



**EUROPEAN  
SPALLATION  
SOURCE**



# An update from the European Spallation Source

PRESENTED BY PASCALE DEEN, SENIOR SCIENTIST FOR SPECTROSCOPY

# ESS

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The European flagship facility for neutron science

Designed to enable scientific breakthroughs in matter and materials research with a particular focus technological competitiveness in the areas of energy, health, smart digitisation and the environment.





# Facts about ESS



5 MW  
particle  
accelerator  
2 MW at start



15  
instruments  
next step is 22



3 000  
guest scientists visiting per  
year  
to conduct experiments



800  
experiments per  
year



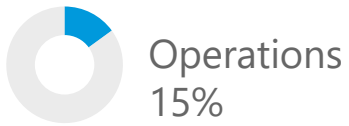
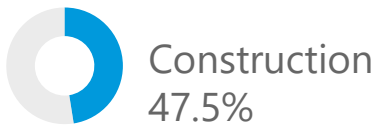
BREEAM  
Renewable  
energy & waste  
heat recovery



# A coalition of 13 European countries

## Host countries

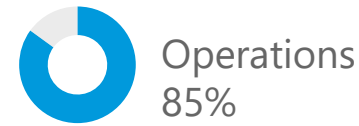
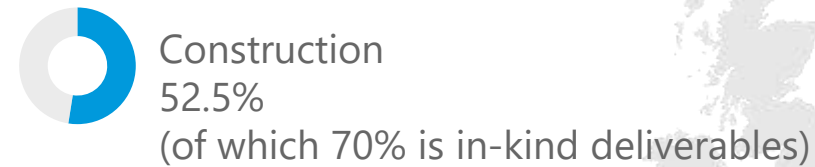
Sweden, Denmark



Base budget for construction  
 €1.84 B<sub>2013</sub>  
 Estimated annual operating  
 budget €140 M<sub>2013</sub>

## Non host member countries

Czech Republic, Estonia, France, Germany, Hungary, Italy, Norway, Poland, Spain, Switzerland, United Kingdom



# Behind the scenes



More than 600 employees from over 61 countries all over the world and in excess of 100 collaborating institutions, are constructing and building the worlds most intense neutron source





Copenhagen University  
M. Meldal



A European research centre for the world



**SCIENCE  
VILLAGE**  
SCANDINAVIA



Lund University  
A. IHuillier



# ESS: a source to deliver meV neutron for the study of materials

Neutrons probes directly **magnetic spins**.

High technology society: magnetic and electronic phenomena.

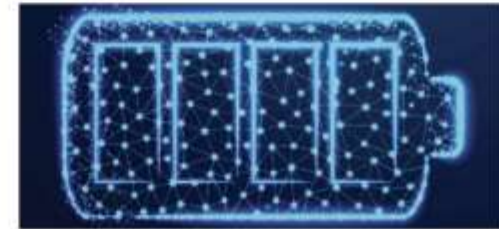
Magnetic spins:

- quantum computing / Classical  
= 200 sec/10 000 years (Google 2021)
- Superconductivity : lossless power transfer
- Magnetocaloric cooling : low carbon

The Nobel Prize in Physics 2016

David J. Thouless, F. Duncan M. Haldane and J. Michael Kosterlitz  
"for theoretical discoveries of topological phase transitions and topological phases of matter"

Neutrons: Probes directly light elements  
**(hydrogen, lithium)**



- Biological processes: where hydrogen (H) atoms are and how they are transferred between biomacromolecules, solvent molecules, and substrates.
- Optimise diffusion in battery materials.

The Nobel Prize in Chemistry 2019

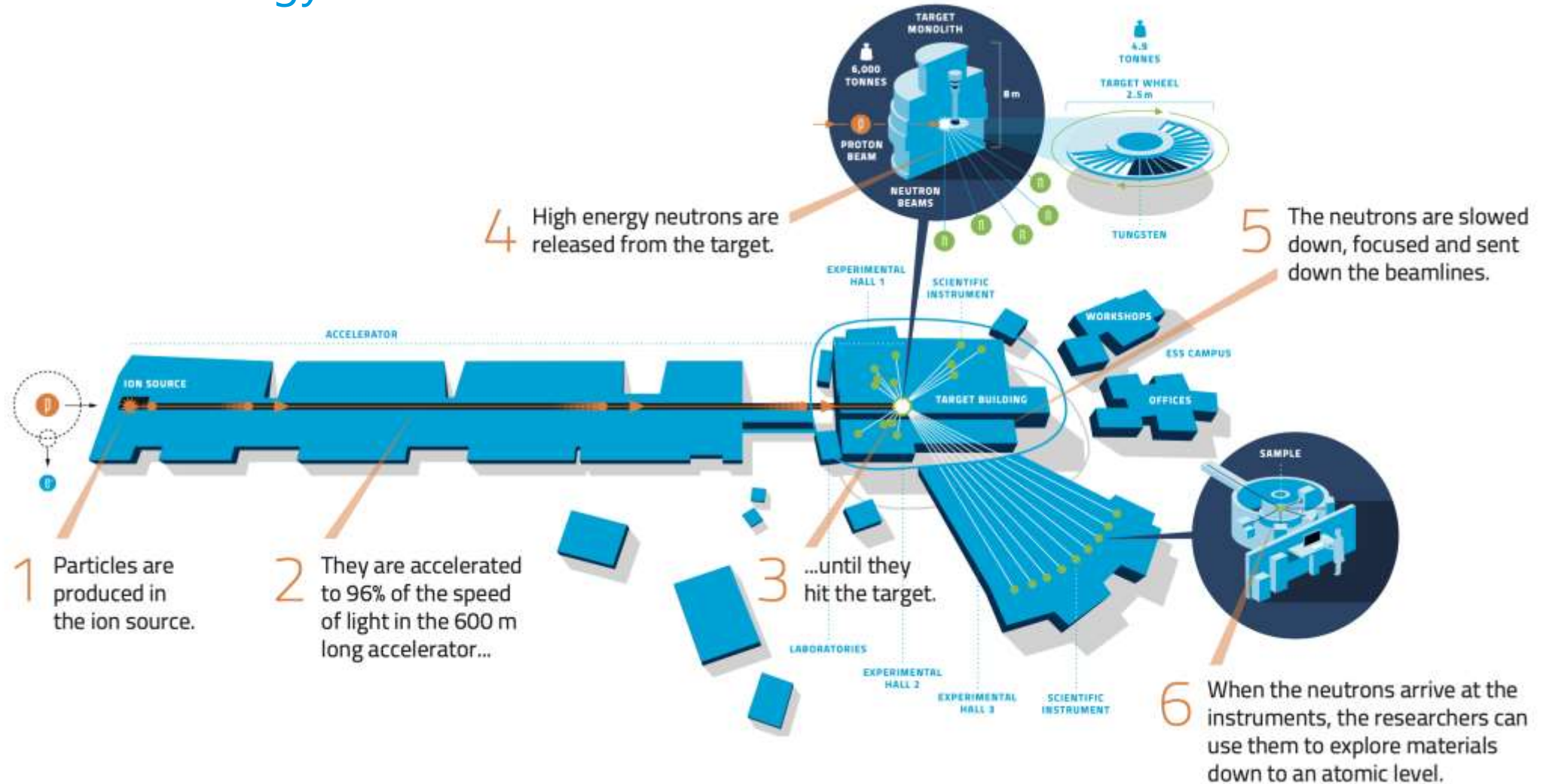
John B. Goodenough, M. Stanley Whittingham and Akira Yoshino "for the development of lithium-ion batteries"

Uniquely with the correct energy scale!!

