SPECIFICATIONS OF CRYOFURNACE
SAMPLE CHANGER FOR THE DREAM INSTRUMENT

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FILES	
ESS-0041033	3D Exchange of Information with ESS Partners
ESS-0042151	Standardization document standards
ESS-0002955	Engineering Drawing Standard Manual ESS
ESS-0439471	Motion Control Components Standard for ESS Applications
ESS-0038163	ESS SE Utility Supplies
ESS-0038078	Sample Environment Mechanical Interfaces for Instruments
ESS-0038165	ESS Sample Environment Software Interfaces
ESS-0365855	ESS Motion Control EtherCAT Electronics Standards
ESS-0037830	ESS template for Project Quality Plan
ESS-1797666.2	Floor mountings systems

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1. Presentation of the LLB and ESS

The LLB is a joint CEA/CNRS laboratory of fundamental research on condensed matter.
It has a mission to build and operate neutron spectrometers for the French research community around various neutron sources. LLB also in charge of the design and the construction of new instruments in collaboration with international partners for the future European source of neutrons European Spallation Source (ESS) under construction at Lund in Sweden. One of these instrument projects is the diffractomer DREAM, built with Forschungszentrum Jülich (FZJ), Germany, to be installed on site and commissioned in 2021-2023 and ready for the user operations in 2024.

2. General framework

The DREAM instrument is being built as an in-kind contribution from the Forschungszentrum Jülich (FZJ) in Germany and the Laboratoire Léon Brillouin (LLB) in France. It will be a ~75m-long diffractometer dedicated to the measurement of the atomic and magnetic structures of solid samples under a large range of ambient conditions (temperature, pressure, atmosphere, magnetic field...). It will be equipped with a cylindrical detector covering a large solid angle that will allow to perform high intensity/high resolution/fast acquisition of scattering data.
The DREAM instrument will be located on beamport S3, in the hall D01 of ESS main building in Lund, Sweden (Figure 1).

The DREAM instrument comprises 4 functional parts:

- The BUNKER/IN-BUNKER OPTICS, which are intended to shape and condition the neutron beam produced by the source and shield unwanted radiations,
- The GUIDE SYSTEM, which controls the neutron beam transport from the bunker to the sample,
- The SAMPLE POSITIONING AND ENVIRONMENT area where is achieved the centring of the sample in the neutron beam and where are set the environmental constrains (temperature, pressure, gas atmosphere, magnetic field…) according to the requirements of the science experiments,
- The DETECTION part, which consists of a set of neutron detectors placed around the sample.

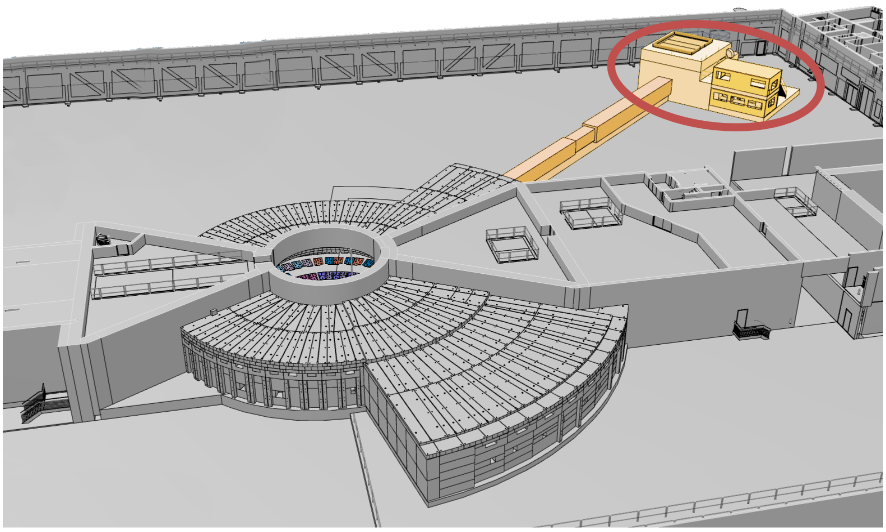


Figure 1. Overview of the DREAM instrument on S3 beamport and location of the CAVE (red ellipse) in hall D01

In order to protect operators from radiation, a biological protection made out of concrete and neutron absorbers is installed around the instrument part. The shielding around the section of the instrument comprising SAMPLE POSITIONING & ENVIRONMENT and DETECTION is called the CAVE (see Figures 1 & 2). The cave provides various access points to fluids (deionized water, gases) exhausts, power and network around the “scattering position” at a platform in the cave (Figure 3) and at a “waiting position” outside the cave (Figure 2). These access points will be available respectively for the operation and the pre-conditioning of the various sample environment systems (closed-cycle cryofurnace but also pressure cell, cryomagnet,…) that one will use alternatively on the instrument.

