Heimdal Instrument @ ESS
STAP October 2020

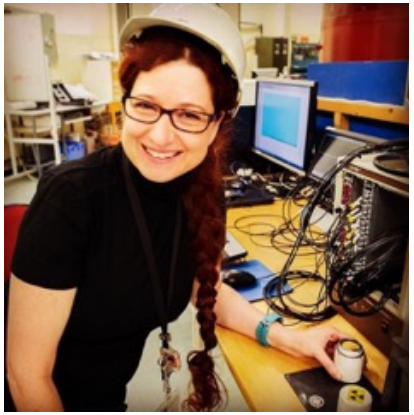
Dan Mannix

Lead Scientist Heimdal Instrument ESS, Lund Sweden

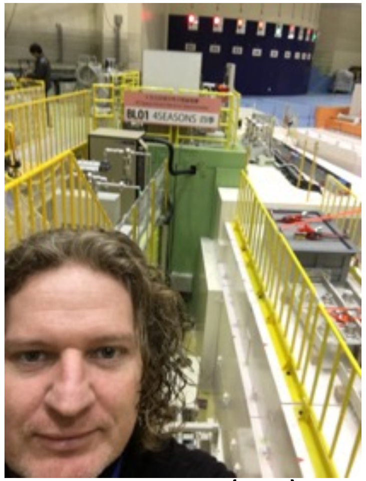
ESS 2020 – October 2020

The Heimdal Team

EUROPEAN SPALLATION SOURCE



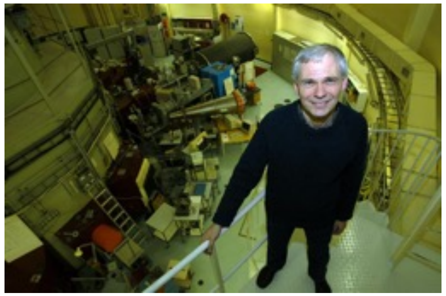
Isabel Llamas (IFE)
choppers



Dan Mannix (AU)
Lead Scientist

Kåre Iversen (AU)
Lead Engineer

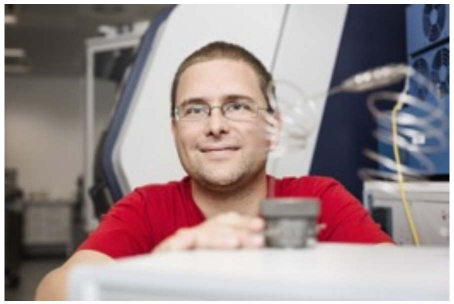
Rodion Kolevatov (IFE)
Neutronics



Bjørn Hauback
Lead in-kind partner IFE

35%

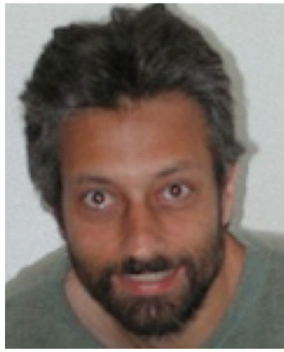
IFE Institute for Energy Technology



Mogens Christensen (PI)
Lead in-kind partner AU

30%

AARHUS UNIVERSITY



Uwe Stuhr
Lead in-kind partner PSI

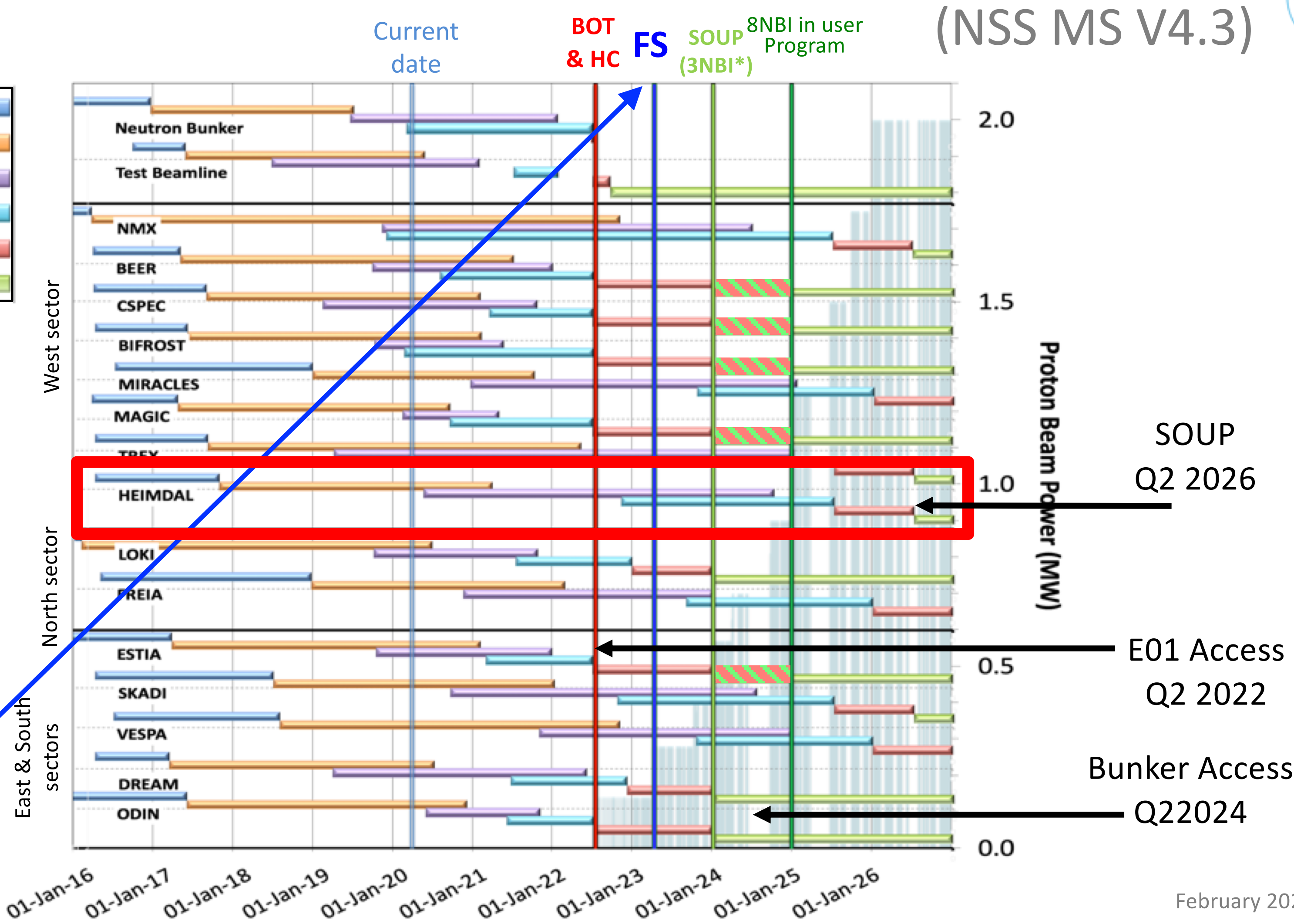
35%

PAUL SCHERRER INSTITUT
PSI

Baseline schedule for Neutron Beam Instruments

(NSS MS V4.3)

Preliminary Design
Detailed Design
Manufacturing & Procurement
Installation & Integration
Hot Commission/Early science
Operation



- **First 3 NBI selected for SOUP: DREAM, LOKI & ODIN** (best chance for early impact, as agreed by NSS, SAC and ESS Council)
- **Back-up instruments:** (for risk of late access to D01 & D03) BEER, CSPEC, MAGIC or BIFROST, ESTIA

March 2023:

- ***First Science (FS)*** *with expert teams on some of instruments above*
- *Review progress of first 3 NBI* for SOUP, implement backup plan if needed.*

* NBI = Neutron Beam Instrument

Project Progress

EUROPEAN SPALLATION SOURCE

Component	Procurement	Design Specification	CTV	KO	TG3	SAT	proposed Installation
NBOA	PSI	X	X	X	Q12021	Q1 2021	Q1 2021
Light Shutter	ESS /AU	X			Mar 2021		Q2 2024
Heavy Shutter	AU	X			Mar 2021		Q2 2024
BWI	AU	X	05/20				Q2 2024
Choppers	ESS / IFE	X	05/19	Oct 2020	tbd		Q2 2024
T0 Chopper	ESS / IFE	X	05/19		tbd		Q2 2024
Thermal Guide	PSI	X	03/19	Delayed Q1 2021			Q2 2023
Slits / Collimator	AU	X	05/20		05/20		Q2 2021 @ Aarhus
Sample X,Y,Z ω	AU	X	05/20		05/20		Q2 2021 @ Aarhus
2D Detector	PSI / CDT	X	05/20	Delayed Q1 2021		Q2 2023	Q2 2024
Detector Collimator	AU	X	05/20		Mar 2021		Q3 2021 @Aarhus
Detector Support	AU	X	05/20		05/20		Q2 2021
Monitors	PSI				Final TG3		Q3 2024
Cave / Beamstop	IFE	X	05/20	12/20	Mar 2021		Q2 2022

Change Request Status

ESS – Required real costing of large equipment and infrastructure to continue

(1) Guide Shielding Costed (ESS Comon) - OK
(2) Chopper Systems all costed (ESS Common) – OK
(3) Cave CTV ready for publication – with ESS
(4) 2D detector (Delayed from PSI) Now moving forward – Q1 2021
(5) Guide optics and vacuum housing – ((Delayed from PSI) Now moving forward – Q1 2021)

If we are within budget we will submit change request Q1 2021.

