The HEIMDAL Instrument at ESS
Diffraction STAP Meeting October 2020
Update Summary

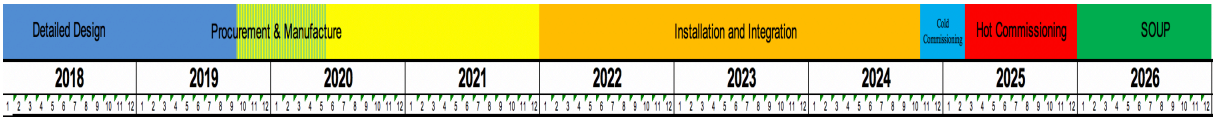
(1) In-kind Agreements and Technical Annex

Partner		MOU	TA
Aarhus University (Denmark)	30%	Signed	Approved by ESS
PSI (Switzerland)	35%	Signed	Approved by ESS in-review by Swiss Government
IFE (Norway)	35%	Signed	Approved by ESS

Current Status: Heimdal has all TA's now signed and approved by ESS as of February 2020. However, our in-kind agreement with was not agreed by the Swiss Government for 2020, due to Heimdal being a later instrument. We are told that this will be agreed for the 2021 budget. This delay in the in-kind agreement has led to some delay in the procurement of the Detector and Guide system from PSI. We expect this move forward at the end of the year.

(2) Current Instrument Timeline:

A schematic of the new Heimdal project management timeline, following the ESS rebaseline is shown in the figure below.



Summary of Main Milestones:
Phase II Instrument (9-16) User operation scheduled for July 2026
Tollgate-2 Review: June 2017
Q1 2021 - Order of monolith optics.
Current Status: Delivery expected Q1 2021 from Swiss Neutronics. Manufacturing could be effected by Coronavirus.
March/May 2019: TG3 CTVs finalised for large items, Guides, Detector, Choppers.
Current Status:
Chopper Procurement: ESs Common Choppers: Kick-off 1st October 2020.
Detector Procurement: Delayed until Q1 2021 due to PSI (so in-kind agreement for Heimdal)
Guide Procurement: Delayed until Q1 2021 due to PSI (so in-kind agreement for Heimdal)

2020 CTV Reviewed for Cave Design. - Ready for Call for Tender publication
Q1 2021 Monolith installation. Risk of delay to manufacturing due to coronavirus.
May 2020 Sub-TG3 for slits, collimator detector & sample table
May 2020 CVT for detector collimator
March 2021 Start of delivery and integration of sample stage & detector to AU.
September 2022 Tollgate-4
January 2023 – Start of Cave Installation
November 2023 - Start of Long Straight Guide + Shielding Installation.
August 2024 - Start of Bunker Installation
2025 – Tollgate-5 start of hot commissioning
June 2026 Start of User Operations.

(3) Change of scope request:

Following the last STAP diffraction meeting, where change request to include more cold guide (figure 1) into scope of Heimdal due to savings on the shielding was discussed. We have decided to move forward with obtaining real contractual costings for all items including Cave, Choppers, Detector and Guides before resubmitting the idea of changing the scope of Heimdal. This was also the advice from the ICEB meeting. This is in progress and delayed due to PSI in-kind agreement with. Swiss Government. We have fully costed Chopper and T0 chopper now.

