
QUICK REFERENCES

DOLLY – π E1 AREA

VARIOX CRYO + BEAMLINER

μ SR FACILITY 2017

last update: 16.06.2017

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This document is available at:

https://www.psi.ch/smus/InstrumentDollyEN/QUICK_REF_VARIOX_DOLLY_june_2017.pdf

The sources are available in the LMU afs disk:

`/afs/psi/project/lmu/Facility/Manuals/DOLLY/Variox.DOLLY/2017_June`

1 IMPORTANT FACTS

Contact person:

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In case Jean-Christophe is not around, contact Hubertus Luetkens (4450).

Main computers:

pc8533: data taking console (No web browsing in this pc, please!!!)

pc8575: users pc (to be used for users analysis)

pc9573: pc to control the beamline

mpc1364: pc to control the spinrotator II

psw411: backend workstation.

2 VARIOX CRYOSTAT – THE BASICS

The heart of the temperature control is the Mercury temperature controller.

The electrical connections from the Variox and Heliox must be directed to the Variox Mercury. This is performed by putting the switches of the switching box in the appropriate configuration.

This Variox Mercury controller will on one side control the temperature of the VTI Heat Exchanger (i.e. Variox) by controlling its heater and the pressure (i.e. eventually the He-flow) in the pumping line of the VTI Heat Exchanger.

The closed loop control of the Variox temperature is achieved by servo-controlling its VTI Heat Exchanger heater.

The closed loop control of the pressure in the VTI Heat Exchanger pumping line is performed by measuring the pressure in front of the main ^4He pump and servo-controlling the needle valve of the Variox.

With a second heater loop, the Variox Mercury will also take care of the temperature stabilization of the sample stick.

Depending on the temperature regime (see below) the needed He-pressure in the pumping-line will be automatically and continuously calculated by the back-end computer and given as a pressure setpoint to the Mercury.

Note that even though the Mercury has the capability to measure the Helium and Nitrogen levels, these are always measured by the Cryomagnetic device LM510. The output of this device is used to control the automatic refilling of the Helium and Nitrogen into the Variox.

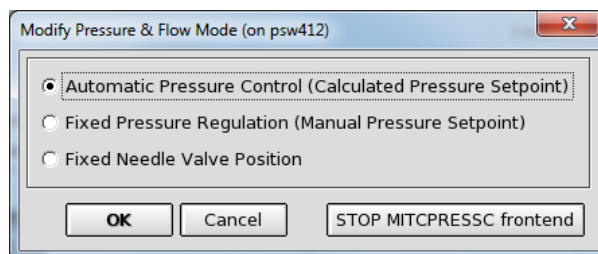
3 VARIOX CRYOSTAT – PRINCIPLE OF OPERATION

The Variox cryostat can be operated in two well defined temperature regimes:

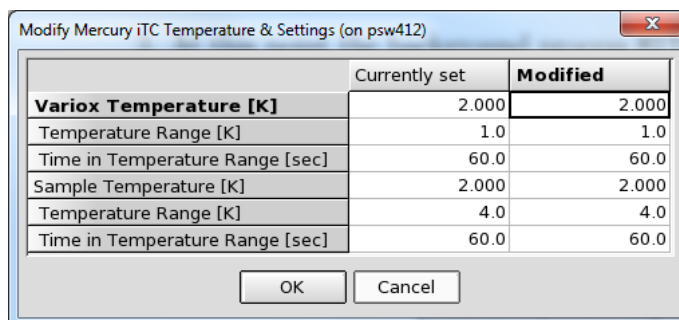
3.1 High Temperature Regime (5 K → 300 K)

For this regime, the pressure in the VTI Heat Exchanger is set in auto mode. The pressure setpoint in the VTI Heat Exchanger pumping line will vary automatically depending on the desired temperature setpoint, the present temperature and the heater output of the Mercury temperature controller.

1. Be sure that the sample chamber has at least 100 mbar of He-gas pressure at high-temperatures.
2. Be sure that the Pressure Mode is set to Automatic Pressure Control.
This is performed in the `deltat` interface by selecting the device Variox with the Modify button and then pressing the Change Pressure Mode button. In the pop-up window, select the Automatic Pressure Control (Calculated Pressure Setpoint) option.



3. At this point the background process MITCPRESSC will automatically send appropriate pressure setpoints (between usually 2 and 55 mbar) to the Mercury needle valve control loop. Note that 1 mbar corresponds roughly to 1 l/min.
4. The desired temperature is obtained by giving new temperature setpoints to the Mercury temperature controller through the interface `deltat`. This is performed in the `deltat` interface by selecting the device Variox with the Modify button and choosing the option Modify Temperature.



Remember that you have to set 2 setpoints. The first for the VTI Heat Exchanger (Variox setpoint) and the second for the Sample Stick (Sample setpoint).

Since the sample stick is solely cooled down by the He-gas which is stabilized at the temperature of the Heat Exchanger, the time constant necessary to reach a given setpoint by cooling can be **extremely long**.

It is therefore strongly recommended to perform the required temperature scans by increasing the temperature.

