Generic Document	
Document Number	ESS-0038078
Project Name	<<Project Name>>
Date	Aug 26, 2015
Revision	2 (5)
State	Preliminary

ESS Sample Environment Mechanical Interfaces for Instruments – Reference Document for WBS 13.6.X.2.3

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SUMMARY

This revised document defines the mechanical interfaces between Sample Environment Systems (SES) and the ESS instruments. Included are all physical requirements that affect the process of preparing, moving, mounting, using, demounting and removal of SES. These will enable SES to be operated safely and according to their specifications. In addition, they impose a set of standards that maximise interoperability between instruments and pool, and simplify alignment and maintenance procedures.

Conforming to this reference will enable the use of ESS common pool SES at the instrument, and easy interchange of SES between instruments.

This document is organised according to workflow. First the transportation of equipment to the instrument, and a potential preparation zone is discussed. Next follow sections on transporting equipment into the cave and onto the sample position. Considerations at and around the sample position are then handled in multiple sections on space requirements at the sample position, beam height, space for auxiliary equipment, etc. Finally, magnetic considerations, labyrinths, and concurrent experiments are handled.

DOCUMENT REVISION HISTORY

Revision	Reason for and description of change	Author	Date
1	First draft issue	Anders Pettersson	2015-06-xx
1.1	Modified according to instrument team comments and internal discussions	Anders Pettersson	2016-02-xx
1.2	Major changes: Clearer definition of sample environment concepts and nomenclature Implementation of the Universal Sample Coordinate System and kinematic mounting systems Modification and refinement of many requirements	Malcolm Guthrie	2017-08-xx

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1. FOREWORD

This first revision of the reference document is updated to take account of new input from many sources, more detailed engineering information on the first 15 instruments and early development of in-house mounting standards.

These standards should now be considered requirements for using pool sample-environment equipment and to access the many other benefits of standardisation.

Throughout this document, consideration has been given to minimising beamloss due to sample environment installation and operation.

This document is the first of a series of references developed by Scientific Activities Division, the other documents are:

[1] ESS Sample Environment Utilities Supplies – CHESS 0038163

[2] ESS Sample Environment Software Interfaces – CHESS 0038165

Note: Numbers in specifications that are not yet finalised are indicated in light blue.

2. INTRODUCTION

The ESS suite will be comprised of next-generation instrumentation that introduces new challenges for the mechanical interfacing of sample environment systems (SES). For example, a majority of instruments are expected to operate with sub-mm samples requiring unprecedented positioning precision and accuracy (see Figure 1). Another important factor will be data collections potentially measured in minutes driving a need for rapid installation, alignment and removal of SEE systems to minimise beamtime losses.

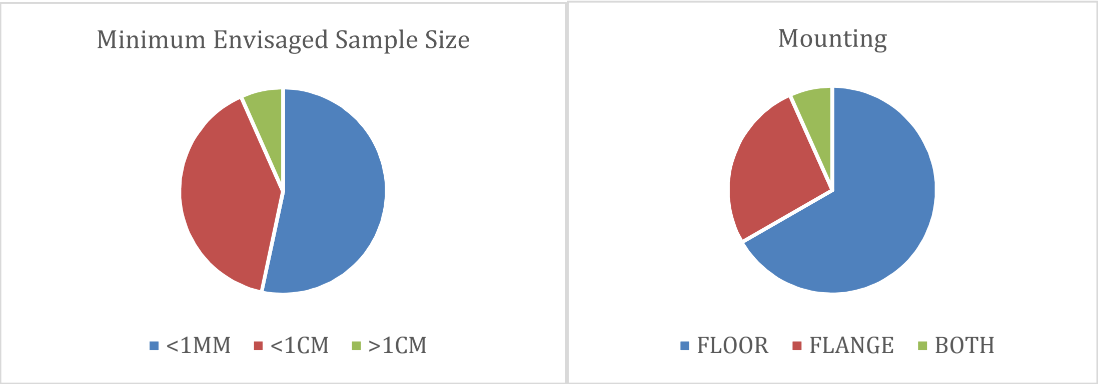


Figure 1 Some statistics taken from TG2 documentation on the first 15 instruments. Left chart categorises the minimum envisaged sample size bands. Right chart shows the available mounting options, a large majority are floor vs flange mount. (Original collated data are stored in embedded excel file.)

This Sample Environment Mechanical Interfaces reference has been written to address these new needs and to ensure maximum scope for enabling specialised SES at all ESS instruments. Also considered are standards to maximise interoperability of expensive equipment such as that in the SEE pool, both to maximise the scientific scope of instruments and to provide redundancies for equipment failure. Equally important at this early stage is to define the requirements necessary to avoid basic mechanical conflicts that will preclude or unnecessarily complicate installation of SEE on all instruments.

2.1 The Sample Environment System Concepts and Nomenclature

Throughout this document, "Sample Environment System (SES)" refers to a complete functioning assembly that includes:

1. the core item of Sample Environment Equipment (SEE) which contains the sample
2. a mounting mechanism that is fixed to the SEE.
3. all auxiliary equipment (AE) needed for the SEE to function (controls, pumps, chillers, etc).
4. all cables, vacuum lines, etc. linking the SEE to the AE and the utility supplies.

Core concepts:

Each SES will have a set of AE, which is connected to utility supplies. Utility supplies must be available were the instrument intends to place AE [1].

SAD requires the ability to maintain continuous connection between SEE and auxiliary equipment during installation and interlocking of the instrument (see Figure 2).

Throughout this document we use the terminology "On-beam" or "Primary" SES to refer to a system that is installed on a beamline. Secondary (tertiary etc) are "off-beam" systems in the process of being prepared offline "staged" for changeover with the Primary SES after a measurement is finished.

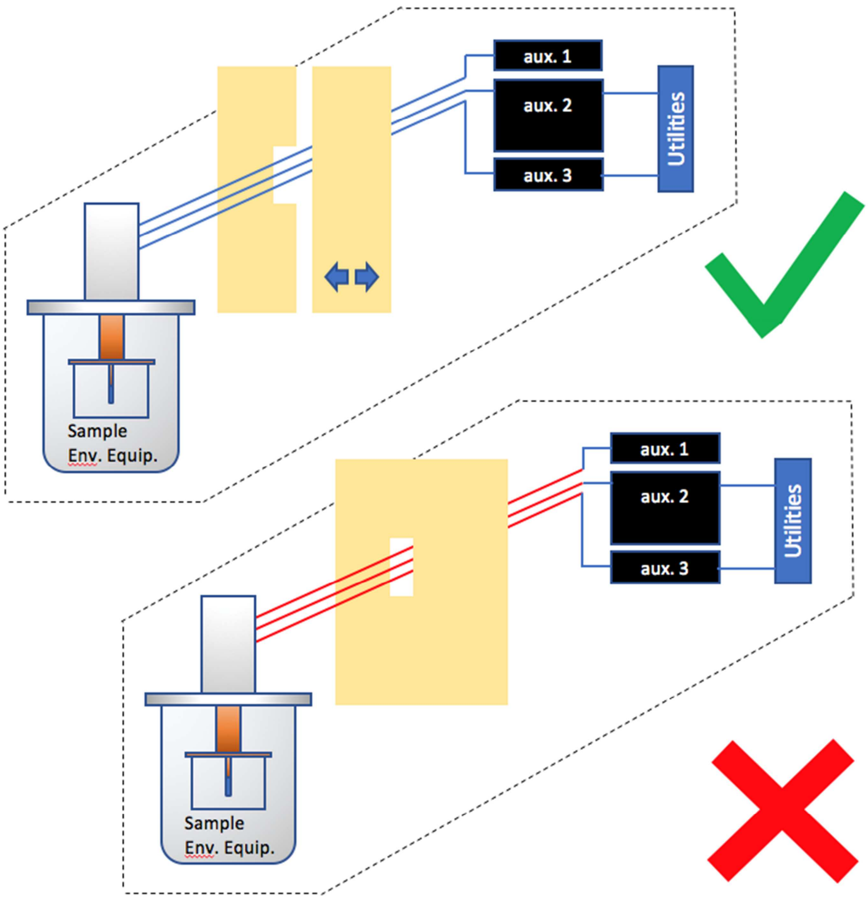


Figure 2 Conceptual image of operational, online SES used at an instrument. Each SES comprises both SEE and interconnected AE. The latter will be connected to utility supplies. It must be possible to maintain connections (blue lines) from the online SEE to the AE during installation and on interlocking the instrument considering shielding, cages for robotics, false/raised floors, other components (yellow structures). Holes e.g. fixed chicanes are not acceptable as in this case the connections need to be broken (red lines, lower image). For (permanently) installed SES and to accommodate (user-supplied) SES exceptionally, labyrinths and patch panels shall be considered on the instrument (See §10).

The challenges of standardising across the diversity of instrumentation at the ESS are significant. To accommodate this, we have defined different classes of instrument with separate standards. In the general case, adopting a 'lower' class will limit the possible SES than can be operated on a given instrument. By following the recommendations and requirements for a given class, an instrument designer is assured that the corresponding SES in the common pool will be straightforward to physically fit and smoothly operate on the instrument. Moreover, future flexibility will be maintained. The work is defined by the generic WBS:13.6.X.2.3 for each instrument X. Other relevant requirements for sample environment can be found in references [1] and [2].

Where it is impossible to follow the exact recommendations within this reference, for example on short instruments with very little surrounding space, it is important to consider alternative solutions to enable the relevant activities. In extremis, one may have to rule them out explicitly in order to enable the rest of the instrument's remit, but this shall be a considered and documented (Tollgate documentation) decision. Please contact SAD to discuss any specific conflicts with your instrument.

3. SCOPE

This document is a reference for all ESS instrument teams in the process of designing the mechanical interfaces for sample environment. It defines the minimum requirements for mechanical interfaces that are needed in order to be able to fully utilise SEE, including the common pool, instrument specific SEE, and most of the foreseeable user SEE. Highly complex or extreme SEE needs to be handled on a case-to-case basis.

The main focus is the mechanical interfaces that are relevant when using sample environment at the normal sample position. However, this document also covers a second experiment preparation area to facilitate parallel setups, e.g. for rapid experiment changeover.

The reference defines:

- **SPACE, LOGISTICAL AND ERGONOMIC REQUIREMENTS. The minimum required space** at the beam position including minimum free distances to the beam and minimum required ceiling height above the sample position. It also considers allocation of space for peripheral equipment, such as mobile Dewars or pumps, equipment transport means and the ergonomics of installation and operation.
- **MECHANICAL INTERFACES:**
  - **The standardised mounting interface for SEE** including sample-to-mount distances, multiple level mount designs, standardised angular relation between beam and mounting surface and mechanical designs for physical mounting mechanisms
  - **Kinematic mounting systems** and **Universal Sample Coordinate System (USCS)** this system will allow high-precision offline pre-alignment of samples and rapid and reproducible installation between multiple instruments. The USCS concept also allows coordinates of specific regions-of-interest to be shared between any instrument and offline system on the USCS.
  - **High-precision alignment** of samples (< 50 µm) can be achieved using a scanning approach based on neutron transmission measurements . Requirements to enable this are specified.
- **MAGNETIC REQUIREMENTS** detailing the specific requirements to enable operation of high magnetic fields on instruments.

The reference will only set up requirements for the mechanical interfaces; the exact implementation will be conducted as part of the instrument construction project, with costs falling within the instrument budget.

Mechanical interfaces in the forms of utilities supplies' connectors and hoses etc. are covered in the Sample Environment Utilities supplies reference [1].

Planned instrument-specific SEE should always be discussed with the instrument SAD contact person as early in the project as possible, to assure that the requirements are set appropriately.

4. NOTE ON REQUIREMENTS

Where a specific requirement is detailed in this document, it is labelled with a number linked to the relevant document section. Conformity to these requirements will be confirmed at tollgates. In addition to requirements, some recommendations are also made, these are unnumbered.

5. INSTRUMENT CATEGORIES

In order to address the challenge of outlining standards and requirements for a highly diverse instrument suite, it has been necessary to define distinct instrument categories. Each category entails specific requirements, therefore, it's important to correctly assess the category for each instrument.

The categories considered are:

- The ultimate weight-bearing physical support for SEE: either floor or flange, with a third possibility of both.
- The maximum size of SEE envisaged (see Appendix A). The default is Large (L) and all instruments must at least accommodate this standard. For instruments anticipating the largest samples or SEE, there is an alternative Extra-Large (XL) option. Without the XL option, certain large samples, high-fields magnets and certain robotic manipulators will be precluded (see Appendix A).
- Whether high magnetic fields are expected or not.
- Whether the volume surrounding the primary SEE is habitually evacuated, not evacuated or whether this is optional.
- Minimum envisaged sample size: <1MM,<1CM,>1CM. (Note: sample size is defined by region of interest, not total external size of sample).
- Whether a polarised neutron beam is present.

Throughout this document, requirements have been grouped according to instrument category in an attempt to maximise legibility.

5.1 Instrument interface description

We have established a table to keep track of the key of the relevant categories for each of the 15 'construction' instruments. This information was extracted based on TG2 documentation. Please contact SAD in the event of any discrepancies.

