Neutron instrument sample environments

PRESENTED BY ALEX HOLMES, EUROPEAN SPALLATION SOURCE ERIC

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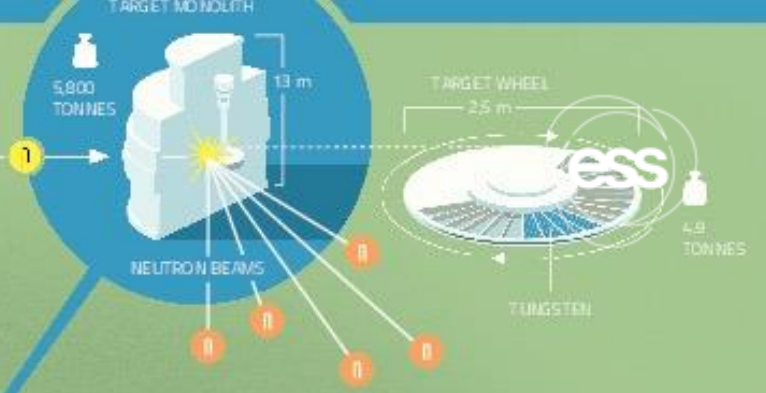
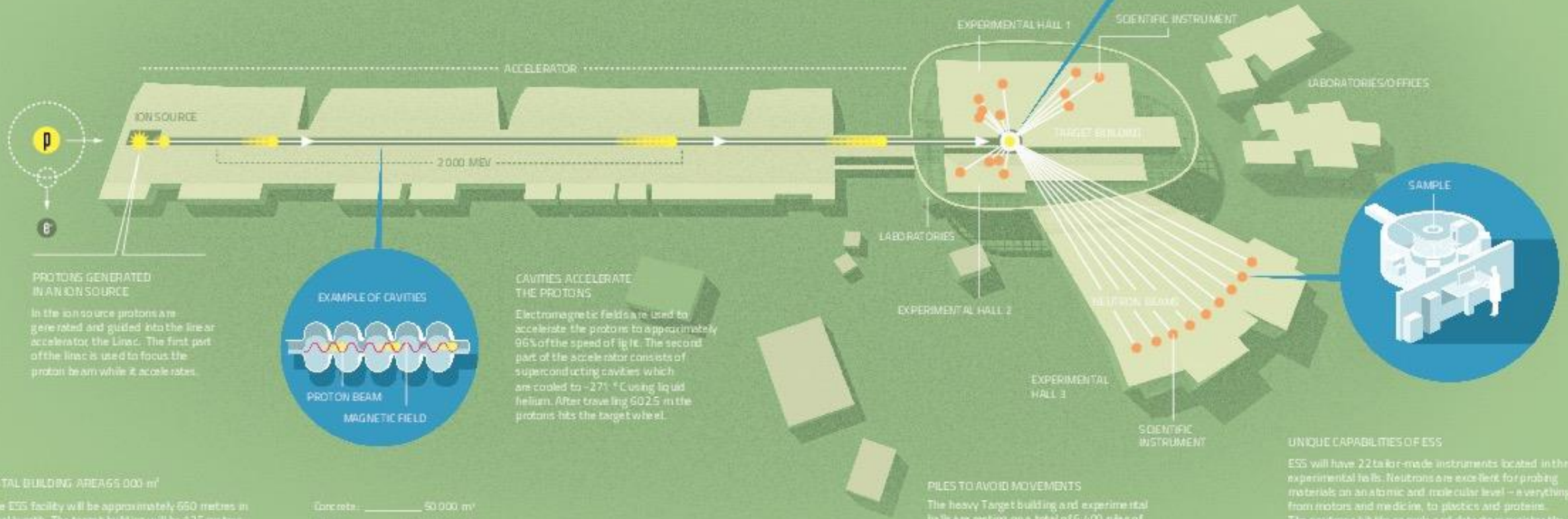
EUROPEAN
SPALLATION
SOURCE

The European Spallation Source (ESS) is a multi-disciplinary research centre based on the world's most powerful neutron source. ESS will give scientists new possibilities in a broad range of research, from life science to engineering materials, from heritage conservation to magnetism. ESS is a pan-European project, with Sweden and Denmark serving as host countries. The main research facility is being built in Lund, Sweden, and the Data Management and Software Centre (DMSC) is located in Copenhagen, Denmark.

THE TARGET IS THE NEUTRON SOURCE

When the accelerated protons hit the rotating tungsten target wheel spallation occurs and neutrons are scattered from the tungsten nucleus. The more neutrons produced and collected in the target, the "brighter" the neutron source. The neutrons are directed through moderators and neutron guides to the scientific instruments where they are used for experiments. The Target monolith consists of the Target wheel, moderators, cooling systems and shielding and weighs approximately 5,800 tonnes.





PROTONS GENERATED IN AN ION SOURCE

In the ion source protons are generated and guided into the linear accelerator, the Linac. The first part of the linac is used to focus the proton beam while it accelerates.

