GPS User Guide

Contents

Laboratory for Muon Spectroscopy
A. Amato & H. Luetkens – June 2015

I. Introduction

1 Regulations

1.1 Generalities

The Experimental Hall is classified as a Zone 1 area. It is therefore not allowed to drink or eat in the Hall (including in the Counting Room).
When leaving the Hall, each user will have to check for possible contamination. Please use the available hands and feet detectors. All material leaving the Zone 1 area has to be checked by a Safety Officer ("SU Kontrolleur"). The phone number of the Officer on duty is indicated near the main exit.

1.2 Dosimeters

When working in the Experimental Hall, each user will have to carry his dosimeter.
The dosimeters are provided, during the working hours, by the dosimetry office located near the reception (building WLGA). During non-working hours, the dosimeters will be provided by the entrance guard.
To obtain a dosimeter, a short (and easy) exam will be required. Inform yourself at the dosimetry office (Building WLGA) for further details.

1.3 Reachable users

Users are requested to remain reachable at all time, during the experiment, by the Control Room and/or the instrument scientist. A mobile PSI phone (# 5880) is available for the person on shift and should be carried also in the PSI Guest House.
Please deposit this mobile phone in the GPS counting room at the end of your experiment.

1.4 Sample mounting

Sample mounting is NOT allowed in the Counting Room. All sample mounting will have to be performed either in the beam area or in the *Sample Preparation Laboratory* located also in the Neutron Hall.

Moreover it is forbidden to handle radioactive material/samples in the *Sample Preparation Laboratory*.

1.5 Radioactive samples

1.5.1 Transport and handling

The transport of radioactive material is subject to authorization. A number of national and international regulations must be fulfilled concerning e.g. labeling, packing, type of shipping and shipping documents. Depending on the type and activity of the radioactive material, special transport or shipping may have to be organized.

On the PSI site, all transports of radioactive material outside a controlled zone (e.g. outside the Experimental Hall) have to be declared in advance to the Safety Officer of the Radiation Protection Group. The name and telephone number of the member on duty can be found on a yellow panel at the entrance door to the GPS area.

Handling of radioactive material is not allowed outside a controlled zone or inside any Counting Room. Moreover it is also forbidden to handle radioactive material/samples in the *Sample Preparation Laboratory*.

All information (type of material, packing) and any operation performed on radioactive material (time of entry to the experimental area, handling, measurements, time of removal from the area) have to be recorded by the Spokespersons in the corresponding Logbook (*Hazardous Samples Logbook*) located in the Counting Room.

1.5.2 Preparation

μSR measurements on radioactive material **must be performed on hermetically sealed samples**, preventing any possible contamination.

All radioactive material has to be properly labeled, allowing complete identification at all times and by any person.

1.5.3 Unexpected Events

Any unexpected event or any suspicion of an unexpected event involving radioactive material (loss, suspected contamination, etc.) must immediately be reported to the Radiation Protection Group (the phone number of the Safety officer responsible for the GPS area can be found on a yellow panel at the entrance door to the experimental area). Outside working hours, the report has to be given to the Accelerator Control Room, internal telephone number 3301 or 3302.

1.5.4 Removal from PSI

Removal of radioactive material from the PSI site will be allowed only after fulfilling the required formalities and is subject to authorization from the Radiation Protection Group and the Safety Officer for Transport of Radioactive Material.

1.6 Hazardous samples

μSR measurements on hazardous material **must be performed on hermetically sealed samples**, preventing any possible contamination.

All hazardous material has to be properly labeled, allowing complete identification at all times and by any person.

All information (type of material, packing) and any operation performed on hazardous material (time of entry to the experimental area, handling, measurements, time of removal from the area) have to be recorded by the Spokespersons in the corresponding Logbook (*Hazardous Samples Logbook*) located in the Counting Room.

2 The beam area (πM3.2)

During measurements the area is locked and its access is controlled by the so-called PSA system and is directly supervised by the Control Room. The entrance gate can be in 3 different states:

Green: The access is free and everybody is allowed to enter the zone. The beam blocker is of course shut.

Yellow: The access is restricted and controlled by the Control Room. The access in the area is possible if the beam blocker is shut, but each person entering the area must take a black key.

Red: The area is locked and nobody can enter in the area. In this state the beam blocker is usually open and μSR measurements are possible.

2.1 Closing the area (from Green to Red)

To close the area, the user will have to perform some simple operations:

- Do first a quick check to ensure that the area is empty.
- Go out and close the door.
- Call the Control Room via the black "CALL" button (CCTV camera and light should come ON).
- Tell the operator (via the microphone) that you want to do a "Rundgang".
  Be prepared to unlock a black key.
- The operator will switch the entrance gate on the "yellow" state.
- Immediately after that, the black keys will be released (hear the characteristic click...).
- Each person going in the area should unlock a black key.
- Put one black key in the door-lock and turn it clockwise.
  When the buzzer is heard, push the door-handle very gently down, and open the door.
- Enter and close the door.
- Check, in the right order, the 4 locations (buttons) indicated on the Figure 1. The locations are also reported on a figure displayed at the door of the area. The location to clear is indicated by a lighted green button, which has to be pressed. At this point you are **responsible** that nobody is staying in the area.
- When finished, go back to the door. Push the "CALL" button on the door (CCTV camera and light should come ON).
- When you hear the buzzer, put your black key in the door-lock (and turn it counterclockwise), or press the little black button near the lock, and gently push down the door-handle.
- Come out, close the door and put back the black keys in their slots.
- The operator should now put by himself the entrance gate in the "red" state. If not, tell him to close the area ("sperren").
- Locate the grey box controlling the beam blocker on the left hand side of the door ("Kanalverschluss KSE301"). Wait until the PSA led is ON (1 minute...) and press the button AUF to open the beam blocker. After some seconds (30 s. ...) the green led AUF will indicate that the beam blocker is open.

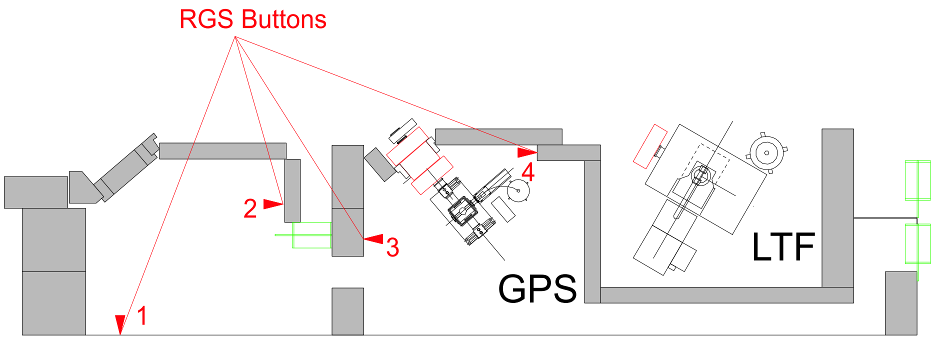

Figure 1: Location of the 4 RGS buttons of the πM3.2 area

2.2 Entering the area (from Red to Yellow)

To enter in the area for a short time, the user will have to perform some simple operations:

- Close the beam blocker by pushing the button ZU on the grey box located on the left hand side of the door ("Kanalverscluss KSE301"). Wait until the red led ZU in ON.
- Call the Control Room via the black "CALL" button (CCTV camera and light should come ON).
- Be prepared to unlock a black key.
- The operator will switch the entrance gate on the "yellow" state.
- Immediately after that, the black keys will be released (hear the characteristic click...).
- Each person going in the area should unlock a black key.
- Put one black key in the door-lock and turn it clockwise.
  When the buzzer is heard, push the door-handle very gently down, and open the door.
- Enter and close the door.
- When finished, go back to the door. Push the "CALL" button on the door (CCTV camera and light should come ON).
- When you hear the buzzer, put your black key in the door-lock (and turn it counterclockwise), or press the little black button near the lock, and gently push down the door-handle.
- Come out, close the door and put back the black keys in their slots.
- The operator should now put by himself the entrance gate in the "red" state. If not, tell him to close the area ("sperren").
- Locate the grey box controlling the beam blocker on the left hand side of the door. Wait until the PSA led is ON (1 minute...) and press the button AUF to open the beam blocker. After some seconds (30 s. ...) the green led AUF will indicate that the beam blocker is open.

2.3 Freeing the area (from Red to Green)

To allow a free access to the area, the user will have to perform some simple operations:

- Close the beam blocker by pushing the button ZU on the grey box located on the left hand side of the door ("Kanalverscluss KSE301"). Wait until the red led ZU in ON.

- Call the Control Room via the black “CALL” button (CCTV camera and light should come ON).
- Tell the operator to free the access (“Zugang frei”)
- The state of the entrance gate should change to the Green state.
  The access is now free.

II. The instrument

3 General description

The GPS Instrument is permanently installed in area πM3.2, using a so-called "surface-muon beam" (i.e., positive muons originating from the decay of positive pions stopped near the surface of the production target M). The typical range of these muons is about 1.5mm in polyethylene or 0.65 mm in aluminum (see also Section 17, page 86). The πM3 beamline is equipped with an electromagnetic separator/ spin rotator allowing to rotate the muon-spin direction with respect to the muon momentum.

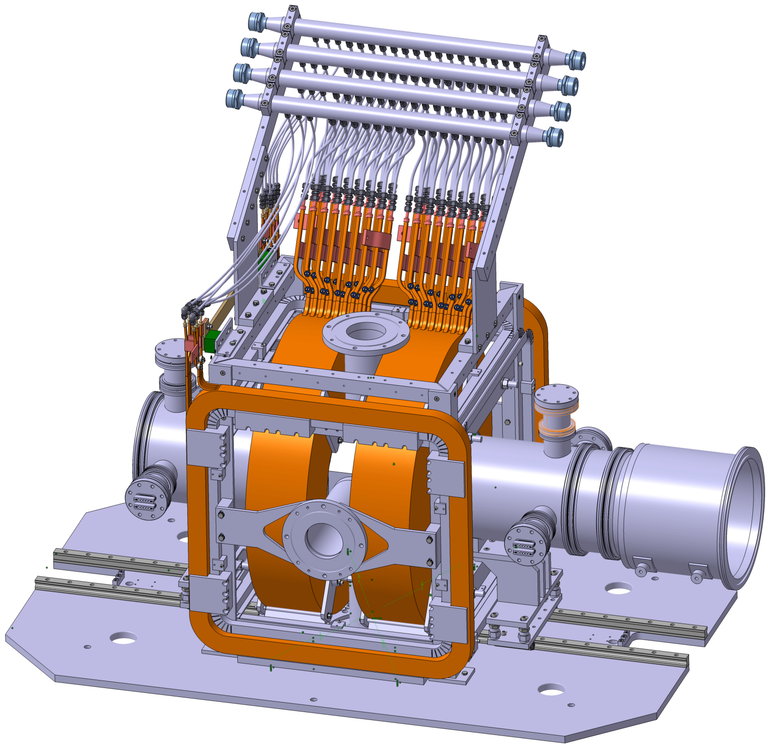

Figure 2: 3D-view of the instrument without sample insert. The muon beam enters the instrument from the right-hand side.

The instrument is designed for zero- (ZF), longitudinal- (LF), and transverse-field (TF) μSR experiments in wide ranges of temperature (see Part III, page 17) and external magnetic field (see Part IV, page 70). A special detector arrangement allows to investigate very small samples. Sample rotation is provided for the study of orientation-dependent effects in single crystals.

The GPS Instrument can be used simultaneously with the Low Temperature Facility (LTF) Instrument either by splitting the beam continuously by widening the spot in front of the collimators located at the entrance to the septum magnet (see Figure 29, page 75) or by triggering an electrostatic deflector ("kicker") on request of one of the Instruments (Muons On REquest, MORE, see also Section 14, page 80).

4 The detectors

The detector arrangement consists of

- A muon detector (M) having a thickness of 0.18 mm.

- Six positron detectors (with respect to the beam direction): Forward (F), Backward (B), Up (U), Down (D), Right (R) and Left (L).
  Some of these detectors (i.e. U, D, R, and L) are actually composed by two different subdetectors.
- A so-called “Mobile” detector which is either added to the R or to the L detector depending on the cryogenic port used.
- Each of the (sub)detector is read on both side by an array (4 or 5) SiPMs photosensors.
- A Backward veto detector (B_{veto}). This detector consists of a hollow scintillator pyramid (B^L_{veto}, B^R_{veto}, B^U_{veto} and B^D_{veto})with a 7x7 mm^2 hole facing the M counter. The purpose of the B_{veto} is to collimate the muon beam to a 7x7 mm^2 spot and to reject muons (and their decay positrons) missing the aperture ("active collimation").
- A forward veto detector (F_{veto}), rejecting muons which have not stopped in the sample (and their decay positrons). It is used with small samples. When the sample/holder assembly stops all muons, F_{veto} it is usually added to the F detector to increase the forward solid angle.

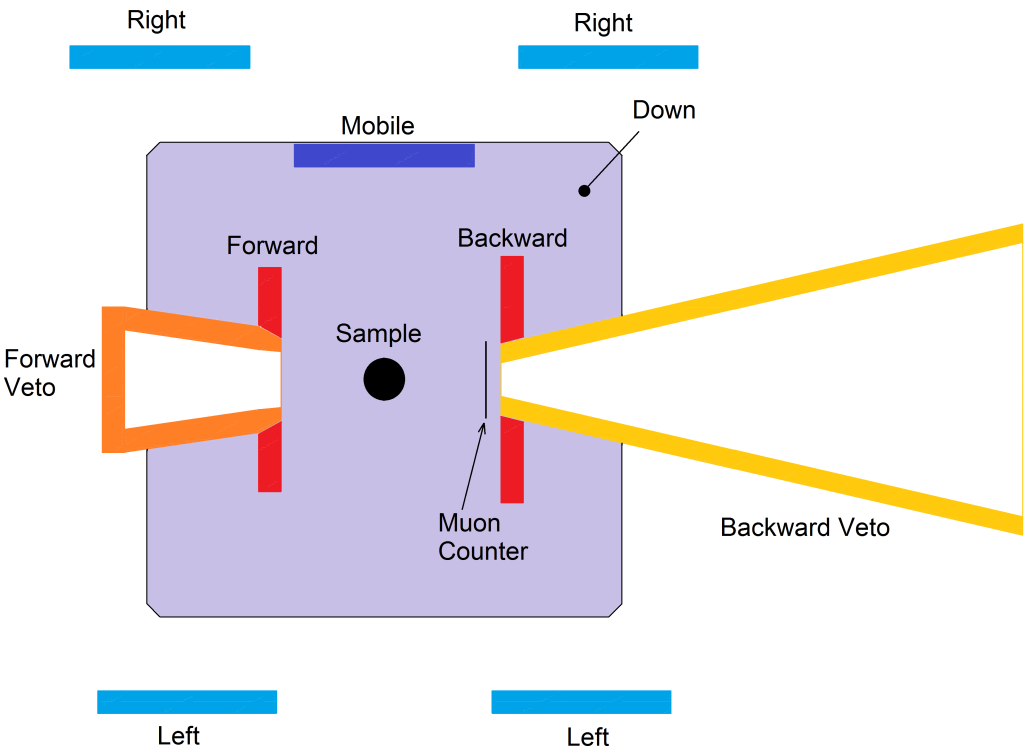

Figure 3: Schematic top view of the detectors. Not shown are the B^U_{veto}, B^D_{veto} and the Up detectors.

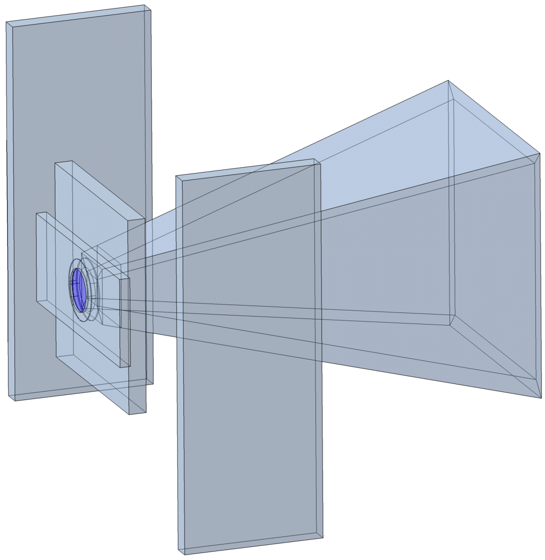

Figure 4: View of the detectors set located up-stream from the sample. The B_{veto} pyramid is clearly visible as well as the Backward, Muon detectors. Portions of the Left and Right detectors are also visible.

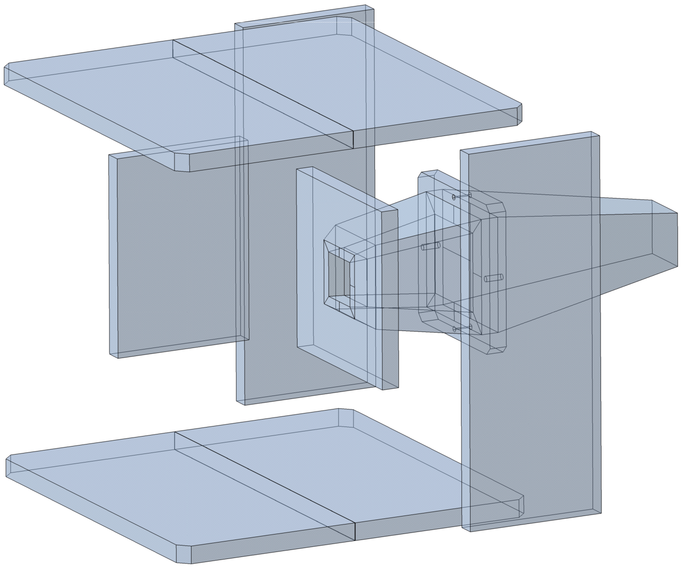

Figure 5: View of the detectors set located down-stream from the sample. The U, D, R (portion), L (portion) and F detectors are visible. The Mobile detector is here in the "Left" position. The pyramid is the F_{veto} detector, which can be added or not to the F definition.

A "stopping" muon is defined as

$$M_{stop} = M \centerdot \overline{V}$$

where V represents a veto event, which is defined as $V = B^L_{veto} + B^R_{veto} + B^U_{veto} + B^D_{veto}$ or $V = B^L_{veto} + B^R_{veto} + B^U_{veto} + B^D_{veto} + F_{veto}$ in the case of small samples where part of the Forward detector is used as veto.

Similarly, a positron event is defined as

$$P = P_{raw} \centerdot \overline{V} \ .$$

In addition the electronics checks for double events, making sure that the detected positron can unambiguously be connected to a given decaying muon.

5 Computers and Electronics

5.1 Data-acquisition and Electronics

Figure 6 shows the overall interconnection of the various hardware items for the GPS instrument. For the normal users, the main item is the Linux console (pc11318). This machine is used as an interface for the actual back-end Linux system (psw415) located in the WHGA building and which runs the data-acquisition.

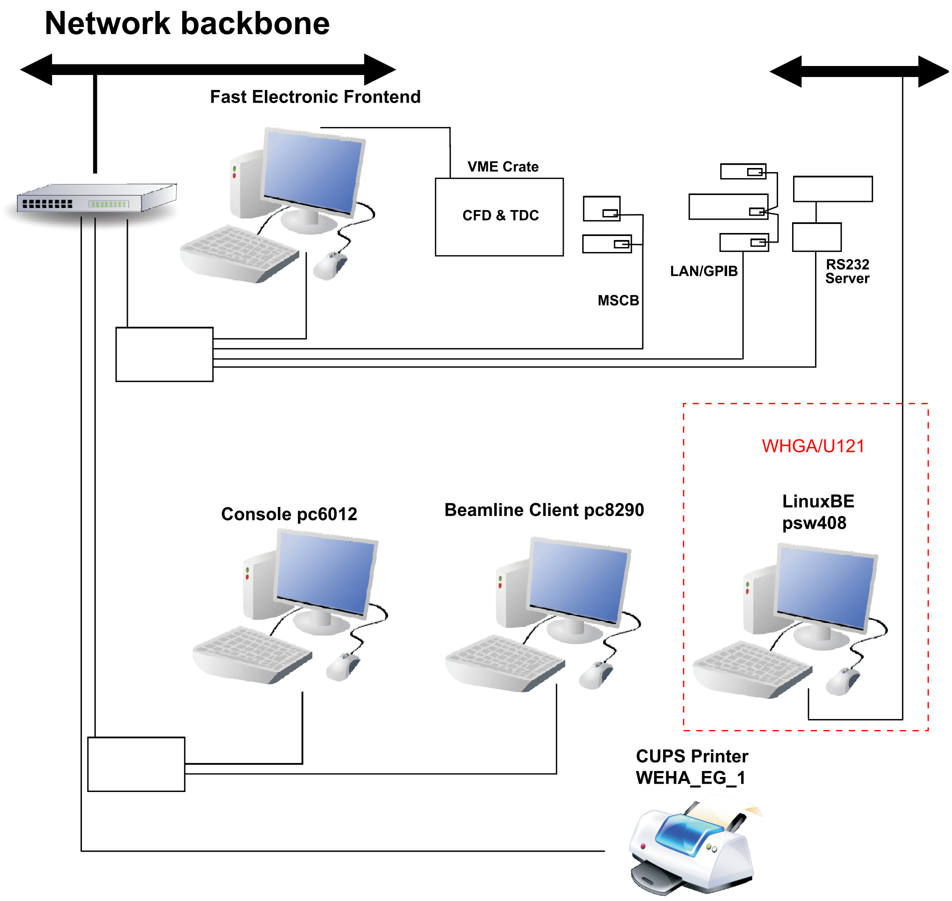

Figure 6: The overall interconnection of the various hardware items for the GPS instrument

5.1.1 New "TDC Electronics"

Introduction: The new electronics consists of a VME crate with programmable constant fraction discriminators (CFD, PSI CFD950), a multihit TDC (CAEN V1190) for digitizing of time information, and a scaler module (SIS3820) for rate measurements.

The VME frontend process to readout the VME TDC data is running on a frontend Linux PC and connected to the VME crate by a SIS 1100/3100 VME-PCI interface.

The complete event evaluation is done by software: the TDC is operated in Continuous Storage Mode, and the frontend process reads all the TDC data. It searches for events that fulfill logics conditions. The data are sent to the Analyzer process running on the Backend, which builds the histograms taking into account post- and pre-pilup conditions, as well as logics conditions (see also Section 4).

The system is also characterized by its flexibility, as the whole logic diagram is simply stored in special setup files, which can be easily modified and loaded for a desired configuration into the online database (ODB) of the MIDAS DAQ system.

Layout: The Figure 7 represents schematically the different modules used in the VME crate.

The analog signals are split by an active signal divider (SP950) into a timing branch sent to the CFD (CFD950 with 8 input channels) and a monitoring branch for CFD threshold adjustment (see TDC-Elctronics Manual).

