EUROPEAN SPALLATION SOURCE

Heimdal Instrument @ ESS Diffraction STAP May 2022

Dan Mannix

Lead Scientist Heimdal Instrument ESS, Lund Sweden

ESS May 2022

HEIMDAL – Hybrid Diffraction

Multi Length Scale Neutron Scattering Instrument: 10^{-2} – 10^{8} nm

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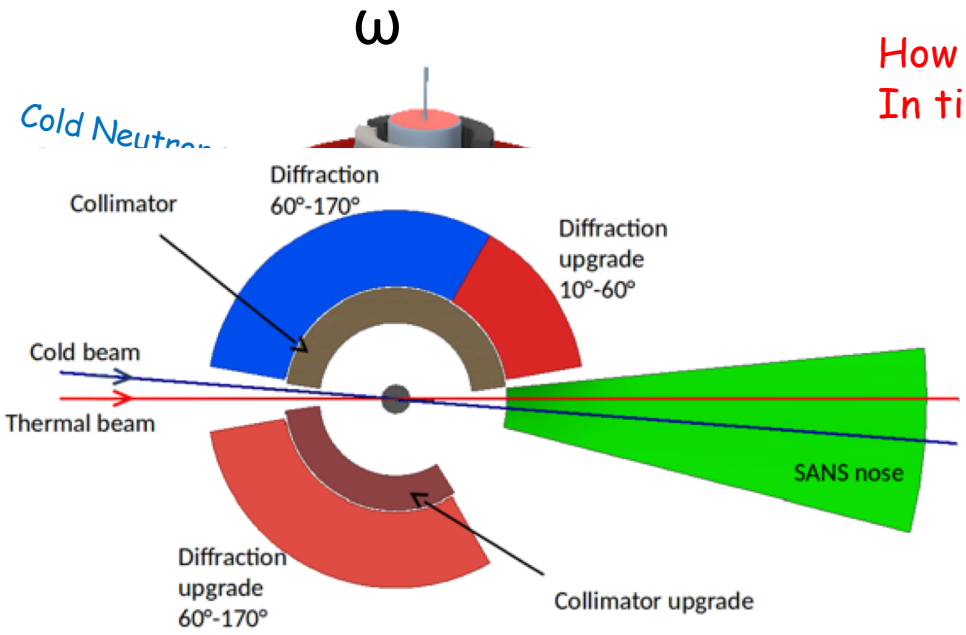
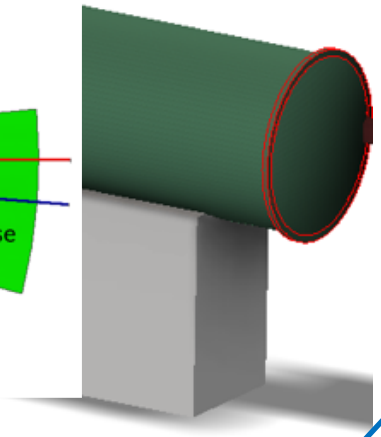


How do we construct Heimdal to full science scope
In timely (reduced shut-downs) and cost effective way ?



Diffraction + SANS + Imaging

(1) Thermal Diffraction (SOUP ~2028)
(2) Cold Guide - SANS (upgrade)
(3) Neutron Imaging (upgrade)

The Heimdal Risk Register

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RISKS to Heimdal project: Delay, Quality & Costs	Lack of Engineering resources based at ESS. Lead Engineer is only Engineering resource, based in Denmark. Close to retirement age. No Engineering manpower based at ESS.	Heimdal cannont complete engineering documentation according to schedule. Lead engineer retiring and not enough overlap with replacement engineer. Risk of delay and quality of final instrument.	Delay in instrument schedule. Quality of Instrument delivered. Increased labor costs from delay.	
RISKS to Heimdal project: Delay, Quality & Costs	20	**Reduce**	Allocation of Engineering resources to Heimdal and based at ESS. Best solution is reuse of engineering resources from eairlier instruments with ESS instrument work experience.	

Heimdal Requires more engineering support based at ESS to deal with large workload & installation

Kåre Iversen – Lead Engineer based at Aarhus University
Dan Mannix – Lead Scientist based at ESS

The Heimdal Risk Register

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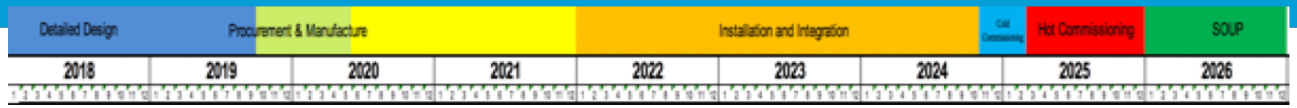
Risk of personnel leaving	Neutron instrument division has requested opening of Heimdal lead scientist position	Dec-20	Low	Unlikely	2	4	Falling
Delay of 2D Detector Procurement from PSI	Issue resolved and moving ahead in 2022. Guide procurement priority (Change in BOT ESS-MS). Detector procurement Q2 Q3 2022.	2020-12-01	Low	Moderate	4	6	Falling
Delay of Guide procurement from PSI	Issue resolved and moving ahead in 2022. PSI Guide tender publication expected Q2 2022. RISK Reduced	2020-12-01	Low	Moderate	4	6	Falling
SANS upgradability	Partners and ESS shall clarify the subject as soon as possible. If the proposed changes are not excepted there has to be some plan that allows a later upgrade with reasonable budget.	2022 Q2	High	Likely	16	15	Rising
T0 Cost / High Background	Search new supplier of T0 chopper. ESS to investigate if it can be built by ESS. Update Feb-22: ESS Chopper group scope. Risk		Very low	Moderate	2	15	Falling
delay to cave installation	Awaiting results of rebaseline	2020-12-15	Low	Moderate	4		New

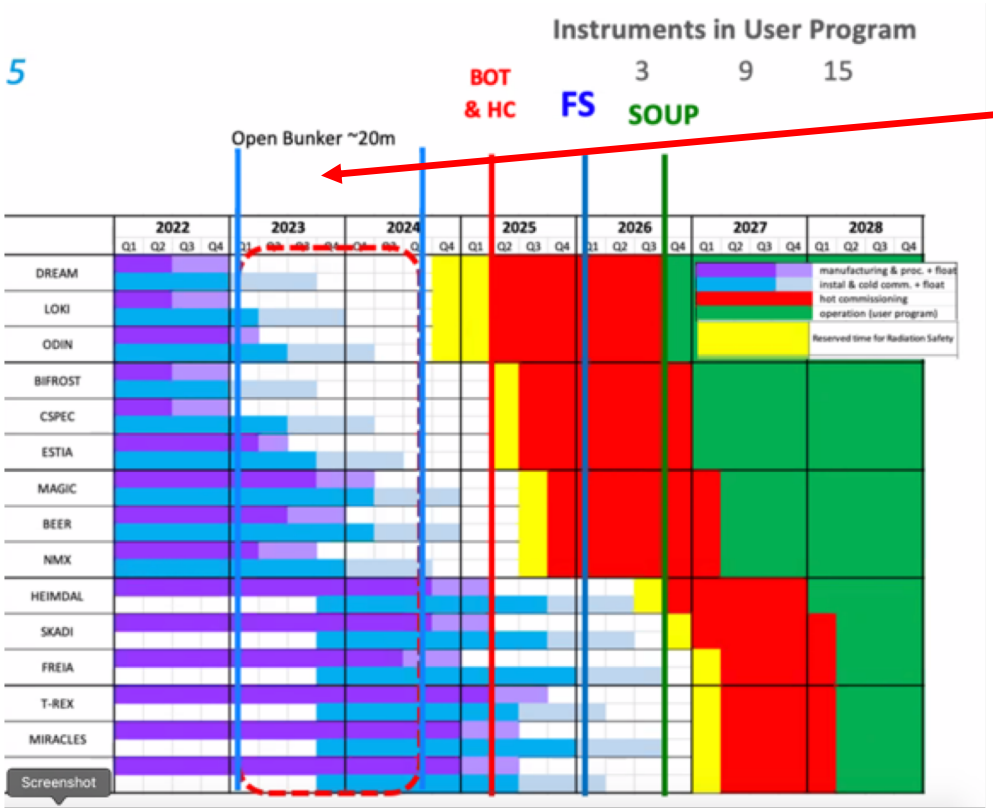
Change Request to include more cold guide scope

Item	Contractor	Costed	Within Budget ?
Chopper Systems	ESS Common	Yes	Yes
T0 Chopper	ESS	Yes	Yes
Guide Shielding	ESS Common	Yes	Yes
Cave Shielding	Mirrotron	Yes	Yes
Detector	CDT	No	Yes ? Reduce coverage if needed
Monitors	ESS Common	Yes	Yes
Guide Optics	Tender published May 2022	No	Depends of how much cold guide ?

By end of 2022 we should know all real costs and know how much cold guide can be bought

Heimdal Timeline





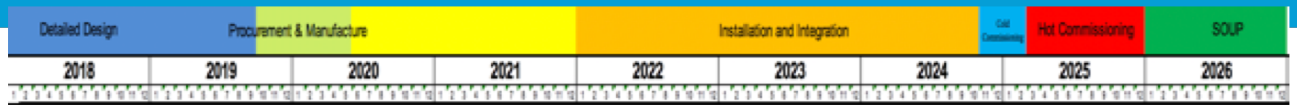
New Build Focus for Instrument:

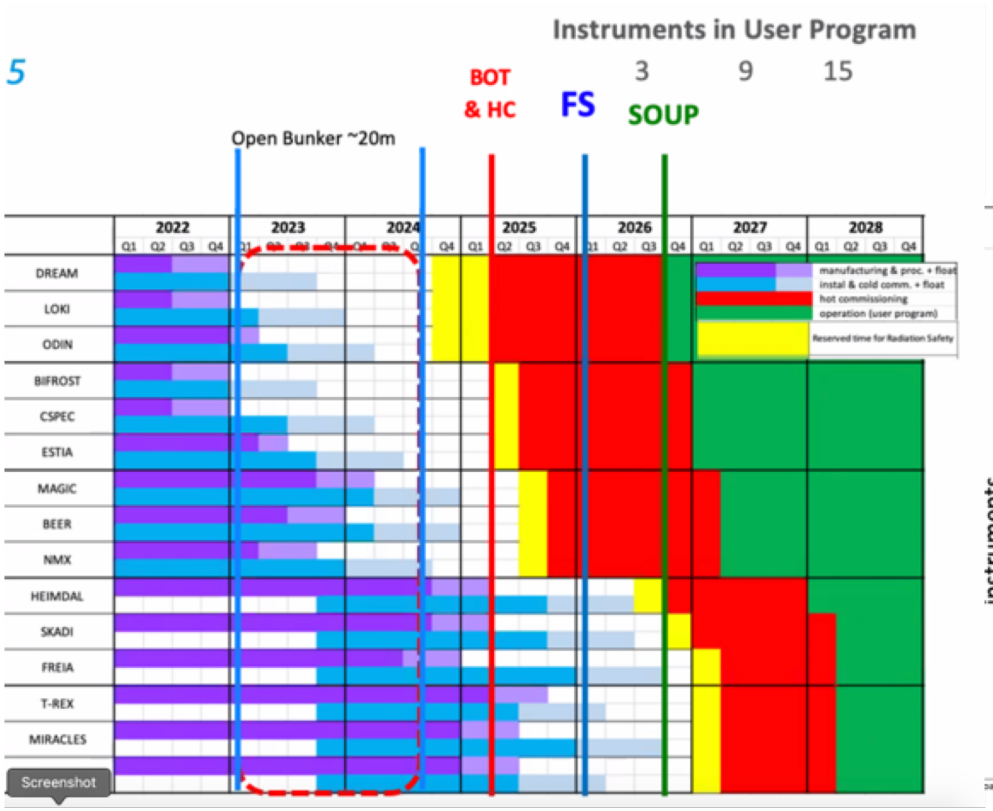
Delay to BOT & Longer open access to bunker