CAVITIES ACCELERATE THE PROTONS

Electromagnetic fields are used to accelerate the protons to approximately 96% of the speed of light. The second part of the accelerator consists of superconducting cavities which are cooled to -271 °C using liquid helium. After traveling 602.5 m the protons hits the target wheel.

TOTAL BUILDING AREA 65 000 m²

The ESS facility will be approximately 650 metres in total length. The target building will be 125 metres long, and about 30 metres high. The 537-meter-long accelerator tunnel is built underground and will be covered with soil.

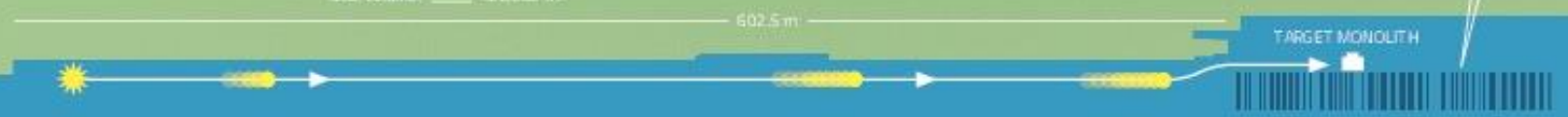
Concrete:	50 000 m³
Rebar:	6 000 tonnes
Pipes:	40 km
Cables:	2,000 km
Total volume:	400 000 m³

PILES TO AVOID MOVEMENTS

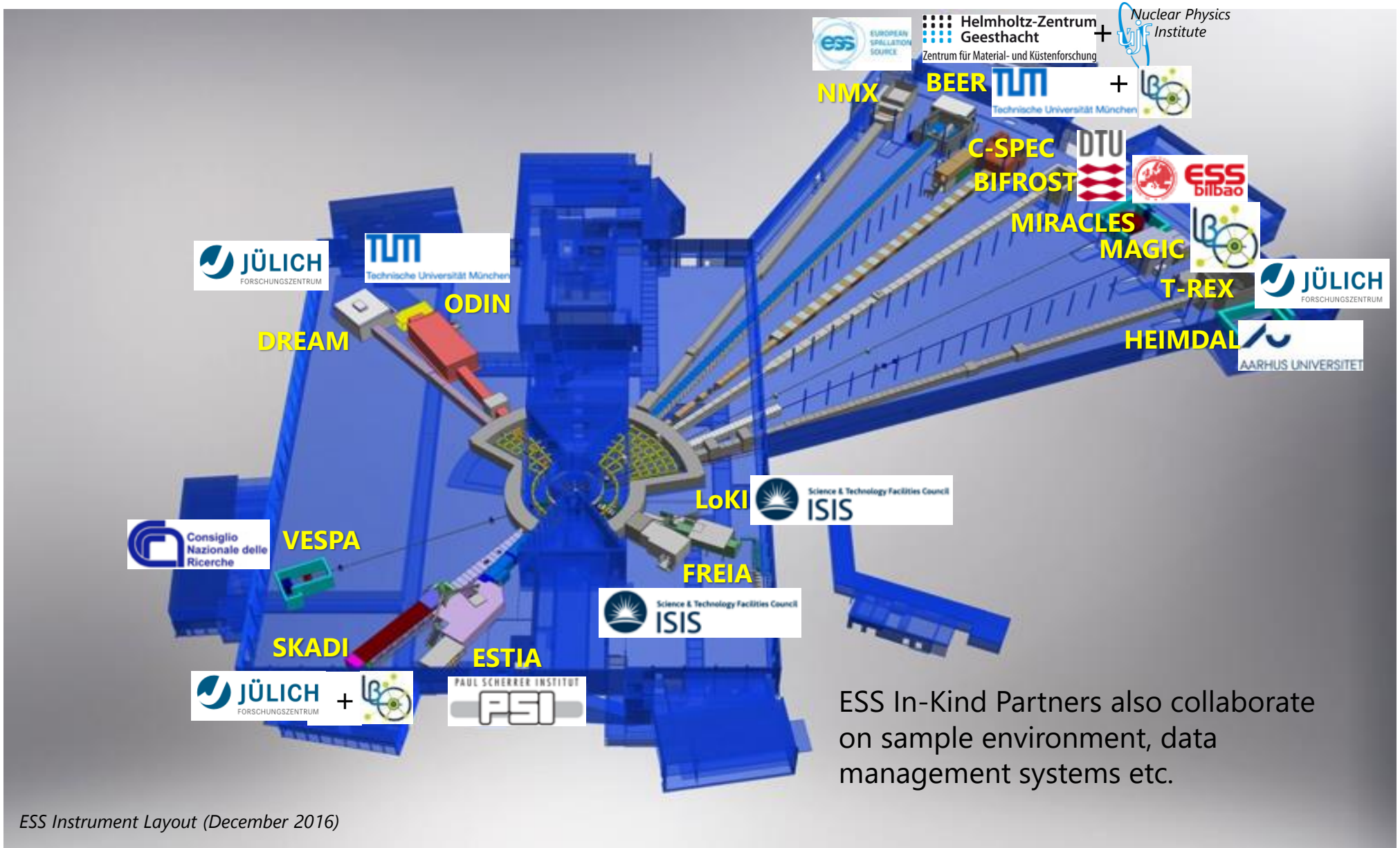
The heavy Target building and experimental halls are resting on a total of 6,400 piles of different types, in order to avoid unwanted movements in the structure.

