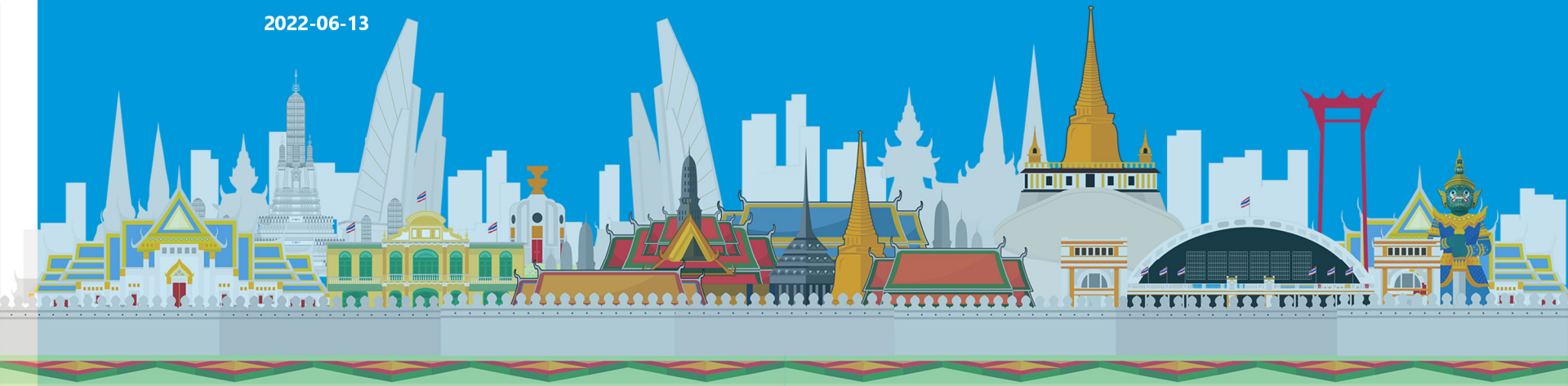
Status of the European Spallation Source