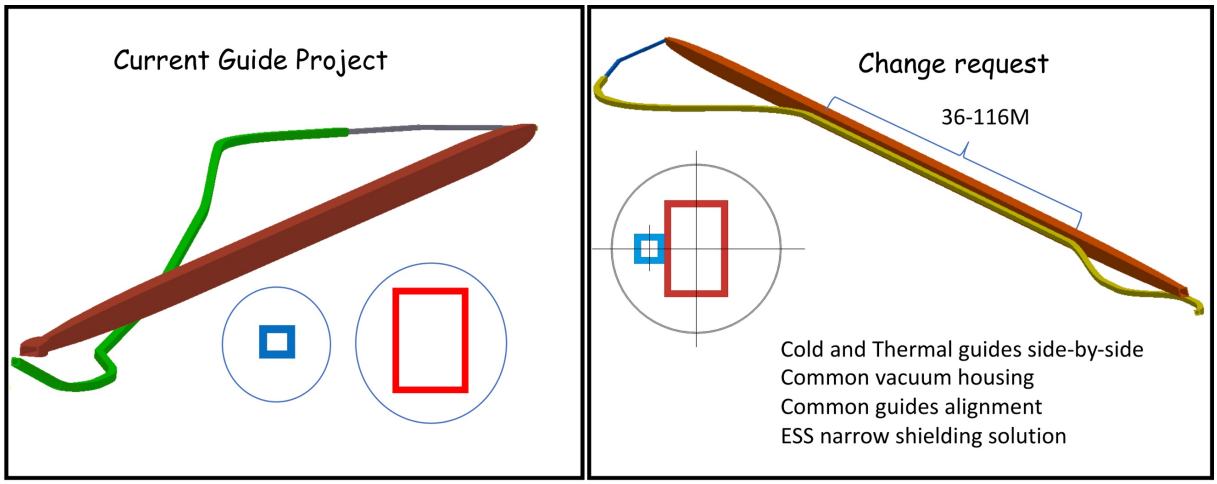


Figure 1. Left: The current Heimdal guide project, which keeps the thermal and cold guide separated in the long straight section and wide shielding (more shielding cost), to allow for a later up-grade of cold guide later. Right: Guide change request - keeping guides together in straight section in common vacuum chamber and common ESS narrow shielding (less shielding cost). Doing this later involves more cost, working with an activated thermal guide and longer shutdown of the Heimdal to upgrade.

(4) TG3 Schedule.

The current TG3 schedule for Heimdal is given below. We have been through the Call For Tender Verifications (CTVs) with ESS for all the large long lead time items - Guides, Choppers and Detectors and Cave Structure. We are likely to request delay to final TG3 due to delay in procurement from PSI tenders for 2D detector and guides.

May'20	October '20	Mar'21
Sub-TG3 [Handled remotly. Deliverables 28April20. Reviewers 28May20	Sub-TG3 [In-Person meeting]	Sub-TG3.4 [In-person mtg]
	(1) Optics	**- Monitors: (ESS Common?) (SSDD: Uwe)**
	- Guides and Support Structure (SSDD: Dan)	**- Detector (SSDD: Uwe)**
	(2) Shielding and shutters	**Detector support**
Bunker Wall Insert	- Light Shutter	**Detector Collimator**
	Chopper Systems	**- Heavy Shutter (SSDD: Kåre/Dan)**
- XYZ table (SSDD: Mogens)	T0 Chopper	**- Instrument Control and Automation** [ESS MCA] (SSDD Kåre/Engineer)
- Slits1 - Divergence Slits (SSDD: Mogens)	Cave & BeamStop	**- PSS** [ESS PSS] (SSDD: Dan)
- Slits2 - Collimating Slits (SSDD: Mogens)	Hutch Cabin	**- DMSC** [ESS DMSC] (SSDD: Mogens/Dan)
	Detector Collimators	**- Vacuum system** [ESS Vacuum Team] (SSDD: Kåre/Engineer)
CTV [Handled remotely]		**- Drawing package of complete system (Kåre/Engineer)**
- Radial collimator		
		Final TG3

(5) ICEB meetings: Last Heimdal ICEB meeting took place on the 2nd June 2020 and which is planned by video-conference due to coronavirus. The main recommendation from the last ICEB meeting was to move forward in obtaining real costing for items before re-submitting our change request. The main risk identified was for the end of contract of our neutrons person in July 2020 and the need to finalize the neutronics calculations for Heimdal, (Cave, Guide, Bunker Wall Insert, Heavy Shutter). This is in progress, with extension of contract until December 2020. CTV for cave ready for publication and neutronics now finalised.

(6) Instrumentation

6.1 NBOA

The NBOA was scheduled for subTG3 process in February 2019, but this was postboned due to delay in the work schedule of Swiss-Neutronics. Work on this project of NBOAs with Swiss neutronics has now restarted again in 2019 and we are still on schedule for delivery before Beam on Target. We currently expect Delivery of NBOA optics in Q1 2021.

6.2. Choppers

We now have a full costing of our chopper systems and will move ahead with procurement. We have joined and had kick-off with the common chopper project.

The T0 chopper: The T0 chopper prototype is currently being manufactured by Mirtron for Dream. Our T0 chopper will require some slight modifications compared to the prototype. From last discussion this might not be possible. Discussion still on-going. If not possible, we will need to buy larger chopper same as Odin, which is more expensive.

6.3 Guides

We have been re-working the design of the cold guide, following the opportunity of cost saving we realised with the ESS common guide shielding project. We now have a new cold guide design with a long straight section ready for approval by the ESS. We have performed McStas neutronics of the cold guide as shown in figure 2 below. The guide procurement is currently on hold due to PSI in-kind agreement. It is expected to be resolved by the end of the year and move forward then.

