supply wiring scheme, please refer to your system's specification sheet.

The switch port and IP address assignments for the magnet power supplies are as follows:

Magnet Power Supply	Switch port	IP address
1	2	169.254.16.2
2	3	169.254.17.2
3	4	169.254.18.2

✓ The support unit power switch is set to "0" (see section 4.5.2).

1. Turn on the magnet power supply.
2. Wait until the magnet power supply's booting sequence is finished.
3. Set the support unit power switch to "I".
   → The cryostat starts up.

7.4 Connecting the External Pumping Set

An external pumping set with KF25 interface, turbo pump, manual valves and pressure reducer is required for different preparation and maintenance tasks. The following picture shows the recommended pumping setup.

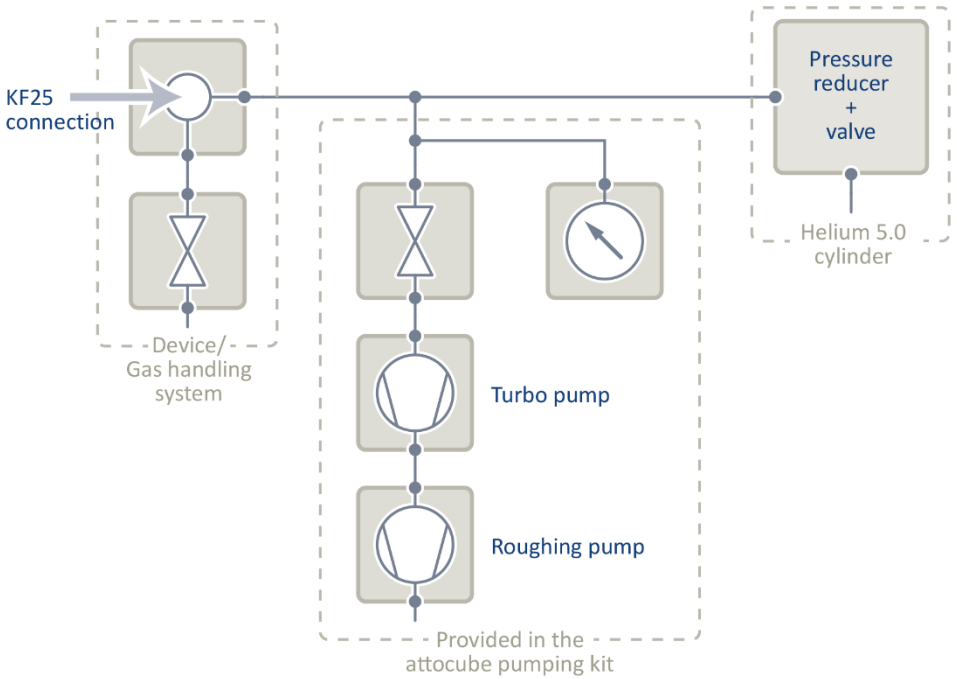

Figure 60 Recommended pumping setup

To connect the external pumping set to the system's respective interface, follow the subsequent instructions.

✓ The external pumping set is set up.
✓ The main valve of the external pump is closed.
✓ The external pump is switched off.

1. If required to reach the respective interface, grab the front panel of the main unit on both sides and carefully pull it off.
2. At the interface, loosen the screw of the KF25 flange and remove the flange.
3. Remove the blind cover from the interface.
4. Connect the external pump to the interface.

TIP
Proceed in the reverse order for disconnecting the external pumping set.

7.5 Evacuating the Dewar Vessel

The control and connection elements referred to in this section are described in section 4.4.2.

✓ All system components are at room temperature.
✓ The external pumping set is connected (see section 7.4) to the system's isolation vacuum interface (see section 4.4.2).

1. Switch on the external pump.
2. Open the main valve of the external pump.
3. Open the valve of the isolation vacuum interface.
   → The Dewar vessel is evacuated.
4. Wait until the pumping circuit reaches a pressure of < 1E-3 mbar (after approx. 4 hours).
5. Close the main valve of the external pump.
6. Close the valve of the isolation vacuum interface.
7. Switch off the external pump.

7.6 Preparing the Cooling Circuits

7.6.1 Evacuating the Cooling Circuits

NOTE
Trapped air in helium tubes can cause contamination of the helium.
- Make sure that all valves internal to the GHS and the cooling circuits are open during the evacuation.