3.2 Low Temperature Regime ($\sim 2\text{ K} \rightarrow 10\text{ K}$)

1. For low temperature measurements, the first step of the cooling process can be performed in two alternative ways:

Alternative 1

- (a) First, evacuate the sample chamber. To do so:
 - Stabilize the temperature of the cryostat between 30 to 50 K.
 - Evacuate the sample chamber with the available diaphragm pump by opening the 3-way valve. Make sure to pump long enough to completely evacuate the sample chamber (one can check the outgoing gas from the pump).

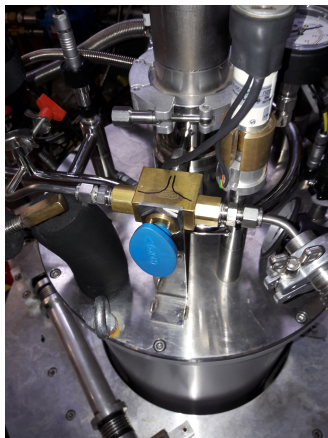
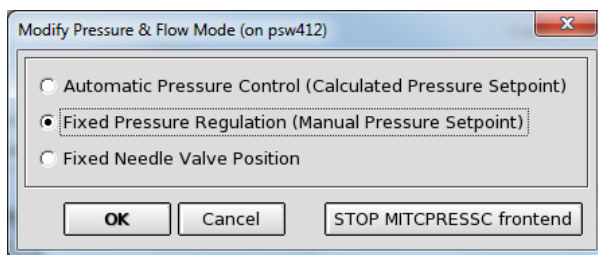


Figure 1: Blue three way valve. Arrow pointing at the center : valve closed, on the right : valve opened to the pump, on the left : valve opened to the recovery line.

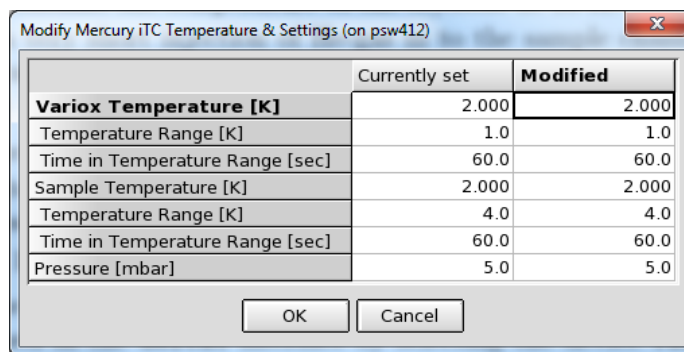
- When finished, remember to close the 3-way valve and switch off the diaphragm pump.
- (b) Slowly stabilize the temperature of the cryostat at 10 K.
 - (c) Allow a very short injection of He-gas in to the sample chamber by slowly opening the 3-way valve to the Helium recovery.

Alternative 2

- Stabilize the temperature of the cryostat at 50 K.
 - Evacuate the sample chamber with the available diaphragm pump down to 50 mbar and close the 3-way valve. Then slowly cool down the temperature to 10 K. In this cooling period, the pressure will further drop.
2. Next, switch the process Pressure Mode to Fixed Pressure Regulation mode. This is performed in the `deltat` interface by selecting the device `Variox` with the `Modify` button and then pressing the `Change Pressure Mode` button. In the pop-up window, select the `Fixed Pressure Regulation (Manual Pressure Setpoint)` option.



3. At this point the background process `MITCPRESSC` will no more send a calculated pressure setpoint to the Mercury and the Mercury will also need a pressure setpoint. This is performed on the same dialog window where the temperature setpoints are entered (see Figure below; note that the pressure setpoint is now accessible).



4. Set the temperature setpoints to 1 K and set a manual pressure setpoint to 5 mbar. Observe the decrease of the temperature and decrease gradually the pressure setpoint down to about 2.5 mbar.
This should provide a base temperature of about 1.5 for the VTHeat Exchanger. The temperature of the Stick will possibly be slightly higher.
5. **Be careful when increasing the temperature starting at base temperature – e.g. set 1.6—3—10—20 K instead of 1.6—20 K**
6. When changing back to the high temperature regime, you need to add some exchange gas in order to avoid temperature gradient between the sample and the temperature sensor on the sample stick. **Do not add too much of the exchange gas. The pressure rises with temperature, and it should not exceed 1 bar at 300K, otherwise it can damage the 10 μm Ti cryostat windows.**

4 MERCURY TEMPERATURE CONTROLLER

The *Mercury* temperature controller connected to the *Variox* cryostat is utilized in a REMOTE-mode and can be directly controlled from *deltat*.

The *Mercury* temperature controller is configured to operate one given sample stick. See with the instrument Scientist for the correct stick.

The following steps describe how to configure and use the *Mercury* temperature controller from *deltat*.

- **Switch the Heaters ON:**

In the tab *Modify Devices* choose the *Variox* entry and hit the buttons *Modify*.

In the pop-up window hit the button *More...* Be sure that the *Variox Heater% Power* and the *Sample Heater% Power* report “*AutoHeater*”.

If they report “*AutoHeater OFF*”, switch the heaters ON with the buttons *Variox HtrMode* and/or *Sample HtrMode*.