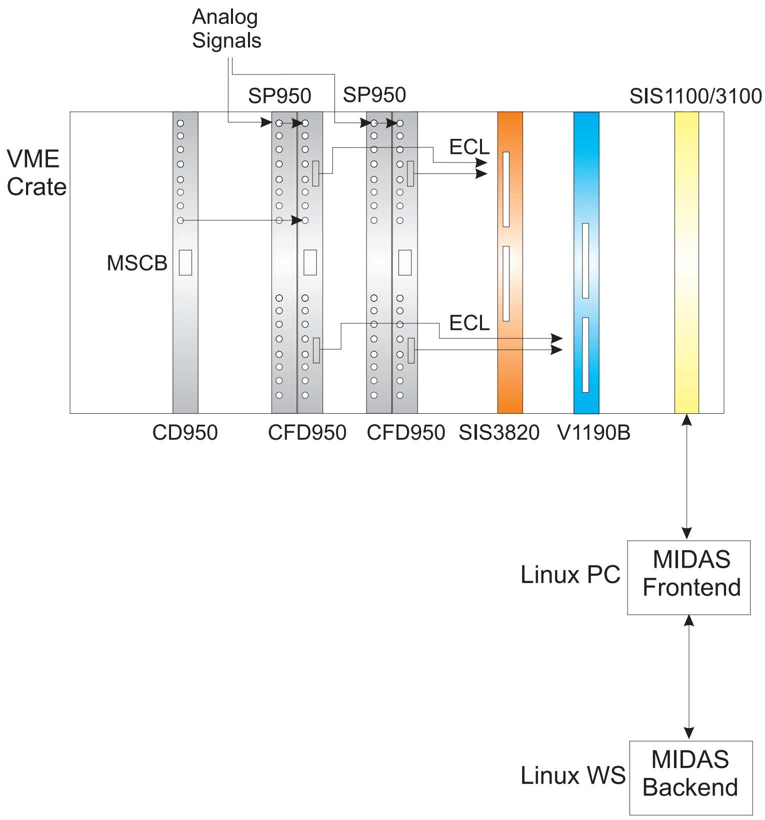

Figure 7: Schematics of a typical VME elctronic crate for a bulk muSR experiment. In additon to the CFDs, TDC, Scaler and VME/PCI interface, the crate is usually also equipped with a PSI Clock (CD950). Also NIM/ECL PSI converters (LC950) and Coincidence Units can be installed.

The signals from the CFD's are sent as ECL signals to the TDC V1190 and also to the scaler. If hardware coincidence is necessary, the ECL or NIM signal outputs of the CFD can be used with a PSI Coincidence Unit FC950 (available from Studio E). The signal can be fed back to the TDC and Scaler by the ECL output of the Coincidence Unit.

The signals from the TDC and Scaler are sent to a MIDAS frontend (Linux PC) through the optical link VME/PCI interface. In the front-end Linux PC, the events are checked for coincidence conditions and are sent to the Analyzer process running on the Backend computer, where the histograms are built according to the trigger and logics conditions defined for a particular setup.

Note that for all the modules developped at PSI, a RS485 connection is available. It allows to setup the module with the MSCB (MIDAS Slow Control Bus) protocol through a MSCB submaster (connecting the RS485 bus to the ethernet). Those settings are saved on flash memory on the boards.

Changing the logic: As said, the logic conditions (as for example switching ON and OFF the Veto counter) can be changed by software. This is done through the GUI application `deltat` (for more information see the Manuals MuSR Graphical User Interface: deltat and TDC-Elctronics Manual).

5.1.2 Slow Control

The slow control devices are mainly controlled via GPIB (IEEE-488) bus, RS-232 serial line, directly through Ethernet/TCPIP, or through the Midas Slow Control Bus (MSCB).

- GPIB: Controlled through an Agilent LAN/GPIB Gateways (E5810A).
- RS-232: Controlled either through a Lantronix ETS8PS 8-channel RS232 terminal server.

5.2 Other computers

Some Linux workstations are available. They can be used with the user's AFS account or with the local account (account *l_musr_tst* and password *DeltatDeltat*).

As described in Section 12.2, the secondary beamline control system, controlling all beamline elements (magnets, slit systems, separator etc.) between the target station and the experiment, is now based on the EPICS architecture.

A client-PC is dedicated to control the beamline (hipa-pim3.psi.ch) and is running under Linux (account *acsop* and password *PSIbeam1*).

5.3 Laptop connections

To use your PC or Laptop on the PSI Network you should enable DHCP to get a PSI TCP/IP address regardless of what host name you choose.

5.4 Printing

CUPS printers are available in the Experimental Hall. The printer WEHA_EG_1 is located on the gallery between the LTF and GPS cabin. The printer WEHA_E5_2 is located in the Experimental Hall near the area πE5. It is also equipped with a xerox machine and a FAX. These printers can be accessed from UNIX and Windows systems (for Windows, just type the print server adress in a Windows Explorer window: *winprintw*.

III. Sample environment

6 Quantum cryostats

6.1 Safety

6.1.1 Hazards

The Quantum Continuous Flow Cryostat contains liquid helium. Consequently, like all equipment using cryogens, certain hazards are present.

The potential hazards are catastrophic rupture of unvented vessels, freezing damage from splashing cryogens and asphyxiation hazard from high concentrations of helium gas. Catastrophic rupture can occur if a cryogen is held in a sealed container while warming. The user should therefore ensure that the necessary valves of the helium recovery lines are kept open.

6.1.2 Asphyxiation hazard

High concentrations of helium gas in a room constitutes an asphyxiation hazard. Although non-poisonous, the gas may reduce the concentration of oxygen below safe levels. When helium concentration is extremely high, then the oxygen in solution in the blood will diffuse out causing a rapid collapse and possible death.

Every year people *die* when inhaling helium gas to try the “squeaky voice trick”. A single deep inhalation of helium gas can be fatal !

6.2 Principle of operation

6.2.1 Description

The QUANTUMCOOLER Continuous Flow Cryostat utilizes liquid helium as a coolant to provide stable, controllable sample temperature. The system is designed for either vertical (cold end down) or horizontal operation. For this reason the transfer line connection is at 45 degrees, so that it can be operated in either position.

The system consists of 3 components:

- The QUANTUM continuous-flow cryostat
- The QUANTUM return vapor-shielded liquid-helium transfer line
- The QUANTUM removable Sample Stick ("QUANTUMSTICK")

As shown in Figure 8, liquid helium from the supply dewar travels trough the center of the transfer line, enters the continuous flow cryostat and the flow is split:

Sample Chamber Flow: The first flow circuit is for sample cooling. Liquid helium from the transfer line enters the top of the Phase Separator (PS), and the liquid from the bottom is expanded through the needle valve V4 then is injected in the Sample Chamber. The cold gas exits at the top of the Sample Chamber and the flow is controlled by the manual valve V2 and the electromagnetic valve V3b and the pumps PUMP2_A and PUMP2_B.

Heat Shield Cooling Flow: The second flow circuit is the heat shield cooling. Liquid helium from the transfer line enters the top of the Phase Separator, and the gas exiting from the top of the PS is used to cool the sample chamber and the main heat shields (EX). The cold return gas is then used to cool the transfer line shield. The flow is controlled by the valve V1 and the pump PUMP1.

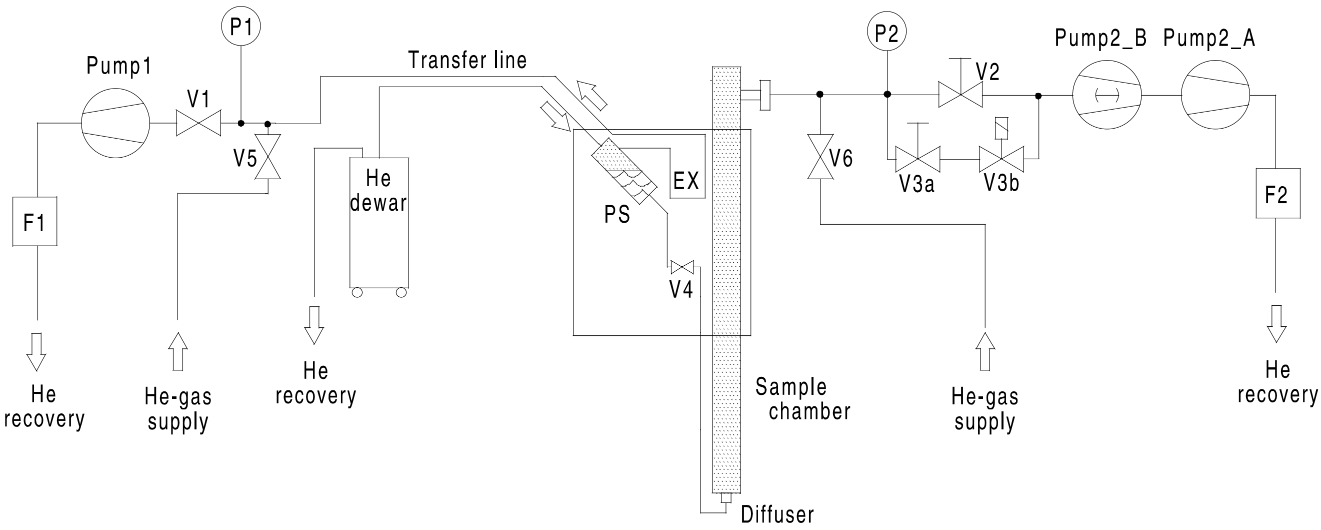

Figure 8: Schematic diagram of the Quantum cryostat.
P : pressure; F : flow; V : valve; EX : heat exchanger; PS : phase separator.

6.2.2 Principle of control action

Phase Separator: For all desired sample temperatures, the temperature of the Phase Separator (T_{PS}) **should be kept constant**.
Utilizing the available *DT-470 Lake Shore Diode*, and taking into account the pressure drop through the heat exchangers, and the uncertainties of the sensors, one should maintain the following temperatures:

Cryostat	T_{PS}
Quantum 9505	$\sim$ 4.6 K
Quantum 9506	$\sim$ 4.3 K
Quantum 9512	$\sim$ 4.1 K

These temperatures are obtained by adjusting, with the valve *V1*, the mass flow through the pump PUMP1.
During test runs, stable T_{PS} could be achieved with the following flows:

Cryostat	*F1*
Quantum 9505	$\sim$ 13.0 l/min
Quantum 9506	$\sim$ 11.5 l/min
Quantum 9512	$\sim$ 12.5 l/min

It is not advisable to operate with a too high flow value, for which temperature instabilities are again observed.

Sample Chamber: The He-gas entering the Sample Chamber is heated at the desired temperature by means of the Diffuser Heater (DH) and its temperature ($T_{diffuser}$) is monitored by a *Cernox* temperature sensor (loop 1 of the temperature controller).
Depending on the desired temperature range, a heater (“Tube Heater”) located on the He-capillary, after the needle valve *V4* (see Figure 9), is used to prevent the sudden flow of liquid helium in the Sample Chamber.
In order to obtain a faster response of the system, a second heater loop is placed on the Sample Stick (temperature sensor: *Cernox*, connected to the loop 2 of the temperature controller).

The operation may be divided into two overlapping temperature ranges:

- $\sim$ 2.1K (or $\sim$ 1.8K using also the PUMP2_B) $< T_{sample} <$ 10K (“Low Temperatures”)
- $\sim$ 4K (cryostat 9512) or 5K (cryostat 9505 & 9506) $< T_{sample} <$ 300K (“High Temperatures”)

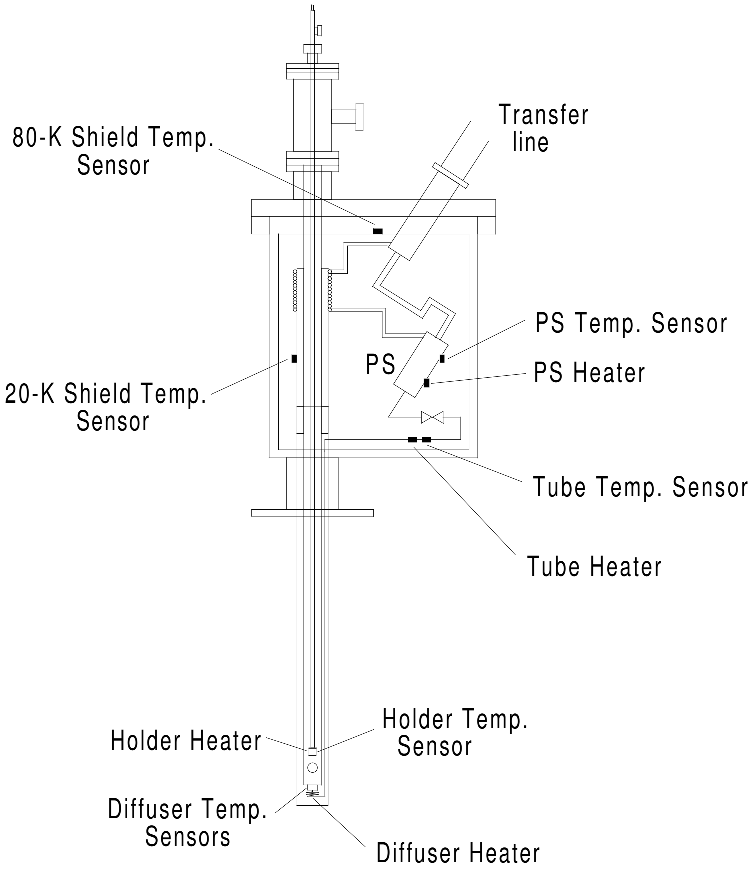

Figure 9: Temperature sensors and heaters

Low Temperatures: In this regime, the manual valve V2 should be kept fully open.
No current should be sent to the Tube Heater.

If a base temperature of ~ 2.1 K is enough for the foreseen measurements, the PUMP2_B **should not be used**. (Control that it is switched OFF). If a base temperature of ~ 1.8 K is required, the PUMP2_B should be switched ON.

The lowest stable temperature is then obtained by gradually closing the needle valve *V4*.
As the valve is closed the pressure *P2* will gradually decrease and the sample temperature will decrease correspondingly.
Do not forget to change the setpoint temperature of the temperature controller.
When the minimum flow is reached, further decrease in the needle valve *V4* will result in a rapid warmup of the sample. In this case the needle valve should be slightly opened and the same operation as above should be repeated.

During test runs, stable base temperatures could be obtained with the following parameters:

Configuration	$T_{diffuser}$	$P2$	$F2$
PUMP2_A	$\sim$ 2.15 K	$\sim$ 32 mbar	5 l/min
PUMP2_A + PUMP2_B	$\sim$ 1.8 K	$\sim$ 5 mbar	5 l/min

Higher temperatures (up to 10 K) are achieved by keeping the He-flow constant and solely changing the setpoints of the temperature controller.
Note that a temperature scan in this regime is only possible once the pressure and flow conditions necessary to reach the lowest temperature are obtained.

Typically, for the lowest temperatures, one will observe a situation with $T_{diffuser}$ slightly above T_{holder}. Upon warming up T_{holder} will increase faster than $T_{diffuser}$ in such a way that both sensors will measure a similar temperature around 3 K. At higher temperatures, $T_{holder} < T_{diffuser}$ and the difference reaches about 1 K at 15 K (with PUMP2_A + PUMP2_B)].
Extensive tests performed by H. Luetkens have show that the temperature of the sample closely follows the holder temperature T_{holder} at all temperatures (see Figs. 10 and 11). This is true independently of the sample mounting (on a silver holder or on a fork).

Therefore, in view of the observed temperature gradients in this temperature regime, users are advised to control the temperature by solely setting a setpoint for $T_{diffuser}$. This can be achieved by putting an arbitrary setpoint of say 1 K for T_{holder}. Alternatively the temperature controller can be set on a one-loop mode. For more details see section 6.4.1. The temperature of the sample is the one given by T_{holder}.

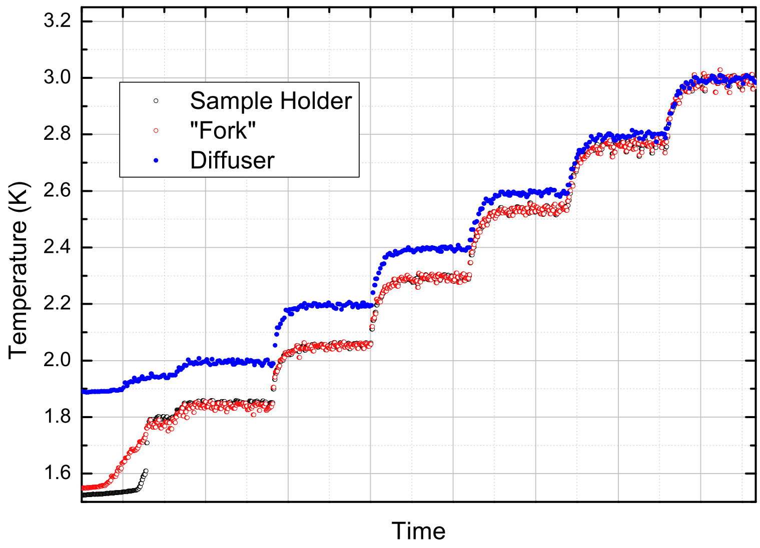

Figure 10: Comparison of the temperatures measured at the diffuser with the ones measured at the sample holder and at the sample position (“Fork"). Note the gradient and the perfect agreement between the sample holder temperature and the “Fork" temperature.

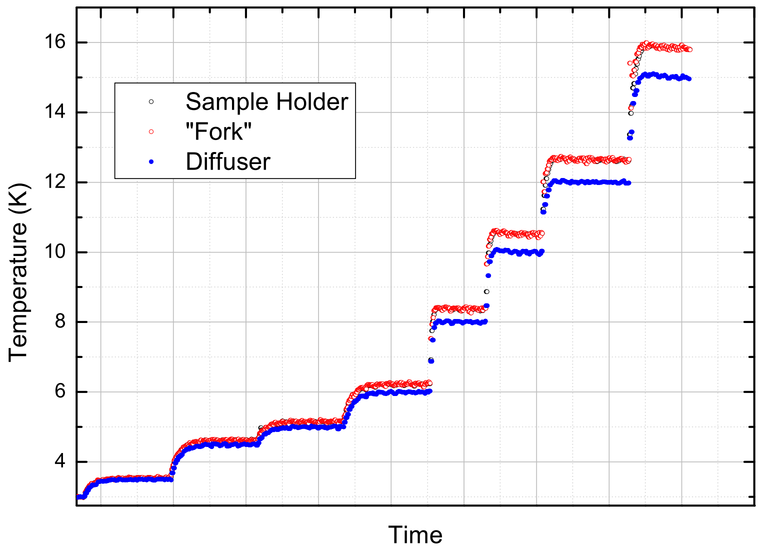

Figure 11: Same configuration as in Fig. 10 for higher temperatures. Note that the gradient is now opposite.

High Temperatures: In this regime, the manual valve *V2* is kept closed, and the electromagnetic valve *V3b* controls the mass flow through the pump PUMP2_A (**make sure that the PUMP2_B is switched OFF and that the valve *V3a* is fully open**).
A heater current should be sent and kept at all times into the Tube Heater.

Cryostat	*Tube Heater Current*
Quantum 9505	230 mA
Quantum 9506	230 mA
Quantum 9512	200 mA

The needle valve *V4* should be about 0.5 mm open (50 units).
If large temperature oscillations are observed at low temperatures (especially around 15-20 K), the needle valve V4 should be further slightly closed.

The desired temperature is obtained by choosing the He-flow F2 according to the Figures 12 (Cryostat 9505), 13 (Cryostat 9506) or 14 (Cryostat 9512) and by sending the required setpoints to the temperature controller. If the flows necessary to reach the lowest temperatures (in this regime) cannot be reached, the needle valve V4 should be slightly more opened.

Since the sample holder is solely cooled down by the incoming He-gas which is stabilized at the temperature of the Diffuser, the time constant necessary to reach a given setpoint by cooling can be *extremely long* (for an example, see Figure 15).
It is therefore strongly recommended to perform the required temperature scans by increasing the temperature.

If long series of runs are required below 10 K, it is **strongly** recommended to switch to the *Low Temperatures* regime (see previous pages) in order to save He-liquid.

Cryostat 9505 :

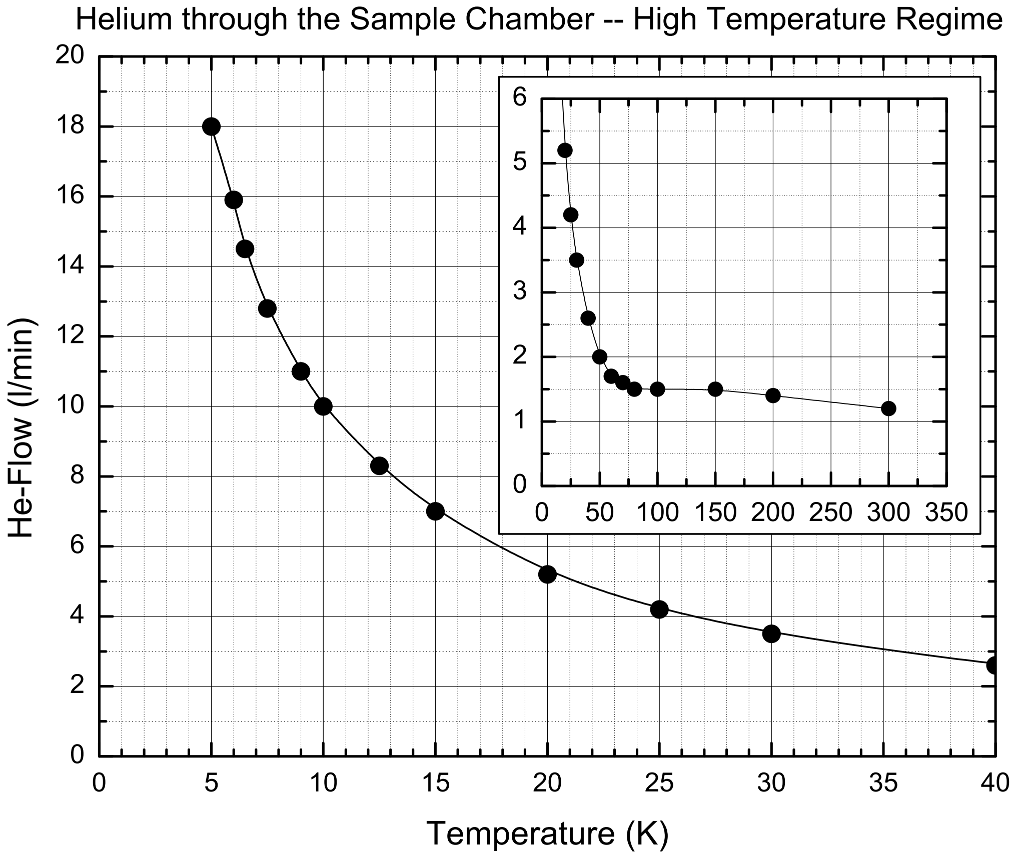

Figure 12: Temperature dependence of the He-flow through the Sample Chamber (flow *F2*) in the "High Temperature regime" (i.e. for 5 K $< T_{diffuser} <$ 300 K). This flow should be controlled by the valve *V3b*. If the recommended low values of flow are not applied at high temperatures, a temperature gradient is usually observed in the sample chamber.