Instrument	SEE mount	SEE size	Magnetic SEE	Polarised beam	Sample Vacuum	Min sample size
LOKI	Floor	XL			No	<1cm
SKADI	Floor		Yes		No	<1cm

ESTIA	Floor		Yes		No	<1cm
FREIA	Floor				No	<1cm
DREAM	Both	XL	Yes		Optional	<1mm
HEIMDAL	Floor	XL	Yes		Optional	<1mm
MAGIC		XL	Yes	Yes		<1mm
NMX	Floor	XL			No	<1mm
BEER	Floor	XL	Yes		No	<1mm
ODIN	Floor	XL	Yes		No	>1cm
BIFROST	Floor	XL	Yes		Yes	<1mm
C-SPEC	Flange	XL	Yes		Yes	<1cm
T-REX	Flange	XL	Yes		Yes	<1cm
VESPA	Flange	<L			Yes	<1cm
MIRACLES	Flange	<L	Yes		Yes	<1cm

6. TRANSPORTATION, LOGISTICS AND ERGONOMICS

6.1 Transport within the experimental hall

Due to the size of the ESS Facility, support workshops and laboratories are not necessarily close to the instruments. Therefore, SES will frequently need to be moved from labs to the instrument and back. To facilitate this task, the full SES will, as far as possible, need to be equipped with wheels and/or lifting eyes for craning. Care must still be taken that appropriate access is available between the sample environment and chemical and biological labs in either E03, D04, or D08, and instrument. For example, assuring path width, sufficient crane capacity and coverage in the experimental halls and at the instrument, smooth floors for transport, etc. into, and out of, instruments. The SEE table in Appendix A gives examples of the dimensions of items that must be easily transported.

Recommendations:

Both SAD and the instrument teams shall work together to ensure CF delivers a functional transport path from sample environment workshops up to the instrument. This will include a sufficiently large transport path and, where required, adequate cranes/lifts to traverse changes in floor level

6.2 Area for SES preparation at the instrument "Staging Space"

At the end of each experiment and beginning of the next one, a rapid changeover of SES is required. There is likely to be a considerable distance from an instrument to the nearest sample environment support lab. Hence the need for a setup or 'staging' space as close as possible to the instrument and the instrument cave, for placement and preparation of equipment ready for the next experiment, see example in Figure 3.

Requirements:

6.2.1 A dedicated staging space of minimum size 2m x 3m x 3m (height) shall be made available at the instrument or, where not possible, within ~20 m to assure sufficient space for staging of SES.

6.2.2 The staging space must be equipped with one utilities supplies standard setup, as defined in the Sample Environment Utilities Supplies Reference, and further considerations relating to sample handling must be made (see reference [10]).

Recommendations:

Consideration should be given to also installing an offline alignment station calibrated to the Universal Sample Coordinate System (see §8.1) at the instrument. Such a station could be envisaged for any mounting level (as defined in §8.3) and would be particularly useful for instruments requiring regular high-precision alignment. Another useful approach would be for instruments to share resources to enable a shared local alignment facility. SAD will have alignment facilities available in their laboratory spaces.

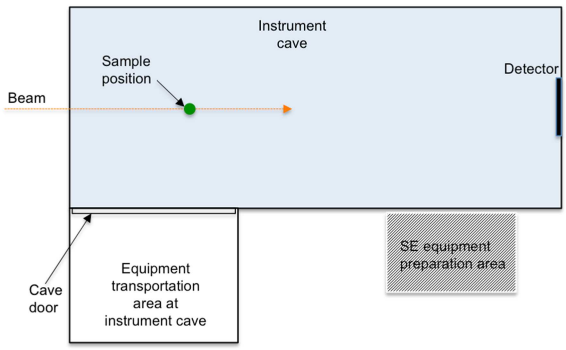


Figure 3. Schematic illustration of a preparation area placed at the instrument close to the instrument cave area

6.3 Access to sample position

In order to smoothly and rapidly install the full SES system (on-beam, ancillary and control units that are all interconnected), access to the sample position must be maintained

Requirements:

6.3.1 At least one access route from the sample preparation area to the closest approach to the sample position must be available and must share a common floor level. where this is not possible, lifting equipment must be provided with a minimum area of 1 x 1.5m (TBD) capable of handling 1000 kg (TBD) payloads. It is *not acceptable* to use a crane to navigate obstructions or changes in floor level to avoid multiple lifts of the individual components of the full SES system.

6.3.2 The access route relating to 6.3.1 shall be smooth and stable in order to minimise vibrations (amplitude TBD) experienced during wheeled transport of SES.

6.3.3 At no point on the access route relating to 6.3.1 shall there be unmovable height restrictions below 2.00 m.

6.3.4 Where the access route relating to 6.3.1 requires entry to a cave. There must be a minimum access area at the cave entrance of 2.0 x 2.5m.

6.3.5 Each instrument shall have access to a 2-axis crane, with at least 1,000kg capacity to lift SEE to the sample position. The crane must cover the distance from the closest approach of wheeled SEE to the sample position. The drive mechanism of the crane must avoid jerky acceleration. The main hall crane must not be appropriated for routine SEE installation. Minimum hook-height requirements are given in § 7.8. (SAD notes that a solution for standardised instrument cranes should be pursued.)

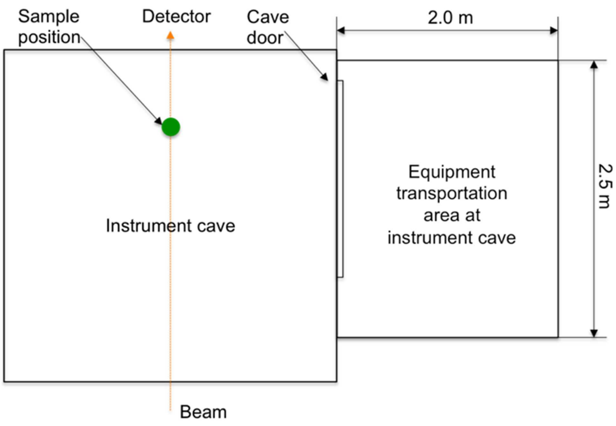


Figure 4. A schematic drawing of a proposed handling area outside the instrument cave. The space needs to be sufficient to use a crane and/or a pallet jack (manual/electric) to transport the SES into the cave.

6.3.6 A continuous corridor with a minimum width of 1.5m shall be maintained from the sample preparation area to the position of closest approach to the sample position. Smaller passages of at least 1.10m are acceptable as long as a minimum clearance of 1.50m is maintained before and after these (see Figure 5).

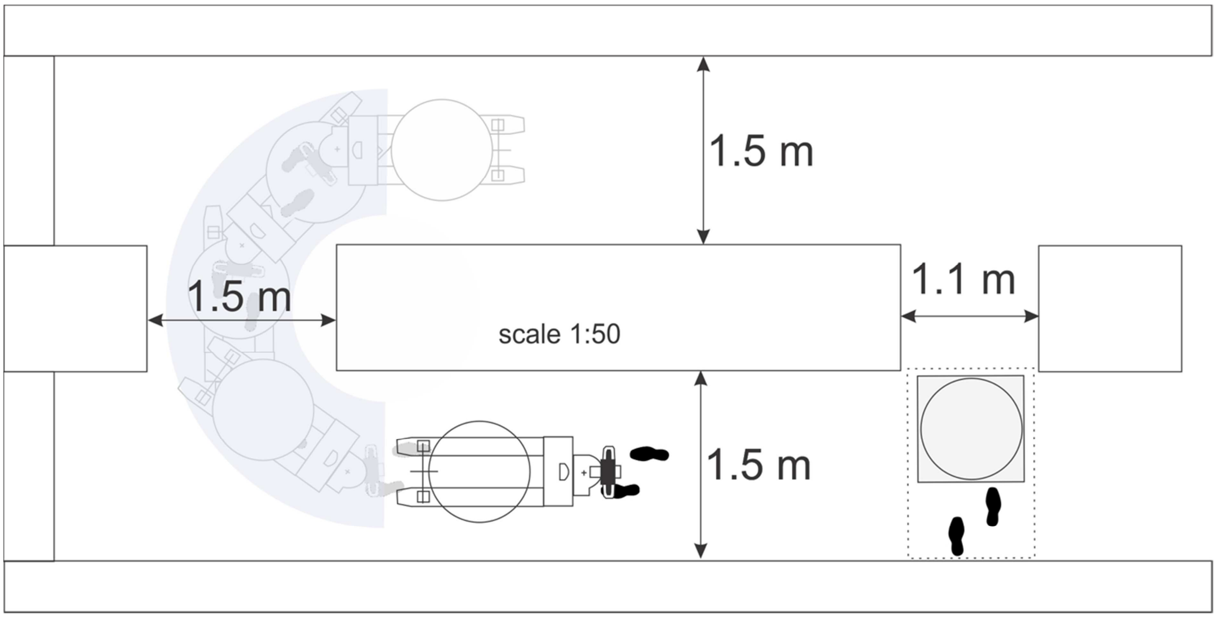


Figure 5 Illustration of transport corridors with minimum dimension of 1.5 m. Right shows alternative narrower opening of 1.1m with open space of 1.5m before and after.

Recommendations:

Beyond the direct route to the sample position, and wherever possible, changes in floor level and thresholds should be minimised.

7. SPACE AROUND SAMPLE POSITION

All SES accommodate a minimum amount of space (see examples in Appendix A) to be installed and operated in an efficient and safe manner. The requirements to enable this are documented here, including factors such as:

- The physical size of on-beam SEE
- Additional space for auxiliary components of the full SES
- Additional space for mounting hardware (distinct for floor and flange)
- Additional space for translations or rotations or combinations of these
- Additional space for personnel during installation/removal

Some of the requirements are defined separately for floor and flange mounted instruments. Furthermore, to balance the needs for flexibility and standardisation two physical standards have been defined “L” and “XL” each implying different requirements.

Requirements:

7.1.1 All instruments are required to adopt at least the requirements related to the L standard. Where this is not possible solutions should be discussed with SAD.

Recommendation:

the XL standard is preferable and recommended wherever possible.

7.2 Online SEE exclusion volume for floor-mounted instruments

This section defines the minimum space required at the sample position for instruments where the on-beam SEE (including the sample) ultimately rests on the ground. This exclusion volume is required to fit larger SEE, although it can be occupied by other equipment, these must be easily removable.

Also, it is important to maximise access to the defined “Levels” for sample installation as defined in §8.3. A specific example is where a floor-mounted stack of translation stages occupies part of the exclusion volume. Where this stack can be broken – to enable access to the exlusion volume – this should occur at one of the defined levels relative to the beam.

7.2.1 The minimum volume described in Figure 6 and Table 1 shall be available at the sample position. Any installations occupying any part of this volume shall be easily removable. (A Catia file representing this volume will be made available).

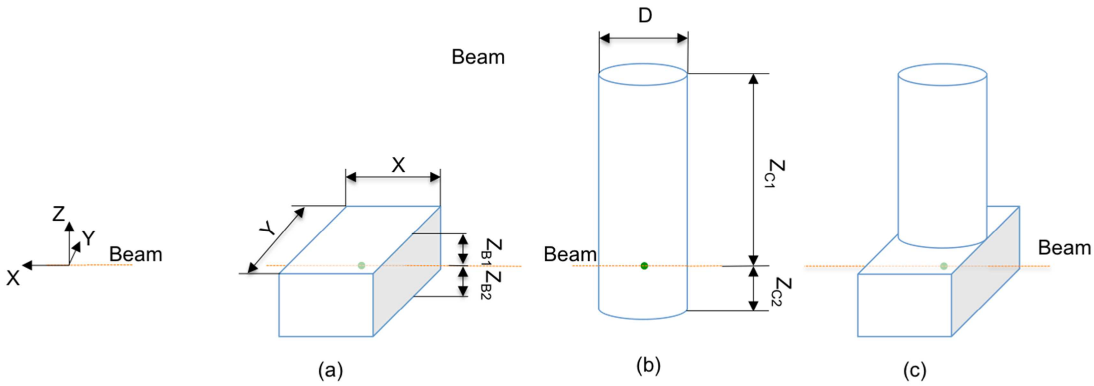


Figure 6. Schematic drawing of the space required for fitting of any SEE as exemplified in Appendix A. The green dot indicates the sample position; see Table 1 for dimensions. (a) Defines a box volume around the green sample position. (b) Defines a cylindrical volume around the sample position. (c) Shows the shape of the total required space at the sample position.

A summary of the dimensions required is presented in Table 1 below. The dimensions here do not include considerations related to operations; for example, swapping a sample stick in a cryostat in situ will require significant extra space in the positive z direction, see §8 for further information.

Space	Parameter	XL	L
Box (a)	X	1000mm	800mm
Box (a)	Y	1500mm	1000mm

Box (a)	Z_{B1}	700mm	300mm
Box (a)	Z_{B2}	500mm	500mm
Cylinder (b)	D	800mm	500mm
Cylinder (b)	Z_{C1}	1500mm[a]	1300mm[a]
Cylinder (b)	Z_{C2}	500mm	350mm (TBD)

Table 1. The table presents the dimensions as referred to in Figure 6 above. [a] dimension not including space required to changes sample, e.g. sample stick change. all instrument components (collimators slits) within the XY box need to be removable for installation and can be (partly) re-installed to ensure adequate beam definition.

7.3 Online SEE exclusion volume for flange-mounted instruments

In flange-mounted instruments SEE will be suspended from a top flange above the sample position.

Requirement:

7.3.1 The minimum volume described in Figure 7 and Table 2 shall be available at the sample position. Any installations occupying any part of this volume shall be easily removable. (A Catia file representing this volume will be made available).

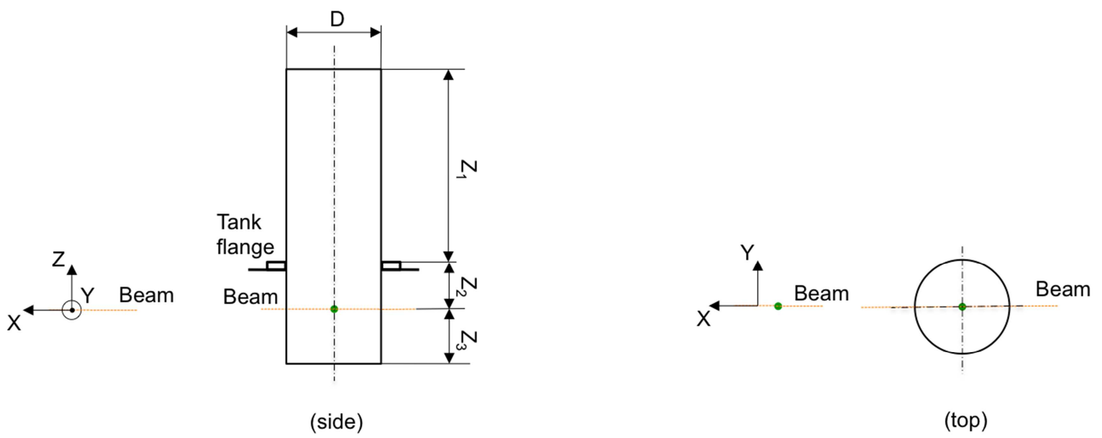


Figure 7. Schematic drawing of the space required to assure smooth mounting of any SEE as shown in Appendix X for a flange-mounted instrument. “Tank flange” indicates the mechanical interface between the tank and the SEE. The green spot indicates the sample position. (side) Defines a cylindrical required volume around the sample position. (top) Shows the top view of the required cylindrical space. (A Catia file representing this volume will be made available).