UNIQUE CAPABILITIES OF ESS

ESS will have 22 tailor-made instruments located in three experimental halls. Neutrons are excellent for probing materials on an atomic and molecular level – everything from motors and medicine, to plastics and proteins. The neutrons hit the sample and detectors register the neutron scattering, giving precise information about the material's structure and dynamics.



Instrument projects: lead partner for construction



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

ESS Instrument Layout (December 2016)

15 Instruments + Test Beamline

Large-Scale Structures

Diffraction

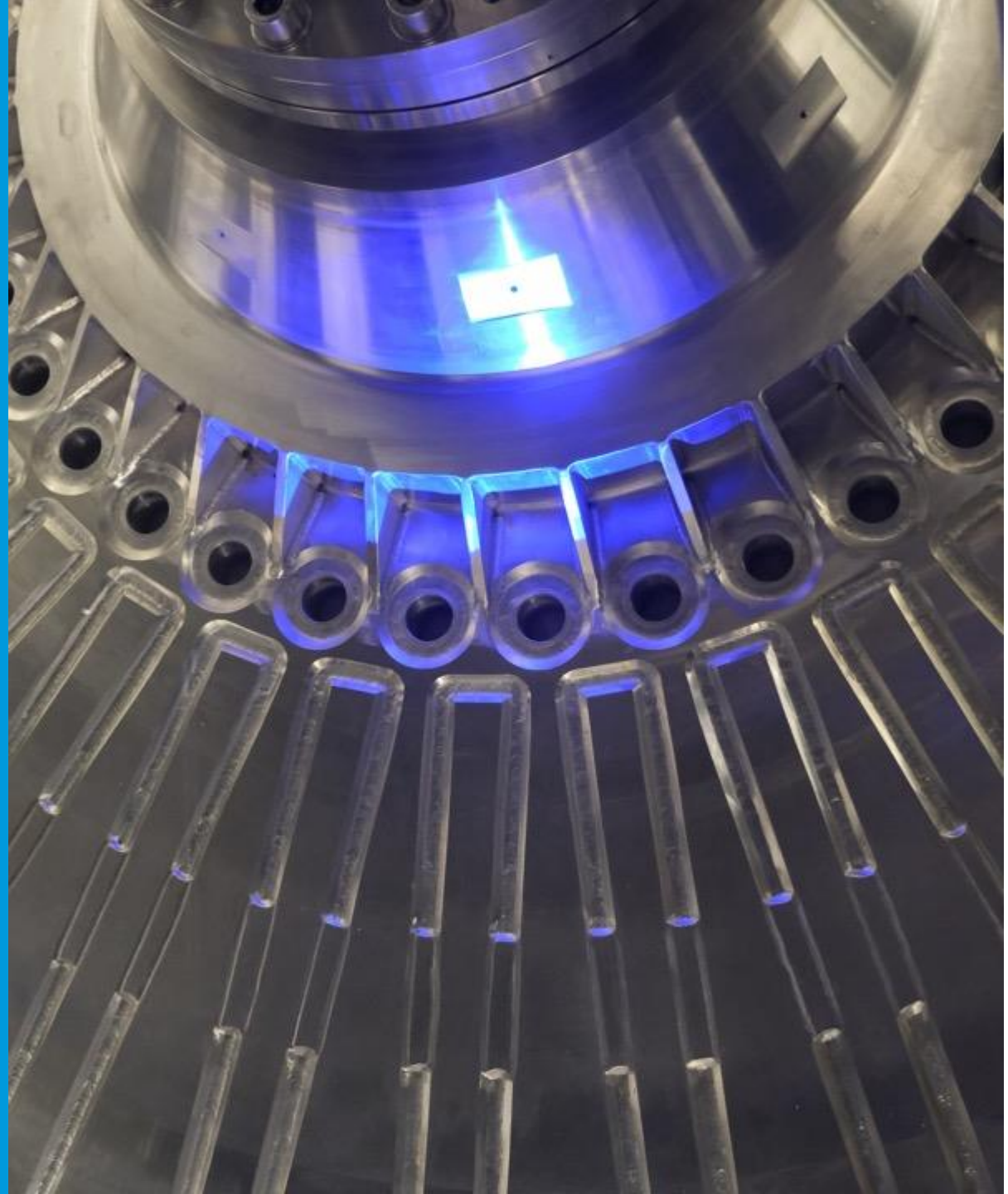
- ODIN Imaging Instrument
- SKADI General Purpose SANS
- LOKI Broadband SANS
- Surface Scattering
- FREIA Horizontal Reflectom.
- ESTIA Vertical Reflectom.
- HEIMDAL Powder Diffract.
- DREAM Powder Diffract.
- Monochromatic Powder Diffract.
- BEER Engineering Diffract.
- Extreme Conditions Diffract.
- MAGIC Magnetism Diffract.
- NMX Macromolecular Diffract.