The pressure values referred to in this section can be observed

- on the touch panel's "Settings" screen (see section 6.1.4),
- or on the "Pressure Monitor" tile of the webserver application's "Main" screen (see section 6.2.2).

✓ All system components are at room temperature.
✓ The external pumping set including helium bottle (see section 7.4) is connected to the GHS' service interface (see section 4.5.3).
✓ The pressure reducer on the external helium bottle is set to < 150 mbar.
✓ The cryo-in and -out valves and the dump-in and -out valves are opened (see section 8.9.2).
✓ The valves of the cryo-in and -out interfaces on the main unit are opened (see section 4.5.1).
✓ The scroll pump is switched on (see section 8.9.3).

1. On the GHS' low-pressure connection panel, open the bypass valve.
2. Switch on the external pump.
3. Open the main valve of the external pump.
4. On the GHS' low-pressure connection panel, open the service valve.
   → The cooling circuits are evacuated.
5. Wait until the pumping circuit reaches a pressure of < 3E-4 mbar (after > 24 hours).
6. Close the bypass valve.

7. Close the main valve of the external pump.
8. On the helium bottle, open the helium valve.
   → The cooling circuits are flushed with helium.
9. Wait until the circuit reaches a pressure of approx. 150 mbar, then close the bottle's helium valve.
10. Open the main valve of the external pump.
11. Open all manual valves on the helium line between helium bottle and external pump.
    → The helium is removed from the cooling circuits.
12. Wait until the pumping circuit reaches a pressure of < 1 mbar.
13. Close the main valve of the external pump.
14. Repeat steps 8 to 13.
15. Switch off the external pump.

TIP
If the helium storage vessel is to be filled subsequently, the external pumping set does not need to be disconnected at this point.

7.6.2 Filling the Helium Storage Vessel

The pressure values referred to in this section can be observed

- on the touch panel's "Settings" screen (see section 6.1.4),
- or on the "Pressure Monitor" tile of the webserver application's "Main" screen (see section 6.2.2).

✓ All system components are at room temperature.
✓ The external helium bottle is connected (e.g. via pumping set, see section 7.4) to the GHS' service interface (see section 4.5.3).
✓ The pressure reducer on the external helium bottle is set to 950 mbar.
✓ The cryo-out valve and the dump-in valve are opened (see section 8.9.2).
✓ The cryo-in valve and the dump-out valve are closed (see section 8.9.2).
✓ The scroll pump is switched on (see section 8.9.3).

1. On GHS' low-pressure connection panel, open the bypass valve and the service valve.
2. On the helium bottle, open the helium valve.
   → Helium flows into the helium storage vessel.
3. Wait until the dump pressure reaches 950 mbar (± 20 mbar).
4. On the helium bottle, close the helium valve.
5. Close the service valve and the bypass valve.
6. On the touch panel or the webserver application, navigate to the "Expert" screen.
7. Close the cryo-out valve and the dump-in valve.
8. Deactivate the scroll pump.

8 Operation

This section describes some basic procedures most relevant for daily operation. For the entire range of functions and settings, see the software description in section 6.

TIP

According to your preferences you can work with the system in one of two possible ways:

- Using the touch panel
- Using the webserver application

The webserver application provides additional functions, such as log file creation.

8.1 Starting the System

✓ The GHS is connected to the power supply.
✓ The water supply to the GHS compressor is opened.
✓ The system is set up completely (see section 7).

1. Set the support unit power switch to "I" (see section 4.5.2).
   → The system starts up.
2. If required, press the "ON" button on the helium compressor of the GHS (see section 4.5.3).
   → The compressor starts.

8.2 Opening and Emptying the Sample Space

NOTE

Trapped air within the sample space may cause contamination and may freeze inside the sample space.

○ Make sure the sample space is all flushed with helium before opening it.

The control and connection elements referred to in this section are described in section 4.5.1.

✓ The sample space is evacuated, closed and sealed with the top flange.
✓ The sample space is at room temperature. If applicable, the message `Sample space is ready to be opened` is displayed on the touch panel.
✓ The pressure reducer on the external helium bottle is set to ≤ 1500 mbar.

1. On the helium bottle, open the helium valve.
   → The helium tube is flushed with helium.
2. If not already connected, connect the helium tube to the helium nozzle on top of the main unit.
3. Open the valve of the helium nozzle.
   → Helium flows into the sample space.