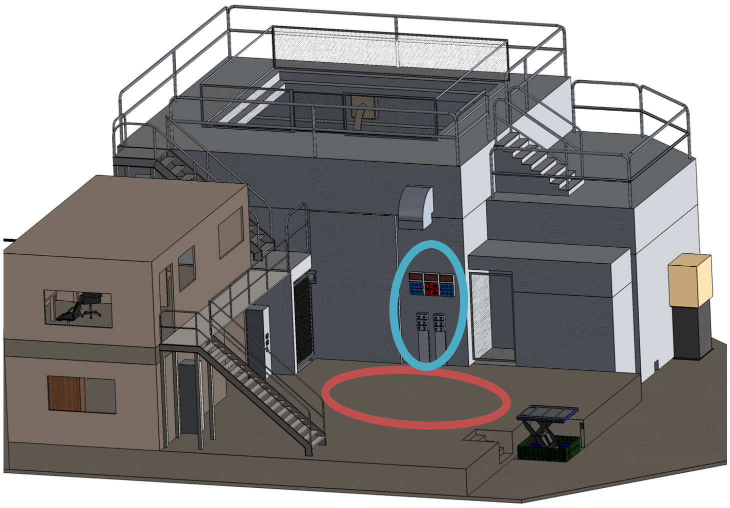
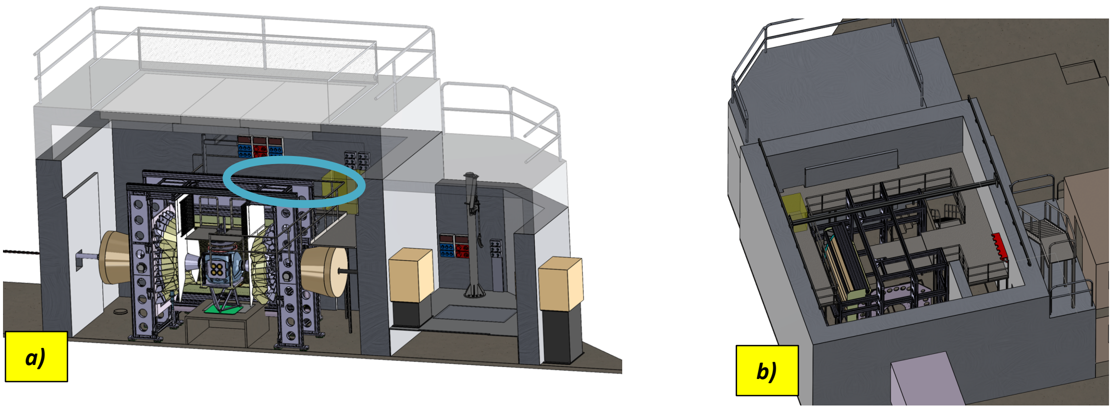
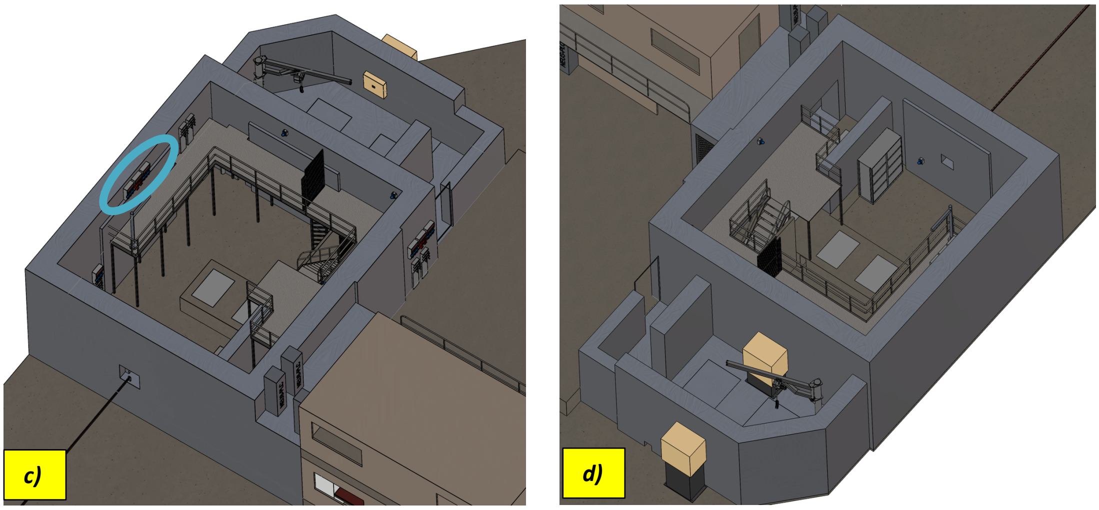


Figure 2: Overview of the cave and access points to fluids, power and network (blue ellipse) at the external “waiting position” for sample environment (red ellipse).

Inside the cave, a platform system enables access around the sample area on 2 levels (Figure 3). This cave will be equipped with a crane (maximum load: 2T) with access to the sample area.