Cryostat 9506 :

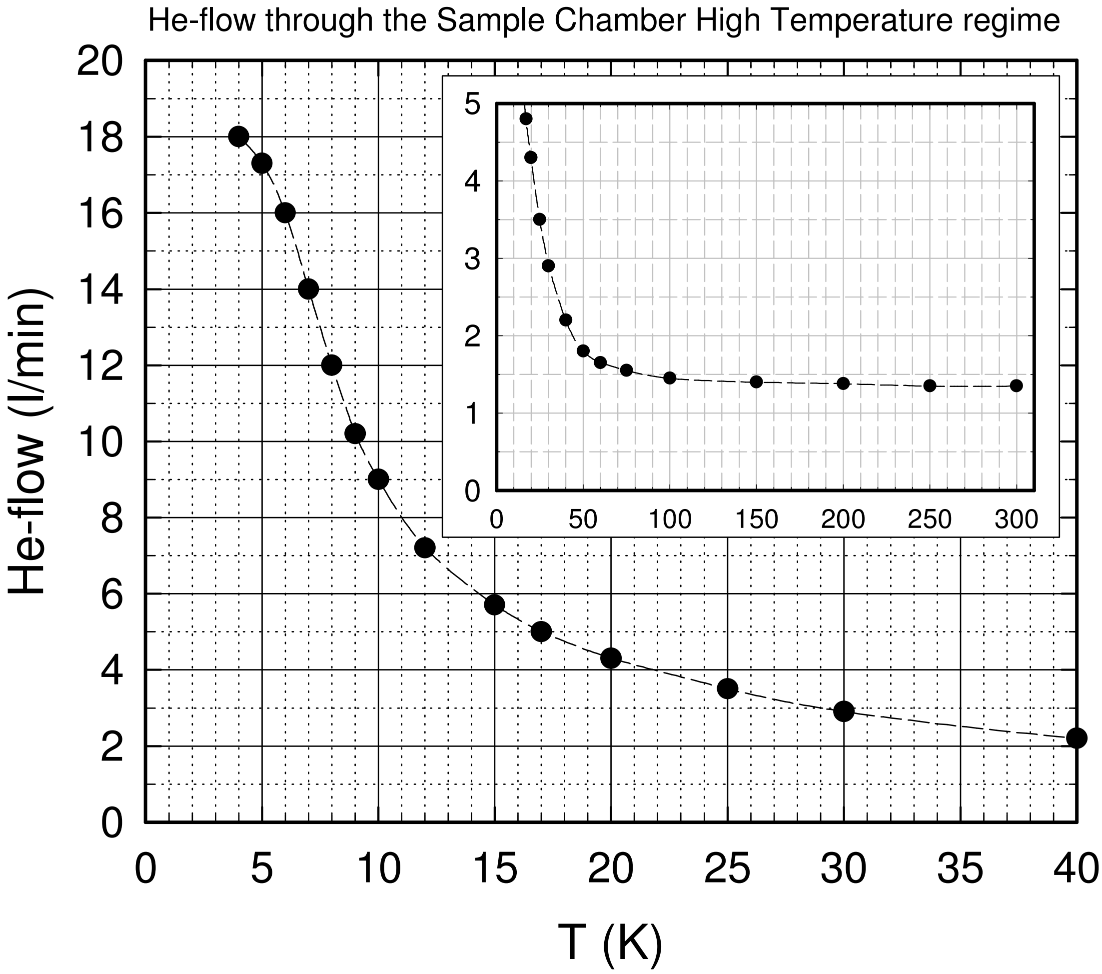

Figure 13: Temperature dependence of the He-flow through the Sample Chamber (flow *F2*) in the "High Temperature regime" (i.e. for 5 K $< T_{diffuser} <$ 300 K). This flow should be controlled by the valve *V3b*. If the recommended low values of flow are not applied at high temperatures, a temperature gradient is usually observed in the sample chamber.

Cryostat 9512 :

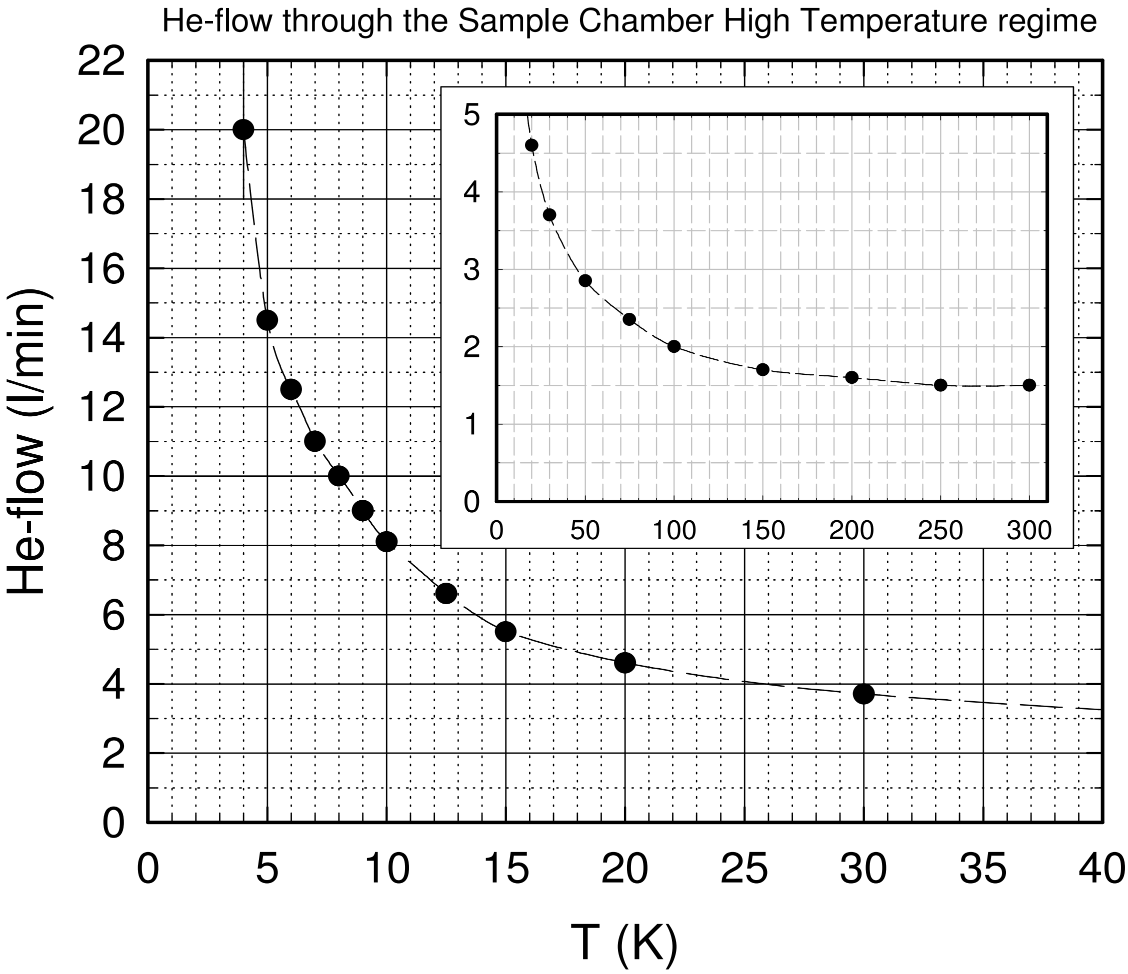

Figure 14: Temperature dependence of the He-flow through the Sample Chamber (flow *F2*) in the "High Temperature regime" (i.e. for 5 K < $T_{diffuser}$ < 300 K). This flow should be controlled by the valve *V3b*. If the recommended low values of flow are not applied at high temperatures, a temperature gradient is usually observed in the sample chamber.

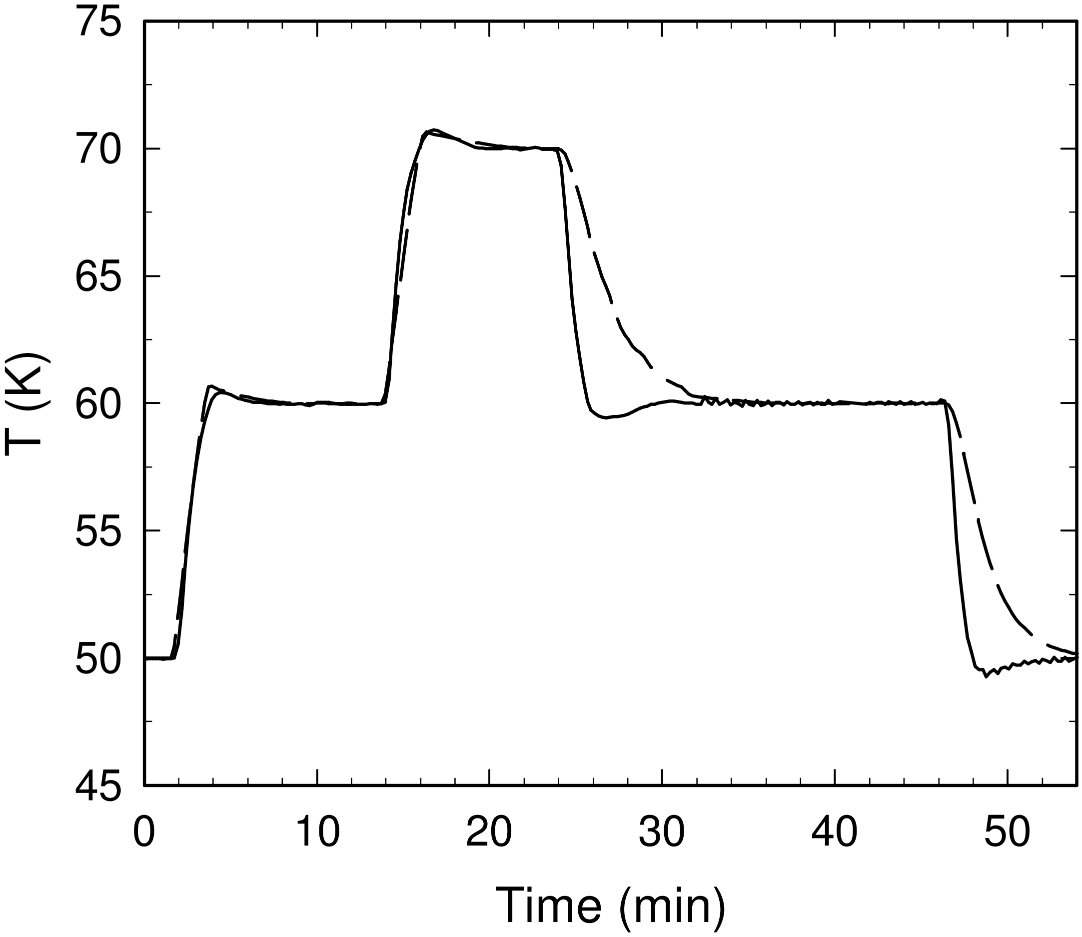

Figure 15: Example of heating and cooling curves (solid line: $T_{diffuser}$, dashedline T_{holder}). Note the large time difference between a heating and cooling process. At higher temperatures, the time difference and the undershoot of $T_{diffuser}$ when cooling, due to the rapid change of the He-capillary impedence, are much more pronounced.

6.2.3 Configuration in the πM3 area

- Pump PUMP1: *Gast* membrane pump.
- Pump PUMP2_A: *Alcatel ADP 30* oil-free pump.
- Pump PUMP2_B: *Alcatel RSV 151B* roots pump.
- Electromagnetic Valve *V3b*: *PFEIFFER EVR116* valve controlled by a *PFEIFFER RVC300* valve controller (located in the beam area).
- The He-flows are measured by two *Hastings* transducers connected to two *Hastings* flowmeter display.
  The units are directly *liters-gas/minute*. The maximum flow which can be measured is 50 l/min.
- The temperature of the Sample Chamber is controlled by a *Conductus LTC-20* temperature controller.
  - The temperature of the Diffuser $T_{diffuser}$ is measured on the channel 1 (loop 1).
  - The temperature of the Sample Holder T_{holder} is measured on the channel 2 (loop 2). The voltage loop 2 of the *Conductus* controls an external *Gossen* power supply.

  The Tables 1, 1 and 3 (first loop) and 4, 5 and 6)second loop) indicate the value of the PID parameters used by the temperature controller for the two loops.
- A *CryoCon 14* (or *LakeShore 208*) thermometer display indicates the temperature of different heat shields and of the Phase Separator.
  - The temperature of the Phase Separator T_{PS} is usually measured on the channel 1.
  - The temperature of the He-capillary (Tube) after the needle valve is usually measured on the channel 2.

Table 1: Cryostat 9505: PID parameters for the Loop 1 (diffuser) of the temperature controller. The *P* parameters are rounded when displayed by the controller. The parameters are stored in a PID Table of the Conductus temperature controller. **The maximum power should be fixed at 40 %.**

Cryostat 9505 - Loop 1				
Break point (K)	P	I	D	Heater Range (W)
300	30	20	4	50
150	30	20	4	50
100	100	30	10	5
50	100	10	4	5
20	250	10	1	5
15	150	5	2	5
10	50	5	1	5
4	200	6	2	0.5
3	100	10	2	0.5
1	2	8	2	0.5

Table 2: Cryostat 9506: PID parameters for the Loop 1 (diffuser) of the temperature controller. The *P* parameters are rounded when displayed by the controller. The parameters are stored in a PID Table of the Conductus temperature controller. **The maximum power should be fixed at 27 %.**

Cryostat 9506 - Loop 1				
Break point (K)	P	I	D	Heater Range (W)
300	10	40	20	50
200	8	40	20	50
150	6	40	20	50
100	30	120	60	5
50	20	24	6	5
20	15	35	16	5
6	18	10	3	0.5
5.5	18	10	3	0.5
3	20	10	3	0.5
1	20	8	2	0.5

Table 3: Cryostat 9512: PID parameters for the Loop 1 (diffuser) of the temperature controller. The *P* parameters are rounded when displayed by the controller. The parameters are stored in a PID Table of the Conductus temperature controller. **The maximum power should be fixed at XX %.**

Cryostat 9512 - Loop 1				
Break point (K)	P	I	D	Heater Range (W)
300	30	30	4	50
70	30	30	4	50
60	40	30	5	5
30	40	17	2	5
15	40	13	2	5
10	10	9	1	5
8	10	10	1	5
4	50	5	1	0.5
3	100	10	1	0.5
1	500	10	1	0.5

Table 4: Cryostat 9505: PID parameters for the Loop 2 (Sample Holder) of the temperature controller. The parameters are stored in a PID Table of the Conductus temperature controller.

Cryostat 9505 - Loop 2			
Break point (K)	P	I	D
300	70	10	2
250	70	10	2
200	70	10	2
150	70	10	2
100	70	10	2
70	10	10	2
40	2	10	2
10	1	8	2
5	1	8	2
1	1	8	2

Table 5: Cryostat 9506: PID parameters for the Loop 2 (Sample Holder) of the temperature controller. The parameters are stored in a PID Table of the Conductus temperature controller.

Cryostat 9506 - Loop 2			
Break point (K)	P	I	D
300	70	10	2
250	70	10	2
200	70	10	2
150	70	10	2
100	70	10	2
70	10	10	2
40	2	10	2
10	1	8	2
5	1	8	2
1	1	8	2

Table 6: Cryostat 9512: PID parameters for the Loop 2 (Sample Holder) of the temperature controller. The parameters are stored in a PID Table of the Conductus temperature controller.

Cryostat 9512 - Loop 2			
Break point (K)	P	I	D
300	70	10	2
250	70	10	2
200	70	10	2
150	70	10	2
100	70	10	2
70	10	10	2
40	2	10	2
10	1	8	2
5	1	8	2
1	1	8	2

6.2.4 Sample change

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

- **For safety reasons, a sample change should only be performed in the "High Temperature regime" with a sample temperature** $T > 30$ **K.**
- Switch OFF the heaters by setting the Conductus (or Neocera) temperature controller in the *Monitor* Mode [by pressing the *Local* button (if necessary) and pressing the *Monitor* button].
- Switch OFF the Tube Heater.
- Disconnect the electrical plug from the sample stick.
- Dismount, if necessary, the rotation motor.
- Stop the He-flow through the pumps PUMP1 and PUMP2_A by closing:
  - the two valves *V2* and *V3a* on the pumping line of the Sample Chamber (do not disconnect the electrical plug of the electrovalve *V3b*).
  - the yellow valve *V1* on the transfer-line pump (use the closing-ring without changing the actual setting of the valve).
- Pressurize slightly the Sample Chamber with He-gas by opening the valve *V6* until you reach a pressure *P2* slightly above 1000 mbar (check if the He-gas cylinder is open).
- **Check carefully and frequently** the pressures *P1* and *P2* in the Phase Separator and in the Sample Chamber. (An overpressure in the Sample Chamber could damage the titanium windows).
- Remove the clamp of the Sample Stick.
- Remove the Sample Stick from the cryostat.
- **Immediately** mount a blind-flange on the cryostat opening.
- Stop blowing He-gas by closing the valve *V6*.
- Restart the He-flow through the He-pumps by opening the valves *V1*, *V3a*.

When you are ready to insert the Sample Stick with the new sample, you should follow an analog procedure as above. Namely:

- Stop the He-flow through the pumps by closing:
  - the two valves *V2* and *V3a* on the pumping line of the Sample Chamber (do not disconnect the electrical plug of the electrovalve *V3b*).
  - the yellow valve *V1* on the transfer-line pump (use the closing-ring without changing the actual setting of the valve).
- Pressurize slightly the Sample Chamber with He-gas by opening the valve *V6* until you reach a pressure *P2* slightly above 1000 mbar (check if the He-gas cylinder is open).
- **Check carefully and frequently** the pressures *P1* and *P2* in the Phase Separator and in the Sample Chamber.
- Dismount the blind-flange very shortly before inserting the Sample Stick.
- Insert the Sample Stick **carefully** (to insert a *warm* Sample Stick requires more force than to remove a *cold* Stick).
- Replace the clamp.
- **Immediately** stop blowing He-gas by closing the valve *V6*.
- Restart the He-flow through the He-pumps by opening the valves *V1*, *V3a* (and *V2* if the low temperature regime is needed).

- Readjust the He-flows.
- When a sufficient He-flow is detectable in the Sample Chamber, set the temperature controller in the *Control* Mode [by pressing the *Local* button (if necessary) and pressing the *Control* button].
  Note that if the sample stick was changed, you will have first to configure the temperature controller via the Console (see Section 6.4.1). You can also switch the temperature controller on Control Mode from the Console.
- If you want to operate in the High Temperature regime, do not forget to switch ON the Tube Heater.

6.2.5 He-Dewar change

Should the He-Dewar levelmeter read below ∼15 % (in the case of a 100-liters dewar) or below 100 mm (in the case of a 250-liters dewar), the He-Dewar needs to be changed.

- **For safety reasons, a He-dewar change should only be performed in the "High Temperature regime" with a sample temperature $T > 30$ K.**
- Stop the He-flow through the pumps PUMP1 and PUMP2_A by closing:
  - the two valves *V2* and *V3a* on the pumping line of the Sample Chamber (do not disconnect the electrical plug of the electrovalve *V3b*).
  - the yellow valve *V1* on the transfer-line pump (use the closing-ring).
- Switch OFF the heaters by setting the Conductus (or Neocera) temperature controller in the *Monitor* Mode [by pressing the *Local* button (if necessary) and pressing the *Monitor* button].
- Switch OFF the Tube Heater.
- Lift up slightly (∼50 cm) the transfer line on the He-dewar side
  (the bottom part of the transfer line in the He-dewar should now be above the liquid-He level).
- Pressurize slightly the Phase Separator with He-gas by opening the valve *V5* until you reach a pressure *P1* of about 1000 mbar (check that the He-gas cylinder is open).
- **Check carefully and frequently** the pressure *P1* and *P2* in the Phase Separator and in the Sample Chamber. (An overpressure in the Sample Chamber could damage the titanium windows).
- Disengage the adaptor of the transfer line from the top of the dewar by releasing the O-rings.
- Slide the adaptor upward along the transfer line.
- Remove completely the transfer line on the He-dewar side.
  Replace the plug of the He-dewar to prevent freezing of the He-dewar.
- **Carefully** warm up the transfer line using the available heat-gun.
- Be sure that the sintered end-part is free of any ice.
- Change the He-dewar.
- **Check that the He-recovery line is connected to the dewar and that the corresponding valves are open. Be sure that the recovery line is not bent and that the He-gas can flow freely.**
- Insert slowly the transfer line in the new He-dewar.
- As soon as the sintered part is enough inserted in the dewar, lower the adaptor and connect it to the dewar.
  Make sure that the adaptor of the transfer line is well inserted in the dewar, and that all O-rings are tightened.
  Leave the transfer line above the liquid-He level.
- Stop blowing He-gas by closing the valve *V5*.
- Open the valves on both He-pumps (do not forget, if necessary, to connect the electrical plug of the electrovalve *V3b*).
  Open the valve *V1* completely.
- Wait 30 seconds.
- Pull down slowly the transfer line in the He-dewar.
  Check carefully and frequently that the transfer line is well aligned with the

dewar and that it does not bent; if necessary move slowly and carefully the He-dewar to align it with the transfer-line.
Be also sure that the transfer line does not touch the bottom of the He-dewar (leave it few centimeters above the bottom).

- The He-flow in the transfer line will first show a rapid increase, due to the sudden overpressure in the He-dewar, which will be followed by a decrease.
  After 1-2 minutes, the He-flow through the transfer line will again increase to its maximum value.
- After a few minutes, the temperature of the Phase Separator should drop to the nominal value.
- Readjust the He-flows.
  (For this last point, experience shows that the transfer line flow F2 should be maintained for few minutes to a high value and gradually decreased)
- When a sufficient He-flow is detectable in the Sample Chamber, set the temperature controller in the *Control* Mode [by pressing the *Local* button (if necessary) and pressing the *Control* button].
- If you want to operate in the High Temperature regime, do not forget to switch ON the Tube Heater.
- Do not forget to tightly close the empty He-dewar and to connect it to the He-recovery line

6.2.6 Startup procedure – Cryostat warm

This section is not intended to a normal μSR Facility user.

- Check vacuum space of cryostat and transfer line.
- Connect transfer line to cryostat.
- Open needle valve *V4* completely.
- Close valve *V1*, *V2* and *V3a*.
- Turn ON vacuum pumps PUMP1 and PUMP2_A.
- Open carefully valves *V5* and *V6* to purge the cryostat.
- **Check carefully and frequently** the pressure *P1* and *P2* in the Phase Separator and in the Sample Chamber. (An overpressure in the Sample Chamber could damage the titanium windows).
- Insert slowly the transfer line in the new He-dewar.
- As soon as the sintered part is enough inserted in the dewar, lower the adaptor and connect it to the dewar.
  Make sure that the adaptor of the transfer line is well inserted in the dewar, and that all O-rings are tightened.
  Leave the transfer line above the liquid-He level.
- Open the valves on both He-pumps (do not forget, if necessary, to connect the electrical plug of the electromagnetic valve *V3b*).
- Wait 3 minutes.
- Pull down slowly the transfer line in the He-dewar.
- Once T_{PS} has reached its nominal temperature (see page 20), the valve *V1* should be partially closed.
  If an increase of T_{PS} is observed this indicate that *V1* has been closed too much and insufficient helium is entering the system.
- Once the optimum *V1* setting has been achieved, the sample temperature can be controlled as described in Section 6.2.2.

6.2.7 Shutdown procedure

This section is not intended to a normal μSR Facility user.

- Stop the He-flow through the pumps PUMP1 and PUMP2_A by closing:
  - the two valves *V2* and *V3a* on the pumping line of the Sample Chamber (remove the electrical plug of the electrovalve *V3b*).
  - the yellow valve *V1* on the transfer-line pump (use the closing-ring).
- Lift up slightly (∼50 cm) the transfer line on the He-dewar side
  (the bottom part of the tranfer line in the He-dewar should now be above the liquid-He level).
- Open the needle valve *V4* completely.
- Pressurize slightly the Phase Separator with He-gas by opening the valve *V5* until you reach a pressure *P1* of about 1000 mbar (check if the He-gas cylinder is open).
- **Check carefully and frequently** the pressure *P1* and *P2* in the Phase Separator and in the Sample Chamber. (An overpressure in the Sample Chamber could damage the titanium windows).
- Disengage the adaptor of the transfer line from the top of the dewar by releasing the O-rings.
- Slide the adaptor upward along the transfer line.
- Remove completely the transfer line on the He-dewar side.
  Replace the plug of the He-dewar to prevent freezing of the He-dewar.
- Connect the transfer line to the He-recovery line.
- If time is not pressing, stop blowing He-gas in the system by closing the valves *V5* (blowing He-gas in the system will speed up the warming process, but will introduce an additional hazard factor...).
- Switch OFF the two vacuum pumps.

