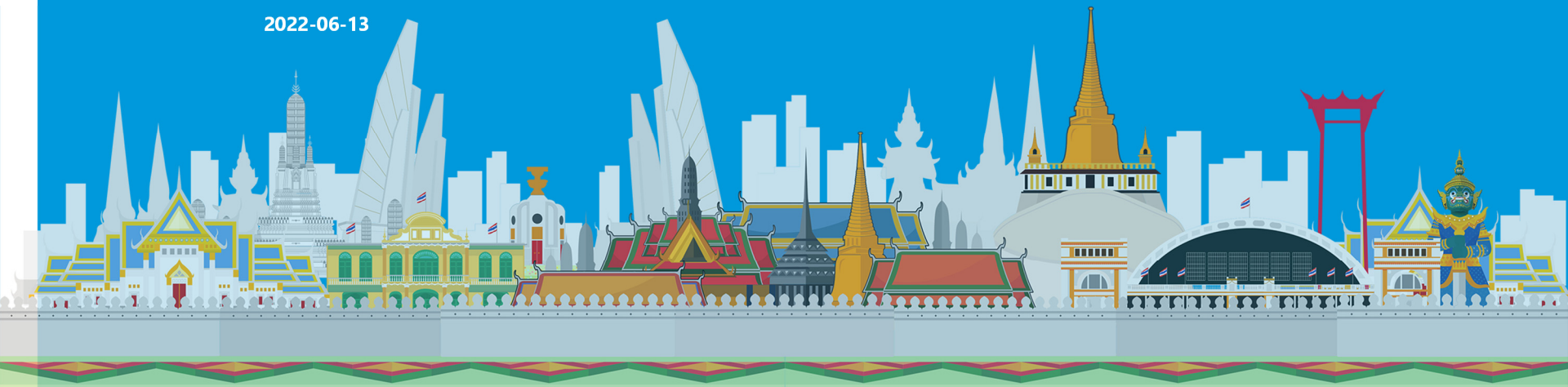


# Status of the European Spallation Source

PRESENTED BY ANDREAS JANSSON

ON BEHALF OF EUROPEAN SPALLATION SOURCE ERIC (ESS)  
AND THE ESS ACCELERATOR COLLABORATION

2022-06-13



# Outline



ESS project

---

Accelerator installation and testing status

---

Target installation status

---

Neutron Instrument status

---

Beam commissioning status and plans

---

In-kind

---

# From Green Field to ESS

May 2014 vs April 2022

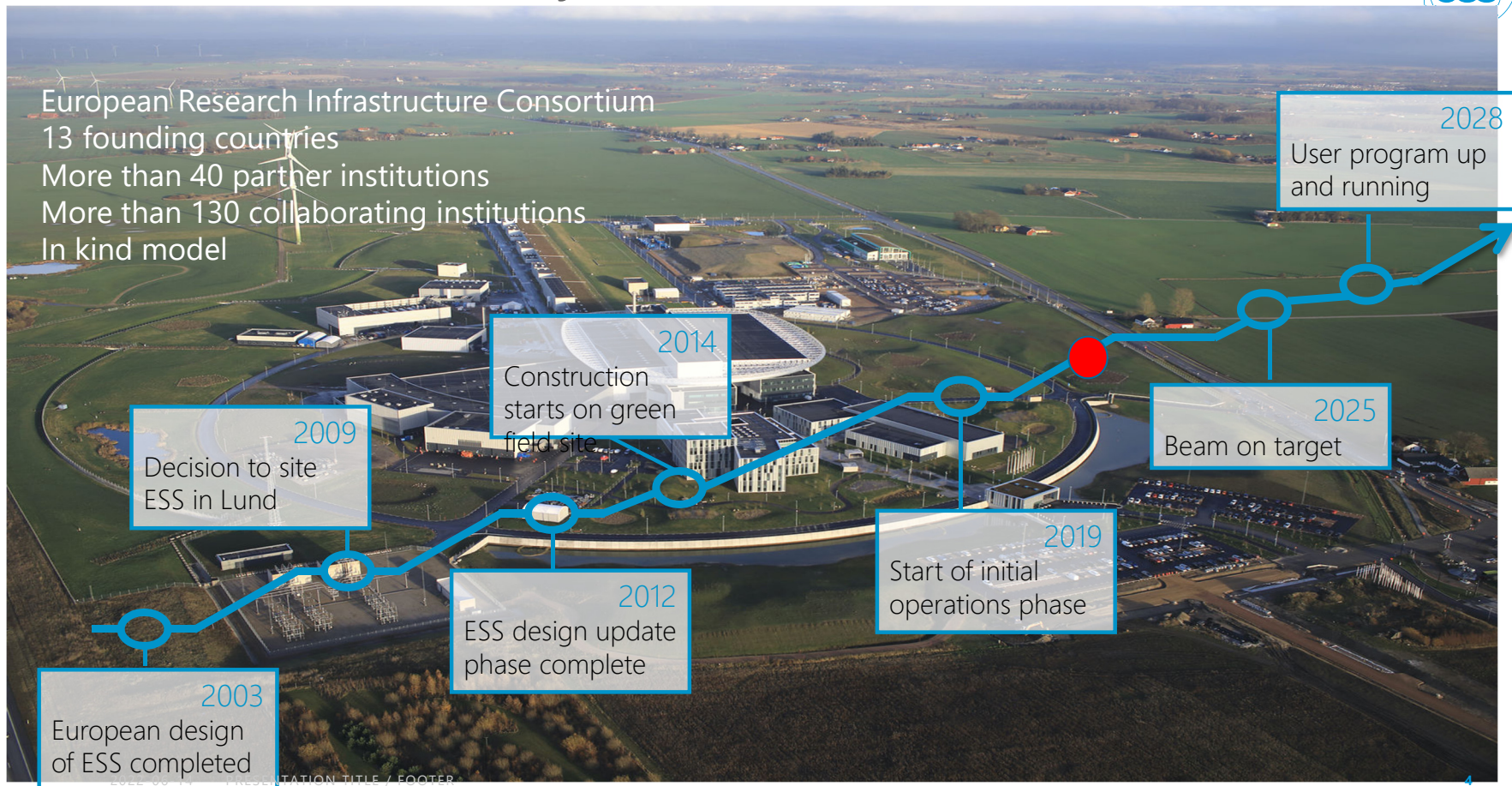




# The ESS Journey



European Research Infrastructure Consortium  
13 founding countries  
More than 40 partner institutions  
More than 130 collaborating institutions  
In kind model