Spectroscopy

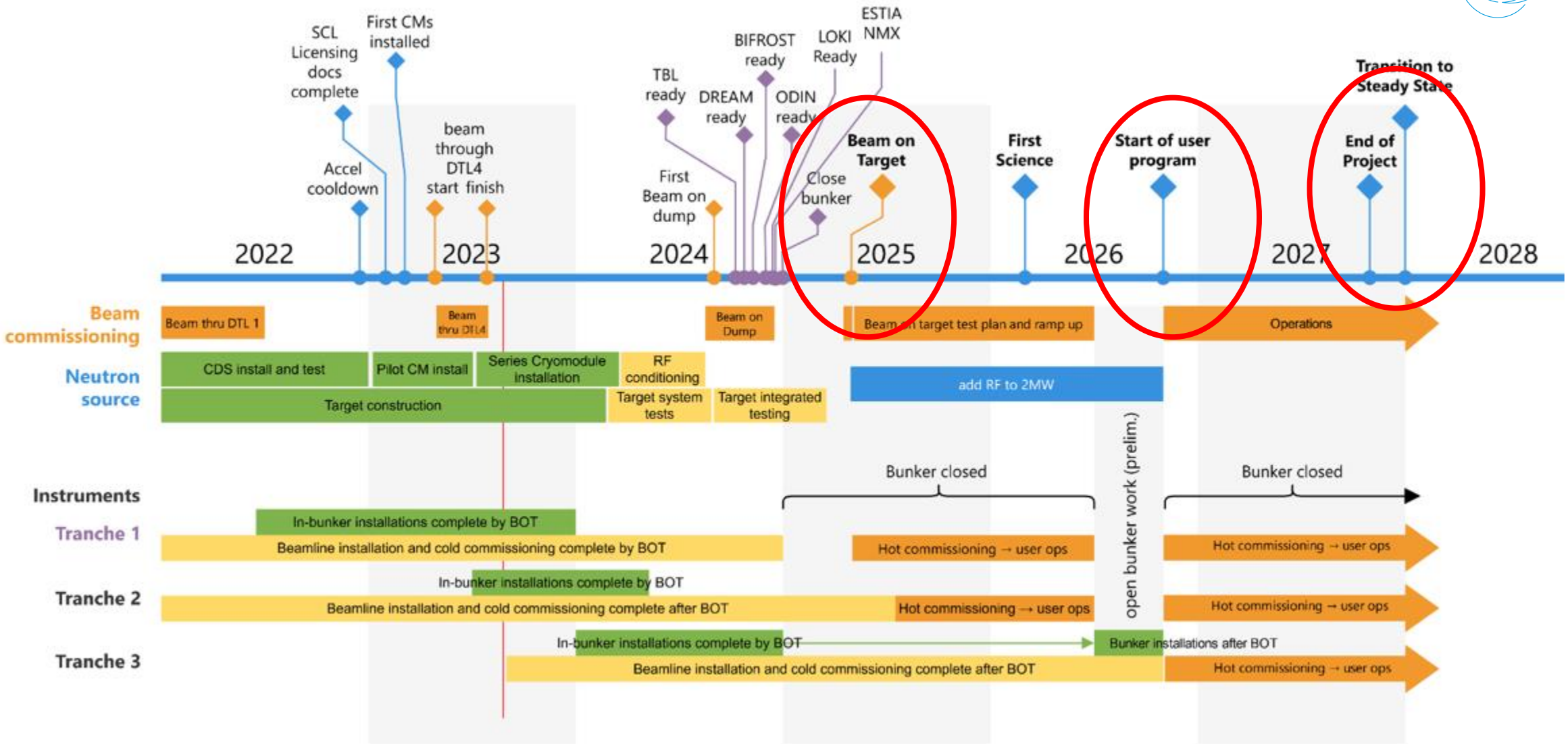
- CSPEC Cold Chopper Spec.
- Broadband Spectrometer
- T-REX Thermal Chopper Spec.
- BIFROST Xtal Analyser Spec.
- VESPA Vibrational Spec.
- MIRACLES Backscatt. Spec.
- High-Resolution Spin-Echo
- Wide-Angle Spin-Echo
- Particle Physics Beamline