6.2.8 Trouble shooting

This section is hopefully intended to help the user coping with several known problems.

- In the High Temperature Regime, $T_{diffuser}$ is oscillating.
  Check that the needle valve V4 *is 0.5 mm open (50 units) (very sensitive...).*
  Check that the Tube Heater is switched ON.
  Check that the He-flow F1 *through the transfer line is high enough (the* T_{PS} *value are given on page 20). Increasing* F1 *slightly usually helps to keep a stable* $T_{diffuser}$.

- Temperature oscillations around 20 K, in the High Temperature Regime.
  Check that the Tube Heater is switched ON
  Close slightly the needle valve V4.

- In the High Temperature Regime: large temperature gradient and very low values of *P1*.
  The needle valve V4 *is probably closed too much.*

- In the High Temperature Regime one cannot reach the values of He-flow needed to obtain the lowest temperature in this regime (i.e. 4 or 5 K, depending on the used cryostat).
  Open slightly the needle valve V4.

- In the High Temperature Regime: large temperature oscillations are seen below 10 K.
  Make sure that the setpoints for the two loops (diffuser – channel 1 and holder – channel 2) are set to the same values. The PID parameters are optimized only for this configuration.

- After a sample change or a long period at high temperature, the lowest temperature in the Low Temperature Regime can hardly be obtained (by closing the needle valve *V4*, a large temperature increase is observed).
  It is just a matter of waiting long enough...If time is crucial, it is advisable to perform a first run at about 2.5-3 K even without the optimal values of P2 *and* F2 *(see Section 2.2.2) but with* F2 *low enough to avoid temperature gradient (say about 6-7 l/min). After this first run, one should be able to obtain the optimal values of* P2 *and* F2 ***which are necessary to reach the lowest temperature and also to start a temperature scan***.

- After a He-dewar change, the flow F1 does not reach the usual values and the pressure *P1* is lower as usual.
  Be sure that the bottom of the transfer line does not touched the bottom of the He-dewar.
  If not, the transfer line is probably partially blocked.
  Remove it from the He-dewar (following the instructions as for changing the He-dewar) and warm it up again. Let a flow of He-gas flowing through the transfer line by opening the valve V5

- Upon reaching the lowest temperature in the *Low Temperatures regime*, the temperature controller does not display the sensor #2 (holder sensor) any more and the controller has jumped to the *Monitor* Mode.
  This happens sometimes at very low temperatures with Diode sensors.Wait few minutes to see if the display comes back to normal.
  If yes, switch the temperature controller to the Control *Mode [by pressing the* Local *button (if necessary) and pressing the* Control *button].*
  If not and you are desperate, put the controller on a one-loop mode with the help of the **`deltat`** *program (Tab:* **`Modify Devices`***, buttons* **`Modify`** *and* **`Modify setup`***.)*

6.3 Dimensions

- Dimensions.
- Sample holder dimension.

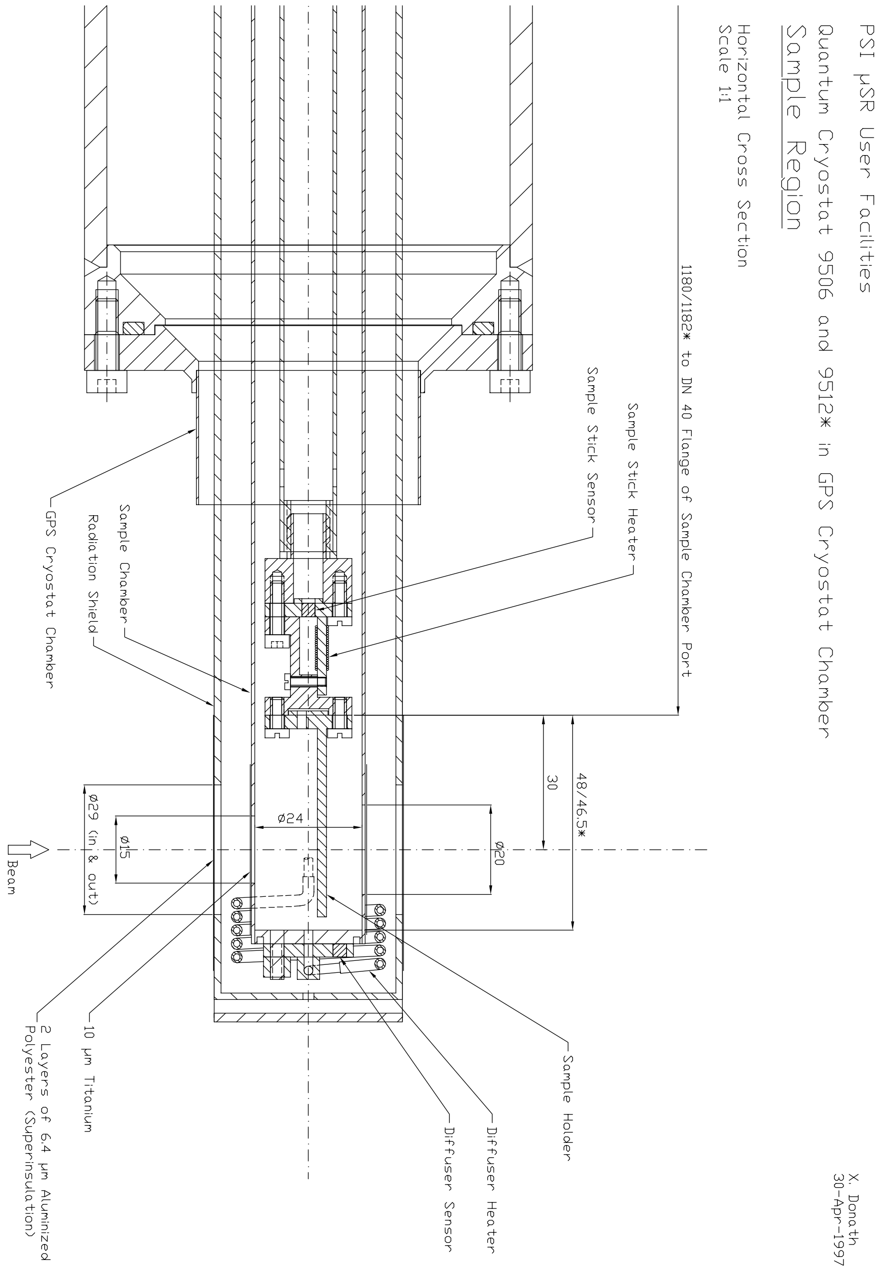

Figure 16: Drawing of the internal part of the Quantum cryostat inside the GPS chamber.

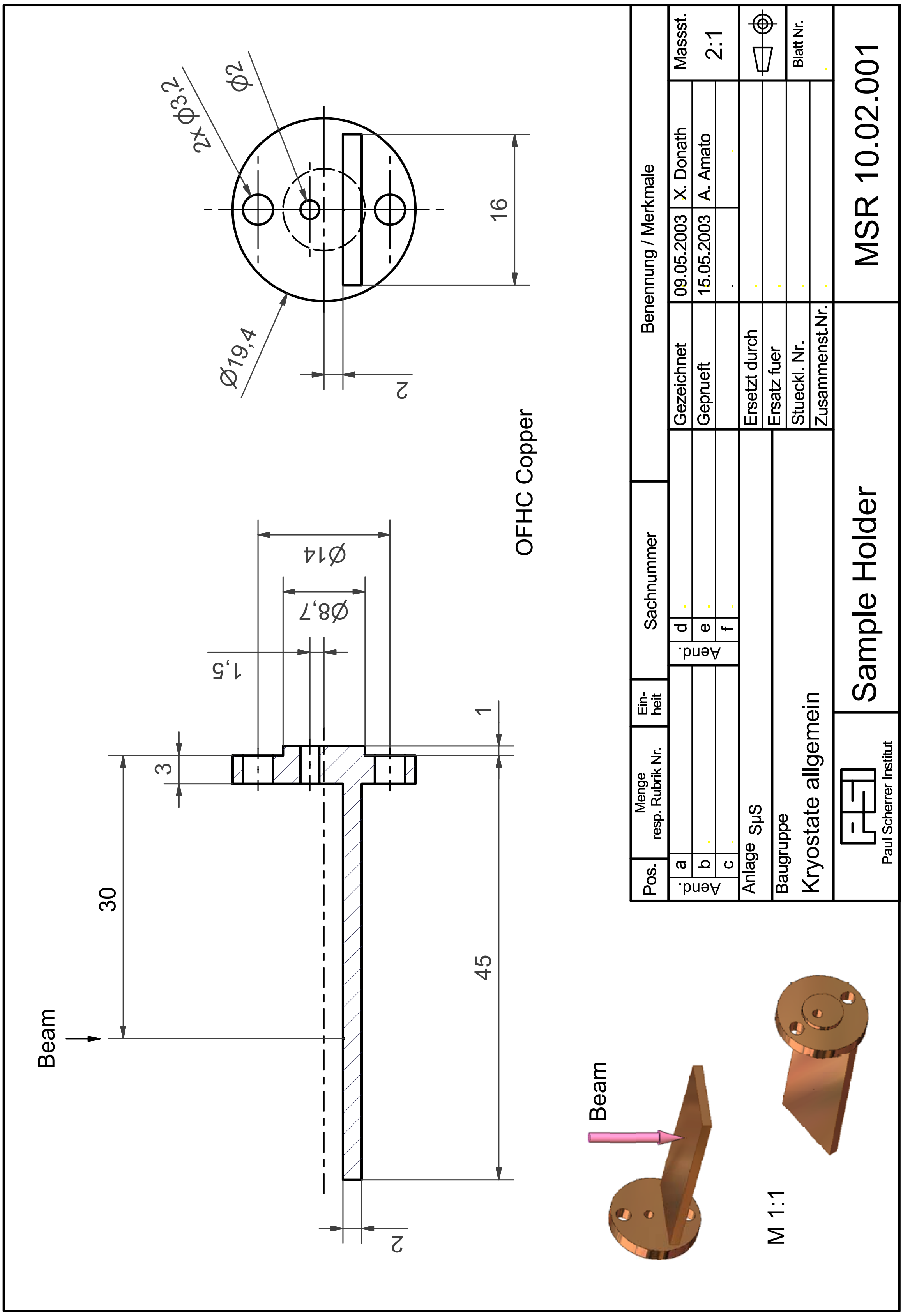

Figure 17: Drawing of the coomonly used sample holder.

- **Material in beam path :**

  Up-stream:

	Material	**Thickness**
Heat Shield Superinsulation	Aluminized Mylar	10 μm (2 layers)
Sample Chamber Window	Titanium	10 μm

  Same for down-stream

- **Window sizes :**

	In	Out
Heat Shield	29.0 mm diam.	
Sample Chamber Window	15 mm diam.	20 mm diam.

6.4 Additional Information

6.4.1 Temperature Controller

The *Conductus* temperature controller connected to the *Quantum* cryostat is usually utilized in a REMOTE-mode and can be directly controlled from **`deltat`**. The following steps describe how to initialize, configure and use the *Conductus* temperature controller from **`deltat`**.

- **Configuration:**
  Each time that you change the configuration of the cryostat (new sample stick), you have to configure the driver controlling the temperature controller.

  In the tab **`Modify Devices`** choose the temperature controller entry and hit the buttons **`Modify`** and, on the pop-up window, **`Modify Setup`**.
  Choose the corresponding sample stick from the drop-down list.
  Hit the **`Next`** button and choose the corresponding **`Entry`** for your setup
  Remember that the QUANTUM is usually controlled by the Conductus in a two-loop mode

  Hit the **`Apply & Exit`** button and at this point the software should automatically detect the PID tables needed and load them into the Conductus temperature controller.

  Remember to put the controller in the CONTROL mode.

- **Setting a temperature:**
  In the tab **`Modify Devices`** choose the temperature controller entry and hit the buttons **`Modify`** and, on the pop-up window, **`Modify Temperature`**.
  On the pop-up window, change for both loops the setpoints and hit the button **`Apply Changes.`**

- **Autorun sequences:**
  Before writing an autorun sequence, be sure that the *Conductus* in the desired mode (one or two-loop mode).
  In the autorun file, do not forget to give all 6 arguments in the two-loop mode (only 3 for the one-loop mode).
  To change the temperature, you will need an entry like:

  ```
  SET Temperature 100.0 1.0 30 100.0 1.5 30
  WAIT Temperature INRANGE
  ```

  In this example the setpoints are 100.0 K for both loops, the tolerances 1.0 K for the first loop and 1.5 K for the second loop and the waiting times are 30 seconds.
  See also page 22, for a discussion about the Low Temperature setpoints.

- **Software setup - done by the μSR Facility team:**
  The on-line database in the backend computer has to be edited. In the database directory
  `/Equipment/templtc/Settings/Devices/LTC21out/DD`
  the variable **`Serial Number`** should be set accordingly.
  In the directory **`/userdisk0/musr/exp/td_musr/dat/ltc/`** of the Backend computer a file **`ltc_NNNN.tab`** should exist (where NNNN is the serial number of the controller).

6.4.2 He-flow control

The He-flow trough the "Sample Space" can only be controlled when solely the Electromagnetic Valve V3b (PFEIFFER EVR116) is used, the big bypass valve V2 is shut and the PUMP2_B is switched OFF.

The control is performed by the Valve Controller PFEIFFER RVC300. The actual He-flow is measured by a flowmeter (HASTINGS HS-50KS) and is also indicated on the center display located at the top of the rack.

- *Setting a flow from* **`deltat`***:*
  In the tab **`Modify Devices`** choose the flow controller entry and hit the **`Modify`** button. Enter the new flow value in the pop-up window and close it.
- *Setting a flow in an autorun sequence:*
  A He-flow setpoint can also be included in a auto-run sequence by using the command **`SET Flow FLOW XXX`** command.

  Example: **`SET Flow FLOW 4.3`**

  With this example, an He-flow setpoint has been set to 4.3 liter-gas/minute.
- *Manual setpoint (only in case of emergency):*
  Locate the RVC300 device in the area rack.
  Press the button locate below **`PARAM`**.
  Press the **`edit`** button to edit the **`SOLL`** value. Change it with arrow buttons (note that 100 mV correspond to 1 l/min).
  Presse the button locate below **`SAVE`**
- *Software setup - done by the μSR Facility team* The on-line database in the backend computer has to be edited. In the database directory **`/Equipment/flowr300/Settings/Devices/RVC300/DD`**, the variables **`Scale`** should be set to 100, **`Flim`** to 25, **`Vlim`** to 6000 and **`Offset`** accordingly.

The time needed for the actual He-flow to reach the setpoint value will depend on the PID parameters of the RVC300 controller.

When increasing the temperature, the He-flow should be changed first, if necessary. The temperature controller setpoint, should be changed in a second step. The opposite should be done when decreasing the temperature. If a large change of flow is required, big temperature overshoots can be observed. To minimize the overshoots, the He-flow setpoint should be changed in different steps prior to change the temperature controller setpoint.

Depending on the setting of the needle valve V4 between the "Phase Separator" and the "Sample Space", it is possible that a desired He-flow cannot be reached eventhough the RVC300 controller will fully open the Electromagnetic Valve V3b. To fix this problem, one should more open the needle valve.

6.4.3 Sample rotation

A step motor and its controller (EL734) can be utilized to rotate the sample.
The motor unit can be mounted on the cryostat on the available holders (3). The motor shaft has to be connected to the sample stick using the available screws (2).

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 **`Position`**. 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 Position ANGLE 100.0
  ```

  With this example, an angle of 100 is requested.

6.4.4 Miscellaneous

- The second loop of the temperature control utilizes the "analog" output of the temperature controller (*CONDUCTUS*). The output is utilized to control the *Gossen* power supply. Figure 18 indicates the necessary settings to interface both instruments. The maximum current for the *Gossen* is therefore limited to about 0.5 Amp.

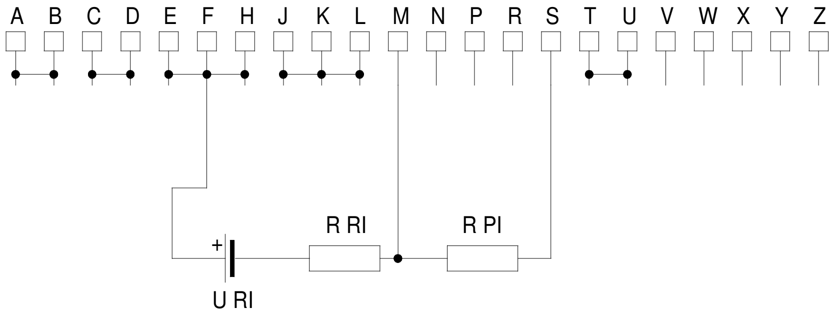

Figure 18: Diagram of the back-connector of the *Gossen* power supply. U_{RI} represents the voltage provided by the temperature controller (max. 10 Volts). R_{RI} is fixed at 2033 Ohms and R_{PI} at 34Ohms. The current furnished will be given by $U_{RI} \times R_{PI} \times I_{FS}/(0.6 \times R_{RI})$ where I_{FS} represents the current full-scale of the Gossen power supply (see Gossen manual).

7 Zürich Oven

7.1 Introduction

Although the "Zürich"-oven can now be used on some Facility spectrometers, it is **not a Facility instrument.** Therefore, the users should be aware that only a limited support will be available from the Facility team.

The oven can be operated between room temperature and 1200 K. The sample holder is connected to a "warm" finger and the oven is operated in vacuum. Therefore the users should take care to obtain a good thermal contact between the sample and the holder. An appropriate method should be used to attach the sample to the holder (**do not use glue !**).

The oven is usually installed on the 2nd cryogeny port of the GPS instrument. As opposed to the situation in the Quantum cryostat, the vacuum chamber around the oven is separated from the main vacuum of the spectrometer. Figure 19 shows the pump connections to the oven.

Therefore, independent pumps are necessary to evacuate this chamber (usually a standard "MOGLI" pumping unit).

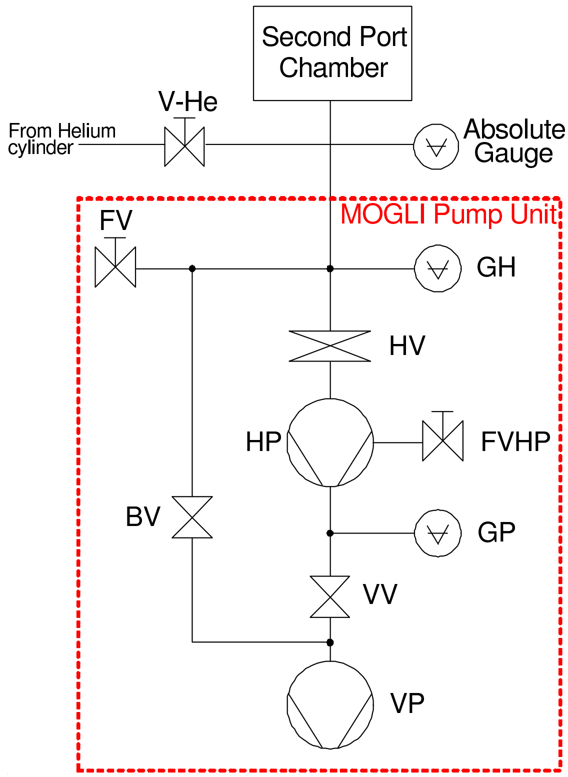

Figure 19: Vacuum diagram for the Zürich oven.

7.2 Temperature control

Three thermocouples (type N) are used to monitor and control the temperature of the different parts of the oven:

- at the heater position,
- at the sample holder,
- on the thermal shield.

The temperature stability loop is based on the thermocouple at the level of the thermocoax heater. The sample temperature is provided by the additional thermocouple

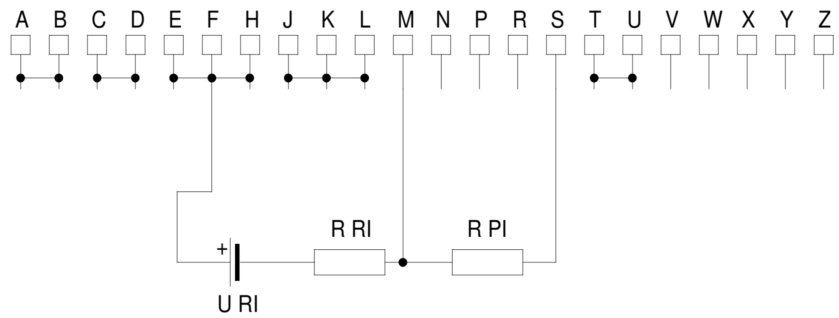

Figure 20: Diagram of the back-connector of the Gossen power supply. U_{RI} represents the voltage provided by the temperature controller (max. 10 Volts). R_{RI} is fixed at 1000 Ohms and R_{PI} at 60 Ohms. The current furnished will be given by $U_{RI} \times R_{PI} \times I_{FS}/(0.6 \times R_{RI})$ where I_{FS} represents the current full-scale of the Gossen power supply (see Gossen manual).

placed on the back of the sample holder. The third thermocouple measures the temperature of the water-cooled shields. Since spare parts are rather difficult to obtain, users should **carefully** handle these thermocouples. Please discuss with the Facility team about an appropriate mounting procedure.

The thermal-shield thermocouple is always connected to the PU5 Thermocouple Display.

Using the LTC Conductus/Neocera temperature controller:
When using the LTC Conductus/Neocera temperature controller both other thermocouples are also connected to PU5 Thermocouple Display, which provide a linear output signal to feed the Conductus/Neocera temperature controller.
The PID values of the temperature controller are kept to fix values (10, 250 and 0 for the parameters P, I and D).

Using the Lakeshore 340 Temperature Controller:
When the Lakeshore 340 Temperature Controller is used, both other thermocouples are directly connected to the controller and not to the PU5 Thermocouple Display. The thermocouple for the heater is connected as sensor C and the thermocouple of the sample is connected as sensor D.
For the Lakeshore, the PID parameters shown on Table 7 are used.

Table 7: Zurich Oven: PID parameters for the Loop 2 of the temperature controller. The parameters are stored in a PID Table of the Lakeshore temperature controller.

Zurich Oven - Loop 2			
Break point (K)	P	I	D
450	15	1.2	3
500	19	1.8	4
700	24	2.4	4
800	30	3.6	4
1200	50	6	5

To heat up the sample, the analog output of the temperature controllers is sent to a GOSSEN power supply (use exclusively the type 24K32R4: 32V/4A). Figure 20 indicates the necessary settings to interface both instruments. The maximum current for the GOSSEN is therefore limited to about 4 Amp.

7.3 Sample change

- Stop heating by switching either:
  - the temperature controller to *MONITOR* mode (if necessary depress first the *LOCAL* button) in case that a LTC Controller is used.
  - or by switching the corresponding button on the HECTOR unit in case that a LS340 is used.
- Wait until the temperature is below 320 K. Be patient ! This can take a **very** long time (hours...).
- Stop pumping by swiching OFF the MOGLI pumping unit . This is performed by pressing the button *LOCK HV* on the MOGLI Controller.
- Remove the screws connecting the oven to the vacuum chamber.
- Slowly open the valve *V-He* to admit He-gas into the chamber. **Check carefully and frequently the pressure in the chamber: do not go beyond 1000mbar.**
- Close valve *V-He*.
- Open the oven.
- Stop the water flow by closing both valves (*IN* and *OUT*).
- Change your sample.
- Carefully remount the thermocouple.
- Open the water flow by opening both valves (*IN* and *OUT*).
- Insert the oven and connect it to the vacuum chamber with the available screws.
- Start pumping by pressing the button *UNLOCK HV* on the MOGLI Controller. Note that the HV valve will only be open when pre-defined conditions will be fullfilled.
- Check again that the water is flowing and switch ON the temperature controller by
  - pressing the button *CONTROL* (if necessary depress first the *LOCAL* button) in case that a LTC Controller is used.
  - or by switching the corresponding button on the HECTOR unit in case that a LS340 is used.

  This last point can be performed directly from the Console running the programme **`deltat`**.

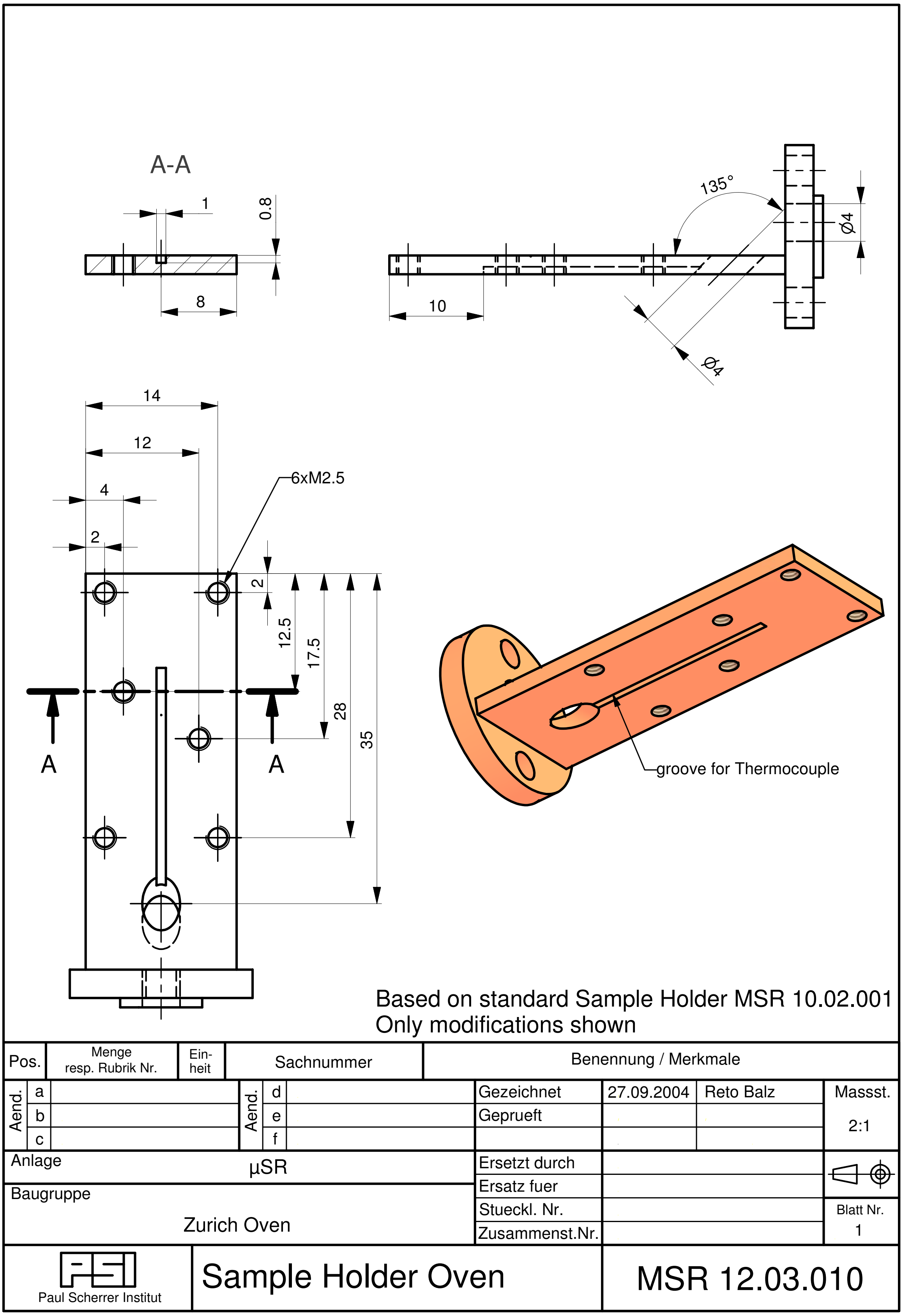

Figure 21: Dimensions of the sample holder to be used in the oven. Only the modifications to the standart sample holder are shown (see Fig. 17).

7.4 Setup made by the Instrument Scientist if a LTC Controller is used

Since the Conductus/Neocera can only handle temperatures up to 799 K and voltages up to 5.8 V, one has to define the output analog voltage limits of the PU5 accordingly:

Table 8: Correspondence between displayed temperature and analog output of the PU5 Display to allow a full scale measurement (800 K) on the Conductus/Neocera temperature controller.

PU5 Display Celsius	Kelvins	Analog Output Volts
0	273.1	0.0
526.9	800.0	5.8
908.4	1185.5	10.0

The 10-V value corresponds therefore to 908.4 and has to be set accordingly into the PU5 Display.

To change the analog output value you must keep [P] pushed and change with [DOWN] or [UP] to the Parameter P20. Then release [P] and change with [DOWN] or [UP] the value. You can skip a digit by pushing [P]. Once your desired value is entered, you have to push [P] for 3 seconds. Horizontal lines on the display indicate that the value is saved. The PU5 will automatically retum to measuring mode.

The Conductus/Neocera temperature controller should have a table **`oven_0800K`**.

With a trick, temperatures higher than 800 K can be achieved. To do so, the reading of the temperature controller is divided by a factor 10! For example a reading of 100 K will correspond in reality to 1000 K. For this configuration, the analog output of the PU5 Display has to be changed accordingly (see table below) and the sensor table **`oven_1200K`** has to be used.

Table 9: Correspondence between displayed temperature and analog output of the PU5 Display to allow measurements up to 1200 K (i.e. 120 K displayed) on the Conductus/Neocera temperature controller.

PU5 Display Celsius	Kelvins	Analog Output Volts
0	273.1	0.0
926.9	1200.0	5.8
1598.0	1871.1	10.0

7.5 Setup made by the Instrument Scientist if a LakeShore 340 Controller is used

A PID table has to be prepared in the back-end computer (psw408) with name Zurich_Oven.pid. It has to be stored in the directory /usrdisk0/musr/exp/td_musr/dat/ls340/.