	Device Readout	Database / Demand	Modified Demand
Variox Sensor Temperature	136.088	NTC X36613vgpd.dat	
Sample Sensor Temperature	135.582	NTC X42093.dat	
Variox Setpoint [K]	2.000	2.000	
Variox PID	100.000, 0.400, 0.100, AutoPIC	TABLE=DollyVariox.pid	
Variox Heater% Power	0.000%, 0.000W, AutoHeater	AutoHeater	
Variox Average Temperature	115.5639	-	
Variox Standard Deviation	78.4356	-	
Variox Number of Values	33148	-	
Variox Temp. Range [K]	Out of Temp. Range	1.000	
Variox Time in T Range [sec]	0	60	
Sample Setpoint [K]	2.000	2.000	
Sample PID	50.000, 0.400, 0.100, AutoPID	TABLE=TESTALEX.pid	
Sample Heater% Power	0.000%, 0.000W, AutoHeater	AutoHeater	
Sample Average Temperature	117.6025	-	
Sample Standard Deviation	80.0971	-	
Sample Number of Values	33054	-	
Sample Temp. Range [K]	Out of Temp. Range	4.000	
Sample Time in T Range [sec]	0	60	
Pressure [mbar]	2.05, Manual Pressure	5.0, Manual Pressure	
Variox Needle Valve%	100.0, AutoFlow and Manual Pr	AutoFlow and Manual Pressure	

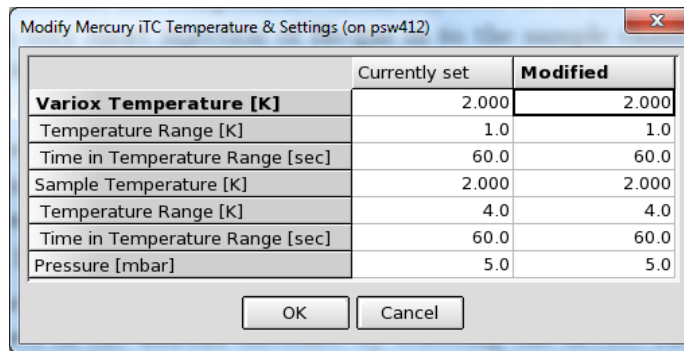
- **Setting a temperature:**

In the tab *Modify Devices* choose the *Variox* entry and hit the buttons *Modify* and, on the pop-up window, *Modify Temperature*.

On the pop-up window, change for both loops the temperature setpoints.

If you are in Low-Temperature Regime (i.e. the *Pressure Mode* set to *Fixed Pressure Regulation* – see above), then change also the pressure setpoint if necessary.

When done, hit the button *OK*.



- **Autorun sequences:**

Before writing an autorun sequence, be sure that the *Mercury* is in the desired temperature regime mode.

In the autorun file, do not forget to give all (6) the arguments in the two-loop mode.

To change the temperature, you will need an entry like:

```
SET Variox 100.0 1.0 30 100.0 1.0 30
WAIT Variox INRANGE 1800
```

In this example the setpoints are 100.0 K, the tolerances are 1.0 K and the waiting times are 30 seconds for both loops. The first loop accounts for the sample temperature and the second one for the **Variox** temperature. The second entry waits for the stability conditions to be fulfilled (note that this line does not need to be put immediately after the one changing the temperature). If the stability conditions are not reached after 1800 seconds, the next line of the autorun sequence will be processed anyway.

5 PRESSURE (He-FLOW) CONTROL

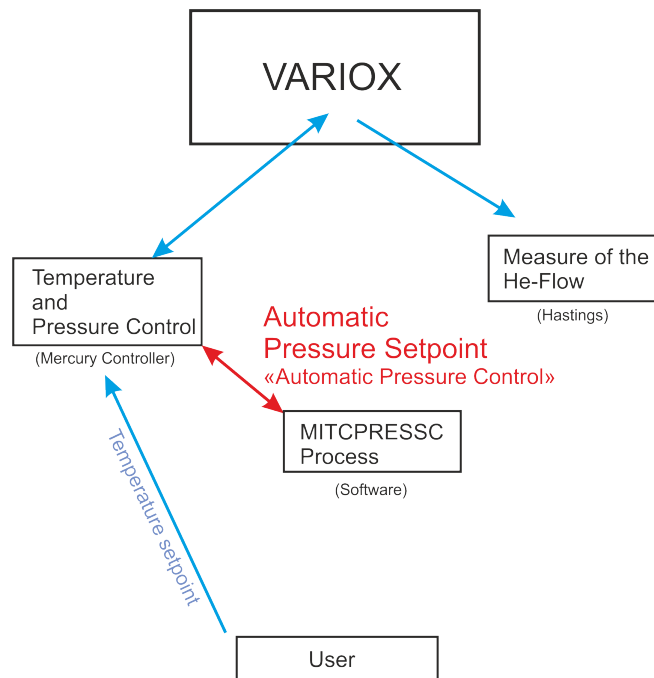
The pressure (He-flow) in the pumping line of the VTI Heat Exchanger is controlled by the position of the needle valve which is connected to the Mercury temperature controller.

Depending on the temperature regime, the setpoint for the pressure control loop is either given to the Mercury by an additional process called MITCPRESSC (High Temperature regime) or directly given through the application `deltat` (or the associated autorun sequence) to the Mercury (Low Temperature regime).

- In the High Temperature Regime, the process MITCPRESSC must be set to AUTO mode (i.e. pressure setpoint will be determined automatically by the MITCPRESSC software and sent to the Mercury controller).