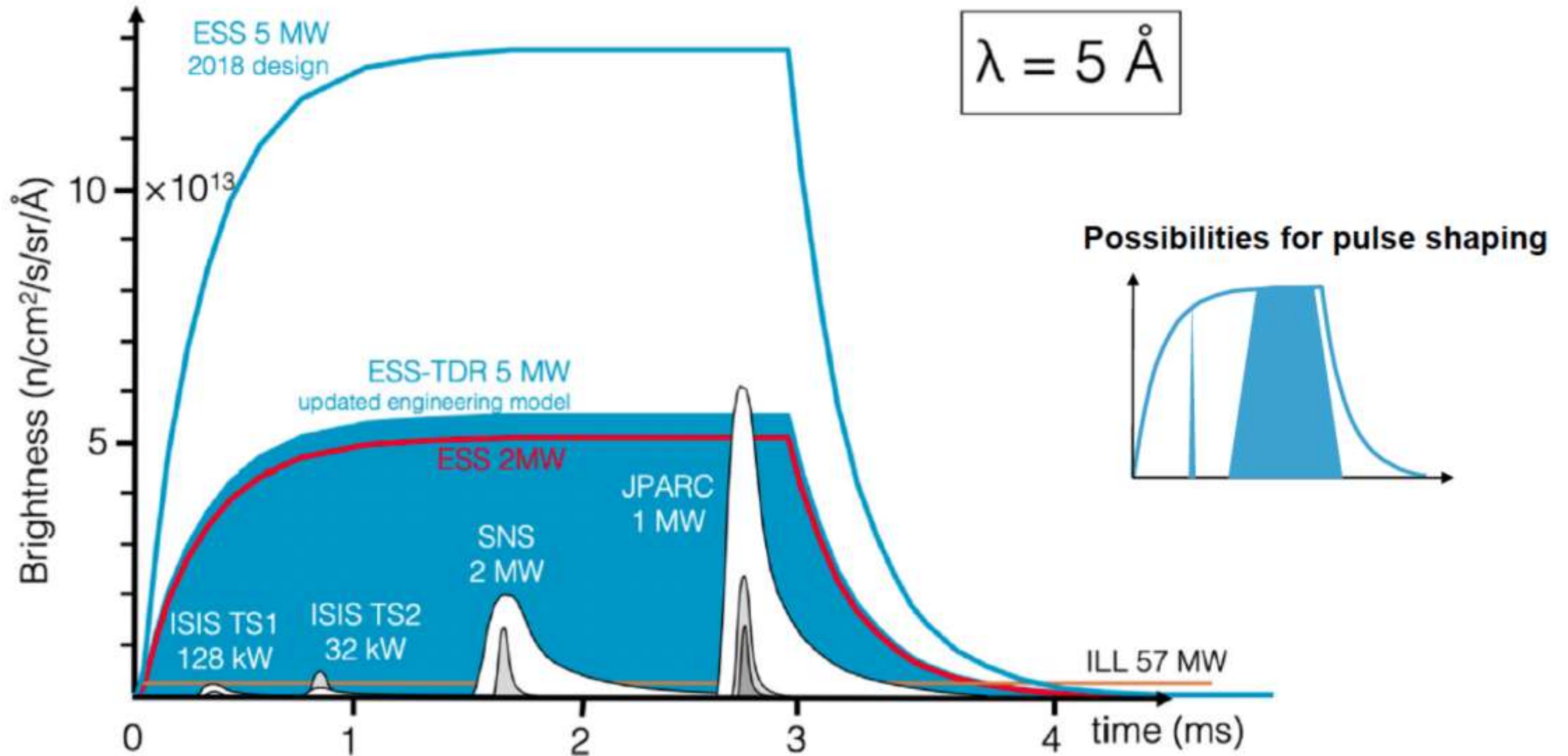


# How it works

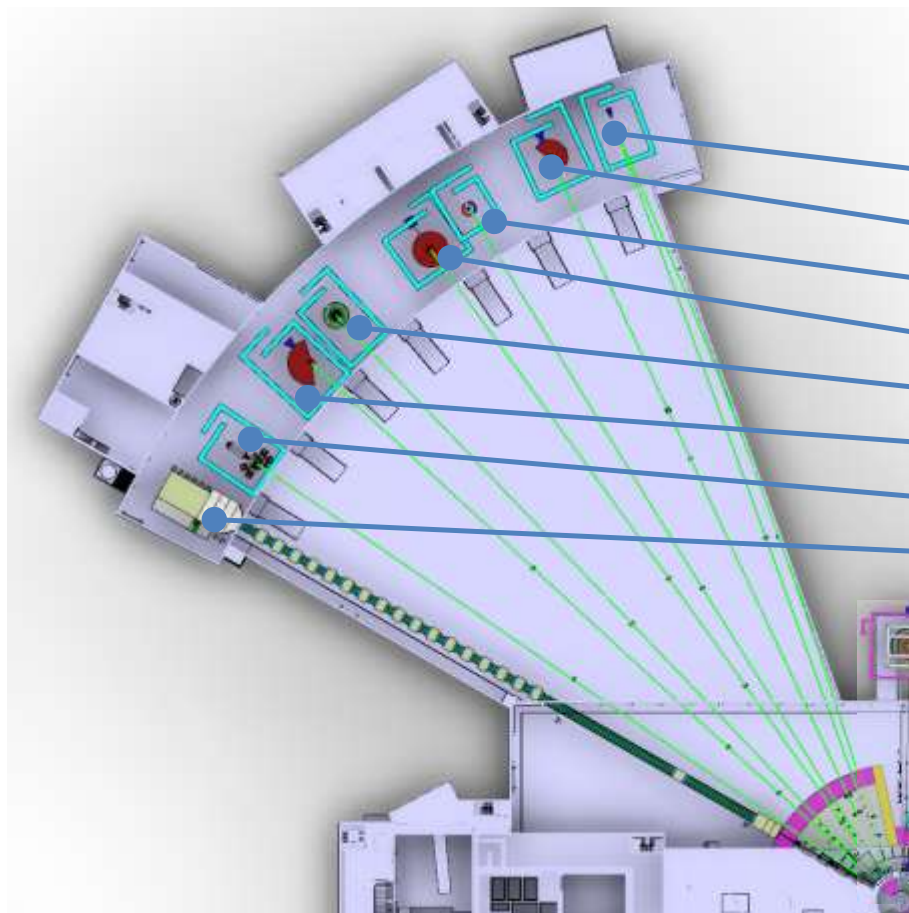
## The technology



# Unique long pulse of ESS (14 Hz)



# Broad instrument suite

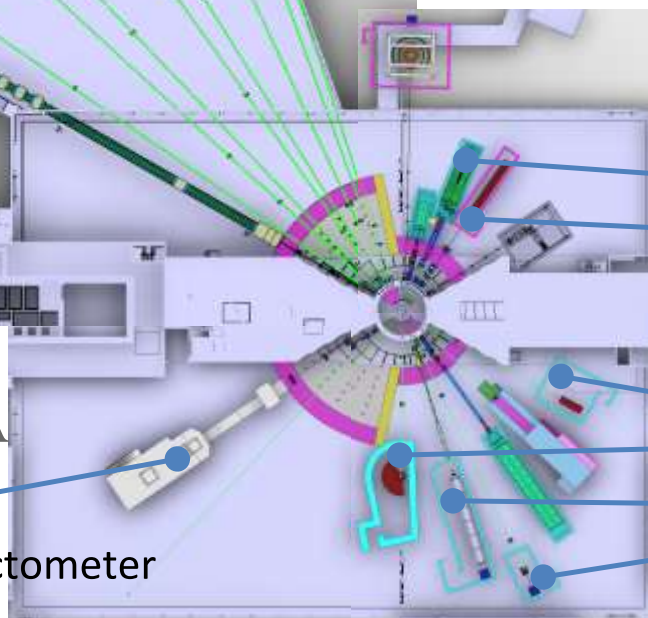


- HEIMDAL – Powder Diffractometer
- T-REX – Thermal Chopper Spectrometer
- MAGIC – Magnetism Diffractometer
- MIRACLES – Backscattering Spectrometer
- BIFROST – Extreme-Environments Spectrometer
- C-SPEC – Cold Chopper Spectrometer
- BEER – Engineering Diffractometer
- NMX – Macromolecular Crystallography

160 m :  $\Delta\lambda \sim 1.7 \text{ \AA}$

40 – 50 m  $\Delta\lambda \sim 6-7 \text{ \AA}$

- ODIN – Imaging
- DREAM – Powder Diffractometer



- LOKI – Broadband SANS
- FREIA – Liquids Reflectometer

30 – 45 m :  $\Delta\lambda \sim 7-9 \text{ \AA}$

- ESTIA – Magnetism Reflectometer
- VOR – Broadband Spectrometer
- SKADI – Low-Q SANS
- VESPA – Vibrational Spectroscopy

# Broad instrument suite & future possibilities



Large-Scale Structures

ODIN Imaging Instrument					
SKADI General Purpose SANS					
LOKI Broadband SANS					
Surface Scattering					
FREIA Horizontal Reflectometer					
Estia Vertical Reflectometer					
HEIMDAL Powder Diffractometer					
DREAM Powder Diffractometer					
Monochromatic Powder Diffractometer					
BEER Engineering Diffractometer					
Extreme Conditions Diffractometer					
MAGiC Magnetism Diffractometer					
NMX Macromolecular Diffractometer					

Diffractometer

Spectroscopy

CSPEC Cold Chopper Spectrometer				
Broadband Spectrometer				
T-REX Thermal Chopper Spectrometer				
BIFROST Crystal Analyser Spectrometer				
VESPA Vibrational Spectroscopy				
MIRACLES Backscattering Spectrometer				
High-Resolution Spin-Echo				
Wide-Angle Spin-Echo				
Particle Physics Beamline				

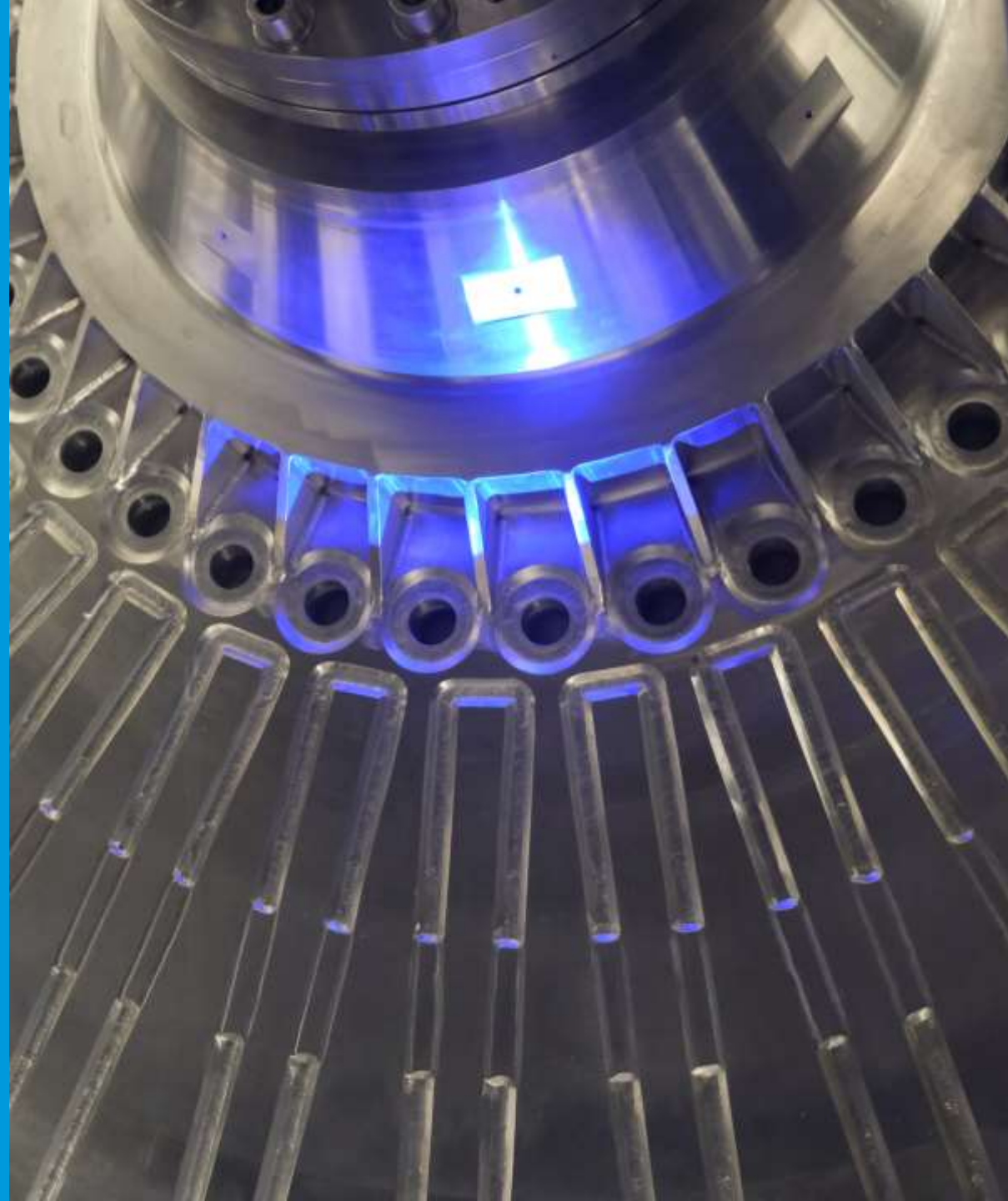
	life sciences		magnetism & superconductivity
	soft condensed matter		engineering & geo-sciences
	chemistry of materials		archeology & heritage conservation
	energy research		particle physics



Beam on Target: May 2025  
Start of user program: November 2026  
15th instrument commissioned: November 2027  
ESS is 73.9% complete

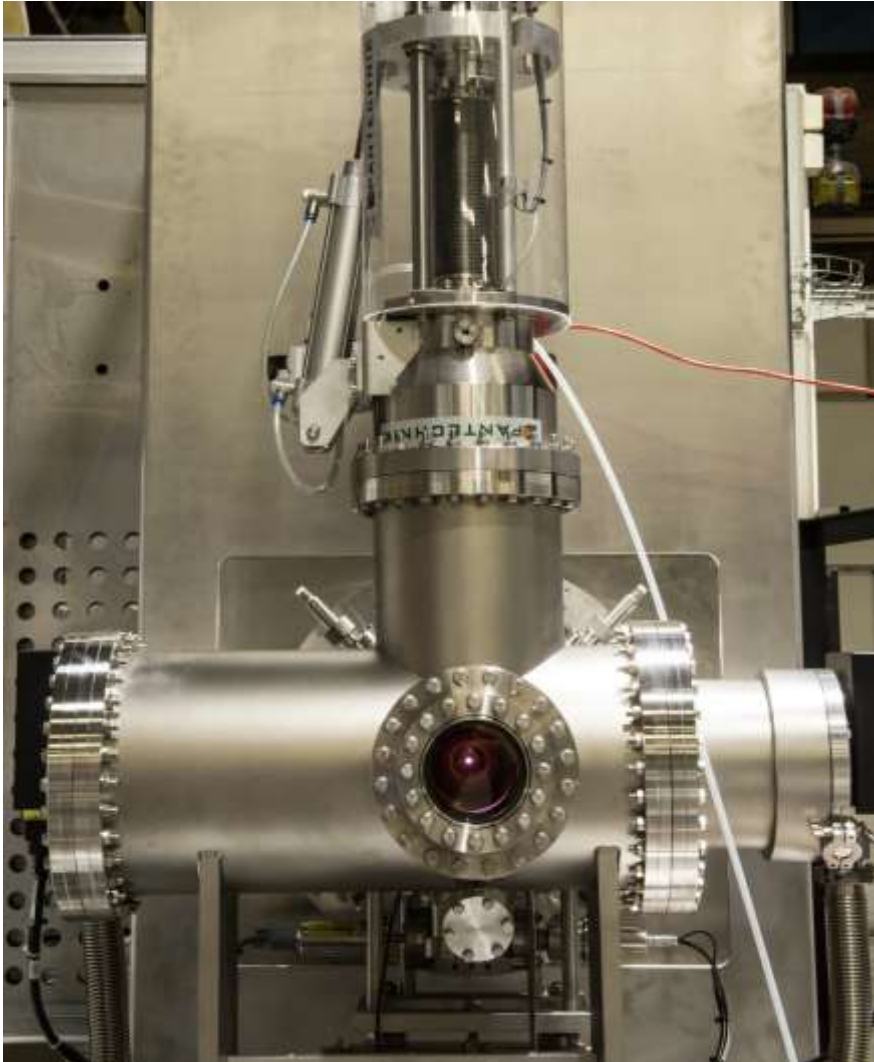
# An overview

- Ion source
- Accelerator
- Target
- Instruments



# Ion source (Delivered 2017)

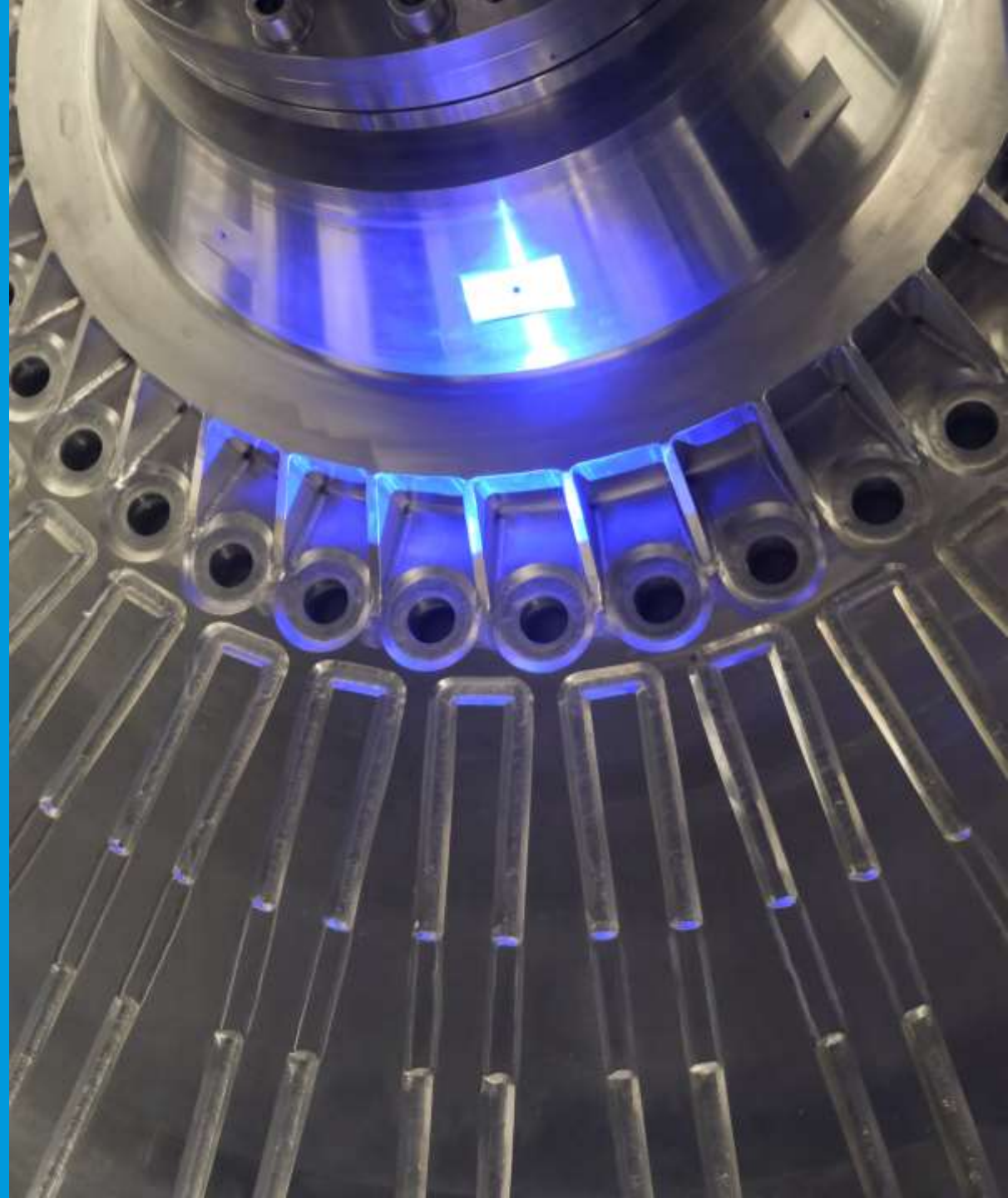
The Ion Source at ESS in-kind partner INFN-LNS, in Catania, Sicily



View of white, glowing ball of proton plasma in the Ion Source.