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

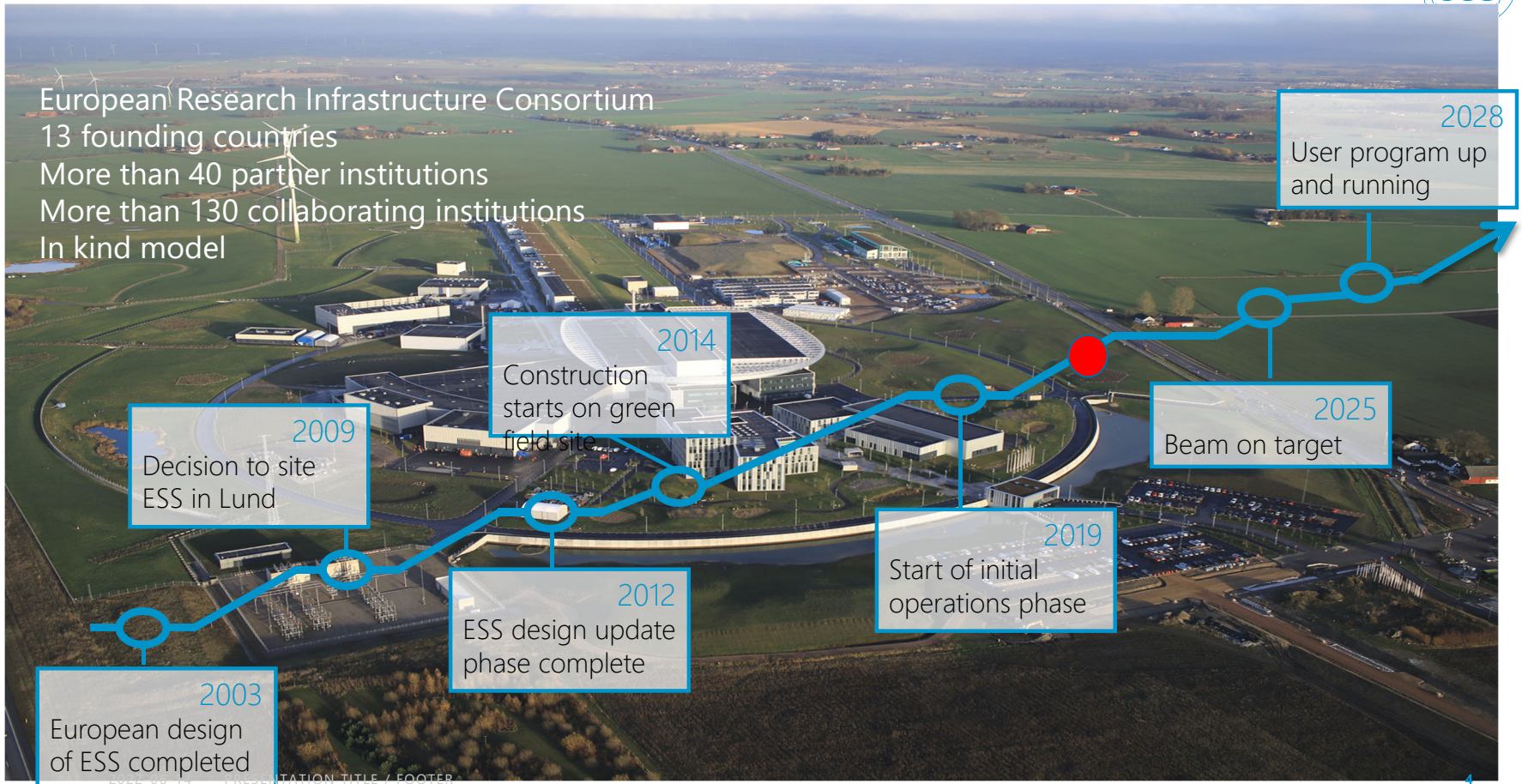
Beam commissioning status and plans

In-kInd

From Green Field to ESS

May 2014 vs April 2022

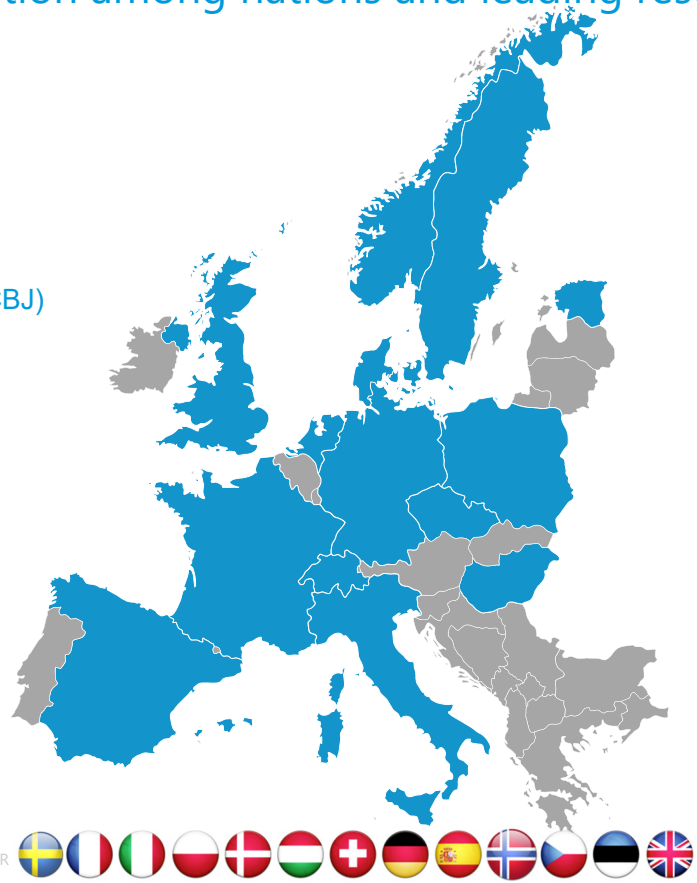
The ESS Journey



Unique International Project

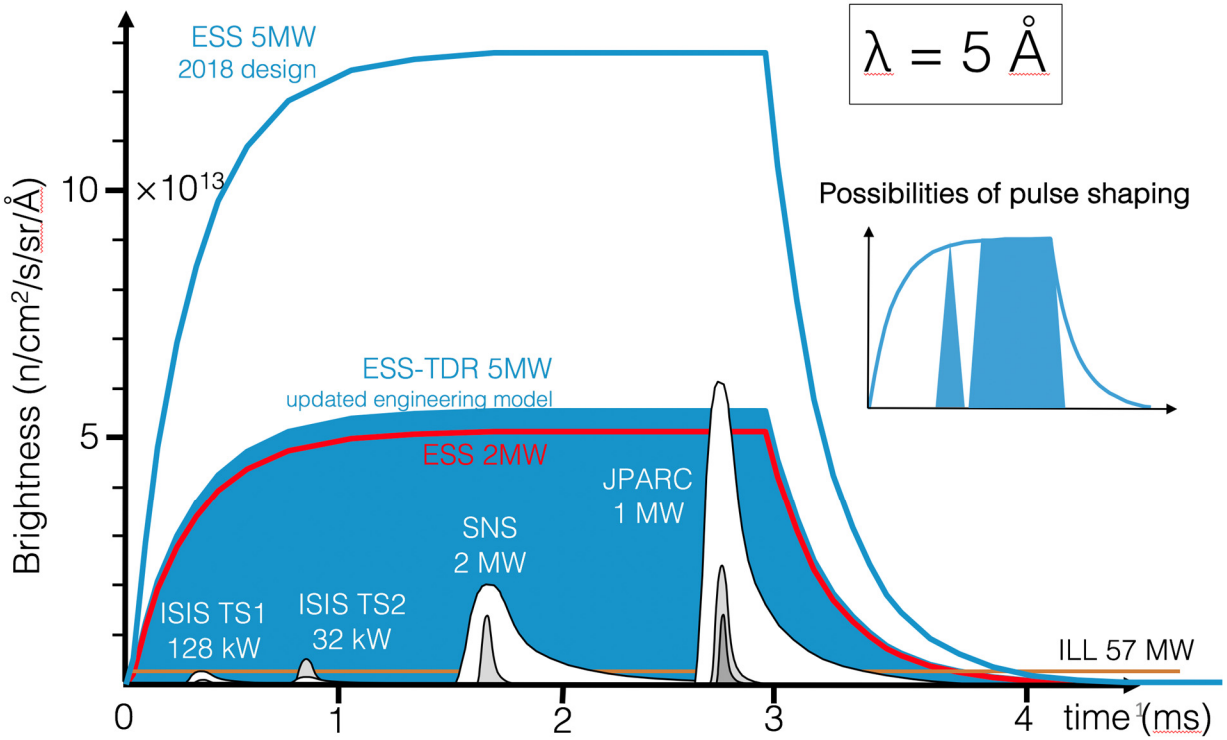
With unique cooperation among nations and leading research insitutes

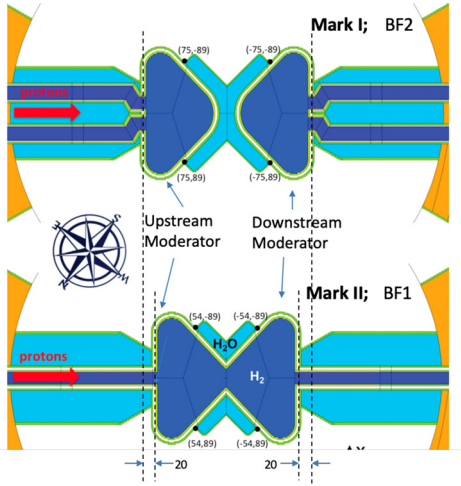
Aarhus University
Atomki - Institute for Nuclear Research
Bergen University
CEA Saclay, Paris
Centre for Energy Research, Budapest
Centre for Nuclear Research, Poland, (NCBJ)
CNR, Rome
CNRS Orsay, Paris
Cockcroft Institute, Daresbury
Elettra – Sincrotrone Trieste
ESS Bilbao
Forschungszentrum Jülich
Helmholtz-Zentrum 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 Brilouin (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)

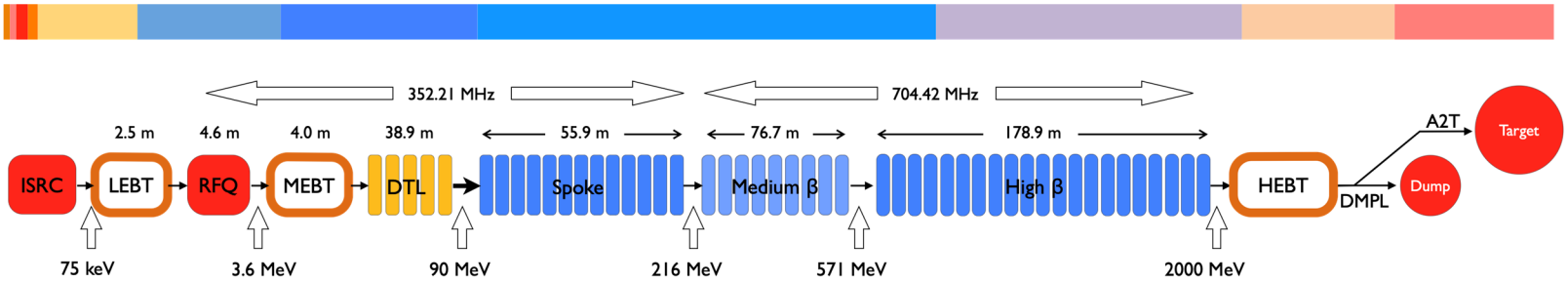
ESS Performance





Descoping in accelerator power (and instrument scope) due to budget restrictions compensated by moderator develo
(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 then 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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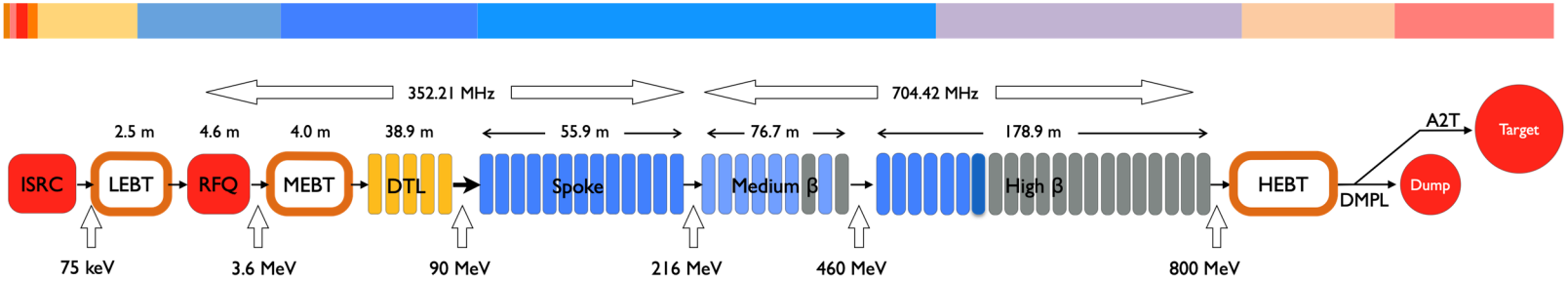

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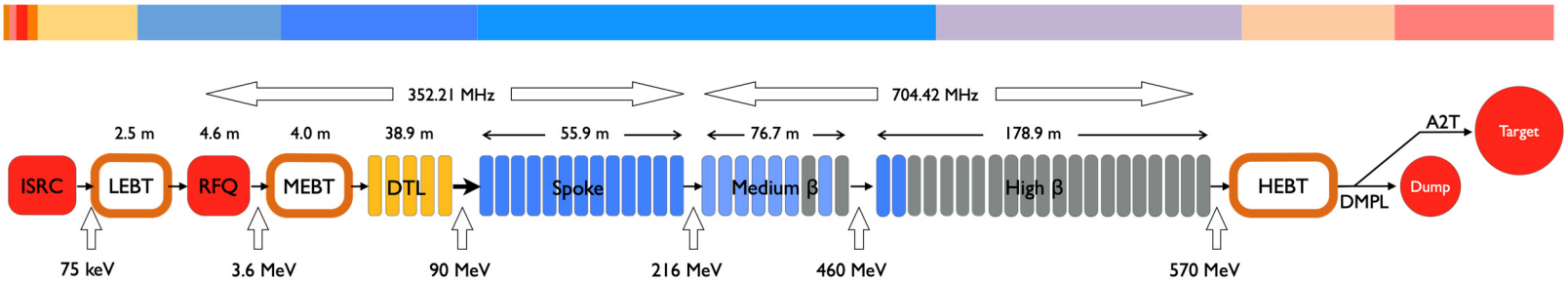

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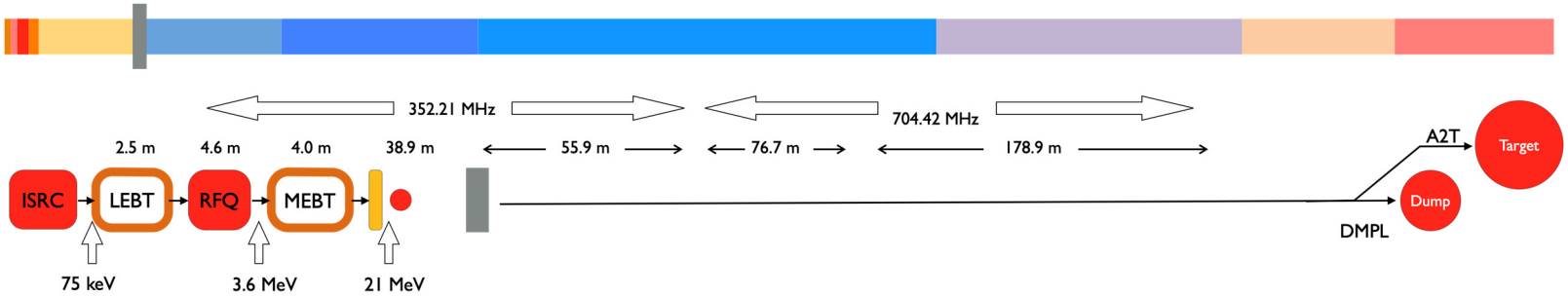