As described in Section 3.1, this is performed in the `deltat` interface by selecting the device `Variox` with the `Modify` button and then pressing the `Change Pressure Mode` button. In the pop-up window, select the `Automatic Pressure Control (Calculated Pressure Setpoint)` option.

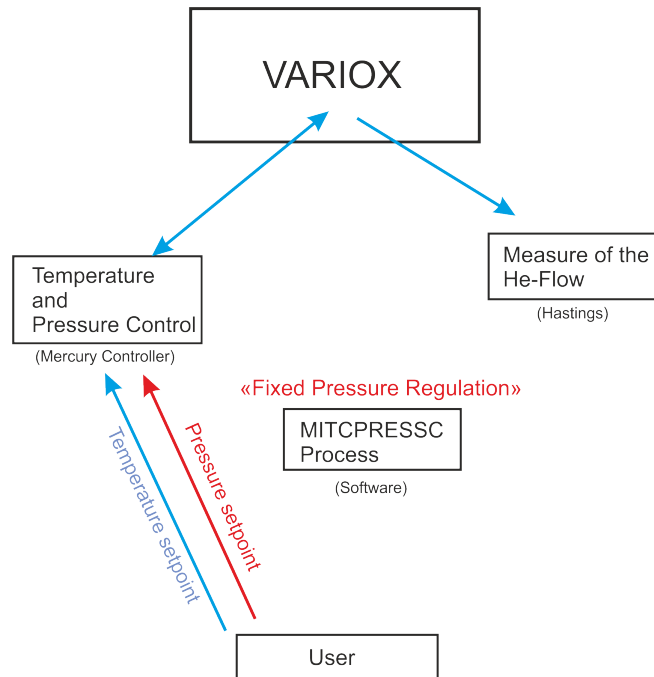
For this regime, the pressure in the Heat Exchanger is automatically set depending on the desired temperature setpoint, the present temperature and the heater output of the Mercury temperature controller.



- In the Low Temperature Regime, the process MITCPRESSC must be disabled and the pressure setpoint will be entered through `deltat`.

As described in Section 3.2, this is performed in the `deltat` interface by selecting the device `Variox` with the `Modify` button and then pressing the `Change Pressure Mode` button. In the pop-up window, select the `Fixed Pressure Regulation (Manual Pressure Setpoint)` option.

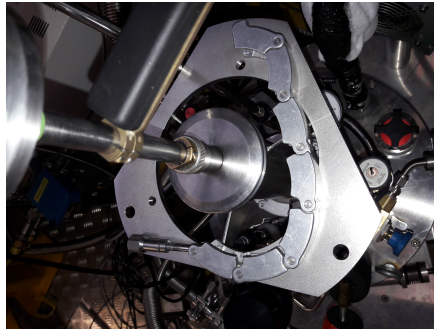
The pressure setpoint will now appear as an additional possible input field when changing the temperature with `deltat`.



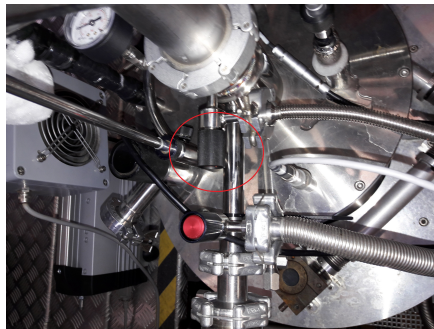
6 SAMPLE CHANGE

The following points describe the process of changing a sample in the VARIOX cryostat.

- **A sample change should only be performed in the “High Temperature regime” with a sample temperature $T > 30$ K.**
- Close the Dolly beamline valve either manually (by pressing a button on the switch box) or remotely from a computer (pc9573).
- Remove the clamp of the sample stick.



- Disconnect the electrical cable of the sample stick.
- Purge the sample chamber with He gas by carefully opening the access to the pressurized Helium bottle gas.



