IPAC17

EUROPEAN SPALLATION SOURCE

Progress on ESS Project Construction

Roland Garoby – Technical Director

15 May 2017

Progress on ESS Project Construction

EUROPEAN SPALLATION SOURCE

ESS facility and construction project

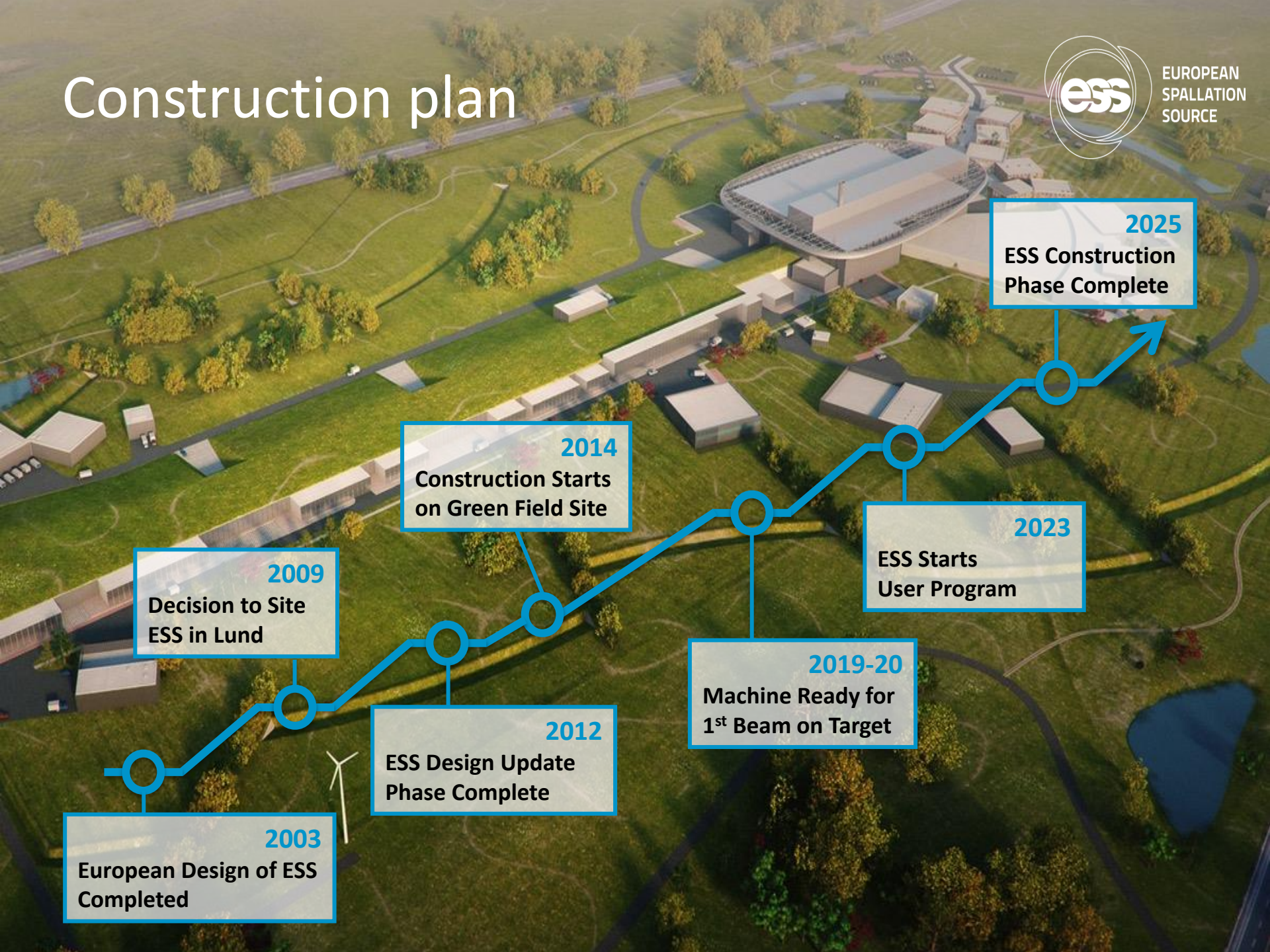
- Status of design and progress in realization
- Global Project status
- Summary

IPAC17

ESS design

EUROPEAN SPALLATION SOURCE

Construction plan



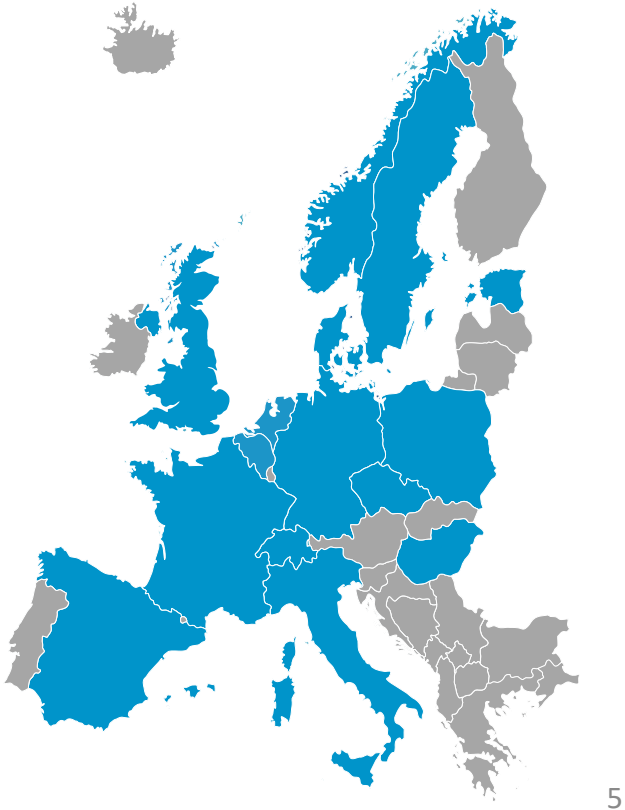
Financing

Host Countries Sweden and Denmark

Construction 47.5% Cash Investment ~ 97%
Operations 15%

Non Host Member Countries

Construction 52.5% In-kind Deliverables ~ 70%
Operations 85%

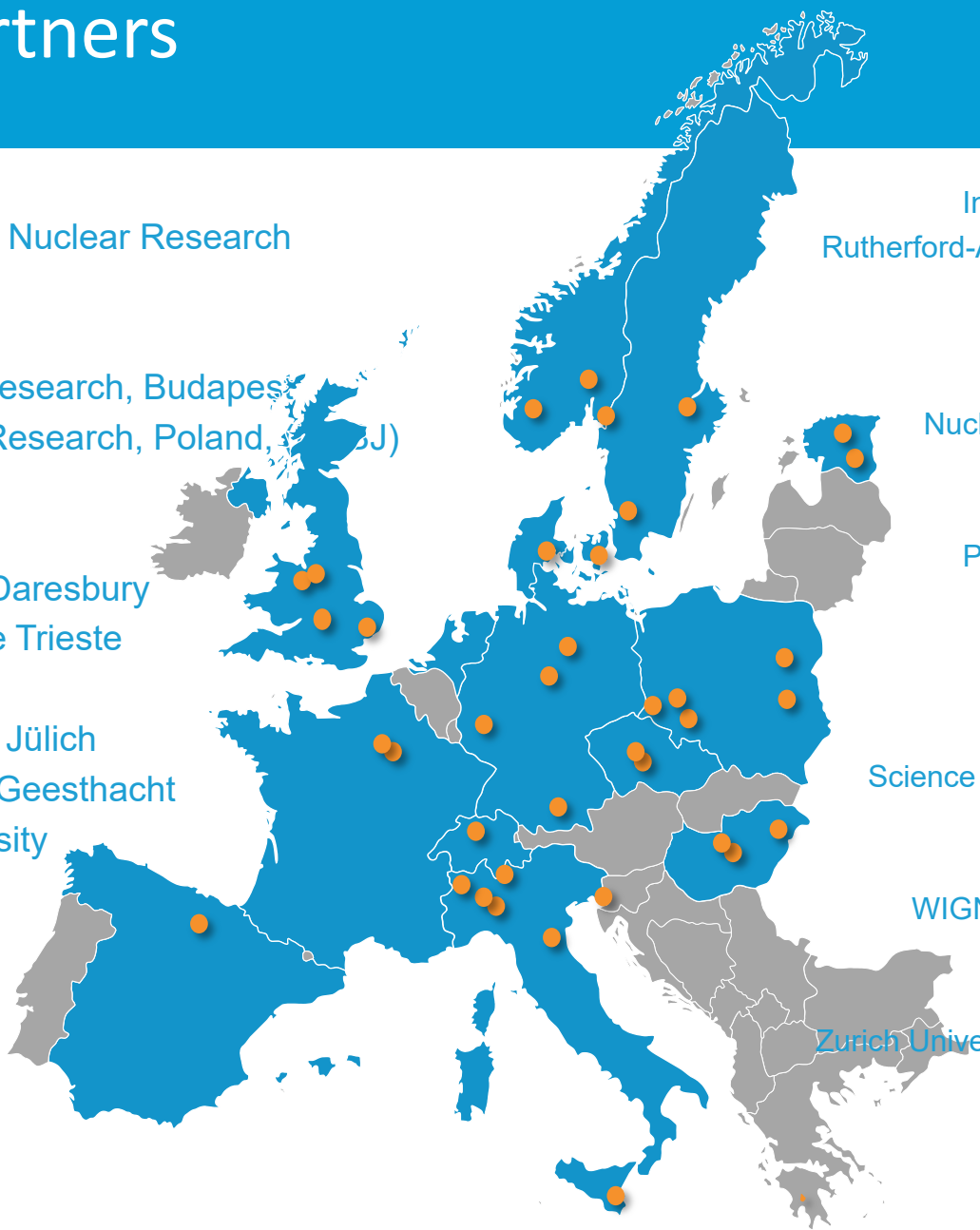


(Jan 2013 pricing)	M €
Conventional Facilities	531.9
Extra CF investment by host countries	-93.0
Accelerator Systems	510.2
Target Systems	155.2
Integrated Control System	73.0
Design & Engineering	33.7
Neutron Scattering Systems	350.0
Project Support & Administration and Licensing	123.8
Contingency	158.2
Total Construction Budget	**1843.0**

ESS partners

EUROPEAN SPALLATION SOURCE

Aarhus University
Atomki - Institute for Nuclear Research
Bergen University
CEA Saclay, Paris
Centre for Energy Research, Budapes
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



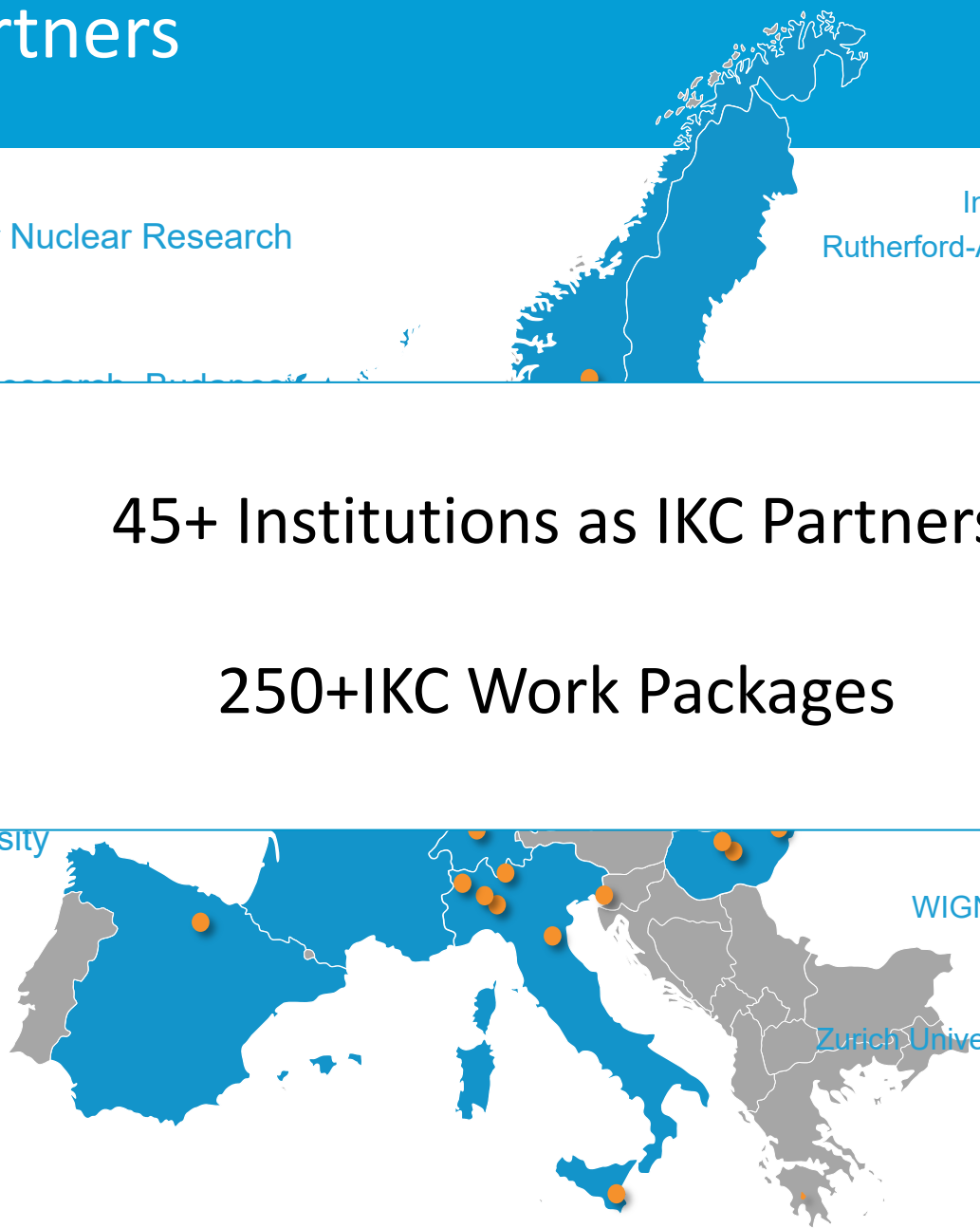
Institute for Energy Research (IFE)
Rutherford-Appleton Laboratory, Oxford(ISIS)
Kopenhagen University
Laboratoire Léon Brilouin (LLB)
Lund University
Nuclear Physics Institute of the ASCR
Oslo University
Paul Sherrer Institute
Polska Grupa Energetyczna - PGE
Roskilde University
Tallinn Technical University
Technical University of Denmark
Technical University Munich
Science and Technology Facilities Council
University of Tartu
Uppsala University
WIGNER Research Centre for Physics
Wroclaw University of technology
Warsaw University of Technology
Zurich University of Applied Sciences (ZHAW)

IPAC17

ESS partners

EUROPEAN SPALLATION SOURCE

Aarhus University
Atomki - Institute for Nuclear Research
Bergen University
CEA Saclay, Paris
Centre for Ene
Centre for Nuc
CNR, Rome
CNRS Orsay, F
Cockcroft Instit
Elettra – Sincro
ESS Bilbao
Forschungszer
Helmholtz-Zen
Huddersfield University
IFJ PAN, Krakow
INFN, Catania
INFN, Legnaro
INFN, Milan



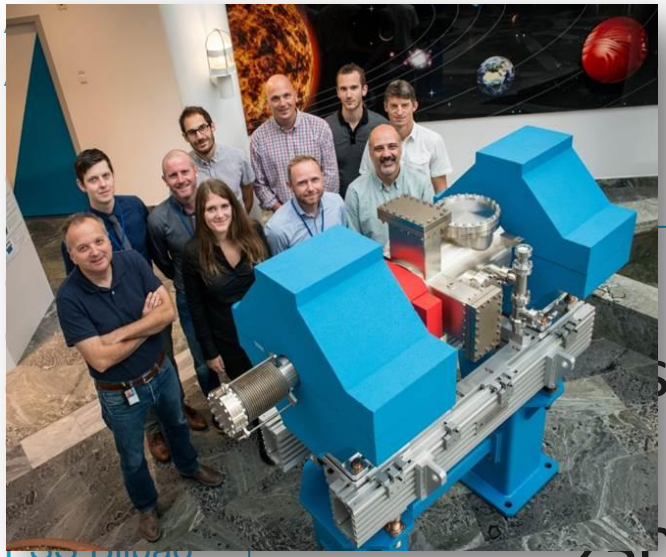
45+ Institutions as IKC Partners

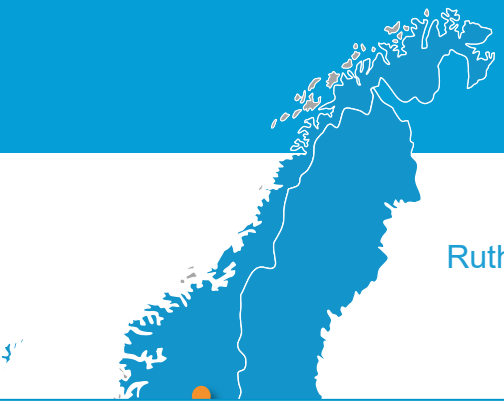
250+IKC Work Packages

Institute for Energy Research (IFE)
Rutherford-Appleton Laboratory, Oxford(ISIS)
Kopenhagen University
Laboratoire Léon Brilouin (LLB)
Lund University
itute of the ASCR
Oslo University
l Sherrer Institute
ergetyczna - PGE
oskilde University
chnical University
ersity of Denmark
University Munich
Facilities Council
University of Tartu
Uppsala University
WIGNER Research Centre for Physics
Wroclaw University of technology
Warsaw University of Technology
Zurich University of Applied Sciences (ZHAW)