```
!  Zurich_Oven.pid
!
!  analog loop zone file for zurich oven
!
!  CDISP <loop>, ,<resistance>, ,
!  -> O=<resistance> Loop 1 only
!
!  CLIMIT <loop>,<SPlimit>„<heater max.  current>,<heater max.  range>
!  -> S=<SetPointlimit>
!  -> C=<heater max.  current> Loop 1 only 1 = 0.25A, 2 = 0.5A,
!  3 = 1.0 A, 4 = 2.0A
! -> R=<heater max.  range> Loop 1 only 0 - 5
!
!  analog loop is used
!  1200K max.  setpoint
S=1200
!
! <zone> <top T> <P>        <I>        <D>    <Mout> <range, loop1 only>
! 1-10   .....   0.0-1000.0 0.0-1000.0 0-1000   0    0-<heater max.  range>
!
!  1, 1200, 20, 4, 8, 0, 0 Parameters from Christophe Boo:  outdated
!
1,450,15,1.2,3,0,0
2,500,19,1.8,4,0,0
3,700,24,2.4,4,0,0
4,800,30,3.6,4,0,0
5,1200,50,6,5,0,0
$
```

8 "Top"-Loading Janis 4 K-Closed Cycle Cryostat

8.1 Introduction

Since 2008, a top-loading Janis 4 K-CCR cryostat is available on the second cryogeny port (SCP) of the GPS instrument. This Janis 4 K-CCR can be operated between 4 K and 475 K, though in different modes.

The 4 K-CCR is usually installed on the 2nd cryogeny port of the GPS instrument. As opposed to the situation in the Quantum cryostat, the vacuum chamber around the 4 K-CCR is separated from the main vacuum of the spectrometer. Therefore, independent pumps are necessary to evacuate this chamber (usually a standard "MOGLI" pumping unit – see also Section 21).

When operating with the second cryogeny port, the external part of the right positron detector is removed, reducing further the counting rate of this counter.

The sample is connected to a sample-stick located in a so-called sample chamber. This sample chamber is located on the side of the cold-head (Sumitomo Heavy-Industries) with a direct access from the top of the cryostat, allowing therefore rapid top-loading changes of sample. (see Figure 22). Cooling is provided by a good thermal-link between the second stage of the cold head and the bottom part of the tube of the sample-chamber.

An aluminum radiation shield surrounds the sample tube, and is cooled by the refrigerator first stage heat station.

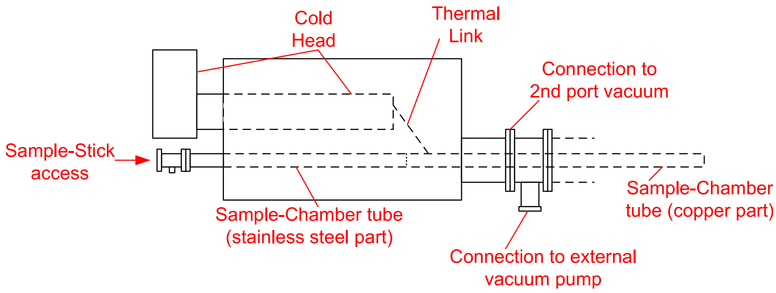

Figure 22: Schematics of the Janis 4 K-CCR.

In the "Low-Temperature Regime" (i.e. up to 300 K), the sample-chamber must contain helium gas to ensure a good thermal contact with the sample. Within this temperature mode, the temperature of the sample is controlled through two heating loops; one for the sample-chamber tube and one for the sample stick. Both loops should have the same setpoint.

On the other side, during high-temperature measurements (i.e. from 300 to 475 K), the sample chamber is permanently pumped and thermal contact kept at a minimum between the stick and the sample-chamber tube. The cold head is also active in this mode and the sample-chamber tube must be maintained at 280 K with the first heater loop. The sample stick acts as a "hot"-finger and its temperature is varied with the second heater loop.

The 4 K-CCR sample holder is similar to the one used for the Quantum cryostat (see Figure 17).

8.2 Principle of operation

8.2.1 Low temperature regime (LTR)

As said, this regime extend between 4 K and 300 K.
In this regime the sample-chamber must contain helium gas to ensure a good thermal contact with the sample.

Preparation: The 2nd port should be put in position by translating the Quantum cryostat (on the 1st port) to the position 119.5 mm.
Interconnecting helium supply and return gas lines should be installed between the cold head and compressor. Tighten each fitting securely with the appropriate sized wrench. Be sure that supply and return lines do not become crossed during installation. Plug the cold head's control power cord into the jack located on the SHI compressor back panel on one side and on the cold-head on the other side..

Connect the thermometry cables from the electronic rack to the cryostat electrical feedthroughs ["A" for the cryostat and "B" for sample stick (if already inserted)].

The vacuum chamber around the 4 K-CCR is connected to the 2nd-port chamber of the GPS instrument and therefore separated from the main vacuum of the spectrometer. Prior to cooldown, connect the "MOGLI" pumping unit and evacuate the second-port vacuum chamber to a pressure of 10^{-5} mbar or less. Better vacuum levels provide greater insulation, resulting in shorter cooldown times and lower final temperatures. After evacuation is complete, the compressor can be started.
After that the cold-head starts to cooldown, seal the vacuum valve *V-2nd* firmly (see Figure 23). Outgassing and O-ring permeation will cause the pressure to rise slowly over time, therefore periodic re-evacuation will be necessary. Re-evacuation is required whenever the minimum temperature obtained begins to increase.

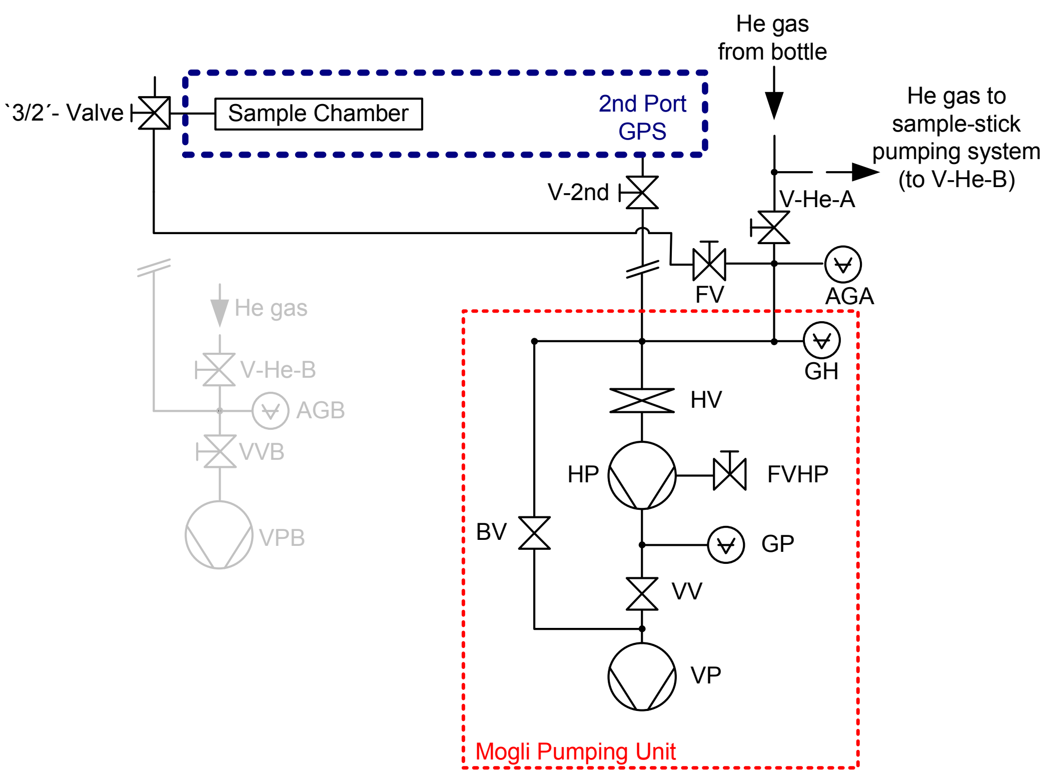

Figure 23: Vacuum diagram for the 4 K-CCR on the GPS 2nd port.

Sample mounting: Remove the 4 K-CCR blind-flange at the end of the sample-chamber, insert the sample-stick in position and fix it using the appropriate clamp. Since within the LTR mode the sample is cooled by exchange gas, special care in thermally anchoring the sample to the holder is not really needed. Be sure to correctly position the sample-stick horizontally and check the longitudinal position (see Figure 24).

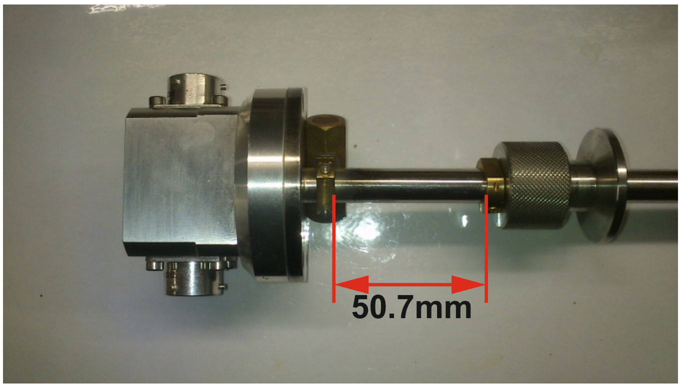

Figure 24: Picture of the outer part of the sample stick with the distance ensuring that the sample inside the cryostat is located in the beam position.

The MOGLI pumping unit can now be connected to the sample chamber. [valve *“V-2nd”* closed; MOGLI on *“lock”* position; pumping pipes connected to the Sample Chamber (see Figure 23 and open the “3-ways” valve (*‘3/2’ valve*) of the sample-chamber)]. Evacuate the sample chamber by putting the MOGLI on *“unlock”*. Once sufficiently evacuate, isolate the MOGLI by putting on *“lock”* and allow about 200 mbar of gas in the sample chamber through the valve *V-He-A*. When done, close the “3-ways” valve to isolate the sample chamber.

Temperature control in LTR: The temperature control is performed by 2 GaAlAs diodes (LakeShore TG-120-SD), controlling two independent heater-loops. The first diode is located on the sample-chamber tube, the second one is located on the sample stick. The temperature controller is normally a LakeShore 340
In normal operation in the Low Temperature Regime, identical setpoints should be provided for both loops.

- The temperature of the Sample-Chamber tube T_{tube}(or T_{heater}) is measured on the channel 1 (loop 1).
- The temperature of the Sample Holder T_{holder} (or T_{analog}) is measured on the channel 2 (loop 2). The voltage loop 2 of the *LakeShore* controls an external *Gossen* power supply (use exclusively the type 24K32R4: 32V/4A). Figure 25 indicates the necessary settings to interface both instruments. The maximum current for the *Gossen* is therefore limited to about XXX Amp.
- Do not forget to switch ON the heaters by pressing the corresponding button on the HECTOR unit in case that a LakeShore 340 temperature controller is used.
  This last point can be performed directly from the Console running the application **deltat**.
- On the application **deltat**, the LakeShore 340 is controlled by the front-end *Temperature_2nd_port*. This front-end should run and configured to operate with the low temperature PID tables.

Sample change in LTR: The sample change can (must) be performed with the compressor/cold-head running

- Stop the heater by pressing the corresponding button on the HECTOR unit located near the LakeShore 240 temperature controller.
- Disconnect the cable “B” from the electrical feedthrough of the sample chamber.
- Pressurize the sample chamber with He-gas by opening the “3-ways” valve (*‘3/2’ valve*) on the sample chamber and the *V-He-A* valve. Gas should blow through the overpressure valve located on the sample chamber.
- Remove the sample stick and immediately connect the blind flange at the end of the sample chamber.
- Isolate the sample chamber by closing the “3-ways” valve (*‘3/2’ valve*) on the sample chamber.
- Change your sample and be sure to dry the sample stick thoroughly.
- When ready pressurize again the sample chamber with He-gas by opening the “3-ways” valve (*‘3/2’ valve*) on the sample chamber and the *V-He-A valve*. Gas should blow through the overpressure valve located on the sample chamber.
- Dismount the blind flange and insert the sample stick.
- Stop blowing He-gas by closing the valve *V-He-A*.
- Decrease the pressure in the sample chamber down to 200 mbar by pumping with the MOGLI pumping unit.
- Isolate the sample chamber by closing the “3-ways” valve (*‘3/2’ valve*) on the sample chamber.
- Reconnect the cable “B” to the electrical feedthrough of the sample chamber.
- Enable the heater by pressing the corresponding button on the HECTOR unit located near the LakeShore 340 temperature controller.
- Set new setpoints from the computer.

8.2.2 High temperature regime (HTR)

This regime extend between 300 K and 475 K.
In this regime the sample-chamber must be continuously evacuate and the sample stick acts as a "hot´´-finger.

Preparation: The 2nd port should be put in position by translating the Quantum cryostat (on the 1st port) to the position 119.5 mm.
Interconnecting helium supply and return gas lines should be installed between the cold head and compressor. Tighten each fitting securely with the appropriate sized wrench. Be sure that supply and return lines do not become crossed during installation. Plug the cold head's control power cord into the jack located on the SHI compressor back panel on one side and on the cold-head on the other side..

Connect the thermometry cables from the electronic rack to the cryostat electrical feedthroughs ["A" for the cryostat and "B" for sample stick (if already inserted)].

The vacuum chamber around the 4 K-CCR is connected to the 2nd-port chamber of the GPS instrument and therefore separated from the main vacuum of the spectrometer. Prior to cooldown, connect the "MOGLI" pumping unit and evacuate the second-port vacuum chamber to a pressure of 10^{-5} mbar or less. Better vacuum levels provide greater insulation, resulting in shorter cooldown times and lower final temperatures. After evacuation is complete, you can start the compressor.
After that the cold-head starts to cooldown, seal the vacuum valve *V-2nd* firmly (see Figure 23).

Outgassing and O-ring permeation will cause the pressure to rise slowly over time, therefore periodic re-evacuation will be necessary.

Sample mounting: Remove the 4 K-CCR blind-flange at the end of the sample-chamber, insert the sample-stick in position and fix it using the appropriate clamp. Since within the HTR mode the sample is warmed by the sample-stick heater, special care in thermally anchoring the sample to the holder is needed. Be sure to correctly position the sample-stick horizontally and check the longitudinal position (see Figure 24).

The MOGLI pumping unit can now be connected to the sample chamber. [valve *"V-2nd"* closed; MOGLI on *"lock"* position; pumping pipes connected to the Sample Chamber (see Figure 23 and open the "3-ways" valve (*'3/2' valve*) of the sample-chamber)].
Evacuate the sample chamber by putting the MOGLI on *"unlock"*. Pump continuously the sample chamber during the full operation in High Temperature Regime.

Temperature control in HTR: The temperature control is performed by 2 GaAlAs diodes (LakeShore TG-120-SD), controlling two independent heater-loops. The first diode is located on the sample-chamber tube, the second one is located on the sample stick. The temperature controller is normally a LakeShore 340.
During operation in the High Temperature Regime, the setpoint of the loop of the sample chamber should be kept at 280K, and the sample-stick setpoint can be changed as desired.

- The temperature of the Sample-Chamber tube T_{tube} (or T_{heater}) is measured on the channel 1 (loop 1).
- The temperature of the Sample Holder T_{holder} (or T_{analog}) is measured on the channel 2 (loop 2). The voltage loop 2 of the *LakeShore* controls an external *Gossen* power supply (use exclusively the type 24K32R4: 32V/4A). Figure 25 indicates the necessary settings to interface both instruments. The maximum current for the *Gossen* is therefore limited to about XXX Amp.
- Do not forget to switch ON the heaters by pressing the corresponding button on the HECTOR unit in case that a LS340 temperature controller is

used.
This last point can be performed directly from the Console running the application **`deltat`**.

- On the application **`deltat`**, the LakeShore 340 is controlled by the front-end *Temperature_2nd_port*. This front-end should run and configured to operate with the high temperature PID tables.

Sample change in HTR: The sample change must be performed with the compressor/cold-head running

- Set the sample-stick setpoint to 300 K and wait until the sample-stick temperature is below about 320 K.
- Stop the heater by pressing the corresponding button on the HECTOR unit located near the LakeShore 340 temperature controller.
- Disconnect the cable “B” from the electrical feedthrough of the sample chamber.
- Stop pumping in the Sample Chamber by isolating the MOGLI pumping unit (press the *lock* button).
- Pressurize the sample chamber by opening the *V-He-A* valve [be sure that the “3-ways” valve (*‘3/2’ valve*) is open]. Gas should blow through the overpressure valve located on the sample chamber.
- Remove the sample stick and immediately connect the blind flange at the end of the sample chamber.
- Isolate the sample chamber by closing the “3-ways” valve (*‘3/2’ valve*) on the sample chamber.
- Change your sample.
- When ready pressurize again the sample chamber with He-gas by opening the “3-ways” valve (*‘3/2’ valve*) on the sample chamber and the *V-He-A valve*. Gas should blow through the overpressure valve located on the sample chamber.
- Dismount the blind flange and insert the sample stick.
- Stop blow He-gas by closing the valve *V-He-A*.
- Start pumping in the sample chamber with the pumping unit MOGLI (press the *unlock* button)
  Be sure that the “3-ways” valve (*‘3/2’ valve*) is open.
- Reconnect the cable “B” to the electrical feedthrough of the sample chamber.
- Enable the heater by pressing the corresponding button on the HECTOR unit located near the LakeShore 340 temperature controller.
- Set new setpoints from the computer.

The Tables 10 and 11 indicate the value of the PID parameters used by the temperature controller for the two loops.

Table 10: Cryostat Janis 4 K-CCR: PID parameters for the Loop 1 (sample-chamber tube) of the LakeShore 340 temperature controller. The parameters are stored in a PID Table in the BackEnd computer and dowloaded on the LakeShore temperature controller when necessary.

Cryostat Janis 4 K-CCR - Loop 1				
Break point (K)	P	I	D	Heater Range (W)
130	5	16	8	100
60	12	50	15	100
30	30	30	0	10
8	30	30	0	1

Table 11: Cryostat Janis 4 K-CCR: PID parameters for the Loop 2 (sample stick) of the LakeShore 340 temperature controller. The parameters are stored in a PID Table in the BackEnd computer and dowloaded on the LakeShore temperature controller when necessary.

Cryostat Janis 4 K-CCR - Loop 1			
Break point (K)	P	I	D
450	90	7	3

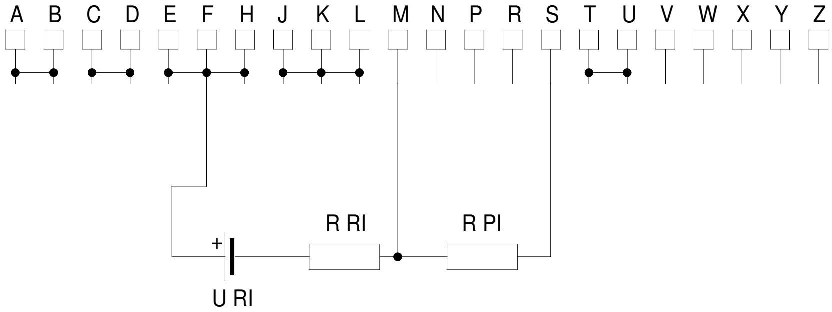

Figure 25: Diagram of the back-connector of the Gossen power supply. U_{RI} represents the voltage provided by the temperature controller (max. 10 Volts). R_{RI} is fixed at XXXX Ohms and R_{PI} at XX Ohms. The current furnished will be given by $U_{RI} \times R_{PI} \times I_{FS}/(0.6 \times R_{RI})$ where I_{FS} represents the current full-scale of the Gossen power supply (see Gossen manual).
Note that when used on the second port of GPS, the settings of the Gossen power supply can be toggled between the 4 K-CCR configuration and the "Zürich" oven configuration (see Figure 18) with the help of a switch located near the Gossen power supply on the dedicated SCP rack.

8.3 Setup made by the Instrument Scientist

For the LTR regime, two PID tables have to be prepared in the back-end computer (`psw408`) with name `ccr_janis_stick_low.pid` and `ccr_janis_cryo_low.pid`. They have to be stored in the directory `/usrdisk0/musr/exp/td_musr/dat/ls340/`.

