



**EUROPEAN
SPALLATION
SOURCE**



ESS Target Station Project Update

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2026-04-13

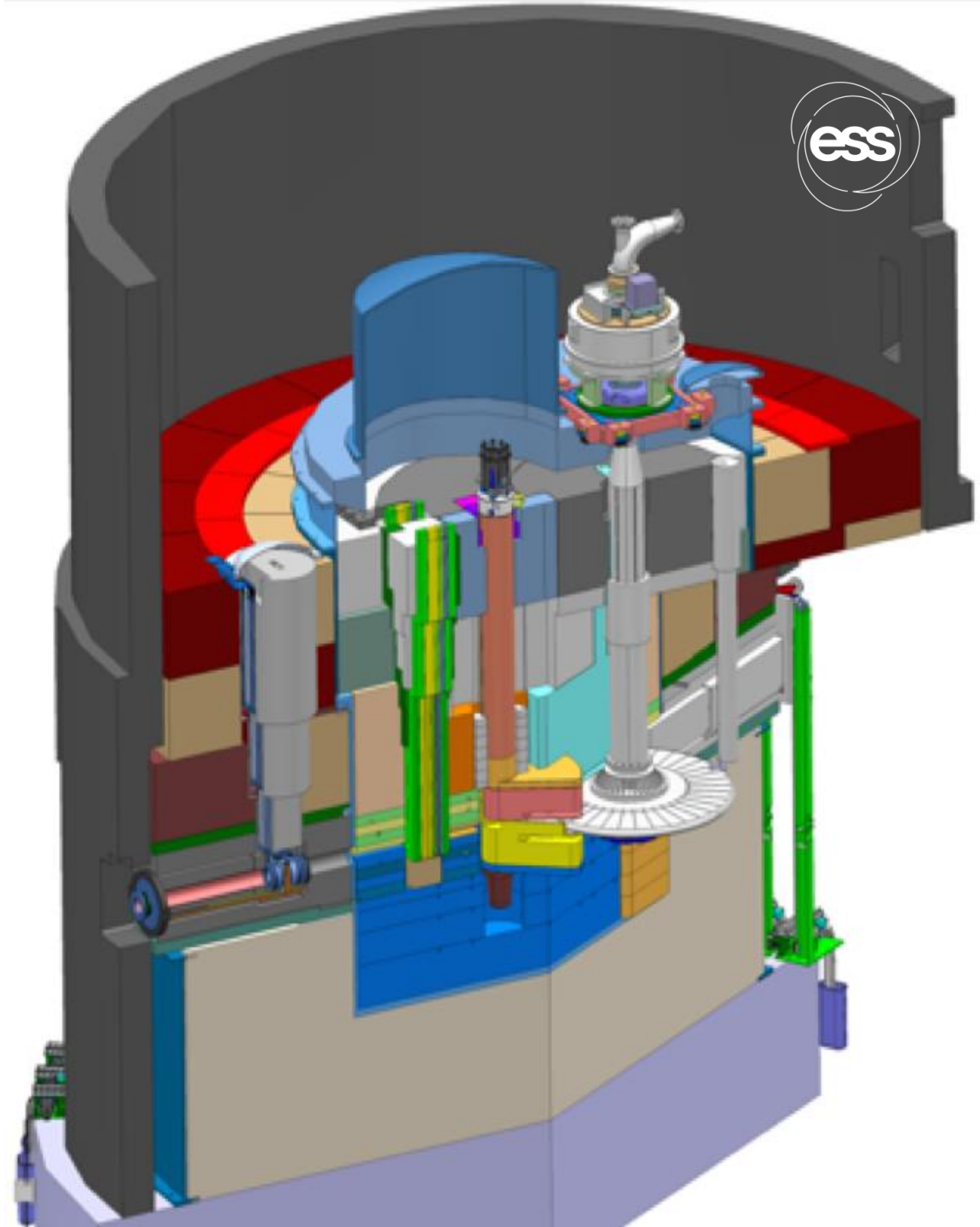


Outline

- 1 Preamble – Background and Context for the ESS Target Project
- 2 ESS Target Station Project Current Status
- 3 Challenges and Issues
- 4 Achievements and Successes
- 5 Concluding Remarks

1

Preamble Background and Context for the ESS Target Project



Preamble



The contextual background for the ESS target station project

Ambitions

- Aiming for unprecedented performance in terms of proton beam power, neutron flux, etc
- Exploring new scientific capabilities
- Creating provisions for future scientific ideas

Building on existing knowledge

- Understanding issues and failures encountered for existing peer facilities
- Reusing well-performing and proven technology

Important conceptual decisions and largely unique features

- 5 MW proton beam power capacity
- Long-pulse (2.86 ms) with 14 Hz repetition rate
- Helium-cooled rotating tungsten target
- Low profile moderators (cold and thermal)
- Maximised access to the neutron source for scientific instruments

Preamble

The realisation of the ESS target station project



Target Safety System

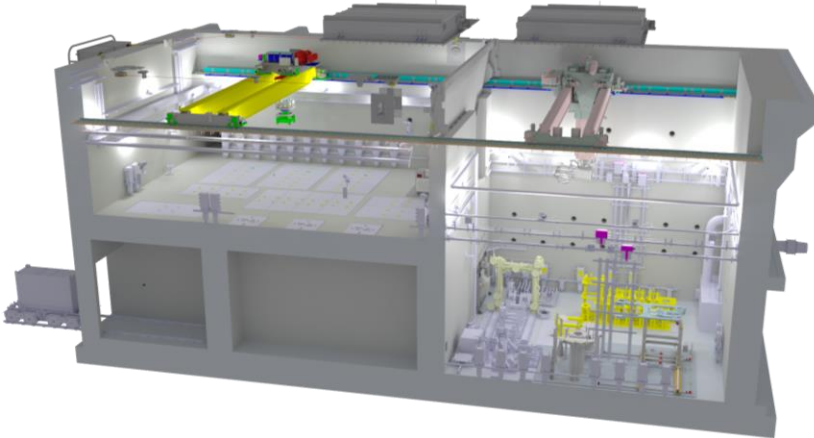
- Monitors five critical operating parameters and prohibits proton beam if outside limits determined by the radiation safety analyses

Target Systems

- Tungsten target material inside a rotating, disc-shaped pressure vessel
- Helium cooling, 3 kg/s, 11 bar, 40 °C inlet/240 °C outlet

Moderators

- Provisional locations of moderators above and beneath the target wheel
- 1st MR exploits the upper space:
 - ✓ Cold, 30 mm high, liquid H₂, 17 K
 - ✓ Thermal, 30 mm high, H₂O, 300 K

