
ess
EUROPEAN
SPALLATION
SOURCE



The Audacity to Build the Impossible: The Path to the First Proton Beam at ESS

Romanian International Conference for Education and Research

Bucharest, 04 October 2026

CIPRIAN PLOSTINAR – HEAD OF ACCELERATOR DIVISION AT ESS

2026-11-04



Neutron Science

Why Neutrons?

"Where are the atoms and what do they do?"

- Diffractometers: Structure
- Spectrometers: Dynamics

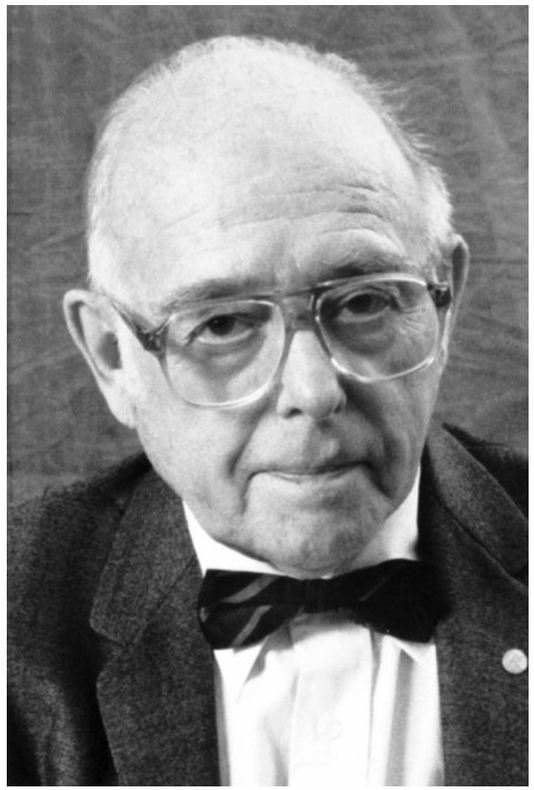
1994 Nobel Prize 1994:

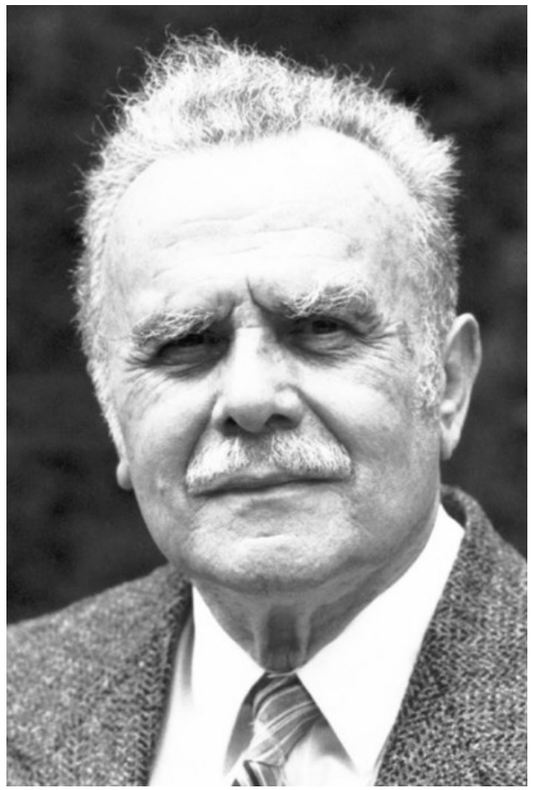
- **Clifford Shull** – neutron diffraction
- **Betram Brockhouse** – neutron spectroscopy

Some Neutron Properties:

- Charge neutral: deeply penetrating … except for some isotopes
- Nuclear interaction: cross section depending on isotope (not Z), sensitive to light elements.
- Spin S = 1/2: probing magnetism

"For pioneering contributions to the development of neutron scattering techniques for studies of condensed matter"





See the 1994 Physics Nobel Prize Press Release

Neutron Science

Why Neutrons?



Because “planes, trains, dinosaurs and ice-cream”!

Mapping stress and fatigue in aircraft wings

Airbus research @ISIS Spallation Neutron Source



Source: airbus.com

Exploring unconventional superconductors using neutron spectroscopy

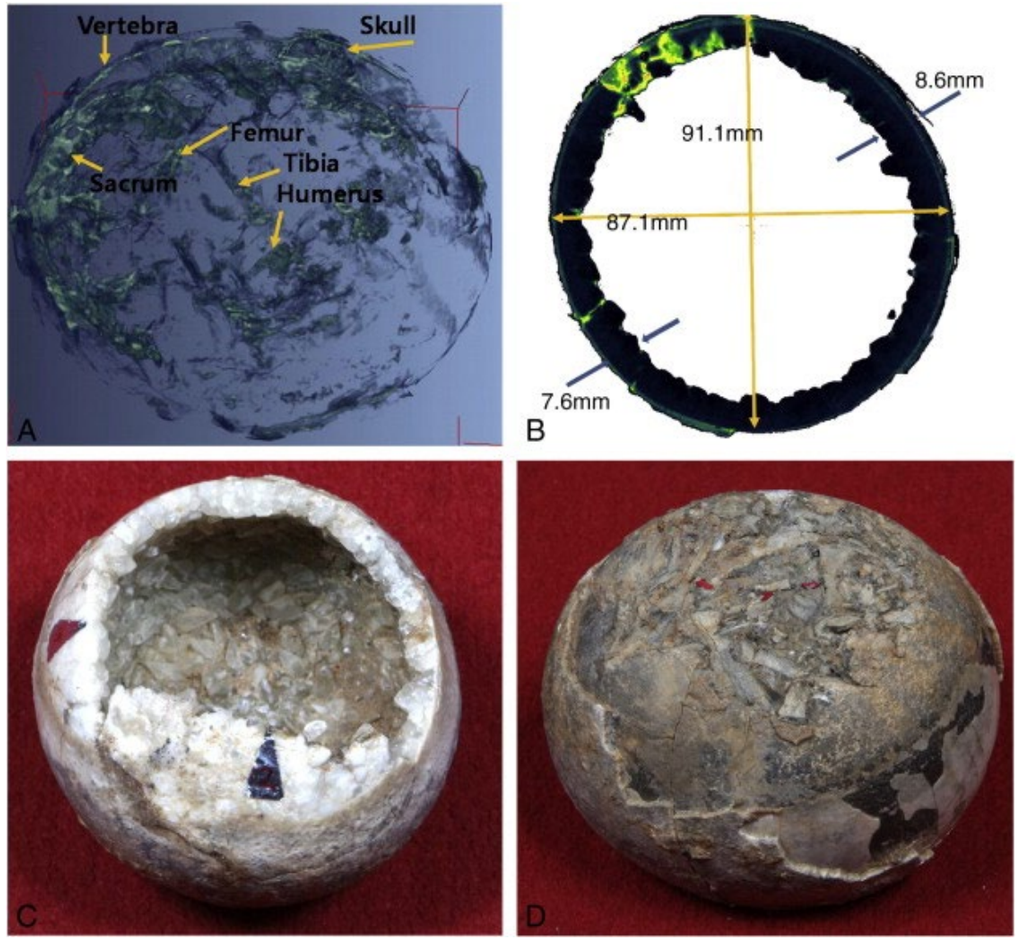
Maglev?