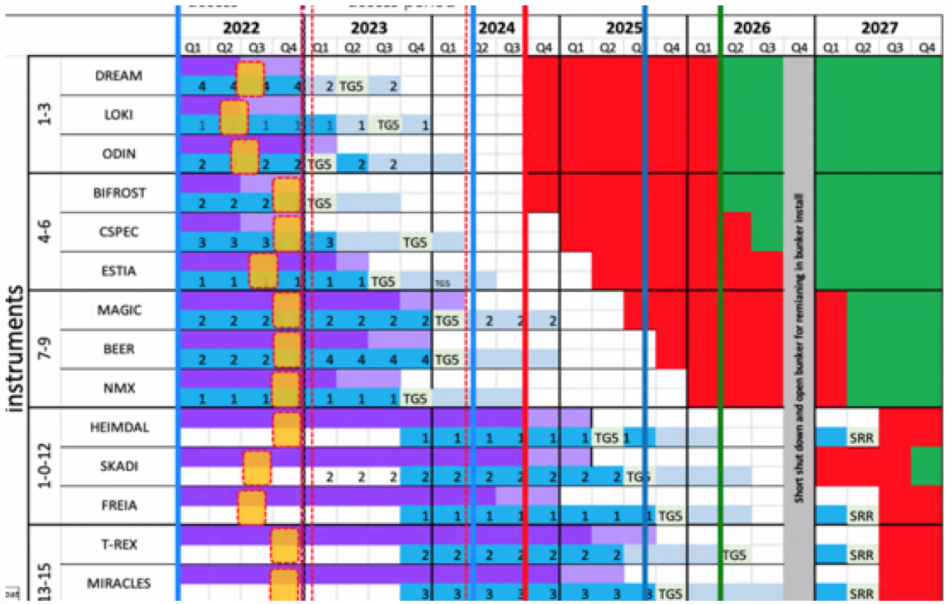
Procurement of Bunker components:

Thermal Choppers
T0 Chopper
Guide Optics, Support & Vacuum Housings
Heavy Shutter
Light Shutter

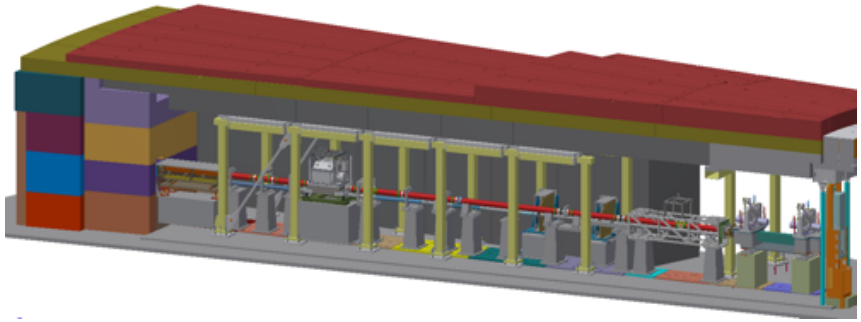
Heimdal Timeline

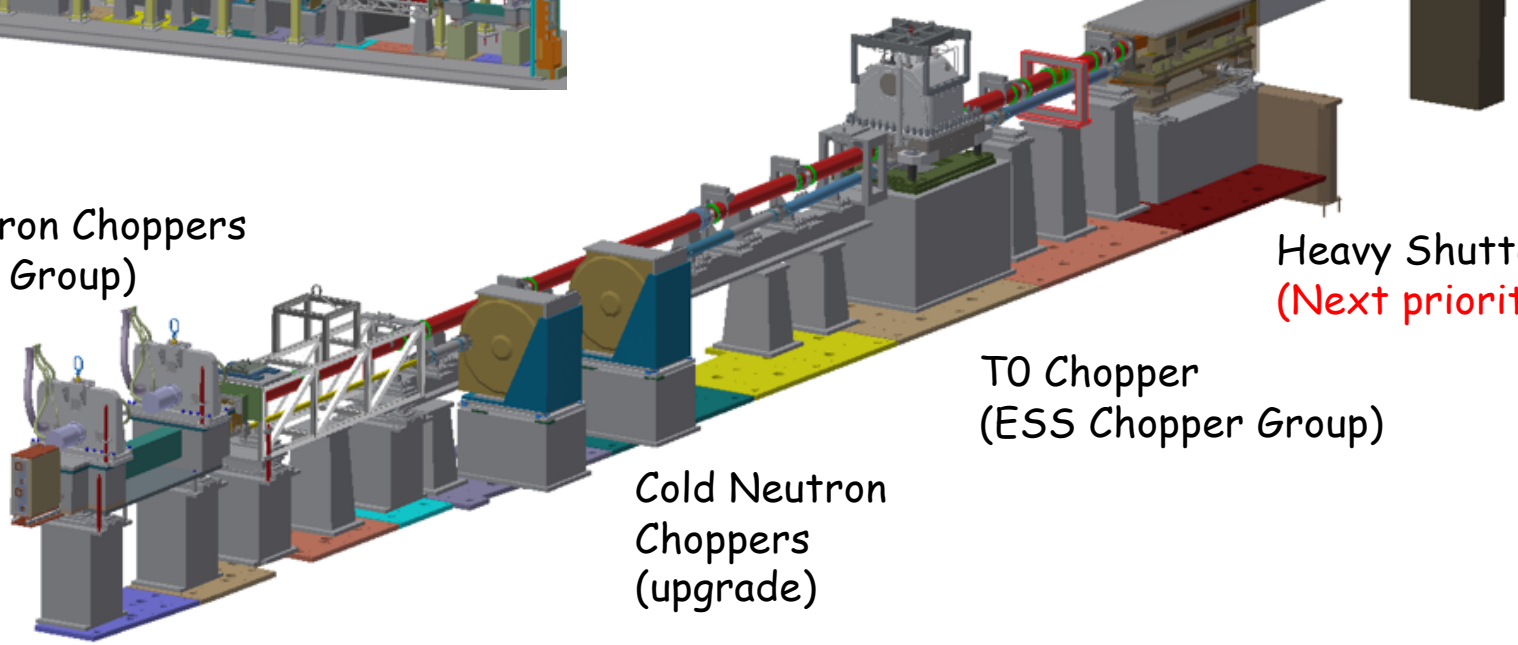






Heimdal inside Bunker Components





Bunker Wall Feedthrough
(Guide procurement PSI)

Thermal Neutron Choppers
(ESS Chopper Group)

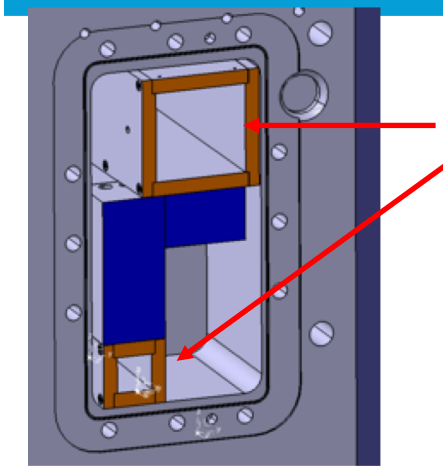
Heavy Shutter (AU)
(Next priority)

T0 Chopper
(ESS Chopper Group)

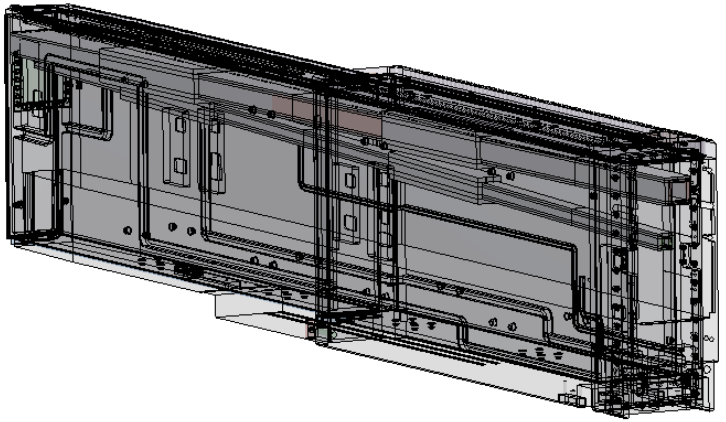
Light Shutter
(AU)
(Next priority)

Cold Neutron
Choppers
(upgrade)

NBOA Project: Swiss Neutronics



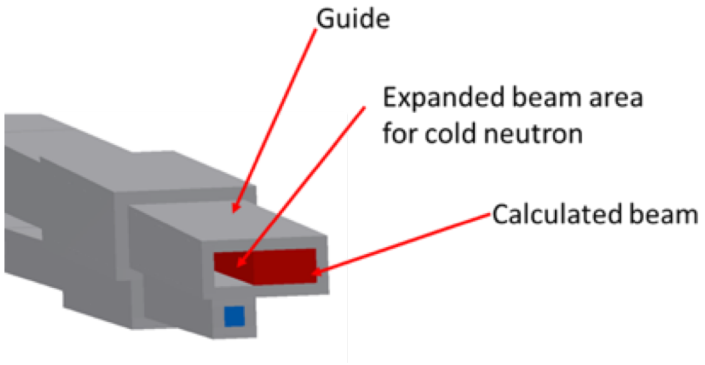
Reduced window thickness
from 2mm to 1.5



Optics sTG3 finalised – Ready for Manufacture

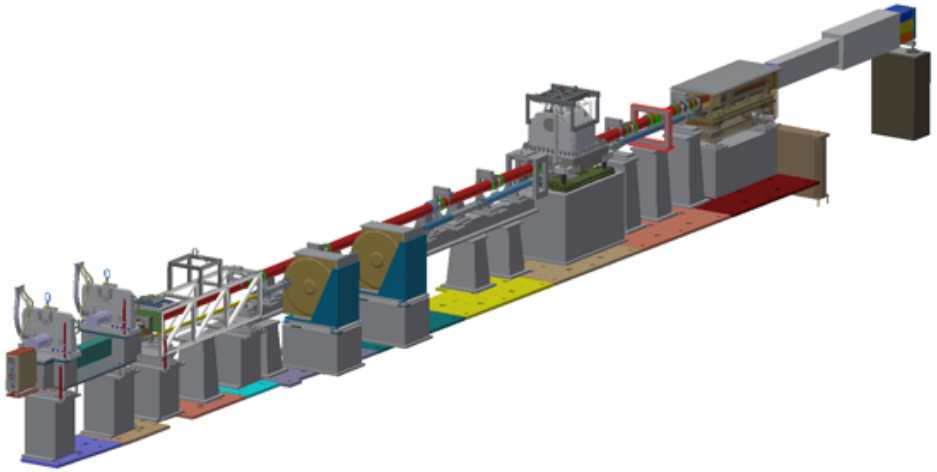
NBPI in queue with other ESS instruments

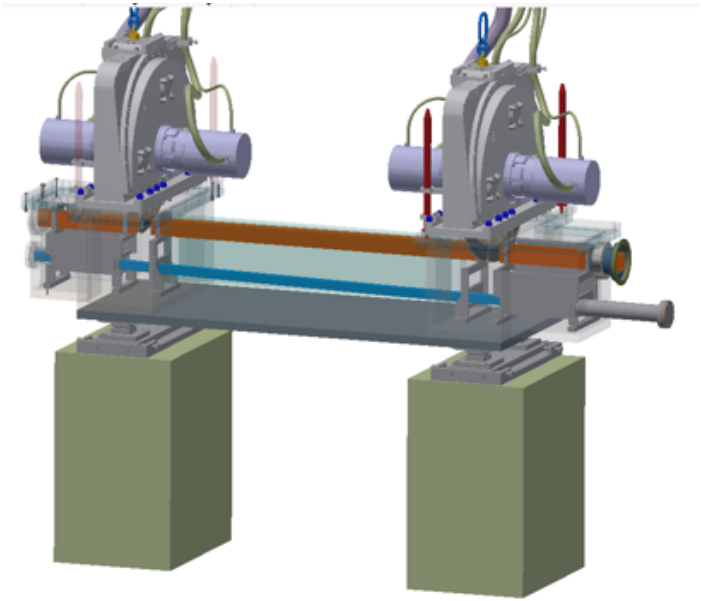
Installation expected before BOT Q4 2023.