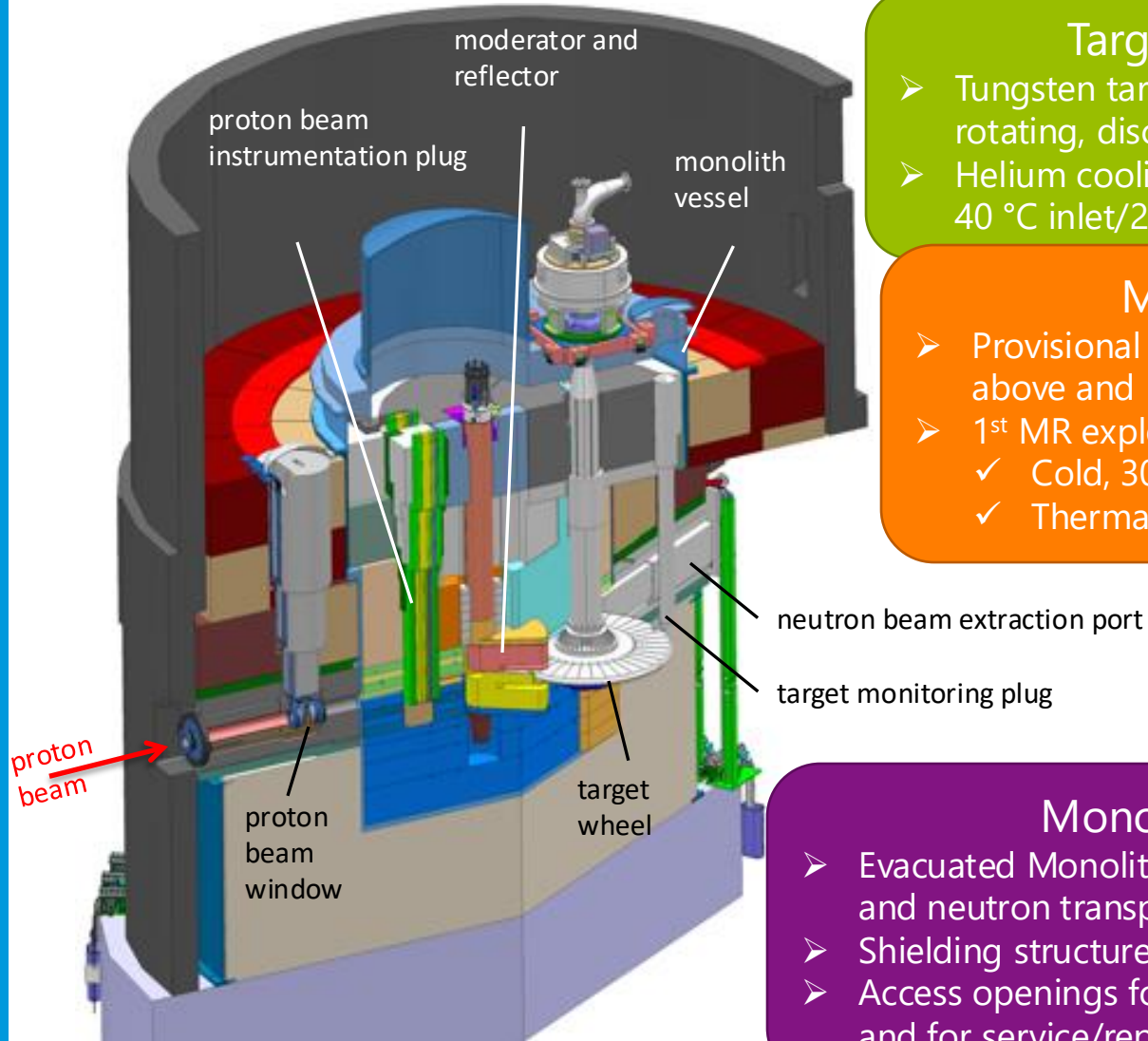


Remote handling systems

- Large active cells for safe storage and processing of spent radioactive target components
- Seven shielded casks for transfer of spent components from monolith to active cells

Monolith Systems

- Evacuated Monolith Vessel for maintaining inert and neutron transparent conditions
- Shielding structures outside and inside the vessel
- Access openings for neutron beam extraction and for service/replacement of internals



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ESS Target Station Project Current Status



Centre for
Energy Research



Centrum výzkumu Řež s.r.o.
Research Centre Rez



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Consiglio Nazionale delle Ricerche

ESS Target Station Project Current Status



The ESS Target Station is close to be ready to operate with proton beam

- By 2025-11 all target station systems for neutron beam production were fully installed, commissioned, and functionally verified
 - Integral testing and commissioning had commenced and are still on-going
 - The project were on track for start of operation 2026-03
 - However, recent events led to damage our Moderator/Reflector Plug which prohibits operation with proton beam until its replacement component becomes available
- Early 2026 the license to operate with proton beam on target was received
- Meanwhile, during 2026, works continue
 - Integral target station operation to gain experience and to train the organisation
 - Addressing findings from the testing and functional integration
 - Resolving remaining punch list items important for reliable future operation
 - Finalising the remote handling systems

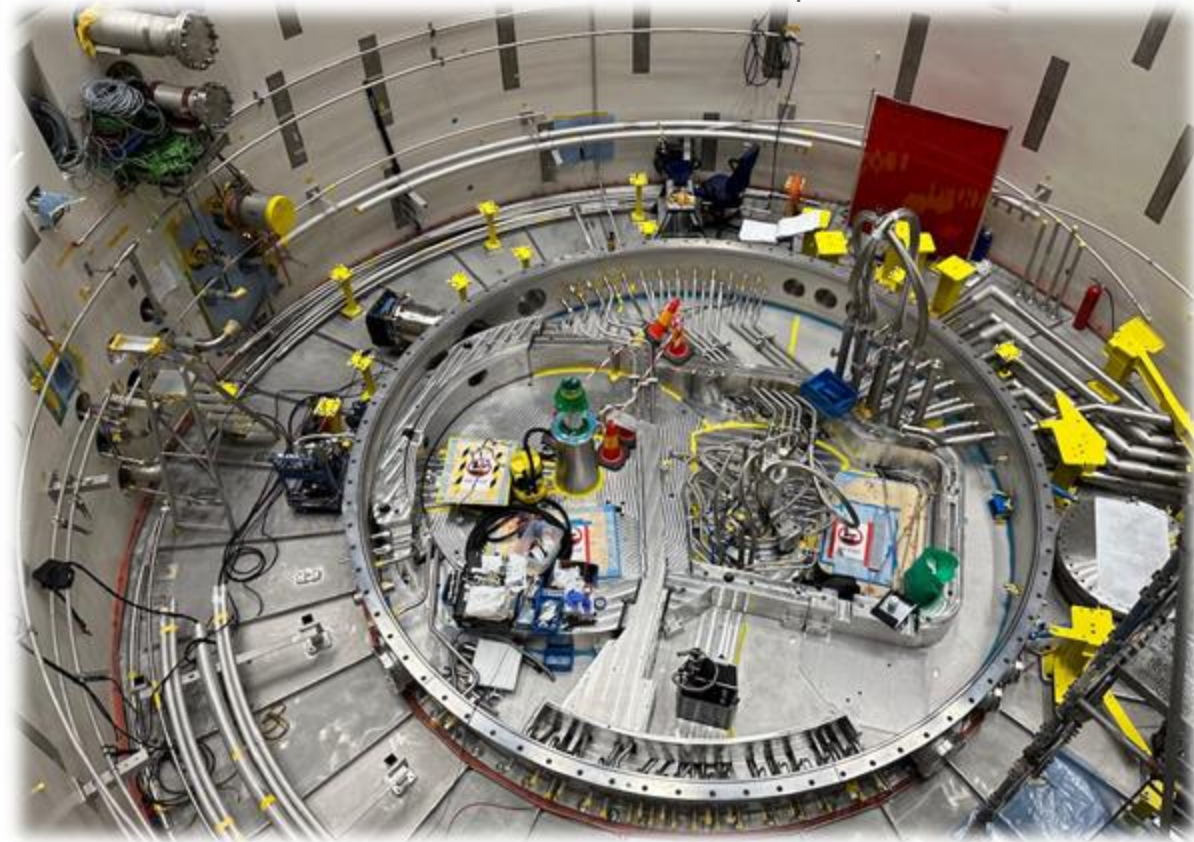
Monolith systems group

Photographs



Water-cooling systems

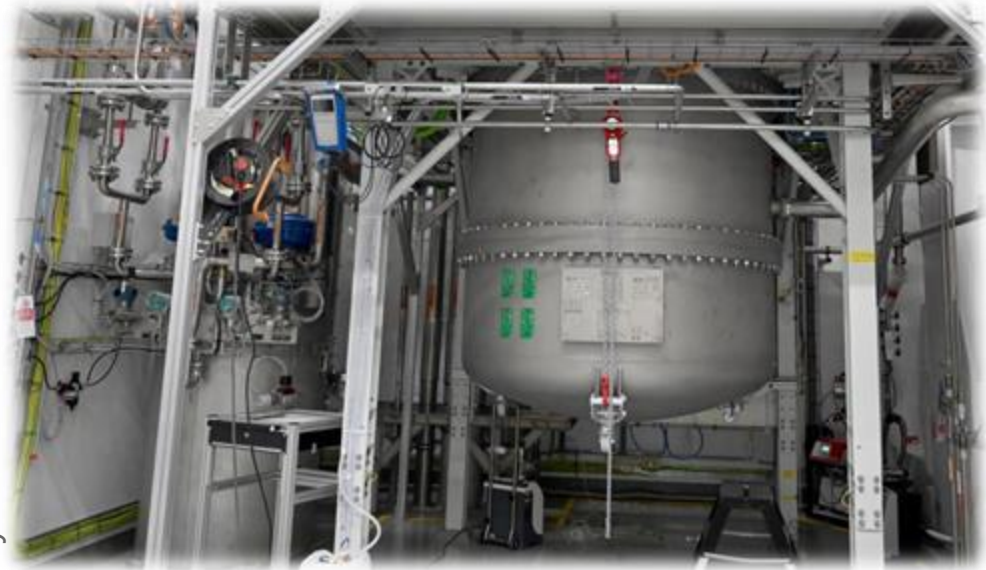
All cooling systems feed and return pipes connected to their monolith vessel penetrations