Figures 3: a) Sectional view of the experimental cave, with the cylindrical detector of DREAM in place (in yellow) b) Top view of the cave, showing up the crane and the platform c) and d) DREAM cave showing the platform and the access points to fluids, exhausts, power and network (blue ellipse).

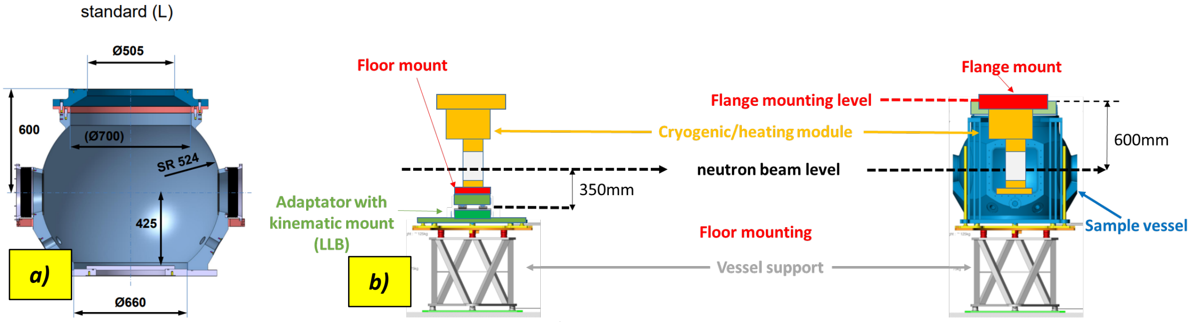
The purpose of this call for tender is the design and the realization of one of such environment system, a closed-cycle cryofurnace (4K-800K) equipped with a sample exchanger allowing precooling and automated measurement of up to 20 samples.

3. Purpose

<u>Principle</u>

The purpose of the CLOSED CYCLE CRYOFURNACE equipped with SAMPLE EXCHANGER (CCR-SE) is to automatically cool or heat samples inside cylindrical sample holders within a 4K - 800K temperature range and position them automatically in the neutron beam for diffraction experiments.
Requirements referred to as 'must', 'will' or 'essential' are qualifying requirements for a tender response to be considered. Requirements referred to as 'desirable' or 'should' will be favourably viewed when considering responses. 'Highly desirable' indicates a strong weight will be given to this criteria.

The CCR-SE will allow handling up to 20 samples of about 0.5 cm^3 volume in a single loading procedure (19/20 on a pre-cooling stage + 1/0 in scattering position). The samples will be top-loaded in the precooling stage of the CCR-SE from room temperature, ambient pressure. It will provide an internal automated sample exchanger enabling to position any sample from the precooling stage to the scattering position and vice-versa. The provided electronics for the sample positioning, temperature control and temperature measurement will be compatible with ESS standards (see reference documents to be provided). The CCR-SE will be attached to the upper flange of DREAM specific vacuum vessel ($P \sim 10^{-6}$ mbar inside the vessel, see Figures 4a) and b) and technical drawings of the vessel for detailed specifications). The coordinates of the centre of the vessel will define the reference position of the sample in the "scattering position". The CCR-SE ensemble must be designed such to be operated on its trolley support outside the cave and rapidly moved to the instrument position without warming up the cryogenic/heating module nor disconnecting the tubes connected to the compressor stage. The bottom part of the CCR-SE will also allow it to be floor mounted using an adaptor plate (provided by CEA) mounted on DREAM support table (see Figure 4b) if one does not want to run it within the DREAM specific vacuum vessel.



Figures 4: a) DREAM specific vacuum vessel (P~10^{-6} mbar inside the vessel, including 1 of the 2 possible flange dimensions (choice to be confirmed later) b) The 2 mounting positions foreseen at the DREAM instrument. The cryofurnace will be equipped with a flange, red on 4b) left and orange in 4b) right, to allow interfacing with the adaptor with kinematic mount (from LLB)

The CCR-SE ensemble will comprise:

- **The cryogenic/heating module (4.1**), including the heater, the sample exchanger and positioning system and its vessel, and relevant temperature probes for the samples on the precooling stage and at scattering position. The upper part of the system will include a flange insuring its adaptation on the top of DREAM dedicated vacuum vessel. The bottom part must allow to centre and fix the system on a basis plate using standard ESS mounting interface. The CCR-SE must be able to operate in any of these configurations.
- **The compressor unit and helium close cycle circuit (4.2)**, including flexible tubes for He circulation and water cooling and electrical cables. This ensemble will be installed on a carriage trolley, which will also hold the cryogenic/heating module when this latter is operated out of the cave when it is not installed on the DREAM instrument. The length of the flexibles and cables shall be sufficient for connecting the cryogenic/heating module in position on top of DREAM vacuum vessel and the equipment on the trolley stationing on the first floor platform, near the fluids and power access points (see Figures 3, 4 & 5).

