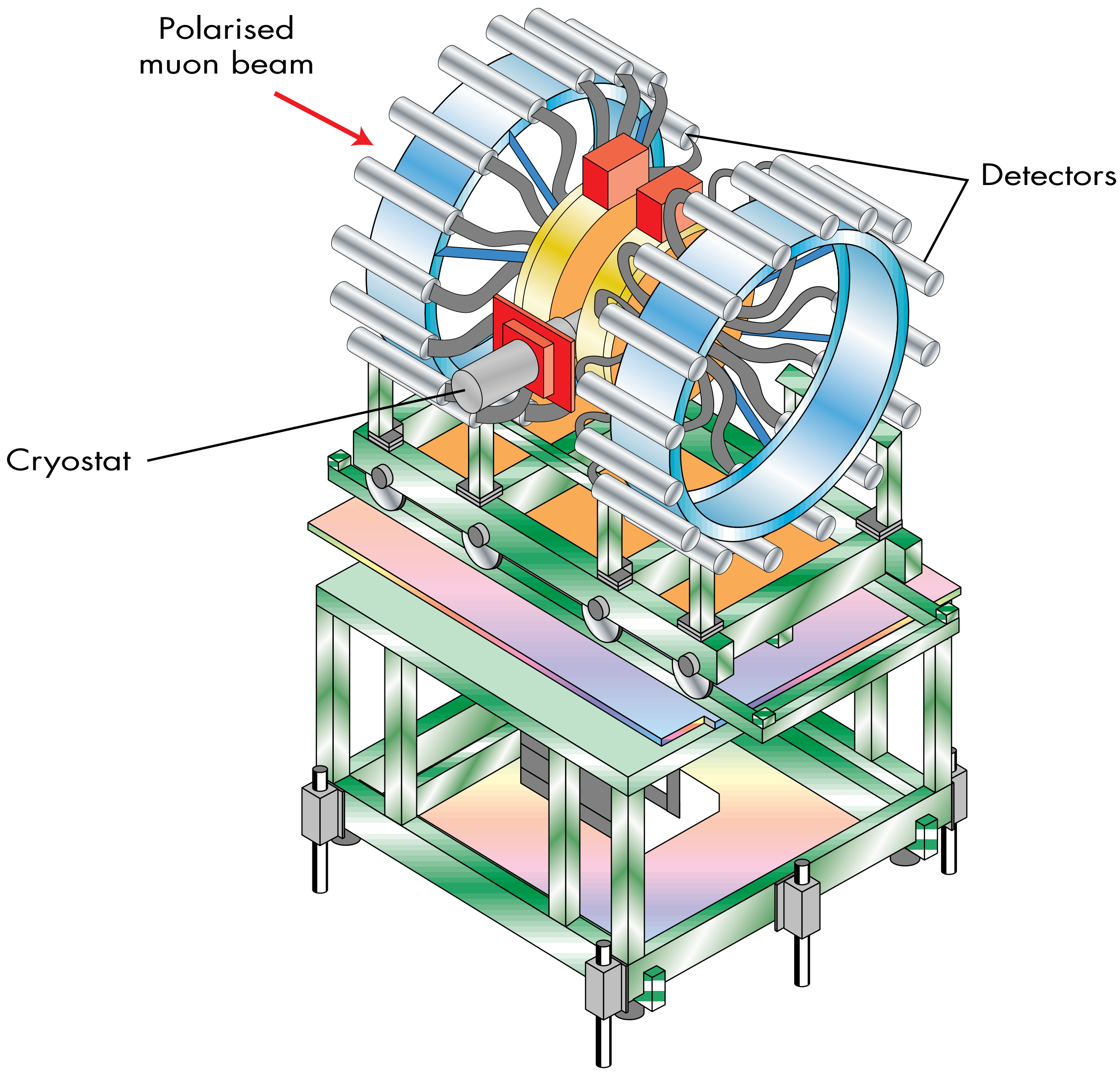
The MuSR User Guide



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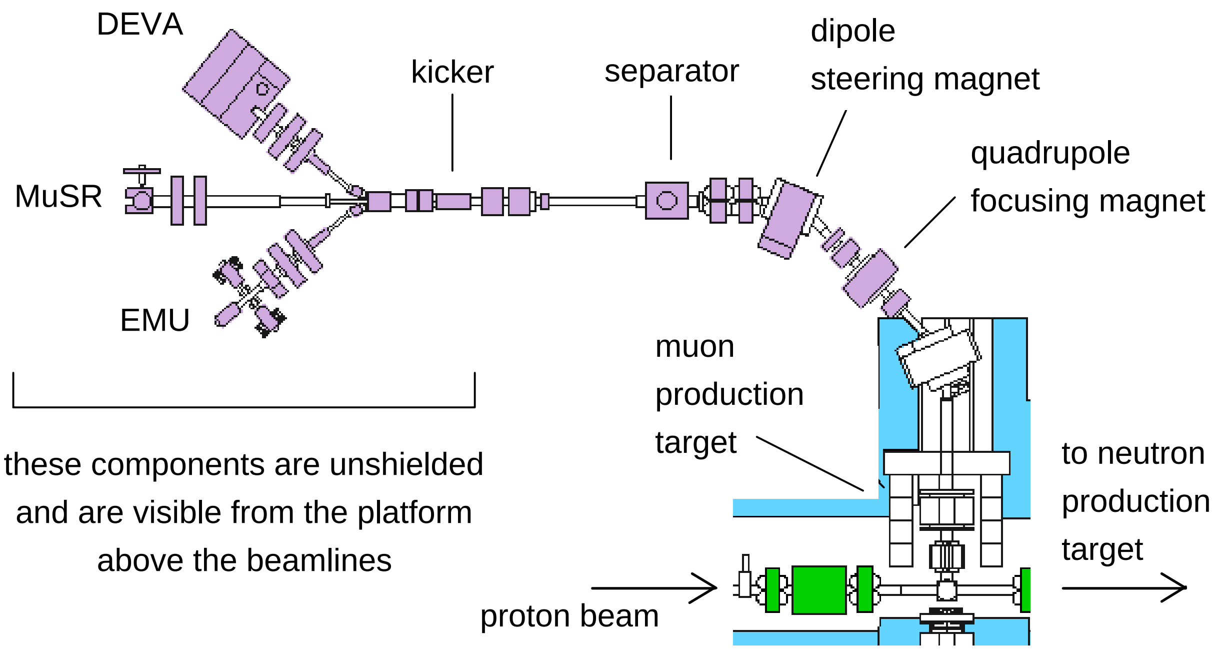


Figure 1. Layout of the ISIS muon beamlines

1. Introduction

This User Guide is intended to be a practical manual to help users of MuSR set up and run an experiment on the instrument. It contains details of all the main procedures, but if there are things you are unsure about always check with your local contact or the instrument scientist.

1.1 Setting up an experiment

There are certain standard procedures common to most of the experiments run on MuSR. Before beginning to take data, the following must be considered:

- correct instrument geometry (see section 2)
- operation of sample environment (see section 3)
- correct magnetic field for
  - (a) compensation of the Earth's field,
  - (b) calibrations,
  - (c) measurements

  (see section 4)
- appropriate beam size, event rate and steering (see section 5)
- use of computing facilities for data acquisition and analysis (see sections 6-8)

Section 9 gives details of other elements of the muon beamline and spectrometer which the user should be aware of, and section 10 is a brief guide to what to do when things don't seem to be working. Further sources of information and details of how to contact people within the facility are given in section 11.

1.2 The MuSR area interlocks

1.2.1 Closing the area

The blocker which prevents muons entering the MuSR area can only be raised once the area interlocks are complete. For this to happen:

1. Close the gate which allows access above the spectrometer on the top of the MuSR platform, remove its key and insert into the key box to the right of the lower area door. Turn the key clockwise.
2. Check that no-one is inside the MuSR area. Close the area door and remove the key from the lock (turning anticlockwise). Insert this key into the key box to the right of the door, turning it clockwise.
3. The key box should now be full. Remove the bottom right hand key and insert it into the green box to the right of the key box, turning it clockwise.
4. Check that the Helmholtz magnet interlock key below the blocker raise / lower buttons is in the vertical position (see section 4.3).
5. The blocker can now be raised: press the red raise button and keep it pressed until the blue area lights come on and the blocker has stopped moving.

1.2.2 Entering the area

To enter the MuSR area

1. If you require the main Helmholtz coil field to not be set to zero, check that the key below the blocker raise / lower buttons is in the override (horizontal) position (see section 4.3).
2. Lower the blocker by pressing and holding the green button. The area lights come on once the blocker is down.
3. Remove the key from the green box by turning it anticlockwise, insert it into the bottom right position on the key box and turn it clockwise.
4. Remove one of the keys (the two left-most keys on the top row are often the easiest) from the key box and insert it into the door lock. Turn it anticlockwise. The door can now by opened by removing the locking bolt.
5. If it is necessary to open the gate on the MuSR platform, remove a second key from the key box and insert it into the gate lock, turning it clockwise.

2. The MuSR spectrometer

Positrons from the decay of muons implanted into the sample under investigation are detected using scintillation detectors. MuSR contains 32 such detectors, each detector consisting of a piece of plastic scintillator joined by an acrylic light-guide to a photomultiplier tube. The detectors are arranged in two arrays around the sample position on a cylinder concentric with the coils of the main Helmholtz magnet.

The detector arrays and Helmholtz coils can be rotated on their support platform about a vertical axis. When the spectrometer is in longitudinal geometry, the Helmholtz coils provide a field (of up to 2000 G) which is parallel to the initial muon polarisation direction. Rotating the spectrometer through 90^0 in a clockwise direction looking from above puts in into transverse geometry, in which the Helmholtz coils provide a field which is perpendicular to the initial muon polarisation direction. In this case, fields of up to about 600 G are useable, limited by the frequency response caused by the finite width of the muon pulse (see section 4.3.1).

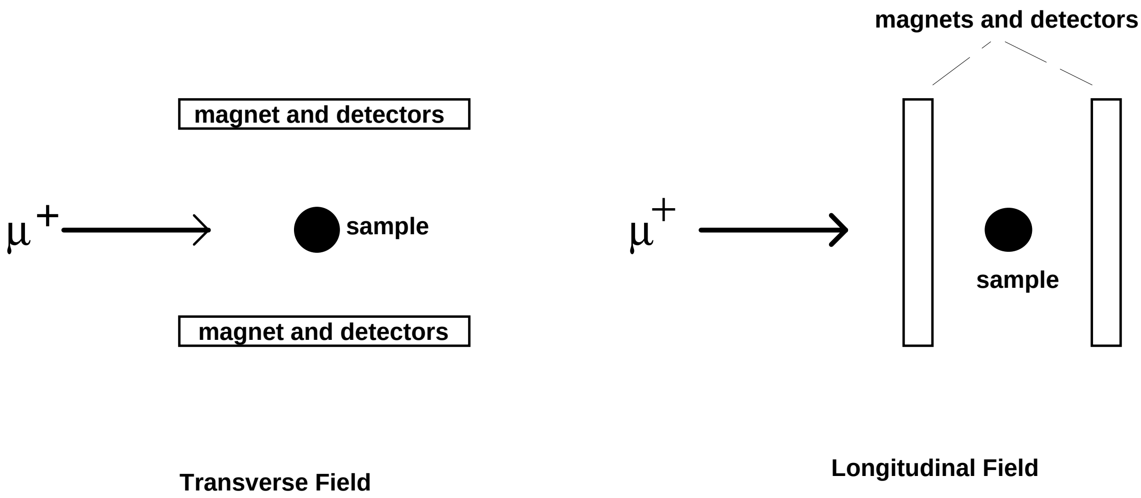


Figure 2. Field and detector arrangements in the two MuSR geometries

In the longitudinal case, one detector array is forward of the initial polarisation direction, and one is backward. Looking upstream (i.e., anti-parallel to the muon momentum, parallel to the initial polarisation direction), the detectors are numbered as below.

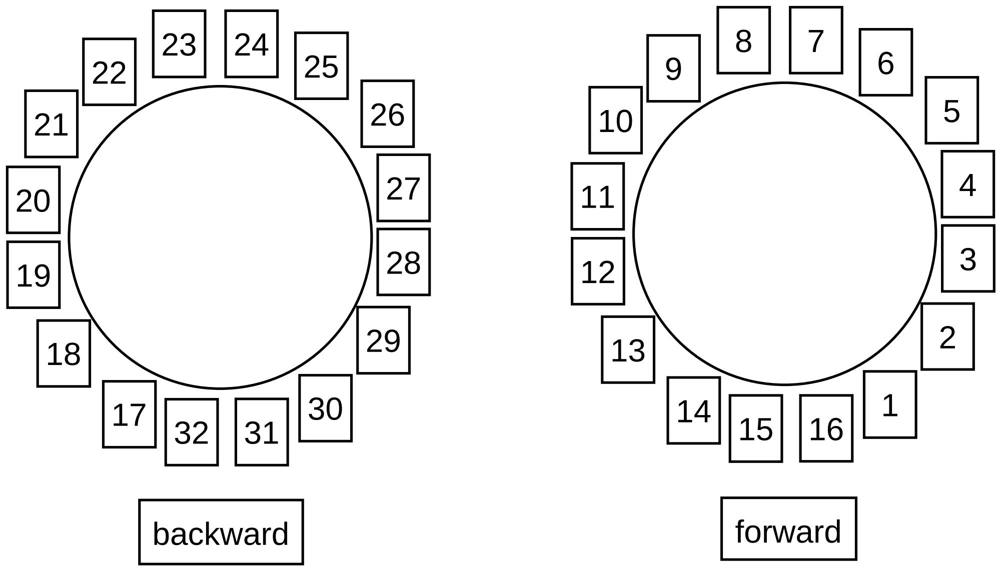


Figure 3. MuSR detector numbering

In order to form a longitudinal forward-backward grouping, detectors 1-16 are summed to form the forward set, and detectors 17-32 summed for the backward set.