Parameter	XL	L
D	800mm	500mm
Z_1	1000mm (TBD)	800mm (TBD)
Z_2	500mm	500mm

Z_3	500mm	500mm
$Z_1 + Z_2 + Z_3$	2000mm[a]	1800mm[a]

Table 2. The table presents the levels of space to be met. [a] dimension not including space required to changes sample, e.g. sample stick change. all instrument components (collimators slits) with the diameter D and within Z2 and Z3 must be removable for installation and can be (partly) re-installed to ensure adequate beam definition.

7.4 Space for auxiliary equipment

The full SES includes both the on-beam SEE and the auxiliary equipment, such as pumps, coolers, Dewars, power supplies, and control racks, to run (see Figure 9). These must remain physically connected to both the online SEE *and* the relevant utility supplies. Consequently, they will have strongly constrained locations. It is proposed that predefined positions for these will be identified and that these locations shall be shielded from the direct and the scattered beam (by a movable B4C chicane / ½ height wall etc

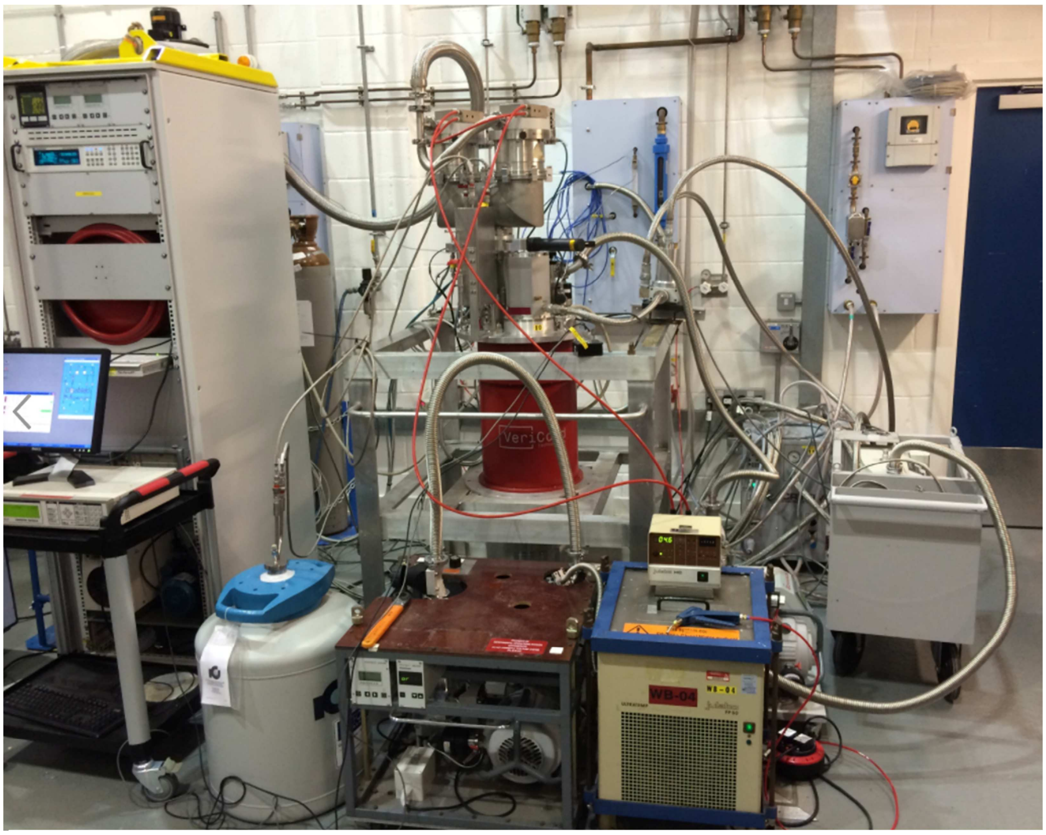


Figure 8 Example of primary SEE (a cryostat with dilution insert), surrounded by the multiple auxiliary equipment required for operation.

A common, but demanding, example is a cryomagnet with dilution insert, which will require at least four separate large items of auxiliary equipment to be as close as possible during routine use (gas handling system, magnet power supply rack, turbo pump set, and mobile filling Dewar). Increased distance from the SEE comes at a price of lower performance or higher cost, due to pump performance, etc.

These requirements for auxiliary equipment space are calculated for one experimental setup.

Table 3 below lists examples of some auxiliary equipment.

Equipment	Mass (kg)	Width (mm)	Length (mm)	Height (mm)
Rough pump	15	300	150	150
Mobile turbo pump set.	25	500	500	700
Compressor	50	600	600	500
Cooler	40	400-500	400 - 600	400 - 600
Power supply	35	400-500	400 - 600	400 - 600
Furnace control unit (?wagon)	100	500	500	1000
Control rack	50	600	600	1500
Gas handling system for dilution cryostat	100	800	600	1700

Table 3. Examples of dimensions and mass of free-standing SES auxiliary equipment

Requirements:

7.4.1 Instrument teams shall ensure space for auxiliary equipment is available, according to Table 4 and illustrated in Figure 9. At least 75% of this area shall be accessible to heavy wheeled equipment (i.e. floor space of some kind), the rest can be, for example, on shelving or tables. The space is to be interconnected to the volumes for the on-beam equipment e.g. chicanes for shielding shall not require the systems to be disconnected Figure 2.

7.4.2 The space allocated for auxiliary equipment shall be less than 2m from the SEE utilities supply panel enabling physical connections to be made

7.4.3 The space allocated for secondary equipment shall be less than x m(TBD) from the online SEE equipment to enable physical connections to be made

7.4.4 The space allocated for auxiliary equipment shall minimise radiation exposure for the equipment. Possible solutions may include a half-height wall, chicane, or primary cave shielding (for example where the AE are located on the roof of an instrument cave).

Table 4 Space for auxiliary equipment

Area	Approx. shape	Number of areas
$0.5m^2$	1m * 0.5m	2
$0.4m^2$	0.6m * 0.6m	2

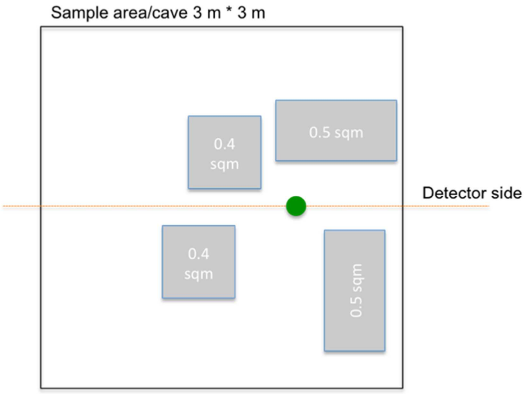


Figure 9. Example of available space for sample environment auxiliary equipment as viewed on a top view of a hypothetical 3 m x 3 m instrument cave. The green dot denotes the sample position and the dotted line the beam.

7.5 Space for SEE mounting hardware

In addition to the physical size of the primary SEE, consideration must also be given to the space requirements of the mounting hardware that will hold it in position and confirm its alignment. The development of different engineering solutions for both floor- and flange-mounted instruments is ongoing and current concepts are described in detail in later sections. However, full engineering drawings are not yet available. Therefore, instruments are advised to take consideration of this additional space requirement as detailed here:

Flange-mounted instruments: should expect at least an additional 100mm (TBD) radial distance to accommodate the Level 0 physical flange that SEE is mounted on. Correspondingly for the XL size standard which accommodates 800mm diameter SEE, *the total clear diameter must be at least 1000mm.*

Floor-mounted instruments: will ultimately rest on the Level 0 three-point kinematic mount (see § 8.4). The current prototype requires an additional depth of 200mm below the defined Level 0 mounting surface (in total 1500mm below the beam). Consideration should be given to recessing these points to maintain a desirable floor-to-beam distance.

7.6 Additional space for translations and rotations

For many instruments, it is likely that the region of interest (ROI) may not be exactly centred at the origin of the USCS (the sample position). For example, extended objects may have more than one ROI, or a cryostat stick may shrink and deform during cooling moving the sample. In another example, even with TOF-Laue, single crystals may need to be tilted to access important regions of reciprocal space where there is limited detector coverage or obstructions from SEE, collimation etc.

These operations can typically be achieved by mounting the primary SEE on a goniometer and the mounting levels (defined later in §8.3) have been chosen to enable this. However, it’s clear that additional space is required to enable this motion. Extreme cases include combinations of a translation and a rotation of an extended object (such as a magnet, or cryostat) about the sample position.

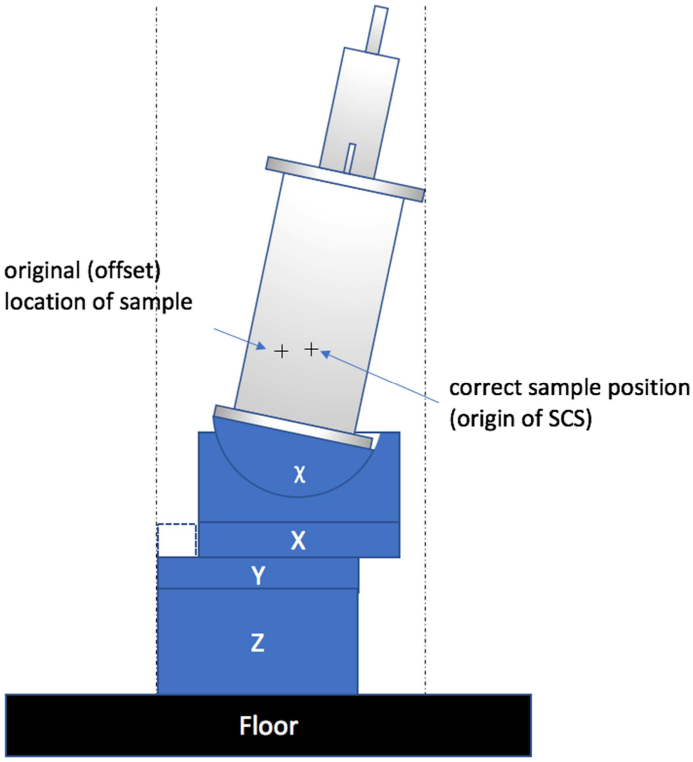


Figure 10 combination of a translation along x and rotation about a χ axis increasing space requirement.

Recommendation

It is recommended that instrument engineers consult with SAD staff to ensure that there is sufficient space for envisaged translations and rotations of primary SEE.

7.7 Space considerations for personnel access during operation of SES

SEE and auxiliary equipment are most often not static equipment. During installation, sometimes complicated connections need to be made during operation, He refilled, valves and regulator manoeuvred/inspected, etc.

To enable this, additional space is required within arms-reach of connection points on the on-beam SEE. Potential solutions may be removable roofs, high ceiling, hatches in the roof, and handling from a mezzanine (placed on top of, or close to, the instrument cave), if this is an option. Considerations need also to be made to assure that the equipment can be reached/operated in an ergonomic and safe way.

The following common use cases must be considered:

- Filling cryogens (helium/nitrogen)
- Changing 1.5m sample stick in 1.5m cryostat

- Making multiple connections (electrical, gas, hydraulic, water) close to the sample position.

7.7.1 Floor space within a radius of 1.0m from the sample position spanning a continuous angle of at least 140° (see Figure 11A) must be available during SES installation. Alternatively, two separate segments each of at least 70° can be made available (see Figure 11B).

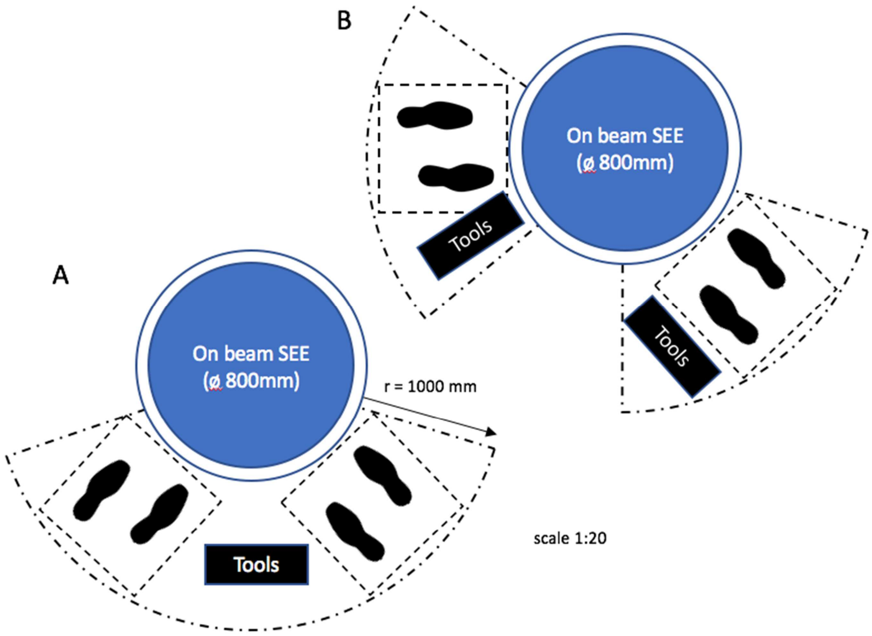


Figure 11 Operational space around on-beam SEE

7.7.2 An access route for personnel and tools to the operational floor space described in 7.7.1 shall be provided.

7.8 Instrument crane height requirements

Consideration must be given to the minimum height of an instrument crane in order to install SEE. Factors include the height of the equipment itself, the extension of the sling and the minimum lifting height for disengaging the interface to enable the horizontal translation away from the sample position. These considerations differ depending on whether the instrument is floor or flange mounted and whether the rating is for L or XL equipment. Figure 12 illustrates the case for XL equipment being installed on a floor mounted instrument (see later §8.3 for description of mounting levels). Note, these are the *minimum* requirements simply to disengage the SEE. If other obstructions are present on the craning route, these should also be considered.