Source: wikipedia.org

Neutron Characterisation Reveals Fossilised Titanosaurus Embryo

G. Grellet-Tinner et al.

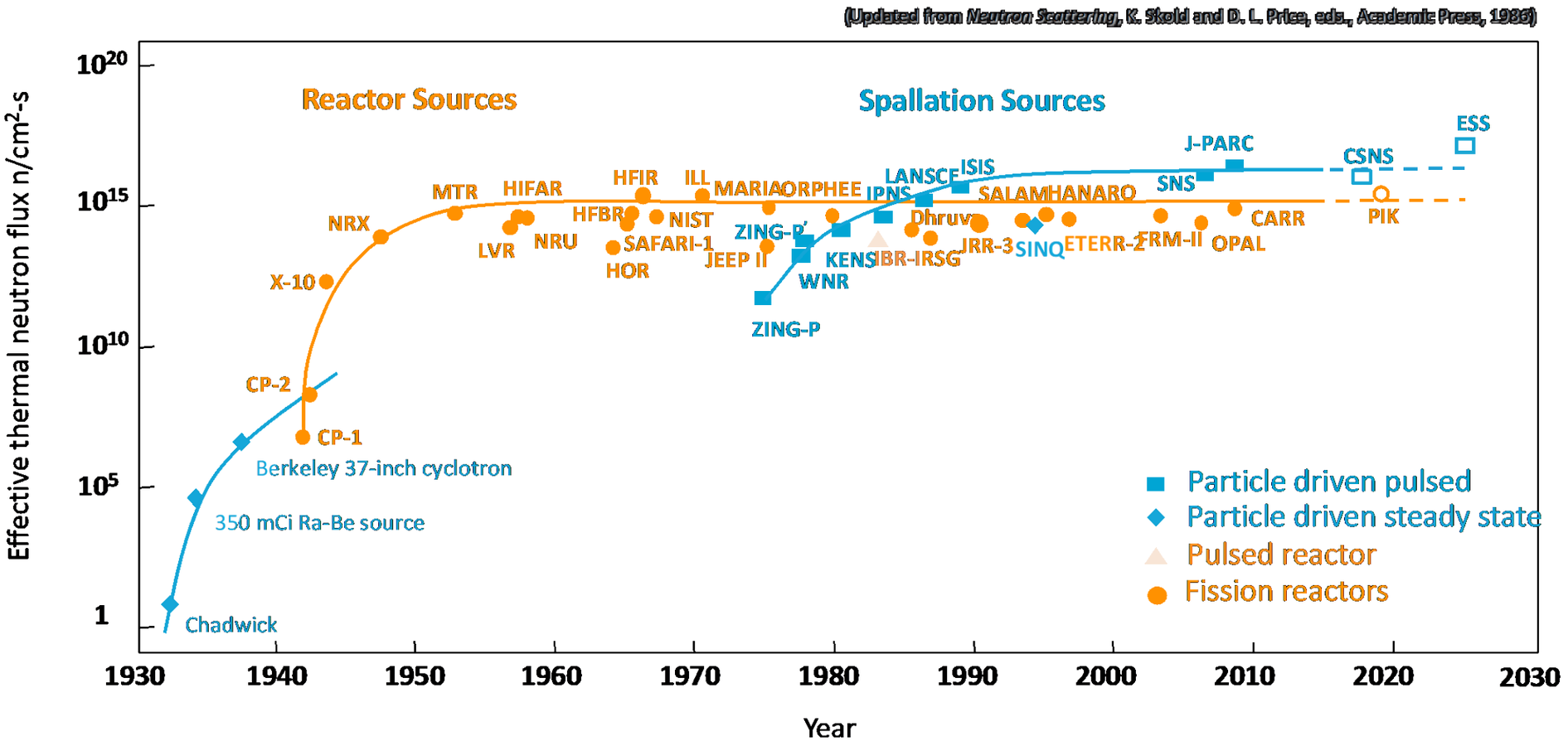


Using neutrons to study the crystallisation of ice cream in real time

Research @ISIS Spallation Neutron Source



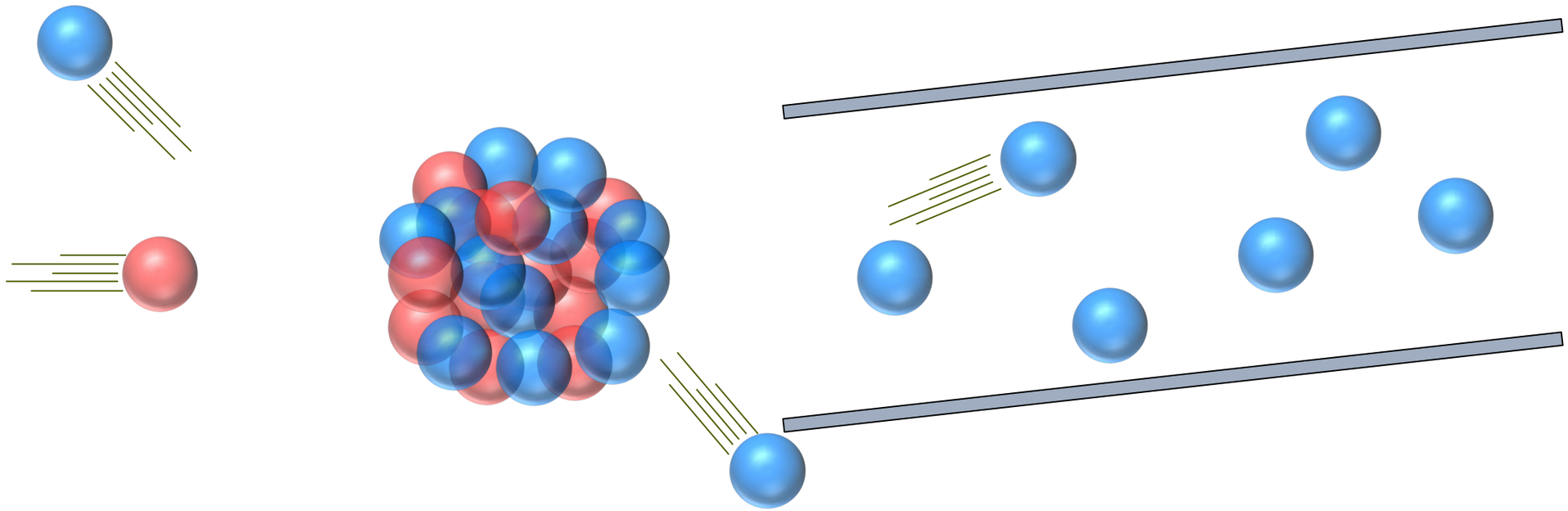
Neutron Production



Neutron Production



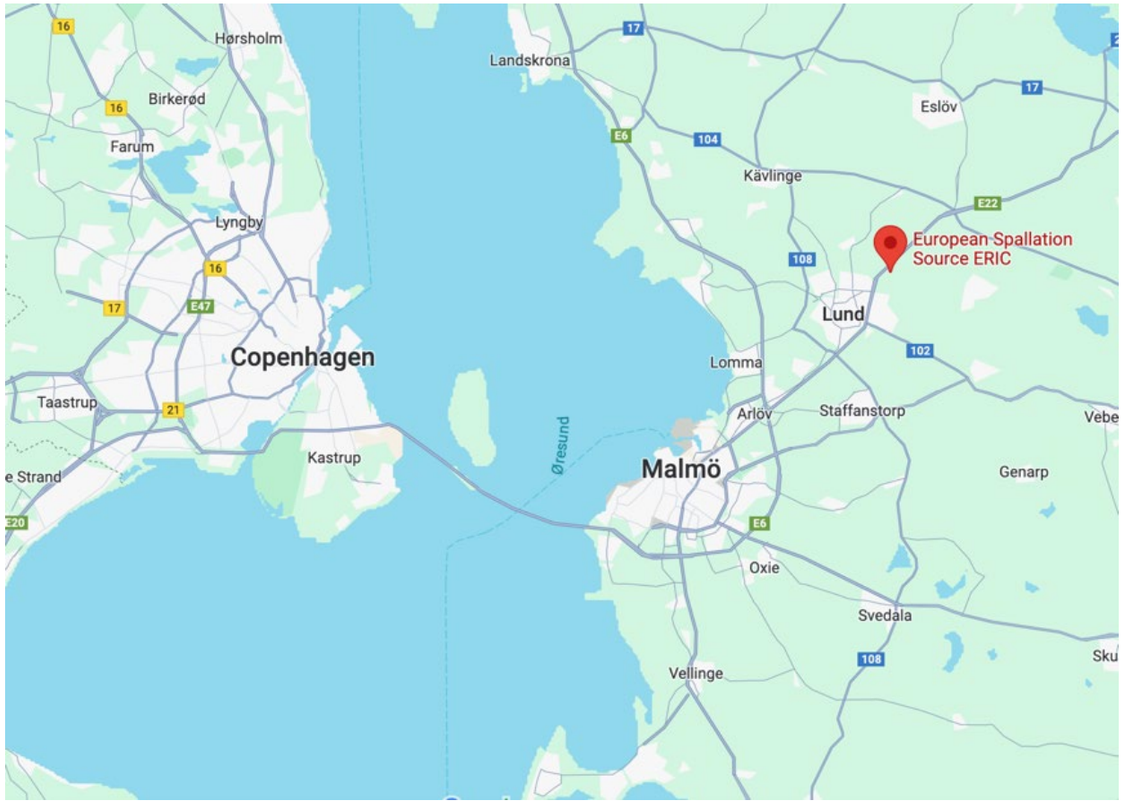
Spallation Principles



- High energy protons hit a heavy nuclei target
  - Neutrons at different energies emitted
  - Spallation: most effective neutron production method
- Complex system:
  - **Accelerator**, **Target**, **Moderators**, **Instruments**, etc.