IPAC17

ESS partners





Institute for Energy Research (IFE)
Rutherford-Appleton Laboratory, Oxford(ISIS)
Kopenhagen University
Laboratoire Léon Brilouin (LLB)
Lund University
itute of the ASCR
Oslo University
l Sherrer Institute
ergetyczna - PGE
oskilde University

stitutions as IKC Partners

230+IKC Work Pa

ESS Bilbao
Forschungszer
Helmholtz-Zen
Huddersfield University
IFJ PAN, Krakow
INFN, Catania
INFN, Legnaro
INFN, Milan

IPAC17

Progress on ESS Project Construction

EUROPEAN SPALLATION SOURCE

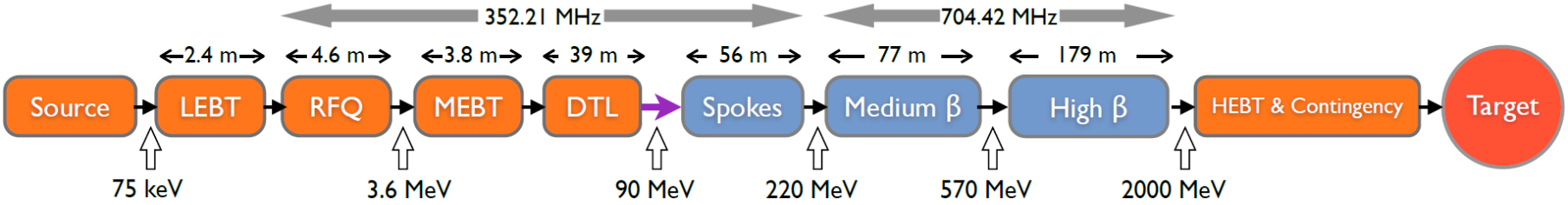
- ESS facility and construction project
- **Status of design and progress in realization**
- Global Project status
- Summary

IPAC17

ESS linac

- Average beam power of 5 MW
- Peak beam power of 125 MW
- Acceleration to 2 GeV
- Peak proton beam current of 62.5 mA
- Pulse length of 2.86 ms at a rate of 14 Hz (4% duty factor)

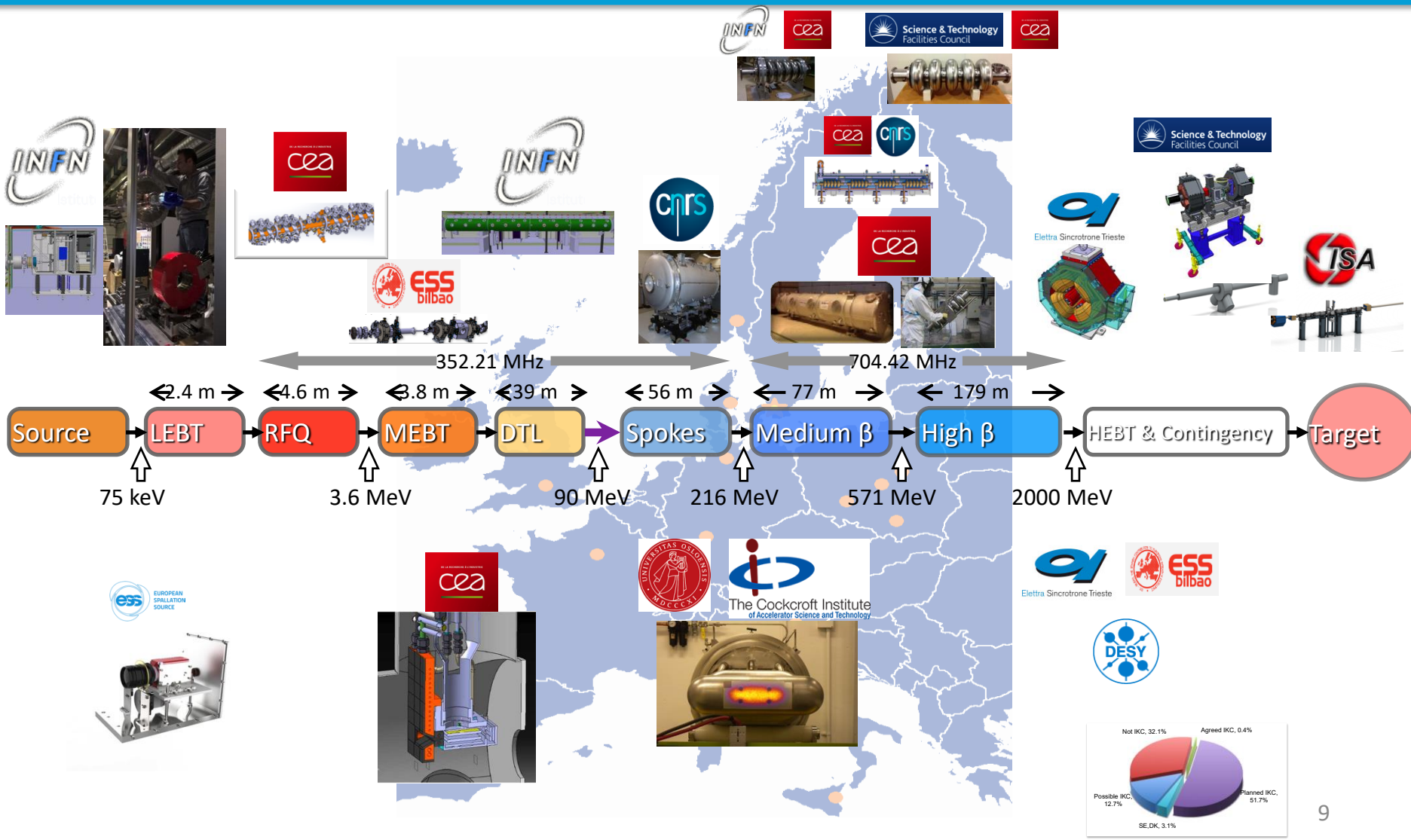
- Low losses
- Minimum energy use & energy recovery
- Flexibility for mitigation or upgrade



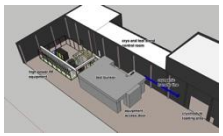
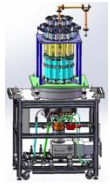
96% of acceleration will be provided by superconducting cavities supplied by 150 high power RF sources (one per cavity):

- 80% of the RF power sources delivering over 1.1 MW of peak RF power
- The RF system is **the** cost driver for the ESS accelerator.

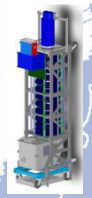
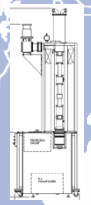
Accelerator components benefit from expert competencies all across Europe



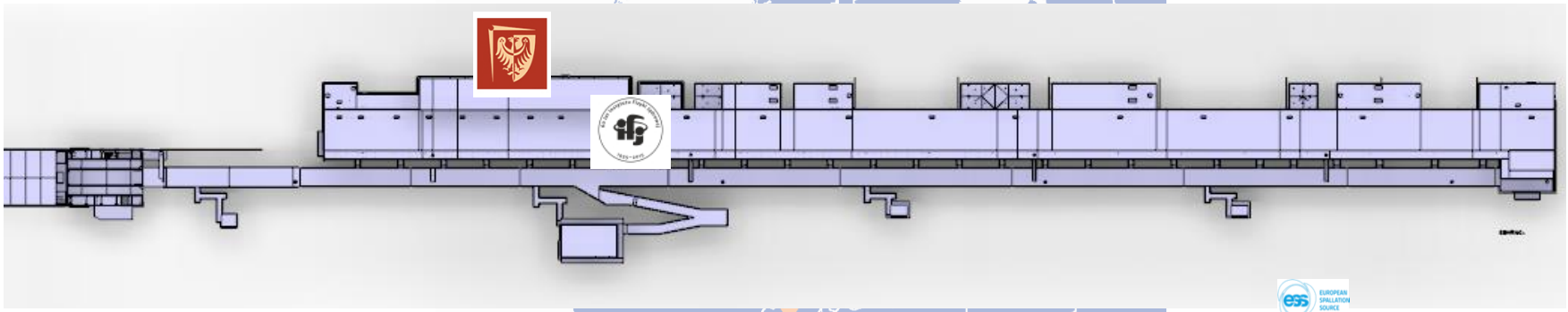
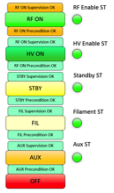
Accelerator components benefit from expert competencies all across Europe

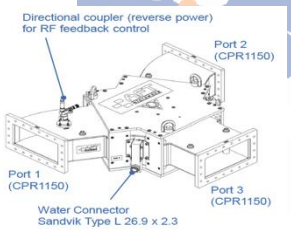





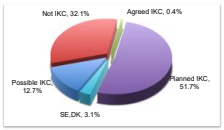









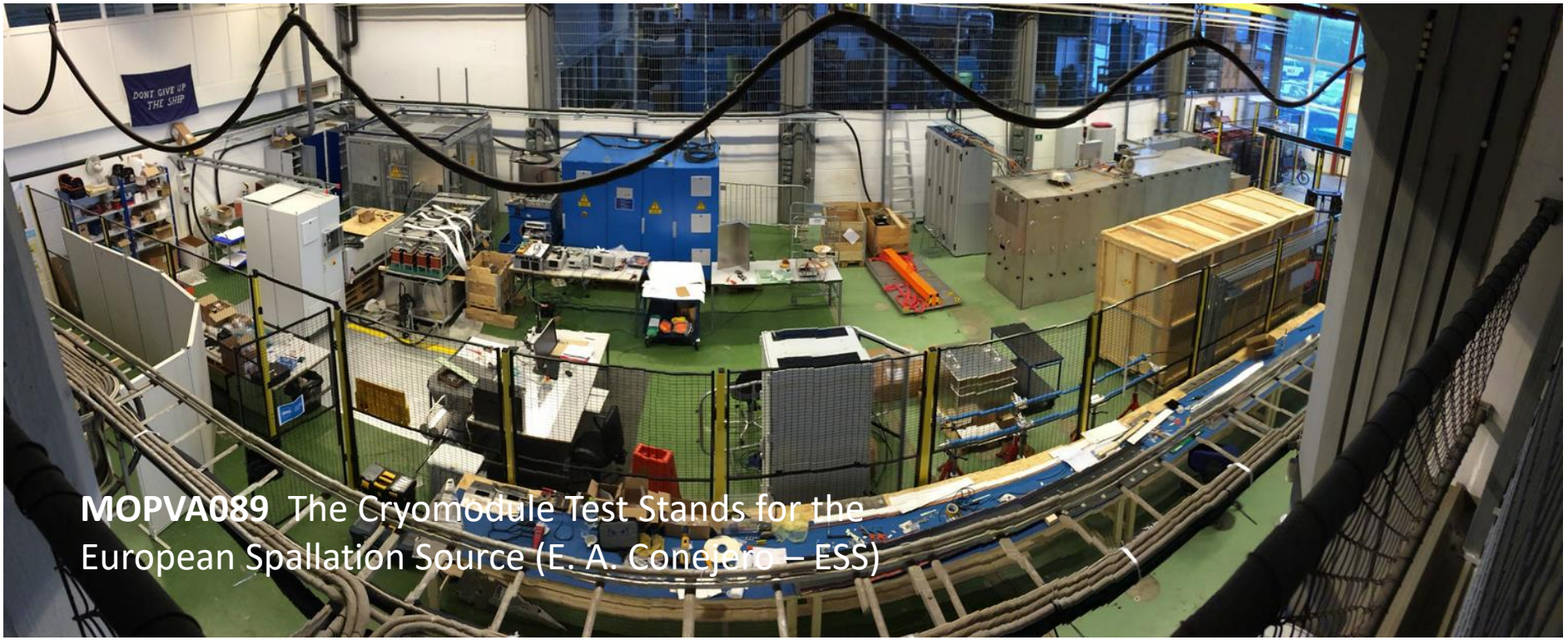
Concept, courtesy of GRE (UK)

Test Stands 1, 2 in Lund and FREIA in Uppsala – Hands-on work has begun!

EUROPEAN SPALLATION SOURCE

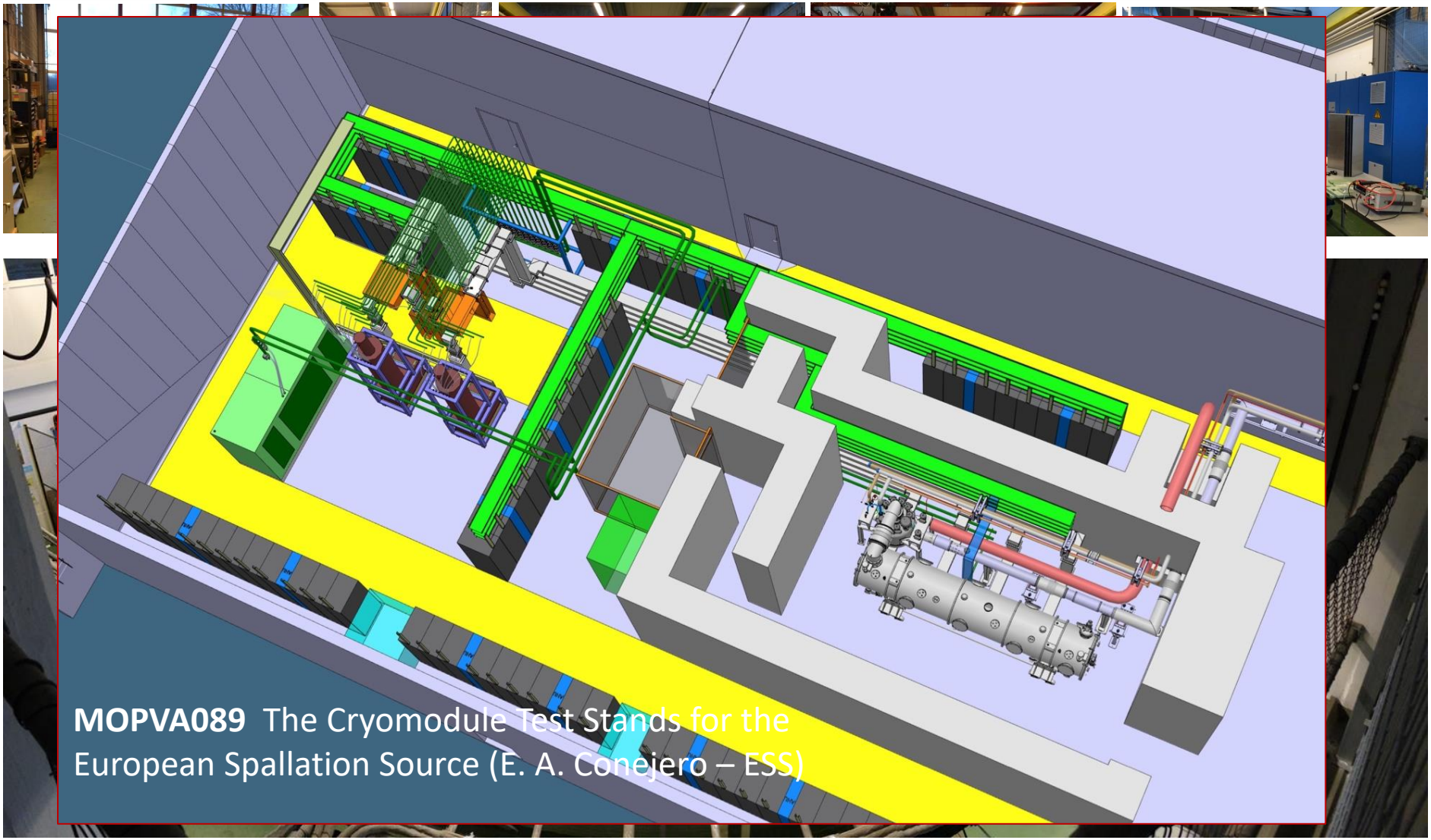






MOPVA089 The Cryomodule Test Stands for the European Spallation Source (E. A. Conejero – ESS)

