2021 Activity Report

1 January – 31 December

Org.nr. 768200-0018
European Spallation Source ERIC

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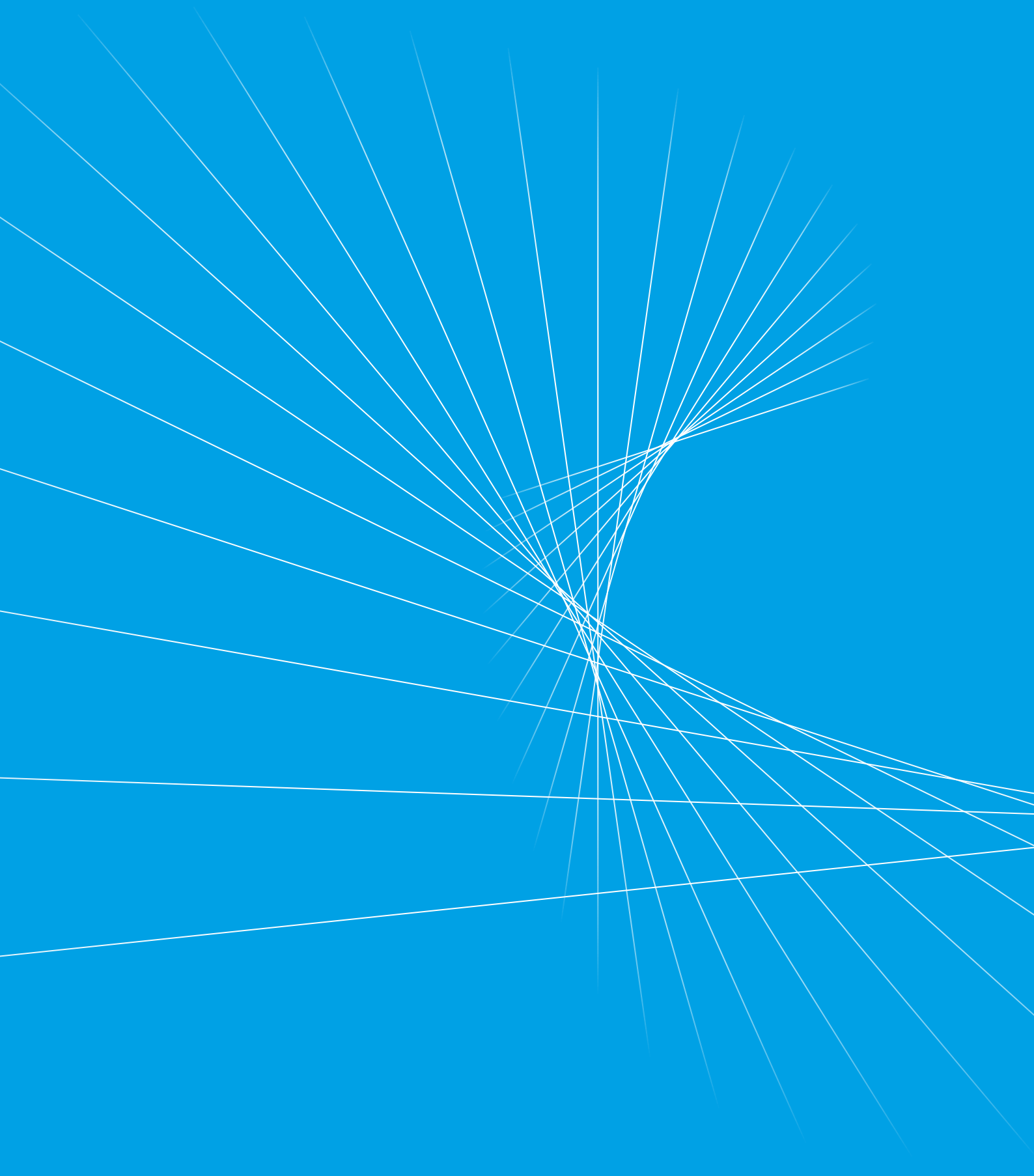


Progress through resilience and innovation

by the Director General

Resilience is an important trait of any human endeavour and a tremendous resource in challenging times, such as during the last two years due to the COVID-19 pandemic. In a crisis, resilience allows us to respond with flexibility and ingenuity, by quickly adjusting the way we do things, and finding new technical solutions. This preparedness takes its strength from our collective know-how, that has been generated by decades of research, and our capacity to convert this know-how rapidly into innovation.

As a scientific organisation, we applaud the fast development of vaccines against SARS-CoV2. This is another example of scientific development with a crucial societal impact, allowing society to save millions of lives and keep the pandemic under control. Because of the many challenges caused by the pandemic, the

"In many ways 2021 was a challenging and hard year, but also a year with remarkable achievements. The close collaboration, strong support and engagement from staff, member states, partners and council made this possible and I extend a sincere thank you!"

Project completion 2027

Our commitment

role of scientific research and technical innovation has become more visible to the general public and policy makers, who have had the opportunity to see how basic and applied research, when leveraged in the appropriate way, are indispensable to guarantee a better quality of life for all.

I am proud of the response and sense of shared responsibility displayed over the last year by the ESS community at large: here in Lund, as well as at our In-Kind partner institutes across Europe. The ESS people have been adjusting the way we work, and managed with persistence and maturity the balance between safety and well-being and the advancement of the ESS project to the extent possible.

At ESS, as we cautiously enter a post-pandemic phase, we have a stronger awareness of the privilege and responsibility to be a scientific research infrastructure: the knowledge that we will enable can and must contribute to building a more sustainable future, for all human beings and for our planet.

To make our significant contribution to a sustainable future, our imperative is to complete the construction of the facility and be ready for the outstanding science programme that ESS will enable. These objectives will fuel our work, year by year. The year 2021 has marked important milestones along this path. All of the conventional facilities have been handed over to ESS by the contractors. This allowed ESS to take possession of the main office, which, with its modern open architcture, offers a good work environment for collaboration. On the construction of the facility, many critical technical components were installed and commissioned in all parts of the technical buildings. Among many, the successful feeding of a particle beam into the first part of the linear accelerator, made possible by a successful collaboration among physicists, engineers, and technicians.

With our In-Kind partners, we celebrate this and other goals achieved, in spite of the severe disruptions caused by the pandemic. In particular, restrictions on travel have negatively affected the project performance, limiting the circulation of people and goods, but also the exchange of knowledge and expertise that is the basis of any big science project.

The pandemic, the highly ambitious project, and other internal factors have

led to delays in the delivery of the facility. To limit the effect of those delays on the remaining part of the project, a re-baselining of the project was carried out in 2021. The collective effort has provided us with a robust and realistic plan to complete the construction of the ESS facility and be ready for operations by the end of 2027, when 15 instruments will be in the final stages of commissioning, with at least half of them ready to receive users. The instruments will be served by an accelerator that will deliver 2MW of beam power to the target station. In the last quarter of 2021, the revised plan was rigorously evaluated by the ESS Project Advisory Committee and endorsed for implementation by the ESS Council.

Throughout the year, our member countries continued to demonstrate their trust in ESS, acknowledging its role in the European and global scientific landscape. On behalf of the whole organisation, I take the opportunity to confirm once more our full commitment to deliver on our engagement and thus demonstrate responsible stewardship of the resources entrusted to us.

Following what was started at the end of 2021, we will continue to further enhance our performance through changes to our organisation, culture, and ways of working, building on the exceptional competence and motivation of our staff and partners.

Deeply rooted in our present commitment to complete the construction of the facility, we will continue to enhance our presence in the international scientific community, building partnerships and fostering knowledge-exchange opportunities among research centres, universities, and the private sector.

ESS is conceived to be a globally leading player in its field for the decades to come. It is my belief that ESS will provide a significant contribution to the advancement of scientific knowledge right from the very start of the scientific programme.

It will then be up to us all to use this knowledge in the most responsible way to achieve progress for the generations to come.

HELMUT SCHOBER
ESS DIRECTOR GENERAL

Top highlights of 2021

1 The delivery of all buildings from Skanska to ESS. Finally, we were able to remove the fences marking the border between the construction site and the campus. Even though construction work will continue for many years to come, it is a remarkable change to be able to walk around outside the buildings without a hard hat and safety shoes.

2 How we handled the pandemic. ESS staff and partners have tirelessly adjusted how we work, and managed the balance between keeping pace in the project and our well-being after the pandemic.

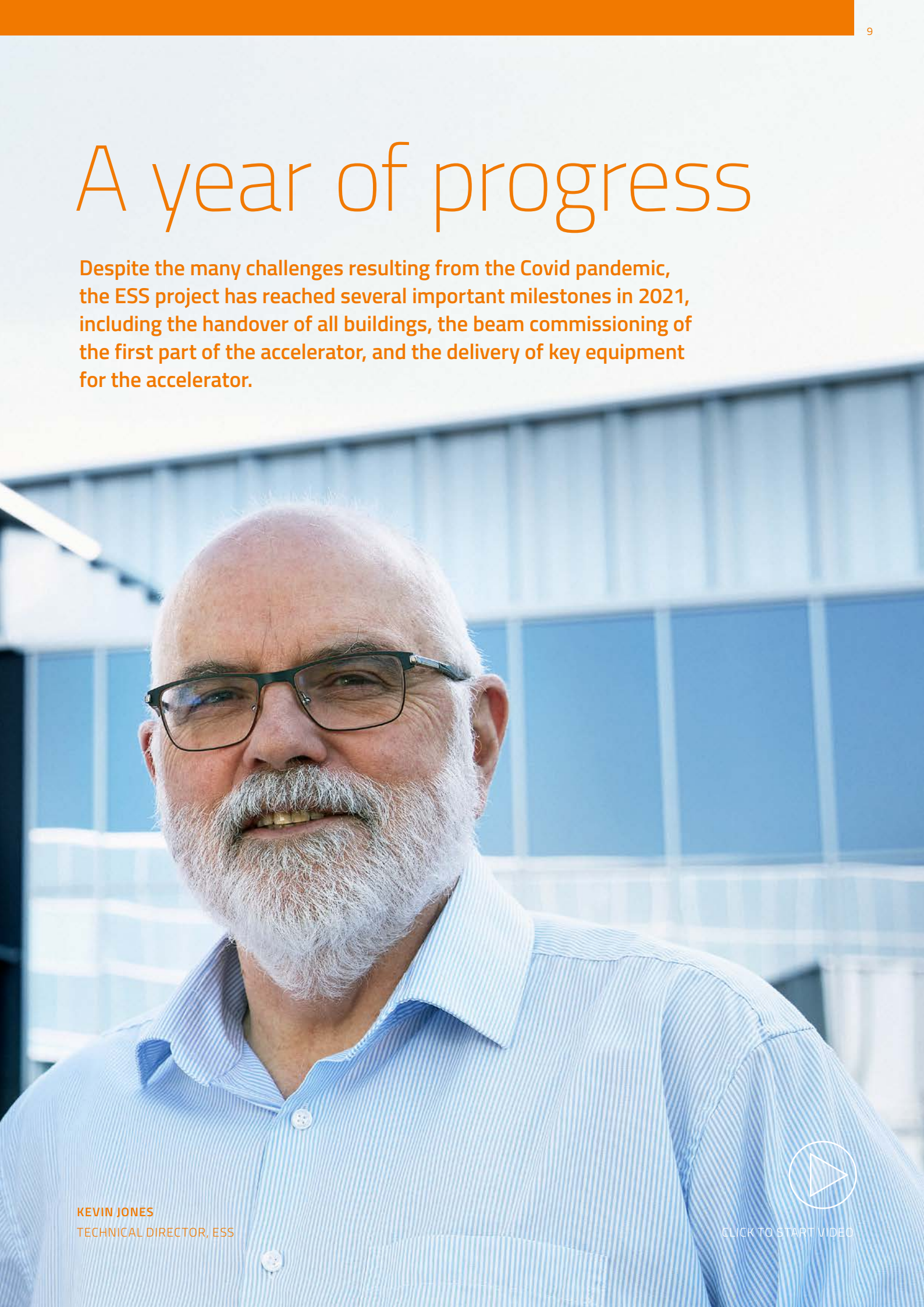
3 The full rework of the plan was completed and implementation started, demonstrating the commitment and determination from member states, partners and staff to deliver the best possible research facility in only five years.

"We now have full access to the facility"

ANDREW KIMBER
ACTING PROJECT DIRECTOR, ESS

A year of progress

Despite the many challenges resulting from the Covid pandemic, the ESS project has reached several important milestones in 2021, including the handover of all buildings, the beam commissioning of the first part of the accelerator, and the delivery of key equipment for the accelerator.