In the transverse case, the two detector arrays are perpendicular to the initial polarisation direction. A suitable way of grouping the detectors in this case is in four groups of eight: top (6-9 + 22-25), bottom (14-17 + 30-32 + 1), forward (10-13 + 18-21) and backward (2-5 + 26-29). These sets can be analysed separately, or further arranged into forward-backward sets (top-bottom, forward-backward).

The two detector arrays can each be moved a small distance along a line parallel to the Helmholtz coil axis. In longitudinal geometry, the two detector halves should be moved outwards (away from the sample position) symmetrically, the amount of movement being determined by a stop on the slide rail of the forward (upstream) set. In transverse geometry, the two detector halves should be pushed in towards the sample until the ends of the detectors are flush with the inside of the Helmholtz coils. These movements slightly increase the maximum asymmetry (from, for example, about 22% to about 23.5% in the longitudinal case) in the two operating modes.

MuSR can be rotated between transverse and longitudinal geometry in about 45 minutes. However, **it is important that an instrument scientist be present when the rotation is carried out**: careless actions during the rotation can damage the photomultiplier tubes or puncture the windows in the beam line or dilution refrigerator.

3. Sample environment

The following sample environment equipment is available on MuSR:

Equipment	Temperature Range
Dilution refrigerator	40 mK - 4.2 K
Sorption cryostat (from Round 1/98)	350 mK - 50 K
‘Orange’ cryostat	1.6 K - 300 K
Closed cycle refrigerator	12 K - 400 K
Furnace	300 K - 1000 K

Generally, the choice of sample environment will have been made several weeks before the start of the experiment and the equipment will have been prepared by the ISIS sample environment (SE) group. Although the SE group will help in the preparation of cryostats, they cannot be expected to provide support 24 hours a day and users should therefore be able to change samples and temperatures unaided.

The spot from the laser mounted on the MuSR area wall is close to the correct beam position and should be used as a guide for positioning samples in the CCR. Cryostats should be inserted into the beamline with the laser spot as close to the cross on the back of the cryostat tail as possible, and the spot should fall on the centre of the 12-pin Jaeger connector on the furnace stick when it is in the correct position.

3.1 Dilution refrigerator

Users of the dilution refrigerator (DR) are expected to arrive at ISIS at least 24 hours before the start of an experiment to work with the local contact mounting a sample and starting the precooling process. This takes place out of the beam during the previous users’ beam time. Once the DR is prepared it has to be lowered into the beam by a licensed crane driver. As few users hold a crane driver's license this will involve the local contact or, in emergencies, a member of the ISIS crew. Data collection and sample environment in the DR is controlled by the software "MCD" (see section 8.1). Details of all DR procedures are in the manual on top of the MuSR platform.

3.2 Orange cryostat

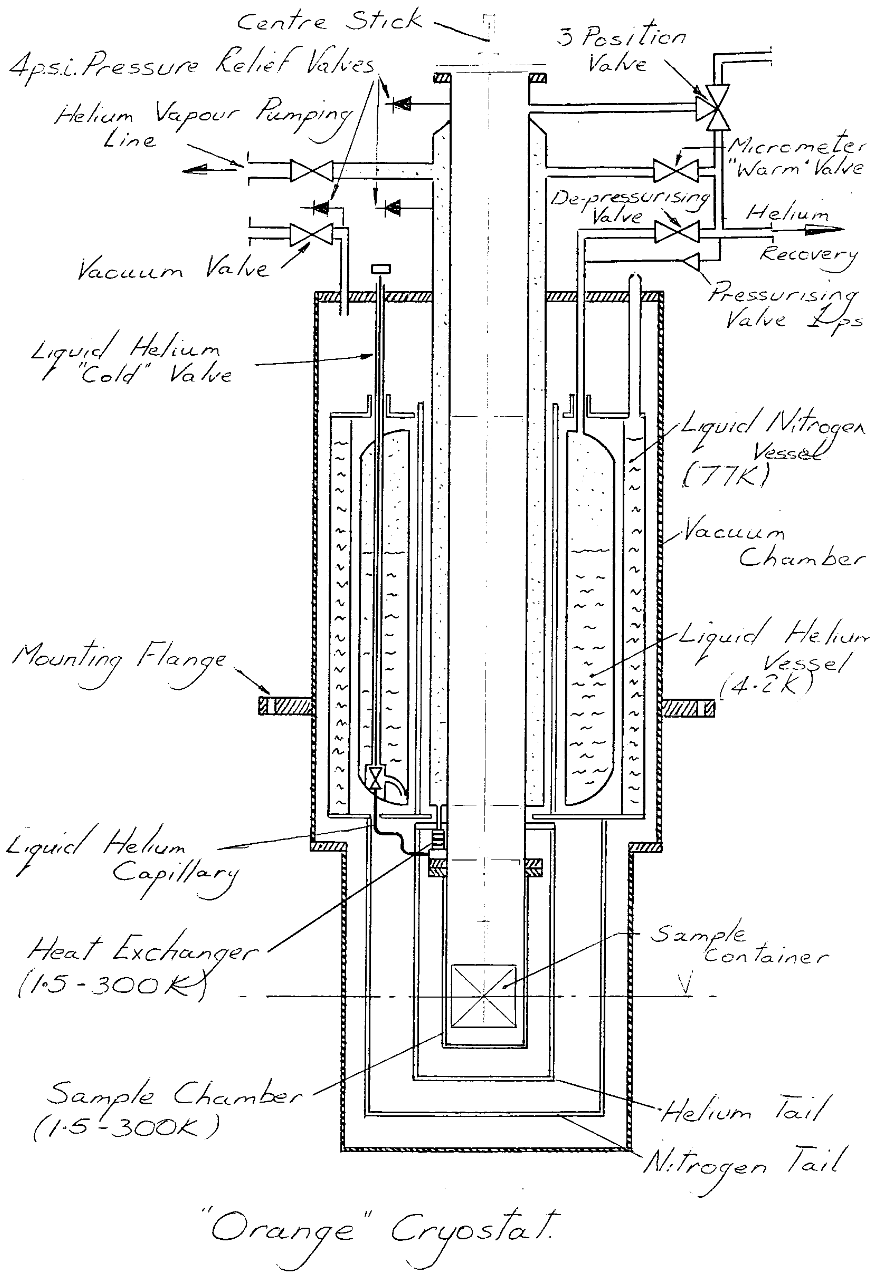


Figure 4. The Orange cryostat

The orange cryostat (OC) will have been prepared off-beam by a member of the ISIS SE group. It must be craned into position on the beamline by a licensed crane driver.

The OC is controlled by the ITC5 temperature controller on the platform above the spectrometer. This device is selected in MCS by typing either `@orange_itc502` (for the stick with sensor number 4962, which must be connected to ITC5 channel 2) or `@orange_itc503` (for the stick with sensor number 5448, which must be connected to ITC5 channel 3). The data switches in the back of the MuSR cabin and in the MuSR area must be set to 'OC'. The cryostat He recovery port should be connected to the He return panel on the platform.

Below is a brief guide to operation of the orange cryostat. More detailed information about filling with helium and changing a sample can be found in the following RAL reports:

- *Use of cryogenic liquids on ISIS instruments*
  J Chauhan, A V Belushkin and J Tomkinson, RAL-92-041
- *Changing a sample on ISIS instruments*
  J Chauhan, A V Belushkin and J Tomkinson RAL-93-006

There is also an ISIS video explaining how to operate an orange cryostat; this can be viewed in the users' coffee area near the Data Analysis Centre.

3.2.1 Removing a sample

1. Ensure the cryostat is at about 25 K.
2. Ensure the cryostat is connected to the He return panel, or that a non-return valve is fitted to the He outlet.
3. Fill the sample space with He by turning blue 'Hoke' valve (valve 5) downwards. Wait until the flow meter on the He return line registers flow again.
4. Remove the sample stick quickly but smoothly and cover the sample space with the blanking flange, screwed down. Return the Hoke valve to its horizontal position.
5. If the cryostat is to be left for a time without a sample present, pump the sample volume (via the Hoke valve, turned to upwards position, using the small rotary pump).

3.2.2 Loading a sample

1. Ensure the sample stick is completely dry before inserting it into the cryostat.
2. Ensure the cryostat is at about 25 K.
3. Ensure the cryostat is connected to the He return panel, or that a non-return valve is fitted to the He outlet.
4. Fill the sample space with He by turning the blue 'Hoke' valve (valve 5) downwards. Wait until the flow meter on the He return line registers flow again.
5. Remove the blanking flange and introduce the sample stick quickly but smoothly. Replace the screws.
6. Pump the sample space (via the Hoke valve, turned to its upwards position) to ~1 Torr using the small rotary pump.
7. Turn the Hoke valve to its downwards position to add He to the sample space, and pump again to about 1 Torr.
8. Add He to the sample space again and pump until the pump meter reads 15 Torr. This is the correct exchange gas pressure.

3.2.3 Cooling the cryostat to 4.2 K

This involves operation of the 'cold valve' (valve 4) and the 'warm valve' (valve 6). The cold valve controls a needle valve which allows liquid helium from the main reservoir into the annular space via a capillary and heat exchanger. To close the cold valve it should be turned clockwise. Be careful not to over-tighten it, otherwise the needle may be damaged.

1. Connect the temperature sensor leads to the ITC5 and the cryostat (check that the sample stick sensor is connected to the correct ITC5 channel).
2. Open the cold valve (rotate it between half and one turn anti-clockwise from when it first 'bites').
3. Open the warm valve until the He flow rate is at maximum on the He return line meter (10 l/min).
4. Wait for the cryostat to cool to the desired temperature.
5. Close the warm valve until the He flow rate is 4-5 l/min.

3.2.4 Cooling the cryostat below 4.2 K

This requires the He brought through the needle valve to be pumped using the large ‘Roots’ pump. The cryostat temperature must be below 50 K before pumping starts.

1. Connect the Roots pump to the He pumping valve (valve 3) of the cryostat.
2. Close the cryostat cold and warm valves fully.
3. Make sure the cryostat valve 3 is closed. Disconnect the flow meter from the Roots pump outlet if one is attached. Turn the Roots pump on (press both green buttons) and open the big isolation valve on the pump to evacuate the line up to the cryostat. Wait until the gauges on the pump read zero.
4. Slowly open valve 3 of the cryostat. Wait for a few minutes, then reconnect the flow meter to the Roots pump outlet line. Open the fine control of the cold valve *very slightly*, until the pump flow meter is reading maximum.
5. When the cryostat has reached the required temperature, close the cold valve until the pump flow meter is reading <4 l/min (this may mean winding the valve control until it is fully closed).

3.2.5 Filling with Helium

The time for which a helium fill will last is greatly dependant upon the type of experiment being carried out. Sustained running at high temperatures or repeatedly cycling between high and low temperatures can require a fill every twelve hours. At the other extreme, a helium fill can last for twenty-four hours if running at a near constant low temperature. As a general guide, the helium level should be checked at least once every twelve hours (don’t forget to fill with nitrogen too).

The following procedure should be followed to fill the cryostat. Users should note that two people are required. Use the flexible transfer tube on the side of the MuSR platform.

1. Switch on the helium level gauge and check it is set for ‘fast’ readout.
2. Open the by-pass valve on the He return line, and the depressurising valve on the cryostat (valve 8).
3. Vent the helium storage dewar by opening the red valve. Open the top valve on the dewar then close both red and green valves.

4. Slowly lower the longer end of the transfer line into the helium storage dewar. The other end of the transfer line will require support. The fitting on top of the storage dewar should be tightened to prevent gas escaping.
5. Helium gas should immediately begin exhausting from the transfer line. After approximately one minute cold gas will be felt and a short while later a plume will form.
6. Once a plume is observed quickly insert the transfer line into the helium fill port on the cryostat (normally closed by a brass plug). Note that if refilling with helium the transfer line should only be pushed approximately halfway into the cryostat dewar.
7. Helium transfer should now take place, the process taking a few minutes (for a refill).
8. During the transfer an over-pressure must be maintained in the helium storage dewar using a He gas line or bladder attached to the red port.
9. When the helium level gauge measures 370 mm stop the transfer by releasing the pressure in the storage dewar, typically by removing the gas line / bladder and opening the red valve. Remove the transfer line from the cryostat and replace the brass plug, ensuring it has been fully tightened (the fitting may require heating). Remove the transfer line from the dewar and open the green valve.
10. Leave the helium storage dewar with both the top valve and the red valve shut and the green valve open.
11. Switch off the helium level gauge.
12. When the He recovery flow has returned to less than 10 l/min. close the He recovery by-pass valve. Close the depressurising valve on the cryostat (valve 8).

