Specification of Cold Sample Environment equipment for the ISIS Muon Instruments

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A. Background

Tenders are invited to provide the Science and Technology Facilities Council (STFC) with an integrated suite of sample environment equipment for use on the EC Muon Beamlines, which form part of the ISIS Neutron and Muon facility. The equipment includes ^{4}He cryostats together with dilution fridge and ^{3}He inserts, to enable facility users to conduct experiments from millikelvin temperatures to above room temperature.

An overview of the items required is given in '*Table 1: Summary of components that are part of this tender exercise*', with a detailed specification for each component set out in Section B of this document. Timescales for the project are defined in Section C, while Section D discusses how tender returns will be evaluated.

The ^{4}He cryostats procured as part of this contract will partner a similar system already available within the facility. Together they will form the core of this sample environment suite, with the supplied inserts expected to work with all systems to deliver the required temperature range.

Item	Number Required	Comment
^{4}He cryostat	2	Compatible with all inserts, and working in tandem with an existing ^{4}He system.
Dilution Insert	4	
Support equipment for dilution insert (temperature controllers and gas handling system)	2	Each set of support equipment should be compatible with all dilution inserts.
^{3}He Insert with support equipment	2	

Table 1: Summary of components that are part of this tender exercise

When tendering, suppliers should be mindful that the equipment is being procured for use within a facility open to external users that runs 24/7. The equipment will be setup by skilled cryogenic technicians at the start of an experiment, but then expected to run with minimal intervention for several days as scientists complete a series of measurements. When evaluating tenders, STFC will look for evidence that suppliers have considered this pattern of use – simplicity and reliability are key requirements.

A one year warranty will be provided; the warranty will start following acceptance of system components by the STFC.

A schematic diagram of the EC Muon Facility is shown in '*Figure 1: ISIS EC Muon Beamlines*'. A beam of subatomic particles (muons) is transported to the sample position within each instrument. The beam is stopped in the sample (requiring an areal density of at least 200mg.cm^{-2}) and the time dependence of the muon decay products monitored to complete the experiment.

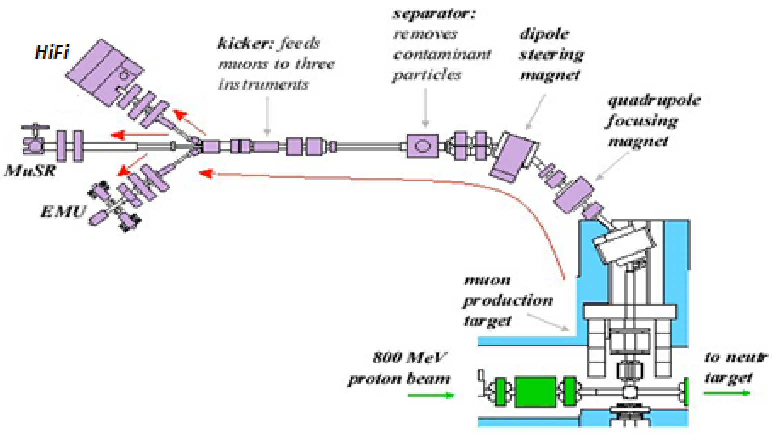

Figure 1: ISIS EC Muon Beamlines

Individual instruments are shown in '*Figure 2: EC Muon Instruments (left to right) MuSR, HiFi and EMU*'. In each case the cryostat is mounted from above, vertically within the instrument. For EMU and HiFi, the instruments include a shared vacuum vessel; cryostats are loaded warm and cooled on the instrument. For MuSR, the systems will be cooled offline and moved into position while at base temperature using a crane.

The existing ^4He cryostat is designed to work with both the HiFi and EMU instruments, while the cryostats being procured as part of this tender will be optimised to fit into MuSR and EMU.

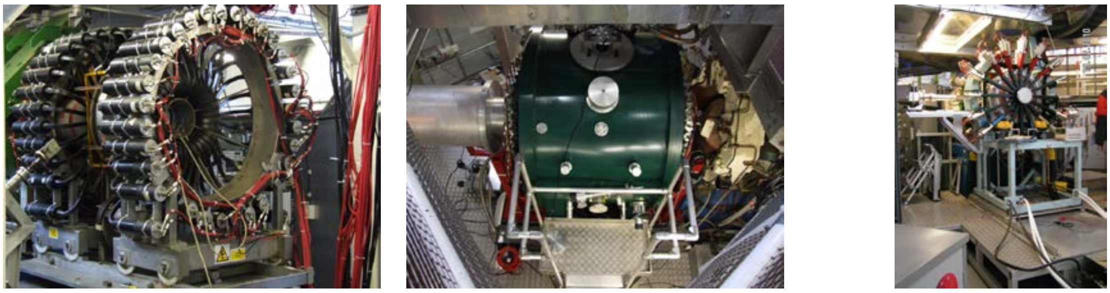

Figure 2: EC Muon Instruments (left to right) MuSR, HiFi and EMU

B. System Specifications

1. Specification of the ^{4}He Cryostat

<u>Performance</u>

1. Full operating temperature range (at the sample plate) will be 1.5K to 320K.

2. Sample cool down from 300K to base temperature, after helium and nitrogen reservoirs are full, and with the cryostat heat exchanger at 300K, will be less than 60 minutes.