4. Wait for the overflow valve to open (at approx. 1100 mbar). Close the valve of the helium nozzle.
5. If applicable, disconnect the sample thermometry cable from the present microscope insert.
6. Loosen the screw of the top flange and remove the flange.
7. Remove the sample space cover or the present microscope insert from the sample space.

8.3 Loading a Microscope Insert

TIP
Consult the manual of the specific microscope insert for instructions on how to place a sample in the microscope.

The control and connection elements referred to in this section are described in section 4.5.1.

✓ The sample space is opened and flushed with helium (see section 8.2).
✓ The microscope insert is prepared.

1. Insert the microscope insert or place the sample space cover.
2. Place and fix the top flange.
3. If applicable, connect the sample thermometry cable to the microscope insert.
4. Close the valve of the helium nozzle.
5. If not already connected, connect the external roughing pump with turbo pump to the helium pump interface on top of the main unit.
6. Switch on the external pump.
7. Open the valve of the helium pump interface.
   → The helium is removed from the sample space.
8. Wait until the pumping circuit reaches a pressure of < 2E-4 mbar. Close the valve of the helium pump interface.
9. Switch off the external pump.
10. Open the valve of the helium nozzle.
    → Helium flows into the sample space.
11. Wait for the overflow valve to open (at approx. 1100 mbar). Close the valve of the helium nozzle.
12. On the helium bottle, close the helium valve.

8.4 Setting the Target Sample Temperature

Touch Panel

✓ The "Main" screen is opened (see section 6.1.2).

1. Tap on the sample temperature settings button.
   → The temperature settings open.
2. Tap on the "Set value" field.
   → The numerical input overlay opens.
3. Enter the desired value.
4. Tap on [✓].
   → The overlay closes and the new target value is displayed in the "Set value" field.
5. Tap on the sample temperature settings button.
   → The temperature settings are closed.
6. Tap on the sample temperature control button.
   → The button turns orange. The temperature control is activated.

Web Application

✓ The "Main" screen is opened (see section 6.2.2).

1. Go to the "Temperature Control" tile.
2. In the sample temperature line, select "Temperature control" from the control mode selection field.
3. Click into the "Target temperature" setting field.
4. Enter the required value.
5. Click on [✓].
6. Click on [Start].
   → The temperature control is activated.

8.5 Setting the VTI Heater Power

The VTI heater power can only be adjusted in the webserver application.

TIP
The VTI heater power is limited to a maximum of 5 W.

Web Application

✓ The "Main" screen is opened (see section 6.2.2).

1. Go to the "Temperature Control" tile.
2. In the VTI temperature line, select "Power control" from the control mode selection field.
3. Click into the "Target heater power" setting field.
4. Enter the required value.
5. Click on [✓].
6. Click on [Start].
   → The heater power control is activated.

8.6 Setting the PID Parameters

The P, I, and D values can be separately set for the temperature control of the sample, the VTI, the condenser and the 40 K stage. The values are applied to discrete temperature zones, which can be defined by the user.

TIP
For standard operations, changing of the default PID values is not necessary.

Touch Panel

✓ The "PID Zones" screen is opened (see section 6.1.5).

1. In the navigation bar, tap on the component the temperature of which is to be controlled.
2. Go to the section of the temperature zone to be adjusted.
3. If required, tap on the temperature limit fields.
   → The numerical input overlay opens.
4. Enter the desired value.
5. Tap on [✓].
   → The overlay closes and the new value is displayed in the respective field.
6. Tap on the fields of the parameters to be adjusted for the temperature zone.
   → The numerical input overlay opens.
7. Enter the desired value.
8. Tap on [✓].
   → The overlay closes and the new value is displayed in the respective field.

Web Application

✓ The "Cryo settings" screen is opened (see section 6.2.4).

1. Go to the tile of the component the temperature of which is to be controlled.
2. Click on the "PID Zones" expand button.
   → The PID controls expand.
7. Go to the section of the temperature zone to be adjusted.
8. If required, click into the temperature limit fields.
9. Enter the desired value.
   → The new value is displayed in the respective field and a pen symbol indicates that the value has been adapted.
10. Click into the fields of the parameters to be adjusted for the temperature zone.
11. Enter the desired value.
    → The new value is displayed in the respective field.
12. Click on [Apply].

8.7 Setting the Magnetic Field Strength

TIP
The differentiation between X-, Y- and Z-values only applies to system's with vector magnets.

