The African Review of Physics (2018) **13**: 0013

Proceedings of the first African Conference on Fundamental Physics and Applications 2018, Namibia. Guest Editors: K. A. Assamagan, M. Backes, D. Charlton, S. Muanza , D. Sahu, and D. Singh

The European Spallation Source as a new tools for discovery: ESS Construction Well Underway

Christine Darve and Laura Hrastar/ESS Communication
European Spallation Source ERIC, Lund, Sweden

The European Spallation Source (ESS) is a pan-European project composed of 15 European nations (members and observers), constructing together a neutron-scattering facility in Sweden, one of the largest science and technology infrastructure projects being built today. The ESS was designated a European Research Infrastructure Consortium, or ERIC, by the European Commission in August of 2015. Scientists and engineers from 50 different countries are members of the workforce in Lund, who participate in the design and construction of the European Spallation Source. This unique facility will enable new opportunities for researchers across the spectrum of scientific discovery, including materials and life sciences, energy, environmental technology, cultural heritage and fundamental physics, and answer the scientific questions of tomorrow.

1. Introduction

The ESS project broke ground for civil construction in the autumn of 2014 just north of Lund, Sweden. From early works with excavation and concrete reinforcement, the location has transformed into a buzzing construction site with 15 of 23 buildings already being built, and some almost complete, as can be seen in Figure 1 [1].

Since the start of construction ESS has rapidly developed technically, organizationally, and in its governance. The project has strengthened its base of international partners on the way to becoming the world's leading neutron user facility.

The pace of activity on the ESS project continues to ramp-up. Several important technical milestones were achieved this spring. Among them was the structural completion of the 537-meter-long accelerator tunnel, which extends from the front-end building containing the ion source, to the target station, where neutrons will be released from the source beam. The first hardware was also installed in the tunnel.

The ESS Accelerator project team plans partial access to the tunnel to begin installations for the linear proton accelerator, or linac, later this year. As of May 2018, the 'earned value', a metric the project uses for measuring progress, shows ESS is already 47% complete.

Figure 1. Aerial over ESS Target area and Campus area, 13 June 2018. © Roger Eriksson

2. Collaboration is the Key to Success

The ESS organization has over 434 staff members representing 50 nationalities employed today in Lund. Much of the technical work will be done by experts at currently 40 partner institutions around Europe. Those partners will deliver components and systems for the ESS Accelerator System, Target System, Integrated Control Systems (ICS), and Neutron Scattering Systems (NSS), which include scientific instruments.

That extensive collaboration is key for ESS. The strategy enables the project to tap into the Europe's collective knowledge and have many teams working in parallel.

The ESS construction budget is based on a 2013 cost estimate of €1.843 billion. That cost is shared by the ESS Member countries, including approximately €685 million of non-cash In-Kind Contributions (IKC). In-Kind Contributions include development and procurement of components or services. They may also be technical support, testing, and installation. There is also the possibility for personnel to be seconded to ESS.

The UK's ISIS neutron facility was the first In-Kind partner to sign a Memorandum of Understanding (MoU) to build ESS instruments LoKI and FREIA.

In the fall of 2016, partners have been identified to deliver nearly €550 million of the IKC scope. This figure will continue to rise and new countries are expected to come on board in coming months. The Conventional Facilities and staff and administration are being paid with cash contributions. The project hosts, Sweden and Denmark, are contributing in cash to the project.

3. A World-Class Instrument Suite

The selection of the ESS suite of instruments has seen notable progress. Through a rigorous, peer-review process involving evaluations by the ESS Scientific Advisory Committee (SAC), a 22-member external expert advisory group, and the ESS Science Directorate's Scientific and Technical Advisory Panels (STAPs), ESS selected the first 16 instruments. The process included a series of three proposal rounds from 2012–2015 during which instrument concepts were

submitted for consideration by experts in neutron instrumentation and scientific users from around the world. The decision was based in part upon the instruments' scientific merits and relevance for the European scientific community. Figure 2 shows the planned instrument layout.

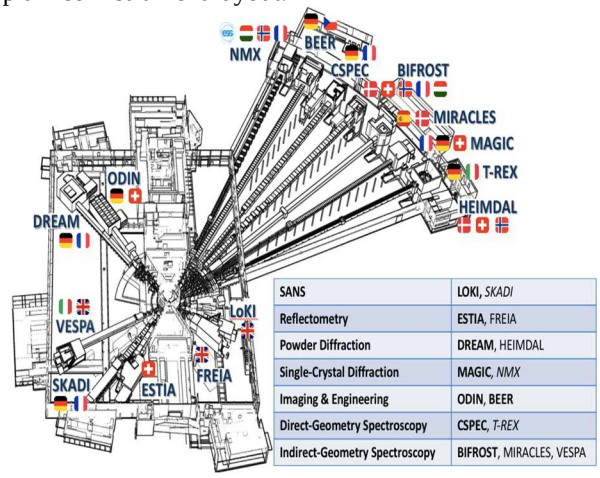

Figure 2. Planned ESS instrument layout.

The instruments are grouped according to technique: macromolecular crystallography, small-angle neutron scattering (SANS), reflectometry, imaging, spectroscopy, and diffraction, as well as for the study of fundamental physics. The NSS construction project aims to launch the ESS User programme in 2023. Beyond the Construction phase, a future selection process will take place for additional instruments to form a full 22-instrument suite at ESS.