KEVIN JONES
TECHNICAL DIRECTOR, ESS

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"The installation of LOKI is now well underway in one of the halls"

KEVIN JONES
TECHNICAL DIRECTOR, ESS

Embracing digital collaboration

The most notable accomplishment of 2021 was the completion of the civil construction work and the handover of all buildings to ESS.

Andrew Kimber, Acting Project Director at ESS, explains: "The completion of the conventional-facilities part of the project was a major achievement. The ESS Facilities Management Group has taken responsibility for all of the buildings on site, which we now own. We started moving in last March when the first parts of the campus buildings were completed. The move to our new offices has been an energy-boost for the ESS staff, even if many of the employees have had to work from home for much of the year due to the pandemic," Andrew Kimber says.

Significant progress in technical installations

Gaining full access to the buildings has also enabled ESS to ramp up installation of technical equipment at the site.

"At the end of December, ESS took over the last buildings from our construction partner SEC, Skanska ESS Collaboration. These were the target building, where the target vessel resides, and the short instrument halls on either side of the target building. This means we now have full access to the facility, enabling us to begin installing equipment and instruments in all parts of ESS," Andrew Kimber explains.

Moving forward despite challenges

Kevin Jones, Technical Director at ESS, describes 2021 as a remarkable year for the project.

"We have really pushed the project in 2021," he says. "Despite the pandemic, we've had a very transformative year. We began receiving regular deliveries of important equipment for every part of the facility, including the accelerator, the target system, and the neutron-scattering instruments."

The accelerator

In 2021, the first sections of the accelerator, the ion source and the radiofrequency quadrupole, were commissioned. This was the first time the proton beam was accelerated through one of the many structures that will ultimately constitute the final accelerator and represents a major breakthrough.

"This demonstrated our ability to integrate all key technical systems that need to work together in order for the first section of the accelerator to function properly," Kevin Jones says. "This includes systems for water, vacuum, power conversion, radiofrequency controls, low-level radiofrequency controls, magnets, interlocks, safety systems, etc."

A second milestone in the accelerator part of the project was the delivery and testing of the first cryomodules from ESS's in-kind partners in France. These units accelerate the protons in the beam, and four out of a total of 13 were delivered and tested during 2021.

Target station

The target systems also underwent major development in 2021. The target vessel arrived at the ESS site in 2020, and in 2021, the 39 port block tubes were attached to it. These tubes will hold the neutron guides that will transport the neutrons from the target to the different experiment stations.

"The port block tubes are welded to the vessel; this is a very complex procedure and probably one of the most critical jobs

at ESS. We must maintain alignment within extremely narrow tolerances to ensure good performance of the neutron-scattering instruments. This means the welding has to be performed with minimal distortion and dimensional changes," Kevin Jones says. "And the results are very good, alignment has been very well preserved."

Another significant accomplishment of 2021 was the completion of the target wheel, including the drive motor system, the shaft, and the wheel itself, comprised of 7 000 tungsten bricks and weighing almost four tonnes. Following the factory acceptance tests, the wheel will be delivered to the ESS site in early 2022.

Neutron scattering instruments

The instruments are still in an early stage, but good progress is being made on many fronts.

"In 2021, we started the installation of one of the short instruments, LOKI, which has been built by our partners in the UK. The installation is now well underway in one of the short instrument halls," explains Kevin Jones.

"We've also made significant progress on the instrument BIFROST. And we've just begun the construction of ODIN and DREAM in a different instrument hall. So the instrument projects are now gaining a lot of momentum, and we look forward to further equipment installation in the instrument halls as we move forward," Kevin Jones continues.

Control system

Critical advances have also been made in the implementation of the integrated control system. The beam test of the accelerator enabled the ESS team to do a full commissioning test of the timing system, which is crucial for the operation of the accelerator. During normal operation, the timing system turns on and off over one million times per day, creating 14 pulses per second, and proper timing and synchronisation is essential for creating a high-quality beam.

"The global control system will allow us to operate and manage all the equipment at ESS in an integrated, holistic way from the main control room. The system will monitor and collect an enormous amount of information, and control over 1.6 million components," Kevin Jones says.

Gradually transitioning into the operations phase

Another sign of the project's progress is the establishment of an HR framework for standard operations, including shift work. This is required, as more and more parts of the project will transition into standard operations over the coming years. This was the case for the ion source in 2021, which now operates 24/7.

Another exciting year to come

Kevin Jones looks back at an eventful year:

"I am proud of what the ESS team has accomplished in 2021 and I would say that we have now completed roughly 50-60% of the total project. We reached some very significant milestones in 2021, despite the Covid pandemic. We will keep our sleeves rolled up, and I am very much looking forward to the things we have planned for 2022," he concludes.

A year of change

2021 was, in many ways, a transformative year for ESS. The entire project was re-baselined, resulting in a new time plan and a revised cost estimate. The ESS organisation and all its partners now have a solid foundation for completing the project by 2027.

"We have been met with extremely positive and professional attitudes"

DIMITRI ARGYRIOU
ASSOCIATE DIRECTOR FOR IN-KIND MANAGEMENT, ESS

"The goal is project completion by 2027"

ANDREW KIMBER
ACTING PROJECT DIRECTOR, ESS

"Even before Covid, many deliveries of key components for the ESS facility were significantly delayed. The pandemic further added to the problem as lockdowns and travel bans, in many cases, made it impossible to work. By the end of 2020, it was apparent to the ESS Council that the probability of the project being completed on schedule and on budget was minimal."

Re-baselining the entire project

In early 2021, the ESS Council therefore decided to re-baseline the entire project and create a new time plan and budget.

Andrew Kimber, Acting Project Director at ESS, has been a key person in this process.

"My task has been to manage the re-baseline effort, and coordinate the work done by the directors and all the subproject managers," he explains. "The technical scope of the project remained unchanged, i.e., 2 MW proton beam power on target and 15 neutron-scattering instruments. The task at hand was to completely reasses what it would take to complete the project and to include realistic contingency for both cost and schedule."

The process began in the spring of 2021. The ESS Council asked the re-baseline group to prepare six scenarios, each with different cost and time restraints, and assess their likelihood of success. At its meeting in early June, the council decided to move forward with one of the scenarios, where the delay would be two years and the additional cost roughly half a billion euros, and directed the group to develop a detailed time plan and budget.

The re-baseline group worked hard throughout the summer months, going through all aspects of the project, to come up with a viable plan for completion.

Planning for unknown factors

"One of the improvements with the new project plan is that we, for the first time, have included both time and cost contingency," says Andrew Kimber. "This is a big improvement compared to previous plans where there was no room for unexpected problems. In our new plan we have included a list of risks and uncertainties and linked these to the different tasks in the project. This has allowed us to estimate the impact these risks and uncertainties have on the schedule in a much better way, and to plan for it in advance. It has also given us a much more tightly-integrated plan, where we see how the different parts of the project affect each other."

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Project performance will be evaluated on a monthly basis, with a greater focus on forecasting, in order to become a more proactive organisation. These monthly follow-ups will create an early warning system, giving all external and internal stakeholders a clear view of where the project is moving in terms of schedule and cost.

Building stronger relationships with in-kind partners

In-kind partners are a crucial part of the ESS project, and their support and input has been vital to the re-baselining process. The Covid pandemic has had a severe negative effect on in-kind partners and their supply chains. An important part of the re-baselining process has therefore been to assess the situation and possibilities for the partners to deliver their parts of the project.

Dimitri Argyriou, Associate Director for In-Kind Management at ESS, explains that ESS's relationships with its in-kind partners have been strengthened in 2021, partly as a result of the re-baseline process.

"Working with our in-kind partners, we have been met with positive and professional attitudes. Everybody has come together as a team, trying to get the job done, no matter what happens," he says. "To get the full picture of the situation, we conducted a series of surveys to get factual information from each of our partner labs regarding the Covid status and their ability to continue their work, as well as clarifying when it will be possible to deliver over 200 pieces of in-kind equipment. This information was crucial input for the re-baseline process."

Final review

In November, the entire re-baseline plan and budget was presented to the Project Advisory Committee (PAC), at a three-day review meeting. All in-kind partners attended and presented the status of their respective parts.

Nearly 100 presentations were given over the course of the meeting and the Project Advisory Committee evaluated every aspect of the re-baseline, including schedule, costs, risks, etc.

The committee wrote a report, which supported almost the entirety of the re-baseline plan, and one month later, Andrew Kimber and his colleagues presented the new plan and budget to the ESS Council. The Council gave the organisation the go-ahead to launch on the trajectory of the re-baseline and initiated negotiations on the split of the extra budget resources.

According to the new plan, ESS will be ready by 2027, two years later than in the previous plan. The extra funds required will amount to 550 million euros.

Financial contingency

To support the implementation of the new project plan, the ESS organisation has taken steps to prepare for the activities of the coming years.

During 2021, Agneta Nestenborg, Director of Project Support & Administration at ESS, made sure the ESS organisation has the required support to complete the project.

"Procurement and logistics are at record levels, showing that the project is in an intense phase. We have reworked our staffing plans during the year to make sure we have enough resources, for example procurement officers, as the project progresses according to the new project plan," she says.

Hard work ahead

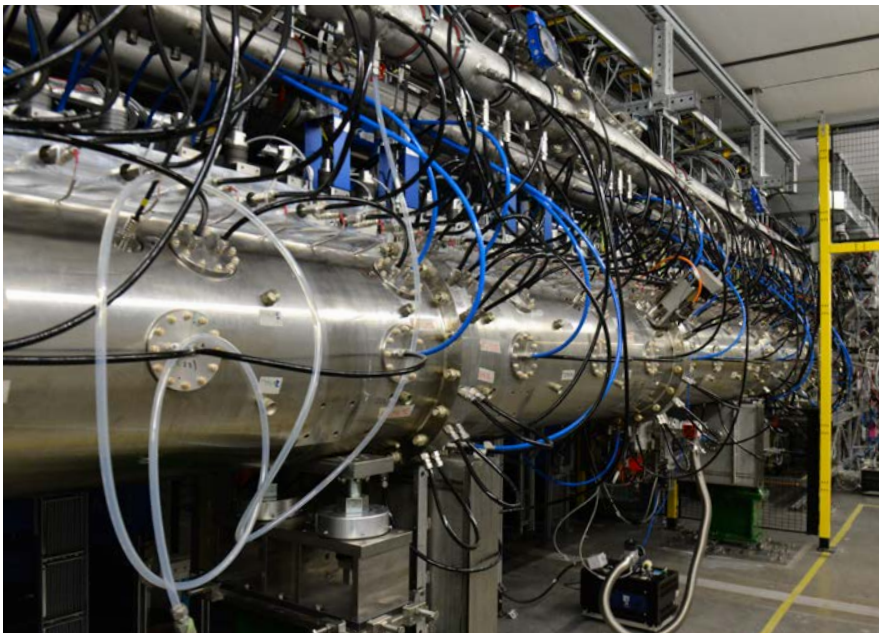
The next phase of the re-baselining process, which is expected to be completed in 2022, is to secure members' commitments and have the funding approved.

Moving forward with the new plan, Dimitri Argyriou has a clear view of what is required to ensure successful completion of the project: "There is no magic bullet. The key thing is to communicate, communicate, communicate. And work hard, work hard, work hard. We in the central organisation, as well as all our in-kind partners, are committed to working as aggressively as possible to hold the time plan. We will fight for every single day of schedule," he concludes.

"The project is in an intense phase"

AGNETA NESTENBORG
DIRECTOR FOR PROJECT SUPPORT AND ADMINISTRATION, ESS

Beam commissioning initiated at NCL



On 28 October 2021, ESS initiated beam commissioning in the normal conducting part of the accelerator (NCL). It is a major step forward on the road to completion for the new multi-disciplinary research facility.

The beam commissioning is a complex process that consists of several steps and involves many physicists, engineers, and technician. All the technical systems, accelerator components, and eventually the beam itself, will be tested, monitored, and optimised, increasing the power in stages until reaching full capacity.

The linear accelerator at ESS will deliver a high intensity proton beam to the target, where the neutrons needed for scientific research will be generated. The normal conducting linac (NCL), located at the far end of the 600-metre-long accelerator, consists of technical components delivered by the ESS in-kind partners INFN (Italy), CEA (France) and ESS-Bilbao (Spain).

Illuminating the unseen

After four years of dedicated research and development, the ESS Beam Diagnostics Team state that they are on track to enable ESS to see an image of the proton beam that travels down the ESS accelerator to hit the ESS Target.

Final tests took place at a thermal spraying company, TSE, in Malmö, overseen by University West, where the mock-up of the Target wheel was coated following the established industrial process that will be applied for coating the target wheel.

