EUROPEAN
SPALLATION
SOURCE

Introduction to ESS

ESS/J-PARC Collaboration Commissioning Workshop

PRESENTED BY KEVIN JONES, TECHNICAL DIRECTOR

Agenda

1 The ESS Site and High-Level Capability

2 Status of the Construction Project

3 Recent Highlights

4 Moving toward Integrated Commissioning and Operation

5 Concluding Remarks

The ESS Site and High-Level Capability

European Spallation Source

Civil construction is complete and the ESS organization now manages the full ESS site

Facts about ESS

2003
Concept design of ESS presented

2009
Decision to site ESS in Lund

2012
ESS design update phase complete

2014
Start of construction

2019
Start of initial operations phase

2022
Today

2025/6
First science

2027
Construction phase completed

5 MW particle accelerator
2 MW at start

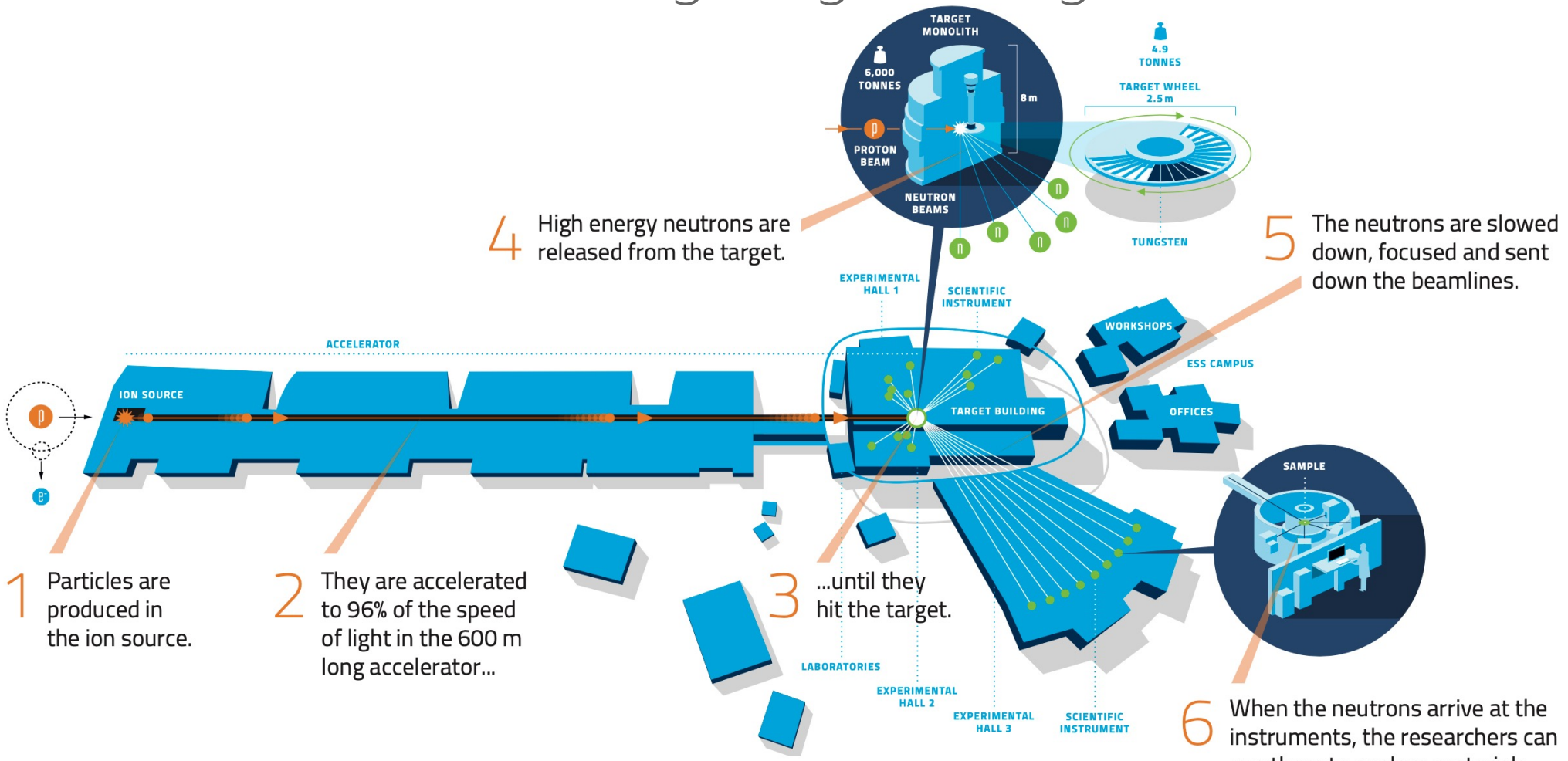
15 instruments
next step is 22

3 000 guest scientists visiting per year
to conduct experiments

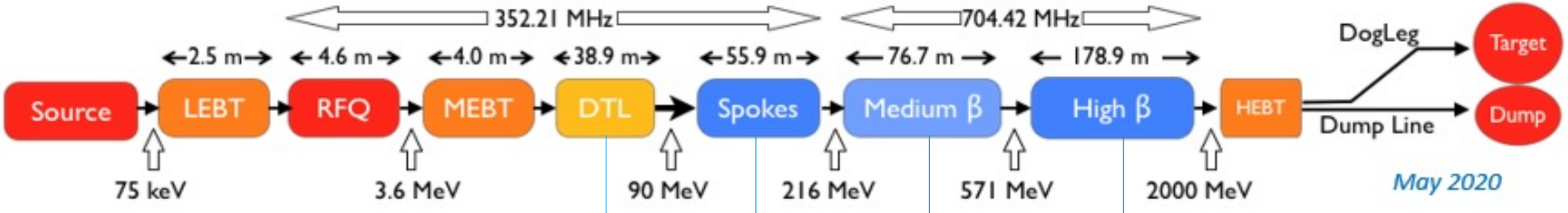
800 experiments per year

BREEAM Renewable energy & waste heat recovery

The ESS neutron source is designed to deliver a 5 MW proton beam to a rotating tungsten target



The ESS accelerator will deliver proton beam pulses at 14 Hz and 2,86 ms to the rotating tungsten target



Full peak current is 62,5 mA, and beam duty factor is 4,0 %

Target has 36 segments and rotates at 23,333 Hz so that each beam pulse strikes a new segment