3.2.6 Care of the cryostat when not in use

The cryostat can be left in its support frame, either on the MuSR platform or at ground level, when not immediately required. In this case, users should leave the cold and warm valves open a very slight amount to allow a small flow through the cryostat; this reduces the chance of the cryostat blocking, but does not use large amounts of helium. **Users should still remember to check the cryogen levels once every twelve hours and refill as required.**

3.2.7 Additional notes

- At low temperatures, the exchange gas in the sample volume may have condensed, leading to poor thermal contact to the annular space. The exchange gas pressure can be monitored using the meter on the small rotary pump (with the pump valve closed, and the blue Hoke valve turned upwards). If the pressure has dropped, add more gas by turning the Hoke valve to its downwards position for an instant, and then pumping the sample space to the required pressure.
- If oscillations in the temperature of the cryostat are observed, the exchange gas pressure may be too high. Try pumping the exchange gas to 5-10 Torr.
- When cooling, the He flow rate through the return line should be controlled by the warm valve setting. If opening the warm valve a small amount doesn't increase the flow rate, open the cold valve until the rate increases and then close the warm valve to achieve the required rate.
- When the cryostat is at the required temperature, the He flow rate should be reduced to about 4-5 l/min. But this rate should be monitored for the first hour or so after cooling as it will be affected by any liquid helium which has entered the annular space. The flow rate may change as this liquid boils off and may become too low when the annular space no longer contains liquid.
- At very low temperatures, an offset between the sample and cryostat thermometers can be expected owing to condensation of the exchange gas in the sample space.

3.2.8 The Oxford ITC503 Temperature Controller

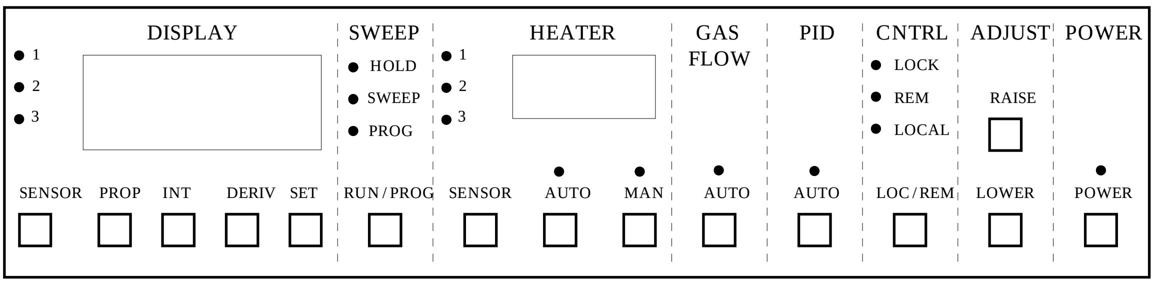


Figure 5. The front panel of the ITC5 temperature controller

A diagram of the front panel of the ITC503 is shown below. Two types of interaction with the controller are possible: inspecting the present settings while running the controller in automatic mode, and switching to manual control to adjust parameters.

Inspecting the controller (automatic operation)

To guard against inadvertently altering settings, the user should ensure the controller is in remote mode (i.e. the remote light is on) before inspecting any parameter. Pressing the ’LOC/REM’ button toggles the controller between local and remote modes of operation.

Requirement	Action
View temperature of sensor 1, 2 or 3	Press the ‘SENSOR’ button until the LED corresponding to the particular sensor is alight.
View current set temperature	Press the ‘SET’ button.
View current heater voltage	Press the ‘AUTO’ button under ‘Heater’.

After checking the parameter ensure that the controller is still in the required mode of operation, usually with the heater in automatic mode.

Manually adjusting parameters

Switch the controller to the local mode of operation by pressing the ’LOC/REM’ button. Note that MCS will periodically return the controller to the remote mode.

Requirement	Action
Adjusting the set temperature	Press the ‘SET’ button with either the ‘RAISE’ or ‘LOWER’ buttons under ‘ADJUST’.
Adjusting the heater voltage	Press the ‘MAN’ button under ‘Heater’ simultaneously with either the ‘RAISE’ or ‘LOWER’ buttons under ‘ADJUST’. The voltage can be read. Note that the heater sensor is always number one.

3.3 Closed-cycle refrigerator (CCR)

The CCR is controlled using the Eurotherm TC820 controller in the rack in the MuSR area. Check that both data switches (in the MuSR area and in the back of the MuSR cabin) are at the CCR position. The sensor and PID values are set by typing `@CCR_TC820` at the MCS prompt.

Users will need to know how to change the sample in the CCR. In preparation for a sample change the temperature should be set to 300K and the compressor turned off. Once the CCR has reached a reasonably high temperature (>270 K) the following procedure can be carried out to remove the sample:

- Close the large isolation valve on the top of the pump
- Switch off the pump
- Open the vent valves to vent the pump and CCR
- Swing the CCR out from between the magnet faces
- Remove the CCR tails and unscrew the sample plate from the copper block

TAKE CARE NOT TO BEND THE RhFe THERMOMETER LEADS

After mounting a new sample, close and restart the CCR in the following way:

- Dry the CCR, heat shield and outer tail (use a heat gun, but be careful not to heat the thermal fuse). Replace the tails, checking that the windows are aligned and facing the muon beam pipe window.
- Swing the CCR back into place taking care not to knock the calibration coils.
- Check the vent valves are closed.
- Start the vacuum pump and switch on the Pirani gauge.
- Slowly open the large pump isolation valve.
- When the Pirani gauge reads $<10^{-1}$ Torr the Penning gauge automatically switches on.
- Below 5×10^{-3} Torr the compressor may be switched on by turning the switch on the front the central compressor (outside the area) from 0 to 1.

The compressor must be left on for all sample temperatures, including those above room temperature.

There is a thermal fuse on the heater lead inside the CCR to prevent excessive heating. Users can check that the heater is working by heating to slightly above room temperature before starting to cool.

3.4 Furnace

The muon furnace is designed to allow μSR experiments to be carried out on the EMU and MuSR spectrometers (with MuSR in either longitudinal or transverse orientation) at temperatures from room temperature up to 1000 K.

It consists of an outer vacuum jacket with a thin (30 μm) titanium window to allow muon entry, into which a centre stick is inserted which holds the sample and heating element. The sample temperature is monitored by a thermocouple sensor mounted on the sample plate, and controlled by a Eurotherm temperature controller; this in turn is monitored and controlled from MCS. The outer body of the furnace is cooled by water flowing through external pipes and around the muon entry window. Two heat shields (also 30 μm Ti) between the entry window and the sample position also reduce heating effects on the furnace window.

3.4.1 Sample mounting

The furnace centre stick allows samples up to 40 mm x 40 mm to be mounted, and the Ti mounting plate is drilled to allow sample holders of the size and shape used on the EMU blue cryostat to be fixed (M3 screw holes arranged in a square with 30 mm between their centres). Titanium sample holders are available for use with powdered samples. These consist of a Ti plate with a depression into which a powder can be packed and over which a thin Ti window can be fixed using a clamping ring. Ti screws and thin Ta wire are available for attaching a sample holder to the mounting plate. Ti produces a negligible depolarisation of the muon signal at furnace temperatures and so is suitable for use as a mask material. Thick windows in front of a sample should be avoided as the four Ti foils (including the one on the sample mount) reduce the muon penetration to less than 70 $mg.cm^{-2}$; a range curve a taken in the furnace is given in figure 8, section 3.8.

It should be noted that Al sample holders are NOT suitable for use in the furnace owing to the low melting point of Al; similarly, users should consider whether their sample has a melting or decomposition temperature within the reach of the furnace and take suitable precautions!

3.4.2 Mounting the furnace on the instrument

MuSR in Longitudinal: The furnace is mounted on MuSR in longitudinal using a support frame which is fixed to the frame holding the photomultiplier tubes. The base part of the furnace support is attached to the four struts fixed permanently to the PMT frame; on top of this is bolted a trolley which allows the furnace to be slid in and out of the spectrometer. The furnace flange must be bolted to the *inside* of the trolley flange for the sample to be in the correct position when the trolley is pushed in.

MuSR in transverse: The furnace is again mounted on its trolley to be slid into the spectrometer; but now the trolley is supported by a larger frame which bolts to the rotating table supporting DIZITAL.

In both cases, the spot from the alignment laser should fall in the centre of the 12-pin Jaeger socket on the centre stick.

3.4.3 Connections

Once the furnace body, with centre stick in place, has been mounted on the instrument connections as shown in the diagram below are made.

1. The lead from the sample thermocouple (thermocouple B) is connected via a red lead to the yellow terminal of the red thermocouple box. A two-way splitter is connected to the white output terminal of the box to feed two leads which attach to the sensor inputs on the Eurotherm controller via Lemo connectors.
2. The 12-pin Jaeger connector on the centre stick is connected to the 4-pin output on the heater power box.
3. The 9V DC output of the Eurotherm is connected to the 9V input on the heater box via Lemo connectors.

4. The flowmeter signal wire is connected to the flow input on the heater box via a Lemo connector.

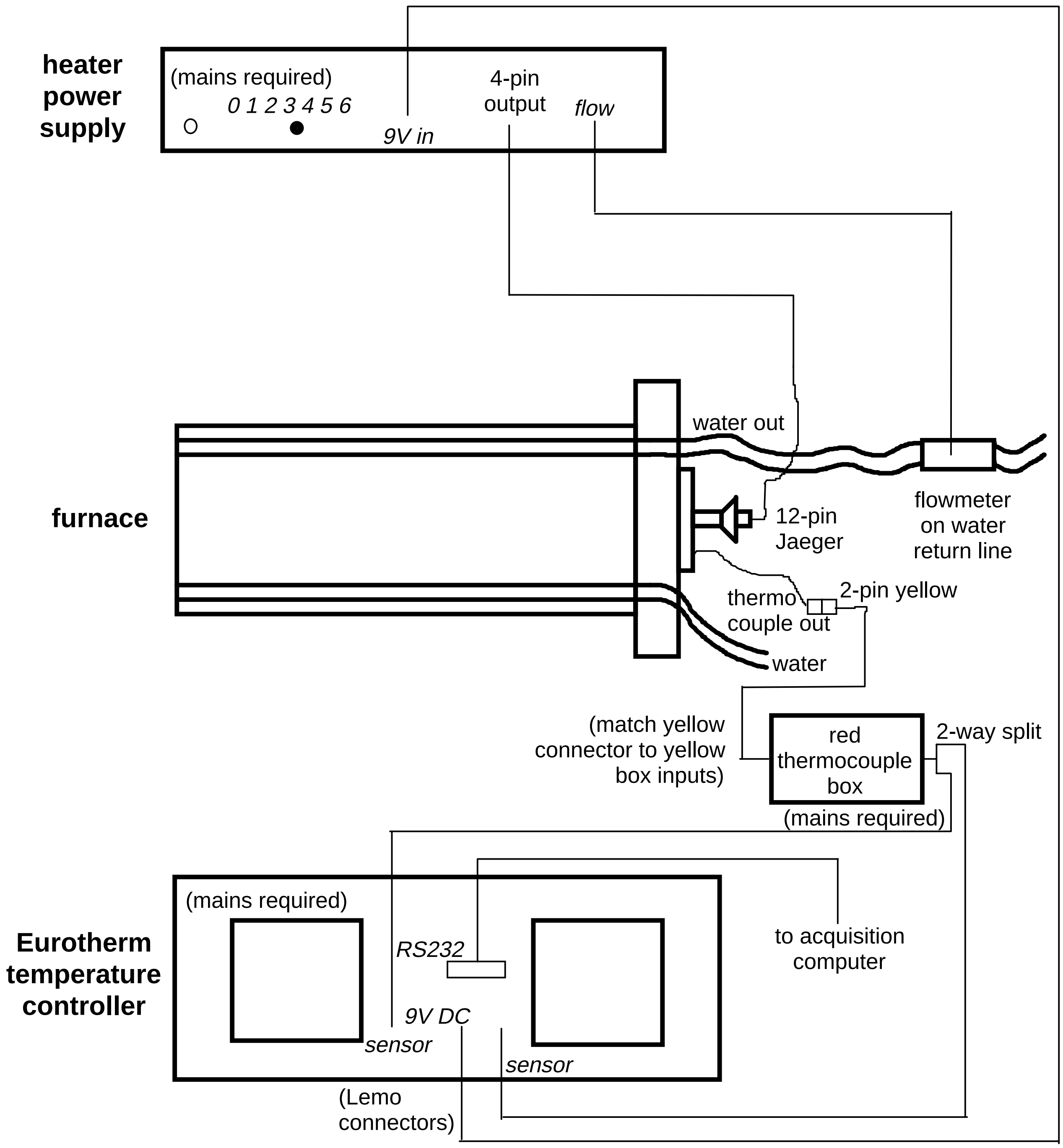


Figure 6. Furnace connections

5. The RS232 link on the Eurotherm is connected to the RS232 cable in the area (use the one normally devoted to the CCR Eurotherm). Check that the two sample environment data switches are in the CCR position.
6. The two cooling water hoses are connected to the two tubes on the furnace body (it doesn't matter which way round). The hose with the flow sensor must then be connected to the water return socket on the area wall, and the other hose connected to the water output socket. Don't forget to turn the cooling water on - there are two taps, one on the feed line and one on the return line.
7. The furnace pumping port on the centre stick is connected to the rotary/turbo pump set in the area via a 4-way cross-piece which also allows connection of a pressure gauge and a valve to admit He exchange gas. It is useful to ensure that there is a valve capable of isolating the furnace in place between the furnace and the cross-piece. The pump set used should be one reserved for a furnace to avoid contaminating a clean set.

The flow sensor on the water return line is designed to cut off the heater power to the furnace if the flow falls to too low a level. The LED on the heater box by the flow input goes out if the heater has been tripped in this way.

3.4.4 Eurotherm set-up

Normally, a dedicated Eurotherm is provided which will be already set up for furnace use. However, in the event of a CCR Eurotherm having to be used to control the furnace, please ask your local contact to configure it for use with thermocouple sensors. For full details of operating a Eurotherm, see 'The Users Guide to the Temperature Controllers' by H.M. Shah (copies are in the filing cabinet in the EMU cabin).