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

Current Status of the ESS Project



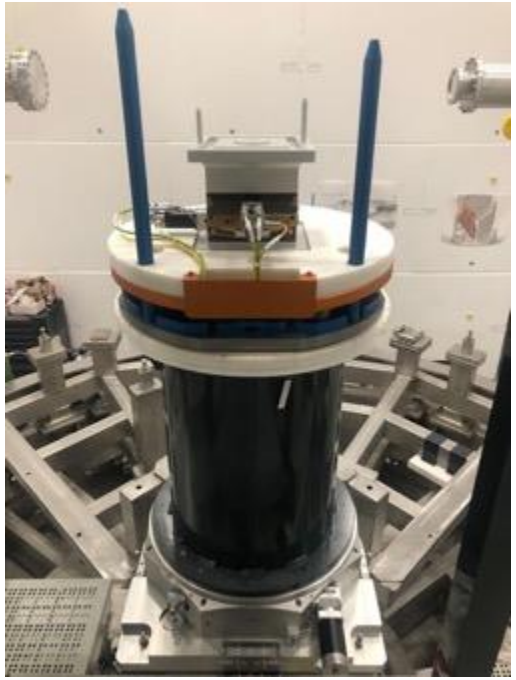
Project Timeline



NSS instrument installation

LOKI Collimation vessel installation

BIFROST sample stack installed



Supermirrors for one of the ESTIA Selene guides

NSS instrument installation

D03 side, NMX neutron guide

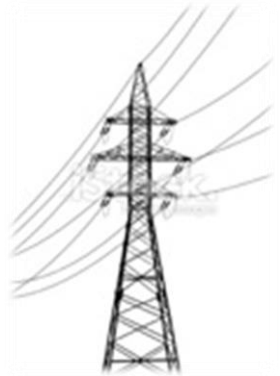
D01 side, ESTIA cave and control hutch is progressing

Neutrons for Science

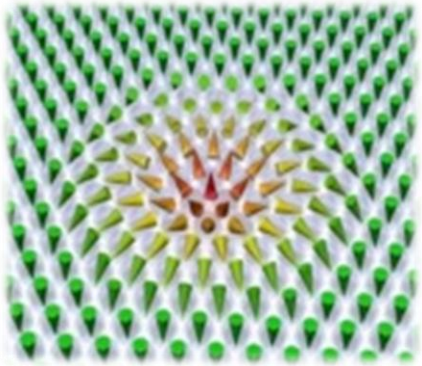
Neutrons for magnetic and electronic phenomena

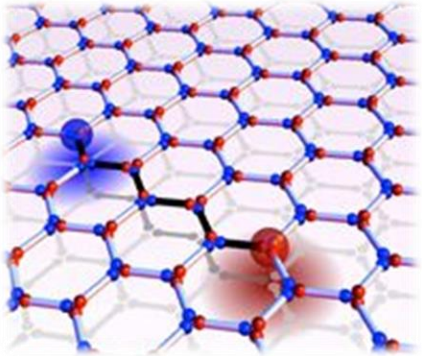
EUROPEAN SPALLATION SOURCE

Hunting for materials that make our technology smarter



Understanding quantum phenomena and novel states of matter in detail





Improving electronic properties and exploiting quantum phenomena

The sensitivity of neutrons to magnetism and the unique ESS neutron flux makes it possible to study quantum materials 'in-operandi' to understand them at a microscopic level.

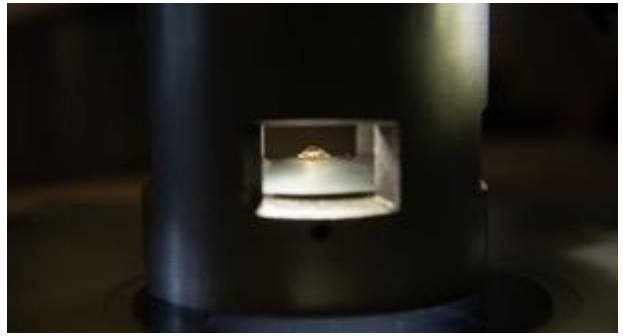
Cryogenics is crucial for this!