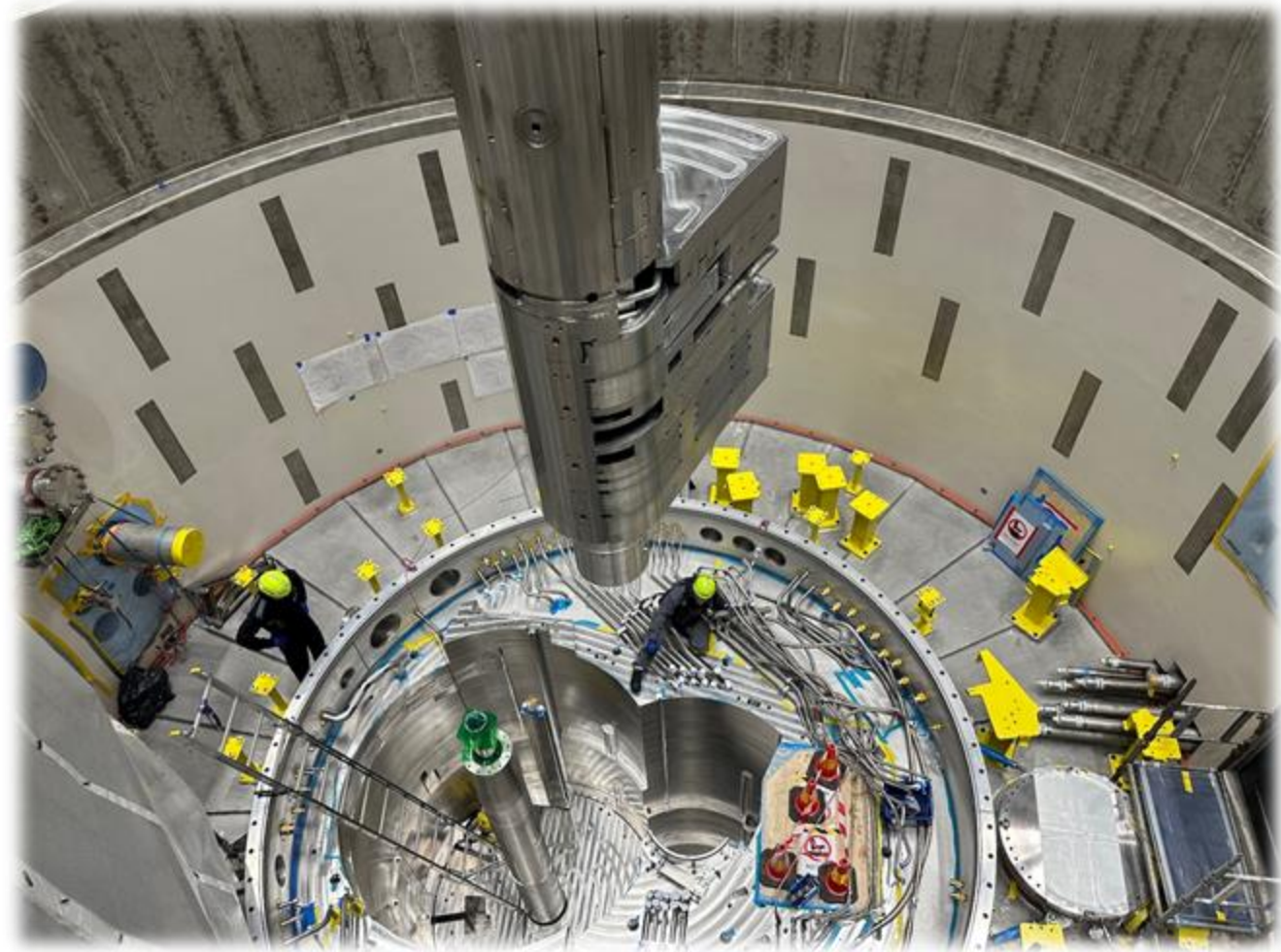
Moderator systems group

Photographs

Cryogenic Moderator System Cold Box



Cryogenic Moderator System Junction Box



Installation of the Moderator/Reflector Plug

Neutron beam extraction systems group

Photographs



Last Neutron Beam Port Insert being installed together with in-kind partner FZJ

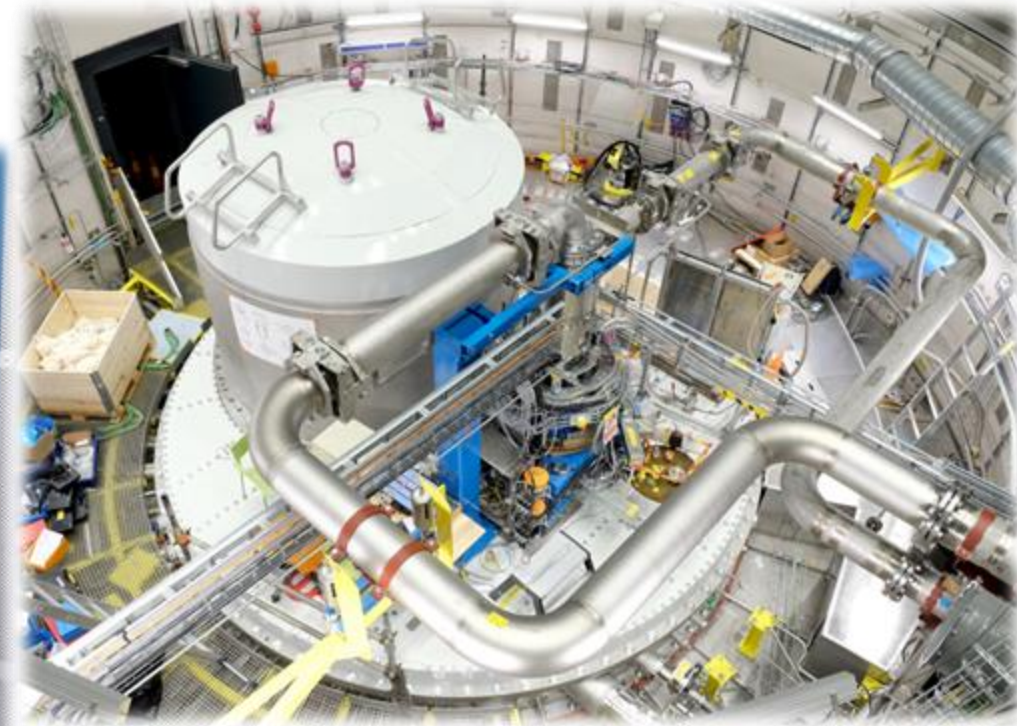
Target systems group

Photographs

Installation of the Target Wheel



Helium screw compressor

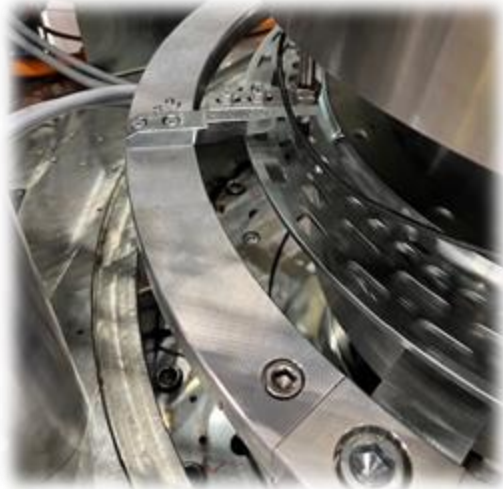


Target drive unit, including the helium rotary union, and helium feed and return lines installed and connected