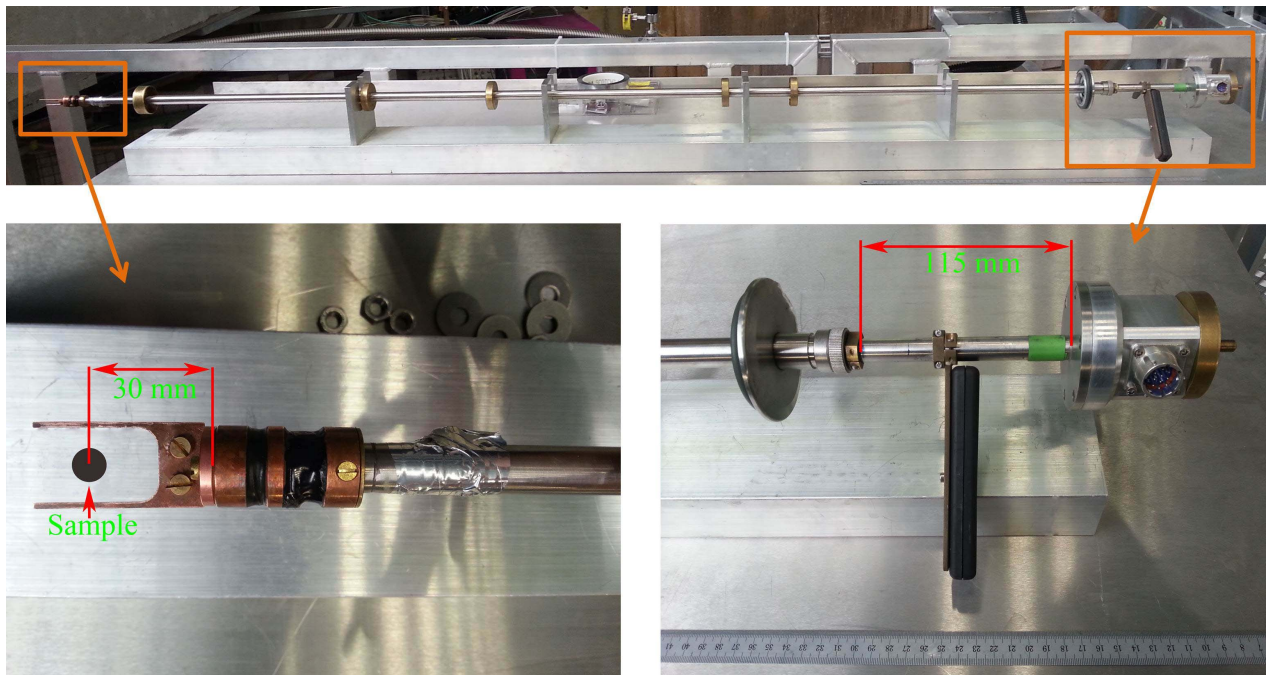
- When He-gas starts blowing out of the O-ring, remove the sample stick (use gloves!!!).
- Close the opening with the blind flange insert.
- Stop blowing He-gas.
- Tighten the clamp of the sample stick and pump out the He gas.
- When ready to re-insert the sample stick, remove the clamp of the blind flange insert.
- Again, purge the sample chamber carefully using He-gas.
- Once He-gas start blowing out of the O-ring, remove the blind flange insert and replace it with the sample stick.
- Immediately stop blowing He-gas and remove some of it with the available pump and the 3-way valve (leave at least 100 mbar to cool down the sample). Remember that in case you intend to run in low temperature mode you have to pump out the gas at 50 K.
- Reconnect the electrical cable.

- If necessary, reconfigure the LakeShore temperature controller if you have changed Sample Stick (see Section 4).
- Put the sample AutoHeater ON.
- Open the Dolly beamline valve and start your measurements :)

7 CHECK-LIST WHEN CHANGING THE SAMPLE

The following points should be checked when changing a sample.

- If your sample is not at the nominal position (30 mm from the back of the sample holder), the brass ring on the outside of the sample stick should be displaced accordingly.
- Using the standard sample holder, the stick can be inserted about 12 mm more than its nominal value.
- Check that the laser located on the external part of the stick corresponds to the sample holder orientation.
- Check that you have exactly **one** O-ring before introducing the target stick into the cryostat.
- The positioning of the sample can also be done by checking the external dimensions of the stick (see the figure below).
- Check (if needed) that the sample holder is perpendicular to the beam (use the laser located on the external part of the stick).
- The cryostat should be at the nominal HUB-position 8 (look at the device `Position_Cryo` in `deltat`). See also Section 9.



8 SAMPLE ROTATION

The motor control unit *EL734* switches automatically to local mode as soon as a local operation is performed.

To rotate manually the sample:

- Be sure that the “+” and “-” buttons are lit (otherwise wait few seconds). Press the green round button corresponding to the motor # 1
The green LED of the button should now be ON
- Press and hold the “+” (or “-”) yellow button to rotate the sample in one or the other direction
- If during this operation, the green square button suddenly lit, it means that the computer has taken the control of the device. In this case, wait few seconds and restart the procedure. The computer connects to the device every 30 seconds..., so be quick...)

To rotate the sample remotely:

- In `deltat`, the tab `Modify Devices` contains the device `Rotation_Sample`. Choose this device and hit the `Modify` button. Enter the new position value in the pop-up window and close it.
- A rotation of the sample can also be included in a auto-run sequence by using the command

```
SET Rotation_Sample ANGLE 100.0 30
```

With this example, an angle of 100 is requested. The parameter 30 represents the maximum optional waiting time for ANGLE (which should be longer than the time necessary to rotate the sample, especially if a run is started as next step).

9 CRYOSTAT VERTICAL POSITION

The vertical position of the cryostat can be adjusted (e.g. to compensate for the thermal expansion of the sample stick). It can be done in `deltat`, the tab `Modify Devices`, and `Position_Cryo`.

