2022 Activity Report

1 January – 31 December

Corporate Identity No. 768200-0018
European Spallation Source ERIC

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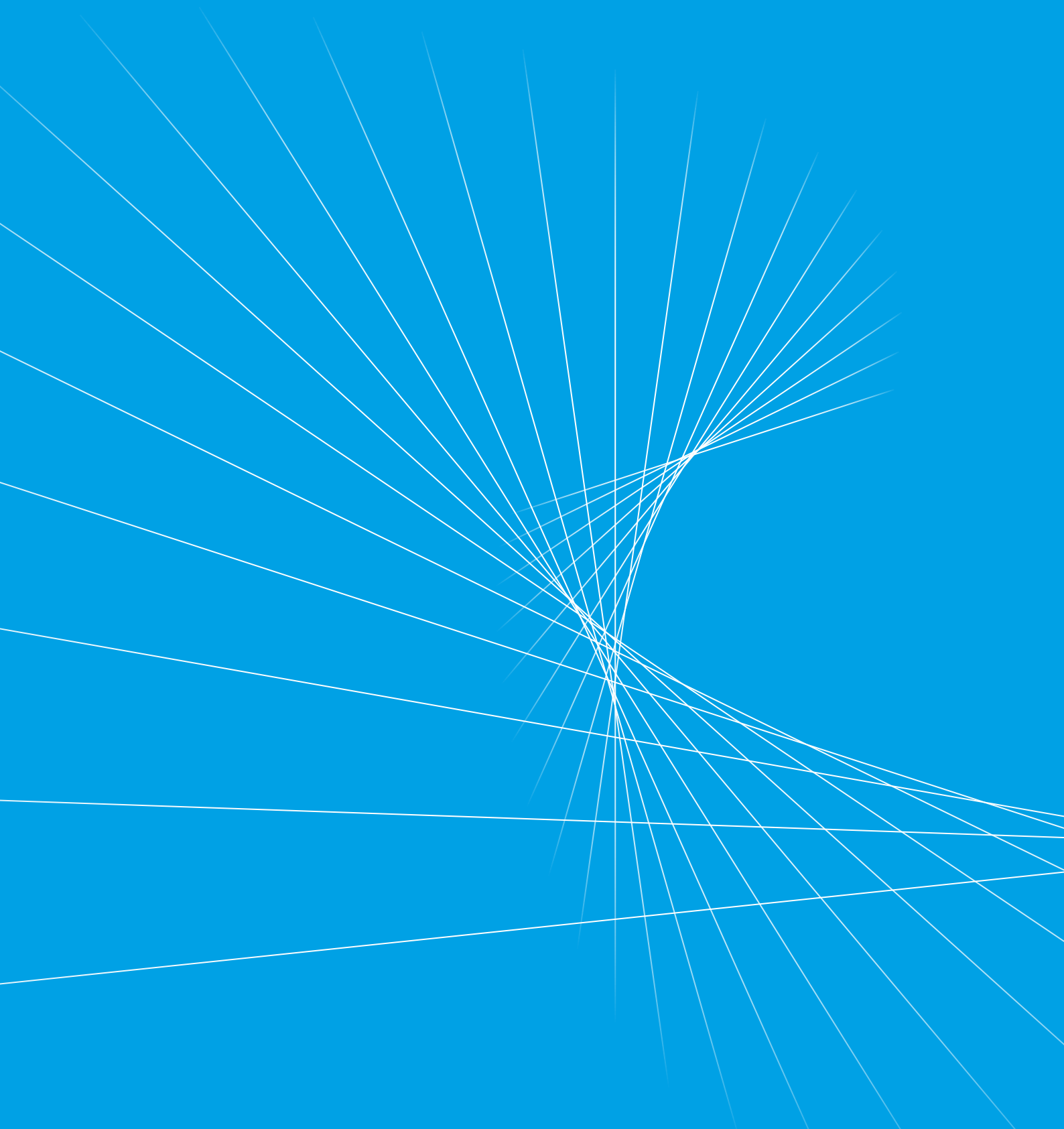

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Pushing hard for the finish line

From the Director General

If the events of recent years have taught us anything, it is that interruptions in global supply and manufacturing chains aren't going away, even as we move into a post-pandemic era. In this context, there is a strong case for rebuilding and reinventing Europe's industrial base if we are to remain competitive and sustainable. Where outsourcing was previously the order of the day, we now need a model that makes European industry less dependent on outside factors, and thereby capable of defending both our environment and our democratic values.

Many believe this new paradigm should be built on resilience, regionalisation, and emerging technologies in the areas of smart manufacturing and mobility, digital health and renewable energy sources in combination with new battery technologies. As it happens, these are all areas where ESS will play a pivotal role as part of the ecosystem of European research infrastructures, by providing a world-class facility to bring academic and industrial research together. If we are to keep up with our global peers, the time to act is now. And I can assure you that everyone at ESS, in cooperation with our academic and commercial partners, is actively pushing to make that happen.

Therefore, I am happy to report that we have achieved significant progress towards our firm commitment to start the user programme by the end of 2027. During 2022, we implemented our new baseline plan, and I want to take the opportunity to thank all of the countries that stand with us and who have worked hard to secure the budget necessary for financing the two-year extension of the project. Concurrently, we have launched a performance enhancement programme to make sure that we are working as efficiently as possible. We have also undertaken a major reorganisation during the year, preparing and planning for the transition from the construction to the operational phase, which steadily approaches.

Rounding up 2022, we took delivery and started the installation of our first set of instruments. Perhaps even more encouraging is that we also reached major technical milestones. For the first time, we fed the beam from the ion source into the radio frequency quadrupole, and later into the first drift tube – the first accelerating structures in ESS's linear proton accelerator. And as we approached the end of the year, we successfully completed the cooldown of the cryogenic distribution system in the accelerator tunnel, which is critical to maintain the schedule for the main milestone for the accelerator sub-project "RBOT" (Ready for Beam on Target).

CLICK TO START VIDEO

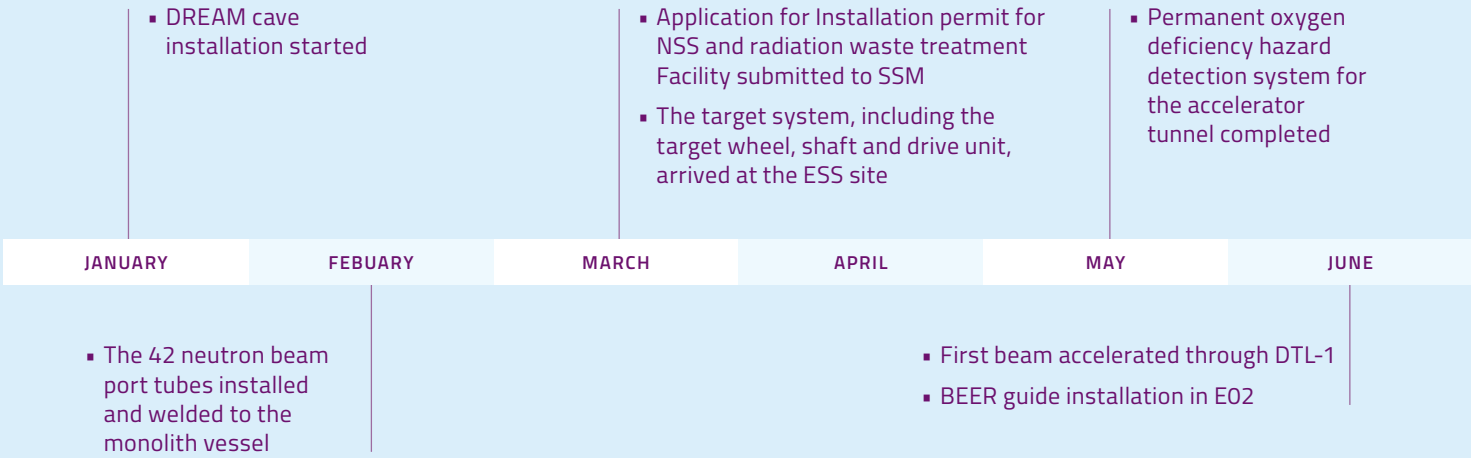
This is not to say that the past year did not bring setbacks. This has always been, and continues to be, an extremely complex and highly technical project. The hurdles we encountered mainly stemmed from quality issues with the equipment delivered to ESS. Surprisingly, many of the problems were related to what might be referred to as "classical industrial manufacturing", rather than to the fact that much of the equipment installed at ESS is bespoke and at the very cutting edge of high technology. While I, of course, would have preferred to have had no quality issues, I see it as a testament to the competence of ESS's staff that the issues were identified at an early stage instead of slipping through the net to cause problems later on, when they would have been much harder to rectify.

While these setbacks resulted in a significant erosion of the schedule contingency, immediate corrective actions, undertaken in close collaboration with our partners, secured adherence to the plan to start the scientific programme at the end of 2027. In this context, our constant attention with regard to tracking and analysing project performance metrics shows its full worth, enabling highly accurate predictions of cost and schedule evolution.

Our mission is, and will always be, to serve Europe's outstanding research community. So, it brings me great pleasure that the interest and support from our stakeholders remain high. During the past year, we enjoyed visits from ministers, ambassadors, media, and representatives from European academia and industry. Our joint ESS/ILL User Meeting in Lund attracted more than 300 neutron researchers from all parts of the continent.

On a final note, I believe I speak for all of us who are involved in this unique undertaking, both here at ESS and at our partner institutions, when I say that 2022 turned out to be not only a little more of a struggle than anticipated, but also a highly successful year. With the pandemic and its supply chain interruptions behind us – and equipped with a realistic plan that we work towards methodically and monitor scrupulously – we are firmly on track and as committed as ever to bring this project home in time to provide Europe with real opportunities for the future. In the meantime, we maintain our focus on the completion of the facility, and on accelerating progress on our Road to Science.

HELMUT SCHOBER
ESS DIRECTOR GENERAL



Selected Milestones/Achievements **2022**

JULY

- ESTIA selene guides arrival and pre-installation in D01

AUGUST

- The moderator/ reflector plug delivered to the ESS site

SEPTEMBER

- Installation permit for NSS and RWTF received from SSM
- Joint ILL/ESS User meeting

OCTOBER

- Cryogenic distribution system cooldown
- Completed DTL-2, DTL-3 and DTL-4 installation
- 10/13 spoke cryomodules and 7/9 Elliptical cryomodules needed for RBOT ready for installation at ESS
- Fast beam interlock system (FBIS) ready for beam on DTL-4 tuning-beam dump
- "Second level" control system for CDS ready
- All medium beta linac radio frequency systems (36/36) and 20/26 spoke radio frequency power stations installed

NOVEMBER

- Controls network for first instruments installed and integrated testing completed

DECEMBER

A strong link is necessary for good collaboration

Tom Erixon, CEO of Alfa Laval, believes that ESS can be a huge lift, both for the Öresund region and the Scandinavian industry, but he raises a finger of warning. ESS needs to reach out to industrial users early and clearly define its scope of services. The industry is much more long-term than academia thinks, often planning their research from a five-year perspective, so the connections must be made well ahead.

With sustainability on everybody's lips and innovation cycles accelerating, there's much pressure on industrial R&D departments. We are rapidly rebuilding the way the world functions, and not least the way the energy systems work. That means we need more advanced research methods and analytical capabilities. We can't do the same amount of trial-and-error testing as before. We need to get it right quicker. This is where facilities such as ESS can make a difference.

Fast-tracking material science

"The fact that the world is now phasing out oil and gas means huge opportunities for Alfa Laval," says Tom Erixon. "Practically all the trends we see are, in one way or another, connected to heat transfer, separation technology, and flow management - three areas where we have a powerful presence and know-how. But to unlock new possibilities for product development, we need breakthroughs in materials technology."

"We are already using MAX IV to gain insights on some of our materials' surface properties," says Tom Erixon. "This happens to be one of our biggest R&D projects ever, and it will help us to improve materials, develop new product designs, and establish a new manufacturing process."

A boost for the region

Alfa Laval is currently not cooperating with any neutron facilities, but it may be an excellent way to go in the future. Tom Erixon believes that ESS will be a massive lift for the Öresund region, the Swedish industry, and hopefully Europe and the rest of the world.

"We already have a big university in Lund, and soon we will have two of the most advanced research facilities in the same location," says Tom Erixon. "On top of that, we have a strong industrial cluster on both the Swedish and the Danish side. That creates a stimulating environment for science and will, without a doubt, attract much talent. As for the industry, it is partly up to us to find a way to take advantage of ESS. But I think that the biggest task lies with ESS themselves."

Start setting the stage early

"Most large-scale research facilities tend to focus mainly on building their technical and scientific capabilities," says Tom Erixon. "They invest billions into developing new instruments and almost nothing into showcasing their offer. You see, nobody in the industry is sitting and waiting for ESS to start accelerating neutrons. We are doing quite well with our current research tools and existing scientific partners. ESS needs to reach out early and start interacting with the industrial sector. Our experience with the large research infrastructures in Europe, including MAX IV, is that they have all suffered from the fact that their link to the industry is too weak."

"I think the question is not about how the industry should prepare for the launch of ESS," says Tom Erixon. "We are not randomly running accelerator tests; we are running specific development programmes where the analytical methods are specified years in advance. The industry is much more long-term than academia thinks, and we are often doing things from a 5-year perspective, so we need to start making connections well ahead."

Take the time to build trust

A significant part of the EU's economic growth derives from research and innovation, which are at the core of the productivity and competitiveness of our economies. Productivity growth, in turn, is a prerequisite for more efficient use of resources that leads to more sustainable production. Research infrastructures such as ESS and MAX IV are essential to this development and play a key role in advancing knowledge and technologies.

Tom Erixon thinks Sweden has a strong enough industrial cluster to create a constructive dialogue with facilities such as ESS, but the two parties need to find each other.

"The companies that are most advanced in material science already have their scientific partners," says Tom Erixon. "They may have a decade or more of relationships with people they know and trust, so for them to make a swap is a rather big step. It is not about the instrument itself being better. The question for an engineer is: Is the result so much better that I am willing to disrupt my current relationships?"

"I believe ESS is strategically essential for Swedish innovation and will provide not only Sweden but the entire Europe with unique conditions for conducting excellent research," says Tom Erixon. "But they have a lot of trust building to do. It takes more than just opening the door and saying: Welcome."

A project on track

2022 was a year of important progress and considerable challenges at ESS. Despite serious delays, technical teams at the facility installed and tested several critical accelerator components. Meanwhile, the implementation of a re-baselined project plan brought new routines for frequent evaluation and forecasting – all to keep the project on track for completion.

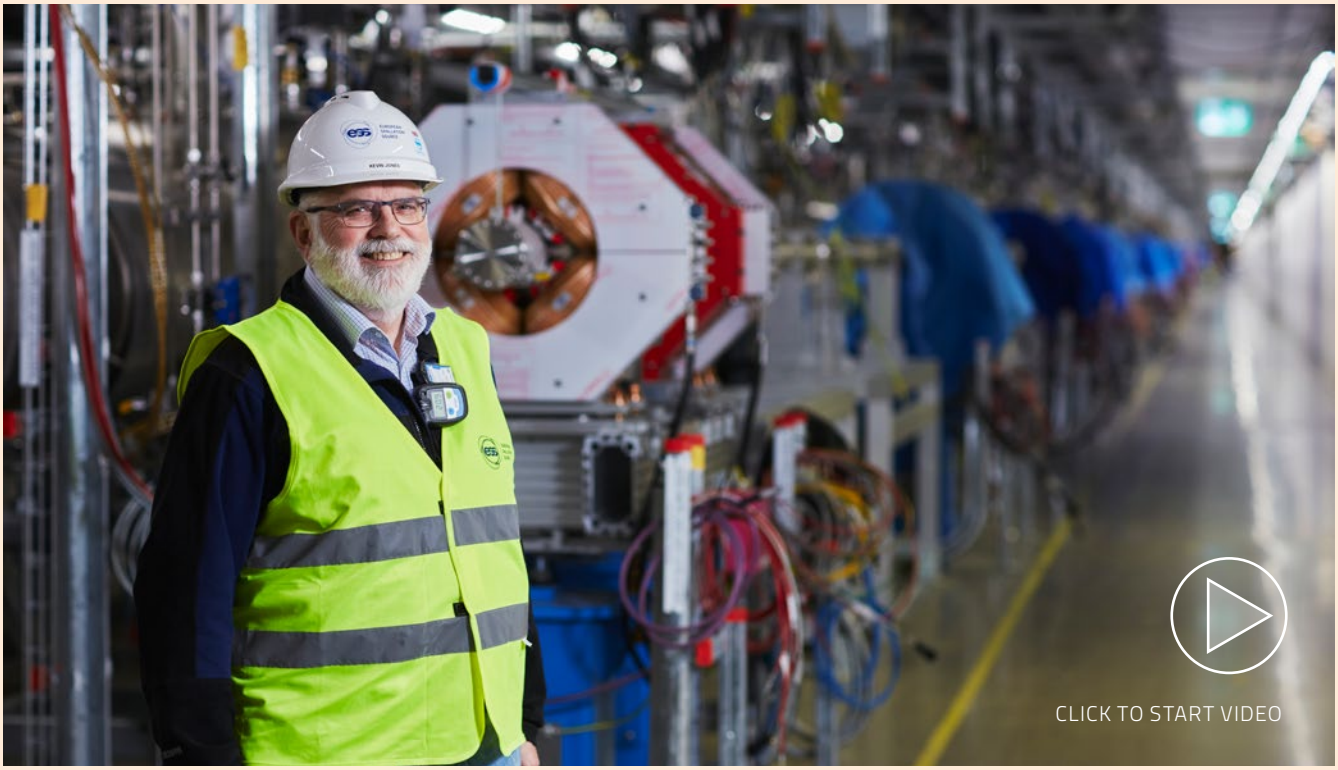
Initiating acceleration

Perhaps the most striking milestone of 2022 was the successful acceleration of protons through the first drift tube linac tank (DTL1). In the finished accelerator, five DTL tanks will add energy to the proton beam before it reaches the superconducting cryomodules. ESS Technical Director Kevin Jones explains:

"While the cryomodules operate with some flexibility, the DTL has to work exactly as planned. It's like a finely tuned musical instrument: it must resonate at exactly the right frequency to bring the proton beam up to speed. If it's out of tune, from temperature changes or defects, there's no acceleration. We have now accelerated the full peak current in a short beam pulse, demonstrating that DTL1 works as designed."