3. Sample warm-up from base temperature to 300K will be completed within 120 minutes. Preference may be given to solutions offering faster warm-up times, perhaps through an additional heater on the sample rod. However, suppliers are reminded of the need for performance to remain compatible with all aspects of this specification, noting particularly point 11 concerning stray fields at the sample position.

4. The cryostat will operate with a static low pressure helium exchange gas in the sample space (IVC), with a continuously pumped heat exchanger providing temperature regulation. It's expected that the heat exchanger will include a heater and 30 point calibrated Cernox sensor (or equivalent) covering the operating temperature range of the cryostat.

5. Assuming additional heaters on the sample rod are not used, agreement at equilibrium between heat exchanger and sample sensors will be better than 15% at temperatures below 5K, with much closer agreement expected at higher temperatures.

6. The performance defined in points 1, 2 and 3 will be achievable by pumping the heat exchanger using a pump not exceeding $40m^3$/hr capacity. Less than 0.5 bar of helium exchange gas will be required (set after sample rod insertion with the cryostat running at 300K), and that the cryostat will run through its full operating temperature range without adjusting the exchange gas pressure.

7. The cryostat will have an automatic needle valve to control liquid helium flow through the heat exchanger. A needle valve heater will be provided to clear blockages.

8. The cryostat will be expected to run unattended above 5K, with the needle valve automatically opening when rapid cooling is required, yet optimising helium consumption when running at a constant temperature. Below 5K, manual control of the needle value is permitted, although preference may be given to suppliers offering a solution for automatic control over the full operating temperature range.

9. Liquid nitrogen hold time will be greater than 18 hours.

10. The liquid helium reservoir will be sufficient to allow for at least 18 hours of normal cryostat operation – this typically involves cooling a sample twice (300K to 1.5K) with temperature control either spanning the full temperature range or holding a constant temperature of 320K. The helium reservoir will be equipped with a 12mm siphon entry.

11. The cryostat must be able to operate in fields up to 0.65 T. Materials selected for construction will be chosen to avoid residual magnetism or superconductivity, even after an arbitrary number of temperature and field cycles. Heaters will be non-inductively wound to avoid stray fields (in excess of 1µT) at the sample position.

12. Acceptance testing will be carried out, with suppliers expected to demonstrate system performance by completing the following sequence. All temperatures are measured on the sample rod; however, the cryostat heat exchanger temperature should also be recorded to demonstrate good agreement between sensors. Stable temperatures should be maintained for at least 30 minutes.

    a) Load a sample rod with the cryostat running at 300K with the cryogens fulland set exchange gas.

    b) Cool to 5K; demonstrate temperature stability and note cooling time.

    c) Demonstrate system base temperature.

    d) Demonstrate stable temperature control can be achieved at 2K, 3K and 4K by controlling temperature of cryostat heat exchanger (additional heaters on the sample rod may not be used for this test).

    e) Warm to 300K, noting time taken for sample rod to reach temperature.

    f) Demonstrate stable temperature control at 250K, 200K, 150K, 100K and 50K.

    g) Note liquid helium and nitrogen consumption during acceptance tests.

<u>Construction and Geometry</u>

13. The position of the cryostat heat exchanger and dimensions of the IVC will allow the dilution fridge and ^{3}He inserts offered as part of this tender to be run in this system. To allow compatibility with the existing ^{4}He cryostat, the system should conform to critical dimensions shown in Appendix 1, '*Figure 6: Cryostat VTI critical dimensions*'.

14. The cryostat will fit into the available vertical space of both the EMU and MuSR spectrometers. The muon beam will enter along the centre of the z axis. See Appendix

1, ‘*Figure 3: Mechanical requirements for EMU*’ and ‘*Figure 4: Mechanical requirements for MuSR*’.

15. For operation in MuSR the system must be self-contained with an outer vacuum tail to form an outer vacuum chamber (OVC) that includes beam entry and exit windows formed of light-tight aluminised Mylar, thickness 125µm. A downward-facing surface, diameter 470mm, is provided to support the cryostat, the surface being at least 1180mm above the beam axis. The surface is provided with two holes 30mm diameter on a 420mm PCD. The line joining these holes is perpendicular to the beam axis.

