

**The HEIMDAL Instrument at ESS  
Diffraction STAP Meeting October 2021  
Update Summary**

**Heimdal lead scientist:** ESS has offered permanent position to Dan Mannix as lead instrument scientist for Heimdal. The ESS contract will start 1st January 2022 after the end of in-kind contract with Aarhus University.

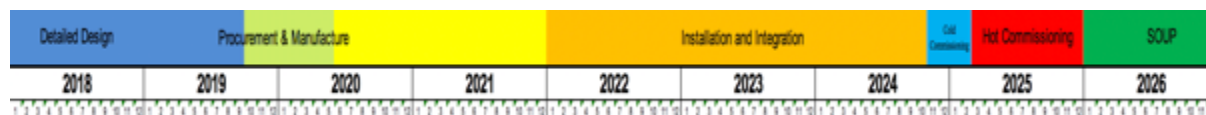
**(1) In-kind Agreements and Technical Annex**

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

**Current Status:** Heimdal has all TA's signed and approved by ESS as of February 2020. The Swiss Government has also not approved the PSI in-kind agreement. We are now moving forward again with procurement of the guide optics and detector with PSI.

**(2) Current (and future) Instrument Timeline:**

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



The ESS is currently discussing a new rebaselining at the end of 2021 and it is not decided at this time how this will effect the schedule of the later (post-first-8) instruments like Heimdal. The current discussion for the new rebaselining is proposing to delay hot commissioning for Heimdal until end of 2026 with SOUP starting beginning of 2028.

**Change of Construction focus:**

With delay to BOT until late 2024 and with new ESS rebaseline, Heimdal have decided to change focus for the instrument construction program. Previously, we were building from the cave and working back to bunker, with bunker access provided during a scheduled shutdown in 2024. There is now an extended open bunker period and we plan to prioritise all of the in-bunker components for take advantage of the delay to BOT.

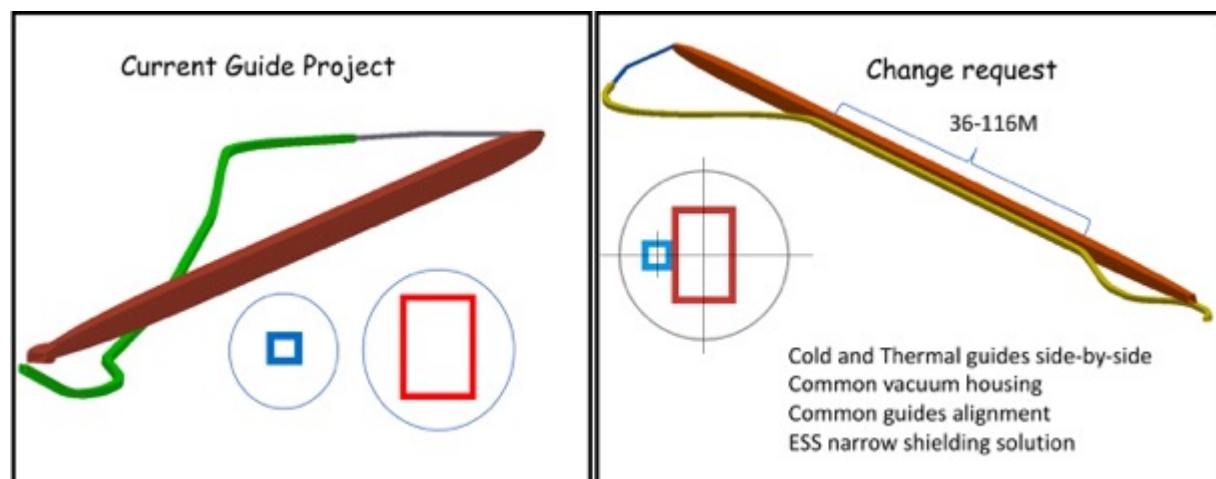
**(3) Change of scope request:**

The change request to include more cold guide (figure 1) into scope of Heimdal due to savings on the shielding is still on-going. 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, but is now moving

forward again. The large items costs are summarised in the following table. So far everything is with-in budget. We still to not have costs for the detector or guide system or cave infrastructure.