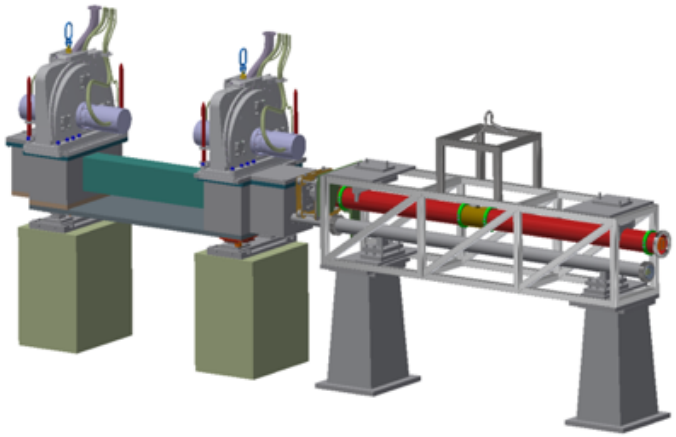


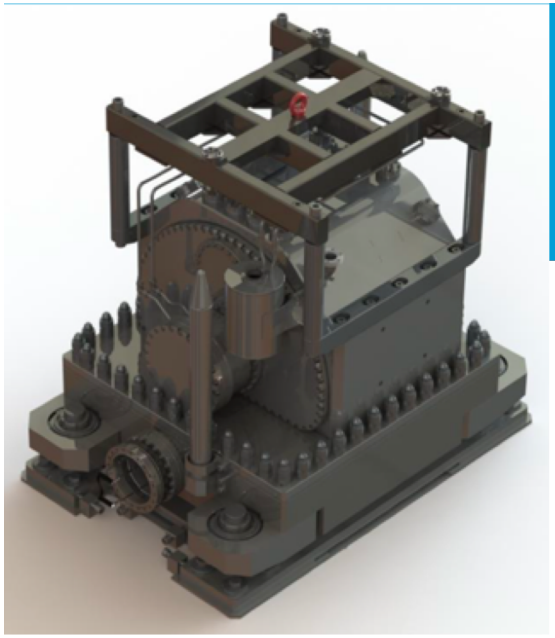
Heimdal Choppers

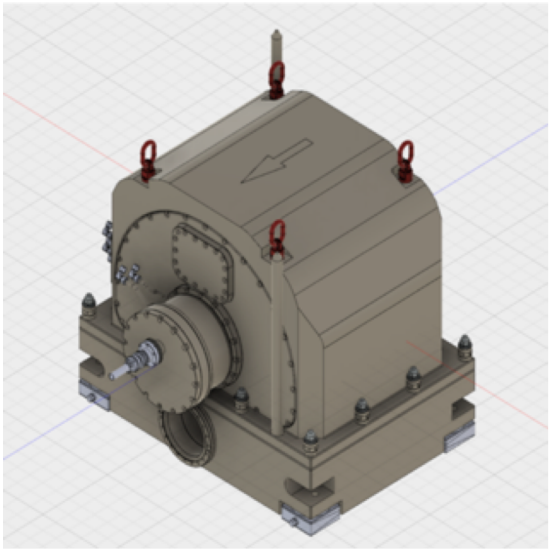
ESS Common Chopper Project
Expected Before BOT Q3 2023
Project within Budget











T0 Chopper

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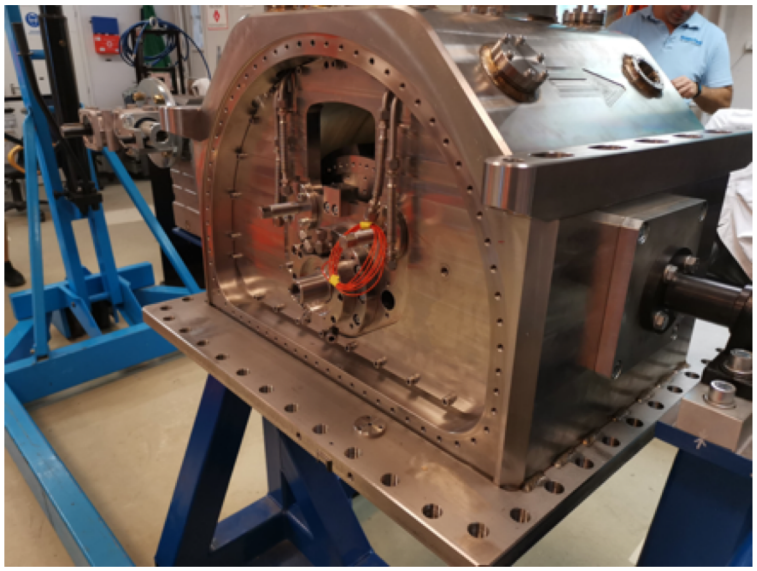
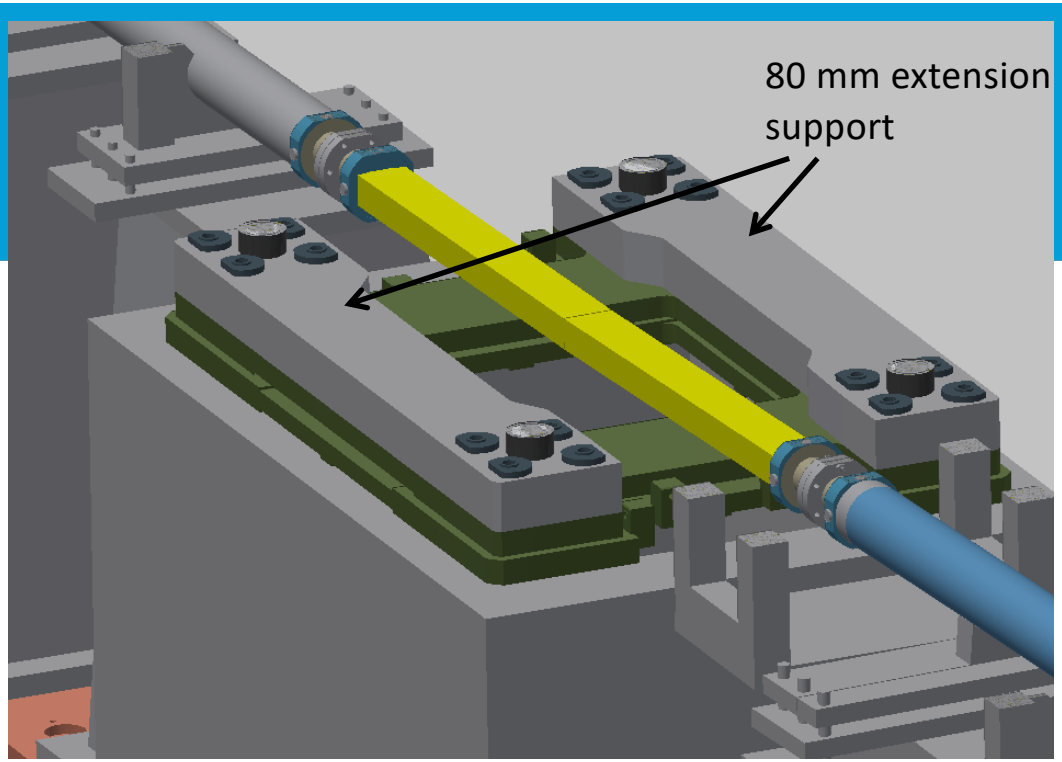
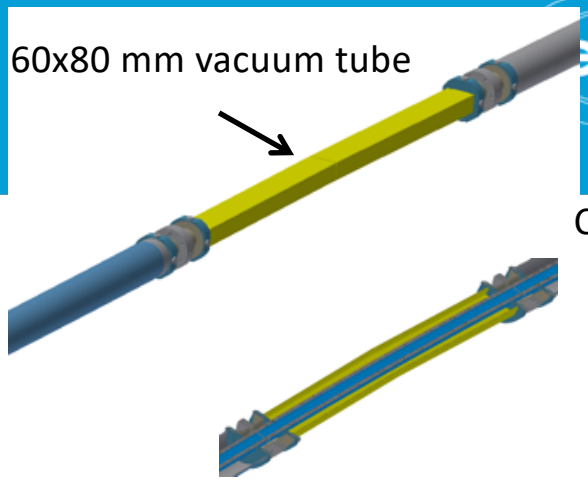


Prototype T0 Chopper Design

Construction with ESS Chopper Group - within budget
Final modified design for Heimdal approved by ESS
Scope transfer from IFE to ESS
Installation ? Maybe after BOT (shutdown 2026). Start with no T0 and vacuum tube.

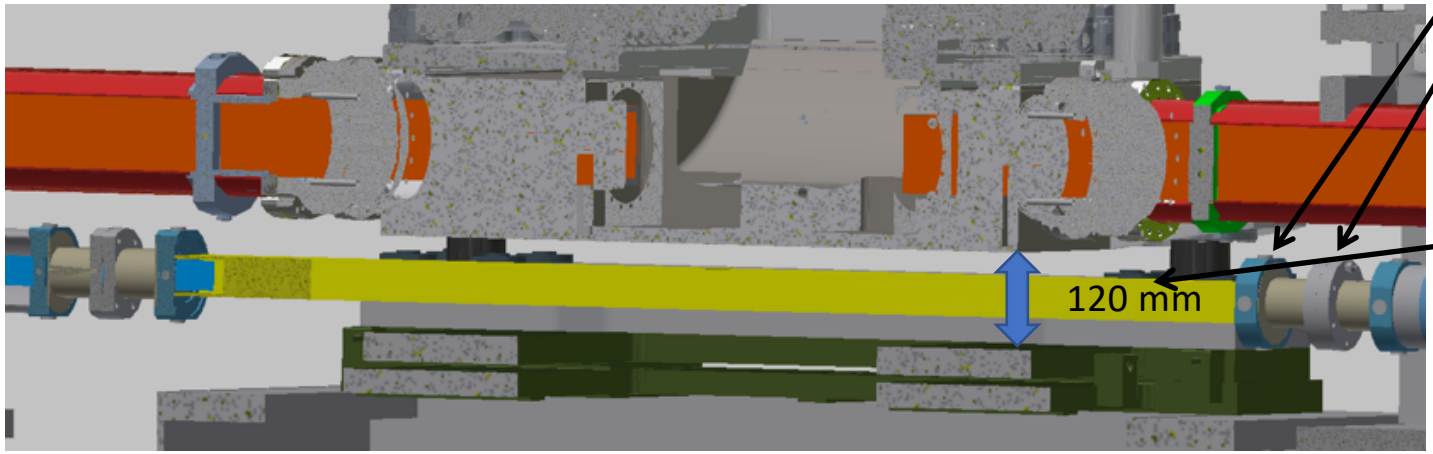




Curved guide

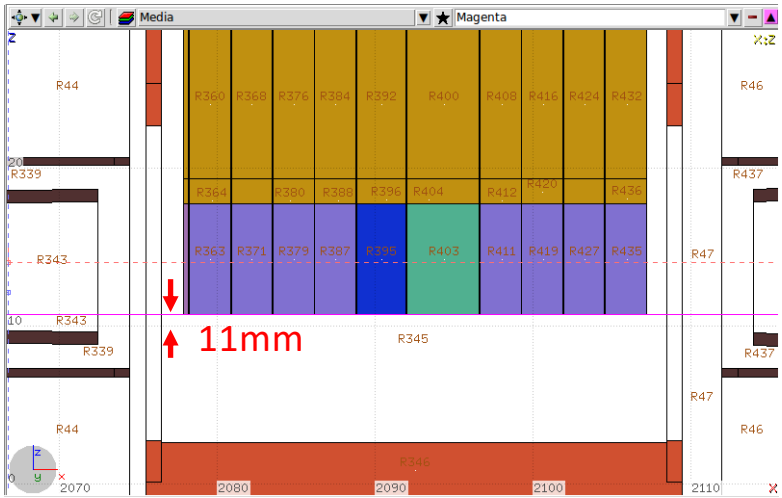
Guide adjusting flange milled to 110 mm square