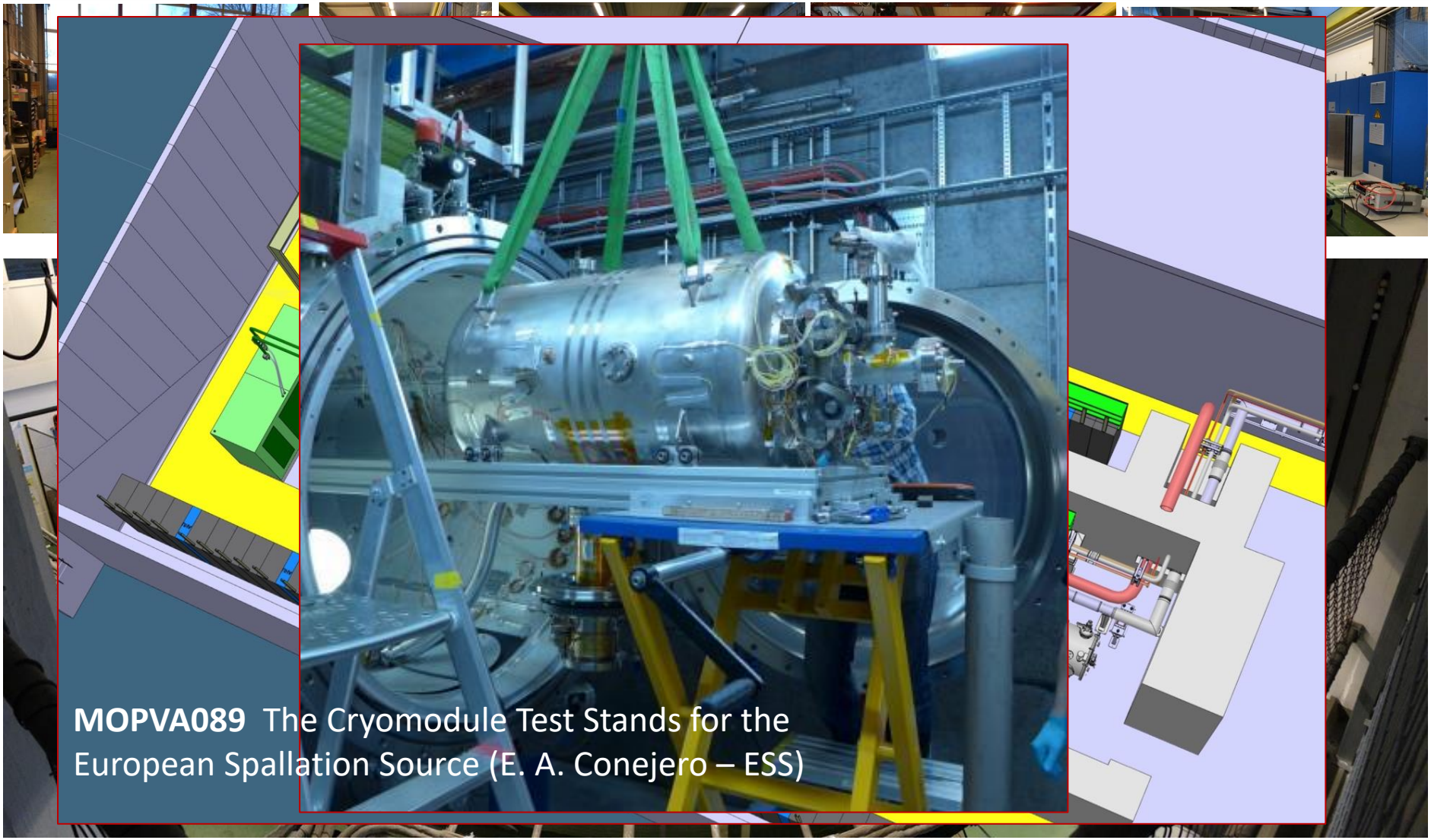
Test Stands 1, 2 in Lund and FREIA in Uppsala – Hands-on work has begun!



MOPVA089 The Cryomodule Test Stands for the European Spallation Source (E. A. Conejero – ESS)

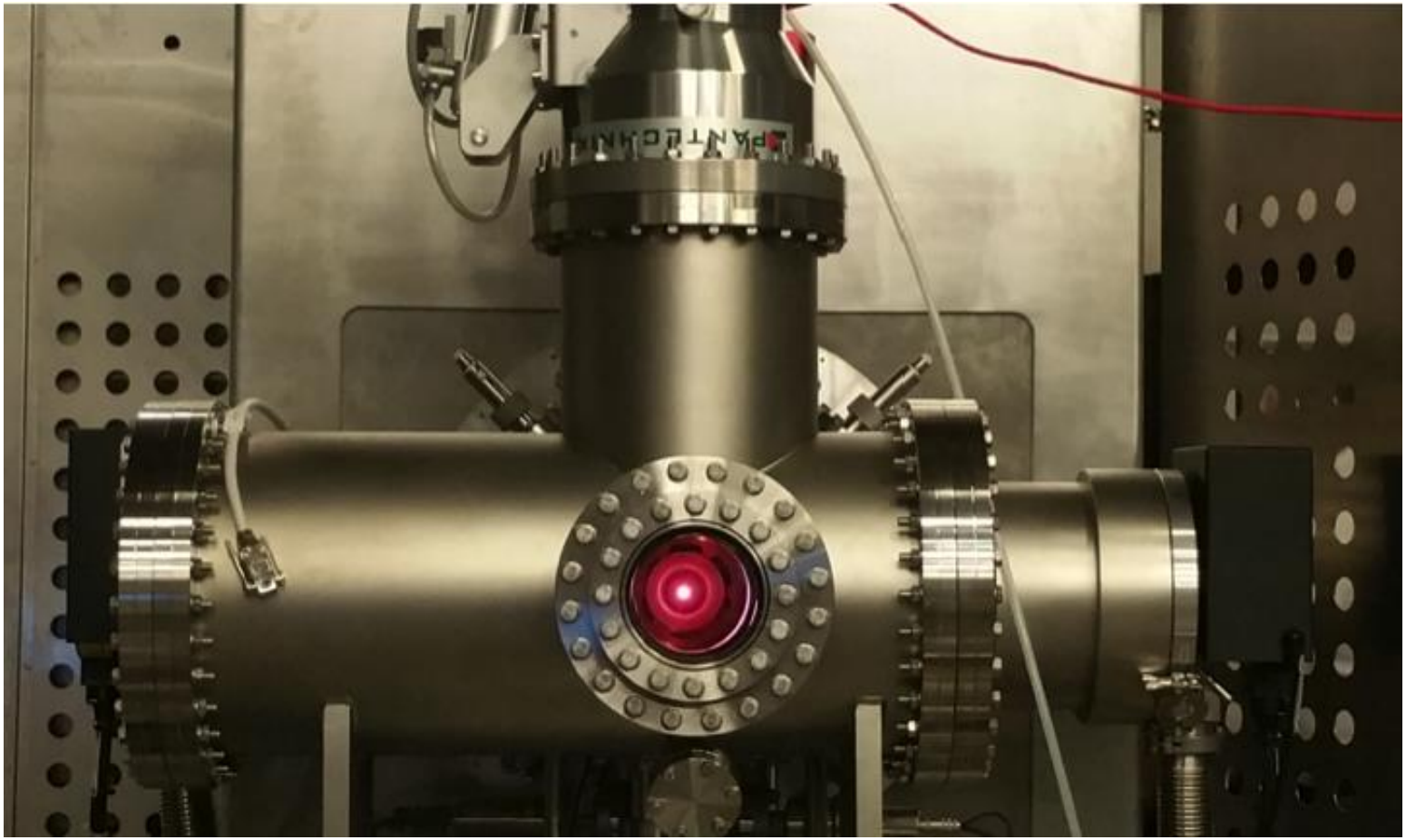
Test Stands 1, 2 in Lund and FREIA in Uppsala – Hands-on work has begun!

EUROPEAN SPALLATION SOURCE

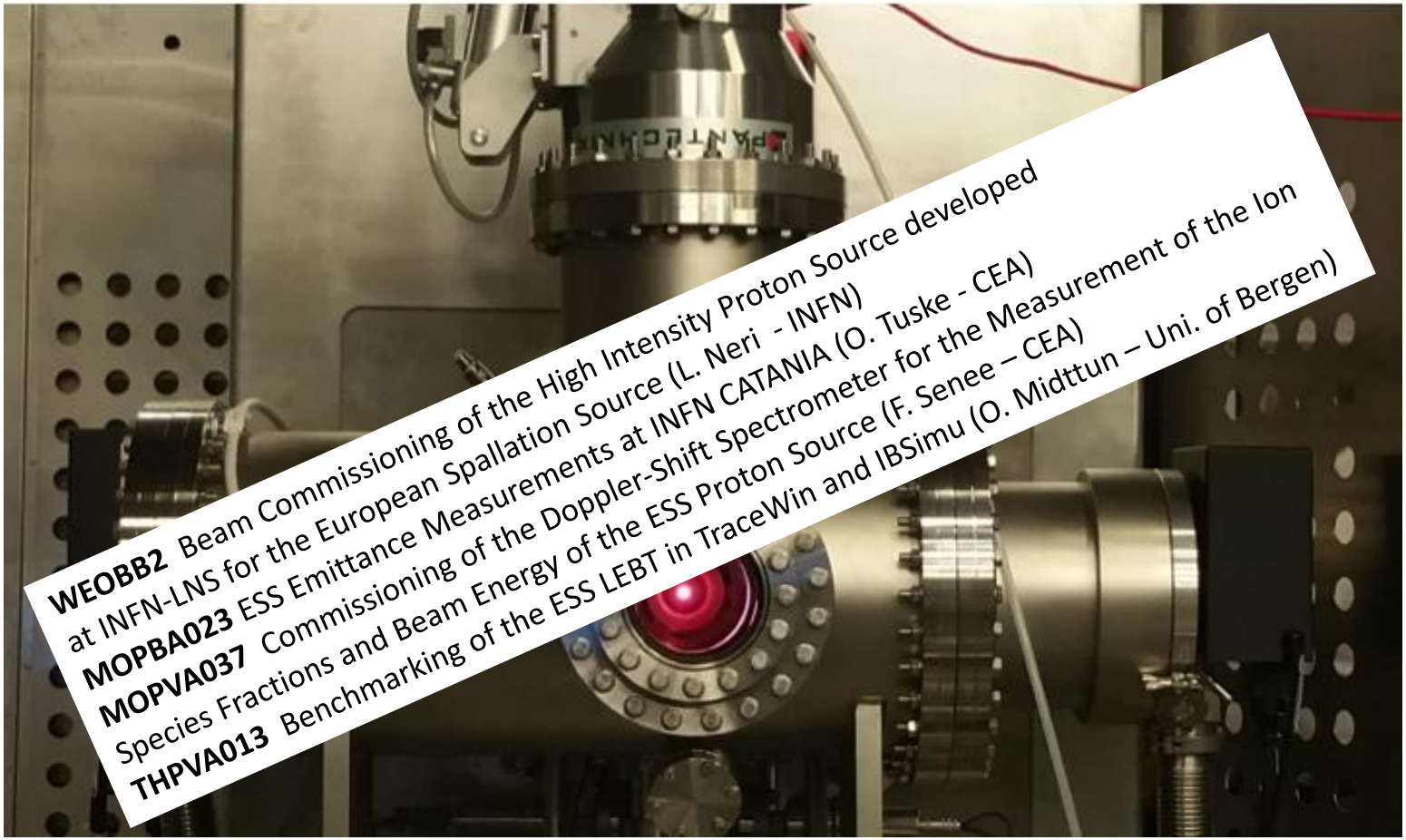


MOPVA089 The Cryomodule Test Stands for the European Spallation Source (E. A. Conejero – ESS)

Ion source in Catania at nominal parameters



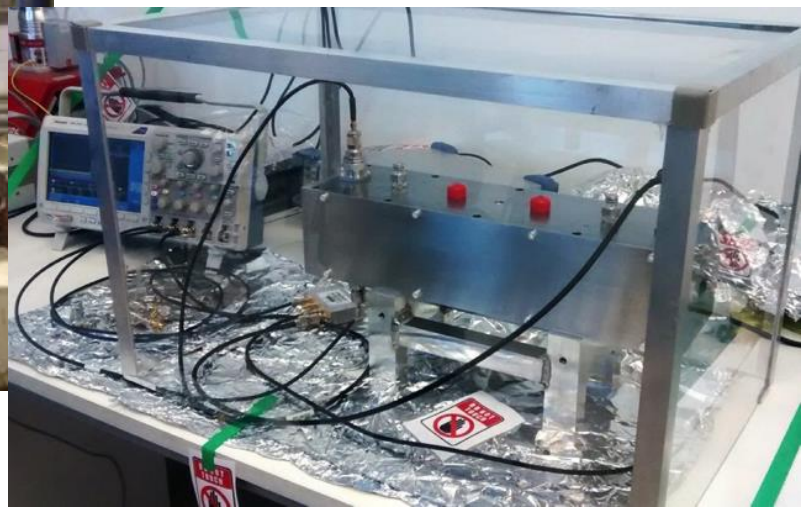
Ion source in Catania at nominal parameters



MEBT design and fabrication are in progress

Buncher Cavity Production and Heat Treatment

Strip Line Chopper Tests Complete

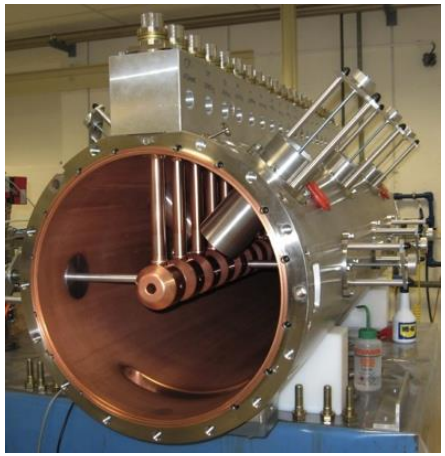


THPIK082 Quadrupole Magnet Design for the ESS MEBT
(D. Fernandez-Canoto – ESS Bilbao)

DTL recent achievements

- 5 tanks

Tank 4: forged 304 L stainless steel



DTL design work at ESS and in Legnaro, 3.6 ->90 MeV.

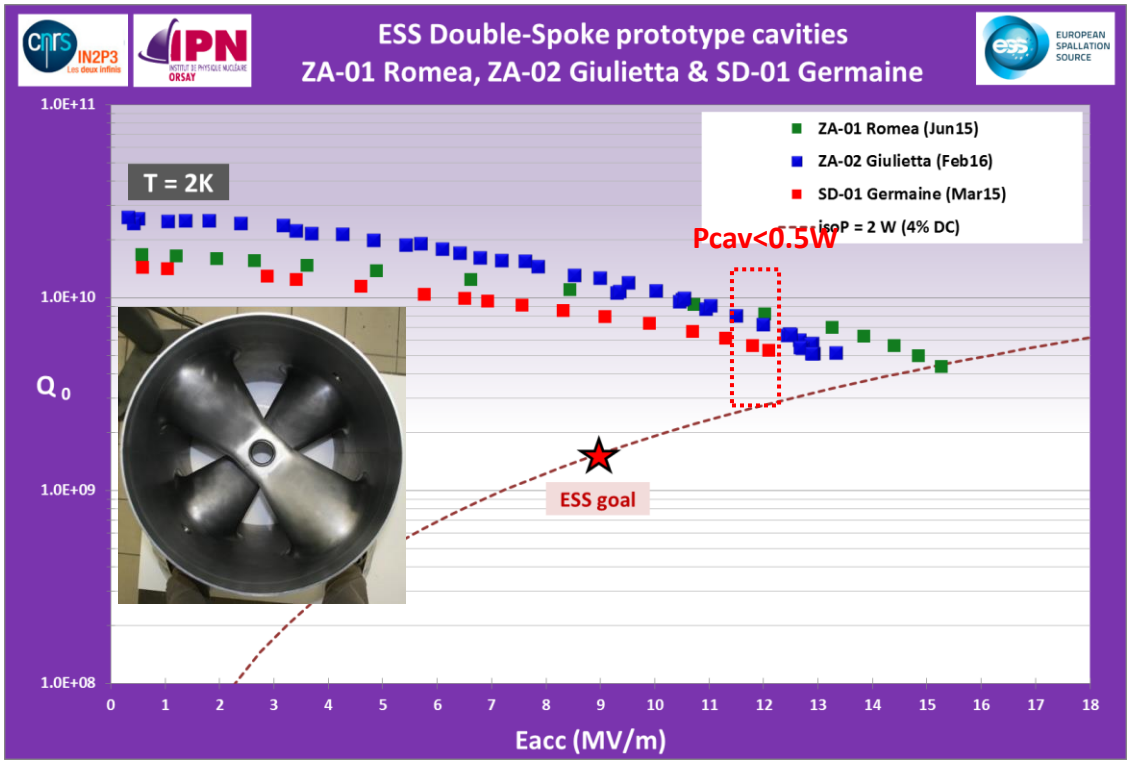
[Picture from CERN Linac4]