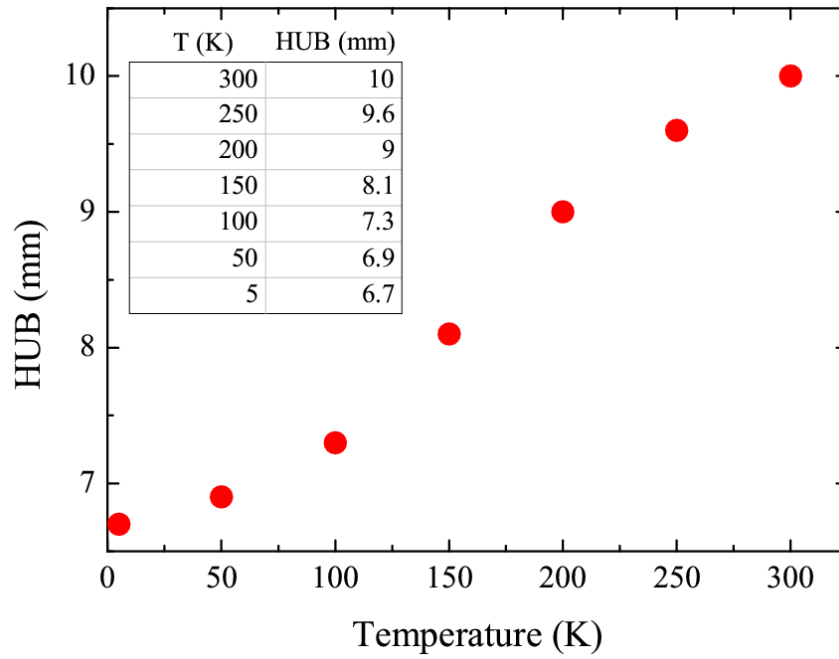


Figure 2: Approximate HUB setting for different temperatures.

10 EPICS-CONTROLLED POWER SUPPLIES

Since 2011, all the power supplies for the beam magnets are now controlled by the system EPICS (Experimental Physics and Industrial Control System). In addition, some power supplies have been replaced and few more will be replaced during the next shutdowns.

All power supplies can be controlled via the Beamline PC (PC9573). The “Experiment Magnets” can be controlled through the `deltat` application running on the console (PC8533). Both computers run EPICS clients applications. The heart of the EPICS control for the π E1 beamline is a VME crate located on the platform near the power supplies.

The beamline PC uses the “SetPoint” application which can be started either:

- with the icon “SetPoint” on the Desktop or
- with the command-line:
`/afs/psi/intranet/HIPA/Secondary/bin/setpoint_new.tcl`

From this application one can set the magnets, switch them ON/OFF, open/close the beam-blockers and also control the Spin-Rotator high-voltages.

11 BEAM-LINE SETTINGS

Some standard settings are normally provided (transverse or longitudinal mode...). The names are normally self-explanatory.

11.1 Spin rotator operation

In **longitudinal mode** the spin rotator runs with a high voltage of ± 50 kV and a current of -67.10 A of the SPIN2 magnet (large hysteresis). Set a current of -50 A and gradually increase this value to find the maximum rate, remember this value and set it after setting the current back to -50 A again.

For **transverse polarization** the high voltage of the spin rotator has to be set to ± 250 kV, with a current of ≈ -340.00 A (optimize for maximum rate as described above). The muon spin is rotated in the horizontal (bending) plane.

When adjusting the muon rate keep an eye on the “Backward Vetos” rate as displayed in the “Dolly Scaler” window, it should not exceed a value of $800'000/\text{sec}$.

11.2 How to set the beam-line ?

- Start the SetPoint application on the PC9573 and load a new setpoint-file (.sp files) from the directory `/afs/psi.ch/intranet/HIPA/Secondary/pie1/`. When loading a new setpoint-file the values are read and displayed in the column “File value”.
- In order to set the power supplies, one should select them (via the button “Select All” for example) and press the button “Set File value (\rightarrow)”. At this point the power supplies should ramp-up to the desired values.
- For the high-voltage power supplies block, the setting is not automatic and one should additionally press the drop-down list on the right-hand side and choose the option “HVSET”. Note that the setting of the high-voltage power-supplies can take several seconds.
- When saving the current setting, the value in the column “Set value” will be written in the file and the column “File value” will be updated accordingly.

If better settings are found, it is strongly requested to save them (with the standard notation and by doing a proper entry in the logbook) to the benefit of the following users.

Use only the slits FS51-U, FS51-L, FS51-R and FS51-0 to modify the beam intensity.

NEVER OVERWRITE EXISTING SETTINGS !!

12 TRUE ZERO-FIELD MEASUREMENTS

Extensive tests have shown that a weak remanent field is present at the sample region after that the main field (WEU) has been set to high values.

This field can be **completely** suppressed by applying, for a very short time, a small field of 100 Gauss with the auxilliary coils (WEV).

After such a WEV cycling, zero field is dynamically performed (compensation better than 30 mG) by a newly installed automatic compensation device. Such compensation relies on a continuous field measurement realized slightly off-center. The correction due to the off-center position is taken into account and regularly performed by the Instrument Scientist.

When performing measurements in applied (such as Knight-shift measurements), any stray fields created by the major magnets located in (or near) the experimental hall are tabulated and automatically compensated by the automatic compensation device.

13 SWITCHING ON THE “FORWARD” VETO

In the normal mode, solely the “active collimator” (Backward veto) is utilized as a veto for the muons and positrons.

If measurements on small samples (and holders) are mandatory, the center part of the Forward detector can be used as an additional veto (Forward veto).

To switch on the Forward veto:

Starting from 2010, solely the CAEN TDC DAQ electronics is used on the instrument DOLLY. With this electronics, the switching between different logics is performed by software by changing the TDC settings. Such TDC settings can be modified/seen/saved by selecting on the `deltat` GUI the tab `TDC Settings` to be active.

By pressing the button `Modify Settings`, you have the possibility to modify the set-up of the TDC used for the experiment (and saved in the ODB – online database). Each setup configuration is saved on a so-called setup file located on the back-end computer. These setup files are maintained by the Instrument Scientist. A setup file contains all the necessary logic as well as the histogram grouping and information on the `t_0` and First Good Bins.