13 cryomodules: 2 cavities per cryomodule

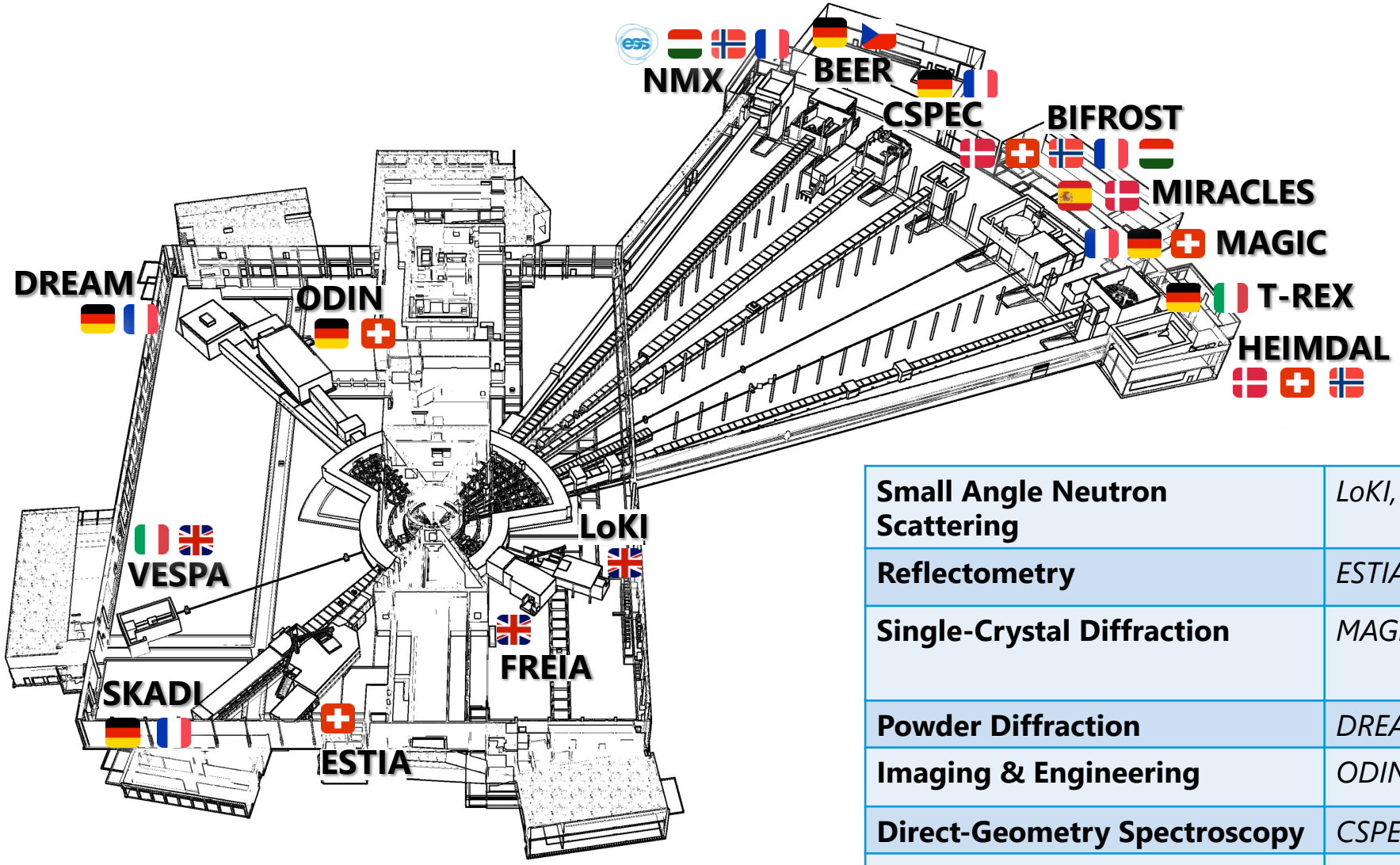
21 cryomodules: 4 cavities per cryomodule

5 tanks: DTL-1 to DTL-5

9 cryomodules: 4 cavities per cryomodule

The ESS Instrument Suite

15 instruments under construction

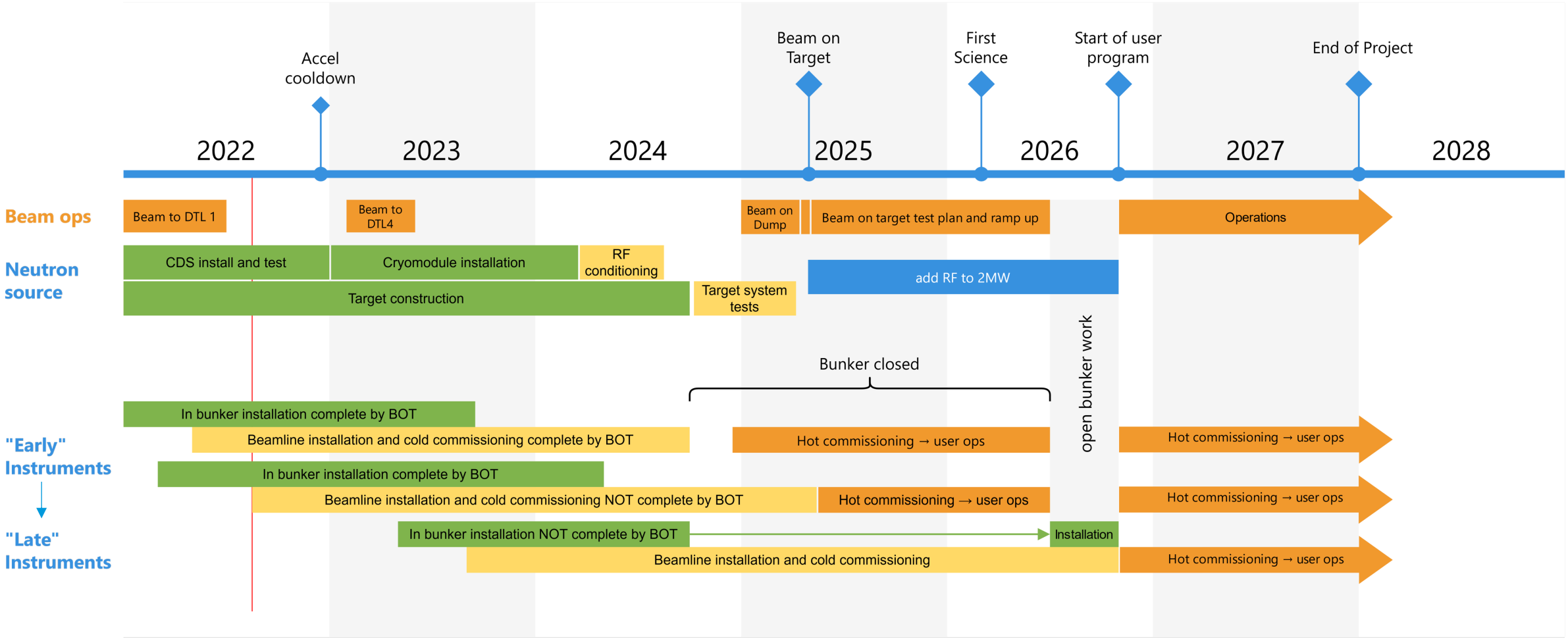


Each instrument designed to be world-leading at 2MW

Small Angle Neutron Scattering	*LoKI, SKADI*
Reflectometry	*ESTIA, FREIA*
Single-Crystal Diffraction	*MAGIC, NMX*
Powder Diffraction	*DREAM, HEIMDAL*
Imaging & Engineering	*ODIN, BEER*
Direct-Geometry Spectroscopy	*CSPEC, T-REX*
Indirect-Geometry Spectroscopy	*BIFROST, MIRACLES, VESPA*