Touch Panel

✓ The "Main" screen is opened (see section 6.1.2).

1. Tap on the required field strength settings button.
   → The field strength settings open.
2. Tap on the "Set value" field.
   → The numerical input overlay opens.
3. Enter the desired value.
4. Tap on [✓].
   → The overlay closes and the new target value is displayed in the "Set value" field.
5. Tap on the field strength settings button.
   → The field strength settings are closed.
6. Tap on the respective field strength control button.
   → The button turns orange. The field strength control is activated.

Web Application

✓ The "Main" screen is opened (see section 6.2.2).

1. Go to the "Magnet Control" tile.
2. Click into the fields of the magnet field direction the strength of which is to be adjusted.
3. Enter the required value.
   → The new value is displayed in the respective field and a pen symbol indicates that the value has been adapted.
4. Click on [Apply changes].
   → The new values are applied to the field strength control.

8.8 Performing the Cool-Down Procedure

Touch Panel

✓ The microscope insert is loaded and the sample space is evacuated (see section 8.3).

1. Navigate to the "Actions" screen (see section 6.1.3).
2. Tap on [Cooldown sample].
   → The button turns orange and the cool-down procedure starts.

Web Application

✓ The microscope insert is loaded and the sample space is evacuated (see section 8.3).

1. Navigate to the "Main" screen (see section 6.2.2).
2. In the cryostat actions tile, click on the "Cool down" button.
   → The button turns orange and the cool-down procedure starts.

8.9 Expert Mode Functions

NOTE

The wrong application of expert mode functions can seriously damage the system. attocube assumes no warranty for damages arising from the use of expert mode functions that are not in accordance with the provisions of this document.

- Strictly obey the instructions and warnings in this document.
- Before using any function of the expert mode, consider the pump and valve arrangement as described in sections 4.4.2 and 4.4.4.
- Do not use any function of the expert mode unless you are properly trained by attocube or a certified representative.

If properly applied, the functions of the expert mode provide you with some useful possibilities to cut short the work or apply individual settings to the sample chamber.

8.9.1 Activating/Deactivating the Expert Mode

Due to its sensitive functions, the controls on the "Expert" screen are locked by default and need to be unlocked to access them.

Touch Panel

✓ The "Expert" screen is opened (see section 6.1.6).

1. Tap on the locking switch.
   → The "Expert" screen is unlocked.
2. Tap on the locking switch.
   → The "Expert" screen is locked.

Web Application

✓ The "Expert" screen is opened (see section 6.2.5).

1. Click on the locking switch.
   → The "Expert" screen is unlocked.
2. Click on the locking switch.
   → The "Expert" screen is locked.

8.9.2 Controlling Valves

The status of each valve is indicated by the highlighting status of the corresponding icon:

- Open valves are highlighted green.
- Closed valves are not highlighted.

Touch Panel

✓ The "Expert" screen is open (see section 6.1.6).
✓ The expert mode is activated (see section 8.9.1).

1. Tap on the icon of the valve the status of which is to be changed.
   → The valve status and the highlighting of the corresponding icon change.

Web Application

✓ The "Expert" screen is opened (see section 6.2.5).
✓ The expert mode is activated (see section 8.9.1).

1. Click on the icon of the valve the status of which is to be changed.
   → The valve status and the highlighting of the icon change.

8.9.3 Controlling the Scroll Pump

The status of the scroll pump is indicated by the highlighting status of the corresponding icon:

- When active, the pump icon is highlighted green.
- When inactive, the pump icon is not highlighted.

Touch Panel

✓ The "Expert" screen is open (see section 6.1.6).
✓ The expert mode is activated (see section 8.9.1).

1. Tap on the icon for the scroll pump.
   → The working status of the scroll pump and the highlighting of the icon change.

Web Application

✓ The "Expert settings" screen is opened (see section 6.2.5).
✓ The expert mode is activated (see section 8.9.1).

1. Click on the icon for the scroll pump.
   → The working status of the scroll pump and the highlighting of the icon change.

8.10 Performing the Sample Exchange Procedure

Note that the sample exchange procedure is a software function that serves to bring the sample to room temperature. This procedure does not include, but can be followed by the actual opening of the sample space etc.

The opening of the sample space and the removing of the microscope insert are described in section 8.2.

Touch Panel

✓ The sample space is at the defined base temperature.