ESS Senior Engineer, Ulf Odén, who is also responsible for the delivery of the Target wheel, says the coating of the Target wheel mock-up was an important verification that the coating procedure will not damage the final Target. Thanks to the successful final coating result, the team is now ready to proceed with coating of the final target once delivered from the In-Kind partner ESS Bilbao.

ESS Labs now in operation

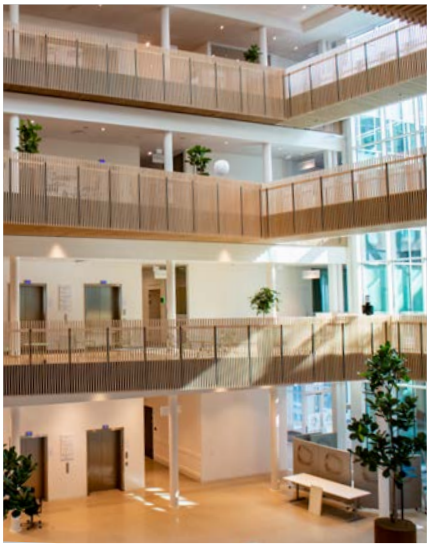
In 2021, the on-site chemistry and life science laboratories adjacent to the instrument hall for the long neutron instrument went operational. Installation works for the short and medium neutron instrument laboratories continue. In the ESS laboratories you will find everything you would expect from a chemical lab and the equipment comes from various sources. Some are machines adopted from other facilities or bought second hand. Some are brand new. Others are on-long term loan from ESS sister facilities around Europe.

"Making use of pieces of high-quality equipment that other labs no longer use is a great way to build sustainably for science" says Sindra Petersson Årsköld, Senior Advisor on policy, communication & strategy in the ESS Science Directorate.

While the laboratories are ready for daily operations, commissioning of instrumentation and preparations continue.

"We are expanding our capabilities and will be extending our suite of laboratory instruments while providing support to ESS. This in turn helps us prepare for supporting the user programme where everything must be in place and well organised," says Monika Hartl, Group Leader for the ESS Sample and User Laboratory Facilities (SULF).

ESS rated outstanding for high sustainability standards



European Spallation Source's (ESS) strong focus on sustainability in the construction and operation of the research facility leads to new sustainability standards for research infrastructures worldwide. In June 2021, the ESS Office building in Lund, Sweden, was environmentally certified Outstanding under the international sustainability assessment method BREEAM with one of the highest scores worldwide (91.5%).

"Since the beginning, ESS has had a very strong sustainability focus, aiming to become one of the most environmentally sustainable research infrastructures worldwide," says Kent Hedin, ESS Head of Conventional Facilities. "The Outstanding rating is proof that all our efforts and hard work, together with our partners, to build the facility in a sustainable way have been successful."

Bringing neutrons to industry

Neutrons offer a unique way to study the structure and function of matter from the microscopic down to the atomic scale. Using neutrons for research enables us to investigate the world around us, as well as to develop new materials and processes to meet the needs of society. Once fully operational, the ESS facility promises to provide unparalleled experimental possibilities to researchers from academia as well as industry. At the same time, an interesting issue arises – how to allocate beam time to various users.

Different access routes for different users

Prof. Dr. Andreas Schreyer is the Director for Science at ESS, which means he will be responsible for the operation of all ESS's neutron instruments. Another part of his role is to organise the process of allocating beam time to users from academia and industry.

"We have studied how other similar facilities are organised, and how they handle access to beam time to find a best practice", Andreas Schreyer explains. "The way it works elsewhere is that there are different access routes for purely scientific experiments, applied science experiments requested by industry, and urgent experiments that require fast access. Usually, incoming proposals from the academia are ranked twice a year by a scientific review board based on scientific excellence to be able to provide beamtime to the best science. The results are then expected to be published in scientific journals; in turn the use of ESS will be free of charge."

Specific access route for the industry

"For industry it will be a little different. Industrial users can, of course, propose scientific questions, but often they have more short-term issues of less scientific but more technological or commercial value where neutrons can really be helpful", Andreas Schreyer continues. "Also, industrial users often don't want to publish their results because of the competition. That is, of course, fine, but then they will have to pay for using our facility. We plan on establishing specific access routes for industrial use based on the experience and advice we've gained from other facilities. Since we'll start accepting users in 2027, we still have some time to formulate a detailed plan."

Another interesting question is how to divide access time between academia and industry.

"First of all, it depends on demand, and on how many proposals and requests we get", says Andreas Schreyer. "Since, based on experience elsewhere, we can expect to have a significant overload, the decision on how much basic and industrial research we do will be up to our owners, represented in our Council. If you look at other similar neutron facilities, you will see that most of them sell less than 10 per cent of their beam time to industry. But then around 10-20 per cent of the proposals have an applied science background, so these are projects that follow the scientific access route but where the results go back to industry. One bold idea would be to offer an access route where proposals are not rated on their scientific excellence but on technological or economic relevance, with the option not to pay for the beamtime if the results are published."

Industrial science using neutrons

Andreas Schreyer is convinced that neutron analysis has a great potential in industrial applications. Neutrons are unique in providing information complementary to other probes, and because of their capability to characterise industrial processes in situ, in operando, and in real time. Since ESS is going to be one of the world's most advanced neutron sources so far, the opportunities are staggering.

"ESS will offer pulsed neutron beams of unparalleled peak brightness and pulse length compared to any other neutron source", says Andreas Schreyer. "This means that it will be possible to do experiments at ESS which can't be

"We will be able to do experiments which can't be done anywhere else"

ANDREAS SCHREYER
DIRECTOR FOR SCIENCE, ESS

done anywhere else. Take challenges such as better industrial processes for lightweight materials or improving industrial components, such as combustion engines, heat exchangers or batteries. For example, conventional in situ and in operando measurements of oil flow in the cylinder heads during engine operation are very limited, and there are no practical means to replicate this kind of dynamics by ex situ studies. However, if you put the engine into a neutron beam, you can actually observe what is happening inside while the engine is running. You can also investigate processes in an operating battery by observing how atomic structures evolve during charging and discharging. Or study material response, such as precipitation behaviour or phase transformations in processes, such as welding or forging. It is such new knowledge which can drive innovation"

Reaching out to industry

However, to get industry onboard, you first need to gain their interest and understanding. Compared to, for example, electron microscopes, which industry can operate itself, neutron facilities are less known among industrial researchers, or considered to be a tool for "experts only".

"We need to have skilled specialists at ESS who understand industrial problems, speak the right language, and act as an interface with industrial users", says Andreas Schreyer. "Also, both universities and mediator companies will play a very important role in enhancing knowledge within industry about neutron characterisation techniques. But I would also recommend that larger companies prepare for the future by hiring somebody with a background in neutron science. For smaller companies, I'd say they should always be curious about new methods. Ideally, industrial users shouldn't rely solely on universities but rather try to gain knowledge themselves. I believe that will allow them to realise the potential of neutron science for solving problems that can't be solved in any other way."

"Our research must create value for society"

"Personally, I don't care about neutrons, or protons, or electrons. What I care about are the results you can get by using them", says Jan-Eric Ståhl, professor at the Production and Materials Engineering Programme at Lund University, who also leads the Sustainable Production Initiative (SPI).

Production and Materials Engineering is an applied science subject. Its purpose is to provide industry with the knowledge needed to improve existing products, and spur innovation in new products. Applied science uses scientific discoveries to solve practical problems. For example, designing windmills to capture wind energy is applied science.

A seamless cooperation between institutions

"It is about collaboration across borders", says Jan-Eric Ståhl "The fact that basic research should support applied research and vice versa. You cannot live with only basic research. And it's from that perspective that ESS comes in, we need to use the best research tools and equipment available."

Going from mineral to vegetable oils

Neutrons have played an important role in the characterisation, development and testing of materials for many years. However, using them in applied science is fairly new, according to Jan-Eric Ståhl.

One example is lubricants. Using neutron imaging makes it possible to study the behaviour of lubricating oil as it circulates through an engine or drivetrain, for example. A large number of the lubricants we use today are based on fossil oils. Many producers, however, are investigating the use of vegetable oils, which are not only the sustainable choice, but also bring several other benefits. Vegetable oils have proved to have a greater lubricating capacity than mineral oils, so that cutting tool wear is reduced, surface finish quality is improved, and machining cycle times are shorter.

"But if we are to switch to vegetable oils, we need to know exactly how to stabilise and modify them for optimal function. This is where ESS and neutron imaging can help," says Jan-Eric Ståhl.

A self-healing coating

"Another example where we could have solved the problem much faster if we'd had the possibility to use neutron imaging is in the transition from leaded to low lead brass," Jan-Eric Ståhl continues. "However, as lead is a heavy metal, toxic even at low levels of exposure, the real question is, how can we remove the lead and still maintain good machinability?"

According to Jan-Eric Ståhl, an alternative is instead adding silicon, but that generally results in increased tool wear and longer manufacturing times. His team found a nitrogen-rich coating which reacted with silicon brass, forming silicon nitride, a ceramic material that can be used as a coating. In this case, when the cutting tool was used, a new protective coating was automatically formed on the surface, thereby extending tool life. "We could very well have followed this process through neutron analysis, see exactly what was happening on the surface of the tool, and be able to further refine the formula."

Working for a sustainable future

Jan-Eric Ståhl leads the Sustainable Production Initiative (SPI), a joint project by Lund University and Chalmers University, and sustainability issues are something that permeate all research activities within SPI.

Cold aging

"A further example where neutrons could be used is in understanding cold aging; the time a cast material must rest at room temperature before it can be further processed - an extremely important area from a sustainability perspective," Jan-Eric Ståhl continues. "The more we know, the more we can reduce the amount of waste and scraps in production, and the need to add new raw materials. Once again, this is where we believe ESS can be of great importance. We can learn how to construct things to be able to recycle and reuse them."

Working for a sustainable future

"One of the main reasons we conduct research and development in my department is to provide industry with the knowledge that enables innovation and creation of solutions that propel our society in the right direction. To succeed in this, we must use all the research tools and resources available, so that we can create value, primarily for our own industry and taxpayers, but also for EU citizens, as we belong the Union", concludes Jan-Eric Ståhl.

Accelerating scientific discovery with AI

When completed, ESS will have a very complex control system. Artificial Intelligence (AI) can help in both processing and visualising research data, and optimising scattering experiments by predicting the best possible instrument configuration. When applied to the facility control system, AI can also advance machine performance and functionality.

Dealing with a deluge of data

There is no doubt that, once operational, ESS will provide science with unparalleled access to the inner workings of molecules and materials. To be successful, however, neutron analysis must be combined with powerful software tools able to extract scientific knowledge and insight from data.

ESS will carry out hundreds of experiments each year, creating up to hundreds of gigabits of data in a single experiment. This rate is beyond what can be effectively analysed with typical technologies.

This is where artificial intelligence comes in, according to Anders Ynnerman, who is leading WASP, Sweden's largest individual research programme, and believes that integrating artificial intelligence into data processing, analysis, and visualisation will help scientists make sense of all the big data.

"Today's scattering experiments can measure everything that is possible to measure. However, only a small fraction of all collected data contributes to a result", he says. We need to create a quick and continuous data flow, where data reduction and analysis can happen in situ, during the experiment. Here, AI can help us make the right choices."

AI makes sense of nonsense

Anders Ynnerman has spent many years building up scientific organisations and research environments, amongst others, the National Supercomputer Centre the Swedish National Infrastructure for Computing (SNIC).

"The data generated by neutron analysis is so massive that you couldn't possibly digest that as a human," he says. "Applying AI offers a new, faster way to extract scientific meaning from the raw experimental data."

"What is exciting is that this pipeline changes dramatically as we add artificial intelligence," says Anders Ynnerman. "AI allows us to greatly reduce the amount of human work needed. AI systems can sort and process the incoming data, find patterns and correlations, understand the images generated, and automatically send feedback all the way to the instrument. This allows for immediate adjustments, and even better data. The benefit is more efficient science."

But AI also has the potential to improve the processes within ESS itself. Accelerator-based research facilities such as ESS are among the world's most complex machines, managed by intricate control systems. The Integrated Control System at ESS plays a key role in the machine performance and operational reliability of the facility, and manages about 1.6 million control signals from 100 000 devices in a large variety of systems. Applying AI and machine learning to this system can increase the operational efficiency at ESS, while reducing operational and maintenance costs.

Scientific output

In 2021 a total of 94 papers were published with scientific contributions of ESS-affiliated authors as compiled in January 2022 from the core collection of the Web in Science. 58 of those were published with some form of open access. These papers have already received 116 citations in 2021, while the complete set of 990 publications from ESS (2008–2021) received a total of 2402 citations in 2021.

As of June 2021, ESS has chosen to highlight scientific papers published by the people of ESS. This not only acknowledges the work of our staff who collaborate with peers on this research, but also promotes the potential benefits their results may lead to and allows them to share their results with others.