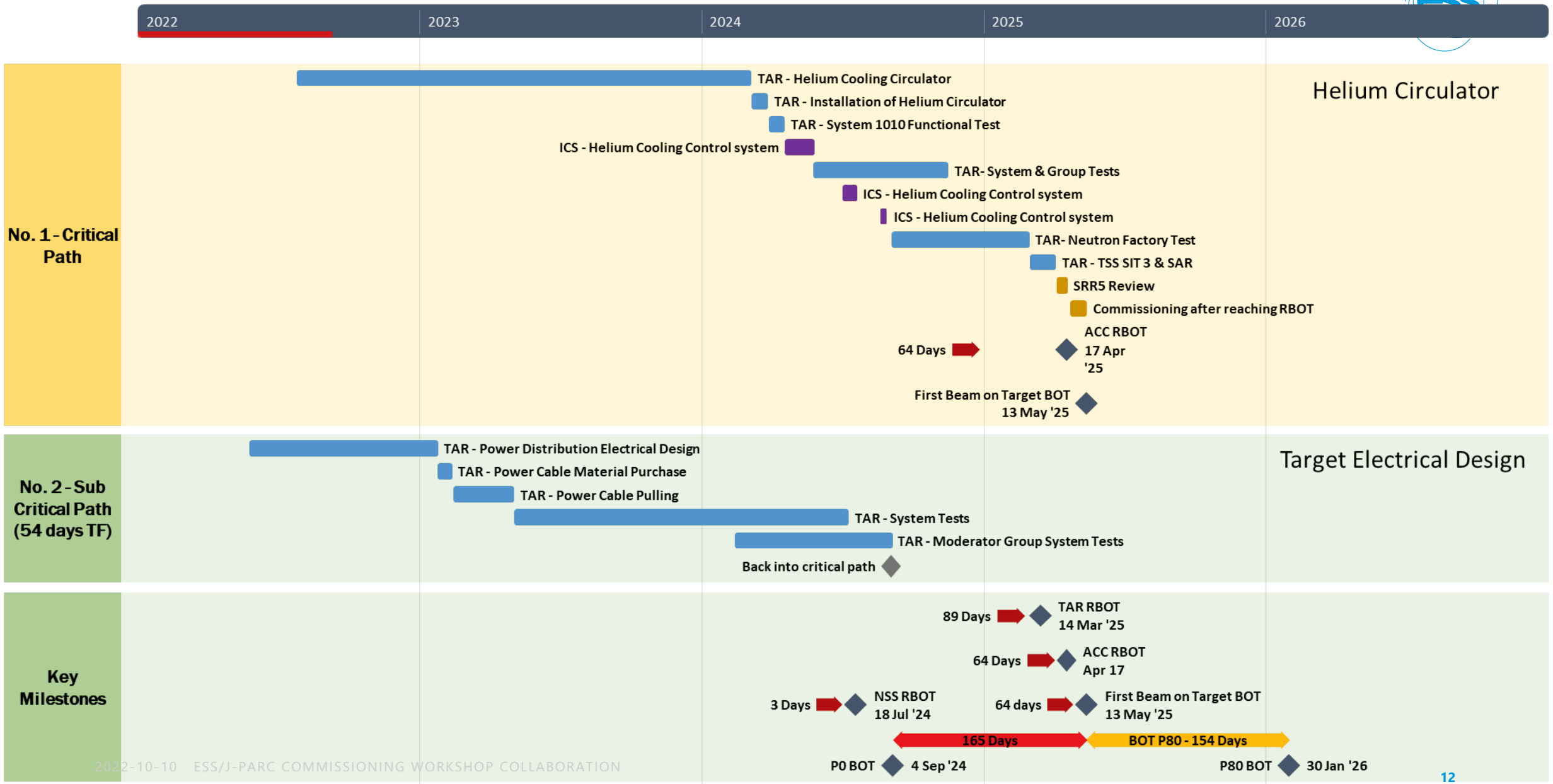
Status of the Construction Project

ESS high-level schedule as of August 2022



Indicative only

The project is addressing a number