European Spallation Source

Location





How ESS Works

In a Nutshell

1 Protons are generated in the ion source

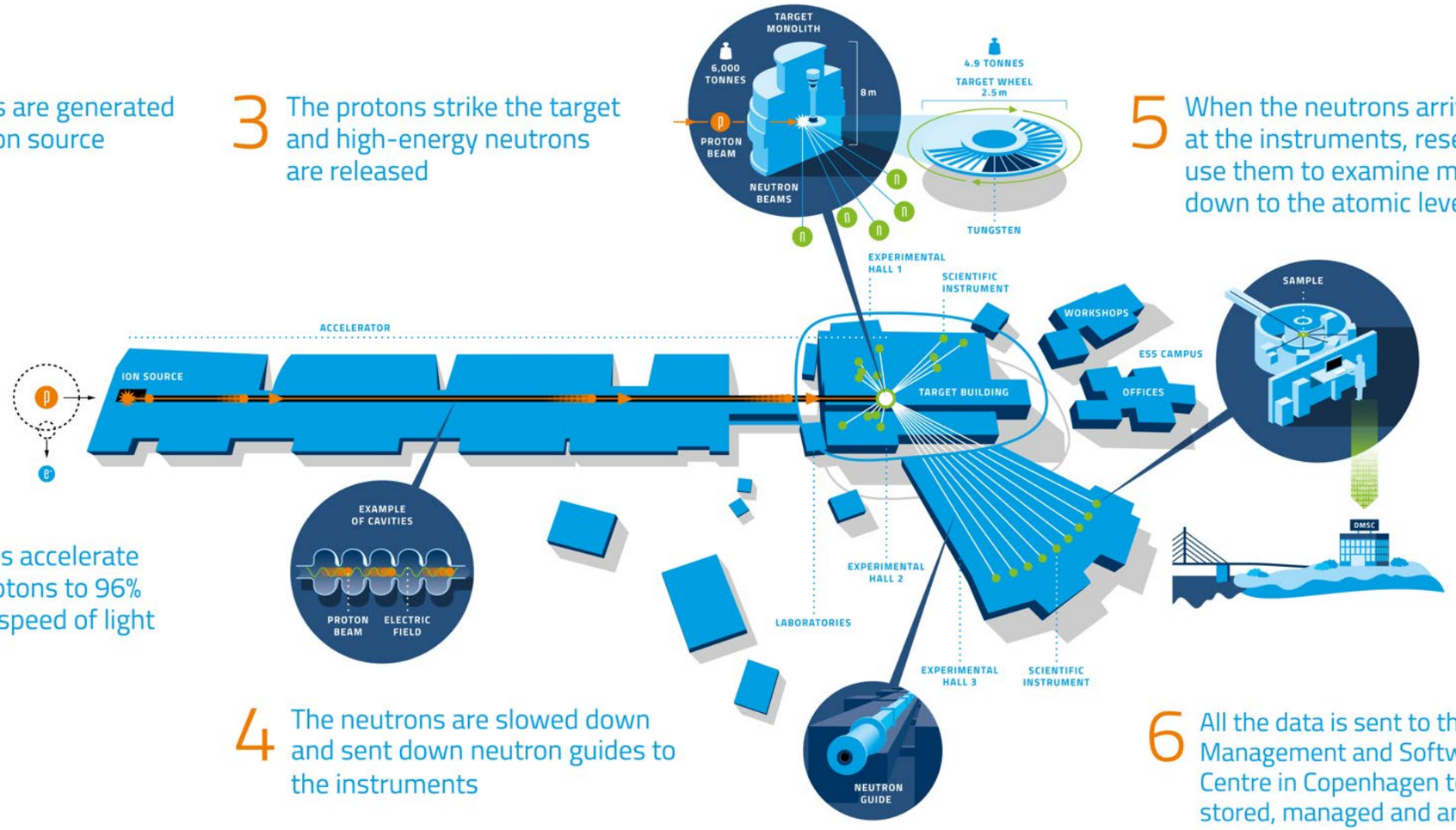
2 Cavities accelerate the protons to 96% of the speed of light

3 The protons strike the target and high-energy neutrons are released

4 The neutrons are slowed down and sent down neutron guides to the instruments

5 When the neutrons arrive at the instruments, researchers use them to examine matter down to the atomic level

6 All the data is sent to the Data Management and Software Centre in Copenhagen to be stored, managed and analysed with the researchers



The ESS Project

13 European countries joining forces and sharing a common ambition!

- Host States:
  - Sweden, Denmark

- Member States:
  - Czech Republic, Denmark, Estonia, France, Germany, Hungary, Italy, Norway, Poland, Spain, Sweden, Switzerland, United Kingdom.

- A 3.5 B€ project, with an estimated annual operations and development cost of about 180 M€.



The ESS In-Kind Model

A unique international project with over 100 in-kind partners

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
Copenhagen University
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)
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
Rutherford Appleton Laboratory, Oxford (ISIS)
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)



(Beam) Power Supremacy!

Rutherford Appleton Laboratory (UK) –> 200 kW





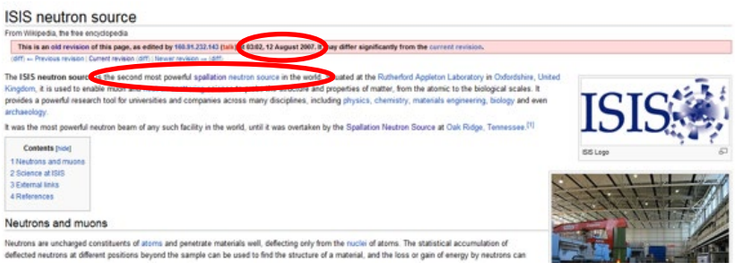
(Beam) Power Supremacy!

A Wiki Story

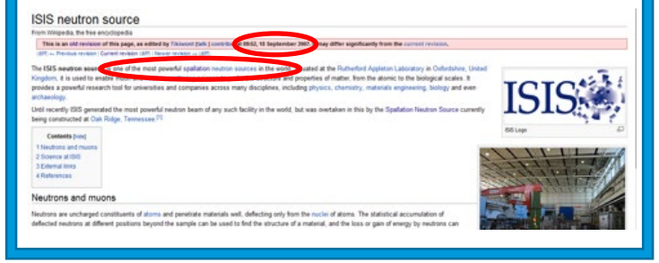
18:18, 21 July 2007, Wikipedia:
ISIS is ”…the most powerful spallation neutron source in the world…”



03:02, 12 August 2007:
ISIS is ”…the second most powerful…”



09:52, 18 September 2007:
ISIS is ”…one of the most powerful…”



09:52, 03 October 2007:
ISIS is ”…a world leading neutron source…”



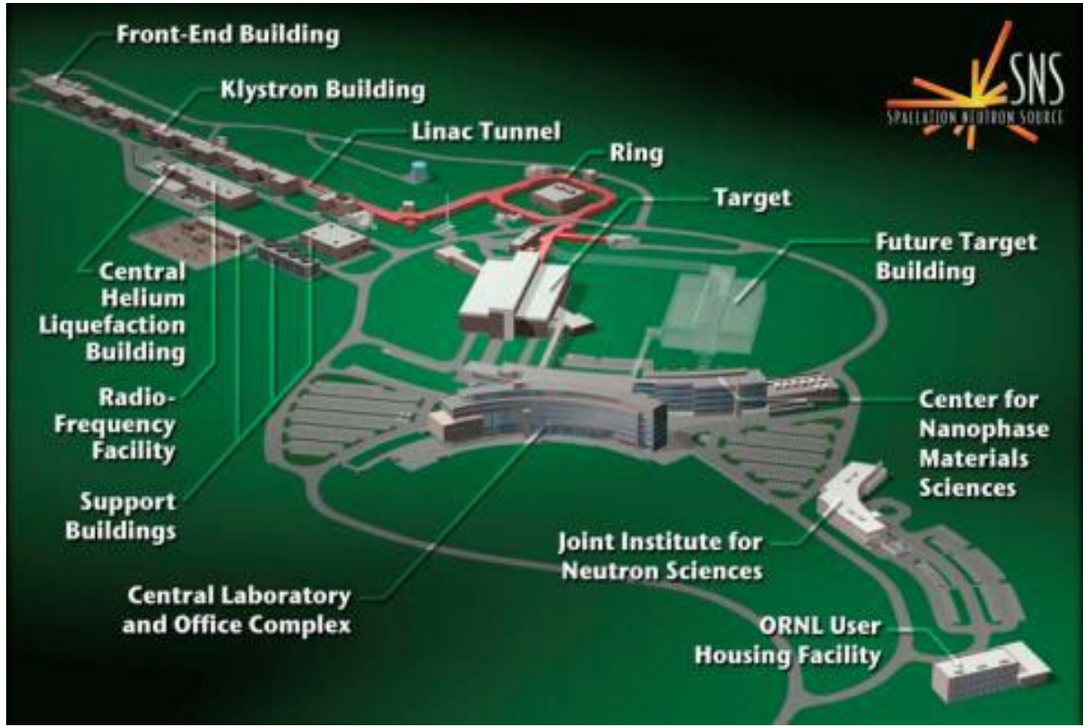
14:00, 19 October 2007:
SNS is ”…the most powerful neutron source in the world…”



(Beam) Power Supremacy!

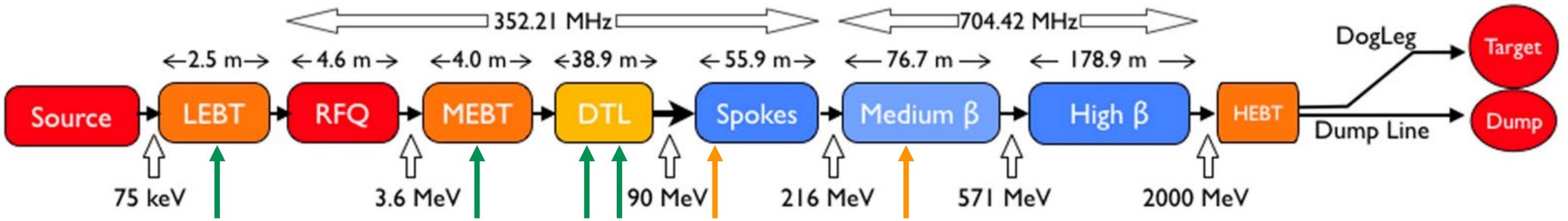
Spallation Neutron Source (US) –> 2 MW





(Beam) Power Supremacy!

ESS (SE) –> 5 MW



Our aim is to build and operate the most powerful linear proton accelerator ever built.