NBOA Status

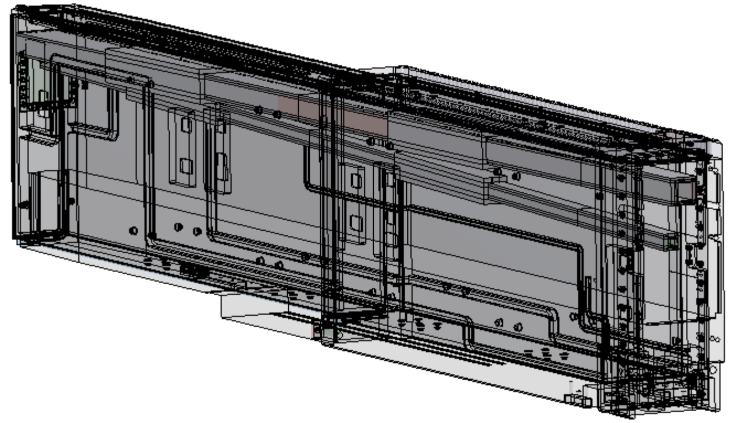
EUROPEAN SPALLATION SOURCE

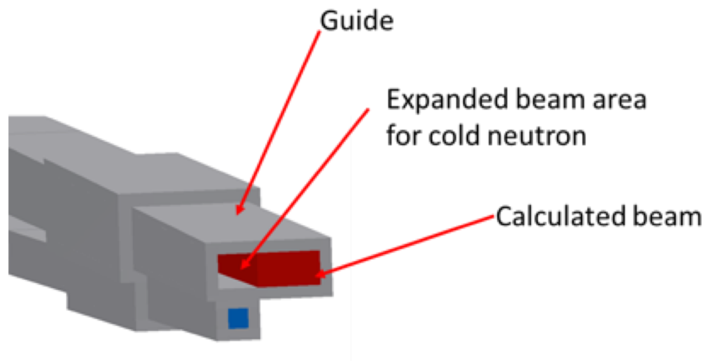
Neutron Optical Components & Instruments SwissNeutronics

SwissNeutronics project data			
Project title	PSI@ESS, HEIMDAL - NBOA neutron guide	Project No.	SN18098
Project manager	Christian Schanzer		
Email	christian.schanzer@swissneutronics.ch		
Customer project data			
Customer	PSI	Customer ref./PO	5200147209
Project manager	Dr. Dan Mannix	Date of contract/PO	--
Email	dan.mannix@esss.se	Amendments	
Report / document data			
Prepard by	Christian Schanzer	Report / Doc. No.	SN18098-002
Date	4-Sep-20	Revision	06
Type	Project management	Status	final

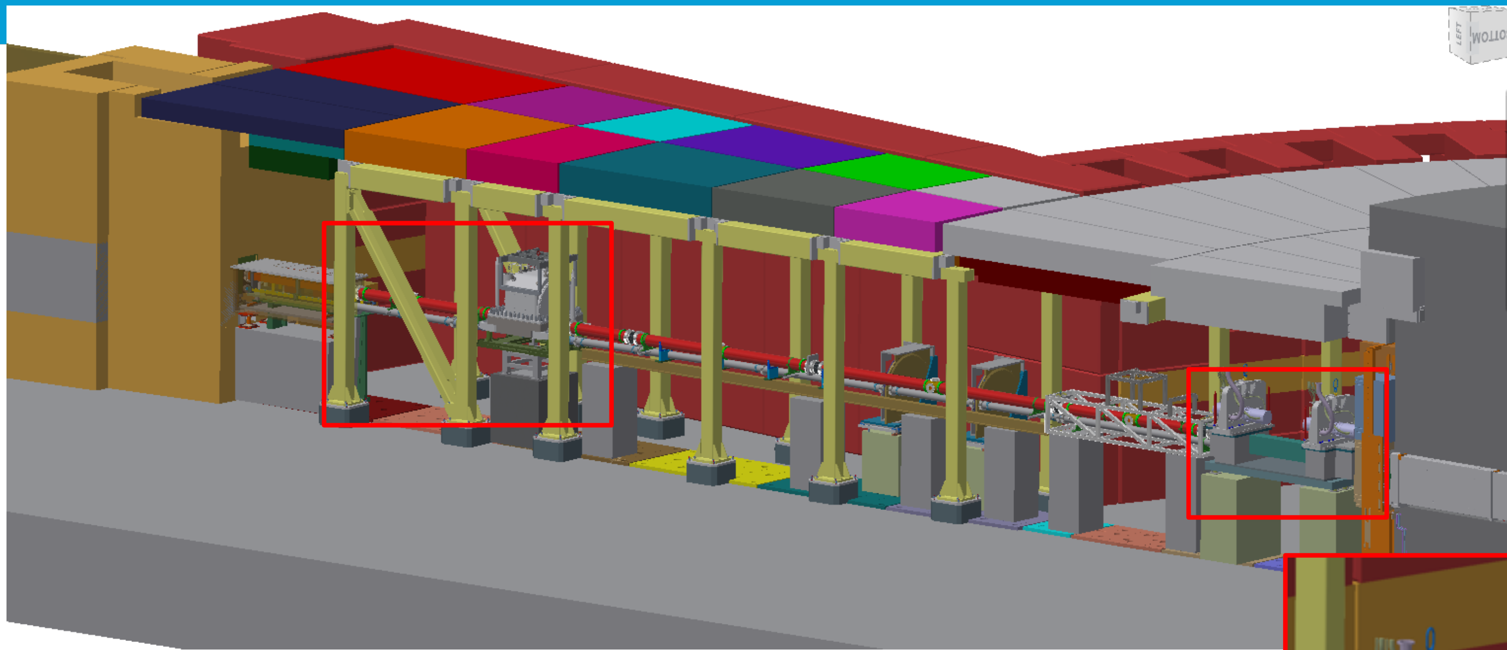
SN18098 Project Report - No. 6

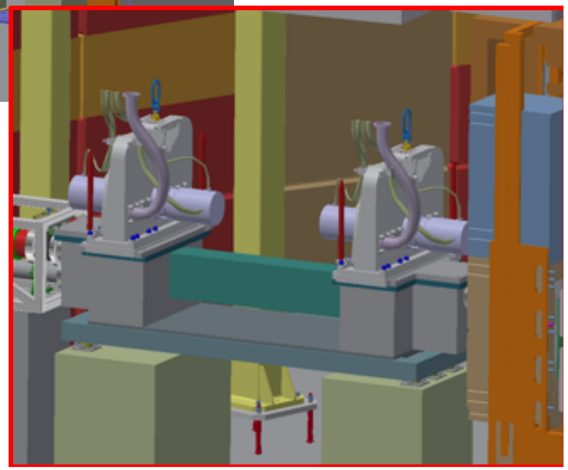
Milestones					
Milestone	Payment	Target date original	Target date updated	Status	Remarks
Final design review	no	31-May-19	tbd.		see status of manufacturability check and open issue No. 1
Ready for manufacturing	yes		tbd.		see status of manufacturability check and open issue No. 1
Ready for delivery	yes	23-Dec-19	expected Apr-2021		assuming a conclusion of the final design by Oct-2020; see also open issue No. 1
Installation	no				
Final acceptance	yes	15-Jan-21			





Choppers System Status

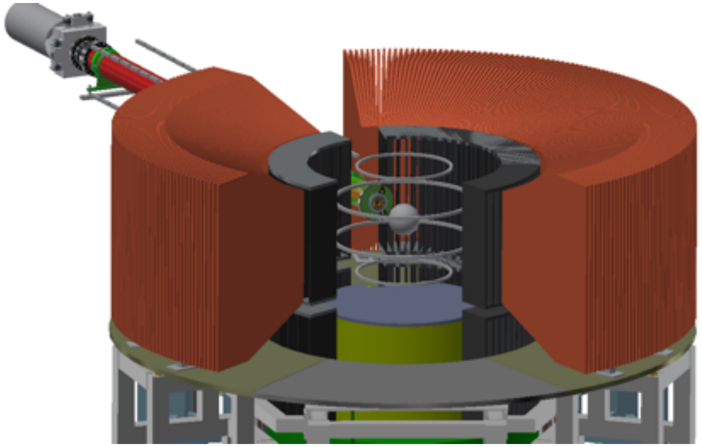


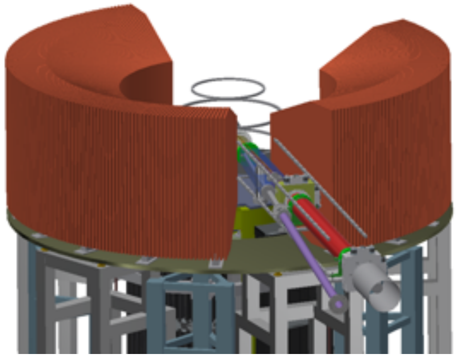


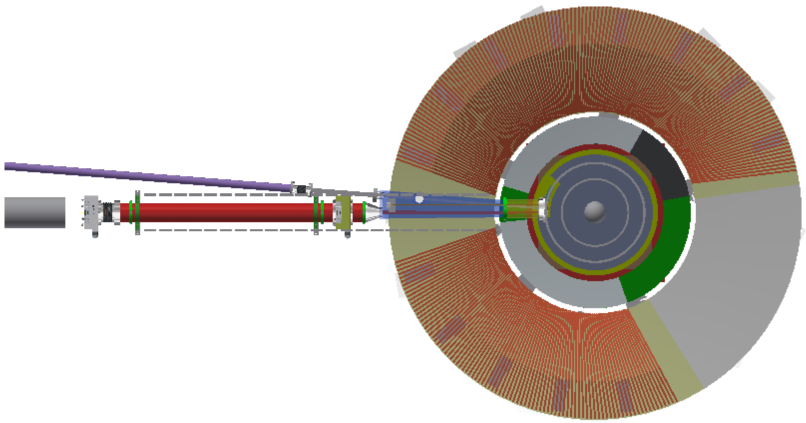
TG3 Chopper Technical Specification approved 21/02/2020
ESS Common Chopper Project
Kick-off scheduled 1st October 2020