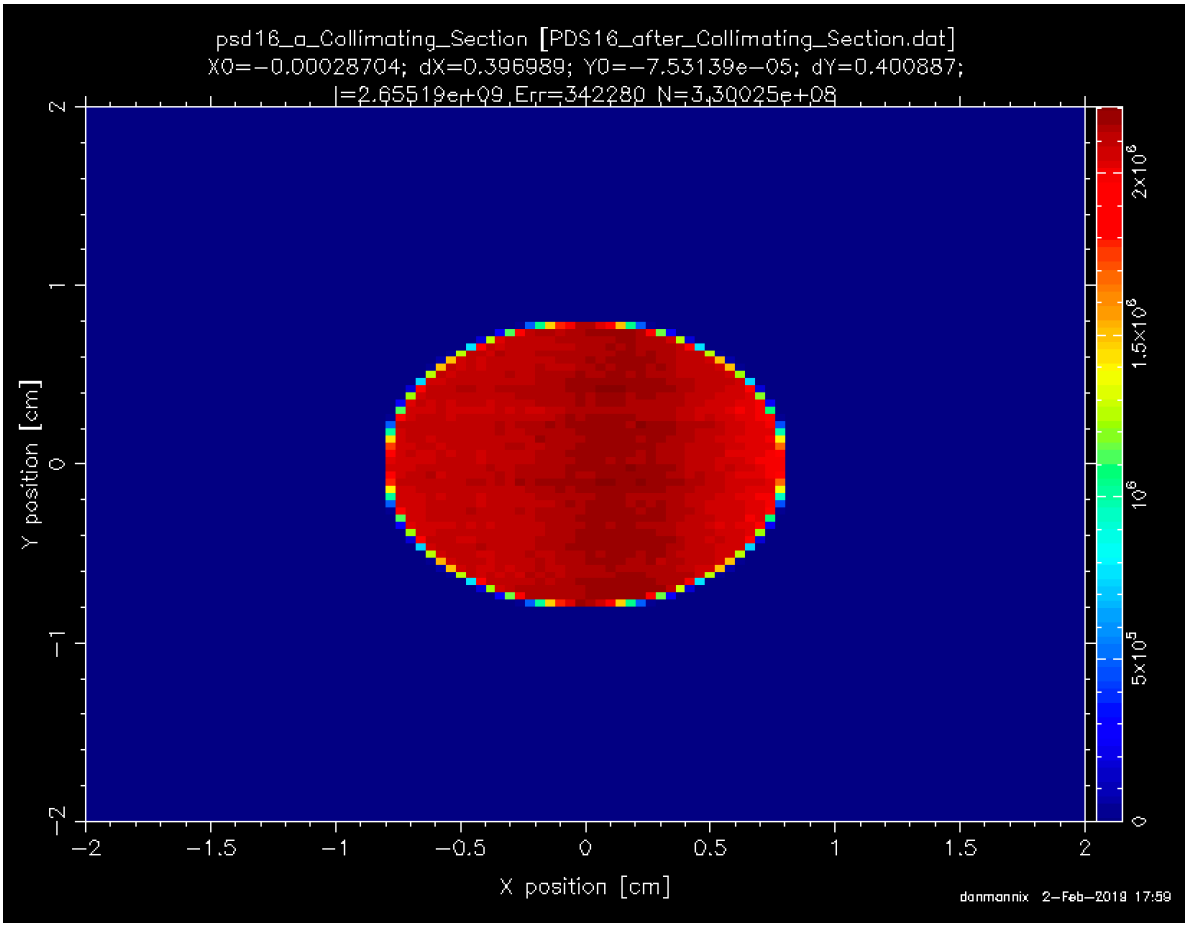


Figure 2 McStas simulations of the beam intensity profile in the collimating section of the new straighter cold guide system. The simulations indicate a slightly higher flux than for the current cold guide.

6.4 Detector:

The 2D detector procurement is ready to go, but is on hold due to in-kind agreement with PSI. We expect this to be resolved by the end of the year. This will means us delaying our final TG3 until most likely end of 2021.