5 MW nominal power (currently 2 MW installed capacity)

A Long Journey

From an idea…



A Long Journey

To a farmer’s field…



A Long Journey

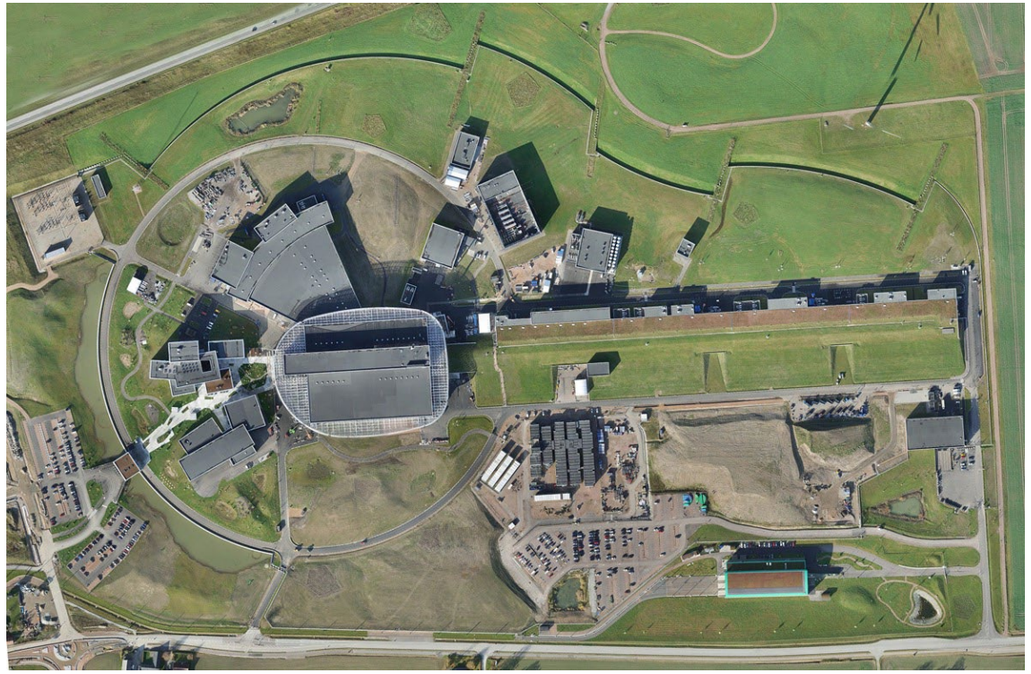
To a construction site…



A Long Journey

To a facility!





ESS Instruments

Each instrument designed to be world-leading at 2 MW

- 15 instruments in baseline budget and currently in development
- Each instrument designed to be world-leading
- 6 instruments (LOKI, BIFROST, ODIN, DREAM, NMX, ESTIA) + Test Beam Line (TBL) ready
- A total of 42 beam ports.