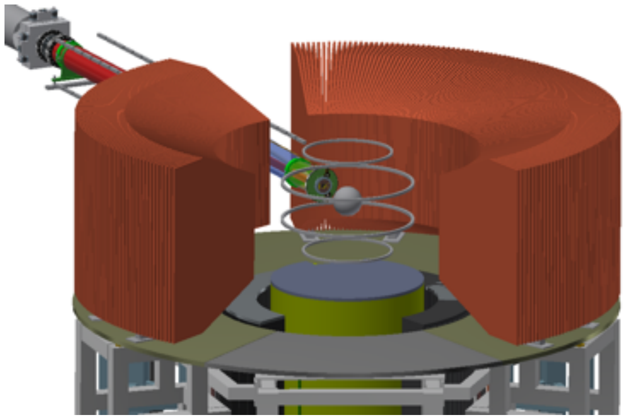
Polarised Neutrons @ Heimdal

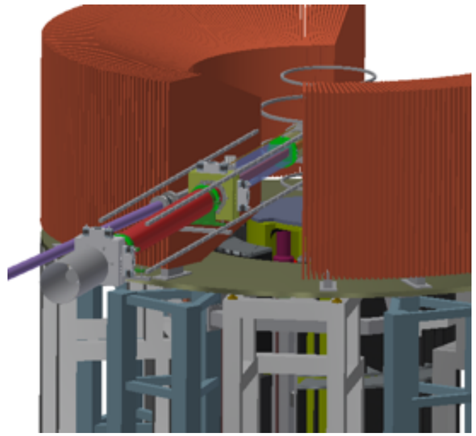
EUROPEAN SPALLATION SOURCE





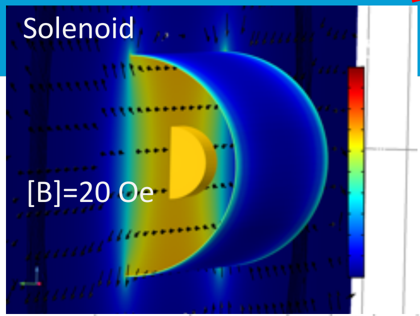


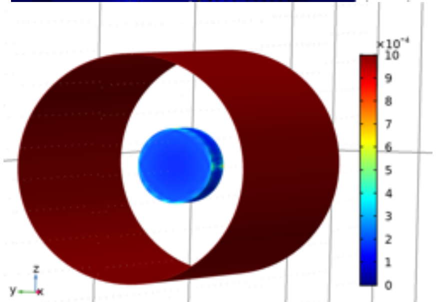




HEIMDAL Polarisation setup

Polariser cell in solenoid
Technique: Polarised ^3He

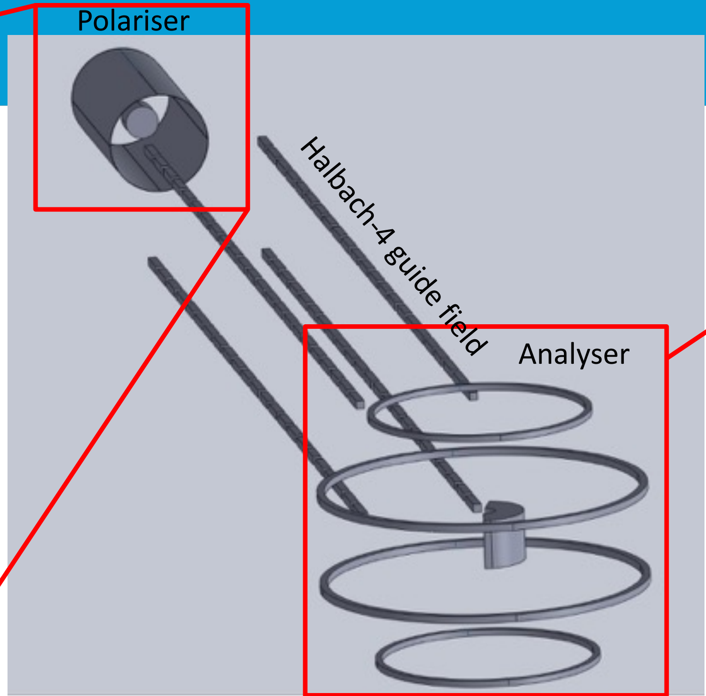




Uniform: gradient < 2E-4/cm

MEOP + local gas exchange
Good: Fast turn-over
Bad: Polarisation decay

SEOP + *in-situ* pumping
Good: Polarisation stable
Bad: 1 day to be ready

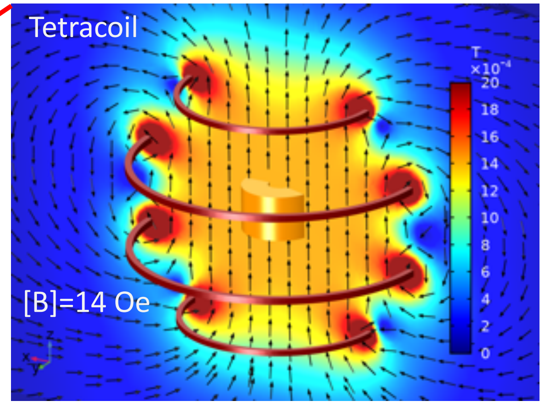


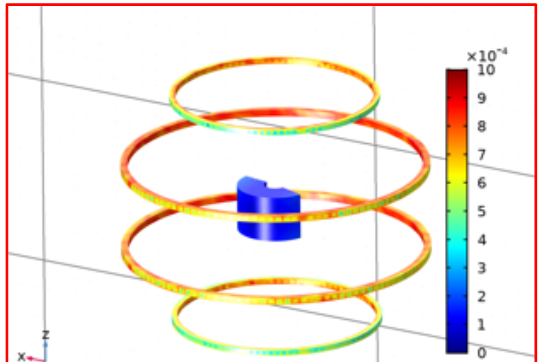
First-cut modelling: a setup will work.

Further development:
- transition region between device.
- Field-turn device
- 3D field

Analyser cell in tetracoil
Technique: Polarised ^3He
MEOP + "Local-filling" to fill cell at HEIMDAL.

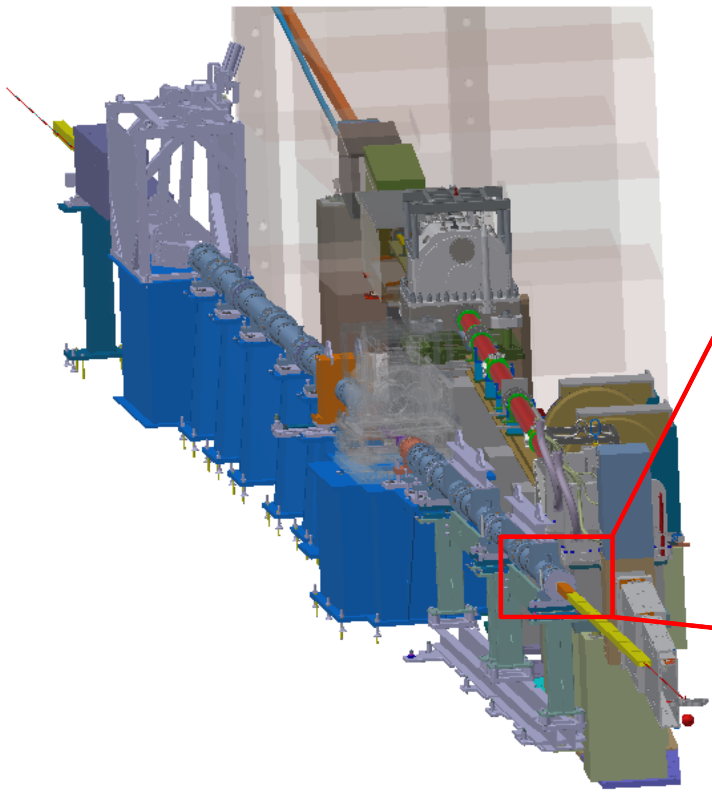
Analyser cell can cover both diffraction and SANS