Target Safety System

Photographs



TSS target wheel rotation sensor



TSS venturi tube flow measurement

TSS field control cabinet



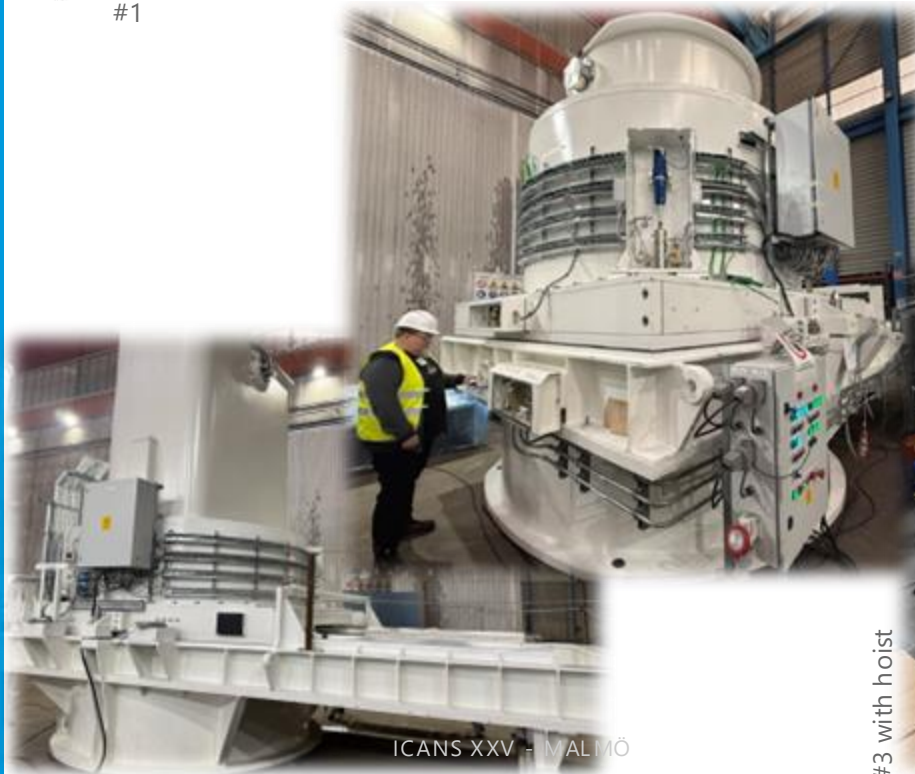
TSS helium temperature sensors



TSS control room cabinet

Remote handling systems

Photographs of casks bodies



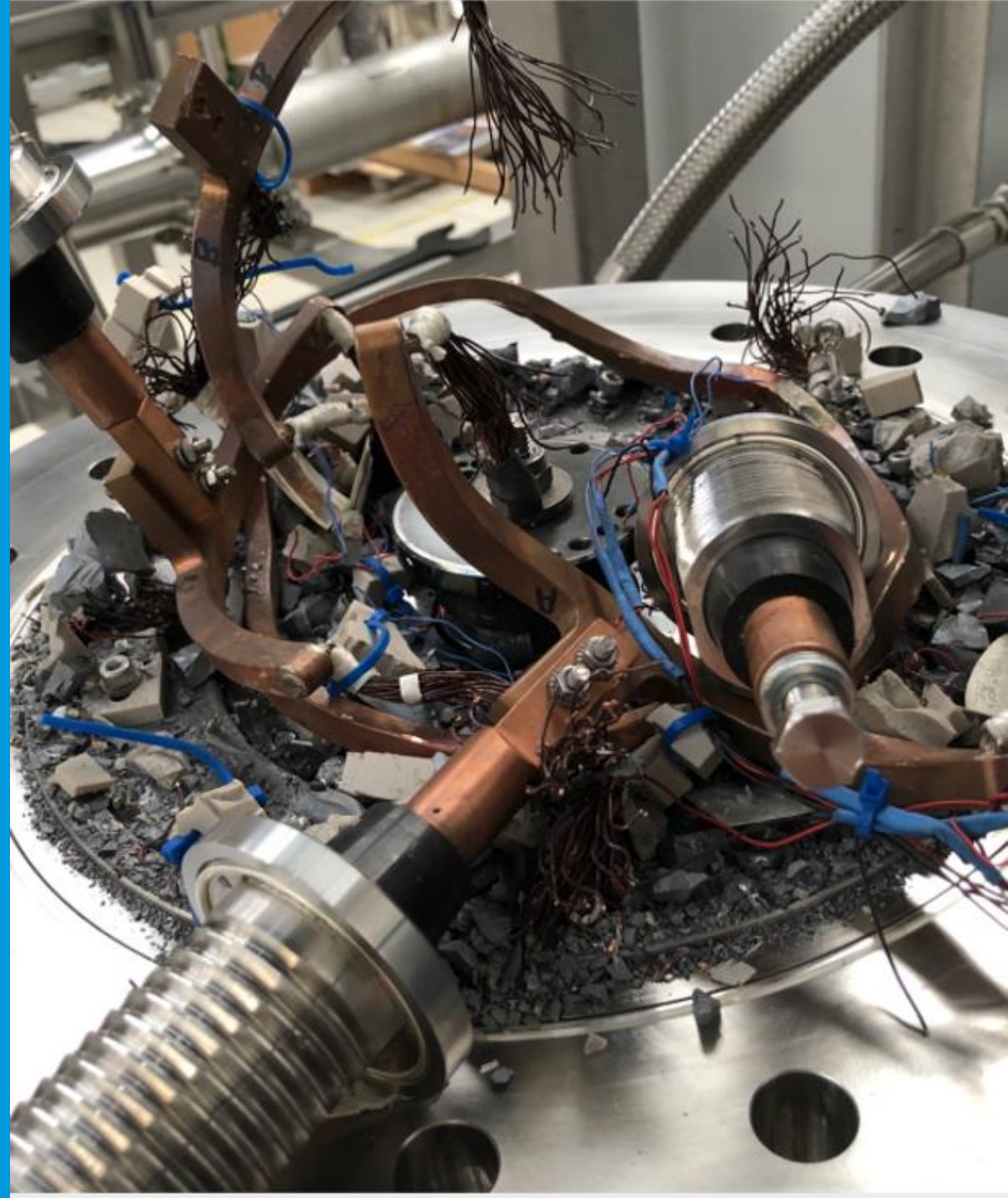
ICANS XXV - MALMÖ

#3 with hoist



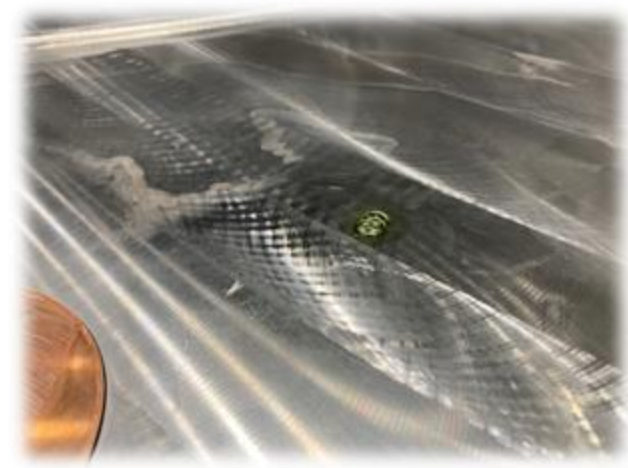
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Challenges and Issues



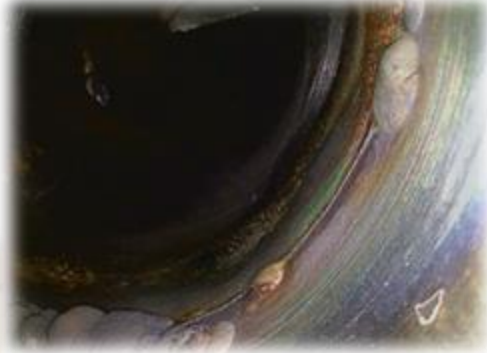
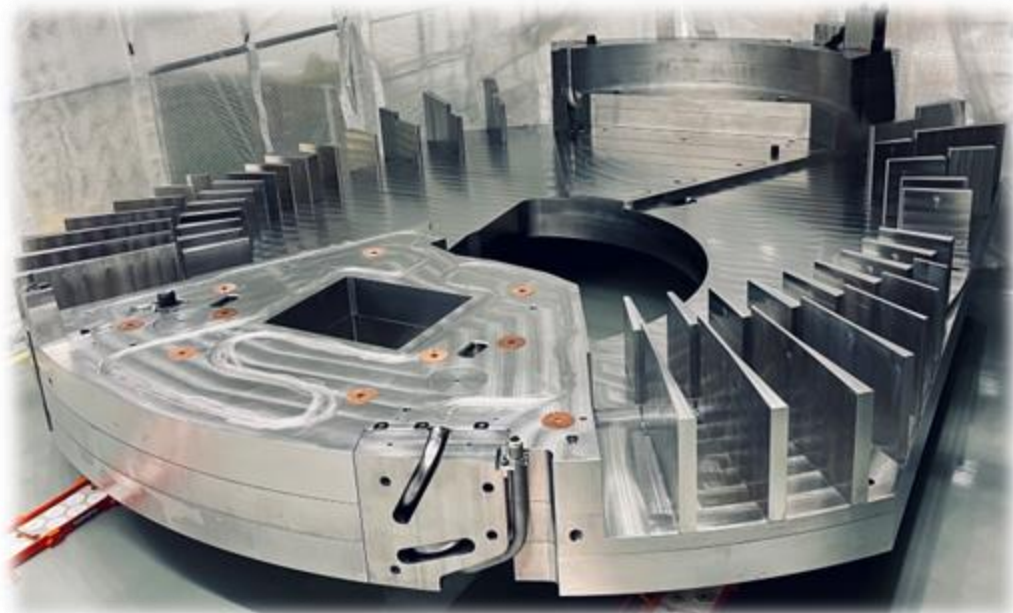
Weld Quality and Cleanliness