A selection of 11 were highlighted from June until the end of year 2021, covering topics such as emergent magnetic behaviour, neutron imaging through advanced event-mode data acquisition, and the measurements of the neutron absorption in supermirror coatings.

This is something ESS is proud to support, and we will continue to add new publications to the dedicated page on our website.

Read more at ess.eu

Better superconductors to improve cancer diagnosis

MRI scanners are vital tools for diagnosing a range of cancers and determining their treatment.

Research at ESS will help in developing a new generation of MRI scanners that will provide doctors with more detailed images for diagnosis, and give patients a greater chance to beat the disease.

In fact, the ability to see inside our bodies with MRI scanners can be twice as likely to help doctors identify the presence of dangerous tumours than is currently possible with invasive techniques like biopsies, as has been shown for prostate cancer.

The challenge in producing better MRI scanners lies in the need for extremely strong magnets to create a large magnetic field within the scanner. Creating a suitable magnetic field relies on special superconducting materials that allow a current to pass through them with almost no resistance. However, such characteristics have only been revealed at extremely low temperatures: metallic superconductivity can only be sustained below –243°C. Today's MRI magnets are typically run at –270°C, requiring bulky and expensive cooling systems.

Researchers are looking to identify novel materials that can exhibit superconducting characteristics at higher temperatures. They have observed superconductivity at temperatures as high as –120°C, but these materials do not work well when building magnets. Understanding superconductivity is key to developing materials that will take MRI diagnosis to the next level.

Beyond medical imaging

Harnessing superconductivity could have far-reaching impacts, beyond medical imaging tools. It is a key to solving the challenge of distributing renewable energy to where it is needed, and a host of other exciting innovations, from fusion energy to super-fast magnetic levitation trains, that are also dependent on the discovery of novel high-temperature superconductors.

What will we see at ESS?

Neutrons are magnetic themselves, and as such are uniquely positioned to investigate magnetic phenomena and the interplay between magnetism and superconductivity. After decades of neutron investigations, we now know that magnetism and superconductivity have a somewhat strange relationship; while magnetism appears able to drive superconductivity, it also seems to compete with it. These properties are difficult to see without extremely powerful neutron instruments, and today's facilities have only given us a glimpse of what is going on.

The unparalleled brightness of the neutron source at ESS will allow investigation into the atomic structure of superconducting materials at a level not possible before. In the BIFROST instrument, which will have the highest intensity of all ESS instruments and a very wide energy coverage, neutrons will be scattered off superconducting materials to reveal the atomic excitations and magnetic forces acting within. Many of these are too weak to be detected today, or fall outside the energy range of existing instruments.

The new understanding made possible at ESS will enable scientists to discover new superconductors, and to manipulate known materials into better superconductors that work at higher temperatures.

New battery materials for a renewable energy future

A key characteristic of renewable energy is its variability. Solar energy is frequently obscured or unavailable, waves come in waves and the wind is famously fickle. Uninterrupted energy flow requires the storage of energy to compensate for this variability.

Among the different energy storage technologies, lithium-ion batteries hold great promise.

A lithium-ion battery is a type of rechargeable battery in which lithium ions move from a negatively charged electrode to a positively charged one during discharge, and back again when charging. This flow occurs at the atomic scale and is therefore difficult to observe and model, limiting researchers' ability to experiment with new materials.

Meanwhile, those materials, used for the electrodes and the electrolytes of a lithium-ion battery, largely determine its capabilities. An in-depth understanding of material behaviours within this complex electrochemical environment is thus critical for the development of advanced materials that will lead to better batteries. These advances are our best hope for renewable energy storage solutions grand enough to contribute to the transformation of the global energy sector.

What will we see at ESS?
Neutrons are the perfect tool for studying positive electrodes with a chemical composition based on nickel, manganese and cobalt. Due to their very similar atomic numbers, which places them near one another on the Periodic Table, these three metals appear indistinguishable when probed with X-ray light. With neutron scattering, however, researchers are able to see clear differences in the three. Astonishingly, neutrons can also locate the position of lithium ions in the structure, and help to visualise the lithium pathways.

At ESS, the instruments will enable the study of experimental battery technologies in real time and under real-world operating conditions.

ESS will reveal a clear and detailed picture of an entire battery cell, at multiple length scales, during operation. This will include the structure and dynamics of its electrodes and electrolytes, as well as the behaviour of its mobile ions, all interacting while the battery is charging or discharging.

Researchers will be able to swap out nickel, manganese and cobalt components as required for each investigation, and observe the impact of the many possible variations on overall battery performance and safety. This will provide an unparalleled understanding of a lithium-ion battery's fundamental processes, while also significantly speeding up the development of this technology so critical to the transformation of the planet's energy profile.

Unlocking the secrets of water

The make-up of the giant ice planets Neptune and Uranus remain shrouded in mystery. While their interiors are known to consist primarily of water, along with ammonia and methane, scientists have also noted that these familiar materials can behave very oddly under the high pressure and temperature conditions seen on these planets.

Back on Earth, water is fundamental to life and, surprisingly, studying it under extreme conditions helps us understand its behaviour. In fact, water in its simplest form, under pressure, exhibits a dizzying array of over fifteen crystalline ice forms. These transformations involve atomic rearrangements, such as carbon atoms rearranging into a diamond under extreme pressures. In addition, as with a diamond, extremely high temperatures are required to melt these dense ice forms. When these extreme pressures are combined with high temperatures, this can create 'superionic' ice that acts as a solid and a liquid simultaneously.

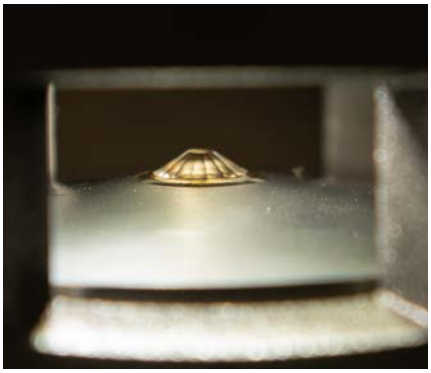
While scientists have been able to identify some of these mysterious ice forms created under certain extreme conditions, experiments are constrained by what is possible to perform using today's scientific instruments. Sample sizes are small by necessity, and it is exceptionally difficult to observe hydrogen atoms in a water molecule.

Beyond water
Research of this kind advances our understanding of the forces that hold water molecules together, and the hydrogen bonds that allow them to interact with their surroundings. This could have far-reaching implications in fields as diverse as quantum physics, biology, pharmaceuticals and volcanology.

What will we see at ESS?
Neutrons are critical for studying ice as they are the only means to see hydrogen atoms. ESS will help us to understand more about the atomic structures and forces of different materials than has ever been possible. For example, the instrument DREAM will allow scientists to observe the behaviour of these and possibly new mysterious types of ice at the atomic level.

Scientists will measure how neutrons are scattered as they bounce off the hydrogen nuclei inside ice samples maintained at enormous pressures, creating a highly-detailed picture allowing researchers to see the formation of water molecules and the onset of hydrogen bonding, detailing the structures and forces at play, and helping to determine what is found in the interiors of the ice giants.

ESS will use new tools, based on large artificial diamonds, to create extreme environments on a much larger scale than previously possible. The exceptionally high flux of the ESS neutron beam is critical in the study of these miniscule samples. The combination of the diamond pressure cell and the brightness of ESS will enable unprecedented insight into the strange atomic world of the water molecule. This exquisite new level of detail is crucial in delivering a step-change in our understanding of distant planets, as well as everything and everywhere water exists on Earth.



A large synthetic diamond set in a diamond anvil cell, developed by ESS in collaboration with Oak Ridge National Laboratory and University of Edinburgh. This is part of a sample environment that will enable a new generation of high pressure experiments with neutrons.

ESS – a catalyst for industrial digitalisation

ESS will have Sweden's most complex control system and uses machine learning to optimise operational reliability. Through several collaborations with industry and technology companies in machine learning and AI, ESS also contributes to digitalisation and technology transfer in industry.

In a recent pilot study, ESS joined forces with the Faculty of Computer Science at Lund University (LU), Big Science Sweden (Sweden's Industrial Liaison Office) and the tech company GoalArt to explore how data from the ESS control system can be used externally for research and innovation in AI and machine learning.

In another recent machine learning project funded by Vinnova, ESS has been collaborating with the tech company DVel to develop machine learning models that can predict issues during operation, before components break or the process stops, and implement these algorithms in the control system.

"The knowledge transfer from ESS and other research facilities are of great importance for the technological development and digitalisation in Swedish and European industry," says Anna Hall, Director Big Science Sweden. "The collaboration projects within machine learning are one example of how ESS contributes to innovation and increased competitiveness, for SMEs as well as large companies."

Powering up to accelerate protons

Commissioning of the RF Sources and RF distribution system has been underway on the ESS site since December 2020, as ESS gears up for RFQ beam commissioning in the summer.

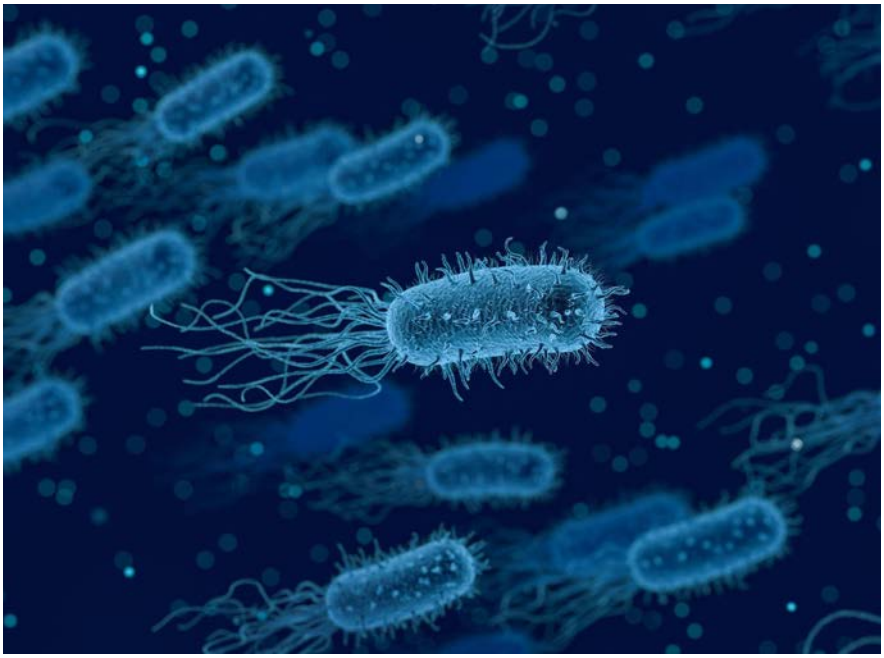
In the ESS Klystron Gallery, which runs above the 600-metre-long Accelerator Tunnel for almost its entire length, you will find equipment that generates the Radio Frequency (RF) power to get protons moving in the ESS accelerator. To be able to produce neutrons, ESS needs to accelerate protons using electromagnetic fields produced by RF sources, until they gain a significant amount of energy and a velocity close to the speed of light. When this high-speed beam of protons hits the ESS Target, neutron spallation occurs.

RF power is produced in specialised machines called Klystrons - also known as RF sources.

During 2021, ESS started the commissioning of the very first RF sources. Once this first part of the RF system is fully tested and commissioned, it will be handed over to operations – then high-power testing of the next section, the Drift Tube Linac (DTL), will follow. The RF team will gradually move their way through the rest of the Gallery, where a total of 156 RF systems are to be tested.

Head of the ESS Accelerator Division, Mats Lindroos, elaborates: "Complexity here is enormous. You have the combination of not only these RF sources, but also the power supply that drives them, called modulators, and all the controls, the cooling system and the networks needed to synchronise and make sure all this works together. It is only when everything in this long hall is complete and ready for operations, that we can start sending beam on to the ESS Target".

ESS, MAX IV & SciLifeLab join forces to create new life science hub



Infra Access for Life Science Sweden (InfraLife) is a joint effort between ESS, MAX IV and SciLifeLab, which aims to maximise the benefits of investments made in Sweden's large-scale strategic research infrastructures.

While ESS's neighbour, MAX IV, houses the brightest X-ray source in the world, and ESS will be the brightest neutron sources in the world, SciLifeLab is a national infrastructure for molecular bioscience research.

As part of InfraLife, the three facilities will engage the broad life science community within the fields of academia, industry, and health care, and jointly develop new technology-, data- and challenge-driven capabilities across all sectors of life science.

One of the goals of the project is to engage with existing challenge-driven and cross-sectorial large collaborations to best utilise available technologies at the three infrastructures, and thereby tackle major challenges within the field of life science.