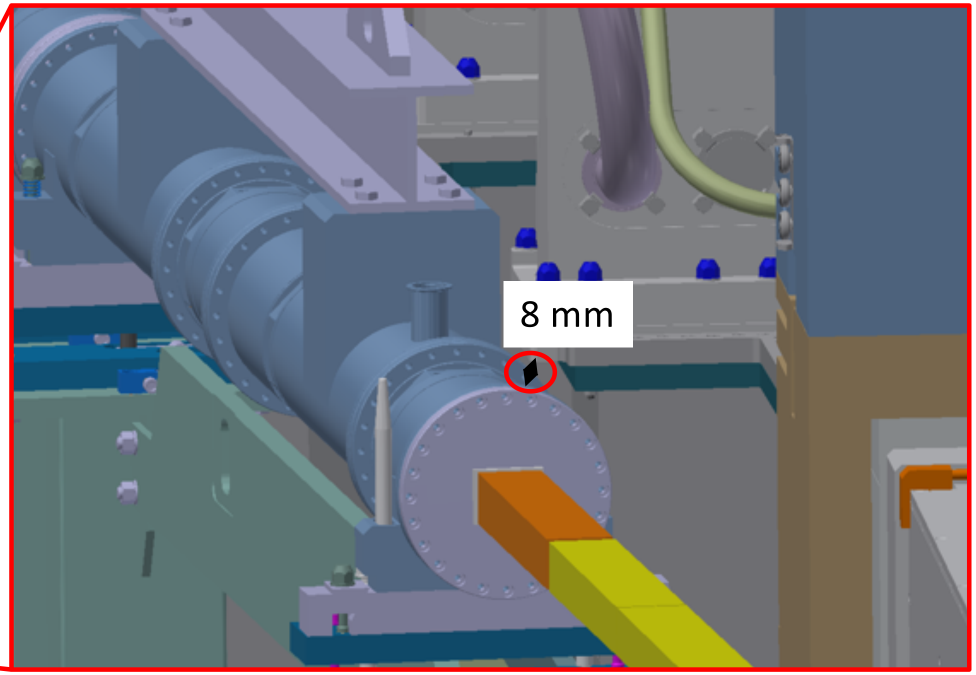




Uniform: gradient < 2E-4/cm

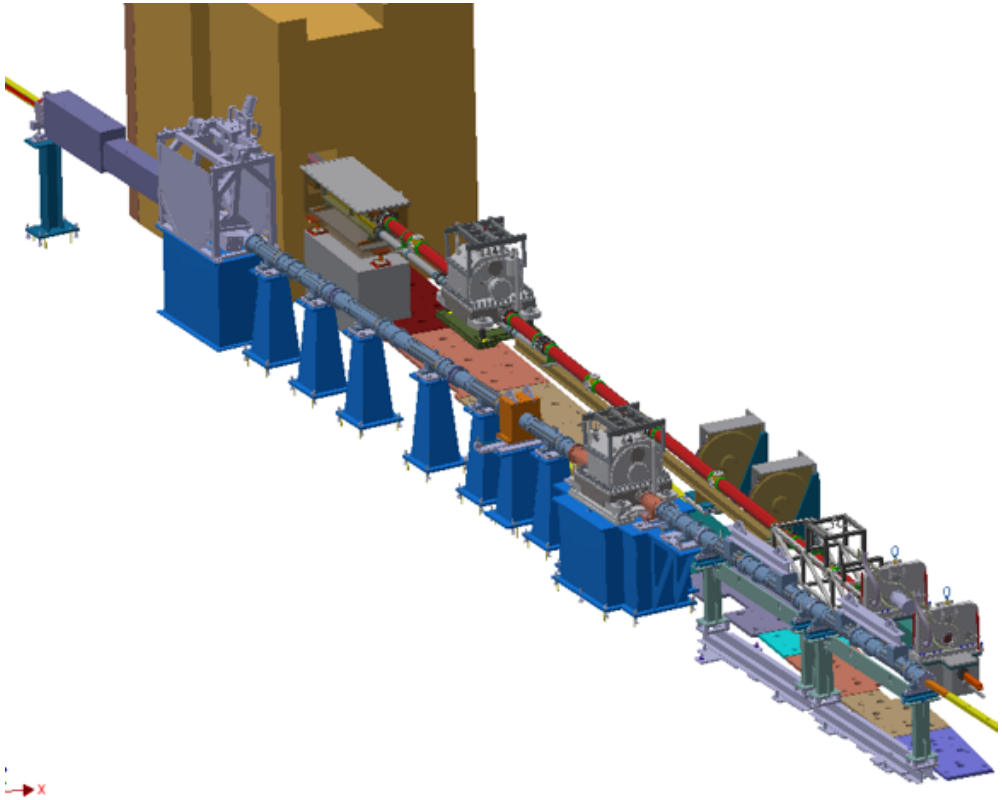
Heimdal – T-rex Clash

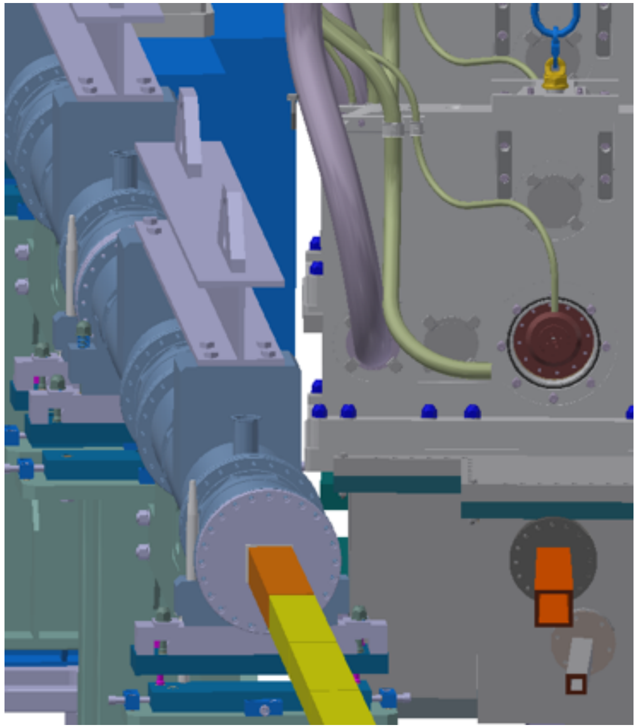




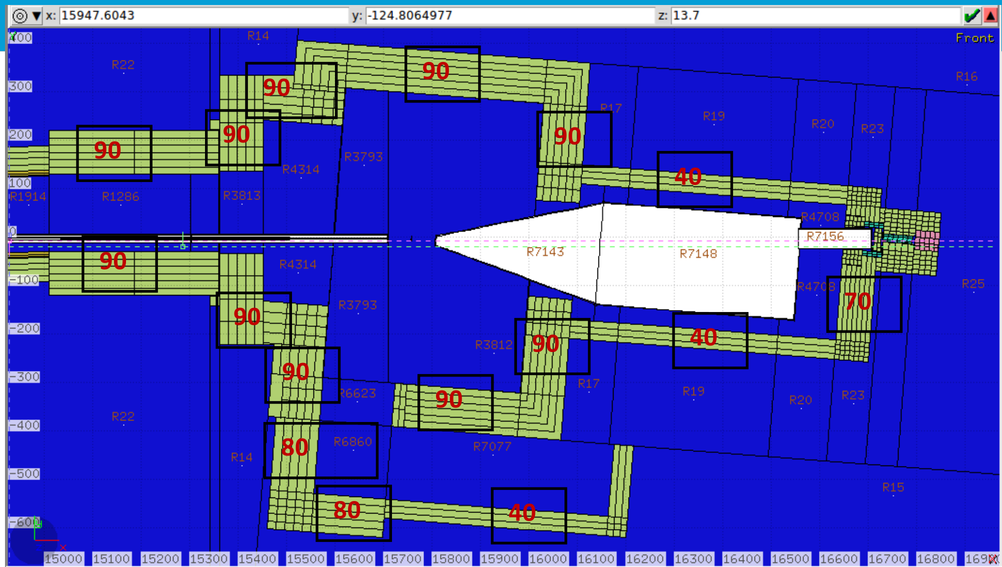
ESS Common Chopper Solution must resolve this issue:
In Discussion

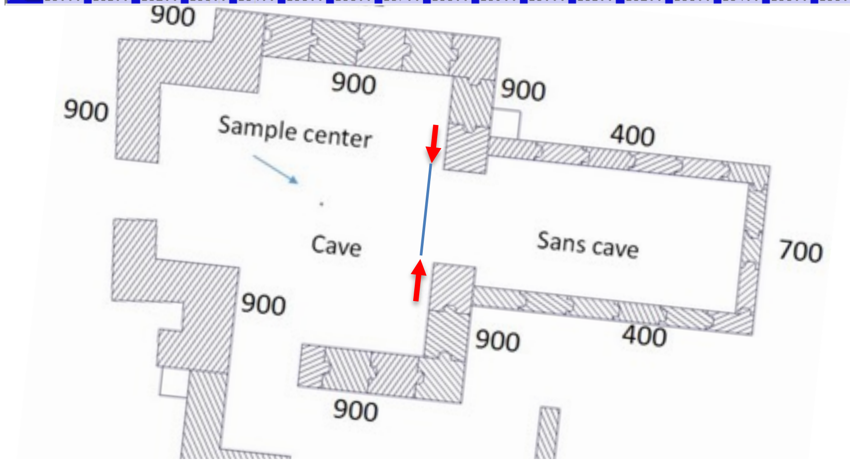
Heimdal – T-rex Clash



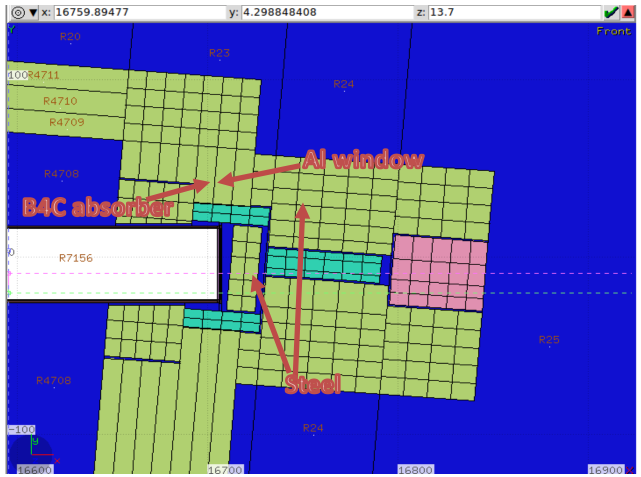


Cave geometry, optimized (Sept 2020)