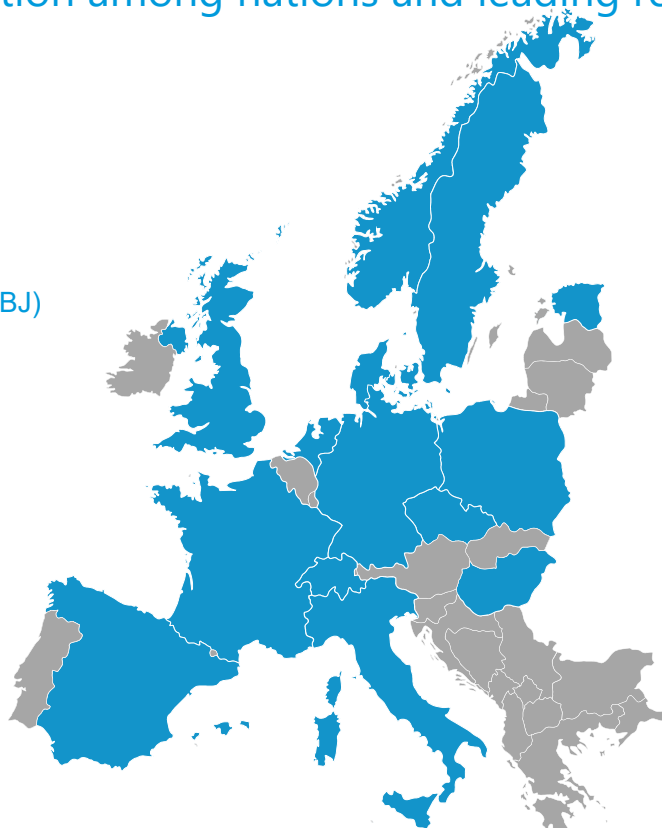


# Unique International Project

With unique cooperation among nations and leading research institutes



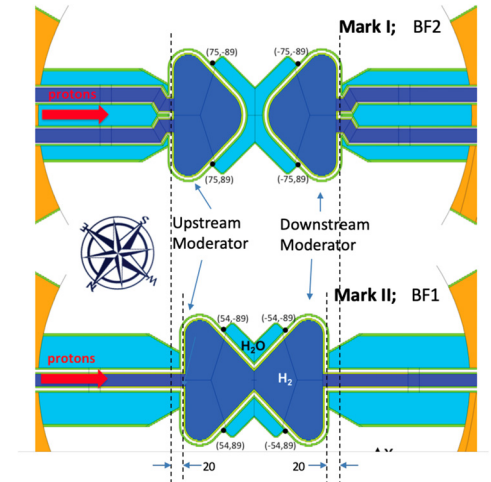
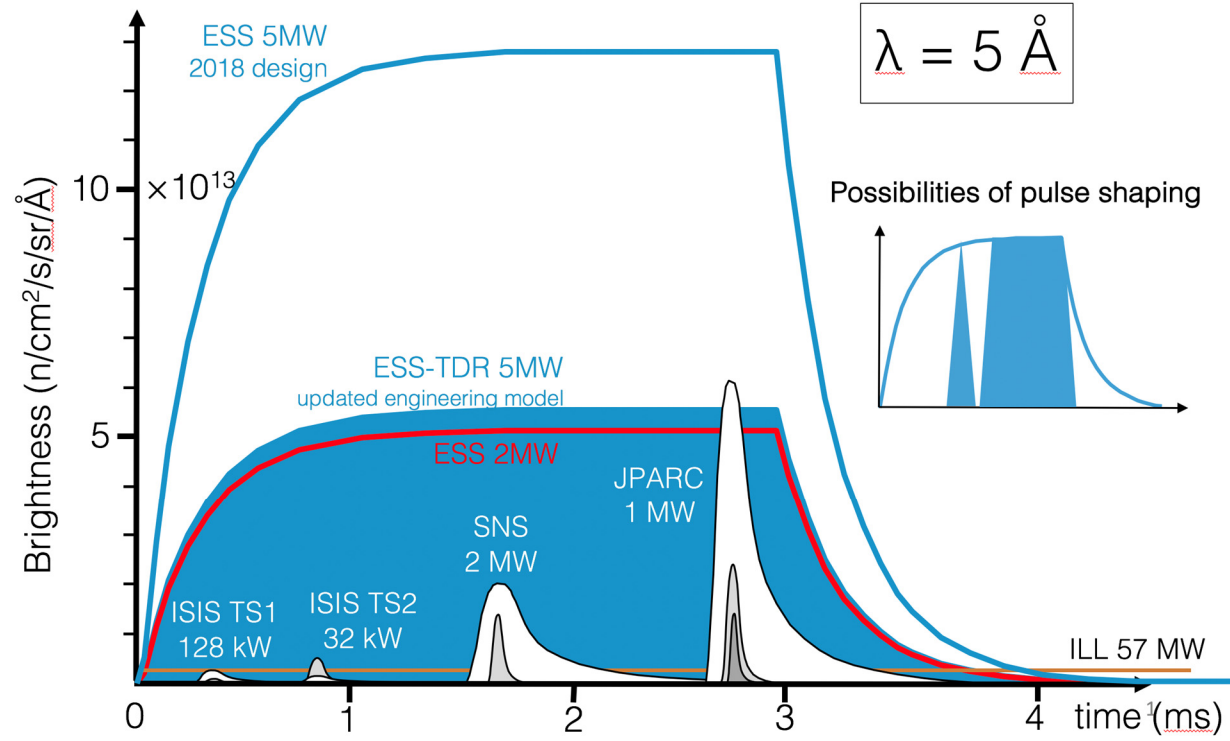
Aarhus University  
Atomki - Institute for Nuclear Research  
Bergen University  
CEA Saclay, Paris  
Centre for Energy Research, Budapest  
Centre for Nuclear Research, Poland, (NCBJ)  
CNR, Rome  
CNRS Orsay, Paris  
Cockcroft Institute, Daresbury  
Elettra – Sincrotrone Trieste  
ESS Bilbao  
Forschungszentrum Jülich  
Helmholtz-Zentrum Geesthacht  
Huddersfield University  
IFJ PAN, Krakow  
INFN, Catania  
INFN, Legnaro  
INFN, Milan  
Institute for Energy Research (IFE)  
Rutherford-Appleton



Laboratory, Oxford (ISIS)  
Kopenhagen University  
Laboratoire Léon Brillouin (CEA/CNRS/LLB)  
Lund University  
Nuclear Physics Institute of the ASCR  
Oslo University  
Paul Scherrer Institute (PSI)  
Polish Electronic Group (PEG)  
Roskilde University  
Tallinn Technical University  
Technical University of Denmark  
Technical University Munich  
Science and Technology Facilities Council  
UKAEA Culham  
University of Tartu  
Uppsala University  
WIGNER Research Centre for Physics  
Wroclaw University of Technology  
Warsaw University of Technology  
Zurich University of Applied Sciences (ZHAW)

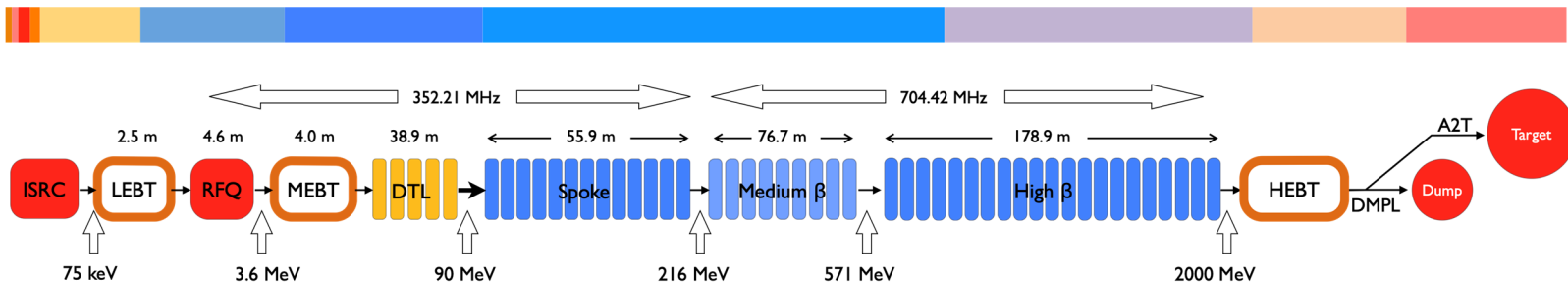


# ESS Performance



Decoupling in accelerator power (and instrument scope) due to budget restrictions compensated by moderator development (Note that deferred scope can be added back later)

# High Power 5MW Proton Accelerator



The ESS accelerator was designed and is built by a collaboration of 23 institutes and universities in Europe

More than 50% of the total budget is delivered as In-kind with most systems being IK deliveries. The main exceptions are the cryo plants, the 704 MHz klystrons and modulators.

ESS accelerator division is responsible for functional requirements, coordination of work, installation including infrastructure, testing & commissioning and operation.

The linac shall in the full scope deliver **5 MW at 2 GeV, 14 Hz with 2.86 ms long pulses**

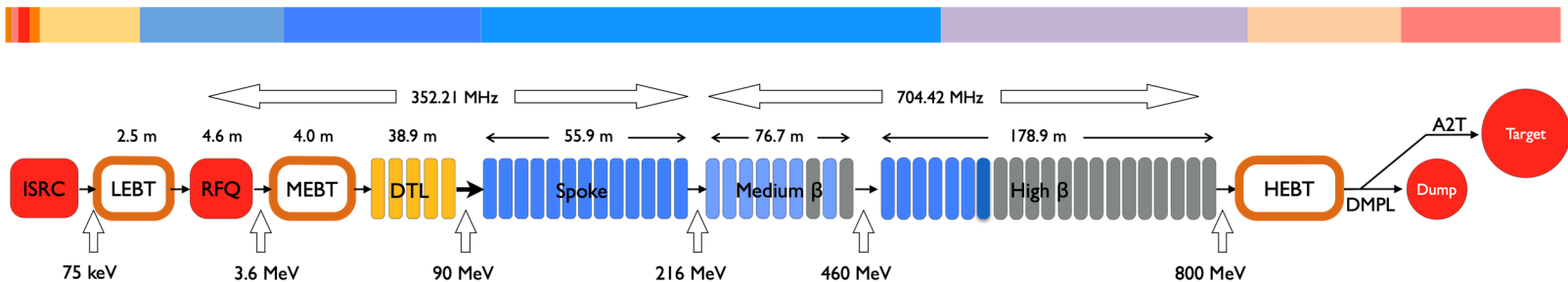
For Beam on Dump and Ready for Beam on target the accelerator will operate at **572 MeV able to put 1.4 MW on the target with nominal duty-cycle**. Planned with the medium beta elliptical section, but two high beta will be used to compensate for medium beta cavities needing reprocessing

For the user program start, an additional 5 high-beta cryomodules will be installed and powered enabling operation at **2 MW, 870 MeV with nominal duty cycle**

The remaining 16 high-beta cryomodules will be installed in the tunnel during shutdowns but not powered with RF. Control and operation of e.g. tuners and cryogenics will be available for all cryomodules.