1. Navigate to the "Actions" screen (see section 6.1.3).
2. Tap on [Sample exchange].
   → The button turns orange and the warm-up starts.
3. Wait until the message `Sample space is ready to be opened` is displayed.
   → The sample exchange procedure is completed.

Web Application

✓ The sample space is at the defined base temperature.

1. Navigate to the "Main" screen (see section 6.2.2).
4. Tap on the "Sample exchange" button.
   → The button turns orange and the warm-up starts.
5. Wait until the message `Sample space is ready to be opened` is displayed.
   → The sample exchange procedure is completed.

8.11 Downloading a Performance Log File

For maximum transparency and control over your experiment, you can download a log file with information about different experiment values (e.g. sample temperature, magnet field strength etc.) during a user-defined time span.

The performance log file can only be created in the webserver application.

Web Application

✓ The "Main" screen (see section 6.2.2) or the "Graphs" screen (see section 6.2.3) is opened.

1. At the "Plot Data" tile, click on the parameter selection field.
   → A drop-down list with possible values appears.
2. Click on the desired value.
   → A graph based on the selected data is shown.
3. Click on the calendar button.
   → The calendar overlay appears.
4. Select the time period and click on [Apply].
   → The selected period is applied to the plot data.
5. Click on either [Save CSV] or [Save Excel].
6. If an overlay appears, click on [Confirm] to continue.
   → Depending on your choice the log file is created as .csv or .xlsx file and stored to your PC's download folder.

TIP
You can create a log file via the "Main" screen as described or in the same way via the "Graphs" screen.

8.12 System Shutoff

NOTE
The helium compressor of the GHS is not supposed to be shut off, except in case of any suspected malfunction or for servicing activities.

- Immediately shut off the complete system, disconnect the power supply and contact attocube in case of any suspected malfunction.

TIP
It is not required to switch off the helium compressor but for purposes of energy savings during extended periods of non-use.

1. Set the support unit power switch to "0" (see section 4.5.2).
   → The system shuts off.
2. If required, press the "OFF" button on the helium compressor of the GHS (see section 4.5.3).
   → The compressor shuts off.

9 Maintenance

9.1 Evacuating the Dewar Vessel

The Dewar vessel must be evacuated at least

- prior to the initial cool-down,
- after extended periods of non-use of the system,
- every 12 months.

TIP
In the case of continuous usage, it is recommended to evacuate the Dewar vessel every 3 months.

1. Evacuate the Dewar vessel according to the instructions in section 7.5.

9.2 Maintaining the Cooling Circuits

The cooling circuits including GHS must be evacuated and the tubing system must be filled with helium

- prior to the initial cool-down
- after extended periods of non-use of the system
- in regular intervals, the extend of which depends on the system's usage frequency

TIP
In the case of a continuous usage, it is recommended to maintain the cooling circuits every 3 months.

1. Evacuate the cooling circuits according to the instructions in section 7.6.1.
2. Fill the helium storage vessel according to the instructions in section 7.6.2.

9.3 Cleaning the Touch Panel

NOTE
Using inadequate cleaning material might damage the touch panel.
- Only use lint-free paper or a microfiber cloth slightly humid to clean the touch panel.

1. Wipe the touch panel clean.

9.4 Updating the Firmware

New firmware releases are automatically delivered to you by attocube. They become effective after their upload to the system.

A firmware upload can only be performed in the webserver application.

Web Application

✓ The new firmware file can be accessed to on your PC or the network.
✓ The "System settings" screen is opened (see section 6.2.6).

1. At the "Firmware Update" tile, click on [Choose File].
   → An explorer window opens.
2. Browse for and select the firmware file.
3. Click on [Open].
   → The file is uploaded and two buttons become available.
4. Click on [Update & Reboot].
   → The firmware is updated and the system reboots.

TIP
You can read out the currently installed firmware version
- on the touch panel's "General Information" overlay (see section 6.1.1),
- or on the "General Information" tile of the webserver application's "About" screen (see section 6.2.7).

9.5 Downloading a Calibration Curve File

To make sure the right calibration curve is applied, it is recommended to check the used calibration file against the original file provided by the sensor manufacturer. In order to do so, you must download the calibration file from the system.

A calibration file can only be downloaded in the webserver application.

Web Application

✓ The "Cryo Settings" screen is opened (see section 6.2.4).

1. Go to the tile of the component the calibration file of which you want to download.
2. In the "Calibration curve" line, click on [Download].
   → The calibration file is stored to the download folder of your PC.