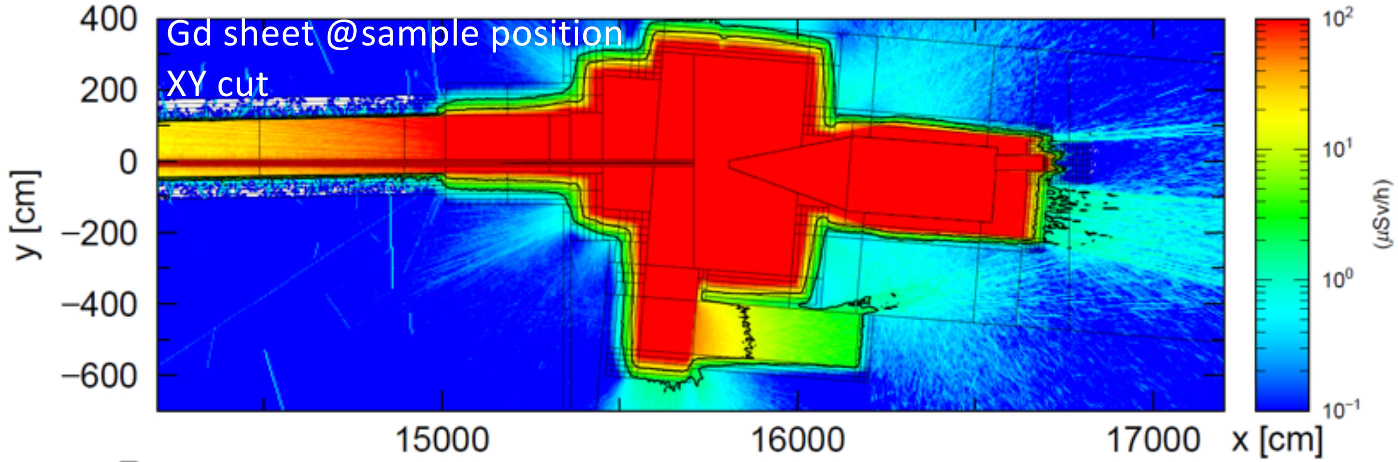


- Reduced length of SANS cave by 2m
  - Had to increase thickness of rear wall to 70cm
- Thermal beamstop moved out of the SANS cave
- Narrowed down connection of diffraction and SANS caves, reduces impact on SANS cave walls
- SANS cave walls thinned down by 20 cm and have a uniform thickness of 40cm.
- Reduced thickness of labyrinth roof

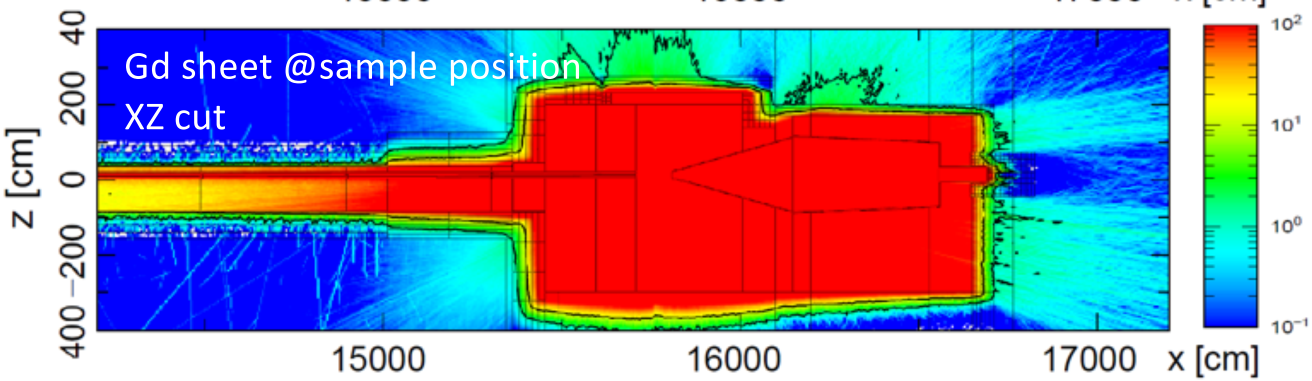


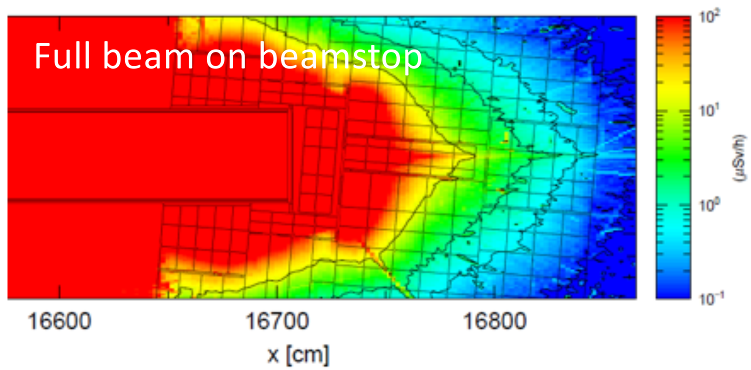
Optimized geometry, performance

Rodion Kolevatov (IFE)

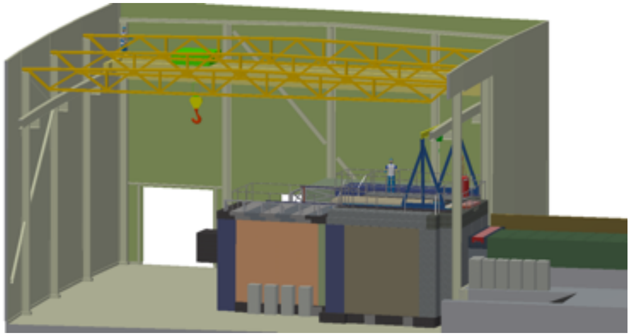


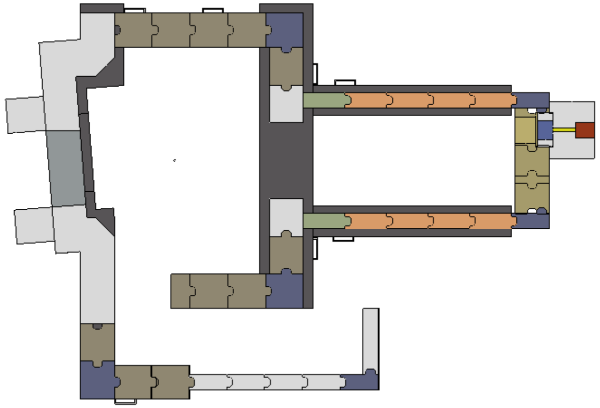
- Reached savings in the amount of concrete compared to initial option
- A tender is to be announced soon

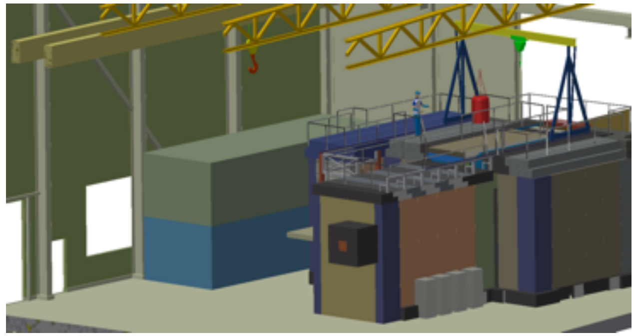


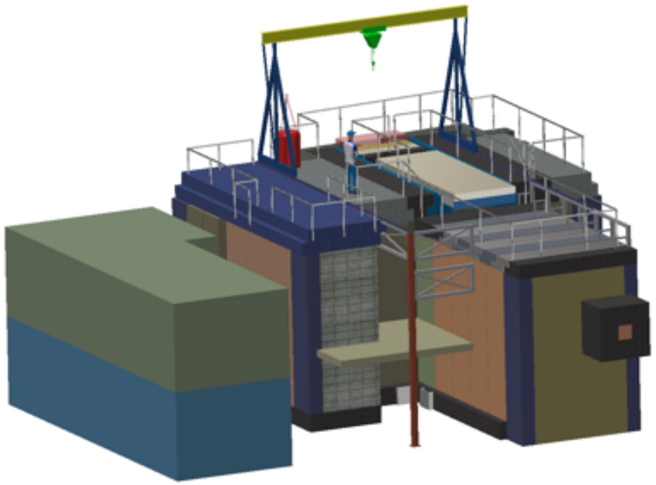


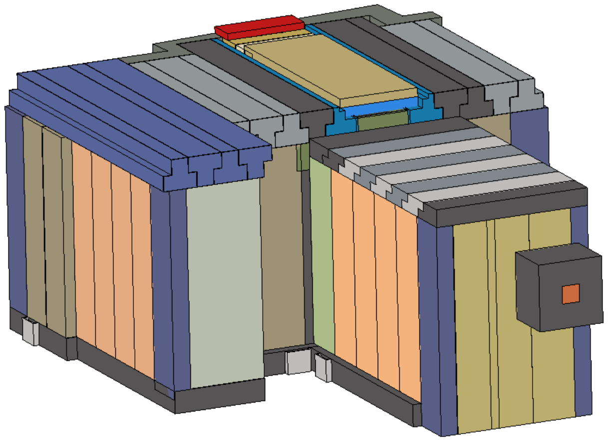
Cave Design CTV Review Complete
Waiting for ESS go-ahead to publish tender