Project director Andrew Kimber adds: "This was a great milestone for the project, because it makes us confident that the other DTL tanks will do their job, and that we will get the beam through DTL4 in 2023 according to plan – with the fifth and final DTL tank installed shortly thereafter."

KEVIN JONES
TECHNICAL DIRECTOR, ESS



ANDREW KIMBER
PROJECT DIRECTOR, ESS

Keeping cool

In early December, the accelerator's cryogenic distribution system (CDS) was successfully cooled down and tested. This was another important milestone, and a good example of how challenges are overcome at ESS. The CDS distributes helium from the cryoplant at a temperature of 4.5 Kelvin, which is crucial for running the accelerator cryomodules. "The CDS was a very busy part of the project," says Andrew Kimber. "There were months of leak testing and detailed fixes, but through hard work and dedicated collaboration between the ESS team and our in-kind partners, the deadline was met."

With the CDS in place, installation of the cryomodules can begin. A majority of the modules needed for Beam on Target (BOT) have been delivered to ESS, and many are ready for installation after successful acceptance tests. "The cryomodules make up a large portion of the accelerator, and most of them will be installed during 2023," says Kevin Jones. "This means that the proton beam will be commissioned to the tuning beam dump in 2024."

"Getting it right from the start will save us a lot of time at later stages"

ANDREW KIMBER
PROJECT DIRECTOR, ESS

Performance on target

The target wheel is where spallation occurs, sending neutrons to the scientific research instruments. It consists of roughly 7000 tungsten bricks, weighs about four tonnes in total, and rotates at 23.3 RPM during operation. During 2022, the wheel, together with its shaft and drive motor, were delivered to the facility by ESS Bilbao. In December 2022, it was time to test the target wheel. "This was a long-term test," says Technical Director Kevin Jones. "We spun the target wheel at its design frequency, non-stop for a week, and it worked extremely well, with very stable performance. This gives us reassurance in our continued work."

New routines

On an organisational level, 2022 brought big changes to the work at ESS in Lund. The re-baselining process that started in 2021 not only produced an updated project plan, it also renewed the routines for evaluation, risk analysis, and reporting. The updated project plan includes contingencies for time and cost, considering risks and uncertainties that could affect the trajectory of the project.

Project performance is now evaluated monthly, and a consolidated forecast is shared with stakeholders. During 2022, a reinforced team of controllers supported the evaluation activity in each sub-project. "It always takes time to implement new routines," says Agneta Nestenborg, Director for Project Support and Administration. "Thanks to a good collaboration between the Project and Administration sides, the monthly evaluations now meet high standards."

Setbacks to the plan

Andrew Kimber is confident that the new routines will help keep the project on track, with ESS reaching completion by 2027. "Thanks to the re-baselining of the project, we saw huge improvements in performance tracking and proactive risk mitigation during 2022," he notes. "Going into 2023, we have an entire year of data which lets us identify areas of improvement and mitigation even better."

The Project Directorate had to address two significant delays during 2022. In June, it was discovered that the time and resources needed for the target's electrical infrastructure design had been underestimated. The Project Directorate created a new work group, and diverted resources to address the delay and get back on track.

A second delay was caused by the helium circulator for the target wheel cooling system. During testing at the

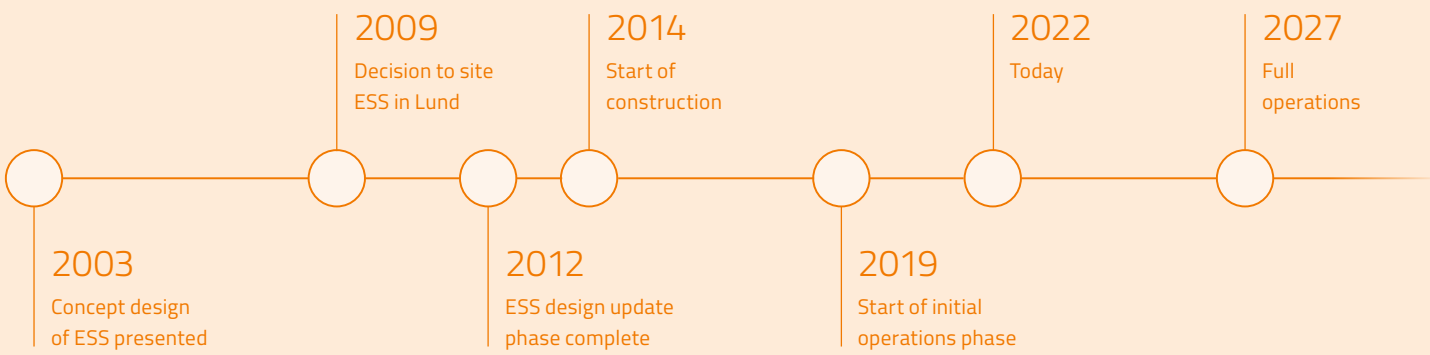
AGNETA NESTENBORG
DIRECTOR FOR PROJECT SUPPORT AND ADMINISTRATION, ESS

manufacturer's site in early August, the circulator pump drive motor units were damaged due to critical malfunction. "We had to work closely with our in-kind partner to mitigate this delay, salvaging undamaged parts, and procuring new ones," says Andrew Kimber.

Technical Director Kevin Jones adds: "We also decided to order a second cooling system from another manufacturer, using different technology, to further mitigate the risk. Both systems will be installed, with the capability to switch seamlessly between them."

Stepping up quality control

"Overall, we've seen a need to step up quality control as an increasing number of components are being delivered, installed, and commissioned" says Andrew Kimber. "During the height of the COVID-19 pandemic, we couldn't be there when our partners designed and tested the equipment. It suddenly became very difficult and complicated to get things exactly right." With the pandemic receding, ESS teams are intensifying quality control at every step, whether it's an in-kind partner, a contractor, or ESS engineers that do the job. "With a project as complex as ESS, it doesn't take much for something to go wrong," says Andrew Kimber. "Getting it right from the start will save us a lot of time at later stages."



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"With this huge and complex undertaking moving closer and closer to completion, it's time to highlight the dedication of our in-kind partners," says Dimitri Argyriou. "They are absolutely crucial to the success of ESS, because they are the ones building the machines. During the pandemic, our partners were seriously affected by faltering supply chains and lab shutdowns. Today, many of them are struggling with staff shortages and cost overruns, because of the global energy and finance crises. Throughout these tumultuous years, we have seen how steadfast their commitment is. For that, they deserve our utmost respect and support."

Finding a common path

In December 2022, the ESS Council and In-kind Management Directorate met with representatives from all in-kind partners to find a common path for the coming years. Together, the parties committed to a plan of strengthened communication and improved quality control. "This is what's needed for ESS to succeed," says Dimitri Argyriou. "To stay on schedule, we need complete clarity and mutuality in our communication with in-kind partners. We also need to spend a lot more time at their sites, reviewing the function and quality of components together, before they are sent to Lund. Our partners are deeply involved and transparent in these issues, which is critical for protecting the ESS schedule."

"The key is to remember that this is all about partnership and collaboration," Dimitri Argyriou continues. "We are not dealing with contractual obligations between a customer and their vendors. There's just one ESS, built by many institutions across the contributing countries. The facility is in Lund – but we own this project together."

Declaring victory together

With an increasing number of components reaching the ESS facility for installation

"We own this together"

Across Europe, scientific and technical institutes are hard at work manufacturing the many components of the ESS proton accelerator and neutron scattering instruments. These institutes are the project's in-kind partners, contributing their effort and expertise rather than fixed sums of money. The ESS Directorate of In-kind Management was formed in 2020 to promote the close and continuous collaboration between ESS in Lund and its partners. Heading the directorate is Dimitri Argyriou, who has been with the project since its early years.

and commissioning, Dimitri Argyriou sees a need for continued conversation with in-kind partners: "Pretty soon, the facility will start producing groundbreaking science," he notes. "This will be a great scientific and technical victory – and we will declare that victory together with our in-kind partners. But we also need to ensure that there is a robust knowledge transfer, from the people who built these machines to the ones who will keep them running. So, we need continued engagement with our partners – we simply can't do this without them."

DIMITRI ARGYRIOU
ASSOCIATE DIRECTOR FOR IN-KIND MANAGEMENT, ESS

Delivering against the odds

Francesco Grespan and Sean Langridge represent two of the many in-kind partners at the heart of the ESS project. Here, they give a glimpse of what it's been like to move ESS forward through challenging times.

Tell us about your institute and its contribution to the ESS project.

Francesco Grespan, INFN: We are an Italian research agency with four main labs and 20 sections connected to Italian universities. We are involved in five major fields of research: subnuclear physics, astroparticle physics, nuclear physics, theoretical physics, and technological, interdisciplinary research, including accelerators. We run our own electron and proton accelerators and have decades of experience in what is now being built at ESS.

For ESS, we constructed the ion source that produces the proton beam. We are also building the drift tube linac (DTL) tanks that make up the initial part of the accelerator, and which are now being installed and commissioned. We will also build the accelerator's superconducting medium beta cavities.

Sean Langridge, ISIS: ISIS is a world-leading neutron and muon facility at the STFC Rutherford Appleton Laboratory in Oxfordshire. Today, we have over 30 neutron and muon instruments with ongoing research for academic and industrial purposes. In 2016, we committed to the creation of two neutron scattering research instruments for the ESS facility.

The first instrument is LoKI, a small-angle scattering instrument that will open new frontiers in the study of complex, nanoscale matter. We expect to finish installing Loki in 2024. The second is Freia, a reflectometer for studying complex systems composed of layers of matter. FREIA will let us study these at the atomic and nano scales, as they vary with time. Significant components for Freia are scheduled to start arriving at ESS next year.

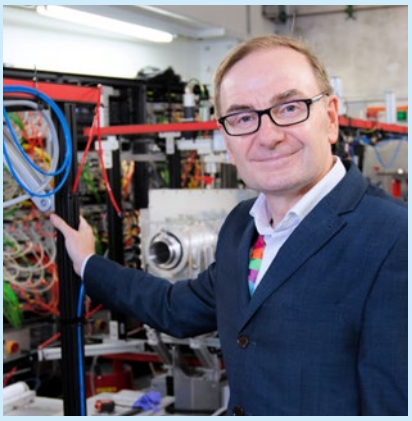
What has this task been like for you?

Francesco Grespan, INFN: We've been involved since the study and planning stages. Early on, we decided to assemble all our components at the ESS site, rather than shipping them from Italy. There are basically no error margins with these components, and transporting them was guaranteed to mess things up. Assembling onsite, we can ensure that everything aligns exactly as it should. We can also pass knowledge to the ESS staff more efficiently. With this kind of equipment, you can't simply write a manual for others to follow.

We started assembling at the site in 2019. Then COVID-19 struck, and everything froze in February 2020. After seven months, we were able to travel again with COVID passes, but had to land in Gothenburg and drive to Lund, with the Danish border shut. We've been able to keep assembling at a slower pace since then. With lots of effort and prioritisation, we've basically kept our time plan. It's been a real adventure – something we'll tell our grandchildren about.

FRANCESCO GRESPAN
INFN

SEAN LANGRIDGE
ISIS



What does it mean for your institute to be part of the ESS project?

Sean Langridge, ISIS: Designing and building neutron scattering instruments for a facility like ESS is a highly complex and challenging undertaking. It's also a great opportunity for sharing and transferring knowledge. There will always be issues along the way, but with dedicated and highly skilled teams on both sides you get around any obstacle – and this is what we've experienced with ESS. Good working relationships and high competence levels have helped us to be agile in delivering the project.

Our plan was to bring co-workers from ESS to take part in the pre-building of components here in the UK. Because of the COVID-19 pandemic, we had to accomplish the knowledge transfer through video calls and video recordings. Once the LoKI pre-builds were completed, we sent 29 lorries to Lund with all the components. It's crucial that ESS gets the in-house knowledge to maintain and develop these instruments – that's why ESS technicians are now assembling LoKI onsite, with support from our installation lead. We are very pleased with the progress of the work, but no doubt there will be challenges to come.

Francesco Grespan, INFN: Taking part in building a megawatt-class accelerator is a once-in-a-lifetime opportunity that we just couldn't miss. The enthusiasm has been very strong in our teams. It's very gratifying to bring the ESS units into the tunnels and see them in action. After all, we have known each machine since it was a small piece of copper. And we are very proud of the results, everything works as expected so far.

We've gained a deeper knowledge of DTLs from this project. And when you are part of one of the biggest scientific ventures in the world, you of course get some attention. We've been approached by stakeholders to help build accelerators in future projects. That said, we would also love to continue our ESS collaboration and be part of the project going forward.

Sean Langridge, ISIS: At ISIS, we have extensive experience of designing, developing, and building instruments at our own facility. This was the first time that we committed to creating instruments for a facility in another country. As part of the neutron research community, it's important for us to deliver world class instrumentation and capability, so that academic and industrial researchers will have access to leading neutron facilities in Europe. It's part of our contribution to the stewardship of neutrons for this diverse and important community.

Working on the two large projects, LoKI and FREIA, has provided a range of opportunities for our ISIS and ESS teams, who have really risen to the challenge of such complex projects. I hope that we and ESS will take advantage of the knowledge transfer these instruments have enabled. Personally, it is a great pleasure to work with what is essentially a super team of technicians, scientists, and engineers from across Europe.

Celebrating the ESS people

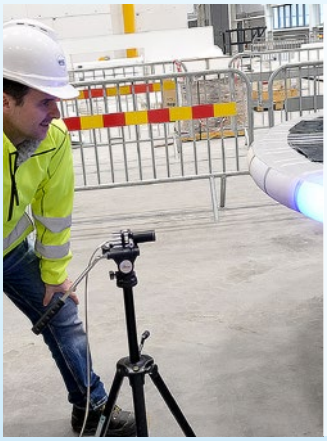
Behind all the progress made in 2022 are the people of ESS. Bringing a diverse set of skills, expertise and creativity to the table, they are absolutely essential to the success of ESS.

21 February

Scientists Werner Schweika and Mikhail Feygenson take a break from their busy day working on the DREAM house built to host the diffraction instrument DREAM.

1 March

Logistics Officer Cassandra Waad and the box containing the target wheel, just delivered from Spanish in-kind partner ESS Bilbao.



7 April

Cyrille Thomas of the ESS Accelerator's Beam Diagnostics Division taking spectral measurements of the luminescent coating applied to the surface of the ESS target wheel.

22 April

Esko Oksanen, Lead Scientist for NMX and member of the First Responders team, running in full gear at the ESS-MAX IV joint spring run event.

17 May

Clara Lopez, Installation Package Lead for the LoKI instrument, is pleased to have installed the very first chopper at ESS.

14 June

Iain Sutton, Technical Coordinator for the neutron scattering systems at ESS, by the newly installed bunker wall insert for ODIN.

25 August

Installation Lead Krister Blomberg proudly shows off the newly delivered steel shielding block to be installed inside the target monolith vessel.

13 September

Lab Technician Katrin Michel in action in the fully operational ESS chemistry lab.

21 September

Vacuum Technician Ralf Huber performing leak-tightness tests from under the neutron beam port insert for the FREIA instrument.

13 October

Bryan Jones, Section Leader for the normal conducting linac, at the installation of the third drift tube linac tank in the accelerator.

14 October

Wolfgang Hees, Cryogenics Engineer, explaining ESS to members of the general public at the Copenhagen Culture Night.

22 October

Tollgate Coordinator Inga Tejedor at the poster session of the joint ESS-ILL user meeting.

22 October

Public Engagement Officer Jo Lewis is using the plunger part of a coffee maker to demonstrate the spinning target wheel and shaft.

22 October

Project Management Assistant Weiying Li is putting posters in place for the poster session of the joint ESS-ILL user meeting.

Giovanna Fragneto:

In the service of science, community, and equality

In August 2022, The ESS Council appointed Giovanna Fragneto as ESS Science Director. In this role, Fragneto will help shape the scientific work at the facility, and secure its place as a centre for cutting-edge research for years to come.

Fragneto, you have been at the forefront of neutron science for many years – can you outline your experience?