TIP
The calibration curve download can also be accessed via the respective settings button in the "Temperature Control" tile of the webserver application's "Main" screen.

9.6 Uploading a Calibration Curve File

A calibration file can only be uploaded in the webserver application.

Web Application

✓ The calibration file can be accessed to on your PC or the network.
✓ The "Cryo Settings" screen is opened (see section 6.2.4).

1. Go to the tile of the component you want to upload a calibration file to.
2. In the "Calibration curve" line, click on [Upload].
   → An explorer window opens.
3. Browse for and select the calibration file.
4. Click on [Open].
   → The file is uploaded.

TIP
The calibration curve upload can also be accessed via the respective settings button in the "Temperature Control" tile of the webserver application's "Main" screen.

9.7 Replacing Fuses

WARNING
Risk of electric shock
The contact with power guiding parts may cause death or severe injury.
- Do not open the fuse compartment unless the power supply to the system is disconnected.

NOTE
Fuses must only be replaced by fuses of the same rating and type.

✓ The system is switched off and disconnected from the mains supply.

1. Carefully remove the cover of the fuse compartment (see section 4.5.2) Use a flat blade screwdriver.
2. Carefully pull out the fuse box.
3. Replace faulty mains fuses.
4. Insert and firmly push the fuse box into the compartment.
5. Close the compartment with the cover.

10 Troubleshooting

This section describes some of the most common issues and provides assistance on how to fix them. If the issue you are experiencing is not listed or you need any assistance, please contact support@attocube.com.

NOTE

Unauthorized error handling may result in permanent malfunction and is not covered by attocube's warranty.

- Do not take any action not proposed for troubleshooting in this document.
- If problems occur that are not mentioned in this section, contact attocube for help.
- If the problems cannot be solved by the proposed action, contact attocube for help.

10.1 Helium Compressor Switches Off

Error message	Solution
`Cold head motor stall`	1. Check and, if required, correct the connection of the cold head power cable to the helium compressor's "COLD HEAD POWER" interface (see section 4.5.3). 2. Grab the support unit's front panel on both sides. Carefully pull off the panel. 3. Check and, if required, correct the connection of the cold head power cable to the pulse tube rotary valve (see section 4.4.3). 4. Check and correct all helium line connections between GHS, support unit and main unit. 5. Restart the compressor.
`Water in temperature high`	1. Check the helium compressor manual for requirements regarding the temperature and flow rate of the compressor cooling water. 2. Check and, if required, correct the temperature and flow rate of the compressor cooling water. 3. If a water filter is used for the cooling water intake, make sure the filter is not clogged.
`Water out temperature high`	
`Oil temperature high`	

If the problem persists, please refer to the helium compressor manual or contact attocube for help.

10.2 Cryostat Does Not Reach the Base Temperature

Possible cause	Solution
High condenser target temperature	○ Make sure the condenser target temperature is < 4 K (see section 6.2.2).
High pressure in the isolation vacuum	Indicators for this error are: - The condenser temperature stays > 4 K. - The Dewar vessel feels cold when touched. - Water condenses on the outside of the Dewar vessel. 1. Verify that no leakage can be detected on the Dewar vessel. 2. Evacuate the Dewar vessel according to section 9.1.
Too little exchange gas in the sample space	1. On the external helium bottle, open the valve and flush the tube. 2. Connect the tube to the helium nozzle on top of the main unit (see section 4.5.1). 3. Open the valve of the helium nozzle for 2 seconds. 4. Wait 2 minutes and check whether the sample temperature decreases.
Additional heat load on the sample	Possible sources of additional heat load are: - strong light or laser directed towards the sample - additional wirings to the sample - electric currents within the sample, the thermometer, or the resistive encoders of the positioners 1. Switch off possible sources one by one and check whether the sample temperature decreases. 2. If required, take measures to reduce the heat load (e.g. by measurement line thermalization, radiation shielding, heat source reduction, …).
Contamination of the helium condensing line	Indicators for this error are: - VTI and sample temperature are equal and between 2 K and 150 K. - The dump-in and -out valves repeatedly switch the opening status (see sections 6.1.6 and 6.2.5). - The cryo-in pressure is not around 950 mbar at 4 K and around 270 mbar at 3 K. ○ Maintain the cooling circuits according to section 9.2.
Lack of cooling power	An indicator for this error is: - The condenser temperature stays > 4 K. 1. Switch off the helium compressor and let the system warm up. 2. Check the compressor's helium pressure. 3. Verify that the pressure is > 240 PSI.