Sample environment turns a measurement into an experiment

Ultra Low Temperature

T < 50mK

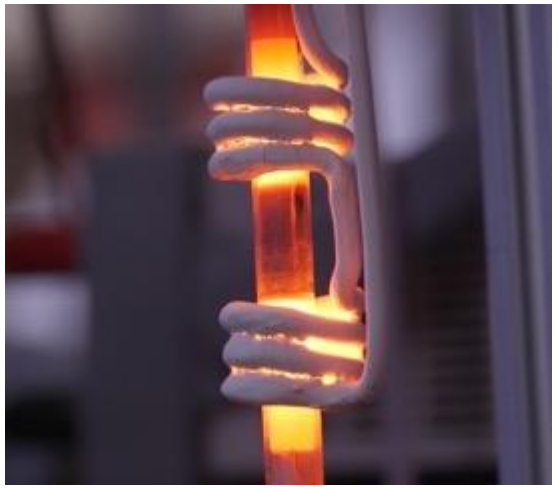
Pressure



P > 100 GPa

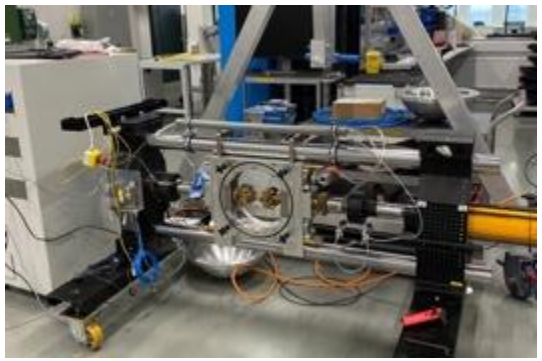
B > 16 T

High temperature

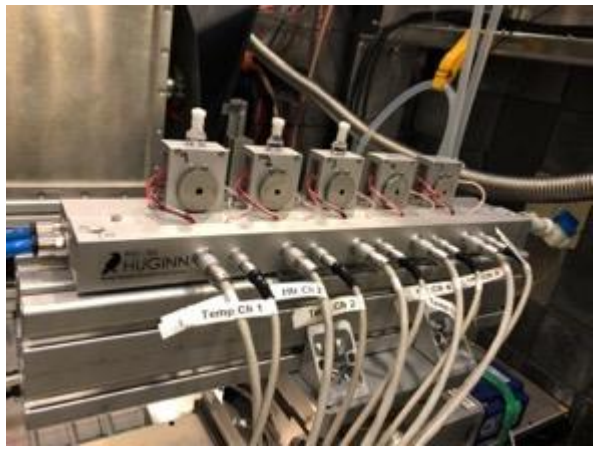


T > 1000°C

Mechanical processing



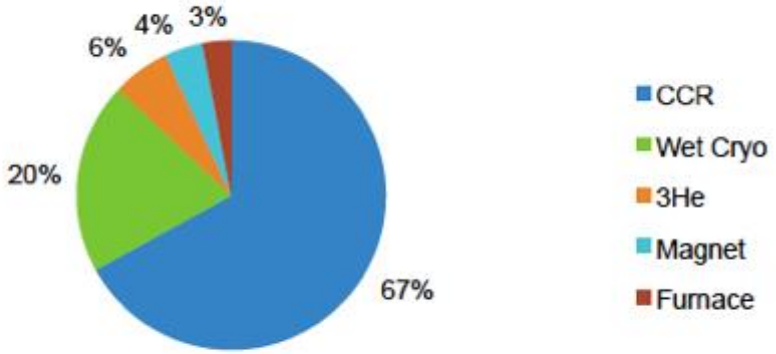
Soft matter



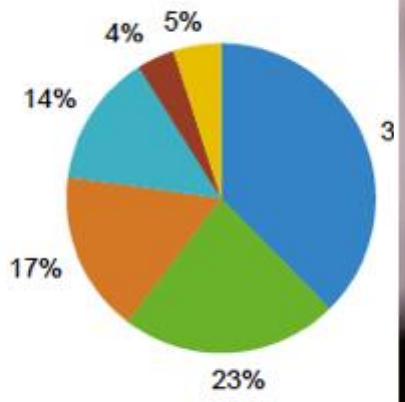
Complex fluids, colloids, interfaces

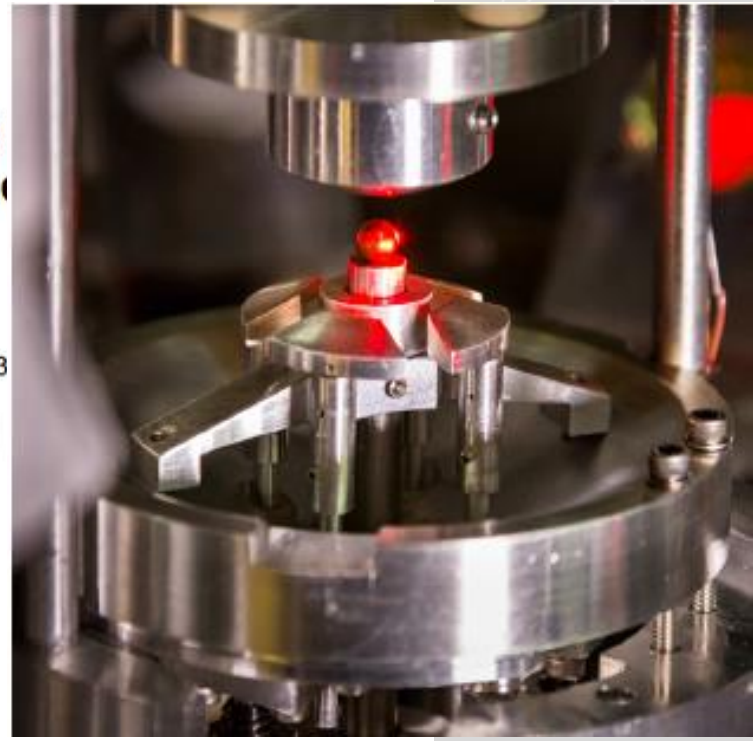
HFIR and SNS Experiment Profiles

HFIR FY 2012, 7 Cycles, 267 Total Experiments

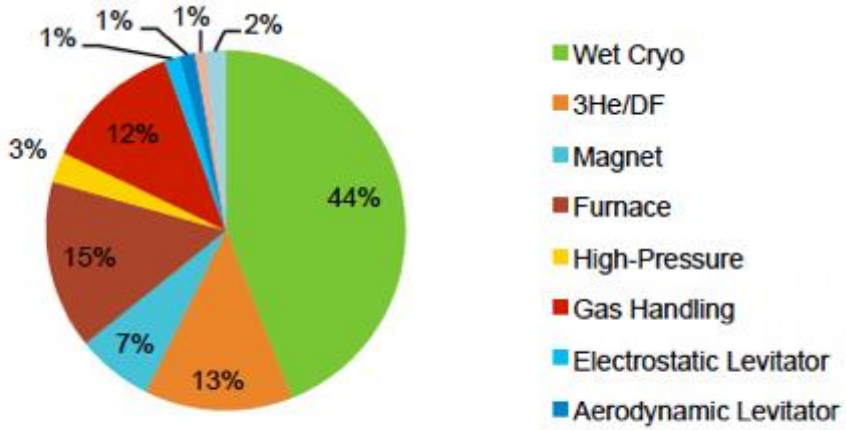


HFIR FY 2015, 6 Experim



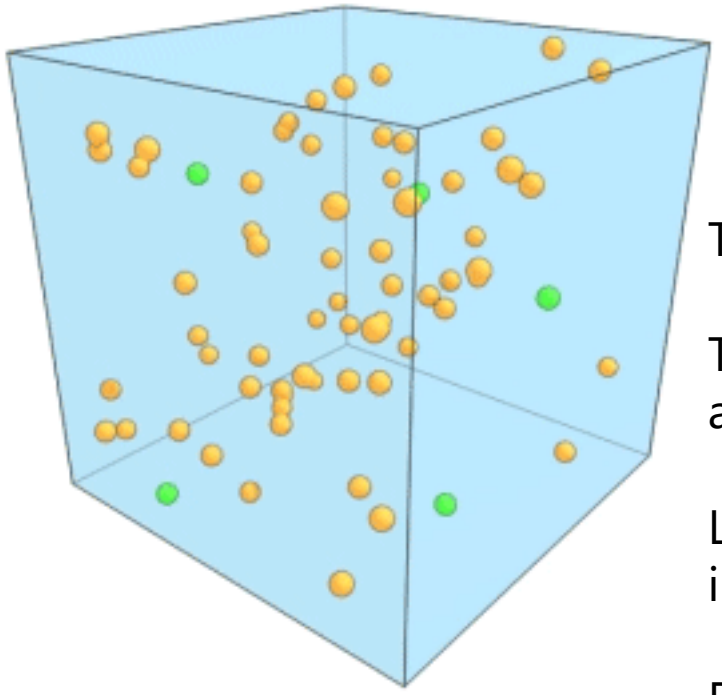


SNS FY 2015, 218 Experiments



Focus on cryogenics