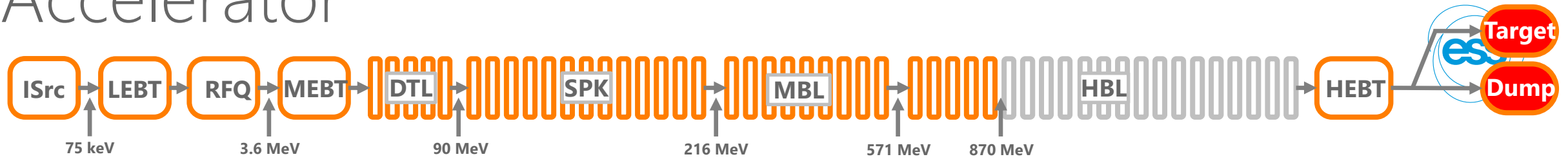
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# Accelerator



DTL 5/5 is in place

11/13 Spoke cryomodules installed, last two arrived & are in preparation.

Most magnets in place

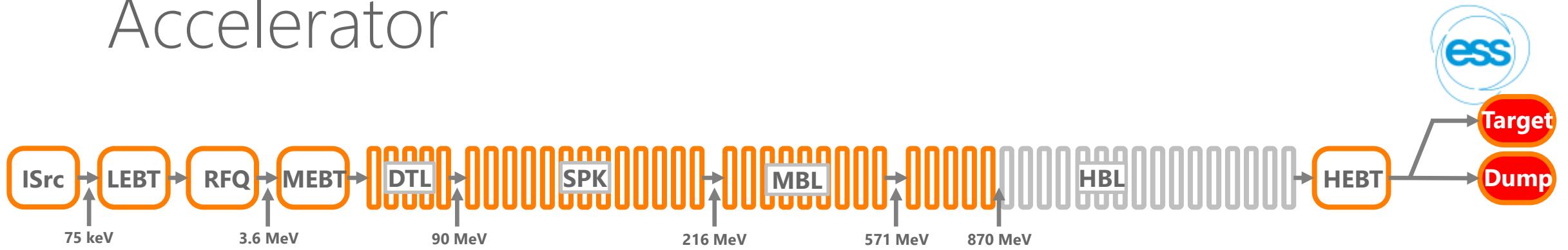
We are close to installing everything we need to deliver neutrons.

2017



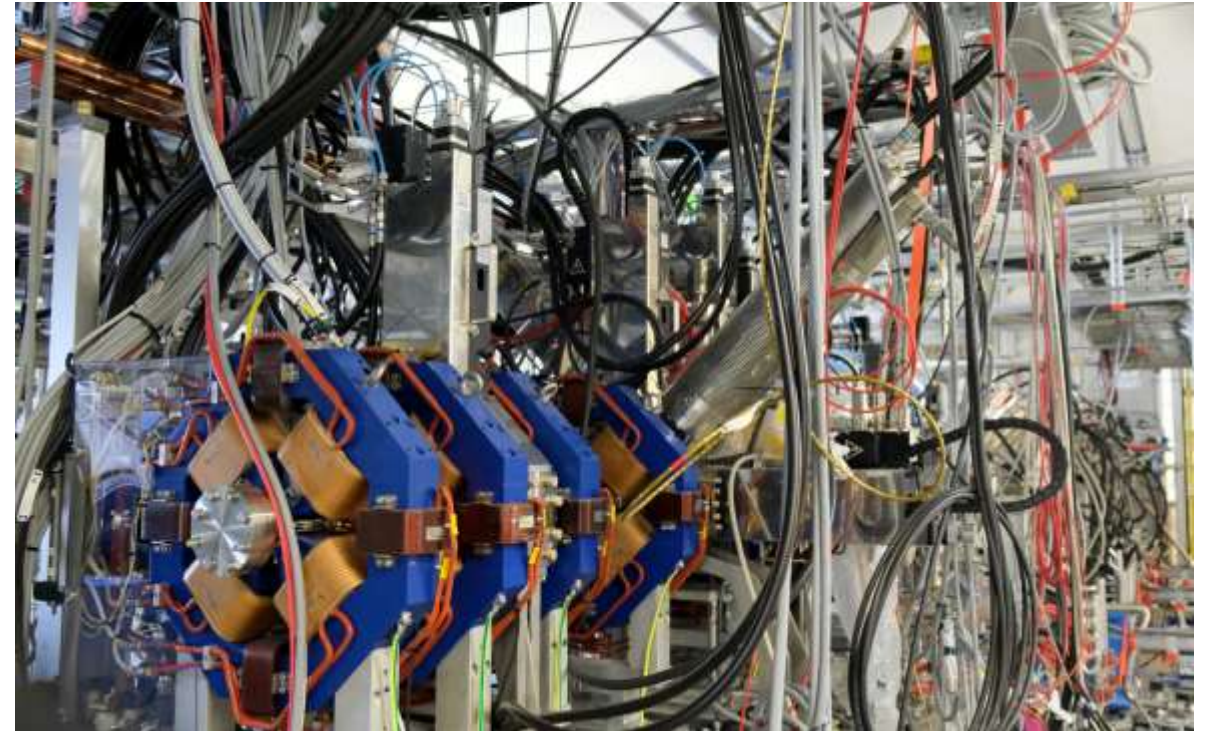
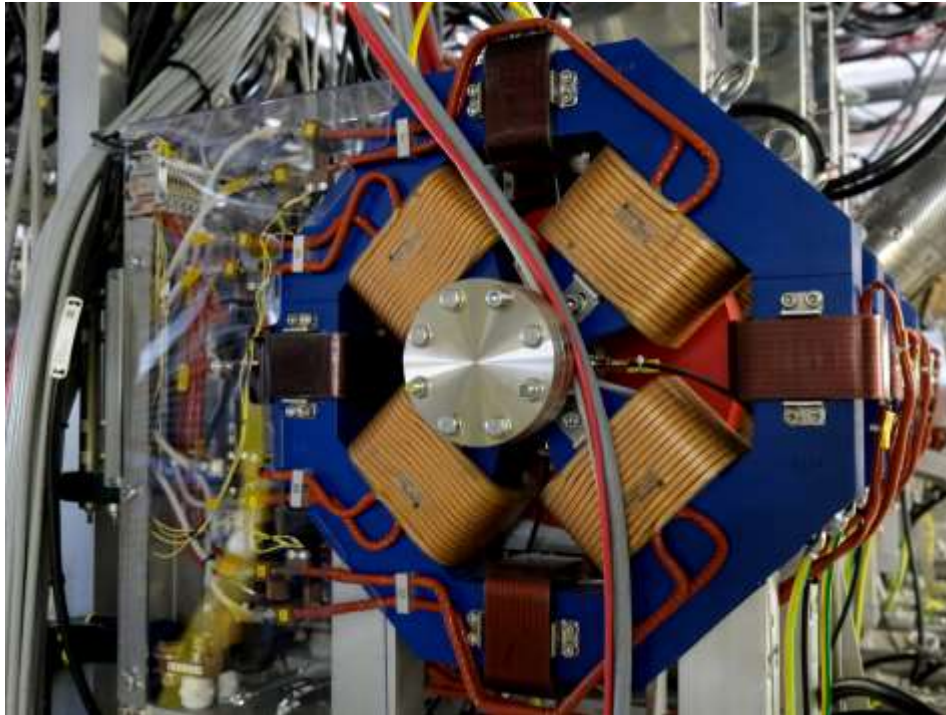
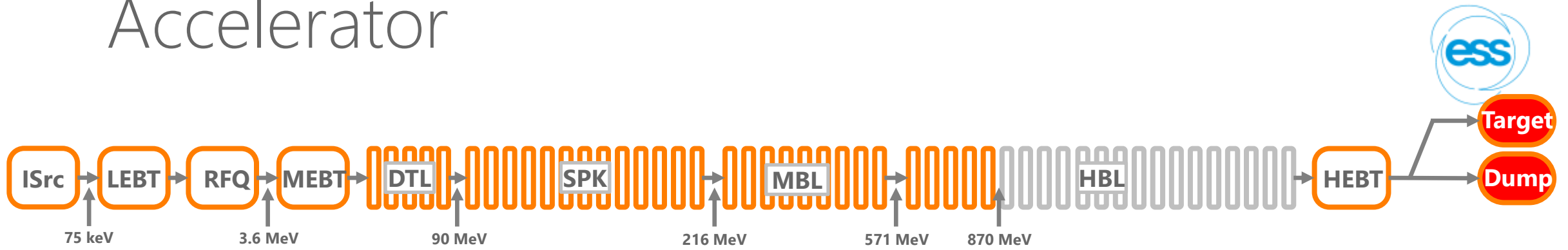
magnets in place  
to deliver neutrons.

# Accelerator



RFQ

# Accelerator



MEBT

# Accelerator

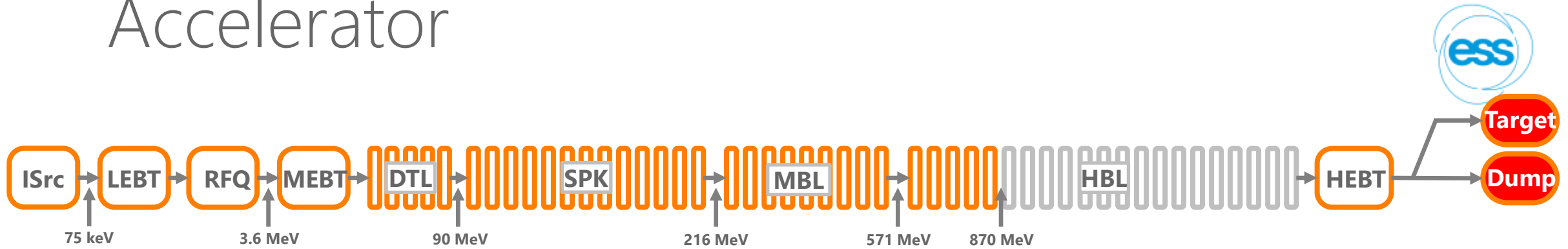


DTL



Klystron

# Accelerator



Cryo Systems for superconducting linac components  
Cooldown of the Cryogenics Distribution System (CDS)