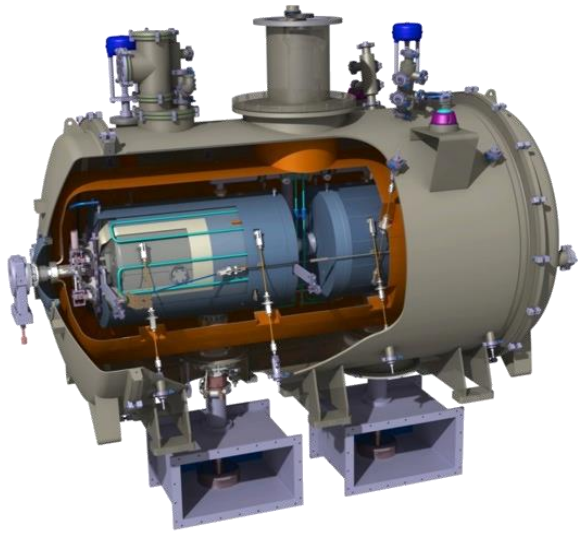
Drift tube prototypes

Spoke Cavities design & prototype performances

Spoke cavity prototype test results (Jan15 – Feb16):

- Excellent performances, well within specifications (both on Eacc & Qo)





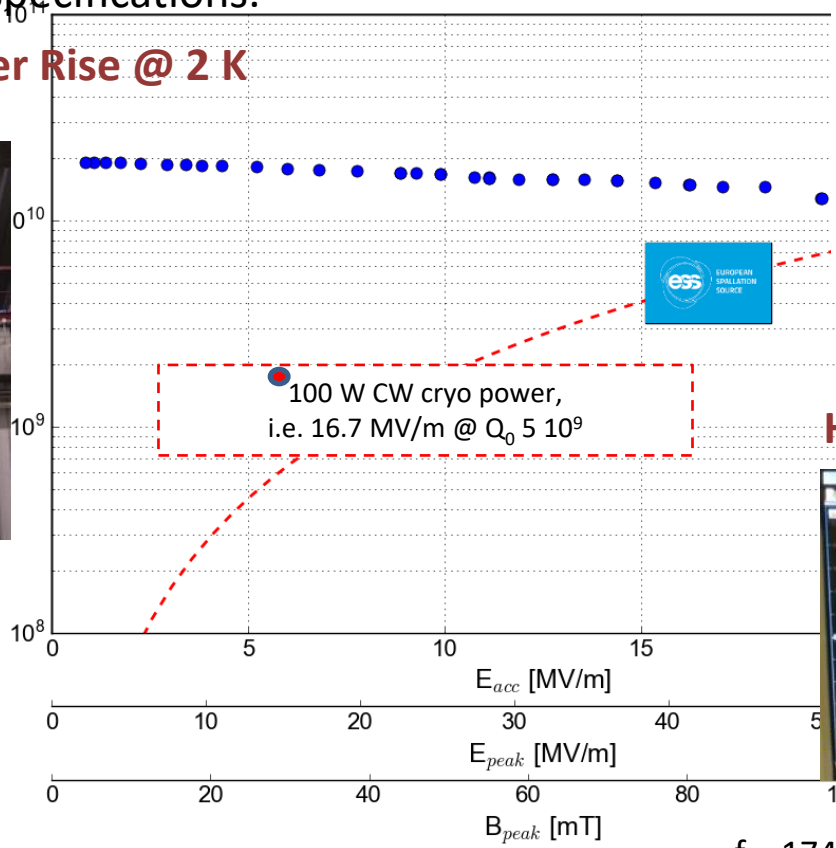
Cryomodule with 2 cavities

THOBB3 ESS SRF Linear Accelerator Components Preliminary Results and Integration (C. Darve (ESS)
MOPVA090 ESS Superconducting RF Collaboration (C. Darve – ESS)

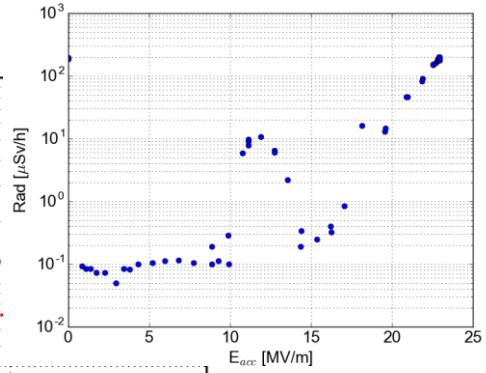
Elliptical Cavities Highlights

The INFN LASA cavity was successfully tested @ 2 K, exceeding the ESS specifications.

Power Rise @ 2 K

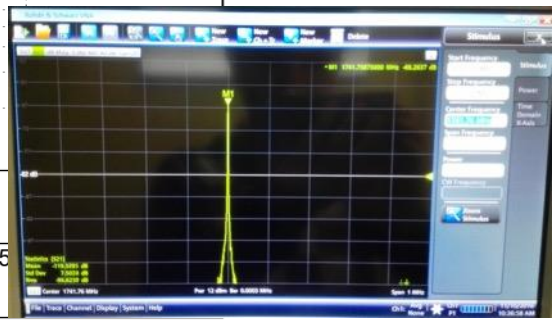


Soft Multipacting barrier



A soft MP barrier was easily conditioned.
This barrier matches with simulations.

HOM near 5th machine line

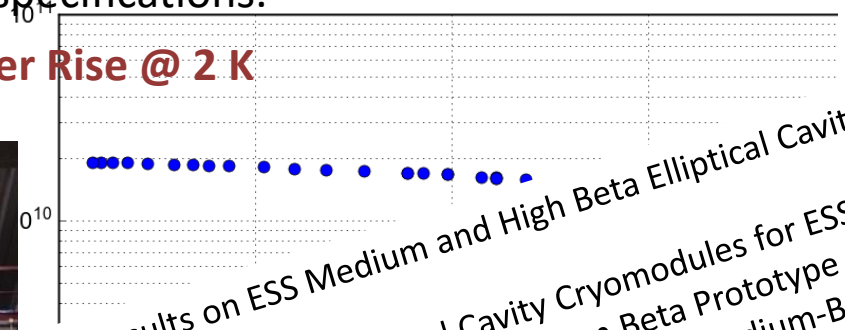


f = 1741.8 MHz (> 19 MHz from machine line)
Δf < 1 MHz from simulations (f =1742.4 MHz).

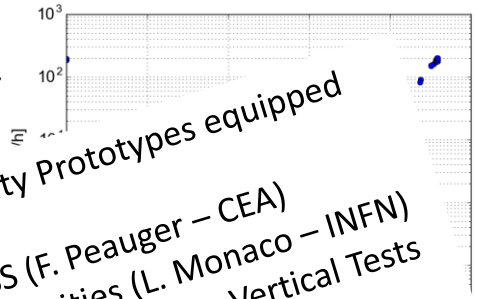
Elliptical Cavities Highlights

The INFN LASA cavity was successfully tested @ 2 K, exceeding the ESS specifications.

Power Rise @ 2 K



Soft Multipacting barrier



MOPVA041 Vertical Test Results on ESS Medium and High Beta Elliptical Cavity Prototypes equipped with Helium Tank (E. Cenni – CEA)

MOPVA040 Development Status of the Elliptical Cavity Cryomodules for ESS (F. Peauger – CEA)

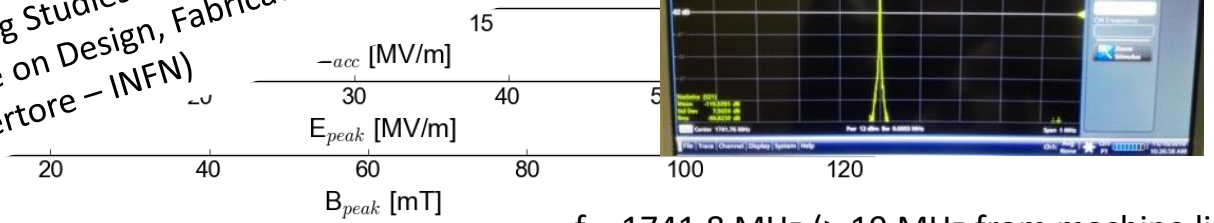
MOPVA060 Fabrication and Treatment of the ESS Medium Beta Prototype Cavities (L. Monaco – INFN)

MOPVA061 Quench and Field Emission Diagnostics for the ESS Medium-Beta Prototypes Vertical Tests at LASA (M. Bertucci – INFN)

MOPVA063 Vertical Tests of ESS Medium Beta Prototype Cavities at LASA (A. Bosotti – INFN)

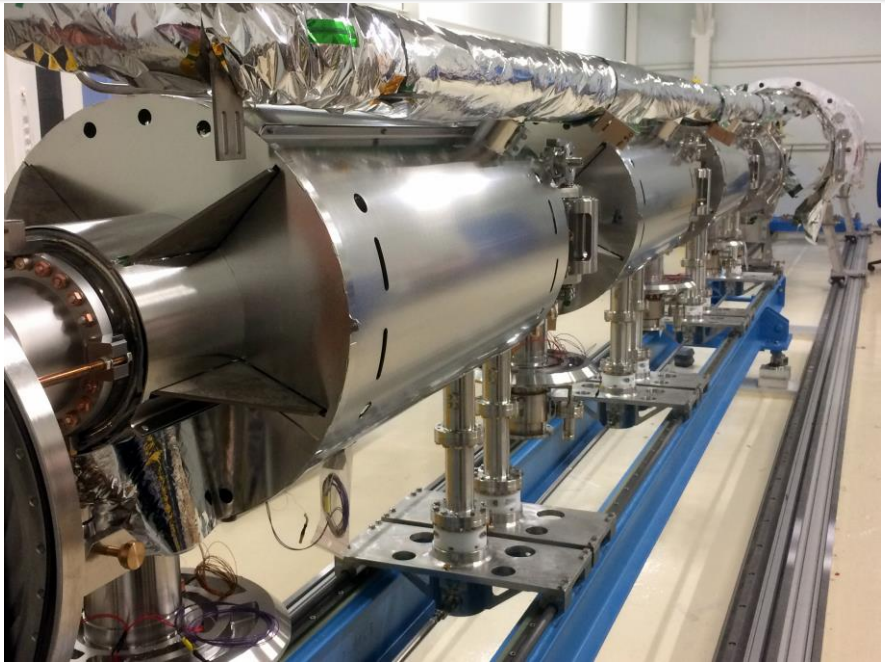
MOPVA064 Multipacting Studies in ESS Medium-Beta Cavity (J. Chen – INFN)

MOPVA068 Experience on Design, Fabrication and Testing of a Large Grain ESS Medium Beta Prototype Cavity (D. Sertore – INFN)

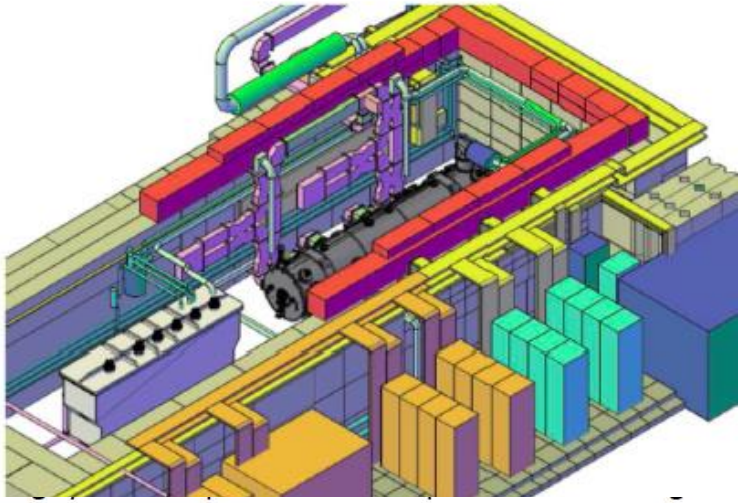


f = 1741.8 MHz (> 19 MHz from machine line)
Δf < 1 MHz from simulations (f =1742.4 MHz).

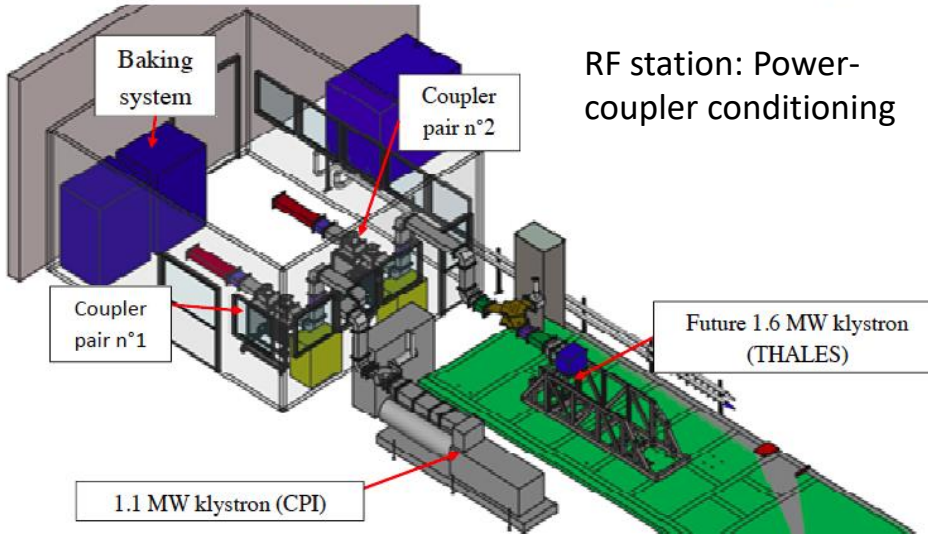
Cleanroom, RF Station, Assembly hall, Test Stand are ready in Saclay



First Medium β String in CEA Saclay Cleanroom

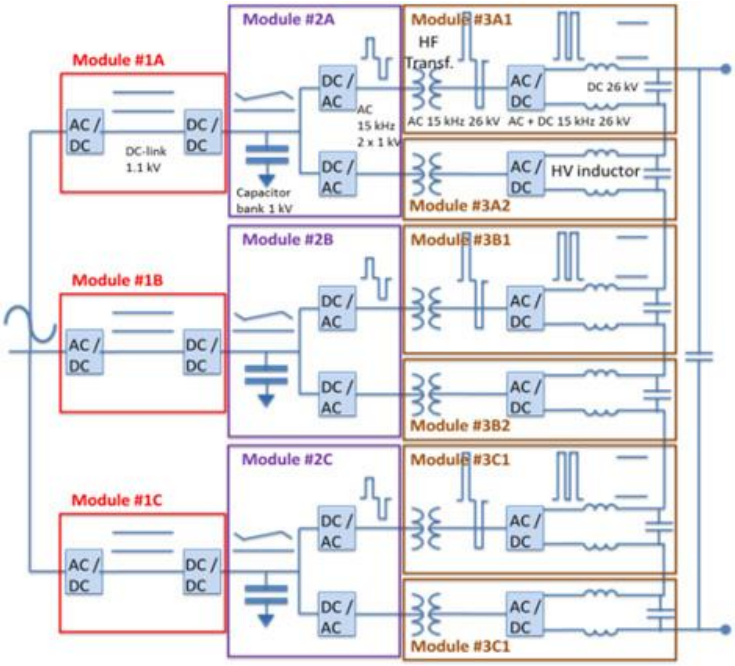


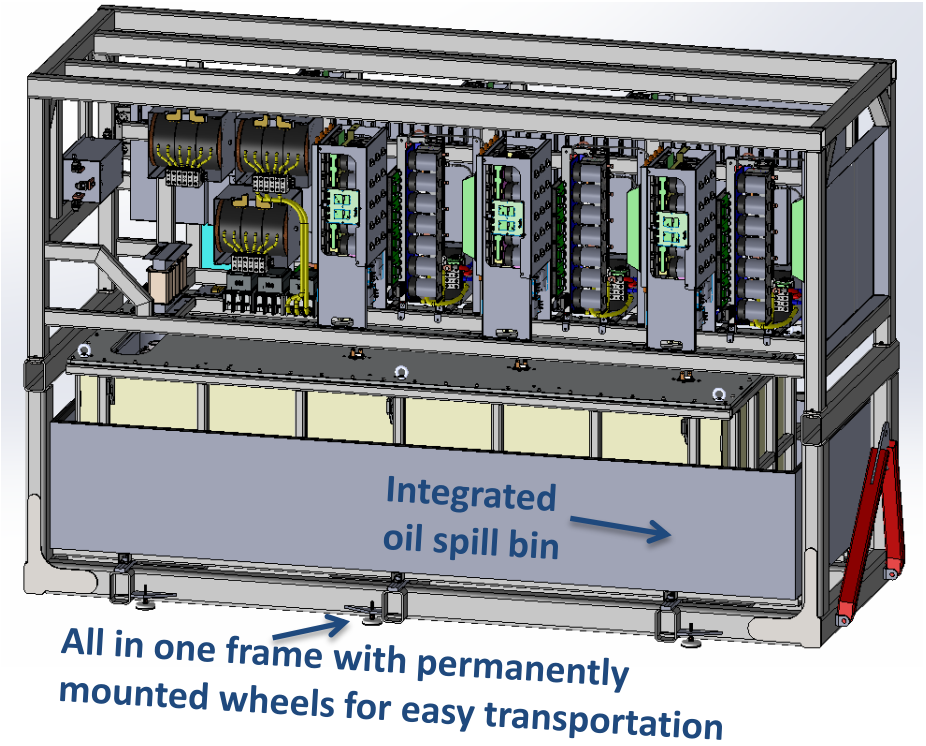
Re-use the current infrastructure of XFEL