CF63 / ø113.5 mm

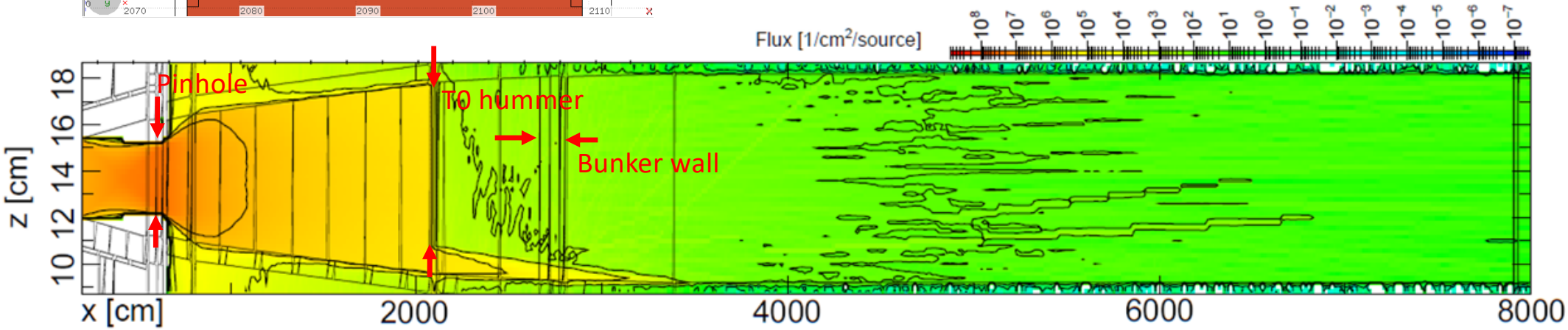


120 mm between support frame and T0 bottom

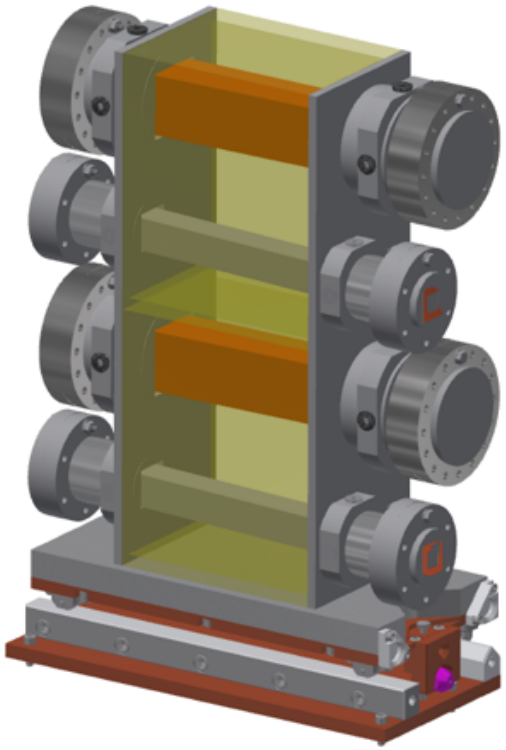
T0 simulation results

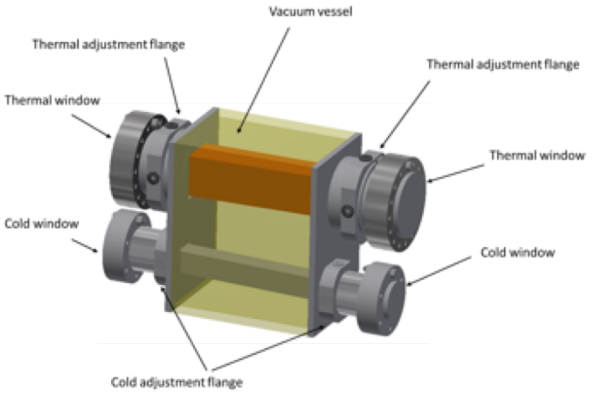


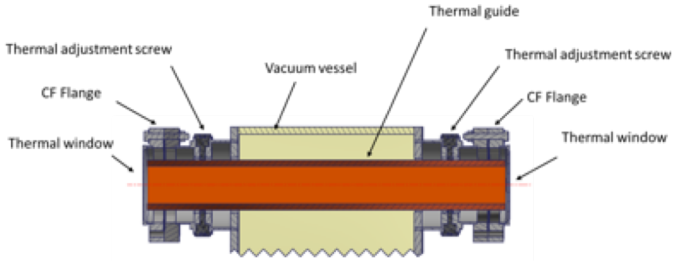
- A T0 chopper is placed leaving 11 mm of the guide space below the hammer open.
- Streaming of neutrons below the hummer is absent beyond 35 meters from target (figure for $E_n > 20$MeV)
- Same background as for full-sized T0
- Radiation safety fulfilled: guide shielding is designed to provide 1.5 uSv/h outside with T0 parked open.
- 300 uSv/h contact dose rate at T0 hammer 1h after shutdown, well within 10mSv/h limit.



Light Shutter (BBG)



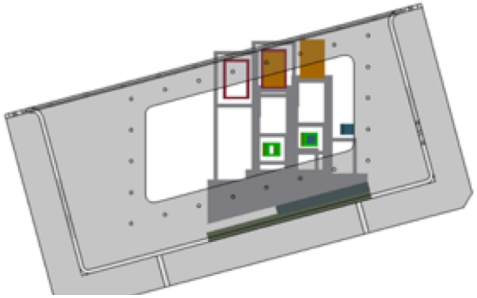




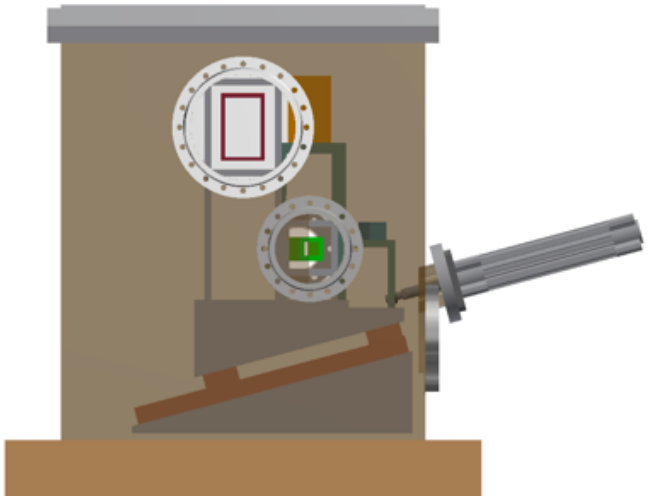
Procurement AU: Next Priority
Delivery before BOT Q4 2023

Heavy Shutter

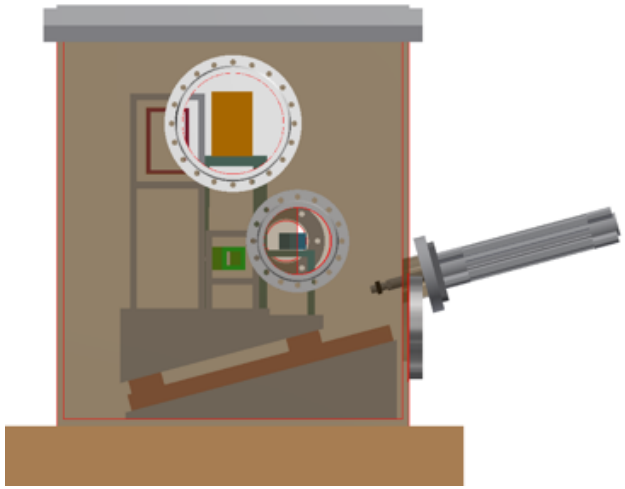
Procurement AU: Next Priority
Delivery before BOT Q4 2023