In the case of floor-mounted instruments, heights are defined relative to the sample position, in the case of the flange-mounted instruments, these are given relative to the mounting flange

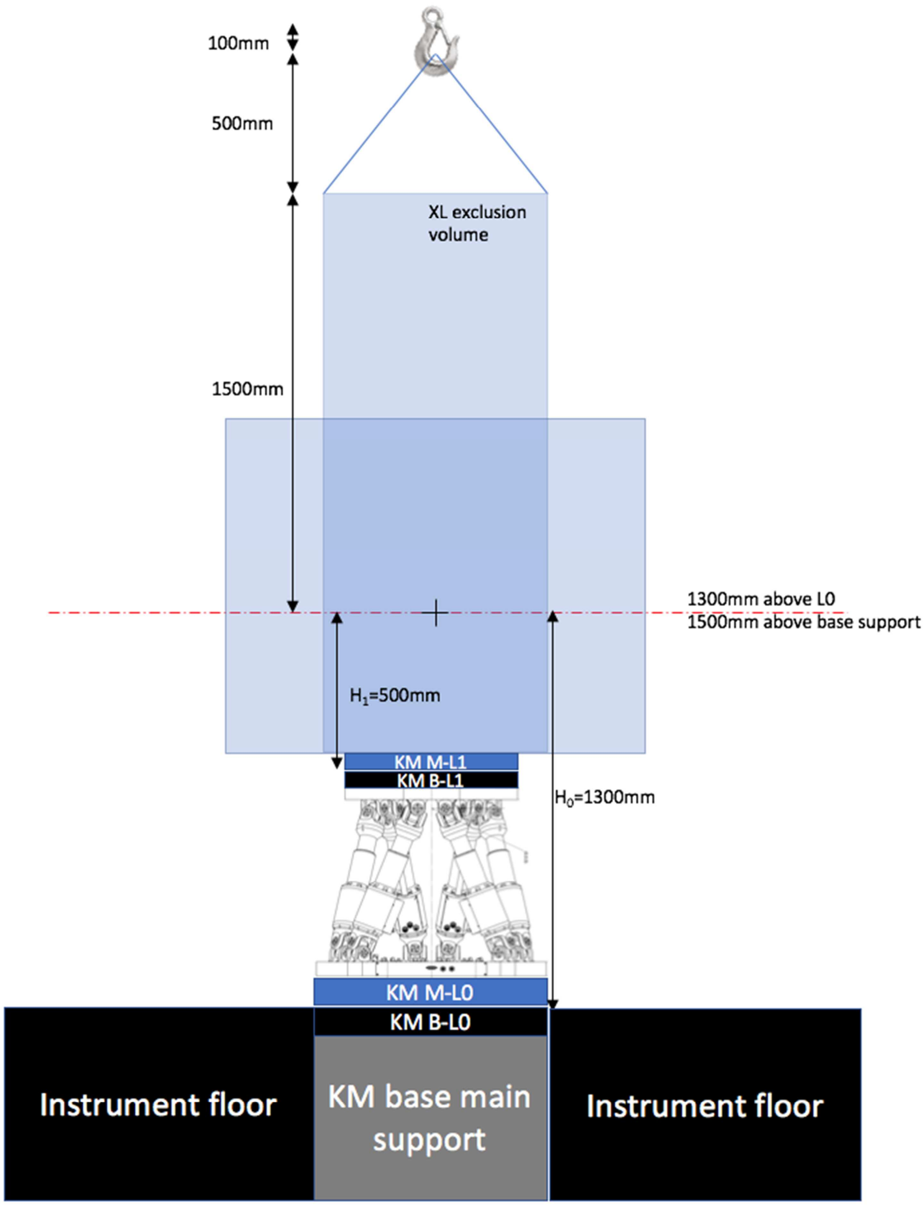


Figure 12 Illustration of lifting height requirements for floor-mounted XL equipment. Here the disconnect point will be at Level 1, which is 500mm below the sample position. To enable the lift, a total height of 2100mm is needed: 1500mm (height of SEE) + 500mm (sling) + 100mm (lifting height).

7.8.1 For floor-mounted instruments, a minimum hook height of 2100mm above sample position/beam is required for installing XL equipment, or 1900mm for L equipment

7.8.2 For flange-mounted instruments, a minimum hook height of 2600mm (TBD) above the flange is needed for installing XL equipment, or 2400mm (TBD) for L equipment.

7.9 Cryostats: Stick changes and cryogen filling

Often a rapid sample change can be affected on a cryostat by swapping out sample sticks. An important consideration is that the stick must be pulled vertically up, requiring sufficient head height (Figure 13).

7.9.1 To allow for sample stick change in top loading cryostats, a minimum free height of 3.5m above the sample position must be available. If a crane is to be used for lifting cryogenic inserts, a hook height of 4m is required above the beam, superseding requirements 7.8.1 and 7.8.2.

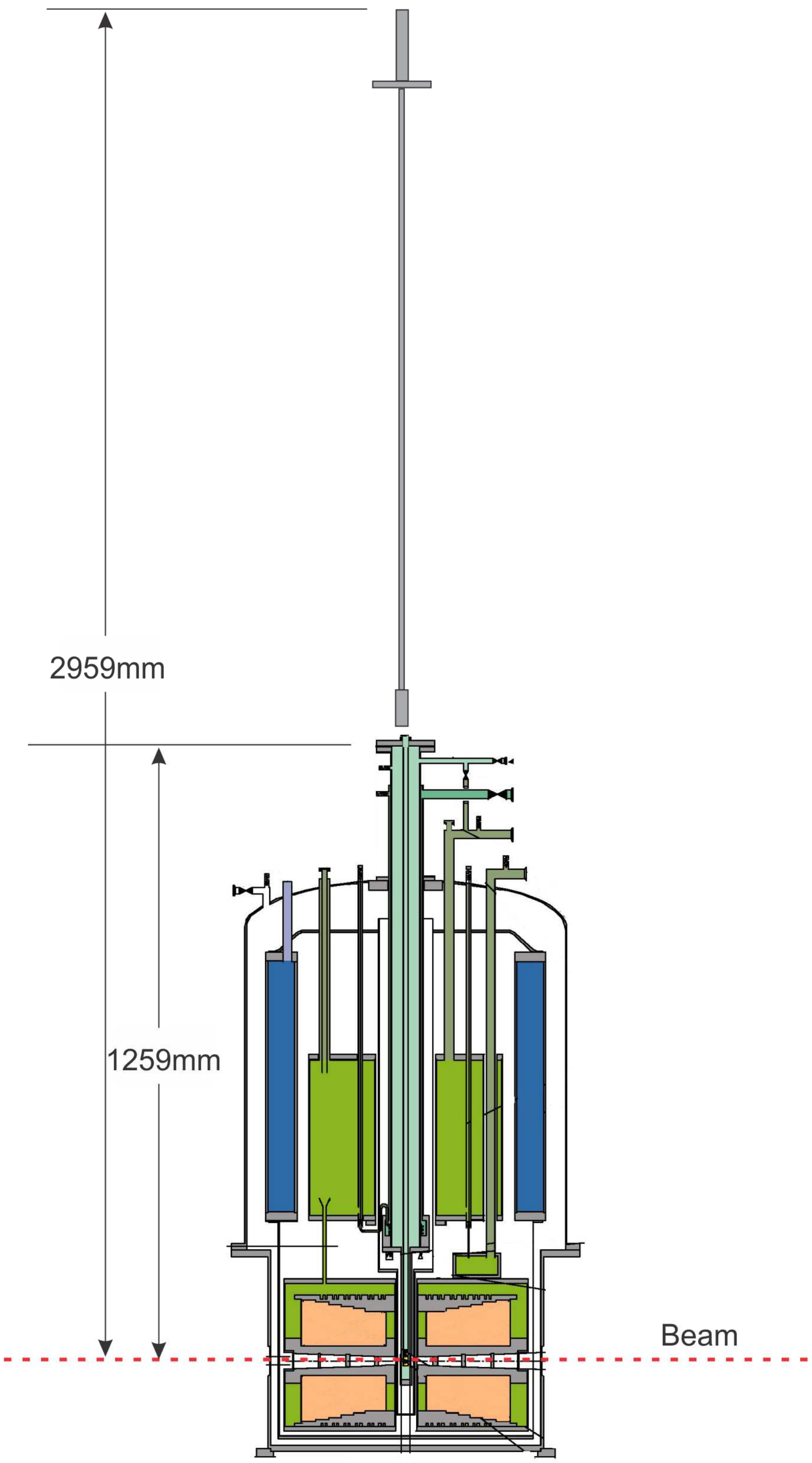


Figure 13 Illustration of height requirement for a stick change

There are additional special considerations for allowing the transfer of cryogens into liquid cryostats (see Figure 14).

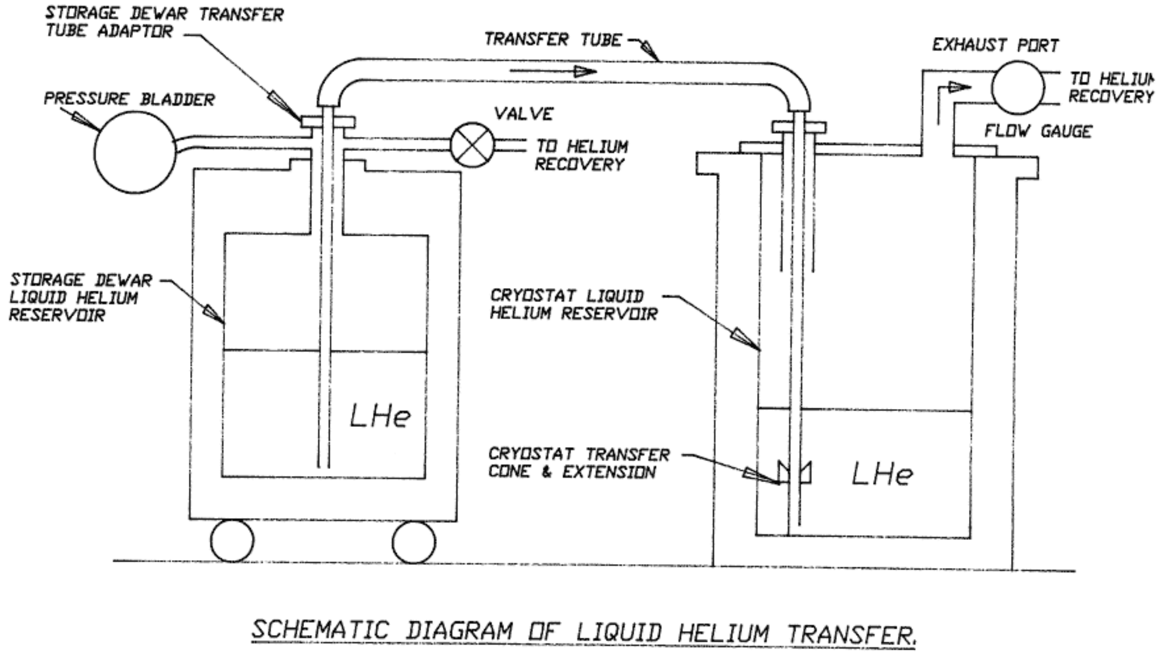


Figure 14 liquid He transfer (Image courtesy PSI).

7.9.2 The space close to the sample position shall allow filling of helium from a 100L mobile storage Dewar (typically ø500mm x 1200mm high) using a semi-flexible helium transfer line (rigid vertical legs, flexible horizontal connection). The difference in height between the top of the storage Dewar and the fill port on the SEE should be minimised as far as possible during transfer. This may be achieved by lifting the Dewar using mobile lifting equipment if the SEE is above floor level, or by the use of long flexible transfer siphons (which reduces efficiency).

7.9.3 Space is required for the transport of the Dewar (with footprint 1x1m), two people to assist with the transfer, and if necessary a stepladder (when the SEE is above floor level).

7.9.4 There must be at least 3m free space above floor level at the Dewar postion to allow insertion of transfer lines into the transport Dewar.

8. MECHANICAL INTERFACE FOR SEE

In addition to overall space requirements, it is also important to define several mounting positions at a fixed distance from the beam/sample position. This will allow mounting of all pool sample environment equipment using a limited number of adaptors.

Furthermore, mechanical interfaces must be defined and standardised for mounting SEE to the floor or instrument flange. By meeting the required mounting standard, all pool SEE can be installed rapidly and with high precision.

As in the previous sections, requirements are defined differently for floor vs flange-mounted instruments.

8.1 The Universal Sample Coordinate System

SAD is in the process of ongoing development of the concept of a Universal Sample Coordinate System (USCS). Correspondingly, any SEE aligned on any instrument, or offline alignment station, that is calibrated to the USCS can be transferred to a second instrument (also on the USCS) and retain an exactly equivalent position relative to the neutron beam and instrument centre.

The USCS is:

- a right-handed Cartesian system defined by the three unit vectors $\mathbf{e}_x$,$\mathbf{e}_y$ and $\mathbf{e}_z$, and an origin centred on the sample position.
- $\mathbf{e}_z$ points vertically up.
- $\mathbf{e}_x$ is the horizontal vector closest to parallel to the beam (which may not be horizontal).