RF station: Power-coupler conditioning

SML modulator topology successfully demonstrated on 120 kVA prototype





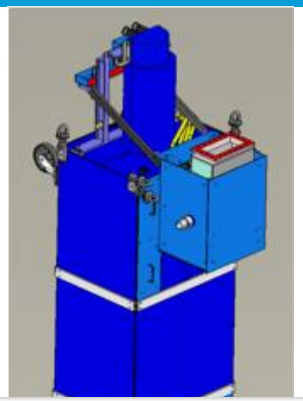
- **Order of 3 units for NC linac by ESS-Bilbao**
- **On-going ESS tender for 9 units for MB linac**

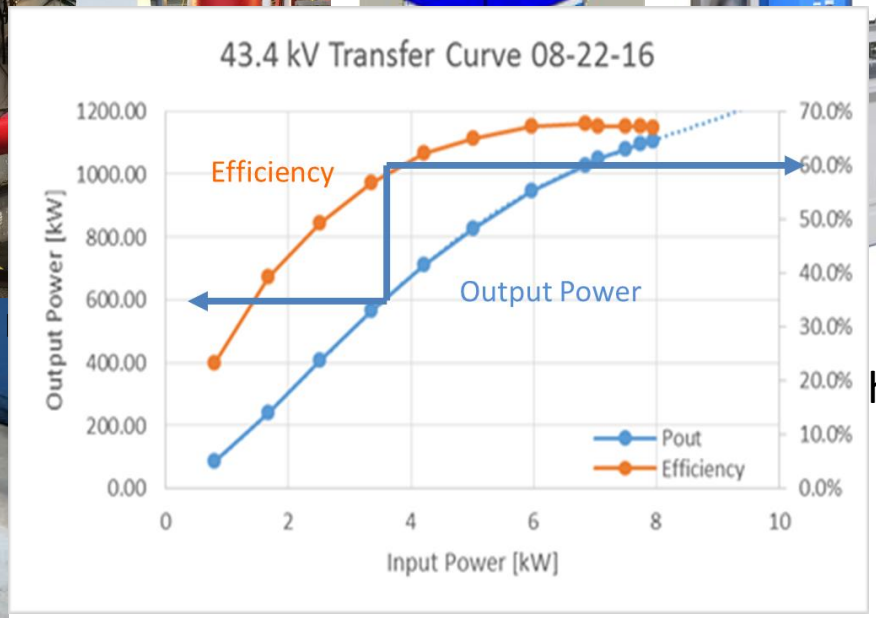
- **Total footprint:** 3.8m x 1.4m (planned was 5.5m x 1.6m, i.e. 40% less);
- **Total weight:** < 4 tons (without oil);
- **Total volume of oil:** ~ 2200 litters;

Klystrons and MB-IOT prototypes

Thales/CPI IOT

L3 IOT





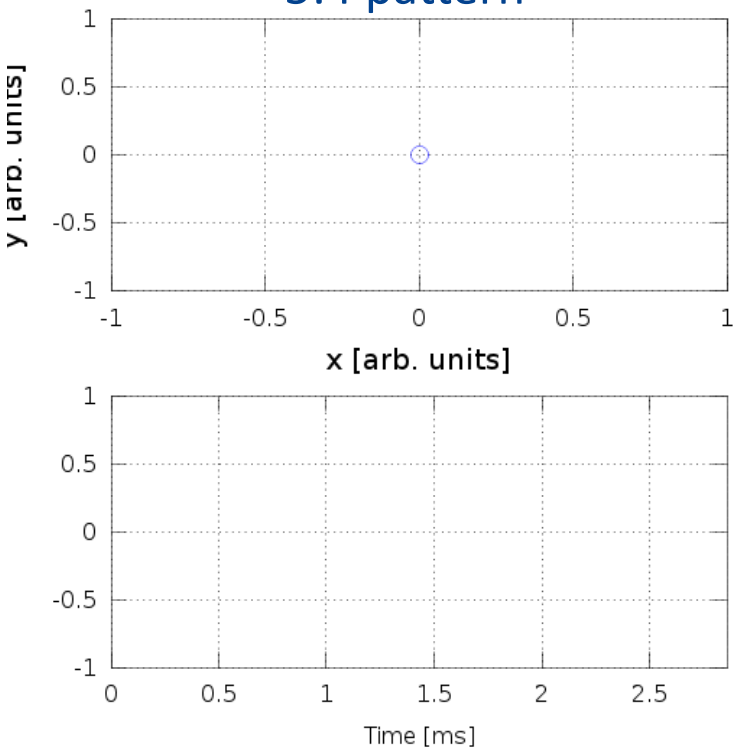
hiba)

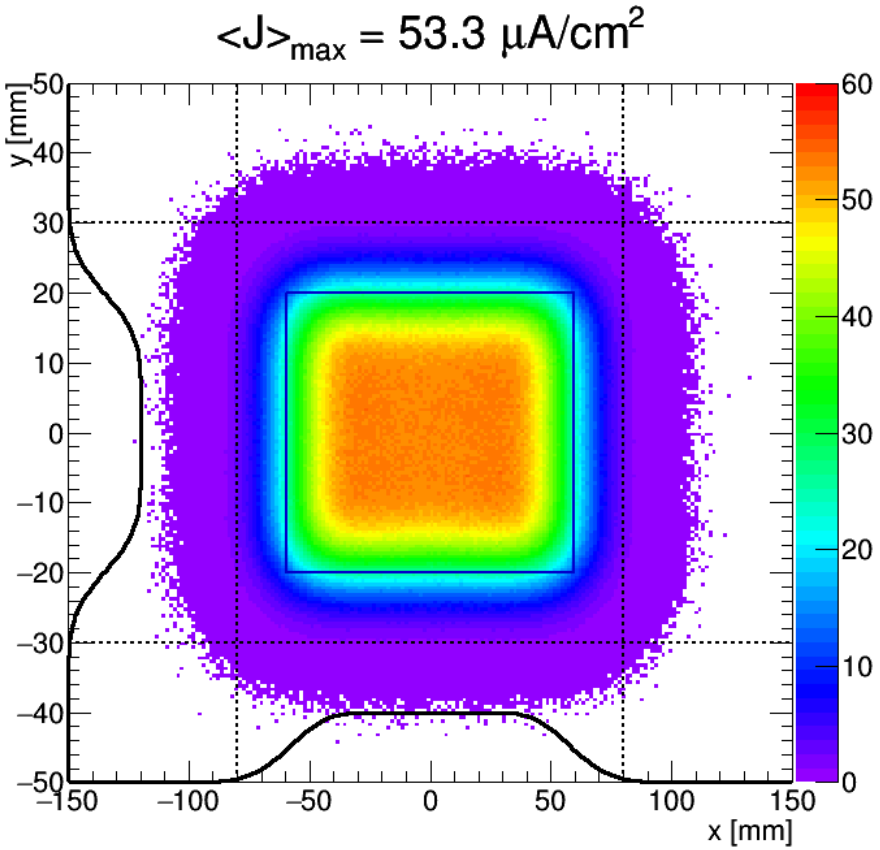
THPIK084 Results from the 704 MHz Klystron and Multi-Beam IOT Prototypes For the European Spallation Source (M. Jensen – ESS)

Beam raster scanning on target

- Raster system sweeping beam in 2D pattern @ target
- 8 colinear magnets, individually powered
- Crosshatch pattern (f_x/f_y, ϕ_{xy}, a_x, a_y) within 2.86 ms pulse

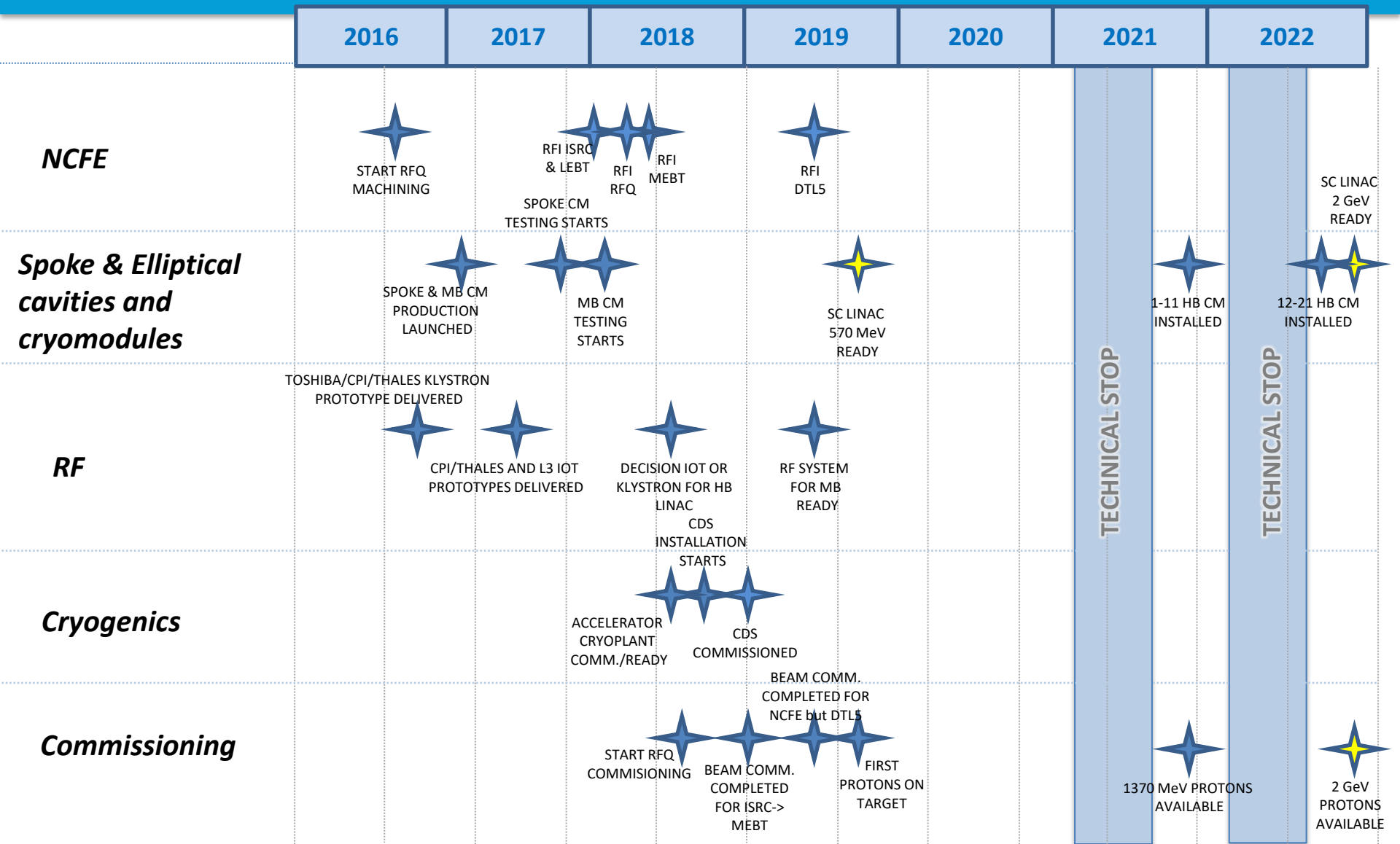
5:4 pattern





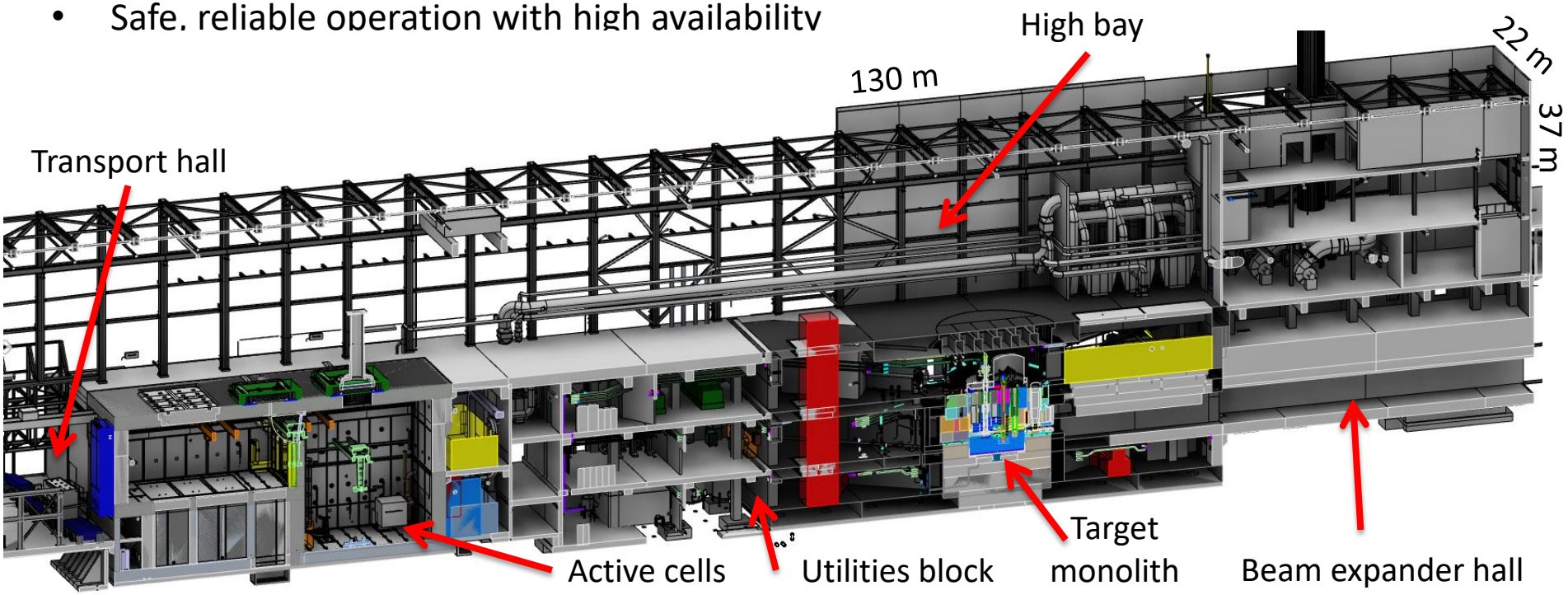
Accelerator schedule

EUROPEAN SPALLATION SOURCE



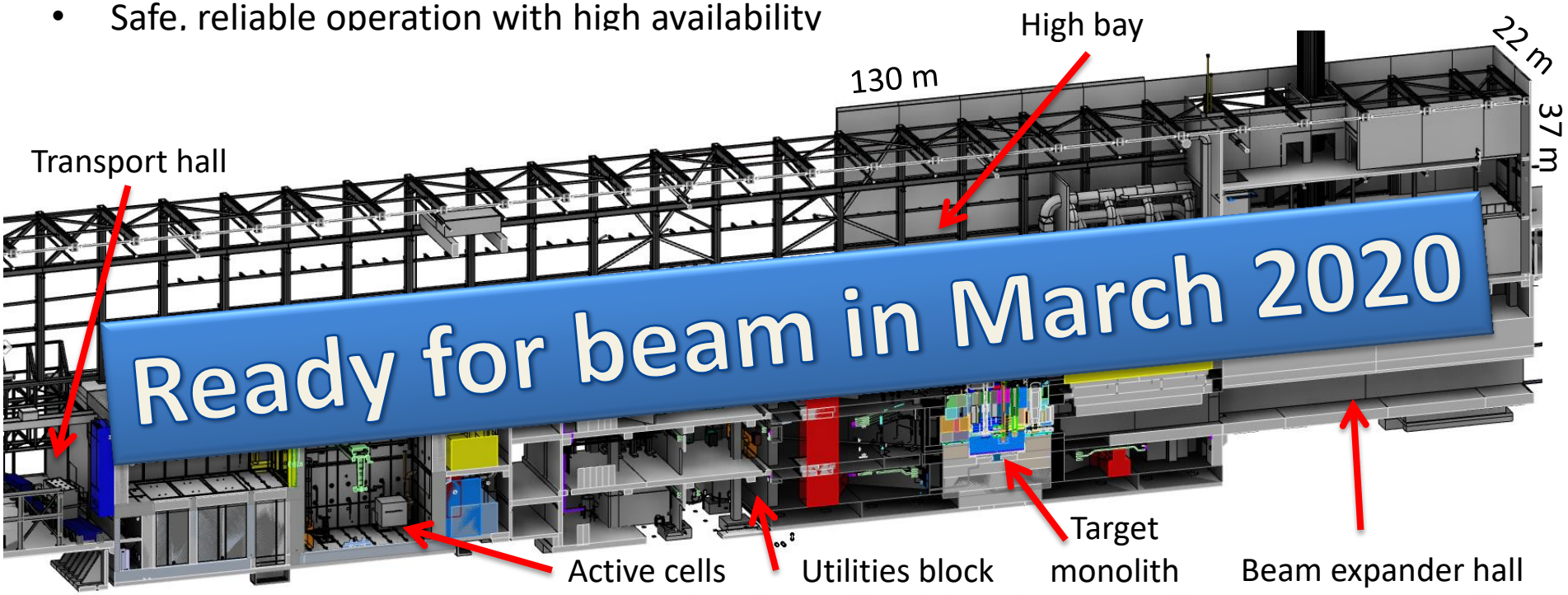
Target Station high level functions

- Generate neutrons via the spallation process using protons produced by the accelerator
- Slow the neutrons to speeds useful for neutron scattering
- Direct neutrons to neutron scattering instruments
- Safe, reliable operation with high availability