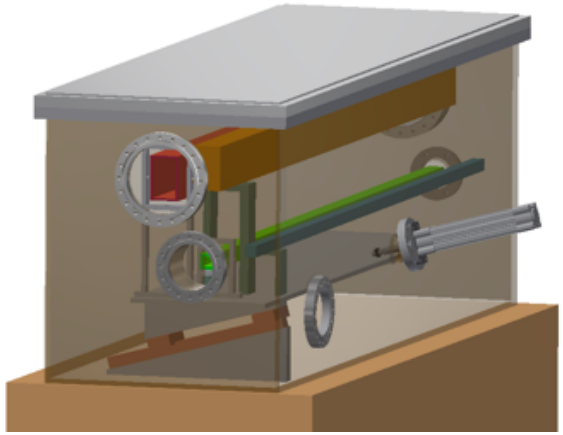


Open position

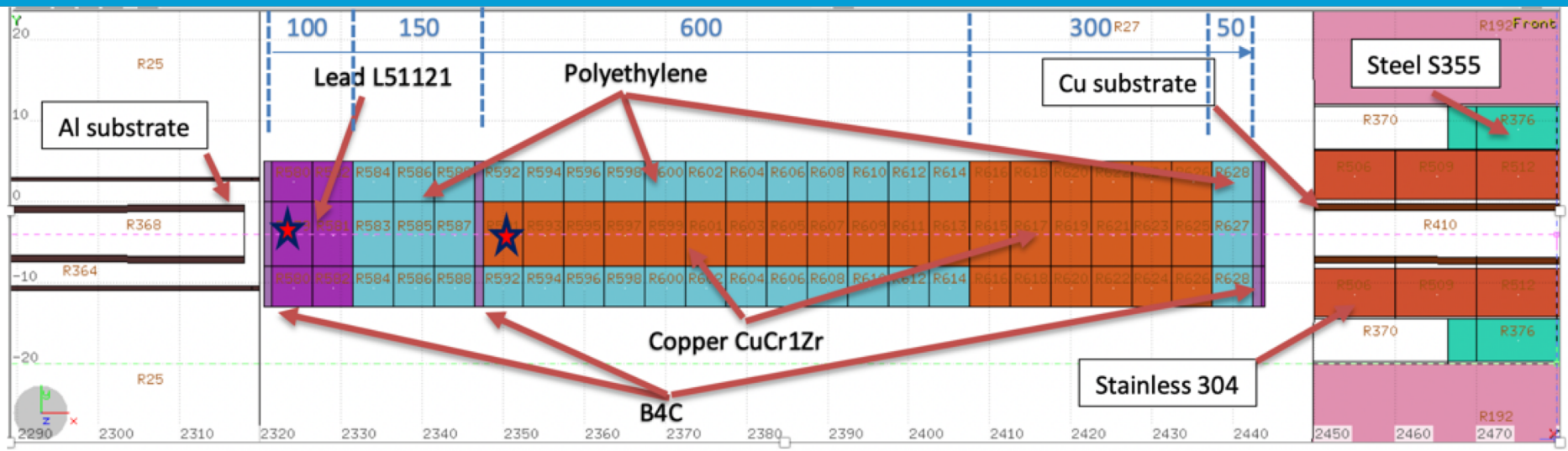


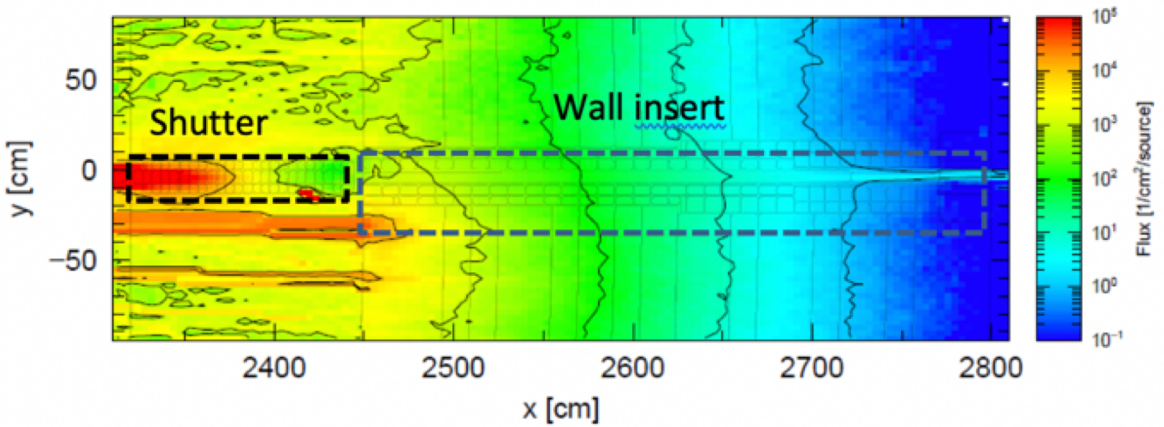
Closed position





Heavy Shutter





Heimdal Cave
Project Timeline

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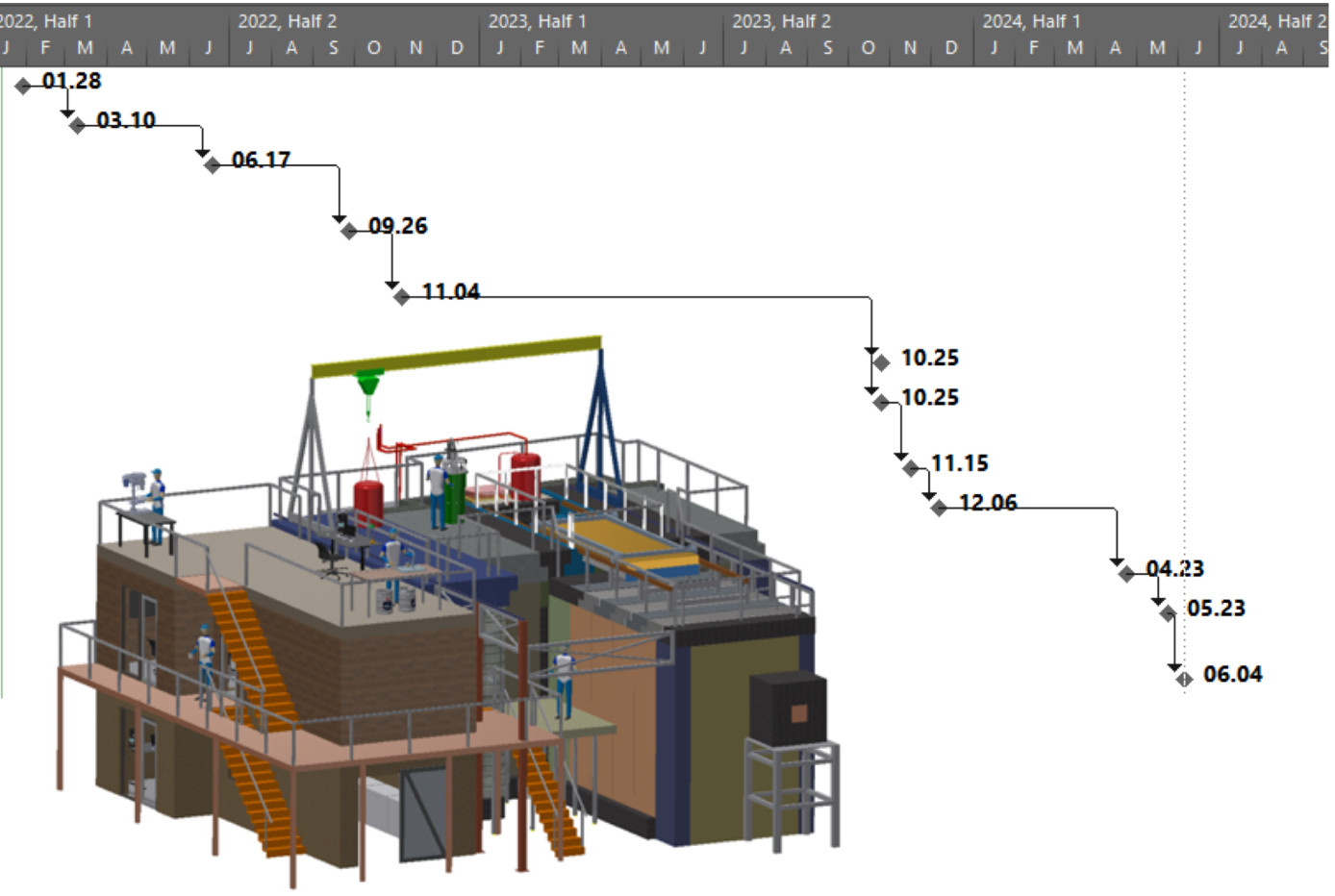
Task Name	Start	Finish
Signed Agreement	Fri 22.01.28	Fri 22.01.28
Kick-Off Meeting	Thu 22.03.10	Thu 22.03.10
PDR - Preliminary Design Review	Fri 22.06.17	Fri 22.06.17
CDR - Detailed design to AU	Mon 22.09.26	Mon 22.09.26
TG3 - Detailed design to ESS	Fri 22.11.04	Fri 22.11.04
MAT	Wed 23.10.25	Wed 23.10.25
FAT - Factory Acceptance Test	Wed 23.10.25	Wed 23.10.25
RFD - Ready For Delivery	Wed 23.11.15	Wed 23.11.15
IGC - Incoming Goods Check	Wed 23.12.06	Wed 23.12.06
INST - Installation	Tue 24.04.23	Tue 24.04.23
SAT - Site Acceptance Test	Thu 24.05.23	Thu 24.05.23
COM - Project complete	Tue 24.06.04	Tue 24.06.04



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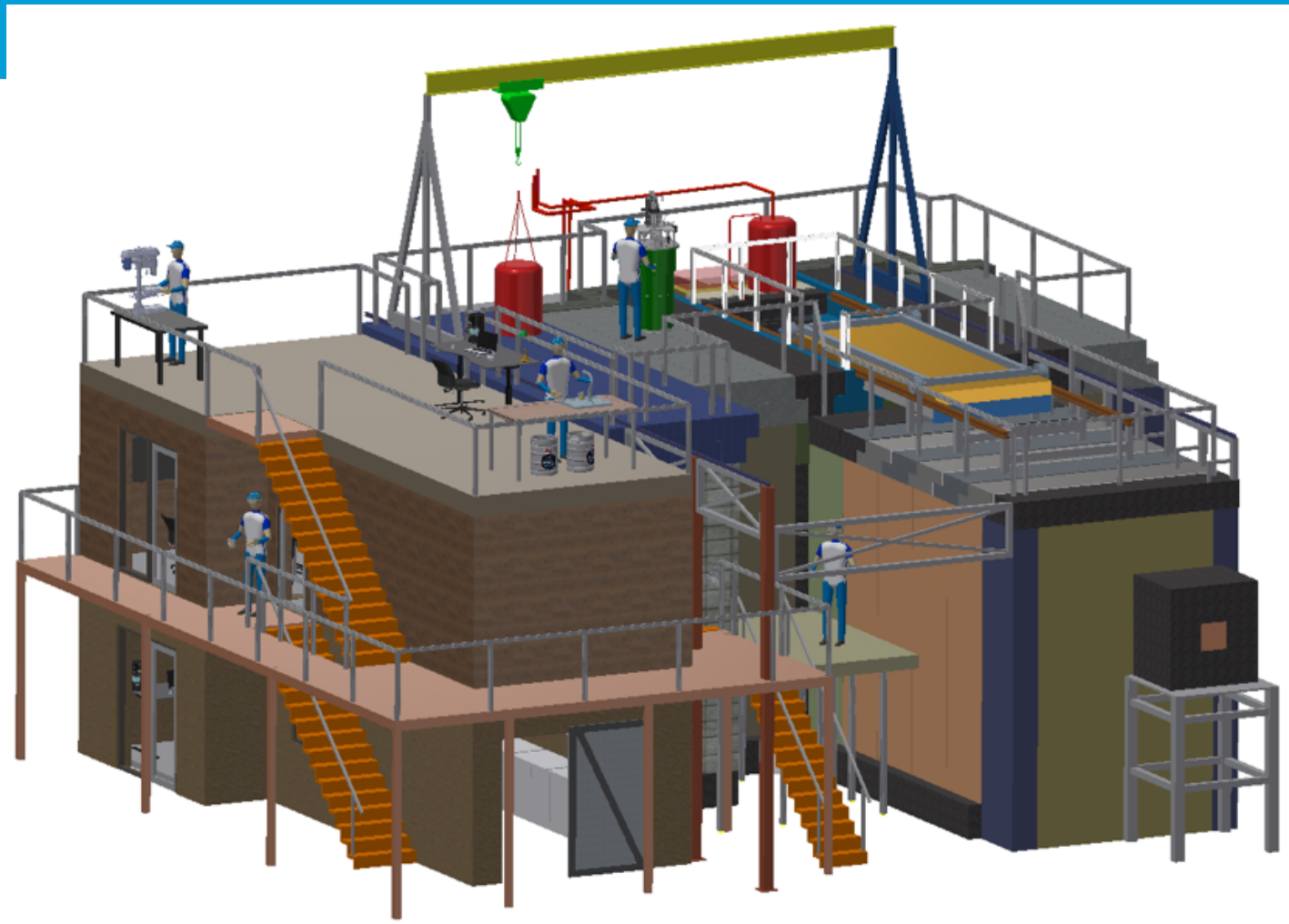
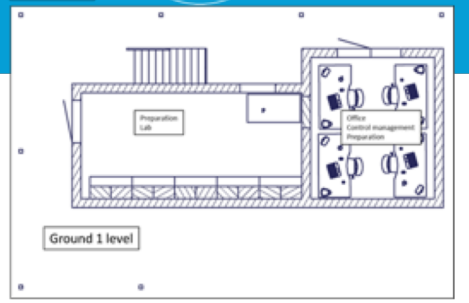
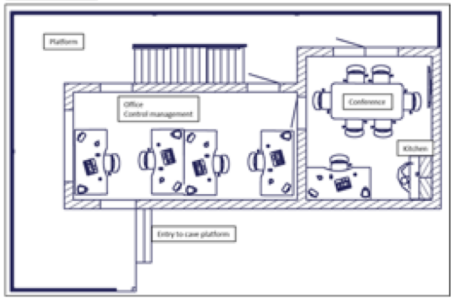