Pioneering Power Converting at ESS

ESS in collaboration with Lund University researchers, and together with ESS Spanish In-Kind Partner, ESS Bilbao, and supplier, Jema Energy, have produced a high-voltage modulator that signifies a paradigm shift for the power supply of linear particle accelerators worldwide.

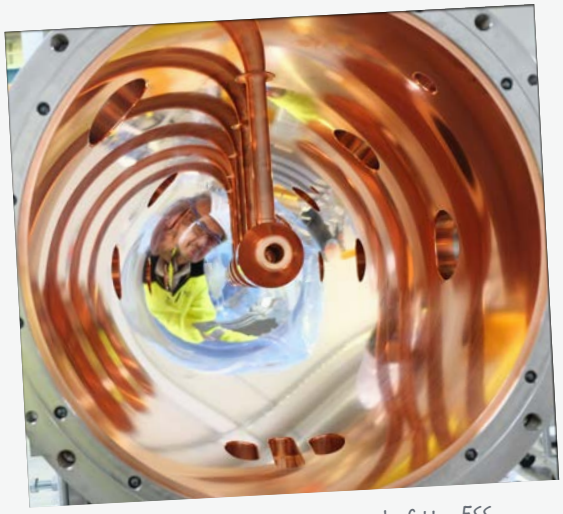
When ESS is in full operation, it will be the world's most powerful superconducting linear accelerator, providing neutron beams that are about 100 times brighter than what is produced today from reactor-based neutron sources. Machines like these which absorb very large amounts of power from the grid can cause a power disturbance on the grid, so traditionally, one needs to have external compensation to counter the fluctuations these machines can create.

"The ESS-designed modulator has an integrated system which basically provides internal line power regulation inside the device. This is called an Active Front End, which takes care of the power quality to secure that there will be no flicker on the grid," explains Carlos Martin, Group Leader, Electrical Power Systems in the ESS Accelerator Division. "This is the first time anybody in the world uses an Active Front End on a modulator."

A project like ESS is all about dedicated, professional and engaged people. Thanks to very strong efforts by all involved, progress was achieved in spite of a pandemic, supply disturbances and technical challenges.

These are a handful moments from 2021 where the camera has captured the people of ESS.

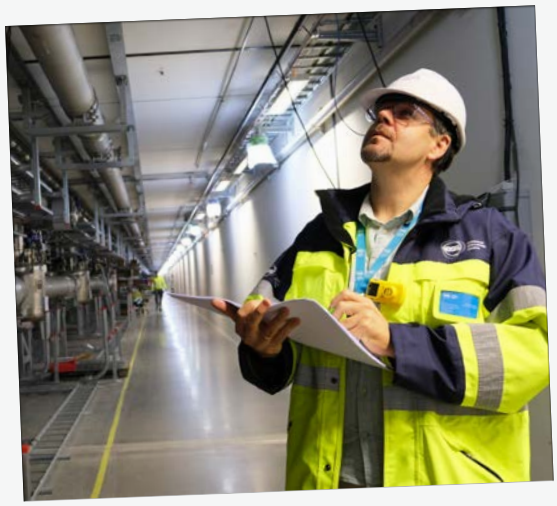
9 March 2022: Morten Jensen, RF section leader, overseeing radiofrequency power tests in the Normal Conducting Gallery.



15 March 2021: Mats Lindroos, head of the ESS Accelerator division, inspecting a Drift Tube Linac structure, under preparation for installation in the Normal Conducting Linac.

22 April 2021: The Sample Handling and User Labs team on a ramp connecting the beamline gallery and the long instrument hall.

23 April 2021: Welcoming the scientists of tomorrow. Master students, Emilie Wiklund and Anton Järild from LTH, Lund, working on their Master's thesis in the ESS laboratory facilities on site.



26 May 2021: Jarek Fydrych, Cryogenics Engineer, in the Superconducting Linac, inspecting the cryogenic distribution system that is installed.

3 June 2021: The first Drift Tube Linac tank, ready to be installed. Italian in-kind team from INFN with ESS in the Gallery loading hall.

16 June 2021: Accelerator Engineer Cecilia Maiano and Cryogenics Engineer Nuno Elias inside the test stand bunker in G02, where power tests and cool down of cryomodules is taking place.

8 October 2021: Taking pride in the project, Protection Systems Technician Mattias Eriksson refreshing the Foundation Stone on display in the ESS office atrium.

12 October 2021: ESS has met with its neighbours regularly for mor than 10 years. In 2021 they visited the new office building for the very first time and got a guided tour in the facility.

2 November 2021: Rigging technician Peter Elmqvist, pulling the so called NN bar, a large piece of stainless steel with space for three neutron beam port inserts, before it was lowered to its rightful.

30 November 2021: The LOKI detector vessel has just made the touch down inside the cave perimeter for the instrument, in the presence of staff from ESS and UK in-kind partner STFC.

MONIKA HARTL

Tell us about your job

I head the group responsible for running the user laboratories that currently support the ESS project in chemistry and material analysis. Once ESS starts operating, we will be focused on supporting the researchers in sample preparation and handling during their neutron scattering experiments in our labs.

What attracted you to ESS?

After my PhD in inorganic chemistry, I worked as a post-doctoral researcher at the neutron source in Los Alamos. I really enjoyed working in a large-scale user facility with researchers and staff from a wide variety of backgrounds. After a decade of being an instrument scientist in Los Alamos, becoming part of the construction of a new, bright neutron source for Europe was an interesting new challenge

Monika Hartl (front/left) in the SULF lab with Alice Corani (rear/right)

Valentina Santoro, Scientist, on campus at ESS

VALENTINA SANTORO

Tell us about your job

I joined ESS in 2015 as a scientist, working in neutronics simulations for the ESS instruments. From 2015 I have been leading the science focus team (SFT) for fundamental physics at ESS. I now work in the target division at ESS coordinating the neutronics interface to the instrument teams, and am the Project Coordinator of the HighNESS (High Intensity Neutron Source at the European Spallation Source) Project.

What do you enjoy about working at ESS?

My background is fundamental physics, which is a field the contributes to designing key components of the ESS facility. I was always fascinated by science because I was, and still am, fascinated by the world around us. I still see it as a mystery with so much unknown that only waits for us to understand it.

ANNA LEUNG

Tell us about your job

I joined ESS in 2016, and am a synthetic chemist working for the Deuteration and Macromolecular Crystallisation (DEMAX) platform, where we apply conventional methods, and establishes new methods, to synthesise deuterated molecules that neutron users need, which can greatly increase the complexity and impact of neutron experiments.

What attracted you to ESS?

I love the applied and varied nature of my work at ESS, and learning about the ways collaborators use the molecules I make in their research. I also appreciate the opportunity to travel, to communicate my research and to collaborate with scientists across the world. I see the same curiosity that I have always had in my daughter, and I hope I can inspire her to be as excited by science as I am in the future.

Anna Leung, Deuteration Scientist, with her daughter, Audrey

JUDITH HOUSTON

Tell us about your job

I joined ESS in 2018 as a second scientist, and am now the lead instrument scientist for LOKI - one of the future small-angle neutron scattering instruments at ESS. The overarching aim of my work is to shed light on the relationship between a material's structure at the nanoscale, and its properties at the macroscale. Understanding this connection is key to tackling both global challenges, and to developing materials which we interact with every day.

What do you enjoy about working at ESS?

As a curious person, I constantly endeavour to understand what makes the world work. For that reason, a career in scientific research with the key ingredients of creativity, problem solving, and a diverse working environment felt like a natural choice for me. I cannot wait to see what the future holds.

Judith Houston, Instrument Scientist, at the Jülich Centre for Neutron Science (JCNS) in 2017

DARIA NOFERINI

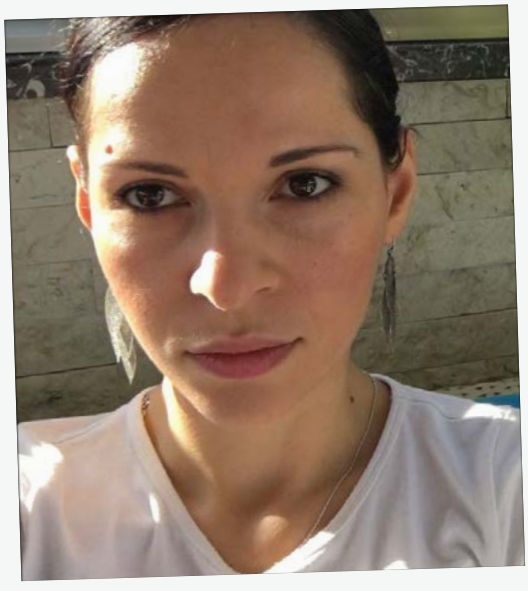
Tell us about your job

I joined ESS in 2020 as an instrument scientist, and am currently focusing on the realisation of CSPEC, the cold chopper spectrometer at ESS, which will help tackle the many challenges of our and future times, from climate changes to diseases, from food provision to space exploration, as well as to improve the quality of life for everyone.

What do you enjoy about working at ESS?

To some extent, I use neutrons to both help preserve the memory of the past and contribute to a sustainable future. Also, I find it fascinating to uncover patterns in disordered materials; for example, investigating the properties of liquids in confinement. Curiosity is my driving force. It is truly exciting to contribute to the CSPEC design and construction, and I look forward to collaborating with all the users who will exploit it once completed.

Daria Noferini, Instrument Scientist, standing on the CSPEC guide at ESS



LALI TCHELIDZE

Tell us about your job

I have been leading the operations section since 2018. The operations section is still a small team, but we are growing fast which makes the dynamic life at ESS even more interesting. We are an international team with various backgrounds but the high sense of responsibility and drive unites us in a common goal to contribute to making ESS a world class facility.

What attracted you to ESS?

During my PhD studies I decided to learn more about accelerators as part of my research, and started attending various accelerator schools in the US, as well as in Europe. It was here I met my future husband, and as he was studying in Lund, I got to travel to Sweden first time in my life. I decided to move to Sweden and got to learn about an emerging large-scale project, European Spallation Source, via a university professor. Within a couple of months, I was offered a job: this was back in 2010, and I've greatly enjoyed working here ever since.

Construction of buildings completed

2021 saw our construction partner, Skanska, complete the construction of the buildings and the surrounding landscape on the 70-hectare site. The civil construction project, one of the largest in recent years in Sweden, started in 2014 and was completed and handed over to ESS in December.

ESS and Skanska have worked in close collaboration since the partnering collaboration for the civil construction of the facility was established in February 2014. Through a joint project management team leading and developing the work, the aim was to provide flexibility and control during the complex construction project.

"Skanska has done an excellent job in the construction of the complex research infrastructure, in close collaboration with ESS, while at all times ensuring a safe work environment for all personnel on site," says Helmut Schober, ESS Director General. "In line with the ambitious sustainability goals of ESS, Skanska has also established a green building site that will set an example of environmentally friendly construction."

The civil construction project was executed based on joint guiding principles, such as openness, honesty and mutual respect. Construction partner Skanska worked side by side with ESS Conventional Facilities to deliver the civil construction project. ESS was granted parallel access to areas to perform time-critical installations throughout the construction.

"ESS is based on collaboration, both as research facility and construction project. The close collaboration and mutual trust between Skanska and ESS have been a prerequisite for the project's success," says Gunnar Hagman, CEO of Skanska Sweden. "Innovation and sustainability are important to Skanska, not only in how we work but also in what we deliver to our customers and to society."

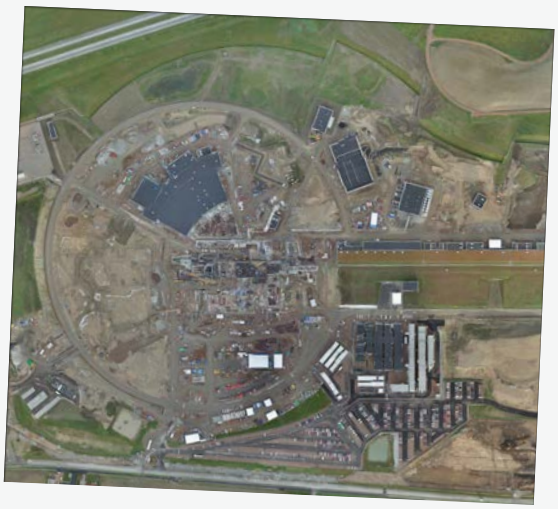
The buildings were handed over to ESS gradually during the Construction Phase. The first buildings, including the accelerator tunnel, were completed in the spring of 2017. Despite the challenges caused by the pandemic, the civil construction works were completed according to plan, when the final buildings - the target station and adjacent instrument halls - were handed over in December 2021.