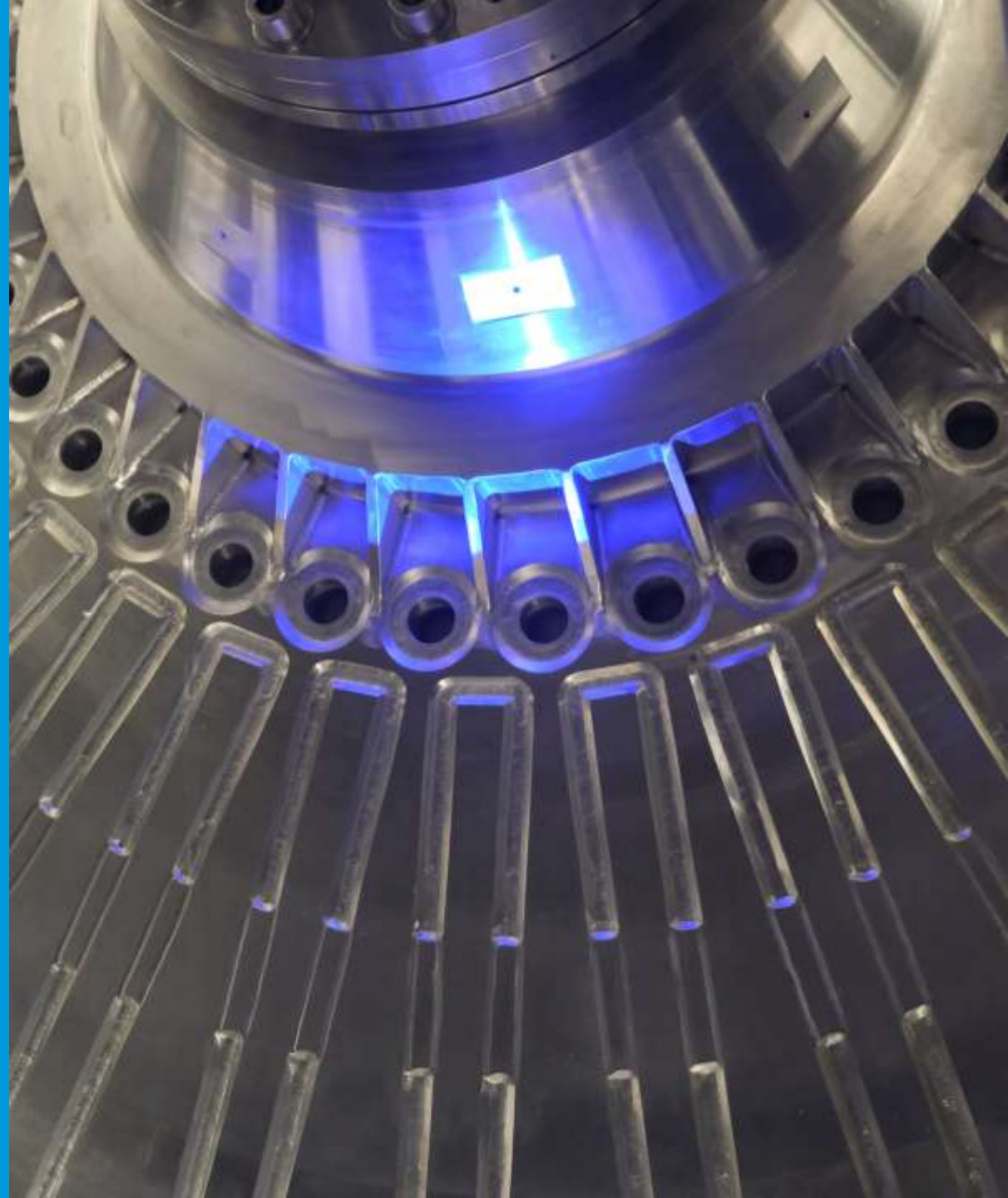


Spoke Cavities being installed



# An overview

- Ion source
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# Target: 2.3 m $\varnothing$

Tungsten rotating target (23 1/3 RPM)





# Target

Tungsten rotating target (23 1/3 RPM)



# Target

Tungsten rotating target (23 1/3 RPM)

Target cooling (Helium 3kg/s), in = 20 - 55°C, out = 180 - 273°C



# Target

Moderator/reflector plug



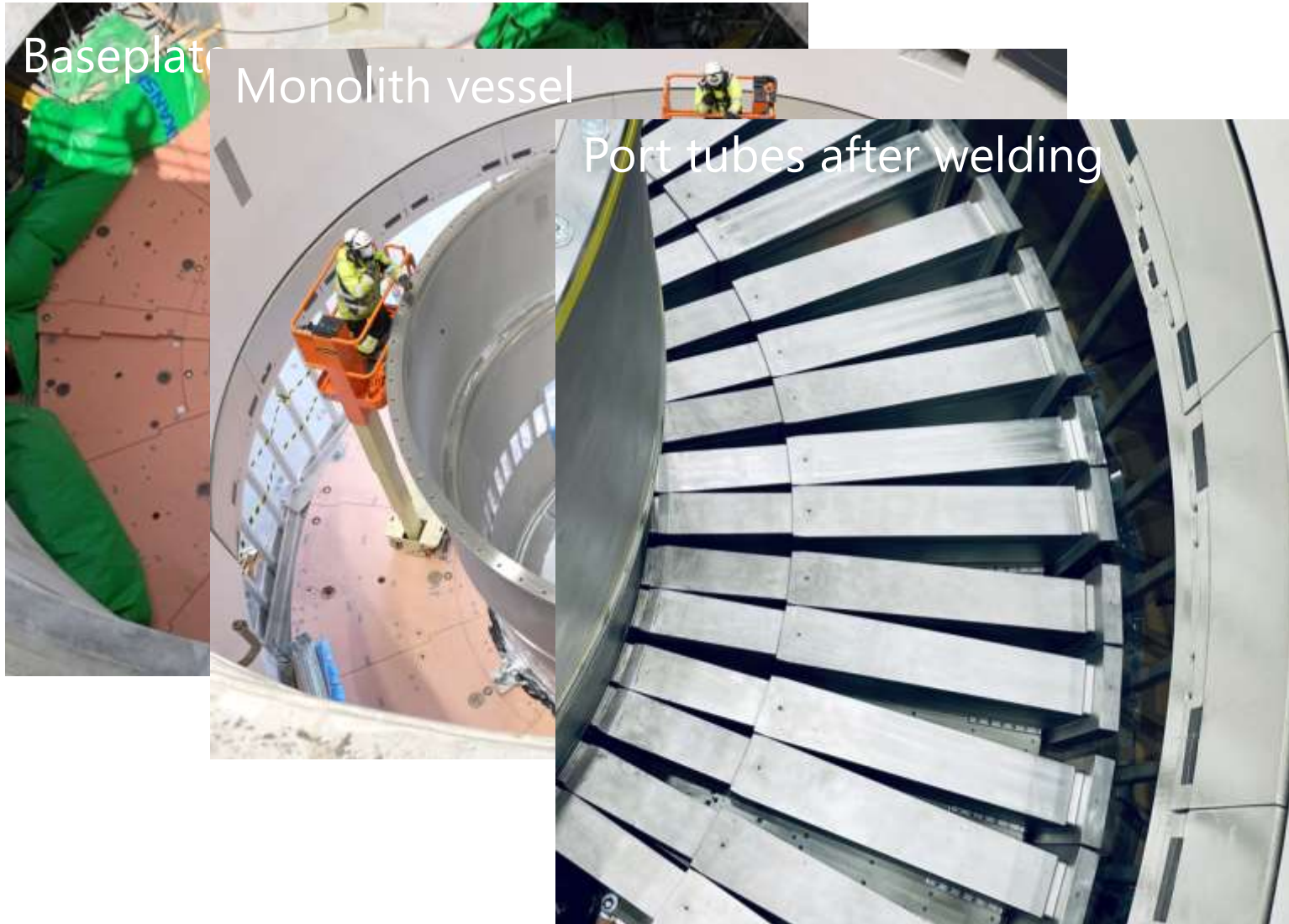
# Building up the target and Beam extraction



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# Building up the target and Beam extraction