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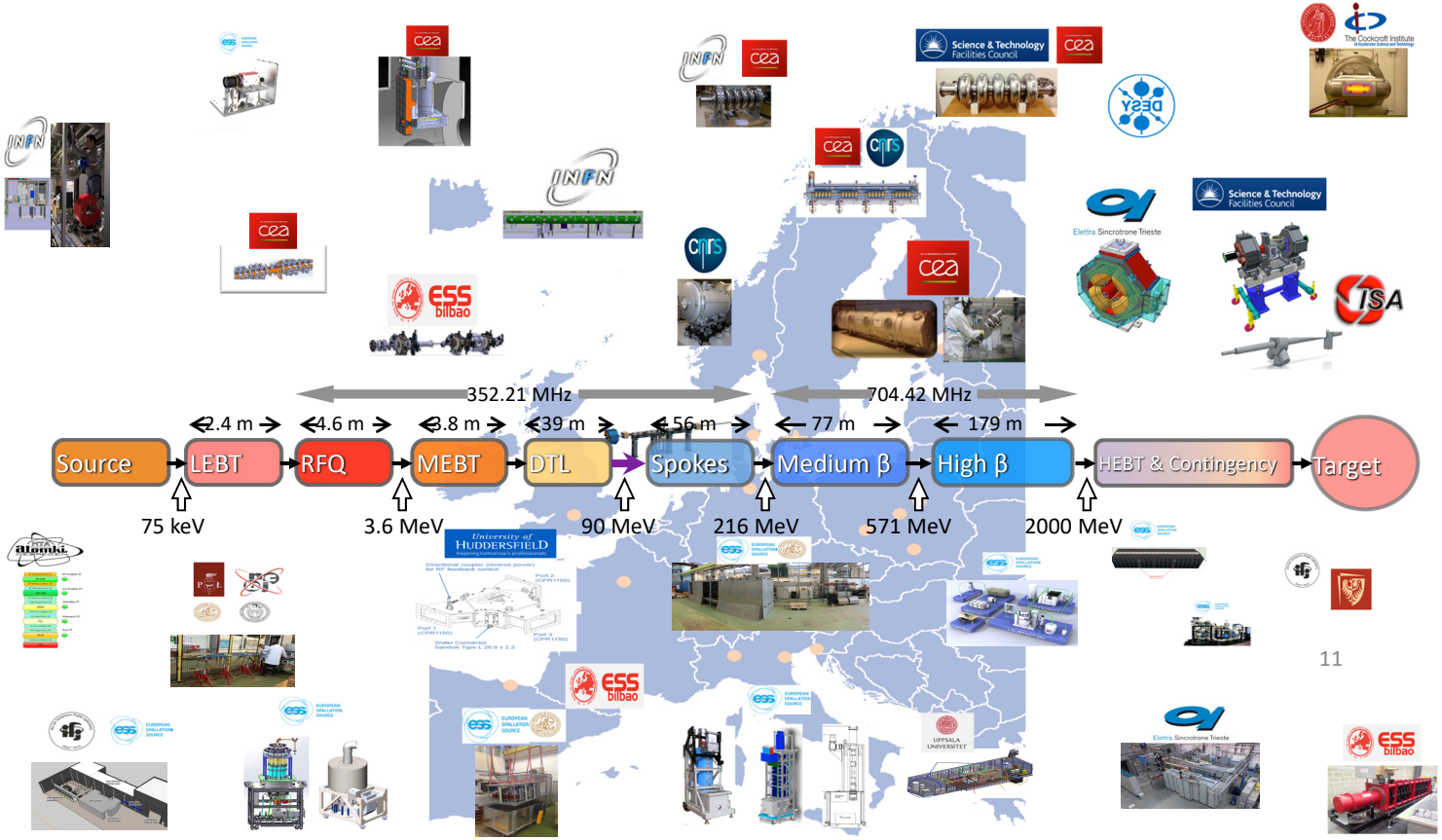
Accelerator Collaboration



Tunnel View Then and Now

Parts of Normal Conducting Linac Under commissioning

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

Klystron Gallery Then and Now

RF for normal conducting part installed and tested.

Installation and testing ongoing in superconducting part

SCL RF Station Testing

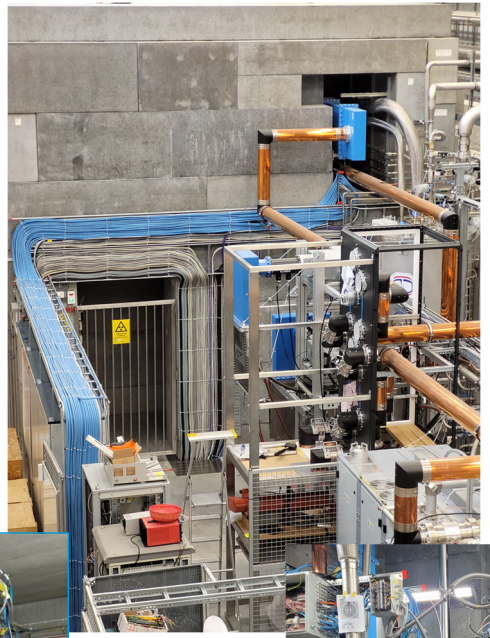
Spoke and Medium Beta RF stations under test in Klystron Gallery

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

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

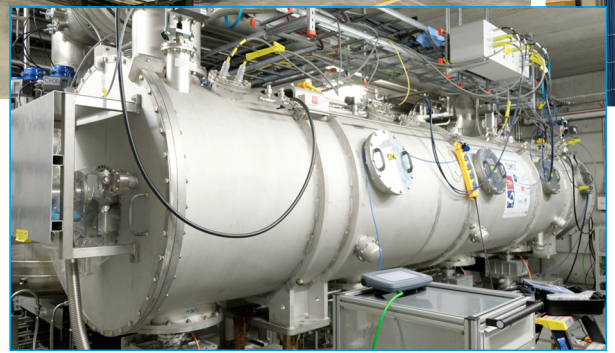
See poster TUPOMS062

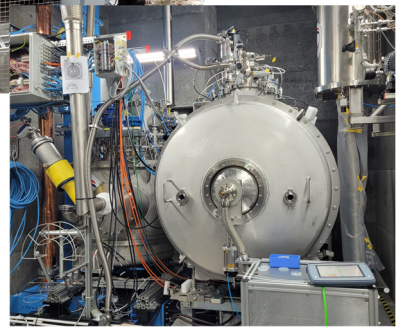
Cryomodule Delivery and Testing



Uppsala Test Stand (FREIA)

8 spoke CMs tested and Delivered to ESS





ESS Test stand (TS2)