of critical path challenges



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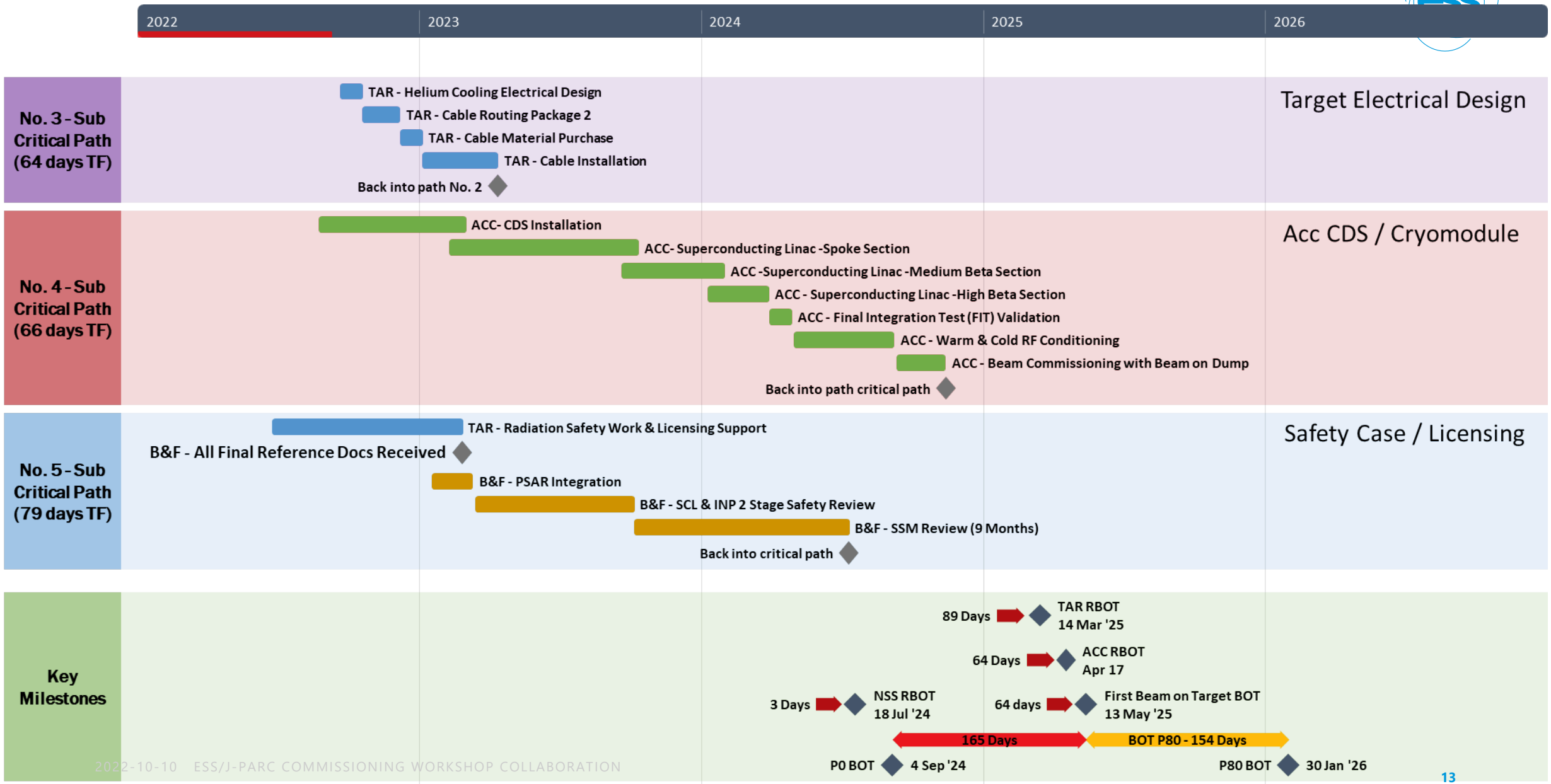
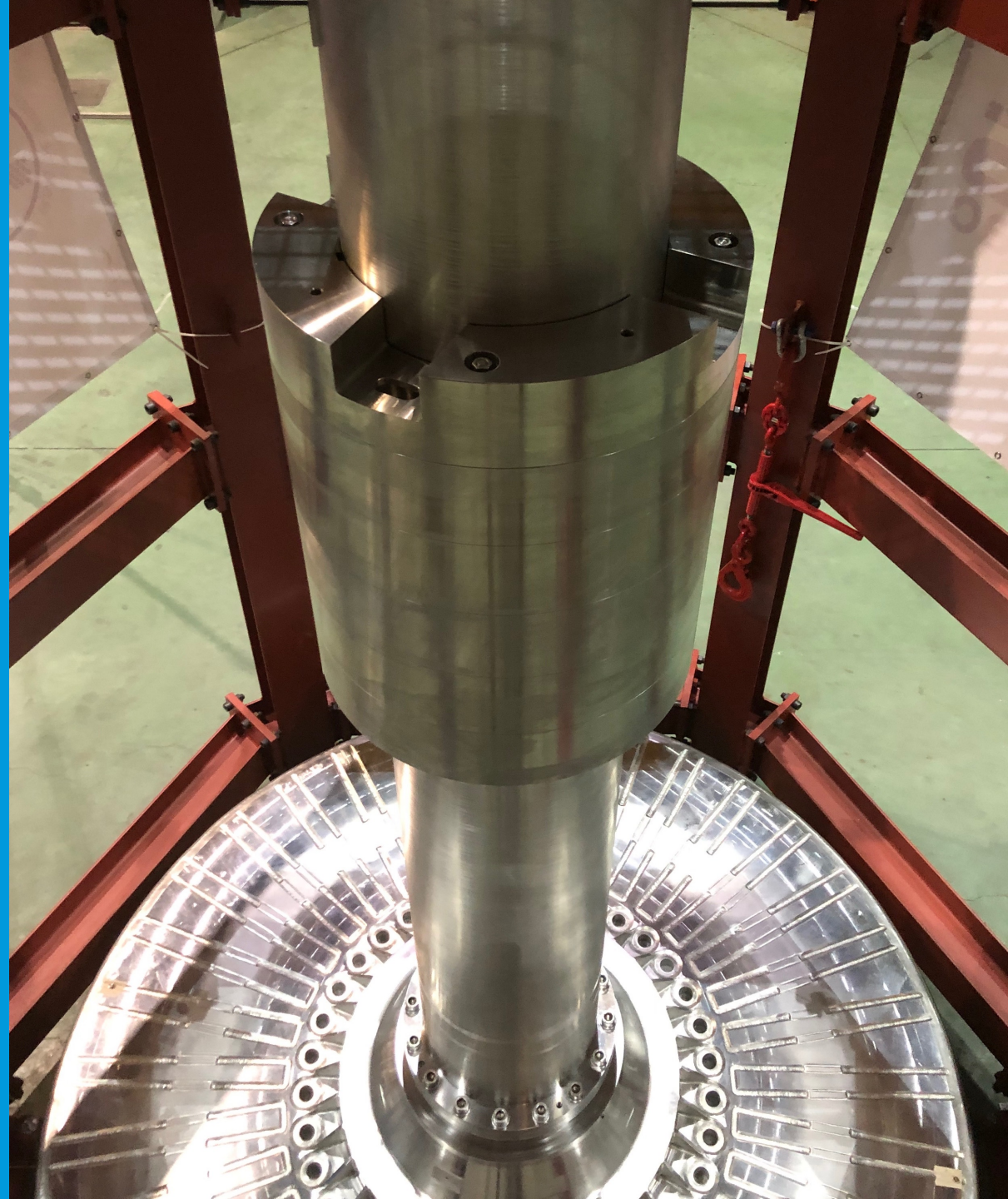