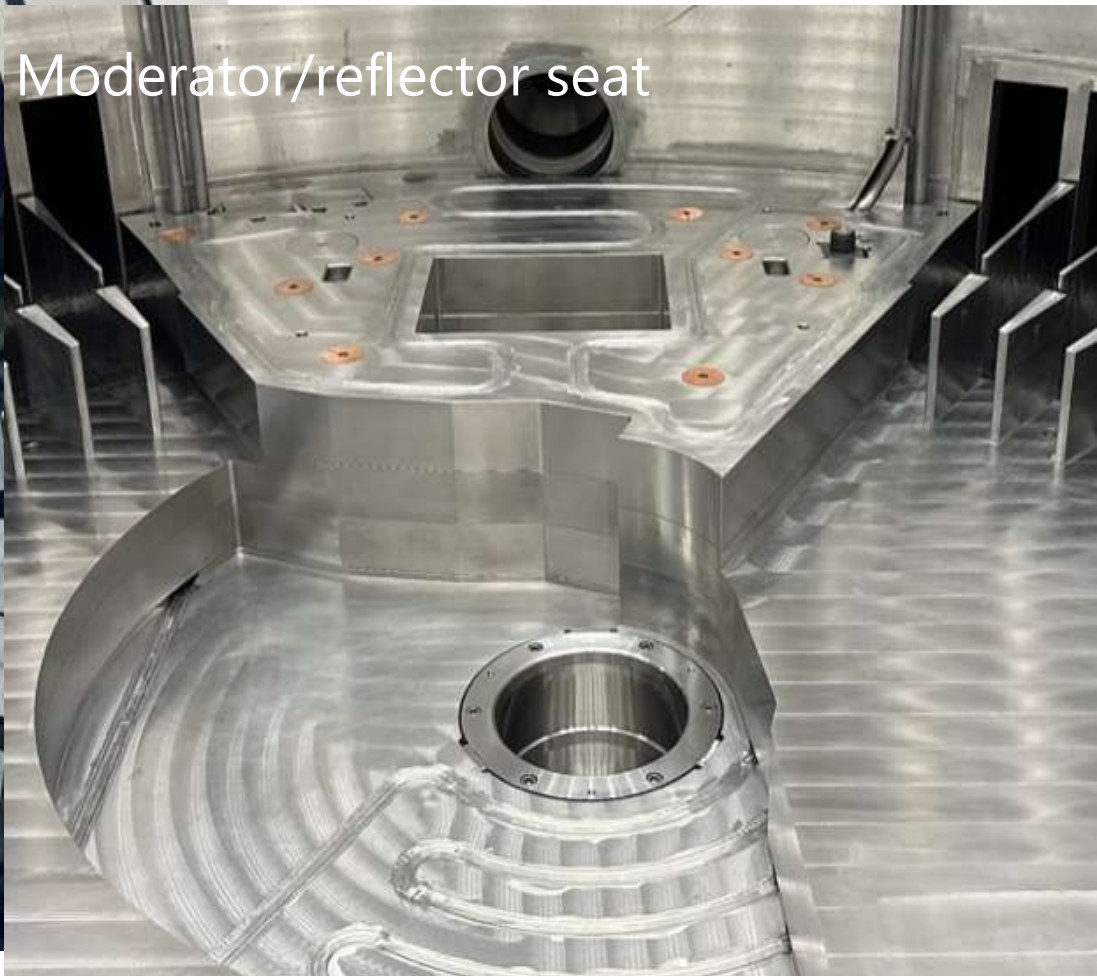


Baseplate

Monolith vessel

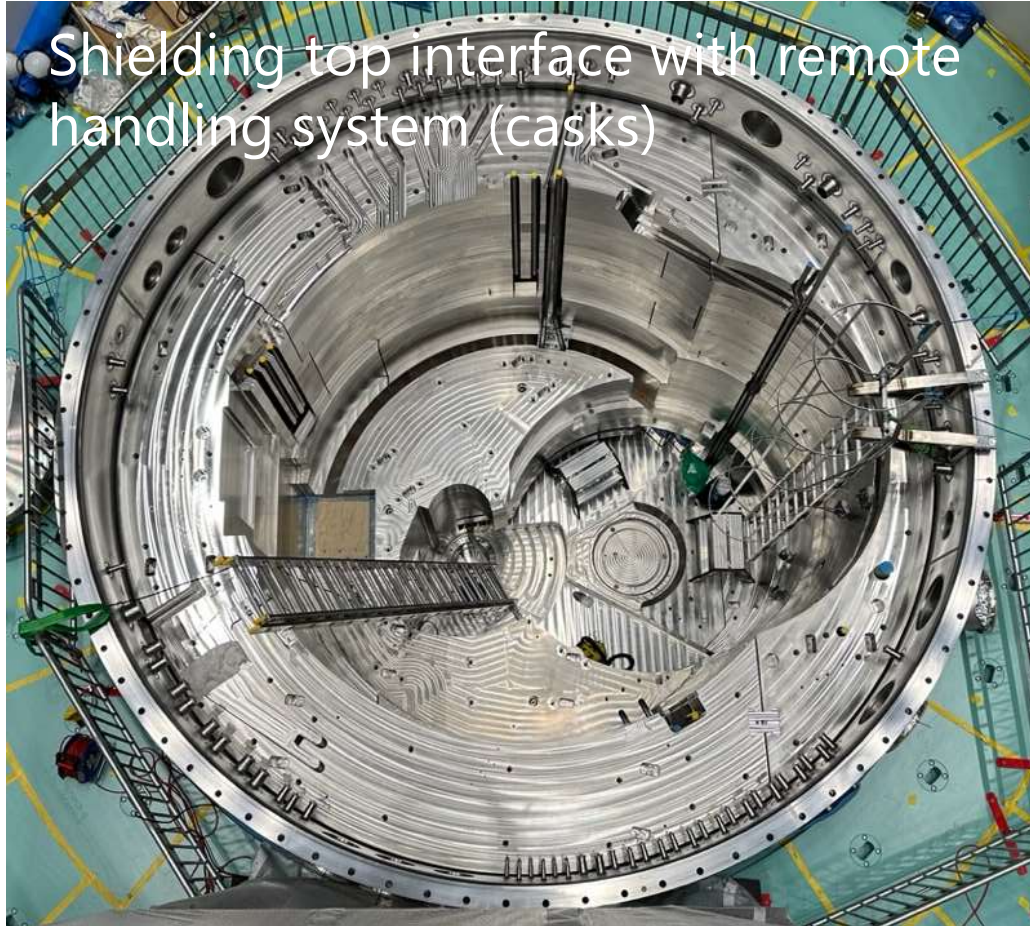


Port tubes after welding



Moderator/reflector seat

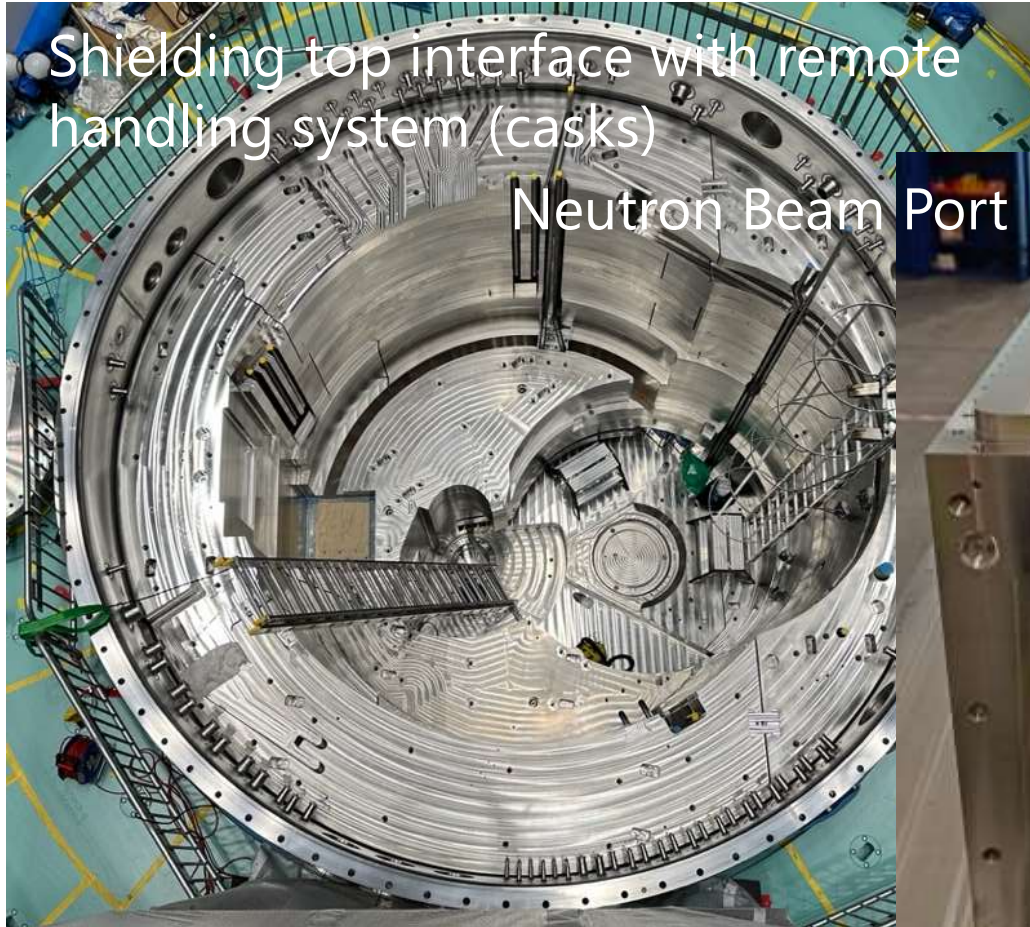
# Building up the target and Beam extraction



Shielding top interface with remote handling system (casks)



# Building up the target and Beam extraction

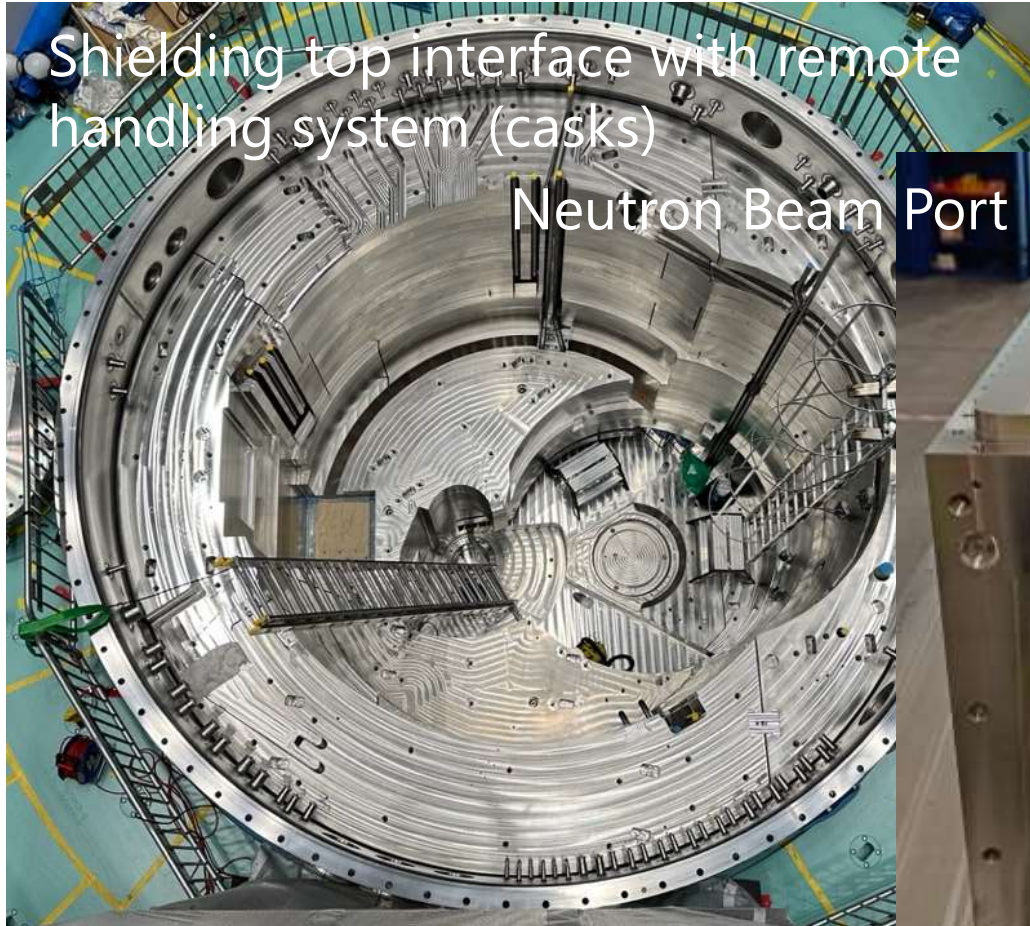


Shielding top interface with remote handling system (casks)

Neutron Beam Port Inserts (NBPI)

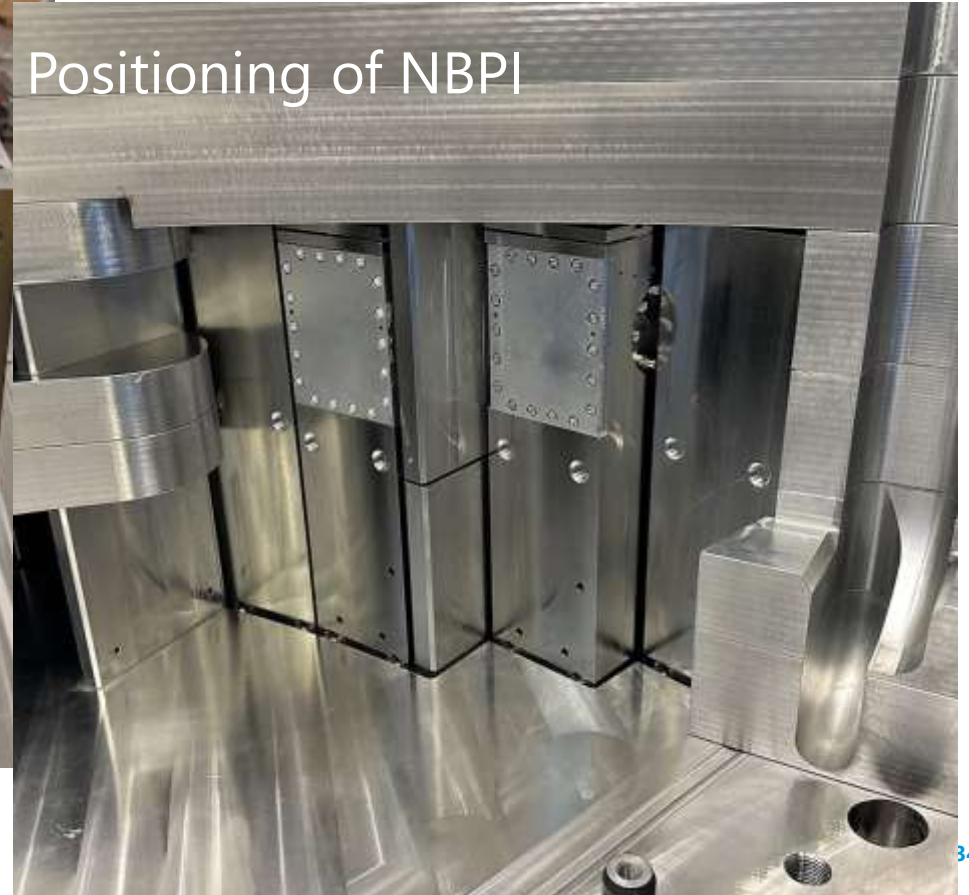


# Building up the target and Beam extraction



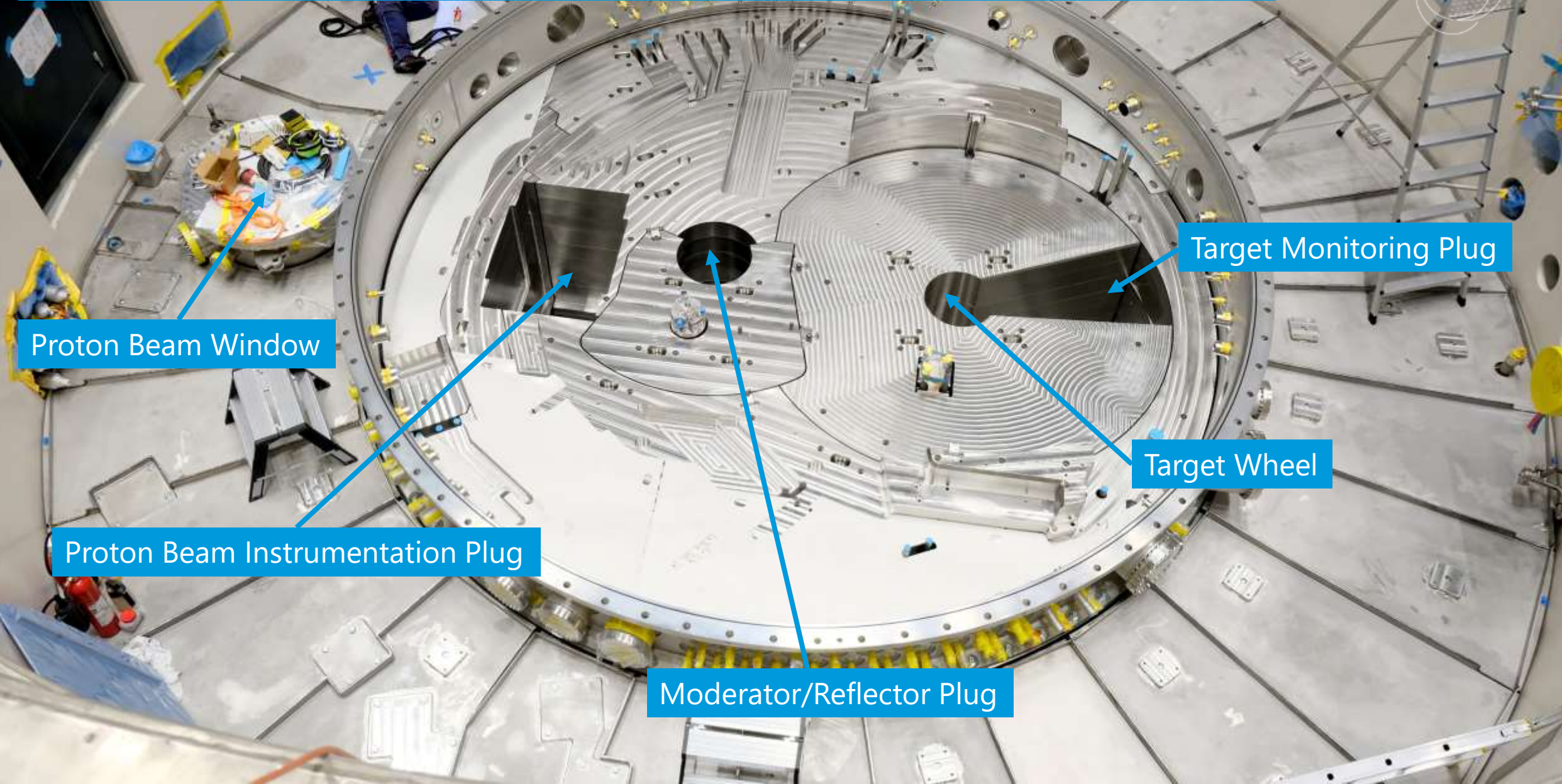
Shielding top interface with remote handling system (casks)

Neutron Beam Port Inserts (NBPI)