Life sciences

Soft condensed matter

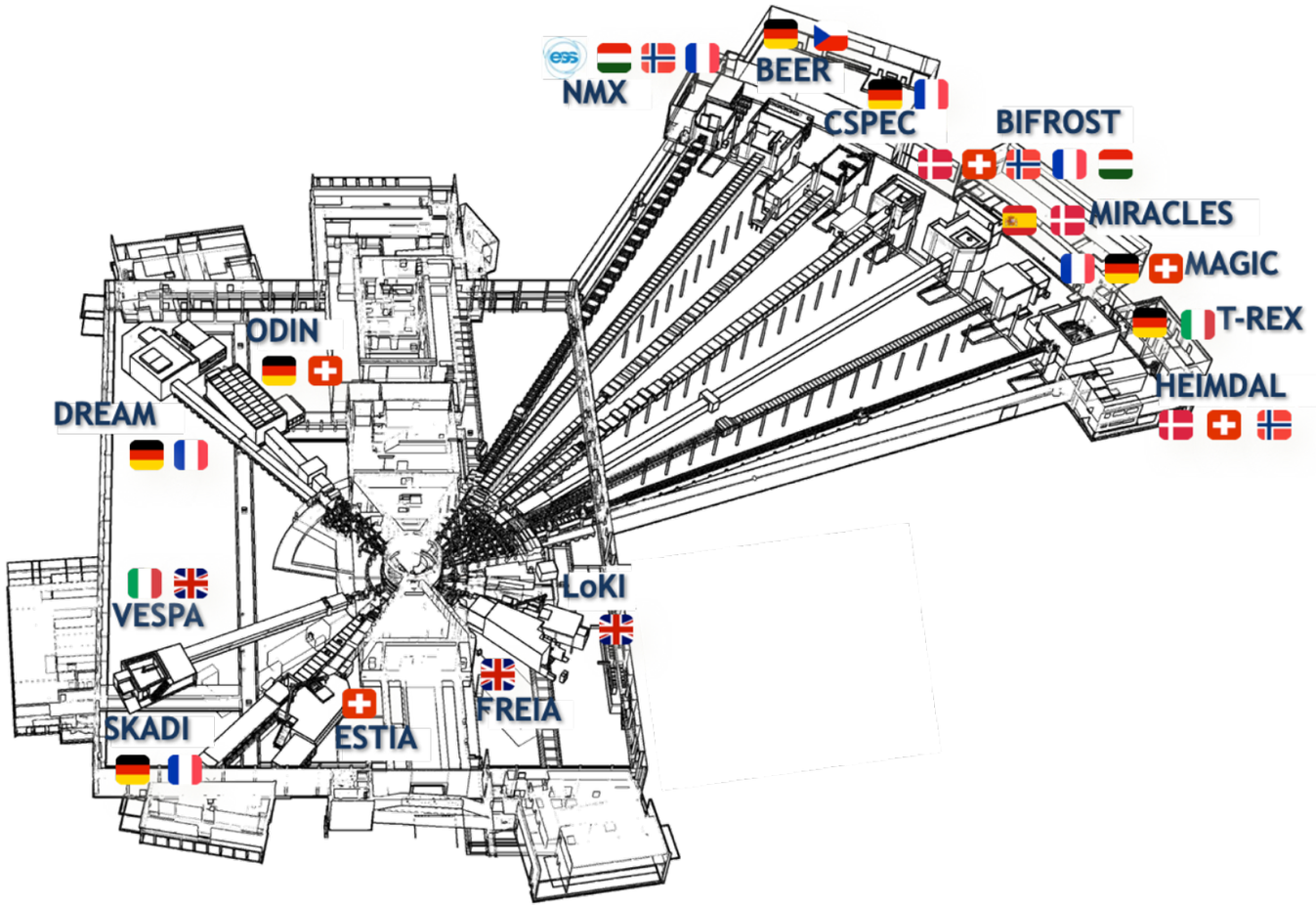
Chemistry of materials

Energy research

Magnetism & superconductivity

Engineering & Geo-sciences

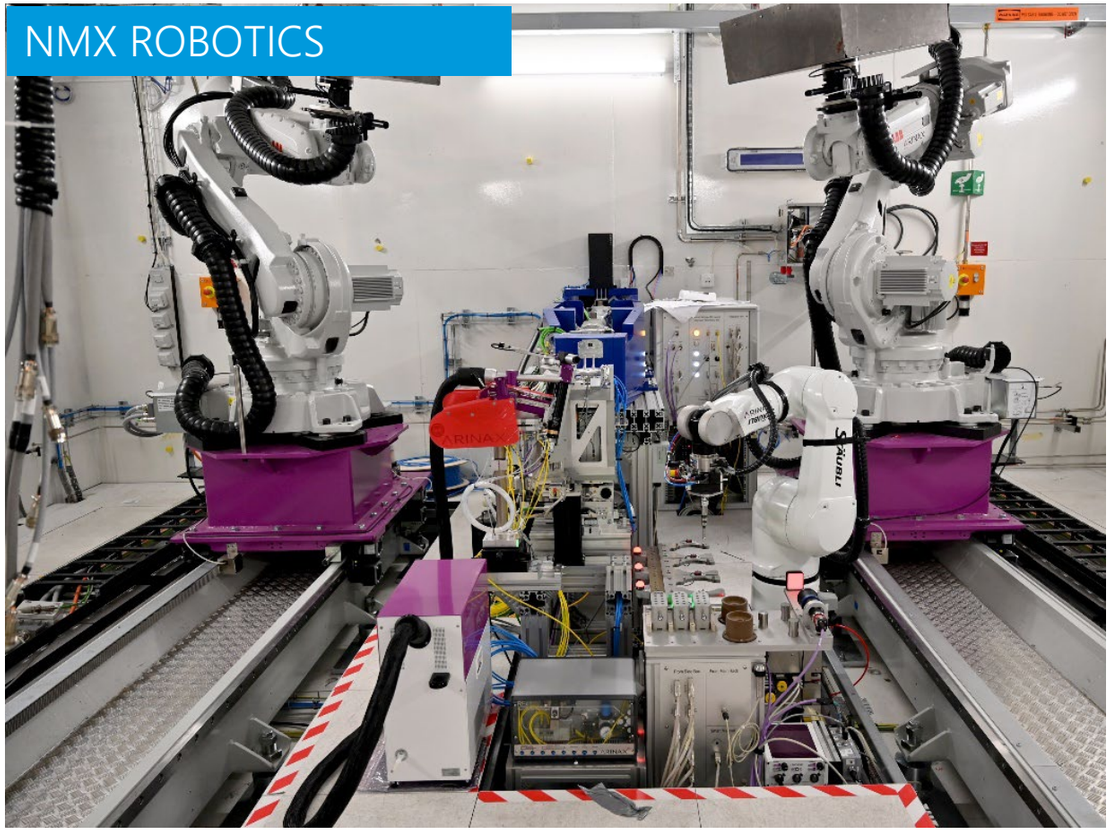
Archeology & Heritage conservation



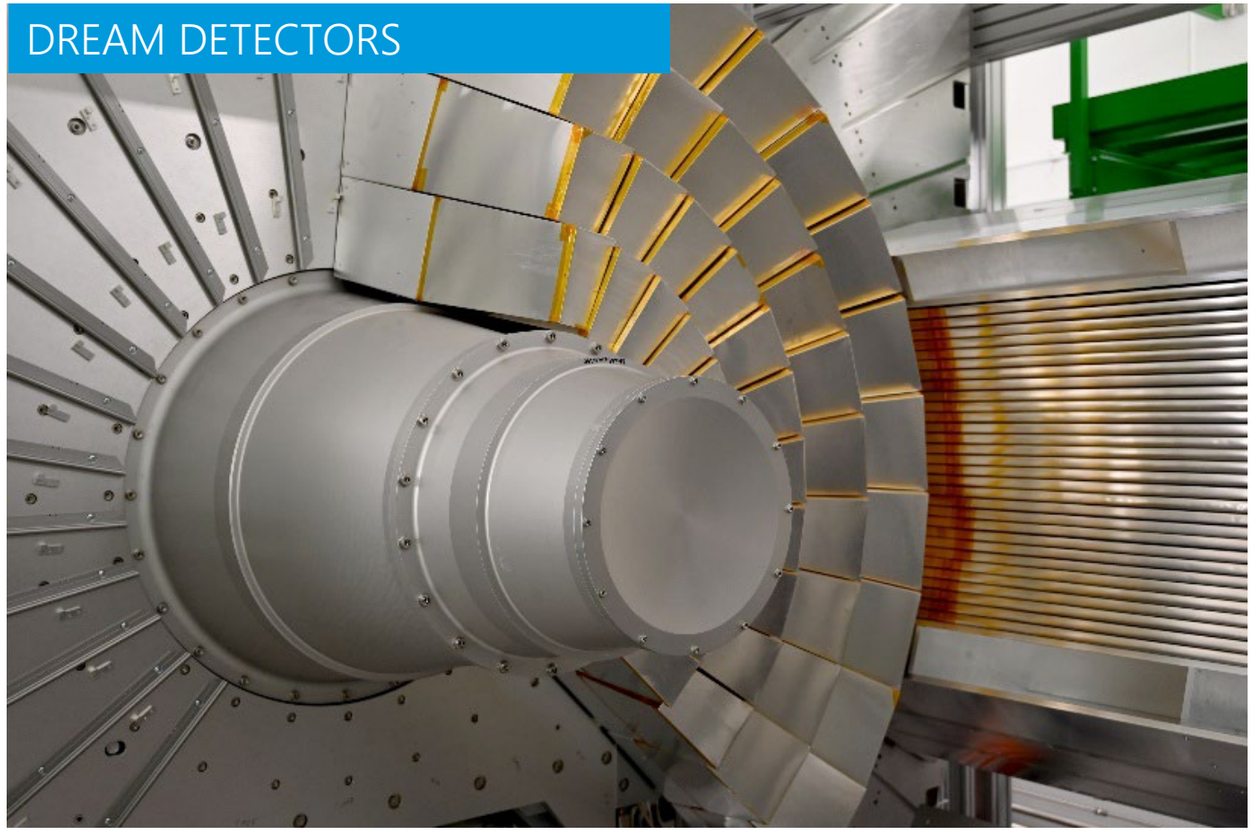
ESS Instruments

A Multi-MW Neutron Source

NMX ROBOTICS



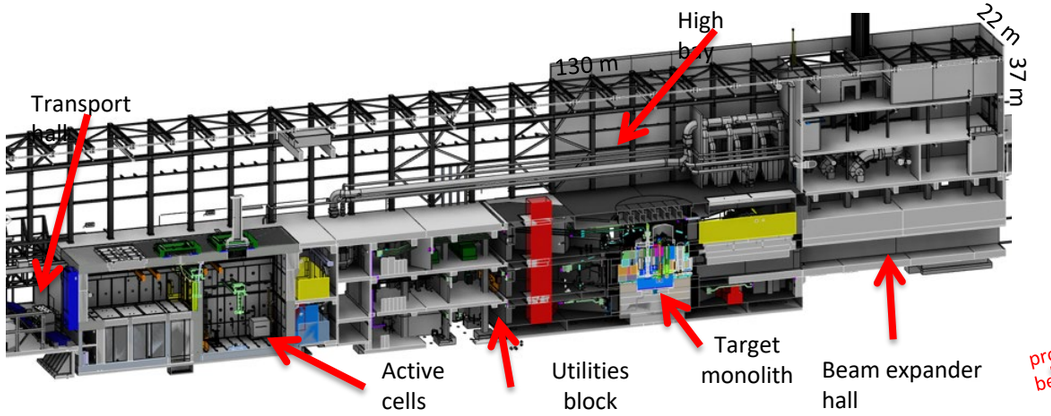
DREAM DETECTORS

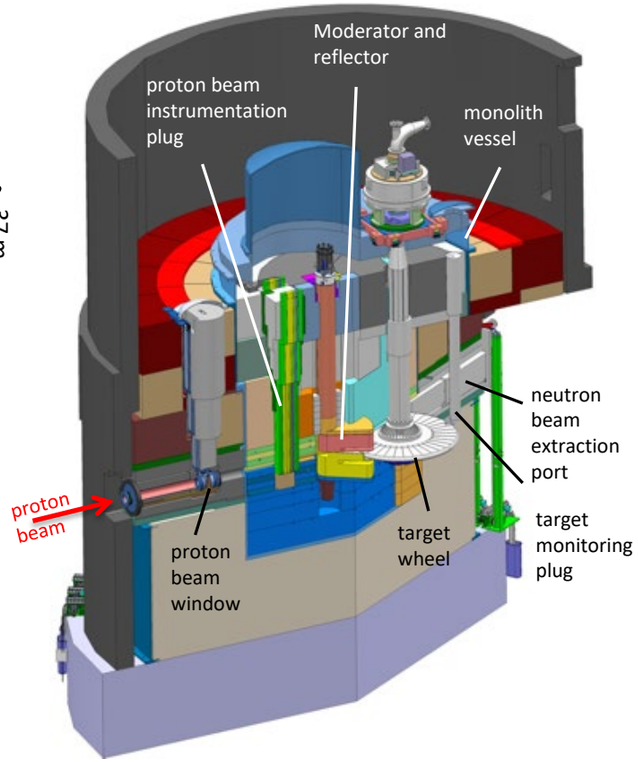


ESS Target

Rotating tungsten wheel

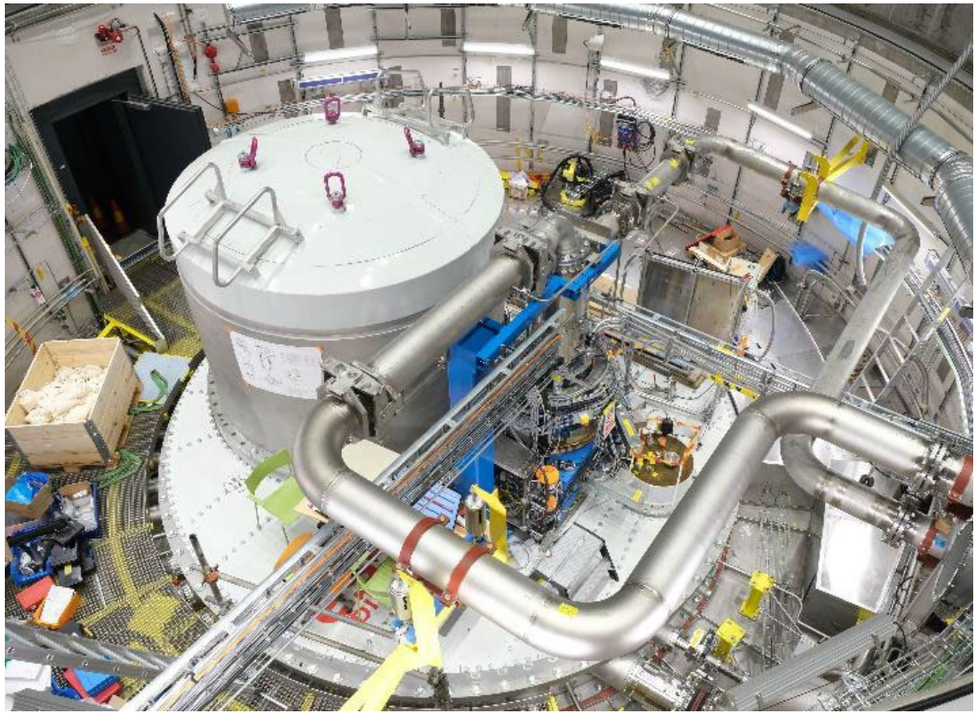
- 5 tonnes rotating tungsten target (~3T tungsten), He cooled
- Suspended by a 5m long shaft
- 36 sectors, rotates @23.3 rpm, synchronized with 14 Hz proton beam
- Expected 5 year lifetime (at 5 MW)