Item	Contractor	Costed	Within Budget ?
<b>Chopper Systems</b>	ESS Common	Yes	Yes
<b>T0 Chopper</b>	ESS	Yes	Yes
<b>Guide Shielding</b>	ESS Common	Yes	Yes
<b>Cave Shielding</b>	Mirrotron	Yes	Yes
<b>Cave Infrastructure</b>	ESS Common	No	?*
<b>Detector</b>	CDT	No	?
<b>Monitors</b>	ESS Common	Yes	Yes
<b>Guide Optics</b>	?	No	Yes

\* Detector area can be reduced to fit with budget in necessary.



**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. As with other instruments the TG3 process is divided into Call For Tender (CTVs) technical specification for detailed design and sub-TG3s (sTG3s) where detailed design is reviewed. We have completed 4/6 CTVs, with the detector and guide system delayed until Q2/Q3 2021 due to delays with in-kind from PSI. Final TG3 date is Q2 2022.

Milestone	Item	Date Submitted	Approved	Comments
<b>CTV.1</b>	Slits, x,y,z table	16/12/19	Yes 11/05/20	
<b>CTV.2</b>	Cave & beamstop	16/12/19	Yes 12/11/20	Published Feb. 2021

<b>CTV.3</b>	Choppers & T0	23/05/19	Yes 21/02/20	ESS common project
<b>CTV.4</b>	2D detector	23/05/19	Yes 01/02/21	Moving forward with PSI
<b>CTV.5</b>	Guides system	22/03/19	No but Reviewed	Moving forward with PSI
<b>CTV.6</b>	BWI Detector collimator	27/05/20	No	comments to address
<b>sTG3.1</b>	Slits x,y,z table	May 2020	No	2D detector detailed design
<b>IDR.1</b>	Detector Table	May 2020	No	2D detector detailed design
<b>sTG3.2</b>	Cave	March 2021		Delay -
<b>sTG3.3</b>	2D Detector /collimator/	May 2021		possible delay
<b>sTG3.4</b>	Guide system	Sept. 2021		possible delay
<b>sTG3.5</b>	Light/Heavy Shutter	Nov.2021		Detailed design
<b>sTG3.6</b>	Monitors, PSS, vacuum, Drawings MCA, DMSC, 3D	March 2022		
<b>Final TG3</b>		March 2022		

**(5) ICEB meetings:** Last Heimdal ICEB meeting took place on the Q2 2021 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.

## **(6) Instrumentation**

### **6.1 NBOA**

The NBOA was scheduled for subTG3 process in February 2019, but this was postponed 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 Q2 2022.