Positioning of NBPI

# Shielding completed



Proton Beam Window

Target Monitoring Plug

Proton Beam Instrumentation Plug

Target Wheel

Moderator/Reflector Plug

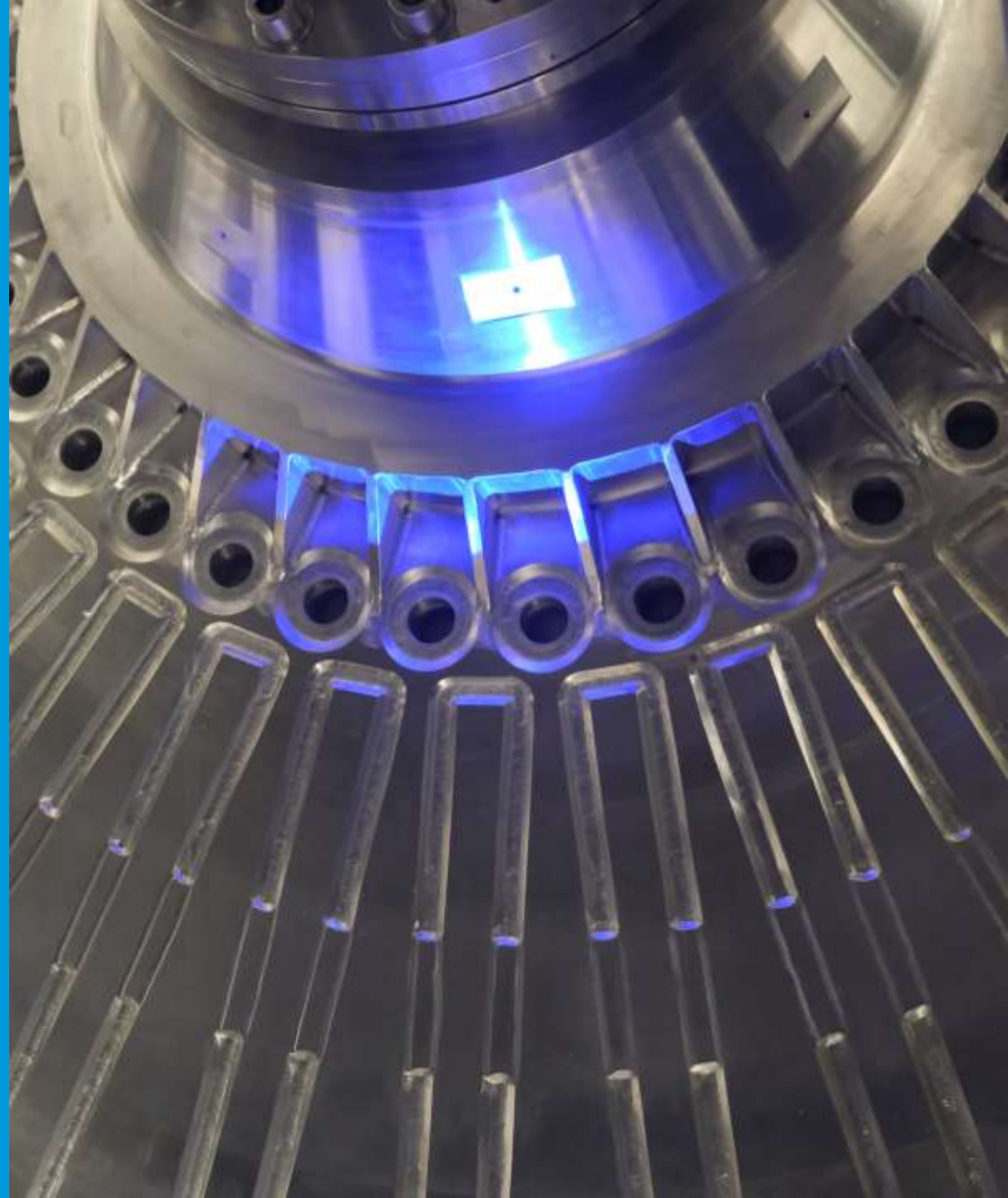
# Light Shutter System

ess

All NBPI and windows installed and vacuum test successful!  
First light shutter system installed

# An overview

- Ion source
- Accelerator
- Target
- Instruments (some)



# LOKI: Broadband SANS Completed 2024



Science and  
Technology  
Facilities Council



Collimation vessel

Infrastructure and cabling  
Detector system delivered

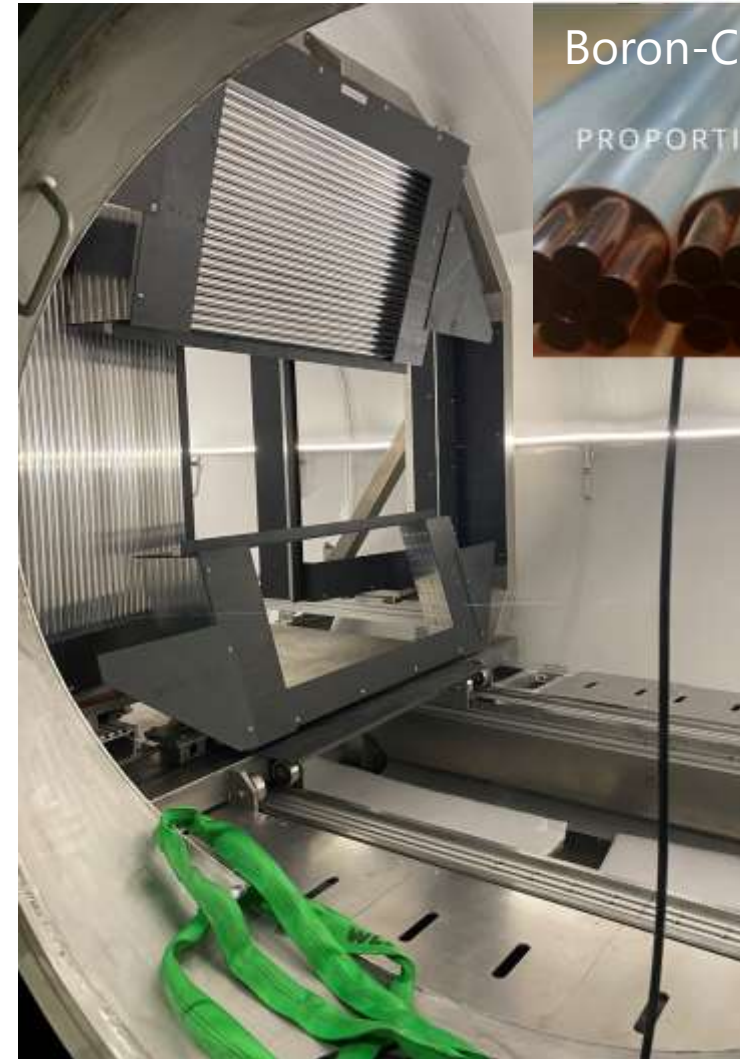


# Loki Broadband SANS

LoKi detector modules for the front and middle frames successfully tested and installed.



Science and  
Technology  
Facilities Council



Boron-Coated Straw Detectors

PROPORTIONAL TECHNOLOGIES, INC.



(ESS): Irina Stefanescu, (ISIS) David Raspino

# DREAM: Bi-spectral general purpose powder diffractometer



Detector support structure



# DREAM: Bi-spectral general purpose powder diffractometer

DREAM sample area.  
Installation of utilities.



# ODIN: Imaging instrument Completed 2024



# ESTIA: Vertical reflectometer for small samples Completed 2025



Selene guide 2 mirror mounting  
Cave and local crane installed

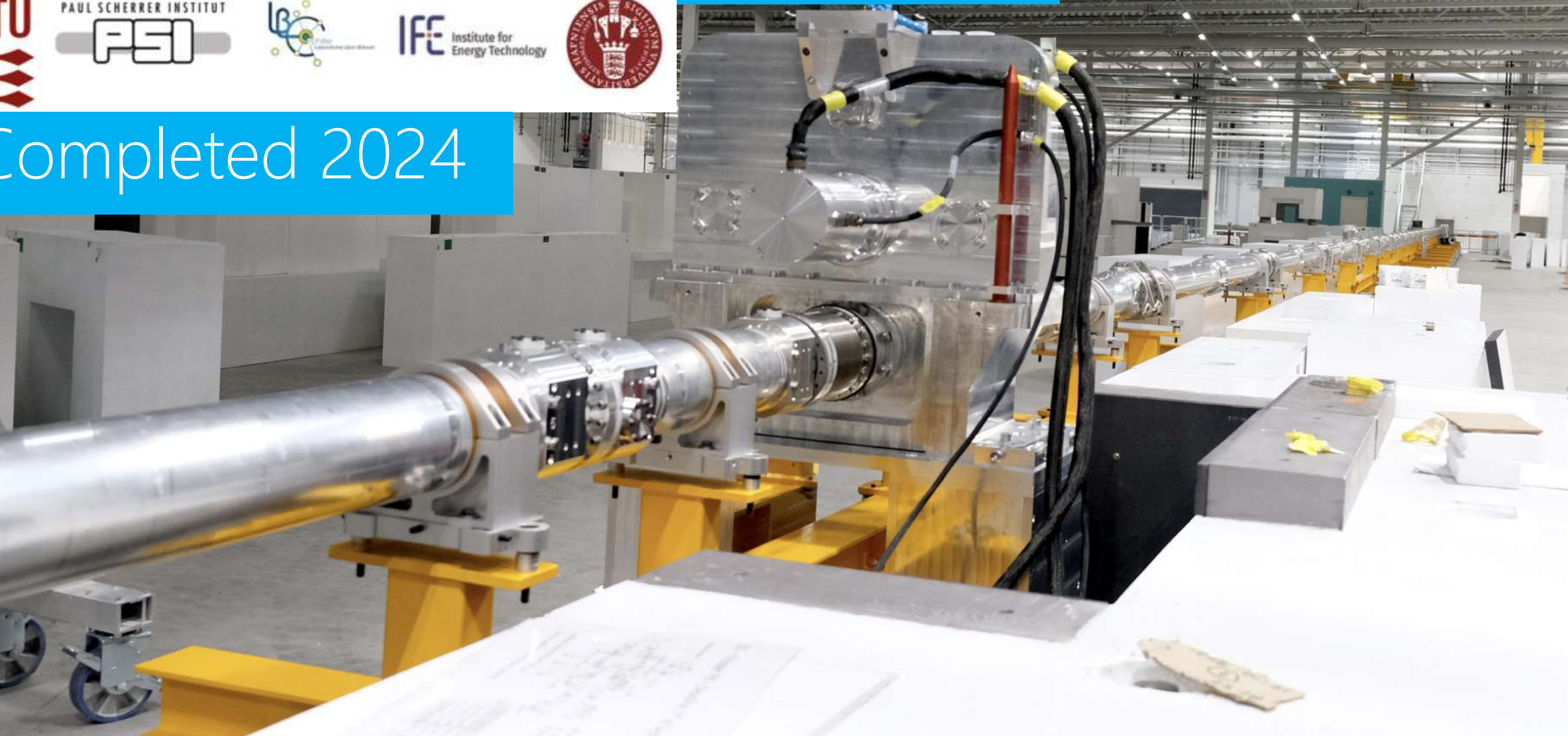
# ESTIA: Vertical reflectometer for small samples