6 medium beta CMs delivered
4 of them tested

Poster TUPOTK002

Linac Warm Units

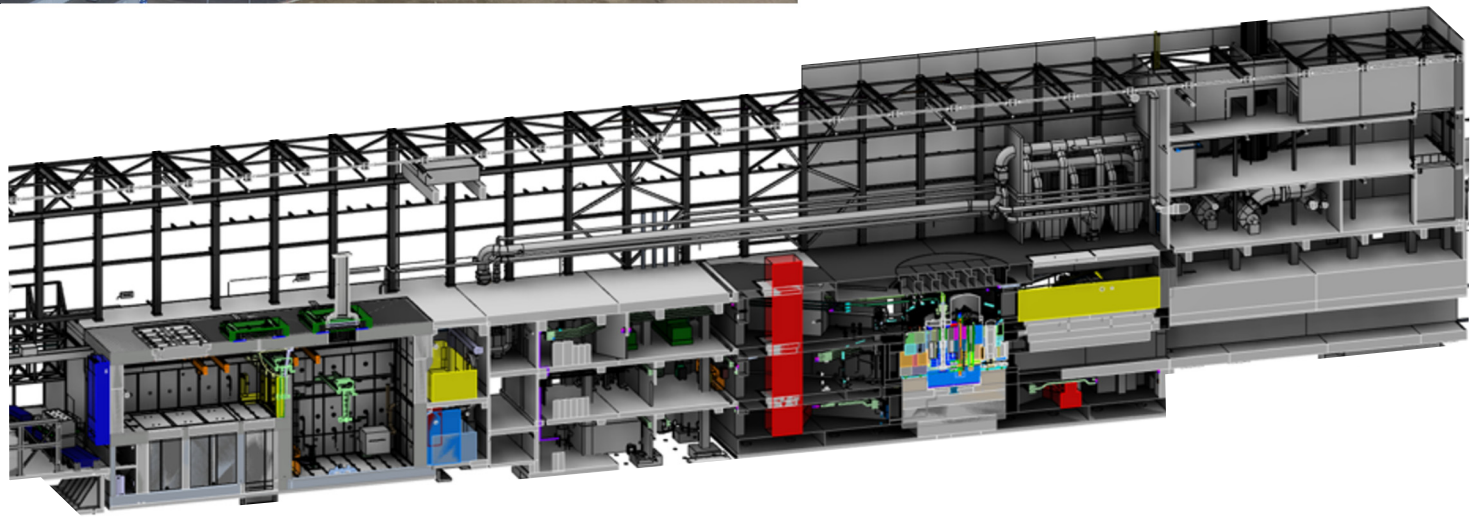
Linac warm units installed in HEBT

Particle free installation

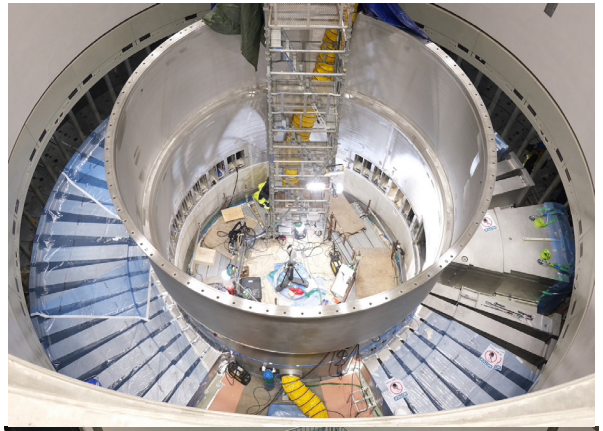
LWU assemblies are delivered as in kind from Daresbury Lab, using magnets from Elettra (also in kind).

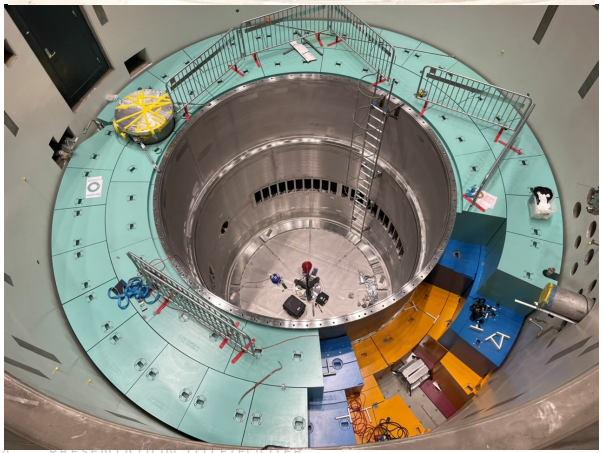
Target

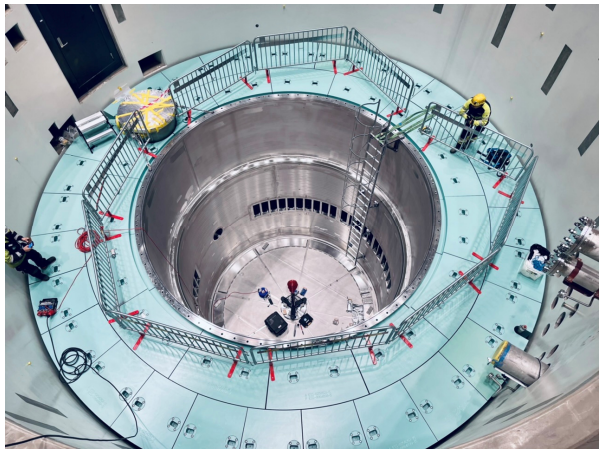
ESS target is a rotating wheel of Tungsten with 36 individual target segments



Core Vessel, Beam Window and Shielding



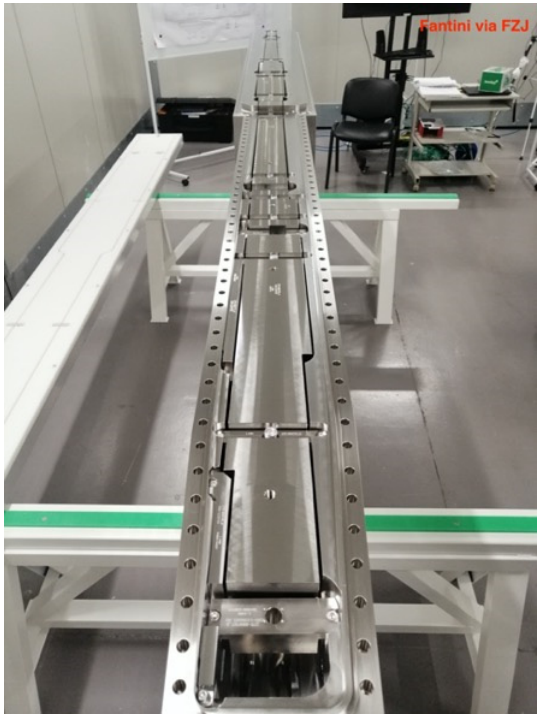


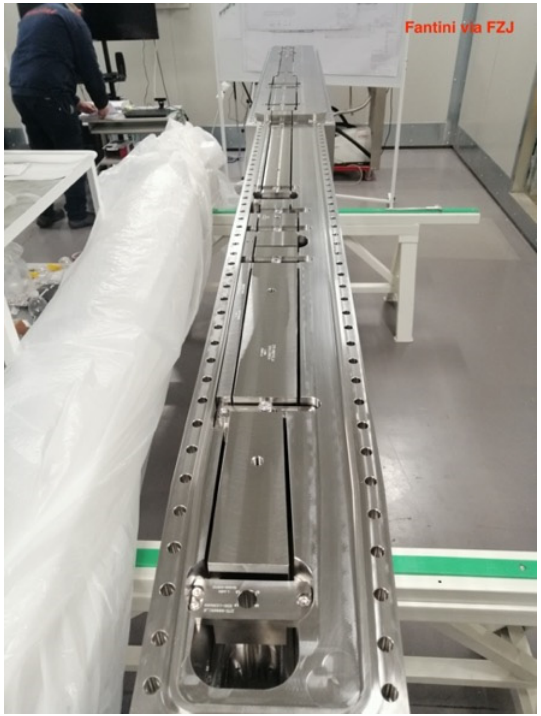


Target Wheel and Moderator

Neutron Port Inserts

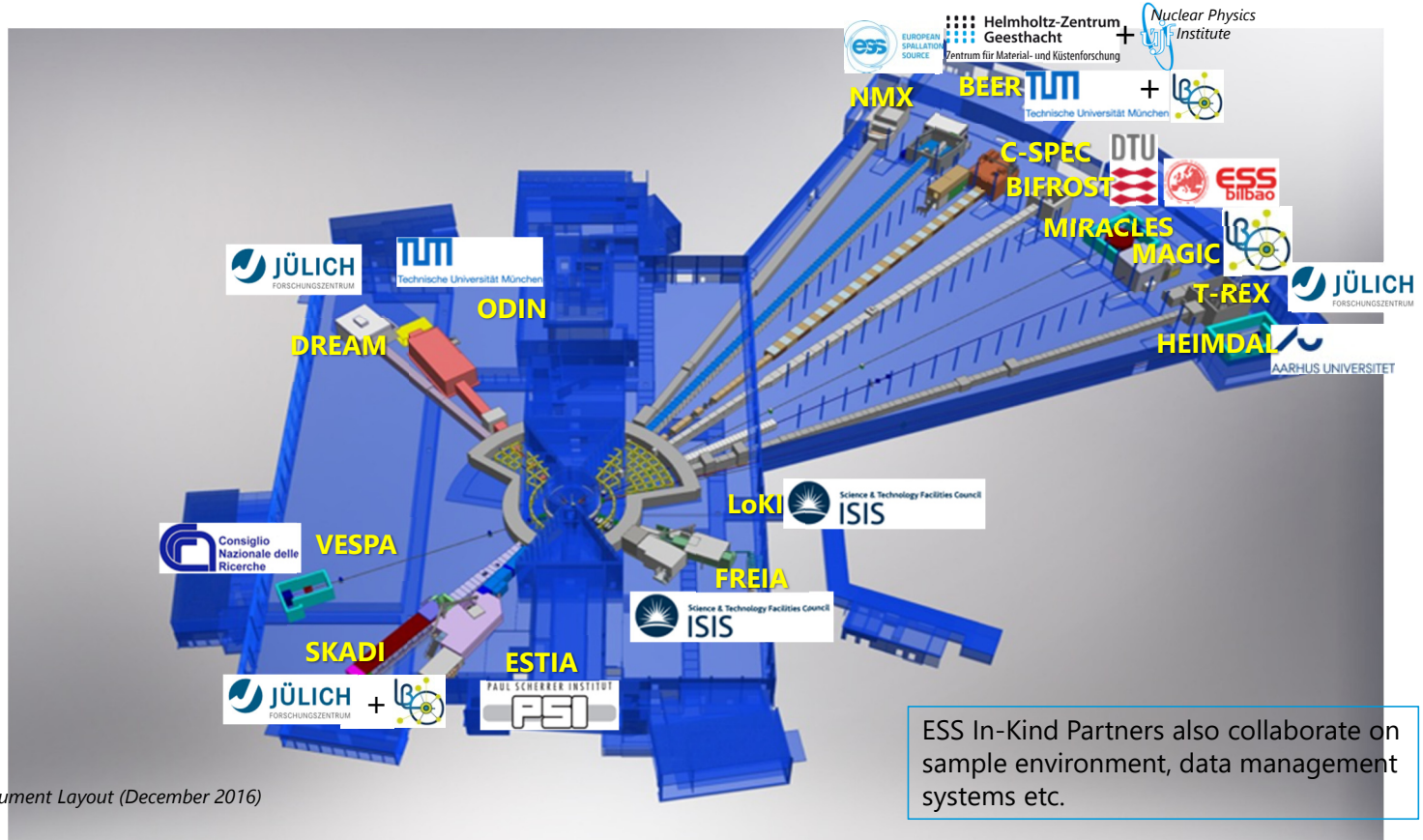
for DREAM and ODIN





NSS Neutron Instrument Positions

ESS Lead Partners for Instrument Construction



ESS Instrument Layout (December 2016)