16. For operation in EMU the outer vacuum tail will be removed and the cryostat will mount on the instrument’s ‘cruciform vacuum vessel’ (ISIS Drawing A0-SI-1101-360). In this configuration there will be a common vacuum shared between the cryostat and the spectrometer. The cryostat will fix to the top flange of the ‘cruciform vacuum vessel’ which contains an O-ring for the vacuum seal. The flange has 16 holes, diameter 9mm, equally spaced on a 190 PCD, with two holes in alignment with the beam axis (see ISIS Drawing A1-SI-1101-363).

17. A pumping port for the cryostat outer vacuum and valve will be provided on the top plate for evacuation of the self-contained system.

18. The total window thickness in the beam path, excluding the windows on the outer vacuum tail, must be no more than $50 mg.cm^{-2}$. Aluminium foil (thickness 5µm) is suggested for the radiation shield, with Kapton (thickness 125µm) proposed for the IVC windows. Suppliers may add an additional thermal shield in front of the Kapton IVC windows; aluminium foil (thickness 5µm) would be acceptable.

19. Window diameters must be a minimum of 45mm on entry and exit. All windows will be accessible for repair. STFC will mount 0.25mm high purity silver plate around all beam entry windows at delivery.

20. The IVC will be 50mm diameter, providing clearance for samples 40mm x 40mm x 5mm thick, placed with the 40mm x 40mm surface facing the muon beam.

21. Two sample rods will be supplied, both with 30 point calibrated Cernox sensors (or equivalent) covering the operating temperature range of the cryostat. A sample blade will be provided for mounting the sample aligned to beam centre. The front face of the sample blade should be 0.5mm behind the vertical centre of the sample rod. The blade will be demountable for special sample cells (leaving the Cernox sensor in place), leaving a >45mm diameter clear path between the entry/exit window centres. The sample mount for blades will be gold plated.

22. Both cryostat and sample rods will have KF-50 flanges for vacuum sealing.

23. A pumping port and pressure gauge (0-1000 mbar) will be provided on the IVC. A connection will be provided between the Helium recovery and the IVC as an alternative means of loading exchange gas from the top of the Helium reservoir; a valve on these lines will be required.

24. Ease of use should be a priority when considering the layout of the top place; the layout should be agreed with STFC prior to manufacture.

25. The emitted particles (positrons) exit in all directions: while they are more penetrating than muons, the sample blade and cryostat tails will be of a light construction, particularly within ±100mm vertically of the beam centre line.

26. Once all contractions have occurred following initial cool down, sample and window centres will be aligned on the beam axis. Sample and window positions will be invariant (±1mm) as the temperature is controlled over the full operating temperature range.

27. All closed volumes within the cryostat will be protected by relief valves.

28. The overall system should be as light as possible; ideally the overall weight will be less than 100kg.

29. The cryostat will be fitted with eyebolts for lifting. Certificates for the eyebolts will be supplied.

<u>Support equipment</u>

30. A temperature controller will be provided.

31. The controller will have a heater and three channels to read the temperature sensors provided with the cryostat. If heaters are provided on the sample rods all channels should provide a heater output. It’s expected that the temperature controller will control/optimise the position of the cryostat needle valve.

32. Level gauges for the liquid helium and nitrogen reservoirs will be provided.

33. For compatibility with existing communication systems, either an RS232 serial interface or an Ethernet network interface (RJ45) will be provided for remote control of the equipment. A full command set will be provided for remote control and readout of the temperature controller and level gauges, and a subset of key values (to be agreed with STFC by month 3 of the project) must be programmatically accessible by the remote interface. A description of the communication protocol will be given. Although a network interface may be provided, the equipment will be able to run indefinitely standalone, without requiring network access.

34. Preference will be given to companies offering either LabVIEW VIs or EPICS drivers (including source code) for remote operation. These particular solutions are chosen for compatibility with an existing data acquisition system.

2. Specification of the Dilution Fridge Insert

Performance

1. A dilution fridge insert for a ^{4}He cryostat is required. The insert will include a Joule Thomson stage to allow operation in a host cryostat running at 2K or 4K.

2. There will be a cooling power of at least 25µW at 100mK.

3. It is envisaged that there will be two different modes of operation:

   a) 'Circulating' mode, where ^{3}He/^{4}He mixture is used to provide cooling power, and temperatures between 35mK and at least 4.2K can be reached at the sample position.

   A weak thermal link is suggested as a solution for maintaining mixture circulation throughout this temperature span (see '*Figure 5: Schematic of dilution fridge sample stage*' for a schematic design). Other solutions to maintain mixture circulation at elevated temperatures will be considered; however, suppliers will be asked to provide evidence of their functionality. A previous track record is preferred, although a fully worked design may be acceptable.

   b) 'High temperature' mode, where the temperature regulation is provided by the host cryostat, with exchange gas cooling the insert and sample.