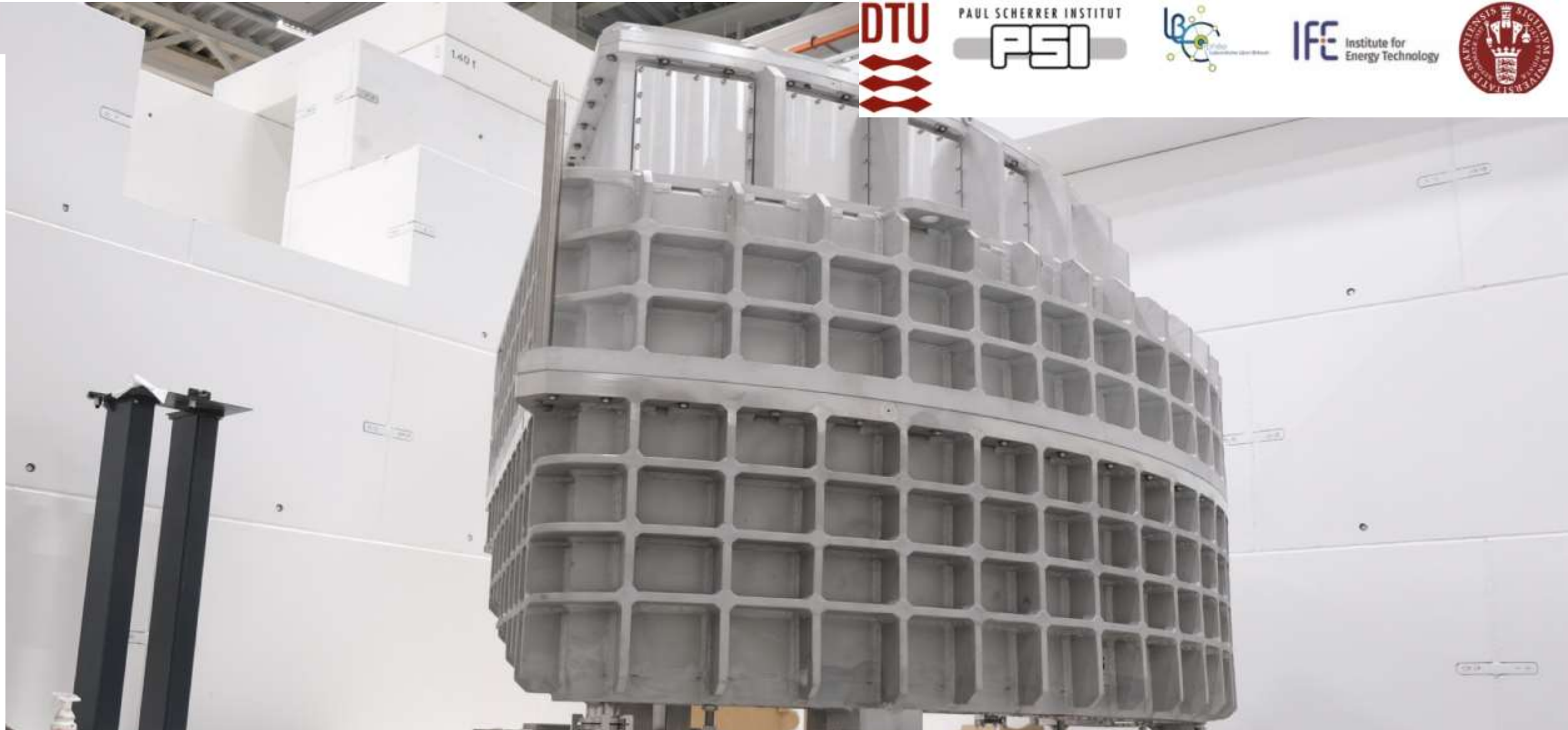


# BIFROST: Extreme environment cold spectrometer



Completed 2024

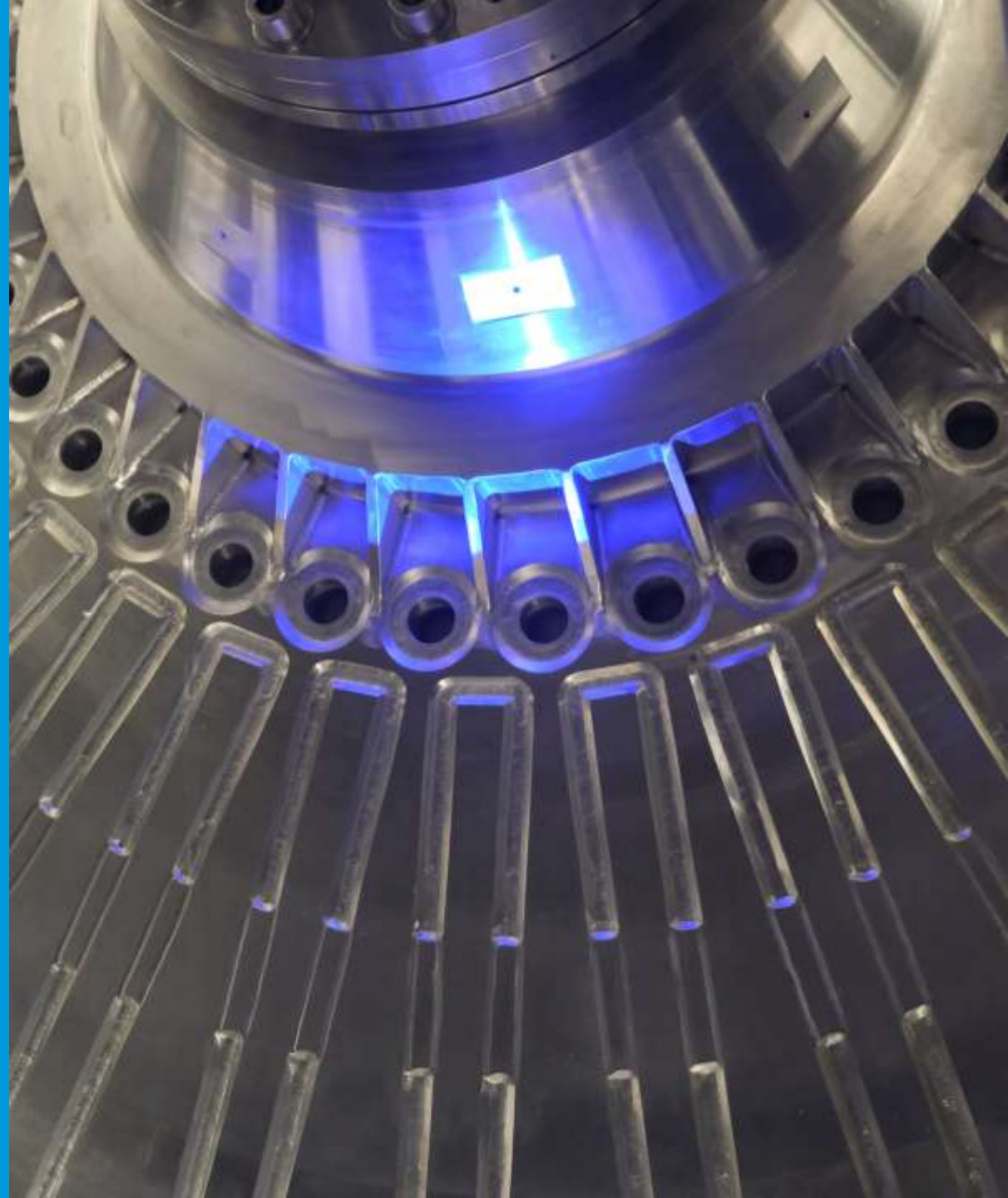




BIFROST: Extreme environment cold spectrometer

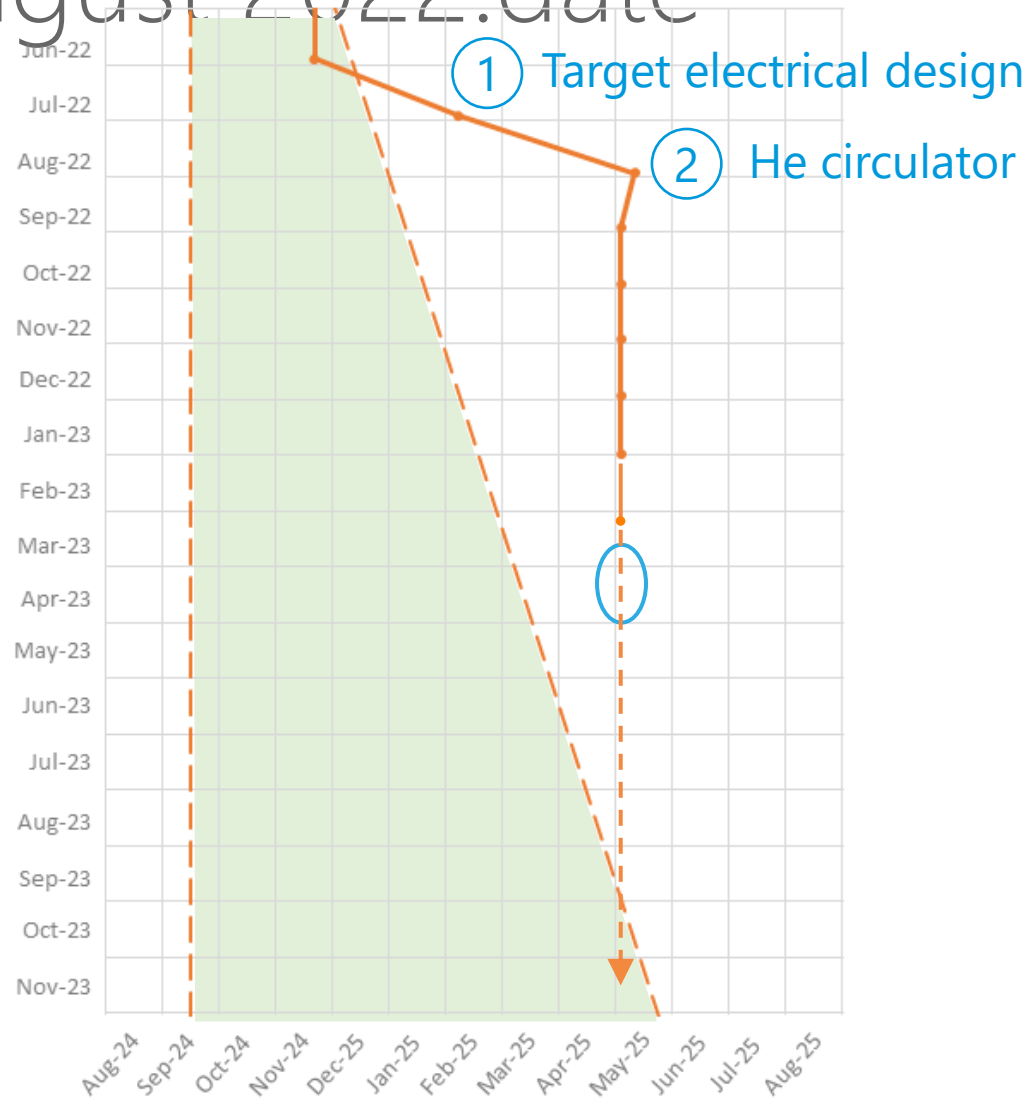
# An overview

- Ion source
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- Project performance



# Recent Project Performance

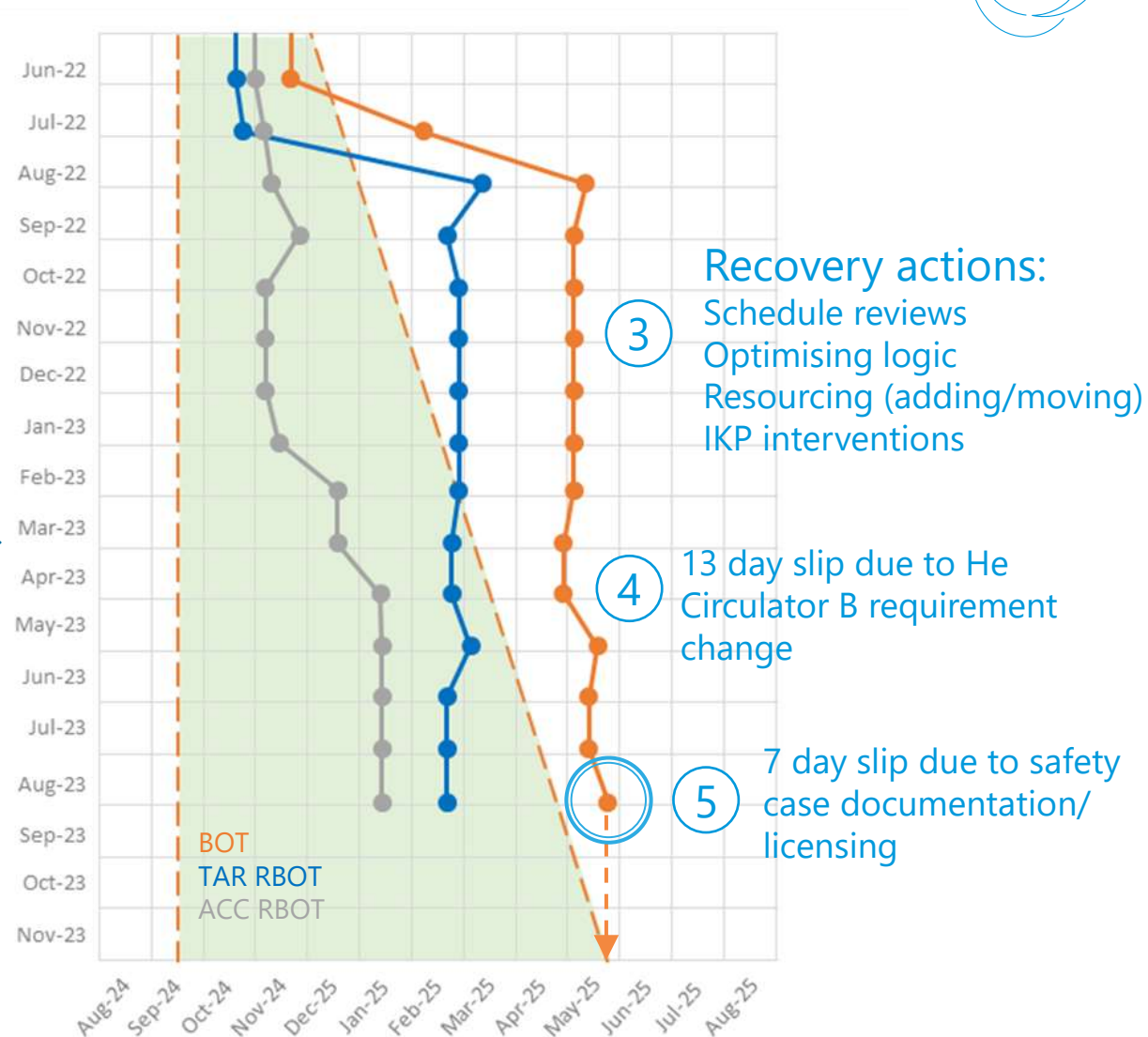
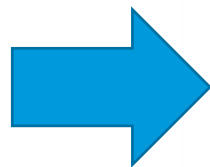
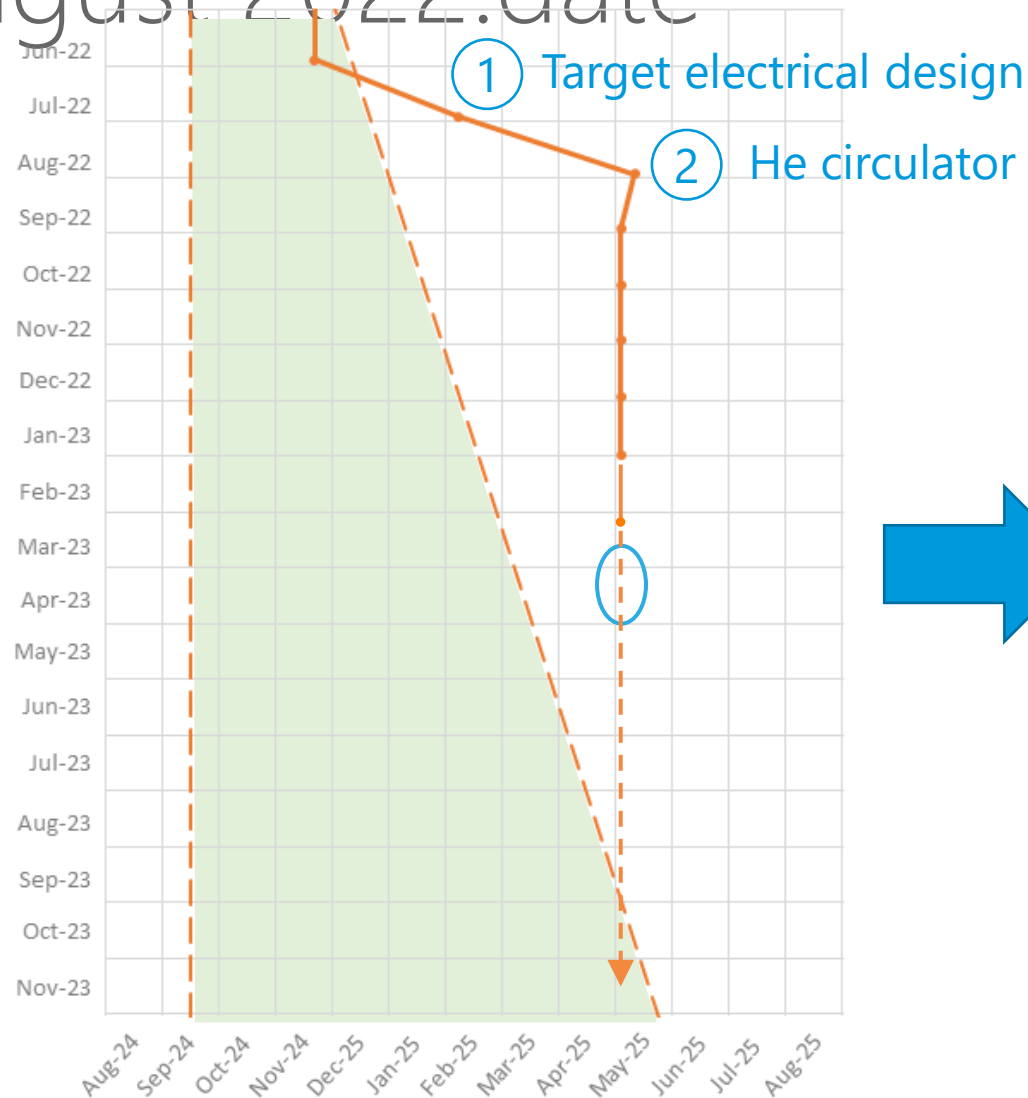
## August 2022:date