6.5 Shielding

As stated previously, there is a possibility for Heimdal to make large savings from ESS common shielding project. He have been working on getting a detailed costing for our shielding to include in the change of scope setting. This has been a slow process due to the stretched resources at ESS for shielding neutronics calculations. We now have a good calculation for the Heimdal source and these can be fed into calculations to optimise the guide shielding. This work is still in progress. Below are some preliminary calculations of shielding designs, but this still needs to be optimised as is give a back-ground of around 3μSv/hr at the surface. Once these calculations are finished and the shielding costed, we plan to submit the change of scope request.

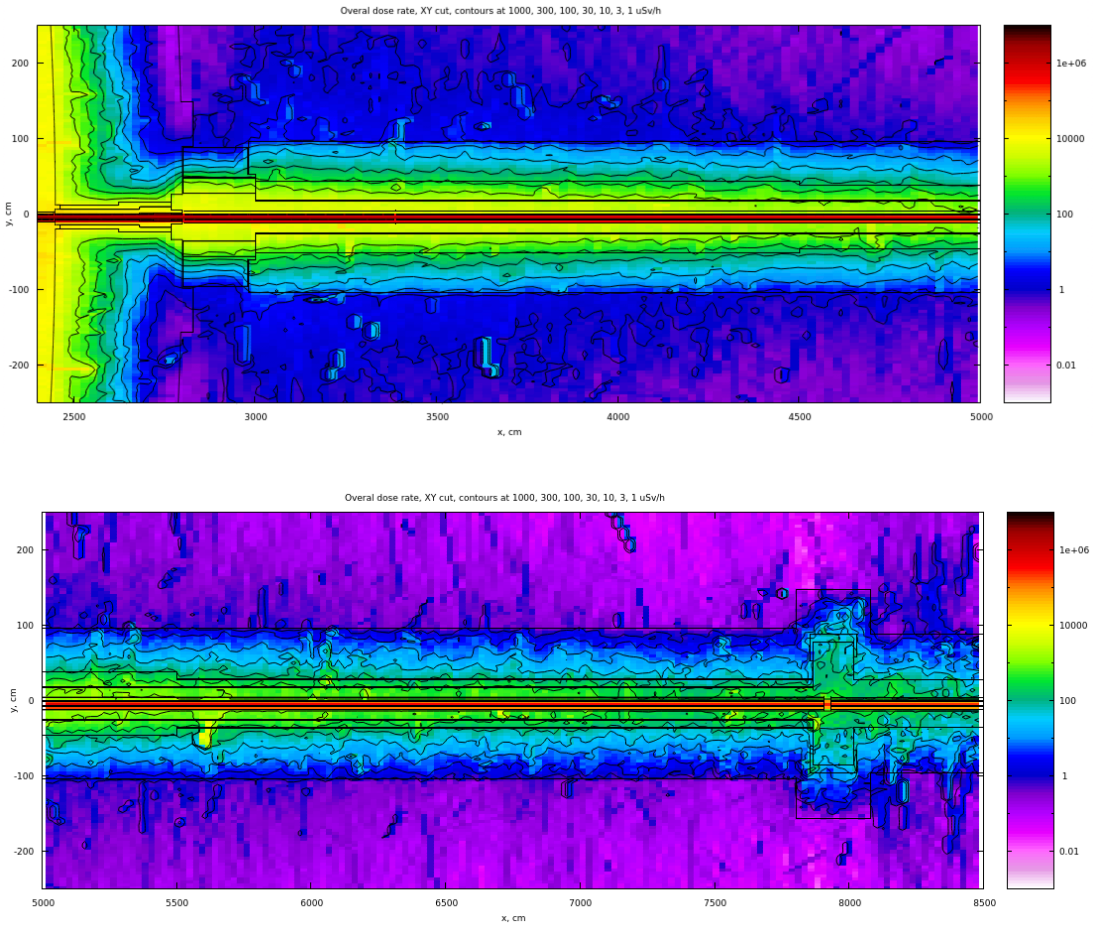


Figure 3. Preliminary shielding calculations for Heimdal guides. Top is for the section after the bunker wall from 25M to 50M. Bottom is from 50m to 85M, just after the frame-overlap chopper. The current design is still giving too high back ground and is being refined. This can be seen by the dark blue area just after the bunker.

The neutronics are performed for the below shielding.
Interface (28-30m, first 2 meters from bunker wall) 20 cm steel 40 cm heavy concrete (3.8 g/cm3)
30-45 m: 25 cm steel 50 cm regular concrete (2.3 g /cm3)
45-55 m: 20 cm steel 55 cm regular concrete
55-chopper pit: 10 cm steel 65 cm regular concrete
Chopper pit shielding according to common shielding project (will need extra steel when contribution from thermal neutron beam will be considered)
Beyond chopper pit: 60 cm regular concrete.
Inner steel shielding is lined with 5 mm B4C both inside and outside B4C/epoxy tiles.