3.4.5 Controlling the furnace

The furnace can be controlled from MCS in a similar way to other pieces of sample environment equipment. To initialise MCS for furnace control, type

```
MCS> @furnace_tc820
```

Set-points can then be entered as normal, TLOG files generated and scripts written for automatic furnace control.

NOTE: *All set points and recorded temperatures are in ^{o}C NOT K.*

PID values used by the furnace are contained in the *furnace.tpar* file in the directory from which MCS is run.

Exchange gas within the furnace vacuum jacket is necessary to allow control over the low temperature part of the furnace range (up to about 200 ^{o}C). The rotary/turbo pump set connected to the furnace pumping port can be valved off once a good vacuum has been reached and 20 mbar or so of He gas introduced into the furnace body. This can then be pumped out for high-temperature operation.

There are six different heater power settings (and an off, '0', setting) on the heater box. The table below shows the heater settings, PID and exchange gas values required at different temperatures.

Max. working Temperature °C	Eurotherm Heater Power (%)	Heater box voltage setting	P (%)	I (s)	D (s)	Exchange gas
100	25	2	0.8	70	14	Yes
200	50	2	0.7	70	14	Yes
300	100	2	2.7	125	25	No
400	25	3	4.9	125	25	No
500	100	3	6.2	105	21	No
600	50	4	16	55	11	No
700	50	5	16	35	7	No

These settings have been optimised to achieve the best possible stability. Users wishing to scan a temperature range on a script may be able to find a compromise in the settings that will still achieve reasonable stability, but will allow unattended operation over an extended temperature range. However, please note the maximum temperature that can be reached for each heater box voltage setting (Eurotherm heater power set at 100%):

Heater box voltage setting	1	2	3	4	5	6
Max. working temperature (°C)	190	380	510	640	700	700

3.4.6 Typical data collection parameters

The wall of the furnace vacuum jacket acts as a degrader in front of the scintillation detectors, preventing the lowest energy positrons from being counted. This has the effect of reducing the count rate (requiring the beam slits to be opened more widely than normal) and increasing the maximum asymmetry (to close to 27% on MuSR). Alpha values close to 1.5 are common owing to the shielding of the backward detectors by the sample mounting plate and heating element. Check with your local contact for correct steering magnet values.

3.5 Sorption cryostat

There is a separate manual describing the operation of the ^{3}He sorption cryostat.

3.6 Temperature control files

Whenever a temperature set-point is sent by MCS to a temperature controller, various other parameters are also passed to enable the temperature to be controlled. These include the appropriate Proportional, Integral and Derivative (PID) values and, for the dilution fridge, the maximum heater power. MCS reads these values from files which sit in the directory `musr$disk0:[musr]` from which MCS is run:

`mtemp.tpar`	for the CCR
`orange_itc5.tpar`	for the orange cryostat
`furnace.tpar`	for the furnace
`dilution.tpar`	for the dilution fridge
`he3_lo.tpar, he3_hi.tpar`	for the sorption cryostat: 0-2K, 2-70K

MCS is told which file to use whenever a command to set up a new temperature controller (such as `@ccr_tc820`) is issued. The file that MCS is reading can be found using the command `show temp/par`, and changed using `set temp/par=filename`. When the Eurotherm or ITC5 controllers are being used, MCS reads the relevant file every time a set-point is sent to the controller. In the case of the dilution fridge, the file is read once when the temperature controlling process started (normally when MCD is begun).

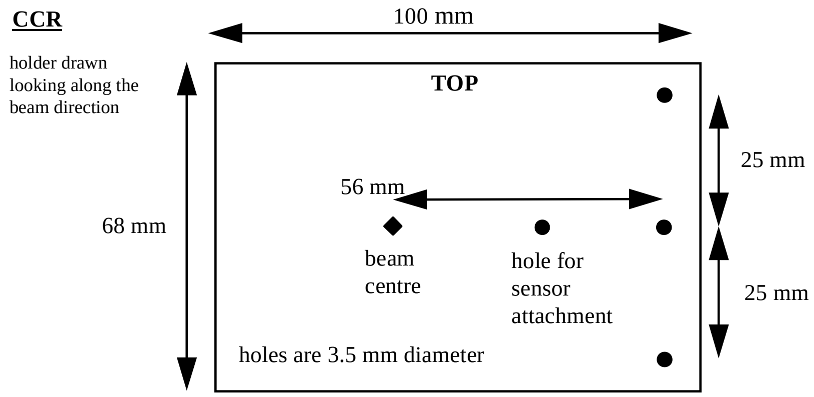
Column label	**function**
TLOW and THIGH (or MINTEMP, MAXTEMP)	specify a temperature range for given PID values
CYCLE	not to be changed
PROP	proportional value
INT	integral value
DER	derivative value
ACCUR	the temperature range around the set point within which MCS will consider the temperature to be stable
WAIT (or TWAIT)	the length of time (mins) that the temperature must be within the accuracy band before MCS will start a run
TMOUT (or TIMEOUT)	the time after which, even if the temperature has not stabilised within the accuracy band, MCS will start a run anyway
MAXI (fridge only)	controls the heater power range

Occasionally, it is necessary to alter the PID values that MCS is using. This can be done by editing the appropriate .tpar file (use the `edit` command within MCS, and exit the editor using `ctrl-z`) and then re-sending the temperature set-point (for Eurotherm/ITC5) or stopping and restarting MTEMP (for the fridge - see section 10.3). Information in the .tpar files is arranged as a table, with columns labelled as in the table above.

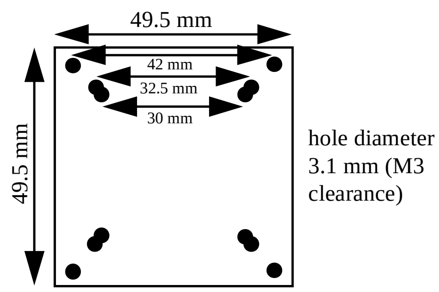
For the Eurotherm and ITC5 controllers P is the proportional band; if temperature oscillations occur, try *increasing* this value.

If you believe that the .tpar files have been altered by a previous user, the default files may be restored using the command `@defaulttpar` within MCS.

3.7 Sample mounts



Orange cryostat



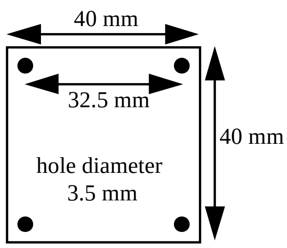
This is the orange cryostat mounting plate - the sample plate to go on top mustn't exceed 49 mm width, and can have four holes drilled to match any of the three sets shown above (the mount will take EMU blue cryostat sample plates and dilution fridge sample plates).

EMU/MuSR Sorption cryostat

Sample holders designed for the MuSR dilution fridge or the EMU blue cryostat can be used in the sorption cryostat; however,users should avoid holders made of Al and other materials which undergo a superconducting transition at low temperatures.

Please remember to bring some thin (~10 µm thickness) silver foil to use as a heat shield.

Dilution refrigerator



Avoid holders made of Al or other materials which undergo a superconducting transition at low temperatures.

Please remember to bring some thin (~10 µm thickness) silver foil to use as a heat shield for fridge samples.

Users should arrive at least one day before the start of their beamtime to allow time for fridge preparation.

MuSR/EMU furnace

The furnace mounting plate can take sample holders with maximum size 40 mm x 40 mm and is drilled to allow EMU blue cryostat holders to be fixed on to it. However, sample holders must not be made of aluminium (which melts within the furnace temperature range) and furnace users are advised to speak to their local contact regarding the best method of sample mounting.

Figure 7. MuSR sample mounts

3.8 Range curve

The muons in the beam hit the front surface of the sample at about $0.25c$ (3.0 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. The actual amount of material traversed and the width of the muon distribution depend upon the material's density - as a rough guide the muon range is roughly 100 mg.cm^{-2} of material i.e. about 1 mm of water, 500 µm of silicon, etc.

Figure 8 below shows the diamagnetic asymmetry (in a 20 G transverse field) as thin titanium foils (thickness about 30µm) are added in front of a thick quartz plate mounted in the MuSR/EMU furnace. Initially a low asymmetry is recorded as all muons are stopped in the quartz where there is an appreciable muonium fraction. Adding more than four titanium foils causes the asymmetry to rise as an increasing proportion of the muons are stopped in the metal (in which all muons thermalise into a diamagnetic state). Full asymmetry is obtained when at least ten foils have been added.

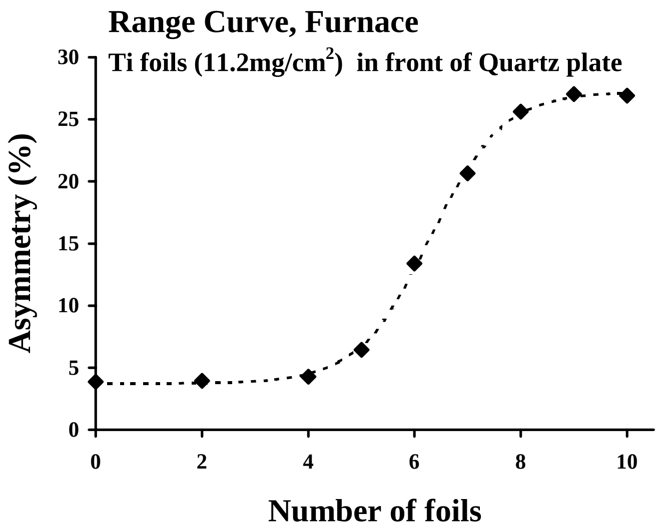


Figure 8. Range curve in the MuSR/EMU furnace.

It should be noted that in the dilution fridge additional windows in the cryostat tails reduce the muons' energy significantly before they reach the sample. Any material placed over samples for the fridge should be very thin indeed (10 µm thick silver is used for heat shields) otherwise the muons may not reach the sample.

Samples for μSR experiments should be appreciably thicker than the average muon stopping distance. When thin samples are used, sheets of metal or plastic should be added in front of the sample to maximise the signal from the sample and to prevent the muons from passing all the way through. The decision to use either metal or plastic as the degrader will generally depend upon the nature of the sample being studied and the need to create a contrasting between the sample and degrader. For samples having a missing fraction, metal is the most appropriate choice (pre-cut 30 μm-thick titanium sheets are available for this purpose) while, conversely, a plastic degrader is ideal for metallic samples.

4. Magnetic fields

4.1 Zero field

Three pairs of orthogonal coils mounted around the sample position are used to cancel the earth's magnetic field. They are powered from the three Gossen power supply units (labelled L V and T) in the electronics rack inside the MuSR area. The field is measured using a triple-axis fluxgate magnetometer which can be fixed at the sample position while setting the output of the Gossens.

Once the field is set to zero remove the probe from the sample position.

If varying the current does not change the field at the sample position check that the coils have been reconnected to the box on the fence between MuSR and EMU. If the field readings remain fixed at about 1000 mG (their maximum) check that neither the T20 coils nor the main Helmholtz coils are on.

4.2 Calibration field

When working in longitudinal geometry it is necessary to start each section of runs (after a sample change or change from CCR to cryostat for example) with a calibration measurement in a transverse field of approximately 20 gauss. These measurements are usually quite short (<5 Mevents) and are often referred to as "T20" runs. Two small coils, which hang either side of the sample, are used to provide a small transverse field. They are powered by a Gossen power supply and controlled by the computer through MCS with the command `@TF20`. The MCS command `@TF0` turns off the calibration coils and defaults to the Danfysik PSU.

4.3 Applied fields

Magnetic fields are provided using the large Helmholtz coils powered by the Danfysik PSU. This is controlled by MCS via a GPIB interface. The maximum field available on MuSR is 2000 G. The Danfysik is operated as follows:

- Turn "CONTROL" power on.
- Select "REMOTE" operation at the Danfysik PSU.
- Turn "MAIN" power on using trailing box.
- Set the manual control to zero.
- Type `@lf0` in MCS; this sets the magnet device to the Danfysik PSU. Set fields using the command `Set mag/set = x`. A read-out of the field is given on the computer screen in the "MAGNET" window.

Whenever the beam blocker is lowered the field generated by the Danfysik is automatically set to zero. It is possible to over-ride this process by carrying out the following procedure:

- Turn the key on the panel by the entrance to the experimental area to "over-ride" **before** lowering the blocker
- Open and close up the area as usual, but return the over-ride key to its original position **before** raising the blocker
- Check there are no red lights illuminated on the Danfysik power supply

If the power supply trips at any time it can usually be reset by switching the power off and on again. If this is not successful check the trip switches (see section 9.1)

After selecting a new magnet device, always check that the field set via MCS has been accepted by the power supply. If the supply is not responding to the computer look at section 10.4 for instructions on how to reset the magnet control process within MCS.

4.3.1 Effects of the finite muon pulse width on useable transverse fields

At ISIS the muons are produced in short pulses (about 80 ns wide at half height) and the approximation is usually made that an average arrival time near the centre of the muon pulse can be used as time-zero. This is adequate if the time-scale of the evolution of the muon polarisation is long compared with the width of the muon pulse but leads to difficulties in cases where the evolution is rapid. The effect is seen clearly by considering a transverse field experiment performed at a succession of magnetic fields. At low precession frequencies the polarisation is seen with full asymmetry. As the frequency increases there is an appreciable phase difference developed between muons from the beginning and end of the pulse and the observed asymmetry falls. This is seen in the plot below, produced from the precession of muonium in quartz in low transverse fields (data taken on EMU, although the MuSR response is the same). Even though MuSR will allow fields of up to 2000 G to be applied when in transverse orientation, the low asymmetry limits the useable field to about 600 G (8 MHz).