"With collaboration as the keyword, we worked as one team enabling us to meet the challenges we faced along the way," states Per Smidfelt, Project Director for Skanska, "We have handed over a fantastic facility to ESS – and we did this on time."

Leading the civil construction project over the finish line Per Smidfelt concludes, "I will follow the continued progress and future science at ESS with great interest. You do not often get the chance to be part of a project that could really improve the world. ESS in Lund is one such project!"

ESS building facts

- The Accelerator tunnel is 537 m long.
- The Target Station is 22 m wide, 37, tall and 130 m long.
- The higherst part is 124 m above sea level.
- In total 72 913 m^3 concrete has been used.
- Stably anchored through 6 077 concrete piles, 458 steel core piles and 63 bored piles anchored to the bedrock.
- The Cantilever, Sombrero protrudes up to 35 metres beyond the façade, with 7 766 aluminium lamellae mounted to the structure its footprint measures 200 × 150 metres.
- The ESS offices are rated Outstanding on the BREEAM scale, the highest rating in the international sustainability assessment for buildings.

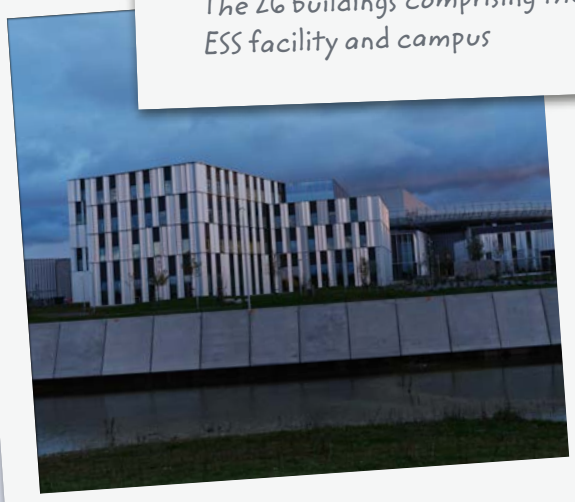


Flight scanning midst construction of ESS, 26 October 2018

The completed construction project, end of 2021

The 26 buildings comprising the ESS facility and campus

The ESS construction project was executed with a strong focus on sustainability



The ESS facility seen from the entrance building

The ESS sombrero at night

Built on collaboration

ESS is built on collaboration, and about 30% of the construction cost is provided by the member states as In-Kind contributions – time and equipment provided to the facility instead of cash. This contributes to the technical excellence of ESS, and drives co-ownership and strong collaboration across borders. With massive amounts of In-Kind work going on at ESS and at member state facilities, only a few examples can be presented here. For more information visit the ESS website.

A **Target Helium Cooling System**

Providing heat removal from the target wheel

NPI/UJF, Czech Republic

E **LOKI detector vessel delivered**

Containing detectors for scattered neutrons

STFC/ISIS, UK

I **ESS Main Control Room Design and Infrastructure**

For monitoring and control of the ESS facility's operations

IFE, Norway

M **Spoke cryomodules tested and delivered**

Preparing to install in Superconducting Linac

Manufactured by CNRS, France
Tested by Uppsala University, Sweden

B **BIFROST spectrometer vessel delivered**

Containing analysers and detectors for neutron experiments

DTU, Denmark

F **Cryogenic Moderator System cryostat delivered**

Providing helium cooling for the Cryogenic Moderator System

Jülich, Germany

J **From assembly to testing of cryomodules**

Preparation for installation of superconducting cavities in the tunnel

Supplied by CEA, France
Cavities from INFN, Italy
Tested by IFJ PAN, Poland

N **Two glove boxes for Radioactive Materials lab installed**

Enabling work with air and moisture sensitive radioactive materials in a safe environment

University of Tartu, Estonia

C **Chemistry Labs operational**

Supporting the installation project whilst preparing for user support

STFC/ISIS, UK

G **Four Spoke Radio Frequency power stations installed**

Generating high power for the Spoke cryomodules

Elettra, Italy

K **Radio Frequency (RF) Interlock system delivered and installed**

Providing safety protection system

Atomki, Hungary

O **Two Selene guides delivered for instrument ESTIA**

Containing neutron guides

PSI, Switzerland

D **42 port tubes welded to the vessel**

Providing containers for the first part of the neutron extraction system

ESS Bilbao, Spain

H **RF distribution system and modulators for Normal Conducting Linac installed**

Generating high power for the klystrons to the RFQ and DTL sections

ESS Bilbao, Spain

L **Floor valves, intrabay doors, Waste Transfer System installed in the Active Cells**

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

UKAEA/RACE

P **Drift Tube Linac tanks 2-5 in assembly**

Preparing accelerating structures for installation in Normal Conducting Linac

INFN, Italy

Q **Installation and testing of elliptical Cryogenic Distribution System**

Transporting helium from the cryoplant to the cryomodules

WUST, Poland

R **Installation and testing of the Radio Frequency distribution system to the Superconducting Linac**

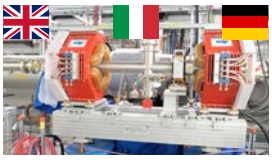
Transporting high power from the RF source to the super-conducting RF cavities

Supplied by: STFC, UK
Tested by: IFJ PAN, Poland

S **Drift Tube Linac tank 1 installed in tunnel**

Enabling next step of beam commissioning in Normal Conducting Linac

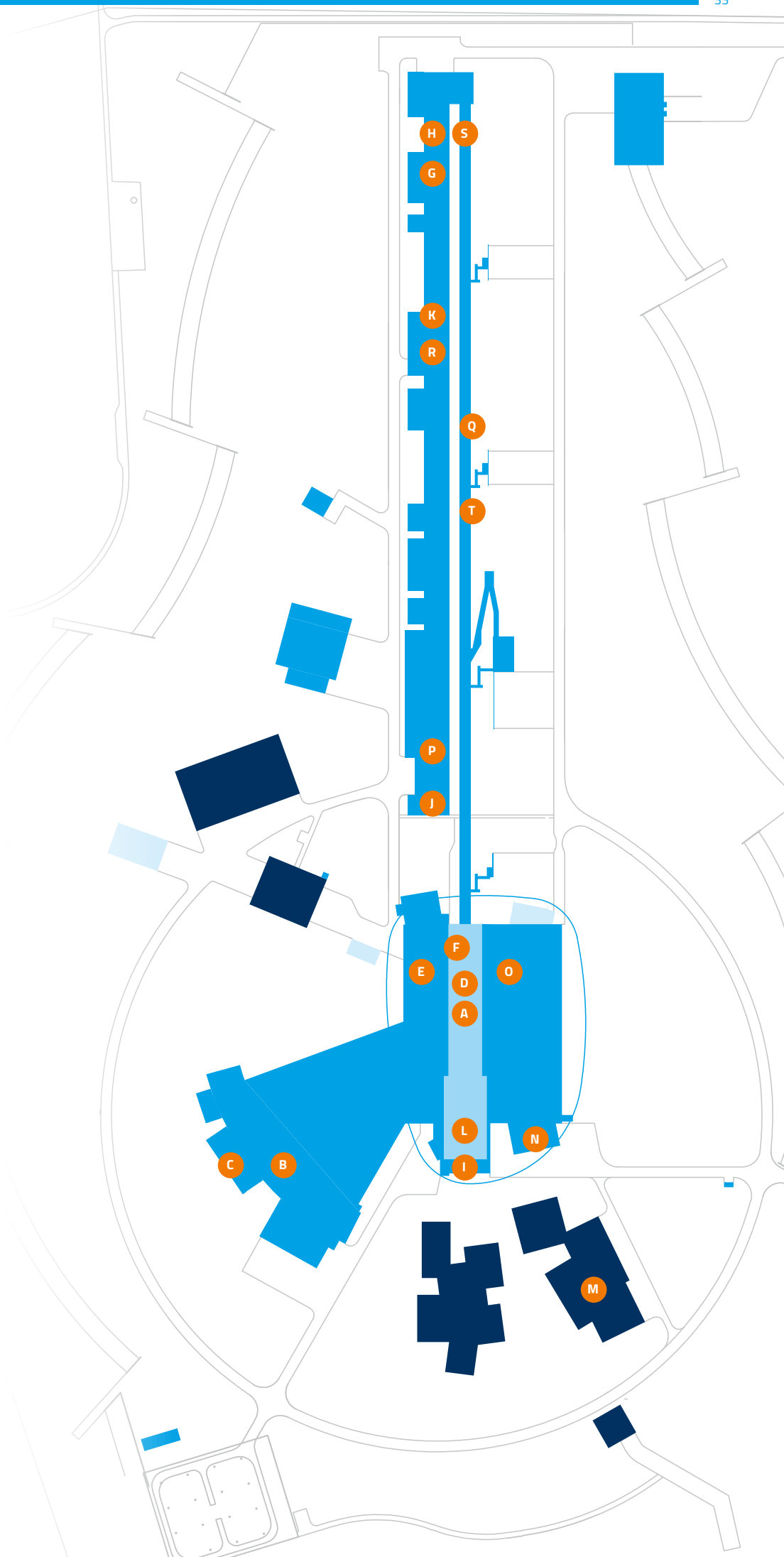
INFN, Italy

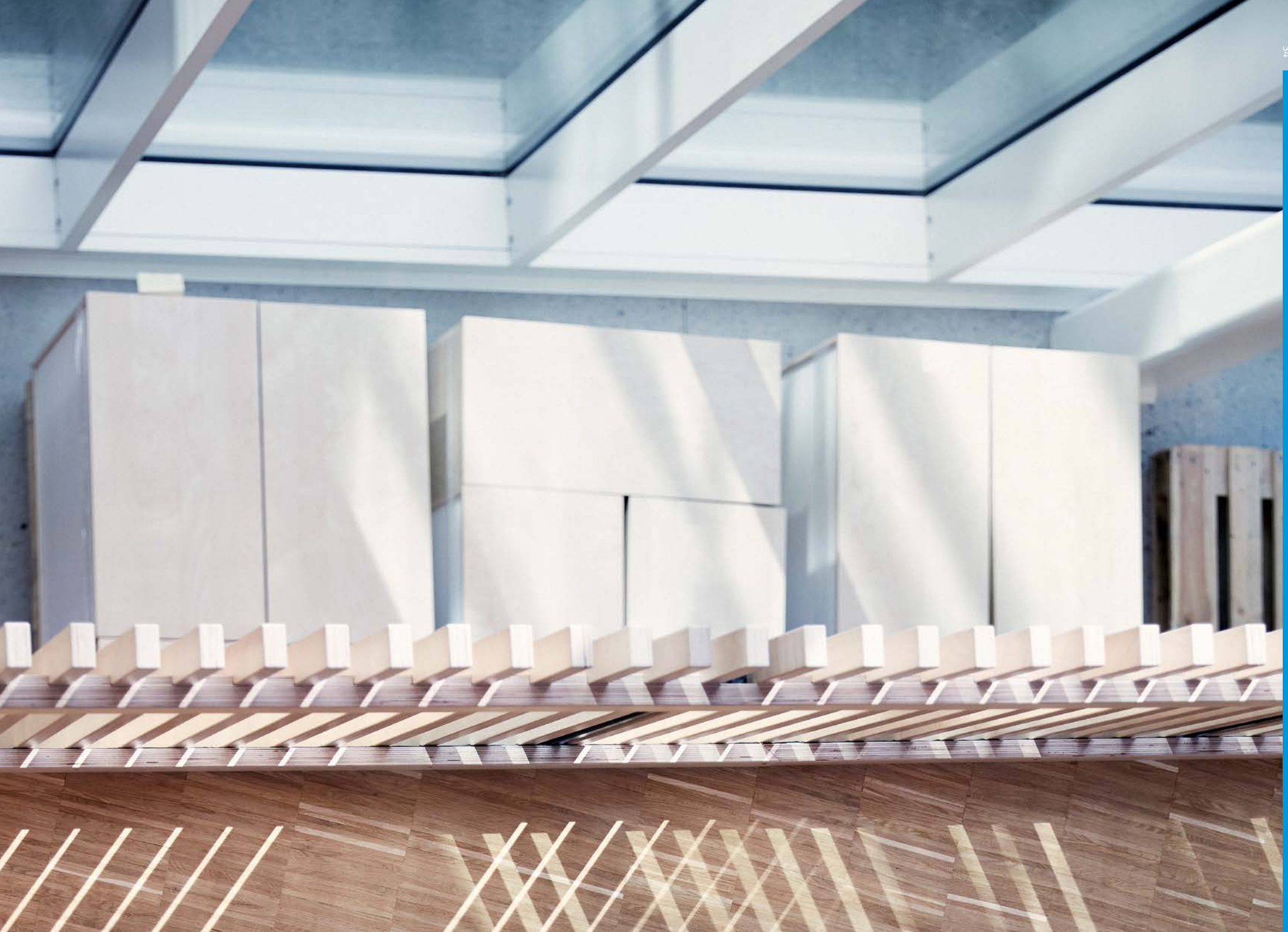


T **Linac Warm Units delivery and Installation**

Focusing, defocusing and monitoring the proton beam

Supplied by STFC, UK
Magnets from Elettra, Italy
Beam Diagnostics by DESY, Germany





Statutory Report

European Spallation Source ERIC
Org. no. 768200-0018

ESS Expenditures Reach Across Europe

The following shows the expenditures (cash basis) at ESS during 2021 for ESS members and other countries. The data is based on invoices paid for the period January – December 2021. The data includes all payments by ESS, including, but not limited to, commercial contracts, including construction costs related to the construction contract with Skanska, rental agreements, collaboration agreements, and travel.