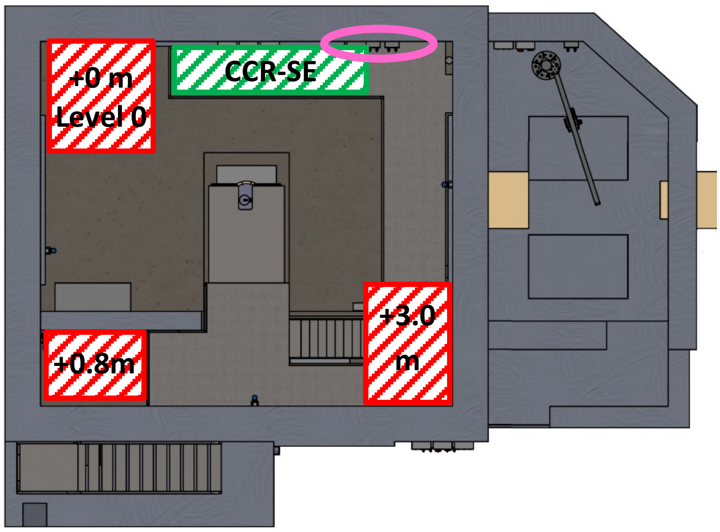


Figure 5. The DREAM cave will be equipped with a 2T crane. The minimum height of the hook with respect to Level 0 is 5.5 m. The CAVE will have 3 loading/unloading areas at various heights, as shown. The possible standing position for the trolley is shown (2x1m green area), at proximity with the network, power, water and gas access points (pink ellipse)

- **The control electronics (4.3)** for the heaters regulating the temperature in the cryostat and for the temperatures probes readout, including corresponding electric cables with enough length to connect to power and network access points of the first floor of DREAM cave (see Figures 3 & 5).

- **The purge circuit (4.4)** comprising the Helium gas supply /turbo pump / exhaust for evacuating/flushing the sample chamber and the thermalisation of the sample. One must be able to send potentially activated exhaust gases coming out from the sample chamber to D01 containment ventilation through the purge circuit when it is connected to neighbouring exhaust pipe in the cave (see Figure 3) & 5.
- **A set of three sample sticks (4.5)** equipped with relevant thermal probes allowing each to install up to 20 samples in the cryofurnace. Three (3) sample stick racks will be located on the platform in order to store the sticks and let them cool down after irradiation.

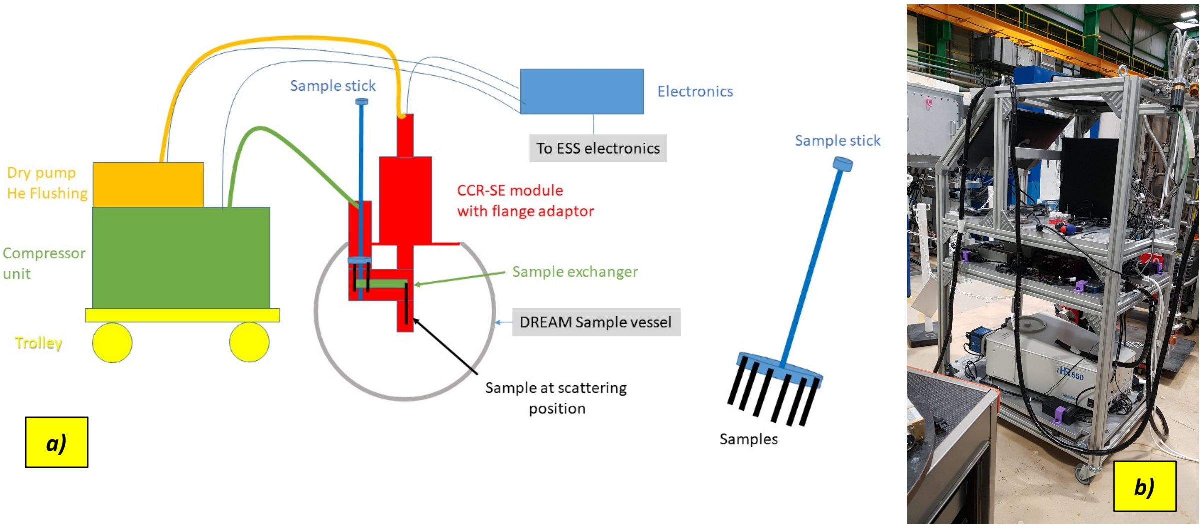


Figure 5. a) Components of the CCR-SE b) Example of trolley carrying secondary equipment (electronic, purge circuit,…)

4. Technical features

The cryofurnace shall be able to cool/heat the sample at the scattering position in the temperature range 4K-800K within not more than 60 min from the reference temperature of 90K, with an accuracy and stability better than 0.1K. Its design shall be compatible with the specific geometry of the DREAM diffractometer, in particular its dedicated spherical vacuum vessel and its large cylindrical detector. It shall also complies with ESS recommendations (electric power, noise, electronic readout).