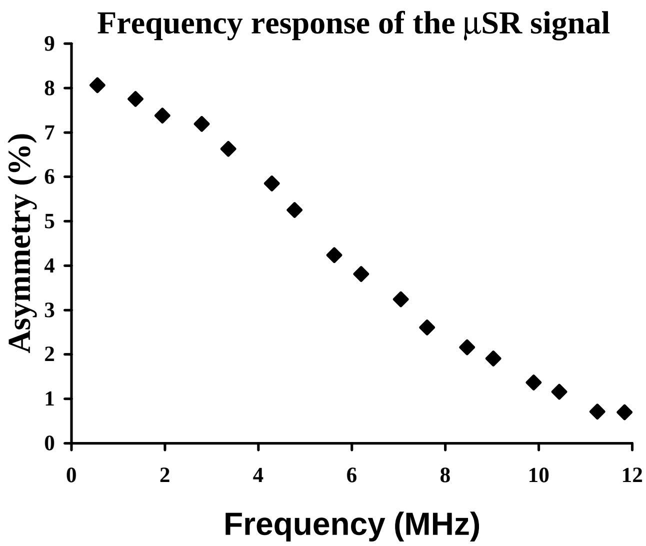


Figure 9. Frequency response in transverse fields

4.3.2 Effects of high longitudinal fields on asymmetry

The asymmetry measured for a large silver plate, mounted in the MuSR CCR, in longitudinal magnetic fields up to 0.2 T, is shown below. As the field is increased there is a small but gradual fall-off in the measured asymmetry, with roughly a 3% reduction at 0.2 T. This change is an artefact that is probably a result of a shift in the value of α caused by the interaction of the magnetic field with both the decay positrons and the photomultipler tubes. Experimental data can be corrected for the effect; however, the precise form of the curve seems to depend on the initial value of α, and you are advised to perform your own calibration and not rely on the curve below.

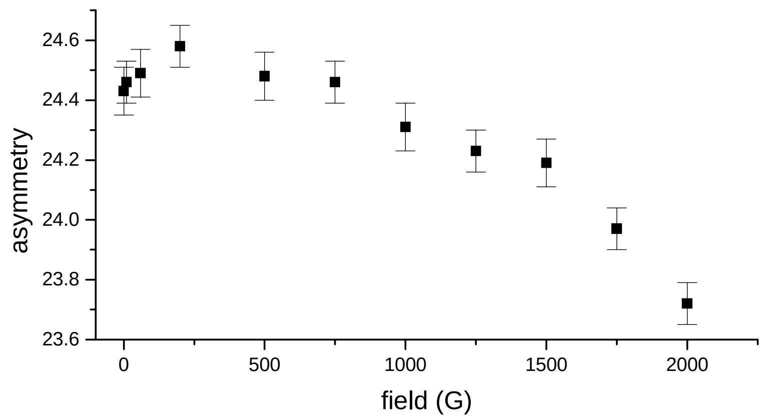


Figure 10. Effect of high longitudinal fields on asymmetry

5. Beam size, event rate and steering

A set of collimation slits in the MuSR beamline just after the kicker can be used to control the size of the muon spot and the rate at which muons hit the sample. The muon beam can also be steered by small amounts in the horizontal and vertical directions to allow it to be centred on a sample.

5.1 The muon beam spot size

The muon beam spot is elliptical. Its size in the horizontal direction can be changed using a set of slits in the beampipe which are controlled from a panel located behind the EMU area under the mezzanine floor.

CARE SHOULD BE TAKEN TO CHANGE ONLY THE MuSR SLITS

As a guide, set the x-slit equal to the x dimension of the sample, then check the data collection rate.

The beam spot size in the vertical direction cannot be altered, and is of the order of 8 mm FWHM.

The beam spot size in the MuSR CCR has been measured for various settings of the beam slits using a haematite sample with a 20 mm diameter silver mask on top. Muons falling on the haematite are rapidly depolarised, whereas those falling on the silver maintain their polarisation. The amplitude of the muon precession signal in an applied transverse field (20 G) is a measure of the fraction of muons falling on the silver and therefore of the muon spot size. Full asymmetry (of 23.9%) was measured using a plain silver plate with no haematite. The results are shown in the plot below.

It should be noted that these measurements were performed in the MuSR CCR with its heat shield and tails in place. The window in the CCR tails (80 μm-thick Mylar) introduces some scattering of the beam, increasing the beam spot size slightly: with the CCR tails removed, an asymmetry of 3.7% was obtained, equivalent to 16% of the muons falling on the mask. The spot size is larger still in the orange cryostat, dilution fridge and furnace, which all have additional windows: typically 30% of the muons fall outside a 20 mm diameter area inside the orange cryostat with the slits set to 8.

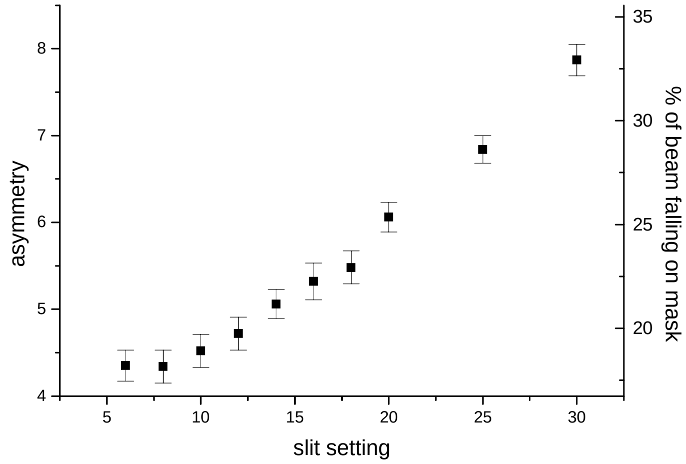


Figure 11. Measurement of the muon beam spot size

The table below gives similar results, expressed as fraction of beam falling on to the mask, as a function of mask size for two slit settings, again in the MuSR CCR. The measurement errors are +/- 1%.

slit setting	**10 mm mask**	**20 mm mask**	**25 mm mask**	**29 mm mask**	**38 mm mask**
12	60.7%	20.1%	12.4%	8.2%	< 4%
20	63.7%	25.6%	15.6%	8.7%	< 4%

Please note that the above figures are guides only. The actual size of the muon spot at a particular time is dependent on factors such as the tuning of the extracted proton beam, and can vary slightly from cycle to cycle.

5.2 The event rate

In addition to controlling the muon spot size, the slits can be used to regulate the event rate and thereby control the distortion at the start of histograms due to detector dead time effects. Because various parts of the detector have limitations on the speed with which they can respond there is a dead time, τ_d, after each event during which further positron decays are missed. The effect of this dead time can be modelled and the reduced rate observed in the experiment, r_{ob}, is found to be related to the true rate, r, by the expression $r_{ob} = r/(1+r\tau_d)$. Although the effect is particularly evident at high event rates, some distortion is always present. Users should therefore always consider using the facilities provided by both UDA and RUMDA to correct for this effect when analysing data. The effects of deadtime on data are shown in figure 16, section 9.3.

As a guide, event rates of between 12-18 M events/hour are a compromise between large dead time distortion at very high rates and inefficient use of the beam time at very low rates.

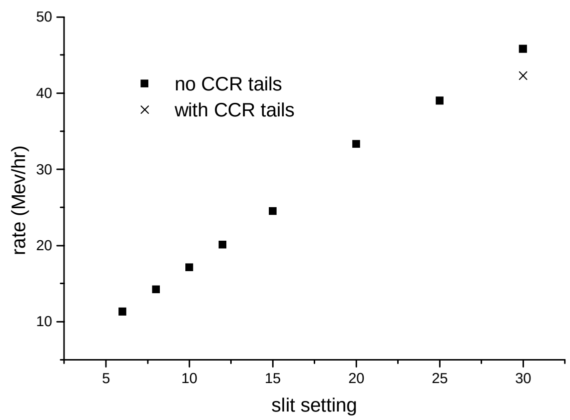


Figure 12. Event rate as a function of slit setting

The graph above shows the event rate as a function of slit width for a large silver plate mounted on the MuSR CCR with the 7 mm muon production target in use and with ISIS running at about 190 µA. The main curve was taken without the CCR tails in place - addition of the tails reduces the event rate slightly (point shown as a cross) and also slightly increases the maximum asymmetry (this effect is greatest in the furnace, where the event rate is two thirds of that in the CCR and the asymmetry is typically a couple of percent higher).

It should be noted that the 'figure of merit' for an experiment is given by ($asymmetry^2$ x rate), so that small changes in asymmetry can be significant.

5.3 Steering the beam

The muon beam can be steered by small amounts to centre it on the sample under investigation. Particularly when small samples are being used, it is important to ensure that the beam is steered correctly to maximise the fraction of muons hitting the sample. Also, in transverse geometry, the applied transverse field shifts the muon beam spot slightly in the vertical direction and it is necessary to compensate for this. On MuSR it is possible to steer the beam in the horizontal and vertical directions using dipole magnets in the beamline. These are controlled from the two Kingshill power supplies at the bottom left of the rack in the back of the MuSR cabin; the current is set on the front of each supply. The horizontal steering is more sensitive than the vertical (the horizontal steering magnet being located further upstream) - movement sensitivity is approximately 25 mm/A horizontally and 5 mm/A vertically.

The two plots below are examples of steering curves produced in the MuSR CCR. The best settings for the steering magnets shown here should not be used in general as they depend on the precise sample position. However, the curves can be used as guides to the steering magnet sensitivity.

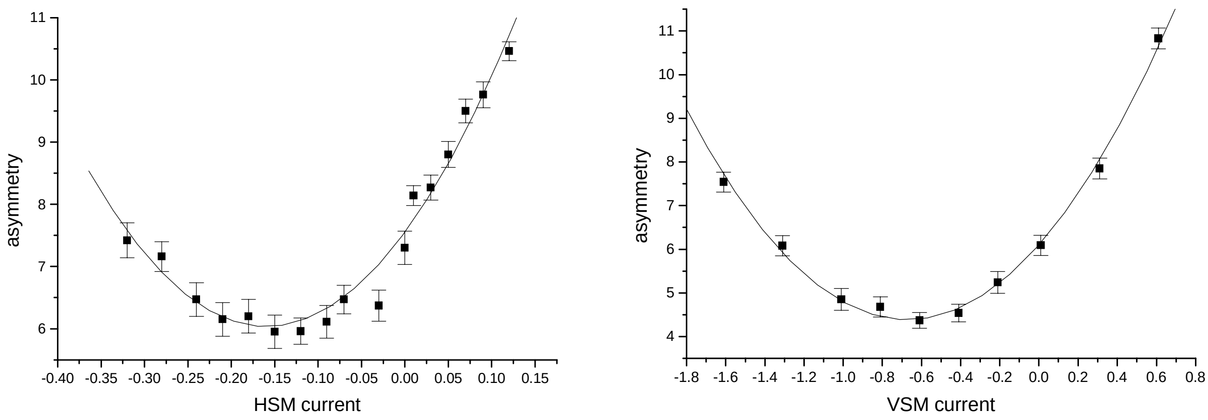


Figure 13. Steering curve examples

The above curves were produced by observing the muon precession amplitude in a 20 G transverse field using a 20 mm diameter silver mask on a haematite sample with the beamline slits set to 8. The steering is therefore best at the asymmetry minimum.

6. Computing

This is a short guide to the computing facilities available to MuSR users. For more details about computing at ISIS see the PuNCH MANUAL MiniGuide1 written by the ISIS Science Computer Support Group.

6.1 General Information

- The three cluster computers available for MuSR users are **MUSR**, **MUWK2** and **ISISE.**
- MUSR is the **data acquisition computer** and should not be used for other purposes. Even seemingly simple tasks can lock up the data collection or in some cases crash the whole MCS facility.
- MUWK2 and ISISE can be logged into from the cabin PC or from terminals in the DAC, and can be used for data analysis, etc.
- The account MUSR01 is available to all users for data analysis.
- The PC in the MuSR cabin can be used for normal PC applications (Microsoft Office, Origin, etc) and as a terminal on to one of the cluster computers using the eXcursion application.

6.2 Data acquisition

The computer **MUSR** is used for data acquisition. The acquisition software MCS (or MCD) is described in section 7.

6.2.1 Logging on to MUSR

The workstation in the MuSR cabin is being used as a terminal on to the MUSR data acquisition computer. To gain access to MCS, you need to log in to the workstation, then log into the acquisition computer, then start MCS:

1. Log in to the workstation in the cabin:

   - When nobody is logged in at the workstation screen, a box prompting for a username and password is displayed. Log in with username MUSR01 and the current password (available from you local contact).
   - When the Session Manager window appears, select the 'Applications' item on the menu, and 'DECTerm' from the drop-down list.

2. Log in to the data acquistion computer:

   - When the DECTerm window appears, type 'set host MUSR' to log in to the MUSR computer. You will be prompted for a username and password: log in as MUSR and ask your local contact for the password.

3. Start MCS:

   - When you have logged in to MuSR, type MCS (or MCD if you are using the dilution refrigerator). The normal MCS windows should appear.

If you want to use the cabin workstation to analyse data, just open another DECTerm window from the Session Manager 'Applications' menu item. The window that appears will be for account MUSR01; if you want to use your own account, use the command 'set host ISISE' (or whatever cluster computer you choose) in the new window to log in as a different user.

You can only type within a window once you have clicked the mouse in it to make it the input focus.

6.2.2 Logging out of MUSR

- Type `LOGOUT` in a DECTerm window to end the current DECTerm login.
- To end the workstation session click the mouse on the 'SESSION' option in the session manager window and select 'END SESSION' from the menu that appears. A further window will appear asking for confirmation which is given by clicking the mouse on the 'OK' button.