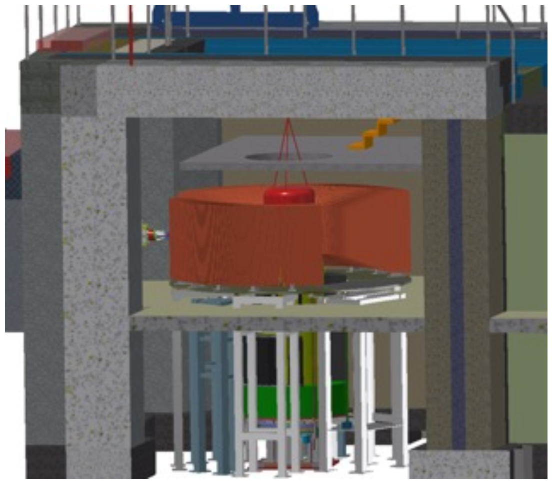


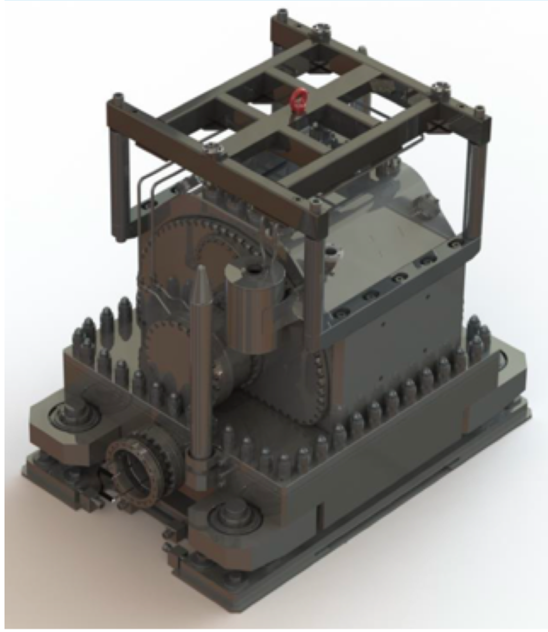




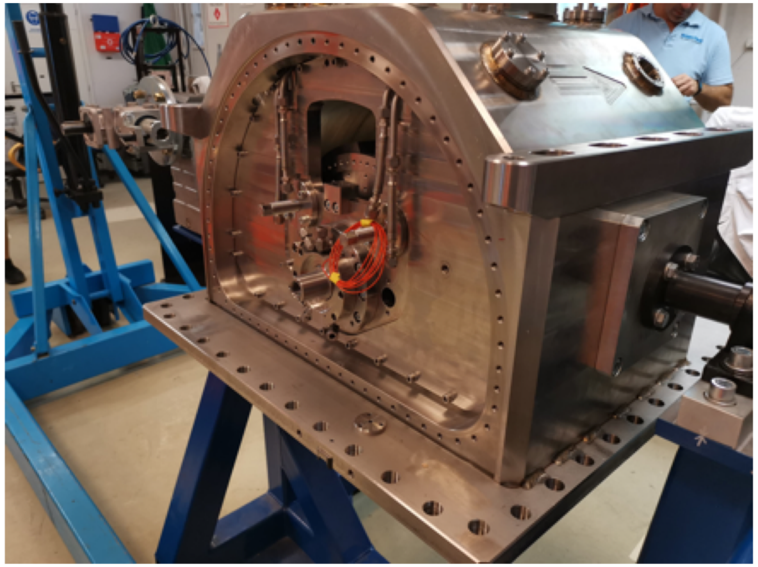


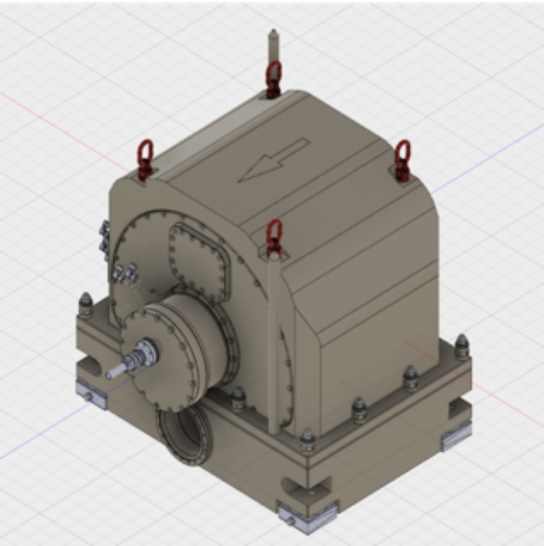






T0 Chopper

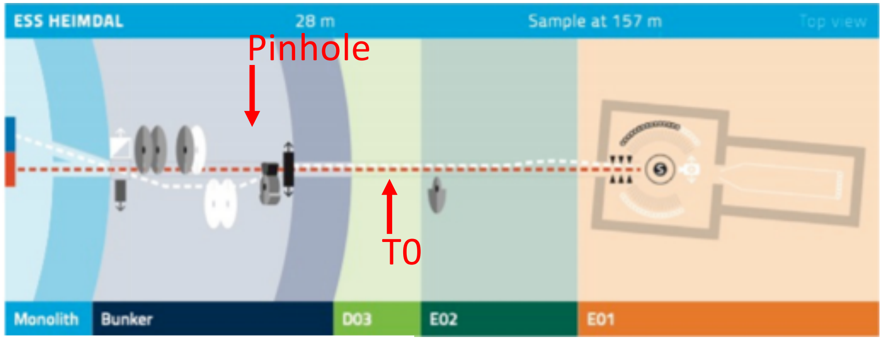




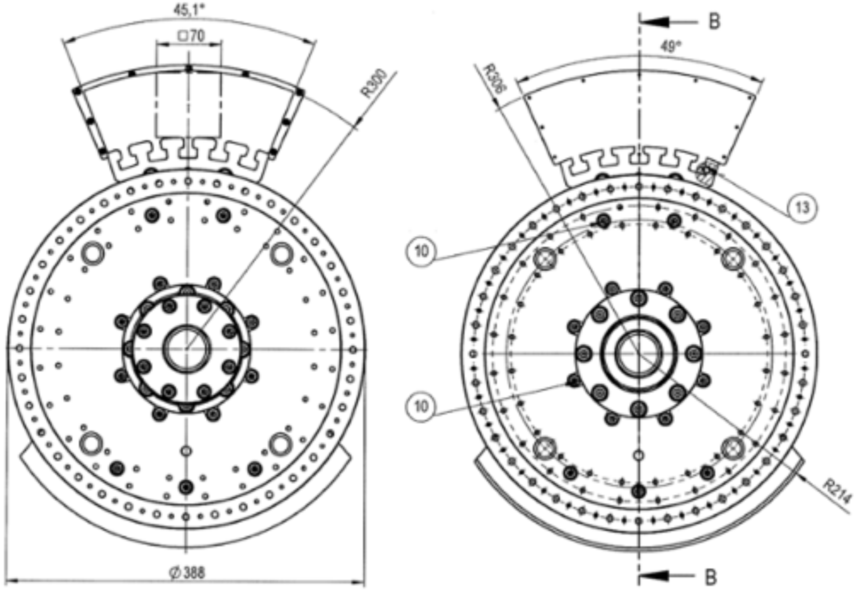
Prototype To Chopper Designed for 60x60 Guide

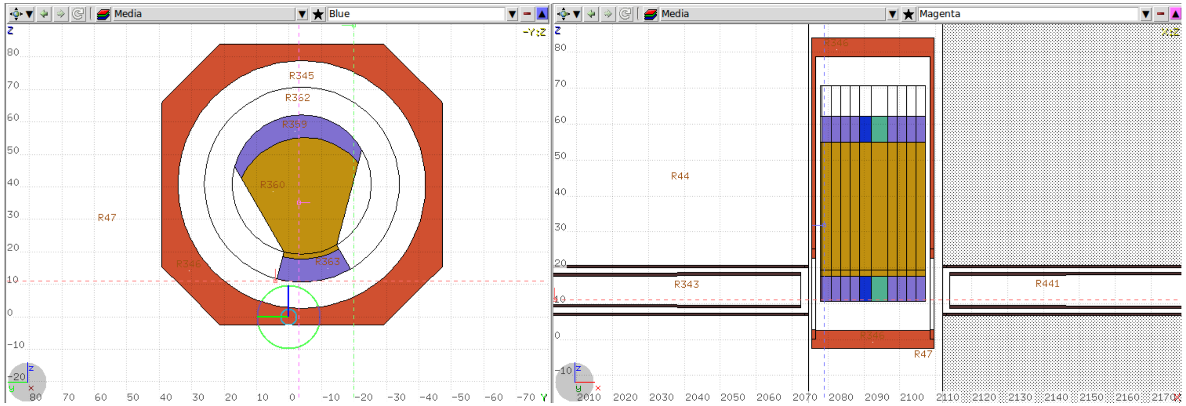
Larger Chopper designed but significantly more expensive
 + include new design costs

T0 chopper



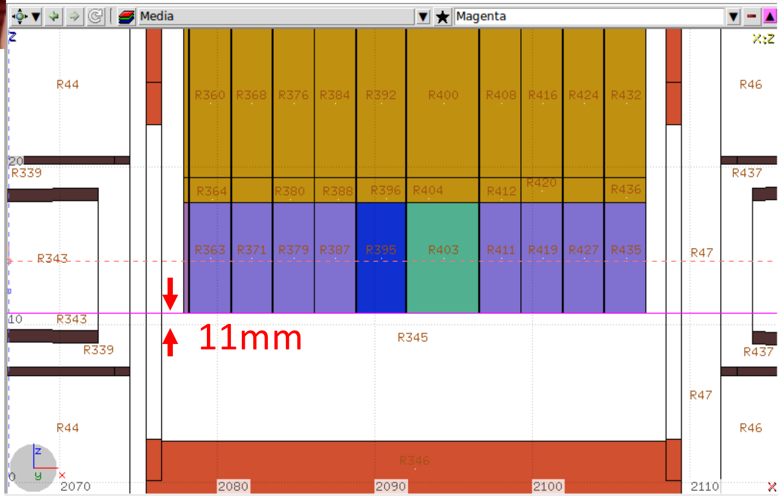
- Standard ESS T0 chopper rotor is designed for 60x60mm guide opening and has 70mm coverage in height
- HEIMDAL guide at a nominal position of T0chopper placement has a height of 81mm
- A pinhole at 6.4 m is 50 mm tall and is fully blocked by the tungsten hammer when viewed from the far end of the guide.
- A possibility for savings from using a rotor with standard hammer dimensions