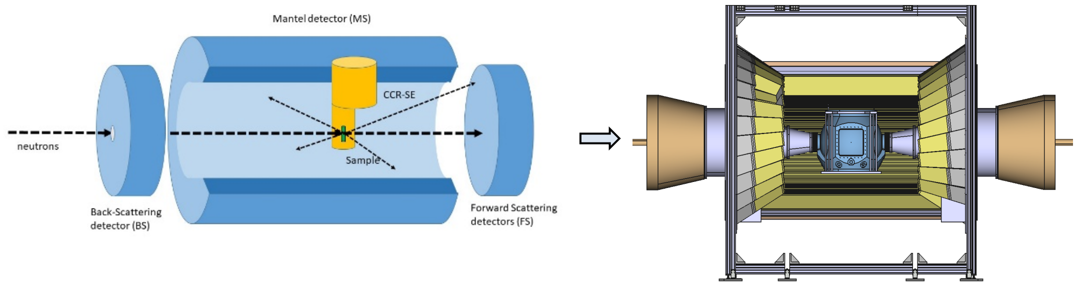
4.1 Cryogenic/heating module - Sample exchanger

The cryogenic/heating module shall offer the following possibilities:

- From the loading time, the samples on the precooling stage shall reach a temperature of 90K (±1 K) in less than 1 h.
- The CCR-SE will allow handling up to 20 samples of typically 0.5 cm^3 volume / 1 cm height in a single loading procedure (19 or 20 on a pre-cooling stage and respectively 1 or 0 in scattering position). It shall be possible to operate the CCR-SE without any sample at scattering position as one will want to be able to measure its background before neutron measurements.
- CCR-SE shall allow changing the vertical position of the sample when in scattering position, for finding the optimum position for the samples with heights below 1 cm.
- The cryogenic/heating module shall be specifically adapted to the DREAM instrument design, in particular its sample area and detector geometry, and its frequent operation in the context of the user program at ESS:

- The cryogenic/heating module shall be able to precool up to 20 samples from room temperature to ~90K in less than 1 h. One shall be able to change sample stick while CCR-SE is running. The precooling stage shall be equipped with 2 sets of thermal probes, covering the adequate temperature range (70K-350K) and connected to the temperature control unit.
- The cryogenic/heating module shall be equipped with an internal automated positioning system able to set reproducibly any of the precooled samples to the "scattering position". The reference scattering position is defined as the centre of DREAM specific vacuum vessel (see Vacuum vessel drawings and ESS reference document ESS-0038078). The coordinate system defined in ESS-0038078 will be used to locate the different sample positions. During the installation of the samples inside the precooling chamber and their movement from/to the scattering position, the samples shall stay upright and any movement that would uncompact or displace the powder inside the sample holders shall be avoided. The average size of the cylindrical samples will be ~0.5cm^3 with maximal dimensions 1x1x1cm. The positioning of the samples at the scattering position of the CCR-SE shall be controlled to better than 0.1mm at ~90 K in all directions once temperature is stabilised and shall be reproducible. The position of this sample shall be measured along all three axes using absolute encoders/sensors, over the 4K-800K temperature range. The system shall be robust enough to sustain about 40 positioning cycles/day, 250 days/year for 10 years. Sample exchange from/to precooling position to/from measurement position shall take less than 5 minutes (excluding thermalisation time).
- The cryogenic/heating module shall be able to cool a typical sample of ~0.5cm^3 at the scattering position at a temperature on 4K ± 0.1K in less than 60 min from an initial temperature of 90K (precooling position). It shall be able to warm up a typical sample at a temperature of 800K ±5K in less than 60 min from an initial temperature of 90K (precooling position), with a stability of ±0.1K after 120 min. The scattering sample position shall be equipped with 2 sets of thermal probes, covering the full temperature range (4K-800K, 2 different type of probes could be used) and connected to the temperature control unit. The probes shall be located in the proximity (<1cm) of the top of the sample at the scattering position. Exchange gas around the sample will be used in order to accelerate thermalisation and reduce temperature gradients.
- The temperature of the pre-cooling stage shall remain stable within 20 K for all temperatures at the measurement position.
- Sample thermometers must be traceably calibrated in the relevant temperature range, and calibration curves provided in electronic format.
- Wiring of resistive sensors must be 4-wire twisted pair (current and voltage pairs twisted separately). Other diagnostic and control wiring must be twisted pair or otherwise configured to avoid electromagnetic interference and crosstalk.
- Thermometers must be chosen with regard to avoiding neutron radiation effects.
- Materials used in vacuum must be chosen so as to avoid excessive outgassing.
- The design and the materials used in the cryogenic/heating module shall be optimized in order to lower the risk of radiological activation by neutrons (typically no Co, Cu or Zn impurities).
- The cryogenic/heating module shall be designed is such a way that it could be easily and reproducibly installed on the DREAM vacuum vessel using the cave crane from a waiting position (see Figure 2) without having to stop it or unplug its compressor unit. It shall therefore be equipped with swivelled lifting eyes. The electric cables and cooling tubes linking both units will be hanged over the detector unit and shall be provided accordingly (see specifications of the cave for power & water supplying and containment ventilation – see reference documentation ESS-0040840).