A Wizard-Tab will lead the user through the setup configuration. On the first wizard-tab, a drop-down menu will present the available setup files for the instrument. Hopefully the names should be self-explanatory.

A complete description of the `deltat` GUI interface is given in the following document:

<http://lmu.web.psi.ch/facilities/software/deltat/deltat.pdf> A complete description of how to setup the TDC electronics is given in the following document:

<http://lmu.web.psi.ch/facilities/electronics/TDC/TDC.pdf>

14 EXAMPLE AUTORUN COMMANDS

```
# Set magnetic field in WEU to 1000 gauss and wait 120 seconds.
SET expmag WEU 1000.0 120
# Start data taking
START Histogram 2 3000000

# Set magnetic field in WEV to 100 gauss and wait 120 seconds.
SET expmag WEV 100 120
# Set magnetic field in WEV to 0 gauss and wait 120 seconds.
# - this procedure is required for the true zero field measurement
SET expmag WEV 0 120
START Histogram 2 3000000

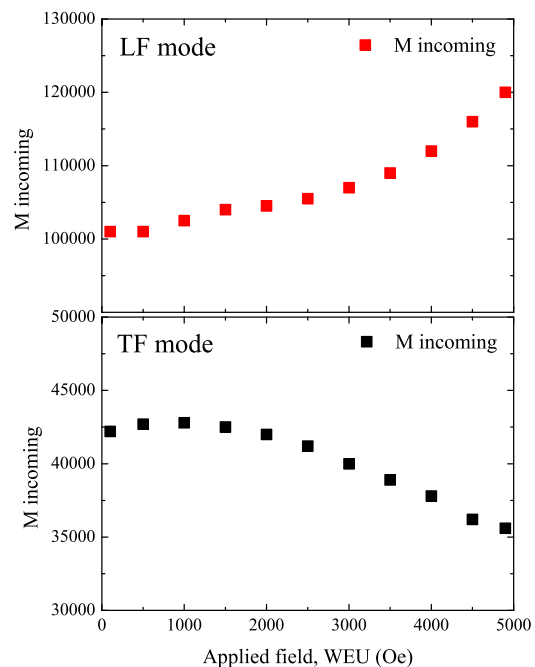
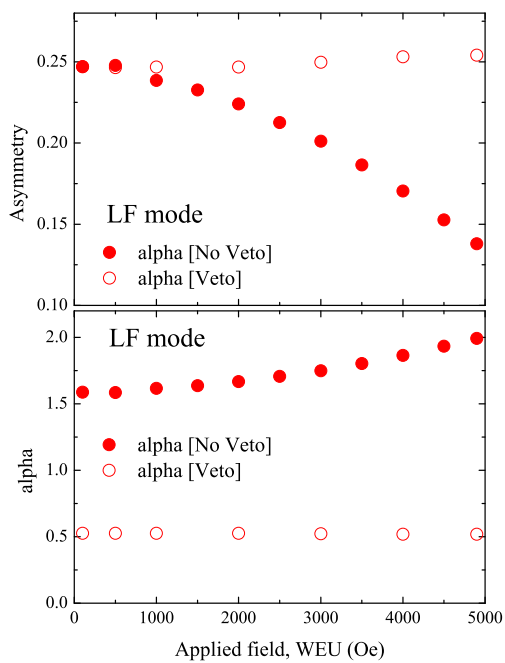
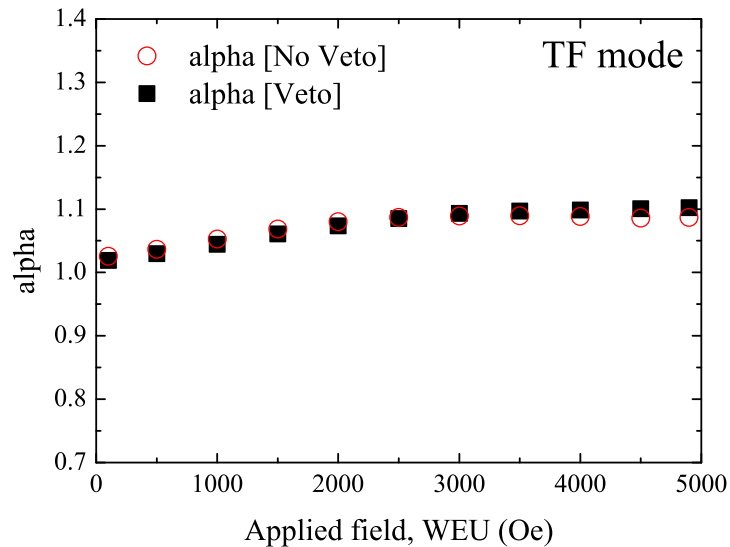
# Set position of the whole cryostat to 11 mm.
SET Position_Cryo HUB 11 120
# Set temperature in the cryostat and on the sample to 290 C
# within a range of 1 C, and the minimum time in the range of 120 s.
SET Variox 290 1 120 290 1 120
# To actually wait for the temperature to be in a range, WAIT command
# has to be used. If the requested temperature is not reached within
# 7200 seconds, the sequence will proceed anyway.
WAIT Variox INRANGE 7200
START Histogram 2 3000000

# Set the slits to 130 and wait 120 seconds
SET Beamline_PiE1 FS51-0 130
SET Beamline_PiE1 FS51-U 130
SET Beamline_PiE1 FS51-L 130
SET Beamline_PiE1 FS51-R 130 120

# Rotate the sample by 30 degrees
SET Rotation_Sample ANGLE 30.0 120
# Set the title of the run
TITLE C=wTF 30deg
START Histogram 2 1000000
```

15 FIELD DEPENDENCE OF DIFFERENT PARAMETERS

The asymmetry and alpha parameters were measured for a silver sample (plate like) in Veto and No-Veto conditions both in LF and TF modes. M incoming rate also collected as a function of applied field both in LF and TF modes. All the data are shown in the figures below. One should note that those values are not references and the asymmetry field behavior can evolved differently regarding your experimental setup (position of the sample, sample holder ...).