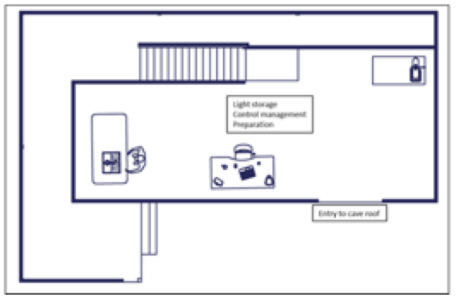
Ground level



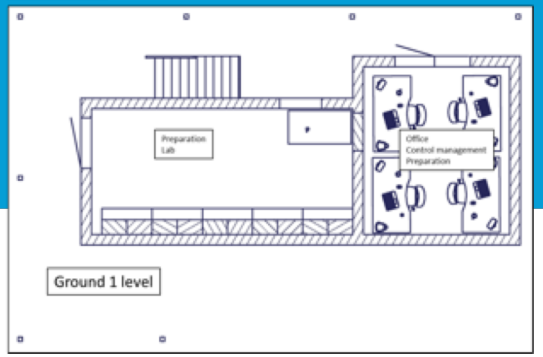
Platform level

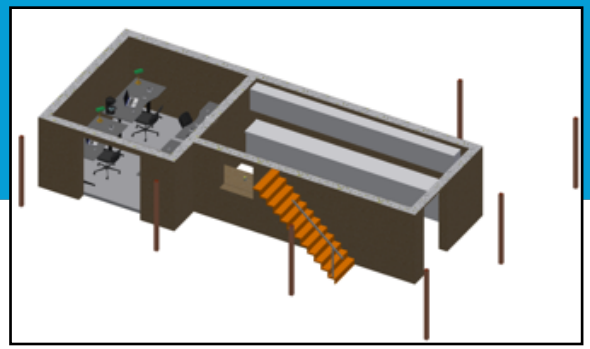


Roof level



Ground level





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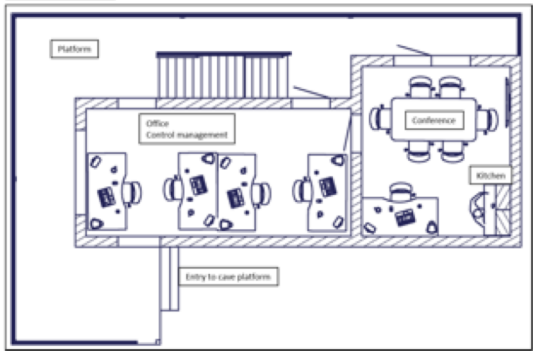
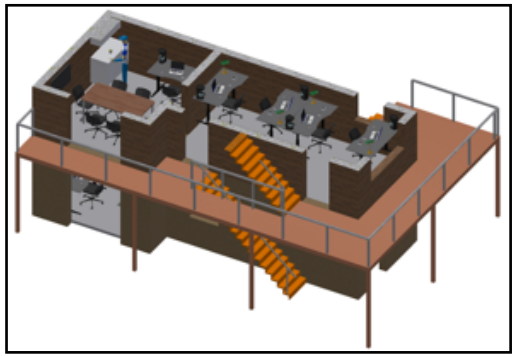
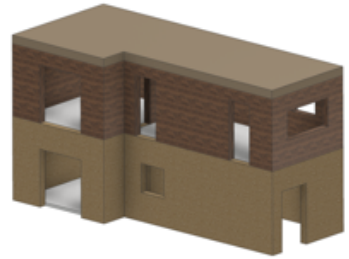
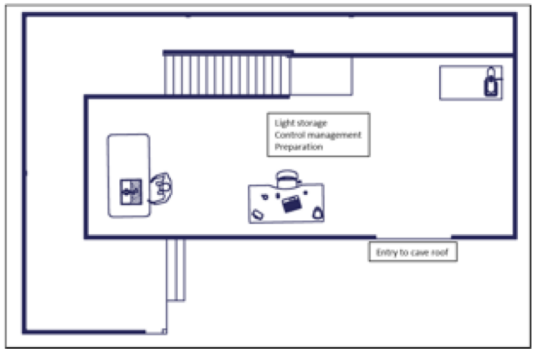
Platform level