### **6.2. Choppers**

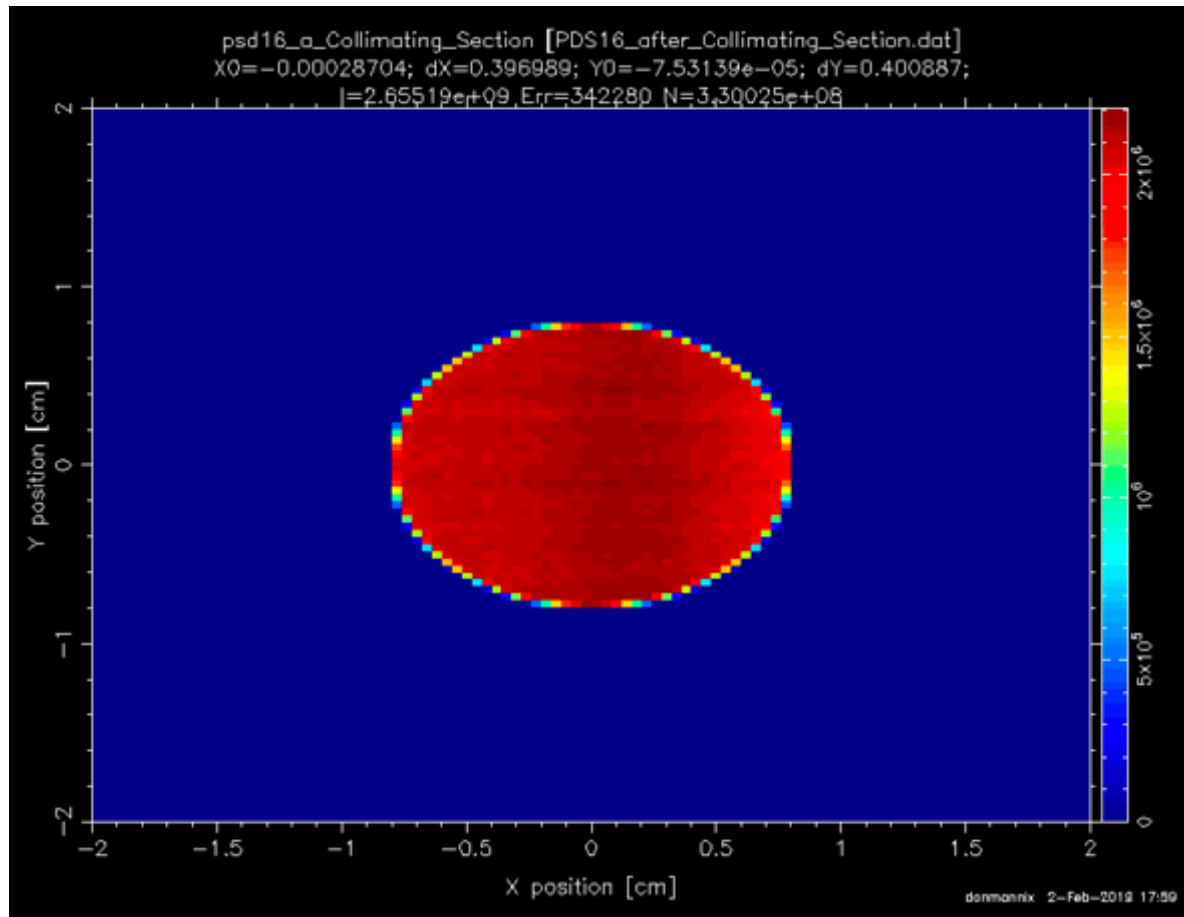
We now have a full costing of our chopper systems and will move ahead with procurement. We have joined and had kick-off with the common chopper project.

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. The

T0 chopper project will move ahead with ESS chopper group and is expected to be within budget.

### 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. We are now working with PSI to complete the call for tender for the guide systems, which we expect to finish by the end of 2021.