I first encountered neutron scattering techniques during my PhD at the Physical and Theoretical Chemistry Laboratory of Oxford University. Later, I was part of the scientific staff at the Institut Laue-Langevin neutron science facility in Grenoble for 25 years. As Lead Scientist, I carried out experiments in collaboration with scientists from all over the world. I was in charge of building a new neutron scattering instrument and when I left, I was Head of the Large-Scale Structures (LSS) and of the Soft Matter Science and Support groups. I have also been involved with the ESS project for a long time, and served on the ESS Scientific Advisory Committee between 2016 and 2019.

You specialise in soft matter science. What role has neutron scattering played in your own research?

In my case, the soft matter has mainly been cell membranes and their components. Because of the way neutrons interact with matter, neutron science provides non-destructive techniques that let us investigate the molecular structures and changes of soft matter as they happen. This enables us to localise molecules in complex assemblies, at molecular or atomic scales. In my work, I have been able to see, for example, where components like cholesterol sit in the cell membrane, and how drugs or virus components can be transported to the cell. The very powerful neutron source at ESS will enable unprecedented levels of detail in this research, which is very exciting.

What are your hopes for ESS and the scientific work here?

My goal is to make ESS an attractive place for scientists, with a lively scientific community and strong connections to academia and industry throughout Europe. Of course, we want to see ground-breaking science that addresses critical issues like health, energy, and the environment. I also hope to establish a strong collaboration with other neutron facilities, to strengthen the European neutron science community. Together, we can ensure that everyone in that community gets access and an allotment of time at a neutron facility that fits their research.

You have also been active in promoting women in science – how?

I was a long-time member of Parité Science, a French association dedicated to encouraging and supporting women in the scientific community. We generally see fewer young people interested in science today. Add to that the expectations and stereotypes surrounding women – the result is a loss of valuable talent and diversity in science. There is a big need for boosting gender equality, especially in fields like physics and engineering. The importance of women taking leadership roles within the scientific community definitely influenced my decision to accept the position as ESS Science Director.

CLICK TO START VIDEO

More than 300 neutron researchers attended the joint ESS-ILL User Meeting in Lund

ESS/ILL User Meeting attendees

Every other year, ESS and ILL arrange the ESS-ILL User Meeting, a major conference for European neutron researchers from academia and industry. The meeting provides the opportunity to showcase the latest developments made possible by neutrons, provide status updates about the facilities, and look ahead to future opportunities for neutron science.

Last year, the three-day conference took place in Lund, bringing together 320 neutron researchers. All the visitors were able to visit ESS and see the progress in technical installations and high-performance instrumentation. The visit consisted of a tour of either the target or the accelerator, and various poster sessions were set up around the facility. The event was then rounded off with a mingle in ESS's impressive Atrium.

Many science talks covering a wide range of research fields were held during the conference, highlighting, for example, the mRNA delivery, such as that used for the COVID-19 vaccines, the function of proteins in the SARS-CoV-2 virus, front-edge research relating to carbon capture, superconducting materials, batteries, and fuel cells, as well as insights into Martian meteorites.

The ESS-ILL User Meetings provide an essential platform for collaboration and exchanging ideas about science and experimental techniques that enable the consolidation of Europe's world-leading role in and shaping the future for neutron science.

"I was impressed not only by the quality of the about 200 oral and poster contributions but even more by the lively discussions during each of the sessions illustrating how neutrons contribute impactfully in so many scientific areas. Seeing so many excited colleagues during the ESS site visit, was a major reward for the joint ESS-ILL team, who put a lot of effort into organising the event."

ARNO HIESS, HEAD OF ESS SCIENTIFIC ACTIVITIES DIVISION AND LEADING THE ESS-ILL USER MEETING ORGANISING TEAM

ESS-ILL User Meeting 2022

- Held in Lund, Sweden (AF-borgen and ESS site)
- 5-7 October 2022
- More than 300 participants
- Scientific programme with 90 presentations and 110 posters
- Tour of the ESS accelerator and target buildings

ESS and ISIS joint Support Laboratory Symposium marked the opening of the first ESS User Labs

Celebrating the opening of the first User Labs at the Lund facility, ESS and ISIS, UK in-kind partner, jointly hosted a Support Laboratory Symposium on 4–5 May.

ESS and ISIS Neutron and Muon Source, a research centre based at the STFC's (Science and Technology Facilities Council) Rutherford Appleton Laboratory, have worked together to design, procure, and install the user laboratories as an in-kind project spearheaded by the ESS Samples and User Laboratories Facilities team. These laboratories include a radiological materials lab, for which the University of Tartu in Estonia provided the glove boxes. The user laboratories will be available to support the users' needs during their time at the ESS instruments.

At the symposium, several speakers from ESS, ISIS, STFC, the University of Tartu, and others emphasised the importance of state-of-the-art user laboratories, assisting the users with sample characterisation and preparation before, during, and after their time using the ESS instruments, ensuring the best possible scientific outcome.

Guests arriving to the Lab Symposium, held in the ESS User Labs

Official handover event at ESS marked a major milestone

Gunnar Hagman, CEO Skanska Sweden, and Helmut Schober, Director General ESS

On 2 March 2022, the European Spallation Source celebrated the official handover of all 26 buildings from construction partner Skanska. Representatives from ESS, its 13 member countries, and Skanska participated in the ceremony.

ESS and Skanska had worked in close collaboration since early 2014, when a partnering collaboration for the civil construction of the facility was established to provide flexibility and control during the complex construction project.

The finalisation of the civil construction of ESS is an essential step towards completing the research infrastructure, which will be fully operational and open for scientific users in late 2027.

Working at ESS

CARINA LOBLEY

Tell us about your job

The heart of my job is to facilitate and report scientific activity at ESS. My current focus is to highlight the scientific expertise at ESS to attract those who will be early users of the facility. We are preparing a user experience with smooth administration and logistics tools, so that the actual visit can be focused on science. As our community grows, it will be increasingly important to report the outcome of the science carried out, and this also lies within my role.

What do you enjoy about working at ESS?

My role at ESS is extremely varied. I enjoy the fact that I can usually choose where to focus my time, ensuring I rarely work a generic day. Since the science potential of ESS covers a wide range of subject areas, I get to look into a wide range of scientific ideas and have some small comprehension of the value to society of what ESS can be.

Carina Lobley
Senior Officer, Scientific Coordination and User Office

Naja Dornonville de la Cour
Work Unit Lead, Target Division

NAJA DORNONVILLE DE LA COUR

Tell us about your job

In 2012 I started as the second ever consultant for ESS, and since 2014 I have been employed working with components residing within the Target Monolith, currently as the person responsible for the Neutron Beam Port Inserts and connecting systems. These 4.5-tonne large chunks of steel house the first part of the neutron guides, providing cooling, alignment and a separate atmosphere for the delicate neutron beam optics.

What do you enjoy about working at ESS?

I enjoy the constantly changing work tasks that keep me on my toes. It is very stimulating as there is always something new to learn. I am also quite lucky in the sense that I am working in the best team at ESS, surrounded by nice and brilliant colleagues. For me that is the difference between a good job and a great job.

TIM BIRKIN

Tell us about your job

After many years in heavy and hazardous industries, I moved from commercial and operational roles into Health, Safety, Quality and Environmental management, where I found my niche in analysis and assessment of risk and finding practical ways to reduce it. I employ my broad experience at ESS by supporting the installation with practical, on-site advice and support through collaboration in order to find the best and safest possible way forward in any given situation.

What do you enjoy about working at ESS?

Apart from ESS being an amazing facility with cutting edge engineering and super interesting installations populated with a diverse workforce, I was drawn to ESS because I wanted to give back some of my experience from industry to a venture that could make the world a better place. I honestly believe that when ESS is operational it will help with scientific breakthroughs that will benefit humanity.

Tim Birkin
OHS Technician

DELPHINE HARDION

Tell us about your job

I joined ESS in 2019 as a Vacuum Technician. My colleagues and I are working everywhere on site and supporting other teams, as there is vacuum from the Ion source all the way through to the instrument laboratories. We are checking for vacuum leaks on all the equipment coming from everywhere in Europe, before and after their installation on site. I'm specialised in particle-free works for high vacuum. Hence, I'm often working inside cleanrooms to do particle-free installations of instruments and connections in the Accelerator tunnel.

What do you enjoy about working at ESS?

Building a particle accelerator is a very interesting, exciting and challenging project and I'm very happy to be part of it. I like the diversity of my work: working in the lab or inside the cleanroom or on site – every day is different. What I also like very much is the friendship in the vacuum team. My colleagues are really great!

Delphine Hardion
Vacuum System Technician

EMANUELE LAFACE

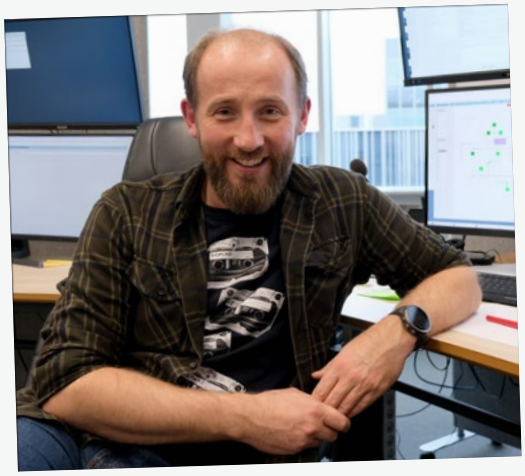
Tell us about your job

My journey at ESS started early - back in 2011. I created a physics model for the online simulator of the proton beam, which today is used in the commissioning phase of the project, helping the operators to predict the behaviour of the particles during machine operations. I also work with data analysis from the accelerator, beam instruments and test facilities. I created a public interface for the control system, and from time to time I give lectures in beam dynamics at Lund University.

What do you enjoy about working at ESS?

ESS is a unique project, with one of the most complicated linear accelerators ever built. This makes the project incredibly interesting for an accelerator physicist. On top of this, I had the opportunity to see ESS from the very beginning, when the massive structure of today in the outskirts of Lund was just a field. To be part of building a facility like ESS from the start is a true privilege. I'm really looking forward to seeing the full machine in operation, after more than a decade of design, construction and tests.

Emanuele Laface
Accelerator Physicist, Control System Software & Services



Arek Gorzawski
Control Room Shift Leader

AREK GORZAWSKI

Tell us about your job

My responsibility starts with coordinating commissioning activities when we do not operate with beam. It also includes preparation of machine studies and sequences to operate safely and efficiently. Finally, during early operations, it involves the supervising role of the control room crew during the studies with the beam. Currently, my days are dedicated to the complex, multi-team spanning task of preparatory work for the next phase of beam commissioning.

What do you enjoy about working at ESS?

The most enjoyable part is the constant interactions with different groups while approaching various tasks. Almost on a weekly basis, we have activities that clash, requiring a revision. The alternating pattern of commissioning activities and early operations provides the environment to create a machine operation culture that currently only exists in scattered procedures and documents. This process is extremely challenging, but will also soon be very rewarding, as it affects everyone who works at or uses the facility.

Shaping the future

The coming years will be crucial for the success of the ESS project. To better address the challenges ahead, significant organisational changes will be implemented during 2023. With a streamlined management structure and more agile ways of working, the aim is to use every resource as efficiently as possible for the completion of the facility.

"This reorganisation is all about getting ESS ready to start producing science," says Anna Hansson Kalaris, Head of Division Human Resources at ESS, and a driving force in finding the right structure for the coming years. "Primarily, we saw a need to strengthen the technical focus, in order to complete the facility on time. We have a lot of technical competence in the project – we simply need to use it as efficiently as possible to avoid delays."

"I think people are hungry for information and for seeing their place in the project"

KEVIN JONES
TECHNICAL DIRECTOR, ESS

High-efficiency support

A first step in this direction is setting up a new Directorate for Operations and Infrastructure. The Directorate will gather roughly 200 employees and consultants in four divisions: Operations, Information Technology, Design & Engineering, and Field Engineering & Site Support. The purpose of the new Directorate is to provide technical service and support resources to the entire organisation, in a more flexible and efficient way.

"By gathering these people and activities under one roof, we can break down department barriers and find synergies among skill sets in the project," says Carlo Bocchetta, who heads the new Directorate. "This makes us more agile and lets us avoid unnecessary double-work and delays. We also hope to benefit from competence overlaps, and use cross-training to expand the work areas for our co-workers, where possible. This will make us less vulnerable to staff changes and shortages."

The new Directorate will eventually play a key role in maintaining smooth operations of the finished accelerator, instruments, and other areas of the ESS facility. Until then, its teams will carry out technical installation, integration, and testing wherever it's needed. They will also help design power and water infrastructure at the site. "Every aspect of the ESS infrastructure: roads, buildings, access – it's all gathered in this Directorate," says Carlo Bocchetta.

New offices

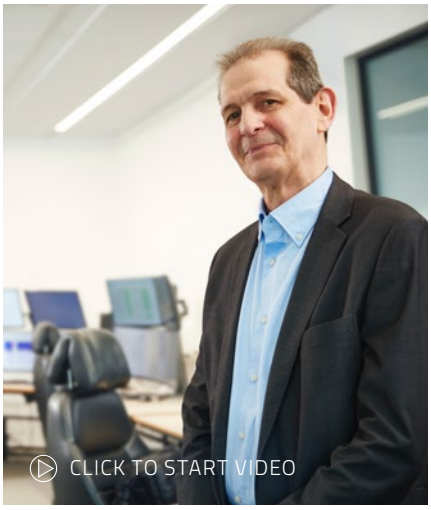
Having faced significant delays during the pandemic years, the Project and Technical Directorates will also be supplemented with new support entities: the Project Office and Technical Office respectively. "As Director, I need help to make sure that things get done as efficiently as possible," says Kevin Jones, ESS Technical Director. "A steady stream of issues and questions are brought to me – the technical office will be there to assist me in organising and grouping the different efforts, which gives me more bandwidth to act."

The Project Office consist of two groups: project controls and project managers. Project controls will support the ESS organisation in matters ranging from planning and risk management to cost control and reporting. "As for the project

ANDREW KIMBER
PROJECT DIRECTOR, ESS

ANNA HANSSON KALARIS
HEAD OF DIVISION HUMAN RESOURCES, ESS

CARLO BOCCHETTA
ASSOCIATE DIRECTOR FOR OPERATIONS & INFRASTRUCTURE, ESS



managers, they are there to drive and improve project performance across the entire scope of ESS," says Project Director Andrew Kimber. "The project managers will support all areas of ESS to deliver their scope, enabling more informed and timely decision making."

Leadership changes

Another major change concerns the diffusion of management throughout the ESS project. "To ensure that co-workers with senior technical knowledge are readily available to help bring the project forward, we are transferring certain line management responsibilities," says Anna Hansson Kalaris, Head of Division Human Resources. Where line managers have, in some cases, been responsible for groups as small as one or two co-workers, many will now take on a more functional leadership role. As a result, fewer line managers will be responsible for larger groups.

"Every functional leader will oversee a certain activity within the project, without having to deal with HR-related questions like salary negotiations and performance evaluations," says Anna Hansson Kalaris. "This is an important step towards a stronger focus on technical progress at a critical time in the project. It also simplifies our paths of communication." Some functional leadership will be permanent, while others will move between tasks as they are completed. Anna Hansson Kalaris also points out that some groups will disappear with time, while others may grow, and again be under line manager leadership.

"This change in responsibility, from line manager to functional leader, can be challenging and confusing for some," says Anna Hansson Kalaris. "Nevertheless, I think most co-workers share the view that we need renewed structures and ways of working to solve our challenges and reach our goals in time. There may be some initial friction, but I hope for a regained focus on the exciting and unique possibilities that we are creating for the world."

Anna Hansson Kalaris sees important work ahead for her Human Resources team: "This kind of organisational change takes time and effort," she says. "We will work closely with line managers and functional leaders to establish clear roles and responsibilities. Everyone should know what to deliver within the new framework. We must also ensure that working conditions are good and that people get the support they need to find the right motivation and enjoy their workdays at ESS."

Communicating progress

In an effort to strengthen the sense of inclusion and community throughout ESS, the entire workforce is invited to monthly project update meetings, in a 'town hall' format. "This started in November 2022," says Andrew Kimber. "It's an opportunity for everyone who isn't directly involved with the day-to-day workings of the project to get a broad understanding of where we are, where we're going, and when we will get there. We give a monthly snapshot, showing our current priorities and issues we're working on. This helps align everyone with the progress of the project."

At the monthly update meetings, Andrew Kimber gives an overview of the project status, with Kevin Jones providing a deeper dive into the technical aspects. Attendees are also given the chance to ask questions. So far, attendance has been good, with positive feedback reaching the Directors: "At the January meeting, we had roughly 100 people in the room, with another 400 calling in on video," says Kevin Jones. "I think people are hungry for information and for seeing their place in the project. These update gatherings are an important effort in bringing us to our goal."

"ESS can help accelerate the clean energy transition"

Hydrogen is critical to a clean energy future, and as a major downstream application of hydrogen, fuel cell technology is gaining ground rapidly. An essential part of the fuel cell and other clean-energy devices is the Polymer Electrolyte Membrane (PEM) – a semi-permeable material that acts as an electrolyte and a separator. PEMs are a focus area of research to address critical issues around durability, performance, and production cost, with neutron scattering emerging as one of the promising research tools.