6.6 Cave Shielding Neutronics:
Cave Shielding is now finalised. CVT ready for publication.

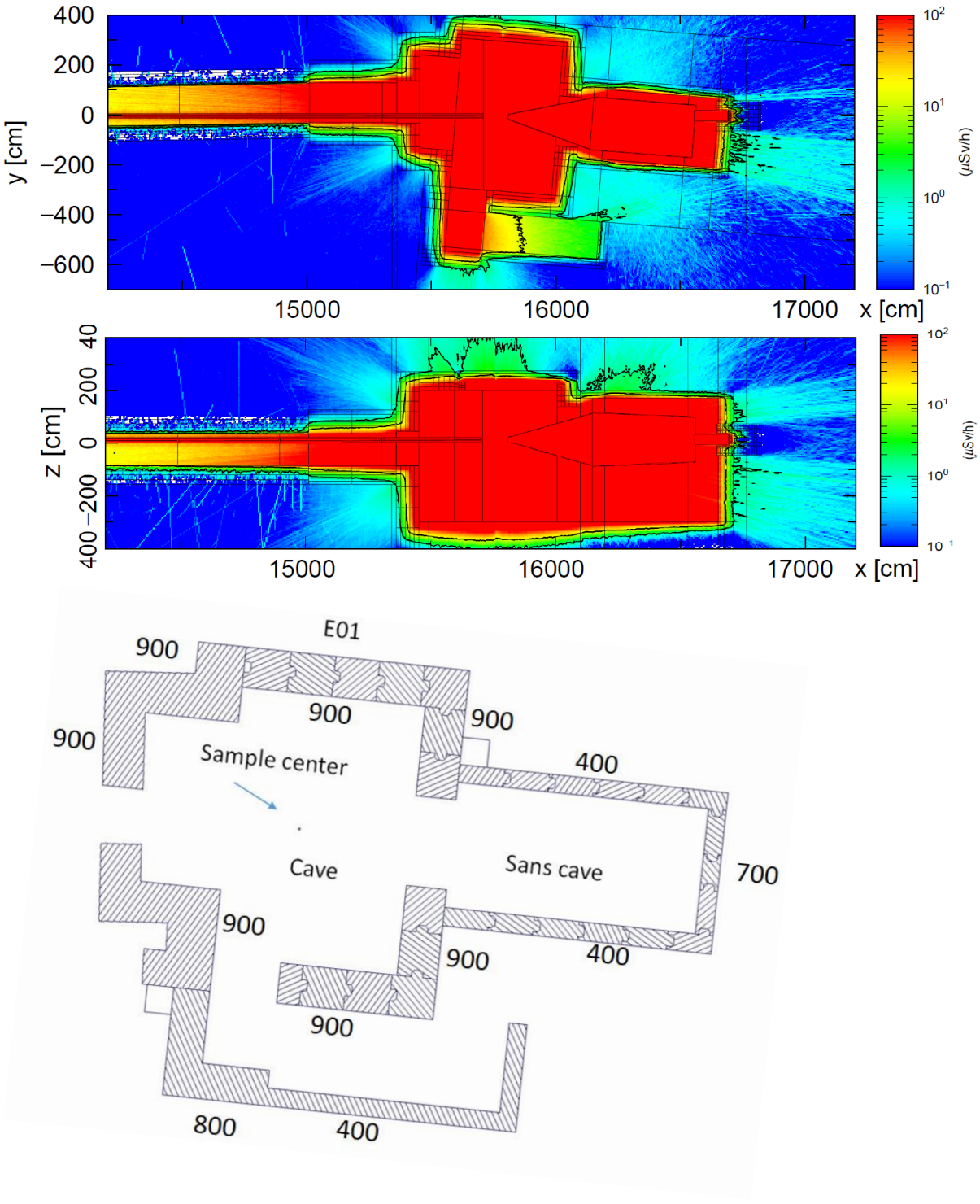


Figure 4. Cave shielding calculations with walls of 40-90cm thick concrete.