# Recent Project Performance

## August 2022:date



Beam on target remain estimated to be May 2025

# ESS is on a great path

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The European flagship facility for neutron science

Designed to enable scientific breakthroughs in matter and materials research with a particular focus technological competitiveness in the areas of energy, health, smart digitisation and the environment.

See you soon





# A world-leading facility built on partnership



ESS will welcome scientists from all over the world to come and conduct their experiments, building a deeper understanding of materials and molecules.

# Active cell handling



Operators are manipulating the Telbot system with the robotic arms of the manipulator in the Active Cell's control room.





# Summary

In the last 6 months we have continued to pass major milestones with visible progress in all areas.

Overall, the project continues to be stable with major milestone dates and project metrics largely unchanged.

However: there remain risks, technical challenges and potential delays that we are tracking closely and mitigating where possible.

We remain highly dependent on our partners to deliver high quality and in a timely manner.



Week 34: Process pipes from the cryomodules are welded to the valve boxes of the cryogenic distribution system.



# Transition into Steady State Operations





**MEDICINE & HEALTH**



**ENERGY**



**ENGINEERING**



**WORLD AROUND US**



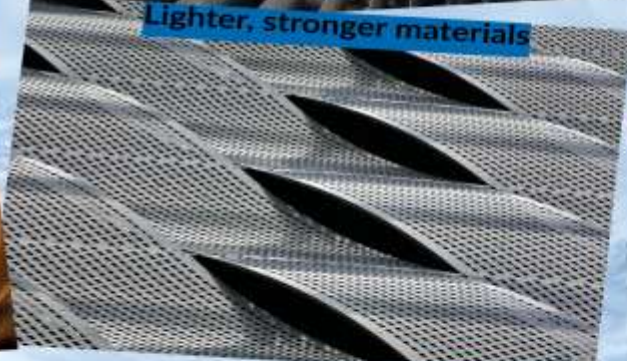
**Drug development**



**Better batteries**



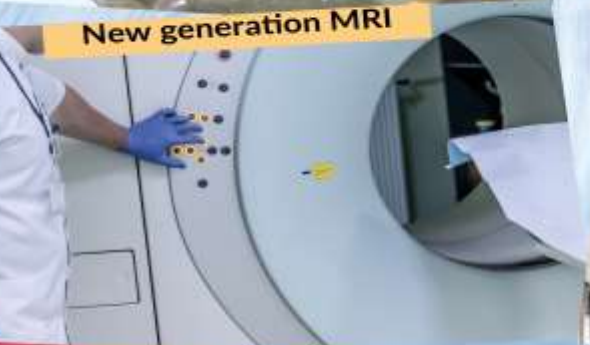
**Lighter, stronger materials**



**Advanced data storage**



**New generation MRI**



**Green fuel**



**Superconductivity**



**Disease resistant crops**



**Cellular biology**



**Improved solar cells**



**Better catalytic systems**



**Examining artefacts**

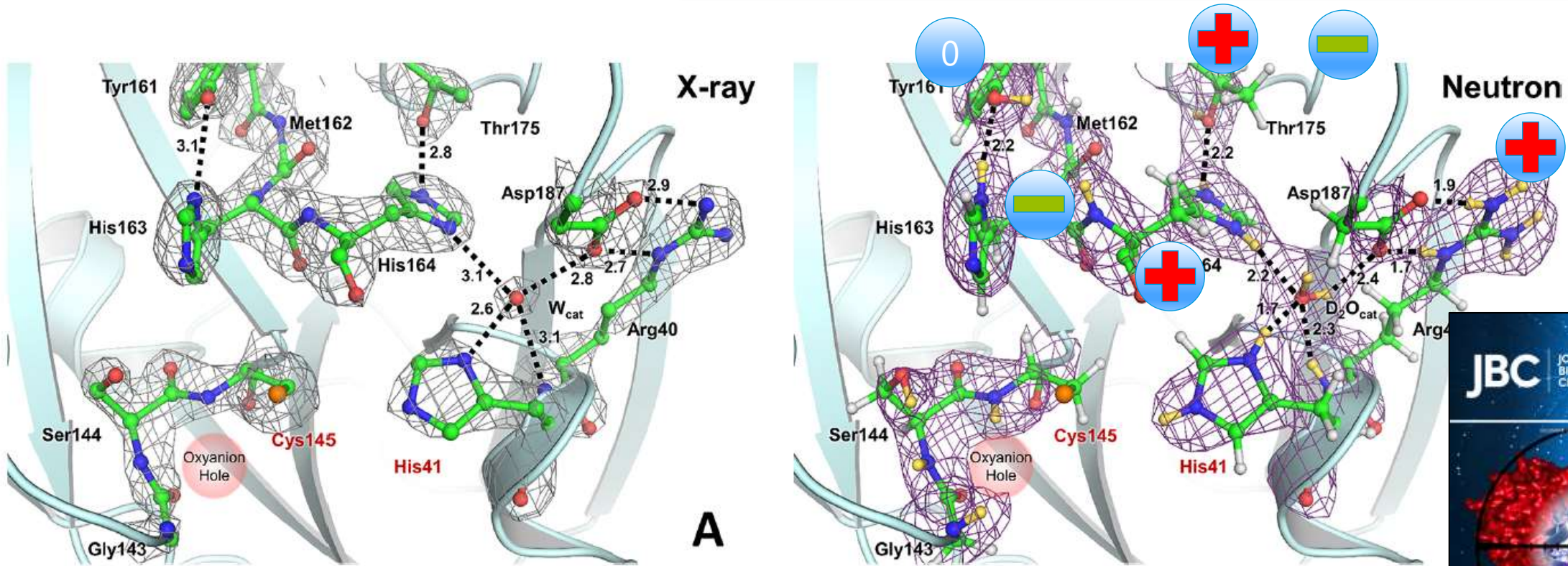


# Helping fight diseases



An example from SNS

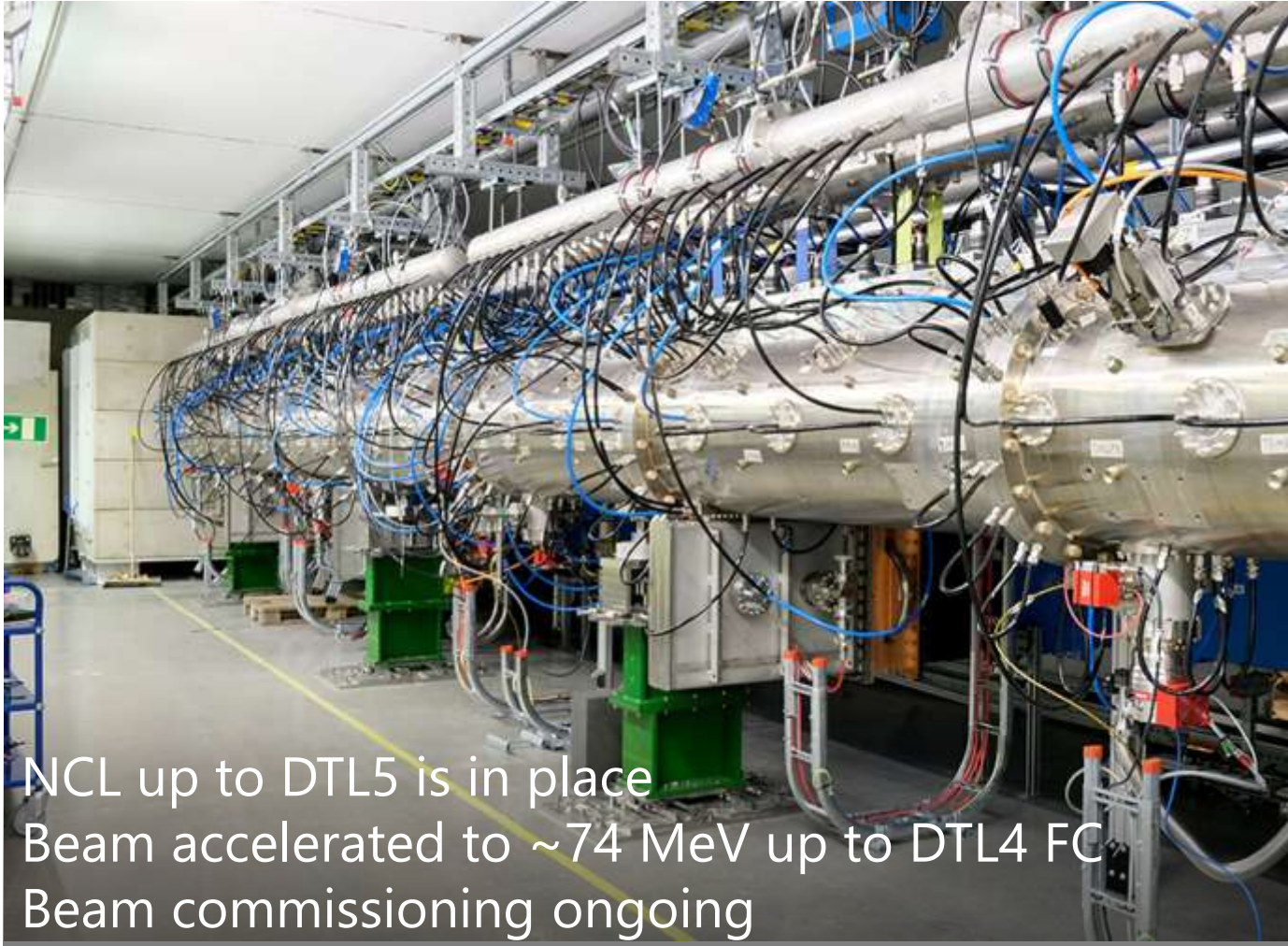
First cysteine (coronavirus) protease neutron structure:  
*non-canonical catalytic dyad is zwitterionic*



Kneller et al. *J. Biol. Chem.* 2020



# Accelerator



NCL up to DTL5 is in place  
Beam accelerated to  $\sim 74$  MeV up to DTL4 FC  
Beam commissioning ongoing



Gallery Spoke and Medium Beta  
RF Systems under high power  
testing



# CDS Cooldown + CM Series Installation

## Cooldown of the Cryogenics Distribution System (CDS)





Let us shape our  
future together