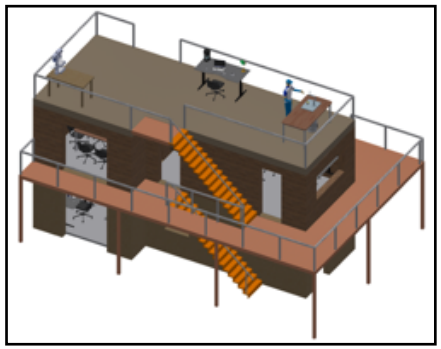


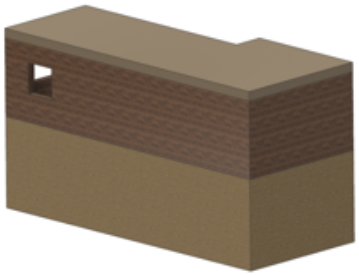


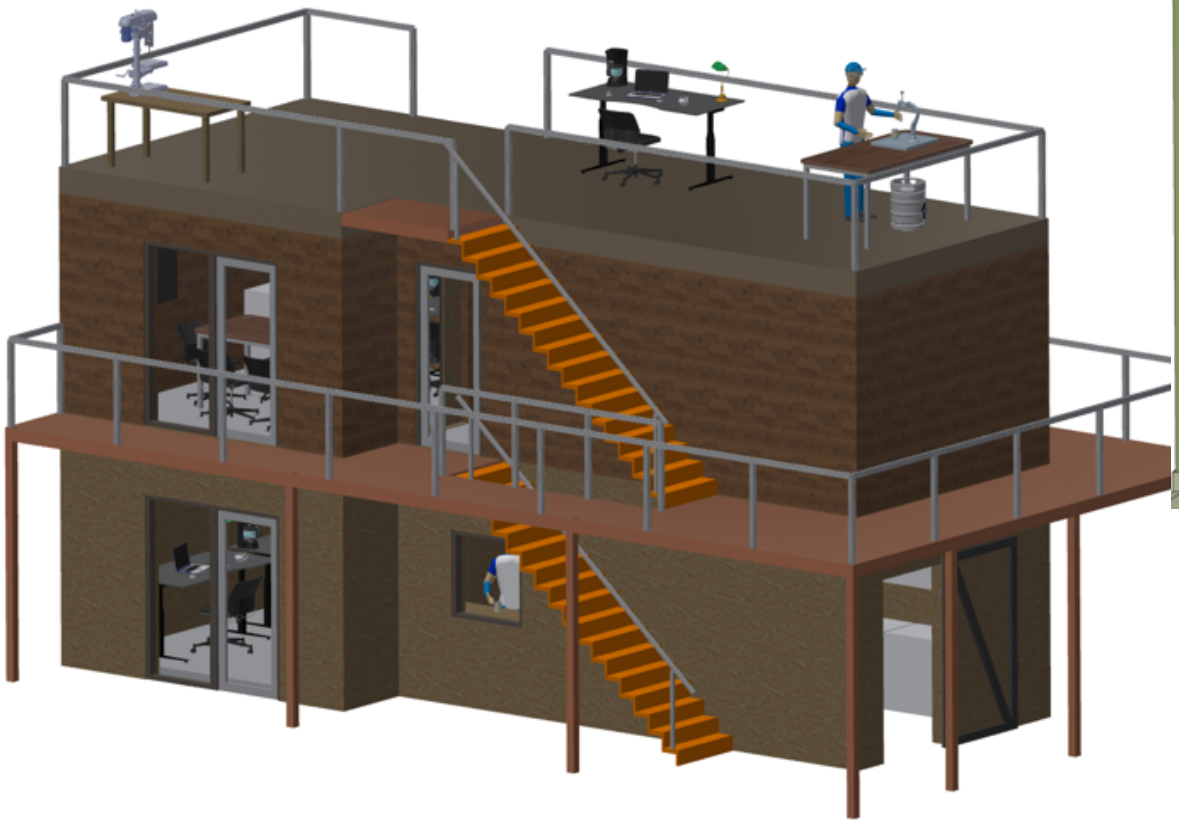


Roof level

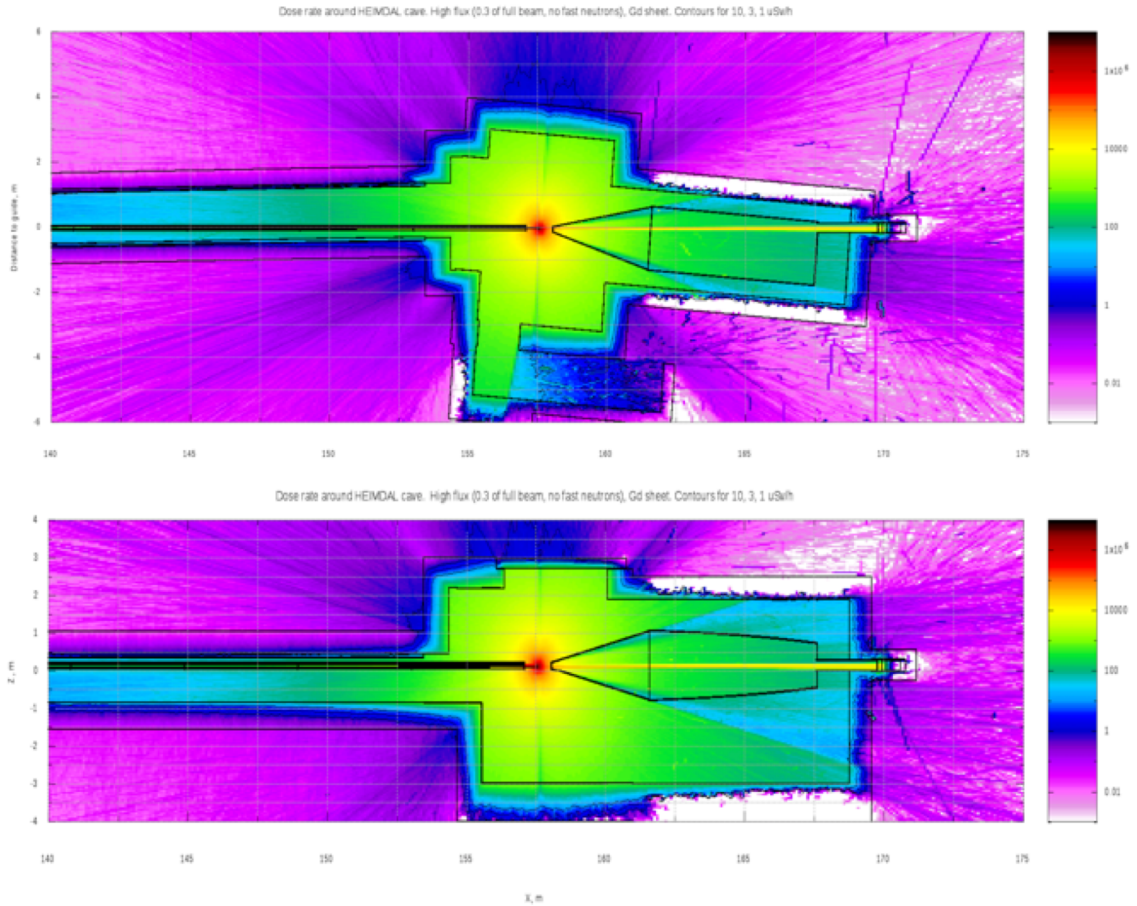








Cave Shielding Calculations

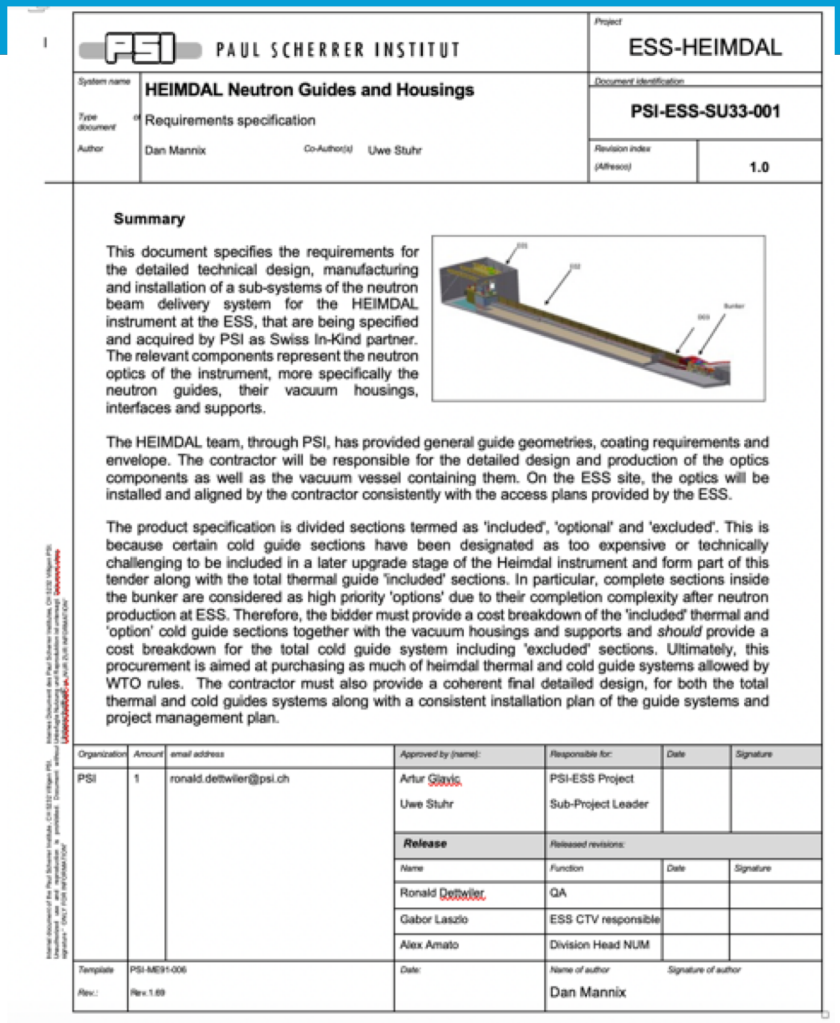


Neutronics Calculations – Optimising costs

90cm concrete walls (Diffraction).
40cm concrete walls (SANS)
70cm concrete roof (Diffraction)
30cm Concrete roof (SANS)
Beam stop Steel Bar inside heavy concrete

H1H2 Scenarios approved (Feb. 2020)

Heimdal Guide Procurement (PSI)



PAUL SCHERRER INSTITUT

Project: ESS-HEIMDAL

System name: HEIMDAL Neutron Guides and Housings

Type of document: Requirements specification

Author: Dan Mannix Co-Author(s): Uwe Stuhr

Document identification: PSI-ESS-SU33-001

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Summary

This document specifies the requirements for the detailed technical design, manufacturing and installation of a sub-systems of the neutron beam delivery system for the HEIMDAL instrument at the ESS, that are being specified and acquired by PSI as Swiss In-Kind partner. The relevant components represent the neutron optics of the instrument, more specifically the neutron guides, their vacuum housings, interfaces and supports.

The HEIMDAL team, through PSI, has provided general guide geometries, coating requirements and envelope. The contractor will be responsible for the detailed design and production of the optics components as well as the vacuum vessel containing them. On the ESS site, the optics will be installed and aligned by the contractor consistently with the access plans provided by the ESS.

The product specification is divided sections termed as 'included', 'optional' and 'excluded'. This is because certain cold guide sections have been designated as too expensive or technically challenging to be included in a later upgrade stage of the Heimdal instrument and form part of this tender along with the total thermal guide 'included' sections. In particular, complete sections inside the bunker are considered as high priority 'options' due to their completion complexity after neutron production at ESS. Therefore, the bidder must provide a cost breakdown of the 'included' thermal and 'option' cold guide sections together with the vacuum housings and supports and *should* provide a cost breakdown for the total cold guide system including 'excluded' sections. Ultimately, this procurement is aimed at purchasing as much of heimdal thermal and cold guide systems allowed by WTO rules. The contractor must also provide a coherent final detailed design, for both the total thermal and cold guides systems along with a consistent installation plan of the guide systems and project management plan.

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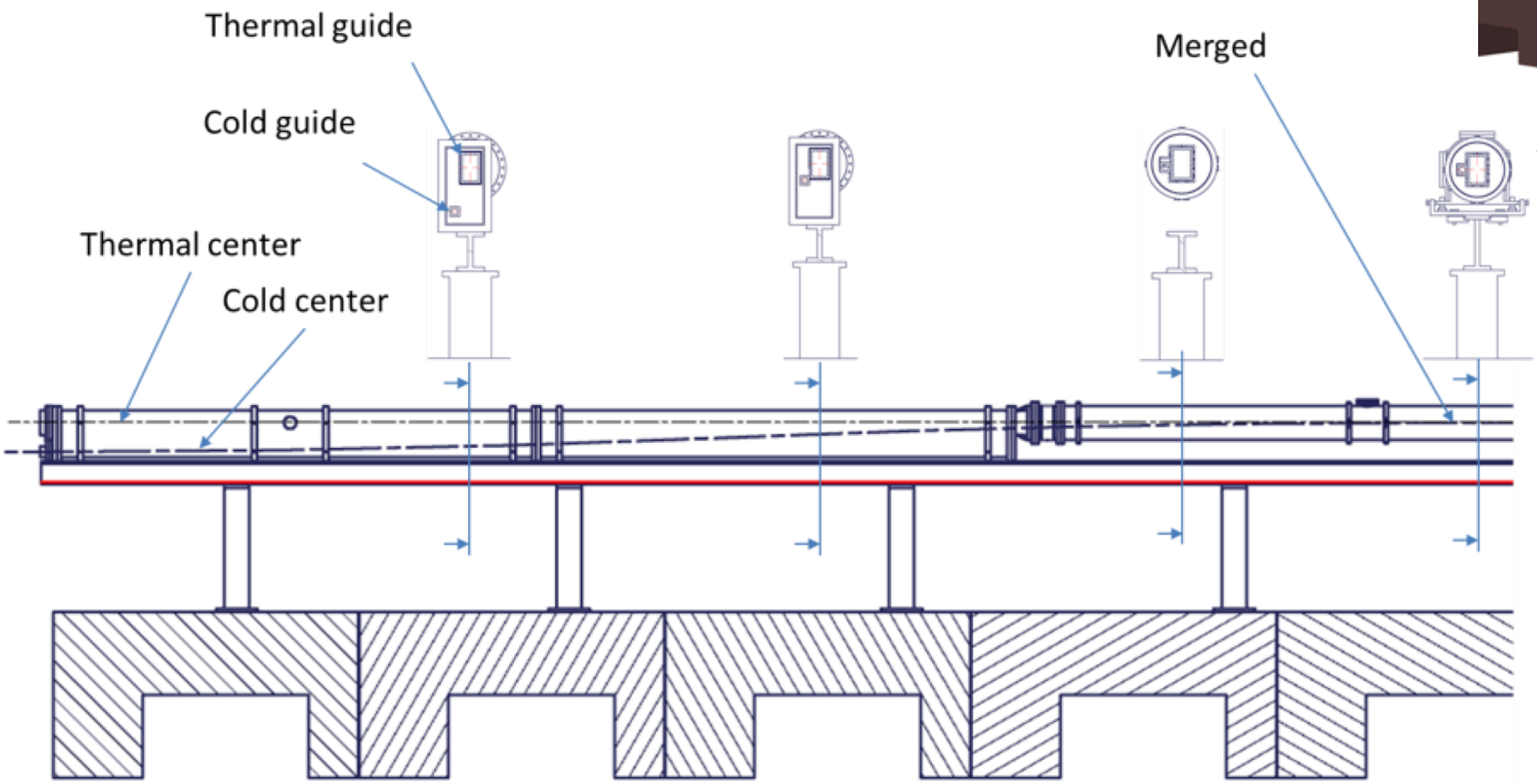
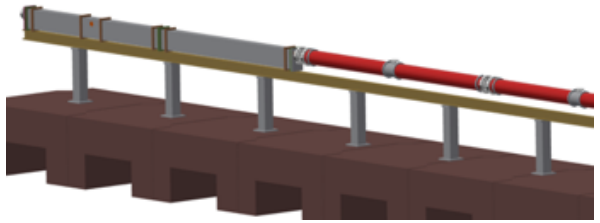
Template	PSI-ME91-006	Date:	Name of author	Signature of author
Rev.:	Rev.1.69		Dan Mannix	

Current priority for Heimdal
Tender Publication May 2022.

Thanks to PSI, Procurement Department
Uwe Stuhr & Artur Glavic

D03 Heimdal Merge of Guides





~80M Merged
Thermal & Cold guide in
long straight section.