To ensure optimal shielding and instrument performance, the design of a common shielding bunker is ongoing, with installation expected for 2019. Planning activities also continue for sample environment equipment and scientific support laboratories in parallel with the instrument construction.

The Data Management Software Centre (DMSC), a key part of the ESS Science Directorate located in Denmark, has also begun ramp-up activities in conjunction with the planned construction of neutron instruments. These include software development, staffing, and a move this spring to permanent premises in COBIS (Copenhagen Bio Science Park) near Copenhagen University. The DMSC will deliver the critical scientific computing services for instrument users to run experiments with neutrons in Lund.

4. Building the Next Generation Neutron Source

The ESS project teams and partners are putting in place a comprehensive integration schedule to provide more detail to manage interfaces and potential bottlenecks project-wide. The schedule incorporates more than 300 milestones that interlink over 3000 milestones in the major sub-projects of ESS.

The project's critical path dictates a workflow focused on construction of the accelerator tunnel, followed by the target area and through to the experimental halls, beamline gallery—which will house the instruments—and adjoining scientific support laboratories.

An important investment ESS has made over the last few years is research into Multi-Beam Inductive Output Tubes (MB-IOT), a type of power-efficient Radio Frequency (RF) source for the linac. The MB-IOTs are projected to deliver typical power savings of 2 to 3 MW of the 19 MW of power required to drive the accelerator. Following scheduled completion of prototype development in 2016, ESS has tested the designs in collaboration with CERN. Together with Lund University, ESS is also optimizing the design of so-called modulators, the power generators of the amplifying RF sources.

In 2015, ESS completed a baseline design for a new flat disc moderator, the ‘butterfly’ moderator, named for the innovative shape of its component canisters. The moderator is part of development work in the target station to optimize the brightness of the neutron source.

The long-pulse source of ESS is anticipated to be brighter and more intense than any existing neutron facility today. The linac will generate a proton beam energy up to 2.0 GeV, with a 5 MW average beam power and 125 MW of peak power. The beam will be delivered in 2.86 millisecond pulses with a repetition rate of 14 Hz. Each pulse will impact the solid, rotating tungsten disc known as the target, and release neutrons for use by the instruments. ESS plans to produce the first neutrons in 2019.

5. New Dimension as European Research Infrastructure Consortium

In addition to technical and concrete progress on construction, ESS is also evolving as an institution. In August 2015, ESS was established as a European Research Infrastructure Consortium (ERIC), an international research institution under the legal framework of the European Commission. A ceremony was held to mark the milestone with attendees including the European Commission's Director-General for Research and Innovation Robert-Jan Smits, as well as the Swedish and Danish Research Ministers. Representatives from the 15 Member countries of ESS also attended.

The new legal structure was followed by a new governance structure, led by the European Spallation Source ERIC Council, see Figure 3. The Council is represented by the Member states. Along with the ESS Director General, these are the leading bodies empowered to steer and finance the project. The ERIC Council is comprised of representatives from 11 Founding Member countries, and currently, 4 Founding Observer countries. Before the ERIC was founded, the legal vehicle for the project was ESS AB, a Swedish

state-owned company with Swedish and Danish shareholders.

Figure 3. Founding members of the European Spallation Source ERIC and European Commission's Director-General for Research and Innovation, Robert-Jan Smits, at the ERIC plate ceremony in September 2015. © Roger Eriksson, ESS.

6. Forging Ahead

The European Spallation Source ERIC gains new leadership in 2016 with the appointment of John Womersley as the Director General of ESS. Through the year, ESS will focus on component installations in the accelerator, optimizing the target schedule, and development and integration of the build plan for the initial ESS suite of instruments. An up-to-date NSS instrument construction schedule and the ESS project integration schedule as well as other project-critical matters will be presented to the ERIC Council for review in December.

An important step ESS recently completed was the submission of an application to the Swedish Radiation Safety Authority SSM for the installation of equipment which can generate ionizing radiation in the research facility. This is the second application of four in the licensing process, which ESS must obtain in order to begin operations.

The ESS project gained further recognition and resources in September 2016 with approval for the BrightnESS grant valued at €20 million under the European Union's Horizon 2020 Research and Innovation programme. The BrightnESS project runs over 36 months, and involves 18 European institutes and universities from 11 countries with the Institut Laue-Langevin (ILL), CERN, Lund University, and Copenhagen University among them. BrightnESS is designed to meet the key challenges to build an ESS that can deliver high-impact scientific and technological knowledge. It funds a European network of field coordinators as well as software that support the management of ESS' IKCs. The software displays progress and calculates the IKC accreditations to Member countries. ESS is also one of 17 partner institutions to receive the European Commission's SINE2020 grant. The grant aims to develop the innovation potential of neutron scattering at large-scale facilities, and foster industry collaboration. It is funded through Horizon 2020.

The ESS project continues at a swift pace and will wholly be realized as a collaborative effort—built in the spirit of cooperation, inclusiveness and transparency by all ESS partners and collaborators for the European scientific community.

References

[1] Laura Hrastar (2016), “ESS Construction Well Underway”, Neutron News, 27:4, 17-20, DOI: 10.1080/10448632.2016.1233013

Received: 11 October, 2018

Accepted: 20 October, 2018