**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.

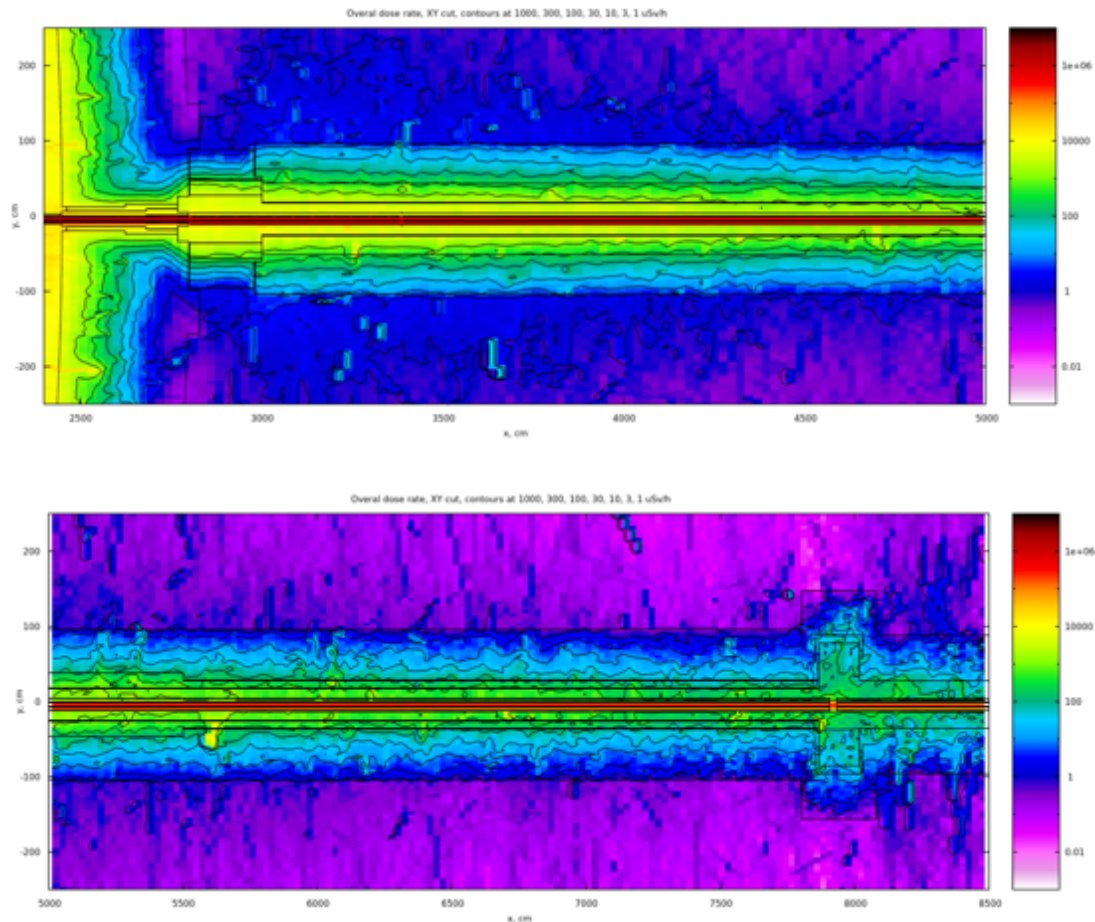
### 6.4 Detector:

The 2D detector procurement is ready to start, but has been on hold due to in-kind agreement with PSI. We are now moving ahead with this procurement and it will be addressed after the guide procurement is finalised with PSI.

### 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 it gives a back-ground of around  $3\mu\text{Sv/hr}$  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 ( $3.8\text{ g/cm}^3$ )

30-45 m: 25 cm steel 50 cm regular concrete ( $2.3\text{ g/cm}^3$ )