   In each mode, the system will be able to be cycled between the upper and lower temperatures in the specified ranges indefinitely and without user intervention.

4. Starting with the host cryostat cold (loaded with cryogens and running at 200K) and the insert prepared for loading, the time to cool the sample to 35mK will be less than 7 hours. Preference will be given to systems offering a faster cooling time.

5. Temperature control stability in 'circulating' mode will be ±0.5mK below 100mK; ±5mK in temperature range at or above 100mK.

6. The insert will incorporate multi-point calibrated thermometers on the sample plate, one thermometer covering the full operating range in 'circulating' mode, and a second covering the full operating range in 'high temperature' mode. The resolution of the thermometry used in 'circulating' mode should match or exceed criteria set out for control stability. The type of thermometers and their calibration range should be stated in the tender.

   Suppliers should note that a three point calibrated thermometer is not acceptable for either temperature range; for example, we would expect sensors calibrated at 30 or more points would be necessary to cover the range 1.5-300K.

   It's understood that it may not be possible to provide a fully calibrated thermometer that covers the full operating temperature range in ‘circulating’ mode. The temperature span of the calibration should be stated in the tender and, if necessary, the calibration should be extended. For example, for a thermometer with a calibration finishing at 50mK, an extended calibration covering temperatures between 25mK and 50mK would be valuable for checking whether the system is still cooling.

7. Additional thermometry should also be installed within the insert for diagnostic purposes. The location and type of this thermometry should be specified in the tender.

8. The time required to achieve temperature stabilisation when heating in ‘circulating’ mode from 100mK to 4.2K will be less than 10 minutes. Stabilisation occurs when the sample plate has been at a constant temperature, within ±5% of set point, for 5 minutes.

9. The time required to achieve temperature stabilisation when cooling in ‘circulating’ mode from 4.2K to 100mK will be less than 30 minutes.

10. The insert will be able to operate in fields up to 5 T. The system will be used in a magnetic field (no greater than ±5 T along the z-axis and, separately, no greater than ±0.65 T along the x-axis) – static fields will not affect the performance of the fridge.

11. Fields will be applied with a maximum ramp rate of 0.05 T/s. Suppliers are asked to estimate the temperature perturbation for the system running at 100mK as fields are ramped.

12. During acceptance testing, suppliers will be expected to demonstrate the system by carrying out the following sequence:

    a) Load the insert with the cryostat running at 200K.

    b) Cool to base temperature of the dilution fridge in ‘circulating’ mode.

    c) Demonstrate performance in ‘circulating’ mode – heat the sample between base temperature and 4.2K, demonstrating the required temperature stability can be achieved at 75mK, 200mK, 1K and 4.2K. Return to base.

    d) Set 2K in ‘high temperature’ mode.

    e) Demonstrate performance of the insert in ‘high temperature’ mode – demonstrate temperature stability at 5K, 35K, 150K and 300K. Return to base temperature of ‘high temperature’ mode.

    f) Remove exchange gas and return system to base temperature in ‘circulating’ mode.

Construction and geometry

13. The insert will be required to work within an existing ^{4}He cryostat and the aforementioned cryostat being procured as part of this contract. Critical dimensions to which the insert must conform are shown in '*Figure 6: Cryostat VTI critical dimensions*'). The insert will have a fixed KF-50 flange.

14. Beam entry and exit windows along the z axis will be provided on the insert tail, two radial windows 180^o to each other and 40mm diameter. Windows should be 125µm light-tight aluminised Mylar.

15. Windows should be centred on the centre of the sample plate (to ±1mm, or better) once contractions have occurred. The insert windows and sample plate will remain centred at all operating temperatures once cooled.

16. Within the insert, there should be clearance for a 40mm x 40mm x 5mm sample plate (on which the sample will be attached) with the largest surface area facing the windows and perpendicular to the beam. The front face of the sample plate should be 0.5mm behind the vertical centre line of the insert.

17. The sample plate will be removable and will be made from low mass density material with a high thermal conductivity. The blade will be gold plated for good thermal conductivity to the sample.

18. It is expected that access to the sample space will involve removing the insert from the host cryostat and demounting the lower section of the insert body, joined at a cone seal. An appropriate tool to separate the sections of the insert should be agreed with STFC.

19. The cone seal on the dilution refrigerator and ^{3}He inserts should be of identical diameter to enable standardisation of the sample blade.

20. The materials must not undergo a superconducting or magnetic transition at any temperature at which they operate. The materials chosen should be specified in the tender. No component, including heaters, should produce a field greater than 1µT at any point on the sample plate.