Recent Highlights



DTL-1 commissioning is complete

Beam through DTL-1 at design peak current

First RF pulse to the RFQ
09 June 2021

Re-establish beam to the LEBT
10 November 2021

First beam through the RFQ
26 November 2021

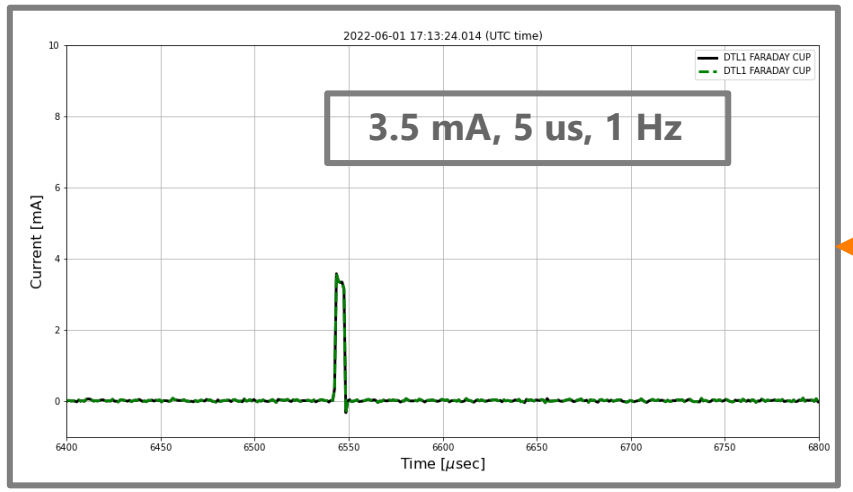
First RF pulse to DTL1
02 March 2022

First nominal current beam through the RFQ
12 March 2022

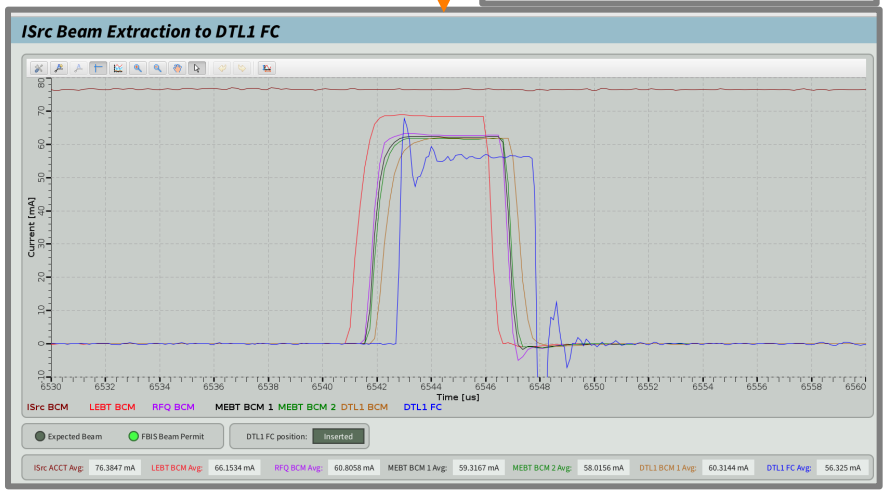
First beam through DTL1
01 June 2022

First nominal current beam through DTL1
01 July 2022

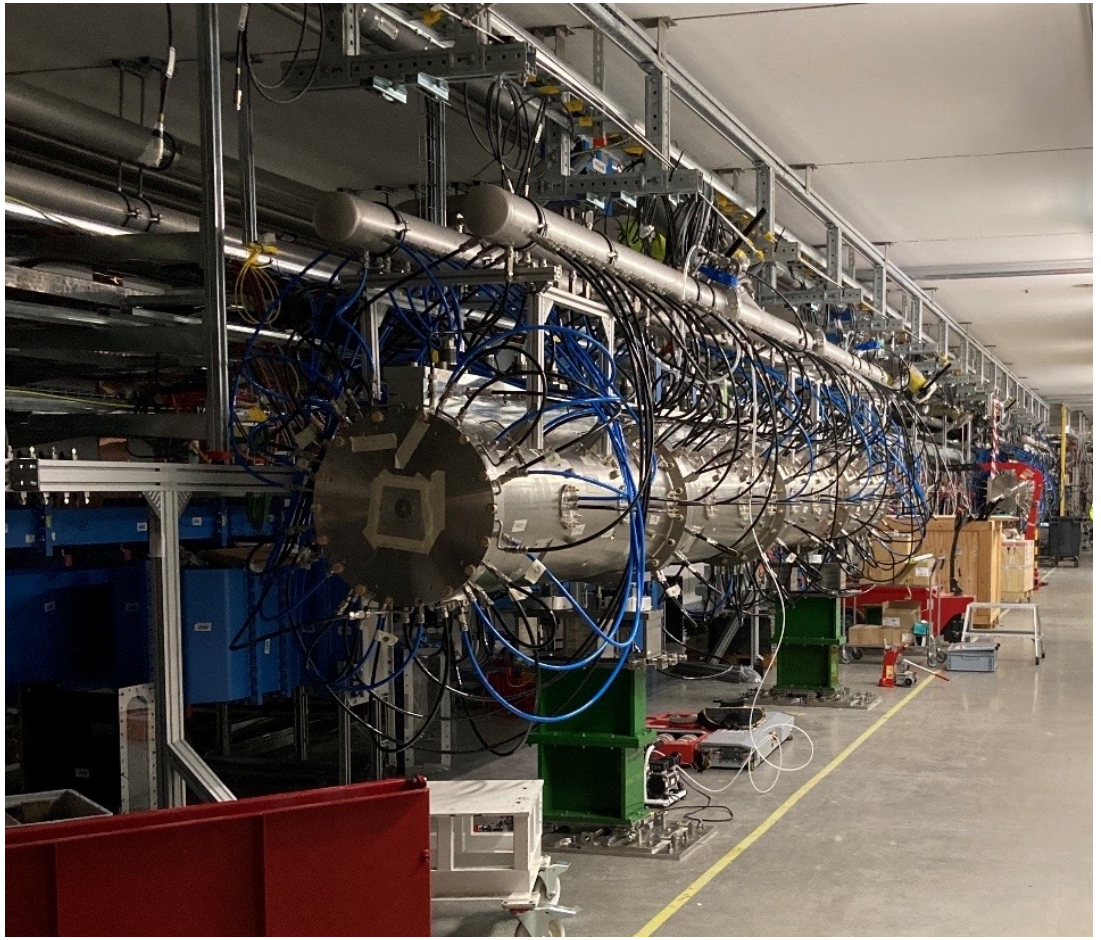
2021 Jun | Aug | Oct | Dec | 2022 Feb | Apr | Jun



60 mA, 5 us, 1 Hz



DTL-4 has been placed in the tunnel

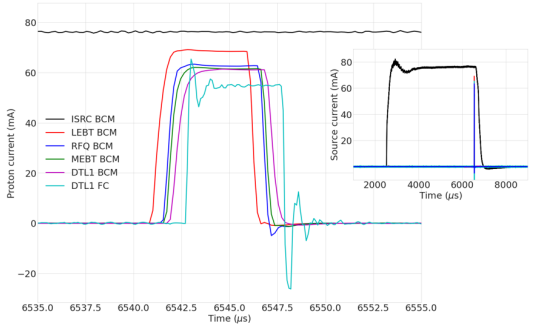


DTL4:

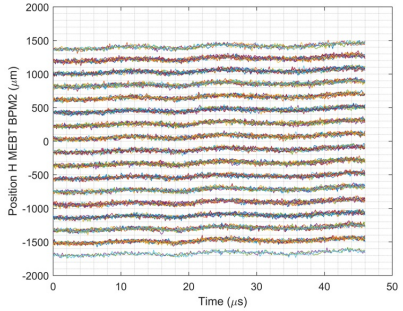
- Transported to tunnel via HEBT loading bay
- Water circuit leak checked and final connections being made
- BI and ICS interface checks to follow

Beam characterization capability is developing

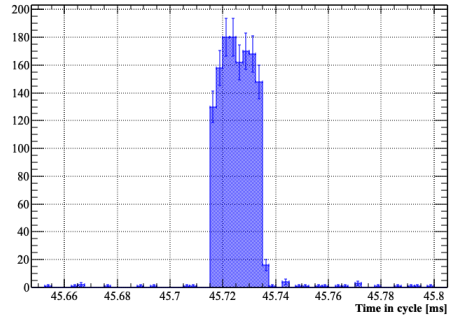
Measurements by Beam Instrumentation during commissioning of DTL-1