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

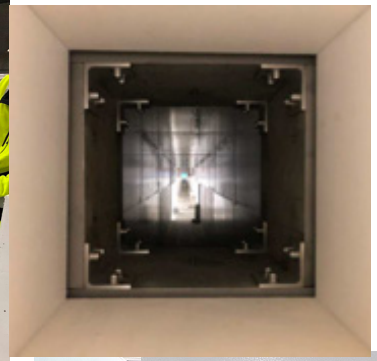
Neutron Instruments

ODIN hutch

DREAM cave & hutch

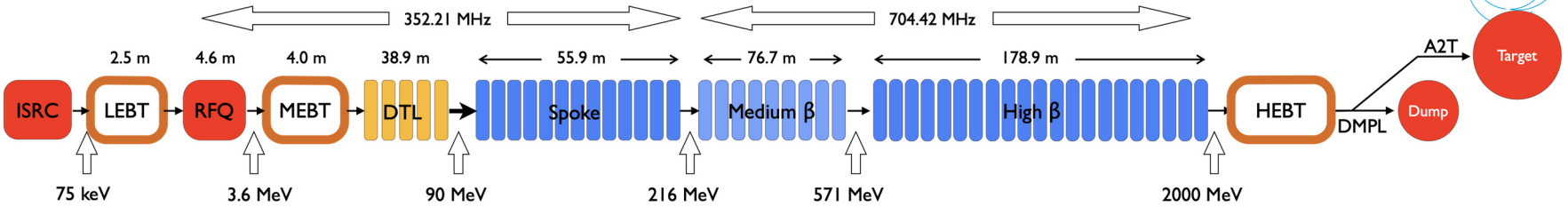
LOKI and bunker (blue)

Choppers, guides, and detectors



Bifrost

Testing & Commissioning Phases



Ion Source License

SRR1 (Isrc & LEBT) – DONE!

NCL License

SRR2a (to MEBT 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

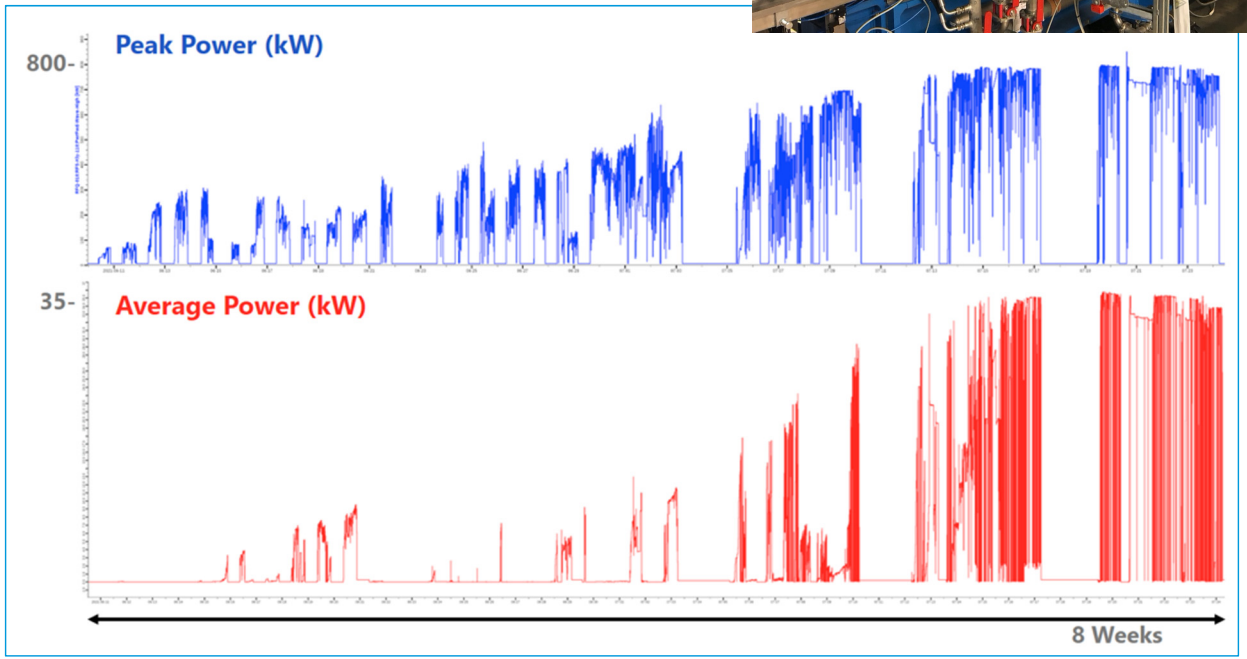
SRR4 (to TBD)