This is illustrated in Figure 15.

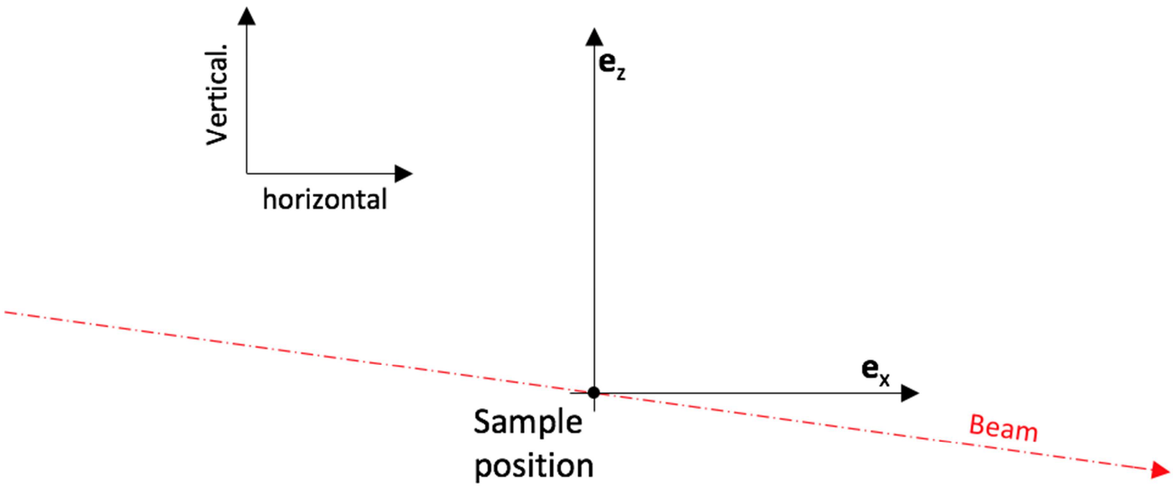


Figure 15 Illustration of the USCS showing an extreme case with an exaggerated, non-horizontal beam. By definition, the direction of $\mathbf{e}_x$ will minimise the angle between it and the beam. $\mathbf{e}_y$ is into the page.

The ultimate achievable tolerances within the USCS are being determined using prototype systems, the current goal is to keep these below 100µm.

Requirements:

8.1.1 All instruments using POOL SEE shall adopt the USCS to describe regions of interest within samples.

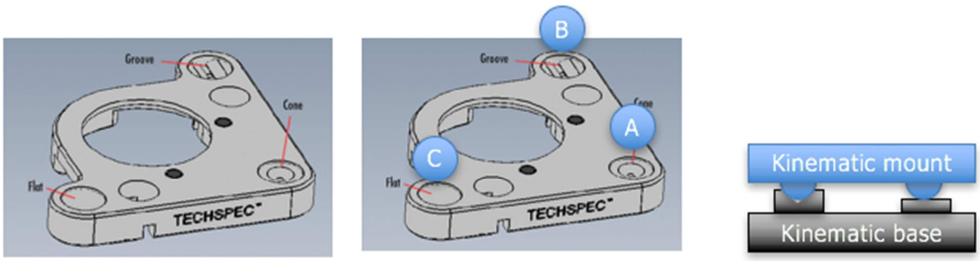
8.1.2 ICS, DMSC, MCS, and other divisions should also ensure that all the USCS compatibility is imposed on all hardware and software related to SES.

Recommendations:

Wherever possible, User developed hardware and software should also follow the USCS.

8.2 Kinematic mounting

The implementation of the USCS depends on the concept of kinematic mounting. This system systematically constrains the 6 degrees of freedom (3 rotations and 3 translations) that uniquely describe the location and orientation of a solid object, thus ensuring reproducible positioning. The *kinematic system* consists of two detachable components: *the kinematic base* and the *kinematic mount*, for consistency, the upper most component will always be called the mount and the lower the base. Normally a *kinematic mount* will be permanently attached to any floor-mountable SEE.



The ESS system employs a cone, flat and groove design, illustrated in Figure 17.

Figure 16 Illustration of principal of kinematic mounting. Here the base contains the three elements of the cone, groove and flat, while the mount contains 3 mating spherical interfaces (labelled A,B and C). The intersection of A with the cone constrains all 3 translational degrees of freedom. The intersection of B with the groove constrains two of the rotational degrees of freedom. Lastly, the intersection of C with the flat constrains the final rotational degree of freedom.

In order to implement the USCS, both the base and the mount must also in the general case incorporate a full set of rotation and translation adjustments. The base adjustments allow the axes of the alignment system to coincide with the USCS. Meanwhile the mount adjustments take account of machining tolerances on different SEE or its mounting.

A custom, calibrated mount will be physically and permanently attached to each unique SEE, with a corresponding base available on each instrument.

8.3 Standard dimensions and mounting levels

In order to maximise the possibilities for interchangeability of pool and other equipment between multiple instruments, it is critical to define specific standard dimensions (including floor/flange-to-beam heights). As in previous sections, these are defined differently for floor versus flange-mounted instruments, but the concept holds for both.

In addition, we have implemented the concept of different mounting levels:

- Level 0: The 'base' level for accommodating the largest envisaged SEE and, for example, a goniometer supporting Level 1 (only floor-mounted instruments)
- Level 1: For accommodating XL size SEE.
- Level 2: A standard level for mounting the most common (L size) equipment.
- Level 3: A 'precision' level for accommodating the smallest SEE and positioning samples such as single-crystals, capillaries, diamond-anvil cells, etc. with extremely high precision.

Each mounting level will have its own kinematic interface, independently clocked onto the USCS. Adapters will be available to enable transitions between levels.

Recommendations:

All instruments should maintain a set of adapters enabling transitions between the mounting levels they routinely use.

8.4 Floor-mounted instruments: definition of levels

As described above, the definition of specific mounting "Levels" allows for the standardisation of mounting hardware between multiple instruments. However, this also introduces constraints on the physical size of SEE and can introduce ancillary consequences, for example, affecting the offline storage space needed. Still another consideration is occlusion of detector angles by mounting hardware. The following specifications have been chosen to optimise these factors.

A primary specification is the total vertical distance between the mounting level and the beam, H_0 for Level 0 etc. This is defined as the distance from the contact plane of the relevant kinematic mount and base (the plane defined by the tips of the 3 mounting spheres), to the $\mathbf{e}_x$-$\mathbf{e}_y$ plane of the USCS (Figure 17). By definition, the mounting surface will be horizontal and so these distances will always be parallel to $\mathbf{e}_z$.

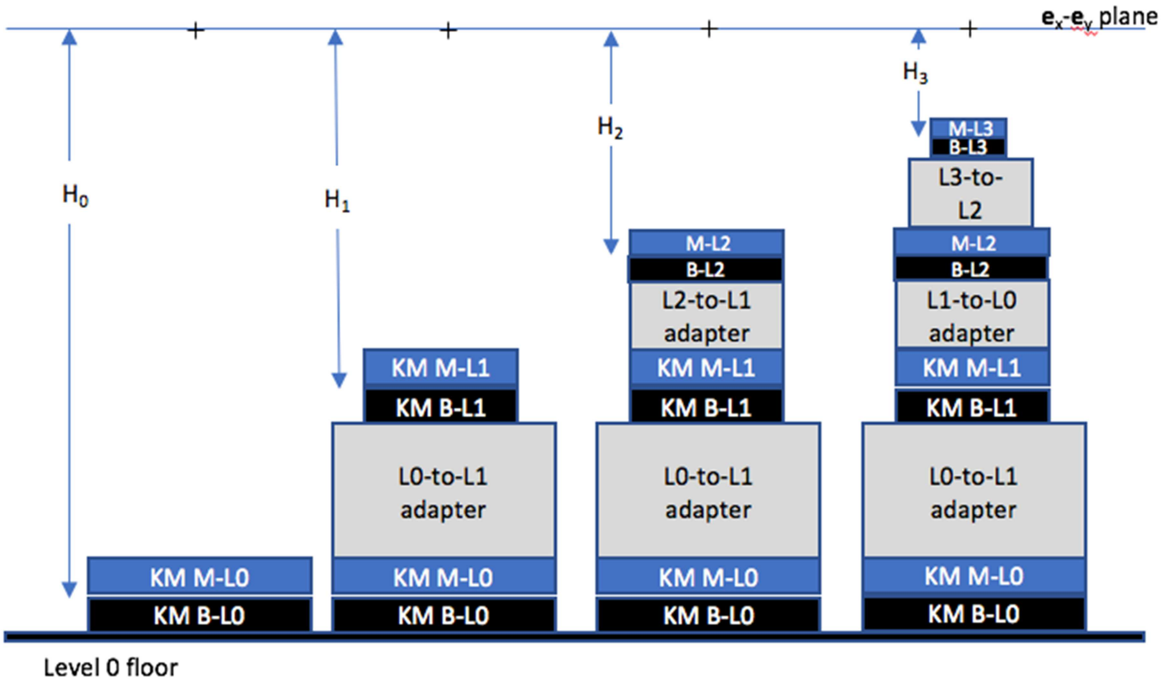
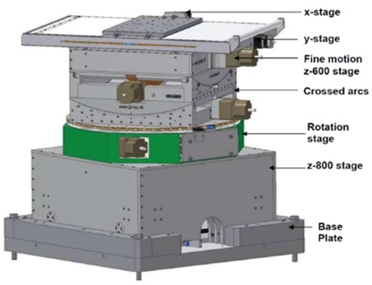


Figure 17. The figure shows a schematic illustrating a floor-mounted instrument and the Level 0,1,2 and 3 interfaces. The dimensions H_n are defined as the vertical distance from the *contact point of the kinematic mount* to the $\mathbf{e}_x$-$\mathbf{e}_y$ plane. Black crosses indicate the origin of the USCS.

Level 0 is the most accommodating mounting level, which must be sufficient to account for the largest expected SEE set up. It is also envisaged to accommodate a goniometer such as



that shown in

Figure 18.

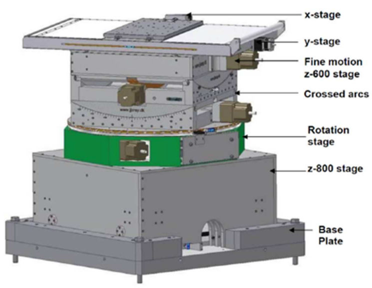


Figure 18. Example CAD drawing of a positioning table used on a floor-mounted instrument. This particular stage, has 6-axes with fine and coarse vertical translations. Below the z-stage additional X, Y positioners are sometimes required (not included in the example). Figure from reference [8].

Level 1 is expected to accommodate the largest equipment in the XL category.

Level 2 will probably be the most heavily used mounting position, accommodating very common equipment such as cryostats, CCR's, furnaces, Paris-Edinburgh cells etc.

Lastly **Level 3** is a high precision level to provide easy installation for the lightest and smallest equipment including vanadium cans, single-crystal goniometers, diamond anvil cells etc.

Level	Distance to beam (mm), H_n	Weight max. (kg)	Interface area (mm)
0	1300mm	2000*	1200x800/Ø850
1 (XL equip)	500mm	1000*	Ø850
2 (L equip)	350mm	300	Φ500
3 (high precision)	200mm	5	Φ250

Table 5. Specifications for different levels all numbers are provisional and subject to revision. *required final mass of envisaged magnets + stages.

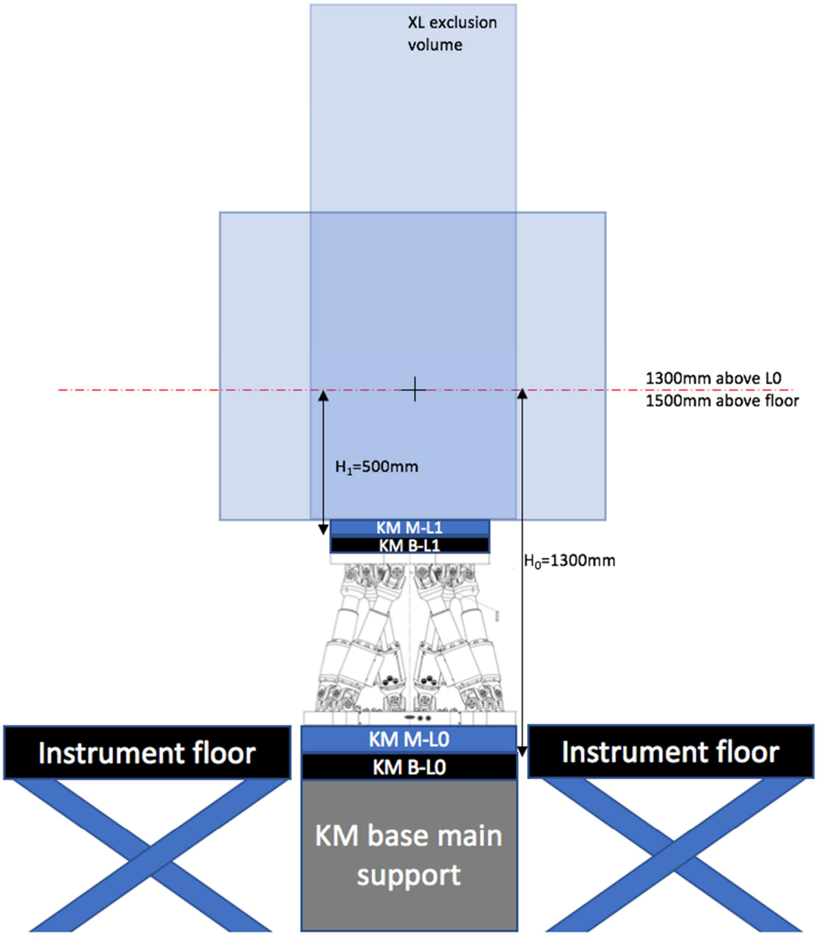


Figure 19 illustration of mounting levels, where a hexapod is used to support the volume defined to accommodate XL primary SEE. In such a scenario, the majority of SEE change outs would be at Level 1. Equipment changeout at Level 0 would only occur to exchange the hexapod (e.g. to affect a repair). Also, note that the Level 0 mount may be recessed relative to the instrument floor.