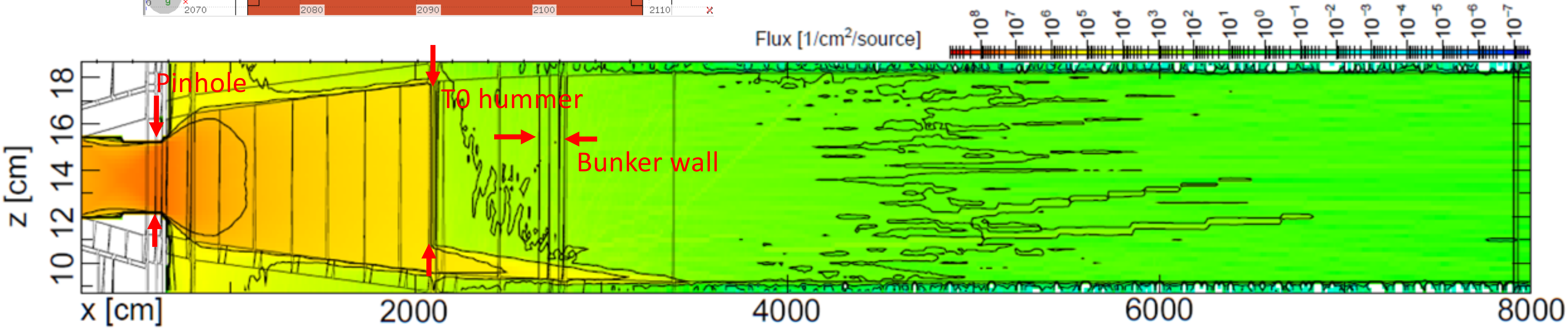


T0 simulation results

Rodion Kolevatov (IFE)



- 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 $E_n > 20\text{MeV}$)
- 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 1 week after shutdown, well within 10mSv/h limit.



Heimdal Jalousie 2D De

ESS simulation effort to look at the Jalousie detector technology.

The simulations results for HEIMDAL indicate a good performance of the detector.

The Jalousie detector technology comes with a great deal of challenges for the data analysis and reduction, but these simulation can help.

G4 - DMSC collaboration on DREAM detector.

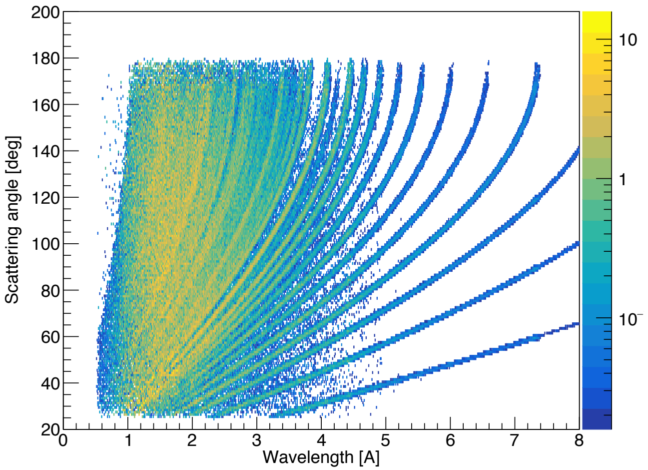
Irina Stefanescu

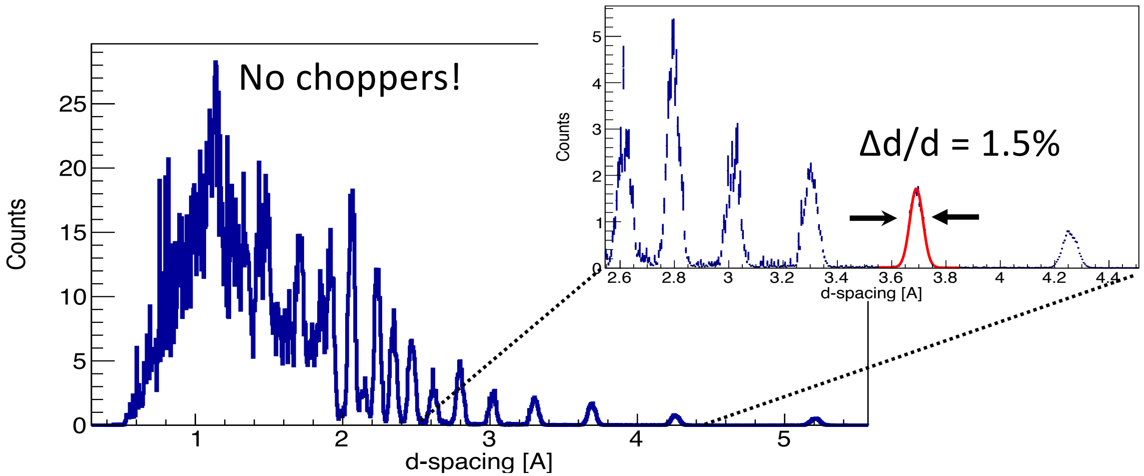
2019 JINST14 P10020

Performance study of the Jalousie detector baseline design for the ESS thermal powder diffractometer HEIMDAL through GEANT4 simulations

I. Stefanescu,[a,1] M. Christensen,[b] R. Hall-Wilton,[a] S. Holm-Dahlin,[c] K. Iversen,[b] M. I
D. Mannix,[a] J. Schefer,[e] C.J. Schmidt,[d,f] W. Schweika[a,g] and U. Stuhr[e]

[a] *European Spallation Source ESS ERIC,*

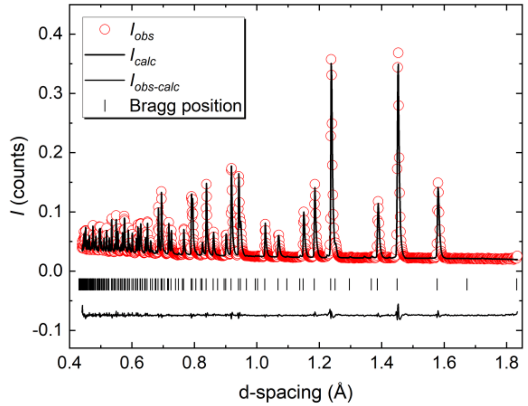




NaCaAlF powder sample + GEANT4 model for the HEIMDAL detector

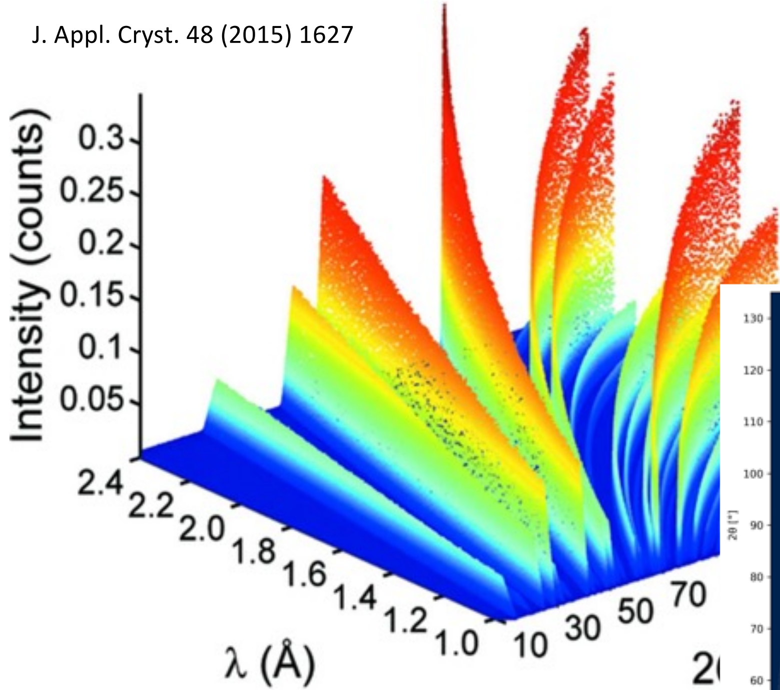
2D Rietveld Refinement
Mathias Mørch Ph.D Starting @ AU 2020