45-55 m: 20 cm steel 55 cm regular concrete

55-chopper pit: 10 cm steel 65 cm regular concrete

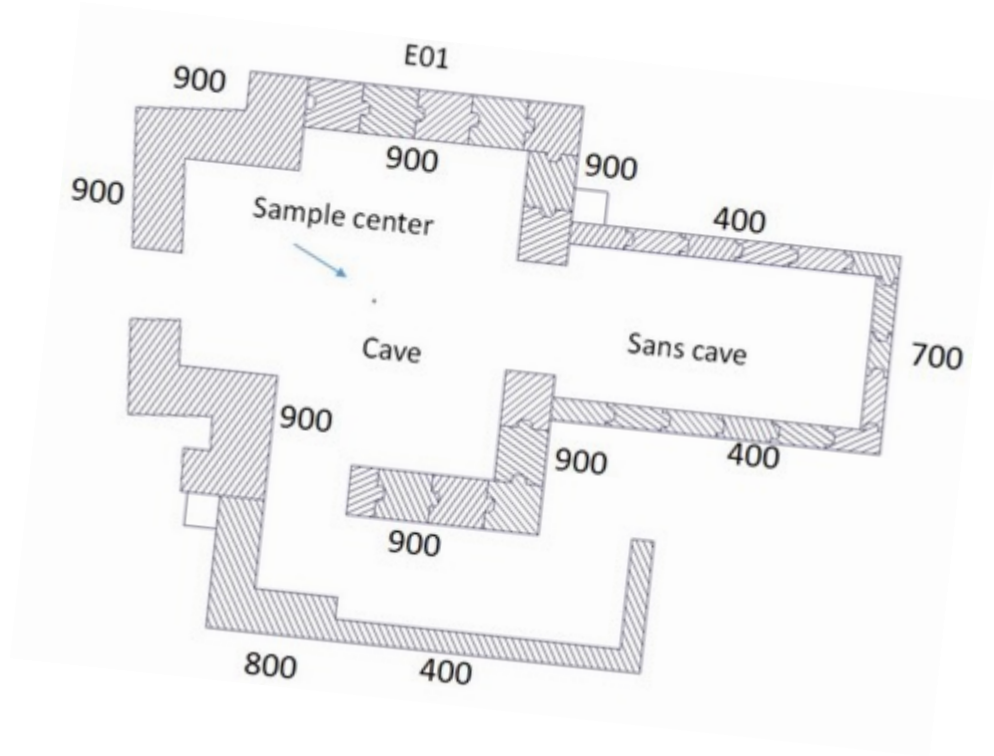
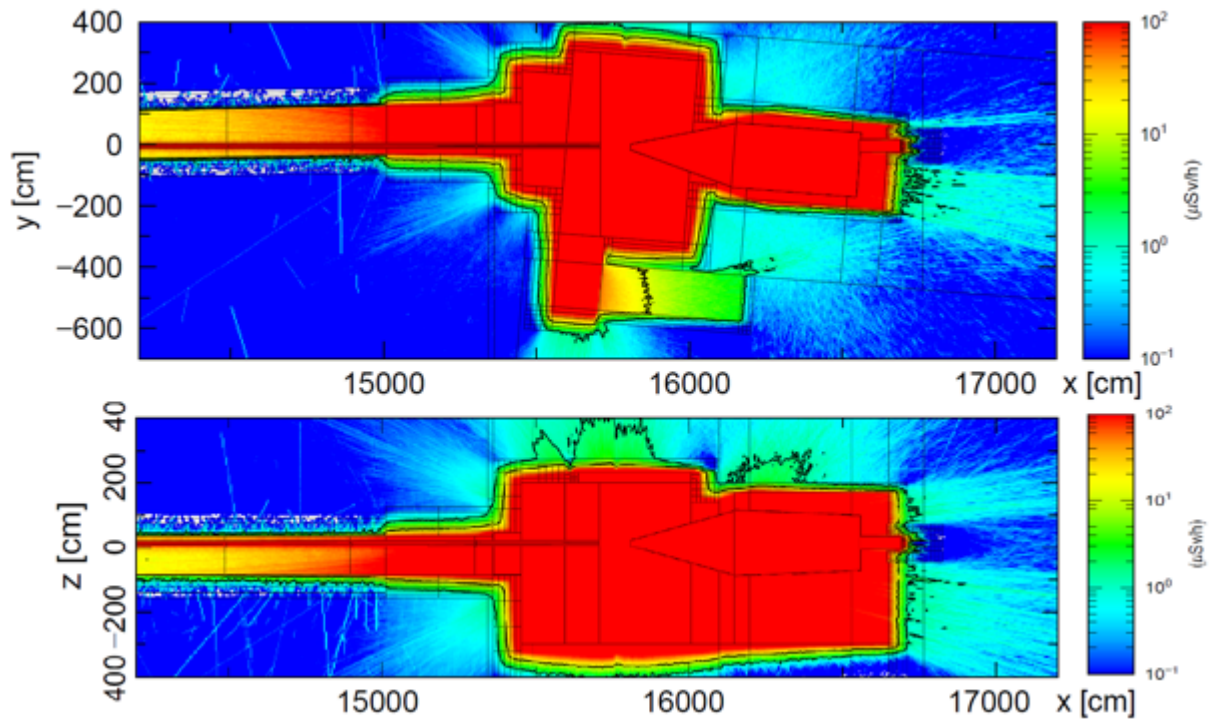
Chopper pit shielding according to common shielding project (will need extra steel when contribution from thermal neutron beam will be considered)

Beyond chopper pit: 60 cm regular concrete.