21. Certified lifting point(s) will be provided at the top of the insert to allow secure lifting, with the insert hung vertically, using a crane. This facility will be used to load and unload the insert from the host cryostat.

22. A spare port will be provided on the insert to allow wiring to the sample space.

Support equipment

With due regard to the requirements set out in '*Table 1: Summary of components that are part of this tender exercise*', support equipment will be provided as follows:

23. A temperature controller will be provided.

24. The temperature controller must constantly monitor the sample temperature, with a separate read back system provided for diagnostic thermometry.

25. PID tables will be provided for both temperature ranges.

26. For compatibility with existing communication systems, either an RS232 serial interface or an Ethernet network interface (RJ45) will be provided for remote control of the equipment. A full command set will be provided for remote control and readout of the temperature controller, and a subset of key values (to be agreed with STFC by month 3 of the project) must be programmatically accessible by the remote interface. A description of the communication protocol will be given. Although a network interface may be provided, the equipment will be able to run indefinitely standalone, without requiring network access.

27. Preference will be given to companies offering either LabVIEW VIs or EPICS drivers (including source code) for remote operation. These particular solutions are chosen for compatibility with an existing data acquisition system.

28. A suitable gas handling system will be provided that includes dry pumps (an Alcatel ACP40 is preferred).

3. Specification of the ^{3}He Insert

<u>Performance</u>

1. A ^{3}He adsorption insert for a ^{4}He cryostat is required. The insert will operate in a host cryostat running at approximately 2K and will have a temperature range between 300mK and 300K.

2. The base temperature and hold time with no applied heat load will be less than or equal to 0.30K for at least 40 hours.

3. It is envisaged that the insert will operate in three different modes:

   a) '^{3}He adsorption' mode, where the sorption pump is heated for temperatures between 300mK and at least 1.2K.

   b) '^{3}He pot heater' mode, where the ^{3}He pot is heated for temperatures between 1.2K and at least 80K.

   c) 'High temperature' mode, where the temperature regulation is provided by the host cryostat, with exchange gas cooling the insert and sample.

   In each mode, the system will be able to be cycled between the upper and lower temperatures in the specified ranges indefinitely (with due regard to point 2) and without user intervention.

   The system will be able to move between '^{3}He adsorption' and '^{3}He pot heater' modes without user intervention.

4. Starting with the host cryostat cold (loaded with cryogens and running at 200K) and the insert prepared for loading, the time to cool the sample to 300mK will be less than 5 hours. Preference will be given to systems offering a faster cooling time.

5. Temperature control stability will be ±2mK below 1.2K; ±5mK in temperature range 1.2K to 10K; ±30mK in temperature range 10K to 80K.

6. The insert will incorporate multi-point calibrated thermometers on the ^{3}He pot, one thermometer covering the full operating range in '^{3}He adsorption' mode and a second covering the full operating range in both '^{3}He pot heater' and 'high temperature' modes. The resolution of the thermometry used in '^{3}He adsorption' mode' mode should match or exceed criteria set out for control stability. The type of thermometers and their calibration range should be stated in the tender.

   Suppliers should note that a three point calibrated thermometer is not acceptable for either temperature range; for example, we would expect sensors calibrated at 30 or more points would be necessary to cover the range 1.5-300K.

7. The time required to achieve temperature stabilisation when heating in '^{3}He adsorption' mode from 300mK to 1.2K will be less than 10 minutes; stabilisation occurs when the ^{3}He pot has been at a constant temperature, within ±5% of set point, for 5 minutes.

8. The time required to achieve temperature stabilisation when heating in '^{3}He pot heater' mode from 1.2K to 20K will be less than 10 minutes.

9. The time required to achieve temperature stabilisation while cooling in '^{3}He adsorption' mode (after condensing) from 1.2K to 400mK will be less than 10 minutes.

10. The insert will be able to operate in fields up to 5 T. The system will be used in a magnetic field (no greater than ±5 T along the z-axis and, separately, no greater than ±0.65 T along the x-axis) – static fields will not affect the performance of the insert.

11. Fields will be applied with a maximum ramp rate of 0.05 T/s. Suppliers are asked to estimate the temperature perturbation for the system running at 300mK as fields are ramped.

12. During acceptance testing, suppliers will be expected to demonstrate the system by carrying out the following sequence:

    a) Load the insert with the cryostat running at 200K.

    b) Cool to base temperature of the ^{3}He adsorption insert.

    c) Demonstrate performance in '^{3}He adsorption' mode – heat the sample between base temperature and 1.2K, demonstrating the required temperature stability can be achieved at 350mK, 500mK, 900mK and 1.2K. Return to base.

    d) Set 3K in '^{3}He pot heater' mode.

    e) Demonstrate performance of the insert in '^{3}He pot heater' mode – demonstrate temperature stability at 2K, 5K, 10K, 25K and 50K. Return to low temperature < 3K.