ESS Target

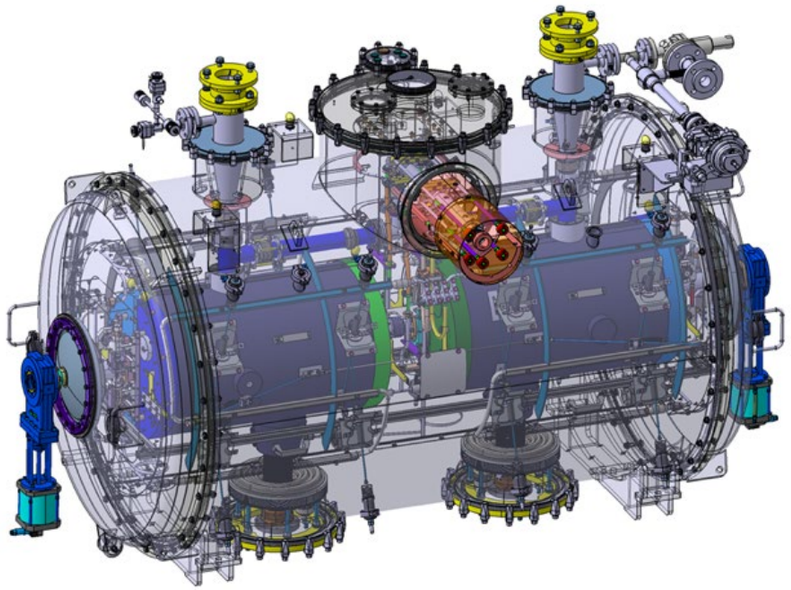
Rotating tungsten wheel

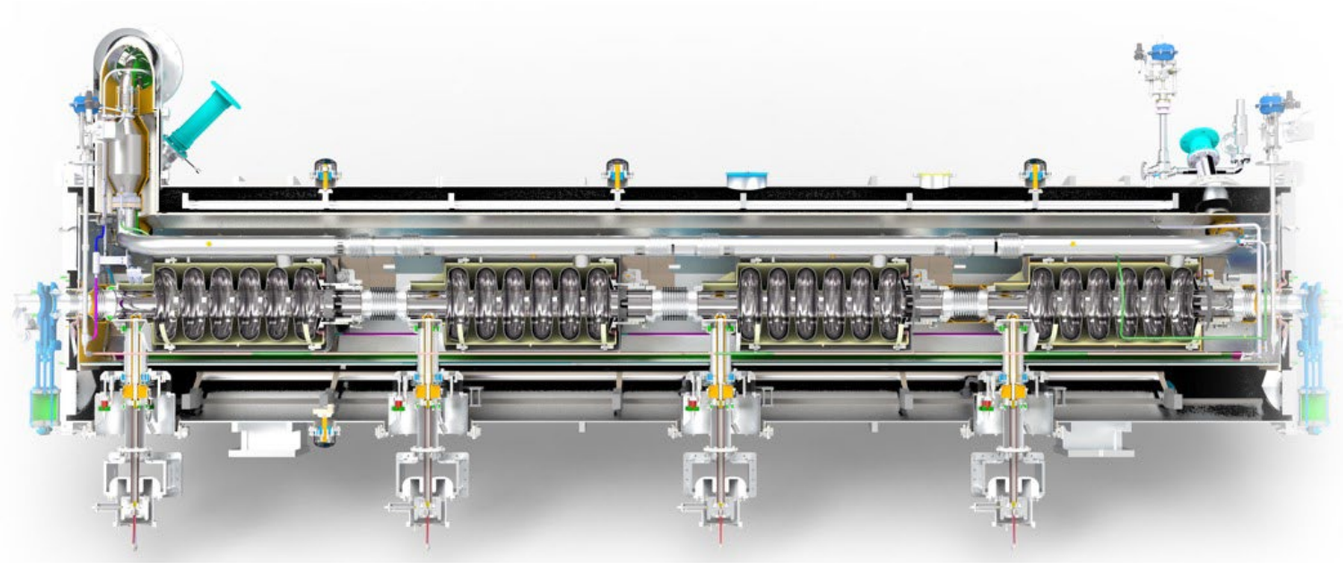




Delivering the ESS Accelerator

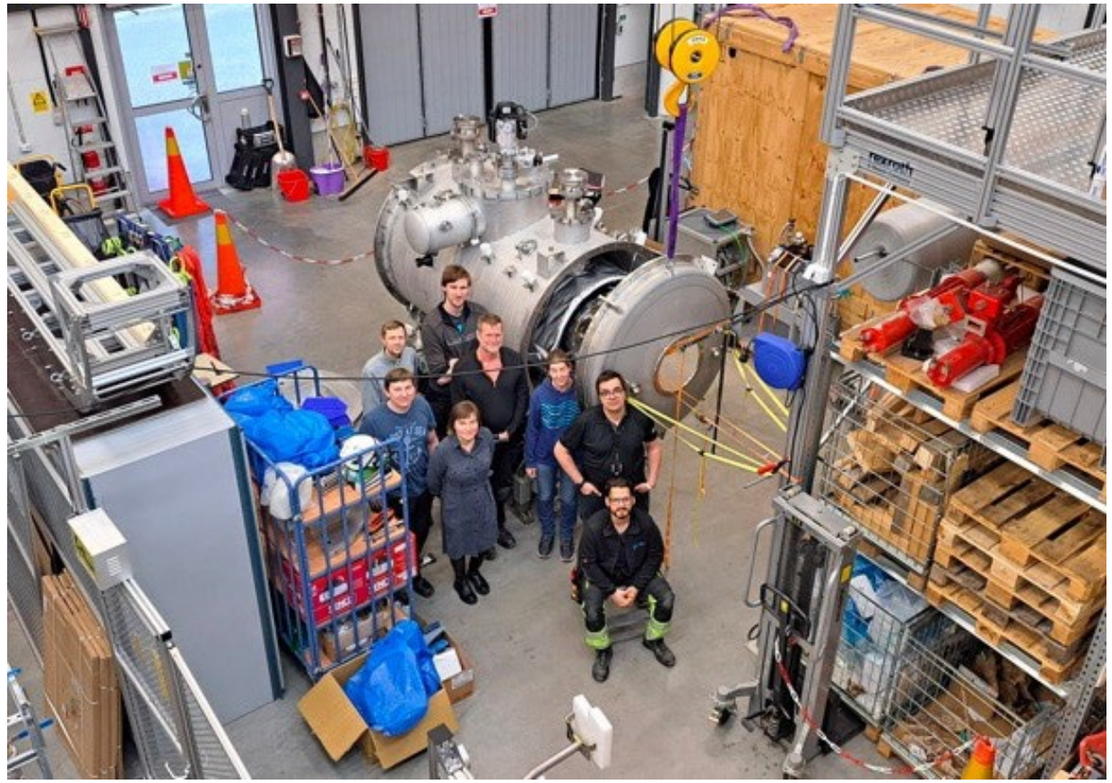
Design

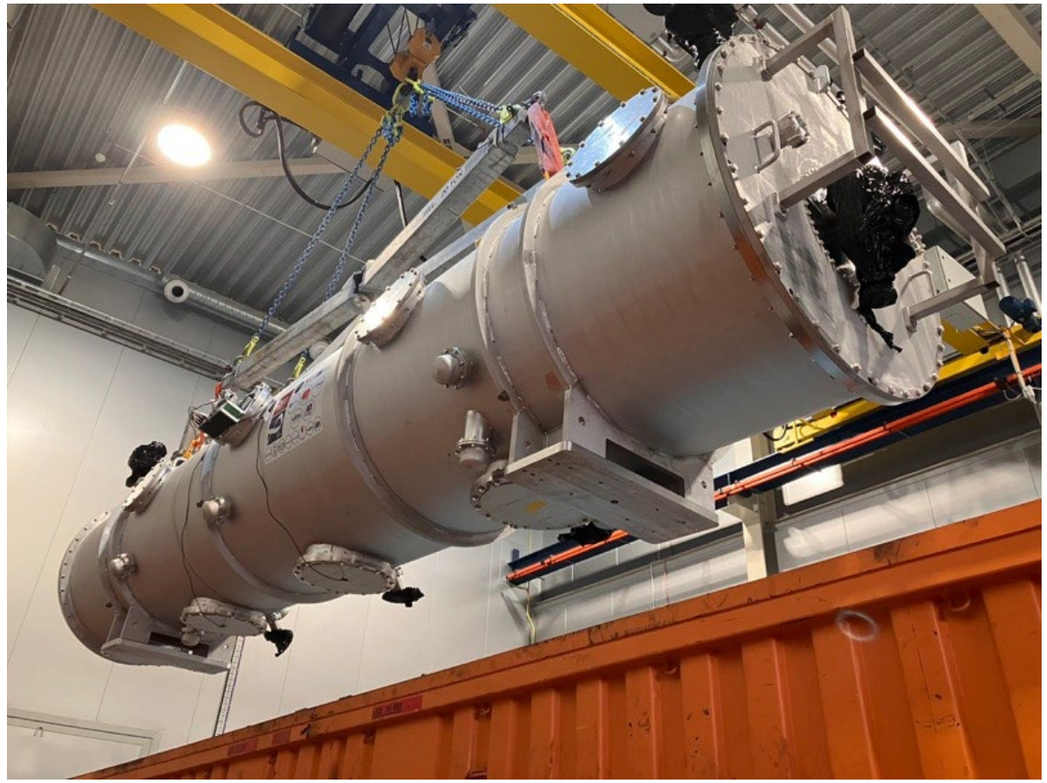




Delivering the ESS Accelerator

Manufacturing and Testing



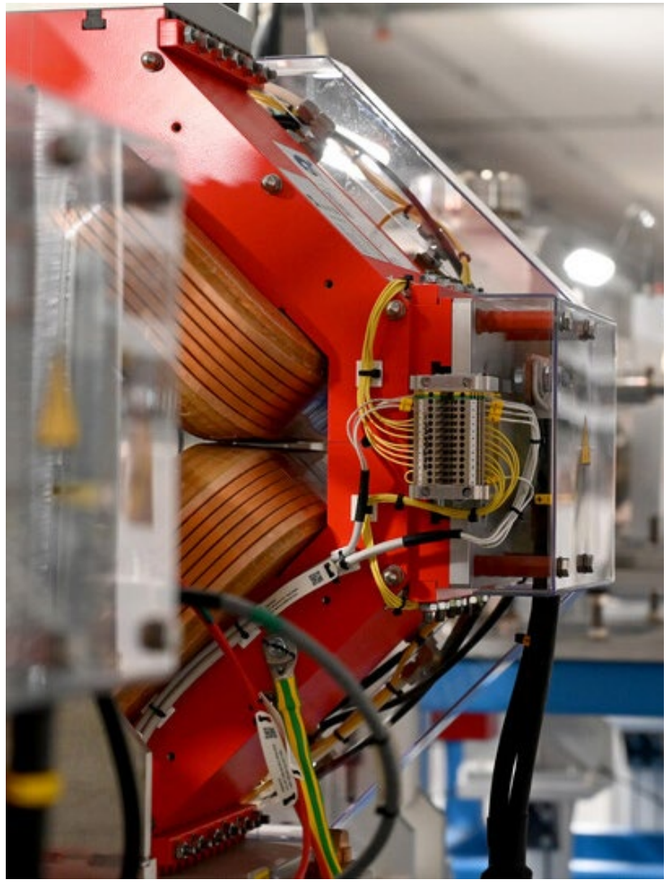


Delivering the ESS Accelerator