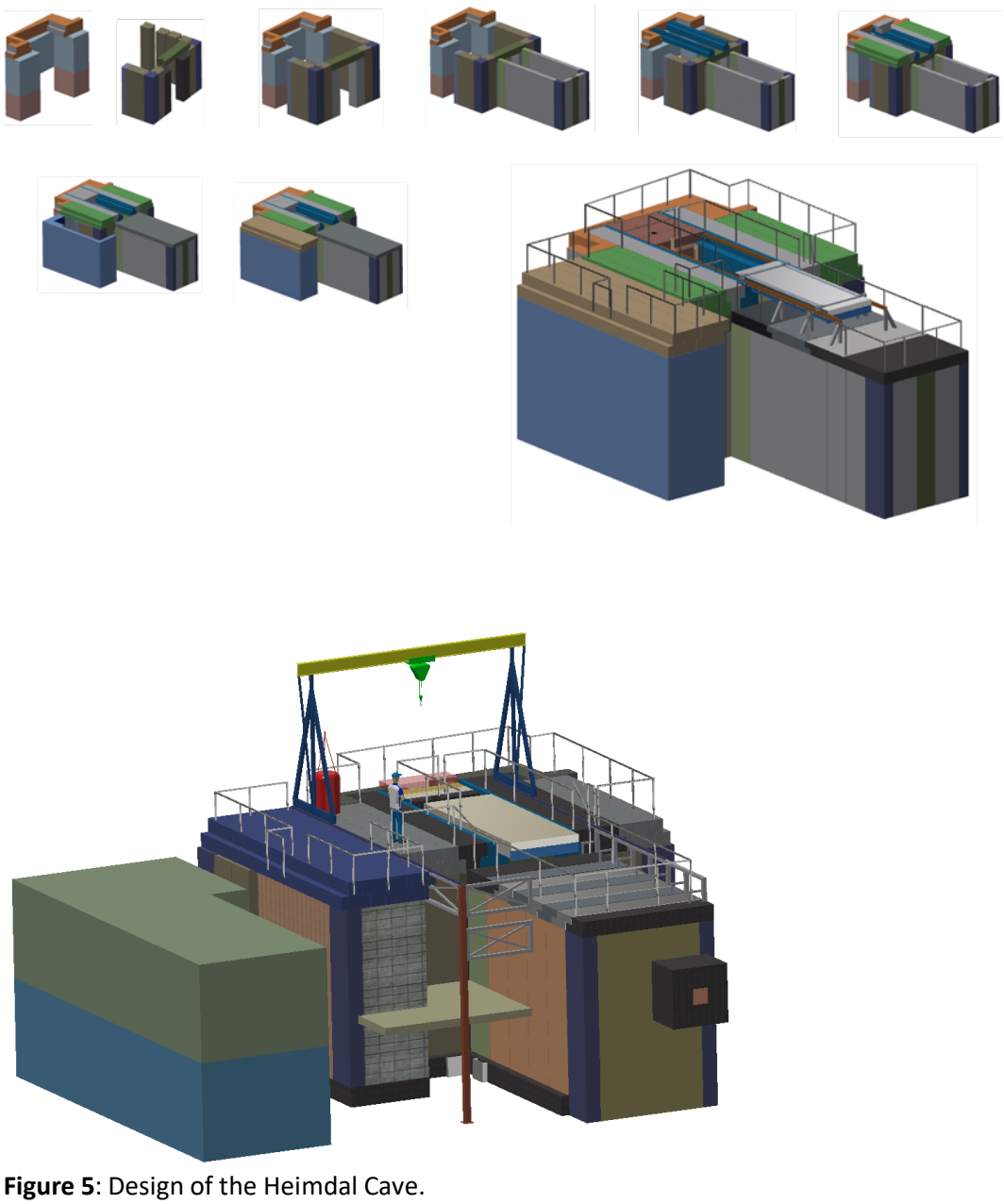


Figure 5: Design of the Heimdal Cave.

6.7 Possible Polarised Neutrons on Heimdal

We have participated in the recent polarised neutron workshop organised by ESS. and we expressed an interest in polarised neutrons for Heimdal. The instrument could easily offer cold polarised neutrons as part of the SANS upgrade, by using a polarising mirror instead of the last deflecting mirror of the cold guide, maybe in some translatable double mirror solution. We have also discussed the possibility of polarised thermal neutrons as part of the initial thermal diffraction installation. This might also be possible using a 3He cell for polarisation analysis, with one section for the diffracted beam and another for the SANS scattered beam. Thus, it would be possible to have both thermal and cold neutrons on Heimdal with polarisation analysis. Discussions are on-going on polarised neutrons.