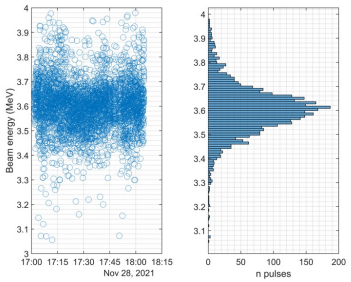
Current from source to DTL



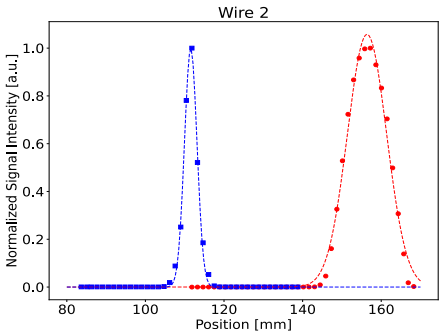
Position of pulses



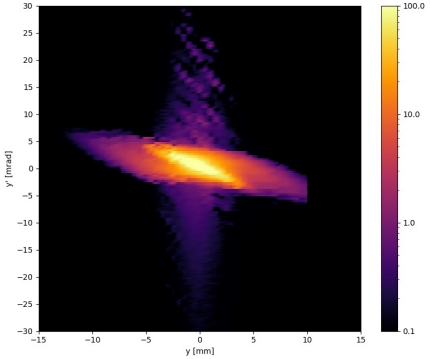
Neutrons detected



Beam energy



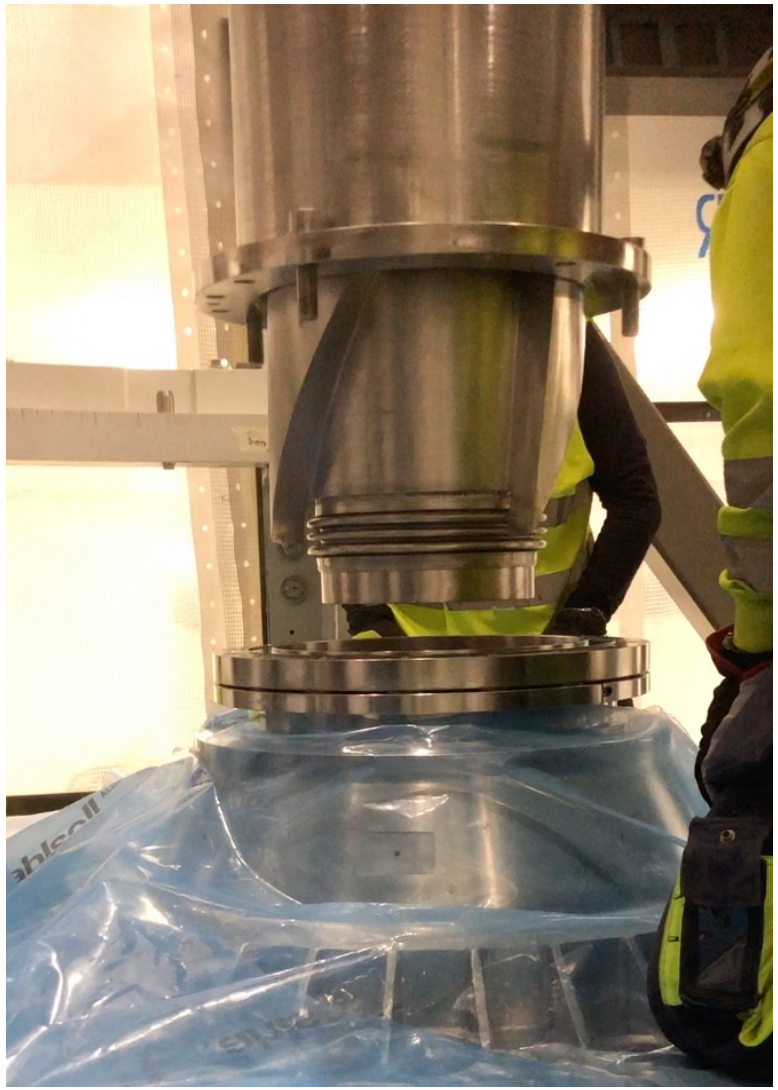
Transverse profiles



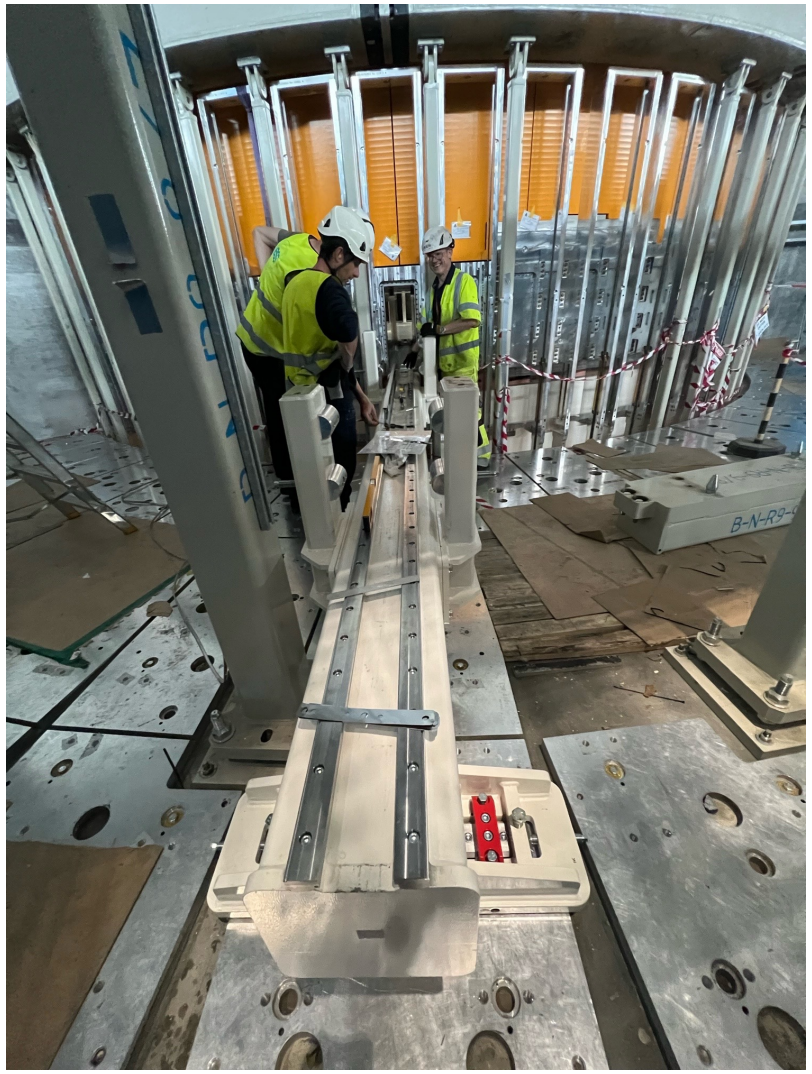
Emittance

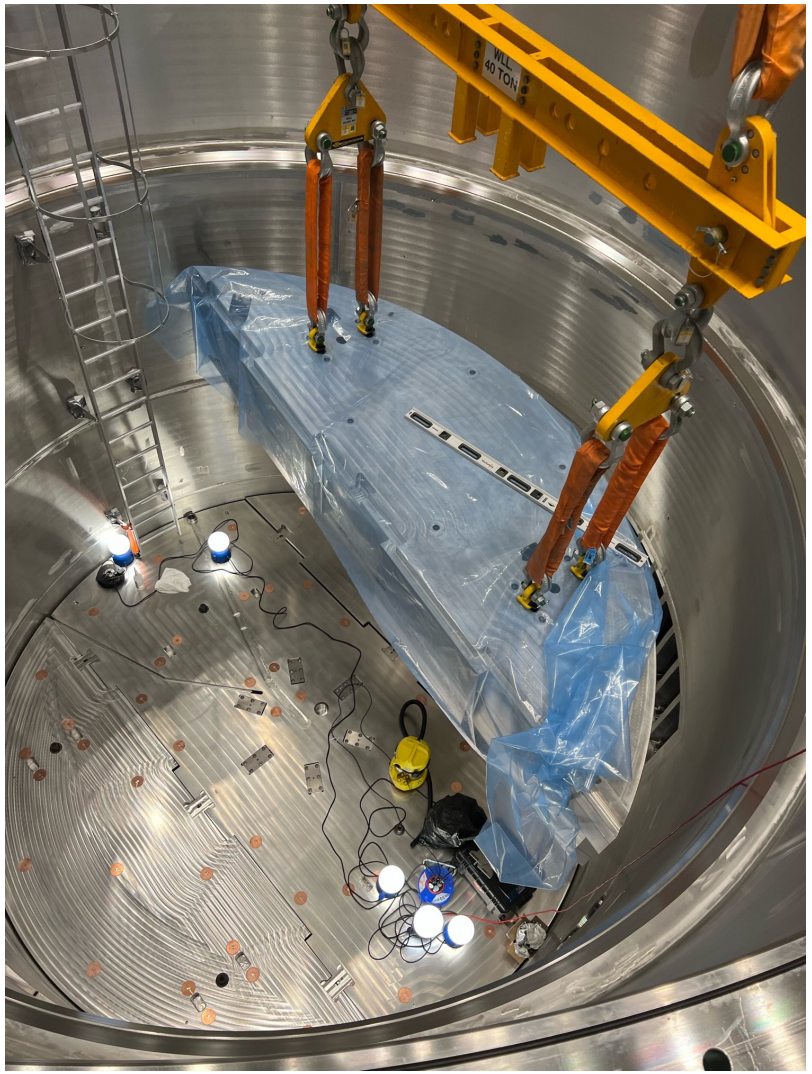
Target systems are being assembled on site