```
!  ccr_janis_stick_low.pid
!
!  analog loop zone file for the janis CCR4K stick at low temperature
!
!  AA35
!
!  CDISP <loop>„<resistance>„
!  -> O=<resistance> Loop 1 only
!
!
!  CLIMIT <loop>,<SPlimit>„<heater max.  current>,<heater max.  range>
!  -> S=<SetPointlimit>
!  -> C=<heater max.  current> Loop 1 only 1 = 0.25A, 2 = 0.5A,
!  3 = 1.0A, 4 = 2.0A
! -> R=<heater max.  range> Loop 1 only 0 - 5
!
!  analog loop is used
!  310K max.  setpoint
S=310
! <zone> <top T> <P>        <I>        <D>    <Mout> <range, loop1 only>
! 1-10   .....   0.0-1000.0 0.0-1000.0 0-1000   0    0-<heater max.  range>
!
!Z T P I D M R
!
1, 450, 90, 7, 3, 0, 0
$
```

```
!  ccr_janis_cryo_low.pid
!
!  heater loop zone file for the janis CCR4K cryo at low temperature
!
!  AA35
!
!  CDISP <loop>„<resistance>„
!  -> O=<resistance> Loop 1 only
!
!
!  CLIMIT <loop>,<SPlimit>„<heater max.  current>,<heater max.  range>
!  -> S=<SetPointlimit>
!  -> C=<heater max.  current> Loop 1 only 1 = 0.25A, 2 = 0.5A,
!  3 = 1.0A, 4 = 2.0A
! -> R=<heater max.  range> Loop 1 only 0 - 5
!
!  heater loop is used
!  25 Ohm heater, 300K max.  setpoint, 2A max.  current, 4 max.  range
O=25
S=310
C=4
R=5
! <zone> <top T> <P>        <I>        <D>    <Mout> <range, loop1 only>
! 1-10   .....   0.0-1000.0 0.0-1000.0 0-1000   0    0-<heater max.  range>
!
!Z T P I D M R
!
1, 8, 30, 30, 0, 0, 3
2, 30, 30, 30, 0, 0, 4
3, 60, 12, 50, 15, 0, 5
4, 130, 5, 16, 8, 0, 5
$
```

For the HTR regime, two PID tables have to be prepared in the back-end computer (`psw408`) with name `ccr_janis_stick_high.pid` and `ccr_janis_cryo_high.pid`. They have to be stored in the directory `/usrdisk0/musr/exp/td_musr/dat/ls340/`.

```
!  ccr_janis_stick_high.pid
!
!  analog loop zone file for the janis CCR4K stick at high temperature
!
!  AA35
!
!  CDISP <loop>„<resistance>„
!  -> O=<resistance> Loop 1 only
!
!
!  CLIMIT <loop>,<SPlimit>„<heater max.  current>,<heater max.  range>
!  -> S=<SetPointlimit>
!  -> C=<heater max.  current> Loop 1 only 1 = 0.25A, 2 = 0.5A,
!  3 = 1.0A, 4 = 2.0A
! -> R=<heater max.  range> Loop 1 only 0 - 5
!
!  analog loop is used
!  475K max.  setpoint
S=475
! <zone> <top T> <P>        <I>        <D>    <Mout> <range, loop1 only>
! 1-10   .....   0.0-1000.0 0.0-1000.0 0-1000   0    0-<heater max.  range>
!
!Z T P I D M R
!
1, 450, 90, 7, 3, 0, 0
$
```

```
!  ccr_janis_cryo_high.pid
!
!  heater loop zone file for the janis CCR4K cryo at high temperature
!
!  AA35
!
!  CDISP <loop>„<resistance>„
!  -> O=<resistance> Loop 1 only
!
!
!  CLIMIT <loop>,<SPlimit>„<heater max.  current>,<heater max.  range>
!  -> S=<SetPointlimit>
!  -> C=<heater max.  current> Loop 1 only 1 = 0.25A, 2 = 0.5A,
!  3 = 1.0A, 4 = 2.0A
! -> R=<heater max.  range> Loop 1 only 0 - 5
!
!  heater loop is used
!  25 Ohm heater, 310K max.  setpoint, 2A max.  current, 4 max.  range
O=25
S=310
C=4
R=5
! <zone> <top T> <P>        <I>        <D>    <Mout> <range, loop1 only>
! 1-10   .....   0.0-1000.0 0.0-1000.0 0-1000   0    0-<heater max.  range>
!
!Z T P I D M R
!
1, 8, 30, 30, 0, 0, 3
2, 30, 30, 30, 0, 0, 4
3, 60, 12, 50, 15, 0, 5
4, 130, 5, 16, 8, 0, 5
$
```

9 Closed Cycle Cryostat – Mark I

9.1 Introduction

The CCR can be operated between room temperature and about 10 K. The sample holder is connected to a "cold" finger and the CCR is operated in vacuum. Therefore the users should take care to obtain a good thermal contact between the sample and the holder. An appropriate method should be used to attach the sample to the holder.

The CCR sample holder is similar to the one used for the Quantum cryostat (see Figure 17).

The CCR is usually installed on the 2nd cryogeny port of the GPS instrument. As opposed to the situation in the Quantum cryostat, the vacuum chamber around the CCR is separated from the main vacuum of the spectrometer. Figure 26 shows the pump connections to the CCR.

Therefore, independent pumps are necessary to evacuate this chamber (usually a standard "MOGLI" pumping unit).

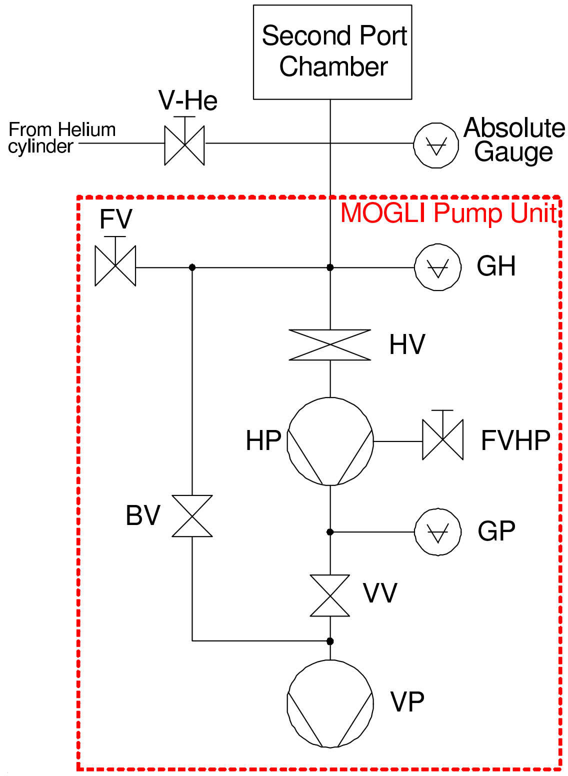

Figure 26: Vacuum diagram for the CCR.

9.2 Temperature control

Two temperature sensors (Cernox) are used to monitor and control the temperature of the CCR. They are both mounted at the end of the cold finger.

The PID values of the temperature controller are, of course, dependent on the temperature controller used.

Table 12: CCR: PID parameters of the temperature controller LTC Conductus/Neocera. The *P* parameters are rounded when displayed by the controller. The parameters are stored in a PID Table of the Conductus temperature controller. **The maximum power should be fixed at 20 %.**

CCR with LTC				
Break point (K)	P	I	D	Heater Range (W)
320	15	62	16	50
200	15	62	16	50
199.999	60	62	16	5
77	60	62	16	5
50	42	50	16	5
40	35	37	9	5
25	22	23	6	5
20	22	23	6	5
19.999	100	15	4	0.5
1.4	100	15	4	0.5

Table 13: CCR: PID parameters of the temperature controller Lakeshore 340. The *P* parameters are rounded when displayed by the controller. The parameters are stored in a PID Table of the Lakeshore temperature controller.

CCR with LS 340				
Break point (K)	P	I	D	Heater Range (W)
320	200	50	3	10
250	200	50	3	10
200	200	50	3	10
150	200	50	3	10
100	200	50	3	10
50	200	12	3	10
40	170	15	5	10
30	300	30	5	1
20	300	50	0	1
10	350	50	15	1

9.3 Sample change

- Heat the sample to room temperature and wait 15 min. after reaching the set-point.
- Switch OFF the CCR compressor.
- Immediately switch OFF the heater by:
  - putting the temperature controller to *MONITOR* mode (if necessary depress first the *LOCAL* button) in case that a LTC Controller is used,
  - or by switching the corresponding button on the HECTOR unit in case that a LS340 is used.
- Stop pumping by swiching OFF the MOGLI pumping unit . This is performed by pressing the button *LOCK HV* on the MOGLI Controller.
- Remove the screws connecting the CCR to the vacuum chamber.
- Slowly open the valve *V-He* to admit He-gas into the chamber. **Check carefully and frequently the pressure in the chamber: do not go beyond 1000mbar.**
- Close valve *V-He*.
- Open the CCR.

- Change your sample.
- If necessary remove the moisture of the CCR with a heat gun.
- Insert the CCR and connect it to the vacuum chamber with the available screws.
- Start pumping by pressing the button *UNLOCK HV* on the MOGLI Controller. Note that the HV valve will only be open when pre-defined conditions will be fullfilled.
- Switch ON the temperature controller by
  - pressing the button *CONTROL* (if necessary depress first the *LOCAL* button) in case that a LTC Controller is used.
  - or by switching the corresponding button on the HECTOR unit in case that a LS340 is used.

  This last point can be performed directly from the Console running the programme **`deltat`**.

9.4 Setup made by the Instrument Scientist if a LakeShore 340 Controller is used

A PID table has to be prepared in the back-end computer (psw408) with name ccr1.pid. It has to be stored in the directory /usrdisk0/musr/exp/td_musr/dat/ls340/.

```
!  ccr1.pid
!
!  heater loop zone file for CCR1 cryostat
!
!  RA36 21-NOV-2006 zone table taken from Christoph Boo Bericht
!
!  CDISP <loop>„<resistance>„
!  -> O=<resistance> Loop 1 only
!
!
!  CLIMIT <loop>,<SPlimit>„<heater max.  current>,<heater max.  range>
!  -> S=<SetPointlimit>
!  -> C=<heater max.  current> Loop 1 only 1 = 0.25A, 2 = 0.5A,
!  3 = 1.0A, 4 = 2.0A
! -> R=<heater max.  range> Loop 1 only 0 - 5
!
!  heater loop is used
!  25 Ohm heater, 300K max.  setpoint, 2A max.  current, 4 max.  range
O=25
S=300
C=4
R=4
! <zone> <top T> <P>        <I>        <D>    <Mout> <range, loop1 only>
! 1-10   .....   0.0-1000.0 0.0-1000.0 0-1000   0    0-<heater max.  range>
!
!Z T P I D M R
!
1, 10, 350, 50, 15, 0, 3
2, 20, 300, 50, 0, 0, 3
3, 25, 300, 30, 5, 0, 3
4, 40, 170, 15, 5, 0, 4
5, 50, 200, 12, 3, 0, 4
6, 100, 200, 50, 3, 0, 4
7, 150, 200, 50, 3, 0, 4
8, 200, 200, 50, 3, 0, 4
9, 250, 200, 50, 3, 0, 4
10, 300, 200, 50, 3, 0, 4
$
```

IV. Instrument magnetic fields

10 Zero field

Zero-field compensation is regularly performed by the Instrument Scientist. Since this operation is quite delicate and requires that the cryostat is at room temperature, **the users are not allowed to perform it themselves**.

Extensive tests have shown that a weak remanent field is present at the sample region after that the main field (WED) has been set to high values.
This field has a value of few hundreds of milliGauss and is directed approximately along the beam direction (angle of about 20 degrees).
High statistic runs have demonstrated that this field can be **completely** suppressed by applying, for a very short time, a small field of 100 Gauss with the auxiliary coils (WEP).
After such a WEP cycling, zero field is dynamically obtained (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 calibrated 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.

See here for more information (reachable from PSI intranet):
http://lmu.web.psi.ch/intranet/manuals/Zero_Field_Compensation_Comprehensive_Manual.pdf

11 GPS magnets

11.1 Introduction

Two sets of Helmholtz coils are available to produce magnetic fields at the sample position:

WED: These are the main coils, producing a field along the muon-beam direction. This field is used either for *Longitudinal Field* studies, when the muon polarization is along the beam direction, or for *Transverse Field* measurements, when the muon spin is rotate with the Spin Rotator.
The maximum field reachable is 5.6 kG (reduced field due to a problem of the magnet) when the coils are operated with the *WED* power supply.
If low field value are required (typically below 100 G) or if a high stability for very low fields is required (typically during muonium studies) the power supply *WEDLow* can be utilized. With this latter power a maximum field of 390 G can be reached.

WEP: This pair of coils produces a horizontal field perpendicular to the muon-beam direction (along the cryostat axis). This field is typically used for calibration purposes (total asymmetry, determination of the parameter alpha,...). The highest field available is 60 G.

11.2 Setting a field

Both magnets are controlled by the **`deltat`** software.
To set a field, choose the tab **`Exp. Magnets`**, choose the desired magnet and provide the new field value. At this point, the software will send the necessary commands to the PC server controlling the beamline. Note that when a specific device has been chosen, the software will automatically switch ON the requested device and switch OFF the two others. Similarly, when a field 0 is chosen for one power supply, the three power supplies will be switched OFF.
For Zero Field measurements, the action to set one device to zero, will automatically switch off all the devices. This is particularly useful in the autorun mode, when a combination of Zero and Longitudinal Field measurements is requested.

In an autorun-sequence file, the field can be changed as shown in the following example:

