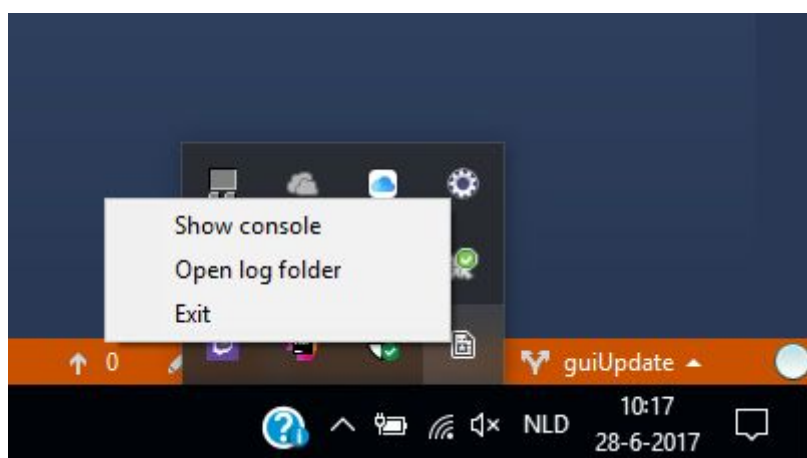


How does the program work?

Start the program

To start the program the server should be started first. Whenever the server is started all the components should be connected, whenever this is not the case the server should be restarted until all components are connected. When the server is successfully started the client can be started which can connect to the server. It is also possible to start the client before the server as it will automatically try to connect to the server. Whenever a connection is broken with a component of the cryostat the server will try to reconnect. When the client is disconnected from the server it will automatically try to reconnect. The server will start without opening any windows, instead an icon appears in the system tray. Right clicking on this icon will give you the option to open the console, which will show debug information of the server, open the log folder to look at the log files or to shut the server down. The system tray with its options can be seen below.



Start a control process

When the server and client are running and the operating mode is standby, meaning that all components are connected but no process is running, a process can be started.

To start a control process first the type of process needs to be selected. This process is one of the following:

- Cool down
- Recycle
- Warm-up

With **Cool down** the cryostat will be cooled from room temperature to 234 millikelvin. This process takes 12 to 14 hours and the cryostat will remain cold for approximately 24 hours.

With **Recycle** the cryostat will be warmed up and then cooled down to 234 millikelvin. This process will take 1.5 hour and the cryostat will remain cold for approximately 24 hours.

With **Warm-up** the cryostat will be warmed up to room temperature. This process takes several hours.

After the desired process is selected there is a choice between **Start Now** or **Scheduled Start**. Start now starts directly after you clicked start. When the scheduled start is chosen a date and time need to be set as start time. When the start time was chosen, the start button

can be pressed. If the Scheduled Start was chosen, a countdown will become visible to show after how long the process will be started.

Cancel control process

Whenever a process is running the cancel button can be pressed. This will cancel the process and leave the values as it was. For example the compressor is turned on and the heaters have all 5V set, those values will remain. This allows manual intervention if something goes wrong in the process which is not automatically handled.

Stop control process

To stop the process and set all values to 0 or off, the stop button can be pressed. The button will always be available so that it can be used if the cancel button is somehow blocked.

NOTE: using this button during a process and resume the process can result in a delay or even a failure of the process.

Start manual control

To start manual control, the manual button should be pressed. This can be done if the server is in standby mode. If there is a process running this should be cancelled or stopped first

(NOTE: stopping the process also turns the compressor off). In the various overviews the components of the compressor can be controlled. In the compressor tab the compressor can be turned on and off. In the He-7 cooler tab the voltages of the heaters can be set.

When the manual control is over the cancel button can be pressed to leave manual mode.

Also the stop button can be pressed to set the heaters to 0 and turn the compressor off.

Whenever cancel is pressed and an automated process is started, the values set in manual mode can be overwritten.

Overview of the tabs

Overview

The overview tab gives a schematic overview of the whole system. The 50K and 3K plate of the radiation shields are visible, along with their temperature. Below that, the He3 Pump temperature and voltage and the He3 switch temperature are visible. The same goes for the He4 Pump temperature and voltage and the He4 switch temperature. This tab cannot adjust the system in any way and is meant to give an overview. Below is an overview of the program and the overview tab.