6.3 Data analysis

6.3.1 Logging on

- **Logging in through an Xterminal.** These terminals are available for users in the Data Acquisition Centre (DAC). Click on the 'CREATE' option at the top of the terminal manager window, and select 'DECterm' followed by the machine you wish to connect to. Then log in as normal using either the MUSR01 account or your own account.

- **Logging in through a PC.** The PC in the MuSR cabin (and other public access PCs) can be used as terminals to log on to ISISE or MUWK2 using the eXcursion application. On the MuSR PC, click on one of the terminal icons on the desktop. If you choose one of the MUSR01 icons, you will just be asked for the current password; otherwise, enter a username and password. A terminal window will appear after a few seconds. In order to allow graphics displays from UDA and other software to appear on the PC screen, it is necessary to type
  `SET DISPLAY/CREATE/NODE=<node>/TRANSPORT=TCPIP`,
  where <node> is the IP number of the PC you are using (the node name and IP number of the MuSR PC are ndnt98 and 130.246.49.129).
  On a public access PC, select
  START: PROGRAMS: EXCURSION V2 APPLICATIONS:
  from the program bar and choose one of the terminal options.

6.3.2. Using the MUSR01 account for data analysis

1. Log on to ISISE or MUWK2 with the username MUSR01. The password is changed periodically - contact an instrument scientist to obtain the current one.

2. Once access has been obtained, a list of users known to the account is displayed. Select the most appropriate, or alternatively use USERX, and type the name at the prompt. The cursor should change to reflect the current user. For example, USERX would proceed as follows:

```
Users known:
SCRATCH    RAL        RUNI       BIRMINGHAM SUSSEX    SHEFFIELD
STUTTGART  SOTON      PARMA      UPPSALA    OXFORD    LEICESTER
BS         LPOOL      CNRS       ILL        USERX     BRAUNSCHWEIG
STANDREWS  CSIC       PARIS      LYON

MUSR01> USERX

***********************************************************
          YOU ARE NOW WORKING ON THE SCRATCH DISK
      FILES IN THIS AREA WILL BE DELETED AFTER 7 DAYS
                 USE: SETUP to access UDA
***********************************************************

USERX>
```

3. Now type SETUP. A list of the analysis software currently available will be displayed. Any of these may be used by typing the program name. For example, to run UDA, USERX would proceed as follows:

```
USERX> SETUP

Commands available:
    TLOGGER - plot temperature logs
    HISTO - look at the raw histograms
    CONVERT_ASCII - turn the binary run data into ASCII format
    HEADERS - make a list of MuSR data file header information
    ASYM - analyse levelcrossing data
    UDA - standard muon data analysis
    RESTMUSR - restore datafile(s) from archive
    PRINT_MAN - print the MuSR manual on LSR5 (MuSR Cabin)
    SUPERPLOT - general plotting program
    SUPERPLOTC - for plotting in colour
```

```
If access to RUMDA is required type RUMDA

If access to MESA or TDSA is required type MESA_SETUP

USERX> UDA
```

4. If access to RUMDA and GENIE is required type RUMDA. Again, a list of the available commands will be displayed which give access to the RUMDA programs. TDSA, an alternative analysis program, and MESA, a maximum entropy analysis program for transverse field data, are available on ALPHA machines by typing MESA_SETUP.

6.3.3 Using your own account for data analysis

1. Login to ISISE or MUWK2 with your own user name and password
2. Type `@inst$disk:[mumgr.musr_users]musr_setup` to gain access to the data analysis software.
3. You may want to edit your LOGIN.COM file (found in your top-level directory) to add the line (preferably at the end of the file):
   `$ setup :== "@inst$disk:[mumgr.musr_users]musr_setup"`
4. Typing SETUP when you next login will work as described above for the MUSR01 account.

NB. If you use both MuSR and EMU instruments, you may wish to add two lines to your LOGIN.COM file, one for MUSR_SETUP and one for EMU_SETUP, as the SETUP files for the two instruments are different. The EMU_SETUP command can be found in the EMU User Guide.

6.4 Utility programs

6.4.1 CONVERT_ASCII: converting data files to ASCII format

The binary files written by MCS can be converted into ASCII files in one of three formats: firstly, in the same format as read by UDA's 'USRFILE' option;

secondly, as a column of raw counts for each histogram (this is ideal for loading into PC spreadsheet applications); thirdly, as asymmetry data (this format can be directly imported into PC analysis programs such as Origin). The conversion program is run from account MUSR01 using the command `CONVERT_ASCII`. The program prompts for first and last files to be converted and the format of the output ASCII data. Depending on the output ASCII file format required, additional information may be requested.

When using format options two or three it is very important that correct values are entered for both the t_0 and α. Check also that the grouping used in option three corresponds to the current detector arrangement.

6.4.2 HEADERS: generating a header listing

A list of data files together with their temperature and field settings is generated using the command `HEADERS`. The output of the program is left in a file named MUSR_HEAD.LIST which may be printed on the MuSR cabin printer using the command `print/que=sys$lsr5 musr_head.list`. NB the temperature and field values given by HEADERS rely on this information having been correctly entered by the user in the label of each run.

6.4.3 TLOGGER: plotting TLOG files

A plot of the temperature log for a data run may be produced using the command `TLOGGER`. The program will request the beamline (select option '2' for MUSR), a run number and the type of graphics device you are using to view the plot (enter `/xw` when using DECwindows and `/retro` when using an Atari or a Pericom). The file number need not have preceding zeros. The TLOG file with highest version number is plotted for the given run; files with lower version numbers are displayed by typing the complete file ending: e.g. `00123.TLOG;1` will plot R00123.TLOG;1. The hard copy option produces a postscript file PGPLOT.PS, and this may then be sent to the MuSR laser printer using the command `PRINT/QUEUE=POST$LSR5 PGPLOT.PS.*`.

6.4.4 RESTMUSR: restoring MUSR data from the archive

Data files can be restored from the archive using the command `RESTMUSR`. The program will request the type of data to be restored (RAW for data files and

TLOG for temperature logs) and the first and last runs to restore. The restored files are placed in the directory SCRATCH$DISK:[MUMGR.RESTORE] (where UDA or TLOGGER will automatically look for them) and will be automatically deleted after one week.

6.4.5 PRINT_MAN: prints a copy of this manual

Type `PRINT_MAN` to print this manual on the printer in the MuSR cabin.

6.4.6 ISISNEWS: the status of ISIS

Typing `ISISNEWS CURRENT` at the DEC prompt gives news on the status of ISIS. Information may also be obtained from looking at the messages in Bulletin, type `BULLETIN` at the prompt.

6.4.7 Archiving data on to a PC floppy disk

Data may be archived on to an IBM PC format floppy disk as follows:

- Convert all data files to ASCII format using CONVERT_ASCII.
- On a PC launch the FTP application by double clicking the left mouse button on the 'WS_ftp32' icon on the left of the desktop.
- The program automatically comes up with a window requesting details of the connection to be made. The 'host name' should be set to either `isise.rl.ac.uk` or to `muwk2.nd.rl.ac.uk`. Enter a user name (eg. MUSR01) and password and click on OK.
- When the connection is made and WS_ftp32 has read in the remote directory, set the appropriate PC directory using the ChgDir box on the left hand side of the WS_ftp32 window (set this to a: for transfer to a floppy), and the mainframe directory on the right hand side (for the MUSR01 account, files will be in `scratch$disk:[musr01.users.userx]` where you should replace `userx` with your own area name.
- For ASCII data, ensure that the ASCII button, below the windows showing files, is checked.
- Highlight the files you wish to transfer and click the appropriate arrow between the two file windows to copy the files.
- Further information can be found in the on-line help within the program.

6.4.8 Writing data to a TK50 tape

This may be done by going to the computer support office in R3. A full description of the process is available in the office.

6.5 The MuSR PC

The PC in the MuSR cabin is available for use as a terminal or to use one of the software packages installed (the PC has Microsoft Office and Origin, as well as normal applications). If it becomes necessary to reboot the PC, the login name and password are both MUSR. The machine's name and IP number are respectively ndnt98 and 130.246.49.129. To start applications, either click on the appropriate icon on the bar on the right hand side of the screen, or use the 'START' menu from the bottom bar. Please ask your local contact for further information if you are unfamiliar with the Windows NT 4.0 operating system.

6.6. Printers

The following printers are available for users:

Black and white laser printers:
LSR0 (R3 Computer Support Office),
LSR1 (R3 2nd floor),
LSR2 (R55, DAC)
LSR3 (MARI cabin)
LSR4 (CRISP cabin)
LSR5 (MuSR cabin)
LSR7 (PRISMA cabin)
LSR8 (SXD cabin)
LSR10 (outside EMU cabin)
LSR11 (HET cabin).

Colour printers:
COLOUR$PS (R3 Computer Support Office)

COLOUR_PHASER0 (R3 2nd Floor),
POST$INK0 - (Deskjet 1200 in MARI),
POST$INK2 (Deskjet 1200 in DAC),
POST$INK4 (Deskjet 1200 in CRISP).

To print PostScript files on the MuSR cabin printer:

```
print/que=post$lsr5 [file.ps]
```

and to print text files:

```
print/que=ansi$lsr5 [file.txt]
```

7. Data acquisition: MCS

The sample environment and data collection on MuSR are controlled by a computer program "MCS" running on the computer MUSR.

After logging into MUSR (see section 6.2.1), start the program by typing `MCS` at the `[MUSR]>` prompt.

To ensure the correct temperature calibration tables, etc. are in use, run the appropriate command file (eg `@CCR_TC820`, `@ORANGE_ITC502`, `@ORANGE_ITC503`, `@DS-HI`) for the sample environment equipment in use. It may be necessary to stop and restart the temperature controlling process after typing these commands - see section 10.3.

7.1 MCS and the Dilution Fridge

There is a second version of MCS, called MCD, to control the dilution fridge temperature. Users must check the two data switches (in the back of MuSR cabin and in the experimental area) so that both are set for the fridge.

To run the fridge program type `MCD` at the `[MUSR]>` prompt, then type `@DS-HI` to set the correct temperature control parameters.

NB. If MCS exits normally then it will be reset to control the CCR. If MCS cannot exit normally (eg a computer crash) then MCS can be reset to the CCR by first initialising MCD and then exiting normally.

If there are any serious problems with or comments about MCS and MCD then the MCS manager (C A Scott) should be notified. This can be done immediately by phone or bleeper if the problems are affecting data collection or by letter or E-mail (C.A.Scott@rl.ac.uk) if it is something that does not require urgent attention.

7.2 Commonly used MCS commands

Command	Action
NEW	Starts new data collection run, asks several questions of the user about sample conditions.
STOP RUN	Stops a data collection run
START RUN	Re-starts a stopped, unsaved data run.
SAVE	Saves a run on disk after confirmation of label details.
SET TEMP/SET=* * *	Sets the sample temperature in Kelvin.
SET MAG/SET=* * *	Sets the magnetic field in gauss.
@TF20	Switches the calibration coils on
@LF0	Switches all magnetic fields off.
@CCR_TC820	Sets up instrument with CCR+Eurotherm defaults
@ORANGE_ITC502 @ORANGE_ITC503	Sets up instrument with OC+ITC5 defaults
SET TEMP/LOG/TLOG	Enables the temperature logging and logging of process communications.
SET HIST/LEN=x	Sets the histogram length. x is number of bins: 1000 ≡ 16 µs, 1500 ≡ 24 µs, 2000 ≡ 32 µs. Use with command below.
SET HIST /ALL /GOOD_INTERVAL=END=x	To be used with the SET HIST /LEN command. Tells MCS the bin range over which good data is taken
SET DISP/LEFT=x/RIGHT=y	Displays data over the range x - y bins
SET DISP/NUM=A/FIRST=B	Displays A (=1,2,8,16) histograms starting with number B (=1 to 32)
HELP	Information about running an experiment under MCS

When saving a file, always answer `NO` (the default) to the `compress data?` option.

7.3 Writing a command file to control the experiment

It is possible to run MCS in automatic mode using a command file generated by either MKSCRIPT or MKSCRIPT2.

1. MKSCRIPT. This is used to program a series of temperature scans at a fixed field. It is run from account MUSR by typing `RUN MKSCRIPT` or from within MCS by typing `SYS RUN MKSCRIPT`.

2. MKSCRIPT2. This is similar to MKSCRIPT but allows for changes in both field and temperature. As with MKSCRIPT it is run by typing `RUN MKSCRIPT2` from MUSR or by typing `SYS RUN MKSCRIPT2` from within MCS.

In both cases the screen changes to a dashboard from which the user can enter the temperature (and field) change for each point. If the temperature (or field) is to remain at the value used for the previous point the option `KEEP` can be selected.
NB The first point must not be a T20 calibration.

Examples of the commands in MKSCRIPT(2)

Command	Action
ADD	Add an entry to the script, setting temperature and event limit
DELETE	Remove an entry from any point in the script
READ	Read a previously written script from disk
WRITE	Save script to a file. Program prompts for the file name
T20	Automatically perform a calibration point

The saved script file is written to MUSR$DISK0:[MUSR] <NAME>.COM.

A script is started from within MCS by typing `@name` where NAME is the name of the script. It may be aborted by typing `CTRL-C` and responding ‘`Y`’ to the question `ABORT PROCESSING OF FILE [N]?`

8. Data analysis: UDA

8.1 Introduction

UDA is the simplified μSR data analysis program. There are three menus in UDA, the Main Data menu, the UDA data Grouping menu and the UDA data Analysis menu.