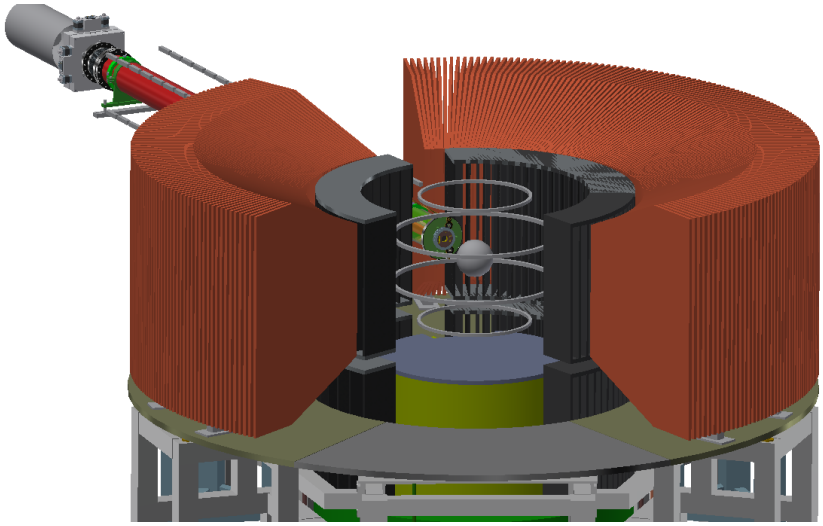


Figure 6: A sketch of the implementation of a possible 3He cell for polarised neutrons and how it might fit onto Heimdal.

7 **Sample environment:**

Discussion at IKON focussed on priority for sample environment. Heimdal expressed an interest in high through-put powder neutron diffraction, with the possibility. to heat, cool and interchange samples rapidly for a high turn-over of structure determinations. Dream are also interested in similar solutions. Some ideas are presented in figure 7 and required further discussion with SAD group.

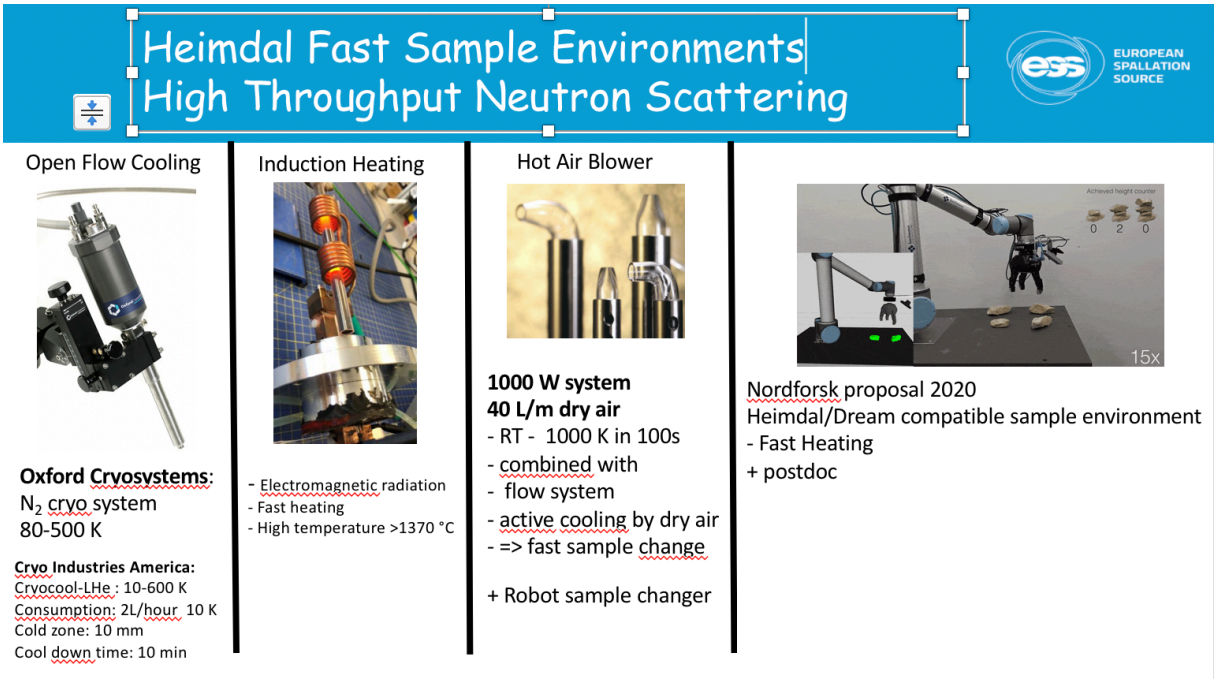


Figure 7. Possible sample environment and sample changer for high throughput powder diffraction.