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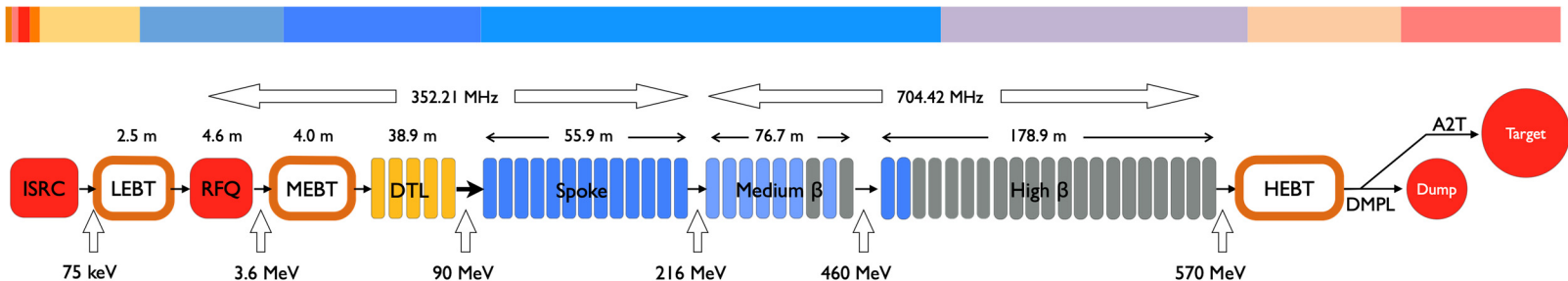
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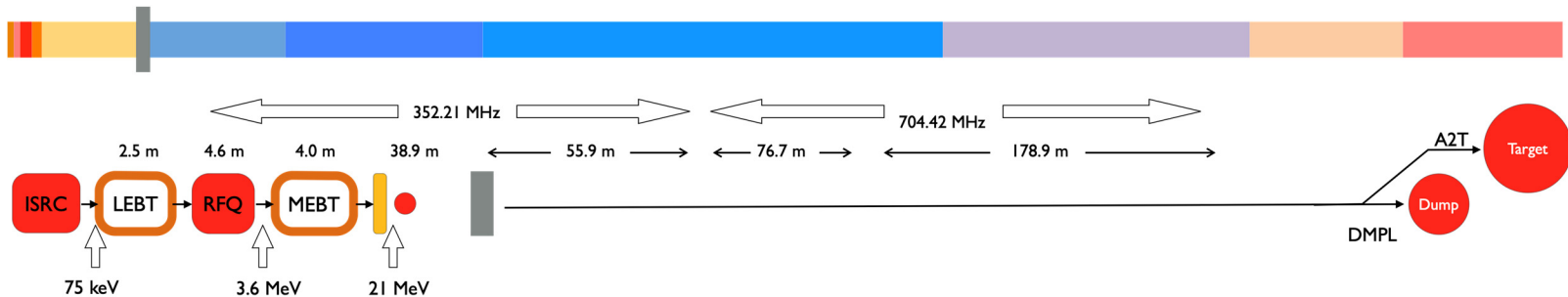
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# Tunnel View Then and Now



Parts of Normal  
Conducting Linac  
Under commissioning



Cryo Distribution Line  
testing upcoming this  
Autumn, followed by  
cryomodule installation

# Klystron Gallery Then and Now



RF for normal conducting part installed and tested.



Installation and testing ongoing in superconducting part



# SCL RF Station Testing

Spoke and Medium Beta RF stations under test in Klystron Gallery



Tetrode RF Power stations in Spoke Section  
Tetrode RFPs provided in kind from Elettra



Klystrons based RF stations in Elliptical Section  
Modulators designed at ESS and provide in kind from ESS-BL



# Cryomodule Delivery and Testing



## ESS Test stand (TS2)

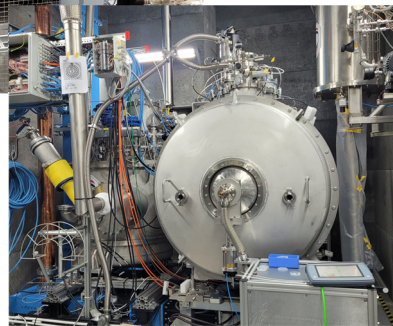
6 medium beta CMs delivered  
4 of them tested

Poster TUPOTK002



## Uppsala Test Stand (FREIA)

8 spoke CMs tested and  
Delivered to ESS



# Linac Warm Units



Particle free installation



Linac warm units installed in HEBT

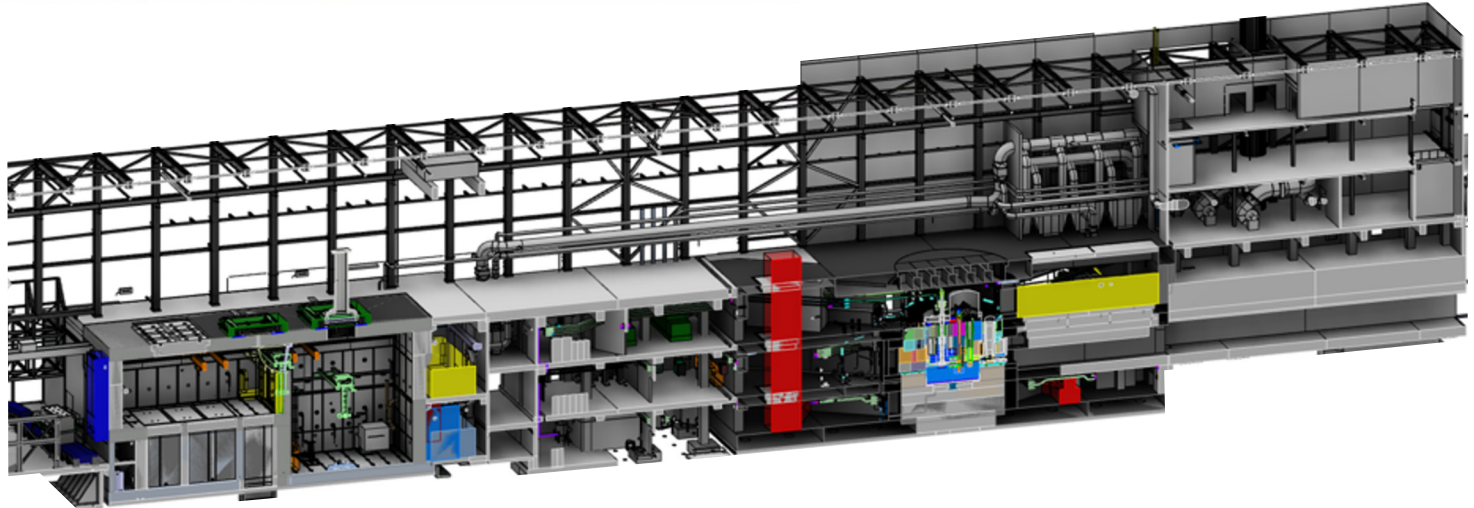
LWU assemblies are delivered as in kind from Daresbury Lab, using magnets from Elettra (also in kind).



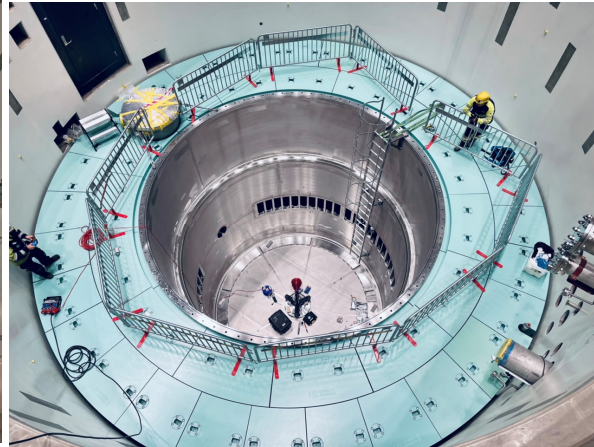
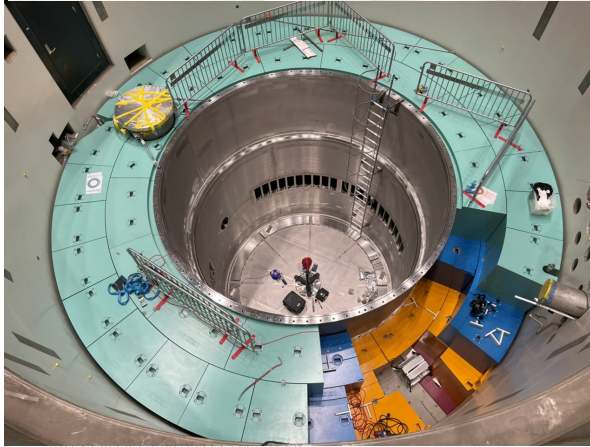
# Target