Cryogenics - Why do we want to cool things?



Translational motion
Credit: Sean Kelley/NIST

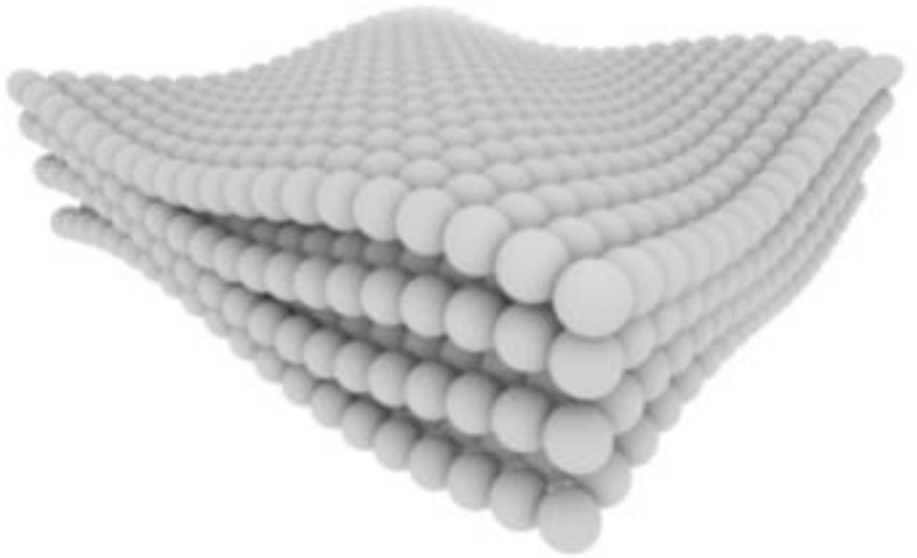
Temperature ⇔ kinetic energy

Translation, vibrations, rotations etc. of atoms, molecules, electrons…

Lower temperature allows other interactions to take over ⇒

Phase transitions:

Classical (e.g.crystallisation)
or
Quantum (magnetism, superconductivity)



Collective motions (phonons).
Credit: Sean Kelley/NIST

Neutron energies match well with phonons and other excitations

Cryogenic & magnet sample environments

Wet, dry, dilution, He3,
Flow cryostats (not to scale)

Typically Variable Temperature Insert into outer cryostat/cryomagnet
To allow rapid sample changeover

Note – helium recovery is available at ESS.