Monolith Inner Shielding



Upon receipt of several monolith inner shielding blocks, issues with both cleanliness and weld quality were found

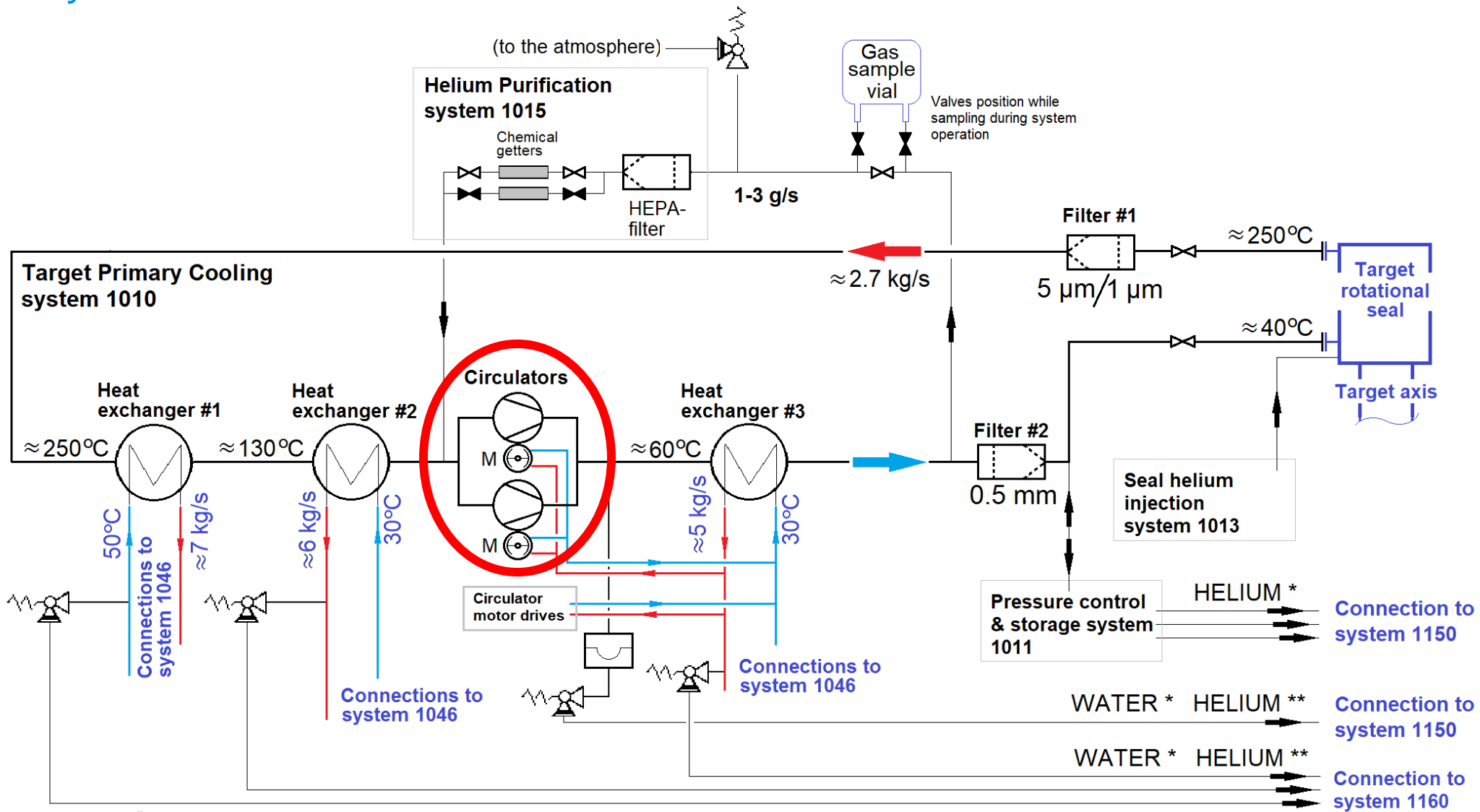
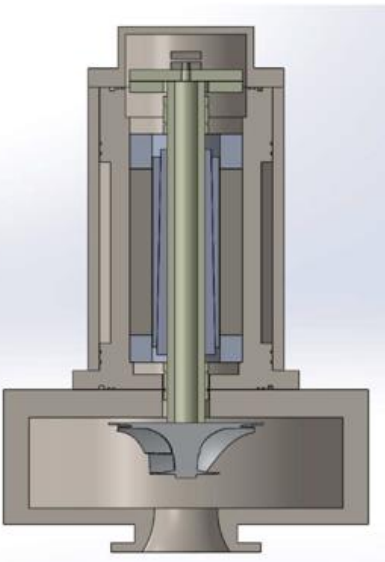
- Already extensive Factory Acceptance Tests and inspection programmes proved insufficient. Our lesson learned was that even more intensified quality control were needed earlier in the process. (And pandemics do not help)
- The necessary remedial measures were technically straight-forward, while the schedule impact were concerning.