ESS target is a rotating wheel of Tungsten with 36 individual target segments

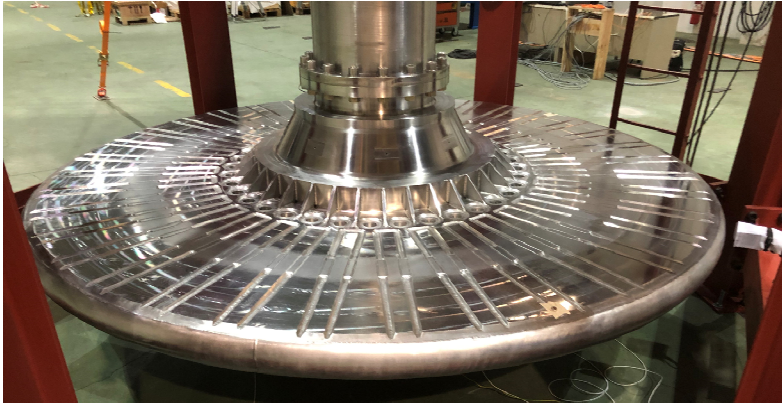


# Core Vessel, Beam Window and Shielding





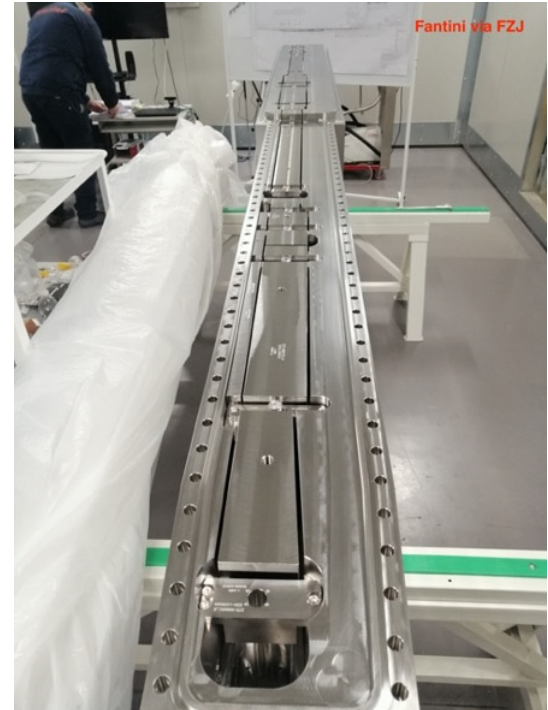
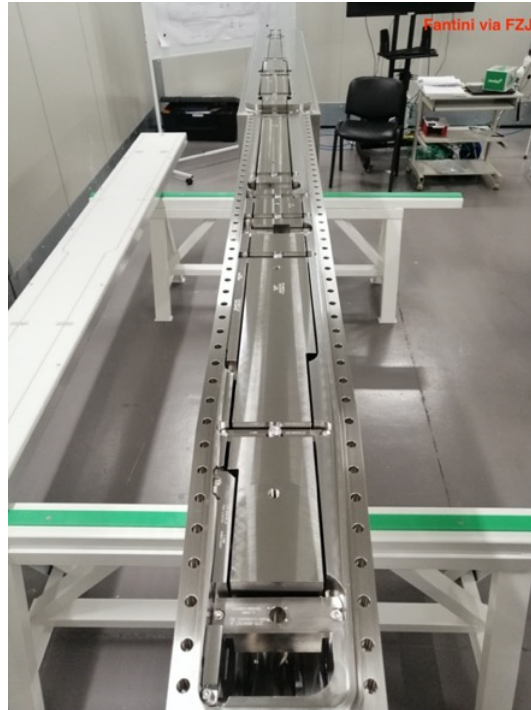
# Target Wheel and Moderator





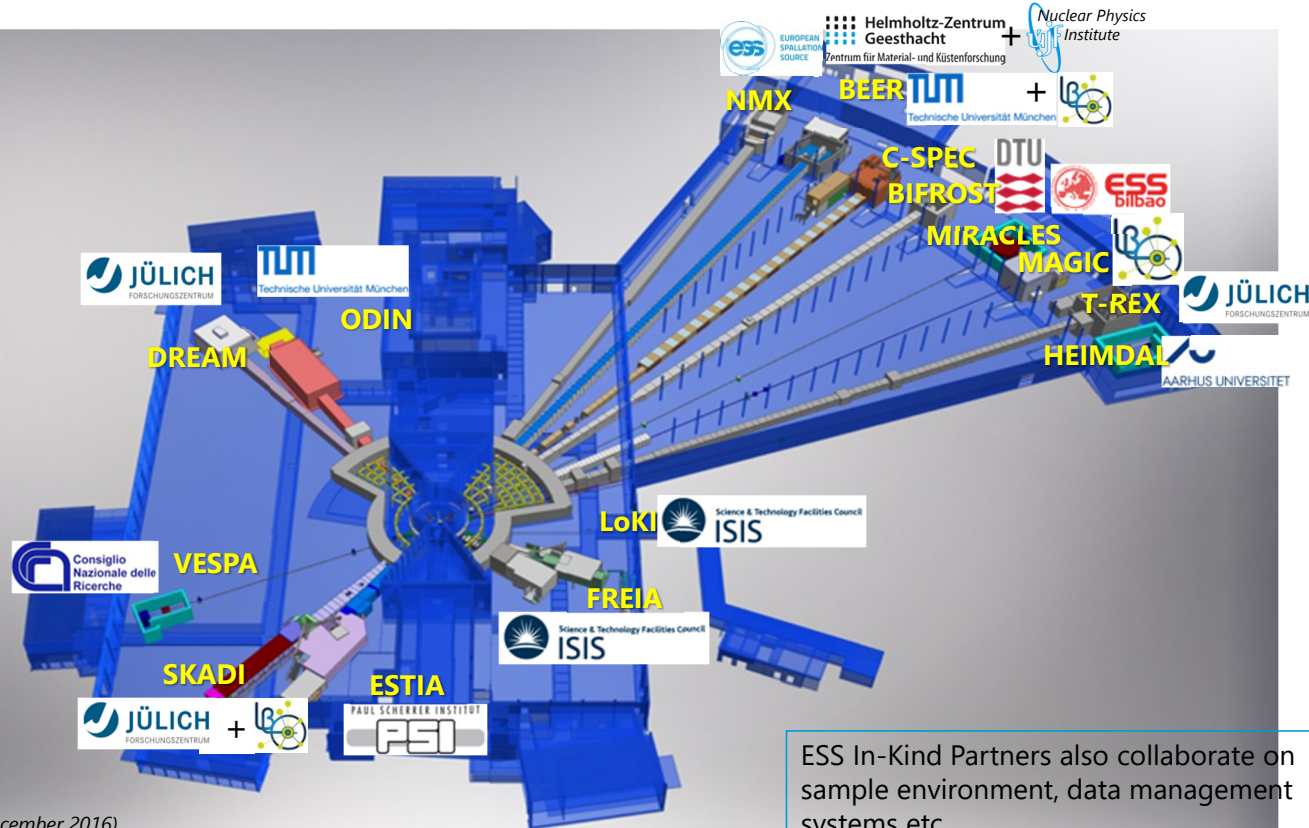
# Neutron Port Inserts

for DREAM and ODIN



# NSS Neutron Instrument Positions

## ESS Lead Partners for Instrument Construction



ESS In-Kind Partners also collaborate on sample environment, data management systems etc.

# Neutron Instruments



ODIN hutch



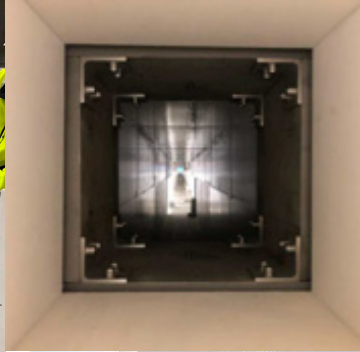
DREAM cave & hutch



LOKI and bunker (blue)