Temperatures ranges, 1.5K-300K (easy), <300mK (hard), <20mK (harder)
Max field standard 15-17T, part of EU grant proposal to go higher…

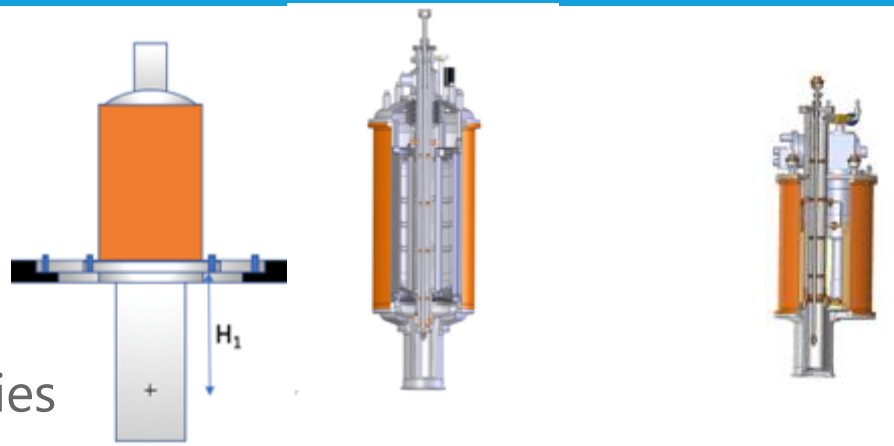
Pictures: ILL, HZB, STFC, other manufacturers are available…

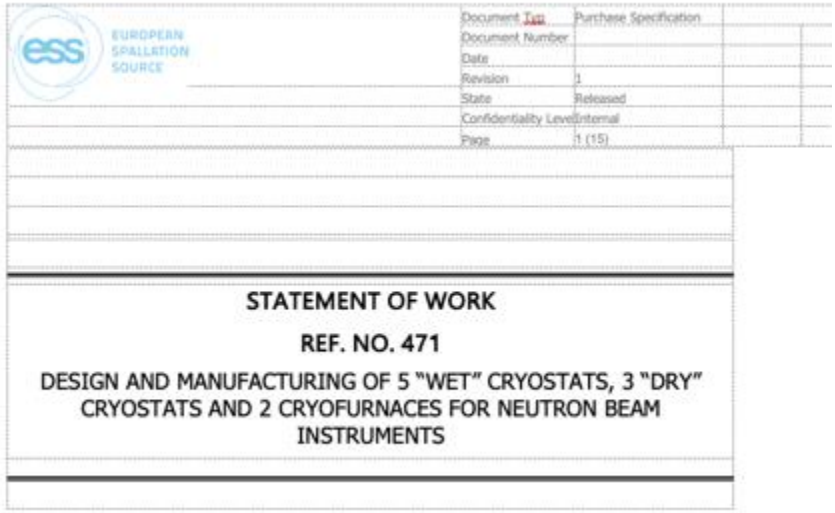
Upcoming tender – 10 wet and dry cryostats/furnaces

- Top loading systems for fast sample change
- VTI type wet systems, with separate sample space
- Vacuum tank instruments mounted on flanges
- Different tails for different instruments, standard bodies
- Current designs based on tubes & flanges, plenty of room for improvement with modern methods (e.g. 3D printing)

Future developments needed

- New concepts?
- Highly reliable automatic sample change in non-ambient conditions





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Date	
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STATEMENT OF WORK

REF. NO. 471

DESIGN AND MANUFACTURING OF 5 "WET" CRYOSTATS, 3 "DRY" CRYOSTATS AND 2 CRYOFURNACES FOR NEUTRON BEAM INSTRUMENTS

Contact : Oleksiy Zadorozhko <oleksiy.zadorozhko@ess.eu>

Special requirements for facility experiments

What do we need beyond usual laboratory type equipment

Reliability
- Beamtime 50k€/day
- Possibility for in-house repair

Connectivity
- Remote monitoring
- Remote control
- *SECOP (see link)*

Physical Interfaces
- Mechanical mounts
- Standard connectors
- Vacuum
- Motion control

Materials
- Activation
- Transmission
- Background scattering
- Magnetism

Portability
- Wheels
- Crane

Timing
- Fast sample change
- Time dependent properties

Geometry
- Shape & Size
- Detector coverage

Sample Environment Communication Protocol (SECoP)
https://doi.org/10.3233/JNR-190143

ISSE
Workshop Båstad 2024

Organised by: MAX IV

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EUROPEAN SPALLATION SOURCE

http://www.sampleenvironment.org/

International Society for Sample Environment Workshop
September 16th-20th 2024

Registration:
https://indico.maxiv.lu.se/event/5246/

Sponsors welcome!