8.5 Floor-mounted levels: definition of standard mount interface

It is expected that each primary SEE will be (semi) permanently attached to its own kinematic mount that will mate with a kinematic base on the instrument. Correspondingly, many possible configurations can be envisaged, each tailored to the specific primary SEE.

8.5.1 In order to use SEE, the instrument shall provide the appropriate level of kinematic base to mate with the kinematic mount on the SEE.

Drawings for the current prototype mount are available with some relevant details given in Appendix C. Figure 16 shows the prototypes for each of the levels.

These drawings constitute our first prototype system and although we are beginning to converge on stable designs, these should still be considered provisional.

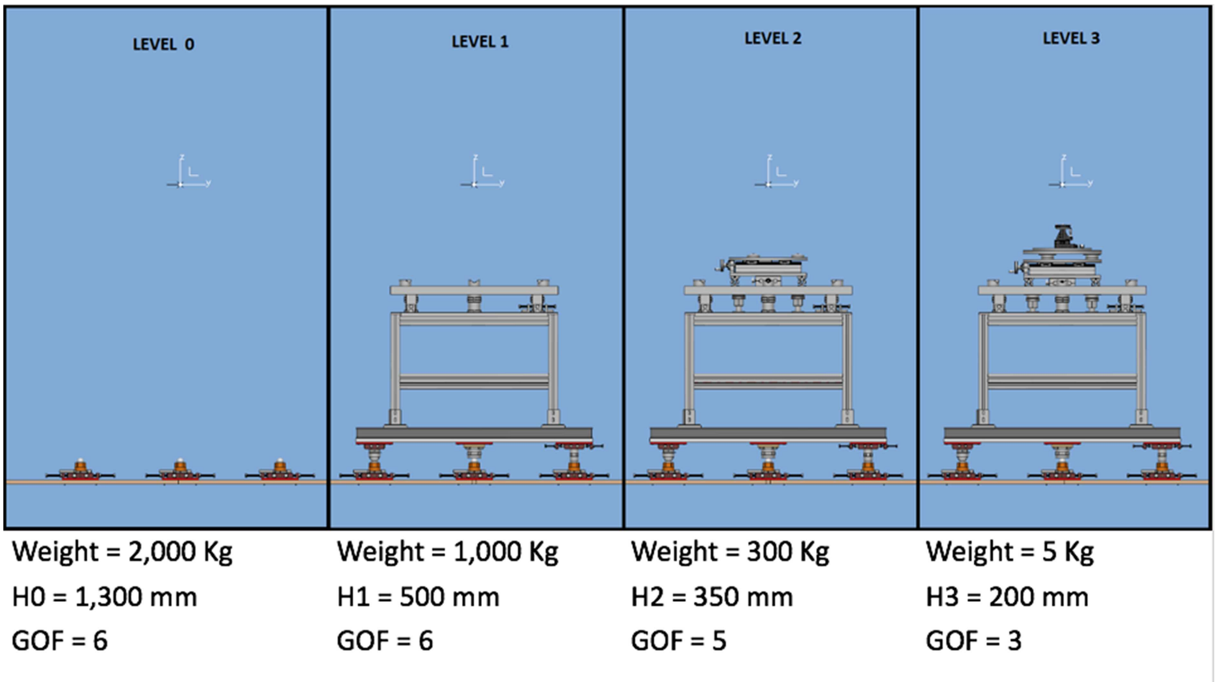


Figure 20 Illustration of prototype k-mount systems for Levels 0-3. From left to right: the L0 kinematic base, an adapter supporting the L1 interface, a second adapter to L2 interface and a third adapter to L3. It is not always necessary to have all interfaces present e.g. a single adapter from L0 to L3 is acceptable.

8.6 Flange-mounted instruments: definition of levels

It is currently not envisaged that there will be a need for a large vertical distance from the main instrument flange to the sample position. Correspondingly, there is no defined Level 0 for flange-mounted instruments, but we retain Level 1 and Level 2, which are defined in an analogous way to the floor-mounted case.

Level 1 is expected to accommodate the largest XL equipment. The standard opening for Level 1 is 805mm[1]. It is recognised that many SEE *do not* need such a large opening and, correspondingly, appropriate adapters can be used to implement smaller flanges.

Level 2 is expected to be the most heavily used position, for the L size SEE.

Level 3 exists to provide easy installation for the lightest and smallest equipment including vanadium cans, single-crystal goniometers, diamond anvil cells etc. In addition, this level has the potential to offer the highest precision, with a correctly calibrated system providing repeatability at the <20 μm level.

In the case of a flange-mounted instrument, both levels are defined by a distance measured from the underside of the flange to the beam, see Figure 21

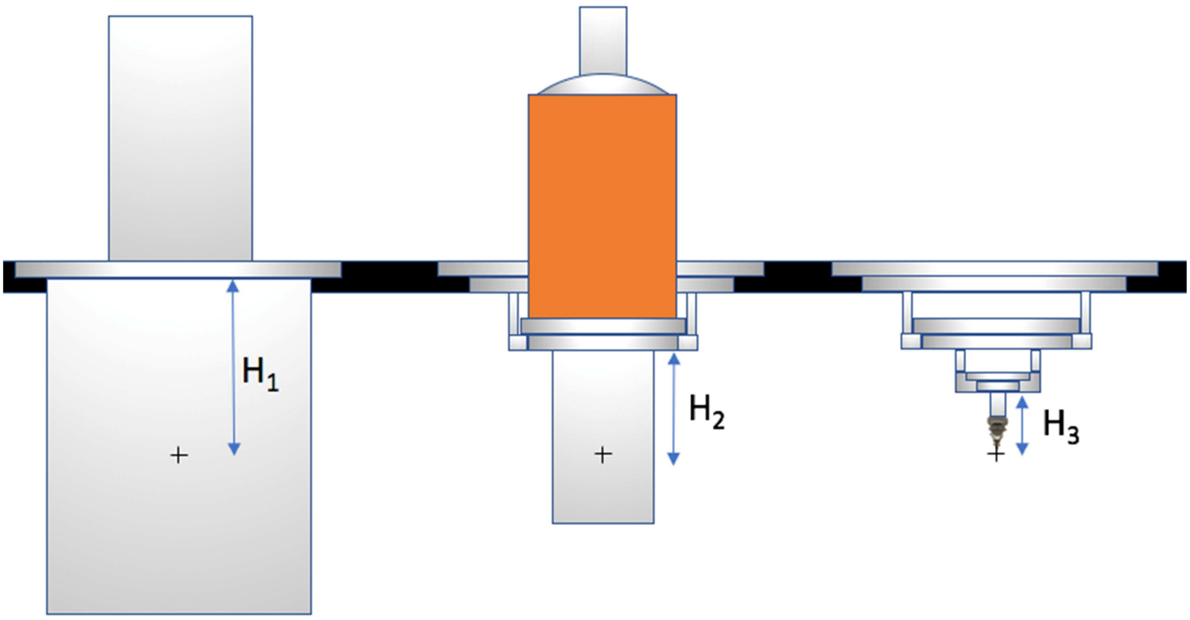


Figure 21 illustration of mounting levels for flange-mounted instruments. Left shows Level 1, corresponding, for instance, to a large magnet. Middle shows Level 2 holding an orange cryostat and illustrates a possible adapter converting from Level 1. Lastly, right shows Level 3, which could be used to precisely locate a single-crystal goniometer sample as shown.

[1] Such that an 800mm diameter object can be accommodated within manufacturing tolerances.

The relevant dimensions are given in the table below. We note that there are large distributions of flange-to-sample distance for current designs of instruments (from 0.5 to 2.5m), therefore, **current numbers are subject to revision**

Level	Distance to beam (mm),H_n	Weight max. (kg)	Opening diameter (mm)
1 (XL)	500mm (TBD)	1000*	Ø805,
2 standard (L)	350mm (TBD)	300	Φ505
3 high-precision	200mm (TBD)	5	Φ255

It is of course critical to have sufficient space available at the sample position, to avoid conflicts with vacuum tank walls, floors, or other items. The minimum space required for SEE is given in §7.3 and is illustrated, relative to the mounting levels in Figure 22

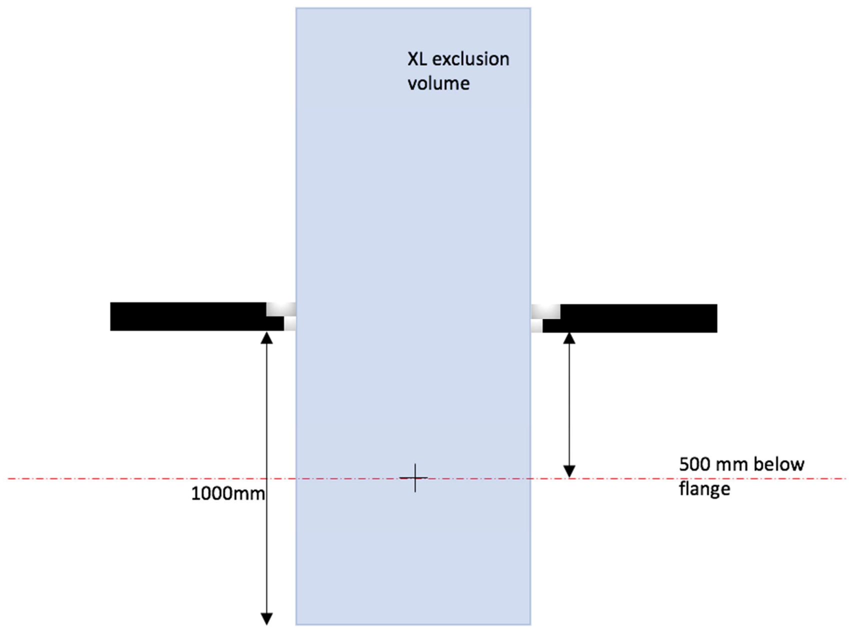


Figure 22 Minimum space requirement for XL SEE in context of mounting levels.

8.7 Flange-mounted instruments: definition of standard mount interface

The concept for our flange system has not yet been prototyped. Our approach will reflect similar philosophies to the floor mounted system described in §8.5. In summary:

- If deemed necessary, we will use a variation of a kinematic positioning system to ensure repeatable positioning of the flange. Such a design will take account of the need for vacuum seals.
- We will develop a "key" mechanism to ensure that the SEE is installed in one or more reproducible rotational orientations defined by the angle made with the x-axis of the SADCS. The key will be designed such that in the exceptional case of an envisaged

magnet that will operate in different rotational positions on different instruments, these set positions will also be accessible.

- The design of flanges will be such to minimise mechanical displacements under the force of 1atm pressure after vacuum is created in the sample volume.
- Similar requirements will be developed for the mating interface on the instruments, with separate requirements on vacuum vessels to minimise displacements and vibrations.

8.8 Equipment handling capability of sample table and flange

The SEE mounting surface, both for flange and floor-mounted instruments, needs to be able to support the weight of the sample environment equipment device. The main forces are vertical from the equipment mass, and a momentum force from any offset centre of gravity (COG), built in or from tilting, as well as atmospheric pressure when under vacuum. Forces arising from the magnetic field when using electromagnets will be discussed in §9. It is important to note that sample tables also need to be sufficiently fastened to the floor.

8.8.1 At ESS, all instruments shall be able to handle loads and resulting moments such that elastic deformations do not exceed a maximum of x µm (TBD).

8.9 High-precision alignment by transmission scanning

SAD has an ongoing project to develop the methodologies to enable transmission scans. Here a target, which is either neutron transparent, or neutron absorbing in some known way is stepped through the beam and the transmitted intensity measured, normalised and plotted for each step. The resulting plot is the mathematical convolution of the beam and the target.

Transmission scans of this type can be used to align samples or SEE with very high precision (such an approach is used routinely on most synchrotron beamlines). As an ancillary benefit, it is also possible to extract (with an appropriate target) a 2D-beam profile measurement. Where a TOF detector is used, this can be also resolved in energy.

Instruments wishing to benefit from this capability require:

8.9.1 Two perpendicular, motorised and controllable translations in directions perpendicular to the beam (these may be provided by SAD as components of particular SEE)

8.9.2 A downstream beam monitor, with a uniform active area *greater* than the beam that is being scanned (i.e. which may have been reduced in size by collimation). A portable option may be provided by SAD, but this is not yet defined.

9. MAGNETIC CONSIDERATIONS

Magnetic fields are an important part of the sample environment for numerous neutron experiments. In order to use magnetised SEE, additional requirements shall be met.

The main considerations are:

1) Safety hazard due to large forces applied to ferromagnetic material.

2) Malfunction and permanent damage of electric motors and encoders; magnetic bearings are particularly vulnerable.

3) Disturbance to very sensitive equipment, erroneous operation of reed switches, or movement of finely balanced magnetic items.

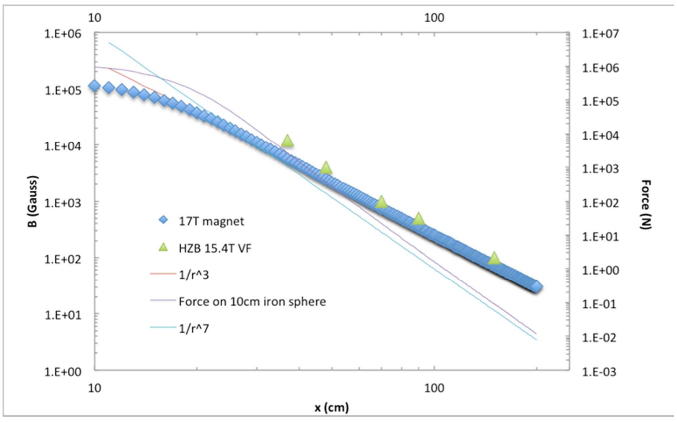


Figure 23. Fields and forces for some example high field cryomagnets. The force shown on the right scale is calculated for a 10cm diameter iron sphere on the axis of the 17T solenoid. Note the very rapid variation with distance.