```
Set Magnet WED 1000 30
```

In this example a field of 1000 G will be applied by the WED power supply, and a stabilization time of 30 seconds is requested. The device **`WED`** can be replaced by **`WEDL`** or **`WEP`**.

Note that the power supply settings and readback values are also displayed on the beamline PC located in the Counting Room. After setting a field from the Workstation, a star "*" will appear, on the beamline PC, in front of the setting of the concerned power supply. This is normal and indicates that another client (the **`deltat`** software in this case) has changed the setting.

Do not try to set the power supplies (WED, WEDL and WEP) from the beamline PC.

The Tables 14 give the relation between the field values and the DAC values of the different power supplies. These tables are already integrated in the DELTAT software and should NOT be considered by a normal μSR user.

11.3 Phase shifts

Figure 27 shows the WED field profile along the incoming muon beam. In the transverse polarization geometry, this long field extension introduces quite a noticeable rotation of the muon spin before the implantation into the sample (see also "Common Logbook" #3, page 079).

Table 14: Relation between the DAC values and the actual field for the different power supplies. The present values can also be found in the directory **`/userdisk0/musr/exp/td_musr/expmag/`** of the Backend.

WEP DAC	Field (G)
500	16.385
1000	33.133
1500	49.586
2000	65.798

WEDLow DAC	Field (G)
0	0.285
100	24.291
500	120.315
1000	240.345
2000	480.405

WED DAC	Field (G)
51	12.63
508	57.76
3048	307.03
10082	995.49
15123	1489.07
20165	1982.64
25206	2475.66
32263	3165.98
35288	3461.92
40329	3955.08
45370	4448.50
50412	4941.96
55453	5435.00
60494	5928.00
65535	6421.50

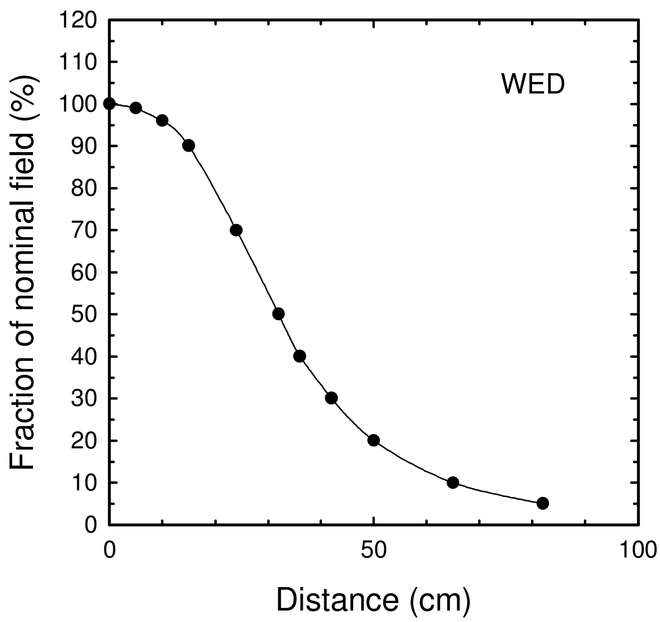

Figure 27: Calculated field profile (WED magnet) along the beam direction.

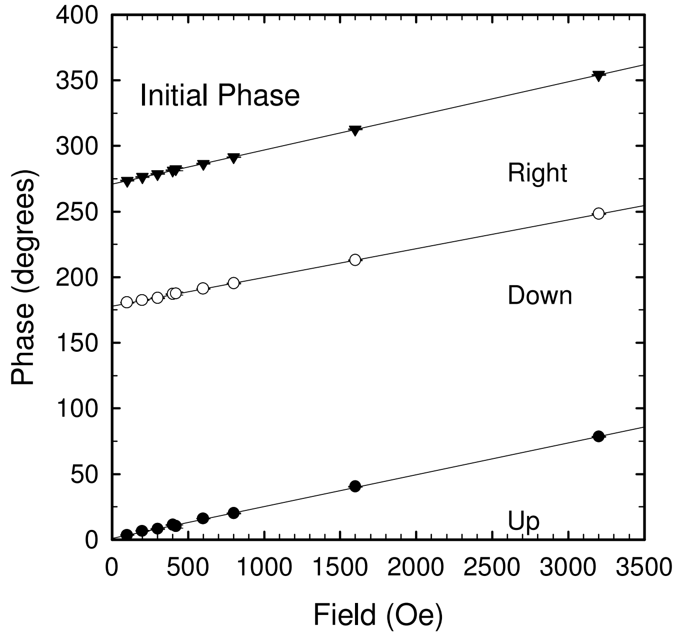

Figure 28: Measured phase shifts as a function of the applied field (WED) for different detectors (by courtesy of Joao Gil).

This "negative time" spin rotation introduces a field dependent phase shift for the detectors "Up", "Down" and "Right" (see Figure 28). The observed phase shift corresponds almost exactly to the calculated one based on the field profile shown in Figure 27. Hence, the phase increase due to the field profile represents about 0.0231 degrees/Gauss.

V. The muon beamline

12 Beam line, power supplies and settings

12.1 The beamline

The πM3 beam line is currently the only beam line dedicated exclusively to μSR experiments with "surface" muons, although the original channel was optimized for pions of up to 350 MeV/c. It is attached to the thin target **M** at 22.5° in the forward direction (see Figure 29) . A 3 m long crossed-field separator, built at CERN, can be used either as an electron/muon separator or as a muon spin rotator. Due to the optical characteristic of this device, its transmission depends strongly on the high voltage settings. A compromise between high rates and a high degree of transverse polarization has been found experimentally, and a muon spin rotation angle as large as 50° is used routinely.

More information on the πM3 beam line can be found here:

http://aea.web.psi.ch/beam2lines/beam_pim3.html

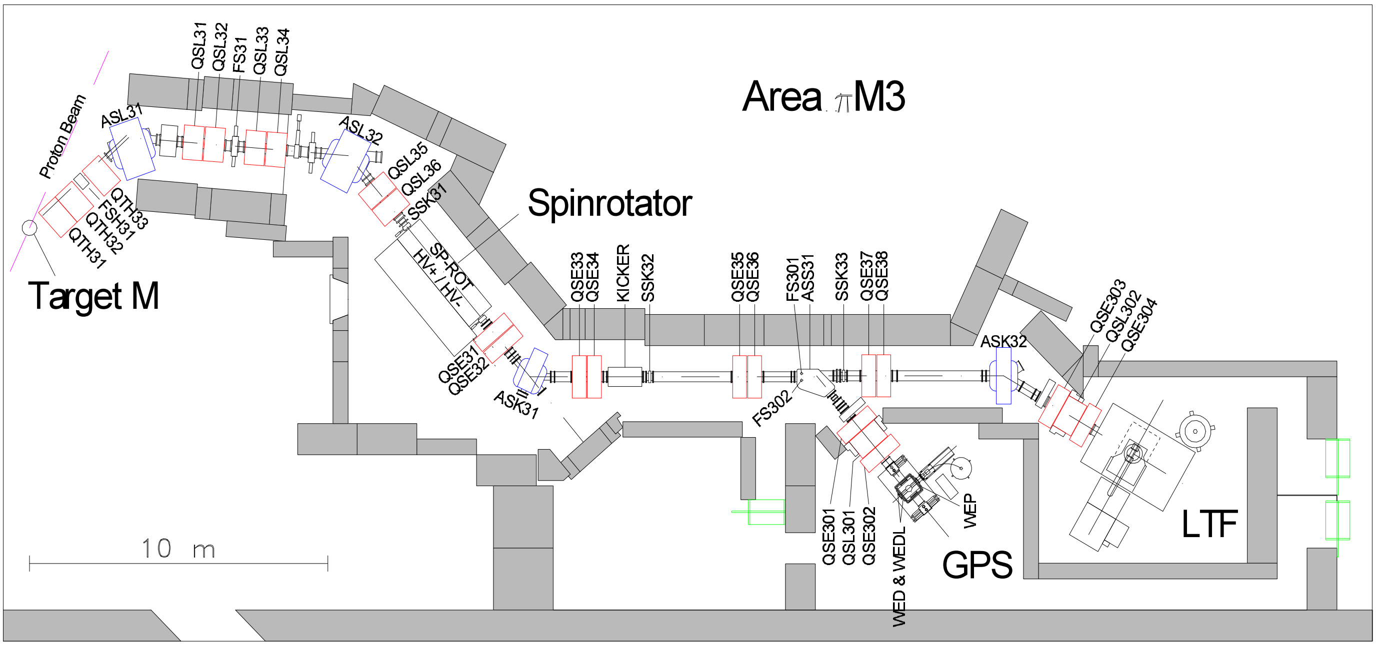

Figure 29: Schematic of the beam magnets of the πM3 beamline. Magnet names of the form QXXNN represent quadrupoles, ASXNN are bending magnets, SSKNN are steering magnets and FSNNN are slits.
The slits FSH31 and FS31 are always fully open. The muon rate at the instrument is controlled with the slits FS302 located just in front of the septum magnet ASS31.

12.2 Setting the beamline

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, almost all the power supplies have been replaced and few more will be replaced during the next shutdown. All but few power supplies (QTH31, QTH32 AND QTH33) are located on the platform above the GPS cabin (see Figure 30).

All power supplies can be controlled via the Beamline PC (PC8290). The “Experiment Magnets" (WED, WEDL and WEP) can be controlled through the `deltat` application running on the console (PC6012). Both computers run EPICS clients applications. The heart of the EPICS control for the πM3 beamline is a VME crate located on the platform above the GPS cabin, in the first left-hand side row of power supplies. This crate contains a processor module and the interface cards for the power supply. In addition, the old power supplies have an additional interface (“multi I/O") located in the same rack.

- The `deltat` Console is usually utilized to set the WED, WEDL and WEP power supplies. This is performed directly in **`deltat`** as explained in Section 11.2.
- The PC is utilized to set the other power supplies. This is performed by the application *SetPoint*.
  This 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.

Some standard settings are normally provided (transverse or longitudinal mode; shared or not shared, MEG or not MEG...). The names are normally self-explanatory.

How to set the beamline ?

- Start the SetPoint application on the PC8290 (see above).
- When loading a new setpoint-file (.sp files) 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 (–>)". 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 colum “File value" will be updated accordingly.

Due to hysteresis effects, cycle the steering magnets SSK31, SSK32 and SSK33: set their minimum values (either -10 or -15 Amps); wait few seconds and put back the proper initial values of the file.

By going from transverse to longitudinal mode, it is sometimes necessary to retune the spin rotator value. Note that this retuning could be necessary over a long time scale (hours...).

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.
NEVER OVERWRITE EXISTING SETTINGS !!

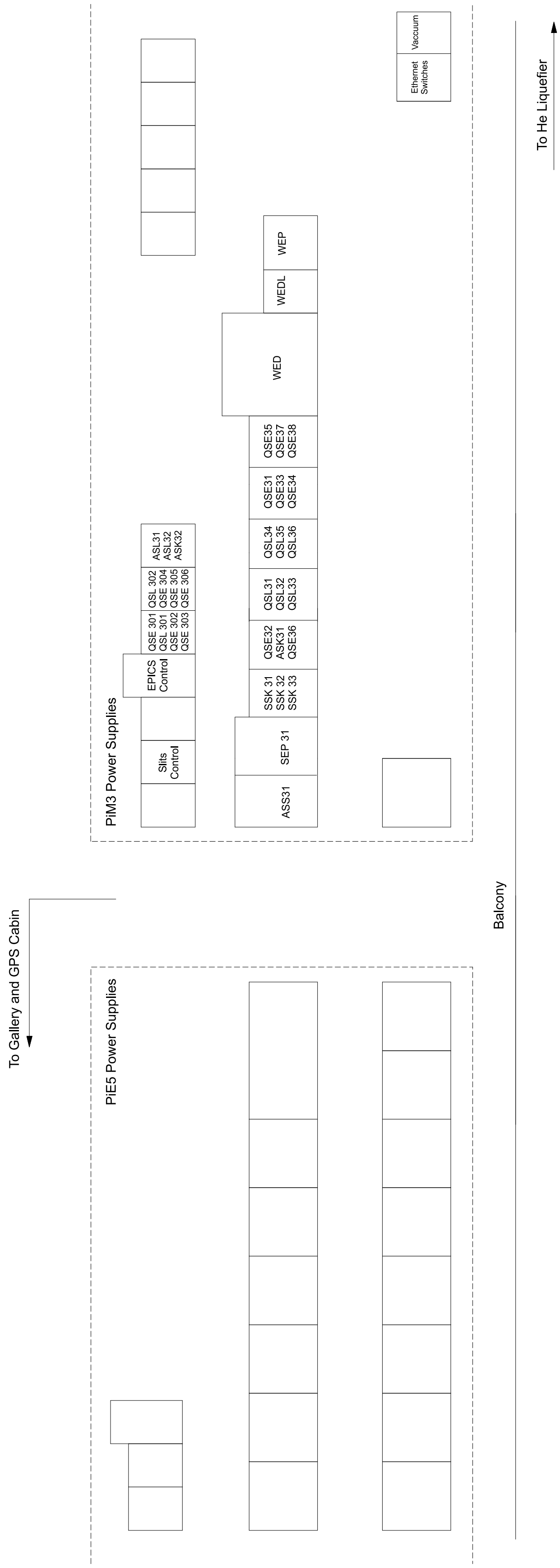

Figure 30: Location of the πM3 beamline power supplies located on the platform above the GPS cabin. The list of the power supplies is given in the Table 20.1 at the page 92.

13 The spin rotator

The spin rotator consists of mutually perpendicular electrical and magnetic fields.

It can be used either as a separator in longitudinal geometry or as a spin rotator in transverse geometry.

13.1 Longitudinal geometry

It this configuration, the spin rotator is used as a separator. The settings of the two fields are correlated so that muons of a particular velocity are transmitted.

The rôle of the separator (spin rotator) is to remove contaminant particles (primarily positrons) from the muon beam.
When the muon beam is deflected by a magnetic field the spin and momentum vectors remain collinear. However, the same is not true if the beam is passed through an electric field, when the muon spin is rotated with respect to its momentum vector. The effect of the electric field in the separator (spin rotator) is to rotate the muon polarization upwards slightly by about 7° so that there is a polarization component transverse to the momentum direction. This component will for example create an oscillatory signal in the Up, Down and Right detectors when a longitudinal field is applied.

13.2 Transverse geometry

In this geometry, the spin rotator will rotate the muon spin upward by about 50°. By increasing the angle, the transmission of the spin rotator is dramatically reduced.

When a transverse field (WED) is applied, the detectors Up, Down and Right have a reduced asymmetry corresponding to the projection of the polarization vector on the field frame.

13.3 Conditioning and maintenance

If the required voltage for the spin rotator (separator) E-field cannot be reached, a conditioning of the electrodes is most probably necessary. That is slowly increasing the voltage with vacuum conditions until the field breaks down and leaving it at this setting for a period before increasing it further. This process is done each year at the start of the beam period or when necessary by the instrument scientist.

The spin rotator is operated with a constant and controlled gas flow (Helium-Neon gas at 1.2×10^{-4}mbar, PSI Nr. 13.700.0000). The gas bottle has to be changed periodically (usually done by a dedicated technician). Figure 31 shows the pressure of the gas bottle as a function of the number of operation days.

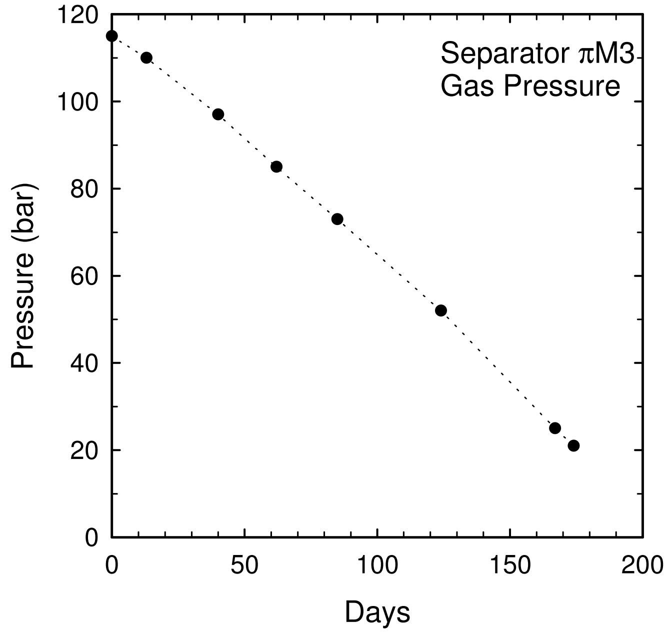

Figure 31: Change of bottle gas pressure as a function of time.

14 Muons on request (“MORE”)

14.1 Introduction

In conventional time-differential μSR experiments, an ideal lifetime spectrum would contain only start-stop events belonging to the same muon. In real experiments using continuous muon beams, however, there is always a certain number of muons escaping detection, e.g. those stopping near but not hitting the muon counter. This results in a random rate of events in the start and stop channels and a random background in the muon-decay histograms, thus limiting the useful time interval to about 10 μs and excluding investigations of low muon-spin precession frequencies or slow relaxation processes.

Pulsed muon beams, on the other hand, deliver many muons per pulse at low repetition rates (e.g. 50Hz at ISIS). In this technique, the time resolution is limited by the finite length of the muon pulses (80ns at ISIS compared to 1ns on the GPS instrument at PSI). However, the background is typically three orders of magnitude lower.

A method to solve the background problem at continuous muon beams has been proposed earlier (see [1, 2]) for surface-muon beams at TRIUMF or KAON but has never been realized. The basic idea is to extract only one muon at a time out of a continuous beam by means of a fast-switching electrostatic deflector ("kicker") on request from a μSR instrument. This makes sure that no other muon reaches the spectrometer until the extracted one has been processed. Moreover, the concept of "Muons-On-REquest" (MORE) does not significantly reduce the intensity of the original beam which is therefore available for the simultaneous use by a second spectrometer, i.e. MORE produces twice as many results of even higher quality (lower background in one spectrometer) than the conventional technique.

14.2 Experimental Setup in the πM3 Area

The main components (Kicker, Septum magnet) installed for MORE in the surface-muon beam line piM3 are shown in the Figure 29 (see also Ref. [3]).

The kicker contains two 1m long, 20cm wide electrodes 20cm apart. Two power supplies for dc voltages up to +5kV and -5kV are connected to the electrodes via fast switches, giving a difference of 20kV between the two field directions and a separation of the muon trajectories of about 5cm at the intermediate beam focus in front of the septum magnet located about 5m from the kicker exit. Each switch consists of a series of 15 high-voltage MOSFET transistors type IXYS 6N100.

The muon detector (M-counter) in the spectrometer (GPS or LTF) is used to trigger the kicker. The kicker is switched to the spectrometer running in "MORE mode" (say, GPS) for a maximum of 5μs at a fixed repetition rate (max. 40kHz, usually 37 kHz). The signal of the first muon hitting the trigger detector (M-counter) after a minimum delay of 200ns is used to switch the kicker back to the spectrometer running in "parasitic mode" (LTF in this case). The delay is necessary to avoid damage to the power switches.

Either instrument, GPS or LTF, can be used in MORE mode while the other one is running in "parasitic" mode.

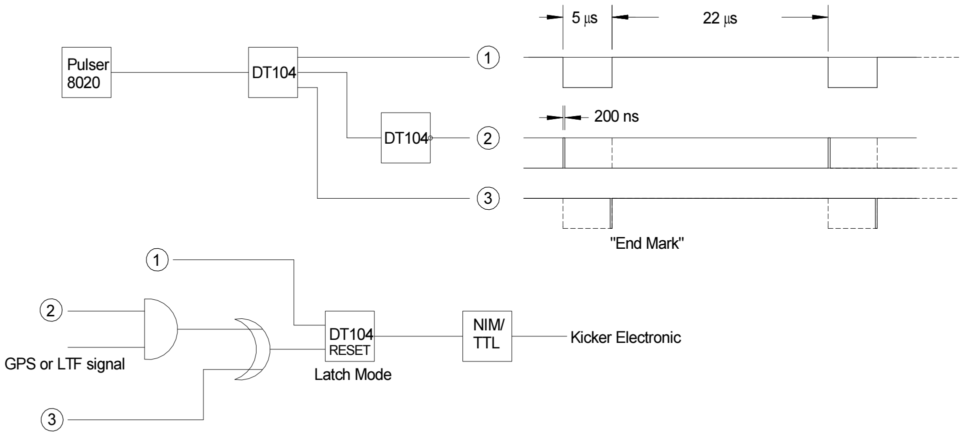

Figure 32: Schematic of the switching logic for the beamline kicker. The instrument to which the muon-on-request will be send is defined by i) the setting of the logical "AND" coincidence, i.e. GPS "AND" and LTF "OFF" for GPS and the opposite for LTF; ii) by changing the mode of the NIM/TTL converter (either NORMAL or COMPLEMENTARY).

14.3 Advantages (but...)

Figure 33 shows an example of μSR in silver in an external magnetic field of 10mT, taken with the GPS in MORE mode. For comparison a conventional spectrum is shown taken at the same event rate. The background in MORE mode is at least a factor of 100 lower than in conventional mode, thus allowing the study of muon-spin precession and relaxation easily up to 20μs.

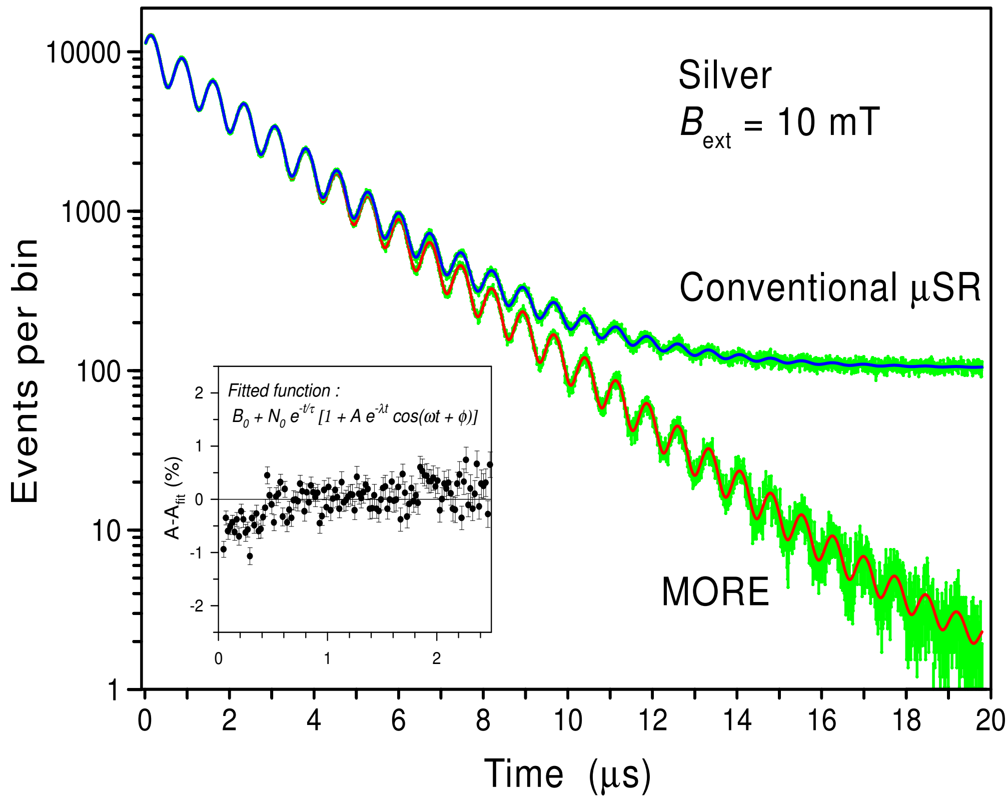

Figure 33: μSR in silver in a magnetic field of 10mT measured at the GPS facility instrument in conventional and in MORE mode. Insert: Reduced asymmetry plot for the first 2μs in MORE mode (function fitted for t > 0.4μs).

In MORE mode with M-counter trigger we observe a small distortion in the spectra at times t < 450ns (insert in Figure 33) which is due to the delay between the passage of the muon and the arrival of the trigger signal at the kicker. During this time, additional muons can enter the spectrometer and "kill" events through pile-up rejection. Fitting the distorted spectra is possible using different values of the fit parameters N0 (normalizing constant) and B0 (background) in the two regions. However, the MORE technique is preferentially used for slow signals where cutting off the first channels does not affect the data analysis.

14.4 Setting up the MORE mode

To measure in MORE mode, the following operations should be performed:

1. Appropriate setting for the beamline magnets (see Section 12.2). The kicker will be switched ON automatically.
   The readback of the kicker should be about 4.6 (corresponding to 4.6 kV)