Installation







Delivering the ESS Accelerator

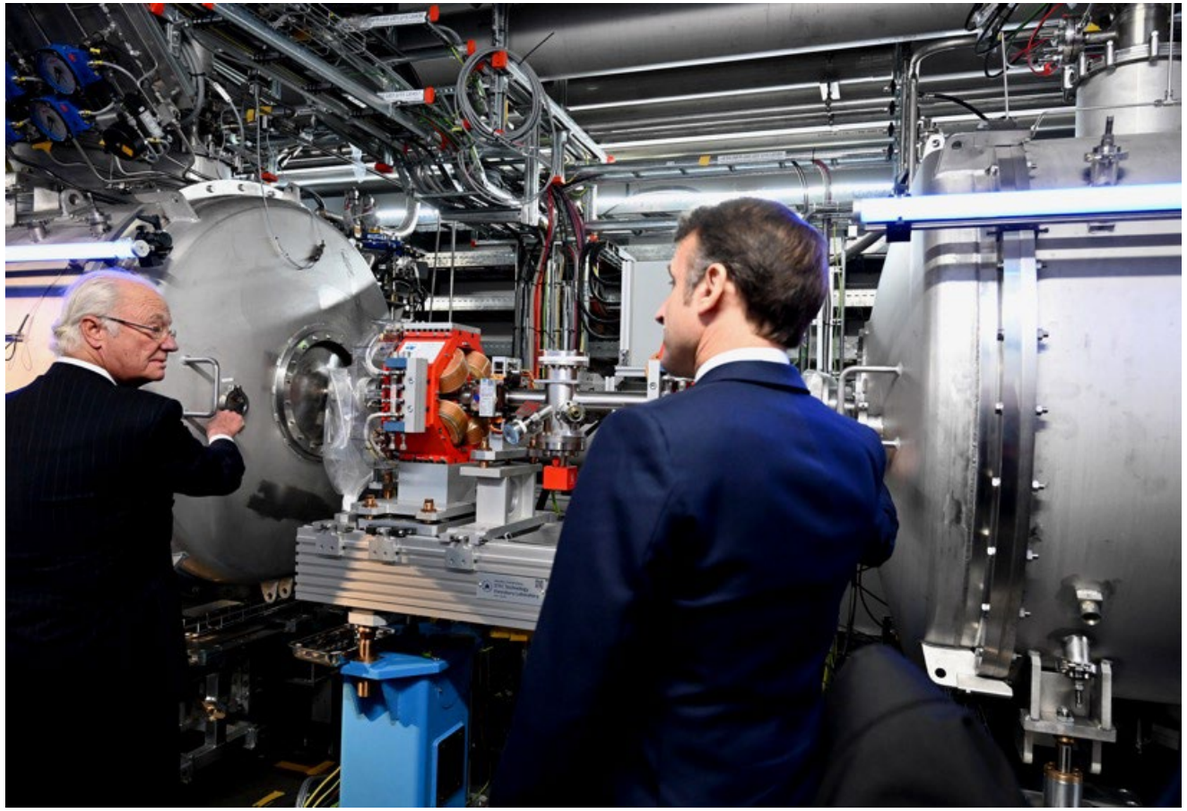
Proud Moments





Delivering the ESS Accelerator

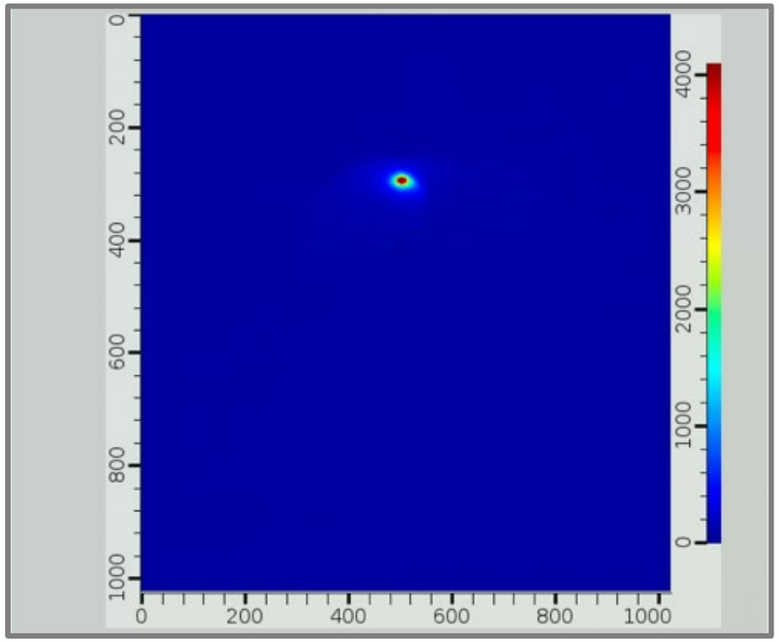
VIP Visit





The Very First Beam on Dump

2025





Accelerators and AI

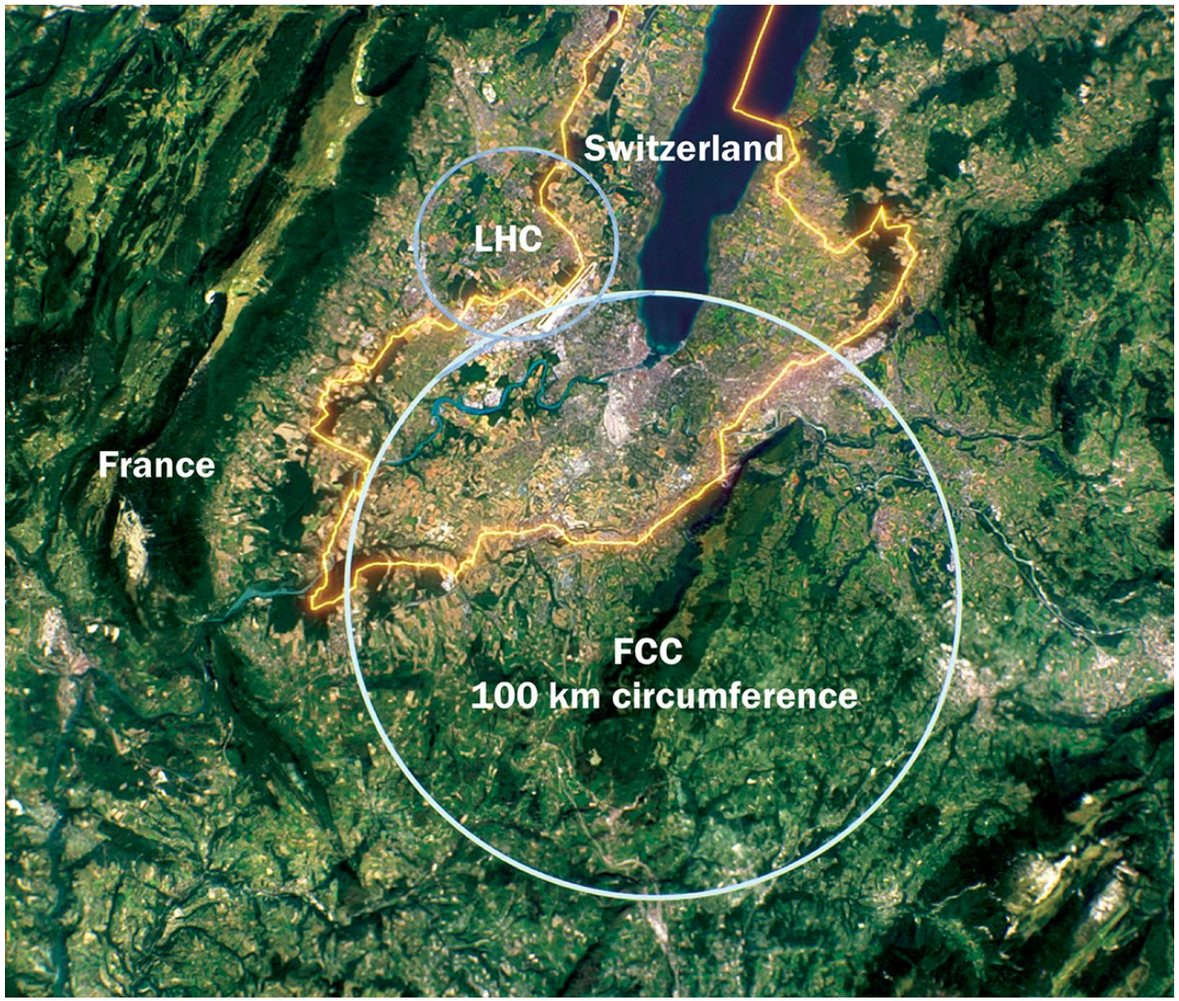
AI is reshaping the future of particle accelerators