SUPPLIERS 2021 BY COUNTRY

	SEK	EUR
Australia	77 045	7 594
Austria	1 382 696	136 169
Belgium	271 278	26 852
Bosnia and Herzegovina	525 222	51 480
Canada	6 560 467	644 350
China	2 233 363	220 340
Croatia	545 961	54 930
Czech Republic	1 150 609	113 360
Denmark	31 621 161	3 112 491
Finland	5 554 778	548 253
France	19 420 428	1 908 358
Germany	50 281 910	4 973 523
Greece	180 664	17 735
Hungary	36 803 339	3 632 285
Ireland	482 964	47 498
Israel	25 059	2 471
Italy	6 744 688	666 890
Japan	10 315 604	1 016 891
Lithuania	3 752	369
Luxembourg	25 675	2 519
Malta	30 420	2 995
Netherlands	8 810 823	866 417
Norway	421 841	41 682
Poland	5 104 294	503 157
Portugal	159 537	15 745
Serbia	3 945	390
Slovenia	2 446 040	240 892
Spain	107 282 669	10 553 175
Sweden	1 554 525 525	153 121 540
Switzerland	17 174 845	1 687 799
United Kingdom	52 480 255	5 173 735
United States	10 815 115	1 064 450
Uruguay	591 260	58 256
GRAND TOTAL	**1 934 053 231**	**190 514 591**

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 2021

Odd Ivar Eriksen
NORWAY

Marek Jezabek
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

James Partington
UNITED KINGDOM

ESS EXECUTIVE TEAM (EET)

Director General	**Helmut Schober**
Director for Project Support & Administration	**Agneta Nestenborg**
Director for Science	**Andreas Schreyer**
Technical Director	**Kevin Jones**
Associate Director for Environment, Safety & Health, and Quality	**Ralf Trant**
Associate Director for Strategy	**Sharon Cosgrove**
Project Director	**Mark Anthony**
Associate Director for In-Kind Management	**Dimitri Argyriou**
Head of Communications	**Martin Sjöstrand**
Senior Executive Assistant	**Karin Hélène**
Head of Conventional Facilities	**Kent Hedin**
Head of Initial Operations	**Therése Welander**

ADMINISTRATIVE & FINANCE COMMITTEE (AFC)

Chair	**Stéphanie Le Van**
Vice Chair	**Xavier Reymond**
Czech Republic	**Ondřej Svoboda**
Denmark	**Morten Scharff**
Denmark	**Ditte Nissen Lund**
Estonia	**Priit Tamm**
France	**Claire Lechevalier**
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 Córdoba Lasuncion**
Spain	**Javier Losada**
Sweden	**Johan Holmberg**
Sweden	**Mikaela Rapp**
Switzerland	**Xavier Reymond**
United Kingdom	**Philippa Kingston**
United Kingdom	**Laura Woodward**

Current as of 31 December 2021

TECHNICAL ADVISORY COMMITTEE (TAC)

Chair Alberto Facco

TAC TARGET

Co-Chair	Graeme Murdoch
Delegate	Eric Pitcher
Delegate	Francisco Martín-Fuertes
Delegate	Jörg Welte
Delegate	Jürgen Neuhaus
Delegate	Masatoshi Futakawa
Delegate	Michel Butzek

ICS

Co-Chair	Mark Heron
Delegate	Cyrille Berthe
Delegate	Eugenia Hatziangeli
Delegate	Markus Janousch

Accelerator

Co-Chair	Frank Gerigk
Delegate	Glen Johns
Delegate	Igor Syratchev
Delegate	Joachim Grillenberger
Delegate	Maud Baylac
Delegate	Mei Bai
Delegate	Stéphane Chel

SCIENTIFIC ADVISORY COMMITTEE (SAC)

Chair	Michael Preuss
Vice chair	Victoria Garcia Sakai
Delegate	William Stirling
Delegate	Fred E. Wietfeldt
Delegate	Bella Lake
Delegate	Juan Colmenero De Leon
Delegate	Emmanuelle Dubois
Delegate	Alessandro Triolo
Delegate	Pascal Manuel
Delegate	Alberto Mengoni
Delegate	Mirijam Zobel
Delegate	Klaus Habicht
Delegate	Henrik Rønnow
Delegate	Luise Theil-Kuhn
Delegate	Jonathan White
Delegate	Daniel Söderberg
Delegate	Giorgio Schiro
Delegate	Elizabeth Blackburn

IN-KIND REVIEW COMMITTEE (IKRC)

Chair	Bjørn Hauback	*Italy*	Giuseppe Gorini
Vice Chair	Dániel Csanády	*Norway*	Erik Wahlström
Czech Republic	Petr Šittner	*Poland*	Adam Maj
Denmark	Søren Pape Møller	*Spain*	Fiamma Garcia-Toriello
Estonia	Piret Pikma	*Sweden*	Jens Birch
France	Alain Ménelle	*Switzerland*	Peter Allenspach
Germany	Tania Claudio-Weber	*United Kingdom*	Robert McGreevy

PROJECT ADVISORY COMMITTEE (PAC)

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

COMMITTEE ON EMPLOYMENT CONDITIONS (CEC)

Chair	Beatrix Vierkorn Rudolph
Member	Lukáš Levák
Member	Martin Müller
Ex-officio member	Katarina Bjelke
Ex-officio member	Bo Smith

Current as of 31 December 2021

ENVIRONMENT, SAFETY & HEALTH ADVISORY COMMITTEE (ESHAC)

Chair	**Paul Berkvens**
Delegate	**John Anderson**
Delegate	**Enrico Cennini**
Delegate	**Frank Kornegay**
Delegate	**Stefan Roesler**
Delegate	**Steven Wakefield**

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**
Delegate	**Marie-Hélène Mathon**
Delegate	**Aldo Covello**
Ex-officio member	**Helmut Schober**
Ex-officio member	**Florian Weissbach**

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 2021.

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 2027. 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 under construction 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 513 employees from 56 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.

Construction project

In 2021, work continued to follow the schedule to be able to complete the project within the established cost framework. On 31 December 2021, all buildings were completed and had been handed over to ESS Facility Management, which has the task of managing the buildings, and the respective division for installation work.

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 Risk Management Plan 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.
- 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 during the year, 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 collision. 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 respective 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. Implementation is based on the energy policy with the energy concept "Responsible, Renewable, Recyclable" and with the goal of consuming less than 270 GWh of electricity per year.

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

d) 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:

e) 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,

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

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

h) 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 ESS's Initial Operations Phase have been continuously evaluated and updated during the year, and been 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 remaining funding risks connected to the Construction Phase relate to reaching a hundred per cent commitment, and financing to secure the project's liquidity needs.

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 and sold to the district heating network in the surrounding area. A fraction of waste heat that maintains lower temperatures will go to the low-temperature district heating network that is being built up in north-eastern Lund.

As the facility has not yet been commissioned, there is no data on the quantities.

During the Construction Phase, storm water and drainage water from shaft pits have been diverted to two of the three surrounding ditching companies via delay reservoirs built on the property. One of the three surrounding ditching companies leads to Kungsmarken, a Natura 2000 area about a kilometre south of the property. No discharges with significant impact have occurred to surrounding ditching companies during the period. 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.

On the facility side, ESS has worked to maintain mass balance; that the masses that have been excavated for construction should remain on the site and be used for the construction of the bank for the accelerator tunnel and for the earthworks carried out to create an attractive environment. The organisation has also endeavoured to ensure that vehicles leaving the construction site during autumn and winter are cleaned of mud and the like to reduce the impact on the living environment of our neighbours.

The move into the new office on the ESS Campus began in January 2021. The office building was completed according to plan and within budget, and was awarded the rating Outstanding, the highest level in the sustainability standard provided by BREEAM international later in the year.

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 environment

ESS stays within the permissible noise levels regulated in the environmental judgment, and has special contact channels with the nearby residents to inform about ongoing and upcoming work, and to receive any complaints. No complaints were received during the year related to the construction of the facility.

ESS has an employee with the task of working with schools and the local community to make them involved in and interested in working with ESS as a research institution. For example, an external committee (EAGLE) was created during the year with the aim of achieving a Public Engagement Strategy, a strategy primarily for engaging students and schoolchildren. EAGLE consists of two people from ESS, as well as teachers from primary schools, upper secondary schools and colleges/universities in the host countries Sweden and Denmark. Due to the pandemic, its meetings have been held digitally, with the aim of holding a physical meeting at ESS in 2022.

Over the past ten years, as stated above, several meetings have been arranged every year with the closest neighbours to inform both them and the organisation about what is happening in the project and how it affects the neighbours. During the pandemic period in 2020/2021, these meetings have unfortunately not been possible on more than one occasion. Planning is underway to be able to carry out new meetings post Covid.

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.

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 2020, ESS received a permit for trial operation of the first 50 m of the accelerator, the so-called warm part. This means that work on the commissioning of this part was able to start in October 2021.

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 Health and Well-being Policy is a clarification of the promotion of health and well-being work within ESS.

The main objectives of the Health and Well-being Policy are to prevent illnesses and accidents by:

1. Making it easier for employees to be better aware of their health and to increase their own welfare.
2. Facilitating access to physical and social activities, and encouraging ESS personnel to participate in these.
3. Being an attractive workplace where people feel good and are satisfied with their work situation.
4. Identifying physical and psychological risks with the personnel through different analyses, and taking preventive measures to minimise and reduce sick leave, both in the long- and short-term.

At ESS, the distribution of the number of employees is 72% men and 28% women. A more even gender distribution is sought.

Since the relocation of the offices to the construction site in June 2019, ESS has introduced a drug and alcohol policy, in order to ensure a safe and healthy workplace.

The number of sick leave cases has remained low in 2021, and decreased by 18% compared to 2020, despite the ongoing pandemic.

No serious accidents were reported during 2021.

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 2021.

The diversity of the workforce and an open and appreciative culture are important success factors in a globalised world, and with 513 employees from a total of 56 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 2021.

Significant events during the year

The move into the new office on the ESS Campus began in January 2021. The office building was completed according to plan and within budget, and was awarded the rating Outstanding, the highest level in the sustainability standard provided by BREEAM international later in the year. Due to Covid-19, it has not yet been possible to use the building to its full capacity, but all functions have been put into operation, including the Kitchen Club restaurant, which serves lunches and, where applicable, business dinners for ESS, its personnel and guests.

In October 2021, the first part of the accelerator was commissioned and a particle beam could be accelerated at ESS for the first time. This has been made possible by constructing a new temporary wall inside the accelerator tunnel so that the warm section can be configured at the same time as the cold section is installed.

At the end of December, the final work on what is known as ESS Civil Construction, the conventional buildings and the landscape, was completed, and all buildings have thereby been completed and handed over from the project to ESS Facility Management. As a result, Skanska has also wound up its construction organisation.

The year has also been characterised by the ongoing pandemic. In mid-March 2020, a Working-from-home policy was introduced at ESS in order to minimise the risk of infection spreading among the personnel and the consultants/fitters working on the site. During the late summer of 2021, it seemed that it would be possible to ease some of the restrictions and allow a certain number to return to work on site, but the continued spread of the infection in society made a more general return to the office impossible. The strategy of keeping the personnel at home who were able to work from home has been successful, to the extent that the infection rate at ESS has always been low. In a few isolated cases, the infection has spread in the ESS area to a very limited group, but, on the whole, the number of infections in the workplace has been relatively small.

However, the pandemic has affected the project in that many in-kind suppliers are located in countries where they have at times had a total lockdown, and as such not been able to complete or deliver vital parts to ESS. Together with other technical challenges, this prompted a Rebaseline project to start during the year, with the stated goal of setting a new schedule for the completion of the facility and investigating what additional costs will be incurred as a result.

At its December meeting, the ESS Council decided that the ESS schedule should be revised so that the facility reaches full operation and opens for research by 2027, two years after the original schedule and with an additional cost of MEUR 550, of which MEUR 400 is the previously estimated operating cost during the two extra years.