Thomas Tingelöf, Head of Hydrogen Fuel Cell Technology at Volvo Cars, has extensive experience in fuel cell development. He is looking forward to the new instrumentation and innovative experiments at ESS that can help create and test new PEM formulations.

Neutrons enable research in real-time

"ESS and other neutron source facilities can play an important role in accelerating the clean energy transition," he says. "Neutrons have been an essential part of the research for hydrogen-fuelled power supply. They can penetrate metallic and ceramic structures so that PEMs can be studied in their operating environment. Instead of studying the secondary effects of the phenomenon we want to improve, we can study the rate-limiting processes directly".

Optimising PEM fuel cell performance

PEM fuel cells produce electrical energy directly from hydrogen, with water as the only byproduct. This means a significant reduction in pollutant emissions compared to traditional fuels – no wonder they are actively researched as an alternative to fossil fuels in transportation. A few major car makers have started producing fuel-cell electric vehicles (FCEV). However, the cost and lifetime of PEM fuel cells are still barriers to their widespread use and commercialisation.

One of the critical factors for the performance and durability of PEM fuel cells is to avoid flooding the electrodes with the water generated as a byproduct. Still, water dynamics in operational PEM fuel cells are not yet well understood.

"Water content and transport greatly impact the operation of a PEM fuel cell and must be managed to maximise performance and durability. One of the great advantages of neutron scattering is that you can beam a fuel cell unit with neutrons to visualise where the reactions take place or where the products of the reactions end up in real time while running the components," says Thomas Tingelöf. "This is one of the keys to finding optimal designs and can accelerate development, which is extremely important for the energy transition that society needs to make."

ESS will accelerate applied research

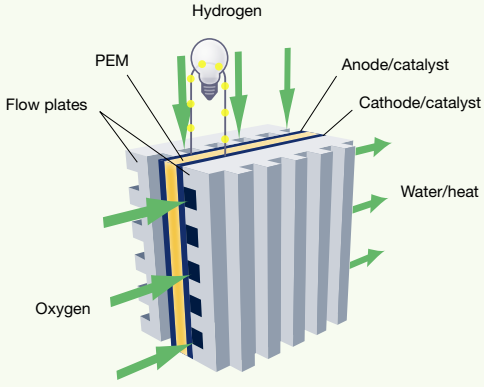
Thomas Tingelöf looks forward to the day the ESS facility is completed.

"It will be a great advantage to have a world-class beamline facility nearby. You can easily meet the scientists face to face and have a good discussion. I think there are a lot of people in the industry who don't realise the incredible opportunities neutron scattering provides. When I talk to colleagues, many of them know that something huge is being built in a field in Lund, but in general, I think people are unaware of the possibilities that exist with this technology. If they don't know that such a method exists in the first place, they will never think of it."

"I think it will be extremely valuable for Swedish and Nordic industry to see that it is not only basic research that benefits from neutron techniques, but that it is also possible to do a lot of applied research that can be useful for industry in both the short and long term. Small improvements in understanding materials and processes often translate directly into significant cost savings and gains," Thomas Tingelöf concludes.

How do PEM fuel cells work?

Fuel cells work like batteries but instead of charging them, they produce electricity and heat as long as fuel is supplied. A fuel cell comprises two electrodes – a negative electrode (or anode) and a positive electrode (or cathode) – sandwiched around an electrolyte. A fuel, such as hydrogen, is fed to the anode, and air is fed to the cathode. In a PEM fuel cell, a catalyst separates hydrogen atoms into protons and electrons, which take different paths to the cathode. The electrons go through an external circuit, creating a flow of electricity. The protons migrate through the electrolyte to the cathode, where they reunite with oxygen and the electrons to produce water and heat.



Source: The US Department of Energy, energy.gov. Picture credit: Wikipedia.

Commissioning of the ESS accelerator progresses according to the plan

In December 2022, a successful cooldown of the cryogenic distribution system (CDS) was performed in the ESS accelerator tunnel. This activity is critical to maintaining the schedule for the entire accelerator project.

The CDS delivers cooling power to the cryomodules. They are part of the superconducting portion of the accelerator (the "cold" part), where the proton beam is accelerated using electric fields in superconducting cavities within the cryomodules.

The CDS cooldown is a complex activity and a large team effort of the Cryogenics team, ICS, and the Operations team. The CDS for the spoke section was delivered to ESS from French in-kind partner National Center for Scientific Research (CNRS) via IJC Lab. The CDS for the medium and high beta sections was delivered from Polish in-kind partner Wrocław University of Science and Technology (WUST).

Part of the team behind the CDS successful commissioning, in front of the screens in the local control room. Image: Ulrika Hammarlund/ESS

In less than 1.5 days, the temperature in the CDS was reduced below 70K, and permanent helium leakage measurements and a tunnel inspection were conducted with satisfactory results. With the CDS fully commissioned, the installation of cryomodules in the superconducting linac can start.

ESS art residency programme 'Nanocosmic Investigations' exhibition

A number of the artists, ESS staff and others involved in the programme standing in front of one of the artworks (by Axel Straschnoy

Since the summer of 2021, ESS has been involved in a remote and mainly digitally-based artist residency called Nanocosmic Investigations – Artists in Conversation with ESS. The collaboration was designed as a pilot project and an experimental residency, as it took place during the COVID-19 pandemic. This meant that the artists were not able to visit the facility. Nevertheless, the conversations were fruitful for all participants, creating new insights into arts and science schemes.

As a result of an international open call, seven artists working within performance, video, and sound were matched with engineers, biologists, and physicists at ESS. They held digital conversations during the autumn of 2021. In April 2022, the Inter Arts Center in Malmö hosted an exhibition to present the different artistic outputs from these conversational collaborations. The artists participating were Christine Kettaneh, Axel Straschnoy, Tim Bishop, Jeannette Ginslov, Keith Lim, Swati Aggarwal, and Ish S.

The residency has been funded by the European Regional Development Fund through Wisdome Innovation and is a collaboration between Malmö Museums, Lund University's Inter Arts Center (IAC), and ESS.

Renewed Memorandum of Understanding between ESS and ISIS (UK)

On 2 December 2022, ESS and ISIS Neutron and Muon Source of the Science and Technology Facilities Council (STFC), as part of United Kingdom Research and Innovation (UKRI), signed the renewal of a Memorandum of Understanding (MoU) between the two facilities.

ESS and ISIS signed the first MoU back in 2014. The renewal of this agreement emphasises the common goal of enabling a strong European neutron community based on knowledge exchange and scientific and technological collaboration.

ISIS Director Roger Eccleston and ESS Director General Helmut Schober signing the MoU

The MoU provides the framework for close collaboration between the two facilities, with an extensive programme for research and technology. It paves the way forward for the mutual development of components and instrument technologies, and the exchange of research and technical staff.

ESS Director General Helmut Schober and ISIS Director Roger Eccleston mutually signed the MoU. It will be valid for a period of 10 years.

Mads Bertelsen received the ENSA award

On 22 August, Mads Bertelsen, Computational Neutron Scattering Scientist at ESS Data Management and Software, received the ENSA Neutron Instrumentation and Innovation Award at the ongoing International Conference for Neutron Scattering in Buenos Aires, Argentina.

He received the award for his work on software relating to simulations of neutron scattering instrumentation, with the simulation package McStas at its core.

Mads added a tool that is used to optimise guides, drastically reducing the time needed, and developed an expansion of McStas that increases the fidelity of the simulation around the sample and sample environment area, including a visualisation tool that can generate stunning images of what happens in complex simulations. He also made a Python interface for McStas, making it simpler to handle large simulations and providing a more intuitive way for new scientists to work with McStas.

Turning data into scientific breakthroughs

Although the instruments at ESS have yet to become operational, the Danish side of the facility is working hard to prepare for the data streams they will generate. The ESS Data Management & Software Centre (DMSC) has already started developing the analysis and modelling software to enable researchers to transform the experimental data produced at ESS into scientific results. Meet Thomas Holm Rod, Acting Head of the DMSC.

From application to publication

"DMSC will provide all the software, data services, and solutions ESS users need to perform their experiments," says Thomas Holm Rod. "This encompasses a fully integrated data pipeline from applying for beamtime to running the experiment, processing and visualising the data, and storing it for future use."

When ESS is in full operation, the DMSC will handle and store vast amounts of experimental scientific data, some 7-11 petabytes (PB) per year. This requires powerful computers, a large storage capacity, and fast networking. But what do the staff do now when no raw data flows between Lund and Copenhagen?

Collaborative software development

"We develop software in collaboration with many other facilities," says Thomas Holm Rod. "Some of our solutions are already in use at the Science and Technology Facilities Council (STFC). Our meta-data catalogue is being used by seven different research institutions, among them MAX IV. In 2022, for example, we concluded the Photon and Neutron Open Science Cloud (PaNOSC) project. PaNOSC is a four-year project that is part of an initiative funded by the EU to make FAIR (Findable, Accessible, Interoperable and Reusable) data a reality, allowing universal and cross-disciplinary access to data through a single access point."

"Back in the old days, scientists saw data as their private property. But we can speed up science by making experimental data easy to find and reuse. Plus, if data obtained at facilities such as ESS can be used more widely, it enhances the return on this massive investment."

Catering to the users' needs

Software that allows a researcher to turn instrument data into publishable data is essential in the experimental process. However, knowledge and understanding of how data processing works vary significantly between users. Many neutron users are non-experts in programming, and to meet their demands, DMSC must provide easy-to-use and understandable software.

"For some users, we need to provide an automated process and simple solutions. But some users want or need to have more control of the entire experiment and data analysis themselves", says Thomas Holm Rod. "Obtaining results from an experiment is considered a limiting step by many, so we are putting a lot of emphasis on support. It is ideal if the users can leave the ESS facility with some results."

From experimental data to scientific understanding

As the experiment is run, data collection begins when the neutrons scattered from a sample are recorded in the instrument's detectors. The information is transmitted to data-aggregating computing stations in Lund and Copenhagen. From here, the goal is to achieve an optimal processing speed that allows ESS to stream the raw data, process it, and return meaningful and scientifically valid data to its users in as close to real time as possible.

The data can be displayed as dynamic visualisations in one or multiple dimensions, so that the researchers can view the output of a neutron scattering experiment as it is taking place and begin to interpret the results.

Slowly scaling up

DMSC currently employs around 35 people. When ESS is fully operational, with thousands of experiments performed annually, the staff is expected to peak between 60-70 employees working as part of the larger support structure of the ESS scientific user programme.

"The activities within DMSC follow the schedule of the engineering and construction of the instruments themselves, so there will be a cold commissioning phase, when we test that the instrument control software is working, and a hot commissioning phase, when we test data processing tools," says Thomas Holm Rod. "There are many things we can't do before we have neutrons, but we try to be as prepared as possible by using other means for testing, such as a test stand at ESS, instruments at other facilities, and simulations."

The Innovation Day helps build a community around ESS

When complete, the ESS will be the brightest neutron source in the world, opening up new frontiers for science in a broad range of fields. Its value will fully become evident in the coming years, but it is already clear that the potential for a range of industries is enormous. However, awareness of the prospects the facility will offer still needs to improve in some of the industrial landscape user communities. One important initiative is to show industry how they can benefit from neutron technology through their involvement in the ESS Innovation Day. This event will take place in August 2023 at Hitachi Energy in Ludvika, Sweden.

An openness that spurs innovation

"This is the second time we will arrange this meeting," says Pia Kinhult, Head of Host State Relations at ESS and project leader for the ESS Innovation Day 2023 event. "Last year's event with ABB in Västerås was a first test of the format, and it turned out incredibly well. What was special was that we were a tight bunch coalesced around a common goal. There were around 40 participants in Västerås, and everyone was given a task during the day. No one was just a passive spectator, and I must say that the dynamic it created was brilliant. The fact that there were relatively few of us made it a little private, and frankly, the openness I experienced was amazing".

"The most important application of neutrons in industrial research, as we learned in Västerås, is the possibility to validate, increase the speed of transformation, and the capability to explore circulate materials. These are all major challenges today for the industry, says Mikael Dahlgren, Head of Corporate Research at ABB.

Building long-term relationships between industry and academia

The event aims to explain to the industry how they can benefit from neutron technology and to open up a dialogue between academia and industry. Building long-term relationships between the university world and the industrial sphere is essential to go hand in hand and build competence hubs around shared issues.

Among the participants at last year's Innovation Day were industry representatives, mainly at the CTO level, i.e., research and development managers, university researchers who work with neutrons, and several key ESS staff.

"Our goal is to identify and understand the industry's challenges and how neutrons can help solve them. Last year we worked around four themes: Materials, Data processing, Life science, and Energy. First, a representative from industry presented the problems they were facing, and then a researcher explained how neutron scattering might be applied in this context."

Neutrons help develop materials for a better life

Something that became clear during the first event was the significance of circularity. Reusing and recycling products is a huge challenge. Let us take metals, the foundation of the modern economy. Mining metals involves a high environmental cost. But a study published in Nature Sustainability looking at the economic lifetimes of 61 commercially used metals found that more than half have a lifespan of fewer than ten years, and most of these metals end up being disposed of or lost rather than recycled or reused.

Advancing science for future generations

"The classic metals can often only be recycled once. When recycled a second or third time, they become rubbish," says Pia Kinhult. "But we must, for both economy within industry and wider societal context, learn how to reuse materials for new products to a much greater extent. And therefore, we need neutron scattering. Research and innovation are crucial to aid us all in the transition to a more sustainable society."

Another important area where neutrons can help is the development of smarter and more efficient batteries. "Batteries can be made smaller, cheaper, and recyclable, but with greater storage capacity and better performance," says Professor Kristina Edström at Uppsala University, who also leads the Ångström Advanced Battery Centre (ÅABC), and the BATTERY 2030+ initiative.

Ramping up the dialogue

"This year, the event will comprise the same four areas, but we want to take them to the next level. The core group will be the same, but we plan to add some new participants from industry and, above all, some new, fresh researchers", says Pia Kinhult. "The scientific community needs to show what the neutrons can do. At the same time, even the scientific world has not fully understood what it is about. The neutron community is still small and learning, compared to the synchrotrons."

"When you go to the ISIS website, you can see what has already been done with neutrons. But we must make it possible to do much more, and much faster than before. So far, it has taken too long, partly in the preparatory work and partly in the experiment itself. For industry, it is the time, not the cost, that is the main obstacle. I believe that ESS will offer a different capacity at a different speed", concludes Pia Kinhult.

KRISTINA EDSTRÖM
PROFESSOR, UPPSALA UNIVERSITY

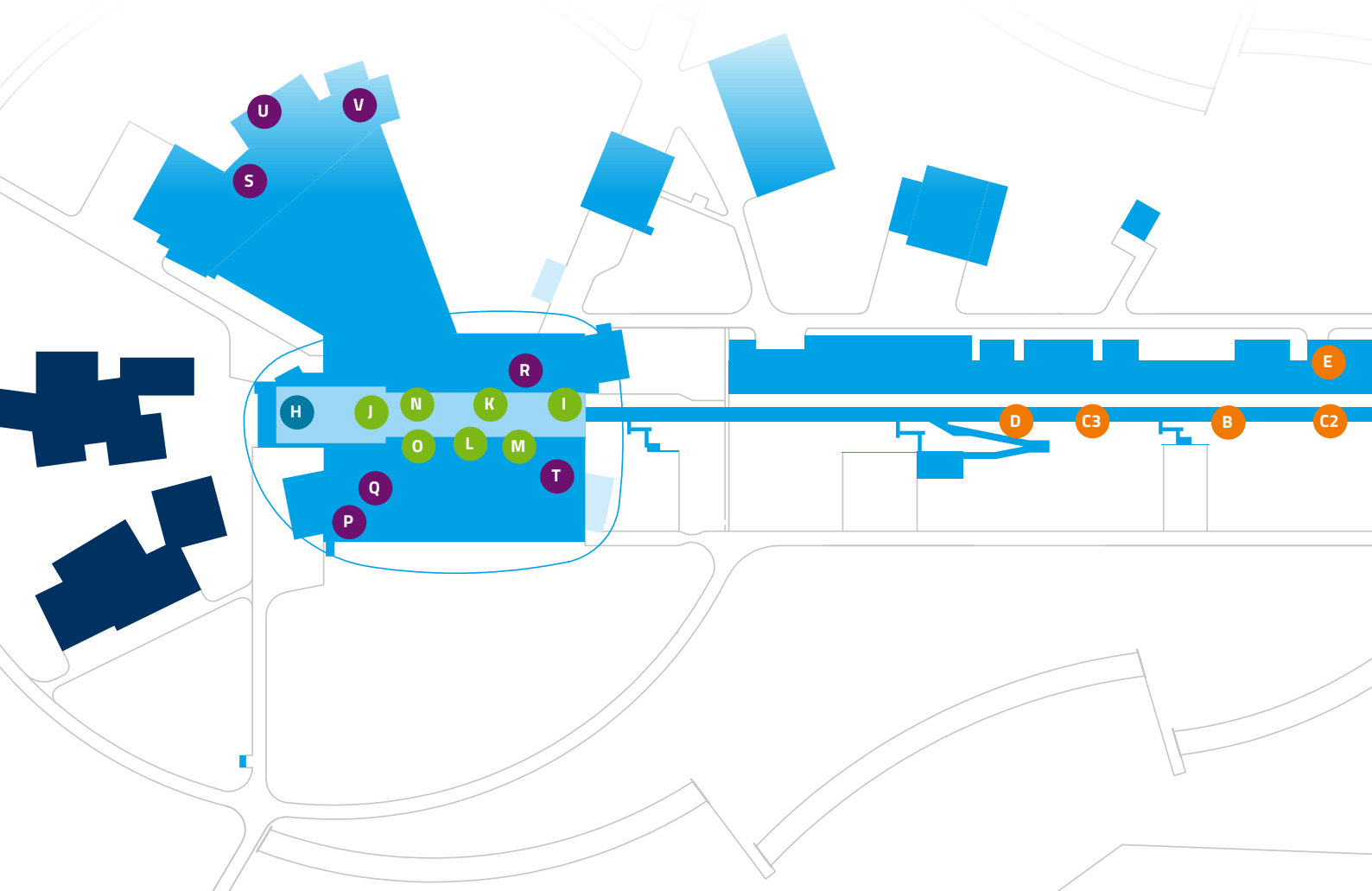
MIKAEL DAHLGREN
HEAD OF CORPORATE RESEARCH, ABB

PIA KINHULT
HEAD OF HOST STATE RELATIONS, ESS

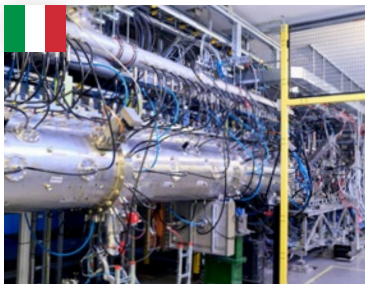
In-Kind Deliveries 2022

A large, high-tech puzzle made possible by in-kind contributions

ESS is working with more than 40 European partner institutions under the in-kind model. The ESS in-kind partners bring their knowledge, equipment, personnel, and experience to the project in the form of in-kind contributions (IKC), or non-cash contributions. The majority of the instruments, the target station and the accelerator are delivered as in-kind. During 2022 a substantial amount of in-kind deliveries made it to ESS in Lund – here are some of them.