- Around the “scattering position”, the incoming and scattered neutron beam paths toward the DREAM detectors shall only go through vanadium screens in order to prevent parasitic scattering signals. The solid angle that these screens shall span is defined by the geometry of the incident neutron beam and the detector geometry (see Fig. 6, reference drawing of the detector and ESS reference documents).



Figures 6: a) Schematic view of the DREAM detector and elements defining the solid angle where neutrons shall only go through vanadium screens. b) More realistic view of DREAM detector (see implementation in the cave in Fig. 3a) – The detector coverage defining the solid angle are in yellow.

- The sample and regulation thermometers and heater resistances for the cryofurnace shall be commercially available (in case of failure) and they shall be resistant to oxidation. They shall be robust and easily accessible for repair, if needed.

4.2 Compressor unit and helium close cycle circuit

The compressor/pumping units will be installed in a trolley of maximal surface dimensions 2x1m equipped with a braking device and lifting eyes. The trolley will be manoeuvrable and equipped with wheels that will minimize the vibrations (large wheel diameter to pass 3mm steps, rubber tires). The pumps shall possess an exhaust in order to be connected to the ESS containment ventilation duct available in the cave (see Figure 6 and reference document ESS-0040840) if necessary (in case of active/toxic samples). Both systems shall also possess an electronic interface, compatible with ESS standards (see ESS ICS reference document) enabling remote control of the device status. The trolley shall be dimensioned so it allows safe craning of the complete CCR-SE equipment (including the cryogenic/heating module and a sample stick, compressor, pumps, electronics and relevant cables and tubes) using the 2T crane available inside DREAM cave.

4.3 Control electronics

The electronics for the control and command of the temperature and sample positioning inside the cryogenic/heating module shall be compatible with ESS standards **(**see ESS ICS reference document ESS-0038165**).** For the temperature command/control, one should privilege controller type already interfaced by SAD/ICS. The electronics shall ensure a reliable positioning of the sample at scattering position (less than 0.1mm from the sample centre to the reference scattering position).

The electronic interface should give access (Read R) or control (Write W) to following parameters:

- Sample temperature, sensor value (ohms, volts etc.) of main probes (R)

- Sample temperature, sensor value (ohms, volts etc.) backup probes (R)
- Regulation temperature, sensor value (ohms, volts etc.) main probes (R)
- Regulation temperature, sensor value (ohms, volts etc.) backup probes (R)
- Heater output (W)
- Vacuum level (measurement chamber, R)
- Vacuum level (pre-cooling chamber, R)
- Valve opening/closing (R/W)
- Motor position (sample/changer, R/W)

The vendor will provide control PC computer with full logic and minimal communication (preferably SECOP, open source code) with the control system. Motors and encoders should be only by types approved by the ESS MCAG. Stepper motors requiring a DC bus voltage of 48 V and current from 0.2 to 14 A are able to be controlled by the ESS motion control system. The details of encoders and step-motor mounting and cabling must be discussed with the Project Manager during the construction phase. If the application cannot fulfil the ESS MCAG recommended components (see Table 1), please contact the Project Manager to discuss further options and solutions. Full documentation, including drawings, will be made available before validation of the tendering.

Table 1 : Recommended components

Supplier	Motor	Current bipolar (A)	Holding torque (Nm)	Flange size [mm]	Shaft ⌀	Motor length [mm]	NEMA	Price (EUR)	Standard level
Phytron	**ZSS.33.200.1.2**	1,2	0,075	32,0	4,00	68,5	-	198,00	
Phytron	**ZSS.43.200.2.5**	2,5	0,260	42,0	5,00	95,0	-	285,00	
Mclennan	**23HT18C330**	2,1	1,350	56,4	6,35	126,5	23	121,55	**L1**
Mclennan	**34HT18C340**	2,8	7,350	86,0	12,70	214,4	34	269,43	
Stögra	**SM 107.4.18 M6**	6,0	17,000	108,0	15,87	311,0	42	1028,65	

4.4 Purge circuit

In order to prevent icing of the samples at low temperature, the top-loading cryofurnace with be equipped with a He/vacuum purging system comprising a 3 ways valve enabling to pump the sample chamber and precooling chamber with a dedicated vacuum dry pump, to inject He gas inside for flushing and for sample thermalisation and to remotely control the inner pressure. The instrument will provide an access point to He, cooling water and power at the trolley waiting positions (Figures 2 & 3c). Connectors and (see ESS-0038163)

