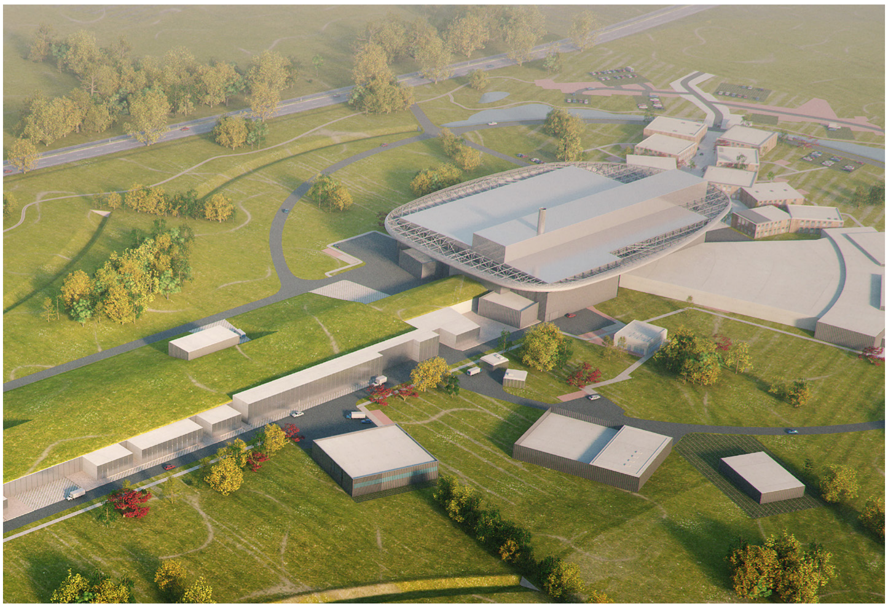
THE EUROPEAN SPALLATION SOURCE

The European Spallation Source (ESS) is one of the largest science infrastructure projects being built in Europe today. Designed to generate neutron beams for science, ESS will benefit a broad range of research, from life science to engineering materials, from heritage conservation to magnetism.



Architectural rendering of ESS. Please visit our website to read more about the design of ESS.

The facility design includes a 5 MW linear proton accelerator, a rotating tungsten target station, 22 state-of-the-art neutron instruments, a suite of laboratories, and a supercomputing data management and software centre.

The facility is being built in Lund, Sweden, next to the world-leading synchrotron light source, MAX IV, and with the Data Management & Software Centre (DMSC) located in nearby Copenhagen. It is anticipated that two to three thousand guest researchers from universities, institutes and industry will participate in the ESS user program each year, making use of the facility's broad range of neutron instruments to answer their scientific questions.

Organised as a European Research Infrastructure Consortium, or ERIC, with Member Countries throughout Europe, this next-generation research facility is being built through the collective global effort of hundreds of scientists and engineers. Together, they have developed and specified a technical design of the facility, including the Accelerator, the Target Station, and instrument concepts. This collaboration resulted in the 2013 delivery of the ESS Technical Design Report and Project Specification. The construction of ESS formally began with the Groundbreaking Ceremony on September 2, 2014.

ESS is a Greenfield project, a challenge that brings with it great potential for society as well as for science. As a facility built from the ground up in the 21st Century, ESS will be constructed and operated with high ambitions for environmental sustainability.

ESS interacts with the international research community in order to ensure that the instrument suite meets the needs of science, enabling the breakthroughs of tomorrow. Instrument concepts for ESS are being developed around Europe, making this a facility built by the scientists, for the scientists.

The ESS construction site, September 2016. Please visit our website to see more aerial photos and site updates.

Scientists, engineers, project managers, and builders are well into the construction of the most powerful neutron source in the world. ESS will provide the tools for analysis that will enable the next important discoveries in nanotechnology, life science, pharmaceuticals, materials engineering, and experimental physics. It is understood that ESS, both through the research that will be performed there and the establishment of the facility itself, will serve as an economic driver for all of Europe.