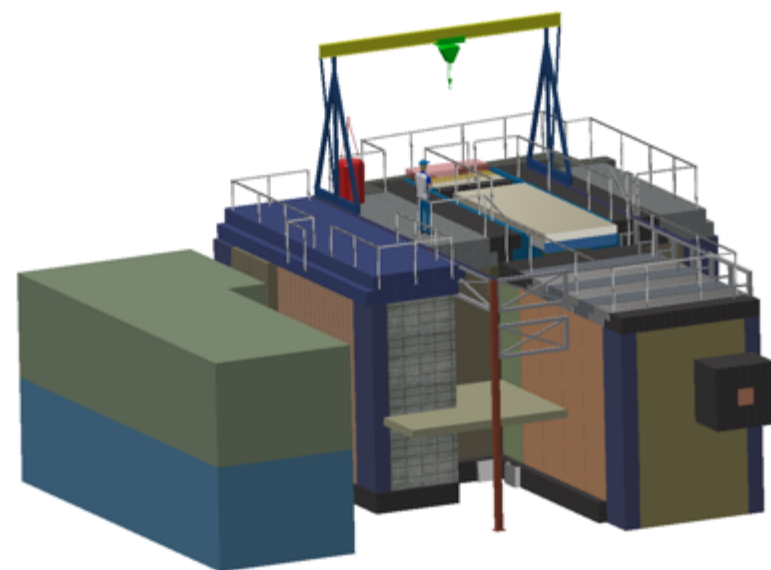
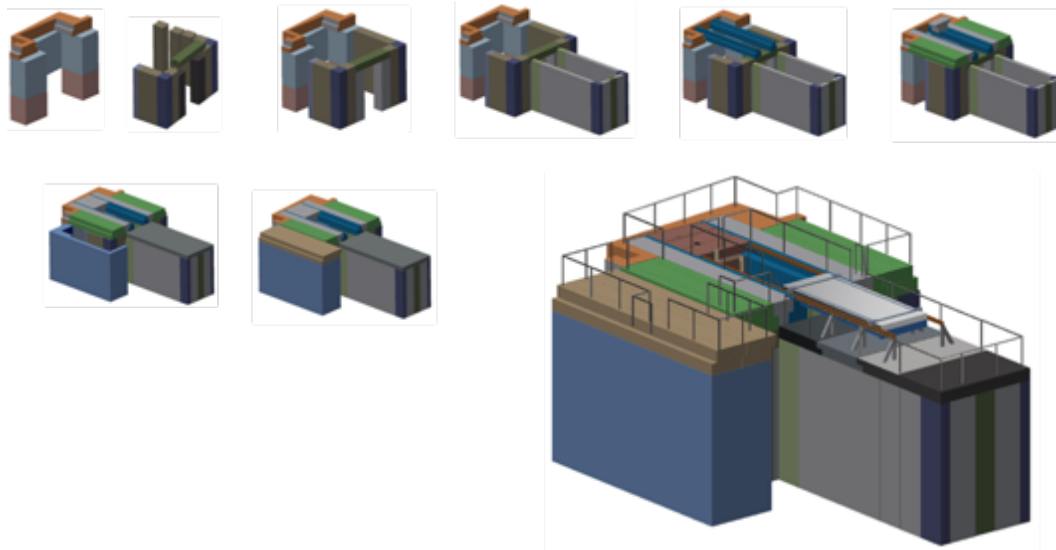
Inner steel shielding is lined with 5 mm B4C both inside and outside B4C/epoxy tiles.