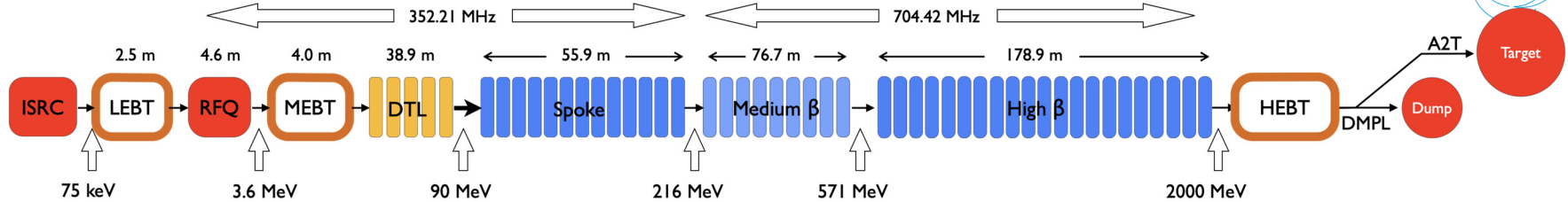
# Choppers, guides, and detectors



Bifrost



# Testing & Commissioning Phases



## Ion Source License

**SRR1** (Isrc & LEBT) – DONE!

## NCL License

**SRR2a** (to MEFT Faraday Cup, with critical diagnostics) – DONE!

**SRR2b** (to DTL1 Faraday Cup, with critical diagnostics) – IN PROGRESS!!

**SRR3** (to DTL4 Faraday Cup, with critical diagnostics)

## Neutron Production License

**SRR4** (to TBD)

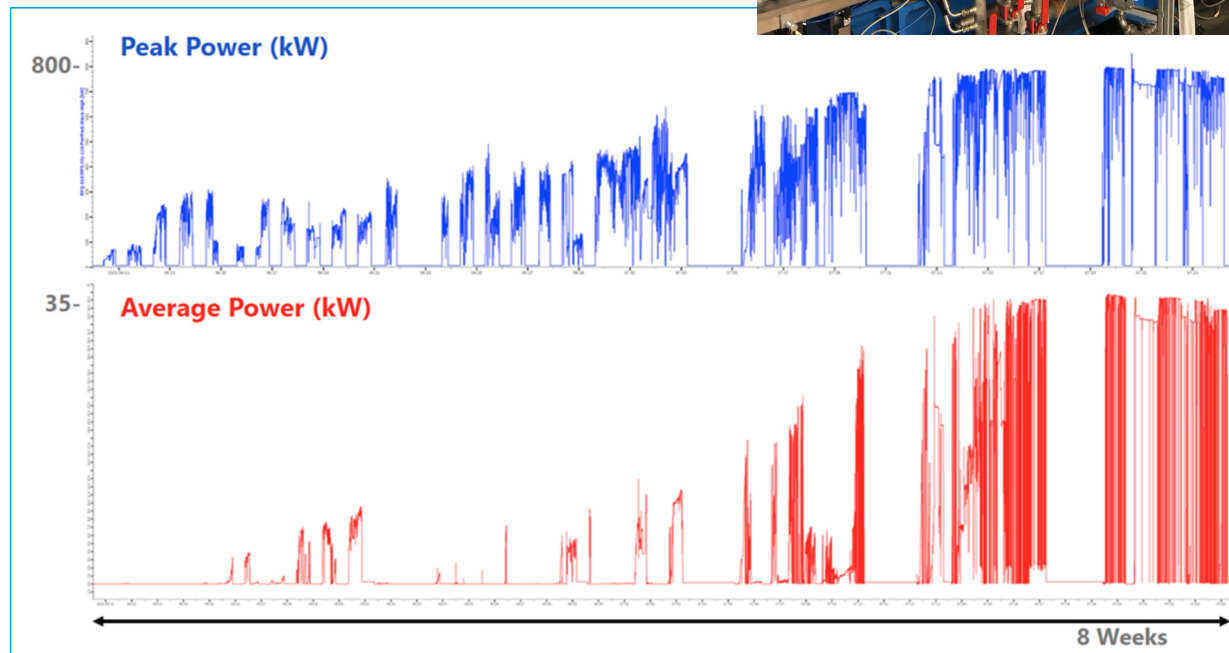
**SRR5**



# RFQ Conditioning



Poster TUPOTK003

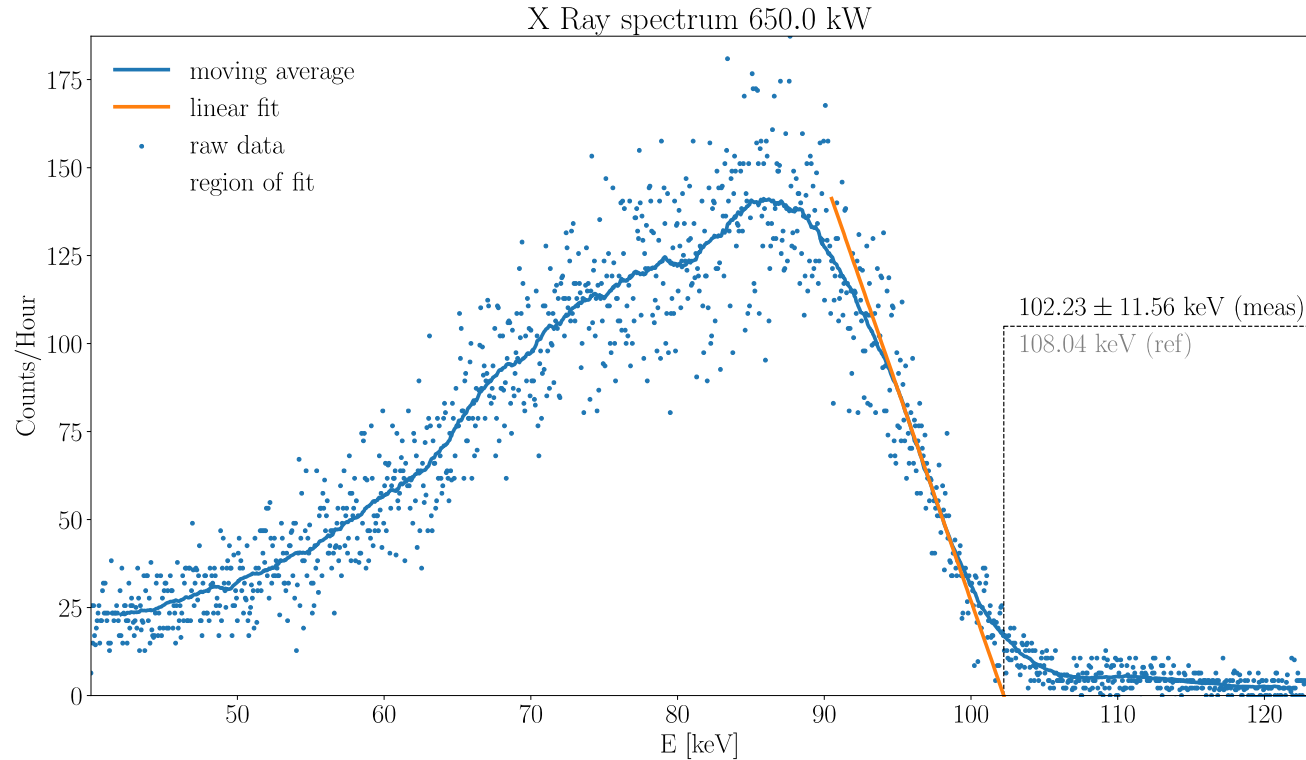


RFQ provided as in kind  
from CEA Saclay



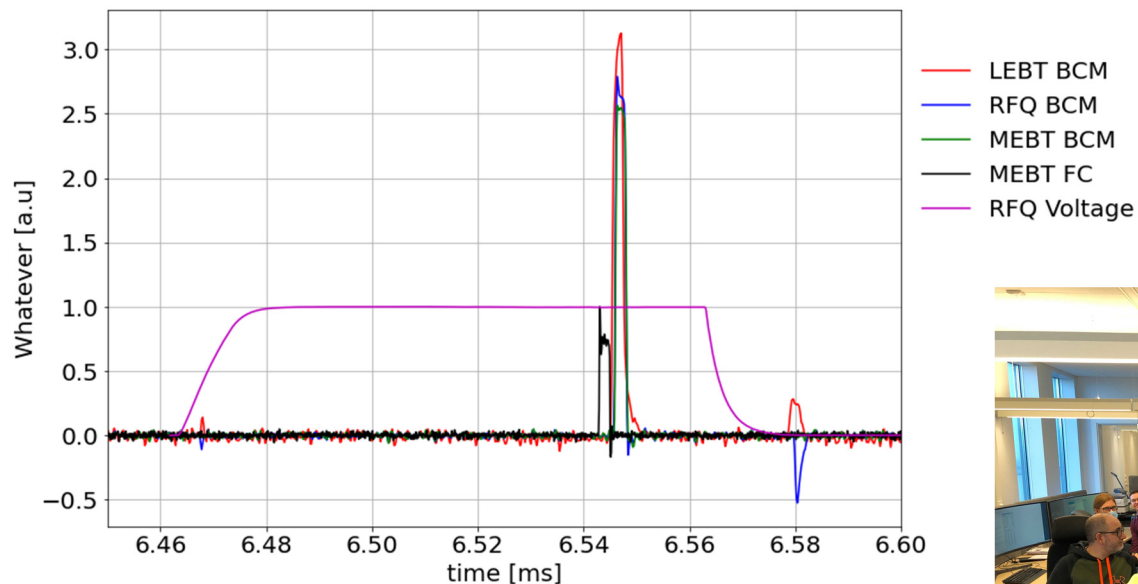
# X-ray Measurement of RFQ Voltage

See poster TUPOTK030



# First Beam through RFQ

June 9, 2021