Helium Circulator Failure

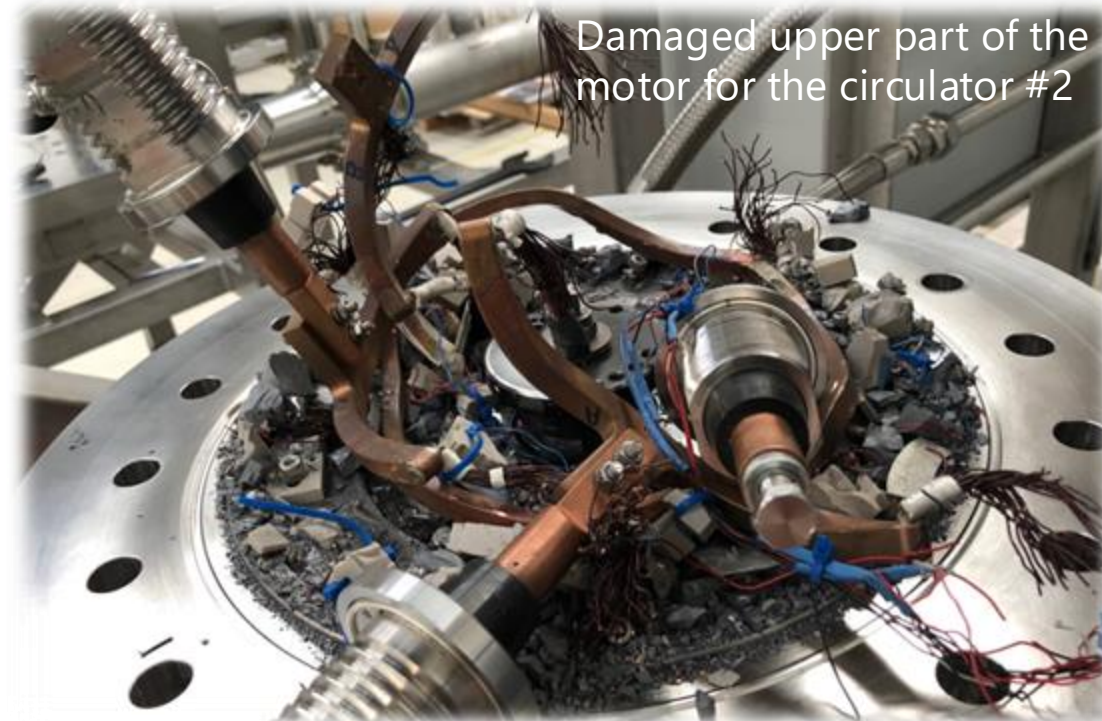
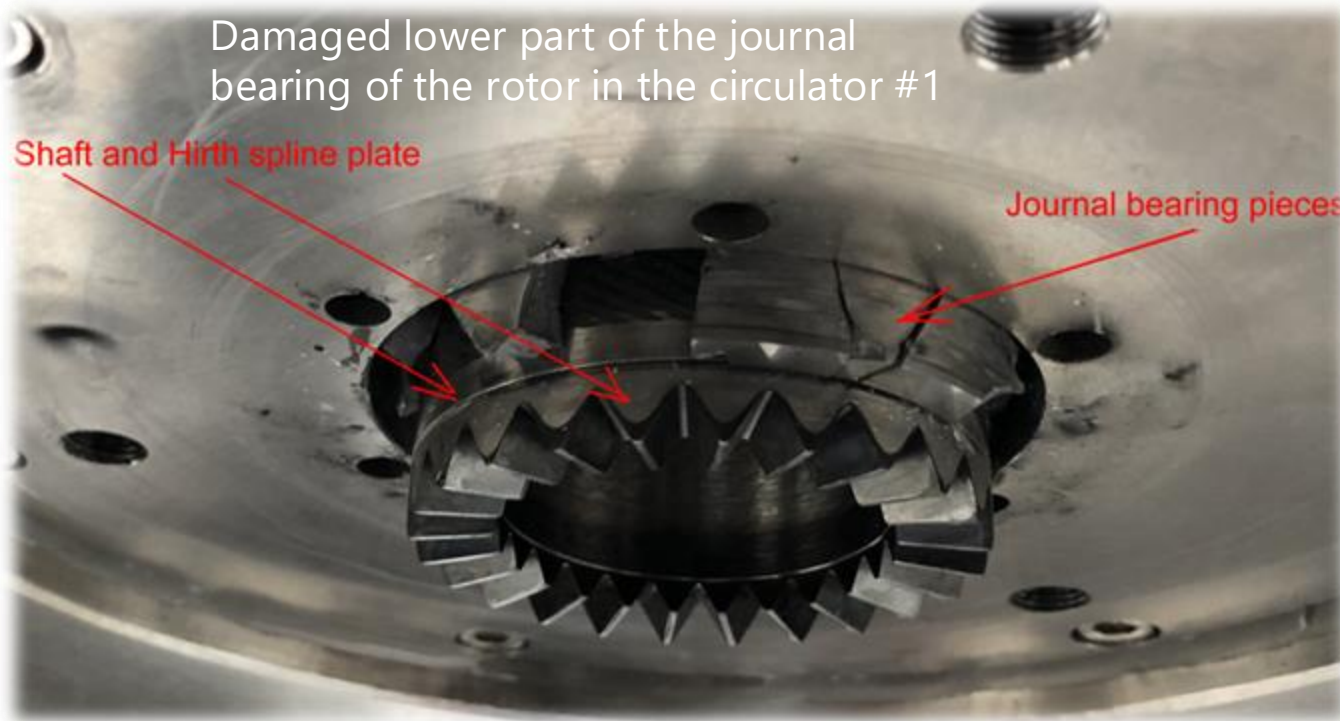


The helium system flowchart



Helium Circulator Failure

Damages to both circulator assemblies



- The most likely direct cause of the failure was debris in the test loop coupled with a non-robust design
- Our two-fold remedial action was **(A) to recover the failed turbo machines** by implementing new motors and bearings of different type and **(B) to procure and install an alternative industrial, robust screw compressor** technology
- For mitigating future risks, **both alternatives were pursued** in parallel

HRU issues

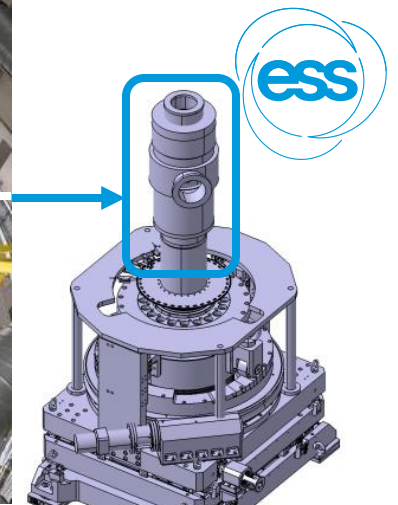
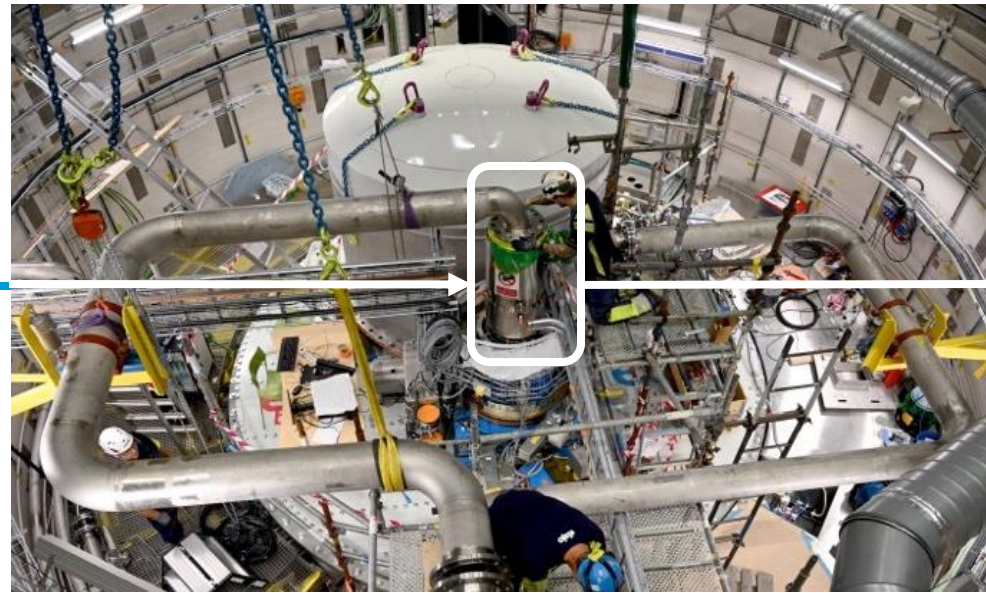
The challenges with the Helium Rotary Union (HRU)

The HRU Function

- Convey helium between stationary piping and rotating target

Challenges

- Complex load pattern
 - Mechanical, static/dynamic/cyclic
 - Thermal, expansion/high temperatures
- Make possible mounting/dismounting
- Leak-tightness
 - Minimising radioactive emissions and He loss
 - Minimising internal by-pass



For mounting purpose

- Internal sleeve

For leak-tightness the HRU has an internal sealing cartridge

- Rubber o-rings
 - between parts without relative rotation
- Graphite rings
 - between parts with relative rotation



HRU issues

The recovery of the Helium Rotary Union (HRU)



Mitigative actions for the HRU challenges are

- HRU version 1 is pursued for primary use at BoT
 - Extensive experience with the component has been gained during cold commissioning
 - Spare parts are available
 - Technicians have trained refurbishment and can get support from manufacturer
- An alternative HRU version 2 is under development
 - Includes lessons learned from HRU#1 through important design modifications
 - Can be fitted sealing cartridges with several different technologies, by modular design
 - Aim is to have this alternative available as backup at time of BoT