Accelerator

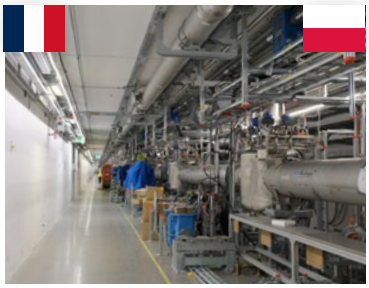


A

Drift tube linac tanks 2-4 installed

Accelerating structures, enabling next step of beam commissioning in normal conducting linac.

INFN, Italy



B

Commissioning of the cryogenic distribution system (CDS)

Transporting cold helium from the cryoplant to the cryomodules.

CDS, spoke section: CNRS/IJC Lab, France

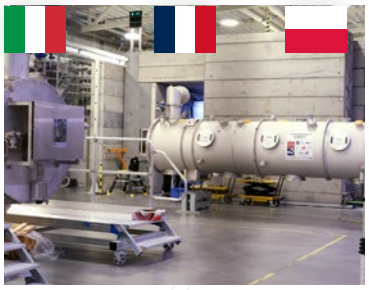
CDS, medium and high beta sections: WUST, Poland

C1

Spoke cryomodules tested, delivered and ready for installation

Manufactured by CNRS, France

Tested by Uppsala University, Sweden

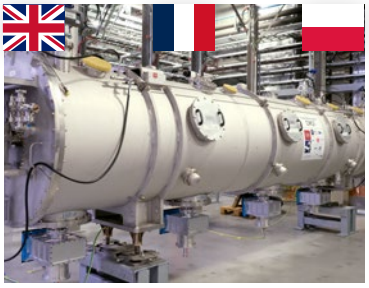


C2

Medium beta cryomodules delivered

Manufactured by CEA-Saclay, France with cavities from INFN, Italy

Tested by IFJ PAN, Poland

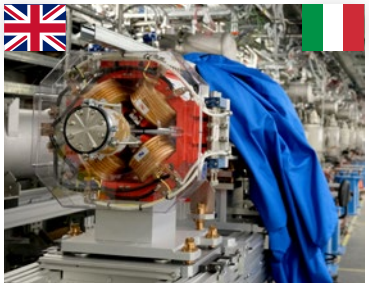


C3

High beta cryomodules delivered

Manufactured by CEA, France, with cavities from STFC, UK

Tested by IFJ PAN, Poland

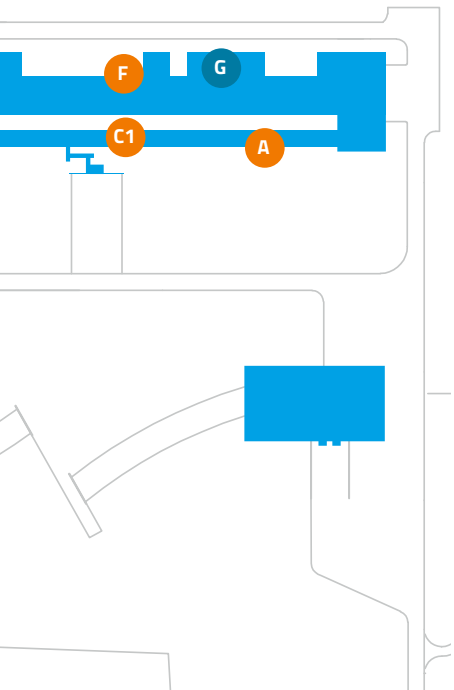


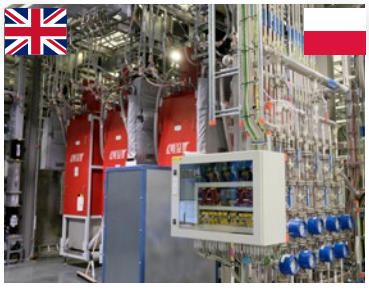
D

All 71 Linac Warm Units delivered

Contain strong quadrupole magnets to focus and steer the proton beam.

Assembled by STFC, UK with magnets supplied by INFN/Elettra, Italy.





E

Installation and testing of the radio frequency (RF) distribution system to the linac

Transporting high power from the RF source to the superconducting RF cavities

Supplied by: STFC, UK

Tested by: IFJ PAN, Poland

F

Half of the 26 spoke radio frequency power stations installed

Supporting the installation generating high power for the spoke cryomodules

Elettra, Italy

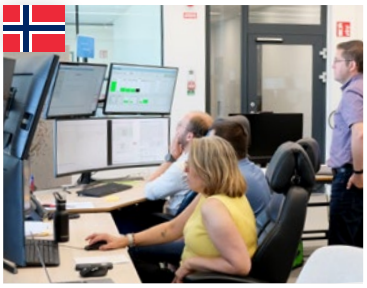
ICS

G

Machine protection system (MPS) for the ESS integrated control system (ICS)

Protects the equipment during neutron production and provides system feedback

ZHAW - Zurich University of Applied Sciences, Switzerland



H

MCR operational and equipped

For monitoring and control of the ESS facility's operations

IFE, Norway

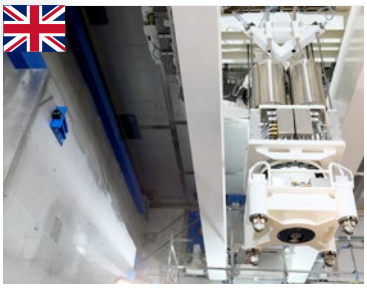
Target

I

Cryogenic moderator system installed

Moderator cooling system ready for commissioning

Forschungszentrum Jülich (FZJ), Germany



J

Grapple crane and shaft cutting station installed in the active cells

Securing safe handling and disposal of radioactive materials from the Target processes

UKAEA/RACE, UK

K

Target wheel, shaft and drive unit delivered and undergoing tests

The heart of ESS where spallation occurs

ESS Bilbao, Spain

L

The target moderator-reflector plug delivered

Slows down the neutrons after spallation to a speed suitable for the experiments

Forschungszentrum Jülich (FZJ), Germany

M

The target vessel connection ring delivered

Contains all media connections to the monolith via penetrations in the ring

ESS Bilbao, Spain

N

Primary and intermediate water cooling systems in place

Provides cooling for the target systems

Nuclear Physics Institute of the CAS, Czech Republic

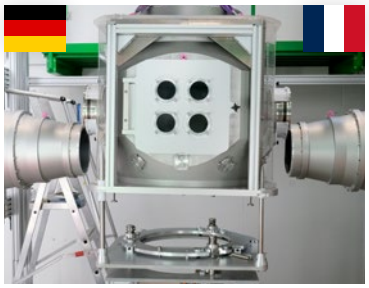
O

HVAC installed

Heating, ventilation and air conditioning for the target systems

Nuclear Physics Institute of the CAS, Czech Republic

Instruments



P

DREAM

Construction of an experimental cave and control cabin

Installation of a frame structure for the detector and sample vessel inside the cave

Forschungszentrum Jülich (FZJ), Germany and Laboratoire Léon Brillouin (LLB), France

Q

ODIN

Construction of a control cabin completed

The base slab for the experimental cave was cast

Technical University of Münich (TUM), Germany and Paul Sherrer Institute (PSI), Switzerland

R

LOKI

Installation of cave shielding walls around the detector tank

Delivery of collimation vessel

STFC/ISIS, UK

S

BIFROST

A sample stage, false floors and a get-lost tube installed inside the cave

Neutron guide installed from in-bunker to sample position

IFE – Norway, LLB – France, PSI – Switzerland, DTU - Denmark

T

ESTIA

In-bunker chopper system delivered and tested

Base slabs for experimental caves were cast for both ESTIA and adjacent instrument SKADI

PSI, Switzerland

U

Laboratories

In operation and supporting the installation community

Lab equipment from STFC/ISIS, UK and University of Tartu, Estonia

V

12 out of 16 neutron beam port inserts (NBPI) delivered

NBPIs provide an accurate extraction path for the neutrons from the target to the Instruments

Forschungszentrum Jülich (FZJ), Germany

ESS hosts the kick-off meeting of the Accelerating Teaching project

ESS is part of a consortium that received an ERASMUS+ grant for a project called "Accelerating Teaching – approaching particle accelerators and new scientific research through online professional development." The project's kick-off meeting was held at ESS on 19 & 20 October, with education partners from EU SchoolsNet, Malmö University, Copenhagen University, and Lund University (including MAX IV, Vattenhallen, and the Experimentarium science centre in Copenhagen) taking part either in person or online. Associate partners from CERN and Liverpool University joined remotely.

The project aims to enhance the relevance of science for students by reaching out to science teachers in the EU and offering free digital online teaching and learning resources relating to state-of-the-art research facilities and the science that comes out of them and will be provided via a Massive Open Online Course (MOOC).

Participants - in person and remotely - at the kick-off meeting for the Accelerating Teaching

The primary aspect of the project will be to construct the online resource, but it will also evaluate and explore teachers' experiences from the course and their use in classroom and non-classroom settings.

BrightnESS² Final General Assembly Meeting

Representatives of 16 organisations from Europe and South Africa gathered at ESS for the BrightnESS² Final General Assembly Meeting on 13 & 14 June 2022. The consortium of BrightnESS² project partners met to mark the completion of the three-and-a-half-year project and to celebrate its many achievements in strengthening Europe's neutron science community to ensure the long-term sustainability of ESS.

Participants at the BrightnESS² Final General Assembly Meeting

BrightnESS² is a European Union-funded project within the European Commission's Horizon 2020 Research and Innovation programme. Led by ESS, the 5 MEUR project kicked off in January 2019. BrightnESS² was structured to implement several key outcomes of the first BrightnESS project (2015-2018). This meeting ended the 25 MEUR, six-and-a-half-year collaboration to ensure ESS's scientific and organisational success.

The project has provided the support necessary to consolidate several groundbreaking initiatives. The project also partnered with the European Neutron Scattering Association (ENSA) to produce an AI-assisted granular analysis of the composition and needs of the sprawling European neutron user community.

ESS and J-PARC celebrated the renewal of their cooperation agreement

Helmut Schober, ESS Director General, and Takashi Kobayash, Director of J-PARC, at the ceremony

On 10 October, a ceremony was held at ESS to mark the extension of the agreement between ESS and J-PARC (Japan Proton Accelerator Research Complex). J-PARC is a high-intensity proton accelerator facility cooperating with ESS since 2012.

Among the guests at the event were J-PARC Director Takashi Kobayashi and Japan's Ambassador to Sweden, Noke Masaki. In conjunction, a two-day commissioning workshop was held involving staff from ESS and J-PARC. A tour of the ESS facility took place after the ceremony.

The renewed cooperation agreement, valid for five years, was signed in June 2022, but the decision was made to combine the renewal ceremony with the joint workshop.

Spain delivers the heart of ESS

Team members from ESS and ESS Bilbao inspect the target wheel during final testing before its onward journey to Lund

Vital technical components for the target have been delivered to ESS as part of Spain's contributions to the facility. The target wheel, shaft, and drive unit have been developed and manufactured by in-kind partner ESS Bilbao and will be installed at the core of the ESS target. Before installing the target wheel, shaft, and drive unit inside the target monolith vessel, the components will undergo thorough technical testing in the ESS mock-up test stand on site.

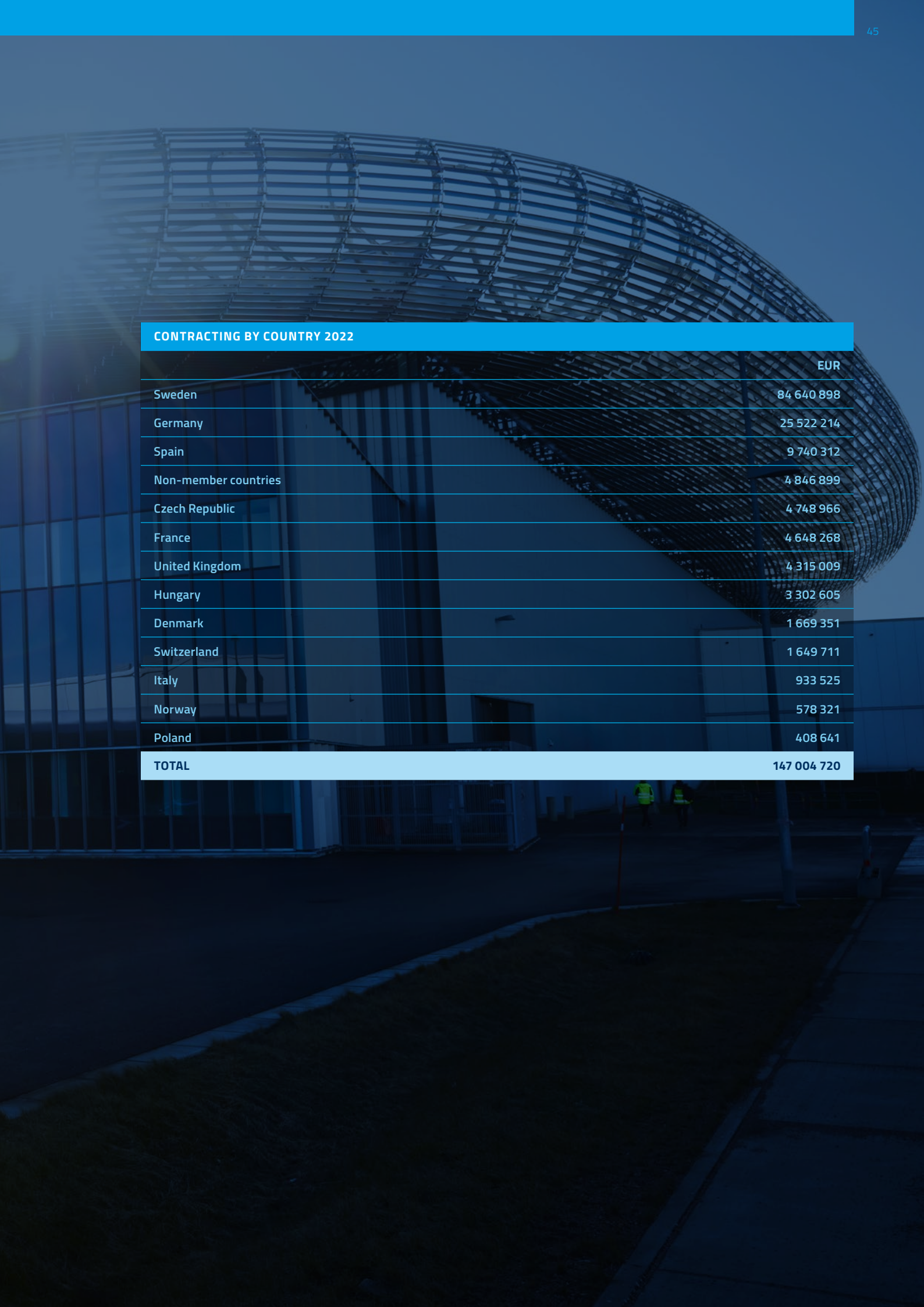
The target system components are an important contribution from Spain, provided through ESS Bilbao and its industrial suppliers AVS, Nortemecánica, and Thune Eureka. Spain is an essential contributor to the construction of the international research infrastructure and has been intensely engaged in the ESS project since the start.