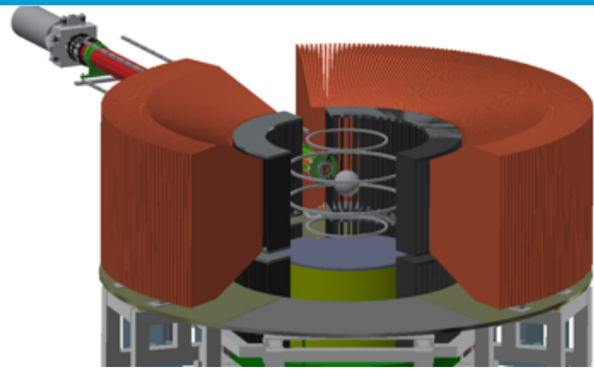
Hugo Rietveld



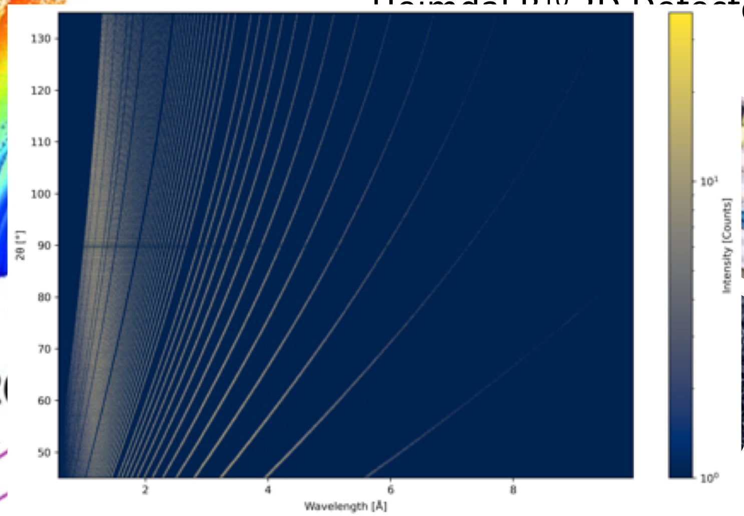
Powder Diffraction

J. Appl. Cryst. 48 (2015) 1627





Heimdal B^{10} 2D Detector



Heimdal General Sample Environment

Cooling

Orange Cryo
1.5K-300K

Dilution
~10s mK

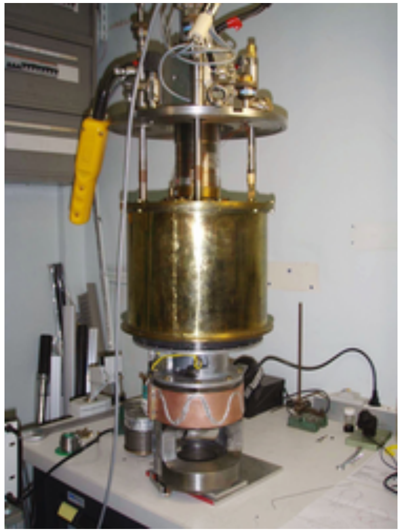
Heating

cryofurnace
1.5K-600K (800K)

Magnetic Field

Cryo-magnetic
8-Telsa

Pressure ? What ?

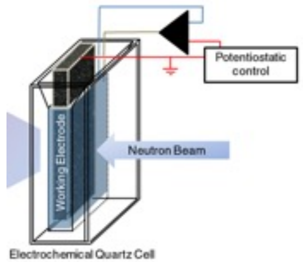


Paris – Edinburgh
Diamond Anvil + Heat
Stress/Strain Cell

Discussion – Malcolm
SAD Group

Electro-chemistry

Diffraction



SANS

Heimdal Fast Sample Environments
High Throughput Neutron Scattering

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

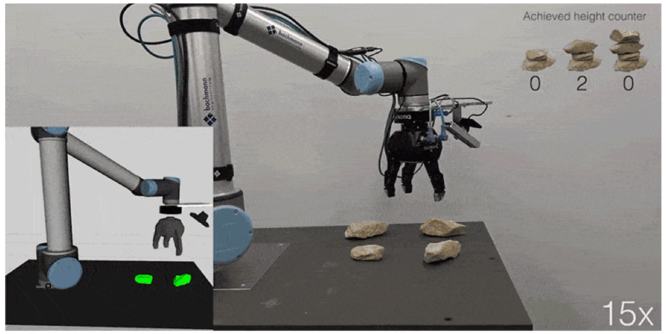
- Electromagnetic radiation
- Fast heating
- High temperature >1370 °C

-Nordforsk proposal +
+Sample Environment
+ postdoc
+ Dream

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

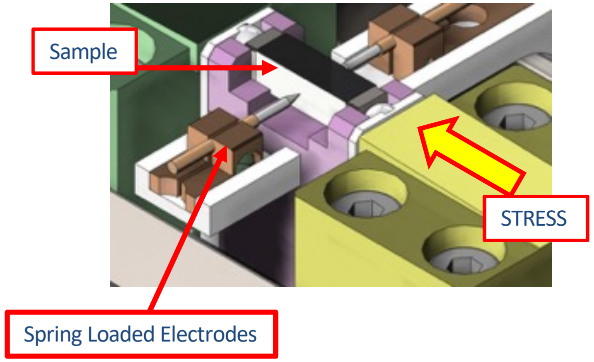
+ Robot sample changer



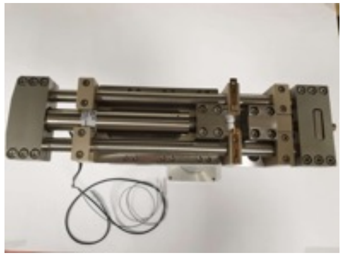
Nordforsk proposal 2020
Heimdal/Dream compatible sample environment
- Fast Heating
+ postdoc

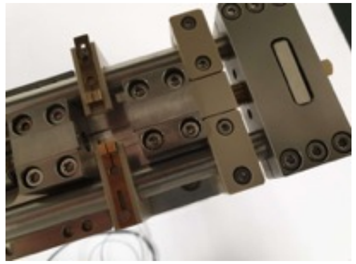
Stress Cell (XMaS UK CRG ESRF)
Markys Cain / Paul Thompson

EUROPEAN SPALLATION SOURCE

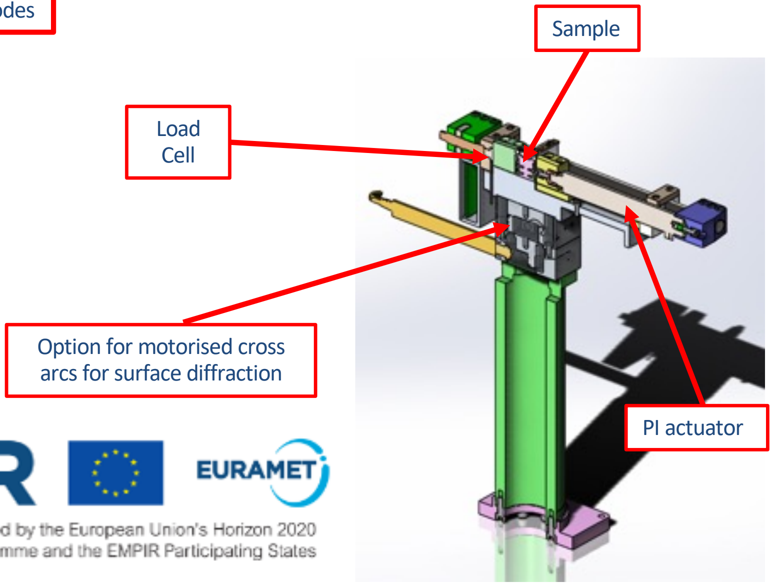


System commissioned and calibrated Aug-Oct 2019

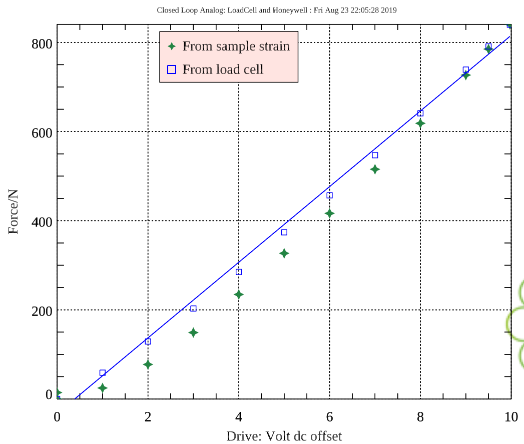




Stress Cell



Modulus=stress/strain.
Sample size 4mm square section.
E ~ 68±1 GPa.



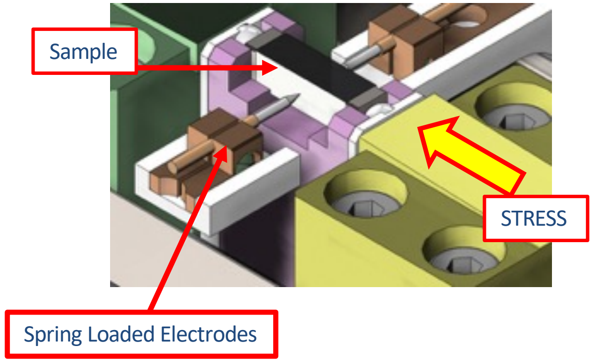
EMPIR EURAMET

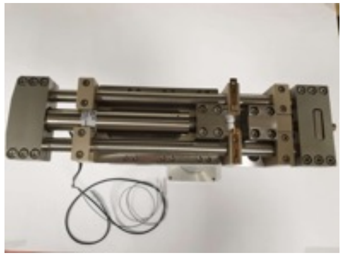
The EMPIR initiative is co-funded by the European Union's Horizon 2020 research and innovation programme and the EMPIR Participating States

electrosciences ltd
Materials Science Consultancy

Stress Cell (XMaS UK CRG ESRF)
Markys Cain / Paul Thompson

EUROPEAN SPALLATION SOURCE





Reciprocal Space Mapping Software

Transform 2D detector hits into H,K,L Maps
Modification to TOF

EMPIR EURAMET

The EMPIR initiative is co-funded by the European Union's Horizon 2020 research and innovation programme and the EMPIR Participating States

electrosciences ltd
Materials Science Consultancy

Upgrade Priority

If Change Request Accepted:
Diffraction
SANS
Imaging
Polarised Cold Neutrons*
Polarised Thermal Neutrons*

If CR Not accepted
Diffraction
Full Diffraction coverage
Polarised* thermal/Cold Neutrons via bi-spectral switch. ^{3}He Cells
****shutdown*****
SANS
Imaging

Upgrade maybe an unlikely scenario