### 6.6 Cave Shielding Neutronics:

The Call for Tender for the cave was published this year and was awarded to Mirrotron with a bid including cave shielding and beamstop which was within budget.



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

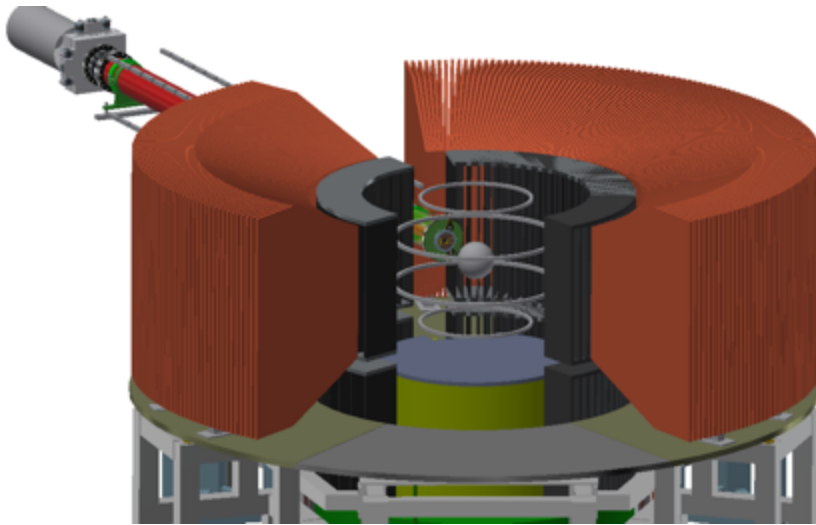


**Figure 5:** Design of the Heimdal Cave.

### 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  $^3\text{He}$  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  $^3\text{He}$  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. We now had a nordforsk postdoc in place working on these sample environments together with the Dream instrument. Some ideas are presented in figure 7 and required further discussion with SAD group.

## Heimdal Fast Sample Environments High Throughput Neutron Scattering



EUROPEAN SPALLATION SOURCE






<p><b>Open Flow Cooling</b></p>  <p><b>Oxford Cryosystems:</b> N<sub>2</sub> cryo system 80-500 K</p> <p><b>Cryo Industries America:</b> Cryocool-LHe : 10-600 K Consumption: 2L/hour 10 K Cold zone: 10 mm Cool down time: 10 min</p>	<p><b>Induction Heating</b></p>  <p>= Electromagnetic radiation - Fast heating - High temperature &gt;1370 °C</p>	<p><b>Hot Air Blower</b></p>  <p><b>1000 W system</b> <b>40 L/m dry air</b> - RT - 1000 K in 100s - combined with - flow system - active cooling by dry air - =&gt; fast sample change</p> <p>+ Robot sample changer</p>	 <p>Nordforsk proposal 2020 Heimdal/Dream compatible sample environment - Fast Heating + postdoc</p>
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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 discussed possibilities for High pressure experiments with Malcolm from sample environment. One interest could be high temperature and pressure measurements in diamond anvil cells.

## Heimdal General Sample Environment



EUROPEAN SPALLATION SOURCE






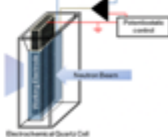
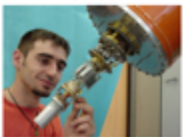
<p><b>Cooling</b></p>  <p><b>Orange Cryo</b> 1.5K-300K</p>	<p><b>Heating</b></p>  <p><b>cryofurnace</b> 1.5K-600K (800K)</p>	<p><b>Magnetic Field</b></p>  <p><b>Cryo-magnetic</b> 8-Tesla</p>	<p><b>Pressure ? What ?</b></p>  <p><b>Paris – Edinburgh ?</b></p>	<p><b>Electro-chemistry</b></p>  <p><b>Diffraction</b></p>  <p><b>SANS</b></p>
 <p><b>Dilution</b> ~10s mK</p>				

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