ESS will begin its user programme and welcome its first researchers in 2023. ☐

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europeanspallationsource.se

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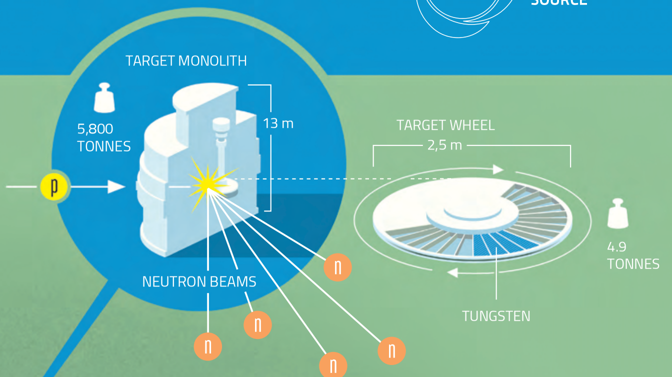
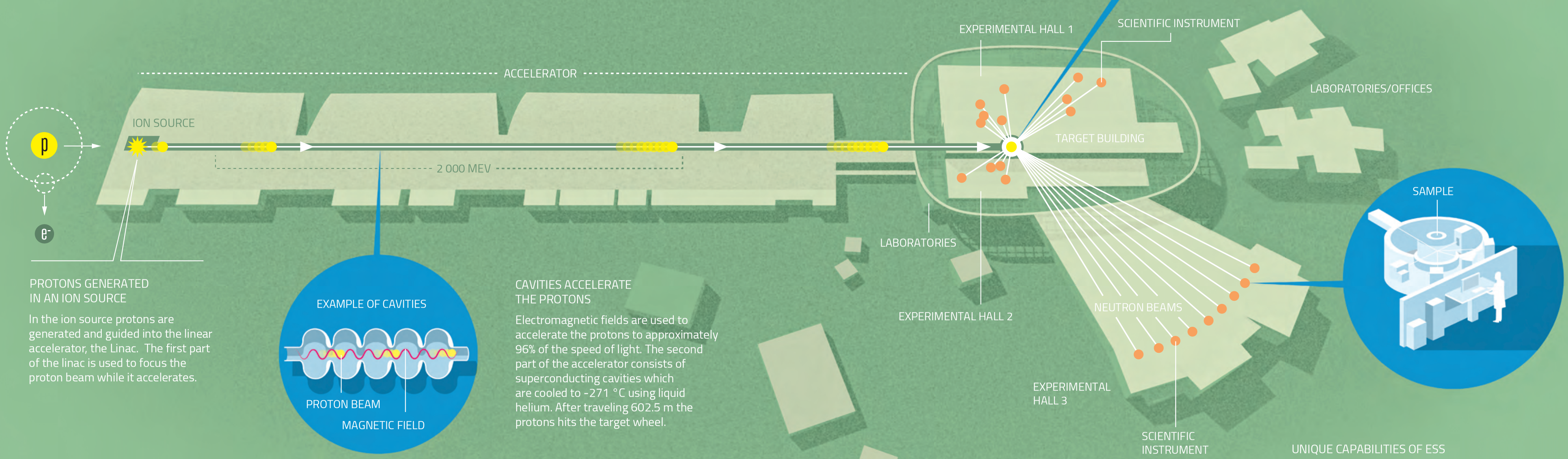
The European Spallation Source (ESS) is a multi-disciplinary research centre based on the world's most powerful neutron source. ESS will give scientists new possibilities in a broad range of research, from life science to engineering materials, from heritage conservation to magnetism. ESS is a pan-European 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.

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.

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.

ESS AND RESEARCH USING NEUTRONS

The span of research possibilities for ESS is as broad as science itself. With a neutron tool kit, we can probe the structure and dynamics of materials over a wide range of length- and time-scales.

The design and construction of ESS is driven by the research needs of the neutron science community, and it is widely anticipated that research at ESS will play a role in addressing and solving some of the grand challenges our changing society faces in the next century. Many of the emerging smart solutions are based on insights at the molecular or atomic level of matter, an area in which ESS will offer unique investigative powers.