Target Station high level functions

- Generate neutrons via the spallation process using protons produced by the accelerator
- Slow the neutrons to speeds useful for neutron scattering
- Direct neutrons to neutron scattering instruments
- Safe, reliable operation with high availability



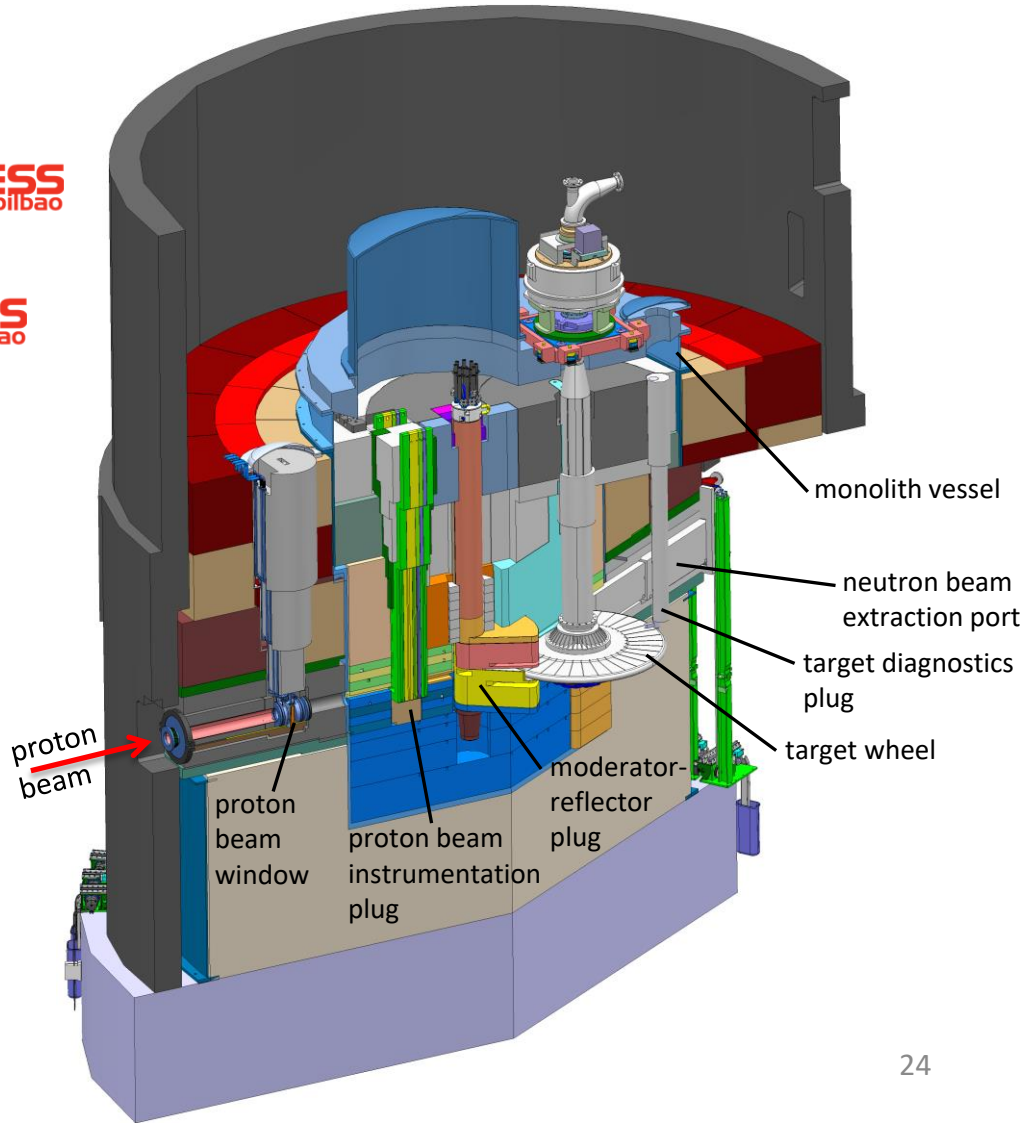
Target Station Partners

IPAC17

Target, monolith, moderators etc.

Main components:

- Monolith:
  - Vessel (6 m diameter x 8 m height)
  - Steel shielding (6000 tons)
  - Instrumentation plugs
  - Proton beam window
  - Neutron shutters
  - Neutron beam extraction system
- Rotating Tungsten target
  - 2.5 m diameter x 10 cm height
  - 7500 Tungsten bricks (3.5 tons)
  - 0.39 rev./s
- Target He gas-cooling
  - 3 MW capacity
  - 3 kg/s flow rate
  - Dt = 200 degrees C
- High brightness moderators
  - 2 liquid H_2 moderators
  - Water premoderators and moderators
  - He cryoplant (35 kW – 16 K)



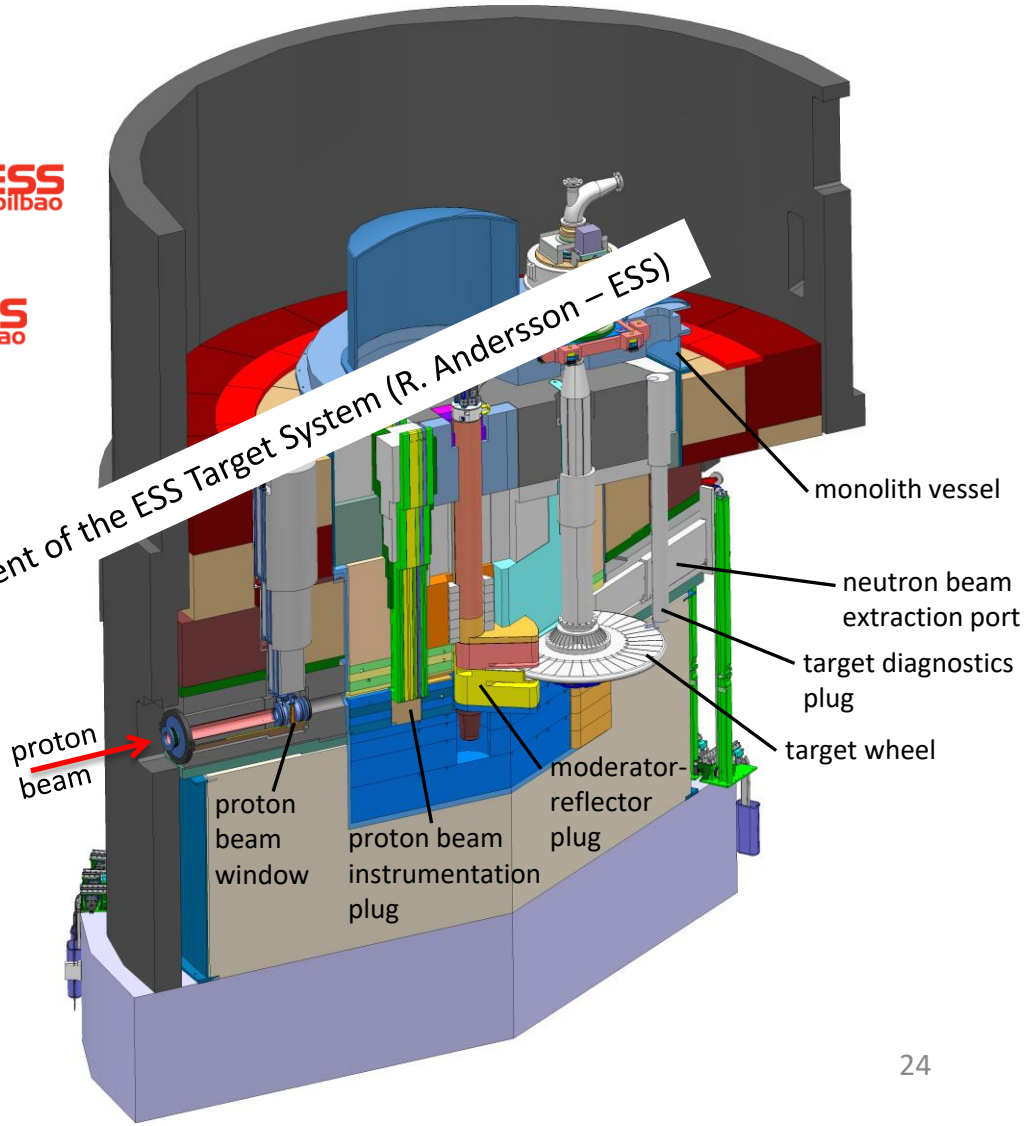
Target, monolith, moderators etc.

Main components:

- Monolith:
  - Vessel (6 m diameter x 8 m height)
  - Steel shielding (6000 tons)
  - Instrumentation plugs
  - Proton beam window
  - Neutron shutters
  - Neutron beam extraction system
- Rotating Tungsten target
  - 2.5 m diameter x 10 cm height
  - 7500 Tungsten bricks (3.5 tons)
  - 0.39 rev./s
- Target He gas-cooling
  - 3 MW capacity
  - 3 kg/s flow
  - Dt = 2 ces C
- High brightness moderators
  - 2 liquid H_2 moderators
  - Water premoderators and moderators
  - He cryoplant (35 kW – 16 K)

Machine Protection Risk Management of the ESS Target System (R. Andersson – ESS)

TUPIK078



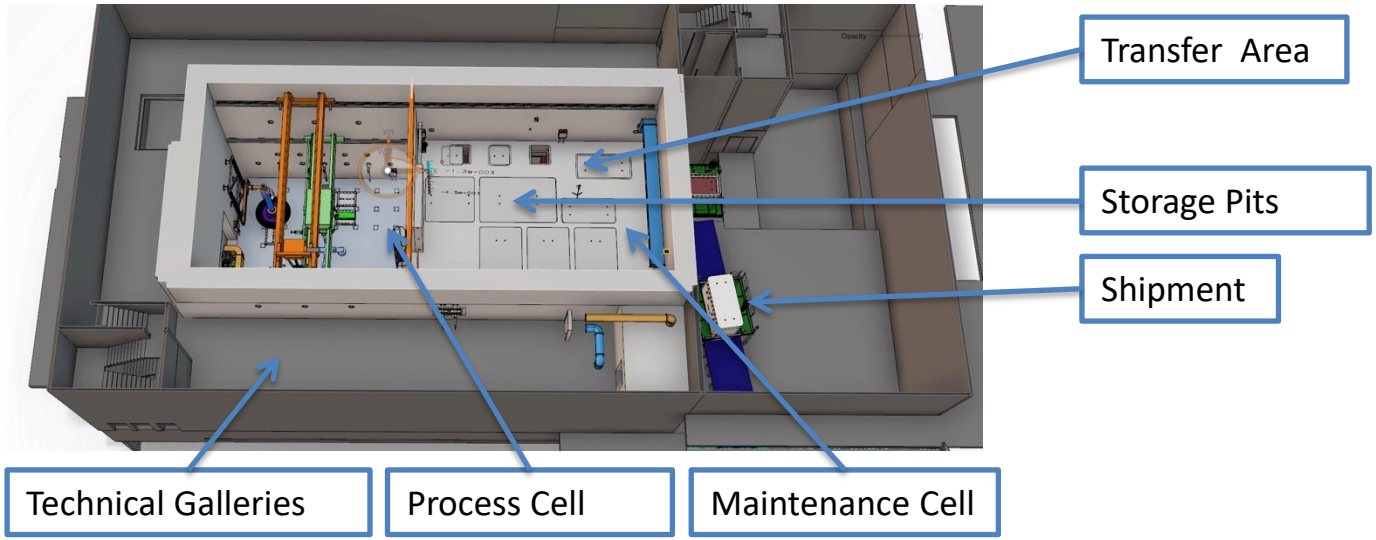
Fluid Systems and active cells

Fluid systems:

- Water cooling systems for thermal moderators, reflector and shielding
- Primary cooling system for proton beam window
- Intermediate water systems
- Helium purification systems
- Ventilation system

Active cell and remote handling systems:

- Hot cell and internals for processing and storing spent radioactive components
- Transfer casks to transport activated components on site
- Support systems (mock-up test stand, local shielding, etc.)



Installation has started !

ECHIR embedment inside the formwork for the monolith foundation

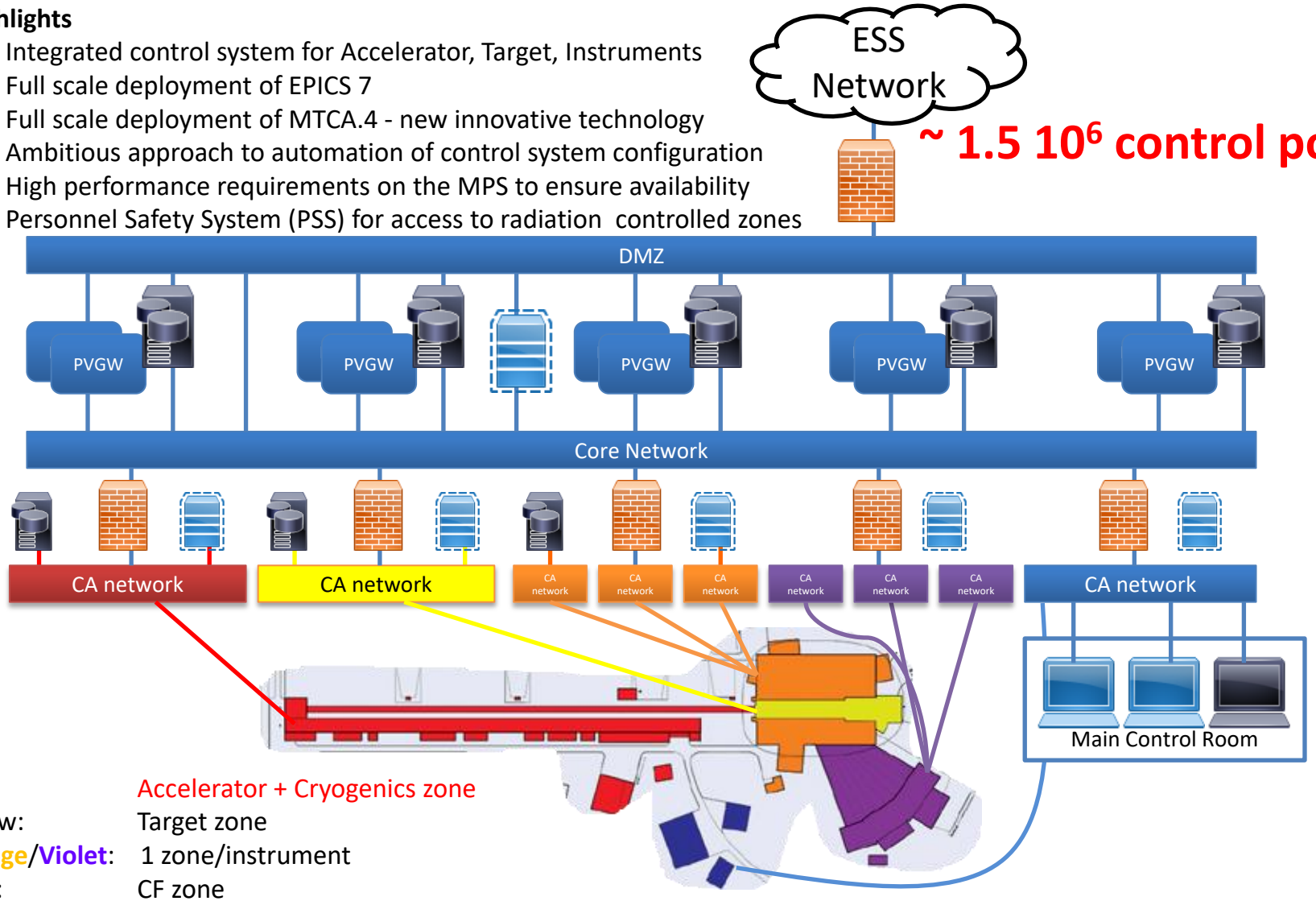
Concrete shielding blocks stacked inside the beam dump cave