SRR5

2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | 2025

RFQ Conditioning

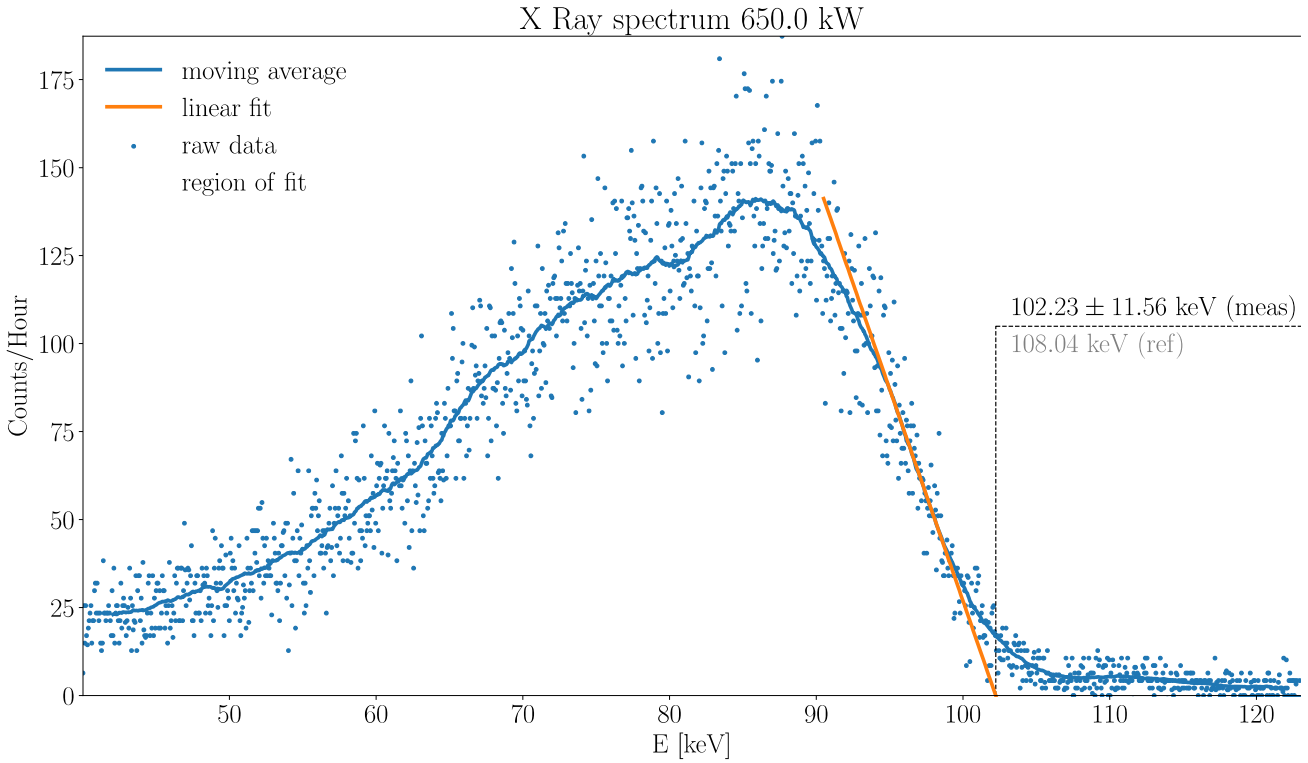
Poster TUPOTK003



RFQ provided as in kind from CEA Saclay

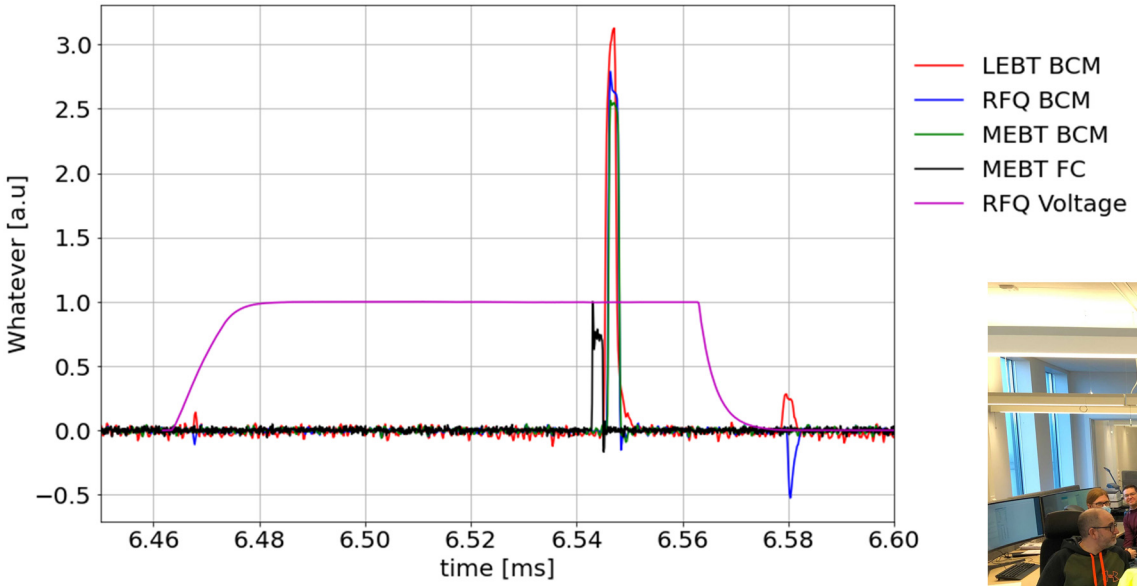
X-ray Measurement of RFQ Voltage

See poster TUPOTK030



First Beam through RFQ

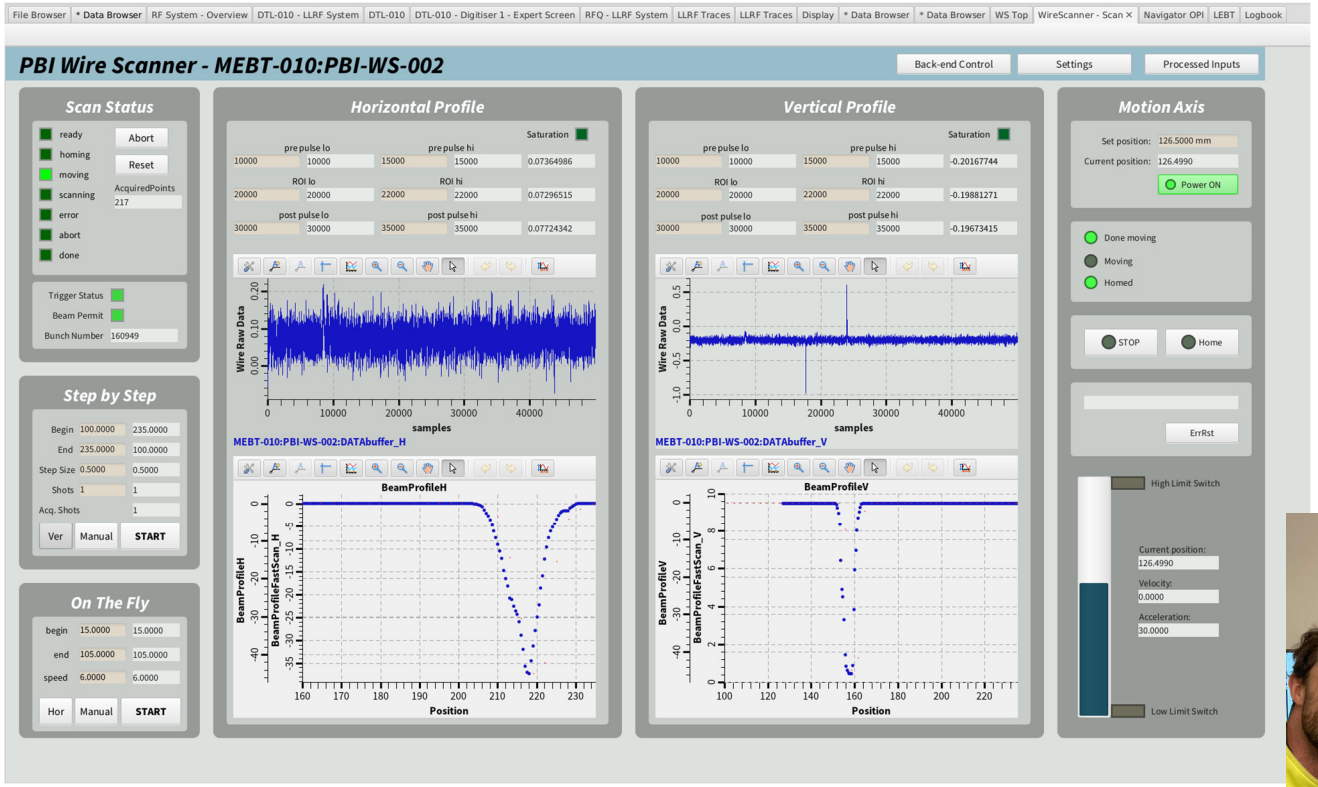
June 9, 2021



First beam pulse with dead-reckoned timing settings

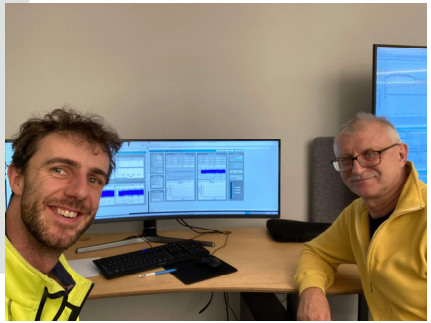
Poster WEPOTK001

First Wire Scan



Wire scanners provided as in kind from ESS Bilbao

Readout Electronics provided as in kind from Elettra

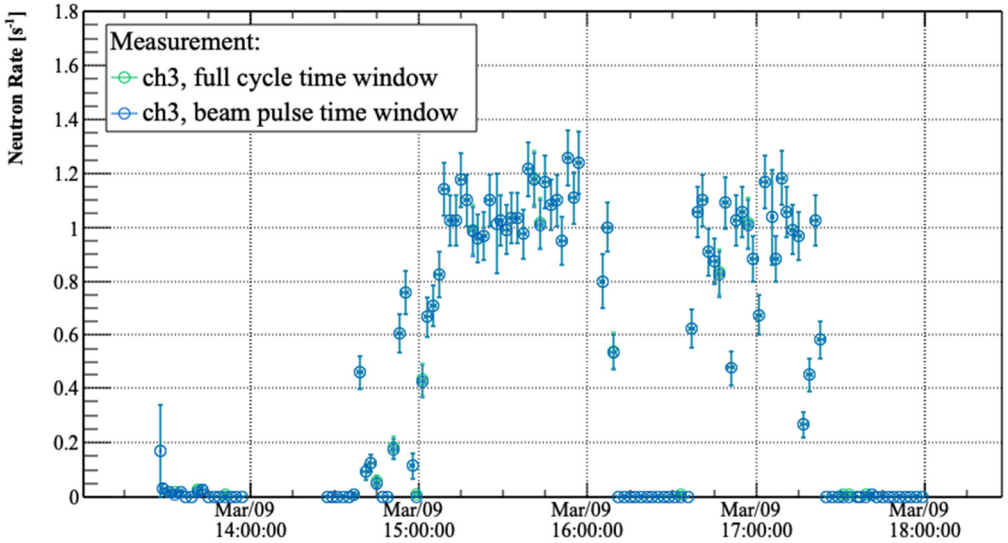


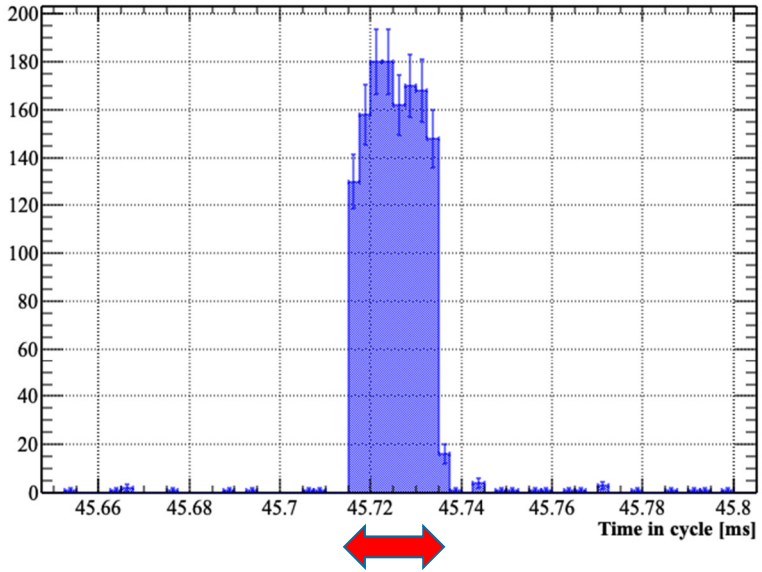
Intial testing of wire scanners (not yet fully controls integrated)