4.5 Sample sticks

The cryofurnace ensemble shall comprise 3 sample sticks. These latter shall enable an easy and fast installation of 20 samples in the sample chamber of the cryogenic module, including when the CCR-SE is already running. The design and materials chosen for the sample sticks shall limit the activation of these latter in the neutron beam. The powder samples will be loaded in closed vanadium cans. The design of the vanadium can lid shall be compatible with grabbing mechanism of the stick and provide airtight sealing of vanadium cans at the same time. The average size of the cylindrical samples will be

~0.5cm^3 with maximal dimensions 1x1x1cm. The mounting system (simple hole where the cylinder can stays by gravity, other) would be defined by the mechanism used to translate the samples from the precooling position to the scattering position. During this movement, the sample cans shall stay upright in order not to displace the powder.

4.6 Mounting strategies

Depending on the experiments, the cryogenic/heating module will be mounted either at the flange level of the Dream sample vessel or at the floor level on the sample table.

4.6.1 Flange level

When mounted at the flange level, the cryogenic/heating module will be inserted inside the vessel from top with a crane. It will be bolted to the sample vessel at the flange level (600 mm above the beam). The ensemble must keep and stand the vacuum. The cryogenic/heating module shall also offer the possibility to be installed and run inside the vessel without its outer vacuum tail.

4.6.2 Floor level

The cryogenic/heating module will lay on an adaptation plate (not part of this call for tender) located on the sample support and will ensure centring of the cryogenic/heating module on the adaptation plate. A flange (red on Figure 4b) left will allow a mechanical connection of the cryogenic/heating module with the adaptation plate. Therefore, the lower part of the cryogenic/heating module shall be designed to undergo the mechanical stress due to the total weight of the module and pipes ensemble.

5. Constraints & References documents

In General, the documentation describing components of ESS equipment shall complies with ***ESS-0042151 ESS Standardization document standards***).

All study plans will have to be provided in format CATIA V6 /STEP format (document ***ESS-0041033 3D Exchange of Information with ESS Partners***) and standards (document ***ESS-0002955 Engineering Drawing Standard Manual ESS***).

For sample positioning, the coordinate system used for the sample changer shall obey the definition specified in ***ESS-0038078*** ***Sample Environment Mechanical Interfaces for Instruments***.

For sample positioning, all motors types will use step by step to avoid the warm-ups and all the coders will be absolute. ESS imposes the characteristics of motors / encoders to use (document ***ESS-0037290 Motion Control Components Standard for ESS Applications***).

The mounting position of the cryofurnace on the DREAM spectrometer is not accessible by ground. The cryofurnace system will be taken to its position with the cave crane whose height under hook is 5.5 m with respect to Level 0 and maximum load is 2T (document ***ESS-0055308 Crane Coverage hall D01***).

The connection to the ESS containment ventilation duct available in the cave shall follow reference document ESS-0040840).

On-site delivery will be by truck with platform truck and will have to follow the instructions (document ***ESS Site Logistics***).

CATIA/STEP drawings of the DREAM specific vacuum vessel (reference point for the sample centring, flange characteristics) will be provided. The top of the XL adapter flange is defined by the ESS document ESS-0197907.3 , the definition of the L-flange is under discussion.

6. Nature of the Services Requested

The call for tender concerns the design and manufacturing, unitary and non-renewable, of a closed-cycle cryofurnace equipped with a sample exchanger for the DREAM spectrometer. The project will be divided into three phases: the Preliminary Design phase, the Critical Design phase and the Manufacturing phase.

6.1 Preliminary Design phase

The Preliminary Design is expected to meet the functional and performance requirements. It will show that correct design options have been selected, interfaces have been identified, verification methods have been described and that the risks have been identified, characterized, and mitigated where appropriate. The Preliminary Design must show sufficient maturity to establish schedule and the bases for proceeding with Detailed Design.
A Preliminary Design review (PDR) will take place at LLB (Saclay, France) at the end of the Preliminary Design phase (3D models and assembly drawing) to check compliance with experimental requirements. After written validation of this phase by the CEA/CNRS, the Detailed Design phase can be launched.

6.2 Detailed Design phase

The Detailed Design phase will include the complete design as described in this Specification document and will end with the delivery of three documents:

1- A technical document with specifications and the design with dimensions in Adobe Acrobat reader and Catia V6 with accurate nomenclature (name, brand, model, reference manufacturers, technical data sheets) and maintenance documentation written in English,

2- A Quality-assurance plan according to ESS standard (***ESS-0037830 ESS template for Project Quality Plan***),

3- A planning of the project until onsite delivery at ESS.

An Intermediate Design review (IDR) will take place during the Design phase when the engineering design is ready (3D models and main assembly drawing) to check compliance with ESS requirements.
Minutes of meetings and decisions shall be written in English and provided to CEA/CNRS within 7 days. After written validation of this phase by the CEA/CNRS and the ESS, the Manufacturing phase can be launched.