IPAC17

The Integrated Control System (ICS) will serve the whole site

Highlights

- Integrated control system for Accelerator, Target, Instruments
- Full scale deployment of EPICS 7
- Full scale deployment of MTCA.4 - new innovative technology
- Ambitious approach to automation of control system configuration
- High performance requirements on the MPS to ensure availability
- Personnel Safety System (PSS) for access to radiation controlled zones



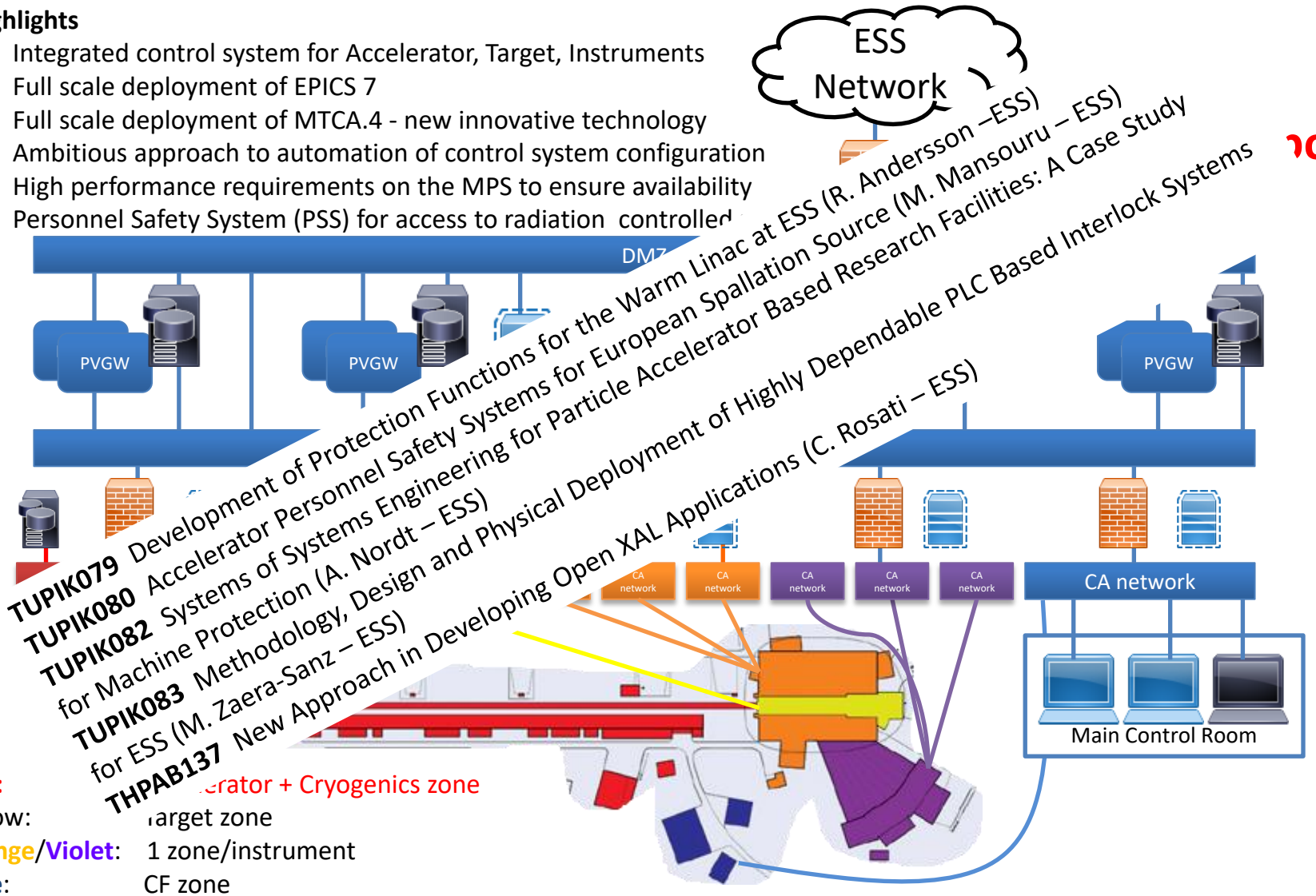
Red: Accelerator + Cryogenics zone
Yellow: Target zone
Orange/**Violet**: 1 zone/instrument
Blue: CF zone

The Integrated Control System (ICS) will serve the whole site

Highlights

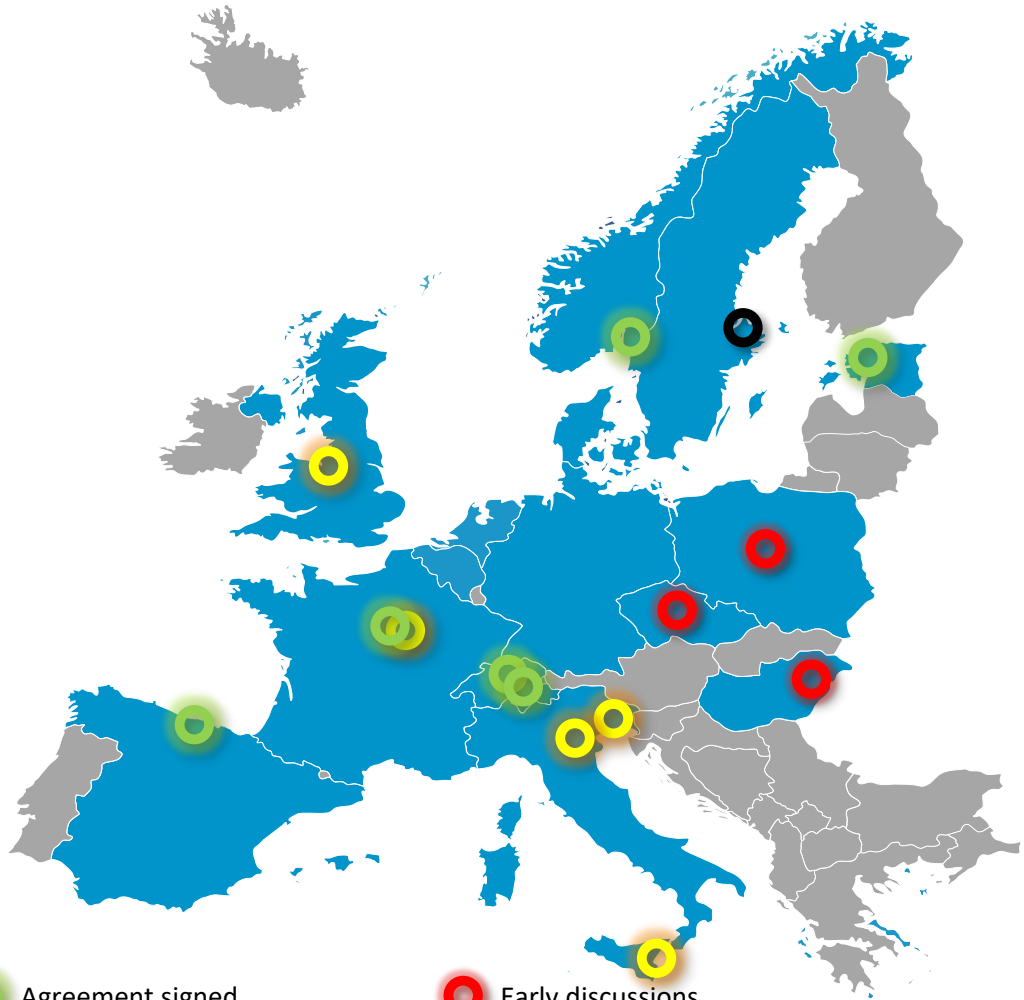
- Integrated control system for Accelerator, Target, Instruments
- Full scale deployment of EPICS 7
- Full scale deployment of MTCA.4 - new innovative technology
- Ambitious approach to automation of control system configuration
- High performance requirements on the MPS to ensure availability
- Personnel Safety System (PSS) for access to radiation controlled

oints!



Red: erator + Cryogenics zone
Yellow: arget zone
Orange/**Violet**: 1 zone/instrument
Blue: CF zone

ICS In-kind partners



Agreement signed

Agreement waiting for signature

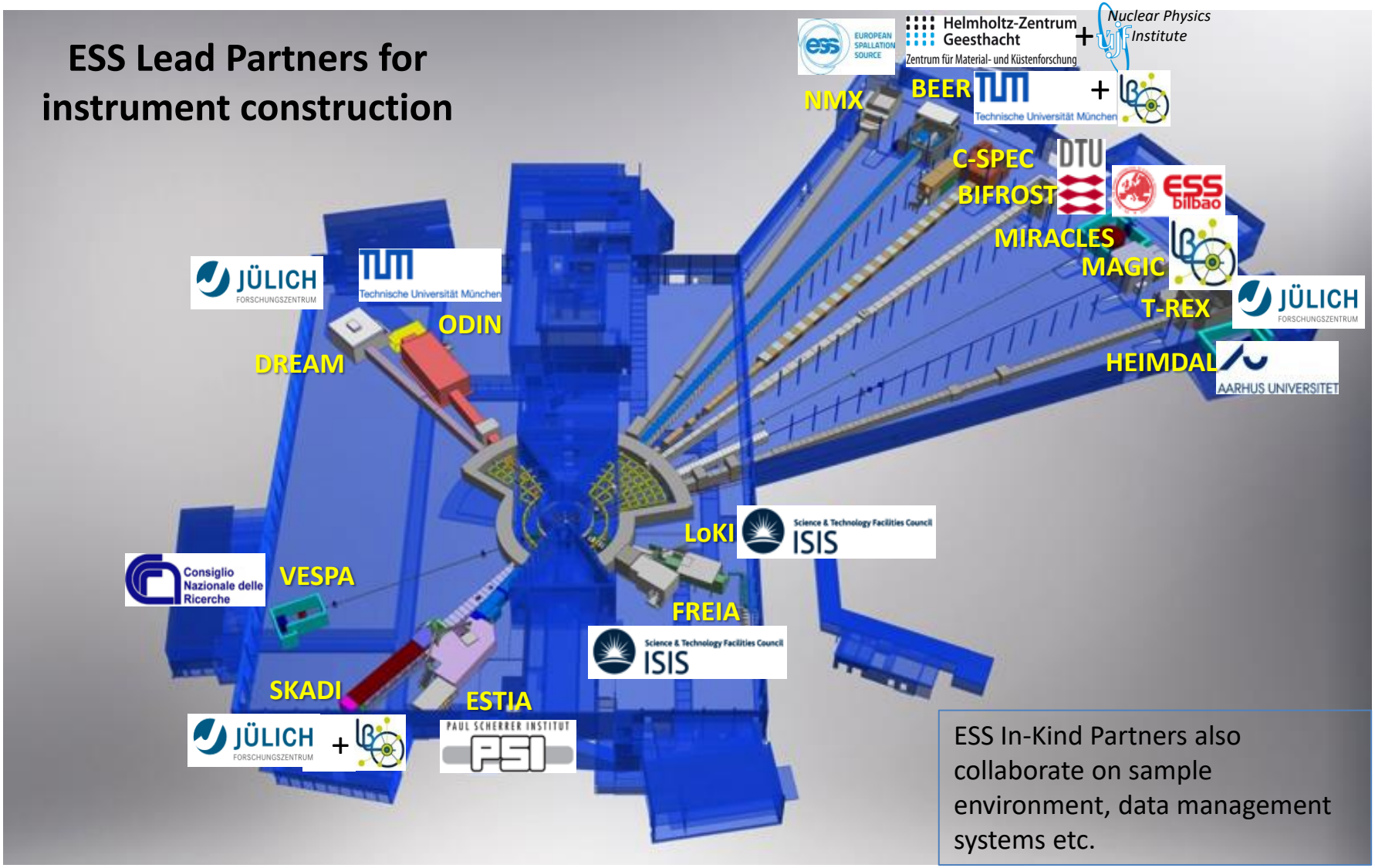
Early discussions

Collaboration agreement

Partner Institutes
Atomki, Hungary
CEA, France
CNRS/IPNO, France
Elettra, Italy
ESS Bilbao, Spain
IFE, Norway
INFN Catania, Italy
INFN Legnaro, Italy
PSI, Switzerland
STFC, UK
Tallinn Technical University, Estonia
ÚJV Řež, Czech Republic
University of Łódź , Poland
Uppsala University, Sweden
ZHAW, Switzerland

First 15 Neutron instruments

EUROPEAN SPALLATION SOURCE



Progress on ESS Project Construction

EUROPEAN SPALLATION SOURCE

- ESS facility and construction project
- Status of design and progress in realization
- **Global Project status**
- Summary