<u>Construction and geometry</u>

13. The insert will be required to work within an existing ^{4}He cryostat and the aforementioned cryostat being procured as part of this contract. Critical dimensions to which the insert must conform are shown in '*Figure 6: Cryostat VTI critical dimensions*'). The insert will have a fixed KF-50 flange.

14. Beam entry and exit windows along the z axis will be provided on the insert tail, two radial windows 180^o to each other and 40mm diameter. Windows should be 125µm light-tight aluminised Mylar.

15. Windows should be centred on the centre of the sample plate (to ±1mm, or better) once contractions have occurred. The insert windows and sample plate will remain centred at all operating temperatures once cooled.

16. Within the insert, there should be clearance for a 40mm x 40mm x 5mm sample plate (on which the sample will be attached) with the largest surface area facing the windows and perpendicular to the beam. The front face of the sample plate should be 0.5mm behind the vertical centre line of the insert.

17. The sample plate will be removable and will be made from low mass density material with a high thermal conductivity. The blade will be gold plated for good thermal conductivity to the sample.

18. It is expected that access to the sample space will involve removing the insert from the host cryostat and demounting the lower section of the insert body, joined at a cone seal. An appropriate tool to separate the sections of the insert should be agreed with STFC.

19. The cone seal on the dilution refrigerator and ^{3}He inserts should be of identical diameter to enable standardisation of the sample blade.

20. The materials must not undergo a superconducting or magnetic transition at any temperature at which they operate. The materials chosen should be specified in the tender. No component, including heaters, should produce a field greater than 1μT at any point on the sample plate.

21. Certified lifting point(s) will be provided at the top of the insert to allow secure lifting, with the insert hung vertically, using a crane. This facility will be used to load and unload the insert from the host cryostat.

22. A spare port will be provided on the insert to allow wiring to the sample space.

<u>Support equipment</u>

23. A temperature control system will be provided, suitable for running the system unattended in the three modes, and for making the transition automatically between '^{3}He adsorption' and '^{3}He pot heater' modes.

24. The temperature controller must constantly monitor the sample temperature.

25. PID tables will be provided for all temperature ranges.

26. For compatibility with existing communication systems, either an RS232 serial interface or an Ethernet network interface (RJ45) will be provided for remote control of the equipment. A full command set will be provided for remote control and readout of the temperature controller, and a subset of key values (to be agreed with STFC by

month 3 of the project) must be programmatically accessible by the remote interface. A description of the communication protocol will be given. Although a network interface may be provided, the equipment will be able to run indefinitely standalone, without requiring network access.

27. Preference will be given to companies offering either LabVIEW VIs or EPICS drivers (including source code) for remote operation. These particular solutions are chosen for compatibility with an existing data acquisition system.

C. Project Timescale

The project is expected to run for no longer than three years from placement of contract. The timescale and structure of the project is outlined below; however, suppliers will be expected to provide a detailed proposal for project delivery with tender returns.

A proposal to stage delivery of components during the period of the project would be welcome. In particular, a project plan that includes delivery of one of the ^{4}He cryostats within 10 months of contract placement, and delivery of both a dilution fridge and a ^{3}He insert within 18 months of contract placement would be viewed favourable when evaluating tenders.

1. Detailed discussion of project with supplier immediately following placement of contract. This will include:

    - Review of contract, components and specification
    - Agreement of project plan, interim payments and delivery schedule for individual components

    (Month 1)

2. Component design complete and sign-off of design drawings by the STFC.

    (Month 3)

3. Manufacture, acceptance testing (at factory) and staged delivery of individual components

    (schedule as agreed at Month 1).

4. Final delivery of components to complete the sample environment suite.

    (schedule as agreed at Month 1, but certainly within three years of contract placement).

A meeting between the supplier and the STFC will be held at least every three months to monitor progress.

Appendix 1: Supporting Figures

Figure 3: Mechanical requirements for EMU

The following schematic diagram shows dimensions of the EMU spectrometer that are relevant to the cryostat: (a) Clear bore diameter of the 'cruciform vacuum vessel'; (b) Maximum diameter of cryostat body; (c) Distance from beam axis to 'cruciform vacuum vessel' top plate.

The top plate of the 'cruciform vacuum vessel' is 450mm from the beam axis, with a clear vertical bore from the plate to the beam centre of 100mm. There is a frame up to a height of 220mm above the flange, with 395mm clear space between the side of the instrument frame. The clear space between detectors is 590mm up to a height of 310mm above the flange. The hole in the platform through which the cryostat mounts has a minimum radius of 510mm.