RESEARCH AREAS USING NEUTRONS:

Energy
We are in urgent need of more renewable energy sources, more effective engines, and materials for lower heat loss, less energy spill and greener processes for industry. Neutrons are an important analytical tool that aids the understanding and development of promising novel materials for solar cells, batteries, fuel cells, thermoelectric materials for waste-heat recovery and refrigeration, and reversible hydrogen storage materials for safe usage of hydrogen as an energy carrier. ESS will deliver the information required to engineer novel, smart materials.
Applications: hydrogen fuel cells; solar power advances; better fuels and catalysts; better batteries; climate technology; waste management.

Information Technology
The IT landscape is evolving more rapidly than any other area. This brings with it challenges of energy supply for server parks and information security, and addresses significant vulnerabilities in this new digital infrastructure. Neutron scattering has a strong track record in clarifying the inner workings of data storage materials, and is a key tool for developing better ones.
Applications: stronger and lighter materials; improved use of LEDs; faster and more powerful computers; data storage.

Materials for Health and Life Science
Our ageing population brings with it a changing disease landscape, calling for better treatments of illnesses such as cancer, diabetes and Alzheimer's disease. Neutrons further our understanding of the mechanisms of disease, help us develop drug delivery systems and contribute to the formulation of drugs into effective pharmaceuticals. Neutron techniques are also used to develop potential new materials for implants and health care devices.
Applications: dramatic improvements for the study of organic molecules; more efficient medicines with fewer side effects; food technology; personal and home care products.

Magnetic and Electronic Phenomena
Neutrons reveal novel states of matter and shed light on quantum phenomena. Two strong fields of research within this domain are magnetism and superconductivity, long thought to be antagonistic properties. Interestingly, in innovative materials they are manifestations of a

new quantum superposed ground state. This reveals the dominant trend in condensed matter research towards increasing complexity, both in the materials themselves as well as the theory to explain their phenomena. Neutrons investigate electronic properties via the interaction of its spin with the electronic state of condensed matter.
Applications: wider use of superconducting materials; stronger and lighter materials; novel concepts in electronic devices; larger and more efficient data storage.

Fundamental and Particle Physics
Exploring the enigmatic antimatter and shapeshifters - the keys to the new Standard Model. For three decades, the Standard Model of particle physics has successfully provided our framework for explaining phenomena involving three of the four known forces of nature. However, there are many reasons to believe that the Standard Model is not the complete theory. Besides the energy frontier, there exists another frontier in the search for what is called the new Standard Model: the high precision, high sensitivity frontier. The pattern of deviations (or their absence) that emerges from precision experiments is like a set of footprints of new forces. The higher intensity and the pulse structure of ESS provide new possibilities for fundamental neutron physics experiments, and it will be possible to investigate a wide range of fundamental phenomena with superior sensitivity to previous experiments.
Applications: human knowledge and understanding.

Cultural Heritage
Non-invasive and precise, neutrons enable gentle studies of precious objects, such as fossils, artwork and artefacts. The study of complex devices and processes for industry, simultaneous diffraction/SANS/imaging studies linking macroscopic and microscopic structures and features are invaluable for sensitive samples of historical and cultural value, as well as their analysis and understanding of their origin and as such constitute a unique potential at ESS. Neutrons can penetrate through coatings and layers of corrosion, and there is generally very little need for cleaning or sample preparation.
Applications: human knowledge and understanding; cultural preservation and restoration.

Engineering Materials
Neutrons see through metal. Machine forensics and material quality control let us fly safely. The penetration ability of neutrons is of prominent importance. It allows scientists to investigate non-destructively the properties of bulk materials, complex assemblies such as multi-component devices, and to investigate inner structure and processes with high precision and sensitivity. Not only can various aspects of structures deep inside a bulk component be investigated locally, as in the case of engineering materials, but the penetration capabilities also allow the study of materials in complex sample environments in order to achieve extreme conditions under which materials, components and devices work, are operating or processed.
Applications: Industrial R&D; construction materials; aerospace engineering; geo-materials in earth sciences; alloy development; thermo-mechanical treatments.

<u>THE UNIQUE CAPABILITIES OF ESS:</u>