Organisation and People

EUROPEAN SPALLATION SOURCE

401

Employees

48

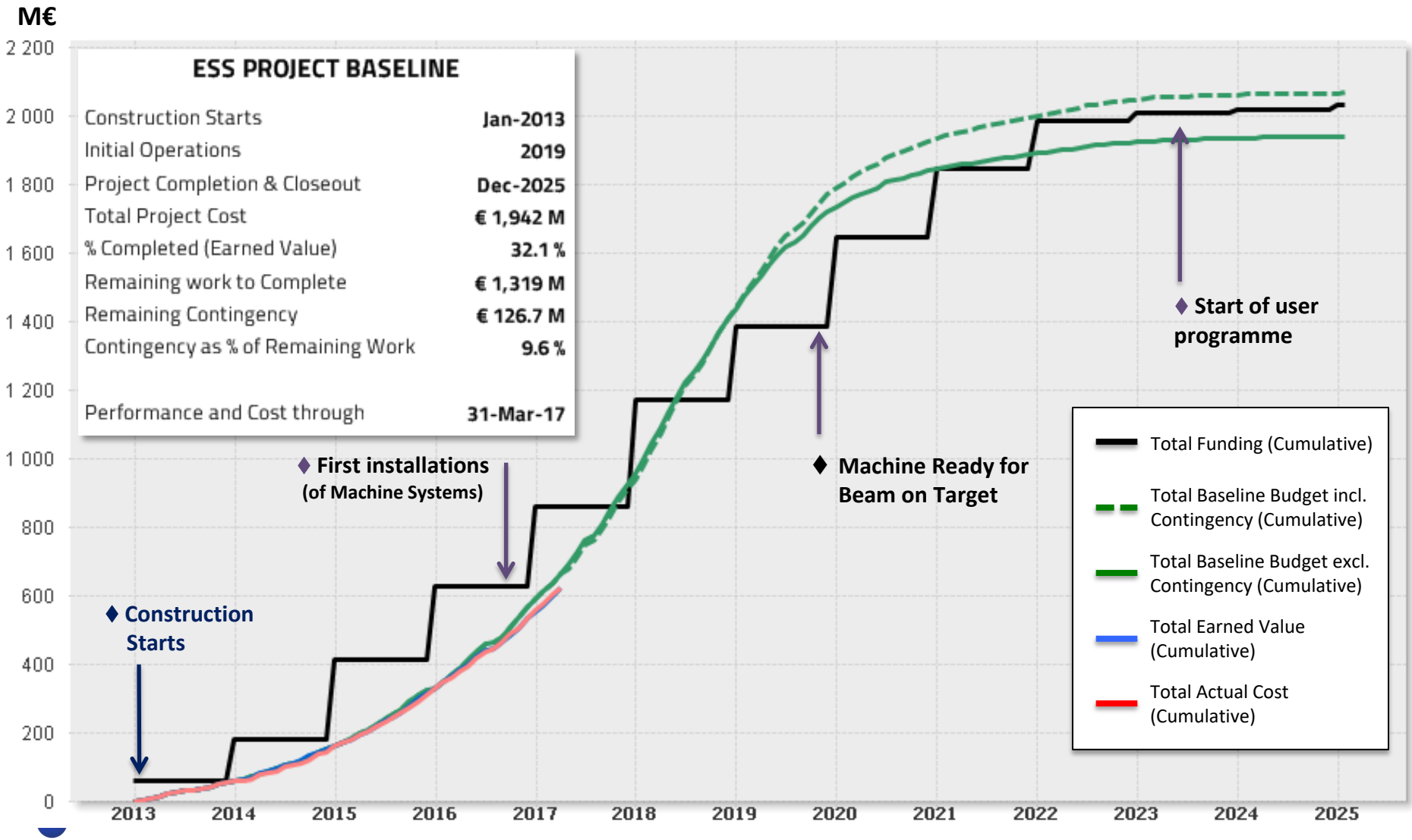
Nationalities

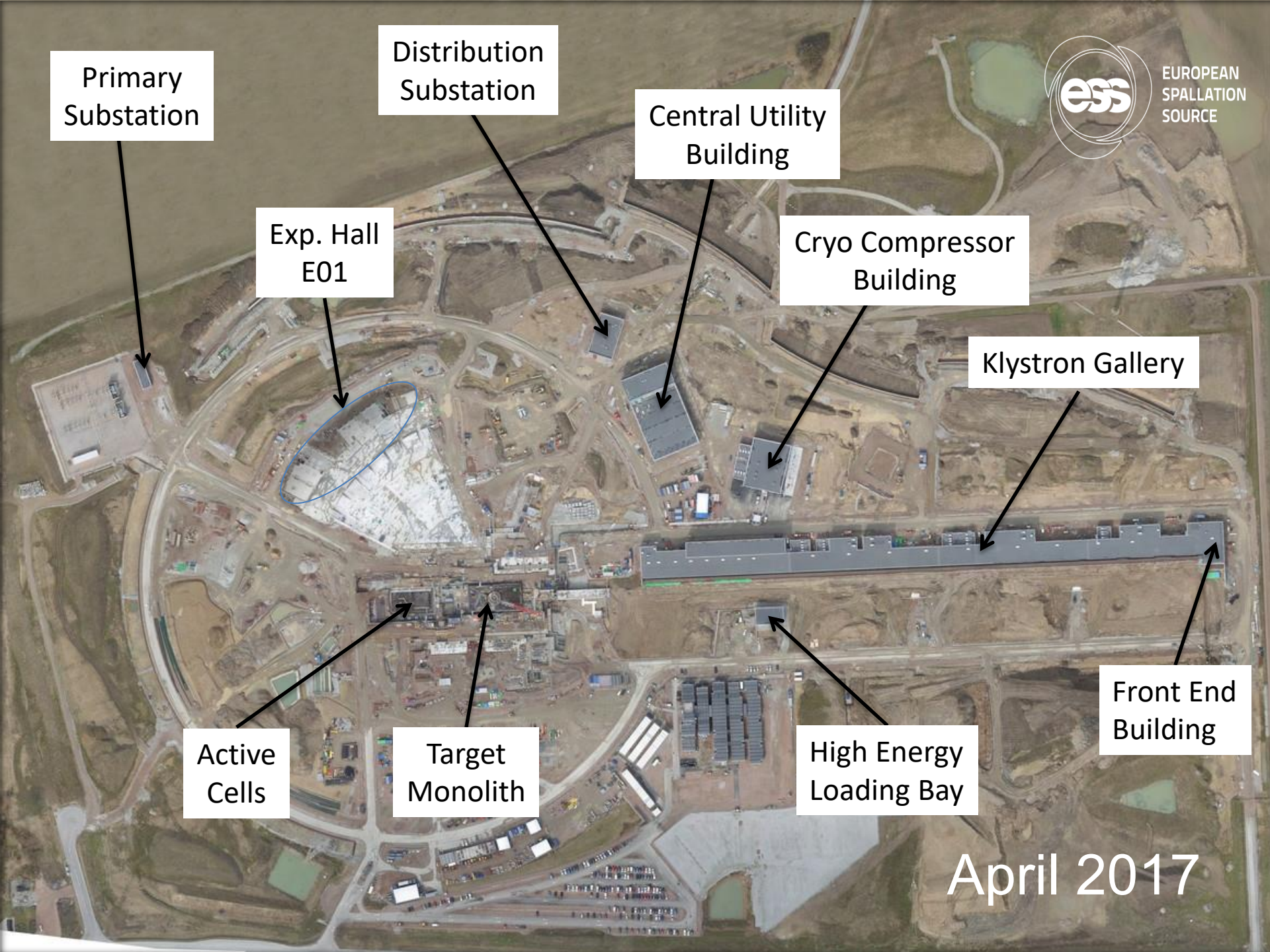
> 45

Collaborating Institutions

Construction funding & budget profile

EUROPEAN SPALLATION SOURCE




Primary Substation
Distribution Substation
Central Utility Building
Exp. Hall E01
Cryo Compressor Building
Klystron Gallery
Active Cells
Target Monolith
High Energy Loading Bay
Front End Building
EUROPEAN SPALLATION SOURCE
April 2017

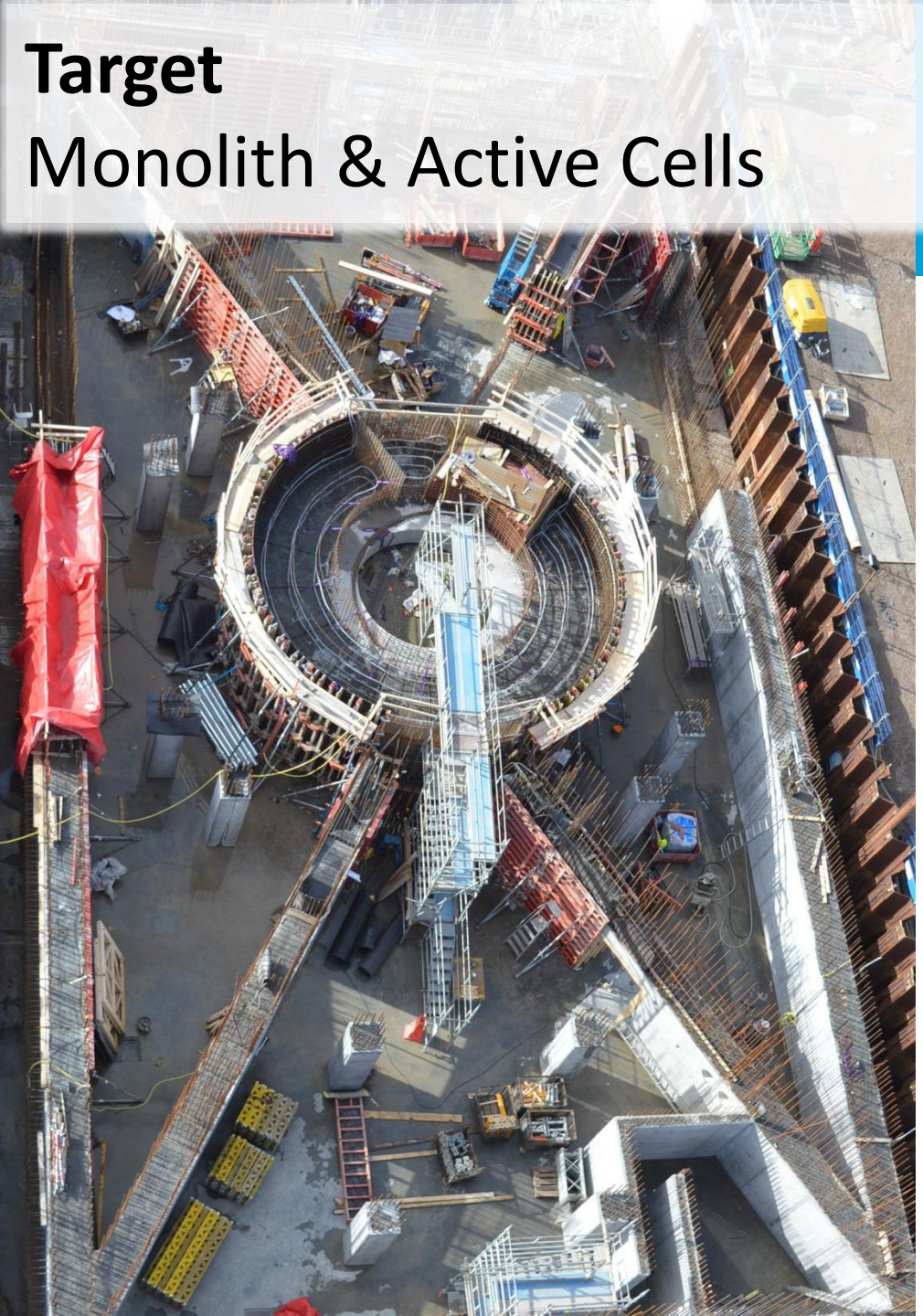
Linac tunnel

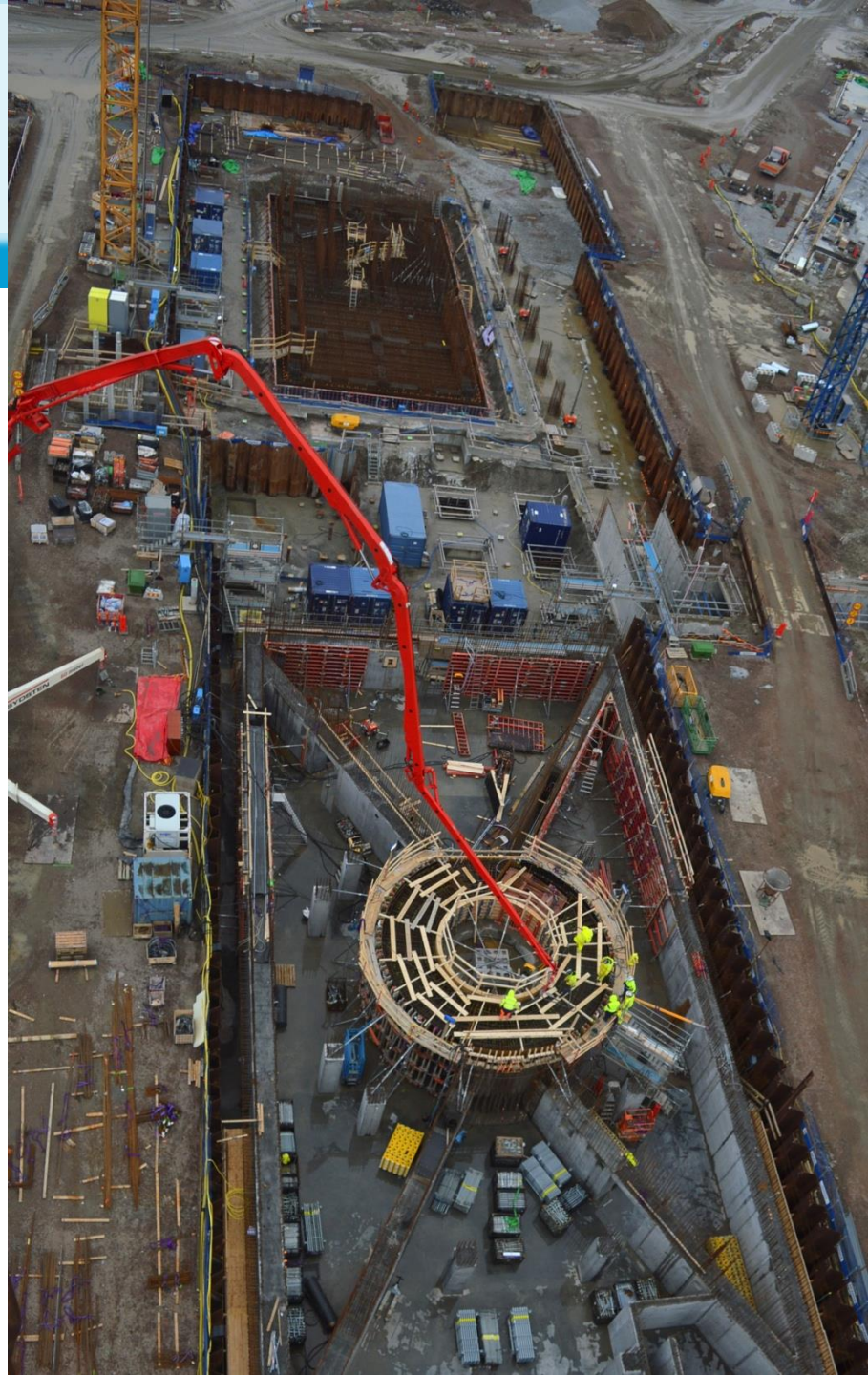
Tunnel, view from HEBT

Front End Building

Cryo Compressor Building

Target
Monolith & Active Cells





Beam Line Gallery

8,000 m^2 base slab – last casting 14/03/2017

Progress on ESS Project Construction

EUROPEAN SPALLATION SOURCE

- ESS facility and construction project
- Status of design and progress in realization
- Global Project status

Summary

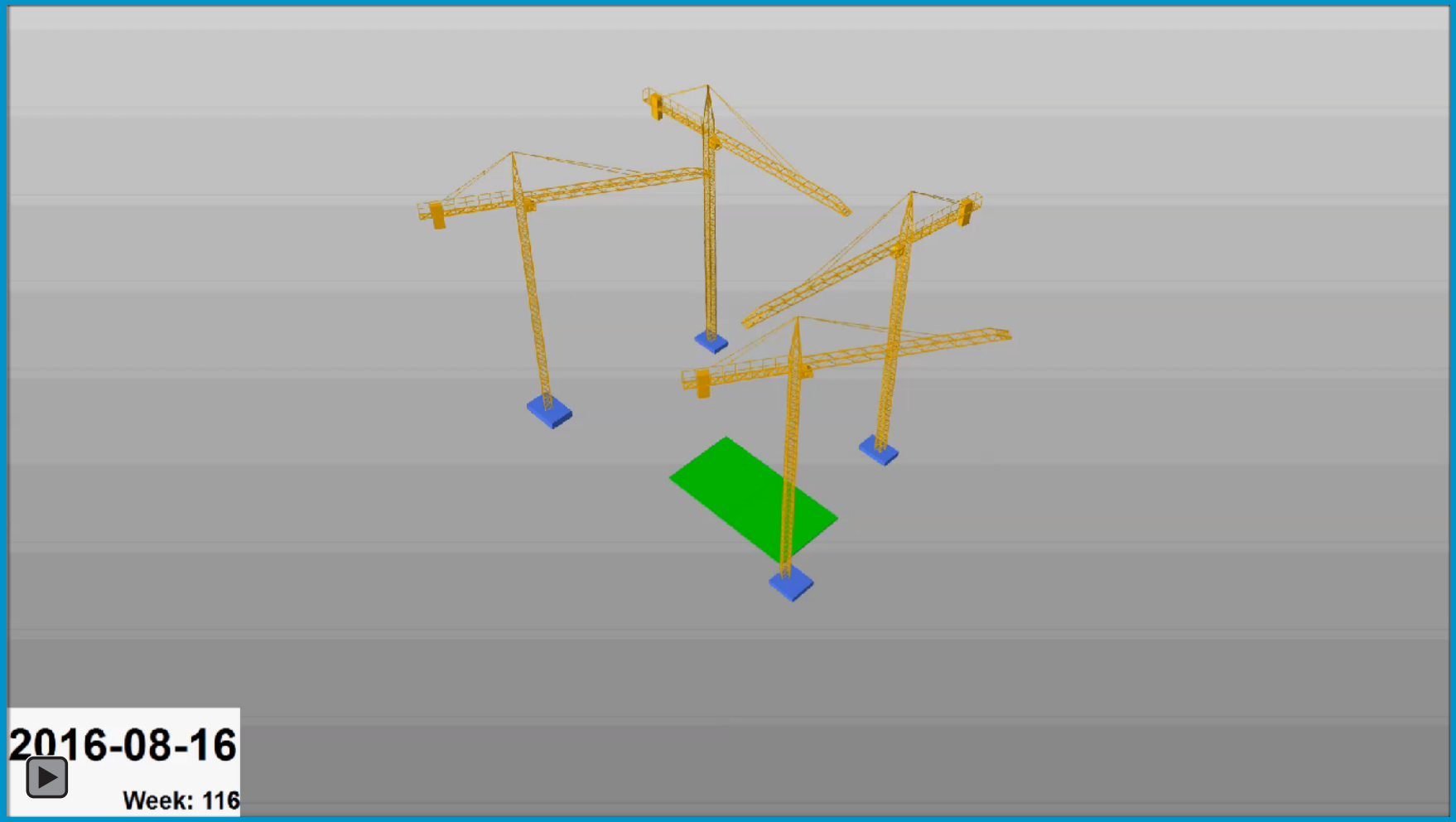
Summary

- ESS will be the world leading neutron spallation source after 2025.
- Starting from a greenfield site it is only possible thanks to the world-wide community knowledge.
- It is materializing thanks to the competences and efforts of many European partner institutions and of European industry.
- The project is on track for the start of the user program in 2023.
- The success of ESS will be a collective success of all those involved!

You are welcome to visit the ESS construction site on Friday!

IPAC17

EUROPEAN SPALLATION SOURCE


2016-08-16
Week: 116