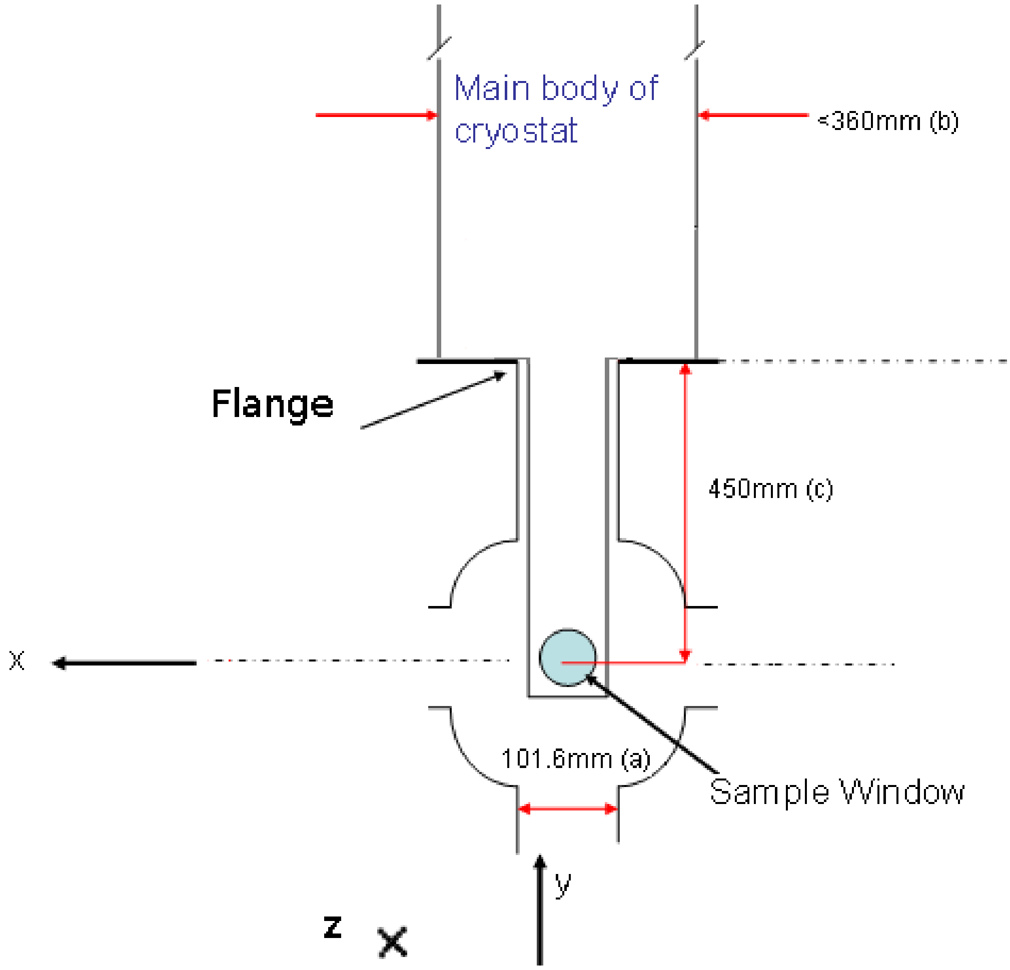

Figure 4: Mechanical requirements for MuSR

The following schematic diagram shows dimensions of the MuSR spectrometer that are relevant to the cryostat: (a) Distance from cryostat support plate to sample position (beam axis); (b) Maximum diameter of cryostat body; (c) Distance from beam axis to top of magnet; (d) Distance from beam axis to bottom plate of spectrometer; (e) Separation of magnet coils (maximum diameter of outer tail); (f) Separation between centres of guide posts of diameter 30mm; (g) Maximum diameter of cryostat support plate.