If the problem persists, please contact attocube for help.

10.3 Magnet Power Supply Does Not Connect to System

Possible cause	Solution
Wrong Ethernet port assignment	1. Check and correct the connection between the magnet power supply and the support unit according to the corresponding specification sheet. 2. Make sure the ports of the Ethernet switch are assigned as given in section 7.3.2. 3. Restart the support unit while the ASP100 is running.

10.4 Magnet Quenches Regularly

Possible cause	Solution
Magnetic material nearby	○ Please make sure not to have any magnetic materials such as steel from construction components or radiators in the vicinity of the main unit.
Other magnets nearby	○ Please make sure to keep the system outside of stray fields generated by other magnets.
Magnet temperature too high	1. Lower the condenser target temperature (see section 6.2.2)to decrease the heat load on the magnet. 2. If quenching only happens at high sample temperatures, reduce the thermal coupling between sample space and magnet. Please contact attocube for help.
Wrong magnet settings	1. Check and, if required, adapt the current magnet settings to the values given in the manual of the magnet. 2. If required, reduce the magnet ramp rates (see section 6.2.4).

10.5 Excessive Sample Space Vibrations

Possible cause	Solution
Changes in the environment	1. Make sure there are no devices (e.g. pumps or compressors) generating excessive vibrations in the vicinity of the cryostat. 2. If required, temporarily switch off the helium compressor to check whether it causes the sample space vibrations.
Lose parts on the microscope insert	1. Please check for any lose components on the microscope insert. 2. If required, retighten insert screws and/or reassemble the positioner stack.

If the problem persists, please contact attocube for help.

11 Optional On-System Features and Upgrades

attocube offers various upgrades to facilitate and improve your work with the system.

TIP
Contact attocube for available features and upgrades.

11.1 Optical Breadboard Add-On

The breadboard add-on offers easy access for optical experiments. Various components can be mounted onto the optical platform, which can be directly attached to the system.

11.2 Basic Measurement Insert

The basic measurement inserts offer the following features:

- 2x12 low-resistance brass wires (as e.g. required for nanopositioners) incl. 5 m 12-pin patch cable and break-out panel to BNC connector
- 12 manganin wires as twisted pairs for customer use incl. 5 m 12-pin patch cable and break-out panel to BNC
- heater stage with calibrated T-sensor
- base plate for sample mounting
- cage plate for mounting LT-APO objective (easily adjustable in height via set screw fixation)
- optical access via top window (diameter 25 mm, fused silica uncoated)
- breadboard based mounting stand for room temperature adjustments

11.3 Pumping Kit

The pumping kit (setup according to section 7.4) includes:

- turbomolecular pump incl. dry diaphragm backing pump (pumping speed for N_2 35-67 l/s, ultimate pressure 1E-7 mbar)
- full range pressure gauge
- valve
- overpressure valve
- 1 m stainless steel hose
- needle valve and rubber bladder for dosing the exchange gas
- all necessary KF fittings

12 System Integration

The system can be integrated with external systems or combined with third-party hardware.

CAUTION

General hazard!

Inadequate hardware connections may cause injury and are likely to damage the system or interfere with an appropriate functioning.

- Always contact attocube for technical support, before combining the system with third-party hardware.
- Do carefully observe the information in this section when combining the system with third-party hardware.

NOTE

attocube is not liable for any damages resulting from an unauthorized combination of the system with third-party hardware. Unauthorized combination with third-party hardware is not covered by attocube's warranty.

13 List of Abbreviations

API ..... Application programming interface
APO ..... Apochromatic
DN ..... Diamètre nominal
GHS ..... Gas handling system
IP ..... Internet Protocol
KF ..... Kleinflansch
LT ..... Low temperature
PID ..... Proportional-Integral-Derivative
VTI ..... Variable temperature insert

attocube systems AG

Eglfinger Weg 2
85540 Haar, Germany
Phone: +49 89 420 797 0
E-Mail: info@attocube.com
www.attocube.com
For technical queries contact:
support@attocube.com
Regional US Sales Representatives:
West Coast: Arcadia, CA
Phone: +1 510 631 2154
Southwest: Henderson, NV
Phone: +1 510 631 1784
Midwest: Delaware, OH
Phone: +1 510 631 133