Expected future development and significant risks and uncertainties

The greatest uncertainty factor moving forward is how the pandemic will develop. At the time of writing, however, most European governments seem to be preparing for a gradual return to how things were before the pandemic, which will ensure that foreign installers will once again be able to come and install equipment and in-kind work in the facility.

Starting on 1 January, implementation began of the plan decided by the Council in December. A review of the organisation has also begun, so that it can better support the progress of the project.

The development of the Company's financial performance and position

The net result for the year amounted to MSEK –1,256 (–1,334). The result includes costs for personnel and consultants, as well as the administrative and technical infrastructure during the Construction Phase. Equity amounted to MSEK 5,274 (4,069).

Investments

Investments were made during the year in fixtures and fittings, and ongoing new facilities totalling MSEK 1,173 (1,564).

Financing and liquidity

During its fiscal year 2021, ESS received contributions from member countries totalling MSEK 2,461 (1,771). Further information on the contributions received can be found in Note 18. Cash and cash equivalents amounted to MSEK 2,513 (1,629).

Income Statement

KSEK	2021-01-01 – 2021-12-31	2020-01-01 – 2020-12-31
Net turnover	–	-
Gross result	**–**	**-**
Administration expenses (Note 5, 6)	–544,944	–521,215
Research and development expenses (Note 6)	–699,980	–828,116
Other operating income (Note 7)	24,871	47,231
Other operating expenses	–6,518	0
Operating result	**–1,226,571**	**–1,302,100**
Financial income (Note 8)	0	4
Financial expenses (Note 9)	–29,609	–31,829
Result after financial items and before tax	**–1,256,179**	**–1,333,925**
Tax (Note 10)	-	-
RESULT FOR THE YEAR	**–1,256,179**	**–1,333,925**

Balance Sheet

KSEK	2021-12-31	2020-12-31
ASSETS		
Non-current assets		
Buildings (Note 11)	5,687,399	22,116
Land (Note 12)	64,250	64,250
Equipment, tools and installations (Note 13)	64,538	49,407
Construction in progress (Note 14)	1,786,190	6,312,175
Total non-current assets	7,602,377	6,447,948
Current assets		
Accounts receivable	863	984
Current receivables (Note 15)	168,569	233,613
Prepaid expenses and accrued income (Note 16)	43,305	43,844
Cash and bank balances	2,513,054	1,628,823
Total current assets	2,725,791	1,907,264
TOTAL ASSETS	**10,328,168**	**8,355,212**

KSEK	2021-12-31	2020-12-31
EQUITY AND LIABILITIES		
Equity		
Capital contribution (Note 18)	6,503,342	5,403,368
Net result	–1,256,179	–1,333,925
Total equity	5,274,163	4,069,443
Long-term liabilities		
Liabilities to credit institutions (Note 19)	4,254,022	3,462,425
Current liabilities		
Accounts payable	327,812	276,959
Current tax liabilities	8,505	0
Other liabilities (Note 20)	22,259	28,857
Accrued expenses and prepaid income (Note 21)	441,407	517,528
Total current liabilities	799,983	823,344
TOTAL EQUITY AND LIABILITIES	**10,328,168**	**8,355,212**

Equity

KSEK	Cash contribution	Previous year's result	Result for the year	Total equity
Opening balance 2020-01-01	8,491,021	–4,858,407	-	3,632,614
Contributions received	1,770,754	-	-	1,770,754
Net result 2020	-	–1,333,925	-	–1,333,925
Opening balance 2021-01-01	10,261,775	–6,192,333	-	4,069,442
Contributions	2,460,900	-	-	2,460,900
Net result 2021	-	-	–1,256,179	–1,256,179
CLOSING BALANCE 2021-12-31	**12,722,675**	**–6,192,333**	**–1,256,179**	**5,274,163**

Cash Flow Analysis

KSEK	2021-01-01 – 2021-12-31	2020-01-01 – 2020-12-31
Operating activities		
Result after financial items	–1,256,179	–1,333,925
Adjustment for non-cash items	18,289	14,479
Cash flow from operating activities before changes in working capital	–1,237,890	–1,319,446
Cash flow from changes in working capital		
Increase(-)/Decrease(+) of operating receivables	65,704	76,181
Increase (+)/Decrease (-) of operating liabilities	–23,361	274,247
Cash flow from operating activities	–1,195,547	–969,018
Investment activities		
Acquisition of tangible fixed assets (Note 12, 13)	–32,850	–23,484
Acquisition of construction in progress (Note 14)	–1,139,870	–1,540,862
Cash flow from investment activities	–1,172,720	–1,564,346
Financing activities		
Cash contributions	2,460,900	1,770,753
Loans	791,598	462,265
Cash flow from financing activities	3,252,498	2,233,018
Cash flow for the year	**884,231**	**–300,346**
Cash and cash equivalents at the beginning of the year	1,628,823	1,929,169
Cash and cash equivalents at the end of the year	2,513,054	1,628,823

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: 5–7 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

Receivables 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

In the coming years, ESS will gradually transition from a construction to an operational phase. This involves organisational changes, with implementations that will be carried out in 2022.

After the closing of the financial year, war has broken out in Ukraine, with significant effects on the world around us. At present, there is some uncertainty about how this will affect ESS in the future, and we are following developments closely.

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

AVERAGE NUMBER OF EMPLOYEES

SWEDEN	2021-01-01 – 2021-12-31	2020-01-01 – 2020-12-31
Men	342	341
Women	142	148
Total	484	489
DENMARK		
Men	33	26
Women	5	4
Total	38	30
TOTAL	**522**	**519**

GENDER DISTRIBUTION IN COMPANY MANAGEMENT

	2021-12-31	2020-12-31
Number of senior executives	8	8
Of which are women	25%	25%

SALARIES, OTHER REMUNERATION AND SOCIAL SECURITY COSTS		
KSEK	2021-01-01 – 2021-12-31	2020-01-01 – 2020-12-31
Sweden	326,815	332,059
Denmark	35,562	29,053
TOTAL	362,377	361,112
Social security costs	101,074	96,527
Pension costs incl. salary tax	87,246	57,197
TOTAL SOCIAL SECURITY AND PENSION COSTS	188,320	153,724
Salaries and other remuneration include:		
to the Director General	3,180	2,577
to other executives in senior management	13,001	12,741

REMUNERATION TO SENIOR EXECUTIVES 2021				
KSEK	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**

REMUNERATION TO SENIOR EXECUTIVES 2020				
KSEK	Basic salary	Other benefits	Pension costs	Total
Director General	2,526	51	674	3,251
Other senior executives (8 ppl)	12,667	74	1,835	14,576
TOTAL	**15,193**	**125**	**2,509**	**17,827**

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		
KSEK	2021-01-01 – 2021-12-31	2020-01-01 – 2020-12-31
Audit assignment, KPMG	399	399
Other assignments:		
KPMG	276	92
PWC	–	488
TOTAL	**675**	**979**

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		
KSEK	2021-01-01 – 2021-12-31	2020-01-01 – 2020-12-31
Leasing agreements where the Company is the lessee:		
Minimum leasing fees	20,324	21,018
Variable fees	10	10
TOTAL LEASING COSTS	**20,334**	**21,028**
Agreed future minimum leasing fees relating to non-cancellable contracts which are due for payment:		
Within a year	7,695	8,681
Between two and five years	4,922	9,390
TOTAL	**12,617**	**18,071**

NOTE 6: DEPRECIATION		
KSEK	2021-01-01 – 2021-12-31	2020-01-01 – 2020-12-31
Depreciation according to plan, distributed by asset:		
Buildings	–572	–572
Equipment, tools and installations	–17,717	–13,907
TOTAL	**–18,289**	**–14,479**
Depreciation according to plan, distributed by function:		
Administration costs	–3,164	–1,633
Research and development costs	–15,125	–12,846
TOTAL	**–18,289**	**–14,479**

NOTE 7: OTHER OPERATING INCOME		
KSEK	2021-01-01 – 2021-12-31	2020-01-01 – 2020-12-31
Exchange rate gains on receivables/liabilities of an operational nature	0	25,056
EU project grants	19,229	17,978
Other operating income	5,642	4,197
TOTAL	**24,871**	**47,231**

NOTE 8: FINANCIAL INCOME		
KSEK	2021-01-01 – 2021-12-31	2020-01-01 – 2020-12-31
Interest income	0	4
TOTAL	**0**	**4**

NOTE 9: FINANCIAL EXPENSES		
KSEK	2021-01-01 – 2021-12-31	2020-01-01 – 2020-12-31
Interest expenses	–29,609	–31,829
TOTAL	**–29,609**	**–31,829**

NOTE 10: TAX ON THE RESULT FOR THE YEAR		
KSEK	2021-01-01 – 2021-12-31	2020-01-01 – 2020-12-31
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.

NOTE 11: BUILDINGS		
KSEK	2021-12-31	2020-12-31
Accumulated acquisition values:		
At the beginning of the financial year	22,879	22,879
Transfer from work in progress	5,665,855	0
TOTAL	5,688,734	22,879
Accumulated depreciation according to plan:		
At the beginning of the financial year	–763	–191
Depreciation according to plan	–572	–572
Closing accumulated depreciation	–1,335	–763
TOTAL NET VALUE	**5,687,399**	**22,116**

NOTE 12: LAND		
KSEK	2021-12-31	2020-12-31
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 INSTALLATION		
KSEK	2021-12-31	2020-12-31
Accumulated acquisition values:		
At the beginning of the financial year	90,310	66,826
Acquisitions	32,850	23,484
TOTAL	123,160	90,310
Accumulated depreciation according to plan:		
At the beginning of the financial year	–40,903	–26,996
Depreciation according to plan	–17,719	–13,907
Closing accumulated depreciation	–58,622	–40,903
TOTAL NET VALUE	**64,538**	**49,407**

NOTE 14: CONSTRUCTION IN PROGRESS		
KSEK	2021-12-31	2020-12-31
Accumulated acquisition values:		
At the beginning of the financial year	6,312,175	4,771,313
Acquisitions	1,139,870	1,540,862
Transfer to buildings	–5,665,855	0
TOTAL	**1,786,190**	**6,312,175**

NOTE 15: CURRENT RECEIVABLES		
KSEK	2021-12-31	2020-12-31
VAT receivables	142,510	171,926
Other tax receivables	24,522	16,012
Receivables, contributions from member countries	1,262	40,911
Other	275	4,764
TOTAL	**168,569**	**233,613**

NOTE 16: PREPAID EXPENSES AND ACCRUED INCOME

KSEK	2021-12-31	2020-12-31
Prepaid rental costs	0	1,527
Prepaid insurance premiums	10,544	14,036
Accrued income, EU projects	22,871	19,356
Accrued interest income	395	172
Other	9,495	8,753
TOTAL	**43,305**	**43,844**

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		
KSEK	2021-12-31	2020-12-31
Czech Republic	234,774	180,907
Denmark	1,873,457	1,587,728
Estonia	25,710	17,615
France	572,255	371,132
Germany	2,072,048	1,766,589
Hungary	71,269	59,436
Italy	411,190	352,929
Norway	428,386	397,834
Poland	169,534	108,922
Spain	46,822	42,073
Sweden	4,608,033	3,554,033
Switzerland	383,757	341,491
United Kingdom	979,826	635,472
TOTAL	**11,877,061**	**9,416,161**

NOTE 19: INTEREST-BEARING LIABILITIES TO CREDIT INSTITUTIONS		
KSEK	2021-12-31	2020-12-31
External loans to credit institutions, due between 1–5 years	3,830,455	1,003,750
External loans to credit institutions, due later than 5 years	423,567	2,458,675
TOTAL	**4,254,022**	**3,462,425**

NOTE 20: OTHER LIABILITIES		
KSEK	2021-12-31	2020-12-31
Employee taxes and fees	17,820	19,149
VAT	3,170	8,946
Other	1,269	762
TOTAL	**22,259**	**28,837**

NOTE 21: ACCRUED EXPENSES AND PREPAID INCOME		
KSEK	2021-12-31	2020-12-31
Property tax	31,800	0
Accrued vacation pay	33,638	30,924
Statutory social security costs	9,121	8,671
Accrued salary tax	10,994	10,185
Advances for EU-related projects	50,728	58,617
Cash in-kind	280,681	344,984
Accrued interest	7,084	4,667
Other accrued expenses and prepaid income	17,361	59,480
TOTAL	**441,407**	**517,528**

NOTE 22: CONTINGENT LIABILITIES AND PLEDGED ASSETS		
KSEK	2021-12-31	2020-12-31
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

European Spallation Source ERIC
Partikelgatan 2, Lund, Sweden

ess.eu