- Target Monitoring System ready for testing in the Mock Up Test Stand (MUTS) and will be installed after the assembly and integration of the Target Wheel and Shaft
- Target Shaft repaired and assembled to the Target Wheel
- Inner Shielding pipe material 321 on a number of inner shielding block cooling connections verified and approved in an NCR (EAM 10254)
- Inner Shielding package #2 is ready for installation
- Installation contract ready to be signed for the piping inside the monolith



Installation of inner shielding, NBPI and light shutter components is ongoing

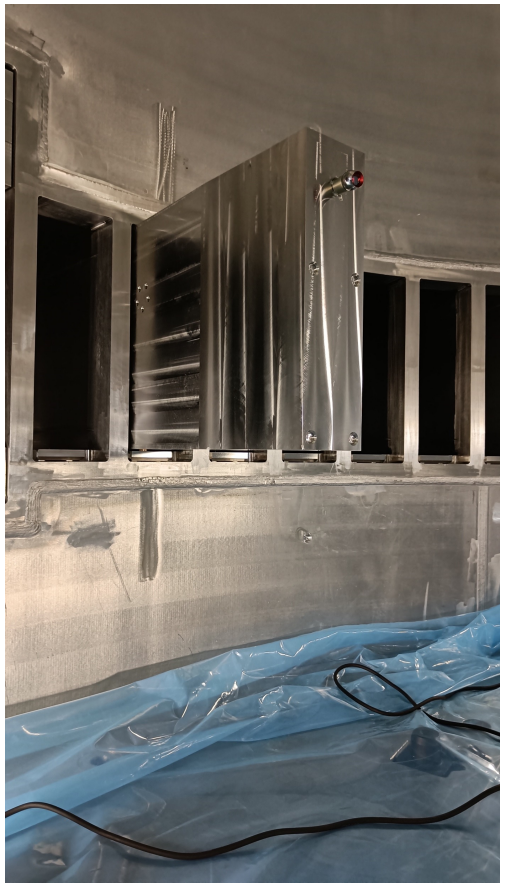


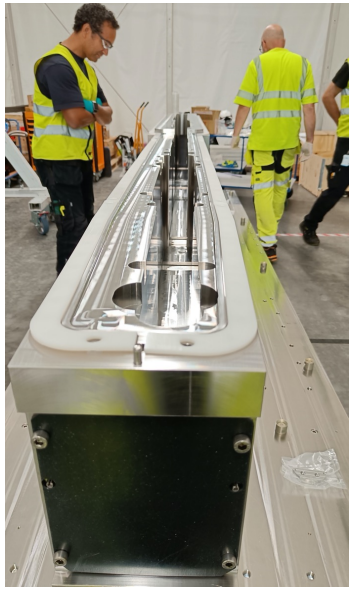


In-vessel component installation is progressing as planned

Neutron Beam Port Inserts

- Test Beam Line, LOKI and ODIN are delivered
- Optics are integrated, sealed, ready for installation
- Batch 2 (5 units) was delivered in week 36
- All Critical Design Reviews (CDR) done
- Installation test successfully done – note that sequencing is critical to integrated assembly of inner vessel components
- FREIA, DREAM, ESTIA, SKADI and VESPA are delivered and inspected
- NBPI prototype is displayed in the foyer

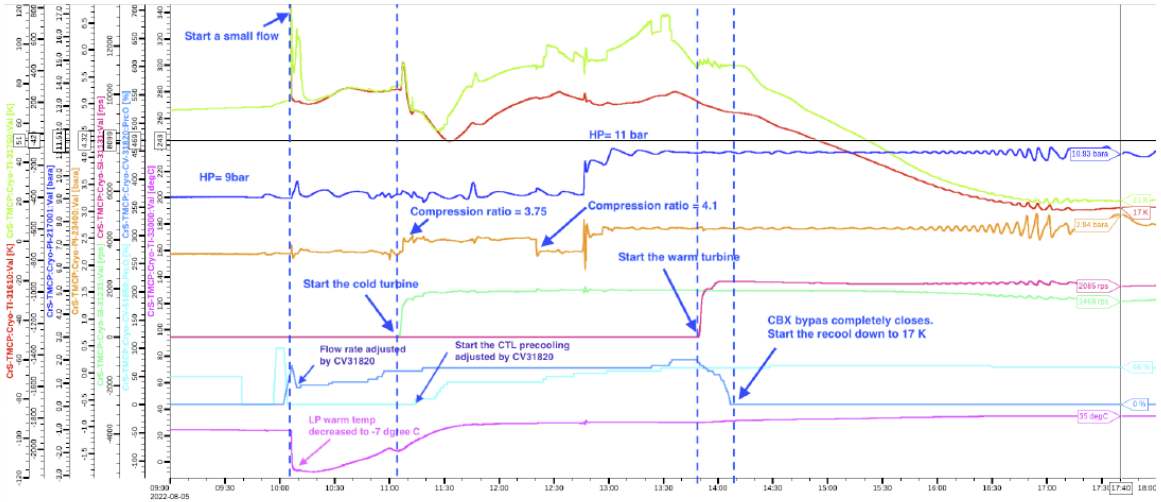




Highlights and Achievements

CMS, HTL, CTL, Valve Box

- Final installation on-going
- First commissioning step 2 (JSB) is started
- 17 K was reached



The first moderator reflector plug is at ESS

- MRP finalized in Jülich
- Delivered to ESS 2022-08-08
- Awaiting integration into MUTS

Instrument Optics

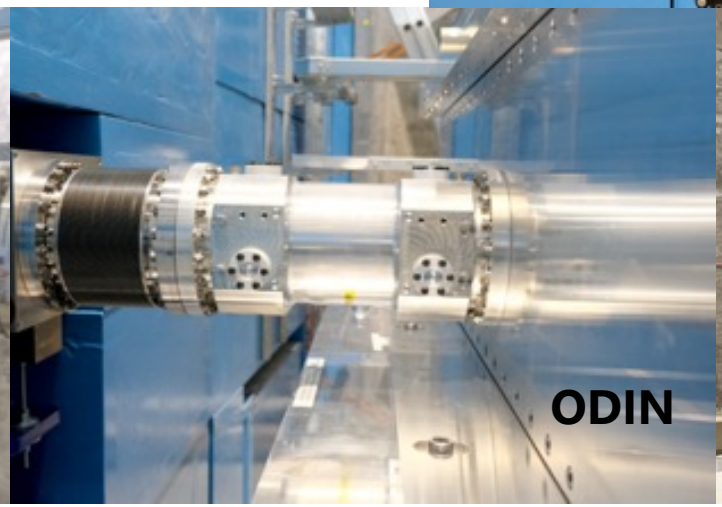
Installation is progressing well

Bunker Installations

- Five (**LOKI, BIFROST, ODIN, CSPEC & NMX**) BWIs installed
- In-bunker optics installed for **ODIN** and **BIFROST**

Planned for Sep-Nov 2022:

- Out of bunker optics for **BEER** (to restart) & **BIFROST**
- **NMX and LOKI** in-bunker optics
- **ESTIA** in-bunker feeder & guide assembly
- **DREAM** BWI