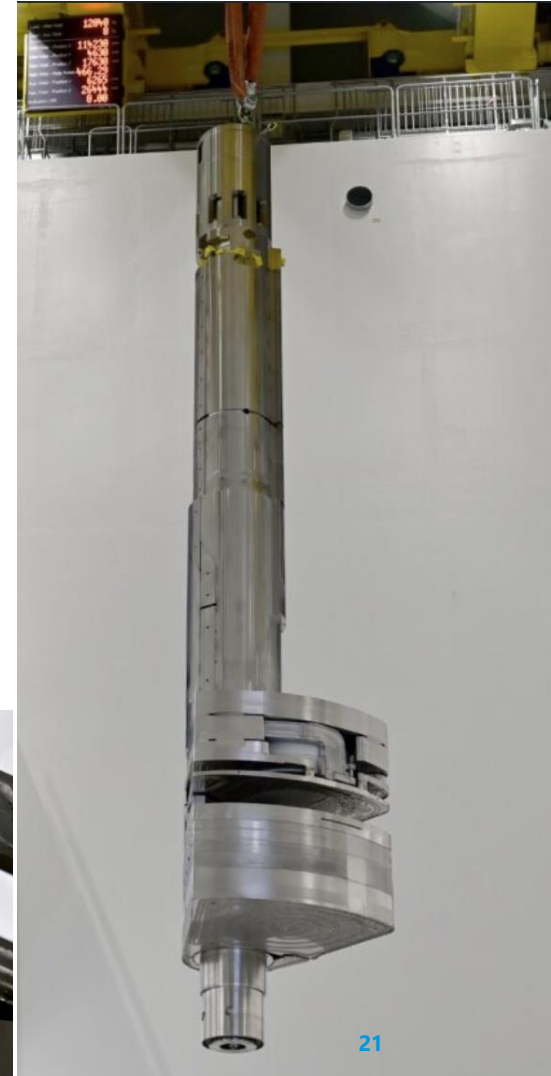
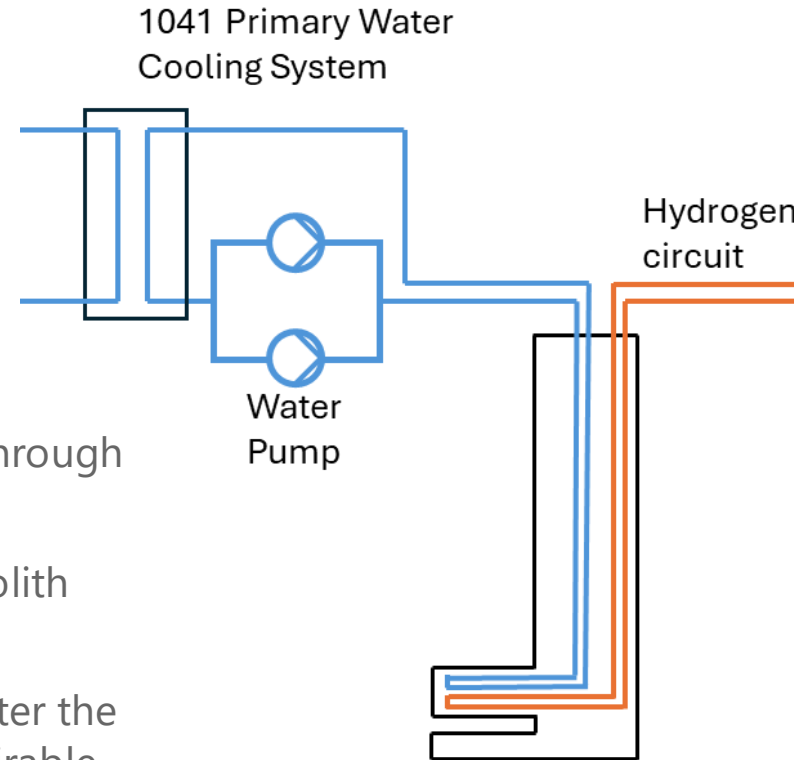


Damage of Moderator/Reflector Plug



2025-11-25 – Target systems were configured for integrated system testing

- Cryogenic moderator hydrogen loop was operating normally
- Thermal moderator/pre-moderator water loop was operating normally
- Power transient caused water pump to trip and restart was delayed
- When pump restarted flow very low likely through bypass loop
- Data indicated loss of vacuum in both monolith and cryogenic pipe insulation
- After extraction of the MRP#1 a few days later the damage was obvious and deemed not repairable
- Direct cause is ice formation due to stagnant water coupled with “tight” design with the cryogen H₂
- The remedial action is to install the MRP#2, which was already in production, during second half of 2026



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Achievements and Successes

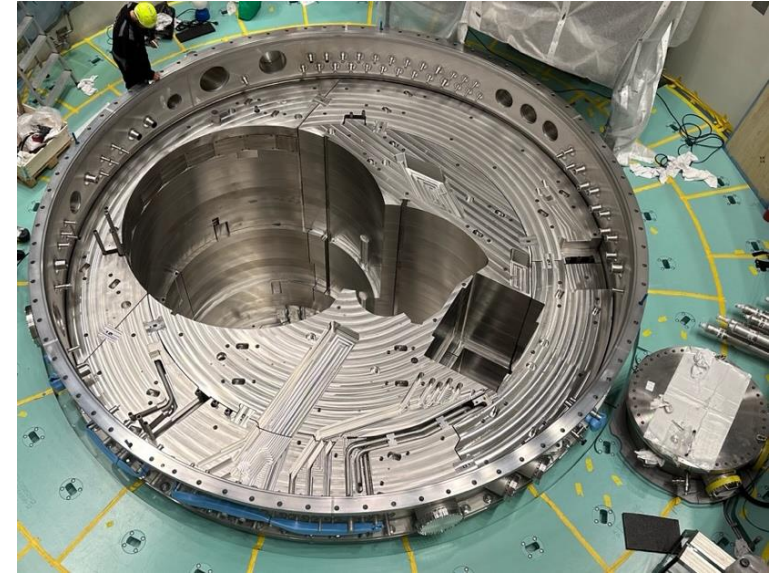
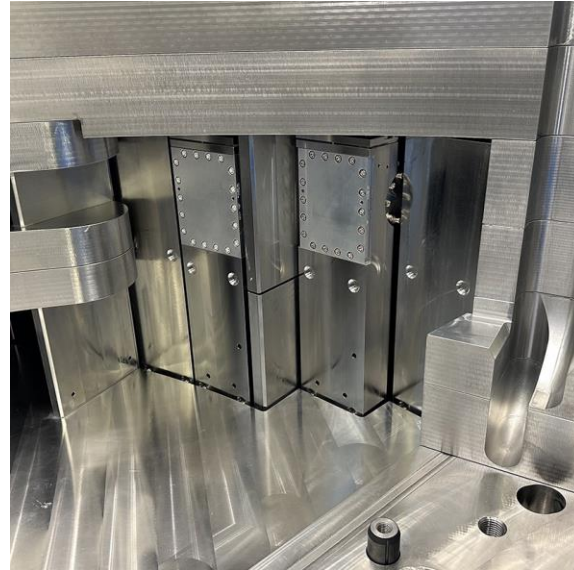


Monolith vacuum performance

Monolith cleanliness and vacuum compatibility

Hardware configuration

- Vacuum boundary
 - Monolith and PBW vessels
 - Connection ring
 - Neutron beam port tubes
 - Neutron beam windows
- Internals
 - Neutron beam port inserts and plugs
 - All permanent inner shielding
 - Feed pipes for water-cooled shielding



Successful achievement of monolith vacuum performance

- Leak tightness confirmed for the vacuum boundary
- No significant contamination of the monolith was found, i.e. sufficient cleanliness
- Excellent repeatability

Precision of the neutron beam extraction



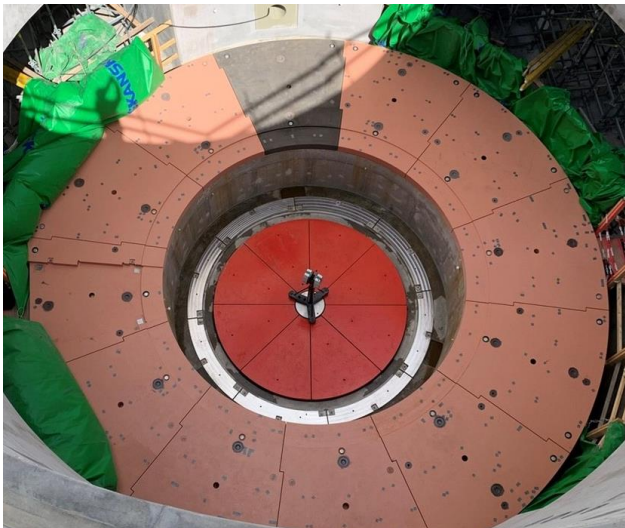
As-installed precision for neutron beam extraction