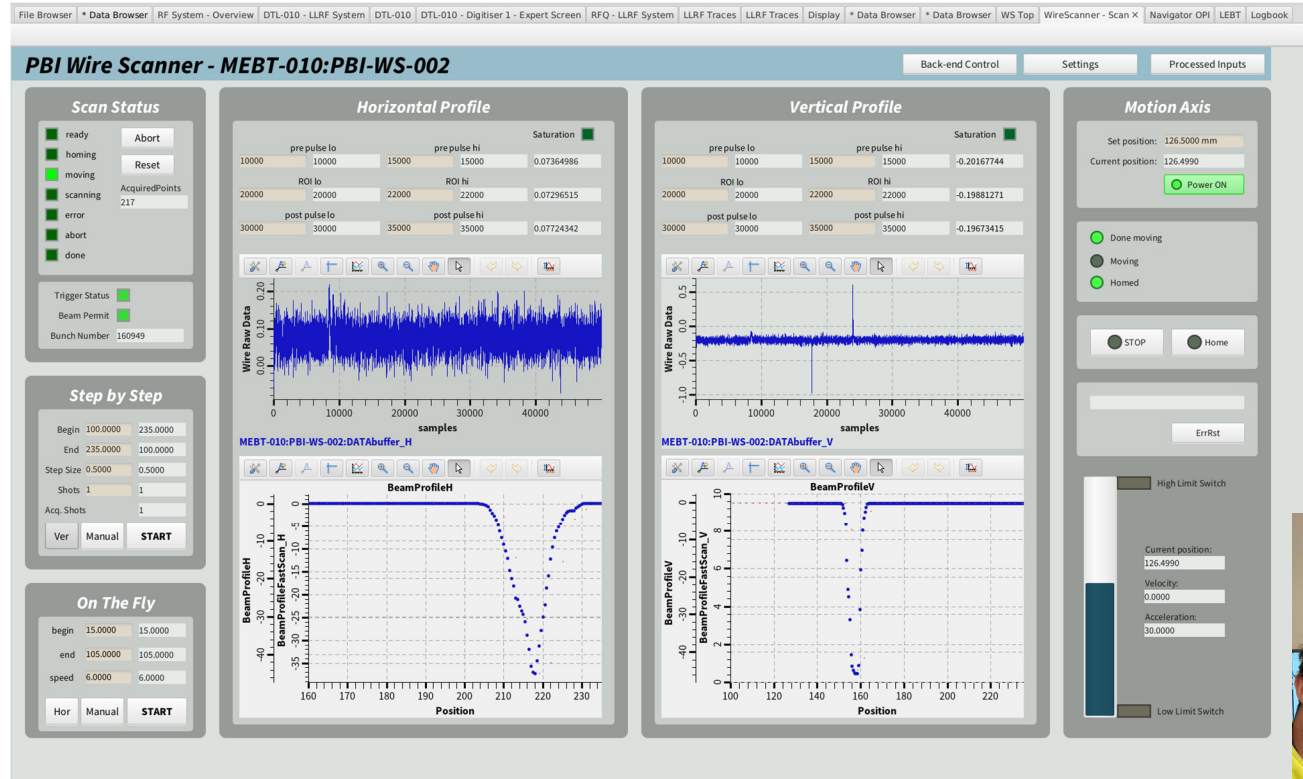


First beam pulse with dead-reckoned timing settings

Poster WEPOTK001

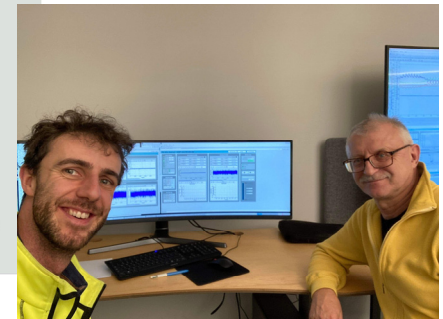


# First Wire Scan



Wire scanners provided as in kind from ESS Bilbao

Readout Electronics provided as in kind from Elettra



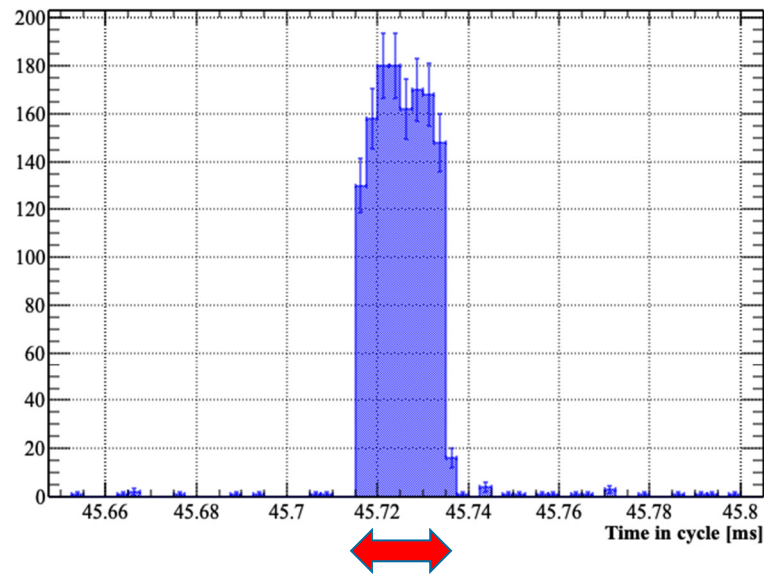
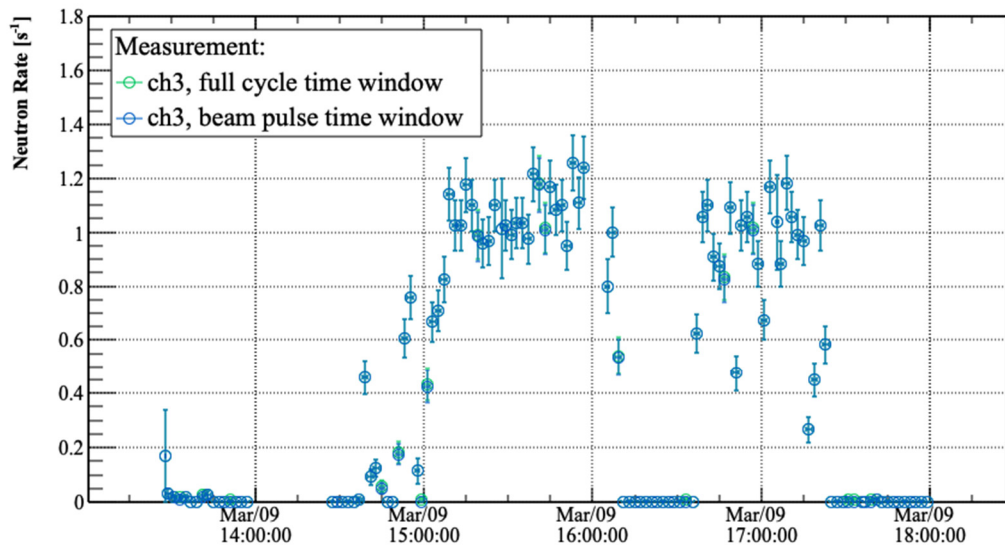
Intial testing of wire scanners (not yet fully controls integrated)

C. Derrez *et al*



# First Accelerator-Produced Neutrons

But not for the users yet...



First measurements of accelerator produced neutrons at ESS (from MEFT chopper dump),  
using micromegas based neutron BLM, provided IK from CEA Saclay

(nBLMs being tested for later phases, not yet fully deployed)