C. Derrez *et al*

First Accelerator-Produced Neutrons

But not for the users yet…





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

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

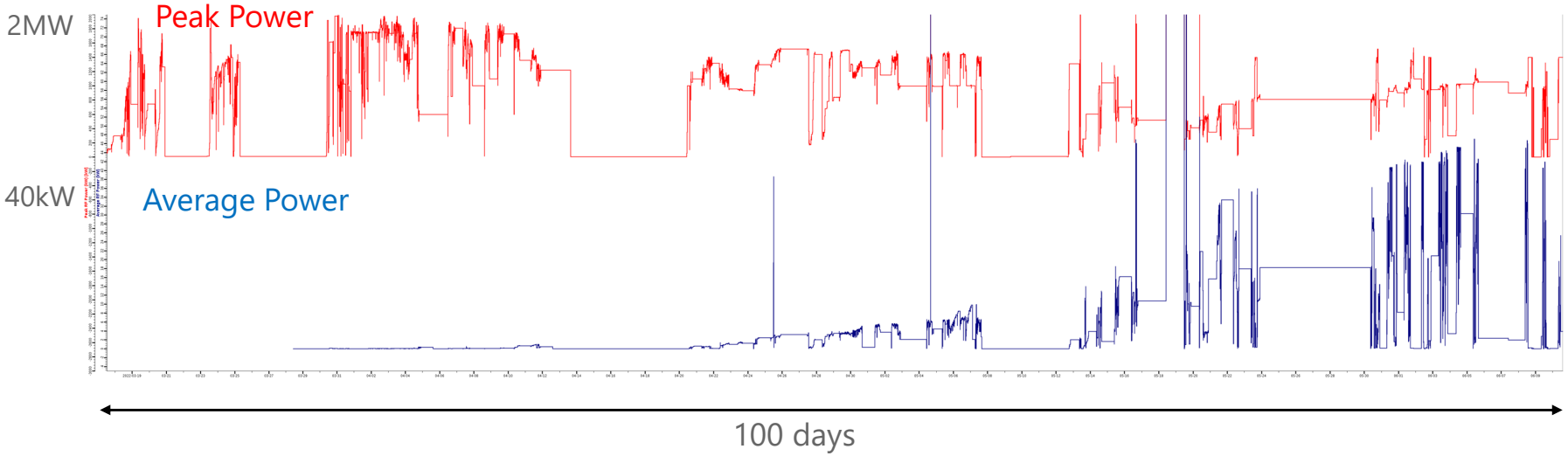
I Dolenc Kittelmann *et al*

DTL Conditioning

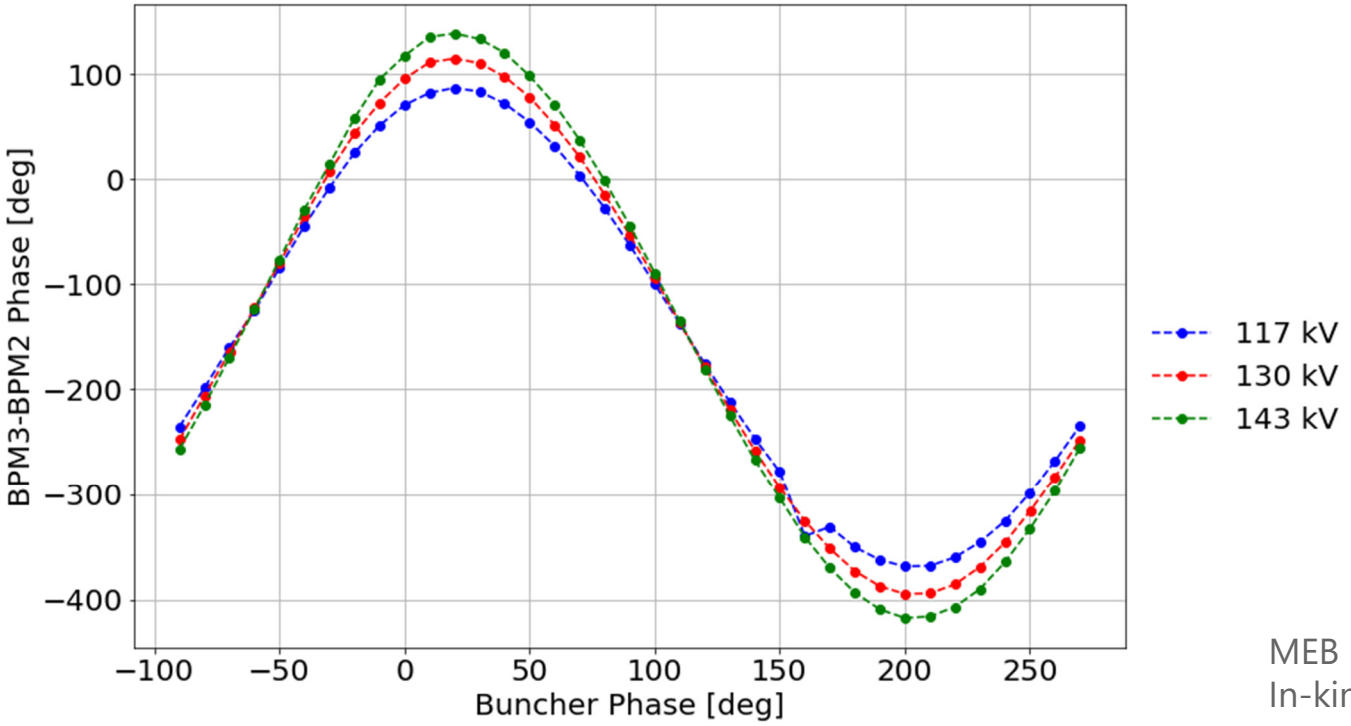
Ongoing, but well past level needed next phases of beam commissioning