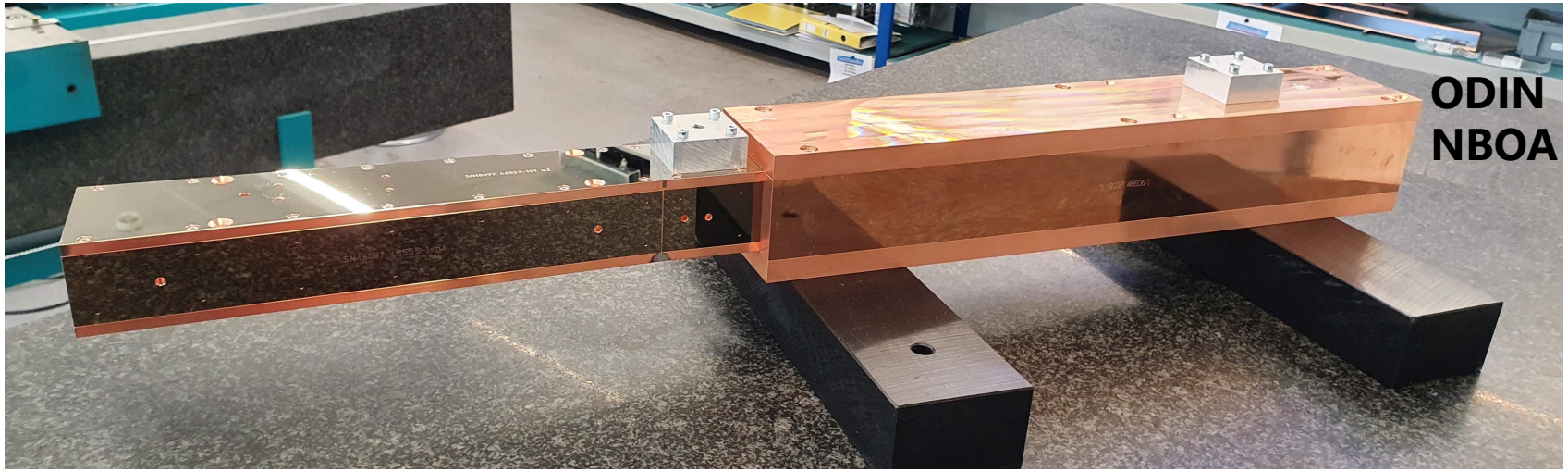


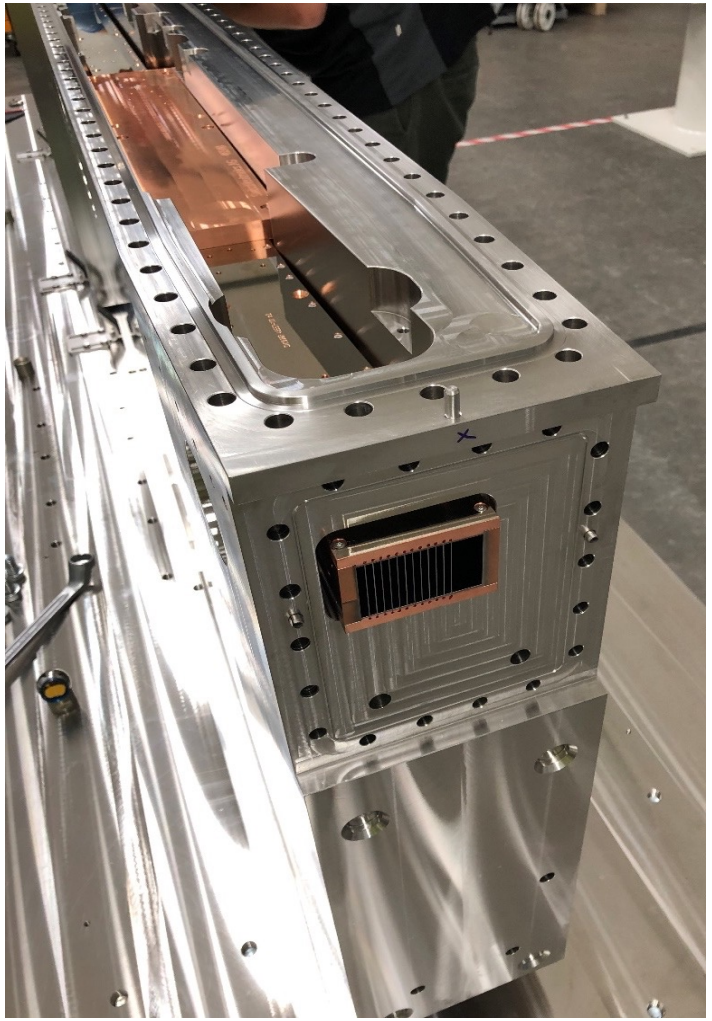
Instrument Optics

NBOA-NBPI integration is performed on-site in E01 temporary tent

Q2 2022: **LOKI, ODIN** **DONE**
Q3 2022: **FREIA, DREAM, ESTIA** **DONE**
SKADI & VESPA **started**

These 7 + TBL (which has no optics) completes 3 bunker sectors: (North, South, East).
Installation (by Target) planned for Nov 2022 - Jan 2023





ODIN NBOA-NBPI

Moving Toward Integrated Commissioning and Operation

ESS has already undertaken a number of early commissioning activities

- The Accelerator Cryoplant is fully commissioned and ready to support commissioning of the cryogenic distribution system
- The Ion Source and LEBT are fully commissioned
- The RFQ is fully commissioned (RF) and has been commissioned with beam to full peak current with short beam pulses
- The DTL-1 tank is fully commissioned (RF) and has been commissioned with beam to full peak current with short beam pulses
- Initial commissioning of beam diagnostic and beam loss systems is complete within the constraints mandated by limited beam operation through DTL-1
- The active cell bay doors have been fully commissioned
- RF systems and modulators are being installed and tested

ESS is beginning the transition from a purely construction project to a hybrid organization

- We are actively recruiting the talents and skills needed to maintain and operate both the civil infrastructure and the technical equipment needed for reliable and efficient neutron source operation
- We are beginning the transformation of the organization to position it for steady state operation while maintaining the capability to support ongoing construction and improvement projects – examples include building out to 5 MW, a SRF maintenance facility, and instruments 16-22
- We are establishing the tools, procedures and protocols needed to sustain reliable and efficient neutron source operation

ESS recognizes that the interleaved commissioning of all major system will be complex

- We can commission the accelerator at low power / low duty factor to the installed beam dump
- The imperative for the instruments is full duty factor (14 Hz, 2,86 ms)
- We need to develop a good strategy for commissioning beam to target to understand:
  - Beam rastering, beam synchronization with target rotation, proton beam window performance, target thermal performance, moderator performance and characterization, hydrogen ortho/para conversion and so on
  - Beam loss management as the beam power is raised
- We need to assess performance and reliability challenges as operations moves to a 24/7 mode, and respond accordingly

ESS recognizes that there will be challenges we will fail to anticipate

- The long instruments and long-pulse nature of the source presents new opportunities for commissioning of instruments
- Your experience in commissioning the J-PARC and MLF facilities and the lessons you share with us during this workshop will help us to limit the surprises we may see!

Concluding Remarks

This workshop will be important in helping ESS plan for integrated commissioning

- The ESS has taken the first small steps toward global facility commissioning
- Much remains to be done!
- We will continue to learn how to balance commissioning activities with ongoing operations as we install the cryomodules while commissioning DTL 2-4 with beam
- We will fully integrate all critical target components in the mock-up test stand (MUTS) before final installation and commissioning in the target monolith
- A fully functional integrated control system and appropriate control room operator tools are essential to this success
- Sequencing and integrating instrument hot commissioning with accelerator and target system commissioning will be challenging
- We appreciate your participation and support in assisting us to develop sound plans for the full commissioning of ESS

Thank you for your attention!