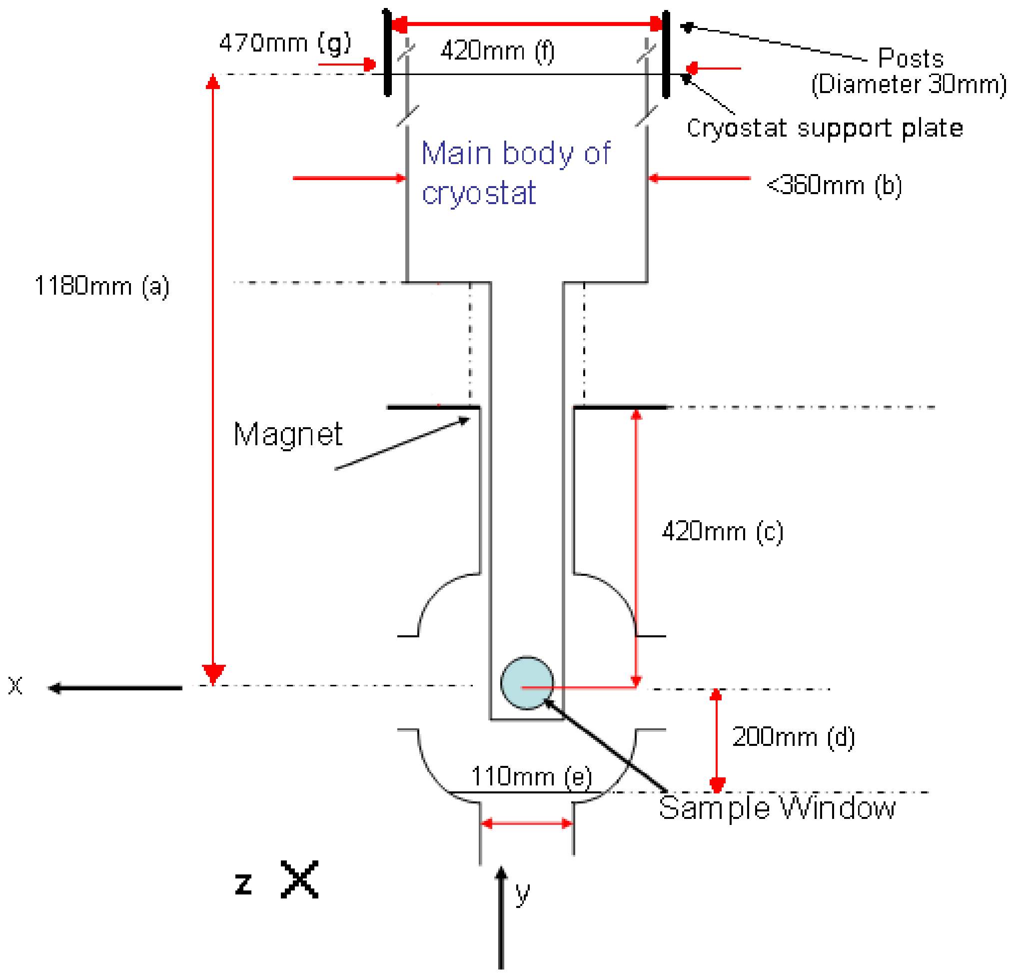

Figure 5: Schematic of dilution fridge sample stage

Schematic diagram of a weak thermal link within the sample stage, suggested as a solution for maintaining mixture circulation throughout required temperature span.

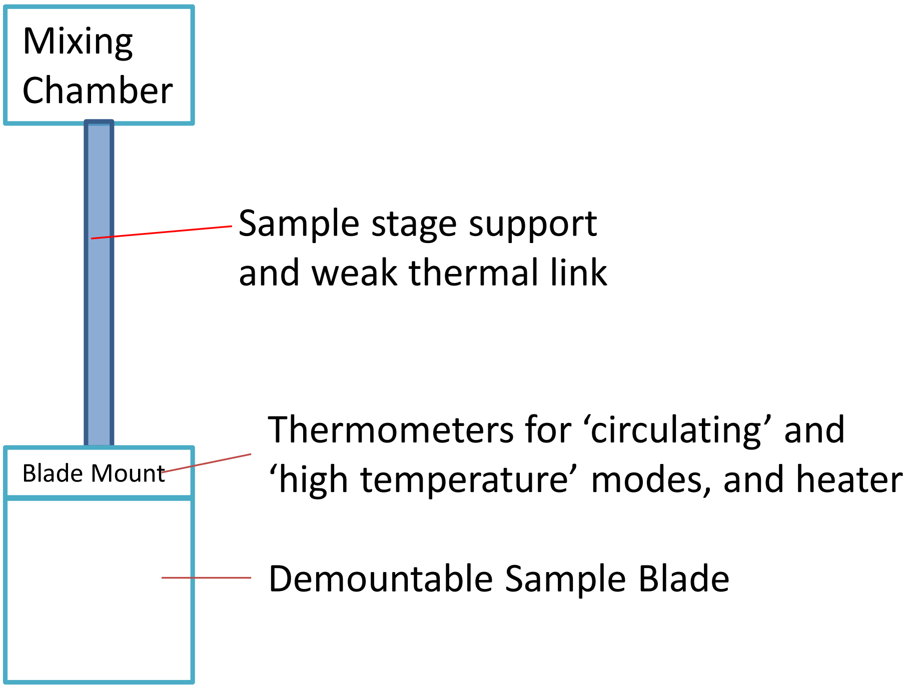

Figure 6: Cryostat VTI critical dimensions

Critical dimensions to which system must conform to ensure cross compatibility of equipment.