Statutory Report

European Spallation Source ERIC
Corporate Identity No. 768200-0018

ESS Procurement Across European Member states

The table shows the procurement values (in EUR) of ESS procurement during 2022 for ESS member countries and non-countries (cumulatively). The data is based on contracts concluded for the period January – December 2022. The data includes all contracts and orders entered into by ESS, including, but not limited to, commercial contracts, consultancy agreements, rental agreements and collaboration agreements.



CONTRACTING BY COUNTRY 2022	
	EUR
Sweden	84 640 898
Germany	25 522 214
Spain	9 740 312
Non-member countries	4 846 899
Czech Republic	4 748 966
France	4 648 268
United Kingdom	4 315 009
Hungary	3 302 605
Denmark	1 669 351
Switzerland	1 649 711
Italy	933 525
Norway	578 321
Poland	408 641
TOTAL	**147 004 720**

Governance, Management and Advisory Committees

Delegates to the ESS Council

The European Spallation Source ERIC Council is composed of up to two delegates from each member country, in addition to a Chair and Vice Chair appointed by the Council.

Beatrix Vierkorn-Rudolph
Chair

Kurt Clausen
Vice Chair

Lukáš Levák
CZECH REPUBLIC

Petr Lukáš
CZECH REPUBLIC

Bo Smith
DENMARK

Jane Hvolbæk Nielsen
DENMARK

Toivo Räim
ESTONIA

Priit Tamm
ESTONIA

Sylvain RAVY
FRANCE

Marie-Hélène Mathon
FRANCE

Andrea Fischer
GERMANY

Martin Müller
GERMANY

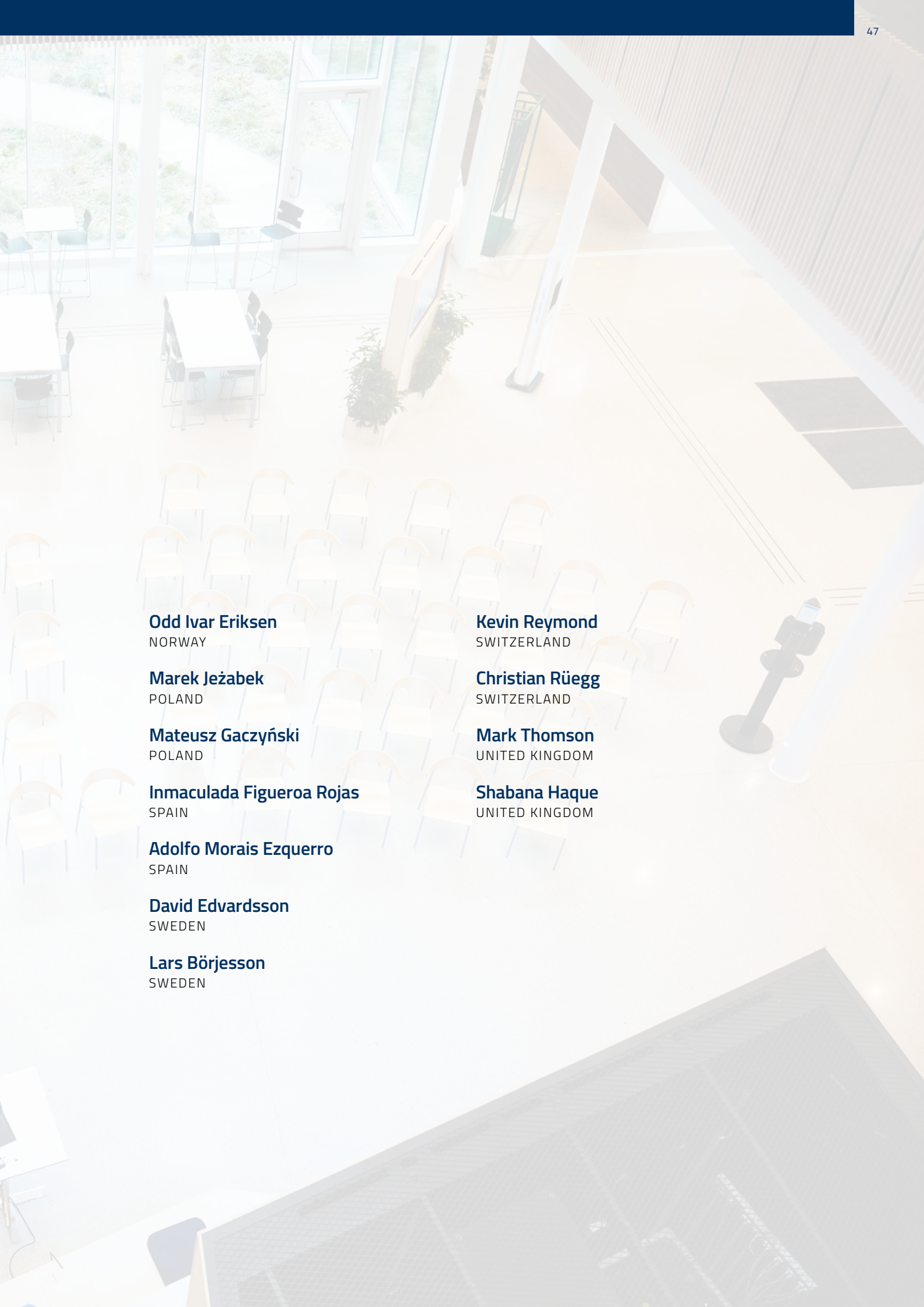
Ákos Horváth
HUNGARY

Balázs Kápli
HUNGARY

Pierluigi Campana
ITALY

Aldo Covello
ITALY

Current as of 31 December 2022



Odd Ivar Eriksen
NORWAY

Marek Jeżabek
POLAND

Mateusz Gaczyński
POLAND

Inmaculada Figueroa Rojas
SPAIN

Adolfo Morais Ezquerro
SPAIN

David Edvardsson
SWEDEN

Lars Börjesson
SWEDEN

Kevin Reymond
SWITZERLAND

Christian Rüegg
SWITZERLAND

Mark Thomson
UNITED KINGDOM

Shabana Haque
UNITED KINGDOM

ESS EXECUTIVE BOARD

Director General	**Helmut Schober**
Director for Project Support & Administration	**Agneta Nestenborg**
Director for Science	**Giovanna Fragneto**
Technical Director	**Kevin Jones**
Project Director	**Andrew Kimber**
Associate Director for In-Kind Management	**Dimitri Argyriou**
Head of Director General's office	**Karin Hélène**

ADMINISTRATIVE & FINANCE COMMITTEE (AFC)

Chair	**Stéphanie Lê Vàn**
Czech Republic	**Ondřej Svoboda**
Denmark	**Morten Scharff**
Denmark	**Line Bekker Poulsen**
Estonia	**Priit Tamm**
France	**Philippe Sassier**
France	**Roxanne Casemayou**
Germany	**Ingo Pfeil**
Germany	**Johanna Brandenburg**
Hungary	**Balázs Kápli**
Italy	**Ileana Gimmillaro**
Italy	**Antonella Tajani**
Norway	**Odd Ivar Eriksen**
Poland	**Michal Rybiński**
Poland	**Michal Wójtowicz**
Spain	**Guadalupe De Córdoba Lasunción**
Spain	**Javier Losada**
Sweden	**Johan Holmberg**
Sweden	**Mikaela Rapp**
Switzerland	**Xavier Reymond (Vice Chair)**
United Kingdom	**Philippa Kingston**
United Kingdom	**Laura Woodward**

Current as of 31 December 2022

TECHNICAL ADVISORY COMMITTEE (TAC)

Chair Alberto Facco

TAC TARGET

Co-Chair	Graeme Murdoch
Member	Christian Nyfeler
Member	Eric Pitcher
Member	Jürgen Neuhaus
Member	Kevin Jones
Member	Masatoshi Futakawa
Member	Michael Butzek

TAC ICS

Co-Chair	Markus Janousch
Member	Cyrille Berthe
Member	Eugenia Hatziangeli
Member	Freddie Akeroyd

TAC ACCELERATOR

Co-Chair	Mei Bai
Member	Glen Johns
Member	Igor Syratchev
Member	Joachim Grillenberger
Member	Mike Glover
Member	Robert Ferdinand
Member	Sara Thorin

SCIENTIFIC ADVISORY COMMITTEE (SAC)

Chair	Michael Preuss
Vice chair	Victoria Garcia Sakai
Member	Alberto Mengoni
Member	Alessandro Triolo
Member	Daniel Söderberg
Member	Elizabeth Blackburn
Member	Emmanuelle Dubois
Member	Giorgio Schiro
Member	Henrik Rønnow
Member	Jonathan White
Member	Klaus Habicht
Member	Luise Theil-Kuhn
Member	Mirijam Zobel
Member	Pascal Manuel
Member	William Stirling

IN-KIND REVIEW COMMITTEE (IKRC)

Chair	Robert McGreevy
Czech Republic	Petr Šittner
Denmark	Søren Pape Møller
Estonia	Piret Pikma
France	Alain Ménelle
Germany	Tania Claudio-Weber
Hungary	Viktória Sugár
Italy	Giuseppe Gorini
Norway	Erik Wahlström
Poland	Dariusz Bocian
Spain	Fiamma García-Toriello (Vice Chair)
Sweden	Jens Birch
Switzerland	Peter Allenspach
United Kingdom	Justin Greenhalgh

PROJECT ADVISORY COMMITTEE (PAC)

Chair	Mark Reichanadter
Member	Christiane Alba-Simionesco
Member	Diane Hatton
Member	Lina Rodríguez-Rodrigo
Member	Pedro Fernandes Tavares
Member	Reinhard Brinkmann
Member	Stuart Henderson
Member	Winfried Petry

Current as of 31 December 2022

COMMITTEE ON EMPLOYMENT CONDITIONS (CEC)

Chair	**Beatrix Vierkorn Rudolph**
Member	**Lukáš Levák**
Member	**Martin Müller**
Host State ex-officio member (SE)	**Katarina Bjelke**
Host State ex-officio member (DK)	**Bo Smith**

CHAIR'S COMMITTEE (CC)

Chair of Council	**Beatrix Vierkorn-Rudolph**
Vice Chair of Council	**Kurt Clausen**
Host State Delegate (SE)	**Lars Börjesson**
Host State Delegate (DK)	**Bo Smith**
Member	**Aldo Covello**
Member	**Marie-Hélène Mathon**
Ex-officio member	**Helmut Schober**
Ex-officio member	**Michela Dell'Anno Boulton**

Statutory Administration Report

The Director General of European Spallation Source ERIC (Corporate Identity No. 768200-0018), with its registered office in Lund, hereby submits the Annual Report for the financial year 1 January – 31 December 2022.

General information on the Company

European Spallation Source (ESS) is an ERIC, European Research Infrastructure Consortium, a legal form of organisation which the European Commission has developed to facilitate major European research facilities. Through the establishment of European Spallation Source ERIC, ESS has acquired a legal status in all member and observer countries, enabling the countries to participate in decision-making and directly contribute to the funding. See also Notes, Note 2.

ESS will be the next-generation neutron source, and will be one of the most powerful in the world when it is completed. The facility will be used for materials research in areas such as energy, health and environment, and will be of great importance in the long-term with regard to the competitiveness of Swedish and European research and industry. The facility is under construction on the outskirts of Lund and is scheduled to be in full operation with 15 instruments in 2028. The project is one of the largest research infrastructure projects in Europe, and is prioritised by the European Strategy Forum for Research Infrastructures (ESFRI).

ESS's operations comprise the research facility with associated Campus and laboratories in Lund, Sweden, and the Data Management and Software Centre (DMSC), in Copenhagen, Denmark. DMSC is operated through the Swedish company with its office in Copenhagen as an "overseas, other company" (Danish: Udenlandsk, anden virksomhed).

At the turn of the year, the personnel comprised 526 employees from 55 different nations.

In addition to its own activities, ESS collaborates with partners from all over Europe and other parts of the world. ESS has 13 member countries: Czech Republic, Denmark, Estonia, France, Germany, Hungary, Italy, Norway, Poland, Spain, Sweden, Switzerland and the United Kingdom.

When the ESS user programme is in full operation, an estimated two to three thousand researchers from around the world will conduct experiments at the facility each year.

In 2022, the new planning baseline was implemented, in particular taking into account the delays caused by the COVID-19 induced supply chain disruptions. Work will be rolled out according to this schedule, assuring project completion within the established cost, scope and schedule framework.

In-kind contributions

The ESS project is based on extensive collaboration with research institutions in member countries, to exchange knowledge, personnel, and experience. ESS is expected to be partially funded through in-kind contributions (approximately 30% of the total estimated construction cost, €1.843 billion, 2013 price level), where, in particular, significant parts of the instruments, the target station, and the accelerator will be delivered as in-kind. During the year, extensive work has continued to secure in-kind collaborations with partner institutions across Europe. More than 100 institutions are now actively involved in the ESS project.

Information on risks and uncertainties

Active and structured risk management contributes to successful execution of the ESS project and fulfilment of ESS's overall objectives. The knowledge ESS accumulates in relation to risks is used to further develop ESS's management system, personnel, and project plans.

ESS has a risk management framework, which is described in two main documents: ESS Risk Management Policy and ESS Risk Management Process. The Risk Management Policy describes in general why and how risk management work is to be carried out. The Risk Management Process describes processes and flow charts, as well as criteria for how risks are assessed at ESS. In addition to these two documents, the ESS Procedure for Risk Management specifies roles, responsibilities, and timeframes for risk-related activities within the organisation.

Risk management objectives

ESS has established the following risk management objectives:

- Frequent and open risk communication that enables a clear and shared view of risks and uncertainties within ESS, as well as among European partners, suppliers, etc.
- A continuously updated risk register for an overview of risks, uncertainties, and risk mitigation measures.

- Reduced risk exposure through rapid and active application of measures and mitigations.
- Focus on risks and uncertainties through effective risk reporting, internally and externally. Risk analyses should be based on qualitative estimates, as well as quantitative calculations, and decisions are made after careful consideration of the results of such analyses, in combination with an impact assessment.

Risks and uncertainties
Any potential event that may affect ESS's overall objectives poses a risk. Risk identification and risk analysis are part of ESS's daily work, and aim at contributing to effective risk management by providing increased insight into the consequences of a particular risk, as well as the probability that it might occur. Structured risk analysis enables comparisons, simplifies risk communication, and is crucial in understanding whether a risk is acceptable or not. A number of accident scenarios have been analysed, and these form the basis of the classification work on which the design of ESS's safety system is based.

Risks are judged from several different perspectives:

Risks related to personal injury
Health and accident risks are assessed for all activities performed, and also cover the management of radiation safety when ESS is in operation. This also includes managing risks related to accidents during the Construction Phase. Processes and rules for the work environment at ESS's construction site have been established in collaboration with our contractors. As the last buildings were handed over from the contractor to ESS in December 2021, ESS has also prepared new rules for personal protective equipment in the area and in the buildings where installation work is in progress. As an example, a reflective vest needs to be used when mobile in the area in order to minimise the risk of incidents. Inside the buildings where the work is in progress, safety helmets are a requirement, as are safety shoes, gloves and goggles. All risk observations, incidents and accidents are registered and followed up by the responsible manager.

Risks related to quality and function
Risks that could potentially impair the quality and thereby the function of technical structures, systems, and components are of great importance to ESS. To handle such risks, ESS continuously refines existing processes for configuration work, as well as rules for design and installation work. Processes and systems for quality management and governance have been continuously developed and implemented with an increasing demand, and in consultation with the ESS management team. Since May 2016, ESS has been a member of EFQM (European Foundation for Quality Management), and, through that network, is able to ensure a world-wide analysis of best practice in the area. Significant focus has been on compliance with the European Product Safety Directives applicable to ESS, and that these are also complied with by suppliers and collaborative partners.

Risks related to the environment and the surrounding area
ESS has the ambition of becoming the world's first major research facility with energy-sustainable operations, thereby paving the way for a new way of building and operating the facilities of the future. This means, among other things, that the facility will be energy efficient, that it will be supplied with electricity from renewable energy sources, and that some of the surplus heat will be utilised in the district heating network.

Other environmental risks are the handling of chemicals, surplus materials, and transport to and from the area. These risks are managed in accordance with current legislation and are followed up regularly with inspections of physical areas as well as associated documentation and processes.