Heimdal Guide (PSI)

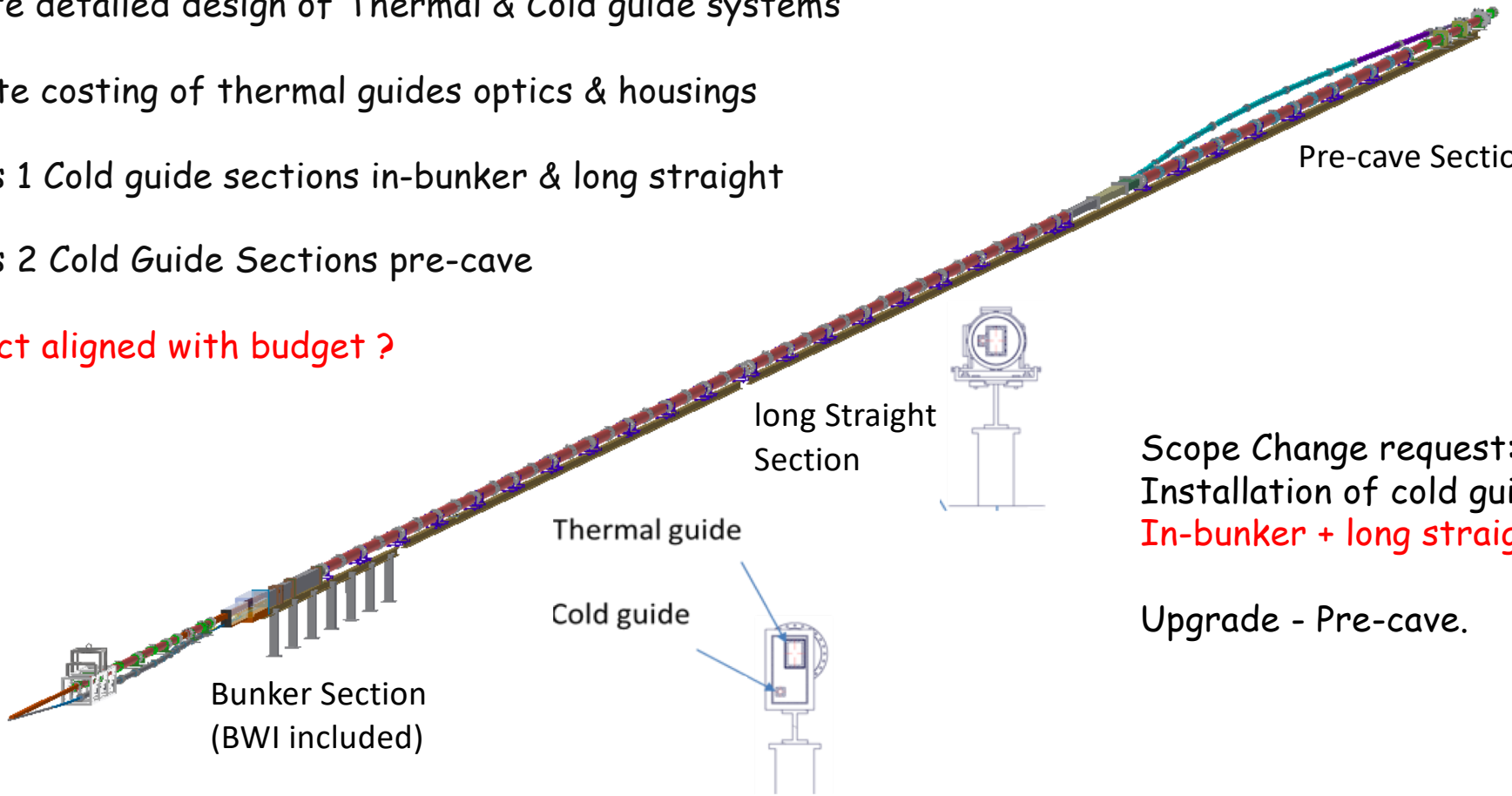
(1) Complete detailed design of Thermal & Cold guide systems

(2) Complete costing of thermal guides optics & housings

(3) Options 1 Cold guide sections in-bunker & long straight

(4) Options 2 Cold Guide Sections pre-cave

Final project aligned with budget ?

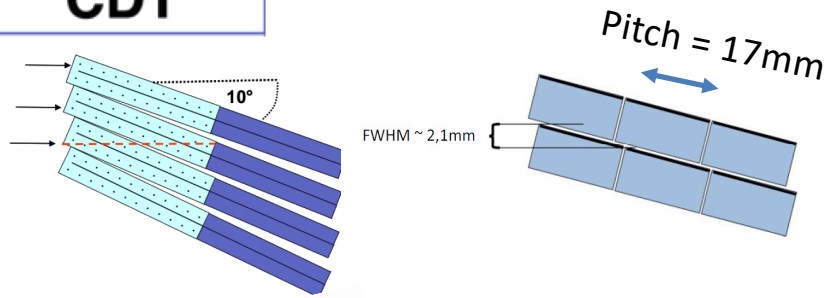


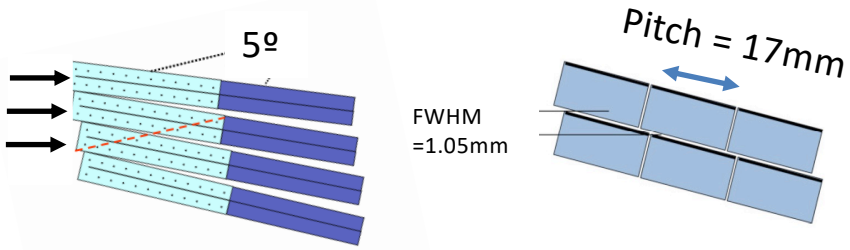
Scope Change request:
Installation of cold guide
In-bunker + long straight

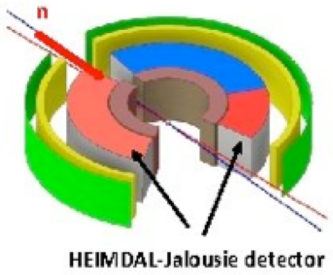
Upgrade - Pre-cave.

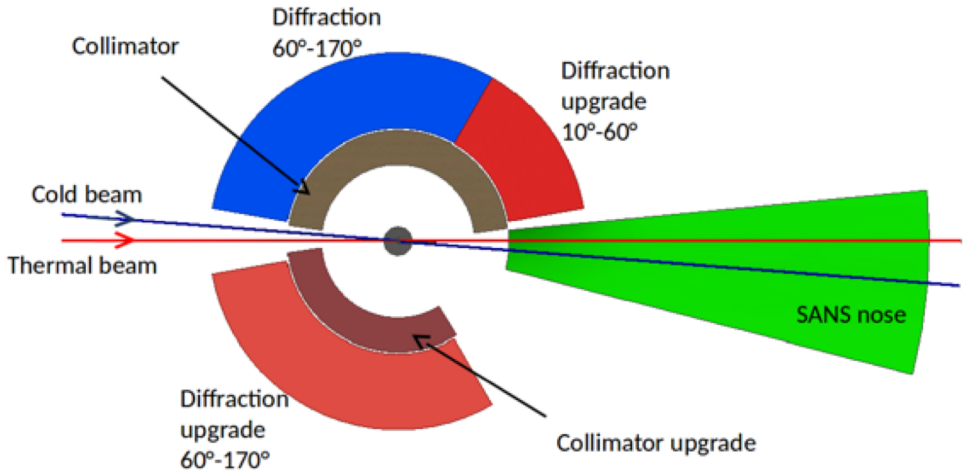
Heimdal Detector System

^{10}B Based Jalousie Detector









Technical Specification May 2022

ESS Dream -> Magic -> Heimdal

Procurement to start May 2022 After Guides with PSI

PSI -> Hopefully not full open tender (only one supplier)

Heimdal General Sample Environment

EUROPEAN SPALLATION SOURCE

Cooling

Orange Cryo
1.5K-300K

Dilution
~10s mK

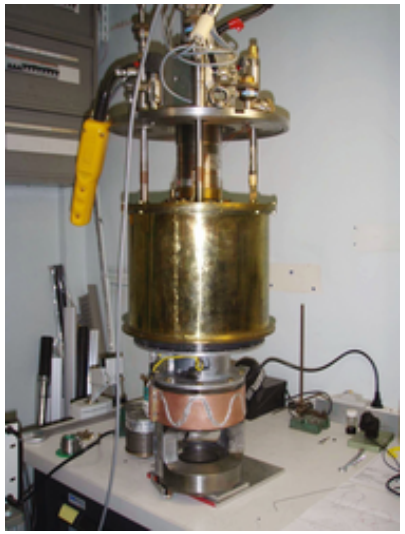
Heating

cryofurnace
1.5K-600K (800K)

Magnetic Field

Cryo-magnetic
8-Telsa

Pressure ? What ?

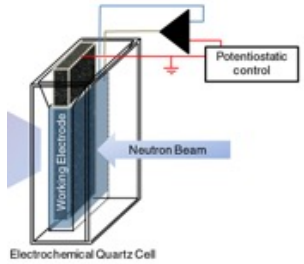


Pari[illegible] Edinbu[illegible]
Diam[illegible] A[illegible] + Heat
Stress/S[illegible] Cell

Dis[illegible]ssion – M[illegible]colm
SAD Group

Electro-chemistry

Diffraction



SANS

Heimdal Fast Sample Environments
High Throughput Neutron Scattering

EUROPEAN SPALLATION SOURCE

Open Flow Cooling

Oxford Cryosystems:
N_2 cryo system
80-500 K

Cryo Industries America:
Cryocool-LHe : 10-600 K
Consumption: 2L/hour 10 K
Cold zone: 10 mm
Cool down time: 10 min

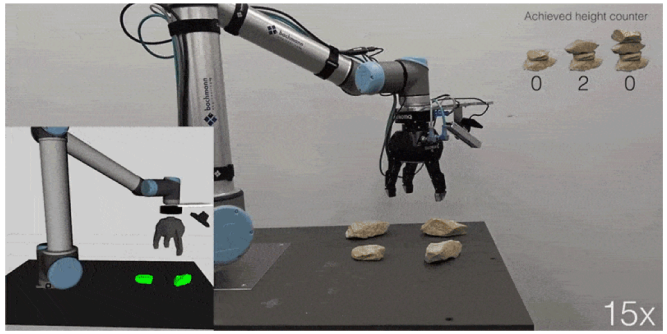
Induction Heating

- Electromagnetic radiation
- Fast heating
- High temperature >1370 °C

Hot Air Blower

1000 W system
40 L/m dry air
- RT - 1000 K in 100s
- combined with
- flow system
- active cooling by dry air
- => fast sample change

+ Robot sample changer



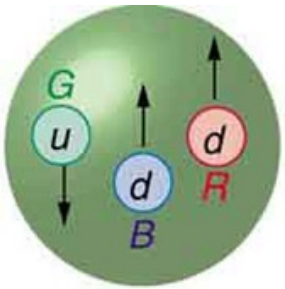
Nordforsk proposal 2020
Heimdal/Dream compatible sample environment
- Fast Heating
+ ~~Post Doc Started @ AU:~~
~~**Jakob Voldum Ahlburg**~~

HEIMDAL Polarised Neutrons

ESS Polarised Neutron Workshop

Design for Polarised Neutrons on Heimdal
Cold guide supermirror
Thermal Guide ^{3}He Cell

Keep open possibility for future

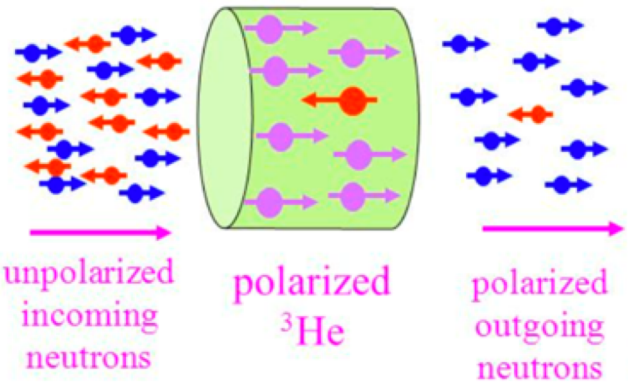


Neutron

Total Spin: $-\frac{1}{2}+\frac{1}{2}+\frac{1}{2}=\frac{1}{2}$

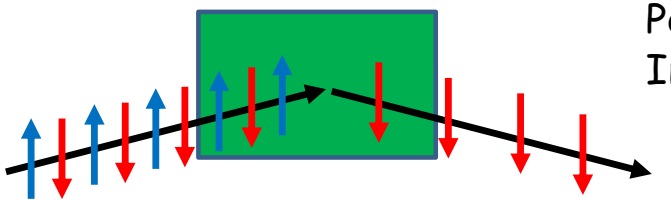
Total Charge: $+\frac{2}{3}-\frac{1}{3}-\frac{1}{3}=0$

^{3}He Cell



Polarised Thermal Neutrons
incident + analysis

Neutron Supermirror



Polarised Cold Neutrons
Incident + Analysis

Heimdal Continues to Make Progress