2. Choose the appropriate MODE for the acquisition software. (In the **`deltat`** programme, chosse the tab **`TDC Settings`** and the button **`Modify Settings`**).
3. Be sure that the MORE electronics is set to send the muon-on request to GPS (see also Figure 32).
4. Start your measurements

15 Vacuum

The beamline vacuum is controlled by different pumps named PS32, PS33 (spin-rotator), PS34, and PS321 (GPS Instrument). Other pumps are located on the LTF branch. Different valves are also located along the beamline: VSD31 (between proton beam and πM3 beamline), VSD32 and VSD33 (up- and down-stream of the spin-rotator) and VSD321 (up-stream of the GPS instrument). In addition, two mylar windows (4 μm) are located at the beginning of the beamline and just in front of the GPS instrument.

The different pumps and valves are controlled from the vacuum-panel located near the entrance to the πM3.2 (GPS) area. During normal operation, all the valves should be open and all turbo-molecular pumps should be ON. Interlocks prevent the opening of, or will close, the valves in case of too large pressure difference.

Since 2011, the whole vacuum equipment of the beamline is operated from the new vacuum control panel located near the entrance of the GPS and LTF area.
Caution should be taken when operating this touch-panel as pumps and valves will close without additional warning.

Figure 34: Location of the vacuum touch-panel located near the entrances of the πM3.2 (GPS) and πM3.3 (LTF) area.

Note that the valves VSD31 and VSD321 are coupled with the beam blockers of the πM3.1 and πM3.2 areas, respectively. Thus, these valves can be operated between positions CLOSE and OPEN only when the respective beam blocker is OPEN. If the latter is CLOSED, the valve can only be operated between positions CLOSED and “SCHARF” (i.e. “READY TO OPEN”). In the “SCHARF” position, the valve will automatically open when the beam blocker will pass in the OPEN position. The beam blockers can either be opened locally at the respective doors or through the EPICS control system (see Section 12.2).

Pressure sensors are located along the beamline at the pumps level. The pressures can be read from the same touch-panel.

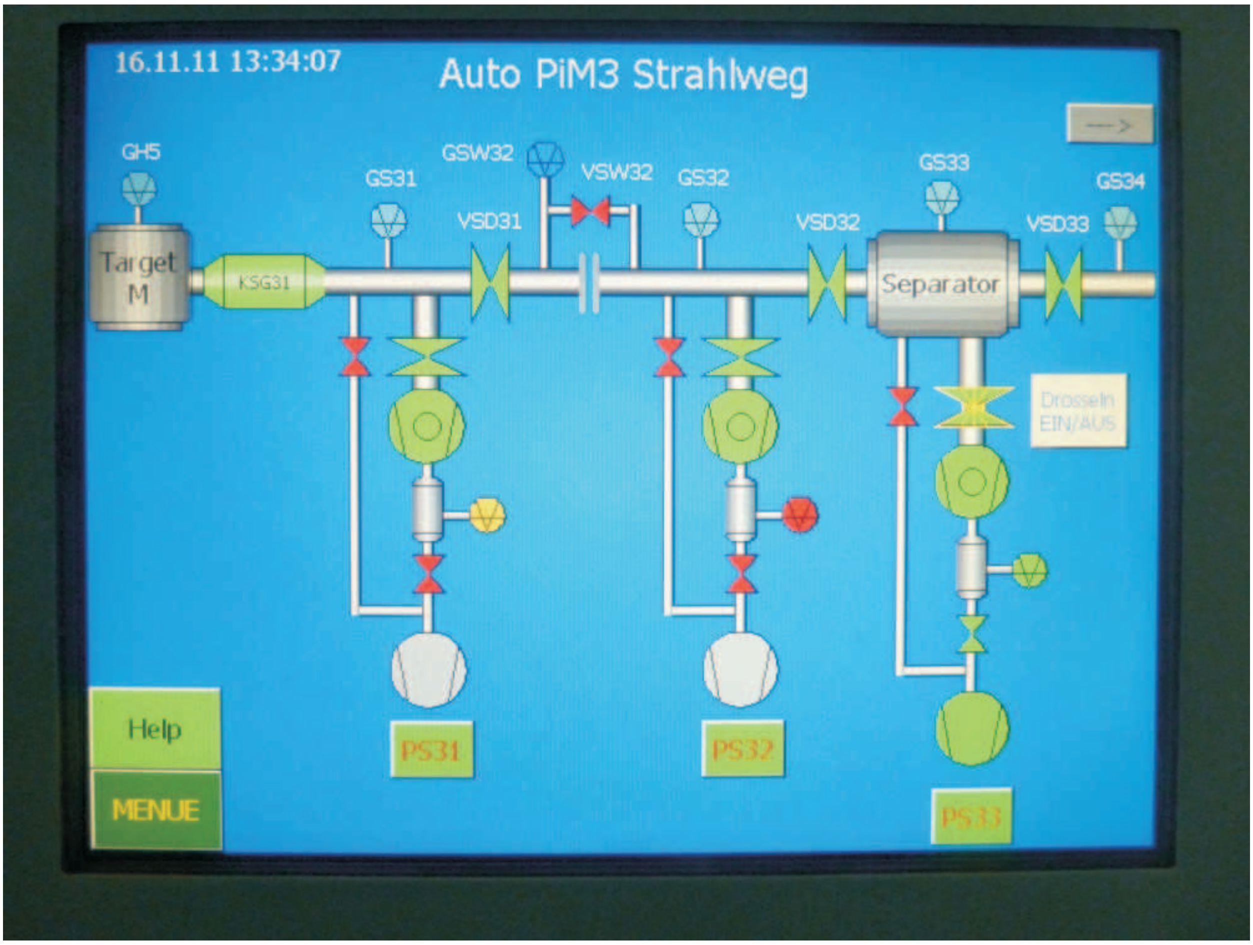

Figure 35: Display of one of the screens of the vacuum touch panel located near the entrances of the πM3.2 (GPS) and πM3.3 (LTF) area. During normal operation all the valves along the beamline should be open (i.e. green on the display). Also all the turbo-molecular pumps should be running (i.e. green on the display). The rough-pumps will only be automatically switched ON when needed (pressure in the buffer tank exceeding a given limit).

VI. Beam properties

16 Beam spot size

The beam spot size at the sample position is mainly determined by the shape of the hole in the Backward-Veto detector. Hence this beam spot size will only marginally depend on the opening of the slits FS302, which will therefore only act as a regulation of the event rate.

The beam spot size has been measured without cryostat (but with all detectors in position) with the help of a detector (width 2 mm). Horizontal and vertical scans have been performed. The results have been deconvolutated to take account of the finite width of the detector.

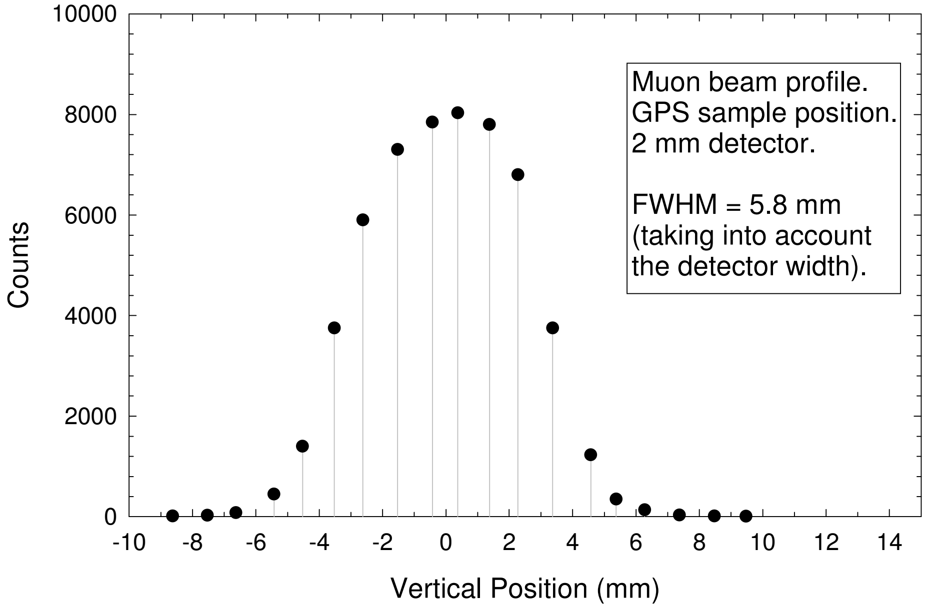

Figure 36: Raw data from a vertical scan of the beam spot at the sample position. After deconvolution, the FWHM is estimated to be 5.8 mm.

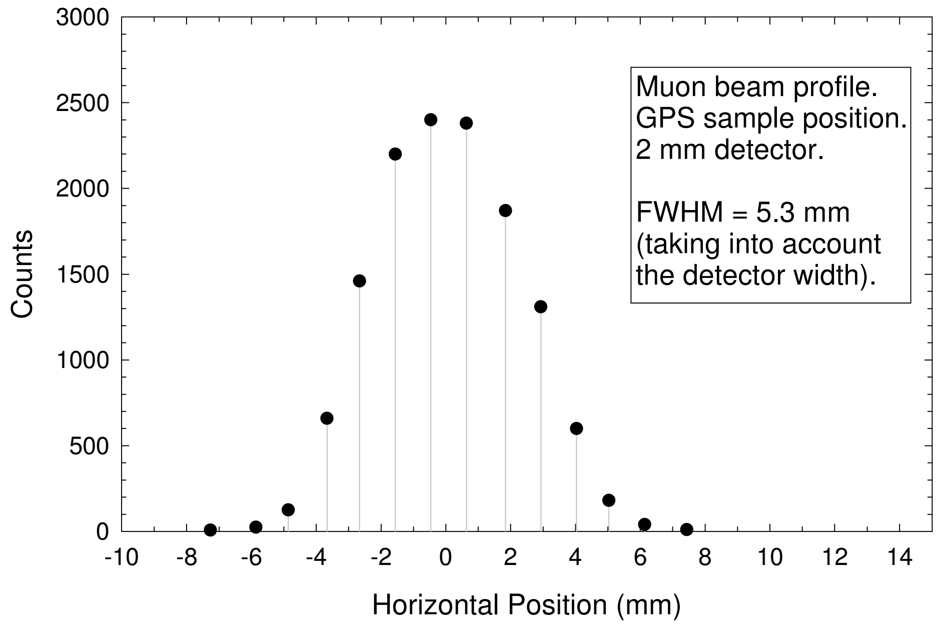

Figure 37: Raw data from a horizontal scan of the beam spot at the sample position. After deconvolution, the FWHM is estimated to be 5.3 mm.

17 Range

The muons in the beam hit the front surface of the sample at about 0.3c (4 MeV) and are then slowed by interactions within the material before stopping. The implantation energy of the muons results in them passing through several hundred microns of material before they come to rest. Prior to hit the sample, the muons will go through different material:

- 2 mylar windows (2×4 μm)
- the M detector (scintillator material: 0.2 mm)
- 2 layers of superinsulation (aluminized mylar: 2×10 μm)
- the cryostat titanium window (10 μm)

When entering the sample, the actual amount of material traversed by the muon and the width of the muon distribution depend upon the materials density - as a rough guide the muon range is roughly 130 $\mathrm{mg/cm^2}$ (compare to the 180 $\mathrm{mg/cm^2}$ just after the production target) of material i.e. about 1.3 mm of water, 0.6 mm of silicon, etc.

Figure 38 shows the fraction of stopped muons in aluminum foils of different thickness. The experiment was performed by piling up foils on a thick quartz plate and comparing the diamagnetic and muonium fraction of the μSR signal. The experiment was performed directly inside of the Quantum cryostat. All muons are stopped for an aluminum thickness of about 0.6 mm.

18 Effect of the field on the α parameter

In longitudinal configuration, the asymmetry is sometimes extracted from the direct difference between the Forward and Backward detectors. To take into account the different design and quality of the detectors, a parameter α is utilized (ideally $\alpha = 1$). This parameter is obtained by performing a measurements in a weak transverse field (usually the WEP magnet – see Section 19)
When a longitudinal field is applied, the interaction of the magnetic field with the incoming muons and the decay positrons creates a change of the parameter α. Figures 39 and 40 show the deduced asymmetry in longitudinal field by *assuming* a α parameter

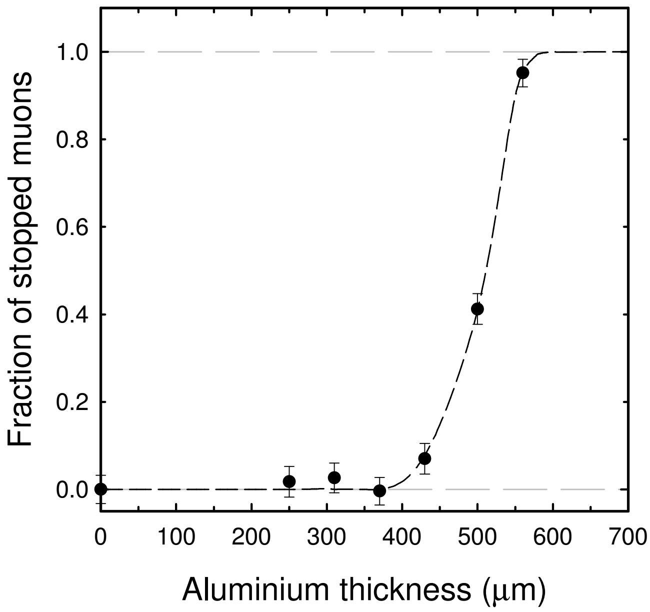

Figure 38: Fraction of stopped muons as a function of aluminum thickness.

constant. Both a small silver sample and a silver plate were measure in "Veto" and "Non-Veto" mode, respectively. This asymmetry change is an artifact that reflects the change of the parameter α. Hence, measurements performed in transverse polarization prove that the asymmetry is constant up to 6 kG, pointing therefore to a change of α to explain the reduction observed for example on Fig 39.

Experimental data can be corrected for this effect; however, the precise form of the curve depends on the initial value of α, and on the tunning used during the experiment. The users are therefore advised to perform their own calibration and not rely on the curves of Figures 41 and 42 which show the relative change of α assuming constant asymmetry in field.
Note also that the use or not of the Forward Veto counter in the definition of the Forward counter strongly affects the form of the apparent field dependence of the reduced asymmetry.

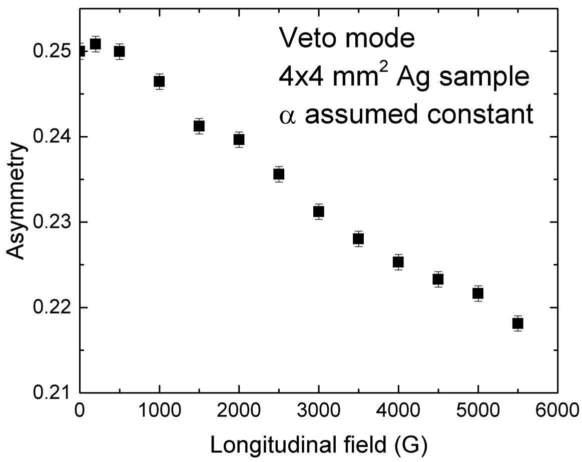

Figure 39: Evolution of the asymmetry deduced from the Forward and Backward detectors by *assuming* a constant parameter α. Measurements performed in "Veto" mode on a 4×4mm^2 silver sample.

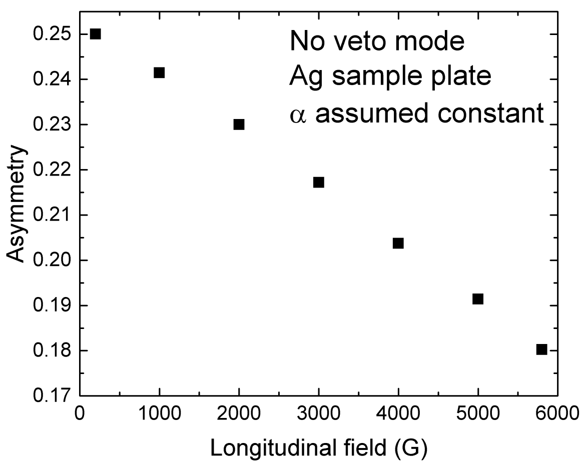

Figure 40: Evolution of the asymmetry deduced from the Forward and Backward detectors by *assuming* a constant parameter α. Measurements performed in "Non-Veto" mode on a large silver plate.

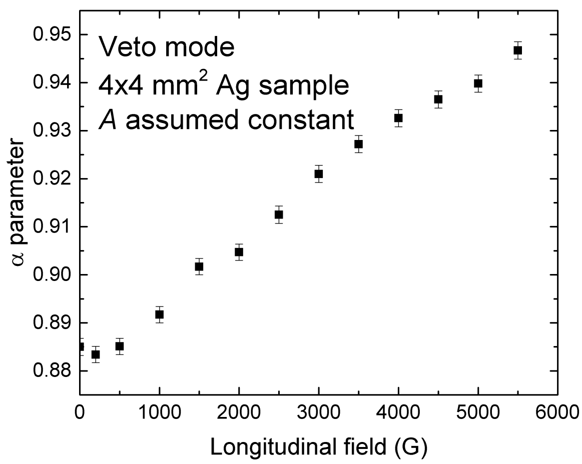

Figure 41: Evolution of the α parameter deduced from the Forward and Backward detectors by *assuming* a constant asymmery parameter. Measurements performed in "Veto" mode on a 4×4mm^2 silver sample.

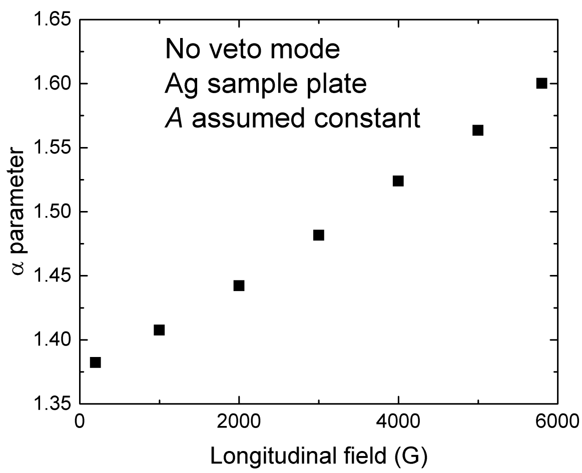

Figure 42: Evolution of the α parameter deduced from the Forward and Backward detectors by *assuming* a constant asymmery parameter. Measurements performed in "Non-Veto" mode on a large silver plate.

19 What to mind when determining the α parameter

In addition to the problem explained above, the users should mind some basics points when determining the α-parameter.
For example, a very slight field dependence of the alpha parameter on the value of the WEP field can be observed (see Figure 43). This dependence arises from the vertical shift of the beam-spot on the target. This is demonstrated by the large shift observed in the α-parameter for the Up/Down detectors measured with the same beam condictions. On the other side, the effect on the α-parameter for the Forward/Backward is rather low, but if extremelly precise determination of α are necessary, it is adviced to extrapolate its value at zero-field by measuring at different WEP values.

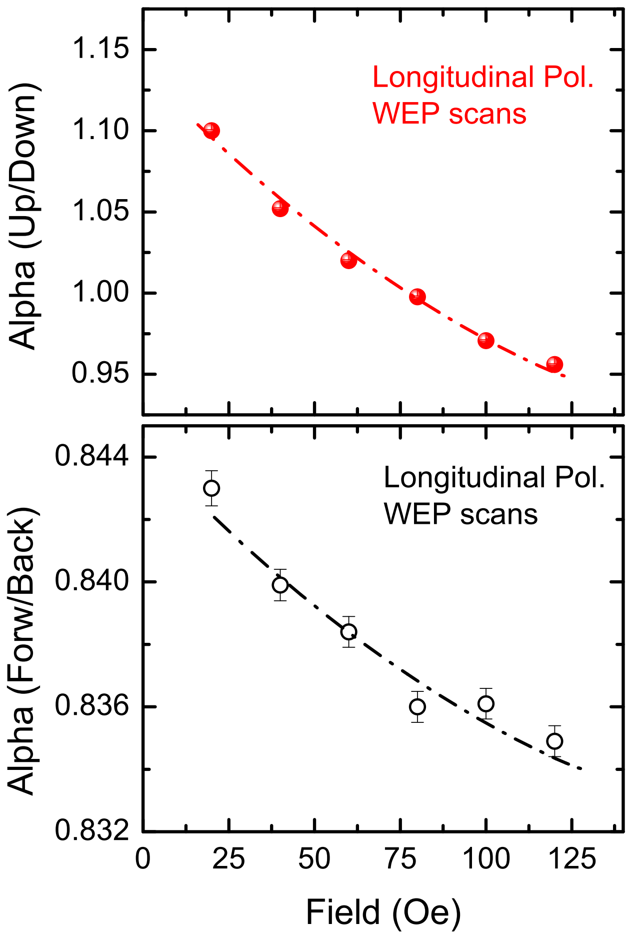

Figure 43: Field dependence on the determination of the parameter α by using the WEP magnet in the longitudinal polarization. Note the much larger shift for the α parameter of the Up/Down counters compare to the one of the Forward/Backward counters. The Forward Veto counter was aded in the definition of the Forward counter.

When performing zero-field experiments in the longitudinal polarization, i.e. using not only the Forward/Backward detectors but also the Up/Down ones, the users should determine the Up/down α parameter using the WEDLow Magnet and not the WEP one. This again arises from to the vertical shift of the beam-spot on the target produced by the WEP magnet (see Figure 44).

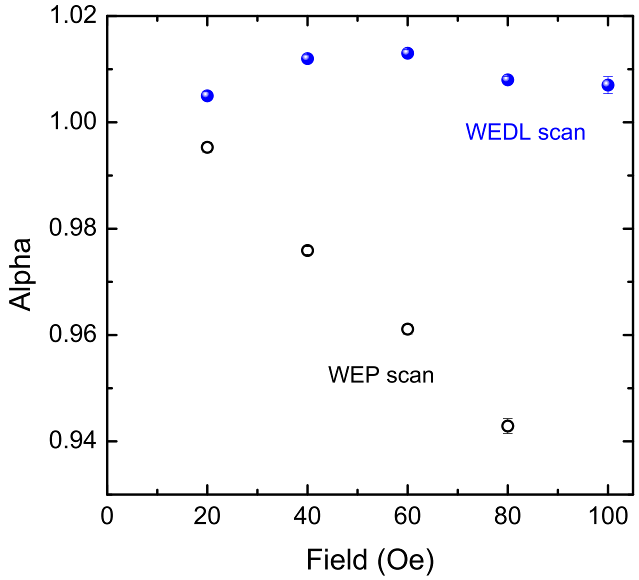

Figure 44: Field dependence on the determination of the parameter α for the Up/Down counters by using either the WEDLow or the WEP magnets with a beam having transversal polarization. Note the much larger shift for the α parameter when using the WEP magnet, due to the vertical shift of the beam-spot on the target.

VII. Annex A

20 Magnet power supplies

20.1 List of power supplies

Table 15: List and specification of the magnet power supplies for the πM3 beam line. A layout of the power supplies location is given on the Figure 30 on page 77.

Magnet	Current	Voltage	Limitation
QTH31	120	50	
QTH32	50	50	
QTH33	50	50	
ASL31	50	12	
QSL31	50	50	
QSL32	50	50	
QSL33	50	50	
QSL34	50	50	
ASL32	50	12	
QSL35	50	50	
QSL36	50	50	
SSK31	10	24	
SPIN-ROT SEP31	500	80	
SPIN-ROT HV+		200 kV	
SPIN-ROT HV-		200 kV	
QSE31	50	50	
QSE32	120	50	
ASK31	120	50	
QSE33	50	50	
QSE34	50	50	
SSK32	10	24	
QSE35	50	50	
QSE36	120	50	
ASS31	500	80	
SSK33	20	24	
QSE37	50	50	
QSE38	50	50	
ASK32	50	12	
QSE303	50	24	
QSL302	50	24	
QSE304	50	24	
QSE301	50	24	
QSL302	50	24	
QSE302	50	24	
WED	650	300	100%
WEDL	50	24	100%
WEP	200	50	100%

VIII. Annex B

21 MOGLI Quick references

21.1 Starting MOGLI

- Make sure the power ("Netz") is connected to a 380V plug socket and all devices are switched on.
- Make sure the compressed-air pipe is connected on the local compressed-air system
- Make sure all the vacuum parts are well connected and the manual flood valves are closed
- If the main switch is on (5F0) the FPS-display should show PST OFF, HV LOCKED.
- Decide wheter to UNLOCK HV or not (F4, F3). If UNLOCK is choosen, the HV valve will open when pre-defined pressure conditions are fullfilled.
- The recipient will be evacuated relatively fast. For evacuating slowly (fragile windows) install an additional fine-adjust-valve between the recipient and the MOGLI unit.
- Press PST ON (F1) to start MOGLI.

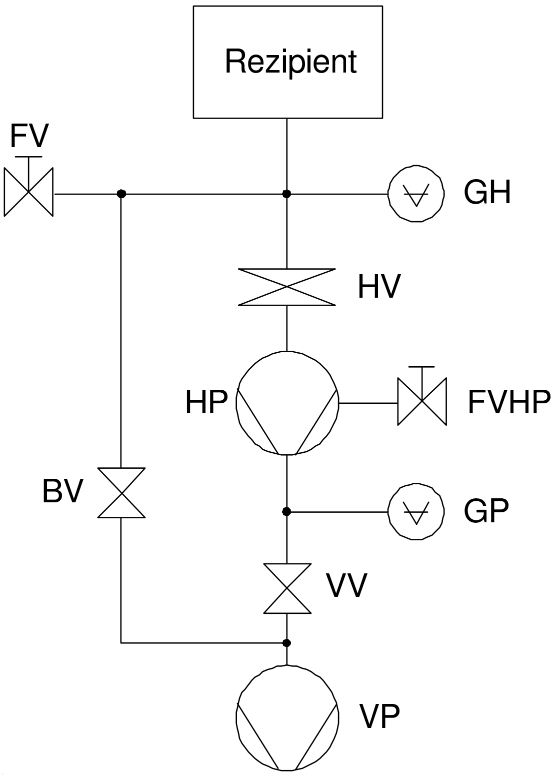

Figure 45: Vacuum diagram of a MOGLI unit.

21.2 MOGLI Running

- While MOGLI is running observe the dual gauge for the actual pressure, the Turbo Control Unit (TCU) for turbo indicators and the FPS-display for messages from the controller (see Table 16).

- To change the turbo-pump to standby-mode use the TCU front-panel.
- Prior to change recipients or open extern valves while MOGLI is running, you must first press the button LOCK HV on the FPS Unit.
- Never use the manual flood valves (FV, FVHP) or the manual switches of pneumatic valves (VV, BV, HV) without well-instructed staff and reading carefully the documentations of MOGLI.

Table 16: Meaning of the FPS indicator LEDs

IN (green LED)		**OUT (red LED))**	
I 01	HP ok.	O 02	HP on
I 02	HP 80%	O 03	VP on
I 03	VP run	O 06	open VV
I 04	VV open	O 07	open BV
I 05	VV closed	O 09	open HV
I 06	BV open	O 11	GP < 0.1mbar
I 07	BV closed	O 12	GH < 1mbar
I 10	HV open		
I 11	HV closed		
I 14	VP at speed		

21.3 Errors

You can find the full version of how to fix an error in the complete documentation. The FPS shows errors on the display as scrolling text messages.

- FPS shows wrong display text
  Solution: load FPS-program “Mogli_v2.fps” from a computer to FPS.
- VP ERROR
  VP is not at speed after 30 seconds.
  Solution: check wiring, let VP run separately (external power).
- HP ERROR
  No feedback HP ok after 30 seconds.
  Solution: check wiring and TCU.
- START TIME ERROR
  GP > 0.1 mbar after 10 minutes.
  Solution: Check Pirani Gauge and vacuum-connections up to HV.
- RECOVERY TIME ERROR
  GP > 0.1mbar after 1 hour when HV open.
  Recipient Volume could be to big.
  Solution: Make sure FV and FVHP are closed. Check GP and GH.
- INGRESS OF AIR
  GH > 1 mbar when HV has been open.
  Most probably a leak in the vacuum system.
  Solution: Fix it.
- COMPRESSED AIR ERROR
  Valves do not react.
  Solution: check compressed-air connections.

If you fixed an error press ERROR RESET (F5). If the problem is solved the error message does not appear anymore.

References

[1] J.H. Brewer *et al.*, Hyperfine Interact. 66 (1990) 1137.

[2] J.L. Beveridge *et al.*, Z. Phys. C 56 (1992) S258.

[3] R. Abela, A. Amato, C. Baines, X. Donath, R. Erne, D.C. George, D. Herlach, G. Irminger, I.D. Reid, D. Renker, G. Solt, D. Suhi, M. Werner and U. Zimmermann, Hyperfine Interact. 120/121 (1999) 575.