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



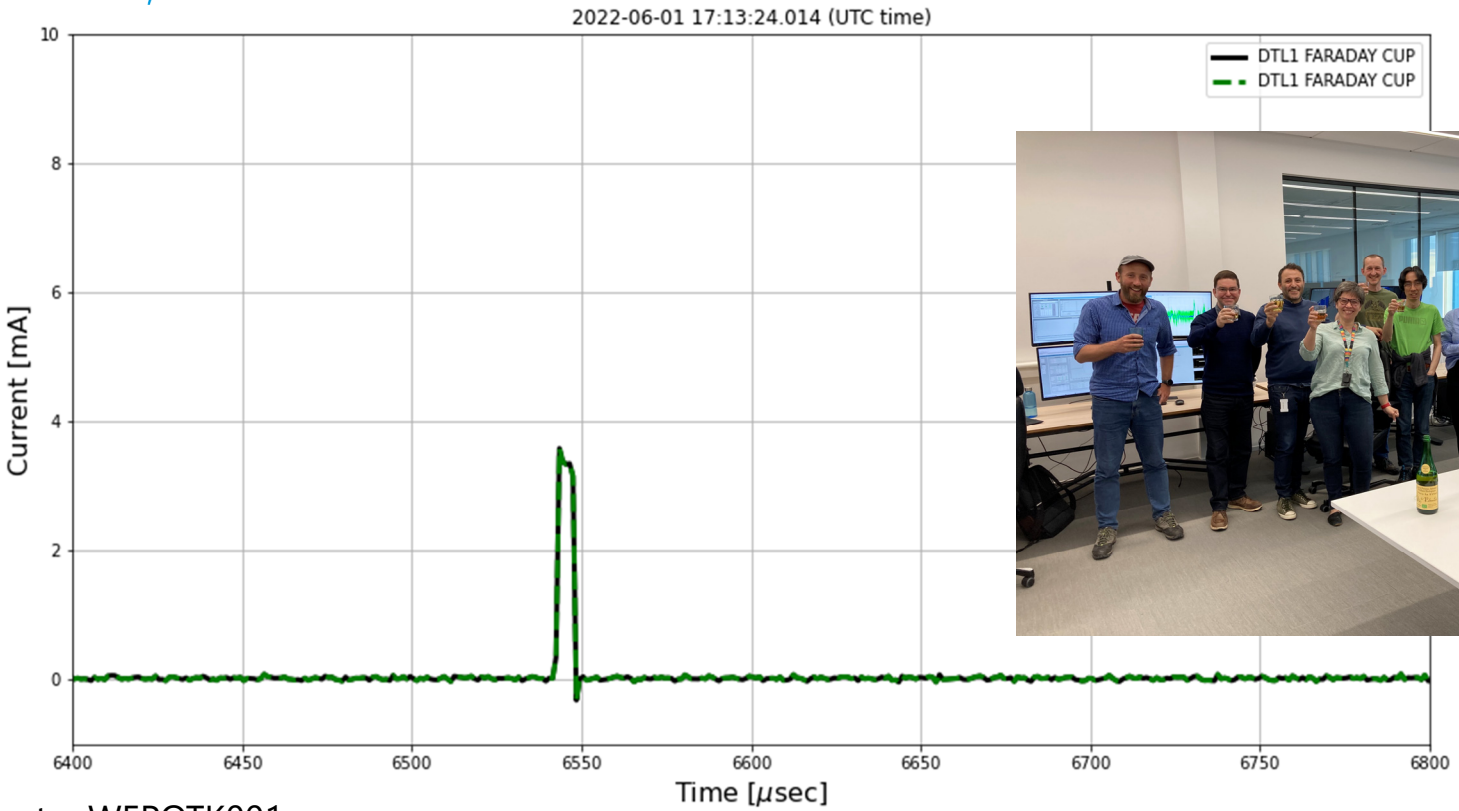
MEBT Buncher Phase Scans



MEB bunchers delivered as
In-kind from ESS-Bilbao

First Beam Through DTL

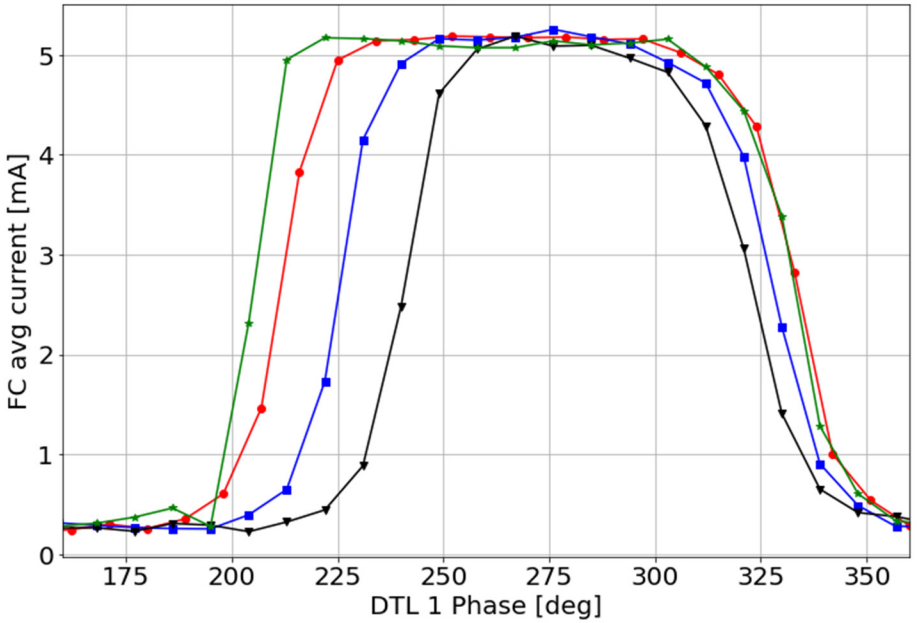
June 1, 2022

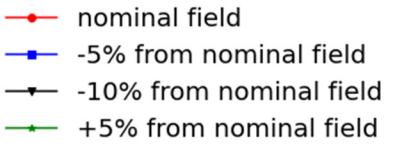


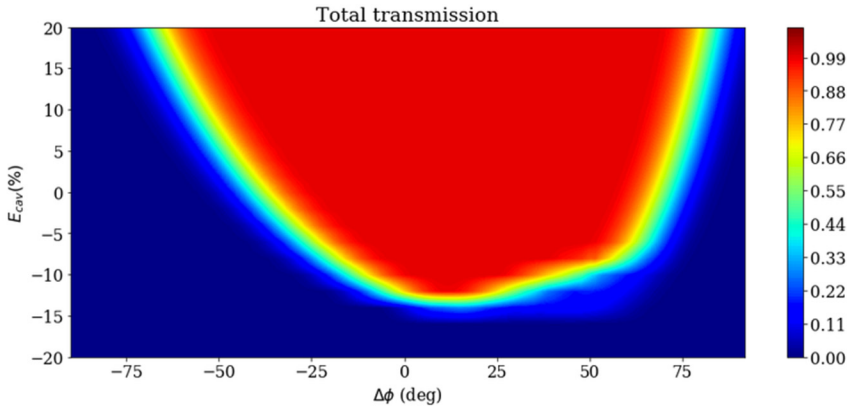
Poster WEPOTK001

*non alcoholic POMMAC celebration in accordance with ESS regula

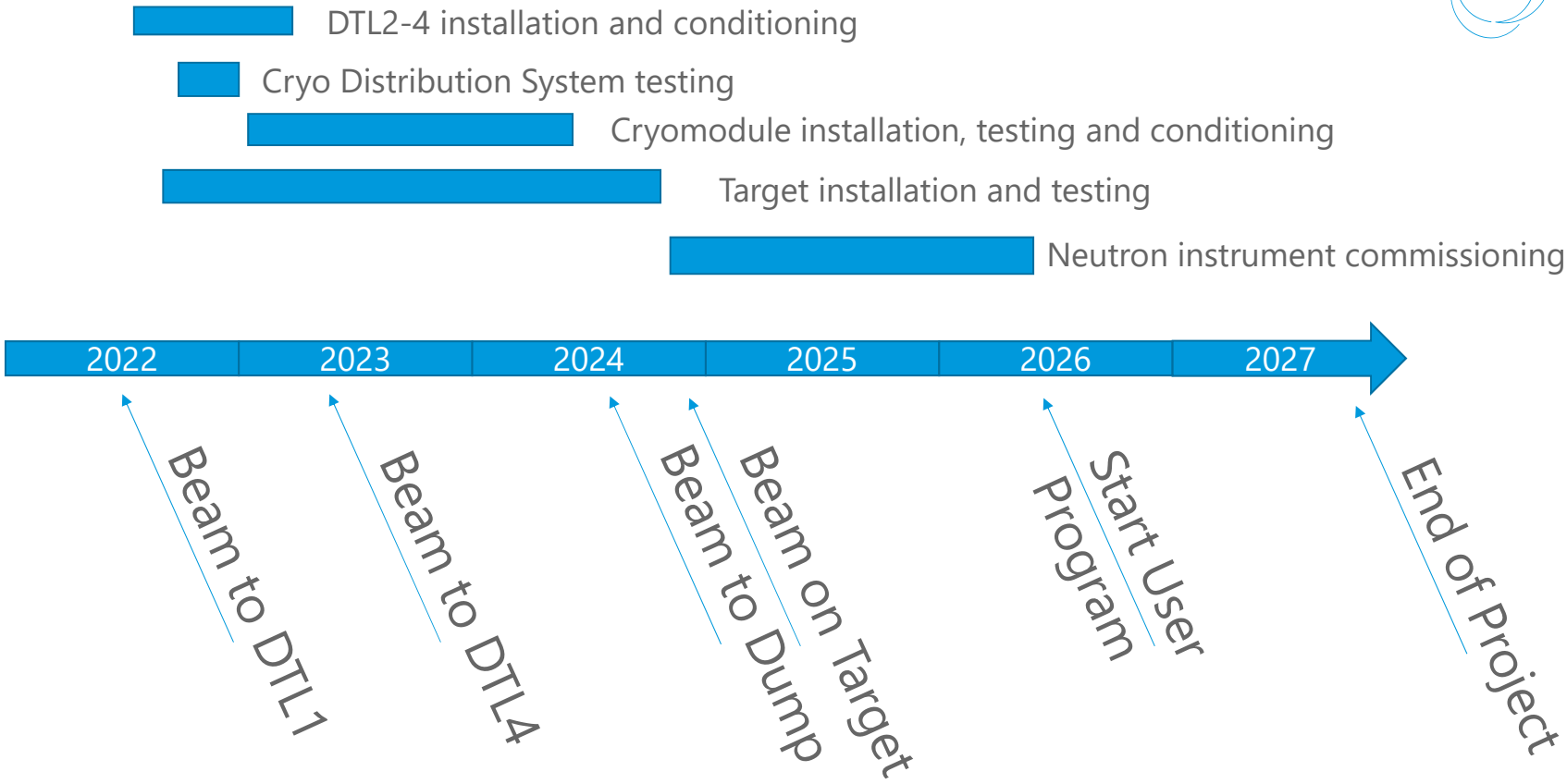
DTL Transmission Scan







Timeline


DTL2-4 installation and conditioning
Cryo Distribution System testing
Cryomodule installation, testing and conditioning
Target installation and testing
Neutron instrument commissioning
2022
2023
2024
2025
2026
2027
Beam to DTL1
Beam to DTL4
Beam to Dump
Beam on Target
Start User Program
End of Project

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 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!