I Dolenc Kittelmann *et al*

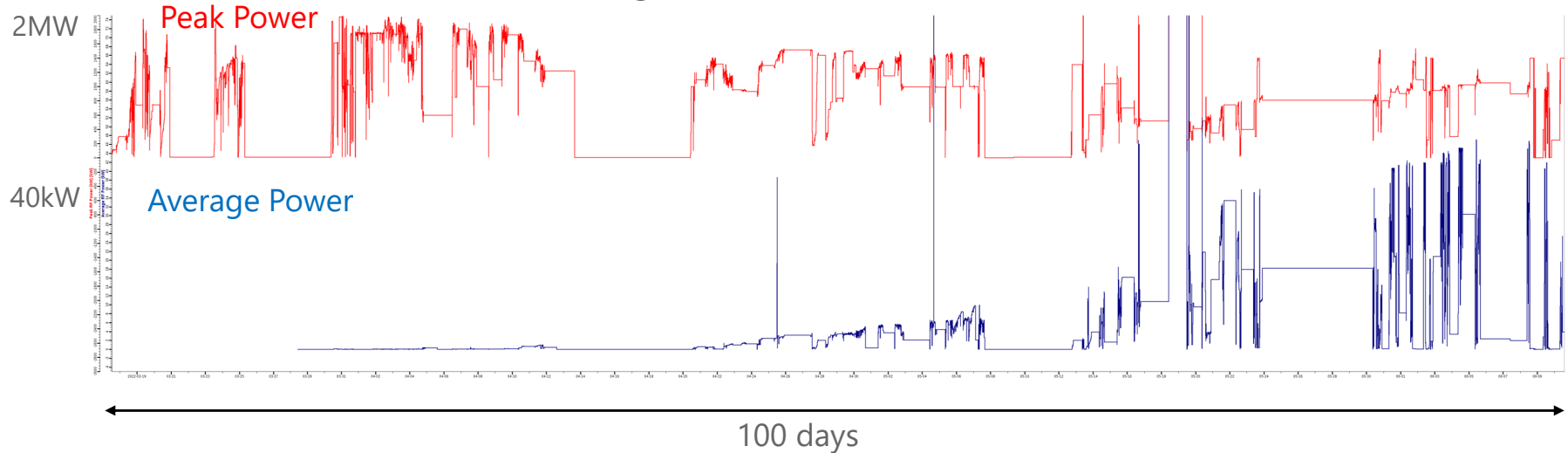
# DTL Conditioning

Ongoing, but well past level needed  
next phases of beam commissioning

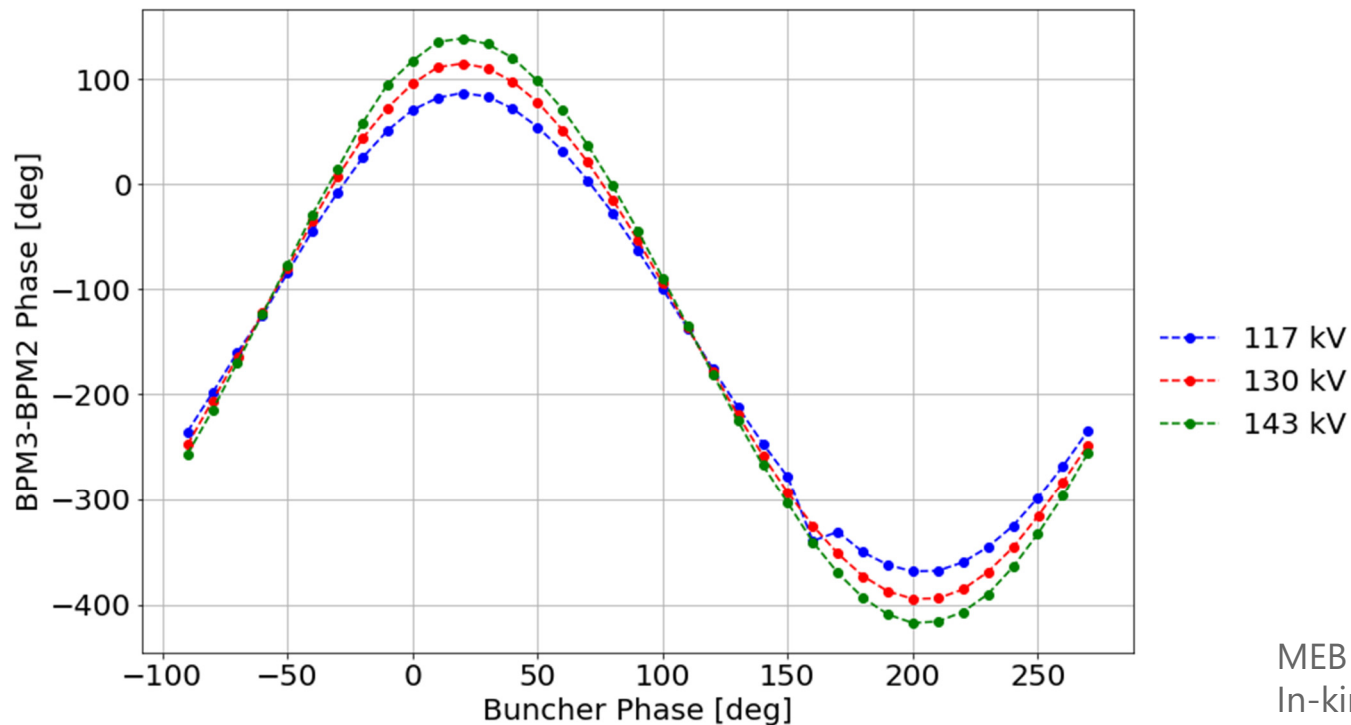
As of June 11 at 93% of nominal gradient  
with full pulse length and rep rate.



DTL is delivered as in kind from INFN Legnaro



# MEBT Buncher Phase Scans

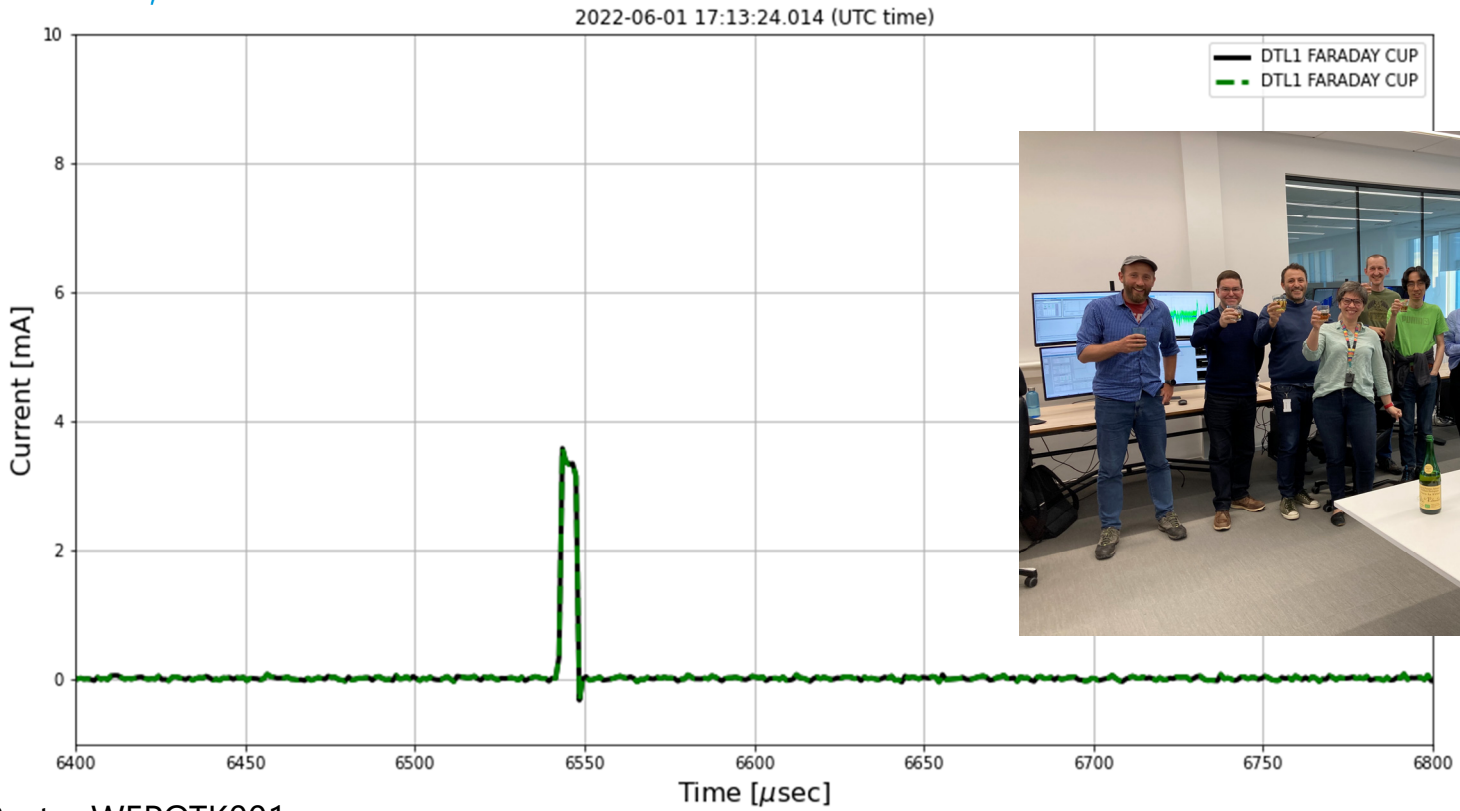


MEB bunchers delivered as  
In-kind from ESS-Bilbao



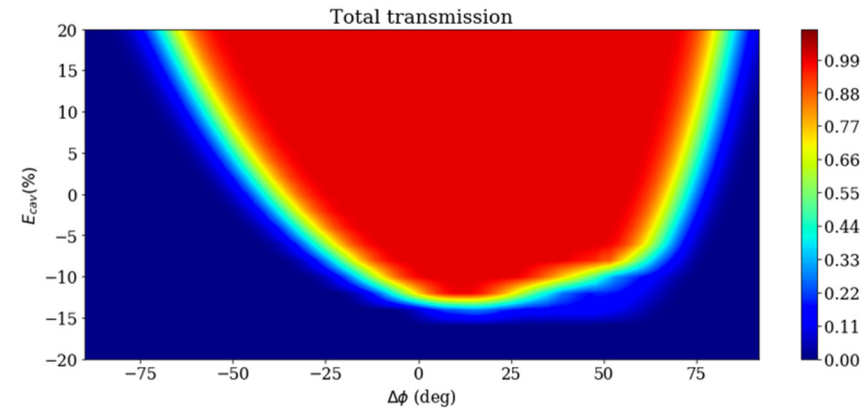
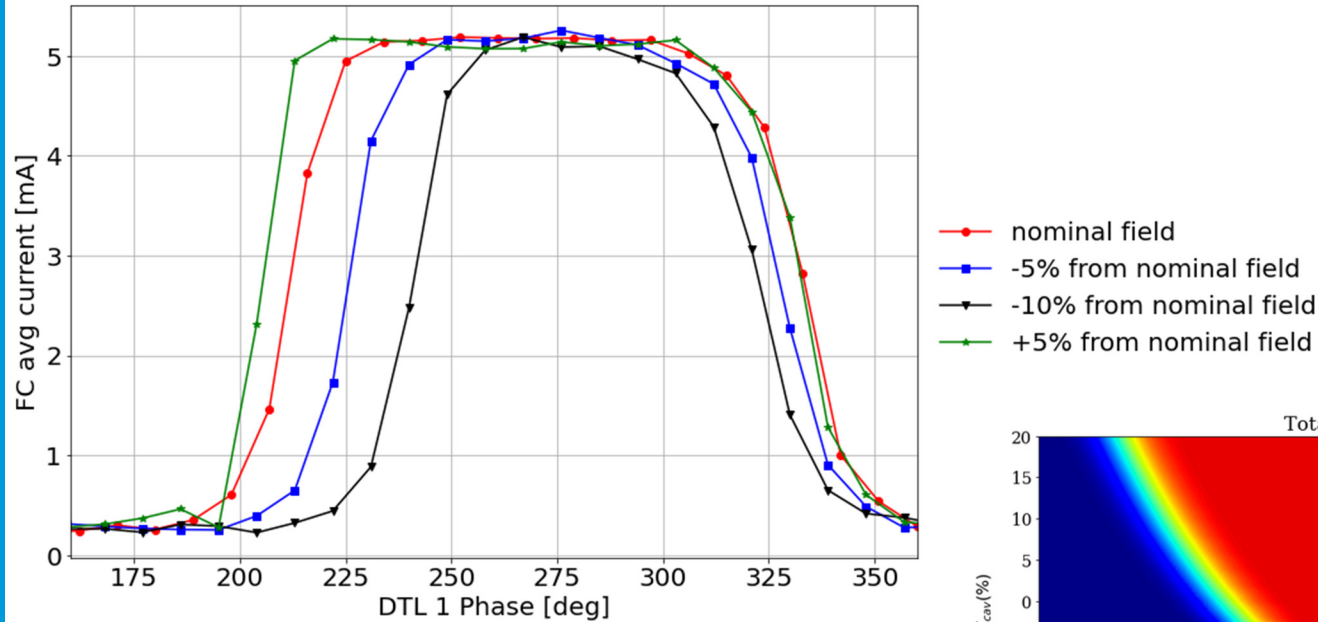
# First Beam Through DTL