- **Intelligent operation**
- **AI-driven design**
- **Human – AI collaboration**
- See: **V. Kain**, Designing for Intelligence: Particle Accelerators in the AI Era, FCC Week 2026, Helsinki, Finland.

- **For existing facilities**: the challenge is moving beyond conventional automation.
  - The biggest barriers are often infrastructure, data continuity and integration.
- **For future facilities**: AI needs to become a design consideration from the outset, including controls architecture, data infrastructure and human–machine interfaces.
  - Can we move from machines that we automate to machines that increasingly learn, optimise and make decisions?

Accelerators and AI

Future machines – FCC?



Accelerators and AI – Helping Deliver the ESS Vision

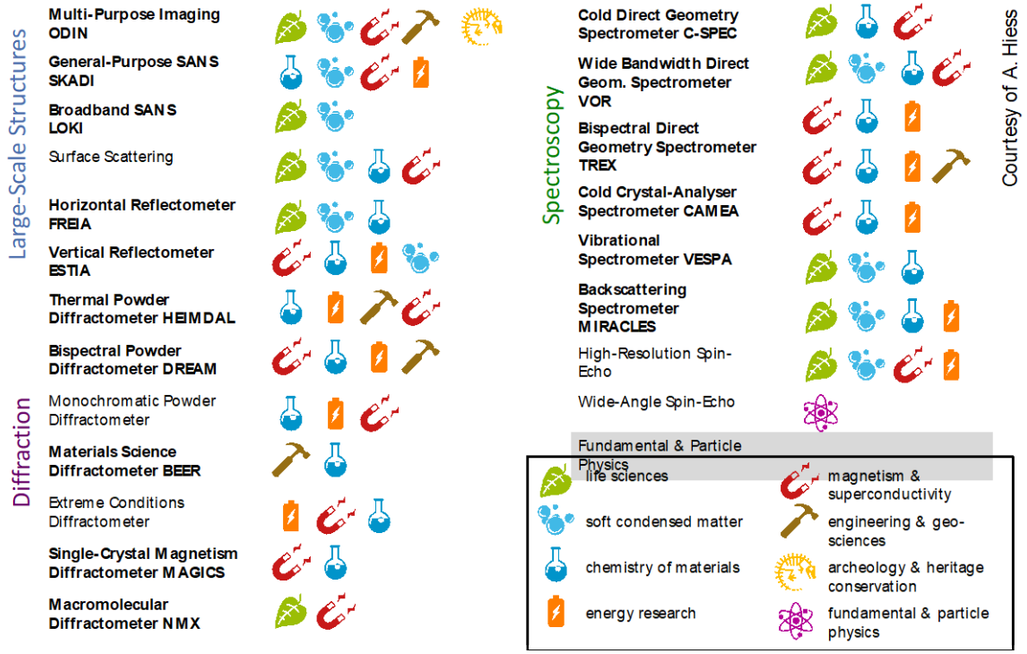
ESS will be a world-leading facility for neutron-based research



Could AI replace the need for accelerators or fundamental research?

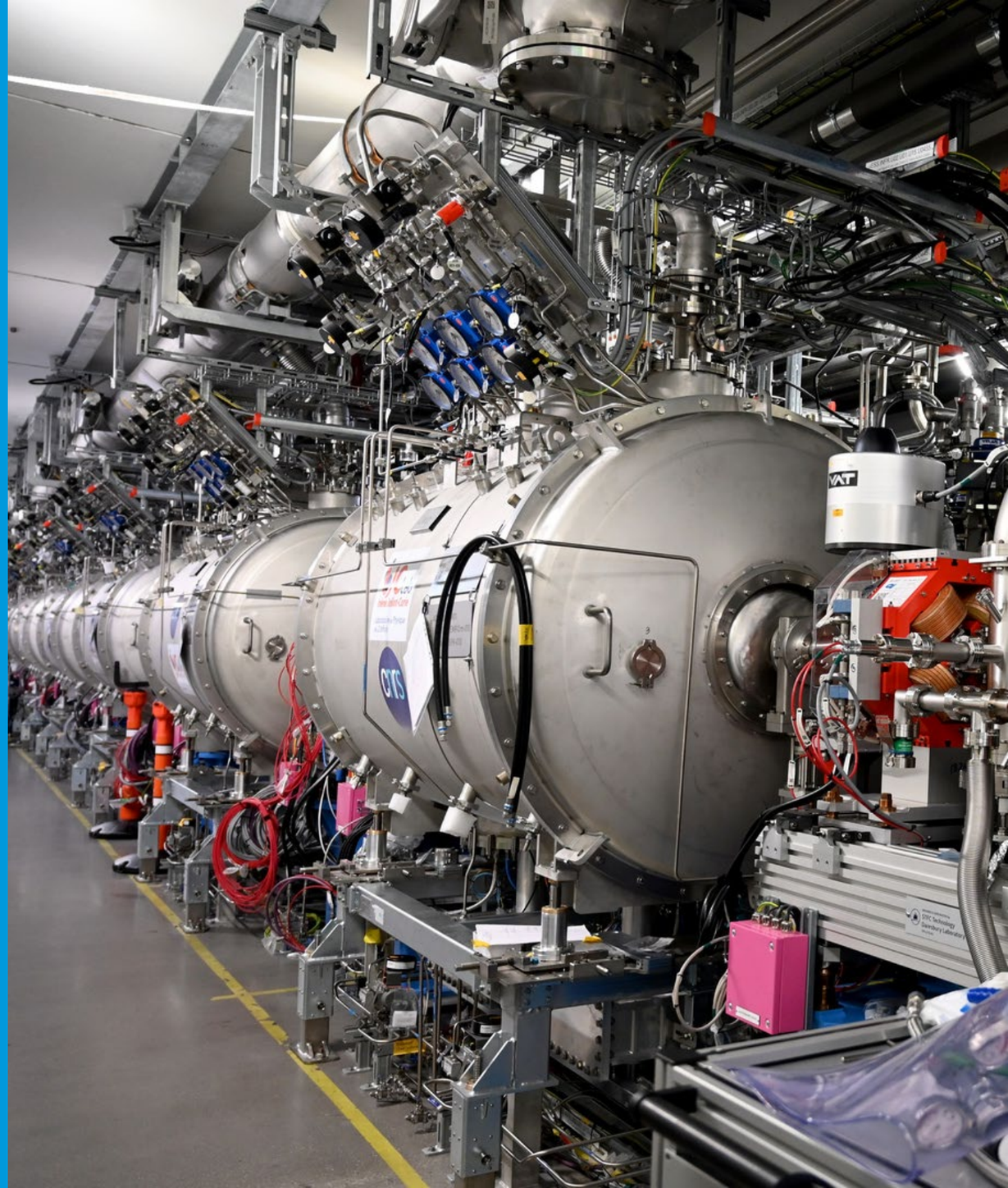
Three reasons why I think the answer is unequivocally NO:

- **AI needs experimental data.**
  - AI models are trained on observations and measurements.
- **Simulation is not discovery.**
  - A model can predict what we expect to observe, but experiments can reveal phenomena that we have not anticipated.
- **Scientific validation.**
  - Even extraordinarily accurate AI predictions need experimental validation, particularly when dealing with new physical phenomena.



The ESS Journey Continues

Next: Beam on Target




EUROPEAN
SPALLATION
SOURCE
Follow the ESS Road to Science
ess.eu
@ess.neutron
@ess-neutron
@essneutron



Getting Ready for Operations

From construction to start of operations

2009	2013	2014	2022	2025	2026	2027	2028	2030s onwards
Decision to site ESS in Lund (SE), with the Data Management & Software Centre in Copenhagen (DK)	Technical Design Report completed	Start of construction	Civil construction completed	Accelerator commissioned (Beam on Dump) Call for input to instrument roadmap, beyond the 15 currently under construction	Six instruments ready for neutrons	First neutrons – the proton beam strikes the target for the first time First science experiments Accelerator upgrade to 3MW	Start of User Programme Start of steady state operations	Upgrade accelerator to 5MW New instruments (for suite of 22) >800 experiments/year >500 publications/year