Risks regarding society's view of ESS
ESS is committed to providing a positive social contribution to the local community in which the organisation is located; to operate the Company as a responsible social actor; to respect the laws, customs and needs regarding the countries that contribute to the development, construction and operation of the research facility; to respect internationally recognised human rights; and to act in an environmentally responsible way by minimising the environmental impact of the activities. In this way, ESS actively contributes to sustainable development. Sustainability is one of ESS's four core values: *Excellence, Openness, Collaboration, Sustainability.*

By 2014, ESS had already established a code of conduct based on the 10 principles of the UN's Global Compact relating to human rights, working conditions, the environment, and anti-corruption, as well as the International Chamber of Commerce's rules on

combatting corruption. As such, ESS has undertaken to comply with these principles and rules. The ESS Code of Conduct encompasses all employees and others who have ESS as their permanent or temporary workplace. ESS also requires equivalent codes of conduct of external collaboration partners. ESS evaluates its suppliers through competitive procurement processes in accordance with Article 23 of the European Spallation Source ERIC procurement rules. ESS may not invite any supplier to submit a bid, or award a contract, if the supplier, or its board of directors, or any other person empowered to represent, decide, or control the supplier when they:

a) have been convicted of any of the following offenses in the last three years: participation in criminal organisation, corruption, fraud, money laundering, terrorist offenses, or a crime related to terrorist activity, child labour, or other forms of illegal trafficking;

b) have failed to comply with current environmental, social, or labour laws in the last three years;

c) has not breached applicable anti-bribery and anti-corruption laws and regulations, trade embargoes, sanctions or other restrictive measures including, but not limited to, whether applicable locally or adopted by the United Nations, the European Union, the United Kingdom or the United States in the last three years;

d) are guilty of gross professional shortcomings, which cast doubt on the supplier's or tenderer's integrity;

e) are involved in, or in the past three years has been involved in, a secret agreement; or where the organisation has knowledge of the occurrence of any of the following circumstances:

f) have an unfair advantage that may distort competition as a result of the supplier's or tenderer's previous participation in the preparation of the procurement process in accordance with Article 28.4,

g) have significant previous shortcomings in the performance of previous contracts awarded by ESS,

h) have committed serious misrepresentation of information in that submitted as part of a tendering procedure, or

i) if the supplier or tenderer is in bankruptcy, or is subject to insolvency or liquidation, or is in an equivalent situation arising from a similar procedure under the laws and regulations of a state.

ESS often requests proof of quality assurance and sustainability, in accordance with ISO 9001 or ISO 14001, or equivalent.

ESS's general procurement terms include requirements on anti-corruption. The supplier shall guarantee that no offer, payment, remuneration, or benefit of any kind which constitutes an illegal or corrupt practice has been, or shall be, made, either directly or indirectly, as an inducement or reward for entering into the contract or implementing the agreement.

At a local level, since 2011, three years before the start of construction, ESS has built up and maintained a collaboration with Odarslöv's village team, an association that brings together those who live in the area around the facility. Between two and three times a year, ESS, via the village team, invites its neighbours to a presentation on what has happened at the facility and to show them around. Great emphasis is also placed on the visiting neighbours having the opportunity to ask questions, give opinions, and meet those responsible for ESS. These meetings are usually well attended and appreciated. Those who live closest to the facility also have their own telephone number for the area managers, where they can call in the event of disturbances, observations and other questions.

Risks regarding timetable
Risks related to the ESS timetable concern the processes and activities that could delay implementation of the project plan.

Risks regarding annual operational costs
In order to achieve ESS's overall objectives, a number of requirements related to the annual operational costs are required. Risks in the form of, for example, maintenance and service, energy consumption, downtime, insurance premiums, and/or loss of property have therefore been identified. Established plans and cost estimates for completing the project and transitioning to steady state operations post-2027 have been continuously evaluated and updated, and presented to the ESS Council.

Risks related to finances and funding
Understanding and managing risks that may have financial consequences in terms of exceeding the project budget are central to ESS, and are managed through established processes related to the identification and analysis of uncertainties in cost estimates. Each part of the project has its own budget, and each risk of exceedance is handled individually. Such measures are handled by the management team in a well-defined process.

The activities undertaken by ESS are funded by all member countries contributing to the financing. The new baseline implemented in 2022 (see section below on significant events during the year) led to additional funding requirements. These are currently being discussed with the members.

Sustainability Report

Environment

One of the cornerstones of ESS's operations is the environment, both in terms of the research that will be carried out at the facility and the actual construction and operation of the facility. As stated in the ESS Environmental Policy, the sustainability perspective and the life cycle perspective shall permeate all activities, and the Energy Guideline shall be implemented. As an example, the surplus heat produced in the facility will be utilised for the district heating network in the surrounding area (Brunnshög). This district heating system is a newly developed low-temperature concept enabling Lund municipality and ESS to re-use energy in a more efficient way than ordinary district heating systems. As the facility has not yet fully been commissioned, there is no data on the quantities.

During 2022, ESS declared the Construction Phase to be over and, with permission from the local County Board, commissioned all detention ponds of storm and drainage water from the site. With this, the most environmentally critical area, the Natura 2000 area Kungsmarken about a kilometre south of the property, can now receive water under regular monitoring from ESS. No discharges with significant impact have occurred to surrounding ditching companies during the whole period from the start of construction in 2014. Permanent delay dams have been created in such a way that they have a natural function in the landscape, including as intrusion protection at the main entrance.

The move into the new office on the ESS Campus began in January 2021. In the spring of 2022, ESS declared the pandemic to be over and the office building could be fully occupied for the first time. The office building has been awarded the rating Outstanding, the highest level in the sustainability standard provided by BREEAM international.

All suppliers who have components or tools to be installed in or used at ESS shall ensure that these comply with EU regulations in relation to CE marking. This applies to both external suppliers and deliveries from in-kind partners.

Social and stakeholder responsibility

ESS stays within the permissible noise levels regulated in the environmental judgement, and has special contact channels with the nearby residents to inform about ongoing and upcoming work, and to receive any complaints. As with previous years, forty of the immediate neighbours around the Lund site were also invited in person to see progress of the project.

ESS welcomed 5111 visitors in 1578 groups in 2022. While in January and February most of the world remained closed due to the Corona virus, ESS stayed open for business-critical visits in order to keep the project on time and on budget. For this reason, most of our visitors came to ESS for business-related reasons. From spring, ESS experienced a high interest from diplomatic corps: we welcomed the Ambassadors of Japan, USA, Australia and Argentina, as well as a total of 21 European Ambassadors. ESS renewed its cooperation agreements with the J-Parc and ILL facilities during the year in a framework of respective ceremonies at the ESS campus. In October, we welcomed our future neutron users at the ESS-ILL Joint User meeting, organised in Lund. 350 potential future users visited ESS at this event. For the first time, the Royal Swedish Academy of Sciences held a symposium at ESS, where members of the Physics class and other participants could learn about the project update while taking a long walk around different parts of the facility. At the same time, ESS continued its engagement with public audiences.

ESS has started implementing the new Strategy for Public Engagement which covers the period until First Science, and outlines priority public and school audiences, and key themes of, for example, engaging with educators and creating opportunities for researcher-public interactions.

ESS participated in an event involving over 2000 members of the public in Copenhagen for Culture Night. Staff members from ESS, including many from DMSC, had meaningful conversations with over 400 adults and children about what ESS is, what it is for, and how it works, and the same number again tested our interactive demonstrations and visited our welcome desk.

We also ran a pilot artistic residency scheme with seven artists from four different continents working via video with people from ESS. The residency was funded by the European Regional Development Fund through Wisdome Innovation, and is a collaboration between Malmö Museums, Lund University's Inter Arts Center (IAC) and ESS. The project culminated with a public exhibition at the Inter Arts Center in Malmö, as well as

a live-streamed seminar, and a visit to the ESS site for artists and the project partners.

Environment, Safety & Health and Quality

The Environment, Safety & Health (ESH) and Quality (Q) Divisions play a key role at ESS, and shall ensure that safety and quality requirements are implemented throughout the organisation and during the actual construction of the facility.

During 2022, the Quality Division has enforced a specific programme for mitigating quality defects, specifically arising from the in-kind partners.

ESH ensures ESS's safety and environmental objectives for personnel and users, as well as the surrounding area. This is done by setting requirements regarding the design, installation, and operation of the facility, among other measures. ESH has an important duty in coordinating and leading the work in order to obtain the required permits from Swedish authorities. The largest and most important task is the permit for ionising radiation, which is being handled by the Swedish Radiation Safety Authority (SSM).

In 2022, ESS received the additional permit for installation of the NSS instruments and the Waste building. Since 2020, ESS has a permit for trial operation of the first 50 m of the accelerator, the so-called Normal Conducting Linac (NCL).

Personnel

All personnel working at ESS are required to comply with the ESS Code of Conduct. It consists of rules describing responsibilities and appropriate procedures for employees at ESS. The rules define business principles, values and norms, and appropriate behaviour for ESS personnel.

The Work Environment Policy at ESS regulates that well-being and health are important issues for the organisation. The ESS Work environment policy clearly describes the ESS´ direction in regards to Work environment. The key points in the policy are the following:

- Prevent injury and ill-health
- Meet all legal requirements
- Ensure that health, safety and well-being are an integral part of our organisation, and are actively supported through management leadership and commitment
- States that it is also employees' responsibility to contribute to a good and safe working environment
- A new policy for safety and health was issued in June 2022. The original Work Environment Policy has not yet been made obsolete, but the intention is to consolidate the two documents during 2023.

At ESS, the distribution of the number of employees is 73% men and 27% women. A more even gender distribution is sought.

The number of sick leave cases has previously been low, with a decrease during 2021. In 2022 there was an increase of 61% compared with 2021. An explanation for this is an increase of registered long-term sick leave cases and an impact of working in the office after the pandemic.

No serious accidents were reported during 2022.

Respect for human rights

The diversity of ESS's employees is its strength. ESS wants to create an inclusive work environment where each employee is valued and individual achievement is recognised.

ESS does not tolerate discriminatory behaviour, either in recruitment or in our daily interaction with each other. We strive to develop the full potential of our employees, regardless of external conditions. To do that, we endeavour to identify and remove obstacles in our thinking and in our processes.

In all procurements, the supplier is required to sign a Declaration of Honour Regarding Exclusion Criteria, which means that they certify that someone in a leading position has not committed a number of defined crimes, including child labour and human trafficking, as well as that they have had no advantage or otherwise committed fraud in the procurement. In addition, clause 8.6 of the ESS's general procurement conditions stipulates that a breach of this clause means that the contract may be terminated. This procedure follows that used by the European Union. No deviations from the requirements have been noted during 2022.

The diversity of the workforce and an open and appreciative culture are important success factors in a globalised world, and with many employees from different countries, cultural diversity is a well-established part of everyday life at ESS.

Anti-corruption

The ESS Code of Conduct specifies that the organisation actively works against corruption in all its forms, including extortion, bribery and other influences directed at the organisation, any of its employees, or related parties. In addition, a Code of Ethics in Contracting has been developed.

This means that ESS has prepared a regulatory framework for how procurements shall be conducted based on five items, where integrity is item 3 with the wording "All procurements shall be carried out in an impeccable manner with full objectivity and without benefits for any person or organisation".

The document Declaration of Honour Regarding Exclusion Criteria contains, in addition to the declaration that no crime has been committed against other people, a declaration that the Company has been guilty of or engaged in something that may be considered corruption. Section 8.6 of the ESS's general procurement conditions also stipulates that a contract can be terminated if the requirements are not met or violated. No deviations from the requirements have been noted during 2022.

Significant events during the year

The year 2022 was marked by the implementation of the new project plan. This so-called re-baselining was made necessary by the COVID-19 pandemic. The pandemic had affected the project via severe supply chain disruption. Many of ESS's suppliers are located in countries where they had to comply with strict local lockdown policies, and as such were not able to complete or deliver equipment to ESS as planned. The re-baseline project was executed during the year 2021, with the stated goal of setting a new schedule for the completion of the facility and investigating what additional costs would be incurred as a result. In November 2021, the new plan was carefully scrutinised by an extended Project Advisory Committee (PAC) meeting. PAC recommended the new plan to be implemented from January 2022. Furthermore, ESS was asked to complete, in parallel, the resource loading of the plan, which led to the final implementation of the Performance Measuring Baseline (PMB) in April 2021. The new plan engages ESS to complete the project by the end of 2027, at which point the user programme is started on at least eight out of the 15 first instruments, with the remaining instruments at the final stages of hot commissioning. The accelerator will possess 2 MW capability, and the target will deliver the corresponding neutronic performance. To reach this goal, both ESS and its Council agreed on the need to improve project execution management and to implement organisational changes to enhance project performance. The necessary actions were bundled within the Performance Enhancement Programme. The first stage of the programme has delivered a new organisational structure implemented as of January 2023, and an improved project management structure to be presented to the Council meeting in February 2023.

One of the many major milestones of the project achieved in 2022 was the successful feeding of a nominal proton beam through the RFQ and the first Drift Tube Linac.

Expected future development and significant risks and uncertainties

ESS is a highly complex technical project. At the current state developments work is finalised for most parts of the installation. The success of the project will now hinge on the quality of the equipment delivered and on its successful integration into systems during the installation. ESS will have to show high reactivity in dealing with quality and integration issues as they arise to keep its ambitious schedule. Particular attention will be given equally to the licensing process as it conditions the commissioning of the various parts of the facility. Last but not least, the extra financial contribution made necessary by the project extension into the years 2026 and 2027 must pass the national approval processes to provide ESS with financial planning security.

The development of the Company's financial performance and position

The net result for the year amounted to MSEK –1 451 (–1 256). The result includes costs for personnel and consultants, as well as the administrative and technical infrastructure during the Construction Phase. Equity amounted to MSEK 7 042 (5 274).

Investments

Investments were made during the year in fixtures and fittings, and ongoing new facilities totalling MSEK 642 (1 173).

Financing and liquidity

During its fiscal year 2022, ESS received cash contributions from member countries totalling MSEK 3 219 (2 461). Further information on the contributions received can be found in Note 18. Cash and cash equivalents amounted to MSEK 3 167 (2 513).

Income Statement

TSEK	2022-01-01 – 2022-12-31	2021-01-01 – 2021-12-31
Net turnover	0	0
Gross result	**0**	**0**
Administration expenses (Note 4, 5, 6)	–536 454	–544 944
Research and development expenses (Note 4, 6)	–900 735	–699 980
Other operating income (Note 7)	36 545	24 871
Other operating expenses	0	–6 518
Operating result	**–1 400 644**	**–1 226 571**
Financial income (Note 8)	6 730	0
Financial expenses (Note 9)	–56 651	–29 609
Result after financial items and before tax	**–1 450 565**	**–1 256 179**
Tax (Note 10)	0	0
RESULT FOR THE YEAR	**–1 450 565**	**–1 256 179**

Balance Sheet

TSEK	2022-12-31	2021-12-31
ASSETS		
Non-current assets		
Buildings (Note 11)	5 770 488	5 687 399
Land (Note 12)	64 250	64 250
Equipment, tools and installations (Note 13)	64 399	64 538
Construction in progress (Note 14)	2 152 818	1 786 190
Total non-current assets	8 051 955	7 602 377
Current assets		
Accounts receivable	3 856	863
Current receivables (Note 15)	89 857	144 047
Current tax receivables	17 014	24 522
Prepaid expenses and accrued income (Note 16)	43 310	43 305
Cash and bank balances	3 166 583	2 513 054
Total current assets	3 320 620	2 725 791
TOTAL ASSETS	**11 372 575**	**10 328 168**

TSEK	2022-12-31	2021-12-31
EQUITY AND LIABILITIES		
Equity		
Capital contribution (Note 18)	8 492 743	6 503 342
Net result	–1 450 565	–1 256 179
Total equity	7 042 178	5 274 163
Long-term liabilities		
Liabilities to credit institutions (Note 19)	2 577 145	3 633 559
Current liabilities		
Accounts payable	150 453	327 812
Current tax liabilities	0	8 505
Other current liabilities (Note 20)	1 094 219	642 722
Accrued expenses and prepaid income (Note 21)	508 580	441 407
Total current liabilities	1 753 252	1 420 446
TOTAL EQUITY AND LIABILITIES	**11 372 575**	**10 328 168**

Equity

TSEK	Cash contribution	Previous year's result	Result for the year	Total equity
Opening balance, 2021-01-01	10 261 775	–6 192 333	-	4 069 442
Contributions received	2 460 900	-	-	2 460 900
Net result 2021	-	–1 256 179	-	–1 256 179
Opening balance, 2022-01-01	12 722 675	–7 448 512	-	5 274 163
Contributions	3 218 580	-	-	3 218 580
Net result 2022	-	-	–1 450 565	–1 450 565
CLOSING BALANCE, 2022-12-31	**15 941 255**	**–7 448 512**	**–1 450 565**	**7 042 178**

Cash Flow Analysis

TSEK	2022-01-01 – 2022-12-31	2021-01-01 – 2021-12-31
Operating activities		
Result after financial items	–1 450 565	–1 256 179
Adjustment for non-cash items	192 685	18 289
Cash flow from operating activities before changes in working capital	–1 257 880	–1 237 890
Cash flow from changes in working capital		
Increase (–) / Decrease (+) of operating receivables	58 700	65 704
Increase (+) / Decrease (–) of operating liabilities	–103 146	–23 361
Cash flow from operating activities	–1 302 326	–1 195 547
Investment activities		
Acquisition of tangible fixed assets (Note 12, 13)	–21 736	–32 850
Acquisition of construction in progress (Note 14)	–620 527	–1 139 870
Cash flow from investment activities	–642 263	–1 172 720
Financing activities		
Cash contributions	3 218 581	2 460 900
Loans	0	791 598
Amortisation	–620 463	0
Cash flow from financing activities	2 598 118	3 252 498
Cash flow for the year	**653 529**	884 231
Cash and cash equivalents at the beginning of the year	2 513 054	1 628 823
Cash and cash equivalents at the end of the year	3 166 583	2 513 054

Notes

NOTE 1: BASIC ACCOUNTING PRINCIPLES

The annual report has been prepared in accordance with the Swedish Annual Accounts Act (Swedish: *Årsredovisningslagen*) and the Swedish Accounting Standards Board's general advice BFNAR 2012:1 Annual report and group consolidation (K3) (Swedish: *Bokföringsnämndens allmänna råd BFNAR 2012:1 Årsredovisning och koncernredovisning* (K3)).