On start-up the program will always enter the Main menu. At this menu you can read and write data files, plot spectra and make changes to the data loaded.

In the data Grouping menu you can select how to map your raw histograms into the "groups" that are used when plotting or analysing. Two different grouping schemes can be used, the Simple (straight, TF) grouping, or the F-B (LF,ZF) grouping. Deadtime correction of data is available using the same correction method as the RUMDA analysis program.

In the Analysis menu you can select a model function and make a least-squares fitting of the model parameters. The fitting result can also be plotted from this menu.

8.2 Running UDA

To access UDA from account MUSR01 type SETUP followed by UDA as described in section 6.3. This will run the most recent version of UDA. The display will be redrawn as a dashboard and the cursor will automatically select the option MCSFILE in the Main menu. To select any other item from the menu use the cursor (arrow) keys or simply type the first letter of that item (e.g. 'P' for PLOT).

8.3 The Main Data Menu

The Main Data menu allows you to read, write and modify experimental data. The options available from this menu are listed below. Plotting of error bars on data points can be turned off/on using the SETUP option.

MCSFILE	Read a MCS run file in the format used by the data acquisition software
USRFILE	Read a uSR file from the disk
OLDFILE	Read one of the old (PDP) run files
WRITE	Write (grouped) data to a uSR file
INSPECT	Inspect run and all histograms
GROUP	Enter the Grouping Menu
CHANGE	Change run file parameters
PLOT	Plot one or more groups on the terminal screen
ANALYSE	Enter the analysis menu
SETUP	Set program configuration parameters
HELP	Enter the VAX/VMS help facility to read the UDA help library.
QUIT	Exit UDA and return to VMS prompt

8.4 The Grouping Menu

The grouping menu is accessed through the option "Group" from the Main menu, and defines the grouping and correction of raw histogram data. There are currently two ways of grouping the histograms:

a) the Simple grouping, where histograms are simply added together.
b) the Forward-Backward (F-B) grouping, where the ’asymmetry ratio’ (F-αB)/(F+αB) is calculated.

Deadtime correction of data is turned on/off using the DeadT option. To compensate for deadtime, UDA uses the same file of deadtime values as the RUMDA analysis program, generated at the start of each cycle from a long silver run. Please ask your local contact if you are analysing data from a previous cycle and so require UDA to use deadtime values from that cycle rather than the current deadtime file. The effects of deadtime correction are shown in figure 16, section 9.3.

The options available for grouping and correcting data are shown below.

CHANGE	Change histogram grouping
READ	Read grouping table from disk
WRITE	Write grouping table to disk
DEADT	Switch deadtime correction on/off
ALPHA	Select (F-B) scaling factor
GUESS	Estimate alpha for a T20 run
BUNCH	Setting the bunching to ‘n’ adds ‘n’ bins together
HELP	Display help text. (Don't panic)
EXIT	Return to UDA Data (main) menu

8.5. The Analysis Menu

The Analysis menu is entered by selecting the option ”Analyse” in the UDA Main menu. Using the options outlined below it is possible to select a model function and make a least squares fit of the model parameters. The results of the fit can also be plotted and output to an ASCII file.

SELECT	Select a group and a bin range to work on.
PLOT	Plot the data and the fit; allows fit to be written to an ASCII file
FIT	Run fitting routine using the starting values displayed in right hand window
HELP	Enter the help system at the Analysis menu level
VALUES	Enter the parameter display to change parameter values/status. To move in the parameter display use UP or DOWN cursor keys. To change a value use the ENTER key. Status codes are changed by typing ~ (vary parameter), ! (fix parameter), = (tie parameters together). Return to the menu by the left or right cursor keys.
THEORY	Select a theory function, number of sub-components and lineshape
ALPHA	Change value of alpha
UNDO	Undo fit and restore original parameters
EXIT	Exit this menu and return to the main UDA menu
WRITE	Write parameters out to a file
READ	Read parameters in from a file
DIST	Distribute parameters to all groups (necessary for transverse geometry)

8.6 Computer files

These files must be copied into the area you are working in. If the area has been selected by SETUP (as described in section 6.3) they will have been copied to the new area automatically.

SETUP.UDA	UDA reads some variables from the file SETUP.UDA. In particular the directory address of the data is set up in this way. Of particular interest are the FORTRAN format strings used to convert a run number to a full file name.
BASETIME.UDA	contains the value which UDA will use for time-zero (see section 8.8).
TRANS.UDA	default transversal grouping
LONG.UDA	default longitudinal grouping
PDF.UDA	parameter definition file
UDAHELP.HLP	help library source, UDA matters

8.7 Theory functions defined in UDA

A number of theory functions are predefined in UDA:

8.7.1 Longitudinal and zero field

Function Name	Definition
1. Lorentzian	$a_o \exp(-\lambda t)$
2. Gaussian	$a_o \exp(-(\lambda t)^2)$
3. LX(exp) - Stretched Exponential	$a_o \exp(-(\lambda t)^\beta)$
4. Abragam (ZF Keren)	$a_o \exp(-2\,(\lambda\tau_c)^2\ (\exp(-t/\tau_c)-1+t/\tau_c))$
5. Kubo-Toyabe (Gaussian)	$a_o(\frac{1}{3}+\frac{2}{3}(1-(\lambda t)^2)\exp(-(\lambda t)^2/2))$
6. Kubo-Toyabe (Lorentzian)	$a_o(\frac{1}{3}+\frac{2}{3}(1-\lambda t)\exp(-\lambda t))$
8. Dynamic Kubo-Toyabe	

(Function 8, the dynamic Kubo-Toyabe, uses numerical integration to produce the fitting function and so requires more time than the other functions. Only fit up to channel 1000 when using this option.)

8.7.2 Transverse field

Function Name	Definition
11. Lorentzian with freq	$a_o \cos(\omega t + \phi)\ \exp(-\lambda t)$
12. Gaussian with freq	$a_o \cos(\omega t + \phi)\ \exp(-(\lambda t)^2)$
13. LX(exp) - Stretched Exponential with freq	$a_o \cos(\omega t + \phi)\ \exp(-(\lambda t)^\beta)$
14. Abragam with freq	$a_o \cos(\omega t + \phi)\ \exp(-(\lambda \tau_c)^2\ (\exp(-t/\tau_c) - 1 + t/\tau_c))$

8.8 Time-zero

Time-zero is usually taken to be the arrival time of the centre of the muon pulse. On MuSR, which receives the second of the two muon pulses produced by the proton beam, this is found to be 0.645 μs after the timing start signal produced by the Cerenkov counter near the muon production target. This corresponds to slightly after the start of bin 40 in the detector histograms (for a bin size of 16 ns). UDA uses this value to set its time-zero position (it is written in the file *basetime.uda*). However, useful data is not produced until after the complete arrival of the muon pulse, so that bins 46 and above can be used for function fitting, etc. [It should be noted that the definition of time-zero in RUMDA is different from that given here. RUMDA generates time-zero by fitting the oscillations in a transverse applied field and finding where the oscillation phase is zero. Owing to the rotation of the muon polarisation by the beamline components (see section 9.2), for a 20 G applied field this differs from the arrival time of the pulse centre by about 0.06 μs, equivalent to 4 histogram bins.]

9. Other components of the muon beamlines

9.1 Beamline power supplies

Located at intervals along the muon beamline between the production target and the spectrometer are dipole and quadrupole magnets which respectively act to steer and focus the muon beam (see figure 1 at the foot of the Contents pages). Most of the beamline magnets are located before the kicker, and therefore any faults will affect all three muon beamlines; however there are also two quadrupoles specifically for MuSR located after the kicker. The power supplies for all the beamline magnets are located on the raised platform on the far East side of the experimental hall (the steps up to this are opposite the steps taking you over the proton beam to the other side of the hall).

On the left at the top of the steps on the platform, and working towards the far wall, are the following units:

1	3	6	9				15	17	20	23
	4	7	10	12	13	14		18	21	24
2	5	8	11				16	19		25
									22	26

Figure 14. Beamline power supply layout

1 Reset buttons for beamline magnet klixons, flow and earth leakage trips
2 Q1 supply
3 Separator B-field supply
4 Q2 supply
5 Q3/5 supply
6 Q4 supply
7 Q6 supply

8 Q7 supply
9 Q8 supply
10 Q9 supply
11 B1/2 supply
12 DEVA Helmholtz supply
13 DEVA septum supply
14 EMU septum supply
15 Reset buttons for quads/coils on individual beamlines
16 Panels showing on/off status of klixons, etc, for quad/coil supplies
17 Q10A supply (DEVA)
18 Q11A supply (DEVA)
19 Q12A supply (DEVA)
20 Q10B supply (MuSR)
21 Q11B supply (MuSR)
22 switchyard magnet supply
23 Q10C supply (EMU)
24 Q11C supply (EMU)
25 Q12C supply (EMU)
26 switchyard magnet supply

The normal working currents for these supplies are shown by them, but call your local contact if you think there is a fault.

9.2 The separator

The separator is located in the muon beamline before the kicker and acts to remove contaminant particles (primarily positrons) from the muon beam. It consists of mutually perpendicular E and B fields which act as a velocity selector. The settings of the two fields are correlated so that muons of a particular velocity are transmitted: with the E field at 100 kV, the B field supply must be run at 43 A (and with E at 90 kV, the B field requires 39 A, etc). The power supply for the B field is located with the other beamline power supplies (see section 9.1); the E field is controlled from a unit located below the mezzanine floor behind the EMU area. The required voltage for the separator E field can only be achieved by ‘conditioning’; that is slowly increasing the voltage until the field breaks down and leaving it at this setting for a period before increasing it further. This process is done at the start of each cycle, but is often required during the middle of a cycle if the separator voltage becomes unstable.

9.2.1 Spin rotation by the separator

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 is to rotate the muon polarisation upwards slightly by about 6^{o} so that there is a component transverse to the momentum direction. This rotation is best observed by examining individual detectors for data taken in small longitudinal fields (up to ~400 G). Under these circumstances there is a precession of the muon spin in the field and an oscillating signal can usually be seen. Shown below is the signal from detector 1 for a silver sample in an applied longitudinal field of 50 G. The oscillations shown have an asymmetry of 2.2%.

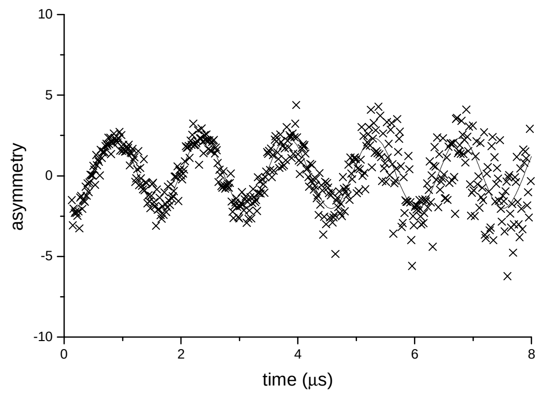


Figure 15. Spin rotation by the separator seen in a single detector

By grouping the detectors, however, the effect is removed. The graph below shows the data from this run arranged into a forward-backward grouping. This plot also shows the effects of deadtime: the grouped data is displayed with (crosses) and without (line) deadtime corrections.

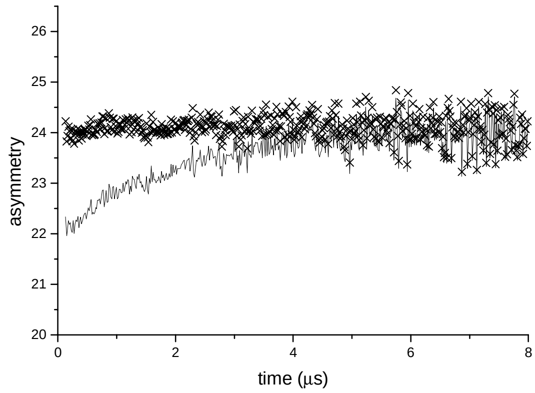


Figure 16. Grouped data with and without dead time correction

9.3 The kicker

The kicker is responsible for supplying muons to the DEVA and EMU areas. Muons are generated at the production target with the same time structure as the main proton beam, i.e. two 80 ns wide pulses separated by 300 ns (50 times per second). The first of these pulses is split in two in the kicker by a central electrode at high voltage. This kicks half the pulse to the left and half to the right, feeding the two side beamlines. In the time between the two muon pulses the voltage on the electrode is reduced to zero, and the second pulse travels undeflected to MuSR. The kicker power supply is located under the mezzanine floor behind the EMU area and consists of a high voltage supply together with timing electronics to ensure that the kick occurs at the correct point with respect to the muon pulses. The timing signal is taken from a lead glass Cerenkov counter located near the muon production target and fed to a delay unit. Instructions on how to reset the kicker are given in section 10.5, but this should only be done by an instrument scientist.

9.4 The photomultiplier tubes

The photomultiplier tubes on the spectrometer are powered from one of the LeCroy crates in the back of the EMU cabin. (The crates are labelled MuSR and EMU - make sure you switch the correct one on or off if you have to). Slots 2 and 3 of the MuSR crate are used to power the MuSR PMTs, with 16 outputs from each slot (addressed 0-15, *not* 1-16). Once the LeCroy crate is powered up it can be controlled from the terminal in the back of the MuSR cabin. It should only be necessary to modify the PMT voltages in two circumstances:

- when rotating the instrument all tubes should be turned **OFF (don't forget to turn them back on again afterwards!)**
- if a scintillator develops a light leak, please turn off the volts to its PMT.

The most commonly used commands for controlling the PMTs from the terminal are shown in the table below.