June 1, 2022

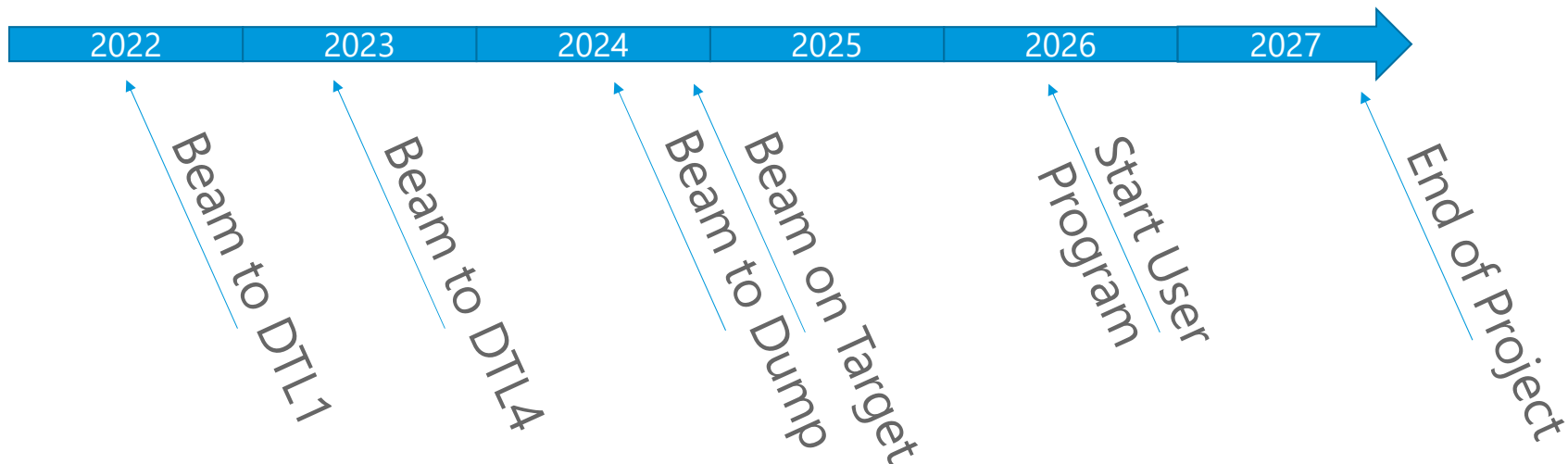
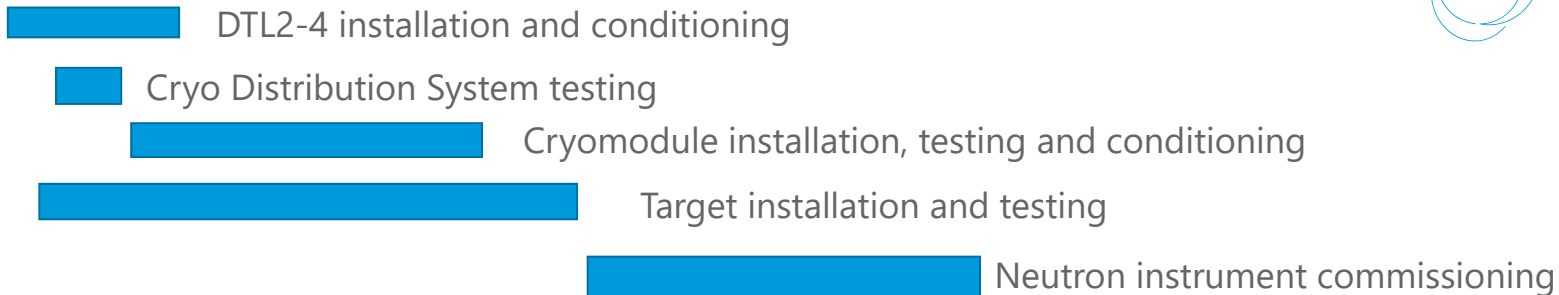


Poster WEPOTK001

# DTL Transmission Scan



# Timeline





# In kind Advantages



- **It would not have been possible to build ESS without in kind partners!**
  - Green field site and no existing organization.
- Very few labs can build everything in house. For a green field site, this is not an option.
- In kind provides access to intellectual property, competence and qualified manpower (including procurement staff) at partner labs.
- For the member countries, it is a way to get local return on investment in a facility located in a different country.

# In kind Challenges



- Scope sometimes divided based on partner lab preferences and interest rather than according to functional breakdown. Can lead to complicated interfaces (and problems tend to happen at the interfaces)
- Partner lab priorities may change after agreements signed
- Partner labs may want to take on scope to expand their competence in areas where they have limited experience.
- Partner labs may lose critical competence, which may not be replaced in time.
- For scope that is procured from industry, adding another communication layer (can be challenging in case issues with vendor need to be resolved)

# IK that Works



- Works best when it is a team effort between partner and host.
  - Partnership rather than subcontracting
- Need a clearly defined recipient (person or group) of the IK scope at host lab.
- Jointly developed high level functional requirements and interfaces descriptions
- Cost book principle: jointly agree on total cost, and understanding of how to manage changes
- Joint ownership of issues
- Good quality control at the IK partner is important
  
- **In short: work together and not on separate islands!**

# Monday/Tuesday Posters Related to ESS



| Paper Code | Title                                                                                                |
|------------|------------------------------------------------------------------------------------------------------|
| MOPOTK061  | Shape Optimization of High-Beta Accelerating Cavity Apertures with a Covariant Iterator              |
| TUPOST017  | PEG Contribution to the LLRF System for Superconducting Elliptical Cavities of ESS Accelerator Linac |
| TUPOTK002  | Results of the RF Power Tests of the ESS Cryomodules Tested at CEA                                   |
| TUPOTK003  | High Power RF Conditioning of the ESS RFQ                                                            |
| TUPOTK004  | Time Resolved Field Emission Detection During ESS Cryomodule Tests                                   |
| TUPOTK019  | INFN-LASA Surface Processing Strategy for Performance Improvement of ESS Medium-Beta Cavities        |
| TUPOTK021  | Recent Update on ESS Medium Beta Cavities at INFN LASA                                               |
| TUPOTK026  | ESS Elliptical Cryomodules Tests at Lund Test Stand                                                  |
| TUPOTK027  | Field Emission Measurements at ESS Lund Test Stand                                                   |
| TUPOTK028  | Tuning of Superconducting Cavities Using the FFT of Transmitted Power                                |
| TUPOTK030  | X-Ray Energy Measurements During the RFQ Conditioning at the European Spallation Source              |
| TUPOMS062  | Overall Performances of 26 Power Stations at 400 kW - 352 MHz                                        |



# Wednesday/Thursday Posters Related to ESS



| Paper Code | Title                                                                                                                     |
|------------|---------------------------------------------------------------------------------------------------------------------------|
| WEPOTK001  | Status of the Normal Conducting Linac at the European Spallation Source                                                   |
| WEPOMS049  | ESS RFQ Electromagnetic, Thermal and Mechanical Fatigue Measurements and Analysis                                         |
| THPOST037  | Analysis with MECAMaster on the Chain of Design Tolerances for the Target Systems at the European Spallation Source - ESS |
| THPOST038  | On-Site Transport and Handling Tests of Cryomodules for the European Spallation Source                                    |
| THPOTK025  | Heat Loads Measurement Methods for the ESS Elliptical Cryomodules SAT at Lund Test Stand                                  |
| THPOTK057  | Vibration Measurements for RFQ Commissioning at ESS                                                                       |

# Thank you for your attention!