16 HOW TO CHECK THE PARAMETERS AND ANALYZE THE DATA

16.1 How to check the different parameters

There is three different possibility to check the stability of the different parameters (temperature, pressure, field ...).

- i) Check directly in Deltat going to **Modify Devices** and click the **Show** button.
- ii) On an internet browser go to the history of Dolly, <http://psw411:8081/HS/All> and check the desired parameter.
- iii) For the temperature, one can also directly check the Mercury with the camera installed in the experimental area going to this address : <http://musr-dolly-4/view/index.shtml>

16.2 How to directly analyze the data

Due to trouble for maintaining the last version of the PSI software in every machine, no analyzing program is directly installed in pc8575. To analyze directly your data with this computer you have to be connected to the virtual machine `musruser` under the name `l_musr_tst`. To do so, open the console and write

```
ssh l_musr_tst@musruser
```

you can ask the password to a member of PSI staff.

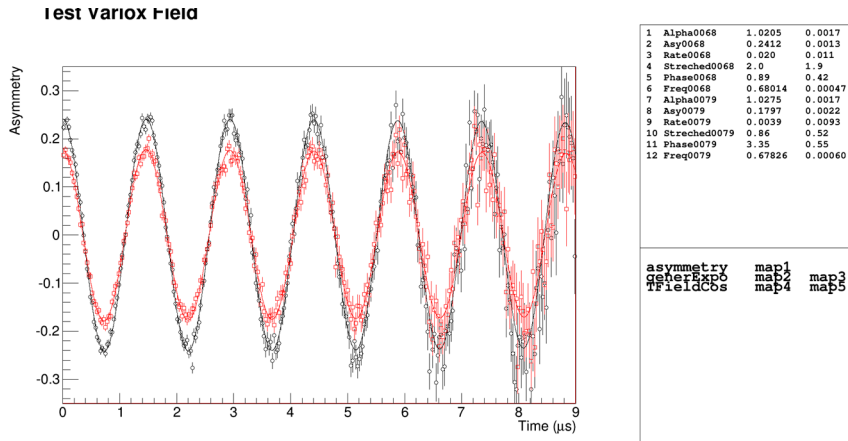
Once you are logged, you can create a folder at your name and work within it using `musredit` and `musrfit`. A manual for this program can be found on the internet : <http://lmu.web.psi.ch/musrfit/user/MUSR/MusrFit.html>

The `novellook` program can also be used with this virtual computer.

17 Variox Characteristics

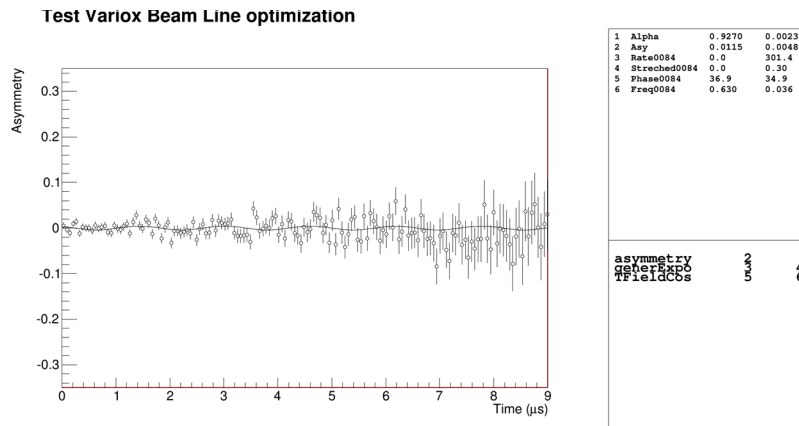
17.1 Initial Asymmetry

In this part we describe the expected initial asymmetry in the Heliox both in longitudinal (black) and transverse (red) polarization under a transverse field of 50 G. We found $A_0^{\text{long}} = 0.241(2)$ and $A_0^{\text{trans}} = 0.180(3)$. One has to keep in mind that as we had to apply a transverse field of 50 G the initial asymmetry in zero field can be slightly different.



17.2 Background

The background was estimated with a 4×4 mm Ni piece. We found for this sample a background of 0.011(5). If one assume a beam size of 8 mm diameter, therefore for a full coverage of the sample one can expect a background lower than 0.003(2).



17.3 Sample position

When studying small samples, one can study the sample position regarding beam by changing the HUB position and computing the ratio $M_{\text{stopped}}/M_{\text{incoming}}$ versus HUB. An example of such experiment done at 80 K with a 4×4 mm Ni piece is given below.