- The **precision of the neutron beam extraction relies on the manufacturing and installation results** of many components, some large and heavy, others very delicate.
- **The ultimate requirement**
 - Maximum misalignment between each neutron extraction optics assembly and their corresponding optimal moderator surface.
 - With reference to each beam line's theoretical centre line the misalignment should be within **± 2 mm (vertical), ± 3 mm (lateral) and ± 5 mm (axial)**.
- **The successful end-result**
 - All individual structures were built and installed within their specified local geometrical tolerances.
 - **Positioning deviation of the neutron beam port inserts**, as-installed, were confirmed **within a few hundred micrometres**, relative to the theoretical moderator position.
 - Together with the expected repeatability precision for replacement of the moderator/reflector plug, i.e., ± 1 mm (vertical) and ± 2 mm (lateral), **the required precision will be accomplished!**

Precision of the neutron beam extraction



Maximum deviation from nominal position



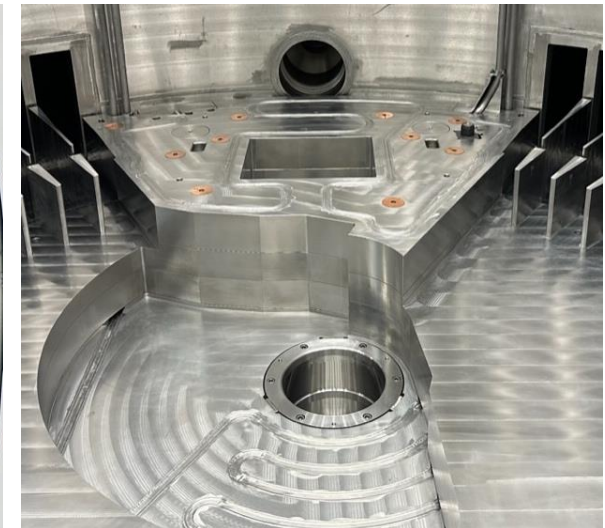
Baseplate
0.6 mm (vertical)



Monolith vessel
0.5 mm



Port tubes after welding
2.9 mm (lateral)



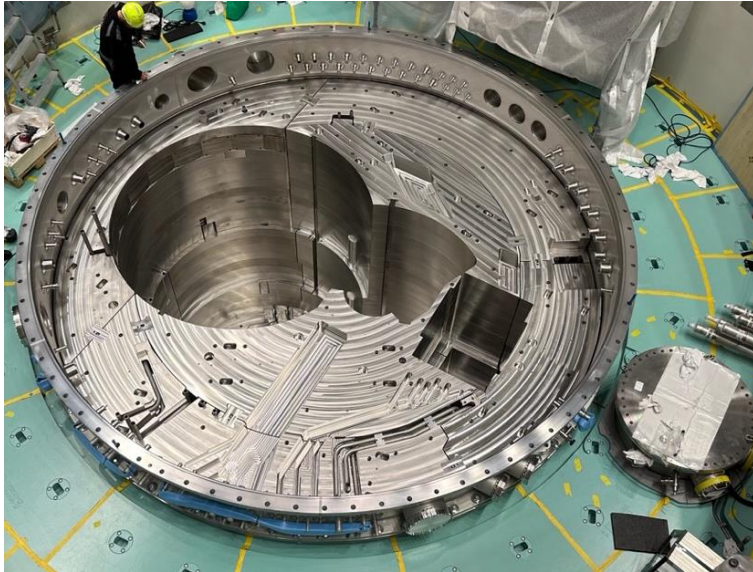
Moderator/reflector seat
0.05 mm (vertical)
0.14 mm (horizontal)

Note that average deviation values are generally significantly better.

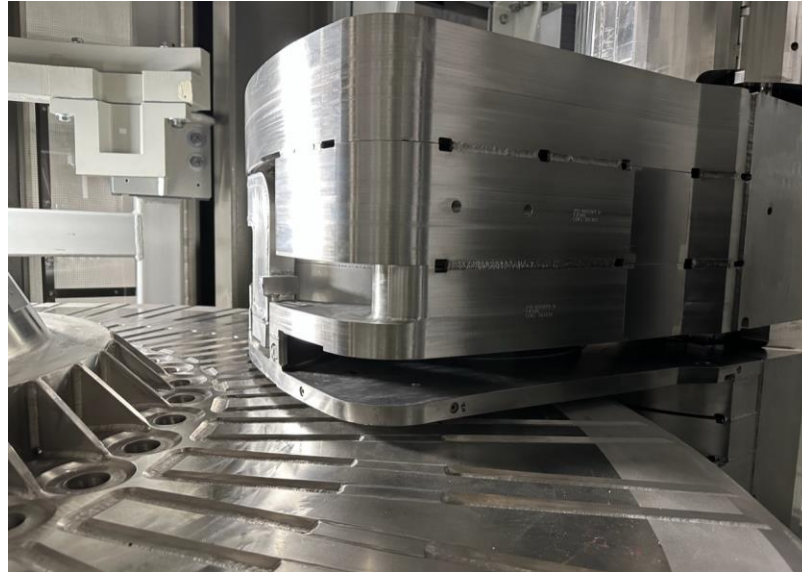
Precision of the neutron beam extraction



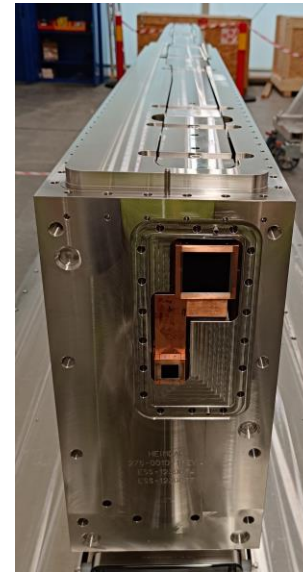
Maximum deviation from nominal position



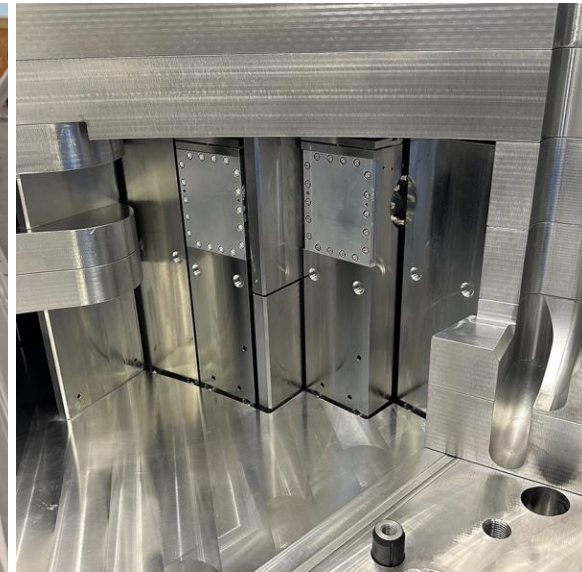
Shielding top interface with remote handling system (casks)
0.6 mm



Moderator/reflector plug positioning
Expected first time install <0.5 mm
Expected replacement repeatability precision, by remote handling, <1 mm (vertical) and <2 mm (horizontal)



Positioning of the Neutron Beam Port Inserts
0.2 mm (vertical)
0.3 mm (lateral & axial)



Note that average deviation values are generally significantly better.

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Concluding Remarks



ESS Target Station Project Current Status



The ESS Target Station is close to be ready to operate with proton beam

- By 2025-11 all target station systems for neutron beam production were fully installed, commissioned, and functionally verified
 - Integral testing and commissioning had commenced and are still on-going
 - The project were on track for start of operation 2026-03, but now forecast early 2027
 - Due to the damage of the MRP#1, BoT relies on delivery of the MRP#2 which is currently forecast 2026-10
 - System modifications for mitigating similar damage to MRP#2 are in work
- Early 2026 the license to operate with proton beam on target was received
- Meanwhile, during 2026, works continue
 - Integral target station operation to gain experience and to train the organisation
 - Addressing findings from the testing and functional integration
 - Resolving remaining punch list items important for reliable future operation
 - Finalising the remote handling systems

Remarks on organisational readiness to operate



Pending installation of MRP#2 we will be ready to start operation with proton beam, but learning to operate stably, efficiently and with expected availability will take time

Getting ready to operate stably and efficiently

- Engineered radiation safety features, performance and capacity requirements are verified and validated
- However, full understanding of the neutron factory behaviour requires extended usage and operation experience
- Training and learning on the job will be instrumental for mastering the art of operating the ESS Target Station

Collaboration will be more important than ever before

- Within ESS; with internal functions, interfaces and stakeholders
- Continued support by and exchange with our project partners
- With the worldwide community and peer facilities



Thank you for your attention

2026-04-13