Command	**Action**
ON,OFF	switch the voltage on all tubes on or off
RE(2-3,0-15)	displays the voltage on all MuSR PMT tubes
RE(slot, channel)	displays the voltage on one tube
WR(slot, channel)0	sets the voltage on a single tube to zero
WR(slot, channel)v	sets the voltage on a single tube to v
Ctrl C	stops screen scrolling

10. Troubleshooting

10.1 No muons

- Check the machine is running at a reasonable rate. In the MuSR cabin there is a proton per pulse (PPP) monitor displaying the pulse intensity in µA. If this reads 00 there are no protons, and if it is flashing any number then ISIS is not running at 50 Hz and therefore the count rate will be lower than usual.

- If ISIS is not running, check the facility status by typing `isisnews current`.

- Check the beam blocker is open: the gate must be closed and locked to allow this. The blue interlock light will be lit if this has been done correctly.

- Check that the high voltage to the photomultiplier tubes is on (this is particularly likely to be the problem immediately after the instrument has been rotated). The red lights on the photomultiplier tube bases should be on. If not, type `ON` on the terminal controlling the high voltage power supply in the back of the MuSR cabin (see section 9.4 for further details of the photomultiplier tube high voltage commands).

- Check the ‘BEAM OFF’ button on the fence in the zone is not pressed. If it is, release it, then restart the bending magnet power supply, B1/2, above the cryostat store using only the ‘START’ button (see section 9.1).

- Check that all the magnets are working by checking their power supplies (see section 9.1 - the current they should be set at is written on each). If necessary, reset or restart using the value given.

- Check that the kicker is working. Instructions for resetting it if it has tripped are at the end of this chapter, but please consult your local contact before doing this.
- Check that the separator is at its correct voltage - typically 80 or 90 kV.

10.2 Computer problems

- If there is no communication via the keyboard then check the 'HOLD SCREEN' (PF1) key. It is not a good idea to use the "hold screen" option for any length of time as it eventually crashes the computer.

- Check any process of MCS by typing `SHOW PROC/ALL`. A stopped process may be restarted by typing `START PROC/PRCNUM=x` at the MCS> prompt, where x is the process number:

1 MACQ
2 MTEMP
3 MWSDISPLAY
4 MWSWINDOWS
5 MMAG

- Quit MCS by typing `EXIT`, logout using the command `LOGOUT`. Logon with user name MUSR and current password, restart MCS by typing `MCS` then proceed as usual.

- When using a PC for data analysis it is sometimes necessary to tell the remote host the node to use for display of the graphics window. If necessary use the command
  `SET DISPLAY/CREATE/NODE=<node>/TRANSPORT=TCPIP`
  where `<node>` should be replaced by the IP number of the PC (see label on the front of the PC).

10.3 Temperature control and MTEMP

MCS controls the sample temperature via the temperature controller using a sub-process known as MTEMP. This process very occasionally crashes while writing a temperature to the controller, or will sometimes need to be reset. To restart MTEMP carry out the following procedure

- Stop the script if one is running
- Type `STOP PROCESS`
- At the prompt, type `2`
- After the 'process crashed' message, type `START PROC`
- At the prompt reply `2`
- Restart temperature logging by typing `SET TEMP/TLOG`
- Amend and restart the script (if required)

10.4 Magnet control and MMAG

If there is no communication between MCS and the magnet power supply the following procedure may rectify the situation:

- Stop the MMAG process by typing `STOP PROC/PRCNUM=5`.
- Turn off magnet supply, wait a minute and turn it back on
- Restart the MMAG process by typing `START PROC/PRCNUM=5`.
- Reselect the device and try to set a field

10.5 Resetting the kicker

If the spectra from the individual detectors displayed on the MuSR data acquisition screen shows the effects of a double pulse the electrostatic kicker has failed and all the muons are passing undeflected through to MuSR. Before resetting the kicker check with the EMU and DEVA users that they have lost all beam. In most cases EMU and DEVA users will notice a kicker failure before MuSR users. The instructions for resetting the kicker are given below and are also attached to the kicker power supply unit.

- Turn key switch **A** through 90° to OFF position

- Turn helipot **B** fully anticlockwise to 0.0 volts

- Wait a few seconds

- Turn key switch **A** through 90° back to ON position

- Observe LED display on front panel. Only the +120I(A) and +120I(B) and the (large) "DELAYED POWER ON" should be unlit at this stage

- After 120s the +120I(A) and +120I(B) LEDs will light

- After a further 180s the "DELAYED POWER ON" will light and the high voltage power supply will be powered up

- Dedicated trigger should light

- While pressing the "READ SET VOLTS" push button turn helipot **B** slowly clockwise to obtain a set volts readout of 32.5kV. The current read-out will be ~2.02mA when the push button is released

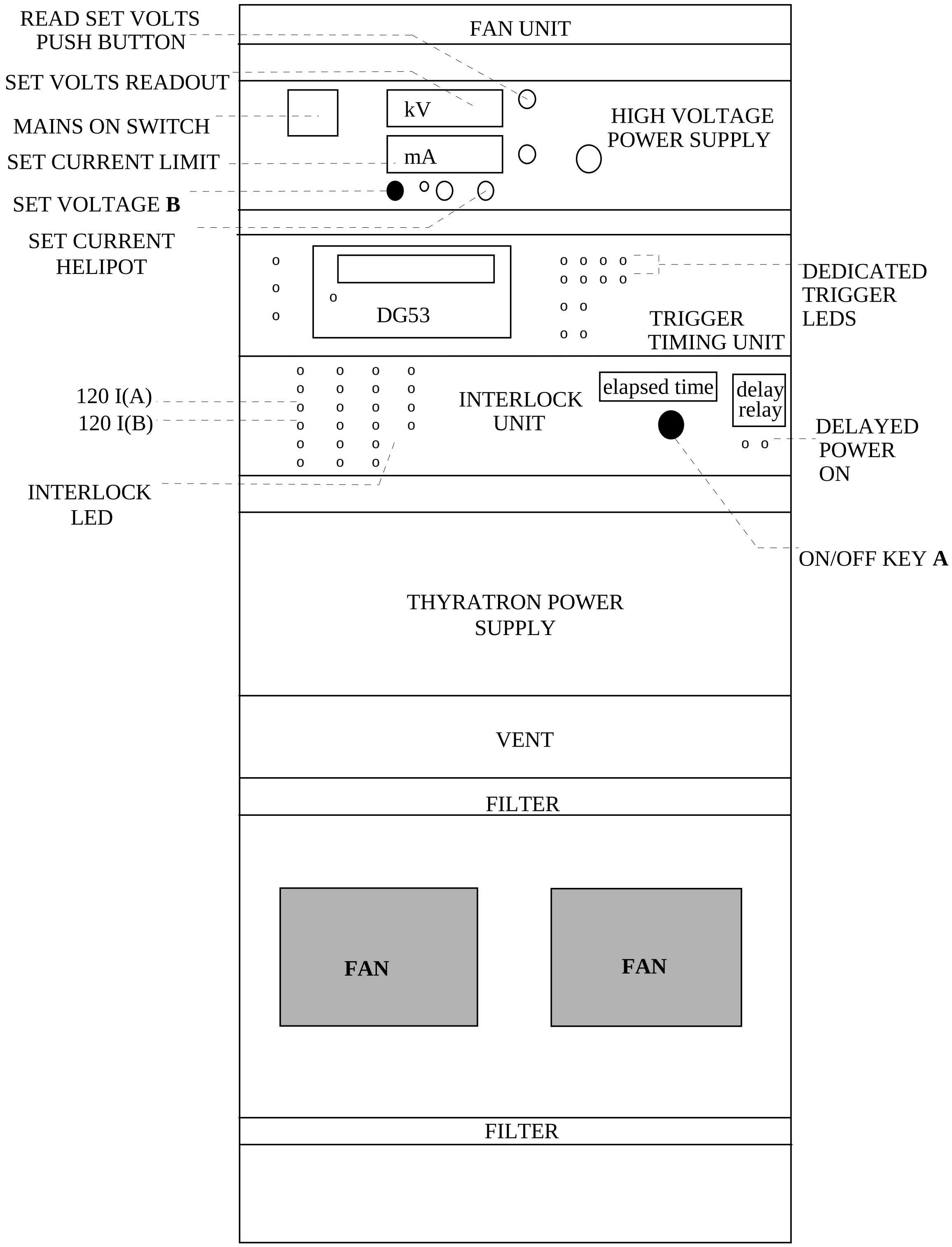


Figure 17. Reference diagram for resetting the kicker

11. Contact Points and further information

11.1 Laboratory contact points

Rutherford Appleton Laboratory,
Chilton,
Didcot,
Oxfordshire,
OX11 0QX.

☎ (01235) 821900	(national)
☎ +44 1235 821900	(international)

Main control room (MCR) .... ☎6789
EMU cabin (R55) .... ☎6831
MuSR cabin (R55) .... ☎6135
DEVA cabin (R55) .... ☎6851
Health Physics/ Sample checking ☎6696
Computer support......................... ☎3029 (0370 858090 from outside the lab)
University Liaison Office .... ☎5592
Cosener's House .... ☎3007 or (01235) 523198
Taxi... ☎5592 (during the night ring the MCR)
Gas bottles (He, N_2 etc)............... ☎6166

11.2 Contacting an instrument scientist

Stephen Cottrell	☎5352	(Email: s.p.cottrell@rl.ac.uk)	bleep 255
Philip King	☎5805	(Email: p.j.c.king@rl.ac.uk)	bleep 275
James Lord	☎5352	(Email: j.s.lord@rl.ac.uk	
Christopher Scott	☎5135	(Email: c.a.scott@rl.ac.uk)	bleep 214

From **outside the laboratory** certain extensions may be direct dialled, the number being formed in the following manner:
(01235) 44xxxx, where 'xxxx' is the required extension.

To **call offsite** from within the laboratory, prefix the number by 9.

The procedure for **radio paging** ('bleeping') the instrument scientists is to:

- Dial 70, and when given various options press '1' (user paging),
- When asked for the user number, type their 3-digit bleep number,

When asked for the 11-digit message number, type XXXX#, where XXXX is your extension number. Then hang up and wait to be called back.

11.3 Further information on the ISIS muon beamlines

For further information on the ISIS muon beamlines, see

Commissioning of the Rutherford Appleton Laboratory pulsed muon facility *GH Eaton et al.* Nucl. Inst. Meth. A269, 483-491, 1988.

The ISIS pulsed muon facility: past, present and future *A Carne et al.* Hyperfine Interactions 65, 1175-1182, 1990.

UPPSET: a pulsed electrostatic kicker to improve the μSR frequency response in the ISIS pulsed muon beam *AI Borden et al.* Nucl. Inst. Meth. A292, 21-29, 1990.

The ISIS pulsed muon facility *GH Eaton* Z. Phys. C 56, S232-239, 1992.

The muon beamline at ISIS *GH Eaton et al.* RAL Report RAL-94-077.

The development of the pulsed muon facility at ISIS *GH Eaton et al.* Hyperfine Interactions 87, 1099-1104, 1994.

Fast E-field switching of a pulsed surface muon beam: the commissioning of the European muon facility at ISIS *GH Eaton et al.* Nucl. Inst. Meth A342, 319-331, 1994.

The ISIS muon group Web pages also contain additional information on the muon facility, as well as the current instrument schedules, etc.; the address is http://www.isis.rl.ac.uk/muons

The main ISIS web pages contain details of all ISIS facility activities, together with information on applying for beamtime, electronic versions of proposal forms and A3 report forms, latest beam information, etc. They can be found at http://www.isis.rl.ac.uk.

11.4 Local information

Transport	
National Rail Enquiries It is usually possible to arrange a taxi to either Didcot Parkway or Oxford stations.	0345 48 49 50 or http://www.railtrack.co.uk/travel/
The Oxford Bus Company Oxford city local buses and coaches to London (X90), Heathrow (X70) and Gatwick (X80).	01865 785400 http://www.oxfordbus.co.uk/index.html
Stagecoach Bus Company (formerly Thames Transit) Oxford city and rural bus services including routes that pass Rowstock Corner (approx. three miles from Lab.).	01865 727000
BAA Flight Information Arrival information for many UK airports including Heathrow and Gatwick.	http://www.heathrow.co.uk/baainfo/baainfht.html
General Information	
Oxford Tourist Information Centre	01865 726871
Oxford Guide on the Web	http://www.comlab.ox.ac.uk/archive/ox/
Eating and Drinking	
Didcot Tandoori, 222 Broadway, Didcot	01235 812206
Chhokar Tandoori, 226a Broadway, Didcot	01235 813573
Cherry Tree Inn, Steventon	01235 831222
Fleur de Lis, East Hagbourne	01235 813247
The George and Dragon, Sutton Courtenay	01235 848252
The Great Western Junction Hotel, Didcot	01235 511091
The Hare Inn, West Hendred	01235 833249
The Harrow, West Ilsley	01635 281260
The Plough, Sutton Courtenay	01235 848801
Red Lion, Drayton	01235 531381
Rose and Crown, Chilton	01235 834249
The Swan Inn, Sutton Courtenay	01235 847446
The Wheatsheaf Inn, East Hendred	01235 833229

MuSR MINI GUIDE

@CCR_TC820	load CCR settings into MCS
@ORANGE_ITC502 @ORANGE_ITC503	load orange cryostat settings into MCS
@FURNACE_TC820	load furnace settings into MCS
SET TEMP/SET= ###	set new temperature (in K)
SET MAG/SET= ###	set new field (in gauss)

@TF20	set up 20 gauss calibration run
@LF0	switches all magnetic fields off

NEW	start new run
STOP RUN	pause data collection
START RUN	resume data collection
SAVE	stop run and save data