We have also expressed interest in several sample environments from. the sample pool, including cooling, heating, dilution, magnets, pressure and electrochemical cells as shown in figure 8. I have discuss possibilities for High pressure experiments with Malcolm from sample environment. One interest could be high temperature and pressure measurements in diamond anvil cells.

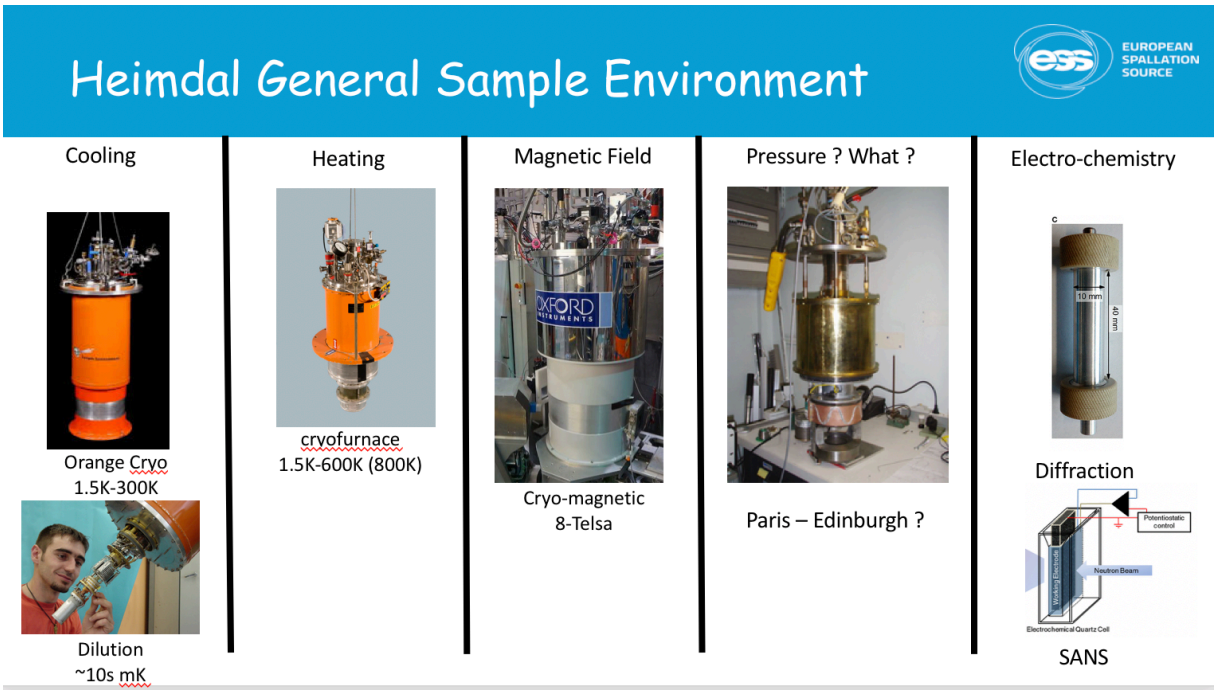


figure 8. Sample environments from the sample environment pool, we have expressed interest in supporting.

9 Instrument Priority for build-up and upgrade.

At present it is difficult to assess the priority for the Heimdal instrument concerning possible upgrades, since the change request to include a large part of the cold guide is still not resolved. Developing the instrument without a cold guide will require a significant shutdown for the upgrade to include SANS. In this case it might be better to build up diffraction capability first (full detector coverage + possible polarised thermal neutrons) and assess when the shutdown could be envisaged for SANS and imaging upgrade. Priority would then likely be:

Diffraction
Full Diffraction coverage
Polarised* thermal/cold Neutrons via bispectral switch.
****shutdown*****
SANS
Imaging

On the other hand, if we manage to have most of the cold guide installed, then the instrument can be developed without a need major shut down, the upgrade priority could follow:

Diffraction
SANS
Imaging
Polarised Cold Neutrons*
Polarised Thermal Neutrons*

* It is not clear also at this point if or when polarised neutrons can be incorporated into the instrument.

Early next year it should be clearer where we are with our budget and the resubmission of our change request. We need permission to go ahead with procurement of the Guide and detector system from PSI before we can have these real costs.