Note: neighbouring instruments may affect each other.

Principal mitigation can be achieved by a) increasing distance b) using non-magnetic materials where possible, or c) using active shielding. The exact requirements depend on the nature of the magnetic SEE.

In general, magnetic effects will follow the rule $\frac{\alpha B^m}{r^n} < A$, where *B* is the field at the sample position, α is a factor ~1 governed by the magnet geometry, *m* is 1 or 2, depending on the effect, *r* is the distance from the sample position, *n* is a power law governed by the physics behind the interaction effect, and the multi-pole order of the magnet windings, and *A* is some threshold above which an effect becomes problematic.

For a given value of *B*, problems can generally be reduced by altering *r*, *A*, and *n* (by using a compensated magnet). The instrument design will fix *A* and *r*, so any subsequent need for higher fields will require expensive refitting or a compensated magnet. Note also that *n* is typically rather large, up to 7 for forces on unsaturated ferromagnetic materials, so small changes in layout can make very significant improvements.
For a detailed description of the various effects and possible mitigations, see Appendix C.

Requirements:

9.1.1 No magnetic material shall be present within 2m of the sample position. This includes moveable fixtures and construction components (including all screws bolts and fixings, goniometer components, rails bearings, as well as girders, frames, steel reinforcement in concrete). While certain grades of stainless steel (austenitic) are usually acceptable, it should be noted that they might regain some ferromagnetism when machined or welded.

We envisage a number of different experimental setups, or levels (see Table 6) which have different requirements, depending on the type of magnet to be used, or the sensitivity of the experiment. Greater precautions against magnetic effects will allow higher-level SEE to be installed. In general little extra effort would be needed for level 1, whilst the difference between levels 2 and 3 is largely in the affected radius.

Spin echo instruments are envisaged to be in a dedicated experimental hall where no uncompensated magnets will be permitted, otherwise instruments should be designed to be robust to the stray fields from neighbouring instruments.

Level	Description
0	Spin echo
1	Electromagnet
2	<10T cryomagnet
3	>10T

Table 6. Levels for electromagnetic fields considerations (see Appendix B).

9.2 Polarised neutrons and guide fields

Where polarised neutron guides are present, special considerations are needed:

9.2.1 Where permanent guide fields are used to maintain neutron polarization they shall point upwards if vertically oriented, or from left to right (viewed facing in beam direction) if horizontal. The magnitude of guide fields shall be chosen taking into account the possibility of stray fields from sample environment on the same instrument and from neighbouring beamlines, so as to avoid the possibility of field cancellation in the beam path.

10. LABYRINTH

The word labyrinth is used to describe an opening through an instrument cave wall through which, for example, cables or pipes can be led. Other common words used are conduits or chicanes. We will here also use the term ‘open labyrinth’ to refer to a labyrinth formed upon closing of a moveable shielding structure such as a door or plug (conceptually illustrated in Figure 2). As described in §2.1 in disconnections between SEE and AE should not be required during SES installation. As such, *only open labyrinths* are permitted for accommodating connections between SEE and AE and these may be beneficial in many cases, saving space in the cave and avoiding radiation exposure of sensitive equipment.

However, in addition to any provision for open labyrinths, a standard (closed) labyrinth is also required to provide a convenient way to allow for future flexibility when adding further utility supplies or as yet unanticipated connections. To facilitate easy access, the labyrinth should be designed to allow an operator to pull cables through the labyrinth, i.e. a normal hand and arm should fit. It is important to note that these labyrinths need to be designed to fulfil any radiological requirements at ESS. A labyrinth in the floor with two openings into the cave on each side of the cave is suggested.

10.1.1 The instruments shall provide a labyrinth for SEE use with a geometry that shall allow insertion of cables and flexible pipes with a bending radius up to 250 mm. The required conduit size is 600mm(horizontal) by 250mm (vertical).

10.1.2 The SEE labyrinth shall not be used for instrument supplies, pipes, tubes, electrical cables etc. If necessary, a separate labyrinth shall be provided to accommodate these.

11. OTHER CONSIDERATIONS

11.1 Vibrations

With high precision requirements on sample positioning, it is important to minimise vibrations of on-beam SEE. Ideally, for sub-mm samples and when the beam itself is small, vibrational amplitudes should not exceed ~50μm (TBD). In addition, many instruments will construct "false" floor to enable a convenient working height to the neutron beam. It is also important that this doesn't vibrate to excess during transportation of heavy equipment on the path from the staging space to the nearest approach to sample position. This requirement is somewhat lower than that of the primary SEE mount itself and ~500um (TBD) amplitudes are acceptable.

12. APPENDICES

APPENDIX A

Equipment	Weight (kg)	Shape	COG	Max tilt (Degrees)	Width (X)/ Diameter (mm)	Length (Y) (mm)	Height (mm)	XL /L	Required Peripherals/comments
General									
Rotating sample holders	< 20							L	
Rheometer	20							L	
Langmuir Trough	< 20	Box	Below half height					L	
Robot	30-1000kg	Spherical						XL	Size dependent on reach required.
Linear sample changer	< 50	Rectangular box	Half height		500	1000	400	L	Z table, cooler
Temperature/ Fields/Temp									
Pulsed Tube Refrigerator (PTR)	40	Cylinder	Top heavy	No restrictions but performance changes	150	150	600	L	2*Vacuum pumps, compressor
Orange cryostat	100	Cylinder	~half height	10-15º?	D 600	n/a	1400	L	Vacuum pump, Dewar
Vertical magnet 5T		Cylinder	low		D 400 D 300*	n/a		L	(VM-3 at HZB)
Cryomagnet 6.5 T		Cylinder	low	10º	D 800 D 520*	n/a	1.700	L	Height including rotation motor.
Cryomagnet 12 T	1000-2000kg	Cylinder	low	10º	D700	n/a	1.800	XL	(VM-1 at HZB)
17T Birmingham magnet	400 kg (inc. cryogens)	Cylinder	460	10º	D 660	n/a	1241	XL	Side loading: space for sample change needed.

Pressure									
Gas cell	5	Cylindrical			D 50		150	L	
Membrane DAC	6	Two cylinders			D 200		200	L	Gas cylinder, Pressure controller (400*400*1000) , and aligning is the stuff that is extra over setting up a cryostat
Clamp	10	Cylindrical			D 100		200	L	
VX5	15	Cylinder			D 200		200	L	
VX3	70	Cylinder			D 300		300	L	
VX in cryostat	120	Cylindrical tank			D 500		800	L	
Clamp in cryostat	100	Cylindrical			D 400		800	L	CCR setup + cell compressor 150x60x80cm (needs 3 phase), gas cylinder,
Graphite heater								L	Power supply , chiller(50x50x50 cm), T controls (50x50x80cm), hydraulic pump (150x60x80cm)
Gas cell in cryostat	100	Cylindrical			D 400		800	L	CCR plus gas cylinder, gas controller (50x50x20cm),

Table 7. Example data on sample environment equipment size, mass and centre of gravity.
* denotes the diameter at beam height. A, B, C are the categories for levels.

APPENDIX B

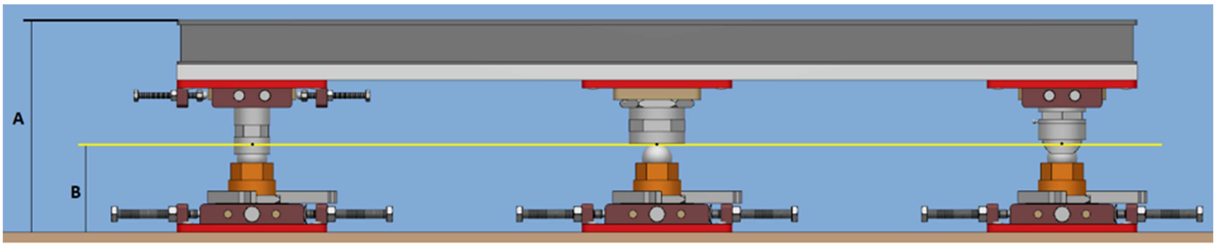
Reason	Power law* B^m/r^n	Approx. range (for level 3) Scale as $B^{m/n}$	Affected item	Effect	Mitigating action	Require for service level (0-3)
Magnetic forces (unsaturated, dipole approx.)	B^2/r^7	0-1m	Cryomagnet, nearby objects	Quench, damage, injury, death	No magnetic material allowed <1m from magnet Force test in position on first use and after any modification	2
	B^2/r^7	1-2m	Moveable magnetic objects	Pulled towards cryomagnet (see <1m)	Remove or fix in position	2
	B^2/r^7	> 2m	Moveable magnetic objects	Equilibrium positions disturbed	Remove or fix in position	2
	B^2/r^7	<5m	Reed switches (including pacemakers!!!)	Erroneous readings, malfunction	Use alternative, distance, warning signs	2
Magnetic forces (permanent magnets/ saturated ferro-magnets)	$\frac{B}{r^4}$	0-1m	Motors, encoders, magnetic bearings	Failure, damage	Move further away	2
	$\frac{B}{r^4}$	1-5m	Motors, encoders, magnetic bearings	Potential malfunction, failure, damage	Test for resilience, shield, move away	2
Saturation effects	B/r^3	< 1.5m	Motors, encoders, magnetic bearings, credit cards, hard disks	Malfunction, damage	Distance, shielding, use alternatives	2
Eddy currents (on quench)	$\dot{B}/r^3$	<0.5m	Conducting loops	Large stresses	Slits, lower conductivity materials	2
Eddy currents (from movement in field)	B/r^3	<2m	Choppers, turbo pumps	Heating, braking	Slits, lower conductivity materials, distance	2

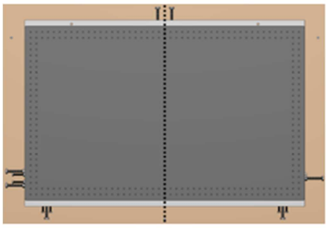
Faraday induction (DC)	B/r^3	0-10m	Sensitive electronics, amplifiers	Microphonics, increased noise.	Use twisted pairs, fix cables, minimise loop area	2
EMI (AC)	$\dot{B}/r^2$	0-100m	Sensitive electronics, amplifiers	Electrical noise	Shielding, twisted pairs, ICS warning signal	1
Hall effect, magneto-resistance	B/r^3	<5m??	Electronics, incl. detectors	Malfunction	Use alternative, shield, move away	2
Lorentz force (electrons)	B/r^3	<10m	Cathode ray tubes, photomultiplier tubes (in detectors /monitors)	Distortion, malfunction	Use alternative, shielding, move away, avoid ferromagnetic materials	2
Larmor interaction (neutrons)	B/r^3	<100m	Polarised neutrons	$?%$##!!!	Distance, shielding, avoid ferromagnetic materials	0

*Note that magnetised structural steel can channel fields over much longer distances, in which case these $1/r^n$ power laws will no longer be valid.

APPENDIX C

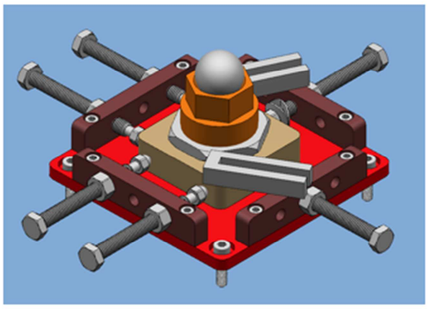
Some details of the current prototype of floor-mounted kinematic positioning systems. This system was designed around a europallet concept. Future designs will be adjusted to accommodate alternative geometries.

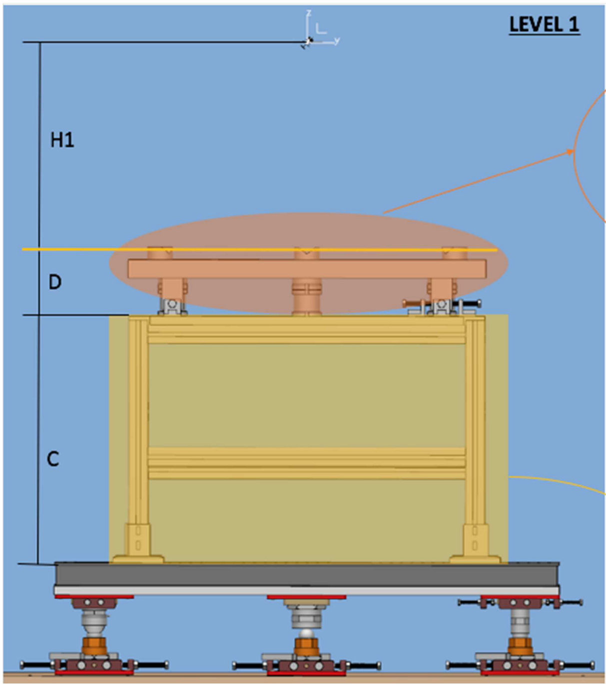


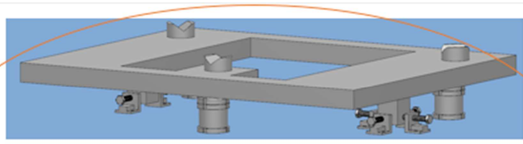


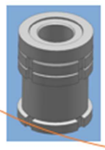
Dimension:
A=266,5
B=113,423
Euro pallet size (1200 x 800)