6.2 Factory Acceptance Test

Once the manufacturing of the cryofurnace is complete, there will be a test to check the quality and conformity of the cryofurnace: the Factory Acceptance Test (FAT) performed at the manufacturer site. The Factory Acceptance Test will be performed by CEA/CNRS will consist of:

- A visual inspection of the components and global design, including reference distances indicative of the positioning of the cryogenic/heating module on the DREAM vacuum vessel.
- A full characterization of the performance of the cryofurnace :
    - Compliance of the cooling of the samples in the precooling stage from the insertion of the samples at room temperature to the nominal temperature of 90K. The cooling time shall not exceed 1h and will be validated by a cooling curve measured with an independent probe at one of the 20 sample positions.
    - Compliance of the cooling of the sample in the scattering position from precooling stage at 90K to the nominal temperature of 4K, from 4K to 800K and from 800K to 4K. The cooling time from 90K to 4K shall not exceed 1h, the heating time from 4K to 800K shall not exceed 1h and the cooling down from 800K to 4K shall not exceed 3h. These will be validated by cooling curves measured with an independent probe at the sample position.
    - Compliance of the temperature measured at the scattering position that shall not depart from more than 0.1K from the setpoint specified, in the 4K-800K temperature range.
    - Stability of the temperature measured at the scattering position that shall be stable for a minimum of 24h.

Minutes of meetings and decisions shall be written in English and provided to CEA/CNRS within 7 days. After written validation of this phase by the CEA/CNRS and the ESS, the FAT is passed and the CCR-SE can be shipped to ESS for SAT.

6.3 Site Acceptance Test

The manufacturing phase will include the delivery of the cryofurnace on its final location within hall D01 at ESS, Lund (Sweden). The delivery shall be compliant with ESS logistic rules (***ESS Site Logistics ver 2.pdf)***.

SAT

The Site Acceptance Test will be performed by CEA/CNRS within a duration of 3 months after the delivery of the cryofurnace on-site and will consist of:

- a visual inspection for damaged components,
- a check of all the dimensions and installation process on DREAM diffractometer including its mounting on the flange of DREAM specific vacuum vessel, and plugging on the electrical and electronic networks and water and exhausts pipes at the sample position and at the “waiting position” outside the cave.
- a test of the electronic control and readout system and its compatibility with ESS systems.
- A control of the craning capability of the CCRE-SE system:
    - Horizontality of the cryogenic/heating module when craned from the trolley support to it’s position on the DREAM instrument, in particular of the horizontality of support flange for the fixation on DREAM dedicated vacuum vessel.
    - Horizontality of the trolley holding the whole CCR-SE system (including the cryogenic/heating module and a sample stick, compressor, pumps, electronics and relevant cables and tubes) when craned inside the cave to its parking position on the platform.
- a test of the correct positioning of the sample using an “alignment station” with/without the neutron beam, including when the cryogenic/heating module is flange-mounted in the vacuum vessel without its outer thermal screen. This may require to include mounting positions for laser tracker fiducials with characteristics to be defined later.

Minutes of meetings and decisions shall be written in English and provided to CEA/CNRS within 14 days. After written validation of this phase by the CEA/CNRS and the ESS, the SAT will be passed.

7. Annex: Expected content and parameters of the system

Expected content	
1)	Cryogenic/heating module equipped with an automated 20 positions sample exchanger
2)	Compressor unit and helium close cycle circuit
3)	Control electronics for the heater, the probes and the positioning of the sample exchanger
4)	Purge circuit comprising the Helium gas supply /turbo pump / exhaust
5)	3 sample sticks equipped with relevant thermal probes
6)	Electric cables and cooling tubes connecting the cryogenic/heating module to compressor unit and helium close cycle circuit and to control electronics
7)	Trolley equipped with lifting eyes for transportation of the for the cryogenic/heating module
Expected parameters	
	The CCR-SE will allow handling up to 20 samples
	From the loading time, the samples on the precooling stage shall reach a temperature of 90K (±1 K) in less than 1 h
	From the precooling stage at 90K, the cryogenic/heating module shall be able to cool a typical sample at the scattering position at 4K ± 0.1K in less than 60 min
	From the precooling stage at 90K, the cryogenic/heating module shall be able to warm up a typical sample at 800K ±5K in less than 60 min with a stability of ±0.1K after 120 min
	The positioning of the sample at the scattering position shall be controlled to better than 0.1mm at ~90 K in all directions
	The position of the sample at the scattering position shall be measured along all 3 axes over the 4K-800K temperature range
	Sample exchange from/to precooling position to/from measurement position shall take less than 5 minutes
	The cryogenic/heating module shall be mounted either on the flange of DREAM vacuum vessel or stand on a support plate on DREAM sample table