The Company's registered office etc.

European Spallation Source ERIC (ESS) is a European Research Infrastructure Consortium, which is a legal entity and has its registered office in Lund, Sweden. The head office's visiting address is Partikelgatan 2 in Lund, with post box address P.O. 176, 221 00 Lund, Sweden. The Company's corporate identity No. is 768200-0018.

Classification etc.

Fixed assets, long-term liabilities and provisions in all materials aspects consist only of amounts expected to be recovered or paid after more than twelve months from the balance sheet date. Current assets and current liabilities n all materials aspects consist only of amounts expected to be recovered or paid within twelve months from the balance sheet date.

Valuation principles etc.

Assets, provisions and liabilities have been valued at acquisition value, unless otherwise stated below. ESS comprises the operations with the facility under construction in Lund, Sweden, and the Data Management and Software Centre (DMSC) in Denmark. DMSC is operated by the Swedish company with its headquarters in Copenhagen as an overseas second company (Danish: *udenlandsk, anden virksomhed*). As for DMSC, monetary items in the balance sheet are valued at the rate when closing the accounts and profit and loss items at the closing rate for each month.

Tangible fixed assets

Tangible assets are recognised as assets if it is probable that future economic benefits will accrue to the business, and the cost of the asset can be measured reliably. Tangible fixed assets are stated at acquisition cost after deductions for accumulated depreciation and any impairment. The acquisition value includes the purchase price as well as costs directly attributable to the asset in order to bring it to the location and condition to be utilised in accordance with the intended purpose. Other additional expenses are recognised as an expense in the period in which they arise. Decisive in the assessment of when an additional expense is added to acquisition value is whether the expense relates to the replacement of identified components, or parts thereof, in which case such expenses are capitalised. Even in cases where a new component has been added, the expense is added to the acquisition value. Any undepreciated reported values of replaced components, or parts of components, are discarded and expensed in connection with the replacement.

Depreciation according to schedule

Depreciation according to schedule is based on the original acquisition values less estimated residual value. Depreciation is linear over the asset's estimated lifetime.

The following depreciation schedules are applied:
Buildings: 25–45 years
IT equipment: 3–5 years
Machinery and equipment: 5–10 years

Impairments

The recorded value of the Company's assets is checked each balance sheet date to determine if there is any indication of the need for impairment. If any such indication exists, the asset's recoverable value is calculated as the higher of value in use and net realisable value.

Impairment is recognised if the recoverable value is less than the recorded value. When calculating the value in use, future cash flows are discounted at an interest rate before tax in order to take into account the market's assessment of risk-free interest and risk associated with the specific asset. An asset that is dependent on other assets is not considered to generate any independent cash flows. Such an asset is instead attributed to the smallest cash-generating unit where the independent cash flows can be determined.

An impairment is reversed if there has been a change in the calculations used to determine the recoverable value.

A reversal is only made to the extent that the assets balance sheet value does not exceed the balance sheet value that would have been recognised, less depreciation, if no impairment had been made.

ESS conducts non-profit activities in accordance with the requirements of the EU regulation relating to an ERIC. Financing the future operation of the facility is planned to be take place through contributions that guarantee full cost coverage. This means that the assessment of external and internal indicators regarding the assessment of need for impairment for ESS, in accordance with K3 regulations, is applied taking into account ESS ERIC´s specific conditions. This specific application complies in all material respects with the principles and methods as expressed in the "Draft accounting statement from FAR Impairments in municipal companies that are covered by the Local Government Act's cost principle" (Swedish: *Utkast till redovisningsuttalande från FAR Nedskrivningar i kommunala företag som omfattas av kommunallagens självkostnadsprincip*), which is thereby similarly applied to ESS.

Receivables

Receivable are recognised at acquisition value, less any impairment.

Receivables and liabilities in foreign currencies

Receivables and liabilities in foreign currencies have been translated at the exchange rate on the balance sheet date. Exchange rate differences in operating receivables and operating liabilities are included in the operating result, while differences in financial receivables and liabilities are recognised under financial items.

Short-term investments

Short-term investments are valued in accordance with the Swedish Annual Accounts Act (Swedish: *Årsredovisningslagen*) at the lower of acquisition value and fair value.

Financial instruments

A financial asset or financial liability is recorded in the balance sheet when the Company becomes a party to the instrument's contractual terms. Accounts receivable are recorded in the balance sheet when the invoice has been sent. Accounts receivable are recorded when the invoice has been sent. A financial asset is removed from the balance sheet when the contractual rights are realised, expire, or the Company loses control over them. A financial liability is removed from the balance sheet when the contractual obligation is fulfilled or otherwise extinguished.

Leasing

All leasing agreements are recognised in accordance with the rules operational leasing. Leasing fees are expensed over the term, based on the usage, and taking into account benefits provided or received at the signing of the agreement.

Cash and cash equivalents

Cash and cash equivalents include cash, immediately available bank balances recalculated at the exchange rate on the balance sheet date, and other money market instruments with original maturities of three months or less. Money market instruments are generally valued at accrued acquisition value.

Accounts payable

Accounts payable have a short expected maturity, and are valued without discounting at the nominal amount.

Remuneration to employees

Defined contribution pensions

Operational payments relating to defined contribution pension plans are recognised as an expense during the period in which the employee performed the services to which the charge relates. Consequently, no actuarial assumptions are necessary in order to calculate the obligation or the cost, and there is no possibility of any actuarial gains or losses. The obligation is calculated without discounting, except in cases where they are not entirely due for payment within twelve months after the end of the period during which the employees perform the related services.

Tax

The tax consists of current tax and deferred tax. Taxes are recognised in the income statement, except where the underlying transaction is recognised directly against equity, whereby the associated tax effect is recognised in equity. Current tax is tax that shall be paid or received for the current year. This includes adjustment of current tax attributable to previous periods. Deferred tax is calculated according to the balance sheet method, based on temporary differences between the recognised and taxable values of assets and liabilities. The amounts are calculated based on how the temporary differences are expected to be settled, and by applying the tax rates and tax rules adopted or announced at the balance sheet date. Temporary differences are not taken into account in the differences attributable to participations in subsidiaries

and associated companies that are not expected to be taxed in the foreseeable future. Untaxed reserves are reported including deferred tax liabilities. Deferred tax assets relating to deductible temporary differences and unused tax losses are only recognised to the extent that it is probable that these will result in lower tax payments in the future.

Contributions

ESS is financed partly with cash and partly with in-kind contributions (non-financial contributions) from the member countries.

Cash contributions

Received contributions from members are recognised in equity in the balance sheet. For a summary of the contributions received, see note 18.

In-kind contributions

The process for approving in-kind contributions during the construction phase is performed by a committee (In-kind Review Committee). The committee reviews underlying agreements and recommends them to the ESS Council, with delegates from the member countries, for final approval. Following this approval, final documented agreements between the parties regarding the value of completed deliveries and signed contribution documents from the contributors are required in order for the in-kind contributions to be recorded.

NOTE 2: RELATED PARTIES WITH A CONTROLLING INFLUENCE

The Council is the highest governing body of the organisation, which consists of up to two delegates from each member of the organisation. The delegates may be assisted by experts. Each member is entitled to the number of votes corresponding to its contribution to the planning and construction costs. Observers are entitled to participate in the Council but have no voting rights.

NOTE 3: SIGNIFICANT EVENTS AFTER THE END OF THE FINANCIAL YEAR

No significant events have occurred after the financial year.

NOTE 4: EMPLOYEES, PERSONNEL COSTS, AND FEES TO AUDITORS

AVERAGE NUMBER OF EMPLOYEES

SWEDEN	2022-01-01 – 2022-12-31	2021-01-01 – 2021-12-31
Men	353	342
Women	139	142
Total	492	484
DENMARK		
Men	30	33
Women	3	5
Total	33	38
TOTAL	**525**	**522**

GENDER DISTRIBUTION IN COMPANY MANAGEMENT

	2022-12-31	2021-12-31
Number of senior executives	8	8
Of which are women	38%	25%

SALARIES, OTHER REMUNERATION AND SOCIAL SECURITY COSTS		
TSEK	2022-01-01 – 2022-12-31	2021-01-01 – 2021-12-31
Sweden	330 642	326 815
Denmark	35 154	29 053
TOTAL	365 796	362 377
Social security costs	102 257	101 074
Pension costs incl. salary tax	86 196	87 246
TOTAL SOCIAL SECURITY AND PENSION COSTS	188 452	188 320
Salaries and other remuneration include:		
to the Director General	2 018	3 180
to other executives in senior management	12 042	13 001

REMUNERATION TO SENIOR EXECUTIVES 2022				
TSEK	Basic salary	Other benefits	Pension costs	Total
Director General	1 965	53	694	2 712
Other senior executives (8 ppl)	12 003	39	2 369	14 411
TOTAL	**13 968**	**92**	**3 063**	**17 123**

REMUNERATION TO SENIOR EXECUTIVES 2021				
TSEK	Basic salary	Other benefits	Pension costs	Total
Director General	3 143	36	844	4 023
Other senior executives (8 ppl)	12 947	55	2 673	15 675
TOTAL	**16 090**	**91**	**3 517**	**19 698**

Incentive programme

ESS does not have an incentive programme.

Severance pay to senior executives

The Director General and other senior executives' employment agreements do not include commitments for severance pay.

FEES AND REMUNERATION TO AUDITORS		
TSEK	2022-01-01 – 2022-12-31	2021-01-01 – 2021-12-31
Audit assignment, KPMG	399	399
Other assignments:		
KPMG	38	92
TOTAL	**437**	**491**

Audit assignments refer to the review of the Annual Report and accounts, other duties that are the responsibility of the Company's auditors to perform, and advice or other assistance which have arisen from observations during such a review, or the implementation of such duties.

NOTE 5: LEASING FEES RELATING TO OPERATIONAL LEASES		
TSEK	2022-01-01 – 2022-12-31	2021-01-01 – 2021-12-31
Leasing agreements where the Company is the lessee:		
Minimum leasing fees	11 769	20 324
Variable fees	35	10
TOTAL LEASING COSTS	**11 804**	**20 334**
Agreed future minimum leasing fees relating to non-cancellable contracts which are due for payment:		
Within a year	8 605	7 695
Between two and five years	10 179	4 922
TOTAL	**18 784**	**12 617**

NOTE 6: DEPRECIATION		
TSEK	2022-01-01 – 2022-12-31	2021-01-01 – 2021-12-31
Depreciation according to plan, distributed by asset:		
Buildings	–170 811	–572
Equipment, tools and installations	–21 875	–17 717
TOTAL	**–192 686**	**–18 289**

NOTE 7: OTHER OPERATING INCOME		
TSEK	2022-01-01 – 2022-12-31	2021-01-01 – 2021-12-31
Exchange rate gains on receivables/liabilities of an operational nature	9 691	0
EU project grants	16 198	19 229
Other operating income	10 656	5 642
TOTAL	**36 545**	**24 871**

NOTE 8: FINANCIAL INCOME		
TSEK	2022-01-01 – 2022-12-31	2021-01-01 – 2021-12-31
Interest income	6 730	0
TOTAL	**6 730**	**0**

NOTE 9: FINANCIAL EXPENSES		
TSEK	2022-01-01 – 2022-12-31	2021-01-01 – 2021-12-31
Interest expenses	–56 651	–29 609
TOTAL	**–56 651**	**–29 609**

NOTE 10: TAX ON THE RESULT FOR THE YEAR		
TSEK	2022-01-01 – 2022-12-31	2021-01-01 – 2021-12-31
Current tax	0	0
Deferred tax	0	0
TOTAL	**0**	**0**

ESS currently has costs that incur ongoing losses from an income tax perspective. Uncertainty regarding the possibilities and timeframe to be able to utilise these unused tax losses means that no deferred tax has been entered. Unused tax losses amounts to 7 753 989 TSEK (6 304 644 TSEK).

NOTE 11: BUILDINGS		
TSEK	2022-12-31	2021-12-31
Accumulated acquisition values:		
At the beginning of the financial year	5 688 734	22 879
Transfer from work in progress	253 899	5 665 855
TOTAL	5 942 633	5 688 734
Accumulated depreciation according to plan:		
At the beginning of the financial year	–1 335	–763
Depreciation according to plan	–170 810	–572
Closing accumulated depreciation	–172 145	–1 335
TOTAL NET VALUE	**5 770 488**	**5 687 399**

NOTE 12: LAND		
TSEK	2022-12-31	2021-12-31
Accumulated cost of acquisition:		
At the beginning of the financial year	64 250	64 250
Sales	0	0
TOTAL	**64 250**	**64 250**

NOTE 13: EQUIPMENT, TOOLS AND INSTALLATIONS		
TSEK	2022-12-31	2021-12-31
Accumulated acquisition values:		
At the beginning of the financial year	123 160	90 310
Acquisitions	21 736	32 850
TOTAL	144 896	123 160
Accumulated depreciation according to plan:		
At the beginning of the financial year	–58 622	–40 903
Depreciation according to plan	–21 875	–17 719
Closing accumulated depreciation	–80 497	–58 622
TOTAL NET VALUE	**64 399**	**64 538**

NOTE 14: CONSTRUCTION IN PROGRESS		
TSEK	2022-12-31	2021-12-31
Accumulated acquisition values:		
At the beginning of the financial year	1 786 190	6 312 175
Acquisitions	620 527	1 139 870
Transfer to buildings	–253 899	- 5 665 855
TOTAL	**2 152 818**	**1 786 190**

NOTE 15: CURRENT RECEIVABLES		
TSEK	2022-12-31	2021-12-31
VAT receivables	87 659	142 510
Receivables, contributions from member countries	2 155	1 262
Other	43	275
TOTAL	**89 857**	**144 047**

NOTE 16: PREPAID EXPENSES AND ACCRUED INCOME

TSEK	2022-12-31	2021-12-31
Prepaid insurance premiums	7 884	10 544
Accrued income, EU projects	27 853	22 871
Accrued interest income	906	395
Other	6 667	9 495
TOTAL	**43 310**	**43 305**

NOTE 17: FINANCIAL INSTRUMENTS AND FINANCIAL RISK MANAGEMENT

Finance policy
No financial instruments have been used to hedge flows or the Balance Sheet.

Liquidity risks and interest rate risks
Cash surpluses are placed in bank accounts or other equivalents.

Credit risks
Credit risks are considered limited, as the Company's other receivables are low in amount.

Exchange rate risks
Exposure to exchange rate fluctuations has been low, and the exchange rate results that occurred during the year relate to exchange rate differences on account payables and bank balances, mainly in EUR.

NOTE 18: CAPITAL CONTRIBUTION		
TSEK	2022-12-31	2021-12-31
Czech Republic	290 316	234 774
Denmark	2 278 700	1 873 457
Estonia	33 119	25 710
France	834 798	572 255
Germany	2 438 313	2 072 048
Hungary	71 269	71 269
Italy	466 255	411 190
Norway	524 272	428 386
Poland	215 835	169 534
Spain	276 928	46 822
Sweden	5 787 033	4 608 033
Switzerland	450 488	383 757
United Kingdom	1 428 316	979 826
TOTAL	**15 095 642**	**11 877 061**

NOTE 19: INTEREST-BEARING LIABILITIES TO CREDIT INSTITUTIONS		
TSEK	2022-12-31	2021-12-31
External loans to credit institutions, due between 1–5 years	2 577 145	3 209 992
External loans to credit institutions, due later than 5 years	0	423 567
TOTAL	**2 577 145**	**3 633 559**

NOTE 20: OTHER LIABILITIES		
TSEK	2022-12-31	2021-12-31
Employee taxes and fees	16 837	17 820
VAT	20 817	3 170
Liabilities to credit institutions	1 056 415	620 463
Other	150	1 269
TOTAL	**1 094 219**	**642 722**

NOTE 21: ACCRUED EXPENSES AND PREPAID INCOME		
TSEK	2022-12-31	2021-12-31
Property tax	3 145	31 800
Accrued vacation pay	25 987	33 638
Statutory social security costs	7 899	9 121
Accrued salary tax	10 823	10 994
Advances for EU-related projects	50 362	50 728
Cash in-kind	373 433	280 681
Accrued interest	19 783	7 084
Other accrued expenses and prepaid income	17 148	17 361
TOTAL	**508 580**	**441 407**

NOTE 22: CONTINGENT LIABILITIES AND PLEDGED ASSETS		
TSEK	2022-12-31	2021-12-31
Contingent liabilities	None	None
Pledged assets	None	None

European Spallation Source ERIC's income statement and balance sheet will be subject to approval at the Council's meeting.

The Director General certifies that, based on my best knowledge, belief and understanding, the Annual Report has been prepared in accordance with applicable accounting rules, that the information provided is in accordance with actual circumstances, and that nothing of significance that would affect the view of the Company as a result of the annual report has been omitted.

HELMUT SCHOBER
ESS DIRECTOR GENERAL

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