He-7 Cooler

This tab shows all the information about the He-7 cooler. It contains information about the temperatures and voltages of the He4- and He3- Pumps, Switches and Heads as well as the 4K and 2K plates. There is also the option to set the voltages of the heaters of the pumps and switches when the manual mode is active. This is done by entering the values and sending those values to the server by pressing the 'Set Voltages' button. To ensure the safety of the system these values will be checked on the server side to prevent system failures.

Bluefors

This tab is simple and contains only 2 values: the temperatures of the 50K and 3K plates of the radiation shields.

Compressor

The compressor tab shows detailed information about the compressor. The information that will be used mostly is shown on the left: the low, high and delta pressures. The same values are also visible in the gauges, which have a green range in which the values should be. Below that is the information about the compressor, including the operating ,warning and error state. If the manual mode is enabled there is the option to turn the compressor on or off using their respective buttons. Finally, on the right sides there are indicators showing the Water In, Water Out, Helium and Oil temperatures. These are used for maintenance and are just there to ensure that the compressor is still functioning correctly. At the bottom the hours of operation is shown, this displays the amount of hours that the compressor is active.

Graph

This tab creates an overview of the system over time by visualizing the data in a line chart. The eight temperatures that are visible (Bluefors 50K- and 3K plates, He7 4K- and 2K plates, He3- Head, Switch and Pump and He4- Head, Switch and Pump) can be toggled on or off using the radio buttons on the left side. Above these radio buttons is the information about the zooming. By pressing the 'Toggle Zoom Axis' button the zoom axis is toggled, the options are X, Y, XY and none. Zooming is available by using the scroll function of the mouse wheel. To zoom out and show all data press the 'Reset zooming' button. In order to zoom on a specified range, use the input fields below the chart. Here it is possible to define the range by giving the Minimum and Maximum X and Y points.

Logging

In this tab it is possible to start a specific log on the server side. The status shows if there is currently a log running, only one specific log can be active at a time. Below that you can enter the interval, the higher the interval the less often data is logged. Finally the user can specify which data should be logged. This can be done by manually pressing all values that need to be logged, or by using one of the specified templates: Everything, Compressor, Bluefors or He-7 Cooler. The logging files will be saved in the folder set in the **settingsfile**. Which is divided in a general and a specific folder structure. General logging will always be performed when the server is running and will start a new file every day.

Settings

The settings tab loads all settings from the server and allows the user to adjust them. These are further described in the Settings section.

Settings

To store static information that should be changeable a settings file was created. This file contains the password used for authentication and is stored on the server side. It also stores the location of the logging files. By default the password is 'ChangeMe!' and the location to store the logs is 'C:\LoggingCryostat'.

During the automated control processes the state machine of the program cools the program down to 234 millikelvin. This is achieved by switching from state to state, depending on a set of defined rules. These rules include a set of numbers, which we refer to as settings. These settings are also stored in a settings file. Adjusting the settings in this tab will also adjust this file. To optimize the automated processes it might be necessary to tweak these numbers. To that extend the settings tab was created. In this tab is a list of all settings and the option to adjust them. All settings and their purpose in the state machine are described below.

He3 heater max power used	The maximum amount of Watts that the He3 heater will use
He4 heater max power used	The maximum amount of Watts that the He4 heater will use
He3 switch voltage used	Amount of voltages put into the He3 switch
He4 switch voltage used	Amount of voltages put into the He4 switch
Pump heating start temperature	Temperature where the controller starts the control loop for heating the He3 and He4 pumps
Pump heating temperature setpoint	Pump heater setpoint, Pumps are heated to this temperature while recycling or cooling down to 4K
Heatswitch ON temperature	Temperature where heat switches are assumed to be in the conducting state
Heatswitch safety temperature	If the 2K plate is above this temperature, the heat switch heaters are turned off, since absorbing is useless
Heatup cycle heater temperature setpoint	Temperature setpoint used in the Heat up sequence
He4 adsorption start temperature	Temperature at which He4 evaporation is started. All He4 should be condensed at this temperature
He3 adsorption start target temperature	Temperature at which He3 evaporation is

	started, All He3 should be condensed at this temperature
Disable heater when switches are above	Pump heaters are disabled when heat switches are over this temperature, since the heat pumps are then conducting to the 2k plate
He3 adsorption start minimal temperature	Minimal temperature at which He3 adsorption will start
He3 adsorption maximum wait time	Maximum wait time to reach He3 adsorption minimal temperature
Heater power while waiting for switches	Heater power while waiting for switches