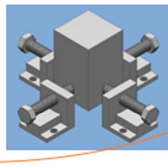
Beam line distance H0 = 1386,6 mm





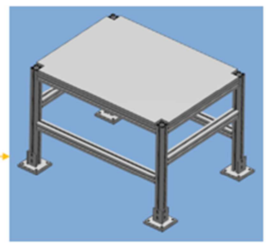




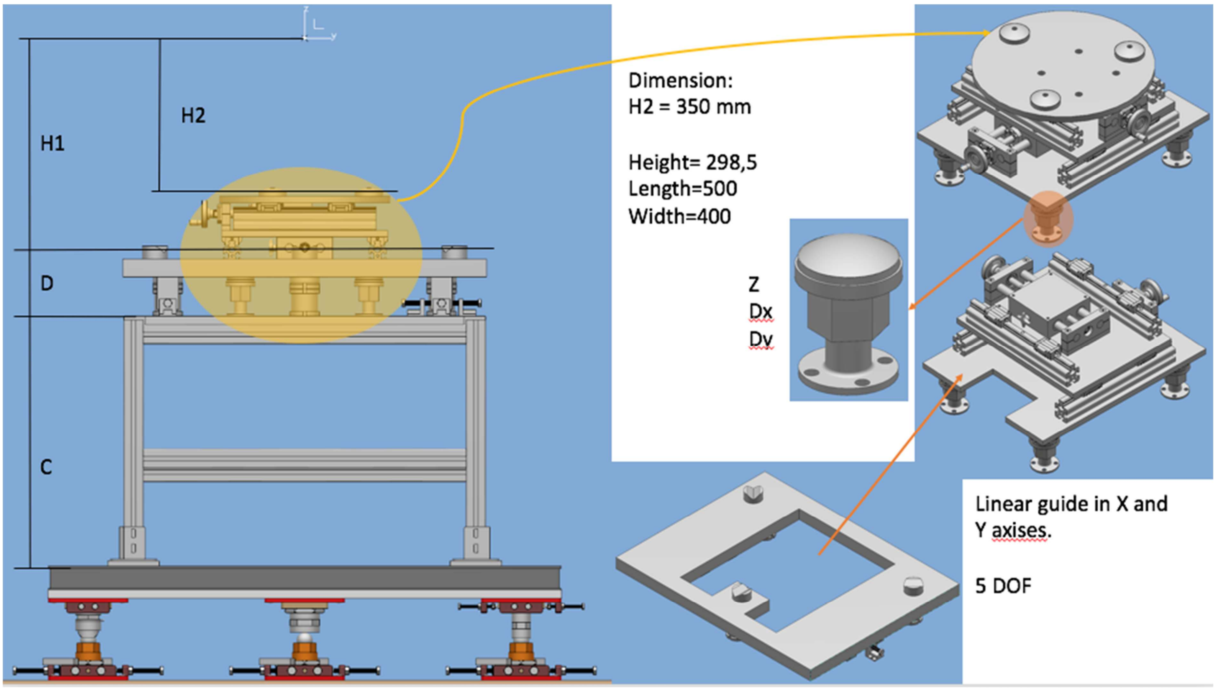


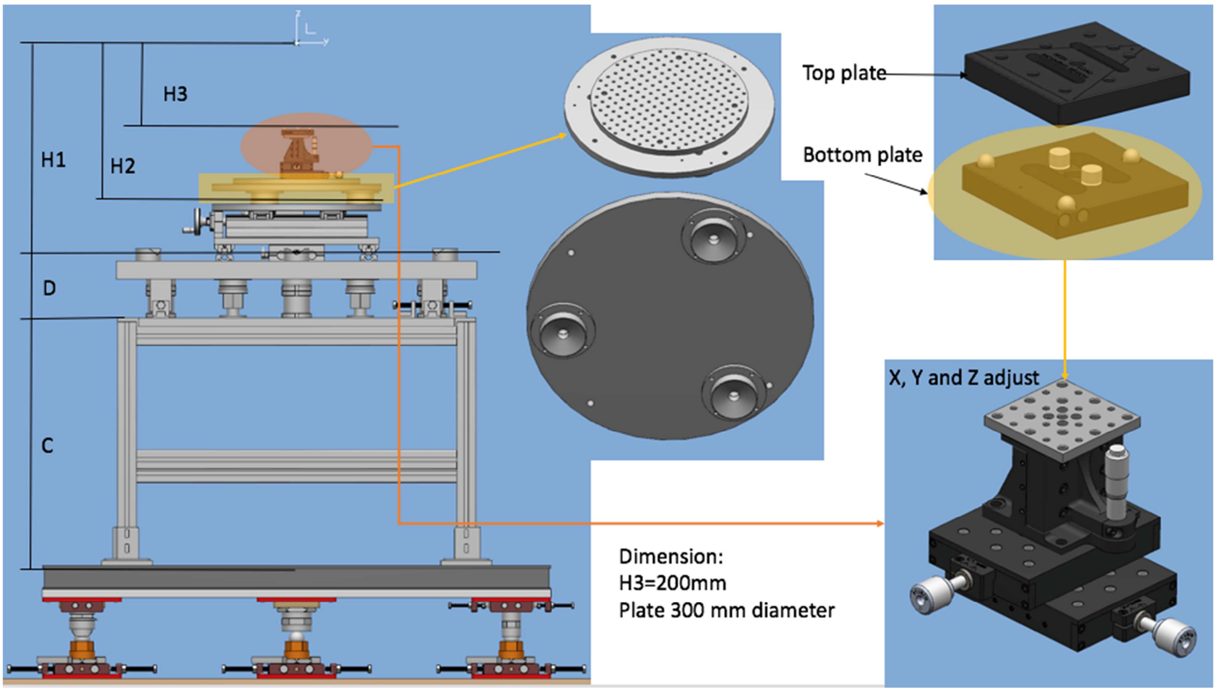
Dimension:

C= 585 mm
D= 148,5 mm
H1= 500 mm



Height= C
Lenght= 845
Width= 645


H1
H2
D
C
Dimension:
H2 = 350 mm
Height= 298,5
Length=500
Width=400
Z
Dx
Dy
Linear guide in X and Y axises.
5 DOF


H3
H1
H2
D
C
Top plate
Bottom plate
X, Y and Z adjust
Dimension:
H3=200mm
Plate 300 mm diameter

13. REFERENCES

[1] ESS Sample Environment Utilities Supplies - Reference Document WBS 13.6.X.5.6 CHESS 0038163

[2] ESS Sample Environment Software Interfaces - Reference Document WBS 13.6.X.5.7 CHESS 0038165

[3] ESS Standard Component group

[4] Reference to CB infrastructure requirements (ICS)

[5] ESS System Requirement Document

[6] NSS System Requirements Document

[7] SSS Systems Requirements Document (TODO)

[8] "Sample stack heights", Webb, N. ISIS.

[9] "Tomkinson Flange Dimensions and Beam Heights", xx, ISIS (TODO)

[10] "Sample Prep. Labs: Safety and sample work flow" ESS

14. LIST OF ABBREVIATIONS

Abbreviation	Explanation of abbreviation
SE	Sample Environment
SEE	Sample Environment Equipment
SAD	Scientific Activities Division
SSS	Science Support Systems
ESS	European Spallation Source
WBS	Work Breakdown Structure
ICS	Integrated Control Systems
LHe	Liquid Helium
USCS	Universal Sample Coordinate System
IID	Instrument interface descriptor
TBD	To Be Determined/Defined

15. SUMMARY OF REQUIREMENTS

In this section, all of the requirements from this document have been extracted. The first two numbers of each requirement indicate the relevant sections in the document.

6.2.1 A dedicated staging space of minimum size 2m x 3m x 3m (height) shall be made available at the instrument or, where not possible, within ~20 m to assure sufficient space for staging of SES.

6.2.2 The staging space must be equipped with one utilities supplies standard setup, as defined in the Sample Environment Utilities Supplies Reference, and further considerations relating to sample handling must be made (see reference [10]).

6.3.1 At least one access route from the sample preparation area to the closest approach to the sample position must be available and must share a common floor level. where this is not possible, lifting equipment must be provided with a minimum area of 1 x 1.5m (TBD) capable of handling 1000 kg (TBD) payloads. It is *not acceptable* to use a crane to navigate obstructions or changes in floor level to avoid multiple lifts of the individual components of the full SES system.

6.3.2 The access route relating to 6.3.1 shall be smooth and stable in order to minimise vibrations (amplitude TBD) experienced during wheeled transport of SES.

6.3.3 At no point on the access route relating to 6.3.1 shall there be unmovable height restrictions below 2.00 m.

6.3.4 Where the access route relating to 6.3.1 requires entry to a cave. There must be a minimum access area at the cave entrance of 2.0 x 2.5m.

6.3.5 Each instrument shall have access to a 2-axis crane, with at least 1,000kg capacity to lift SEE to the sample position. The crane must cover the distance from the closest approach of wheeled SEE to the sample position. The drive mechanism of the crane must avoid jerky acceleration. The main hall crane must not be appropriated for routine SEE installation. Minimum hook-height requirements are given in § 7.8. (SAD notes that a solution for standardised instrument cranes should be pursued.)

6.3.6 A continuous corridor with a minimum width of 1.5m shall be maintained from the sample preparation area to the position of closest approach to the sample position. Smaller passages of at least 1.10m are acceptable as long as a minimum clearance of 1.50m is maintained before and after these (see Figure 5).

7.1.1 All instruments are required to adopt at least the requirements related to the L standard. Where this is not possible solutions should be discussed with SAD.

7.2.1 The minimum volume described in Figure 6 and Table 1 shall be available at the sample position. Any installations occupying any part of this volume shall be easily removable. (A Catia file representing this volume will be made available).

7.3.1 The minimum volume described in Figure 7 and Table 2 shall be available at the sample position. Any installations occupying any part of this volume shall be easily removable. (A Catia file representing this volume will be made available).

7.4.1 Instrument teams shall ensure space for auxiliary equipment is available, according to Table 4 and illustrated in Figure 9. At least 75% of this area shall be accessible to heavy wheeled equipment (i.e. floor space of some kind), the rest can be, for example, on shelving or tables. The space is to be interconnected to the volumes for the on-beam equipment e.g. chicanes for shielding shall not require the systems to be disconnected Figure 2.

7.4.2 The space allocated for auxiliary equipment shall be less than 2m from the SEE utilities supply panel enabling physical connections to be made

7.4.3 The space allocated for secondary equipment shall be less than x m(TBD) from the online SEE equipment to enable physical connections to be made

7.4.4 The space allocated for auxiliary equipment shall minimise radiation exposure for the equipment. Possible solutions may include a half-height wall, chicane, or primary cave shielding (for example where the AE are located on the roof of an instrument cave).

7.7.1 Floor space within a radius of 1.0m from the sample position spanning a continuous angle of at least 140° (see Figure 11A) must be available during SES installation. Alternatively, two separate segments each of at least 70° can be made available (see Figure 11B).

7.7.2 An access route for personnel and tools to the operational floor space described in 7.7.1 shall be provided.

7.8.1 For floor-mounted instruments, a minimum hook height of 2100mm above sample position/beam is required for installing XL equipment, or 1900mm for L equipment

7.8.2 For flange-mounted instruments, a minimum hook height of 2600mm (TBD) above the flange is needed for installing XL equipment, or 2400mm (TBD) for L equipment.

7.9.1 To allow for sample stick change in top loading cryostats, a minimum free height of 3.5m above the sample position must be available. If a crane is to be used for lifting cryogenic inserts, a hook height of 4m is required above the beam, superseding requirements 7.8.1 and 7.8.2.

7.9.2 The space close to the sample position shall allow filling of helium from a 100L mobile storage Dewar (typically ø500mm x 1200mm high) using a semi-flexible helium transfer line (rigid vertical legs, flexible horizontal connection). The difference in height between the top of the storage Dewar and the fill port on the SEE should be minimised as far as possible during transfer. This may be achieved by lifting the Dewar using mobile lifting equipment if the SEE is above floor level, or by the use of long flexible transfer siphons (which reduces efficiency).

7.9.3 Space is required for the transport of the Dewar (with footprint 1x1m), two people to assist with the transfer, and if necessary a stepladder (when the SEE is above floor level).

7.9.4 There must be at least 3m free space above floor level at the Dewar postion to allow insertion of transfer lines into the transport Dewar.

8.1.1 All instruments using POOL SEE shall adopt the USCS to describe regions of interest within samples.

8.1.2 ICS, DMSC, MCS, and other divisions should also ensure that all the USCS compatibility is imposed on all hardware and software related to SES.

Recommendations:

Wherever possible, User developed hardware and software should also follow the USCS.

8.5.1 In order to use SEE, the instrument shall provide the appropriate level of kinematic base to mate with the kinematic mount on the SEE.

8.8.1 At ESS, all instruments shall be able to handle loads and resulting moments such that elastic deformations do not exceed a maximum of x µm (TBD).

8.9.1 Two perpendicular, motorised and controllable translations in directions perpendicular to the beam (these may be provided by SAD as components of particular SEE)

8.9.2 A downstream beam monitor, with a uniform active area *greater* than the beam that is being scanned (i.e. which may have been reduced in size by collimation). A portable option may be provided by SAD, but where although this is not yet defined.

9.1.1 No magnetic material shall be present within 2m of the sample position. This includes moveable fixtures and construction components (including all screws bolts and fixings, goniometer components, rails bearings, as well as girders, frames, steel reinforcement in concrete). While certain grades of stainless steel (austenitic) are usually acceptable, it should be noted that they might regain some ferromagnetism when machined or welded.

9.2.1 Where permanent guide fields are used to maintain neutron polarization they shall point upwards if vertically oriented, or from left to right (viewed facing in beam direction) if horizontal. The magnitude of guide fields shall be chosen taking into account the possibility of stray fields from sample environment on the same instrument and from neighbouring beamlines, so as to avoid the possibility of field cancellation in the beam path.

10.1.1 The instruments shall provide a labyrinth for SEE use with a geometry that shall allow insertion of cables and flexible pipes with a bending radius up to 250 mm. The required conduit size is 600mm(horizontal) by 250mm (vertical).

10.1.2 The SEE labyrinth shall not be used for instrument supplies, pipes, tubes, electrical cables etc. If necessary, a separate labyrinth shall be provided to accommodate these.